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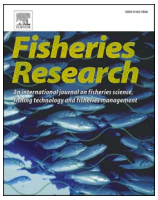

Willingness to pay for harvest regulations and catch outcomes in recreational fisheries: A stated preference study of German cod anglers

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ABSTRACT

Atlantic cod (*Gadus morhua*) is one of the most important target species of marine recreational anglers in the western Baltic Sea, but the stock is collapsed, and regulations of both commercial and recreational fisheries have recently tightened. To analyze the preferences of anglers for harvest regulations and catch outcomes in the western Baltic recreational cod fishery, we developed four different choice experiments, which were embedded in a large online survey of 1795 German marine anglers. The different choice experiments were used to investigate the consistency of anglers' preferences in different choice contexts and with varying payment vehicles. We additionally assessed preferences for harvest regulations with opinion-type questions where no obvious trade-offs were involved in the question framing. Our study shows that German cod anglers received benefits from catching and harvesting cod, catching species other than cod, and catching cod as large as possible. There was no utility associated with catching and releasing cod, indicating the highly consumptive nature of this fishery. Anglers preferred stricter quotas of the commercial cod fishery and stricter length-based harvest limits for the recreational fishery compared to the current management. Preferences for the specific configuration of the daily bag limit varied depending on the choice treatment, but a reduction to a daily bag limit of two cod per day and angler consistently resulted in a significant reduction in the willingness to pay. Therefore, the recent collapse of the western Baltic cod stock, lower harvest prospects, and the recent reduction of the bag limit to one cod per day have caused a substantial welfare loss for German cod anglers.

1. Introduction

Recreational fisheries contribute substantially to the overall capture fisheries sector in Germany in terms of harvest volume and economic impact (Arlinghaus et al., 2015, 2019). Overall, more than three million people fish recreationally in Germany (Arlinghaus, 2004), from which around 161,000 anglers fished approximately 1.2 million days per year in 2014/2015 in the western Baltic Sea, which is the most popular area for marine angling in Germany (Weltersbach et al., 2021). One of the most important species for both commercial and recreational fishing in the Baltic Sea is Atlantic cod (*Gadus morhua*) (Hyder et al., 2018; Lindegren et al., 2009; Rose, 2019). Both the eastern and the western Baltic cod stocks are in a dire state, due to commercial overfishing in the past in combination with climate change-induced recruitment bottlenecks (ICES, 2021a, 2021b; Möllmann et al., 2021; Sguotti et al., 2019). In 2017, a quota reduction by 88% was proposed for the commercial western Baltic cod fishery, which amounts to a moratorium on the directed commercial western Baltic cod fishery due to significant bycatches of cod in other fisheries. Policy makers tried to distribute the burden of stock rebuilding between the commercial and the recreational fisheries sector more equally, and therefore a daily bag limit was introduced for the first time for the western Baltic recreational cod fishery in 2017 (EU, 2016). The new regulation allowed each angler to harvest three cod per day during the main spawning season in February and March, and a maximum of five cod per day during the rest of the year (EU, 2016). Due to a further deterioration of the stock status in

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recent years, eventually resulting in a collapse of the stock in 2020/2021 (ICES, 2021a, 2021b; Möllmann et al., 2021), the daily bag limit has been lowered to one cod per angler and day for 2022. Furthermore, from 15th of January until 31st of March anglers are not allowed to harvest any cod from the western Baltic cod stock (EU, 2021).

The first-time introduction of a daily bag limit for anglers in 2017 was accompanied by public debates among scientists, stakeholders (e.g. angling associations or individually organized marine angler groups) and the public about the utility and necessity of a regulation of the recreational cod fishery (Haase et al., 2022). Anecdotally, cod angling in the western Baltic Sea is assumed to be a strongly consumptive fishery (Haase et al., 2022), conforming with the general German culture that the key socially accepted reason for recreational fishing is to catch fish for personal consumption (Arlinghaus, 2007). Thus, reductions in the quantity of fish that can be taken home per angling day could affect the attractiveness of the fishery, lower participation and reduce local fishing effort, which has been shown in several consumptive freshwater and marine fisheries in North America (Beard et al., 2003; Trudeau et al., 2022). Although it would have been preferable to know the preferences and likely behavioral reactions of western Baltic cod anglers before implementing novel regulations, such as the daily bag limit (Haase et al., 2022), this knowledge did not exist at that time. Considering the recent changes in the management of the western Baltic cod fishery, our objective was to investigate the acceptance and the welfare consequences of regulatory policies for recreational anglers fishing for cod in the western Baltic Sea in Germany.

Preferences for policies and management regulations can be estimated using survey-based stated preference methods, such as choice experiments (CE). They are appropriate when preferences for the attributes of a good in question are of interest and can be adopted in situations where consumer choice data does not exist (Johnston et al., 2017). CE have the unique feature that they allow to analyze the trade-offs that people are willing to make, including options that may not exist but could in the future. Results from CE can then be used to get a better understanding of trade-offs policy makers face in their decision-making process (Dorow et al., 2010). Additionally, results of CE can also increase the effort in value-based decision-making processes.

CE have been widely applied in environmental valuation (Mariel et al., 2021), tourism (Kelly et al., 2007), or health care (Green and Gerard, 2009). During the last two decades, CE have also been used to increase the understanding of the role of product attributes in purchase decisions for food in general and seafood in particular (Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Gassler and Spiller, 2018; Jaffry et al., 2004; Johnston et al., 2001) and to evaluate experiences from outdoor recreation, including recreational fishing (Andrews et al., 2021; Carr-Harris and Steinback, 2020; Dorow et al., 2010; Goldsmith et al., 2018; Hunt et al., 2019; Koemle et al., 2022; Koemle and Morawetz, 2016; Lew and Larson, 2014; Scheld et al., 2020). In their review of the use of both stated and revealed choice models in recreational fisheries, Hunt et al. (2019) showed that anglers generally prefer higher catch and harvest rates, species diversity and react sensitively to different kinds of constraints like harvest regulations and higher cost for angling. Furthermore, many anglers prefer the catch of large fish over smaller individuals. In recent years, stated preference surveys in the context of recreational angling have increased (Hunt et al., 2019), but there are still too few willingness to pay (WTP) estimates for harvest regulations to allow a proper synthesis across many studies. Methodologically, the most common format of a CE in recreational fisheries is an angling experience-based choice format, where respondents are trading-off catch outcomes with harvest regulations or license or fishing-day costs (Arlinghaus et al., 2020).

Specifically for marine fisheries, the existing literature on CE in recreational fisheries reports mixed results for different species and countries regarding anglers' preferences for voluntary catch-and-release-fishing (Andrews et al., 2021; Carter and Liese, 2012; Lew and Larson, 2014) and policy attributes like actual and hypothetical license fees (Whitehead et al., 2001). For example, Carter and Liese (2012) surveyed anglers in the USA and estimated WTP for different attributes of marine fishing trips. Results from a mixed logit model in WTP space showed that anglers received a diminishing utility from catch rates, and WTP for management regulations depended on the target species. They found that a restrictive bag limit for red snapper (*Lutjanus campechanus*) and grouper (*Epinephelus* spp.) would decrease the fishing effort whereas a similar limit on king mackerel (*Scomberomorus cavalla*) would result in a much smaller effort reduction. Moreover, the results showed that the WTP for catch-and-keep fishing was larger than for catch-and-release fishing. The same result was found in a CE study by Anderson and Lee (2013) for Pacific salmon (*Oncorhynchus spp*.) in Washington and Oregon, USA. Larson and Lew (2013) estimated a repeated mixed logit demand model for Southeast Alaska residents for king (*Oncorhynchus tshawytscha*) and silver (*Oncorhynchus kisutch*) salmon. The results suggested that the marginal utility of harvest rates for target species differed from the marginal utility from non-target species. Lew and Larson (2014) also revealed that the average recreational angler, fishing Pacific halibut (*Hippoglossus stenolepis*) and king and silver salmon in the Gulf of Alaska, preferred catching larger fish to smaller ones, less restrictive regulations, and lower trip costs.

In consumptive angler populations, anglers tend to have preferences for maintaining liberal harvesting opportunities (Carlin et al., 2012; Dorow et al., 2010). By contrast, a recent study by Koemle et al. (2022) on less consumptive fish (i.e., pike (*Esox lucius*), in brackish lagoons of north-eastern Germany) showed that German recreational fishers were willing to self-regulate, particularly with respect to stricter size limits as well as reduced bag limits. Particularly specialized trophy anglers were willing to pay relatively large amounts for stricter harvest regulations. However, this study did not include preferences for commercial fisheries or regulation of fish-eating animals in the design, such that it remains obscure whether the preferences for self-regulation would remain to the same degree if anglers would be confronted with policy scenarios that have other tools than just angling regulations. Thus, it can be expected that the consumptiveness of the species and the angler results in different preferences for harvest regulations. However, it remains open how consistent preferences for angler regulations are when payment vehicles and choice contexts vary, as all previous studies have employed only one choice context.

Andrews et al. (2021) is the only study that applied CE in the context of Atlantic cod angling in Europe. UK cod anglers preferred the status quo in terms of daily bag limits and size limits over changing harvest regulations. Moreover, US and UK cod anglers have been reported to prefer landing cod over other marine species and to receive more utility from harvesting than from releasing cod (Andrews et al., 2021; Lee et al., 2017). Both studies also reported diminishing marginal returns of increasing catch rates, i.e., cod anglers had a large benefit from the first fish caught and kept, while at high catch rates additional catches provided little additional utility. Considering these insights on cod angler preferences in other countries, we aimed to understand the preferences of German cod anglers for various angling-related harvest regulations and catch outcomes. We assessed the consistency of preferences for different classical harvest regulations, specifically length-based harvest limits and daily bag limits, using various choice and question formats. Specifically, we compared opinion-type assessments of preferred size limits and daily bag limits in the absence of trade-offs in the question frame with preferences recorded using a CE in two treatments, in which anglers were explicitly forced to trade-off attributes against each other. In one choice treatment, anglers evaluated their angling experience, trading off regulations of cod angling with catch outcomes and costs similar to the study of Andrews et al. (2021) and the majority of previous choice experiments in recreational fisheries. In the other treatment, inspired by Dorow et al. (2009), the anglers were exposed to a policy choice experiment where angling regulations were traded off against regulations of commercial fisheries and costs.

As the stated preferences may depending on the context and thus

	Policy 1	Policy 2	Policy 3	Status Quo
Daily bag limit for angler	2	2	9	5
Size based harvest limit (angler and fisher)	38 cm - 60 cm	38 cm - 70 cm	38 cm - 60 cm	38 cm - not bounded above
Change of commercial quota compared to today in %	+50%	-25%	-25%	as today
Closed season (angler and fisher)	March (1 month)	Feb-March (2 months)	Jan-March (3 months)	Feb-March with a bag limit of 2 cod
Control frequency (angler and fisher)	every 50 trips	every 10 trips	every 50 trips	as today
Additional costs for an angling day in €	25	10	50	none
Recovery of cod stock to the level of before 1980 in years	15	15	10	not known
I choose :	◯	◯	◯	◯

Fig. 1. Example of a choice set for the treatment "policy choice - additional costs". Each respondent was presented with eight such choice sets. Anglers ticked one of the choice boxes in each card to indicate whether they would prefer a cod management scheme with these characteristics or the current management situation (Status Quo).

might vary with the payment vehicle (Johnston et al., 2017), we additionally employed two different payment vehicles within each choice treatment. The first was costs per angling day that allows anglers to take fish within the constraints of harvest regulations, the second was a novel and less familiar pay-per-harvested-cod setting, which could be implemented through a harvest tag system and which would free anglers of any annual license cost but internalize the costs of keeping fish (Abbott, 2015; Jungers et al., 2022). Consequently, we ended up with four split samples and four independent CE (two treatments and two payment vehicles). The two payment vehicles are suited for capturing bandwidths of WTP values and to test the robustness of the preferences. Moreover, the different CE scenarios provide information on how anglers would respond to different designs of policy.

Note that harvest tags may be a substitute to daily bag limits, as stated by Jungers et al. (2022), but we choose to use the pay-per-fish payment vehicle within scenarios that also included daily bag limits because this is the current policy scenario for western Baltic cod and it is hard to imagine that daily bag limits will be completely substituted by alternatives, at least in the short term.

We hypothesized that 1) German cod anglers are consumptive and derive utility from harvest rather than catch-and-release of cod, 2) German cod anglers generally prefer liberal harvest regulations in terms of daily bag limits and length-based size limits and the status quo, and 3) these preferences would be consistently recovered in all choice formats and in the opinion-type assessment.

2. Material and methods

2.1. Sampling design and survey

In the period from December 2020 until March 2021, we conducted an online survey to investigate preferences of western Baltic cod anglers for harvest regulations and catch outcomes. The questionnaire consisted of five parts. In the first part, we asked general questions about fishing and cod angling for leisure, in the second part we were interested in anglers' perceptions about the development of the western Baltic cod stock. The third part comprised the CE, before the fourth part contained questions regarding attitudes and preferences of cod management strategies, including preferences for desired and optimal minimum-length limits, daily bag limits and closed seasons. Hereafter we refer to the latter question format as the "opinion-type" assessment for regulations. In the final part, respondents provided sociodemographic information.

The questionnaire was distributed to 3957 German cod anglers who were recruited by a professional survey company (imug, Hannover, Germany). Recruitment took place through five channels, namely computer assisted telephone interviews (CATI) (735), E-mail distribution (76), using contacts from already known cod anglers as well as recruiting anglers on-site at different harbors along the German Baltic coast (17) and advertising the survey in print and social media (3129). Participants of the CATI were recruited from a list of anglers who had bought fishing permits for the Baltic coastal waters of Mecklenburg-Western Pomerania (MV) and voluntarily provided their contact details to participate in scientific studies. The contact data were provided by the State Office for Agriculture, Food Safety and Fishery of MV (LALLF). Due to the Covid-19 pandemic the on-site recruitment was not successful. After the pre-selection by the mixed method sampling and an electronic confirmation of the e-mail address of the individual angler, the participants received the survey link from the survey company. A reminder was sent out after two days if the anglers did not use the link. Participating anglers had to be older than 14 years, had to be fishing for cod on the German Baltic coast at least once in the past or had to have plans to do so within the next three years. Participation was incentivized by an electronic 10 € voucher for an angling shop for a completed interview. Additionally, respondents who completed the survey had the chance to win one of three gift-certificates for an online angling shop worth 500 € each in a raffle in spring 2021.

2.2. Choice experiment

CE are a survey-based method that generally confronts respondents

	Angling experience 1	Angling experience 2	Angling experience 3	I do not go cod fishing
Daily bag limit for angler	9	2	5	
Average catch number of cod per day	1 cod every 2 days	14 cod per day	3 cod per day	
Size of largest caught cod in cm	90	60	50	
Size based harvest limit	38 cm - 50 cm	38 cm - 80 cm	38 cm - not bounded above	
Number of additional catches of other species than cod	15	30	15	
Control frequency (angler and fisher)	every 10 trips	every 2 trips	every 2 trips	
Harvest tag per caught and kept cod in €	2	5	2	
I choose :	◯	◯	◯	◯

Fig. 2. Example of a choice set for the treatment "angling experience - harvest tag". Each respondent was presented with eight such choice sets. Anglers ticked one of the choice boxes in each card to indicate whether they would prefer a cod angling day with these characteristics or not.

repeatedly with a choice among mutually exclusive alternatives. Respondents are asked to select the alternative with the highest utility for them. By systematically varying the characteristics (attributes) of the alternatives, respondents' preferences can subsequently be derived from their choices among alternatives. If the CE includes a cost attribute, WTP estimates for marginal changes of the non-monetary attribute levels can be calculated. They express the amount of money respondents would be willing to give up for getting the change in the attribute levels. Constructing a stated CE overall consist of four steps: (1) Defining the product (e.g., angling experience) or policy in question by developing a list of attributes describing it; (2) creating an experimental design that allocates attribute levels to alternatives; (3) collecting data by asking respondents often several times to choose the most preferred alternative from mutually exclusive alternatives on a choice set; and (4) analyzing the data by estimating econometric models relating changes in the attribute levels to the probability of choice and calculating welfare measures such as WTP estimates (Hensher et al., 2015; Louviere et al., 2010; Mariel et al., 2021). In this study, we designed four independent CE to elicit preferences of cod anglers for harvest regulations and catch outcomes. Each angler was assigned only to one of the CE variants. The CE differed with respect to the treatment (policy choice vs. angling experience choice) and with respect to the payment vehicle within each treatment (harvest-tag per retained cod vs. additional costs of an angling day). The additional costs were defined as a flat rate per angling day payment. The policy choice required respondents to choose between four different alternatives describing policy mixes (including the status quo) without direct (individual) catch outcomes. The status quo for the policy treatment represented the actual policy regulations in the period in which we carried out the study (December 2020 – March 2021, i.e., a daily bag limit of 5 (2 during spawning season) cod per day and angler) (Fig. 1). By contrast, in the angling experience choice, respondents were confronted with three different angling experience alternatives and an opt-out option (I would not go cod fishing) (Fig. 2). The status quo or opt-out option did not vary across choice sets.

Each CE comprised seven attributes with five levels each, except for the payment vehicle that had six levels (Table 1). The attributes daily bag limit, size-based harvest limit and control frequency of harvesters (fishers and anglers) were kept identical in the policy and angling experience CE, which allowed us to compare the consistency of the expressed preferences among different treatments and payment vehicles. Moreover, the daily bag limit and the size-based harvest limit was also assessed as an opinion-type assessment without explicitly formulated trade-offs as shown in Table 2. The attributes and levels for the different CE were chosen based on expert knowledge with key policy makers involved in cod management and for catch outcomes based on information from ongoing on-site access point intercept surveys that estimated typical catch rates and sizes of cod in the catch (Lewin et al., 2021; Strehlow et al., 2012). The selected attributes represented the most important possible management levers in the western Baltic cod fishery.

The CE design was discussed and tested in 4-hour personal interviews with six cod anglers and adjusted accordingly to increase comprehensibility. Additionally, the survey was pretested with 32 German cod anglers. First, 22 anglers were recruited via telephone by the survey company and invited to take the online survey and provide feedback. A follow-up survey took place a few days after participation in which the participants were asked about their experiences completing the survey. Moreover, the survey was pre-tested in a personal meeting with ten anglers from angling associations in Schleswig-Holstein, Germany.

Having defined the attributes and their levels, the experimental design of the CE was created. With three alternatives, seven attributes and five attribute characteristics for six of the attributes and six attribute characteristics for one of the attributes, a full factorial design would comprise too many choice sets. Thus, we used a Bayesian efficient design (Mariel et al., 2021; Rose et al., 2008; Rose and Bliemer, 2009) with uniform priors for the attribute parameters. For the optimization, the D-efficiency criterion for the multinomial logit model was selected. To allow for uncertainty concerning the value of the priors, 1000 Sobol draws were taken for each parameter prior from uniform distributions (ChoiceMetrics, 2021). The final design comprised 60 choice sets. Out of those, each respondent faced eight choice sets that were randomly

Table 1
Attributes and levels of the CE for cod anglers.

Attributes policy choice	Level	Status quo	Attributes experience choice	Level
Daily bag limit for anglers (cod per day)	2, 5, 7, 9, 12	5 (2 in spawning season)	*Daily bag limit for anglers ((cod per day)*	2, 5, 7, 9, 12
Size-based harvest limit (angler and fisher). 38 cm to…	50 cm, 60 cm, 70 cm, 80 cm, not bounded above = minimum length limit	38 (35) cm to not bounded above = minimum length limits	*Size-based harvest limit (angler and fisher) 38 cm to…*	50 cm, 60 cm, 70 cm, 80 cm, not bounded above = minimum length limit
Change of commercial quota compared to today in %	− 50%, − 25%, 0%, + 25%, + 50%	as today	*Average catch number of cod per day*	1 cod every second day, 1, 3, 8, 14
Closed season (angler and fisher)	None, March (1 month), Feb-March (2 months), Jan-March (3 months), Jan-April (4 months)	Feb- March with a daily bag limit of 2	*Size of largest caught cod in cm*	50, 60, 70, 90, 110
Control frequency (angler and fisher)	Every 2/5/10/20/50 trip	as today	*Control frequency (angler and fisher)*	Every 2/5/10/20/50 trip
Additional costs for an angling day / (harvest tag per caught and kept cod) in €	10, 25, 50, 100, 200, 400 (0.5, 1, 2, 3, 4, 5)	none	*Additional costs for an angling day / (harvest tag per caught and kept cod) in €*	10, 25, 50, 100, 200, 400 (0.5, 1, 2, 3 ,4, 5)
Recovery of cod stock to the level of before 1980 in years	5, 10, 15, 20, 25	not known	*Number of additional catches of other species than cod per day*	0, 5, 10, 15, 30

drawn without replacement to avoid fatigue and ordering effects among respondents. We used the same experimental design for all four CE.

The respondents received a description of the current situation of western Baltic cod as well as a detailed description of the attributes and an exemplary choice set before they faced the eight choice sets (Figs. 1 and 2 as examples).

2.3. Econometric framework

The CE analysis is based on the argument of Lancaster (1966) that individuals derive utility from product attributes rather than the good itself and on random utility theory (McFadden, 1974). It is assumed that individuals choose an alternative that provides the highest level of utility. According to random utility theory, the utility U_{njt} of an angler n from an alternative j in a choice set t is described as the sum of the deterministic component ($\beta_n^{'} x_{njt}$) that is observable to the researcher, and a random component ε_{njt} which is unknown

$$U_{njt} = \beta_n^{'} x_{jt} + \varepsilon_{njt} , \quad (1)$$

where x_{jt} is a vector of attributes of alternative j on choice occasion t. The unobserved error term ε_{njt} is assumed to be independent and identically distributed (IID) type-I extreme value (Greene, 2012). To account for unobserved preference heterogeneity among individuals, the mixed

Table 2
Opinion-type single regulation type preferences of German western Baltic cod anglers in the absence of trade-offs.

	Policy choice		Experience choice	
	Harvest tag	Additional costs	Harvest tag	Additional costs
Number of respondents	451	453	450	441
Minimum length limit is desirable (% share of respondents)				
yes	98.23	97.80	97.28	98.44
no	0.44	1.10	1.13	0.67
indifferent	1.33	1.10	1.59	0.89
The minimum length limit should be in cm (SD):[a]				
	45.12 (4.73)	44.65 (5.34)	46.41 (6.88)	46.60 (7.80)
Just acceptable minimum length limit should be in cm (SD):[a]				
	40.96 (4.73)	41.02 (4.75)	42.06 (5.35)	42.85 (6.50)
Harvest slot limit is desirable (% share of respondents)				
yes	82.48	78.15	82.77	81.78
no	14.86	16.34	13.15	12.67
indifferent	2.66	5.52	4.08	5.56
Harvest slot should be in cm (SD):[a]				
	43.50 (7.81) - 73.24 (12.07)	43.40 (6.62) - 73.84 (11.00)	44.65 (7.74) - 76.95 (13.86)	45.46 (6.84) - 78.09 (12.70)
Just acceptable harvest slot in cm (SD):[a]				
	41.12 (7.45) - 70.29 (13.74)	41.86 (6.27) - 70.81 (11.97)	42.91 (7.47)- 74.07 (14.09)	43.50 (7.08) - 75.79 (13.75)
Daily bag limit is desirable (% share of respondents)				
yes	89.82	89.78	86.67	91.97
no	8.00	8.39	10.74	7.66
indifferent	2.18	1.82	2.59	0.36
Daily bag limit should be:[a]				
	6 cod	6 cod	5 cod	6 cod
Just acceptable bag limit:[a]				
	5 cod	5 cod	4 cod	5 cod
Angling and fishing bans during the spawning season in the spawning areas are desirable (% share of respondents)				
yes	96.00	95.14	93.65	92.44
no	2.00	2.87	2.49	4.44
indifferent	2.00	1.99	3.85	3.11
Closed season is desirable (% share of respondents)				
yes	92.68	93.38	88.21	84.67
no	2.66	3.09	5.44	5.33
indifferent	4.66	3.53	6.35	10.00

[a] arithmetic mean; Std. dev. in parenthesis

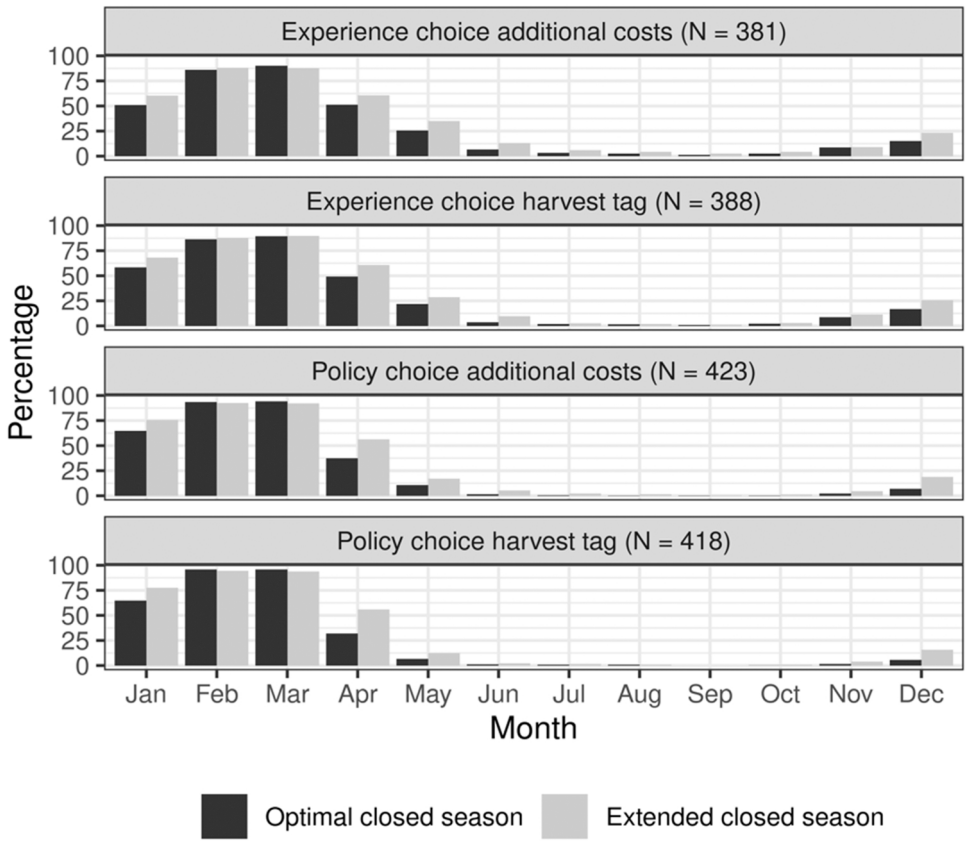

Fig. 3. Relative shares of an optimal and extended period for a closed season of the western Baltic Sea recreational cod fishery.

logit model (MIXL) became the standard approach to analyze discrete choices, (McFadden and Train, 2000). Thereby, β_n is a vector of tastes that is assumed to vary across individuals with the density function f ($\beta|\theta$), where θ is a vector of distribution parameters (e.g. mean and standard deviation) (Greene, 2012).

While the marginal utility parameters β are generally estimated in preference space, researchers who are first of all interested in the associated welfare measures can directly estimate WTP measures in WTP space (Scarpa and Willis, 2010; Train and Weeks, 2005). The advantage of WTP space models is that the model parameters can directly be interpreted as welfare estimates (marginal WTP). Following Train and Weeks (2005), the utility function from alternative j at time t can be specified as

$$U_{njt} = -\sigma_n(cost_{njt} + wtp_n^{'}x_{njt}) + \varepsilon_{njt,} \quad (2)$$

where $cost_{njt}$ is the cost according to the payment vehicle, wtp_n is a vector of WTP for each non-cost attribute (Table 1), and σ_n is a random scalar. $\sigma_n = \frac{\pi_n}{k_n}$, where π_n is the cost coefficient in preference space and k_n is the scale parameter of angler n. $wtp_n = \frac{\beta_n}{\sigma_n}$, where β_n is the vector of the non-cost coefficients in preference space. Finally, ε_{njt} is the random component.

When allowing for preference heterogeneity, the researcher must choose an appropriate distribution for the WTP parameters. If it is reasonable to assume symmetric preferences and that WTP can take positive and negative values, it is standard to choose the normal distribution. If the sign of the parameter is known ex-ante (e.g. price), a log-normal distribution is standard (Revelt and Train, 1998; Train and Weeks, 2005).

A simulated maximum likelihood estimator was used to estimate the parameters using 1000 Halton draws using the STATA package mixlogitwtp (Hole, 2015). We included an Alternative Specific Constant (ASC) in the model, which reflects the WTP for the status quo/ not going fishing option. The status quo was specified as a non-random parameter. All variables except price were dummy coded and their associated parameters were assumed to be normally distributed. The cost coefficients were assumed to follow a log-normal distribution. For each of the two treatments with the two different payment vehicles (Table 1), a separate model was estimated.

3. Results

3.1. Sample Description

From the 3957 invited anglers 1995 finished the entire survey (50.4%). Of the latter, 615 respondents were recruited via CATI, 57 via email, 1319 through social media and 4 anglers through direct communication. We removed respondents from the analyses, who had not completed the survey and did not answer two test questions hidden in item batteries (i.e., Please choose “fully agree”) correctly. This left us with a sample of 1795 respondents (540 CATI, 54 email, 1198 social media, 3 direct communication) used for the subsequent analyses. Overall, there were no large differences in the demographic composition of the samples for the four CE (Table A1). On average and in terms of majorities respondents were male, around 45 years old, lived in a household with 2.7 members in Mecklenburg-Western Pomerania, were organized in an angling organization and had an angling experience of around 33 years from which they had 20 years’ experience of cod angling. Moreover, around 36% of the anglers had a university degree and a household net income between 2000 € and 4999 € per month.

3.2. Opinion-type assessment of harvest regulation preferences

As mentioned above, the fourth part of the questionnaire contained questions regarding the preferences for harvest regulations which were

Table 3
Mixed logit estimates in WTP space the of policy and experience choice experiments for western Baltic cod angling.

	Policy choice				Experience choice			
	Harvest tag		Additional costs		Harvest tag		Additional costs	
	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)
Status quo	-22.545 * **		-476.081 * **		-4.973 * **		-79.711 * **	
	(3.182)		(40.297)		(0.742)		(20.233)	
Cost[a]	-0.008 * **	0.004 * **	-4.967 * **	0.0478 * **	-0.277 * **	0.017	-0.014 * **	0.004 * **
	(0.001)	(0.012)	(0.068)	(0.103)	(0.263)	(0.036)	(0.002)	(0.001)
Daily bag limit for anglers, base: 5 cod								
2 cod	-3.374 * **	6.282 * **	-89.537 * **	94.180 * *	-3.380 * **	6.280 * **	-52.489 * **	29.960 * *
	(0.941)	(1.231)	(21.273)	(47.587)	(0.659)	(0.840)	(10.803)	(14.838)
7 cod	1.693 * **	0.020	-2.064	85.998 * *	-1.597 * **	2.371 * **	-33.507 * **	33.948 * **
	(0.648)	(1.036)	(18.811)	(37.272)	(0.499)	(0.859)	(10.439)	(10.287)
9 cod	-0.177	4.654 * **	-42.779 *	137.918 * **	-2.198 * **	2.752 * **	-60.218 * **	66.001 * **
	(0.803)	(1.759)	(22.834)	(21.401)	(0.469)	(0.582)	(11.956)	(14.455)
12 cod	-0.298	6.347 * **	-66.957 * **	86.583 * **	-3.082 * **	4.200 * **	-78.758 * **	78.835 * **
	(0.807)	(1.207)	(19.656)	(19.871)	(0.617)	(0.715)	(12.769)	(16.178)
Size-based harvest limit for anglers and fishers, base: 38 cm to not bounded above								
38–50 cm	-4.255 * **	6.238 * **	-40.826 *	75.668	-1.725 * **	3.853 * **	-24.318 *	97.182 * **
	(1.121)	(1.173)	(24.121)	(53.595)	(0.560)	(0.679)	(14.020)	(13.362)
38–60 cm	-1.272	7.413 * **	36.818 *	170.830 * **	0.277	1.284 *	29.978 * *	30.006 *
	(0.835)	(1.305)	(19.483)	(26.265)	(0.459)	(0.660)	(12.882)	(16.725)
38–70 cm	2.520 * **	6.155 * **	80.617 * **	120.532 * **	1.765 * **	2.651 * **	47.141 * **	63.629 * **
	(0.725)	(1.173)	(17.324)	(32.246)	(0.499)	(0.739)	(12.913)	(14.024)
38–80 cm	1.820 * *	4.035 * **	31.908 *	83.515 * **	0.728	2.106 * **	29.050 * **	29.586 * **
	(0.712)	(1.164)	(17.086)	(31.229)	(0.470)	(0.638)	(9.544)	(10.953)
Change of commercial quota compared to today in %, base: no change								
-25%	3.675 * **	6.873 * **	76.749 * **	133.016 * **				
	(0.905)	(1.154)	(17.897)	(25.917)				
-50%	2.963 * **	4.945 * **	67.540 * **	122.279 * **				
	(0.796)	(1.045)	(15.928)	(27.902)				
25%	-3.099 * **	4.039 * **	-80.784 * **	172.056 * **				
	(0.882)	(1.090)	(17.855)	(21.893)				
50%	-7.791 * **	10.179 * **	-161.830 * **	203.120 * **				
	(1.390)	(1.685)	(26.107)	(28.540)				
Closed season for anglers and fishers, base: February and March (2 months)								
None	-6.555 * **	5.751 * **	-121.908 * **	161.448 * **				
	(1.272)	(1.254)	(23.080)	(39.979)				
March (1 m)	-3.711 * **	3.417 * *	-31.817	108.814 * **				
	(0.901)	(1.520)	(19.913)	(29.486)				
Jan-March (3 m)	0.176	5.431 * **	42.311 * *	121.011 * **				
	(0.695)	(1.192)	(17.564)	(36.587)				
Jan-April (4 m)	-0.422	6.079 * **	22.194	54.600				
	(0.799)	(1.209)	(18.610)	(132.956)				
Control frequency	-0.073 * **	0.054 * *	-11.649 * *	41.541 * **	-0.097 * **	0.176 * **	-0.508 * *	1.372 * **
	(0.017)	(0.023)	(5.740)	(6.421)	(0.015)	(0.021)	(0.224)	(0.356)
Recovery of cod stock to the level of before 1980	-0.802 * **	0.815 * **	-16.061 * **	15.035 * **				
	(0.123)	(0.124)	(1.516)	(1.414)				
Average number of captured cod, base: 1 cod every second day								
1 cod each day					1.496 * **	4.970 * **	35.495 * **	94.212 * **
					(0.559)	(0.821)	(12.648)	(13.244)
3 cod each day					5.614 * **	5.495 * **	137.685 * **	113.533 * **
					(0.700)	(0.710)	(13.980)	(14.116)
8 cod each day					5.049 * **	6.482 * **	124.577 * **	146.363 * **
					(0.727)	(0.805)	(13.443)	(14.258)
14 cod each day					3.012 * **	7.495 * **	97.400 * **	142.682 * **
					(0.590)	(0.847)	(14.354)	(13.200)
Size of largest cod caught in cm, base: 50 cm								
60 cm					1.029 * *	2.602 * **	56.648 * **	44.249 * *
					(0.470)	(0.641)	(12.516)	(18.507)
70 cm					2.304 * **	3.186 * **	79.578 * **	89.434 * **
					(0.522)	(0.724)	(11.675)	(12.037)
90 cm					2.665 * **	1.673 *	69.832 * **	61.805 * **
					(0.535)	(0.895)	(11.505)	(13.497)
110 cm					3.039 * **	4.005 * **	69.622 * **	115.293 * **
					(0.628)	(0.648)	(15.602)	(19.600)
Number of additional catches of other species than cod per day								
0–10 other					0.244 * **	0.312 * **	5.855 * **	10.126 * **
					(0.049)	(0.057)	(1.114)	(1.717)
15–30 other					0.140 * **	0.196 * **	2.857 * **	4.204 * **
					(0.024)	(0.032)	(0.570)	(0.777)
Number of respondents	451		453		450		441	

(*continued on next page*)

Table 3 (*continued*)

	Policy choice				Experience choice			
	Harvest tag		Additional costs		Harvest tag		Additional costs	
	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)	Mean (μ)	SD (σ)
Number of choices per respondent	8		8		8		8	
LL	-3959.53		-3945.08		-3921.15		-3877.08	
AIC	7997.07		7968.16		7924.3		7836.15	
Standard errors in parentheses								
* ** p < 0.01, * * p < 0.05, * p < 0.1								

[a] The cost coefficient is presented in de-logged form using the formulas: $mean = exp(\mu + \sigma^2/2)$ and $sd = \sqrt{exp(2\mu + \sigma^2)[exp(\sigma^2) - 1]}$.

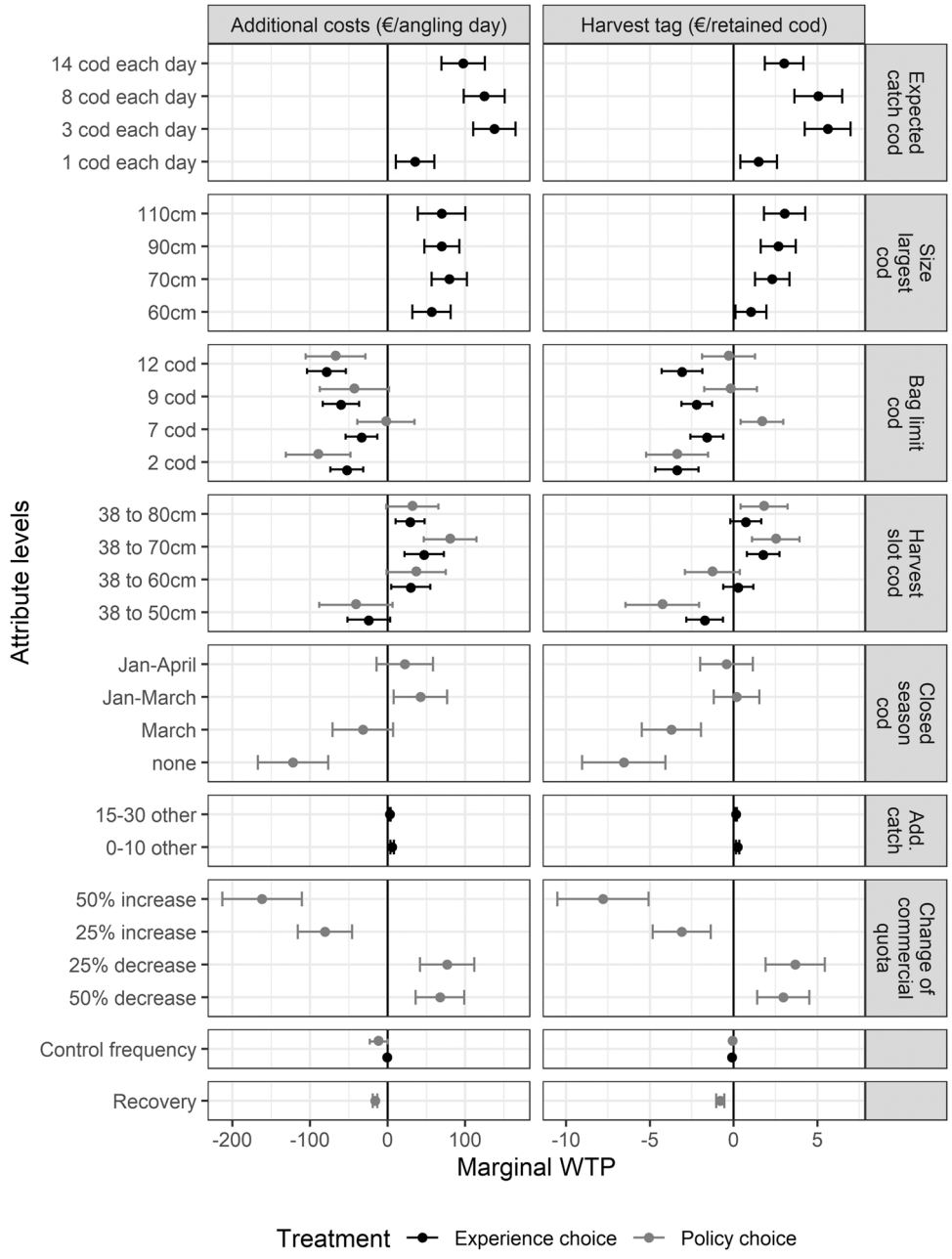

Fig. 4. Mean WTP and corresponding 95% confidence intervals based on the analysis of the policy and experience discrete choice experiments with western Baltic cod anglers in Germany.

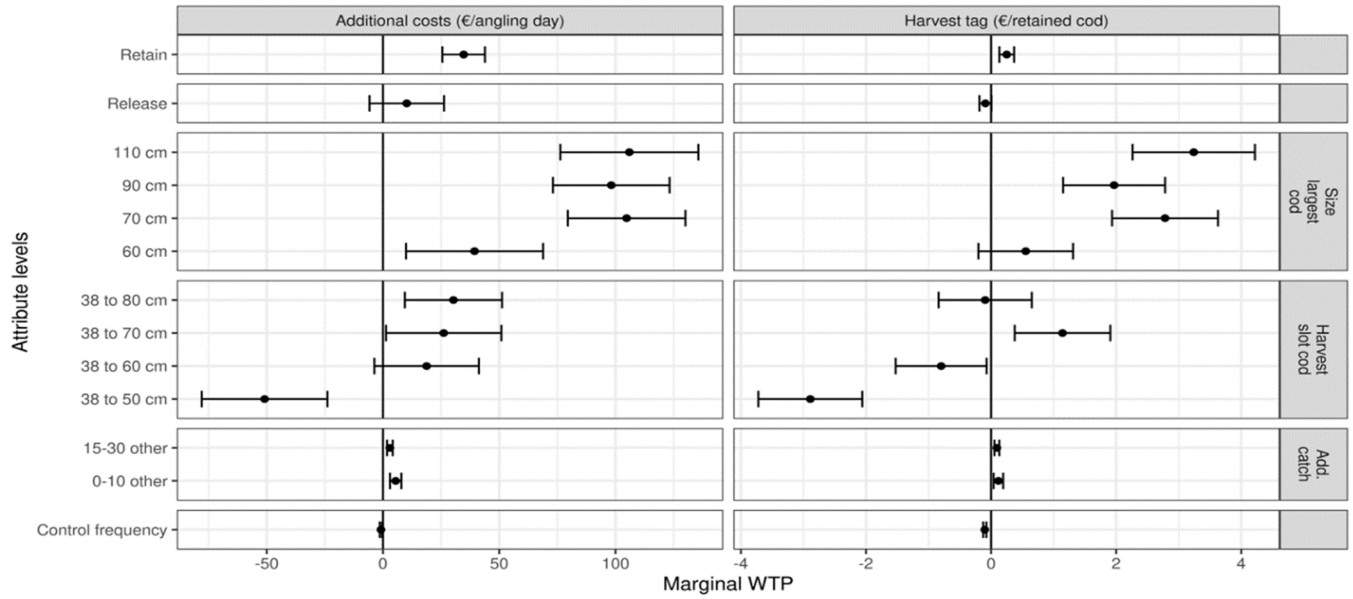

Fig. 5. Mean WTP and corresponding 95% confidence intervals based on the analysis of the experience discrete choice experiments with western Baltic cod anglers in Germany for the retain and release model.

assessed in the "opinion-type" questions in the absence of trade-offs (Table 2). These assessments were used as a first preference assessment to complement the insights gained from the CE. More specifically, for each of the five harvest regulations, we asked whether the respondent considered a given harvest regulation as appropriate for improving the condition of the western Baltic cod stock. Additionally, we asked how the specific harvest regulation should explicitly look like (e.g., which exact size limit the respondent would find optimal) and which configuration of the different strategies the respondent would find just acceptable. We asked for preferences related to minimum-length limits, harvest slots, daily bag limits and a general closed season to protect the spawning period. Results were analyzed descriptively.

Most respondents (> 82–98%, depending on CE subsample) considered all harvest regulations as desirable (Table 2). The approval of minimum-length limits as a harvest management tool was highest and close to 100% in all four samples. On average, the German cod anglers showed a preference for a minimum-length limit of 45–46 cm and an average minimally accepted minimum-length limit of 41–43 cm, depending on the CE sample (Table 2). These values were higher than the status quo of 35 cm (Mecklenburg-Western Pomerania) and 38 cm (Schleswig-Holstein). The overall approval of harvest slots was slightly less, but still above 78% of all anglers, with ideal harvest slots ranging between 43/45 and 73/78 cm and minimally acceptable ranges between 41/43 and 70/75 cm depending on the subsample (Table 2).

Daily bag limits were approved by > 86% of all respondents in all four subsamples. The daily bag limits found optimal or just acceptable ranged on average between 4 and 6 cod per day and angler. Very high approval was also discovered for both fishing bans during the spawning season (> 92%) or closed seasons in general (> 84%). The highest share of the respondents preferred the period between January and March as optimal for a seasonal closure (Fig. 3).

3.3. CE estimates and welfare measures

Out of the 1795 respondents, 451 answered the policy CE in the harvest tag context and 453 respondents the CE with the additional costs. The experience choice was answered by 441 anglers using the harvest tags and 450 anglers using the additional costs as payment vehicle. The results of the mixed logit estimation in WTP space for all four CE are presented in Table 3. In all estimated models the cost parameter had the expected negative sign and was significant. The parameter of the status quo alternative was negative and significant, indicating that respondents did not tend to choose the status quo alternative more often than can be explained by differences in attribute levels.

3.3.1. Willingness to pay for cod harvest regulations

The mean WTP for the standard harvest regulations (daily bag limits and length-based size limits) were assessed in both the policy choice and the angling experience choice treatment (Table 3). Looking at the daily bag limits, the policy choice in the harvest tag context showed that anglers had the highest significant WTP for a daily bag limit of 7 cod (1.69 € per retained cod) relative to the base of a daily bag limit of 5 cod. By contrast, the mean WTP for even higher daily bag limits of 9 or 12 cod were significantly negative using the additional costs as payment vehicle (Table 3). Importantly, in the policy treatment we found a significantly negative mean WTP of − 3.37 € per retained cod for a daily bag limit of 2 cod per day, which indicated an aversion against this low bag limit relative to the status quo.

Results were not consistent when assessing preferences for daily bag limits in the angling experience treatment using a harvest tag as payment vehicle relative to the policy scenario. Here we found a significantly negative WTP for all daily bag limits (of 2, 7, 9 and 12 cod per day and angler) that deviated from the status quo of 5 cod per day and angler. The very same result of aversion to all other bag limits than the one currently in place was found in the angling experience treatment with additional costs (Table 3, Fig. 4). However, all our four CE pointed to the fact that the current bag limit of 5 fish per day and angler was often the most preferred regulation. By contrast, reductions to a daily bag limit of 2 consistently created reductions in WTP. The different CE were inconsistent in whether anglers had a negative WTP from daily bag limits of either 9, 7 or 12 fish per day or whether anglers equally preferred these more liberal regulations compared to the status quo.

We found a positive and significant mean WTP for a harvest slot of 38–70 cm relative to the current minimum-length limit of 38 cm in all four experiments, suggesting the anglers preferred to keep large cod in the stock. The mean WTP for this harvest slot was estimated as 2.52 € per retained cod in the policy choice treatment and 1.77 € per retained cod in the experience choice treatment. In the additional cost context, the average angler was willing to pay 80.62 € per angling day for a harvest

Table 4
Mean WTP estimates in a policy scenario exercise.

	Daily bag limit	size-based harvest limit	Change of commercial quota	Closed season	Average number of captured cod	Policy choice: Harvest tag Mean	SD	% negative	Add cost Mean	SD	% negative	Angling experience choice: Harvest tag Mean	SD	% negative	Add cost Mean	SD	% negative
Scenario 1 (base)	**2**	***38–70 cm***				**-3.37**	8.93	64.72	**-52.72**	127.93	65.99	**-3.38**	6.41	70.10	**-22.51**	42.40	70.23
Scenario 2	2	38–60 cm				**-0.85**	9.72	53.50	**-8.92**	195.07	51.82	**-1.62**	6.82	59.36	**-5.35**	70.33	53.03
Scenario 3	7	38–70 cm				**4.21**	6.16	24.68	**78.55**	148.07	29.79	**0.17**	3.56	48.12	**13.63**	72.12	42.50
Scenario 4	7	38–60 cm				**1.69**	7.41	40.97	**34.75**	191.26	42.79	**-1.60**	2.70	72.32	**-3.53**	45.31	53.10
Scenario 5	12	38–70 cm				**2.52**	8.84	38.78	**13.66**	148.41	46.33	**-1.32**	4.97	60.46	**47.14**	63.63	22.94
Scenario 6	2	38–70 cm			1 cod each day							**-0.12**	8.44	50.56	**30.15**	117.57	39.88
Scenario 7	2	38–70 cm		March		**-4.57**	9.44	68.57	**-8.92**	187.72	51.89						
Scenario 8	12	38–60 cm		none		**-6.56**	11.33	71.86	**-152.05**	250.49	72.81						
Scenario 9	2	38–70 cm	-25%	March		**-0.89**	12.56	52.83	**67.83**	259.15	39.68						

% negative indicates the calculated share of anglers lying on the negative domain of the normal distribution for each attribute parameter, the SD for the combined measured is calculated as: $\sqrt{\sigma^2_{b1,k}+\sigma^2_{b2,k}}$

slot of the same range in the policy treatment and 47.14 € more for an angling day in the angling experience treatment. In the different choice treatments, the mean WTPs for the size-based harvest limits also showed similar trajectories, growing from the narrow harvest slot over to the highest WTP at intermediate harvest slot sizes, further declining when the harvest slot widened above the maximum of 70 cm. Consistently over the treatments and payment vehicles, we found significant positive mean WTP for a generally stricter length-based policy than presently the case.

3.3.2. Willingness to pay for catch outcomes

The WTP for catch and harvest outcomes of cod and of other marine fish species were elicited in the angling experience treatment only (Table 3, Fig. 4). Relative to the base category of one cod every second day, all average numbers of captured cod (1 through 14) showed positive and significant WTP in both payment vehicle contexts. The highest mean WTP was found for an average of 3 captured cod per angling day. Using the harvest tags as payment vehicle, we found a mean WTP of 5.61 € per retained cod and using the additional costs as payment vehicle we found a mean WTP of 137.69 € per angling day. In both contexts, the highest WTP values for the average number of captured cod were achieved at intermediate catch rates (3–8 cod per day and angler) and declined towards a catch of 14 cod per day and angler. Thus, the mean WTP for the average catch rate of cod showed an inverted u-shaped pattern for different daily cod catches in the angling experience treatment, suggesting increased aversion to very high catch rates after the optimal catch (Fig. 4). The WTP values dropped in both treatments after a catch of 8 cod per day and angler was reached. The maximum daily bag limit presented in the choice experiments was 12 cod per day, suggesting that the lower WTP of large cod catches that cannot be fully retained might indicate consumptive preferences. To examine this effect more efficiently, we recoded the attributes to numbers of cod that can be kept vs. mandatorily released and re-ran the models (see below).

Also, the WTP for the number of additional catches of other species was significantly positive in both treatments with the two payment vehicles, indicating preferences for high catch rates of other species than cod. We found diminishing marginal WTP for additional units of catch rates, as indicated by the lower WTP for the catch of 15–30 other fish than cod relative to the higher WTP for the catch of 0–10 fish of other species than cod. The average angler also had a higher WTP for increasingly larger cod in terms of the size of the largest cod (Fig. 4). For example, relative to the catch of a 50 cm cod, the mean WTP for the catch of the largest cod of 110 cm was 3.04 € more per caught and kept cod in the harvest tag context and 69.62 € more per angling day using the additional costs as payment vehicle.

To test our hypothesis 1, we recoded the daily bag limits and daily cod catches to end with attributes that represent the numbers of retained and released cod. Model estimates showed a positive WTP for retaining as many cod as possible within the bag limit. We found a WTP for retain of 0.25 € per retained cod and 34.70 € per angling day. However, we found a negative WTP for cod that must be released (Fig. 5, which shows the plotted mean WTPs and the corresponding 95% CI, the estimated results are given in Table A2 in the Supplementary material), indicating there is no utility of just catching cod.

3.3.3. Willingness to pay for closed seasons

In the policy treatment, we found that cod anglers preferred a closed season from January to March, indicated by a positive and significant WTP of 42.31 € per angling day in the context of additional costs (Table 3, Fig. 4). However, in the harvest tag policy treatment a closed season from January to March did not result in a significant mean WTP compared to the current regulation of a spawning closure from February to March (Table 3). Nevertheless, there was a consistent aversion against a reduction of the closed season to just March or removal of the closed season altogether. However, similar as the case of the daily bag limits, the policy treatments did not fully recover identical findings, in some

cases preferring a three month closed season over the status quo gained the highest WTP. In other cases we could not find significant WTPs.

3.3.4. Willingness to pay for regulating other sectors, controls, and recovery time of cod

In relation to regulating other sectors also targeting cod (i.e., commercial fisheries), in both policy treatments, the anglers had significant and positive WTP for a reduction of the commercial quota by either 25 or 50% compared to today's situation. The highest WTP was expressed for a quota reduction of 25% compared to today, which was 3.68 € per retained cod in the policy treatment and 76.75 € per angling day in the angling experience treatment. Thus, anglers preferred to regulate commercial fisheries through quota cuts over keeping the current harvest regulations for commercial fisheries. Anglers also expressed a negative WTP towards a low control frequency for fishers and anglers in all four CE (Table 3). Moreover, we found that anglers had a consistently and significantly positive mean WTP for the recovery speed of the western Baltic cod stock in the policy choice treatment, preferring a short recovery time of the stock.

4. Welfare changes for policy scenarios

Welfare measures can be used to outline welfare gains or losses and may help to suggest policy changes if the goal is to address angler well-being in future western Baltic cod management policies. As stated in Oh et al. (2007), results of stated preference studies can be used to rank management scenarios compared to a base condition or status quo (Dorow et al., 2010; Lawrence, 2005). In our policy estimations we followed Haase et al. (2022), who compared different cod management options for harvest savings and suggested that more liberal bag limits combined with a higher size-based harvest limit, or the introduction of a tight harvest slot could produce welfare gains for cod anglers. However, Haase et al. (2022) only indirectly estimated these welfare gains, where cod harvest was assumed equivalent to well-being. Our study is now able to quantify the welfare effects of altered policies quantitatively. We compare potential impacts on the WTP for changes in harvest regulations and catch outcomes. In addition to reporting the WTP estimates we computed the share of anglers falling on the negative side of the normal distribution (Table 4) using the formula $100^{*}\Phi(\mu_k - \sigma_{b,k})$, where Φ is the cumulative standard normal distribution and γ_k and $\sigma_{b,k}$ are the mean and standard deviation of the k^{th} MIXL WTP coefficient, respectively.

Table 4 shows 9 scenarios, in which we combined the mean WTP estimates for individual attributes (Table 3) to formulate selected policy scenarios. The base category (scenario 1) for the scenario evaluation was a daily bag limit of two cod and a size-based harvest limit of 38–70 cm, resulting in a mean WTP of − 3.37 € per retained cod and − 52.72 € per angling day in the policy treatment. For the angling experience treatment, the base WTP was − 3.38 € per retained cod and − 22.51€ per angling day. Thus, the base WTP for the policy scenarios using the harvest tag as payment vehicle is similar in both CE treatments.

Reducing the size-based harvest limit to 38–60 cm (Scenario 2) led to a welfare improvement, measured in WTP, in all four CE. This effect was particularly evident in the additional cost context (Table 4). For instance, in the experience choice the mean WTP increased in scenario 2 to − 1.62 € per retained cod or − 5.35 € per angling day. Thus, we can see that the size of the cod conserved to some degree compensated for the negative effect of the reduction of the daily bag limit.

Increasing the daily bag limit in the scenarios 3 and 5 beyond 5 cod per day, we observed an increase in welfare, which was more pronounced using the additional costs as payment vehicle than in the harvest-tag scenarios. Importantly, the angler's average WTP for higher bag limits was positive when we framed the CE as a policy treatment, while it turned negative in the angling experience treatment, indicating that preferences for daily bag limits were sensitive to the choice contexts. Specifically, we estimated a welfare gain of 78.55 € per angling day for the scenario 4 including a bag limit of 7 and a size-based harvest limit of 38–70 cm in the policy choice and a gain of 13.63 € per angling day in the experience choice. Also, the share of anglers who had a negative WTP for these combinations compared to the single measures decreased. The gain decreased again, when we increased the bag limit to 12 cod, expect for the angling experience choice with the additional costs.

In scenario 6, we allowed the anglers to capture one cod per day. This scenario simulated a strict bag limit of one fish per angler and day, which resulted in a welfare gain compared to the status quo in the angling experience treatment, which was − 0.12 € per retained cod and 30.15 € per angling day.

Looking at the policy treatment, we saw that the combination (scenario 8) of a high bag limit (12 cod) and a size-based harvest limit of 38–60 cm with no closed season led to a combination that around 72% of the respondents did not prefer. The WTP of this combination was − 6.56 € per caught and kept cod or − 152.05 € per angling day. This suggested that having a closed season produced high welfare to the anglers. Indeed, when combining the bag limit of 2 with a size-based harvest limit of 38–70 cm, and a closed season in March the WTP increased to − 4.57 € per retained cod and − 8.92 € per angling day. Additionally, in scenario 9 we reduced the commercial quota by 25%. This led to a small welfare loss of − 0.89 € per retained cod but a WTP gain of 67.83 € per angling day, indicating that angler well-being would benefit from regulating the commercial fishing mortality on cod further.

5. Discussion

The western Baltic cod is a preferred target species of marine recreational anglers in Germany (Weltersbach et al., 2021). However, the stock is in a poor state, and management have tightened to deal with the recent cod collapse (Möllmann et al., 2021). Using an online survey of 1795 German cod anglers, we assessed preferences for standard harvest regulations directed at anglers, such as size-based harvest limits and daily bag limits in four different CE (angling experience and policy treatment, with two different payment vehicles, i.e., pay per day vs. pay per fish) and qualitatively compared the results with an assessment of preferred regulations in the absence of trade-offs.

We found strong support for our first hypothesis that German cod anglers are highly consumptive and therefore willing to pay for harvesting cod, while the German anglers do not receive any utility from mandatorily catching-and-releasing cod. The lack of positive utility of just releasing cod in Germany strongly indicates that the species is highly consumptive in the German culture. In addition, German cod anglers were also found to enjoy benefits from catching very large cod. This result fits with other studies that also reported anglers generally receiving positive utility from various catch outcomes, such as catch rate, harvest rate (in consumptive fish) and size of fish in the catch (Birdsong et al., 2021, 2022; Carter and Liese, 2012; Goldsmith et al., 2018; Lew and Larson, 2015). However, angler populations vary in terms of how much utility they derive from either catching and releasing or from subsequent harvest of fish. In many cases, particularly in many marine fisheries, the consumption of fish is highly relevant (Carter and Liese, 2012; Lew and Larson, 2014; Lee et al., 2017; Hunt et al., 2019; Andrews et al., 2021), and similar results have been reported for other fish species in the German angling culture (e.g., for European eel (*Anguilla anguilla*); Dorow et al., 2010). German cod anglers seem to be even more consumptive than North American and UK cod anglers, as Lee et al. (2017) and Andrews et al. (2021) also reported utility generated from the catch and release of cod. One reason for the high consumptive orientation of German cod anglers is not only the culinary value of the species, but also German animal welfare regulations that confine recreational fishing to the condition that it is done for personal consumption (Arlinghaus, 2007).

We found positive WTP for the size of the largest cod being between

60 cm and 110 cm relative to the base category of 50 cm. These positive mean WTPs for size were consistent in the treatments with both payment vehicles. The high relevance of the size of fish for angler well-being has also been reported in other studies (Aas et al., 2000; Birdsong et al., 2021, 2022; Hunt et al., 2019; Lew and Larson, 2015). On average, anglers also had a positive WTP for catches of other fish species than cod, similar to the study on other cod angler populations of Lee et al. (2017) and Andrews et al. (2021), but the relevance of catches of other species to angler well-being showed diminishing marginal returns, which is in line with results from other studies (Arlinghaus et al., 2014, 2020; Lawrence, 2005). Andrews et al. (2021) found that anglers in the UK compensated one caught and kept cod with roughly more than two caught and kept fish of another species. Therefore, declining cod catches may be substitutable to some degree by the catch of other species.

Our second hypothesis was rejected as we did not find support for German cod anglers generally preferring the most liberal harvest regulations in terms of size and daily bag limits, which again agreed with previous work in different angler populations (Aas et al., 2000; Dorow et al., 2010; Lew and Larson, 2012; Goldsmith et al., 2018), including Atlantic cod (Andrews et al., 2021).

In fact, strong evidence was found that anglers preferred harvest slots of intermediate dimensions over the minimum-length limit, which is currently in place. These findings show that anglers are indeed willing to self-regulate and thereby contribute to cod conservation, which is in line with many other studies from both freshwater (Dorow et al., 2010; Hunt et al., 2019) and marine environments (Andrews et al., 2021; Jungers et al., 2022; Lee et al., 2017; Lew and Larson, 2015).

Our results revealed that anglers did not want to deviate from the daily bag limit of 5 cod per day and angler, which is important for recreational fishing policy discussions on western Baltic cod that have been largely centered on bag limit changes. However, as expected for a consumptive fishery, western Baltic cod anglers showed negative WTP for a bag limit of 2 cod per day and angler in most cases. On the other hand, we failed to find evidence that the anglers wanted a more liberal bag limit beyond 5 cod per day either. The preference for the bag limit of 5 cod per day and angler can either indicate a status-quo bias (Meyerhoff and Liebe, 2009) after getting used to this bag limit after its introduction in 2017 or could be caused by the western Baltic cod stock being at such a low level that catch rates of more than five cod per day were rare events at the time of the survey (Haase et al., 2022). Another explanation is that the poor stock status reinforces conservation awareness. As anglers in general opted for less liberal harvest regulations in addition to the preferences of a 5 cod per day bag limit, such as implementation of a harvest slot limit, and a 3-month spawning closure (January to March), conservation awareness is the more likely explanation for the status quo preferences of the 5 cod bag limit.

However, it is important to note that exact preferences for a given level of a daily bag limit varied quite strongly among the CE context, like the case for closed seasons in the policy choice scenario. Therefore, we would conclude that although broadly the different CE and the opinion-type assessment recovered a consistent preference structure, there were contextual effects in the details of the preferences, e.g., for the specific levels of daily bag limits that were revealed in the different choice contexts.

We must note that our survey was done before the daily bag limit was cut to 1 cod per day and angler in 2022 (EU, 2021). However, based on our results, we can conclude that this reduction strongly reduced the benefits of cod anglers and thus their welfare. A recent simulation study showed that a liberal daily bag limit coupled with more restrictive length-based harvest limits and the introduction/extension of seasonal closures would probably be more effectful in terms of controlling western Baltic cod harvest with only moderate impacts on angler welfare than a management solely based on daily bag limits (Haase et al., 2022). Our policy analysis supports these findings as combinations with a harvest slot limit of 38–70 cm including a bag limit of 7 cod (scenario 3 Table 4) led to welfare gains in all four CEs.

In general, the policy choice treatment and the assessment showed a clear trend that western Baltic cod anglers preferred the existence of a seasonal closure. This finding is in line with Haase et al. (2022), who also found a strong preference of German marine anglers (mainly western Baltic Sea anglers) for seasonal closures. However, preferences on the duration and the timing of the seasonal closure varied within the policy CE between the additional cost and the harvest tag context.

In all CE, the anglers stated a significant negative mean WTP for a low control frequency, as we measured the control frequency descending from controls every two trips to controls every 50 trips. Therefore, we can conclude that anglers prefer a higher control frequency. This is in line with a study by Marta et al. (2001) who conducted a regional survey on a Portuguese recreational freshwater fishery where the majority of the interviewed anglers stated that the number of inspectors and the efficiency of the controls were insufficient. Similar results have also been found for a marine recreational fishery in Spain where most anglers reported very infrequent inspections and desired more controls (Cardona and Morales-Nin, 2013).

When comparing the patterns of WTP with the same payment vehicle but across the two treatments, we largely detected similar WTP estimates for most of the regulatory attributes that were present in both treatments. This was particularly the case for the positive WTP for size-based harvest limits in the range of 38–70 cm, the aversion to low intensity controls and the positive WTP for a bag limit of five cod per day over alternatives, although the details of which concrete daily bag limit was preferred or not more strongly varied by choice context.

Our sample consisted of a convenience, non-random sample that was dominated by self-selected respondents who were recruited by advertising the online survey in print and social media (79%). Therefore, this sample may not be representative of the whole German western Baltic cod angler population and caution should be exercised when extrapolating the results of our survey to the general angler population (Gundelund et al., 2020; Sexton et al., 2011). For example, the average participant of our online survey was slightly younger (45 vs. 49 years) and had a higher education (university degree vs. apprenticeship) compared to participants of a representative CATI survey on marine recreational fishing in Germany from 2014/2015 (Weltersbach et al., 2021). This might be a result of the online-only administration of our survey as other research has shown that older people might be underrepresented in online surveys (Gigliotti and Dietsch, 2014). It is also likely that the participants of our survey were more specialized and avid compared to the average German cod angler as it has been shown by other studies that compared participants and non-participants of scientific surveys (Fisher, 1996; Pollock et al., 1994). This could be particularly relevant for this study as more specialized anglers may have a higher concern for preservation of a resource and accept harvest constraints more than the representative angler (Oh and Ditton, 2006). However, the relatively large sample size (1795 respondents) may have helped to limit these biases but future studies using probability-based sampling methods are needed to validate our results.

6. Conclusions

We conclude that German cod anglers are highly consumptive and receive high benefits from retaining cod, but do not benefit from mandatory catch-and-release. Cod anglers are willing to self-regulate to some degree and prefer stricter size-based length limits than the one that is presently in place as well as closed seasons, a daily bag limit of 5–7 cod per day, sufficient controls, and a reduction of the commercial cod quota. Moreover, cod anglers receive benefits from catching large cod and from the catch of other species than cod, although the WTP for catching other species is less than that for catching cod. Given these preferences, the recently installed reduction in the daily bag limit from 5 to 1 cod per day and the generally lower catch and harvest prospects due to the poor stock situation has created a relevant welfare loss to which cod anglers are likely to respond by reduced participation and relocation of effort to alternative species or to cod stocks in other regions. Future studies should examine whether changes in participation and effort, emerging from our

stated preference work, can be empirically supported.

CRediT authorship contribution statement

Julia Bronnmann: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Dieter Koemle:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Juergen Meyerhoff:** Conceptualization, Methodology, Writing – review & editing. **Harry V. Strehlow:** Conceptualization, Writing – original draft, Writing – review & editing. **Marc Simon Weltersbach**: Conceptualization, Writing – original draft, Writing – review & editing. **Robert Arlinghaus:** Conceptualization, Validation, Investigation, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Appendix

(See here Appendix Table A1, A2).

Table A1
Summary of the sample characteristics.

		Policy choice		Experience choice	
	Unit	Harvest tag	Additional cost	Harvest tag	Additional cost
Participants	Number	451	453	441	450
Federal state	residency				
Baden-Württemberg	Share (%)	2.44	2.19	2.72	2.00
Bavaria	Share (%)	4.43	4.81	3.17	7.56
Berlin	Share (%)	3.77	7.00	4.08	3.56
Brandenburg	Share (%)	8.20	8.32	8.39	6.89
Bremen	Share (%)	0.67	0.88	0.45	0.44
Hamburg	Share (%)	4.21	5.91	4.54	5.11
Hesse	Share (%)	3.33	2.63	3.85	4.00
Mecklenburg-Western Pomerania	Share (%)	18.63	16.41	17.46	18.22
Lower Saxony	Share (%)	11.97	12.47	14.29	12.44
North Rhine-Westphalia	Share (%)	6.65	7.22	8.39	11.56
Rhineland Palatinate	Share (%)	0.44	1.31	2.27	0.89
Saarland	Share (%)	0.00	0.22	0.23	0.00
Saxony	Share (%)	6.21	4.60	6.58	5.56
Saxony-Anhalt	Share (%)	3.33	3.50	4.08	3.56
Schleswig-Holstein	Share (%)	22.39	20.13	17.01	16.22
Thuringia	Share (%)	3.33	2.41	2.49	2.00
Member angling association	Share (%)	74.06	73.09	75.28	72.89
Male	Share (%)	98.23	97.37	97.05	97.56
Degree	Highest degree of respondents				
Polytechnical high school	Share (%)	10.42	8.75	8.62	9.33
College entrance qualification	Share (%)	11.97	8.10	9.75	10.00
School leaving	Share (%)	4.88	7.44	6.35	5.78
University degree	Share (%)	37.25	38.29	33.56	36.89
High school	Share (%)	13.97	12.04	16.78	13.78
No information	Share (%)	0.44	1.09	1.59	1.11
None	Share (%)	0.00	1.31	0.45	0.44
Secondary school	Share (%)	21.06	22.98	22.90	22.67
Income	Household net income in €				
Low income	% < 2000€	28.38	28.01	28.34	26.89
Middle income	% 2000€ - 4999€	52.99	48.36	51.02	52.44
High income	% > 4999€	18.63	23.63	20.64	20.67
Age	Mean age	47.69 (12.96)	45.00 (13.40)	45.25 (13.69)	44.93 (12.70)
Household size	Average household size	2.70 (1.72)	2.80 (1.15)	2.70 (1.09)	2.80 (1.69)
Experience	Average years of angling experience	33.51 (14.73)	32.03 (15.21)	33.04 (15.04)	32.96 (14.58)
Experience cod	Average years of cod angling experience	21.07 (13.53)	19.96 (13.50)	20.42 (13.74)	19.30 (12.50)

Std.dev in paratheses

Table A2
Estimation results.

Experience choice	Harvest tag		Additional cost	
	Mean	SD	Mean	SD
Opt out	-6.677 * **		-98.577 * **	
	(0.552)		(17.949)	
cost	-0.278 * **	0.019	-0.010 * **	0.007 * **
	(0.022)	(0.053)	(0.001)	(0.001)
Retain	0.250 * **	0.863 * **	34.696 * **	72.347 * **
	(0.060)	(0.086)	(4.674)	(5.037)
Release	-0.090 *	0.637 * **	10.227	20.275
	(0.049)	(0.074)	(8.177)	(16.923)
Size-based harvest limits for anglers and fishers, base: 38 cm to not bounded above				
38–50 cm	-2.890 * **	2.602 * **	-50.917 * **	-105.760 * **
	(0.424)	(0.562)	(13.787)	(16.500)
38–60 cm	-0.798 * *	-1.076	18.767	16.959
	(0.371)	(1.551)	(11.469)	(24.036)
38–70 cm	1.142 * **	2.301 * **	26.101 * *	44.381 * *
	(0.390)	(0.548)	(12.658)	(21.071)
38–80 cm	-0.094	2.370 * **	30.293 * **	57.752 * **
	(0.380)	(0.555)	(10.665)	(15.167)
Size of largest cod caught in cm, base: 50 cm				
60 cm	0.554	3.065 * **	39.378 * **	89.432 * **
	(0.386)	(0.499)	(15.042)	(20.326)
70 cm	2.781 * **	2.827 * **	104.789 * **	74.321 * **
	(0.432)	(0.586)	(12.899)	(15.073)
90 cm	1.967 * **	2.786 * **	98.182 * **	45.856 * **
	(0.416)	(0.492)	(12.798)	(14.767)
110 cm	3.240 * **	3.516 * **	105.954 * **	122.136 * **
	(0.499)	(0.532)	(15.143)	(16.118)
Control frequency (for fishers and anglers)	-0.100 * **	0.140 * **	-0.867 * **	2.737 * **
	(0.013)	(0.016)	(0.264)	(0.353)
Number of additional catches of other species than cod per day				
0–10 other	0.117 * **	0.264 * **	5.464 * **	11.432 * **
	(0.039)	(0.056)	(1.254)	(1.441)
15–30 other	0.092 * **	0.188 * **	2.956 * **	4.312 * **
	(0.020)	(0.026)	(0.621)	(0.724)
Number of respondents	441		450	
Number of choices per respondent	8		8	
LL	-4075.86		-3894.44	
AIC	8209.72		7846.87	
Standard errors in parentheses				

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

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