THE IMPACT OF A LARGE TROPICAL HYDROELECTRIC DAM: THE CASE OF TUCURUÍ IN THE MIDDLE RIVER TOCANTINS.

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ABSTRACT

In this paper we discuss the main impacts of the Tucuruí dam on fisheries and human populations. Above the reservoir, positive impacts on fisheries outweighed negative ones, although currently flourishing fisheries may not be sustainable in the long run. Below the barrage, the negative impacts are much stronger. High mosquitoe populations make everyday life very difficult in the reservoir area.

INTRODUCTION

The first Brazilian hydroelectric dam was built in the Rio Paraibuna (afluent of the Rio Paraíba), in the city of Juiz de Fora in 1889, generating 0.252MW. Since then, hundreds of private or public

dams have been built, many of them located in the Rio Paraná basin. In 1982, PAIVA calculated the hydroelectric potential for Brazil at 106,450MW, and estimated that 33,140MW would be exploited by 1990 (PAIVA, 1982). In the Amazon basin, the construction of large dams started in the 70's. At present, the three largest are those of Tucuruí (Rio Tocantins), Balbina (Rio Uatumá) and Samuel (Rio Jamarí).

IMPACTS

GENERAL CONSIDERATIONS

When attempting to assess the impacts of a (large) dam on its river, it is necessary to consider the conditions of the original terrestrial landscape and the water quality prior to the impoundment. In the case of the Rio Tietê, which is heavily polluted by domestic and industrial sewage, traversing as it does the city of São Paulo, six dams under the authority of CESP (Centrais Elétricas de São Paulo) have a positive effect. There is a gradual improvement of the quality of the water downriver, as it flows from one reservoir to the next. This for the following reasons:

(1) the deposition of dissolved solids as the water flow decreases in each reservoir in the direction of the barrage;

(2) the water aeration as it flows through the spillway. In addition, organic pollution fertilizes the water, increasing primary production, although unintentional ecosystem enrichment is a controversial issue (TUNDISI et al., 1988).

For these reasons, fish diversity and stock density increase, providing for local and sport fishing. In the region of the Três Irmãos dam, the last reservoir to be built on the Rio Tietê, the fish fauna may still be considered representative of its original communities (H. BRITSKI, personal communication).

When a dam is built in an unpolluted river with its basin still intact, the positive effects such as the increase in fish stocks in the reservoir as well as immediately upriver following dam closure (PETRERE, 1989), the generation of electric energy, and the availability of water for irrigation provide little consolation when compared to the negative ecological impacts, both above and below the barrage.

HUMAN IMPACTS IN THE AREA OF TUCURUÍ RESERVOIR

The Tucuruí dam, the largest Amazonian impoundment, was closed in September 1984, inundating an area of 2,830 km² during 206 days. Its average depth is 17.3m, with a maximum of 75m near the barrage. It has a perimeter of 6,400 km, and a length of 130 km, with an average water residence time of 51 days. With all the turbines in operation Tucuruí would generate 8,000 MW (CET/ELETRONORTE, 1988). This energy would save U$3,431,000,000 per year (citing CAULFIELD (1982) a barrel of oil cost U$23.50 including transport and insurance, and 1MW is equivalent to a daily burn of 50 barrels).

Tucuruí is at present responsible for a series of undesirable impacts, some of them foreseen before its construction (GOODLAND, 1978; EDINGTON & EDINGTON, 1979; BAXTER, 1977). The main negative impact concernig the human populations in the area is the increase in the numbers of mosquitoes or "muriçocas" (*Mansonia titilans*) which transmit two different arboviroses to man. The species is responsible for 98% of the mosquitoes caught in the area. A second troublesome species is the voracious hematophagous horsefly called "mutuca-cabo-verde" (*Lepiselaga crassipes*), the bites of which can cause lesions. Both species reproduce in the roots of the macrophytes *Salvinia auriculata* and *Eichhornia crassipes,* both very abundant in the reservoir. Immediately following closure, when the macrophyte biomass started to increase, scientists from INPA (Instituto Nacional de Pesquisas da Amazônia, Manaus) detected increase in muriçoca populations which were measured in terms of attack, reaching at times an average of 500 bites/man/hour.

The gravity of the problem was discussed in a report by INPA to Eletronorte (Brazil, ELETRONORTE, 1989) which informed that

Mansonia has a dispersal radius of up to 30 km, and warned that the level of infestation could make human occupation of the area inviable. According to local populations, these mosquitoes were present in the reservoir area before impoundment, but in low densities. The "plague" of muriçoca began in 1985 in the localities of Vicinal 45 and Gleba Parakanã, four months after dam closure. Since then, it has been expanding. The incidence of this mosquito is high all year round, worsening in the beginning of the rainy and dry seasons. They attack day and night with higher intensities at sunset and sunrise. During the day, they remain in the foliage and attack when the vegetation is touched. They attack and kill young domestic animals such as cattle and fowl. The phenomenon has obliged many settlers to leave their plots, which are being bought at low prices by rich cattle ranch owners. After 1987 the mutuca also started to increase in abundance. According to Inocêncio Gorayeb, an entomologist of the Museu Paraense Emílio Goeldi, Belém, Eletronorte in lowering the water level of the reservoir by 1m, in an attempt to control the macrophyte populations (pers. comm.). Gorayeb was also informed by the settlers that Eletronorte was giving them DDT tablets to be burnt in fires, with the idea that the smoke would control the mosquitoes.

The main reasons for the mosquito and horsefly infestations were listed in a report by a Commission of 13 different institutions (Brazil, ELETRONORTE, 1989):

(1) the formation of the lake offering an extensive surface for the proliferation of mosquitoes;

(2) as the original forest was not removed before flooding dead logs provide a source of nutrients enhancing the proliferation of macrophytes and facilitating the reproduction of mosquitoes;

(3) increase in secondary nurseries for the mosquitoes due to the human occupation;

(4) increase in the density of wild animals, distributed through a smaller area following dam closure, the intensification of human occupation in the lake margins, and increasing numbers of domestic animals, all potential prey for the mosquitoes.

The recommendations of the Commission for the solution of this difficult problem may be classified in three different items:

I. Actions in the lake, the primary focus of infestation:

(1) exploitation of the submerged dead logs, as the highest densisties of macrophytes are in the areas of "paliteiros" (areas of standing dead trees);

(2) use of the macrophytes as a source of energy, fertilizer or animal food (the phytomass in the areas invaded by macrophytes was estimated at 300t/ha);

(3) establishment of programs for raising buffalo which, besides feeding on the macrophytes, produce feces which are herbicidal.

II. Actions in the secondary nurseries around the villages:

(1) clearing the small streams, draining and/or filling in the areas of stagnant water;

(2) elimination of mosquito larvae through biological control.

III. Actions for individual protection:

(1) screening the houses;

(2) use of mosquito nets.

HUMAN IMPACTS BELOW THE RESERVOIR

Following dam closure, 80-90% of the sediments carried by the Rio Tocantins are retained by the reservoir due to the presence of the barrage(Miriam Leal Carvalho, Instituto Brasileiro do Meio Ambiente, Ibama, Brasília; Weber Pires de Sá Jr., Universidade Federal de Minas Gerais, UFMG, Belo Horizonte, pers. comm). Without the annual renewal of these sediments, the islands in the lower Tocantins, the original zones of sedimentation, are now being eroded. The loss of nutrients seems to be affecting the growth of the palms açaí (*Euterpe oleracea*), and buriti (*Mauritia vinifera*), and cocoa (*Theobroma cacao*), vital to the economy of riverine populations. These traditional crops now require additional fertilization (Penny Magee and Marília Brasil, Museu Paraense Emílio Goeldi, Belém, pers. comm.). Due to this decrease in

productivity, some people are already migrating to Belém, the capital of the state of Pará.

The water intake for the turbines is 30m below the surface of the reservoir. Water quality at this level, wich comprises the main part of water taken in the summer, is very bad. It is undrikable, because of the taste and the smell of H_2S. We interviewed some people living in the small village of Nazaré dos Patos, who informed us that in the summer (dry season) they have to walk several kilometers to obtain clean water in a small creek; a well built by Eletronorte ironically dries out at this time. This running water is rich in filamentous algae, and professional fishermen complain that it is impossible to fish with gillnets, because it quickly become staturated with a green lime. The few fishes which are caught taste bad (RIBEIRO & PETRERE, 1988).

IMPACTS ON FISHERIES

The fish fauna of the Rio Tocantins—Araguaia is not very rich, by Amazonian standards, with only approximately 300 species (PAIVA, 1983; SANTOS et al, 1984). Here we report on the fisheries in the Tocantins valley studied during an expedition from Porto Nacional to Cametá (about 1,200km), through interviews of professional and subsistence fishermen (RIBEIRO & PETRERE, 1988).

FISHERIES ABOVE THE RESERVOIR

Fishermen were unanimous in informing that after the closure of the dam there was a generalized increase in fish abundance, with immediate and positive results for the regional economy. The total estimated landing for the Tocantins basin is comparatively low, not exceeding 4,000t/year in its most abundant stretch, between the town of Imperatriz and the reservoir (360km). Between the towns of Porto Nacional and Estreito (540km) it never exceeds 400t/year, where the Rio Tocantins is encased in a deep valley. These regions are exploited by small organised groups of professional fishermen (*Colônias*), fishing with small diesel engine boats, and keeping the fish in ice boxes. There

are also subsistence fishermen, fishing sporadically. In 1988, in the market called "O Povo Merece" in the town of Imperatriz, 45 groups of fish species were commercialized, caught by the local fishing fleet and totalling 841t, of which curimatã (*Prochilodus scrofa*) represented 54%. The large majority of the catches was performed in the river bed, using beach seines (47% of the catches), castnets (29%) and gillnets (24%). In the non-commercial fisheries the main methods employed were rod-and-line and hand-hook-and-line. The increase and decrease in abundance of some species was attributed in 76% of the interviews to the formation of the reservoir. It was reported that curimatã had increased, but that the large migratory catfishes had undergone a generalized decline (Brazil, ELETRONORTE, 1989).

BARTHEM et al. (1991) presented evidence that the large migratory catfish *Brachyplatystoma filamentosum, B. flavicans, B. vaillantii, Goslinia platynema* and *Lithodoras dorsalis* spawn in the headwaters of the Amazon and its tributaries and that the estuary of the Amazon is the main nursery ground used by their alevins. On this hypothesis the impact of hydroelectric dams on these populations is discussed in terms of interruption to fish migration routes upriver, and the movements of larvae downriver.

FISHERIES IN THE RESERVOIR

From October 1987 to September 1988, 1,424t of fish were caught in the Tucuruí reservoir. From this total, tucunaré (*Cichla* spp.) contributed 57% of the catches and pescada (*Plagioscion* spp.) 21% by weight; this from a total of 49 fish species. This indicates in grossterms that species richness (but not species composition) in the reservoir remained unchanged. The main fishing methods were rod-and-line (68%) and gillnet (20%), the remainder being caught by castnet and by a hook-and-line in series (Brazil, ELETRONORTE/ENGEVIX/THEMAG, 1989). From this we can see that the fisheries of the reservoir are very different from those performed upriver.

In 1988 there were 800 licensed fishermen operating in the reservoir. The license is highly valued by the professional fishermen, as

they claim that the fish stocks in the reservoir are more abundant. This increase in abundance in the reservoir, when compared to the river, is due to the drowned vegetation which evidently benefits fisheries, because the higher catches are taken in this biotope (Brazil, ELETRONORTE/ENGEVIX/THEMAG, 1989; EDINGTON & EDINGTON, 1979). Beyond being a nutrient reserve and so increasing primary production, notable in the case of Tucuruí where decomposition is probably predominantly anaerobic (CAULFIELD, 1982), the submerged logs make a very suitable surface for the encrustation of algae and invertebrates, prey for the fish. But this increased abundance may not be sustainable, because of to the rotting and fall of the dead logs, which may cause general productivity to drop, as hypothesized in Figure 1. We see here the conflict: the submerged forest is responsible for human health problems (mosquito and horsefly plagues) while on the other hand benefitting fisheries.

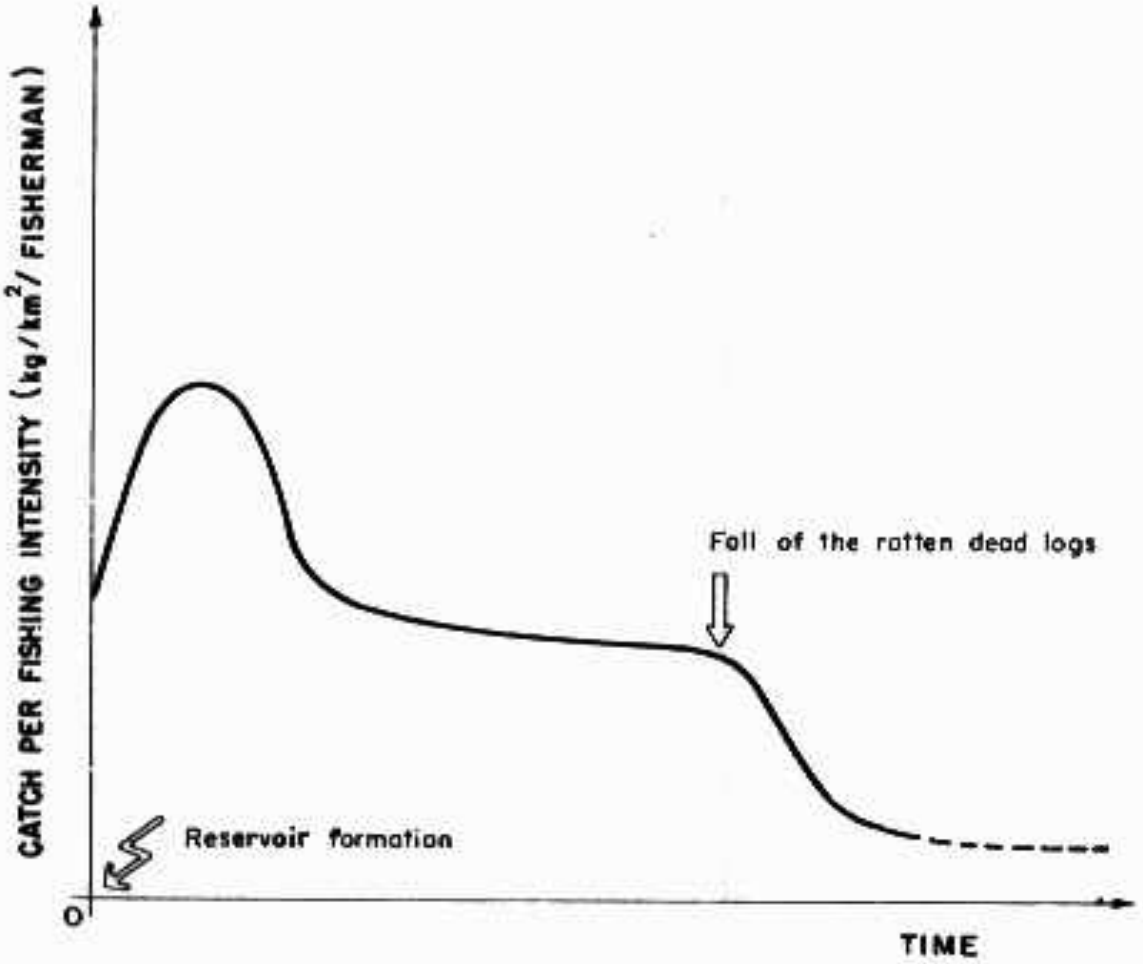

Fig. 1. Expected reservoir fish production (kg/km^2/fisherman) in time following dam closue.

FISHERIES BELOW THE RESERVOIR

Below the barrage, fisheries were affected negatively, with a fall of 65% in the two years following damming (COLLART, 1986). Presently it seems that there is a slow recovery of the stocks. For example, mapará (*Hypophthalmus* spp.) and curimatã, which had virtually disappeared, are becoming more abundant, including larger specimens again being caught in the upper stretches near Tucuruí. Further downriver, however, in the villages of Mocajuba and Cametá, the situation remains critical, with only small maparás being available (RIBEIRO & PETRERE, 1988; RIBEIRO et al, in prep.).

POWER GENERATED VS. AREA INUNDATED

It is not our main aim here to compare Tucuruí with other Amazonian reservoirs, and we refer the reader to PAIVA (1982) and SCHAEFFER (1986) for general discussions on the impacts of large reservoirs. We have mentioned here some positive results, notably at

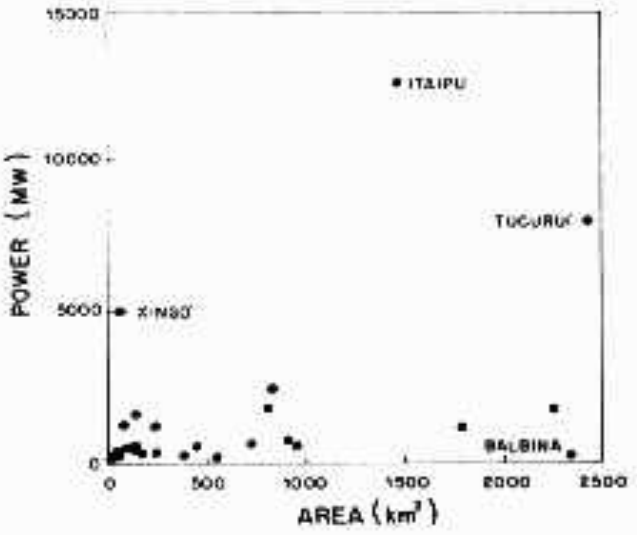

Fig. 2. Power (MW) x Area (km^2) for some selected Brazilian reservoirs. These data are only illustrative, as they are not a result of a random sample from the existing reservoirs in the country. Source: ELETROBRAS. 1986. Plano Diretor para Proteção e Melhoramento do Meio Ambiente nas Obras e Serviços do Setor Elétrico. MME, Diretoria de Planejamento e Engenharia. Departamento de Recursos Naturais. Rio de Janeiro, Brasil.

least temporarily concerning fishing in the reservoir, and we also emphasize, that the area inundated per unit of hydroelectric power generated can be considered favourable when compared to such as the Balbina dam on the Rio Uatumá (FIG. 2) which, besides having evidently provoked and irreversible ecological disaster (FEARNSIDE, 1990; NODA & NODA, 1990), has an extremely low efficiency in these terms.

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