Darwin Initiative for the Survival of Species

Final Report

Fisheries Management for Biodiversity Conservation in the Brazilian Amazon

Imperial College

London UK

Instituto de Pesquisa Ambiental da Amazonia

Belem Brazil

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1 Darwin Project Information

Project title	*Fisheries Management for Biodiversity Conservation in the Brazilian Amazon*
Countries	*UK, Brazil*
Contractor	*Imperial College, London*
Project Reference No.	*08/126*
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2 Project Background

While public interest has concentrated on the destruction of the Amazon rainforest, another great tropical frontier, the Amazon floodplain, is also under increasing pressure. Though comprising only a small fraction of the basin, the floodplains of the Amazon river system have an importance in terms of biodiversity, economic activity, and the ecological services that the floodplains perform that far outweighs their relative area. The sustainable development of fisheries plays a key role in the conservation of floodplain biodiversity, firstly because the Amazon fish stocks are the most diverse found in any river system in the world, and secondly because the fisheries depend on the ecological services of the floodplain system and may provide a major economic incentive for the conservation of this key habitat.

Amazon floodplain fisheries are currently under threat from two sources: direct fishing pressure and habitat modification. Over the last 30 years, Amazon fisheries have undergone dramatic changes. The introduction of modern fishing technology, combined with the growth of urban and export markets, have increased pressure on Amazon fish stocks. Stocks of several commercially important species are considered overexploited, and locally many other species are also under excessive pressure. Amazon fisheries are exploited by mobile, often urban-based commercial fishers, and by local, subsistence-oriented fishers resident in the varzea. The expansion of commercial fishing has resulted in increasing levels of conflict between the two groups, and communities have increasingly sought to restrict the exploitation of local floodplain fisheries through community management schemes. If development of the Amazon continues, with further growth of urban centres and improved access to markets away from the river, the likelihood is great that Amazonian fisheries will follow the same path of overexploitation that other major river systems of the world have experienced, resulting in the progressive impoverishment of the fish fauna and ultimately the collapse of the regional fishery.

Another fundamental threat to the biodiversity of the varzea arises from progressive modification of this habitat for transport, flood control, agriculture and cattle ranching. The sustainable use of varzea resources can provide important economic incentives for the conservation of this habitat. Fisheries are a major economic use of the varzea, and their productivity and diversity are closely linked to its ecological integrity. Indeed, many initiatives for conservation of the varzea through sustainable use of its resources have focused on the development of fisheries for income generation. However, there has been no systematic assessment of the economic benefits the fisheries provide, the way fisheries interact with other economic activities in the varzea, or the effects of recent and proposed developments in the management of fisheries on these aspects.

Amazonian fisheries are exploited both commercially and for subsistence. Commercial fishing is carried out predominantly by mobile and often urban-based professional fishers, while subsistence-oriented fishing is carried out locally by rural people resident in the floodplain areas. Both commercial and subsistence-oriented fishers exploit stocks in the main river channel as well as in floodplain lakes, many of which are accessible to large commercial boats in the flooded season. The resulting pressure on fisheries resources has led to widespread attempts by rural communities to restrict commercial fishing in local floodplain lakes. Under the new Brazilian federal fisheries law, fishing regulations devised by local communities may be legally recognised and enforced by the government. Effectively the new law creates a co-management system where local communities and the government share responsibility for fisheries management and enforcement

This is a critical period in the process of fisheries development, and the future of Amazonian fisheries will depend in a large part on the policies which are developed and their effectiveness in reconciling the complementary objectives of conserving biodiversity and taking advantage of the long term productive potential of the floodplain ecosystem. This project aimed to contribute to the development effective conservation policies through the evaluation of alternative policies in terms of their likely impacts on fish stocks and the levels of direct and indirect income and employment generated by the fisheries.

This project was conceived jointly by IPAM, a Brazilian NGO devoted to the sustainable development of the Amazon basin through research, policy analysis and community action; and the Department of Environmental Science and Technology (DEST) at Imperial College. IPAM has long been active in fisheries management initiatives as part of its varzea programme. It collaborates widely with community and commercial fisheries organisations, with other projects, and with relevant government bodies. Imperial College DEST is a leading international centre for fisheries research, with particular strengths in modelling and quantitative analysis. Joining force has enabled IPAM and DEST to conduct a rigorous, integrated evaluation of the economic role of fisheries, and the likely impacts of development trends and alternative management policies. IPAM remains committed to promoting the sustainable development of Amazon fisheries. As a direct result of the Darwin project, IPAM now enjoys a leading position in the analysis of fisheries management policies in the Amazon, and is likely to exert a strong influence on future policy development.

3 Project Summary

3.1 Purpose and objectives

The purpose of the project was the evaluation of fisheries management approaches to the conservation of floodplain (varzea) habitats.

The purpose has been addressed through the achievement of a set of discrete objectives:

(1) Analysis of the economic strategies of the different types of fishers

(2) Analysis of the responses of fishers to alternative management measures

(3) Analysis of the role of the fisheries sector within the Amazon regional economy.

(4) Development of a bio-economic model

(5) Evaluation of management policies

These objectives have been broadened substantially from those stated in the original memorandum to include subsistence-oriented as well as commercial fishers. This change was indicated because it became obvious early on in the project that the subsistence-oriented fishers account for the largest share of fisheries exploitation, and that conflicts between the sectors are a major driving force of management initiatives. It was decide to broaden the existing outputs rather than reformulate them fundamentally. No formal request was made to change the objectives, but the Darwin Secretariat was informed of, and has acknowledged their broadening.

Broadening objectives to include analyses of subsistence-oriented fisheries brought with it a requirement for extensive field surveys in varzea communities. Hence project staff became far more heavily involved in fieldwork that originally envisaged, and a three-month extension was required to complete the work.

3.2 Relation to articles of the Convention on Biological Diversity

The project relates directly to the following articles of the CBD (in order of importrance):

- Article 8 (In-situ conservation): The project was concerned with the regulation of biological resources, including the effects of fisheries conservation areas.
- Article 10 (Sustainable use): The project aimed to promote conservation through sustainable use, and provided research support for co-management by local populations and government.
- Article 11 (Incentive measures): The project aimed to demonstrate and increase the incentives provided by sustainable fisheries for the conservation of the varzea.

- Article 13 (Public awareness): Project results on the value of fisheries and the effects of management measures have been disseminated to fishers and varzea communities.
- Article 6 (General measures): The project has evaluated the effects of the co-management agreements promoted under the new Brazilian Federal Fisheries Law, and the results are likely to influence future policy.

3.3 Success in achieving objectives

Project has been highly successful in achieving its objectives. The project has provided the first rigorous quantitative assessments of

- The value of the fisheries sector in the Amazon economy
- Regional differentiation in the commercial fishing sector
- The role of fishing in the livelihoods of varzea households
- The impacts of co-management agreements on floodplain lake fisheries
- The bio-economic status of the lower Amazon fishery and the likely effects of external trends and management policies

As mentioned earlier, these achievements go substantially beyond the outputs originally envisaged. The original focus of the study was the commercial fishery, but the project has integrated subsistence-oriented fisheries and provided the first integrated bio-economic assessment of both sectors. The continued active involvement of IPAM in the fisheries policy development and capacity building for management will ensure the translation of project outputs into policy.

4 Scientific, training and technical assessment

4.1 Staff

Imperial College

Dr Kai Lorenzen (Principal Investigator)

Ms Oriana Almeida (Darwin Fellow)

Dr Caroline Garaway (Social Research Advisor)

Mr Robert Banes (MSc candidate)

IPAM

Dr David G. McGrath (Principal Investigator)

Ms Nalinda de Coutinho

Ms Lucilene Silva

Ms Tatiane Santos

Ms Ivoneide Moreira

Ms Lucilene Silva

Ms Luciene Campos Sales

Ms Rosandra Santos

Ms Leusabeth Silva

Ms Kemerson Silva

Project IARA/IBAMA

Ms Cleidmar Azevedo (Director)

4.2 Project activities

The project comprised a range of distinct but closely integrated studies:

- Survey of the fisheries and support sector
- Analysis of regional differentiation in the commercial fisheries sector
- Survey of subsistence-oriented fisheries and the effect of co-management agreements in the Santarem region
- Analysis of commercial fisheries in the Santarem region
- Integrated bio-economic analysis of the fisheries in the Santarem region
- Policy workshops

No substantial field studies were envisaged, or budgeted for in the original project proposal. The broadening of studies to include of subsistence-oriented fisheries necessitated such surveys, however, and funding for the associated field costs has been obtained from WWF Brazil.

4.2.1 Survey of the fisheries and support sector

To assess the economic importance of the fisheries sector along the Amazon-Solimões river, businesses and Municipal Fishermen's Union leaders were interviewed in 15 out of a total of 51 cities along the Amazon-Solimões river. Fieldwork was conducted from April to June 2001. All three cities larger than 250.000 inhabitants were selected and a random sample of 12 was chosen from the remaining 48 cities. In each city all fish processing plants, stores selling fishing gear, petrol stations, fish restaurants, fish markets, ice factories, and boatyards were sampled. Businesses were identified based on interviews with key informants such as presidents of Fishermen's Unions, government officials, researchers, and businessmen. For activities such as boatyards and petrol stations, owners were asked to estimate the proportion of business attributable to the fishing sector. About 17% (n=238) of market vendors and 76% of other businesses were interviewed. Interviews were short and included questions on the number of employees, production or volume of product sold, selling prices and seasonal variation in economic activity. The number of fishermen and fishing boats in

each city were obtained from the local Fishermen's Union and Coast Guard in each city. The economic importance of the fishing sector was estimated in terms of employment, gross income and value added. Gross product or just income (as it is called here) is the value of the goods and services in the market and an important macroeconomic performance indicator.

The study on the fisheries and support sector has been submitted for inclusion in the Proceedings of the Second International Large Rivers Symposium, and will be subjected to peer review (Annex D).

4.2.2 Analysis of regional differentiation in the commercial fisheries sector

Field studies on costs and returns in commercial fishing were ongoing before the project started, and were continued by project staff. Surveys were conducted in the main ports of four regions: Belém in the estuary, Santarém in the lower Amazon, Manaus in the central Amazon and Tefé in the middle Solimoes. The fishing areas associated with these ports are largely, but not fully isolated. Interviews were conducted at the main landing sites for each port.

Interviews essentially followed the same model in all ports and included questions on the characteristics of the fishing vessel, number of fishermen and canoes, ice use and fuel consumption, trip itinerary and duration, catch volume and composition, and the ex-vessel price of fish. Interviews also included questions on the life history of the skippers (birth place, age, level of education, involvement in activities other than fishing) and fishing activities (where and when fishing activities occurred, conflicts with other fishermen, bank loans).

Multiple comparisons of means with confidence limits were used to describe regional differentiation in fleet and skipper characteristics. A Cobb-Douglas production function was estimated to determine output elasticities for the different inputs, and test for regional differentiation in stock levels.

A peer reviewed paper on the regional differentiation study is in press (see Annex B).

4.2.3 Survey of subsistence-oriented fisheries and the effect of co-management agreements in the Santarem region

Detailed interviews were carried out with 259 families in 18 communities in the Santarem region during the period of October to December 2000 (low water season), and again during July 2001 (high water season). Questions covered general household social and economic aspects, and detailed information on fishing activities carried out and catches obtained during the previous week. Additional interviews were carried out with community leaders in most of the communities with co-management agreements in order to establish their motivation for setting up agreements.

The study was designed as a replicated, paired comparison of fishing effort and catch between communities with established and successful co-management agreements and communities without such agreements. At first, nine communities with established, successful co-management agreements were selected from a list of registered agreements. Only communities where co-management was perceived to be successful by community leaders, the commercial fisher's union, the federal environmental agency

(IBAMA), and NGOs alike were selected. For each such community with a co-management agreement, a similar local community without a functioning management agreement was selected for the paired comparison. Pairing was based on similarity in terms of geographical proximity, dominant land type (upland or floodplain), and the size of lakes in the vicinity of the community.

Results of the evaluation of co-management regimes have been published in the web-based proceedings of the 9th Biennial Conference of the International Association for the Study of Common Property (see Annex C). A slighly modified version will be submitted to a peer-reviewed journal. A paper on the role of fishereis in the livelihoods of varzea residents and their interaction with other activities is in preparation.

4.2.4 Commercial fisheries in the Santarem region

A descriptive study of the commercial fishery in the Santarem region has been completed early on in the project and published. Trends in the commercial fisheries effort and catch were assessed using the Santarem landings database maintained by Project IARA/IBAMA since 1992. The database holds a complete record of landings at the fish market and the processing plants of Santarem, the main urban centre of the region. In addition to fish landings the database holds information on the duration of each fishing trip, location of the fishing ground, the number of fishers on board and quantity of other inputs, and the price obtained. These records were analysed for long-term trends in effort and catch. Furthermore, the response of commercial fishers to changes in stock availability was explored. The descriptive analysis of the Santarem commercial fleet has been published in a peer-reviewed paper (see Annex A). The trend analysis forms part of a forthcoming paper on the bio-economic analysis, to be submitted for peer review in due course (Annex F).

4.2.5 Analysis of aggregated catch-effort relationships in multi-species fisheries

An empirical analysis of aggregated catch-effort relationships in multi-species fisheries was carried out to identify a suitable harvest function for the bio-economic model. Three alternative models were tested on data sets from the Amazon lake study and from two separate studies in Laos. The relationship is of a sigmoid shape and hence differs significantly from the logistic curve that forms the basis of much fisheries management thinking. A manuscript on the analysis has been drafted (Annex E), and will be submitted to a peer-reviewed journal in due course.

4.2.6 Integrated bio-economic analysis of fisheries in the Santarem region

An integrated bio-economic model for the commercial and subsistence-oriented fisheries in the Santarem region has been developed. A baseline of commercial and subsistence-oriented fishing effort and catch in the main river channel and the floodplain lakes was constructed on the basis of landings records and the household survey. Cost and revenue functions were specified, and the economic behaviour of fishermen explored.

The development of an appropriate harvest function (the relationship between fishing effort and catch) posed particular problems. Firstly, the fishery is of a complex, multi-species and multi-gear nature, and only aggregated catch and effort statistics are available for the

subsistence-oriented fishery. Secondly, the long-term catch and effort data showed an extremely static commercial fishery, and provided virtually no information on catch responses to changes in effort. Hence an innovative approach had to be developed, allowing the bio-economic analysis to be carried using an aggregated harvest function while accounting for changes in the value of unit yields as a result change in species composition related to effort levels.

Results of the bio-economic analysis have been discussed with peers during the final workshop. A manuscript has been drafted (Annex F) and will be submitted to a peer reviewed journal after revision.

4.2.7 Policy workshops and dissemination

Two large policy workshops were held as part of the project, in November 2001 in Belem and in September 2002 in Santarem (Figure 1). Both workshops were attended by representatives of commercial fishers, varzea communities, government and non-governmental organisations, and research scientists. The first workshop aimed principally at eliciting perspectives on the management of Amazon fisheries from the different groups present. The second workshop aimed to disseminate and discuss research findings and foster a constructive dialogue on the future management of Amazon fisheries.

Figure 1. Participants of the second policy workshop, Santarem, September 2002

Summaries of research results and workshop outputs are being published as reports in Portuguese by IPAM (Annexes G and H).

4.3 Research results

4.3.1 Fisheries sector study

Fishing is a major source of income and employment in the Brazilian Amazon. Total fishery landings in urban markets amount to about 46,000 t per year, while subsistence fishing by rural households yields an additional 27,000 t. We estimated that the commercial fishery alone employs about 29,000 fishers, operating from 5,500 boats. In addition, most of the estimated 44,000 rural households in the floodplain area are involved in fishing, mostly for subsistence.

Total income of the fisheries sector is estimated at R$472 million (Table 1). The main activities generating this income are the fishing fleet, fish processing plants, fish markets, boatyards, ice factories, commercial establishments, petrol stations and fish restaurants. The activities that contribute most to total sector income are fish processing plants, subsistence fishermen, the commercial fleet and fish markets, generating 48%, 18%, 16%, and 9%, respectively. The importance of fish processing plants, despite the small number operating in the Amazon, is due to their large size and high income per plant (averaging R$10 million in sales). Fish markets, in contrast, are important despite the low income per vendor (R$19.000.year^{-1}) because of the large number of vendors (1366) and markets (109). Fish processing plants are a major contributor to total sector income and value added (48% 33% respectively), while the subsistence and commercial fishing fleet are the major contributors to sector employment (90% of the total employment).

Implications for management

Results suggest that total income generated by the sector is approximately R$472 million, almost ten times then earlier estimates based on data from commercial fish landings and the average ex-vessel price. Deficiencies in government statistics are both cause and consequence of the lack of attention that the sector receives from government policy makers. When sustainability is taken into account, the fisheries sector can be a far more important generator of income and employment than e.g. the forestry sector.

Table 1. Annual income and employment along the Amazon and Solimões rivers bank, Brazil, 2001.

	Annual Income (R$)			Annual Employment		
	Average per Business per year	Total for riverbank	%	Average per Business per year	Total for riverbank	%
Subsistence fishermen (a)	*1884.2*	*82,929,671*	*18%*		*49,955*	*57%*
Commercial fishing fleet (b)		*74,934,000*	*16%*		*29,089*	*33%*
Market booth	*19,022*	*41,560,716*	*9%*	*1.3*	*2,839*	*3%*
Commerce	*50,274*	*4,120,027*	*1%*	*2.8*	*324*	*0%*
Ship yard	*134,650*	*3,859,594*	*1%*	*4.63*	*124*	*0%*
Ice factory	*296,278*	*12,918,190*	*3%*	*9.61*	*397*	*0%*
Fish processing plant	*9,679,653*	*225,367,069*	*48%*	*147.47*	*4,044*	*5%*
Gas station	*264,173*	*21,578,166*	*5%*	*4.29*	*301*	*0%*
Fish restaurant	*128,101*	*4,364,332*	*1%*	*6.93*	*259*	*0%*
Total		*471,631,765*	*100%*		*87,332*	*100%*

		Annual Income (R$)	
	Value added	Total for riverbank	%
Subsistence fishermen (a)		*82,929,671*	*37%*
Commercial fishing fleet (b)	*56%*	*41,963,040*	*19%*
Market booth	*25%*	*10,390,179*	*5%*
Fish processing plant	*40%*	*90,146,828*	*40%*
Total		*225,429,718*	***100%***

1. *44013 families * [2468.4kg/family (Queiroz 1999) & 1300 (McGrath* et al. *1998)] * R$ 0,72 per kilo (Almeida & McGrath 2000).*
2. *Based on regressions.*

4.3.2 Regional differentiation of the commercial fisheries sector

Overall the commercial fisheries sector throughout the Brazilian Amazon is characterised by a high degree of professionalism. In all regional fleets, the majority of operators are dependent on fishing as their main source of income. With the exception of the Belém fleet, the majority of boat operators have always worked in the sector.

However, apart from these common characteristics the study identified substantial regional differentiation in the characteristics of skippers and crew. Boats landing in smaller cities tend to be operated by the owner and use permanent crew while the reverse is true for larger cities. Overall, this suggests a high degree of specialisation and relatively low mobility of operators in the sector as a whole. Hence any changes in management are unlikely to lead to rapid entry into or exit from the sector. Labour mobility in the fisheries sector is highest in Belém, where boats tend to be operated by non-permanent crews under the command of relatively young skippers who, although presently dependent on fishing for their income, have had previous occupations outside the sector (Tables 2 and 3).

The majority of fishermen in the lower Amazon are based in rural areas, while the fishermen in the upper Amazon/Solimoes are predominantly urban-based. Consequently benefits from the commercial exploitation of fisheries resources accrue in rural areas of the lower Amazon, but are effectively transferred to urban areas in the upper Amazon/Solimoes.

Levels of affiliation with the Fishermen's Union are generally high, and highest in the fleets landing in smaller towns. This suggests that the Fisherman's Unions can effectively represent the majority of commercial fishers throughout the Brazilian Amazon.

The production function analysis indicates that there are no regional effects on efficiency that could indicate differences in stock levels. This suggests that stock levels are similar in different regions of the Amazon basin, and that observed differences in fleet characteristics are unlikely to reflect adaptations to differences in resource availability. While there is no regional effect linked to stock levels, an indirect regional effect is introduced by the legislation banning the use of purse seines in the lower Amazon state of Para, which includes the ports of Santarem and Belem. Given that the use of purse seines results in 28% higher catches for the same level of other inputs, boats operating in the lower Amazon effectively do so at lower levels of efficiency that those operating in the middle and upper Amazon. No significant scale effects on efficiency were detected.

Table 2. Key boat characteristics. Means with 95% confidence intervals. Means followed by the same letters are not significantly different.

Port	Belém	Santarém	Manaus	Tefé (Boats)	Tefé (Canoes)
Length (m)	10.0 [9.5, 10.5] A	12.1 [11.4, 12.8] B	14.4 [14.0, 14.8] C	11.8 [11.2, 12.4] B	7.9 [7.7, 8.0] D
Ice storage capacity(t)	4.8 [4.4, 5.2] A	4.3 [2.5, 6.1] B	11.1 [9.8, 12.4] C	3.6 [2.7, 4.4] B	0.5 [0.4, 0.6] D
Engine power (hp)	30 [27, 33]A	26 [21, 30]A	36 [33, 40]B	23 [18, 28]A	8.1 [7.3, 8.8] D
Number of fishermen	5.2 [4.9, 5.5] A	8.6 [7.2, 10.0] B	8.2 [7.8, 8.6] B	5.7 [5.0 6.4] A	3.1 [2.7, 3.4] C
Proportion using purse seines (%)	0A	0A	49[44, 54]B	36 [22,50]C	11[4, 19]D
Catch (t per month)	2.8 [2.6, 3.1] A	5.1 [3.1, 7.1] BD	7.1 [5.8, 8.5]B	3.8 [2.1, 5.5]AD	1.6 [1.2, 1.9]C

Table 3. Socio-economic characteristics of fishing boat operators landing in major ports of the Brazilian Amazon basin. Means with 95% confidence intervals. Means followed by the same letters are not significantly different.

	Belém	Santarém	Manaus	Tefé
Operator is owner (%)	33 [29, 37] A	60 [41, 79] B	34 [29, 39] A	78 [70, 86] B
Affiliated to Colonia (%)	68 [63, 73] A	86 [78, 94] B	52 [46, 58] C	77 [69, 85] A,B
Uses permanent crew (%)	37 [32, 42] A	90 [82, 98] B	39 [34, 44] A	94 [83, 100] B
Fishing only source of income (%)	96 [94, 98] A	60 [49, 71] B	86 [82, 90] C	82 [75, 89] B,C
Fisherman based in rural area (%)	53 [48, 58] A	89 [79, 99] B	39 [34, 44] C	25 [17, 33] D
Age (years)	37 [36, 38] A	40 [37, 42] A	40 [38, 41] A	39 [37, 41] A
School education (years)	3.1 [2.9, 3.3] A	3.0 [2.6, 3.4] A,B	3.2 [2.9, 3.5] A	2.4 [2.0, 2.8] B
Always worked as fisherman (%)	32 [28, 36] A	51 [40, 62] B	78 [74, 82] C	57 [48, 66] B

Implications for co-management

Many of the fleet characteristics and their regional differentiation reported above have implications for the ability of the commercial fishers to respond to and engage with co-management agreements. Overall the fishing sector is characterized by very low labour mobility and a high level of dependence on fishing as the sole or dominant source of income. This suggests that most commercial fishers will remain in the sector even though their activities will be increasingly restricted by the proliferation of co-management agreements. The high level of affiliation of commercial fishers with their Fishermen's Unions suggests that these institutions would be well placed to represent commercial fishers in the co-management process.

As many co-management agreements restrict the size of boats allowed to operate on floodplain lakes, a possible response would be for commercial operators to switch towards smaller boats. Constant elasticity suggests that such a change would be neutral with respect to the economic efficiency of fishing.

While it seems there is a higher level of conflict in the Upper Amazon then in the Lower Amazon. Conditions in the lower Amazon region of Santarém are in many ways the most favourable for the institutional sustainability of co-management systems. The majority of commercial fishers are rural based, i.e. part of communities that may instigate co-management agreements or have already done so. By virtue of their residency, these commercial fishers have a say in local agreements and may reap benefits from increases in local resource abundance that may partially compensate for access restrictions elsewhere. Moreover, commercial fishers in the Santarém region have a high level of affiliation with the Fishermen's Union, which is informally involved in many local agreements. A comparatively high proportion of operators have sources of income other than fishing and may therefore be more able and willing to change their fishing effort and practices than the more strongly fisheries-dependent operators elsewhere.

4.3.3 Subsistence-oriented fisheries and the impact of co-management agreements in the Santarem region

Fishing in the livelihoods of varzea residents

For varzea residents, fishing is part of a diversified livelihoods strategy. The survey revealed that fishing is the most important activity of floodplain residents, in terms of both participation (73% of households), and income. On average, fishing accounts for 31% of total income (in cash and in kind) of varzea households, followed by pension payments (27%), agriculture (18%) and salaried employment (10%).

Among households, income from fishing was positively correlated with income from agriculture, but unrelated to income from retirement or wage labour, or the level of cattle ownership. This suggests that fishing does not, in general, substitute for other activities. Rather, fishing serves to meet subsistence requirements independently of the other economic activities a household may engage in (see also 4.3.6, Figure 8).

Fishing agreements: rules and compliance

Interviews with leaders of communities operating successful co-management agreements indicated that most agreements had been established with the objective to safeguard fish supply for the subsistence needs of the community, while restricting commercial fishing by outside boats. All fishing agreements banned gill net and drag net fishing in the low water period, and many agreements also set daily catch limits or limits to the size of boats allowed to enter the lakes. Some agreements explicitly restrict commercialisation of the catch.

In the household survey, most interviewees (85%) correctly reported the main rules set out in the local agreement. The majority (80%) of interviewees in communities with co-managed fisheries considered the agreements successful.

There was no noticeable difference in standardized household fishing effort between communities with and without co-management agreements. However, the proportion of fishing effort expended by gill nets was significantly lower in communities with co-management agreements (38% on average) than in those without (76%). This indicates a reasonable degree of compliance with restrictions on gill net use. However, the reduction in gill net effort appears to be compensated to a large extent by an increase in effort expended with other gears.

Impact of co-management on fisheries productivity

Fisheries productivity as measured by catch per unit of effort (CPUE), was significantly, and very consistently higher in communities with co-management agreements than in those without (Figure 2). On average, CPUE was 60% higher in managed fisheries.

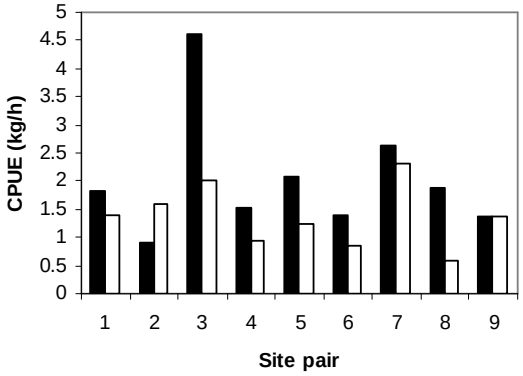

Figure 2. Comparison of fisheries productivity (catch per unit of effort, CPUE) in communities with (solid bars) and without (open bars) co-management agreements.

A comparison of catch-effort relationships in managed and non-managed lakes indicates that the former show higher levels of catch for the same level of (subsistence-oriented) fishing effort (Figure 3). This may be due to the additional effort and catch by commercial fishers in the non-managed lakes, which was impossible to quantify directly. However, further analysis using an equilibrium catch-effort model has indicated that the observed effect is unlikely to be explained by additional effort unless it represents a transitional (non-equilibrium) response.

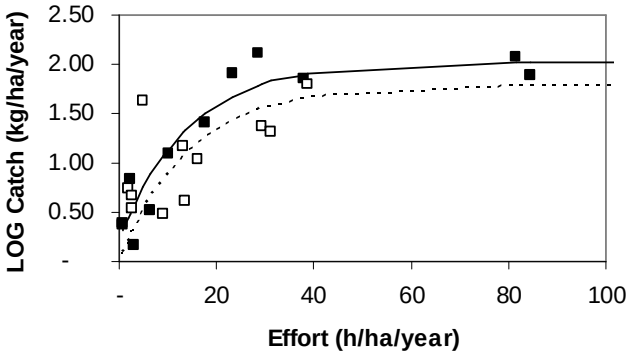

Figure 3. Relationship of yield to fishing effort in managed (closed symbols and solid line) and non-managed (open symbols and dotted line) floodplain lake fisheries.

Yield-effort relationship for management decision support

A model relating fishing effort and yield per unit area was derived for floodplain lake fisheries (Figure 4). This model provides a tool for the assessment of individual lake fisheries, and has also been used to gauge regional level of fisheries exploitation in constructing the bio-economic model.

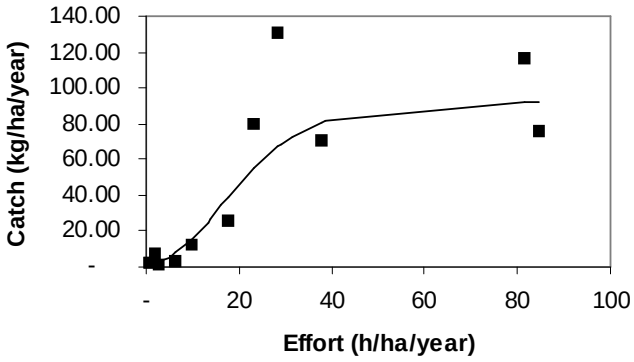

Figure 4. Relationship between fishing effort and catch in managed lakes.

Implications for management

Results show that fishing is the single most important economic activity of varzea residents and that therefore, protecting the productivity of the fishery is of major social importance. However, varzea households do not appear to substitute fishing for other activities that may be more destructive to the varzea habitat, such as cattle ranching. Hence the hopes pinned on fisheries development in many sustainable use initiatives may be unfounded, at least unless the demand for fisheries products increases substantially (see also 4.3.6). Co-management agreements appear to be effective in raising the productivity of lake fisheries, even though mechanisms underlying this effect are not entirely clear.

4.3.4 Commercial fisheries in the Santarem region

Total catch and effort of the commercial fishery in the Santarem region have been remarkably stable over the past 10 years (Figure 5). While there is evidence of seasonal variation and some other fluctuations, there is no evidence of significant trends. Further analyses were carried out by major species, but again most did not show any trend in catch or cpue. The commercial fishery in the Santarem region is thus overall in a very static condition.

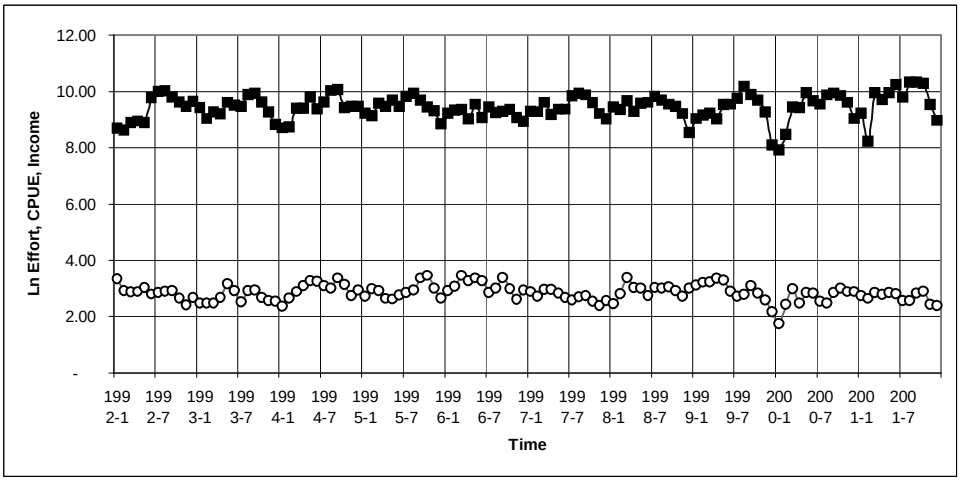

Figure 5. Long-term trends in the Santarem commercial fishery: fishing effort (solid squares), catch per unit of effort (open circles).

Implications for management

In contrast to widely held beliefs, commercial fisheries in the lower Amazon have been extremely static over the past 10 years. This also implies that the long-term records provide very little information on responses of the stocks to changes in effort.

4.3.5 Analysis of aggregated catch-effort relationships in multispecies fisheries

The analysis of aggregated catch-effort relationships in three multi-species fisheries showed that in all cases, a sigmoid model provided a better fit than asymptotic or quadratic models (Figure 6). This has important management implications because in the sigmoid model, a reduction in fishing effort does not always improve productivity (catch per unit of effort).

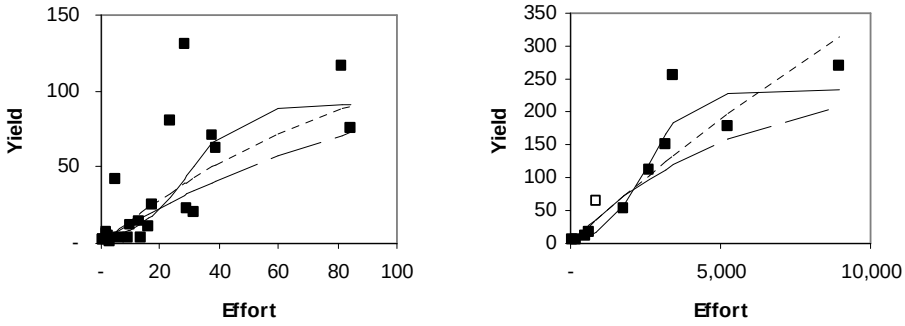

Figure 6. Alternative models of aggregated multi-species catch-effort relationships in Amazonian and Lao floodplain lake fisheries. Sigmoid (solid line), asymptotic (dashed line) and quadratic (dotted line) models. Note that effort units are not comparable.

4.3.6 Integrated bio-economic analysis of fisheries in the Santarem region

The fishery

The fishery in the Santarem region is made up of two sectors with very different economic behaviour, commercial and subsistence-oriented fishers. Commercial fishers generate monetary income from fishing and respond positively to variation in catch per unit of effort (Figure 7).

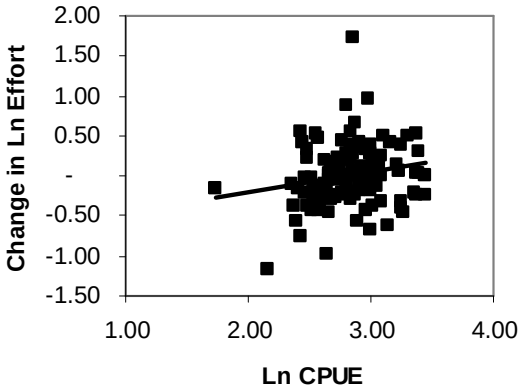

Figure 7. Monthly change in commercial fishing effort in relation to catch per unit of effort: commercial fishing effort increases when returns are high.

Subsistence-oriented fishers show a very different behaviour, responding to higher CPUE with reduced fishing effort. Fishing serves mainly to satisfy their subsistence needs (even though some of the catch may be sold), and where productivity is high these needs are met with lower effort and time saved is allocated to other activities (Figure 8).

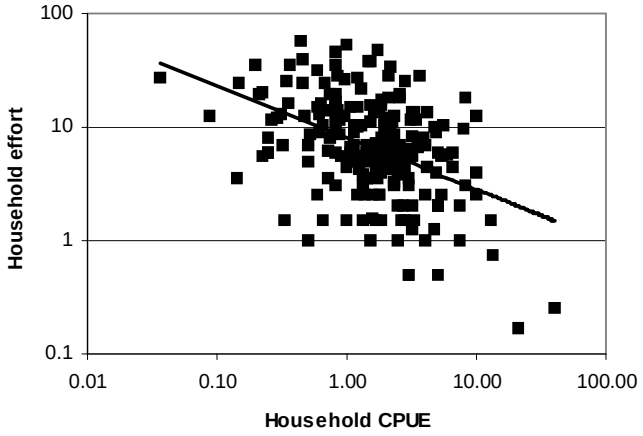

Figure 8. Relationship between household effort and CPU in the subsistence-oriented fishery: Subsistence fishers reduce effort when returns are high.

Total fishing effort expended, and catch obtained by the two sectors in the Santarem area have been estimated from information on the IARA landings database and from household surveys conducted as part of the current project. The resulting baseline scenario for the region is shown in Table 4.

Table 4. Baseline scenario of the bio-economic model

		Fishing Effort (days per year)	**Catch (t per year)**
Commercial	**River**	63000	1165
	Lakes	98000	1610
Subsistence	**River**	115000	2130
	Lakes	250000	4110

The bio-economic model

A bio-economic model was developed to explore interactions between the commercial and subsistence-oriented sectors of the fishery, and evaluate the likely impacts of alternative policies. To account for large uncertainties regarding the biological dynamics of the fishery, bio-economic analyses were conducted using a set of

alternative harvest models. The alternative models involved fundamentally different relationships between catch and effort, different assumptions about the current exploitation status, and different assumptions about the degree of interaction between lake and river fish stocks.

Two alternative functional forms of the relationship between the aggregated multi-species catch and fishing effort were used throughout the analysis: a sigmoid and an asymptotic model. The sigmoid model has the form

$$Y(E) = \frac{Y_{\max}}{1 + \exp(a(b - E))}$$

where Y_{max} is the asymptotic yield, a determines the steepness of the relationship, b is the effort level at which yield equals 50% of the asymptotic yield. The asymptotic model with monotonically declining slope has the form

$$Y(E) = Y_{\max}(1 - \exp(-a(E - b)))$$

where Y_{max} is the asymptotic yield, a determines the steepness of the curve, and b its position relative to the origin. An empirical analysis of several multi-species artisanal fisheries suggests that the sigmoid model provides the best description of aggregated catch-effort relationships (4.3.5). The asymptotic model was used as a plausible alternative model that conforms more readily to the tenet that catch per unit of effort declines continuously with increasing effort.

Using the catch-effort relationship for floodplain lakes derived in the current project and other comparative information, it was estimated that current yields are equivalent to 30% of the multi-species maximum yield achievable. Projections were therefore generated for assumed baseline exploitation levels of 30, 50 and 70%.

A further source of uncertainty is the degree to which lake and river fish stock are connected. To deal with this uncertainty, we constructed two different models, one assuming that the lake and river fisheries exploit entirely separate stocks, and one assuming that they exploit the same stock. The real situation is likely to be in between these two extremes. All analyses were thus carried out using twelve alternative models to account for uncertainty.

Predicted yield was converted to revenue using an empirical relationship for price as a function of supply at the landing site in Santarem. The price elasticity of supply was estimated as –0.23. The model also includes a price elasticity of effort, to account for the fact that lower levels of effort may increase the proportion of high value species and size groups in the catch. This relationship has been defined such that the average price at very low effort corresponds to that of the most valuable species.

Cost data for the commercial fishery were obtained from economic surveys of fishing fleet. The average variable costs (excluding labour) and depreciation were estimated as 7.7 R$/day, while the average cost of labour was estimated at 5 R$/day.

The bio-economic status of exploitation

Biologically, the fishery of the lower Amazon is exploited at about 30% of the multi-species maximum yield. This level of exploitation of the multi-species system suggests that some of the large and slow-growing species may be overexploited, while smaller species may not yet be fully exploited, a conclusion supported by other assessments.

Economically, the commercial fishery operates at the open access equilibrium, i.e. the revenue just equals the opportunity costs of input (Figure 9). There is no room for

further expansion, unless either fish prices increase or costs are reduced. Both alternative models give similar predictions of commercial revenue responses to changes in fishing effort, although the sigmoid model predicts lower gains from effort reduction. The model differ more in their predictions of effects of commercial effort on subsistence fishery yields, predicting either no change or a moderate increase in subsistence catch and cpue by up to 20%.

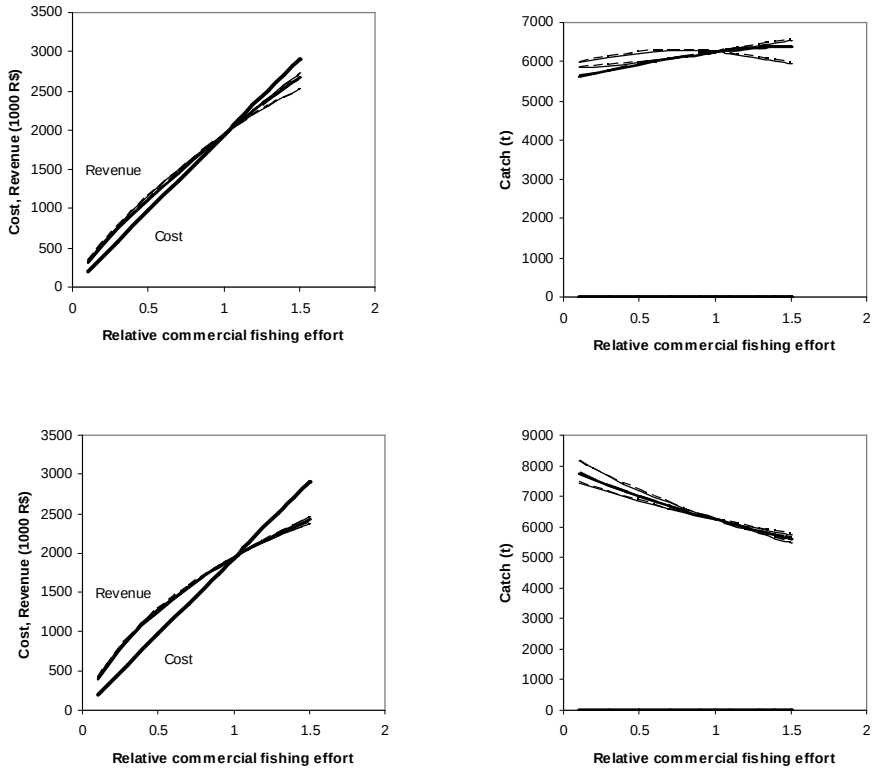

Figure 9. Effect of changes in commercial fishing effort on revenue and costs of in the commercial fishery (left), and on yields in the subsistence-oriented fishery (right). Results from two alternative catch-effort models: sigmoid (top) and asymptotic (bottom)

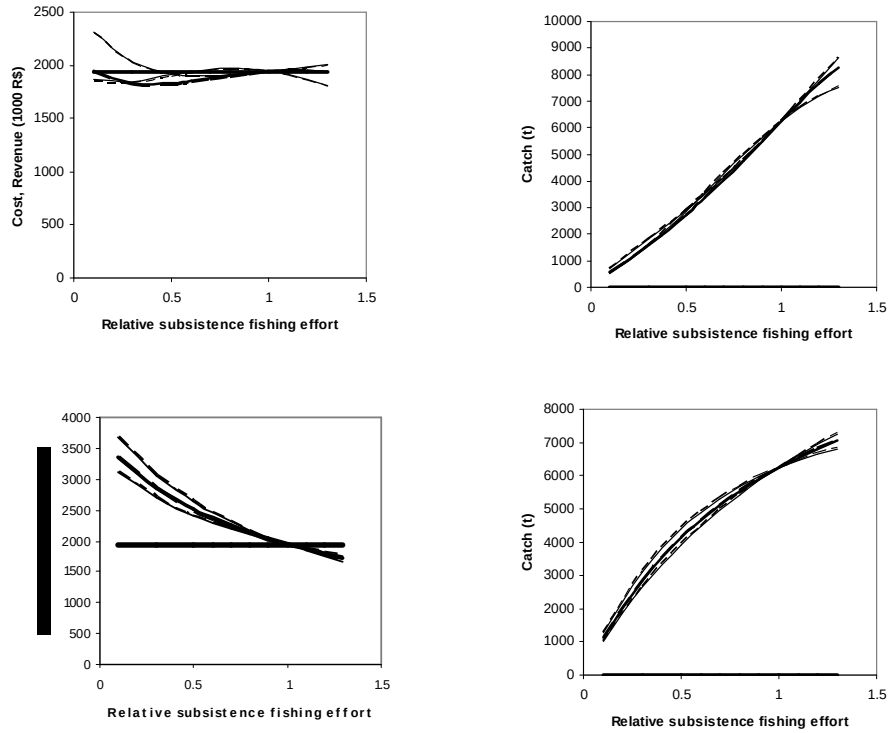

Figure 10. Effect of changes in subsistence-oriented fishing effort on revenue and costs of in the commercial fishery (left), and on yield in the subsistence-oriented fishery (right). Results from two alternative catch-effort models: sigmoid (top) and asymptotic (bottom)

A reduction in subsistence-oriented effort is predicted to have only a marginal (sigmoid model), or a moderately positive impact on commercial fishery revenue or subsistence-oriented CPUE. Overall the sigmoid model suggests that at the current level of exploitation, yield will change in proportion with effort and hence productivity is insensitive to effort.

Analysis of management policies and external influences

The model was used to evaluate the impacts of different management policies and trends on the status of the fishery, in particular:

- Proliferation of co-management agreements leading to exclusion of commercial fishers from lakes
- Charging commercial fishers for access
- Allowing the use of more efficient gear
- Expansion of markets due to improved transport access to inland areas

If co-management agreements were to proliferate and effectively close all lakes to commercial fishermen, the models predict a slight increase (sigmoid model) or decrease (asymptotic model) in commercial effort by no more than 10%. The overall subsistence catch is predicted to remain unaffected in either case, because the effect on lake fisheries of removing commercial effort will be largely compensated by the opposite effect on river fisheries of concentrating commercial effort there. Locally, the impact of lake management will depend on specific circumstances (e.g. commercial lake effort, or access to the river by subsistence fishers). Nonetheless, each community entering a co-management agreement will gain from reducing commercial effort in their lake, but the displaced effort will be re-directed to the remaining un-regulated waters (river and non-managed lakes), i.e. the costs will be shared by all. Hence the benefit to the individual community becomes smaller as more lakes are managed, and at a regional level the effect is simply one of re-distributing effort. Effective effort management must take a regional perspective.

A possible management policy that has attracted increasing interest recently is to charge commercial fishers for access to fishing grounds. This could be done by the government or by communities if they were given property rights. Charging would have the effect of increasing the cost of fishing, and fishermen would respond by reducing effort until a new equilibrium is reached. The amount recoverable by charging for access (the resource rent) it equals the maximum difference between the revenue and cost curves. A rent of about 100,000-300,000 R$/year could be extracted from the commercial fishery, leading to a reduction in effort by about 50% and an increase in the market price of fish by about 10%. While the reduction in effort would be considerable, the rent is rather small: less than 1R$/ha/year of water area. Allowing the operation of more efficient gear such as purse seines would reduce the cost of fishing. In an unregulated fishery, this would lead to higher effort levels. However, in a regulated fishery more efficient gear would allow a higher rent to be extracted. Allowing the use of purse seines (currently banned in the lower Amazon, but used upstream) while charging for access could increase resource rent by up to 30%.

Expansion of the market for fisheries products would result in increased ex-vessel prices, and may lead to a very considerable expansion of the fishery. It is predicted that even a small increase in average price by just 10% may increase effort by 50-100% if open access to the fishery is maintained. Alternatively, license fees or taxes could be introduced to stabilise effort and extract a rent from the fishery. The latter change is of particular interest in the Santarem region, where the paving of the Santarem-Cuiaba road will provide easy access to the large agricultural areas of Rondonia.

Management implications

The Amazon fishery is unusual in that, due to market limitation, the bio-economic open access equilibrium has been reached at a relatively low level of biological exploitation. Measures aimed at restricting effort to current levels carry no immediate social cost, but would prove highly beneficial if, as is expected, markets will expand.

4.3.7 Policy workshops

The policy workshops brought together representatives of all major stakeholders (government, fisher and community representatives as well as scientists) to review management issues (workshop 1) and to discuss project results and their managemnt implications (workshop 2). The workshops were arranged so as to allow different stakeholder groups to discuss and consolidate their perspectives on management and

conservation issues in small groups before plenary synthesis sessions. This approach was much appreciated by stakeholders because it allowed a balanced representation of different interests.

Participants at the final workshop commended the fact that the project had developed the first integrated bio-economic analysis of Amazon fisheries, and provided new primary data pertinent to many aspects of management. Project results challenged participant's perceptions by demonstrating the dominance of subsistence-oriented fisheries in the Santarem region; the static nature of commercial fisheries; and the fact that interactions between the sectors and between lake and river fisheries are likely to moderate the effectiveness of management initiatives. Participants emphasised the need to adopt an integrated approach to the evaluation of management policies, and suggested to adapt the bio-economic model to other regions of the Amazon. The expansion and further development of co-management initiatives was seen as crucial to safeguarding the productivity of the fishery in the face of possible market expansion, despite the limited overall effectiveness of such measures under current conditions.

4.3.8 Conclusions

- The overall economic importance of the Amazon fisheries sector is far greater than previously realised. This provides strong policy-level incentives for the conservation of fisheries and the habitats upon which they depend.
- There is a high degree of regional differentiation in fleet characteristics of the commercial fishery, and the relative importance of commercial and subsistence-oriented fisheries.
- Fishing is the dominant source of income in varzea households. However, fishing is subsistence-oriented and there is little indication that households substitute fishing for other activities even when returns are high. Hence it is unlikely that fisheries management initiatives will reduce reliance on other activities that may be more damaging to the varzea environment.
- Empirical data show that co-management agreements are effective at increasing productivity of managed lakes, at least in the short term. Modelling studies suggest that such increases will be at least partially compensated by reduced productivity in the river fisheries.
- Two important tools have been developed to aid management decision making: an equilibrium catch-effort relationship for lake fisheries, and an integrated bio-economic model.
- The expansion and further development of co-management initiatives was seen as crucial to safeguarding the productivity of the fishery in the face of possible market expansion, despite the limited overall effectiveness of such measures under current conditions.
- By providing a transparent and rigorous analysis of management issues, the project has fostered a constructive dialogue on the future development of Amazon fisheries, and their role in the conservation of floodplain habitats.

5 Project impact

The project has successfully evaluated fisheries management policies for the Brazilian Amazon, and the incentives that fisheries provide for conservation of the varzea habitat upon which they depend. The results have been disseminated to, and discussed with a broad group of stakeholders, and are contributing directly to the ongoing policy process.

The project has helped Brazil to meet its obligations under the CBD by providing the first rigorous evaluation of fisheries management policies in the Amazon and the incentives they provide for habitat conservation. By providing solid information and careful analysis of the bio-economic effects of management policies to stakeholders, the project has promoted better co-operation between them, and contributed to resolving long-running controversies. Policy initiatives are now assuming a more integrated perspective, looking beyond lake management agreements to regional regulation strategies and their implications for habitat conservation. In addition, the finding that the fisheries sector is far more important economically than previously realized has increased overall government attention to the aquatic resources of the Amazon.

The project has greatly increased local capacity to undertake integrated bio-economic analysis of management policies. The project's Darwin Fellow Ms Oriana Almeida has returned to Brazil to act as a consultant to ProVarzea, the new Government programme to promote sustainable development of the varzea.

The collaboration between Imperial College and IPAM has effectively put IPAM in a leading position in the analysis of fisheries management policies within the Amazon. Following the well attended second project workshop, other organisations in the Amazon are turning to IPAM for advice on bio-economic analysis.

The main beneficiaries of the project are varzea residents and commercial fishers who have gained a much improved basis for policy dialogue and management decision making.

6 Outputs

Complete lists of outputs are given in the appendices. All agreed project outputs have been achieved, plus several additional outputs. As mentioned earlier, the scope of the project has been broadened substantially to integrate subsistence-oriented fisheries. This has let to additional studies and publications, some of which have only just been

drafted but will be submitted to peer-reviewed journals in due course. Dissemination of outputs will continue, and cost will be born by the project partners, in particular IPAM.

7 Project Expenditure

Table 3: Project expenditure

Item	Budget	Expenditure

The project expenditure has remained in line with the agreed budget.

8 Project operation and partnerships

The project was conceived and carried out jointly by IPAM and Imperial College. The project has interacted with a wide range of stakeholders, including local community organisations, commercial fisher's cooperatives, governmental and non-governmental organisations and the international PPG7 programme. The integrated modelling work was carried out in direct collaboration with the federal environmental agency (IBAMA) and the PPG7 project, giving both organizations co-ownership of the results and thereby promoting adoption.

9 Monitoring, Evaluation and Lessons

Project objectives and outputs had been defined mostly in terms of research products. These products have been achieved as demonstrated by the results reported here and in the annexed papers and reports. All work has been or will be peer reviewed. Indeed, the final workshop has exposed the work to a critical review by Brazil's top experts in Amazon fisheries and varzea conservation.

Perhaps the key lesson to be drawn from this project is that small projects such as those supported by the Darwin Initiative can achieve big impacts by integrating and critically assessing work carried out by larger initiatives such as development projects.

10 Darwin identity

Project staff and collaborators made every effort to publicise the Darwin Initiative. The Darwin logo has been used on all project material and displayed prominently at the collaborator's premises and at policy workshops.

The workshops have been extremely well attended by conservation professionals from the Amazon region, and have done much to promote knowledge of the Darwin Initiative. The fact alone that most of the region's key aquatic resources and varzea conservation professionals attended the workshops at their own institution's expense shows that the project was regarded as an important contribution to the field.

Although the project was closely integrated with other, larger initiatives in fisheries management and varzea conservation, it maintained a distinct identity due to the conceptual advances and integrated, quantitative analyses carried out by the project.

11 Leverage

Substantial additional funding has been obtained from various organisations including WWF during the lifetime of the project. This funding was crucial in enabling the field surveys on subsistence-oriented fishers to be carried out.

The project partners IPAM had already demonstrated a good capacity to attract funds from international donors before the Darwin project started. However, the project has substantially improved their capacity to carry out advanced analyses of the fisheries sector, and this will further enhance their capacity to obtain funding for projects with substantial research components.

12 Sustainability and legacy

Project achievements are likely to endure in various forms. Imperial College and IPAM will continue their successful collaboration established in the Darwin Project. Darwin Fellow Ms Oriana Almeida has returned to the Amazon and will take a leading role in future research in the area.

IPAM has received a five year grant from DFID/WWF to continue its work on the conservation of the varzea. IPAM will create a network of managed lakes that will be monitored continuously and will offer fisheries products from sustainably managed lakes for national and international markets. At the same time, IPAM received funding from PPG7 to create a centre for artisanal fishermen in the lower Amazon. The centre will offer courses on legislation, organization, fish biology, accounting, and processing, to strengthen the capacity of communities for preparing and implement fishing agreements.

Results from the current Darwin project proved vital research and policy support for the above initiatives, providing the first integrated analysis of the impacts of co-management agreements on the local fishers and mobile commercial fleets, and the value of fisheries production supported by the varzea environment.

13 Value for money

The project has provided excellent value for money. With limited funding (effectively the cost of a research assistant for three years) it has generated key primary data, and drawn together much previous research in the first integrated analysis of Amazon fisheries. The integrative aspect was particularly important: by catalysing the integrated analysis of much previous research, the project has achieved a substantial output from very limited inputs.

Author(s) / Date

Dr Kai Lorenzen, 28 September 2002

List of Annexes

A) Almeida, O.T., McGrath, D.G. & Ruffino, M.L. (2001) The commercial fisheries of the lower Amazon: an economic analysis. Fisheries Management and Ecology 8: 253-269.

B) Almeida, O.T., Lorenzen, K. & McGrath, D.G. (2002) Commercial fishing in the Brazilian Amazon: regional differentiation in fleet characteristics and efficiency. Fisheries Management and Ecology, in press.

C) Almeida, O.T., Lorenzen, K. & McGrath, D.G. (2002) Impact of co-management agreements on the exploitation and productivity of floodplain lake fisheries in the lower Amazon. Proceedings of the Ninth International Conference of the IASCP.

D) Almeida, O.T., Lorenzen, K. & McGrath, D.G. (2003) The role of the fisheries sector in the regional economy of the Brazilian Amazon. Submitted for inclusion in the Proceedings of the Second International Large Rivers Symposium.

E) Lorenzen, K., Almeida, O.T., Garaway, C.J. & Nguyen Khoa, S.D.T. The relationship between aggregated catch and effort in multi-species artisanal fisheries: conservation may reduce returns to effort. Draft manuscript.

F) Lorenzen, K., Almeida, O.T., Avzeiro, C. Interactions between commercial and subsistence-oriented fisheries in the lower Amazon: a bio-economic analysis. Draft manuscript.

G) Almeida, O.T., Lorenzen, K. & McGrath, D.G. (2002) Oficina de Políticas Pesqueiras para o Baixo Amazonas: Resultados de pesquisa

H) Almeida, O.T., Lorenzen, K. & McGrath, D.G. (2002) Oficina de Políticas Pesqueiras para o Baixo Amazonas: Recomendações

Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use	10	Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	-	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities which have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	40	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation	-	Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity	20	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures	20	Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	-	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).

13. Public Education and Awareness	10	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
14. Impact Assessment and Minimizing Adverse Impacts	-	Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources	-	Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology	-	Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information	-	Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol	-	Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

Appendix II Outputs

Code	**Total to date (reduce box)**	***Detail (←expand box)***
	Training Outputs	
1a	Number of PhD qualifications obtained 1	Ms Oriana Almeida has been undertaking part-time PhD studies and is expected to submit in 2003
4a	Number of undergraduate students receiving training 8	Students trained in social survey methods
	Research Outputs	
8	Number of weeks spent by UK project staff on project work in host country(s) 61	Time spent in country by O.T. Almeida, K. Lorenzen & W. Cavendish
9	Number of species/habitat management plans produced for Governments, public authorities or other implementing agencies in the host country 1	O. Almeida, K. Lorenzen & D. McGrath (2002) Oficina de Políticas Pesqueiras para o Baixo Amazonas: Resultados de pesquisa e recomendações
11a	Number of papers published or accepted for publication in peer reviewed journals 2	0.T. Almeida, D.G. McGrath and M.L. Ruffino (2001): The commercial fisheries of the lower Amazon: an economic analysis. Fisheries Management and Ecology 8:253-269 0.T. Almeida, K.Lorenzen, and D.G. McGrath (2002): Commercial fishing in the Brazilian Amazon: regional differentiation in fleet characteristics and economic efficiency. Fisheries Management and Ecology 9
11b	Number of papers published or accepted for publication elsewhere 2	O. Almeida, K. Lorenzen & D. McGrath (2002) Impact of co-management agreements on the exploitation and productivity of floodplain lake fisheries in the Lower Amazon. Proceedings of the Ninth Biennial Conference of the IASCP. Almeida, O.T., & Lorenzen, K., McGrath, D. The fisheries sector in the Amazon regional economy. Proceedings of the 2nd International Large Rivers Symposium.
12a	Number of computer-based databases established and handed over to host country 2	Commercial fisheries and household survey databases

Dissemination Outputs		
14a	*Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work* *2*	*Policy workshop 1 in Belem, November 2001* *Policy workshop 2 in Santarem, September 2002*
14b	*Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.*	*8th IASCP conference in Indiana, USA 2000* *9th IASCP conference in Zimbabwe 2002*
15a	*Number of national press releases or publicity articles in host country(s)* *2*	*Articles in local newspapers*
19c	*Number of local radio interviews/features in host country (s)* *2*	
Physical Outputs		
23	*Value of additional resources raised for project* *US$ 120,000*	*Received from WWF to support field studies on subsistence-oriented fisheries*

Appendix III: Publications

The following publications are publicly accessible at present.

Type	Detail	Publishers	Available from	Cost £
Journal Article	0.T. Almeida, D.G. McGrath and M.L. Ruffino (2001): The commercial fisheries of the lower Amazon: an economic analysis. Fisheries Management and Ecology 8:253-269	Blackwell Science	o.almeida@ic.ac.uk	-
Journal Article	0.T. Almeida, K.Lorenzen, and D.G. McGrath (2002): Commercial fishing in the Brazilian Amazon: regional differentiation in fleet characteristics and economic efficiency. Fisheries Management and Ecology 9	Blackwell Science	o.almeida@ic.ac.uk	-
Conf. paper	O. Almeida, K. Lorenzen & D. McGrath (2002) Impact of co-management agreements on the exploitation and productivity of floodplain lake fisheries in the Lower Amazon**.** Paper presented at the Ninth Biennial Conference of the IASCP. Zimbabwe. 17-21 June 2002.	International Association for the Study of Common Property (IASCP)	www.iascp.org	-
Policy report	O. Almeida, K. Lorenzen & D. McGrath (2002) Oficina de Políticas Pesqueiras para o Baixo Amazonas: Resultados de pesquisa	IPAM	www.ipam.br	
Workshop report	O. Almeida, K. Lorenzen & D. McGrath (2002) Oficina de Políticas Pesqueiras para o Baixo Amazonas: Recomendações	IPAM	www.ipam.br	

The following manuscripts have been or will be submitted and are included with this report:

Almeida, O.T., & Lorenzen, K., McGrath, D. The fisheries sector in the Amazon regional economy.

Lorenzen, K., Almeida, O.T., Garaway, C.J. & Nguyen Khoa, S.D.T. The relationship between aggregated catch and effort in multi-species artisanal fisheries: conservation may reduce returns to effort. Draft manuscript.

Lorenzen, K., Almeida, O.T., Avzeiro, C. Interactions between commercial and subsistence-oriented fisheries in the lower Amazon: a bio-economic analysis. Draft manuscript.

Appendix IV: Darwin Contacts

To assist us with future evaluation work and feedback on your report , please provide contact details below.

Project Title	**Fisheries Management for Biodiversity Conservation in the Brazilian Amazon**
Ref. No.	**08/126**
UK Leader Details	
Name	**Dr Kai Lorenzen**
Role within Darwin Project	**PI**
Address	**Department of Environmental Science and Technology** **Imperial College** **London SW7 2BP**
Phone	
Fax	
Email	
Partner 1	
Name	**Dr D.T. McGrath**
Organisation	**IPAM**
Role within Darwin Project	**PI**
Address	**IPAM, NAEA, Campus Profissional, Universidade Federal do Para, 66.075-9709 Belem, PA, Brazil**
Fax	
Email	