

Research Article

Sustaining local ecological knowledge of artisanal fishers: a perspective from northern Colombia

Fausto Pineda¹ , Esteban Molina¹ , Ana C. Torregroza-Espinosa² 
Cesar Cardona-Almeida³  & Andres Suarez¹ 

¹Departamento de Civil y Ambiental, Universidad de la Costa, Barranquilla, Atlántico, Colombia

²Departamento de Ciencias Naturales y Exactas, Universidad de la Costa
Barranquilla, Atlántico, Colombia

³Corporación Autónoma Regional del Río Grande de la Magdalena - Cormagdalena
Barranquilla, Colombia

Corresponding author: Andres Suarez (asuarez24@cuc.edu.co)

ABSTRACT. Fishing is one of the oldest activities developed by humans for both food subsistence and economic gain. Artisanal fishing has a great social impact; it helps satisfy basic nutritional needs and generates income for communities. Therefore, local ecological knowledge associated with such fishing practices is important because of its capacity to provide data on fishing research. Fishing in the study area is largely artisanal for subsistence, a consequence of the fact that there are no fishing associations or cooperatives which might empower local workers and help promote the sector. We based our study on a quantitative approach. Through this approach, we analyzed factors that influence future fishing decisions among artisanal fishers in a community in northern Colombia. We found that socioeconomic conditions and pollution were important considerations when respondents contemplated future fishing prospects. Respondents' perceptions of institutional support also influenced their attitudes about fishing. Most respondents planned to continue fishing. We encourage local authorities in such communities to address the challenges faced by artisanal fishers and develop strategies to improve the socioeconomic and environmental conditions in which such people work.

Keywords: artisanal fishing; socioeconomic conditions; local traditions; pollution; vulnerability

INTRODUCTION

Fishing is one of the oldest activities developed by humans for both food subsistence and economic gain (Souza & Le 2021). About 85% of the fish and shellfish consumed by Latin American households comes from artisanal fishing (Quizán-Plata et al. 2020). Accordingly, artisanal fishing is an activity that has a great social impact since it helps satisfy basic nutritional needs and generates income for local communities. Artisanal fishers possess traditional ecological knowledge that is cumulative and dynamic, responding to social, economic, ecological, and technological changes (Brián et al. 2015). Such knowledge is a product of adaptation to local environmental conditions and the use of multiple techniques, enabling fisherfolk to identify oceanographic and meteorological condi-

tions, exploit diverse aquatic organisms, and develop various fishing methods (Bender et al. 2014, Braga et al. 2020). This knowledge is acquired empirically and, in most cases, is transmitted from generation to generation in fishing families (García-Allut 2003, Salam 2018).

In Colombia, artisanal fishing is a sector typified by small-scale fisheries. It is classified as an unplanned activity practiced by a segment of the population from the lowest socioeconomic levels (Borda & Cruz 2004, Torres-Guevara et al. 2016). Furthermore, the development of artisanal fishing activities has led to multiple problems that endanger the future practice of fishing, such as overexploitation of fish stocks and other ecosystem services, contamination of water sources, lack of government oversight and regulation, and security problems (Saavedra-Díaz et al. 2015,

López-Angarita et al. 2018). Moreover, artisanal fishers continue to work despite various challenges (Saavedra-Díaz et al. 2015). The management of fishery resources in Colombia is the responsibility of the National Fisheries and Aquaculture Authority (AUNAP, by its Spanish acronym), whose strategic objective is to execute the fisheries and aquaculture policy in Colombian territory for research, planning, administration, control, and surveillance of fishing resources, and promotion of aquaculture, promoting productive development and social progress. However, there is still a lack of effort to generate actions aimed at the socioeconomic, environmental, ecological, and fishing characterization and to promote the strengthening of associativity and accompaniment to the formalization of the country's artisanal fishers.

Malambo's Swamp is located between the Soledad and Malambo municipalities east of the Department of Atlántico in northern Colombia (Fig. 1). The swamp's average depth during the low-water season is 1.2 m. In contrast, it is about 2.4 m deep in the high-water season. Fishing in Malambo is largely artisanal for subsistence, a consequence of the fact that no fishing associations or cooperatives might empower local workers and help promote the sector (Hernández & Martínez 2016). Fishing activity is carried out in small and primitive boats (canoes), and the main fish collected in the swamp are native species such as bocachico (*Prochilodus magdalenae*) and catfish (genus *Pseudoplatystoma*). It is important to highlight that this area suffers diverse socio-ecological pressures, mainly given the high pollution levels, socioeconomic vulnerability, and governmental abandonment.

Water quality in the swamp has been analyzed, and results state high levels of micro-biological pollution (Sarmiento et al. 2019) and eutrophication problems generated by cyanobacterial growth (Díaz-Urbe et al. 2021). The main problem facing the swamp is the poor management of wastewater discharges (domestic and non-domestic wastewater), which are made directly into the swamp without any pre-treatment. These wastewaters originate in the surrounding industrial park and Malambo town and are discharged directly without pre-treatment (Liseth et al. 2005). In addition, on the swamps banks, there is evidence of illegal constructions and landfills, actions carried out to invade and subtract area from the body of water due to the lack of control exercised by local and environmental authorities over the ecosystem. Some studies propose the analysis of the socio-ecological system as a fundamental tool when studying and understanding the impacts and affectations generated in the highly degraded ecosystems due to pollution and the effects of anthropic activities and their effects on the develop-

ment of artisanal fishing activities (Andrade et al. 2019, Speake et al. 2020). Therefore, this is the case in Malambo's Swamp since around 150 fishers go out to the swamp every day in search of their livelihood. Still, there are high levels of contamination, and even there have been constant fish mortalities due to water contamination.

In this sense, the problems confronted by artisanal fishers in Colombia require attention because this vocation is not considered competitive or sustainable. There is a need to understand the perspective of local traditional fishers to promote strategies that will support and preserve this artisanal activity. There is a need to understand the perspective of local fishers to promote sustainable fishing practices. There is abundant literature on the importance and characteristics of artisanal fisheries; however, there is a lack of information on the factors that influence artisanal fishers to continue working into the future. To fill this gap, we analyzed some of these factors in a vulnerable coastal fishing community in northern Colombia.

MATERIALS AND METHODS

We based our study on a quantitative approach. Through this approach, we wanted to identify factors influencing fishers' willingness to maintain their fishing activities. As few studies address analysis on willingness to maintain the activity, we used as proxy variables identified in previous studies where artisanal fishing activities are under pressure, and the fishers face difficulties. We identified variables related to fishing *per se* (*A*) regarding economic performance (*E*), ecological conditions (*Ec*), general context (*C*), and social dimension (*S*). Some variables proved to have a positive contribution to supporting the activities, but others proved to affect the capacity to perform artisanal fishing (Table 1).

According to the variables mentioned, it is possible to identify in (*A*) that the variables which showed positive trends were when fishers have several years of experience (Mariz et al. 2014, Santos et al. 2016) and when they spend more time fishing (Kramer et al. 2002). However, the lack of equipment affects the capacity to perform the activity (Chaves et al. 2002). Now, regarding (*E*) positive variables related to performing fishing as the main activity (Ramires et al. 2012, Mariz et al. 2014, Martins et al. 2015), and when the activity generates middle incomes (Acauan et al. 2018). Nevertheless, when the activity produces low incomes, the variables have the potential to affect negatively (Ramires et al. 2012, Evangelista-Barreto et al. 2014).

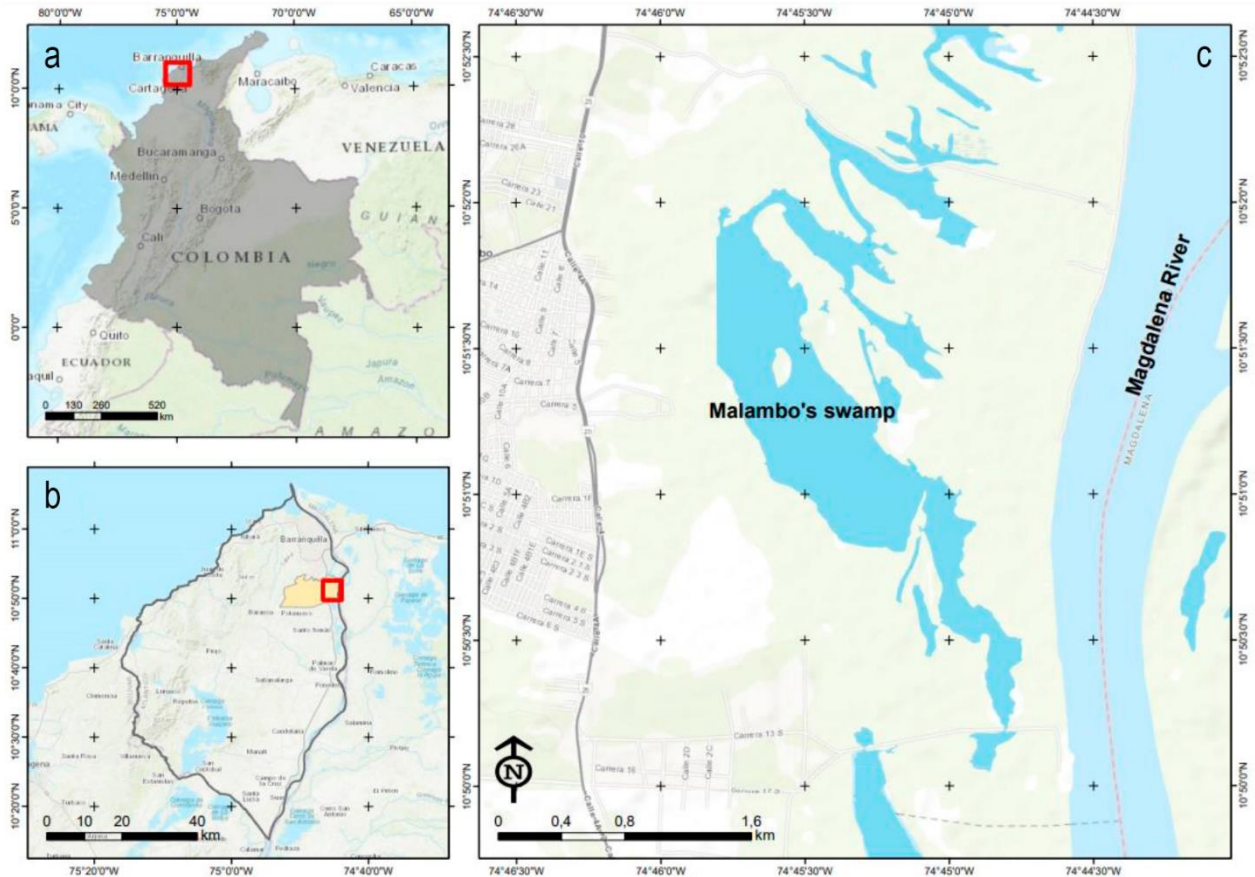


Figure 1. Study area. a) Location of the Malambo's Swamp in northern South America, b) view of the northern coast of Colombia and the location of the Malambo's Swamp, c) close-up of the Malambo's Swamp.

Table 1. Variables influencing traditional fishing activities maintenance. *Potential influence of the variables for maintaining the activity in difficult contexts.

Variable	Influence*	Author
A_1 Time spent fishing	(+)	Kramer et al. (2002)
A_2 Lack of equipment	(-)	Chaves et al. (2002)
A_3 Years of experience	(+)	Mariz et al. (2014), Santos et al. (2016)
E_1 Engagement in additional activities	(-)/(+)	Kramer et al. (2002), Evangelista-Barreto et al. (2014), Dominguez et al. (2016), Jara et al. (2020)
E_2 Incomes (middle)	(+)	Acauan et al. (2018)
E_3 Main economic activity	(+)	Ramires et al. (2012), Mariz et al. (2014), Martins et al. (2015)
E_4 Incomes (low)	(-)	Ramires et al. (2012), Evangelista-Barreto et al. (2014)
Ec_1 Target species shortages	(-)	Chaves et al. (2002), Touré et al. (2015)
C_1 Legislation restricted the use of certain gear at particular times.	(-)	Chaves et al. (2002)
C_2 Urbanization level (withdraws the youth from the fishing community)	(-)	Mariz et al. (2014)
S_1 Participation in organizations	(+)	Moreau & Coomes (2008), Acauan et al. (2018)
S_2 Educational level (low)	(+)	Ramires et al. (2012), Evangelista-Barreto et al. (2014), Mariz et al. (2014)
S_3 Lack of incentives for young people	(-)	Santos et al. (2016)

The variable engaging in additional activities proved a contrasting influence; in some studies, it proved to affect positively, but in others negatively (Kramer et al. 2002, Evangelista-Barreto et al. 2014, Dominguez et al. 2016, Jara et al. 2020). Another variable that influences negatively is the target species shortages (Chaves et al. 2002, Touré et al. 2015), directly affecting the activity. Some context variables (*C*) affect negatively too, mostly related to legislation (Chaves et al. 2002) and the influence of urban areas on young people (Mariz et al. 2014). In addition, some social aspects (*S*), such as being part of a social committee or organization, help sustain the activity (Moreau & Coomes 2008, Acauan et al. 2018). In addition, low educational levels are evidenced to be a variable that positively affects the development of the activity, given that low-educated people are more prone to remain in the activity; however, the lack of incentives for young people to continue the activity affect negatively (Santos et al. 2016).

Now, considering the variables identified in the literature, we proceeded to identify the influence of these groups of variables through a questionnaire in our study area (Table S1). We tested all the variables instead of *C* because the context of our study is particular; for instance, regarding *C*₁, currently, there exists a policy that stimulates artisanal fishing in the area, and regarding *C*₂, our starting point was the understanding that Malambo is a swamp mainly urban. The rest of the variables were included in an ordered logistic regression with the next question as a dependent variable: "How interested are you in maintaining fishing activity in the area?" We provided five ordered categories for the response, ranging from 1, not interested, to 5, extremely interested. We used the Stata 14[®] statistical package for the statistics in the paper.

We modified the approach used by Suarez et al. (2018). We divided the questionnaire into three sections: 1) socioeconomic characteristics, 2) analysis of fishing activity to address variables in Table 1, and 3) perceptions about the state of the ecosystem. According to the respondents, all these variables were useful to elicit the probability of maintaining artisanal fishing in the study area. We applied a simple random sampling method to calculate the number of artisanal fishers we wanted to have participated in the study. According to local census data, the area has a population of 154 inhabitants (Alcaldía de Malambo 2019). We used a 5% error and a 99% confidence level and thus identified 68 people in the community involved in artisanal fishing. We lost data from six respondents. As the context of the swamp is particularly pressure for environmental pollution, we applied a chi-

square to test for a significant association between the respondent's perception of environmental quality variables and fishing yields through time ($P > 0.05$) to test the next hypothesis: as the context of the swamp is adverse due to environmental conditions, the fishers have perceived fish stocks affectation.

RESULTS

Socioeconomic characteristics

We found depressed socioeconomic conditions in the sampled population (Table 2).

Most respondents were men (98%), many older than 40 (42%), who had low monthly incomes (74% in the range of 0-400,000 COP [US\$ 0-116]). Nearly one-fourth (23%) had been victims of the Colombian armed conflict. Only 10% were part of a local organization, and 87% were enrolled in the health system. The mean number of persons per household was 5.6.

Responses to the questionnaire indicated that most respondents were familiar with fishing. Some 19% had fished 1-3 years ago, 14% had been fishing for 4-7 years, and 33% had been fishing for at least eight years. Respondents said they worked fishing for about 3.7 days per week, and most did not perform the activity for more than 5 h a day (83%). Although most respondents conducted their fishing activities independently, 81% expressed interest in joining and participating in a fisher's association. Surprisingly, more than 70% said they did not know the local fishing authority, so their satisfaction with its performance was generally low (66%). Only 13% were officially certified as fishers.

Regarding the economic importance of the activity, 71% of respondents indicated that they supported their families by fishing, 42% traded fish in the community, and 58% used the fish they caught for their consumption (Table 3). Respondents used an array of different fishing gears, among them: 'chinchorro' (44% of respondents), trammel nets (29% of respondents), and throw nets (18% of the respondents). Nearly all (97%) of the respondents use boats for fishing. In the study area, fishing activities focus on capturing fish in the exotic cichlid genus *Oreochromis*, with some 68% being *O. niloticus*, known locally by the misnomers black or silver "mojarra." Only 4% of respondents reported targeting species native to the region (e.g. *Prochilodus magdalenae* and *Pseudoplatystoma*).

We asked if respondents had noticed changes in the fish populations over time, and 84% said that fish have diminished in recent years. Half of the respondents noted a decrease in the number of birds in the area, and this variable had a significant association with diminished fishing in recent years ($P = 0.010$).

Table 2. Socioeconomic characteristics of the respondents (n = 62). COP: Colombian Peso, US\$ 1 = COP 3504 (02/12/2019). The monthly minimum legal wage in Colombia is COP 887,803.

Variable	Frequency	%	Variable	Frequency	%
Gender			Monthly incomes		
Male	61	98	0-400.000	46	74
Female	1	2	401.000-828.116	14	23
Age			829.000-1.656.000	2	3
15-17	5	8	Health system		
18-25	13	21	Yes	54	87
26-39	18	29	No	8	13
>40	26	42	Local organization		
Armed conflict victim			Yes	7	10
Yes	14	23	No	55	90
No	48	77			

Table 3. Information related to fishing activities.

Variable	Frequency	%	Variable	Frequency	%
Fishers association			Fisher certified		
Yes	50	81	Yes	8	13
No	12	19	No	54	87
Know authority			Fishing sustains the family.		
Yes	13	21	Yes	44	71
No	49	79	No	18	29
Satisfaction with authority			Other economic activity		
Very unsatisfied	27	43	Yes	50	81
Unsatisfied	14	23	No	12	19
Acceptable	48	14	Collected fish		
Satisfied	4	6	Self-consumption	36	58
Very satisfied	8	13	Trading	26	42

Probability for sustaining fishing activities in the study area

We wanted to identify the respondent's interest in continuing to fish in the study area and used an ordinal scale from 1 to 5, representing low to high-interest levels, respectively. Percentages for each response were: level 1 (6%), level 2 (1%), level 3 (34%), level 4 (32%), and level 5 (26%), indicating >90% of the responses fell in the upper three categories, 3-5. An ordered logit regression showed that the explanatory variables that influenced the probability of choosing an option ($P < 0.05$) were monthly income, years of fishing, fishing as a family tradition, and use of the captured fish for self-consumption (Table 5).

Variables with negative coefficients, such as monthly income (-2.24), number of years fishing (-0.7), and fishing as a family tradition (-2.3), opted for lower levels in the dependent variable, i.e. they seem to be less inclined to continue fishing. Likewise, respondents who fish for self-consumption, with a positive coefficient (1.9), were an important variable in leading

people to choose a higher level in the dependent variable.

DISCUSSION

Our results revealed that socioeconomic constraints and pollution were important considerations when respondents contemplated future fishing prospects. Respondents' perceptions of institutional support also influenced their attitudes about fishing. In addition, we found that most respondents planned to continue fishing. In the next lines, we will discuss those aspects in light of current literature, and we provide additional insights.

Subsistence fishery

Small-scale fisheries in southern countries are often vital to rural livelihoods (Ramalho 2015). Also, small-scale fishing, beyond just work, is a way of life (Sedrez et al. 2013, Fernandes et al. 2014, Mariz et al. 2014, Meireles et al. 2017). As we found in this study,

artisanal fishing is a long-term traditional activity, mainly performed by men with little education and low-income levels (Table 2). This scenario is common in southern countries where such fishing activity is performed mainly by under-educated adult men who endure dire socioeconomic circumstances (Mariz et al. 2014, Marín-Monroy & Ojeda-Ruiz de la Peña 2016). Our results also indicate that older people persist in artisanal fishing, whereas young people are less interested in becoming fishers, a phenomenon reported by others (Moreau & Coomes 2008, Santos et al. 2016). Regarding the time dedicated to fishing, our data contrast with results from other studies in which fishers reported working 10-14 h per day, 4-6 days per week (Fernandes et al. 2014), or even 21 continuous days (Brennan & Portman 2017, Hoque 2018). A possible reason for this difference is that Malambo's Swamp is next to where fishers live, making it easier for them to access fishing sources.

Environmental conditions and fishing

Because Malambo's Swamp is embedded in an urban context, environmental degradation is unsurprising (Table 4). Others have pointed out that urbanization influences the environmental conditions of artisanal fishers (Touré et al. 2015, Filho et al. 2020). Fishers' perceptions regarding ecosystem pollution have been identified as important factors for identifying changes in fishing dynamics (Effiong & Ogbonna 2017) and ecosystem valuation (Enriquez-Acevedo et al. 2018). Some have concluded that local perceptions about pollution can reduce artisanal fishing, given that small-scale fishers make rational production decisions that affect production (Effiong & Ogbonna 2017). Although we found no association between respondent's perception of pollution and declining fish catch (Table 4), we found that 84% of respondents perceive that there has been a decline in the number of fish in the swamp, resulting in a significant association with perceptions about the faunal decrease in the area which is an interesting result, given that it has been recognized that birds are good environmental bio-indicators, because they are easy to detect. Their presence is usually notable (Egwumah et al. 2017). Moreover, this local knowledge is important because highlighting local knowledge can guide efforts toward more sustainable fishing practices (McClean et al. 2022).

Studies have found that fishers who perceive substantial competition and increased pollution are more likely to adopt multiple strategies (Malakar et al. 2018), one of which is forming an association (Sedrez et al. 2013, Paudel et al. 2016). Although most of the respondents in our study conducted their fishing activities independently, most felt the need to be part of

a fisher's association. Being a member of such an organization has shown to be important for increasing sales by fishers and coping with the changing environment (Malakar et al. 2018). On the other hand, the expansion of exotic species worldwide has accelerated because of economic globalization, and the effects of exotic species invasions on recipient ecosystems have become global biological issues (Gurevitch & Padilla 2004). The abundance of exotic species, reflected in this study by the high percentage (68%) of respondents who reported extraction of exotic *O. niloticus*, represents a threat to native species from the competition, predation, disease transmission, hybridization, and erosion of the gene pool, all of which drive a decline in biodiversity (Avlijaš et al. 2018). Invading exotic fish species in freshwater systems is critically important for the sound management and sustainability of native resources (Xia et al. 2019).

Sustaining traditional fishing

Despite the many challenges confronted by traditional fishers, we found that most respondents in our study were willing to continue fishing in the future. These results are consistent with the findings of other studies, which showed that rural people resist abandoning their traditions and activities (Muñoz-Rios et al. 2020, Trung-Thanh et al. 2021). We identified several variables that influence whether fishers opt to continue artisanal fishing in the future. These variables partially confirmed the variables identified in Table 1. For instance, our significant variables ($P < 0.05$) showed that the higher the income, the decreased probability of continuing the activity. This result contrasts with studies showing that higher income positively affects activity (Acauan et al. 2018) or lower income negatively affects it (Ramires et al. 2012, Evangelista-Barreto et al. 2014) (see Table 1, E_2 and E_4). Another contrasting variable was the number of years of fishing. At the same time, studies have identified that this variable could produce a positive effect on traditional fishing activity (Mariz et al. 2014, Santos et al. 2016) (see Table 1, A_3), we found the contrary trend; the more years fishing, the probability to rate lower values increased. More research is needed to understand this mismatch, but the nature of the research could provide an answer. We aimed to provide factors that influence the willingness to maintain activity and not only identify variables related to the activity (under pressure).

However, the trend was similar when considering fishing as a family tradition as a proxy to the variable S_3 (we found a negative impact). Finally, although we did not find more significant variables to contrast with Table 1, we found an interesting variable that proved

Table 4. Local perceptions about the environmental conditions in the swamp.

Variable	Frequency	%	Variable	Frequency	%
Garbage			Urban streams		
Yes	31	50	Yes	50	81
No	31	50	No	12	19
Garbage collection			Bad smells		
Yes	4	6	Yes	43	61
No	58	94	No	19	31
Solid wastes			Wastewater into the swamp		
Debris	22	35	Yes	51	82
Wheels	11	18	No	11	18
Plastic	13	21	Amount of birds as before		
Pane	5	8	Yes	31	50
Other	11	18	No	31	50

Table 5. Ordered logit for choosing the levels for sustaining fishing activities for the future. * $P < 0.05$, ** $P < 0.01$.

Maintaining the activity	Coef.	Std. Err.	Z	$P > z$	[95% Conf. Interval]
Educational level	-0.163	0.0924	-1.77	0.076	-0.3451 0.0172
Organization (yes)	-1.52	1.035	-1.47	0.140	-3.555 0.5030
Monthly incomes	-2.24	0.6148	-3.65	0.000*	-3.446 -1.03
Fish amount	1.137	0.6677	1.70	0.088	-0.1710 2.446
Authority satisfaction (yes)	-0.481	0.2465	-1.95	0.051	-0.9643 0.0019
Only activity (yes)	-0.383	0.4099	-0.94	0.349	-1.187 0.4195
Additional activity (yes)	-0.276	0.1572	-1.76	0.079	-5.844 0.0321
Years of fishing	-0.729	0.2972	-2.45	0.014**	-1.311 -0.146
Why become fishers					
-Family tradition	-2.33	1.071	-2.18	0.029**	-4.436 -0.236
-Enjoyment	1.079	0.9780	1.10	0.270	-0.8371 2.996
-Only known activity	-0.020	1.378	-0.01	0.988	-2.721 2.681
-Only employment option	1.077	0.8785	1.23	0.220	-0.6441 2.799
Days/week fishing	0.1473	0.2219	0.66	0.507	-0.2875 0.5822
Hours/day	0.0986	0.3704	0.27	0.790	-0.6273 0.8247
Fishes for self-consumption	2.290	0.7087	3.23	0.001*	0.90111 3.679
Equipment own (yes)	-1.45	0.8103	-1.80	0.072	-3.044 0.1322
Number of observations	62				
Log-likelihood	-56.830				
LR $\chi^2(16)$	50.59				
Prob > χ^2	0.000				
Pseudo R^2	0.3080				

important to maintain the activity, such as fishing for self-consumption, representing that traditional fishing is important in the study area to support food security, as has been highlighted for the Caribbean region (Quizán-Plata et al. 2020).

On the other hand, one interesting finding in this study was that the fishing authority had not played an active role in fisheries management (79% did not know the authority and were thus unsatisfied with management). It was an important finding in that some authors have noted that a lack of institutional support could lead to the failure and disappearance of local

initiatives (Mouro et al. 2018). The same authors stressed that institutional change could be integrated into local narratives, thereby positively contributing to a process that acknowledges the collective identity and local traditions. Regarding fishing regulations in the country, there is Law 13 of 1990, which corresponds to the general fishing statute. This document outlines how fishery resources' comprehensive management and exploitation should be regulated to ensure sustainability. Likewise, decree 4181 of 2011 establishes the AUNAP functions. Despite the regulations and the existence of a national entity, fishing activity in the area

needs more modernization, investment, staff qualification, and government support for developing fishers and their activity.

CONCLUSIONS

We identified socioeconomic characteristics in a small fisher community in northern Colombia, which revealed the probability of artisanal fishing continuing. Environmental pollution and socioeconomic conditions are serious challenges faced by the fishers. Furthermore, negative perceptions on the part of respondents related to institutional support must be considered to understand the complex problems in the area. Despite all the problems, most respondents indicated they would continue to fish. Local authorities must become involved and develop strategies to improve socioeconomic and environmental conditions to help sustain the artisanal fishery in the future. On the other hand, with this research, we provide a list of variables related to fishing in a complex context, and we implicate these variables in an analysis of local traditional fishers' willingness to maintain the activity. We were able to verify the variables identified in the literature, and we contributed to the field by highlighting the factors that influence fishers' responses.

REFERENCES

- Alcaldía de Malambo. 2013. Plan de ordenamiento territorial de Malambo. Usos del suelo. [https://www.scribd.com/document/525101569/01-Acuerdo-Municipal-POT-Malambo-01#]. Reviewed: July 05, 23.
- Acauan, R.C., Branco, J.O., Teixeira, B., Rodrigues Filho, J.L. & Polette, M. 2018. Artisanal fisheries in the city of Penha (SC): a rereading of socioeconomic context of the activity and the adaptive sector capacity. *Desenvolvimento e Meio Ambiente*, 49: 150-166. doi: 10.5380/dma.v49i0.58078
- Andrade, L., Hidalgo, C. & Ther-Rios, F. 2019. Análisis de redes sociales en un sistema socio-ecológico estuarino del sur de Chile (41,6°S): diagnóstico y contribuciones para la mejora de la gobernanza en contextos ribereños. *Desenvolvimento e Meio Ambiente*, 50: 151-169.
- Avlijaš, S., Ricciardi, A. & Mandrak, N.E. 2018. Eurasian tench (*Tinca tinca*): the next Great Lakes invader. *Canadian Journal of Fisheries and Aquatic Sciences*, 75: 169-179. doi: 10.1139/cjfas-2017-0171
- Bender, M.G., Machado, G.R., De Azevedo-Silva, P.J., Floeter, S.R., Monteiro-Netto, C., Luiz, O.J. & Ferreira, C.E.L. 2014. Local ecological knowledge and scientific data reveal overexploitation by multi-gear artisanal fisheries in the Southwestern Atlantic. *Plos One*, 9: e110332. doi: 10.1371/journal.pone.0110332
- Borda, C.A. & Cruz, R. 2004. Pesca artesanal de bivalvos (*Anadara tuberculosa* y *A. similis*) y su relación con eventos ambientales, Pacífico Colombiano. *Revista de Investigaciones Marinas*, 25: 197-208.
- Braga, H.O., Pereira, M.J., Musiello-Fernandes, J., Morgado, F., Soares, A.M.V.M. & Azeiteiro, U.M. 2020. The role of local ecological knowledge for the conservation and sustainable fisheries of the sea lamprey (*Petromyzon marinus* Linnaeus, 1758) in the Iberian Peninsula. *Ocean and Coastal Management*, 198: 105345. doi: 10.1016/j.ocecoaman.2020.105345
- Brennan, R.E. & Portman, M.E. 2017. Situating Arab-Israeli artisanal fishermen's perceptions of marine litter in a socio-institutional and socio-cultural context. *Marine Pollution Bulletin*, 115: 240-251. doi: 10.1016/j.marpolbul.2016.12.001
- Brián, G., Ramos, A. & Nancy, G. 2015. Pescadores artesanales del Bajo Paraná Argentino: entre la complejidad y la tragedia de los comunes. *Avá*, 26: 61-81.
- Chaves, P., Pichler, H. & Robert, M. 2002. Biological, technical and socioeconomic aspects of the fishing activity in a Brazilian estuary. *Journal of Fish Biology*, 61: 52-59. doi: 10.1006/jfbi.2002.2066
- Diaz-Uribe, C., Angulo, B., Patiño, K., Hernández, V., Vallejo, W., Gallego-Cartagena, E., et al. 2021. Cyanobacterial biomass as a potential biosorbent for the removal of recalcitrant dyes from water. *Water*, 13. doi: 10.3390/w13223176
- Dominguez, P.S., Zeineddine, G.C., Rotundo, M.M., Barrella, W. & Ramires, M. 2016. A pesca artesanal no Arquipélago de Fernando de Noronha (PE). *Boletim do Instituto de Pesca*, 42: 241-251. doi: 10.5007/1678-2305.2016v42n1p241
- Effiong, M.O. & Ogbonna, C.U. 2017. Ecosystem perception among artisanal fishermen: a case study of Akpabuyo and Bakassi coastal fishing communities in Cross River State, Nigeria. *Annual Research and Review in Biology*, 19: 1-11. doi: 10.9734/ARRB/2017/37431
- Egwumah, F., Egwumah, P. & Edet, D. 2017. Paramount roles of wild birds as bioindicators of contamination. *International Journal of Avian & Wildlife Biology*, 2: 194-199. doi: 10.15406/ijawb.2017.02.00041

- Enriquez-Acevedo, T., Botero, C.M., Cantero-Rodelo, R., Pertuz, A. & Suarez, A. 2018. Willingness to pay for beach ecosystem services: the case study of three Colombian beaches. *Ocean and Coastal Management*, 161: 96-104. doi: 10.1016/j.ocecoaman.2018.04.025
- Evangelista-Barreto, N.S., Cleusa, A., Daltro, S., Paim, I. & Bernardes, F.D.S. 2014. Indicadores socioeconômicos e percepção ambiental de pescadores em São Francisco do Conde, Bahia. *Boletim do Instituto de Pesca*, 40: 459-470.
- Fernandes, L.P., Keunecke, K.A. & Di Benedetto, A.P.M. 2014. Production and socioeconomics of the artisanal fishing of the sea-bob shrimp in northern Rio de Janeiro state. *Boletim do Instituto de Pesca*, 40: 541-555.
- Filho, F.T., Da Paz de Souza-Paiva, R.F., Poll, A.P., Batista, A.P. & de Freitas, W.K. 2020. The effects of urban/industrial expansion in Guanabara Bay on the perception of artisan fishermen. *Revista Ambiente e Sociedade*, 23. doi: 10.1590/1809-4422ASOC20180301R1VU2020L1AO
- García-Allut, A. 2003. La pesca artesanal, el cambio y la patrimonialización del conocimiento. *Debate e Investigación*, 44: 75-83.
- Gurevitch, J. & Padilla, D.K. 2004. Are invasive species a major cause of extinctions? *Trends in Ecology and Evolution*, 19: 470-474. doi: 10.1016/j.tree.2004.07.005
- Hernández, J. & Martínez, D. 2016. Modelación hidrodinámica y de la calidad del agua para la evaluación ambiental de vertimientos generados a la ciénaga mesolandia, atlántico - Colombia. Repositorio Universidad de La Costa. [<https://repositorio.cuc.edu.co/handle/11323/644#:~:text=Se%20logr%C3%B3%20evaluar%20ambientalmente%20los%20vertimientos%20que%20se,obteniendo%20resultados%20favorables%20en%20cortos%20intervalos%20de%20tiempo>]. Reviewed: July 05, 23.
- Hoque, M., Shamsuzzaman, M., Un-Nabi, R. & Harun-Al-Rashid, A. 2018. Socioeconomic characteristics and fishing operation activities of the artisanal fishers in the Sundarbans Mangrove Forest, Bangladesh. *Turkish Journal of Fisheries and Aquatic Sciences*, 18: 81-90. doi: 10.4194/1303-2712-v18
- Jara, H.J., Tam, J., Reguero, B.G., Ganoza, F., Castillo, G., Romero, C.Y., et al. 2020. Current and future socio-ecological vulnerability and adaptation of artisanal fisheries communities in Peru, the case of the Huaura province. *Marine Policy*, 119: 104003. doi: 10.1016/j.marpol.2020.104003
- Kramer, R.A., Simanjuntak, S.M.H. & Liese, C. 2002. Migration and fishing in Indonesian coastal villages. *Ambio*, 31: 367-372. doi: 10.1579/0044-7447-31.4.367
- Liseth, A., Luis, G. & Santiago, G. 2005. Copépodos planctónicos del complejo cenagoso de Malambo (Atlántico, Colombia) y su relación con algunos factores físicos y químicos del agua. *Revista Dugandia*, 1: 17-38.
- López-Angarita, J., Tilley, A., Díaz, J.M., Hawkins, J.P., Cagua, E.F. & Roberts, C.M. 2018. Winners and losers in area-based management of a small-scale fishery in the Colombian Pacific. *Frontiers in Marine Science*, 5: 1-12. doi: 10.3389/fmars.2018.00023
- Malakar, K., Mishra, T. & Patwardhan, A. 2018. A framework to investigate drivers of adaptation decisions in marine fishing: evidence from urban, semi-urban and rural communities. *Science of the Total Environment*, 637-638: 758-770. doi: 10.1016/j.scitotenv.2018.04.429
- Marín-Monroy, E.A. & Ojeda-Ruiz de la Peña, M.Á. 2016. The role of socioeconomic disaggregated indicators for fisheries management decisions: the case of Magdalena-Almejas Bay, BCS. Mexico. *Fisheries Research*, 177: 116-123. doi: 10.1016/j.fishres.2016.01.009
- Mariz, D., De Souza, A.C.F.F., Teixeira, S.F., Campos, S.S., De Lucena, R.F.P. & Da Nóbrega-Alves, R.R. 2014. Effects of urban development on socioeconomic aspects of a tropical artisanal fishing community. *Indian Journal of Traditional Knowledge*, 13: 637-646.
- Martins, N.G., Rodrigues, D.A., Ribeiro, G.M. & De Freitas, R.R. 2015. Avaliação da atividade pesqueira numa comunidade de pescadores artesanais no Espírito Santo, Brasil. *Journal of Integrated Coastal Zone Management*, 15: 265-275. doi: 10.5894/rgci514
- McLean, E.L., Forrester, G.E. & García-Quijano, C.G. 2022. The disconnect between knowledge and perceptions: a study of fishermen's local ecological knowledge and their perception of the state of fisheries and how these are managed in the Dominican Republic. *Human Ecology*, 50: 227-240. doi: 10.1007/s10745-022-00308-6
- Meireles, M.P.A., Meireles, V., Dos Santos, L.V. & De Barros, R.F.M. 2017. Perfil socioeconômico dos pescadores artesanais da comunidade Passarinho, Resex Marinha do Delta do Parnaíba, Araisos/MA. *Revista Espacios*, 38: 9 pp.
- Moreau, M.A. & Coomes, O.T. 2008. Structure and organization of small-scale freshwater fisheries: aquarium fish collection in Western Amazonia.

- Human Ecology, 36: 309-323. doi: 10.1007/s10745-008-9160-y
- Mouro, C., Santos, T. & Castro, P. 2018. Past-present discontinuity in ecological change and marine governance: an integrated narrative approach to artisanal fishing. *Marine Policy*, 97: 163-169. doi: 10.1016/j.marpol.2018.06.008
- Muñoz-Rios, L.A., Vargas-Villegas, J. & Suarez, A. 2020. Local perceptions about rural abandonment drivers in the Colombian coffee region: Insights from the city of Manizales. *Land Use Policy*, 91: 104361. doi: 10.1016/j.landusepol.2019.104361
- Paudel, S., Levesque, J.C., Saavedra, C., Pita, C. & Pal, P. 2016. Characterization of the artisanal fishing communities in Nepal and potential implications for the conservation and management of Ganges River dolphin (*Platanista gangetica gangetica*). *PeerJ*, 4: e1563. doi: 10.7717/peerj.1563
- Quizán-Plata, T., Carrasco-Miranda, J.G., Murillo-Castillo, K.D., Corella-Madueño, M.A.G., López-Teros, V. & Frongillo, E.A. 2020. Determinants and consequences of food insecurity in artisanal fishing families from the coastal community of Sonora, Mexico. *Food and Nutrition Bulletin*, 41: 459-473. doi: 10.1177/0379572120965874
- Ramalho, C.W.N. 2015. A desnecessidade do trabalho entre pescadores artesanais. *Sociologias*, 17: 192-220. doi: 10.1590/15174522-017003812
- Ramires, M., Clauzet, M., Rotundo, M.M. & Begossi, A. 2012. A pesca e os pescadores artesanais de Ilhabela (SP), Brasil. *Boletim Do Instituto de Pesca*, 38: 231-246.
- Saavedra-Díaz, L.M., Rosenberg, A.A. & Martín-López, B. 2015. Social perceptions of Colombian small-scale marine fisheries conflicts: Insights for management. *Marine Policy*, 56: 61-70. doi: 10.1016/j.marpol.2014.11.026
- Salam, A. 2018. Technological adaptation in traditional fisheries: way to survive. *IOP Conference Series: Earth and Environmental Science*, 139. doi: 10.1088/1755-1315/139/1/012038
- Santos, M., Dos Santos, C.F., Branco, J.O. & Barbieri, E. 2016. Caracterização da pesca e dos pescadores artesanais de camarões penaeidae em salina no município de Macau - Rio Grande do Norte. *Boletim do Instituto de Pesca*, 42: 465-478. doi: 10.20950/1678-2305.2016v42n2p465
- Sarmiento, L.A., García, Y., Suarez, M., Inés, H.V. & Becerra, J.E. 2019. Bifidobacterias como indicadores de contaminación fecal en aguas tropicales. *Revista de Biología Tropical*, 67: 562-571. doi: 10.15517/RBT.V67I3.33843
- Sedrez, M.C., Dos Santos, C.F., Marenzi, R.C., Sedrez, S.T., Barbieri, E. & Branco, J.O. 2013. Characterization socioeconomic of the artisanal fishing of the sea-bob shrimp in Porto Belo, SC. *Boletim do Instituto de Pesca*, 39: 311-322. doi: 10.20950/1678-2305.2013v39n3p311
- Souza, A. & Le, F. 2021. How the fishing effort control and environmental changes affect the sustainability of a tropical shrimp small-scale fishery. *Fisheries Research*, 235: 105824. doi: 10.1016/j.fishres.2020.105824
- Speake, M.A., Carbone, M.E. & Spetter, C.V. 2020. Analysis of the socio-ecological system of the Bahía Blanca estuary (Argentina) and its impact on ecosystem services and human well-being. *Investigaciones Geograficas*, 2020: 121-145. doi: 10.14198/INGEO2020.SCS
- Suarez, A., Arias-Arévalo, P., Martínez-Mera, E., Granobles-Torres, J.C. & Enríquez-Acevedo, T. 2018. Involving victim population in environmentally sustainable strategies: an analysis for post-conflict Colombia. *Science of the Total Environment*, 643: 1223-1231. doi: 10.1016/j.scitotenv.2018.06.262
- Torres-Guevara, L.E., Lopez, M.C. & Schlüter, A. 2016. Understanding artisanal fishers' behaviors: the case of Ciénaga Grande de Santa Marta, Colombia. *Sustainability*, 8: 1-17. doi: 10.3390/su8060549
- Touré, E.O., Romagosa-Casals, F. & Breton-Renard, F. 2015. Análisis de la situación de la pesca artesanal en el delta y valle bajo del río Senegal a partir del marco conceptual DPSIR1. *Estudios Geograficos*, 76: 703-731. doi: 10.3989/estgeogr.201525
- Trung-Thanh, H., Tschakert, P. & Hipsey, M.R. 2021. Moving up or going under? Differential livelihood trajectories in coastal communities in Vietnam. *World Development*, 138: 105219. doi: 10.1016/j.worlddev.2020.105219
- Xia, Y., Zhao, W., Xie, Y., Xue, H., Li, J., Li, Y., et al. 2019. Ecological and economic impacts of exotic fish species on fisheries in the Pearl River basin. *Management of Biological Invasions*, 10: 127-138. doi: 10.3391/MBI.2019.10.1.08

Supplementary Material

Table S1. Questionnaire.

Variable	Type of variable	Description
Socioeconomic characteristics		
Gender	Categorical	Male Female
Age	Ordinal	15-17 18-25 26-39 >40
Armed conflict victim	Categorical	Yes No
Monthly incomes	Ordinal (COP)	0 to 400,000 401,000 to 828.116 829,000 to 1,656,000
Health system	Categorical	Yes No
Local organization	Categorical	Yes No
Fishing activities		
Years of experience	Ordinal	1 to 3 years 4 to 7 years 8 to 11 years 12 to 15 years >16 years
Time spent fishing	Ordinal	<4 h 5 to 7 h 8 to 11 h >12 h
Days/week fishing	Ordinal	1 2 3 4 5 6 7
Why became fisher	Categorical	Family tradition Enjoyment Only known activity Only employment option
Participation in organizations	Categorical	Yes No
Ownership of fishing equipment	Categorical	Yes No
Would like to participate in an organization	Categorical	Yes No
Know fishing authority	Categorical	Yes No
Certified as fisher	Categorical	Yes No
Fishing sustains the family.	Categorical	Yes No

Continuation

Variable	Type of variable	Description
Fishing trading	Categorical	Community Fishing market Other
Use of fish capture	Categorical	Self-consumption Selling
Fishing gears	Categorical	Chinchorro (traditional net to fish) Trammel nets Throw nets
Type of fish	Categorical	<i>Oreochromis niloticus</i> <i>Prochilodus magdalenae</i>
Satisfaction with the fishing authority	Ordinal	Very unsatisfied Unsatisfied Acceptable Satisfied Very satisfied
Other economic activity	Categorical	Yes No
Diminishing fishing in recent years	Categorical	Yes No
Perceptions about the state of the ecosystem		
Changes in the fish populations	Categorical	Yes No
Decreasing the number of birds	Categorical	Yes No
Garbage in the swamp	Categorical	Yes No
Service of garbage collection in the area	Categorical	Yes No
Presence of solid wastes	Categorical	Debris Wheels Plastic Pane Other
Presence of urban streams	Categorical	Yes No
Bad smells in the swamp	Categorical	Yes No
Wastewater into the swamp	Categorical	Yes No