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# Estimating the demand for Sea Angling in Irish Waters using on-site travel cost models

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**Abstract**

This paper's contribution to the understanding of marine recreational pursuits in Ireland is based on the estimation of the first sea angling demand function. We use this empirical work to inform the more general debate surrounding resource allocation between commercial fisheries and recreational anglers. The study compares the use of Poisson and negative binomial count data models to estimate sea angling trip demand. The models also account for truncation and endogenous stratification; two issues that need to be controlled for when dealing with on-site sampled populations. The models are then used to estimate the mean willingness to pay of the average sea angler for an angling trip and the aggregate use value of sea angling recreation in Ireland. The results indicate the high value of the Irish marine environment as a recreational angling resource.

**Keywords:** On-site and household sampling, recreation demand, hurdle count data models, truncation, endogenous stratification, angling.

**JEL Classification:** Q22, Q26.

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## 1. Introduction

Sea anglers are one of the main marine recreation user groups in Ireland. Within Ireland, an estimated 126,250 people go sea angling every year along Ireland's 5,600 kilometres of coastline (Inland Fisheries Ireland, 2015). In comparison Armstrong et al. (2013) report that 884,000 from England, 76,000 from Wales and 125,000 from Scotland go sea angling each year[1]. Sea Angling in Ireland can be divided into three distinct categories; shore angling (fishing from beaches, rocks, estuaries, quays and piers), inshore angling (fishing from small boats up to 6 metres in length, generally less than 5km from land) and deep sea angling (fishing offshore for shark and other deep water species). As pointed out in a number of previous studies, the recreational activities of sea anglers can make significant contributions to local economies but this group also gain considerable non-market value from their interaction with marine ecosystems (Beaumont et al. 2008; Stolk, 2009; Armstrong et al., 2013; Tourism Development International, 2013; Jobstvogt et al., 2014).

While there are numerous species of fish of interest to the sea angler around Ireland, Sea Bass is a particularly popular target species[2]. Inland Fisheries Ireland (2015) estimate that there are 35,434 anglers specifically targeting sea bass each year, i.e. almost 30% of all sea angling participants annually. This species has been in decline in European waters in recent years and the EU Scientific, Technical and Economic Committee for Fisheries (STECF) (2014) estimate that recreational anglers account for approximately 25% of total sea bass removals in European waters and can therefore have an important impact on the health of the stock. The importance of sea bass to sea anglers in Ireland is reflected in the fact that it is the only marine fish species that is retained for the recreational angler and no Irish commercial vessels may fish it. This ban on commercial fishing of sea bass by the Irish fleet has been in place since 1990. Indeed, due to concerns over stock levels, EU member states agreed in 2015 on an extension of the moratorium of commercial fishing for sea bass in Irish waters to include all vessels[3]. This was a considerable U-turn on discussions taking place 2 years previously where the EU were considering introducing a quota for this non-TAC (total allowable catch) species. Those discussion were shelved on the back of scientific advice which

[1] This is not a direct comparison with the Irish data as the UK figures are for residents in each country only and do not include overseas visitors as in the Irish case.

[2] Some of the main fish species targeted by sea anglers in Irish waters include bass, flounder, turbot, ling, pollack, mackerel and ray. For a full listing and description of species targeted by anglers in Irish marine waters see http://www.fishinginireland.info/sea/species.htm

[3] Other measures decided upon at an EU level to better manage the declining sea bass population included: 1) an emergency closure on pelagic trawling during the spawning season from 26 January to 30 April, 2) a 3 fish bag limit for recreational anglers reducing to a 1 bag limit in the second half of 2016, 3) monthly catch limits for commercial vessels as well as the complete closure around Ireland for commercial fishing 4) an increase in the minimum size from 36 to 42 cm which applies to both recreation and commercial fishermen.

indicated that sea bass have suffered a steep decline in both quantity and size since 2010 and fisheries scientists have called for landings to be reduced by up to 80 per cent (STECF, 2014).

There is continuous debate around whether it makes economic sense for a species such as sea bass to be managed exclusively as an anglers' rather than a commercial species. It could be argued that managing the stock for sea anglers is more sustainable as they are often more interested in the sport of landing a fish and would be happy to return the fish to the water unharmed once caught (catch and release) rather than actually taking it for consumption. Commercial fishermen on the other hand are predominantly interested in the return (revenue) to be made from permanently removing the fish from the marine environment. A key question then revolves around the economic benefit of maintaining a fish species for recreational fishing compared to the economic benefits of allowing the fish to be commercially exploited. If a catch and release policy is practiced by sea anglers and survivability is high then it may be the case that the potential marginal recreational values exceed the marginal values from commercially fishing the stock. As argued by Tinch et al. (2015) this may be the case because "angling has many participants and relatively few externalities, with a potentially limited impact on fish stocks and the physical environment [especially if a catch and release policy is in place]. In contrast, in some commercial fisheries the revenue generated barely covers the costs of catching fish. Thus economic rents could be low".

As discussed by Edwards (1990) an appropriately standardised benefit-cost analysis of allocation between commercial and recreational fisheries would determine whether any proposed management measures would increase net national benefits from the use of fish for food versus recreation. Often however it is difficult to determine the net economic returns from a change in management policy as the information on the welfare impacts on both the recreational and commercial fishers (as well as on other relevant groups such as consumers of seafood and charter boat operators) are difficult to obtain.

While the value of commercial landings in Irish waters is assessed on an annual basis at both the national and EU level, much less emphasis is given to the value of marine fish stocks from a recreational use perspective[4]. Future fisheries management plans aimed at generating greater overall value to society requires that the benefits of recreational anglers also be quantified. With this

[4] Sea Bass is not the first species to be considered in this 'commercial versus recreation' debate in Ireland. Prior to the complete ban on drift netting for wild salmon in Ireland in 2007, the debate about the allocation of this species between recreation and commercial pursuits was ongoing for over a decade. As early as 1995, the much respected Irish economist and statesman Dr. T.K. Whitaker noted that "Indiscriminate commercial exploitation of wild salmon, as hitherto practised, is not compatible either with scientific management of stocks specific to river systems, or with the optimum availability of wild salmon for recreational exploitation" (Whitaker, 1995).

in mind this paper focuses on the ecosystem service use value associated with sea angling in Irish marine waters.

A travel cost modelling approach is employed to estimate the sea angling use value of the marine resource around Ireland in terms of anglers' willingness to pay (WTP) and consumer surplus. As discussed by Hanley and Barbier (2009) consumer surplus is considered as a good approximation of a welfare measure for this type of use value. The travel cost method (TCM), as applied to sea angling, measures benefits from the recreational use of the marine environment through analysing the factors that affect sea angling demand. To monetise the demand, the costs of undertaking a sea angling trip such as travelling to and from the sea angling location, purchasing bait, the opportunity cost of lost working time, equipment rentals, etc. may be included in the estimation. The economic hypothesis is that, in general, the frequency of visits is lower for sea anglers with higher travel costs, meaning that demand for angling trips decreases with higher prices.

In what follows we first review the literature related to the valuation of sea angling. In section 3 we then present the on-site survey methodologies and review the count data modelling specifications applied. Section 4 then presents the model results and welfare estimates, while section 5 presents a discussion of results and offers some conclusions.

## 2. Estimating the value and benefits of sea angling pursuits

The recreation value of recreational fishing has been extensively investigated in the literature (see for example Hynes et al. 2015; Bilgic and Florkowski, 2007; Loomis, 2003; Curtis, 2002; Haab and McConnell, 2002; Ward and Beal, 2000). Indeed, Johnstone & Markandya (2006) identified over 450 non-market valuation studies that deal with recreational fishing benefits and values while Loomis et al. (1999) carried out a meta-analysis involving 109 CS estimates of recreational fishing demand in the United States. The vast majority of these studies however focused on inland recreational fisheries rather than sea or coastal based angling. The reason for this may be the fact that sea angling tends to be widely dispersed along the coastal margin whereas river and lake based angling is usually focussed around key fishing spots and access points. This means that collecting the necessary survey information may be more difficult when dealing with sea anglers. The most common form of modelling approach employed in recreational angling studies has been the revealed preference travel cost model (Loomis and Walsh, 1997; Curtis, 2002; Murdock, 2006).

Within this modelling framework the Poisson and the Negative Binomial count data model specifications have remained particularly popular due to the non-negative integer nature of the demand for pursuits such as recreational fishing (as measured by the frequency of trips). As shown by Hynes et al. (2015) whether this trip data is collected on-site or at the household level will have a bearing on the ultimate specification used. With on-site surveys, data issues such as truncation and endogenous stratification need to be controlled for as in Curtis (2002) model of salmon angling demand. If the survey has been carried out randomly in the population at the household level the fact that you are likely to see a high proportion of zero trips amongst any given sample need to be addressed. The latter issue has been dealt with previously in the recreational angling demand modelling literature using zero inflation count models (Loomis, 2003) or hurdle count models (Bilgic and Florkowski, 2007 and Hynes et al. 2015).

Prayaga et al. (2010) used count data travel cost models to estimate the value of recreational fishing as at a number of sites on the Capricorn Coast in Central Queensland, Australia. They found that the annual number of fishing trips demanded decreased as the costs of travel, the number of days spent fishing, the distance from residence to boat ramp and as the age of recreational anglers increased. On the other hand the annual number of fishing trips increased as the number of people in the group, catch rates and the value of the boat increased. The consumer surplus per trip estimated for the travel cost model, converted to 2009 Euro values, was €110 per angler. Another example of an on-site survey based on sea angling recreation is a study by Pyo et al. (2008). In this case the authors estimated the value for recreational sea angling in the Tongyeong coastal area of South Korea using the individual travel cost method. A Poisson, negative binomial, a truncated Poisson and a truncated negative binomial model was applied to the collected observations of sea anglers in the area. The results based on the preferred truncated negative binomial model indicated a consumer surplus per trip value of approximately €135 (converted from Korean won).

Revealed preference travel cost random utility models (RUM) (also referred to as site choice models) have been also applied in a number of studies of sea angling. In these cases, the demand for sea angling pursuits at alternative sites is modelled as a function of the attributes associated with each site such as potential catch rates, species on offer and distance to each site. The results are then used to infer the sea angler’s economic values for site access and site characteristics. A recent paper by Raguragavan et al. (2013) investigated sea angling site choices in Western Australia using national survey data covering eight major angling regions and forty-eight fishing sites. The authors used the data to estimate a random utility model (RUM) of site choice with a supporting negative binomial model of angler-specific expected catch rates.

An earlier effort in modelling economic values associated with access to sea angling sites and the quality of the sea angling experience using the RUM based site choice models was a study by Haab et al. (2001) where the geographical focus was on the United States from North Carolina to Louisiana. The authors used data that described where sea anglers fish, the fish they catch, and their socio-economic characteristics. Similar to earlier work by McConnell and Strand (1994)[5] and Hicks et al. (1999), a two-stage nested random utility model was employed which assumed that sea anglers first choose the mode/species combination in which they will participate, and then choose the destination where they will fish.

A number of sea angling demand studies have also used choice experiments to model the demand for the sport. While this approach is also RUM based the choices facing the respondents are hypothetical rather than real as in the previously discussed site choice models. In the case of a choice experiment the sea angler is presented with choice cards with a number of hypothetical sea angling opportunities which vary in terms of their attribute levels. The respondent must consider the levels for each attribute presented in each option of each choice set and pick the option that he/she most prefers. For example, Lawrence (2005) developed a choice experiment to assess how the value of the recreational sea angling experience in South West England would change as characteristics of the hypothetical angling experience options changed. The study found that increasing the size of individual fish would have a larger impact on sea angling demand than increasing the catch per day, although this was found to vary by species. With a similar focus to the Lawrence study, Lew and Larson (2015) also used a choice experiment approach to examine how the value anglers place on charter boat fishing is affected by bag and size limit regulations in Alaska.

[5] McConnell and Strand (1994) use 1987/1988 Marine Recreational Fishery Statistical Survey (MRFSS/United States) data to evaluate values for Atlantic sports fishing. They derived benefit estimates for increases in fish catch, for extra game fish catches and for a fishing trip.

Contingent Behaviour travel cost models are another approach to valuing sea angling demand where the standard count data models have been expanded to include additional information about how users might change their behaviour if certain contingent conditions existed. In a typical contingent behaviour model the respondents are first asked about the frequency of past trips. They are then presented with a hypothetical scenario with different site conditions and asked if they would change their intended number of visits. The revealed and stated trip responses are then analysed using panel count data modelling techniques (Hynes and Greene, 2013). In a sea angling example, Prayaga et al. (2010) (whom also estimated standard TCM count models of demand as outlined above), also used a panel data truncated negative binomial contingent behaviour model to estimate the change in the value of recreational fishing as conditions along the Capricorn Coast in Queensland, Australia changed.

Although there have been a number of studies on recreational fishing in Ireland that have analysed angler numbers and expenditure patterns using surveys (e.g. Whelan and Marsh, 1988; Marine Institute, 1997; Inland fisheries Ireland, 2013), only three Irish studies have involved the estimation of demand functions for recreational fishing. O'Neill and Davis (1991) estimated a demand function for coarse and game angling in Northern Ireland using an OLS modelling approach while Curtis (2002) estimated a demand function for salmon angling in Co. Donegal, Ireland. In a more recent study, Hynes el al. (2015) developed two recreational angling demand models for domestic anglers in Ireland where the total demand for angling trips by Irish residents was estimated. In that study the authors compared the results from an on-site angler intercept survey, with econometric corrections for on-site sampling issues, to results from a household survey where the issue of excess zeros is addressed using a hurdle modelling approach. The study found that welfare estimates from the two modelling approaches differ substantially across and argues that the underlying samples may represent two different types of anglers. The non-use value associated with recreational fishing in Ireland was also examined in a study by Inland Fisheries Ireland (Tourism Development International, 2013) where the contingent valuation method was employed to estimate the value to the general public of preserving Ireland's natural fish stocks and the current quality of recreational angling in Ireland.

We add to the above literature by estimating the first sea angling demand function for Irish marine waters. Given the aforementioned dispersed nature of sea angling activity the chosen model does not focus on one specific site as is common in the literature for count data travel cost models but rather estimates the total demand for sea angling in the season no matter where the angling takes place along the Irish coast. We also examine if targeting sea bass as opposed to other sea species has a significant impact on sea angling trip demand and whether the extra effort needed to fish from a boat rather than the shore has an impact on trip demand.

## 3. Research design and model estimation methods

In order to obtain information relating to the demand for sea angling in Ireland, an on-site survey of sea anglers was conducted in Ireland in 2012. The on-site survey was carried out over a 9 month timeframe from March to November 2012 across 16 sampling locations right around the coast of Ireland (the Republic). All interviews were carried out by the company Tourism Development International. The sample comprised of individuals age 15 plus from the both the Republic of Ireland and overseas, whose main purpose of visit was recreational angling. The timing of the on-site survey was scheduled to coincide with the full sea angling season. The sampling locations were chosen in consultation with the Irish semi-state body responsible for the management of sea angling in Ireland in order to maximise the overall representativeness of the survey and to ensure that all regions were fully covered[6].

When carrying out the survey sea anglers were approached on the shoreline as they fished or prior to their departure by boat. The majority of anglers agreed to be interviewed on the spot but some expressed a preference to be interviewed at the end of the day's angling or to complete the survey by telephone or on-line. These options were accommodated by the survey team. In total, 240 sea angler surveys were completed. Following best practice, earlier focus group discussions and pilot testing of the on-site survey instrument were carried out to refine the questions asked in the main surveys.

Respondents to the survey were first asked about the type of sea angling they pursued (whether they mainly fished from shore or by boat, whether they were targeting Sea Bass particularly, whether they were members of an angling club, the average number of individuals they fished with on any given trip). Importantly, from a demand modelling perspective, the respondents were also asked about the frequency and costs of sea angling trips taken in Ireland. Specifically, respondents were asked how many sea angling trips they had taken in the previous 12 months. Focusing on each sea angler's most recent trip,

[6] The survey of sea anglers was part of a broader nationwide recreational angling survey that also interviewed coarse and game anglers in Ireland's rivers and lakes.

additional information was collected about the expenditure incurred under a number of different category headings including fishing tackle, bait, boat hire, guide services, transport, etc. Socio-demographic information relating to age, nationality, employment status, income, education level attained, number in household, etc. Finally, respondents were also asked a number of Likert scale attitudinal questions related to the quality of the sea angling resource in Ireland.

In order to model the demand for sea angling recreation it is necessary to account for the unique sampling issues connected with an on-site survey approach. In particular, the travel cost modelling approach chosen must recognise that the number of sea angling trips taken is a non-negative integer, i.e. a count of the number of trips (Creel and Loomis, 1990 and Cameron and Trivedi, 1986) and the distribution of trips tends to be positively skewed towards zero. Given these characteristics and the almost definite presence of over-dispersion in the data[7], the standard Ordinary Least Squares estimator may not be the appropriate choice. Rather it is generally accepted that Poisson and negative binomial count data models can capture most of these issues and result in an unbiased and consistent estimator (Englin and Shonkwiler, 1995; Loomis, 2003;Haab and McConnell, 2002).

Following Martínez-Espiñeira and Amoako-Tuffour (2007) and Hynes et al. (2015) we illustrate the family of count model alternatives available starting with the Poisson model. Assume $T$ is the number of sea angling trips made during period $j$. The Poisson model is defined with a probability density function (PDF) given by:

$$\Pr(T = t) = F_p(t) = e^{-\lambda}\frac{\lambda^t}{t!}, \quad t = 0,1,... \qquad [1]$$

where $\lambda$, the expected number of trips, is modelled as a function of the explanatory variables thought to influence $T$, which can include travel cost, time and angler specific socio-demographic variables. That is:

$$\lambda = exp(\beta X) \qquad [2]$$

where $\beta$ is a vector of unknown regression coefficients that can be estimated by standard maximum likelihood methods (Greene, 2007), and $X$ is the vector of variable thought to influence trip demand. The Poisson distribution assumes equality of the conditional mean and variance which tends not to be a realistic in recreation demand modelling, since the

[7] Overdispersion can occur when a few recreationalists take a large number of trips, resulting in the variance in trips taken being larger than the mean.

conditional variance often exceeds the mean resulting in overdispersion (Cameron and Trivedi, 1986). A more generalized model to account for over-dispersed counts is based on the negative binomial probability distribution expressed as:

$$\Pr(T = t) = F_{NB}(t) = \left[\frac{\Gamma(t+\alpha^{-1})}{\Gamma(t+1)\Gamma(\alpha^{-1})}\right]\left[\frac{\alpha^{-1}}{\alpha^{-1}+\lambda}\right]^{1/\alpha}\left[\frac{\lambda}{\alpha^{-1}+\lambda}\right]^{t},\ t = 0,1,... \qquad [3]$$

where $\Gamma$ denotes the gamma function, and $\alpha$ and $\lambda$ are the parameters of the distribution. The ancillary parameter $\alpha$ is a nuisance parameter. When $\alpha$ is equal to zero, the negative binomial distribution is the same as [1]. The larger is $\alpha$, the greater the amount of overdispersion in the data. For count data models the negative binomial distribution can be thought of as a Poisson distribution with unobserved heterogeneity or as a mixture of Poisson and gamma distributions. The conditional mean is $\lambda$ and the variance equals $\lambda(1+\alpha\lambda)$. Where $T$ exhibits overdispersion, the negative binomial model is a consistent estimator and preferred to the Poisson model.

Two additional important issues associated with on-site sampled data need to be addressed in estimation. First, those anglers who make zero trips in the time period are not observed and their value of the sea angling resource is not accounted for in the valuation results. This problem is referred to as truncation of the data at zero trip level (Shrestha et al., 2002). The second issue for estimation arises due to the fact that the most frequent users of the recreational site tend to be over-represented by on-site sampling (Shaw, 1988). Welfare measures based on the analysis of on-site samples that fail to account for these sampling issues will therefore overstate the benefits derived from access to the angling resourse by the general population and overestimate total demand.

Both the traditional and truncated Poisson and negative binomial models have been extended to account for this issue which is generally referred to in the literature as endogenous stratification (Shaw, 1988; Englin and Shonkwiler 1995). The truncated negative binomial (TNB) model provides unbiased and consistent estimates in the presence of overdisperson and its probability density function is given by:

$$\Pr(T = t \mid T > 0) = F_{TNB}(t) = \left[\frac{\Gamma(t+\alpha^{-1})}{\Gamma(t+1)\Gamma(\alpha^{-1})}\right](\alpha\lambda)^{t}(1+\alpha\lambda)^{-(t+1/\alpha)}[1-F_{NB}(0)]^{-1} \qquad [4]$$

$$t = 1,2,...$$

The conditional mean is given by $E(T \mid X, T > 0) = \lambda[1 - F_{NB}(0)]^{-1}$. Extending the zero-truncated negative binomial model to also account for endogenous stratification (the GNB model) results in the following probability density function:

$$\Pr(T = t \mid T > 0) = F_{TSNB}(t) = t \cdot \left[ \frac{\Gamma(t + \alpha^{-1})}{\Gamma(t+1)\Gamma(\alpha^{-1})} \right] \alpha^{t} \lambda^{t-1} (1 + \alpha\lambda)^{-(t+1/\alpha)} \; t = 1,2,... \qquad [5]$$

The conditional mean and variance are equal to $E(T \mid X, T > 0) = \lambda + 1 + \alpha\lambda$ and $Var(T \mid X) = \lambda(1 + \alpha + \alpha\lambda + \alpha^2\lambda)$ respectively. Estimating a travel cost model for sea anglers in Ireland, and correcting for zero-truncation and endogenous stratification, allows us to recover the underlying latent demand function for angling trips for the entire population of anglers in the country.

Following Englin and Shonkwiler (1995), and using the results of our travel cost models we estimate the per-person value of a sea angling trip as:

$$CS_{perTrip} = \frac{1}{-\hat{\beta}_{TC}} \qquad [6]$$

The aggregate access value is calculated by multiplying this estimate by the total number of trips in the relevant time period, such that $CS_{Total} = CS_{perTrip}.Total$ where *Total* is the total number of trips over the relevant season. In what follows, we compare the results obtained from the standard Poisson and negative binomial specifications (ignoring the on-site sampling issues) to two negative binomial specification corrected for firstly truncation alone and then for truncation and endogenous stratification combined.

## 4. Results

Table 1 presents summary statistics for the population of sea anglers in the sample. In presenting these statistics and in estimating all models we exclude from the sample those that indicated an average stay per trip in excess of 18 days or those who make more than 30 fishing trips per year. Excluding these 12 outliers resulted in a useable sample of 228 observations. From table 1 it can be seen that the average sea angler takes 7.83 trips in the year and spends on average 4.26 days on any one trip. Forty three percent of the sample were members of an angling club while 42% indicated that they had taken an angling trip outside of Ireland in the past 3 year period. Interestingly, 47% of the sample mainly fish from a boat when sea angling while 32% indicated that they were mainly targeting sea bass when sea angling[8]. The average age of respondents in the sample was 48.6 and 48% of the sample is represented by Social Class C1 which is made up of supervisory, clerical and junior managerial, administrative or professional individuals. Approximately half of the sample of the sample was made up of residents from the island of Ireland (52%) while a further 36% were from Scotland, Wales or England. Figure 1 shows the distribution of sea angling trips amongst the sample over the previous 12 month period. The sample of sea anglers also appear to believe that the quality of the angling experience and the value of money in Ireland is good with 79% and 73 of the sample ranking these features of a sea angling as being good or very good. Only half of the sample (51%) give the same ranking however to the quality of the fish stock available.

- **Table 1 here**

Table 2 presents a breakdown of sea angler's self-reported expenditure (both annual and for the latest trip). The major items of expenditure on both an annual and current trip basis are accommodation, tackle, food and drink and transport. While accommodation and food and drink account for nearly 30% of annual expenditure it should be kept in mind that some of the expenditure on these items will not directly relate to the angling experience. Anglers may stay in an area for other reasons as well as the fishing product (e.g. they may stay around to do other sightseeing and other recreational activities) and they would also spend a certain amount on food and drink no matter what they are doing. In using travel cost to estimate the use value of the angling resource we need to be congestive of this issue. The category of 'other expenses' on items such as angling clothing, competition fees, etc. is also a relatively high element in the cost of angling trips. While the average amount spend on guide services is relatively low at just €13.26 it is still an important expenditure item for a number of anglers. For example, for the 18 visiting anglers from abroad in the sample who used angling guide services on their current trip an average of €192 was spend on this item of expenditure; for the small number of Irish residents using guides the equivalent figure was €78.

- **Table 2 here**

[8] The anglers were asked to distinguish between sea bass angling in particular versus fishing for any other sea species. No further breakdown of the species being mainly targeted by sea anglers was collected in the survey instrument.

Tables 3 and 4 show the results of the different travel cost models as specified in the previous section. In each specification, *the number of sea angling trips taken = f (travel cost per trip (transport, bait, boat hire, guide services), annual investment in tackle, permits and clothing, Age, Social class, average number of days per trip, sea bass targeted, affiliated with angling club, gross income, fishing from a boat, nationality and fishing group size)*[9]. Following Parson's (2003) and Hynes et al. (2015) trip cost includes all expense required to make the angling trip possible. As discussed previously, while food and drink and accommodation were presented in the breakdown of both annual and latest trip expenditure in Table 2, they are not included in the travel cost variable used in the models as they are elements of expenditure that may not be directly linked to the activity of sea angling. Also, expenditure on tackle and other expense items such as clothing may be considered as investment as they will presumably last beyond a single season and indeed when we include these expenditure elements separately in the model we see that the higher the investment in these items the greater the demand for sea angling trips. The same explanatory variables were used in all specifications.

- **Table 3 here**

The parameter estimates for the standard Poisson and negative binomial models are presented in Table 3[10]. In general, the signs and significance of the estimated coefficients are consistent with economic theory and previous angling demand studies. In the restricted sample, the dependent variable, the number of trips, is distributed with a mean equal to 7.83 and a variance of 84.66, which suggests that overdispersion may be a problem for the application of models assuming a Poisson distribution. As expected a test of overdispersion indicates a preference for the negative binomial specification over the Poisson. The likelihood-ratio test statistic $\chi^2$ value of 339 implies that the probability that one would observe these data conditional on $\alpha = 0$ is virtually zero. In addition, a goodness-of-fit test on the Poisson model also clearly rejects the hypothesis that the Poisson regression is adequate to model the

[9] As noted by Hynes et al. (2015) while it is common and good practice to include the travel cost to substitute sites in a single site demand function, we avoid the need in this study as our demand function is for all sea angling trips in a season to all of the respondent's preferred sites in Ireland.

[10] Given the fact that we are estimating a demand function for all sea angling trips taken in the season to any sea angling spot we have a wider distribution in trip frequency than one might expect from a single site model. This might suggest that the standard ordinary least squares (OLS) model may be appropriate to estimate the travel cost demand function. However, we still see in the distribution of figure 1 a high frequency of lower trip numbers and we are still dealing with integer values. This along with the inability of the OLS specification to deal with the on-site sampling issues present means that our preference is still to use the count data specifications.

dependent variable. While the basic NB model is preferred to the basic Poisson model they are both rejected in favor of the negative binomial models that adjusts for the on-site sampling issues of truncation (the TNB model) and for both truncation and endogenous stratification (the GNB model). As expected, these models were also found to be a better fit for the data in terms of the log likelihood values and information criteria statistics.

- **Table 4 here**

As with the standard negative binomial model, in the preferred on-site negative binomial models, $\alpha$, the overdispersion parameter is positive and significant, indicating that the data is overdispersed. The estimated coefficients for travel cost across both on-site adjusted models are of the expected sign and significant at the 99 percent level of confidence. All coefficients across both the models display the same sign and significance. The coefficients are also very similar in magnitude across the two models which indicates that even before accounting for endogenous stratification, correcting for truncation and overdispersion takes care of the more substantial bias related to on-site sampled recreation demand data. It is also interesting to note that even though the GNB model is the fully valid model for on-site samples, the TNB model would appear to be a slightly better fit, displaying as it does the lowest absolute value for the maximum log-likelihood (albeit just a 2 point difference). This result is similar to that found by Martínez-Espiñeira et al. (2008).

As expected, the higher the level of investment in tackle or gear over the season the higher the trip frequency is likely to be. Unlike the basic Poisson and NB specifications age is no longer found to be significant. However, similar to the basic models, the insignificance of the gross income parameter suggests that there is no income effect on the number of sea angling trips demanded over the season. This is a similar result to that found for Irish anglers previously by Curtis (2002) and Hynes et al. (2015). Not surprisingly, residents on the island of Ireland (Northern Ireland and Republic) are likely to make a higher frequency of sea angling trips in the season that overseas visitors. British anglers appear to make a significantly lower number of trips compared to other non-Irish visiting anglers. One might expect that the longer the average trip, in terms of days spend, the fewer trips might be taken overall in a season but this proves to be only a significant finding in the basic Poisson model.

As expected, being affiliated with an angling club indicates that the number of fishing trips demanded is likely to be higher. It would also appear that those anglers who are mainly targeting sea bass are no more likely to make a higher number of trips in the season compared to those targeting any other sea species. *A priori* we thought that the specialized sea bass angler may make a higher frequency of trips in the season although there is no specific reason, or evidence in the literature to indicate why that may be the case. Interestingly, sea anglers fishing away from shore (on a boat) are likely to making a lower number of fishing trips over the season. Given the extra complication of dealing with a vessel and perhaps the extra cost involved this is not a surprising result. The size of the group that the respondent goes fishing with was also found to negatively influence the number of fishing trips demanded over the season. The TNB model’s estimate of the mean number of sea angling trips demanded amongst the population was estimated to be 6.91 while the GNB model predicted a slightly lower 4.99 trips per season. This is a lower figure than the actual mean of 7.83 trips observed in the sample or the figure of 7.88 as predicted by the standard negative binomial model that does not control for the on-site sampling issues.

*Welfare estimates*

The welfare estimates derived from the standard and adjusted for on-site sampling modelling approaches are presented in table 5. Consumers’ surplus was estimated following Englin and Shonkwiler (1995) as outlined in section 3. In the basic Poisson model, the consumers' surplus per trip is estimated to be €426. This estimate of per-trip consumer surplus is estimated with 95% confidence to be between €331 and €598.

- **Table 5 here**

In the case of the standard negative binomial model, unadjusted for the on-site sampling issues, the consumers' surplus per trip is estimated to be lower at €323 with an associated 95% confidence interval between €220 and €605. By summing the average consumer surplus per angler with the average travel cost for the sea anglers we get a measure of the average willingness to pay (WTP) for a sea angling trip in Ireland. The corresponding mean CS values in the TNB and GNB models are lower at €261 and €242 respectively. As shown in table 5, multiplying the WTP by each model’s predicted number of trips per year implies that the annual recreational value of sea angling to the estimated 126,728 sea anglers is €367 million according to the TNB model and €254 million according to our GNB model.

## 5. Discussion and Conclusions

Sea angling is a highly demanded marine recreation experience and it is therefore important for fisheries managers and policy makers to understand the value of such activity in order to generate management plans that provide the greatest welfare benefits to society. Even allowing for sampling issues and conceptual issues, such as the role of site congestion and the treatment of multiple destination trips, travel cost analysis still remains one of the best tools for valuing such recreational activity (Haab and McConnell, 2002). In this paper we employed a Poisson and negative binomial count data model with and without the econometric corrections for the on-site sampling issues of endogenous stratification and truncation. Interestingly, the estimated coefficients across the negative binomial models, whether adjusted for on-site sampling issues or not, were not significantly different. This similarity of coefficient estimates across on-site count data models has also been found elsewhere in the literature (Meisner and Wang, 2006, Hynes and Hanley, 2006, Hynes et al. 2015). Neither did accounting for endogenous stratification and truncation yield any significant differences in welfare estimates across the alternative model specifications. Accounting for theses on-site sampling issues did however result in a substantial difference in estimates of trip demand.

Our analysis shows that sea anglers in Ireland derive considerable utility from this recreational activity. While many angling studies focus on the anglers expenditure activity when calculating the economic impact on the local or national economy this expenditure cannot measure the total economic benefit of the activity. The expenditure does represent a benefit to locals but it also represents a cost to the sea anglers. The difference between what a trip actually costs and what the anglers would have been willing to pay for it represents the true net economic value (the consumer surplus) to those sea angling. Using the results of the preferred GNB model, we estimated a per trip consumer surplus of €242. This extrapolates to a total annual consumer surplus value of approximately €153 million. Given that the consumer surplus is 60 per cent of total willingness to pay this would suggest that sea anglers in Ireland receive benefit from angling well in excess of their angling costs.

Given the current debate surrounding the allocation of fishing rights to sea bass anglers rather than commercial fishers in Irish waters it is also interesting to examine the value of the angling experience to the sea bass anglers in particular. The model results indicated that the demand pattern of sea bass anglers specifically was not significantly different from sea angler' targeting other fish species. Using the GNB model we would estimate that total use value of the sea angling experience to sea bass angler (travel cost plus CS) is €81 million, €65 million[11] of this being the consumer surplus. Assuming an average price per kilo of approximately €10 for commercially landed sea bass and the dissipation of any resource rents in the industry (i.e. due to an over-allocation of effort, producer surplus is competed away) the commercial fleet would need to catch approximately 8100 tonnes to achieve the same value of €81 million.

While these figures are comparable in the sense that they tell us what the relative sources of value are between commercial and recreational sea bass fishers, they do not directly reveal anything about the consequences of changing allocations of fishing rights between these different commercial and recreational stakeholders. Also, given the state of the stock at present, commercial landings of just 5.9 tonnes of sea bass in Irish marine waters in 2014[12] and ICES advice for 2016 that no more than 541 tonnes of sea should be caught by all EU recreational or commercial fishers[13], landings of 8100 tonnes by the commercial fleet operating in Irish waters is not likely to happen for the foreseeable future and if it did could have significant impact on the health of the remaining stock.

Although, it might appear that the economic value of recreational angling for sea bass may outweigh the commercial value of sea bass in Irish waters we would need to expand our analysis to definitively answer the question of how any total allowable catch should be allocated across both anglers and commercial fishers. Within a cost benefit analysis framework we would need to identify which combination of shares between angler and fisher would maximise net national benefits from use of any total allowable catch. In other words, to calculate the most efficient allocation we need to find the one which maximizes the sum of consumer and producer surpluses in both uses. This would require estimating the consumer surplus not just for the anglers but for consumers who enjoy consuming the fish purchased in the retail markets and the producer surplus generated for charter boat operators, hoteliers and

[11] Calculated based on predicted trips*population of bass anglers of 35,434*CS per trip

[12] STECF data for 2014 indicates that there was sea bass landings of 2170 tonnes across EU waters but only 5.9 tonnes were caught within the Irish EEZ.

[13] It has been shown elsewhere that data from the International Council for the Exploration of Sea (ICES) suggests that the EU bass stock has been fished above levels that would lead to a stock size with maximum sustainable catch levels for the entire 28-year period that data is available for (Williams and Carpenter, 2015)

angling supply stores on the one hand and the producer surplus for the retail, wholesale, processing and primary wild fishers from commercial fishing on the other.

Such research would demonstrate if, relative to the commercial exploitation of certain stocks, and following a mainly catch and release programme, recreational sea angling offers a more economically efficient use of scarce natural resources that could also help sustain a number of over fished sea species. Given that the majority of the fish commercially caught in Irish waters is landed elsewhere by foreign owned and operated fleets this is a particularly relevant question for Ireland[14]. This expanded analysis is beyond the scope of this paper where we have just concentrated on the maximum amount consumers are willing to pay for sea angling and the associated consumer surplus. It would however be an interesting avenue for future research. From an ecosystem management perspective it should also be kept in mind that fish species interact through complex relationships and a management measure focused solely on the conservation of one species for sea anglers, under say a catch and release programme, could result in a reduction of other fish species.

Another limitation of the results discussed in this paper is the fact that the economic estimates represent just the direct user value to the sea angling population. We would expect that sea anglers also have non-use values connected with the resource. For example sea anglers (and indeed other individuals in society) may derive existence and bequest values from knowing that sea angling activity exists and that the resource base is being maintained for future generations of sea anglers. They would be willing to pay something to preserve the activity and the resource for the enjoyment of these groups. The travel cost method does not allow the researcher to pick up on such values. To do so would require the use of stated preference valuation methods such as contingent valuation or choice experiments.

These limitations aside, the results that have been presented should still be of interest to fishery scientists as well as fishery managers as they facilitate a better understanding of sea angling demand in Ireland and its economic value. We would still caution however that any changes in resource allocation should be assessed in terms of their marginal impacts, not the total values of the sectors concerned. Also, as pointed out by Tinch et al. (2015) economic efficiency is only one criterion on which policy decisions surrounding the use of natural

[14] An analysis of European and Irish fisheries data sources would suggest that the Irish fleet accounted for just 42% of the landings from Irish waters in 2013.

resources should be judged – other criteria, such as fairness and sustainability, need also to be considered.

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**Figure 1. Distribution of Annual Sea Angling Trips**

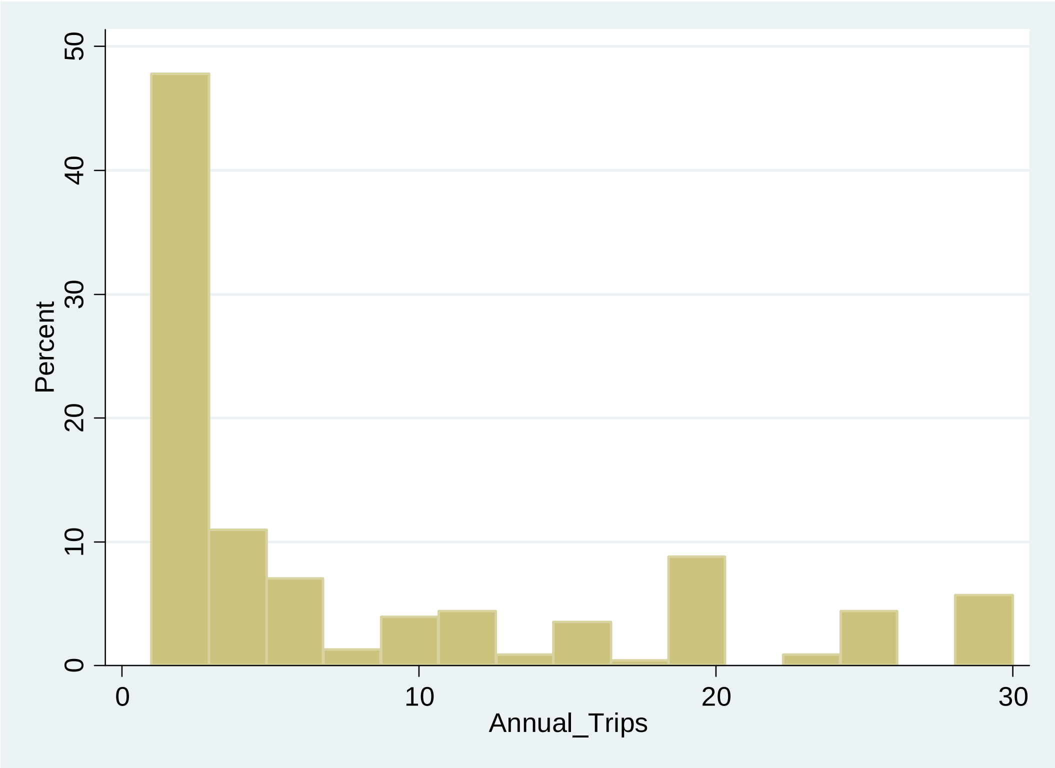


**Table 1. Sample Summary Statistics**

| Variable | Mean | Std. Dev. |
|---|---|---|
| Number of days stayed on current trip | 4.26 | 3.61 |
| Travel cost per angling trip* | 159.41 | 98.30 |
| Number of Fishing Trips in Ireland last 12 months | 7.83 | 9.2 |
| Age | 48.6 | 13.21 |
| Social Class C1 | 0.48 | 0.5 |
| Fishing from boat (%) | 0.47 | 0.5 |
| Targeting Bass (%) | 0.32 | 0.47 |
| Affiliated to Angling Club (%) | 0.43 | 0.49 |
| Number in group (aged 15+) | 3.82 | 4.04 |
| Gross Income/1000 | 39.66 | 22.98 |
| Republic & Northern Irish (%) | 0.52 | 0.5 |
| Scottish, Welsh, English (%) | 0.36 | 0.48 |
| Retired (%) | 0.03 | 0.16 |
| Self Employed (%) | 0.04 | 0.18 |
| Unemployed (%) | 0.03 | 0.16 |
| Have taken foreign fishing trip in last 3 years (%) | 0.42 | 0.5 |
| Quality Ratings | | |
| Quality of Angling Experience ranked as "Good" or "Very Good" (%) | 0.79 | 0.41 |
| Quality of Fish Stocks ranked as "Good" or "Very Good" (%) | 0.51 | 0.5 |
| Value for Money ranked as "Good" or "Very Good" (%) | 0.73 | 0.44 |

* Travel cost for sea angling only includes expenditure on bait, boat hire, guides and transport in Ireland (i.e. petrol, car hire, etc).

**Table 2. Sea Angler Expenditure in Ireland**

| Items of Expenditure per Angler (€) | Expenditure last Trip | | Annual Expenditure | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Tackle | 55.21 | 158.82 | 521.43 | 732.31 |
| Bait | 21.56 | 42.89 | 148.39 | 238.65 |
| Boat Hire | 72.6 | 260.44 | 162.23 | 349.66 |
| Guide Services | 13.26 | 47.71 | 18.29 | 70.26 |
| Food and Drink | 189.75 | 351.08 | 404.78 | 740.38 |
| Accommodation | 226.28 | 494.98 | 247.37 | 434.05 |
| Transport in Ireland (i.e. petrol, car hire, etc) | 78.6 | 130.8 | 562.77 | 824.79 |
| Other Expenses (Clothing, Retail, Competition Fees, etc) | 46.62 | 73.35 | 304.73 | 437.98 |
| Total Costs | 690.61 | 989.32 | 2351.7 | 2474.93 |

**Table 3. Parameter Estimates for the Poisson and Negative Binomial Models**

| Parameter | Poisson | Negative Binomial |
|---|---|---|
| Travel cost per trip | -0.002*** (0.001) | -0.003*** (0.001) |
| Invest | 0.000*** (0.0001) | 0.000*** (0.0001) |
| Age | -0.302*** (0.002) | 0.005 (0.005) |
| Social Class C1 | -0.302*** (0.050) | -0.301*** (0.108) |
| Duration of stay (days) | -0.045*** (0.014) | -0.006 (0.028) |
| Fishing from boat | -0.364*** (0.091) | -0.359** (0.176) |
| Targeting Bass | 0.278*** (0.060) | 0.232* (0.129) |
| Affiliated to Angling Club | 0.279*** (0.053) | 0.268** (0.114) |
| Number in group (aged 15+) | -0.028*** (0.010) | -0.032* (0.017) |
| Gross Income/1000 | 0.001 (0.001) | 0.001 (0.003) |
| Republic & Northern Irish | 1.378*** (0.166) | 1.506*** (0.263) |
| British | -0.262 (0.172) | -0.293 (0.225) |
| Constant | 1.367*** (0.208) | 1.069*** (0.385) |
| Ln (Alpha) | - | -1.023*** (0.136) |
| Log Likelihood | -752.12 | -582.48 |
| Likelihood Ratio $\chi^2$ Statistic (11d.f.) | 1418.79 | 252.96 |

Standard errors in parenthesis. *** indicates significance at 1%, ** indicates significance at 5%, * indicates significance at 10%. Social Class C1 is made up of supervisory, clerical and junior managerial, administrative or professional individuals

**Table 4. Parameter Estimates for the On-Site Sampling Adjusted Models**

| Parameter | Truncated Negative Binomial | Generalised Negative Binomial |
|---|---|---|
| Travel cost per trip | -0.004*** (0.001) | -0.004*** (0.001) |
| Invest | 0.0003** (0.0001) | 0.0003** (0.0001) |
| Age | 0.009 (0.006) | 0.010 (0.007) |
| Social Class C1 | -0.372** (0.149) | -0.385** (0.165) |
| Duration of stay (days) | -0.037 (0.044) | -0.052 (0.048) |
| Fishing from boat | -0.540** (0.244) | -0.579** (0.268) |
| Targeting Bass | 0.268 (0.181) | 0.275 (0.200) |
| Affiliated to Angling Club | 0.363** (0.156) | 0.383** (0.172) |
| Number in group (aged 15+) | -0.057** (0.027) | -0.061** (0.029) |

| | | |
|---|---|---|
| Gross Income/1000 | 0.001 (0.004) | 0.001 (0.004) |
| Republic & Northern Irish | 2.114*** (0.397) | 2.250*** (0.424) |
| British | -0.730** (0.347) | -0.781** (0.364) |
| Constant | 0.354 (0.574) | -1.880 (1.219) |
| Ln (Alpha) | -0.43** (0.20) | 1.85*** (1.12) |
| Log Likelihood | -519.9159 | -521.51 |
| Likelihood Ratio (Wald for GNB model) $\chi^2$ Statistic (12d.f.) | 221.57 | 299.16 |

Standard errors in parenthesis. *** indicates significance at 1%, ** indicates significance at 5%, * indicates significance at 10%. Social Class C1 is made up of supervisory, clerical and junior managerial, administrative or professional individuals

## Table 5. Expected Trips and Benefit Estimates

| | **Poisson** | **Negative Binomial** | **Truncated Negative Binomial** | **Generalised Negative Binomial** |
|---|---|---|---|---|
| Predicted Trips | 7.82 | 7.88 | 6.91 | 4.99 |
| Consumer surplus per trip (€)[a] | 426<br>(331, 598) | 323<br>(220, 605) | 261<br>(170, 554) | 242<br>(157, 528) |
| Willingness to Pay per trip (€)[b] | 585 | 482 | 420 | 401 |
| Aggregate WTP (€ million) | 580 | 481 | 367 | 254 |

a. Confidence intervals in parenthesis. b. willingness to pay per trip is the addition of average travel cost (where TC only includes bait, boat hire, gillies and transport) and consumer surplus per trip. Aggregate willingness to pay is based on: predicted trips* population of domestic anglers of 126,728*(CS per trip +average travel cost).

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