Working Paper No. 529

March 2016

Fisheries management for different angler types

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Subsequently published in “Irish coarse and game anglers’ preferences for fishing site attributes”, *Fisheries Research*, Vol. 190, June, 2017, pp. 103-112, http://www.sciencedirect.com/science/article/pii/S0165783617300255

Abstract: On-site survey data from coarse and game angling sites in Ireland is used to estimate count data models of recreational angling demand. To investigate the existence of preference heterogeneity across angler-types, three demand functions are estimated according to angler type; coarse, game and a combination of both. Comparison of these demand functions indicates that the fishery characteristics which drive demand differ depending on angler-specific characteristics. For example treating all anglers as an homogeneous group led to results suggesting angling demand is higher where there is a greater provision of angling services (such as guide-hire and tackle shops). While this relationship pertained for the game angling demand function, angling service levels had no effect on coarse angling demand. Water quality, which was not found to be significant in driving demand in the combined case, was identified as a significant determinant of angling demand in game fisheries. Overall the results strongly support the need to specifically address angler characteristics when analysing angler preferences. Improved survey design that attains more detailed information such as anglers' quarry-type, skill level, etc. will improve the ability of analysts to understand angler preferences and provide more effective policy recommendations.

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Keywords: angling; travel cost; game angling; coarse angling

Acknowledgements: Funding from Inland Fisheries Ireland is gratefully acknowledged. Our thanks to Gavin Smith for assistance with accessing the water quality data, and to Inland Fisheries Ireland for providing the TDI angler survey and site characteristics datasets. All errors are our own.

1 Introduction

Recreational fishery managers have multifaceted jobs. Among their goals are the conservation and improvement of fish stocks, which encompass the enhancement of environmental quality and eco-system services within fishery catchments. Generally, fishery managers also seek to deliver a high quality experience for anglers. But anglers are a heterogeneous group, and the definition of what constitutes a high quality experience is not synonymous to all anglers. Multiple angler types have been identified across many fisheries (Chipman and Helfrich, 1988; Fisher, 1997; Connelly et al., 2001; Arlinghaus and Mehner, 2005; Hutt and Bettoli, 2007; Strong, 2012). For example, Connelly et al. (2001) identify seven types of anglers among registered anglers within New York state and diverse angler types generally seek different fishing experiences (Fisher, 1997). Furthermore, within a specific fishery, angler preferences can vary substantially. Subgroups often differ in the importance they attach to various characteristics of a fishery. Highly specialised and skilled anglers, often targeting specimen fish, tend to derive their utility not only from catching fish, but also from releasing them (Arlinghaus et al., 2007) and frequently favour restrictive harvest regulations, e.g. catch or size limits, as well as catch and release. Less specialised anglers tend to derive more utility from the act of harvesting fish and are more satisfied with smaller fish and more liberal harvest regulations (Chipman and Helfrich, 1988; Hutt and Bettoli, 2007). In a study of recreational angling demand Strong (2012) highlights the mistake of 'lumping' all species within a single category of target fish. In addition to preferences around catch rates, regulations and size of fish, Beardmore et al. (2014) find that non-catch outcomes, such as the number of other anglers and diversity of angling locations are also important factors in angler satisfaction. Consequently, the ambition of fishery managers to deliver a high quality experience to all types of anglers is very challenging. Achieving high satisfaction levels among anglers implicitly requires fishery managers to possess a strong insight into angler preferences across angler types. However, if management strategies focus on a singular 'typical' angler they are likely to be resource inefficient and result in poor satisfaction levels among many angler types.

The benefits of understanding angler preferences for fishery management strategies have long been recognised. Studies have identified divergence between angler preferences and the fishery attributes that managers tend to prioritise (Hampton and Lackey, 1976), the importance of experience level in shaping those preferences (Schoolmaster and Frazier, 1985), the implications for management when considering revealed vs. stated angler preferences

(Harris and Bergersen, 1985) and the need for regulations to be admissible to anglers if they are to be successfully adopted (Renyard and Hilborn, 1986). More recently a number of studies have investigated how angler preferences have management repercussions in specific fisheries. For example, angler preferences for 'trophy' fish has led to a proliferation of waters stocked with non-native species in the UK, in many cases illegally stocked with potentially irreversible ecological consequences (Hickley and Chare, 2004). This example highlights the potential for management goals to be incoherent. Eden and Bear (2011) find that anglers selectively interpret what constitutes the 'balance of nature' and favour management measures which promote ecosystem equilibriums that benefit catch rates. Fishery managers may therefore adopt species specific measures, such as habitat development and predator culling, that put fishery objectives in conflict with wider ecosystem management/conservation goals (Williams and Moss, 2001; Reynolds and Tapper, 1996). A study of angler preferences in Wisconsin developed a basis for predicting angler effort and harvest rates based on stock densities and bag limit regulations with an objective of maintaining fish stock densities (Beard Jr et al., 2003). At a more strategic level Sutinen and Johnston (2003) simply suggest integrating recreational anglers into the management of fisheries through the vehicle of angling management organizations, which are community-based organisations designed to conform to basic principles of integrated fishery management. Whereas Johnston et al. (2013) have suggested using an integrated modelling approach, based on ecology, economics and human-dimensions research, to investigate how fish life-history and angler types influence both fish stocks and the behaviour of anglers exploiting them. But there is little evidence that much interdisciplinary discussion occurs on management issues. For instance, Fenichel et al. (2013) using bibliometric data, find that there is little disciplinary crossover, particularly between fisheries biology, including applied ecology, and quantitative social science, including economics. This in part reflects the fact that there is neither a deep nor widespread understanding of angler preferences, even though there have been many fishery-specific studies on angler demand. In fact, knowledge of participation rates in recreational fishing, which is basic information about angling activity, is relatively poor or subject to a high degree of uncertainty in many countries (Arlinghaus et al., 2015).

This paper aims to demonstrate that recognising multiple angler types and understanding their respective demand preferences will assist fishery managers in making more effective and resource efficient fishery management decisions. We demonstrate this using data from game and coarse anglers in Ireland. We estimate angling demand functions for coarse anglers, game anglers and for the combination of game and coarse anglers to determine angler preferences and subsequently contrast the differing management implications that are inherent in the model results. The estimated models reveal characteristics of both anglers and of the fisheries that are most important in explaining angler demand. The apparent importance of these characteristics in explaining the number of angling days demanded varies depending on whether we distinguish between angler types. For example, if angler type is not distinguished the model estimates suggest that demand for angling is greater where there are higher levels of angling services (defined as guides, tackle and bait shops). Whereas in the case of coarse anglers only, the level of angling services available had no effect on the level of angling demand. As mentioned earlier, the literature suggests that angler preferences can differ depending on angler skill or specialisation, as well as by individual species (e.g. brown versus rainbow trout, or pike versus bream), however, in this empirical application the data available could only distinguish between anglers on the basis of main target species: coarse or game species. Nonetheless, it provides clear evidence that accounting for differences in the preferences of angler types is necessary to ensure the efficacy of fishery management decisions.

The paper proceeds as follows: section 2 discusses the methodology used to carry out the analysis; section 3 presents the model results and a comparison of the three demand curves that are estimated. Finally, section 4 discusses the results and concludes the paper.

2 Methodology

The modelling approach employed to ascertain information about angler preferences is the well established travel cost demand model (Clawson and Knetsch, 1966; Johnson, 1966; Parsons, 2003). The travel cost methodology is outlined below, followed by a discussion of the data and model specification.

2.1 Angling Demand

The travel cost model (TCM) is a widely used approach to estimate recreational angling demand (Shrestha et al., 2002; Curtis, 2002; Pyo et al., 2008; du Preez and Hosking, 2011; Mangan et al., 2013; Lothrop et al., 2014). The TCM relies on the assumption that although access to angling sites may have no explicit price, travel costs, including transportation, accommodation and fishing expenses can be used to approximate an implicit price associated with angling demand. Anglers respond to changes in travel costs in the same way they would respond to changes in an entry fee, so the number of trips to a fishing site and or their duration should decrease as travel costs increase.

$$y_i = f\left(TC_i, x_i\right) \tag{1}$$

where y_i is individual i's demand for site trips (or days), TC_i is travel cost and x_i represents angler or site characteristics. Variable y_i is count data, comprising non-negative integer values. Following a theoretical underpinning provided by Hellerstein and Mendelsohn (1993) count data models have become common in estimating recreational demand models. Both Poisson and negative binomial distributions are frequently assumed in estimating count models, as the distribution of site trips is usually left-skewed and characterised with probability mass concentrated on a few values. The model estimates presented in this paper use the Poisson distribution, as empirically the negative binomial did not provide a better fit.[1] The Poisson distribution, which is a special case of the negative binomial, assumes that the mean and variance are equal.

The angler data used for model estimation were collected by on-site intercept survey at multiple angling locations. This type of data collection introduces two features within the data that must be accommodated within model estimation: truncation and endogenous stratification. When the data is collected on-site the distribution of Y is truncated at zero, i.e. no non-participant anglers are interviewed. The issue of endogenous stratification arises because the likelihood of being sampled is positively related to the number of trips taken to the site, meaning that the sample is over-represented with high frequency anglers.[2] The issue of truncation in count models was addressed by Carson (1991), whereas endogenous stratification was first addressed by Shaw (1988). Englin and Shonkwiler (1995) developed an application of a truncated, endogenously stratified Poisson model, which we follow here. Assuming a Poisson population density function with parameter λ_i, the likelihood function for the on-site sample is

$$L = \prod_{i=1} \frac{e^{-\lambda_i} \lambda_i^{y_i - 1}}{(y_i - 1)!} \tag{2}$$

with

[1] The estimate of the over-dispersion parameter in the negative binomial models was not statistically significant.

[2] Haab and McConnell (2002) discuss in further detail (p.175).

$$\begin{aligned} E\left(y_i|x_i\right) &= \lambda_i + 1 \\ Var\left(y_i|x_i\right) &= \lambda_i \end{aligned} \tag{3}$$

The model is extended into a regression framework by defining λ_i as a function of regressor variables, x_i, as described in equation 1. The conventional approach is to model expected latent demand, λ_i, as a semi-logarithmic function of explanatory variables x_i, such as price, i.e. travel cost, and other angler or site characteristics such that

$$ln\lambda_i = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_j x_{ji} \tag{4}$$

Although maximum likelihood estimation using (2) is feasible, the parameters of the demand equation (4) can be estimated with a standard Poisson regression of $y_i - 1$ on the independent variables (Englin and Shonkwiler, 1995).

From a fishery management perspective a key item of interest is understanding how angler demand varies with differences in either angler or site characteristics, which can be recovered by the following:

$$\frac{\partial E\left(y_i|x_i\right)}{\partial X_{ji}} = \lambda_i \beta_j \tag{5}$$

Also of interest is the estimate of the welfare benefit of anglers, which is discussed in the next section.

2.2 Welfare

An angler's consumer surplus is derived by integrating the demand function (4) over the relevant price range and is given by (6) (Hellerstein and Mendelsohn, 1993).

$$CS = \int \lambda_i dTC = \frac{-\lambda_i}{\beta_p} \tag{6}$$

where β_p is the coefficient on the travel cost variable. Frequently angler CS is reported per day (or per trip), as it has more policy relevance in that format. This is usually calculated as $CS = -1/\beta_p$ on the basis that the mean number of days (or trips) is the Poisson mean, λ_i.[3]

[3]For anglers interviewed on site the mean number of days is given by (3) and mean consumer surplus per day for sampled anglers becomes $CS = -\lambda_i/\beta_p(\lambda_i + 1)$, similar to Martínez-Espiñeira and Amoako-Tuffour (2008).

2.3 Data

Angler data was collected by on-site survey at sites around the Republic of Ireland. The survey was undertaken between March and November 2012 and included the prime angling season in respect of each angling category. While the survey included all angling categories, the analysis here focuses specifically on game and coarse anglers, with the latter including pike anglers. The survey collected travel cost data for the intercepted trip. We excluded data observations that were not consistent with the basic assumptions of the travel cost model, including where the interviewed angler paid the expenses of multiple anglers; where no travel cost data was reported; and where the trip length exceeded 14 days on the assumption that the primary purpose of these trips may not have been solely angling. For example, the longest trip length specified was 120 days. There are 35 separate angling sites in our data set with game angling occurring at 26 sites and coarse angling at 12. A full description of the survey design and implementation is available in Tourism Development International (2013).

Water quality data for the period 2007–2009 from water quality monitoring stations proximate to the angling survey sites were downloaded from `http://gis.epa.ie/`. Water quality monitoring and data is summarised in McGarrigle et al. (2010). As this is the most recently available data we are assuming that water quality at the angling sites was unchanged at the time of the angler surveys. We used the WFD ecological status as an indicator of quality and created a dummy quality variable distinguishing between 'High/Good/Moderate' or 'Poor/Bad' ecological status.

Data about angling site characteristics was sourced from Inland Fisheries Ireland. Fishery managers scored each angling site, usually on a scale between 0 and 10, for a variety of site characteristics (e.g. angling services, food, accommodation, etc.). This data was rescaled into binary variables with a value of 1 indicating a relatively high scoring for the characteristic (i.e. generally between 7 and 10 points), or zero otherwise. These and other variables used in the analysis are presented in Table 1.

2.4 Model specification and variables

The models estimated are conditional on targeted species: coarse, game, or coarse and game combined. We specify a demand model for the number of angling days demanded within a trip using $TripDays$ as a dependent variable, which is defined as the number of days spent angling on the current

Table 1: Mean data values

Variable	Coarse	Game	Combined	Description
TripDays	3.949	2.290	2.810	Days angling on current trip
DailyCost	0.148	0.222	0.199	'travel cost' per angling day (incl. fishing, transport, food expenses, etc.) €'000
Income	34.710	37.891	36.896	Annual gross income, €'000
MissInc	0.348	0.488	0.444	=1 if Income not reported, 0 otherwise
*Age*65+	0.072	0.158	0.132	=1 if aged 65+, 0 otherwise
*Adults*3+	0.326	0.195	0.236	=1 if 3+ adults in angling group, 0 otherwise
Ireland	0.536	0.660	0.621	=1 if angler from Republic of Ireland, 0 otherwise
NIreland	0.094	0.132	0.120	=1 if angler from Northern Ireland, 0 otherwise
Elsewhere	0.370	0.208	0.259	=1 if angler from elsewhere, 0 otherwise
HiWaterQ	0.725	0.927	0.864	=1 if water quality High/Good/Moderate at angling site, 0 otherwise
PhysicalAccess	0.928	0.561	0.676	=1 if good level of physical access, 0 otherwise
AnglingServices	0.659	0.756	0.726	=1 if good provision of tackle/bait shops, guides/boat availability within 10km, 0 otherwise
RestRecreation	0.899	0.931	0.921	=1 if good provision of pubs, dining and family activities nearby, 0 otherwise
Accomodation	0.283	0.650	0.535	=1 if good provision angler friendly or self catering accomodation nearby, 0 otherwise
Information	0.681	0.479	0.542	=1 if good provision of guidebooks, information, maps, signage for fishery, 0 otherwise
ScenicValue		0.475	0.367	=1 if scenery largely wild and unspoilt, 0 otherwise
Species	0.739			=1 if abundant coarse species available at fishery, 0 otherwise
Specimen	0.848			=1 if specimen fish regularly caught at fishery, 0 otherwise
Bagweight	0.739			=1 if likely bag weight of caught fish exceeds 50lbs (22.7kgs), 0 otherwise
StockMgt	0.638			=1 if predator control takes place on the fishery, 0 otherwise
FisheryStatus		0.825		=1 if fishery is open, =0 if Catch & Release fishery
LicenceReq		0.875		=1 if National Licence distributor within 5km of the fishery, 0 otherwise
PermitReq		0.759		=1 if permits are easily available for the fishery, 0 otherwise

trip. This is the specification to which our data is most suited, as the travel cost data specifically relates to the number of angling days counted in the variable $TripDays$.

Explanatory variables used in the models include angler characteristics such as their country of origin, and income level. However, not all anglers provided information about their income. As a means of preserving observations for model estimation we assigned the median sample income level to observations with missing values for income but included a dummy variable $MissInc$ in model estimation to identify those observations. The variable $Age65+$ controls for anglers who are retired and therefore potentially have greater flexibility to fish more frequently. Some anglers participate with friends and the variable $Adults3+$ is used to control for larger angling groups, as it may be more difficult to organise fishing trips with larger numbers of people. The variable $DailyCost$ is the travel cost price variable on a per diem basis for all expenses related to the angling trip, including angling, food, accommodation and travel expenses. Across all anglers the mean travel cost price is €199 per day. Game anglers' expenditure is €222/day whereas coarse anglers spend just €148 per day.

Site characteristic variables include those that are relevant to all sites such as water quality, $HiWaterQ$, and the provision of services at angling sites, such as good access ($PhysicalAccess$) and bait/tackle shops ($AnglingServices$), as well as other rest and recreational services (*RestRecreation*, *Accommodation*). Some site characteristics are specific to coarse or game target species. For coarse fisheries these include variables that relate to species abundance (*Species*), specimen fish (*Specimen*) and likelihood of high bag weights (*Bagweight*). For game fisheries, these relate to whether the site is a 'catch & release' fishery (*FisheryStatus*) and the easy availability of licences (*LicenceReq*) and permits (*PermitReq*), which are only a feature of certain game fisheries.

3 Model Estimates

The model estimates are reported in Table 2. The dependent variable in each model is *TripDays*, which is the number of days the angler was planning to spend fishing during the trip in which they were interviewed. The first two columns of Table 2 are conditional on angler type, whereas the third column is for all anglers without controlling for angler type. Based on the literature cited earlier our prior expectation was that the parameter estimates would differ by angler type, which is what we find. Parameter estimates differ both in magnitude and also in sign, which means that depending on the model selected relevant policy guidance is likely to differ.

3.1 Travel costs

The parameter estimate on the *DailyCost* variable in the combined model is -1.442 and is comparable in magnitude to the estimate in the game angler model of -1.340 but both are substantially higher than the estimate for coarse anglers of -3.327. From the discussion of equation (6), the negative inverse of this parameter is equivalent to anglers' mean consumer surplus per day. If relying on the combined model, the estimate of anglers' mean surplus in excess of actual mean expenditure per day is approximately €700. But from the coarse angler model the mean consumer surplus is €300 per day's angling, whereas the estimate for game anglers is approximately €750. If we add these estimates to mean travel costs, i.e. *DailyCost*, the total value of a day's coarse angling is €450, and €970 for game angling. Relying on the combined model yields an estimate of a day's angling, irrespective of target species, of just less than €900. While this is slightly less than the estimate for game anglers, it overestimates the value of coarse angling by 100%.

Curtis and Stanley (2015) previously estimated an angling demand function using the same TDI dataset. Their modelling approach was to estimate a single demand equation for all anglers, though differentiating between an-

Table 2: Estimation Results

	Coarse Anglers	Game Anglers	Combined
Dependent Variable	*TripDays*	*TripDays*	*TripDays*
DailyCost	-3.327**	-1.340***	-1.442***
	(-2.91)	(-5.28)	(-6.41)
*Age*65+	-0.149	0.325*	0.0389
	(-0.80)	(2.43)	(0.39)
*Adult*3+	-0.0510	0.0475	0.0912
	(-0.44)	(0.37)	(1.15)
Income	-0.000885	0.00845***	0.00165
	(-0.40)	(3.96)	(1.37)
MissInc	-0.0920	0.151	-0.120
	(-0.70)	(1.10)	(-1.45)
NIreland	2.581***	1.538***	1.751***
	(6.69)	(6.87)	(10.36)
Elsewhere	3.763***	2.541***	3.189***
	(10.06)	(15.17)	(24.07)
HiWaterQ	-0.139	0.939**	0.103
	(-0.11)	(3.13)	(0.84)
PhysicalAccess	-1.212	-0.402**	0.124
	(-0.67)	(-2.74)	(1.25)
AnglingServices	-0.671	1.878**	0.534***
	(-0.61)	(3.25)	(4.62)
RestRecreation	-1.164	1.460*	-0.465***
	(-0.84)	(2.39)	(-3.34)
Accomodation	0.252	-1.466*	-0.0212
	(0.16)	(-2.51)	(-0.21)
Information	0.0936	-0.107	-0.0871
	(0.07)	(-0.73)	(-0.85)
ScenicValue		0.0109	-0.459***
		(0.07)	(-3.87)
Species	1.946*		
	(2.05)		
Specimen	1.563		
	(0.81)		
Bagweight	-1.062		
	(-1.31)		
StockMgt	0.379		
	(0.23)		
FisheryStatus		1.171**	
		(2.77)	
LicenceReq		0.572*	
		(2.16)	
PermitReq		2.121***	
		(3.60)	
Constant	-0.850	-7.405***	-1.131***
	(-0.62)	(-5.80)	(-5.37)
Observations	138	303	441
pseudo R^2	0.617	0.537	0.547
Log likelihood	-176.7	-323.3	-555.6

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

gler types via dummy variables for coarse and game anglers. Their estimate of mean willingness to pay (or total value) for a day's angling is €810 per day for coarse anglers and €870 for game anglers, which are quite close to the €900 estimate from the combined model here. The similarity of the estimates for coarse and game anglers is mainly due to the fact that the effect of travel cost on angling demand is restricted to a single estimate of the parameter β_p. This restricts anglers' consumer surplus per day such that it must be equal across angler types. The difference in the estimates of willingness to pay is due to differing travel costs for coarse and game anglers. Similar to the combined model here, Curtis and Stanley's single equation approach highlights the potential error of not estimating demand preferences conditional on angler type. Essentially, because the estimates of consumer surplus for both coarse and game anglers are based on the single parameter estimate of $-1/\beta_p$, the estimates of total willingness to pay for coarse and game angling are similar in magnitude.

The price elasticity of angling days demanded is $\beta_p X_{pi}$ where X_{pi} refers to travel costs, which we evaluate at sample mean values.[4] For coarse anglers the estimated price elasticity is -0.5, whereas for game anglers it is -0.3. Coarse anglers are substantially more sensitive to price than game anglers. Such information is of use to fishery managers whom have influence over some of the costs that anglers incur; for example it indicates that demand for coarse angling is likely to fall more significantly if there is an increase in the price of fishing licenses and tickets.

3.2 Angler characteristics

The explanatory variables in the estimated models include a number of angler characteristics such as age, group size and income. In the combined model, these variables appear to have no significant effect on angling days demanded. However, in the angler specific models there are some significant effects. For example, game anglers that are retired or have higher incomes demand a marginally greater number of angling days. This result does not extend to the coarse angling case. The various parameter estimates related to the variables $NIreland$ and $Elsewhere$ reflect the differing demand for angling opportunities in Ireland versus anglers resident in the Republic of Ireland. For example, mean additional days demanded by Northern Ireland compared to Republic of Ireland anglers was 7-8 days for coarse angling compared to

[4]The elasticity is calculated as $\frac{\partial E\left(y_i|x_i\right)}{\partial X_{ji}} \frac{X_{ji}}{\lambda_i} = \beta_j X_{ji}$

1-2 days for game angling.

3.3 Site characteristics

There is more variation in parameter estimates for site characteristic variables. Game anglers have a preference for higher quality waters, fishing on average one-sixth of a day more at sites with better water quality compared to lower quality sites. There was no significant statistical effect of water quality on coarse angling demand. These results are consistent with the fact that coarse species, such as roach and bream, can tolerate much lower oxygen levels than salmonids and can prosper in more eutrophic waters.

Ease of access to angling sites is generally more of a concern for coarse anglers, as they transport much more equipment to the fishing site. Surprisingly we find that the estimate of the *PhysicalAccess* parameter was statistically insignificant in the coarse demand equation. However, the result possibly reflects the fact that 92% of coarse angling trips in our dataset were to sites with good physical access.[5] Equally surprising was the negative *PhysicalAccess* parameter estimate for game anglers. This result suggests a preference among game anglers towards less accessible angling locations, however, this merits further investigation. Angling services, such as bait and tackle shops, as well as guide and boat availability, is important for game but not coarse anglers. Game anglers spent almost one day less fishing, on average, on sites with poor provision of such services.

Of the site characteristics that were specific to coarse angling the one that is most important statistically is the abundance of coarse species. On sites where there is good abundance of species coarse anglers spend on average 2.5 more days fishing per trip. The analysis also suggests that predator control does not have a significant effect on coarse angling demand. In the case of game-specific site characteristics, anglers preferred 'open' as opposed to 'catch & release' fisheries, as well as sites that had easy availability of licences and permits, where they were required. On average, game anglers' trips were one-third of a day shorter at 'catch & release' compared to 'open' fishery sites.

[5] An alternative coarse angler demand specification also included explanatory variables for car parking within 50 metres and the amble provision of fishing swims/stands instead of the *PhysicalAccess* variable. The availability of parking nearby had a significant and positive effect on coarse angling demand, whereas the effect of good provision of fishing stands was statistically insignificant.

4 Discussion and Conclusion

The primary objective of this paper is to show that failure to treat of preference heterogeneity amongst angler types may lead to erroneous conclusions about angler preferences and therefore poorly prescribed policy advice to fishery managers. The empirical analysis demonstrated this very clearly, wherein failure to estimate coefficients for individual groups of anglers lead to a misrepresentation of angler preferences. Specifically, the combined demand function suggested that anglers' willingness to pay for a day's fishing was €900, on average; that they were not overly sensitive to price/costs; that demand for angling was higher at sites where there is good nearby availability of fishing guides, boats and bait/tackle shops; and that good water quality does not affect the level of angling demand. On the basis of these results, fishery managers could be advised to invest in angling services (i.e. *AnglingServices*) to bolster demand, especially for international tourist anglers. In addition, the results suggest that since anglers' consumer surplus is €700/day on average, and given that demand appears to be quite inelastic, some of the costs of investment in angling services might be recovered from anglers without substantial impact on the level of angling demand. For coarse angling however, the results suggest that investment in angling services would have no effect on the level of demand, as the parameter estimate on *AnglingServices* proved to be insignificant. Furthermore, with a price elasticity of -0.5 (rather more than the -0.3 value estimated for game angling demand), any measure to recover costs would have a much greater reducing effect on the level of angling days demanded from coarse anglers compared to game.

There are some additional points to note. Firstly, for game anglers, the combined model misrepresents the importance of good water quality. Additionally, without estimating an angling demand equation specifically for coarse anglers, the analysis would not have highlighted the fact that species abundance and proximity to car parking are among the key preferences for coarse anglers. Finally, it would not have been possible to demonstrate that coarse anglers' valuation of a day's fishing is about half that of game anglers. Overall, aside from stressing the need to analyse angler preferences by angler type in future studies, the results highlight the fact that survey design must facilitate this possibility at the outset. Surveys collected by researchers and fishery managers that contain specific questions about the types of species anglers target, their level of experience and other such angler specific information, will greatly improve the insights gained from the analysis of angler preferences. This in turn can improve the specificity of the policy recommendations that arise out of such studies and the ability of fishery managers to tailor fishery characteristics to angler preferences.

One caveat to note in this study is that despite the attempt made to specify demand functions by angler type, the results are still largely based on what are essentially grouped classes of anglers. It is plausible, for example, that amongst coarse anglers, there are groups that have different preferences to those indicated by the coarse angler demand function estimated here. Future work would benefit from the use of surveys in which 'angler types' are more specifically defined and where the sample size is sufficiently large to allow each angler-type subset to have a demand functions estimated.

Acknowledgements

Funding from Inland Fisheries Ireland is gratefully acknowledged. Our thanks to Gavin Smith for assistance with accessing the water quality data, and to Inland Fisheries Ireland for providing the TDI angler survey and site characteristics datasets. All errors are our own.

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Year	Number	Title/Author(s) **ESRI Authors/Co-authors *Italicised***
2016	528	Poorest made Poorer? Decomposing income losses at the bottom of the income distribution during the Great Recession *Michael Savage*
	527	Profile of second-level students exempt from studying Irish *Emer Smyth and Merike Darmody*
	526	Modelling the Vietnamese Economy Pho Chi , *John FitzGerald*, Do Lam , Hoang Ha , Luong Huong, Tran Dung
	525	Attitudes to Irish as a school subject among 13-year-olds *Emer Smyth and Merike Darmody*
	524	Attitudes of the non-Catholic Population in Northern Ireland towards the Irish Language in Ireland *Merike Darmody*
	523	An auction framework to integrate dynamic transmission expansion planning and pay-as-bid wind connection auctions *Niall Farrell, Mel T. Devine* and Alireza Soroudi
2015		
	522	Surplus Identification with Non-Linear Returns *Peter D. Lunn* and Jason J. Somerville
	521	Water Quality and Recreational Angling Demand in Ireland *John Curtis*
	520	Predicting International Higher Education Students' Satisfaction with their Study in Ireland Mairead Finn and *Merike Darmody*
	519	What Factors Drive Inequalities in Carbon Tax Incidence? Decomposing Socioeconomic Inequalities in Carbon Tax Incidence in Ireland *Niall Farrell*
	518	A Menu Approach to Revealing Generator Reliability Using a Stochastic Bilevel Mathematical Program *Mel T. Devine and Muireann Á. Lynch*