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Revealed preference valuation of beach and river water quality in Wales

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ABSTRACT

This paper estimates the value of water quality for outdoor recreation in Wales, considering all beaches and rivers in the country, and accounting for the value accrued to existing visits and generated from new visits. The values were aggregated for the population and mapped to show where the benefits of improving water quality are higher. We used a revealed preference method that links models of choices of beaches and rivers with models of the monthly number of visits to all beaches and rivers. We found that improving water quality of a beach from good to excellent has an estimated value of £2.58 per existing visit and leads to an average 52% increase in the number of visits, resulting in an overall value of £199,164/month per person. Improving water quality of a beach from sufficient/poor to good has a smaller value and impact on number of visits. Improving water quality of a river stretch to above bad/poor has a value of £0.99 per existing visit and leads to a 64% increase in the number of visits, resulting in an overall value of £15,671/month per person. We discuss how the assumptions made in the analysis might affect these results.

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1. Introduction

Visiting rivers and beaches are two of the most popular outdoor activities around the world, accounting for many recreation trips every year (Bell et al. 2007; Jensen and Guthrie 2006). The number of trips that people make, and the benefit they derive from those trips, depends on water quality in the sites visited. There is also evidence that people are willing to pay for improved water quality for recreation (Söderqvist 1998). However, water quality in rivers and beaches is currently threatened by pollution (Abu-Hilal and Khordagui 1993; Derraik 2002); water scarcity and droughts (Mosley 2015); climate change (Arheimer et al. 2005; Murdoch, Baron, and Miller 2000); environmental impacts linked to the fast growth of tourism (Almeida et al. 2007; Torres-Bejarano et al. 2018); and encroachment of urban areas on coastlines and water bodies (Almeida et al. 2007; Ouyang, Zhu, and Kuang 2006). These threats can have a large negative impact on recreational uses of beaches and rivers (Toimil et al. 2018). Concerns about water quality have also led to actions at the national and international level. For example, the Water Framework Directive established a legislative framework for protecting and improving water resources in the European Union (EP/EC 2000).

These issues are highly relevant in Wales, one of the four countries in the United Kingdom, with 2530 km of coastline and 7450 km of rivers. Among the residents who made at least one outdoor visit within a year, 77% visited a beach and 67% visited a river (NRW 2015). Water quality is one of

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the main determinants of the choice of which beach to visit, among other characteristics, such as quality of sand, cleanliness, and safety (Tudor and Williams 2006). Water quality has improved during the last decades in areas that traditionally had intensive mining and heavy industries, but is still affected by diffuse water pollution from industrial sources and surface water drainage from populated areas and farms (NRW 2013).

The definition and implementation of policies to improve water quality in beaches and rivers requires objective estimates of the value of water quality for recreational use, among other uses. This is useful to compare the benefits of improving water quality in different beaches and rivers, and to compare these benefits with the costs of achieving the improvement. Previous studies have quantified the value of water quality using the two main methods for the economic valuation of non-market goods: stated preference and revealed preference. However, few studies have considered the value generated by new trips to beaches and rivers and even fewer have aggregated the values at the country level or mapped how the value varies within the country.

This paper estimates the value of potential improvements in beach and river water quality in Wales, using a revealed preference method (travel cost). We first estimate models of the choice of beaches and rivers visited as a function of water quality and travel cost. These models are used to calculate indicators (known as 'inclusive values') of the maximum expected utility individuals gain from the set of all beaches and rivers. These indicators are then included as a variable in models of the number of visits to beaches and rivers. This method allows us to calculate the impact of changes in water quality on the per-visit value of existing and new visits, and on the number of visits. By using a dataset from a national survey of outdoor recreational visits, and data on all beaches and rivers in Wales, the approach can be used to aggregate and map values at the country level.

The rest of the paper is split into nine sections. Section 2 reviews previous studies valuing beach and river water quality. Sections 3–5 present data, methods, and descriptive statistics. Sections 6–7 present the estimated models. Section 8 shows the values estimated from the models. Sections 9–10 discuss the assumptions used in the analysis and conclude the paper.

2. Literature review

The value of beach and river water quality for recreational uses has been estimated with the standard methods of economic valuation, which fall broadly into two categories: stated preference and revealed preference.

Stated preference methods use surveys to capture preferences about different aspects of the recreational use of beaches and rivers, and estimate the willingness to pay for improvements in those aspects. Contingent valuation was used in many early studies in this field to value beach/coastal water quality (Bockstael, McConnell, and Strand 1989; Georgiou et al. 1998; Machado and Mourato 2002), and river water quality (Carson and Mitchell 1993; Ferrini, Schaafsma, and Bateman 2014; Green and Tunstall 1991; Magat, Huber, and Viscusi 2000). However, this method is prone to generate protest answers, with many participants stating that they are not willing to pay any amount.

More recent studies have used choice experiments to value aspects of the recreational use of beaches and rivers, including water quality. This method has three strengths. First, it can be used to estimate more preference trade-offs between costs and water quality improvements than those obtained with contingent valuation - for example by considering improvements in different sites at different times (Glenk, Lago, and Moran 2011). Second, it can estimate trade-offs between the use value of water quality for recreation and non-use value (e.g. biodiversity) (Eggert and Olsson 2009; Pakalniete et al. 2017). Third, it can capture trade-offs between water quality and other characteristics of beaches and rivers. For example, studies about beaches found that users value characteristics such as the availability of facilities (e.g. showers, restrooms), information, cleanliness, presence of a lifeguard, sand quality, lack of pollution and debris, safety, and congestion (Beharry-Borg and Scarpa 2010; EFTEC 2002; Hynes, Tinch, and Hanley 2013; Meyerhoff, Dehnhardt, and Hartje 2010; Penn et al. 2016). Studies about rivers found that users value the restoration of water flows and riverbanks, lack of debris and pollution, and reduced flood risk (Brouwer et al. 2016; Hanley, Wright, and Alvarez-Farizo 2006; Morrisson and Bennett 2004; Perni, Martinez-Paz, and Martínez-Carrasco 2012).

The problem of stated preference methods is the hypothetical nature of the scenarios presented to participants, which tends to lead to an overestimation of willingness to pay. Revealed preference methods solve that problem by modelling observed behaviour, i.e. real choices made by individuals, thus accounting for behavioural constraints that are not usually considered in stated preference studies. One possibility is hedonic pricing, i.e. models relating property prices with indicators of water quality in beaches or rivers in the surrounding areas (Artell 2014; Hjerppe et al. 2017; Leggett and Bockstael 2000; Poor, Pessagno, and Paul 2007). These models can produce powerful results – when they can be estimated. In practice, it is difficult to disentangle the value of water quality from the value of the many other aspects influencing property prices.

The travel cost method is another common revealed preference method. It assumes that the travel cost to visit a site (beach or river) is an indicator of the price of accessing that site. The number of trips that individuals make to different sites, or to the same site at different moments in time, can be modelled as a function of travel cost and various site-specific variables. Willingness to pay can then be derived from the estimated models. Lew and Larson (2005) used this method to estimate how the choice of which beach to visit depends on water quality and other beach characteristics (lifeguards, activity management, and availability of parking) in a region in the USA. Studies in Finland estimated the value of water quality for swimming, fishing, and boating trips (Vesterinen et al. 2010) and for trips to second homes (Huhtala and Lankia 2012). In England, Bateman et al. (2016) used the travel cost method to map willingness to pay for water quality improvements over a river catchment area. However, few studies mapped values across a whole country. An exception is Day and Smith (2017), who valued improvements to beaches in England, as a part of a wider assessment of outdoor recreation sites. The values were then transferred to beaches in Wales.

What was seldom acknowledged in previous studies was that improving water quality adds not only to the value of existing trips, but also generates new value, from new trips. This aspect can be integrated in the analysis by adding a contingent behaviour question in surveys, asking how many trips participants would make for given levels of water quality. Examples of these studies include Whitehead, Haab, and Huang (2000) and Loomis (2002) in the USA; Hanley, Bell, and Alvarez-Farizo (2003) in Scotland; and Lankia, Neuvonen, and Pouta (2019) in Finland.

An alternative method is to link the number of trips to the utility that can be derived from the available sites. Bockstael, Hanemann, and Kling (1987) used this method in a model with two linked components. A site choice model explains choices of sites as a function of the characteristics of the sites and travel cost to access them. A participation model explains number of visits to all sites as a function of individual characteristics and an indicator of the maximum expected utility each individual gains from all sites. This indicator is known as the inclusive value or log sum and can be derived from the site choice model (Small and Rosen 1981; Williams 1977). The model thus accounts for site substitution effects and changes in the number of visits to all sites. Johnstone and Markandya (2006) and Anciaes, Metcalfe, and Sen (2020) used this model to value various aspects of river water quality in the context of angling trips in England. There are no examples of papers valuing both beach and river water quality and all recreational uses.

In the present paper, we use the Bockstael, Hanemann, and Kling (1987) method to value beach and river water quality, considering the value for existing trips and new trips. Our contribution to the literature is twofold. First, we use the method to value both beach and river water quality, for all recreational uses. Second, we use the method to estimate values at the national level, based on the behaviour of a nationally representative sample, aggregated for the whole population of Wales, and mapped to show where potential benefits of improving water quality are higher.

3. Data and variables

3.1. Visits

We used data on visits to beaches and rivers, extracted from the Welsh Outdoor Recreation Survey (WORS) 2014–2015. This is a survey ran by Natural Resources Wales of a representative sample of 5995 Welsh residents. Most of the survey data is openly available, including participant characteristics (demographic, socio-economic, and attitudinal), the number of outdoor trips for recreation in the last four weeks, and details on the most recent trip. Data on the home location of each participant (postcode) and location of the main site visited in the last trip was provided by Natural Resources Wales. The data also includes a participant weight (representative of the Welsh adult population) and a visit weight (representative of the visits taken by that population). These weights adjust data for area, season, non-response rates per group (age, gender, working status, and social grade), and unequal probabilities of selection of an individual within a household.

The number of outdoor visits in the last four weeks was collected in the survey in a closed-ended question with nine possible intervals of values. We took the mid-point of all intervals and the lower end of the last interval (101+). We then approximated the monthly number of visits to beaches, sea, or coastline locations as the number of all outdoor visits made in the last four weeks, if the participant visited those types of sites in their last visit. Similarly, the monthly number of visits to rivers, lakes, or canals was the number of all outdoor visits made in the last four weeks, if the participant visited those types of sites in their last visit. In Section 9, we discuss the implications of these and other assumptions.

3.2. Beach and river characteristics

The data on beach characteristics was extracted from the British Beaches Info website (https://britishbeaches.uk) in November 2017. The data contains the location of 225 beaches in Wales and information on water quality, as assessed by Natural Resources Wales in the summer of 2017. Water quality is classified annually in Wales as excellent, good, sufficient, or poor, based on four years of analyses (during the summer bathing season) of samples for two types of bacteria: Escherichia coli and intestinal enterococci. The British Beaches Info website also contains information on other beach characteristics, including available facilities (e.g. showers), beach features (e.g. promenade), types of sea life (e.g. seals), and activities (e.g. windsurfing). Table A1 in Appendix lists all characteristics. Descriptive statistics on all variables extracted from the data will be presented in Section 5.

The data on river characteristics was extracted from a spatial dataset that includes all water bodies managed by Natural Resources Wales under the Water Framework Directive. We retrieved the data in November 2017 from the Natural Resources Wales website. The data contains the location and shape of 737 river stretches and other information. Water quality is classified using the Water Framework Directive classification scheme (good, high, moderate, poor, or bad), which is based on chemical and ecological conditions (EP/EC 2000; Quevauviller et al. 2008). The data also contains the result of an assessment of water flow (pass or fail) and information on whether the river stretch is a highly modified water body. We calculated two additional variables using a geographic information system: the proportion of the area around 200 m of the river stretch that is green (an indicator of the recreational value of the site) and the proportion of the same area that is urban (an indicator of the accessibility of the site). The data on green spaces and urban areas was extracted from the UK Ordnance Survey Open Green Space dataset and Ordnance Survey Geography Open Data, respectively. Descriptive statistics will be presented in Section 5.

Figure 1 shows the beaches and river stretches included in the analysis, and the location of the three main urban areas in Wales.

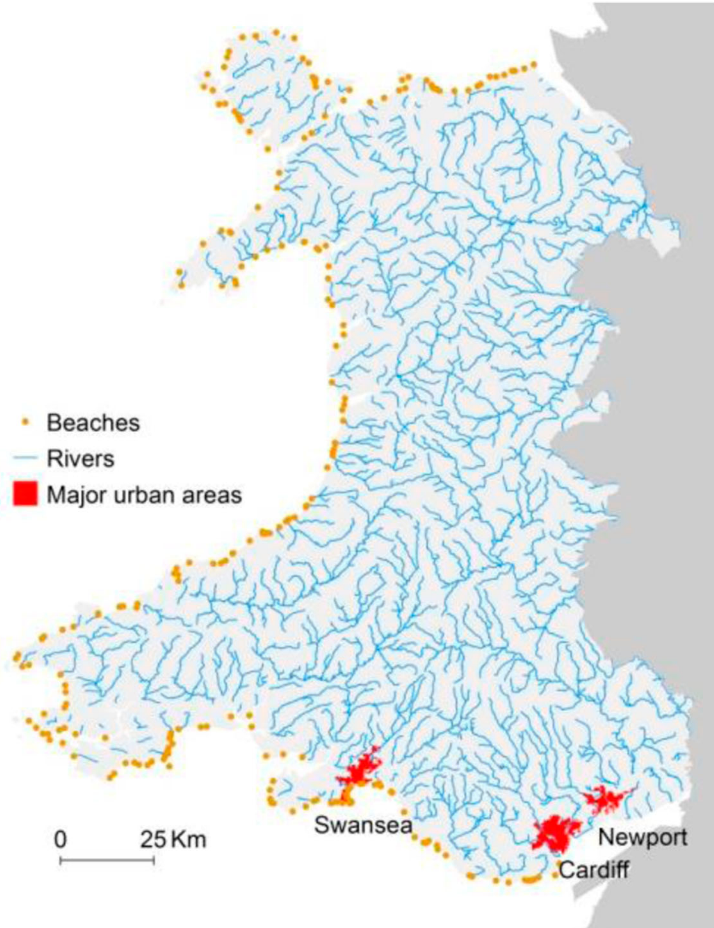

Figure 1. Wales: beaches, rivers, and major urban areas.

We estimated travel distance on the road network from the home location of all WORS participants to all beaches and rivers in the British Beaches and Water Framework Directive datasets. The home location was identified as the centroid of the postcode area stated by participants. We built a bespoke model of the Welsh road network from line data of Great Britain's road network, extracted from the Ordnance Survey Open Roads dataset. We assigned a travel speed of 110 km/h to motorways; 110 and 75 km/h to dual-carriageway roads in non-built-up and built-up areas, respectively; and 50 and 40 km/h to other roads in non-built-up and built-up areas, respectively. We then estimated the fastest routes from the home location of all WORS participants to all beaches and rivers, using ArcGIS 10.4 Network Analyst.

The travel cost of a return trip by car from homes to each beach and river was then calculated by multiplying the return trip distance by a unit cost. This unit cost is the sum of two components. The first component is the out-of-pocket cost, equal to £0.134/mile. This is the average of the petrol and diesel costs, as given by the Automobile Association in 2014 (https://www.theaa.com). The second component is the opportunity cost of the time spent travelling. This is the ratio between the value of non-work travel time as given by DFT (2015a), and 48 mph (the average speed on single carriageway roads outside urban areas, as given by DFT (2015b)). The value of non-work travel time depends on travel distance: £2.15 (<5 miles), £3.36 (5–20 miles), £5.97 (20–100 miles), or £9.08 (>100 miles).

3.3. Matching visits to sites

We then matched the locations of the beaches and rivers visited by the WORS participants and the locations of beaches and rivers in the British Beaches and Water Framework Directive datasets. The match did not include WORS participants who: (1) did not provide home location; (2) made no visits to beaches/rivers; (3) made visits to locations outside Wales; (4) did not provide location of the visit; or (5) made visits to beaches/rivers that were not the main site of the visit (and so were not asked in the survey about location of those beaches/rivers). 633 participants were retained in the beach visits dataset and 200 participants were retained in the river visits dataset.

We then identified the visited beaches and rivers of the retained participants as the nearest beach and river in the British Beaches and Water Framework Directive datasets. Visits where the nearest water body was a lake or canal, not a river, were excluded. We assumed that the sites that could be matched to a beach are indeed a beach and not sea or coastline features. Visits more than 800 m straight line distance from the nearest beach or river were excluded. 416 visits to beaches and 105 visits to rivers were matched.

4. Model specification

4.1. Overview

We used the model introduced by Bockstael, Hanemann, and Kling (1987) mentioned in the literature review. The model has two components. The site choice model explains the WORS participants' choice of which beach or river to visit as a function of the beach/river characteristics and the estimated travel cost. The participation model explains the number of visits over a month as a function of the participants' characteristics and the inclusive value derived from the site choice model. The inclusive value is an indicator of the maximum expected utility each individual can gain from the set of all available sites. The expectation is that an improvement in water quality at a site increases the utility of that site in the site choice model, which then increases, via the inclusive value, the number of visits predicted in the participation model.

4.2. Site choice model

We used a conditional logit specification for the site choice model (McFadden 1974). The utility U_{ij} for individual i visiting site j on a given occasion depends on the travel cost to the site (c_{ij}), the characteristics of the site (x_j), and a random error term (ε_{ij}) accounting for unobserved factors. The vectors δ and λ are parameters to be estimated.

$$U_{ij} = \delta c_{ij} + \lambda x_j + \varepsilon_{ij} \tag{1}$$

If the error terms are independently and identically distributed with a Type I Extreme Value distribution, the probability P_{ij} that individual i chooses site j, given all available sites l, can be expressed as in Equation (2) below (McFadden 1978). The parameters δ and λ can be estimated by maximum likelihood.

$$P_{ij} = \exp(\delta c_{ij} + \lambda x_j) / \sum_l \exp(\delta c_{il} + \lambda x_l) \tag{2}$$

The inclusive value V_i of individual i is given by the natural logarithm of the denominator of Equation (2):

$$V_i = \ln\left(\sum_l \exp(\delta c_{il} + \lambda x_l)\right) \tag{3}$$

The beach and river choice models included 1881 and 1727 WORS participants respectively, i.e. participants who provided home location and who made at least one visit to a beach/river in Wales during the last month. Participants with missing location for the visit were included, because they attach utility to the visits and so their inclusive value can be calculated. The models were estimated in an expanded dataset containing multiple records per participant, i.e. one record for each beach/river, plus a record for sites with no location information or not matched to a site in the beaches or rivers datasets, and a record for sites not visited as the main site of the trip. These two records are identified in the model by dummy variables.

The dependent variable of the model is a dummy variable equal to 1 if the beach/river was visited and 0 otherwise. The explanatory variables of the beach choice model were the return trip travel cost to the beach; dummy variables for beach water quality; and the number of different facilities, beach features, types of sea life, and activities available in the site. The explanatory variables of the river choice model were the return trip travel cost; dummy variables for river water quality; and dummy variables for other river characteristics (flow, highly modified water body status, and proportions of the areas within 200 m of the river that are green and urban). Both models were weighted using the WORS visit weight.

4.3. Participation model

We used a negative binomial specification for the participation model, following Hynes, O'Reilly, and Corless (2015) and Breen, Curtis, and Hynes (2018). This specification accounts for the high proportion of individuals who made zero visits and for unobserved heterogeneity, i.e. differences across individuals that are not captured by the explanatory variables. Alternative specifications could be quasi-poisson, generalised poisson, and zero-inflated models.

Equation (4) gives the distribution of the number of visits T_i made by individual i over a month. Equation (5) gives the conditional mean ($\mu_i\eta_i$) of the number of visits, which depends on the characteristics of the individual (r_i), the inclusive value for that individual (V_i), and a random error term ε_i accounting for unobserved factors uncorrelated with the characteristics of the individual. The vectors θ and ξ are parameters to be estimated.

$$f(T_i|r_{i,}\eta_i) = (\exp(-\mu_i\eta_i)*(\mu_i\eta_i)^{Ti})/T_i! \tag{4}$$

$$E(T_i|r_{i,}\eta_i) = \mu_i\eta_i = \exp(\theta r_i + \xi V_{i+}\varepsilon_i), \quad \text{where} \ \ \eta_{i=} \exp(\varepsilon_i) \tag{5}$$

If η_i follows a gamma distribution with $E(\eta_i) = 1$ and $\mathrm{Var}(\eta_i) = 1/z_i$, the conditional variance of the number of visits is:

$$\mathrm{Var}(T_i|r_i) = \mu_i(1 + \mu_i/z_i) \tag{6}$$

If $z_i = z = 1/\sigma$ for all individuals and $\sigma > 0$, Equation (6) can be rewritten as

$$\mathrm{Var}(T_i|r_i) = \mu_i(1 + \mu_i/z) = \mu_i(1 + \sigma\mu_i) \tag{7}$$

Since μ_i and z are positive, the conditional variance is greater than the conditional mean. σ is an indicator of dispersion, as higher values for σ result in a higher conditional variance.

The model includes all 5995 WORS participants, as the model estimates the influence of demographic variables on the number of visits, even when participants are missing an inclusive value.

The model consists of a pair of equations predicting two outcomes: the probability that the individual made zero visits to a beach/river in the last month, and the number of visits made during that month. The explanatory variables are the inclusive value derived from the beach/river choice model, a dummy variable for participants with no inclusive value because they were not included in the beach/river choice model, and dummy variables for the characteristics of the participant. The model was weighted using the WORS participant weight. Variables not significant at the 10% level were excluded from the final model. However, the inclusive value was always kept in the model.

4.4. Value

The per-visit value for existing visits for changes in water quality in an unspecified beach/river was estimated from the site choice model as the ratio of the coefficient of the variables representing those characteristics and the coefficient of travel cost. Confidence intervals were calculated using the Krinsky Robb parametric bootstrap method (Krinsky and Robb 1986).

We then used the site choice model to estimate the inclusive value, which was entered in the participation model to estimate the total number of trips to all beaches/rivers. This was done for the current situation and for hypothetical scenarios of improvements of water quality or other characteristics in each of the beaches/rivers separately. The number of visits was then aggregated for the population using the WORS participant weight.

In each scenario, the benefit B_i^J for individual i of improving beach/river j was estimated as the product of the predicted number of visits T_i^J and the inclusive value V_i^J after the improvement, subtracted by the same product before the improvement ($T_i\ V_i$), and divided by the cost coefficient of the site choice model (δ).

$$B_i^J = (T_i^J V_i^J - T_i V_i)/\delta \tag{8}$$

We then calculated the following three outcomes of separate improvements in each beach/river, where n is the number of beaches/rivers:

- Average % change in the number of visits to the improved beach/river: $100 * \sum_J \left(\sum_i T_{i,j}^J / \sum_i T_{i,j} - 1 \right) / n$
- Average value for existing and new visits, as a ratio of the existing number of visits: $\sum_J \left(\sum_i B_i^J / \sum_i T_i \right) / n$
- Average value per month for existing and new visits: $\sum_{i,J} B_i^J / n$

5. Descriptive statistics

Table 1 shows descriptive statistics of the explanatory variables in the two site choice models, for all 225 beaches and 737 rivers, and for visits to beaches and rivers made by WORS participants.

Water quality was not measured in 56% of the beaches. 36% of the beaches have excellent water quality, 5% have good quality and 2% have sufficient or poor water quality. On average, beaches have almost half (2.67) of the six possible types of facilities, but a small number of beach features, types of sea life, and activities, compared with the maximum possible number. On average, the set of visited beaches have smaller travel costs, better water quality, and more facilities, beach features, and activities than the set of all beaches, which suggests that these factors influence the choice of beaches.

39% of the rivers in Wales have good or high water quality, 53% have moderate quality, and 8% have poor quality. 3% failed the water flow assessment and 13% were classified as heavily modified water bodies. The two indicators of land use around the river have a small mean but a high standard deviation as a proportion of the mean. The set of visited rivers have smaller travel costs; higher proportion of rivers that have moderate water quality and are highly modified; and higher proportions of green and urban areas with 200 m of the rivers.

Table 2 shows descriptive statistics of the explanatory variables of the two participation models. The age groups in the sample are similar to those in the Welsh adult population. The other demographic characteristics of the sample are also consistent with those of the population: the majority live in urban areas, have medium qualifications, and has access to a car/van.

6. Site choice models

Table 3 shows the estimated site choice models. As expected, participants prefer to visit beaches with excellent water quality, following by those with good water quality, and those with sufficient

Table 1. Site choice models: explanatory variables.

	All beaches		Visited beaches		All rivers		Visited rivers	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Travel cost (return trip)	£59.1	£37.4	£7.7	£14.6	£50.8	£31.2	£2.3	£5.3
Water quality (beaches)								
Excellent	0.36	–	0.51	–				
Good	0.05	–	0.07	–				
Sufficient or poor	0.02	–	0.01	–				
Not measured	0.56	–	0.41	–				
Other beach characteristics								
Number of facilities (max:6)	2.67	1.63	3.46	1.41				
Number of beach features (max: 25)	1.02	1.19	1.32	1.35				
Number of sea life (max: 4)	0.20	0.63	0.12	0.50				
Number of activities (max: 24)	4.25	1.95	4.83	1.94				
Water quality (rivers)								
Good or High					0.39	–	0.21	–
Moderate					0.53	–	0.74	–
Poor or Bad					0.08	–	0.06	–
Other river characteristics								
Flow: fail					0.03	–	0.04	–
Highly modified water body					0.13	–	0.48	–
Proportion of green area within 200 m of river					0.01	0.05	0.08	0.09
Proportion of urban area within 200 m of river					0.03	0.11	0.31	0.31
Number of observations	225 beaches		416 visits		737 river stretches		105 visits	

Notes: (1) The same beach/river was included more than once in the calculation of statistics of visits, if the beach/river was visited by more than one participant. (2) The means of the water quality, flow, and 'highly modified water body' dummy variables can be understood as proportions of the sample.

or poor water quality. Participants also prefer visiting beaches with lower travel costs and with more facilities, beach features, types of sea life, and activities.

Participants prefer to visit rivers with moderate/good/high water quality than those with bad/poor quality. They also prefer visiting rivers that have satisfactory water flow, are highly modified water bodies, and are surrounded by a higher proportion of green or urban areas.

We calculated the inclusive value for each individual, using the model coefficients and the characteristics of all beaches and rivers, and travel costs to access them. We then interpolated these values to obtain a surface covering Wales (Figure 2). As expected, in the case of beaches, coastal areas have higher inclusive values and areas inland have lower values. The highest values are in the southwest coast. In the case of rivers, there are no clear patterns in the distribution of inclusive values, as rivers are dispersed throughout the country. However, there is a cluster of high inclusive values in the southeast, around Cardiff (the largest city of Wales). This might be explained by better accessibility by road to all rivers in the country and to the higher proportion of urban areas surrounding the rivers, rather than by differences in local river water quality.

7. Participation models

Table 4 shows the estimated participation models. As expected, individuals with higher inclusive value make more trips to beaches. Individuals who live in rural areas, have high qualifications, care for a relative/friend, and own a dog, also make more trips. Individuals with lower inclusive value, who are aged 16–24 or above 75, live on the fringes of towns or in rural areas, have low qualifications, have a disability, do not care for a relative/friend, and do not have access to a car/van have a higher probability of making no trips to a beach over a month. The dispersion parameter is significant, which shows that the dependent variable is overdispersed and is better modelled using a negative binomial model than a Poisson model.

As expected, people with higher inclusive value make more trips to rivers. However, the inclusive value was not significant at the 10% level. Individuals who live in rural areas, are not in full-time

Table 2. Participation models: explanatory variables.

	Frequency (population)	Frequency (sample)	Beaches Mean	Beaches Standard Deviation	Rivers Mean	Rivers Standard Deviation
Number of visits			4.230	10.670	4.860	11.949
Number of visits = 0			0.702	–	0.687	–
Inclusive value						
Value			5.099	0.126	5.237	0.031
Value = missing			0.033	–	0.033	–
Participant characteristics						
Age: 16–24	0.149	0.150				
Age: 25–44	0.302	0.300				
Age: 45–64	0.325	0.330				
Age: 65–74	0.120	0.120				
Age: >75	0.104	0.100				
Type of area: urban	0.672	0.600				
Type of area: town fringe	0.158	0.200				
Type of area: rural	0.328	0.196				
Qualifications: high	0.245	0.273				
Qualifications: medium	0.496	0.591				
Qualifications: low	0.259	0.136				
Full-time work	0.420	0.398				
Illness or disability limiting activities	0.227	0.214				
Cares for a relative/friend with illness/disability	0.121	0.202				
Has access to a car/van	0.771	0.836				
Owns/cares for a dog	0.291	0.360				
High environmental concern	–	0.188				

Notes: Number of observations = 5995. Population data source: Census 2001, except 'owns/cares for a dog': National Survey Wales 2014/2015. Rural: village, hamlet, isolated dwelling. Low qualifications: never went to school; not finished school; or no qualifications. High qualifications: higher education/professional or vocational equivalent, or higher. High environmental concern: answer 5 (in a scale 1–5) to question about concern for changes to biodiversity in Wales. Age group sample proportions not significantly different from population proportions, at 1% level.

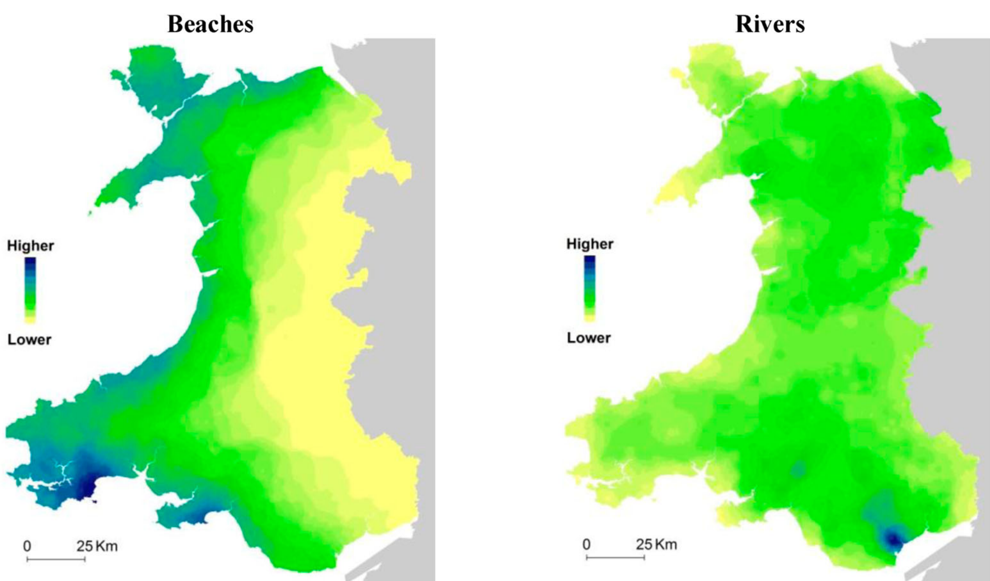

Figure 2. Inclusive values

Note: The scale of the inclusive values is not meaningful.

Table 3. Site choice models:results.

Variable	Beaches			Rivers		
	Coefficient	Standard error	*p* value	Coefficient	Standard error	*p* value
Travel cost	−0.158	0.001	<0.001****	−0.501	0.005	<0.001****
Water quality (beaches)						
Excellent	0.519	0.014	<0.001****	–	–	–
Good	0.112	0.025	<0.001****	–	–	–
Sufficient or Poor	0.078	0.062	0.206	–	–	–
Other beach characteristics						
Number of facilities	0.249	0.005	<0.001****	–	–	–
Number of beach features	0.046	0.005	<0.001****	–	–	–
Number of sea life	0.044	0.013	<0.001****	–	–	–
Number of activities	0.041	0.003	<0.001****	–	–	–
Water quality (rivers)						
Bad or Poor	–	–	–	−−0.495	0.050	<0.001****
Other river characteristics						
Flow: fail	–	–	–	−−0.851	0.566	<0.001****
Highly modified water body	–	–	–	0.740	0.026	<0.001****
Proportion of area within 200 m of the river that is green	–	–	–	2.391	0.128	<0.001****
Proportion of area within 200 m of the river that is urban	–	–	–	1.614	0.046	<0.001****
Sites with missing location						
Sites with no location or not matched	3.883	0.020	<0.001****	3.405	0.024	<0.001****
Sites not visited as the main site in trip	4.509	0.020	<0.001****	5.309	0.023	<0.001****
Number of participants		1881			1727	
Number of observations		428,868			1,276,253	
Pseudo R^2		0.681			0.891	

Notes: Significance levels: ****0.1%. Omitted category (beaches): water quality not measured. Omitted categories (rivers): high, good, or moderate water quality; flow = pass; not highly modified water body.

Table 4. Participation models.

	Beaches			Rivers		
	Coefficient	Standard error	*p*-value	Coefficient	Standard error	*p*-value
Number of visits						
Inclusive value						
Value	0.815	0.289	0.005***	0.156	1.282	0.903
Missing inclusive value	4.237	1.507	0.005***	1.390	7.066	0.844
Participant characteristics						
Type of area: rural	0.170	0.087	0.050**	0.188	0.094	0.046**
Qualifications: high	0.167	0.076	0.030**			
Full-time work				−0.151	0.074	0.041**
Illness or disability limiting activities				−0.225	0.103	0.029**
Cares for a relative/friend with illness/ disability	0.140	0.084	0.098*			
Owns a dog	0.542	0.073	<0.001****	0.407	0.074	<0.001****
Constant	−1.990	1.491	0.182	1.668	7.070	0.814
Probability of zero visits						
Inclusive value						
Value	−6.377	0.417	<0.001****	−6.617	1.549	<0.001****
Missing inclusive value	−32.44	2.153	<0.001****	−36.36	8.524	<0.001****
Participant characteristics						
Age: 16–24	0.819	0.151	<0.001***			
Age: >75	0.471	0.192	0.014**	0.742	0.193	<0.001****
Type of area: town fringe	0.365	0.131	0.005***	−0.254	0.113	0.025**
Type of area: rural	0.264	0.128	0.038*			
Qualifications: low	0.491	0.163	0.003***	0.284	0.151	0.060*
Illness or disability limiting activities	0.367	0.129	0.005***	0.463	0.123	<0.001****
Cares for a relative/friend with illness/ disability	−0.228	0.120	0.058*			
Has access to car/van	−0.439	0.151	0.004***			
Owns a dog	–	–	–	−0.329	0.094	<0.001****
High environmental concern				−0.358	0.144	0.013**
Constant	33.40	2.133	<0.001****	37.14	8.53	<0.001****
Dispersion parameter	0.840	0.061	0.015**	0.906	0.063	0.057*
Number of observations		5995			5995	
Number of zero observations		4062			4180	

Notes: Significance levels: *10%, **5%, ***1%, ****0.1%. Omitted categories: age 25–74, urban areas, high or medium qualifications, not in full-time work, no limiting disability, is not a carer, does not have access to a car/van, does not own a dog, do not have high environmental concern.

work, do not have a disability, and who own a dog also make more trips. Individuals with lower inclusive value and those who are aged above 75, do not live in town fringes, have low qualifications, have a disability, do not own a dog, and did not state high environmental concern, have a higher probability of making no trips to a river over a month. The dispersion parameter is significant.

8. Value

Table 5 shows the value of changes in water quality and other beach characteristics for existing visits and its 95% confidence interval, the average impact on the number of visits, and the average value for all visits (existing and new). Improvements in water quality from good to excellent in a given beach have a value of £2.58 for existing visits and lead, on average, to a 52% increase in the number of visits to that beach. The average value for all visits (existing and new) is £3.24 (as a ratio of existing visits). This represents a total value of £199,164 per person per month, in 2014 prices. Improvements in beach water quality from sufficient/poor to good have a much smaller impact on number of visits (4%) and value (£0.23/existing visit and £4423/month in total). Improvements in water quality to excellent in beaches where the water quality is currently not measured leads to an increase

Table 5. Value and impact on visits of improvements in water quality and other beach characteristics.

Type of improvement	In an unspecified beach			Separate improvements in each beach		
Type of change	Value for existing visits			Average change in visits	Average value, for all visits (existing and new)	
Unit	Per existing visit (central value and 95% confidence interval)			%	Per existing visit	Per month
Water quality						
Good → Excellent	£2.58	(£2.43,	£2.72)	52%	£3.24	£199,164
Sufficient/Poor →Excellent	£2.80	(£2.20,	£3.39)	57%	£3.59	£69,156
Sufficient/Poor →Good	£0.22	(−£0.27,	£0.67)	4%	£0.23	£4423
Not measured →Excellent	£3.29	(£3.12,	£3.46)	69%	£4.43	£153,606
Not measured →Good	£0.71	(£0.40,	£1.03)	12%	£0.76	£26,172
Not measured →Sufficient	£0.50	(−£0.27,	£1.27)	8%	£0.52	£17,906
Other site characteristics						
1 extra facility	£1.58	(£1.52,	£1.64)	29%	£1.80	£84,588
1 extra beach feature	£0.29	(£0.23,	£0.35)	5%	£0.30	£13,890
1 extra activity	£0.26	(£0.22,	£0.30)	4%	£0.26	£12,359

Note: Values per person, in 2014 prices.

of 69% in number of visits and a value of £4.43/existing visit and £153,606/month in total. Improvements to good or sufficient have a much smaller impact and value.

Figure 3 shows the average value per month of separate improvements in each beach to achieve excellent water status, i.e. the values in the last column of Table 5. The map on the left shows the values in beaches where the water quality is currently measured, i.e. beaches where the water quality would improve from sufficient/poor or good to excellent. The map on the right shows the values in beaches where the water quality is not currently measured, i.e. beaches where the water quality would improve from unknown water quality to excellent. In both cases, the highest values are in the South coast, especially near Swansea (the second largest city in Wales), followed by the North coast. The values are smaller in the West coast, which is explained both because of the remoteness of this area (attracting fewer visits) and because many beaches in that area already have excellent water quality.

Table 6 shows the value of changes in water quality and other river characteristics for existing visits and its 95% confidence interval, the average impact on the number of visits, and the average value for all visits (existing and new). Improvements in water quality to moderate/good/high in a given river stretch have a value of £0.99 for existing visits and lead, on average, to a 64% increase in the number of visits to that river stretch. The average value for all visits (existing and new) is £1.31 (as a ratio of existing visits). This represents a total value of £15,671 per person per month in 2014 prices.

Figure 4 shows the shows the average value per month of separate improvements in each river stretch to achieve water status above bad/poor, i.e. the values in the last column of Table 6. The values are higher in the southeast part of the country.

9. Discussion

The methods used in this paper rely on some assumptions and have some caveats, which we discuss in this section.

Our indicators of the number of visits are imperfect, because participants who visited a beach/river in the last outdoor trip did not necessarily visit a beach/river in all outdoor trips made in the last month. On the other hand, participants who did not visit a beach/river in the last trip may have visited one in a previous trip. The assumption is that our indicators balance these conflicting factors and produce a reasonable approximation of the true number of visits. It should also be noted that visits were made in 2014–15 and water quality was measured in 2017. Water quality in some beaches and rivers could have changed between 2014–15 and 2017.

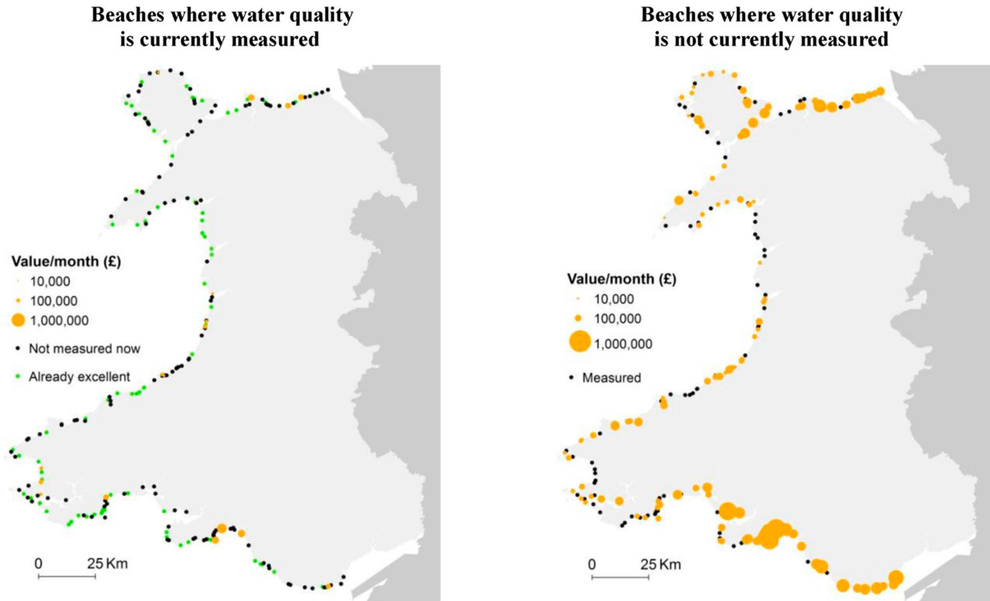

Figure 3. Value of improvements to excellent beach water quality (£/month)
Note: Values per person, in 2014 prices.

Many visits could not be matched to known beaches and rivers in Wales, and so they could not be analysed in relation to site characteristics. This can be explained by poor accuracy of the locations of some visits (which was indicated by WORS participants and then geo-coded). Participants may also have wrongly classified a site as a beach (for example when the location stated is inland) or meant to identify a sea or coastline feature, rather than a beach (as those two types of features were provided together with beaches in the same possible answer, in the WORS questionnaire). The existence of unmatched visits is a limitation, as information about the preferences of individuals with unmatched visits is lost - the remainining individuals may not be representative of the population. However, the estimated models were robust enough to provide information on the variables significantly affecting site choice, and on the association between the utility derived from the choice set of all beaches/rivers and the number of visits made. In addition, as shown in Table A2 in Appendix, there are no major differences between the characteristics of participants with matched and unmatched locations. As such, we are confident that the models are representative of the behaviour of Welsh residents who visited beaches and rivers.

Table 6. Value and impact on visits of improvements in water quality and other beach characteristics.

Type of improvement	In an unspecified river			Separate improvements in each river		
Type of change	Value for existing visits			Average change in visits	Average value, for existing and new visits	
Unit	Per existing visit (central and confidence interval)			%	Per existing visit	Per month
Water quality						
Bad/Poor → Moderate/Good/High	£0.99	(£0.79,	£0.99)	64%	£1.31	£15,671
Other site characteristics						
Flow: Fail → Pass	£1.70	(£1.47,	£1.92)	135%	£2.84	£65,451
+1% green within 200 m	£0.048	(£0.043,	£0.053)	5%	£0.49	£8044

Note: Values per person, in 2014 prices.

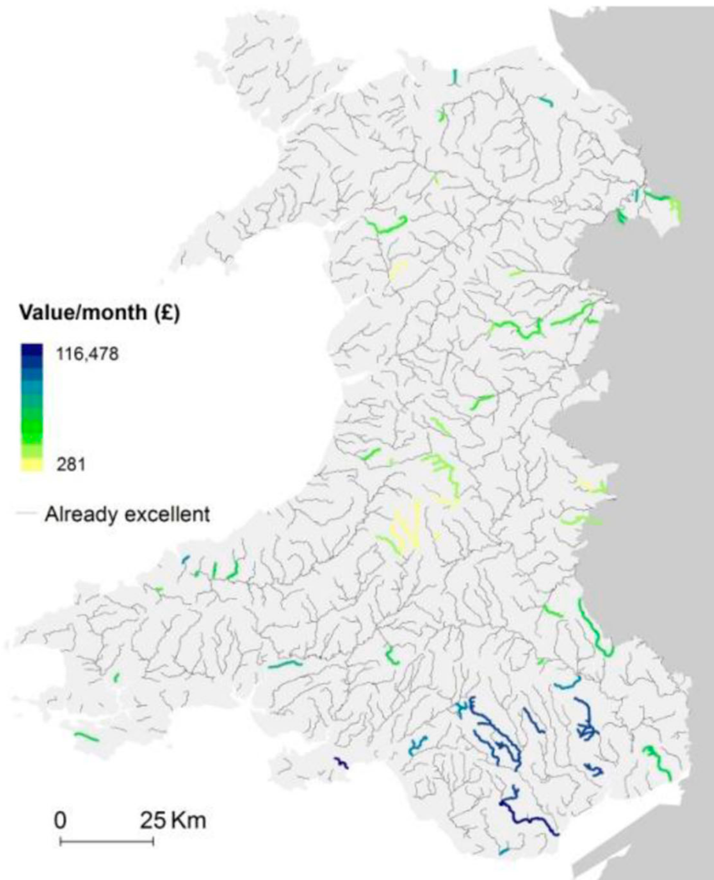

Figure 4. Value of improvements to rivers (£/month)
Note: Values per person, in 2014 prices.

We also made assumptions regarding cut-off distances in the spatial analyses. The cut-off distance to identify matched beaches and rivers was 800 m. Using a shorter distance (400 m) would imply dropping 44% of the visits to beaches and 19% of the visits to rivers. Using a longer distance (1000 m) would only lead to an increase of 7% and 13% of visits to beaches and rivers, respectively. In the calculation of the variables measuring the area around rivers, we used a distance of 200 m. Variables based on other distances (100 and 400 m) were insignificant in the river choice model.

The calculation of travel costs was also supported by assumptions. We considered that trips to beaches and rivers are made by car. As such, the estimated travel costs do not reflect the travel costs of individuals who use other modes (e.g. public transport, cycling), which are associated both with longer travel times and with different costs per mile travelled. In addition, we assigned values of travel time savings to trips based only on distance, from a study by the UK Department for Transport (DfT 2015a). However, values of travel time savings also depend on income and travel mode. The assumed trip purpose (non-work) also comprises types of trips, other than recreation. In addition, the value was derived from a study focusing on England, but Wales has different geographic, demographic, and economic conditions.

Due to the lack of data, the models did not include variables on hard-to-measure aspects that might explain site choice, for example the aesthetic appeal of the sites, seclusion, and remoteness. However, there is no reason to believe that these aspects are correlated with water quality, and so we are confident that the influence of water quality on site choice is not due to confounding factors.

The WORS data also had no survey date, which could be used to account for the effect of seasonality in the number of visits to beaches and rivers. Furthermore, we had no information on the real number of visits to each beach/river, preventing the calibration of the model predictions.

The model specification assumed that survey participants are aware of the characteristics of all beaches/rivers and that site choice is not influenced by habit or by previous experiences. In other words, there is no relationship between the choices of the same individuals on different occasions. The use of a conditional logit specification for the site choice model also assumed that all individuals have the same preferences and that the choice between two options is not affected by the introduction or removal of other options. It was computationally infeasible to estimate a model that relaxes this assumption (e.g. a mixed logit model). Nevertheless, the estimated models were in line with prior expectations, i.e. individuals prefer sites that have better water quality and are cheaper to access, and make more trips when the utility of the available sites is higher.

Finally, revealed preference methods have limitations. The values may be underestimated because the method does not capture non-use value (e.g. the value of the site beyond its use for recreation). The method is also sensitive to correlations between attributes, in contrast with stated preference methods, which can reduce this correlation by producing experimental designs with combinations of attribute levels. The conjunction of revealed preference and stated preference methods could confirm the results obtained in this paper.

10. Conclusions

This paper estimated the value of potential improvements in water quality in beaches and rivers in Wales, considering both existing and new visits. We used data on visits reported in the Welsh Outdoor Recreation Survey, adapting an existing revealed preference method that accounts for the value accrued to existing visits and generated by new trips. We added to the literature by: (1) valuing both beach and river water quality, for all recreational uses, and (2) estimating values at the national level, aggregated for the whole population of Wales, and mapped to show the areas where potential benefits of improving water quality are higher.

We found that improving water quality of a beach from good to excellent has a value of £2.58/visit for existing visits and leads to an average increase in 52% in the number of visits to that beach, resulting in an overall value of £199,164 per month per person, in 2014 prices. The highest values are in the beaches near Swansea in the south coast. Improving water quality of a beach from sufficient/poor to good has a much smaller value and impact on number of visits. Improving water quality of a river stretch to above bad/poor has a value of £0.99/visit for existing visits and leads to an increase in 64% in the number of visits to that river stretch, resulting in an overall value of £15,671 per month. The highest values and in the south east part of Wales.

The paper also identified the parts of the country that are currently better served in terms of better (i.e. cheaper) access to beaches and rivers with better water quality. This is shown in the maps of the inclusive values that were derived from the site choice models, as those values are indicators of the utility that an individual living in a given location can derive from the set of all beaches/rivers in the country, taking into account both the quality of those beaches/rivers and travel costs to acess them. We found that the southwest part of the country has the best access to beaches with better quality but the southeast part (around Cardiff) has the best access to rivers with better quality.

Notwithstanding the caveats discussed in the previous section, the study produced estimates based on real-world behaviour and so it can be useful for planning and management purposes. For example, the results can be integrated in decision-supporting tools that allow users to specify bespoke scenarios with respect to changes in water quality for a specific beach or river and predict the change in the number of visits to that beach or river and the value for existing and new visits.

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Appendices

Table A1. Beach characteristics.

Facilities	Campsite; food; litter bins; shops; slipway; toilets
Beach features	Amusements; boat trips; bowling; children's rides; country park; crazy golf; dunes; funfair; gardens; golf; information centre; leisure centre; lighthouse; museum; nature reserve; nature trails; pier; promenade; Royal Society for the Protection of Birds reserve; rock pools; sea-life centre; sports centre; tourist information; visitor centre; yacht club
Sea life	Dolphins; otters; porpoises; seals
Activities	Bird watching; boating; canoeing; climbing; cycling; donkey rides; fishing; fossil hunting; horse riding; jet-skiing; kayaking; power boating; rock pooling; sailing; scuba diving; snorkelling; sunbathing; surfing; swimming; walking; waterskiing; water sports; windsurfing; yachting

Table A2. Characteristics of WORS participants: matched vs. unmatched visits (%).

	Participants with matched visits		Participants with unmatched visits	
	Beaches	Rivers	Beaches	Rivers
Age				
16–24	12.5	16.0	8.0	9.8
25–44	36.7	36.2	30.6	33.6
45–64	33.6	32.6	40.3	37.3

(*Continued*)

Table A2. Continued.

	Participants with matched visits		Participants with unmatched visits	
	Beaches	Rivers	Beaches	Rivers
65–74	10.5	12.9	12.5	12.0
>75	6.7	2.3	8.7	7.4
Type of area				
Urban	59.0	68.4	66.6	60.7
Town fringe	23.3	21.1	16.3	19.1
Rural	17.0	10.2	16.6	19.7
Qualifications				
High qualifications	31.2	19.8	35.1	33.1
Medium qualifications	61.9	70.6	55.0	57.8
Low qualifications	6.9	9.5	9.9	9.1
Other				
In full-time work	46.4	37.6	40.8	45.4
Illness or disability limiting activities	14.8	16.0	23.1	17.1
Carer	23.1	28.9	28.6	22.6
Have access to a car/van	88.4	89.2	88.7	89.6
Owns/care for a dog	40.1	59.0	37.2	37.0
High environmental concern	24.6	8.5	20.5	19.5