STUDIES ON THE BIOLOGY OF THE REEF FISHES OF GUAM

PART I: Distribution of Fishes on the Reef Flats of Guam

PART II: Distribution of Eggs and Larvae of Fishes at Selected Sites on Guam

By

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UNIVERSITY OF GUAM MARINE LABORATORY

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GENERAL INTRODUCTION

Guam's reefs are predominantly fringing reefs. The processes of reef growth, erosion, and sedimentation typical of such fringing reefs have produced an extensive reef flat environment which extends from the shoreline out to the reef margin. The reef flat is absent along some portions of Guam's coastline, but in other areas extends almost one kilometer from the shore (Randall and Eldredge, 1976). Because it is contiguous with the shoreline of Guam, the reef flat is the recipient or potential recipient of all effluent discharges from the island. The reef flat is also subject to dredging and filling and other modifications associated with shoreline developments on Guam.

In order to better understand the ecological significance of present and future impacts on the reef environment, the University of Guam Marine Laboratory, under contract to the Office of Coastal Zone Management, Department of Planning of the Territory of Guam, has been carrying out a series of studies on the existing biota of selected reef flat areas around Guam. These studies have been designed to provide baseline data on existing biological communities on the reef flat and to indicate some of the important ecological factors of the reef flat environment which promote the development and maintenance of these communities. This report presents the results of studies on fishes associated with the reef flat environment. The study is divided into two parts: one dealing with the distribution of resident fishes on the reef flat and the other dealing with the distribution of eggs and larvae of fishes found in the waters associated with various reef areas.

PART I. Distribution of fishes on reef flats on Guam

Fish are a conspicuous component of the reef flat community. They are important economically as potential sources of food for man, for their value in the aquarium trade, and for the enjoyment they provide to recreational snorklers and divers. They may also be important ecologically in maintaining the balance of the reef community by grazing and cropping of marine plants, by redistributing nutrients in their waste products, and by serving as food for reef carnivores.

The study presented here has a three-fold purpose:

1) to provide baseline data on the species composition and abundance of resident fishes on selected reef flats on Guam;
2) to indicate patterns of fish distribution on reef flats that might be generally applicable to a variety of reef areas on Guam; and
3) to suggest environmental factors which influence the composition of reef flat fish communities.

The information provided herein should make it possible to make some reasonable predictions of the impact of various types of environmental modification on the structure of the reef flat fish community on Guam.

METHODS

Fishes were assessed quantitatively by laying out a transect line from the shoreline to the reef margin. A swimmer equipped with snorkeling or scuba gear moved along the transect line identifying and enumerating all species of fish observed within one meter of either side of the line. Separate counts were made for each 10-meter interval along the transect line so that patterns of zonation of the fishes could be determined. The locations of each of the transect sites are shown in Figure 1, and Table 1 provides information on the lengths of the transects and the dates on which the censuses were made.

RESULTS AND DISCUSSION

Rabbitfish

Before the more general aspects of the distribution of fishes on the reef flat can be discussed, it is necessary to deal with the special case of the rabbitfish, family Siganidae. Two species of siganids, *Siganus spinus* (Linnaeus) and *S. argenteus* (Quoy and Gaimard), are common on Guam, although other rabbitfish species have been recorded here (Kami et al., 1968; Kami, 1975). The life cycle of these fishes exhibits a marked seasonal pattern. A pelagic, planktivorous larval stage in offshore waters develops into an herbivorous juvenile form, known locally as manahac, which takes up residence on the reef flat. The appearance of the juvenile rabbitfish on the reef occurs primarily during the months of April and May (although sugsequent runs during June and October occasionally take place) and is closely tied to the moon phase, occurring within a few days of the last quarter of the moon (Kami and Ikehara, 1976). The juveniles spend 4 to 8 weeks (*S. argenteus*; Tobias, 1976) to several months (*S. spinus*; Bryan, 1975) on the reef flat feeding on algae and growing, and then, as subadults, move to deeper areas beyond the reef front. Although the seasonal occurrence of the juvenile siganids on the reef is predictable, their abundance from year to year fluctates widely and, seemingly, randomly (Kami and Ikehara, 1976).

During the course of this study, significant numbers of juvenile siganids were seen on several reef flats from April 13 to June 17, 1977 (Tables 3 to 12), whereas none were seen during the surveys made from December 15, 1977, to March 29, 1978. During the period of time when rabbitfish were observed on the reef flat, average densities in some reef zones were as high as six per square meter (Table 3), and within particular 20 m^2 census areas reached densities of 16 per square meter. Creel censuses carried out by the Guam Division of Aquatic and Wildlife Resources have indicated that the rabbitfish run in the spring of 1977 was one of the largest yet recorded, while the run in the spring of 1978 has been one of the smallest (M. Molina, pers. comm.).

Although the juvenile siganids may have a significant impact on certain species of algae growing on the reef flat (FitzGerald, 1976), they appear to have no major influence on the standing stock of resident reef flat fishes. Of the three transects run during the spring 1977 rabbitfish run and recensused seven to eleven months later, one (Table 5) showed resident fish to be less abundant during the rabbitfish run and two (Tables 8 and 9) showed resident fishes to be more abundant during the run. Observations made during the 1977 run indicated that the young rabbitfishes moved across the reef flat in very dense aggregations, feeding on the algae growing there. Certain resident damselfishes (Pomacentridae) which protect patches of algae for their own use (so-called "farmer fish" of the genus Eupomacentrus) were very actively, but seemingly ineffectively, trying to drive the rabbitfish away from their territories. As the rabbitfish appear to be selective in their choice of algal foods (Tsuda and Bryan, 1973), even large runs may leave sufficient quantities of algae on the reef flat to support resident herbivores.

In the subsequent discussions of the distribution of fishes on the reef flat, emphasis will be placed on resident fishes. Siganids, which may be important during certain periods, do not otherwise seem to be a significant part of the reef flat fish community, and will be ignored (as they are in Figures 2 to 11).

Zonation

The reef flat environment is clearly not homogeneous with respect to fishes. There are differences in fish abundance and species composition from area to area and differences in the abundance and composition of zones in the same reef area. Because area to area differences appear to be largely a reflection of varying representation of different zones in t he different areas, zonation patterns will be considered first.

One of the most conspicuous patterns is a relatively low abundance of fishes on the nearshore part of the reef flat with an increase in abundance with greater distance from shore. This pattern is exhibited on virtually all of the transects (Figures 2 to 11). Additionally, some reefs show a decline in fish abundance on the extreme outer reef margin. These zonal variations in abundance seem to be closely related to the availability of cover for fishes. The inshore areas on the Tumon and Agana transects and on Agat transect 2 have a long stretch of sand substrate with very little topographic relief. Few fishes reside in this habitat, and those which do occur here are generally in association with isolated coral colonies. Fish abundance increases in coral-dominated areas and in areas where the substrate is dissected and there is a significant amount of topographic relief. These habitats are found in the outer portions of the inner reef flat and on some of the outer reef flats.

On the outer reef flats in Agana Bay fewer fish are found primarily because these areas exhibit little topographic relief and are subject to heavy wave assault. It was difficult for the investigator to census the fish in these areas because of the strong action of the waves, and it is presumed that the same factor may be at work to limit the number of fish which can occupy this environment.

The diversity of species shows a similar, though less marked, pattern as the abundance of fishes, with a relatively low number of species in the nearshore areas, increasing toward the reef margin. On some reefs, species richness is low at the reef margin (Figures 4 to 7) because heavy wave assault makes this zone inhospitable to fishes. On other reefs, species richness is notably higher on the reef margin because of the topographic relief here which makes more habitats available to more types of fish. In most cases, the increase in the number of species on these reef margin areas is due to the occurrence of reef front species which have not previously been encountered on the reef flat. The low species richness in nearshore areas is due to the lack of topographic relief and habitat diversity in these environments.

Species Patterns

Various fish species encountered in the reef flat environment show rather clear-cut patterns of zonation in their distribution. Four species making up two congeneric pairs (*Halichoeres trimaculatus* and *H. margaritaceous* and *Glyphidodontops glaucus* and *G. leucopomus*) exhibit very marked zonation patterns and their distributions along the transects are show in Figures 2 to 11. These and other species will be discussed below.

Halichoeres trimaculatus is one of the dominant species on the inner reef flat. It occurs over sandy bottoms where no cover is present. It is generally in low abundance on the outer reef flat, although it was abundant in this environment on Agat Bay Transect 2 (Tables 9 and 10); on these transects, however, it was considerably more abundant on the inshore portion of the outer reef flat than in the reef margin areas.

Other species associated with sandy substrates on the inner reef flat were various species of sand-dwelling gobies and blennies and occasional groups of young Lutjanus fulvus (a snapper), goatfishes (Mullidae), and the surgeonfish Acanthurus triostegus. Where an isolated coral head provided cover, numbers of the damselfishes Dascyllus aruanus and, in lesser abundance, Plectroglyphidodon leucozona were seen.

As scattered corals became more numerous, D. aruanus became more abundant, and various other species were also encountered, including the sharp-nosed puffer Canthigaster solandri and the cardinalfish Apogon novemfasciatus.

The greatest variety of fishes generally occurred in the coral-rich inner reef flat zone. The various farmer-fishes of the genus Eupomacentrus often reached their highest abundance in this zone.

On the outer reef flat, three species dominated: Glyphidodontops glaucus on the inner portion, G. leucopomus on the outer portion, and Halichoeres margaritaceous throughout this zone. There was generally very little overlap between the two species of Glyphidodontops. These three fishes were characteristic of areas of strong surge and were found on the outer reef flats of virtually all of the transects.

Four damselfish species, Eupomacentrus fasciolatus, Plectroglyphidodon dickii, P. lachrymatus, and Pomacentrus vaiuli, were found almost exclusively just over the reef margin out of the heavy surge zone. Two surgeonfish species Acanthurus lineatus and Ctenochaetus striatus, were often common just beyond the reef front and penetrated the reef flat in areas where there was sufficient topographic relief.

Area Comparisons

Of the fish communities surveyed, the major differences are between those found on relatively wide reef flats (Tumon Bay, Agana Bay, and Agat Bay Transect 2) and those found on narrow reef flats (Agat Bay Transect 1, Fouha Bay, and Ylig Bay). On the narrower reef flats, the sand bottom inner reef flats are reduced or absent, and so those fish species typical of this environment (see above) are in reduced abundance. The reef flat as a whole in these areas tends to most closely resemble the outer reef flat zone on the wider reefs. Almost the whole of the reef flat is subject to relatively strong wave action and surge and so those species adapted to these conditions predominate.

Environmental Factors

The composition of the fish community on the reef flat is influenced primarily by two environmental factors, wave action and topographic relief. A third important factor, substrate composition, is, to a large extent, under the control of the two primary factors. On the reef margin and outer reef flat zones, wave assault and associated surge is great. This prevents any accumulation of sand except in protected holes. Where this zone is relatively flat and shallow, the fish assemblage is dominated by *H. margaritaceous*, *G. leucopomus*, and *G. glaucus*, and few other species are encountered. These are the conditions found on the outer reef flats of the Agana Bay transects and on Agat Bay transect 1. In those areas where the outer reef flat is characterized by channels and grooves providing somewhat deeper water access to the reef front (Tumon Bay transects, Agat Bay transect 2, Fouha Bay and Ylig Bay), additional species are found on the outer reef flat, among them Acanthurus lineatus, Ctenochaetus striatus, species of Eupomacentrus, and various labrid (wrasse) species. Behind the outer reef flat zone, the reef deepens and may support a diverse community of corals which provides a variety of habitats for many species of reef flat residents. Further toward the shore, wave action and surge is reduced and sand deposits accumulate. This rather uniform environment supports few fish species in low numbers, although isolated coral colonies may harbor a variety of species not seen elsewhere in this zone.

Economically Important Species

The major types of fishing done of Guam's reef flats are throw-net and surround-net fishing. During the seasonal manahac (rabbitfish) runs, thousands of pounds of these fish may be harvested from the reef flats (Kami and Ikehara, 1976). Another seasonally abundant fish, the "mackeral" or atulai (Trachurops crumenopthalmus), may also be harvested in great quantities on the reef flat (however, none were seen during the transect studies reported here). Various other fishes, including goatfish (Family Mullidae), young jacks (primarily young Caranx melampygus), and surgeonfish (Family Acanthuridae), are taken in lesser quantities by throw net fishermen on the reef flat.

Some species of fish which are commonly harvested by spearfishermen and pole and line fishermen off the reef flat, spend their juvenile stages on the reef flat. These include the parrotfishes (Family Scaridae), goat-fishes (Family Mullidae), and snappers (Family Lutjanidae).

The marine aquarium trade on Guam is small and caters to a local market. There may be opportunities for expansion in this trade, as Guam has many attractive marine fishes which are adaptable to aquarium life and which are not generally available in other parts of the United States or in Japan. Many of these species, including damselfishes (Family Pomacentridae), wrasses (Family Labridae), sharp-nosed puffers (Family Canthigasteridae) and butterflyfishes (Family Chaetodontidae), occur on the reef flat.

The reef flat is the most accessible marine environment to local residents and tourists. The reef flats in Tumon Bay may provide tourists with their first glimpse of a living reef community, and the opportunity to observe a variety of active brightly-colored reef fishes must contribute to their enjoyment of their stay in Guam.

CONCLUSIONS

The patterns of fish distribution discussed above appear to be generally similar in all the reef flat areas studied, differing only insofar as the various reef flat zones are differently represented in different reef areas. None of the surveyed areas show any signs of improverishment due to human interference.

Reef flat fishes produce large numbers of eggs during their lifetimes, and it is generally believed that many more young fish are available to take up residence on the reef than the reef can supports. This extra production guarantees that there will be an adequate source of new residents, should an isolated fish kill occur. The habitats left open after a die-off will quickly become inhabited by new recruits.

Of more serious consequences, however, is the destruction of fish habitats through blasting, dredging, filling, and sedimentation. Changes in topography, circulation patterns, substrate composition, and coral growth will result in significant changes in the associated fish communities.

Table 1. Location, length (m), and sampling dates of the fish census transects

TUMON BAY			
Transect 1	Off Guam Reef Hotel	500	9-10 July 1978
Transect 2	Off Fugita Road	500	31 May-2 June 1977
EAST AGANA BAY			
Transect 1	Alupang Cove	640	29 Apr. 1977
Transect 2	Off China Restaurant	600	13 Apr. 1977; 7 Mar. 1978
AGAT BAY			
Transect 1	Off Rizal Beach	90	24 May 1977; 15 Dec. 1977
Transect 2	Off Agat Cemetery	300	24-26 May 1977; 15 Dec. 1977
FOUHA BAY			
Transect 1	South Side	90-100	5 Jan. 1978; 29 Mar. 1978
Transect 2	North Side	50	29 Mar. 1978
Transect 3	North Side	80	29 Mar. 1978
Transect 4	North Side	110	29 Mar. 1978
YLIG BAY			
Transect 1	South Side	60	17 June 1977
Transect 2	South Side	100	17 June 1977

Table 2. Abundance of fishes (no. per m^2) on Tumon Bay Transect 1, July 9-10, 1978. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Scattered Coral Subzone; C=Inner Reef Flat--Coral Subzone; D=Outer Reef Flat--Pavement and Pool Subzone; E=Outer Reef Flat--Pavement Subzone.

	A (0-150 m)	B (150-260 m)	C (260-340 m)	D (340-390 m)	E (390-500 m)
ACANTHURIDAE					
Acanthurus lineatus					.12
A. nigrofuscus					.02
A. pyroferus					.01
A. triostegus			.01		.01
juvenile acanthurids	.01				
APOGONIDAE					
Apogon novemfasciatus	.02		.01	.01	
BALISTIDAE					
Rhinecanthus aculeatus	<.01				
BLENNIIDAE					
unidentified blenniids			.01	.02	.01
CANTHIGASTERIDAE					
Canthigaster solandri	.01				<.01
CARANGIDAE					
Caranx melampygus	<.01				
CHAETODONTIDAE					
Chaetodon citrinellus			.01		
C. ephippium	<.01				
FISTULARIIDAE					
juvenile *Fistularia*		<.01			
GOBIIDAE					
Amblygobius albimaculatus	.01				
unidentified gobiids	.03	.03	.05		
HOLOCENTRIDAE					
Myripristis sp.					<.01
LABRIDAE					
Halichoeres margaritaceus					.26
H. marginatus					<.01
H. trimaculatus	.04	.14	.06	.11	
Stethojulis bandanensis	.01	.01	.03	.30	.06
Thalassoma quinquevittata					.03

Table 2. continued

	A (0-150 m)	B (150-260 m)	C (260-340 m)	D (340-390 m)	E (390-500 m)
LUTJANIDAE					
Scolopsis cancellatus	.02				
MUGILIDAE					
unidentified mugilids			.01		
MULLIDAE					
Mulloidichthys samoensis	<.01		.01		
Parupeneus pleurostigma					.01
POMACENTRIDAE					
Abudefdef septemfasciatus			.01		
Dascyllus aruanus	.09				
Eupomacentrus albifasciatus					<.01
E. fasciolatus					.05
E. nigricans	<.01			.04	
Glyphidodontops glaucus			.14	.20	.02
G. leucopomus					.61
Plectroglyphidodon dickii					.01
P. leucozona	<.01				.04
juvenile pomacentrids	.02				
unidenfied pomacentrids	.01	.01	.01		
SCARIDAE					
juvenile scarids					.02
SIGANIDAE					
Siganus spinus	.01	.01			
SYNODONTIDAE					
Synodus variegatus					<.01
ZANCLIDAE					
Zanclus cornutus					.01
No. Species	18.	6	12	6	21
Total Fish Abundance ($No./m^2$)	.28	.21	.35	.68	1.32
Total Abundance Excluding Siganids	.27	.20	.35	.68	1.32

Table 3. Abundance of fishes (no. per m^2) in reef flat zones on Tumon Bay Transect 2, May 31, 1977. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Scattered Coral Subzone; C=Inner Reef Flat--Coral Subzone; D=Outer Reef Flat.

	A (0-130m)	B (130-200m)	C (200-430m)	D (430-500m)
ACANTHURIDAE				
Acanthurus triostegus		.01	.02	
Ctenochaetus striatus				.02
APOGONIDAE				
Apogon novemfasciatus	.02	.01	<.01	.01
Apogon sp.	<.01			
BALISTIDAE				
Rhinecanthus aculeatus	<.01	.01	<.01	
BLENNIIDAE				
Plagiotremus tapeinosoma			<.01	
unidentified blenniids	.06	.01	.03	.02
CATHIGASTERIDAE				
Canthigaster bennetti		.01	.01	
C. solandri		.03	.02	
CHAETODONTIDAE				
Chaetodon citrinellus			<.01	
FISTULARIIDAE				
Fistularia petimba			<.01	
GOBIIDAE				
unidentified gobiids	.04	.02	.02	
HOLOCENTRIDAE				
Flammeo sp.	.01	.01		.01
LABRIDAE				
Halichoeres margaritaceous			.09	.37
H. trimaculatus	.04	.06	.20	.01
Stethojulis bandanensis			.02	.02
Thalassoma quinquevittata				.01
juvenile labrids		.01		.01
LUTJANIDAE				
Scolopsis cancellatus		.01		
MULLIDAE				
Mulloidichthys samoensis			<.01	
Parupeneus barberinus	.01	<.01		
P. trifasciatus			<.01	
POMACENTRIDAE				
Dascyllus aruanus		.06	<.01	
Eupomacentrus albifasciatus	<.01		.27	.85
E. fasciolatus				.06
E. nigricans		.03	.05	.01

Table 3. continued

	A (0-130m)	B (130-200m)	C (200-430m)	D (430-500m)
<u>Glyphidodontops glaucus</u>			.08	
<u>G. leucopomus</u>			.02	.82
<u>Plectroglyphidodon dickii</u>				.01
<u>P. lachrymatus</u>				.01
<u>P. leucozona</u>	.05	.06		
juvenile pomacentrids	.06	.04	<.01	
SCARIDAE				
juvenile scarids			.06	.01
SIGANIDAE				
<u>Siganus argenteus</u>	.01	.07	.49	.54
<u>S. spinus</u>	.13	.51	1.22	5.99
SYNGNATHIDAE				
unidentified syngnathids		.01	<.01	
No. Species	13	19	25	18
Total Fish Abundance (No./m^2)	.45	.97	2.63	8.78
Total Abundance Excluding Siganids	.31	.39	.92	2.25

Table 4. Abundance of fishes (no. per m^2) in reef flat zones on Agana Bay Transect 1, April 29, 1977. A =Inner Reef Flat— Sand Subzone; B =Inner Reef Flat-- Scattered Coral subzone; C =Inner Reef Flat-- Coral Subzone; D =Outer Reef Flat-- Pavement and Pool Subzone.

	A (0-460m)	B (460-520m)	C (520-610m)	D (610-640m)
ACANTHURIDAE				
Acanthurus triostegus			.01	
APOGONIDAE				
Apogon novemfasciatus			.03	
BLENNIDAE				
unidentified blenniids	<.01		.01	
CANTHIGASTERIDAE				
Canthigaster bennetti			.01	
C. solandri		.04	.02	
CHAETODONTIDAE				
Chaetodon citrinellus			.01	
GOBIIDAE				
Unidentified gobiids	.01		.02	
LABRIDAE				
Halichoeres margaritaceous			.19	.15
H. trimaculatus		.06	.20	.02
Labroides dimidiatus			.01	
Stethojulis bandanensis		.05	.08	.02
juvenile labrids	<.01		.02	
LUTJANIDAE				
Lutjanus fulvus	<.01			
Scolopsis cancellatus	<.01			
MULLIDAE				
Parupeneus barberinus		.01		
POMACENTRIDAE				
Dascyllus aruanus	<.01	.04	.02	
Eupomacentrus albifasciatus	<.01		.04	
E. fasciolatus			.01	
E. nigricans		.02	.11	
Glyphidodontops leucopomus			.01	.20
SCARIDAE				
juvenile scarids		.25	.06	
SIGANIDAE				
Siganus spinus	.05	1.17	1.61	
SYNGNATHIDAE				
unidentified syngnathids	<.01		.01	
No. Species	9	8	20	4
Total Fish Abundance (No./m^2)	.08	1.63	2.48	.38
Total Abundance Exluding Siganids	.03	.46	.87	.38

Table 5. Abundance of fishes (no. per m^2) in reef flat zones on Agana Bay Transect 2, April 13, 1977. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Scattered Coral Subzone; C=Inner Reef Flat--Coral Subzone; D=Outer Reef Flat--Pavement and Pool Subzone; E=Outer Reef Flat--Pavement Subzone.

	A (0-220m)	B (220-310m)	C (310-480m)	D (480-570m)	E (570-600m)
ACANTHURIDAE					
Acanthurus triostegus				.01	
APOGONIDAE					
Apogon novemfasciatus	.01	.01	.01	.04	.02
BALISTIDAE					
Rhinecanthus aculeatus				.01	
BLENNIIDAE					
unidentified blenniids	.01				
BOTHIDAE					
Bothus	<.01				
CANTHIGASTERIDAE					
Canthigaster solandri		.01		.01	.02
CHAETODONTIDAE					
Chaetodon auriga				.01	
C. citrinellus				.01	
C. lunula				.01	
C. trifasciatus			.01		
GOBIIDAE					
unidentified gobiids	.02	.01	<.01		
HOLOCENTRIDAE					
Flammeo sp			<.01		
LABRIDAE					
Halichoeres marginatus			<.01	.01	
H. trimaculatus	.01	.13	.23	.16	
Hemigymnus melapterus			.01		
Stethojulis bandanensis		.01	.01	.02	.02
unidentified labrids			<.01		
MONACANTHIDAE					
Oxymonacanthus longirostris			.01		
MULLIDAE					
Parupeneus barberinus		.01			
POMACENTRIDAE					
Abudefduf coelestinus				.01	
Amphiprion melanopus			<.01		
Chromis caerulea			.02		
Dascyllus aruanus	.06	.25	.45	.01	
Eupomacentrus albifasciatus			.01		
E. lividus			.01		
E. nigricans		.01	.05	.12	

Table 5 Continued.

	A (0-220m)	B (220-310m)	C (310-480m)	D (480-570m)	E (570-600m)
Glyphidodontops glaucus				.67	.27
G. leucopomus				.06	.22
Plectroglyphidodon leucozona	.01		.01		
juvenile pomacentrids	<.01	.01			
SCARIDAE					
juvenile scarids			.06	.04	
SIGANIDAE					
Siganus argenteus					3.45
S. spinus	.08	.05	.02		
SYNGNATHIDAE					
unidentified syngnathids	<.01				
SYNODONTIDAE					
Synodus variegatus			<.01		
ZANCLIDAE					
Zanclus cornutus				.01	
No. Species	10	10	20	17	6
Total Fish Abundance (no./m^2)	.21	.48	.91	1.18	3.98
Total Abundance Excluding Siganids	.13	.43	.89	1.18	.53

Table 6. Abundance of fishes (no. per m^2) in reef flat zones on Agana Bay Transect 2, March 7, 1978. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Scattered Coral Subzone; C=Inner Reef Flat--Coral Subzone; D=Outer Reef Flat--Pavement and Pool Subzone; E=Outer Reef Flat--Pavement Subzone.

	A (0-220m)	B (220-310m)	C (310-480m)	D (480-570m)	E (570-600m)
ACANTHURIDAE					
Acanthurus nigrofuscus			<.01		
A. triostegus				.02	
Ctenochaetus striatus			.01		
Naso sp.(juvenile)	<.01				
APOGONIDAE					
Apogon novemfasciatus	<.01	.02	<.01	.01	
Apogon sp.		.01	<.01		
ATHERINIDAE					
unidentified atherinids	.01				
BALISTIDAE					
Pseudobalistes		.01			
Rhinecanthus aculeatus			<.01		
BLENNIIDAE					
unidentified blenniids			.01	.03	.02
CANTHIGASTERIDAE					
Canthigaster solandri		.06	.02	.07	
CHAETODONTIDAE					
Chaetodon auriga		.01	.01		
C. ephippium			<.01		
C. quadrimaculatus			<.01		
C. trifascialis		.01			
C. trifasciatus		.01	.04		
C. ulietensis			<.01		
C. vagabundus			.01		
Heniochus chrysostomus			<.01		
GOBIIDAE					
unidentified gobiids			<.01		
HOLOCENTRIDAE					
Flammeo sp.		.07	.02		
Myripristis sp.			<.01		
LABRIDAE					
Halichoeres marginatus			<.01		
H. trimaculatus	.01	.03	.35	.42	.02
Hemigymnus melapterus			<.01		
Stethojulis bandanensis	<.01		.01	.08	
juvenile labrids	<.01	.01	<.01	.03	
MONACANTHIDAE					
Oxymonacanthus longirostris			.04		

Table 6 continued

	A (0-220m)	B (220-310m)	C (310-480m)	D (480-570m)	E (570-600m)
MULLIDAE					
Parupeneus barberinus	<.01				
POMACENTRIDAE					
Abudefduf coelestinus			.01		
Chromis caerulea		.01	.08		
Dascyllus aruanus	.10	.31	.90	.07	
Eupomacentrus albifasciatus			.16	.32	.07
E. lividus	<.01	.07	.08		
Glyphidodontops glaucus				.37	.55
G. leucopomus				.04	.73
Plectroglyphidodon leucozona	<.01				
juvenile pomacentrids				.05	
SCARIDAE					
juvenile scarids			.04		
SYNGNATHIDAE					
unidentified syngnathids				.01	
No. species	10	13	29	13	5
Total Fish Abundance (No./m^2)	.23	.59	1.81	1.51	1.38
Total Abundance Excluding Siganids	.23	.59	1.81	1.51	1.38

Table 7. Abundance of fishes (no. per m^2) in reef zones on Agat Bay Transect 1, May 24, 1977. A=Inner Reef Flat; B=Outer Reef Flat.

	A (0-70m)	B (70-90m)
ACANTHURIDAE		
Acanthurus triostegus		.03
Ctenochaetus striatus		.03
BALISTIDAE		
Rhinecanthus aculeatus	.01	
CANTHIGASTERIDAE		
Canthigaster bennetti	.04	
C. solandri	.01	.03
CHAETODONTIDAE		
Heniochus acuminatus		.03
ELEOTRIDAE		
Eleotrides strigatus	.01	
GOBIIDAE		
unidentified gobiids	.01	
HOLOCENTRIDAE		
Flammeo sp.	.01	
LABRIDAE		
Halichoeres margaritaceous	.07	.20
H. trimaculatus	.10	.03
Stethojulis bandanensis		.08
Stethojulis juveniles	.01	
LUTJANIDAE		
Lutjanus fulviflamma	.02	
L. fulvus	.04	
L. monostigmus	.01	
MULLIDAE		
Parupeneus trifasciatus		.03
Parupeneus sp.	.06	
POMACENTRIDAE		
Abudefduf coelestinus	.03	
A. saxatilis	.14	
Eupomacentrus albifasciatus	.01	.03
Glyphidondontops glaucus	.04	.03
G. leucopomus	.06	.83
Plectroglyphidodon leucozona	.01	
juvenile pomacentrids	.01	
SCARIDAE		
juvenile scarids		.10
SIGANIDAE		
Siganus argenteus		.03
S. spinus	.42	1.95

Table 7 continued.

No. Species	21	14
Total Fish Abundance (no./m^2)	1.11	3.38
Total Abundance Excluding Siganids	.69	1.40

Table 8 Abundance of fishes (no. per m^2) in Reef Zones on Agat Bay Transect1, December 15, 1977. A=Inner Reef Flat; B=Outer Reef Flat.

	A (0-70m)	B (70-90m)
ACANTHURIDAE		
Acanthurus lineatus	.02	.13
A. triostegus	.05	
Ctenochaetus striatus	.01	
APOGONIDAE		
Apogon novemfasciatus	.01	
BALISTIDAE		
Rhinecanthus aculeatus	.01	
BLENNIIDAE		
unidentified blenniids	.01	
CANTHIGASTERIDAE		
Canthigaster solandri	.01	
CHAETODONTIDAE		
Chaetodon lunula	.01	
LABRIDAE		
Halichoeres margaritaceous	.13	.13
H. trimaculatus	.06	
Stethojulis bandanensis	.01	
POMACENTRIDAE		
Glyphidodontops glaucus	.04	
G. leucopomus	.16	.65
Plectroglyphidodon leucozona	.01	
juvenile pomacentrids	.01	
No. Species	15	3
Total Fish Abundance (No./m^2)	.53	.90
Total Abundance Excluding Siganids	.53	.90

Table 9. **Abundance of fishes (no. per m^2) in reef zones on Agat Bay Transect 2, May 24, 1977. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Seagrass Subzone; C=Outer Reef Flat.**

	A (0-70)	B (70-180)	C (180-300)
ACANTHURIDAE			
Acanthurus triostegus			<.01
APOGONIDAE			
Apogon novemfasciatus		.01	.03
BALISTIDAE			
Rhinecanthus aculeatus			<.01
BLENNIDAE			
unidentified blenniids			.01
CANTHIGASTERIDAE			
Canthigaster bennetti			.03
CARANGIDAE			
Caranx melampygus (juveniles)		<.01	
CHAETODONTIDAE			
Chaetodon auriga		<.01	
C. citrinellus			<.01
GOBIIDAE			
unidentified gobiids	.10	.17	.04
LABRIDAE			
Halichoeres margaritaceous			.13
H. trimaculatus		.04	.14
Stethojulis bandanensis			.04
juvenile labrids			<.01
LUTJANIDAE			
Lutjanus fulvus	.01	.01	
MULLIDAE			
Parupeneus barberinus		<.01	
Parupeneus sp.		.01	
POMACENTRIDAE			
Abudefduf coelestinus		.01	<.01
Dascyllus aruanus			<.01
Eupomacentrus albifaciatus			.09
E. nigricans			.07
Glyphidodontops glaucus			.14
G. leucopomus			.51
SCARIDAE			
juvenile scarids	.01	<.01	.02

Table 9 continued

	A (0-70)	B (70-180)	C (180-300)
SIGANIDAE			
Siganus argenteus		.01	.14
S. spinus	.24	2.67	1.00
No. Species	4	12	20
Total Fish Abundance (No./m^2)	.36	2.95	2.39
Total Abundance Excluding Siganids	.12	.28	1.25

Table 10. Abundance of fishes (no. per m^2) in reef zones on Agat Bay Transect 2, December 15, 1977. A=Inner Reef Flat--Sand Subzone; B=Inner Reef Flat--Seagrass Subzone; C=Outer Reef Flat.

	A (0-70)	B (70-180)	C (180-300)
ACANTHURIDAE			
Acanthurus lineatus			.05
A. triostegus			.01
Ctenochaetus striatus			.01
APOGONIDAE			
Apogon novemfasciatus		.04	.01
BLENNIDAE			
unidentified blenniids			<.01
CANTHIGASTERIDAE			
Canthigaster solandri			.01
CHAETODONTIDAE			
Chaetodon citrinellus			.02
ELEOTRIDAE			
Eleotrides strigatus			.01
GOBIIDAE			
Amblygobius albimaculatus		.01	
unidentified gobiids		.04	.01
LABRIDAE			
Halichoeres margaritaceous			.08
H. marginatus			.01
H. trimaculatus			.12
Labroides dimidiatus			.01
Stethojulis bandanensis			.01
Stethojulis sp. (juvenile)		<.01	
Thalassoma quinquevittata			.01
Xyrichthys taeniourus			<.01
unidentified labrids			.01
LUTJANIDAE			
Lethrinus sp.		.01	
Lutjanus fulvus	.08	<.01	
MULLIDAE			
Parupeneus barberinus		<.01	
POMACENTRIDAE			
Dascyllus aruanus			.01
Eupomacentrus albifaciatus			.25
E. nigricans			.03
Glyphidodontops leucopomus			.53
Plectroglyphidodon leucozona		<.01	.01
unidentified pomacentrids			<.01
juvenile pomacentrids			<.01

Table 10 continued

	A (0-70)	B (70-180)	C (180-300)
SCARIDAE			
juvenile scarids			.05
No. Species	1	9	25
Total Fish Abundance (No./m^2)	.08	.13	1.28
Total Abundance Excluding Siganids	.08	.13	1.28

Table 11. Abundance of fishes (no. per m^2) on Fouha Bay Transects. A=North Side Reef Flat Transect 1, March 29, 1978; B=North Side Reef Flat Transect 2, March 29, 1978; C=North Side Reef Flat Transect 3, March 29, 1978; D=South Side Reef Flat Transect 1, January 5, 1978; E=South Side Reef Flat Transect 2, March 29, 1978.

	A (0-50 m)	B (0-80 m)	C (0-110 m)	D (0-100 m)	E (0-90 m)
ACANTHURIDAE					
Acanthurus lineatus	.03		.01	.04	.02
A. nigrofuscus			<.01	.01	
A. triostegus	.02		<.01	.01	.10
Ctenochaetus striatus			.01	.03	
APOGONIDAE					
Apogon novemfasciatus	.01				.01
BLENNIIDAE					
Meiacanthus atrodorsalis	.01				
unidentified blenniids	.02	.01	.01		
CANTHIGASTERIDAE					
Canthigaster solandri				.01	
CHAETODONTIDAE					
Chaetodon citrinellus	.01			.01	.01
C. lunula				.01	.01
ELEOTRIDAE					
Eleotrides strigatus		.01			.01
GOBIIDAE					
unidentified gobiids	.03	.03	.01	.01	.03
LABRIDAE					
Halichoeres margaritaceous		.03	.01	.34	.21
H. marginatus			<.01	.02	.01
H. trimaculatus	.07	.08	.04		.09
Labroides dimidiatus				.01	
Macropharyngodon meleagris				.01	
Stethojulis bandanensis			.02	.01	.01
Thalassoma quinquevittata			.03	.02	.01
juvenile labrids				.05	
MUGILIDAE					
Chelon vaigiensis		.16			
MULLIDAE					
Parupeneus barberinus	.01				
Parupeneus sp.					.01
MURAENIDAE					
unidentified muraenids			<.01		
POMACENTRIDAE					
Abudefduf sordidus	.01				.01
Eupomacentrus albifasciatus				.05	
E. faciolatus			.04	.01	

Table 11 continued

	A (0-50 m)	B (0-80 m)	C (0-110 m)	D (0-100 m)	E (0-90 m)
Glyphidodontops glaucus	.02	.38	.12	.09	.55
G. leucopomus	.25	.19	.52	.84	.72
Plectroglyphidodon leucozona			<.01		
Pomacentrus vaiuli	.01				
unidentified pomacentrids	.01		<.01		
SCARIDAE					
juvenile scarids					.02
No. Species	13	9	17	19	17
Total Fish Abundance (No./m^2)	.50	.88	.85	1.53	1.73
Total Abundance Excluding Siganids	.50	.88	.85	1.53	1.73

Table 12. Abundance of fishes (no. per m^2) on South Reef Flat, Ylig Bay Transects I and 2, June 17, 1977. A=Transect I, Inner Reef Flat; B=Transect I, Outer Reef Flat; C=Transect 2, Inner Reef Flat; D=Transect 2, Outer Reef Flat.

	A (0-50m)	B (50-60m)	C (0-70m)	D (70-100m)
ACANTHURIDAE				
Acanthurus triostegus	.08		.12	.05
Ctenochaetus striatus	.23	.25	.51	.45
juvenile acanthurids		.05		
APOGONIDAE				
Apogon novemfasciatus	.01	.15	.01	.02
BALISTIDAE				
Rhinecanthus aculeatus			.01	
BLENNIIDAE				
Plagiotremus tapeinosoma			.01	.03
unidentified blenniids	.01		.01	.07
CANTHIGASTERIDAE				
Canthigaster solandri			.05	
CARANGIDAE				
Caranx melampygus (juvenile)			.07	
CHAETODONTIDAE				
Chaetodon auriga	.01			
C. citrinellus			.03	.03
Heniochus acuminatus				.02
ELEOTRIDAE				
Ptereleotris microlepis	.01			
FISTULARIIDAE				
Fistularia petimba			.01	
GOBIIDAE				
unidentified gobiids	.06	.05	.04	.02
LABRIDAE				
Halichoeres margaritaceous			.08	.07
H. marginatus			.03	
H. trimaculatus	.15		.05	.07
Hemigymnus melapterus			.01	
Labroides dimidiatus		.05	.02	.05
Macropharyngodon meleagris			.02	
Stethojulis bandanensis	.03		.05	.02
juvenile labrids	.09	.15	.01	.10
unidentified labrids	.02			
LUTJANIDAE				
Gnathodentex aureolineatus				.17
Lutjanus fulvus			.03	
Scolopsis cancellatus	.06	.15	.34	.02

Table 12 continued.

	A (0-50m)	B (50-60m)	C (0-70m)	D (70-100m)
MULLIDAE				
Mulloidichthys auriflamma			.18	
M. samoensis				.07
Parupeneus bifasciatus			.01	
P. trifasciatus	.03	.05	.01	.03
POMACENTRIDAE				
Eupomacentrus albifasciatus	.02		.08	.10
E. fasciolatus				.03
E. nigricans	.03			.02
Glyphidodontops biocellatus	.03			.02
G. glaucus	.20		.16	
G. leucopomus	.12	.20	.19	.78
Plectroglyphidodon leucozona	.02		.06	.05
juvenile pomacentrids	.03		.01	
SCARIDAE				
juvenile scarids		.25	.11	.10
SCORPAENIDAE				
Synanceja				.02
SIGANIDAE				
Siganus argenteus	.15	4.10	.65	1.93
S. spinus	.07		.24	.57
No. Species	22	11	32	27
Total Fish Abundance (No./m^2)	1.46	5.45	3.22	4.88
Total Abundance Excluding Siganids	1.24	1.35	2.33	2.38

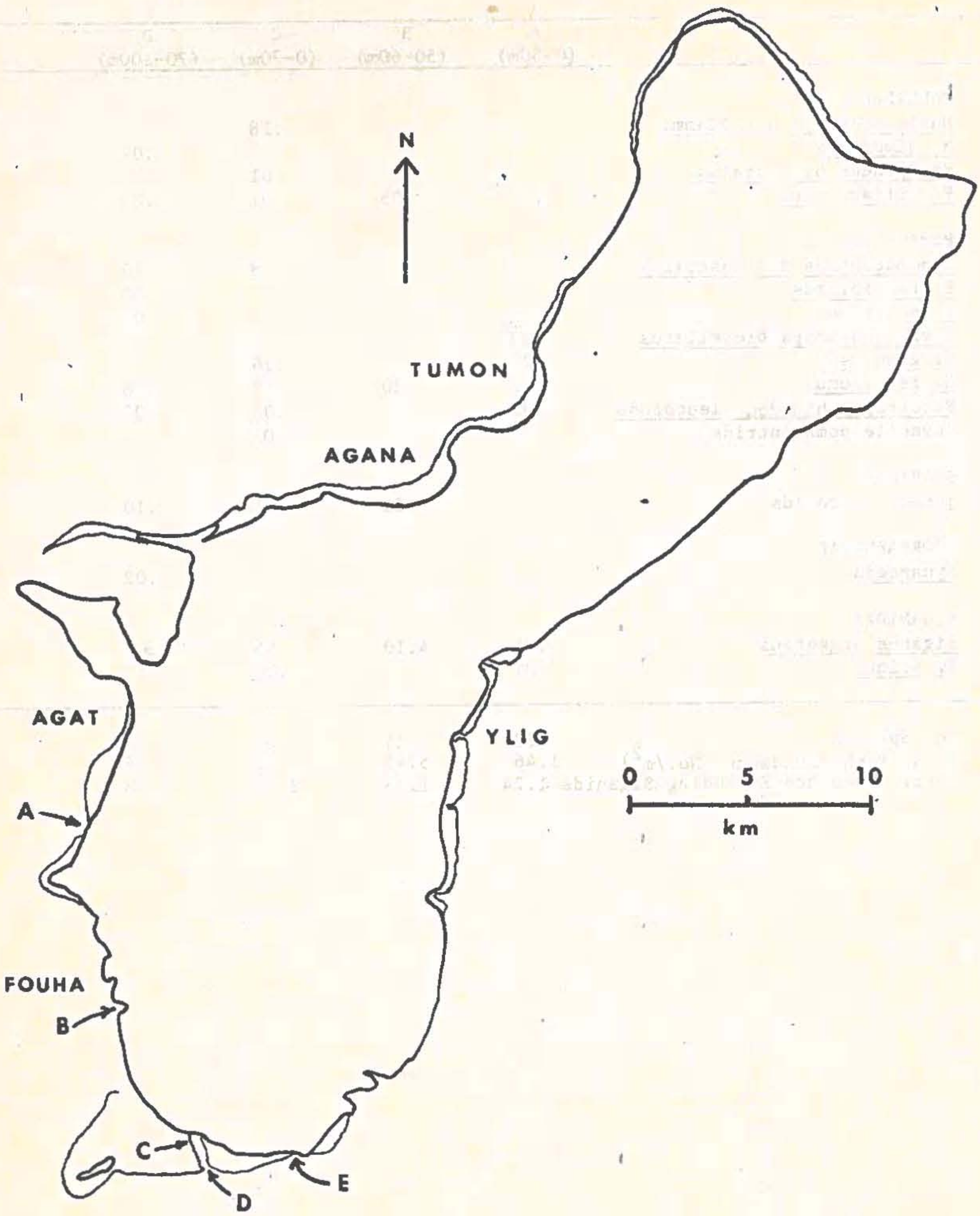

Figure 1. The island of Guam, with the locations of the transecting areas and the sites of the plankton tows. A=Nimitz Channel; B=Umatac Bay; C=Achang Bay; D=Manell Channel; E=Ajayan Bay.

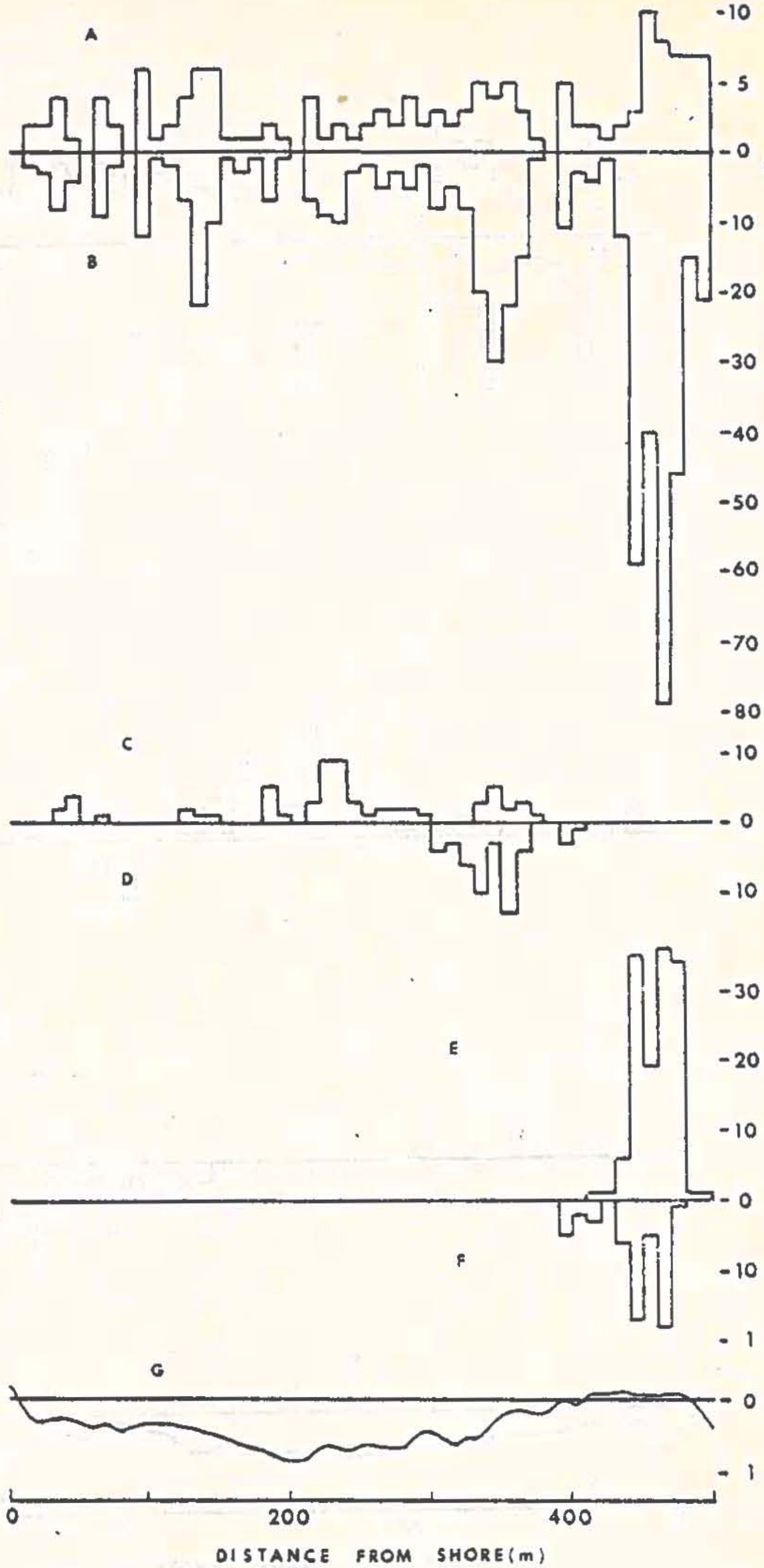

Figure 2. Tumon Bay Transect 1, 9-10 July 1978. Fish census data for each 10-meter interval. A=number of species; B=number of individuals; C=number of *H. trimaculatus*; D=number of *G. glaucus*; E=number of *G. leucopomus*; F=number of *H. margaritaceous*; G=reef profile (meters) with respect to MLLW.

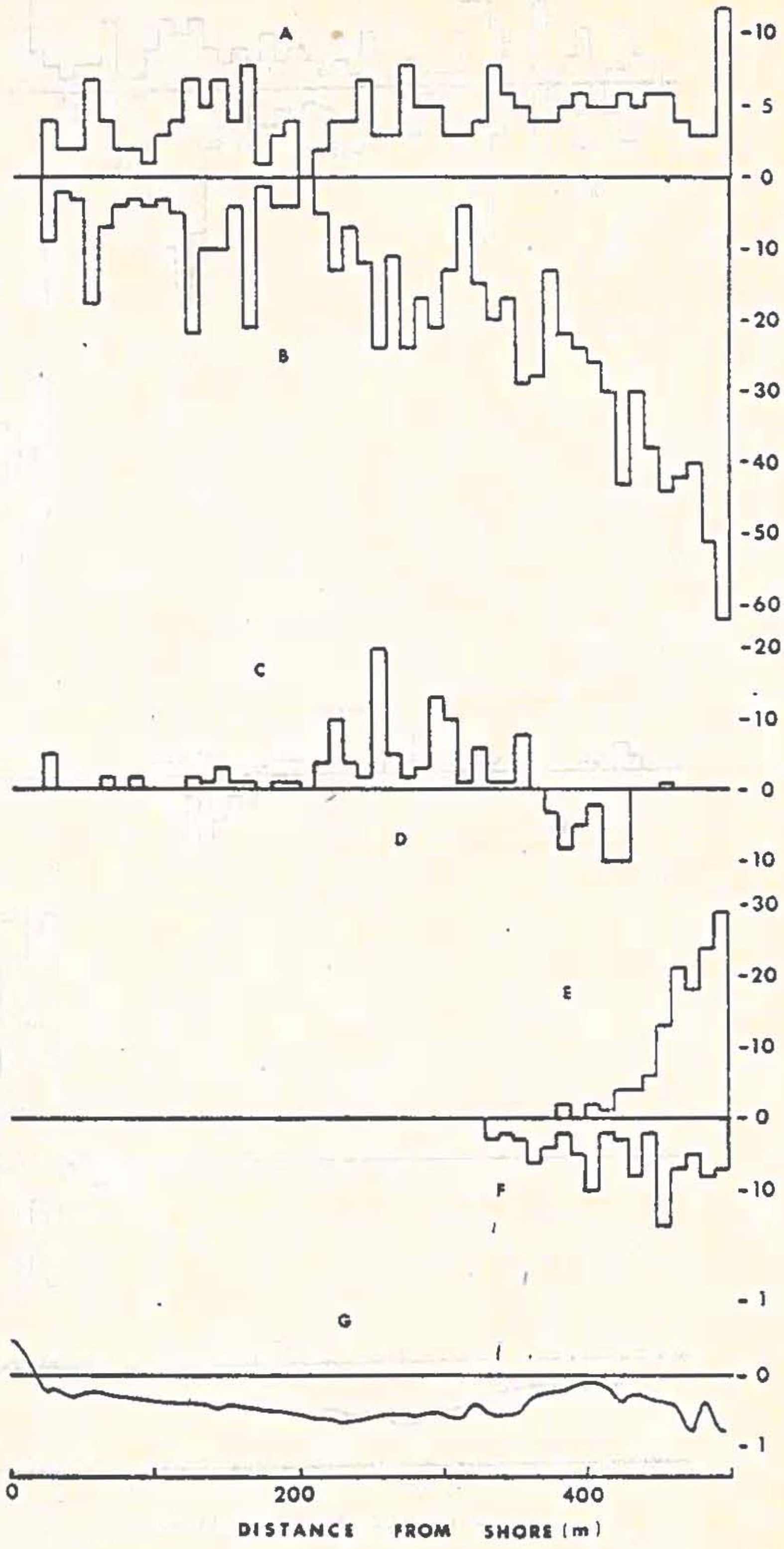

Figure 3. Tumon Bay Transect 2, 31 May-2 June 1977. Fish census data for each 10-meter interval. A=number of species; B=number of individuals; C=number of H. trimaculatus; D=number of G. glaucus; E=number of G. leucopomus; F=number of H. margaritaceous; G=reef profile (meters) with respect to MLLW.

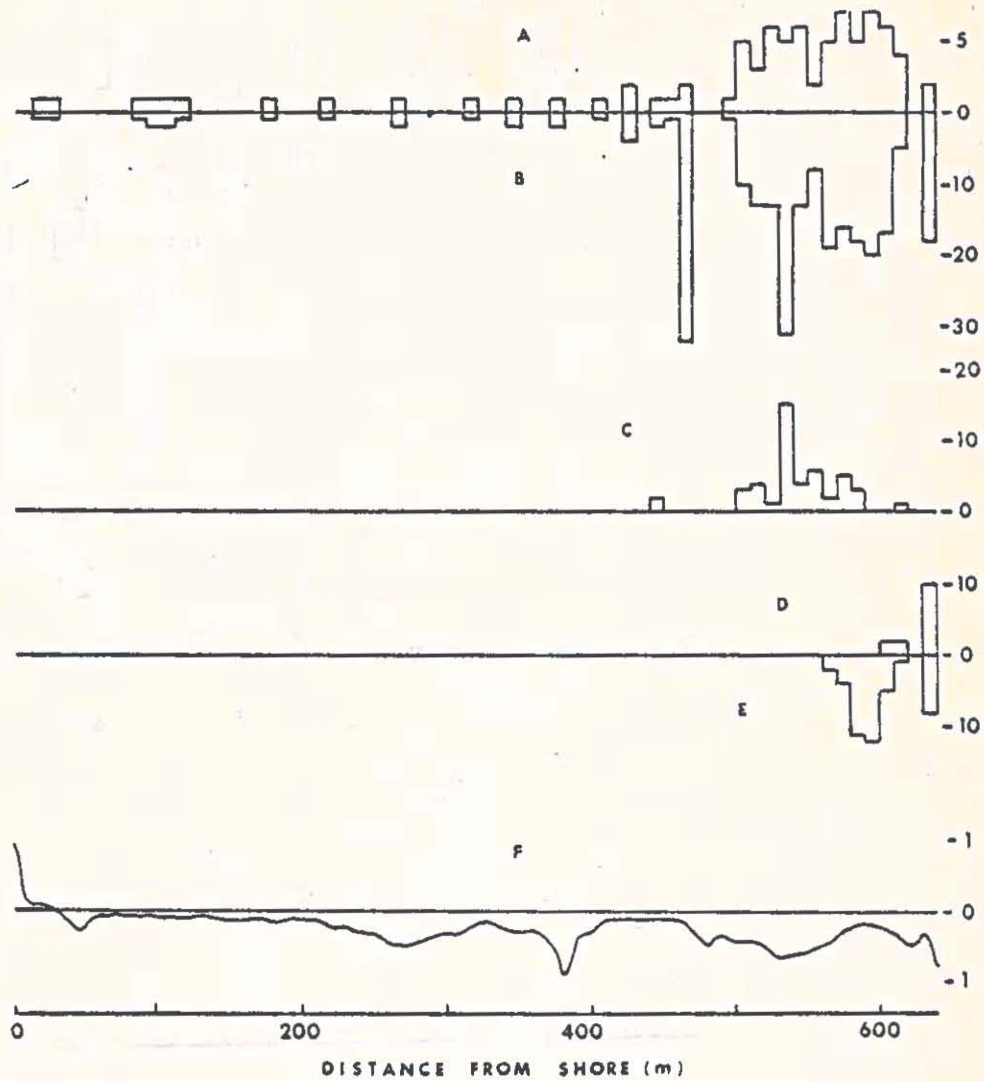

Figure 4. Agana Bay Transect 1, 29 April 1977. Fish data for each 10-meter interval. A=number of species; B=number of individuals; C=number of *H. trimaculatus*; D=number of *G. leucopomus*; E=number of *H. margaritaceous*; F=reef profile (meters) with respect to MLLW.

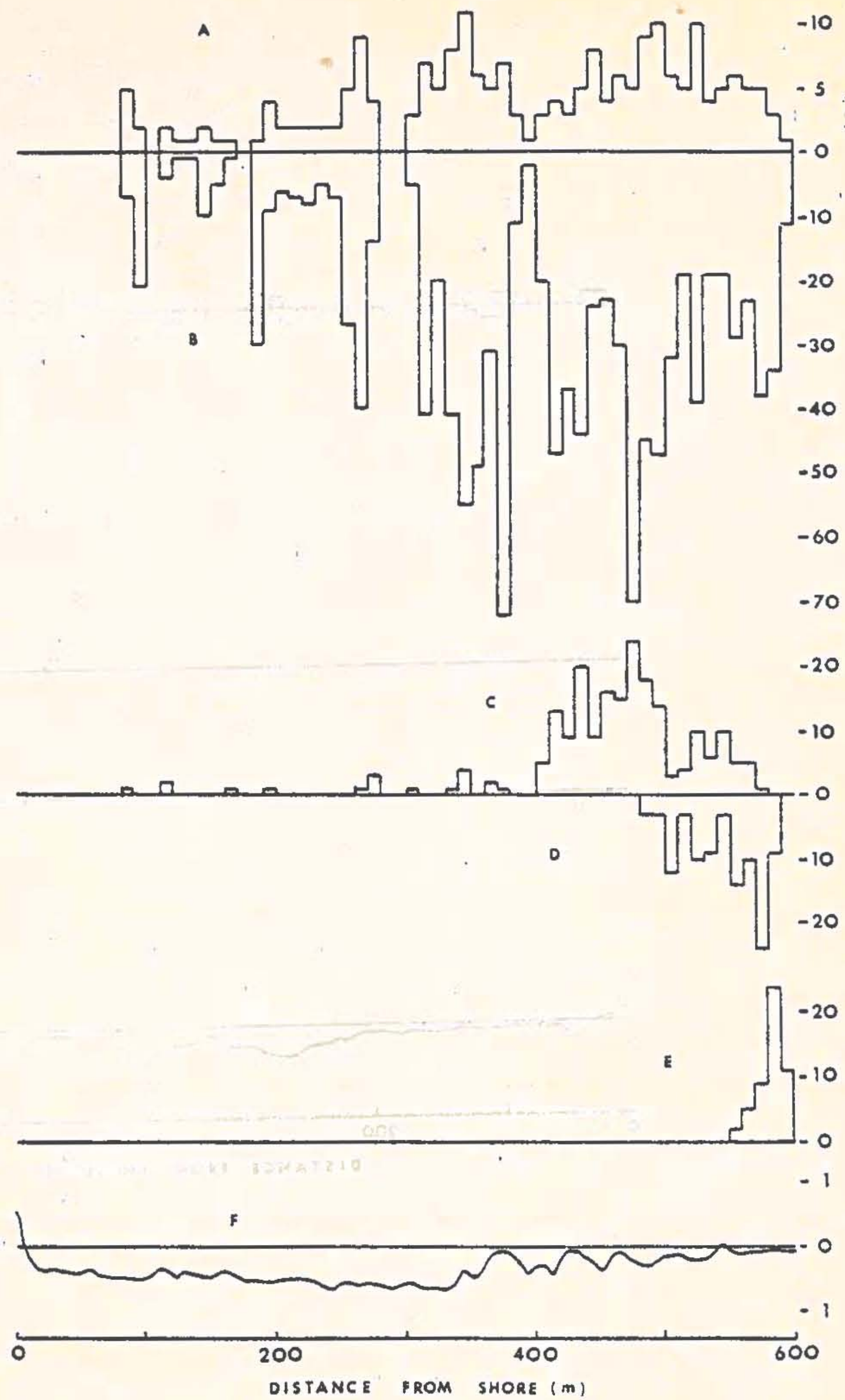

Figure 5. Agana Bay Transect 2, 13 April 1977. Fish census data for each 10-meter interval. A=number of speices; B=number of individuals; G=number of H. trimaculatus; D=number of G. glaucus; E=number of G. leucopomus; F=reef profile (meters) with respect to MLLW.

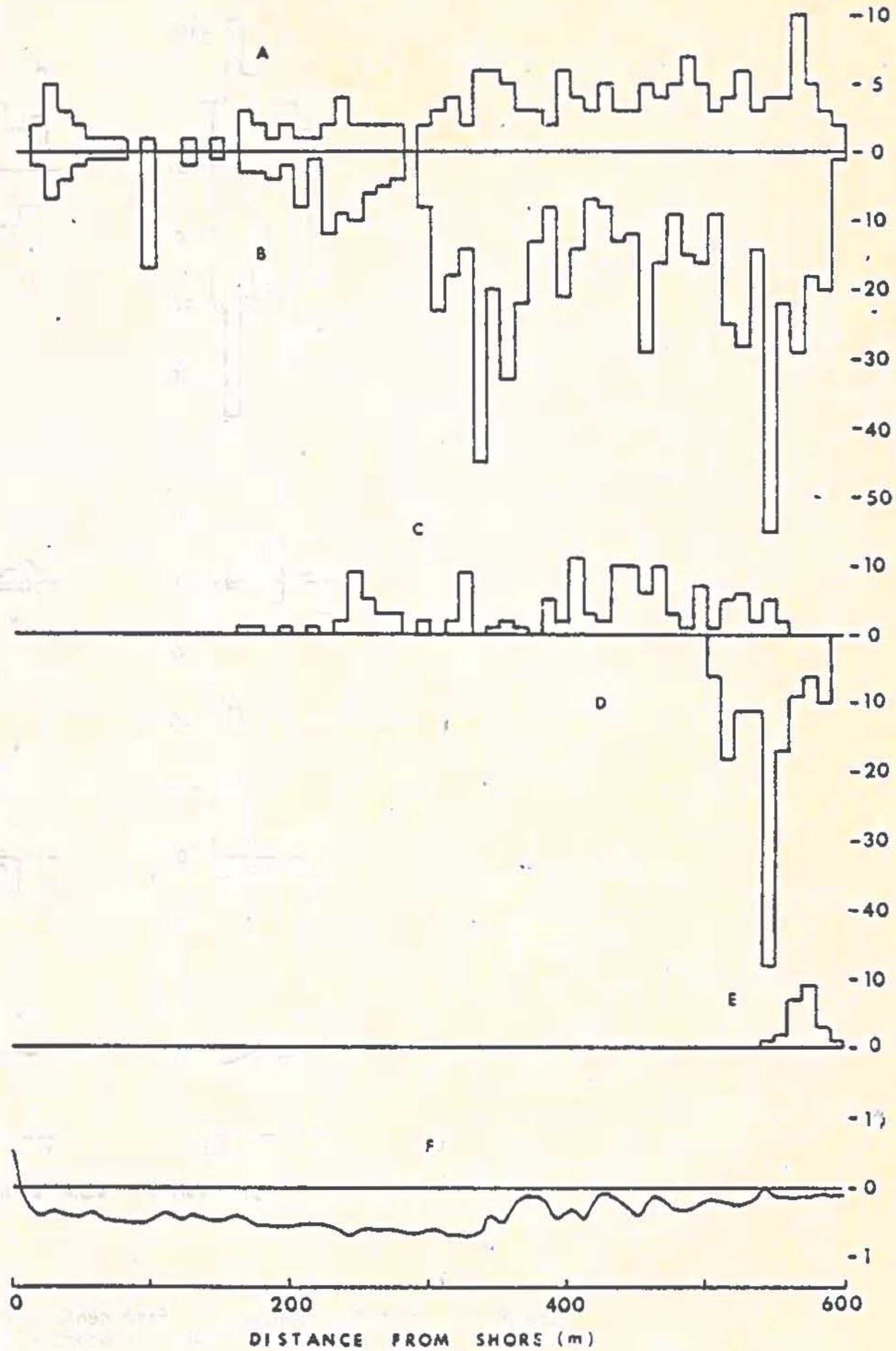

Figure 6. Agana Bay Transect 2, 7 March 1978. Fish census data for each 10-meter interval. A=number of species; B=number of individuals; C=number of *H. trimaculatus*; D=number of *G. glaucus*; E=number of *G. leucopomus*; F=reef profile (meters) with respect to MLLW.

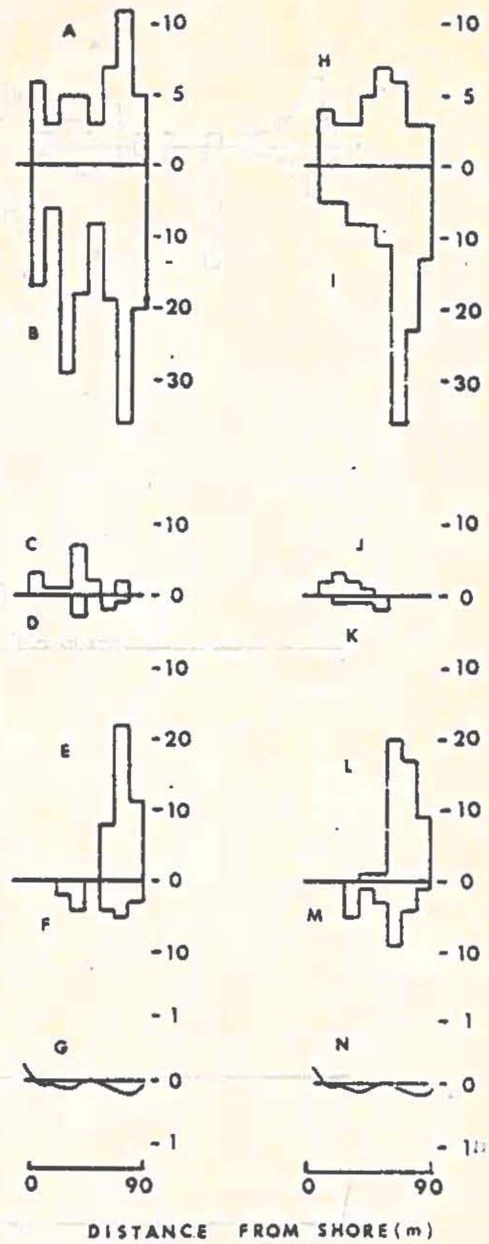

Figure 7. Agat Bay Transect 1. Fish census data for each 10-meter interval. A-G: 24 May 1977; H-N: 15 December 1977; A, H=number of species; B, I=number of individuals; C, J=number of H. trimaculatus; D, K=number of G. glaucus; E, L=number of G. leucopomus; F, M=number of H. margaritaceous; G, N=reef profile (meters) with respect to MLLW.

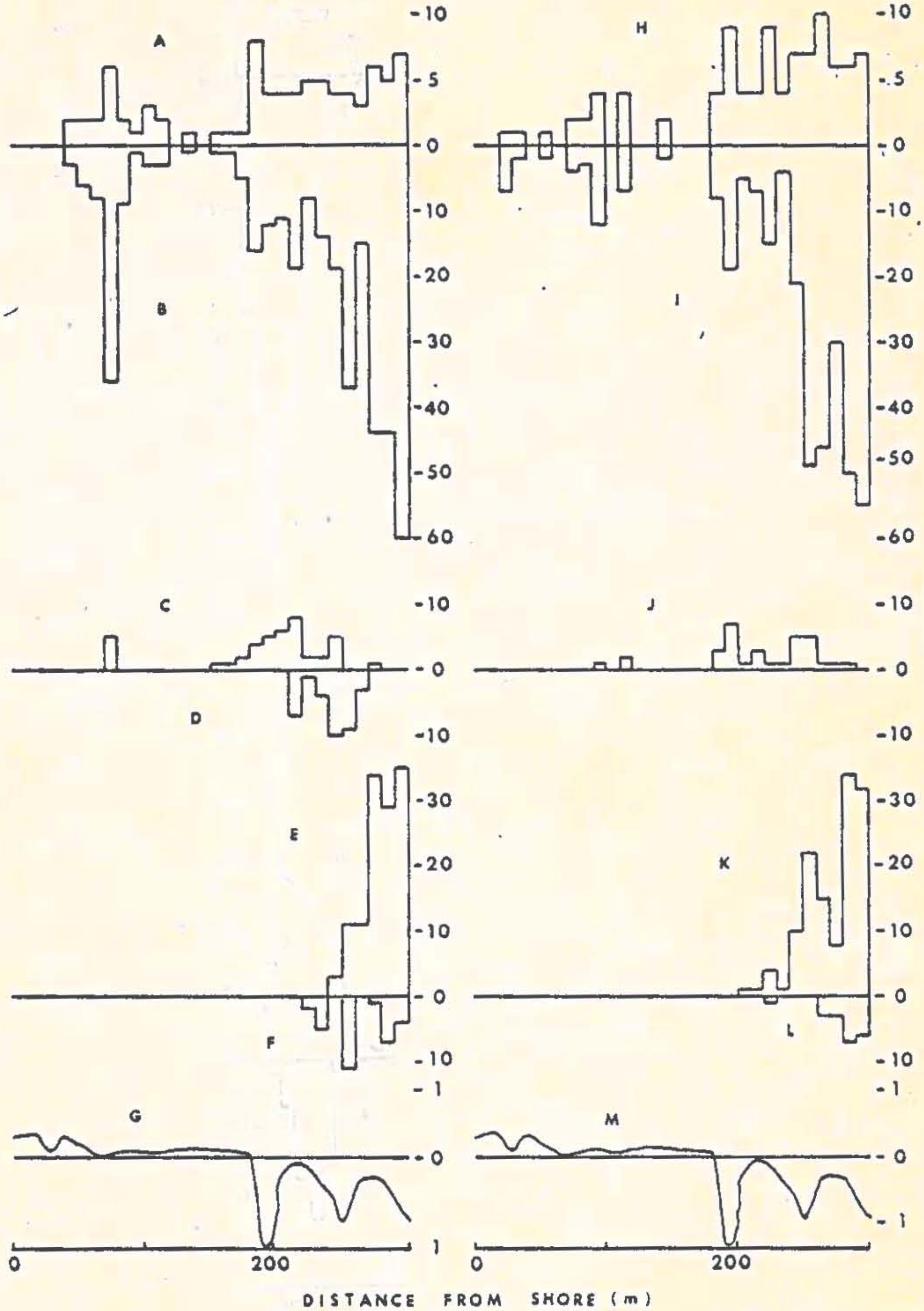

Figure 8. Agat Bay Transect 2. Fish census data for each 10-meter interval. A-G: 24-26 May 1977; H-M: 15 December 1977; A, H=number of species; B, I=number of individuals; C. J=number of H. trimaculatus; D=number of G. glaucus; E, K=number of G. leucopomus; F, L=number of H. margaritaceous; G. M=reef profile (meters) with respect to MLLW.

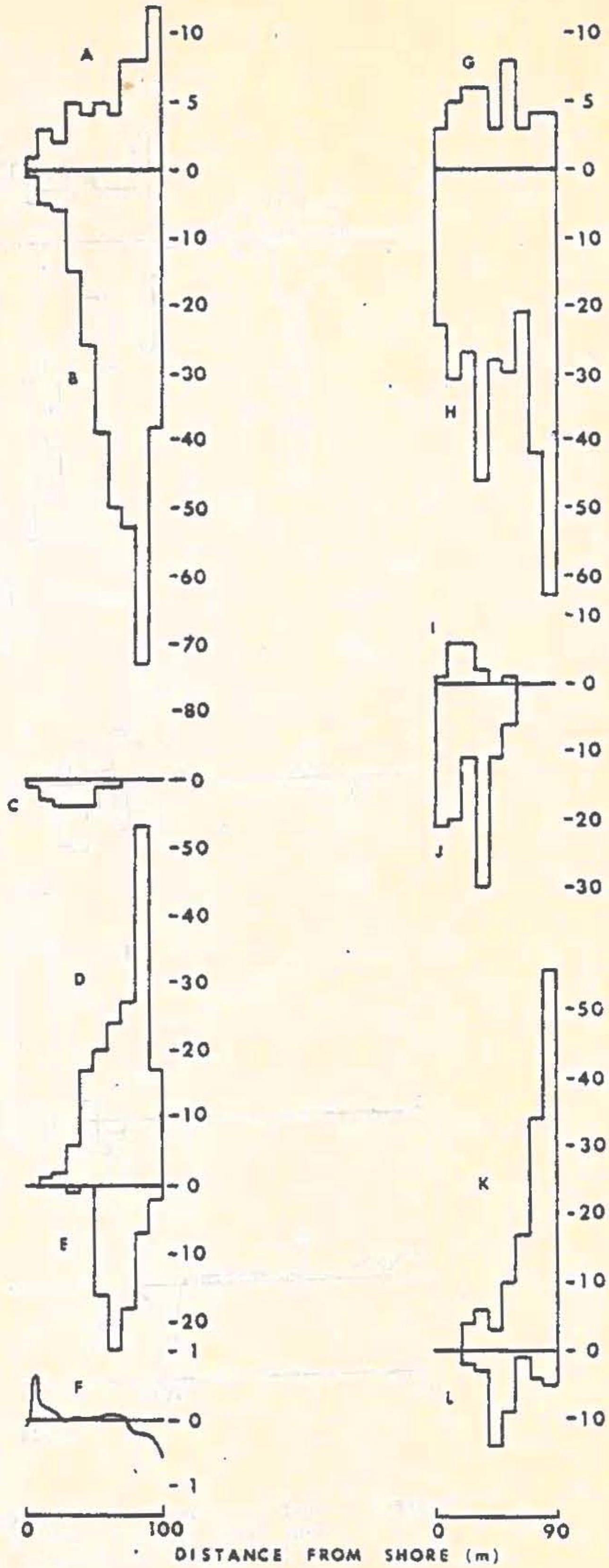

Figure 9. Fouha Bay Transect 1. Fish census data for each 10-meter interval. A-FL 5 January 1978; G-L: 29 March 1978; A, G=number of species; B, H=number of individuals; I=number of H. trimaculatus; C. J= number of G. glaucus; G. K=number of G. Teucopomus; E, L=number of H. margaritaceous; F=reef profile (meters) with respect to MLLW.

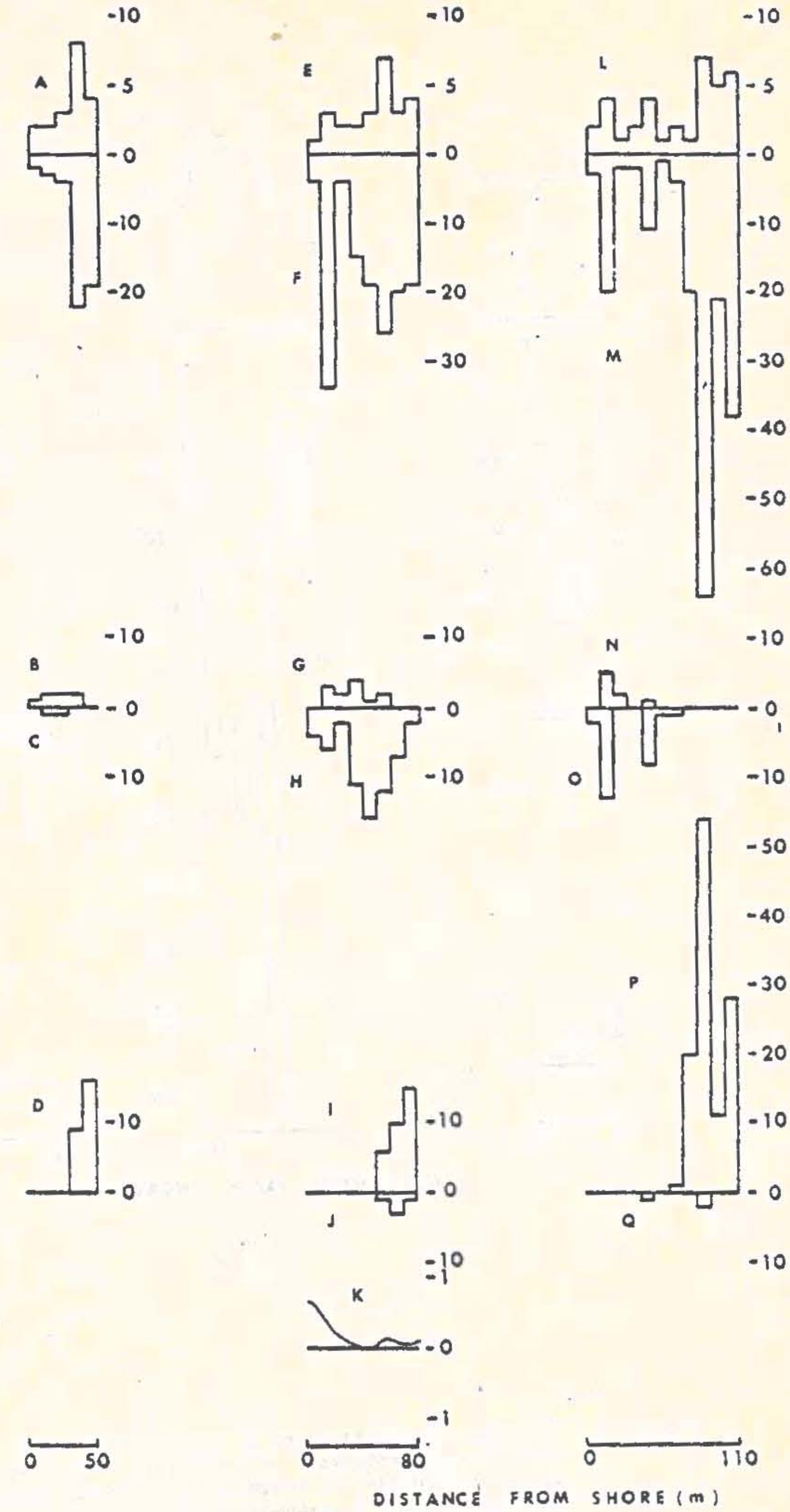

Figure 10. Fouha Bay Transects 2-4, 29 March 1978. Fish census data for each 10-meter interval. A-D=Transect 2; E-K=Transect 3; L-Q=Transect 4. A (upper), E, L=number of species; A (lower), F. M=number of individuals; B, G, N=number of H. trimaculatus; C, H. O=number of G. glaucus; D, I, P=number of G. leucopomus; J, Q=number of H. margaritaceous; K=reef profile (meters) with respect to MLLW.

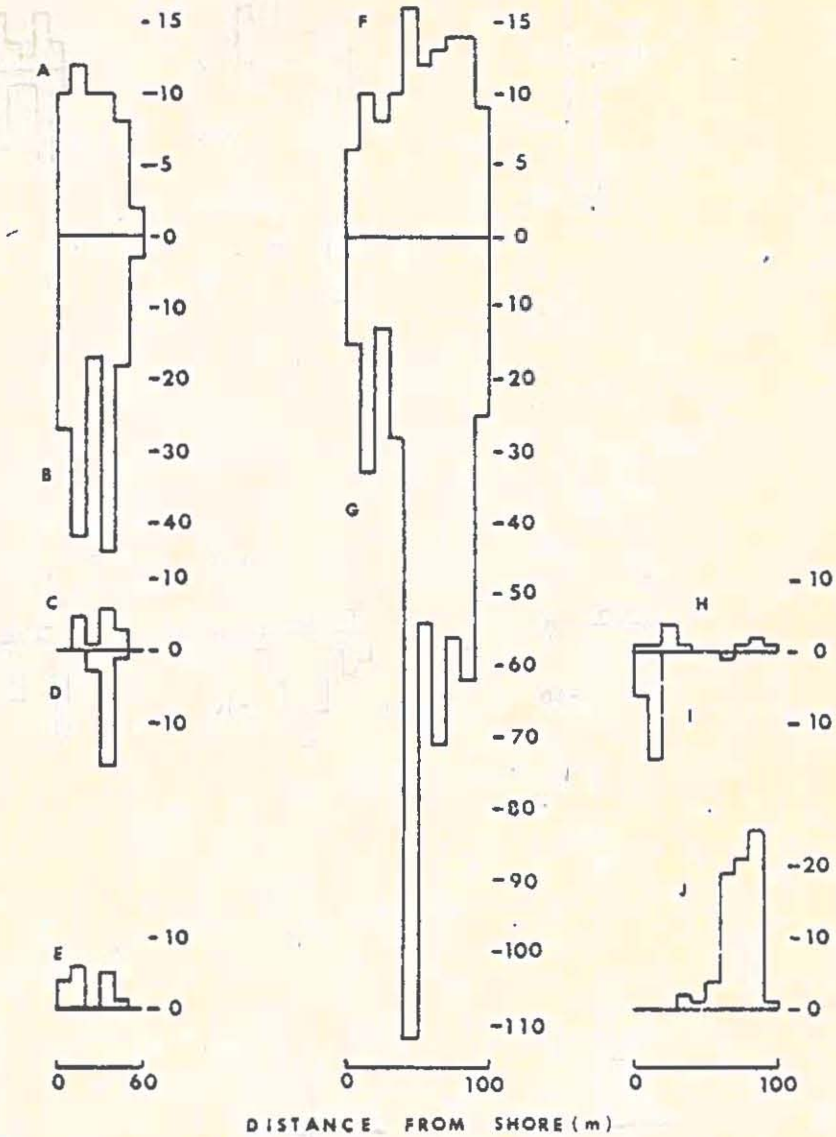

Figure 11. Ylig Bay, Transects 1 and 2, 17 June 1977. Fish census data for each 10-meter interval. A-E=Transect 1; F-J=Transect 2. A, F= number of species; B, G=number of individuals; C, H=number of H. trimaculatus; D, I=number of G. glaucus; E, J=number of G. leucopomus.

PART II: Distribution of the eggs and larvae of fishes at selected sites on Guam

The life cycles of most species of tropical reef fishes have not been studied in detail. From what information is available (see Breder and Rosen, 1966), some general patterns can be described. Tropical marine teleost fishes (which excludes the sharks and their relatives) all exhibit external fertilization; that is, the female releases unfertilized eggs into the water and the male sheds his sperm fertilizing the eggs. The fertilized eggs, then, develop outside the body of the female fish. In many species, notably most gobies (Family Gobiidae), blennies (Family Blenniidae), and damselfish (Family Pomacentridae), the eggs are attached to the substrate while the embryonic fishes are developing and the parent fish may protect the developing eggs to varying degrees (see Ross, 1978). Many cardinalfishes (Family Apogonidae) are mouth breeders, and one of the parent fishes carries the developing eggs in its mouth until they hatch. Most other groups, however, do not attach nor care for their eggs, and the fertilized eggs are pelagic, floating freely in the water while the embryos inside are developing.

The developing egg, of course, cannot swim nor do anything in its own defense, and most of them are eaten or otherwise destroyed before they develop to the point of hatching. Fish are well-known for their production of vast numbers of eggs, and this is necessary to insure that at least a few of them will survive to hatch and mature. Species which care for their eggs generally produce much smaller broods, because the protection provided by the parents guarantees that a larger percentage will survive to hatching.

Once hatched, the developing fish, now referred to as a larva, takes up residence in the planktonic communities of the waters in which it lives. Pelagic larval fishes have limited powers of locomotion and some of them, for instance puffers (Family Tetraodontidae and other related families) and scorpionfishes (Family Scorpaenidae), have arrays of spines to deter predators. Despite these assets, mortality is also high among fish larvae. Some are eaten by various plankivorous animals, some starve, and some are carried by currents to areas where conditions are unfavorable to their survival. A planktonic larval stage is common to virtually all marine reef fishes, and even some species which live in fresh waters as adults have larvae which develop in the ocean. The larval stage is limited in duration, and the larvae of those fish species which live on the reef as juveniles and adults must return to the reef environment within a certain period of time to complete their development. Many larvae are no doubt lost by being carried away from the reef, preventing them from completing their development. Once returned to the reef, the juvenile fish must encounter the particular type of reef habitat to which it is adapted and must be able to establish itself in this habitat. Many juveniles no doubt perish during this process, being eaten by reef predators or excluded from potential habitats by the presence of competitors of their own species or similarly adapted species.

Clearly, the survival of any given egg to maturity or recruitment is very unlikely, and for this reason, marine teleost fishes produce great numbers of eggs so that, on the average, one pair of eggs of all those produced in a life time, will replace one pair of spawners. Over short periods of time, however, the survival of eggs and larvae is quite variable, and some species, for instance the rabbitfishes, may have years in which larval survival is very high and years in which it is very poor (Kami and Ikehara, 1976). Because of the many factors affecting the survival of the early life stages of marine fishes, it is not possible to predict the probability of recruitment during a given year for any species of reef fish.

Fish are a conspicuous component of Guam's marine communities and have economic, ecological, and aesthetic value. There is some concern that future developments of Guam's coastal zone may have unforeseen impact on areas which are important for the early development of fishes. Little is known of the distribution of the larvae and eggs of fishes in Guam waters, and virtually nothing is known of the conditions which are favorable to the early stages of development of Guam's fish fauna.

The purpose of this study is to determine the relative abundance of pelagic fish eggs and larvae at selected locations in the waters surrounding Guam. The locations were selected to provide information on the influence of nearby mangrove habitats, seagrass habitats, reef channels, and offshore habitats on the numbers of fish larvae in the water. The composition of the associated plankton community is analyzed to indicate relationships between the abundance of fish eggs and larvae and other planktonic organisms.

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METHODS

Fish eggs and larvae were sampled with a 50 cm diameter zooplankton net with mesh apertures of 0.35 mm. A second net, 25 cm in diameter with 171 gauge mesh was towed simultaneously to collect a sample of phytoplankton. The nets were towed 1 to 2 meters below the surface for measured periods of time. The locations of the sampling sites are shown in Figure 1. The plankton samples were preserved in 10% formalin and were brought to the laboratory for further analysis. Subsamples from each collection were examined under a dissection microscope, and the fish eggs and larvae and other zooplanktonic organisms were enumerated. The phytoplankton samples were placed in graduated cylinders, and settling volume was determined.

RESULTS AND DISCUSSION

Fish eggs are a prominant part of the plankton. In the collections made in this study, the density of fish eggs varied from 4.2 to 223.3 per cubic meter of water, and their relative abundance varied from 2.7 to 91.1% of the planktonic organisms collected. Notwithstanding the wide range in their abundance, fish eggs appear to be distributed randomly in the water: the coefficient of dispersion (variance/mean) for their densities over all collections was 1.1652, only very slightly more than 1.0, the expected C.D. value for a randomly distributed organism.

The larvae of fishes are very much less abundant than fish eggs, however. Their greatest density was 6.3 per cubic meter of water in a collection where they comprised 5.1% of all planktonic organisms taken. In several tows, they were not collected at all. Fish larvae appear to be moderately aggregated in their distribution and had a coefficient of dispersion of 2.0037. This tendency toward aggregation does not imply that the larvae school, and most studies on the schooling of fishes indicate that this behavior does not develop until somewhat later in life, during the juvenile stages.

The data suggest that these is some seasonality in the abundance of fish eggs, with the highest densities occurring in the summer months (July and August) (Table 23). The density of larvae is at the lowest during the summer months, although these is considerable overlap in densities among all the months sampled.

The highest densities of fish eggs were found in the Achang Bay-Manell Channel area and in Ajayan Bay. Areas of particularly low densites of fish eggs were Nimitz Channel and Umatac Bay. Fish larvae showed no consistant pattern of dominance in particular areas. The highest density was recorded from the Nimitz reef front near Alutom Island; other relatively high concentrations were found in Ajayan Bay, Nimitz reef front near the Channel, Achang Bay and Nimitz Channel.

It has been suggested that mangrove or seagrass areas may be nursery areas for developing fishes. The sites surveyed in this study were selected in this study were selected to provide some information on this hypothesis: the site in Agat Bay just off Alutom Island is near a relatively extensive seagrass flat as is the Ajayan Bay site (Randall and Eldredge, 1976). Achang Bay is surrounded by a mangrove shoreline, and Manell Channel is flanked by seagrass beds. The other sites sampled are not in areas of mangrove or well-developed seagrass. The two highest densities of fish larvae were recorded off Alutom Island and in Ajayan Bay, but both of these areas were also sampled when very few fish larvae were present. Nimitz channel and the reef front adjacent to it also showed high larval densities, but these areas are not close to developed seagrass beds. Seagrass beds may be important to certain species at certain times of the year, but other types of areas are apparently suitable for fish larvae.

The distribution of fish eggs is determined by the spawning areas of the parent fishes, and water circulation patterns, since eggs have no way to actively seek out particular habitats. The very high densities of fish eggs in Ajayan eggs in Ajayan Bay and in the Achang Bay-Manell Channel area suggests that various species of fish are spawning in these areas.

There is no statistical relationship between the volume of phytoplankton collected and the density of fish larvae (correlation coefficient = 0.115). The phytoplankton net tended to catch, in addition to phytoplankton, microplanktonic crustacea and water-borne silt. These contaminants may have compromised the validity of our phytoplankton measurements.

CONCLUSIONS

The various areas sampled showed considerable variations in the abundance of fish larvae and eggs from location to location and at different sampling periods. Although it might be tempting to rate the various areas on the basis of their importance in the production of young fishes, it must be noted that the young stages of the many hundreds of fish species in the waters around Guam may have specific habits and preferences which differ from one another. The high density of fish eggs in Achang Bay-Manell Channel may be due to the presence of the near-by mangrove environment. Seagrass may well be important for other fish species, and clearly many species have egg and larval stages which reside in quite different environments. The preservation of a wide variety of environments will help to insure that fish species with differing ecological requirements will be able to complete their life cycles.

Table 13. Plankton collected in Agat Bay February 2, 1977. Relative abundance (%) of various groups.

PLANKTON	TOW #1	TOW #2
Fish Eggs	37.2%	31.0%
Fish Larvae	2.3	2.8
Foraminifera	5.6	0.5
Radiolarians	1.9	2.8
Medusae	0.5	-
Siphonophores	0.9	0.9
Gastropod Larvae	0.5	-
Heteropods	4.7	0.5
Pteropods	-	0.5
Copepods	15.3	17.1
Mysids	3.7	1.9
Amphipods	1.9	-
Stomatopod Larvae	0.9	-
Crab Larvae	6.5	11.2
"Shrimp" Larvae	11.6	24.5
Chaetognaths	4.2	1.9
Larvaceans	0.5	1.9
Miscellaneous	1.9	2.8

Table 14. Plankton collected in Agat Bay, March 14, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A=Nimitz Channel; B=Nimitz Reef Front Near Channel; C=Nimitz Reef Front Near Alutom Island; D=1/4 Mile Offshore.

PLANKTON	A	B	C	D
Fish Eggs	5.5(12.4)	8.0(24.7)	2.0(34.3)	12.0(57.6)
Fish Larvae	1.3(2.8)	0.3(1.0)	0.6(1.1)	0.04(0.2)
Foraminifera	2.5(5.6)	2.2(6.7)	1.3(2.1)	0.8(4.0)
Radiolarians	- -	0.3(1.0)	- -	5.6(26.8)
Siphonophores	- -	0.2(0.5)	0.2(0.4)	0.2(0.8)
Polychaete Larvae	0.3(0.6)	0.3(1.0)	- -	- -
Gastropod Larvae	0.3(0.6)	- -	- -	- -
Pteropods	0.8(1.7)	0.2(0.5)	1.0(1.8)	- -
Copepods	17.0(38.4)	15.8(49.0)	28.8(49.3)	0.6(2.8)
Mysids	- -	0.2(0.5)	0.6(1.1)	- -
Amphipods	- -	- -	0.2(0.4)	- -
Crab Larvae	12.5(28.2)	2.5(7.7)	0.8(1.4)	1.0(4.8)
"Shrimp" Larvae	0.8(1.7)	0.2(0.5)	1.0(1.8)	0.1(0.4)
Chaetognaths	2.3(5.1)	2.0(6.2)	2.9(5.0)	- -
Echinoderm Larvae	- -	- -	- -	0.2(0.8)
Larvaceans	1.3(2.8)	0.3(1.0)	0.6(1.1)	0.2(0.8)
Miscellaneous	- -	- -	- -	0.2(0.8)
TOTAL	44.3(100.0)	32.3(100.0)	58.3(100.0)	20.8(100.0)
Phytoplankton Volume (ml/m^3)	0.233	0.111	0.264	0.067

Table 15. Plankton collected in Agana Bay, March 14, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A= Central Agana Bay-Reef Front; B=East Agana Bay-Off Alupat Island.

PLANKTON	A	B
Fish Eggs	33.3(34.1)	50.3(91.0)
Fish Larvae	0.7(0.8)	0.04(0.06)
Foraminifera		0.3(0.5)
Radiolarians	0.5(0.5)	- -
Polychaetes	0.3(0.3)	- -
Pteropods	0.8(0.8)	- -
Copepods	54.0(55.4)	2.3(4.1)
Mysids		0.3(0.5)
Crab Larvae	1.0(1.0)	1.3(2.3)
"Shrimp" Larvae	0.3(0.3)	- -
Chaetognaths	4.3(4.4)	- -
Larvaceans	2.5(2.6)	- -
Miscellaenous	- -	10.0(1.8)
TOTAL	97.5(100.0)	55.3(100.00)
Phytoplankton Volume (ml/m^3)	-	0.350

Table 16. Plankton collected in Agat Bay, April 15, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A=Nimitz Channel; B=Nimitz Reef Front Near Channel; C=Nimitz Reef Front Near Alutom Island; D=1/4 Mile Offshore; E=1/2 Mile Offshore.

PLANKTON	A	B	C	D	E
Fish Eggs	8.2(7.0)	7.5(7.4)	16.3(13.1)	5.1(44.7)	13.7(76.7)
Fish Larvae	0.06(0.05)	2.1(2.1)	6.3(5.1)	0.4(3.5)	0.04(0.2)
Foraminifera	0.7(0.6)	0.8(0.8)	0.8(0.7)	0.3(2.6)	- -
Medusae	0.4(0.3)	- -	- -	- -	- -
Siphonophores	- -	0.4(0.4)	0.4(0.3)	- -	- -
Pteropods	0.4(0.3)	- -	0.4(0.3)	- -	- -
Ostracods	- -	0.8(0.8)	2.5(2.0)	0.3(2.6)	- -
Copepods	41.1(35.2)	55.5(54.7)	59.6(48.1)	0.9(7.9)	1.2(6.7)
Mysids	- -	2.1(2.1)	0.8(0.7)	- -	- -
Cumaceans	- -	0.4(0.4)	- -	- -	- -
Amphipods	- -	0.8(0.8)	- -	- -	- -
Crab Larvae	52.5(45.0)	14.6(14.4)	8.8(7.1)	1.5(13.2)	0.3(1.7)
"Shrimp" Larvae	11.1(9.5)	5.0(4.9)	9.2(7.4)	2.1(18.4)	0.3(1.7)
Chaetognaths	0.7(0.6)	2.5(2.5)	2.1(1.7)	- -	- -
Larvaceans	0.4(0.3)	8.8(8.6)	12.5(10.1)	0.9(7.9)	2.4(13.3)
Miscellaneous	0.7(0.6)	- -	- -	- -	- -
TOTAL	116.8(100.0)	101.3(100.0)	123.8(100.0)	11.5(100.0)	17.9(100.0)
Phytoplankton Volume (ml/m^3)	0.714	0.361	0.333	0.167	0.143

Table 17. Plankton collected in Agat Bay, July 1, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A=Nimitz Channel; B=Nimitz Reef Front Near Channel; C=Nimitz Reef Front Near Alutom Island; D=1/2 Mile Offshore; E=1 Mile Offshore.

PLANKTON	A	B	C	D	E
Fish Eggs	7.5(5.7)	27.1(13.3)	46.3(55.5)	82.9(76.2)	80.8(91.1)
Fish Larvae	0.5(0.4)	0.08(0.04)	- -	0.04(0.04)	- -
Foraminifera	- -	2.1(1.0)	0.8(0.4)	8.3(7.7)	1.3(1.4)
Medusae	1.7(1.3)	- -	- -	- -	0.4(0.5)
Polychaete Larvae	- -	0.8(0.4)	- -	- -	- -
Polychaetes	- -	1.7(0.8)	- -	- -	- -
Pteropods	- -	- -	- -	0.4(0.4)	- -
Copepods	7.5(5.7)	125.8(62.0)	32.1(16.1)	6.3(5.7)	3.8(0.9)
Isopods	- -	0.4(0.2)	- -	- -	- -
Crab Larvae	112.5(85.4)	39.6(19.5)	2.1(1.1)	8.8(8.0)	0.8(0.9)
"Shrimp" Larvae	1.7(1.3)	3.8(1.8)	1.3(0.7)	1.3(1.1)	- -
Chaetognaths	- -	0.4(0.2)	0.4(0.2)	- -	- -
Salps	- -	0.8(0.4)	- -	0.8(0.8)	- -
Larvaceans	- -	0.4(0.2)	0.4(0.2)	- -	1.7(1.9)
Miscellaneous	0.8(0.6)	- -	- -	- -	- -
TOTAL	131.7(100.0)	202.9(100.0)	83.3(100.0)	108.8(100.0)	88.8(100.0
Phytoplankton Volume (ml/m^3)	0.067	0.300	0.233	0.117	0.100

Table 18. Plankton collected in Manell Channel, July 6, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A=Achang Bay; B=Manell Channel Tow #1; C=Manell Channel Tow#2; D=Manell Channel Tow #3.

PLANKTON	A	B	C	D
Fish Eggs	62.5(14.2)	28.0(14.6)	71.7(15.4)	58.8(13.5)
Fish Larvae	1.5(0.3)	0.2(0.1)	0.7(0.2)	0.4(0.1)
Foraminifera	- -	1.2(0.6)	0.4(0.1)	- -
Copepods	310.0(70.3)	142.9(77.8)	352.1(75.6)	286.3(65.6)
Amphipods	0.8(0.2)	- -	- -	- -
Crab Larvae	29.2(6.6)	9.5(5.0)	10.8(2.3)	8.3(1.9)
"Shrimp" Larvae	34.2(7.8)	8.9(4.7)	29.6(6.4)	82.5(18.9)
Chaetognaths	0.8(0.2)	0.6(0.3)	0.4(0.1)	- -
Larvaceans	1.7(0.4)	- -	- -	0.4(0.1)
TOTAL	440.8(100.0)	191.1(100.0)	465.8(100.0)	436.7(100.0)
Phytoplankton Volume (ml/m^3)	0.533	-	-	0.333

Table 19. Plankton collected at various sites on July 6, 1977. Density (no./m^2) and, in parentheses, relative abundance (%). A=Ajayan Bay; B=Cocos Lagoon; C=Umatac Bay; D=Agat Bay-Nimitz Channel.

PLANKTON	A	B	C	D
Fish Eggs	171.7(88.4)	26.7(19.6)	25.0(25.8)	40.8(67.6)
Fish Larvae	0.05(0.03)	0.28(0.21)	0.06(0.06)	0.21(0.35)
Foraminifera	0.8(0.4)	7.9(5.8)	- -	- -
Gastropods	- -	- -	6.7(6.9)	- -
Copepods	18.3(9.4)	80.4(59.0)	52.5(54.3)	8.3(13.8)
Amphipods	0.8(0.4)	- -	- -	- -
Crab Larvae	- -	10.0(7.3)	1.3(1.3)	5.0(8.3)
"Shrimp" Larvae	1.7(0.9)	11.3(8.3)	0.8(0.9)	5.0(8.3)
Chaetognaths	- -	- -	3.3(3.4)	- -
Larvaceans	- -	- -	7.1(7.3)	1.3(2.1)
TOTAL	194.2(100.0)	136.3(100.0)	96.7(100.0)	60.4(100.0)
Phytoplankton Volume (ml/m^3)	0.533	0.267	0.283	0.133

Table 20. Plankton collected at various sites on August 18, 1977. Density (no./m^3) and, in parentheses, relative abundance (%). A=Ajayan Bay; B=Achang Bay; C=Manell Channel; D=Umatac Bay; E=Nimitz Channel.

PLANKTON	A	B	C	D	E
Fish Eggs	52.9(85.8)	182.5(66.3)	223.3(83.6)	10.4(26.3)	7.5(52.9)
Fish Larvae	- -	0.04(0.02)	0.06(0.02)	- -	- -
Foraminifera	3.3(5.4)	- -	2.5(0.9)	0.8(2.1)	2.5(17.6)
Polychaete Larvae	- -	- -	- -	- -	0.4(2.9)
Copepods	4.2(6.8)	87.1(31.6)	34.2(12.8)	25.4(64.2)	1.7(11.8)
Amphipods	- -	- -	- -	- -	0.4(2.9)
Crab Larvae	0.8(1.4)	4.2(1.5)	1.7(0.6)	1.3(3.2)	1.3(8.8)
"Shrimp" Larvae	0.4(0.7)	1.3(0.5)	4.2(1.6)	- -	- -
Chaetognaths	- -	- -	- -	1.7(4.2)	- -
Larvaceans	- -	0.4(0.2)	1.3(0.5)	- -	0.4(2.9)
TOTAL	61.7(100.0)	275.4(100.0)	267.1(100.0)	39.6(100.0)	14.2(100.0)
Phytoplankton Volume (ml/m^3)	0.267	0.450	0.283	0.417	0.317

Table 21. Plankton collected in Agat Bay, January 5, 1978. Density (no./m^2) and, in parentheses, relative abundance (%). A=Nimitz Channel; B=Nimitz Reef Front Near Channel; C=Nimitz Reef Front Near Alutom Island; D=1/2 Mile Offshore.

PLANKTON	A	B	C	D
Fish Eggs	12.2(21.7)	77.5(71.3)	47.1(28.3)	27.3(83.2)
Fish Larvae	0.33(0.59)	0.25(0.23)	0.58(0.34)	0.03(0.1)
Nedusae	- -	0.4(0.4)	- -	- -
Siphonophores	- -	- -	2.9(1.8)	0.3(1.0)
Polychaetes	1.2(2.1)	9.2(8.4)	0.8(0.5)	0.3(1.0)
Ostracods	- -	- -	1.3(0.8)	0.3(1.0)
Copepods	11.2(19.9)	10.8(10.0)	95.0(57.1)	2.8(8.6)
Isopods	1.2(2.1)	0.4(0.4)	- -	- -
Crab Larvae	23.2(41.2)	4.6(4.2)	5.8(3.5)	0.2(0.5)
"Shrimp" Larvae	5.7(10.1)	4.6(4.2)	11.3(6.8)	1.3(4.1)
Chaetognaths	1.3(2.4)	0.4(0.4)	1.7(1.0)	0.2(0.5)
Miscellaneous	- -	0.8(0.8)	- -	- -
TOTAL	56.2(100.0)	108.8(100.0)	166.3(100.0)	32.8(100.00)
Phytoplankton Volume (ml/m^3)	0.200	0.167	0.200	0.067

Table 22. Plankton collected at various sites on January 5, 1978. Density ($no./m^3$) and, in parentheses, relative abundance (%). A=Ajayan Bay; B=Manell Channel; C=Umatac Bay.

PLANKTON	A	B	C
Fish Eggs	24.2(2.7)	32.0(3.8)	4.2(12.2)
Fish Larvae	2.5(0.28)	0.67(0.08)	0.18(0.53)
Foraminifera	- -	- -	0.4(1.2)
Radiolarians	- -	- -	0.4(1.2)
Polychaetes	- -	6.0(0.7)	- -
Gastropod Larvae	- -	- -	9.5(28.0)
Copepods	446.7(49.3)	316.0(37.9)	14.6(42.7)
Isopods	- -	- -	0.4(1.2)
Lucifer	0.8(0.1)	- -	- -
Crab Larvae	38.3(4.2)	22.0(2.6)	1.3(3.7)
"Shrimp" Larvae	391.7(43.2)	446.0(53.5)	1.7(4.9)
Chaetognaths	1.7(0.2)	11.0(1.3)	1.7(4.9)
TOTAL	905.8(100.0)	834.0(100.0)	34.2(100.0)
Phytoplankton Volume (ml/m^3)	0.367	0.333	0.200

Table 23. Mean densities (and standard deviations) of fish eggs and fish larvae in the months sampled.

	March	April	July	August	January
Fish Eggs	18.52	10.16	56.14	94.32	32.07
	(4.37)	(2.16)	(6.48)	(10.04)	(4.93)
	N=6	N=5	N=13	N=5	N=7
Fish Larvae	0.50	1.78	0.31	0.02	0.65
	(0.69)	(1.63)	(0.65)	(0.17)	(1.78)
	N=6	N=5	N=13	N=5	N=7

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