CHAPTER 1

Review of River Fisheries Valuation in Central and South America

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1. INTRODUCTION

Central and South American (CSA) fisheries present some interesting paradoxes. Despite the wide biodiversity, its large share of the world's fish species[1] - up to 20 per cent of the planet's fresh water sources in the Amazon alone - Central and South Americans have never eaten large amounts of fish. Even though the continent is an important source of fish (Chile and Peru are among the top five marine fish producers in the world), the majority of their catch goes into fishmeal production rather than appear on the table as food. In fact, a recent study found that while Brazilians enjoy eating fish, only 2 per cent of the freshwater fish eaten in Brazil are native species caught in inland waters[2]. However, fishing for sport is the favorite pastime of an estimated 6 million Brazilians, and the continent is a popular destination for fishing tourists from Europe and North America (Worldpaper 1999).

The production potential in Central and South America is, theoretically, huge. While South America, in particular, contains two of the largest river basins in the world (the Amazon and the Plate), the largest freshwater wetland in the world (the Pantanal in Brazil), and the river with the largest volume in the world (the Amazon), Central and South America account for just 2 per cent of all the freshwater fish caught in the world.

Unlike Africa and Asia, where a large part of the population are heavily dependent upon fishing for their livelihoods, fishing for a living in the interior of CSA remains a marginal occupation for all but the most isolated of families. As such, the economics and management of fisheries on the continent have received little attention from within the continent and the rest of the world. Nonetheless, the waters and fish of the region have been the focus of considerable attention by taxonomists, biologists and ecologists, and the region has been the center of debate regarding the role and importance of biodiversity and the significance of a stable ecosystem for the well being of the planet.

The following study shows that while a number of studies have been carried out on fishing in the region, they tend to be limited in their geographical focus and time scale. Although fishing of freshwater species may appear to be comparatively insignificant in the region, the rivers of CSA are very important. The continent contains a large number of dams, and hydropower accounts for 90 per cent of the total power consumption in Brazil (La Rovere and Mendes 2000:vii). Many of these dams, however, were built before the application of Environmental Impact Assessment became commonplace. As a result, it is often difficult to compare situations before and after this practice because before data simply do not exist.

This report, therefore, analyzes the literature available on CSA river fisheries and attempts to draw out an economic value of these fisheries. This has not been an easy task, not least because so few studies have been done on the topic. Furthermore, as dams can have such an important impact on the ecosystem in CSA, a literature survey has also been conducted on the impact of dams and related hydropower and irrigation projects on the aquatic environment in general and fisheries in particular.

1 Eighty per cent of known freshwater fish species and three times the flora compared to similar areas in Africa and Asia (La Rovere and Mendes 2000:v).

2 The other 98 per cent are exotic species raised in tanks and ponds, most of it coming from Santa Catarina, the smallest state in the Federation (Worldpaper 1999).

1.1 Methodology

As noted above and expounded below, there is a paucity of information on freshwater fisheries in Central and South America compared to the same resources in other continents. The Internet provides a considerable amount of gray literature – particularly statistics from government web sites and information on locally managed projects dealing with fishery issues. Standard bibliographic databases reveal a considerable amount of literature published on biological matter in the region, but very little on the economics or the value of the fisheries in Central and South America. Unlike Africa and Asia, where English is often the academic lingua franca, Central and South America use Spanish and Portuguese as the main languages in all sectors. Consequently, it is possible that studies have been conducted on the economic valuation of river fisheries that have never been published in English-language journals.

A substantial part of the statistics used in section 2 is from the FAO FISHSTAT PLUS database. FAO statistics are, however, only as reliable as the underlying (national) sources and it is very possible that capture statistics for remote areas – particularly those fish destined for subsistence household consumption –do not appear in the figures presented here. Few studies on the region have specifically mentioned the problem with data collection, although the work of Dias-Neto and Dornelles (1996) and Paiva (1997) stand out in this regard. They point out the difficulty of establishing the veracity of statistics for the Amazon basin in particular. Common to all isolated fishing communities, collecting statistics for artisanal fisheries in the Amazon basin is complicated because fishers tend to catch a large variety of fish and the catches are distributed at a large number of landing sites, many of which are only accessible by river.

This report is divided into a number of sections. First, the authors describe the major river basins on the continent, characterize their fisheries, and place freshwater fisheries in CSA into a global context. Second, the authors provide a review of valuation techniques for fisheries and use this analytical framework to review the principal literature on freshwater fisheries in the region. Then they turn their attention to the economic impact of dams and water abstraction schemes, reviewing the available literature to ascertain how/if economic values are computed for the impact on fisheries. Finally, they offer some conclusions and recommendations on the direction for future studies of freshwater fisheries in CSA.

2. THE RIVERS, ENVIRONMENT AND FISHING ACTIVITY OF CENTRAL AND SOUTH AMERICA

2.1 The Main River Basins in Central and South America

Because of their importance from a hydrological and ecological point of view, the rivers of Central and South America (those in Brazil in particular) have received a great deal of biological attention, but little work has been done on the economics of the fisheries operated there[3].

All the major rivers of the continent are to be found in South America as opposed to Central America (see Appendix 1). The Brazilian Amazon covers an area of 5 million km^2, nearly 60 per cent of the territory of Brazil[4]. The river

3 However, a £3 million project funded by CIDA started work in Brazilian inland waters in January 2003. This project (Brazil inland fisheries, sustainable livelihoods and conservation http://www.worldfish.org/proj_sa_3.htm) aims to focus on the social and economic side of fishing in the region.

runs 5,700 km from the Andes to the Atlantic Ocean; with all its entire system including about 1,100 rivers and lesser streams. The Amazon basin, which accounts for a fifth of the freshwater on the planet, includes the white water rivers such as the Amazon that are rich in minerals and suspended particles, the clear water rivers such as the Tapajos that also carry important quantities of suspended particles, and the black water rivers such as the Negro that are much poorer and owe their dark color to acids derived from decomposing organic materials in the flooded forests at their margins. The basin is also divided into the Lower and the Upper Amazon. The Lower Amazon has been analyzed by various authors (Bayley and Petrere 1989; Merona 1990; Santos and Ferreria 1999; Ceideira, Ruffino and Isaac 2000).

The Amazon River system drains the world's largest tropical rain forest as well as the Pantanal, the largest freshwater wetland in the world. The Amazon basin provides over 50 per cent of Brazil's freshwater supply, and substantial parts of that of Peru, Bolivia, Venezuela, Colombia and Ecuador (Map 1). Petrere et al. (1992, 2003) studied the West Amazon Basin and Almeida et al. (2003) studied the Amazon as a whole (See Section 4 for more details, and Appendix 1a for the map).

Brazil has the majority of the principal river basins of the continent: the Nordeste, Tocantins-Araguaia, Paraguay, Leste, Do Sul and Sao Francisco lie exclusively within Brazil although information on these other rivers and river basins is limited. Despite a large number of biological studies conducted in the region, basic information on its fish species is still patchy; taxonomic descriptions and life-cycle studies are only limited to species of greatest commercial importance (Petrere 1994) or to specific rivers, e.g., Tejerina-Garro et al. (1998) conducted a biological study of fish communities in the Araguaia river (part of the Amazon basin). A few studies have been conducted on fishers and their interactions with the environment: Cetra and Petrere (2001) on the middle Tocantins and the impact of the Tucuruí dam on the fisheries; Batista et al. (1998) on fishing gears used in the Lower Solimões river (the local name for the western part of the Amazon); and Agostinho and Gomes (nd) on the links between biodiversity and fisheries management in the Paraná basin. In addition, Silva (1986) documented the upper Paraguay basin, which is the habitat of many large migratory fishes and thus popular with recreational fishers.

Many of the rivers in the region are highly seasonal, resulting in the basins having a flooding and emptying cycle. The DFRP (2001) notes that a number of rivers in the Parnaiba basin (362,000 km^2) dry up completely during the summer. However, the larger rivers have been dammed to generate hydropower (see Section 5) and have in turn created a large number of reservoirs: the São Francisco basin, for example, has 11 dams that account for 25 per cent of the reservoir area of the whole country (PLANSVAF 1989).

If information on rivers within Brazil is scarce, information on rivers in the rest of the continent is even more limited. Take, for example, the case of the Rio de la Plata basin, which is the second largest in the region and the fourth largest in the world. Covering Paraguay and large parts of Bolivia, Brazil and Uruguay, it forms the largest wetland corridor in the world, from the Pantanal in Mato Grosso to Rio de la Plata, which flows into Argentina. Surprisingly, there are no known studies on this basin, although a search on the Internet demonstrates that sport fisheries predominate

4 Usage of the word "Amazon-"' is often very loose. Amazonas is the name of a State in Brazil, which stretches from the western-most border to just east of Manaus. About three-fourths of the Amazon river is in Amazonas State, and the other quarter is in Para State. The western-most stretch of the Amazon is also called the Solimões. Amazonia tends to be used to refer to the rainforest that covers the basin.

here. The Orinoco basin is shared by three countries: Brazil, the Guyanas and Venezuela, but the only reference encountered on this river system was from the 1970s when Auburn University (USA) conducted a survey on the Upper Meta River System. Ninety-two per cent of the Pilcomayo basin lies in Bolivia; the river then runs down into Paraguay, where it joins the Uruguay River, which flows into Argentina and empties into the Atlantic Ocean. There are currently around 30 small mining companies operating at Potosi on the Upper Pilcomayo; these contribute considerable waste to the river system. As a result, considerable attention has been focused on water quality in this basin. Various projects have been put forward to monitor water quality in the river and to control mining pollution, but few appear to have met with any degree of success (http://www.gci.ch/GreenCrossPrograms/waterres/water/pilcomayo.html).

The Bio-Bio River in Chile empties into the Pacific and is a significant source of hydroelectric power for the country as is the Colorado River in Argentina, which drains into the Atlantic. This river, the traditional and historic border between Spanish/Mapuche populations in Chile, is 380 km long, flows down the Andes into the Pacific, and has a number of dams constructed across it. It has a watershed surface area of 24,260 km^2. Over a million inhabitants are estimated to rely upon its resources for drinking and irrigation water, recreation and fisheries.

Finally, Mérigoux et al. (1998) described freshwater fisheries in coastal streams in French Guiana; Mol et al. (2000) examined the effects of drought on freshwater fisheries in Suriname; and Beltran Zurriago and Villaneda Jiménez (2000) briefly mentioned inland artisanal fishing in Colombia.

Central America has many rivers (e.g., the Belize and Monkey rivers in Belize; the Corobibi, Sarapiquí and Tabacón rivers in Costa Rica; and the Rio San Juan River in Nicaragua), but no evidence could be found of any studies on the economics or management of fisheries in those rivers. However, it appears that several of the rivers offer excellent opportunities for sport fishing and whitewater rafting (www.uncommonadventure.com); many offer ecologically unique habitats to fish species (See www.si.edu/bermlab, for examples.) and quite a few are linked to important wetlands such as the Laguna del Tigre National Park in Guatemala (www.worldbank.org) and a variety of Ramsar sites in Nicaragua (www.ramsar.org/profiles_nicaragua.htm).

2.2 Other Water Resources: Lakes and Reservoirs

With such a large quantity of water, hydroelectric power has always been important to the region. As a consequence of having a large number of dams built across the region (see section 5), numerous artificial lakes and reservoirs have been created (Paiva 1976; 1983). Lake Titicaca, however, is the largest natural lake in CSA and the only natural lake upon which any information could be found. The lake, which is shared by Peru and Bolivia, covers 8,372 km^2 and consists of two parts: Lago Mayor, the deep main basin and Lago Pequeño, the smaller, shallower one (Ghishan nd). Extensive anthropological work has been conducted on the fishers that work the lake (see Orlove 1986, 1989, 1990), but no economic assessment has been done.

2.3 Main Species Caught in the Region

Amazon fisheries, in common with other tropical freshwater fisheries, have a number of special characteristics. They are multi-species and fished with a wide range of gears. Temporal variation in capture is high because most fish are caught during the dry season, the least during the wet season. In these circumstances, traditional fisheries population models are not able to predict the potential yield with any certainty, and it is also difficult to calculate marginal costs of production (Etchart 2000).

The Lower Amazon is characterized by great diversity and high production. Catch composition presents a significant spatial and temporal diversity, dominated by *Plagioscion squamosissimus* (Table 1). The only industrial freshwater fish in the Amazon is the Piramutaba

Table 1: Principal fishes caught in South and Central American Rivers

Local name	Latin name	Notes
Curvino	Plagioscion squamosissimus	Brazilian Amazon
Tucunaré	Cichla monoculus	
Jaraquis	Semaprochilodus insignis, S. taeniatus	
Curimatá	Prochilodus nigricans,	
Anostomideos		
Hemiodontideos		
Tambaqui	Colossoma macropomum	
Cardinal tetra	Paracheirodon axelrodi	Ornamental fishery catch from Rio Negro
Piramutaba	Brachyplatystoma vaillanti	The only fish used in industrial fishery
	Prochilodus lacustris, P. cearensis, P. argenteus	Parnaíba
Pescada	Plagioscion sp	
Piaus	Schizodon sp, Leporinus sp	
Tilapia do Nilo	Tilapia niloticus	
Piaui	Plagiosion squamosissimus	
Camaroes	Macrobrachium spp	
Tucunare comum	Cichla ocellaris	
Curimatá comum	Prochilodus cearensis	
Pintado	Pseudoplatystoma corruscans	Paraná
Dourado	Salminus maxillosus	
Barbado	Pirinampu pirinampu	
Piaparas	Leporinus elongates, L. obtusidens	
Mandi	Pimelodus maculates, Iheringichtyhys laborosus	
Armado	Pterodora granulosus	
Curimbas	Prochilodus lineatus	
Pequenos caracideos	Astyanax spp, Moenkhausia intermedia	
Traira	Hoplias malabaricus	
Pintado	P. corruscans	São Francisco
Curimata	Prochilodus marggravii	
Dourado	Salminus brasiliensis	
Traira	Hoplias malabaricus	
Bagres	Pimelodidae	
Cachara	Pseudoplatystomas fasciatus	Paraguay
Pintado	P. Corruscans	
Pacu	Piaractus mesopotamicus	
Curimba	Prochilodus lineatus	

Acarahuazu Boquichico Corvina Doncella Dorado Gamitana Llambina Maparate Paiche Palometa Ractacara Sardina Yahuarachi Yulilla Zungaro	 Ray Ophidiidae Spanis aurata Trachinotus	Peruvian Amazon (many of these terms are used by the locals in the region and scientific names are not known).
Camaron de Rio Carachi Pejerrey Trucha	Crayfish Argentina elongata Salmo	Sierra waters

Source: DFRP 2001; Siamazonia 2002

(*Brachyplatystoma vaillant, Prochilodus lacustris, P. cearensis, P. argenteus*), found at the mouth of the river. Catches of these fish reached 28,829 tonnes in 1977, declined to 7,070 tonnes 1992, but had again risen to 22,087 tonnes by 1999 when the fish were considered to be recovering from overfishing (DFRP 2001). There is a significant fishery for ornamental fish in the lower Rio Negro, which is dominated by the Cardinal Tetra. In general, fisheries resources in Amazonia were considered underexploited by Petrere (1983) and Welcomme (1990), but with localized risk. Recent literature has reported declining catches close to large urban centers, and the decline in catches landed at Manaus was demonstrated by Bittencourt (1991), who suggested that fishing in this region was approaching the MSY level.

2.4 Central and South America River Fisheries in a Regional and Global Context

Since 1965, fisheries production from freshwater resources in Central and South America has never amounted to more than 4.2 per cent of fisheries production overall; it has normally been in the region of 1-3 per cent[5]. Over that same period, marine production has generally been above 10 million tonnes per year[6] (Table 2).

In a global perspective then, while a number of South American nations (notably Peru, Chile and Argentina) remain among the top marine capture producers in the world, the CSA share of global inland fish capture

5 Freshwater capture fisheries data do not include other aquatic animals (crocodiles, etc.) nor cultured fish production. A complete breakdown of capture production by species and country can be found in Appendix 2; figures for culture production can be found in Appendix 3; and those for crocodiles in Appendix 4.

6 Most of the marine production is destined for fish meal and the majority of this is caught by Peru and Chile, the second and fifth highest capture fisheries producers in the world (FAO 2000a).

Table 2: Marine and freshwater production in Central and South America (tonnes)

	Fresh (capture)	Marine	Total F + M	Freshwater capture as % of total
1965	150 200	8 645 065	8 795 265	1.7
1970	143 500	14 442 840	14 568 340	0.9
1975	251 138	5 409 696	5 660 834	4.4
1980	279 247	7 428 839	7 726 086	3.6
1985	319 136	11 440 871	11 760 007	2.7
1990	306 664	13 695 296	14 001 960	2.2
1995	376 166	18 837 534	19 213 700	1.9
2000	356 300	17 116 213	17 472 513	2.0
2001	351 735	13 962 671	14 314 406	2.4

Source: FAO FISHSTAT PLUS database

production has never exceeded 4 per cent in the period since 1965 (see Table 3).

This difference in production levels between the marine and freshwater sectors has occurred, in part, because a) the marine fisheries, particularly in the Eastern Pacific and Southern Atlantic are highly productive, and b) while there is an abundant amount of freshwater within continental Central and South American river basins, the population density in these areas is extremely low compared to the coast. Thus, production of the continent has always been far higher on the coast.

The disparity in production between the coast and the inland areas also helps explain the dearth of information on freshwater fisheries production: government support has traditionally been focused on the industrial marine sector, with the artisanal marine sector coming second. The inland sector only comes onto the agenda in countries that have a comparatively high freshwater production, such as Brazil. The paucity of economic or management literature on river fisheries in Central and South America is also attributable to the position of Central and South America in the global context. From an international aid perspective, little attention has been paid to freshwater fisheries production in Central and

Table 3: Central and South American fresh and marine production (excluding aquaculture) as a percentage of world production

	Fresh water (capture)			Marine		
	World	**CSA**	**CSA% of total**	**World**	**CSA total**	**CSA% of total**
1965	4 905 010	150 200	3.1	39 215 628	8 645 065	22.0
1970	5 754 441	143 500	2.5	52 820 006	14 424 840	27.3
1975	6 354 730	251 138	4.0	51 473 209	5 409 696	10.5
1980	6 995 335	279 247	4.0	55 449 299	7 428 839	13.4
1985	7 985 983	319 136	4.0	64 677 099	11 440 871	17.7
1990	8 787 867	306 664	3.5	69 099 914	13 695 296	19.8
1995	10 542 978	376 166	3.6	72 181 590	18 837 534	26.0
2000	11 938 651	356 300	3.0	72 816 750	17 116 213	23.5
2001	12 037 442	351 735	2.9	70 277 170	13 962 671	19.8

Source: FAO FISHSTAT PLUS database

South America simply because African and Asian fisheries offer more scope (production is much higher and is more significant in terms of livelihoods and poverty reduction).

However, while considerable attention has been paid to the biology of freshwater fish in Central and South America, in particular in the Amazon, little academic interest has been placed on fishing as an economic activity.

2.5 Freshwater Production Trends on the Continent

Overall capture production rose every year from the 71,600 tonnes recorded in 1950 to a peak of 376,166 tonnes in 1995[7]. Freshwater production since 1950 (the earliest available FAO data) shows that Brazil is by far the largest producer. Production from Brazilian freshwater resources rose from 30,600 tonnes in 1950 to 199,159 tonnes in 50 years, having peaked at 200,621 tonnes in 1985. For much of the same period, Colombia was the second most significant producer recording a growth of some 140 per cent, although production in 2000 stood at 24,854 tonnes, still significantly less than Brazil. Argentina's production has been erratic; although production in 1950 was recorded at 13,700 tonnes, it dipped to 5,400 tonnes by 1970, then climbing to 15,045 tonnes five years later before dipping again in 1980. Towards the end of the 1990s, however, Argentinian production experienced a sharp rise and, by 2000, it was the third largest producer on the continent. Peruvian production has also experienced a dramatic rise since the 1980s, making it the second largest producer in 2000. Other countries that have experienced a growth in their capture fisheries production include Venezuela and Paraguay, which saw production almost double between 1990 and 1995; and Guatemala, where production has increased from 4,500 tonnes in the 1970s to 7,301 tonnes in 2000 (Table 4).

2.6 Aquaculture and Harvest of Aquarium Fish and Other Aquatic Species

While the bulk of freshwater production comes from capture fisheries (85%), inland culture fisheries production rose 168 per cent in the five years between 1995 and 2000. Much of this rise is attributable to Brazil and Colombia. There is also a sizeable and growing fishery for other aquatic animals from the freshwaters of Central and South America. Most notable of these is the market for crocodiles, caimans and alligators (Appendix 2). While there are no readily available figures for the price of meat from these animals, caiman skins have a first sale value of US$ 5-10, an export value of US$ 50 each and up to US$ 200 each on reexport from European tanneries. Crocodile skins retail at about five times the price of caiman skins, with a typical shipment of 2,000 skins for export selling for up to US$ 200,000[8]. There is also evidence that the hunting of manatees (a protected species) provides livelihoods in certain parts of the Peruvian Amazon (Reeves et al. 1996). Manatees – large aquatic mammals that were recorded in Brazilian fisheries statistics during the 1950s – are no longer included. Also of note is the trade in tropical aquarium fish. Most of the fish destined for aquaria in Europe, North America and the Far East come from the Rio Negro. Fish caught in the wild from Brazil make up 5-10 per cent of the global ornamental fish market and cardinal tetra make up 85 per cent of the total catch in the Rio Negro basin (OFI Journal 2002; Chao and Prang 1997).

2.7 Regional Importance of Fishing as a Livelihoods Option

South America still has a low share of the total global fishers although after a marginal decrease in absolute numbers between 1970

7 A complete breakdown of production by species in all Central and South American countries is found in Appendix 4.
8 http://www.wcoomd.org/ie/En/Topics_Issues/Cross_borderCrime/Cites/broche/17.htm

Table 4: Freshwater capture production in Central and South America (tonnes)

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Argentina	13 700	7 900	14 700	12 900	5 400	15 045	8 327	9 715	10 281	17 111	30 298
Belize	.	.	.	.	<0.5	25	25	1	1	<0.5	<0.5
Bolivia	500	600	700	1 800	1 100	1 050	4 179	3 770	3 223	4 842	5 256
Brazil	30 600	41 200	54 000	94 000	93 300	173 327	184 273	200 621	191 111	193 042	199 159
Chile	.	.	.	.	.	.	.	1	32	.	.
Colombia	14 500	17 000	11 400	25 900	33 200	42 027	46 706	47 708	33 940	23 524	24 854
Costa Rica	<0.5	<0.5	<0.5	<0.5	<0.5	48	323	300	300	900	1 000
Ecuador	.	.	.	.	.	.	206	867	600	300	400
El Salvador	800	900	1 400	1 600	800	869	1 818	2 791	3 641	4 324	2 831
French Guiana	.	.	.	.	.	.	.	.	.	.	.
Guatemala	.	100	200	200	400	550	400	47	2 599	4 025	7 301
Guyana	.	.	.	.	.	.	681	800	800	700	800
Honduras	.	.	.	.	100	170	76	32	45	127	61
Nicaragua	100	200	600	1 100	1 300	359	79	84	150	538	1 076
Panama	.	.	.	.	.	.	.	50	15	130	20
Paraguay	400	500	600	700	1 800	2 800	3300	7 500	12 490	21 000	25 000
Peru	.	1 000	1 000	3 000	2 000	6 671	12 538	27 791	28 321	50 789	32 297
Suriname	.	300	300	500	300	295	71	228	350	140	200
Uruguay	.	.	.	.	.	245	312	660	218	844	2 295
Venezuela	11 000	7 300	7 900	8 500	3 800	7 657	15 933	16 170	18 547	53 830	23 452
TOTALS	71 600	77 000	92 800	150 200	143 500	251 138	279 247	319 136	306 664	376 166	356 300

Source: From FAO FISHSTAT PLUS database

and 1980, the number of South American fishers and fish farmers grew by over 50% during the 1990s (FAO nd) However, throughout this period fishing has been a locally important livelihood option.

Artisanal fisheries in the Amazon basin are a very important source of employment and income (DFRP 2001). In inland areas, these fisheries often provide one source of employment for lowly or unqualified persons (in urban and rural areas), and they are generally conducted in conjunction with agriculture. The Solimões river at the western end of the Amazon accounts for around 45 per cent of all fishers in the Amazon River basin (Bayley and Petrere 1989), yet as demonstrated in Table 5, accurate data on the number of fishers are hard to find, and the figures are often conflicting among reports. Part of the accounting problem arises because artisanal fishers often combine the fishing activity with farming or off-farm work and the fishing portion of labor is aggregated into the agricultural statistics, or because many parts of the Amazon and other river basins are very remote and accurate counting of fishers is not possible. In the more remote parts of South America , where many fishers are subsistence fishers and do not join cooperatives or organizations to which commercial and many artisanal fishers belong, attempts at counting fishers through official organization membership can be misleading.

What is known is that in more remote parts of the interior, fishing is likely to make up a sizeable proportion of the animal protein intake and annual income, especially where alternative sources of employment or farming are not possible (Fernandez-Para 1998). Diegues (2002) has conducted extensive work on the artisanal fishers of Brazil where the form of fishing, the organization of fishing firms and the marketing relations are described. The DFRP (2001) highlights issues with fishers in the Parnaiba basin (362,000 km^2) where activity is highly seasonal as the Pindar, Grajua and Mearim rivers dry up completely during the summer. Almeida et al. (2003) provide the numbers of commercial and artisanal fishers on the Western Amazon (see Table 5).

Table 5: Numbers of fishers on certain rivers/basins

River/ Basin	No. of Fishers
Sao Francisco	26 000 (DFRP 1985)
Solimões	29 089 commercial (Almeida 2003) 77 485 artisanal (Almeida 2003) 102 870 commercial and artisanal on Floodplain (Bayley and Petrere 1989) 146 742 corrected for population growth which gives 117 653 subsistence (Almeida 2003)
Amazon	49 955 on the floodplain 228 600 subsistence and commercial (Bayley and Petrere 1989)

Finally, activity on other waterbodies is covered by Ghishan (nd), who estimates that 6,000 tonnes of fish are caught on the Titicaca by an estimated 800 fishers.

3. THE ECONOMIC VALUE OF RIVER FISHERIES

"As is true of all natural resources, fishery resources constitute capital assets from the point of view of society. Similar to man-made capital assets, such as factories and machinery, fishery resources are capable of producing a stream of returns to society over time" (Munro 1981:129). However, Central and South American fisheries are just one small piece of a complex regional environmental puzzle and, moreover, as they invariably only form one element of a human livelihood strategy[9], it would be remiss to analyze them in isolation from their immediate aquatic surroundings. Tropical and temperate river basins offer a wide spectrum of goods and services to society. These range from conventional and non-conventional extractive opportunities, such as biodiversity prospecting and the harvesting of timber, medicinal plants, rubber and wildlife as well as aquatic resources, to non-extractive options such as ecotourism, scientific research, and repositories for the unwanted carbon produced by local, national and global economic growth[10]. Equally, the institutional or public policy environment impacts to modify use patterns and the realization of value derived from a particular locale over time. In Chile, for example, the provision of public subsidies via the 1974 Forestry Law, covering 75 per cent of the costs of planting and tending trees, produced an internationally competitive lumber industry, albeit with suggestions of negative effects on both the rural population and native forest ecosystems (Clapp 1995a, 1995b; Lara and Veblen 1993).

Nevertheless, while economic valuations of such complex ecosystems and, indeed, the individual components thereof are a difficult task, there are strong grounds for undertaking such exercises as noted by Winpenny (1991:6):

- Valuation highlights the rate at which resources are being depleted/harvested, serving as a reminder that environmental capital is not a *free* good. A 1989 World Bank study, for example, computed that the overexploitation of demersal fish stocks in the Philippines *cost* the country annually between US$ 50-90 million.

9 See Scoones, Melnyk and Pretty (1992)

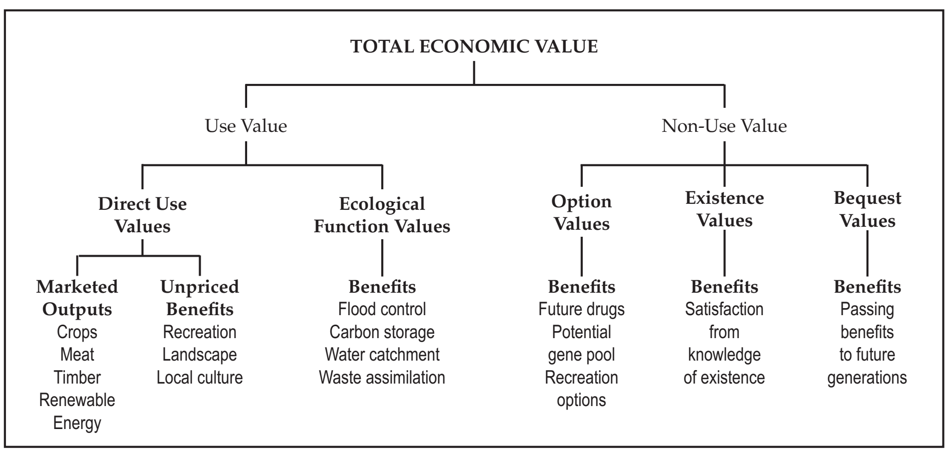
10 A number of studies have examined the role of tropical rainforests as carbon 'sinks', for example. Fankhauser (1993) calculates the carbon sequestration value of such forests at around US$ 20 per tonne, while work reported by Van Kooten (1992) produces figures varying between US$ 2 and US$ 275 per tonne. Aylward et al. (1995:6), using Fankhauser's figure, suggest that at this price preserving tropical rainforests as carbon sinks may well be the most beneficial option. Aylward (1993) has also calculated that the worth of extracted biodiversity as an input into the pharmaceutical research process may lie anywhere between US$ 15 and US$ 24 million per species.

- Valuation seeks to monetize unpriced benefits and costs so that they are not precluded from consideration in decision-making processes. Samples et al. (1986), for example, have calculated *preservation bids* that can be used in estimating the social value of species preservation (their research encountering an annual willingness to pay approx. US$ 36-57 for the humpback whale within a group of 240 paid student subjects).

- Valuation, by internalizing such benefits and costs, offers a more comprehensive frame-work for policymaking. The environmental and social impact report on the Cana Brava Hydroelectric power plant on the Toncantins river in the central and western parts of Brazil, for example, led to a figure of US$ 25.5 million [6 per cent of the total project cost] being incorporated subsequently into the Management Plan to provide for the rehabilitation of degraded areas, to conserve the local fauna, to mitigate impacts on the wild fauna and ichtyofauna, and to rescue important archeological artifacts among other things (IADB 2000).

Valuation is not an unchallenged panacea, however, and has its fair number of critics[11]. These challenges notwithstanding, accurate evaluation also remains critically dependent upon precise technical, scientific and economic data – data which may frequently be either unavailable, or costly to obtain. This is particularly true, as Section 4 of this paper shows, in the case of Central and South American river fisheries. Yet, in the absence of an accepted alternative technique that permits the aggregation of both monetary and non-monetary benefits and non-benefits within a standard evaluating framework, such methodological limitations are perhaps excusable. Consequently, this report elects to summarize the extant literature [published and gray] through recourse to the TEV (Total Economic Value) framework advanced by Hodge (1995:7), with the objective of assessing the direct economic and the wider

Figure 1: Total economic value and its components



Source: Hodge (1995:7)

11 Criticisms of economic valuation techniques generally divide into three categories. First, that it is impossible to assign a monetary value to intangibles like human life, the importance of species diversity, depletion of the ozone layer, preservation of pristine rainforests etc., and attempts to do so merely degrade the whole exercise. Second, that the valuation process is open to manipulation, whether consciously or unconsciously [given the set of values held by the evaluator], with the means – the valuation process – simply being used to justify the desired ends (Bowers 1990). Third, that valuation techniques derived in the developed world are rendered meaningless in the developing world – for example much of the work on fish population dynamics and eutrophication resulting from farm chemical runoff used to inform valuation methodologies has been done in temperate conditions, and similar causal relationships may not prevail in the tropics.

social values of Central and South America's river fisheries.

3.1 Total Economic Value

TEV can be disaggregated into two sub-components: use values and non-use values. Use values in turn can be further decomposed into direct use values [both marketed and non-marketed] and ecological, or indirect, use values, while non-use values can be split into option, existence and bequest values (See Figure 1).

In the case of Central and South American rivers, *marketed use values* would include the capture of food fish for local and/or external markets and ornamental fish for export (OFI 2002), while non-fishery marketed use values of the region's rivers might include (although would not be limited to) the hunting of crocodiles to satisfy international market demand for luxury leather goods (NRC 1983; Wallis 1980), the generation of hydro-electric power (Correa 1999), and the panning for gold from barges in the Peruvian Amazon (www.panda.org). At a secondary level, it also includes forward and backward linkages in the fisheries, for instance, activities such as the construction of boats/gear (backward) and the subsequent processing and marketing of the harvested resource (forward), which constitute the wider social value in the terminology of the TOR. *Non-marketed usevalues* of the fishery would cover fish caught for the purposes of self-consumption (Diegues 2002), as baitfish, or for recreational and sport purposes (www.thefishfinder.com/links/Destinations/Lodges South_America/Ref), with the riverine environment permitting further non-marketed use values such as the abstraction of water for irrigation (FAO 2000b), washing clothes (Escobar et al. 2003) or recreational purposes. While the river basin affords a number of *ecological, or indirect, use values* including benefits through flood control and the assimilation of mercury effluents resulting from the gold mining process (www.unido.org), the fisheries-specific benefits principally relate to the relationship between species diversity and the underlying stability and resilience of the aquatic ecosystem (Peterson et al. 1998; Kublicki 2003). Overfishing may well change local fish population dynamics and have unintended impacts upon the wider ecosystem[12] although to date little work has been done globally to quantify these impacts in economic terms.

In contrast, *non-use values* refers to the value that *resides* in the particular ecosystem [in this case the riparian environment] and is presently unexploited - either because the individual or society chooses (or is coerced) to conserve the resource at the present point of time (option value) for the benefit of future generations (bequest value) or simply because the resource is seen as an asset (existence value).

The concept of *existence values* gained recognition following a 1967 paper by Krutilla that evaluated allocation decisions involving unique natural resources. The Southern Austral cone of Chile, for example, not only provides consumptive services to scattered local communities, but it also satisfies the *armchair environmentalist* who does not make use of the asset but derives pleasure from the preservation of such a complex pristine environment. Indeed, an American environmentalist Douglas Tomkins was so captivated by the beauty of the region that he was prepared to actually invest substantial funds to preserve the uniqueness of this environment by donating the land acquired for the Parque Pumalin Foundation, which now manages just under 300,000 hectares

12 Jackson and Marmulla (2001), for example, has documented how historical overfishing has led to the collapse of coastal ecosystems, while Pauly et al. (1998) document the very real dangers of fishing down 'marine food webs'. See too, the various papers emanating from the Ecopath with Ecosim project (www.ecopath.org).

(Larrain and Stevens 2002; www.gochile.cl)[13]. Some organizations (Rainforest Alliance, Save the Whale, etc.) explicitly use existence values as a means of encouraging concerned individuals to donate to causes oriented towards protecting endangered species and/or ecosystems. Fish species and fisheries too may have existence values, and Samples et al. (1986) have analyszd the preservation value of the humpback whale.

Option values refer to the returns that might be expected if the resource were to be subsequently exploited by the current generation. Peters et al. (1989), for example, suggest that the option value of a hectare of Amazonian rainforest could rise to as much as US$ 9,000 once the commercial value of the standing forest has been factored in, while Myers (1988) suggests that a hectare of tropical forest could produce US$ 200 of wildlife products annually[14]. The benefits are perhaps even greater once the potential of the resource as a gene pool is incorporated; the US pharmaceutical giant Merck, for example, paid US$ 2 million for the right to evaluate the commercial prospects of a limited number of plant, insect and microbial samples collected from Costa Rica's conservation areas in 1991/2 (Eberlee 2000)[15]. While the aquatic gene pool is presently being tapped to support transgenic crop research (Thorpe and Robinson 2003), the more palpable (fisheries) option value is related to the failure to fully exploit fish stocks. As increased fishing effort would simply convert this option value into a direct, observable use value, there is a strong case for incorporating such option values (where computation is possible) into any TEV evaluation.

Related to option values is the notion of *bequest values*, whereby the individual or society elects to conserve the resource for the benefit of descendents or future generations[16]. Generally unquantified, although frequently expressed, such motives are often encountered in field research.

Ideally then, a thorough assessment of the TEV of Central and South American river fisheries would aggregate both use and non-use values of the underlying resource. However, as many of these values [particularly non-use ones] remain unpriced, it is crucial to apply appropriate evaluation techniques to accurately capture their true value.

3.2 Valuation Techniques (Applicable to River Fisheries)

The *market analysis/value* approach is the most commonly used natural resource valuation method, largely due to its ease of application. It is relatively undemanding to count the ornamental fish and reptiles extracted from the Orinoco River and to obtain a figure for the value of the Negro's ornamental fish and reptile trade by weighing them in accord with their marketed price. Two caveats are in order. First, while there are well-established marketing channels for such products that aid information retrieval, not all trade may pass through such formal avenues, particularly if such a trade is prohibited due

13 Pumalin was one of the six protected areas included in a 1997 Chilean National Parks Service study on the total economic value (TEV) of such areas. Significantly, the study concluded that, thanks to non-use values, the estimated TEV was almost 40 times higher than the monetary incomes obtained by the residents of the areas (De la Maza 1997).

14 Both of these studies indicate the superiority of a managed approach to the forest resource, and the alternatives such as ranching in the Peters case and logging in the Myers study generate less income (US$ 3,000 and US$ 150, respectively).

15 Crook (cited in Eberlee 2000), however, is more downbeat about such bioprospecting, commenting: "compared to alternative values of the land, for example in timber values alone*, the earnings appear unlikely to increase the real value of natural ecosystems to any real extent."* (The emphasis is the author's.)

16 If there is no expressed desire to either subsequently exploit the resource for one's own benefit, or to conserve it for the benefit of one's descendents, then bequest and option values become indistinguishable.

to the fish/reptile being placed on the CITES Appendix I list of most endangered species, as is the case with *Dermatemydidae*, the Central American river turtle. Second, there is a question of which price is the appropriate one, the final price paid by the British collector of tropical fish in Manchester, or the price paid to the Brazilian fisher who ensnares the fish.[17]

In relation to this, the *Effect on Production* (EOP) method is used to examine the change in direct use values resulting from a given environmental activity, such as identifying the physical effects associated with the change. Market values can be generated if these physical effects are then monetized through recourse to relevant market and/or shadow prices. The partial closing of the local river channel following construction of the Porto Primavera dam in Brazil, for example, sharply reduced fish migration and caused upstream fish catches to fall by around 80 per cent (Kudlavicz 1999), although no monetary value was imputed to such losses.

Alternative techniques are necessary to establish the economic value of sport fishing as the market value of the fish caught by recreational fishers invariably bears little relation to the value placed on the activity itself. For example, *The Travel Cost Method* (TCM), although originally developed to evaluate the worth of public recreation locations in the USA, could potentially be deployed to gauge the benefits of freshwater dorado (bream) fishing in the Plate and Parana rivers in Argentina (www.jeep-ika.com.ar, www.acuteangling.com). In this case, aggregating the travel and opportunity costs incurred by surveyed individuals would produce an indirect measure of the unpriced benefits of recreational fishing on the river.

In some instances, direct markets (and prices) are absent and so *hedonic methods* are used by observing the prices of surrogate goods (generally property values and labor wage-rates) –that are affected by the environmentally based activity. Although the authors are not aware of any studies employing hedonic pricing methods to capture non-marketed use values within a fisheries context, riverine environments do offer some scope for the application of such techniques. For example, water abstraction for irrigation purposes could be valued by interrogating property registers to identify the price differential between irrigated and non-irrigated land that is identical in all other respects.

Preventative Expenditures (PE) and *Replacement/Relocation Cost* (RC) methods are more commonly used to track the amounts that people are prepared to spend to mitigate the degradation of the environment or ecosystem (PE) or alternatively, to either spend to restore the environment to its original state after it has been adversely affected (Replacement Cost), or to *replace* the environment by moving away from the degraded area (Relocation Cost). Although income constraints in the developing world are likely to bias both PE and RC valuations downwards, this can be offset by commissioning objective professional estimates of such costs, as is increasingly commonplace in Environmental Impact Assessments (EIA). In the case of the Porto Primavera dam alluded to above, the construction of fish ladders to minimize the impact of the dam on species migration would have been an example of PE, while the RC of fishing and other displaced households following construction of the Yacyretá dam was priced at US$ 24,000 per household.[18]

17 Equally, the quantity of food fish harvested from, say, the Bio-Bio river can be multiplied by market prices to obtain the direct food fish value of the fishery. If levels of fish used for bait or subsistence can be ascertained, then appropriate shadow prices may be applied to generate the non-marketed use values of food fish. While there is a greater likelihood of food fish catches going unrecorded, the difference between the price paid to the fisher and the final market price is likely to be correspondingly lower than in the ornamental fish case.

18 This value was the cost of the homes built at the beginning of the relocation process, but cheaper constructions, known as *shellhouses* were later estimated to have cost just US$ 4,000 by the residents. This discrepancy raised questions as to which figure (if either) represents the *true* relocation cost. Kudlavicz (1999) has also pointed out that the limited number of displaced Brazilian fishermen who were actually compensated following the early Brazilian dam projects were often rehoused in the city, forcing them to abandon their traditional activities.

Finally, *the Contingent Valuation Method* (CVM) surveys seek to elicit people's willingness to pay (WTP) to maintain/retain a specified environmental benefit such as the preservation of the Amazonian river dolphin (currently on the CITES Appendix II list of threatened species), or willingness to accept [WTA] compensation for a loss of environmental quality. Although widely applicable, and indeed indispensable if option and existence values are to be obtained, the technique has two principal weaknesses. First, unlike the TCM, it does not require survey participants to back up their response by parting with cash, and so a hypothetical bias is more likely[19]. Second, there are problems in identifying the relevant target group to survey, particularly in developing countries where information about environmental benefits is limited, and then *grossing-up* these values to get an aggregate WTP or WTA, particularly in those instances where non-use values are concerned (Winpenny 1991:60/1).

A variety of techniques are available to help determine the value of the distinctive components of riverine ecosystems and the fisheries found therein. While the methodology used for computing the value emanating from the direct use of fisheries resources is relatively straightforward, measurement of both indirect use values and non-use values is more problematic. The main difficulty in applying such techniques in the developing world is, however, the paucity of primary data that is presently available and the cost of augmenting such a limited knowledge base. Such shortcomings seriously hamper attempts to construct a robust picture of the TEV of any region's fisheries, including Central and South America.

3.3 Aggregating Use and Non-Use Values and Decision-Making

Barbier (1993) suggests that a comprehensive evaluation of the full potential TEV of any environmental resource or ecosystem can be obtained by adding the various components together. In other words,

TEV = (Use + Non-Use) Values

or alternatively,

TEV = (Marketed + Non-marketed + Ecological + Option + Bequest + Existence) values

A failure to either include, or correctly value, any of the component parts is likely to result in environmental degradation. For example, if both ecological and non-use (option, bequest and existence) values are excluded from the equation, then the misleading impression is given that TEV can be maximized by identifying marketed and non-marketed outputs. In the riverine fisheries case, a logical corollary of this is overfishing, although the private returns to increased fishing effort have a high opportunity cost at the margin (possible species extinction leading to an irreversible loss in option, bequest, existence and ecological values). It is equally crucial that decision-making that may affect the prevailing *status quo*, whether it be to authorize new nets or vessels in a fishery, to abstract or change the volume and flow of water, or to construct new settlements on the river banks, is subjected to scrutiny in terms of the impact such a policy/project will have on aggregate TEVs.

19 In the real world, actual bids have a resource cost. In the hypothetical CVM world, bids do not and so the respondent may be inclined to over- or underbid. Pearce and Turner (1990) further identify other factors, such as design (respondents may be swayed in their valuation decision by the information supplied to them), starting-point (responses are affected by the initial valuation price suggested by the researcher), strategy (respondents believe their response may, in fact, affect the course of events), or vehicle (payment method proposed), as potential obstacles to the effective application of CVM methodologies.

Historically, following the lead of Dupuit (1844), cost-benefit analyses (CBA) were deployed as a decision-making tool to quantify the costs and benefits accruing from major proposed projects. Project acceptance was conditional upon TEV being improved (i.e., net benefits exceeding net costs), with a positive net present value (NPV) the normal guiding criterion. However, the utilitarian and anthropocentric basis of CBAs (Turner 1991:213) and their depreciation of environmental values (Rees 1985:324) led some to place more emphasis on the generation of Environmental Impact Analyses (EIA). First advanced by the US environmental lobby during the 1960s, EIA purports to provide a more comprehensive appreciation of the environmental consequences of a proposed course of action[20] although the technique is open to similar criticisms to those leveled at CBA. The most common criticisms of such aggregating techniques include:

- *The Distribution of Costs and Benefits.* Although the net outcome may be favorable, not everyone benefits. For example, while the Tucurui Hydropower Complex (THC) in Brazil raised the total commercial fish catch from 1,500 to 4,600 tonnes per year, catches downstream from the dam fell by 80 per cent (WCD 2000:61). Some projects make specific provision for the losers to be compensated, as in the case of the Yacycretá dam project where affected fishers were offered US$ 8,000 to renounce any further claims for compensation.

- *Irreversibility.* Project acceptance sets in motion a chain of events that may well be irreversible. The decision to construct the THC, for example, is irreversible and had the consequence of causing the total number of fish species to decline by over 28 per cent (50 species) in the reservoir area after damming (WCD 2000:60).

- *Discounting.* As individuals generally exhibit a positive time preference (preferring present to future satisfaction), it is incumbent to discount future benefits and costs so that they reflect such a preference. The problem arises in choosing the appropriate discount rate, particularly as Foy and Daly (1989), among others, have argued that environmentally sensitive benefit streams should be subject to a low(er) discount rate. In the case of the THC, for example, hydroelectric costs per MWh ranged from US$ 40 to US$ 58 depending on whether an 8 or 12 per cent discount rate was applied.

- *Immeasurable Items.* Despite the plethora of valuation techniques identified above, the worth of certain resources or ecosystems may still remain unquantifiable in monetary terms. Regional examples of this include, for example, Lake Titicaca (Peru and Bolivia), the El Tigre wetlands (Guatemala), Laguna Merim and Bañados del Este (Brazil and Uruguay), the Patagonian wetland lagoons (Argentina), the Llanos (Venezuela) and the Pantanal (Brazil, Bolivia and Paraguay), all of which have been identified for possible inclusion on the list of World Heritage sites (www.unep-wcmc.org).

These caveats notwithstanding, the objective of the next section of this report is to apply the methodological principles enunciated above in reviewing the extant literature (both published and gray) so as to provide some preliminary indications as to the true economic value of the region's fisheries.

20 Bisset (1978), however, has shown they are just as prone to manipulation and value judgments as CBAs.

4. TOTAL ECONOMIC VALUE OF THE REGION'S FISHERIES

4.1 The Amazon Basin

While Central and South America's principal river system, the Amazon, accounts for 20 per cent of the world's freshwater and is home to four-fifths of the 2,500 known species of freshwater fish, it is paradoxically the very size and associated diversity of its ecosystem that has precluded extensive study of the TEV of the system. Indeed, the most comprehensive work undertaken on this river basin, by the Amazon Rivers Program of the Rainforest Alliance under the direction of Michael Goulding between 1990 and 1999, focused on methods to protect and promote the conservation of Amazonian aquatic wildlife rather than place a tangible value on its economic or social worth[21]. Equally, even the economic research on specific riverine subsystems has generally not been formulated with the primary objective of assessing economic value, but rather to document information deficiencies (viewed from a management perspective) and alternative or improved management models, as will become clear in the ensuing review below (in which the studies are grouped together by region rather than by their relative merits in relation to the given TOR). Fortunately, information and data on economic values are a little more apparent in those instances where major ecosystem changes, such as the construction of dams or new industrial waterways, are proposed, as detailed in Section 5.

A. *The Commercial Fishing Sector in the Regional Economy of the Brazilian Amazon (Almeida et al. 2003).*

This study attempts to highlight the importance of the Amazon-Solimões river to the regional economy by estimating employment within and the gross income and value added generated by the commercial fisheries sector in 2001. In their quest, the authors visited all three major cities with the population over 250,000 (Belém, Manuas and Santarém) and one quarter of the 48 smaller cities to interview Municipal Fishers' Union leaders, the Coastguard and all boatyards, fish processing plants, fishing gear stores, gas stations, ice factories and fish restaurants. In addition, a few fish vendors were interviewed in all public fish markets (with the exception of Belém and Manuas, where sample groups were chosen).

On the basis of the information collected, statistics were collected of the total fleet [5,457 vessels], number of commercial [29,089] and subsistence [49,955] fishers, and landings in urban markets [46,269 tonnes]. The total estimated sectoral income of R$ 472 million (US$ 160 million) is computed by aggregating the assumed income arising from four subactivities (input and input provision, fishing, processing and marketing, and services), although the major portion is derived from fishing, processing and marketing (89%). The authors then used these amounts to show both the lacunae in official survey methods and the real economic superiority of fishing over forestry in the region. For the former, the most recent agrarian census of 1997 estimated that just 17,742 persons were employed in the fisheries sector, resulting in the sector not receiving the attention and support it merits. For the latter, the authors pointed out that the NPV of the fisheries sector, at R$ 93 million or R$ 11,238 per hectare (US$ 31.62 million or US$ 3,821, respectively), is almost double that derived from forestry, at R$ 50 million or R$ 6,250 per hectare[22].

21 See for example "The Catfish Connection: Ecology, Migration, and Conservation of Amazon Predators" (Barthem and Goulding 1997), "Floods of Fortune: Ecology and Economy along the Amazon' (Goulding et al. 1997), and "So Fruitful a Fish: Ecology, Conservation and Aquaculture of the Amazon's Tambaquí" (Araujo-Lima and Goulding 1997). In contrast, only a cursory three-page article "The Economic Value of the Amazonian Flooded Forest from a Fisheries Perspective" (Araujo-Lima et al. 1998) appears to have emanated from the project regarding valuation of the resource.

22 The R$ was worth approximately US$ 0.34 in September 2003.

While the contribution of Almeida et al. is welcomed, providing as it does a tangible figure for the primary and secondary marketed use values generated by fisheries in the region, the findings must be treated with some caution. Not only do the authors provide no details as to how they arrived at various figures, for example, the assumption of 1.14 fishers per household used in estimating the number of subsistence fishers, and the stated NPV quoted above, but there also appears to be a fundamental definition problem because the term ***commercial*** is used in two senses. On the one hand, it is used to identify those ***employed*** in the commercial fleet while, on the other hand, it is used to encompass the value of the landings of both the commercial and subsistence sectors, which are two rather different things[23]. Equally, MacFadyen's global findings (2002: Box 1) *that for every one fisher there are approximately ten employed in input or postharvest operations* stands in stark contrast to the study's findings, which suggest that there are nine fishers for every one person involved in other fish-related activities.

B. Production Analysis of Commercial Fishing in the Lower Amazon (Almeida et al. 2000)

In this paper, Almeida et al. use a Cobb-Douglas regression model to estimate the production function of commercial fishers in the Lower Amazon (defined as those fishers supplying the fourth largest fish market in the Amazon, at Santarém), with a view to contributing to the "formulation of policies in support of the region's small-scale floodplain lake fisheries" (p.1). While fishers operate in pairs from canoes using nets, long lines, harpoons and fishing poles, the catch is stored in a separate boat with a built-in storage compartment. Larger storage boats are often owned by non-fishers who supply the boat and cover the expenses for every voyage, purchasing the daily catch at a price related to the prevailing market price for each species.

Standard economic assumptions were applied (boat owners are profit maximizing pricetakers who possess perfect market information, and input and output markets are perfectly competitive) although the paper made no subsequent attempt to either relax such assumptions or discuss the likely impact of relaxing them upon the regression findings. Catch size and composition were obtained for 2,992 landings in 1997 as part of an IARA/IBAMA project, and supplementary research established local values for gear, canoes, fuel and ice[24].

The paper concluded that economies of scale were minimal in the Lower Amazonian commercial fishery, before suggesting that production could be increased through the provision of lower cost ice. While the paper did not go as far as computing the revenues generated by the fishery, and hence marketed use values, access to the raw data would permit such a calculation to be made. No consideration of non-marketed use values or non-use values was attempted beyond the recognition that four major species in the Lower Amazon (i.e., the tambaqui, surubim, piramutaba and pirarucu) are under excessive pressure, and the final rejoinder that the best policy is more cheap ice "combined with appropriate management measures to protect vulnerable species" (p.7).

C. Amazonian Fisheries: Socioeconomic Issues and Management Implications (Fernandez-Boca 1998)

Fernandez-Boca reviews the current state of inland fisheries in the Peruvian Amazon with a view to identifying key gaps in the economic,

23 Equally, using the term subsistence in this sense is incorrect as it fails to capture the values generated by the wholly subsistent fishers [non-market use values] whose landings do not enter the market. *Semi-commercial* fishers might be a better term.

24 Information on voyage duration and trip itinerary, ice and fuel consumption, number of fishers and canoes, and sale price of fish was obtained at the same time.

social and biological information needed to assist fishery decision-makers.

Noting the high levels of animal protein derived from fish products in parts of the Amazon (for example, 61 per cent in the Ucayali valley), the author proceeds to show how commercial fisheries have grown considerably in importance to service this demand, with commercial vessels from Manaus now undertaking round trips of up to 2,500 km in pursuit of fish. While official data are plotted to show a *modest* upward tendency in landings at both Iquitos and Pucallpa over the period 1980-92, this was accompanied by a sharp increase in effort (and a marked drop in cpue) that suggested some likelihood of overfishing. The failure to value these recorded landings, however, preclude us from identifying whether marketed use values have risen, declined or remained stable over time.

D. The Experience of Community-based Management of Middle Amazonian Fisheries (Isaac et al. 1998)

This paper by Isaac et al. seeks to propose a new management model for floodplain fisheries in the state of Pará in the Middle Amazon, where around 1.2 million people depend on fishing for their livelihood and 200,000 are active fishers. In order to emphasize the importance of developing an effective management model, the authors provide a fleeting idea of the marketed use value of the fishery by multiplying the 4,000 to 6,000 tonnes annually landed at the four principal towns in the Middle Amazon (Santarém, Alenquer, Monte Alegre and Óbidos) by average fish prices [US$ 1 per kg] to produce a regional income figure of US$ 4-6 million per year. Although the authors comment that the subsistence portion of the total catch is much larger, they fail to impute a value for this.

E. Strategies for Managing Biodiversity in Amazonian Fisheries (Ruffino 2001)

Ruffino's paper examines the experience of, and lessons learned from, the 1991-98 IARA project on participatory management in the Middle Amazon[25]. While chiefly concerned with documenting how biodiversity has been incorporated into fisheries management in the case of migratory ***caracoideae***, sedentary species and large migratory catfish, the paper suggests that the Amazon fishery has a ***use value*** [marketed and non-marketed food fish] in the order of US$ 100 million per year, based on a catch of 200,000 tonnes per year (as estimated by Bayley and Petrere 1989) and an average price of US$ 0.50 per kg. Ancillary information culled from secondary historic sources is provided on the export fishery; prawn and piramutaba exports from Pará alone were worth around US$ 35-45 million between the 1970s and 1990s (10 per cent of the state's total exports), and ornamental fish exports numbering around 17 million by the late 1980s were worth US$ 2 million (employing 10,000 people, principally in the Rio Negro region of Amazonas State). An overview of stock exploitation levels for the major riverine species is also given, as shown in Table 6, although no price data are disclosed).

While the paper notes the recent emphasis given to sport fishing with the establishment of "The National Program for the Development of Amateur Fishing" [PNDPA], it also confirms the absence of reliable statistics to help gauge its economic worth or impact.

F. The Floodplain Resources Management Project (FRMP- Provárzea)

The FRMP has four components: strategic studies to support public policy formulation (notably in the areas of natural resource

25 The findings from this project contributed to formulation of the Floodplain Resources Management Project (FRMP-Provárzea 2000) sponsored by IBAMA and the international community [See F.].

Table 6: Landings in Amazonas State

Species/Landing Point	Peak Landings – tonnes (Year)	Present Landings-tonnes	MSY?	Status of Stock
Piramutaba	32 000 (1977)	20 000	20-21 000	Overexploited
Tambaqui (Manaus)	15 000 (1972)	800		Overexploited
Surubim (Amazonas)		2 500		Overexploited

management, environmental legislation, and the economic and environmental use of the region's resources); promoting the development of innovatory systems of management that are economically, socially and environmentally sustainable; co-ordination of the project; and, most significantly in the context of this report, implementation of an integrated monitoring and control program, including the construction of a statistical data-bank on the riparian fishery. The program produces excellent monthly data on landings (by species, waterbody, vessel and gear type) and average prices for seventeen municipalities scattered along the river[26]. The results for 2001 were published in a 73-page document, *Estatística Pesquiera do Amazonas e Pará – 2001,* which details the methodology employed to collect and store the data, and an analytical summary for each municipality. The report is accompanied by one hundred tables, plus an annex containing the questionnaire applied in the study. On the basis of the data provided, it is a relatively simple matter to compute the marketed use value of the fishery in each municipality, while complementary tables can be constructed to show the economic value of individual species fisheries (such as the Apapá and the Mapará) for the surveyed municipalities. However, it is interesting to note that the project has not conducted this level of analysis so far with the large quantity of verifiable and good quality data available.

Two things emerged from this project. First, the wide variation in prices that prevail across regional Amazonian ports (in the case of Apapá, average prices vary from R$ 0.50 (US$ 0.21) in Monte Alegre to R$ 2.17 (US$ 0.93) in Tabatinga, a difference of 334 per cent, the difference for Mapará is even greater – 592 per cent), variations that complicate further the task of placing an economic value on the Amazonian fishery (See Table 7.).

Second, based on the figures available in the 2001 report, it is possible to calculate a crude figure for the first sale value of the fishery then and the quantity of landings (See Table 8.). However, it should be noted that for whatever reason, the project team has not done this and there may be a good reason why they feel that such a calculation would be misleading.

Thus, according to the Provarzea project, the current best estimate of the value of the fishery on the Amazon River is R$ 49,622,541 or US$ 21,337,692.

G. The Sustainable Development Reserve of Mamirauá, Amazonas State (Begossi 2002).

Begossi's paper provides an overview of Mamirauá, a 1.1 million-hectare reserve located entirely in the Amazonian flooded forest, between the Solimões, Japurá and Auati-Paraná rivers. Created in 1991, the reserve is home to 5,277 individuals. The annual mean earning of families in the reserve is US$ 900, with 72 per cent of this income being generated through fisheries activity. While the author suggests that primary exploitation of the reserve [i.e., fishing, logging, caiman hunting and agriculture]

26 The municipalities chosen extend from Tabatinga in the far western reaches of the Upper Amazon, to Belém in the lower eastern reaches. The locations can be seen, and the statistics also accessed, via the main web page [http://www.ibama.gov/br/provarzea/varzea/menu.php?id=7].

Table 7: Landings and price data for Amazonas

Municipal	Landings	Ave Price	VALUE R$	Landings	Ave Price	Value
Abaetetuba	155 109	0.95	147 353.55	1 066 811	1.10	1 173 492.1
Alenquer	80	1.43	114.4	5 030	0.95	4 778.5
Alvarães	-	-	-	-	-	-
Belém	177 505	1.01	179 280.05	220 870	1.17	258 417.9
Coari	-	-	-	-	-	-
Fonte Boa	-	-	-	245	N/A	-
Itacoatiara	-	-	-	384 795	0.69	265 508.55
Manacapuru	-	-	-	226 104	0.51	115 313.04
Manaus	-	-	-	2 481	1.25	3 101.25
Monte Alegre	8 169	0.5	4 084.5	198 262	0.74	146 713.88
Óbidos	5 011	0.77	3 858.47	1 046 976	0.65	680 534.4
Oriximiná	1 144	1.02	1 166.88	19 683	0.94	18 502.02
Parintins	3 703	0.81	2 999.43	264 831	0.83	219 809.73
Prainha	-	-	-	111	0.70	77.7
Santarém	40 840	1.19	48 599.6	860 216	0.76	653 764.16
Tabatinga	983	2.17	2 133.11	18 375	2.56	47 040
Téfe	1 010	0.52	525.2	2 420	0.37	895.4
Totals	**393 554**		**390 115.19**	**4 317 210**		3 587 948.3

* The first three columns relate to the Apapá fishery, the latter three to the Mapará fishery. Landings are in kilograms, and prices are average prices in R$ per kilogram.

yields a marketed use value of US$ 2.4 million annually between 1991 and 1995, this figure is significantly overstated due to summative errors in the accompanying table[27].

H. Projeto Piaba: Developing toward a Sustainable Natural Resource in Amazon Freshwater Fisheries

Projeto Piaba is an ongoing community-based interdisciplinary project established in 1989 to understand the ecological and sociocultural systems of the middle Rio Negro basin, Amazonas, Brazil, in order to conserve and maintain the live ornamental fishery and other renewable resources at commercially feasible and ecologically sustainable levels. Nevertheless, it does also provide some aggregated data on the ornamental fish for export market, suggesting export receipts totaled US$ 2,216,620 in 1998 when 18.5 million fish were exported[29].

I. Siamazonía (Sistema de Información de la Diversidad Biológica y Ambiental de la Amazonía Peruana)

Siamazonía is an offshoot of the National Environmental Council (CONAM), being entrusted with the management and exchange of information relating to the biodiversity and ecology of the Peruvian Amazon. As such, it does not purport to value the watershed, nor has it produced any

27 Table 1 [p.17] effectively double-counts fishery resources. Removing the double-counting error produces a lower revenue stream [US$ 1.5 million], of which fisheries accounts for about two-thirds.

28 In mid-2001, the Real was worth US$ 0.43.

29 The project authors note that this is only the figure for ornamental fish exported officially from Manaus. If, as the authors suggest, between 30-40 million ornamental fish are caught annually, then this component of marketed use value may be substantially underestimated.

Table 8: Landings and gross first-sale value on the Solimões and Amazon rivers, 2001[28]

Municipality	Tonnes	Gross first-sale value in R$
Abaetetuba	3 363	2 690 400*
Alenquer	247	254 381
Alvarães	73	nd
Belém	9 295	13 570 116*
Coari	577	766 373
Fonte Boa	337	nd
Itacoatiara	1 593	1 593 039
Manacapuru	2 544	2 174 551
Manaus	12 868	13 250 229
Monte Alegre	785	594 234
Óbidos	1 879	1 570 528
Oriximiná	269	290 548
Parintins	2 793	3 644 405
Prainha	104	80 000
Santarém	3 995	4 417 097
Tabatinga	1 197	3 394 015
Tefé	1 986	1 332 624.50
TOTAL	43 904	49 622 541

Source: ESTATÍSTICA PESQUEIRA DO AMAZONAS E PARÁ - 2001

* The total value is not known; these figure are average values based on the average first-sale price in that municipality multiplied by total landings.

working papers. Its database, however, does offer a limited snapshot of the quantities of fish extracted and/or marketed in the municipality of Loreto that could be used to compute a use value [marketed and non-marketed food fish] for the vicinity.

4.2 Other Inland Waterbodies

If there are few sources offering any indication as to the economic value of Amazonian fisheries, there is a real paucity of information of any sort on the other river systems in the region. An extensive Internet search allied to a thorough search of the main economic and social science bibliographic databases disclosed no articles of any relevance to this report.

A number of other studies on river fisheries make only a cursory mention of documented landings in the study region. Such studies include the following:

Coordenação-Geral de Capítulo 2: Tema: Recursos Pesqueiros: Pesca Extractiva e Aqüicultura (DFRP 2001)

This review of catch statistics for Brazil notes that overall catches rose steadily during 1960-85 when around 78 per cent of catches came from marine waters and 22 per cent from inland waters. Since that time, there has been a decline to 744,600 tonnes/yr: 60% from marine sources and 40% from inland waters. But by 1990, the production had fallen to 640,300 tonnes. The rise in production, however, was largely attributable to inland (culture) production, given that marine production appears to be stagnating. Inland capture fisheries (of which 98 per cent were fish and 2 per cent crustacean, represented 25 per cent of the national production for that year) have declined since 1996 due to gold mining, domestic and industrial pollution, and agricultural inputs, the construction of barriers for hydroelectricity and the canalization of rivers (DFRP 2001). However, many of the instruments used to mitigate these problems cause new problems for the maintenance of fish stocks such as the restocking of exotic species. The study also notes that marketing of inland fisheries is dominated by a network of intermediaries, from the individual trader (generally someone from within the community) that specializes in buying and selling fish to the representatives of companies that buy and finance production. Because the extent of this marketing is small and irregular, it is difficult to generate internal capital. Producers are highly dependent on sources of finance, be it for the improvement of the species, and credit for hut supplies, ice, diesel oil, or fishing equipment.

5. THE ECONOMIC IMPACT ON FISHERIES OF DAMS AND WATER MANAGEMENT SCHEMES

According to the *Pilot Analysis of Global Ecosystems (PAGE): Freshwater Systems* report, much of the degradation of the world's freshwater systems is due to habitat destruction, construction of dams and canals, introduction of non-native species, pollution, and overexploitation. (www.rivernet.org/general/WRI%20report.htm). With comparatively few non-renewable sources of power and so much water, it is not surprising that states in Central and South America have harnessed their water resources to generate energy, improve transportation across long distances, and for irrigation development. The continent provides many examples of large dams, hidrovias (large scale industrial canals), and at least one example of a large-scale irrigation development (Sistema Hidraulico Yacambú in the Llanos of Venezuela Nucete 2000).

An evaluation of the full impact of dams is an integral part of the EIAs and with increased public awareness of the potential negative side-effects of dam building, the costs of building dams is now expected to accommodate their impacts on the environment and populations from the local level up to the global level, as it is possible (See Section 3.) to place a value on the loss of biodiversity and cultural heritage among other things. The negative effects of dams are most observable in the short term, i.e., in the immediate aftermath of the construction. Such impacts include damage to the physical environment (first order impacts) as large areas of land (often forest in the case of Central and South America) are flooded; loss of aquatic and land-based species diversity as land disappears and the oxygen levels of water change; downstream effects as natural changes in flooding cycles are disrupted; increased erosion of river banks as the flow of water rises in parts of the river; and increased anoxia in other parts of the river as the natural water flow is disrupted (second order impacts). Finally, there are third order impacts that follow from the first two and are characterized by lower fish catches; a rise in disease (malaria for example) as water levels and ecosystems change; changes in microclimate as valuable wetlands and watersheds are damaged; and social displacement that has direct costs (of moving peoples) and indirect costs (such as the fragmentation of vulnerable indigenous groups in parts of Brazil).

Some positive social benefits are also derived from dam construction. For example, Boa Nova and Goldemberg (1999 cited in WCD 2000) note that demographers attribute the reduction of the birth rate in Brazil to the increased availability of cheap hydroelectricity that the authorities in Sao Paolo (among others) provide to 2 million slum residents. With access to electricity, residents are able to watch television (a prime source of information on family planning). Other benefits that accrue from dam construction include increased employment opportunities in the construction phase and later in (expanding) industry as a result of increased power production. It is worth noting, however, that the WCD 2000 review of large dam projects came to the conclusions that while there are benefits accruing from their construction, these are not likely to trickle down to those who have borne the brunt of the costs of the construction.

Creating a legislative framework that would allow adequate consideration of the economic and social impacts of large dams would be a step forward in minimizing (if not eliminating) the negative impacts of dams. The WCD notes that the Rio Grande Hydroelectric

Project in Colombia incorporated a royalty payment scheme whereby those benefiting from the production of electricity contributed to a fund that was used to compensate those who had lost out through the building of the dam. The same principle was also applied in the Tucurui dam case. (See below.)

Evaluating the impacts of dams, canalization and water abstraction is a complex task because the effects can spread much further than the immediate physical area. The WCD report (2000) notes that while a cost-benefit spreadsheet analysis may be useful for some projects to evaluate impacts, in the case of most large dams they are often too complex for such an exercise to have any meaning; for example, livelihood, environmental and economic impacts do not allow for easy currency or metric comparisons. Furthermore, the report notes that poor accounting of the true costs and benefits of large dams in economic terms may mean that the efficiency and profitability of such schemes remains occluded (WCD 2000).

The available literature on dams (examined below) offers little in the way of economic evaluation of the impacts on fisheries. Dams certainly hinder the migratory routes of fish even though there are means of mitigating this (see below). Goulding et al. (1997) noted that no studies on the impact of fish had been conducted on the five large dams built in the Amazon River basin by 1996. The impact on fishing is often contradictory: while the type of fish caught and the level of catch in specific areas may fall, catch levels overall can rise. However, Jackson and Marmulla (2001) urged caution in this regard, noting that the further downstream the dam, the less likely the fishery in the newly flooded reservoir can compensate for lost catches on the other side of the dam wall. Yet, in many cases, the change in fish catches is rarely mentioned (i.e., little data available on values of the catch before and after construction) although relocation and compensation costs are provided. Relocation costs (in so far as these can act as proxy values for the livelihoods of fishers) can be problematic because resettlement is frequently to areas that are wholly unsuitable (for example, fishers/farmers offered apartments in the city; occupants of wetlands moved to dry savannah areas) or at best less productive.

The Influence of Dams on River Fisheries (Jackson and Marmulla 2001)

The authors assess the status of catches from reservoirs in South America (principally Brazil) and find that more than half the catch from northeastern Brazil is made up of tilapia. They also state that, compared to other regions, the productivity of reservoirs is very low (from 2.1 kg/ha/year in the Uatum river up to 11.5 kg/ha/year in the Itaipu dam); they conclude that this is due to the length of time the water stays in the reservoir, affecting its quality and its suitability as a habitat for many species. The authors also assess dams in Central America (the only article that does so). Because rivers in Central America are generally much shorter and less important from a livelihoods point of view, reservoirs created by damming have served to provide extra fisheries opportunities. The authors cite the case of Panama where peacock bass, an exotic species (which had previously decimated native stocks) rapidly became an important commercial species providing a good source of income for local small fishers. Unfortunately, with no price or systematic landings data, it is not possible to derive any use value of peacock bass from the information given by the authors.

5.1 The Itaipu Dam

Biodiversity and Fisheries Management in the Paraná River Basin: Successes and Failures (Agostinho and Gomes 2003)

The Upper Paraná river is defined as the upper third of the Paraná river basin, stretching down to the Itaipu dam. Agostinho and Gomes analyze how biodiversity in this river has been affected by past fisheries management decisions, focusing in particular on adverse impacts of the construction of dams on fisheries. As reported, 130 of the dams are greater than 10 meters in height, and 26 of them cover an area larger than 100 square kilometers. Besides, it was not until relatively late in the day (1981) that it became mandatory for hydroelectric companies to produce EIAs ex-ante. While the article notes the failure of management programs designed to facilitate fish migration (1920-50s), and to increase yield by stocking exotic and/or native species (1950-90s), it merely alludes to the virtual absence of large fish species in the Upper Paraná and the low yields of artisanal fisheries in the south-southeastern reservoirs as evidence of the impact of dam construction. No corroborative figures are cited to support the authors' assertions.

5.2 The Tucurui Dam

Tucurui Hydropower Complex Brazil (La Rovere and Mendes 2000)

This study was conducted as part of a global report entitled "Dams and Development – a new framework for decision making" for the World Commission on Dams. The Tucurui Hydropower Complex (THC) is located in the Tocantins River on the Tocantins-Araguaia River Basin. Construction was started in 1975 and completed in 1984. Phase II began in 1998 with the turbine starting in 2002. Although primarily built for hydropower production, it has a secondary goal of providing a navigable water route.

The river is estimated to contain some 300 species of fish and the ecosystem is reportedly one of the richest in the world. Prior to the construction of the dam, there were two distinct groups in the region: (three) indigenous peoples and the colonists[30] who survived mostly on fishing, gold and diamond mining, and subsistence agriculture. Fishing was estimated to produce 1,534 tonnes per year, 900 of which came from downstream of the dam. The dam was started under the Military Junta and the process was largely driven by the industrial sector, with concern at the time more on the impact of the ecosystem on the dam than vice versa. An attempt at an EIA was made in 1977, two years after construction began, but it was too late to have had any influence. The regularization of water flow affected natural flooding cycles that were responsible for natural fertilization processes; a large amount of nutrient-rich organic matter was now trapped behind the dam wall with lower agricultural yields downstream as a result. Although the 1977 assessment predicted that fish populations would be affected, there was insufficient information available on pre-dam populations to allow any realistic predictions. However, with reduced water quality downstream of the dam, observations suggested that *large-scale fish deaths* were occurring and the diversity of species was estimated to have been reduced by 19 per cent. In particular, the ubarana, a commercially significant fish species, came close to extinction as a marked decline in downstream *catch rates* was reported by fishing populations. But no bequest value for the ubarana was identified. Fish populations also suffered, with a reported 29 per cent

30 A term used to describe non-indigenous Brazilians encouraged to migrate to the remote interior mainly during a period of border securing in the 1970s.

drop in reservoir species diversity and 25 per cent drop of species upstream of the reservoir. By the mid-1990s, scientists were able to demonstrate that fish productivity overall had risen by 200 per cent and reservoir catch had increased by 900 per cent, while the downstream catch had dropped by 45 per cent. No attempt is made, however, to ascribe a monetary value to the lost catches.

While the report does not put a monetary figure on the TEV of the dam, it does provide a breakdown of financial compensation paid to the various municipal districts [based on flooded area affected and ranging in price from R$ 30,000 for Itupiranga to R$ 287,900 for N. Repartimento (p. 89)]. This could be seen as providing an indication of the perceived value of the resource in terms of its foregone *option* and *bequest* values. However, the authors also note that while some indigenous groups (eventually) received sizeable compensation (replacement/relocation costs) for loss of land and livelihoods and a fund of US$ 740,000 was made available to assimilate one group into modern society, other non-indigenous small holders did not. This information suggests that using such figures as proxies for the economic impact of the dam would be incomplete. The authors also provide a rudimentary cost/benefit analysis of the various components of the dam project (p. 132).

Cana Brava Hydroelectric Power Plant: Environmental and Social Impact Report (IADB 2000)

As this power plant on the Tocantins River was still under construction at the time of writing, this report only offers an examination of the potential impacts of the dam. Implications of the construction are identified, namely, environmental implication (the loss of land through flooding, increase of soil erosion, and decrease in fish populations); mineral implication (the loss of potentially valuable alluvial deposits under the reservoir); and socioeconomic implication (258 families to be relocated with $ 4 million allocated to cover resettlement costs). The US$ 15,503 value attached to each family relocation appears to be much lower than other values given in reports on other dam resettlement calculations. The project has, however, a very sophisticated program in place to evaluate environmental changes following flooding.

5.3 The Yacyretá Dam

Report of Social Impacts of Dams; Distributional and Equity Issues – Latin American Region (Ferradas 2000)

This author notes that most studies focus on the upstream impacts of dams. Also, because many of the large dams from the 1970s were built as much for power as for political reasons, studies and information on the possible effects of impacts of the dams were negligible at the time. Besides, these dams were often built before EIA evaluation methods were commonly applied, and so there was little necessity to collect data before and after the construction. Largely based on her experience with the Yacyretá dam on the Paraná river, the author describes the political and economic contexts of the building of many large dams on the continent and outlines some of their biggest problems (lack of public consultation, relocation and requisition of indigenous lands, destruction of habitat and fishing livelihoods, etc). She notes that only when the democratization process began in the region did the issue of the social impacts of dams find a way onto the agenda.

Ferradas notes that fishers who were affected by the Yacyretá dam were offered US$ 8,000 each as compensation for loss of earnings (i.e., low catches, harder access to the river) provided they agreed to make no further claims. However, according to Ferradas, fishing activities were not identified as a possible source of conflict in the original plans for the dam possibly because many fishers were reluctant to identify themselves as such because it was an admission of poverty. The paper highlights a number of important issues. First, it assumes that decisions to accept the offer on the table were taken on the basis of *perfect information*. Given the isolated nature of the communities, their lack of access to public information services, the high levels of functional illiteracy and an inability to foresee the consequences, it is likely that the compensation accepted placed a far lower value on the resource and the livelihoods affected than was appropriate.

Brazil employs a system of royalties as a means of redistributing the benefits from dams. Ferradas mentions the distribution of some US$ 989 million from the Itaipú dam (Brazil, Argentina, Paraguay border) although states have no control over how monies received are allocated. While ideally this amount should go towards compensating the losers from the project, it is not guaranteed nor protected by law. Again, the royalties could be viewed as an indication of the *lost* use values of the resource (in terms of foregone earnings from fishing, for example) and the non-use values of the environment as a whole (in terms of the loss of natural habitat, for example).

5.4 The Itá Dam

Large Dams and Their Alternatives: Social and Resettlement Issues (World Commission on Dams)

Bermann (1999) reports on the Itá dam, built on the Uruguaia River. The figure given in compensation (the relocation value) to each of the displaced 4,000 families was US$ 93,750 per family under the conventional resettlement plan, but this amount fell to only US$ 47,920 per family under the community-managed resettlement plan that was introduced following the privatization of the company building the dam. Although the reduction in the cost of relocation is cited in the report as a benefit, this is only obviously so from a corporate perspective, and it is unclear which of the two figures is the more realistic forgone use value of the resettled inhabitants.

5.5 The Porto Primavera Dam

Kudlavicz (1999) reports that the building of the Porto Primavera dam on the Parana River (that began in the 1970s and is still uncompleted) has had a dramatic effect on fish stocks: there are no mechanisms in place to mitigate upstream migration problems; the flooding of natural upstream lakes has impacted upon breeding cycles with the result that downstream catches have fallen by 80 per cent and some 700 fishers have been affected by the dam. Kudlavicz does not, however, attempt to place a monetary value on the use values foregone through the decreased catches.

5.6 The URRA Dam

Fishing production dropped from 6,000 to 1,700 tonnes per year (Correa 1999) in the lower Sinu Basin following the construction of the URRA dam in Colombia in the early 1990s. This has had a particularly devastating effect on the people who depended upon fish as their main source of animal protein even though the study failed to quantify this consumption shortfall.

5.7 The Ralco Dam

The Ralco Dam and the Pehuenche People in Chile: lessons from an ethno-environmental conflict (Aylwin 2002)

As with many dams built in Central and South America, the issue of indigenous peoples is prominent in the discussion. The standoff between the Pehuenches and the Chilean government over the imminent flooding of the Bio-Bio river, downstream of the Ralco dam, is analyzed by Aylwin. In common with all the available literature on the dam, the indigenous rights aspect of the project has overshadowed the environmental aspects; indeed, there is evidence that environmental assessments ordered by the World Bank on the Pangue dam further upstream were suppressed by the government. However, Aylwin does describe the impact of the dam on the fisheries, noting that six species endemic to the Bio-Bio River are likely to be lost when the valley is flooded, resulting in some loss of existence values. Moreover, he points out that the Pehuenche people who have traditionally relied upon the river for their livelihoods will suffer a potential loss in income as the river changes in nature (from a fast-flowing, steep river to a sluggish river) and the fisheries are consequently affected. No values are ascribed to the fisheries or their potential loss or change. In terms of relocation values, the figures quoted by the Miami Herald (6 November 2002) show that 84 of the 92 families who were affected by the dam have already moved out while 7 remained (the core of the indigenous protest), and that US$ 20 million was allocated for the relocation (which amounts to US$ 217,391 per family). This comparatively high figure perhaps reflects the bequest value assigned to the unique Pehuenche culture as much as the costs of moving and rebuilding. Evidence available on various environmental lists on the Internet also suggests that the marketed non-use value of tourism on the Bio-Bio (renowned as a white-water rafting destination) will be adversely affected by the flooding of the valley, although, once again, no supporting figures are given.

5.8 Hidrovia projects

Critical environmental costs of the Paraná-Paraguay waterway project in South America (Bucher and Huszar nd)

The Hidrovia project aims to create a navigable waterway 3,442 km long between Caceres in Brazil and the harbor at Nueva Palmira in Uruguay. This will involve drastically altering the course of the river and would affect the Pantanal, the largest wetland in the world. Bucher and Huszar argue that if the critical value of the environmental costs of the project (i.e., the existence and bequest values) were included in the evaluation, they would tip the balance towards preserving the Pantanal rather than building the Hidrovia. Although no figures are presented to back up their assertions, the authors indicate that the implications of disturbing the water flow through the Pantanal would be complex and critical; water flow in rivers would increase, causing increased erosion and flooding during the rainy season. They also cite the potential loss of fish biodiversity as particularly important, but again no figures are given. Finally, the authors argue that while the current economic evaluation of the project shows a net positive return, the underlying assumptions are very sensitive and the environmental costs have not been internalized.

Analysis of the EIA for the Araguaia-Tocantins Hidrovia Project (CEBRAC 2000)

The Hidrovia is set to be an industrial waterway designed to transport grain from the interior of Brazil to the coast for onward export. The system will link to the Tucurui hidrovia through a system of locks. CEBRAC evaluated the resubmitted EIA for the Hidrovia project because the first EIA for the project was rejected wholesale by the Federal Chamber of Deputies of Brazil on the grounds that it was full of errors. They list a catalogue of potential ecological, social and economic disasters should the plan be carried out. Many indigenous groups dependent on fish for their livelihoods will be directly affected; changes in fish populations will also have knock-on effects on other species in the food web. The analysis is scathing of the impact of this vast hydrological project; the authors find no justification at all for it. They argue that the economic cost of the project is seriously underestimated as the feasibility of the project is simply based on comparing the savings in transportation costs with the costs of building the hidrovia. Unfortunately, the authors provide no data to support their claims.

5.9 Pollution Effects

Mining has been present on many rivers in CSA since the time of the Spanish occupation in the 16th century; as a result, the rivers have often acted as sinks for mining debris and the inputs used in the mining process (notably mercury). Research on the Internet also reveals that mining is currently the most commonly mentioned factor in river pollution in CSA. Many cases are cited on the Internet about the pollution of rivers in the region (See http://www.globalminingcampaign.org/theminingnews/case.html.), but many of them are anecdotal, and there are few academic texts that quantify the level of pollution and its impact on fish resources. A recent cyanide spill on the Omai River (in the Essequibo River basin in Guyana), for example, caused the death of thousands of fish, and the Pan-American Health Organization, responding to the call for assistance by the government of Guyana, concluded that the Omai River was a dead river, devoid of any life. The fact that no baseline data exist for the many aquatic species of the river means that the impact will never be fully known.

6. CONCLUSION

In order to calculate a TEV for the river fisheries of Central and South America, a considerable amount of data is required on both direct and indirect use values. Thus, data are needed not only on the value of the fishery (marketed and non-marketed values) but also on the value of the underlying biodiversity of the system, the *existence* of the fishery, the livelihoods of the fishers, the existence (now and in the future) of the environment in a pristine or altered state, the continued existence of certain indigenous groups, the aesthetic value of the resource (the river, the falls, the lake), and so on.

Yet, the importance of the inclusion of non-use values is highlighted in the study carried out in the Chilean National Parks (see section 3), where the TEV for the parks exceeded by forty times the non-use values calculated. In other words, a failure to account for both the value of the fishery and the surrounding ecosystem is likely to seriously undervalue the real value of the resource. However, with much of the necessary data on non-use values absent and very little data on the value of the fishery itself, computing a TEV for the freshwater river fisheries of CSA is impossible at present.

This report also looked at the impact of altered water courses on fisheries, particularly the impact of dams and water abstraction schemes. The report found that, again, there was a paucity of information on this topic. While many dam evaluations have cited a change in catches from rivers, or a change in the diversity of fish stocks, few attach numbers to such assertions and not one report attempts to quantify the level of impact in an economic/market sense. The only indication the reports give of the *value* ascribed to the area is in the size of the relocation grants given to affected households. These relocation monies represent the cost of rebuilding a house, and some also represent the potential lost earnings as a result of being shifted to less productive land or to an entirely different environment. There is an additional problem, however, of using relocation prices as a proxy for the impact of dams on fisheries. The bargaining power of the fishers is very weak and their acceptance of the relocation package may be wrongly interpreted as a *willing-to-accept* payment for their lost/changed livelihood rather than as a *having-to-accept* payment. Many of the fishers are functionally illiterate and are certainly not able to negotiate relocation costs either on the basis of a good understanding of the implications of these decisions, or on the basis of complete information. Conversely, of course, in some cases the sums offered (and accepted) for relocation may stand for a fair representation of the impact of the dam on livelihoods; for example, some fishers may be more than happy to accept an apartment in the city in exchange for a precarious livelihood based on an unstable resource in the rural areas.

However, despite the less than positive summary above, some studies conducted on discrete parts of the continent have provided us with examples of the sorts of values we might hope to obtain. The authors suggest that attempts to value CSA river fisheries could be developed in two directions. First, the Provarzea project run by IBAMA (see section 3) has offered detailed catch and price data for selected parts of the Amazon basin and could provide a useful starting point for computing a more all-embracing value of the TEC of local fisheries. However, it will not be easy to extend such analyses to encompass the entire river basin, let alone the continent's other inland fisheries.

Second, the value of sport fishing in CSA (like in most parts of tropical Africa and Asia) remains an unknown quantity. A cursory glance on the Internet shows that the Amazon and Plate river basins offer numerous opportunities for sport fishing ventures (both for locals and foreign tourists), yet sport fishing as a contributor to the local economy is rarely taken seriously. Likewise, the role of white-water rafting and other riverine-based tourist activities could (and probably do) contribute significant amounts of foreign exchange to Peru, Bolivia, Chile, and many countries in Central America; yet there are no studies known that attempt to establish an economic value of these activities. The authors thus propose that a series of CVM studies be conducted on the principal sport fishing venues in Brazil, Uruguay, Argentina and Chile as a first step in generating a value for recreational fishing in the region.

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APPENDIX 1: MAJOR RIVER BASINS AND THEIR TRIBUTARIES IN SOUTH AMERICA

River Basin	Characteristics
Amazon Brazil	**Amazon**: Has up to 1,000 tributaries, including 7 more than 1,000 miles long Total length: 6,516 km 7,180,000 km sq drainage Western-most reaches refered as the Solimões **Negro**: Venezuela and Brazil **Tocatins**: Brazil, flows into Para Length: 2,699 km **Para:** **Madeira**: Confluence of Beni and Maumore rivers, forms Bolivia-Brazil boundary Length: 3,238 km **Purus**: Length: 3,590 km
Nordeste Basin Brazil 362 000 km sq drainage	**Parnaiba** Total length: 1,485 km **Mearim** **Das Balsas** **Pindare**
Tocantins-Araguaia Brazil	**Tocantins (**See Amazon Basin**)** **Araguaia** **Das mortes**
Paraguay Brazil	**Paraguay**: Brazil-Paraguay, Argentina, flowing into Parana River Total length: 2,549 km **Parana**: Confluence of Paranaiba and Grande, flowing into Plate River Total length: 4,498 km Parana-Paraguay system flows through Brazil, Bolivia, Paraguay, Argentina and Uruguay
Leste Brazil	**Paraiba do Sul**
Tiete-Parana Brazil	**Grande** **Parana** (See Paraguay Basin) **Paranapanema** **Ivai** **Paranaiba** **Tiete**
Do Sul Brazil	**Ibicui** **Canal de Sao Goncalo** **Jacui** **Lagoa Mirim** **Lagoa dos Patos** **Taquari** **Uruguai**
Rio de la Plata Brazil	**Pilcomayo**: Headwaters in Bolivian Andes, flowing into Paraguay River Total length: 1,999 km Flows into Atlantic 4,700 km long 2,650,000 km sq drainage
Sao Francisco Brazil	**Sao Francisco**: Headwaters in southwest Minas Gerais, Brazil, flowing into Atlantic Total Length: 3,198 km **Corrente** **Grande**

Orinoco Brazil	Headwaters in Serra Parima Moutains, VZLA, flowing into the Atlantic Total length: 2,062 km 1,086,000 km sq drainage
Pilcomayo Argentina Bolivia Paraguay	Headwaters in Bolivia Flows into Atlantic in Argentina Total Length: 2,500 272,000 km sq drainage, 92% in Bolivia
Bio-Bio Chile	Headwaters on Chile/Argentina border Flows into Pacific Total Length: 380 km 24,260 km sq drainage
Colorado Argentina	Headwaters in Chilean/Argentinean Cordillera, flowing into Atlantic

APPENDIX 1a: MAP OF LATIN AMERICAN RIVERS

APPENDIX 2: CROCODILE CAPTURES IN CENTRAL AND SOUTH AMERICA 1985-2001

		1985	1990	1995	2000	2001
Bolivia	Spectacled caiman	.	300	.	.	28 170
	Nile crocodile	.	.	.	1 477	50
	Spectacled caiman	.	.	369	8 286	1 253
Colombia	American crocodile	.	.	.	.	100
	Spectacled caiman	.	119 612	828 533	832 203	704 313
Guyana	Cuvier's Dwarf caiman	.	.	.	409	476
	Smooth-fronted caiman	.	.	.	270	423
	Spectacled caiman	158 190	12 633	1 556	9 880	5 917
Honduras	Spectacled caiman	.	5 000	2 000	.	.
Mexico	Morelet's crocodile	.	.	2	1 228	3 643
Nicaragua	Spectacled caiman	.	.	4 238	6 440	.
Panama	Spectacled caiman	.	.	2 005	10 250	9 926
Paraguay	Spectacled caiman	.	.	19 793	9 750	3 792
Venezuela	Spectacled caiman	.	91 861	55 195	23 655	14 978
	TOTAL PIECES	158 190	229 406	913 691	903 848	773 041

APPENDIX 3: FRESHWATER CULTURE PRODUCTION IN CENTRAL AND SOUTH AMERICA 1965-2000

		1965	1970	1975	1980	1985	1990	1995	2000
Argentina	Giant river prawn	.	.	.	.	.	.	12	.
	Pacu	.	.	.	.	.	.	.	700
	Rainbow trout	5	19	42	90	250	300	1 412	952
	Red claw crayfish	.	.	.	.	.	.	.	32
	Tilapias nei	.	.	.	.	.	.	.	10
Bolivia	Argentinian silverside	.	.	.	.	.	290	.	.
	Common carp	.	.	.	.	.	30	26	40
	Freshwater fishes nei	.	.	.	.	.	51	.	.
	Nile tilapia	.	.	.	.	.	.	70	30
	Rainbow trout	.	.	.	.	.	144	520	335
Brazil	Cachama	.	.	.	.	.	.	2 330	9 776
	Characins nei	.	.	.	.	.	.	4 070	5 081
	Common carp	.	.	.	.	.	.	16 865	54 566
	Freshwater fishes nei	.	.	100	3 291	10 000	18 000	1 644	25 788
	Freshwater siluroids nei	.	.	.	.	.	.	2 452	2 475
	Giant river prawn	.	.	112	273	400	600	341	4 531
	Prochilods nei	.	.	.	.	.	.	.	1 363
	Rainbow trout	.	.	.	.	.	.	762	1 447
	Tilapias nei	.	.	.	.	.	.	12 014	32 459
Chile	Atlantic salmon	.	.	.	.	.	.	.	.
	Coho(=Silver)salmon	.	.	.	.	.	.	.	.
	Rainbow trout	.	<0.5	<0.5	92	619	3 628	2 630	655
	Sea trout	.	.	.	.	.	.	.	.
Colombia	Barred sorubim	.	.	.	.	.	.	.	20
	Cachama	.	.	.	.	.	.	.	510
	Common carp	.	.	.	.	5	50	4	1 000
	Dorada	.	.	.	.	.	<0.5	<0.5	30
	Duckbill catfish	.	.	.	.	.	.	.	10
	Freshwater fishes nei	.	.	.	.	10	5	.	450
	Giant river prawn	.	.	.	.	1	60	.	.
	Netted prochilod	.	.	.	.	.	<0.5	<0.5	.
	Nile tilapia	.	.	19	93	300	2 040	3 747	3 720
	Pirapatinga	.	.	.	6	50	1 100	3 181	14 980
	Prochilods nei	.	.	.	.	.	.	.	1 510
	Rainbow trout	.	.	29	98	400	1 200	9 297	9 016
	Redbreast tilapia	.	.	.	.	2	<0.5	<0.5	.
	Tilapias nei	.	.	.	.	.	.	12 310	19 150
Ecuador	Cichlasoma nei	.	.	.	.	.	.	.	.
	Giant river prawn	.	.	41	385	671	849	800	800
	Green terror	.	.	.	.	.	3	<0.5	.

		1965	1970	1975	1980	1985	1990	1995	2000
	Ichthyoelephas humeralis	.	.	.	.	.	1	.	.
	Nile tilapia	.	.	.	.	.	18	.	9 201
	Pacific fat sleeper	.	.	.	.	.	25	.	43
	Rainbow trout	.	.	.	.	.	414	.	33
	Red claw crayfish	.	.	.	.	.	.	.	30
El Salvador	Common carp	.	.	.	.	.	.	5	.
	Freshwater fishes nei	.	.	.	.	.	.	<0.5	<0.5
	Giant river prawn	.	.	.	.	.	4	10	9
	Jaguar guapote	.	.	.	.	.	1	<0.5	<0.5
	Nile tilapia	.	.	.	.	15	3	196	56
French Guiana	Atipa	.	.	.	.	.	.	.	.
	Common carp	.	.	.	.	.	.	.	.
	Freshwater fishes nei	.	.	.	.	.	.	.	6
	Giant river prawn	.	.	.	.	15	83	.	25
	Grass carp (=White amur)	.	.	.	.	.	.	.	.
Guatemala	Blackbelt cichlid	.	.	.	.	.	6	140	30
	Blue tilapia	.	.	.	.	.	.	.	143
	Channel catfish	.	.	.	.	.	.	3	8
	Cichlasoma nei	.	.	.	.	.	.	1	11
	Common carp	.	.	.	.	<0.5	6	28	14
	Freshwater crustaceans nei	.	.	.	.	.	.	.	.
	Freshwater fishes nei	.	.	.	.	.	.	.	7
	Freshwater molluscs nei	.	.	.	.	.	.	7	10
	Freshwater prawns, shrimps nei	.	.	.	.	.	.	9	3
	Giant river prawn	.	.	.	.	5	10	99	46
	Jaguar guapote	.	.	.	.	.	5	40	40
	Mozambique tilapia	.	.	.	.	.	.	.	104
	Nile tilapia	.	.	.	.	.	.	.	1 035
	Red claw crayfish	.	.	.	.	.	.	.	15
	Tilapias nei	.	.	.	.	70	150	593	606
Guyana	Atipa	.	.	.	.	.	<0.5	<0.5	<0.5
	Giant river prawn	.	.	.	.	.	.	.	.
	Mozambique tilapia	.	.	.	.	.	.	.	1
	Nile tilapia	.	.	.	.	.	.	.	1
	Tilapias nei	.	.	.	.	.	.	.	1
Honduras	Cachama	.	.	.	.	.	3	20	.
	Freshwater fishes nei	.	.	.	.	136	5	10	.
	Giant river prawn	.	.	.	7	18	<0.5	<0.5	<0.5
	Nile tilapia	.	.	.	6	35	120	172	927
	Silver carp	.	.	.	.	.	4	10	.
Nicaragua	Blue tilapia	.	.	.	.	2	3	5	.
	Common carp	.	.	.	.	.	1	.	.
	Nile tilapia	.	.	.	.	.	.	.	18

		1965	1970	1975	1980	1985	1990	1995	2000
Panama	Bighead carp	.	.	.	.	1	1	1	.
	Blue tilapia	.	.	.	.	4	<0.5	<0.5	<0.5
	Cachama	.	.	.	.	53	56	7	<0.5
	Common carp	.	.	.	.	26	29	25	2
	Cyprinids nei	.	.	.	.	<0.5	<0.5	<0.5	<0.5
	Freshwater fishes nei	.	.	.	.	.	.	.	.
	Giant river prawn	.	.	.	.	5	6	3	<0.5
	Grass carp (=White amur)	.	.	.	.	20	29	57	.
	Jaguar guapote	.	.	.	.	<0.5	<0.5	<0.5	.
	Nile tilapia	.	.	.	.	69	8	.	900
	Silver carp	.	.	.	.	69	138	40	.
	Tilapias nei	.	.	.	.	.	41	186	.
Paraguay	Channel catfish	.	.	.	.	.	.	.	7
	Characins nei	.	.	.	.	.	10	30	20
	Common carp	.	.	.	.	.	25	80	20
	Grass carp (=White amur)	.	.	.	.	.	.	.	10
	Prochilods nei	.	.	.	.	.	.	.	6
	Tilapias nei	.	.	.	.	<0.5	26	80	40
Peru	Arapaima	.	.	.	.	.	20	<0.5	.
	Argentinian silverside	.	.	.	.	.	.	2	.
	Cachama	.	.	.	.	.	85	7	73
	Characins nei	.	.	.	.	.	<0.5	<0.5	.
	Common carp	.	.	.	.	.	35	.	.
	Dorada	.	.	.	.	.	<0.5	2	.
	Freshwater fishes nei	.	.	.	.	.	60	2	.
	Giant river prawn	.	.	.	.	.	5	100	13
	Netted prochilod	.	.	30	120	160	20	3	810
	Nile tilapia	.	.	.	10	52	186	.	8
	Pirapatinga	.	.	.	.	.	77	2	17
	Rainbow trout	.	40	269	350	607	1 608	635	3 075
	Velvety cichlids	.	.	.	.	.	<0.5	<0.5	.
Suriname	Freshwater fishes nei	.	.	.	.	.	.	<0.5	<0.5
	Giant river prawn	.	.	.	.	<0.5	<0.5	<0.5	<0.5
Uruguay	Common carp	.	.	.	.	.	.	2	1
	Red claw crayfish	.	.	.	.	.	.	.	.
	Siberian sturgeon	.	.	.	.	.	.	.	5
	South American catfish	.	.	.	.	.	3	4	3
	Sterlet sturgeon	.	.	.	.	.	.	.	70
Venezuela	Barred sorubim	.	.	.	.	.	.	.	180
	Cachama	.	.	4	32	160	49	680	3 000
	Prochilods nei	.	.	.	.	.	.	.	250
	Rainbow trout	.	20	130	240	345	212	230	500
	Tilapias nei	.	.	.	.	.	4	1 650	970

“nei” is the FAO term for “not elsewhere included”

APPENDIX 4: FRESHWATER CAPTURE PRODUCTION FOR CENTRAL AND SOUTH AMERICA 1950-2000

		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Argentina	Characins nei	9 300	4 700	7 700	9 100	1 700	10 551	4 685	6 937	6 734	11 700	3 000
	Freshwater fishes nei	3 600	2 300	6 000	1 500	1 700	2 125	886	344	308	2 908	6 098
	Freshwater siluroids nei	800	900	1 000	2 300	2 000	2 369	2 756	2 284	3 089	2 500	3 500
	Prochilods nei	.	.	.	.	.	.	.	.	.	.	17 700
	Rainbow trout	.	.	.	.	.	.	.	150	150	3	.
Belize	Freshwater fishes nei	.	.	.	.	<0.5	25	25	1	1	<0.5	<0.5
Bolivia	Common carp	.	.	.	.	.	.	.	.	.	.	.
	Freshwater fishes nei	500	600	700	1 600	1 000	1 000	4 129	3 720	2 987	4 726	4 911
	Rainbow trout	.	.	.	200	100	50	50	50	236	116	345
Brazil	Cachama	.	.	.	.	.	.	.	.	.	11 379	4 965
	Characins nei	12 600	16 800	21 800	40 000	38 500	80 726	72 155	97 787	95 400	81 433	67 297
	Cichlids nei	1 200	1 600	2 100	2 800	4 200	8 359	7 784	11 233	14 700	12 045	8 145
	Cyprinids nei	.	.	.	<0.5	<0.5	10	65	214	100	119	355
	Freshwater crustaceans nei	500	1 000	1 800	700	1 100	2 385	.	.	9	<0.5	<0.5
	Freshwater fishes nei	7 200	9 600	12 400	22 200	5 600	20 473	33 659	21 505	20 397	40 372	49 593
	Freshwater siluroids nei	9 000	12 000	15 500	25 500	35 400	52 630	51 314	50 165	42 800	40 048	58 474
	Rainbow trout	.	.	.	.	.	.	.	91	5	<0.5	<0.5
	River prawns nei	100	200	400	2 800	8 400	6 719	9 854	9 751	6 600	1 412	2 437
	Tilapias nei	.	.	.	.	100	2 025	9 442	9 875	11 100	6 234	7 893
	Common carp	.	.	.	.	.	.	.	.	.	.	.
Chile	Freshwater prawns, shrimps nei	.	.	.	.	.	.	.	1	32	.	.
Colombia	Characins nei	9 500	11 000	7 000	17 700	18 200	26 158	28 630	24 978	19 507	5 698	6 600
	Freshwater fishes nei	1 000	1 500	3 000	4 900	7 600	8 751	10 473	16 300	10 202	9 108	7 800

		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
	Freshwater siluroids nei	4 000	4 500	1 400	3 300	7 400	7 118	7 603	6 430	4 231	8 718	10 454
	Giant river prawn	.	.	.	.	.	.	.	.	.	.	.
Costa Rica	Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	48	323	300	300	900	1 000
Ecuador	Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	206	867	600	300	400
El Salvador	Catfishes nei	.	.	.	.	.	.	.	.	.	250	142
	Freshwater crustaceans nei	.	.	.	.	.	.	.	<0.5	4	5	9
	Freshwater fishes nei	800	900	1 400	1 600	800	869	1 818	1 232	865	967	1 177
	Freshwater molluscs nei	.	.	.	.	.	.	.	.	.	.	8
	Jaguar guapote	.	.	.	.	.	.	.	.	.	608	324
	Nile tilapia	.	.	.	.	.	.	.	1 559	2 772	2 494	1 171
French Guiana	Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Guatemala	Cichlids nei	.	.	.	.	.	.	.	.	.	5	192
	Freshwater fishes nei	<0.5	100	200	200	400	550	400	47	2 599	4 020	7 109
Guyana	Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	681	800	800	700	800
Honduras	Freshwater fishes nei	.	.	.	<0.5	100	170	41	.	45	127	61
	Giant river prawn	.	.	.	.	.	.	35	32	.	.	.
Nicaragua	Freshwater fishes nei	100	200	600	1 100	1 300	359	79	84	150	538	396
	River prawns nei	.	.	.	.	.	.	.	.	.	.	<0.5
	Tilapias nei	.	.	.	.	.	.	.	.	.	.	680
Panama	Peacock cichlid	.	.	.	.	.	.	.	.	15	120	4
	Tilapias nei	<0.5	<0.5	<0.5	<0.5	.	.	.	50	.	10	16
Paraguay	Characins nei	.	.	.	.	.	.	.	2 000	3 990	7 700	9 000
	Freshwater fishes nei	400	500	600	700	1 800	2 800	3 300	2 500	2 500	3 800	4 000
	Freshwater siluroids nei	.	.	.	.	.	.	.	3 000	6 000	9 500	12 000

		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Peru	Arapaima	.	.	.	.	.	.	.	.	.	420	273
	Cachama	.	.	.	.	.	.	.	.	.	.	963
	Freshwater fishes nei	<0.5	1 000	1 000	3 000	2 000	6 671	12 538	27 791	28 321	44 452	19 387
	Netted prochilod	.	.	.	.	.	.	.	.	.	5 088	10 942
	Pirapatinga	.	.	.	.	.	.	.	.	.	.	324
	Rainbow trout	.	.	.	.	.	.	.	.	.	509	220
	Velvety cichlids	.	.	.	.	.	.	.	.	.	320	188
Suriname	Freshwater fishes nei	.	300	300	500	300	295	71	228	350	140	200
Uruguay	Characins nei	.	.	.	.	<0.5	163	238	576	128	763	1 690
	Freshwater fishes nei	<0.5	<0.5	<0.5	<0.5	.	12	14	43	32	45	312
	Freshwater siluroids nei	.	.	.	.	.	70	60	41	58	36	293
Venezuela	Characins nei	9 000	5 200	5 000	2 200	1 300	2 668	5 059	4 388	3 672	8 778	5 773
	Common carp	.	.	.	.	.	.	.	.	20	544	1 390
	Freshwater fishes nei	.	.	.	.	<0.5	491	5 452	6 804	1 297	4 524	450
	Freshwater siluroids nei	2 000	2 100	2 900	6 300	2 500	4 498	5 422	4 978	9 194	19 497	6 226
	Prochilods nei	.	.	.	.	.	.	.	.	4 364	20 430	9 613
	Rainbow trout	.	.	.	.	.	.	.	.	.	57	.