

THE MANAGEMENT OF FISH RESOURCES IN THE RESERVOIRS OF THE SÃO PAULO ELECTRICITY COMPANY – CESP

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PRELIMINARY CONSIDERATIONS

Reservoirs are open systems that differ totally from rivers and lakes. They are subject to the influences of the physical, chemical and biological processes occurring in their tributaries. Their communities, although recent, have their origin in populations previously present in the intercepted river, and are distinct from those typical of natural lakes. These unstable ecosystems require continuous monitoring and appropriate management of their animal and plant populations. For these reasons, it is essential to have an understanding of the biotic and abiotic characteristics of reservoirs for the application of appropriate techniques for fish management – the maintenance and, when possible, the enhancement of fish stocks and a healthy fish fauna. Reservoirs can, by this means, play an important role in the production of animal protein, with significant regional social and economic consequences.

Concessionary companies dealing in hydroelectric energy have to work within a legal framework, which includes a number of laws dealing with the environmental impacts incurred by dam construction. For example, Regulation No. 0001/4th January 1977 of the Brazilian Superintendency for the Development of Fishing (Superintendência do Desenvolvimento da Pesca – SUDEPE, currently under the umbrella of the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – Ibama), provided the regulatory terms for Article 36 of the Decree-Law 221/28th February 1967 (the Fishing Law), which determined the protection and preservation of aquatic resources affected by the construction of dams through the adoption of procedures for mitigating impacts. The major impacts occur along lagoon areas and marginal swampland, both of which tend to be reduced in size, besides the total destruction of riverine forests and

marginal vegetation. Another serious consequence of dam construction involves the interruption of the trophic and reproductive migrations of numerous fish species. Migrations are consequently limited to minor tributaries. The spawning of commercially valuable autochthonous species, such as the dourado (*Salminus maxillosus*), pacú (*Piaractus mesopotamicus*) and pintado (*Pseudoplatystoma corruscans*), can be seriously affected, and populations may be partially substituted by other species better adapted to the newly created environment and of lesser economic importance.

The São Paulo Electricity Company (CESP) created its Department of Natural Resources in 1978. Priority was immediately given to the development of fish breeding stations as the best means of increasing fish stocks in the Company's reservoirs. As a result of the successful programs of these stations, thousands of juveniles of allochthonous and exotic species were introduced into reservoirs without any prior knowledge of their limnological or ichthyological characteristics.

In 1980, CESP changed its policy, and gave emphasis to the introduction of autochthonous spawning species, while, however, still lacking a sufficient understanding of the biological, chemical and physical characteristics of the reservoirs and, as a result, of the alternatives for management techniques. Research, therefore, concentrated on technologies for the breeding of autochthonous spawning species such as: curimatá (*Prochilodus lineatus*), piava-três-pintas (*Schizodon borelli*) and pirapitinga-do-sul (*Brycon reinhardti*). Production of these species eventually surpassed that of the allochthonous and exotic species. 1982 saw a restructuring of the Department, which was subsequently given a new name — the Department of Environment and Natural Resources — and adopted a new policy. Emphasis was given to obtaining prior knowledge of the aquatic ecosystems and communities as well as evaluating the results and effects of its activities. Research subprograms were set up in a number of reservoirs. These included limnological evaluation, ichthyological studies, studies of population dynamics, the localization and characterization of fish reproduction areas in the tributaries, and surveys and monitoring of fishing productivity. Environmental

education campaigns, concentrating on local fishermen, were also established. Over the years this has begun to provide a data base for the evaluation and adjustment of the management techniques adopted. In 1986, CESP established an official Fishing Management Program for its 19 reservoirs, which total some 900,000 ha and generate approximately 8,800 MW.

THE FISHING MANAGEMENT PROGRAM – MAJOR OBJECTIVES OBJECTIVES

a) To refine the fishing management policy through the development of research subprograms in selected reservoirs, with recycling and evaluation on an annual basis to permit the selection and implementation of management techniques for sustained fish production.

b) To refine fish-stocking programs through annual evaluations and the incorporation of new information resulting from the studies on fish biology mentioned above.

c) To develop and transfer technologies for the aquaculture of autochthonous species to private and public institutions interested in fish breeding.

EXISTING SUBPROGRAMS

Limnological characterization

The limnological characterization of a reservoir is essential for an understanding of its structure and functioning. The studies involved permit the immediate application of the data collected for the

introduction of preventive and corrective measures for the maintenance of water quality. They also permit predictions concerning future changes in the system, which may be prejudicial to its functioning. This subprogram aims specifically to estimate biological productivity, both before and after the construction of the reservoir, through the evaluation of the biological, chemical and physical characteristics of its waters. The following reservoirs are at present under study: Ibitinga, Promissão, Três Irmãos, Nova Avanhandava, Salto Grande and Rosana. Promissão has been studied for several years and is relatively well known. It is polymictic and mesotrophic (Carlson's Trophic Index), showing however, a tendency to eutrophication. These characteristics indicate favourable conditions for fish production (Brazil, CESP, 1990a). The reservoirs of the Rosana dam (Rio Paranapanema) and the Três Irmãos dam (Rio Tietê) were the first to provide a limnological characterization before and after flooding. This enabled the application of informed management plans which has resulted in the preservation of the fish communities and the development of a healthy fish production (Brazil, CESP, in press c).

Ichthyological studies and population dynamics

The objectives of this subprogram include: the analysis of the structure and trophic dynamics of the fish communities; research on the reproductive biology, nutrition, growth, and net selectivity of species important for fishing; description and evaluation of local fishing activities; and evaluations of impacts caused by large, as well as medium and small hydroelectric projects (PCHS), for the proposal of adequate mitigating measures. As in the limnological studies, the reservoirs involved are Ibitinga, Promissão, Três Irmãos, Nova Avanhandava, Salto Grande and Rosana. Preliminary studies in the Promissão reservoir were concentrated on three species, pescada-do-piauí (*Plagioscion*

squamosissimus), piava-catinguda (*Leporinus friderici*), and pirambeba (*Serrasalmus spilopleura*), involving studies of population dynamics, selectivity in net mesh size, estimation of the size at first gonadal maturation, diets, etc. Such information has contributed to the development of management techniques and the rationalization of fishing activities in the reservoir (Brazil, CESP, 1990b). Surveys in the other reservoirs, especially Rosana and Três Irmãos, have also concentrated on the commercially valuable species.

Fish production surveys

The rapid changes observed for the stretches of the Rios Tietê, Paranapanema and Paraná where dams were constructed, resulted in emphasis being given to research on the reservoirs rather than on the rivers. A knowledge of the biotic and abiotic characteristics, and the long-term fish production of the reservoirs is essential for effective management programs. Medium and long-term variations in these aspects may result from such as overfishing or pollution, but only by monitoring them can corrective measures be carried out. The objectives of the fish production surveys are, therefore, as follows: a) to determine variation in fish production, both total as well as for each species; b) check on the contribution of stocking; c) to provide complementary data for the limnological characterization and the ichthyology and population dynamics subprograms; d) to evaluate fishing effort and fish catching effort per species for each reservoir; and e) to establish links with and obtain the cooperation of the professional fishermen operating in each reservoir. The Barra Bonita, Ibitinga, Promissão, Nova Avanhandava, Três Irmãos, Jupia, and Água Vermelha reservoirs are included in this subprogram. CESP is one of the few electric energy concessionary companies which maintain a program of regular evaluations of fish production (and professional

fishing activities) in their reservoirs. Results to date have provided the following range in average annual catches by weight: Barra Bonita — 188 t (two years); Ibitinga — 64 t (two years); Promissão — 234 t (five years); Nova Avanhandava — 57 t (two years); Jupia — 172 t (two years); and Água Vermelha — 120 t (total for just one year). Of note is the relatively high catch in the Barra Bonita reservoir which presents high organic and industrial pollution levels and has not been subject to restocking. Fish production there is higher than in some other reservoirs which are not polluted (Brazil, CESP, in press a).

The most commonly caught species in these reservoirs are mandi-guaçu (*Pimelodus maculatus*), pescada-do-piauí (*P. squamosissimus*), which was successfully introduced by CESP, curimbatá (*P. lineatus*), (minnows or lambaris), and two species of saguirus (*Steindachnerina insculpta* and *Cyphocharax nagelli*). The constant contact with the fishermen has enabled the development of environmental education programs and also good relations with the fishing cooperatives. As a result of this it has been possible to develop a special program in the Água Vermelha reservoir (authorized by Ibama), using the method of waiting nets coupled with "enclose and beat" for Nile tilapia (*Oreochromis niloticus*), the common tilapia (*Tilapia rendalli*), the Amazonian tucunaré (*Cichla ocellaris*), and pescada-do-piauí (*P. squamosissimus*).

Localization and characterization of fish reproduction areas

Reservoir construction results in the isolation of a number of commercially important species from the river's tributaries. These species include pescada-do-piauí (*P. squamosissimus*) and traira (*Hoplias lacerdae*), and most importantly those which traditionally breed in tributaries such as dourado (*S. maxillosus*), curimbatá (*P. lineatus*), pintado (*P. corruscans*), and pacú (*P. mesopotamicus*).

The objectives of this subprogram include: a) to identify, register and characterize potential fish breeding areas; b) to analyse the spatial and temporal variations in the basic environmental parameters of these sites; c) to characterize the use of these areas by the fish communities and examine the potential for enhancing their use by autochthonous spawning species; and d) to establish measures for their protection. The Barra Bonita, Ibitinga, Promissão, Nova Avanhandava, Três Irmãos, Salto Grande, Rosana, Jurumirim, Jaguari, Paraibuna, Euclides da Cunha, and Limoeiro reservoirs are included in this subprogram.

Preliminary results have identified several tributaries important for breeding sites feeding the Barra Bonita reservoirs, and although heavily polluted, the major efforts underway to restore the Rio Tietê will undoubtedly result in improved fish catches in the coming years. The Promissão reservoir, also on the Rio Tietê, has the best potential in this sense with a number of species able to complete their reproductive cycles in unpolluted tributaries still maintaining riverine vegetation, lagoons and marginal swamps (Brazil, CESP, 1988, 1990d). The Rosana reservoir on the Rio Paranapanema also has a large number of species and numerous potential breeding sites, as evidenced by the high numbers of alevins caught there.

Environmental education and professional fisherman

By working with fishing cooperatives and professional fisherman, the aim of this subprogram is to put into practice the management and technology necessary for sustained production and the preservation of the fish communities. Punitive measures are ineffective if not followed up by educational campaigns. The specific objectives of this subprogram are, therefore; a) to increase the awareness of environmental problems amongst the professional fishermen and their families; b) to reduce the incidence of predatory fishing; and c) to inform these communities of the activities of CESP (Department of

Environment and Natural Resources). This subprogram is to date limited to just one reservoir — Promissão (Mário Lopes Leão).

AQUACULTURE TECHNOLOGY AND ALEVIN PRODUCTION

An important part of the Fishing Management Program is the research carried out on fish breeding and the production of alevins for stocking, restocking and sale, carried out at the Hydrobiology and Aquaculture Stations. The technology developed is transferred to fish breeders in the private and public sectors. The Research Stations are located in five of the reservoirs: Paraibuna (Rio Paraibuna), Barra Bonita (Rio Tietê), Promissão (Rio Tietê), Salto Grande (Rio Paranapanema), and Jupuí (Rio Paraná). The following species are involved:

1. "barbado" (*Pirirampus pirinampu*)/1
2. "cascudo-chinelão" (*Rhinelepis aspera*)/1
3. "curimatá" (*Prochilodus lineatus*)/3
4. "dourado" (*Salminus maxillosus*)/1;/2
5. "jacundá" (*Crenicicla ocellaris*)/1
6. "jaú" (*Paulicea luetkeni*)/1
7. "jurupoca" (*Hemisorubim platyrhincus*)/1
8. "jurupecê" (*Sorubim lima*)/1
9. "pacú-guaçú" (*Piaractus mesopotamicus*)/3
10. "pacú-prata" (*Myleus tiete*)/1
11. "piabanha" (*Brycon sp*)/1;/2
12. "piapara" (*Leporinus obtusidens*)/2
13. "piava-bicuda" (*Leporinus conirostris*)/1;/2
14. "piava-três-pintas" (*Schizodon borelli*)/2
15. "piauí-palhaço" (*Leporinus copelandii*)/1;/2
16. "pintado" (*Pseudoplatystoma corruscans*)/1

17. "piracanjuba" (*Brycon orbignyanus*)/1
 18. "pirapitinga-do-sul" (*Brycon reinhardti*)/2

/1: breeding at experimental level

/2: production for stocking reservoirs

/3: production for repopulation and sale of alevins

Species bred at each Station:

- . Paraibuna: 3, 5, 11, 13, 15, 18.
- . Promissão: 1, 3, 4, 7, 9, 12, 14.
- . Salto Grande: 3, 8, 9, 10, 12, 14, 16.
- . Jupia : 2, 3, 6, 9, 12, 14, 17.

Approximately 10,000,000 alevins are produced each year, of which 10% are sold or distributed to the public sector, and the remainder are used for restocking reservoirs. The main species involved in the restocking programs are: curimbatá (*P. lineatus*), pacú-guaçú (*P. mesopotamicus*), pirapitinga-do-sul (*B. reinhardti*), piava-três-pintas (*S. borelli*), and piapara (*Leporinus obtusidens*). Some of the breeding programs result from direct collaborative agreements with private entities or local governments (for example between CESP, the municipal government of Pariquera-Açú, and the Cacau-Açú farm, see Brazil, CESP, 1991).

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