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Impacts of changes in water quality on recreation behavior and benefits in Finland

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ABSTRACT

The implementation of the European Union Water Framework Directive (WFD) requires nationally generalizable estimates of the benefits of protecting inland and coastal waters. As an alternative to benefit transfers and meta-analyses, we utilize national recreation inventory data combined with water quality data to model recreation participation and estimate the benefits of water quality improvements. Using hurdle models, we analyze the association of water clarity in individuals' home municipalities with the three most common water recreation activities – swimming, fishing and boating. The results show no effect on boating, but improved water clarity would increase the frequency of close-to-home swimming and fishing, as well as the number of fishers. Furthermore, to value the potential benefits of the WFD, we estimate the consumer surplus of a water recreation day using a travel cost approach. A water policy scenario with a 1-m improvement in water clarity for both inland and coastal waters indicates that the consumer surplus would increase 6% for swimmers and 15% for fishers. In contrast to previously estimated abatement costs to improve water quality, net benefits could turn out to be positive. Our study is a promising example of applying existing national recreation inventory data to estimate the benefits of water quality improvements for the purposes of the WFD.

1. Introduction

The EU Water Framework Directive (WFD), adopted by the European Commission (2000), aims to harmonize water protection in the EU countries. Its goal is to ensure that all aquatic ecosystems achieve 'good ecological status' by 2015. However, the objectives set out in the Directive are not intended to be met for every water body at any cost: the implementation should avoid costs that are disproportionate to the achievable benefits. The need to find a balance between costs and benefits has created demand for both benefit and cost studies connected with the WFD in several European countries (Bateman et al., 2006; Hanley et al., 2006).

As inexpensive approaches, meta-analysis and benefit transfer have been appealing methods to generate value estimates for planning national environmental policies (Hanley et al., 2006). However, one problem associated with the use of single-site studies in benefit transfer is the uniqueness of the valuation situations; it is often "interesting hot-spot areas" that are chosen for analysis (Hoehn, 2006). Lindhjem and Navrud (2008) have shown that using benefit transfer studies from another country, even a culturally similar one, increases transfer error considerably. We suggest an alternative approach that draws on national recreation inventory data to produce nationwide valuation information. Especially in countries with few transferable studies, existing recreational inventory data (Dehez et al., 2008; Cordell et al., 2005) combined with water quality data may provide an accessible and reliable basis for producing nationally consistent benefit estimates. Particularly in water-rich countries, such as the Nordic countries and the US, recreation is considered one of the most important reasons for conserving water bodies (Söderqvist, 1998) and is estimated to account for over 60% of the total benefits from water protection (Rodgers et al., 1990). We illustrate the usability of inventory data for the valuation of recreational benefits from water protection in Finland, the country often called "the land of a thousand lakes".

Water quality improvements have been valued using the travel cost method on the Swedish coast, which has water conditions similar to those in Finland.[1] (Sandström, 1996; Soutukorva, 2005). In these studies, carried out before the implementation of the WFD,

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[1] More recent Nordic stated preference studies with WFD-relevance include Eggert and Olsson (2009) and Laitila and Paulrud (2008).

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water quality was valued as an attribute affecting an individual's choice of destination site or region, as is often done in the analysis of water recreation demand (e.g. Parsons et al., 2003; Egan et al., 2009). However, an abundance of water recreation opportunities has an effect on the applicability of various types of recreation demand models. When modeling water recreation demand in a water-rich country like Finland, the focus should be on understanding the conditions enabling everyday, close-to-home water activities – ones forming a significant proportion of recreation – rather than the choice of remote sites. Site choice approaches are limited when the aim is to evaluate the effects of a water policy affecting citizens' everyday living environment on a national scale. National-level policies require a wider focus than the demand for water quality at a single lake or in particular small regions, and it is on the national scale that EU-wide policies such as the WFD seek to improve water quality. Assessing the impacts of policy on the national level makes it particularly important to link water quality to general recreation behavior (Ribaudo and Piper, 1991). Site-based approaches would be difficult in this kind of setting since the WFD is intended to affect many lakes in various regions simultaneously. In contrast, national recreation inventory data can provide a solution to evaluate the effects of policy, as the data encompass participation in activities, frequency of participation, and information on the respondents' home municipality. To the best of our knowledge, there has been only one study to date that has analyzed water recreation in relation to close-to-home water quality (Ribaudo and Piper, 1991).

This study illustrates the use of national outdoor recreation inventory data in assessing the welfare effects of water quality change. Improvements in water quality and thus the everyday living environment, may affect water recreation behavior in two ways: Non-users are more likely to become recreational users, and current users to increase the number of days spent on a particular activity. For some individuals the decision on the number of use days is irrelevant due to personal preferences or a lack of suitable water areas or other resources.

The first objective is to analyze the association between recreation participation for three water activities – swimming, fishing and boating – and water quality, using water clarity as the indicator. Secondly, we estimate the consumer surplus of a water recreation day and the marginal social net benefits of an exogenous improvement in water quality. To illustrate the usability of this benefit assessment, we then take the analysis a step further and compare the benefits to the associated costs.

Our approach in modeling participation econometrically is to use hurdle models, which are further used to estimate the change in the number recreation days associated with water quality change. The value of a recreation day is estimated using the travel cost method. The current information on the costs of water quality improvements is expressed in physical measures, such as the abatement of nutrient emissions, whereas benefits are gauged in terms of easily perceived quality indicators, such as water clarity. Finally, we illustrate the linkage between physical measures, water clarity and the monetary costs and benefits.

2. Water resources, recreation participation and water quality indicators

Finland, with a population of about five million, has one lake for every 26 people. There are 187,888 lakes larger than 500 square meters, and water areas cover about 10% of the country. The Baltic Sea and its extensive archipelago are also actively used for water recreation. The Finnish national outdoor recreation demand and supply inventory confirms the importance of water resources in outdoor recreation. Over two-thirds of the population swim in natural waters every year, swimming being the second most popular outdoor recreation activity after walking. Participation rates in fishing and boating are slightly above and below 50%, respectively (Pouta and Sievänen, 2001). Given the Finnish climate, with only four summer months on average, such a level of water recreation activity is almost surprising.

The main water recreation activities in Finland are swimming, fishing and boating. The water quality in a citizen's home municipality is particularly important for these activities, as the majority of one-day or shorter visits (68% for boating, 79% for fishing, 86% for swimming) take place close to home (Pouta and Sievänen, 2001). The natural resources for these activities are readily available, as the median distance from an individual's home to the nearest area suitable for swimming, fishing, or boating is only 2 km.

In the setting described, it is appealing to focus on the question how the availability and quality of recreation resources in individuals' living environment affect their participation in recreation activities. The environmental quality of a person's home region and its effect on his or her recreation behavior has been the subject of a number of recreation demand studies (Ribaudo and Piper, 1991; Boxall and McFarlane, 1995; Neuvonen et al., 2007). High provision of recreational opportunities in people's living environment has generally been found to promote active living that includes participation in recreation (Henderson and Bialeschki, 2005). The environmental quality of the recreational setting is positively associated with the level of recreational activity and the health of community members (Kaczynski and Henderson, 2007).

The water environment is part of a high-quality environment that increases physical activity and enhances human health (Bauman et al., 1999; Giles-Corti and Donovan, 2002; Humpel et al., 2004). Nearby water areas and their quality have been found to be a significant factor in hedonic property price studies (e.g. Leggett and Bockstael, 2000; Michael et al., 2000; Tyrväinen, 1997) and in landscape preference studies (e.g. Dramstad et al., 2006). However, the approaches used in this research did not focus on how water quality affects recreation on a general scale. To the 'authors' knowledge, the only study analyzing the correlation between water quality and participation in water recreation in an individual's home region is that conducted by Ribaudo and Piper (1991), which focused on fishing.

There are several types of substitution effects in the case of water recreation participation (e.g. Freeman, 1995; Hanley et al., 2003). Participation is naturally dependent on close-to-home resources. However, more distant water resources can provide a substitute; the typical Finnish substitute is a summer cottage owned by the household. Other activities are likely substitutes when the resources for those activities, such as recreation areas, forests and nature conservation areas, moderate participation in water-related activities. In the Finnish case, the high proportion of forested land and 'everyman's right – free public access to the land and waterways – provide abundant substitutes for other activities.

To analyze the effect of water quality improvement on recreation behavior, it is important to select a water quality indicator that is meaningful for both active and potential recreationists. The WFD states that water bodies are to be of good ecological status, a description that covers indicators such as fish, water plants, zoobenthos and plankton species. In the WFD current ecological status is compared to natural status, yet ecological status may not be a quality indicator easily observable by the public that would have an effect on recreation behavior. Site selection studies have used a multitude of water quality variables, from the amount of suspended solids (e.g. Egan et al., 2009; Parsons et al., 2003) and harmful bacteria in water (Parsons et al., 2003) to subjective measures of water quality (Whitehead et al., 2000; Whitehead, 2005). Both objective and subjective measures of water quality

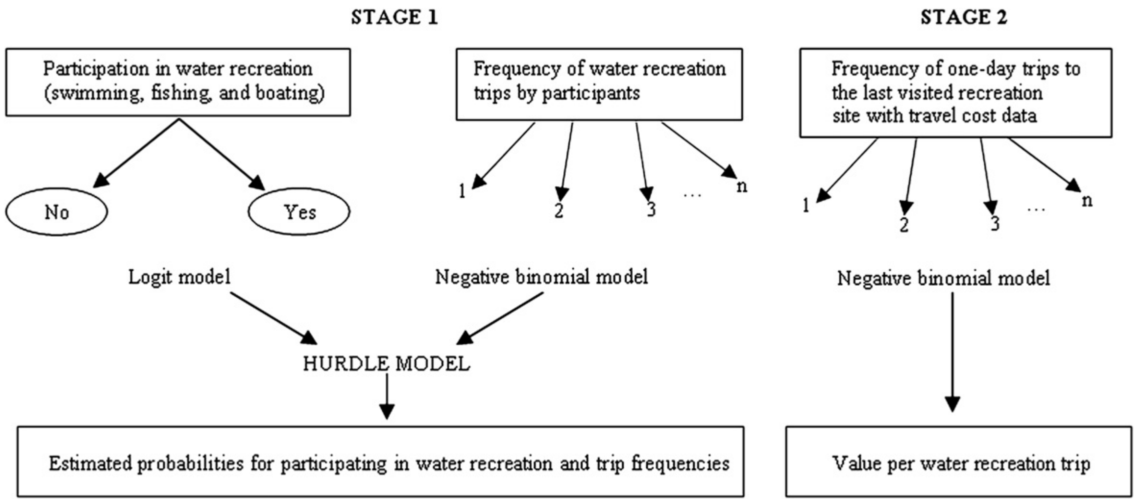

Fig. 1. Stages of water recreation behavior and benefit estimation.

have been proven feasible in explaining stated and behavioral choices (Adamowicz et al., 1997; Poor et al., 2001). As argued by Sandström (1996) and Soutukorva (2005), among others, water clarity is an easily observed indicator of quality for users and is correlated with nutrient levels and thus eutrophication. Since we are interested in the most voluminous water recreation activities – swimming, fishing and boating – we use water clarity as an indicator to capture the effect of water quality on recreation activities. While swimmers and boaters should find water clarity a good indicator of water quality, fishers, who are mainly interested in the catch rate, may not be sensitive to water clarity as such. Some sought-after species dwell in murky but otherwise clean waters and thus not all fishers will necessarily benefit from less eutrophic waters. However, since many of the nationally valued fish species in Finland, such as brown trout and vendace, require clear, high-quality waters, the use of water clarity as an indicator of water quality is defensible in the case of fishing as well. Then again, water clarity may not be the best quality indicator for humic inland lakes, which may have good ecological status despite relatively poor clarity. While the ecological status of lakes is likely to be closely linked to the quality perceived by recreationists, we still lack a conception of water quality that would be usable in valuation studies. Moreover, understanding the linkage between water quality as perceived by the public and measures affecting the physical attributes of water quality is crucial for policy making.[2] We will elaborate on this issue when discussing our data on water quality.

3. Methods

3.1. Participation models

We estimated benefits from water quality changes in two stages, as shown in Fig. 1. The first stage was to model water recreation participation and participation frequencies for each activity. The second stage was to estimate the value of one water recreation trip using the travel cost method.

In modeling water recreation behavior, we decompose water recreation participation into two components: the overall rate of participation within a time period and, for those who participate, the frequency of participation as measured by the number of recreation trips in that period. In order to participate, both environmental conditions, such as water quality, and personal conditions, for example, skills and equipment, have to be met. Thus there exists a basic investment, or threshold, swimming, fishing and boating participation. The overall decision to participate and the decision on participation frequency may be affected by different factors (compare Huhtala and Pouta, 2009). Previous studies of outdoor recreation have shown that gender, age, social status, income and education are the variables having the most explanatory power as regards differences in recreation behavior. These variables may affect participation rate and frequency of participation separately or jointly.

Changes in participation rate and frequency can be seen to contribute to the overall welfare impact of a change in water quality. As the significance of both components contributing to the ultimate impact is an empirical question, we investigated the impact through participation and frequency models separately for each activity using a hurdle model. Hurdle models estimate simultaneously a logistic binary choice model for a participation decision and a count data model for the number of times an individual participates. The count data models assume a negative binomial distribution in order to correct for possible overdispersion, i.e., variance higher than the mean in the dependent variable.

Let us assume that participation in an activity is a binary process, with $s_i = 0$ indicating that respondent i does not participate and $s_i = 1$ representing participation. The two probabilities are

$$\Pr_{\text{Logit}}(s_i = 0) = (1+\mu_{1i})^{-1} = \frac{1}{1+\exp(\beta_0+\beta q+\boldsymbol{\theta}\mathbf{x})}$$

$$\Pr_{\text{Logit}}(s_i = 1) = 1 - \Pr_{\text{Logit}}(s_i = 0) = 1 - (1+\mu_{1i})^{-1} = \frac{\exp(\beta_0+\beta q+\boldsymbol{\theta}\mathbf{x})}{1+\exp(\beta_0+\beta q+\boldsymbol{\theta}\mathbf{x})}, \quad (1)$$

where $\mu_{1i} = \exp(\beta_0 + \beta q + \theta x)$ is the mean parameter for non-participation (Cameron and Trivedi, 1998). The probability of non-participation depends on the vector of individual characteristics, $\mathbf{x}$; their respective coefficients in vector $\boldsymbol{\theta}$; water quality, q, and its coefficient β; and the constant β_0.

Following Cameron and Trivedi (1998), the estimated negative binomial probability of individual i making j recreation trips is formally given by

[2] This is especially the case when water quality is low enough to be hazardous to recreationists. Lepesteur et al. (2008) study on recreational behavior and risk perception on the Australian coast shows that people may overestimate water quality, which signals a need to raise awareness of potential hazards.

$$\Pr_{\text{Negbin}}(s_i = j | j > 0) = \frac{\Gamma(s_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(s_i + 1)} \left(\frac{1}{(1 + \alpha\mu_{2i})^{\alpha^{-1}} - 1} \right)^{-\alpha^{-1}} \left(\frac{\mu_{2i}}{\mu_{2i} + \alpha^{-1}} \right)^{s_i}, \tag{2}$$

where $\mu_{2i} = \exp(\xi_0 + \eta q + \omega x)$[3] is the mean of non-zero recreation trips to be estimated, α is the dispersion parameter and Γ is the gamma function. The probability of making j trips is estimated in the hurdle model as

$$\Pr(s_i = j) = \left[\frac{1 - \Pr_{\text{Logit}}(s_i = 0)}{1 - \Pr_{\text{Negbin}}(s_i = 0)} \right] \Pr_{\text{Negbin}}(s_i = j | j > 0), \tag{3}$$

where the bracketed term on the right-hand side represents the correction for the possible misspecification of assuming that the same data generation process applies to non-participation, $j = 0$, for both potential and non-participants. Let us define the indicator function $1_S = 1$ when $s_i > 0$and $1_S = 0$ when $s_i = 0$. The joint likelihood LL_{Hurdle} is estimated by maximizing separately the log likelihoods of both equations LL_{Logit} and LL_{Negbin},

$$\begin{aligned} LL_{\text{Hurdle}} &= LL_{\text{Logit}} + LL_{\text{Negbin}} \\ LL_{\text{Logit}} &= \sum_{i=1}^{n} 1_S(s_i = 0) \ln[\Pr_{\text{Logit}}(s_i = 0)] + \sum_{i=1}^{n} 1_S(s_i = 1) \ln[1 - \Pr_{\text{Logit}}(s_i = 0)] \\ LL_{\text{Negbin}} &= \sum_{i=1}^{n} 1_S(s_i > 0) \ln\left[\Pr_{\text{Negbin}}(s_i = j | j > 0)\right]. \end{aligned} \tag{4}$$

3.2. Travel cost model

After modeling the participation with the hurdle model, the second stage (Fig. 1) was to estimate the value of a water recreation trip by applying the travel cost method. We constructed a travel cost model pooling all three recreational activities, which was then estimated using zero-truncated negative binomial regression, expressed in Eq. (2). Contrary to traditional travel cost models focusing on a specific site, we modeled the demand for recreation trips to a representative site (Creel and Loomis, 1990; Zawacki et al., 2000; Pouta and Ovaskainen, 2006), which is a combination of destinations defined by our sample rather than any single area. We estimated the annual frequency of one-day trips from home to the last-visited water recreation site. The data had information only for trips identical to the most recent trip, with the same primary and secondary activities. Accordingly, people whose primary and secondary activities on their most recent trip were boating and swimming, respectively, would indicate the number of trips including both boating and swimming to the same site in the past 12 months, but not trips with only swimming, boating or any other activity. The travel cost models used the same explanatory variables as the count data component of the hurdle models, as well as additional travel cost measures and indicators for the most important recreational activities during the trip. The travel cost model was used to estimate the benefit of one water recreation day. In the case of the negative binomial model, the consumer surplus per day is $CS = -1/\beta_P$, where β_P is the coefficient of the travel cost variable (e.g. Ovaskainen et al., 2001).

We use the participation models to illustrate the effects on near-home recreation of a hypothetical policy affecting water clarity. The two hypothetical policies chosen would produce a one-meter increase or a one-meter decrease in water clarity. The estimates from the participation models reveal that water clarity influences the probability of participation and trip frequency. Linking the estimated change in the aggregate number of trips with the value of a water recreation day from the travel cost model, we obtain the total change of recreation benefits in monetary terms.

4. Data

We combined two national scale databases for purposes of the analysis. The primary data source described national outdoor recreation demand over a three-year span; this was supplemented by a national database on surface water quality. The combined dataset and its components are presented in the following subsections.

4.1. Outdoor recreation inventory

Data on water recreation behavior were acquired from the survey for the Finnish national outdoor recreation demand and supply inventory, conducted between 1998 and 2000 (Virtanen et al., 2001). The survey was carried out in two phases through telephone interviews of and a mail-in questionnaire sent to a random sample of Finns aged 15–74. We extracted data for the three most voluminous water recreation activities: swimming, fishing, and boating. In addition to participation, respondents reported the annual frequency of recreational trips[4] per activity. Previous findings (Pouta and Sievänen, 2001) indicate that approximately 87% of recreation days take place form of one-day trips. Only 11% of these trips were to sites over a half an hour away from home by car. These figures make us quite confident that the vast majority of trips were made in 'respondents' home municipalities.

Information on participation in water recreation and on annual trip frequency during the twelve month period prior to the survey was available for 5414 respondents.[5] The data were not location-specific for all the instances of participation, but rather provided detailed information on only one – the most recent – recreation trip the individual had made. As the activities on these most recent trips varied among 90 different alternatives, only some provided information on water recreation related trips. Detailed trip information was available for 167 swimming,[6] 175 fishing and 89 boating trips.

[3] As in the logit model, ξ_0 represents the intercept, η is the parameter associated with water quality $\boldsymbol{q}$, and ω is the vector of parameters associated with the vector of individual characteristics, $\boldsymbol{x}$. Note that the same set of individual characteristics can be used in both parts of the hurdle model.

[4] A trip was defined as lasting longer than 15 min and occurring outside the 'respondent's home. If the respondent made trips lasting longer than one day, each consecutive day was counted as a trip in calculating the annual trip frequency. Thus, a three-day trip constituted three trips in the database.

[5] Of these 5414 respondents, 5, 8 and 115 respondents were removed from the swimming, fishing and boating traveling frequency data, respectively. The screening removed outliers and inconsistent survey responses. Respondents with annual traveling frequencies of more than one per day were considered outliers. The larger number of rejected boater responses is due to reported non-participation or missing data on participation.

[6] In the travel cost analysis, recreational swimming includes snorkeling, surfing and water skiing. All winter activities, such as winter swimming and fishing, were rejected, as were trips from places other than home.

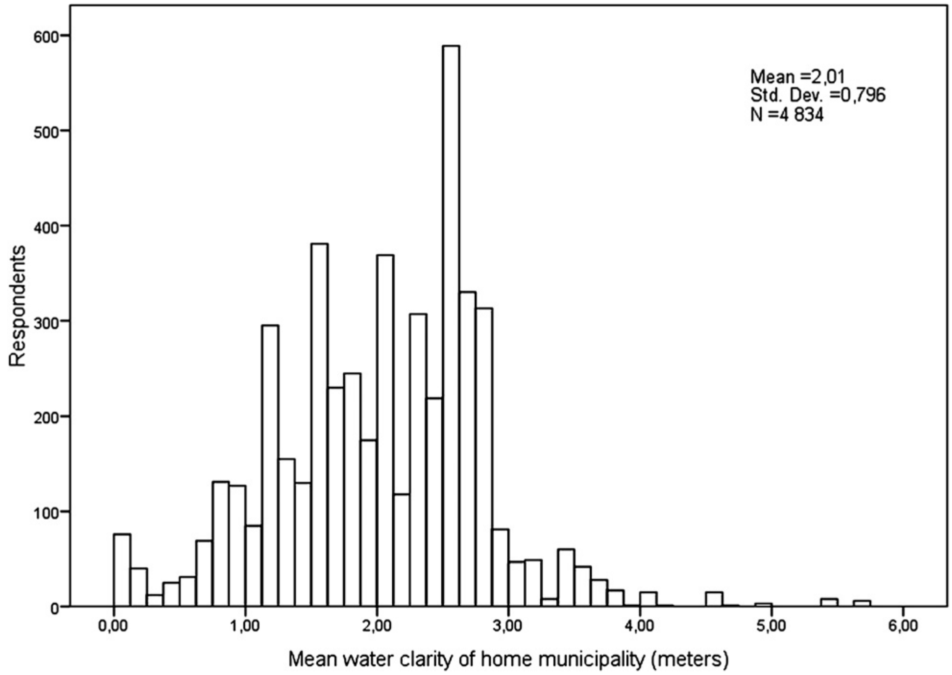

Fig. 2. Distribution of mean water clarity in the home municipality of the sampled respondents between 1998 and 2000.

These data furnished the basis for the travel cost model and included the purpose of the trip, the number of annual visits to the same site for the same purpose,[7] travel distance and time, mode of travel, and estimated costs per person. Roughly 24% of these water recreation trips were to costal sites and 76% to lake sites. These trips cannot be considered a representative sample of water recreation trips in Finland, but they did provide us an opportunity to illustrate the benefit estimation procedure.

In Finland it is not self-evident that an individual's home region or municipality can be defined as the dominant recreational setting. Recreation at a summer cottage or other type of vacation residence (owned or rented long term) is a common substitute for recreation opportunities close to home, as 45% of Finns have access to such resources on a regular basis (Sievänen et al., 2007). Roughly one-third of all summer cottages are located in the 'owners' municipality of residence.[8] Summer cottage access affects participation in many recreational activities (Pouta et al., 2006; Sievänen et al., 2007) and water quality near summer cottages can be assumed to affect participation in water recreation. However, according to data from the national inventory (Virtanen et al., 2001), only some 18% of one-day water recreation trips originated from respondents' summer cottages. Based on this finding, we may quite safely assume that the environmental quality of an individual's home region has a dominating effect on his or her water recreation behavior.

4.2. Water quality measurement data

Water quality data were taken from the Finnish Environmental 'Institute's State of 'Finland's Surface Waters (PIVET) database for the summer seasons of 1998, 1999 and 2000. We defined the summer season as beginning in June and ending in September. The PIVET database has multiple water quality indicators for lakes, rivers and the coast, with measures for water clarity,[9] chlorophyll, turbidity, color, total phosphorus and nitrogen, and coliform bacteria levels. The water quality database covers over 3000 lakes and 1400 measuring points at sea, with data on some 24,000 and 14,000 water samples, respectively. As the data give 10 measuring points per municipality on average, we can consider them an adequate description of water quality on the municipal level.

Although national resources for water recreation are exceptionally abundant and the quality of water is generally quite good, there are also lakes and regions where good water quality is either threatened or has been lost, as indicated by Fig. 2. The figure shows a histogram of near-home water clarity for the representative sample of Finns used in this study. The water quality data shows water clarity being highly significantly correlated between chlorophyll levels, turbidity, color, total phosphorus, total nitrogen, as well as coliform bacteria levels.[10] The proportion of the sample living in a municipality where water clarity is less than 1 m on average is likely to suffer from compromised water quality. Eutrophication is the principal reason for degraded water quality. As municipal sources of eutrophicating nutrients have been tackled through enhancements in wastewater treatment, the pressure to implement abatement measures has shifted to agriculture. The trend towards centralizing animal farming threatens to increase nutrient runoff and eutrophication, particularly in the basins of southern and western Finland, and will have a profound effect on the quality of Finnish surface waters (Uusitalo et al., 2007).

As we are interested in the effect of water clarity in 'individuals' home municipality, water quality data were combined with

[7] Limited to one trip per day per year.

[8] Personal communication with Statistics Finland (building and residence statistics).

[9] Measured with a secchi disc, an 8-inch round disc with alternating black and white quadrants. The water clarity measure is the depth, in meters, at which the secchi disc disappears from sight.

[10] Coliform bacteria level is a standard quality indicator for swimming waters. The correlation between heat resistant coliform bacteria (thcf) level and water clarity were −0.057 at 1% significance level and −0.035 at 5% significance level for marine and lake environments, respectively.

recreation behavior data based on respondents' home municipality. Water clarity on the municipal level was the mean for the study period and the measurement points in each municipality.[11] Since water clarity data were not available for rivers, we excluded rivers from the analysis, and thus our results can only be generalized to coastal and lake recreation.

4.3. Variables for model specifications

We expected water recreation to be weather dependent and thus included in the analysis the regional[12] frequency of days warmer than 25 °C, considered hot weather in Finland, during the twelve months prior to the survey response date. We expected hot days to increase participation and participation frequency in swimming and boating. The effect on fishing was thought to be less certain since preferences for weather depend on the species of fish sought.

Respondent characteristics used in the estimation included age, gender, education, work participation, family composition and the average income per adult in the household. The effect of summer cottages was captured by including a dummy variable "summer cottage access". We also included the distance to the nearest water recreation site as reported by the respondent.[13] We corrected for possible bias in the reported water recreation frequency by adding a time lag indicator for responses outside the summer season. For each municipality, the water clarity values for all recreation sites for which such values were available were aggregated into a single value. The model thus incorporates nearby substitute recreation sites, although the data do not allow for a more explicit treatment of substitute sites than the dummy variable for summer cottage access. We also note that while our model assumes that all day trips occur in the home municipality, it is likely that people living near municipal borders take advantage of recreational opportunities in neighboring municipalities. The assumption may decrease the significance of the home municipality's water clarity in the estimation, especially if many neighboring municipalities have very different clarity levels. On the other hand, as water bodies are not limited by municipal boundaries, adjoining municipalities with large water bodies should have similar average clarity levels.

In the travel cost models we used two alternate measures: reported and calculated travel costs. Reported costs were estimated by the survey respondents as round-trip travel costs per person; calculated round-trip costs for car travelers were estimated as 0.33 euros per kilometer.[14] Opportunity costs of time were also incorporated in the estimations, with travel time costs estimated at one-third of the wage rate.[15] Additionally, we constructed dummy variables for respondents who had reported that water recreation was a secondary activity at the site and for those whose main and secondary visiting purposes both involved water recreation. The more detailed nature of the travel cost data allowed us to exclude trips than other the ones originating from the 'respondents' homes. The descriptive statistics of all variables are listed in Table 1.

Table 1
Sample description.

Variable	Mean	Std. dev.	N
Swimming participation	0.735	0.442	5414
Fishing participation	0.489	0.500	5414
Boating participation	0.494	0.500	5414
Swimming frequency	28.402	34.242	3921
Fishing frequency	31.443	40.663	2624
Boating frequency	25.274	32.351	2664
Mean water clarity in home municipality (meters)	2.011	0.796	4834
Number of hot days (>25 °C) in home region	13.036	10.714	5414
Distance to nearest swimming site, kilometers	3.251	5.165	4996
Distance to nearest fishing site, kilometers	5.351	14.040	4677
Distance to nearest boating site, kilometers	6.125	15.924	4685
Age	41.423	15.648	5414
Gender (female = 1)	0.558	0.497	5535
Monthly income (1000€)	1.292	0.680	4828
Number of adults in household	2.149	0.990	5432
Number of children in household (under 18)	0.625	1.048	5432
Academic education (over high school education = 1)	0.268	0.443	5535
Unemployed	0.077	0.267	5535
Retired	0.147	0.354	5535
Homemaker	0.045	0.208	5535
Access to summer house	0.443	0.497	5276
Access to car	0.880	0.325	5276
Access to boat	0.461	0.499	5535
Months since summer (June–September)	3.017	2.771	5535
Travel cost variables, Swimming			
Annual swimming trips to the site	32.606	68.156	142
Reported travel costs per person, €	1.213	5.013	148
Calculated travel costs per person, €	1.854	8.614	167
Opportunity cost of time per person, €	1.838	4.620	144
Fishing			
Annual fishing trips to the site	29.732	58.015	153
Reported travel costs per person, €	3.051	5.217	157
Calculated travel costs per person, €	5.642	12.146	171
Opportunity cost of time per person, €	3.071	5.201	153
Boating			
Annual boating trips to the site	32.055	56.574	73
Reported travel costs per person, €	2.251	4.302	75
Calculated travel costs per person, €	1.436	5.105	87
Opportunity cost of time per person, €	2.690	5.537	70

5. Results

5.1. Recreation participation and water quality

The results from the first stage of the estimation (Fig. 1) – the hurdle model for annual participation in each activity and participation frequency – are shown in Table 2. Due to item non-responses in the questionnaire, a set of 3536 to 3749 of all 5414 observations was available for modeling. The decision to participate in swimming, fishing or boating – a logit binary choice – is reported in the first column for each activity. According to the results, water quality, defined as water clarity in a 'respondent's home municipality, did not restrict annual participation in swimming or boating. In the case of fishing, water clarity had a significant positive effect on the probability of participation. For the three activities, the distance to the nearest recreation site was not a consideration precluding participation in fishing or boating. The probability of participation in swimming, on the other hand, was negatively associated with increased distance to a usable recreation site (p-value 0.09), which

[11] This increases the weight of points with frequent measurements. Measurement points are, however, chosen by the Finnish Environment Institute to represent areas of interest or frequent changes in water quality, and thus may in fact properly weight areas that are heavily used.

[12] The information on the number of hot days was obtained from data provided for 20 weather stations by the Finnish Meteorological Institute. These were linked to the survey responses based on the home municipality of each respondent and the province where each station was located.

[13] The distances to recreation sites were limited to 100 km for swimming and 200 km for fishing and boating. This procedure removed less than 0.5% of the sample.

[14] The cost is based on the official kilometer allowance of 1.99 Finnish Marks for the year 1999 granted by the Finnish Tax Administration. Of the non-car travelers (61% of the total), five swimmers and one fisher used public transport, while the majority (83% of non-car travelers) walked or cycled. Travel costs were set at zero for all non-car travelers in the calculated travel cost figure.

[15] The wage rate was determined by dividing the household income by the number of adults in the household.

Table 2
Results of the hurdle model for water recreation activities.

Independent variables	Swimming		Fishing		Boating	
	Logit	Negbin	Logit	Negbin	Logit	Negbin
	Coefficient (t-ratio)					
Water clarity in home municipality	−0.006 (−0.110)	0.059[b] (2.321)	0.107[b] (2.335)	0.097[a] (3.287)	0.070 (1.462)	0.020 (0.763)
Distance to nearest recreation site	−0.015[c] (−1.681)	−0.014[a] (−5.640)	0.004 (1.578)	0.002[c] (1.692)	−0.001 (−0.336)	0.001 (0.400)
Number of hot days	0.041[a] (10.198)	0.016[a] (9.062)	0.006[c] (1.722)	−0.002 (−0.719)	0.012[a] (3.405)	0.002 (1.217)
Gender (female = 1)	0.085 (1.026)	0.086[b] (2.304)	−1.077[a] (−14.522)	−0.015[a] (11.475)	−0.528[a] (−6.862)	−0.333[a] (−6.902)
Age	−0.025[a] (−6.005)	0.010[a] (5.415)	−0.001 (−0.357)	0.010[a] (3.383)	−0.015[a] (−4.042)	0.006[b] (2.371)
Income (1000€)	0.206[a] (2.737)	0.027 (0.864)	0.005 (0.082)	−0.173[a] (−3.352)	0.075 (1.097)	−0.060 (−1.449)
Academic education	0.130 (1.381)	−0.031 (−0.731)	−0.238[a] (−2.856)	−0.205[a] (−0.3362)	0.048 (0.567)	−0.141[b] (−2.544)
Student	0.315[c] (1.832)	0.208[a] (3.260)	0.043 (0.318)	−0.008 (−0.079)	−0.235[c] (−1.677)	0.116 (1.342)
Unemployed	0.073 (0.478)	0.065 (1.022)	0.061 (0.444)	0.483[a] (4.865)	0.032 (0.218)	0.219[b] (2.415)
Retired	−0.019 (−0.130)	−0.023 (−0.306)	0.168 (1.162)	0.140 (1.365)	−0.055 (−0.368)	0.210[b] (2.209)
Homemaker	−0.414[b] (−2.210)	−0.327[a] (−3.613)	−0.510[a] (−2.900)	−0.218 (−1.270)	−0.351[c] (−1.892)	−0.101 (−0.815)
Number of children	0.041 (0.921)	0.008 (0.459)	0.054 (1.483)	−0.083[a] (−3.140)	0.027 (0.692)	−0.003 (−0.155)
Number of adults	−0.018 (−0.377)	0.042[c] (1.793)	0.013 (0.361)	−0.001 (−0.043)	−0.073 (−1.640)	0.006 (0.207)
Access to summer house	0.381[a] (4.541)	0.268[a] (6.999)	0.613[a] (8.223)	0.358[a] (6.606)	0.221[a] (2.668)	0.251[a] (5.216)
Access to car	0.346[a] (2.853)	0.128[b] (2.158)	0.438[a] (3.761)	0.305[a] (3.425)	−0.036 (−0.301)	0.096 (1.236)
Access to boat					1.550[a] (18.664)	0.711[a] (14.501)
Months since summer season		0.004 (0.661)		0.015 (1.547)		−0.007 (−0.772)
Intercept	0.985[a] (3.596)	2.172[a] (18.503)	−0.205 (−0.875)	2.772[a] (14.781)	0.008 (0.035)	2.316[a] (15.467)
N	3749		3536		3560	
LL (hurdle model)	−14271		−10462		−10096	
LL (restricted model)	−64722		−65417		−48667	
χ^2 (hurdle model)	100901		109910		77142	
Pseudo R^2	0.78		0.84		0.79	
Alpha	1.053[a] (29.621)		1.328[a] (21.741)		1.086[a] (22.885)	

[a] p-Value < 0.01.
[b] p-Value < 0.05.
[c] p-Value < 0.10.

indicates that other recreation resources may well provide substitutes for swimming opportunities. The probability of water recreation participation increased with the number of hot summer days, confirming our expectations. The results suggest that, at least for swimming and boating, hot days are a strong inducement to participate in water recreation, whereas water clarity has no direct effect in the pivotal decision.

The results also reveal an association between socioeconomic variables and water recreation participation. They show that fishing and boating were predominantly male activities, while swimming was enjoyed equally by both genders. Elderly persons were not as likely to participate in swimming and boating as younger people; the difference between the two groups was not significant in the case of fishing. Surprisingly, swimming was more popular with increasing income. Compared to other socioeconomic groups, students tended to participate more in swimming, but less in boating. Homemakers participated less in all activities across the board. The results did not show any significant effect for unemployed or retired people, suggesting that participation in all three activities was similar across the sample regardless of employment status. On balance, time constraints may not be important factors in the decision to participate in water recreation. We also found that family composition had no effect on participation probability. Having access to a summer house – indicating an available substitute for close-to-home opportunities – and having a car or boat at 'one's disposal all had highly significant positive coefficients.

The second part of the hurdle model, the model for annual water recreation frequencies, is presented in the second column for each activity (Table 2). Water clarity in the home municipality had positive effects on the frequency of fishing and swimming but not boating. 'Boaters' insensitivity to water clarity may relate to the spatial scale for their activity as it extends beyond their home municipality. Distance to the nearest recreation site only affected swimming frequency with high significance. In the case of fishing, proximity of a site had a weakly significant positive coefficient and may relate to active fishers looking for high-quality sites farther away from home. The interaction between distance and water clarity for fishers is interesting, because it may indicate that they are willing to travel longer distances to reach clearer waters. In many previous studies, fishers have had specific preferences for the catch rate. In our case, the fish population was one example of the ecological information we lacked and could thus not include in our models. One explanation for the sensitivity of fishing to the level of water clarity is that the nationally most valued fish species require clear waters.

Only swimming frequency was affected very significantly by the number of hot days. Swimming trips require less advance planning compared to fishing and boating, and therefore it seems logical that weather conditions such as the number of hot days have a stronger positive effect on swimming frequency than on the frequency of the other activities.

As regards socioeconomic variables, the recreation frequency estimates showed trends similar to those for participation, but with some interesting differences. Women, for example, were estimated to swim more often than men, although the coefficient value was not very high. Higher age increased the frequency of participation. Available time was associated with many socioeconomic factors that further determined participation frequency. Non-working groups, apart from those who were homemakers, tended to make more water recreation visits. Students were active swimmers, while unemployed people went fishing and boating. In the case of fishing, an academic education and income had both negative and highly significant coefficients, suggesting that a lack of time decreased the number of fishing trips made. Fishing and boating are both naturally more time-intensive hobbies than swimming, and thus it is not surprising that they were more sensitive to 'respondents' time-related answers. As in the case of decisions to

Table 3
Negative binomial travel cost model for water recreation using four travel cost measures.

Model	Calculated travel costs	Reported travel costs	Calculated travel costs + time costs	Reported travel costs + time costs
Independent variables	Coefficient (*t*-ratio)			
Travel cost	−0.053[a] (−4.555)	−0.159[a] (−4.139)	−0.053[a] (−5.518)	−0.121[a] (−6.110)
Water recreation secondary activity at site	0.586[c] (1.759)	0.349 (1.025)	0.540 (1.608)	0.324 (0.990)
Water recreation primary and secondary activity at site	0.404 (−0.498)	0.087 (0.105)	−0.555 (−0.710)	0.080 (0.106)
Boated	0.248 (0.495)	0.365 (0.630)	0.278 (0.568)	0.448 (0.841)
Fished	0.031 (0.071)	0.145 (0.336)	0.070 (0.161)	0.353 (0.854)
Water clarity in home municipality	−0.187 (−1.109)	−0.017 (−0.090)	−0.165 (−1.017)	−0.020 (−0.118)
Number of hot days	−0.006 (−0.341)	−0.001 (−0.061)	−0.007 (−0.436)	−0.006 (−0.350)
Gender (female = 1)	−0.154 (−0.429)	0.046 (0.121)	−0.160 (−0.453)	0.083 (0.248)
Age	−0.001 (−0.058)	−0.004 (−0.271)	−0.005 (−0.401)	−0.006 (−0.459)
Income (1000€)	0.031 (0.107)	0.096 (0.320)	0.118 (0.414)	0.098 (0.353)
Academic education	0.042 (0.098)	0.329 (0.852)	−0.040 (−0.097)	0.173 (0.464)
Student	−1.296[b] (−2.242)	−1.609[a] (−2.953)	−1.403[b] (−2.496)	−1.379[b] (−2.476)
Unemployed	0.353 (0.698)	−0.172 (−0.313)	0.396 (0.815)	−0.267 (−0.548)
Retired	0.709 (1.261)	0.665 (1.143)	0.814 (1.378)	0.644 (1.196)
Homemaker	1.104 (1.557)	1.082 (1.500)	1.117 (1.587)	1.755[b] (2.159)
Number of children	−0.198 (−1.505)	−0.239[c] (−1.694)	−0.219[c] (−1.738)	−0.220[c] (−1.795)
Number of adults	0.098 (0.483)	0.347[a] (2.614)	0.193 (0.905)	0.024 (0.114)
Access to summer house	−0.104 (−0.297)	0.018 (0.048)	−0.085 (−0.249)	0.004 (0.010)
Access to car	−0.534 (−1.058)	−0.638 (−1.251)	−0.552 (−1.039)	−0.745 (−1.413)
Access to boat	0.047 (0.138)	0.044 (0.130)	−0.057 (−0.171)	−0.060 (−0.180)
Months since summer season	−0.046 (−0.895)	−0.044 (−0.797)	−0.050 (−0.982)	−0.079 (−1.531)
Intercept	3.691[a] (3.614)	2.860[a] (3.131)	3.801[a] (3.870)	4.062[a] (4.008)
N	263	242	255	234
LL (negbin model)	−1065	−959	−1034	−927
LL (restricted model)	−6782	−5781	−6152	−5124
χ^2 (negbin model)	11435	9643	10236	8394
Pseudo R^2	0.84	0.83	0.83	0.82
Alpha	3.530[a] (4.130)	3.459[a] (3.843)	3.083[a] (4.522)	2.742[a] (4.527)
Consumer surplus €	18.90	6.30	18.98	8.28

[a] *p*-Value < 0.01.
[b] *p*-Value < 0.05.
[c] *p*-Value < 0.10.

participate in the activities, access to a summer house, car and boat had very significant positive effects on participation frequency.

5.2. Benefit estimates

The second stage in evaluating water quality changes was to estimate a travel cost model for valuing water recreation activity days. Due to the small number of observations for the most recent trip for each water recreation activity, we pooled the three activities and estimated a value for a generic visit. Table 3 shows the results. The table presents four models for different travel cost estimates. As the significant alpha coefficients reveal, the negative binomial model was suitable to correct for data overdispersion. As the demand theory assumes, an increase in travel costs decreases the

Table 4
Estimated participation rates, days and benefits per activity at present and under two policy alternatives, water clarity +1 m and water clarity −1 m.

	Swimming			Fishing			Boating		
	Present	Water clarity increase +1 m	Water clarity decrease −1 m	Present	Water clarity increase +1 m	Water clarity decrease −1 m	Present	Water clarity increase +1 m	Water clarity decrease −1 m
Population, millions (age 15–74)	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
Proportion of participants %	78.10	78.10[a]	78.10[a]	53.24	55.91	50.56	51.85	51.85[a]	51.85[a]
Number of participants, million	3.046	3.046[a]	3.046[a]	2.076	2.180	1.972	2.022	2.022[a]	2.022[a]
Activity days/participant/year	26.52	28.12	25.01	20.78	22.90	18.85	18.31	18.31[a]	18.31[a]
Total number of activity days, million/year	80.78	85.65	76.28	43.14	49.93	37.17	37.06	37.06	37.06
Consumer surplus per day (€), low estimate	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30
Consumer surplus per day, (€), high estimate	18.98	18.98	18.98	18.98	18.98	18.98	18.98	18.98	18.98
Total benefits, low estimate, million €	508.5	539.2	479.6	271.6	314.3	234.0	233.1	233.1	233.1
Total benefits, high estimate, million €	1532.8	1625.2	1445.7	818.6	947.4	705.3	702.8	702.8	702.8
Change in total benefits %		*6.03*	*−5.68*		*15.73*	*−13.84*		*0*	*0*
Change in total benefits, million €		*30.6 to 92.4*	*−28.9 to −87.1*		*42.7 to 128.8*	*−37.6 to −113.3*		*0*	*0*

Figures are rounded for readability, but calculated by using unrounded data, hence the seeming discrepancies in aggregate figures.
[a] Estimated coefficient not significant.

rate of visits to a site. The only other significant variable across all four models was being a student. Students returned to the site of their previous visit less frequently than others, a finding perhaps attributable to their having a wider selection of destination sites, as they may have two home municipalities. The data leave this question open. Number of children had a negative effect on visiting frequency to the last-visited water recreation site in three of the four models. In the model of calculated travel costs, it was estimated that respondents for whom water recreation was a secondary activity took more trips to the last-visited site. Water clarity on the municipal level was not a significant variable in the model. This is natural, for this model explains the number of visits to a specific site, not the general participation intensity, which is the focus of the hurdle model.

The results of the travel cost model were used to estimate the per-trip benefits of visits. The model based on respondents' reported travel costs yielded the smallest benefit estimates per trip per person, which ranged from approximately 6.30–8.30 euros; calculated travel costs for people traveling by car provided higher estimates, in the range of 18.90–19.00 euros per visit per person. In both instances, the higher figures result from our taking the opportunity cost of time into account.[16]

The hurdle models (Table 2) were used to calculate the current rate and frequency of water recreation participation for the whole population (Table 4). The probability of participation was estimated at roughly 78% for swimming, 53% for fishing and 52% for boating. The models produce slightly higher participation rates than the sample (compare Table 1). The estimated number of activity days per participant varied from about 27 days for swimming to 21 for fishing and 18 for boating. The fishing and boating models underestimate sample means somewhat; the estimated values are closer to the median number of trips, which is 20, 17, and 14 days for swimming, fishing and boating, respectively. The figures in Table 4 for total number of activity days capture the effect of both, the rate and frequency of participation, as well as the total benefits for each activity. It must be noted that adding annual benefits together would most likely not provide correct benefit estimates for water recreation as whole, because the recreation types are interrelated; there may be synergies and substitute effects that do not show when estimating activities separately. Our data do not allow for a proper study of substitution effects between the activities.

5.3. Policy effects

Table 4 shows the sensitivity of participation and total benefits to water quality change from the national status quo to a one-meter improvement/degradation in water clarity. An improvement would increase the probability of fishing by 2.7% and add 2.1 days of fishing annually on average. Swimming participation levels and boating behavior as a whole were not estimated as being affected by water clarity. Improved water quality was, however, predicted to increase the average number of swimming trips per person by 1.6 days annually. The policy alternatives affected swimming and fishing days in particular, whereas boating days were not sensitive to policy changes. Fig. 3 shows the estimated change in water

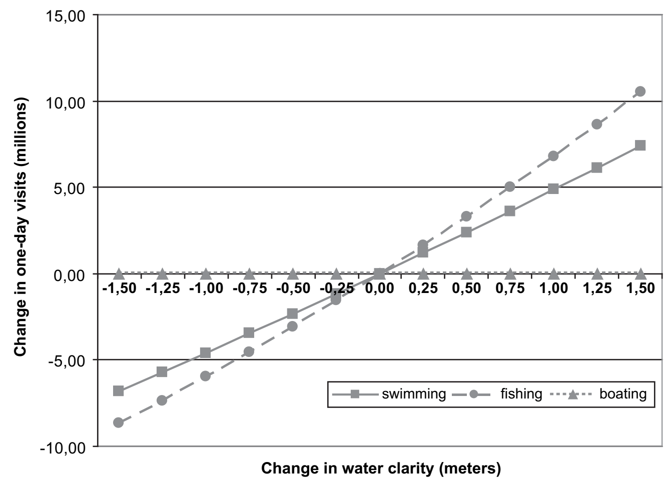

Fig. 3. Estimated change in water recreation activity for changes in aggregate local water clarity.

recreation visits due to altered water clarity. The data presented take into account the estimated water clarity coefficients only where they were significant in the estimations.

Table 4 also shows how changes in water clarity would affect water recreation benefits. A one-meter reduction in average water clarity would lead to a loss of swimming benefits on the order of 29–87 million euros annually. The decrease in fishing benefits would be larger, since our results indicate that the number of participants would also change[17]. The fishing benefits lost would range between 38 and 113 million euros per year. Since boating was not affected by water clarity in our estimations, no monetary loss can be estimated. However, this does not mean that 'boaters' consumer surplus would not diminish. If water clarity were to improve by 1 m on average, 'swimmers' consumer surplus would increase by 31–92 million euros per year, while fishers would enjoy an even larger enhancement in benefits, from 43 to 129 million euros annually.

5.4. Comparison with costs

For policy purposes it is imperative to understand the costs as well as the benefits of improving water quality. Our study examined water clarity as an indicator of water quality, with a particular interest in eutrophication problems. Even for a rough comparison of the benefits and costs of reducing eutrophication, we would need to know how nutrient levels interact with both sea and inland water clarity and what the associated annual costs of reducing nutrients are.

As policy measures regarding water quality and previous evaluations of policy costs are associated with nutrient discharge instead of water clarity, we constructed simple regressions for converting nutrient reductions into water clarity improvements in both the sea and lakes. We set water clarity[18] dependent on temperature, depth of measurement point and inverse measures of both total nitrogen and phosphorus. Both clarity models had significant signs for nutrient levels, and the R^2 figures of 0.72 and 0.44 for the lake and sea models, respectively, suggest that we were

[16] From previous studies (Pouta and Ovaskainen, 2006) using the same dataset, we know that, regardless of the activity, welfare estimates per day in the case of multiple-day trips are approximately 60% of the estimates for one-day trips. One-day trips account for approximately 87% (Pouta and Sievänen, 2001) of recreation days and the effect of multiple-day trips is minor particularly in this case, where we are interested in water quality improvement in 'respondents' home municipality. Although the welfare estimates are in line with previous findings for other recreation activities (Pouta and Ovaskainen, 2006), they need to be used with caution due to the small size of the subsample used.

[17] As the fishing model underestimates the participation frequency compared to the observed number of trips, it also underestimates total benefits. However, the problem is minor in terms of relative benefit change.

[18] The water clarity regressions used national scale data from six years: the period from 1998 to 2002, and the year 2004.

Table 5
Nutrient level effects on water clarity, OLS regression results.

Independent variables	Water clarity	
	Lake	Sea
	Coefficient (*t*-ratio)	
Total phosphorus (inverse)	13.513[a] (86.077)	9.346[a] (25.811)
Total nitrogen (inverse)	357.723[a] (50.564)	428.609[a] (27.795)
Water temperature	0.011[a] (6.702)	0.000 (0.116)
Depth of measurement point	0.018[a] (41.702)	0.034[a] (49.781)
Intercept	−0.022 (−0.659)	0.117[c] (1.673)
N	16,308	8210
R^2	0.72	0.44
Std. error of the estimate	0.704	0.895

p-Value < 0.05.
[a] p-Value < 0.01.
[c] p-Value < 0.10.

better able to estimate water clarity for lakes. The results for the two models are shown in Table 5.

Using the regression results, we estimate that a uniform reduction of 38 and 37% in nutrient levels in lakes and on the coast, respectively, would be required to achieve a 1-m improvement in average water clarity. Söderqvist and Scharin (2000) found that in the Stockholm archipelago a one-meter improvement in clarity from 1.5 to 2.5 m would require approximately a 30% reduction in nitrogen, while a similar improvement from a better initial water clarity of 2.5 m would require a smaller, 21% reduction.

Helin et al. (2006) estimated that a 50% reduction in nitrogen flow from Finnish agriculture to the Gulf of Finland would cost 34.9–47.6 million euros annually, depending on the policy regime. Although inland water eutrophication is more often phosphorus-limited, our simple water clarity models suggest that reductions in nitrogen flows to the sea also have an effect on inland waters, providing additional benefits. In this rough and indicative comparison of Helin's results with the recreational benefits we have derived, which likely represent a lower bound estimate since non-use values are excluded, it seems that the benefits of water clarity improvements are at least close to the associated costs.

6. Conclusion

Our results constitute a twofold contribution. First, the approach presented provides a methodical alternative for estimating the benefits of improving the quality of surface waters as required by the Water Framework Directive. The use of data from a national recreation inventory in combination with data on water quality make the method applicable for assessing WFD-related benefits in other European countries – at least twelve at this writing – where national recreation inventory data exist (Dehez et al., 2008). What is more, using recreation inventory data in assessing the effects of environmental changes may encourage countries without such data to conduct multipurpose inventories.

Second, the empirical models of participation in the three most common water recreation activities – swimming, fishing and boating – are particularly useful for the evaluation of water conservation policies. Using a hurdle model for participation in water recreation and frequency of recreation trips, we found that close-to-home water clarity affected recreation behavior positively: The annual number of swimming trips and the number of fishers were estimated to increase with an improvement in water clarity. We found boating unresponsive to changes in water clarity, as did Sandström (1996) in his study on the Swedish coast.

Using a representative site travel cost model, we estimated benefits for the average water recreation visit. The aggregate of these benefits represented a lower bound of total benefits since non-use values were excluded from the analysis, but was still large enough to be at least on the same level as the associated costs for improved water quality. This preliminary cost-benefit comparison thus suggests that current water conservation measures should be intensified.

To improve the valuation part of our approach, we recommend that future national recreation inventories use nationwide and spatially precise information on recreation. A combination of stated preference and revealed preference approaches could also improve the accuracy of benefit estimation (e.g. Whitehead et al., 2000).

In an additional finding, we identified gaps in the ecological information on water quality: No transfer function could be derived linking nutrient concentrations with observable water clarity. To bridge this gap we estimated the relationship using water quality data. The model cannot mimic dynamic natural processes such as algal blooming and eutrophication, a shortcoming that underscores the need for models lying between indicators of water quality, which inform policy, and indicators such as water clarity, which are meaningful to the public.

Finally, we found the number of hot summer days to increase water-related recreation, making climate change an important aspect of future studies. A warming climate is likely to increase the demand for water recreation, but may also have an adverse effect on water quality in the form of increased algal blooming or drought. Models of these ecological interactions would provide an opportunity to estimate changes in water recreation benefits in the near future.

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