

HYDROBIOLOGICAL STUDY OF MACAJALAR BAY

James A. McKeough, S.J.

Elvira O. Tan

Pedro T. Escudero

Thelma A. Rivera

Macajalar Bay was first studied¹ in 1967-69 to gather information on its hydrographical and biological features. The study seems to indicate some hydrographic effects on the bay's marine population.

There was, however, a need to further investigate the various interrelationship between Macajalar Bay and its fisheries. Hence, the study was extended starting July 15, 1970. The extended study² lasted for two and a half years.

Review of Literature

Studies on the biology of commercial fish species in the Philippines are very meager. Tiews (1958), in his report to the Philippine government, mentioned the work on the biology of the different demersal and pelagic fish species of Manila Bay such as the slipmouth (Leiognathidae), lizard fish (Synodontidae), threadbream (Nemipterids), roundsad (Decapтерus), mackerel (Scombridae), and anchovy (Engraulidae).

The published works on sardines are mostly on taxonomy. Umali (1936) identified and described the different species of the genus *Sardinella*. Herre (1953) enumerated the sardine species found in the Philippine waters.

Published works on flying fish are also meager. Martin (1938) wrote about the flying fish industry of the northwestern and south-

eastern coasts of Cebu. Herre (1953) listed the species of flying fish in Philippine waters. Parin (1960) described the various species of flying fish in the northwestern Pacific, he mentioned their important biological features and geographical distribution that included Philippine waters.

Hydrographic and biological surveys and studies have been conducted by the Philippine Fisheries Commission in various parts of the country. An oceanographic survey was made on the waters of Lingayen Gulf (Sebastian *et. al.* 1959). Hydrographic investigations have also been conducted in San Miguel Bay, Batangas Bay, and Malampaya Sound (Ronquillo 1959).

Materials and Methods

Eight hydrographic stations were regularly sampled every month. In March 1971, three new stations (stations 11, 12, and 14) were set up near the mouth of Cagayan River. After a number of observations, stations 12 and 14 were eliminated. Observation at station 9 was resumed in July 1971. Station 7 in the outer part of the Bay was sampled only in September and December 1971.

At every station, water was sampled for salinity, dissolved oxygen and pH and temperatures were determined at standard depths, using a Nansen reversing water bottle with a reversing thermometer attached to it. In depths exceeding 300 m, the deepest casts were 250 m. Water samples for oxygen analyses (Modified Winkler Method) were immediately fixed on board the banca and further analyses were carried out in the laboratory. Salinity was determined by Mohr Method. Direct pH readings were taken with a Hitachi-Horiba pH meter.

Observations on weather, fish schools, wind, and sea surface conditions were logged. Air temperature reading was taken with a centigrade thermometer while the Secchi disk was used for transparency determination. Plankton samples were collected using the Marutoku-type net. Vertical hauls were made from 150 m at stations deeper than 150 m and from 50 m at stations less than 150 m deep. Plankton samples were preserved in 4% buffered formalin solution and later analyzed qualitatively and quantitatively. The volume was determined

by the displacement volume method, after which fish eggs and fish larvae were photocopied and sent to the Southeast Asian Fisheries Development Center, Singapore, that made preliminary identifications.

Random sampling of fish at the market was done for a month to verify the most common fish species brought there from Macajalar Bay. In mid-November 1970 the species for biological work were selected. Routine random sampling, once a week for the sardines and twice weekly for the flying fishes were made. Twice weekly market survey on the kind and quantity of fish brought to the market were also made. On the survey day, data were gathered at different times of the day.

The length, weight, and sexual maturity of fish specimens for biological studies were noted. Some stomachs and gonads were preserved for further study. A millimeter normal measuring board was used to measure the length. The specimens were weighed up to the tenth of a gram on an Ohaus Balance. The sexual maturity stages were determined, with the use of a low-power (20X) compound microscope whenever necessary, through the eight-stage maturity classification.

Meristic counts and morphometric measurements of fish species were patterned after the methods of Staiger (1965) and Tsukahara, *et. al.* (1957).

The study on the fecundity of the sardines, *Sardinella fimbriata* (C.V.) and flying fish (*Oxyporhampus micropterus* (C.V.) that was started in the early part of September 1971, utilized their preserved ovaries at stage IV. The gravimetric method was used in the analysis. Besides the counts, the sizes of the ova were also measured.

In addition, fish market surveys were also conducted at the Cagayan de Oro market. These surveys were all-day, twice-weekly listings of the kinds, quantity and source of fish brought into the market. The fishes were listed by their local names and classified according to origin into three groups – Macajalar Bay, Bay Approach and Other Places. Fish from municipalities bordering the bay were deemed to be caught in the Bay. Those from the outer bay (beyond Punta Gorda) were considered to have been caught off the Bay approach. Fish from municipalities outside the bay (Initao, Naawan, etc.), including those from other provinces were grouped under "Other Places."

Results and Observations

BIOLOGY OF FISHES

Sardines (Clupeidae)

The sardines species (genus *Sardinella*, family Clupeida) is a pelagic fish known to be gregarious, moving in immense schools, followed and preyed upon by bigger species of pelagic fishes, such as the tunas, bonitos, and mackerels (Umali, 1936). Eleven species have been recorded from Philippine waters (Herre, 1953). Five species — *Sardinella fimbriata* (the most common), *S. longicens*, *S. sirm*, *S. melanura*, and *S. perforata* — were found in the samples collected from Macajalar Bay. *S. longiceps* (C. V.) appeared only once — in a sample taken in April 1972.

Fishermen from Macabalan, Bonbon, and Bayabas — the towns along the bay — catch *tamban*, either during the day or at night. In daytime fishing, a *palangre*, a type of hook and line, is used. At night the kerosene lamp light draws the fish near the sea surface where they are caught by a dip net, or a scoop net, or a gill net.

Morphometric and meristic studies were conducted in order to verify the identity of the species.

Length Frequency Distribution. A wide range of lengths of fishes was observed in the study. The predominance of small fishes is indicated by a very low average value in June 1971. The smallest fish — only 48 mm long — was recorded in June 1972. The largest fishes — each 189 mm long — were noted in February and March 1972. There was an almost 1:1 sex ratio except in September 1971 when the sample showed 32.47% female and in February 1972 when the females made up 35.66% of the sample.

Length-Weight Correlation. The formula $W = cL^n$ was used to determine the correlation between the total length and the weight of a fish. The actual and calculated weights increased with the length in a curved trend. For the males (1,813 specimens), $c = 5.43383$ and $n = 3.16272$. For the females (2,170 individuals), $c = 5.42785$ and $n = 3.15904$.

Length-Maturity Relation. No mature (including maturing stage) male was less than 100 mm long. No mature females were found to be less than 100 mm long. Males were found to be all mature at 160 mm long while the females at 165 mm.

Spawning Habits. Although a few juveniles were found, mature spawners dominated the female samples in November and December 1970. Juveniles, however, made up the greatest percentage of the samples in January-April 1971 but their number declined in May 1971 when those in the developing stage had increased. They continued to dominate the samples in June-September. In October, those in the maturing and mature stages dominated the samples again and in November, a few gravid females were observed. In January 1972 the juveniles dominated the samples. By March the juveniles and gravid fish made up the greatest percentage. Juveniles continued to dominate the samples until the study ended in August. Spawning females were still observed in March-April.

During the entire study, the juveniles and the mature fish were found in samples in almost all the months. This led us to believe that the *S. Fimbriata* (C.V.) continuously breeds the year round with peaks of spawning in November-December (perhaps up to January) and in March-April.

Fecundity. The number of ova in each mature female varied markedly. The highest count of 47,552 ova was observed in a specimen measuring 176 mm and weighing 46.0 gm while the lowest count of 9,177 ova was noted in a specimen measuring 143 mm and weighing 19.7 gm.

Fecundity length and fecundity-weight correlations were made using the formula $Y = a + bx$. Despite the remarkable variation in the number of ova per female, a direct correlation was observed between fecundity and length and weight. As pointed out by John S. MacGregor (1957), the fecundity-weight correlation is better than fecundity-length or the fecundity-age correlation.

The fecundity-length correlation gave us these values: $a = 155.30877$; $b = 0.90961$. For the fecundity-weight correlation, $a = 2,225.49177$ and $b = 1,285.15573$.

The ova diameters which measured 0.1775-0.355 mm consistently dominated ovaries of stages IV and V followed by those with diameter of less than 0.1775 mm.

The Flying Fish (Exocoetide)

The members of the family Exocoetidae are numerous and of wide distribution. They are found in the Indian, Atlantic, and Pacific Oceans (Herre, 1953; Parin, 1960). All Exocoetidae species are marine and vary in sizes. Their chief characteristic is their ability to glide in air with the aid of their long pectoral fins, and in some species, also of their ventral fins. Their presence is an indicator of the concentration of larger fish such as the marlins, sailfish, and the tunas, and mammals such as the dolphins – all of which prey on them (Parin, 1960). Exocoetidae species are very common in the southern Philippine waters where they are a major source of fish food. A better understanding therefore about their biology is necessary for the proper management of fishery.

During the study, four genera – under which were 15 species – were identified, using as references works by Weber, *et. al.* (1922), Schultz (1953) and Parin (1960). They were further verified and confirmed by Mr. Agustin F. Umali of the National Museum. The four genera were the *Oxyporhampus* Gill, *Exocoetus* Linne., *Prognichthys* Breder, and *Cypselurus* Swainson. The various species under these genera were as follows:

Oxyporhampus micropterus micropterus (C.V.)

Exocoetus monocirrhus Richardson

Prognichthys brevipinnis (C.V.)

Cypselurus oxycephalus (Bleeker)

Cypselurus speculiger (C.V.)

Cypselurus poecilopterus (C.V.)

Cypselurus spilopterus (C.V.)

Cypselurus atrisignis Jenkins

Cypselurus furcatus (Mitchill)

Cypselurus katoptron (Bleeker)

Cypselurus spiloptopterus (Bleeker)

Cypselurus unicolor (C.V.)

Cypselurus oligolepis (Bleeker)

Cypselurus opisthopus (Bleeker)

Cypselurus arcticeps (Gunther)

Two species, *E. monocirrhus* Richardson and *C. unicolor* (C.V.), were reported in the studies of Herre (1953) and Parin (1960) on flying fish in the Philippines. Hence, these species are considered new records to the Philippine fish fauna.

Of the 15 species, three were common in the samples. Another three species were also quite frequently noted in the samples but in fewer numbers than individuals of more commonly observed species. It will be noted that 81-95.5% of the species belong to six species. It might be worthwhile to delve more into the actual location of the catch and behavior of different species.

Biological investigation of the four most common species in the samples were conducted. Life history studies were limited to length, weight, sexual maturity, spawning habit and fecundity.

1. *Oxyporhampus micropterus micropterus* (C.V.)

Length-frequency distribution. *Oxyporhampus micropterus micropterus* is consistently dominant in all samples. It is the smallest member of the family, measuring 96-211 mm. The monthly average size varies from 149.07 to 181.57 mm. The specimens in October 1971 were predominated by smaller fish. The sex ratio was observed to be almost equal.

Length-Weight Correlation. The formula $W = cL^n$ was used in calculating the length-weight correlation. These were the values obtained:

For males: $c = 6.02892$

$n = 3.35106$

For females: $c = 5.79623$

$n = 3.2466$

Length-maturity. There was much overlapping in the total length over each maturity stage. The length at first maturity was 126 mm for males and 130 mm for females. Males 170 mm long were found to be all mature.

Fecundity. Thirty-seven pairs of ovaries at stage IV were examined for the fecundity study which showed marked variations in the number of ova among the specimens. The lowest count of about 1,570 ova was observed in a specimen measuring 179 mm and weighing 31.6 gm. The highest – about 12,240 ova – came from a specimen 194 mm long and which weighed 44.9 gm.

Fecundity-length and fecundity-weight correlatives were made using the formula $Y = a + bX$. The value of $a = -20,644,67880$ and $b = 153.69266$. Like the fecundity-length correlation, the fecundity-weight correlation varied greatly among the individuals. The values were found to be $a = 4,236.796232$ and $b = 323.01638$.

The number of ova in each size group was investigated. The ova less than 0.355 mm in diameter were the most dominant in all the ovaries, followed by those 0.3535-0.8875 mm and over 0.8875 mm in diameter.

Spawning habits. The monthly maturity stage distribution indicates year-round presence of mature fishes. Gravid females were observed in the November and December 1970 samples. By March until August 1971, the developed fish increased. Few juveniles were observed in July and young fish were dominant in the samples of October 1971. From November 1971 to August 1972 developed fish were dominant. This shows that *O. micropterus micropterus* has its spawning peak between November to July, though it may spawn the year round.

2. *Exocoetus monocirrhus* Richardson

E. Monocirrhus, which ranked second to *O. micropterus* in abundance, is considered a new record to Philippine fish fauna. Its identification was done based on the work by Parin (1960). Its morpho-meristic characteristics were also examined.

This species is characterized by a pair of long pectoral fins, which extend behind the dorsal end, and a pair of short ventral fins. Its anal origin is opposite – sometimes slightly behind – the dorsal end. The ventral fins insertion is nearer the posteriormost end of the gill cover than the caudal.

Other characteristics are: dorsal rays 12-14; anal 12-14; pectoral 15-16; ventral rays 6; predorsal scales 19-21; gill rakers 23-27. The body depth is 4.8-5.7 mm in fork length; head 3.7-4.7 mm in fork length. The number of vertebrae is 42-43, usually 42. Weak teeth are found only on jaws. Eye, 3.2-3.7 mm in head length. The adult specimen's head is brownish at the back and upper side and silvery-white at the sides and lower side.

Length-frequency distribution. No distinct size groupings were observed. Sex ratio was almost equal. The species is medium-sized, 119-221 mm long. Samples were sometimes very few.

Length-weight correlation. Using the formula $W = cL^n$, $c = 5.40760$ and $n = 3.11381$ for the male and $c = 4.51970$, and $n = 2.72115$ for the female.

Length maturity. Overlapping of the total lengths over each maturity stage was observed. No mature male and female fish were less than 165 mm and 160 mm long, respectively. Males 205 mm long and females 195 mm long were found to be all mature.

Spawning habits. Gravid females were observed in November and December 1970. The juveniles were dominant in April of each year. (Spawning females were also observed in April.) A few juveniles were observed in July and August 1971 during which developing individuals were dominant. In September 1971-March 1972, developed females were dominant. By April, however, the juveniles were dominant although there were still spawning females. Gravid females were dominant in May and spawning was again observed in July – which indicates spawning the whole year round, with several peak months.

3. *Prognichthys brevipinnis* (C.V.)

Length-frequency distribution. *P. brevipinnis* is a medium-size fish, 105-212 mm long. Small ones predominated the samples in September 1971. The sex ratio was observed to be almost equal.

Length-weight correlation. The formula $W = cL^n$ was used in calculating the length-weight relation. For males, $c = 4.34206$ and $n = 2.64670$. For the females $c = -4.28058$ and $n = 2.60585$.

Length-maturity. No mature males were less than 135 mm long and the females' length at first maturity was 145 mm. All males 195 mm long and females 190 mm long were found to be matured.

Spawning habits. Developed females were preponderant in the November 1970 samples. By January through April 1971, gravid females were plentiful. The juveniles appeared for the first time in May and were dominant in September. Again by November, gravid females appeared in the samples. They continued to appear in samples until May 1972. Juveniles predominated the samples in June-August 1972. Spent specimens were observed in January 1971 and 1972. The spawning peak of this species coincides with — although perhaps of shorter duration than — that of other flying fish.

4. *Cypselurus oxycephalus* (Bleeker)

C. oxycephalus was found almost throughout the study although it was not as numerous as the species earlier discussed.

Length-frequency distribution. *C. oxycephalus* is a medium-size fish, 108-236 mm long. Based on its average size, small specimens predominated the samples in April 1971 and June 1972.

Maturity and spawning habits. The size at first maturity was 175 mm for males and 185 mm for females. As this species appeared intermittently in the samples and in small numbers, the sexual maturity distribution over the months could not be very accurately assessed. However, it was observed that mature and juvenile species were found together, indicating that the fish spawns also the year round. But the peak in spawning could not be ascertained from the data available.

5. *Cypselurus opisthopus* (Bleeker)

C. opisthopus was found in the samples in most months although it was not as numerous as the previously discussed species. Its length ranged from 110 mm to 250 mm. Immature fishes predominated the samples.

6. *Cypselurus katoptron* (Bleeker)

C. Katoptron was one among the species that appeared frequently in the samples. Like *C. opisthopus*, there were few individuals per sample. The specimens' length range was 111-250 mm. The specimens were mostly mature.

7. Other species of flying fish

Nine other species comprising 4.5-18.9% of the samples were also found and examined in the study.

A few members of the species *C. arcticeps* appeared more or less regularly starting April 1971.

C. unicolor (C.V.) is a new addition to the record of fishes in Philippine waters. Its final identification was based on the work by Parin (1960), with the following description:

Dorsal 12-14; anal 8-11; pectoral 12-14; predorsal scales 26-31; axial lateral scales 43-53.

Head 3.8-4.1 in body length, depth 5.1-5.9 in body length. Teeth present on jaw (Woods and Schultz state that teeth are sometimes present on palatines). Anal origin is opposite 5th-9th dorsal ray. Ventral origin nearer to posterior edge of head than to lower caudal lobe origin. Pectoral fins extend up to dorsal end, ventral up to mid-anal. Grayish brown pectoral fins, posterior and inner edges transparent; ventrals transparent; dorsal gray; caudal fin dark (grayish brown).

FISH MARKET SURVEY

Most fishermen in the bay use a banca or motor banca and utilize various types of gear such as hook and line, and gill nets of different meshes. Beach seines and fixed traps or corrals are also used to catch fish at certain times of the year. A group of fishermen in El Salvador use purse seine to capture flying fish.

There are various fish landing areas along the bay shores, among them El Salvador, Molugan, Opol, Tagoloan, Villanueva, and Jasa-an. Some fish are also landed at Bonbon and Macabalan in Cagayan de Oro City. At these areas the fish are packed in boxes and transported by jeep or truck to Cagayan de Oro City's central market. Some fish are

also transported overland from distant places such as Zamboanga, and Misamis Occidental.

Because the fish brought came from different places, they were grouped into three categories: Macajalar Bay, Bay Approach, and Other Places. More than 54 kinds of fish were found in the market. The most common kind from the Bay are sardines, caranx, mackerel, moonfish, and tuna. Fish from the Bay constitute only about 38% in weight of fish brought to market. Fish from the bay approach constitute about 18% in weight and from other places 43% (Fig. 4).

Among the bay fishes ever present relatively large quantities in the market were from these groups: sardines – *Sardinella* (C. V.), locally known as “tamban”, which was the most common; caranx – *Decapterus macrosoma* (“linya-linya”), and *Decapterus russelli*, (“bugsawan”); *Rastrelliger* (“anduhaw”); moonfish – *Mene maculata* (“tabas”); and tuna – the genus *Auxis* (“pidlayan”). Other common species were the marlins, croaker, and hairtail.

The catch from the bay were mostly pelagic species. This could be attributed to the topography of the bay which has a very narrow shelf area with steep slopes.

The flying fish were predominant in the bay approach catch, constituting more than 55% in weight of fish from the area.

The fry of some goby species were found to be present only during certain months. The fry of *Sicyopterus* sp. and *Chonophorus* sp. (“hipon”) were caught in remarkably great quantities off Macabalan near the Cagayan River mouth and near the Tagoloan River mouth January-August, with January-April as the peak months of abundance. Studies on their migratory habits and biology would be of importance to their management. It is of common knowledge that similar occurrences also take place in other regions in the Philippines.

In 1967-69 a correlative trend was observed between the plankton volume and quantity of fish caught from Macajalar Bay (McKeough and Yap 1969). Similar correlative trend was observed.

PLANKTON

Macajalar Bay is so deep that in most stations the plankton were collected from a maximum 150 m depth. However at some coastal

stations, particularly those along the Cagayan River, samplings were taken at a maximum of 50 m deep.

The monthly average plankton volume varied from 5.66 ml/m² (from a column of water 150 m deep) to 25.93 ml/m². Except in October-November 1970, the average plankton volume was more than 12.00 ml/m² (Fig. 5).

Considering the variation in stations, the volume for samples taken from 150 m deep maximum depth ranged from 3.14 to 42.17 ml/m². Those collected from 50 m deep only varied from 2.52-24.54 ml/m².

Organisms in the plankton numbered 7,600-64,200 individuals/m² from samples taken at maximum 150 m deep. (These do not include the fish eggs and larvae which were sorted out.) Their monthly average range is 20,000-33,500 individuals/m², with the highest averages in January 1971 and February 1972 and low average counts in October-December 1970, August 1971, January 1972 and June 1972.

A comparison between the monthly average volume and the monthly average number of individuals indicates a correlative trend, with slight variations (Fig.-6).

Copepods were the most predominant, followed by other crustaceans and chaetognaths. Tunicate and mollusks larvae and coelenterates were also quite common. The Echinoderm plankton and polychaete were occasionally found in the samples.

More detailed discussion on plankton are included in a work now being prepared.

FISH EGGS AND FISH LARVAE

Fish eggs and fish larvae were sorted out from the plankton samples collected (150 m max. depth), using a net with an opening of 0.1589 m², from all stations except stations 11, 12, and 14 where samples were collected from a shallower depth (50 m max.). Station 11, a shallow station very near the coast, accounted only for 82 fish eggs and 16 fish larvae in April 1971. At deeper stations (150 m max depth), the higher counts were observed. Station 5 samples yielded 37 fish eggs and 11 fish larvae in February 1972 while Station 3 samples yielded 32 fish eggs and fish larvae in August 1972. These were not the highest fish

larvae counts. The highest count — 25 — came from Station 1 samples in November 1971. Figures 7-10 show the plotted quarterly numbers of fish eggs and larvae per square meter in samples collected from a maximum depth of 150 m.

The distribution was very variable. In general, the fish eggs were more numerous in the inner part of the bay except during certain months, as indicated in quarterly charts, December 1970 and September 1971. The fish larvae showed a less distinct trend.

Some photographs and drawings of the fish eggs and fish larvae were made. A few were preliminarily identified, at least up to the genus.

HYDROGRAPHIC STUDY

TEMPERATURE

Ranges over the period, September 1970 to August 1972. Surface temperature ranged from 26.10°C to 31.19°C, with an average range of 26.99-30.45°C. The lowest and highest temperature readings were registered at Station 3 in February 1970 and September 1970, respectively.

At 50 meters, the temperature range was 24.23-29.30°C with an average range of 24.93-28.99°C. Station 10 registered the lowest temperature in March 1972. Station 3 in October 1970 recorded the highest temperature reading.

At 250 meters, temperature range was 12.99-16.61°C with an average range of 13.05-14.33°C. Stations 8 and 10 came up with the lowest reading in December 1970 and Station 4 the highest reading in April 1972.

Seasonal Variation. Average temperatures were taken at different levels. From surface to 100 m below, the average temperatures followed almost the same trend. Highest average temperatures was noted in September 1970, when the readings were 30.45°C at the surface and 24.21°C at 100 m deep. In September 1971, the average temperatures dipped to 29.93°C at the surface but remained at 24.21°C at 100 m deep. The lowest average surface temperatures — 26.99°C at

the surface and 21.75°C at 100 m deep – were read in March 1972.

At 200 meters, the average temperature ranged from 14.58°C to 15.41°C . The temperature change was so slight that its rise and fall were not as pronounced as those at the upper layers.

SALINITY

Ranges over the period, September 1970 to August 1972. Surface salinity ranged from $14.46^{\circ}/\text{oo}$ – $34.09^{\circ}/\text{oo}$, with an average range of $28.44^{\circ}/\text{oo}$ – $32.75^{\circ}/\text{oo}$, excepting Station 11. Station 11 showed the lowest salinity ($14.46^{\circ}/\text{oo}$) in August 1972. The next lowest in the bay was Station 3 ($24.47^{\circ}/\text{oo}$). Station 1 in April 1971 showed the highest salinity.

At 50 meters, salinity ranged from $32.94^{\circ}/\text{oo}$ to $28^{\circ}/\text{oo}$, with an average range of $33.14^{\circ}/\text{oo}$ – $34.53^{\circ}/\text{oo}$. Station 11 showed the lowest salinity, followed by Station 5, in February 1971. Station 4 and 10 in July 1971 showed the highest salinity.

At 250 meters, salinity ranged from $33.37^{\circ}/\text{oo}$ to $34.92^{\circ}/\text{oo}$ with an average range of $33.46^{\circ}/\text{oo}$ – $35.11^{\circ}/\text{oo}$. Station 8 recorded the lowest salinity while Station 2 showed the highest salinity, both in February 1971.

Seasonal Variation. The lowest average surface salinity – $28.44^{\circ}/\text{oo}$ – was recorded in February 1971. The highest average surface salinity – $32.70^{\circ}/\text{oo}$ – was noted in May 1972. The rise and fall of salinity was much pronounced on the upper layer. But from 50 m down the surface trend – although less marked – continued to a certain degree (Fig. 12).

DISSOLVED OXYGEN CONTENT

Ranges over the period, September 1970 to August 1972. Surface dissolved oxygen content ranged from 4.19 ml/l to 5.84 ml/l, with an average range of 4.34-5.64 ml/l (Fig. 13). Station 1 in January 1971 showed the lowest dissolved oxygen content and Station 10 in October 1970 the highest.

At 50 meters, the dissolved oxygen content range was 3.21-5.29 ml/l, with an average range of 3.43-4.88 ml/l. The lowest was observed at Station 1 in February 1972 while the highest was at Station 4 in October 1970.

At 250 meters, dissolved oxygen content range was 0.85-1.46 ml/l with an average range of 1.03-1.43 ml/l. Station 3 in October 1971 recorded the lowest dissolved oxygen content and Station 4 in January 1972, the highest.

Seasonal Variation. There was definite rise and fall in the average dissolved oxygen content at the surface down to 100 m, with the highest (5.64 ml/l) noted in January 1972 and the lowest (1.22 ml/l) in December 1970.

pH

Ranges over the period, September 1970 to August 1972. Surface pH ranged from 8.00 to 9.18. The highest average surface pH range of 8.31-8.79 was recorded at Station 2 in July 1971.

At 50 meters, the pH range was 8.12-9.05 with an average range of 8.34-8.77. Station 1 showed the lowest pH in May 1971 and Station 4 the highest pH in November 1970.

At 250 meters, pH ranged from 7.84 to 8.50, with an average range of 8.02-8.36. Station 2 recorded the lowest pH in July 1971 while Station 3 the highest pH in September 1971.

Seasonal Variation. The average pH ranges at the surface to 200 m were all very pronounced, and followed the same monthly trend. Average pH range at 200 meters was 8.05-8.38. Average surface pH was highest (8.79) in December 1970 and lowest (8.31) in July 1971.

Summary and Conclusions

The fishes investigated were the sardines (Clupeidae) and the flying fish (Exocoetidae).

Five species of the genus *Sardinella* (C.V.) were identified. *Sardinella fimbriata* (C.V.), the most common species showed a wide length range and an almost equal sex ratio. No mature fish was found less than 100 mm long. *S. fimbriata* (C.V.) is believed to continuously

spawn the year round, with peaks in November-December, perhaps until January and in March-April. Its fecundity was quite variable.

Four genera and 15 species of flying fish were identified in the samples. *Cypselurus unicolor* (C.V.) and *Exocoetus monocirrhus* Richardson, were considered new records to the Philippine fish fauna. Three species, *Oxyporhampus micropterus micropterus* (C.V.), *Exocoetus monocirrhus* Richardson, and *Prognichthys brevipinnis* (C.V.) were frequently found – though not as numerous as the two newly found species – in the samples. The rest of the species appeared intermittently and in much fewer numbers than the others. All species showed a wide length range and similar spawning habits. Due to the inadequacy of the data collected, the spawning habits of those species, which relatively had fewer specimens, could not be ascertained.

Five groups of fish out of 54 kinds brought into Cagayan de Oro City's central market were observed to be always present in a relatively large quantities throughout the study. These were the carangoids, bonito, mackerel, sardines, and the moonfish. The flying fish comprise the major part of the catch from the bay approach. The fry of some goby species were found abundant off Macabalan and off Tagoloan in January-August.

A correlative trend was observed between the plankton volume and the amount of fish caught from Macajalar Bay.

Larger organisms, such as jelly fishes, fish eggs, and fish larvae, were excluded from the average plankton volume were both observed to be quite variable. Copepods predominated the animals present in the samples.

Fish eggs were more numerous in the inner bay part, except in certain months, especially in December 1970 and September 1971. A less distinct trend was observed for the fish larvae.

The average surface temperature was observed to be variable. The average temperatures at 0-100 m had almost the same trend. At 200 m, the temperature change was not pronounced as on the upper layers.

The rise and fall of salinity was much pronounced on the upper layers. Although not as marked as those salinity fluctuations on the upper layers. The rise and fall of salinity at 50 m, down followed the same trend to a certain degree.

A definite rise and fall of the average dissolved oxygen content at the surface down to 100 m was observed. The average pH ranges from the surface to 200 m depth were all very pronounced and followed the same monthly trend.

JAMES A. McKEOUGH, S.J. is chairman, Department of Biology, Xavier University in Cagayan de Oro City. He obtained a master of science in biology degree (1958) from Fordham University.

ELVIRA C. TAN is director, Fisheries Research Division, National Science Development Board. She obtained a doctorate degree in natural science (1963) from the Institute of Oceanography, Christian Albrecht University in Kiel, Germany.

PEDRO T. ESCUDERO teaches at Mindanao State University, Marawi City where he finished his B. S. in Fisheries in 1968.

THELMA A. RIVERA teaches at Xavier University. She obtained a bachelor's degree in pharmacy (1964) from the University of the Philippines.

NOTES

1. The first study, "A General Hydrographic and Biological Survey of Macajalar Bay" was done on a grant of the National Science Development Board and the National Research Council of the Philippines Project 2,127.

2. A project member was sent on a month's training on the taxonomy of fishes at the National Museum in July 1970 and another month's training on general marine fisheries at the Philippine Fisheries Commission Experimental Station in Malabon, Rizal. In addition, the Researcher-Consultant provided continuing technical advice and guidance during the study.

3. The palangre is made up of a long mainline — a thin nylon string — with several branch lines, each about eight inches long and at whose each end is a fine hook. An adequate lead weight hangs at one end of the main line. The branch lines are attached to the mainline with brass swivels. The hooks are camouflaged by the strips of silk cloth meticulously fashioned into a bait designed for "tamban".

REFERENCES

- Barnes, H.
1959 **Apparatus and Methods in Oceanography, Part 1. Chemical.**
London: Allen and Unwin.
- Food and Agriculture Organization
**FAO Fisheries Biology Branch: Manual of Laboratory Methods
in Fisheries Biology, Part 1. Physical, and Chemical Methods
in Meteorology and Oceanography.**
- Herre, A. W.
1950 (Fam. Exocoetidae) **Twenty-six Noteworthy Philippine Fishes,**
Philippine Journal Science, vol. 79, Bureau of Science Depart-
ment of Agricultural Communication.
- 1953 (Fam. Oxocoetidae) **Checklist of Philippine Fishes, U.S.**
Government Printing Office.
- Lewis, John B.
1961 **The Growth, Breeding Cycle and Food of the Flyingfish**
Parexocoetus brachypterus hillianus (Gosse). Bulletin of Marine
Science of the Gulf and Caribbean. Vol. 11, No. 2.
- MacGregor, J. S.
1957 **Fecundity of the Pacific Sardine (Sardinops caerulea). Fishery**
Bulletin 121, vol. 57, U. S. Government Printing Office,
Washington
- McKeough, J. A. and W. Yap
1969 **A General Hydrographic and Biological Survey of Macajalar**
Bay. Department of Biology, Xavier University (unpublished).
- Parin, N. V.
1960 **The Flying Fishes (Exocoetidae) of the Northwest Pacific.**
(Translated from Russian. IPST Cat. No. 618). Office of
Technical Services, U.S. Department of Communication,
Washing, D.C.
- Schultz, Leonard P. and Loren P. Woods
1953 **Fishes of the Marshalls and Marianas Islands. U. S. National**
Museum, Washington.
- Staiger, J. C.
1965 **Atlantic Flying fishes of the genus Cypselurus, with Descrip-**
tion of the Juveniles. Bull. Mar. Sci., vol. 15, No. 3
- Strickland, J.D.H. and T. R. Parsons
Manual of Sea Water Analysis. Fisheries Research Board of
Canada, Bull. No. 25 (2nd Edition).
- Tiews, K. F.
1958 **Report to the Government of the Philippines on Marine**
Fishery Resources. Phil. Jour. Fisheries, vol. 6, No. 2.

- Tsukahara, H.
1956 Studies on the Flyingfishes of the Amakusa Islands. Part 1. Faunal Discussion with the Life-historical notes. Reprinted from the *Journal of the Faculty of Agriculture, Kyushu University*, vol. 22, No. 2
- 1957 Tsukawa Shiokawa, and Tadashi Inao. Studies on the flying-fishes of the Amakusa Islands, Part 3 and 4, The Life histories and habits of three species of the genus *Cypselurus*; *Science Bulletin of the Faculty of Agriculture, Kyushu University*, vol. 16, No. 2
- Umali, A. F.
1936 *Edible Fishes of Manila*. Manila: Bureau of Printing.
1936 *Edible Fishes of Manila*. Manila, Bureau of Printing.
1936 *Philippine Fishes Reprints*, vol. 3
1950 *Key to the families of Common Commercial Fishes in the Philippines*. U.S. Government Printing Office.
- Vaux, D.
1964 *Field Manual of Observation in Fisheries Oceanography*, C. S. I. R. O. Division of Fisheries and Oceanography, Cronulla, N.S. W.
- Weber, M. and L. F. de Beaufort
1922 *Fam. Exocoetidae, The Fishes of the Indo-Australian Archipelago*; vol. 4, E. J. Brill Ltd.