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ON THE *BENTHOS BIOMASS* AND ITS SEASONAL VARIATIONS IN MANILA BAY AND SAN MIGUEL BAY AND A COMPARISON OF THEIR *FORAMINIFERAN FAUNA*

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ABSTRACT

This is the first quantitative analysis of benthos in Philippine waters and was intended to help in clarifying whether trawl fishing harms the benthos communities (bottom fauna) as believed by certain fishermen. This paper analyses the results obtained from 317 benthic samples taken from Manila and San Miguel Bays from 1957-1958. The surveys were necessary to learn more about the benthos biomass and its role in the understanding of the food supply of the commercial fish and shrimp populations. The study showed that although the animal densities of Manila Bay and San Miguel Bay are numerically similar, the latter is much richer as shown by the presence of larger animals. The benthos biomass was found in more or less quantities in areas whether there was trawl fishing, or not.

INTRODUCTION

Soon after researches on Manila Bay fishes were started, investigations on its benthos and of San Miguel Bay were included in the overall marine biological program, initiated by the senior author under a UNTAB Program (Tiews, 1959), and conducted in the Philippines from 1956 to 1958. Manila Bay and San Miguel Bay were chosen for the benthos survey as they belong to the foremost fishing grounds of the Philippines.

Presented at the 13th Session, Indo-Pacific Fisheries Council Meeting, 1968.

This study which was conducted from 1957 to 1958 was necessary to learn more about the benthos biomass as a contribution to an understanding of the food supply of the commercial fish and shrimp populations. It is the first quantitative analysis of benthos in Philippine waters and was intended to help in clarifying whether trawl fishing was destructive to benthos communities, as claimed by certain groups of fishermen.

MATERIALS AND METHODS

All sampling operations in Manila Bay were done on board the M/V DAVID STARR JORDAN, a 30-ton research vessel of the Bureau of Fisheries.

A 45-kilogram Petersen bottom grab, covering one-tenth square meter was used to collect the benthos samples. A meter wheel to determine the depth of the water and a set of coarse and fine wire sieves having 1 $cm.^2$ and 2 $mm.^2$ meshes respectively, were used for sorting the samples.

In San Miguel Bay, bottom samplings were performed on board the commercial otter trawlers M/L ARCO and M/L MIRIAM together with other studies conducted there (Tiews, 1959).

As planned, the survey of Manila Bay was started by making a large number of random samples from stations established inside and outside the bay to get a general idea of the bottom topography with regard to the type of sediments and organisms found thereat. A total of 67 stations were initially established. Of these only 9 stations were retained for this study as representative of the different biotopes which were then occupied monthly, station 1, 12, 16, 22, 34, 38, 40, 55 and 665 (Fig. 1).

In San Miguel Bay, only three collections were made during the research period (1957-1958): I — in September-October, 1957; II — February-March; III — May-June, 1958. As commercial fishing boats owned by private operators were used, taking samples from regularly established stations was not always feasible. A total of 15 stations were occupied more or less regularly during the one-year period of operation (Fig. 2).

A total of 260 samples was taken in Manila Bay and 57 samples in San Miguel Bay.

In the field, after each haul, the grab sample was emptied into a metal tub. Volume, texture (sandy, muddy, etc.) and color were recorded. At times, the grab was not filled to capacity when used on hard or stony bottom or when used in deep water.

About 50 grams of the mud sample were kept in a one-quart "Ball jar" for sediment study. The rest of the sample was passed through the set of sieves with the use of running water. Everything left in the sieves, particularly the live organisms, was carefully collected and placed in the same jar. Finally, 5% formalin was added to preserve the specimens.

Ordinarily, three samples were made at each station. However, due to such unavoidable circumstances as bad weather, there were times when only one sample was collected.

In the laboratory, the samples were washed again for further sorting of the different components. The preserved organisms were separated from the rest of the materials, and then weighed to get their biomass.

The specimens were classified into major animal groups. The calcium materials (shells) together with the sand and pebbles were separated, then washed, dried and kept in paper envelopes for more detailed study.

The fine sediments were washed by the decantation method for a further microscopic examination of their composition with regards to foraminifera.

To determine the density of the foraminifera in the different areas, the number of all individuals in one cubic centimeter of the sediment was counted without regard to identification.

DESCRIPTION OF RESEARCH AREAS

1. *Manila Bay*

Manila Bay has an approximate area of 1,350 square kilometers. The mouth is guarded by the island of Corregidor, forming northern and southern channels. From the deepest portion (100 meters) off the northern channel, there is a gradual shoaling of the bottom towards the head of the bay. Fig. 1 shows the established stations in Manila Bay and their corresponding depths. Inside are two smaller bays, the Pampanga Bay, situated at the north western portion and Bacoor Bay at the opposite side.

The bottom topography of Manila Bay may be divided into four major areas based on the type of sedimentation. (Fig. 1). Area I is the portion of the bay surrounding Manila and environs, the Quarantine Anchorage off the breakwaters, the area fronting Sangley Point and the Navotas fishing boats' anchorage. It is predominantly characterized by a greyish or at times black muddy sub-stratum, caused by the large amount of various waste materials, especially organic wastes, discharged by Pasig River and the various sewer outlets of the cities of Manila and Pasay. The discharge from the many ships anchored in this area contributes greatly to the pollution of the water and ultimately to that of the bottom of this area. The area is not devoid of benthic life, however, but in places where there is constant pollution, no sign of animal life may be found.

The greatest portion of the bay, Area II, on the northwestern side, bounded more or less on the southwestern side by an imaginary line connecting Corregidor Island and the mouth of Bulacan River, is characterized by greenish-mud sub-stratum. This area is rich in hydrogen sulphide due to the presence of abundant decaying organic matter deposited into it by numerous river systems from Bataan, Pampanga, and Bulacan provinces. The highly acidic nature of the bottom substratum is attested by the scarcity of calcium material, e.g., shellfish found there have very thin and delicate shells. The thin shelled mollusks, however, are adapted to the very soft substratum, where there is very little bottom current disturbance. Sedentary worms predominate among the annelids. They form tubes of mud. Brachyuran and macruran crustaceans are also found in numbers.

Area III faces Cavite Province along the vicinity of the San Nicolas Shoals from Corregidor Island to Sangley Point. This is characterized by a generally sandy substratum, e.g. from small stones and pebbles to very fine sand, brownish to almost black in color. This area is subjected to violent underwater turbulence, being the open path of the prevailing incoming water current from outside the bay. The water current in this area has served as a selective factor for the organisms thriving here. The mollusks found here have thicker shells, unlike those found in a muddy substratum. Both the free-moving and sedentary annelids are found here. In the case of the latter, they are encased in sturdy tubes formed from the sand particles incorporated by mucous secretions of the animal. The Lancelet, *Branchiostoma* sp., is found only in this area, buried in the sand. The greater concentration of calcium carbonate in the area allows the mollusks to construct thicker shells. This area has the least degree of mixing of fresh water from the rivers and the sea water coming in from the outside.

Area IV comprises the approaches of the Bay. The area fronting Corregidor Island down to the edge of the continental shelf (200 meters deep) is generally sandy though there are always traces of, at times, large amounts of mud mixed with the substratum.

2. *San Miguel Bay*

San Miguel Bay on the east coast of Luzon has an approximate area of 520 square kilometers. The coastline, which extends from Culasi Point to Quelun Point, measures 88.4 kilometers. The deepest portion (40 meters) is at the mouth and, as in Manila Bay, there is a gradual rise of the bottom towards the head where extensive mud flats exist.

During the northeast monsoon months (October to April), when Manila Bay is generally calm, San Miguel Bay is relatively rough all the time, both outside and inside the Bay. The more open mouth of the bay allows the entrance of larger swells coming from the open sea causing constant disturbance and mixing of the water layers inside resulting in a fertilizing effect, since nutrients from the mud are stirred up, and made available to living organisms.

The Bicol River and the Look River (lagoon) provide the main sources of fresh water flowing into the bay, augmented by several brooks and brooklets, especially those found on the southeastern part of the bay.

The Bay was arbitrarily divided into five different areas based on their substrata V (Fig. 2). Area I is that region included at the head of the bay characterized by a more or less greyish mud substratum. Unlike Manila Bay, the headwaters of San Miguel Bay are far less polluted for the surrounding area is being far less industrialized and populated.

The Central portion of the bay designated Area II is of greenish mud and has the greatest degree of silting.

Area III, the eastern side of the Bay is sandy-mud, or sometimes sandy-clay. This area is within the path of the incoming swells from outside the bay during the prevailing monsoon.

The western side of the bay is sandy-muddy (Area IV).

The area outside the bay (Area V) has a bottom substratum which is sandy with traces or with large amounts of mud.

DISCUSSION OF RESULTS

A. Macrobenthos in the Different Areas

1. *Manila Bay*

a. BIOMASS

Manila Bay has an average biomass of 0.78 gm/0.1m². Fig. 3 shows the monthly variations in the biomass of Manila Bay from August 1957 to July 1958. The histogram shows a trimodal picture with the months of September, April and May having an average biomass above 1 gm/0.1 m², but September has the highest value followed by May and April. February and March, i.e. during the dry seasons, have the lowest values (0.2 gm/0.1 m²).

The monthly variation by areas is shown in Fig. 4.

Area I turned out to have the largest standing crop, but the month-to-month fluctuation of the biomass in the area is very abrupt. An average biomass of 0.05 gm/0.1 m² for August is followed by a sudden rise of 3.46 gm/0.1 m² in October (Fig. 4). This may be due to the effect of effluents from the fresh water bringing with it nutrients from the land soon after a heavy rainfall and may fluctuate depending on when the typhoons come. A similar condition is observed during the dry season when the biomass shoots high in May (the middle of the dry season) although the hydrographic conditions are more or less constant. A high population of *Venus* is found, making the area very rich.

The other areas do not show such a very conspicuous monthly variation of the standing crop. In area II, January is the most productive month, with an average biomass of 1.89 gm/0.1 m². Area III has a more or less steady high production from September to November after which there is a drop. February and March are the least productive months, as was the case in all areas.

Area IV is the least productive. However, its standing crop is distributed evenly, having the least monthly fluctuations, possibly related to its more uniform hydrological conditions.

b. POPULATION DENSITY

Manila Bay as a whole has an average population density of 5.76 individuals/0.1 m² (Fig. 5). There is a regular rise from March to June while August (1957) has the highest average density. There is a very great decrease in the following months (dry season).

Fig. 6 shows the population density for all areas in Manila Bay and its monthly variations.

Area I and Area II are thinly populated. Area III appears to be the most highly populated area. The monthly variations are great especially from the months of February to August, the last month being the peak.

Area IV is the next most densely populated area, although a great scarcity of organisms was noted in January.

Table I shows the relation between the average population density of the different areas in Manila Bay with their corresponding average biomasses (gm/0.1 m²) and average weight per individual. Area I with greenish-mud shows an average individual weight of 0.51 gm which is the highest. The average weight of animals for the whole bay is only 0.14 gm.

The percentages of the biomass and frequency of occurrence of the major animal groups are shown in Fig. 7. The miscellaneous group forms about 1/3 of the total population and biomass.

The brachyurans (crabs and crab-like crustaceans) comprise the greatest biomass percentage (25.5%). The identified genera include *Macrophtalmus, Doclea, Thalamita* and *Cycloe*. The bivalves, which comprise 9.8%, include the well known genera *Paphia* and *Arca*. Of the chordates, (6.9%), the Lancelet and the gobiod fishes are the most important. The errant annelids (4.9%) include those belonging to the families Polynoidae Nereidae, Syllidae, Glycoridae, and Aphroditidae. The macrurans (2.8%) include the commonly encountered *Glaucothoe* and the numerous tiny shrimp-like decapods. The tube-living sedentary annelids mostly found in the muddy areas of the bay comprise 2.4% and include those of the families Sabellidae and Terebellidae.

In terms of frequency of occurrence, the errant annelids have the largest percentage (28.1%), followed by the macrurans (17.3%). The other major animal groups are listed in the descending order as follows: Brachyurans (5.8%), ophiuroids (4.1%), sedentarians (4.1%), chordates (3.7%), amphipods (2.4%), pelecypods (1.9%), archiannelids (1.5%), echiuroids (1.5%) and gastropods (0.2%).

2. *San Miguel Bay*

a. BIOMASS

San Miguel Bay has an average biomass of 6.26 gm/0.1 m², which is about eight times as high as Manila Bay.

TABLE I. Benthos of Manila Bay.

Locality and type of sediment	Average Population density indiv./0.1 m^2	Average biomass gram/0.1 m^2	Average Weight per indiv.(gm)
Area I greenish-mud	2.00	1.01	0.51
Area II greyish-mud	2.20	0.83	0.38
Area III sandy	11.74	0.91	0.08
Area IV sandy-mud	7.11	0.38	0.05
Total Average:	5.76	0.78	0.14

Of the three samplings, Operation I, made during the months of September-October 1957, yielded the largest biomass, with an average of 9.42 gm/0.1 m^2. The highest yield was in Area II (28 gms). (Fig. 8).

b. Population Density

San Miguel Bay has an average population density of 6.6 individuals/0.1 m^2 which is just a little greater than that of Manila Bay (5.8). The highest value was found with 24 individuals in area II during Operation I, decreasing to 17 in Operation II and ultimately to 1 individual in Operation III.

Fig. 9 shows the variability of population density by cruises within the area as well as between the areas themselves.

The relation between the population density of the different areas in San Miguel Bay with their corresponding average biomasses, is shown in Table II. Area II has the greatest annual density, 14.0 individuals/0.1 m^2. Areas I and IV have closely similar densities throughout the year, about 6.7 and 6.5 respectively.

The average weight of each individual in the different areas is shown on the third column. Area III has the highest average weight for the whole bay and the general average weight for the whole bay is 0.95 gams, which is 6.8 times greater than that found in Manila Bay.

The percentages of the biomass of the different animal groups for San Miguel Bay is shown in Fig. 10. The pelecypods make up more than one-half of the total biomass. The sedentarians comprise 13.6%. The other groups are arranged in descending order of their percentages: Miscellaneous, echinoids, gastropods, brachyurans, ophiuroids, nemerteans, macrurans, and amphipods.

The above findings show that although the animal densities of Manila Bay and San Miguel Bay are numerically similar, the latter is much richer because of much larger animals, with an average weight of 0.95 gm/individual as compared with those found in Manila Bay, of 0.14 gm/individual.

Although Manila Bay (1,350 sq. km) is 2.6 times larger than San Miguel Bay (520 sq. km), the standing crop of the macrobenthos biomass of the latter is 32,600 metric tons, about 3.1 times larger than that of the former which is only 10,500 metric tons (Table III).

This study does not show evidence that trawl fishing harms the bottom fauna as believed by certain fishermen. The benthos biomass

TABLE II. Benthos of San Miguel Bay.

Locality and type of sediment	Ave. density Indiv./0.1 m^2	Ave. biomass gram/0.1 m^2	Average wt (gm)
Station in the Bay			
Greyish-mud (Area I)	6.67	5.96	0.89
Greenish-mud (Area II)	14.00	13.11	0.94
Sandy-mud (EAST) (Area III)	2.00	6.83	3.42
Sandy-mud (WEST) (Area IV)	6.48	1.17	0.18
Stations outside the Bay			
Sandy-mud (Area V)	4.00	4.23	1.06
Total Average:	6.63	6.26	0.95

TABLE III. A comparison of the benthos biomass and community size (number of individuals) of Manila Bay and San Miguel Bay.

		Per 0.1 m^2	Per qkm	in total area
Manila Bay	Biomass	0.78 g	7.8 t	(1,350 qkm) 10,500 t
	comm. size (individuals)	5.76	57.6×10^6	$77,760 \times 10^6$
San Miguel Bay	Biomass	6.26 g	62.6 t	(520 qkm) 32,600 t
	comm. size	6.63	66.3×10^6	$34,476 \times 10^6$
Biomass ratio (Manila : San Miguel Bay)			1 : 3.1	
Ratio of comm. size (Manila : San Miguel Bay)			1 : 0.44	

TABLE IV. Comparison of number of genera and density of foraminiferans represented in corresponding Areas in Manila Bay and San Miguel Bay.

Comparable Area	Manila Bay			San Miguel Bay		
	Genera	Density/ccm (indiv.)	Ave. Depth	Genera	Density/ccm (indiv.)	Ave. Depth
I	3	46	15 m	2	1,511	4 m
II	17	1,865	28 m	0	0	7 m
III (M. Bay) II + IV (S.M. Bay)	19	3,376	17 m	7 5	1,220 1,525	6 m
IV (M. Bay) V (S.M. Bay)	20	11,944	108 m	15	5,717	14 m
Whole Area	Total 33	Average 4,036	Ave. 42 m	Total 18	Average 1,894	Ave. 8 m

was found in more or less equal quantities in areas where trawl fishing and no fishing were done.

3. *Foraminiferan fauna*

Because of the presence of tests of foraminifera in the stomach contents of shrimps and demersal fishes, being investigated at the same time as the present study, it was decided to include in this study a qualitative analysis of this group of protozoans. Manila Bay and San Miguel Bay, though having an almost similar bottom topography and distribution of sediments, differ in some degree with regard to this group.

The foraminiferans are almost entirely marine animals, and except in a few of the simplest types, there is a test, developed either of agglutinated foreign material, or of chitin or of calcareous material secreted by the animal itself(Cushman, 1948). Most foraminiferans are benthic forms, crawling slowly about on the surface of the mud and ooze of the ocean bottom, or attached to various objects of the sea bottom. A few species have, however, become adapted to a pelagic existence.

The qualitative and quantitative distribution of foraminiferans is determined by environmental factors. With these protozoans the water temperature and salinity are the great controlling factors in their distribution. In areas where there is large amount of calcium carbonate the thick tests of the animals are made of this material, otherwise the organism will utilize whatever is available.

Manila Bay has an average density of 4,036 foraminiferans per cubic centimeter. There were 33 identified genera represented in the bay (Table V).

Area IV, the station outside the bay is the richest both in density of individuals and the number of genera represented. There were 20 genera recorded at this station, with a population density of 11,944 individuals per cc. The dominant genera in this area are: *Globigerina, Globigerinella, Eponides, Discorbis, Cabicides, Loxostonum, Textularia, Rotalia and Spiroloculina.*

In Area III were represented 19 genera, with a density of 3,376 /per cc. Most, if not all, of the tests of the foraminiferans found in this area were of calcium carbonate and they were practically worn out due to the constant water current disturbance of the bottom. The dominant groups are those belonging to the genera. *Quinqueloculina, Triloculina, Elphidium, Amphistegina, Calcarina* and *Alveolinella.*

TABLE V. The genera foraminiferans represented in Manila Bay and in San Miguel Bay.

Genera	Manila Bay	San Miguel Bay
Amphistegina	x	x
Anomalira	x	x
Articulina	x	None
Bolivina	x	None
Bulimina	x	x
Calcarina	x	x
Cibicides	x	None
Discorbis	x	x
Elphidium	x	None
Eponides	x	None
Globigerinella	x	None
Globorotalia	x	None
Guttulina	x	x
Gyroidina	x	None
Lagena	x	x
Loxostomum	x	None
Miliammina	x	None
Nodosaria	x	x
Nonion	x	x
Operculina	x	None
Orbulina	x	None
Peneroplis	x	None
Planorbulina	x	x
Quinqueloculina	x	x
Robulus	x	None
Rotalia	x	x
Spiroloculina	x	x
Textularia	x	x
Triloculina	x	x
Uvigerina	x	x
Vertebralina	x	None
Wiesnerella	x	x
Reusella	None	x
Globigerina	x	x
TOTAL	33	18

Area II occupies the largest portion of Manila Bay. The acidic nature of the sediments due to the presence of hydrogen sulphide accounts for the virtual absence of foraminifera with tests of calcium carbonate. The tests found were less sturdy than those found at Area III. Most of the individuals were juvenile, with very few adult forms. The genera *Nonion, Bolivina* and *Rotalia* were the dominant groups, though other groups occurred occasionally. There were 17 genera identified, and a density of 1,865 per cc/m.

Area I is the least populated area of foraminiferans in Manila Bay, with a density of 46 per cc. The 3 genera found were *Rotalia, Textularia* and *Guttulina*. The highly polluted bottom substratum of this area, due to the accumulation of large amount of waste materials, does not afford an environment suitable for these organisms. Further, this area has the lowest salinity most of the year, which is not a normal environment and is probably even detrimental (Megia *et al.* 1953).

Table IV is a summary of the pertinent comparable data on foraminiferan fauna by areas.

In San Miguel Bay, only 18 genera of foraminiferans were represented in the samples. Additional genera were found however in the diet of *Leiognathus* (Tiews et. al 1968). The whole area, both inside and outside, has an average density of 1,894 cc., about two times less than that of Manila Bay. This may be explained by the shallower nature of the bay, and its more turbid waters.

Area V, the area outside, just like Area IV of Manila Bay, is the richest area in this bay. Fifteen genera were identified, with a density of 5,717/cc. The common genera represented were: *Rotalia Elphidium, Calcarina, Globegerina, Loxostomum, Spiroloculina, Nonion* and the *Miliolids*.

Area I, corresponding to Area I of Manila Bay is richer compared to Manila Bay. With an average density of 1,511/cc., compared to 46/cc. in Manila Bay, it suggests that this area has more favorable environmental conditions, characterized by less pollution and less fresh water inflow.

In number, *Rotalia* presents the bulk of the population and they are practically all of the juvenile form.

Area III and Area IV are both sandy with mud although they occupy opposite positions in the bay. Both have almost the same population density. Area III has a density of 1,220/ccm. and seven identified genera, while Area IV has a density of 1,525 ccm. and five genera represented.

Area II, occupying the center of the bay does not seem to be favorable for foraminiferans. The thick silt deposited here is quite acidic in nature making it impossible for the foraminiferans to multiply. This appears to be the area where fresh and salt water mixes leading to rapid sedimentation of suspended materials, which may be detrimental to these animals.

This review on the foraminiferan fauna is preliminary to a more detailed study for a clearer picture of the number and kinds of the bottom foraminiferans.

SUMMARY

1. Benthos surveys were conducted in Manila Bay and San Miguel Bay from August 1957 to June 1958, for a comparative study of the productivity of the benthos biomass in these areas.

2. The monthly surveys of Manila Bay were conducted on board the research vessel, M/V "David Starr Jordan" while the survey of San Miguel Bay, covering three operations, was conducted on board commercial otter trawlers. A total of 260 samples were taken by means of a Petersen bottom grab in Manila Bay and a total of 57 samples in San Miguel Bay and analysed.

3. San Miguel Bay showed a benthos biomass per unit of area of about 8.02 times more than that of Manila Bay (6.26 g/0.1 m^2 against 0.78 g/0.1 m^2). For population density of the two bays, the ratio is about 1:1 (5.76 Ind. /0.1 m^2 for Manila Bay and 6.63 Ind. /0.1 m^2 for San Miguel Bay). Considerable differences were noted in the different areas, which were distinguished according to the nature of the bottom.

Based on these findings, the standing crop of San Miguel Bay (520 sq. km) is 3.1 times higher than that of Manila Bay although the latter is 2.6 times larger (1,350 sq. km).

4. The organisms in both areas were grouped in the following major taxonomic categories: brachyurans and macrurans; errant and sedentary annelids; pelecypods and gastropods; chordates; echiurodeans; ophiuroideans; amphipods; archiannelids and miscellaneous.

5. A total of 33 genera of foraminiferans were identified in Manila Bay It was noted that Area IV (Manila Bay approach) was the

richest area of the bay both in density and kinds with 20 genera represented. Area III where there is always a strong prevailing water current has quite different genera from those represented in Area IV. The tests of Area III forms were usually worn out. Area II (acidic substratum) was very poor in foraminiferan fauna due to the accumulation of hydrogen sulphide, while in Area I, due to the polluted substratum, only three genera were found. The average density for the whole bay is 4,036 individuals/cc.

6. San Miguel Bay which is much shallower than Manila Bay has a poorer foraminiferan fauna, with only 15 genera represented and with an average density of 1,894 individuals/cc., about one-half of Manila Bay. However, it is interesting to note that Area I is 30 times more densely populated by this protozoan than the corresponding area in Manila Bay, indicating the much greater fresh water dilution and industrial pollution of the latter. Areas III and IV being much more muddy than the corresponding area in Manila Bay have a density of only one-half. The center of the bay has too much siltation, with an acidic muddy bottom, which is detrimental to these protozoans and practically no catches were made there.

7. This study did not show any evidence that trawl fishing harms the bottom fauna, as is believed by certain fishermen.

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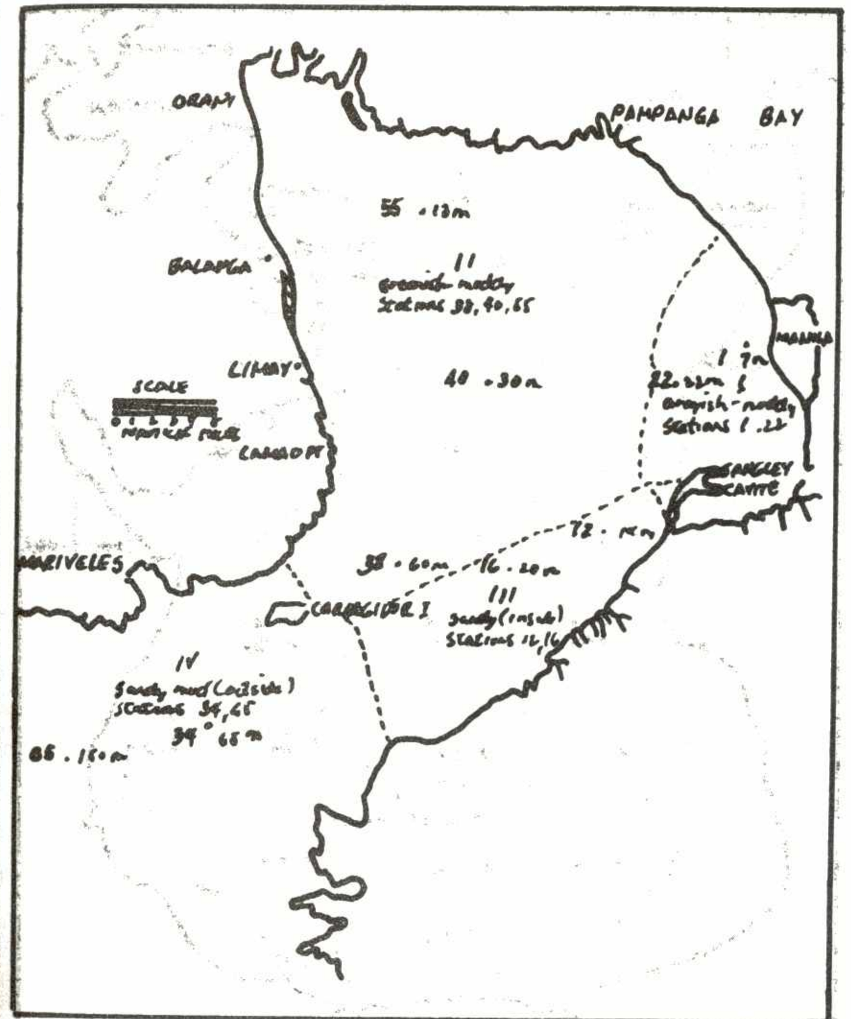

FIG. 1. Map of Manila Bay showing the benthos stations, principal bottom areas and depths (m.)

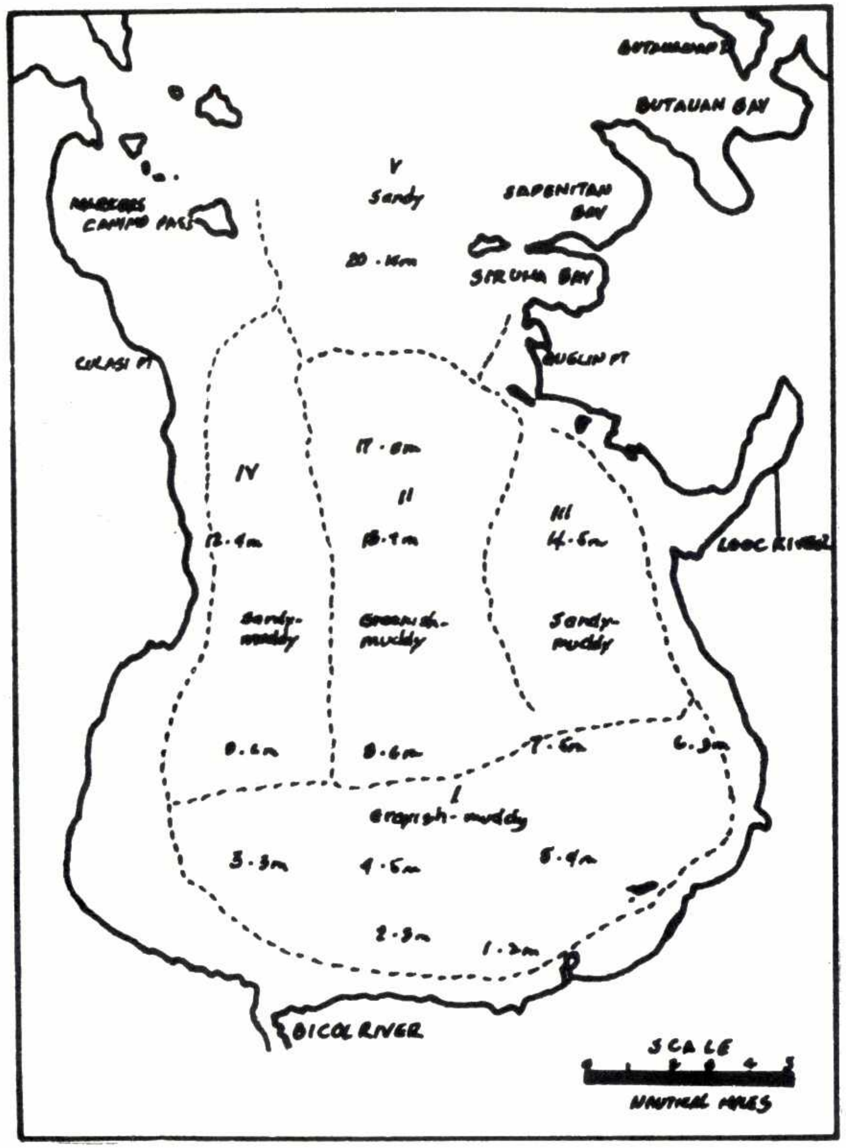

FIG. 2. Map of San Miguel Bay showing the benthos stations, principal bottom areas and depths (m).

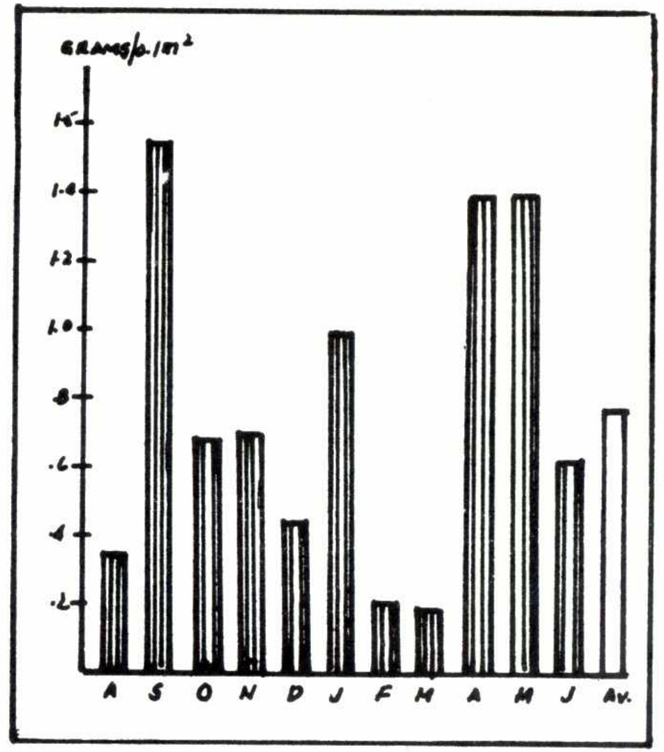

FIG. 3. Monthly variations in the benthos biomass of Manila Bay from August 1957 — June 1958 (average of all areas).

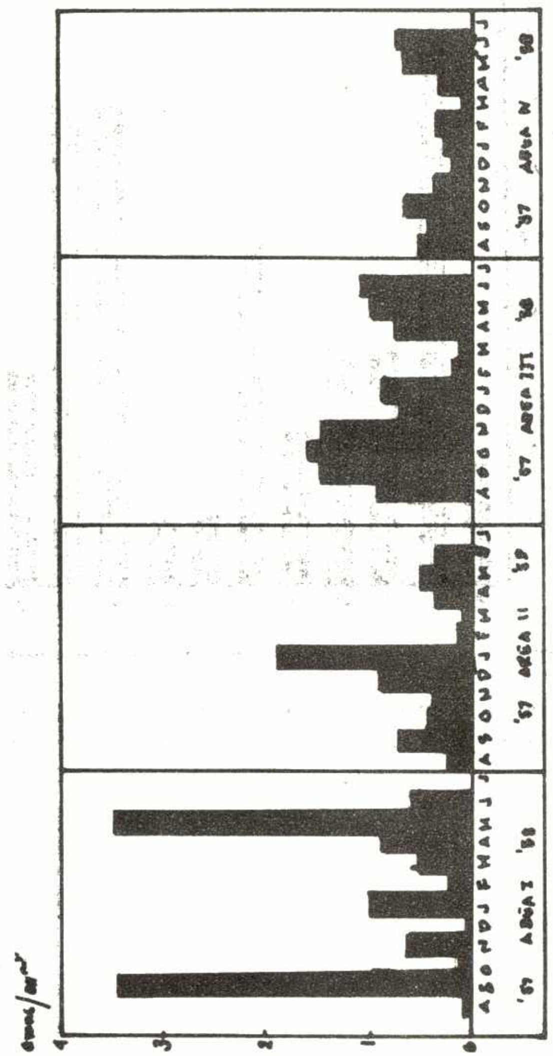

FIG. 4. Monthly variations in the benthos biomass of the different areas in Manila Bay, from August 1957 — June 1958.

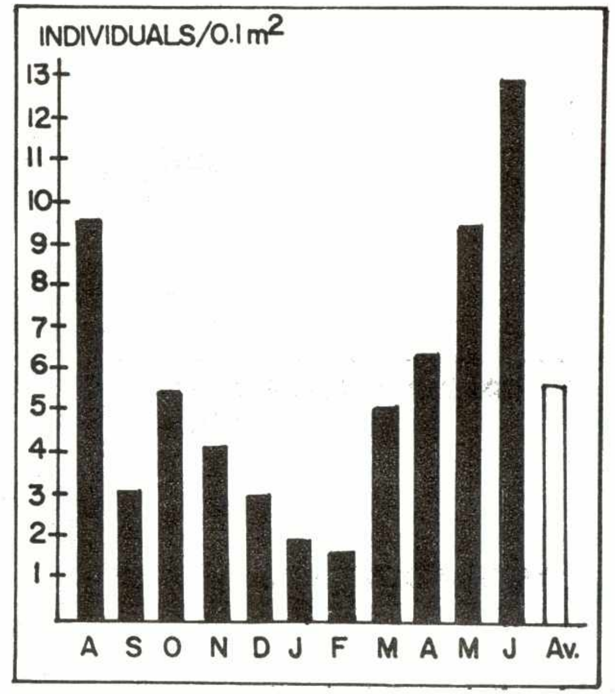

FIG. 5. Monthly variations in the population density of benthos in Manila Bay from August 1957 to June 1958.

FIG. 6. Monthly variations in the population density of benthos of different areas in Manila Bay from August 1957 to June 1958.

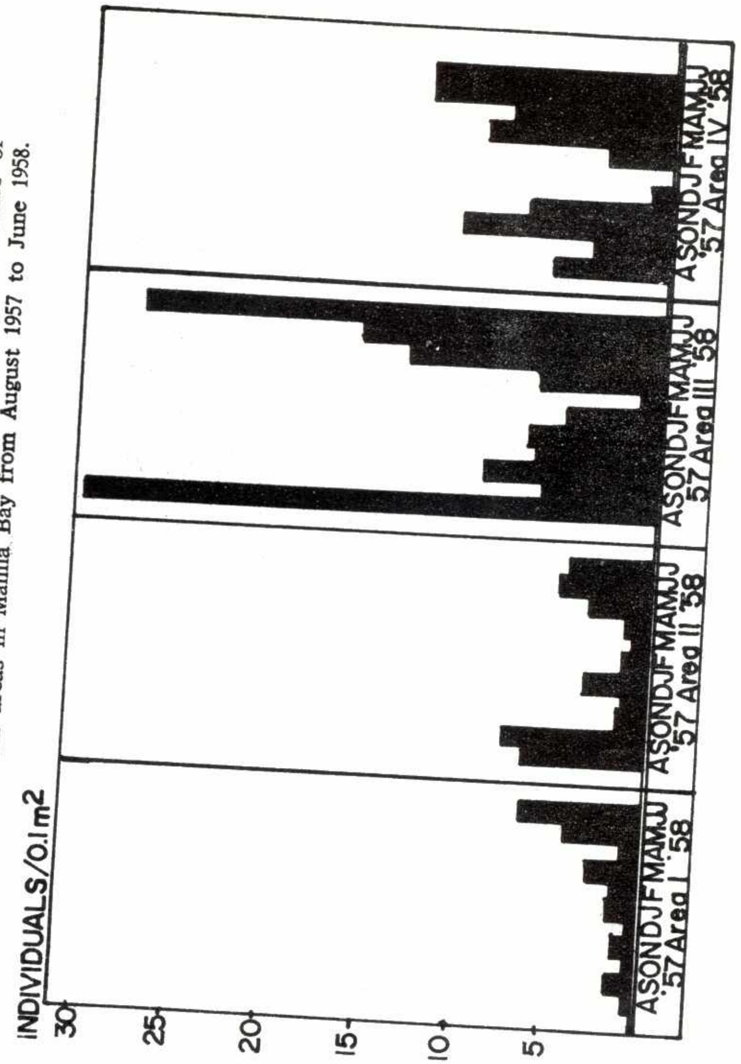

FIG. 7. Percentage biomass frequency distribution (no.) of the major animal benthos in Manila Bay, 1957-1958.

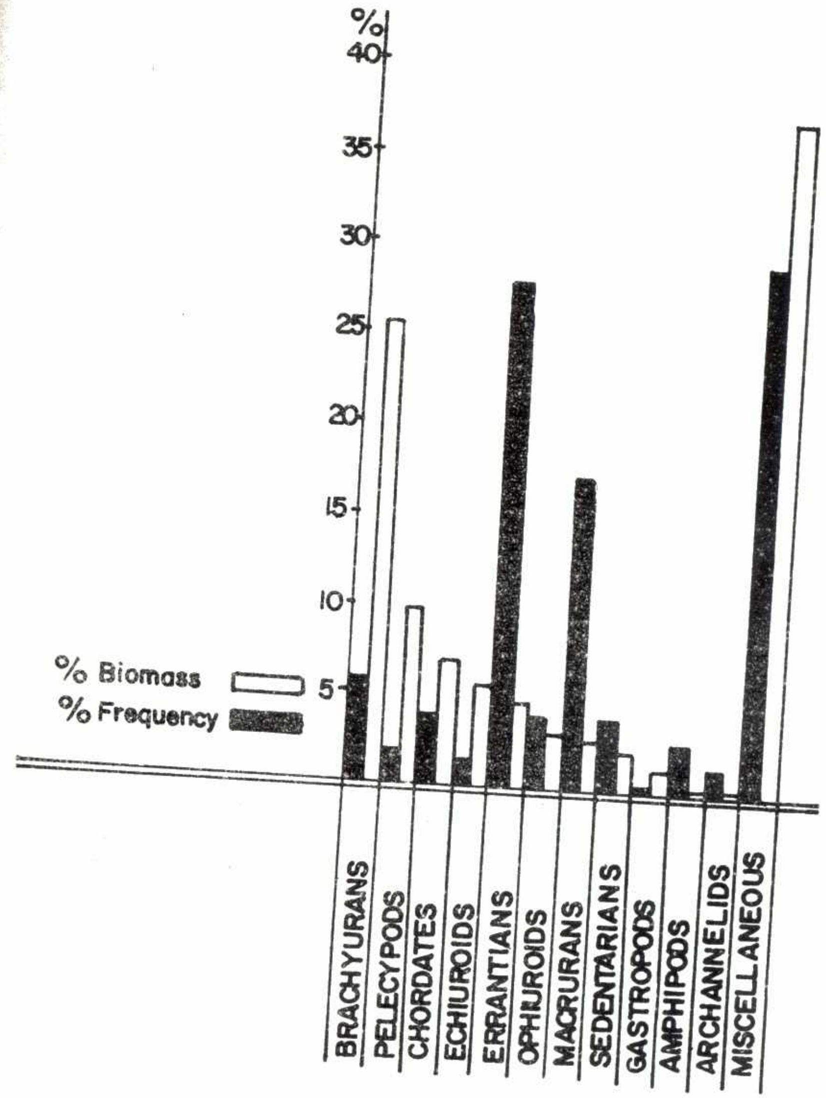

FIG. 8. Variations in the benthos biomass of the different areas in San Miguel Bay from September 1957 to June 1958.

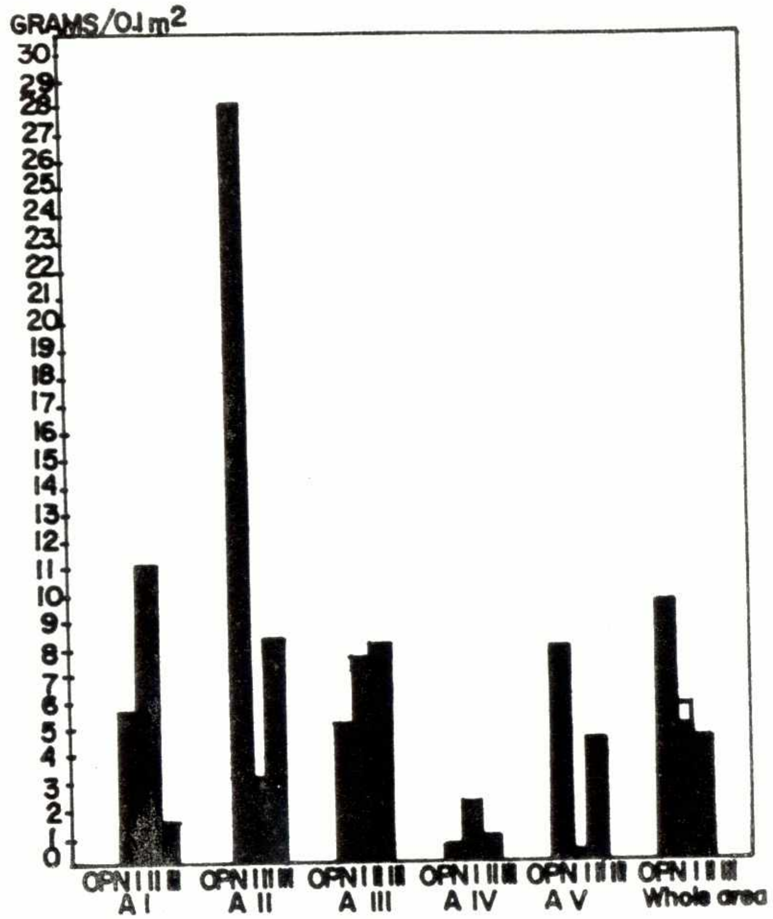

FIG. 9. Variations in the population density of benthos in the different areas in San Miguel Bay, from September 1957 to June 1958.

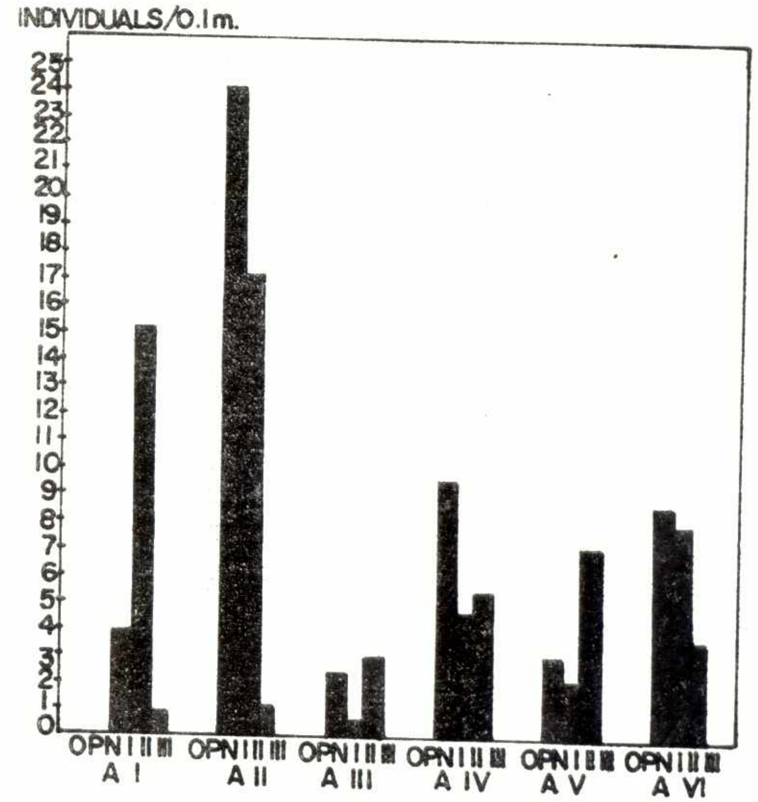

FIG. 10. Percentage biomass and frequency distribution (no.) of the major animal group in San Miguel Bay.