LIMNOLOGICAL SURVEY OF LAGUNA DE BAY—A PILOT STUDY ON AQUATIC PRODUCTIVITY [1]

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ONE TEXT FIGURE

ABSTRACT

A two-year survey of Laguna de Bay, the largest freshwater unit of the Philippines, has just been completed. As far as facilities could be available, the physico-chemical conditions, the biological characteristics, and the fisheries of the lake were investigated. Under UN/EPTA assistance, this work is being continued and will be expanded to cover other physico-chemical factors and the various trophic groups of living plants and animals participating in the food cycle. Present knowledge of this productivity relationships in this lake is discussed.

THE LAKE

Laguna de Bay, with an area of 90,000 hectares, is the largest body of freshwater in the Philippines. It is located in the lower third of the island of Luzon, bounded on the north by Rizal province and on the south, by Laguna province. On the average, it is slightly above sea level, being known to be at about 6 feet elevation. The lake water fluctuates during the year at an average range of two meters. Its water is supplied by an extensive watershed which pours into the lake through its several effluents. It has one outlet, the Pasig River, which flows into the Manila Bay.

The lake is extremely important to the economy of Laguna and Rizal provinces and vicinities. It is a source of fish for human food. About 80 million kilograms of fish valued at 25 million pesos are harvested from it each year.

At present, this lake is chiefly used as a source of animal feed, specially for the flourishing duck industry along the lake shores. For this purpose, a total of 240,000 tons of animal feeds, consisting mainly of snails, together with shrimps, fish, clams, aquatic plants and insects, are withdrawn from the lake each year.

[1] Contribution of the Philippine Delegation to the 11th Session, Indo-Pacific Fisheries Council, Kuala Lumpur, Malaysia, 1964.

The lake has become an institution, a medium of access and transportation to the twenty-eight populous towns along its shores. A small portion of its water is pumped to irrigate ricefields along its fringes. Some of the areas along its vicinities and within the lake are scenic and have been developed for recreation purposes and as summer resorts.

THE PROBLEMS

Significant changes in lake productivity of economic aquatic products and changes in lake conditions have long been noted by science workers, administrators and the people. The serious problems involved that need immediate solution are the following:

1. The depleted and/or declining condition of the fisheries and related problems of poverty, difficulties in enforcement of conservation regulations, etc.
2. Very rapid siltation in the lake with attendant shallowing and continuous turbid condition of the water.
3. Recurrent weed and algal decay problem.
4. The growing menace of pollution from industrial plants and population centers.
5. General lack of knowledge on the lake which holds the key for a rational solution of the above-listed problems.

THE PROGRAM

The clamor for a definite solution to the growing problems of Laguna de Bay culminated with the creation of the UN–assisted Freshwater Fisheries Investigations Unit (Limnology) of the Philippine Fisheries Commission at Barrio Bambang, Los Baños, Laguna. The program of the Unit has a two-point objective, namely:

1. To establish a continuing research program, designed to study the lake waters and their resources, isolate major problems and seek their solution.
2. To determine the characteristics and inter-relationships of the habitat, population and fisheries. Continuous measurement of these changes in the habitat, population and fisheries provides a sound basis for determining factors of abundance which is of course fundamental in making recommendations for the appropriate management of the resources.

To carry out these objectives, the Unit has put the necessary laboratories and the required organizational set-up of personnel. The personnel staff is divided into two sections, the Aquatic Resources Section and the Biology Section. The

Aquatic Resources Section evaluates the withdrawals and value of the various aquatic resources and assesses related economic factors, like fishing gear, boats used, fishermen, and the like. The Biology Section is divided into a Fisheries Group and a Limnology Group. The Fisheries Group takes up problems of fish population, biology and life history studies of fish and taxonomic studies; while the Limnology Group investigates hydrological aspects of the habitats as well as specialized studies on plankton, benthos, aquatic plants, and other non-fish resources.

The Unit also undertakes the training of limnologists and other freshwater fisheries workers. This is done by inservice training in the laboratory with quite a few through scholarships abroad.

The Unit has availed of the technical assistance of foreign limnology experts through UN/FAO aid. The experts have been charged with responsibilities to train the personnel, acquire equipment and seek foreign scholarships.

The Unit is at its third year of functional existence. A number of valuable data on the lake have been secured, some of which are reported in this paper. It is quite gratifying to note that the data obtained are giving much greater understanding on the conditions of the lake. Undoubtedly, the data will be useful for its proper management.

RESULTS OF STUDIES

Following the accepted thesis of biologists, we recognize *productivity* as the relative yield per unit time and space in terms of organic matter or energy in a given environment. The yield or product here can be in various forms and can best be recognized in terms of *trophic or production levels,* such as *primary producers* (the green plants and chemosynthetic bacteria), *plant or primary consumers* or *herbivores,* and a series of *secondary consumers, the carnivores.* The yield at each trophic level in terms of actual weights of organic matter produced is what we refer to as production at each specific level.

Status of Physical Factors Involved.—Laguna de Bay as a habitat for aquatic production possesses the following physical features: The confines of the lake of 90,000 hectares are uniformly shallow with an average depth of 2.5 meters. The estimated total volume of water in the lake is 2,700,000,000 cubic meters. This water is supplied by the 90 inches (229

centimeters) annual rainfall, and by the 210,000 hectares watershed which pours water into the lake through its effluents about 3,800,000,000 cubic meters per year. The lake level is constantly maintained by the corresponding removal of water to balance the additions from effluents and rainfall. These consist per year of about 1 billion cubic meters lost through evaporation. The coastline is quite regular but with big indentations, thus stretching it to a distance of over 200 kilometers. The bottom is uniformly muddy and rich in organic matter. The water temperature is typically high throughout the year, averaging 27.6°., fluctuating from 22°C. to 34°C. The lake water is normally turbid with a Secchi disc transparency average of 40 centimeters. Conductivity values for the lake water are high, averaging 1,300 micromhos (mho.).

Chemical Conditions Observed.—The lake is well supplied with dissolved oxygen at all depths throughout the year with an average of 8.5 parts per million (ppm). Free carbon dioxide is negligible and the pH ranges from near neutral to slightly alkaline, averaging 7.2. Total alkalinity values indicate an average of 115 ppm, while total hardness, 170 ppm. The chlorine content is relatively high but fluctuating and averaging 8 ppm. No nutrient analyses for nitrogen and phosphorous nor essential minerals have been made as yet in these first set of data.

Suspended Organic Matter—The Yield from Primary Producers.—No direct determination of the production of primary producers has been determined but an important segment of this trophic group may be deduced from the production of suspended organic matter in the lake. This mainly represents the plankton. Regular sampling of plankton is being conducted and results so far showed that the lake water has an average of 9.5 milligrams per cubic meter or equivalent to a standing crop of 25,000 kilograms at any one time in the entire lake to support the production of higher aquatic and economic organisms, such as fish, snails, shrimps, etc. While the above figure appears apparently small, it should be remembered that the organisms involved here are microscopic with inherent extremely rapid rate of replenishment or turnover.

Unfortunately, in connection with the evaluation of the entire primary producers in the lake, the value of higher aquatic plants (both submerged and emergent) has not yet been fully assessed.

Benthos Production.—Studies on the bottom organisms which compose one of the major trophic levels of organic production in the lake was continued and assessment was made of data accumulated for a three-year period, 1962–64. It was found that for this period the average standing crop of benthic forms amounts to 423 kilograms per hectare or equivalent to 38,070,000 kilograms for the entire lake. This consisted mainly of snails which accounted for 400 kilograms per hectare or 95%, midges (Chironomid larvae) 16 kilograms or 4% and annelids, 7 kilograms or 1%. Since there are differences in the type of lake bottom, significant variations occurred in amounts and kinds of benthos among different stations where the samples were taken.

From the above standing crop of benthos organisms of the lake, a surprisingly large amount of withdrawal is being made annually to fill the very high and increasing demand for feed of the duck raising industry around the lake. Special types of bottom dredges, commonly called snail dredges, because of their major catch, are used for this purpose. Data obtained for a two-year period (1962 and 1963) showed an average annual withdrawal of 244,042,000 kilograms or equivalent to 2,700 kilograms per hectare per year. These consisted of 150,888,500 kilograms or 62% snails; 16,134,000 kilograms or 3% clams; and 85,087,500 kilograms or 35% miscellaneous forms (shrimps, fish, insect larvae, and vegetative types). The above data show that the very high withdrawal of over 240 million kilograms each year is six times as much as the average standing crop of about 40 million of these benthic forms. It will show further that these forms must increase at very high replenishment rate to support this withdrawal or face extinction. The present characteristic withdrawal of small immature forms of snails and clams and even shrimps and fish is a bad sign for this trophic level, a problem which needs further study.

Shrimp Biology and Production.—Some observation on the biology of the dominant species of freshwater shrimps in the lake, the *Macrobrachium lanceifrons* Dana, were completed during the period. Spawning and larval development of this species were observed and it was found that spawning takes place all year round with each female spawner of sizes ranging from 30 to 55 mm. long, laying from 180 to 800 eggs per spawning.

Fairly large quantities of shrimps are being withdrawn from the lake for human food and for duck feed each year. For a two-year period (1962-1963), the average annual withdrawal with the use of three major shrimp-catching methods, brush shelter, motorized push net and manual push net, was 19,096,210 kilograms valued at ₱5,733,610. This harvest is equivalent to 219 kilograms per hectare per year from the lake.

Fish Biology and Production.—At least twenty-four species compose the fish fauna of this lake. The major bulk of the catch consists of the silver perch or *ayungin, Therapon plumbeus;* white goby or *biyang puti, Glossogobius giurus;* and land-locked catfish or *kanduli, Arius manilensis.* The perch and goby are most abundant although these are relatively small and are not very desirable. The catfish is a highly desired species and was once the major catch from this lake but it has continued to decline through the years. Other species indigenous in this lake are mudfish or *dalag, Ophicephatus striatus;* freshwater catfish or *hito, Clarias batrachus; dulong* or minute mirror goby: *Mirogobius lacustris,* and other species of gobies; and climbing perch or *martiniko, Anabas testudineus.* Some species have also been introduced and those established are the common carp, *Cyprinus carpio*; *Tilapia mossambica; plasalit, Trichogaster* spp; and *tawes, Puntius javanicus.* Sporadically, some saltwater species may come up the lake but serious pollution of the Pasig River has now greatly restricted their entrance. Milkfish fingerlings are regularly stocked since 1956 as a management measure to augment the fish population of the lake.

Studies on the biology of the major species have been made and work on feeding habits of *Therapon, Glossogobius* and *Arius* have been completed. Preliminary report on the biology of *Glossogobius* has also been finished.

The total catch estimate of the major fishing gears of Laguna de Bay was evaluated during the period from 1961-1963 and it was found that the overall production of fish during the period amounted to 82,881,595 kilograms, valued at ₱24,976,980.00. This is equivalent to a production of 920 kilograms per hectare per year, valued at about ₱280.00. The fishing gear used in this calculation includes fish corral or *baklad,* gill net or *pante,* drive-in-net or *seket,* motorized push net or *turo,* and drag seine or *pukot.* If the fish production

were included in the shrimp withdrawal of 210 kilograms per hectare per year a total of 1,130 kilograms of fish and shrimps may be withdrawn per hectare per year from the lake. It is apparent that the production is high but the monetary value of such production is relatively very low, which indicates either inferior quality products such as small types of fish less desirable species, or immature sizes of fish. This is confirmed by the fact that the unit price of fish and shrimps landed from Laguna de Bay is only ₱0.31 per kilogram. In spite of the apparent high yield per unit area of lake water (1,130 kg.) and the relatively satisfactory earning of the fishermen estimated at about ₱1,900.00 per year per fisherman, or a monthly income of ₱150.00, the present diagnostic characteristics of the lake fisheries have varied indications that, unless drastic steps are taken to regulate withdrawal of fishery resources in the lake, coupled with positive measures, such as periodic stocking, the lake resources will continue to be rapidly depleted.

The Role of Ducks and Man.—The major portion of the lake production is channeled to feed ducks. Duck raising for eggs is an established industry along the shores of this lake. From it, some 245,000 metric tons of feed materials are derived per year to support the duck industry, consisting of snails, shrimps, fish, clams, and aquatic vegetative matter and insect forms. At the end of 1963, there were 4,324 duck farms with a duck population of 516,980. These were producing 219,300 eggs per day or a net production of 80 million eggs per year.

Man exploits the fisheries of the lake. There are some 13,000 full-time fishermen upon whom 55,000 people directly and 500,000 indirectly depend for their livelihood from the lake fisheries. Also, the entire population of Rizal and Laguna provinces and Manila and suburbs, totalling some 3 million people, in some way or other, derive some advantages from this lake.

There are 41 types of fishing gear operating in Laguna de Bay, totalling 9,520 units of which 5,650 or 60% operate the whole year round; 3,462 or 35% operate for 6 to 10 months, and 408 or 5%, in less than six months. The most important gears are fish corral or *baklad,* seine or *pukot,* gill net or *pante,* drive-in-net or *seket,* mechanized push net or *turo,* scoop net or *salap,* shrimp brush shelter or *bonbon ng hipon* and snail

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dredge or *kaladkad suso*. The fishing operations involve 7,149 boats of which 2,599 or 35% are motorized while 4,590 or 65% are nonmotorized.

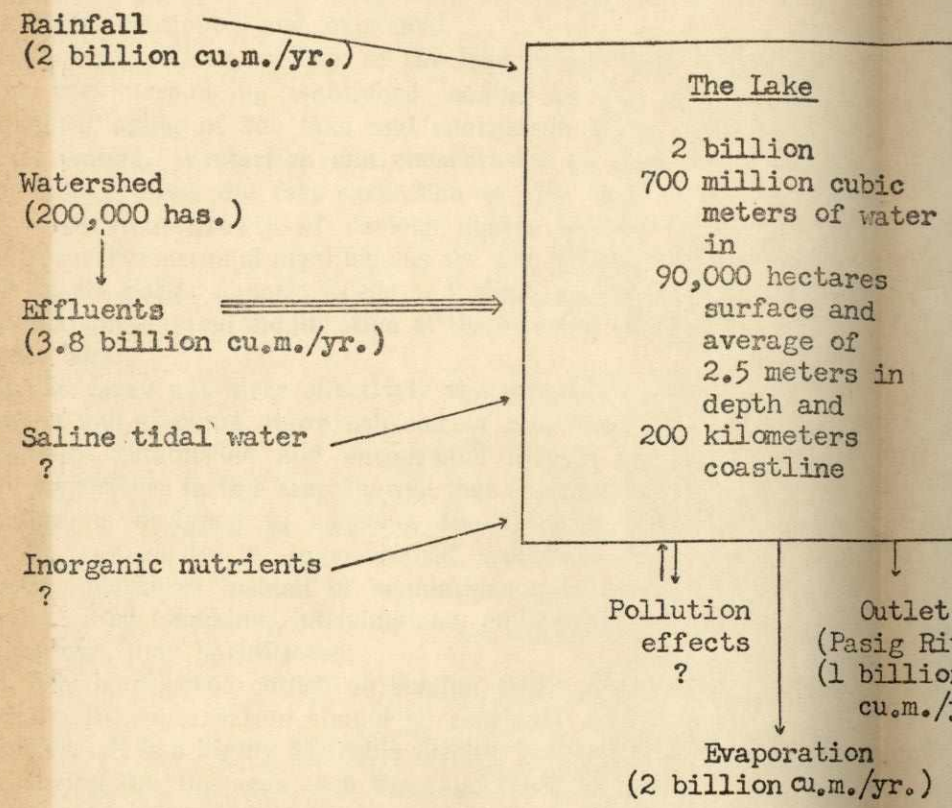
The Lake Food Chain (See Figure 1).—There is a number of non-living influences that greatly affect the lake. These include: (1) the 200,000 hectares watershed pouring 3.8 billion cubic meters of water per year through effluents into the lake, (2) 90 inches (228.6 centimeters) of annual rainfall, (3) saline tidal water of unknown quantity and inorganic nutrients coming in with the effluents and other sources, (4) pollution which acts two-ways—destructive or enrichment, and (5) actual removal through Pasig River outlet and natural evaporation. All these contribute to the make-up of Laguna de Bay as a physical environment for the production of aquatic organisms.

Biological production in this lake is started off by the primary producers, the green plants, which consist of two main forms—the microscopic suspended forms or plankton and the higher aquatic plants of various types. The suspended forms have a standing crop of 25,000 kilograms which is probably rapidly being replenished. The rate of use of these forms by higher trophic levels and rate of turnover will need further study. An estimate of the biomass of higher aquatic plants has not been made but a part that was used in the food chain has been evaluated to be about 10,000 tons per year. These are probably the submerged soft types collected by dredges while the emergent and fringing hard forms are probably more of a liability in the chain of production in the lake.

The suspended forms support the production of shrimps, fish and benthos. The benthos production, mainly of snails, is about 420 kilograms per hectare per year; shrimps, 120 kilograms, and fish, 920 kilograms.

Almost all of the benthic (mainly snails) and a major part of the shrimps and fish production are funneled to support the extensive duck population of over 500,000 along the lake shores. Raised in 4.000 duck farms, these form the source of 80 million eggs per year.

A selected portion of withdrawn fish, shrimps and mollusks from the lake is used for human food. This is exploited by 13.000 full-time fishermen with 55,000 direct and 500,000 indirect dependents. Three million people from the most populous region of the Philippines also derive some form of advantage from the lake.



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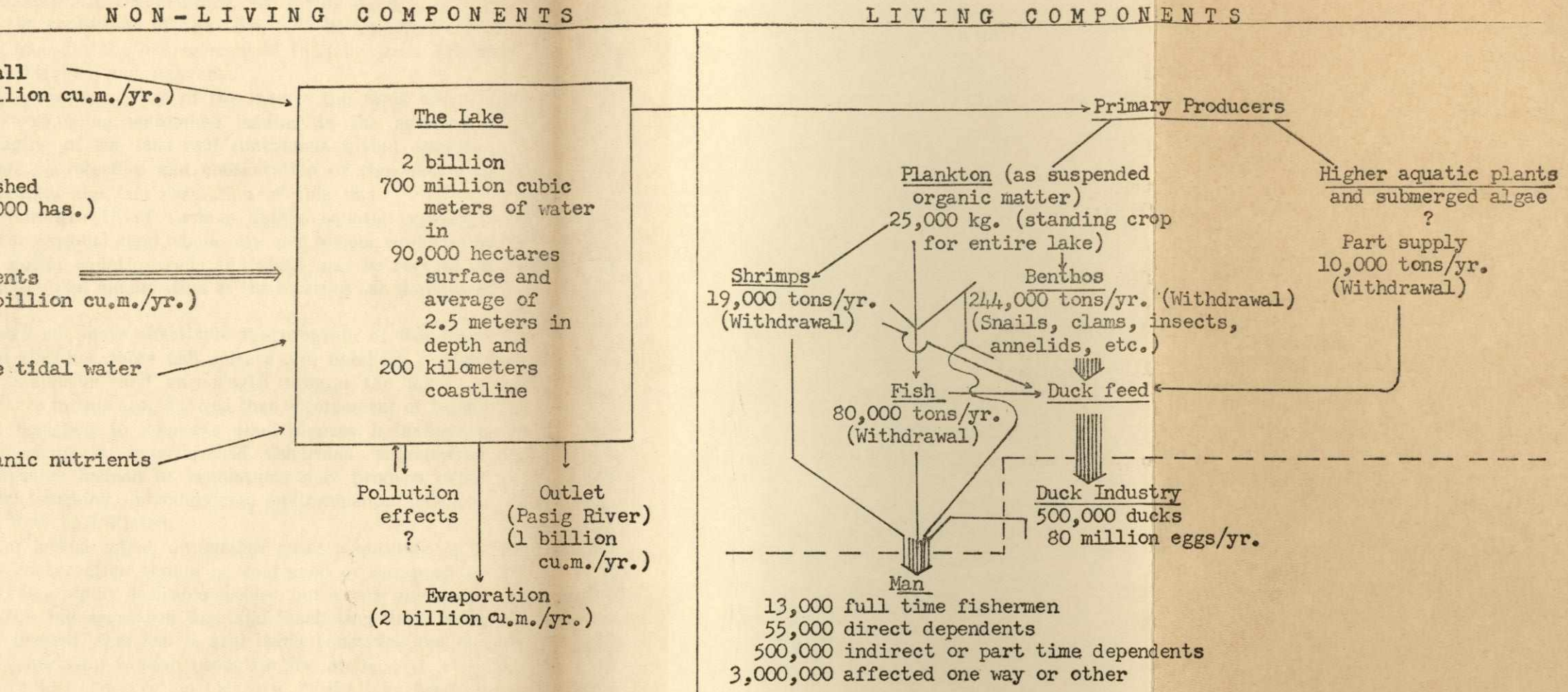

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CONCLUSIONS AND RECOMMENDATIONS

1. The results obtained by the Laguna de Bay Limnology Project, although still fragmentary, are giving a much clearer picture of the conditions of the lake. To be conclusive and effective as tools for the management of the lake, these studies should be continued and expanded.

2. A very serious problem of the lake is the rapid siltation from the surrounding watershed leading to the accelerated geological aging of the lake and continuous turbid condition of its waters. Protection and conservation of the watershed will help prevent the fast extinction of this lake.

3. Luxuriant growth of various higher aquatic vegetation and recurrent seasonal algal blooms are also serious problems of this lake. Softer aquatic weeds and algae may be reduced by the introduction and modification of the existing fish population in the lake.

4. To carry out more effectively the program of fish introduction and stocking, more fish culture and hatchery projects should be established and encouraged around the lake.

5. Experience in this area showed that enforcement of fishery regulations designed to conserve the fisheries is extremely difficult, especially in impoverished fishermen communities. Positive measures instead of regulations may produce better results. Fish stocking, introductions, environmental improvements, etc., may be initiated.

6. The land-locked catfish or *kanduli* poses a question as to whether its conservation should be continued or scrapped altogether. It is a highly desirable species, but a very vulnerable one, laying few big eggs each time and incubating them in its mouth. At present, this fish is still being conserved but the question of conserving *kanduli* needs further study.

7. A less radical conservation measure for the lake fisheries is to designate certain strategic areas as fish sanctuaries. There are evidences that the lake shore communities will support this. One of the municipalities has already petitioned for this measure to be applied in its area (Siniloan, Laguna).

8. Industrial plants have been and are being established along the lake shores or near some of its effluents. Likewise, the towns and villages have grown and are dumping greater amounts of wastes into the lake. For this lake to continue producing fishery resources at maximum levels and of desirable quality, the dangers of pollution should be minimized and/or

ILLUSTRATION

TEXT FIGURE