INCOME EVALUATION OF SMALL - SCALE FISHERS IN TWO BRAZILIAN URBAN RESERVOIRS: REPRESA BILLINGS (SP) AND LAGO PARANOÁ (DF)

PETRERE JR., M.[1], WALTER, T.[2] and MINTE-VERA, C. V.[3]

[1]Departamento de Ecologia, UNESP, C. P. 199, CEP 13560-900, Rio Claro, SP, Brazil

[2]Escritório de Licenciamento de Atividades de Petróleo e Nuclear,
Praça XV de Novembro, 42/90 A, Centro, CEP 20010-010, Rio de Janeiro, RJ, Brazil

[3]UEM-NUPELIA, Avenida Colombo, 5790, CEP 87020-900, Maringá, PR, Brazil

Correspondence to: Miguel Petrere Junior, Departamento de Ecologia, UNESP, C. P. 199, CEP 13560-900, Rio Claro, SP, Brazil, e-mail: mpetrere@rc.unesp.br

Received February 15, 2005 – Accepted April 5, 2005 – Distributed August 31, 2006

ABSTRACT

The income of small-scale fisheries of two urban reservoirs in Brazil: Represa Billings (127 km^2) located in the metropolitan region of São Paulo, the capital city of the state of São Paulo and Lago Paranoá (38 km^2) located in Brasília (DF), the capital city of Brazil were calculated and compared. Both fisheries are mainly based on the alien Nile tilapia *Oreochromis niloticus* (more than 80% of the total catch). Although these reservoirs are nearly 900 km apart, their native fish fauna belong to the Upper Paraná Province. The Represa Billings fishers have, on average, a daily profit of R$ 15.8 (U$ 8.4 mostly employing gill nets) and Lago Paranoá fishers R$ 46.6 (U$ 24.9, mostly employing cast nets), which is a statistically significant difference ($P < 0.001$). The profit of the fisheries is explained by the factor "reservoir" and covariate "days of fishing". Due to the increasing violence in the metropolitan region of São Paulo, the Represa Billings fishery is vanishing.

Keywords: small-scale fisheries, financial analysis, Represa Billings, Lago Paranoá, Brazil.

RESUMO

Avaliação da renda dos pescadores de pequena escala em dois reservatórios urbanos brasileiros: Represa Billings (SP) e Lago Paranoá (DF)

Neste artigo, foi calculada e comparada a renda média de pescadores de pequena escala, que operam em dois reservatórios urbanos no Brasil: na Represa Billings (127 km^2), localizada na região metropolitana da cidade de São Paulo, e no Lago Paranoá (38 km^2), localizado em Brasília (DF). Ambas as pescarias são baseadas em espécies exóticas, principalmente a Tilápia do Nilo, *Oreochromis niloticus* (mais de 80% das capturas). Os pescadores da Represa Billings têm um ganho médio diário de R$ 17,75 (U$ 8,4), empregando principalmente a rede-de-espera. Os pescadores do Lago Paranoá têm um ganho médio diário de R$ 46,58 (U$ 24,9), empregando principalmente a tarrafa. A renda dos pescadores de Brasília é estatisticamente superior à dos pescadores de São Paulo ($P < 0.01$). O lucro dessas pescarias é explicado pela natureza do reservatório (Paranoá ou Billings) e pelos dias de pesca. Devido ao aumento da violência na região metropolitana de São Paulo, as pescarias na Represa Billings estão desaparecendo.

Palavras-chave: pescarias de pequena escala, análise financeira, Represa Billings, Lago Paranoá, Brasil.

INTRODUCTION

Small-scale fisheries are common in inland waters (rivers, lakes and reservoirs). Reservoirs are man-made lakes with the primary purpose of storing water for power generation, flood control and water supply among others. Reservoir construction markedly modifies the original aquatic ecosystem interfering with all life forms. Dams obstruct the water flow causing permanent

flooding upriver and increasing water residence time. Sediment transport processes are replaced by sediment deposition. The new ecosystem has been considered intermediate between a river and a lake (Margalef, 1983; Tundisi, 1986).

Environmental changes resulting from a dam lead to considerable modifications in the structure of aquatic communities, originally adapted to the lotic habitat. The reservoir community results from the restructuring of the original river community mainly by local extinction and abundance alterations of most populations (Araújo-Lima *et al.*, 1995). The species that persist are those able to reproduce and feed in the new ecosystem (Fernando & Holcik, 1991) or in adjacent ecosystems such as an upstream floodplain (Agostinho, 1994). In Brazil, native and alien species from other river basins and from other continents constitute the fish fauna of large reservoirs (Agostinho, 1994; 1996; 1997; Agostinho *et al.*, 2000; Welcomme, 1988).

In many Brazilian areas, small-scale fisheries are the only source of protein for the poor (McGrath *et al.*, 1993; Cerdeira *et al.*, 2000), including urban areas with water bodies large enough to maintain harvestable fish populations, such as the reservoirs of Represa Billings in the city of São Paulo, Lago Pampulha, in Belo Horizonte and Lago Paranoá, in Brasília (Petrere, 1995).

The small-scale fisheries of Represa Billings (Paraná river basin) were described by Minte-Vera & Petrere (2000) based on a year round study (February/1996 to January/1997). The main species, which was caught, was the alien Nile tilapia *Oreochromis niloticus* (81.4% of the total landings in weight, 147,593.5 kg), followed by lambari *Astyanax eugenmanniorum* (13%), common carp *Cyprinus carpio* (2.4%), traira *Hoplias* aff. *malabaricus* (2.1%) and the saguirú *Cyphocarax modestus* (1.1%). Other species also landed such as bagre (catfish) *Rhamdia* sp, cascudo (armoured catfish) *Hypostomus* sp, acará *Geophagus brasiliensis*, Congo tilapia *Tilapia rendalli*. Its fish fauna belongs to the Upper Paraná Province (Bonetto, 1986), comparatively well studied in its middle and final stretches (Bonetto, 1986; Barrela & Petrere, 1994; Barrella & Petrere, 2003; Beaumord & Petrere, 1994; Agostinho & Julio, 1996; Britsk *et al.*, 1999). Minte-Vera (1997) estimated the fish production of Represa Billings at 63 kg ha^{-1} $year^{-1}$. This value is quite high when compared to other reservoirs of the Paraná basin, like Itaipú (11.6 kg ha^{-1} $year^{-1}$; Petrere, 1996), and low when compared to the Brazilian Northeastern dams (from 18 to 667 kg ha^{-1} $year^{-1}$; Petrere, 1995).

In Lago Paranoá, the cast net and gill net small-scale fisheries have been prohibited since 1966. The only legal fishery was the recreational hook-and-line fishery. The prohibition had no biological basis since the catches were almost exclusively of alien species such as tilapias and carps, and was most likely related to a security concern in the capital city during the military government. Albeit being an illegal activity, there were at least 100 families living exclusively from the Lago Paranoá's fisheries in the Federal District in 1985, where the city of Brasília is. According to the most experienced fishers, the annual production was around 200 t of fish in 1985 (48.08 kg ha^{-1} $year^{-1}$). The landings were totally consumed in the satellite towns around Brasília and the supply was below the demand. Fishers sold the fish to bar owners and middlemen or directly to consumers in street markets (Dornelles & Dias Neto, 1985; Walter, 2000).

Through snowball type interviews, Walter (2000) estimated that there were 55 active fishers in 1999 in Lago Paranoá all coming from the poorest neighborhood around the Federal District of Brasília. The annual catch was estimated at 39 kg ha^{-1} yr^{-1}, consisting mainly of Nile tilapia *Oreochromis niloticus* (84.9% of the 62.5 t total catch), followed by the common carp *Cyprinus carpio* (11.1%) and 4.1% of other species. Its fish fauna also belongs to the Upper Paraná Province (Ribeiro, 1994), although it has been less studied. The monthly income from the activity was on average U$ 238.7, but very variable among fishers (s = U$ 171.8, n = 22). In addition, each fisher hired three other people indirectly. Only 39.6% of the fishers were exclusively in fishery activities, a small percentage when compared to the fishers of the Represa Billings, but large when taking into consideration that the fishery was illegal, unregulated and unreported at that time.

The Represa Billings and Lago Paranoá are both located in large metropolitan cities, subject to pollution, conflicts concerning water use, disordered occupation of its basin, etc. Nevertheless the small-scale fisheries in these reservoirs supply the needs of the poor and are important sources of income and cheap protein. In both reservoirs, the main

captured species is the Nile tilapia. In the Represa Billings the fish is sold filleted to middlemen while in Lago Paranoá, it is sold raw and is mainly for the consumers. In addition, in Lago Paranoá the travel distances are shorter than in Represa Billings allowing for the use of non-motorized canoes. These aspects of fishing are likely to have an impact on the fisher's profit from both reservoirs. In this paper, we carried out a comparative analysis to highlight the factors that are important in defining the income in both reservoirs.

Financial data are not typically collected in a systematic way in small-scale fisheries. Although these fisheries are complex bio-socio-economic systems, most of the attention is always given to biological data, mainly due to the training of fishery biologists (Hilborn, 1985). Here we have calculated the costs, incomes and profits from two small-scale fisheries and use these data in a financial analysis in order to compare the two reservoirs.

MATERIAL AND METHODS

Study areas

Represa Billings

Represa Billings is located in the metropolitan region of São Paulo (23° 42' and 23° 45'' S, 46° 27' and 46° 22'' W), in the headstreams of the Tietê River, the main left bank tributary of the Paraná River in São Paulo state. It has an area of 127 km^2 and a total volume of 1228.7 x 10^6 m^3. It is divided into two compartments separated by a barrier (Pedreira with 112 km^2 and Rio Grande with 15 km^2). The mean depth is 10 m and the perimeter is about 900 km (Rocha, 1984). The average water residence time (AWRT) ranges between 50 to 100 days (CETESB, 1996). The reservoir was constructed with the purpose of storing water for hydropower generation for the city of São Paulo. The construction began in 1925 but only in 1950 was the reservoir prepared to reach its maximum quota (Macedo, 1992). A complex system of pumps, levees and dams let the water flow from the Tietê and Pinheiros rivers, which cross the city of São Paulo, to be reversed to the upstream Billings reservoir and further up to the Rio das Pedras reservoir. From there, the waters fall 740 m to the Henri Borden generator (880 MW, Abreu, 1990) into the city of Cubatão at sea level, in the foothills of Serra do Mar (Rocha, 1984).

Represa Billings has a long history of species which started in 1948 with the introduction of the common carp *Cyprinus carpio* (Rocha, 1984). In 1953, the Congo tilapia (or black tilapia as it is locally known) *T. rendalli* was introduced there (and for the first time in Brazil, Rocha *et al.*, 1985). This species quickly proliferated, becoming dominant. According to the local fishers, the Congo tilapia started to decline in 1984, when the Nile tilapia *Oreochromis niloticus* started to appear in the landings. There were also attempts of introducing native migratory species, without success (Minte-Vera, 1997). The present ichthyofauna is dominated by the alien Nile tilapia and followed by some native species, (Costa, 1998; Costa *et al.*, 1998) several of which are a target for the fishers (Minte-Vera & Petrere, 2000).

The professional fisheries in the Billings reservoir mainly consist of cast nets and gill nets in motor canoes made of wood or aluminum with engines from 2 to 30 HP, crewed by one or two fishers. The gill net may be used actively in a fishery locally known as *batida* (beating) where the fishers beat the water surface with a bamboo stick to guide the Nile tilapias towards the net (Minte-Vera & Petrere, 2000). The tilapias are also caught with cast nets. The lambari (*Astyanax eigenmaniorum, A. bimaculatus*), carp (*Cyprinus carpio)*, traíra (*Hoplias aff. malabaricus*) and sagüiru (*Cyphocarax modestus*) are caught with passive gill nets. Gill nets are set mainly overnight. Most of the fishers maintain an informal commitment of exclusivity with the middlemen (Minte-Vera *et al.*, 1997). Nile tilapia catches are higher in areas close to Pedreira Pumping Station (Minte-Vera, 1997). Besides professional fishing, a sport called ravine fishing is also practiced by thousands of recreational fishers.

Lago Paranoá

Lago Paranoá is located in the urban district of Brasília (15° 48' S and 47° 50' W), the capital city of Brazil. The reservoir was filled in 1959, when Brasília was being built. At that time, the construction of the reservoir was finished having the aims of increasing the relative air humidity, generating hydroelectric power, making a recreation area and a fish nursery, improving the landscape and disposing of sewage and rainwater (França *et*

al., 1964). Its hydrographic system belongs to the Paraná river basin and it receives the waters from River Paranoá, 5 main perennial tributaries and 21 small streams feed it. The reservoir area is 38 km^2, with a volume of 498 x 10^6 m^3, a mean depth of 13 m, a maximum depth of 40 m, and an AWRT of 299 days (Starling, 1998). Lago Paranoá's hydrographic basin has 1,046 km^2 and in 1986 its main uses were as a preservation area (41%), indefinite occupation (19%), urban occupation (18%), agriculture and livestock (8%), small farms (7%) and water surface (4%, Silva *et al.*, 1998). In spite of having a large preserved area, it joins a population of 500,000 inhabitants in its margins and sub-basins (mainly Riacho Fundo, Gama and Torto), who substantially contribute to pollution (Silva *et al.*, 1998).

In 1979, the Company of Water and Sewage of Brasília CAESB observed that phosphorous was the main limiting nutrient to the eutrophication process of the lake that was accelerated by receiving non-treated or inadequately treated sewage. Aiming to improve the water quality of the reservoir, two sewage treatment plants were built: ETE SUL that started operating in 1993 and ETE NORTE in 1994. After three years, Lago Paranoá showed signs of recovery (Starling, 1998). The health hazards posed by the consumption of the fish were evaluated in a multi-agency study in 1997 (ISDF/CAESB/UnB/IBGE, 1997). Heavy metal, organochlorine compounds and fecal coliform analyses were carried out in all fish species from the Lago Paranoá in several places, including the ones close to sewage discharges and the concentrations were all below the detection level.

Since the construction of the reservoir, several fish species were introduced in order to stock the reservoir and enhance the small-scale and recreational fisheries. Fish surveys done since 1959 have found viable populations of native and alien species with the dominance of Nile tilapia (*Oreochromis niloticus*), common carp, Congo tilapia (*Tilapia rendalli*), lambari (*Astianax* sp), acará (*Geophagus brasiliensis*), sagüirú (*Steindachnerina insculpta)*, traíra (*Hoplias aff. Malabaricus*), tucunaré (*Cichla* sp), (Dornelles & Dias-Neto, 1985; Grando, 1989; Starling, 1989; 1998; Lazzaro *et al.*, 1998; Lebourges-Dhaussy *et al.*, 1998).

The professional fisheries in Lago Paranoá mainly consist of cast nets and gill nets in rowing canoes, crewed by individuals or pairs of fishers. Fishers sometimes make their own equipment in order to reduce costs. The fishers come from different satellite-towns around Brasília. Some of these are outside the DF state, located in the state of Goiás. The landing places are scattered along the reservoir shores, however it is possible to determine four main areas of concentration of fishers: Vila da Telebrasília (an area which has illegally been invaded since 1956), Vila Paranoá (satellite-town close to the dam); around ETE SUL, used by fishers coming from the satellite town of Ceilândia) and around ETE NORTE. In 1999 there were 70 registered legal professional fishers. There is also a large number of sport fishers, mainly using hooks and lines.

Data collection

Data were collected using closed questionnaires, containing personal information (name, sex, age, education, non-fisheries income, number of residents in the dwelling, number of dependents, fishing experience in years), costs related to the fishing activity and to commercialization. The questionnaires were based on current methodology in social sciences successfully applied by IBAMA/DNOCS/GTZ (1992) in small-scale fisheries in NE Brazilian "açudes", where a fisher is initially interviewed and he/she is asked to introduce the scientist to another fisher, who takes her/him to another and so on, until all the available fishers are interviewed. This procedure is known as snowball. Two surveys were conducted in each reservoir, one in the rainy season and another in the dry season. In Represa Billings, the surveys took place on October 15 to 16, 1999 and July 15, 2000 and in Lago Paranoá, on October 10 to 29, 1999 and on July 26 to 30, 2000.

In addition to the interviews, a data collection system was implemented in order to obtain daily landing information. The system was in place from 15 October, 1999 to 15 January, 2000 and from 15 July, 2000 to 15 November, 2000 in both reservoirs. In Lago Paranoá, 17 fishers were included in the daily landing data collection and 12 in Represa Billings. The fishers were asked about the catch by species, equipment and craft used, and effort in hours. The information was used to estimate the fisher's income to detect the main species, the equipment type and quantity, as well

as the amount of fuel used for the boats (in Billings reservoir). Moreover, the prices of the equipment and boats were obtained from sellers and fishers.

Data analysis

After the surveys, data were stored in a database to calculate descriptive statistics. The formulae used for the computation of fisher's income, costs and profits, closely follows Ceregato and Petrere (2003).

We tested the hypothesis of equality of the mean profit per fisher for the two reservoirs using a two-tail t-test (Zar, 1996). The power of the test was also computed (Zar, 1996). We used a multiple regression analysis (Chatterjee & Price, 1991) to identify and quantify the social factors that influence the profitability of the fisheries.

Firstly, a list of some continuous or discrete (dummy) Xji variables that may be important in generating the profit for the i^{th} fisher (i = 1,2,…,f) were included in a multiple regression linear model:

The profit (Y_i) can be expressed as a linear combination of the social factors of the fishers:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + ... + \beta n X ni + \varepsilon_i$$

where:

Y_i - profit of the i^{th} fisher;

β_0, …, β_n parameters to be estimated using sum of squares;

ε_i - random variable assumed N ~ (0, σ^2).

RESULTS

Situation of the fisheries

The small-scale fishery in Represa Billings is in a process of disarray. In 1997, there were 100 active fishers (Minte-Vera *et al.*, 1997). In October, 1999, 52 fishers were interviewed, and only nine claimed they were still fishing in the reservoir. The others abandoned the activity or moved to Barra Bonita reservoir downstream (≅ 300 km). During the week, they fish in Barra Bonita and at weekends, return to the Represa Billings to stay with their families. The situation was so serious that the middlemen also moved down to Barra Bonita and the restaurants around Represa Billings sold fish which came from Barra Bonita. In the Colônia community (where there were six active fishers) the middleman reduced his visits from five to three times a week. The disarray was caused by an increase in the violence in the metropolitan area of São Paulo, mainly in the poor outskirts. The former largest fishing spot of Pedeira (Minte-Vera, 1997) is close to the Grajaú slum, a very violent area. We were told about the occurrence of armed robbery of fishers in canoes in order to steal the engines, resulting in the murder of one fisher. The nine active fishers moved to less productive fishing spots in areas close to their residences, affecting their profits negatively.

In the second survey in July 2000, the situation had become even worse. From the nine original fishers, only three were still active. The middlemen stopped buying fish and one of the fishers sold the fish straight to the consumers. The fish was being sold cheaper than in the previous survey (R$ 2.80 a kilo of tilapia filet, instead of R$ 3.00). However, one of the three fishers started to sell it close to his residence for R$ 4.00 the kilo.

In Lago Paranoá, there were only 6 active fishers in November 1999. This situation was mainly due to the activity still being illegal and the prohibition being efficiently enforced by the police (Walter, 2000). In February 2000, the professional fishery with cast nets was legalized. In spite of this, in July, 2000 there were only 11 active fishers, mainly because of the occurrence of a very cold winter (Walter, 2000). Some of the interviewed fishers continued to fish illegally with gill nets: four fished exclusively with gill nets, four fished exclusively with cast nets and three with both types of equipment.

Socioeconomic aspects of the fishers

Among 29 fishers interviewed, just 3 were female, all in Represa Billings. The age varied between 22 and 68 years, with an average of 42.5 years (n = 29, s = 12.7), and 27.6% are illiterate. From the interviewees, 62.1% were married. However, Minte-Vera *et al.* (1997) and Walter (2000) point out that in both reservoirs it is common that the fishers do not differentiate between marriage and cohabitation. In several situations, there could be more residents in the dwelling than just the fishers and their dependents, since some may not have enough financial autonomy to live in separate houses.

Fishing

The small-scale fisheries in both reservoirs are mainly based on Nile tilapia. However, in the Represa Billings the fishers also capture lambaris and sagüirus. In both reservoirs, fishers use active (*batida*) and passive gill nets and cast nets. Fishers work alone or in pairs in small canoes. When in pairs, fishers share expenses or hire an assistant paying a fixed salary or 30% of the catch. Some fishers have their children, husbands or wives as crew, concentrating the income inside the family. However, the main family participation is in the fish processing and commercialization, with 31% of the relatives helping in both processes.

On average, the fishers of Represa Billings fish for 4.5 days a week (s = 1.5) and those at Lago Paranoá's fish for 5.4 days a week (s = 0.8). Extrapolating this information for a year, the reservoirs are not statistically different (Represa Billings: mean = 234.6, n = 12, s = 75.4; Lago Paranoá: mean = 279.1, n = 17, s = 41.0, t = 1.89, $P > 0.05$). The experience of the fishers in years can be one of the factors that explain differences in the profit. The average years of experience of Lago Paranoá's fishers is 28 (n = 17, s = 14.2 years) and significantly higher than that of the Represa Billings which is 17.8 years (n = 12, s = 8.6, t = 2.21, $0.01 < P < 0.05$). Aiming to assess whether fishing is sufficient in order to maintain the fisher and the family, two other factors are important: whether the families have another source of income and if there is a period with no harvests (*entressafra*). Among the 29 interviewees, 13 families have another source of income besides fishing. On average, these fishers have an "extra" income of R$ 410.9 (s = R$ 352.5), ranging between R$ 136.00 and R$ 1500.00. Minte-Vera (1997) and Walter (2000) did not observe an *entressafra* in either reservoir.

Costs

The costs of fishing mainly result from expenses with canoes and the engine, fishing equipment and its maintenance and fuel. In the Represa Billings, the boats are built of wood or aluminum, with an average length of 5.4 m, which are more expensive but last more (Table 1). In Lago Paranoá, the boats are exclusively made of plywood, with an average length of 3.8 m which are less expensive and durable (Table 1). In Represa Billings, the canoes of all but one fisher are powered by an engine and in Lago Paranoá none of the canoes have engines. The main cost of the engine is its acquisition and fuel, which in general is bought from the middlemen. During the data collection period, the average monthly exchange rate was 1 U$ = R$ 1.9695 in October/1999, R$ 1.9299 in November/1999, R$ 1.8428 in December/1999, R$ 1.8037 in January/2000, R$ 1.7978 in July/2000, R$ 1.8092 in August/2000, R$ 1.8392 in September/2000, R$ 1.8796 in October/2000 and R$ 1.9480 in November/2000 (average for the period 1 U$ = R$ 1.87).

Fuel consumption was estimated to be on average 2.16 liters for a trip (s = 0.9, n = 12; R$ 1.50 liter^{-1}). The average cost of an engine was about R$ 2066.7 (s = R$ 1025, n = 12). Its price varied according to its power and the degree of depreciation when acquired (it is common for fishers to buy second hand engines). An engine lasts on average 12.2 years (s = 7.3, n = 12).

The two reservoirs present differences in the acquisition and maintenance of the equipment. In

TABLE 1

Costs (R$) and lifetime of a canoe (n = 30). During the data collection period the average monthly exchange rate was 1 U$ = R$ 1.9695 in October/1999, R$ 1.9299 in November/1999, R$ 1.8428 in December/1999, R$ 1.8037 in January/2000, R$ 1.7978 in July/2000, R$ 1.8092 in August/2000, R$ 1.8392 in September/2000, R$ 1.8796 in October/2000 and R$ 1.9480 in November/2000 (average for the period 1 U$ = R$ 1.87).

	Cost (R$)			Duration (years)		
Boat	**Aluminum**	**Wood**	**Plywood**	**Aluminum**	**Wood**	**Plywood**
Minimum	1500.00	350.00	40.00	1.5	1.5	0.5
Maximum	2500.00	700.00	100.00	10	4	6
Mean (sd)	1862.50 (449.77)	438.34 (129.68)	87.81 (27.14)	8.25 (5.3)	2.6 (1.1)	1.67 (1.4)

both reservoirs, there are three different strategies to obtain fishing equipment: i) the equipment is bought at the local market; ii) the raw materials are bought at the local market, but the equipment is handmade by the fisher himself and; iii) the raw material is bought by the fisher who pays somebody else to make the equipment. A similar situation is observed for equipment maintenance: i) it is done by the fisher himself/herself; ii) the fisher hires somebody to do it; iii) no maintenance at all is carried out. According to the strategy adopted, the costs will vary from one fisher to another.

As we already mentioned, fishers in both Represa Billings and Lago Paranoá reservoirs use gill nets and cast nets. However, in Represa Billings it is common for the fishers to have a larger amount of extra equipment, unlike Lago Paranoá, where fishers have exactly what they use on a daily basis. In the first case, we considered the average length of the gill nets used daily to calculate the expenses. The cast net is sometimes used in Represa Billings. However, it is the only equipment allowed by the legislation in Lago Paranoá. Its cost is highly variable due to the fact that some fishers make it and others buy it (Table 2).

Other costs may result from commercialization or from expenses related to transport. Taking this into consideration, there are differences between the two reservoirs. In Represa Billings, the main product is the filleted tilapia and acará, followed by raw lambari and saguirú, sold raw. The fillets are wrapped in Styrofoam trays and sold to the middlemen (who usually supply the trays). To produce a kilo of fillet, four kilos of raw fish are necessary (Minte-Vera, 1997). In Lago Paranoá, the fish is eviscerated and sold to the consumers by kilo or in fish strings of 1 or 2 kg, and to the middlemen, in cans or by kilo. A can contains, on average, 13.80 kg of fish (Walter, 2000). The fish sold to consumers incurs other expenses on ice (on a lesser scale), the rent of a tent in the market and transportation. A third expense in Lago Paranoá is related to transport from their homes to the reservoir, since the fishers live far from the reservoir. Out of the 17 interviewees, 12 fishers reported expenses on bus tickets. Three reported expenses on fuel for their cars. On average, they spent R$ 6.2 day^{-1} on transport (n = 15, s = R$ 5.1), varying from R$ 3.00 to R$ 25.00. Five fishers rented a tent in the street market, with a weekly cost of on average R$ 1.4 (n = 5, s = R$ 1.3).

Income

The income is the result of the total catch excluding the consumption and donations multiplied by the price of the fish. In the studied period, the total catch was 40,240 kg (Table 3) and the total comsumption/donation was 199 $kg.week^{-1}$. In represa Billings, the main commercial species were alien tilapias (51.2%) and the natives acará (33.3%), lambari (10.5%) and saguirú (2.7%). Other species correspond to 2.3%. In Lago Paranoá,

TABLE 2

Gill nets cost (in R$/month) and cast nets cost (R$) and their duration (in days). When the data was collected, the average monthly exchange rate was 1 U$ = R$ 1.9695 in October/1999, R$ 1.9299 in November/1999, R$ 1.8428 in December/1999, R$ 1.8037 in January/2000, R$ 1.7978 in July/2000, R$ 1.8092 in August/2000, R$ 1.8392 in September/2000, R$ 1.8796 in October/2000 and R$ 1.9480 in November/2000 (average for the period 1 U$ = R$ 1.87).

	Cost		Duration	
	Billings	**Paranoá**	**Billings**	**Paranoá**
Gill nets				
Minimum	0.70	0.75	90	124
Maximum	2.60	3.00	1095	365
Mean (s)	1.40 (0.55)	1.78 (0.59)	546 (292.6)	337 (80.)
Cast nets				
Minimum	70.00	50.00	60	29
Maximum	150.00	160.00	1278	548
Mean (s)	117.50 (28.32)	106.47 (41.52)	371.2 (434.8)	191.7 (143.1)

the main species are the alien tilapias (90.9%) and carp (8.9%). Other species correspond to 0.2%. The market price varies according to the fish species and the sale type (wholesale and retail), as well as the reservoir (Table 4).

Profit

Lago Paranoá's fishers have on average a daily profit of R$ 46.6 (sd = 24.9, n = 12) while Represa Billings's fishers have a profit of only R$ 15.75 (sd = 24.7, n = 17,). The high profit in Lago Paranoá is clear, since the intervals do not overlap ($t = 44{,}90^{**}$, df =27, with a retrospective power (Thomas, 1997) higher than 0.99 for $\alpha = 0.01$). Furthermore, in Represa Billings one fisher was interviewed, who we later discovered (after having calculated it) had a loss not a profit! Minte-Vera & Petrere (2000) point out that in Represa Billings, there are two types of fishers: the first group that catches tilapias exclusively, with beat gill net fishing and the second one that also fishes for lambaris, sagüirus and traíra with gill nets, catching tilapias in a smaller proportion. According to the authors, the first group catches more, however only one fisher from this group was interviewed during the surveys, showing an extreme profit when compared to the others. Finally, we calculated the monthly profit of the fishers multiplying the daily profit by the number of days of the month that they were active for both seasons (Table 5).

Factors that influence the fishers´ profit

To analyse the profits, a multiple linear exploratory regression model was initially considered with the following variables: dummies – sex, marital status, fishing period (dry or rainy), fishing equipment, kind of partnership (partner/assistant), reservoir (Billings or Paranoá); continuous variables - number of dependents, years of experience, other sources of income, formal education and days of fishing. The variables: fishing equipment and kind of partnership are not orthogonal. Therefore, three out of four possibilities were considered: fishing alone (yes = 1, no = 0),

TABLE 3
Total landings (kg) for both periods and reservoirs.

	Rainy season		Dry season	
	Billings	**Paranoá**	**Billings**	**Paranoá**
Tilápia *Oreochromis niloticus* (fillet)	465.6	0	956.7	0
Tilápia (raw fish or per string)	360.0	3963.6	136	9484.0
Tilapia (cans)	0	379.5	0	501.5
Carp *Cyprinus carpio* (kg)	50	440	137.65	1477.4
Carp (cans)	0	42.2	0	2
Acará *Geophagus brasiliensis* (filet)	431.2	0	446.0	0
Acará (raw)	241.5	0	272.5	0
Sagüiru (Billings) *Cyphocarax modestus* (raw); Sagüiru or saúba (Paranoá) *Steindachnerina insculpta*;	309.5	0	10	0
Lambari *Astyanax* spp (raw)	537	0	735	0
Manjuba (this species was just cited by the fishers to our data collector. None of us ever saw a single specimen) (raw)	0	0	13	0
Pirambóia *Synbranchus marmoratus* (raw)	2	0	0	0
Traíra *Hoplias* aff. *malabaricus* (raw)	7.5	0	38	34.2
Bagre *Rhamdia* sp (raw)	5	0	19	0
Total corrected per kg of non-eviscerated fish *	5099.6	10224.0	6972.0	17944.0
Number of fishers	5	5	3	10
Number of months	3	3	4	4
Catch Fisher^{-1} month^{-1}	340.0	681.6	581.0	448.6

*Corrections based on Minte-Vera (1997) and Walter (2000).

TABLE 4
Average price (R$) of the fish marketed at Represa Billings and Lago Paranoá (n = 29). When the data was collected, the average monthly exchange rate was 1 U$ = R$ 1.9695 in October/1999, R$ 1.9299 in November/1999, R$ 1.8428 in December/1999, R$ 1.8037 in January/2000, R$ 1.7978 in July/2000, R$ 1.8092 in August/2000, R$ 1.8392 in September/2000, R$ 1.8796 in October/2000 and R$ 1.9480 in November/2000 (average for the period 1 U$ = R$ 1.87).

	Billings		Paranoá				
	Wholesale		Wholesale		Retail		
Species	Filet (kg)	Raw fish (kg)	Raw fish (kg)	Cans	Raw fish (kg)	Strings (1 kg)	Strings (2 kg)
Tilapia	3.22	1.30	1.54	18.00	2.70	2.25	5.00
Acará	3.12	0.67	-	-	-	-	-
Carp	-	2.00	1.70	18.00	2.60	-	-
Lambari	-	2.00	-	-	-	-	-
Saguirú	-	0.75	-	-	-	-	-
Bagre	-	1.83	-	-	-	-	-
Traíra	-	1.90	-	-	-	3.50	-
Tucunaré	-	-	-	-	-	4.50	-

TABLE 5
Fishers´ profit (R$) per month in Represa Billings and Lago Paranoá. When the data was collected, the average monthly exchange rate was 1 U$ = R$ 1.9695 in October/1999, R$ 1.9299 in November/1999, R$ 1.8428 in December/1999, R$ 1.8037 in January/2000, R$ 1.7978 in July/2000, R$ 1.8092 in August/2000, R$ 1.8392 in September/2000, R$ 1.8796 in October/2000 and R$ 1.9480 in November/2000 (average for the period 1 U$ = R$ 1.87).

	Billings			Paranoá		
	Rainy season	Dry season	Both seasons	Rainy season	Dry season	Both seasons
Mean	416.69	185.23	353.57	1069.95	1050.70	1058.19
Standard deviation	662.10	169.55	569.48	817.76	427.18	580.88
CV	1.59	0.92	1.61	0.76	0.41	0.55
Minimum	- 9.96	0.03	- 9.96	152.25	332.10	152.25
Maximum	2005.23	332.82	2005.23	2370.90	2842.16	2842.16
N	9	3	12	6	11	17

fishing with relatives (yes = 1, no = 0), fishing in partnership (yes = 1, no = 0), fishing with an assistant (yes = 1, no = 0). The variable: fishing equipment was also separated into three levels: cast net, gill net and beat fishing, only two were included in the model simultaneously.

The variable: formal education was transformed into ranks (Zar, 1996), where: Illiterate = 1, < 4 years of study = 2, 4 years = 3, > 4 and < 8 years = 3, 8 years = 4, > 8 and < 12 years = 4.

The full model is:

Profit = constant + sex + marital status + fishing period + fishing equipment + kind of partnership + reservoir + number of dependents + years of experience + other sources of income + formal education + days of fishing.

The residuals of this model presented heterogeneity of variance. Therefore, asquare rooth transformation in the response variate (Profit) was applied.

The adjusted final (minimum) model was:

- $(\text{Profit})^{0.5}$ = 0.06 + 3.56* reservoir + 0.01* days of fishing; and
- where reservoir: Paranoá = 1; Billings = 0; n = 28, $R^2 = 0.642$; $F_{2,25} = 22.4^{**}$.

So, the new residual analysis did not detect any violations of the usual assumptions of a linear model.

DISCUSSION

As explained, the fishers in both reservoirs are not organized, and fishing is unregulated. In spite of

this, the activity supplies fishers´ needs of income and protein. In both reservoirs, fishing is practised by the poor population, as previously shown by Minte-Vera *et al*. (1997) and Walter (2000). In Lago Paranoá, the catch is exclusively of Nile tilapia, in contrast to Represa Billings's, where fishers use strategies to catch other species, mainly the lambari and the saguirú apart from the main species, Nile tilapia.

The profit of Lago Paranoá's professional fishers is far higher than the profit from the Represa Billings fishers. This difference can be explained by several factors: i) the use of cheaper canoes, with no engine and thus no fuel expenses by the Paranoá's fishers; ii) less fishing effort due to shorter fishing trips and lower investment; iii) direct commercialization to the final buyer in Lago Paranoá, where the raw and eviscerated fish from Lago Paranoá have similar prices to Represa Billings, which are the most appreciated filleted fish.

However, Lago Paranoá is smaller (38 km^2) than Represa Billings (127 km^2), with countless accesses, which facilitates small displacements and use of rowing canoes. Another factor that explains the presence of cheaper canoes with no engines in Lago Paranoá was the illegality of fishing from 1966 to 1999, with a great risk of the craft (and fishing equipment) being confiscated by the police. When fishing was legalized in December, 1999 this tended to change, so much so that nowadays there are already fishers acquiring engines. The increase in fishing can mean more income, but its higher cost can reduce their profit. Furthermore, in Represa Billings there is a need to use more equipment on each fishing trip, increasing the cost of equipment maintenance and replacement.

A second consideration is the commercialization strategy of the fishers. In Represa Billings, the fish is filleted, which makes it easier to be sold. There is also a strong link to the middlemen, necessary due to the isolation where the fishers of the Colônia community live that hinders them selling it directly and which in turn could increase the income, if the fishers could sell it at the landing place. This is unlikely since the landing places are isolated and far from potential markets.

The profit in both reservoirs, in spite of the disarray of both fisheries, is high when compared to other fisheries. Ceregato & Petrere (2003) when comparing the profit of small-scale fisheries in the Urubupungá complex of reservoirs in the river Paraná downstream, found average daily profits of R$ 13.2 (U$ 11.3 as 1 U$ = R$ 1.1628 in July/98) (s = 25.4) for the reservoirs of Ilha Solteira (SP) and Jupiá (SP), of R$ 4.1 (U$ 3.5) (s = 21.3) for the Paraná river and of R$ 1.5 (U$ 1.3) (s = 35.1) for downstream Porto Primavera dam, in the dry period. In the rainy period, the daily profit was: R$ 19.5 (U$ 10.2 as 1 U$ = R$ 1.9231 in February/99) (s = 37.4) for the reservoirs of Jupiá and Ilha Solteira, R$ 12.9 (U$ 6.7) (s = 46.0) for the Paraná River between these reservoirs and Porto Primavera and R$ 23.0 (U$ 11.97) (s = 29.2) below the dam. Cetra & Petrere (2001)) calculated the daily income of fishers from the Tocantins River at US $2.00. Okada *et al.* (1997) calculated the daily income of the fishers of two reservoirs in the Iguaçú River at US $12.00. The monthly profit of fishing in the Itaipú reservoir is US $25.00 (Agostinho *et al.*, 1994).

In the present study, the profitability of the fishery is mainly explained by its context, *i.e.* by the reservoir where it is carried out and by the number of days of fishing. Ceregato & Petrere (2003), when studying Rio Paraná's professional fishers, observed that the profit could be explained also by other variables such as formal education and type of fishing equipment.

Fisheries are complex bio-socio-economic systems, but they are mainly studied only in biological aspects. Financial data are important to understand fishers´ behavior as well as motivations and thus to assess how management policies affect them.

Economic fishery information has been seldom collected, even in highly industrialized large-scale fisheries due to the lack of tradition and poor training in the subject by fishery biologists. This information is usually not taken into consideration for management purposes or in order to give bank credit to a fisher when he/she applies for it trying to improve his/her technology. It can be observed in this paper that this aim is not difficult to attain, as most of the necessary information has been obtained just by interviewing the fishers about their daily activities and the financial analysis carried out is arithmetic. Therefore this study together with Agostinho *et al.* (1994) and Ceregato & Petrere (2003) is another example of applying financial analysis on two small-scale fisheries where a lot

of the economic agreements are informal and thus official statistics are difficult to obtain. In view of the results here, it is not difficult to assess the adoption of different stock management strategies in order to increase fishers´ income and hopefully protect the fish stock.

Acknowledgments — We are grateful to the fishers from Lago Paranoá and Represa Billing for their willingness to participate in this study. To Sônia Aparecida Medina, Wadson and Roseane Ramos Feijão for the their work in the landing data collection, Manoel David de Souza Jr, Dr. Fernando Starling and Dr. Mauro Ribeiro for field support. Funding for this project was provided by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) Fundação de Amparo a Pesquisa do Estado de São Paulo (FAPESP - Grant # 98/10.060-9), UNESP and UEM.

REFERENCES

ABREU, R. M., 1990, Estratégia para despoluir as águas da Billings. *Ambiente, 4*(1): 36-43.

AGOSTINHO A. A., 1994, Pesquisas, monitoramento e manejo da fauna aquática em empreendimentos hidrelétricos. *In: Seminários sobre fauna aquática e o setor elétrico brasileiro.* Caderno I, Fundamentos. Rio de Janeiro, COMASE/ELETROBRÁS.

AGOSTINHO A. A., 1996, O lado oculto da introdução de peixes. *Boletim Informativo da Abrapoa, 7*(9): 1-9.

AGOSTINHO, A. A., 1997, Biodiversidade em águas interiores: introdução de espécies. *Boletim da Sociedade Brasileira de Ictiologia, 4:* 11.

AGOSTINHO A. A., OKADA E. K. & GREGORIS J.,1994, Caracteristicas economicas y sociales de las actividades pesqueras en el Embalse de Itaipu, Brasil. *In*: *Simposio Regional sobre Manejo de la Pesca en Embalses en America Latina, 24 al 28 oct 1994, 100p, Habana, Cuba*. FAO, Rome.

AGOSTINHO A. A. & JÚLIO JR. H. F., 1996, Ameaça ecológica: peixes de outras águas. *Ciência Hoje. 21*(124): 36-44.

AGOSTINHO, A. A, JÚLIO, JR. H. F. & TORLONI, C. E. C., 2000, Impactos causados pela introdução e transferência de espécies aquáticas: uma síntese. pp. 59-75. *In*: J. E. P. Cyrino, J. C. Moura, A. C. Caseiro & A. M. B. M. Sampaio (eds.), *Anais VIII Simpósio Brasileiro de Aqüicultura*. FEALQ, Piracicaba, Brazil.

ARAÚJO-LIMA, C. A. R. M., AGOSTINHO, A. A. & FABRÉ N. N., 1995, Trophic aspects of fish communities in Brazilian rivers and reservoirs. *In:* J. G. Tundisi, C. E. M. Bicudo & M. Matsumura-Tundisi (eds.), *Limnology in Brazil*. Academia Brasileira de Ciências, Sociedade Brasileira de Limnologia, Rio de Janeiro.

BARRELLA, W. & PETRERE, M., 2003, Fish community alterations due to pollution and damming in Tietê and Paranapanema rivers (Brazil). *River Res. Applic., 19*: 59-76.

BARRELLA, W. & PETRERE, M., 1994, The influence of environmental factors on fish community structure in the Jacaré Pepira River, Brazil. *In*: I. G. Cowx (ed.), *Rehabilitation of Freshwater Fisherie*. Fishing News Books, Bodman, UK.

BEAUMORD, A. C. & PETRERE, M., 1994, Fish communities of Manso river, Chapada dos Guimarães, MT, Brazil. *Acta Biologica Venezuelica, 15*(2): 21-35.

BONETTO, A. A., 1986, The Paraná River system. *In*: B. R. Davies & K. F. Walker (eds.), *The Ecology of River Systems*. Dr. W. Junk Publishers, Dordrecht.

BRITSK, H. A., DE SILIMON, K. Z. S. & LOPES, B. S., 1999, *Peixes do Pantanal. Manual de Identificação*. EMBRAPA, Brasília.

CERDEIRA, R. G. P., RUFFINO, M. L. & ISAAC, V. J., 2000, Fish catches among riverside communities around Lago Grande de Monte Alegre, Lower Amazon, Brazil. *Fisheries Management and Ecology, 7*: 355-374.

CEREGATO, S. A. & PETRERE, M., 2003, Financial comparisons of the artisanal fisheries in urubupungá complex in the middle paraná river (Brazil). *Braz. J. Biol, 63*(4)*:* 673-682.

CETESB, 1996, *Avaliação do complexo Billings*: comunidades aquáticas, água e sedimento (out. 92 - out. 93). Unpublished Report, 27p.

CETRA, M. & PETRERE, M., 2001, Small-scale fisheries in the middle River Tocantins, Imperatriz (MA), Brazil. *Fisheries Management and Ecology, 8*: 153-162.

CHATTERJEE, S. & PRICE, B., 1991, *Regression Analysis by Example*. John Wiley, New York.

COSTA, M. P., 1998, *A Ictiofauna Como Indicadora da Qualidade Ambiental do Complexo Billings.* São Paulo. Instituto de Biociências, Universidade de São Paulo, São Paulo, Brasil, MSc Dissertation, 134 pp + annexes.

COSTA, M. P., CARVALHO, P. S. M., MARTINS, M. C., FERNANDES, A. J., RODRIGUES, P. F. & VARGAS-BOLDRINI, C., 1998, Contamination and community structure of fishes from Billings reservoir, São Paulo, Brazil. *Verh. Internat. Verein. Limnol., 26*: 2215-2219.

DORNELLES, L. D. C. & DIAS-NETO, J., 1985, Sugestão para uma exploração racional do Lago Paranoá. *Encontro dos Engenheiros de Brasília, 15 to 18 of May 1985*, 6p.

FERNANDO, C. H., & HOLCIK, J., 1991, Fish in reservoirs. *Int. Revue ges. Hydrobiol., 76*: 149-167.

FRANÇA, V. C., GURGEL, J. J. & BRAGA, R. A., 1964, *Exame biológico-pesqueiro do Lago "Israel Pinheiro"*. (Brasília, Brasil). Unplished Report to DNOCS, pp. 35-53.

GRANDO, J. V., 1989, *Considerações Sobre o Estágio Larval da Ictiofauna e Aspectos Alimentares de Quatro Espécies de Peixe do Lago Paranoá*. Brasília, DF. Brasília, Universidade de Brasília, MSc Dissertation, 115p.

HILBORN, R., 1985, Fleet dynamics and individual variation: why some people catch more fish than others. *Canadian Journal of Fisheries and Aquatic Sciences, 42*: 2-13.

IBAMA/DNOCS/GTZ, 1992, *Técnicas para um Diagnóstico Rural Rápido voltado para Comunidades Pesqueiras*. Documento Nº 4, Projeto Aproveitamento Pesqueiro dos Açudes do Estado do Ceará, PAPEC, Fortaleza (CE), 40p.

ISDF/UnB/CAESB/IBGE., 1997, *Avaliação da Qualidade Sanitária do Pescado do Lago Paranoá* (Brasília - DF). Final Report to Fundação de Apoio à Pesquisa do Distrito Federal (FAPDF), Brasília (DF), 120p.

LAZZARO, X., GRANDO, J., RIBEIRO, M. C. L. B., RIBEIRO FILHO, R. A., MATA, M., ARAÚJO, A. T. P. & VASCONCELOS, S., 1998, Serviço de Levantamento Hidroacústico (Ecossondagem) no Lago Paranoá: Calibração pela pesca Experimental com Redes de Emalhar. pp. 24-49. *In*: *Serviço de Levantamento Hidroacústico (Ecossondagem) do Lago Paranoá.* Brasília, DF. Fundação Sustentabilidade e Desenvolvimento, Final Report, Brasília (DF), Brazil.

LEBOURGES-DHAUSSY, A., DHAUSSY, P. & LAZZARO, X., 1998, Serviço de Levantamento Hidroacústico (Ecossondagem) no Lago Paranoá: Avaliação do Estoque Pesqueiro por Ecossondagem. pp. 50-70. *In*: *Serviço de Levantamento Hidroacústico (Ecossondagem) do Lago Paranoá,* Brasília, DF. Fundação Sustentabilidade e Desenvolvimento, Final Report., Brasília (DF), Brazil.

MACEDO, T., 1992, *Billings Viva! Secretaria de Educação, Cultura e Esportes*. Prefeitura do Município de São Bernardo do Campo, São Bernado do Campo, 12p.

MARGALEF, R., 1983, *Limnologia.* Barcelona, Omega.

McGRATH, D. G. F., CASTRO, F., FUTEMMA, C., AMARAL, B. D. & CALABRIA, J., 1993, Fisheries and evolution of resource management on the Lower Amazon floodplain. *Human Ecology, 21*: 167-195.

MINTE-VERA, C. V., 1997, *A Pesca Artesanal no Reservatório Billings* (São Paulo). Instituto de Biologia, Universidade Estadual de Campinas, Campinas, Brasil, MSc Dissertation, 86p.

MINTE-VERA, C. V, CAMARGO, S. A. F., BUBEL, A. P. M. & PETRERE, M., 1997, Artisanal fisheries in an urban reservoir. *Brazilian Journal of Ecology, 1:* 143-147.

MINTE-VERA, C. V. & PETRERE, M., 2000, Artisanal fisheries In urban reservoirs: a case study from Brazil (Billings Reservoir, São Paulo Metropolitan Region). *Fisheries Management and Ecology, 7*: 537-549.

OKADA, E. K., GREGORIS, J., AGOSTINHO, A. A. & GOMES, L. C., 1997, Diagnóstico da pesca profissional em dois reservatórios do rio Iguaçu. pp. 293-318. *In*: A. A. Agostinho & L. C. Gomes. *Reservatório de Segredo: Bases Ecológicas para o Manejo*. Editora da Universidade de Maringá, Maringá.

PETRERE, M., 1995, A pesca de água doce no Brasil. *Ciência Hoje, 19*(110): 28-33.

PETRERE, M., 1996, Fisheries in large tropical reservoirs in South America*. Lakes and Reservoirs: Research and Management, 2*: 111-133.

RIBEIRO, M. C. L. B., 1994, *Conservação da Integridade Biótica das Comunidades de Peixes do Ribeirão Gama APA Gama - Cabeça de Veado Distrito Federal*. UNESP, Rio Claro, Brasil PhD Thesis, 373p.

ROCHA, A. A., 1984, *A Ecologia, os Aspectos Sanitários e de Saúde Pública da Represa Billings na região metropolitana de São Paulo*. Uma contribuição a sua Recuperação. Universidade de São Paulo, Faculdade de Saúde Pública, São Paulo, Brazil, PhD Thesis*,* 166p.

ROCHA, A. A, PEREIRA, D. & PÁDUA, H. B., 1985, Produtos de pesca e contaminantes químicos na água da represa Billings, São Paulo (Brasil). *Rev. Saúde Pública, 19*: 401-410.

SILVA, M., CAVALCANTI, C. G. S., CORDEIRO, A. & CAMPELO, R. E., 1998, *Diagnóstico Simplificado da Situação do Lago Paranoá.* Grupo de Gerenciamento *Costeiro do Lago Paranoá*, 17p.

STARLING, F. L. R. M., 1989, *Estudo Experimental dos Impactos de Peixes Planctófagos sobre a Comunidade Planctônica e a Qualidade de Água no Lago Paranoá*. Brasília, DF. Brasília, Universidade de Brasília, Msc dissertation, 250p.

STARLING, F. L. R. M., 1998, *Development of Biomanipulation Strategies For The Remediation Of Eutrophication Problems In An Urban Reservoir*. Lago Paranoá, Brazil. University of Stirling, PhD Thesis, 159p.

THOMAS, L., 1997, Retrospective power analysis. *Conservation Biology, 11*(1): 276-280.

TUNDISI, J. G., 1986, Limnologia de represas artificiais. *Boletim de Hidráulica e Saneamento, 11*: 46.

WALTER, T., 2000, E*cologia da Pesca Artesanal no Lago Paranoá.* Brasília, DF. Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, Brasil, MSc Dissertation*,* 227p.

WELCOMME, R. L., 1988, International Introductions of Inland Aquatic Species. *FAO Fisheries Technical Paper*, *294*: 318.

ZAR, J. H., 1996, *Biostatistical Analysis* (3rd. ed.), Prentice Hall, NJ, 662p.