The small-scale urban reservoir fisheries of Lago Paranoá, Brasília, DF, Brazil

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(With 4 figures)

Abstract

In many cases in large urban centers, which have appropriate waterbodies, small-scale fisheries are the only source of cheap protein for the poor. In Lago Paranoá, located in Brasília, the capital city of Brazil, fishing was studied by conducting interviews with 53 fishers filling in logbooks from March, 1999 to March, 2000 in three fishing communities. The fishers come from the poorest towns around Brasília, known as satellite-towns. They have been living there on average for 21.7 years (s = 9.6 years), their families have 4.9 members (s = 3.6) on average and 44.2% do not have a basic education. However, such characteristics are similar to the socioeconomic indices of the metropolis where they live. In spite of being illegal between 1966 and 2000, fishing generated an average monthly income of U$ 239.00 (s = U$ 171.77). The Nile Tilapia *Oreocrhromis niloticus* is the main captured species (85% of a total number of landings in weight of 62.5 t.). Fishing is carried out in rowing boats, individually or in pairs. The fishing equipment used are gillnets and castnets. Gillnets were used actively, whereby the surface of the water is beaten with a stick to drive Tilapias towards nets as they have the ability to swim backwards. This fishing strategy was used in 64.7% of the fisheries, followed by castnets (31.1%) and by gillnets which were used less (4.2%). The fish is sold directly in the streets and fairs of the satellite-towns to middlemen or to bar owners. Three communities have different strategies in terms of fishing equipments, fishing spots and commercialization. Consequently, there are statistically significant differences in relation to the monthly income for each one of these communities.

Keywords: Inland small-scale fishery, urban reservoir fisheries, fishing income, Lago Paranoá, Brasília, Brazil.

A pesca de pequena escala no Lago Paranoá Brasília, DF, Brazil

Resumo

Em muitos centros urbanos, com corpos d´água apropriados, as pescarias de pequena escala são a única fonte de proteína barata para os pobres. No Lago Paranoá, localizado em Brasília, a atividade pesqueira foi estudada através de entrevistas com 53 pescadores que vivem em cidades satélites, de Março/1999 a Março/2000, em três comunidades pesqueiras. Nesse período os pescadores viviam nas cidades satélites em média há 21,7 anos (s = 9,6 anos), com famílias de 4,9 membros (s = 3,6) e 44,2% deles não possuíam instrução mínima. Entretanto, suas condições são semelhantes aquelas apontadas pelos indicadores socioeconômicos das áreas onde residem. A pesca, embora clandestina de 1966 a 2000, gerou um rendimento médio de U$ 239,00 (s = U$ 171,77). A tilápia do Nilo *Oreochromis niloticus* foi a principal espécie capturada (85% de um rendimento total em peso de 62,5 t). As pescarias foram realizadas em canoas a remo, individualmente ou em duplas. As artes empregadas foram a malhadeira e a tarrafa. A malhadeira foi empregada de modo ativo sob a forma de batida, onde se bate na água com um bastão para afugentar as tilápias em direção às redes. Essa estratégia foi empregada em 64,7% das pescarias, seguida pela tarrafa (31,1%) e pela malhadeira empregada passivamente (4,2%). O pescado foi vendido diretamente nas ruas e em feiras das cidades-satélite, por atravessadores ou donos de bar. As três comunidades de pescadores apresentam estratégias diferentes para pescar e comercializar o pescado. Assim há diferenças significativas em relação à essa fonte de renda, entre as comunidades.

Palavras-chave: Pescaria continental de pequena escala, pescaria em reservatório urbano, renda proveniente da pesca, Lago Paranoá, Brasília, Brasil.

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1. Introduction

In 2000, the total amount of fish landing in the world was close to 95 million tons, of which 8.8 million (9%) were fresh water fish (FAO, 2003). In 2000, in Brazil it a total production of 847 thousand tons was estimated (FAO, 2003).

Small-scale fisheries are the main suppliers of good quality protein for local populations. Fishers use a wide variety of equipment and most of the boats are not motorized. The fishers go fishing on their own, in pairs or in small groups from four to six individuals and they are under economical pressure which makes them select fish of a larger value. Their relationship with the market is characterized by the middlemen's presence (Bayley and Petrere, 1989; Petrere, 1989; Fischer et al., 1992; Diegues, 1995). Diegues (1995) estimated that 550.000 small-scale fishers in Brazil are responsible for a high proportion of quality fish which is sold on the domestic and external market.

In many Brazilian urban-reservoirs, small-scale fishery is the only source for the poor population. In many great cities, there are appropriate water structures, such as in the Represa Billings (127 km^2) in the capital city of São Paulo, in Lagoa Pampulha (0.3 km^2) in the capital of Belo Horizonte and in Lago Paranoá (38 km^2) in Brasília, the capital of Brazil (Petrere, 1995). Minte-Vera and Petrere (2000) estimated there were 101 fishers in the Represa Billings and a production of 63 kg.ha.$^{-1}$.year^{-1}, where 81.4% of the total landings in weight (147.6 tons) is represented by the Nile tilapia *Oreochromis niloticus*.

In Lagoa Pampulha in Belo Horizonte, there are approximately 1,600 fishers and for 83.3% fish is a basic food. It is considered that many of the fish which are caught are tilapia *Oreocrohomis* sp. (82.4% of 944 fish), followed by traíra *Hoplias cf. lacerdae* (4.9%) and matrinchã *Brycon lundii* (3.9%), (Godinho et al., 1992).

Lago Paranoá dam was built in 1959, one year before the new capital city of Brazil was inaugurated (Figure 1). At that time, the purpose of building the reservoir was to increase the relative humidity of the air to produce electric power, to serve as a recreation area, a place to keep fish, landscape, a place for sewer effluents and rainwater (França et al., 1964). The lake has an area of 3,800 ha and is in the urban district of Brasília and there were two million inhabitants in 2000 (CODEPLAN, 2000). During the 60's and 70's, Lago Paranoá went through a eutrophication process due to the inefficiency in collecting and treating sewers in the two treatment stations (North and South) located on their banks (Palmer, 1969; Oliveira and Krau, 1970; Branco, 1976). However, from 1993 onwards the new treatment stations started to operate, both using a sewer treatment system removing nutrients in order to enable the ecosystem of the lake to recompose. After three years, the lake showed obvious signs of recovery (Fernandes and Pinto, 1998).

After constructing the reservoir, various species of fish were introduced for recreational purposes and as a place for posterior fish farming around Brasília. Small-scale fishing, which had not been contemplated, started spontaneously. In 1998, after doing a very well-designed hydro-acoustic experiment, the lake fish total biomass was estimated at 1,400 toneladas (Lebourges-Dhaussy et al., 1998), mainly consisting of acará *Geophagus brasiliensis*, bagre (catfish) *Rhamdia quelen*, cascudo (armoured fish) *Hypostomus* sp., jeju *Erytinus erytinus*, lambari *Astyanax* sp, mussum *Synbranchus marmoratus*, planaltina *Planaltina meyersi*, saúba or sagüiru *Steindachnerina insculpta*, tamoatá *Hoplosternum litorale*, traíra *Hoplias malabaricus* and trairão *Hoplias*
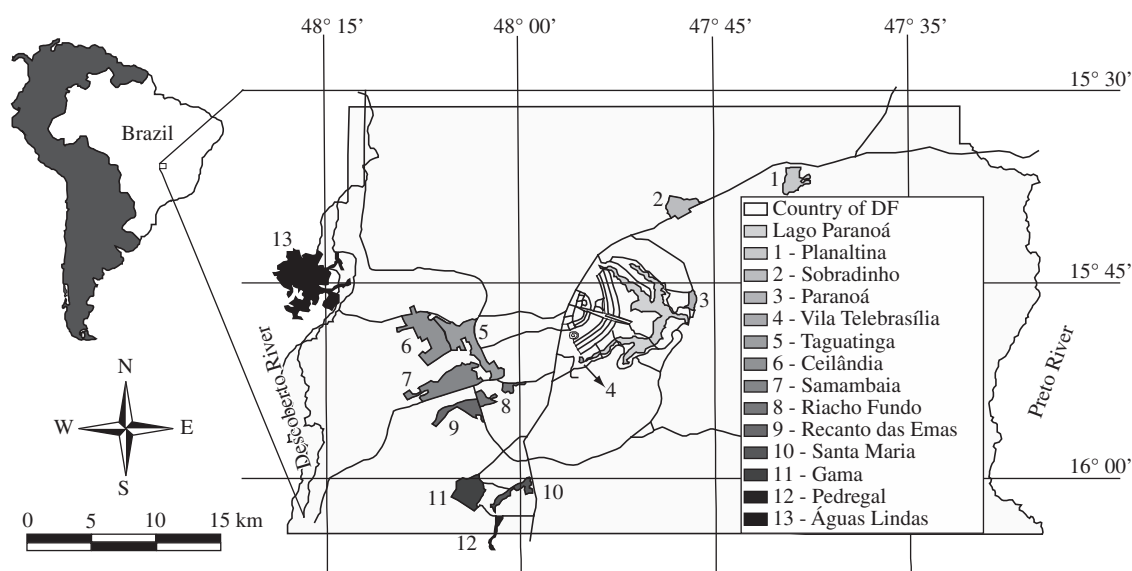
Figure 1. Study area including the Federal District and the main fishing spots at Lago Paranoá.

lacerdae, all native species of the Paranoá basin (Lazzaro et al., 1998). The introduced species were bluegill *Lepomis macrochira*, common carp *Cyprinus carpio*, silver carp *Hypophthlmicthyes molitrix*, Congo tilapia *Tilapia rendalli*, Nile tilapia *Oreochromis niloticus* and tucunaré (oscar) *Cichla* sp. (Lazzaro et al., 1998). T h i s biomass estimation is equivalent to a production higher than 300 kg.ha^{-1}. This result places Lago Paranoá among the most productive ecosystems when compared to temperate and subtropical lakes (Brabrand et al., 1990; Bachmann et al., 1996).

Although small-scale fishing started when the dam was built, commercial fishing with castnets and gillnets was prohibited between 1966 and 1999 and was only made legal when the Lebourges-Dhaussy et al. (1998) experiment was being conducted. Even though it was illegal, in 1985 there were at least 100 families living exclusively from fishing at Lago Paranoá. According to information given by older fishers, the annual fish production at that time was estimated around 200 annual tons (48.1 kg.ha^{-1}.year^{-1}). The landings were almost all tilapias, carps but rarely, catfish and tucunarés. The fish was totally consumed in the satellite-towns in great demand. As always, all fish was sold by middlemen (Dornelles and Dias Neto, 1985). However, from 1991, an increase in the efficiency of inspections, as well as a Police Station which was built opposite the best fishing spot of the lake caused a decline in professional fishing. On the other hand, the stock assessment of Lago Paranoá detected a large tilapia biomass leading to an increased concentration of phosphorous making the water quality worse, because they stirred the bottom, releasing deposited and inactive phospohorous (Marmori, 1995; Starling and Lazzaro, 1997 and; Starling, 1998). This led to some environmental agencies making professional fishing legal on the lake in order to reduce the population of tilapias.

The main objective of this paper is to describe the socioeconomic importance of professional small-scale fishing at Lago Paranoá as a supplier of income and protein for the poor population of the Federal District (DF) in order to subsidize its permanent legalisation.

2. Materials and Methods

The socioeconomic description was made by conducting interviews with professional fishers, whose questionnaires were closed and modified from Valêncio (1995). Sampling was at random, as described by IBAMA/DNOCS/GTZ (1992), where an available fisher interviewee recommended others and so on. This procedure was also adopted because we did not know the number of existing professional fishers at Lago Paranoá beforehand. Data collection was carried out between 24/01/99 and 25/03/99 in four areas of interviews: Acampamento da Telebrasília (28 fishers), Vila Paranoá (12 fishers), at Estação de Tratamentos de Esgotos Sul – ETE Sul (9 fishers) and at Estação de Tratamentos de Esgotos Norte ETE Norte (4 fishers). After the inter-

views, catching and data was done in three of the described communities, except in ETE Norte. Landings were monitored from March/1999 to March/ 2000, making a total of 1,498 fishing trips.

The sampling unit is for each fishing trip, once in Lago Paranoá, apart from 32 trips in which one piece of fishing equipment was used. The catch was defined by the total amount in weight (kg) of round fish. As a scale was not always available to weigh the fish, two alternatives were adopted. The first one consisted of counting the number of 18-liter cans with fish in as some fishers sell their products in these containers. Later, we weighed a few cans at random containing tilapias or carp separately and calculated their average weight for future conversion. The second alternative was to quantify a fisher's estimated catch in weight according to Petrere (1978) who points out that a fisher often knows the precise weight of the catch and the correction can be made making use of a simple linear regression. The X variable, which is always available, is the estimated catch by a given fisher in weight and the Y variable is the real, corresponding weighed catch by a scale, in a random experiment. Finally, some fishers weighed the fish after evisceration. For correction of those values, we calculated a linear regression between the rounded up weight (in kg) Y and the corresponding weight (in kg) of the eviscerated fish X for each species.

After the convenient data transformation, a simple linear regression was done in order to explore the relationship between catch and effort. A socioeconomic analysis was carried out making use of descriptive statistics. The average monthly income was calculated from the catch information and from the commercialization price from each fisher. A comparison among incomes was made by an ANOVA and a further Scheffé test of multiple comparison *a posteriori*. During the interviews, US$ 1 = R$ 1.80.

3. Results

3.1. The professional fishers

3.1.1. Their origin and settlement time

The site with a larger concentration of interviewed fishers was Vila da Telebrasília (28 fishers), followed by Vila Paranoá (12), Buraco (9) and ETE Norte (4). Vila Telebrasília and Vila Paranoá are places where people live. The other two are landing places (Figure 2). From the interviews, we estimated that there were 55 active fishers in Lago Paranoá, showing that we nearly reached the whole population using our non-random sampling procedure.

The fishers have lived in the Federal District or in the satellite-towns for 21.7 years, on average (s = 9.6 years, n = 53), where 49% have lived there for more than 21 years. We judge that this average is quite high as Brasília was founded in 1960 in an original noman's land. From these, 11.5% were born in the Federal

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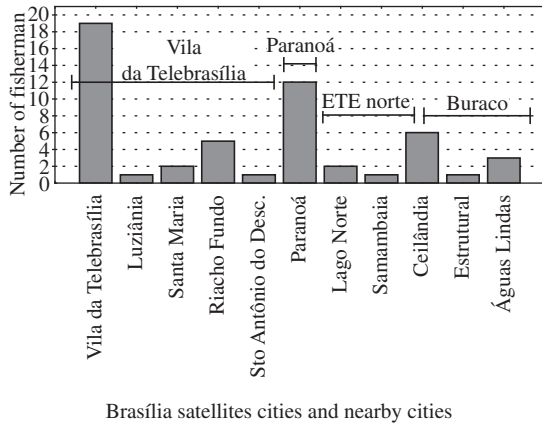
Figure 2. Home places of interviewed active professional fishers of Lago Paranoá.

District. From the remaining, the most representative area is the Northeast (64.1%), followed by the Center-West (32.1%) and the Southeast (3.8%).

3.1.2. Home conditions, basic sanitation and electric energy

Most of the fishers own their own houses (41 fishers), followed by those who pay rent (5), those who live with relatives (3), those who live in invaded areas (3) and one who is a caretaker. The average size of the houses is of 76.2 m² (s = 59.59 m². n = 52). The smallest house has 2 m² and the largest, 360 m².

The average size of the families is 4.9 people (n = 53, s = 3.62) varying from 1 to twelve members.

The houses have masonry walls (32 houses) or wood (21). The material of the roofs is usually made of fibrocement (48 houses) or tiles (3). There are 2 fishers who live in canvas huts. The floors are made of rough cement or burned "vermelhão" (40 houses), followed by tile or ceramic floors (9) and soil (4).

In 50 houses, the source of energy comes from the public electric power system, 2 from kerosene lanterns or candles and 1 from the community's generator. The fuel used for cooking is from gas jars (51) and firewood (2). In 46 houses, the water comes from the public supply.

In 50 houses there are sanitary facilities. From these, 32 are connected to the public sewage system, 11 have raw sewage, 7 have a septic tank and 1 throws the sewage into a ditch.

In 44 houses, there is public garbage collection, in 9 the garbage is burnt, in 3 it is buried, in 2 it is taken to wastelands and in 1 it is disposed of in water.

3.1.3. Sex and age of the fishers

While being interviewed, there was only one fisherwoman, although as mentioned previously, there is a larger amount of fisherwomen. The youngest fisher was 17 years old and the oldest 67 (n = 52). On average, the interviewees' age was of 40.7 years (s = 12.8). 50% of the interviewees' were between 17 and 40 years old. There were two classes of fishers, an older one (between 41 and 67 years) and a younger one, made up mainly of their children, who are married and who are also fishers.

3.1.4. Education

From the 52 Lago Paranoá fishers, 52% never attended school or went for less than four years, 21.1% were illiterate, 5.8% knew " how to read and write", but never went to school, 1.9% were at adult primary school and 23.1% did not finish school (Table 1).

3.1.5. Importance of fish in the diet

The fish caught in the lake is an important basic food as it is consumed by 61.2% of the families more than three times a week, on average (Table 2).

3.2. The fisheries

3.2.1. Dedication to fishing

Dedication to fishing is important in order to evaluate if the activity is sufficient for the fisher and his family to survive. Another important factor is the time between harvesting periods, when the fisher leaves the activity to do something else or changes fishing strategies in order to catch other fish species.

Throughout the interviews, three groups of fishers could be observed (Table 3). In the first one, fishing is their main activity and they may or may not have a second source of income (39.6%, n = 53). The second group stops fishing due to inspection checks and only returns when there are no more (32.1%). The third group is partially active (28.3%), stopping when another job opportunity arises or when the fishing equipament is taken by the police. Among the active fishers, 47.6% (n = 21) only live off fishing.

Among the unstable fishers, when they were being interviewed, 40.0% (n = 15) did not have another source of income and 46.7% were autonomous. Among those fishers that stopped fishing, 17.6% (n = 17) were unemployed.

Throughout 1999, 18.9% (n = 53) of the fishers only lived off fishing, which is a low number when compared to 1995, where 73.9% of the interviewees (n = 46) only lived off fishing (Walter, 2000).

The remaining fishers have the fishery as a main source of income. From the 39.6% (n = 53) who are autonomous, all of them have few professional qualifications. However, all the fishers affirmed that they fish all year round, except for two that only fish at the end of the dry period and one that only fishes when he is unemployed.

3.2.2. The fishing boats and its crew

In the Lago Paranoá, professional fishing is done in paddle wooden canoes with one or two crew members. Only 7.5% (n = 53) said they fished alone. The crews are made up of friends (50.9%), relatives (32.1%) and employees (9.4%, n = 51). In relation to the fisheries,

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95.6% fish in pairs (n = 1495) and 4.4% with a single crew member. In general the pairs are not always the same. In fact with few exceptions, the partnership is highly unstable. According to their information, this fact is a consequence of many conflicts when fishing, as well as due to the instability of fishing, where many fishers shift to other jobs. Those fishers that have employees pay them with a percentage of fish or in money and those that fish in partnerships have the catch at the same propor-

tion. In this case, both are fishers, unlike when there is payment for the activity, where the crew consists of a fisher and an assistant. There are some cases where the fishing assistant is a member of the family as a son. In these cases, there is no remuneration, as the income is in the same family.

The canoes are usually made by their owners at an average cost of U$ 38.60 (n = 48, s = 15.05).

3.2.3. The fish species

According to Gulland (1976), in some fisheries, the crew uses a combination of various techniques to catch a target species. In some cases, together with this species there is a catch, which is either discarded or sold at a low price. In Lago Paranoá, the target species are the Nile tilapia *Oreochromis niloticus* and the saúba or sagüirú *Steindachnerina insculpta*. The other non-target species are associated to catching these two, but some are economically important, such as the traíra *Hoplias malabaricus* or they may often appear, such as the common carp *Cyprinus carpio*, so they cannot be considered as a catch because they are not discarded. With the exception of the common carp, these species have a better price on the market.

The carp is the non-target species which appears in more trips (48.8%) followed by Congo tilapia (19.3%). traíra (15.4%) and tucunaré (10.4%, n = 1.498). According to the fishers, carp and congo tilapia are sold to the middlemen mixed with Nile tilapia. When sold in retail, common carp is not well accepted and the tilapias are sold mixed. Traíra and tucunaré are either consumed or sold for higher prices than the tilapias. Species such as the silver carp, tambaqui, piapara and African catfish are considered special as they are the most expensive on the market.

The three more frequent species in the fisheries are invaders: Nile tilapia (appeared 96.7%), common carp (48.8%) and Congo tilapia (19.3%).

3.2.4. Random sampling experiments

Table 4 shows the average weight and other statistics of interest from random samples of Nile tilapia and common carp, contained in 18-litre cans. These averages were further used to express the total number of catches in weight.

When analyzing the Y (Weighed catch)* X (Fisher's estimated catch), it was observed that although the relationship was fairly linear, the variance was not constant

Table 1. Distribution of the degree of education of Lago Paranoá professional fishers-DF (n = 52).

Education	Frequency (%)
Illiterate	21.1
Only read and write	5.8
Studying at primary school	1.9
Primary incomplete	23.1
Primary complete	11.5
Studying first degree	5.8
First incomplete degree	19.2
First complete degree	7.7
Second complete degree	3.8

Table 2. Participation of the fish caught in the lake in the diet of the family of fishers from Lago Paranoá-DF.

Number of days in which the fish of the lake are consumed per week	Frequency (%)
Less than once a week	12.2
Once	4.1
Twice	22.4
Three times a week	22.4
Four times a week	10.2
Five times a week	4.1
Seven times a week	24.5

Table 3. Dedication to fishing (n = 53).

Class	Activity	% in each class	% in the total number of fishers
Active (39.6%)	Just fishing	47.6	18.9
	Merchant	9.5	3.8
	Employee	9.5	3.8
	Autonomous	33.3	13.2
Partially (32.1%)	Unemployed	40	12.8
	Merchant	6.7	2.1
	Employee	6.7	2.1
	Autonomous	46.7	15.0
Inactive (28.3%)	Unemployed	17.6	5.0
	Merchant	17.6	5.0
	Employee	23.5	6.6
	Autonomous	41.2	11.7

Table 4. Weights (in kg) obtained from 18 liter-cans, used by the fishers for us to measure the fish.

	Tilápia	Carp
n	20	10
Average	13.9	13.9
Standard deviation	1.03	1.08
CV	7.4%	7.8%
Minimum	11.8	11.7
Maximum	15.3	15.2

as it increased with estimated weights presenting a cornet effect. We log transformed the data and the regression presented no tendentious residues, however with out normal distribution, with three outlier. However, removing these three values, the residues remained non tendentious and normal (g1 = -0.186 and g2 = 0.027). The final equation was: y = 1.2 x 0.921 (n = 168; r = 0.986; p <0.001).

Table 5 shows the linear relationships between the fresh round fish (Y) and fresh eviscerated fish for 5 fish species. Note the high correlation coefficients in all cases.

3.2.5. Fishing equipment and fishing strategies

According to Minte-Vera and Petrere (2000), some fishing strategies may consist of a combination of different equipment with appropriate mesh and type of habitat. Due to these combinations, a fisher tries to increase his/her chance of catching the target species. Therefore, in Lago Paranoá two types of equipment are used in professional fishing: castnets and gillnets. A gillnet can be used in two ways: actively or passively. When used actively, the following local technique called batida (beat) is used: the fishers beat the water surface with a stick driving the tilapias towards the net as they have the ability to swim backwards. The purpose of Batida is to mainly catch Nile tilapia. Therefore, 35.8% of the fishers fish exclusively with castnets (n = 51) and 22.6% fish exclusively with gillnets. The others (41.6%) fish with both. However, the fishers from Vila da Telebrasília only used castnets, except for three, who also used gillnets. On the other hand, the Vila Paranoá fishers only fish with batida and the Buraco fish fishers with castnets and gillnets, except for two, one who only uses castnets and another only gillnets. The four fishers interviewed in ETE Norte only fish with castnets.

In the Lago Paranoá, the gillnets used in batida have from one to three sets of nets tied together with the same or different mesh sizes. The average total length of the whole set is 142.2 m, average mesh size of 9.4 cm between opposite knots and an average height of 2.0 m.

The castnets are also used in catching saúba and Nile tilapia (31.1% of the fisheries). Saúba fishing is done in the outlet of the streams mainly for subsistence. Because of this, the castnets (tarrafas) are smaller (tarrafinha), with an average mesh size of 2.7 cm between opposite knots and an average height of 1.8 meters.

Castnets used in tilapia fishing are the only ones which were made legal by the Brazilian Institute of the Environment and the Renewable Natural Resources (IBAMA) in December, 1999. These castnets have an average mesh size of 7.14 cm between opposite knots, an average height of 2.8 m and a diameter of 21.8 m.

The nets are usually bought at U$ 1.03/mr (n = 28, s = 0.39) and the castnets and tarrafinhas can be made or bought costing U$ 48.57 on average (n = 35, s = 15.72).

3.2.6. The landings

The total amount of fish caught at the Lago Paranoá from March, 1999 to March, 2000 was 62.50 tons in 1,498 trips (41.7 kg/trip; s = 26.43, minimum = 0.00, maximum=170). The most captured species was the Nile tilapia (84.9%), followed by the common carp, 11.1%, Congo tilapia 2.2%, traíra 1.0% and 0.8% of the other species (Table 6). The total catch varied monthly (Figure 3). On average, 21.4 fishers were active per month (s = 12.37) in 115 fisheries (s = 41.56). The average yield was of 224.7 kg/fisher/month.

The saúba were not sorted out, except in those cases where the fishers differentiated all the species. Therefore, it does not correspond to catching saguirú exactly.

Considering the total area of the lake is 3,800 hectares, the fishing productivity of the reservoir is 16.4 kg.ha^{-1}.year^{-1}.

The weight of the landing proportions in 1,498 fishing trips was: Vila Paranoá (49.4% of a total of 62,500 kg), followed by Buraco (38.4%) and Vila da Telebrasília (10.9%).

3.3. Fish commercialization

Most of the time, fish is directly sold to the consumers (84.9%, n = 53) in fairs (69.8%, n = 53) or in the streets (49.1%, n = 53) of the satellite-towns and municipal districts of the State of Goiás. Selling it at fairs usually happens at the weekends, mainly on Sundays. On other days of the week, the fishers sell the fish in the streets. Fish is also sold to middlemen (37.7%). The fish sold to middlemen or to consumers may take place by the lake (7.5%) or in houses (35.8%). There are two cases where fishers supply bars with fish. However, throughout the research it was observed that the fish buyers or the bars always resell the fish directly to the consumers and many bar owners buy the fish from middlemen for more accessible prices. Therefore, between the fisher and consumer, there are at least two more people.

The price and the way to sell fish vary according to the buyer´s type and the fish species. The tilapias and

Table 5. Linear regression between the weight (kg) of fresh fish (y) and fresh eviscerated fish (X) for each of the five species with the straight line going through the origin.

	Nile tilapia	Congo tilapia	Common carp	Traíra	Tucunaré
b	1.133	1.136	1.126	1.053	1.053
Standard error of b	0.0049	0.0076	0.013	0.018	0.0038
r^2	0.9991	0.9995	0.9973	0.9987	0.9999
n	46	11	19	4	5

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carps can be sold in cans, in fish strings (6 fish/string hung by the gill) and by kilo. Price varies according to fish numbers or size. On average, the average price of the tilapia sold directly to the consumer was U$ 1.23/kg (n = 24, s = 0.37) and U$ 1.52/string (n = 20, s = 0.45).

Carp is sold in a similar way. Its final average cost was U$ 2.06/string (n = 12, s = 2.06) or U$ 1.24/kilo (n = 21, s = 0.37). The traíra and the tucunaré are sold by the kilo to the consumer for an average price of U$ 1.74 (n = 23, s = 0.39) and U$1.99 (n = 12, s = 0.45), respectively. On average, the saúba costs U$ 1.94/kilo (n = 20, s = 0.67). The fish is sold to the middlemen in cans or by kilogram.
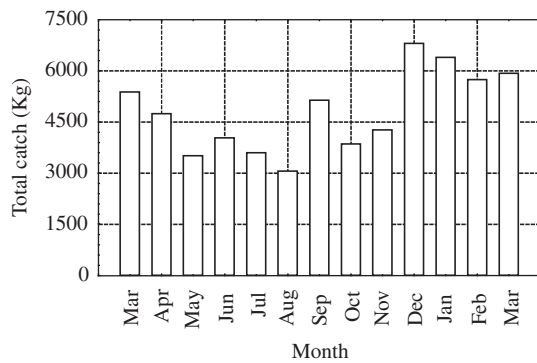
Figure 3. Variation of the monthly total catch (kg) in Lago Paranoá from March/1999 to March/ 2000.

The weight of a can is approximately 14 kg. On average, a tilapia can costs U$ 7.58 (n = 11, s = 2.09) and carp costs U$ 7.93 (n = 7, s = 2.02). Many fishers said they sold mixed fish to middlemen and the value of a can increased according to the number of traíras and tucunarés it contained. When sold to the middlemen in kilogram, the price of the fish varied between U$ 0.28 and U$ 1.11.

Some fishers removed traíra and tucunaré for their own consumption or it was given to relatives or neighbours. Only four fishers reported selling traíra to middlemen for U$ 1.18/kg (s = 0.79).

3.4. Differences presented by the fishing communities in relation to fishing strategies and marketing

Throughout the work, it was observed that the communities had different strategies regarding the equipment used, the area of the lake used for fishing, the period of day when fishing took place and the kind of commercialization areas.

For instance, the community of Buraco only fishes at the southern end of the lake. When this was illegal, they used batida at night. After it was made legal in February, 2000 they started fishing with castnets in the daytime and at night (Table 7).

The Paranoá community used all the areas of the lake to fish, mainly the central area. Their strategies consisted of fishing at night, only with batida.

The Vila da Telebrasília community fishes mainly with castnets and some fishers also use gillnets and bat-

Table 6. Description of catching each species from March/1999 to March/ 2000 (From Walter, 2000).

	Nº of trips catching fish	Average catch per trip (in kg)	Total catch by species (kg)	% of the total
Congo tilapia (*Tilapia rendalli*)	290	4.77	1379.53	2.21
Nile tilapia (*Oreochromis niloticus*)	1450	36.60	53068.87	84.90
Common carp (*Cyprinus carpio*)	795	8.74	6947.03	11.10
Tucunaré (*Cichla* spp.)	95	1.24	118.22	0.19
Traíra (*Hoplias malabaricus*)	241	2.57	620.05	1.00
Cascudo (*Hypostomus* sp.)	19	1.25	23.86	0.04
Saúba or sagüiru (*Steindachnerina insculpta*)	21	10.84	238.43	0.38
Lambari piaba (*A. Bimaculatus lacustris*)	5	2.08	10.43	0.02
Lambari branquinha (*Astyananax eigenmanniorum*)	7	1.51	10.60	0.02
Acará (*Geophagus brasiliensis*)	26	1.19	31.00	0.05
Tamoatá (*Callichthys callichthys*)	5	0.77	3.84	0.01
Silver carp (*Hypophthalmichtyes molitrix*)	5	7.23	36.15	0.06
Other	4	3.27	13.09	0.02
Total	1498	41.7	62501.03	100.00

Table 7. Summary of the strategies used by each fishing community.

Community	Equipment	Sub-areas	Period of the day	Cpue (kg.hour^{-1}.boat^{-1})
Telebrasília	Castnet	Southern end of the lake	Day/night	9.0
Buraco	Batida/castnet	Southern end of the lake	Night/day	16.0
Paranoá	Batida	Whole lake	Night	12.5

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ida. The fishing area is mainly at the southern end of the lake and people fish mainly during the day.

Regarding commercialization, it was also observed that places and different ways of selling are used by each one of the communities. For instance, when Vila Paranoá's fishers sell fish directly in the streets, they sell it in strings and the main place is in the Vila itself. Most of the fishers there sell eviscerated fish to the middlemen and they measure it in kilograms. In this community, there is a third group that sells fish in fairs by kilogram, mainly in Planaltina town. Fishers commented that when the fish buyer does not show up, they sell the fish on the streets of Paranoá, Gama or Santa Maria. Gama was mentioned as the best place. The fish buyers that buy the fish in Paranoá resell it in Paranoá itself, in Santa Maria, Gama and Luziânia (Figure 1).

The fishers in Buraco sell fish on the streets (mainly in Ceilândia - Figure 1) in strings or to the middlemen and bar owners in cans. Trade is mostly done in Ceilândia, Parque das Emas or in Águas Lindas, areas where they live (Figure 1). In fairs, it is sold in Ceilândia or in Águas Lindas.

The fishers in Vila da Telebrasília sell fish mainly in fairs in Pedregal, Gama and Céu Azul (Figure 1). They rarely sell fish to middlemen, but when they do the fish is sold in cans.

3.5. Income

In Figure 4, the calculated monthly income to the community is shown. This information is the financial result of the different community strategies related to fishing and fish commercialization. For this analysis, the information was considered according to the community the fishers belong to, the fishing equipment, payment to the other crew members, how often people fished, monthly catches and the number of months in which fishing took place.

The monthly average income was U$ 238.73 (s = 171.77), however the results demonstrate that there
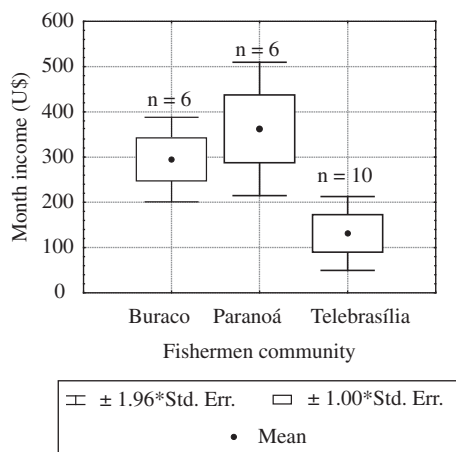
Figure 4. Gross average monthly income of the three studied communities.

is a significant difference among the incomes of the three communities (p = 0.0135), where the monthly income of Vila Paranoá's community (U$ 362.18, s = 184.17) is significantly higher than Vila da Telebrasília (U$ = 131.18, s = 131.68, p = 0.0202). The monthly income of Buraco (U$ = 294.52, s = 116.78) does not differ from the income of Paranoá (p = 0.72) and Telebrasília (p = 0.12), (Figure 4).

4. Discussion

4.1. Professional fishers

Assessing the fish stock does not only mean evaluating the catch and the income. It is important to focus on the information from fishers and the market system, which governs the catch per unit of effort, as well as the biological characteristics of the species and to recognize that the fishers are the political centre of the fishery. Moreover, profit is what measures the success of the management (Hilborn and Walters, 1992).

Understanding the socioeconomic reality of the fishers is of great importance, as far as implementing measures of fish stock management are concerned as well as the economic development of these populations. Bazigos (1974) recommends doing censuses in order to find out the population of fishers in tropical areas of difficult access, so that afterwards a data collection system can be made on the statistics of fish which have landed.

In Lago Paranoá, the importance of studying the reality of professional fishers entails understanding how much involved they are in society and in the job market, where a regulated fishery can create jobs in the Federal District (Paviani, 1992).

Although professional fishers are concentrated in four main communities (Figure 2), they belong to several areas of the Federal District and its surrounding towns which are the poorest according to official statistics (CODEPLAN, 1997).

The small estimated number of fishers in each one of the administrative regions (AR) does not allow us to make comparisons between the places where the fishers belong. However, a general analysis can be made evaluating the fishers as a single group, as well as the situation of the population of the administrative regions to which they belong. It is important to point out that there are no official statistics in the towns from the State of Goiás (which surround the Federal District) and Vila da Telebrasília.

In the general context of the Federal District, the average size of a family is of 4.15 members. The most numerous families live in Santa Maria (4.57 members) and Riacho Fundo (4.40 members, CODEPLAN, (1997), smaller than the average fisher's families (4.9 members).

The poor education level of a population restricts its employment opportunities because the job market is increasingly more complex (Borges, 1997). The level of education in the Federal District is comparatively low, where 40.9% do not reach the first degree (CODEPLAN,

1997). In poorer villages, this situation is even worse. In Brazilândia town, 81.8% of the heads of the families do not have basic education, in Recanto das Emas 81.2%, in Samambaia 79.06%, in Planaltina 78.6%, in Ceilândia 77.6% and in Paranoá 90% (CODEPLAN, 1997). Professional fishers are in this situation, as they are more likely to be unemployed (Paviani, 1992).

The time of residence of fishers is higher in relation to the rest of the population of the DF: 35.3% have lived there from 0 to 9 years, 29% from 10 to 19 years, 22.7% from 20 to 29 years and 13.0% has lived there for more than thirty years (CODEPLAN. 1997). From the interviewees, only 11.5% were born in the DF, which is a low figure when compared to the rest of the population (43.9%), (CODEPLAN, 1997). However, the official statistics refer to the whole population and not just to the heads of families, who do not consider their children who were born in the capital.

Houses are owned by 46.0% of the families in the DF, 37.2% live in somebody else's properties and 10.8% of the population occupies dubious land: they are owners of their houses, but not of the plots of land. Therefore, they are a typical case of the establishments promoted by the government for the poor (CODEPLAN, 1997). Most fishers claimed to live in their own houses. 41.6% of the population of the DF lives in houses, which are at most 60 m^2. This situation is worse in the Recanto das Emas (77.5%), São Sebastião (66.7%), Planaltina (64.9%), Paranoá (63.4%), Samambaia (61.7%) and Santa Maria (61.6%), (CODEPLAN, 1997). 40.4% of fishers live in areas of up to 60 m^2, which is an improvement than the rest of the DF, putting them in a minority class in relation to the average of RAs in which they live. However, this reality is regardless of the size, because concerning the material used in the construction, the DF has: i) 69.1% of masonry houses, 17.7% are apartments and 10.2% huts (CODEPLAN, 1997); ii) 39.4% of the houses have ceramic floors and 39.8% cement, reaching 60% of the houses in the RAs whose population has a smaller purchasing power; iii) asbestos tile floors (72.4%), followed by mud floors (13.8%); and iv) the sanitary facilities are collective in 6.4% of the homes in the DF (CODEPLAN, 1997). The houses of the fishers are among the most precarious, however the number of fishers who use collective bathrooms is smaller.

Besides being one of a citizen's fundamental rights, housing is the centre of sociability where organization of the family takes place. However, the quality of the house depends not only on intrinsic factors such as education and income, but also on sanitary facilities provided by public policies and ecological characteristics of the area (Borges, 1997). Electric power supply, water, sewage and garbage collection are public services for most of the DF population (CODEPLAN, 1997). This condition is above the national average (IBGE, 1996) and it reflects the high degree of urbanization of the fishers and their dependence on public policies (in this case we can include the situation of land concession).

The fish in Lago Paranoá is comparatively important (Table 5) as it is more consumed than in the Represa Billings, where 87% of the families of fishers consume the fish from the reservoir twice a week on average (Minte-Vera et al., 1997). In two reservoirs in the Iguaçu River in the State of Paraná, the number of fish is low, as 41.4% of the fishers' families consume fish once a week (Okada et al., 1997). When studying the community of the Mina d'Água (an invaded land that existed in 1985 close to the Lago Paranoá), Dias (1994) pointed out that the fish in the reservoir was the only source of protein for many families. Petrere (1995) also points out the importance of fish in the fishers´ diet, where in urban reservoirs such as the Lago Paranoá (DF), the dam Billings (SP) and the Lagoa da Pampulha (MG), it is their only source of protein.

Payne (2000) considers that small-scale fishers come strictly from rural communities. However, in the Lago Paranoá, the fishers come from urban communities. This situation was also observed by Nehrer and Begossi (2000), where small-scale fishers from Posto Seis in Copacabana come from the slums of Rio de Janeiro city. Minte-Vera et al. (1997) argue that Reservatório Billings's fishers come from the metropolitan area of São Paulo, which is also urban.

Acheson (1981) points out that in industrial fisheries there is a division of work: while the men fish, women are responsible for the housework. Minte-Vera et al. (1997) also argue that 16.4% of the fishers from Billings are women, including fishing as a whole: they handle all the equipment, hire assistants and own their own production and most of the time they are independent from the fishermen

In Lago Paranoá, the presence of a class of younger fishers, consisting mainly of fisher's children shows that there is continuity in fishing. All these fishers said that they were previously assistants of their parents when fishing. However, in spite of the high participation of the family in fishing, there is no work division in Lake Paranoá by age or sex.

4.2. The fisheries

4.2.1. Dedication to fishing

The group of fishers that are devoted exclusively to fishing in a given place shows not only its cultural importance, but also that fisheries supply the need of income to a family. In the Lago Paranoá, the proportion of fishers who fish exclusively is low, mainly compared to the Represa Billings, where 87.3% of the fishers only live from the fisheries (Minte-Vera et al., 1997). However, the small number of fishers and their decrease throughout the months is attributed to the secrecy of the fishing. In two reservoirs in Iguaçú River, where fishing is prohibited, only 6.7% of the fishers live exclusively from fishing (Okada et al., 1997). However, there is no time between harvests in Lago Paranoá.

When we refer to the poor population, its inclusion in the job market makes it possible to understand it on

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an individual level. Jobs are very important because they are the main source of income of the poorest population (Baltar and Dequech Fo, 1990). The more precarious the way an individual is seen in the job market, the larger the difference between his/her income and the necessary income to satisfy his/her basic needs. As a consequence, the larger his/her dependence is in relation to other aspects: public attendance, attendance of private and familiar institutions (Troyano, 1990). The three groups of distinguished fishers reflect this situation. Only 39.6% of the fishers are devoted to fishing, the others stopped due to low qualification jobs, reflecting the difficulty in the job market. This is the general situation of inequality in modern Brazil, which is even worse in Brasília where jobs are not very diversified (Costa, 1992).

4.2.2. Fishing economic resource

The professional fisheries in Lago Paranoá have general attributes of small-scale fisheries: a small number of crew members who are usually partners, some of whom have friendly relationships; they have boats without engines; very defined strategies and some are very knowledgeable fishers (Bayley and Petrere, 1989; Petrere, 1989; Fischer et al., 1992; Diegues, 1995). Tomanik (1997) points out that the community from Porto Rico (PR) fish in pairs in a partnership system. Everything is divided and shared. Even the boat and most of the equipment belong to one of the partners and this is not taken into account when sharing out the earnings or responsibilities. Partnerships are usually set up among fishers, who have already had vast experience in fishing and who have some kind of fishing equipment. Another type of relationship is established when there is a difference of age, professional experience and ownership. In these cases, the oldest fisher can hire a younger assistant, who has little experience and still does not have his own equipment. He is paid a percentage without any expenses.

The fishing economic resource (Bazigos, 1974) in Lago Paranoá is a wooden canoe with one or two castnets. Therefore, the initial investment in fishing is U$ 184.55 for gillnet fishing and U$ 87.22 for castnet fishing. It is a low investment when compared to other places, mainly those that use motorized boats. In the lower part of the São Francisco River, the price of an aluminium boat is U$ 1,317.15, a wooden one costs U$ 359.64, the engine costs U$ 1,165.72, the caceia net costs U$ 473.48, the gillnet costs U$ 122.11 and the castnet U$ 145,16 (Camargo and Petrere, 2001). In the reservoir in Itaipú in the State of Paraná, the average cost for full equipment is U$ 818 (Agostinho et al., 1994). However, the comparatively low investment in fishing in Lago Paranoá is due to constantly replacing material and to inspections, which does not encourage the fisher to invest more. On the other hand, the small amount of equipment per fisher and the use of paddle canoes reduce the number of fishers.

4.2.3. The species which are caught

There are few species of fish in the small-scale fisheries in Lago Paranoá and the Nile Tilapia represents 84.9% of the haul in weight, followed by the common Carp (11.1%) and the Congo Tilapia (2.21%, Table 7).

In many other places in the tropical world, small-scale fisheries are sustained by these species (Fernando, 1991; Fernando and Holcik, 1991). In Colombia, in Honduras and in the Dominican Republic, the Nile Tilapia is the species which is caught most (FAO, 2003). In the Brazilian Northeastern dams, when Tilapias were introduced, they increased the fishing productivity of these reservoirs, ranging from 18 to 667 kg.ha^{-1}.year^{-1} (Paiva et al., 1994). In 2000, 231 thousand tons were caught worldwide (FAO, 2003).

In Java, there are reservoirs with very high production, for instance, a lake of 25 hectares has a productivity from 500 to 600 kg.ha^{-1}, mostly consisting of Cyprinus carpio (data compiled by Lowe-McConnell, 1991). The fisheries in Lake Tana in Ethiopia is confined to the Golf of Bahir with a low production of 4 kg.ha^{-1}.year^{-1}. There are two main types of fishing: i) a small-scale subsistence fishery, consisting of papyrus canoes mainly catching Nile Tilapia and Barbel *Barbus tsanensis* and ii) motorized fishing, which catches *Barbus* sp and the African catfish *Clarias gariepinus* (Wudneh, 1998). Since 1952 in Sri Lanka, the Tilapia *Oreochromis mossambicus* is the most important species in inland fisheries with an estimated productivity ranging from 270 to 300 kg.ha^{-1}.year^{-1} (Pet, 1995). The Tilapia *Oreochromis aureus* and the Cyprinidae family are the main produce in Cuban reservoirs (Quirós and Mari, 1999).

The composition of the haul in Lago Paranoá´s professional fisheries differs from the experimental gillnet fishing carried out by Lazzaro et al. (1998), where the common carp was more abundant (23.4% from a total of 342.6 kg) followed by the Nile Tilapia (18.8%). The explanation is due to the castnets used in the professional fisheries, equipment which was not used by Lazzaro et al. (1998) in their sampling.

The low richness and high species dominance observed in the Lago Paranoá fish community is indicative of communities who suffer from stress, which is due to i) the transformation of a lotic ecosystem to a lentic one; ii) the posterior eutrophization; and iii) the introduction of species (Magurran, 1988).

4.3. Commercialization

Selling fish in the Lago Paranoá has many particular aspects. The first consists of not having a real by-catch where the other species have a market value or are sold together with the Tilapias. This rarely happens in other fisheries, such as Minte-Vera and Petrere (2000). The fisheries in Reservatório Billings point out that the caborja *Hoplosternum littorale* is not well accepted, even in bad season fisheries.

A second interesting aspect is the fisher who takes the best fish for his own consumption. This could be a consequence of not catching many of these species associated to the highly valued Tilapia. However, the most important aspect of the commercialization system in Lago Paranoá was attributed to fishers who are owners of their own

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production. Therefore, these fishers do not depend on the middlemen providing them with food (the fishing trips are local and short) and paying for their fishing equipment. The choice between directly selling to the consumer or to the middlemen is free, and therefore the price obtained for their fish is higher than many of the Brazilian reservoirs, even if commercialization is represented mainly by a single species, which is the Nile Tilapia. In the Represa Billings, for example, Tilapia is sold filleted (four kilos of fish is needed for a kilo of filet, Minte-Vera and Petrere, 2000) and is sold to the middlemen for U$ 1.55. The fish which reaches the highest prices in the reservoir at Sobradinho (4,200 km^2) in the State of Bahia was sold for U$ 1.50 the kilo to the middlemen (Agostinho, 1997).

In the middle part of the São Francisco River, selling takes place by an unjust income distribution where fishers only receive 5% of the final price of their product. The consumers have to pay for the costs of quite complex a chain of middlemen (PROJETO BRA/90/005).

In the Northeastern dams selling depends on middlemen where the participation of the fisher in the final price of the fish is 28% (PROJETO BRA/90/005).

On the other hand, fishers or at the most two middlemen at the Lago Paranoá set their price. Fish is not exported to other federations, as it is supplied fresh at an accessible price to the local population. It is cheaper than most of the original fish from other places and the fishers are paid more. This situation is due to fact that Lago Paranoá is the only appropriate fishing waterbody in the Federal District and its population consumes a larger amount of fish (12.8 kg.capita^{-1}.year^{-1}) in relation to the Brazilian average (5.8 kg.capita^{-1}.year^{-1}), (PROGRAM OF FISH FARMING OF DF, unpublished). The DF imports 4,000 tons of fish a year (Rui Donizzeti – civil servant from the Ministry of Agriculture – Fish Farming Project of the DF – personal communication to TW, 1999) and the fish caught in Lago Paranoá represents less than 2% of its total consumption.

A final aspect, which is a consequence of fishers selling directly in streets and fairs, is also an important social role which encourages solidarity and possibly comes from small rural communities. It involves exchanging their production with people in the neighborhood. Amoroso (1981) points out that in the poor outskirts of Manaus, donating or exchanging food is common, mainly in poor families.

4.4. The monthly income

Income generated by fishing is a consequence of the strategies used by fishers and the decisive social function of fisheries (Hilborn and Walters, 1992).

The monthly income is higher in Vila Paranoá (U$ 362.18) in relation to Vila da Telebrasília (U$ 131.18), possibly due to most of the fishers from Paranoá fishing full time, even if most sell the fish for smaller prices. The Vila da Telebrasília community tends to fish as well as doing other activities. The Buraco community has an income of U$ 294.52, although it is not significantly different from the other two.

It is worth mentioning that the income of Lago Paranoá's fishers is high, when compared to other Brazilian reservoirs, as the productivity and the amount of fishers is larger and they have species which are accepted more on the market. In the Sobradinho reservoir, for example, the monthly income of the fishers who fish in the most productive areas is U$ 375.21 (Agostinho, 1997). In Billings reservoir, where the main fish species is also the Nile Tilapia, 34% of the fishers said they had a basic income of U$ 105.00 to U$ 210.00 (Minte-Vera and Petrere, 2000). Cetra and Petrere (2001) calculated that the daily income of the professional fishers of the middle part of the Tocantins River was U$ 2.00. They attributed this low income due to the middlemen who control the means of production. Okada et al. (1997) calculated that the income of the fishers from two reservoirs in the Iguaçú River is U$ 12.00/day. The monthly profit of fishing in the Itaipú reservoir is only U$ 25.00 (Agostinho et al., 1994). However, in these places fishing is done on motorized canoes, there is a supply of ice, freezers and more equipment used by each fisher, which increases his/her costs.

A second interesting comparison is to evaluate the income with the average values of social groups IV and V (CODEPLAN, 1997) to which these fishers belong. In this situation, even if fishing is the only source of the family's income, the family would have the same living standards of other non-fishing families, and therefore if fishing was regularized, it would be economically sustainable.

5. Conclusions

Small-scale fishing has been present at the Lago Paranoá ever since it was built. The fishers have adapted catching the fish species according to its evolution, presenting different strategies, according to the community they belong to: Vila da Telebrasília, Buraco, Vila Paranoá and ETE Norte.

Among the poorest population in the Federal District, the fishers have a source of income as well as cheap protein and the important task of supplying it to the rest of the population. The sale may not be in cash and donating fish is quite common.

Although some of it is illegal, the annual catch has reached 62.5 tons with an income of 41.7 kg.fishery^{-1} equivalent to 224.7 kg.fisher^{-1}.month^{-1} and a productivity of 15.4 kg.ha^{-1}.year^{-1}. Therefore, low productivity in fishing is due to its secrecy: i) where it is not worth investing in fishing material; ii) there is a limit to catching and effort from which it is not worth running the risk of having the material confiscated by inspectors; and iii) there are no landing facilities, freezers and supply of ice, which would limit catching the fish and increase fishing costs.

The high amount of tilapias and carps, which are caught, is a consequence of them being dominant in this reservoir and the fact that appropriate catching strategies are used.

Selling fish is mainly the responsibility of the fisher, as he/she owns cheap fishing equipment and is free to choose to whom he/she sells the fish.

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Productivity together with the added value given by the fish, as well as a high demand/offer, makes fishing profitable when compared to small-scale fishing elsewhere, and is a good job alternative. Therefore, the professional fisheries at Lago Paranoá have particular characteristics compared to other inland Brazilian fisheries.

The fishery also has pleasant environmental and social requirements: the catch in weight of alien species is 98% of the total; the Tilapias caught by castnet are beneficial in order to control algae; the fishers come from the poor population and fishing is profitable economically. The cultural aspects of fishing can still be seen as part of the patrimony of the capital city of Brasília.

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