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Heterogeneous Preferences for Water Quality Attributes: the case of Eutrophication of the Gulf of Finland, Baltic Sea

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Abstract. This paper examines the preference heterogeneity regarding water quality characteristics, and provides the welfare estimates (WTP) for three nutrient reduction scenarios that improve the water quality in the Gulf of Finland, Baltic Sea. In the choice experiment, the improvement is described in terms of four water quality characteristics (attributes): water clarity, abundance of so called coarse fish, status of bladder wrack population, and mass occurrences of blue green algae blooms. The data are analysed with multinomial logit (MNL), random parameters logit (RPL), and latent class (LCM) models. The analysis reveals the importance of water clarity and low occurrence of blue green algae over small number of coarse fish and status of bladder wrack. The preference heterogeneity for water quality characteristics stems from income, age, gender, and whether the respondent has residential contact to the Gulf of Finland or has personal experience on the harm caused by eutrophication. Women, young, people with higher income and people with residential or recreational contact to the Gulf of Finland are more willing to contribute to the water quality improvement. The WTP estimates for three nutrient reduction scenarios range from 9 905 million € to 12 896 million €.

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1. Introduction

Eutrophication, caused by the excess amount of nutrients, is a threat for the good ecological status of the Baltic Sea. Besides the harm caused by eutrophication for the state of the marine ecosystem, also the worsened recreational possibilities incur the loss of benefits. In this paper, we assess the harm caused by eutrophication of the Gulf of Finland, the most eutrophied sub-basin of the Baltic Sea (Pitkänen et al., 2001). Our analysis covers the Finnish side of the gulf. The coast and archipelago of the gulf is an important area for recreation. According to the Population Register Center, one fourth of the Finnish population lives, and about 30 thousand Finns owns a summer cottage in the municipalities situated on the coast of the Gulf of Finland. Moreover, the Gulf of Finland has estimated to be a primary fishing resort for 100 thousand recreational fishers (Pitkänen, 2004).

To assess the benefit associated with the improvement of the state of the Gulf of Finland, we apply the environmental valuation method based on stated preferences, the choice experiment (CE). The CE, in addition to producing benefit estimates, allows for identifying which characteristics of the sea water people consider the most important. To catch the multidimensionality of eutrophication, we describe water quality improvement in terms of changes in four sea water characteristics: the water clarity, the abundance of so called coarse fish species (*Cyprinids*), the state of the bladder wrack (*Fucus vesiculosus*) population, and the mass occurrences of the blue green algae (*Cyanobacteria*) blooms. Accounting for the multidimensionality is important in deciding which policies to implement to increase social welfare, as the policies may be targeted for instance to different nutrients (nitrogen or phosphorous) and lead to different changes in the separate water

quality characteristics. After estimating the marginal prices for improvements in each of the characteristics, we calculate the welfare effects of three management scenarios (Bennett and Adamowicz, 2001).

The valuation literature concerning improved water quality is diverse in terms of water quality descriptions and geographical scale. The examples of various descriptions of quality improvement are: reduced eutrophication (Söderqvist, 1996; Gren et al., 1997a), prevented asphyxiation (Goffe, 1995), reduction in occurrence of harmful algal blooms (Scatista et al., 2003), and improvement in sight depth (Söderqvist and Scharin, 2000). Eggert and Olsson (2004) described the quality with different water quality characteristics: the level of fish stock, bathing water quality and biodiversity level, and their study indicated the existence of preference heterogeneity. Out of the studies related to the Baltic Sea, Söderqvist (1996) and Gren et al. (1997a) considered improved quality of the entire Baltic Sea, while Söderqvist and Scharin (2000) conducted a regional study in Stockholm archipelago. Along with their study, our research serves as a case study for the Baltic Sea wide benefit estimation and, on the other hand, produces an important component of the general view of the Gulf of Finland: the estimate of benefits from water quality improvement.

The special focus of our study is the examination of the less-studied issue: the heterogeneity of preferences of general public for water quality attributes that we expect to exist given the diversity of the consequences of eutrophication. To explore the heterogeneity in the sample and to examine the distributions of welfare changes in the population, we analyse the responses with the random parameters logit model (RPL) (McFadden and Train, 2000, Hensher and Greene, 2003) and the latent class model (LCM) (Greene and Hensher, 2003) that reveal the differences in the respondent's preferences for separate attributes. As they do not assume homogeneous preferences through the sample, they are able to reveal more information, and relax the stringent assumptions of

the basic multinomial logit model (MNL) (Swait, 2006). Besides the heterogeneity for attributes, we expect respondents with higher income, or residential contact (i.e. living permanently and/or owning a cottage on the coast), and the recreational fishers to be more willing to pay for the improvement.

The three aims of this paper are to provide the benefit estimates related to the reduction of harm caused by eutrophication of the Gulf of Finland by evaluating the selected nutrient reduction scenarios, to identify the most important water quality characteristics, and to examine the sources of preference heterogeneity regarding the characteristics. The paper is structured as follows: the next section describes the study area and the current policy setting, and the section 3 the valuation method and the application. The section 4 reports the results, and the last section concludes the paper.

2. Study area and policy setting

The Baltic Sea is a semi-closed European inland sea with rather low biodiversity, special geographical, climatological and oceanographic characteristics. Its catchment area is settled by 85 million people, and the sea is very prone to the excess amount of nutrients. The Gulf of Finland is the most eutrophied sub-basin of the Baltic Sea when measured as the ratio of nutrient load and surface area. The inflow of nutrients to the Gulf of Finland exceeds the average load to the Baltic Sea with 200–300 % (Pitkänen et al., 2001). The catchment area of the Gulf of Finland, settled by 20 million people, produces a considerable excess amount of nutrients necessary for plant growth, nitrogen (N) and phosphorous (P). In general in the Gulf of Finland, nitrogen is more important as a regulator of eutrophication (Tamminen and Kivi, 1996). However, some blue green algal or

cyanobacteria species (*Nodularia spumigena* and *Aphanizomenon* sp.) blooming in the open sea are able to fix nitrogen dissolved from the atmosphere, and for those species, phosphorous is a limiting nutrient (Pitkänen, 2004). The excess amount of nutrients leads to several changes in the state of the Gulf of Finland, such as turbidity of water, intense growth of annual algae that harms the growth of perennial species such as the bladder wrack (*Fucus vesiculosus*), harmful and potentially toxic algal occurrences, and changes in fish populations (improved growth of some species, and increased amount of fish and especially cyprinids, small fish and fries) (Kiirikki and Blomster, 1996, Pitkänen, 2004). The previous surveys related to the perceptions of general public of the nuisance caused by the consequences of eutrophication of the Gulf of Finland indicate the harmfulness of turbidity of water, toxicity of algae, slimy beaches, and abundance of littoral filamentous algae (Kiirikki et al., 2000, Kiirikki et al., 2003).

Several national and international actions and decisions, such as legislation, operation recommendations and programmes, aim at protecting the state of the Baltic Sea and Gulf of Finland. Since 1974, the Helsinki Commission (HELCOM) has protected the marine environment of the Baltic Sea through intergovernmental cooperation. To implement the Helsinki Convention signed in 1992, the HELCOM adopted a 20-year investment programme directed to the most polluting sources. In 1988, the Ministerial Declaration for the Baltic Sea states was set to reduce the nutrient load from each state by half by the year 1995. In 1998, to implement the updated declaration, Finnish Council of State issued the decision-in-principle to prevent further deterioration of waters and to improve the conditions where contamination already had occurred, and established Water Protection Targets for 2005. After a new decision-in-principle in 2002, the program was revised with regard to measures mainly in agriculture sector and rural settlement as, according to the assessment, the objectives would probably not have been reached. The resulting Action Plan for the Protection of the Baltic Sea and Inland Water Courses had two aims. First, to contribute to the

Finnish Programme for the Protection of the Baltic Sea as an implementation of the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) coordinated by United Nations Environment Programme (UNEP). Second, to facilitate to the preparation of the river basin management plans which are required by the Act on the Organisation of River Basin Management to be completed by the end of 2009. The most recent Baltic Sea wide programme by HELCOM, the Baltic Sea Action Plan, aims at achieving a good environmental status by 2021. The countries are to develop national nutrient reduction programmes by 2010. (Action Plan..., 2005, HELCOM, 2007)

The implemented policies and abatement measures have not been enough to reach the nutrient reduction targets. In 1999, Finland reached the reduction-by-half target with respect to phosphorous from the point sources. The nitrogen load from the point sources reduced by a fifth (21 %), but despite the abatement measures, nutrient load from the non-point sources did not reduce clearly (Lääne et al., 2002). In 2000, the total load of nitrogen (N) to the Gulf of Finland was 124 000 tons, and of phosphorous (P) 6300 tons. The load had decreased by almost 40 % from the late 1980's, mainly resulting from the economic change in Russia that resulted in decrease in agricultural and industrial production. Estonia reduced extensively fertilizer use and intensified nutrient removal in the most polluting sources. In Finland, the loading from point sources such as industry, fishery, and settlement decreased but agriculture as a non-point source remained a significant loader with a share of 51 % of nitrogen and 62 % of phosphorous in 2003 (Rekolainen et al., 2006). Regardless of the reduction in external loading to the Gulf of Finland, the water quality did not improve. One reason is internal loading that accelerated in the middle of 1990's supposedly due to the increased area of anoxic sea bottom and strengthened stratification (Pitkänen, 2004).

The ecologists have not reached the consensus about the effect of nutrient reduction on the marine ecosystem as for instance temperature, wind, winter conditions, salinity pulses, and internal loading may affect the development of the state (see e.g. Kiirikki et al., 2003 and Strategi för hav..., 2005). Some scenarios of the future state of the Gulf of Finland have been forecasted with a Baltic Sea ecosystem model (Kiirikki et al., 2003, Pitkänen et al., 2007a) that accounts for flows of nitrogen and phosphorous to the Gulf of Finland from land sources and the adjacent sub-basins, and hydrodynamic-biogeochemical processes of the sea. The ecosystem part of the model consists of two algal groups: "nitrogen-fixers", (i.e. cyanobacteria or blue green algae in layperson's terms), and "other phytoplankton" (as in Tyrrell 1999). According to the model, the long term (30+ years) development of the Gulf of Finland is highly dependent on where the nutrient reductions take place. The national measures alone can improve the state of the coastal waters only but international measures are needed for the improvement of the entire Gulf of Finland. The placement of reductions affects differently the biomasses of algal groups. For example, a 7 % reduction in the bioavailable loads of both nitrogen and phosphorous through measures in Finland, Estonia, and Russia and the reduction of atmospheric load would lead to a slight decrease in both cyanobacteria and other algae. If instead, the waste waters of the city of St. Petersburg were purified with 75 % efficiency regarding N and 80 % efficiency regarding P which results in a 5 % decrease in bioavailable nitrogen and 17% in bioavailable phosphorous, the biomass of cyanobacteria would decrease considerably and other algae slightly. The combination of the above-mentioned scenarios together with the nutrient reductions in Poland corresponding to the reduction-by-half target of the 1988/98 Ministerial Declaration would considerably decrease both the biomasses of cyanobacteria and other algae. (Pitkänen et al. 2007a, 2007b)

In our study, we use different water quality characteristics to reflect the effect of the reductions in nitrogen and phosphorous on the water quality of the Gulf of Finland, and estimate the magnitude

of the benefits from the nutrient reductions for Finns. The application of the choice experiment is described in the next section.

3. Method and application

Stated choice methods elicit the preferences of citizens for environmental goods that do not have market price. The most popular valuation methods that involve the stated preferences are the contingent valuation (CV) and the choice experiment (CE). Both assess the benefit resulting from policy implementations, and the choice experiment, in addition, allows for identifying which characteristics (or attributes) of the environmental good people consider the most important. The respondents are asked to choose between the alternative policy options that are characterized by attributes, and the choice data and the probabilistic choice model are used estimate the marginal prices (i.e. the willingness-to-pay, WTP) for each attribute. Then, the WTP estimates for different outcomes or policies are calculated. (Bennett and Adamowicz, 2001)

3.1. Econometric specification

Until recently, the most used probabilistic discrete choice model has been a multinomial logit (MNL) (or conditional logit) that features the independence of irrelevant alternatives (IIA) property. This means that all alternatives among which the respondents choose are assumed to be equally similar or dissimilar. The assumption of the equality of the utility functions across the respondents results in homogeneous taste parameter estimates. The systematic (i.e. linked to the observed characteristics of the respondent) individual heterogeneity can be introduced either by interacting socioeconomic variables with alternative-specific attributes or by dividing the sample into

segments. These approaches, however, may lead to many variables or the misspecification of groups as we use the beforehand knowledge about the sources of preference variations (Hensher and Greene, 2003). The increasingly popular models are random parameters (or mixed) logit model (RPL) and latent class model (LCM) (e.g. Birol et al., 2006; Milon and Scrogin, 2006; Morey et al., 2006; Wang et al., 2007). These models provide a more sophisticated way of introducing preference variation either at individual or group level, and, by letting individuals differ in respect to preferences, relax the IIA property. The RPL addresses random heterogeneity in the model by assuming, for each individual's preferences, a distribution chosen by the researcher. The LCM, in turn, formulates the parameter heterogeneity across individuals with a discrete distribution by setting the respondents into one of the classes (or segments) determined by the data but remained latent for the researcher. Within each class, the preferences are homogeneous and both the choice and the class membership probabilities are generated by the multinomial logit model. (Greene, 2003)

The probabilistic choice model exploits the random utility framework, where the utility U_{ji} of the alternative j to individual i consists of the observable additive component V_{ji} and the unobservable component ε_{ji} :

$$U_{ji} = V_{ji} + \varepsilon_{ji} = \alpha_{ji} + \beta \mathbf{x}_{ji} + \varepsilon_{ji},$$

where α_{ji} is the alternative-specific constant, the vector \mathbf{x}_{ji} consists of the attributes of alternatives (and individual specific factors such as age, gender, and income), and ε_{ji} is unobserved heterogeneity for individual i and alternative j . The error terms are assumed to be independently and identically distributed with identical type I extreme value distribution (the IIA property). The

parameter vector β is, depending on the model, either sample-specific β_s for the MNL, individual specific β_i for the RPL, or class-specific β_c for the LCM. The individual's choice of alternative that maximises his/her utility U_{ji} is formulated as a probability that the respondent chooses the alternative j :

$$\begin{aligned} \Pr(\text{choice} = j) &= \Pr(U_{ji} > U_{qi}), \forall q \neq j \\ &= \frac{\exp(\alpha_{ji} + \beta' \mathbf{x}_{ji})}{\sum_{q=1}^{J_i} \exp(\alpha_{qi} + \beta' \mathbf{x}_{qi})} . \end{aligned}$$

For the simple RPL model version, the random heterogeneity in preferences is introduced in the parameter vector $\beta_i = \beta_{ki}$ that consists of the population mean β_k , the individual specific heterogeneity (with mean zero and standard deviation one) ν_{ki} , and the standard deviation σ_k of the distribution of the individual-specific parameter vectors β_{ki} around population mean:

$$\beta_{ki} = \beta_k + \sigma_k \nu_{ki} .$$

For the full vector of K random coefficients in the model, the full set of random parameters is $\rho_i = \rho + \Gamma \mathbf{v}_i$, where $\Gamma = \text{diag}(\sigma_1, \sigma_2, \dots, \sigma_k)$. Any random utility model can be approximated by some RPL model specification (McFadden and Train, 2000).

The latent class model contains, in addition to a choice probability function, another probability function for class membership. The probability of the class membership follows the multinomial logit form:

$$P(\text{class} = c) = \frac{\exp(\theta'_c \mathbf{z}_i)}{\sum_{c=1}^C \exp(\theta'_c \mathbf{z}_i)}, \theta_c = 0$$

where \mathbf{z}_i is a set of individual specific characteristics, and the parameter vector θ_c for one class is normalised to zero. Given the membership of the class c , the probability that the respondent chooses alternative j in the choice situation t , is

$$P(\text{choice}_{ji} = j \mid \text{class} = c) = \frac{\exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})}{\sum_{j=1}^J \exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})}.$$

The choice model is conditional on the class membership and the class membership model. For an individual, the model's estimate of the probability of a specific choice is the expected value over classes of the class specific probabilities (Swait, 2006):

$$\Pr(y_{it} = j) = E_c \left[\frac{\exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})}{\sum_{j=1}^{J_i} \exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})} \right] = \sum_{c=1}^C \Pr[\text{class} = c] \left[\frac{\exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})}{\sum_{j=1}^{J_i} \exp(\alpha_{ji} + \beta'_c \mathbf{x}_{ji})} \right].$$

The calculation of welfare effects of different scenarios for the individual i is based on the estimated parameters α and β of the utility functions. The calculation follows the expression of Hanemann (1984):

$$WTP_i = \frac{1}{\gamma} \left[\ln \left(\sum_{k \in K} \exp(\alpha + \beta X_k^0) \right) - \ln \left(\sum_{k \in K} \exp(\alpha + \beta X_k^1) \right) \right],$$

where WTP_i is the individual specific welfare measure, γ refers to the marginal utility of income, and X^0 and X^1 refer to the status quo scenario and the policy scenario. In the latent class model, the welfare measures are weighted by the class membership:

$$WTP_i = \sum_{c=1}^C \pi_c \left(\frac{1}{\gamma_c} \left[\ln \left(\sum_{k \in K} \exp(\alpha + \beta_c X_k^0) \right) - \ln \left(\sum_{k \in K} \exp(\alpha + \beta_c X_k^1) \right) \right] \right)$$

where π_c is the membership probability to the class c (Boxall and Adamowicz, 2002).

3.2. Application

The core of the stated preference survey is the valuation question where the policy options that respondents compare are combinations of attributes that reflect the eutrophication status of the Gulf of Finland. Eutrophication leads to a large amount of consequences. Finding a set of attributes that illustrate broad and interdependent consequences of eutrophication, and are relevant to both policy makers and respondents (Bennett and Adamowicz, 2001) is important and challenging. Our choice of attributes was based on the information on the most experienced and the most harmful consequences according to previous studies (Kiirikki et al., 2000, 2003), our own pilot testing, and the indicators used by environmental administration. In the pilot phase, we asked the representatives of the general public about their perceptions on the consequences of eutrophication. We started with the list of consequences from previous studies (Kiirikki et al., 2000, 2003), and reduced the number of attributes by several interviewing rounds. The pilot results and the consultation with the ecologists in the Finnish Environment Institute and the University of Helsinki led to the choice of four attributes (in table 1): water clarity, abundance of so called coarse fish species, state of bladder wrack population, and mass occurrences of blue green algae blooms.

Water clarity and blue green algae blooms were found harmful and familiar for general public, and the abundance of coarse fish potentially harms recreational fishers. In the pilot interviews, respondents considered the bladder wrack as important for reproduction and development of small fish, and thus, the bladder wrack may serve as an indicator of existence value of the healthy sea ecosystem. Moreover, the monitoring of bladder wrack populations is part of coastal monitoring program required by the Water Framework Directive (Bäck et al., 2006). The levels of attributes captured the range of current and potential future trends in the state of the Gulf of Finland. As an example, the levels of the bladder wrack attribute correspond to the descriptions of ecological status in the Water Framework Directive such that the level ‘good’ corresponds to the high and good states, the level ‘weakened a bit’ to the moderate state, and the level ‘weakened a lot’ to the poor and bad states (S. Bäck, personal communication, 2007). The most damaging extent in the future was presented by the *status quo* alternative that serves as a reference point to utility change calculations (Bennett and Adamowicz, 2001). In addition to the water quality attributes, the price attribute was included in the policy options.

In the 12-page mail survey questionnaire constructed following the survey practice recommended by Dillman (2002) the respondents stated their preferences for alternative policies that prevent the deterioration of water quality of the Gulf of Finland by the year 2030. The core section presented the future scenario of the Gulf of Finland without new policy implementations (the status quo option), and provided an alternative: the better state resulting from the international co-operation and the rise in taxes for 20 years. 72 choice tasks consisting of the status quo alternative and two policy alternatives were created with help of Sawtooth Software’s balanced overlap procedure that allows for some overlap of the attribute levels within the choice task. The choice tasks with dominant alternatives were modified. Each respondent faced six choice situations, and in each, picked the preferred alternative. The beginning of the questionnaire introduced the study area and

the issue in question by examining respondent's connections to Gulf of Finland, experience about harm caused by eutrophication, and perceptions of the current state of the Gulf of Finland. In the end, information on answering the choice questions and about the respondent was collected.

4. Results

4.1. Descriptive statistics

The sample of 1900 Finns of ages 18-80 drawn from the Census Register was stratified on the grounds of the residential contact to the Gulf of Finland to be able to test hypotheses of the differences in the WTP's of non-coastal residents, part-time coastal residents who own summer cottage in coastal municipalities, and permanent coastal residents. After two mailings with a reminder in between and the removal of the questionnaires containing missing answers, the response rate was 42.7 %.¹ The identification of protesters (10.5 percents that were excluded from the analysis) was based on the following motivations given for reluctance to pay: 'polluters should pay', 'tax is too high' and 'don't believe that the measures would improve the state of the Gulf of Finland'. The table 2 shows the comparison of the descriptive statistics of the sample and the corresponding statistics of the Finnish population. For almost all pairs, the null hypothesis of the t-tests for equality of means cannot be rejected at 5 % level. Only the null hypotheses regarding age, the share of households with dependent children, income, coastal residence and cottage ownership are rejected. Thus, as the sample population, on average, is older, has higher income, and includes fewer households with dependent children and more coastal residents and cottage owners than the

¹ The questionnaires were split into three regarding the framing of the scenario: the base case with certain options, the case of uncertain policy options, and the case of uncertain status quo option. This paper does not study the uncertainty issue.

Finnish population, the WTP estimates may not be fully representative for a whole Finnish population.

In the lower part of the table 2, the characteristics related to the Gulf of Finland imply that the sample knows the study area rather well. Two thirds (63.09 %) live permanently on the coast, and one third (32.78 %) owns a cottage on the coast. About one third (32.92 %) has no residential contact to the Gulf of Finland. Almost all (96.05 %) have heard about the issue from the media, and as many as two out of three (71.07 %) have spent free time on the coast. One third (29.20 %) has fished on the Gulf of Finland during the year 2005. The current state of the Gulf of Finland is considered rather unsatisfactory as the most common perception of the current state was 'poor'. Slightly more than a half (55.54 %) has experienced harm from eutrophication. Regarding those respondents, the investigation of the harm caused by turbidity of water and blue green algae blooms reveals the differences in the perceptions of and the magnitude of the harmfulness. The turbidity of water is less often perceived as both 'very harmful' (the high extreme of the 4-point scale) and 'not harmful at all', implying that blue green algae blooms cause harm only for some respondents but then the harm is considered substantial. The same applies for the comparison of the water clarity with the weakened bladder wrack population. The amount of coarse fish is not considered very harmful.

4.2. Models

All models were estimated using Limdep 9.0 Nlogit 4.0. The variable ASC is the alternative specific constant (specified zero for status quo alternative and one otherwise), and the variable *price* refers to the price attribute. The coding of the 3-level water quality attributes is continuous (0, 1,

2)². We report the results of MNL and RPL models (table 3), the hypothesis testing (table 4), the IIA test (table 5), and the LCM (tables 6 and 7).

Multinomial logit and hypothesis testing

The basic multinomial logit (or, in this case conditional logit) model with only alternative-specific attributes as the explanatory variables serves as an essential starting point for modelling (Hensher and Greene, 2003). A second column of the table 3 presents the results. The overall fit of the model measured by McFadden's ρ^2 is fairly good (0.17), and the coefficients are significant at less than 5 % level indicating that all parameters significantly affect the choice. The positive sign of the ASC indicates the higher utility when choosing the policy alternative instead of the *status quo*. The expected negative sign of price coefficient implies higher utility from alternatives with lower price levels, while the positive signs of water quality coefficients, as expected, imply higher utility from alternatives with higher water quality levels. The comparison of the magnitudes of water quality coefficients reveals the highest importance of water clarity followed by blue green algae, fish, and bladder wrack.

The introduction of interaction terms accounts for heterogeneity in the sample and uncovers whose welfare is affected by the changes in the environmental state (Boxall and Adamowicz, 2002). We tested various sociodemographic variables as interactions with either alternative-specific constants or attributes of the alternatives. The former captures heterogeneity towards choosing the policy vs. *status quo* options and the latter towards different attributes. We also tried several interaction

² For quantitative attributes, dummy or effects coding is recommended (see e.g. Louviere et al., 2000). In our case, however, where the status quo levels of three-level attributes are not included in other alternatives, the inclusion of all eight effects coded variables leads to non-convergence of the model. We compared the WTP estimates from different coding schemes when only two attributes, water clarity and blue green algae, were in the model. The continuous coding resulted in higher scenario WTP estimates than effects coding with 18.5–31.8 %. The effect was stronger for the scenarios with lower attribute levels.

effects of the attributes, but as they did not fit the data well, we ended up studying the main effects only. The results from the model including interactions with alternative-specific constants (in table 4) confirm our hypotheses on stronger preference for water quality improvement of coastal residents, cottage owners, and recreational fishers. Moreover, younger respondents, women, and respondents whose yearly household income is higher than 40 thousand euros more likely choose the policy alternatives instead of the *status quo* alternative.³

The results of the MNL model with interactions with water quality attributes are reported in the third column of the table 3. The inclusion of interaction terms into the model improves the overall model fit measured by McFadden's ρ^2 (0.22) compared to the model without interactions (0.17). The likelihood ratio test of the null hypothesis that the MNL model with interactions makes no difference from the MNL model without interactions is rejected at 5 % level. However, out of the highly significant water quality coefficients of the basic MNL, only the one for water clarity remains significant. The interaction MNL model accounts for the heterogeneity of preferences for water quality attributes stemming from the characteristics that we found to fit the data: age, gender, income, residential contact to the Gulf of Finland (either permanently lives or owns a summer cottage in a coastal municipality), and whether the respondent has experienced harm due to eutrophication. Younger people and females tend to choose the alternatives with higher level of blue green algae attribute. In addition, females choose more often than males the alternative with higher level of bladder wrack. People with higher income choose more often the alternatives with higher levels of water clarity, bladder wrack and blue green algae. Coastal residents tend to choose the alternatives with high levels of blue green algae attribute, and non-coastal residents the alternatives with high levels of bladder wrack attribute. If the respondent has experienced harm

³ Further testing of preference variation by interactions of sociodemographic characteristics with the price attribute reveal that the coastal residents (permanent residents and cottage owners), recreational fishers and people with higher income tend to choose more expensive alternatives reflecting higher willingness to pay for water quality improvement. However, the coefficients are very small (0.000–0.003) though statistically significant at 1 % level.

from eutrophication, he tends to choose alternatives with higher levels of bladder wrack and blue green algae. None of the selected sociodemographic characteristics affect the variation of valuation for fish attribute, and cottage ownership does not affect preference variation in any water quality attribute.

The common problem of the MNL, the assumption of independence of irrelevant alternatives (IIA), is tested by the Hausman and McFadden (1984) test (table 5). When comparing the P-values to 0.05, the null hypothesis cannot be rejected. This indicates that, in our case, the rejection (or inclusion) of one alternative or a change in its attributes does not change the ratio of choice probabilities of other alternatives, i.e. the model takes the (dis)similarity of the alternatives into account. Although the result suggests no need for a more complex model than MNL (see Hensher et al., 2005, p. 601), we use the random parameters logit to reveal whether there is random preference variation regarding the attributes, and the latent class model to model the heterogeneity in the group level instead of the individual level.

Random parameters logit

The fourth and fifth columns in table 3 report the results of the no-interaction RPL model and the RPL with interactions of sociodemographic characteristics. The models are based on 1000 simulation draws. The ASC and the price attribute were specified to be non-random, and the random water quality parameters were specified normally distributed. Both RPL models show statistically significant standard deviations of some of the water quality coefficients indicating random variation of preference among the respondents for that attribute. The standard deviation coefficients for water clarity and blue green algae are significant in both RPL models, and additionally the standard deviation coefficient for fish in the no-interaction RPL model. The

heterogeneity across respondents is relatively large as the standard deviation coefficients are larger than the mean coefficients. In the RPL model comparison, the inclusion of interaction terms that reveal the heterogeneity observed by the data improves the model fit measured by McFadden's ρ^2 (0.25 and 0.29) and the likelihood ratio test. The interpretation of the coefficients of the interaction terms follows the MNL interaction model. The additional heterogeneity revealed by the RPL model is that older people choose more likely the alternatives with high levels of bladder wrack, and the respondents with harm experience the alternatives with higher levels of water quality.

Latent class model

The optimal number of classes in the LCM was identified by assessing the information criteria (Akaike and Bayesian), ρ^2 and the log likelihood statistics (see e.g. Swait 2006) from the models with 2, 3, 4, and 5 classes (table 6). The log likelihood and ρ^2 values present remarkable changes from the 3-class to the 4-class model and even a slight change when the fifth class is added in the model. This indicates that while the model improves remarkably until the fourth class, a 5-class model is not that much better than the 4-class model. To strengthen the choice of four classes, both information criteria by their minimum values suggest the use of the 4-class model.

The results of the latent 4-class model reported in table 7 support the existence of preference heterogeneity in the sample for water quality characteristics. Two attributes that over the classes significantly affect the choice are the price of the policy and water clarity. In addition, other significant factors are fish attribute for classes B and C, bladder wrack for classes A, B, and C, and blue green algae for classes B, C, and D. The significant signs of the coefficients imply that the higher price of the policy and the lower state of the water quality characteristics has a negative effect on the respondent's utility from the alternative, while non-significance implies that the

attribute does not affect the choice. The within-class comparison of coefficients reveals the differences between the classes in regard to the highest valued attributes. While the classes A and D rank water clarity the first, the highest valued attribute for the classes B and C is blue green algae. The class A values bladder wrack almost as much as water clarity, but in other three classes, bladder wrack is the least valued attribute. However, the class C puts almost equal values for the water quality attributes. The positive and statistically significant constants for the classes A and C indicate preference for the policy options (i.e. the better state of the Gulf) for the reasons not captured by the attributes, while the significant negative constant of class D is unexpected.

The lower part of table 7 shows the results of the class membership model. The estimates for the fourth class are normalised to zero, and the other classes are compared to that class. Women and cottage owners are likely members of the class A that puts high value for water clarity and bladder wrack, while respondents with higher income and residents of the coastal municipalities likely are members of the class B that favors improvements in the blue green algae. Younger people are likely members of the class C that revealed no strict ranking of the attributes. The model addresses 53 % of the sample to class A, 12 % to the class B, 13 % to the class C, and 22 % to the class D. The relatively high ρ^2 (0.53) indicates good model fit.

Among MNL, RPL, and LCM, the best fitting one was found by conducting the likelihood ratio test for nested models, and the Ben-Akiva and Swait (1986) test for non-nested models. The likelihood ratio test shows that, at 5 % level, the RPL is better than MNL as the chi-square statistics (20.01) clearly exceeds the critical limit for 4 degrees of freedom (9.49) allowing us to reject the null hypothesis that the RPL is no better than the MNL. According to the Ben-Akiva and Swait (1986) test for comparison of non-nested models, RPL with interactions is outperformed by the latent class model, as the probability that the RPL is better is negative (-53.19).

4.3 Marginal prices for attributes

The marginal price is the marginal benefit from a discrete one-level change in water quality attribute (or the willingness to pay for a one-level improvement in an attribute all else being constant). (Bennett and Blamey, 2001) The upper part of table 8 presents the WTP estimates from MNL, RPL, and the latent 4-class model, for which the WTPs are the weighted sums of class-specific values presented in the lower part of the table 8. For each respondent, the *a priori* probabilities for the class membership are multiplied by the marginal WTP's of the classes calculated from the model parameters. The marginal prices for the attributes and the corresponding standard errors from the MNL and RPL models are calculated with Limdep 9.0 Nlogit 4.0 by the Delta method, i.e. by dividing the coefficient of water quality attribute by the coefficient of the price attribute (Louviere et al., 2000).

The measure of consistency between the models, the order of ranking of the attributes, stays equal over MNL, RPL, and LCM. In all three models, water clarity is the highest ranked attribute followed by blue green algae, fish, and bladder wrack, although in the LCM specification, the differences are smaller. The class specific marginal prices for attributes show that the magnitudes of preferences for and the ranking orders of water quality characteristics differ between the classes. Only the class D follows the ranking order of the weighted marginal prices. For the class A, the marginal prices of water clarity and bladder wrack are almost equal, and the marginal price of fish is half of that. The class A does not see the improvement blue green algae worth paying for. The class B values blue green algae the most and considerably as the marginal price (237.44 €) is almost twice the marginal price of the next-ranked water clarity. Moreover, the class B assigns relatively

high values for all attributes compared to other classes. The marginal prices of classes C and D are fairly small compared to the classes A and B.

The internal validity of the results is tested in two ways: by comparing the ranking to the perceptions of harmfulness of the consequences of eutrophication and the most important attribute in the choice situation stated by the respondent. The ranking order based on the marginal prices is in line with the frequency of harmfulness experience but not with the magnitude of harmfulness reported in section 4.1. Either the answers for the most important attribute are not in line with the estimated model parameters that imply the highest ranking of water clarity. 23.5 % of the respondents who stated the existence of more important attribute(s) reported blue green algae the most important. The corresponding share for water clarity was 17.0 %. One explanation may be that the latent class B expressed high importance of blue green algae, but as only 12 % of the sample was allocated to that class, in the weighted latent class analysis this effect disappeared. To test the equality of marginal prices obtained from different models, we conduct the t-test that assumes normal distribution of marginal prices. We conclude that, at 5 % level, the marginal prices from the MNL and the LCM differ from each other regarding all attributes, while the marginal prices from the LCM equal the marginal prices from the RPL regarding fish and blue green algae.

4.4 Welfare estimates of nutrient reduction policies

The marginal prices reflect the benefit from the improvement of one attribute at time. From the policy maker's view, the benefit estimates of different nutrient reduction policies that induce the improvements in water quality attributes would be more interesting. We construct the combinations of the attributes such that they somewhat loosely correspond to the long term forecasts of the Baltic Sea ecosystem model described in section 2. The resulting states of the Gulf of Finland are

improvements over the status quo that represents the result in the case that the Finnish Programme for the Protection of the Baltic Sea fails and does not include new policy implementations (Kiirikki et al., 2003). The forecasts differ in terms of intensity of reduction and effect on different algal groups (cyanobacteria, other algae). The group 'cyanobacteria' corresponds to the blue green algae attribute. The group 'other algae' is linked to the bladder wrack attribute as the share of littoral filamentous algae increases at expense of bladder wrack (Pitkänen, 2004), and water clarity and fish attributes improve together with the bladder wrack attribute.

The scenario 1 in table 9 results from nutrient reductions in Estonia, Russia and Finland due to the most stringent alternative in the Guidelines for Water Protection to 2015 (Rekolainen et al., 2006) that corresponds to the reductions of 33 % of total nitrogen and 44 % of total phosphorous from Finland compared to the mean loads of 1997–2002. In the ecosystem, this will lead to a slight (up to 15 %) reduction in the biomasses of both cyanobacteria and other algae. The scenario 2, that is the intensified purification of waste waters in the city of St. Petersburg leading to as much as 49 % and 53 % reductions in nitrogen and phosphorous loads of the year 2004, results in a considerable (15–35 %) reduction in the cyanobacterial biomass and a slight (up to 15 %) reduction in the biomass of other algae. The scenario 3 consists of the scenarios 1 and 2 combined with the nutrient reductions in Poland according to the Ministerial Declaration 1988/98 i.e. 21 % of nitrogen and 25 % of phosphorous compared to the mean loads of 1995–1999 of rivers and 2000 for coastal point sources. The result of this combined scenario is a considerable (more than 15 %) reduction in the biomasses of both cyanobacteria and other algae. (Pitkänen et al., 2007a, 2007b) The slight reduction in the algal biomass corresponds to low improvement in the attribute and the considerable reduction to high improvement.

The benefit estimates for three scenarios (table 9) are based on the marginal prices from the best fitting model, the LCM. The first WTP column presents the mean annual willingness to pay estimates for the average Finnish household: 363 € for scenario 1, 390 € for scenario 2, and 473 € for scenario 3.⁴ The second WTP column presents the WTP of Finnish population consisting of 2.405 million households (Statistics Finland, 2006) for the first year of payment. In the third WTP column, the total willingness to pay estimates for scenarios are discounted by the rate of 7 % over 20 years time as was specified in the questionnaire. The total WTPs for three scenarios are 9 905 million €, 10 630 million €, and 12 896 million €, and these divided by 20 years give the total annual WTPs presented in the last column. Cost estimates are available for the alternative nutrient reduction policies (see e.g. Gren et al., 1997b, Rekolainen et al., 2006, Vodokanal, 2006), however, the appropriate comparison of benefits and costs to identify the optimal investments is beyond the scope of this paper.

5. Conclusion

We conducted a choice experiment survey and estimated the willingness to pay for the water quality improvement of the Gulf of Finland characterized by four water quality characteristics: water clarity, amount of so called coarse fish (*Cyprinids*), health of bladder wrack (*Fucus vesiculosus*), and mass occurrences of blue green algae (*Cyanobacteria*). We identified the preference heterogeneity for water quality characteristics and explored the sources of heterogeneity by including interaction terms to the multinomial logit and the random parameters logit models and by the latent class model.

⁴ As the sample did not fully represent the Finnish population (a higher share of people with residential contact), and the estimations may be biased upwards.

The willingness to pay estimates for three nutrient reduction policies ranged from 9.9 to 12.9 billion euro. The high estimates relatively close to each other indicate high willingness to pay of Finnish population for ‘doing something’ for the unsatisfactory state of the Gulf of Finland by the year 2030. The implementation of any policy to improve the state increases especially the welfare of people with close connection to the Gulf of Finland (residential or recreational contact), female sex, higher income, and young age. The implementation of policies targeted to the reduction of blue green algae blooms (such as water purification in the city of St. Petersburg) increases especially the welfare of young people and coastal residents.

As the most important water quality characteristics, the average respondent regarded water clarity followed by blue green algae blooms, fish, and bladder wrack, from which ranking the latent class model showed deviations. People living on the coast or earning high income valued the reduction of the mass occurrences of blue green algae the most, and expressed the highest willingness to pay. Young people had no clear priorities for the water quality attributes, although they also valued highest the blue green algae. In contrast, cottage owners and females ranked water clarity and bladder wrack the most important. As a conclusion from all models, coastal residents and younger people focus on blue green algae, the nuisance that occurs rarely but may then be of great harm. Instead older people, cottage owners, and non-coastal residents put more value on the bladder wrack that is less use related and more ecosystem health related than the other attributes, revealing a more protection oriented relationship to the Gulf of Finland.

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Table 1. Attributes and levels (the *status quo* levels bolded).

Attributes	Attribute levels
Tax for household once a year for 20 years (€)	0 , 5, 30, 70, 150, 350, 500
Water clarity (in 1m depth)	Bottom clearly visible, hardly visible, not visible
Amount of so called coarse fish (<i>Cyprinids</i>)	Small, large, very large
State of bladder wrack population	Good, weakened a bit, weakened a lot
Mass occurrences of blue green algae during summer	1–4 days, 5–21 days, 22–60 days

Table 2. Descriptives of the data and the corresponding data on the Finnish population.

	Sample average	Finnish average ¹
Sample size	727	5255580
<i>Sociodemographic characteristics</i>		
Age*	51.48	45.88
Gender (% of males)	51.79	49.55
Household size	2.34	2.14
Dependent children in the household (% with dep.ch.)*	12.32	41.18
Education (% with polytechnic or university degree and above)	36.7	13.84
Unemployment (% without employment)	2.64	5.35
Income (net, thousand € / year)*	37.8	31
<i>Characteristics related to the Gulf of Finland</i>		
Coastal residence (% living on the coastal municipalities)*	63.09	23.47
Cottage Ownership (% of cottage owners on the coast of the Gulf of Finland)*	32.78	2.44
No residential contact to the Gulf of Finland (%)	32.92	-
Recreational fisher (%)	29.2	-
Heard from the media about the issue (%)	96.05	-
Spent free time on the coast (%)	71.97	-
Perception of the current state of the Gulf (1 = excellent, 5 = very poor), modal answer	4 = poor	-
Experienced harm from eutrophication (%)	55.54	-
Water clarity considered very harmful / not at all harmful (%)	13.09 / 0.69	-
Amount of coarse fish (cyprinids) considered very harmful / not at all harmful (%)	4.41 / 11.02	-
Weakened bladder wrack population considered very harmful / not at all harmful (%)	16.94 / 5.79	-
Blue green algae considered very harmful / not at all harmful (%) ²	29.51 / 2.82	-

*) The means are not equal at the 5 % level according to the t-test. ¹) The data of Finnish Population is from Statistics Finland (2006). ²) The measure of harmfulness related to blue green algae is the mean value of the perceptions about 'blooms in the open sea', 'large amounts of algae', 'small amounts of algae', and 'potential health risk'.

Table 3. The results of multinomial logit and random parameters logit without and with interaction terms.

Variable / Model	MNL	MNL with interactions	RPL	RPL with interactions
ASC	0.872 (0.117)***	1.057 (0.131)***	1.584 (0.283)***	1.939 (0.360)***
Price	-0.007 (0.000)***	-0.007 (0.000)***	-0.009 (0.000)***	-0.010 (0.000)***
Water clarity	0.312 (0.044)***	0.312 (0.180)*	0.380 (0.059)***	0.397 (0.230)*
Fish	0.212 (0.045)***	-0.120 (0.185)	0.241 (0.058)***	-0.140 (0.233)
Bladder wrack	0.092 (0.043)**	-0.188 (0.172)	0.110 (0.053)**	-0.245 (0.214)
Blue green algae	0.230 (0.042)***	0.208 (0.172)	0.253 (0.055)***	0.077 (0.232)
Age*water	-	-0.004 (0.003)	-	-0.006 (0.004)
Age*fish	-	0.005 (0.003)	-	0.006 (0.004)
Age*blwrack	-	0.005 (0.003)	-	0.006 (0.004)*
Age*bgalgae	-	-0.008 (0.003)***	-	-0.010 (0.004)**
Male*water	-	0.033 (0.091)	-	0.006 (0.114)
Male*fish	-	-0.118 (0.093)	-	-0.169 (0.118)
Male*blwrack	-	-0.146 (0.087)*	-	-0.189 (0.107)*
Male*bgalgae	-	-0.178 (0.088)**	-	-0.228 (0.116)**
Income*water	-	0.004 (0.002)**	-	0.006 (0.003)**
Income*fish	-	0.002 (0.002)	-	0.003 (0.003)
Income*blwrack	-	0.004 (0.002)**	-	0.005 (0.002)**
Income*bgalgae	-	0.006 (0.002)***	-	0.009 (0.003)***
Coast*water	-	-0.079 (0.104)	-	-0.118 (0.131)
Coast*fish	-	0.103 (0.109)	-	0.135 (0.138)
Coast*blwrack	-	-0.254 (0.099)**	-	-0.308 (0.123)**
Coast*bgalgae	-	0.344 (0.101)***	-	0.470 (0.139)***
Cottage*water	-	-0.002 (0.117)	-	-0.008 (0.146)
Cottage*fish	-	0.016 (0.124)	-	0.034 (0.152)
Cottage*blwrack	-	-0.109 (0.111)	-	-0.105 (0.136)
Cottage*bgalgae	-	0.038 (0.101)	-	0.029 (0.148)
Harm*water	-	0.012 (0.008)	-	0.019 (0.010)*
Harm*fish	-	0.001 (0.008)	-	0.002 (0.010)
Harm*blwrack	-	0.020 (0.007)***	-	0.021 (0.009)**
Harm*bgalgae	-	0.017 (0.008)**	-	0.026 (0.010)**
St.Dev Water	-	-	0.586 (0.218)***	0.704 (0.234)***
St.Dev Fish	-	-	0.603 (0.197)***	0.312 (0.433)
St.Dev Blwrack	-	-	0.290 (0.275)	0.214 (0.357)
St.Dev Bgalgae	-	-	0.729 (0.227)***	1.020 (0.257)***
Number of obs	3946	3490	3946	3490
Log Likelihood	-3273.449	-2717.54	-3262.72	-2708.13
ρ^2	0.16869	0.21852	0.24738	0.29368

Standard errors are in parentheses. ***(**)*significant at 1(5)10 % level

Table 4. The MNL model with interactions with alternative-specific constant (ASC).

Attributes	Coef	Interactions	Coef
ASC	0.959***(0.215)	Age*ASC	-0.006*(0.003)
Price	-0.007***(0.000)	Male*ASC	-0.745***(0.104)
Water clarity	0.319***(0.045)	Inc40*ASC	0.906***(0.117)
Fish	0.216***(0.045)	Fish*ASC	0.448***(0.139)
Bladder wrack	0.096**(0.043)	Coast*ASC	0.245***(0.107)
Blue green algae	0.232***(0.043)	Cottage*ASC	0.256*(0.137)
	No of obs	3946	
	LogL	-3194.961	
	ρ^2	0.18863	

Standard errors are in parentheses. ***(**)*significant at 1(5)10 % level

Table 5. The IIA test results.

Alternative dropped	Chi-squared value	P value
A	75.15	0.000
B	87.95	0.000
C	0.24	0.972

Table 6: Criteria for selecting the optimal number of classes.

Number of classes	LogL	ρ^2	AIC	BIC	Parameters (P)
2	-2212.81	0.4896	4463.63	2291.48	19
3	-2217.83	0.5115	4499.67	2350.32	32
4	-2035.77	0.5304	4161.53	2222.08	45
5	-2022.97	0.5334	4161.94	2263.76	58

AIC=Akaike Information Criterion: $-2(\text{LogL}-P)$, BIC=Bayesian Information Criterion: $-\text{LogL}+(P/2)*\ln(N)$, $N=3946$

Table 7: Model results from the latent class model.

Variable / Class	A	B	C	D
<i>Utility function</i>				
ASC	3.130 (0.260)***	4.330 (3.990)	3.822 (0.388)***	-2.048 (0.593)***
Price	-0.009 (0.000)***	-0.007 (0.000)***	-0.085 (0.007)***	-0.050 (0.004)***
Water clarity	0.275 (0.088)***	0.991 (0.092)***	0.424 (0.202)**	0.795 (0.197)***
Fish	0.136 (0.088)	0.790 (0.090)***	0.440 (0.237)*	0.399 (0.207)
Bladder wrack	0.264 (0.081)***	0.348 (0.087)***	0.376 (0.182)**	0.007 (0.221)
Blue green algae	-0.096 (0.085)	1.637 (0.108)***	0.488 (0.189)***	0.678 (0.221)***
<i>Class membership function</i>				
Constant	2.036 (0.620)***	0.032 (0.778)	1.723 (0.722)**	-
Age	0.000 (0.011)	-0.015 (0.013)	-0.025 (0.013)*	-
Male	-0.912 (0.339)***	-0.580 (0.382)	-0.333 (0.404)	-
Income	-0.001 (0.001)	0.018 (0.006)**	-0.001 (0.001)	-
Coast	-0.451 (0.348)	1.635 (0.468)***	0.043 (0.410)	-
Cottage	0.807* (0.476)	0.640 (0.500)	0.334 (0.588)	-
Harm	-0.000 (0.001)	-0.000 (0.001)	-0.001 (0.001)	-
<i>Latent class probs</i>	0.53	0.12	0.13	0.22
<i>Number of obs</i>	3946			
<i>Log likelihood</i>	-2035.77			
ρ^2	0.5304			

Standard errors are in parentheses. ***(**)*significant at 1(5)10 % level

Table 8. Marginal prices (and the 95 % confidence intervals in the parentheses) for the discrete one-level changes in attributes derived from the MNL and RPL models without interactions and the latent class model (weighted and class-specific estimates).

Model / Attribute	Water clarity	Fish	Bladder wrack	Blue green algae
MNL	45.08 (32.45-57.71)	30.66 (17.99-43.32)	13.35 (1.36-25.34)	33.22 (21.48-44.96)
RPL	44.23 (31.63-56.84)	28.04 (15.22-40.85)	12.86 (1.02-24.70)	29.4 (16.97-41.84)
LCM Weighted	37.33 (34.87-39.79)	23.8 (21.78-25.83)	21.99 (20.96-23.03)	26.61 (22.03-31.19)
Class A	29.9 (11.13-48.68)	14.81 (-3.81-33.43)	28.72 (11.82-45.61)	-
Class B	143.66 (116.61-170.72)	114.57 (88.91-140.23)	50.47 (26.60-74.35)	237.44 (211.22-263.66)
Class C	5.01 (0.35-9.66)	5.2 (-0.00-10.40)	4.44 (0.46-8.43)	5.77 (1.70-9.85)
Class D	15.77 (7.96-23.58)	6.73 (-1.26-14.71)	0.13 (-8.44-8.70)	13.45 (5.35-21.55)

Table 9. Benefit estimates of three alternative nutrient reduction scenarios

No	Biomass reductions	Improvements in attributes	Mean annual household WTP (€)	Population WTP / year 1 (m€)	Total WTP (m€)	Total annual WTP (m€)
1	Other: <15 % Cyano: <15 %	Wat: low, Fish: low Blw: low, Bga: low	363	874	9905	495
2	Other: <15 % Cyano: >15 %	Wat: low, Fish: low Blw: low, Bga: high	390	938	10630	532
3	Other: >15 % Cyano: >15 %	Wat: high, Fish: high Blw: high, Bga: high	473	1138	12896	645