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Proposal for a Fisheries management plan for the responsible and sustainable use of *Arapaima* in the Ecuadorian Amazon

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Abstract: This document aims to provide the technical bases for the implementation of a fisheries management plan focused on the responsible and sustainable use of the *Arapaima* in the Ecuadorian Amazon. It should standardize environmental, social, economic, and institutional criteria. The information contained in the manual is based on field surveys conducted during the months of August 2020 and March 2021, with key informants, generating and obtaining information, and consulting official records of the Ministry of Environment, Water and Ecological Transition (MAATE acronym in Spanish); Vice Ministry of Fisheries and Aquaculture (VPA acronym in Spanish), Directorate of Amazonian Aquatic Spaces of the National Navy (DIRAMA acronym in Spanish); and the Environmental Police Unit (UPMA acronym in Spanish). Forty-three local participants were interviewed, including representatives of indigenous and mestizo riverine communities, and institutions from Ecuador and Peru. The proposal examines the natural distribution of the species, the context of its wild use for subsistence, illegal commercial extraction of meat and juveniles to assess management measures focused on the institutional framework of the fishing sector in the Ecuadorian Amazon, to promote its governance; aquaculture restocking; fishing management tools such as closures, minimum sizes, extraction quotas, fishermen's registry; as well as generate scientific information.

Key words: *Arapaima gigas*, *Arapaima*, responsible and sustainable management, Ecuador.

Introduction

Thanks to the Regional Project for the management, monitoring and control of species of wild fauna and flora threatened by trade (Bioamazon Project), this proposal is a commitment between the Amazon Cooperation Treaty Organization (ACTO), and the German Government through the non-reimbursable financial cooperation channeled by the German Development Bank (KfW). The proposal will contribute to the conservation of the Amazonian biodiversity, especially, of the species included in the CITES Appendices, by increasing the efficiency and

effectiveness of the management, monitoring and control of species of fauna and wild flora threatened by trade in ACTO Member Countries.

The few studies that have been carried out in Ecuador on *Arapaima aff gigas*, both in the natural environment (Burgos-Morán, 2018; Salvador & Zapata-Ríos, 2018) and in captivity (Burgos-Morán, Ortega, Silva, Sanchez, et al., 2018; Burgos-Morán, Sánchez, Andino, Torres, Salazar, Ortega, et al., 2018; Burton et al., 2016; Ligña-Navarrete et al., 2018), provide clues to their management; however, the status of

their wild populations, as well as their spatio-temporal dynamics, is still unknown. These data are extremely important, as there is evidence of large population variations, with reductions due to fishing activity during the decades from 1970 to 1990 in Brazil and Peru (Petersen, Brum, Rossoni, Silveira & Castello, 2016), data that were later recovered through consultation processes thanks to community management (Campos-Silva & Peres, 2016). Invasive processes documented in the last 20 years in the Bolivian Amazon (Carvajal-Vallejos, Van Damme, Cordova, & Coca, 2011; Macnaughton *et al.*, 2015; Watson *et al.*, 2013), and perspectives of geographic displacement due to climate change (Oliveira *et al.*, 2020) in the near future, guide the implementation of precautionary management actions and new technologies, especially related to the genetic record of the species such as the advances made from Brazil and Germany (Du *et al.*, 2019; Vialle *et al.*, 2018) with the publication of its genome; in addition to environmental monitoring techniques with eDNA barcoding carried out in Peru (García-Dávila *et al.*, 2014; García-Dávila *et al.*, 2018).

In this sense, the management in nature and in captivity must have clear scientific and administrative guiding principles for the correct traceability of populations to provide food and economic security to those communities, for which this resource is one of their livelihoods, considering practical examples for cases of fisheries management in Brazil (Campos-Silva & Peres, 2016; Campos-Silva, Hawes, Andrade, & Peres, 2018), Peru (IIAP, 2012; Rojas & Noriega, 2006), Colombia (Rojas, 2019)

and Bolivia (SERNAP, 2020), all within the Amazon Basin.

This document focuses on: “Providing the technical bases for the implementation of a fisheries management plan focused on the responsible and sustainable use of the Arapaima in the Ecuadorian Amazon. It should standardize environmental, social, economic, institutional (administrative, technical, normative), and organization criteria. Specifically, it was proposed to: i) Conduct a preliminary assessment of the state of the native populations of *Arapaima aff. gigas* and its probable natural distribution in the Ecuadorian Amazonian aquatic environments; ii) clarify the state of subsistence, commercial and recreational fisheries on *Arapaima aff. gigas* in the Ecuadorian Amazon; and iii) establish fishing management guidelines for the responsible and sustainable use of *Arapaima aff. gigas* in the Ecuadorian Amazon.

Methodology

Area of study

The Ecuadorian Amazon represents only 2% of the Amazon basin. Its population is approximately 0.9 million, 65% concentrated in urban (Charity, Dudley, Oliveira, & Stolton, 2016) areas, with the highest inequality due to economic income and high informality; depending on subsistence agriculture, forestry, and fishing. This situation accounts for at least 10% of child malnutrition (ARA, 2011; Gray & Bilsborrow, 2020). The lower river courses with *varzea* areas and

meandering lagoons of the Napo, Pastaza and Morona rivers have been considered in this study, and they have also been identified with the code 316 of the world ecoregions of freshwater ecosystems, corresponding to the Amazon lowlands (Abell *et al.*, 2008). This corresponds to the westernmost area of the Amazon biome with a noticeably short transition in the ecological continuum that composes them.

The protected areas of the Yasuní National Park (PNY) and the Cuyabeno Fauna Production Reserve (RPFC) stand out; the National System of Protected Areas of the Ministry of the Environment, Water and Ecological Transition (MAATE); in addition to the Tagaeri-Taromenane Intangible Zone (ZITT), considering this set a landscape of flooded forests, within the Napo basin, in the so-called "Cuyabeno-Lagartococha-Yasuní wetland complex" where several river axes (Tirira & Rios, 2019) are connected, which are beyond the 2018 Ramsar declaration (MAAE, CI-Ecuador, & SEDEFA, 2019). In addition to the areas mentioned, there are other conservation proposals through civil society such as the Initiative "Sacred Basins, Territories for Life" ("Informes – Cuencas Sagradas", 2021), which includes a landscape scale especially focused on indigenous communities on the Ecuador-Peru border. Towards the South, however, there are large gaps in conservation efforts with respect to aquatic habitats, such as the Morona River.

Local participation

The information here contained is based on field surveys conducted during the months of August 2020 and March 2021, through the identification and direct consultation with key informants, generation and obtaining information, and official records of the Ministry of Environment, Water and Ecological Transition (MAATE); Vice Ministry of Fisheries and Aquaculture (VPA), Directorate of Amazonian Aquatic Spaces of the National Navy (DIRAMA); and the Environmental Police Unit (UPMA). Therefore, forty-three local participants were interviewed, including representatives of indigenous and mestizo riverine communities, and institutions from Ecuador and Peru as direct input for the generation of this proposal.

Diagnostic

A survey was conducted on the state of the native populations and the fishing pressure of *Arapaima aff. gigas*, such as IUU fishing (illegal, unreported and unregulated), adapting FAO guidelines based on Agnew *et al.*, (2009); y Macfadyen, Caillart & Agnew (2016).

Based on this guide, simplified models of fishing¹ extraction were developed, contrasting with the fishing situation in the Amazon Basin and its current institutional and legal framework. All the information presented was compared with that of official databases such as CITES and FAO FishStatJ. In addition, the legal frameworks of Amazonian countries and available scientific

¹ The analysis models are explained in the extended version of this document.

research were compared through an in-depth bibliographic review.

Fisheries management proposal

The proposal was the result of selected strategies and guidelines with data generated from a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats), identifying vulnerabilities observing the code of conduct for responsible fishing in small-scale FAO fisheries, management opportunities, and proposals from the local community and institutional actors.

Results and discussions

Natural distribution records

Ecuador still has no systematized or official updated distribution record on *A. aff. gigas*, and there are only general criteria for its inclusion in the red list of species, in addition to the guide to its population (Aguirre *et al.*, 2019) status. These populations are the westernmost in the Amazon Basin and have the greatest hydrological distance between them. With these records:

Table 1, Records of *Arapaima aff. gigas* in Ecuador

River axis	Registration sites	Type of study	Source
Aguarico	- Cuyabeno, Cocaya	Population status	Burgos-Morán, 2018
	- Lake complex Lagartococha, Zancudo cocha, Garza cocha	General inventory	Barriga, 1986
		Livelihoods	Vickers, 1989
Napo	- Pañacocha, Jatuncocha, Yasuní river	General inventory	Stewart <i>et al.</i> , 1987
	- Añangu	Ecotoxicology	Webb <i>et al.</i> , 2004
	- Yuturi, Wiririma	Population status	Salvador & Zapata-Ríos, 2018
Curaray	- Lorocachi	Ethno ichthyology	Guarderas <i>et al.</i> , 2013
	- Zueilan, Dantacocha, Wiñacocha	Fishing	Burgos-Morán <i>et al.</i> , 2014
Pastaza / Corrientes river	- Achuar, Kapawi, Charapacocha territory	Livelihoods	Descola, 1988
Morona	- Laguna CREA	nd	Obs. Personal / Nugra com.
	- Laguna Negra		Pers:

In Table 1, the records of *A. aff. Gigas* are observed, which are circumscribed to scientific or development studies, without fishing statistics as in the cases of Brazil, Peru, Colombia, and even Bolivia (Doria *et al.*, 2018; Jézéquel *et al.*, 2020; PROMPEX, 2006; Salinas-Coy & Agudelo-Cordoba, 2000;

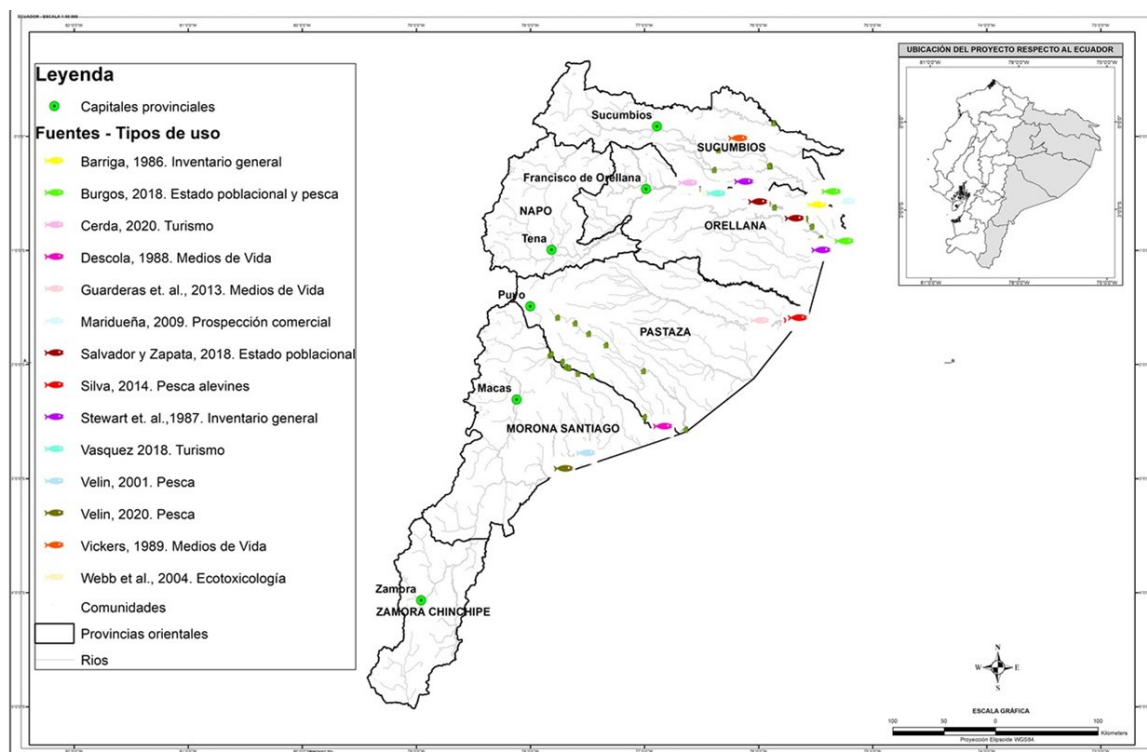
SERNAP, 2020), being necessary to complement data such as:

- Demographics (number of individuals, age structure, sex ratio),
- Genetic variability (polymorphism), population genetic structuring, inter- and intra-population gene flow.

- Social structuring, territoriality in relation to age and gender, and anthropogenic impact assessment.

In accordance with the descriptions made, the places of registration of natural populations are depicted.

Map 1. Approximation to the natural distribution of *Arapaima aff. gigas* in Ecuador.



Source: Those cited on the map.

The information contained in table 1 and in map 1, guide the conservation, fisheries, and aquaculture management actions of *A. aff gigas* (Cavole, Arantes, & Castello, 2015).

The status of the fishing of *A. aff gigas* in the Ecuadorian Amazon.

From the information obtained, these are classified into three subgroups:

i) formal, immersed in the Río Napo Association, which is the only officially recognized fishermen’s association in the Amazon province of Orellana, but it

does not comply with the landing declaration processes due to the absence of government support;

ii) informal, presumably foreigners with access to cross-border populations or close to the border, especially in Sucumbíos, Orellana, and Pastaza; and,

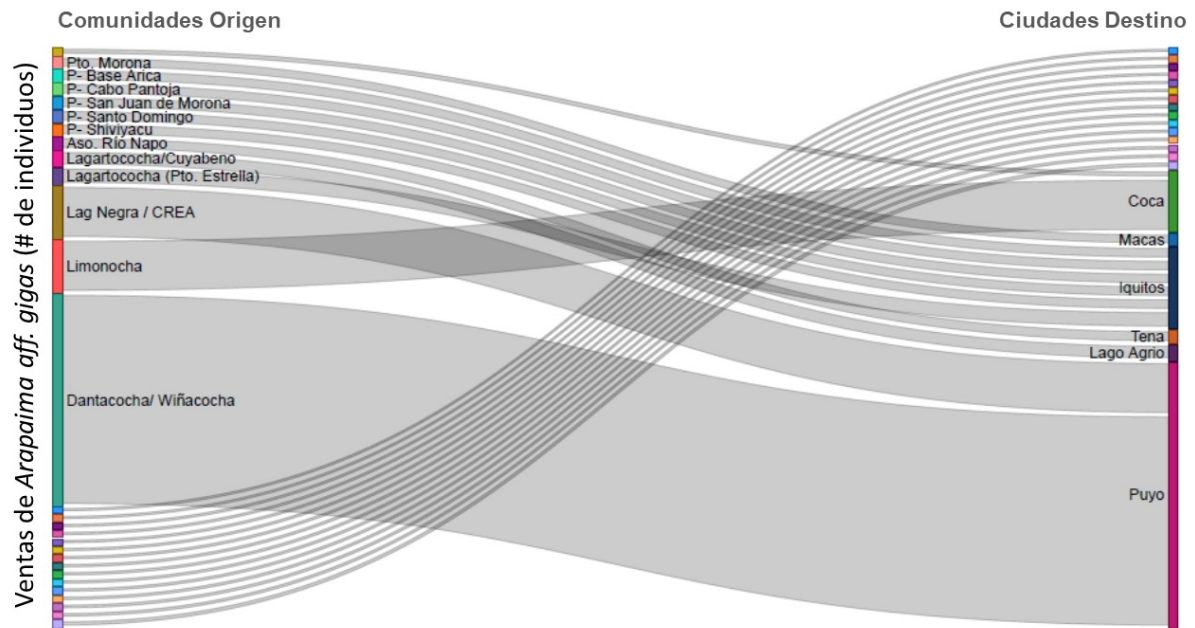
iii) "ranchers" of juveniles, that is, they capture live fish in specific areas of Cuyabeno, Curaray, and Morona to supply initiatives for species cultivation.

The modeled fishing scenarios allow to explain the links of detected catches,

their monetary value, the extraction sites, and the final destination of the

arapaima fishing; according to graphs 1 and 2:

Figure 1, Sales flow of *A. aff. gigas* captured in the Ecuadorian Amazon expressed in number of individuals

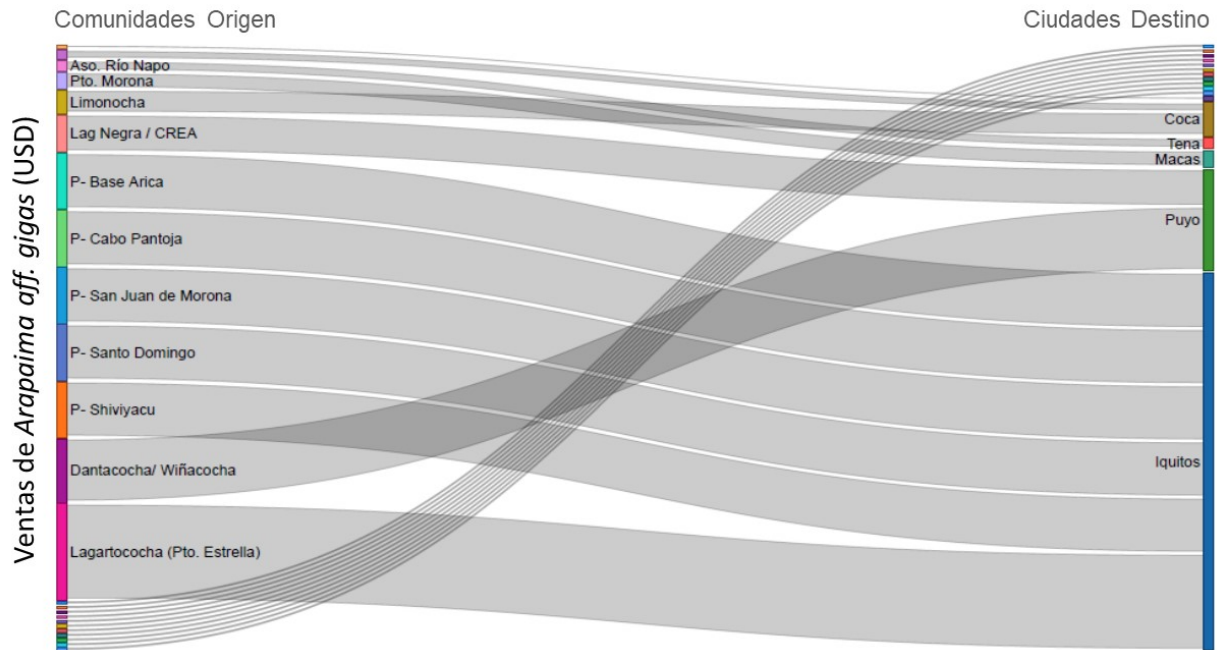


Note: Sankey chart for superior simulation scenario of individual sales. The bands' width represent the magnitudes of the quantities

Graph 1, illustrates that the greatest source of extraction of *A. aff. gigas* occurs in the places identified as capture areas to supply aquaculture systems such as the Dantacocha, Laguna Negra (or nearby), Limoncocha and the

Lagartococha - Cuyabeno lake complex, accounting for approximately 70% of the catches.

Figure 2, Sales flow of *A. aff. gigas* captured in the Ecuadorian Amazon expressed in monetary values (USD)



Note: Sankey chart for superior simulation scenario of sales in monetary value. The bands' width represent the magnitudes of the quantities

Graph 2, depicts that, when considering the monetary value of the catches, there is more balanced participation of all the communities of origin; However, in the destinations, there is relevant participation of the city of Iquitos as the main market for *Arapaima* meat; meanwhile, the economic contribution

from the commercialization of wild-caught juveniles would be much lower (close to 15%), whereby the city of Puyo is the main destination and center for the brooding of juveniles, mainly destined for aquaculture.



Photo 1, Arapaima confiscation in Yasuní National Park. Source: MAATE

As a reference to the detection of illegal fishing of *A. aff. gigas*, it can be seen in photograph 1, two adult individuals

caught in the control of Tambococha, Nuevo Rocafuerte.

Analysis and identification of measures for sustainable fisheries management

Considering the Amazonian context and guiding criteria regarding the FAO global fishing code of conduct, a set of

measures have been identified through interviews that reflect both the expectations of local communities and technical factors that could make their adoption feasible.

Table 1. Identification and analysis of guidelines to be implemented

Fisheries management guidelines (strategies / tools)	Contribution						Priority
	Criteria			Aspects			
	CC	MO	KS	B	SE	LP	
Basic regulation tools							
Basic driving practices							
Implementation of administrative measures for closures, minimum catch sizes (TMC) and fishing efforts.	3	3	3	3	2	2	16
Producing scientific generation							
Monitoring and handling of databases for adequate fisheries management, such as fish populations, catch sizes, landings, among others.	3	3	3	3	2	1	15
Fishing resource management proposals							
Resource governance							
Associated community fishermen formalize their interaction with local authorities to provide control and technical support.	3	3	3	3	3	2	17
Restocking aquaculture							
In key species cases for <i>A. gigas</i> , produced or captured juveniles are submitted to temporary captivity to increase their survival and restock in local water bodies. They are previously marked with pit tags (chips). Tourists would have the opportunity to adopt individuals.	3	2	2	3	3	3	16
Catchment quota agreements							
A participatory consensus of all actors related to fishing, including of binational nature.	3	1	2	2	3	2	13

Equitable distribution of benefits							
Direct actors share income with emphasis on indigenous communities and women	3	2	2	0	3	2	12
Experiential fishing and quota exchange							
Diversification of tourist activities that offer recreational fishing with local indigenous fishermen in possession of a quota agreement or territorial right of use.	2	2	2	2	3	1	12
Opening to artisanal fishing							
To formally take advantage of catches to be sold in local markets and tourist restoration ventures.	1	1	2	0	3	2	9
Fishing vessel management							
Improvement of river transport efficiency							
Regulation of vessels, autonomy, load capacities, and engines (noise) with clear zoning of permissible routes and restrictions	0	2	2	3	1	1	9

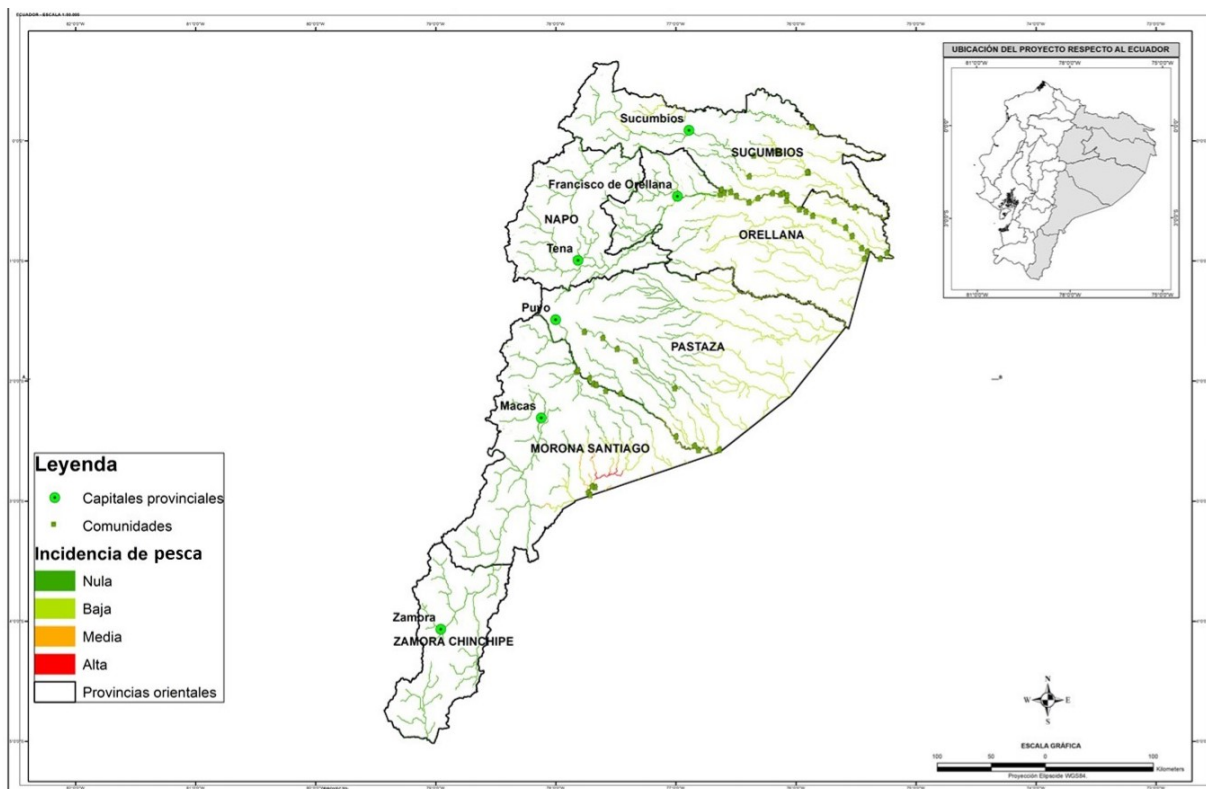
- **Notes:** CC, Code of Conduct; MO, Management opportunities; KS, key species; B, Biologicals; SE, Socioeconomic; LP, Legal and Political

A simplified weight was given for each strategy identified in order to prioritize future implementation, as follows: High (3), significant contribution to strengthening management or sustainability issues in the territory; Medium (2), medium contribution to strengthening management or sustainability issues; Low (1), not significant in strengthening management or sustainability; and, not applicable (0), no evaluation and no apparent interaction.

The risks of pressure due to the incidence of fishing should also be

considered in the guidelines, identifying that the southern Amazon, specifically, the arapaima population in lagoons of the Morona river fluvial axis, is subject to the highest pressure due to lack of protected areas, which generate at least a large-scale catch deterrent effect. This phenomenon is observed in the northern Amazon, classified as low-risk, since the presence of fishermen from communities on the other side of the border has been identified fishing with their larger nets, but limited by the transport capacity of their boats.

Map 1, classification of fishing incidence risks for *Arapaima aff. gigas*.



Conclusions and recommendations

Biological aspects

From the biological point of view, these guidelines are intended to contribute to making visible the nutritional, economic and tourist importance of *Arapaima aff. gigas* in the Ecuadorian Amazon Region (RAE), starting with a focus on the use, management, and conservation of local fish species, with special emphasis on *Arapaima aff. gigas*. This could be considered an example at the national and international level considering the situation of the species in international river waters.

The “charisma” of the species in a landscape with a high incidence of

aquatic ecosystems, although it is not perceived with the naked eye, generates great responsibility with reference to the administration of its use. The good application of the measures proposed in this study could help to obtain a better impact on the populations identified, as well as on public opinion.

There are still important gaps in terms of knowledge of the interrelationships and ecological processes in the aquatic ecosystems of the western Amazon, as is the case of the RAE. In this sense, it is recommended to consistently support scientific studies, which may impact directly on the benefit of local communities, such as their application in the other countries of the Amazon Basin, with cases of resounding success, such

as those of the Mamirauá Sustainable Management Reserve in Brazil.

Socioeconomic aspects

Proper management of small-scale inland fisheries is a delicate process that, if well managed, generates a social and economic impact on local communities. In the case of the RAE, there is great potential due to the fact that there is a tourist demand, although diminished, due to the current pandemic. However, local Amazonian capacities in Ecuador is still a needed, as there are still no similar management experiences in this country.

The application of these guidelines could generate new local jobs, with the potential to extend to the entire species' distribution area in Ecuador, since all areas of the Amazonian territory with water bodies and floodplains have INDNR fishing pressure.

Legal aspects

Ecuador still does not have specific legislation for fisheries management in Amazonian conditions, worse still, in protected areas, so this document can

contribute to establish a discussion in this regard, which should be taken in an intersectoral manner, considering cross-sectional small-scale fishing with vulnerable populations that live in conditions of limited income and need to boost their economy.

Institutional aspects

The institutional presence of entities related to fishing is incipient, since this activity is concentrated on the Pacific coast of the country, with very few technical visits from the Public Institute for Aquaculture and Fisheries Research (IPIAP), due to the closure of the Fishing Inspectorate in the Amazon since 2017.

In this context, the presence of the Vice Ministry of Aquaculture and Fisheries (VAP) should be strengthened and should coordinate actions with the MAATE to implement these guidelines. Likewise, local fishermen must be formalized and the actions of local Decentralized Autonomous Governments (GADs) must be integrated in order to facilitate and initiate records of fishing landings to facilitate control of the activity in the RAE.

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