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How to fish? Key factors influencing the probability of choosing a recreational fishing modality

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Abstract

A fishing policy oriented to influencing the behavior of recreational fishermen requires, as a first step, an analysis of the variables affecting their fishing habits in order to establish actions aimed at reducing the impact of this extractive activity. The main objective of this study is to increase existing knowledge concerning recreational fishing by analyzing the key factors that are behind the choice of a fishing modality by each fisherman. This involves investigating the reasons which induce them to switch between different fishing modalities: shore fishing, boat fishing or spearfishing. Data were collected to obtain information about socio-economic aspects, target species and captures of recreational fishermen in the Canary Islands. Information was obtained through face-to-face interviews carried out between April and November 2010. Multinomial models were fitted to identify which variables could determine the choice of a fishing modality. Our model predicts that any policy that increases the cost of the fishing journey would negatively affect the probability that an angler chooses fishing from a boat or spearfishing, but it has almost no effect on the probability of fishing from the shore. However, increasing the price of fishing licenses *per se* did not affect the behavior of recreational fishermen. The results could have several policy and management implications. Beyond this economic measure, education is drawn as a very useful tool for influencing the behavior of fishermen.

Keywords: Recreational fishing, fishing policy, multinomial probit model, Canary Islands.

1. Introduction.

There is no doubt that recreational fishing plays a very important role on the state in which many fishing resources are found in different parts of the world (Arlinghaus et al., 2002; McPhee et al, 2002; Cooke & Cowx, 2004; Coleman et al., 2004; Ihde et al., 2011; Strehlow et al., 2012), particularly in those countries where it is also a relevant economic sector (Cowx, 1998; Soliva, 2006; FAO, 2010; Nicolai, 2017). Therefore, it is necessary to establish strategies which integrate these recreational fisheries into management systems designed to minimize the impact of fishing, via the control and limitation of catches (McPhee et al., 2002; Eero et al., 2014), but without proving detrimental to their economic potential. However, combining both these objectives is by no means an easy task, and must coincide with the idea of fishery regulatory compliance behavior by recreational fishermen, something that is not satisfactory for the latter (Thomas et al., 2015).

Recreational fishing takes place in several broad modalities (i.e. angling from the shore or from boats, and spearfishing) and not all of them have the same impact and access to such a diversity of resources. Thus, while seaside fishing has a spatial impact limited to a few meters from the beach, spearfishing shows a much greater resource access, not only in its spatial scope (up to 30 or 40 m depth), but also because of the capacity of fishermen to select species and the size of individuals, which generally act as top-predators or large spawners in these shallow bento-demersal ecosystems (Beal et al., 1998; Cooke & Cowx, 2006; Arlinghaus & Cooke, 2009; Santana-Ojeda, 2014). According to fishing power, measured as the accessible proportion of the fishing grounds, fishing from a boat has a greater incidence on the whole fishing area and on a wider number of target species than the other two previous fishing modalities, even in very deep waters with the help of electric reels (Jiménez-Alvarado, 2016). In this way, Pita et al. (2018) reported that boat anglers, representing 20% of recreational fishermen of Galicia (NW-Spain), obtained 40% of the total estimated recreational catch. But, spearfishermen, with a natural physical depth limitation (Coll et al., 2004), have a relatively higher capture per unit of effort (Kg/fisherman/hour) (Morales-Nin et al., 2005; Pinheiro

& Joyeux, 2015; Pita et al., 2018). And, it is this differential fishing capacity that has led to access restrictions in some traditionally free fishing areas (Veiga et al., 2013; Santana-Ojeda, 2014).

Therefore, it is necessary to devise strategies that discourage the development of more impacting fishing modalities, via each fisherman's own decisions, motivating them to switch to other ways of fishing that are less aggressive with resources (e.g.: catch and release; Cooke & Schramm, 2007), or that have a more limited spatial impact. In this way, a growing interest has emerged in knowing the reasons which motivate fishermen to fish, in particular those of recreational fishermen (Calvert, 2002; Arlinghaus, 2006; Farr et al., 2014; Morales-Nin et al., 2015; Young et al., 2016), as well as the attitude of the latter with respect to the regulatory aspects of their fishing activity (Thomas et al., 2015; Cardona & Morales-Nin, 2013). Nevertheless, so far, the studies carried out on the motivation of fishermen have mainly been focused on the reasons to fish (relaxation, time with family and friends, personal challenge, contact with nature, etc.), or their satisfaction with certain regulatory measures (Ormsby & Innes, 1999; Reid, 2008; Mostegl, 2011; Cardona & Morales-Nin, 2013; Thomas et al., 2015; Martin et al., 2016; Young et al., 2016), only a few have been dedicated to studying the motivation for a specific fishing mode (e.g. Bockstael et al., 1989).

The aim of this paper is to analyze the choice of a fishing modality by a fisherman. It is important to identify the key factors that determine the individual choice of a fishing method or fishing modality, since these could prove a very useful tool for the management of recreational fishing. Thus, for example, altering the recreational fisherman motivation through the variation of one or several of these variables, could encourage a change in the fishing modality, and indirectly modify the theoretical pressure on specific target species or fishing grounds. As such, it is expected that the selection of a fishing modality by a fisherman will be strongly influenced, at least, in the first instance by his/her physical capacity, age and socio-economic characteristics, the costs associated with each fishing modality, the regulatory constraints and the target species.

Discrete choice models have been widely used to analyze the angler's behavior (see Fenichel et al., 2013). So, this empirical approach has been employed to determine the choice of fishing site (McConnell et al., 1995; Morey at al., 1993; Schuhmann & Schwabe, 2004; Raguragavan et al., 2013; Knoche & Lupi, 2016), the angler's choice of species (Carson et al, 2009 and, the angling trip duration (Curtis & Breen, 2017).

Within this framework of a discrete choice model, various econometric methods have been also proposed in the literature to estimate which attributes of the fishing mode and which characteristics of fishermen are the most significant in explaining the choice of one alternative or another among the ones available (Bockstael et al., 1989; Morey et al., 1991; Herriges & Kling, 1999). But, unlike these latter studies, where multinomial logit and nested-logit models are applied, it is necessary to go beyond the scarce existing literature regarding the choice of fishing modality by applying a multinomial probit model (MNP). As Cameron & Trivedi (2009) have highlighted, the MNP in comparison to other alternatives allows a more flexible pattern of error correlation and does not need the specification of a nesting structure. It is for this reason that we have chosen the MNP model to study the selection of a recreational fishing modality from amongst the three models previously described.

2. Material and Method

We estimate different multinomial discrete choice models to determine the variables influencing the probability that a recreational fisherman in the Canary Islands decides to fish with a rod from the shore or from a boat, or alternatively, opts to practice spearfishing.

The multiple response models are those where the choice set is discrete, but there are more than two mutually exclusive and exhaustive alternatives. In this study, we consider a recreational fisherman i from a sample of N individuals who has to choose a fishing modality j from a set of three unordered alternatives (j=1 shore fishing; j=2 boat, and j=3 underwater fishing). Thus, the decision made by the fisherman is modeled through a categorical variable y_i, so that the latter will take the value $y_i=j$ if the individual has chosen the j alternative.

The theoretical framework of these specifications is based on an additive random utility model (McFadden, 1973, 1974), which is summarized below.

Formally, for the *i* individual, it is assumed that the utility derived from choosing the *j* alternative, U_{ij}, is the sum of two components: a deterministic component, V_{ij}, dependent on the regressors and the estimated parameters associated to them, and an unobserved random error component ε_{ij}, which demonstrates that apparently identical individuals can choose different options:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

The standard model of multiple choice specifies that the deterministic component can be expressed as $V_{ij} = x'_{ij}\beta + z'_{i}\gamma_j$, where z_i are specific regressors of the case and x_{ij} are specific regressors of the alternative. Therefore, some regressors do not vary across alternatives (i.e. individual characteristics as gender, age, etc.), and are called alternative-invariant or case-specific regressors. Those that do vary across alternatives are called alternative-specific or case-varying regressors (i.e. costs or catch weight). From now on, and following other terminology also found in the literature (i.e. Cameron & Trivedi, 2009), the former will be identified as characteristics of the individuals and the latter as attributes of the alternatives.

The outcome $y_i = j$ will be observed if the alternative *j* maximizes the utility of the individual. In our case, the recreational fisherman will choose the first alternative (fishing from the shore) only if the following inequality holds:

$$\Pr(y_i = 1) = \Pr(U_{i1} \geq U_{i2}) \text{ and } Pr(U_{i1} \geq U_{i3})$$

That is to say:

$$\Pr(y_i = 1) = \Pr(\varepsilon_{i2} - \varepsilon_{i1} \leq V_{i1} - V_{i2}) \text{ and } \Pr(\varepsilon_{i3} - \varepsilon_{i1} \leq V_{i1} - V_{i3}) \qquad (2)$$

Then, the probability that the individual *i* chooses the alternative *j*, p_{ij}, can be expressed as a function of a set of explanatory factors that may refer to specific characteristics of each alternative and others that are case-specific.

Different assumptions about the joint distribution of errors $\varepsilon_{i1}, \ldots, \varepsilon_m$ will lead to different models. The distribution functions most commonly used are the logistics and the normal ones, giving rise to logit and probit models, respectively. In this paper we consider both a mixed logit and a multinomial probit model.

2.1. Mixed logit and multinomial probit models

The mixed logit model (ML) is used when the database contains variables relating to all the available alternatives, and not only those chosen by the individual (see, for example Hoffman and Duncan, 1988). Then, the ML explains the probability of choosing a fishing modality as a function of the case-specific regressors that define the economic and social context of the angler (economical resources, age, family responsibilities, etc.) as well as fishing habits (days per week, time of the day, fishing alone or in group, etc.), together with the attributes of all the other alternatives, where values change for each alternative.

That is to say, the ML model specifies that:

$$p_{ij} = \frac{\exp(x_{ij}'\beta + z_i'\gamma_j)}{\sum_{l=1}^{3}\exp(x_{il}'\beta + z_i'\gamma_l)}, \quad \forall\, j = 1, 2,3 \qquad (3)$$

The estimated coefficients of the characteristics of the individuals (γ_j) can be interpreted as parameters of a binary logit model between the *j* and the base category. Thus, a positive coefficient means that as the regressor increases, the individual *i* will be more prone to choosing the fishing modality *j* rather than the base category.

If the alternative-specific regressors are called x_r and their associated coefficients are denominated β_r, then, the effect of a change in x_{rik}, that is, in the value of the variable r for the *i*-individual and the *k*-alternative, will be:

$$\frac{\partial p_{ij}}{\partial x_{rik}} = \begin{cases} p_{ij}(1 - p_{ij})\beta_r & j = k \\ -p_{ij}p_{ik}\beta_r & j \neq k \end{cases} \qquad (4)$$

If $\beta_r > 0$ then the own-effect is positive because $p_{ij}(1 - p_{ij}) > 0$ and the cross- effect is negative due to $-p_{ij}p_{ik} < 0$. Thus, a positive (negative) coefficient indicates that if the explanatory variable of a category (i.e. cost of fishing journey) increases (decreases) by one unit, then that category will be selected more (less).

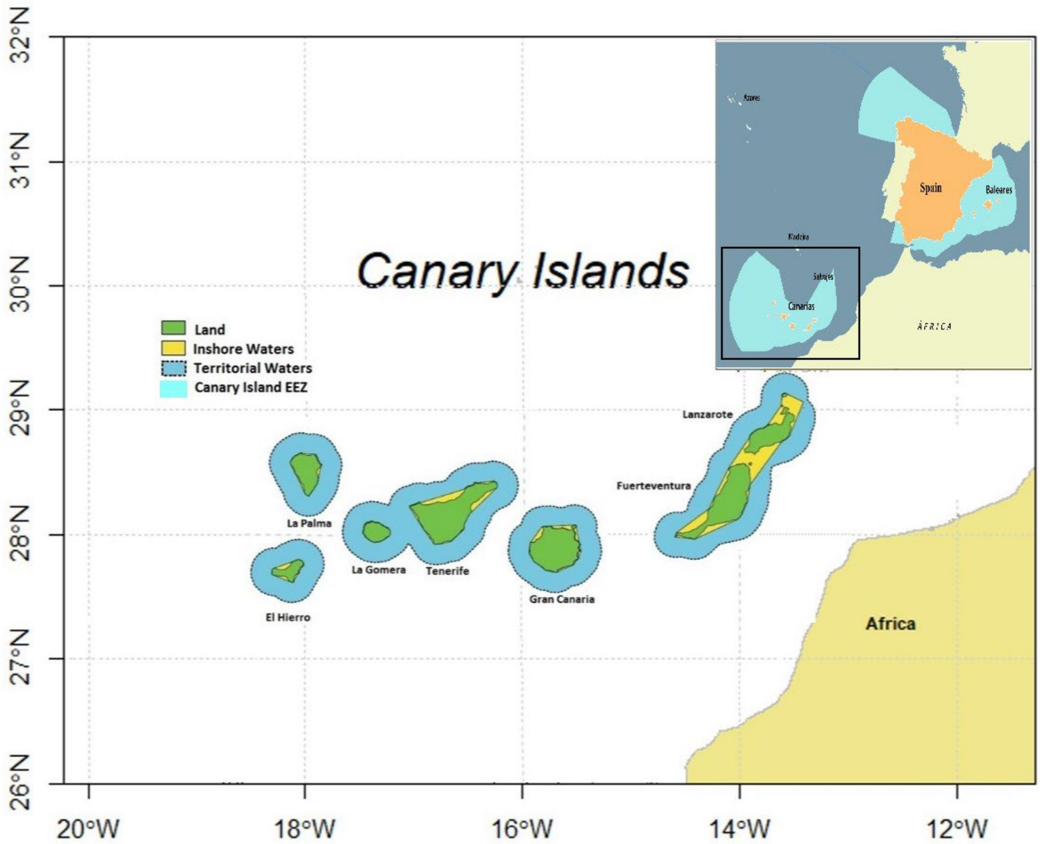
The multinomial probit (MNP) uses the same evaluation function as the ML, that is, it includes alternative-specific regressors (x_{ij}) and case-specific variables (z_i). But in the MNP the random components (ε_{ij}) of utility functions are assumed to be normally distributed and these errors are allowed to be correlated. Thus, the MNP allows relaxation of the assumption of independence of irrelevant alternatives (see, for example, McFadden & Train (2000).

The independence of irrelevant alternatives (IIA) assumption implies that the individual's choice of an alternative relative to another does not have to change if a third alternative is considered in the set choice. In our analysis, it would mean that the fisherman who can only choose between boat and shore will not change his/her relative probability of choice between both options if they have, in addition, the possibility of choosing the alternative of underwater fishing. This requires the independence of the errors ε_{ij} and that the relative probabilities between two fishing modalities do not depend on the attributes of the other alternatives.

3. Study area and fishing data

The Canary Islands (Spain, Central-East Atlantic) is one of the outermost regions of the European Union (Figure 1). The recreational fishing activity takes place around the territorial sea, both inshore and offshore waters, surrounding the islands and can be done through three modalities: angling from the shore or from boats and spearfishing. Recreational fishing from the shore or from a boat is allowed exclusively with a fishing rod or handline, with a maximum of 3 hooks per line, but when fishing from a boat it is also possible to fish with trolling, and a squid-jig per line if catching pelagic cephalopods. Natural baits or lures are allowed, but electronic elements that attract fish are forbidden. On the other hand, spearfishing can only be done via snorkelling with a speargun, knife or hand-spear.

Figure 1. Map of the Canary Islands Exclusive Economic Zone



The acquisition of a fishing license, valid for three years, is mandatory in order to fish in any of the modalities, with prices that do not vary much from each other (15.79, 31.56, and 23.67 € for fishing with rod from the shore or with boat, and spearfishing, respectively). The number of recreational anglers holding fishing licenses for one, two or all modalities in the Canary Islands between 2008 and 2010 are shown in Table 1.

Table 1. Number of recreational anglers holding fishing licenses for one, two or all modalities in the Canary Islands between 2008 and 2010 (licenses are valid for 3 years).

Fishing licensed anglers	**2008**	**2009**	**2010**
One modality	19709	34825	31154
Two modality	2229	4043	3153
Three (all) fishing modalities	258	496	352
Total new licenses per year	22,194	39,364	34,659
Total current licenses (3 years)	**71,697**	**87,000**	**96,217**

Along the last two decades recreational fishing in the Canary Islands has acquired a more relevant role in a chronic overfishing context (García-Cabrera, 1970; González, 2008). According to Castro et al. (2005), over the last 50 years, the fishing resources of the Canaries have been reduced by about 90%, and the impact of recreational fishing in this generalized overfishing situation seems to be significant (MAPyA, 2006; Couce-Montero et al., 2015; Jiménez-Alvarado, 2016). Unfortunately, in the Canary Islands there are no official records of fishing effort or captures related to this recreational activity, and an approach based on questionnaires is the only one possible in order to shed some light on the impact of recreational fishing in this area (MAPyA, 2006; Pascual et al., 2010; Jiménez-Alvarado, 2016).

Most of the information obtained has been dedicated to a description of the recreational fisherman profile and/or to obtaining estimations of captures landed by the recreational fishing collective in specific islands or in the whole Archipelago. However, none of these studies have clarified the role played by management strategies in the problem of overfishing and economic context of the Canaries.

The available official data regarding recreational fisheries in the Canary Islands refer only to the quantity and type of license. Consequently, the socio-demographic characteristics and level of activity developed by the recreational fishermen population in the Canary Islands are unknown. In any case, and as usual, we have considered the license number as a proxy for the real population. For this reason, we have obtained samples from all the islands, although mostly in the more populated ones since they are home to almost 70% of the total fishing licenses. From this point of view, we think that given the available information, our sample is adequate and representative.

When it comes to gathering the data for recreational fishing there are three general types of surveys: on-site surveys, phone surveys and log book or diary programs involving a sample of recreational fishers who voluntarily keep records of their fishing activities. Of these, the on-site survey method which is the one selected to conduct our analysis, is considered superior in terms of the quality of effort and catch data collected for several reasons: there is less reliance on fisher recall, most of the data and information collected on-site can be verified by field staff and the rates of non-response or refusal are usually much lower (Pollock et al. 1994; Steffe & Chapman 2003).

The on-site survey of recreational anglers was carried out over an 8-month time frame from April to November 2010. The timing of the on-site survey was scheduled to coincide with the high season of fishing (i.e. Easter and Summer holidays). A list of frequent angling locations throughout the archipelago was drawn up. This approach was used to maximize the overall representativeness of the survey and to ensure that all island and angling categories were fully covered.

The sample for the on-site survey was comprised of individuals resident in the Canary Island. Data were obtained from 203 face-to-face interviews with anglers operating in the fishing grounds along the coast or at the hour of disembarkation at the harbors or marinas of the archipelago. The interview comprised a set of questions divided in two different sections (see Annex 1). The first one (9 questions) gathered information about the socio-demographic characteristics of recreational fishermen. The second one (12 questions) collected information about the characteristics of their daily fishing activity: fishing costs, captures, equipment, etc.

The dependent variable is the set of three fishing modes, as we discussed earlier. Boat fishing is the predominant modality (57.1% of the anglers interviewed), followed by shore fishing (35.9%) and underwater fishing (7%), in accordance with the number of fishing licenses in the Canary Islands (see Table 2).

In order to estimate the different modal choice models, we have divided the independent variables into two categories depending on whether they refer to fishermen's characteristics or reflect mode attributes. In the first category some socioeconomic variables such as age, gender, education, occupation or family commitments, are considered. Given that we lack data concerning the angler’s income in our questionnaires, this was estimated using the Wage Structure Surveys of the Canary Islands in 2010 (INE, 2013), taking into account the average monthly salary by gender, occupation, status (employment or unemployment) and education level.

The cost associated with each of the fishing modalities considered in this analysis refers to the fishing costs incurred in the daily fishing activity; that is, all expenses inherent to travel, bait, etc., besides the cost of licenses.

In this study we have also used the expected catch weight as a proxy of the anglers’ skills, acting as a case-specific variable, such as age or economical capacity. An adequate assessment of the anglers’ skills requires information which is not readily available, such as years of experience, knowledge of fish biology and fishing grounds, etc. Therefore, the alternative proposed has been to estimate a regression model relating the observed weight of each fisherman’s catch to a cubic polynomial in the mean catch rate per island and modality, as well as controlling for the angler’s age. The predicted values for this model were then used as an indicator of the fisherman’s ability.

At interview stage questions asked included whether or not the individual fishes alone or with a partner (coded as 0 if alone and 1 accompanied); whether the angler respects the prohibition to sell the catches (respect = 0; not respect = 1); the nature of their family responsibilities (0= without family responsibilities; 1 = with family responsibilities); if the fisherman is willing to report catches (=0 no;

1=yes), as well as whether the fisherman should be federated (=0 no; 1=yes). In addition, a series of dummy variables is included to represent unobservable characteristics of the island on which the recreational fishing takes place.

Regarding alternative-specific regressors, both the costs and the catch weight associated with each fishing modality have been used. As fishermen were only asked about the mode that they had chosen for these variables, the attributes of the rival alternatives were inferred from each individual's responses. In this case, the capture obtained depends on the fishing modality rather than the fishermen's skills, and it should be considered as an attribute of the choice alternative. Hence it should appear as an explanatory variable in the mixed logit models.

The names of the variables used in the estimations, descriptions, means, and standard deviations are shown in Table 2.

For the purpose of detecting possible problems of multicollinearity among the independent variables, a variance inflation factor (VIF) test was conducted. The reduced values obtained for the VIF statistics, less than 2.5, suggest the absence of multicollinearity among all the explanatory variables, so that their joint inclusion in econometric models would not affect the standard errors of the estimated parameters.

Table 2. Descriptive statistics by modality

	Shore (35.9%)		Boat (57.1%)		Spearfishing (7%)	
	Mean	SD	Mean	SD	Mean	SD
Case-specific variables						
Gender (male = 1)	0.918	0.276	0.931	0.254	0.929	0.267
Age (years)	30.11	9.959	32.47	11.896	28.92	11.691
Monthly income (€)	1,276.45	546.72	1,249.89	476.54	1,533.11	665.88
Family responsibilities (1 = with responsibilities)	0.602	0.493	0.612	0.489	0.571	0.514
Respect prohibition to sell (1 = no respect)	0.151	0.360	0.198	0.400	0.285	0.468
Fishes with a partner (1 = accompanied)	0.192	0.396	0.215	0.413	0.429	0.513
Angler's ability (Expected catch weight in kg.)	7.151	4.730	20.823	7.958	11.812	3.011
Federated (1 = federated)	0.493	0.503	0.379	0.487	0.285	0.468
Catch reporting (1= reports)	0.342	0.605	0.422	0.621	0.571	0.755
Alternative-specific variables						
Variable / Choice						
Cost (€) / Shore	16.835	7.524	29.612	11.661	15.935	4.687
Cost (€) / Boat	16.188	5.372	30.431	19.082	15.784	5.215
Cost (€) / Spearfishing	17.785	4.613	31.400	12.889	16.785	10.849
Catch (kg.) / Shore	6.849	2.459	20.917	2.655	11.391	1.224
Catch (kg.) / Boat	6.644	1.472	20.784	9.312	11.334	1.292
Catch (kg.) / Spearfishing	6.672	1.501	21.830	2.998	11.928	2.437

NOTE: Boat fishing is the predominant modality (57.1% of the anglers interviewed), followed by shore fishing (35.9%) and underwater fishing (7%), in accordance with the number of fishing licenses in the Canary Islands

4. Results

We begin by estimating, via maximum likelihood methodology, a mixed logit model (ML) that includes the two alternative-specific variables (cost and the catch weight) plus the others case-specific regressors, except for the angler's ability. According to the results obtained for this specification, shown in column 1 of Table 3, the relationship between the modal choice and the set of independent variables is not significant.

INSERT TABLE 3 ABOUT HERE

The best ML model was obtained through the equation that relates the fishing modality with a single alternative-specific variable, the cost associated to the fishing journey, and with the following individual's characteristics: income, fishing accompanied, federated, catch reporting and the fishermen's skills represented by the weight of the capture (see column 2 in Table 3). Other case-specific variables such as age, gender, family responsibilities, educational level, professional status, island of fishing, fishing schedule (day or night), number of days fishing per week and if part of the catch was illegally sold, do not have a significant influence on the probability of choosing a particular fishing mode. Similar results were obtained considering three categorical variables for income (monthly income level scaled as less than 1,000 €, from 1,000 to 1,800 € and higher than 1,800 €) and age (younger than 25, between 26 and 45 and older than 45 years old).

Additionally, and with the aim of relaxing the IIA-assumption, we have estimated a multinomial probit model using a maximum simulated likelihood technique. Specifically, the Geweke-Hajivassiliou-Keane simulator described in Train (2003) has been used. Moreover, the parameters of our model have been estimated using robust standard errors. The figures in column 3 of Table 3 show that most of the variable parameter estimates are statistically significant. Furthermore, by comparing the ML and the MNP results, we observe that there is very little difference between the estimated coefficients of both models. However, according to the likelihood ratio test and the significance of the correlation coefficient for the random components(ε_{ij}), the MNP model proves to be better than the ML model. In order to identify the terms of the variance-covariate matrix, we have normalized the variance of the alternative boat fishing to one. The variance obtained for the third choice ($\sigma^2_{\varepsilon 3}$) was 1.029 and the correlation between the second and third choices $\rho_{\varepsilon_2,\varepsilon_2}$ = 0.167.

The results of the MNP model indicate that the cost of the fishing modality is significant, and as expected, its negative coefficient (-0.041) suggests an inverse relationship between an increase in cost associated with any fishing modality and its unpopularity, at the same time favoring the popularity of the other fishing alternatives. In relation to the case-specific regressors, expected catch weight is significant and negative in both fishing from the shore and spearfishing (-0.422 and -0.223, respectively). That is, in relation to the probability of fishing from a boat, an increase in expected catch (fishing ability) produces a decreasing probability of choosing from the shore fishing or spearfishing. In addition, being federated favors the probability of fishing from the shore, while being willing to provide information on the catch increases the probability of underwater fishing. The other regressors, income and partners are positive but only statistically significant for spearfishing. This means that in relation to the probability of fishing from a boat, being accompanied on the fishing trip or an increase in the angler's economic capacity, may in turn increase the probability of choosing spearfishing as the fishing modality.

To facilitate the understanding of the previous coefficients, we calculated the marginal effects (ME) related to the probability of choosing each fishing modality with changes in the explanatory variables, evaluating the latter at their mean values (see Table 4). In this way, when the cost of a fishing journey for the modality with a boat increases by 1 €, the probability of choosing it is reduced by 0.009, at the same time increasing the probability of choosing shore by 0.005 and spearfishing by 0.003. A practically inverse results would occur if the cost of fishing from the shore or spearfishing increased by 1 €.

INSERT TABLE 4 ABOUT HERE

The MEs related to the probability of selection based on the expected catch weight indicate that an increase of 1 Kg in captures (or fishing ability) increases the probability of choosing fishing from a boat by 0.077 but reduces by 0.013 and 0.063 the probabilities of selecting spearfishing and shore fishing, respectively. Moreover, the ME for the variable "fishing accompanied" indicates that when a fisherman fishes accompanied, this increases the probability of choosing spearfishing (0.118).

The federation of a fisherman reduces the probability of choosing fishing from a boat (0.188) but increases the selection of fishing from the shore (0.168), while being willing to report catches reduces the choice of boat mode by 0.124 and increases spearfishing by 0.07. Finally, of all the marginal effects related to the economic capacity of the angler only spearfishing is significant, although the change is so small that it can be considered negligible.

The estimated coefficients of MNP allow us to predict how the probability of choosing a particular fishing modality varies with changes in some of the explanatory variables. In particular, it analyzes how this probability varies with a change in fishing ability and in the cost of the fishing journey.

Figure 2 shows the probability of choosing each fishing modality when the fisherman's ability changes. As fishing ability increases using expected captures as a proxy, the probability of fishing from the shore decreases and increases the tendency to fish from a boat, reaching a probability close to 1. Specifically, when captures are higher than 13 kg it is more probable that an angler will choose fishing from a boat at the expenses of fishing from the shore. However, the results could also receive the interpretation that an individual may start fishing from the shore but as his fishing ability increases he changes to fishing from a boat. In contrast, the probability of spearfishing is less sensitive to changes in this variable, because there are other parameters that condition this fishing modality more such as having a fishing partner or the access to high value species.

Figure 2. Probability of choosing each modality in line with changes in the angler's "ability" (expected catch)

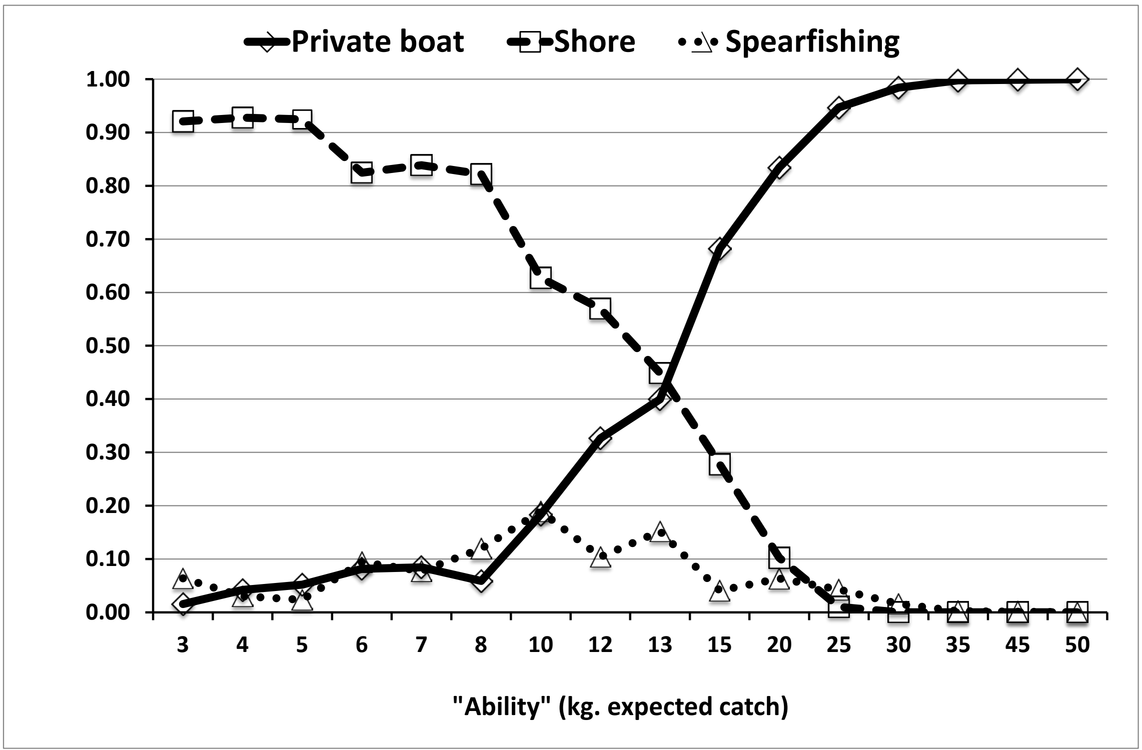
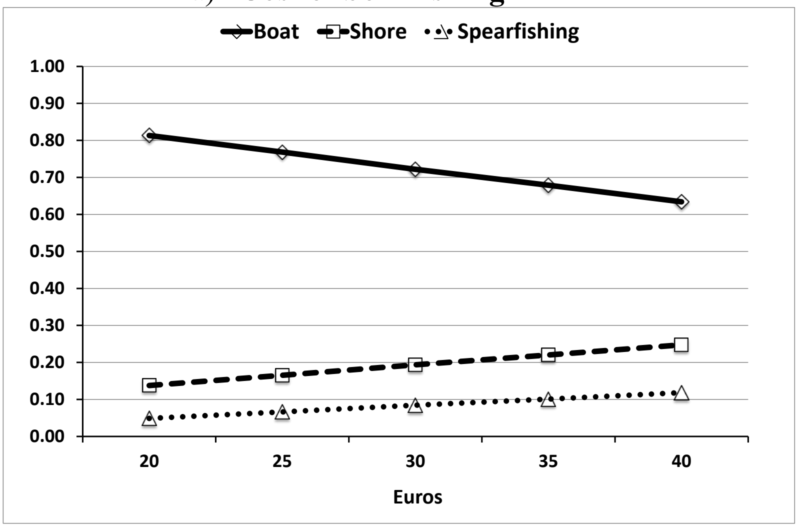


Figure 3 shows the changes in the probability of modal choice when raising the costs of the fishing journey, and it is observed that the three modalities differ in their sensitivity to changes in this cost. In this way, when the cost of fishing from a boat increases by 10 € over the average cost (30.4 €), the probability of choosing it decreases from 0.72 to 0.63, but consequently it increases the probability of doing spearfishing from 0.08 to 0.11 and shore fishing from 0.19 to 0.25 (panel 3A). Similar results are observed when the cost of fishing from the shore and spearfishing journey increase (panel 3B and 3C, respectively), although the effects are more moderate in these cases.

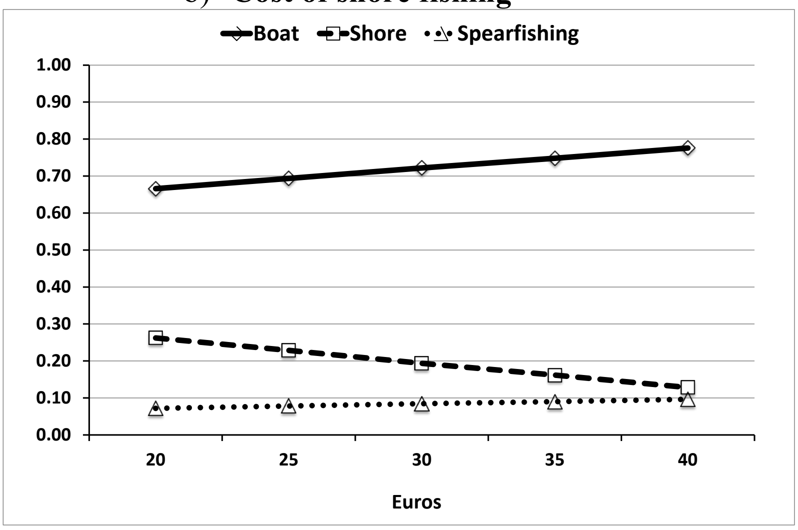
The latter results show that political measures which attempt to modify the choice of each mode by increasing the cost of fishing trips would have little effect. Within our variable fishing trips' cost, only one component is controlled by the Administration: the price of the licenses. Taking into account that the validity of the licenses is three years and given the average value of the fishing journey, the previous example of increasing the cost of fishing from a boat by 10 € over the average cost (30.4 €) shows that this increase per fishing trip would be equivalent to multiplying by almost 50 the price of the fishing license for the boat modality. This example clearly indicates that rising the price of the licenses will not only fail to achieve any appreciable results but also seems totally unrealizable from the point of view of public policy due to the potential public resistance. Obviously, any measure reducing the duration of the licenses would affect the fishing trips' cost and, therefore, would have similar results.

Figure 3. Effects on the probability of choosing a particular modality in line with changes in the fishing journey cost.

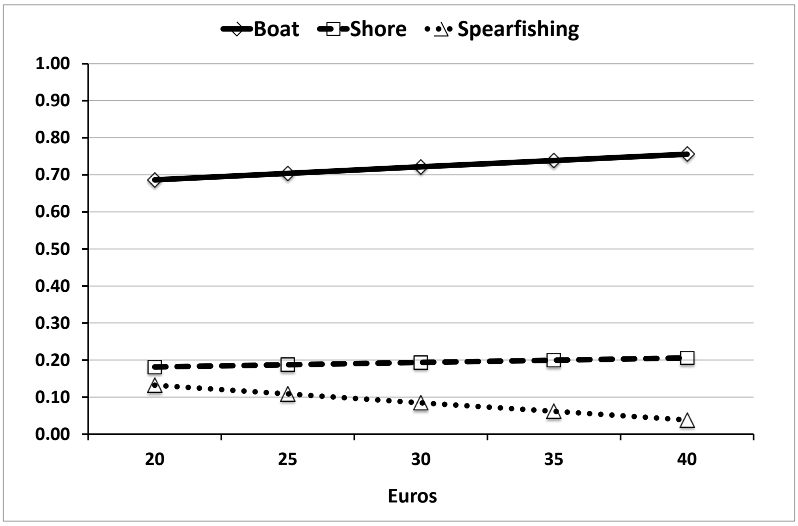
a) **Cost of boat fishing**



b) **Cost of shore fishing**



c) **Cost of underwater fishing**



5. Discussion

In the Canary Islands, while the number of professional fishermen has progressively declined to less than 1500 (decreasing by about 80% over the last 50 years), the number of recreational fishermen has experienced an important increase, passing from about 40,000 in 2005 to over 114,000 in 2011 (91,046 in 2017), assuming a more relevant role in the fishing pressure on resources (Castro et al., 2015; Couce-Montero et al., 2015). In this context, it is essential to understand those factors that affect the selection of a fishing modality by anglers. This knowledge would prove conducive to the development of different management strategies in order to minimize the impact on resources of some recreational fishing modalities.

We assume that rod fishing by the seaside has a lower access to fish resources, in contrast to rod fishing using boats, that also can access deep water species using electric reels. On the other hand, spearfishing impacts significantly on more vulnerable species (i.e. territorial, long lived and slow growing species with low reproductive potential), high trophic level ones (i.e. groupers; *Epinephelus marginatus*), and ecosystems (Coll et al., 2004; Morales-Nin et al., 2005; Soliva, 2006; Lloret et al., 2008). So, it is of interest to know which variables influence anglers when selecting a fishing modality with a lower resource impact.

At the outset when estimating a model, we had to decide how the information to be used would be collected: either from an on-site survey of users or from a general household survey. Due to the fact that both types of recreational surveys could be subject to sample-selectivity bias (i.e. the on-site survey is more likely to intercept individuals who participate more and the household survey is less likely to pick up on these individuals and is instead more prone, to selecting those anglers who only make a couple of short fishing trips in a year or the more opportunistic angler), we decide to use the on-site survey because its advantages (see section 3) outperform its drawbacks.

From the various econometric approaches we used, the MNP model seems to best explain the features of recreational fishing in the Canary Islands. This model predicts that any policy that increases the cost of the fishing journey would negatively affect the probability that an angler chooses fishing from a boat or spearfishing, but it has an almost negligible effect on the probability of fishing from the shore and could be a way to reduce the pressure on most of the fishing resources although its potential to do so is low as shown by the marginal effects estimated.

Besides, the price of the license is the only component of the cost of the fishing journey that could be more easily implemented as a regulatory tool. However in this context, Sipponen & Muotka. (1996), when studying the demand for recreational fishing opportunities in Finnish lakes, observed that the average annual price index for recreational fishing was so low that it did not affect the behavior of recreational fishermen. Similar results were reported by Bedi (1987) in Lake Ontario (US), and by McGrath et al. (1997) for South African line fishery.

In a similar manner to that indicated by the previously cited authors (Bedi, 1987; Sipponen & Muotka, 1996; McGrath et al., 1997), the MNP model shows that increasing the price of licenses for fishing per se did not affect the behavior of recreational fishermen in the case of the Canaries. This is not only because the cost of each fishing journey has a low or negligible marginal effect on the probability of choosing a recreational fishing modality, but also because the price of fishing licenses has a minor role (exerts little weight) on the cost per fishing journey.

Therefore, whatever the selected policy measure affecting the cost of the fishing journey, it should be accompanied by other complementary measures, such as fishing quotas (TACs), limitation of weekly fishing days, or seasonal fishing closure on a suite of high-value demersal species. But, according to Metcalf et al. (2010), any of these changes in management could lead to unexpected outcomes in fishermen behavior (i.e. a shift towards targeting alternative species), that could potentially create new management problems.

To correctly predict the impacts of these behavioral changes without having an analysis of the basic data is not an easy task. And our results indicate that there are many variables that influence the motivation of fishermen when choosing a specific fishing modality, such as age, monthly incomes, family responsibilities, catches, and if fishing alone or accompanied. But, the cost of the fishing journey, despite its inverse relationship with the popularity of any fishing modality, does not seem to be one of the key aspects at the moment of deciding how to fish, due to its low impact on the probability of choosing one or other modality. In this sense, other measures such as increasing security requirements, implementing mandatory courses of good fishing practices, etc., could prove useful.

If fishing from a boat becomes more profitable in terms of captures, something also related with a fisherman's ability to fish (in the way expressed by Acheson, 1981, and Squires & Kirkley, 1999), then the smaller the probability that the recreational fisherman chooses fishing from the shore or spearfishing. However in this last case, as the level of partnership increases and good friends become available to go fishing, spearfishing gains popularity. Curiously, this partnership effect was not observed in both modalities of rod fishing.

Consequently, a fishing policy that pretends impacting on fishermen behavior requires, as a prior step, an analysis of the factors affecting the decision to choose a particular way of fishing (i.e. fishing modality), in order to determine which strategies would prove adequate if the intention is to reduce the impact of recreational fishing. Beyond increasing the cost of fishing journey and quantity control, educational and awareness campaigns seem to be a mandatory tool for achieving fishing sustainability, and recreational anglers seem to be sensitive to this. As more biological information is given to recreational fishermen, and the more they participate in citizen science programs, providing information about their fishing action (reporting catches, species seeing, etc.), increases their willingness to change the modality fishing from boat to spearfishing. Possibly this change could be motivated by their erroneously belief that spearfishing is the most selective fishing method as well as their assumption that being selective is good and always the best way to fish (Coll et al., 2004). Moreover, anglers that belong to a sportfishing federation, or are committed to becoming federated, also show a greater willingness to fishing from the shore.

Moreover, due to the fact that fishing limitations always generate a certain negative response on the part of recreational fishermen, who see their rights harmed as compared to other fishermen, especially professional ones, this often leading to strong social pressure on administrators and politicians (McPhee et al., 2002; Veiga et al., 2013; Thomas et al., 2015; Martin et al., 2016), educational and awareness campaigns may also be useful in partially neutralizing this negative response.

In order to achieve a greater degree of reliability in the predictive capacity of these multiple response models, and the consequences of changes in management on fishermen behavior, it is necessary to significantly increase the number of surveys and time ranges as well as introduce other variables addressed to gaining an in-depth knowledge of the motivation of anglers, such as accessibility to high-value and vulnerable species, status of alternative species, costs of fishing equipment and its amortization, etc.

A potentially interesting policy measure aimed at gaining a better understanding of the impact of recreational fishing, and therefore its management and improved regulation, would be to link the acquisition and renewal of fishing licenses to the mandatory completion of periodic questionnaires, and courses regarding of sustainable fishing practices.

Moreover, these questionnaires, properly designed, would provide information on key variables, such as the species caught, fishing grounds or the duration of the fishing journey (in hours).

We conclude that our approximation contributes towards laying the groundwork for establishing new ways of managing and regulating recreational fishing, through strategies based on the motivation of fishermen when faced with the choice of several alternative fishing modalities that differ in terms of fish resource accessibility, and therefore on the impact on fish resources. In this way, and as a consequence of the present study, the Canary Islands Government is creating an app that allows, after its activation, the introduction of capture data by recreational fisherman, and estimates the duration of the fishing journey, but also automatically locates the captures with the help of the GPS of the mobile phone. This app will soon work in a voluntary testing phase, but the objective is that in the near future it will work as a mandatory link to each fishing license. The monitoring of recreational fishing would provide valuable data for stocks assessment, as well as insight on the dimension of its real economic impact.

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Table 3. Parameter estimates from the mixed logit and multinomial probit

	Mixed logit		Mixed logit		Multinomial probit	
Alterative-specific variables	Coefficient		Coefficient		Coefficient	
Cost	-0.0071 (0.0112)		-0.0464** (0.0199)		-0.0412*** (0. 0148)	
Catch	0.0101 (0.0232)					
Case-specific variables	Shore/Boat	Spearfishing/Boat	Shore/Boat	Spearfishing/Boat	Shore/Boat	Spearfishing/Boat
Constant	-1.6359 (1.1485)	-4.3983** (1.8032)	3.7390*** (1.1997)	-2.4481*** (1.3738)	3.8030*** (1.0711)	-1.6393** (0.8767)
Age	-0.0563*** (0.0198)	-0.0392 (0.0355)				
Income	0.0002 (0.0003)	0.0010** (0.0004)	0.0003 (0.0004)	0.0012** (0.0005)	0.0003 (0.0004)	0.0009** (0.0004)
Family responsibilities	0.5704** (0.2595)	0.2867 (0.5516)				
Sell catch	0.7818* (0.4652)	-0.0498 (0.8295)				
Fishes with a partner	-0.0417 (0.4019)	1.0927* (0.5772)	-0.1399 (0.5564)	1.2466** (0.6004)	-0.2069 (0.5107)	0.9623** (0.4456)
Angler's ability			-0.4379*** (0.0575)	-0.2554*** (0.0394)	-0.4223*** (0.0467)	-0.2231*** (0.0298)
Federated	0.5320* (0.3261)	-0.1754 (0.6621)	1.1211** (0.5549)	0.2081 (0.6907)	1.0934** (0.4953)	0.4549 (0.4516)
Catch reporting	-0.2992 (0.2655)	0.3931 (0.4167)	0.4445 (0.3840)	0.9106** (0.3970)	0.4346 (0.3527)	0.7536** (0.3036)
Num. of obs.=609 Num. of cases =203	Wald χ^2 (16) = 27.72 Prob > χ^2 =0.0341 Log pseudolikelihood = -165.63		Wald χ^2 (11) = 76.27 Prob > χ^2 =0.0001 Log pseudolikelihood = -90.38		Wald χ^2 (11) = 96.99 Prob > χ^2 =0.0001 Log pseudolikelihood = -88.85	

***, ** and * are statistically significant at 1%, 5% and 10% level, respectively. Figures in parentheses are the standard errors. Shadowed cell mean that these variables do not belong to the model.

Table 4. Marginal effects at means from multinomial probit estimates

	Pr(choice = Boat)	Pr(choice = Shore)	Pr(choice = Spearf.)
	dP/dx	dP/dx	dP/dx
Alterative-specific variables			
Boat Cost (€)	-0.00896***	0.00548***	0.00346**
	(0.00313)	(0.00205)	(0.00146)
Shore Cost (€)	0.00548***	-0.00671***	0.00121**
	(0.00205)	(0.00238)	(0.00059)
Spearfishing Cost (€)	0.00346**	0.00121**	-0.00468**
	(0.00146)	(0.00059)	(0.00196)
Case-specific variables			
Income (€)	-0.00011	0.00002	0.00010**
	(0.00007)	(0.00006)	(0.00004)
Fishes with a partner (1= accompanied)	-0.05488	-0.06383	0.11870**
	(0.09715)	(0.08083)	(0.05259)
Angler's ability (Kg)	0.07703***	-0.06371***	-0.01322***
	(0.00817)	(0.00725)	(0.00451)
Federated (1=federated)	-0.18884**	0.16890**	0.01993
	(0.09305)	(0.0786)	(0.04992)
Catch reporting (1=reports)	-0.12457*	0.04973	0.07483**
	(0. 06485)	(0. 05519)	(0. 03401)

***, ** and * are statistically significant at 1%, 5% and 10% level, respectively. Figures in parentheses are the standard errors.

Annex 1. **Recreational fisheries questionnaires**

Date: / / - Time:

1. Sex: Male ☐ Female ☐

2. Age:

3. Marital status: Single ☐ Married ☐ Widowed ☐ Separate / Divorced ☐

4. Place of residence:

5. Studies carried out: No one ☐ Primary ☐ BUP or FP ☐ Middle / higher education

6. Profession to which he habitually devotes:

7. Do you have a degree related to fishing? (Fishing pattern, naval mechanic, etc.) indicate which one:

8. Number of family members:

9. Is anyone engaged in fishing?

10. Fishing gear: - Buoy - Lead

11. How many hooks?

12. Specific bait: Yes ☐ No ☐

13. Number of individuals / kilos per catch:

14. Do you respect the minimum sizes? Yes ☐ No ☐

15. Time you spend fishing: - Times per week: - Hours:

16. Fishing: -Daytime -Nighttime

17. Fishing alone or is it usually accompanied?

18. Do you fish and release or only capture?

19. For sale or own consumption?

20. Money spent (€) by fishing day approx (bait, tackle, transport, etc.):

21. Do you have a fishing license? Yes ☐ No ☐ Type:

22. Do you see well the license to fish? Yes ☐ No ☐ DK / DA

23. Do you think that recreational fishing has a negative impact on fish stocks or only negatively affects is by professional fishing? ☐

24. What do you think its repercussion is?

Very high ☐ High ☐ Normal ☐ Very low ☐

25. What type of sport fishing is more harmful?

Fishing from the shore ☐ Fishing from a boat ☐ Underwater fishing ☐

26. Do you know people who sell the catch illegally? Yes ☐ no ☐

27. Would you report it? Yes ☐ no ☐

28. Do you think there is a lot of legal pressure on sport fishermen? Yes ☐ no ☐

29. What do you think of sport fishing being restricted in the same way that hunting is done? (three months a year and three days a week).

30. Do you think that sport fishermen should be federated? Yes ☐ no ☐

31. Would you be willing to give information about of your catches (kilos caught and species) if the Government established a way to do it?

Via Internet ☐ At the nearest port ☐ By letter ☐ other ☐