Review of River Fisheries Valuation in Central and South America

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1. INTRODUCTION

Central and South American (CSA) fisheries offer up some interesting paradoxes. Despite the wide biodiversity, its large share of the world's fish species[1] and with up to 20% of the planet's fresh water sources in the Amazon alone, Central and South Americans have never eaten large amounts of fish. The continent is however, an important source of fish (Chile and Peru are amongst the top five marine fish producers in the world) yet the majority of their catch goes into fish meal production rather than appearing on the table as food. In fact a recent study found that whilst the Brazilians enjoy eating fish, only 2% of the freshwater fish eaten there are native species caught in inland waters[2]. Fishing for sport if not for food, however, is the favourite 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. South America in particular contains the two largest river basins in the world (the Amazon and the Plate), the largest freshwater wetland in the world (the Pantanal in Brazil), and the largest volume river in the world (the Amazon) - yet CSA account for just 2% 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 fishing on the continent have received little attention either from within the continent, or from the rest of world. The waters and fish of the region however have been the focus of much attention by taxonomists, biologists and ecologists, and the region has been the centre 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 whilst 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 hydro accounts for 90% 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 common place, as a result it is often difficult to compare before and after situations because 'before' data simply do not exist.

This report, therefore, analyses 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

[1] 80% 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% are exotic species raised in tanks and ponds, most of it coming from Santa Catarina, the smallest state in the Federation (Worldpaper, 1999).

has also been conducted on the impact dams and related hydrovia and irrigation projects have had on the aquatic environment in general and fisheries in particular.

1.1 Methodology

As noted above and expanded upon 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 provided a considerable amount of grey literature – particularly statistics from government web-sites and information on locally managed projects dealing with fishery issues. Standard bibliographic databases revealed a considerable amount of biological published matter on 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 uses Spanish and Portuguese as the main language 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 are 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 household consumption – do not appear in the figures presented here.. Few studies on the region have specifically mentioned the problem with data collection, though the work of Dias-Neto and Dornelles (1996) and Paiva (1997) stand out in this regard. They point to 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 they tend to catch a large variety of fish spread out through a large number of landing sites, many of which are only accessible by river.

This report is divided into a number of sections. First we describe the major river basins on the continent, characterise their fisheries and place freshwater fisheries in CSA into a global context. Second, we provide a review of valuation techniques for fisheries and, using this analytical framework, we review the principal literature on freshwater fisheries in the region. We then turn our 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, we 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 conducted on the economics of the fisheries conducted there[3].

[3] However, a £3 million project funded by CIDA started work in Brazilian inland waters in January 2003. This new project (Brazil inland fisheries, sustainable livelihoods and conservation

All the major rivers of the continent are to be found in South as opposed to Central America (see Appendix 1). The Brazilian Amazon covers an area of 5 million km^2, nearly 60% of the territory of Brazil[4]. The river runs 5700 km from the Andes to the Atlantic; with all its tributaries it has 1100 rivers and lesser streams and the basin contains a 5th of the freshwater on the planet. The basin includes the white water rivers such as the Amazon which are rich in minerals and suspended particles, the clear water river such as the Tapajos which also carry important quantities of suspended particles and the black water rivers such as the Negro which are much poorer and owe their colour to the acids derived from decomposing organic materials in the flooded forests at their margins. It is also divided into the lower and the upper Amazon. The **Lower Amazon** has been analysed by various authors (Bayley and Petrere, 1989, Merona, 1990, Santos and Ferreria, 1999, Isaac and Ruffino, 2000).

The Amazon basin also drains the largest tropical rain forest in the world and the Pantanal, the largest freshwater wetland in the world. The Amazon basin drains over 50% of Brazil's fresh water supplies and substantial parts of that of Peru, Bolivia, Venezuela, Colombia and Ecuador (see 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 map).

Brazil contains the majority of the principal river basins of the continent: the **Nordeste**, **Tocantins-Araguaia**, **Paraguay**, **Leste**, **Do Sul** and **Sao Francisco** lie within Brazil exclusively 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 fish species there is still very limited; taxonomic descriptions and life-cycle studies are limited to species of greatest commercial importance (Petrere, 1994) or to specific rivers: Tejerina-Garro *et a*l (1998) conducted a biological study of fish communities in the **Araguaia** River (part of the Amazon basin). A limited number of studies have been conducted on fishermen 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) describe fishing gears used on the Lower **Solimões** River (the local name for the western part of the Amazon) and the links between biodiversity and fisheries management is explored by Agostinho and Gomes (nd) in the **Paraná** basin. Silva (1986) documents the upper **Paraguay basin** which is home to many large migratory fishes and is popular with recreational fishers.

Many of the rivers in the region are highly seasonal; the basins have a flooding and emptying cycle and 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 produce hydropower (see Section 5) and have in turn produced a large number of reservoirs: the **São Francisco basin,** for example**,** has 11 dams which account for 25% of the reservoir area of the whole country (PLANSVAF, 1989).

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http://www.worldfish.org/proj_sa_3.htm) aims to redirect focus most onto the social and economic side of fishing in the region. The project has produced no discernable outputs as yet.

[4] Use of the definition '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 ¾ of the Amazon River is in Amazonas state, the latter ¼ is in Para State. The western most length of the Amazon is also called the Solimões. Amazonia tends to be used to refer to the rainforest that covers the basin.

If information on rivers within Brazil is scarce, information on rivers on the rest of the continent is even more limited. The **Rio de la Plata basin** is the second largest in the region and the fourth largest in the world. It takes in Paraguay and large parts of Bolivia, Brazil and Uruguay and the largest wetland corridor n the world, from the Pantanal in Mato Grosso to Rio de la Plata which empties in Argentina. There are no known studies on this basin, though a search on the internet demonstrates that sports fisheries predominate here. The **Orinoco basin** is shared between Brazil, the Guyanas and Venezuela, 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 percent of the **Pilcomayo basin** lies in Bolivia, although the river runs down into Paraguay where it joins the Uruguay river and then flows into Argentina where it empties into the Atlantic. There are currently around 30 small mining companies operating at Potosi (on the Upper Pilcomayo) which contribute considerable waste to the river system, as a result considerable attention on this basin has focussed on water quality. Various projects have been put forward to monitor water quality on the river and control mining pollution, though few appear to have met with any degree of success (http://www.gci.ch/GreenCrossPrograms/waterres/water/pilcomayo.html; FAO, 1984)

The **Bio-Bio** in Chile empties into the Pacific and is a significant source of hydro electrical power for Chile as is the **Colorado** in Argentina, which drains into the Atlantic. The Bio-Bio, the traditional and historic border between Spanish/Mapuche populations in Chile, is 380 km long, flowing 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 the resources for drinking and irrigation water, recreation and fisheries.

Finally, Mérigoux *et al* (1998) describe the freshwater fisheries in coastal streams in **French Guiana**; Mol *et al* (2000) and examined the effects of drought on freshwater fisheries in **Suriname**. Finally, Beltrán Turriago and Villaneda Jiménez (2000) also briefly mention inland artisanal fishing in **Colombia**.

Central America has many rivers (e.g. the **Belize** and **Monkey** River in Belize, the **Corobibi**, **Sarapiquí** and **Tabacón** in Costa Rica and the **Rio San Juan** in Nicaragua) though no evidence could be found of any studies on the economics or management of fisheries in those rivers. However, it appears that many of the rivers offer excellent opportunities for sport fishing and white-water rafting (www.uncommonadventure.com); many of them offer ecologically unique habitats to fish species (see www.si.edu/bermlab for examples) and many of them 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 the large number of dams across the region (see section 5) there are a large number of artificial lakes and reservoirs (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 is shared between Peru and Bolivia. The lake covers 8,372 km^2 and consists of two parts: the deep main basin (Lago Mayor) and the smaller, shallower Lago Pequeño (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 conducted.

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 potential yield with any certainty and it is also difficult to calculate marginal costs of production (Etchart, 2000).

The lower **Amazon** is characterised by large diversity and high production. Catch composition presents a significant spatial and temporal diversity, dominated by *Plagioscion squamosissimus* (see above table). The only industrial fresh water fish in the Amazon is the Piramutaba (*Brachyplatystoma vaillant, Prochilodus lacustris, P. Cearensis, P. argenteus*) which is found at the mouth of the river. Catches of these fish reached 28,829MT in 1977, declined to 7,070MT by 1992, but had risen to 22,087MT by 1999; it is now considered to be recovering from over fishing (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 under-exploited by Petrere (1983) and Welcomme (1990) but with localised risk. More recent literature has reported declining catches close to large urban centres, and the decline in catches landed at Manaus is demonstrated by Bittencourt (1991) who suggests that fishing in this region is approaching MSY.

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 e S. taeniatus	
Curimatá	Prochilodus nigricans,	
Anostomideos		
Hemiodontideos		
Tambaqui	Colossoma macropomum	
Cardinal tetra	Paracheirodon axelrodi	Ornamental fishery catch from Rio Negro
Piramutaba	Brachyplatystoma vaillanti	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		Peruvian Amazon (many of these terms of local to the region and the scientific name is not known).
Boquichico		
Corvina	Ray	
Doncella	Ophidiidae	
Dorado	Spanis Aurata	
Gamitana		
Llambina		
Maparate		
Paiche		
Palometa	Trachinotus	
Ractacara		
Sardina		
Yahuarachi		
Yulilla		
Zungaro		
Camaron de Rio	Crayfish	Sierra waters
Carachi		
Pejerrey	Argentina Elongata	
Trucha	Salmo	

Source: DFRP, 2001; SIAMAZONIA, 2002

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% of fisheries production overall and has normally been in the region of 1-3%[5]. Over that same period, marine production has generally been above 10 million MT per year[6] (see table 2).

Table 2: marine and freshwater production in Central and South America (MT)

	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	14,424,840	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 and FAO Waicent

In a global perspective then, whilst a number of South American nations (notably Peru, Chile and Argentina) remain amongst the top marine capture producers in the world, the CSA share of global inland fish capture production has never exceeded 4% in the period since 1965 (see table 3) .

Table 3: Central and South American fresh and marine production (excluding aquaculture) as a % 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 Waicent and FAO FISHSTAT PLUS

This difference between the production levels from the marine and freshwater sectors has occurred, in part, a) because the marine fisheries, particularly in the Eastern Pacific and Southern Atlantic are highly productive and b) because whilst there is an abundant amount of fresh water within continental Central and South American river

[5] Freshwater capture fisheries data does 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, those for crocodiles in Appendix 4.

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

basins, the population density in these areas is extremely low compared to the coast. Thus, production on the continent has always been far higher on the coast than inland.

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 towards the industrial marine sector, the artisanal marine sector coming second and the inland sector only coming onto the agenda in countries such as Brazil which have a comparatively high freshwater production. The paucity of economic or management literature on river fisheries in Central and South American is also attributable to the position of Central and South America in a global context. From an international aid perspective, little attention has been paid to freshwater fisheries production in Central and South America simply because African and Asian fisheries offer more scope (production is much higher and 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, and in particular in the Amazon, little academic attention has focused on fishing as an economic activity.

2.5 Freshwater production trends on the continent

Overall capture production rose every year from the 71,600MT recorded in 1950 to a peak of 376,166MT 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 MT in 1950 to 199,159MT in 50 years, having peaked at 200,621MT in 1985. For much of the same period, Colombia was the second most significant producer recording a growth of some 140%; although production in 2000 stood at 24,854MT, still significantly less than Brazil. Argentina's production has been erratic: production in 1950 was recorded at 13,700 MT, by 1970 it had dipped to 5,400 climbing to 15,045 five years later before dipping again in 1980. Towards the end of the 1990s, however, Argentinean production experienced a sharp rise and, by 2000, it was the 3rd largest producer on the continent. Peruvian production has also experienced a dramatic rise since the 1980s making it the 2nd largest producer in 2000. Other countries that have experienced a growth in their capture fisheries production are Venezuela; Paraguay - which saw production almost double between 1990 and 1995, and Guatemala where production has increased from 4-500 MT in the 1970s to 7,301MT in 2000 (see table 4).

Table 4: freshwater capture production Central and South America (MT)

[7] A complete breakdown of production by species by all Central and South American countries is found in Appendix 4.

	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	1100	1300	359	79	84	150	538	1076
Panama	.	.	.	.	.	.	.	50	15	130	20
Paraguay	400	500	600	700	1800	2800	3300	7500	12490	21000	25000
Peru	.	1000	1000	3000	2000	6671	12538	27791	28321	50789	32297
Suriname	.	300	300	500	300	295	71	228	350	140	200
Uruguay	.	.	.	.	.	245	312	660	218	844	2295
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

2.6 Aquaculture and harvest of aquarium fish and other aquatic species

Whilst the bulk of fresh water production comes from capture fisheries (85%), inland culture fisheries production rose 168% 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, caiman and alligators (see Appendix 4). While there are no readily available figures for the price of meat from these animals, caiman skins have a first sale value of $US5-10, an export value of US$50 each and up to US$200 each on re-export from European tanneries. Crocodile skins retail at about five times the price of Caiman skins, with a typical shipment of 2000 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 – a large aquatic mammal - were recorded in Brazilian 'fisheries' statistics during the 1950s, but are no longer included. Also of note, is the trade in tropical aquarium fish. Most of the fish destined for aquariums in Europe, North America and the Far East come from the Rio Negro. Wild caught fish from Brazil make up 5-10% of global ornamental fish market and in the Rio Negro basin cardinal tetra make up 85% of total catch (OFI Journal, 2002; Chao and Prang, 1997).

2.7 Regional importance of fishing as a livelihoods option

South America has maintained a low share of total global fishers; although after a marginal decrease in absolute numbers between 1970 and 1980, the number of South American fishers and fish farmers grew by over 50% during the last decade of the

[8] http://www.wcoomd.org/ie/En/Topics_Issues/Cross_borderCrime/Cites/broche/17.htm

eighties (FAO, 2001). 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 they are often one source of employment for the low- or unqualified (in urban and rural areas), and artisanal fisheries are generally conducted in conjunction with agriculture. The Solimões River, at the western end of the Amazon accounts for around 45% of all fishers in the Amazon River basin (Bayley and Petrere, 1989), yet as Table 5 demonstrates, accurate data on the number of fishers is hard to find, and the figures are often contested between reports. Part of the accounting problem arises because artisanal fishers often combine the activity with farming or off-farm work and the fishing portion of labour gets 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 in particular, where many fishers are subsistence fishers and do not join cooperatives or organisations to which commercial and many artisanal fishers belong, attempts at counting fishers through official organisation membership can be misleading.

What is known is that in the 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 organisation of fishing firms and the marketing relations are described. The DFRP (2001) highlights issues with fishermen in the **Parnaiba basin** (362,000 km^2) where activity is highly seasonal as the rivers Pindar, Grajua and Mearim dry up completely during the summer. Almeida et al 2003 also calculate the numbers of commercial and artisanal fishers on the Western Amazon (see Table 5).

Finally activity on other water bodies is covered by Ghishan (nd) who estimates that 6,000 MT is caught on Titicaca by an estimated 800 fishers.

TABLE 5: numbers of fishers on certain rivers/basins

River/Basin	No. of Fishermen
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)

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 analyse them in isolation from their immediate aquatic surrounds. Tropical and temperate river-basins offer a spectrum of goods and services to society, ranging 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 eco-tourism, 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 realisation 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, 1995).

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 Winpenny (1991:6) notes;

- 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.

- Valuation seeks to monetise 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’ which can be used in estimating the social value of species preservation (their research encountering an annual willingness to pay of between US$36-57 for the humpback whale within a group of 240 paid student subjects).

- Valuation, by internalising such benefits and costs, offers a more comprehensive framework for policy-making. The environmental and social impact report on the Cana Brava Hydroelectric power plant on the Toncantins river in the centre-west of Brazil, for example, led to a figure of US$25.5 million [6 per cent of 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

[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 as around US$20 per ton, whilst work reported by Van Kooten *et al.* (1992) produces figures varying between US$2 and US$275 per ton. 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 to US$24 million per species.

> fauna and ichtyofauna, and to rescue important archeological artefacts amongst other things (World Bank, 2000).

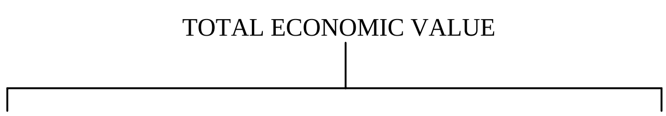
Valuation is not an unchallenged panacea however, and has its fair number of critics[11]. These challenges notwithstanding, accurate evaluation also remains critically dependent upon precise technical, scientific and economic data – data which may frequently be either unavailable, or costly to obtain. 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 which permits the aggregation of both monetary and non-monetary benefits and disbenefits within a standard evaluatory framework, such methodological limitations are perhaps excusable. Consequently, this report elects to summarise the extant literature [published and grey] through recourse to the TEV (Total Economic Value) framework advanced by Hodge (1996:7), with the objective of assessing the direct economic – and the wider social – value of Central and South America's river fisheries.

3.1 Total Economic Value

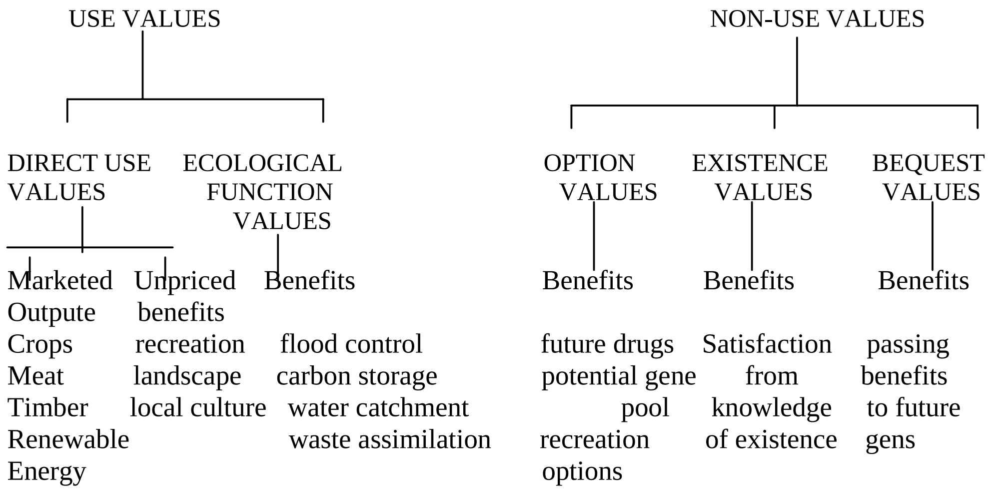
TEV can be disaggregated into two sub-components; use values and non-use values. Use-values in turn can be further decomposed into direct use-values [both marketed and non-marketed] and ecological, or indirect, use-values, whilst non-use values can be split into option, existence and bequest values (See 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), whilst 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 of gold from barges in the Peruvian Amazon (www.panda.org). At a secondary level, it also includes forward and backward linkages – in the fisheries instance, activities like the construction of boats/gear (backward) and the subsequent processing and marketing of the harvested resource (forward) – the wider social value in the terminology of the TOR. *Non-marketed use-values* of the fishery would cover fish caught for the purposes of self-consumption **(**Diegues, 2002), as bait-fish, or for

Figure 1: total economic value and its components.



[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 (see 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 run-off used to inform valuation methodologies has been done in temperate conditions, and similar causal relationships may not prevail in the tropics.



Source: Hodge (1995: 7)

recreational/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), to wash clothes (Escobar *et al.*, 2003) or for 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 little work has been done globally to date 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) into conserving the resource at the present point of time (option value), or for the benefit of future generations (bequest value), or simply because the resource is seen as an asset (existence value).

Existence values gained recognition following a 1967 paper by Krutilla which 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 the 'armchair environmentalist' – who does not make use of the asset, but wishes it to exist - equally 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 – donating the land acquired to the Parque Pumalin Foundation which now manages

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

just under 300,000 hectares (Larrain and Stevens, 2002; www.gochile.cl)[13]. Some organisations (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 analysed the preservation value of the humpback whale.

Option values refers 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 ascend to as much as US$9,000 once the commercial value of the standing forest has been factored in, while Myers (1988) suggests a hectare of tropical forest could produce US$200 of wildlife products annually per hectare[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 mined to support transgenic crop research (Thorpe and Robinson, 2003), the more palpable [fisheries] option value relates to the failure to fully [over]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 benefits of one's descendents or future generations rather than oneself[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 un-priced, applying appropriate evaluation techniques to accurately capture their true value is crucial.

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[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 those resident in the areas (De la Maza, 1997).

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

[15] Crook (cited in Eberlee) however, is more downbeat about such bio-prospecting, 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 ecosystemecosystems to any real extent* (the emphasis is ours)".

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

3.2 Valuation Techniques (Applicable to River Fisheries).

The most commonly used natural resource valuation method, largely due to its ease of application, is the *market analysis/value* approach. It is relatively undemanding to count the ornamental fish and reptiles extracted from the Orinoco river say and, by weighting in accord with their marketed price, obtain a figure for the value of the Negro's ornamental fish and reptile trade. Two caveats are in order. First, while there are well-established marketing channels for such products which aids information retrieval, not all trade may pass through such formal avenues – particularly if such trade is prohibited due 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, 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 fisherman who ensnares the fish?[17].

Related to this, the *Effect on Production* [EOP] method examines the change in direct use values resulting from a given environmental activity - identifying the physical effects associated with the change. Market values can be generated if these physical effects are then monetised 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 fishermen invariably bears little relation to the value placed on the activity itself. *The Travel Cost Method* (TCM), although originally developed to evaluate the worth of public recreation locations in the US, 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), for example. Aggregating the travel and opportunity costs incurred by surveyed individuals would produce an indirect measure of the un-priced benefits of recreational fishing on the river.

In some instances, direct markets (and prices) are absent and so *hedonic methods* are used, observing the prices of surrogate goods – generally property values and labour wage-rates - 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 – 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, for example.

Preventative Expenditures (PE) and *Replacement/Relocation Cost* (RC) methods are more commonly used to track the sums that people are prepared to spend to mitigate

[17] Equally, the quantity of food fish harvested from say, the Bio-Bio can be multiplied by market prices to obtain a value for the direct food-fish value of the fishery. If levels of fish used for bait or self-consumption can be ascertained, then appropriate shadow prices can 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 fisherman and the final market price is likely to be correspondingly lower than in the ornamental fish case.

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 minimise the impact of the dam on species migration would have been an example of PE, whilst the RC of fishing and other displaced households following construction of the Yacyretá dam was priced at US$24,000 per household.[18]

Finally, *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 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 then to help place a value on 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 as we have indicated. The main difficulty in applying such techniques in the developing world, Central and South America included, however is the paucity of primary data that is presently available – and the cost of augmenting such a limited knowledge base – shortcomings that seriously hamper attempts to construct a robust picture of the TEV of the region’s fisheries.

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[18] This value was the cost of the homes built at the beginning of the relocation process but later, cheaper constructions, known as ‘shellhouses’ were estimated to have cost just US$4,000 by the residents – raising questions as to which figure (if either) represents the ‘true’ RC. 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 re-housed in the city, forcing them to abandon their traditional activities.

[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 under-bid. Pearce and Turner (1990) further identify 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), strategic (respondents believe their response may, in fact, affect the course of events), or vehicle (payment method proposed) bias as further potential obstacles to the effective application of CVM methodologies.

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

Barbier (1991) suggests that a comprehensive evaluation of the full potential TEV of any environmental resource or ecosystem can be obtained by summing 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 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 maximised by maximising marketed and non-marketed output. 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 which may affect the prevailing *status quo* – whether it be to authorise 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.

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 (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 purport 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 levelled at CBA. The most common criticisms levelled at such aggregating techniques are:

- *The Distribution of Costs and Benefits.* Although the net outcome may be favourable, 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 tons 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.

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

- *Irreversibility.* Project acceptance sets in motion a chain of events which 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], then 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) amongst 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.* Notwithstanding 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 grey] so as to provide some preliminary indications as to the true economic value of the region's fisheries.

4. TEV OF THE REGION'S FISHERIES.

4.1 The Amazon Basin

While Central and South America's principal river system - the Amazon - contains 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 the ecosystem that has precluded extensive study of the TEV of the system. Indeed, the most comprehensive work undertaken on the river-basin, by the Amazon Rivers programme 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 sub-systems has generally not been formulated with the primary objective of assessing economic

[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.

value, but rather to document informational deficiencies [viewed from a management perspective] and alternative/improved management models, as will become clear in the ensuing review below [we group the studies together by region rather than their relative merits in relation to our given TOR]. Fortunately, information and data on economic values is a little more actualised in those instances where major ecosystem changes – such as the construction of dams or new industrial waterways – are proposed, as the ensuing section of the report (Section 5) details.

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. The authors visited all three major cities of over 250,000 population (Belém, Manuas and Santarém) and one quarter of the 48 smaller cities to interview Municipal Fishermen's Union leaders, the Coastguard, and all boatyards, fish processing plants, fishing gear stores, gas stations, ice factories and fish restaurants in their quest. In addition, a sample of fish vendors were interviewed in all public fish markets [exception of Belém and Manuas where a sample were chosen].

On the basis of the information collected, estimates were produced of the total fleet [5,457 vessels], number of commercial [29,089] and subsistence [49,955] fishermen, 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 estimated income arising from four sub-activities [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 use these estimates to show both the lacunae in official survey methods [the most recent agrarian census of 1997 estimated that just 17,742 were employed in the fisheries sector for example] which has resulted in the sector not receiving the attention and support it merits, and the real economic superiority of fishing over forestry in the region [the authors suggest the NPV of the fisheries sector, at R$93 million, or R$11,238 per hectare (US$31.62 million or US$374,000/ha respectively), is almost double that derived from forestry – R$50 million, or R$6,250][22] .

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

[22] The R$ was worth approximately US$0.34 in September 2003.
[23] Equally, using the term subsistence in this sense is incorrect as it fails to capture the values generated by the wholly subsistent fisherman [non-market use values] whose landings do not enter the market. Semi-commercial fisherman might be a better term.

employed in input or post-harvest operations stands in stark contrast to the study's findings which suggest there are nine fisherman for every one person involved in other fish-related activities.

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 fishermen operate in pairs from canoes using nets, longlines, 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-fishermen who supply the boat and cover the expenses of each 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 maximising price takers 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 was obtained for 2992 landings in 1997 as part of an IARA/IBAMA project, supplementary research establishing local values for gear, canoes, fuel and ice[24].

The paper finds that economies of scale are minimal in the lower Amazonian commercial fishery, before suggesting that production could be increased through the provision of lower cost ice. While the paper does 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 is attempted**, beyond the recognition that four major species in the Lower Amazon [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).'

Amazonian Fisheries: Socio-Economic 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, social and biological information needed to assist fishery decision-makers.

Noting the high levels of animal protein (61% in the Ucayali valley, for example) derived from fish products in parts of the Amazon, 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 is plotted to show a 'modest' upward tendency in landings at both Iquitos and Pucallpa over the period 1980-92, this was accompanied

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

by a sharp increase in effort [and a marked drop in cpue] which suggested some likelihood of over-fishing. The failure to monetise these recorded landings however, preclude us from identifying whether **marketed use-values** have risen/declined or remained stable over time.

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 [200,000 are active fishers]. In order to emphasize the importance of developing an effective management model they provide a fleeting idea of the **marketed use value** of the fishery – multiplying the 4,000-6,000 tonnes annually landed at the four principal towns in the Middle Amazon [Santarém, Alenquer, Monte Alegre and Óbidos] by average fish prices [US$1 a kilo] to produce a regional income figure of US$4-6 million p.a. Although the authors comment that the subsistence portion of the total catch is much larger, they fail to impute a value for this.

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

Ruffino's paper examines the experience of, and lessons learnt, from the 1991-8 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 the Amazon fishery has a **USE Value** [marketed and non-marketed food fish] of the order of US$100 million p.a., based on a catch of 200,000 tonnes p.a (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], ornamental fish exports – numbering around 17 million by the late 1980s and worth US$2 million [employing 10,000 people, principally in the Rio Negro region of Amazonas state], and an overview of stock exploitation levels for the major riverine species [Table 6 - although no price data are disclosed] is given.

Table 6: Landings in Amazonas state

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

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

[25] The findings from this project contributed to formulation of the Floodplain Resources Management Project (Provárzea 2000-) sponsored by IBAMA and the international community [see 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 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, to implement an integrated monitoring and control programme – including the construction of a statistical data-bank on the riparian fishery. The Programme produces excellent monthly data on landings [by species, water-body, vessel and gear-type] and average prices for seventeen municipalities scattered along the river[26]. The latest results (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 emerge 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 which 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 in 2001 and the quantity of landings (see table 8). However, it should be noted that for whatever reason, the project team have not done this and there may be good reason why they feel that such a calculation would be misleading at this time.

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.

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. Annual mean earnings of families in the reserve is US$900, with 72 per cent of these revenues being generated through fisheries activity. While the author suggests that primary exploitation of the reserve [fishing, logging, caiman hunting and agriculture] yields a

[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].

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

Table 7: landings and price data for Amazonas

Municipal.	Landings	Ave Price	VALUE R$	Landings	Ave Price	VALUE
Abaetetuba	155109	0.95	147353.55	1066811	1.10	1173492.1
Alenquer	80	1.43	114.4	5030	0.95	4778.5
Alvarães	-	-	-	-	-	-
Belém	177505	1.01	179280.05	220870	1.17	258417.9
Coari	-	-	-	-	-	-
Fonte Boa	-	-	-	245	N/A	-
Itacoatiara	-	-	-	384795	0.69	265508.55
Manacapuru	-	-	-	226104	0.51	115313.04
Manaus	-	-	-	2481	1.25	3101.25
Monte Alegre	8169	0.5	4084.5	198262	0.74	146713.88
Óbidos	5011	0.77	3858.47	1046976	0.65	680534.4
Oriximiná	1144	1.02	1166.88	19683	0.94	18502.02
Parintins	3703	0.81	2999.43	264831	0.83	219809.73
Prainha	-	-	-	111	0.70	77.7
Santarém	40840	1.19	48599.6	860216	0.76	653764.16
Tabatinga	983	2.17	2133.11	18375	2.56	47040
Téfe	1010	0.52	525.2	2420	0.37	895.4
Totals	**393554**		**390115.19**	**4317210**		**3587948.3**

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

Table 8: landings and gross first sale value on the Solimões and Amazon Rivers, 2001[28]

Municipality	Tonnes	Gross first sale value 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
*total value not known, these figure are average values based on average first sale price in that municipality multiplied by total landings.

[27] Table 1 [p.17] effectively double-counts fishery resources. Removing the double-counting error produces a lower revenue stream [US$1.5 million], of which fisheries accounts for about two-thirds.
[28] In mid 2001, the Real was worth$US0.43

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 socio-cultural 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. It does, nevertheless, also provide some aggregated data on the ornamental fish for export market – suggesting export receipts totalled US$2,216,620 in 1998 when 18.5 million fish were exported[29].

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

4.2 Other Inland Water Bodies.

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:

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 between 1960-85 when around 78% of catches came from marine waters and 22% from inland waters. Since that date there has been a decline (by 1990 production had fallen to 640,300) to 744,600MT/yr: 60% from marine sources and 40% from inland waters. The rise in production, however, is largely attributable to inland (culture) production given that marine production appears to be stagnating. Inland capture fisheries (of which 98% were fish and 2% crustacean, represented 25% of national production in 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 canalisation 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 specialises in

[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 under-estimated.

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, credit for hut supplies, ice or diesel oil or for 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, the construction of dams and canals, introduction of non-native species, pollution, and over-exploitation. (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. 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 are an integral part of their 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 impact 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, in the immediate aftermath of 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 which follow from the first two, and are characterised by lower fish catches; a rise in disease (malaria for example) as water levels and ecosystems change; changes in micro-climate as valuable wetlands and watersheds are damaged; and social displacement which has direct costs (of moving peoples) and indirect costs (such as the fragmentation of vulnerable indigenous groups in parts of Brazil).

Social benefits are also derived from dam construction. Boa Nova and Goldemberg (1999, cited in WCD, 2000) note, for example, that demographers attribute the reduction of the birth rate in Brazil to the increased availability of cheap hydro electricity which the authorities in Sao Paolo (amongst others) provide to 2 million slum residents. With access to electricity residents were able to watch television (a prime source of information on family planning). Other benefits that accrue from dam construction are increased employment opportunities in the construction phase but also 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 whilst there were benefits accruing from their construction, they were not likely to flow towards those who had born 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 minimising (if not eliminating) the negative impacts of dams. The WCD note 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 that 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, canalisation and water abstraction is complex because the effects can spread much further than the immediate physical area. The WCD report (op cit) notes that whilst a cost-benefit spreadsheet analysis may be useful for some projects to evaluate impact, with most large dams they are often too complex for such an exercise to have any meaning: livelihood, environmental and economic impacts, for example, do not allow for easy currency or metric comparison. What is more, they note 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 fishes, though there are means of mitigating this (see below) but, even so, Goulding notes that no studies on the impact of fish had been conducted on the 5 large dams built in the Amazon River basin by 1996 (Goulding et al, 1997). The impact on fishing is often contradictory: whilst the type of fish caught and the level of catch in specific areas may fall, overall, catch levels can rise. However, Jackson and Marmulla (2001) urge caution in this regard noting that the further downstream the dam, the less likely the fishery in the newly flooded reservoir is to compensate for lost catches on the other side of the dam wall. Yet in many cases the change in fish catches is rarely mentioned (though with little data on value of the catch pre/post construction, this is not very surprising) though relocation and compensation costs are. 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 (fishermen/farmers offered an apartment in the city; occupants of wetlands moved to dry savannah areas for example) 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 Northeast 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 11.5kg/ha/year in the Itaipu dam) which they conclude 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. They 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 to local small fishers. Unfortunately, with no price or systematic landings data, it is not possible once more to derive any use values 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).
Agostinho and Gomes analyse how biodiversity in the Upper Paraná river [defined as the upper third of the Paraná river-basin, stretching down to the **Itaipu dam**] has been affected by past fisheries management decisions. In particular, the construction of dams – 130 dams are greater than 10 metres in height, 26 have an area bigger than 100 square kilometres – although it was not until relatively late in the day [1981] that it became mandatory for hydro-electric companies to produce EIAs ex-ante. While the article notes the failure of management programmes designed to facilitate fish migration [1920-50s], and to increase yield by stocking exotic and/or native species [1950-1990s], 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-Southeast reservoirs as evidence of the impact of dam construction. No corroborative figures are cited to support the authors' assertion.

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 in the Tocantins-Araguaia River Basin. Construction was started in 1975 and completed in 1984. Phase II began in 1998 with the turbine due to start 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 groups and the colonists[30] who survived mostly on fishing, gold and diamond mining and subsistence agriculture. Fishing was estimated to produce some 1534 MT/year, 900 MT 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 about the impact of the ecosystem on the dam than vice versa. An attempt at an EIA was made in 1977, 2 years after construction began, but was already too late to have any impact. The regularisation of water flow affected natural flooding cycles which were responsible for natural fertilisation 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

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

populations be to able to make 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%. 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% drop in reservoir species diversity and species upstream of the reservoir dropped by 25%. By the mid 1990s, scientists were able to demonstrate that fish productivity had risen by 200% overall and reservoir catch had increased by 900% while downstream catch had dropped by 45%. No attempt is made, however, in ascribing 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 30,000R$ for Itupiranga to 287,900R$ for N. Repartimento (pg 89)] which 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 whilst 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 - which would suggest 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 (pg 132).

Cana Brava Hydroelectric Power Plant: Environmental and Social Impact Report (IADB)
As this powerplant is still in the early stages of construction on the Tocantins River, this report offers an examination of the potential impacts of the dam. They identify construction (as it is built); environmental (the loss of land through flooding, soil erosion is set to increase, decrease in fish populations); mineral (the loss of potentially valuable alluvial deposits under the reservoir); and socio-economic (258 families will be relocated with $4 million allocated to cover resettlement costs) implications. 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 programme 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. What is more, these dams were often built before EIA evaluation methods were commonly applied and so there was little necesssity to collect data from before and after. Largely based on the author's experience with the **Yacyretá** dam on the Paraná river, she describes the political and economic context of the building of many of the large dams on the continent and outlines some of the

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 democratisation process began in the region did the issue of the social impacts of dams find a way onto the agenda.

Fishermen were affected at the Yacyretá dam. Ferradas notes that fishermen were offered $8,000 each by way of compensation for loss of earnings (catches had fallen, access to the river was much harder) provided they agreed to make no further claims. Fishing activities were not identified as a possible source of conflict in the original plans for the dam however, possibly argues Ferradas, 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 notes the distribution of some $989million from the Itaipú (Brazil, Argentina, Paraguay border) dam, though states have no control over how monies received are allocated – whilst ideally it should go towards compensating the losers from the project, this is not guaranteed nor protected in 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**) for each of the displaced 4,000 families was US$ 93,750 per family under the conventional resettlement plan - but fell to only US$47,920 per family under the community managed resettlement plan (which was introduced following the privatisation of the company building the dam). Although the reduction in the cost of relocation is cited as a benefit in the report, this is obviously 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 (which began in the 1970s and is still uncompleted) has had a dramatic effect of 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%; with some 700 fishermen affected by the dam. Kudlavicz does not, however, attempt to place a monetary value on the **use-value**s foregone through the decreased catches.

5.6 The URRA Dam

Fishing production dropped from 6,000 to 1,700 MT 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 because the population depended upon fish as their main source of animal protein 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 stand-off between the Pehuenches and the Chilean government over the imminent flooding of the Bio-Bio river downstream of the Ralco Dam is analysed 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 there are six species endemic to the Bio-Bio which are likely to be lost when the valley is flooded, suggesting some loss of **existence values**. Moreover, he notes 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**, latest figures quoted by the Miami Herald (6 November 2002) show that 92 families in total who were affected by the dam, 84 have already moved, 7 remained (the core of the indigenous protest) and that $US20 million was assigned 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 3442 km long between Caceres in Brazil and the harbour 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. The authors argue that if the critical value of the environmental costs (i.e. **the existence and bequest values**) of the project 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 implications of disturbing the water flow through the Pantanal are complex and critical, water flow in rivers would increase, causing increased erosion and flooding during the rainy season. They cite the potential loss of fish biodiversity as particularly

important although no figures are given. Bucher and Huszar argue that while the current economic evaluation of the project shows a net positive return to the project, it is not only sensitive to the underlying assumptions but, critically, the environmental costs have not been internalised.

Analysis of the EIA for the Araguaia-Tocantins Hidrovia Project (CEBRAC)
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 as 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 upon 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; they find no justification at all for the project. 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 such 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. There are many cases cited on the internet of pollution of rivers in the region (see http://www.globalminingcampaign.org/theminingnews/case.html), but many of them are anecdotal, there are few academic texts that quantify the level of pollution and its impact on fish resources. A recent cyanide spill on 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 base line data exists 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 in-direct use values. Thus data on the value of the fishery (marketed and non-marketed value) is not only needed, but also data on the value of the underlying biodiversity of the system, the ‘existence’ of the fishery and the livelihoods of those fishing, on the existence (now and in the future) of the environment in a pristine or altered state, on the continued existence of certain indigenous groups, on 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 changed water courses on fisheries – particularly the impact of dams and water abstraction schemes. The report found that, again, there was a real paucity of information on this topic. Whilst many dam evaluations have cited a change in catches from rivers, or a change in the diversity of fish stocks, few attached numbers to such assertions and not one report attempts to quantity the level of impact in an economic/market sense. The only indication the reports give as to 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 fishermen 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 a 'having to accept' payment. Many of the fishermen 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 perfect information. Conversely, of course, in some cases the sums offered for relocation (and accepted) may offer a fair representation of the impact of the dam on livelihoods (some fishermen 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, small studies on discrete parts of the continent have been conducted and provide us with examples of the sorts of values we might hope to obtain. The authors suggest that attempts to value CSA river fisheris could be developed in two directions. First, the Provarzea project run by IBAMA (see section 3) offers 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. It will not be easy to extend such analyses to encompass the river-basin, let alone the continent's other inland fisheries, however.

Second, the value of sport fishing in CSA (as in most parts of tropical Africa and Asia) remains an unknown quantity. A cursory glace on the internet shows that the Amazon and Plate river basins offer numerous opportunities for sport fishing ventures (both for locals and for 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 of 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 1000 tributaries, including 7 more than 1000 miles long Total length: 6,516 km 7,180,000 km sq drainage Western most reaches refered as the Solimões **Negro**: Venezuela and Brazil Length: **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: 3590 km
Nordeste Basin Brazil 362,000 km sq drainage	**Parnaiba** Total length: 1485 km **Mearim** **Das Balsas** **Pindare**
Tocantins-Araguaia Brazil	**Tocantins (**see amazon basin**)** **Araguaia** **Das mortes**
Paraguay Brazil Parana-Paraguay system flows through Brazil, Bolivia, Paraguay, Argentina and Urugay	**Paraguay**: Brazil-Paraguay, Argentina, flows into Parana River Total length: 2549 km **Parana**: Confluence of Paranaiba and Grande, flows into River Plate Total length: 4498 km
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 Flows into Atlantic 4,700 km long 2,650,000 km sq drainage	**Pilcomayo**: Headwaters in Bolivian Andes, flows into Paraguay River Total length: 1999 km
Sao Francisco	**Sao Francisco**

Brazil	Headwaters in southwest Minas Gerais, Brazil, flows into Atlantic Total Length: 3198 km **Corrente** **Grande**
Orinoco Brazil Headwaters in Serra Parima Moutains, VZLA, flows into Atlantic Total length: 2062 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, flows 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	-
	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

		1965	1970	1975	1980	1985	1990	1995	2000
	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
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	.	.	.	.	-	-	-	-

		1965	1970	1975	1980	1985	1990	1995	2000
	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

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

		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
	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
	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

		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
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
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	.