Recreational boating site choice and the impact of water quality

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Abstract

This paper examines whether water quality has an effect on recreational boating activity. The analysis is based on survey data collected by face-to-face interviews with recreational visitors to 10 waterway sites across Ireland. We model the respondent's choice decision to travel to a specific site for the purposes of beginning their recreational boating activity. Water quality data is from European Union Water Framework Directive monitoring stations. Across recreational sites, which have generally high water quality levels within our sample, we find that boaters favour sites with better water quality; as indicated by biological oxygen demand and phosphates metrics. We also find that for each additional 10 km distance from respondents' homes the probability that a site is visited declines by up to 10%. Preferences for other site attributes, such as boat slipways, parking and toilet facilities, were counter to expectation but reflects the fact that all boat users do not necessarily access or need all facilities provided.

Keywords: Economics, Geography

1. Introduction

The EU Water Framework Directive (WFD) (Directive 2000/60/EC, 2000) has led to the evaluation of European waterways using a suite of metrics. Biological quality

(i.e. fish, benthic invertebrates, aquatic flora), hydromorphological quality, physical–chemical quality, and chemical status are all now factors that feed into the overall evaluation of a water body's 'status'. The Directive was intended to achieve good status of all EU water bodies by 2015. This target was not met (Hering et al., 2010; Ball, 2016) though significant improvements in water quality have been achieved (Pérez-Domínguez et al., 2012; Wilson et al., 2015; Azimi and Rocher, 2016; Van Grinsven et al., 2016). Discourse around improved application of the WFD in the future, and the quality of EU waterways in general, are ongoing. Central to these considerations will be the value that people place on such improvements.

Many benefits arising from improvements in water quality accrue to recreational users engaged in activities such as swimming, boating and fishing. Recreational user benefits have been widely examined including studies related to fishing (Bockstael et al., 1987; Egan et al., 2009; Curtis and Stanley, 2016), swimming (Needelman et al., 1995), beach visits (Hanley et al., 2003), boating (Lipton, 2004) as well as many other water-based recreational activities (Curtis, 2003; Hynes et al., 2008; Gürlük and Rehber, 2008; Paudel et al., 2011). Recreational users express their preferences for environmental attributes, such as water quality, through decisions regarding site use. For example, the number of trips to a specific location, or the length of time spent at a location. User preferences are also revealed when individuals select a particular site above other alternative sites to pursue their recreational activity. This paper focuses on site choice decisions, specifically examining whether differences in water quality across sites affects the destination for recreational boating trips. The analysis considers boating trips in Ireland and the objective of the paper is to illustrate the extent to which water quality influences boating trip destinations and consequently provide evidence to support investment in water quality improvements. While the achievement of 'good' water quality status under the WFD is a legislative requirement on EU member states, limited economic resources and conflicting sectoral interests mean that investment decisions are prioritised, including funds specifically earmarked for water quality remediation. Information on how recreational users benefit from good water quality will help better inform decisions about investment priorities.

2. Background

Many studies examining demand for recreational pursuits and the associated demand for environmental quality use the random utility model (RUM) framework of McFadden (1973), and build on the early work of Bockstael et al. (1987, 1989). These studies model the decision process of choosing a recreation site from a finite set of mutually exclusive alternative sites. Site choice decisions for each trip are treated as a utility maximisation process, where the person chooses from a number

of alternative sites (with different site attributes, including environmental quality) and selects the one that yields the highest expected utility level on any given choice occasion. The literature on the impact of water quality on water-based recreational activity ranges across many activities, as mentioned earlier. Work by Farr et al. (2014) suggests that there are substantial differences in the key factors (e.g. income, age, residency duration, and marital status) influencing the probability and frequency of participation in various water-based recreational activities, including boating. Therefore, insights from studies of non-boating activities may not be particularly relevant or useful to understand the impact of water quality on boating activity. In a review of benefits of water quality on marine recreation Freeman (1995) finds just one study of significance that considers boating activity. That study, by Bockstael et al. (1989), suggests that there are substantial benefits in cleaning up perceptible water pollution problems. In the intervening period a small number of studies consider water quality in the context of recreational boating activity. Lipton and Hicks (1999) using a multinomial logit model to examine the determinants of where vessel owners berth their boats find that boat owners' perception of water quality has an important influence on site choice. In a study of boaters in Maryland, USA, Lipton (2004) find that water quality does impact the enjoyment of boating and that boaters would benefit by a significant amount if water quality were to improve. In another study from the United States Egan et al. (2009) consider recreational activities at Iowa's 129 principal lakes, at which boating was the most popular activity along with fishing, picnicking, wildlife viewing and swimming. Their analysis shows that lake visitors are responsive to the full set of water quality measures used by biologists to identify the impaired status of lakes. And finally, in England Ziv et al. (2016) find mixed evidence on the effect of good water quality on boat site visitation. Although the number of studies is limited, the results on effect of water quality on boating activity are consistent; better water quality generally has a positive effect on boating activity. This paper adds to this narrow empirical literature providing the first estimates of the impact of water quality on site choice for boating activity in Ireland. The paper's contribution is as an application of existing methodologies to produce new empirical estimates.

An issue with site selection modelling is establishing the set of sites from which the selected or visited site is chosen (i.e. the choice set). Invariably there is data on the site actually chosen by the recreational user but in many instances the researcher has limited or no information on the alternative sites considered, which is the case for our Irish boating dataset. Data on alternative sites can be collated from all known recreational sites within a specific geographic area creating a universal site choice set. In such circumstances researchers often assume that individuals are aware of all elements of this set. Parsons and Hauber (1998) find that there exists some threshold distance beyond which adding more recreational sites into the choice set has negligible effects on welfare estimates, whereas Peters et al. (1995) were among

the first to demonstrate that using a universal choice set compared to a model that considered a sampled individual's actual choice set produces model parameters and welfare estimates that are quite different. Commonly used rules of thumb, such as distance rules, for defining choice sets do not necessarily lead to the proper choice set specification. Hicks and Strand (2000) make similar findings and conclude that caution must be exercised when defining appropriate choice sets and suggest direct questioning of survey respondents is required to specify the choice set. Parsons et al. (1999) make a counter argument to limiting or deleting sites from the universal choice set. They acknowledge that individuals may be unfamiliar with many of the sites, and that individuals may only credibly consider a narrow set of sites but argue that there is more important preference information in understanding which sites people know about (familiar sites) and sites that they really consider (favourite sites). This information is missing in the approaches that merely delete sites, such as the distance rule. Parsons et al. (1999) retain all sites in the choice set for estimation but specify different site utility functions for familiar and unfamiliar sites on the basis that the role site attributes play in site selection is likely to be different for familiar versus unfamiliar sites. They incorporate favourite sites in the likelihood function as being preferred to unfavoured sites. One difficulty with allowing for familiar or favourite sites during estimation is their identification. Obtaining consistent definitions for familiar and favourite sites can be difficult and identifying such sites during survey interviews can be problematic (Parsons et al., 1999), while Horowitz and Louviere (1995) also question whether the desired information can be acquired. On the basis of Monte Carlo experiments examining choice set formation models in the random utility framework Li et al. (2015) conclude that choice set formation should be central in project design, data collection, as well as during modelling and welfare analysis. More recently Thiene et al. (2017) show that choice set formation is behaviourally relevant and that motivations are important determinants of preliminary site screening for choice set inclusion, as well for site selection.

We add to the literature through a study of recreational boating, examining whether water quality has an effect on boating site choice decisions. In particular, we model the respondent's choice decision to travel to a specific site for the purposes of beginning their recreational boating activity. Consistent with the existing empirical literature we find that boaters prefer sites with better water quality. The rest of the paper is organised as follows: section 2 describes the datasets utilised in our analysis, while section 3 outlines the models employed to model recreational site choice decisions. Model results are presented in section 4 and section 5 offers a discussion, which is followed by a concluding section.

3. Materials

3.1. Survey of waterway users

Waterways Ireland is responsible for the management, maintenance, development and restoration of seven inland navigable waterways on the island of Ireland, principally for recreational purposes. During 2010 and again in 2014 Waterways Ireland commissioned surveys of waterway users to obtain information on the demographic profile of waterway users, to ascertain satisfaction levels with available facilities and to measure awareness of Waterways Ireland as the management authority on the navigations. The surveys were conducted face-to-face amongst a sample of waterway users across 23 points on the seven waterways. The sampling points were spread across both urban and rural areas with interviews occurring at different times and days across the interview periods. Interviews took 10 minutes on average to complete and were undertaken from August–October 2010 and October–November 2014. A total of 1632 and 1247 interviews were collected in each year respectively. The sampling methodology employed was 'very next person' interviewing and was weighted towards busier areas to reflect actual usage of the waterways.

For inclusion in this study we selected respondents that participated in boating activities, which comprises 299 individuals interviewed over the two survey periods and comprises 14 distinct sites. Due to the absence of water quality data at some sites the estimated models relate to the choice decisions of 266 individuals across 10 sites. The two cross-section surveys are similar in terms of socio-demographic variables plus in preliminary model estimation the estimated parameter on a year dummy variable was insignificant. Consequently the two cross-section surveys are pooled to create a single dataset, which provides more degrees of freedom for model estimation. The surveys were not designed to model site choice decisions, nor did they collect information on familiar, favourite or alternative sites that respondents considered in making their boating site choice decision. This means that we cannot follow best practice for defining the choice set, as discussed earlier (Thiene et al., 2017; Li et al., 2015; Parsons et al., 1999). Our method instead is to follow an approach often used in the literature where a universal choice set is created based on known recreational boating sites and a distance based rule is used to define individuals' choice sets (Parsons and Hauber, 1998; Peters et al., 1995). A number of models are estimated based on variations in the distance rule prior to selecting preferred models based on goodness of fit. Our distance rule for populating each respondent's choice set is based on all boating sites within 125%, 150%, 175% and 200% of the distance travelled by the respondent to their selected boating site where they were interviewed. This means that the modelled choice set for each individual potentially differs as the distance rule is altered, and also that the number of alternate

Table 1. Visited sites – travel distances, km.

Waterway	Site	Number of visitors	Mean distance	Std. Dev.	Min	Max
Barrow	Carlow	2	49	44	18	80
Grand Canal	Shannon Harbour	62	123	43	48	195
	Grand Canal Basin	2	104	19	91	118
Royal Canal	Kilcock Harbour	2	85	2	84	86
Shannon Erne	Leitrim Village	22	190	66	43	318
	Keshcarrigan Harbour	17	181	58	43	292
Shannon	Dromineer	13	106	60	22	200
	Athlone	42	126	40	40	209
	Carrick-on-Shannon	101	165	47	40	274
	Terryglass	3	95	66	34	165
	All Sites	266	146	55	18	318

sites varies across individuals (varying from 1 to 9 alternate sites). For example, as the distance rule is relaxed, i.e. from 125% to 150% the choice set for one respondent may remain unchanged, whereas for another it may increase, depending on the distance they actually travelled and their proximity to alternate sites.

Travel distances were calculated using spatial software as the driving distance from the individual's county of residence to the boating site. Mean travel distances to each of the 10 boating destinations is reported in Table 1. For example, 2 individuals visited the Carlow site on the Barrow waterway for boating activities with estimated travel distances of between 18–80 km and a mean of 49 km. The average distance travelled across all sites was 146 km. Though the Carlow site was visited by just two boat users, the site itself is within 125% of the actual travel distance of 29 individuals who have a mean travel distance to the Carlow site of 81 km, as shown in Table 2. There are 37 individuals for which the Carlow site is within 200% of the travel distance to their chosen boating site, with a mean distance of 92 km. As different travel rules are applied in calculating the choice set the potential mean travel distance, as reported in Table 2, does not increase substantially across the sites. There is no obvious threshold at which choice sets change dramatically in terms of mean distance or numbers of individuals potentially considering specific sites in their choice decisions and therefore Table 2 provides no insight on selecting the most appropriate choice set.

3.2. Water quality

Water quality data for 2010 and 2014 were sourced from monitoring stations that were proximate to the waterway sites where surveys were conducted. Water quality data were obtained from the Environmental Protection Agency (http://gis.epa.ie/) for river and lake sites and data for canal sites was provided by Waterways Ireland (www.waterwaysireland.org). A summary of water quality metrics is provided in Table 3. Generally water quality at the sites in our dataset is at a relatively high level

Table 2. Visitor mean potential travel distances to choice set sites (266 individuals).

Site	Sites within 125% of distance to selected site		Sites within 150% of distance to selected site		Sites within 175% of distance to selected site		Sites within 200% of distance to selected site	
	mean, km	Individuals	mean, km	Individuals	mean, km	Individuals	mean, km	Individuals
Carlow	81	29	87	33	87	35	92	37
Shannon Harbour	115	166	115	187	113	208	114	210
Grand Canal Basin	49	129	53	134	63	143	74	153
Kilcock Harbour	57	133	58	145	69	156	81	175
Leitrim Village	101	179	106	198	115	223	115	238
Keshcarrigan Harbour	107	174	111	188	115	226	114	238
Dromineer	138	115	141	161	143	171	143	173
Athlone	109	179	114	195	107	218	107	222
Carrick-on-Shannon	103	184	106	201	114	226	114	241
Terryglass	136	166	134	187	135	208	134	210

Table 3. Water quality measures.

Site	BOD mg O$_2$/l		Phosphates mg P/l		Ammonia mg N/l		Dissolved Oxygen % Saturation		Fecal Coliform Count/100ml	
	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014
Carlow	0.046	0.046	0.026	0.026	0.046	0.046		94.4		
Shannon Harbour	1.235	0.014	0.017	0.038	0.024	0.014			20	25
Grand Canal Basin	1.500	0.051	0.027	0.059	0.100	0.051			525	1976
Kilcock Harbour	2.703	0.051	0.040	0.080	0.062	0.051			8801	1787
Leitrim Village	2.478	0.021	0.035	0.064	0.030	0.021			30	62
Keshcarrigan Habour	2.478	0.021	0.035	0.064	0.030	0.021			30	62
Dromineer	0.800	0.019	0.013	0.009	0.020	0.019	100.5	110.5		
Athlone	0.658	0.025	0.029	0.025	0.031	0.025	93.7	95.7		
Carrick-on-Shannon	1.190	0.506	0.020	0.051	0.099	0.506	84.1	103.5		
Terryglass	0.850	0.016	0.019	0.010	0.033	0.016	98.8	106.5		

The data presented are site specific annual means.

with two exceptions. There are elevated levels of phosphorus and fecal coliform in the waters at Kilcock Harbour and Grand Canal Basin. Nonetheless, the analysis here is not comparing recreational activity at pristine versus very polluted sites, rather it is comparing recreational activity across sites that are generally of a relatively high standard. Consequently, the results of the analysis are likely to be more muted than if the dataset also contained sites with relatively low water quality standards. While Table 3 reports summary statistics for several water quality metrics, only biochemical oxygen demand (BOD) and phosphates are included in the reported model estimates because the models with the other water quality variables did not converge during estimation, the most likely reason for which is lack of variability and insufficient data points. For instance, fecal coliform data was only available for 5 canal sites. We confine our discussion of the water quality variables below to BOD and phosphates.

Recreational users have limited information about water quality because only official bathing sites have a statutory requirement to post monitoring results, none of which are in our dataset. Instead, boating decisions on site choice are based on a range of

criteria including individual's own assessment of water conditions. The models are intended to identify whether users' behaviours are responsive to water quality, as indicated by the various quality metrics, e.g. BOD.

3.2.1. Biochemical Oxygen Demand (BOD)

BOD is a metric that indicates whether a water body is in a eutrophied state. Higher BOD levels of a water body are associated with low dissolved oxygen levels. For instance, when large quantities of organic material are present in a water body bacterial uptake of oxygen outstrips the natural replenishment of dissolved oxygen from the atmosphere and by photosynthesis. Eutrophication arises when dissolved oxygen levels become so low that respiring aquatic organisms are unable to absorb sufficient oxygen from the water. While individuals involved in water based activities, such as swimming, are likely to be most sensitive to eutrophic conditions, the demand for all recreational activities in or near eutrophic waters are likely to be impacted due to impediment of activity, discomfort and visual unpleasantness. Irish regulations giving statutory effect to the WFD and Directive 2008/105/EC on environmental quality standards in the field of water policy (Directive 2008/105/EC, 2008) require rivers with 'good' status have mean BOD levels less than or equal to 1.5 mg/l and that the 95th percentile should be less than or equal to 2.6 mg/l.[1]

3.2.2. Phosphates

Phosphate carrying pollutants like fertilisers, waste-water, detergents and run off from paved surfaces can exacerbate algal growth in fresh water systems, leading to algal blooms and eutrophication. Phosphates are the limiting factor in fresh water plant and algal growth, which makes its control and monitoring critical, if eutrophication is to be avoided. Total phosphates is the sum of orthophosphates, polyphosphates and organic phosphorous.[2] Orthophosphate is the most readily available form for uptake during photosynthesis. High concentrations generally occur in conjunction with algal blooms. For rivers with 'good' WFD status mean orthophosphate levels must be less than or equal to 0.035 mg P/l and the 95th percentile be less than or equal to 0.075 mg P/l.

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[1] SI 272/2009 – European Communities Environmental Objectives (Surface Waters) Regulations 2009. Available online: http://www.irishstatutebook.ie/2009/en/si/0272.html.

[2] Phosphates arise in waterways in organic or inorganic form. Sources of the former include sewage and the breakdown of organic pesticides. Inorganic phosphates are made up of orthophosphates and polyphosphates. Orthophosphates are commonly referred to as reactive phosphorous, and it is this form of phosphorous directly taken up by plant cells to grow. Polyphosphates, commonly used in detergents, are unstable and eventually convert to orthophosphates.

Table 4. Recreational site attribute data.

Sites	Toilets	Showers	Laundry	Parking	FuelPoint	Slipway
Carlow				X		X
Shannon Harbour	X	X	X	X		
Grand Canal Basin	X	X				X
Kilcock Harbour						
Leitrim Village	X	X	X	X	X	X
Keshcarrigan Harbour	X	X	X	X		X
Dromineer	X	X		X		X
Athlone	X	X				X
Carrick-on-Shannon	X	X	X	X		X
Terryglass	X			X		X

X indicates presence of a facility/service.

3.3. Other site attributes

Data on other site attributes are reported in Table 4, which was provided directly by Waterways Ireland. The variables are binary, indicating the presence of the attribute. The attributes include toilet and washing facilities, parking, as well as fuel points and slipways for launching boats.

4. Methodology

The RUM is the standard framework used to estimate behavioural choice models within which a boater chooses between a number of boating sites and selects the one that yields the highest expected utility level on any given choice occasion. Sites comprise a number of attributes (e.g. water quality, washing facilities, slipway, etc.), with the level of the attributes differing across choice alternatives. The utility that boater i would obtain from site j is

$$U_{ij} = \beta x_{ij} + \epsilon_{ij} \tag{1}$$

where x_{ij} is a vector of observed variables, β a vector of unobserved coefficients and ϵ_{ij} is an unobserved error term. A boater chooses among J possible site alternatives. Whenever the utility from boating at site j is greater than the utility from all other sites, site j will be chosen. The RUM model can be specified in different ways depending on the distribution of the error term. Assuming the error terms are identically and independently distributed (iid) extreme value, the RUM model is specified as a conditional logit (CL) (McFadden, 1973). The CL model is the workhorse for analysing discrete choice data with many applications (e.g. Siderelis et al. (1995); Parsons and Massey (2003); Provencher and Bishop (2004); Pradhan and Leung (2004)). The probability of boater i choosing site j is

$$P_{ij} = P(y_i = j) = \frac{exp(\beta x_{ij})}{\sum_{j=1}^{J} exp(\beta x_{ij})} \tag{2}$$

where y_i is the choice made by boater i. The parameters of the conditional logit model, β, are estimated through the use of maximum likelihood with the following log-likelihood expression:

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i=1}^{J} D_{ij} \, log \, P_{ij} \tag{3}$$

where N is the number of boaters and D_{ij} is a dummy variable that takes the value of 1 if boater i chooses site j and 0 otherwise.

5. Results

Conditional logit model estimates using four distance rules for generating boaters' choice sets are reported in Table 5. The choice sets include sites within 125%, 150%, 175% and 200% of the distance actually travelled by each individual boater. In addition to the water quality and site attribute variables, the models also include a variable measuring a boater's distance to each specific site, specified in units of 10 km. The distance variable is incorporated to allow site preferences vary by site proximity. A negative coefficient estimate is anticipated indicating more distant sites being less popular. A constant for each site, termed an alternate specific constant (ASC), was incorporated to control for unidentified characteristics associated with each site. For instance, some sites are canal sites, some rivers, and others are combinations of both, while some are in urban and others in rural locations. We begin by comparing the CL models estimates across the four different choice set assumptions.

Standard tests for model comparison are not applicable, i.e. likelihood ratio tests, as the models are not nested. The model is unchanged across estimations in terms of parameters and observations (i.e. boaters) though with different numbers of choice alternatives across the four estimations. We evaluate models using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) statistics and also use McFadden's pseudo-R^2, which compares the log-likelihood from an intercept only model to the log-likelihood from the model with all covariates included (McFadden, 1973). Higher values of McFadden's pseudo-R^2 represent a better fit. Comparing across the four estimated models in Table 5, pseudo-R^2 declines in magnitude as the choice set expands. Although not a formal test of model specification the statistic does suggest that the narrower choice sets (i.e. the 125% set) may more applicable, though as we will discuss shortly it will be discounted for other reasons. Both AIC and BIC are often used to help in model selection, with lower value statistics being considered to be closer to the truth in the case of AIC or more likely to be the true model in the case of BIC. Both statistics suggest that the narrower choice set (i.e. 125%) is the preferred model. Both AIC and BIC

Table 5. Conditional logit regressions.

	Choice set includes sites within % of actual travel distance			
	125%	**150%**	**175%**	**200%**
Distance	0.246***	0.023	−0.069**	−0.101***
	(0.063)	(0.038)	(0.027)	(0.032)
BOD	−0.421	−0.594*	−1.188***	−1.010**
	(0.324)	(0.326)	(0.346)	(0.411)
Phosphates	−10.459	−34.483*	−19.994	−25.540
	(21.211)	(18.366)	(13.005)	(17.288)
Toilets	0.106	−1.915	−2.842*	−2.388
	(1.904)	(1.920)	(1.688)	(2.121)
Showers	2.398**	3.832***	3.496***	3.902***
	(1.099)	(1.348)	(1.231)	(1.295)
Laundry	2.049**	2.213***	2.396***	1.958***
	(0.818)	(0.769)	(0.638)	(0.743)
Parking	−1.084**	−0.865*	−0.508	−0.513
	(0.516)	(0.489)	(0.433)	(0.416)
FuelPoint	−0.133	0.715	−0.206	0.025
	(0.490)	(0.459)	(0.416)	(0.401)
Slipway	−1.313	−1.256	−0.454	−1.514
	(1.528)	(1.326)	(1.104)	(1.347)
ASCs	yes[a]	yes	yes	yes
Pseudo R^2	0.282463	0.227744	0.217178	0.224755
Log Likelihood	−263.255	−320.984	−354.462	−361.077
AIC	562.5	678.0	744.9	758.2
BIC	627.0	742.5	809.4	822.7
Observations	266	266	266	266
Site choices	1566	1764	1955	2063

Standard errors in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.
ASCs = Alternative Specific Constants.
[a] Algorithm was unable to estimate a standard error for ASCs.

indicate relative quality between alternatives but neither say anything about absolute quality or interpretation of the models. Comparing the parameter estimates across models there are substantial differences in their magnitude, which is consistent with Peters et al. (1995) who find that model parameter estimates can be quite different depending on the choice set used in estimation. The positive sign on the *Distance* variable in some of the models is not as anticipated, indicating that people prefer more distant sites. The statistically significant coefficient in the 125% choice set model with an associated odds ratio of 1.28, indicates a site 10 km further distance is 28% more likely to be visited. This is counter to intuition though not inconsistent with some empirical findings in the literature, where it is argued that there is positive value in travel time or distance (e.g. Cao et al., 2009; Jain and Lyons, 2008; Ory and Mokhtarian, 2005). For instance, if some boating trips are a part of annual vacation, as opposed to everyday recreational activity, respondents may have a preference towards more distant sites to get away from the normal routine. Other parameter estimates that draw doubt on the narrower choice sets (i.e. 125%–150%) are the negative and statistically significant coefficient on the *Parking* variable indicating that boating participants disregard parking facilities in their decisions. Also the maximum likelihood algorithm was unable to estimate a standard error for the ASCs

Table 6. Odds ratios – conditional logit model.

| Variable | Choice set includes sites within % of actual travel distance | | | |
	125%	150%	175%	200%
Distance	1.28***	1.02	0.93***	0.90***
	(0.08)	(0.04)	(0.03)	(0.03)
BOD	0.66	0.55**	0.30***	0.36***
	(0.21)	(0.18)	(0.11)	(0.15)
Phosphates	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Toilets	1.11	0.15***	0.06***	0.09***
	(2.12)	(0.28)	(0.10)	(0.19)
Showers	11.00	46.15	32.97	49.52
	(12.09)	(62.23)	(40.60)	(64.14)
Laundry	7.76	9.15	10.98	7.09
	(6.35)	(7.03)	(7.00)	(5.27)
Parking	0.34***	0.42***	0.60	0.60
	(0.17)	(0.21)	(0.26)	(0.25)
FuelPoint	0.88	2.04	0.81	1.03
	(0.43)	(0.94)	(0.34)	(0.41)
Slipway	0.27*	0.28*	0.64	0.22***
	(0.41)	(0.38)	(0.70)	(0.30)

Standard errors calculated by the delta method in parentheses.
* $p<0.10$, ** $p<0.05$, *** $p<0.01$. Null hypothesis odds ratio $= 1$.

(not reported) in the case of the 125% specifications using a number of algorithms (i.e. Gauss–Marquardt, Davidon–Fletcher–Powell, Newton's method, Berndt, Hall, Hall, and Hausman). Even though the information criterion statistics suggest the narrower choice set models (i.e. 125%–150%) are preferable in terms of which models describe the data better, these models have less credibility from an economic or practical sense. For the remaining models based on the 175%–200% choice sets there is not much to distinguish between them. The models have similar McFadden's pseudo-R^2 statistics, and similar relative probability based on the AIC statistics. With the parameter estimates not directly interpretable the related odds ratios reported in Table 6 are more useful.[3] The magnitude of the odds ratios are broadly similar across the two preferred models. The very high (and incredible) odds ratio estimate for the Showers variable is not statistically significant from 1. However, the odds ratios associated with the *Toilets* and *Slipway* variables are unanticipated but statistically significant. We discuss the interpretation of the parameters in the next section.

6. Discussion

6.1. Data limitations

Prior to discussing the model estimates it is important to review some of the limitations of the dataset. The first point is that the boating recreation dataset was not

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[3] With a logit model the odds ratio is calculated as the $exp(\beta_k)$ where β_k is the parameter associated with attribute x_k (Greene, 2012).

collected for the purposes of estimating a recreational site choice model. As noted earlier, both Li et al. (2015) and Thiene et al. (2017) suggest that investigating choice set formation should be central in project design and data collection, and not just an issue for data analysis stages. Misspecification of the choice set can under estimate welfare measures by 30–50% (Li et al., 2015). Welfare estimates with that level of bias could substantially mislead policy decisions and hence we do not undertake welfare analysis here. Instead, the primary focus is on whether water quality affects or coincides with site choice preferences for recreational boating activity. The original survey dataset limits the methodological approaches feasible and the current best practice approach could not be followed. However, within the bounds of the existing dataset the approach taken to generate choice sets has been widely used previously (Parsons and Hauber, 1998; Peters et al., 1995). Consequently, the analysis does provide insights into recreational boaters' preferences, in particular with respect to water quality where there has been relatively limited empirical research. Empirically demonstrating such a relationship is also important information for decision makers involved in water resource protection and management.

An issue not previously discussed is that the analysis is confined to 10 specific sites. These sites are among the most popular boating recreational locations on the waterways that Waterways Ireland has responsibilities. However, there are potentially many other boating sites within the Waterways Ireland network and even more boating sites on other waterways. The implication for site choice modelling is that individuals' real choice sets may include sites beyond the 10 sites included in the analysis. The potential existence of such unknown sites echoes the concerns of Thiene et al. (2017); Li et al. (2015); Hicks and Strand (2000) among others. Unfortunately, there is no framework to remedy this issue within the current dataset.

The earlier discussion of water quality noted that sites within the analysis had relatively high water quality (see Table 3). Mean values for the BOD and $Phosphates$ variables are approximately equal to the threshold between 'moderate' and 'good' status for those metrics for rivers under the WFD. Accordingly, there may be potential sample selection issues within the dataset. The most popular recreation sites, where the face-to-face interviews were conducted, may occur at sites with relatively high levels of water quality. Boating activity may be more likely to occur at these sites because site facilities and water quality may be superior compared to other potential boating sites. To capture the full extent of the impact of differences in water quality on recreational boaters would require data across a sample of recreational sites covering the spectrum of water quality (and other boating facilities).

The sample of boaters used in the analysis is relatively small at 266 individuals, each taking a single trip. This limits the power of the model to estimate parameters across the full range of preferences. Mindful of this and the other data issues, we nonetheless

proceed with estimation, as the analysis provides insight in an area where there is little prior empirical work.

6.2. Water quality

Boat users may not be aware of a site's water quality measurements, as water quality test scores are not posted at recreational sites in this sample. Including water quality metrics as site attributes within the site choice model enables us to examine whether boating enthusiasts, as they perceive water quality, are responsive to laboratory measures of water quality. The results suggest that boaters are responsive to water quality conditions, as indicated by both BOD and phosphorus levels. Based on the odds ratio estimates from the 175%–200% choice set models, for a 1 mg O_2/l increase in BOD level the odds that a site would be selected for a boating trip is 64–70% less. Odds ratio estimates are constant and independent of the level of the underlying variable but to put it in context a 1 mg O_2/l increase in BOD level is equivalent to a 70% increase from the mean value in our sample. For a 1 mg P/l increase in phosphates the odds that a site is chosen for a boating trip is almost 100% less. An increase by 1 mg P/l is equivalent to 27-fold increase from the mean phosphates level within our sample of sites. As the sample of sites in our data is not representative and our user sample is relatively small the estimated scale of the odds ratio may have limited policy application for other non-sample sites. However, the odds ratio estimates are statistically significantly different than one, which is an important result indicating that recreational boaters are sensitive to water quality levels in terms of preferred boating locations.

As mentioned earlier the water quality at the sites in our sample is quite high and the magnitude of the water quality levels reported in Table 3 would not be immediately visually perceptible to waterways users. This has potential implications for the conclusions that we can draw from our model. In particular, do the estimated BOD and phosphates odds ratios capture boater response to water quality levels or are they are correlated with some other unknown factor. We know that Waterways Ireland discouraged recreational activity a number of sites due to high fecal coliform contamination, namely the Kilcock Harbour and Grand Canal Basin sites. These sites are among the sites with higher BOD and phosphate levels so the estimated model may be capturing a correlation between fecal coliform and BOD and phosphate levels. Consequently, the magnitude of the estimated odds ratios may not be fully attributable to BOD and phosphate levels but the conclusion that recreational boaters are sensitive to water quality levels is still valid.

The results above are consistent with previous research on the impact of water quality on recreational boating activity. For instance, Lipton and Hicks (1999) find that boat owners' perception of water quality has an important influence on site choice

while Egan et al. (2009) find that water users, including boaters, are responsive to the full set of water quality measures used by biologists to identify impaired water status. However, more recent research by Ziv et al. (2016) finds that water quality, as indicated by WFD status, is a poor predictor of sites with high levels of recreational use. Ziv et al.'s results may reflect an alternative methodological approach. First, WFD status is used as the sole water quality metric, which none of the prior boating studies use. WFD status comprises an assessment across a number of biological and physiochemical measures with WFD status itself assigned as the minimum status of biological and chemical components. The biological component of WFD status will have little relevance to boaters but may be the determining factor in WFD status so it is not surprising that WFD status is a poor predictor of recreational use. However, Ziv et al. (2016) make an important point that recreational users' preferences with respect to water quality may be determined by the actual recreational choices available. If there is limited availability of relevant infrastructure (e.g. moorings, slipways, etc.) preferences with respect to water quality may be compromised in favour of the practical alternatives available.

6.3. Other site attributes

While travel distance might not be considered a site attribute, it is an attribute to boaters considering between alternative boating sites. In the larger choice set models (i.e. 175% & 200%) the coefficient on the *Distance* variable is negative, as one would anticipate. As distance to sites increases, the probability that they are visited declines. The odds ratios in Table 6 suggest that for each 10 km increase in distance to a site, the probability that it is visited declines by 7–10%.

When we examine other site attribute variables we have several results different than one might anticipate. Boat ramps or slipways (*Slipway*) facilitate access to waterway sites and would generally be considered a positive attribute for a recreational boating site. The point estimate across all the models estimated is negative, which is counter to intuition, though may reflect the fact that many users do not trailer boats to their recreational sites. The odds ratio for the *Toilets* variable in the 175%–200% models being substantially less than 1 is also counter to intuition. Many 'cruiser' boats have toilets on board so such water-side facilities are not needed by many boat users. With the exception of two sites, all locations have toilet facilities available. Consequently, the toilets result may be capturing other factors associated with these sites. One of the sites without toilets, Carlow, has relatively poor opportunities for longer range navigation due to low water levels. So the result may be capturing the absence of boating opportunities at the site compared to other sites that have much more extensive boating opportunities available. The parameter estimate on the *Parking* variable is also negative. Designated parking facilities are available at 7 of

the 10 sites and generally would be considered a positive attribute. However, absence of designated parking does not mean absence of parking, as on-street parking is generally available. It is more conceivable that parking is not a particularly important site attribute for boaters, which is the case in the preferred 175%–200% models where the coefficient estimates are not statistically significant. In general the revealed preferences for slipways, parking and toilet facilities that are counter to expectation may reflect the possibility that many boaters do not necessarily access or need all available facilities. Alternatively, the variables may also be correlated with some other negatively perceived attribute not considered within the model. For instance, opportunities for social engagement, such as those that occur at waterside restaurants and pubs, are frequently considered an important component of boating excursions are not captured within the estimated models. Finally, it should also be noted that these results reflect the fact that model estimation is based on only 266 individuals, leaving limited scope to fully resolve the complexity of boat users' preferences.

7. Conclusion

This paper models recreational boating site choice decisions for the purpose of investigating the extent to which water quality influences the site selection decision. The paper is based on an existing survey of recreational waterway users in Ireland, with the analysis confined to boaters using ten specific waterway sites. The use of a pre-existing dataset presented a number of challenges for the analysis. These included how to model the actual site choice set when the survey data only indicated the site actually visited by boaters, and the fact that the analysis pertains to just ten sites, albeit popular boating sites. With the analysis confined to a small number of waterway sites, which have generally high water quality levels, it is likely that sample selection issues arise. The analytical difficulties encountered during the research confirm the difficulty of modelling site choice decisions and the need to use a bespoke dataset. Mindful on these difficulties, we estimate a model that provides some insight into boaters preferences for site attributes, including water quality.

Water quality test scores are not posted at recreational boating sites, nor are they easily accessible online without concerted effort and expertise to retrieve the results. Consequently, it is likely that most boaters are unaware of a site's water quality measurements. Including water quality metrics as site attributes within the site choice model enables us to examine whether boating enthusiasts, as they perceive water quality, are responsive to laboratory measures of water quality. Our results find that boaters are responsive to water quality conditions, as indicated by both BOD and phosphorus levels. The results may also reflect official guidance discouraging waterway users from engaging in activities at a number of sites with high fecal coliform levels. While we are unable to separately control for such guidance within

our model, conclusions of the analysis remain that recreational boaters are sensitive to water quality. Due to this and also because the analysis is based on a small unrepresentative sample of both sites and users it is not reasonable to undertake welfare analysis or draw policy implications with respect to the scale of boaters' response to changes in water quality.

One quantitative finding that has policy relevance is that travel distance to water sites is an important factor in choosing between alternative locations for water based recreational activities. For each 10 km increase in distance to a site, the probability that it is visited declines by 7–10%. All else equal, water users are more likely engage in their boating activity at their 'local' waterway. This finding echoes the importance of achieving good water quality across all sites and ongoing efforts to improve the quality of the EU's waterways. However, it is notable that water quality monitoring for ecological status under the Water Framework Directive does not require monitoring for fecal coliforms, which is the pollutant that recreational users may be most responsive in terms of their boating activity and also immediately impacted health wise. Better information on how recreational users benefit from water quality improvements will enhance decision making with respect to investment priorities, especially when facing limited economic resources and competing priorities.

Declarations

Author contribution statement

John Curtis: Conceived and designed the experiments; Performed the experiments; Analysed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Stephen Hynes: Analysed and interpreted the data; Wrote the paper.

Benjamin Breen: Analysed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Funding statement

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

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