Strategies for Managing Biodiversity in Amazonian Fisheries

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Abstract

Biodiversity loss is a matter of great concern, particularly in the Amazon region with its diversity of aquatic life. Uncontrolled exploitation of the floodplain (Várzea) is leading to its gradual deterioration. As Brazilian fisheries and environmental legislation has not proved adequate in conserving the aquatic resources, civil society developed its own measures, a good example of which was the IARA Project, which promotes participatory management in the middle Amazon. This paper sets out the experiences of this project, lessons learned, proposals for the future, and the active involvement of the sector's main government agency, IBAMA, in supporting participatory management.

Introduction

About twenty years ago the loss of genetic resources, habitats and ecosystems as well as species extinction began to appear in papers published in scientific publications such as "Conservation Biology" and "Biological Conservation". The theme was also taken up by the various organizations dedicated to the principles of biological conservation such as the World Conservation Union (IUCN), World Resources Institute (WRI) and the World Wide Fund for Nature (WWF) (Ryman *et al.* 1995). Since that time the need to protect aquatic biodiversity has become more apparent. The current precarious state of aquatic biodiversity, with its extremely high loss rate, is aggravated by an almost complete inability to manage aquatic resources (Philipp *et al.* 1995).

Fish represent more than half the world's total known aquatic vertebrate species. (Nelson 1994). Well distributed throughout the world (Moyle & Cech 1982), they are exploited in both marine and fresh water environments due their significant economic value (Pitcher & Hart 1996).

South America is home to a great number of fish species, the total of which has yet to be established. However, it is known that the largest diversity is found in the Amazon Basin (Menezes 1996). Böhlke *et al.* (1978) equate the current level of knowledge of fish in South America with that of the United States and Canada a century ago. Roberts (1972) estimates that there are more than 1,300 species throughout the basin, more than in any other basin in the world. Given that at least 40% of Amazonian fish species have not yet been described, the above estimate could rise to around 1,800 species. Menezes (1996) puts the estimate even higher at around 3,000 species.

Various factors have been advanced as the cause of such great diversity. They are: the age and size of the watershed; a high environmental heterogeneity promoting a wide range of niches; and, on a geological time frame, the interchange of fauna through the influx of rivers from neighbouring basins (Lowe-McConnell 1987). Nevertheless it is probable that the above figures underestimate the actual number of species, because it is still common to find new

species, and there are various groups which have not been the subject of thorough investigation. This lack of knowledge of Amazonian ichthyofauna even extends to species that are well known to fisher folk of the region. One example is *Merodontotus tigrinum*, a largish (55cm) species of Pimelodidae (Siluriforms), which was only described recently (Britski 1981). According to Menezes (1996), it would not be difficult to imagine future research revealing that, in the headwaters of Amazonian rivers, large numbers of what had been considered the same species are in fact separate species. This could include such common fish as filhote and piraíba (*Brachyplatystoma filamentosum).*

Goulding & Ferreira (1996) divide the ecosystem that sustains the Amazon fisheries into three components, the flood plains, the river channels and the estuary of the Amazon. Each one supports hundreds of fish species with diverse habitats for energy, seasonal reproduction and protection against predators. The trophic chains of the Amazon fisheries are sustained by four principal sources of primary production: flooded forests, floating vegetation, phytoplankton and perifíton.

Giacometti (1996) states that loss of biodiversity as a result of habitat destruction and uncontrolled exploitation of natural resources can be evaluated in terms of direct and indirect values. Indirect values affect the sustainability of populations that depend on these resources, as well as damaging the genetic pool. This is most likely to have far reaching consequences for those species, affecting their evolutionary potential because of reduced genetic variety. Losses of direct values can now be estimated using as a base the values of products collected and commercialized.

Amongst other things, the destruction of habitats results in loss of biodiversity. However, there are only a few studies that show how much has vanished from the various regions. The most immediate concern is the loss of Várzea forest and herbaceous plants, because of the important role they play in the food chain and habitat of Amazonian commercial fish.

Deforestation, ranching, chemical pollution, organic pollution from farming, silting and excess turbidity in rivers caused by mining activities, urban and agricultural expansion, and hydroelectric schemes which block the reproductive path of migratory fish are important impact factors. As they are environmentally harmful and difficult to manage, they should be controlled or else they will damage the whole ecosystem, impacting on the ichthyofauna and consequently affecting the fishery.

In other words it is only through integrated processes of natural resource management that viable solutions can be found to strike a balance between impact and conservation that allows the resource to be used in a sustainable way, while keeping environmental damage to a minimal sustainable level.

Territorial extension, complexity of the environment and the diversity of economic activities present enormous challenge for government with regard to the management of the resources.

The current system, which is centralized and non-participatory, has shown itself incapable of regulating the use of natural resource in the Amazon.

This paper presents the various implementation phases of a participatory management process for the fishery of the middle Amazon, with the aim of conserving the fisheries resource and consequently the biodiversity of the Amazonian Várzea.

The fishery resource and its exploitation

The Amazonian fishery is diverse, consisting not only of a food fishery but also a sports fishery, and a fishery for ornamental fish.

The food fishery is one of the most traditional productive activities in the Amazon. It provided the base for urban development in a region that until recently suffered from a lack of domestic animal production. The total production for human consumption of fish from the Amazon basin was calculated by Bayley and Petrere (1989) and was based on known fish landings, catches from other regions in the world with similar conditions and the *per capita* fish consumption in the region. The authors estimated the production as 200,000 t/year, which represents 20% to 25% of Brazil's total marine and freshwater production (Dias Neto & Mesquita 1988).

The Amazon fishery generates at least US$ 100 million per year with no subsidy whatsoever from either State or Federal Government. This is calculated on the basis of a catch in excess of 200.000 tons and an average price of US$0.50/kg. This production, generating over 200,000 directly related jobs (Fischer *et al*. 1992), provides the principal source of protein for the Amazon population (Shrimpton & Giugliano 1979; Jesus *et al.* 1991). In addition it supports both a direct and an indirect economy, based on fishery related industries (netting, mechanical, ice making, shipbuilding and other related products). The economy generated by the fishery also assists the river transport system by supporting an infrastructure of service industries such as shipyards, mechanical workshops and ports that are used by small and medium sized vessels. Also fishing boats are frequently converted to passenger or cargo vessels and vice versa to the extent that many vessels, not currently engaged in fishing, were at one time involved in this activity.

Fish is exported by fish processing plants that have been licensed by the Ministry of Health to sell fish outside the State. Fish exports were more important to the economies of the Amazonian States in the 70s, 80s and beginning of the 90s, than they are now. The exported value of piramutaba (*Brachyplatystoma vaillantii*) from Pará State was in excess of US$12 million in 1986. In 1993 Amazonas State exports of the same species were worth around US$1,5 million. Exports from Pará of prawn and piramutaba, which started in the 70s, generated around US$35 to US$45 million per year. This accounted for approximately 10% of the State's total exports between 1975 and 1984. At that time fish was fifth in the table of exports from Pará. When production of iron ore started with the Carajás project, the total value of exports from the State rose to an average of US$1,156 million, with fish falling to

only 3% of the total. The reduction in the catches of prawn and piramutaba has further reduced significantly the contribution they make to the total value of exports.

Exports of ornamental fish are also an important revenue source for the region, generating US$2 million and giving employment to around 10,000 people (Chao 1993). The major exports are from Amazonas State, accounting for 90% of total production. The remaining 10% come from Pará. This activity started in 1959 in the town of Benjamin Constant situated on the frontier between Brazil and Peru, later expanding throughout the State of Amazonas. Exports of ornamental fish peaked in 1979, when 20 million fish were exported. This fell to less than13 million fish between 1982 and 1983, and by the end of the 80s was fluctuating around 17 million fish.

Harvesting ornamental fish represents a viable economic alternative for various areas in Amazônia where there are few options for making a living. While the Rio Negro is known for low catches of food fish, catches of ornamental fish have increased there. This area is the principal supplier for the export market, employing 60% to 75% of all Amazonians involved in this activity (Chao 1993). Some towns have ceased all other activities and are dedicating themselves exclusively to this fishery. Barcelos, on the Rio Negro, stopped timber production and is currently the "capital of the ornamental fish trade".

The development of sport fishing is now official policy and has its own specific program – The National Programme for the Development of Amateur Fishing (PNDPA), which has the aim of transforming sports fishing into a means for social and economic development and environmental conservation in Brazil. The aims of the program are the regulation of the fishery, improvement of controls over it, its inclusion in development plans and programs and the promotion of the activity in designated appropriate areas. The States of Amapá, Tocantins and Pará were pioneers in State regulation of this fishery. The regulatory process for Amazonas State, initiated with a workshop held in the year 2000, is set out in a document "Management Plan for Sports Fishing within Amazonas". This fishery has great potential for development within Amazônia. However, to date its growth has been slow, and currently there are no reliable statistics to evaluate its economic impact.

Summary of target species status and resource trends

Isaac & Barthem (1995) and Araújo-Lima & Ruffino (2001) report on the present state of fish stocks within the Amazon region of Brazil, presenting an overview of current stock exploitation levels. Currently available information on the major species over the last few years, described below, is based on conventional stock assessment methods.

Piramutaba (*Brachyplatystoma vaillantii*) is the main fish, by weight, caught in the Amazon since the 1970s. Landings increased after 1972, peaking at 32,000 tons in 1977 (IBAMA, 1999a). They decreased irregularly until 1992, but have since recovered to 20,000 ton/y. Because approximately 30% of the catch is rejected as too small, it is probable the total catch has been higher. Effort, however, has been increasing and therefore catch per unit effort

(CPUE) has been consistently decreasing. This species is considered to be overexploited (Barthem & Petrere, 1995; IBAMA, 1999a). Indications of overexploitation are the high catch-to-biomass ratio found in the estuary and the decreasing size of landed fish. The maximum sustainable yield calculated using the Schaeffer model from two sources was 19,929 tons/y and 20,900 tons/y, with a maximum effort of 48 boats and 5,900 days, respectively.

Piramutaba trawlers land only a percentage of their actual catch, dumping undersized and non-commercial fish. There is also a by-catch, which has yet to be quantified, consisting of some commercial species, such as dourada (B. flavicans), gurijuba, cangatá and other small catfish

The amount of discards has varied over the years. The average size composition of piramutaba landed in 1983 was smaller than landings not only in previous, but also later years. This was because some export buyers started to accept smaller fish, which made landing them commercially viable. Discard rates dropped to 16% in that year. The export market changed again, resulting in the discard rate rising again to around 26%. In recent years the national market has started to accept smaller size piramutaba, which combined with currency stabilisation has made the industry more economically viable. In spite of this development, there is still an unacceptable discard rate, which hinders the management of the stocks. The influence of economic factors means that catch per unit effort figures do not reflect accurately the relationship between stock abundance and catch effort. The existence or otherwise of markets directly influences the volume of discards, and consequently landings. This combination of factors could hide a reduction in stock abundance, affecting adversely any management measures to control the exploitation of the resource.

The tambaqui (*Colossoma macropomum*) fishery was very important in the 1970s, but landings in Manaus have decreased markedly from 15,000 tons/y in 1972 to 800 tons/year in 1996. When they applied the Schaeffer production model (1954) to the Manaus data between 1976 and 1986, Merona & Bittencourt (1988) concluded that the species was overexploited. Isaac & Ruffino (1996) applying the yield per recruit model to data for the middle Amazon, also found evidence of growth over-fishing. Increasing the minimum size from 28 cm to 55 cm would appear to be the best way to correct this trend.

Surubim (*Pseudoplatystoma tigrinum*) is an important catfish in the Amazonas state fishery, with annual landings of around 2,500 tons. However, landings of surubim in Manaus market averaged less than 100 tons/y between 1986 and 1996). In the middle Amazon, surubim reached 500 tons/y in 1993 (Ruffino *et al.* 1998). The average landing of *P. tigrinum*, which represents 6% of the total landing in Santarém, was 215 tons between 1992 and 1996 (Ruffino & Isaac, 1999), with average catch per unit effort (CPUE) at 3.7 kg/fisher/day. The same authors, using a yield per recruit model, considered this species to be overexploited.

Mapará (*Hypothalmus marginatus*) landings have only recently been reported. In seven fish-processing plants near Manaus, landings averaged ~400 tons/year between 1995 and 1997 (Rezende 1998). In Santarém, Pará State, landings were 810 tons in 1993 (Ruffino *et al.*

1998). Data for Belém were not available, but IBAMA reported landings ranging from 2,400 to 3,100 tons/y (IBAMA, 1996, 1997a, 1998, 1999b).

Although there is no definite scientific evidence, it is most probable that the pirarucu (*Arapaima gigas*) is also over-fished (Isaac *et al.* 1998), particularly since this species has been heavily exploited over the last two centuries by the indigenous and traditional communities (Veríssimo 1895). Fisher folk report a reduced abundance of this species in recent times.

Over-fishing in the Amazon basin would seem to be a reality. The species under threat have in common that they are greatly appreciated as food fish, and grow to relatively large sizes. As well as being heavily exploited, they all have low growth rates, so that recruitment to adult class is relatively slow. These species, known as "K-strategists", are extremely sensitive to heavy exploitation. The first sign of overexploitation is a decrease in the numbers of large individuals captured, and an increase in the numbers of juveniles captured. Growth over-fishing occurs when mortality through fishing effort exceeds the replacement growth rate in the remaining population. In other words the fish are caught before they are mature enough to contribute significantly to the stock biomass.

On the other hand, based on what little knowledge is currently available, it cannot be said with certainty that there is over-fishing of the species with faster growth and replacement rates (r-strategists), such as jaraqui *Semaprochilodus* spp, pacu *Methynnis* spp, *Mylossoma* spp, curimatã *Prochilodus nigricans* and aracu *Schizodon* spp, *Leporinus* spp. It would seem evident, with regard to these species, that hydrological parameters such as the speed and intensity of the floods have a greater effect on the levels of annual recruitment than does over-fishing (Merona 1993). Nevertheless further biological studies are needed to test this hypothesis.

Importance of biodiversity in the fishery

The composition of Amazonian ichthyofauna is based principally on the super-order Ostariophysi, which includes around 85% of Amazon species, of which 43% are Characiformes, 39% Siluriformes and 3% Gymnotiformes. The remaining species belong to 14 families of other orders (Lowe-McConnell 1987).

The Brazilian part of the Amazon basin contains 68% of the total watershed. Evaluation of its diversity has been carried out in different regions. Goulding *et al.* (1988) identified at least 450 species of fish in the Rio Negro, but estimated that this total would pass 700 species when the differing biotopes had been properly sampled. Santos (1986/87) found more than 260 species in the Jamari, Machado, Guaporé e Mamoré rivers in Rondônia State. Bayley (1982) found more than 220 species in the Solomões várzeas near Manaus. Santos *et al.* (1984) registered more than 300 species in the lower Tocantins river alone. Ferreira *et al.* (1998) lists more than 130 commercial fish species in the várzea region of Santarém. Many species are widely distributed, particularly the migratory fish such as the tambaqui (Araújo-

Lima & Goulding, 1998) and the large catfish (Barthem & Goulding, 1997). Others are restricted to specific regions due to environmental barriers, like the Amazon River itself, for species that live in the headwaters of its tributaries, or the chemical composition of the waters. For example, distribution of *Symphysodon discus* is restricted to clear waters while *S. aequifasciata* is restricted to white waters (Junk, 1997).

The principal trophic sources that sustain aquatic biota in the Amazon basin are those areas periodically flooded by white waters. These areas are known as várzeas, and are found on either side of the Amazon River from Pucallpa, in Peru, down to the river mouth. The várzea supplies fruits, seeds, leaves, terrestrial arthropods and other food sources for fish. The trophic chain is extremely complex, not only for the range of food items that fall into the aquatic system, but also for the diversity of the ichthyofauna, and the wide feeding spectrum of those species present (Lowe-McConnell, 1987, Goulding, 1979, 1980; Bayley, 1982; Junk *et al*., 1989).

The entry of outside material into the aquatic system sustains a biomass of fish that are caught for human consumption. Bayley (1982), working in the Solimões várzea near Manaus, estimated productivity to be 7-144 kg/ha. The predators make up a large section of the biomass, with some species such as *Brachyplatystoma filamentosum* and *Arapaima gigas* (Barthem & Goulding, 1997) reaching a size of two metres or more.

Based on the catches, the Amazonian fishery can be divided into three major fish groups, defined by their migratory and reproductive patterns. They are: those that migrate over large distances, those that have a short migration pattern; and, those that move between different aquatic habitats, thus not needing to migrate to complete their biological cycle (Barthem *et al.*, 1997).

The species that migrate extensively are those that cover long stretches of the river, and have strong links to the estuary. The two species that belong to this group are the piramutaba (*Brachyplatystoma vaillantii*) and the dourada (*B. flavicans*). Although the reproductive cycle of these is still unknown, recent data suggest that these species cover the whole of the Amazon, using the estuary as a reproduction area and the upper reaches of the river to spawn (Barthem & Goulding, 1997).

Species that have a moderate migration pattern are those using the main river to move upstream from one tributary or várzea to another tributary or várzea. The species that regularly migrate in this way are of the order Characiformes, such as tambaqui *Colossoma macropomum*, pacu *Mylossoma* spp., jaraqui *Semaprochilodus* spp., curimatã *Prochilodus nigricans* amongst others. Based on the migratory behaviour of jaraqui (Ribeiro & Petrere, 1990) and tambaqui (Goulding, 1979), three types of migratory pattern can be defined: trophic, reproduction and dispersal. During the flood season these species stay in the flooded areas feeding on forest products. Once the river level begins to fall they start a dispersal migration in the main river and always upstream. The shoals then stop moving and wait for the rains and the river to rise again. When this happens, the shoals of reproducing fish move

to the spawning area. This is the reproduction migration. Following spawning they move into the flooded areas. This is the trophic migration.

Species which do not need to migrate to complete their biological cycle are those typical of the várzea such as pirarucu (*Arapaima gigas*), aruanã (*Osteoglossum bicirhosum*), tucunaré (*Cichla* spp.), acará (Cichlidae em geral) and the pescada (*Plagioscion* spp.), amongst others. The reproduction cycle for these species can be either annual of bi-annual. They do not need to migrate to complete their life cycle.

There are also significant effects of various fisheries on non-target species. One example is the trawl fishery for piramutaba (*Brachyplatystoma vailantii*) in the estuary, where there is a by-catch of other important commercial species. Another example is the gill net fishery for tambaqui *Colossoma macropomum*), which uses a mesh size suitable for tambaqui, but catches other commercially valuable species as well. A further example is the drift net fishery for dourada (*B. flavicans*) in the river between September and October, where tambaqui is also caught.

Management history - successes and failures

Although there are many different government regulations in effect in Brazil, all fishing activities are governed by Decree-Law 221/67 and Law 7679/88, which apply to the whole country. On the basis of these statutes, national, state, and regional legislation have been enacted, with a view to regulating specific cases. Administrative ordinances were until recently specific, aiming at solving isolated problems in particular locations. In areas not covered by specific legislation, fishing was controlled by Administrative Ordinance 466, which covered all inland waters in Brazil. This administrative ordinance was flawed because it considered all inland waters as a single environment. It did not take into account the different characteristics of the fishing environments, not even in terms of the main Brazilian ecosystems. Ordinance 466, issued in 1972, was apparently designed only for the south-eastern and southern regions of the country,

Fisheries management in the Brazilian Amazon has until recently been conducted in the conventional centralized manner. The federal government instituted decrees, regulating fishing activity by classic methods such as closed seasons during spawning migrations, limits on mesh size, minimum sizes, and the prohibition of especially noxious gear such as explosives and poisons (Isaac *et al.* 1993). Such decrees were not always based on scientific evidence, and enforcement of such a great variety of measures was not effective.

Nevertheless, with a view to correcting imbalances resulting from the lack of a fishery policy, the federal environmental agency, IBAMA (The Brazilian Environmental and Renewable Natural Resources Institute) established the basis of an integrated Fisheries Management Program. The program is designed to ensure sustainability by taking into account both the impact on the resources and the relevant cultural, ecological, economic, and social factors (Fischer *et al.*1992).

Despite the existence of these regulations, government agencies have neither sufficient personnel nor resources to enforce compliance, so commercial fisheries have largely developed in a regulatory vacuum. As a result, fishing conflicts between riverine communities and outside commercial fisherfolk have proliferated in the last two decades. Due to limited government presence in the várzea, many riverine communities began to develop and implement their own management regulations, referred to as "fishing agreements" (Acordos de Pesca), to protect their interests. These rules were apparently developed for the purpose of protecting the fishing rights of community members and are totally unrelated to any environmental considerations.

Despite the ecological feasibility of lake management by the community and the increasing number of such schemes in some areas, few communities had been successful in this endeavour, mostly due to difficulties in setting up an internal control system. Such a system requires the concerted efforts of commercial fisherfolk from other regions and local fisherfolk, as well as an efficient internal community organization.

After studying the institutional and organisational schemes used by fisherfolk, Schönenberg (1994) concluded that in order to propose fisheries management measures it was necessary to know the target groups and their forms of social organizations. The author reported on the heterogeneity of the numerous organizational structures of the fishing sector and the randomness of their relations with municipal, state and federal institutions. She found that although traditional forms of organization at community level did not specifically represent fisherfolk interests, these were implicit in their social, commercial and spiritual interests, which were much sounder and dominant forms.

In order to ensure the success of any future legal regulation of fisheries by IBAMA, it would be necessary to know the intra- and inter-institutional relations of the various target groups, which are characterized by socio-economic and ecological-cultural heterogeneity, as well as to obtain the participation of such organizations.

Thus IBAMA together with the German Agency for Technical Cooperation (GTZ) and the consultancy firm GOPA initiated a project for "the Administration of the Middle Amazon Fisheries Resources" – Project IARA. The aim of this project was to develop strategies for environmental management, which would guarantee sustainable exploitation of the fisheries resources. Although conceived as a project of political and management intervention, activities in the first phase (1991-1995) concentrated principally on gathering the background knowledge that would provide the basis for future activities adapted specifically to local characteristics. To this end studies were undertaken covering biology, fisheries ecology, socio-economics and fisheries technology. In order to link these research studies to the reality of riverine life with its diversified economy and the inter-dependence between the different várzea ecosystems, it was necessary to include studies on terrestrial alternatives (animal husbandry, gathering etc) and their impact on fishing (IBAMA 1995).

The IARA project, acting as the main executive arm of IBAMA's program, used a participatory approach in order to integrate the target group – fisherfolk, riverine communities and fisheries-related institutions - within the fisheries administration system. This was based on the idea that sustainability cannot be achieved by decree. It can only come about through a system of co-management where all the fisheries interest groups can identify with the proposed measures. This approach creates a greater likelihood that future management strategies will work. Such a concept requires a more direct contact with the interest groups than is normally established by government. For this the project developed the following methodologies, while at the same time focussing on the two paths of research and intervention:

1) to obtain basic information on the fishery and the socio-economic situation of the riverine population. Thus, "The Community Statistical Census" CSC (Isaac *et al*. 1999; Mitlewski *et al.* 1999b; Ruffino *et al.* 1999) was developed to enable first contact to be made with the fishing communities, to encourage their participation, to appreciate their culture, to learn about their concept of reality, and to familiarize technicians from institutions involved in regional fisheries management;

2) the Rapid Rural Appraisal (Mitlewski, 1999a; Oliveira *et al*., 1999) was used to deepen this knowledge and understand better the social and economic dynamics of the communities;

3) in two micro-regions research into fish consumption by the riverine communities was carried out, with their active participation, (Cerdeira *et al.* 1997; Cerdeira *et al.* 2000); and,

4) monitoring of fish landings was implemented by collecting landings statistic at the major ports (Isaac & Ruffino 2000a; Isaac & Ruffino, 2000b; Isaac *et al*.1996; Ruffino *et al.* 1998).

Working closely with the riverine people and the fisherfolk led to a re-interpretation of the problem of local economic sustainability and the strategies necessary to achieve it. There were basically three aspects that needed to be reviewed:

1) It became clear that the inclusion of studies on alternative activities to fishing and incentives for some of them was only the first step in understanding the integrated nature of the economy and the impacts that a partial or total breakdown would cause by provoking non-sustainable use of the natural resources. It was obvious that the sustainable use of the várzea natural resources was only feasible when an integrated concept was used, of treating the ecosystem as a whole rather than using one resource at the cost of the others. It was realized that if a management system is to guarantee a sustainable fishery, it must not only direct the fisheries administration, but should also include all the relevant sectoral administrations in a single system;

2) Regardless of whether a monosectoral or a multisectoral strategy was to be used, the initial project strategy considered the fisheries problems in the region to be essentially of a technical nature. Potential monosectoral solutions were: to fit fisheries regulation to local peculiarities (set minimum sizes of fish, of mesh, gear and fishing method restrictions, closed seasons); to try forms of protection ("Pulse Fishing", closure of areas); and, to improve yield and storage (diversify products, improve hygiene, transport and storage facilities). Potential multisectoral solutions were: reduction of activities with negative impact (ranching and intensive agriculture); restoration of damaged areas (replanting the shoreline with fruit trees, agroforestry culture systems); and incentives to increase economic diversification (raising wild animals, use and commercialization of medicinal plants).

Although varying combinations of these measures could solve different problems, it was discovered from various sources (riverine communities, fishing and other user organizations, and government), that there existed a whole array of more fundamental problems. These were related to the history of Amazonian várzea occupation, and the political and economic structures that have dominated the region for centuries. The basic problem is insufficient socio-political organization at all levels of the local rural and urban society and large gaps in social communication systems, both formal and informal). There is a lack or malfunctioning of the normal democratic instruments that guarantee representation to those seeking ways of sustainable natural resources management. Such instruments are sectoral and/or inter-sectoral forums, professional organizations, community associations etc. This in turn leads to a situation where the common good turns to the good of no one, or rather the benefit of the strongest. Thus it was concluded that sustainability of the Amazonian fishery would not form part of the technical plan, but of the political organizational plan.

Based on these two major conclusions the principal focus of action was directed towards organizational strengthening at both institutional and user-organizational levels, as well as encouraging a wide communication network that, in the long term, could unite those involved in the use of the Várzea resources (Mitlewski, 1999b).

It was evident that sustainable use of the fishery resources could only be achieved if it was based on technical/scientific evidence, the participation of the users in the management process (co-management), and principally in the development of integrated management processes that included fishing activities and the normal process of regulating them.

Participation by the users in the management process was recognized as fundamental to its success. Given the magnitude and nature of fisheries problems, it was realized that government could not deal only with individuals or small groups in isolation, because these did not represent the common interest. Therefore it would be necessary to strengthen the organizational structures of the parties involved. A training program was initiated for community representatives from some regions to train community leaders to act as stimulators, motivators, coordinators, representatives and links in the management process. A

fuller discussion process also began with all the sectors involved in the fisheries, which resulted in a series of municipal fisheries forums.

Monitoring showed a progressive maturing of attitudes amongst those involved in fishing agreements with respect to the formulation of such accords. As a result these agreements began to be formalized by IBAMA decrees. IBAMA realized that the active participation of the people in the administration of the development process promoted a decentralized decision taking process. This meant that it had to involve itself directly in the planning, execution, control, evaluation and adjustment of activities generated by local demands. Adoption of this type of environmental management, working together with the different groups in the fishery, is compatible with the political re-democratization process currently underway in Brazil. It is an essential precondition of any sustainable development process. IBAMA believes that civil society's participation will only be effective if the decision making process is carried out in an organized manner through the legitimate representative organizations. Thus one of the basic directives for the implementation and consolidation of the participatory management process was to strengthen the organizational structure of the various parties involved. In this way it enabled its integration and formal links with the legitimate process so that their respective interests could be represented. In the mid-Amazon region the resident riverine population constituted an important role in this process. However, their organizational fragility restricted the effectiveness of their involvement. Thus IBAMA developed an on-going process of leadership training for those involved, essential for the success of the process. The program aimed at training community leaders to ensure the decision-making process considered community interests. It also provided training in the organization, leadership, and maintenance of existing community groups as well as providing constructive leadership in dealing with intra and inter-community conflicts.

However, enforcement was, and still is, a key element in the implementation of fishing agreements. The majority of the fisherfolk living in the region agreed that failure to comply with the terms of the fishing agreements, by local as well as outside fisherfolk, was the main problem in the implementation of the co-management process. The essential ingredient in maintaining this partnership was to persuade all parties to comply with the conditions of the fishing agreements. Therefore, as part of the process of co-management, the community's participation in the enforcement process was formalized, complementary to government's role. As part of this process the voluntary environmental agent (see below) was expected to act as an environmental educator for his community. Participatory enforcement has its own objectives and principles. The objective of the fishing community's involvement in the enforcement process is to change their role from onlookers to participants, enabling them to contribute to, control and monitor its execution and results. The efficiency of official bodies involved in the surveillance process is also improved through local community-based proposals for improved direction of enforcement to meet their needs and, if required, through logistical support. Some years ago there were incidences of informal and spontaneous involvement of communities in the enforcement of fishing agreements. Based on these experiences and on a resolution of the National Environment Council, the voluntary

environmental agents, a scheme was introduced. These agents are community members who carry out voluntary surveillance of the fisheries in their area. The scheme is based on the following three assumptions:

1) the work has to be carried out by at least three persons to reduce the individual element – community members acting alone are prone to pressure and threats against their person by offenders, as well as having a certain reluctance to denounce their fellow community members;

2) as they are in constant contact with their communities, the environmental agents must be communicators linking the environmental institutions with the communities; and

3) the environmental agents must give priority to inter-community conflicts rather than to enforcement by external sources.

The success of the voluntary environmental agents was such that there is still a huge demand for them from communities in other regions.

The IARA project, funded under international technical cooperation terms, was finite and closed at the end of 1998. It had created, over the years, co-management as well as organisational and communication/information structures with their own dynamics, which possibly did not require a project's support to continue. However, its termination was a retrograde step for three reasons:

1) a system of monitoring fisheries production had been established, which required continuity to facilitate fisheries planning based on objective information. A break in this work could reduce the value of data already collected, because such data need to be collected over lengthy periods to allow comparative analysis to be made. Any lack of data in the future could well devalue past data;

2) Although the implementation of participatory fisheries management had begun, the consolidation of this process still required a large amount of institutional energy, creativity and credibility. As systems of co-management create both expectations and suspicions, it is essential that the idea is carried forward in a serious and transparent manner. Any interruption in IBAMA's support of this process would serve to discredit both the image and credibility of the institution as well as the management process. This would pose a serious threat to the sustainability of the Várzea ecosystem.

3) The tendency of the regional economy towards monoculture can only be countered by continuing efforts to promote and advise on diversifying, using the various available resources. The IARA project developed successful methods and demonstrated potential ways of doing this. It is essential that the momentum be continued. At the

same time local and regional politicians should be made aware of the issues in a continuing effort to conserve the social and biodiversity of the Amazonian Várzea.

How biodiversity has been incorporated in fisheries management

Some measures adopted by the government and the communities are unintentionally incorporating biodiversity conservation strategies, whether it is through regulation of the fisheries or conservation of habitats

Basically the fishery resource can be exploited because of the availability of certain stocks, which is directly linked to the flood cycle, namely:

1) **Management of migratory caracoideae** - takes into account the seasonal variations in river levels, fish behaviour and the fishery in relation to those factors. Management strategies for this group are divided in accordance with the differing life cycles of the fish:

   - **k-strategist species:** with a slow growth rate and late sexual maturity, a typical example being tambaqui *Colossoma macropomum*, which, in order to correct growth overfishing, are protected by a minimum size limit set at 55 cm, which is the median size at which they reach sexual maturity.

   - **r-strategist species:** amongst the migratory caracoideae species with r-strategist characteristics, which are most targeted by the commercial fishery, are: jaraqui (*Semaprochilodus* spp), curimatã (*Prochilodus nigricans*), pacu (*Methynnis* spp and *Mylossoma* spp), aracu (*Schizodon* spp and *Leporinus* spp), matrinchã and jatuarana (*Brycon* spp) and sardinhas (*Thriportheus* spp). However there is no evidence at the moment that these species are being over-fished. Ribeiro & Petrere (1990) reported observing large concentrations close to Manaus, during the spawning run, which made the fish an easy target for the commercial fishing fleet of that city. The current strategy for conservation of these species is to ban fishing during the spawning season at the beginning of the rainy season. However, the question could be asked, as to what seems to be the point of protecting the shoals during the spawning run and not during the upstream migrations during the dry season? The net effect of concentrated fishing effort on the migrating shoals would be the same whether the fish are on a dispersal migration or a reproduction migration. Therefore the ban could theoretically be extended to start before reproduction, to cover the low water period when the fish are at their most vulnerable. However, as stated above, the yearly hydrological fluctuations seem to have a greater effect than fishing effort on the annual abundance of these species. Also given that there do not appear to be any signs of over-fishing, it would seem that such a measure would be merely of symbolic value, with doubtful effect.

2) **Management of sedentary species** - Várzeas and igapós, the slow moving lake environments of the Amazon basin, are the nursery areas for the young caracoidae, as well as the permanent habitats for sedentary, non-migratory species such as the Cichlidae (tucunaré, acará), Sciaenidae (pescada), Osteoglossidae (aruanã) and Arapaimidae (pirarucu). Fishing agreements implemented by riverside communities can be a reasonably effective instrument to protect these environments. It is possible that an integrated system, including all the lakes in a given region, could have a positive effect on the stock recovery of sedentary species of high commercial value, such as the pirarucu (Goulding 1983; McGrath *et al.* 1993). Regulation by IBAMA of a controlled system of fishing agreements, prohibiting commercial fishing, either intermittently or on a rotation basis, could ensure a replacement gene pool of those species that are being intensively exploited in other regions where it is no longer possible to limit commercial fishing effort (Isaac *et al.* 1993). An experimental system of management would be to close lakes on a rotational basis, each one for two or three years. This system, known as "pulse fishing", would allow aquatic fauna management measures to be combined with measures to protect and renew perimeter areas of lakes.

3) **Management of large migratory catfish** - Ruffino *et al.* (2000) reported that juveniles of these species are found in the estuary areas, while reproducing adults are found in the Brazilian, Colombian and Peruvian upper Amazon. This indicates that the same stock uses environments, far removed from one another, to complete their biological cycle, covering distances of over 3,500 km. The course of the Amazon provides a very important environment for the predatory catfish. Besides providing a natural path for larval dispersal, it is also the environment where the adults find their prey. Improved knowledge of the life cycle and geographical distribution of the large catfish is essential for the development of a management policy to control the exploitation of this natural resource. The situation is complicated by the fact that the stock is exploited by fishing fleets from different countries. Thus, management of these species would only be possible by means of a macro-regional policy integrating the regulations of the three neighbouring countries. A first step was taken in this direction with the "the Tri-national Meeting to Regulate the Fishery for the Large Catfish of Amazônia", held in Leticia, Colombia in November 1995. During this meeting current knowledge regarding the large catfishes was presented, analyzed and discussed by representatives from Brazil, Columbia and Peru. As a result of the meeting various conclusions and recommendations were formulated with regards to research and management (administration and regulation) to be presented to the respective government fisheries institutions for consideration. At the same time COPESCAL initiated a dialogue between the three countries with the aim of identifying ways in which the problem could be addressed jointly. However, to date each country continues to act individually.

It is important to remember that classical concepts of overfishing, derived from single species fisheries, are difficult to apply in multi-species fisheries of this type. Individual species may

become over-fished and disappear from the catch according to classical population dynamics models, but the yield from the fishery as a whole tends to remain the same (FAO, 1998).

Results and lessons learned

IBAMA recognizes the importance of biodiversity in fisheries management. However, an acceptable scientific model has yet to be developed that takes into account ecological and cultural aspects as well as the regional fisheries dimension, or which provides a quantitative basis that would contribute towards the development of a more effective management and regulatory measures. IBAMA understands that the search for solutions cannot wait for the development and results of complex evaluation models, nor for the collection of data over long periods. The practical necessities are imposing a resource evaluation system that combines theoretical and empirical, conventional and alternative, and the development of multi-disciplinary approaches. Current efforts are concentrated on developing a multi-disciplinary proposal that takes into account the application of classical models (bio-economic studies), as well as the experience and knowledge of the fishing communities (social studies). At the moment work is concentrated on measures to monitor the process by means of an "adaptive", interactive management system, where correction of possible mistakes follow consensus experiments.

With regards to biological information, IARA carried out various studies that led to a revision of existing regulations. As far as the fishing accords are concerned, IARA simply revived this form of management, already practiced by the riverine populations, gave it form and structure so that it could be a viable form of fisheries regulation to be used by IBAMA. Experience gained through local and regional projects has shown that the rational use and conservation of fisheries resources require the following:

1) **Local support** - In an area as extensive as the várzea, only actions that are accepted and approved by the local population have a chance of success. As far as the fisheries are concerned there are already mechanisms established by the riverine communities and supported by IBAMA. One promising example is the success of fishing agreements. When a fishing agreement is established with the participation of people and institutions representing the different stakeholders, it achieves positive results with regards to compliance with closed seasons, monitoring and enforcement. The application of punishments remains exclusively the prerogative of government. IBAMA published a notice confirming the legality of fishing agreements and specifying the procedures to formalise them.

2) **Decentralized management** - Field experience demonstrated the importance of decentralised and participatory management. IBAMA has already started the process of decentralised management and increasing the number of users participating in this process. These changes resulted from social pressure generated by clashes between user groups over control of the resources. As a result organised community groups throughout the Amazon várzea are assuming control of fisheries resources management.

3) **Influence on and formulation of coherent policies** - There are very few studies evaluating the impact of government policies, (rural credit, electricity supply, river navigation, waterways and ports) on economic trends, aggravation of social unrest, and environmental deterioration of the várzea. This should be corrected with the assistance of pilot projects planned for the region.

4) **Involving the large landowners** - Discussions on participatory management have tended to concentrate on the communities, ignoring the large landowners and companies (timber firms, commercial fishing companies, fish processing establishments and large cattle and buffalo ranches). In some regions the majority of the lakes covered by fishing agreements are situated alongside large properties.

5) **Diversifying the economic base** - Some experimental projects are developing economic alternatives to fishing (reforestation, vegetable growing, medicinal plants, agriculture, rearing wild animals, etc.). Preliminary results have shown advances in production systems. However, there still are various obstacles to multi-use of the várzea natural resources. These include the lack of socio-economic organization in the communities (such as cooperatives), and lack of an adequate marketing system.

Guidelines, policies or legislation that have resulted from this experience

Based on the experiences of the project IARA, a new type of democratic and decentralized regulatory system was given effect by IBAMA through decree 07/96. The decree delegates to the State representatives of IBAMA, responsibilities for regulating the fishery as they consider appropriate. Thus it is hoped that there will be more coordination in determining close seasons and areas for fishing.

Decree 08/96 revoked a series of previous decrees, set out regulations concerning fishing gears and methods, and set minimum sizes for four species throughout the Amazon basin, thus correcting various problems that had been occurring.

IBAMA published a document called “Participatory Management, a Challenge for Environmental Management" (IBAMA, 1997b), which set out strategic directives for the fisheries. This contained strategic directives for the fisheries, and also established management criteria to regularize the informal practices used over many years by the riverine communities of the middle and lower Amazon. Such practices had demonstrated their importance as informal fisheries management strategies. As they were backed by the common will, they were more effective than existing government policies. These were the so-called “Community Fishing Agreements” ("Acordos de Pesca Comunitários"), which brought together varying numbers of artisanal fishing communities (both commercial and subsistence), set prohibitions and specific regulations to manage the fishery in accordance with local requirements.

A decentralized surveillance system was set up with the participation of organized civil society in the shape of the Voluntary Environmental Agent.

Since 1996, based on the results of biological studies and conventional single-stock assessment, the legislation regulating fisheries has begun to be simplified and systematized, correcting inconsistencies and eliminating unnecessary measures. At present, in the Amazon, current legislation regulating minimum size of capture exists for only four species: *Arapaima gigas* (150 cm), *Pseudoplatystoma tigrinum* and *P. fasciatum* (80 cm) and *Colossoma macrompomum* (55 cm). In addition, fishing for certain species of characins is prohibited during the period of upstream reproductive migration, December through February. There are also restrictions on the number of vessels and the mesh size in the industrial piramutaba (*Brachyplatystoma vaillantii*) fishery.

A variety of different measures are being employed in the fishing accords. Frequently, the lake system is divided into zones based on the kind of use permitted (no fishing, subsistence, or commercial fishing). Local fishers may also restrict access to the lakes to surrounding communities, prohibiting access to those from other areas. In other cases, specific gear types, such as gillnets, are prohibited, either permanently or seasonally. Another measure concentrates on storage capacity and may involve restrictions on use of ice or limitations on the size of icebox. Others proposals include a closed season, gear regulations, zoning of use and the prohibition of boats with a storage capacity exceeding five tons. To preserve habitat, it is proposed that buffalo be removed from lands surrounding the lake and lake margins be reforested with fruits and other native tree species.

In order to consolidate, strengthen and expand the experiences of the middle Amazon to other areas in Amazônia IBAMA submitted the Floodplain Natural Resources Management Project (ProVárzea) to the Pilot Programme to Conserve the Brazilian Rain Forest (PPG7) to meet its broader objectives, as a pilot initiative, covering the length of the Amazon River. The PPG7 is a joint undertaking of the Brazilian government, civil society, and the international community that seeks to find ways to conserve the tropical rain forests of Brazilian Amazon. The goal of the programme is to maximize the environmental benefits of the forests in a way that is consistent with the development goals of Brazil and its people.

The Floodplain Resources Management Project, which was initiated in July 2000, aims to establish scientific, technical and policy foundations for the environmentally and socially sustainable conservation of natural resources of the Várzea floodplains of the central Amazon Basin region, with emphasis on fisheries resources. ProVárzea was formulated with the idea of consolidating, replicating and expanding IARA's experiences over the full length of the Amazon/Solimões, with increased political and social emphasis and adapted to the various particular regional needs. The specific objectives are:

1) to develop administrative and management systems that are ecologically, economically and socially sustainable;

2) to ensure the integrity and functionality of the floodplain ecosystem, by preserving the main habitats and the floodplain biodiversity;

3) to strengthen the capacity of the institutions and of the community and grassroots organizations for the sustainable management of the floodplain natural resources;

4) to set up a nucleus of a regional network of users organizations linked with institutions at the federal, state or municipal level, with a view to manage the floodplain natural resources aiming at its conservation; and

5) to set up a control and monitoring system of the floodplain natural resources that covers the entire extension of the Amazon River floodplains.

Thus the management strategy proposed for the Amazon fisheries resources will be one of socio-ecologically sustainable development, where fisheries management would be considered just one component in the management of the whole ecosystem. The objectives of fisheries management based on ecosystem management would include the sustainable use of the environment as well as the resources, the safeguarding of essential ecological processes and the conservation of biological diversity at all levels.

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