Fisheries Management and Ecology, 2001, **8**, 163–171

Social and financial aspects of the artisanal fisheries of Middle São Francisco River, Minas Gerais, Brazil

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Abstract The presence or absence of motorized boats, partnerships and multispecies catches characterize the fisheries of São Francisco River, Minas Gerais, Brazil. Fishing activity based on 109 interviews, carried out in the wet (high water: February and March) and dry (low water: July and August) seasons, with professional fishermen are described. Aiming to identify the fishery income components, a covariance model was proposed, with the income as the response variable, related to the factors: fishing ground; use of motorized or paddle boat; seasonality; presence of fishing assistant; and the following covariates: capture in weight in the week prior to the interview; fisherman experience in yrs; and distance (km) travelled for fishing. The results indicated that the main contributions to income were the absence of an engine (because of high price of the fuel), the absence of a partner (because of low capture) and the amount of fish caught by the fishermen.

KEYWORDS: Brazil, commercial fisheries, fishery economy, São Francisco River.

Introduction

The São Francisco River is 2780 km long and its basin encompasses seven States and 450 municipal districts. Eighty-three percent of its area lies in States of Minas Gerais and Bahia, harbouring approximately 13 million inhabitants (Petrere 1989; Cappio, Martins & Kirchner 1995). The local people practise commercial and subsistence fishing. The traditional fishing communities are characterized by an understanding of the dynamics of the fishery resources they exploit. A total of 73 species were listed in the Três Marias Reservoir region, plus 37 in seven permanent and two temporary floodplain lakes above Três Marias in the upper São Francisco River (Petrere 1996).

In this context, the social and economic organization of the artisanal fishermen and the fishery yields are considered to be influenced by the exploitation strategy of available resources. The sharing of the fish stock, at the local level, is directly linked to the way resources are accessed with spatial patterns of exploitation of the resources and with intra- and inter-community interactions, especially with the State Government.

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The objective of this paper was to develop an assessment of the financial and ecological status of the fishery to support the planning, by the State and fishing community resource administration, and examine the local implementation of fishery regulations, using the São Francisco River basin as a case study.

Materials and methods

Data collection and interviews

During 1997, data were collected from the headquarters of the following fishing communities: Januária, Pirapora, Três Marias and São Francisco town, as well as the closest towns to those communities: Itacarambí, Pedras de Maria da Cruz, São Romão, Ribanceira and Buritizeiro (Fig. 1). Thirty-three artisanal fishermen were interviewed in the wet season (February and March), and 76 in the dry season (July and August) (Table 1).

During the field campaign in the wet season, an extensive questionnaire was used. However, most of the interviewed fishermen did not cooperate in answering all the questions, so the questionnaire was modified for the dry season campaign to emphasize only the aspects related to fishing activity, but excluded questions related to health, environmental perception and all the generic questions about socio-economic aspects. Income was estimated through the amount of fish caught by each fisherman and the fish selling prices.

Basic information collected included:

1. inventory of the fishing gear;
2. identification of the most important variables in the process of income generation from commercial fishing;
3. spatial pattern of distribution of fishermen.

Table 1. Number of interviews and data collection sites

Locality	Latitude	Longitude	Interviews in the wet season 1997	Interviews in the dry season 1997	Estimate of the total number of fishermen
Januária	15°488′ S	44°362′ W	5	9	336
Itacarambí	15°102′ S	44°092′ W	3	4	60
Pedras de Maria da Cruz	15°607′ S	44°391′ W	2	3	30
São Francisco	15°949′ S	44°864′ W	7	21	227
São Romão	16°369′ S	45°069′ W	3	12	85
Ribanceira*			2	3	8
Pirapora	17°345′ S	44°942′ W	4	12	350
Buritizeiro†	17°351′ S	44°962′ W	1	1	40
Três Marias‡	18°206′ S	45°242′ W	6	11	160

* Ribanceira is a district of São Romão and its location is the same of that town.

† In the statistical analysis it was included together with Pirapora as these two towns are one in front of another in the river margins.

‡ In Três Marias community, there are approximately 2700 registered fishermen, although only 160 fish regularly.

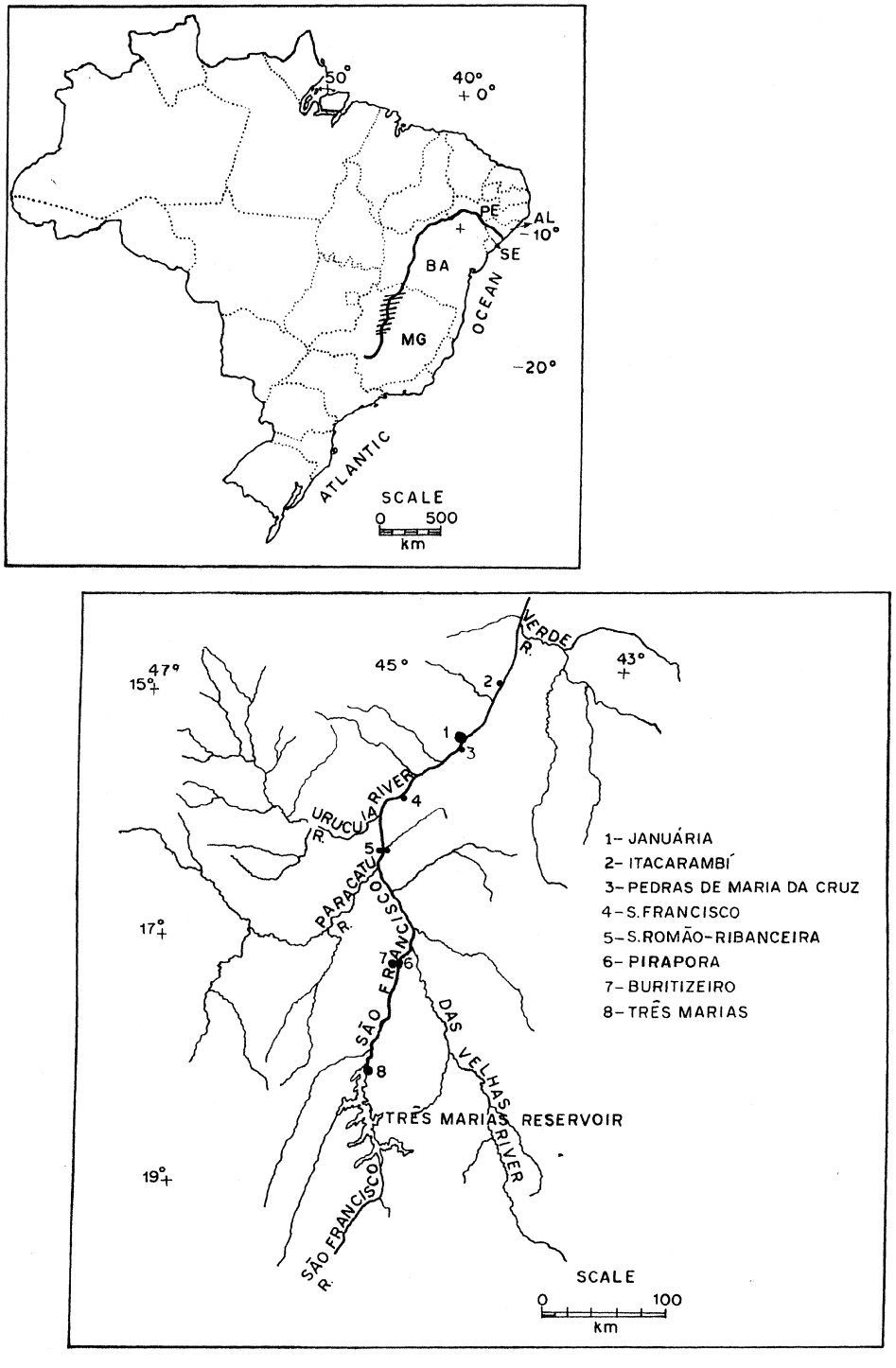

Figure 1. Location of the sites of data collection.

The number of fishermen to be included in the samples was not fixed *a priori* as it varied according to their availability at the location and time of the interview. First, an interview was carried out with a leading fisherman of the community, when the researchers asked for information about other fishermen. This procedure was repeated until the number of interviews mentioned in each location was reached.

Procedure for analysis of income formation

Only data from 105 interviews were used because of the large number of missing data in the rest of the forms. To identify and quantify the variables that determined income formation, an analysis of covariance (ANCOVA) was performed, in which the response variable was the income rate (R), expressed in the current Brazilian currency, the Real (1US$ = R$1.0916 in August 1997). The explanatory variables are:

Factors:

G: fishing ground (Três Marias = 1; Buritizeiro and Pirapora = 2; Ribanceira = 3; São Romão = 4; São Francisco = 5; Pedras de Maria da Cruz = 6; Januária = 7 and Itacarambí = 8);

M: use of motorized or paddle boat (motor = 1; paddle = 2);

S: seasonality (wet = 1; dry = 2);

A: presence of fishing assistant (present = 1; absent = 2).

Covariates:

C: capture rate, in weight, in the week prior to the interview;

E: fisherman experience (yr);

D_k: distance in km, travelled to fish.

The initial model is described by

$$R = \mu + G + M + S + A + \beta_1(C - \bar{C}) + \beta_2(E - \bar{E}) + \beta_3(D_k - \bar{D_k}) + \text{Interactions} + \varepsilon \quad (1)$$

where μ is the overall mean and ε the random variable supposed $N(0, \sigma^2)$. $\bar{C}$, $\bar{E}$ and $\bar{D}_k$ are means across all the data.

Results

The mean age of fishermen was 44.4 yr ($n = 106$). Approximately half were illiterate or semi-illiterate and the remainder had a low level of education. The average experience of fishing was between 28 and 30 yr ($n = 102$) and 97.3% of this time ($n = 73$), this was only practised in the São Francisco River basin. Half of the fishermen also practiced subsistence agriculture on islands or the mainland during the dry season.

Nearly all fishermen (90.9%, $n = 33$) had an assistant. The average share of catch between the two persons was 33.3% ($n = 33$) in the wet season and 44.7% ($n = 50$) in the dry season. In all cases the fisherman was responsible for the operating costs. The sale of the fish was directly to dealers, either at fishermen's residence, in camps, streets, communities or in free markets.

During the wet season no fuel was used in 78.8% of the cases ($n = 26$) and in the remaining 22.2%, the daily consumption averaged 10.9 L ($n = 7$). The average expenses

for the maintenance of the production input per week was R$15.3 ($n = 13$). In the dry season, the average daily fuel consumption was 6.8 L ($n = 30$).

Relatives accompanied the fisherman at 36.4% and 34.2% of the time, in the wet and dry seasons, respectively ($n = 73$).

Fish landings

Table 2 shows the species composition (%) per season and its average landing price (R$) paid by the fish dealers.

The fishermen did not know the exact weight of each species in their own catch. When it was not possible to weigh the fish, the weight of the total mixture was considered instead. In this situation, the mean catch weight was 36.3 kg fisherman^{-1}, in the week prior to the interview.

During the dry season, the most important species caught were curimatá *Prochilodus affinis* Reinhardt and *P. marggravii* (Walbarum) with an average catch of 21.0 kg fisherman^{-1} week^{-1} ($n = 21$), corvina *Pachyurus francisci* (Cuvier) and *P. squamipinnis* (Agassiz) catch rate was 6.0 kg fisherman^{-1} week^{-1} ($n = 2$) and dourado *Salminus brasiliensis* (Cuvier) 14.7 kg fisherman^{-1} week^{-1} ($n = 6$).

During fishing for catfish, surubim *Pseudoplatystoma coruscans* (Agassiz), there was a differentiation made by the fishermen concerning its sexual maturity. The adult fish and those above the minimum legal size (80.0 cm) are denominated 'surubim'. The same fish, but immature or below the legal size are called 'moleque'. In a single case, the fisherman caught 41.0 kg of 'moleque'. The surubim *Pseudoplatystoma coruscans* catch rate was 24.1 kg fisherman^{-1} week^{-1} ($n = 4$).

Table 2. Species composition (%) per season and its average landing price

Species	Catch composition (%)		
	Wet season (n = 33)	Dry season (n = 76)	Average price
Curimatá *P. affinis* Reinhardt and *P. marggravii* (Walbaum)	42.42	80.26	R$ 2.00 (n = 56)
Corvina *Pachyurus francisci* (Cuvier) and *P. squamipinnis* Agassiz	–	9.21	R$ 2.40 (n = 6)
Dourado *S. brasiliensis* (Cuvier)	12.12	35.53	R$ 4.30 (n = 25)
Surubim *Pseudoplatystoma coruscans* (Agassiz)	21.21	44.74	R$ 5.60 (n = 28)
Piranha *Serrasalmus piraya* (Cuvier)	6.06	11.84	R$ 1.80 (n = 7)
Pirá *Conorhynchus conirostris* (Valenciennes)	3.03	10.53	R$ 2.40 (n = 7)
Mandí *Pimelodus maculatus* Lacépede	3.03	7.89	R$ 2.50 (n = 5)
Pacamã *Lophiosilurus alexandri* Steindachner	3.03	7.89	R$ 2.60 (n = 5)
Traíra *Hoplias malabaricus* (Bloch)	–	2.63	R$ 2.00 (n = 1)
Piau *Leporinus elongatus* Valenciennes and *Schizodon knerii* (Steindachner)	–	1.32	–
Matrinchã *Brycon lundii* Reinhardt	–	1.32	–

Fishery and inventory of fishing gears

In Januária, fishing is usually carried out from paddle or sail-driven wooden boats or with the aid of drift nets. In the wet season, the fisheries were mainly subsistence. The community only sold its fish after July, when catch rates were higher. Trade during the other seasons was scattered and each fisherman sold his catch freely. The fishery characteristics in Pedras de Maria da Cruz and São Francisco were similar to those of Januária. Skills represented by weaving of drift nets are common among the fishermen.

In Itacarambí, the fishermen use wooden boats propelled by paddles and the main fishing gear is the drift net, but hooks, nets and harpoons are also used.

In São Romão, after fishing the wooden boats are left in the river and the bicycle is used for personal and load transport. During the reproductive season, fishermen use a combination of weighted hooks, a weight and drift hooks, and long lines with a superficial float and a weight in the bottom of the river. There are four dealers in the city who buy and take all the fish to the municipality of Ibiaí, 70 km upriver.

Most of the fishermen of Pirapora use wooden boats propelled by paddles, drift nets, several types of fish hooks and harpoons, the latter of which are by far the most important fishing gear. Fishing with harpoon is carried out at night with a battery-powered light placed in the prow of the boat. Using these methods, the most common species gaffed is the curimatá *P. affinis* and *P. marggravii*: the greatest number of species were caught in August–October. Catch rates declined from November onwards, when reproduction starts and fishing is forbidden.

Laws forbid fishing in rapids or from large rocks in the middle of the river. Nevertheless, there is a closed group of clandestine fishermen between Pirapora and Buritizeiro who constantly fish in these places, with a hierarchy that determines when and where pairs of fishermen will fish.

In Três Marias, the more important fishing gears in the main channel of the São Francisco River are the cast net and hooks. Harpoons are forbidden although they are used at night. There are two other types of fishery: (i) the 'terrena' that is accomplished with the boat in motion, while a long line is released, (ii) the 'trela', which consists of a long line with two fish hooks 2.2 m^{-1}. The main species caught in the main channel of the São Francisco River, below Três Marias Reservoir, are curimatá *P. affinis* and *P. marggravii* and dourado *S. brasiliensis*.

Aluminium boats (mean length of 5.2 m) are used occasionally. They cost R$1033.30 on average ($n = 3$) and last for about 8 yr. Wooden boats, with an average length of 6.2 m ($n = 77$) are more widely used, which have a lifespan of 3.6 yr ($n = 18$), and cost around R$392.50 ($n = 67$).

The engines used are 3.5 or 5.0 hp, but there are two further types of motors: (i) outboard, with power varying between 8.0 and 25.0 hp; and (ii) inboard, diesel motors of 18.0 hp.

Drift nets are the most common fishing gear. They are on average 3.1 m high ($n = 126$), 111.3 m ($n = 129$) long, with a 15.8-cm stretched mesh ($n = 121$). Drift nets are used for an average of 3.2 yr ($n = 31$) and cost about R$472.10 ($n = 103$). The most frequent length of the drift net is 100 m and the mesh size is 15 cm.

The cast net is 2.8 m ($n = 141$) high with a perimeter of 15.3 m ($n = 123$), and a 10.0-cm stretched mesh ($n = 152$). Cast nets can be used for an average 2.6 yr ($n = 54$) and cost about R$158.30 ($n = 130$).

Fitting the model

The complete linear model, given by Eq (1), was adjusted empirically, by taking the initial model without interactions, and then discarding one by one the factors or covariates with higher *P*-values. The optimal model reached was

$$R = \mu + M + A + \beta_1(C - \bar{C}) + \varepsilon$$

In this model, the interactions *MA*, *CM* and *CA* were examined and were not significant at the 5% level. This (Table 3) suggested independence between the factors. Thus, income is explained by the presence/absence of motors, assistant and the amount of fish caught.

The full ANCOVA model could not be examined because there were not enough degrees of freedom left. Thus, the model was run with the factors and covariates that were judged to be more relevant.

The residuals analysis showed some outliers and leverage. When these outliers and leverage were removed, the predictive power of the model decreased. The use of the logarithmic transformation was not satisfactory. The analysis of the residuals also showed that the distribution of the residuals was slightly asymmetric to the left. Kurtosis was not significant.

Discussion

This study describes the artisanal fisheries of São Francisco River, emphasising its financial aspects. It is important to note that no data were available prior to this study.

Throughout the year, fishes with higher market prices are sought, such as surubim *Pseudoplatystoma coruscans* and dourado *S. brasiliensis*. However, the composition of the catches varies seasonally. Curimatá *P. affinis* and *P. marggravii* are also target species, not for their market value but for their abundance in the river.

In Três Marias, there was greater investment in the fishery, the fishermen were better equipped (higher concentration of aluminium boats and stern motors) and they were devoted exclusively to intensive fishing.

Table 3. Analysis of covariance of the minimum model

Dependent variable, *R*		$n = 105$	$r^2 = 0.823$		
Source of variation	Sum of squares	d.f.	Mean square	*F*	*P*
M (use of motorized or paddle boat)	6107.992	1	6107.992	23.799	0.000
A (presence of fishing assistant)	1917.683	1	1917.683	7.472	0.007
C (capture rate, in weight, of the previous week of the interview)	118 943.458	1	118 943.458	463.453	0.000
Error	25 921.295	101	256.646		

It was concluded that a culture of saving money does not exist among fishing communities. Despite the differences between such communities, the profits from fishing are extremely variable. Thus it is difficult to understand how fishermen make money. Accumulation of capital is constrained by highly variable costs and fluctuating catch rates. There is no accounting for fishermen's labour when the fish is sold, i.e. the costs of labour are not included in the final price of the fish. Moreover, as fishermen cannot preserve the fish, they are obliged to sell it at any price, so being subject to the opportunity cost.

In the model to explain the income, fish price was excluded from the analysis as it did not show seasonal variation, even with regard to the distance travelled to the fishing location. It could be argued that hooks are key in the reproductive season and so this must affect catches. But this is obscured by the intensive use of the forbidden drift nets, which catch more fish than the hooks, which, in any case, are not preferred by São Francisco fishermen. The variables related to the fishing effort were also not significant as all the fishermen used drift nets or cast nets. The way fish was preserved and sold was also not significant.

The variable costs of fishing were directly linked to the catch and, as a consequence to the gross revenue. The main factor in the variable costs is the proportion attributed to the fishing partner, who can take between 33.3% and 44.7% of the catch free from direct costs of capture. The use of motors, both in the dry and wet season, was, in some instances, prejudicial on economic grounds, because the fisherman used fuel but did not capture enough fish to cover its cost.

The fishermen who worked in the main channel of the São Francisco River exhibited territorial behaviour, mainly related to the ownership of regularly fished and cultivated areas in islands or in the floodplain, habitual places for camps and appropriate places in the river for setting the drift nets. Fishermen usually defend their territory strongly and in some cases they can even kill other persons who invade their areas. There was no internal conflict among the commercial fishermen in distant areas. The problem associated with how the resource is accessed is more relevant, especially when the interactions between sport and commercial fishermen are considered. Sport fishermen fish for leisure. They belong to the middle class and come from the surrounding towns and cities. In this case, the conflicts are concerned with the location of commercial fishing gears in the river. These commercial gears may impede navigation of the sport fishermen's boats.

Relevant modifications of commercial fishing activity in Minas Gerais are expected. In this State, there is a tendency to prohibit commercial fishery for the foreseeable future. This action has been implemented directly through decrees of the State Governor. Commercial fishing communities have been questioning whether legislation is constitutional in the high courts of Minas Gerais and, up to March 2000, a resolution has not been advanced. This clearly reflects the great intensity of the conflict between the two kinds of fishermen. Sport fishermen have a greater capacity to lobby, easy access to the press and sympathy of the politicians they support, and so have influence on the courts.

Acknowledgments

We thank all the fishermen of São Francisco River for the information obtained during the interviews; Dra Miriam Leal Carvalho, Dr Carlos F. A. Fischer, Dra Maria B. Boschi,

Menderson Mazucatto and Jorge Francisco José Minte-Vera for the field support. The project was supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, Proc. No. 96/08103-6).

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