REPORT ON THE FISHERY-OCEANOGRAPHIC OBSERVATIONS IN TAYABAS BAY AND ADJACENT WATERS

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ABSTRACT

This paper presents the results of the fishery-oceanographic survey work conducted on board the R/V RESEARCHER by the research and technical personnel of the Bureau of Fisheries and Aquatic Resources from March 13 to 26, 1974.

Covering approximately 4,000 sq/km, oceanographic sampling operations and fishing experiments were conducted in Tayabas Bay and adjacent waters, to determine some of its physico-chemical and biological characteristics in relation to its fishery. This survey was done in connection with the Test-Fishing Program being implemented by the Bureau which aims to investigate further the economic potentials of the country's fishing grounds.

The emphasis is placed on the oceanographic aspects which are significantly responsible in establishing the inter-relationship between the environmental factors and the fishery resources in the area. The results show some phenomenal features in oceanography that are evident in the lower sub-surface temperature readings which persist up to the surface resulting in a thick homogeneous layer before a thermocline occurs, and water masses of disturbed nature as analyzed from the T-S diagram. These include the higher plankton biomass, especially phytoplankton, and higher oxygen concentration particularly in the surface, which are normal if the water masses described earlier were of another nature.

These oceanographic findings which can be considered ideal for a fishing ground are not substantiated by the unexpected poor catch of the trawl operations in the shallow and deep areas. However, the catch composition results show that the deeper waters are potentially promising with the yield of first class fishes like crevalle (*Caranx*), mackerel (*Rastrelliger*), bream (*Ne-*

mipterus), grouper (*Epinephelus*), and moonfish (*Mene*), although almost all of them were immature. This may suggest an off-season for spawners and breeders which is complemented by the absence of fish eggs and larvae.

The analysis of the data showed that a variable water mass present in the area evidently gave phenomenal water characteristics which are either normal or abnormal for the north-easterly season prevailing during the survey. For this reason, a seasonal investigation is being mapped out to double check the veracity of the results and to make a more accurate correlation of the fishery-oceanographic factors.

INTRODUCTION

This paper presents a study on some of the oceanographic and biological conditions in Tayabas Bay and adjacent waters to understand inter-playing factors in the ecological make-up of the area. This is one in the series of fishery-oceanographic investigations being conducted in one of the traditional fishing grounds of the Philippines in connection with the implementation of the Test-Fishing Program of the Bureau of Fisheries and Aquatic Resources.

The survey was conducted from March 13 to 26, 1974 covering exploratory trawl fishing and oceanographic activities. This was undertaken at an area of approximately 4,000 sq km of Tayabas Bay and adjacent waters. This area is regarded as one of the good trawling grounds with production rate of 400-600 kg catch per day as reported by Manacop (1955). However, fishing activity is not confined to trawling alone. Other means of exploitation may have caused some modifications in the production rate or in the over-all productivity of the area.

This paper compares the present state of the area and the previously reported productivity. The correlation of the fishery-oceanographic factors was analyzed and indicated that the area is really a rich fishing ground.

METHODS OF SAMPLING ANALYSIS

Oceanographic work

Meteorological observations as well as hydrological samplings for physico-chemical determinations and biological samplings were undertaken in Tayabas Bay and vicinity. The survey was confined in the area covered by latitude 13°14.5'N to 13°51.5'N and longitude 121°29.0'E to 122°29.6'E or approximately 4,000 sq km. Fig. I shows the location of sampling stations. To facilitate analysis, the area was subdivided into three sub-areas, each enclosed by broken lines.

Bottom samples were collected using the Van Veen type of bottom grab to determine the nature of the bottom. The samples were passed through a series of sieves of different mesh sizes and the materials retained were preserved for further detailed studies.

Serial water samples were collected using the Nansen reversing bottles at standard depth levels, with the maximum casts being made to 500 m only. The temperature was read from the protected thermometer attached to each bottle and corrected from the accompanying correction tables. Dissolved oxygen was analyzed by Winkler's method. Salinity was determined through conductivity using the Autolab Salinometer.

Bathythermograph (BT) casts were made at depths of 150 and 250 m to determine the location of the thermocline.

Plankton samples were collected by the vertical hauling of the CSK standard twin-net, one with 0.33 mm mesh size for zooplankton and 0.11 mm mesh size for phytoplankton. The nets were lowered at 150-m standard depth in waters deeper than 150 m. At stations shallower than 150 m the nets were lowered with a 5-m allowance above the bottom. Each net was fitted at the center with a flowmeter which was calibrated beforehand, to measure the total volume of the water filtered. Volume of the samples was measured by the wet displacement method. The plankton biomass is expressed in ml/1000 m^3 of sea water.

Fish eggs and larvae were collected by horizontal surface tow using the stramin net with a mouth diameter of one meter. Individual fish eggs and larvae were counted and recorded. Fish eggs and larvae collected thru vertical hauling were likewise sorted out and recorded.

Exploratory fishing

Two drags using the Norwegian type of otter trawl were made in the survey area north of Marinduque Island and Mompog Pass. The first operation lasted for 2.25 hours while the second, for 2.5

hours. Fig. 2 shows the location of the fishing operations including the bottom feature of the whole area.

Fish biology

Length measurements and maturity stage determinations were made on moonfish (*Mene maculata*), red bullseye (*Priacanthus* sp.), silverpike (*Chirocentrus dorab*), lizardfish (*Saurida tumbil*), trumpetfish (*Fistularia* sp.), cutlass (*Trichiurus* sp.), goatfish (*Upenoides* sp.) glassfish (*Pentaphrion longimanus*) and slipmouth (*Leiognathus bindus*).

RESULTS

OCEANOGRAPHY

Bottom feature

As shown in Fig. 2, the bottom is characteristically muddy with some spots like those off Lucena coast, Mompog Pass, and Bondoc coast which are sandy-muddy and the coast around Marinduque Island, which is sandy. It may be noted that these spots are rather isolated which may indicate that a strong underwater current affects shallow areas, most especially or that these features are original of the area. However, the muddy bottom of Tayabas Bay and Mompog Pass (sub-areas 1 and 2) may have originated from the neighboring deep waters where the underwater current may not have reached the extreme bottom.

Temperature and thermocline

The surface water temperature of the survey area is found to have a maximum value of 26.91°C which differs only by 1.02°C from the lowest value of 25.89°C and 0.85°C from the average of 26.06°C. Hence, the temperature distribution in the surface is limited within these values which are dependent entirely on the nature of the area.

In Fig. 3, a gradual horizontal temperature gradient is observed from sub-areas 1 to 3, with about 2°-5° difference per 2-5 nautical miles distance from an isotherm distribution to the other. The maximum value of 26.9°C isotherm lay at the west coast of Marinduque Island and from there, the isotherm value diminishes to 25.95° flowing obliquely towards the center and attains the value of 26.0°C when it reaches the Lucena coast. An isoline of 25.9°C exists from the northern coast of Tayabas Bay across to the northern coast of Marinduque Island bordering sub-areas 1 and 2. From hereon, the value increases to more than 26.0°C up to sub-area 3.

Thus, from these observations, sub-area 3 exhibits a higher superficial water temperature than the two sub-areas. Sub-area 1 evidently has the lowest except for Lucena coast and west of Marinduque Island where the effect of wastewater effluent from their inhabited coasts is strongly felt and retained by their surface water.

The cross-sectional temperature distribution in Fig. 4 shows the marked thermal stratification and extent of the depth of observation in the whole area. All sub-areas exhibited a higher isothermal value of more than 25.0°C at layers less than 100 m which gradually decreases with depth. At the maximum depth of 200 m in sub-area 1, a minimum isothermal value of 15.0°C was observed. Sub-area 2 which is the most shallow, at less than 100 m has 24.0°C minimal isotherm and sub-area 3 which has the greatest observed depth of 500 m has the lowest isotherm of 11.0°C. No abrupt decline was noted except for a concentration of isothermal lines from depths less than 100 m to less than 200 m of sub-areas 1 and 3 where most thermocline were observed.

An isothermal value of 25.5°C which flows continuously from sub-area 1 to 2 at upper 50 m coincided with the area of lower surface isotherm distribution in Fig. 3. This may indicate a lesser influence of environmental activities or may be due to the effect of colder water flowing in from the deep-water of Sub-area 1, and may therefore give a homogeneous characteristic. It may be noted that Sub-area 2 is surrounded by deep waters which may influence its thermal character.

Water masses of homogeneous isothermal values distributed at various depths in all areas may give an impression of a continuous distribution of stratified homogeneous water mass throughout. This can be observed more clearly in deep waters of sub-areas 1 and 3 where the same isothermal values at sub-surface depths almost linearly coincided with one another. This condition is most defined at depths less than 50 m where an isothermal value of 25.2°C traverses horizontally from sub-area 1 to 3 as shown in Fig. 5. Likewise, the isoline of 25.5°C in sub-area 1 has a similar pattern as that of sub-area 3. This tallied with the isotherm distribution of the same value at upper 50 m in the cross-sectional observation in Fig. 4 at 50 m, the effect of superficial temperature on the sub-surface temperature is still imminent especially in Sub-area 1 where the isotherm distribution varies with only 1.5°C difference from the superficial values. However, the west coast of Marinduque Island has less difference which is 0.9°C from the surface observation. This may suggest that the effect of run-off water from this area is still felt at the 50 m depth. Sub-area 3 remains highest with an isotherm of above 25.0°C which differs only by 1.0°C from the surface isotherm value. This nearly same temperature from the surface to a depth may indicate a relatively thick upper homogeneous layer which may be due to a possible vertical turbulence or mixing of entirely different water masses resulting to the prevention of any abrupt change or thermocline.

Fig. 1 shows the sampling stations including the bathythermograph operations as indicated by different symbols. It may be noted that castings were made in deep waters of 150 and 250 m. The vertical profile of two-depth operations was collectively illustrated in Fig. 6, where the bathythermograph recorded an initial discontinuity at the depth range of 100-120 m except for one which occurred at 65 m. In the 150-m observation, the decline starts at the temperature range of 22.3°C-25.5°C and stops at a constant temperature at 140 m. The thermocline in the 250-m cast occurs at 120 m with a temperature range of 21.5°C 23.0°C which stops at 200 m. The decline for both observations terminates at the temperature range of 16.0°C-18.0°C. The thermocline of the 250-meter observation is thicker (40-80 m) and colder than the thermocline of 150-meter cast (20-40 m).

Thus, it is clearly defined that the thermocline occurs at an intense depth with considerable thickness which explains the thickness of the homogeneous upper layer. This may suggest a probable vertical turbulence where intermixing of water from the sea bed and the superficial layer prevented an early formation of thermocline which consequently may have resulted in the very small variation between the surface temperature and the sub-surface temperature in the upper 100 m.

Temperature and salinity

Generally, the surface salinity of the survey area is high with values within the range of 33.03 - 34.30 per mile (°/oo) with an average value of above 34.00°/oo. However, Sub-area 1 has comparatively lower salinity (within the range of 33.66-34.09°/oo) than Sub-areas 2 and 3 (within the range of 34.07 - 34.30°/oo). Considering that these areas are coastal in nature, apparently, these values are even higher than those recorded in the previous years for the southwest and northeast monsoon in the South China Sea (Shirota, *et. al.*, 1972).

As to the order of lowest to highest saline water value, Sub-area 1 ranks lowest with an average isohaline distribution of 34.0°/oo, Sub-area 2 follows with 34.2°/oo, and Sub-area 3 with the highest value of 34.3°/oo (Fig. 7). It may be observed that the east and west coasts of Marinduque Island are characterized by isohaline values of above 34.0°/oo. It may be further noted that the isohaline of above 34.00°/oo flows from the west coast of Marinduque Island distinctly across to Bondoc Peninsula indicating a constant isohaline flow. Lucena coast (along Tayabas Bay) has waters of low salinity.

Stratification of saline waters is illustrated in Fig. 8 where a minimum superficial isohaline range of 33.92 - 34.15°/oo and a maximum of 34.00°/oo - 34.40°/oo at the sub-surface of 100-500 m were distributed variably at all depths. Sub-area 1 has still the lowest minimum value of 33.92°/oo at the surface and a maximum of 34.00°/oo at 400 m sub-surface. Sub-area 2 is intermediate with isohaline surface value of 34.00°/oo and a maximum of 34.20°/oo at 100 m. Sub-area 3 surface isohaline minimum is highest at value of 34.15°/oo and with a maximum of 34.40°/oo at 500 m. An apparent influence of the deep water property of high salinity on both sides of Sub-area 2 may have given this shallow area an unusually high surface salinity.

To have a better understanding of the characteristic property of water mass of the survey area, a temperature-salinity diagram was drawn in Fig. 9. Four types of water masses were observed in the area which added to the complex property of the water for this particular season. These are: 1) the water layer of 0 to 50 m deep which is hot and of low salinity 2) the same water layer which is hot but of high salinity, 3) the intermediate layer (75-100 m deep) with properties of the first and second type, and 4) the water layer below the 100-m depth which is cold and of high salinity. A water mass of the first and second types was observed in Sub-area 1 at the 0-50-m depth with values within the temperature range of 25.0°C - 25.9°C bounded by salinity range of 33.7°/oo - 34.2°/oo and the temperature range of 24.4°C - 27.2°C by the salinity range of 34.0°/oo - 34.2°/oo. Likewise, a similar structure was noted at the 75-100-m plot where the temperature range of 23.0°C - 25.0°C falls within the salinity range of 33.7°/oo - 33.9°/oo and the temperature range of above 24.0°C - 25.0°C within the salinity range of 34.00°/oo - 34.25°/oo. Sub-area 3 has a water mass of the second type where the temperature range within 24.0°C - 25.6°C and has a salinity range of 34.15°/oo - 34.35°/oo at depths less than 100 m. Both sub-areas however, have the Type 4 water mass at depths greater than 100 m with temperature values within the range of 13.0°C - 21.0°C falling within the salinity range of 34.0°/oo - 34.5°/oo. Generally, Sub-area 2 has a water mass of the third type being shallow. Thus, 50 per cent of Sub-area 1 and almost 100 per cent of Sub-area 3 have the property of deep water, while Sub-area 2 has almost equal percentages of deep and shallow water properties.

From the results, it may be presumed that a degree of vertical turbulence or distribution which may be dependent on some forces of undetectable origin, may have resulted in the intermixing of the surface and deep waters giving a variable water mass. This may also have largely determined the very small variations in temperature at depths less than 100 m.

Dissolved oxygen

A normal vertical oxygen distribution was observed in the survey area with values above 4.0 ml/1 generally found at the surface which gradually decreases with depth, as shown in Fig. 10. However, values of above 4.0 ml/1 are observed notably at the euphotic zone of 0-30 m deep but the maximum is attained at depths of 10 to 20 m where photosynthetic activity is also maximal. From 50 m downwards, the concentration gradually decreases and the deficiency is most pronounced at 100-m-deep with diminishing values from 2.0 ml/1 to 0.50 ml/1.

It was further observed that values of above 4.0 ml/1 occurred at 0 - 30 m in areas of less than 100 m whereas, they remained up to 50-m in the 500-m-depth observation. This may indicate a probable biological utilization by higher forms which aggregate in waters of less depth.

Moreover, in Fig. 11, the average oxygen concentration at 0 - 50 m deep indicates a lower average value in Sub-area 2 with a minimum isoline of 3.7 ml/1 and a maximum of 4.1 ml/1, as compared with the minimum isoline value of 3.9 ml/1 and maximum of 4.2 ml/1 in Sub-areas 1 and 3. This also denotes a degree of biological activity although it is far from being deficient since the waters are shallow.

However, an increment is noted at the boundary of Sub-area 1 where the dissolved oxygen concentration increased to 4.2 ml/1 towards the northern coast of Tayabas Bay.

In Fig. 12 where the vertical distribution of stratified oxygen concentration is shown, it was further noted that a normal concentration occurs at layers less than 50 m. From 50 m, the value decreases with depth, the minimum occurs at 500 m with an isoline of 0.90 ml/1. Isolines of 4.0 ml/1 - 4.3 ml/1 are observed at waters less than 50 m deep in Station 9 of Sub-area 1 to Station 19 of Sub-area 2 which serve as boundary of the two sub-areas where higher oxygen concentration was earlier observed.

Plankton biomass

Phytoplankton dominates the high plankton biomass of the survey area especially in the eastern portion of Tayabas Bay near Mompog Pass (boundary of Sub-areas 1 and 2) with an average phytoplankton biomass of 1,902.92 ml/1000 m^3 or by volume, which placed this area as the richest. This area is also very rich in zooplankton with the average biomass of 582.41 ml/1000 m^3. Accordingly, in Fig. 13, it can be noted that isolines of 1,000 to 2,500 ml/1000 m^3 run parallel to northern Marinduque Island and Tayabas Bay coastline. Low phytoplankton volume of 100 - 900 ml/1000 m^3 was observed at the approach of Sub-area 1 and a value of 320 - 900 ml/1000 m^3 at Sub-area 3. These areas have comparatively low phytoplankton biomass.

A similar situation is observed in zooplankton distribution. In Fig. 14 showing the zooplankton distribution, the boundary of Sub-areas 1 and 2, which has apparently the highest phytoplankton biomass had also the highest zooplankton volume of 300 - 800 ml/1000 m^3 isolines, as compared with Sub-area 1 (approach to Tayabas Bay) with isoline values of 100 - 300 ml/1000 m^3 and Sub-area 3, with 200 - 300 ml/1000 m^3.

In Fig. 15 showing the phytoplankton and zooplankton biomass relationships, it can be noted that zooplankton grazing is not intense as evidenced by the unproportionately high biomass plot of phytoplankton over zooplankton. This is most defined in shallow areas with the exception of the plot of almost equal intensity in the deeper waters. The high plankton biomass is evident in shallow areas where sampling was done in depths less than 70 m. An apparently low biomass was noted in the 150-m depth sampling. Thus, it is higher in coastal and shallow areas than in deep waters.

Dissolved oxygen and plankton biomass

In as much as dissolved oxygen is one of the gases of biological importance especially to plankton existence, it seems fit to discuss some observed relationship between the two, even in a brief manner.

From the results of the plankton biomass and dissolved oxygen observations in the area, it could be noted that the eastern portion of Tayabas Bay near Mompog Pass which serves as a boundary between Sub-areas 1 and 2, has the richest concentration of oxygen and plankton. Where the average oxygen content varies from 4.0, 4.1, to 4.2 ml/1 isolines in Fig. 11, plankton biomass likewise varies from 1,000, 2000, to 2,500 ml/1000 m^3 for phytoplankton (Fig. 13) and 300 - 800 ml/1000 m^3 for zooplankton (Fig. 14). The relative values of low oxygen content (isolines of 3.9 - 4.2 ml/1) in Sub-areas 1 and 3 may have contributed to the low plankton biomass (phytoplankton isolines, 100 - 900 ml/1; zooplankton, 100 - 300 ml/1).

The above relationship may indicate that the concentration of phytoplankton may have increased the oxygen content in the area which consequently attracted a volume of zooplankton filling-in their oxygen requirement. However, in Fig. 15 showing the relationship of plankton with oxygen, the high average oxygen values of Sub-areas 1 and 3 have been influenced by high plankton biomass of Sub-area 2, or vice versa.

Fish eggs and larvae

Table 1 shows the larval flow data and Fig. 1, its sampling stations.

A total of 391 individual fish eggs and larvae were collected from 14 stations with an average towing time of 45 minutes, of which 244 were fish eggs and 141 were fish larvae (31 post-larvae and 10 eel larvae). These were mostly collected from Tayabas Bay approach (Stations 11 and 12), and Mompog Pass (Stations 15 and 24). The presence of *mysis* (larvae of shrimps) in all larval stages may indicate a possible shrimp potential of the area. Moreover, the very few number of individual fish eggs may suggest that either this particular season is not spawning time yet, or very few fish species select this area as their spawning place.

Exploratory Fishing

Table 2 shows the total catch composition from two trawling operations, each consisting of one haul.

It can be seen that catch consists mostly of demersal fish species which are of medium grade category although a few pelagic species are included. Slipmouths are the dominant species comprising almost 50 per cent of the total catch.

Aside from this species, crevalle (*Caranx* sp.), moonfish (*Mene maculata*), goatfish (*Upenoides* sp.), squid (*Loligo* sp.), black pomfret (*Apolectis niger*), and threadfin bream (*Nemipterus* sp.) are the ranking species caught, comprising about 45 per cent of the total catch. (See Fig. 6).

However, the relative abundance of the above-mentioned species varies with every operation or haul as shown in Table 3. It could be observed that slipmouths are the most abundant in operation No. 2 which occupies 53.4 per cent in the total catch while it gave an almost negligible yield in operation No. 1. Threadfins are the most dominant species in operation No. 1 which yielded about 24.0 per cent. The first operation obviously gave a poor catch of 2.86 kg (127 kg/catch/hr) total weight while the second operation gave a total catch of 58.9 kg (23.56 kg/catch/hr).

Since the two trawl operations were undertaken at different depths, variations in species abundance and composition are normally expected. With the very poor yield of the first operation due to the slight malfunctioning of the net, comparison of species composition by operation may not produce a valid analysis. Therefore, species differences are attributed to the depth of operation as shown in Table 4.

The table shows that species like pomfret, dorab, crevalle, crab, red bullseye, barracuda, cutlass and hairtail comprising about 7.0 per cent in the total catch from the 25-fathom operation were absent in the composition of the catch from the 40-fathom depth. On the other hand, species like sea urchins, shrimps, mackerel, cardinal fish, flathead, grouper, and crabs which comprised 26.5 per cent of the total catch in the 40-fathom operation were absent in the 25-fathom operation. Most species of commercial importance are found in the 40-fathom depth.

Fish biology

Table 5 shows the summary of biological determination on species selected from the catch. However, five species were specially chosen for biological analysis. These were slipmouth (*Leiognathus bindus*), moonfish (*Mene maculata*), goatfish (*Upenoides* sp.), glassfish (*Pentaphrion* sp.) and black pomfret (*Apolectis niger*). Fig. 17 illustrates the frequency of these species in the catch including their length and maturity stages.

Leiognathus bindus of which there were more than 2,000 total individual samples in the catch ranged from 4.5 - 12.0 cm in total length with a mean length of 8.85 cm. Majority of the species belonged to size group 8.5 - 9.5 cm. Maturity stages were found to be from I to V with Stage II covering about 45 per cent of the individuals of size group 7.0 - 14.0 cm. Incidentally, there were more males than females.

The examined specimens of *Mene maculata* yielded a total length range of 8.0 cm to 12 cm and a mean length of 9.75 cm. From the total 266 individual fishes examined, the dominant group was found to have a size range of 9.0 - 10.0 cm. However, very few (less than five per cent) in that particular size group exhibited maturity stage III. Almost all individuals were immature whereby 65 per cent belonging to group size range 8.5 - 12.0 cm were in stage II. Males dominated the species.

Forty-seven individuals of *Upenoides* sp. have a size range of 9.5 - 13.0 with 11.58 cm as mean length. The dominant size group belonged to length range of 11.0 - 12.7 cm. Maturity stages I to III were found in 70 per cent of the specimens in size range 10.5 - 13.0 cm. Like the three major species above, there were more males than females.

Pentaphrion sp. had two age groups — one ranging from 8.0 - 11.5 cm and the other 11.5 - 14.0 cm, with mean length of 10.52 cm for both groups. Most individuals, however, fell under size groups 9.0 - 10.0 cm range. All species exhibited immature eggs under maturity Stage I with females dominating the sex composition.

Twenty specimens of *Apolectis niger* have a size range of 13.0 - 15.5 cm with most of the individuals falling under 13.5 - 15.0 cm. All individuals were immature (Stage I); most of them, however, were females.

DISCUSSION OF RESULTS

Hydro-biological evidences

Based on the temperature-salinity relationships, an almost homogeneous upper layer, and the late occurrence of thermocline, it is possible that either of the following reasons may have caused the formation of the phenomenal types of water masses:

a) Northeasterly wind blowing the surface water away from the coast could have caused a slight upwelling of sub-surface water whereby water of different properties intermixed to cause an almost homogeneous water structure in less than 100 m deep which was noted to be more disturbed.

c) A current of outside origin could have caused a turbulence at a greater depth causing a stirring effect which may have influenced the water structure not only of the surface but of the whole sub-surface body.

The possible effect of tidal fluctuation may offer a good explanation, and if this is so, other given reasons may be eliminated and therefore, a conclusion that these results are normal for this kind of water may be surmissed. However, the present data do not suffice to offer any valid and formal conclusion. A constant investigation for a knowledge of seasonal fluctuations, considering also the surrounding internal waters which may influence their nature, is needed for this kind of study.

Plankton, which is one of the indicators of the productivity of a body of water, is high in biomass with phytoplankton dominating the composition. If there was a vertical upward motion of the water as a result of the reasons mentioned above, a highly nutritive water which is brought to the upper layer by this process is truly beneficial to plankton growth. It has been shown that nutrient salts, especially phosphates concentration, increase with depth (Sverdrup, *et al.*, 1942): hence, an upward motion in the body of water could bring them to the sulphotic layer where photosynthesis hastens fertilization favorably for phytoplankton growth. Thus, an excessive phytoplankton fertility is evident from the results which consequently substantiate a higher oxygen content even though any upward motion could bring the low-oxygen content water onto the surface.

In any case, plankton biomass is higher in coastal and shallow areas than in deeper waters. Normally this is to be expected since high nutrient run-offs, from rivers carrying domestic wastes from inhabited coasts are deposited temporarily along the coasts. High plankton biomass produced in the process eventually decreases towards the deeper portion where it disseminates. This may explain the lower biomass in the deep waters.

Fishing exploration and fish biology

Observations on fishing activities may classify the area as purse seining ground since a concentration of purse seiners was observed at various coasts bordering Marinduque Island and Bondoc Peninsula. Since these areas have deep water, very few trawlers were seen during cruising time except in waters with depths of 10-25 fathoms. At any rate, the R/V RESEARCHER'S trawl operations in the two-depth sectors in Mompog Pass area yielded promising catches as could be noted from the composition of the catch. However, this result is not enough to tally with Manacop's calculation of 400-600 kg catch per day since the operation is limited only to the two-depth sectors with the accompanying net trouble hindering its efficiency.

At any rate, ecological factors, most especially the depth, may have affected the catch, not only its composition but also its volume. The depth at which the first operation was taken was deeper than what was actually designated as the ideal depth for trawling. Aside from the partial inability of the net, this factor may have contributed to the very poor catch. The second operation, which was taken at 25 fathoms was quite successful with good economic catches although the net was also partially damaged. From this result, a selectivity of species was noted from the two-depth operation where some species not present in 40 fathoms were present in 25 fathoms and vice-versa.

However, the result of the trawl operation cannot be relied upon for proper evaluation with the gear efficiency in question. Therefore, further investigations should be done which will be focused on the coverage of wider area so that it can be grouped into good, intermediate, and poor fishing grounds, taking also into consideration the relationship of fish catch by seasons, depths and other possible factors.

From the biological examination of the fishes from the catch, it could be noted that none of them exhibited milt and mature eggs. Obviously, it is not the spawning season of the fishes concerned. Some oceanographic factors may have affected not only their spawning activity, but also the plankton abundance which is necessary for their subsistence. Low larval composition may have been due to these chain reactions.

CONCLUSION AND RECOMMENDATIONS

Based on the results presented, it is therefore assumed that Tayabas Bay and the waters in its vicinity have variable water masses with a more disturbed sub-surface layer in less than 100 m depth, due to some disturbances which are either normal or abnormal for the northeasterly monsoon prevailing during the period of survey. This could have stirred a chain reaction on the hydro-biological parameters including the fisheries thereat. Nevertheless, plankton biomass and the catch composition results measure the waters as potentially promising specifically the deep water. The evidences presented are not conclusive in the sense that no comparative study has yet been done and the data collected are not sufficient enough to justify a strong conclusion. For this reason, a seasonal investigation is being programmed for an accurate correlation of the factors involved and to futher check the veracity of the preliminary conclusions made from the facts collected and analyzed.

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Table 1. Larval tow data in Tayabas Bay (Cruise R74-2).

Station No.	Fish Eggs (NO.)	Fish Larvae (No.)	Eel Larvae (No.)
2	7	4	2
4	8	5 -2*	-
9	28	-	-
11	59	-	-
12	50	1	1
13	None	-	-
14	1	4 -7*	-
15	5	83 -15*	6
17	None	-	-
18	3	1	-
20	2	3	-
21	2	3	-
22	-	5	-
24	79	7*	1
TOTAL	244	106+	10

* Post fish larvae

+ Including post fish larvae

Table 2. Total catch composition.

SPECIES	Total Weight (kg)	Percentage (%)
1. Slipmouth (*Leiognathus* sp.)	32.53	48.36
2. Crevalle (*Caranx* sp.)	13.60	20.86
3. Moonfish (*Mene maculata*)	5.54	8.49
4. Goatfish (*Upenoides* sp.)	5.08	7.79
5. Squid (*Loligo* sp.)	1.60	2.45
6. Black pomfret (*Apolectis niger*)	1.50	2.30
7. Threadfin bream (*Nemipterus* sp.)	1.09	1.67
8. Glassfish (*Pentaphrion* sp.)	0.84	1.24
9. Dorab (*Chirocentrus dorab*)	0.80	1.22
10. Crezalle (*Caranx leptolepis*)	0.70	1.07
11. Lizardfish (*Saurida* sp.)	0.48	0.73
12. Trumpetfish (*Fistularia* sp.)	0.36	0.50
13. Crab (*Neptunus pelagicus*)	0.30	0.46
14. Red bullseye (*Priacanthus* sp.)	0.30	0.46
15. Barracuda (*Sphyraena* sp.)	0.20	0.30
16. Cutlass (*Trichiurus* sp.)	0.20	0.30
17. Sea urchins	0.19	0.29
18. Roundscads (*Decapterus* sp.)	0.18	0.27
19. Shrimps	0.16	0.24
20. Mackerel (*Rastrelliger* sp.)	0.15	0.23
21. Cardinal fish (*Apogon* sp.)	0.12	0.18
22. Hardtail (*Megalaspis cordyla*)	0.10	0.15
23. Flathead (*Platycephalus* sp.)	0.06	0.09
24. Grouper (*Epinephelus* sp.)	0.05	0.07
25. Crab (*Charybdis cruciata*)	0.03	0.04

Table 3. Percentage species composition by operation.

Operation No.	1	2
Position Setting	13°37.0'N- 122°02.6'E	13°36.5'N- 122°09.1'E
Hauling	13°43.0'N- 121°56.0'E	13°41.9'N 122°02.0'E
Date/Trawling time (hrs)	1974-03-19/2.25	1974-03-24/2.50
Total catch (kg)	2.86	58.90
SPECIES	Percentage by wt	Percentage by wt
1. Slipmouth (*Leiognathus* sp.)	1.05	53.40
2. Crevalle (*Caranx* sp.)	7.00	22.70
3. Moonfish (*M. maculata*)	18.90	8.50
4. Goatfish (*Upenoides* sp.)	2.30	2.78
5. Squid (*Loligo* sp.)	7.00	2.40
6. Pomfret (*Apolectis niger*)	-	2.50
7. Threadfin bream (*Nemipterus* sp.	24.10	0.70
8. Glassfish (*Pentaphrion* sp.)	4.90	1.20
9. Dorab (*Chirocentrus dorab*)	-	1.40
10. Crevalle (*C. leptolepis*)	-	1.20
11. Lizard fish (*Surida* sp.)	2.80	0.70
12. Trumpetfish (*Fistularia* sp.)	2.10	0.50
13. Crab (*Neptunus pelagicus*)	-	0.50
14. Red bullseye (*Priacanthus* sp.	-	0.50
15. Barracuda (*Sphyraena* sp.)	-	0.30
16. Cutlass (*Trichiurus* sp.)	-	0.30
17. Sea urchins	6.60	-
18. Roundscad (*Decapterus* sp.)	2.30	0.20
19. Shrimps	5.60	-
20. Mackerel (*Rastrelliger* sp.)	5.25	-
21. Cardinal fish (*Apogon* sp.)	4.20	-
22. Hardtail (*H. cordyla*)	-	0.20
23. Flatfish (*Platycephalus* sp)	2.10	-
24. Grouper (*Epinephelus* sp.)	1.70	-
25. Crab (*Charybdis cruciata*)	1.05	-

Table 4. Percentage composition by depth.

Depth (fathoms) / SPECIES	25	45
1. Slipmouth (*Leiognathus* sp.)	53.40	1.05
2. Crevalle (*Caranx* sp.)	22.70	7.00
3. Moonfish (*Mene maculata*)	8.50	18.90
4. Goatfish (*Upenoides* sp.)	2.78	2.80
5. Squid (*Loligo* sp.)	2.40	7.00
6. Black pomfret (*Apolectis niger*)	2.50	-
7. Threadfin bream (*Nemipterus* sp.)	0.70	24.10
8. Glassfish (*Pentaphrion* sp.)	1.20	4.90
9. Dorab (*Chirocentrus dorab*)	1.40	-
10. Crevalle (*Caranx leptolepis*)	1.20	-
11. Lizardfish (*Saurida* sp.)	0.70	2.80
12. Trumpetfish (*Fistularia* sp.)	0.50	2.10
13. Crab (*Neptunus pelagicus*)	0.50	-
14. Red bullseye (*Priacanthus* sp.)	0.50	-
15. Barracuda (*Sphyraena* sp.)	0.30	-
16. Cutlass (*Trichiurus* sp.)	0.30	-
17. Sea urchins	-	6.60
18. Roundscad (*Decapterus* sp.)	0.20	2.80
19. Shrimps	-	5.60
20. Mackerel (*Rastrelliger* sp.)	-	5.25
21. Cardinal fish (*Apogon* sp.)	-	4.20
22. Hardtail (*Megalaspis cordyla*)	0.20	-
23. Flathead (*Platycephalus* sp.)	-	2.10
24. Grouper (*Epinephelus* sp.)	-	1.70
25. Crab (*Charybdis cruciata*)	-	1.05

Table 5. Summary of biological determination on selected species taken from the catch.

SPECIES	No. of samples	Size range (cm)	M.L.	Maturity Stages	Dominant Stage	Sex Ratio M:F
Slipmouth (*Leiognathus bindus*)	2,067	4.5 - 12.0	8.85	I-V	II & III	1.36:1
Moonfish (*Mene maculata*)	266	8.0 - 13.0	9.79	I-III	I & II	1.14:1
Goatfish (*Upenoides* sp.)	47	9.5 - 13.0	11.58	I-IV	II & III	1.73:1
Glassfish (*Pentaphrion* sp.)	26	8.0 - 13.5	10.52	I-III	III	0.46:1
Lizardfish (*Saurida tumbil*)	10	10.0 - 24.0	14.35	1-IV	II	0.43:1
Black pomfret (*Apolectis niger*)	20	13.5 - 15.0	14.20	I	I	0.73:1
Red bullseye (*Priacanthus* sp.)	6	10.0 - 15.0	11.90	I-II	II	0.33:1
Dorab (*Chirocentrus dorab*)	5	36.0 - 38.0	36.90	II	II	-

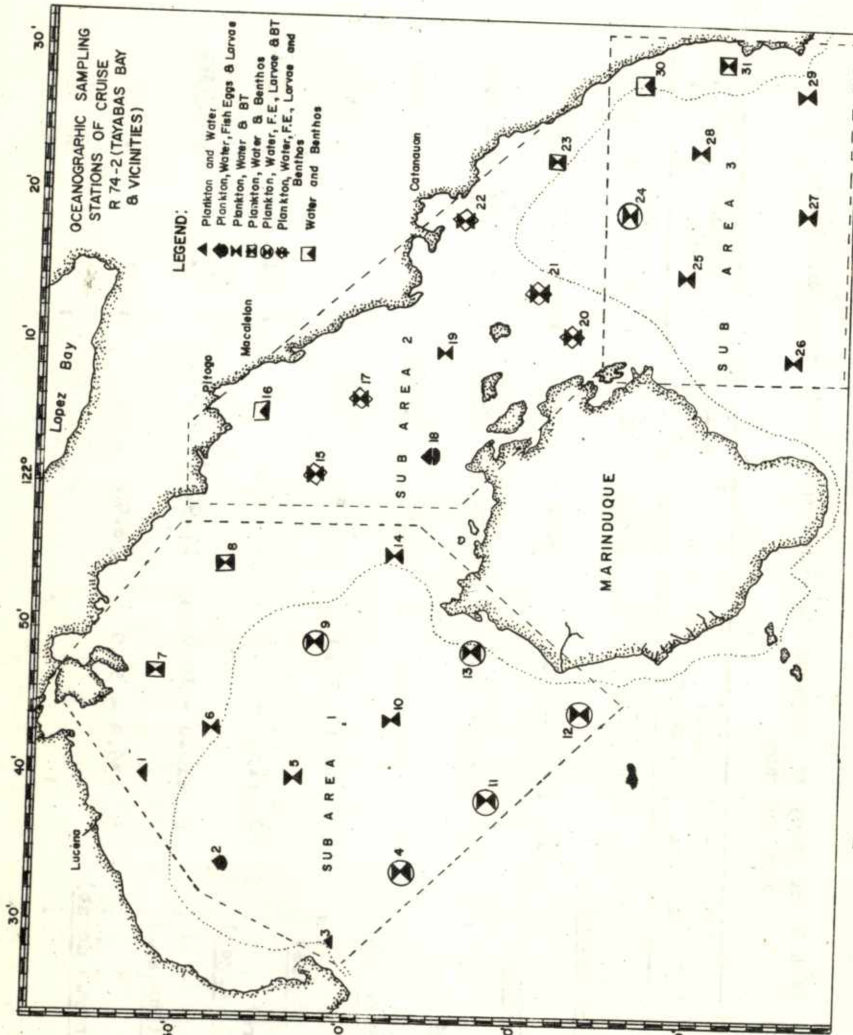

Fig. 1. Chart showing location of sampling stations.

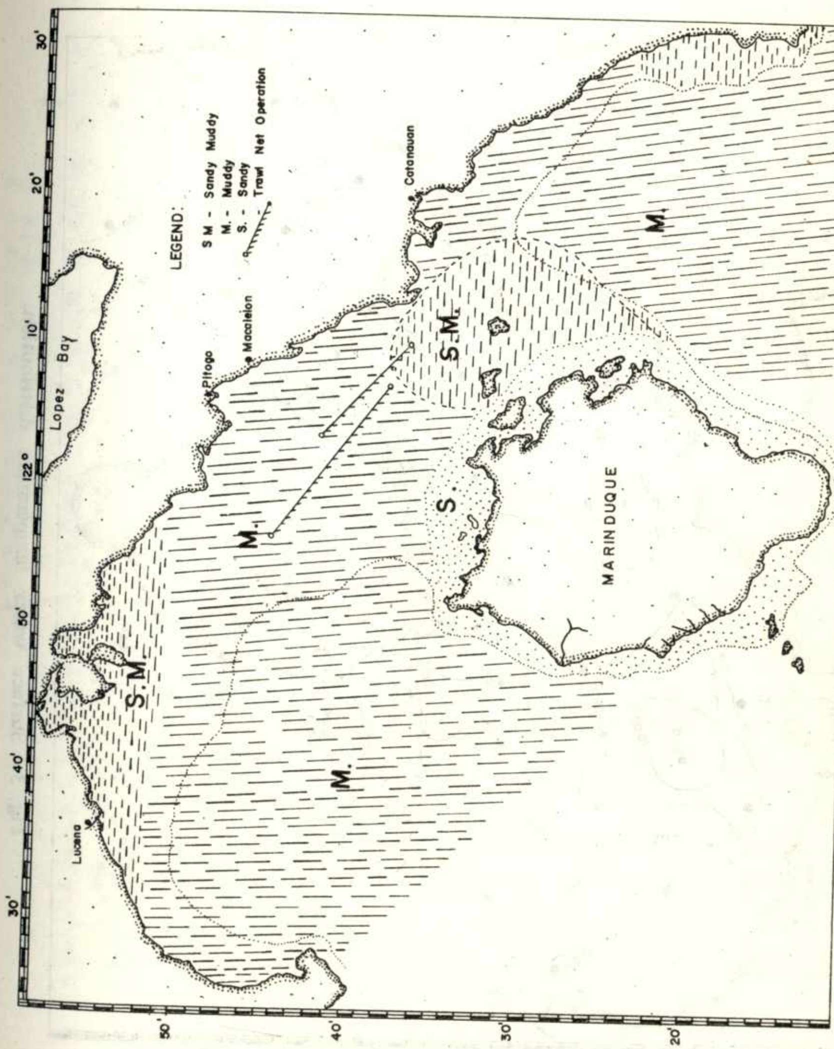

Fig. 2. Chart showing location of trawl fishing operations and bottom feature.

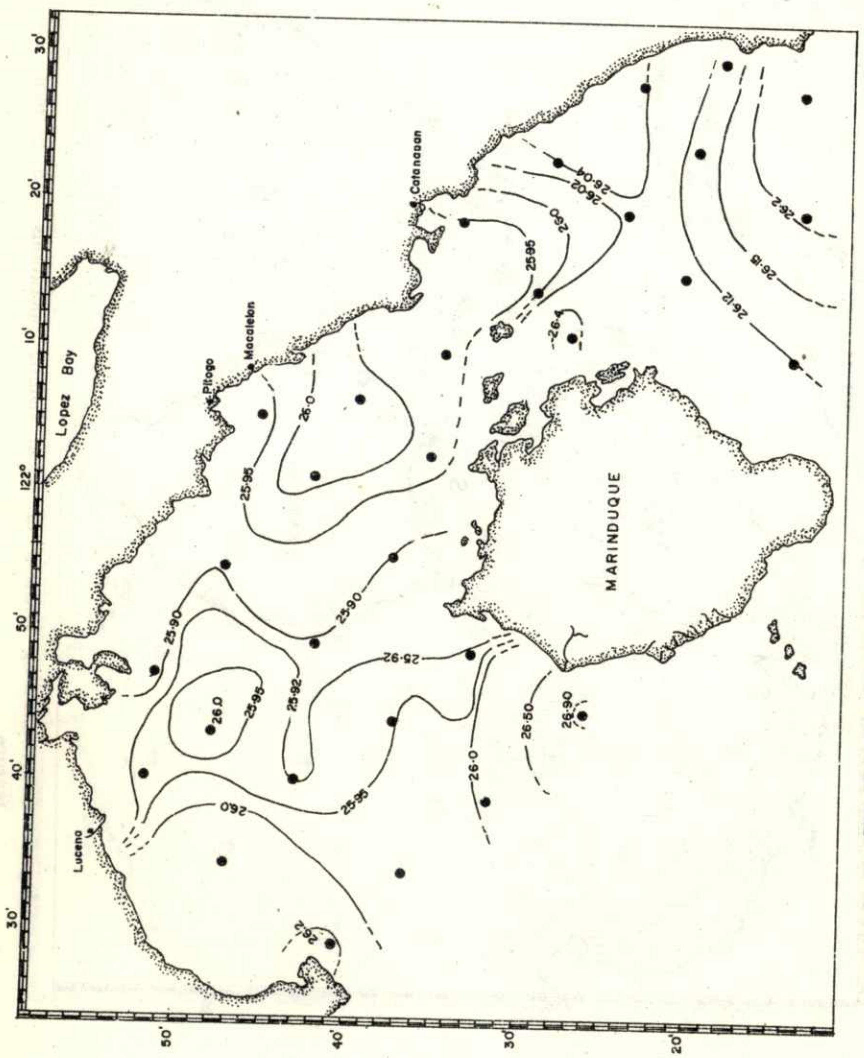

Fig. 3. Surface water temperature distribution.

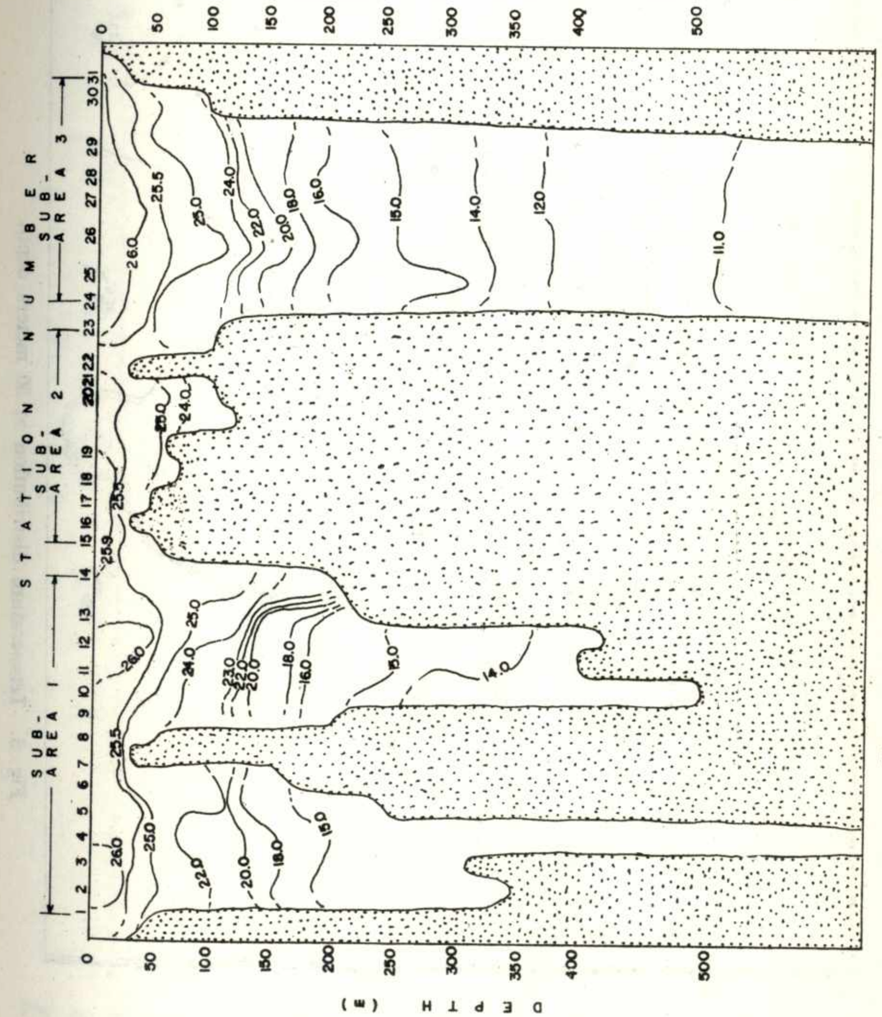

Fig. 4. Isothermal distribution with depth

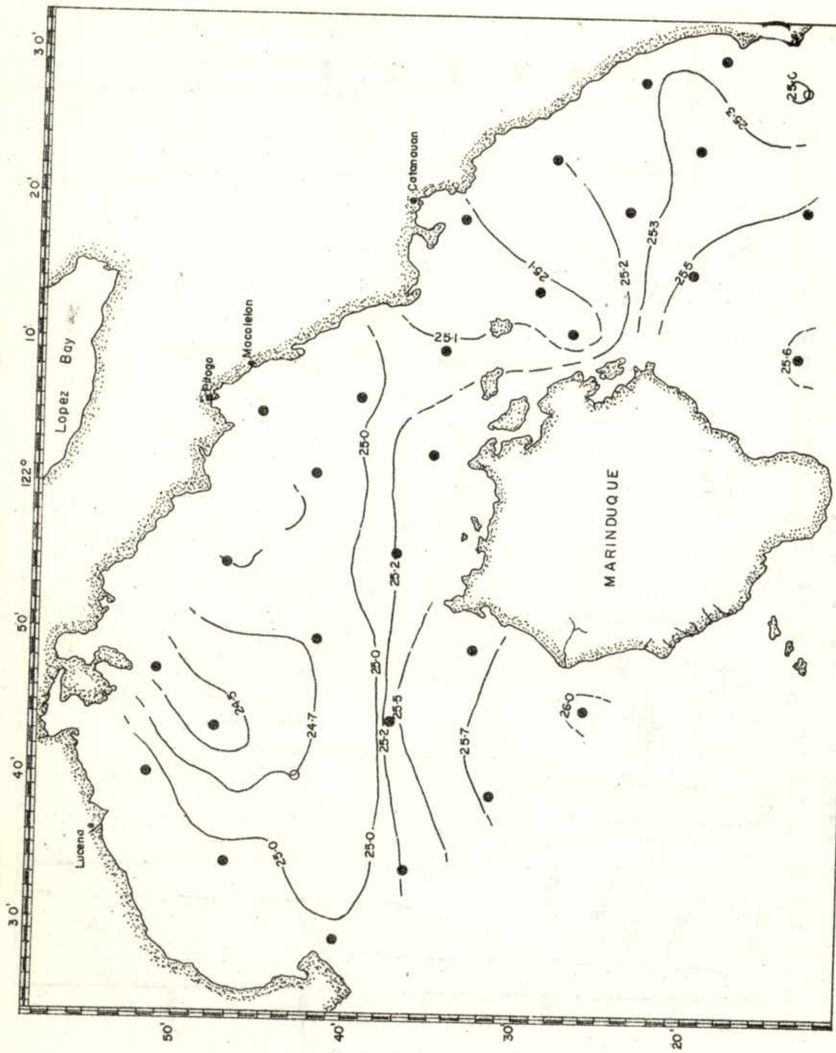

Fig. 5. Temperature distribution at 50 meters depth

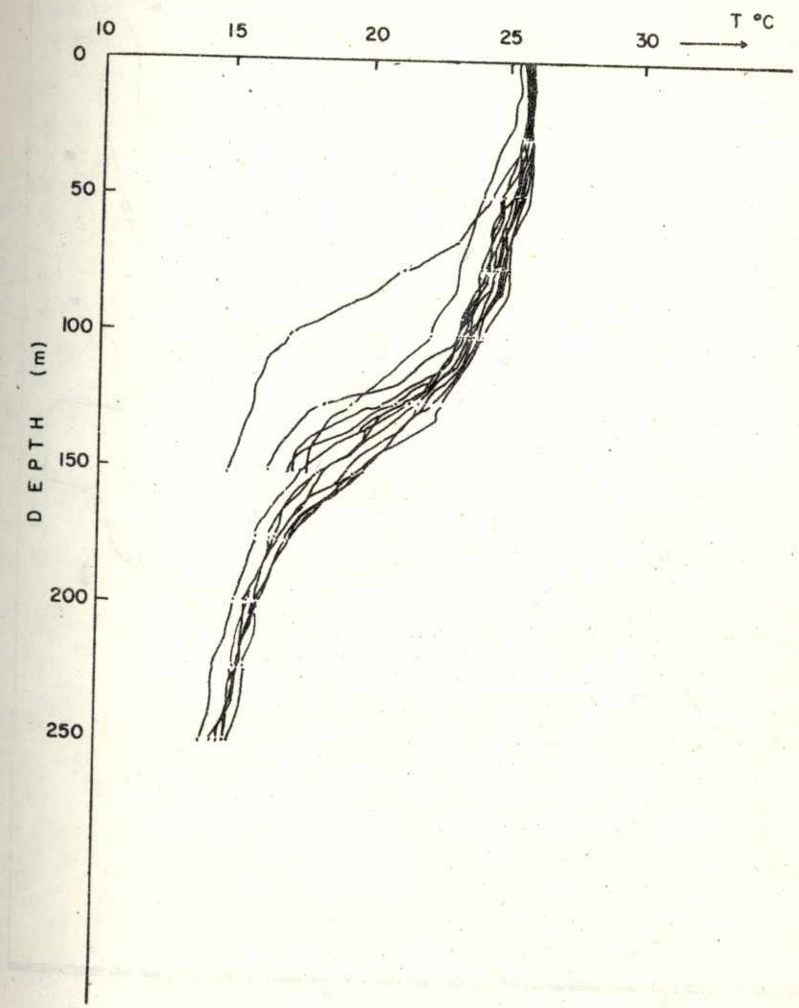

Fig. 6. Thermocline at 100 and 150 meters depth as recorded by Bathythermograph

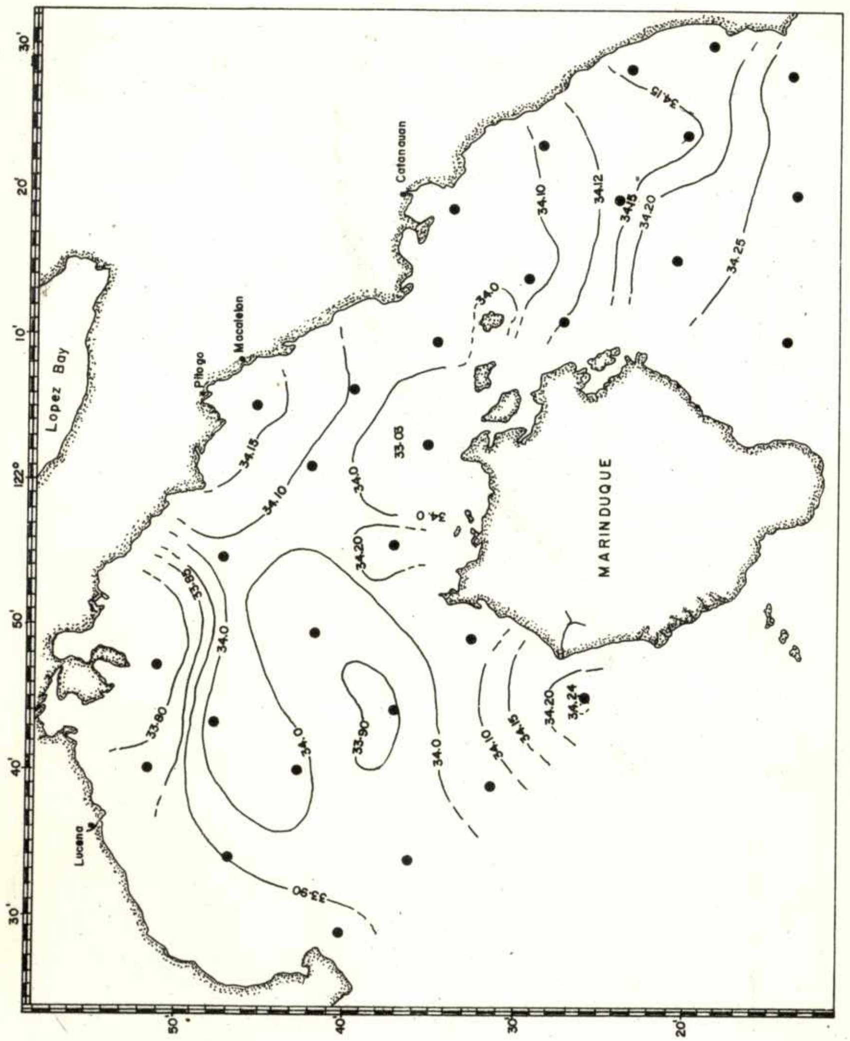

Fig. 7. Surface salinity distribution

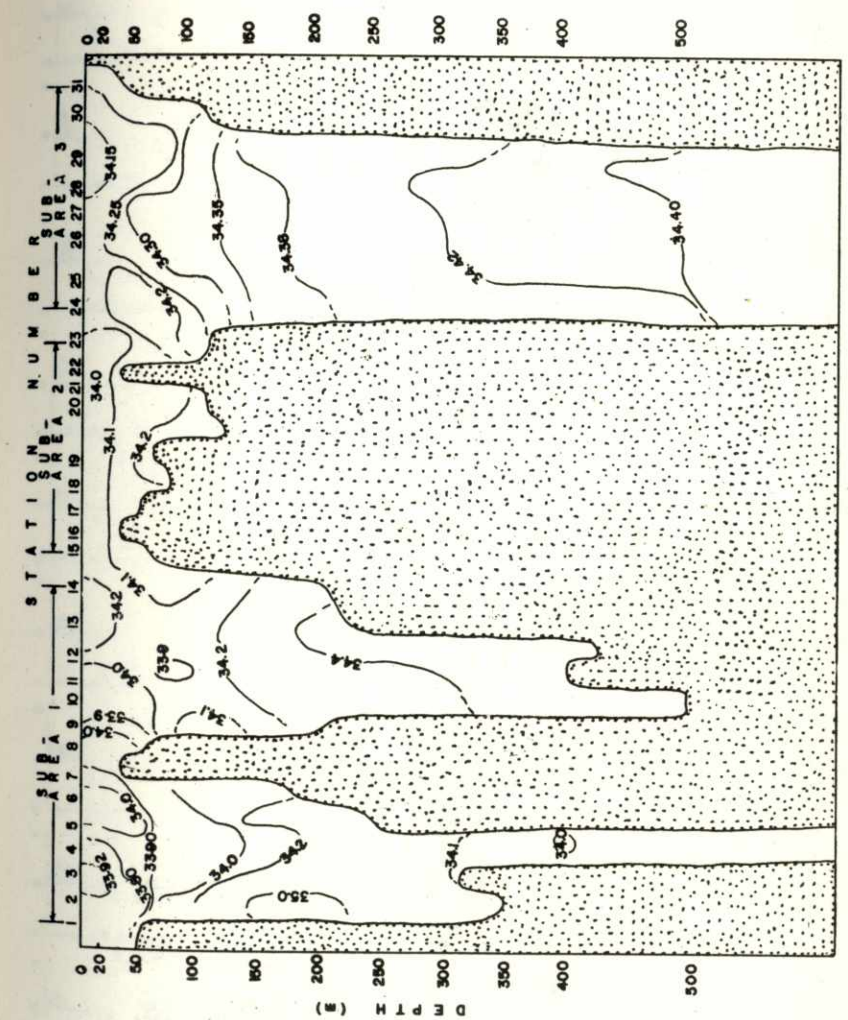

Fig. 8. Isohaline distribution with depth

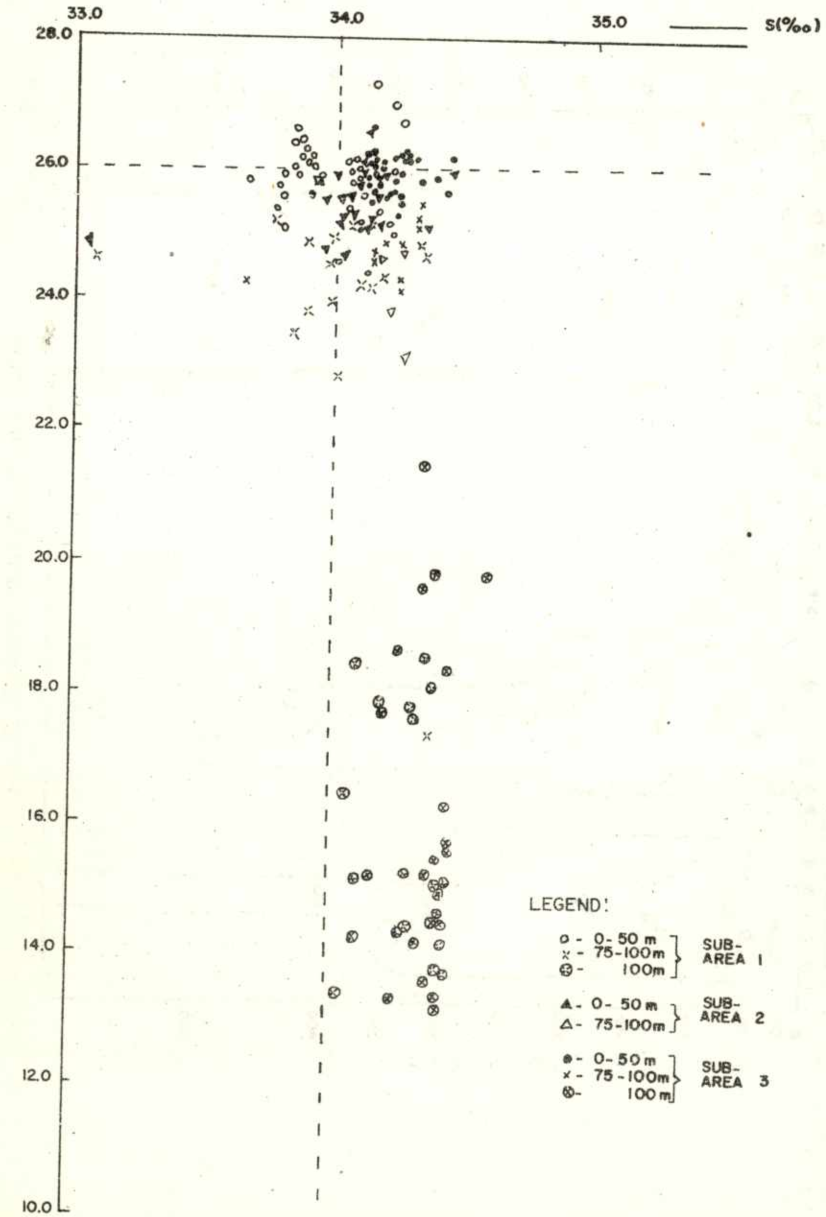

Fig. 9. Temperature — salinity plot of 3 areas of observation at different depths

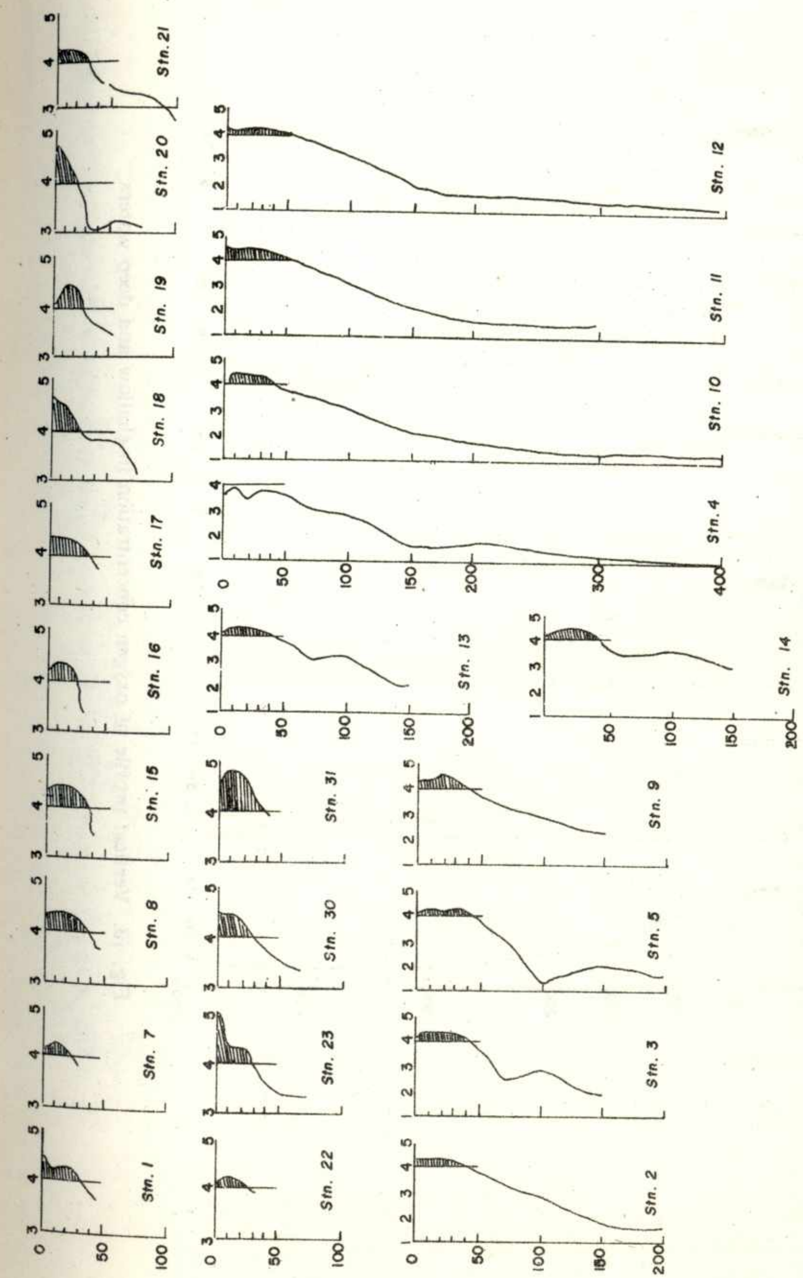

Fig. 10. Vertical profile of oxygen concentration in shallow and deep waters

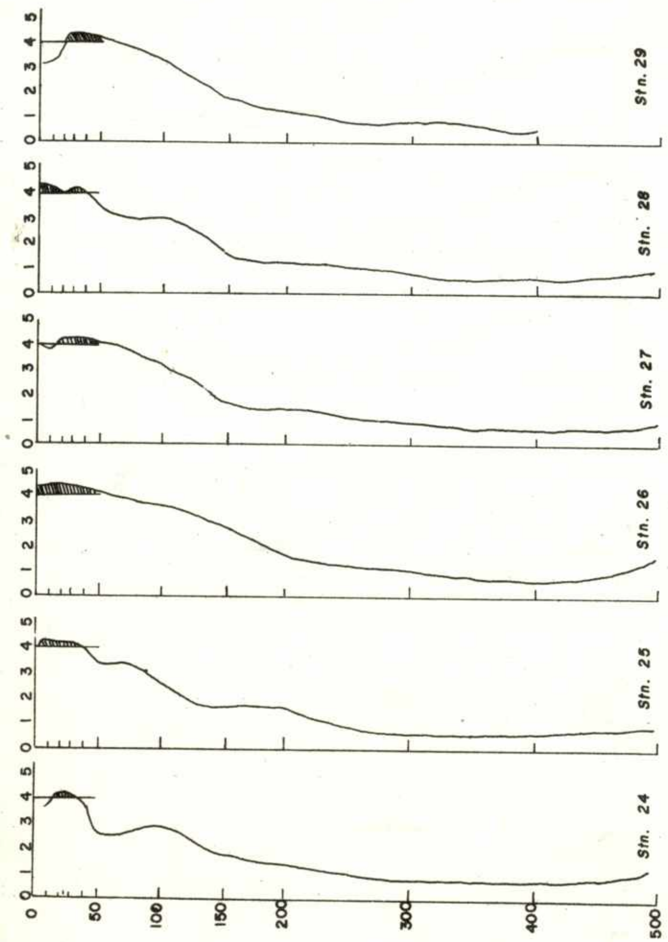

Fig. 10. Vertical profile of oxygen concentration in shallow and deep waters

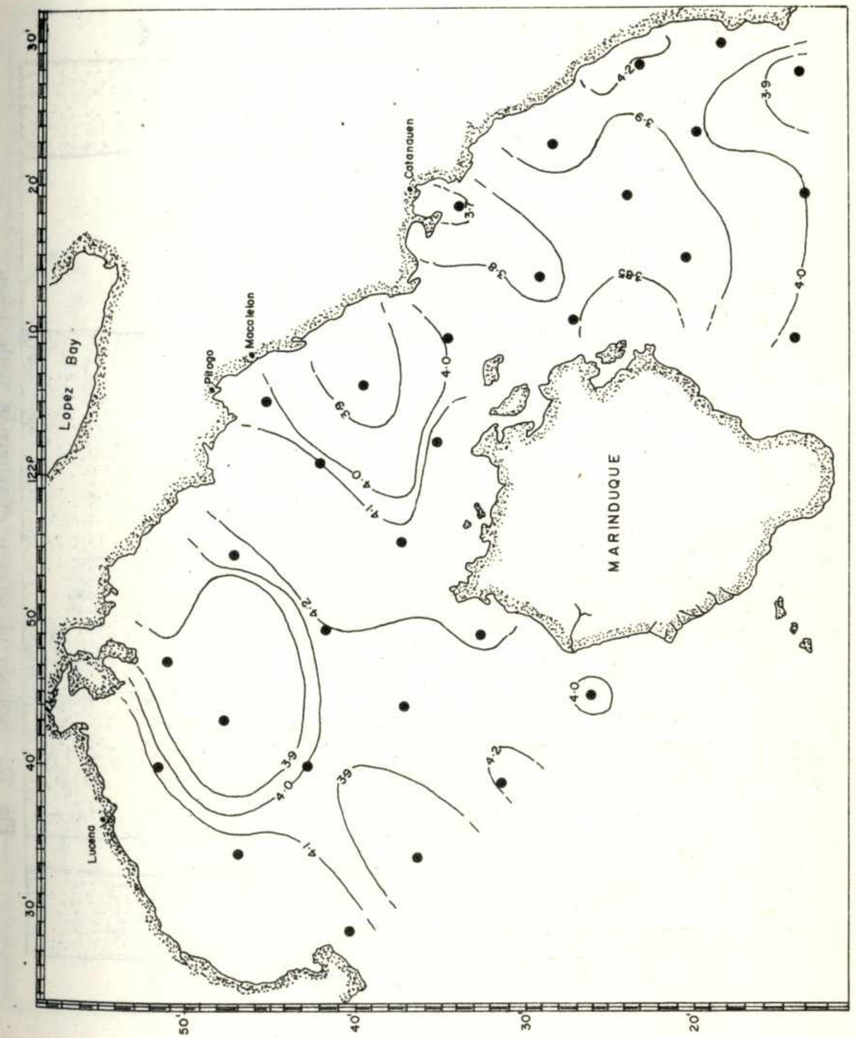

Fig. 11. Average of 0-50 meters oxygen concentration in horizontal distribution

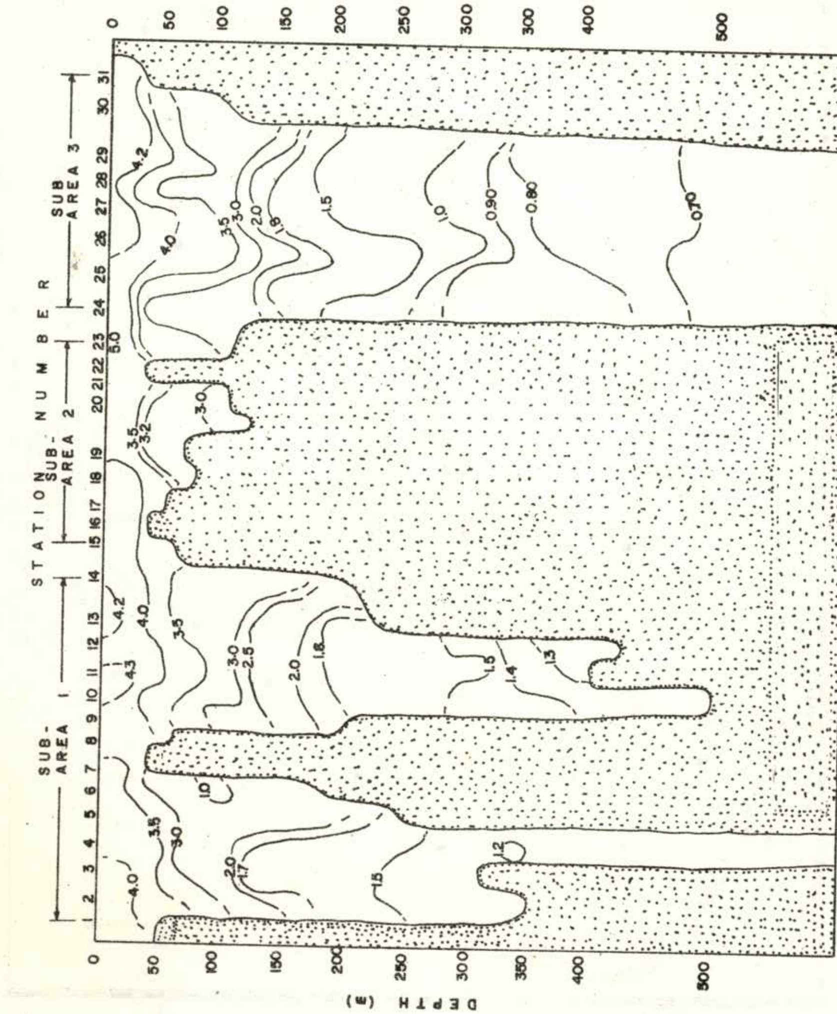

Fig. 12. Isolines of oxygen distribution with depth

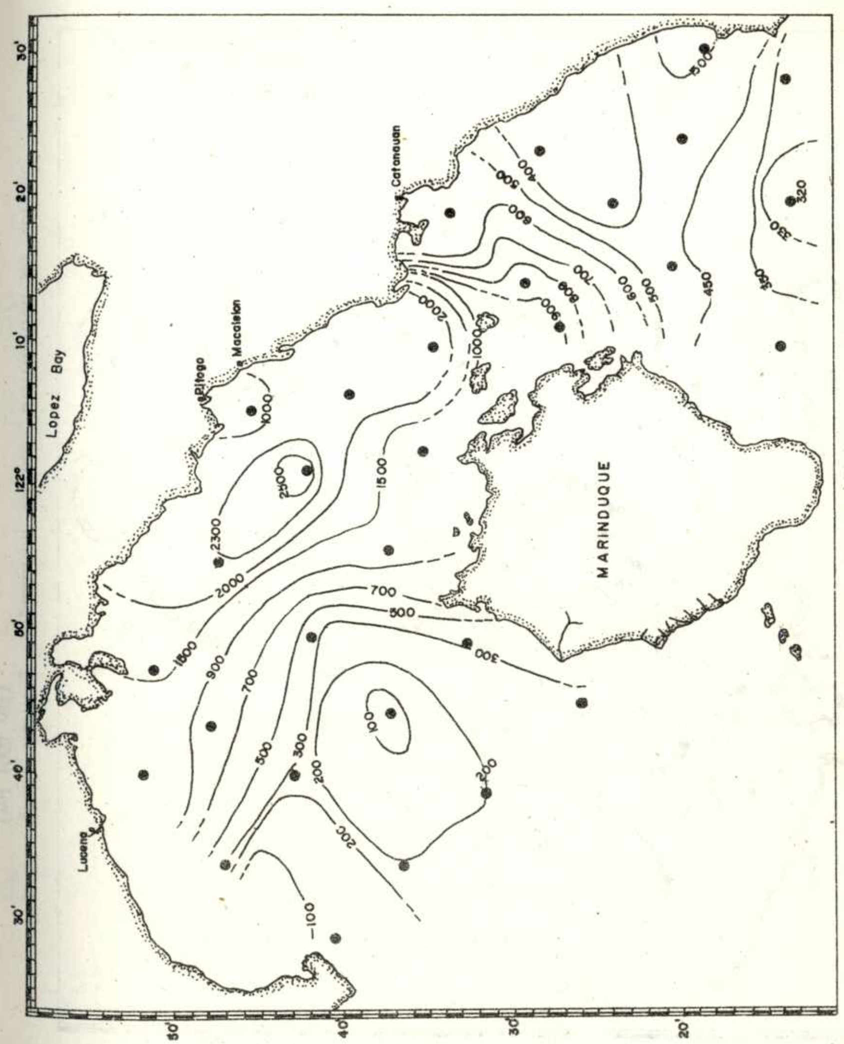

Fig. 13. Chart showing phytoplankton biomass distribution by volume (ml/1000 m^3)

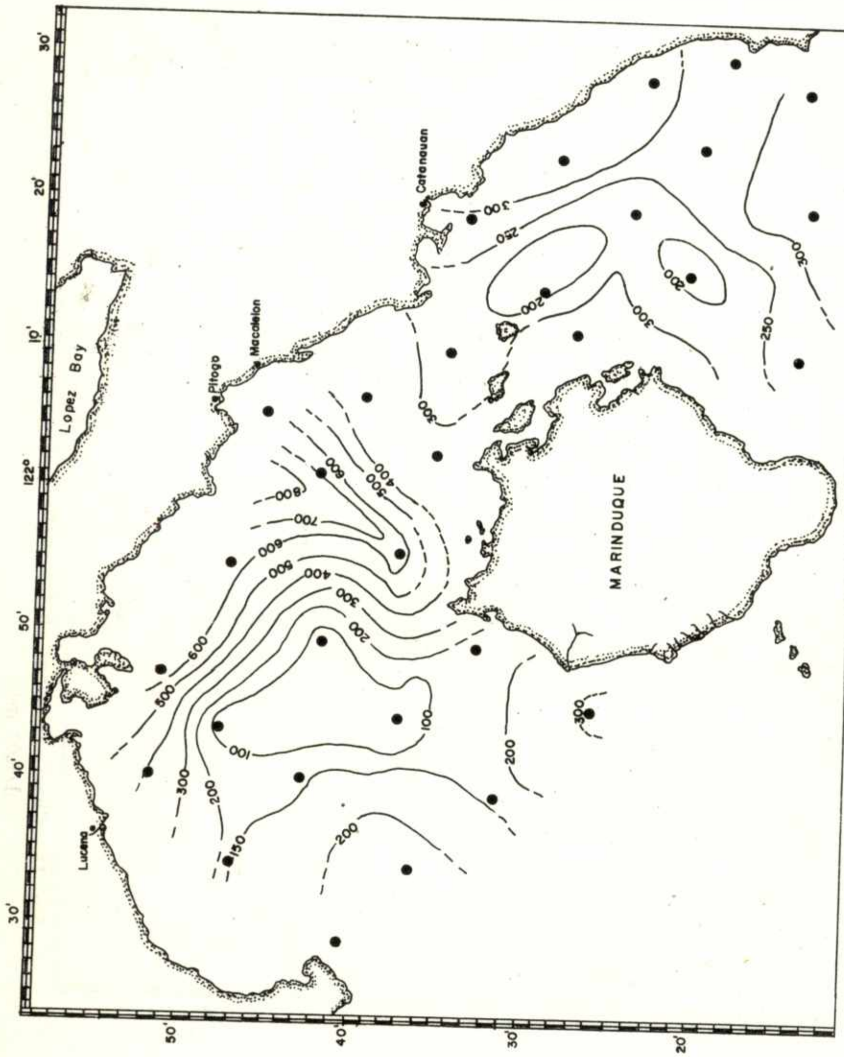

Fig. 14. Chart showing zooplankton biomass distribution by volume (ml/1000 m³)

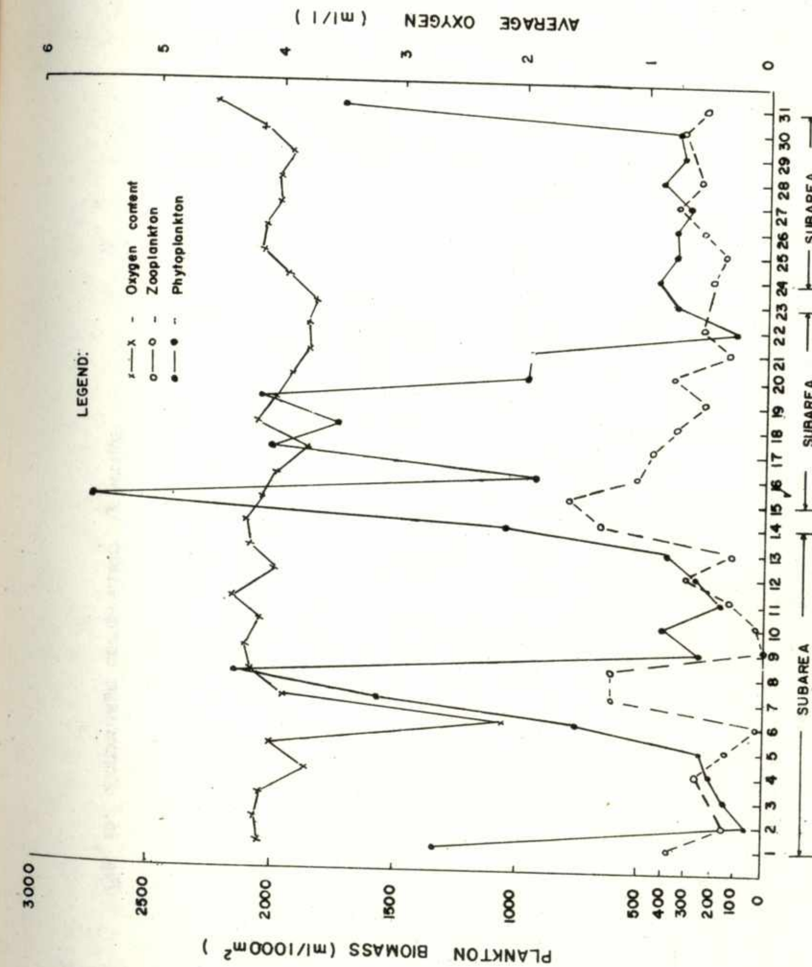

Fig. 15. Plankton biomass — oxygen relationships

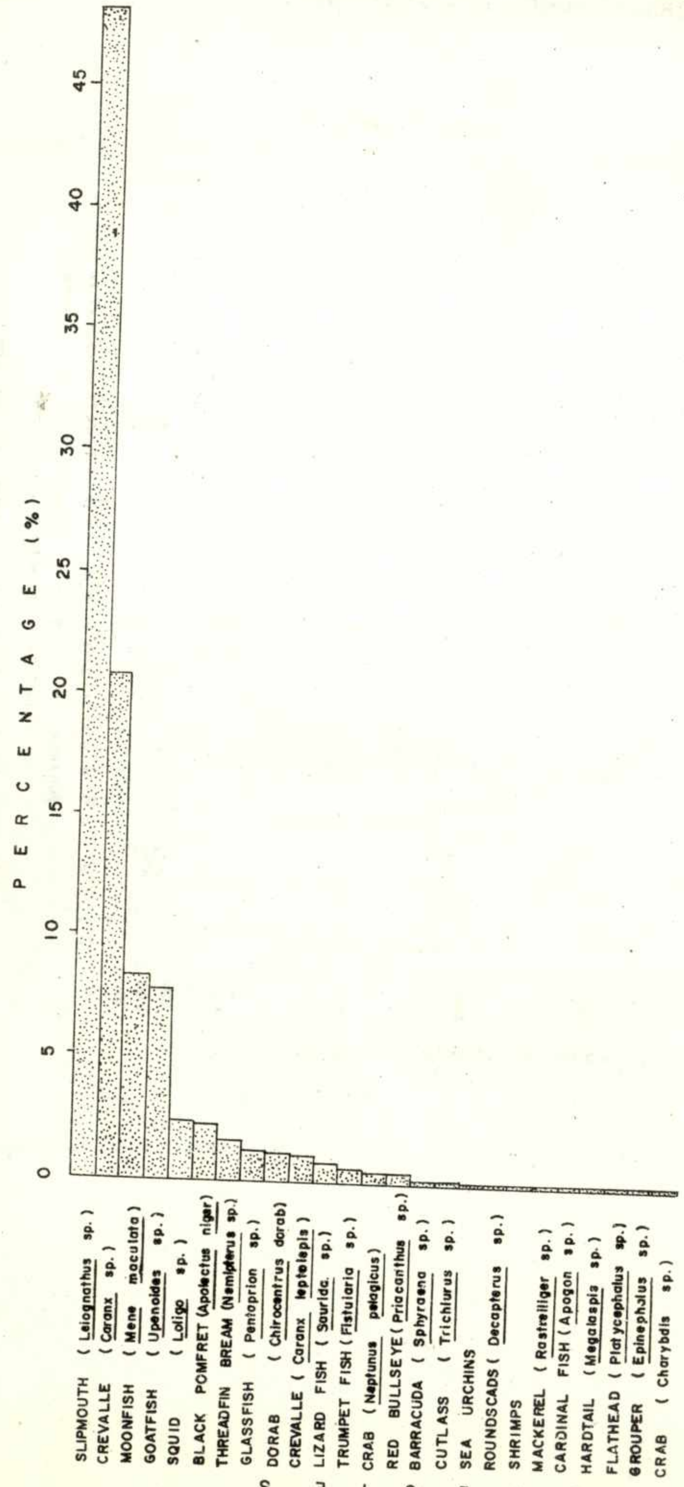

Fig. 16. Percentage composition by weight

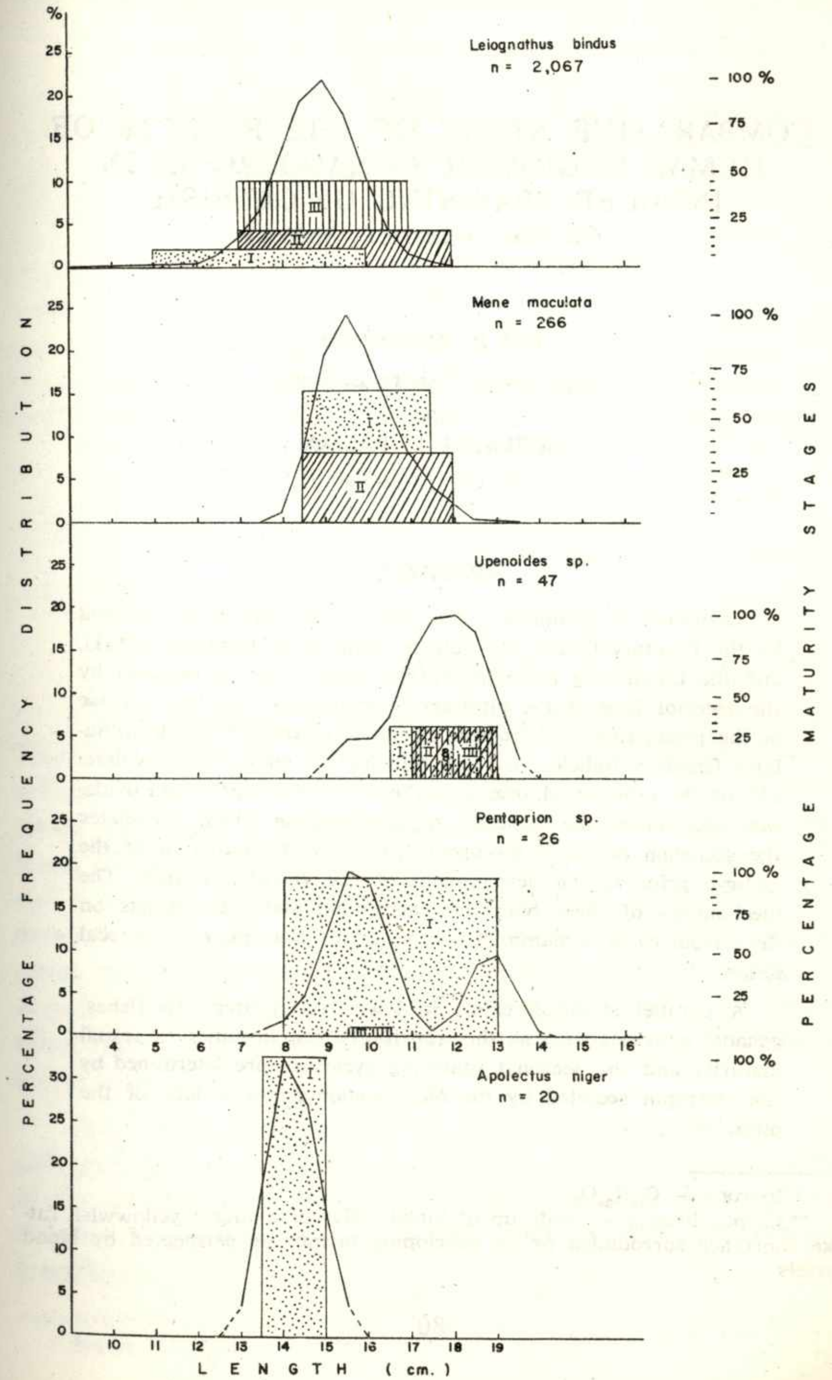

Fig. 17. Percentage frequency distribution and maturity stages of five (5) species