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CEDE. Calle 19A No. 1 – 37 Este, Bloque W.
Bogotá, D. C., Colombia Teléfonos: 3394949- 3394999,
extensiones 2400, 2049, 3233
infocede@uniandes.edu.co
<http://economia.uniandes.edu.co>

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Fisheries, Fish Pollution and Biodiversity: Choice experiments with Fishermen, Traders and Consumers

Camilo Andres Garzon¹

Maria Catalina Rey²

Paula Juliana Sarmiento³

Juan Camilo Cardenas⁴

Abstract

The increasing rates of per capita consumption of fish around the world should be a matter of concern for those interested in the threats to fishing stocks, aquatic biodiversity and human health. Fish consumption has positive health benefits but also brings higher risks of intake of heavy metals for humans. This increase in the demand for fish products has also been accompanied with fishing practices that threaten biodiversity. This article aims at evaluating from an economic perspective how important are these health and biodiversity components for those in the fish value chain, from fishermen to final consumers, using an experimental approach to estimate, through conjoint valuation techniques, the economic value of these aspects in the decision making of these agents. We find that final consumers place a significant economic value to the reduction of exposure to mercury contamination in fish; we also show that consumers respond positively to an education campaign showing the effects of mercury contained in fish, and that this money value could be used to create campaigns that transmit better price signals throughout the chain value. On the other extreme, the fishermen, we find that they place a positive economic value in a reduction of contamination in their fish as well, which could be aligned with the results for consumers, creating opportunities for Pareto improving measures in the regulations and prices which could translate into lower demand for more contaminated fish.

JEL Codes: Q22, Q51 Q52, C93

Keywords: Fisheries, Fish chain value, Pollution, Choice experiments, Conjoint valuation.

¹ ca.garzon972@uniandes.edu.co. Maestría en Economía, Universidad de los Andes. Bogotá.

² mc.rey11@uniandes.edu.co. Maestría Escuela de Gobierno Alberto Lleras Camargo, Universidad de los Andes Bogotá.

³ pj.sarmiento101@uniandes.edu.co. Maestría en Economía, Universidad de los Andes. Bogotá

⁴ Corresponding author: jccarden@uniandes.edu.co. Facultad de Economía, Universidad de los Andes. Bogotá

Pesca, Contaminación y Biodiversidad: Experimentos de Elección con Pescadores, Intermediarios y Consumidores

Camilo Andres Garzon⁵

Maria Catalina Rey⁶

Paula Juliana Sarmiento⁷

Juan Camilo Cardenas⁸

Resumen

El aumento de las tasas de consumo per capita de pescado en el mundo debería generar preocupación entre quienes estén interesados en las amenazas a los stocks pesqueros, la biodiversidad acuática y la salud humana. El consumo de pescado tiene impactos positivos a la salud pero también genera mayores riesgos por la ingesta de metales pesados para los humanos. Este incremento en la demanda por productos pesqueros también ha venido acompañada de prácticas que amenazan la biodiversidad. Este artículo tiene como objetivo evaluar desde una perspectiva económica la importancia que tienen estos componentes de salud y la biodiversidad para quienes están en la cadena de valor del pescado, desde los pescadores a los consumidores finales, utilizando un enfoque experimental para estimar, a través de técnicas de valoración de conjoint, el valor económico de estos factores en la toma de decisiones de estos agentes. Los resultados sugieren que los consumidores finales asignan un valor económico positivo y significativo a la reducción de la exposición a la contaminación por mercurio en el pescado; también mostramos que los consumidores responden positivamente a una campaña de educación ambiental sobre los efectos del mercurio contenido en el pescado, y que este valor adicional podría ser utilizado para crear campañas que transmitan mejores señales de precios en toda la cadena de valor. En el otro extremo, los pescadores, encontramos que ellos asignan un valor económico positivo en la reducción de la contaminación en el pescado, y que podría ser alineado con los resultados de los consumidores, creando oportunidades para mejoramientos Paretianos con políticas las regulaciones y los precios, que podrían traducirse en una menor demanda de los peces más contaminados.

JEL Codes: Q22, Q51 Q52, C93

Palabras claves: Pesca, Cadena de valor del pescado, Contaminación, Experimentos de elección, Valoración de Conjoint.

⁵ ca.garzon972@uniandes.edu.co. Maestría en Economía, Universidad de los Andes. Bogotá.

⁶ mc.rey11@uniandes.edu.co. Maestría Escuela de Gobierno Alberto Lleras Camargo, Universidad de los Andes Bogotá.

⁷ pj.sarmiento101@uniandes.edu.co. Maestría en Economía, Universidad de los Andes. Bogotá

⁸ Corresponding author: jccarden@uniandes.edu.co. Facultad de Economía, Universidad de los Andes. Bogotá

1. Introduction

The production and consumption of fish worldwide continues to grow steadily not only in absolute magnitudes but at the per capita level (Figure 1), although the stocks of many fisheries around the world continue to suffer and encounter pressures that threaten their ecological sustainability. The contribution of farmed fish has been also growing for the last decades, partially stopping these forces, but there is no sign that aquaculture will revert the threat over marine and freshwater fisheries. The increasing demand for fish and seafood, and the pressure over fishing stocks have been also threatening the levels of marine biodiversity, key to the sustaining of the oceans and freshwater ecosystem services (Worm et al. 2006; FAO, 2014).

As more people make fish part of their daily protein diet, also the concerns over the quality of the products consumed have increased. Fish consumption has been linked to healthier lives, for instance in the case of coronary diseases (He, K., Y. Song, et al., 2004) but it also has been linked to increases in intake of heavy metals with severe health risks (Järup, L., 2003), although some authors argue that the health benefits may outweigh the risks posed by intake of contaminants (Mozaffarian & Rimm, 2006). Nevertheless, the difficulties in controlling the environment where captured fish absorbs these contaminants make this problem more concerning (FAO, 2014).

Figure 1. World per capita fish, seafood intake (kg/capita/year). Source: FAOSTAT.

These trends justify a closer look at the economic importance of how contamination of fish affects the value chain, from the fishermen all the way to the final consumers. Little is known, however, about the economic value that each of these agents in the chain assign to the problem of fish contamination due to environmental conditions that affect the concentration, for instance, of heavy metals in the fish being captured, marketed and finally consumed. Further, although the importance of marine biodiversity has been studied by natural scientists (Worm et al. 2006), not much is understood from the standpoint of the agents in the value chain with respect to how fish consumption may affect the conservation of the diversity and how much economic value they place on these two attributes beyond the nutritional component itself.

Our study addresses some of these questions, from an empirical point of view, by using a series of choice experiments among fishermen, middlemen and final consumers in the value chain of fish in Colombia. Our experimental approach allowed us to estimate economic values to some of these attributes (fish contamination and biodiversity preservation) given the difficulties of the market prices to reflect them. Our aim is to contribute to understand the quality dimension of the microeconomics of fish extraction, distribution and consumption, given the increasing role it is playing in the human diet.

To achieve this goal we use the results of three studies with fishermen, traders and final consumers, using conjoint analysis and an experimental method in which individuals from these groups evaluate different scenarios where we manipulate the attributes' levels that are salient to the respondents in terms of their direct benefits and costs of capturing, trading and consuming fish, but also other attributes associated with the intake of contaminants and the harm that certain fishing practices may have on the biodiversity where extraction happens.

The results suggest that the positive economic valuation of reduced contamination and protection of biodiversity found for many of the respondents in the fish value chain could be used to design strategies to realign the price signals and therefore the demand and supply for healthier fish and more sustainable fishing practices that do not harm the biodiversity.

The rest of the article goes as follows. In the next section (2.) we explain the empirical and conceptual approach we take using a conjoint valuation approach and how the experimental design allows us to capture the indirect values for these attributes. Section 3 describes the three choice experiments conducted in the field through three case studies in different locations of the country. After presenting the econometric results from each of the case studies, we derive some policy implications and final conclusions.

2. Conjoint experiments to estimate the economic value of fish contamination and biodiversity changes.

Experiments are particularly useful to analyze goods and services whose value cannot be determined by market prices, for instance, environmental services. Based on welfare and environmental economics it is possible to value these goods and services through the estimation of the agents' Willingness to Pay (WTP). Our approach through an experimental design using conjoint analysis allows us to achieve such goal.

We use non-incentivized economic experiments to observe stated preferences about mercury contamination in fish and biodiversity conservation through different alternatives offered to fishermen, traders and final consumers in different locations of Colombia. In order to identify preferences, participants are asked to compare bundles of attributes in contexts similar to their own reality, in a way that allows the researcher to analyze the variable of interest controlling for the rest of attributes (List, 2011).

In environmental economics different tools have been developed to estimate the agents' WTP for a non-marketable service, among which there are two tools widely used in literature: contingent valuation (CV) and choice experiments (CE) based on the conjoint valuation approach. CV is based on the application of surveys where agents are asked directly about their WTP for a particular environmental service, usually using price ranges previously defined. In contrast, CE does not ask directly about agents' valuation but obtains it indirectly from declared preferences identified through a series of cards or scenarios with attributes that are compared by agents. CE assumes that each agent has a utility function

derived from the attributes of the environmental service described in each card, so in the moment of comparing scenarios the agent evaluates which one gives him more utility.

CE is based on the variations of attributes. Each card represents a unique scenario built from a combination of different levels for each attribute. After having the total set of cards, a subset of cards is randomly selected by each agent. Then, the agent compares between those cards and evaluates the trade-offs between those different attributes, thus declaring his preferences.

In the case studies we present in this paper the individuals surveyed were asked to organize a number of scenarios with varying attributes, thus we used the declared preferences of respondents in the alternatives organization to infer the implicit value of some attributes.

(i) *The indirect utility approach in conjoint valuation.*

The random utility model assumes that the indirect utility $V_q(.)$ ⁹ an individual q perceives is derived from her valuation of the N attributes the good possess, taking its private cost c_q also into account (Eq. 1). This indirect utility can be expressed as:

$$V_{qk} = V(x_{1k}, x_{2k}, \dots, x_{nk}, \dots, c_{qk}) \quad (1)$$

where x_{nk} represents the level of the attribute n in the alternative k . Therefore, the individual q will give a better ranking to the alternative k over the alternative j if and only if it holds that $V_{qk} > V_{qj}$, $j \neq k \in A$. Where A represents the set of alternatives from which the individual q must make his choice. It implies that the probability of choosing k over j is $P_{ij} = Prob(V_{ik} > V_{ij})$, $k \in A, k \neq j$. Assuming the condition of Independence from Irrelevant Alternatives (IIA) is satisfied, it is possible to formulate a Multinomial Logit Model (MNL) to calculate the probability that agent i chooses the alternative k as the most preferred:

⁹ The indirect utility function is defined as the maximum utility that can be attained given money income and goods prices. On the contrary, the direct utility function is defined as the maximum utility that can be attained given the quantities consumed. Both functions are related by the duality between prices and quantities in the theory of demand (Lau, 1969).

$$P_{ij} = \frac{\exp(V_{ik})}{\sum_{j=1}^J \exp(V_{ij})} \quad (2)$$

Nevertheless, MNL just considers the most preferred alternative within A at the moment of estimating the probability. But, since it is possible to obtain more information by ordering the alternatives according to preferences, we define the vector $r_i = (r_{i1}, \dots, r_{ij})^{10}$ as the chosen order by agent i , where r_{i1} is the most preferred alternative, r_{i2} is the second most preferred, and so on until r_{ij} , which is the least preferred. Finally, the probability of choosing a specific rank r_i is:

$$Prob(V_{ir_{i1}} > V_{ir_{i2}} > \dots > V_{ir_{ij}}) = \prod_{j=1}^{J-1} \frac{\exp(V_{ir_{ij}})}{\sum_{j=1}^J \exp(V_{ir_{ij}})} \quad (3)$$

This model is known as Rank-Ordered Logit (ROL) or Plackett-Luce model (Marden, 1995). ROL model can be seen as a series of MNL, where we have a MNL for the most preferred alternative, then another MNL for the second most preferred alternative and so on. It is important to note that the formula only goes until $J-1$ because the least preferred alternative has a probability of 1 of being ordered (Fok *et al.*, 2012).

Now, returning to Eq. 1, when varying the levels of x and c , and using the declared preferences from a large sample of individuals who faced different combinations of costs and attributes, it is possible to apply a ROL model where the estimated coefficients reflect the marginal utility obtained by a unitary change of each attribute, so in practice the equation estimated is:

$$V_{qk}(X_{qk}, S_q) = \beta_{0qk} + \beta_1 X_{1k} + \dots + \beta_N X_{Nk} + \beta_{N+1} S_{1q} + \dots + \beta_{N+M} S_{Mq} \quad (4)$$

Where S_q represents the characteristics of individual q , S_{Mq} represents the level of the characteristic M of individual q , β_{0ik} is the alternative specific constant, and the other β are the estimated coefficients for each attribute (Can & Alp, 2012). Thereby, the condition $\frac{\partial V / (\partial X_j)}{\partial V / (\partial X_k)}$ represents the substitution rate between an attribute j and an attribute k that is equivalent to the quotient $-\beta_j / \beta_k$. This model allows us to estimate the exchange between the benefit of an attribute and the associated cost represented in monetary units, which at

¹⁰ For a complete development of the model see Fok *et al.* (2012).

the end is an implicit price for a one-unit increase in one attribute or Willingness to Pay (WTP) (Eq. 3):

$$WTP_i = -\frac{\beta_i}{\beta_{price}} \quad (5)$$

where β_i is the estimated coefficient of the attribute and β_{price} the estimated coefficient of the monetary attribute. The logic of this exercise is to find the indifference point between increasing the price in 1COP and reducing the attribute in the corresponding unit. These reflects the optimal consumption of the respondent and the economic value of the attribute of interest (Mackenzie, 1990, 1993).

Therefore, estimating the coefficients for the attribute i against the coefficient for the monetary attribute will provide us with an economic value for a change in such attribute of interest, that is, an economic estimation of the value placed on these non-monetary components of interest. In our case, we will conduct this exercise for attributes such as the levels of contamination in the fish being extracted, traded or consumed, and the impacts of fishing on the biodiversity involved in the activity.

(ii) The experimental design

The first step in the design of a Choice experiment is to decide which attributes will be included in the economic valuation. Usually, the chosen attributes are the ones the communities participating value the most. Attributes of central interest for the study, for instance, fish pollution and biodiversity, are chosen as well. Then it is necessary to define the corresponding levels of those attributes that will be included in the experimental design. Some tools for making these decisions could be pilot surveys, interviews, focal groups and other field work that helps to understand the context (Champ *et al.*, 2003).

The next step is to design the election cards that combine the levels. This cards present different scenarios where the attributes' levels are combined in a way that every card shows different options for the participant to make a decision. This is what gives the participants the possibility to choose or rank alternatives that fit the most to their

preferences in terms of all variables. Lastly, an orthogonal design can be used to eliminate redundant cards and chose a reduced number of combinations with enough variation and no correlation between the attributes, which still allow a comparison among that subset of cards (Green, 1974; Cárdenas, 2009; Cerda et al., 2013).

The design of the cards needs to be illustrative and simple, with the minimum information to be read by the participants, especially when dealing with people with lower levels of education and literacy (e.g. fishermen). Figure 2 illustrates the general overview of how the cards were design in our studies. In this general case each respondent will evaluate a set of cards with different levels for each of the attributes. In the case of fishermen the “price” attribute will reflect the amount of money he will receive for such particular case, and in the case of traders and consumers the price to pay for that bundle of attributes. In either case these respondents will reflect the economic valuation they have for these attributes.

Scenario N°		
Level of fish contamination	Level 1 Level 2 Level 3	Image for attribute 1
Species abundance	Level 1 Level 2 Level 3	Image for attribute 2
Usage of protected species bait	Yes No	Image for attribute 3
Control attributes	(Different for each case)	Image for attribute 4
Price to pay	Price 1 Price 2 Price 3 Price 4	Image for attribute 5

Figure 2. Outline of the conjoint cards design.

Finally, participants rank a subset of cards. With this information it is possible to estimate the relative importance of each attribute. For a sample of responses large enough and by dividing the coefficient of each attribute of interest by the coefficient of the

monetary attribute (equation (5)), one can estimate the economic value of these non-market components of the fish captured, traded or consumed, depending on the case study.

3. The choice experiments in the field.

Using the methodology described three Choice experiments were designed and implemented in the field to estimate the economic value for environmental attributes such as mercury contamination in fish and biodiversity conservation. The experiments were applied to different agents involved in the fish value chain, namely, extraction, commercialization and consumption of fish. This section presents first the case studies for fishermen in the Caribbean coast of Colombia and in the Amazonian river. Then, we present two case studies for fish traders in Leticia¹¹ and Bogotá, and finally we present a case study for the final consumers in Bogotá, the largest fish market by far, which concludes the study of the complete value chain.

The following table exhibits the samples for each case study and the dates in which each experiment was done.

Table 1. Sample size for our Choice Experiments

Type	Location	No. Participants	Dates field work
Fishermen	Cartagena	124 fishermen	September 2015
Fishermen	Leticia	34 fishermen	September 2015
Traders	Leticia	33 traders	September 2015
Traders	Bogotá	19 traders	February 2016
Consumers	Bogotá	870 consumers (360 face-to-face, 510 online)	August-October 2015

¹¹ Leticia is one of the major fish gathering cities on the Amazon River.

Case 1: Artisanal fisheries

(i) Sample and design

To study the preferences of artisanal fishermen about pollution and biodiversity two choice experiments were applied. Its design required an exhaustive research about the description of fishing as an economic activity around Cartagena Bay and Leticia city, the two cities chosen for the study. That, in order to choose the attributes that were most relevant for the two communities, and hence its correspondent levels (Guzmán, 2006; Mendoza *et al.*, 2008; Vilorio *et al.*, 2014). With this information a preliminary design was made, and then a pilot test was applied on April 2015, for the case of Cartagena, to corroborate the relevance of the attributes and levels chosen for the experiment. In Leticia, in-depth interviews were made on May 2015 for the same purpose. After minimal adjustments the chosen attributes for Cartagena were: labor time, fuel used in the fishing trip, pollution level, fish price and biodiversity. For the case of fishermen in Leticia the most relevant attributes were size of the fish, abundance of species in the Amazonian river, type of bait used for fishing, fish pollution level and fish price.

Both choice experiments (fishermen in Leticia and Cartagena) involved a series of cards which combined different levels for each attribute. These cards represented a fishing day to catch 5 kilograms of fish in Cartagena, and sale 1 kilogram of fish to the local fish traders in Leticia. In each card visual aids were added to facilitate comparison. Using SPSS an orthogonal design was made to eliminate redundant cards, so from a possible set of 405 cards for the first exercise and 720 for the second only 25 were selected for each one. In both cases an additional card was added in representation of the *statu quo*¹².

Surveys were conducted on September 2015. In Cartagena 124 fishermen who belonged to the villages of Ararca, Caño del Oro and Barú, near Cartagena in the Caribbean coast of Colombia were surveyed. In Leticia 34 fishermen did the choice experiment¹³. Fishermen

¹² This card was used to show the participants what we believed was the actual situation and help them understand the procedures of the experiment.

¹³ The fishermen population in Leticia (Amazonas) is much smaller than the population in the Caribbean coast. For Leticia, the recruitment criteria to participate in the study was to fish or commercialize a particular fish species that

were asked to select randomly 6 cards of the 25 possibilities, to what we included the *statu quo* card to form a final subset of 7 cards. Then, they were asked to order the cards from the most preferred to the least preferred one. Using the results, a Rank-Ordered Logit was applied to estimate the economic valuation of fishermen regarding to pollution and biodiversity (Garzón, 2016; Rey, 2016).

0	Fishing 5 kg of fish	
Fishing time	7 hours
Fuel used	1 gallon and a half
Pollution level	Current pollution
Fish price	8000 COP per kilogram
Variety and abundance of fishes	Medium

Figure 3. Example of a conjoint card for Cartagena Bay fishermen

(i) Results

After analyzing data we found that artisanal fishermen in Cartagena have a significant valuation for fish contamination, therefore we could estimate that the mean WTP to diminish pollution by 10% is \$2,710 COP¹⁴ per kilogram of caught fish. Nevertheless, it is important to consider the ranges between which these values move. Considering confidence intervals at 95%, we estimate that WTP is found between -\$130 COP and \$5,550 COP. This negative WTP occurs because standard deviation is higher than the mean, what shows a great heterogeneity of preferences (Hanley *et al.*, 2005). In the case of biodiversity, the mean WTP to improve biodiversity from a low level to a medium level was \$5,391 COP

has considerable levels of mercury: *Calophysus macropterus*. In the case of the Caribbean coast, fishermen available for interview were selected.

¹⁴ This is equivalent to 0.99 USD using an exchange rate of 2,743 COP=1 USD (Banco de la República, 2016).

per kilogram of caught fish, ranging between -\$40 COP and \$10,822 COP with a confidence interval of 95%.

We also split the sample by different categories such as age, education and village and we found different WTP to diminish pollution according to these characteristics. Dividing by ages, we found that people 50 years and younger have a mean WTP of \$3,326 COP to diminish pollution by 10% and a mean WTP to improve from low biodiversity to medium biodiversity of \$6,489 COP, both WTP calculated per kilogram of caught fish, while the other age groups did not show a significant WTP. Dividing by education, we found that people with only high school have a WTP of \$1,947 COP to diminish pollution by 10% and a mean WTP to improve from low biodiversity to medium biodiversity of \$4,716 COP, both WTP calculated per kilogram of caught fish, while the other groups did not have a significant WTP. Finally, dividing by villages we found that fishermen from Barú have a WTP of \$1,550 COP per kilogram of caught fish to diminish by 10% the pollution, while the WTP of other villages were not significant either to diminish pollution or to improve biodiversity.

Table 2. Rank-Ordered Logit results for Cartagena

Variables	Order
Attributes	
Fishing Time (Hours)	-0.0315 (0.0386)
Pollution Level (Percentage)	-1.010* (0.586)
Fish Price (1000 COP)	0.0656* (0.0365)
Medium Biodiversity	0.214** (0.104)
High Biodiversity	0.170 (0.160)
Interactions	
Pollution * Age	0.193 (0.508)
Pollution * Education	-0.242 (0.313)
Pollution * Village1	0.145 (0.434)
Pollution * Village2	0.465 (0.486)
Fish Price * Age	-0.0204 (0.0407)
Fish Price * Village1	0.00395

Fish Price * Village2	(0.0453) -0.1000** (0.0429)
Observations	828
Number of groups	119
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	
Village1=1 if it is Barú. Village2=1 if it is Caño del Oro.	

As part of the study in the Amazonian river, through the choice experiments in Leticia we also found that fishermen in the area had a significant positive valuation for mercury contamination and biodiversity conservation. The mean WTP for diminishing the fish mercury level for Leticia fishermen was \$1,333 COP per kilogram of caught fish. The former is the mean value within a confidence interval at 95% that ranges from 10 COP to \$2,656 COP. For biodiversity conservation fishermen in Leticia are willing to pay even more. The mean WTP for using other types of baits instead of protected species as dolphins or caimans was \$5,175 COP, ranging between \$1,777 COP and \$10,822 COP with a confidence interval of 95%.

Case 2: Fish traders in Leticia & Bogotá

These choice experiments were conducted to study the preferences and economic valuation of traders in Bogotá and Leticia for unmarketable goods such as mercury contamination in fish, and biodiversity conservation. The design of this choice experiment was based on in-depth interviews done to this communities during the month of May 2015. The interviews were applied in order to identify which where the attributes that where most important to the traders at the moment of buying the fish they were going to sell to consumers. The chosen attributes were the size of the fish caught, the abundance of species in the river, the type of bait used to fish, contamination level and fish price per kilogram bought.

As this choice experiments had an initial set of cards with hypothetical scenarios that combined 5 attributes and its respective levels, an orthogonal design was used to reduce the number of cards from 720 to 25 and still be able to evaluate each attribute independently of the others. This study also added an additional card that showed the

status quo based on what the traders interviewed had said, this card was very useful at the moment of explaining the experiment to the participants.

Surveys were conducted in September 2015 to one-third of the population of traders in Leticia and in February 2016 to one-third of the population of fish wholesalers in Bogotá. Both communities were asked to select randomly 6 of these scenarios plus the *status quo* card and then rank them from the most preferred to the least preferred one, according to their preferences and the attributes they considered most important. Based on the results of this surveys a Rank-Ordered Logit was used to estimate the economic value of fish traders for fish contamination and biodiversity conservation.

N° card	Buy/sell 1 kilogram of fish	
Average size of caught fish	Ideal size (sexual maturity)
Abundance of species in the river	Very Abundant
Type of bait used for fishing	Dolphin
Mercury level	High
Price	COP 5.000

Figure 4. Example of a conjoint card for fish traders in Leticia and Bogotá.

(i) Results

We found that fish traders in Leticia and Bogotá have a significant valuation for pollution reductions and biodiversity conservation, but since the price is not statistically significant within the model it is not possible to estimate a WTP for this goods (see table 3).

Table 3. Rank-Ordered Logit results for Leticia

Variables	Order
Size of caught fish	0.130 (0.0935)
Middle Biodiversity	0.478** (0.233)
High Biodiversity	0.433* (0.241)
Type of bait	-1.329*** (0.411)
Pollution Level	-0.339* (0.204)
Price	0.325*** (0.125)
Pollution* Education	0.323 (0.235)
Pollution* Age	-0.223 (0.269)
Price*Age	-0.210* (0.126)
Pollution*Borne in Amazonas	-0.186 (0.238)
Observations	228
Number of groups	34

Robust standard errors in parentheses,
 *** p<0.01, ** p<0.05, * p<0.1

To explore why the price was not statistically significant for traders, Rey (2016) did a focus group in Leticia and also interviewed individually some of the traders. In the focus group she asked them directly what they thought could explain the fact that they were showing a lot of interest in aspects such as pollution and biodiversity but not so much on the price they would be willing to pay in different scenarios. Discussions led to the explanation that their structure of expenditures and revenues have a significant fraction represented by fixed costs that impede them to change (increase) prices of their products in order to pay for the negative externalities they generate.

However, when traders were asked in the survey about the costs they had to incur, averaging their answers Rey (2016) obtained the profitability of the business is almost 70% their initial investment (see Table 4). This profit margin shows that even though there are considerable costs, there could be margin for paying for ecological services such as contamination reduction or biodiversity conservation.

Table 4. Costs per 1.000 kg in USD¹⁵ and COP (average along the year)

	USD	COP
Employees		
Arranging process	25.52	\$70,000.00
Packing process	21.87	\$60,000.00
Energy	145.82	\$400,000.00
Land Freight	9.11	\$25,000.00
Air Freight	729.13	\$2,000,000.00
Packing materials	27.34	\$75,000.00
Taxes	27.34	\$25,000.00
Costs after taxes	967.92	\$2,655,000.00
Incomes per 1000kg	16,405.40	\$4,500,000.00
Benefit	672.62	\$1,845,000.00
Profitability	69.5%	69.5%

Source: Rey (2016).

Case 3: Fish Consumers

(i) Sample and design

To explore the preferences in fish consumption decision of consumers in Bogotá we conducted a choice experiment (CE) through an online and a face-to-face survey with a total of 870 respondents. According to their preferences, the respondents ordered different scenarios with variations in the attributes. Using the collected data we applied a rank-ordered logistic model to estimate the economic value that consumers would pay for fish sanity and for avoiding the usage of Amazon dolphins as a bait. In addition, we evaluated the impact on the Willingness to Pay from acquiring information -through a video¹⁶- about mercury contamination in certain fishes and the consequences of its consumption on health.

¹⁵The exchange rate used is the average rate for 2015 in Colombia: 1 USD = 2.743 COP.

¹⁶This video presents scientific information about the accumulation of mercury in fish, the way that it reaches consumers in Bogotá and the harmful consequences of mercury intake in human health, the video uses the example of a catfish commonly known as “Mota” (*Calophysus Macropterus*). It lasts two and a half minutes and uses drawings and explanations for easy understanding (Sarmiento, 2015).

In order to select the relevant attributes to consumers in fish consumption decision, we conducted a pilot survey¹⁷, and to adjust the attributes categories or levels we did a field work research visiting and calling different sales points in Bogotá. We also took into account a similar survey applied to restaurant costumers (Lopez, 2015). After all these steps the attributes selected where the following: fish presentation, freshness, place to buy, mercury concentration, dolphins captures and price.

The CE consisted on a series of cards which combined different levels of each attribute, as shown in the example card in Figure 5. In order to have comparable scenarios, all cards represented one pound of fish. In each card visual aids were added to facilitate comparison (for all the attributes levels see the final selection of scenarios or card designs in the Appendix). Finally, we used an orthogonal design to eliminate redundant cards, so from a possible set of 720 cards only 25 orthogonal alternatives were selected.

Every individual randomly picked 5 alternatives from the 25 possible, which they needed to order from the most preferred to the least preferred. In addition, some individuals randomly watched a video before the experiment was done (view figure 5).

	Price per pound	Freshnes	Presentation	Level of Mercury	Place to buy	Dolphin Captures
Option A	\$5.900 \$	More fresh Caught a day ago Expires in 5 days	Whole fish	Level 2: low mercury concentration	Fish Shop	Dolphins bait is used

Figure 5. Conjoint valuation card for final consumers in Bogotá

(ii) Case Results

We found that an average consumer would be willing to pay a positive premium over the fish market price in order to reduce the mercury concentration and also to avoid the usage of dolphin meet as bait. An average consumer in our sample will be willing to pay additional

¹⁷ This pilot survey mentioned a list of factors that could be important to individuals in order to make their fish consumption decisions, respondents had to select the important factors for them and organize them according to their preferences

991COP¹⁸ per pound of fish to reduce the mercury level by 1% and between 18,390 COP - 33,719 COP¹⁹ in a fish pound if dolphin bait was not used in the fishing. This willingness to pay estimates are significantly different depending on the survey modality. For the face-to-face survey, the estimated WTP is much higher than the estimates in the online survey (view table 5).

Table 5. Estimated WTP of consumers in Bogotá to diminish fish pollution by 1% and to avoiding threats to river dolphins, according to the survey modality

VARIABLES	Currency	(1)	(1-a)	(1-b)
		WTP Whole sample	WTP Online sample	WTP Face-to-face sample
Mercury	COP	-991***	-674***	-1,366***
	USD	0,36	0,24	0,49
Biodiversity	COP	-26,055***	-21,980***	-31,453***
	USD	9,49	8,01	11,46
Observations		4,350	2,550	1,800

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: Sarmiento, 2016.

The results from this study showed that ignoring an attribute as the mercury contamination in fish, diminishes the willingness to pay in that attribute as other studies have shown (Carlsson *etal.*, 2010), so this suggest that the provision of effective information to agents could be a way to increase their WTP. Individuals who are unaware about the problem of mercury are willing to pay 152 COP less for a 1% mercury reduction than those who are aware.

Consistent with the previous findings, the WTP estimates for those individuals that randomly were selected to watch the video were significantly higher than the WTP estimates for the respondents that were not selected (24% higher). This evidence shows that better information can translate into greater willingness to pay in an average consumer to diminish the contamination of the fish he or she consumes (view table 6).

¹⁸ This is equivalent to 0.36USD using an exchange rate of 2,743 COP=1 USD (Banco de la República, 2016).

¹⁹ This is equivalent to 6,7 USD and 12,2 USD, respectively, using an exchange rate of 2,743 COP=1 USD (Banco de la República, 2016).

Table 6. Estimated WTP of consumers in Bogotá to diminish fish pollution by 1% with and without watching the informative video

VARIABLES	Currency	(5) WTP Whole sample	(5a) WTP Online sample	(5b) WTP Face-to-face sample
Without watching video	COP	936***	638***	1,255***
	USD	0,34	0,23	0,45
Watching video	COP	1,163***	828***	1,527***
	USD	0,42	0,30	0,55
Observations		4,340	2,550	1,790

*** p<0.01, ** p<0.05, * p<0.1

Source: Sarmiento, 2016

Finally, reinforcing the previously mentioned we found that among individuals who did not receive any additional information, their awareness about mercury contamination in fish is an important factor –it increases WTP. However, among respondents who watched the video the statistical difference generated by such beliefs disappears, which may suggest that the information provided placed all individuals in a similar state of knowledge regarding the issue.

4. Analysis

Each of the previous studies illustrate how a methodological tool can be used to study a non-monetary valuation problem and explore policy implications. These choice experiments can be applied to analyze the preferences and incentives of the different agents participating in the value chain of fish, so that we can identify market failures that prevent the efficient functioning of the markets where all opportunities to improve could be exploited. Our estimates show that individuals along the value chain have a negative perception of both increases in contamination in fish and threats to biodiversity due to harming fishing practices.

Both mercury contamination of fish and threats to biodiversity are negative externalities from different human activities; the former negatively affects consumers of contaminated

fish while the latter, being the biodiversity a public good, affects all agents alike though some are more worried and more sensitive about it than others. The consumer, who is the one directly affected in terms of health has the highest WTP in the fish value chain; it is her who receives the heavier costs generated through contamination in the activities along the chain, however it is to be noted that he is also the one with the largest income within the value chain (The average income of fishermen in Cartagena is 1716 USD per year).

Figure 6. Externalities in the fish chain value

As shown in our CE case 3, the fish consumers in Bogotá are willing to pay a positive premium over the market price to improve the health conditions of the fish they purchase. Using the WTP estimates and the frequency in fish consumption of the individuals surveyed, Sarmiento (2016) valued the market within the sample surveyed of a 7.1% reduction in fish mercury levels in a month, she calculated a monthly expenditure per capita of \$12,766 COP for those individuals that are not aware of mercury contamination in fish (281 individuals), and \$16,417 COP for those that are aware (543 individuals). According to the sample interviewed, the total value of the market would be about \$12'501.414 COP monthly, for a reduction in 7.1% in the fish mercury levels. However, these price premiums are not as clear in the estimations for fishermen in Cartagena and Leticia.

In a sense, this potential higher premium by consumers is not exploited in the markets upstream in the value chain; we do not observe other traders and fishermen in our samples aiming marketing healthier fish species or strategies to reduce mercury levels. Research on

the latter could enhance fish quality and the generation of market value like the above mentioned that could make consumers better off, and traders, fisherman, and other agents involved in fish production could take advantage of such market surplus and therefore of potential increases in social welfare.

Furthermore, the 24% increase in the WTP of those who watched the video regarding those who did not watch it, opens further opportunities for economic gains in the value chain. Those who profit from the fish commercialization could exploit this market opportunity by improving the information to consumers along by commercializing fish with lower levels of mercury contamination, that is, herbivores and in general those fish lower in the food chain.

Case 1 analyzed the WTP of fishermen in Cartagena and Leticia to diminish pollution and biodiversity loss and it found that these were significant. Particularly, fishermen from Cartagena had an average WTP to diminish fish pollution by 10% of \$2.710 COP per kilogram of caught fish. Now, with data of total fish catch per year in Cartagena and with information provided by pilot survey²⁰, Garzón (2016) estimated the annual consumption of fish for artisanal fishermen of Cartagena and the total WTP for each year (Table 7).

Table 7. Estimated WTP of artisanal fishermen of Cartagena to diminish fish pollution by 10%, current prices of 2015

		Annual consumption of fish estimated for artisanal fishermen of Cartagena (Tons)		
		2012*	2013*	2014*
Currency	WTP	178.89 tons	119.93 tons	58.56 tons
COP	\$ 2710 /kg.	\$ 524,790,960	\$ 345,124,740	\$ 162,568,990
USD	\$ 0.99 /kg.	\$ 191,320	\$ 125,820	\$59,267

Source: Garzón (2016).

*Monetary values were calculated at present value using annual inflation (Banco de la República, 2015).

For Leticia, Rey (2016) found that for fishermen the average WTP to diminish fish pollution was \$1,333 COP per kilogram of caught fish. From another point of view, these values represent the loss of wellbeing of artisanal fishermen due to fish pollution, because they

²⁰ According to pilot survey, artisanal fishermen consume in average 29% of their total catch.

show the amount of money that would be required to compensate the negative effects of pollution in order to maintain equal wellbeing. Hence, these values are estimates of how big is the negative externality that is caused by fish pollution, through fish consumption of fishermen.

The information gathered and the values shown in Table 7 are useful to policymakers for elaborating policies that internalize the negative effects of pollution, by approximating how big the market failure is due to pollution and what opportunities could be created if better information and regulations were to be implemented to guide traders towards consumers, and fishermen towards traders. Nevertheless, to design an optimal and suitable policy it is necessary to take into account all the relevant actors along the fish value chain as well as more precise information about fish consumption, so this case seeks to contribute with the point of view of fishermen.

Additionally, Garzón (2016) split the sample by age and found that fishermen 50 year old and younger have a significant WTP to diminish pollution, although older fishermen do not. This implies that population 50 years old and younger can be more receptive to environmental information, particularly regarding pollution, so they can be focused to introduce environmental policies or environmental education. In addition, when sample was divided by ranges of education, Garzón (2016) found that people with high school have a significant WTP to diminish fish pollution, in contrast with people that only have primary or none study, which shows the importance of education to preserve and protect environment, reinforcing the importance of environmental education.

As summarized in Figure 6, negative externalities caused by fish contamination do not seem to be of central concern for fish traders. This could be the first argument to bring about when trying to explain why Letician traders and Bogotá wholesalers are not willing to pay for this goods that does not affect them directly. From a public policy point of view this could translate into market distortions that lead to inefficient levels of appropriation and excessive exploitation of the resources (Hardin, 1968; Gordon, 1954).

5. Policy implications

As shown in the previous section, one of the most interesting problems at the moment of pricing non-marketable goods and services is the different valuations across groups. In this study we analyze the Willingness to Pay of actors through the different linkages along the fish value chain. We find that both the supply side (fishermen) and the demand side (consumers) are willing to pay for a reduction in fish contamination and biodiversity loss. The latter offers the possibility to explore innovative solutions to externalities that are complex to handle, and give better information for the authorities and institutions to make better policy decisions.

Note that polluting agents do not take into account their economic activities' social costs, therefore generating socially inefficient outcomes. Pollution and biodiversity loss in Cartagena Bay and Leticia associated with downstream runoff and overfishing generate negative externalities that reduce agents' welfare —a reduction that is not being compensated—. Several mechanisms have been proposed from the supply side to reduce negative effects on fishermen and consumer's wellbeing. One of such proposals states that the implementation of a pigouvian tax to reduce those negative effects via internalizing the social costs of their economic activity (Chiroleu & Fodha, 2014).

The main objective of a pigouvian tax in this case would be to compensate affected agents and discourage subsequent externalities. This compensation should correct the market failure, *ergo* it should guarantee the same welfare level as if there was no externalities at all. In order to achieve this it is required *i*) to identify the polluting agents and their contribution to pollution, and *ii*) to calculate the exact amount of welfare losses. However, this presents some practical challenges due to lack of information and difficulties in the process of tracking the contaminants —although advances have been reached in this aspect (Zhang *et al.*, 2014)—.

In the case of Cartagena Bay most part of contaminants are transported through the Dique Channel, originated in the mining and industries upstream (Olivero & Johnson, 2002). However, illegal mining is difficult to tax due its informality nature. On the other hand, WTP is an estimation of the welfare lost due to pollution or biodiversity losses, but it is important

to highlight that the exact amount of welfare lost by an agent depends on different factors, such as socio economic characteristics, individual preferences and the characteristics of each community. So the values showed in this study are approximations that show a loss in welfare due to pollution and biodiversity loss, which could be due in the design of policies regarding these issues, but further studies must be completed to find more precise estimates.

On the other hand, proposals can be made from the demand side. Measurement of contaminants in fish such as mercury, and warnings about it are important, as shown in the study case #3 where people value this information, so it could trigger an improvement through redirecting markets in favor of healthier fishes.

Both personal experience and new information influence the consumer decision-making process, therefore efforts to transmit easily interpretable information in a short and efficient ways may have an impact on redirecting the decisions of fish consumers. The 24% percent increase in the WTP of those surveyed who were exposed to an awareness video, sized the impact of environmental and health education, which suggests awareness campaigns as a public policy that seeks to open new markets where traders and other agents in the chain could benefit.

Brought to reality, the previous increase in the WTP from a segment of consumers could justify the costs of an environmental education campaign that promotes the change in consumer habits and send the right price signals through the supply chain of fish, providing a Pareto improvement along the value chain. The distribution of additional revenue due to the expected increases in consumer WTP, the possible reductions in producer surplus from some markets –those of highly contaminated fish- and the offset effects of looking up for substitute species are elements of the dynamics of the production chain and the market that could be subject to further investigation. In this scenario this research suggests that traders and fishermen could offset lower revenues from the non-marketing of highly polluted fish by price increases in more healthy and sustainable fish which consumers seem to be willing purchase according to the results; this suggests the need to explore the elasticities of demand through economic experiments or surveys.

All this opens the discussion about how feasible it is to exploit new markets. In Bogotá there is a high variety of fish species that are marketed and, therefore, we can think there are opportunities to substitute polluted species with those with lower mercury levels that traders could use to shift their trading (Gómez, 2015). There is also an opportunity to think about environmental and health education to final consumer as a platform to establish healthier and friendlier markets to the environment.

From the point of view of the protection and conservation of biodiversity, a typical public good case, it is also important to take into account that all members in society could benefit from its conservation. However, incentives for traders and fishermen for overexploitation could reduce the provision of these benefits.

For instance, the Brazilian government faced a difficult situation in 2014 related to biodiversity conservation. The fishing of a fish called *Calophysus macroterus* was encouraging fishermen in the Amazonian river to hunt protected species such as dolphins and crocodiles to be used as bait. This occurred because it was more profitable than other type of baits, so the State was forced to ban the fishing of *Calophysus* for 5 years in order to protect these other species used as bait, involved in the activity (Instituto de pesca Sao Paulo, 2014).

Finally, it is important to have in mind that most of these dilemmas do not operate under the traditional logic of theories of regulation. Restrictive measures within the markets or even privatization of threatened territories or resources could generate even worst scenarios when there are asymmetries of information and high costs of monitoring and sanction (Sethi and Somanathan, 1996). In this sense, national authorities such as the National Institute of Food and Drug Monitoring (INVIMA) and the National Authority for Aquaculture and Fisheries (AUNAP) play an important role in public recognition of these issues, while economic solutions are proposed involving all actors in the value chain by harnessing market forces towards the common good.

6. Final notes.

Through three connected studies in the fish value chain in Colombia we have explored to what extent the individuals in this chain are concerned and economically motivated with

respect to the threats from fish contamination and the harm that fishing may cause to biodiversity, as two critical aspects in the fishing industry. Although the problems of overfishing have been in the research and policy agenda for a long time, the increasing rates of human consumption of fish and sea products should also raise awareness of the problems associated with the environmental externalities associated with fishing, not only because of over extraction but also because of the health effects and its impact in biodiversity, for instance in terms of the bait being used for the capture. Our study is one of the few that combines both the overfishing problem with that of pollution and health threats.

To pursue this question, we designed a series of choice experiments and used the conjoint valuation approach to evaluate, from the stand point of fishermen, traders and final consumers, to what extent they would be willing to sacrifice income to improve these characteristics, namely, levels of mercury contamination in the fish and its relationship with respect to biodiversity in the fishing site.

We are well aware that we have used slightly different methodological designs in each of the sites and therefore comparability across the sites has to be considered with caution. For this reason we have presented these as three case studies where a similar approach was used to address the question of valuing the importance of these externalities in the fish value chain. The results show that there is room for several avenues in terms of policy design. For instance, our results show that simple educational information to the consumers is a powerful driver for changing the economic valuation of fish contamination and therefore it could send the right signals to the fish value chain and thus to the traders and fishermen in the fishing regions.

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Appendix A

Interview Form Survey for the analysis of Choice Experiment

Interviewer name: _____.

Interview date: __ / __ / __ Start Time: __: __ a. m. / P. m.

Place of interview (village or township): _____.

Introduction to the respondent:

Best regard. We would like to interview you as part of a study about the use of fisheries resources in this region. This study is funded by non-profit organizations and universities, such as Hernan Echavarria Olozaga Foundation and the Universidad de los Andes. The results of this research will be divulged among the community within a few months.

The interview includes questions about issues regarding how you and your neighbors in this community use fishery resources, and it includes an exercise with cards.

The information we collect in this interview is anonymous and absolutely confidential. Your name will not appear in any report or result. Only the overall results will be used to make proposals to improve the welfare of this community and the management of natural resources.

We appreciate your help in answering this interview. We have estimated approximately 30 to 40 minutes for answer it.

With this in mind, we want to confirm that you wish to participate in this study.

<< Confirm >>

If so, please see the following document. << Show informed consent >>. This document is called "informed consent" and it summarizes what I just explained. This document is signed by a teacher, who is the principal investigator, and you also will sign it to make you feel comfortable to participate in this study and in order to you are totally certain that all the information provided by us is true, and that information will be handled properly. We will give you a copy of this document so you can have it at home.

<< Read the informed consent >>

Part A: Location of natural area of communitarian use and their resources.

"Many of the questions in this interview we will refer to the area of Cartagena Bay and Barbacoas Bay, which we have identified as important sources of natural resources for this community".

A.1. Which of the two bays do you visit more for fishing? [Best if it is possible to demarcate a zone, e.g. near the mangrove].

☐ Cartagena Bay ☐ Barbacoas Bay ☐ Other (e.g. Open sea): _____.
[Zone: _____.]

A.2. Mention the three most important reasons or benefits for you and your community by which these areas should be taken care (choose only three):

_____, _____,

A.3. Who do you think is (are) the current owner (s) of the area?

☐ The state ☐ The community ☐ A nonprofit foundation ☐ A private agent
☐ Don't know ☐ Other: ¿Which one? _____

A.4. How long have you and your family live in this community? ____ Years.

A.5. How much of your and your family year revenue depend on resources from Bay?

☐ Almost all ☐ More than half (3/4) ☐ Half (1/2) ☐ Less than half (1/4)
☐ Almost nothing

A.6. How much time per year do you and your family spend on average using resources from the bay (fishing, snorkeling, etc.)?

☐ Almost all ☐ More than half (3/4) ☐ Half (1/2) ☐ Less than half (1/4)
☐ Almost nothing

A.7. What proportion of what is extracted from the bay do you sell?

☐ Almost all ☐ More than half (3/4) ☐ Half (1/2) ☐ Less than half (1/4)
☐ Almost nothing

A.8. Do you think that the variety of fish from the bay of Cartagena is in danger and there are some species in danger of disappearing from this area?

☐ Yes ☐ No

A.9. If you answered "Yes", mention three important species that you think are most at risk of disappearing from this area:

_____, _____, _____.

A.10. To the following statements mark with plus sign (+) the sentence that you support more and mark with minus sign (-) the sentence that you support less:

() "We must keep extracting the same quantity and variety of fish from the bay of Cartagena for our own consumption and to sell."

() "We must stop extracting a portion of fish stocks for leaving something to the future generations of this community."

() "We must completely stop the extraction of bay resources for leaving something to new generations of this community."

A.11. How many times do you and members of your family go fishing on average per month? ____ Number of fishing trips / month.

A.12. How many kilograms do you capture on a good day? I capture on average ____ kilograms of fish on a good day.

A.13. How many kilograms do you capture on an average day? I capture on average ____ kilograms of fish on an average day.

A.14. How many kilograms do you capture on a bad day? I capture on average ____ kilograms of fish on a bad day.

A.15. How big are the fish caught in the last two months?

☐ Very small ☐ Small ☐ Medium ☐ Big ☐ Very big

The species _____ is _____ long, and it weighs ____ pounds.

The species _____ is _____ long, and it weighs ____ pounds.

The species _____ is _____ long, and it weighs ____ pounds.

A.16. Which fishing gear do you use? I use _____ or _____.

A.17. How many hours on average have you spent on your last fishing trips? On average I've spent ____ hours per fishing trip.

A.18. If you use engine, on average how many gallons of gasoline have you used on your last fishing trips? On average I've used ____ gallons of gasoline per trip.

A.19. How polluted do you think are the waters of the Bay of Cartagena?

☐ It's not polluted ☐ A little bit polluted ☐ Half polluted ☐ Very polluted
☐ Totally polluted

A.20. If you think that it is contaminated, mention three pollutants that you think are present in the water of the Bay of Cartagena.

A.21. On average, how much does cost a kilogram of fish (by species)?

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

Species _____ Price: _____ per kilo

A.22. How do you think the fishery resources have been in recent months? ☐ Scarce
☐ More or less abundant ☐ Abundant

A.23. How diverse are the fishes in the bay?

☐ Few diverse ☐ More or less diverse ☐ Very diverse

A.24. How important is for you to have diversity of fish?

☐ Not important ☐ More or less important ☐ Very important

Part B: The problem of management of natural resources. (Contextualization of the problem).

"We'll tell you a similar situation that you and your community face when using natural resources in this region. We all use the resources of the bay surrounding us in many ways. It provides us fish to consume or sell on the market, or we can do other activities like snorkeling and many others.

"In addition to providing these services to the community, the bay is home for a variety of animals and plants that in some cases are unique in the world, which are very important for us and other people outside this community. For some people, animals or plants have a value because they make them feel good with nature; and for others, these plants and animals may be in the future source of food or drugs that could help society. Additionally, natural areas are important to develop environmental education, scientific research, recreation and tourism.

"However, if we want that the bay keeps providing these services to each of us and the rest of our community and others outside it, we must solve a major dilemma: a person can earn more if he extracts more resources; but if everyone in our community extracts too much, we can generate a lot of pressure on fish stocks, and thus the capacity of the bay to lend these services is reduced. Some plants and animals begin to run out and the water we use starts

to become contaminated.

Part C: Methods of work.

"Here we present a series of cards depicting possibilities of work you could do on a fishing trip in the bay of Cartagena.

Each card represents a scenario of work. Some options will be more attractive to you than others, either because the level of contamination, or the benefits generated or the costs involved for you. Each possibility of work can generate good things for you and your community, such as protection of the variety and abundance of fish.

"You will think about each of these job possibilities to see which you like more and then you will sort them. When you are sorting each of the options that we will present, consider your current income and conditions, the current use of resources in this zone; in other words, consider carefully what you lose and what you would win with every possibility of work if they would be implemented in reality.

"You should organize the most preferred possibility of work to the least preferred. The most preferred card indicates that you are more in line with the benefits of this option and you would be more willing to do it in reality. If you have questions about the exercise, please ask. [Interviewer please answer the questions if there is]. Now we can start with the game.

[Interviewer please take the card number 0: *status quo*; and explain it]

"The first card that we will consider is "to do nothing" or *status quo*. Obviously, a possibility we have is that nothing is done and things continue as now.

"Now, you will pick randomly, one by one, six cards which have different types of benefits and costs or sacrifices for you. We will be putting on the table each card for you to thinking about them, which you like most and which you like least. When we have the seven cards on the table, we will ask you to organize them from the most preferred to the least preferred. "

[Interviewer please take out the other cards at random, one by one, in a different order each time and explain the meaning of the colors and drawings].

"The drawings in the cards can help you to compare them and think which you prefer."

"For these cards you selected randomly, please organize them from the most preferred to the least preferred. It is important to observe what would you win and lose with each card, comparing with 0 option of doing nothing, "

C.25. Table for data selected by the respondent:

Position	Number of the chosen card
1	
2	
3	
4	
5	
6	
7	

Part D: Additional information about the interviewe.

"These final questions are important to complement your views on the management of natural resources in this community. Remember that your answers are completely anonymous and confidential, and it is very important for us to know what you really think. Some questions refer to you as a person, and others refer to your family; by family we mean people living with you at home. "

D.27. How many people do live in your home now? (Include yourself).___ people.

D.28. Of these, how many are younger than 7 years? _____.

D.29. Please indicate the age, gender and last year of formal education that you and your family have received (include all persons who regularly live with you in the house).

<u>Members</u>	<u>Age</u>	<u>Gender</u>	<u>Last year of education</u>
-You	_____	_____	_____
-Your couple	_____	_____	_____
-Son or daughter 1	_____	_____	_____
-Son or daughter 2	_____	_____	_____
-Son or daughter 3	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

D.30. Besides fishing, which is the occupation in which you spend more time during the year?

- ☐ Artisan or other manual activity ☐ Agriculture (own crops)
☐ Public employee. Entity: _____ ☐ Employee of a private company

- ☐ Extraction of wood or other products ☐ Merchant
☐ Cattle raising (own animals) ☐ At home
☐ Works for wages ☐ Student
☐ Other: _____

D.31. In the above list, highlight the activity that produces economically more for you and your family. If it is fishing, point it here: ☐☐Fishing.

D.32. How much was your income in the last month? _____.

D.33. How much is your average monthly income? _____.

End of interview. End time __: __ a. m. / P. m.

"We want to thank you for this time. We know your time is important and we are confident that this information will be very useful for this study and the conclusions that result in better programs management of fishery resources for the benefit of this and other communities."

"If at this point you have questions about the interview or the study, please let us know. If not, thank you again for your time. "

Appendix B

Survey number: _ _ _ _ _

Date: DD/MM

Hour: __ a.m. / p.m.

Place: _____

Interviewer: _____

Survey to fish consumers in Bogotá

Hi. First, we want to thank you for your participation in this exercise that is part of a study on fish consumer's preferences, particularly freshwater fish consumers.

At first you will answer some basic questions about your preferences and habits in eating fish and then we will make a game in which you have to decide whether to buy hypothetically different possibilities of catfish or other freshwater fish in the market.

Your responses will be completely anonymous and general results will be used to make proposals to improve the welfare of this community.

1. What is your role at home?

- ☐ head of household
- ☐ spouse of household head
- ☐ employee household member

2. Do you buy the fish from your home?

- ☐ Always
- ☐ Sometimes
- ☐ Never

3. How often do you or your family eat freshwater fish?

- ☐ More than once a week (more than 4 times in a month)
- ☐ Sometimes in the month (1-4 times in a month)
- ☐ A few times a year or on special occasions
- ☐ Never

4. How often do you or your family eat catfish? (Examples of catfish: capable, pintadillo golden speck, among others)

- ☐ More than once a week (more than 4 times in a month)
- ☐ Sometimes in the month (1-4 times in a month)
- ☐ A few times a year or on special occasions
- ☐ Never

5. Did you watch the program Informantes in channel Caracol about pink dolphins and mercury concentration in some catfish?

- ☐ Yes
- ☐ No
- ☐ I did not watch it but somebody told me about it

6. Do you think that in some catfish's fisheries, fisherman hunt dolphins or alligators to use their meat as bait?

- ☐ Yes
- ☐ No

☐ I do not know

7. Would you pay money out of pocket to contribute to a conservation fund in order to care of the river dolphins?

☐ Yes

☐ No

8. Who should be responsible for the protection and conservation of species such as river dolphins? (You can check more than one answer)

☐ The government

☐ Everyone

☐ Foundations and environmentalists

☐ Fishermen

☐ No one

9. If you were to eat a fish with some mercury concentration, do you think it could have some effect on your health? (You can check more than one answer)

☐ Any effect

☐ Good effect, I will feel well

☐ I could get sick a few days

☐ I could become seriously ill

☐ Me or my future children could get sick

☐ I do not know

10. Do you think that some freshwater fish sold in Bogota are contaminated with mercury?

☐ Yes, some (or a lot) of them are contaminated

☐ No, the fish sold in Bogotá is in most of the cases (or always) from good quality

☐ I do not know

11. Would you pay money out of pocket to contribute to a fund to monitor the quality of the fish consumed in Bogota? (You can check more than one answer)

☐ Yes

☐ No, the government should do it

☐ No, the fish sell in Bogota is of good quality

☐ No, the fish is already expensive.

You have finish the first part of the survey, now let's make a draw to see which questions you will answer now. Does your identity card ends in an even number or in an odd number?

- ☐ Par (0,2,4,6,8)
- ☐ Odd (1,3,5,7,9) → continue directly with the choice experiment

(if <<Par>>) Interviewer: How much of the video was watched by the respondent?

- ☐ did not watch it
- ☐ watched less than half
- ☐ watched half
- ☐ watched more than half
- ☐ watched full

Choice experiment

Now let's make a game. We will show you some cards and each card represents a possibility of freshwater fish that you could buy. For each fish option you will know the following characteristics:

[interviewer show explanation card]

With these characteristics in mind, assume the following scenario: you're heading to do market and you will decide which fish to buy. When you get to the place of purchase, you find yourself with different options of freshwater fish and naturally you will like some options more than others.

Here I have 25 cards, each card represents an option of freshwater fish with certain characteristics that you could buy, this is an example of card [interviewer show example card]. Remember that this is a hypothetical exercise and thus some of these cards may seem unrealistic but if they were real we would like to know your opinion.

You will take five cards randomly and using each card information, you should organize them, from the one you like more to the one you like the least. When you are organizing them, keep in mind your current income and the amount you or your family members eat freshwater fish because each card has a price, which in real life you would pay out of pocket.

Do you have any questions? If you have any questions, let's start with exercise.

Order Card

- 1
- 2
- 3
- 4
- 5

You have finished your choices. Are you sure this is the order in which you would prefer the alternatives in the real life? Remember that if this were true, you would have to pay the price out of pocket.

Finally, we will ask you some very brief questions to complement your opinions about eating catfish in Bogotá.

1. How many recipes to prepare catfish do you know?

- ☐ Many
- ☐ Some
- ☐ Very few
- ☐ Any

2. Have you seen pink dolphins in real life?

- ☐ yes
- ☐ no

3. Do you buy organic food?

- ☐ always or sometimes
- ☐ never

4. Do you recycle or have you recycled any time?

- ☐ I do
- ☐ I did before
- ☐ I have never

5. How often do you read the newspaper (physical or online)?

- ☐ Everyday
- ☐ Occasionally
- ☐ Rarely
- ☐ Never

6. Age: ____

7. Gender: F M

8. Stratum: 1 2 3 4 5 6

9. What is the highest educational level you have reached?

- ☐ none
- ☐ Some primary
- ☐ Primary
- ☐ Some high school
- ☐ High school
- ☐ Technical
- ☐ University
- ☐ Post-graduate

10. How many children under 5 live at your home? ____

11. Between which of the following ranges are your monthly expenses?

- ☐ Less than \$ 700,000
- ☐ Between 700,000 and 1,500,000
- ☐ Between 1,500,000 and 3,000,000
- ☐ Between 3,000,000 and 5,000,000
- ☐ Over 5,000,000
- ☐ I do not want to answer

<< Thank you for your participation in this exercise, you have contributed to a research that seeks to propose improvements to the welfare of your community >>

Orthogonal design for choice experiment in case #1 (Cartagena)

Card Number	Fishing Time (Hours)	Fuel Used (Gallon)	Pollution Level (Percentage)	Fish Price (COP/kg.)	Variety and Abundance of fishes
0 (<i>Status quo</i>)	7	1.5	100%	8000	Medium
1	7	1.5	100%	4000	Medium
2	9	2	100%	6000	Low
3	7	1.5	100%	8000	Low
4	7	1.5	50%	8000	Low
5	5	1	100%	10000	Low
6	9	2	100%	4000	Low
7	7	1.5	50%	12000	Medium
8	9	2	100%	12000	Medium
9	5	1	50%	4000	High
10	9	2	50%	4000	Low
11	7	1.5	100%	12000	High
12	5	1	0%	12000	Low
13	7	1.5	0%	4000	Medium
14	7	1.5	50%	10000	Low
15	9	2	50%	12000	Low
16	9	2	0%	10000	Medium
17	7	1.5	0%	6000	Low
18	7	1.5	100%	10000	High
19	9	2	100%	8000	Medium
20	9	2	0%	8000	High
21	5	1	100%	6000	Medium
22	5	1	50%	8000	Medium
23	7	1.5	50%	6000	Medium
24	9	2	50%	6000	High
25	9	2	50%	10000	Medium

Orthogonal design for choice experiment in case #3

Card	Price per lb	Freshness	Presentation	Mercury level	Place	Biodiversity threats
1	\$ 10.300	less days to expire	post	2	marketplace	does not threats dolphins
2	\$ 15.100	more days to expire	post	4	supermarket	threats dolphins
3	\$ 5.900	more days to expire	whole	2	fish shop	threats dolphins
4	\$ 10.300	less days to expire	fillet	3	supermarket	threats dolphins
5	\$ 1.900	more days to expire	whole	2	supermarket	threats dolphins
6	\$ 5.900	less days to expire	post	3	supermarket	threats dolphins
7	\$ 5.900	less days to expire	whole	4	marketplace	does not threats dolphins
8	\$ 15.100	less days to expire	whole	1	supermarket	does not threats dolphins
9	\$ 15.100	less days to expire	post	2	marketplace	threats dolphins
10	\$ 10.300	more days to expire	whole	1	supermarket	threats dolphins
11	\$ 20.300	less days to expire	post	1	fish shop	threats dolphins
12	\$ 15.100	more days to expire	fillet	1	marketplace	threats dolphins
13	\$ 10.300	more days to expire	post	1	fish shop	does not threats dolphins
14	\$ 20.300	more days to expire	fillet	2	supermarket	does not threats dolphins
15	\$ 1.900	more days to expire	post	3	marketplace	does not threats dolphins
16	\$ 10.300	more days to expire	whole	4	marketplace	threats dolphins
17	\$ 1.900	less days to expire	whole	1	supermarket	does not threats dolphins
18	\$ 1.900	more days to expire	post	1	marketplace	threats dolphins
19	\$ 15.100	more days to expire	whole	3	fish shop	does not threats dolphins
20	\$ 5.900	more days to expire	post	1	supermarket	threats dolphins
21	\$ 5.900	more days to expire	fillet	1	marketplace	does not threats dolphins
22	\$ 1.900	less days to expire	fillet	4	fish shop	threats dolphins
23	\$ 20.300	more days to expire	post	4	supermarket	does not threats dolphins
24	\$ 20.300	more days to expire	whole	3	marketplace	threats dolphins
25	\$ 20.300	less days to expire	whole	1	marketplace	threats dolphins

Orthogonal design for choice experiment in Leticia cases

Card number	Size of caught fish	Abundance of fish in the river	Type of bait	Pollution	Price
0 (Statu quo)	sexual maturity (35 cm)	Middle abundance of fish	Remains of beef and pork	Medium	\$ 3,000
1	maximum size (45 cm)	Middle abundance of fish	Aquatic mammals	High	\$ 5,000
2	maximum size (45 cm)	Low abundance of fish	Aquatic mammals	High	\$ 2,000
3	below permitted (15 cm)	Middle abundance of fish	Remains of beef and pork	Medium	\$ 3,000
4	minimum size (25 cm)	High abundance of fish	Aquatic mammals	Medium	\$ 2,000
5	sexual maturity (35 cm)	Middle abundance of fish	Aquatic mammals	Medium	\$ 1,000
6	below permitted (15 cm)	High abundance of fish	Aquatic mammals	High	\$ 4,000
7	minimum size (25 cm)	Low abundance of fish	Remains of beef and pork	High	\$ 3,000
8	sexual maturity (35 cm)	Low abundance of fish	Remains of beef and pork	Low	\$ 5,000
9	maximum size (45 cm)	Middle abundance of fish	Remains of beef and pork	None	\$ 3,000
10	maximum size (45 cm)	High abundance of fish	Aquatic mammals	Low	\$ 3,000
11	maximum size (45 cm)	High abundance of fish	Remains of beef and pork	Medium	\$ 5,000
12	maximum size (45 cm)	Middle abundance of fish	Remains of beef and pork	High	\$ 1,000
13	maximum size (45 cm)	High abundance of fish	Remains of beef and pork	High	\$ 1,000
14	sexual maturity (35 cm)	High abundance of fish	Remains of beef and pork	None	\$ 4,000
15	maximum size (45 cm)	High abundance of fish	Remains of beef and pork	None	\$ 2,000
16	minimum size (25 cm)	Middle abundance of fish	Remains of beef and pork	High	\$ 4,000
17	below permitted (15 cm)	Low abundance of fish	Aquatic mammals	None	\$ 1,000
18	maximum size (45 cm)	Low abundance of fish	Remains of beef and pork	Medium	\$ 4,000
19	sexual maturity (35 cm)	Middle abundance of fish	Remains of beef and pork	High	\$ 2,000
20	minimum size (25 cm)	Middle abundance of fish	Aquatic mammals	None	\$ 5,000
21	sexual maturity (35 cm)	High abundance of fish	Aquatic mammals	High	\$ 3,000
22	maximum size (45 cm)	Middle abundance of fish	Aquatic mammals	Low	\$ 4,000
23	below permitted (15 cm)	Middle abundance of fish	Remains of beef and pork	Low	\$ 2,000
24	below permitted (15 cm)	High abundance of fish	Remains of beef and pork	High	\$ 5,000
25	minimum size (25 cm)	High abundance of fish	Remains of beef and pork	Low	\$ 1,000