Assessing the impact of management on sea anglers in the UK using choice experiments.

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Abstract

Recreational sea angling is a popular activity generating significant socio-economic benefits but can impact on fish stocks. The motivations of recreational sea anglers go beyond catch, with a diverse range of motivations relating to physical health and well-being. Heterogenous motives and the popularity of catch and release practices mean that applying commercial fisheries management goals (maximum sustainable yield) to recreational fisheries could result in reduced participation, increased non-compliance, and a subsequent loss of both market and non-market values generated through recreational angling activities. Hence, assessment of sea angler preferences for management is important for the development of appropriate management strategies. In this study, a choice experiment was conducted to assess sea anglers' preferences for changes in UK sea angling management measures. Stated preferences for catching, keeping, and releasing fish due to bag limits and minimum-landing sizes were assessed. Willingness to pay (WTP) estimates for marginal changes of catching the first sea bass on a trip were between £11 and £31 depending on whether the fish could be kept or released and between £11 and £28 for cod, respectively. WTP was much higher for fish caught and kept than caught and released suggesting that consumption of fish was an important motivation. Minimum size was the most considered choice attribute for respondents, while cost was less commonly considered. The implications of the findings are discussed in the context of future management of recreational fisheries.

Keywords: Stated Preference, Choice Experiment, Recreational Angling, Fisheries Management

Highlights

- UK anglers exhibit decreasing marginal utility for the amount of catch.
- Keeping the catch was more valuable than releasing it.
- Minimum size should be a key consideration for policy makers.

1. Introduction

The belief that open access renewable resources are subject to unsustainable depletion was first introduced through the concept known as 'The Tragedy of the Commons' (Hardin, 1968), which highlights how harvesters maximising immediate personal gain leads to resource exhaustion and future scarcity for resources with unrestricted access (Suphaphiphat et al., 2015). Fisheries is an example of an open access resource that can be 'rival but not excludable', which means that the resource is not available to anyone else once it has been extracted (e.g., harvested fish). Therefore, the conflicts among different user groups requires some form of management to ensure sustainable exploitation and maximise the societal benefits created (Arlinghaus, 2005).

Historically, fisheries management has focused on regulating commercial fisheries, but the inclusion of marine recreational fisheries (MRF) within fisheries governance has been limited (e.g. Potts et al., 2020). The potential for impact of MRF on fish stocks is recognised (e.g. Coleman et al., 2004; Cooke and Cowx, 2006; Hyder et al., 2017; Radford et al., 2018), leading to increasing inclusion in fisheries management with separate catch limits set for commercial and recreational fisheries (e.g. Ryan et al., 2016).

Motivations for recreational fishing vary greatly between individuals resulting in highly heterogeneous benefits (Arlinghaus et al., 2008; Johnston et al., 2010). These include benefits derived from catch, but also related to physical health and well-being like spending time in nature, socialising with friends, exercise, and relaxation (Birdsong et al., 2021; McManus et al., 2011). This means that the traditional management approaches used for commercial fisheries of Maximum Sustainable Yield (MSY) may not be appropriate for generating benefits from MRF (McManus et al., 2011; Arlinghaus et al., 2019). MRF catches, objectives, benefits,

64 and governance has led to conflict with commercial fisheries, especially where management is
65 needed to prevent stock decline (Ngoc and Flaaten, 2010).

66 MRF can have significant economic and social benefits (e.g. Arlinghaus et al., 2019;
67 Arlinghaus and Cooke, 2009; Cisneros-Montemayor and Sumaila, 2010; Cowx, 2002; Hyder
68 et al., 2017, 2018; Hynes et al., 2017). Information on the social and economic benefits of MRF
69 is needed for fair and equitable allocation of resources, but is often lacking (Hyder et al., 2014,
70 2017, 2018, 2020). Data collection programs have been introduced to provide evidence for
71 decision makers and to develop targeted policies to mitigate the impact of recreational fisheries
72 on stocks (Hyder et al., 2014, 2017, 2018). Identifying and understanding the breadth and depth
73 of recreational angler preferences for catch and regulatory characteristics is essential to
74 developing effective fishing policies (Bennett and Blamey, 2001). It also provides decision
75 makers with essential information to appreciate the different angling conditions and
76 preferences (Paulrud and Laitila, 2004), which might impact on compliance and sustainable
77 fisheries management strategies (Arlinghaus et al., 2019).

78 Sea angling, as one particular form of MRF, contributes to local and national economies and
79 anglers gain benefits at least as much as their expenditures (tackle, bait, boat hire etc.) (e.g.
80 Armstrong et al., 2013; Drew, 2004; Roberts et al., 2017). However, using expenditures as a
81 proxy for benefits can be controversial as these methods do not account for the consumption
82 of non-market goods and services (e.g. fish caught, angling experience). The difference
83 between these costs and what anglers are willing to pay for their angling experience represents
84 the consumer surplus (or non-market value) (Hynes et al., 2017). To estimate this non-market
85 value, stated and revealed preference-methods can be used to examine the trade-offs anglers
86 make through actual or hypothetical choices of angling experiences. While revealed preference
87 methods use observable behaviour to examine trade-offs (e.g. travel time and cost versus
88 fishing experiences - Drew, 2004; Hunt, 2005; Pascoe et al., 2014) such methods cannot be

used to assess goods or services that do not exist (e.g. future changes in fisheries regulations). In contrast, stated preference methods, such as choice experiments (CE), elicit preferences by asking individuals to choose between hypothetical experiences or goods described by several relevant attributes (Bateman et al., 2002). Such preference measures can be used to model and simulate fishery management outcomes at a larger scale (Lee et al., 2017) making them a particularly suitable method for informing policy decisions regarding changes in recreational sea angling management.

CE have been used to examine angler preferences for management in a range of settings including freshwater (Aas et al., 2000; Arlinghaus et al., 2014; Knoche and Lupi, 2016; Paulrud and Laitila, 2004) and MRF (Hicks, 2002; Lawrence, 2005; Oh and Ditton, 2006; Oh et al., 2007; Carter and Liese, 2012; Anderson et al., 2013; Kenter et al., 2013; Lee et al., 2014; Lew and Larson, 2012, 2014, 2015; Carr-Harris, A., Steinback, S., 2020). Hunt et al. (2019) reviewed multiple MRF CE and suggested that site-specific models to study catch and environmental characteristics are popular and provide behavioural based policy insights, but they often do not produce WTP estimates for angling management options. In addition, many previous studies failed to define the frequency duration, method of payment or mandatory/voluntary nature of costs resulting in less-than-optimal welfare estimates (Johnston et al., 2017).

For this reason, a CE was designed to explore the preferences of UK recreational anglers for trips with varying catch and management characteristics for North Atlantic cod (*Gadus morhua*) and European sea bass (*Dicentrarchus labrax*). CEs are very flexible valuation methods, but caveats exist in producing reliable and valid WTP measures. Hypothetical bias and credible contingent policies can undermine the credibility of estimates. Here, we mitigate these issues using ex-ante (appropriate survey testing, design and protocols, binary question formats, clear descriptions of consequences of the choice) and ex-post strategies (attribute non-

attendance and protesters' responses). The results are discussed in the context of strategies for future management of recreational sea angling.

2. Methods

2.1. Data collection

Anglers' WTP for catching & keeping and catching & releasing due to management measures was estimated for two commonly targeted species: North Atlantic cod (*Gadus morhua*) and the European sea bass (*Dicentrarchus labrax*). Cod and sea bass were used as they are in the top ten species caught by sea anglers in the UK (e.g. Armstrong et al., 2013) and are also important commercial species, but stocks have declined in recent years (ICES, 2020a, 2020b). Previous choice experiments have utilised registers (such as licenses) to identify suitable target populations (Boxall and Macnab, 2000, Carr-Harris and Steinback, 2020). There is no sea angling licence in the UK and response rates to phone and mail surveys are low, making probabilistic sampling difficult and prohibitively expensive. Instead, a convenience sample was obtained by publicising the survey online through social media, e-newsletters and through key stakeholders on sea angling forums. Over 17,000 invitation emails (including links to an information page and the online survey) were sent directly to a broad range of recreational sea anglers including those who had participated in a previous angling survey (Brown 2012) and the Sea Angling Diary project (https://www.seaangling.org/). Invitation emails were also distributed to stakeholder contacts for distribution to their contacts. The online survey was implemented using Qualtrics (https://www.qualtrics.com) customised using JavaScript and html to be suitable for a CE (see https://github.com/leeper/conjoint-example). The survey consisted of seven sections measuring sea angling activity, views on data collection, views on fish stocks, the CE tasks, views on funding for sea angling, views on management of sea

137 angling and angler demographics. Only the CE section is reported here (see Brown et al., 2019
138 for the full survey instrument).

139 To be consistent with utility maximisation theory, the attributes in a choice task should
140 represent all characteristics relevant to angling trip choice. Practically, this is never possible
141 due to the large sample size and cognitive burden it would place on respondents. Hence
142 attributes were chosen to reflect those most relevant to angler choice and management
143 measures of interest. To reduce the number of attributes whilst capturing preferences of
144 relevance to future management measures, a catch disposition approach was adopted (Carter
145 and Liese, 2012). As WTP for kept and released fish can be significantly different (Milon,
146 1991), this approach facilitates the exploration of differences in angler preferences for quantity
147 (bag limit) and size (minimum landing size) of different species (Carter and Liese, 2012).

148 An initial consultation with recreational fisheries experts and government representatives was
149 held to determine attribute levels and the payment vehicle. Several payment mechanisms were
150 tested for palatability in interviews with anglers. These included compulsory license fees,
151 fishing costs, and increases in local taxes. All were assessed in terms of both interviewees'
152 opinions and their acceptability amongst anglers. Consultation with recreational sea anglers,
153 angling experts, and piloting revealed that introducing licences was highly controversial and
154 that an angling development fund was the least controversial and most plausible payment
155 vehicle. To increase trust in the payment mechanism, respondents were informed that the fund
156 would be administered by an independent body and would only be used to benefit and further
157 recreational sea angling. To reduce hypothetical bias respondents were reminded of their
158 budgetary constraint and the consequentially of their responses at the beginning of each choice
159 card (Fig. 1). In addition, protests against the payment vehicle were identified through follow
160 up questions asking respondents whether they would contribute to a sea angling development
161 fund if one were immediately implemented. If an angler stated that they would not pay, then

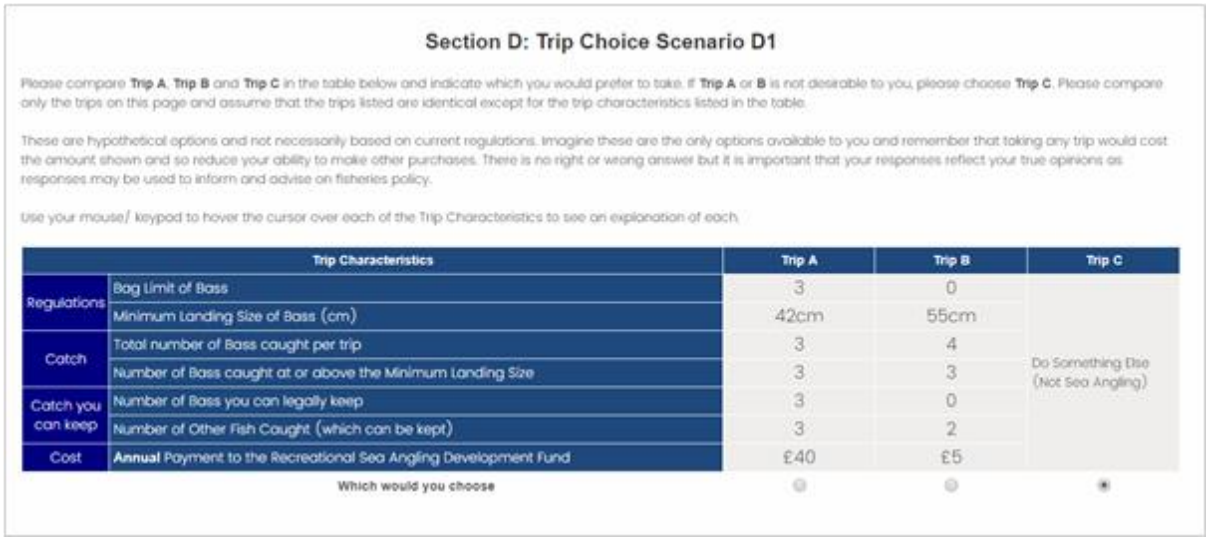
their preferences were not used to estimate WTP as the respondent was not trading off the choice task attributes against the cost. These preparatory steps contributed to reducing hypothetical bias and to providing credible survey information (Johnston et al., 2017; Kataria et al., 2012; Morrison et al., 2000).

The attributes and levels used in both the choice task and experimental design are shown in Table 1. It should be noted that the bag limit, the total number of fish caught, and the number caught above the Minimum-Landing-Size (MLS) were presented to participants in the choice tasks, but were not included in the experimental design. Instead, they were derived from the design attributes that is coherent with the catch disposition model described in Carter and Liese (2012). For instance, the total number of fish caught was calculated as the sum of the number of fish that can be legally kept, the number released due to the bag limit, and the number released due to the MLS. Likewise, the bag limit was calculated from the total number caught minus the number released due to MLS and the number released due to the bag limit.

A discrete dichotomous choice format was adopted as a more dependable format for use in welfare analysis than other choice formats (Johnston et al., 2017). In each choice task, respondents compared two management regimes described using seven trip attributes (Figure 1), versus a third option to do something else. This non-participation opt-out alternative created a way for respondents to avoid the choice tasks (Kontoleon and Yabe, 2003) without forcing respondents to choose an unfavourable scenario (Banzhaf et al., 2001; Louviere et al., 2000). Choice cards were derived using NGENE (Choice Metrics, 2018) adapting a Bayesian D-Efficient design, which has been found to be more efficient than factorial designs (Ferrini and Scarpa, 2007). Bayesian priors were based on parameters estimated from an initial pilot survey of 200 anglers.

To minimise respondent fatigue, each angler was presented with just four consecutive choice tasks. An explanation of the choice context was provided alongside each choice task. Respondents were prompted to treat each trip as identical except for the differences listed on the choice cards (full choice cards are provided in Brown et al., 2019). The online survey was configured to ensure respondents could only view the current choice card, with descriptions of catch and management attributes available on each card. To ensure respondents had the relevant knowledge and experience to make informed choices, choice tasks were tailored to respondent's angling experience by pivoting the species used in the choice tasks on the species (cod or sea bass) that the individual had spent most time fishing for in the last 12 months. To further ensure relevance of the choice scenarios, only anglers who had been sea angling in the past 12 months were recruited.

Fig. 1. Example of a choice card used in the choice experiment showing the information provided and the trip selection presented to the respondents. Additional functionality was provided that cannot be demonstrated that included pop-up descriptions of trip characteristics to support respondents in making informed choices.



Section D: Trip Choice Scenario D1

Please compare **Trip A**, **Trip B** and **Trip C** in the table below and indicate which you would prefer to take. If **Trip A** or **B** is not desirable to you, please choose **Trip C**. Please compare only the trips on this page and assume that the trips listed are identical except for the trip characteristics listed in the table.

These are hypothetical options and not necessarily based on current regulations. Imagine these are the only options available to you and remember that taking any trip would cost the amount shown and so reduce your ability to make other purchases. There is no right or wrong answer but it is important that your responses reflect your true opinions as responses may be used to inform and advise on fisheries policy.

Use your mouse/ keypad to hover the cursor over each of the Trip Characteristics to see an explanation of each.

	Trip Characteristics	Trip A	Trip B	Trip C
Regulations	Bag Limit of Bass	3	0	
	Minimum Landing Size of Bass (cm)	42cm	55cm	
Catch	Total number of Bass caught per trip	3	4	
	Number of Bass caught at or above the Minimum Landing Size	3	3	Do Something Else (Not Sea Angling)
Catch you can keep	Number of Bass you can legally keep	3	0	
	Number of Other Fish Caught (which can be kept)	3	2	
Cost	**Annual** Payment to the Recreational Sea Angling Development Fund	£40	£5	
	Which would you choose	○	○	◉

Table 1. Choice experiment attributes and attributes levels for cod and sea bass. Levels of each attribute are separated by a forward slash (/), with choice cards generated at random from levels of the individual attributes.

Attribute	Choice Modelling	Cod Choice Tasks	Sea bass Choice Tasks
Bag limit	N/A	0/1/2/3	0/1/2/3
Minimum landing size	0/1/2/3	35cm/39cm/ 42cm/46cm	42cm/46cm/ 50cm/55cm
Total number caught	N/A	2/3/4/5/6/7/8	2/3/4/5/6/7/8
Number caught above the minimum landing size	N/A	1/2/3/4/5	1/2/3/4/5
Number that can legally be kept	0/1/2/3	0/1/2/3	0/1/2/3
Number of other fish that can by kept	0/1/2/3	0/1/2/3	0/1/2/3
Number released due to bag limit	0/1/2/3	N/A	N/A
Number released due to MLS	0/1/2/3	N/A	N/A
Cost	1/2/3/4	£5/£10/£20/£40	£5/£10/£20/£40

2.2. Model estimates and WTP calculation

Modelling of CE responses is based on Random Utility Theory (McFadden, 1974), where individuals are assumed to be rational decision makers choosing alternatives that maximise their utility. Modelling proceeds through the estimation of an indirect utility function composed of observable and unobservable components. To account for the known heterogeneity in anglers' preferences, a mixed logit model (Campbell et al., 2009; Hoyos et al., 2009) was fitted to the choice data. Mixed logit models can approximate any discrete choice model derived from the random utility maximisation framework (McFadden and Train, 2002), and can account for anglers' variations in trip choice preferences by allowing the estimated slopes of utility (coefficients) to be random. Hence, the mixed logit estimation does not rely on the assumption of independence from irrelevant alternatives (IIA) which are inherent in other estimation models (e.g. conditional logit (CL) model). The choice of the random parameter can be supported by using t-statistic, the likelihood ratio (LR) and the Lagrange multiplier (LM) (McFadden and Train, 2002). However, the final choice of the distribution of parameters relies on the analyst's judgment related to the meaningful of parameters (Grilli et al., 2021; Scarpa

et al., 2007). If a variable was significant the average WTP was calculated by $\overline{WTP} = -\beta_i/\beta_{cost}$ with β denoting the respective significant coefficient.

2.3. Choice task evaluation

Ex-post control of responses is considered essential to validate the quality CE data and to control for hypothetical bias. Choice tasks were evaluated to identify protestors and to investigate the main attributes driving trip selection. Protestors were defined as those that would not pay the development fee under any conditions. In addition, the main attributes driving selection of trip were investigated through attribute non-attendance questions.

3. Results

In total, 1,527 surveys were returned by anglers who had been recreational sea angling in the UK within the 12 months preceding the survey. 805 respondents completed all the choice tasks. This yielded 805 usable respondents who made 3,205 choices in total with an even split between the three trip choices for all species. Fifteen anglers dropped out before completing the fourth and final choice situation (3 targeting cod, 12 targeting sea bass), resulting in 3,205 out of 3,220 potential choice occasions (Table 2). The whole survey took around 20 minutes to complete with respondents required to be aged 16 years or over.

Table 2. Angler trip choices for cod, sea bass, and total (n = 805 anglers).

Choice	Frequency (%)	Choice Card: Cod	Choice Card: Sea bass
Angling Trip A	1082 (34%)	317 (34%)	765 (34%)
Angling Trip B	1098 (34%)	298 (32%)	800 (35%)
Trip C (something else)	1025 (32%)	314 (34%)	711 (31%)
Total Choices made	3205	929	2276
Number of Anglers	805	233	572

3.1. Characteristics of the sample population

While there is no comprehensive list of sea anglers in the UK, the Water-sports Participation Survey (WPS, Arkenford, 2018) a face-to-face omnibus survey of 12,000 UK households about water sports participation includes questions about sea angling (Hyder et al., 2020a). This provides the best available data on the characteristics of the population, including demography (e.g. age, home location, social group) and fishing characteristics (e.g. number of fishing trips). In comparison, respondents to the CE were more avid, angling an average of 18 days from the shore and 7 days from boats (median 10 and 4 days), compared to 9.4 days from shore and 3.3 days a year, respectively (Hyder et al., 2020a). A large proportion of respondents were male (97%) and aged over 55 years (70%), while this is generally reflective of the UK angling population (Hyder et al., 2020a), our sample was on average older. In terms of the location of sea anglers, the largest proportion of the sample were from the South West and South East of England, which is similar to that found in the WPS (Hyder et al., 2020a).

3.2. Estimating WTP

Mixed logit choice models were fitted to cod and sea bass separately using only non-protest respondents who completed all choice tasks (Table 3). Conditional logit models were also fitted as a reference baseline (see supplementary materials). For sea bass, the MLS, the number of other fish caught and kept as well as the Alternative Specific Constant (ASC) were included as random (see supplementary material for tests). This suggests that respondents hold heterogeneous preferences for these management options. The ASC mean coefficient was not significant, but the variance was. This implies that overall respondents are indifferent to change sea angling regulation, but a substantial proportion of the respondents expressed a desire to maintain the current regulations. The proportion of people who hold a preference for keeping the status quo equates to 40% for sea bass and 41% for cod, based on Gaussian distribution

assumption on the population of respondents (McFadden and Train, 2002). For cod, the number of cod caught and kept were found to be significant as random variables indicating significant heterogeneity in preference for catching and releasing cod.

Table 3. Mixed Logit model results for sea bass (n = 408 decision makers, 1632 individual choices) and cod anglers (n = 162 decision makers, n = 648 individual decisions). Number indicates coefficients, with the standard errors in brackets. Significance is denoted by stars with * representing p<0.05, ** p<0.01 and *** p<0.001. MLS is minimum landing size and BL is bag limit.

Attribute	**Sea Bass**	**Cod**
	Average Effects	
ASC	-0.427 (0.544)	-0.742 (1.109)
Minimum Landing Size –46cm/39cm	-0.402 (0.235)*	-0.618 (0.394)
Minimum Landing Size – 50cm/42cm	-0.352 (0.201)*	-0.582 (0.351)*
Minimum Landing Size – 55cm/46cm	-0.730 (0.250***	-1.426 (0.491)***
Number of sea bass/cod caught and kept - One Fish	2.083 (0.291)***	2.306 (0.596)***
Number of sea bass/cod caught and kept – Two Fish	2.277 (0.316)***	3.533 (0.640)***
Number of sea bass/cod caught and kept – Three Fish	2.227 (0.293)***	0.377 (0.618)***
Number of sea bass/cod caught and released due to MLS - One fish	0.759 (0.229)***	0.895 (0.364)**
Number of sea bass/cod caught and released due to MLS - Two fish	1.008 (0.272)***	1.167 (0.432)***
Number of sea bass/cod caught and released due to MLS - Three fish	1.292 (0.274)***	1.894 (0.511)***
Number of sea bass/cod caught and released due to BL – One fish	0.824 (0.263)***	1.069 (0.512)**
Number of sea bass/cod caught and released due to BL – Two fish	1.547 (0.295)***	2.008 (0.549)***
Number of sea bass/cod caught and released due to BL – Three fish	1.646 (0.270)***	2.111 (0.515)***
Number of other fish (not cod or sea bass) caught and kept – One fish	0.890 (0.219)***	1.292 (0.415)***
Number of other fish (not cod or sea bass) caught and kept – Two fish	1.427 (0.267)***	1.864 (0.513)***
Number of other fish (not cod or sea bass) caught and kept – Three fish	1.858 (0.320)***	2.832 (0.611)***
Cost	-0.067 (0.009)***	-0.083 (0.016)***
Attribute	***Random Effects (std dev.)***	
ASC	3.638 (0.348)***	5.312 (0.970)***
Number of sea bass/cod caught and kept - One Fish		0.259 (0.464)
Number of sea bass/cod caught and kept – Two Fish		-0.889 (0.445)**
Number of sea bass/cod caught and kept – Three Fish		1.686 (0.410)***
Minimum Landing Size – 39/46cm	0.091 (0.239)	
Minimum Landing Size – 42/50cm	-0.709 (0.319)**	
Minimum Landing Size – 46/55cm	0.809 (0.289)***	
Number of other fish (not cod or sea bass) caught and kept – One fish	0.556 (0.541)	
Number of other fish (not cod or sea bass) caught and kept – Two fish	0.531 (0.267)**	
Number of other fish (not cod or sea bass) caught and kept – Three fish	0.835 (0.242)***	
Log likelihood Null model	-1792.9	-711.91
Log likelihood	-1338.67	-474.26
McFadden Pseudo R^2	0.25	0.33

Both cod and sea bass anglers exhibited preferences consistent with normal expectations, with increasing positive preferences for catching & keeping and catching & releasing increasing numbers of sea bass, cod, and other species. Translated into WTP, it was estimated that for a trip in which a single sea bass or cod is caught & kept, respondents were willing to pay £31 and £28, respectively (Table 4). For sea bass this value only increased by approximately £3

when two fish were caught & kept; while for cod it increased by £15, respectively (Table 4). For sea bass, the value decreased for the third sea bass caught & kept (compared to the second) while for cod it increased by just £2, respectively. Sea bass anglers showed positive and significant preferences for catching & releasing undersized sea bass (i.e., sea bass released due to the MLS). Again, significant marginality can be observed in the WTP estimates, with the first undersized sea bass caught & released being valued at £11 while catching & releasing two fish only increased WTP by £4 and catching & releasing three only added another £4 (Table 4).

Table 4. Willingness to Pay for different characteristics of recreational sea angling management regimes. Values are in GBP, which was equivalent to $1.31 US at the time of the survey in 2019. MLS is minimum landing size and BL is bag limit. 95% confidence intervals in parenthesis.

Fish	WTP for catch &	One Fish	Two Fish	Three Fish
Cod	Keep	£27.77 (£11.80-£43.74)	£42.54 (£24.87-£60.21)	£45.39 (£31.80-£58.98)
	Release due to MLS	£10.78 (£2.67-£18.89)	£14.06 (£5.92-£22.19)	£22.81 (£13.22-£32.40)
	Release due to BL	£12.87 (£1.88-£23.86)	£24.18 (£14.21-£34.15)	£25.42 (£17.30-£33.54)
	Keep Other Fish Species	£15.56 (£6.33-£24.78)	£22.45 (£11.01-£33.88)	£34.11 (£21.36-£46.86)
Sea bass	Keep	£31.13 (£21.11-£41.14)	£34.03 (£23.89-£44.16)	£33.28 (£25.89-£40.67)
	Release due to MLS	£11.34 (£5.15-£17.54)	£15.07 (£8.38-£21.76)	£19.33 (£12.10-£26.56)
	Release due to BL	£12.31 (£5.34-£19.28)	£23.13 (£15.72-£30.53)	£24.61 (£18.10-£31.11)
	Keep Other Fish Species	£13.30 (£7.02-£19.57)	£21.33 (£13.60-£29.05)	£27.77 (£18.78-£36.77)

The WTP for catching & keeping sea bass was nearly three times higher than the WTP for catching & releasing undersized sea bass. This suggests that anglers' value being able to catch & keep sea bass, however, this difference decreased with increasing catch quantity. For an increasing number of sea bass caught & released due to a bag limit (i.e., sea bass above the MLS), a positive and significant influence on angler choice preferences was found. The average angler valued catching & releasing sea bass due to a bag limit more than an MLS probably due

to the presumption that fish released due to a bag limit will be above the MLS. WTP for catching & releasing due to the bag limit was less than 2.5 times that for catching & keeping sea bass. The difference between the first and the second sea bass released due to the MLS was only £4, while the difference for catch & release of the first and second sea bass caused by BL was £11.

For cod, WTP estimates for releasing legally sized fish (i.e. releases due to the bag limit) were approximately about 2.7 times lower than that for catching & keeping a fish (Table 4). Anglers generally showed positive preferences for catching an increasing number of non-target (other) species. The WTP to catch & keep three non-target species (£34) was less than that of catching & keeping three cod (£45), and larger than that for catching & releasing three cod due to a bag limit (£25) (i.e. legal sized cod). Sea bass anglers exhibited lower WTP for catching any number of other fish compared to cod. WTP estimates for catching & keeping one, two or three non-target fish were similar to that for releasing one, two or three legally sized sea bass (Table 4).

3.3. Choice task evaluation

To identify protest responses all respondents were asked if they would contribute to the proposed sea angling development fund. 220 respondents (27%) stated they would not pay under any circumstance, 68 were for cod and 152 for sea bass (Table 5). Looking at the trip choices of these 220 protest respondents, 73% of the choices made were for trip C “to do something other than go sea angling”. All respondents were also asked how often they considered each of the characteristics in the choice scenarios when making their trip choices (Table 6). The trip characteristic which anglers most frequently stated they always considered overall in the choice tasks were MLS, while cost was most frequently reported as never being considered by non-protestors (Table 6).

Table 5. Angler responses to follow up question regarding use of the proposed payment mechanism (n = 805). Response categories included: "yes, I would contribute", "yes, I would contribute if certain conditions were met", "I don't know", and "I would not pay under any circumstances".

Response	Cod	Sea bass	Total
Would pay (unconditionally)	37 (15%)	86 (15%)	123 (15%)
Would pay (conditional)	80 (33%)	201 (36%)	281 (35%)
Don't know	38 (16%)	101 (18%)	139 (17%)
Would not pay under any circumstances	68 (28%)	152 (27%)	220 (27%)
Missing	17 (7%)	25 (4%)	42 (5%)

Table 6. Angler responses to attribute attendance follow up question for protestors (n = 202), non-protestors (n = 552), and in total (n = 772).

Protestor	Response	Total Catch	MLS	Bag Limit	Catch > MLS	Keep	Other Fish	Cost
Protestor	Always	46%	60%	47%	46%	49%	40%	63%
	Sometimes	20%	15%	21%	22%	18%	31%	5%
	Never	34%	25%	32%	32%	33%	29%	32%
Non-Protestor	Always	55%	66%	56%	59%	59%	47%	39%
	Sometimes	34%	25%	28%	29%	21%	37%	31%
	Never	10%	10%	16%	12%	20%	16%	29%
All	Always	53%	64%	53%	55%	56%	45%	46%
	Sometimes	30%	22%	26%	27%	21%	35%	24%
	Never	17%	14%	21%	18%	23%	20%	30%

4. Discussion

The results of our CE analysis showed that UK recreational sea anglers obtain substantial benefits from their recreational angling trips. Anglers who had fished in the previous 12 months prior to completing the CE had positive preferences for both keeping & releasing target and other fish species. Estimates of WTP for catching fish under different management scenarios suggest that anglers in this sample preferred management regimes in which they could catch one rather than two cod or sea bass. It should be noted that greater variation in the estimates of WTP for catching & keeping for cod than for sea bass was due to the inclusion of the random coefficients of the standard deviation in the model. The high value anglers attribute to the first sea bass caught & kept could be the result of conservation minded anglers who believe that no

more than one or two sea bass should be caught & kept on any angling trip. An alternate explanation is that anglers rarely catch more than one or two sea bass of sufficient size to keep, so did not view this as a realistic option.

Mixed logit models showed that cod and sea bass anglers in our sample had mixed preferences for the status quo option (ASC in Table 3) as the average effect is insignificant, but the variance is significant signalling that there is heterogeneity in anglers preferences to maintain the current management regime in this sample. This provides mixed support for previous observations of the popularity of catch & release practices and preferences of sea bass anglers for management measures that support sustainability of stocks (Grilli et al., 2019).

We claim that our CE provides interesting insights for future RSA although scepticism still exits toward stated preference results. Our survey minimized the hypothetical bias through implementing ex-ante and ex-post measures and the most neutral payment vehicle available. Contrary, few details are reported in previous CE studies regarding the validity of results and comparisons remain difficult.

Drew (2004) reported WTP values from a CE of UK recreational sea anglers. While the species of fish were not specified, it was found that anglers were willing to pay £0.22 per 1% increase in the size of caught fish and £11 to catch a different fish to what they normally catch. Shore anglers were willing to pay £0.81 for catching an additional fish, while boat anglers were found to have a negative valuation of catching more fish. To our knowledge, no other UK based studies have used CE methods to estimate WTP for catching & keeping and catching & releasing sea bass, hence, our estimates need to be compared to those from CE carried out in other regions. Carter and Liese (2012) estimated angler WTP for catching & releasing groupers, red snapper, dolphinfish, and king mackerel ranged from $11.81 (Dolphinfish) to $80.40 (grouper) in 2003 dollars for catching & keeping the second fish on a trip. Adjusting this to

2018 values is equivalent to £12.88 to £88.02 (using a simple purchasing power calculator giving a range of $16.10 to $110 which was then converted to GBP using the average 2018 exchange rate). Although not comparable species, the two WTP estimates for catching & keeping two cod or sea bass overlap with this range.

Results of this choice experiment survey provide several insights into recreational sea angler's preferences for current management measures in the UK (bag limits and minimum landing sizes). For both cod and sea bass, anglers are more likely to choose one of the proposed management regimes on average thus expressing a preference for changes to current bag limits and minimum landing sizes. However, significant heterogeneity in preferences for the "do something other than sea angling" option for both cod and sea bass suggests that a proportion of anglers also have preferences for not changing current management measures.

While anglers indicate strong preferences towards management regimes with the option of catching & keeping sea bass or cod, this preference was most pronounced for catching & keeping one sea bass with marginal WTP decreasing substantially for additional sea bass and further for the third sea bass which could be kept. In contrast, cod anglers exhibited stronger preferences for keeping a second cod and thus less marginality. This difference may be a result of sea bass anglers habituating to bag limits which permit the retention of a single sea bass or greater conservation awareness. Despite these differences in marginality, these results emphasise the importance of maintaining the ability for anglers to retain some fish through measures such as bag limits. This suggested that despite catch not being stated as the main motivation for sea angling (Brown et al., 2019), consumption of fish is still an important motivation for UK sea anglers as it has been suggested for other regions (Cooke et al., 2018). Catch orientation is considered to be one of the main motivations for anglers alongside behavioural commitment, skill, and centrality-to-lifestyle (Beardmore et al., 2011; Birdsong et al., 2021). Attribute attendance results also highlighted the importance of MLS to anglers'

choices further emphasising the conservation orientation of recreational anglers in this sample and the importance policy makers should ascribe to MLS.

For sea bass, it was unclear how the value of recreational trips might change with increased bag limits due to a relatively large amount of value being attributed to the first sea bass caught. Hence, value maximisation may not be as straightforward as simply increasing bag limits as aggregated value will be determined by the relative number of fish caught and kept and caught and released by the wider population of anglers. For example, the additional value brought by the option of keeping a second legally sized fish (£3) is approximately a quarter of that for releasing the first sea bass due to a bag limit. The value of the option to keep sea bass decreases significantly after the first fish caught & kept, which emphasises the importance of the angling experience on its own. However, for sea bass catching & keeping the third fish results in a disutility with a slight reduction in WTP for the third fish.

A similar pattern of preferences is observable for cod; however, the value of a kept cod decreases significantly only after the second cod can be kept. The effect of disutility created by the third fish caught & kept as observed for sea bass is not present for cod, however, the marginal value of the third fish is a lot lower than the second. The estimated coefficient of the standard deviations for keeping cod increased with the number of cod caught suggesting large heterogeneity in preferences to keep an increasing number of cod compared to sea bass. This highlights the importance of considering the marginal and diverse nature of angler preferences for both kept and released fish.

The option to keep sea bass or cod had more value than other non-target fish, so simple displacement to other species will not retain a similar level of value for these anglers despite possibly satisfying the need to retain fish for food. As the non-target species caught were not specified, it is possible that anglers were interpreting this attribute in different ways. However,

random effects for other fish caught and kept were only significant for sea bass, so this was unlikely to be the case. In addition, there were clear differences between the outcomes for cod and sea bass, suggesting that willingness-to-pay does not generalise across species, despite some similar trends. Managers and policy makers should explicitly account for the marginal nature of angler preferences for catching fish as demonstrated to avoid misstating the aggregate value of changes in management measures.

Comparison of the sample obtained for this study with that of larger samples of recreational sea anglers (Arkenford, 2018) showed respondent to our survey to be older and more avid anglers. Re-weighting the sample to account for these differences could reduce potential biases (e.g., Hyder et al., 2020b), however the size of the population survey provided by Arkenford (2018) limits the potential level of stratification that can be employed. Generating probabilistic samples of sea anglers is challenging and, even where a full list of anglers is available, only people that are willing to respond to the survey are captured making self-selection bias a problem in these surveys. Whilst angler skill and experience has the potential to bias WTP results by presenting low experience respondents with choice tasks involving multiple catch and management attributes. This may introduce its own bias as a lack of experience with proposed choices may lead to inadvertent errors in choice task responses (Johnston et al., 2017).

While results of this choice experiment provides insight into recreational sea angler's preferences for current management measures in the UK (bag limits and minimum landing sizes), it also provides useful information for future management. For example, the preference structure of sea anglers targeting cod and seabass could be used to assess the potential effect of implementing different management measures on the value created by sea angling. As such, it allows evidence-based trade-off analysis between sustaining the cod and sea bass stock at specific levels and the value cod and sea bass creates for sea anglers, which might be gained or lost by introducing different management measures. The impact on the social value of

recreational angling can be predicted combining available information on the fisheries characteristics, economic value, and stock status (Hyder et al., 2020b, 2021). This will allow an assessment of impact of management options on the social use value created by sea angling before rather than after implementation of the measures. In addition, these values could be used to inform allocation decisions between recreational and commercial fisheries (e.g. Lee et al., 2017; Tidbury et al., 2021), if similar values exist for the commercial fisheries. This becomes increasingly important where the stocks area important for both sectors and are in decline.

5. Conclusions

Analysis of the online CE results in this study provide estimates of UK recreational anglers WTP for catching & keeping and catching & releasing sea bass and cod, two of the most important recreational species in the UK. Previous choice experiments of recreational anglers' have focused on site choice models to elicit preference of anglers. While these are useful to understand why an angler chooses to fish at a particular site, they are not well suited to assessing the welfare implications of resource management. Adopting a catch disposition model allowed for the differentiation of recreational angler WTP for catching & keeping and catching & releasing due to both size and quantity restrictions. We were able to further differentiate between WTP for catching additional numbers of fish and catching & keeping non-target fish. In doing so, we have shown that there is significant marginality in recreational angler WTP for catches with WTP for catching & keeping sea bass increasing up to just two fish after which it declines. This result stresses that for the UK sea anglers targeting sea bass or cod, eating the caught fish is an important motivation for angling.

Management measures will always be a trade-off between sustainable stock management and maintaining the value created by recreational sea angling. This study has demonstrated how CEs and a catch disposition approach can be used to inform the management of recreational

fisheries by providing WTP estimates for catching & keeping and catching & releasing under different management measures. These WTP estimates can be used in conjunction with angler catch data, fish stock models and participation data to assess the impact of management measures or catch may have on both the relative value of recreational sea angling and vulnerable fish stocks. As there is no simple approach to allocating catches between commercial and recreational fisheries, it is crucial that decision makers have all the information available to understand how management impacts the benefits provided by sea angling and help identify appropriate strategies for the co-management of recreational and commercial fisheries.

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