FINANCIAL COMPARISONS OF THE ARTISANAL FISHERIES IN URUBUPUNGÁ COMPLEX IN THE MIDDLE PARANÁ RIVER (BRAZIL)

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(With 1 figure)

ABSTRACT

The main objective of this study was a bio-economic survey of artisanal fishing so as to compare average profit of the fishermen, in two different environments (reservoirs and river) and seasons (dry and rainy). To carry out financial comparisons of artisanal fisheries in Urubupungá Complex in the middle Paraná River (Brazil), three habitats were considered: I) Ilha Solteira and Jupiá reservoirs; II) the Paraná River between the Jupiá and Primavera dams; III) the Paraná River downstream from the Primavera dam. Data collection was done through questionnaires addressed to a total of 187 fishersmen; just 164 of the resulting interviews were considered valid. They were held in July 1998 (dry season) and February 1999 (rainy season). The daily average profit of the resevoir fisherman was R$ 13.19 during the dry and R$ 19.54 during the rainy season; R$ 4.10 and R$ 12.92 for fishermen located on the Paraná River between Jupiá and Primavera dam; and R$ 1.48 and R$ 23.01 for those located on the Paraná River below Primavera dam (R$ 1.00 = US$ 0.86 during the dry season; R$ 1.00 = US$ 0.52 during the rainy season). A linear model had been tried to explain the profit variable, in relation to those variables directly linked to fishing (e.g., as habitats; seasons, dry or rainy; gear used; days spent fishing) as well as several sociological variables (age, marital states, number of dependents, and education). However, due to large variability in profits, the proposed model only explained 48.4% of variability, and the only significant factors were education, type of gear, and covariant fishing days.

Key words: inland fisheries, dams, rivers, bio-economics.

RESUMO

Comparação financeira entre as pescarias artesanais no complexo de Urubupungá, no médio rio Paraná (Brasil)

Este trabalho teve por principal objetivo o levantamento bioeconômico das pescarias artesanais, a fim de comparar o lucro médio dos pescadores, considerando os diferentes ambientes (reservatórios e leito do rio) e épocas (seca e chuvosa). Para a execução das comparações financeiras das pescarias artesanais no Complexo de Urubupungá no rio Paraná (Brasil) foram considerados 3 ambientes: I) reservatórios de Ilha Solteira e Jupiá; II) rio Paraná entre as barragens de Jupiá e Primavera; e III) rio Paraná a jusante da barragem de Primavera. O levantamento de dados foi realizado mediante a aplicação de questionários, num total de 187 pescadores entrevistados, sendo consideradas válidas 164 entrevistas. As entrevistas foram realizadas em julho/98 (época seca) e fevereiro/99 (época chuvosa). O lucro médio diário nas épocas seca e chuvosa, respectivamente, foi de R$ 13,19 e R$ 19,54 para os pescadores dos reservatórios; de R$ 4,10 e R$ 12,92 para os pescadores do rio Paraná entre as barragens de Jupiá e Primavera; e de R$ 1,48 e R$ 23,01 para os pescadores do rio Paraná a jusante da barragem de

Primavera (R$ 1,00 = US$ 0,86 durante a época seca e R$ 1,00 = US$ 0,52 durante a época chuvosa). Buscou-se determinar um modelo para explicar a variável-resposta "lucro", em função das variáveis ligadas diretamente à atividade pesqueira (ambiente em que o pescador atua, época da entrevista – seca ou chuvosa –, aparelhos utilizados na pesca, dias em que pesca), bem como de algumas variáveis sócio-econômicas (idade, estado civil, número de dependentes, instrução). Porém, como a variabilidade do lucro é muito grande, o modelo proposto explicou 48,4% dessa variabilidade e apenas os fatores educação, aparelhos de pesca e a covariável número de dias que pesca foram significativos.

Palavras-chave: pesca interior, represas, rios, bioeconomia.

INTRODUCTION

Rivers have been pivotal in settling many regions worldwide, as water is an essential element for life. By being at the center of any society and its environment, fresh water systems suffer constant changes in their distribution, abundance, and quality. These pressures upon aquatic ecosystems reflect on the integrity of the systems themselves, as well as in human cultures (Naiman & Turner, 2000).

Since ancient times, dam and reservoir construction constitute an alternative to provisioning and irrigation, besides protecting against flooding and being useful for aquaculture. These constructions, however, affect natural ecosystems (Petrere, 1996).

The main objective of this work was to compare the average profits obtained by reservoir and riverbed fisherman, and to obtain a model whose variables, gathered during field-work, could explain these profits. The initial hypothesis was that riverbed fishermen had a higher profit than those working in the reservoir. One of the strongest reasons leading to this hypothesis is that riverbed fishermen invest less in fishing gear (smaller nets, long-lines, and fishing rod) than those on the reservoir, who cast more expensive gill-nets of up to 800 meters long. Moreover, the distance traveled to find suitable fishing spots should be considered: riverbed fishermen travel lesser distances to find fishing shoals, while in the reservoirs there are generally no shoal formations.

Between 1986 and 1994, 38 species of fishes were sampled through experimental fishing carried out by CESP (Centrais Elétricas de São Paulo) in Ilha Solteira Reservoir and 46 species in Jupiá Reservoir. The total catch in Jupiá and Ilha Solteira, during 1994, was 174,809 kg and 97,539 kg, respectively (CESP, 1996).

The presence of species such as the "dourado", *Salminus maxillosus*; the "jaú", *Paulicea luetkeni*; and the "barbado", *Pinirampus pirinampu*, at Ilha Solteira, indicate their growth in the reservoir. Moreover, the introduced cichlids "tucunaré", *Cichla monoculus*, and the "Nile tilapia", *Oreochromis niloticus*, strongly contributed to commercial fishery, and indicating good adaptation to reservoir conditions (CESP, 1996).

At Jupiá, the "curimbatá" *Prochilodus lineatus,* presents significant results in commercial fishery. The existence of tributaries in the Jupiá region favors "curimbatá" reproduction. Besides, it was the only migratory species taking part in the stocking program developed by CESP from January 1979 to July 1995, demonstrating good adaptation to reservoir conditions. The "tucunaré", *Cichla monolucus*, also significant in commercial fishery, is also well adapted to reservoir conditions (CESP, 1996).

In the section of the Paraná River between Jupiá and Primavera dams, species regarded as noble, such as the "pintado", *Pseudoplatystoma curruscans*; the "dourado", *Salminus maxillosus*; and the "jaú", *Paulicea luetkeni*, were well represented in fisheries in recent decades. This has changed over time, because of dam construction combined with the introduction of the exotic species "curvina", *Plagioscion sqaumosissimus;* "tucunaré", *Cichla monolucus;* "common carp", *Cyprinus carpio;* and "Nile tilapia", *Oreochromis niloticus* (Petrere, 1995).

Albeit not fully working, the Primavera dam is already causing impacts, as showed by a study carried out by scientists from UEM/NUPELIA with marked fishes. The study verified that fish migration in the Paraná River is being affected, since individuals marked above the dam also occurred below the dam, while the opposite was not observed (Dr. A.A. Agostinho, UEM/NUPELIA personal communication).

The ichtyofauna belonging downstream from the Primavera dam suffered alterations when the Itaipu Reservoir was closed in 1982, because flooding Guaíra Falls (Sete Quedas), which had acted as a geographic barrier for fish dispersion, allowed at least 13 species to reach the section above the dam (Agostinho *et al.*, 1994a). Of the 113 species identified by experimental fisheries before the reservoir was closed, only 83 were caught after the flooding. Among the factors that probably contributed to this are: 1) the dispersion of some species, previously confined above Guaíra Falls, which with the formation of the reservoir had free access to this section of the Paraná River and the Itaipu Reservoir and 2) the semi-lentic conditions of the reservoir's fluvial zone, which resulted in the co-existence of lentic and lotic species (Agostinho *et al.*, 1994a).

An alarming fact about the Paraná River is that there exists only a single undammed river section, having a 230 km extension within Brazil. This is the one between Primavera and Itaipu dams (Agostinho & Zalewski, 1996). This section corresponds to about 28% of the Paraná River course in Brazilian territory, from the confluence of the Grande and Paranaíba rivers until the confluence with the Iguaçu River, which has an extension of about 810 km (www.aneel.gov.br). The construction (currently postponed), of another hydroelectric plan (Ilha Grande) would eliminate this lotic environment (Agostinho *et al.*, 1995).

MATERIAL AND METHODS

Study Area

This study was carried out in a sub-region of the Paraná River basin, which includes the reservoirs of the Urubupungá complex (formed by Jupiá and Ilha Solteira Hydroelectric Plants) and the Paraná River downstream (Fig. 1). The area was divided into three main habitats: **Habitat 1**, reservoirs of the Francisco Lima de Souza Dias Complex (or Urubupungá Complex), which includes the Engenheiro Souza Dias (Jupiá) and Ilha Solteira Hydroelectric reservoirs; **Habitat 2**, the Paraná River between the Urubupungá Complex and the dam of Engenheiro Sérgio Motta (formerly Porto Primavera) Hydroelectric reservoir; **Habitat 3**, the Paraná River immediately below the Porto Primavera dam.

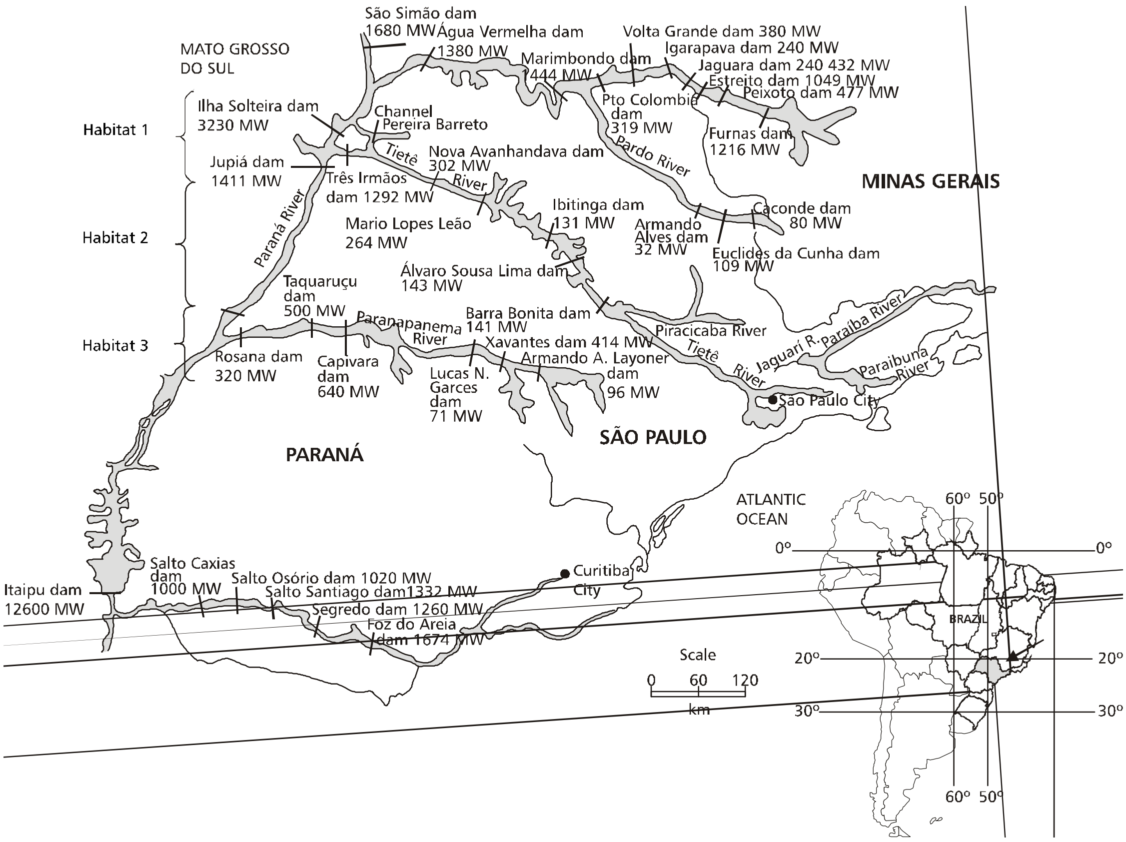

Fig. 1 — Study area.

The sampling points for this work were the fishing villages in some localities within the study area; Ilha Solteira, Itapura, and Rubinéia, in São Paulo State, with fishery in Habitat 1; Três Lagoas, in Mato Grosso do Sul State, Presidente Epitácio, and Panorama, in São Paulo State, with fishery in Habitat 2; Porto Rico, in Paraná State, and Primavera, in São Paulo State, with fishery in Habitat 3.

Calculation of the costs, incomes and profits

Calculations of costs, income, and profits of the fishermen were based upon information they supplied through a questionnaire. The formulas used to calculate costs, income, and profits followed Agostinho *et al*. (1994b) and Okada *et al*. (1997), and were as follows:

Calculations of the costs

Costs to the fishermen were divided into two components: **fixed costs**, associated with expenses for maintenance and depreciation of boats, propulsion systems, and fishing gear, and **variable costs**, associated with fuel consumption, type of fish conservation, and wages for assistants.

Fixed costs — fishing gears

Once the gear, and gear components (hooks, lines, nets, ropes, etc.), used by the fishermen were identified, the following variables were identified: **unitary price** (P_G) **of the gear**, encompassing gear manufacturing costs; **depreciation of the fishing gear** ($D_G = P_G / t_G$), with the unitary price and fishing gear lifespan (t_G) in years, annual depreciation can be determined. Depreciation in this case was not considered a function of maintenance, though decreasing with time; **gear maintenance** (M_G), varying according to gear type. Corresponds only to material needed to repair gear (lines in the case of gill-nets and cast-nets, and lines and hooks in the case of long-lines), since the fishermen themselves or their family members do the work. Average maintenance cost was based on the information provided by the fishermen.

For long-lines and rod/reel, the unitary value, maintenance, and lifespan in years were regarded as being the same for the three habitats in each sampling period. The unitary value for the cast-nests was fixed for all the habitats, for each period, but the maintenance costs and lifespan varied. For the gillnets, the maintenance costs, lifespan, and unitary values (as a function of the mesh) varied. This differentiation was applied because the information provided by the fishermen differed considerably among the habitats. To minimize calculations, gillnets were classified into four categories: mesh ≤10, mesh = 12, mesh = 14, and mesh ≥ 14.

Thus, fixed cost of the fishing gear, denoted by C_{FG}, is given by:

$$C_{FG} = D_G + M_G$$

Fixed costs — boat and propulsion system

Once the boat type and the propulsion system used were specified, the following variables were determined: **unitary price of the boat** (P_B) and **propulsion system** (P_P), as well as of the lifespan in years, t_B and t_P, of the boat and of the propulsion system, respectively; annual **depreciation of the boat** ($D_B = P_B/t_B$), and **propulsion system** ($D_P = P_P/t_P$). Again, it was assumed that depreciation does not vary as a function of maintenance: **maintenance of the boat** (M_B) and of the **propulsion system** (M_P). Usually, the maintenance of the boat represents 10% of its unitary cost (Okada *et al*., 1997). The maintenance of the propulsion system varies according to its type. In this study, each fisherman was asked the annual cost of gear maintenance, and an average value was calculated.

Thus, the fixed unitary cost for the boat and the propulsion system (C_{FBP}), is:

$$C_{FBP} = D_B + M_B + D_P + M_P$$

Units for fixed cost values were in years. By dividing each value of the fixed cost (boat, motor-board, fishing gears) by 360 (number of days considered in a commercial year), it was possible to obtain the daily cost per fisherman. Later, daily profit per fisherman was calculated. This cost, multiplied by the number of days that the fisherman worked during a week, is proportional to work days for each.

Variable costs

The variable costs to the fisherman, denoted by C_V, are: **fuel consumption**, how much the propulsion system consumes (gasoline and oil), on the average per trip; **fish conservation**, varies as a function of the type (ice, refrigerator, freezer); **assistants' wages**, may be either fixed or a percentage of production.

Thus, the cost (C) to fishermen is given by:

$$C = C_{FG} + C_{FBP} + C_V$$

Income calculation

To calculate income, it was necessary to know the amount (kg) of the species S caught (K_S) and the average sale price per kg (P_S). This information was obtained directly from the fishermen. Since most of the time, they have no control over the amount of fish caught, we attempted to reduce as much as possible the time allotted to this information, in order to avoid bias. Thus, we asked about the catch in the week previous to the interview, or from the last trip preceding it.

Thus, income (I) of the fishermen is given by:

$$I = \sum_S K_S \cdot P_S$$

Profit calculation

Once income and costs were calculated, profit (P) is obtained by subtracting the costs from the income. Thus,

$$P = I - C$$

Statistical analysis

It was possible to identify and quantify some variables and to verify how significant they are in the profit through an analysis of covariance (Sokal & Rohlf, 1995). The explanatory variables that might be significant for profits were as follows: **quantitative variables or covariates**, considered as linear, making possible the analysis of their effects (linear or not) on the response variable (profit). The covariates used were: AGE, fisherman's age (in years); F_T, fisherman's experience (in years); and F_D, fishing days on a weekly basis (in days). **Categorical variables or factors** were defined as dummy variables (Chatterjee & Price, 1991) in order to differentiate the several levels of these factors or categories. In this case, the category variables or factors (fixed) considered were: F_{PL}: fishing site, with three levels (1, Jupiá and Ilha Solteira reservoirs; 2, stretch of the Paraná River between the Jupiá and Primavera dams; 3, Paraná River below the Primavera dam; F_{PR}, fishing period (1, dry season; 2, rainy season); C_S, marital status of the fishermen (1, single; 2, married; 3, widower; 4: divorced); I_L: educational status (1, illiterate; 2, literate; 3, primary school unfinished; 4, primary school completed; 5, middle school unfinished; 6, middle school completed; 7, first level unfinished; 8, first level completed; 9, high school unfinished; 10, high school completed; 11, attended and completed trade school); B_M: boat material (1, wood; 2, aluminum); P_{SY}: propulsion system (1, without and 2, with a motor-board); F_G: fishing gear used in fisheries (1, cast-net; 2, gillnet; 3, long-line; 4, rod and reel; 5, cast-net and gillnet; 6, cast-net and long-line; 7, cast-net and rod/reel; 8, gillnet and long-line; 9, gillnet and rod/reel; 10, long-line and rod/reel; 11, cast-net, long-line, and gillnet; 12, cast-net, gillnet, and rod/reel; 13, gillnet, long-line, and rod/reel; 14, gillnet, cast-net, long-line, and rod/reel).

Thus, profit can be expressed according to the following model:

$$P = m + F_{PL} + F_{PR} + C_S + I_L + B_M + P_{SY} + $$
$$+ I_S + F_G + b_1\left(AGE - \overline{AGE}\right) + b_2\left(F_T - \overline{F_T}\right) +$$
$$+ b_3\left(F_D - \overline{F_D}\right) + e$$

where:

$P =$ response variable (profit);
$m =$ populational average;

$b_1, b_2, b_3 =$ covariate coefficients of AGE, F_T, F_D, respectively;

$\overline{AGE}, \overline{F_T}, \overline{F_D} =$ total average of AGE, F_T, F_D, respectively;

$e =$ independent errors normally distributed, $N\left(0, s^2\right)$.

During ANCOVA execution, some outliers can be detected through studentized residuals, whose absolute values are higher than 3. Once outliers are detected, the decision of whether or not they should be dropped from the subsequent analysis depends on verifying some diagnostic measures and also on considerations about the extent to which such outliers are important to the data set. In this analysis, to detect outliers we used the leverage measures (h_i) and the Cook distance (D_i) (Chatterjee & Price, 1991).

RESULTS AND DISCUSSION

In order to compare average profits of the fishermen in the different habitats it was necessary, first, to calculate their costs (Table 1) and incomes (Table 2) with respect to their work. During data collection, such information was often difficult to obtain, since most of the fisherman were unable to calculate with precision their expenditures, the value of their equipment and fishing gear, not to mention their production. Wooden boats, though used by the minority of the fishermen, in both sampling periods (28.2% in the dry season, and 29.0% in the rainy season), had the lowest daily cost: R$ 0.84 in the dry season (R$ 1.00 = U$ 0.86) and R$ 0.56 in the rainy season (R$ 1.00 = U$ 0.52). This is because most of the fishermen build their own boats, re-using material taken from old boats. Aluminum boats predominate even though their average daily costs are higher: R$ 0.95 for the dry season, and R$ 0.58 for the rainy season. The main reason cited for using aluminum boats was that they have a longer lifespan (ca. 10 years), while wooden boats last for about 4.9 years. Thus, even though aluminum boats had a higher unitary cost, the depreciation is lower when compared to that of wooden boats.

TABLE 1
Fixed and variable costs in the three habitats: habitat 1, Ilha Solteira and Jupiá reservoirs; habitat 2, Paraná River lotic section between Jupiá and Primavera dams; habitat 3, Paraná River lotic section below the Primavera dam.

Daily costs fixed and variable	Values (R$)*					
	Dry season (July/98) – habitats			Rainy season (February/99) – habitats		
	1	2	3	1	2	3
Total	324.98	633.44	378.63	354.15	1.179.25	627.21
Number of fishermen	16	27	17	17	39	31
Minimum	5.63	3.51	9.48	9.03	7.39	2.26
Maximum	52.12	100.09	60.59	39.06	75.84	56.21
Average/Fisherman	20.31	23.46	22.27	20.83	30.24	20.23
Standard deviation	12.74	17.58	15.06	7.38	19.18	12.15

*R$ 1.00 = US$ 0.86 in July/98 and R$ 1.00 = U$ 0.52 in February/99.

TABLE 2
Daily income in the three habitats: habitat 1, Ilha Solteira and Jupiá reservoirs; habitat 2, Paraná River lotic section between Jupiá and Primavera dams; habitat 3, Paraná River lotic section below Primavera dam.

Daily income	Values (R$)*					
	Dry season (July/98) – habitats			Dry season (February/99) – habitats		
	1	2	3	1	2	3
Total	536.06	744.23	403.75	686.38	1683.18	1340.63
Number of fishermen	16	27	17	17	39	31
Minimum	8.12	0.00	0.00	6.50	0.00	1.95
Maximum	82.5	65.50	161.50	157.50	240.00	140.00
Average/Fisherman	33.50	27.56	23.75	40.38	43.16	43.25
Standard deviation	20.59	17.03	37.80	38.96	41.20	31.10

*R$ 1.00 = US$ 0.86 in July/98 and R$ 1.00 = U$ 0.52 in February/99.

With respect to the propulsion system, a relationship was observed between motor-board use and habitat type. In the reservoirs, 100% of fishermen interviewed in both periods had a motor-board, with maintenance and costs amounting to R$ 1.53 per fisherman in the dry season (R$ 1.00 = U$ 0.86) and R$ 1.45 in the rainy season (R$ 1.00 = U$ 0.52). Motor-boards classified as center-positioned or prow-positioned are more common in habitats 2 and 3, suggesting that fishermen there, unlike those in the reservoir, do not need potent motor-boards to reach appropriate fishing areas.

Fishing gear costs showed great variation, as the fishermen use different gears according to the fish species presenting higher productivity in a given season. Intensity of gear use also differs, so that gear lifespan varies with the habitat. Thus, gear with the lowest daily cost was gillnet with mesh 12 cm, opposite knots, in habitat 1, during the dry season. This was basically because this gear is underutilized in this habitat, thus increasing its durability, and decreasing maintenance costs. On the other hand, gear with the highest cost was cast-net in habitat 3, during the rainy season. Higher use frequency reduces its lifespan. Moreover, the fishermen reported that its maintenance costs are also higher because sometimes this gear is trapped beyond recovery by underwater branches.

Fuel consumption cost is lower in the reservoirs than in the river, even though fishermen in the reservoirs need to travel greater distances to find suitable fishing sites. This is possibly because after finding their sites, they set their gear and go elsewhere. After a certain period of time (usually one night), they return to the sites. Fishermen in the river use a different tactic, as their fisher conditions are more dynamic. Moreover, high water velocity demands continuous operation of the motor-board, so that fuel cost increases are to be expected.

Even though 74.5% of the interviewed fishermen had access to publically supplied electric energy, only a few used freezers or refrigerators to store their fish. During the dry season, 9.8% of the fishers used freezers for fish conservation, while in the rainy season, with its higher air temperatures, this proportion increased to 18.3%. These values are well below the one observed for Itaipu Reservoir below Porto Primavera (89.7%), where all fish are commercialy frozen (Agostinho *et al*., 1994b). The few fishermen using this form of conservation also use freezers or refrigerators for this purpose. The average daily costs varied between R$ 0.61 to R$ 0.92 in the different habits and seasons, while the average daily cost with ice exceeded R$ 10.00.

This situation leads to situation in which, because he is unable to conserve his fish long enough to obtain better prices, the fisher must sell his product as soon as possible, sometimes for less than the average price. Thus, these fishermen cannot increase their profits and, therefore, cannot afford to buy a refrigerator or freezer. This problem has already been pointed out by Leonel (1998) in a study of the social use of the Amazonian rivers and forms of fish commercialization.

Petrere (1995) reported that the noble species such as the "pintado", "dourado" and "jaú" at one time were well represented in fisheries. However, with accumulating impacts in the aquatic systems, this situation has changed and these three species now represent only 6.0% of the 9,309 kg captured by the fishermen in the two sampling periods. In habitat 3, high production of "armado" stands out (10% of total production in the two periods). This species is one of those that dispersed when Itaipu Reservoir was formed (Agostinho *et al.*, 1994a); before, it had been confined below Guaíra Falls (now gone) but after 1982, it became widespread upriver, with a concomitant increase in fishery.

The information provided by the fishermen on their production, as well as costs, are diffuse. Notwithstanding, average daily profit per fisherman was calculated as a function of the habitat (Table 3).

After calculating average profit of the reservoir fishermen, a comparison was done to verify if differences existed among them. The values found in both periods for the three habitats, oscillated numerically in relation to values reported in other studies. At the Santiago and Osório falls in Iguaçu River the average daily profit per fisherman was R$ 10.88 (Okada *et al*., 1997). For Itaipu Reservoir, Agostinho *et al*. (1994b) estimated an average daily profit of U$ 0.80, confirming its low productivity and, thus, the low profit of the Paraná Basin reservoirs (Petrere & Agostinho, 1993; Petrere, 1996).

Using the values of the response variable (profit, in *reais*, the Brazilian curreney) and for the explanatory variables, the ANCOVA was performed to obtain a model explaining the response variable (fishermen profit).

TABLE 3
Daily profit in the three habitats: habitat 1, Ilha Solteira and Jupiá reservoirs; habitat 2, Paraná River lotic section between Jupiá and Primavera dams; habitat 3, Paraná River lotic section below Primavera dam.

Daily profit	Values (R$)*					
	Dry season (July/98) – habitats			Dry season (February/99) – habitats		
	1	2	3	1	2	3
Total	211.07	110.79	25.12	332.23	503.93	713.43
Number of fishermen	16	27	17	17	39	31
Minimum	–30.69	–55.09	–48.59	–13.73	–53.73	–29.21
Maximum	66.03	51.66	123.85	140.67	214.09	111.55
Average/fisherman	13.19	4.10	1.48	19.54	12.92	23.01
Standard deviation	25.45	21.26	35.13	37.35	46.02	29.21
Coef. of variation	192.9%	518.5%	2373.6%	191.1%	356.2%	126.9%

*R$ 1.00 = US$ 0.86 in July/98 and R$ 1.00 = U$ 0.52 in February/99.

Considering as valid only the data for fishermen actively engaged at the time of the interview, a minimum model, although with some outliers, was obtained. After further investigation (and removal outlier), the analysis proceeded and the results are presented in Table 4.

Two analyses were carried out: first, keeping the observation relative to habitat 3 (second sampling data), which is an outlier and, second, after removing it. Both situations are presented in steps 5(a) and 5(b), keeping the outlier (Table 4), and in steps 6(a) and 6(b), with the outlier removed. In the later steps, a minimum model without outliers was obtained. After investigation, we decided to exclude it, as it showed an atypical value in comparison with the others, whose explanatory variables had similar characteristics.

Thus, we reached the minimum model for the response variate (profit) given by:

$$P = m + I_L + F_G + b_3\left(F_D - \overline{F_D}\right)$$

The significance of this model was verified through an analysis of variance table (Table 5). It can be seen that the minimum solution is highly dependent on the data set, which is typical in observational studies such as this one. Moreover, due to the high profit-variability (see the last line in Table 3), the model can only explain 48% of profit variability. In an attempt to evaluate which factors are responsible for profits of the fishermen, it was concluded that the educational level, number of fishing days, and the type of fishing gear used were significant. This result is coherent, since better educated fishermen would be more able to manipulate different gear type, and to effect adaptations most suitable to conditions prevailing in a given period and habitat. Moreover, the number of days a fisherman worked directly affected production and, consequently, profits. However, while significant, these variables only explain 48% of the profit variability, owing to the high variability of the response variable.

Within this context, fishery at present is an economic activity in which profit depends on the educational level of those who devote themselves to it profit inequalities detected in this study, and also Okada *et al.* (1997) and Agostinho *et al.* (1994b), support the points raised by in those of Daily & Ehrlich (1996) and Firth (1998) in discussing the effects of public educational policies on profits of less-favored populations. Accordingly to Brenton (1991), fishering communities can be regarded as relatively homogeneous social groups, but their internal components require study because, depending on the variables considered, project development can lead to different hypotheses and concrete solutions. Sometimes, results obtained in projects carried out in such communities indicate the need to conceive in a broader way the social dimensions of fisheries.

TABLE 4
ANCOVA

Steps	**n**	**R^2 (%)**	**Outliers**			**Leverage (h_i)**	**Cook's D (D_i)**	**Critical leverage**	**Critical cook**	**Minimum model**
			N. quest.	**Habit**	**Season**					
1	146	2.9	14	3	1	0.017	0.100	0.226	0.549	$P = m + F_{PR}$
			22	1	2	0.012	0.075			
			1	2	2	0.012	0.191			
			10	2	2	0.012	0.068			
			17	3	2	0.012	0.044			
2	104	22.5	14	3	2	0.236	0.219	0.317	0.650	$P = m + F_{PR} + I_L + F_T$
3	103	25.5	8	3	1	0.106	0.067	0.320	0.653	$P = m + F_{PR} + I_L + F_T$
			2	2	2	0.142	0.094			
			11	3	2	0.060	0.035			
4	128	37.8	26	2	2	0.055	0.029	0.258	0.586	$P = m + I_L + F_D + F_G$
			6	3	2	0.350*	0.202			
			12	3	2	0.114	0.037			
5 (a)	126	43.4	3	1	1	0.134	0.047	0.262	0.591	$P = m + I_L + F_D + F_G$
			6	3	2	0.350*	0.234			
6 (a)	125	44.0	6	3	2	0.350*	0.250	0.264	0.593	$P = m + I_L + F_D + F_G$
5 (b)	125	47.5	3	1	1	0.134	0.052	0.264	0.593	$P = m + I_L + F_D + F_G$
6 (b)	124	48.4	—	—	—	—	—	—	—	$P = m + I_L + F_D + F_G$

Where: $P =$ profit; $m =$ constant; $F_{PR} =$ fishing period; $I_L =$ educational level; $F_G =$ gear used in fishery; $F_D =$ days of fishing on a weekly basis (in days); $F_T =$ fisherman's experience (in years).

TABLE 5
ANOVA for the minimum model.

Dependent variate: profit			**n = 124**		**R^2 = 0.484**
Source of variation	***SS***	***df***	***MS***	***F***	***p***
Educational level	11,815.67	9	1,312.85	4.79	0.000
Days spent fishing (week basis)	1,923.47	1	1,923.47	7.02	0.009
Fishing gear	8,436.78	12	703.06	2.57	0.005
Residual	27,666.04	101	273.92		

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