Environmental Conservation **34** (1): 12–22 © 2007 Foundation for Environmental Conservation doi:10.1017/S0376892907003566

Aquarium fish exploitation in western Amazonia: conservation issues in Peru

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Date submitted: 9 February 2006 Date accepted: 14 December 2006 First published online: 5 March 2007

SUMMARY

The Amazon basin is a key supplier of wild freshwater fishes to the multi-billion US$ global aquarium market, yet limited information exists on the organization of the regional trade, its importance to local economies or conservation impacts. Through field interviews and review of government statistics, this paper describes the state of the industry in Peru, reporting on the scale and value of the trade, the nature of the fishery and the characteristics and roles of key actors in regional supply networks. An economically important industry is revealed, with 28 firms officially exporting over nine million fishes worth US$ 2.5 million to 24 countries in 2001, and involving fish species from 36 families transported from rainforest catchments up to 1100 km distant from the export centre of Iquitos. Most fish are however collected close to the city, with 10 species representing >70% of trade volume. Some 10 000 people earn income from the trade, among them many rural poor who depend on aquarium fish collection as a primary or supplementary source of cash income. The industry is currently undergoing an important transition towards supplying new Asian and European markets, increasing exports of species biologically unsuited to heavy exploitation as a result, and highlighting the conservation need for improved knowledge and management of the trade in Amazonia.

Keywords: Amazon, aquatic conservation, artisanal fisheries, non-timber forest products, ornamental fish trade, rural livelihoods

INTRODUCTION

The collection of wild fishes for the international aquarium trade is of increasing conservation concern (Andrews 1990; Wood 2001). Aquarium fishes are the most popular pets in the world, and drive a growing, global industry worth US$ three billion in annual retail sales of fishes alone in 1999 (Olivier 2001, p. iii). Freshwater species make up 90% of the trade value, with all but *c.* 10% of freshwater specimens produced in captive breeding facilities (Olivier 2001, p. 17). Nonetheless, ongoing collection from the wild is large in scale and scope, involving millions of fishes from a myriad of freshwater habitats worldwide. The trade has contributed to local population extinctions among South-east Asian freshwater fishes (Ng & Tan 1997) and possible declines in the Brazilian Amazon (Chao 1992; Crampton 1999). Of growing interest to conservation groups is the promise of well-managed fisheries for freshwater aquarium species to provide sustainable livelihoods to the rural poor, as evidenced by projects underway in South America (Project Piaba: Chao 2003; Sociedad Civil Mamirauá and the Zoological Society of London: H.J. Hall, personal communication 2005; Iwokrama: Iwokrama International Centre for Rainforest Conservation and Development 2005) and suggested for equatorial Africa (Brummett & Teugels 2003).

The Amazon basin is among the most important sources of wild-caught freshwater fishes in the global aquarium trade. The region holds exceptional aquatic biodiversity: estimates of the total number of fish species in the basin range from some 1200 (Géry 1984, p. 353) to 3000 (Henderson & Robertson 1999, p. 45), greater than any other river system in the world. Although South America ranks behind Asia, Europe and North America in terms of number of fish supplied to the industry, unlike these regions, its trade is nearly entirely composed of wild-sourced fishes (Olivier 2001). It was an Amazonian species, the neon tetra *Paracheirodon innesi* Myers, that first popularized fish-keeping as a hobby upon its commercial introduction in 1936 (Prang 2001). Today, the Amazon continues to be a source of novel species to the market, and to supply many of the freshwater trade's most popular species, either directly, or by providing the wild genetic material necessary to maintain healthy strains of captive-bred fishes. The primary exporters are Colombia (42% of declared South American export value in 1999), Brazil (33%) and Peru (21%) (Olivier 2001, table 7.5). The Amazonian aquarium fish trade is highly diverse and, although the precise number of species captured remains unknown, hundreds of varieties are exported each year from the basin.

Despite the long history of the Amazonian fish trade, its economic and strategic importance to the international industry and reliance on potentially vulnerable wild fish populations, the aquarium trade in Amazonia has been the subject of limited study. Detailed published information is available only on the trade based along the Rio Negro in Brazil. There, researchers describe a large and valuable commerce (with nearly 20 million fishes exported annually from Manaus) focused primarily (some 80% of annual exports) on the

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https://doi.org/10.1017/S0376892907003566 Published online by Cambridge University Press

cardinal tetra *Paracheirodon axelrodi* Schultz and providing income to upwards of 10 000 rural inhabitants (Chao & Prada-Pedreros 1995; Chao & Prang 1997; Prang 2001, 2004). In the municipality of Barcelos, the chief supply area, aquarium fish earnings account for at least 60% of municipal revenue (Prang 2001). For western Amazonia, documentation of the aquarium trade consists of unpublished institutional reports that are not easily accessible to a wide readership and are dated or limited in scope.

This paper presents the first comprehensive description of the trade in Peruvian Amazon aquarium fishes, describing in turn the scale, composition and destinations of exports; sources, fishing seasons and capture methods of the aquarium fishery; and the organization of the local industry. Our study points to an important resurgence in the trade, with growing emphasis on the capture for export of high-value species that are vulnerable to heavy exploitation. Such trends, coupled with the economic importance of the trade for fisherfolk, many of whom count among the rural poor, pose significant challenges for species conservation, similar to those faced for other aquatic biological resources that are harvested artisanally.

METHODS

Setting

The aquarium fish trade of the Peruvian Amazon is centred on the city of Iquitos, capital of the Department of Loreto. The region is characterized by extensive lowland humid tropical rainforest, and by a rich and dynamic mosaic of aquatic habitats created by the annual flooding of the Amazon and its tributaries. Iquitos is the largest urban area in the Peruvian Amazon, with over 300 000 inhabitants, and serves as the principal market for agricultural, fisheries and forest products extracted in the region (Barham *et al.* 1999; Kvist *et al.* 2001). The city sits at the hub of an extensive river transportation network, but lacks roads to the rest of Peru or direct commercial flights to international destinations. In 2001, 28 aquarium fish export firms were established in the city, exporting fishes to 24 countries via Lima (Ministerio de Pesquería 2001). The other aquarium fish trading centre of the Peruvian Amazon, the city of Pucallpa, located roughly 1100 km south of Iquitos on the Ucayali River, is of minor importance. According to informants in Iquitos, some five firms operated out of Pucallpa, sending fishes by air primarily to companies in Iquitos for export out of the Amazon, and secondarily to firms in Lima (see also Hanek 1982; Kullander 1986).

Regulations on the regional aquarium trade are weakly enforced. The chief piece of national legislation on Peruvian Amazon fisheries (Reglamento de Ordenamiento Pesquero en la Amazonía Peruana, adopted by Ministerial Resolution No. 147–2001-PE) requires all ornamental fishers to be licensed, calls on collectors and traders to minimize mortality, and bans collection from the wild and sale of the fry and juveniles of 41 species also deemed to be important to the commercial food fishery (see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 1). One of these species, the *paiche* (*Arapaima gigas* Schintz) is additionally listed on Appendix II of the Convention on International Trade in Endangered Species (CITES), with export allowed only under permit from national authorities. The government has further established minimum standards of operation for firms to obtain and retain a license to export fishes (Ministerial Resolutions No. 287–2000 and 219–2001).

Data collection

Information presented here is drawn from fieldwork conducted by M.-A. Moreau and a local assistant between June and September 2002, and from trade statistics, focusing primarily on the year 2001. In Iquitos, semi-structured interviews (consisting of a set series of open-ended questions) were held with 12 representatives of 10 export firms. Firms were purposively selected to reflect the range in trade volume and value and market orientation (i.e. selling to national clients only, North American only or more widely international) of export companies operating in the city. Initial information on firms' trade volumes and shipping destinations was obtained through the Ministry of Fisheries (Department of Loreto office; see below). During interviews, company representatives were asked about the size of their business, the sources and destinations of their fishes, the quantities traded and sale prices of their most important species, relationships with suppliers and clients, holding and transport procedures, and mortality levels and conservation concerns. Interviews were usually followed by a tour of the facility.

In addition to export company representatives, 42 current or former fisherfolk and/or intermediary buyers in the aquarium trade were interviewed. Of these, 10 were based in Iquitos, four in Requena (an important transit point in aquarium fish supply networks on the Ucayali River), and the remainder in three rural communities located less than 50 km by water from Requena on the Ucayali and Tapiche rivers. These individuals were suggested as informants by company representatives in Iquitos, or were encountered in the course of a related socioeconomic study of rural household participation in the trade.

Prior to beginning research with local trade participants, meetings were held with an aquarium fish importer based in Montreal (Canada), and with two fisheries researchers and a Ministry of Fisheries official in Iquitos, to gain knowledge of the region's trade and identify available documentary sources.

The Ministry of Fisheries (Loreto) provided statistics on the Iquitos aquarium trade compiled for 2000 and 2001. Export companies based in Iquitos must obtain a permit from the Ministry prior to each shipment by completing a *Certificado de Procedencia* (Certificate of Origin), with information provided on the forms summarized annually. The summaries list *inter alia* units and value of fishes that are exported nationally and internationally by fish name,

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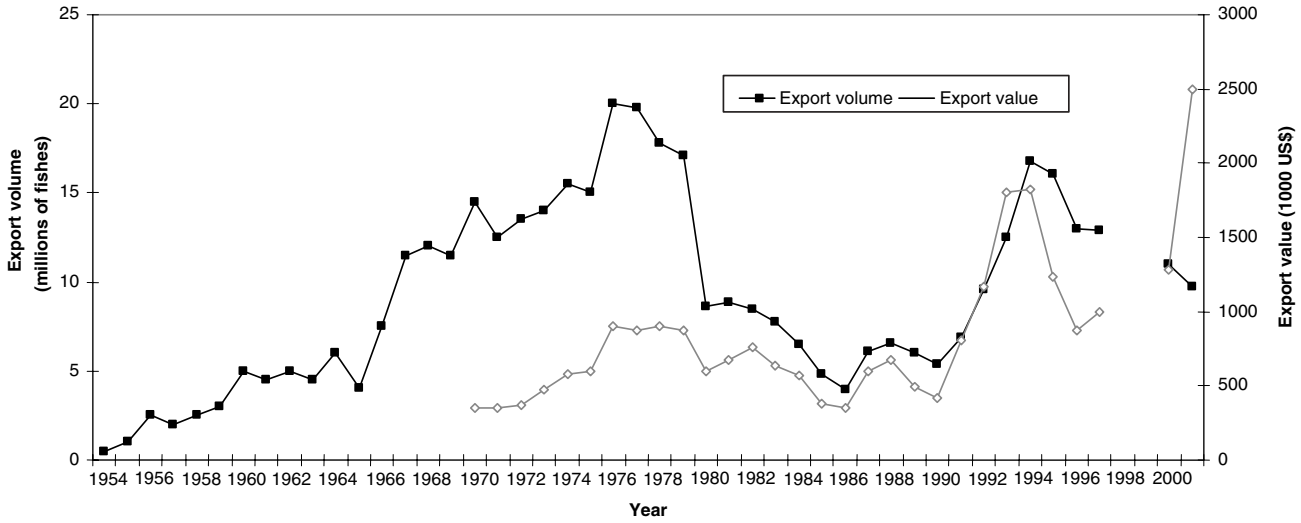


Figure 1 Annual volume and value of aquarium fish exported (national and international destinations combined) from Iquitos (Peru), 1954–2001. Value is given as fob (free-on-board, i.e. cost of goods before considering freight, packing and duties). Sources: 1954–1977 Hanek (1982, fig. 30); 1978–1988 Tello and Cánepa (1991); 1989–1997 Soregui and Montreuil (1998); 2000–2001 Ministerio de Pesquería (2000, 2001).

firm, country and city, and export destinations shipped to by individual firms. Ministry officials are meant to verify information provided on declarations through inspections of shipments, but exporters reported that most boxes went unchecked, and that, in any case, officials were usually unable to identify fishes. According to informants, this allowed for the export of restricted species through purposeful mislabelling of shipments. Exporters also reported under-declaring the export value of shipments in order to reduce taxes (set at 2–3% of value), and under-declaring the shipment volumes in anticipation of clients' deductions from the final payment for dead-on-arrival fishes. This under-declaration in local export trade statistics is estimated to be at least 20% (Soregui & Montreuil 1998). Despite these shortcomings, available statistics provide an indication of the trade's taxonomic diversity and a minimum estimate of scale.

Export volumes and values for years prior to 2000 were obtained from the Ministry of Fisheries (Loreto) data presented in institutional reports (Hanek 1982; Tello & Cánepa 1991; Soregui & Montreuil 1998). Given that the USA is the largest importer of Peruvian aquarium fishes, data on that country's aquarium fish imports from Peru in 2001 were solicited from the US Fish and Wildlife Service for comparison with export data for the same year.

Most fishes are referred to in the regional trade by common name only, with variations within species in size and colour giving rise to a plethora of different names. Where scientific names are used, these are often mistaken or out of date. To obtain an estimate of the number of aquarium fish species, genera and families exported from Iquitos at the time of this study, a list was compiled of all fish names recorded in 2001 trade statistics and on summer 2002 stock lists provided by interviewed export company representatives. The resulting list was simplified by correcting obvious spelling errors and removing duplicate entries, and grouping under a single name fishes that, (*a*) had the same name in translation (for example tetra black point and tetra punto negro) and/or, (*b*) were referred to by the same scientific name. The spelling and validity of scientific names were checked and corrected in the text (according to Eschmeyer 2004). Where no scientific names were given, as was most often the case, fishes were assigned to a genus based on their common name.

RESULTS

Aquarium fish exports

The Peruvian Amazon aquarium fish trade has experienced five distinct phases over its 50-year history (Fig. 1). Following an initial phase of steady growth (1954–1965), export volumes increased rapidly with the supply of low-unit value fishes to the market. The trade declined precipitately after 1979 owing to competition from captive breeders abroad (Hanek 1982). After a period of stagnation, in which exporters focused on shipping higher-priced species at low volumes, aquarium fish exports began to recover in the mid-1990s, based on supply of high unit-value fishes in relatively large numbers to international markets.

In 2001, aquarium fish were the third most valuable official export from the Department of Loreto, accounting for 6% of total recorded international export value after timber and oil (Banco Central de la Reserva 2001). In the same year, 9 749 252 aquarium fishes were exported from Iquitos, with 7 323 642 (75.1%) sent to international clients and the balance to national destinations, primarily Lima (Ministerio de Pesquería 2001). The declared total export value of the trade in that year was US$ 2.5 million (Fig. 1), with international trade officially generating US$ 1.37 million (Ministerio de Pesquería 2001).

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Table 1 Taxonomic diversity of fishes traded out of the Peruvian Amazon in 2001, with the five most important families (by volume) indicated in bold. Source: Ministerio de Pesquería (2001) and exporters' summer 2002 stock lists. Export share data is missing for families included on exporters' stock lists but not in export statistics. [a]Trade appellation is the name used by local traders to refer to a fish group. [b]Dwarf cichlids. [c]Discus cichlids (*Symphysodon* spp.). [d]Wide-bodied loricariids. [e]Thin-bodied loricariids. [f]Not native to region.

Order	*Family*	*Trade appellation*[a]	*No. of genera*	*No. of varieties*	*Export volume share (%)*
Batrachoidiformes	Batrachoididae	–	1	1	
Characiformes	**Characidae**	Variedad	24	133	**17.5**
	Ctenoluciidae	Variedad	1	2	0.07
	Curimatidae	Variedad	4	7	1.2
	Cynodontidae	Variedad	2	2	0.16
	Erythrinidae	Variedad	3	7	0.05
	Gasteropelecidae	Variedad	3	5	**5.8**
	Lebiasinidae	Variedad	4	23	2.3
	Prochilodontidae	Variedad	1	1	0.01
Cyprinodontiformes	Aplocheilidae	–	2	2	0.03
	Poeciliidae	–	2	2	0.006
Gymnotiformes	Apteronotidae	Macana	1	5	0.15
	Gymnotidae	Macana	2	26	
	Hypopomidae	Macana	1	2	
	Rhamphichthyidae	Macana	1	2	
	Sternopygidae	Macana	1	1	
	Unknown	Macana	–	2	
	Electrophoridae	Anguilla	1	1	
Lepidosireniformes	Lepidosirenidae	–	1	1	0.06
Osteoglossiformes	**Osteoglossidae**	Arahuana	1	1	**10.9**
Perciformes	Belontiidae	–	1[f]	1	0.005
	Cichlidae	Bujurqui[b] or Disco[c]	15	84	2.9
	Nandidae	–	1	1	0.21
Pleuronectiformes	Soleidae	–	1	1	0.013
Rajiformes	Potamotrygonidae	Raya	1	29	0.15
Siluriformes	Ageneiosidae	–	1	8	0.03
	Aspredinidae	Banjo	2	5	0.28
	Auchenipteridae	–	7	26	0.45
	Callichthyidae	Shirui	5	107	**20.4**
	Cetopsidae	–	2	15	0.11
	Doradidae	–	11	16	1
	Helogeneidae	–	1	1	
	Hypophthalmidae	–	1	1	<0.001
	Loricariidae	Carachama/Pleco[d] or Shitari/Loricaria[e]	13	98	**32.1**
	Pimelodidae	Zúngaro	19	61	3.8
Synbranchiformes	Synbranchidae	–	1	3	0.011
Tetraodontiformes	Tetraodontidae	–	1	1	0.31
Unknown	Unknown	–	–	20	0.05
TOTAL	36		139	704	100

Actual trade volumes and values are likely to have been at least 20% higher, if not more. Comparison of trade volume data from the Ministerio de Pesquería (2001) and the US Fish and Wildlife Service (2001) indicates that an estimated 41% of imports to the USA were undeclared at export. Whereas the 20 firms appearing in both sets of statistics declared total exports of 6 226 748 fishes, of which 68% (or some 4 234 190 fishes) were assumed to be destined for the USA (based on the known market share for all 24 Loreto firms exporting to that country), USA importers declared receiving 7 228 100 fishes.

In 2001–2002, some 704 putatively different fish varieties were exported from Iquitos, with 248 referred to by a scientific name. These varieties represented some 139 genera, 36 families and 13 orders; trade participants grouped fishes into a smaller number of commercial categories (Table 1). In 2001, 620 aquarium fish varieties were exported from Iquitos; 445 to national markets and 502 to international destinations (Ministerio de Pesquería 2001). The 10 most traded fishes alone represented 70% of declared national and international export volume and included a catfish identified as *Otocinclus affinis* (29% of total volume, likely one or a mix of the five valid species of *Otocinclus* recorded in the Peruvian Amazon, of which *O. affinis* is not one), silver arawana juveniles (*Osteoglossum bicirrhosum* Cuvier, 11%), the bleeding

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Table 2 Top 10 most important aquarium fish exports from Iquitos in 2001, by international sales value. Source: Ministerio de Pesquería (2001). [a]Spanish (English) common names. [b]Unit value = international sales value/international export volume. [c]Total export volume = international and national exports combined. [d]Listed as *Otocinclus affinis* in trade statistics, but species does not occur in the Peruvian Amazon. Category probably includes five species, dominated by *O. vittatus* (W. Junk, personal communication 2006) [e]Listed as *Corydoras julii* in trade statistics, but species does not occur in the Peruvian Amazon.

Rank	*Fish variety*[a]	*Family*	*International export value (US$)*	*Unit value*[b] *(US$)*	*% of total international export value*	*Rank by total export volume*[c]
1	Arahuana (Silver arawana) *Osteoglossum bicirrhosum* Cuvier 1829	Osteoglossidae	559 615	0.55	42.0	2
2	Peje torre (Red tail catfish) *Phractocephalus hemioliopterus* Bloch & Schneider 1801	Pimelodidae	69 408	0.97	5.2	16
3	Tigrinus zúngaro (Tiger-striped catfish) *Brachyplatystoma tigrinus* Britski 1981	Pimelodidae	67 907	14.57	5.1	97
4	Raya motoro (Ocellate river stingray) *Potamotrygon* sp.	Potamotrygonidae	64 186	5.91	4.8	59
5	Otocinclus (Otocinclus)[d] *Otocinclus* spp.	Loricariidae	53 510	0.02	4.0	1
6	Julii (Leopard corydoras)[e] *Corydoras* sp.	Callichthyidae	29 309	0.07	2.2	4
7	Otocinclus cebra (Zebra otocinclus) *Otocinclus* spp.	Loricariidae	25 499	1.17	1.9	30
8	Raya tigre (Tiger ray) *Potamotrygon* sp.	Potamotrygonidae	18 951	76.10	1.4	320
9	Punto rojo (Bleeding heart tetra) *Hyphessobrycon erythrostigma* Fowler 1943	Characidae	18 580	0.04	1.4	3
10	Pimelodella angélica (Pictus cat) *Pimelodus pictus* Steindachner 1876	Pimelodidae	16 492	0.10	1.2	11
–	Other ($n = 610$)		407 543		30.8	
TOTAL			1 331 000		100	

heart tetra (*Hyphessobrycon erythrostigma* Fowler, 6%) and the callichthyid catfish identified as *Corydoras julii* (5%, although that species is not known to occur in the Peruvian Amazon).

Only four of the 10 most numerically important aquarium fish varieties were also among the 10 most economically important for 2001 (Table 2). Silver arawana was by far the highest sales-generating species, representing 42% of international export value. Unit prices for fishes sold to international clients were US$ 0.02–84, the majority however being worth a dollar or less to Iquitos-based exporters (74%, $n = 502$ fish varieties). The 20 highest-priced fishes (worth ≥ US$ 15) were primarily large charismatic species (10 stingrays, four pimelodid catfishes and two knifefishes), but also included two smaller loricariids and two newly-discovered varieties of *Corydoras* catfish.

Taken together, 27 of 28 firms in Iquitos shipped fishes internationally to clients in 24 countries and 42 cities; 17 companies shipped at least once to national clients (Ministerio de Pesquería 2001). Fishes sent to the national market were primarily being re-exported abroad (exporter interviews). Most of Iquitos' international exports by volume were destined for the USA (68%), with the remaining exported in 2001 primarily to Hong Kong SAR (9.3%), Germany (9%) and Japan (7.4%) (Ministerio de Pesquería 2001). Despite its much greater volume of imports, the USA accounted for just 33% of total international export value, Hong Kong accounting for 29%. In terms of both volume and value, Miami, Los Angeles, Frankfurt and Hong Kong were the most important international destinations for aquarium fishes exported from Iquitos, accounting for 84% of all fish traded internationally and 69% of international sales (Fig. 2).

According to export firm representatives, clients in the USA were ordering the widest variety of fishes, but focusing primarily on high-volume low-value characins and callichthyid catfishes. Asian clients ordered the more expensive silver arawana, stingrays, *peje torre* (Table 1) and other pimelodid catfishes in large quantities, whereas the European market was strong for novel species (particularly of *Corydoras* and *Apistogramma*).

The aquarium fishery

Virtually all fishes in the regional trade were taken from the wild, with no local firm able to commercially breed fishes in captivity. Wild fishes were drawn from throughout north-eastern Peru, although collection was concentrated near Iquitos (Fig. 3). Informants and available statistics cited 21 rivers as supplying the trade, with three rivers (the Nanay, Itaya and Ucayali) easily accessible from Iquitos providing over 75% of all fishes received at exporters' facilities in 2001 (Ministerio de Pesquería 2001). Based on interviews, exporters also drew supplies from as far away as Pucallpa (*c.* 1100 km by river), Yurimaguas (*c.* 700 km) and Ramón Castilla on the Colombian border (*c.* 450 km).

Although trade statistics and interviews provided information on the river of origin of aquarium fishes (see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 2), most species were not

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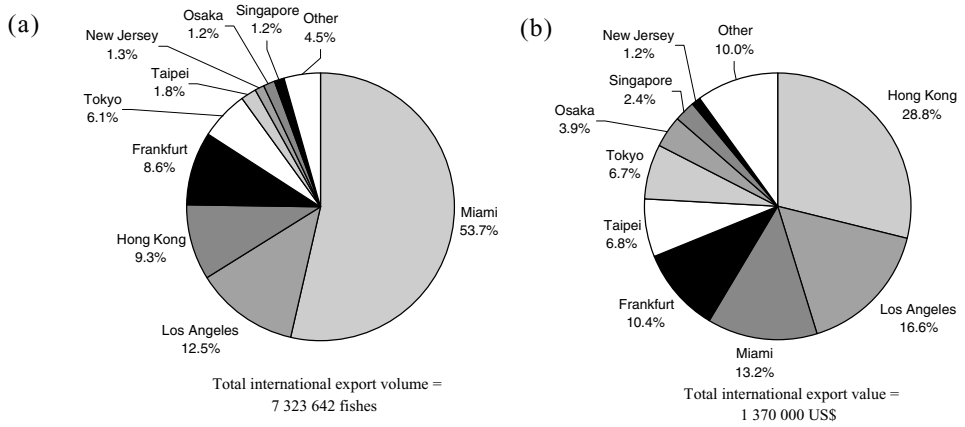


Figure 2 International destinations of aquarium fishes exported from Iquitos in 2001, (*a*) by share of total international export volume and (*b*) by share of total international export value.

caught in the main river channels, but rather from adjoining water bodies. These included small tributaries (*quebradas* and *quebraditas*), floodplain oxbow lakes (*cochas*), swamps (for example flooded moriche palm forest, the *aguajal*) and remote upland streams.

The supply of fish in the regional aquarium trade was closely tied to the annual flood cycle. According to informants, otocinclus, callichtyid and loricariid catfishes, as well as most *variedades* (Table 1), are largely collected in the low-water ('summer') season when water bodies shrink in size and fishes are easiest to capture. Other species such as juveniles of silver arawana and pimelodid catfishes are caught as water levels are rising, or at high-water, such as the bleeding heart tetra.

Whereas the differential timing of the flood pulse across the Upper Amazon afforded exporters some opportunity to shift their sources of supply, most aquarium fish species were only readily available to firms in Iquitos from June to early November, when low-water conditions prevail along the most easily accessible rivers. Demand for aquarium fishes from international clients was reported to be constant year-round, although prices varied markedly with seasonal supply. For example, exporters reported buying otocinclus catfish for just

No.	River	Volume supplied (% of total)
1	Amazonas	7.5
2	Ampiyacu	0.04
3	Algodón	0.003
4	Putumayo	0.7
5	Napo	4.5
6	Manití	0.5
7	Momón	0.02
8	Nanay	23.8
9	Itaya	19.8
10	Tahuayo	0.03
11	Yavarí	0.01
12	Ucayali	32.5
13	Marañón	0.1
14	Tigre	0.04
15	Pastaza	0.001
16	Huallaga	0.04
17	Samiria	n.a.
18	Pacaya	n.a.
19	Tapiche	8.1
20	Blanco	2.3
21	Aguaytía	0.001

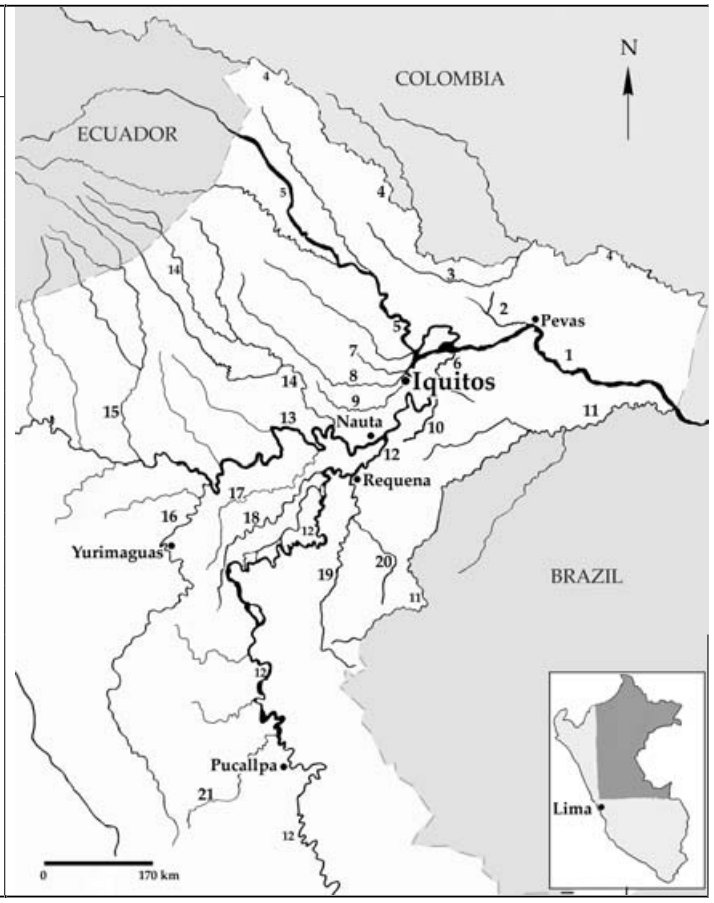


Figure 3 Map of rivers supplying the Peruvian Amazon aquarium fish trade. The adjoining table provides a key to the rivers, together with the per cent share contributed by each river to the total volume of aquarium fishes supplied to exporters in 2001. Sources: Ministerío de Pesquería (2001); interviews with trade participants, summer 2002.

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Table 3 Principal fishing gear and methods used by aquarium fish collectors in the Peruvian Amazon.

Gear	*Characteristics*	*Methods*	*Types of fish targeted*
Tarrafa net	5-mm mesh size	Cast from boats to capture swimming schools	Small, mobile fishes (such as loricariid and callichthyid catfishes)
Bolichera net	2–10-mm mesh size; 25–40 m length	Used at water's edge to encircle schools of fishes, or to block waterbody's entrance	
Llica or *pusahua* net	Long-handled scoop net (variable mesh size and hoop diameter)	Used to scoop up fishes trapped by larger nets	
		Used in shallow waters, where fishes must be searched out	For example the highly cryptic leaf fish *Monocirrhus polyacanthus*
		Used in combination with bait	The bleeding heart tetra
		Used in combination with a bundle of leaves, mimicking overhanging shelter	The discus, *Symphysodon* spp.
Trampa net	Gill nets of varying length and mesh size. For arawana: 10–12-cm stretched mesh size, 50–115-m long, 3–4-m wide	Set at the water's surface, to hang perpendicularly in the water column	Silver arawana (principally); stingrays
Piscicides	*Barbasco* (*Lonchocarpus* spp.), the natural plant source of rotenone	Poured into water body; targeted fishes are collected and revived in fresh water	Discus
By hand (no gear)	–	Reach into submerged holes	Juveniles of the peje torre
		Search the surface of submerged logs	Carachama, the suckermouth catfishes

US$ 6 per 1000 fish at peak availability and US$ 23 per 1000 fish during the low supply season in 'winter'.

While the aquarium fishery drew on rudimentary equipment and manpower ('artisanal'), the associated knowledge of fish behaviour and habitats could be quite complex, as indicated by the variety of gear and methods used by fisherfolk (Table 3). Fisherfolk were generally travelling in dugout canoes or, for long-distance expeditions involving groups of fisherfolk, wooden boats of approximately one tonne capacity propelled by a longshaft (5–15 hp) or small outboard (for example 25 hp) motor.

Transit times for fishes from capture to sale to export companies varied from less than 24 h to over three weeks. No sound estimates were obtained of mortality rates between fish capture and delivery over this transport phase.

Trade organization

Of the 28 exporting firms operational in 2001, the five largest accounted for 57% of international trade volume. Two of these same firms were among the five reporting the highest sales, together generating 59% of total international export value (Ministerio de Pesquería 2001). Based on extrapolations from interviews, export firms in Loreto altogether were employing 67 people in management and 175 as full and part-time workers.

Local trade participants informally classified companies into two categories: *miamero* companies, whose main clients were wholesalers in the USA (primarily Miami), and *destino final* (DF) companies that largely bypassed American distributors and shipped directly to 'final destination' clients in Europe, Asia and the Americas. Miamero companies usually dealt in small cheap fishes (such as *shiruis* and variedades; Table 1), and lacked the facilities and technical expertise to hold fish for extended periods or to ship them over long distances. DF companies, in contrast, specialized in supplying specific kinds and numbers of healthy fishes, some of which were difficult to obtain (for example novel varieties). Most firms fell along the miamero-DF spectrum, however, with only six firms in Iquitos strictly of the miamero type in 2001, and only three companies having no American clients (Table 4).

According to informants, the establishment of DF companies in Iquitos dated from *c*. 1990 and reflected changes both in the international market and local business environment. In 1981, 88.5% of aquarium fish exports from Iquitos were destined for the USA (Hanek 1982), as compared to 68% in 2001 (Ministerio de Pesquería 2001). Exports of species popular on the Asian market had greatly increased since the 1970s, with silver arawana and peje torre juveniles together representing 12% of total export volume in 2001, compared to just 0.06% in 1978 (Tello & Cánepa 1991). At the same time, competition abroad had greatly reduced demand for traditional mainstays of the regional trade. This is best illustrated by the case of the neon tetra, which accounted for 50% of all annual exports in the years before 1978 (Hanek 1982) but just 3.7% of total export volume in 2001. Only five of the top 10 species (by volume) exported in 1978 (Hanek 1982) were still among the top 10 in 2001.

Export firms in Iquitos were linked through a multitude of shared supply networks to intermediaries and fish collectors

https://doi.org/10.1017/S0376892907003566 Published online by Cambridge University Press

Table 4 Key features of Miamero versus Destino final export firms operating in the Peruvian Amazon aquarium trade in 2002.

Feature	*Miamero firms*	*Destino final firms*
Ownership	Local	Often foreign
Primary clients	Wholesalers (mainly USA based)	Wholesalers (USA and international); specialty importers
Primary exports (typically)	Low-value, abundant fishes (shiruis, variedades)	High-value species: arawana and peje torre, but also zúngaro catfishes, stingrays, and newly-discovered species
In operation	May close during high-water season	Year-round
Marketing	Use local trade names	Carefully grade and identify fishes; may use numbering system of international trade catalogues
Client relations	Often tenuous. Communicate by e-mail or fax alone. Clients often fail to send full payment, citing (unverifiably) high mortalities	May know clients personally, particularly where firm is foreign-owned

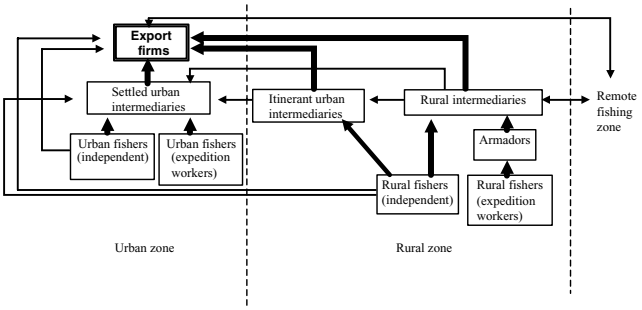


Figure 4 Schematic representation of supply networks in the aquarium fish trade based out of Iquitos, Peru, in 2002. Thicker arrows indicate the most common supply networks. Double-arrow lines indicate that actors fish themselves for supplies.
Source: Interviews with trade participants, summer 2002.

living throughout the urban zone (Iquitos and suburbs) and rural hinterland (Fig. 4). Intermediary traders (*proveedores*) brought in the bulk of fishes, although export firms were also buying fishes directly from fisherfolk or, more rarely, organizing their own fishing expeditions. Most intermediaries currently fished, or had fished in the past, with both intermediaries and fish collectors commonly referred to as *piaberos* (people who catch *piabas* [aquarium fish]). Firms tended to buy from a regular set of intermediaries (in order to ensure fish quality and good relations with suppliers), but intermediaries generally sold to more than one firm. The number of active intermediaries varied depending on season and year. The largest firm in Iquitos claimed to buy from 300 proveedores, although informants at six other firms reported buying regularly from 10–64 intermediaries each.

The majority of intermediaries were settled within the rural zone, though a small number of urban intermediaries, primarily established in the ports of Bélen and Masusa, appeared to play a disproportionate role in the trade. Unlike rural intermediaries, who were usually supplying fishes from one particular river zone (such as the lower Napo River), the port intermediaries bought fishes not only from around Iquitos, but also from fisherfolk and intermediaries arriving on riverboats from throughout north-eastern Peru.

Intermediaries used several strategies to obtain fishes, often in combination. They might set up basic holding facilities to which local fisherfolk brought their catch for sale, as observed in Iquitos ports and Requena. Rural intermediaries could ply the rivers in their area, on privately-owned or public boats, purchasing fishes from local communities. Rural and urban intermediaries with their own boat(s) might also choose to lead or sponsor fishing expeditions, on which hired labourers were paid by the piece for fishes captured, on trips into the interior that lasted from several days to three weeks. Expeditions for silver arawana could involve 12 labourers or more, whereas trips targeting lower-value shiruis and variedades hired 4–6 workers. Some urban intermediaries also settled in rural communities seasonally to catch and buy fishes locally.

Most people catching aquarium fish for the regional trade were from among the rural poor living in traditional, riverine peasant communities. Men were the primary participants in the trade, with expeditions in particular regarded as men's work, from catching fish to sorting, handling and selling the catch. Women and children sometimes also collected fish, typically close to home and for species that required little skill to capture (such as peje torre and *carachama* catfishes; Table 1). Individuals varied widely in their involvement in the trade, from fishing year-round at the exclusion of nearly all other economic activities (most common among expedition workers) to undertaking the occasional fishing trip at times when fishes were particularly easy to catch, prices were very high or complementary income was badly needed (M.-A. Moreau, unpublished data, 2002). Fisherfolk active year-round often complained that at low-water 'everyone is a fisherman', emphasizing the significant seasonal variation in participation.

We estimate that close to 10 000 people in the region were earning at least some income from collecting fishes for the trade. Assuming 300 intermediaries were operating in the trade, and that half of these ran at least one expedition a year involving 5–12 people, some 750–1800 people were earning income as expedition fishers. These same intermediaries, and the remaining 150, were each also estimated to buy fishes at least once per year from 25 fisherfolk, for a total of 7500 people earning aquarium income outside the expedition system. An additional 250 fishers or so may deal directly with exporters.

Aquarium fish collectors were either operating independently, particularly if fishing only occasionally, or were

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involved in contractual relations with intermediaries. The most common arrangement was *habilitación* (type of debt-merchandize contracting widespread in the agricultural and extractive industries of Amazonia; see Chibnik 1990; Barham & Coomes, 1994). Habilitación usually consisted of advances to fisherfolk of basic supplies of food, money and gear. However, the support could sometimes be broader, whereby intermediaries sponsored a trusted person (the *armador*) to lead a fishing expedition, advancing supplies but also providing (at no direct charge) boats, motors and specialized information on fishing grounds or techniques; collectors working under the armador are paid on a piece-rate basis. In Belén alone, five intermediaries acted as patrons to 20–30 people each, and at least 15–20 patrons were working year-round in the rural town of Requena (50 during silver arawana season), a smaller number of whom sponsored armadors. Intermediaries could themselves receive advances of basic supplies from export companies, particularly during the arawana fishing season, when exporters were competing for access to supplies (Moreau & Coomes 2006).

Intermediaries typically paid their suppliers by the piece, at half the unit price they themselves received from fishes' sale. Exporters also paid intermediaries by the piece, giving them the same price in Nuevo Soles (NS) as that of sale to international clients. For example, if an intermediary received NS 15 on delivery of a stingray to an Iquitos export firm, the exporter would be selling the fish for US$ 15 (at US$ 1 = NS 3.47 in summer 2002; this represents a 71% discount to the intermediary on the export price). Despite such deep discounts, the habilitación relation, where it occurred, did not appear to be unambiguously exploitative; fisherfolk switched between patrons if unsatisfied, were not generally coerced into contracting large debts and reported that without their patron's support they would be unable to fish.

DISCUSSION

This study reveals that in Peru, a major contributor of Amazonian fishes to the international aquarium trade, the industry is undergoing an important transition from a focus on high-volume low-value fishes to delivery of high-value fishes in increasing numbers to new and discriminating markets. This shift and resurgence in the regional trade follows nearly two decades of stagnation, and brings new conservation concerns for the future of aquarium fishes and the industry in Peru and elsewhere in Amazonia.

The regional trade occurred on a large scale, with over nine million fishes officially exported in 2001. The real number was likely closer to 12.4 million fishes, if the discrepancy revealed in comparisons of export volumes from Loreto with import volumes to the USA held constant for all international export destinations. Mortality rates prior to export were unknown, although Soregui and Montreuil (1998) estimate minimum rates of 3–5% between capture and sale to exporters, similar to Chao's (2003) report of 5% average mortality over a similar transport phase in the Brazilian Amazon trade. Mortality in holding might also be substantial, particularly among smaller miamero firms, based on observations of rudimentary export facilities and the perceived need among informants for enforcing minimum operating standards.

Exploitation was focused on a handful of species, despite the high level of biodiversity present in the trade. Among these were traditional mainstays of the Amazonian trade, such as tetras, other characins and callichthyid catfishes. Such small and relatively short-lived species reproduce early, are naturally adapted to high mortality rates and can withstand high levels of exploitation pressure (Junk 1984; Chao & Prada-Pedreros 1995). The traditional collection methods and marked seasonality of many aquarium fisheries are argued to provide additional safeguards against over-collection (Andrews 1990). These claims remain unexamined for most aquarium fish populations however and are unlikely to apply to species with restricted geographic ranges (for example certain loricarid catfishes and dwarf cichlids endemic to small rainforest streams) where over-collection is a significant risk (Bayley *et al.* 1992) or to those biologically unsuited to heavy exploitation (for example large late-maturing low-fecundity species such as stingrays and silver arawana). Yet it is these large charismatic species (and, to a lesser extent, novel endemic varieties) that fetched the highest prices in the regional trade and were driving growth in exports. At the time of this study, no management plans were in place for aquarium fish populations in the region, although options were being developed for managing silver arawana populations in protected areas. Sustainable management of the large and growing fishery for that species may be particularly warranted, given the routine practice of killing mouth-brooding males prior to collecting their young for the trade (Moreau & Coomes 2006). In Brazil, since 2003, export of certain stingrays (7 of 18 recognized species) is only allowed under quota, although the measure is difficult to enforce (Araújo *et al.* 2004).

The ban by the Peruvian government on collection of juvenile food fishes for the ornamental trade is of questionable conservation value, given that many of the species so protected are abundant, geographically widespread and highly fecund. Furthermore, the ban is deeply resented (and often ignored) by aquarium fisherfolk, underlying the need for conservation and management plans to be designed in closer consultation with stakeholders if they are to be successful. Consideration of stakeholders is particularly important given that 10 500 people (of which some 10 000 are fish collectors) may directly rely on the aquarium trade for at least some of their income, with aquarium fishing representing a key livelihood activity for many of the rural poor. Compared to other livelihood activities available to rural households, aquarium fishing is relatively lucrative. Aquarium fish sales provided a higher daily income than agriculture, food fishing or day-labour (US$ 18.90 versus US$ 4.12) among households in two rural communities of the Peruvian Amazon (Kvist *et al.* 2001). In addition, households can specialize heavily in aquarium fishing, some obtaining up to 90% of annual income from the activity in one aquarium fishing community near Requena (M.-A.Moreau,

https://doi.org/10.1017/S0376892907003566 Published online by Cambridge University Press

unpublished data 2002), although this ranges widely both between and within villages (Takasaki *et al.* 2001; Coomes *et al.* 2004). Even where households earn a relatively small proportion of their income from aquarium fish collection, however, the earnings can be critical to smooth fluctuations in income. Indeed, many people collect aquarium fish only as a complement to their primary income sources, often targeting peje torre and silver arawana juveniles, fishes that become available when agricultural lands are flooded; labour demands are consequently low and few other livelihood activities are practicable.

In the aquarium fish trade of the middle and upper Rio Negro basin, a similar distinction is made between people who collect fish as a supplement or complement to subsistence production and those who might be considered full-time fisherfolk (Prang 2004). The latter travel to fishing areas with their patrons, as do expedition workers in Peru, and are usually paid in cash or credit. At peak production period, up to 1050 people in the region collect aquarium fish (primarily the cardinal tetra), selling to 60–70 intermediaries (Prang 2004).

Identifying conservation concerns in the trade and managing these effectively for local livelihoods will be particularly challenging in the Amazonian context where diversity of species and habitats is high, regions are vast and difficult to access and monitor, and financial, human and technical resources are limited. Scientific assessments of whether exploitation for the aquarium trade represents a threat to species cannot be expected for all fishes (see Gerstner *et al*. 2006). Instead, researchers should work with knowledgeable trade participants to identify general precautionary management measures (such as protection of key habitats and use of appropriate fishing methods) as well as prevailing property regimes that may influence interventions. Efforts underway to develop a sustainable aquarium fish trade, such as in the Mamirauá Sustainable Development Reserve in the Brazilian Amazon, could serve as a model (P. Petry, personal communication 2006).

Raising business standards in the regional trade should be a high priority, to both reduce conservation pressure (by lowering fish mortality and building a more diversified export base) and improve local livelihoods (for example by raising export prices). The international industry could help by training suppliers, transferring technology, and sharing business development and marketing expertise. Prices paid to fisherfolk perhaps could be further enhanced by developing fish certification schemes modelled on those of the Marine Aquarium Council. Attempts to bypass intermediaries entirely are not necessarily to be recommended however, unless solutions are in place to provide high-risk loans and other forms of support to poor fish collectors.

It is essential to recognize that the greatest threats to the sustainability of the Amazonian aquarium trade will likely come from outside the sector itself. The expansion of land resource use in Amazonia (through agricultural colonization, hydroelectric development, mining and road-building) will seriously affect wetlands and water bodies, and associated fish habitats, through both physical change and pollution (Junk & Soares 2001). Mobilizing the political will to address these issues will depend on demonstrating the economic value of healthy ecosystems to human populations. The aquarium fish trade represents just such an example of how biodiversity contributes to people's livelihoods and potentially to poverty alleviation. Realizing this potential, however, will require concerted efforts by researchers and resource managers to better understand the dynamic of local people's participation in the aquarium fish trade and the conservation implications of their choices.

ACKNOWLEDGEMENTS

Our sincerest gratitude to the exporters, traders and fisherfolk who gave so generously of their time for this study. We thank also Carlos Rengifo Upiachihua and Violeta Peña Flores for excellent field assistance, and Cesar Correa Jirón and Victor Montreuil for sharing their knowledge of the industry with us. The manuscript greatly benefited from the insightful comments and suggestions of Keith Davenport, Wolfgang Junk, Paulo Petry, Gregory Prang, Ian Watson and the Editor. This work was supported by funding from the Natural Sciences and Engineering Research Council of Canada and the Canadian International Development Agency (to M.-A. Moreau), and from the Social Sciences and Humanities Research Council of Canada (to O.T. Coomes).

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