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The commercial fisheries of the lower Amazon: an economic analysis

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Abstract This study characterizes the fishermen and the commercial fishing fleet of the lower Amazon, based on data collected from 5446 boats operating out of the city of Santarém in 1997. An economic analysis of the activities of these boats was based on 50 interviews with boat operators. Larger and smaller boats use essentially the same technology, but there are significant differences in fishing strategies. Smaller boats supply local markets and their catch consists of a large variety of fish species. Larger boats tend to specialize in a small number of catfish species, and supply fish processing plants. Smaller boats are less efficient in terms of catch per unit effort (CPUE) (kg fisherman^{-1} day^{-1}), but are more efficient economically, earning more for each unit of capital invested than larger boats. Most boats operating from Santarém have a storage capacity of < 4 t. Boats in this size ($0 < 4$ t) account for 87% of the total fleet direct employment, and 73% of total income. Thus despite the lack of attention from regional policy makers, these smaller boats are an important source of food, income and employment in the lower Amazon region.

KEYWORDS: Amazon, commercial fishery, employment, income generation.

Introduction

Amazon fisheries have undergone profound changes over the last 30 years, partly as a result of technological innovations which increased the catch and storage capacity of fishing vessels, and in part to the growth of urban and regional export markets. Today, the commercial fishery is one of the principal sectors of the regional economy, employing more than 30 000 people and generating between US$100 and US$200 million annually at the wholesale level (Ruffino 1996).

This process of expansion and intensification has transformed the regional fisheries in terms of the resource, types of fish products and the profile of commercial fishermen.

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Whereas in the past, commercial fishing was a seasonal activity based on the exploitation of a restricted number of species and producing dried salt fish, it is now practised all year round, exploiting a larger number of species and involving the marketing of fresh, iced fish. In the past, fish products were destined primarily for the regional market, especially the rural extractivist population. Today, the fishery is oriented towards urban consumers and exports frozen fish to other regions of Brazil and the exterior (Smith 1979, 1985; Goulding 1983).

Expansion of the commercial fishery was accompanied by a large increase in the number of people involved in the sector. The decline of floodplain cash cropping (jute) resulted in the shift of rural labour from agriculture to fishing. Earlier, the floodplain resident was a commercial farmer and subsistence fisherman (McGrath, Castro, Futemma, Amaral & Calabria 1993). Today, much of the floodplain population of the Lower Amazon, as well as a significant part of the urban population, depends on the commercial fishery for at least part of the family income (Ruffino, Mitlewski Isaac, & Oliveira 1999).

The development of the fishery has also been characterized by the rise of a class of full-time professional fishermen or fish packers. Based in the main regional ports, fish packers and their teams of fishermen travel throughout the surrounding network of floodplain lakes in search of fish. Exploiting individual lake fisheries, often over the protests of local floodplain communities, the fish packer has become the central figure in Amazon commercial fisheries. He is also the subject of considerable controversy. On the one hand, he is the main supplier of fish to urban markets, and on the other, he is regarded by floodplain communities as responsible for the depletion of lake fish resources.

While the commercial fisheries are based in half-a-dozen main urban centres, boats operating from these centres now exploit the fish stocks of virtually all the navigable portions of the Amazon river system (Barthem, Guerra & Valderrama 1995). Although the biology of Amazon fisheries have been intensively studied over the last two decades, the economics of these fisheries have received considerably less attention. Lack of information on the economics of Amazonian fisheries is a major barrier to their sustainable management for at least two reasons. Firstly, fisheries management takes place through the implementation of policies which influence the behaviour of commercial fishermen and not the fish they exploit. An understanding of the economics of fishing is, therefore, essential for predicting how fishermen will react to different management measures. Secondly, although the commercial fishery is an important generator of regional employment and income, the sector is largely invisible to regional development planners and politicians, with the result that policies detrimental to the development of the sector are frequently implemented with little consideration for their negative economic and ecological impacts. The purpose of this paper is to present the results of an economic analysis of the Santarém commercial fishing fleet and explore some of the implications of this analysis for Amazonian fisheries management policy.

Materials and methods

The research is based on two main sources of data: daily fish landing data for the port of Santarém collected over a 1-year period, and more detailed interviews undertaken with 50 commercial fishermen representative of the major types of fishing boats landing fish in

Santarém. A third data set, compiled by Projeto IARA-IBAMA, which describes the physical characteristics of 211 fishing boats, was also utilised.

The landing data used to characterize the Santarém fishing fleet were collected daily by Projeto IARA during 1997. Interviews were undertaken during the peak hours at the main landing sites (markets and processing plants) and included information on the characteristics of the fishing vessel, trip itinerary, catch size and composition, number of fisherman and canoes, duration of the voyage, ice and fuel consumption and the sale price of fish. This data set consists of 6418 interviews. The landing data distinguish four categories of boats: canoes, fishing boats, buyer boats and passenger boats. This study is based on the analysis of data from the 3144 interviews with fishing boat operators. These data were used to classify boats in size categories according to ice capacity.

More detailed analyses of fishing activity are based on interviews conducted during the months of January and February 1998. During this period 50 boat operators were interviewed. Interviews included questions on the life history of the fishermen (birth place, age, involvement in other activities, etc.), fishing activity (period of the year engaged in fishing, fishing conflicts, bank loans) and details of the most recent fishing trip (catch size and composition, type and number of gear types used, number of fishermen involved, and consumption of ice and fuel, etc.).

Using this data set, the cost structure and net income per fishing trip were calculated for the months of January and February for each of the different size classes of fishing boats identified earlier. The IARA-IBAMA data set was then used in combination with the interview data set to calculate monthly net income for the other 10 months of the year. The combination of these two data sets made it possible to account for seasonal variation in catch size, composition and price over the course of the year. The main assumption here is that the cost structure of fishing trips, as opposed to gross income, does not vary significantly from month to month.

Results

Characteristics of the Santarém regional fishery

Santarém, located at the confluence of the Tapajós and Amazon rivers, is the fourth largest fishing port in the Brazilian Amazon after Manaus, Belém and Tabatinga (Isaac, Milstein & Ruffino 1996) (Fig. 1). It is the principal fish market of the lower Amazon region which extends from the border between the states of Amazonas and Pará to the mouth of the Xingu River. Annual fish landings in Santarém have fluctuated between 3000 and 4000 t over the last 5 years (Ruffino 1996), with the total for 1997, the year on which this study is based, around 3300 t.

In the Santarém area, growth of the commercial fishery began in the late 1970s, and reached a peak in the late 1980s (Fig. 2). In addition to the more general factors noted earlier, the growth of the Santarém fleet is probably linked to flows of capital originating in the informal mining sector of the middle and upper Tapajós basin, then at the peak of the gold boom. The IARA-IBAMA data set indicates that the growth of the Santarém fishing fleet has slowed considerably during the 1990s. This is consistent with trends in the

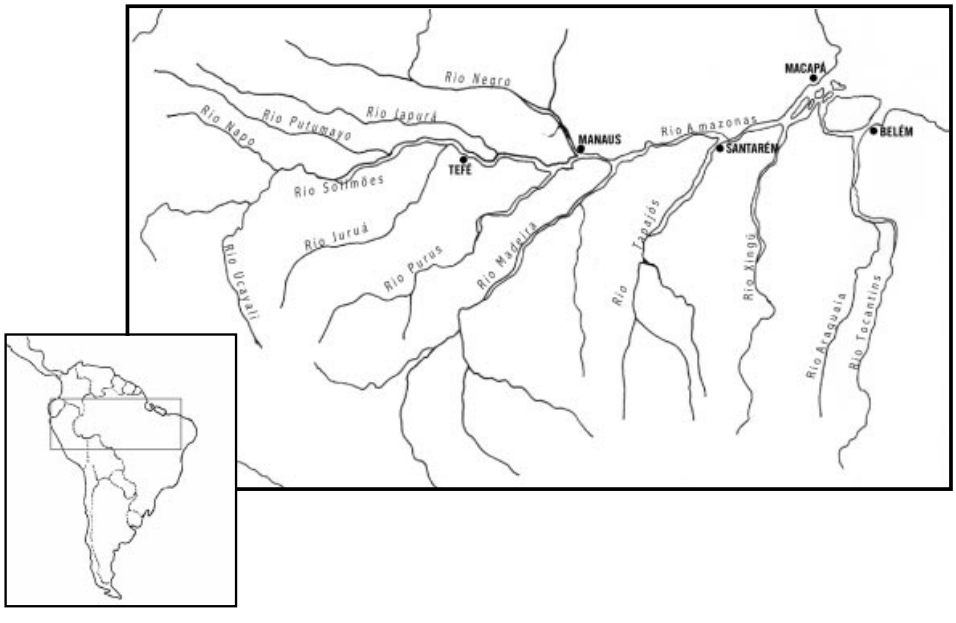

Figure 1. Main fishing ports in the Brazilian Amazon.

landing data of the last 5 years, which indicate that the annual catch has remained stable over the period, and observations of the lack of major new investments and technological changes in the regional fishery over the same period.

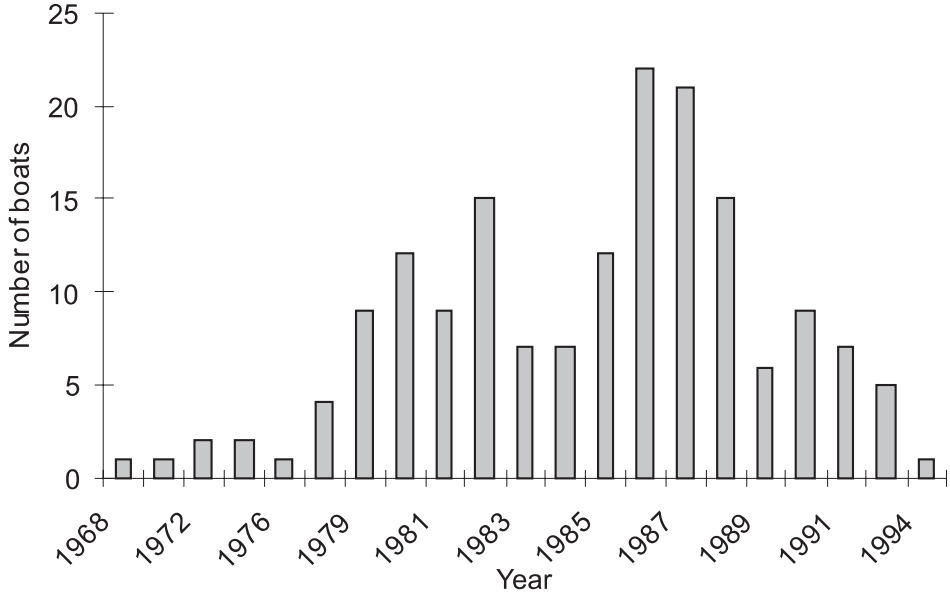

Figure 2. Year of construction of fishing boats, Santarém 1997.

The Santarém regional fishery consists of two somewhat overlapping groups of fish, corresponding to the traditional distinction between catfish and fish with scales. The first fishery concentrates on two groups of catfish: migratory species such as the dourada, *Brachyplatystoma flavicans* (Castelnau) and piramutaba, *B. vaillantii* (Valenciennes) which are caught primarily in the major river channels during their annual upstream migration, and more sedentary species such as the mapará, *Hypophthalmus* spp. and fura calça, *Pimelodina flavipinnis* (Steindachner) which are caught in floodplain lakes (Isaac *et al.* 1996). The second fishery includes a variety of species, principally characins and cichlids, which are caught primarily in floodplain lakes, although some species are also caught in the river during annual migrations. The two fisheries supply different markets. Catfish are purchased by fish processing plants which export frozen fish to other parts of Brazil, while the catch of the second fishery is marketed and consumed locally (Fig. 3).

Fish are transported to the Santarém market in several different ways, including fishing boats, passenger boats and buyer boats. Of the three types, fishing boats are the most important, accounting for 68% of the total volume landed. In 1997, more than 500 fishing boats landed a total of 2300 t of fish in 3144 landings for an average of 682 kg trip^{-1}. The second category, buyer boats, are specialized in the purchase of fish in rural areas for resale in Santarém. These boats accounted for 16% of the total catch in 307 landings for an average of 1721 kg trip^{-1}. The third category, passenger boats, was responsible for 16% of total catch in 1644 landings for an average of 337 kg trip^{-1}.

Two important characteristics of the Santarém fleet are the homogeneity of fishing technology and the unspecialized nature of most fishing boats. While there is considerable

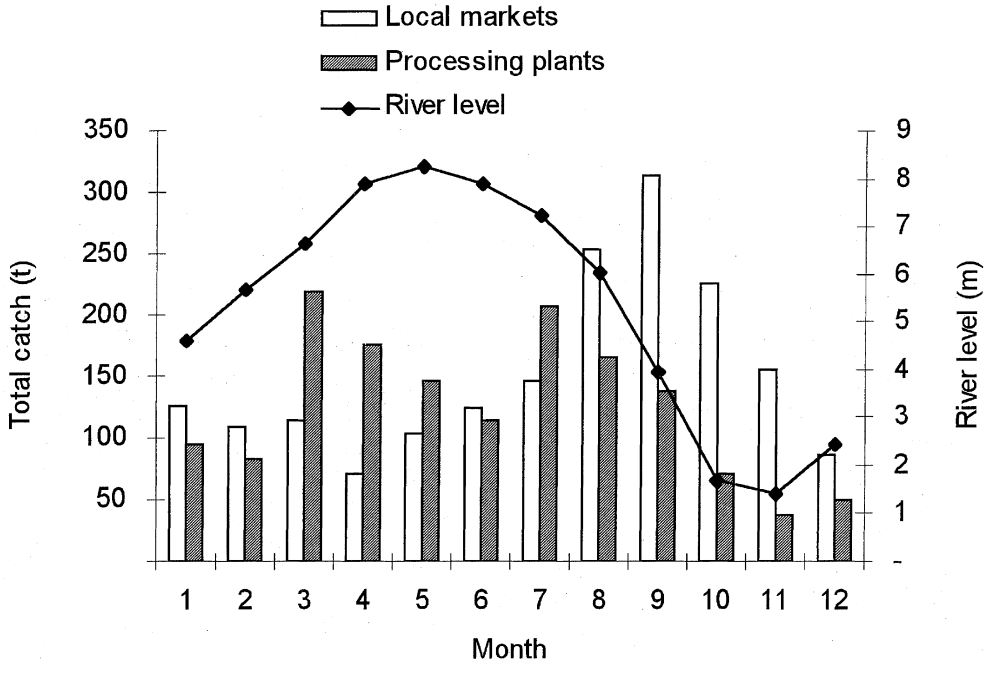

Figure 3. Volume of fish landed at regional markets, fish processing plants and river level, Santarém 1997.

diversity of fishing gear, ranging from gill nets to bow and arrow (with gill nets of various types accounting for the major share of the regional catch), there is very little difference between boats in the kind of gear used and in the way it is employed. The principal unit of capture is the canoe operated with two fishermen. The fishing boat is not directly involved in catching fish and serves to transport fishermen and canoes to the fishing grounds, and to store and transport the catch to market. Generally, the owner of the boat owns the fishing gear (mainly gill nets) and canoes, and maintains a team of fishermen who sell their catch to him. Fuel, ice, food and other expenses are financed by the owner of the boat. The boat anchors at the fishing site and pairs of fishermen move off to fish in the vicinity. Once or twice a day, canoes return to the mother boat where the total weight per species is recorded as the fish are transferred from the canoe to the mother boat.

As the great majority of fishing boats are designed for general use, very few have storage compartments built into the hull. Smaller boats use one or more styrofoam ice chests while larger boats use removable styrofoam-lined wooden boxes. Consequently, the correlation between boat size (measured in length) and ice storage capacity tends to be weak. In a sample of 211 boats registered by IARA-IBAMA, for example, the correlation between size and storage capacity was only 55% (Snedecor & Cochran 1980). As would be expected, the correlation was lower for smaller boats (15%) and higher for larger boats (48%). This relatively low correlation is a reflection of the generalist character of the regional fishing fleet, in which owners move in and out of the fishery, switching between fishing and other activities such as transport of cargo, cattle or passengers over the course of the year.

Classification of boats

The homogeneity of the fleet in terms of gear and hull design is also reflected in the size distribution of boats. In 1997, 575 boats landed fish in the port of Santarém. These boats varied in size from 200 to 38 000 kg ice capacity, with boats in the lower part of this range dominating the local fleet. As there are no technical criteria for classifying the fleet, boats were classified into five categories on the basis of ice capacity: <1, 1 to <4, 4 to <8, 8 to <15 and ≥ 15 t.

While smaller boats dominate the fleet, the larger boats account for a significant share of the total catch landed (Table 1). The two smallest categories account for 89% of the fleet, 93% of landings and 58% of the catch. The relationship between proportion of fleet, landings and catch is reversed for larger boats (Table 1). The larger boats which comprise only 11% of the Santarém fleet, are responsible for almost half of the total catch (42%) landed at Santarém by commercial fishing boats (Table 1).

Table 1. Number of boats, landings and catch by size class, Santarém 1997

	<1 t	1 to <4 t	4 to <8 t	8 to <15 t	≥ 15 t	Total
Average capacity	507	1669	5728	10 782	28 301	46 987
Number of boats	348	162	31	22	12	575
Number of trips	1940	830	117	75	30	2992
Total catch (kg)	550 627	660 452	247 713	365 684	278 837	2 103 313

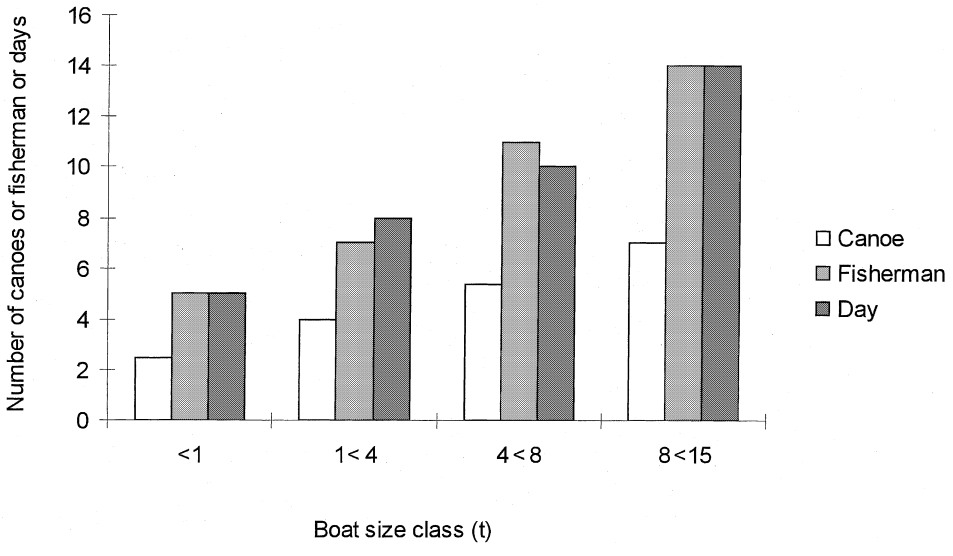

Figure 4. Number of canoes, fishermen and days per fishing trip by boat size, Santarém 1997.

As noted earlier, differences between large and small boats are largely quantitative, with the number of fishermen and canoes and the duration of fishing trips increasing with boat size (Fig. 4). The number of fishermen and canoes increases from five fishermen and two canoes in boats <1 t to 14 fishermen and seven canoes in the $8<15$ t category. Duration of fishing trips also increases, from five days in boats <1 t, to 14 days in boats of $8<15$ t (Fig. 4).

In addition to differences in the number of fishermen, the different categories of boats exploit different species and have different marketing strategies. Smaller boats exploit a larger variety of species than larger boats, both in terms of the number of species captured and in terms of the relative importance of each species in the total catch. For example, boats below 1 t capacity exploit approximately 47 species with no one species accounting for more than 21% of the total catch. In contrast, boats in the 8 to <15 t category exploit 22 species of which the most important, mapará, accounts for 69% of the total catch. The Shannon diversity index calculated for each category confirms this impression (Krebs 1989). Boats below 1 t capacity have a score of 2.83 in the global diversity index while boats in the 8 to <15 t category have a score of 1.3. Using the diversity index as the dependent variable and ice capacity as the independent variable, there is a significant

Table 2. Catch diversity index (H′) by boat size from fleet of the Lower Amazon, Santarém 1997

	<1 t	1 to <4 t	4 to <8 t	8 to <15 t	≥ 15 t
Number of species	47	42	31	22	14
Index average	0.693	0.755	0.51	0.443	0.281
Standard deviation	0.477	0.499	0.467	0.469	0.245
Coefficient of variation (%)	69	66	91	106	87
Global index	2.834	2.6	1.68	1.303	1.021

negative relationship between the two, indicating that as boat capacity increases catch species diversity decreases ($r = -1.97 \times 10^{-5}$ and $P < 0.0001$) (Table 2).

While smaller boats exploit a fairly large range of fish over the course of the year, the larger boats tend to specialize in two species of catfish, catching dourada in the river during the low water season (July–September) and mapará in floodplain lakes during the flood season (March–May). The different fishing strategies also lead to different strategies for marketing their catch. Most of the smaller boats sell their fish in the principal markets of the city, where fish with scales are preferred, while larger boats sell their fish to the fish processing plants which purchase almost exclusively catfish (Fig. 5).

Profile of fishermen

Unlike other sectors of the Amazon economy, such as logging and large-scale commercial farming, the fishermen who now dominate the commercial fleet have their origins in the traditional economy of the lower Amazon floodplain. The 50 boat owners/skippers interviewed for this study were all born in Santarém or other municipalities of the Lower Amazon, and the great majority (73%) continue to live in rural areas. The average age of boat owners was 39, indicating that they are all men well along in their professional lives. The great majority have always been involved in fishing, 37% as their sole economic activity with another 24% combining fishing with farming or ranching. Most of those interviewed (80%) are full-time fishermen, with fishing being the sole family income source for about two-thirds of the total. There is a general tendency for the importance of fishing in household income to decline with boat size from 71% in the two smallest categories to 46% in the two largest.

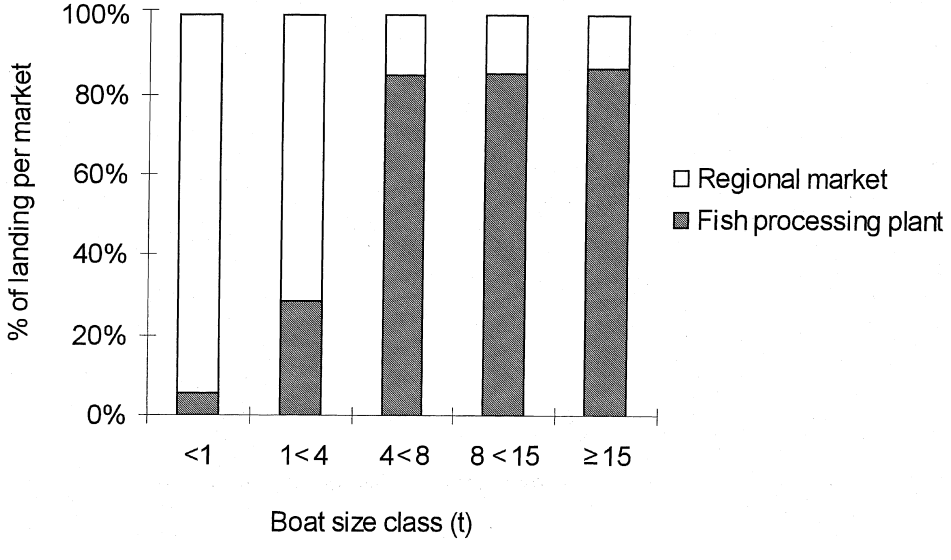

Figure 5. Percentage of landing per market, Santarém 1997.

The fleet is dominated by independent boat owners. All but 10% of those interviewed own their boats and 87% own only one boat. When differentiated by size category, there is a slight tendency for the percentage of owners with two or more boats to increase with boat size. There are no owners with two or more boats in the smallest category, 20% of owners have two boats in the second category, 33% in the 8 to <15 t category and 40% in the largest (≥ 15 t). The only cases of owners with three boats is in this last category.

With only one exception, owners purchased their present boat with their own resources, derived from combinations of savings and/or the sale of cattle and other property. The sale of cattle was involved in 41% of purchases and was the sole source of funds in 31%, making it the main source of funds for acquisition of boats. Only one of the fishermen interviewed purchased his boat with funds derived from a government loan programme, and no one admitted to having relied upon loans from other sources for boat purchase. Cattle also figure prominently in the investment strategies of boat owners. While there is apparently little surplus for investment in the three smaller categories (<1, 1 to <4 and 4 to <8 t), 55% of boat owners in the two largest categories (8 to <15 t and ≥ 15 t) invest their profits in cattle.

Economic analysis

The economic analysis of fishing activity concentrates on four issues: (a) the relationship between cost structure and owner income; (b) the relationship between the size of the boat and fishermen income; (c) the economic efficiency of fishing activity at different scales and (d) income and employment generation by the Santarém fishing fleet.

Cost structure of fishing operations and income of boat owners. The cost structure of fishing operations consists of six main items: payments to fishermen, fuel, ice, food, gear maintenance and capital depreciation. With the exception of the smallest size class, the cost structure of fishing appears to be fairly similar for all categories (Table 3). The largest expense is payments to fishermen for fish, which ranges from 30% for the smallest boats (<1 t) to 63% for the largest (8 to <15 t). The next four items, fuel, ice, food and capital depreciation seem to be of roughly equivalent importance, although the order of

Table 3. Cost structure per fishing boat in the Lower Amazon, Santarém 1997

	Cost (%)			
	<1 t ($n = 11$)	1 to <4 t ($n = 22$)	4 to <8 t ($n = 9$)	8 to <15 t ($n = 8$)
Fisherman payment	30	55	51	63
Fuel	19	8	12	10
Ice	17	14	17	12
Food	12	7	7	4
Gear maintenance	7	5	3	3
Casual depreciation	12	11	9	8
Other	4	0	0	0
Total costs	100	100	100	100

importance appears to vary. Fuel and ice costs, for example, vary from 8 to 19% of the total for fuel and 12–17% for ice. Depreciation and food are slightly lower, ranging from 8 to 12% and 4–12%, respectively. Finally gear maintenance accounts for 3–7% of total costs.

Catch per fishing trip ranges from 284 kg for the smallest category of boats to 4262 kg for the largest (8 < 15 t), resulting in a gross income to the boat owner/operator ranging from US$152 per trip for the smallest boats to US$1914 for the largest (Table 4). Subtracting costs, net income per trip ranges from US$53 for the smallest boats to US$520 for the largest (8 to < 15 t) (Table 4), resulting to 10-fold difference in income between the largest and smallest categories.

Table 4. Catch, income, cost and profit per trip per month based on landing trips in the Lower Amazon, Santarém 1997

	Boat size (t)			
	< 1	1 to < 4	4 to < 8	8 to < 15
Per trip				
Price (US$ kg^{-1})	0.55	0.50	0.46	0.45
Catch (kg)	284	785	2085	4262
Standard deviation	212	926	1646	2894
Gross income (US$ kg^{-1})	152	392	953	1914
Standard deviation	116	419	695	1439
Total cost	99	271	653	1394
Profit	53	120	300	520
Days of trip	5.52	7.69	9.39	11.97
Standard deviation	2.83	2.88	3.63	3.20
Number of fisherman	5.16	7.41	10.42	14.05
Standard deviation	2.49	2.88	6.13	5.37
CPUE (kg fishermen^{-1} day^{-1})	9.97	13.78	21.31	25.34
Per year				
Catch (kg)	15 880	32 115	69 266	110 971
Gross income (US$ kg^{-1})	8693	15 886	31 677	49 842
Variable costs	5010	9880	20 007	33 394
Fixed costs	599	1129	1692	2908
Profit	3084	4877	9978	13 541
Profit (%)	35	31	31	27
Labour payment	677	821	1115	1663
Per month				
Catch (kg)	1337	2676	5772	9248
Gross income (US$ kg^{-1})	724	1324	2640	4154
Total costs	467	917	1808	3025
Variable costs	417	823	1667	2783
Fixed costs	50	94	141	242
Profit	257	406	831	1128
Labour payment	56	68	91	136
Labour minimum wage	0.80	0.97	1.32	1.96
Income/costs	1.55	1.44	1.46	1.37

Since smaller boats undertake more trips per month, the contrast between the monthly net income of the largest and smallest boats is less than half that for individual trips. Here average monthly income varies from US$257 for boats < 1 t to US$1128 for boats in the 8 to < 15 t category (Table 4). Profit margins are around 30%. However, in contrast to the trend in income, profit margins tend to decrease with boat size from 35% for the smallest boats to 27% for the largest.

Fishermen's income. Relations between boat owners and fishermen tend to be quite stable and 85% of boat owners work with a fixed team of fishermen. As noted earlier, payment to fishermen is the main expense of the fishing trip and represents a significant proportion of the return to fishing activity, once the other expenses are subtracted from gross income. The division of this income takes various forms on fishing boats in the region. As the unit of production is the canoe with one or two fishermen, payments to fishermen are a proportion of their individual catch and are not related to the total catch of the trip. The price per kilogram that the fishermen receive is typically a percentage of the sale price of the catch at the end of the trip. This percentage varies depending on the degree of dependence of the fishermen on the boat owner. Where the fishermen has his own gear and canoe, the percentage paid is greater and tends to be lower where he uses the boat owners equipment.

The main exception to this general pattern is the smallest size category in which 41% use family labour, twice that of the next size category. These boats tend to operate more as a single economic unit, with only 44% of boat owners, as compared with 85% in other categories, purchasing fish from their fishermen. The proportion of boat owners paying fishermen's expenses is also lower in this category, indicating that costs are shared among those participating in the fishing trip. Finally, in contrast to the situation in larger boats, fishermen are responsible for repairing nets in only 22% of the boats in this category, indicating a much greater involvement of other family members, especially women, in maintenance of fishing gear.

The percentage of the sale price received by fishermen varies with boat size, increasing from 34% for boats below 1 t to 46% for boats ranging from 8 to < 15 t (Table 4). The fishermen's monthly income follows a similar trend, increasing progressively with the size of the boat. In the smallest boats, in which a significant proportion of fishermen are related to the boat owner, fishermen earned an average of US$56 per month. In the larger boats, on the other hand, the relationship between boat owner and fishermen tends to be more professional and the fishermen earn US$136 per month. Thus, fishermen from larger boats earn about 2.5 times more than fishermen in the smallest boats (Table 4).

Economic efficiency. Productivity and efficiency of fishing trips can be analyzed in terms of either the quantity caught per-unit-effort or its value per-unit-effort. Given the homogeneity in technology and fishing practices of the Santarém fleet, one would not expect to find significant differences in productivity between fishing boats. However, despite the technological homogeneity there are significant differences in fishermen productivity so that CPUE, measured in terms of kg fisherman^{-1} day^{-1}, increases with ice

storage capacity, from 10 kg fisherman^{-1} day^{-1} for boats in the <1 t category to 25 kg fisherman^{-1} day^{-1} in the 8 to <15 t group (Table 4). These results confirm the observation that the larger the boat the more professional and efficient the operation.

From an economic perspective, however, the productivity of fishing effort should not be measured solely in terms of kg-per-unit of labour because economic efficiency depends on the relative value of the product and of labour. Instead, in an economic analysis, fishing effort should be measured in terms of income in relation to expenses, given that costs involve both labour and capital. When the data are analysed in this fashion, quite a different pattern emerges in which smaller boats are more efficient than larger ones. For example, boats below 1 t capacity had an economic efficiency of 1.55. For every US$1 invested, these boats had an income US$1.55. For boats in the largest category (8 to <15 t), this relationship declines to 1.37 (Table 4).

Income and employment generation of the Santarém fishing fleet. The Santarém fleet of 563 boats generates a total of 4086 jobs including those of fishermen (3523) and boat owners (563) (Table 5). The largest category was not included because the boats were not from the surrounding counties. The smallest category of boats alone accounts for half of total fleet employment. The two smallest categories together account for 83% of total employment, with the two largest accounting for the remainder.

Total income generated by the fleet is estimated at US$5.5 million dollars, of which US$3.0 million goes to fishermen and US$2.5 million to boat owners (Table 5). The pattern of income generation is similar to that of employment although here the difference between large and small boats is less. Again, smaller boats are responsible for 41% of total income and the two smaller categories together account for 73%. The two large categories together generate the remaining 27%.

A second issue is the geographic distribution of fleet income and employment. Boats of the Santarém fleet come from 14 municipalities of the lower Amazon region with the three municipalities of Santarém, Óbidos and Alenquer accounting for more than 90% of the total (Ruffino, Issac & Milstein 1998). Thus, the fleet generates 3677 jobs and $4.9 million dollars in these three municipalities. Within this region, the fleet's contribution to employment and income is greatest in rural areas where 70% of the fleet is based.

Table 5. Employment and income (US$) estimates per fishing boats per year in the Lower Amazon, Santarém 1997

Category (t)	Boats	Fishermen	Owners	Total employment	Income (US$)		
					Fishermen	Owner	Total
0 to >1	348	1740	348	2088	1 177 980	1 073 232	2 251 212
1 to >4	162	1134	162	1296	931 014	790 074	1 721 088
Sub-total	510	2874	510	3384	2 108 994	1 863 306	3 972 300
4 to >8	31	341	31	372	380 215	309 318	689 533
8 to >15	22	308	22	330	512 204	297 902	810 106
Sub-total	53	649	53	702	892 419	607 220	1 499 639
Total	563	3523	563	4086	3 001 413	2 470 526	5 471 939

Employment and income generated by marketing and processing, on the other hand, which are not included in this study, tend to be concentrated in urban areas, especially Santarém.

Discussion

The results of this analysis of the Santarém fleet are consistent with the general impression of fishing activity in the region. Despite the relatively high diversity of fishing gear, the fleet as a whole is quite homogeneous. The main differences between boats are quantitative and not qualitative, and most of the variation is in terms of the size of the boat and the number of fishermen and canoes associated with it. Furthermore, there is a low level of specialization in fishing boat design. Only the large boats have storage compartments built into the structure of the hull, while the great majority use removable boxes, enabling boat owners to use their boats for other activities such as transport of cargo, cattle and passengers. One of the main features which distinguishes the Santarém commercial fishery from that of other fishing ports such as Manaus, Tefé and Belém, is the predominance of gill nets in the catch and the homogeneity of gear across different size categories of boats. In Manaus, for example, purse seines account for approximately 70% of the catch and gill nets for only 30% (Batista 1998). Tefé follows a similar pattern with purse seines accounting for 51% and gill nets 33% (R.B. Barthem, personal communication). The pattern in Belém is similar to that of Santarém with gill nets predominating, although here the situation is more complicated because the fleet exploits both inland and coastal waters.

The immediate explanation for the contrast in gear between Manaus and Tefé, on the one hand, and Santarém and Belém, on the other, is legal. Until recently, purse seines were prohibited in the inland waters of the state of Pará, where Santarém and Belém are located, while their use is legal upstream in the state of Amazonas where Manaus and Tefé are found. However, given the generally low level of compliance with fisheries regulations, it is difficult to believe that the law would be obeyed if there were not other powerful reasons for ignoring seines. R.B. Barthem (personal communication), for example, suggests that a combination of factors, including different ecological conditions and differences in the behaviour of the main commercial species, on the one hand, and the relatively high cost of this technology on the other, may provide a more satisfactory explanation. Given the marginal ecological conditions, there is little incentive to invest in the more expensive gear. The absence of any apparent change in the lower Amazon fishery, despite the recent rescission of the law prohibiting seines, is evidence that there is minimal interest in using seines in the region.

Differentiation of the fleet

Despite considerable technological homogeneity, this study indicates that the fleet is composed of two distinct groups of boats with many of the characteristics of the classic formal–informal sector dichotomy in incipient form. In this case the informal sector is characterized by a large number of independent fishing boats which supply the local market, while the incipient formal sector is composed of a much smaller number of large boats supplying export-oriented fish processing factories.

The parallels go further. The smaller boats tend to be more generalist in construction, with a low correlation between capacity and boat size, while larger boats tend to be more specialized with a relatively high correlation between size and ice capacity. There are other technological differences. Larger boats tend to have motorized canoes, and use a larger total area of net per fishermen than do the smaller boats of the informal sector. Labour relations are also different. The smaller boats tend to use more family labour and short-term partnerships, while in larger boats the relationship between owners and fishermen is more contractual. Incomes also tend to be higher in large boats, for both owners and fishermen, although in smaller boats there may be other non-cash benefits of family relations not revealed by this study.

The fishing strategies of the two groups of boats are also different. Smaller boats, for obvious reasons, tend to make a larger number of shorter trips over the course of the month. Limited by fuel and ice capacity, smaller boats tend to concentrate effort in areas near Santarém and to fish the same areas year in and year out. Larger boats adopt more itinerant strategies covering a larger total area and consequently place less emphasis on any one fishing ground.

Finally, marketing strategies, as noted earlier, are also quite different. Smaller boats supply the local domestic market with characins and cichlids, while larger boats supply processing plants with catfish for export to other parts of Brazil. Furthermore, while the smaller boats supply exclusively the Santarém market, the largest boats operate on a regional scale, monitoring prices in several markets and choosing the most advantageous to land their catch. These boats are only seasonally present in the Santarém market, operating elsewhere during the rest of the year.

Another question is the degree of competition between the two sectors and the implications of this competition for trends in the fleet. From one perspective, the growing dominance of the more formal sector within the fleet seems obvious. While the three largest categories (including boats over 15 t) account for only 11% of the fleet, they contribute 42% of the total catch. Furthermore, as noted earlier, the larger boats are also more productive in terms of conventional measures of fisheries productivity (kg man^{-1} day^{-1}, CPUE). However, from an economic perspective, the situation is quite different. Profitability, measured in terms of returns to capital, is highest in small boats and decreases with boat size. The greater economic efficiency of small boats is due to the combination of labour, fishing and marketing strategies described earlier.

The key point here is the relatively little competition between the two groups because they exploit different species for different markets. While large boats may account for 42% of the annual catch, virtually their entire catch goes to the fish processing plants (Fig. 5), and almost the entire catch of smaller boats is landed in the domestic market. But why do large boats not avoid the domestic market if it is more profitable? Firstly, they probably could not employ the strategies which make small-scale fishing boats more profitable because they are in large part scale-dependent.

Secondly, one problem large boats face is the small size of the domestic market. The average catch landed by the large boats is equivalent to the average daily catch (5000 kg) landed at Santarém. Large boats, then, tend to have a significant impact on market conditions, depressing local prices. As a result, they tend to receive lower than normal

prices in the Santarém market. The fish processing plants, in contrast, often pay higher prices for large catches. In addition, the local market may take several days to absorb the entire catch, while frigorificos can absorb it as fast as it can be unloaded. These differences between the two markets tend to maintain the segmented nature of the fishery, and protect the smaller boats of the domestic market from the competition of larger boats.

The importance of the fisheries sector in the regional economy

In official statistics there is no specific category for employment in fisheries which is included within the category of primary sector activities such as farming, logging and mining. The primary sector is the largest in the regional economy accounting for 41% of employment in the three adjacent municipalities of Santarém, Óbidos and Alenquer where most of the Santarém fishing fleet is based and operates.

While it is not possible to compare our estimate of employment generation by the Santarém fleet with government statistics, it is possible to compare it with estimates for other sectors of the regional economy. For example, the 4086 jobs generated by the Santarém fleet (Table 5) is somewhat less than the 5277 jobs of the manufacturing sector, which accounts for 6% of regional employment, but more than the 3900 and 3800 jobs, respectively, of the transportation and communication, and construction sectors, which each accounts for 4% (IBGE 1993). Direct employment generated by the Santarém fleet, thus, accounts for about 5% of the regional total, and, is equivalent to that of the major sectors of the regional economy.

A second issue is the quality of employment in the fisheries sector, within the context of the regional pattern of income distribution. Here, it is important to look at fishermen and owner income by category since there is great variation between groups. The conventional Brazilian system of measuring monthly income in terms of fractions and multiples of the official minimum salary is followed here. Fishermen's income ranges from one to two minimum salaries, for an average for the fleet of roughly one minimum salary. Approximately 60% of the working population falls into this income range. At the low end, where most fishermen employment is concentrated, salaries are higher than those of 18% of the population and equivalent to those of 32%. At the upper end, salaries are equivalent to those of 10% of the population and higher than those of 67% (Fig. 6).

The range of incomes of boat owners is greater than that of fishermen. Incomes for boat owners in the two smaller categories ranges from three to five minimum salaries, comparable to that of 10% of wage earners and higher than that of 86%. Owners in the 4 to <8 t category earn incomes in the 5–10 minimum salary range, equivalent to 5% and higher than 93% of the population. Finally, owners in the 8 to <15 t category earn salaries in the range of 10–20 minimum salaries, equivalent to 2% and higher than 97% of the population.

Policy implications

While official statistics on fisheries employment and income generation are not available, the results of this study indicate that the Santarém fleet, in addition to its role in

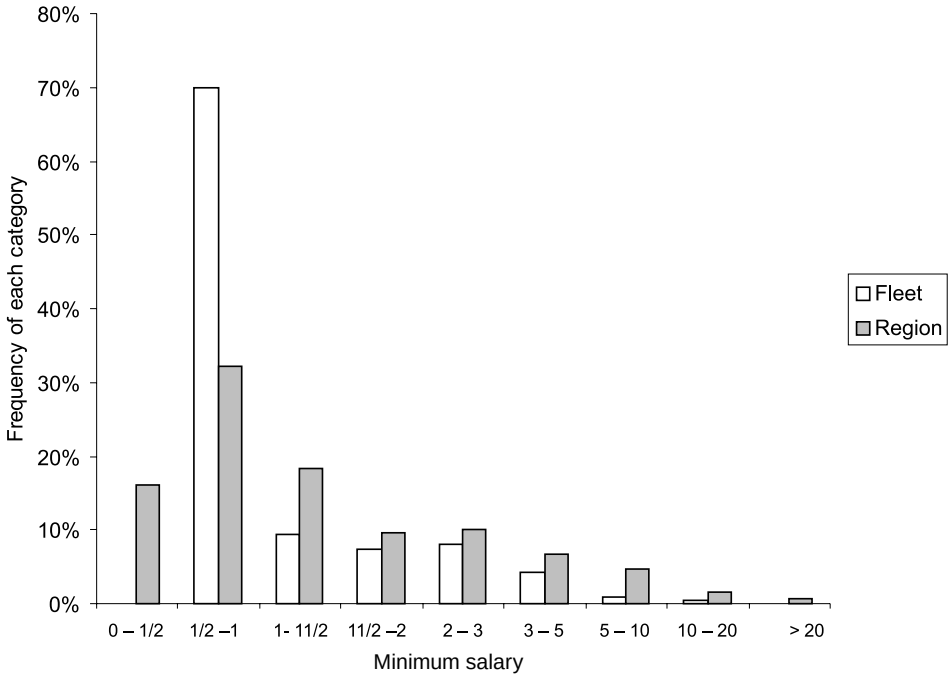

Figure 6. Income distribution of fleet (fisherman and owner) and region, Santarém.

supplying low cost, high quality animal protein for the regional population, is a major contributor to regional employment and income, comparable to that of other sectors which receive considerably more attention and support from government agencies. Furthermore, far from being a marginal activity, salaries of fishermen, although low in an absolute sense, are within the range of salaries earned by most of the regional labour force. Finally, a large proportion of the employment and income generated by the fleet and virtually all the fish consumed by the local population are supplied by smaller boats, those up to 4 t capacity. It is these smaller boats which are primarily responsible for the exploitation of floodplain, as opposed to river channel, fisheries, and therefore, policies addressing the problems of managing floodplain fisheries should focus on this group, while those concerned with management of migrating catfish should focus on larger vessels and fish processing plants.

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