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Socioeconomic assessment of the fisheries resources of the Bolivian Amazon lowlands

Report summary

Introduction

The fishing sector in the Bolivian Amazon is in process of change after many decades of stagnation. Fisheries production estimations in the Amazon fluctuated around 3000-4000 tons per year between 1980 and 2010 (Van Damme *et al.* 2011), and landings were concentrated in a small number of larger catfish and characid species. In the last decade, however, new trends emerged, both in terms of total production, which seems to increase to meet new demands, as in catch composition, which is currently also including smaller species. There is also a better official recognition of the contribution of fisheries to food security, exemplified by the recent enactment of the "Sustainable Fisheries and Aquaculture Law" (Law No. 938).

However, these positive changes also coincide with an emerging crisis affecting the fisheries sector. Fisheries are now facing main threats which may be forerunners of worse to come, or in some cases may be converted in opportunities. The introduction of invasive species (Van Damme *et al.* 2015), the proliferation of dams associated with the loss of river connectivity (Anderson *et al.* 2018), the exploitation of new species and the aquaculture boom (Vega *et al.* 2018) are all factors which may alter the fisheries landscape.

The Bolivian Amazon fisheries sector is highly vulnerable to change and has low adaptive capacity. It employs many marginalized people which are not adequately represented at regional or national levels. There is a significant but invisible participation of women, especially in the comercial value chain nodes. Many of the fishers do not shift easily to new employment. Contrary to conventional belief, it is not easy to convert fishers in fish culturists.

Many of these empirically obtained production data and social trends remain underreported, cause Bolivia is lacking an oficial fish landing or market registration system (Van Damme *et al.* 2011). The scarce data available, that have mostly been collected by non-governmental or academic institutions, lack continuity (Doria *et al.* 2018). This data paucity hinders the crafting of fisheries development plans, management measures and impact mitigation (Allison & Mills 2018).

In the face of these data and information deficiencies, very common for third world countries, an increasing interest in using cost-efficient indirect methods for estimating fish production emerged. Fluet-Chouinard *et al* (2018), for example, used household consumption data and expenditure surveys to estimate fish production, whereas traditional market studies (Allison & Mills 2018) may equally reveal tendencias in the landings if origen of the sales is known.

The present report evaluates Amazon fish landings and catch composition through market studies done in 12 intermediate-sized cities situated in the lower Amazon, complementing a more comprehensive study done earlier in nine larger cities (Navia et al. 2018). In particular, we have interest in estimating the relative contribution of introduced species (especially *Arapaima gigas*), migrating species and cultivated fish to the landings. This is a preliminary report with uncomplete data, and a more elaborate version will be published in a next stage.

Material and methods

Of the 21 intermediate cities recogized in the Bolivian Amazon (INE 2012) we selected twelve ad random. These intermediate cities, which are located in the five departaments overlapping the Amazon river basin, ranged between 10 000 and 73 000 habitants, with exception of Porvenir and Puerto Rico (4 000-5 000 habitants), which have been included to have a broader geographic range. In each intermediate citiy, we visited all the fish markets and restaurants. We also visited two smaller localities which are at the same time important landing sites, Bella Vista and Puerto Villarroel (Table 1).

In each market, all salesmen and restaurant owners were interviewed. Each interviewee provided data on the mínimum, mean and máximum total weight of different fish species sold daily in the markets over a period of one year, the mínimum, mean and maximum price for each species, as well as the mínimum, mean and máximum number of salesmen present in the market along the year. The same procedure was followed in restaurants.

For the purpose of the present report, the fish sold in the markets were divided in five functional groups: long-distance migratory fish (> 1 500 km), medium-distance migratory fish (100-1500 km), residents (< 100 km), invasive and cultivated species. The latter group was included for the purpose of comparison with wild fisheries. We did not include other fish protein sources (marine imported fish, canned fish, etc.) in the analysis.

Table 1. Number of habitants (INE 2012) in the Intermediate cities visited during the market survey

Departments	Markets	Nr. habitants	Salesmen	Restaurants
BENI	Bella Vista*	2 541		X
	Guayaramerín	41 775	X	X
	Magdalena*	11 377		X
	Rurrenabaque	19 195	X	X
	San Ignacio de Moxos	22 163		X
	Santa Ana de Yacuma	16 668	X	
LA PAZ	Palos Blancos	24 636	X	X
PANDO	Porvenir	4 267		X
	Puerto Rico	4 739	X	X
SANTA CRUZ	San Ignacio de Velasco	52 276	X	X
	San Julián	47 323	X	X
COCHABAMBA	Villa Tunari	72 623	X	X
	Puerto Villarroel**	46 642		X
	Entre Ríos	31 307	X	X

*Bella Vista (2 541 habitants) forms part of the municipality of Magdalena (11 377 habitants, including the ones of Bella Vista).

**The municipality of Puerto Villarroel includes the town of Ivirgarsama which has more than 30 000 habitants. In the framework of the present study we visited only the locality of Puerto Villarroel, which has less than 5 000 habitantes.

Results

Tabla 1 lists the species which were offered for selling in the markets. Ten species are medium- distance migratory, one is long-distance migratory, three are residents and one is invasive. Two characid species, *Collosoma macropomum and Piaractus brachypomus*, are caught in the wild but are also cultivated, as well as hybrids between the two species.

Table 2 shows that 70% of the market volumen in the 14 markets is represented by fish that migrate medium distances, whereas resident, invasive and cultivated fish represented respectively 7, 6 and 16%. Long-distance migratory species represented only 1% of the total.

Table 2. List of species marketed in intermediate cities in the Bolivian Amazon.

ORDEN	FAMILY	SCIENTIFIC NAME	LOCAL NAME	FUNCTIONAL GROUP
CHARACIFORMES	Characidae	*Brycon amazonicus*	Yatorana	Medium-distance migratory
		Salminus brasiliensis	Dorado	Medium-distance migratory
	Serrasalmidae	*Piaractus brachypomus*	Tambaquí	Medium-distance migratory/ Cultivated
		Colossoma macropomum	Pacú	Medium-distance migratory/ Cultivated
		Mylossoma duriventre	Pacupeba	Medium-distance migratory
		Pygocentrus nattereri	Piraña	Resident
	Prochilodontidae	*Prochilodus nigricans*	Sábalo	Medium-distance migratory
OSTEOGLOSIFORMES	Arapaimidae	*Arapaima gigas*	Paiche	Invasive
PERCIFORM	Cichlidae	*Cichla pleiozona*	Tucunaré	Resident
	Sciaenidae	*Plagioscion squamosissimus*	Corvina	Resident
SILURIFORM	Pimelodidae	*Brachyplatystoma rousseauxii*	Dorado (de cuero), plateado	Long-distance migratory
		Calophysus macropterus	Blanquillo	Medium-distance migratory
		Phractocephalus hemioliopterus	General	Medium-distance migratory
		Pseudoplatystoma fasciatum, P. tigrinum	Surubí	Medium-distance migratory
		Zungaro zungaro	Muturo	Medium-distance migratory

Figura 1. Contribution (in %) of five functional fish groups in the fish markets of 14 intermediate cities in the Bolivian Amazon.

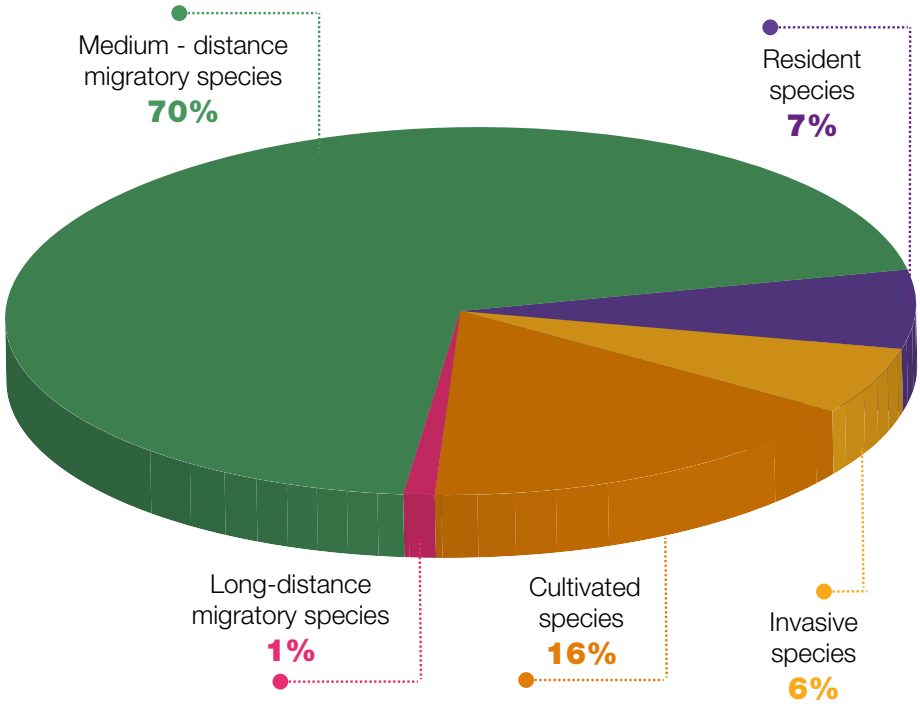

Table 3. Market value of five functional fish groups in intermediate cities in the Bolivian Amazon (present study)

FUNCTIONAL GROUP	ECONOMIC VALUE OF FISH IN INTERMEDIATE CITIES (2018)	
	US$/year	%
Long-dstance migratory fish species	21 407	0.7
Medium-distance migratory fish species	2 135 622	71.2
Resident species	190 475	6.4
Invasive species	141 164	4.7
Cultivated species	510 971	17.0
Total	**2 999 640**	**100.0**

Discussion

The intermediate cities included in this study only represent a small fraction (<5%) of the total human population in the Bolivian Amazon river basin (which also includes large cities such as Santa Cruz, Cochabamba, and La Paz). However, in contrast with the latter, the intermediate cities are situated in the lowlands, which are generally characterized by relative large distance to markets, high vulnerability to climatic variability, and relatively low access to farmed protein sources. Notwithstanding their low demographic importance, the anual economic value of the marketed fish is in the range of 3 000 000 US$.

This study shows the high dependence of fish markets in intermediate cities, and hence of fish protein consumption, on migratory fish species. This result suggests that food security in these cities highly depends on the maintenance of river connectivity. The long-distance migrating species (> 1 500 km), such as the dorado *(Brachyplatystoma rousseauxii),* which at present are affected negatively by the Jirau and San Antonio dams, represent only 1% of market value. If disruption of rivers would increase in scale and affect also the medium-distance migrating species, this may result in overall impoverishment of fish resources, loss of economic value and increased risk of food insecurity. The high dependence of food security on medium-distance migrating species illustrates that connectivity should be maintained, or that alternative fish protein sources should be explored. Invasive and cultivated species may fill this gap, but the environmental impact of invasors and aquaculture is not yet well understood.

Migratory fishery resources are negatively affected by hydroelectric dams, interrupting river connectivity. In particular, the Jirau and Santo Antônio dams, built in the middle basin of the Madera River, have blocked migration routes for long-distance migratory fish that spawn in the Bolivian Amazon (Van Damme *et al.* 2019). Though these species only represent a small porcentaje of total landings, valuing aproximately 20 000 US$ in the study área, their extinction may induce top-down impacts trickling down along the food web (Hauser 2018; Van Damme *et al*. 2019). These fish consume mostly medium-sized characid species (Barbarino Duque & Winemiller 2003), which may proliferate in the absence of this predator. Though we can not predict the full nature of these cascading ecosystem effects, it is probable that the environmental and economic consequences of predator extinction will be significant.

The introduction of the invasive species *Arapaima gigas* (introduced from the north to the southern Peruvian Amazon and from there invading Bolivia) has induced significant changes in the fish production chain and has negatively affected the contribution of native species that were traditionally landed, as well as may affect native fish biodiversity (Van Damme *et al*. 2015). In the present study, the contribution of paiche is relatively low, the main part of the landings being transported to the larger cities, where it scores higher prices. In the lowland intermediate cities, this species is low-valued.

The third, and main, threat for inliand fisheires is the incipient growth of inland aquaculture producing cheap fish protein now flooding the markets and competing with wild fish, and, on the other hand, generating environmental impacts that can indirectly affect the diversity of native fish species (Blanca *et al.* 2018). Many of this cheap cultivated fish is increasingly imported illegaly from neighbouring countries.

The present study highlights the strong link between energy generation, food security and river connectivity and quality. This nexus should be given better attention in Amazon development planning.

Figura 2 Migratory fish species of the Bolivian Amazon: surubí *(Pseudoplatystoma fasciatum)*, pacú *(Colossoma macropomum)*, yatorana *(Brycon amazonicus))*

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