Monetary valuation of recreational fishing in a restored estuary and implications for future management measures

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Abstract

Recreational fishing is considered a cultural ecosystem service, important in terms of the socio-economic benefits that it provides. In the Nerbioi estuary (northern Spain), investments in water treatment and the closure of polluting industries have led to several benefits such as improvements in water quality, fish abundance and richness and recreational fishing activity. Currently, this activity is performed along the whole estuary including areas that previously were severely polluted. Valuing the benefits of recreational fishing is crucial to support the management of the estuary. The economic valuation is performed using a multi-site travel cost analysis. In addition, the effect on welfare measures of future scenarios where environmental conditions and accessibility change is analysed. Results indicate that each recreational trip in Nerbioi has a use value of 14.98 euros, with an aggregate value of 1.12 M euros year^{-1} for the whole recreational fishers´ community. The simulated scenarios suggest that further environmental improvements would have a positive effect in the activity, increasing the current welfare by 7.5-11.5%. In contrast, worsening of environmental conditions and accessibility could translate into a welfare reduction up to 71%. The monetary use value of recreational fishing partially covers (4.7%) the costs of maintaining the environmental quality of the estuary (i.e. treatment plant maintenance costs).

Keywords

Economic valuation, ecosystem services recovery, random utility models, recreational fishing, travel cost.

1. Introduction

Ecological restoration can reverse the environmental degradation caused by human activities, resulting in a positive impact on ecosystem services (Benayas *et al.*, 2009; Matzek, 2018). Consequently, an improvement on ecosystem services will have positive outcomes for human wellbeing, which is known to depend, to some extent, on the natural environment (Summers *et al.*, 2012).

With 43% of the world´s population living no further than 50 km from an estuary (O'Higgins *et al.*, 2010), estuaries have become some of the most degraded ecosystems (Lotze *et al.*, 2006). Numerous human activities have historically developed around them (Barbier *et al.*, 2011), increasing pressures, generating impacts and compromising their ecological integrity and capacity to provide ecosystem services (Lotze *et al.*, 2006; Barbier, 2017). Investing in restoration of degraded estuaries could help to enhance their ecological status, to recover the ecosystem services they provide, and will likely contribute to improved human wellbeing.

When located in urban areas, healthy estuaries are considered "blue spaces" from which inhabitants can benefit in multiple ways (e.g. recreation, social interactions) (Bullock *et al.*, 2018) and translate into physical and mental health benefits (Nutsford *et al.*, 2016). Recreational fishing is one of the many recreational activities taking place in estuaries, important in terms of the socio-economic benefits that they provide (Pita *et al.*, 2017). It is a cultural ecosystem service (Ghermandi *et al.*, 2012), which, according to the Common International Classification of Ecosystem Services (CICES), are the non-material outputs of ecosystems that affect physical and mental states of people (Haines-Young and Potschin, 2018). Recreational fishing can involve the consumption of material (i.e. catch), and therefore, it has been described as a cultural-consumptive service (Ghermandi *et al.*, 2012). In developed countries, there is an increasing trend for catch-and-release fishing, which does not involve keeping the captured fish (Cooke and Schramm, 2007).

The benefits of recreational fishing can be assessed in monetary terms, for which non-market valuation techniques are considered more adequate than market valuation techniques (Viana *et al.*, 2017). First, because even if it involves the consumption of fish, to base the economic value entirely on the market price of fish-catches would not capture the social benefits that fishers obtain through the practice of the activity. Indeed, the motivations for practicing recreational fishing have been described as a combination of non-catch and catch-related motives (Fedler and Ditton, 1994). Similarly, in the overall satisfaction of fishing, both catches and social aspects are important (Arlinghaus, 2006; Pouso *et al.*, 2018b). Second, non-market valuation techniques are preferred because they estimate consumer values.

The non-market valuation techniques available to assess the recreational benefits are classified in two groups: stated preference and revealed preference methods. Stated preference are direct methods, as user´s are asked how much they are willing to pay or receive for an environmental quality change, while the latter are indirect methods, because they use user´s actual behaviour to build models (Adamowicz *et al.*, 1994).

Travel cost is a well-established revealed preference technique, commonly applied to value recreational uses of the environment (Boyle, 2003). The simplest travel cost models are the single-site models, which estimate access value of a recreational site based on the number of trips demanded by a person in a season and the trip cost of reaching the site (Parsons, 2003). However, these models are unable to account for changes on natural settings that can affect users´ recreational choices.

As recreational fishers choose the fishing site considering expected catches and a wide set of factors (e.g. environmental conditions, infrastructures) (Arlinghaus *et al.*, 2017), incorporating those variables into the econometric models can provide more accurate estimates. The multi-site Random Utility Models (RUM) consider the site-characteristics known to influence the frequency of the recreational trips and are preferred over single-site models because they allow the analysis of value change when those characteristics change (Parsons, 2003). Indeed, RUMs have often been used to analyse the variables that influence both professional and recreational fisher´s decision on where to fish (Hutniczak and Münch, 2018; Pokki *et al.*, 2018).

The use of RUMs for valuing recreational fishing benefits could be especially interesting in restored ecosystems. Environmental factors conditioning the recreational activity could have improved after restoration (Pouso *et al.*, 2019), and if the RUM contains those improved factors, an economic value can be assigned to the improvement, establishing a direct link to the social benefits. Monetary valuation of recreational benefits on restored ecosystems (i.e. valuing changes in recreational ecosystem services) is also useful for assessing the outputs of a restoration project (De Groot *et al.*, 2013). Managers could use the monetary estimate of the benefits to design future management measures, accounting for all the loss and gains that each alternative will involve.

The objective of this study is to assess in monetary terms the current and future recreational fishing benefits generated in the restored Nerbioi estuary. Recreational fishing in Nerbioi has been described as an important social activity highly dependent on the environmental amelioration (Pouso *et al.*, 2018b); performing an economic valuation of the activity could complement these data. To achieve the objective, a multi-site RUM is built. The results of the econometric model are used to value, in monetary terms, the gain/loss of recreational fishing benefits as consequence of future plausible changes in estuarine environmental and access conditions.

2. Methodology

2.1. Nerbioi estuary restoration and recreational fishing

The Nerbioi estuary (Fig. 1) is located on the coast of the Basque Country (northern Spain). It has two distinct zones: the inner estuary, a narrow (25-270m width) channel of 15km length; and the outer estuary, a coastal embayment of 30km^2 that flows into the Bay of Biscay.

During the 19th and 20th Centuries, the intense economic development of the region transformed the area into one of the most economically developed areas of Spain, but it irreversibly changed the morphology of the estuary, altering its ecological conditions (Cearreta *et al.*, 2004). During the 20th Century, Nerbioi was considered one of the most polluted European estuaries; domestic and industrial sewages were directly discharged into its waters causing intense pollution, with anoxic conditions in the inner part (Cearreta *et al.*, 2004; Borja *et al.*, 2006). The sanitation plan, approved in 1979, led to the implementation of a wastewater treatment plant (WWTP) in 1990. The wastewater treatment was completed with the addition of the biological treatment in 2001. These actions, together with the closure of heavily polluting industries, allowed the progressive recovery of the water quality (Borja *et al.*, 2006, 2010), biotic components (Uriarte and Borja, 2009; Pascual *et al.*, 2012), and the recovery of several cultural ecosystem services, such as beach recreation and recreational fishing (Pouso *et al.*, 2018b, 2018a).

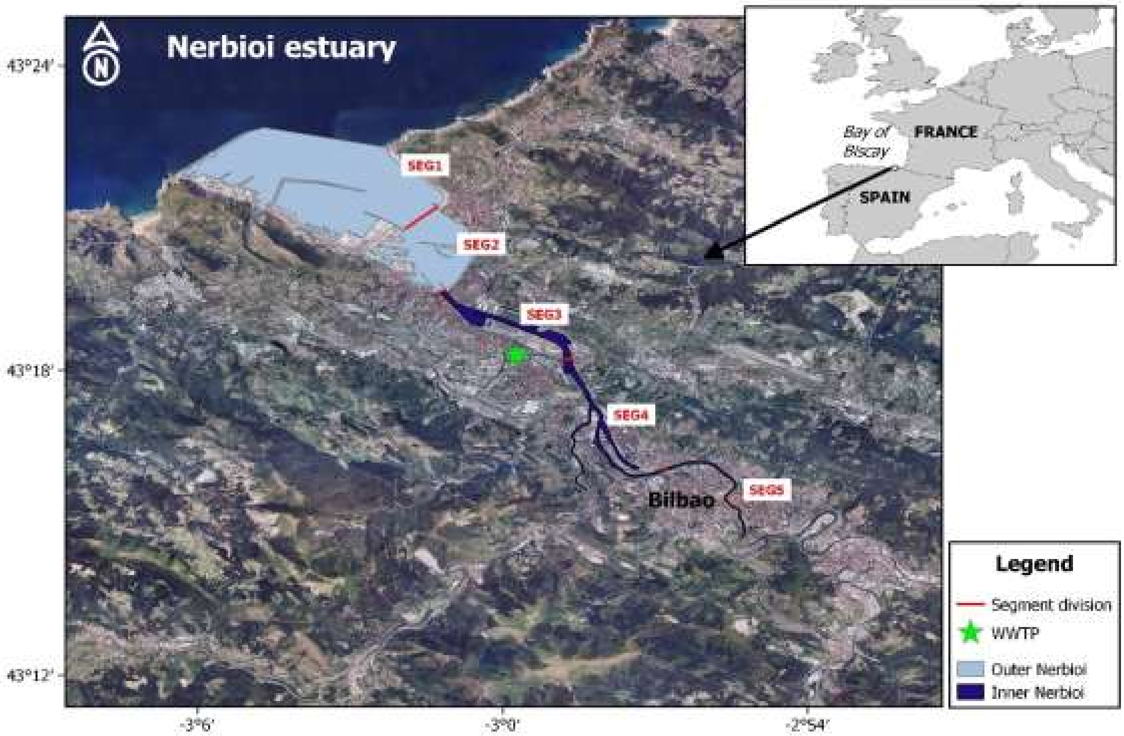

Fig. 1 - Location of Nerbioi estuary within the Bay of Biscay. Estuary division in segments (SEG), used as alternatives on the Random Utility Model. WWTP: Wastewater Treatment Plant.

For this study, the estuary was divided in five segments (SEG), two in the outer estuary (SEG1 and SEG2) and three in the inner estuary (SEG3, SEG4 and SEG5) (Fig. 1). The segments were defined according to the existing sampling stations of the environmental monitoring programmes (Pouso *et al.*, 2019) and following previous studies on ecological status and recreational fishing (Uriarte and Borja, 2009; Pouso *et al.*, 2018b). The sampling stations were established to obtain representative data along the salinity gradient.

In a previous study, Pouso *et al.* (2018b) analysed recreational fishing patterns within the same segments of the Nerbioi estuary, crossing historical biotic and abiotic data and recreational fishers' behaviour and perceptions obtained from a survey (Pouso *et al.*, 2018b). The activity was found to be mainly practiced by locals, middle-aged males whose motivations were more social-oriented than catch-oriented (Pouso *et al.*, 2018b). Significant differences on fishing patterns between SEGs were found, with fishers preferring to fish from shore and in the outer part, having fished in the inner part over more recent years, after restoration of the estuary (Pouso *et al.*, 2018b).

2.2. Multi-site random utility travel cost model

To perform the economic valuation of the recreational fishing in Nerbioi, a multi-site RUM-travel cost model was defined. Contrary to the single-site models, where the dependent variable is the quantity demanded (i.e. number of trips to a recreational site), in RUMs, the dependent variable is the site selected (Parsons, 2003).

The information required to define the model was retrieved from previous studies that analyse recreational fishing in the estuary (Pouso *et al.*, 2018b, 2019) and the entire Basque Country (Ruiz *et al.*, 2014). Environmental data from two monitoring networks (Borja *et al.*, 2016) were also used in the model. The coefficients of the RUM were used to estimate in monetary terms the effect that environmental and access changes can have in the current recreational fishing benefits.

2.2.1. Description of the model

The theoretical basis of the RUM is that individuals make choices under a "utility maximisation framework", and that individual´s utility (U_i) for a given site is a function of observable (V_i) and unobservable (ε_i) characteristics (McFadden, 1973):

$$U_i = V_i + \varepsilon_i \quad (1)$$

As a non-market valuation technique, RUM can be applied in travel cost recreational demand analyses, assuming that the individual (i) chooses a site (j) based on the cost incurred to get there (TC_{ij}) and site-specific characteristics (Z_j) (Pendleton and Mendelsohn, 2000; Haab and McConnell, 2002; Viana *et al.*, 2017). Therefore, the utility associated with visiting a site is a function of the travel costs (TCij), site-specific characteristics (Zj) and a random error term (e_{ij}):

$$U_{ij} = f\left(TC_{ij}, Z_j\right) + e_{ij} \quad (2)$$

To specify a RUM for recreational fishing in Nerbioi, the five SEGs defined by Pouso *et al.* (2018b) (see 2.1.) were used as the alternative-sites. We assumed that the respondents compared the SEGs using site-specific characteristics and travel cost to reach the sites, choosing the option that maximized the utility.

Based on these premises and with the information on the number of trips per year that each fisher makes to each SEG, a conditional logit model (i.e. considering only alternative specific variables) was specified (McFadden, 1973). Precisely, each trip made by each respondent over a year was considered as a single choice occasion and assumed not to be conditioned by previous choices made. The conditional logit model was calculated with the *mlogit* package (Croissant, 2018) in software R (R Core Team, 2015).

The parameters of the model were used to estimate the relative WTP of each attribute known to affect the site chosen,

$$WTP_x = {}^{\beta_x}/_{-\beta_{tc}} \tag{3}$$

where β_x is the coefficient for the *x* attribute, one of the site-specific characteristics (Z_i), and β_{tc} is the coefficient of the travel cost. The "maximum expected trip utility" (EU^0) was estimated for each trip as:

$$EU^0 = ln\{\sum_{ij}^{s} exp(\beta_{tc}tc_{ij} + \beta_Z Z_j)\} \tag{4}$$

where β_{tc} and β_z represent the coefficients of the travel cost (tc_{ij}) and the site-specific characteristics (Z_j), respectively. The mean maximum utility value per trip in monetary units ($\bar{s}$) was estimated dividing the sample mean "maximum expected trip utility" ($\overline{EU}^0$) by the travel cost coefficient:

$$\bar{s} = {}^{\overline{EU}^0}/_{-\beta_{tc}} \tag{5}$$

The aggregated value per recreational fisher ($\bar{S}$) was calculated as:

$$\bar{S} = \bar{s} \cdot T \tag{6}$$

where T is the average seasonal number of trips per recreational fisher, and fixed to 30 (Ruiz *et al.*, 2014; Pouso *et al.*, 2019). The aggregated seasonal value was calculated as:

$$AS = \bar{S} \cdot POP \tag{7}$$

where *POP* is the recreational fishers´ community in Nerbioi, estimated in 2,500 fishers (Pouso *et al.*, 2019).

2.2.2. Travel cost estimation

The travel cost was calculated using data gathered from a survey administered to recreational fishers in Nerbioi (Pouso *et al.*, 2018b). The questionnaire was distributed between January and September 2016 using two approaches: (i) on-site face-to-face interviews (*in situ* sampling) and (ii) contacting fishing clubs and federations (*ex situ* sampling). A total of 146 questionnaires were completed (50 *ex situ* and 96 *in situ*), which represents 5.8% of the estimated recreational fisher´s community in Nerbioi. More details on questionnaire design and distribution can be found in Pouso *et al.* (2018b).

The travel cost for each respondent in each SEG was estimated using the survey questions regarding: (i) the fishing experience in each of the SEG (if they fish nowadays in the SEG and how many days year^{-1}); and (ii) questions about the specific day when they answered the questionnaire (if they fished in the estuary that day, which was the fishing site destination, the origin and the transport used to reach it).

For each respondent *i* and each alternative *j*, travel cost (TC_{ij}) was defined as the sum of the travel expenses required to reach the fishing site (TE_{ij}) and the time cost (tC_{ij}):

$$TC_{ij} = TE_{ij} + tC_{ij} \tag{8}$$

The origin was unique for each respondent and considered as the coordinates of the centroid of the postal code from where they began their journey (e.g. home, work) to the five alternatives. The first destination estimated was the real destination, i.e. the SEG visited by the respondent the day when answering the questionnaire. The coordinates for the remaining alternatives were fixed selecting the two most popular fishing spots in each SEG, one per estuarine bank, with the information collected on the previous study (Pouso *et al.*, 2018b). When various fishing spots in the same SEG and estuarine bank received similar number of visitors, we selected the one that was better connected by road and by public transport. Also, mobility between the two banks of the estuary is easy and it would not be uncommon for the same fisher to move from one bank to the other to practice fishing. However, in order to keep the number of alternatives fixed to five (i.e. one per SEG), we assumed that each respondent will remain on the same bank (i.e. bank of the real destination) and reach all the SEGs using the same transportation.

The distance and time were calculated using the *ggmap* package (Kahle and Wickham, 2013) in R environment (R Core Team, 2015), following the methodology explained in Pouso *et al.* (2018c). The travel expenses (TE_i) were dependent on the type of transport used to reach the fishing site; therefore, considered equal to zero when the fisher walked or cycled. When public transport was used, the price of a round ticket from origin to destination was considered. If the visitor reached the fishing site driving, the travel expenses were calculated as:

$$TE_{ijCar} = 2 \times (toll_{ij} + D_{ij} \times carCost) + parkfee_j \times tfishing_{ij} \quad (9)$$

where $toll_{ij}$ is the one-way price of the highway toll; D_{ij} is the distance travelled; *carCost* is the average running cost per km of a vehicle in Spain (=0.35€)[1]; *parkfee* is the price per hour of car park (=0.53€, only applicable in the left bank at SEG4); and $tfishing_i$ is the time spent fishing. For visitors who travelled by car and accompanied, the TE_{ijCar} was divided by 2 because they were expected to share the costs.

Time costs (tC_{ij}) for each visitor and segment were calculated as:

$$tC_{ij} = t_{ij} \times tC_{mean} \quad (10)$$

where t_{ij} is the time spend travelling from the origin to the destination (*j*) by each visitor; and tC_{mean} is a constant that indicates the monetary value of the time spend travelling (€ min^{-1}), calculated as:

$$tC_{mean} = VTT \times {}^{I_{ind}}/_{wh} \times {}^{1}/_{60} \quad (11)$$

where I_{ind} is the mean available income per individual in the sample (=10,920 € year^{-1}); wh is the average annual working hours (=2080 h); and VTT is the average value of travel time per income, which following Fezzi *et al.* (2014) was considered equal to $3/4$.

[1] The average running cost per km of a vehicle was estimated with the information from the report that estimated the average cost of maintenance of petrol and diesel cars in Spain in 2017 (http://aeaclub.org/cuanto-cuesta-tener-coche/), and considering the diesel/petrol car-fleet ratio in Spain (http://www.acea.be/statistics/article/Passenger-Car-Fleet-by-Fuel-Type)

2.2.3. Site-specific variables

The RUM assumes that site-specific attributes influence individual´s choices and should be included in the model. Recreational fishing is considered to be influenced by fishers characteristics (Abernethy *et al.*, 2007), by the infrastructures around fishing sites (Griffiths *et al.*, 2017), by environmental conditions (Hampton and Lackey 1976) and by the possibility of catching fish (Fedler and Ditton, 1986; Arlinghaus, 2006). These variables can potentially determine the recreational experience and consequently, fisher´s satisfaction with the activity (Hunt, 2005; Arlinghaus *et al.*, 2014, 2017), ultimately influencing the fishers´ choice and the number of trips to a site. Considering the effect of catch and non-catch variables to the overall recreational fishing experience, we selected four site-specific variables to be included in the RUM (Table 1).

Table 1 – Site-specific variables considered to be introduced in the Random Utility Model. SEG: Segment

Variable	Description	SEG1	SEG2	SEG3	SEG4	SEG5
Fish	The ecological status in each segment was estimated using the data from (Borja *et al.*, 2017).	High	High	Good	Good	Moderate
Water access	The number of metres available to fish from shore, calculated by (Pouso *et al.*, 2019).	1500	3500	1755	1020	450
Car park facilities	1= if there are car park facilities close to the fishing spots and 0=if there are not car park facilities or if facilities are shared with other groups such as residents.	1	1	0	0	0
Aquatic conflicts	1= If there is conflict with aquatic activities such as fishing boats, aquatic sports, etc. and 0=No conflict	1	1	1	0	0

The *Fish* variable is qualitative and defined considering the AZTI's Fish Index (AFI) values (Uriarte and Borja, 2009) measured between 2007 and 2017. From these measurements, we differentiated the segments according to three categories: "high" ecological status, for the two segments in the outer Nerbioi, "good" in the SEG3 and SEG4, and "moderate" for the innermost SEG5 (Table 1).

Facilities in the recreational site could affect the number of trips taken by fishers. Therefore, two indicators were selected to be included in the RUM: (i) *water access*, defined as the shoreline metres available to fishers to practice the activity; and (ii) *car park facilities*, a dummy variable indicating the availability of car park facilities. Finally, to represent the possible conflicts with other activities that might have a negative effect on the recreational fishing activity, we defined an additional dummy variable, *aquatic conflicts*, which represents the conflict that might arose when the space is shared with other aquatic activities (e.g. recreational sports, maritime transport) (Table 1). The values of *car park facilities* and *aquatic conflicts* for each SEG were based on recreational fishers´ comments when carrying out the recreational fishing survey (Pouso *et al.*, 2018b).

2.3. Future scenarios

The RUM coefficients were used to calculate the future welfare changes in recreational fishing benefits, which might occur if environmental conditions or accessibility change, by defining and simulating future scenarios.

Seven future scenarios were defined considering the site-specific variables included in the final RUM and based on plausible changes in the estuarine environmental conditions and the disappearance of certain SEGs as fishing sites (see Table 3). All the scenarios were defined considering previous studies, current space conflicts and possible management measures, which could change the estuarine conditions in coming years and affect the recreational fishing activity.

Scenarios SC1 and SC2 simulate extreme changes, based on the disappearance of recreational fishing from the outer Nerbioi. The SC1 simulated a fishing ban in SEG1, while SC2 simulated a ban in SEG1 and SEG2. These scenarios could only happen if the competition between recreational fishing and other activities (e.g. maritime transport, professional fishing, cruises) lead managers to ban the recreational fishing from the outer estuary.

In SC3 and SC4, improvement/worsening of environmental conditions were simulated for the whole estuary. The improvement of environmental conditions (SC3) could be achieved if a coastal submarine outfall, which would divert the WWTP inputs to the open sea, is built (Pouso *et al.*, 2019). Currently, the WWTP outputs are discharged to SEG3, negatively affecting the environmental conditions in the estuary. In SC4, the opposite situation, general worsening in environmental conditions, was simulated. This scenario could be related with future accidental failures of the WWTP, intense dredging works, etc. (Pouso *et al.*, 2019). Although this is unlikely to occur, this scenario gives an idea of how much welfare has been gained due to the improvement after the ecological restoration of the estuary.

In SC5 and SC6, the loss of accessible shoreline in the most popular SEGs (SEG1 and SEG2) (Pouso *et al.*, 2018b) is simulated. In SEG2, a recreational port has recently been expanded to allow cruise mooring in an area that is intensively used by recreational fishers, making the coexistence of the two activities difficult. In SEG1, the most popular recreational fishing site is a small port located on the left bank of the estuary, where the competition with other activities (mainly maritime transport) and the presence of boats (professional and recreational) is high. Therefore, the disappearance of shoreline in SEG2 (SC5) or a combined shoreline loss in SEG1 and SEG2 (SC6) were considered plausible scenarios. The SC7 is a combination of the previous SC3 (improvement of environmental condition) and SC6 (loss of shoreline in SEG1 and SEG2).

Following Parsons (2003), the change on welfare due to the disappearance of a fishing sites (ΔW_l), is calculated based on the equation for the maximum expected trip utility (eq. 4):

$$\Delta W_l = \frac{\left[\ln \sum_{j-1}^{i} exp(\beta_{tc}tc_j + \beta_z Z_j) - \ln \sum_{j}^{i} exp(\beta_{tc}tc_j + \beta_Z Z_j)\right]}{-\beta_{tc}} \quad (12)$$

where the difference between the maximum expected utilities with (j-1) and without (j) the disappearance of one site are divided by the travel cost coefficient. Change in welfare is again calculated per choice occasion (i.e. trip).

The welfare change per choice occasion (i.e. trip) after changes in estuarine conditions ΔW_q was calculated as:

$$\Delta W_q = \frac{\left[\ln \sum_j^i exp\left(\beta_{tc} tc_j + \beta_z Z_j^*\right) - \ln \sum_j^i exp\left(\beta_{tc} tc_j + \beta_z Z_j\right)\right]}{-\beta_{tc}} \qquad (13)$$

where Z_j^* captures the quality change in the variable Z on site j.

A mean value per trip is estimated as the mean value of ΔW_l or ΔW_q for the sample. The seasonal value per fisher and for the estuary were calculated following equation (6) and (7) for each change scenario.

3. Results

3.1. Characteristics of the sample

A total of 95 out of the 146 questionnaires obtained were used for defining the RUM. The rest were discarded due to: (i) respondents answered the questionnaire on a day when they did not fish inside Nerbioi, not providing information on transport (n=29); or (ii) the information regarding fishing days in each SEG was incomplete (n=22). The demographical characteristics of the sample are resumed in the Appendix Table A.1.

3.2. Valuation of recreational fishing benefits

Out of the four site-specific variables considered (Table 1), two were included in the RUM: *fish* and *water access*. *Car park facilities* and *aquatic conflicts* were tested but also discarded, as their contribution to the model was negligible.

In the selected RUM (Table 2), the TC estimate was negative and significant, meaning that the likelihood of choosing a specific site for fishing decreases as travel costs increase. The *fish* estimates are positive, meaning the lower the fish quality, the lower the recreational benefit that recreational fishers obtain from the estuary. The *water access* variable was positive, meaning that utility increases as the number of metres available for fishing increases.

Table 2 - Coefficients of the Random Utility Model in the Nerbioi.

	Coefficient	**Std. Error**	**z-value**	**Pr(>|z|)**
Travel Cost	-0.1837	0.0050	-36.7315	**<0.0001**
Fish "good"	1.7510	0.0712	24.5804	**<0.0001**
Fish "high"	2.2722	0.0781	29.0818	**<0.0001**
Water access (m)	0.0003	0.0000	21.0661	**<0.0001**
log-Likelihood	-14,762			

The mean maximum expected utility per trip was estimated at 14.97€ per trip (sd=3.93). Considering the mean number of trips that each fisher makes to Nerbioi, the seasonal utility per fisher was estimated at 449€ per year, while the aggregated value for the entire recreational fishers´ community was 1.12M€ per year. The marginal WTP was 9.53€ per trip for *fish* in "good" status with the higher value corresponding to *fish* in "high" condition (12.37€ per trip). The *water access* variable affects each trip in a positive way, 0.1€ per trip per 100m (0.001€ m^{-1}).

3.3. Future scenarios

The disappearance of recreational fishing sites from Nerbioi, simulated in scenarios SC1 and SC2 (complete disappearance of SEG1 and SEG1+SEG2, respectively) resulted in recreational fishing welfare loss with respect to the baseline, especially high for SC2 (42.4%).

Changes in estuarine conditions were simulated by modifying the values of the variables *fish* and *water access* in the RUM (Table 3). The SC3 corresponded to an improvement scenario, where *fish* was upgraded to "high" and resulted in a welfare increase of 11.5%. The worst scenario was registered in SC4, where *fish* was worsened to "moderate", leading to a welfare loss of 71%. The reduction of the variable *water access* (SC5: loss of 1000m in SEG2 and SC6: additional loss of 700m in SEG1) had a moderate negative impact, with the lowest welfare change from the seven simulations.

The effect of change in *fish* was more intense than that observed after change in *water access*. Indeed, when changes in both variables were combined (SC7), the positive effect of fish improvement was able to compensate the shoreline loss, resulting in a final welfare gain of 7.5%.

Table 3 – Welfare change for seven scenarios. In SC1 & SC2 the complete ban of fishing in some sites (SEG) was simulated. In SC3-SC7 changes in *fish* and *water access* variables were simulated. Data in italic indicates welfare change values. Key: “Change”, gain or loss in the aggregated seasonal value; “Absolute”, the aggregate seasonal value for each scenario and estimated by applying to the baseline aggregate seasonal value (1.12M euro year^{-1}) the value indicated in “Change”.

Scenario	**Description**	**€ trip^{-1} (mean)**	**€ season^{-1} (fisher)**	**€ season^{-1} (fishers´ community)**	
				Change	**Absolute**
Baseline	Current situation	14.98	449.4		1,123,426
Change in access					
SC1	Fishing is forbidden in SEG1	*-1.28*	*-38.4*	*-95,915*	1,027,511
SC2	Fishing is forbidden in SEG1 and SEG2	*-6.35*	*-190.5*	*-476,220*	647,206
Change in quality					
SC3	*Fish* improves to “high” in all SEG	*+1.73*	*+51.8*	*+129,571*	1,252,997
SC4	*Fish* decreases to “moderate” in all SEG	*-10.64*	*-319.2*	*-797,909*	325,517
SC5	Shoreline reduction: 1000m (35%) in SEG2 right bank	*-0.61*	*-18.3*	*-45,645*	1,077,781
SC6	Shoreline reduction: 1000m (35%) in SEG2 right bank & 700m (47%) in SEG1 left bank	*-0.82*	*-24.6*	*-61,549*	1,061,877
SC7	Combination of SC3 & SC6	*+1.12*	*+33.5*	*+83,676*	1,207,102

4. Discussion

The probability of visiting the different fishing sites in the Nerbioi is determined by the costs and distances to reach the fishing sites, the environmental conditions (i.e. fish conditions) and the length of accessible shoreline. The dependence of the utility with the different characteristics is consistent with previous economic valuation studies performed in other aquatic environments (Bateman *et al.*, 2016). Indeed, spatial restrictions, crowding, fish catches and environmental quality are some of the most important variables considered to influence recreational fishers´ satisfaction (Arlinghaus, 2005; Griffiths *et al.*, 2017). We included two of those four variables in the model (i.e. spatial restrictions and environmental quality), while crowding and fish catches could not be added due to lack of data.

The environmental improvement of the Nerbioi estuary in the last decades (Borja *et al.*, 2010; Cajaraville *et al.*, 2016) is responsible for the current good status of fish (Uriarte and Borja, 2009). Also, the RUM highlighted the importance of fish status in the fishing utility associated with the SEGs, as the better the fish status in a specific SEG, the greater the probability of a fisher visiting it. Therefore, the current value of recreational fishing (estimated at 449€ $year^{-1}$ $fisher^{-1}$ and in 1.12M€ $year^{-1}$ for recreational fishers´ community) is a direct consequence of the management measures adopted to improve the estuarine sanitary and ecological conditions. Environmental changes can encourage recreational fishers to change their behaviour (Fulford *et al.*, 2016), as reported for Nerbioi (Pouso *et al.*, 2018b), and this results in additional social benefits that can be monetarily assessed.

The analysis of future scenarios suggested that the environmental conditions (i.e. fish status) impact the recreational fishing activity. Indeed, the highest welfare gain and loss were obtained in the scenarios where improvement and worsening of *fish* status were simulated. The presence of fish and the possibility of catching them is essential for fishers when deciding where to fish (Fedler and Ditton, 1986; Arlinghaus, 2006). The combination of shoreline loss with improvement on fish status resulted in a positive effect on welfare, which indicates that environmental conditions (in terms of fish and catches) are more important than shoreline accessibility on fishing-site choice.

Changes in accessible shoreline have a lower effect on recreational fishing than changes in fish condition, as reflected in the scenarios where the changes in shoreline were analysed alone. The incidence on welfare was relatively lower for shoreline loss than for fish variable changes. The low number of accessible fishing spots has been pointed out as an important limitation for recreational fishing in urban areas (Arlinghaus and Mehner, 2004); therefore, future management measures which negatively affect accessibility should be carefully analysed. Indeed, the extension of the industrial port in the left bank at SEG1 worsened the accessibility in the outer Nerbioi in the last decades. According to Pouso *et al.* (2018b), this activity was intensively practiced in this part of the estuary before the port extension, but the welfare loss could not be estimated due to the lack of historical data on recreational fishing in Nerbioi. Even with the reduction of shoreline, the competition with other activities in outer Nerbioi, and the improvement of the environmental conditions in the inner estuary, fishers still prefer to fish in the outer Nerbioi (Pouso *et al.*, 2018b). Therefore, the monetary value of recreational fishing in the estuary is highly dependent on the outer area. However, if other maritime activities continue to compete with recreational fishing in the outer Nerbioi and the environmental conditions continue to improve in the inner part, a change in recreational fishers´ preferences and behaviour might occur.

The functional form of the RUM selected result in certain limitations and therefore, the estimated value should be used with caution. The relatively low number of surveys and the high number of trips taken by each respondent led to the adoption of a model where each trip is a single choice occasion, independent of the previous trips taken by the same individual. Considering that previous trips will not influence decisions taken by anglers in future trips (e.g. where to fish) is an important assumption (Parsons and Massey, 2003). Also, the model only uses site-specific variables as explanatory variables, ignoring the characteristics of the decision-maker (Paltriguera *et al.*, 2018). The number of responses did not allow the application of the more precise mixed conditional model, which introduces decision-makers characteristics as dependent variable and allows the correlation between the different aspects of the utility (Paltriguera *et al.*, 2018).

The data used for aggregation was based on Ruiz *et al.* (2014) and Pouso *et al.* (2019), who estimated the fisher community in Nerbioi in 2,500 fishers, with 30 fishing trips per year in mean. This is a rough approximation to the recreational fishers´ community, and future studies able to differentiate between active and inactive recreational fishers, as well as preferred fishing areas, would improve the accuracy of the aggregated value.

This study suggests that recreational fishing in Nerbioi is an important economic activity, which adds to its social importance (Pouso *et al.*, 2018b). Furthermore, this activity is only one of the multiple activities that could have benefited from water improvement, and that the positive effect could be even higher for the others. Viana *et al.* (2017), who studied different recreational activities in a marine sanctuary, found that the group of recreational users that place the less relative importance to environmental quality were indeed recreational fishers.

The monetary valuation of recreational fishing complements previous studies that analysed the activity for its social importance and environmental dependency (Pouso *et al.*, 2018b, 2019). These studies offer complementary information, and their combination could be helpful in advancing towards an integrative approach for ecosystem services valuation and for better understanding and managing of these social-ecological systems (Outeiro *et al.*, 2017). Marine recreational fishing has been reported as an important activity in terms of economic and social revenues for other Spanish regions and Europe (Hyder *et al.*, 2017; Pita *et al.*, 2018); however, research and information on the activity is still scarce, especially in southern European countries (Pita *et al.*, 2017). This study, together with the aforementioned studies covering social and environmental aspects of the recreational fishing in Nerbioi, can help to advance towards a better understanding of the activity in southern European countries.

The monetary value of recreational fishing estimated in this study adds to a previous study that estimated the recreational use value of the estuarine beaches (Pouso *et al.*, 2018c). The aggregated use value of these two activities is estimated in more than 4.6M€ year^{-1}, which is an important amount able to partially cover the costs of WWTP maintenance, estimated in 23.7M€ year^{-1}.

Due to the econometric methodology followed in this study and the one performed in beaches (Pouso *et al.*, 2018c), the benefits provided in Nerbioi have only been partially valued. First, because the travel cost methodology can only estimate the use values of the activities, but this environment can also provide non-use values. To calculate non-use benefits, the current information could be complemented with a stated preference method exercise, asking direct questions to identify both use and non-use values. Also, the economic valuation is considered partial because, recreational fishing and beach recreation are only two of the multiple recreational activities happening in Nerbioi, activities that have not been valued yet, and that will increase the economic value of the ecosystem services provided by this restored ecosystem.

The valuation of cultural ecosystem services and their non-market benefits, such as recreational fishing, provide useful information to managers, who could incorporate the data in analysis for policy decisions (Viana *et al.*, 2017). Nerbioi estuary, being in a highly populated area, offers to its inhabitants many recreational opportunities, and ecological restoration has increased those opportunities. Indeed, increasing recreational outdoor opportunities in urban areas can have a greater impact on welfare than in rural areas, which could be related to the scarce number of similar recreational alternatives (Bateman *et al.*, 2016).

5. Conclusion

Economic valuation of changes in recreational activities in restored ecosystems can be performed specifying multi-site travel cost RUMs. This revealed preference technique allows the incorporation of the environmental conditions that changed after ecosystem restoration and that potentially influenced the recreational activity. The economic valuation of restored ecosystems provides valuable information for managers in two ways: first, because it allows the valuation of the welfare change after restoration; and second, because the built model can be used to simulate future conditions and analyse the expected gains or losses in welfare.

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