A view of the lake.

Tilapia in a Peruvian Lake

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Lake Sauce is located in mountainous jungle (Selva Alta) near the Huallaga River (76°12, 5'W; 6°46, 5'S) at an elevation of 650 m. The area of the lake is around 430 ha. The area and volume of the lake vary according to the amount of precipitation. There are two seasons—one with light rainfall (June-December) and the other heavy (January-May).

The village of Sauce is situated on the lake. Its approximately 2,000 inhabitants obtain their animal protein mainly from the artisanal fishery.

In 1962, the Peruvian Fisheries Ministry stocked the lake with juvenile *Arapaima gigas*, an air-breathing fish known to reach 150 kg. *Tilapia rendalli* were introduced from Brazil which reproduced so rapidly that endemic species such as the cichlid *Aeguidens vittatus* were almost completely displaced. In 1976, *Tilapia* comprised 92% of the fish in the lake (excluding *Arapaima* and the guppy, *Poecilia reticulata*). The guppies and later the tilapia were introduced as food for *Arapaima*.

For the appropriate management of the lake, investigations, primarily biological, were necessary. Of foremost importance was the population dynamics of *Tilapia rendalli*. In addition, their biomass was estimated and an explanation was sought for dwarf forms resulting after introduction to the lake. Special emphasis was put on the use and comparison of various methods to determine biomass, taking into consideration those most economical for such a developing country.

Preparing beach seine.

Estimating Tilapia Biomass

First, the "swept area" method was used to estimate biomass.

Each month, the lake was fished in seven representative areas with a beach seine. The average values of the catches were extrapolated over the entire area of the lake, yielding a biomass estimate of 42.8 t.

In October 1976, the first Latin American echo sounding for the determination of fish biomass in a lake was carried out with the assistance of two experts from a FAO/NORAD/IMARPE* project. It was found that *Tilapia* were present in the entire lake, mainly at a depth of 10 m. Large concentrations were found at the mouth of the Pucayacu River and at the border between the narrow and wide parts of the lake. This could be due to the larger food concentrations at these locations; the first influenced by the transport of nutrients from the river and the second due to the overflow of the deep water from the wide basin into the narrow one.

The biomass estimation using echo sounding yielded only 18.8 t. However, the assumed average weight and the fish concentrations on the lake borders were underestimated. Taking these underesti-

*NORAD – Norwegian Agency for International Development; IMARPE – Instituto del Mar del Perú.

mations into account, the biomass estimation was recalculated to be 37.5 t.

The accumulative fishery (Delury) method was also used, in which successive catches were made in a specific area. Within the 95% confidence interval, this method coincided well with the results of the "swept area" method. To account for seasonal fluctuations, one should, however, repeat the procedure in different months.

Biomass determination by tagging was attempted. Approximately 2,000 *Tilapia* were tagged in June 1976 to determine their growth in length, biomass and movements. However, only a few fish were recovered.

Age Determination

A maximum of 8 scale rings was read for *Tilapia* males and 5 rings for females (excluding spawning rings). The question was: how many rings are formed annually? For this reason, the distance was measured between the outermost ring and the edge of each scale. Averaging these measurements in the various months showed that the increments of growth were largest in January and June. This implies that two rings are formed per year. The maximum age in the catches was therefore 4 years (males) and 2 ½ years (females). A single male, length 30.7 cm, had around 13 rings which signified an age of 6 ½ years.

The average length of *Tilapia* was only 12.2 cm (males) and 11.4 cm (females). The age structure of the stock shows that only very few fish (12%) were older than 2 years and around 1% older than 3 years, this being a result of a high total mortality (Z) = 3.0.

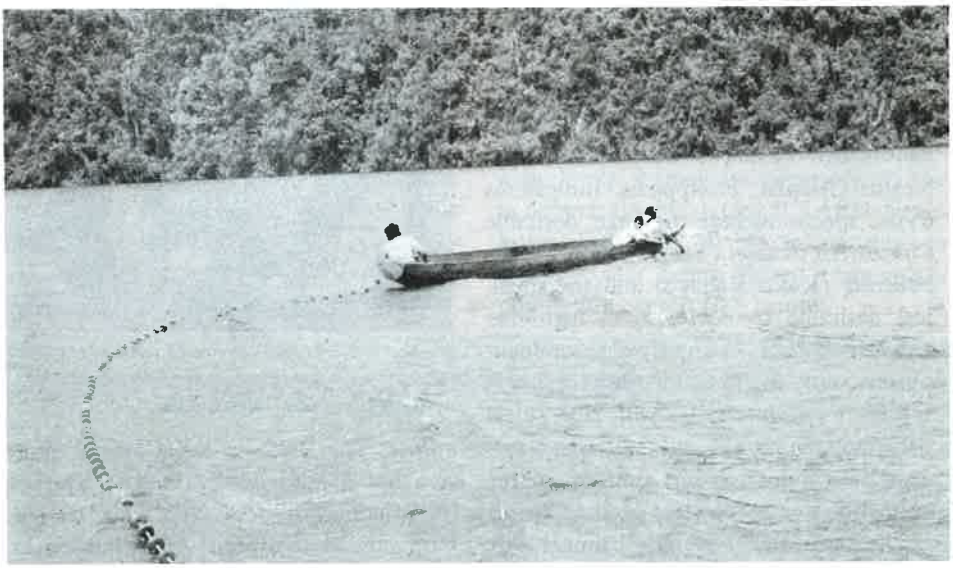
Overcrowding

One of the factors which influence the growth or age composition of a fish population is its population density. It was recommended that the Peruvian Fisheries Ministry increase the fishing intensity on *Tilapia,* as the present fishery does not suffice to control this fish population. In this case only a beach seine fishery would be efficient. However, the people cannot afford such nets.

Lessons Learned

Considering the reservations against the introduction of foreign fish into an ecosystem, the introduction of *Tilapia rendalli* into Lake Sauce was very profitable as long as the *Tilapia* attained commercial size. The existing ichthyofauna was not sufficient to serve a large fishery. Even today, *Tilapia rendalli* serves as animal protein for the villagers. In addition, the aim of providing food for *Arapaima gigas* was fulfilled.

As the *Arapaima* seems to be acclimatizing itself to the lake (first successful spawning outside its original area), a two-species stock could be maintained through wise management by the Fisheries Ministry, promising a better yield than the original multispecies stock. In order to obtain the highest *Tilapia* yields and simultaneous *Arapaima* fry production for intensive culture, a balance must be achieved by increasing the numbers of *Arapaima gigas* and intensifying the fishery on *Tilapia.* The few existing fish farms have yet to solve the problem of the production of *Arapaima* fry. •



Setting the net.

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