People in Nature

WILDLIFE CONSERVATION IN SOUTH AND CENTRAL AMERICA

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To José Márcio Ayres, 1954–2003

That this book is dedicated to Marcio Ayres is powerfully appropriate, in that Marcio touched the lives and the intellects of so many of the authors. Marcio influenced the course of conservation in the Amazon probably more than any other single person in recent memory, and community-based management was at the heart of everything that he did.

Marcio will be forever associated with the creation of the Mamirauá and Amanã Reserves, two huge protected areas in central Amazonia that involve local communities in their management and development. In 1996, when the first was gazetted, Marcio helped introduce a new concept—the "sustainable development reserve." As opposed to a national park, which in Brazil called for the removal of local people from the reserve, the sustainable development reserve actively involved local inhabitants in management. Brazil's President Fernando Henrique Cardoso would later call Mamirauá "a living example of how it is possible to create positive coexistence between the inhabitants of a region and the preservation of that region." This was not empty rhetoric. Marcio had realized early on that in the absence of strong governmental institutions in the Amazon, local people driven by their own self-interest could become the guardians of nature and natural resources. Mamirauá, situated in the flooded forests, contains important wildlife, timber, and especially fish resources. The management plan granted usufruct rights to the local people, allowing them with the help of government agencies to exclude nonresidents from fishing in the reserve. The result was one of those rare "win-win" situations: the average income of local fishermen rose from R$320 in 1999 to R$845 in 2001, based largely on an increase in fish production from management lakes from 6.2 to 15 tons, while at the same time populations of pirarucu (*Arapaima*), the most important fisheries species, tripled in density. And local people have seen a dramatic rise in their educational achievement and health.

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Fisheries in the Amazon Várzea

HISTORICAL TRENDS, CURRENT STATUS, AND FACTORS AFFECTING SUSTAINABILITY

WILLIAM G. R. CRAMPTON, LEANDRO CASTELLO, AND JOÃO PAULO VIANA

The várzea floodplain flanking the sediment-rich whitewater rivers of the Amazon basin is a mosaic of seasonally inundated rain forests, lakes, and winding channels. This ecosystem is exceptionally productive and species rich, with a large proportion of endemic taxa adapted to the prolonged annual floods. Várzea floodplains cover about 180,000 km^2, or approximately 2.6%, of the 7 million-km^2 area of the Amazon basin (Bayley and Petrere 1989). This figure does not include the less productive floodplains of nutrient impoverished blackwater and clearwater rivers. Junk (1997) estimated that the total area of seasonal floodplains in the Brazilian Amazon basin is 307,300 km^2, of which 40% (106,000 km^2) is typical whitewater várzea (Bayley and Petrere 1989). An additional one million km^2 of the Brazilian Amazon's terra firme forest (above the seasonal floodplain) are periodically inundated by the flash flooding of streams (Junk 1997).

Várzeas support an astonishingly diverse fish fauna (Henderson, Hamilton, and Crampton 1998) and highly productive fisheries (Goulding, Smith, and Mahar 1996). Fish are unquestionably the most economically important of all natural resources in the várzea (Batista 1998; Queiroz and Crampton 1999a). They provide the main source of income for the rural settlers (*ribeirinhos*), underpin entire regional economies, and provide the main source of protein for the Amazon's rural and urban population. The fisheries of the Brazilian Amazon currently employ around 25,000 professional and 70,000 subsistence fishermen (Batista 1998). In the early 1990s fishing in the Central Amazon generated profits exceeding US$ 200 million/year (Batista 1998). The main theme of this article is that with appropriate management, várzea fisheries could provide a major contribution to economic growth and rural development in the Amazon basin, as well as a powerful incentive to conserve the habitats that várzea fishes rely upon.

Although there is growing evidence for the overfishing of some species (Bayley 1997; Barthem and Goulding 1997; Crampton 1999a, 2001), studies suggest that the overall fish productivity of intact Amazonian várzeas can comfortably support contemporary levels of exploitation (Bayley and Petrere 1989; Crampton and Viana 1999). The main threat to the fish stocks of the várzea is not overfishing but habitat loss (Goulding 1999). Floodplain fishes depend upon flooded forests and floating meadows for sustenance, refuge, and breeding sites (Goulding 1980; Crampton 1999b). Because the alluvial soils of the várzea support outstanding agricultural production in comparison to terra firme forests, most of the natural várzea forests and meadows of the middle to lower course of the Amazon have already been cleared or severely degraded by livestock ranching, agriculture, and predatory logging (Smith 1999). More than 70% of várzea forests may have already disappeared (Alexander 1994), whereas the loss of Amazonian terra firme rain forest is estimated at 10 to 14% (Ayres and Fonseca 1997; Schwartz 2000). Relatively intact várzea forests and meadows are still found in the Upper Amazon regions of Brazil and Peru, but their future is uncertain (Laurance 2000).

A major challenge to fisheries management in the várzea is restricting access and economic benefits to independent groups of fishermen. The federal government owns all the várzeas of the Brazilian Amazon. Fishing is permitted in any water body accessible by boat, and there are no formal regulations defining exclusive fisheries rights for any group of stakeholders, including the local populations (McGrath et al. 1999). The only exceptions to this situation occur in some conservation units and in a rising number of local lake-protection schemes that have received official recognition by Brazil's Institute for the Environment and Renewable Resources, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). For the most part, fisheries legislation in the Brazilian Amazon comprises state-imposed restrictions that are so poorly enforced as to be effectively nonexistent (Isaac, Rocha, and Mota 1993; Crampton and Viana 1999; McGrath et al. 1999). These conditions of almost unrestricted access and impotent regulation define the fish stocks of várzeas as a typical "open access resource," meaning that few stakeholders have exclusive rights of access or the incentive to control their own activities.

Following the collapse of several major fisheries around the world (McGoodwin 1990), planners are losing faith in state-imposed regulation and devoting serious attention to community-based models of fisheries management (Anderson 1986; Berkes 1989). In some ways várzea fisheries are ideally suited to community-based management. First, várzea settlers have evolved a semicommunal organization with cooperative labor (Lima 1999). Second, the outstanding economic value of floodplain fisheries provides the incentive for fishermen to defend their resources and undertake management. Third, várzea settlements are often located at strategic positions such as the entrance to lake systems. Finally, várzea fishermen have an excellent understanding of fish ecology.

In other ways várzea fisheries are less amenable to management. Many species of

have complex migratory life histories, and their abundance in any given location is primarily a function of exploitation levels elsewhere. Local management has negligible effects on the stocks of these migratory species.

Self-motivated lake vigilance schemes began to appear spontaneously around the Amazon basin in the mid-1970s in response to invasions of predatory fishing fleets from the growing cities. These schemes had limited success, mainly because of political weakness and lack of infrastructure (Lima 1999). More recently, many self-motivated social movements (e.g., lake-protection schemes and rubber-tapping syndicates) have formed alliances with state or nongovernmental conservation organizations. Such alliances are intended to strengthen community projects by providing funding, training, and technical cooperation (Lima 1999). These kinds of partnerships may represent the most promising direction for fisheries management in the várzea (Ruffino and Isaac 1994; McGrath et al. 1999; Ruffino 1999).

This article brings together information from a variety of disciplines to provide a broad review of the history and status of várzea fisheries in the Brazilian territories of the Amazon. We emphasize the polarization of contemporary management strategies toward (1) government-based regulation and (2) community-based lake-management schemes, including those working in alliance with government authorities or NGOs.

VÁRZEAS: A LONG HISTORY OF HUMAN SETTLEMENT

The reports of early expeditions (Fritz 1922; Acuña 1942; Hemming 1978) and the abundance of archaeological sites along the Amazon suggest that a large indigenous population existed before European colonization (Palmatary 1939; Lathrap 1970; Smith 1980; Porró 1981; Meggers and Evans 1983; Porro 1983; Costa et al. 1986; Roosevelt 1987, 1991; Denevan 1996; Roosevelt 1999). Smith (1999) speculated that there might have been as many as fifteen million Amerindians in the basin before Europeans arrived. Archaeological studies reveal a pattern of large settlements closely spaced along the Amazon and located mostly on terra firme bluffs near várzea (Lathrap 1970; Denevan 1996; Roosevelt 1999). Here, Amerindians benefited from the resources of both várzea and terra firme ecosystems but avoided the flooding and biting insects of the várzea. We do not know when humans first arrived in the Amazon, but there is evidence for settlements near várzeas dating back to 11,000 or perhaps even 16,000 years ago (Roosevelt et al. 1991; Roosevelt 1999; Roosevelt et al. 1996).

How did várzeas provide such a large indigenous population with a sustainable supply of protein? The answer seems to be that several protein sources were exploited, with fish being less important than today. Roosevelt (1999) described the preponderance of turtle carapace fragments at sites dating from 11,200 to 9,800 years near Santarém, Pará. Roosevelt (1999) also found the bones of many fish species, including small characiforms, catfishes, and the pirarucu (*Arapaima gigas*), at paleo-indian sites (from 11,200 to 8,000 years ago) and in more recent pre-Colombian sites. Roosevelt et al. (1991) reported that freshwater mussels were an important food source near várzeas of the Central and Lower Amazon.

Accounts of travelers and naturalists until the beginning of this century suggest that turtles provided the main protein supply for Indians along the Amazon (Spix and Martius 1822–1831; Wallace 1853; Bates 1863; Coutinho 1868; Fontes 1966; Ferreira 1971, 1972). The most important species at the time was the giant turtle (*Podocnemis expansa*), which emerges onto nesting beaches at low water. Indians harvested turtles for meat and collected eggs to make lard and lamp oil. Manatees (*Trichechus inunguis*) were also abundant before mass slaughters occurred in the seventeenth century (Vieira 1925–1928) and perhaps also represented a significant food supply.

Soon after the arrival of Europeans, the indigenous population of the Amazon suffered a massive decline, mainly because of lack of resistance to Old World diseases (Hemming 1978). Few European immigrants took their place and for the next two centuries much of the basin became almost devoid of human population and commerce. Verissimo (1895) reviewed fishing in the Amazon between the sixteenth and eighteenth centuries. From 1667 until 1827 the imperial administration established Royal Fisheries for commerce in the states of Amazonas, Pará, and Maranhão. It is clear from Verissimo's accounts that fishing pressure in the Amazon was generally low during this period. However, during the late nineteenth and early twentieth centuries, turtles were exploited recklessly for the manufacture and export of an oil made from the eggs. The populations of *P. expansa* and some other species were almost obliterated (Sternberg 1995), and today turtles form a negligible (although prized) component of the Amazonian diet. In the late twentieth century caiman, which were previously abundant in várzeas, were reduced drastically by skin hunters. The black caiman (*Melanosuchus niger*) was particularly affected. However, hunting restrictions have since resulted in a wide-scale recovery of populations (R. da Silveira, INPA, pers. comm.).

The rubber boom from the 1870s to the 1920s (and a minor boom after World War II) brought a wave of immigrants into the Amazon, but most of the latex tapping took place in terra firme forests or in seasonally inundated blackwater igapó forests away from the várzeas. Following the final collapse of the rubber boom in the 1920s, many unemployed workers settled in várzea floodplains. Settlements grew around the outposts of the patrons who controlled trade in the area through the aviamento system of debt bondage. The major economic activities in the early twentieth century were the cutting of firewood for steam ships and the commercial extraction of pirarucu, manatees, and turtles. During the 1940s and into the 1970s, jute growing provided a substantial source of income in the várzea and, along with agriculture and fishing, attracted even more rural Amazonians away from the less productive blackwater and terra firme systems (Goulding, Smith, and Mahar 1996).

By the late 1960s the rural population of the Amazon had grown steadily but was still low in comparison to the estimated pre-Columbian population (Smith 1999). The cities of the Amazon were only just beginning to grow rapidly, and the pres-

lation had become concentrated in várzea floodplains. As the jute industry collapsed in the early 1970s and as the urban market for fish began to grow at about the same time, many várzea farmers turned to fishing (McGrath, Silva, and Crossa 1998; Smith 1999). With turtle, manatee, and caiman populations almost extirpated, fish remained as the only major natural source of protein. In the next chapter of Amazonian history—the explosive growth of the urban population—várzeas and their fish stocks were poised to play a new and central role in the regional economy.

OPERATION AMAZÔNIA: URBANIZATION AND COMMERCIAL FISHING

The status of várzea fisheries changed radically with the implementation of Operação Amazônia in 1966. In just three decades this package of resettlement and development projects resulted in more changes to the ecological fabric of the Amazon than in all previous human history (Kohlhepp 1984; Goulding, Smith, and Mahar 1996). The human population of the Brazilian portion of the Amazon basin (considering Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins) increased from 1.8 million in 1960 (Costa 1992) to 9.2 million in 1991 (IBGE 1991) and to 12.9 million in 2000 (IBGE 2001). Most of the growth occurred in urban areas. Manaus grew from just 320,000 in 1970 (Costa 1992) to 1.4 million in 2000 (IBGE 2001) and continues to grow by 6% per year (Costa 1992). In Amazonas, 74.8% (2.10 million) of the total population (2.81 million) lives in towns with over 800 inhabitants (IBGE 1991).

In the 1970s and early 1980s fish represented the primary protein source for people in large Amazonian cities. Estimates of average per capita fish consumption of Manaus at this time varied from 102 g/day (Amoroso 1981) to 155 g (Shrimpton and Giugliano 1979). These figures represent fish consumption of between four and seven times the world average. The dominance of fish continues to prevail in the towns of the Upper Amazon, although in Manaus fish is declining in importance because of imports of cheap poultry and meat from Southern Brazil.

Rapid urban growth and dependence upon fish protein in the 1970s and 1980s created a demand for fish above that supplied by rural fishermen. The response was the development of commercial fishing fleets. Cheap credit and engines were easily available at the time, and the number of (inboard) motorized boats in the Amazonas interior increased from around 70 to 1,700 between 1970 and 1988 (Costa 1992). In 1995 the commercial fishing fleet of the Central Brazilian Amazon (encompassing the Amazon and its tributaries from Tabatinga, Amazonas, to Ilha Tupinambarana, Pará) comprised around 2,500 fishing vessels with inboard engines (Batista 1998).

Until the 1970s salting and the production of a fishmeal called *piracui* were the main preservation methods for fish. The wide scale introduction of ice not only shifted the market toward fresh fish but also allowed fishing to occur at much greater distances from port. The modern fleet of geleiras (boats with ice holds) can travel to fisheries hundreds of kilometers away. Várzea lakes were targeted from the onset due to the ease with which tambaqui (*Colossoma macropomum*), pirarucu, and other premium quality fish could be harvested using seine and gill nets. These techniques can be devastatingly indiscriminate, and the geleira crews often discard the lower-value species. The expansion of predatory commercial fishing practices throughout the várzeas of the Brazilian Amazon introduced not only unprecedented pressure on key commercial species but also a new era of conflicts over fishing rights with the local ribeirinho communities.

FISHERIES OF THE MODERN VÁRZEA

The commercial and subsistence fisheries of várzeas and adjacent whitewater river channels are multispecific, seasonal, and dependent on several types of equipment (Meschkat 1961; Batista 1998). They focus on three ecological categories of fishes:

- Resident várzea species spend their entire life cycle inside the várzea. They include pirarucu, aruanã (*Osteoglossum bicirrhosum*), tucunaré (*Cichla* spp.), many other cichlids, and some armored catfishes (Loricariidae) (Crampton 1999b).
- Migratory characiforms undertake most or at least the initial part of their growth phase in várzea floodplains and then disperse upstream to colonize whitewater and low-nutrient floodplain systems up to several hundred kilometers away. These fishes stay upstream and eventually spawn along the edge of whitewater river channels. Their juveniles are recruited into várzea floodplains adjacent to and downstream of the spawning sites (Goulding 1980). Commercial species with this type of complex migratory life history include tambaqui, pirapitinga (*Piaractus brachypomus*), pacus (Myleinae), curimatá (*Prochilodus nigricans*), jaraquis (*Semaprochilodus* spp.), aracus (Anostomidae), and the matrinchãs (*Brycon* spp.).
- Migratory catfishes of the family Pimelodidae (*peixe-liso*) undertake long-distance migrations up the Amazon's main whitewater rivers. At least two species, the dourada (*Brachyplatystoma flavicans*) and the piramutaba (*B. vaillantii*), migrate from the Amazon's estuary to headwater tributaries thousands of kilometers away (Barthem and Goulding 1997). Other species such as the surubim (*Pseudoplatystoma fasciatum*) and the caparari (*P. tigrinum*) are thought to undertake shorter migrations, but the distances involved are unknown (Goulding, Smith, and Mahar 1996).

The capture of characiform fishes and catfishes in the main river channels is undertaken on an almost completely commercial basis. Fishermen distinguish between the long-distance upstream movement of migratory characiform fishes, the *arribação*, the timing of which varies among species, and local spawning runs, the *piracema*, which occur during the rising water period. Piracemas usually involve movements out of whitewater or black/clear water floodplains into spawning grounds along whitewater river margins. Migrating characiform fishes are sold to

urban fish markets, while catfishes from the main rivers and their side branches (*paranás*) are mostly sold to *frigoríficos* (freezer storage plants) for export to Colombia, Southern Brazil, and Peru. Fishing within the floodplain is undertaken both by visiting professional fishermen and by ribeirinhos for subsistence and local sale. Falabella (1994) and Batista (1998) describe fishing methods in the Amazon, updating earlier accounts by Petrere (1978 a,b), Goulding (1979), and Smith (1979).

MODELS OF FISHING SUSTAINABILITY IN THE AMAZON VÁRZEA

Várzea floodplains, because of their relatively nutrient-rich waters and annual deposits of alluvium, are much more productive than the floodplains of nutrient-impoverished blackwaters and clearwaters (Schmidt 1973a,b; Fittkau et al. 1975; Schmidt 1976; Goulding, Carvalho, and Ferreira 1988; Henderson and Crampton 1997; Saint-Paul et al. 2000). Few studies have attempted to quantify the fish productivity of Amazon floodplains. Using carbon flow-analysis in várzeas near Manaus, Bayley (1989) estimated that around 1% of the carbon fixed annually by photosynthesis is assimilated by fishes, representing a total fish biomass production of between 174,000 and 523,000 kg/km^2/year. Bayley (1980) previously calculated a maximum fishing yield of 12,000 kg/km^2/year for the same area—around 17% of total annual fish production.

Bayley and Petrere (1989) reviewed potential yield estimates from tropical floodplains and concluded that a conservative sustainable yield of fish from typical whitewater floodplains is probably closer to 5,000 kg/km^2/year. This is within Welcomme's 1979 estimated range of sustainable tropical floodplain fish yields of from 4,000 to 6,000 kg/km^2/year. Quantitative estimates of actual yields for várzeas include 2,000 kg/km^2/year near Manaus in the late 1970s (Bayley and Petrere 1989) and 1,800 kg/km^2/year near Iquitos, Peru, in 1981 (Bayley et al. 1992).

The total area of whitewater floodplain in the Brazilian Amazon basin is an estimated 106,400 km^2 (Bayley and Petrere 1989). Assuming a minimum production of 4,000 kg/km^2/year, a per diem consumption of 100 g of fish biomass by the entire population, and a conservative estimate that half of this fish biomass is edible (Batista 1998), the whitewater várzeas of Brazilian territory should theoretically be able to provide 11.7 million people (almost the entire population of the Brazilian Amazon) with the World Health Organization recommended minimum daily protein requirement of 50 g.

However, fishing pressure is not evenly applied to standing fish biomass. Of the estimated 2,500 or more species of fishes in the Amazon basin (Val and Almeida-Val 1995), of which perhaps around 700 frequent várzeas, only a few dozen are eaten in appreciable quantities. Fewer than ten species provide more than three-quarters of the fish biomass extracted from várzeas by commercial fishing (Goulding 1979; Smith 1979b; Gerrits and Baas 1997; Barthem 1999a). Today's várzea fisheries are characterized by the overexploitation of a very small number of key species. There is no evidence of overexploitation for the majority of other species (Crampton and Viana 1999).

Goulding, Smith, and Mahar (1996) speculated that urban centers with more than 5,000 inhabitants account for more than three-quarters of the total fish consumption of the Amazon basin. However, Batista (1998) argues that, even though rural Amazonians are a minority, they eat so much more fish than urban Amazonians that they create a greater overall demand. Batista (1988) reported per capita/day fish consumption in several Amazonian towns: Manacapuru (34 to 104 g), Itacoatiara (160 g), Parintins (60 g), and Santarém (28 g). Batista (1998) and Cerdeira, Ruffino, and Isaac (1997) recorded per capita/day fish consumption of from 400 to 800 g in rural settlements or small towns (less than 5,000 people) in Pará and Amazonas. Batista's argument for a larger rural consumption of fish seems compelling when one considers the following calculations. In the states of Amazonas and Pará combined, 44% (4.01 million) of the total population (9.00 million) lives in rural settlements with fewer than 800 inhabitants (IBGE 2001). Assuming a maximum per capita daily consumption of 100 g for the urban population and a minimum per capita daily consumption of 400 g for the rural population, rural Amazonians consume at least 3.2 times more fish than urban Amazonians. Although commercial fishing fleets are driven by the demands of urban Amazonians, rural Amazonians seem to make the greatest demands on fish biomass. This overlooked consideration is important for the planning of fisheries. It implies, for example, that as much as two-thirds of the total fish landings of the Brazilian Amazon cannot be assessed or monitored using the standard method of monitoring market landings.

CONTEMPORARY STATUS OF FISH STOCKS

MAJOR SPECIES

Pirarucu was exploited throughout the colonial period as a substitute for sun-dried salted codfish. Records show a stable supply to Manaus and Belém from 1885 to 1920, with landings exceeding 1,000 tons/year (Fontenele 1948). Following the collapse of the rubber boom in the 1920s, many workers settled in várzeas and took to pirarucu fishing. Landings started to decline during the 1930s (Fontenele 1948), and by the late 1940s only around 300 tons/year were landed in Belém (Menezes 1951). Until the 1970s, pirarucus were mostly harpooned. Now, commercial fishermen employ gill nets, which are far more effective. Few quantitative data are available on the overall status of pirarucu in the Amazon basin, but two trends are clear. The first is that the size structure of pirarucu populations has changed over the last three decades in all but the most remote areas. Pirarucus up to 3 m long were once common but specimens over 2.5 m long are now rare. The second trend is that in some areas pirarucu have reportedly been depleted to the point of commercial extinction (Goulding, Smith, and Mahar 1996).

Tambaqui was once a staple food species. It accounted for around 50% of the to-

tal fish catch in the Manaus fish market during the 1970s (Goulding, Smith, and Mahar 1996) and was not considered overexploited until the mid-1980s (Petrere 1983). Merona and Bittencourt (1988) reported declining tambaqui landings in Manaus during the late 1980s. Today, large adults (over 70 cm) are rare throughout most of the Amazon, and the majority of marketed fish are undersized (Goulding, Smith, and Mahar 1996). Evidence for overexploitation of tambaqui has been reported around Tefé (Costa et al. 1999), Manaus (Ribeiro and Petrere 1990; Batista 1998), and Santarém (Isaac and Ruffino 1996).

Pimelodid catfishes are captured in huge numbers along the entire course of the Amazon, mostly for the frigorifico market. Pimelodid catfishes are usually captured during their upstream migrations. The piramutaba is the most important of all fish species exported from the Amazon basin since the 1970s (Goulding, Smith, and Mahar 1996). In the late 1970s 22,000 tons were landed annually in the Amazon estuary, of which three-quarters were exported. By 1990 the harvest had halved. Due to declining yields, the value of the harvest dropped from a peak of US$ 13 million in 1980 to around US $ 3 million in 1986 (Barthem and Petrere 1992). The dourada also appears to be overfished in the Amazon estuary, with the Belém market now dominated by juveniles (Goulding, Smith, and Mahar 1996). Goulding, Smith, and Mahar (1996) predicted that the industrial-scale exploitation of estuarine dourada and piramutaba populations would eventually precipitate a collapse of the inland fisheries of these species. Gerrits and Baas (1997) have already reported declining landings of piramutaba in the Óbidos area of Pará, some 600 km inland. On the basis of market landing data, Isaac, Ruffino, and McGrath (1998) reported overfishing of surubim and caparari in the lower Amazon region of Santarém. The status of other pimelodid catfishes is unknown.

OTHER MAJOR COMMERCIAL SPECIES

In terms of biomass the detritivorous curimatá and jaraquis (Prochilodontidae) are probably now the dominant food fishes in Amazon markets (Batista 1998; Barthem 1999a,b). There is, as yet, no firm evidence for overexploitation, although Batista (pers. comm.) has observed a reduction in jaraqui sizes at Manaus markets over the last decade. Detritus constitutes a major proportion of the biomass of Amazonian aquatic systems (Araujo-Lima et al. 1986; Bayley 1989), perhaps explaining the enormous productivity of these fishes. Likewise, the abundance of newly recruited fishes in várzeas means that the exclusively piscivorous tucunarés represent a direct trophic conversion of a vast but unmarketed protein resource. Goulding, Smith, and Mahar (1996) speculate that this explains the apparent resistance of tucunarés to intense fishing pressure. Several characiform fishes, such as matrinchãs, pacus, and the sardinhas (*Triportheus* spp.), are omnivorous, eating seeds, fruit, insects, and other fish in floodplain forests. The generalist nature of these fishes may account for their continued abundance, despite heavy fishing pressure.

MINOR SPECIES

In addition to the fish groups discussed above, some 150 other várzea fish species are eaten (Goulding 1979; Smith 1979b; Barthem 1999a; Crampton and Viana 1999; Crampton et al. this volume). Some of the previously less popular food species, such as piranhas (*Serrasalmus* and *Pygocentrus*), are now marketed in increasing quantities to compensate for shortages of other fishes.

MONITORING FISH LANDINGS

The assessment of fish stocks in the Amazon basin is based almost entirely on market landing data. The regional planning of várzea fisheries is limited by the paucity of such data. It is impossible to tell, for example, what the current total landings of fish are in the Brazilian Amazon. The markets of Manaus were monitored from 1976 to 1978 (Petrere 1978b), for a few years in the early 1980s (Merona and Bittencourt 1988), and then from 1993 to date (Batista 1998). Landing data have been collected at Tefé by the IDSM (Instituto de Desenvolvimento Sustentável Mamirauá) since 1992 (Barthem 1999a) and at Santarém since 1994 by Instituto Iara (Instituto Amazônico de Manejo Sustentável de Recursos Naturais, i.e., Amazon Institute for Sustainable Resource Management) (Ruffino, Isaac, and Milstein 1998; Ruffino 1999). Short-term landing data were collected in the late 1970s at Porto Velho (Goulding 1979) and Itacoatiara (Smith 1979b). Data from these studies and some governmental statistics from Manaus and Belém constitute just about all that is known about fish landings in the Brazilian Amazon.

Even the best market surveys are only partially informative about total landings. In the first place two-thirds or more of fish consumption may be on a subsistence basis (see above). Also, the trade in controlled species (such as pirarucu) and undersized or closed-season catches is usually diverted from public markets. Finally, the sale of large catfishes to frigorificos and the transport of fish to distant markets via passenger boats are notoriously hard to monitor. Despite these difficulties, landing data probably represent a more realistic means of assessing the (relative) status of stocks of Amazonian fishes than direct stock assessments from wild populations. Researchers from the University of Amazonas, the Federal University of Pará, the Mamirauá Sustainable Development Institute (IDSM), the Iara Institute, and Projeto Várzea in Santarém are joining forces with IBAMA to form a linked web of data collectors throughout the Brazilian Amazon.

ALTERNATIVE PROTEIN SUPPLIES

The management of wild fish stocks should continue to be a regional priority, but the protein demands of the Amazon's expanding population will inevitably need to be met by other forms of production. Cattle and water buffalo ranching are ecolog-

ically unacceptable forms of protein production in várzeas (Goulding, Smith, and Mahar 1996). Promising and more acceptable options are fish and poultry farming. Several species of Amazonian fishes, in particular pirarucu and tambaqui, respond well to domestication, and fish farming is now becoming lucrative business in the Amazon and in southern Brazil (Cerri 1995; Smith 1999). Cerri (1995) reports that farmed pirarucu and tambaqui can yield up to 4,560 kg/ha/year and 2,800 kg/ha/year respectively of marketable flesh. This compares very favorably with the production of water buffalo (225 kg/ha/year), cattle (203 kg/ha/year), and sheep (144 kg/ha/year) (Cerri 1995).

Chicken is cheaper than all premium quality fishes and represents a growing supply of animal protein in the Brazilian Amazon. Most is imported frozen from Southern Brazil, but the Amazonas State Livestock Development Institute, IDAM (Instituto de Desenvolvimento Agropecuário do Estado do Amazonas), is promoting poultry production in Amazonas state (E. Nunes de Sá, IDAM, pers. comm.). The captive production of Amazonian turtles is also expanding, and tagged and IBAMA-certified captive-raised turtles are now sold in some Manaus supermarkets. Smith (1999) describes other options for forest-friendly livestock production, including pigs, ducks, and such domesticated game as capybara (see Nogueira-Filho and Nogueira, this volume).

ACCESS RIGHTS AND FISHERIES LEGISLATION IN THE VÁRZEA

All seasonally flooded land in the Brazilian Amazon is owned by the state. In fact, the semiaquatic nature of várzea places it under the juridical responsibility of the Brazilian Navy. Although the state can concede rights of use to individuals or companies, as it has done in some parts of Pará, várzeas cannot be privately owned (McGrath et al. 1999). Many ranchers and ribeirinhos in várzeas of the lower Amazon hold title deeds that routinely change hands, but these documents have no legal standing. The poorly defined status of land tenure is a major barrier to defining management plans for várzea fisheries.

The formulation and enforcement of inland fisheries legislation in Brazil is the direct responsibility of IBAMA. By law, fishermen are permitted unrestricted access to all waterways under the control of the state (i.e., all várzeas) except those within reserves and national parks. Streams and ponds in the terra firme surrounded by private land are recognized as private property but do not support substantial fisheries.

RESTRICTIVE REGULATIONS

IBAMA policy for inland fisheries regulation is based on a series of legally binding restrictions on fishing activities. The early framework was devised in the late 1960s and covers restrictions on equipment, minimum sizes, and closed seasons. These restrictions were based on fisheries research from southern Brazil and in many cases were inappropriate for Amazonian waters (Isaac, Rocha, and Mota 1993). Closed seasons for pirarucu (fig. 6.1), however, were based on regional studies. Three categories of fishing were defined by this early legislation: commercial, scientific, and sport fishing (although not, to universal surprise, subsistence) (Fischer, Chagas, and Dornelles 1992). In recent years there have been extensive modifications and additions to the laws, including minimum size limits, closed seasons for additional species, and a list of 175 fish species that can be legally exported for the aquarium

FIGURE 6.1 1995 IBAMA notice posted in ports and fish markets to remind fishermen of the closed season (defeso) for pirarucu (above) and tambaqui (below).

trade (IBAMA 1996). Some IBAMA regulations are highly restrictive. On the grounds that pirarucu had reached an "advanced stage of over-exploitation," IBAMA-Amazonas declared a statewide ban on the capture and commercialization of pirarucu in 1996. This ban has been extended without interruption and was still in effect as of July 2002.

An important law in 1994 recognized the authority and competence of regional IBAMA superintendents to enact temporary fishing regulations or closed seasons of up to two months in response to information concerning overexploitation. For instance, a 1997 decree introduced measures to control the total number of commercial fishing boats in Lake Tefé, Amazonas (L. McCulloch, IBAMA, pers. comm.). The devolution of decisions to the heads of regional IBAMA posts is part of a trend toward combating local problems through tactical response rather than a fixed global strategy. Nonetheless, each decision must still be codified as a formal decree (*portaria*) and published in the government's official gazette (*Díario Oficial*) before it can be enacted. These decrees can be subject to long delays, and it is not unknown for them to disappear in a sea of paperwork.

Another advance in IBAMA policy is the recognition of the potential of lake-protection schemes set up by ribeirinhos. Many fishing accords developed by communities around the Amazon have been granted legal backing by IBAMA decrees. IBAMA posts encourage communities to submit management plans prepared by regional fishing councils (Conselhos Regionais de Pesca). Proposals that make provisions for reconciling rights of access with commercial fishermen are supposedly favored. Nonetheless, IBAMA-supported lake-protection schemes are unpopular with commercial fishermen. They argue that IBAMA is awarding privileges to communities, marginalizing professional fishermen, and ignoring the question of how both parties could benefit from joint management (Batista 1998).

THE CHALLENGES OF ENFORCEMENT

Many of IBAMA's restrictive regulations are believed to be both unrealistic and based on insufficient research. Isaac, Rocha, and Mota (1993) provide a critique of the main problems of contemporary fisheries regulations. One recurring criticism refers to the protection of fish during their migrations, when in fact they are often more vulnerable during the lowest water period (Goulding, Smith, and Mahar 1996). Moreover, IBAMA is unable to enforce most of the wide range of measures intended to control fishing in the Brazilian Amazon. IBAMA posts are widely spaced, underfunded, and operated by staffs that are historically undermotivated. Consequently, most of the Amazon basin receives only superficial vigilance (Goulding, Smith, and Mahar 1996; Isaac, Ruffino, and McGrath 1998; Ruffino, Silva, and Castro 1998b; Crampton and Viana 1999; McGrath et al. 1999). Manifestations of IBAMA's failure to enforce regulations include the continued trade in pirarucu following its 1996 suspension in Amazonas and the ubiquitous marketing of undersized tambaqui.

IBAMA REFORM

In response to the difficulties discussed above, IBAMA is currently undergoing considerable reform, including the employment of a new generation of staff (Anon. 2000) and the aforementioned devolution of management decisions to regional offices. One of IBAMA's most innovative recent initiatives is the training of Voluntary Environmental Agents (AAVs), who are expected to complement the activities of IBAMA's field agents and to take responsibility for environmental education in local schools and village meetings (Crampton et al. this volume). IBAMA has also for some time been contemplating the potential for schemes of integrated fisheries management that operate at a regional level (Fischer, Chagas, and Dornelles 1992). The IBAMA-supported Instituto Iara in várzeas near Santarém, Pará, was the first working example of this kind of scheme (Ruffino 1999) and is described later.

These initiatives typify IBAMA's general trend toward decentralized administration and comanagement with the public sector. A seminal internal report (IBAMA 1997) conceded that resource management in the Amazon cannot be resolved through the straightforward enforcement of rules (instructive management). Instead, IBAMA instigated a policy of forging new institutional cooperation and consultation with a wide range of stakeholders (consultative management), such as municipal authorities, fishing and extractive syndicates, environmental NGOs, research institutes, and universities.

COMMUNITY-BASED FISHERY MANAGEMENT

MANAGEMENT PROCEDURES

Várzea communities have practiced basic fishery management techniques for at least the last four decades (Lima 1999). Lakes are usually divided informally into protection, subsistence, and commercialization categories, with the latter often located further away from the community. Subsistence lakes are managed with frequent, low-intensity harvesting and selective fishing techniques. Commercialization lakes are fished infrequently but intensively with less selective techniques (such as. gill netting) and are often left for a period of fallow before being refished. Studies have demonstrated that fish production of várzea lakes increases under community management schemes (IPAM 2000a). McGrath, Castro, and Futemma (1994) demonstrated that a várzea lake near Santarém under community management produced up to double the yield of an unmanaged lake for some commercial species. Crampton et al. (this volume) and Viana et al. (this volume) describe community lake-management schemes in the Mamirauá Sustainable Development Reserve, RDSM (Reserva de Desenvolvimento Sustentável Mamirauá).

Floodplain communities regard commercialization and protection lakes as economic security. During times of difficulty, for example when crops fail due to an unusually protracted flood, the bumper yields of commercialization lakes can pro-

vide much needed cash. For the same reasons many families in the várzea like to keep a few head of cattle that can be sold in times of difficulty.

MIGRATORY FISH STOCKS: MANAGEMENT DIFFICULTIES

The migratory life history of many characiform fishes means that their recruitment in any given várzea is primarily a function of exploitation conditions elsewhere. Species like tambaqui are therefore less amenable to in situ management than are resident species like pirarucu. Ribeirinho communities make no attempt to protect or manage the migratory pimelodid catfish stocks of whitewater rivers. The main channels of the Amazon are considered by ribeirinhos to be free for all. Moreover, local management would have negligible effects on their stocks.

CONFLICTS AND VIGILANCE

In the early 1980s campaigns for the defense of community lakes sprung up in várzeas along the Amazon basin. This came chiefly as a response to the growth of predatory fishing by commercial fleets. The early stages involved assistance from the Catholic Church through its Pastoral Land Commission, the Comissão Pastoral de Terra (CPT), and provided some empowerment for communities to expel commercial fishermen (CPT 1992; Lima 1999; McGrath et al. 1999). Around this time villages began to use the term *comunidade* (community) with hierarchical levels of organization and a village committee. These early lake-protection schemes met with some success, but the campaigns were blighted by intercommunity disputes, the weak legal status of várzea residency, and transport or communication difficulties. Moreover, government authorities never endorsed these early lake-protection schemes.

ECOLOGICAL PARTNERSHIPS

Escalating concern about environmental degradation and inequitable development stimulated a recent increase in the number of Brazilian and international conservation-oriented NGOs operating in the Brazilian Amazon. At the same time the growing recognition of the importance of involving local people in biodiversity conservation has encouraged many conservation and development projects to forge partnerships with previously existing social movements (Lima 1999). These alliances can greatly strengthen self-motivated movements by providing the funding, the legal support, and the technical cooperation necessary to formulate management plans, enhance production efficiency, or pursue alternative economic activities. Many ecological partnerships involve programs of environmental education, which seek to increase the general ecological awareness of rural people (Hall 1997). Environmental education programs usually also work with government educational authorities to improve basic educational standards. Illiteracy and innumeracy are perhaps the greatest constraints to the economic independence and self-confidence of rural people.

Many conservation alliances between local people of the Brazilian Amazon and either NGOs or government agencies concentrate on extractive forest products or timber and are based in areas where fishing is not a major economic activity (Lima 1999). There are currently only three projects in the Brazilian várzea that are based on community participation and that have a substantial fisheries component.

PROJETO VÁRZEA

Located at Santarém, Projeto Várzea promotes the sustainable exploitation of fisheries and other natural resources in várzeas of the Middle Amazon (fig. 6.2). This project is run by the (nongovernmental) Institute for Amazonian Environmental Research, IPAM (Instituto de Pesquisa Ambiental da Amazônia), in partnership with local communities and other stakeholders in the Santarém region. The project lists six goals (IPAM 2000b): to develop and strengthen community lake-management programs, to diversify the management strategies of várzea communities, to develop a program of environmental education, to study economic and ecological trends in the fisheries sector, to develop regional fisheries policies, and to provide management and marketing training to local fisheries organizations.

Projeto Várzea is working with várzea communities and the commercial fishing syndicate of Santarém to consolidate a framework for rights of access and regional

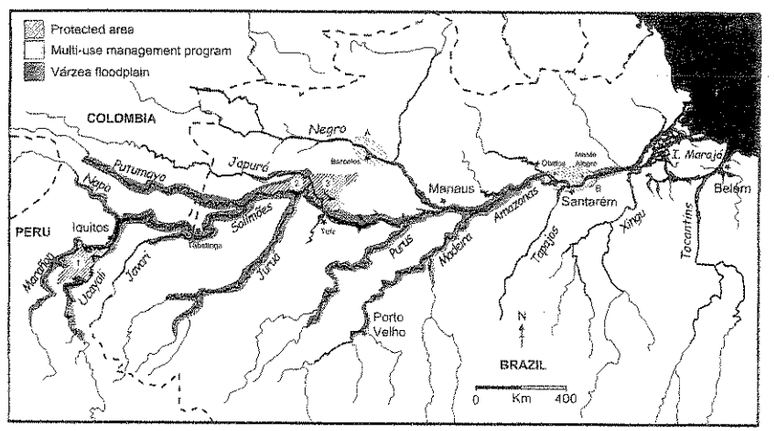

FIGURE 6.2 Location of major fisheries conservation and management programs in the Amazon basin: Pacaya-Samiria National Reserve, Loreto, Peru (1); Mamirauá Sustainable Development Reserve (2); Amanã Sustainable Development Reserve (3); ornamental fish catching initiatives directed by Projeto Piaba (A); and multiple-use fishery management initiatives directed by Projeto Várzea and Instituto Iara (B).

fisheries management. It is also working with communities to promote agricultural activities that reduce the destruction of levee forest and floating meadows and to restore floating meadows damaged by buffalo and cattle ranching (M. Crossa, Projeto Várzea pers. comm.). McGrath, Castro, and Futemma (1994) and McGrath et al. (1994, 1999) review the fisheries management activities at Projeto Várzea.

INSTITUTO IARA

Also based at Santarém, Instituto Iara (previously Projeto Iara) is responsible for the administration of fisheries resources in the Middle Amazon. The Institute's acronym, Iara, is a mythical nymphlike apparition in Amazonian folklore (Smith 1996). Since 1996 Instituto Iara has been "developing, testing and consolidating institutional measures for the sustainable use of fisheries resources in the Middle Amazon that are compatible with the interests and needs of local populations and of the regional and national economy and society" (IBAMA 2000). Instituto Iara is based on technical and financial cooperation between IBAMA and the German technical cooperation agency, GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit). It also involves cooperation with several Brazilian academic institutions. Through a multidisciplinary program of research, training, environmental education, and monitoring, Instituto Iara is working closely with the full spectrum of stakeholders involved in fishing in the Middle Amazon region to define rights of access to fisheries resources and to develop management plans for sustainable use. The training of Voluntary Environmental Agents from local communities and from Santarém's fishing cooperative (Colônia de Pescadores-Z20) forms an important part of these initiatives. Instituto Iara's sphere of influence affects around 250,000 people living in várzeas along a 200-km stretch of the Rio Amazonas between Óbidos and Monte Alegre (fig. 6.2) (M. Ruffino, Instituto Iara, pers. comm.). Many of the activities and results of Projeto Iara are described by Fischer (1995) and Ruffino (1999).

THE MAMIRAUÁ AND AMANÃ SUSTAINABLE DEVELOPMENT RESERVES (RDSM/RDSA)

The RDSM is an 11,240-km^2 area of várzea located at the confluence of the Rios Solimões and Japurá. This Reserve was originally established in 1990 and was given Sustainable Development Reserve (SDR) status in 1996. Here, local people in partnership with the Mamirauá Sustainable Development Institute (IDSM) are mounting an integrated sustainable resource use program. Crampton et al. (this volume) and Viana et al. (this volume) provide a detailed overview of fisheries management in the RDSM. This reserve constituted the first of a new category of Brazilian conservation unit that permits the presence of traditional peoples and allows them exclusive rights of access to the natural resources of the area. In 1999 a second SDR, the 23,500-km^2 Amanã Sustainable Development Reserve (RDSA) was inaugurated (fig. 6.2). This reserve is also administered by IDSM and was established to form a contiguous corridor between the RDSM and the Jaú National Park on the west bank of the Rio Negro. Fisheries management in the RDSA is planned for the future and will follow the RDSM model.

OTHER PROJECTS

The only major conservation and development projects in a várzea floodplain outside Brazilian territory are being developed in the Reserva Nacional Pacaya-Samiria in Peru (see Tello this volume). This 21,508-km^2 state-administrated reserve located at the confluence of the Rios Ucayali and Marañon (fig. 6.2) has an active fisheries management program built around community participation and a multiple-use zoning system (COREPASA 1986; Bayley et al. 1992; Durand and McCaffrey 1999).

One other fisheries-dominated project in the Brazilian Amazon deserves a mention although it is not based in várzea floodplains. Projeto Piaba is based in the town of Barcelos on the blackwater Rio Negro (fig. 6.2) and has investigated the biological and economic sustainability of ornamental fish catching in the area (Chao et al. 2001). The ornamental fish trade involves around 1,600 part-time fishermen in the area and contributes to more than 60% of the economy of the municipality of Barcelos. Commercial food fishing is relatively unimportant in the nutrient-poor blackwaters of the middle Rio Negro. Chao et al. (2001) concluded that current extraction levels of ornamental fishes, including the heavily exploited cardinal tetra (*Paracheirodon axelrodi*), are sustainable. They argue that the trade encourages habitat conservation and contributes positively to local economies and livelihoods. In addition to research Projeto Piaba is developing a program to improve the production and marketing efficiency of rural fishermen.

HABITAT CONSERVATION

Several authorities on Amazonian conservation have stressed that habitat loss through the deforestation of floodplains and river margins or through the construction of hydroelectric dams has a far more devastating and irreversible effect on fish stocks and diversity than does overfishing (Goulding 1983; Leite 1991; Ribeiro, Petrere, and Juras 1995). The two most important fish habitats in the várzea are seasonally flooded forests (Goulding 1980) and floating meadows (Junk 1973, 1983; Crampton 1999b; Henderson and Crampton 1997). Both provide seasonal refuge and sustenance for a huge diversity of fishes. The meadows have an especially important role as nurseries for juveniles of many commercially important species (Crampton 1999b). Of the various types of forest in várzea floodplains (Prance 1979; Ayres 1993) the tall restinga forests found on the higher levees host the highest terrestrial and arboreal biodiversity and provide much of the sustenance for commercially important fruit- and seed-eating fishes, such as tambaqui and pacu (Goulding 1980).

The destruction of levee forest by ranching, agriculture, and predatory logging,

as well as the trampling and grazing of floating meadows by livestock, have detrimental effects not just on overall biodiversity of várzeas but also on fisheries production (Goulding, Smith, and Mahar 1996). Although any commercial fishermen in the Amazon will tell you that degraded várzeas offer poor fishing for key commercial species in comparison to intact ones, there is little quantitative data to substantiate this. Ruffino and Isaac (2000) report average catch per unit effort (CPUE) estimates of around 10 to 20 kg/fisherman/day in the Santarém area. Batista (pers.comm.) reports around 20 kg/fisherman/day in the Manaus area. Viana (pers. obs.), on the other hand, estimates that the average CPUE in the Tefé region is from 50 to 80 kg/fisherman/day. The extent to which these discrepancies reflect the diminished and fragmented forest cover in the lower reaches of the Amazon (Santarém and Manaus) versus higher fishing pressure is unknown.

DISCUSSION

Fisheries management in the Brazilian várzea has polarized toward two approaches: state (IBAMA)-imposed restrictive regulations at one end of the spectrum and self-motivated community lake-management programs at the other. The first of these approaches is not working. Like fisheries agencies around the world, IBAMA is unable to adequately enforce its regulations. The second approach, community management, is often extolled as a miracle solution. However, proponents of community management place a great deal of faith in the abilities of rural people to manage and defend resources. We argue that community management is unlikely to work unless five provisos are satisfied:

1. A single group of users is awarded guaranteed rights of access.
2. There are strong economic incentives for defending and managing fish stocks.
3. The users have a general ecological awareness and understand the concepts of resource depletion and management.
4. Management is based on sound scientific grounds and/or traditional ecological knowledge.
5. There are concerted efforts to preserve the intricate mosaic of flooded forests and floating meadows upon which many várzea fish depend.

A worldwide analysis of community-based management programs by Barret et al. (2001) concluded that the capacity of communities to manage resources has been overemphasized and that the success of these programs rarely matches the fanfare. Without financial, legal, and scientific support, local fishing communities are unlikely to be able to satisfy the five provisos above. Alliances between self-motivated social movements and conservation/development-oriented external agencies (governmental or nongovernmental) probably represent the most promising direction for fisheries management in várzeas.

Of the three such alliances with a strong várzea fisheries component currently being developed in the Brazilian Amazon, all approach the challenges of manage-

ment in different ways. The RDSM is the only one to undertake fisheries management in the context of a protected area in which local people enjoy legally binding rights of access. Projeto Várzea and Instituto Iara operate in the normal context of state-owned várzea. These three projects also differ in their emphasis on habitat conservation, geographical coverage, and the extent to which the interests of the entire spectrum of stakeholders are included.

HABITAT CONSERVATION

The long-term health of várzea fisheries is ultimately dependent upon the conservation of relatively intact forests and floating meadows. The RDSM is unique in prioritizing habitat protection. The reserve effectively compensates for a closed zone of complete biodiversity protection by offering local people a surrounding sustainable use zone. Here, integrated fisheries and forest management, along with a package of economic incentives, promote sustainable exploitation and encourage economically favorable alternatives to such destructive land use as livestock ranching (Crampton et al. this volume; Viana et al. this volume). The RDSM contains a considerable proportion of Brazil's remaining areas of relatively intact várzea floodplain habitats. Assuming two-thirds of the estimated 106,000 km^2 of Brazilian várzeas (Bayley and Petrere 1989) have already been severely degraded (Alexander 1994), around 32% of the remaining, relatively intact area lies within the RDSM, including its Subsidiary Area (7% within the Focal Area alone).

Instituto Iara is solely concerned with fisheries management. It focuses on the important issues of access rights and market incentives but does not directly address habitat preservation. Projeto Várzea is attempting to promote sustainable forest management and to encourage forms of livestock production and agriculture that are less damaging to várzea habitats. However, it does not emphasize the need for completely protected areas of forest. In fact, there are very few undamaged forests left to protect in the lower Amazon region, making habitat restoration, rather than conservation, the main concern.

GEOGRAPHICAL COVERAGE

Fisheries projects operating on a regional scale are arguably better suited to the management of migratory fish stocks and better prepared for managing the full range of economic concerns and conflicts that decide the fate of management. Instituto Iara is the most expansive fisheries project in Brazil, operating over a 200-km stretch of the axis of the Rio Amazonas and encompassing around 3,000 km^2 of várzea. This initiative was originally projected to affect around 600,000 people in an area extending from Itacoatiara in Amazonas downstream 1,000 km to Almeirim in Pará. However, this area was subsequently considered to be too large to be effectively managed with available resources. Likewise, because of logistic difficulties and funding limitations, management activities in the 11,240-km^2 RDSM have

been restricted to an area of 2,600 km^2. The difficulties the Mamirauá and Iara initiatives have experienced in expanding the geographical scale of their operations indicates that single fisheries management programs are unlikely to be effective over areas much larger than 3,000 km^2 unless they are spectacularly well funded.

STAKEHOLDER INCLUSION

Due to their larger, regional nature, both Instituto Iara and Projeto Várzea seek to reconcile the needs of both várzea residents and commercial fishermen. These projects provide a forum for negotiating mutually acceptable divisions of fishing rights and provide technical cooperation for the production of management plans. For example, the commercial fishing syndicate of Santarém contains many associates who are from the communities of the surrounding várzeas, allowing a balanced forum for discussing fishing agreements and a consolidated front for excluding fishermen from outside the region (e.g., from Belém). Likewise, IBAMA's training program for Voluntary Environmental Agents is providing training for community representatives from both local communities and the urban fishing fleet (M. Ruffino pers. comm.).

In the Upper Amazon region of Tefé, there has always been a much greater separation between várzea fishing communities and the urban fishing fleets of the local towns (Lima 1992). This separation is probably in part a historical consequence of the fact that the rural population of the state of Amazonas is smaller and younger than that of Pará. The rural fishermen of the lower Amazon have for some time been a more forceful political force and have developed a more integrated and mutually beneficial relationship with commercial fishermen.

The fishermen of the RDSM are especially divergent in organization and interests from the nearby urban fishing syndicate of Tefé. Under the area's legal status as an SDR, the resident and user communities are awarded exclusive rights of access to the natural resources of the region. The RDSM is criticized by commercial fishermen from Tefé for providing access rights to 6,000 ribeirinhos while at the same time restricting access rights to almost everybody else in the area. The situation was aggravated by the demarcation of the Amanã Sustainable Development Reserve, which contains large areas of várzea to the east of the RDSM (fig. 6.2). With the formal closure of both the RDSM and RDSA, the Tefé commercial fishing syndicate argues that it has been left with almost no viable fishing grounds. Likewise, ribeirinhos in the remaining unprotected várzeas of the Tefé region are indignant that their lakes are now under much greater pressure.

Anticipating the necessity to concede some access rights to the commercial fishing syndicate of Tefé, the reserve's 1996 management plan made provisions for communities to concede temporary access rights to some lakes for visiting commercial fishermen. However, most communities of the reserve subsequently opted not to provide such concessions (see Crampton et al. this volume). This deadlock has provoked serious debate. How can the managers of a protected area justify developing one part of a regional rural economy at the expense of another?

Protected Areas Act as Fish Supply Areas and Restocking Nuclei The Mamirauá Sustainable Development Institute has argued that managed fisheries and the protection of core no-use zones in the RDSM should, in time, guarantee not only a permanent supply of reasonably priced premium quality fish for the urban markets of the region but also generate surplus stock that will replenish surrounding fisheries (Queiroz and Crampton 1999a). Skeptics argue that there is no evidence that protected areas have the capacity to generate surplus stock and that local communities are in any case likely to maximize harvesting for their own gain. The reluctance of the residents of the RDSM to negotiate fishing concessions with commercial fishermen no doubt fuels this skepticism. So far there is no scientific evidence that the RDSM (or any other protected fishing ground in the Amazon) is restocking adjacent areas. There is evidence, however, for significant increases in the stocks of pirarucu, tambaqui, and caiman in the core protection zone of the RDSM (Crampton et al. this volume; Viana et al. this volume).

The Value of Intact Biodiversity Intact várzea floodplains are among the most diverse and yet threatened ecosystems on earth. The human population is rapidly growing in the Upper Amazon regions where most of the remaining intact várzeas are located (Cincotta, Wisnewksi, and Engelman 2000). Some proponents of biodiversity conservation argue that the economic marginalization of some stakeholders through lost rights of access to protected areas like the RDSM is an unfortunate but necessary price paid by societies that place value on conserving their ecological and genetic heritage (Pimm et al. 2001).

CONCLUSION

Fisheries management is conventionally about providing people with a sustainable supply of fish protein. However, in the Amazon basin the issues are complicated by the multiple interfaces between fish stocks, habitats, and livelihoods. Fisheries managers in the Amazon are concerned with habitat preservation, with sustainable use and development, and with resolving social conflicts.

Of the three contemporary community-based fisheries management models described in this article, all are experimental in nature. They are also young, and results indicating their successes and failures are only just emerging. These three models all have attendant theoretical merits and shortcomings, and strategies for the management of várzea fisheries will in the future probably need to incorporate features of all three. For example, protected areas like the RDSM may in the future need to concede larger areas of várzea for access to outside commercial fishing fleets. Likewise, some areas of the regional fishing grounds in the middle Amazon region may need to include zones of protection. We argue that an increase in the number of fisheries management initiatives would be more effective than expanding the geographical range of existing reserves or multiple-use management programs to much more than around 3,000 km^2, which seems to be about the upper limit for effective administration.

Goulding, Smith, and Mahar (1996) proposed a chain of reserves for "fish forests" and "fish meadows" along the axis of the Amazon River and an integrated regional management program. We envisage a similar model that combines features of contemporary fisheries management schemes by including multi-use regional fisheries management programs and Sustainable Development Reserves, which would need to be arranged in a constellation along the major whitewater rivers of the Amazon (Amazon, Juruá, Purus, Madeira, etc.). Each initiative could be independently managed but coordinated within an overall scheme for national fisheries management within Brazil and Peru (and internationally between the two countries). The administration of such a chain of fishery management initiatives would need to involve the entire spectrum of stakeholders, including communities, businesses, the environmental authorities, commercial fishing syndicates, conservation organizations, and research institutions. Institutional cooperation between the Amazonian countries of Brazil, Peru, Bolivia, Colombia, and Ecuador would also be necessary to formulate management plans for the some migratory catfishes.

Finally, a word of warning: in the drive to establish integrated, socially appropriate models of management, it is important not to forget the biology of the fish. Scientific studies are still needed to define the migratory ranges of commercially important characiform fishes and catfishes, as well as the minimum size of single blocks of várzea necessary to sustain viable populations of commercial fish species.

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Fisheries Management in the Mamirauá Sustainable Development Reserve

WILLIAM G. R. CRAMPTON, JOÃO PAULO VIANA, LEANDRO CASTELLO, AND JOSÉ MARÍA B. DAMASCENO

Fisheries management in the Brazilian Amazon has polarized toward state-imposed regulations at one extreme and community-based management at the other (Crampton, Castello, and Viana this volume). At present there is no overall government fisheries conservation policy for Amazônia, and existing state fisheries restrictions are almost completely ineffective (Hall 1997; Crampton and Viana 1999). Since the 1970s fishing has become an increasingly important source of income for the ribeirinho people of the whitewater várzea floodplain and a growing number of várzea communities have set up lake reserves (reservas de lagos de várzea) to manage fish stocks and to guard them from predatory fishing by the commercial fleets of major towns. The Pastoral Land Commission, Comissão Pastoral da Terra (CPT), of the Catholic Church supported many of these initiatives and reports that up to 15% of all major lakes in Amazonas are inside such reserves (Hall 1997). These self-motivated lake-vigilance schemes met with only limited success due to political weakness, poor infrastructure, and lack of recognition by the state authorities (Hall 1997; Lima 1999). Alliances between local social movements and state or nongovernmental organizations can greatly strengthen the former by providing funding, training, and technical or legal support. These kinds of alliances represent one of the most promising directions for the management of Amazonian fisheries (McGrath et al. 1999; Ruffino 1999; Crampton, Castello, and Viana this volume).

At present, three partnerships between NGOs and local people of Brazilian várzeas involve a substantial fishery component. Projeto Várzea and the Iara Institute (Instituto Amazônico de Manejo Sustentável dos Recursos Naturais) are two multidisciplinary projects designed to promote sustainable fishing at the regional level in the state of Pará (Crampton, Castello, and Viana this volume). These projects seek to reconcile the needs of várzea communities, commercial fishermen,