OCEANOGRAPHIC RESEARCH IN THE PHILIPPINES [1]

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ABSTRACT

The Philippine Archipelago, being surrounded by bodies of water of different depths, has been the object of visits by several foreign research vessels since 1846. All the studies made of Philippine waters were mostly aimed to investigate the extent of the Philippine Deep.

The U. S. Fish and Wildlife Service through the Philippine Fishery Program, with the use of the *S. F. Baird,* focused its investigations on coastal and inshore areas from 1947 to 1950, forming the basis of future oceanographic research in the islands. Upon the termination of the Program and with the turn-over of the *David Starr Jordan* to the Philippine Bureau of Fisheries, a well-planned investigation of bays and gulfs was carried out in Manila Bay and Lingayen Gulf.

In November, 1956, the Section of Hydrology and Fisheries Biology started the marine fishery biological research programme with the help of the FAO technical assistance officer on marine biology. The programme was divided into two phases—fishery biology and oceanography. Again the oceanographic activities were confined to Manila Bay and approaches which, however, were later on extended to San Miguel Bay in Southern Luzon.

Oceanographic investigations include studies on hydrology, plankton, benthos and primary productivity. From the different hydrographic stations that were occupied, temperature, salinity, oxygen, pH, phosphate and transparency data were collected.

The study on the distribution of plankton was made to show its relation to fish stock abundance in the bay. It was found out that the phytoplankton materials were more abundant in the shallower parts of the Bay while the zooplankton organisms

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were more abundant in the deeper portions. It was noted that blooms of copepods follow a rich phytoplankton bloom and this could be correlated with the better fish catches in subsequent months.

Benthos studies, on the other hand, determine the density of animal life in the sea bottom which is found to have direct bearing on the abundance of bottom-feeding fishes.

Studies on primary productivity by means of the radioactive C–14 technique were also undertaken in connection with the research programme.

EARLIER WORK

The first Danish *Galathea* Expedition in 1845–1847 visited and made collections in Manila, Dinagat, and Surigao in 1846. However, the H.M.S. *Challenger* Deep-Sea Expedition in 1875 collected more data on the Philippine deep seas and animal life due to improved equipment. Since then almost all world-wide oceanographic expeditions have visited the Philippine seas. Among the most noteworthy is the *Albatross* Philippine Expedition of 1907–1909 which made the most extensive investigation of sea life in the islands. This expedition was sponsored by the then U. S. Bureau of Fisheries.

Other oceanographic investigations are those of the German survey vessel *Planet* (1907–1912) and cruiser *Emden* (1927); the Danish research vessel *Dana* II (1929); the Dutch *Snellius* Expedition (1929); the U. S. Naval vessel *Cape Johnson* (1945); and the Danish Deep-Sea *Galathea* Expedition (1951–1952) which trawled the deepest part of the Philippine trench. The Philippine Deep, once the world's deepest, attracted the attention of most research vessels of the expeditions.

The studies of Philippine waters were mostly confined to the investigation of the extent of the Philippine Deep. It was not until 1947 that an intensive oceanographic exploration of the Philippines and adjacent seas was undertaken on a wide coverage.

POSTWAR ACTIVITIES IN OCEANOGRAPHY AND FISHERIES

Through the operation of the *"S. F. Baird"* of the Philippine Fishery Program of the U. S. Fish and Wildlife Service during the period from 1947 to 1950, more than 1,100 hydrographic stations spreading over an area of more than 800,000 square miles were occupied. Observations made at each station included temperature, salinity, dissolved oxygen, phosphate, nitrate, hydrogen ion, and silicate. The observations extended generally to the depth of 2,000 meters and, in some cases, to 4,000 meters.

The waters surveyed included the Celebes Sea, the Sulu Sea, all of the smaller seas of the Philippines, the nearby waters of the South China Sea, and the waters of the Pacific east of the Philippines now known as the Philippine Sea to a distance of about 300 miles from the shore. Most of the areas were surveyed twice, once during the northeast monsoon and once during the southwest monsoon. These investigations made the Philippine waters one of the most surveyed areas in the world. As far as it is known, only a small part of the collected data has been processed and published.

This contribution of the U. S. Fish and Wildlife Service to Philippine oceanography served not only as a foundation of later oceanographic research in the country but also as an example in the extension of the work to coastal inshore areas. The training it provided to Philippine workers who were with the survey ship is invaluable.

Following the termination of the Philippine Fishery Program, the 30 ton *David Starr Jordan*, a small but sturdy vessel, together with important oceanographic equipment was turned over to the Philippine Bureau of Fisheries. A program of investigation of bays and gulfs was undertaken later by the Bureau with the use of this research vessel and equipment. Monthly surveys of Manila Bay and Lingayen Gulf were undertaken to determine the cycles of oceanographic conditions and their relation to wind, weather and season. Exploratory surveys were also conducted in Batangas Bay, Balayan Bay and Malampaya Sound.

Of the areas surveyed since the work commenced in February, 1951, Manila Bay in Luzon Island has been the most comprehensively studied. The area was visited every month for one year, occupying a total of fifteen stations whenever weather conditions permitted. A total of 3,115 measurements of physical and chemical properties of the waters of Manila Bay was taken during the year of survey. A report on the oceanography of Manila Bay describing the inter-relationship between the physical and chemical parameters was published by Megia *et al.* in 1953. The data on Lingayen Gulf have already been

PROGRAMMES OF MARINE FISHERIES RESEARCH, 1956–1959

A very important work of the Bureau of Fisheries was launched at the Section of Hydrology and Fisheries Biology of the Division of Fisheries Research in 1956. This is the marine fisheries research program which was initiated and carried out into fruitful operation by Dr. K. F. Tiews of the Institüt für Küsten und Binnenfishcherei of Hamburg when he was detailed as FAO technical assistance officer on marine biology in Manila under the United Nations Expanded Technical Assistance Programme.

All the activities were conducted at the Dagat-dagatan Salt-water Fishery Research Station at Malabon, Rizal where more than 50 technical men and women assistants underwent training in the rudiments of fishery biology.

The work of the Section is broadly divided into two categories—fishery biology and oceanography. The studies relating to fishery biology deal with the fish stocks, migrations, distributions, life histories and other aspects of fish life which have bearing on fishery problems. The major pelagic and demersal fisheries of Manila Bay as anchovies, roundscads, chub mackerels, slipmouth, threadfin breams, lizard fishes and shrimps were investigated in detail in an attempt to understand the factors involved in their biology, abundance and availability.

Oceanographic activities were confined to Manila Bay and approaches, where a line of five stations starting from the head of the bay to the entrance was occupied every month. Two stations are within the approaches of the Bay and three are inside the Bay.

Hydrographic data are collected monthly on special oceanographic trips in connection with special research on water movement, the distribution of plankton, fish eggs and larvæ, bottom ecology and primary production.

In addition, a team of 3 assistants goes with commercial otter trawlers in Manila Bay every two weeks to measure fishes on board and collect samples for study at the shore laboratory.

Likewise, at each station of net hauling, water temperature readings and water samples for nutrients and salinity are taken from the surface and bottom water layers. Further, an experimental small trawl has been operated in Manila Bay for at least four days a week since April, 1957.

San Miguel Bay in Southern Luzon, on the Pacific side, was included in this study in September, 1957, and similarly surveyed every three months thereafter, for comparison of the conditions there with Manila Bay.

From 1,258 hydrographic stations in Manila Bay, data for 2,085 temperature readings, 2,160 salinity, 412 oxygen, 76 pH, 401 phosphates and 174 transparency determinations were collected.

The data are being compiled presently and will be used for the interpretation of biological findings. They will be published as raw data in mimeographed form. The results taken in connection with the biological investigations will be published as further observations on the hydrography of Manila Bay, 1957–1959.

PRELIMINARY RESULTS ON OCEANOGRAPHY OF MANILA BAY AND SAN MIGUEL BAY, 1957–59

Hydrography.—Comparisons of the present observations with those made in 1951–1952 show a temperature difference of 2.43°C at the surface and 1.52°C at the bottom. There was a difference in the surface salinity of 6.99‰ and 0.77‰ at the bottom. Differences were also found in the oxygen and phosphate content of the surface and bottom waters.

These observed deviations, especially of the temperature changes of Manila Bay, indicate the necessity of continued researches along this field as it may help explain the fluctuations on the movement and availability of fish stocks in Manila Bay.

Although temperature readings and salinity determination which were made during the field trips to San Miguel Bay tally in a general way with those made in Manila Bay, yet they are insufficient to allow a direct comparison.

Plankton Ecology.—The investigations on the distribution of plankton are made with special regard to the fluctuations in the availability of food organisms to the fish stocks and the distribution of fish eggs and fish larvæ in and near Manila Bay.

The plankton collection was started in April, 1957, after the arrival of plankton nets from the FAO Headquarters, Rome. During the monthly field trips in Manila Bay, three vertical hauls with a Hensen egg net and a 10-minute horizontal drag with a larval ring trawl were made at each of the five standard stations occupied. Since then, 274 vertical and 90 horizontal samples have been taken. Of these, 268 were roughly sorted and components determined. Similar study was extended to the San Miguel Bay area and samples were systematically taken

at three fixed stations, which were occupied once every three months.

Analysis of samples by animal type and number was made from Stations B in Manila Bay and D outside the Bay for comparison of catches during the first year and is being continued to the present. Samples of plankton materials were taken to England for verification by the assistant on planktonology who is now undergoing training there under the Colombo Plan.

Based on 104 vertical hauls made at Stations A, B and C from April, 1957, to March, 1958, it has been observed that catches were highest in the center of the Bay at Station B, followed by Station A, indicating a greater abundance of plankton inside the bay than outside by a ratio of 2 to 1.

Based on the average of 104 plankton tows made at stations A, B and C whose depths correspond to the average depth of the Manila Bay of 27 meters, it has been calculated that the average standing crop of plankton in Manila Bay is 49,000 metric tons. This represents the minimum value inasmuch as the cod end used in the Hensen egg net was nylon parachute silk instead of regular No. 3 bolting cloth and this proved to be very unsatisfactory. Checked with this material in the latter part of 1958, it was observed that an average increase of catches up to 167 per cent was made indicating that the efficiency of the nylon net was only 38 per cent.

Considering this error, it may be estimated that the plankton standing crop of Manila Bay amounts to at least 157,000 metric tons equivalent to 1,160 kg. per hectare. This estimate is still low when we consider the observed large changes in the catch composition because the biological turnover has not been included and since most of the microplankton and many of the larger forms shall have escaped the net. Tiews, (1958).

It was observed that there are more phytoplankton in the shallower part of the bay, and that zooplankton is more abundant inside the bay.

Plankton catches inside the bay were maximal in June and above average in October and December, 1957, and March, 1958. Significant bloom of *Chaetoceros*, filamentous algæ, *Thalassiothrix* and *Rhizosolenia* contributed to this high value observed from Station B. The following organisms were also found to

It is not as yet possible to detect the real correlation between the plankton abundance and abundance of fish stocks in the bay due to lack of accuracy in the fish catch statistics. However, it seems that the rich phytoplankton bloom of June, 1957, gave rise to the bloom of copepods, an important food item which was observed abundant in the following months; likewise, it was observed that the fish catches then were generally better than in the previous months.

Benthos.—A benthos survey with a Petersen bottom grab was initiated in Manila Bay to determine the density of animal life in the sea bottom upon receipt of two grabs of 1/10th square meter size from FAO Headquarters, Rome. Research on the benthos biomass in tropical waters is rare and this study may therefore fill an important gap in the knowledge on the production biology of tropical waters.

In September, 1957, nine stations were selected from a series of 67 stations occupied in the previous month. These nine stations were occupied monthly until June, 1958, when the second bottom grab was lost. Three bottom samples were taken from each station. In this survey, 333 bottom samples were taken, sieved, and roughly sorted and analyzed. Similar research was extended to San Miguel Bay where 32 different stations were occupied in September, 1957, February and May, 1958, and from which 68 samples were analyzed. The following observations were made:

There was a great difference in the benthos biomass of Manila Bay and San Miguel Bay. The average of 260 Manila Bay samples from 9 standard stations was only 0.74 gram per 0.1 square meter, whereas it was 7.96 grams from 57 San Miguel Bay samples from 15 stations. In the average, 3.5 animals were taken per 0.1 square meter in Manila Bay as compared to 5.8 in San Miguel Bay. Most of the 917 animals caught in Manila Bay were small errantian polychaetes, small macrurans, sedentary polychaetes, brachyurans, and others.

The composition of bottom samples from San Miguel Bay is quite different. More than one half of the 330 animals taken were sedentary polychaetes, the others were errantian polychaetes, ophiuroids, brachyurans, nemerteans, macrurans, and others.

The different composition of the benthos fauna in both areas is reflected in the difference which was observed in the average weight of organisms caught, namely, 0.21 gram in

In both areas, the nature of the bottom was classified according to their substratum of grayish mud, greenish mud, sandy mud and sand. In Manila Bay, grayish mud was most productive followed by sandy substratum and greenish mud; sandy mud was least productive. In San Miguel Bay, the greenish mud zone in the center of the Bay was most productive followed by sandy mud and grayish mud. Sandy substratum was least productive.

It is believed that the higher productivity of benthos biomass in San Miguel Bay has direct relationship to the more abundant catch of shrimps and flatfishes there than in Manila Bay. It has been demonstrated that shrimps feed on bottom organisms. Investigations on the food habits of flatfishes have been initiated to determine the food in the area.

Although Manila Bay with an area of 1,350 sq. km. is 2.6 times larger than San Miguel Bay (520 sq. km.), the standing crop of benthos biomass of the latter is 4 times greater, namely, (40,000 metric tons). In short, the standing crop of Manila Bay is 74.1 kg./ha., while that of San Miguel Bay is 795.7 kg./ha.

In both areas there was no evidence that trawl fishing influences the bottom fauna as believed by certain fishermen. Benthos organisms were found in similar densities in areas in which no trawling is done.

Primary Production.—In March, 1958, research to determine the primary productivity of Manila Bay by means of the radioactive C–14 technique was initiated thru the kind cooperation of Dr. Maxwell Doty of the University of Hawaii who was then studying the productivity of marine waters in this part of the Pacific. This study will give indications of the relative fertility of different areas which may help in the proper development of the fish resources of areas not yet adequately developed.

Since then, 69 samples together with 138 control samples in Manila Bay were treated by standard procedure; 33 samples plus 66 control samples from San Miguel Bay were similarly treated. All dried materials were sent to the University of Hawaii for radiation analyses. The data from these analyses will be correlated with other researches on plankton abundance, hydrography, and availability of fishes.

Preliminary results obtained indicate that the carbon uptake

Productivity rates were generally found to be higher in the shallow coastal areas than in the deeper off-shore parts of the bay. This high value is more or less confirmed by the average fish catch of Manila Bay based on the total catch figure of 8,381 metric tons as given in the Fishery Statistics which is about 62 kg. per hectare in 1956.

Based on the findings of a small experimental trawl boat operated in the shallower areas of Manila Bay, the average catch per year is estimated to be at least 10 metric tons for one small trawler. With 1,500 small trawlers operating in the Bay, their total catch is roughly estimated at 15,000 metric tons per annum, excluding the catch of bagnetters, otter trawlers, and fish corrals. It is, therefore, calculated that the total fish production of Manila Bay amounted to at least 20,000 to 25,000 metric tons in 1957.

Apparently, Manila Bay is one of the most productive fishing areas of the world, being comparable to the best fishing ground of Europe.

The general conception that tropical waters are poor in fisheries productivity can obviously not be applied to the Philippine waters which have a higher productivity than, for example, the North Sea, one of the richest fishing grounds of the world, yet only with an average productivity of 26.4 kilograms per hectare in 1948. Although fishing areas like the Manila Bay are rare in the Philippine Archipelago, the Bay gives an excellent example as to the extent in which such a fishing area can be developed if modern gear like the small trawl, otter trawl, and bagnet are used for the exploitation of the resources. All these studies are being continued to give more reliable results.

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