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Recreational angling demand in a mixed resource fishery

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Abstract: Several large Irish lake fisheries comprise both pike (Esox Lucius) and brown trout (Salmo trutta). Due to predation on trout, pike stocks are actively managed in several locations with the objective of enhancing the trout fishery, which is a policy strongly supported by some trout anglers but intensely opposed by pike anglers. In the context of scientific support for management decisions concerning these mixed resource fisheries there is a dearth of economics knowledge. This paper addresses some of that knowledge gap, investigating factors affecting angling recreational demand within these mixed resource fisheries and whether there are significant differences between pike and brown trout anglers. We estimate a travel cost model and test whether pike and trout anglers have different demand preferences. The most substantive policy-relevant finding from the research relates not to differences associated with target species but to angling club membership. Angling club members are more price inelastic in their demand and particularly so in the case of trout anglers.

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1. Introduction

Natural resources significantly contribute to the livelihood of small rural communities (Garrod et al., 2006). Water resources increasingly contribute to the rural economy with the development of recreational angling, which supports local income through anglers' expenditures. Recreational angling is a popular activity worldwide and contributes to the rural tourism industry with millions of jobs through angling shops, boarding houses, boat rentals and ancillary businesses (Lynch et al., 2016). In Ireland recreational angling supports 12,000 thousands jobs in angling shops, accommodation providers, boat rentals and ancillary businesses and generates angling-related expenditures of more than €315 million (IFI, 2015). Despite being considered a consumptive leisure activity, angling does not always have negative consequences on the environment. Environmental impacts can be minimised with some best practices aiming at reducing fish harvest, for example fishing catch and release, and pollution (Zwirn et al., 2005; Honey, 2008). However, environmental pressure increases with participation, therefore angling frequency should be carefully monitored. Ireland provides excellent opportunities for recreational anglers with many freshwater sites providing angling opportunities several species, including pike (*Esox lucius*) and brown trout (*Salmo trutta*). When aiming to develop angling tourism, it is important for fishery managers to understand tourist anglers' preferences to facilitate effective marketing strategies, in particular when different angler groups show contrasting preferences for fishery management (Bower et al., 2014; Brown and Trebilco, 2014).

Anglers are not a homogeneous group. Several studies demonstrate that there are many distinct cohorts of anglers across fisheries, seeking different angling experiences (Fisher, 1997). In some cases, different groups of anglers may have conflicting views on fishery management (Garlock and Lorenzen, 2017; Lee et al., 2016). Different segments of anglers may also show different consumptive preferences (Kyle et al., 2007). Pike and brown trout anglers represent an example of potential contrasting stakeholders of water resources. Due to pike and brown trout cohabitation, recreational anglers targeting pike or trout often share fishing locations, however they have different attitudes and objectives for fishery management due to the interactions between the species. In some designated wild trout fisheries in Ireland pike stocks are actively managed due to predation on trout (Hyvärinen and Vehanen, 2004). While opinions and preferences for stock management have already been studied (Curtis, 2018), a robust understanding of the economic benefits that pike and brown trout anglers enjoy plus their contribution to the economy is still incomplete. This aspect is important because it allows further insights into the economic benefits of recreational angling to the economy and tourism development, as well as providing an economic justification for stock management decisions in addition to fishery or biological concerns.

With this in mind, the objective of this paper is to assess demand preferences of pike and trout anglers and estimate the benefit that anglers obtain from fishing. We also investigate whether there are significant differences in consumer surplus (CS) for pike anglers, brown trout anglers and anglers targeting both species. We explore how welfare measure and angling participation is associated with club membership, as well as factors affecting decisions to go fishing. The study is conducted using a travel cost method (TCM) to estimate the demand for recreation and it is applied to a dataset of domestic and overseas anglers having fished in Ireland in 2016. TCM models have been used to evaluate the benefits of recreational activities in many settings, including forest recreation (Willis and Garrod, 1991; Paletto et al., 2017; Bertram and Larondelle, 2017), birdwatching (Czajkowski et al., 2014) and fisheries (e.g., Samples and Bishop, 1985; du Preez and Hosking, 2011). With respect to pike and brown trout angling, previous studies investigated other aspects of pike-trout dichotomy. Curtis (2018) investigated preferences for pike stock management and habitat attributes and found that the majority of trout anglers opposed pike controls. Other contributions focused on ecological studies of pike and trout stocks (Mann, 1985). While studies on economic assessment of multiple species (Shrestha et al., 2002; Greene et al., 1997; Haab et al., 2012), salmon angling (Grilli et al., 2018b; Lin et al., 1996; Olaussen, 2016) or differences between game and coarse angling (Curtis and Breen, 2017) are available in the literature, this is the first paper that specifically estimates demand preferences in a mixed pike trout fishery in Ireland.

The rest of this manuscript is organised as follows. In the second section we describe data collection, the theoretical framework for our analysis and research methods. The third section is dedicated to results description. The fourth is a discussion section, where results are interpreted and some policy implications of our study are provided. The fifth section offers some conclusions.

2. Methods

2.1. Data

The study dataset originated from a questionnaire survey that was carried out in 2016. The survey was administered to pike and trout angler members of a voluntary angler research panel that fish in Ireland. Unfortunately due to the absence of an angler register in Ireland, the representativeness of the surveyed anglers to the wider population of pike and trout anglers cannot be established. The panel may be subject to selection biases. For instance, it is likely that more avid anglers are panel members. However, extensive efforts were undertaken to recruit anglers to the panel via social media, national and local newspapers including notices in 'angling notes', local radio interviews, posters in fishing tackle shops, and direct communication with angling representative bodies and clubs. Nonetheless, the dataset should be considered a convenience sample (Etikan et al., 2016).

The questionnaire consisted of a total of 61 questions and required approximately 20 minutes to complete. The questionnaire comprised sections regarding an angler's individual fishing activity, target species, fishing frequency, angling expenditures, views on fishing regulations and their socio-demographic background. A total of 565 anglers were invited by email to participate in the survey in October 2016, of which 380 anglers responded. Some 205 respondents fished only for pike and/or trout with 175 respondents also fishing for additional species. Application of the travel cost model, estimating demand functions for pike and trout angling, necessitates expenditure data specifically associated with these target species. As the angling expenditure questions related to all angling activity, the 175 respondents that also targeted other species were excluded from the analysis.

Pike and trout anglers reported that they each fished on average 48 days over the prior year, while anglers fishing for both species fished 54 days, on average. The mean expense for purchasing clothes, equipment (e.g. lines, hooks, etc.) and travel costs made over the prior 12 months among pike anglers is €82/day-trip, and considerably lower for both trout anglers and those fishing for both species at €46/day-trip. These figures, if multiplied with mean number of trips per year, yield an annual expenditure of approximately €3,900 for a pike angler, €2,200 for a trout angler and €2500 for anglers fishing for both species. From a total of 205 respondents, 75% anglers were members of a fishing club. About 46% of respondents were aged between 45–65, followed by 35–44 years (29%) and 25–34 years (15%). Notably, anglers younger than 24 years' age comprised just 1.7% and above 65 years was 7%. Income of the respondents had a mean of €51,650 across the sample. The trout anglers had a higher mean income of €61,000 compared to pike anglers at €43,400. With respect to occupation, more than 80% of the respondents were engaged in professional, managerial and technical jobs, the remaining 20% were involved in non-manual or manual jobs. When asked about angling skills, 67% ofanglers believed that they had above average or advanced skills in angling and 29% reported themselves as either an average or novice angler. There is a considerable difference between trout and pike anglers with respect to harvesting of caught fish. About 64% of pike anglers always release the fish and 30% occasionally keep the fish. On the other hand, only 44% trout anglers always release the fish and 40% occasionally release it. That translates into higher harvesting of trout by anglers in comparison to pike.

2.2. Theoretical approach and Econometric analysis

TCM is a non-market technique that is frequently used to estimate the value of recreational destinations. The method stems from traditional economic theory, for which individuals are aware of the utility provided by the consumption of goods and services and try to maximise their utility subject to a budget constraint (Ezebilo, 2016; Besanko and Braeutigam, 2011). When the price of a good increases, the quantity that is consumed decreases, thus leading to a negative relationship between price and quantity. TCM replicates this relationship in a recreational setting, in which the quantity of recreation angling is the number of trips taken in a given time span and the price is the cost of an average angling trip (Hellerstein, 1991). When the cost of an angling day increases the total number of trips declines due to the budget constraint assumption. For example, the number of trips is anticipated to decrease with increased travel distance to the angling site because it is more costly and time consuming for people to reach the destination (Camp et al., 2018). The general specification of demand for the angling trip is (Englin et al., 1997):

$$T_i = f(C_i, R, D_i) \tag{1}$$

where T_i is the count representing number of trips undertaken by an individual i; C_i is the cost of trip; R is the site specific characteristics; and D_i is the personal characteristics of individual i. The benefit of a fishing trip is calculated from this demand model in terms of consumer surplus (CS), which is the common welfare measure derived from a TCM and indicates the difference between the amount of money that an angler was willing to pay versus what was actually paid for the trip (Haab and McConnell, 2002).

The econometric specification used to model the number of trips must take into account the nature of the dependent variable, T_i, which only takes non-negative integer values. The ordinary least squares (OLS) estimator may not be adequate because it may return negative predicted values. At the same time, OLS assumes symmetry and a normal distribution of the error term, which is not likely to be the case for recreational trips because very often the distribution is left-skewed. The distribution of annual number of trips stated by respondents is shown in Figure 1, which highlights the left-skewed distribution. Count data models such as Poisson and negative binomial regression are the models that are most frequently used for TCM. In a Poisson framework, the probability that an individual i undertakes a t_i trips is given by (Greene, 2012):

$$Pr[T = t] = \frac{\exp^{-\mu} \cdot \mu^{t_i}}{t_i!} \tag{2}$$

where μ is the rate parameter, which is usually parametrised in a regression framework as an exponential function $\mu = exp(X^{'}\beta)$, in which X is a matrix of covariates and β is the vector of parameters to be estimated. The Poisson distribution has the restrictive assumption of equidispersion, i.e. the mean equal to the variance.

The negative binomial (NB) model is a mixture of a Poisson and a Gamma distribution and overcomes the limitations of Poisson with an extra parameter that accounts for overdispersion (Hilbe, 2011):

$$Pr[T = t] = \frac{\Gamma(\alpha^{-1} + t)}{\Gamma(\alpha^{-1})\Gamma(t + 1)} \times (\frac{\alpha^{-1}}{\alpha^{-1} + \mu})^{\alpha^{-1}} \times (\frac{\mu}{\alpha^{-1} + \mu})^{t} \tag{3}$$

where Γ is the gamma function and α a parameter describing the over-dispersion of the data. The suitability of a NB model was tested with a log-likelihood ratio test.

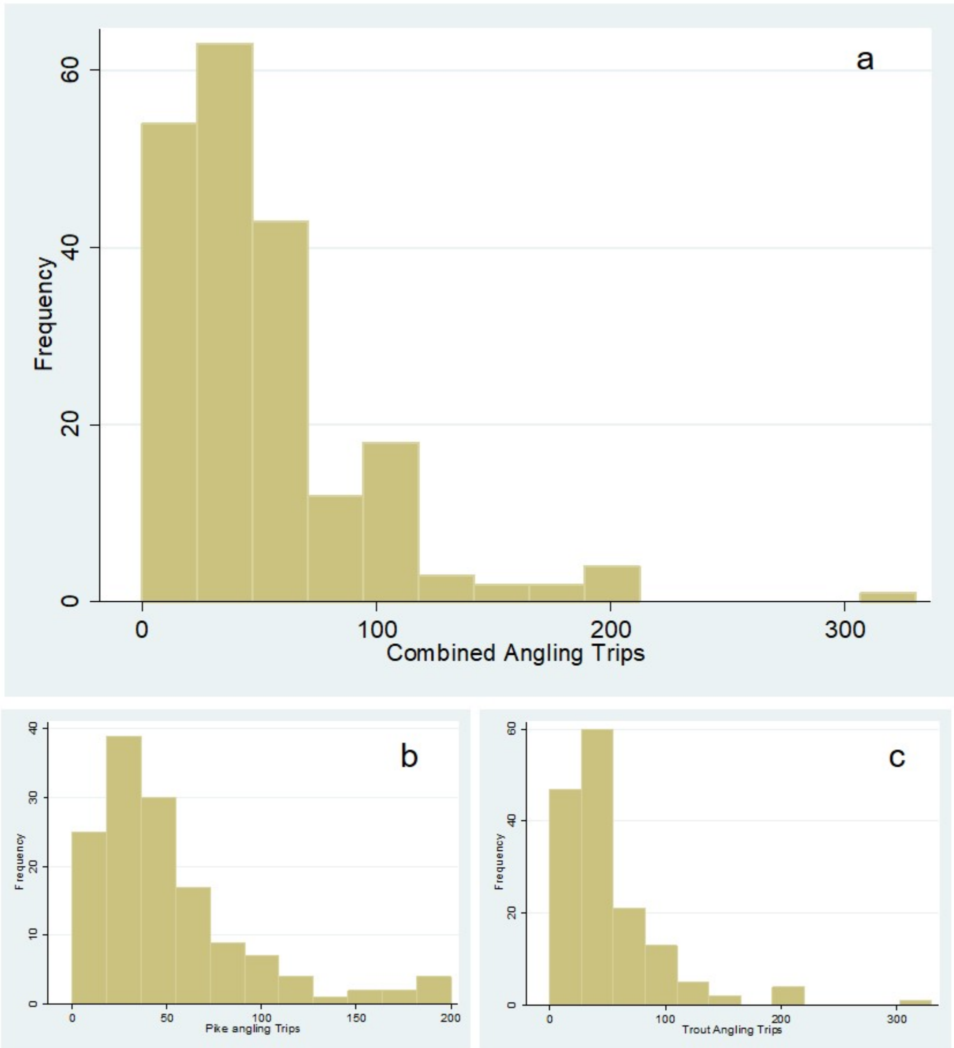

Figure 1: Distribution of angling trips over previous 12- month period (a) Combined angling population (b) Pike anglers (c) Trout anglers

Three separate econometric models were estimated. The first is a Poisson model with one interaction term between the cost variable and angler category, which represents the baseline of our analysis. The second is a negative binomial model containing the same terms as that of the Poisson model, labelled NBM1, and provides a useful comparison with the Poisson to understand the effect of overdispersion. The third is a negative binomial model including a three-way interaction term between the cost variable, anglers' target species and club membership, and which is labelled NBM2. Consumer surplus is calculated for all three models as the negative inverse of the cost coefficient (Haab and McConnell, 2002):

$$CS = -\frac{1}{\beta_c} \tag{4}$$

where β_c is the estimated parameter associated with the cost variable. We distinguish between the CS of pike and brown trout anglers with an interaction between the cost variable and dummies for these different anglers cohorts. Another important statistic that can be obtained from a TCM model is the price elasticity of demand, i.e. the expected change in the number of trips due to a change in the average price per trip. The elasticity is calculated as follows:

$$\frac{\partial E(\mu)}{\partial X_c}\frac{X_c}{\mu} = \beta_c X_c \tag{5}$$

An elastic demand provokes a proportionate change in the number of trips larger than the proportionate change in price (elasticity coefficient <-1), while an inelastic demand leads to a proportionate change in the demanded quantity lower than the proportionate price change (elasticity coefficient between 0 and -1). The calculation of the price elasticity is important because it indicates to what extent anglers are responsive to price, and consequently may influence the decisions of fishery managers or associated tourism industry players related to the prices anglers face.

3. Results

Results of the estimated TCM models are summarised in Table 1. As a first task we conducted a log-likelihood ratio test on the dispersion parameter to check the suitability of the negative binomial model (Cameron and Trivedi, 2005). The test returned a χ^2 value of 3234.92 (p-value = 0.000), thus the null hypothesis of equidispersion was rejected. This indicates that a model that accounts for overdispersion should be preferred over the Poisson model. This hypothesis is also confirmed by the significant α parameter.

With respect to model goodness of fit, both AIC and BIC statistics suggest that both negative binomial models perform better compared to the simple Poisson.[1] The travel cost coefficients for the three anglers' cohorts are all negative and statistically significant. The negative sign was anticipated and complies with economic theory, as it suggests that the number of angling days decreases as unit cost of a fishing day-trip increases. The coefficient associated with investments in tackle (i.e. durable multi-annual equipment that are excluded from daily expenses, for example rods, boats etc.) is positive and statistically significant at 1 percent confidence level in the Poisson and at 10 percent in both NB models. This indicates that larger expenses in durable goods are associated with a greater number of fishing days demanded. This has already been found in previous research in Ireland (Hynes et al., 2017; Grilli et al., 2018a) and suggests that anglers spending money on equipment that presumably lasts for several angling seasons are more likely to fish more days. Being member of a fishing club increases the probability of fishing a higher number of days. Club membership allows fishing in some fisheries with restricted access, therefore a positive relationship with

[1]We do not consider NB1 and NB2 to be competing models but rather complementary, because they are created with different covariates and interaction terms to examine different policy questions.

Table 1: Regression model estimates for angling days demanded

	Poisson	NBM1	NBM2
Pike angler's expense/day	-6.727***	-5.474***	
	(0.309)	(0.945)	
Trout angler's expense/day	-8.703***	-7.346***	
	(0.475)	(1.662)	
Pike+Trout angler's expense/day	-8.223***	-5.633***	
	(0.397)	(0.914)	
Investment	0.0395***	0.0460*	0.0484*
	(0.00383)	(0.0232)	(0.0233)
ClubMembership	0.193***	0.231*	
	(0.0245)	(0.104)	
FishingSkill(Advanced)	0.529***	0.543***	0.538***
	(0.0253)	(0.102)	(0.102)
FishingLocation(OwnBoat)	-0.223***	-0.205*	-0.185
	(0.0223)	(0.104)	(0.102)
FishingLocation(HiredBoat)	-0.385***	-0.353*	-0.288
	(0.0423)	(0.165)	(0.171)
OccupationBlueCollar	0.301***	0.355**	0.320*
	(0.0269)	(0.131)	(0.131)
club non-member Pike angler's expense/day			-6.590***
			(1.577)
club non-member Trout angler's expense/day			-14.03***
			(3.866)
club non-member Pike+Trout angler's expense/day			-10.40***
			(1.985)
Club member Pike angler's expense/day			-5.522***
			(1.050)
Club member Trout angler's expense/day			-6.455***
			(1.727)
Club member Pike+Trout angler's expense/day			-4.898***
			(0.995)
Constant term	3.820***	3.671***	3.853***
	(0.0348)	(0.139)	(0.122)
α		-1.018***	-1.039***
		(0.102)	(0.102)
N	199	199	199
AIC	5099.5	1865.1	1864.1
BIC	5132.5	1901.4	1906.9
Log likelihood	-2539.8	-921.6	-919.0
Chi-squared	1989.0	87.47	92.52

Standard errors in parenthesis and * p<0.05, ** p<0.01, *** p<0.001
Cost/day and Investment variables in €000

fishing effort was anticipated. Anglers who reported above-average angling skills are more likely to fish for a higher number of days. The coefficients on the variables related to fishing from owned or hired boats are negative indicating a lower number of fishing trips compared to on-shore anglers, however, the coefficients are not statistically significant in the NB2 model. In general one would anticipate a lower number of angling trips for anglers that hire boats compared to boat-owners due to the increased daily expenditure. Anglers working in manual sectors fish more often compared to other anglers. With respect to the three way interaction of the model NB2 all coefficients are negative, and statistically significant, and suggest an inverse relationship between trip cost and number of day-trips undertaken. The difference in magnitude of these coefficients across angler cohorts (i.e. club member & target species) indicates a difference in price responsiveness across angler types.

Table 2: Null hypothesis tests of differences in cost coefficients equal to zero

Test Hypothesis	Difference in coefficients	Std. Error	
Model NB1			
Pike = Trout	1.871	1.698	
Pike = Pike+Trout	0.158	1.185	
Trout = Pike+Trout	-1.713	1.701	
Model NB2			
Non-Club Pike = non-Club Trout	**7.441**	**4.005**	*
Non-Club Pike = non-Club Pike+Trout	3.807	2.424	
Non-Club Pike = Club Pike	-1.068	1.741	
Non-Club Pike = Club Trout	-0.135	2.160	
Non-Club Pike = Club Pike+Trout	-1.692	1.766	
Non-Club Trout = non-Club Pike+Trout	-3.634	4.230	
Non-Club Trout = Club Pike	**-8.510**	**3.870**	**
Non-Club Trout = Club Trout	**-7.576**	**3.929**	*
Non-Club Trout = Club Pike+Trout	**-9.134**	**3.885**	**
Non-Club Pike+Trout = Club Pike	**-4.876**	**2.129**	**
Non-Club Pike+Trout = Club Trout	-3.942	2.419	
Non-Club Pike+Trout = Club Pike+Trout	**-5.500**	**2.110**	***
Club Pike = Club Trout	0.934	1.823	
Club Pike = Club Pike+Trout	-0.624	1.340	
Club Trout = Club Pike+Trout	-1.558	1.820	

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

Table 2 reports results of hypothesis tests comparing equality of means of cost coefficients associated with different angler cohorts depending on their club member and targeted species. Statistically significant differences in coefficient magnitudes indicate that the associated angler cohorts have different price sensitivities. In that instance it is likely that CS will also differ between cohorts. With respect to the NB1 model, there are no statistically significant differences in the price coefficients of angler cohorts differentiated by target species, as reported in the first three rows of Table 2. However, the NB2 model differentiates between anglers by both target species and club membership and in that instance differences among anglers cohorts are more evident. The bold typeface highlights the tests where there was a statistical difference between coefficients. With one exception the rejected null hypothesis tests occur where there is a comparison between club and non-club members. Differences in the price responsiveness of anglers appears to be more closely associated with whether they are an angling club member than the species they target. However, it is important to emphasise that there are several instances where the null hypothesis of equality of price coefficients between club members and others are not rejected.

Table 3: Estimates of consumer surplus, price elasticity, and predicted angling days demanded

Angler cohorts	CS (€)		Price Elasticity		Angling days	
NB1 Regression:						
Pike angler	182.7	***	-0.30	***	51.6	***
	(31.5)		(0.05)		(2.9)	
Trout angler	136.1	***	-0.40	***	48.0	***
	(30.8)		(0.09)		(3.0)	
Pike+Trout angler	177.5	***	-0.31	***	51.3	***
	(28.8)		(0.05)		(2.9)	
NB2 Regression:						
Club non-member Pike angler	151.7	***	-0.36	***	50.2	***
	(36.3)		(0.09)		(3.6)	
Club non-member Trout angler	71.3	***	-0.77	***	38.9	***
	(19.6)		(0.21)		(4.6)	
Club non-member Pike+Trout angler	96.2	***	-0.57	***	43.7	***
	(18.4)		(0.11)		(3.3)	
Club member Pike angler	181.1	***	-0.30	***	52.4	***
	(34.4)		(0.06)		(3.2)	
Club member Trout angler	154.9	***	-0.36	***	50.4	***
	(41.4)		(0.09)		(3.4)	
Club member Pike+Trout angler	204.2	***	-0.27	***	53.8	***
	(41.5)		(0.05)		(3.2)	

$*p < 0.1$, $**\,p < 0.05$, $***p < 0.01$. Standard errors in parenthesis

While the results just discussed are noteworthy, the issue of greater practical policy relevance is whether specific cohorts of anglers differ in terms of price elasticity (i.e. price sensitivity), their predicted number angling days, and consumer surplus measure, which are reported in Table 3. First, we discuss consumer surplus, which is a measure of the value of a angling trip in excess of trip expenditure, and in all cases the estimates are significantly different than zero. Generally, anglers that fish for pike have higher CS estimates than anglers that fish for trout only. However, the differences in CS between trout and pike anglers are not statistically different, as indicted by the estimates from model NB1. The CS estimates from the NB2 model show a larger difference depending on whether the angler is an angling club member, especially for trout anglers. Anglers with the highest CS are club members. An estimate of a total willingness to pay for a day's fishing is given by the sum of CS and the relevant mean trip expenditure, which were reported in section 2.1 as €82/trip for pike anglers and €46/trip for trout anglers, as well as anglers who target both species.

Overall, the value or worth of a day's fishing is higher for pike anglers.

The price elasticity estimates from the NB1 model indicate an inelastic demand, which is consistent with several other estimates for Irish anglers (Curtis and Stanley, 2016; Curtis and Breen, 2017). Though one recent study associated with prestige salmonid fisheries indicated elastic demand, with a price elasticity estimate of -1.04 (Grilli et al., 2018b). The estimates associated with the NB2 model indicate that price elasticity varies considerably by angler cohort. Anglers that are not club members, and specifically those that target trout, have a higher price elasticity (i.e. -0.57– -0.77 compared to approximately -0.3 for other cohorts).

Finally, the estimates of predicted angling days demanded is also reported in Table 3. Focusing on the NB2 model, mean angling days demanded is higher among club members by approximately 9 days compared to non-club anglers.

4. Discussion

The results of our TCM analysis show that pike and trout anglers obtain substantial benefits from their recreational activity. Among anglers that target pike, target trout, or target both species the estimated consumer surplus varies between €136–182 per day-trip. With a mean number of fishing day-trips per annum of 51, the total surplus per annum is substantial. However, the sample is not representative of the population of pike and trout anglers and is likely biased in favour of more avid anglers. This is evident in the sample mean angling days per annum of 51. While the study may not be reflective of pike and trout angling generally, it does make an important contribution. First, there are no studies specifically investigating pike or trout angling demand in Ireland. Second, while the sample is likely to be over-represented with more avid anglers, such anglers represent an important stakeholder group for fishery managers. Understanding the demand preferences of this angler cohort is critical for the future development of the fishery resource, and particularly so if such development is being driven as a tourism resource. The caveats relating to the sample aside, the CS welfare estimates are broadly comparable to other studies, both in Ireland and internationally. For example, Hynes et al. (2017) estimated a CS of about €242 for day for sea anglers, while Curtis and Breen (2017) estimated a CS for coarse anglers of €246 with a substantially higher estimate for salmon and trout anglers combined of €677. In South Africa, du Preez and Hosking (2011) estimate a CS value of \$344 per day in a trout fishery ($\approx$ €240), while in Norway salmon angling was estimated to be worth NOK 763($\approx$ €92) per day (Olaussen and Liu, 2011).

The primary objective of the research was to establish whether anglers targeting pike and trout in Ireland have different demand preferences. The most substantive policy-relevant finding from the research relates not to differences associated with target species but to angling club membership. Club members are more price inelastic in their demand and particularly so in the case of anglers targeting trout. Additionally, the mean number of fishing days demanded, at least in this sample, differ by over 20% when comparing club member to non-members. Angling clubs are distinctive components of many fisheries worldwide and club affiliation affects not only effort but also the recreational experience. Club membership generally guarantees access and therefore facilitates higher angling frequency, which is beneficial to the local economy but may also exert high environmental pressure. The literature suggests that anglers' ecological understanding increases with specialization (e.g. Gray et al., 2015), thus club members may be more aware of environmental problems due to angling pressures and be more responsible. From an economic perspective, club members enjoy a relatively large surplus versus non-members and also have relatively inelastic demand. Thus, where anglers seek greater public investment in the protection and enhancement of fishery resources there is a reasonable argument to be made that anglers, and specifically club anglers, may be able to make a larger contribution to such investment without any substantive decline in angling demand.

Non-club anglers can be reasonably considered synonymous with tourist anglers, as they don't enjoy preferential access that club membership affords and their fishing options entail either public access fisheries or pay daily fees associated with private or restricted access fisheries. This research has relevance where local fisheries are being advocated as a tourist attraction and a means to expand the local economy. The price elasticity of demand of tourist trout anglers, at -0.57– -0.77, is the least inelastic of all the elasticity estimates in Table 3 and up to twice the value associated with most other angler cohorts. Furthermore, the consumer surplus associated with a tourist trout angling day-trip is substantially lower than trout anglers that are club members, by between €83–108. Tourist trout anglers are the most price sensitive and have the lowest consumer surplus of all trout anglers, therefore, the tourist angler cohort is the most likely to curtail activity in the face of increased costs, whether direct angling costs (e.g. ghillie fees, permits, etc.) or associated trip costs (e.g. transport, food, accommodation, etc.). The challenge facing those hoping to boost local economic activity via trout angling tourism is to find a way to expand the tourist angler client base rather than focusing on increasing expenditures among existing tourist anglers. This is not the case for pike anglers that, irrespective of whether they are angling club members or not, have similar price elasticities of approximately -0.3 and the difference in CS per day-trip is just €29.

It is widely recognised in the literature that anglers are a heterogeneous group and multiple angler cohorts have been identified across many fisheries with different objectives, preferences and expectations of fishery management (e.g. Wilde and Ditton, 1991; Fisher, 1997; Connelly et al., 2001; Arlinghaus and Mehner, 2005; Hutt and Bettoli, 2007; Arlinghaus et al., 2017; Morey et al., 2006). Preference heterogeneity associated with angling club membership is not often considered but there is evidence, both in this paper and elsewhere, that it may be an important explanator. Gigliotti and Peyton (1993) find that members of angling organisations are generally more experienced, specialised and avid anglers; and also are more supportive of conservation regulations than non-members. Fisher (1997) similarly find that club membership is most prevalent among higher-specialisation anglers. Jakus et al. (1996) find that angling club membership is correlated with angler perceptions of regulatory complexity, while Sutton (2006) find that anglers that are members of fisheries-related organisations are more likely to participate in public consultation programs. Future research examining angler preference heterogeneity should be mindful of the role that membership of angling clubs or organisations may play in understanding angler preferences.

5. Conclusions

This paper estimates a demand model for angling within a mixed resource fishery with the objective of identifying whether there are significant differences in preferences between pike and trout anglers. A standard travel cost methodology is utilised and a number of model specifications are estimated. When anglers' membership of angling clubs is not specified within the models, estimates of price elasticity, consumer surplus, and predicted angling demand are not statistically differentiable between pike and trout anglers. When the estimated models control for angling club membership substantial differences are evident. Trout angling club members have price elasticity estimates approximately half that of non-club members and their estimates of consumer surplus also differ by a similar ratio. The extant literature has highlighted the heterogeneity of angler preferences but this finding suggests affiliation with angling organisations or angling club membership are important angler attributes explaining preferences, and which have not been widely considered previously.

From an economic perspective there is not much to distinguish between pike or trout anglers in these mixed species fisheries. With the exception of angling club membership, there is no statistical difference between pike and trout anglers, in terms of price elasticity of demand, consumer surplus nor predicted day-trip demand. The most substantial difference among angler types related to expenditure. Within the sample, mean expenditure per day-trip among pike-only anglers was €82 compared to €46 for anglers targeting trout. There is a wider debate on the merits of a pike stock control policy (Curtis, 2018; Viney, 2015), because environmental improvements may be offset by changes in anglers' fishing activity. This analysis suggests that the potential economic contribution to the local economy of a marginal pike angler is not less than that of a trout angler.

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7. References

Arlinghaus, R., Alós, J., Beardmore, B., Daedlow, K., Dorow, M., Fujitani, M., Hühn, D., Haider, W., Hunt, L., Johnson, B., Johnston, F., Klefoth, T., Matsumura, S., Monk, C., Pagel, T., Post, J., Rapp, T., Riepe, C., Ward, H., and Wolter, C. (2017). Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. *Reviews in Fisheries Science & Aquaculture*, 25(1):1–41. http://dx.doi.org/10.1080/23308249.2016.1209160.

Arlinghaus, R. and Mehner, T. (2005). Determinants of management preferences of recreational anglers in Germany: habitat management versus fish stocking. *Limnologica-Ecology and Management of Inland Waters*, 35(1):2–17. https://doi.org/10.1016/j.limno.2004.10.001.

Bertram, C. and Larondelle, N. (2017). Going to the woods is going home: Recreational benefits of a larger urban forest site –a travel cost analysis for Berlin, Germany. *Ecological Economics*, 132:255–263. https://doi.org/10.1016/j.ecolecon.2016.10.017.

Besanko, D. and Braeutigam, R. R. (2011). *Microeconomics*. John Wiley & Sons, New Jersey.

Bower, S. D., Nguyen, V. M., Danylchuk, A. J., Beard Jr, T. D., and Cooke, S. J. (2014). Inter-sectoral conflict and recreational fisheries of the developing world: Opportunities and challenges for co-operation. *Enhancing Stewardship in Small-Scale Fisheries: Practices and Perspectives, ed. P. McConney, R. Medeiros, and M. Pena. Too Big To Ignore (TBTI) and Centre for Resource Management and Environmental Studies, Technical Report*, (73).

Brown, C. J. and Trebilco, R. (2014). Unintended cultivation, shifting baselines, and conflict between objectives for fisheries and conservation. *Conservation biology*, 28(3):677–688.

Cameron, A. C. and Trivedi, P. K. (2005). *Microeconometrics: methods and applications*. Cambridge University Press.

Camp, E. V., Ahrens, R. N., Crandall, C., and Lorenzen, K. (2018). Angler travel distances: Implications for spatial approaches to marine recreational fisheries governance. *Marine Policy*, 87:263–274. http://dx.doi.org/10.1016/j.marpol.2017.10.003.

Connelly, N. A., Knuth, B. A., and Brown, T. L. (2001). An angler typology based on angler fishing preferences. *Transactions of the American Fisheries Society*, 130(1):130–137. https://doi.org/10.1577/1548-8659(2001)130<0130:AATBOA>2.0.CO;2.

Curtis, J. (2018). Pike (*Esox lucius*) stock management in designated brown trout (*Salmo trutta*) fisheries: Anglers' preferences. *Fisheries Research*, 207:37–48. https://doi.org/10.1016/j.fishres.2018.05.020.

Curtis, J. and Breen, B. (2017). Irish coarse and game anglers' preferences for fishing site attributes. *Fisheries Research*, 190:103–112. http://doi.org/10.1016/j.fishres.2017.01.016.

Curtis, J. and Stanley, B. (2016). Water quality and recreational angling demand in Ireland. *Journal of Outdoor Recreation and Tourism*, 14:27–34. https://doi.org/10.1016/j.jort.2016.04.005.

Czajkowski, M., Giergiczny, M., Kronenberg, J., and Tryjanowski, P. (2014). The economic recreational value of a white stork nesting colony: A case of 'stork village' in Poland. *Tourism Management*, 40:352–360. https://doi.org/10.1016/j.tourman.2013.07.009.

du Preez, M. and Hosking, S. G. (2011). The value of the trout fishery at Rhodes, North Eastern Cape, South Africa: a travel cost analysis using count data models. *Journal of Environmental Planning and Management*, 54(2):267–282. http://doi.org/10.1080/09640568.2010.505837.

Englin, J., Lambert, D., and Shaw, W. D. (1997). A structural equations approach to modeling consumptive recreation demand. *Journal of Environmental Economics and Management*, 33(1):33–43. https://doi.org/10.1006/jeem.1996.0976.

Etikan, I., Musa, S. A., and Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1):1–4. https://doi.org/10.11648/j.ajtas.20160501.11.

Ezebilo, E. E. (2016). Economic value of a non-market ecosystem service: an application of the travel cost method to nature recreation in Sweden. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 12(4):314–327. https://doi.org/10.1080/21513732.2016.1202322.

Fisher, M. R. (1997). Segmentation of the angler population by catch preference, participation, and experience: a management-oriented application of recreation specialization. *North American Journal of Fisheries Management*, 17(1):1–10. https://doi.org/10.1577/1548-8675(1997)017<0001:SOTAPB>2.3.CO;2.

Garlock, T. and Lorenzen, K. (2017). Marine angler characteristics and attitudes toward stock enhancement in Florida. *Fisheries research*, 186:439–445.

Garrod, B., Wornell, R., and Youell, R. (2006). Re-conceptualising rural resources as countryside capital: The case of rural tourism. *Journal of Rural Studies*, 22(1):117–128. https://doi.org/10.1016/j.jrurstud.2005.08.001.

Gigliotti, L. M. and Peyton, R. B. (1993). Values and behaviors of trout anglers, and their attitudes toward fishery management, relative to membership in fishing organizations: a Michigan case study. *North American Journal of Fisheries Management*, 13(3):492–501. https://doi.org/10.1577/1548-8675(1993)013<0492:VABOTA>2.3.CO;2.

Gray, S., Hilsberg, J., McFall, A., and Arlinghaus, R. (2015). The structure and function of angler mental models about fish population ecology: the influence of specialization and target species. *Journal of Outdoor Recreation and Tourism*, 12:1–13.

Greene, G., Moss, C. B., and Spreen, T. H. (1997). Demand for recreational fishing in tampa bay, florida: A random utility approach. *Marine Resource Economics*, 12(4):293–305.

Greene, W. (2012). *Econometric Analysis*. Pearson, Essex, UK, 7th edition.

Grilli, G., Curtis, J., Hynes, S., and O'Reilly, P. (2018a). Sea bass angling in Ireland: A structural equation model of catch and effort. *Ecological Economics*, 149:285–293. https://doi.org/10.1016/j.ecolecon.2018.03.025.

Grilli, G., Landgraf, G., Curtis, J., and Hynes, S. (2018b). A travel cost evaluation of the benefits of two destination salmon rivers in Ireland. *Journal of Outdoor Recreation and Tourism*. https://doi.org/10.1016/j.jort.2018.02.004.

Haab, T., Hicks, R., Schnier, K., and Whitehead, J. C. (2012). Angler heterogeneity and the species-specific demand for marine recreational fishing. *Marine Resource Economics*, 27(3):229–251.

Haab, T. C. and McConnell, K. E. (2002). *Valuing environmental and natural resources: the econometrics of non-market valuation*. Edward Elgar Publishing, Cheltenham, UK.

Hellerstein, D. M. (1991). Using count data models in travel cost analysis with aggregate data. *American Journal of Agricultural Economics*, 73(3):860–866. https://doi.org/10.2307/1242838.

Hilbe, J. M. (2011). *Negative binomial regression*. Cambridge University Press.

Honey, M. (2008). *Ecotourism and sustainable development: Who owns paradise?* Island Press, Washington.

Hutt, C. P. and Bettoli, P. W. (2007). Preferences, specialization, and management attitudes of trout anglers fishing in Tennessee tailwaters. *North American Journal of Fisheries Management*, 27(4):1257–1267. https://doi.org/10.1577/M05-215.1.

Hynes, S., Gaeven, R., and O'Reilly, P. (2017). Estimating a total demand function for sea angling pursuits. *Ecological Economics*, 134:73–81. https://doi.org/10.1016/j.ecolecon.2016.12.024.

Hyvärinen, P. and Vehanen, T. (2004). Effect of brown trout body size on post-stocking survival and pike predation. *Ecology of Freshwater Fish*, 13(2):77–84.

IFI (2015). The economic contribution of brown trout angling in ireland. *Report to the National Strategy for Angling Development*. https://www.fisheriesireland.ie/national-strategy-for-angling-development/socio-economics/530-the-economic-contribution-of-brown-trout-angling-in-ireland/file.html.

Jakus, P. M., Fly, J. M., and Wilson, J. L. (1996). Explaining public support for fisheries management alternatives. *North American Journal of Fisheries Management*, 16(1):41–48. https://doi.org/10.1577/1548-8675(1996)016<0041:EPSFFM>2.3.CO;2.

Kyle, G., Norman, W., Jodice, L., Graefe, A., and Marsinko, A. (2007). Segmenting anglers using their consumptive orientation profiles. *Human Dimensions of Wildlife*, 12(2):115–132.

Lee, K. J., Scott, D., Floyd, M. F., and Edwards, M. B. (2016). Social stratification in fishing participation in the United States: A multiple hierarchy stratification perspective. *Journal of Leisure Research*, 48(3):245–263.

Lin, P.-C., Adams, R. M., and Berrens, R. P. (1996). Welfare effects of fishery policies: Native American treaty rights and recreational salmon fishing. *Journal of Agricultural and Resource Economics*, pages 263–276.

Lynch, A. J., Cooke, S. J., Deines, A. M., Bower, S. D., Bunnell, D. B., Cowx, I. G., Nguyen, V. M., Nohner, J., Phouthavong, K., Riley, B., et al. (2016). The social, economic, and environmental importance of inland fish and fisheries. *Environmental*

Reviews, 24(2):115–121.
Mann, R. (1985). A pike management strategy for a trout fishery. *Journal of Fish Biology*, 27:227–234.
Morey, E., Thacher, J., and Breffle, W. (2006). Using angler characteristics and attitudinal data to identify environmental preference classes: a latent-class model. *Environmental and Resource Economics*, 34(1):91–115.
Olaussen, J. (2016). Catch-and-release and angler utility: evidence from an Atlantic salmon recreational fishery. *Fisheries Management and Ecology*, 23(3-4):253–263. https://doi.org/10.1111/fme.12167.
Olaussen, J. O. and Liu, Y. (2011). On the willingness-to-pay for recreational fishingescaped farmed versus wild Atlantic salmon. *Aquaculture Economics & Management*, 15(4):245–261.
Paletto, A., De Meo, I., Grilli, G., and Nikodinoska, N. (2017). Effects of different thinning systems on the economic value of ecosystem services: A case-study in a black pine peri-urban forest in central Italy. *Annals of Forest Research*, 60(2):313–326.
Samples, K. C. and Bishop, R. C. (1985). Estimating the value of variations in anglers' success rates: An application of the multiple-site travel cost method. *Marine Resource Economics*, 2(1):55–74.
Shrestha, R. K., Seidl, A. F., and Moraes, A. S. (2002). Value of recreational fishing in the brazilian pantanal: a travel cost analysis using count data models. *Ecological economics*, 42(1-2):289–299.
Sutton, S. G. (2006). Understanding recreational fishers' participation in public consultation programs. *Human Dimensions of Wildlife*, 11(5):329–341. https://doi.org/10.1080/10871200600894969.
Viney, M. (2015). Another life: Our pike are noble predators, not alien villains. *The Irish Times*. http://www.irishtimes.com/news/environment/another-life-our-pike-are-noble-predators-not-alien-villains-1.2152970.
Wilde, G. R. and Ditton, R. B. (1991). Diversity among anglers in support for fishery management tools. In *Warmwater fisheries symposium*, volume 1, pages 329–335.
Willis, K. G. and Garrod, G. D. (1991). An individual travel-cost method of evaluating forest recreation. *Journal of Agricultural Economics*, 42(1):33–42.
Zwirn, M., Pinsky, M., and Rahr, G. (2005). Angling ecotourism: issues, guidelines and experience from Kamchatka. *Journal of Ecotourism*, 4(1):16–31.

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