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The Impact of Cultural and Ecological Change on Amazonian Fisheries

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ABSTRACT

Fish have long provided an important item in the diet of Amazonians, but ecological and cultural changes threaten the long-term productivity of aquatic ecosystems. Population growth, the opening of extra-regional markets and the introduction of new or improved technologies, have increased pressure on fisheries of Amazonia, the world's largest freshwater catchment. Habitat destruction due to agricultural expansion and development projects also threatens to undermine fishing yields. Modern conservation practices, such as the establishment of parks and reserves and the enactment of protective legislation, are only gaining a tentative foothold in the region.

INTRODUCTION

The 7 million km^2 Amazon basin contains the most intricate and voluminous network of waterways in the world (Fig. 1). Depending on the season, the Amazon discharges between one fifth and one quarter of the world's freshwater. The numerous rivers and streams of Amazonia flow across a wide assortment of soils and plant communities, thereby opening up an abundance of niches. Lakes, waterfalls, rapids, sluggish channels and shaded streams provide habitats for close to 2000 fish species.

Hydrochemistry and paleoecology are also responsible for the rich diversity of fish in the Amazon basin. Water colour ranges from the

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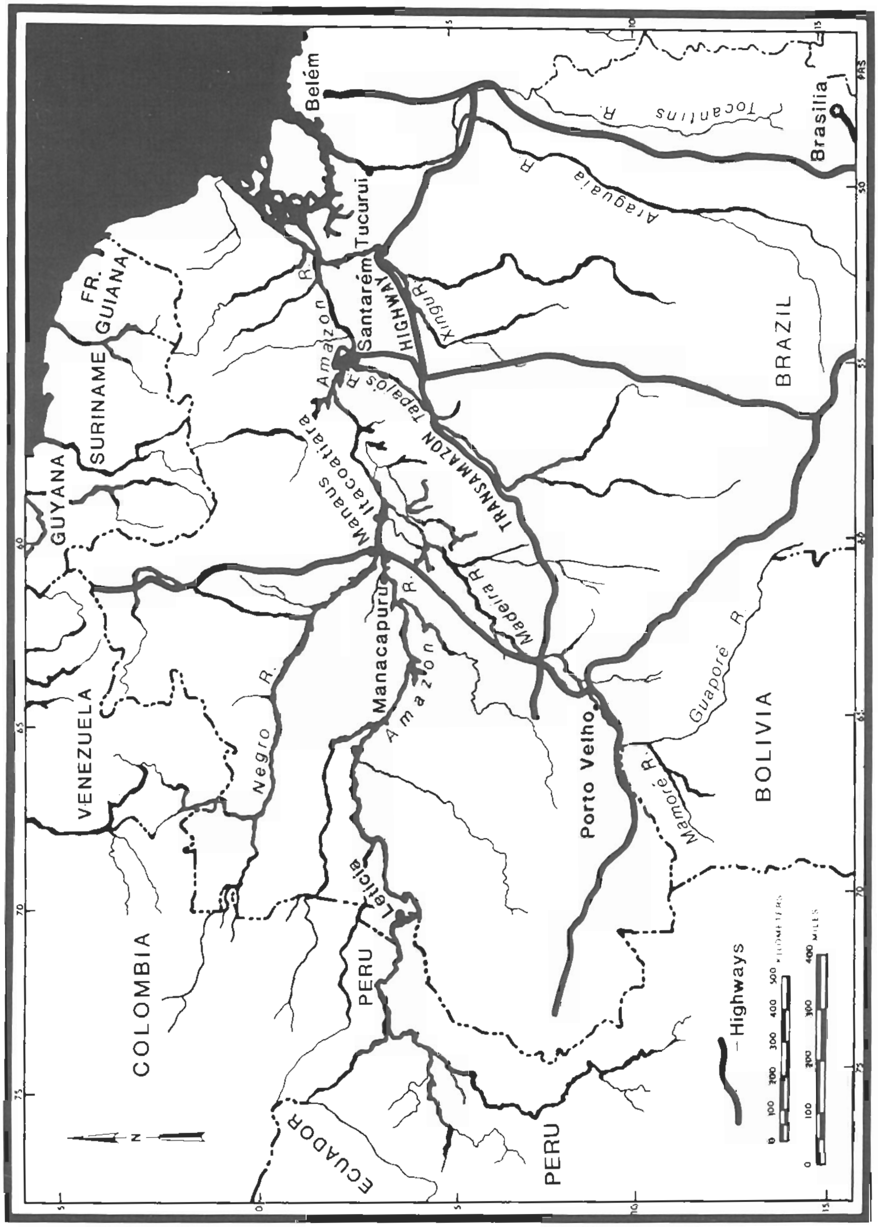

Fig. 1. The Amazon basin with selected urban centres and highways.

creamed-coffee complexion of white water rivers, such as the Amazon and twisting Purus, to clear rivers, such as the Tapajós, and black rivers, best typified by the Negro (Sioli, 1975*a*, *b*; Sternberg, 1975). Geology, soils, geomorphology, climate and vegetation largely determine the appearance and chemical qualities of Amazonian waters. The spectrum thus ranges from black to white, whereas some rivers change colour seasonally (Goulding, 1981). White water rivers pick up much of their characteristically heavy sediment loads from the Andes where erosion is active and volcanic soils provide nutrients for primary production. The relatively broad floodplains of white water rivers embrace numerous lakes and side channels, further favouring the development of sizeable fish populations. Clear and black water rivers, on the other hand, contain fewer nutrients and are more acid; fish biomass is thus generally lower. This mosaic of water types has fostered speciation; some fishes are restricted to a particular water type, whereas others thrive in a range of aquatic environments. Year-round warm temperatures and a history of wet and dry climatic cycles that isolated fish populations have also led to the proliferation of species.

The Amazon basin contains nearly four times as many fish species as the Congo and about ten times as many as the Mississippi (Roberts, 1972). In one lake near the confluence of the Amazon and Negro, at least 200 species have been found (Agassiz, 1874). Approximately 100 different fishes are eaten by people living within a 60 km radius of Itacoatiara, a Brazilian town of about 30 000 on the left bank of the Amazon (Smith, 1981*a*). Amazonians consume roughly 400 kinds of fish, four times the number found in the freshwaters of Argentina.

Fish availability has greatly influenced settlement and livelihood patterns in Amazonia. People have historically concentrated along rivers, especially the white water ones, to take advantage of the abundance of fish, turtles and manatees (Smith, 1979). Hunters and gatherers penetrated the region tens of thousands of years ago and congregated along floodplains, particularly during the dry season, to harvest fish trapped in shrinking lakes and constricted channels. Later, farmers also settled mostly along rivers to crop fertile alluvial soils as well as to capture fish.

Fish have long provided an important item in the regional diet (Lathrap, 1968, 1972; Veríssimo, 1970; Meggers, 1971; Denevan, 1976). Fish are harder to catch during high water because they are more dispersed; catches were thus often sun-dried for later consumption.

Orellana's expedition down the Amazon in 1542, for example, encountered a village near the mouth of the Madeira with an impressive quantity of fish placed out to dry (Medina, 1934). Fish are still dried today, particularly pirarucu *Arapaima gigas*, which is also salted. Formerly, a powdery meal was prepared from dried fish for use in soups and stews, but this practice is now much less common. Boiled, roasted and fried fish remains a staple in the regional diet; in Manaus, a rapidly-expanding city of 700 000 on the left bank of the Negro, fish accounts for a third of protein intake and the proportion would be higher without wheat subsidies (Shrimpton & Giugliano, 1979). Poor people, who comprise the majority of the population, depend heavily on fish for high quality protein since it is cheaper than beef, chicken, or pork (Amoroso, 1981).

The historical prominence of fish in the regional diet is currently threatened by cultural and ecological change. Five main forces are undercutting the long-term productivity of the region's fisheries: unprecedented population growth, the opening of extra-regional markets, new technologies, habitat destruction and the breakdown of cultural checks to over-exploitation.

POPULATION PRESSURE

For a long time after contact with Europeans, the regional population plummeted, due mainly to the introduction of Old World diseases that devastated aborigines. Around 1500, Amazonia may have contained as many as 6·8 million inhabitants, but the population dipped dramatically soon after the arrival of Portuguese, Spanish and Dutch settlers (Denevan, 1976; Smith, 1980). For over 400 years, harvesting pressure on fisheries abated as Indians died out or withdrew to headwaters or interfluvial forest. Between 1900 and 1957, for example, 87 of Brazil's 230 tribes, most of them in the Amazon region, became extinct (Ribeiro, 1970).

During the colonial period, certain aquatic animals, such as turtles *Podocnemis* spp. and the Amazon manatee *Trichechus inunguis*, were heavily exploited for oil, fat and hides, but fishing pressure generally slackened after contact. Only in the late 1800s and in this century have fish been heavily harvested again. The population of the Brazilian Amazon, for example, stood at only 90 000 in 1800 and 695 000 in 1900, but by 1980 it had reached 5·9 million (Bunker, 1980; IBGE, 1981). Only in the last few decades has the region's population regained the level of 1500. The main difference now is that the population is much more urbanized and wastage is greater; catches deteriorate on the way to market because ice melts and fish spoil waiting to be sold. Also, some fishermen discard catches in order to capture more lucrative species if there is insufficient room or ice on board the mother ship. Roughly a fifth of the regional fish harvest is thus lost every year.

EXTRA-REGIONAL MARKETS

A major reason why fisheries were not extensively depleted in pre-contact times in spite of dense human populations is that inter-regional exchanging of goods was limited, particularly with regards to foodstuffs. But the tempo and extent of exports quickened considerably after the arrival of Europeans. A brisk trade developed in turtle egg oil and hides and salted flesh of manatees (Parsons, 1962; Veríssimo, 1970; Smith, 1974, 1981*b*; Domning, 1982). Royal fisheries were established along the Amazon and some major tributaries to supply garrisons with cooking and lighting oil and salted fish, but little fish was initially exported from Amazonia. Settlements in other parts of Latin America were more easily provisioned by local fisheries and Europeans were supplied more cheaply with fresh fish and salted cod and herring from the North Sea and the Atlantic.

Within the last two decades, however, Amazonian fisheries have been tapped on a large scale for export. In Belém, for example, several processing plants have recently been established to prepare frozen catfish fillets for shipment to the United States, particularly the South where deep-fried catfish is a regional delicacy. Piramutaba *Brachyplatystoma vaillanti* figures prominently in this trade and is caught mostly in the mid to lower Amazon and along the lower reaches of the Tocantins. Manaus has also attracted several firms engaged in preparing catfish (siluroids) for export to the United States. Even relatively small Amazonian towns, such as Itacoatiara, are sites for commercial fish-freezing plants geared to the export trade.

The first fish processing plant in Itacoatiara was established in late 1975 and by 1977 two firms were buying siluroids and some scaled fish from locals (Fig. 2). After cleaning and freezing, the bagged fish is transported in refrigerated trucks on barges to Belém and then the frozen cargo is

Fig. 2. Fisherman eviscerating several catfish species for a fish-processing plant in Itacoatiara, Brazil.

driven south along the Belém-Brasília highway which was paved in 1974, a decade after its inauguration. One of the plants, Frigorífico Brasília, purchased 478 tonnes of eviscerated and headless fish (78% siluroids) between 1975 and 1977 (Smith, 1981*a*).

The penetration of pioneer highways into Amazonia and the advent of refrigerator trucks have facilitated the extraction of Amazonian fish for markets in central and southern Brazil. As in the case of the US market, the export trade focuses on catfish. In the early 1970s, for example, refrigerator trucks followed in the wake of bulldozers preparing the Transamazon road-bed to buy catfish, mostly piraíba *Brachyplatystoma filamentosum*, in riverside towns such as Altamira and Itupiranga. Early in the same decade, catfish in the Madeira began to be harvested on a systematic basis following the opening of the Porto Velho-Cuiabá highway. The annual yield of catfish captured from the Teotonio cataracts upstream from Porto Velho fluctuated between 100 and 350 tonnes between 1971 and 1979 (Goulding, 1981).

In some cases, it has proved profitable to air-freight Amazonian catfish to distant markets. In the Colombian Amazon, for example, iced catfish are flown from Leticia to Bogotá in the Andes. Many of the fish flown to the Colombian capital are captured in Brazil and Peru. In the mid 1970s, this trade had reached 9000 tonnes annually (Bayley, 1981).

The large-scale harvesting of catfish for export has thus far not clashed significantly with local food needs. Slippery-skinned fish are not esteemed in Amazonia since they are reputed to trigger a series of health complaints. Most catfish, particularly when they are mature, are classified as *remoso* which is derived from the Latin *rheum*, meaning thick fluid. Piraíba and mapará *Hypophthalmus* spp., for example, are believed to transmit leprosy (Pereira, 1974). People living along the Madeira shun jaú *Paulicea luetkeni* because it is thought to provoke haemorrhoids and miscarriages (Goulding, 1981). *Remoso* fish are deemed especially likely to exacerbate skin problems. This aversion to eating catfish stems largely from Indian cultures.

TECHNOLOGICAL INNOVATION

Fishing technologies and methods of storing catches have changed radically since the advent of Europeans. Prior to 1500, the repertoire of aboriginal fishing methods included the bow and arrow, spear, hook and line, traps, short passive seines and poisons. These techniques are still used, but other methods have become more important, particularly gillnets and large, active seines. More efficient harvesting methods now threaten the long-term sustainability of many Amazonian fisheries.

Fishing methods employed by Indians prior to the colonial period were effective, but it is unlikely they caused widespread damage to fisheries. The commonly used bow and arrow can only pierce one fish at a time. The harpoon can only be thrust effectively against the larger fish that surface. Harpoons and gigs do not appear to have been important to tribal societies and when they are used, they have often been acquired from mestizos (Steward, 1948).

Other aboriginal fishing technologies have also had a limited impact on the long-term productivity of fisheries. Handline fishing, formerly using hooks fashioned from bone, wood, ant mandibles, or harpy eagle *Harpia harpyja* talons, snagged only the smaller fish. Some tribes have employed nets using twine made from the inner bark of trees, the tough frond fibres of tucumã palm *Astrocaryum* spp., or cotton. The Carajá of the Araguaia have used passive seines made from fibres pulled from ubiquitous, sun-loving *Cecropia* trees to trap pirarucu in narrow channels (Machado, 1947). Overall, however, nets were not extensively used in pre-contact times.

One aboriginal fishing method which is widely regarded as highly destructive and is therefore currently outlawed in Brazil is the use of piscicides. Several wild and domesticated plants contain compounds that paralyse the gill mechanism so that fish flounder at the surface, where they are easily speared or scooped up in baskets. Some rural mestizos, unaware or sceptical of epidemiological findings, attribute some malaria outbreaks to drinking water tainted upstream by piscicides. Piscicidal plants, perhaps among the first South American cultigens, are only used in relatively shallow and narrow water courses because the large volume of water in rivers and lakes dilutes the active ingredients. This ancient fishing method therefore only affects fish populations along short stretches of certain streams.

Fishing methods introduced or improved since 1500 have, in contrast, helped upset the balance that once existed between man and fisheries in the region. Traditional fish hooks, for example, have been mostly replaced by metal hooks that are cheap and readily available. Metal hooks are more efficient than traditional ones and can capture even the largest fish.

Large metal hooks, the size of meat hooks, and steel gaffs enable fishermen to impale the giant, bottom-dwelling catfish which are heavily exploited for the export trade. Fishermen in canoes bait bottom lines with fish and extend them for approximately 100 m perpendicular to river banks to capture massive siluroids such as piraíba, jaú and pirarara *Phractocephalus hemiliopterus*. Gaffs, used in rapids, are also new weapons that permit fishermen to pluck out the large catfish. Metal hooks and gaffs are partly responsible for the decline of catfisheries in several areas, particularly along the Amazon and Madeira (Goulding, 1981). As catfish stocks in the Madeira dwindled, the fishing frontier moved upstream in 1977 to the Mamoré and Guaporé. In the vicinity of Itacoatiara, the large specimens of the giant catfish were creamed within five years. One of the two fish-processing plants consequently closed, while the other operates from a barge that can be towed away if yields decline further.

Although fish have been speared in the Amazon basin for a long time, steel and electricity have increased the effectiveness of lances that were formerly tipped with bone or shell. Night-fishing with pronged metal gigs, for example, is even more effective now that fishermen employ flashlights powered by car batteries placed in the botton of the canoe. Harpoons, tipped with detachable steel points, are hurled at pirarucu in lakes at low water (Fig. 3). A fisherman sits at the bow of his canoe, harpoon in one hand and paddle in the other, waiting for the air-breathing, torpedo-shaped fish to surface. After piercing pirarucu, which can weigh up to 90 kg, an hour may pass before the large-scaled fish tires sufficiently to be hauled in and clubbed.

Fig. 3. Fishermen dragging a freshly harpooned pirarucu up the shore of a floodplain lake of the Amazon near Itacoatiara, Brazil.

Prior to 1800, pirarucu were apparently not heavily exploited, possibly due to aboriginal taboos. The silvery fish became increasingly important in the regional diet as overhunting depleted manatee stocks (Goulding, 1983). A lucrative trade developed in dried pirarucu (Table 1) and in the last century the fish emerged as a basic food for Amazonians (Veríssimo, 1970). Salted and dried pirarucu provided sustenance for rubber tappers, gatherers of essential oils and nuts from forest trees, diamond miners, and urban dwellers. Families made annual trips to lake margins to harvest and prepare pink-fleshed pirarucu for sale. White water rivers with broad floodplains, such as the Amazon and Purus, were the most productive

TABLE 1
Pirarucu Production from the Brazilian Amazon

Year(s)	*Dry wt (kg)*	*Location*	*Source*
1858	221 910	Manaus	Avé-Lallemant (1961)
1881–83	307 103	Purus R.	Marc (1890)
1881–83	26 438	Madeira R.	Marc (1890)
1897	244 110	Amazonas St.	Georlette (1902)
1898	227 826	Amazonas St.	Georlette (1902)
1899	438 124	Amazonas St.	Georlette (1902)
1902	237 953	Amazonas St.	Gonçalves (1904)
1918	1 148 375	Amazonas St.	Bitencourt (1925)
1919	1 376 830	Amazonas St.	Bitencourt (1925)
1919	1 663 721	Pará St.	Bitencourt (1925)
1920	1 117 063	Amazonas St.	Bitencourt (1925)
1920	1 503 446	Pará St.	Bitencourt (1925)
1921	1 102 913	Amazonas St.	Bitencourt (1925)
1921	1 105 067	Pará St.	Bitencourt (1925)
1922	909 052	Amazonas St.	Bitencourt (1925)
1922	882 636	Pará St.	Bitencourt (1925)
1923	1 239 573	Amazonas St.	Bitencourt (1925)
1924	789 596	Amazonas St.	Bitencourt (1925)
1924	574 293	Pará St.	Bitencourt (1925)

pirarucu fisheries; the Purus, for example, provided thirty times as much commercialized pirarucu as the narrow, white water Madeira in 1881–82 and eighty times as much in 1902 (Nery, 1885; Gonçalves, 1904). In the middle of the last century, fishermen annually killed some two million pirarucu in Amazonas state alone (Avé-Lallement, 1961). By the late 1950s, however, pirarucu had become increasingly rare and expensive and no longer served as a common fish for the mass of the population (Bitencourt, 1951).

Metal hooks, gaffs and projectiles have quickened the pace of fisheries exploitation, but nets are the main threat to the overall productivity of the region's fish stocks. Nets capture a broad spectrum of species, are set out day and night and are used in a wide range of aquatic environments. Lampara seines, for example, are usually between 30 and 300 m long and can encircle an entire school of fish. In the Amazon region, it is not unusual for a seine to engulf 60 000 fish (Petrere, 1978). Pirarucu and other fish fall victim to seines in lakes, but the deep nets are mostly used in rivers, particularly after the crest of the annual flood when large schools leave the floodplains of major rivers for tributaries. The stretched mesh size of seines is only 3 cm so many immature specimens perish.

Lampara seines have only dominated the total catch since the arrival of nylon in the last two decades. Seines accounted for an estimated 73 % of the commercialized catch in Amazonas state in 1974 (Brazil, n.d.), approximately 70 % of the catch in the environs of Itacoatiara in 1977 (Smith, 1981*a*) and about half of the landed catch in Manaus during 1976 (Petrere, 1977). Seines have increased the yield of catfisheries several fold; in the Amazon estuary, the nets were annually capturing 20–30 000 tonnes of piramutaba during the late 1970s, about one fifth of the region's total fish catch (Goulding, 1983).

Gillnets also figure prominently in Amazonian fish catches, accounting for most of the catfish caught along the Madeira and 36 % of the landed catch in Manaus in 1976 (Petrere, 1977; Goulding, 1981). Gillnets were not widely used in the Amazon until the arrival of synthetic twine in the 1960s (Meschkat, 1961). Cotton gillnets rot within a couple of years, whereas nylon nets last five years if periodically repaired. Clear, monofilament nylon gillnets are used in waters with little suspended sediment, whereas tougher, dark multifilament gillnets are draped in murky lakes, channels and rivers.

Gillnets used in the Amazon are between 2–3 m deep and up to 200 m long. To set up a long gillnet, sections are tied together and the ends are attached to stakes, trees, or floating vegetation. The passive net is suspended by plastic bottles, pieces of styrofoam, sections of aninga *Montrichardia arborescens*, an aquatic aroid, or clumps of membeca *Paspalum repens*, an elongated grass with buoyant stolons. Gillnets are popular with fishermen because they can be used year-round, when it is light or after sundown and in a wide range of habitats; these attributes enable fishermen to capture more species of fish than with less flexible methods. In the vicinity of Itacoatiara, for example, adaptable gillnets entangle approximately half of the 100 different fishes eaten in that area (Smith, 1981*a*). Gillnets can destroy fisheries because large numbers of immature specimens are often caught. Also many struggling fish are devoured by piranhas *Serrasalmus* spp., especially piranha caju *S. nattereri*, before they are extricated from the net.

One of the most devastating acquisitions to the arsenal of Amazonian fishermen is gunpowder. Detonating explosives for fishing is outlawed in Brazil (article 35, law 221/67), but crudely-made bombs have been used in the North for decades (Gourou, 1950; Junk, 1975). Fishermen pack dynamite into a can or bottle, light a short fuse at one end and toss the container into the water. Most fish within 20 m of the ensuing blast are stunned or killed outright. Many fish sink and are lost, while others drift away and die. Alvelins also succumb, so wastage is high. Commercial fishermen are generally responsible for this destructive practice; locals object to the bombing of lakes and channels since it undermines their food supply. But apprehending offenders and prosecution are difficult, particularly in view of the small contingent of game wardens in the vast region. Fishermen in other parts of the Third World, such as Nigeria, East Africa and the Pacific, also use explosives with virtual impunity (Johannes, 1981; Randall, 1983).

Technological innovation in the powering of fishing boats and the preservation of catches have also accelerated the fishing pace. The introduction of diesel-engined boats and ice in this century have extended the range of craft in search of fresh fish. Well insulated ice boxes prevent the deterioration of catches for up to six weeks. The first ice factory in Amazonia was apparently established in Belem in 1897, mainly to supply hospitals, offices and schools (Weinstein, 1983). Firms manufacturing ice for fishermen have only been operating in the region for the last few decades. In 1980, four Manaus firms were selling ice to fishermen; in Itacoatiara, two companies were preparing 50 kg slabs of the product and in Manacapuru one plant was selling ice with a competing facility under construction in the same year. Fish-processing plants often manufacture ice and managers assert that the product accounts for a significant share of their earnings.

HABITAT DESTRUCTION

Fish populations are not only coming under pressure from increased harvesting rates but also because of large-scale environmental changes wrought by settlers and development projects. The clearing of floodplain forest for crops and pasture eliminates an important source of food for frugivorous fish, many of which are important in commerce and subsistence. The much-prized tambaqui *Colossoma macropomum*, for example, consumes at least 25 different fruits (Smith, 1981*a*). The food chain of 75 % of the commercial fish catch in Amazonia is anchored in floodplain forests (Goulding, 1980). Some species, such as aruanã *Osteoglossum bicirrhosum*, a relative of pirarucu that enters the aquarium trade, thrive in lakes, but it seems likely that productivity of Amazonian fisheries will generally decline if floodplain deforestation continues. Tree clearing is particularly evident on the floodplains of silt-laden rivers since they encompass the richest soils; white waters also contain the most productive fisheries. Deforestation of uplands for small farms, ranches, plantations and mines accelerates soil erosion and alters the properties of clear and black waters. It remains to be seen whether such environmental manipulation will affect the fisheries of those rivers.

Floodplain forests and the hydrochemistry of rivers are also being radically modified by hydroelectric dams. Spurred by a mounting foreign debt and the financial burden of importing three-quarters of the nation's petroleum needs, the Brazilian government understandably plans to tap the hydroelectric potential of its many rivers further. The energy potential of the Amazon basin's rivers, excluding the Amazon itself, is in the order of 100 000 MW (Goodland, 1980; Caufield, 1982, 1983). Several hydroelectric dams have been built in the Amazon, but they are all under 40 MW capacity. However, the Tucurui dam that will harness the Tocantins will generate 4000 MW and inundate 2000 km^2 of upland and floodplain forest (Goodland, 1982). Major dams are slated for construction on the Xingu and other affluents of the Amazon.

Most of the dams in place, under construction, or planned are in clear water rivers which do not rival white waters in fishing yields. Hydroelectric dams across clear water rivers will nevertheless disrupt fisheries in other rivers. Many commercially important fish, such as jaraqui *Semaprochilodus* spp., ascend clear water courses after breeding in white waters. No fish ladders have been built, nor are any planned, for hydroelectric projects in Amazonia; migratory routes for many fish will thus be blocked. In Africa, migratory fish disappeared from the Volta above the dam (Lowe-McConnel, 1973).

Dams across clear water rivers are likely to have an adverse effect on downstream fisheries in other ways. Sediments and nutrients are trapped behind dams and the water turning the turbines is more acid when forest is drowned. Water properties change above and below dams and thereby alter the composition of fish communities. Behind the Curuá-Una dam near Santarém, for example, piranhas have proliferated (Junk *et al.*, 1981). Reservoirs can be used for aquaculture, but the fish most commonly employed to stock artificial water bodies in the tropics, tilapia and carp, are exotics and it may not be wise to release them in Amazonian waters. Suitable indigenous species may exist for stocking reservoirs, but captive breeding of commercially valuable Amazonian fishes has only just begun. Alternative sources of protein can be found, such as raising poultry, but they will be more expensive.

SUSTAINABLE FISHERIES

As fishing technologies become more potent and population pressure builds, careful management of fisheries becomes more urgent. Unfortunately, no long-term studies of Amazonian fisheries have been conducted and little is known about the life cycles of many species important in commerce and subsistence. Size at sexual maturity for most species is not known. In Brazil, SUDEPE (Superintendência do Desenvolvimento da Pesca), has established minimum catch sizes for some commercialized fishes in Amazonia, but these limits are based on insufficient biological data and are largely ignored anyway.

In addition to basic information on the life history of Amazonian fishes, institutions and individuals responsible for managing fisheries need to know more about how fish species respond to harvesting. Sometimes fishing a previously unexploited fish stock leads to faster growth and earlier breeding of the surviving population (Lawton & May, 1984). Fishing represents a considerable new selection pressure on fish stocks; resulting changes in population dynamics and gene pools need better documentation. Most tropical fisheries are extraordinarily rich in species and classical fisheries models, based on studies of single species in cold and temperate zone waters, are not very useful in warmer climates. Fish populations in Amazonian waters, as in the oceans, not only fluctuate seasonally but probably vary according to longer-term cycles. Separating this background oscillation from overfishing is an important task confronting icthyologists and ecologists (May, 1984). Surveys of fish stocks in the numerous river systems of the Amazon and natural history studies of the many species important in commerce and subsistence will require sustained support for a large number of field biologists and taxonomists.

One way of maintaining the productivity of fisheries is to set aside periods, generally during the breeding season, when it is illegal to harvest the resource. But in the tropical climate of Amazonia, every month finds some species breeding. Outlawing the capture of certain species during a portion of the year has been attempted in the Brazilian Amazon, but enforcement was lax. If this strategy is to be pursued, more information is needed on the breeding patterns of the hundreds of species consumed in the region.

Until the life cycles of Amazonian fishes are better understood and enlightened legislation to curb overfishing can be enforced, protection of various habitats is urgently needed. In pre-contact times, buffer zones between hostile tribes created extensive sections of floodplains and upland forest that were rarely disturbed (Harris, 1978; DeBoer, 1981). Today, settlements are more spread out along rivers and fewer areas remain unmolested than formerly.

In addition to no-man's-lands created by hostility, supernatural beliefs have helped check the overexploitation of fish and game (Smith, 1983). Fear of monsters and spirits has kept people away from certain spots along rivers and in the forest. Supernatural parks originated in aboriginal cultures and have continued to the present, but their integrity is being violated by the aggressive expansion of fishing fleets with crews who have little respect for local superstition. When a fishing boat from a large city penetrates a lake that is traditionally regarded as unsafe due to the rumoured presence of a giant water snake, for example, locals assume that the place is safe to fish. Cultural checks to overexploitation are being dismantled as development of the region proceeds.

Scientifically managed parks and reserves are needed to bolster or take the place of zones once avoided due to supernatural reasons or hostility. But efforts to implement parks in Amazonia are still in their infancy (Barrett, 1980; Wetterberg *et al.* 1981; Rylands & Mittermeier, 1983). As of 1981, 20 parks and reserves covering 24 million ha had been designated in the Brazilian Amazon alone and when parks in other parts of the basin are included, the total area reserved for limited or no commercial use is around 30 million ha. Unfortunately, aquatic environments are poorly represented in parks or reserves and protection is unreliable. Many parks have been invaded by squatters, while others have been sliced by pioneer roads.

Amazonia is thus in limbo between traditional restraints to overexploitation that are breaking down and scientific management which has hardly gained a foothold. The enormous size of Amazonia often creates the impression that environmental disruption can be mitigated and that there is little urgency to protect fisheries and other natural resources. A fish shortfall is not imminent in the region, but desirable species are becoming scarce and expensive. Just as in the case of turtles, the larger species are heavily exploited and poorer people are adjusting their diets to accommodate smaller and less popular species. With more scientific studies and wiser management, a renewable resource can be sustained and thereby provide valuable protein for a growing population, employment and much-needed foreign exchange.

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