VALUATION OF REDUCED EUTROPHICATION IN THE GULF OF FINLAND

Choice Experiment with Attention to Heterogeneous and Discontinuous Preferences and Respondent Uncertainty

Anna-Kaisa Kosenius

Department of Economics and Management
University of Helsinki

ACADEMIC DISSERTATION

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Supervisors:	Professor Markku Ollikainen Department of Economics and Management University of Helsinki Helsinki, Finland
	Professor Eija Pouta MTT Economic Research Helsinki, Finland
Pre-examiners:	Ph.D. Juha Siikamäki Resources for the Future Washington DC, U.S.A.
	Professor Tore Söderqvist Enveco Miljöekonomi Stockholm, Sweden
Opponent:	Professor Anni Huhtala MTT Economic Research Helsinki, Finland
Custos:	Professor Marko Lindroos Department of Economics and Management University of Helsinki Helsinki, Finland

Cover design: Laura Korkalainen
Cover photos: Anna-Kaisa Kosenius (Hanko 2003 and 2006)

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Abstract

Eutrophication of the Baltic Sea is a serious problem. This thesis estimates the benefit to Finns from reduced eutrophication in the Gulf of Finland, the most eutrophied part of the Baltic Sea, by applying the choice experiment method, which belongs to the family of stated preference methods. Because stated preference methods have been subject to criticism, e.g., due to their hypothetical survey context, this thesis contributes to the discussion by studying two anomalies that may lead to biased welfare estimates: respondent uncertainty and preference discontinuity. The former refers to the difficulty of stating one's preferences for an environmental good in a hypothetical context. The latter implies a departure from the continuity assumption of conventional consumer theory, which forms the basis for the method and the analysis. In the three essays of the thesis, discrete choice data are analyzed with the multinomial logit and mixed logit models.

On average, Finns are willing to contribute to the water quality improvement. The probability for willingness increases with residential or recreational contact with the gulf, higher than average income, younger than average age, and the absence of dependent children in the household. On average, for Finns the relatively most important characteristic of water quality is water clarity followed by the desire for fewer occurrences of blue-green algae. For future nutrient reduction scenarios, the annual mean household willingness to pay estimates range from €271 to €448 and the aggregate welfare estimates for Finns range from 28 billion to 54 billion euros, depending on the model and the intensity of the reduction.

Out of the respondents (N=726), 72.1% state in a follow-up question that they are either "Certain" or "Quite certain" about their answer when choosing the preferred alternative in the experiment. Based on the analysis of other follow-up questions and another sample (N=307), 10.4% of the respondents are identified as potentially having discontinuous preferences. In relation to both anomalies, the respondent- and questionnaire-specific variables are found among the underlying causes and a departure from standard analysis may improve the model fit and the efficiency of estimates, depending on the chosen modeling approach. The introduction of uncertainty about the future state of the Gulf increases the acceptance of the valuation scenario which may indicate an increased credibility of a proposed scenario.

In conclusion, modeling preference heterogeneity is an essential part of the analysis of discrete choice data. The results regarding uncertainty in stating one's preferences and non-standard choice behavior are promising: accounting for these anomalies in the analysis may improve the precision of the estimates of benefit from reduced eutrophication in the Gulf of Finland.

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List of essays

This thesis is based on the following essays:

I Kosenius, Anna-Kaisa. 2010. Heterogeneous preferences for water quality attributes: the case of eutrophication in the Gulf of Finland, the Baltic Sea. *Ecological Economics* 69: 528-538.

II Kosenius, Anna-Kaisa. 2010. Respondent uncertainty in choice experiment: causes and implications for WTP estimation. Manuscript.

III Kosenius, Anna-Kaisa. 2010. Does accounting for discontinuous preferences improve the willingness to pay estimates for reduced eutrophication in the Gulf of Finland? Manuscript.

The essays are referred to in the text by their roman numerals.

List of abbreviations

ASC	alternative-specific constant
CE	choice experiment
CL	conditional logit
CS	consumer surplus
CV	contingent valuation
ECM	error component multinomial (logit)
EV1	extreme value type 1
HEV	heteroscedastic (extreme value) logit
IIA	independence of irrelevant alternatives
IID	independent and identically distributed
LCM	latent class model
MNL	multinomial logit
MXL	mixed logit
RPL	random parameters logit
RP	revealed preference
RUM	random utility model
SP	stated preference
WTP	willingness to pay

1 Background

1.1 Eutrophication and its consequences

The eutrophication of both salt-water and fresh-water systems is a worldwide environmental problem. Eutrophication refers to the accumulation of an excessive amount of nutrients (nitrogen and phosphorous) in an aquatic ecosystem, leading to an increased primary production and growth of plants. Eutrophication has numerous undesirable effects, such as increased turbidity of the water, accelerated growth of potentially toxic algae blooms, reduced biodiversity, and changes in the populations of species as well as in the structure and functioning of marine ecosystems. The increased mass of dead plants settling to the sea bottom to be decomposed by benthic organisms causes a decrease in oxygen levels in the sea bottom and, especially in stratified waters, even oxygen depletion (EEA 2001).

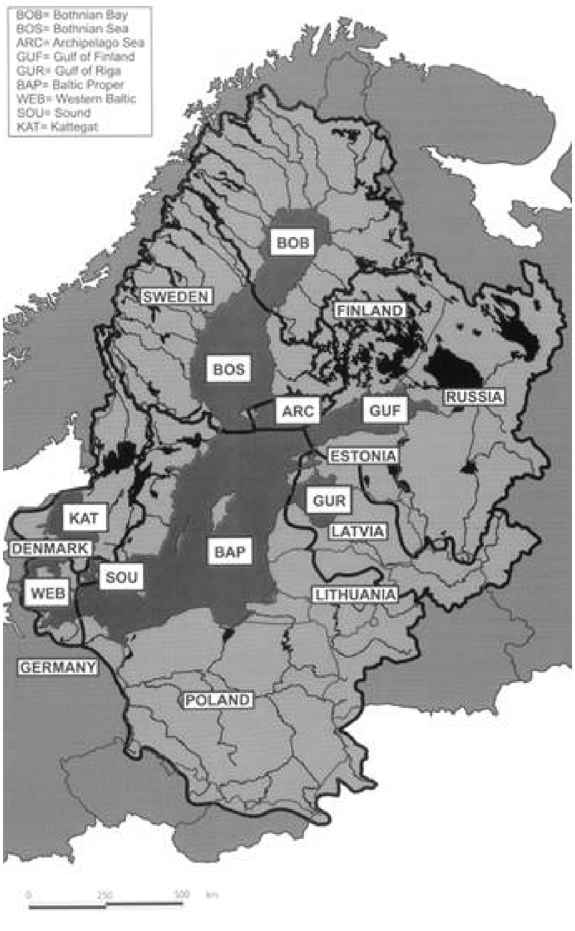

Figure 1-1. A map of the catchment area of the Baltic Sea. GUF = The Gulf of Finland. (Source: HELCOM)

The Baltic Sea (Fig. 1-1), situated in north-eastern Europe, is very sensitive to eutrophication for several reasons. First, it is a semi-closed inland sea. Water renewal is slow owing to the fact that the only connection between the Baltic Sea and the North Sea is through the narrow and shallow Danish Straits. The rarity of the inflows of salty water rich in oxygen worsens the risk of hypoxia, i.e., a lack of dissolved oxygen (O_2) in bottom waters. In addition, due to the slow water renewal, the nutrients related to the eutrophication process stay in the sea for decades (HELCOM 2009).

Second, the large catchment area (1,700,000 square kilometers) surrounding the Baltic Sea produces, through many rivers, a large inflow of fresh water into the sea. This causes a vertical stratification with respect to salinity, impeding the oxygenation of the bottom waters and sediments. In anoxic conditions, the sediments release considerable quantities of phosphorous into the sea water. This phenomenon is known as “internal loading” (HELCOM 2009).

Third, the large catchment area with a high population density implies that a great number of human activities impact the Baltic Sea. Approximately 85 million inhabitants live in the catchment area of the Baltic Sea. The nutrients that pass into the sea come from 1) air deposition caused by fossil fuel combustion from energy production and transport, 2) loading from point sources, such as municipalities and industry, on the coast and in the catchment area, and 3) run-off from diffuse sources, that is, agriculture and scattered dwellings (HELCOM 2009).

Fourth, brackish water implies rather low biodiversity because few species can survive in brackish water. Having a small number of species makes an ecosystem more vulnerable to changes in surrounding environmental conditions, such as the undesirable effects of eutrophication.

The Baltic Sea consists of sub-areas that differ in terms of, e.g., the salinity and residence time of the water as well as the level of eutrophication. One of the most eutrophied sub-areas, measured by the ratio of the nutrient load and the surface area, is the Gulf of Finland. It receives a nutrient inflow that is 200–300% larger than the average level of nutrient inflow in the Baltic Sea (Pitkänen et al. 2001). The Gulf of Finland is the second-largest sub-basin of the Baltic Sea after the Baltic Proper. The gulf is rather shallow with a mean depth of 37 meters. The complex coastline encourages the accumulation of nutrients (Fleming-Lehtinen et al. 2007).

In total amounts, in 2006 (2000), 130,000 (124,000) tons of nitrogen (N) and 5,000 (6,300) tons of phosphorus (P) ran into the Gulf of Finland from the catchment area, which is settled by 20 million people (Pitkänen et al. 2001, HELCOM 2009). The impact of nutrient reductions in the Gulf of Finland depends on which nutrient is reduced and where the reduction takes place. Since some blue-green algae species, that is, cyanobacteria in layperson's terms, such as *Nodularia spumigena* and *Aphanizomenon* sp., are capable of fixing nitrogen from the atmosphere, they react to changes in the phosphorous of marine water. The growth of other algae species is limited by nitrogen. Concerning the location of nutrient reduction, Finnish national measures alone can improve the state of coastal waters, but international measures are needed to improve the water quality in the entire gulf (see Kiirikki et al. 2003).

Many aspects related to eutrophication are still not well known. One of them is the link between nutrient reduction and the corresponding improvement in water quality in the Gulf of Finland as perceived by the general public. The other uncertain issue relates to the response of the sea ecosystem to nutrient reductions and, on the other hand, the development of the state of the gulf without new policy implementations. Internal loading is one reason for the uncertainty of the results of policy implementations.

As a consequence of the excessive amount of nitrogen and phosphorous, the marine ecosystem of the Gulf of Finland has changed. The average water clarity in the Gulf of Finland, measured by the Secchi depth, has decreased from 8 meters to 5 meters (with a variation of 3 to 7 meters depending on time and place) (Fleming-Lehtinen et al. 2007). In addition, seasonal hypoxia (low oxygen) occurs, and communities of benthic invertebrates have degraded in the open areas of the Gulf of Finland. The annual fast-growing species of algae (e.g., *Cladophora glomerata*) thrive at the expense of perennial species such as a seaweed species called bladder wrack (*Fucus vesiculosus*). In the coastal zone, the bladder wrack is a key species that provides shelter and food for numerous invertebrate species and a reproduction environment for fish species (HELCOM 2009). As a result of eutrophication, the abundance of blooms of harmful and even potentially toxic blue-green algae (e.g., *Aphanizomenon* sp. and *Nodularia spumigena*) has increased. Eutrophication improves the growth of some fish species and increases the amount of small fish, fries, and in particular so-called coarse fish species (e.g., cyprinid fishes, *Cyprinids*) that are not attractive to anglers (Kiirikki & Blomster 1996, Pitkänen 2004).

The eutrophication-induced changes that have occurred in the ecosystem influence people's welfare, e.g., by reducing income from tourism and from fish farming and shellfish farming, and by decreasing the gulf's recreation value (EEA 2001). With regard to the influence of eutrophication on Finnish citizens, the coast and the archipelago of the Gulf of Finland are intensely used for recreational purposes. The coastal municipalities[1] are the place of residence of 1.3 million Finns, that is, a fourth (23%) of the Finnish population. The number of summer cottages in the coastal municipalities is around 30 thousand, that is, 6% of the summer cottages in Finland (Statistics Finland 2006). The Gulf of Finland is a primary fishing resort for 100 thousand recreational anglers (Pitkänen 2004).

Regarding the nuisance caused by the consequences of the eutrophication of the Gulf of Finland for the general public, turbid water, toxic algae, slimy beaches, and an abundance of littoral filamentous algae were especially perceived as inconvenient in a survey of the citizens of the region of Uusimaa, which is situated on the coast of the Gulf of Finland (Kiirikki et al. 2000, Kiirikki et al. 2003). Although knowledge of people's perceptions of eutrophication and the related nuisance is very relevant for the planning of new policies for combating eutrophication, monetary estimates of the eutrophication-induced loss of benefits are needed to decide which policies to implement to increase social welfare. The economic impact in terms of the loss of income from tourism and fisheries can be derived from economic data, but an estimation of the value of recreation as well as the non-use aspects of the marine environment requires the use of environmental valuation methods.

1.2 The valuation of reduced eutrophication

A monetary valuation of an environmental change, such as reduced eutrophication in the Gulf of Finland, is about eliciting the preferences of citizens for a non-marketed public good that holds no market price. Environmental goods have the properties of a public good: non-rivalry (i.e., numerous individuals may perform recreational activities on the coast of the Gulf of Finland) and non-excludability (i.e., no individual can be prevented from engaging in recreational use of the Gulf of Finland or from enjoying the improved water quality in the gulf). The estimation of welfare measures for an environmental change requires information on people's preferences for that particular environmental change. The preferences are analysed in the framework of microeconomic consumer theory. The monetary measure is either the willingness to pay (to achieve environmental improvement or to avoid degradation) or the willingness

[1] From the west to the east, in 2006: Hanko, Tammisaari, Inkoo, Siuntio, Kirkkonummi, Espoo, Kauniainen, Helsinki, Vantaa, Sipoo, Porvoo, Pernaja, Loviisa, Ruotsinpyhtää, Pyhtää, Kotka, Hamina, and Virolahti.

to accept (to accept environmental degradation or the absence of improvement). The willingness to pay (WTP) refers to the amount of money the individual is willing to trade off from the consumption of ordinary goods to an environmental good (Louviere et al. 2000).

The Gulf of Finland is associated with many values. Typically the values of environmental goods are divided into use values and non-use values. Among use-related values, the provision of recreational possibilities and tourism activities as well as natural resources such as fish are examples of the direct use of a marine resource. Another type of use value is the indirect use value, referring to the life-supporting services of a water ecosystem, such as primary production, genetic diversity, and the provision of habitats. Non-use values of an environmental good capture a more abstract component of value, such as the existence value of a marine ecosystem (the intrinsic value) and the value of its survival for future generations. Non-use values are likely to be present when no close substitutes exist for the good. This applies to the Baltic Sea being globally unique as a brackish water area (Bateman et al. 2002, Söderqvist and Hasselström 2008). All these values are threatened when eutrophication takes place in the Gulf of Finland. Monetary estimates of these values can be obtained by environmental valuation methods.

The valuation of environmental amenities has been practised for decades, with different methods applied to different policy problems. Due to the importance of water resources to life, the history of surface water quality valuation goes back to as early as the 1930s. In 1936 in the United States, the Flood Control Act required that, for any implemented water resource projects, the benefits should exceed the costs. In addition to this practical view, welfare theory improved. The formal statement of the Kaldor-Hicks compensation principle (Kaldor 1939, Hicks 1940) stimulated the progress of the methodology and practices of the non-market valuation of environmental amenities, and one example of an early valuation study related to surface water quality is Krutilla and Eckstein (1958, ref. Smith & Desvousges 1986) (Smith & Desvousges 1986).

For the valuation of a good associated with multiple values, the choice of an appropriate valuation method depends on which values are of interest and relevance to the decision makers. When the non-use aspect is an important component of a value of a good, as it is for the Gulf of Finland, stated preference (SP) methods can be applied. The preferences of the general public are elicited in a hypothetical market context with the help of a survey conducted by mail, phone, internet, or face-to-face interviews. The idea of the method – asking people directly about their valuation of public goods – was presented by Ciriacy-Wantrup (1947), and another important step in the history of contingent valuation (CV) was Krutilla's (1967) identification of existence value. The first application of contingent valuation, the most popular SP method to date, studied the value of a recreational area to hunters (Davis 1963). The increase in the use of CV started in the early 1990s after the Exxon Valdez oil spill off the coast of Alaska (Carson et al. 2003).

From the turn of the millennium, the choice experiment (CE, also called choice modelling) method has become more and more popular. Before its appearance in the field of environmental economics, the CE method was first applied to research on transportation choice (Louviere & Hensher 1982) and marketing (Louviere & Woodworth 1983). The first CE study applied to water quality improvement modelled the choice of recreational site (Adamowicz et al. 1994). A fundamental difference between the contingent valuation method and the choice experiment is how the environmental change – the scenario – to be valued is defined in the survey. CV presents and produces the willingness to pay (WTP) estimate for one environmental change, e.g., a 50% decrease in nutrient loading in a bay (Frykblom 1998) or the improvement of the status of the Baltic Sea to a sustainable level (Söderqvist 1996, Markowska & Zylicz 1999). In the CE, alternative environmental changes are described in terms of multiple characteristics (attributes), e.g., the level of fish stock, the quality of water for swimming, and the level of biodiversity (Eggert & Olsson 2009).

An advantage of the CE is that the definition of water quality improvement in terms of attributes allows for two types of WTP estimates: the marginal rates of substitution between attributes and the benefit estimates for several environmental changes described in terms of attributes. This is useful especially when the diverse characteristics of water quality are differently affected by alternative policy options. For instance, in the case of the Gulf of Finland, the growth of one particular blue green algae is phosphorus limited, whereas the growth of another algae is nitrogen limited. The flexibility of the CE does not come without cost: the method requires a more detailed description of the environmental change. In turn, the greater amount of information faced by the respondents may make the process of stating one's preferences in a hypothetical market context more difficult (Louviere et al. 2000, Bennett & Adamowicz 2001).

In contrast to stated preference methods, which work in a hypothetical world, revealed preference (RP) methods exploit information from real markets about economic behaviour and environmental quality. The price of an environmental good is isolated from prices of marketed goods, such as travel costs incurred from travelling to a recreational site (the travel cost method) or housing prices (the hedonic pricing method). The idea of the travel cost method was introduced in 1947 by Hotelling, and after early applications (e.g., Trice & Wood 1958, Clawson 1959, Clawson & Knetsch 1966; ref. Garrod & Willis 1999) the method has been applied especially to the valuation of recreational benefits. Hedonic analyses were carried out as early as the 1920s by Waugh (1928). Since then, the method has been applied to agricultural products as well as to other commodities, the most well-known application of the valuation of environmental amenities being housing markets. An important theoretical development occurred when Rosen (1974) connected the hedonic equilibrium price function to consumers' preferences in relation to the characteristics of a heterogeneous good (Champ et al. 2003).

In comparison to RP methods, SP methods are advantageous because they are able to evaluate the benefits of policies that are not yet implemented and of environmental goods that relate to non-use values. However, while RP estimates are based on the behaviour observed in actual markets, SP methods utilize the information on the willingness to pay gathered from hypothetical markets. This hypothetical nature of the WTP question has been the main source of the criticism of SP methods. In surveys used for preference elicitation, a common assumption is that respondents hold complete certainty about their preferences. But, because respondents are inexperienced in making trade-offs concerning environmental goods, the expression of real preferences might be difficult. The hypothetical nature of SP methods has been suspected to be one source of respondent uncertainty, which inhibits the precision of WTP estimates (Hanemann 1984, Li & Mattson 1995, Shaikh et al. 2007).

Besides its hypothetical nature, another limitation of SP methods highlighted in the previous literature is the theoretical framework exploited in the analysis: a utility-maximizing individual with well-behaving (continuous) preferences chooses the preferred alternative. In the choice experiment, this refers to the assumption that the respondents perform choices by making trade-offs of all the attributes and by considering all the attributes to the same extent. This assumption may not necessarily hold due to an actual non-compensatory preference ordering by the respondent or the use of a simplifying strategy in order to cope with the cognitive burden of a complicated choice task. Ignoring discontinuous preferences in the analysis may lead to a failure in preference revelation (see, e.g., Spash & Hanley 1995, Lockwood 1999, Rosenberger et al. 2003, Saelensminde 2006, Hensher et al. 2005b).

This thesis studies both the above-mentioned methodological issues: respondent uncertainty and discontinuous preferences. These are discussed in more detail in section 3. The next section shortly reviews empirical applications for water quality valuation.

1.3 Empirical applications for water quality valuation

The literature on the empirical applications of valuation methods to water quality issues is extensive. Considering here only surface water quality and ignoring groundwater quality, the studies have estimated the benefits of lakes, rivers, and reservoirs as well as wetlands, estuaries, and coastal waters. The diversities of the study areas and of the associated benefits have resulted in numerous ways of revealing and eliciting preferences for water quality improvements. For instance, recreation is closely related to waters in many ways, e.g., fisheries, swimming, and boating. The studies related to fisheries vary greatly in terms of the good being valued (catch rate, access to a fishing area with single or multiple species, coast, river) and of the geographic extent of the market (local, regional, one US state, several states). Typically the recreational benefits associated with a change in water quality have been estimated in terms of the change in recreational user days or trips, improved access to a body of water with improved water quality, the increase in recreational enjoyment, the value of a trip or annual access per person to a beach, or the impact of unpolluted coastal shoreline on boating activity or of unpolluted beaches on swimming activities. The studies estimating the total value of water quality change have valued, e.g., the increase in river flow, water quality levels, or reservoir water levels as well as the surface area of new reservoirs, or have estimated the benefit of implementing a wetland improvement programme, maintaining the minimum flow of a river or a certain quality level (e.g., suitable for swimming), cleaning up a river, or conserving endangered species. In addition, the implicit prices for an increase in water clarity and for a change in the pH of water as well as for proximity to different wetland types or a lake have been estimated (Freeman 1995, Wilson & Carpenter 1999, Beaumont et al. 2008).

Turning from a general change in water quality to a particular problem related to waters, the loss of benefits related to eutrophication in inland and marine waters has been widely studied. Eutrophication leads to losses in two main types of values: use values, referring directly to the use of the natural resource, and non-use values, which reflect the existence value. The studies addressing use values have usually applied revealed preference methods (e.g., Kaoru 1995, von Haefen & Phaneuf 2003, Egan et al. 2009). One popular indicator of water quality is water clarity measured by the Secchi depth. The regression model links the Secchi depth relatively easily to the amount of nutrients in the water (see, e.g., Sandström 1996, Egan et al. 2009).

The stated preference studies use various descriptions of water quality improvement. Descriptions which are perceived subjectively by the respondents must be linked to objective water quality measures (Phaneuf & Smith 2005). Examples of descriptions of water quality improvement in the marine context are a reduction in eutrophication such that the ecosystem recovers to a sustainable level (Söderqvist 1996, Markowska & Zylicz 1999), the prevention of asphyxiation (Goffe 1995), and a decrease in the occurrence of harmful algal blooms and in the risk of shell-fish poisoning (Kosenius 2004). A related issue to the value of water quality improvement, namely the value of marine biodiversity, has also been studied (see, e.g., McVittie & Moran 2008). In addition to the studies concerning the marine context, the valuation of water quality has been defined as all waters in a country (Viscusi et al. 2008), river basins (Urama & Hodge 2006), rivers (Hanley et al. 2006), wetlands (Birol et al. 2006, Milon & Scrogin 2006), coastal biotopes (Gren et al. 1996), and recreational possibilities (Morey et al. 2006).

In the Baltic Sea area, the benefit estimates related to eutrophication have been assessed with both revealed preference methods (Sandström 1996, Soutukorva 2001) and stated preference methods. The selection of eutrophication-related stated preference valuation studies is presented in table 1-1. The studies vary greatly in terms of population, sample size, valuation method, and geographical scope as well as in the description of the good. The studies of Söderqvist (1996) and Markowska and Zylicz (1999) are related to the Baltic Drainage Basin Project, which estimated the welfare effects of basin-wide water quality improvement (see Turner et al. 1999). In addition to estimating the national willingness to pay for water quality improvement for the entire Baltic Sea area, local and regional valuation studies have been conducted. Local and regional refer here both to the sampled population and the scale of water quality improvement.

Comparing the annual mean WTP estimates for water quality improvement in different studies is not a straightforward task but may reveal causes of the variation in the WTP. The estimates from contingent valuation studies (studies 1-4) range from €29 to €662. The comparison of the estimates from different countries for the same good reflects the difference in the economic conditions of the countries (studies 1 and 2). The geographical scale of water quality improvement also seems to influence the WTP as the estimates for local goods are lower than the estimates for the goods of a larger scale (studies 1 and 3). An interesting result is that the studies using different payment vehicles and different scenarios (studies 3 and 4) produced WTP estimates that are rather close to each other. Regarding the CE applications (studies 5 and 6), one potential reason for the difference in WTP estimates is the proximity of the respondent to the water area being valued. The attribute WTP estimates for a smaller area, the western Swedish coast, are higher than the WTP estimates for all Swedish waters, but the sample includes only the residents living close to the coastal area.

Table 1-1. The selection of stated preference studies in the Baltic Sea area.

	Author and publ. year	Country	Sampled population	Sample (resp. rate)	Survey method (year)	Scale	Payment vehicle	Scenario / Attribute	Mean WTP / year	WTP (€ May 2009)
1	Söderqvist (1996)	Sweden	Swedish citizens	600 (60%)	CV (1995)	Baltic Sea	Increased tax for 20 years	An improvement to the sustainable level in 20 years	6500-7000 SEK	€ 614-662
2	Markowska & Zylicz (1999)	Poland	Polish citizens	600 (50%)	CV (1994)	Baltic Sea	Increased tax for 20 years	An improvement to the sustainable level in 20 years	129-236 PLN	€ 29-54
3	Frykblom (1998)	Sweden	residents in three municipalities	500 (67%)	CV (1996)	Laholm Bay	Increased tax for 20 years	A 50% decrease in nutrients	747 SEK	€ 71
4	Söderqvist & Scharin (2000)	Sweden	residents in the counties of Stockholm and Uppsala	4000 (47%)	CV (1998)	Stockholm archipelago	Increased price for agricultural products and tap water	One meter improvement in sight depth	436-624 SEK	€ 41-59
5	Eggert & Olsson (2009)	Sweden	residents in the counties of Västra Götaland and Halland	800 (43%)	CE (2002)	Coastal waters on the Swedish west coast, Kattegatt, and Skagerrak	User fee for one year for adults	Avoiding a reduction of biodiversity level	1400 SEK	€ 132
								Improvement of biodiversity	600 SEK	€ 57
								Improvement of water quality for swimming	600 SEK	€ 57
								Improvement of cod stock (kg)	1300 SEK	€ 123
6	Kataria & Lampi (2008)	Sweden	Swedish citizens	1000 (34%)	CE (2007)	Swedish marine waters	Increased tax for 5 years	Number of endangered animals and plants	510 SEK	€ 48
								Percent increase in the oversight of oil and chemical discharges	492 SEK	€ 46
								Increase in cod stock (%)	525 SEK	€ 49
								Number of small-scale fismermen at risk of losing their jobs	437 SEK	€ 41

The WTP estimates are converted into euros from the original currencies by using the average exchange rate in May 2009 (SEK=10.5820, PLN=4.4103). No adjustments for economic growth were made.

1.4 Objectives of the thesis

This PhD thesis contributes to the valuation of the protection of the Gulf of Finland and to the methodological discussion of the implications of respondent uncertainty and discontinuous preferences for welfare estimation.

The first objective of the thesis is to estimate the benefits of reduced eutrophication in the Gulf of Finland. Up to now, decisions about nutrient reductions affecting the state of the Gulf of Finland have been made without considering the monetary benefits of the implemented policies. No estimates concerning the improvement of water quality in the whole Gulf of Finland have been available, although monetary estimates are crucial for choosing policies that increase social welfare. The thesis provides welfare estimates for three alternative future scenarios of the Gulf of Finland: modest water quality improvement, modest improvement combined with a considerable reduction in the occurrence of blue-green algae blooms, and considerable improvement in terms of all water quality attributes used in the study. When aiming to estimate the welfare effects of different policies as accurately as possible, the analysis accounts for the taste differences across the Finnish population for different consequences of eutrophication.

The second objective is to gather information on the causes and consequences of respondent uncertainty, which, after several contingent valuation studies have addressed the issue, has only recently been studied in the choice experiment context. Questioning the plausibility of the assumption that the respondents are able to state their preferences with full confidence is especially relevant in the choice experiment, which includes a rather complex hypothetical market situation with a large amount of information provided to the respondent. To appropriately design stated choice questionnaires, knowledge of the causes of respondent uncertainty is useful. In the case of the Gulf of Finland, one potential cause that is of special interest is the impact of introducing uncertainty 1) in outcomes resulting from alternative nutrient reductions and 2) in the development of water quality in the absence of new policies. In order to evaluate alternative approaches to account for respondent uncertainty, this thesis applies three alternative ways of treating uncertain choices and analyses the associated implications for WTP estimation in terms of model fit and the efficiency of WTP estimates. The efficiency refers here to the precision of WTP estimates in terms of the range of the 95 % confidence interval.

The third objective of the thesis is to analyse the impact on the WTP estimation of identifying potential discontinuous preference ordering by the respondents and accounting for this in the analysis. It is realistic to assume that not all water quality attributes that describe water quality improvement are equally relevant in the behavioural sense to all respondents. Also, previous studies have suggested that in the choice experiment context, respondents may not consider the choice tasks and the associated water quality attributes in a similar way, and that ignoring the discontinuous preference structure of respondents may lead to biased estimates. This thesis explores the incidence of discontinuous preferences in the data set and the underlying causes. Finally, the analysis reveals the impact of accounting for preference discontinuity for the WTP estimates for the reduced eutrophication of the Gulf of Finland.

These aims are discussed in three essays. While Essay I provides the WTP estimates for the protection of the Gulf of Finland and thus has a more policy-oriented nature, the methodology-oriented Essays II and III depart from the standard assumptions of discrete choice experiments by exploring respondent uncertainty and preference discontinuity, respectively. Through these three essays, firstly, this thesis contributes to the important discussion of the feasibility of the theoretical assumptions behind the choice experiment. Secondly, the thesis gathers more efficient welfare estimates by paying attention to the non-standard features in preference elicitation. Thirdly and, from the viewpoint of the actual protection of the Gulf of Finland, most importantly, the thesis produces estimates of the benefit of alternative nutrient reduction scenarios in the Gulf of Finland. The importance of this is due to the lack of previous monetary estimates for this particular area of the Baltic Sea as well as the need for monetary valuations of water quality improvement in general.

2 Theoretical framework and econometric specification

2.1 Utility maximization in a random utility framework

The choice experiment method is grounded on neoclassical microeconomic consumer theory. In a choice situation related to future states of the Gulf of Finland, a respondent chooses among alternatives the one that yields the highest utility. The alternatives are described in terms of water quality characteristics and the price of implementing a policy. This description of the good follows the Lancasterian approach to utility (Lancaster 1966), according to which an individual derives the utility from objective characteristics possessed by a good (water quality characteristics and price) rather than from a good itself (water quality improvement in the Gulf of Finland). While Lancaster's approach applies to goods that are divisible, Rosen (1974) further developed the model to be consistent with indivisible goods, such as water quality improvement (Louviere et al. 2000).

Respondent n faces a set of alternatives Q. The utility maximization problem of the respondent is the following:

[1] $$MaxU(x_1, x_2 ..., x_k) \quad \text{subject to} \quad p(x_1, x_2 ..., x_k) + d = y$$

where vector $X = (x_1, x_2, ..., x_k)$ is the characteristics of an environmental good with k characteristics, $p(x_1, x_2 ..., x_k)$ is the price of the associated policy implementation, d is the composite of ordinary goods (see Hicks 1946), and y is disposable income. The price is defined as one of the characteristics of the good. Since the budget constraint defined in terms of characteristics is non-linear, and since for an indivisible good, $p(X)$ is not necessarily linear, it is appropriate to define the characteristics of the good in terms of their absolute levels rather than in terms of characteristics per monetary unit. In contrast, the composite good d is set to be a *numeraire*, i.e., its price equals one monetary unit (Louviere et al. 2000)

In the choice experiment, the choice of the preferred alternative is of a discrete nature (see Hanemann 1984), that is, only one alternative from a set of alternatives Q can be chosen. The chosen alternative is independent of irrelevant alternatives, that is, the attributes of the non-chosen alternatives do not affect the utility of the chosen alternative. Then, we can formulate the utility-maximizing discrete choice of alternative j as an unconditional indirect utility function for respondent n as (see Alpizar et al. 2003):

[2] $$V_{nj}[X, p, y] = \max[V_{n1}(X_{n1}, y - p_{n1}), ..., V_{nQ}(X_{nQ}, y - p_{nQ})]$$

where $V_{nj}[...]$ is the utility for respondent n from alternative j from a set of Q alternatives, X refers to the attribute vector (excluding price), p to the price of the alternative, and y to disposable income. According to the assumptions of the consumer theory, the well-behaving preference ordering for all alternatives relevant to an individual satisfies the following axioms: reflectivity, completeness, transitivity, non-satiation, strict convexity, and continuity (Mas-Colell et al. 1995).

The choice experiment is consistent with the framework of random utility, which links the theoretical utility model to the statistical model (McFadden 1974). The random utility model (RUM) for a single choice set consisting of three alternative future states of the Gulf of Finland $j = 1,2,3$ is specified as follows:

[3] $$\begin{aligned} U_{n1} &= V_{n1} + \varepsilon_{n1} \\ U_{n2} &= V_{n2} + \varepsilon_{n2} \\ U_{n3} &= V_{n3} + \varepsilon_{n3} \end{aligned}$$

where the utility of each alternative $j = 1,2,3$ is divided into a deterministic component V_{nj} and a stochastic component ε_{nj}. These components and their specifications are presented in more detail in the next two sections, starting with the stochastic part.

2.2 The stochastic part of utility

The error term, ε_{nj}, captures the unobserved factors of utility for individual n and alternative j. Due to the stochastic term, the respondent's choice is purely up to probability. As respondent n chooses alternative j in the set of Q alternatives if and only if $U_{nj} > U_{nq}$, $\forall q \neq j \in Q$, the choice in random utility terms is:

[4] $$(V_{nj} + \varepsilon_{nj}) \geq (V_{nq} + \varepsilon_{nq}).$$

Rearranging the equation yields:

[5] $$(V_{nj} - V_{nq}) \geq (\varepsilon_{nq} - \varepsilon_{nj}).$$

Because the difference in the stochastic terms $(\varepsilon_{nq} - \varepsilon_{nj})$ cannot be observed, the researcher assigns the probability that $(\varepsilon_{nq} - \varepsilon_{nj})$ is less than the difference in the deterministic terms, $(V_{nj} - V_{nq})$:

[6] $$P(choice = j) = P[(V_{nj} + \varepsilon_{nj}) \geq (V_{nq} + \varepsilon_{nq})] = P[(\varepsilon_{nq} - \varepsilon_{nj}) \leq (V_{nj} - V_{nq})], \ \forall q \neq j \in Q .$$

This means that for *any* individual with sociodemographic and questionnaire characteristics c who faces a set of alternatives Q, the probability of choosing j equals the probability that the difference between the unobserved utility of alternatives q and j is less than the difference between the systematic utility of alternatives j and q (Louviere et al. 2000).

The distribution for $(\varepsilon_{nq} - \varepsilon_{nj})$ across the population is specified to translate the unobserved factors into the observed component. In the logit models, the random elements in utility are independent across alternatives and identically distributed (IID). This property will be discussed in the next section. In discrete choice analysis, the most often used distribution is the extreme value type I (EV1), which is also known as Weibull, Gumbel, or double-exponential distribution. The EV1 distribution is defined in terms of ε_j's as

[7] $$P(\varepsilon_j \leq \varepsilon) = \exp(-\exp - \varepsilon) = e^{-e^{-\varepsilon}}$$

(Louviere et al. 2000).

2.3 The deterministic part of utility

The deterministic part V_{nj} refers to observed factors such as the characteristics of water quality, the respondent, as well as the questionnaire. The structure of the systematic part of the utility function represents how the characteristics of the good and of the individual together impact choice probabilities and the predictive capability of the model. The functional form of the utility function can be specified as linear in attributes. This specification leads to little loss of generality in estimating the significance of the determinants of V_{nj} (Louviere et al. 2000).

The structure of V_{nj} depends on which model specification is chosen for analysis. The popular models in the analysis of the discrete choice data are the Conditional Logit (CL) and Multinomial Logit (MNL) models. While the former models the choice based on the levels of the attributes of the alternatives, the latter model also includes individual-specific characteristics. These models assume that the utility functions are identical across respondents and thus, the models provide homogeneous taste parameter estimates. Preference heterogeneity can be introduced into the MNL model in two ways: by interacting the respondent-specific or the questionnaire-specific characteristics with the alternative-specific attributes or by dividing the sample into segments according to previous knowledge about the sources of preference variations (Hensher and Greene, 2003).

The CL and MNL models feature the Independence of Irrelevant Alternatives (IIA) property. The IIA follows from the assumption that the error terms of the utility function (i.e., the stochastic part of the utility) are independent and identically distributed (IID). The independence of irrelevant alternatives means that, for all respondents, all alternatives in the choice set are equally similar or dissimilar. In terms of cross choice elasticity, the IIA implies that the percentage change in the probability that the respondent chooses a particular alternative, P_j, given the percentage change in any other alternative, is uniform for all alternatives. The equality of the odds ratios of different alternatives must be preserved if any alternative is added or deleted to/from the choice task. In a choice task consisting of three alternatives (e.g., two policy alternatives and one business-as-usual alternative), the respondent would choose between the alternatives with an equal probability of 0.33. If one policy alternative is deleted from the choice task, the new choice probabilities would be 0.5 for both remaining alternatives, although, originally, the policy alternatives were more similar. Thus, it is more likely that the new choice probabilities would be 0.33 for the business-as-usual alternative and 0.33+0.33 for the remaining policy alternative (Louviere et al. 2000).

Though the IIA assumption makes the maximum likelihood estimation easier, it is empirically very restrictive and non-realistic. For instance, in the case of the Gulf of Finland, it is plausible to assume that the respondent perceives the opt-out option – no improvement in the state of the Gulf of Finland – somewhat differently than the alternatives associated with policy implementations that result in water quality improvement. The validity of the assumption in the data set can be tested by the Hausman and McFadden (1984) test (Greene 2003).

If necessary, the IIA property can be avoided by applying, instead of the MNL model, another econometric model. For instance, as a variant of the MNL model, the Nested Logit model (sometimes called tree logit or hierarchical logit) captures the correlations among alternatives. The alternatives are grouped into subgroups, and while the IIA holds within a subgroup, the variances differ between subgroups. Thus, the assumption of equal variances of alternatives is partially relaxed. The Heteroscedastic (Extreme Value) Logit model HEV (see, e.g., Allenby and Ginter 1995, Bhat 1995, Hensher 1997) goes further by allowing for differing variances of unobserved factors for all alternatives. The random effects HEV model has different scale parameters for the error terms of alternatives. In turn, the fixed effects HEV model (or Covariance Heterogeneity model) uses one scale parameter across alternatives, and the scale parameter is a function of attributes associated with alternatives and individual-specific characteristics.

Although the logit models are the most widely used in discrete choice modelling due to the ease of analysis and interpretability, another possibility is the Multinomial Probit model (see, e.g., Thurstone 1927). This model is free from the IIA problem as it allows for the determination of any substitution pattern that is appropriate for the data set. Moreover, the Multinomial Probit model is able to analyse random taste variation and unobserved factors that are correlated over time. The lack of these abilities limits the above-mentioned models, while the limitation of the Multinomial Probit model is that the normal distributions required for the stochastic part of utility may not always be appropriate (Louviere et al. 2000, Greene 2003, Train 2003).

The family of logit models includes a model that does not suffer from the IIA property and other restrictive qualities of the regular logit models, namely, the Mixed Logit (MXL) model (see, e.g., Revelt & Train 1998, Bhat 2000, McFadden & Train 2000, and Provencher & Bishop 2004). This increasingly popular generalisation of the standard MNL can be specified in terms of random coefficients (Random Parameters Logit, RPL) or error components (Error Components Multinomial Logit, ECM). Additionally, another useful extension of the MNL model is the Latent Class Model (LCM). The LCM differs from the RPL such that, instead of providing its own coefficient estimates for each individual, it assigns individuals into classes within which the preferences are assumed to be identical. This is reminiscent of the standard MNL model in which *all* individuals are assumed to have identical preferences.

Concerning the Mixed Logit model (MXL), the random coefficient approach and the error component approach are formally equivalent, but they can be applied in different circumstances. Random coefficient specification (RPL) is applicable when the researcher is interested in the taste variation with respect to each attribute (see McFadden & Train 1996, Revelt & Train 1998). The error component specification (ECM) can be used when the interest is in providing realistic substitution patterns, for instance between alternatives (see Brownstone & Train 1999, Brownstone et al. 2000). To the error component specification, a scale parameter can be included in order to explore differences in the variance of unobserved factors due to, e.g., preference ordering (Campbell et al. 2008), status-quo bias (Scarpa et al. 2005), or choice consistency (Saelensminde 2001) (Train 2003).

Going back to the deterministic part of utility, V_{nj}, as presented in equation [2], its structure can be determined as follows:

[8] $$V_{nj} = \alpha_j + \sum_k \beta_k x_{njk} + \sum_m \eta_m c_{mn} \alpha_j + \sum_k \gamma_{kn} z_{njk}$$

where

1) the alternative-specific constant α_j, specified as zero for one alternative for identification purposes, captures the average effect of unobserved factors (Train 2003);
2) in the term $\sum_k \beta_k x_{njk}$, the coefficient β_k for attribute k represents the average tastes of the respondents, and x_{njk} is the value of attribute k for alternative j for individual n;
3) the term $\sum_m \eta_m c_{mn} \alpha_j$ accounts for the respondent- or questionnaire-specific characteristics c_{mn} (interacted with the alternative-specific constant α_j due to invariance across alternatives for each individual), and η_m is the associated coefficient;
4) in the last term, $\sum_k \gamma_{kn} z_{njk}$, γ_{kn} refers to the deviation parameter for attribute k that represents the tastes of individual n relative to the average taste given by β_k, and z_{njk} is the value of attribute k for alternative j for individual n. For the multinomial logit (MNL) model, the deviation parameters equal zero.

The error component specification (ECM) is equivalent to the random-coefficients model with fixed coefficients for variables x_{njk} and random coefficients with zero means for variables z_{njk}. For the random coefficient specification (RPL), $x_{njk} = z_{njk}$, and the coefficients of variables k are decomposed into mean β_k and deviation γ_{kn}, $\beta_{kn} = \beta_k + \gamma_{kn}$.

2.4 Estimation of parameters

The parameters α_j, β_k, η_m, and γ_{kn} in equation [8] are estimated through a maximum likelihood procedure. By maximizing the probabilistic function with respect to the parameters, maximum likelihood estimates are obtained. For the MXL model, the maximum likelihood estimates and the parameters are estimated through simulation. The vector of coefficients $\beta_{kn} = \beta_k + \gamma_{kn}$, decomposed into mean β_k and deviation γ_{kn}, varies over the population with density $f(\beta|\theta)$ where θ refers to a true parameter vector of the taste distribution, in which r draws are extracted from $f(\beta|\theta)$ for each β_{kn}. The logit probabilities for choice tasks i, $L_{ni}(\beta^r)$, are calculated for each draw r, and the results are averaged.

The logit probability for the specification that allows for repeated choices for each respondent[2] refers to the probability that the individual makes a sequence of T choices specified as $i = \{i_1, ..., i_T\}$. Thus, $L_{ni}(\beta)$ is the product of the logit formulas for each of the respondent's choices with the assumption of a utility linear in attributes

[9] $$L_{ni}(\beta) = \prod_{t=1}^{T} \left[\frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}} \right] = \prod_{t=1}^{T} \left[\frac{e^{\beta_n' x_{ni_t t}}}{\sum_j e^{\beta_n' x_{njt}}} \right].$$

The mixed logit choice probabilities P_{ni} that the individual makes the observed sequence of choices i are unconditional on the actually estimated parameters. The choice probability P_{ni} takes the form of integrals of the standard logit probabilities over the density of parameters

[10] $$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta,$$

where the weighted averages are taken from the logit formula evaluated at different values of β. The weights are given by the density $f(\beta)$ as the mixing distribution that can be specified as either discrete or continuous in β. The discrete specification relates to the Latent Class Model (LCM), which is based on the idea that the population consists of a specified number of segments (classes) that each have their own preferences. For the model with M classes, β takes M possible values $b_1, ..., b_M$. In addition to the *b*s for the segments, the analysis estimates the shares of the population in each segment s_m. The shares s_m refer to the probability for $\beta = b_m$. Unlike the MXL model, the estimation of the parameters of the LCM does not necessitate simulation. To date, the MXL

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[2] The MXL model can be specified either to treat each choice of each respondent independently or to allow for repeated choices by each respondent. The latter means that the coefficients entering the utility vary over the respondents but are constant over the choices of each respondent, that is, the tastes of the respondent are stable over the time period of the sequence of choices.

This study uses the latter approach as it follows the analysis procedure of the Latent Class Model (LCM). For the former approach, the logit probability is $L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}}$ (Train 2003).

specifications for environmental amenities have more commonly involved a discrete distribution than a continuous distribution.

Alternative continuous distributions for $f(\beta)$ are normal, lognormal, triangular, gamma, or Rayleigh. In the case of a normal distribution, as applied in this study, the density of β has mean b and covariance W, and the choice probability becomes

[11] $$P_{ni} = \int \left[\prod_{t=1}^{T} \left(\frac{e^{\beta_n' x_{ni_t t}}}{\sum_j e^{\beta_n' x_{njt}}} \right) \right] \phi(\beta | b, W) d\beta \, .$$

In order to estimate the WTP of the population, both mean b and covariance W are estimated in order to examine the average taste of the respondents and the distribution of tastes in the population. To find the value of the true parameter vector θ that maximizes the simulated log-likelihood function, simulated choice probabilities P_{ni} are inserted in the simulated log-likelihood function (Train 2003).

The major advantages of the Mixed Logit (MXL) model over the simpler models (CL, MNL) are its behavioural realism and its flexibility. With appropriate variables and appropriate mixing distribution, the MXL model is able to approximate any random utility model under the assumptions of both utility-maximizing as well as non-utility-maximizing behaviour (Train 2003, McFadden & Train 2000). Another advantage of the MXL model is its ability to produce individual parameter estimates, which are created by a simulation procedure. One example of the usefulness of individual parameter estimates is the exploration of uncertain choices, as individual parameter estimates allow for the calculation of the expected utilities of the alternatives for each individual. This information is useful in the recoding of choices.

The superiority of discrete choice models can be assessed based on, in addition to theoretical and behavioural relevance, statistical measures of fit: the pseudo R^2 (the likelihood ratio index) and the percentage of correct predictions. The formula for the calculation of the pseudo R^2 is

[12] $$R^2 = 1 - \frac{LL(Estimated)}{LL(Base)}$$

where $LL(Estimated)$ refers to the log likelihood value at convergence and $LL(Base)$ refers to the log likelihood value of the model estimated without coefficients. The pseudo R^2 expresses the proportion of variation in the data explained by the model in comparison to a model estimated assuming equal choice shares among alternatives. According to the rule of thumb, a measure of 0.3-0.4 refers to a decent model fit for a discrete choice model. This measure is equivalent to the R^2 of 0.6-0.8 in the linear regression model (Hensher et al. 2005a).

Besides the pseudo R^2, the model performance can be determined by the percentage of correct predictions produced by the model. This measure is calculated by comparing, for each alternative, the number of choices made by respondents and the number of times the alternative is predicted to be selected. The number of correct predictions is divided by the total number of observations (Hensher et al. 2005). Using a cut-off value of, say, 0.5 means that at that point the ability of the model to predict the choices correctly is better than the prediction of choice by chance for a three-alternative model, but as the measure ignores the actual predicted probabilities of the alternatives, it is unclear whether a model surviving the cut-off value of 0.5 is good or bad.

2.5 Derivation of WTP estimates and confidence intervals

The product of the choice model is the welfare implication of a particular nutrient reduction policy. The WTP estimates refer to the amount of money an individual is willing to pay to obtain the water quality improvement in the Gulf of Finland resulting from a specific nutrient reduction policy implementation. In addition to the WTP estimates for water quality improvement described in terms of changes in several water quality characteristics, marginal WTP estimates (or, implicit prices or the marginal rates of substitution) for the change in each of the water quality attributes can be produced. In the linear-in-utility model, the marginal WTP estimate is represented by the negative of the ratio of water quality parameter k and price parameter p, all else staying constant: $MWTP_k = -\beta_k / \beta_p$ (Louviere et al. 2000).

The welfare measure for a policy – a consumer surplus (CS) in the case of an increase in the supply of an environmental good – can be derived for individual n using the standard Hanemann (1984) utility difference expression for the discrete choice model:

[13] $$E(WTP_n) = -1/\beta_p \left[\ln\left(\sum \exp(V^1)\right) - \ln\left(\sum \exp(V^0)\right)\right]$$

where $E(WTP_n)$ refers to the expected WTP of individual n, β_p is the parameter estimate of the price attribute, V^1 is the utility evaluated in the policy case, and V^0 is the utility evaluated in the business-as-usual case. For the Multinomial Logit model (MNL), the mean WTP for a particular policy defined in terms of attribute levels can be calculated simply by substituting the estimated parameters in the following formula:

[14] $$E(WTP_n) = -1/\beta_p \left(V^1 - V^0\right) = -1/\beta_p \left[\sum \beta_k (x_k^1 - x_k^0)\right]$$

where β_k are the parameter estimates of attributes other than price, and x_k^1 and x_k^0 refer to the levels of attribute k in the policy case and in the business-as-usual case, respectively.

For the Latent Class Model (LCM) with M classes, the corresponding formula for the calculation of the WTP is the following:

[15] $$E(WTP_n) = \sum_{m=1}^{M} \pi_m \left\{-1/\beta_{pm} \left[\sum \beta_{km} (x_k^1 - x_k^0)\right]\right\}$$

where π_m is the estimated probability of individual n being assigned to class m, and β_{pm} and β_{km} are the parameter estimates for the price attribute and water quality attribute, respectively, for class m. The WTP estimates are weighted by class membership, and the marginal utility of income is constant over the individuals grouped in each class m (Boxall & Adamowicz 2002).

The simple calculation of the mean WTP estimates for the MNL model and the LCM does not apply to obtaining the mean WTP estimates for the RPL model. For the RPL model, the mean WTP for individual n is obtained through simulation. For the random parameters assumed to be normally distributed, random draws are taken from a normal distribution, and these are used together with the unconditional parameter estimates obtained from the RPL model to derive the mean WTP for individual n:

[16] $$E(WTP_n) = -1/\beta_p \left(V^1 - V^0\right) = -1/\beta_p \left[\sum (\beta_k + stde_k * rna_k)(x_k^1 - x_k^0)\right]$$

where $stde_k$ refers to the estimated standard deviation of parameter β_k, and rna_k refers to a draw from a random distribution (Hensher et al. 2005a).

The simulation approach is also used in the estimation of the willingness to pay's standard error, which is needed to calculate the confidence intervals for the WTP estimate. The standard error, i.e., the square root of variance, is the standard deviation of the sample distribution. By the delta method, the standard errors of the WTP estimate are obtained by taking a square root of the variance of WTP, $\mathrm{var}(WTP)$. The variance is approximated by taking a first-order Taylor expansion around the mean value of variables and calculating the variance as follows:

[17] $$\mathrm{var}(WTP) = \left[\partial WTP/\partial\beta \quad \partial WTP/\partial\beta_p\right]\begin{bmatrix}\mathrm{var}(\beta) & \mathrm{cov}(\beta,\beta_p)\\ \mathrm{cov}(\beta,\beta_p) & \mathrm{var}(\beta_p)\end{bmatrix}\begin{bmatrix}\partial WTP/\partial\beta\\ \partial WTP/\partial\beta_p\end{bmatrix}$$
$$= \left[(W\hat{TP}_\beta)^2\,\mathrm{var}(\beta) + (W\hat{TP}_{\beta_p})^2\,\mathrm{var}(\beta_p)\right] + 2W\hat{TP}_\beta W\hat{TP}_{\beta_p}\,\mathrm{cov}(\beta,\beta_p)$$

where $W\hat{TP}_\beta$ and $W\hat{TP}_{\beta_p}$ are the partial derivatives of the WTP with respect to parameters β and β_p. In addition to the delta method, the standard errors in discrete choice experiments can be obtained, e.g., by the Krinsky-Robb method (Krinsky & Robb 1986). After the approximation of the standard errors of the WTP, the 95% confidence interval for the WTP estimate is calculated by

[18] $$WTP \pm 1.96 * \sqrt{\mathrm{var}(WTP)}$$

(Greene 2003, Hole 2007).

3 Methodological issues

In addition to the estimation of benefit for reduced eutrophication in the Gulf of Finland, this thesis discusses two deviations from the standard economic theory associated with the stated preference methods: the respondents' inability to state their preferences with full certainty and the continuity of respondents' preferences.

3.1 Respondent uncertainty

A standard assumption in the stated preference surveys is that the respondents have complete certainty about their preferences for the environmental good. However, expressing real preferences in a hypothetical market situation may in fact be complicated by the unfamiliarity of making trade-offs concerning environmental goods or the inability to understand the contingency in question (e.g., Li & Mattson 1995, Shaikh et al. 2007). The implications of respondent (or preference or response) uncertainty on the accuracy of welfare estimates have been studied (e.g., Ready et al. 1995, Li & Mattsson 1995, Polasky et al. 1996, Champ et al. 1997, Welsh & Poe 1998, Johannesson et al. 1998, Ready et al. 2001), but no systematic evidence has been produced. The impact depends on the method of information collection, the recoding of the answers, and the model used in the analysis.

In CV surveys, which form the major part of the applications concerning respondent uncertainty, the methods for collecting information are 1) embedding the certainty question in the response options (*Yes*, *Don't know*, and *No* instead of just *Yes* and *No*) (see, e.g., Ready et al. 1995, Wang 1997, Samnaliev et al. 2006) and 2) asking a separate question about the level of certainty in the preceding valuation question (see, e.g., Li & Mattsson 1995, Loomis & Ekstrand 1998). The embedding approach results in a larger variation of WTP estimates than the approach with expressed level of certainty (Samnaliev et al. 2006).

The elicitation format for uncertainty affects the re-estimation of data when respondent uncertainty is considered. While in the case of separate questions, the *Yes* answers can be weighted according to the level of certainty, the embedded questions allow for the recoding of the uncertain *Yes*/*No* answers. In evaluating the potential improvement in explanatory power, the predictive validity of the model, and the goodness-of-fit, the impact of the empirical model used in the analysis must be accounted for. An analysis with the weighted likelihood function model, the asymmetric utility model, or the fuzzy model decreases the WTP estimate, while the symmetric utility model and random valuation model lead to the opposite result (Loomis & Ekstrand 1998, Shaikh et al. 2007).

In CE surveys, respondents are asked to state their certainty about their choice after having chosen the preferred option. The recoding of choices is facilitated knowing the order of superiority of the alternatives measured by the utility from each alternative for each respondent. Likewise in the CV context, the way that responses are recoded plays a major role in the model performance and WTP estimates in the CE surveys (Lundhede et al. 2009b).

In earlier studies, both respondent-specific and questionnaire-specific factors for respondent uncertainty have been discovered. Uncertainty increases with a lack of prior issue-related thought (Loomis & Ekstrand 1998, Jorgensen et al. 2006), a lack of prior visits to the area proposed for protection (Loomis & Ekstrand 1998), and female gender (Lundhede et al. 2009a).[3] Concerning questionnaire-specific features, uncertainty increases with the closeness of a bid (the price of the environmental good) to the true WTP (Wang 1997), an intermediate bid level instead of low and high bids (Jorgensen et al. 2006), and a small difference between the utilities of alternatives in a choice set (Lundhede et al. 2009a). The expression of response uncertainty (certainty) may indicate the rejection of (support for) the proposed project (Wang 1997, Samnaliev et al. 2006).

3.2 Discontinuous preferences

In the CE context, discontinuous preferences refer to the violation of the continuity axiom in the standard neoclassical consumer theory (see Mas-Colell et al. 1995). The axiom refers to the idea that an individual chooses a utility-maximizing alternative on the basis of a comparison of losses in one attribute to gains in another attribute, that is, the trade-off between the attributes of alternatives. The continuity axiom does not hold if an individual does not pay attention to the set of attributes but rather to the subset of attributes and the standard utility function is not applicable. Then, the marginal rates of substitution cannot be computed for each individual, and the sample-wide substitution rates may be biased. Neglecting discontinuous preferences may lead to erroneous welfare estimates (Lockwood 1996, Campbell et al. 2008).

One non-compensatory decision process is lexicographic preference ordering, which can be strict or modified (Rosenberger et al. 2003). Strict

[3] For more information on preferences and gender differences, see Croson and Gneezy (2009).

procedures refer to the situation in which certain goods (or attributes in the case of the choice experiment) are always prioritized over other goods, that is, certain attributes are ignored in the choice experiment. Modified lexicographic preferences mean that the respondent either imposes thresholds on attribute levels or assigns a condition to one attribute on the level of another attribute (see, e.g., Swait 2001, Cantillo & Ortuzar 2005, Hensher et al. 2005b, Cantillo et al. 2006).

Many reasons for discontinuous preference ordering have been suggested. First, the indication of real lexicographic preferences comes from the identification of discontinuous preferences (strict or modified) in relatively easy tasks, measured by the number and familiarity of the attributes (Mazzotta & Opaluch 1995, Saelensminde 2006). Second, discontinuity may reflect actual non-lexicographic preferences when the ranges of attribute levels are specified too broadly to capture the actual preferences, or third, may imply a simplifying strategy implemented to cope with a difficult choice task (de Palma et al. 1994, Saelensminde 2006). The evidenced causes for discontinuous preferences are the situation of making a choice (Diederich 2003, Saelensminde 2006) and respondent-specific characteristics such as cognitive ability (Drolet & Luce 2004), education (Saelensminde 2006), income, and age (Hensher et al. 2007). In the CV context, one important cause of lexicographic choices has been an ethical position towards nature, which refers to an inability to make trade offs between environment and money (see, e.g., Rosenberger et al. 2003). In our analysis, we only consider the discontinuity between the attributes without paying attention to which attribute (price or water quality characteristics) is not accounted for.

The choices not reflecting compensatory behaviour, once identified either by follow-up questions or inspecting actual choice behaviour (e.g., Spash & Hanley 1995, Lockwood 1999), can be eliminated (e.g., Hensher et al. 2005b) or taken into account parametrically by adjusting a statistical model (Saelensminde 2006), such as allowing for a scale parameter to capture the variance of unobserved factors (Campbell et al. 2008). Eliminating non-standard responses may bias the sample if significant determinants for non-standard preferences can be found. The variation in the implications of discontinuous preferences for the model fit and the robustness of WTP estimates among studies (DeShazo & Fermo 2004, Hensher et al. 2005b, Cantillo et al. 2006, Saelensminde 2006) may reflect a difference in which good respondents are lexicographic for, that is, whether they are lexicographic for a particular environmental attribute or money attribute. The literature suggests that information processing strategies should be viewed endogenously and be built into the estimation of the choice data of stated choice studies (Hensher 2006).

4 The choice experiment applied to eutrophication in the Gulf of Finland

4.1 Experiment

The choice experiment is a stated preference (SP) method which belongs to a family of choice modelling techniques together with contingent ranking, contingent rating, and paired comparisons. Out of these techniques, only the choice experiment is consistent with welfare theory as well as contingent ranking in the case that a currently feasible alternative is included in the choice set. The consistency of the method with welfare theory follows from 1) the fact that the respondents must trade-off the changes in attributes and the associated cost, 2) the respondents can choose the alternative of no environmental improvement with no cost, 3) in the analysis, the rational probabilistic choice is represented by the parallel econometric technique, and 4) the welfare estimates can be derived from the output of the econometric technique (Bateman et al. 2002).

The choice experiment builds on the choice between alternatives, out of which one is an opt-out or a status quo or 'do nothing' alternative. This alternative is important because it allows the welfare estimates to be reported *relative* to the current situation, which is useful for the purpose of, e.g., the cost-benefit analysis. In addition to the value of the scenarios, the information on which attributes significantly determine the values people place on non-market goods and the implied ranking of the attributes is valuable information in a policy context (Bateman et al. 2002).

In order to elicit the preferences of the general public for a specified environmental improvement by choice experiment survey, the construction of the survey begins with an iterative definition of the research problem, alternatives, attributes, and attribute levels. The attributes should be behaviourally relevant to the respondents and usable by decision makers. The attribute levels can be either quantitative or qualitative. There are two important issues concerning the attribute levels. First, the number of levels must be sufficient for a good enough approximation of the true utility function. For instance, two levels only allow for an estimation of the linear utility function, which may not correspond to the reality. Second, the extreme ranges (or end points) of the levels should be defined outside the experienced levels but still be credible to the respondents. The latter also applies to the ordinal qualitative attributes, for which there exists a natural order for the levels. In addition to environmental attributes, alternatives include a price attribute as a definition of a payment vehicle (Bennett & Blamey 2001, Bateman et al. 2002, Hensher et al. 2005a).

The aim of this PhD thesis is to elicit the preferences of Finns for reduced eutrophication in the Gulf of Finland and to provide welfare estimates for selected nutrient reduction scenarios. The alternatives in this choice experiment – states of the Gulf of Finland in the year 2030 – were described in terms of the price attribute, referring to the cost associated with the policy implementation, and four seawater characteristics, referring to the resulting water quality improvements. The choice tasks (Fig. 4-1) consisted of two policy alternatives and one opt-out option with no improvement and no cost involved. The opt-out option referred to staying on the business-as-usual (BAU) path. The alternatives were labelled as "Agreement A", "Agreement B", and "No Agreement (C)".

CHOICE SITUATION 1

	AGREEMENT A	**AGREEMENT B**	**NO AGREEMENT (C)**
TAX FOR THE HOUSEHOLD	€70 / year	€30 / year	€0 / year
SEA BOTTOM CAN BE SEEN	clearly	hardly	not at all
NUMBERS OF CYPRINIDS	small	rather large	large
BLADDER WRACK IS	good	a bit weakened	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … **(please check one)** →	**A** ☐	**B** ☐	**C** ☐

Figure 4-1. Example of a choice task in a base case questionnaire in the absence of explicitly mentioned uncertainties in achieving the described future state.

The water quality attributes were chosen using an earlier study concerning citizen's perceptions of the most experienced and most harmful consequences of eutrophication in the Gulf of Finland (Kiirikki et al. 2000, 2003), indicators used by the environmental administration (see Bäck et al. 2006), focus groups, and a pilot study conducted by mail. In addition to consulting with ecologists, representatives of the general public were asked about their perceptions of the most important consequences of eutrophication. The water quality attributes presented in table 4-1 were water clarity, the abundance of so-called coarse fish species[4] (*Cyprinids*), the state of the population of the perennial macro algae species bladder wrack (*Fucus vesiculosus*), and the number of days that mass occurrences of blue-green algae blooms are seen each year.

[4] *Coarse fish* means fish that thrive in eutrophied conditions and are unattractive to anglers.

Each water quality attribute had three qualitative levels. The levels captured the range of current and potential future trends in the state of the Gulf of Finland. The opt-out option represented the worst levels of attributes, while the policy options are different combinations of higher levels of attributes. The levels of the price attribute were defined according to previous literature on water quality improvements and focus group interviews.

Table 4-1. Attributes and levels.

Attribute	Description	Attribute levels		
Tax for the household (TAX)	Tax for household once a year for 20 years (€)	0, 5, 30, 70, 150, 350, 500		
		Best	Middle	Worst
Water clarity (WAT)	Visibility of sea bottom (at 1m depth)	Clearly visible	Hardly visible	Not at all visible
Numbers of Cyprinids (ROA)	Numbers of so-called coarse fish (*Cyprinids*)	Small	Rather large	Large
Bladder wrack (BLW)	State of the bladder wrack population	Good	A bit weakened	Weakened a lot
Blue-green algae bloom (BGA)	Mass occurrences of blue-green algae in summer	1–4 days	5–21 days	22–60 days

The questionnaire version with uncertain policy options included the attribute "Likelihood of achieving the state", which had the levels 100% (BAU option), 80%, and 60%. The questionnaire version with the uncertain BAU option had no additional attributes.

From a policy viewpoint, a relevant aspect related to the marine environment is the unpredictability (or uncertainty) of the impacts of implemented policies on water quality. In order to examine the variation in the response uncertainty that results from accounting for this outcome uncertainty, we built three questionnaire versions - the base case, the policy uncertainty, and the business-as-usual (BAU) uncertainty - that differed in terms of the framing of alternatives. The questionnaire versions can be found in Appendices I-III.

In the base case, the certainty of achieving the marine states of both the policy and the BAU options was not explicitly mentioned. Instead, in the case of uncertain results of the policy, an additional attribute was included in the alternatives to define the likelihood of the policy to result in that state. In the case of policy failure the BAU state, that is, the worst case scenario, would result. For the policy options, the likelihood was either 60% or 80%, and the BAU level was defined as certain. By contrast, in the BAU uncertainty case, the policy would result in the described state with 100% certainty, but in the worst environmental state with an 80% likelihood and a better state with a 20% likelihood.

The term *experiment* means the systematic manipulation of the levels of one or more variables and the observation of the effect of the manipulation on one variable. In the choice experiment, this means using statistical design theory to combine the levels of attributes into the alternatives to be grouped into the choice sets as well as observing individuals' choices (Bateman et al. 2002). In our study, the experimental design was conducted with the help of a balanced overlap procedure in the Sawtooth Software program that allows for overlap of the attribute levels within the choice task. Therefore, the balanced overlap procedure can lead to more precise estimates of the interaction effects than other design procedures in Sawtooth Software, such as complete enumeration, which does not allow the same levels of attributes for the alternatives in a choice set (Sawtooth Software 1998). Several random designs were created, and the one with the greatest statistical efficiency was chosen.

In total, two sets of 36 choice tasks were constructed: one set for the base case and the BAU uncertainty versions and another for the policy uncertainty version due to the additional attribute (the likelihood of achieving the state in 2030). The sets were blocked into six blocks of six tasks. The choice tasks with dominant alternatives (i.e., one alternative is the best in terms of all attributes) were modified. The design matrices are in Appendix IV.

4.2 Collection of the data

Apart from the core of the choice experiment – a series of choice questions concerning future states of the Gulf of Finland – the questionnaire contained other questions. The 12-page mail survey questionnaire (see the English translation in Appendix I) was constructed following the survey practice recommended by Dillman (2000) and it consisted of five parts. In the first two parts, the study area and the issue in question were introduced by examining the respondent's connections to the Gulf of Finland, her experience of the harm caused by eutrophication, and her perceptions of the current state of the Gulf of Finland. The core section presented the future scenario of the Gulf of Finland without new policy implementations (the BAU option) and provided an alternative: a somewhat better state resulting from international co-operation and a rise in taxes for 20 years. The last two parts elicited information about answering choice tasks, such as her attribute-processing strategy and uncertainty as a respondent, and her socio-demographic characteristics.

Table 4-2 (p. 33) illustrates the collection of data for analysis: sampling utilizing three strata, the mailing of questionnaires, and the reassigning of the respondents into subsamples. The addresses of 2,000 Finnish citizens were obtained from the Population Register Centre of Finland. The sampling process was conducted in three steps. First, a sample of 1,000 people was selected randomly out of the Finnish population ("citizens"). Then, a sample of 500 people was selected randomly out of the residents of municipalities along the coast of the Gulf of Finland ("coastal residents"). Before doing this, the Finns already selected were deleted in order to avoid anyone being selected twice. Finally, a sample of 500 people was selected randomly out of the owners of summer cottages[5] in municipalities along the Gulf of Finland ("cottage owners"). The information about cottage ownership was available in the Population Register Centre of Finland. Again, the group out of which the selection was taken consisted of people not yet selected. Due to non-random sampling, weighting is an issue when estimating the mean WTP of a population. This will be discussed in section 6.

The reason for the stratification was to be able to study the differences in WTP in relation to the closeness of contact with the Gulf of Finland, which also relates to familiarity with the good (Bateman et al. 2002). The "coastal residents" and the "cottage owners" live on the coast of the gulf, either full-time or part-time. Thus, they are identified as users of the Gulf of Finland, at least to a certain extent. In addition to use values, these groups may hold non-use values of the water quality improvement in the Gulf of Finland. For the "citizens", non-use values are likely to be important, although some of the "citizens" may also use the Gulf of Finland for recreational purposes. Due to the national uniqueness of the Gulf of Finland as a marine area, the stratum "citizens" included Finns from all over Finland.

The pilot survey of 100 respondents was conducted by mail in March 2006, and the final survey data were collected by mail in June and July 2006. The first row in table 4-2 shows that a sample of 1,900 respondents was divided into three subsamples as follows: the numbers of "citizens", "coastal residents", and "cottage owners" were 943, 473, and 484, respectively. Three questionnaire versions, i.e., uncertainty treatments called "base" with no explicit uncertainty, "policy uncertainty", and "BAU uncertainty", were randomly distributed. Two mailing rounds, a reminder in between, and the deletion of questionnaires with missing answers to the questions relevant to the analysis resulted in 812 responses

[5] In Essay I and Appendix V, the word "vacation home" is used instead of the word "summer cottage".

(42.7% of the sample), out of which 354 were from the strata “citizens”, 184 from the strata “coastal residents”, and 274 from the strata “cottage owners”. The shares of usable questionnaires out of those sent were 37.5% for the sample “citizens”, 38.9% for the sample “coastal residents”, and 56.6% for the sample “cottage owners”.

As demonstrated in the lower part of table 4-2, before the analysis the respondents were reassigned into subsamples based on the information in the questionnaires due to the non-exclusiveness of the strata. At this stage, 265 respondents had no residential contact with the Gulf of Finland, 272 respondents had a permanent residence in a coastal municipality, and 275 owned a summer cottage on the coast of the Gulf of Finland. Unfortunately, the actual response rates of the subsamples cannot be specified. For instance, it is impossible to gather information on the owners of coastal summer cottages among the non-respondents of the other samples. Concerning the overlap of the subsamples, an important note is that, out of the “cottage owners”, 87.8% also lived permanently in a coastal municipality. While the information on the permanent residence in the coastal municipality was based on the address of the respondent, the ownership of the summer cottage was identified according to the respondents’ answers to question 1G (see the questionnaire in Appendix I).

After reassignment of the data, protest answers were identified with the help of a follow-up question (question 13) among those who chose alternative C (business-as-usual) in all six choice tasks. The protesters gave the following motivations for their behaviour: “The polluters should pay”, “I don’t believe that the measures would improve the state of the Gulf of Finland”, and “Other countries should be responsible for the improvement of the Gulf of Finland”. The average share of protesters was 10.6% of the usable questionnaires, while the subsample-specific shares of protests were 9.8%, 8.5%, and 13.5% for “citizens”, for “coastal residents”, and for “cottage owners”, respectively. After excluding the protesters, the number of respondents left for analysis was 726 (38.2% of the sample), consisting of 239 “citizens”, 249 “coastal residents”, and 238 “cottage owners”.

Table 4-2. Summary of the sampling and data treatment.

SUBSAMPLES	CITIZENS (1)	COASTAL RESIDENTS (2)	COTTAGE OWNERS (3)	
COLLECTION OF DATA				
Number of questionnaires	943	473	484	1900
Usable questionnaires	354	184	274	812
	37.5 %	38.9 %	56.6 %	42.7 %
REASSIGNMENT INTO SUBSAMPLES				
Number of respondents	265	272	275	812
Protesters (to be excluded)	26	23	37	86
	9.8 %	8.5 %	13.5 %	10.6 %
Number of respondents in the analysis	239	249	238	726 38.2 %

4.3 Analysis of the data

Table 4-3 presents a summary of the three questionnaire versions (i.e., uncertainty treatments) and their use in the analyses reported in the three essays of the thesis. The data (N=726) included 240 respondents to the "base" questionnaire version, 252 respondents to the "policy uncertainty" version, and 234 respondents to the "BAU uncertainty" version. The members of different subsamples "citizens", "coastal residents", and "cottage owners" (see table 4-2) are rather equally distributed among uncertainty treatments.

Table 4-3. The use of uncertainty treatments in the essays.

TREATMENTS	BASE	POLICY UNCERTAINTY	BAU UNCERTAINTY	
ANALYSIS				
Design set	1	2	1	
Number of respondents	240	252	234	726
Members of subsamples (1)+(2)+(3) *)	89+74+77	75+92+85	75+83+76	726
ESSAYS				
	I	II	III	
Number of respondents	726	726	307	
Number of observations	3946	3946	1687	
Econometric models	MNL RPL LCM	RPL	ECM	
Specification of ASC	BAU	POLICY	BAU	
Control for:				
uncertainty treatment	No	Yes	No	
coastal residency	Yes	No	No	
cottage ownership	Yes	No	No	

**) Subsamples refer to the last row in table 4-2: 89+75+75=239, 74+92+83=249, and 77+85+76=238.*

In all the analyses except for Essay III, the data from the different treatments are pooled: 726 respondents and 3,946 observations, i.e., choice tasks, are analysed. In Essay III, a random representative sample of Finnish citizens was used, resulting in 307 respondents and 1,687 choice tasks. The models applied are the MNL model, the RPL model, and the LCM in Essay I, the RPL model in Essay II, and the ECM in Essay III. The models included the main effects of the attributes, the alternative-specific constant (ASC), and several other variables. The ASC was specified as one for the BAU option in Essays I and III, while the opposite holds for Essay II. The uncertainty treatment is controlled by a dummy variable in Essay II but not in Essays I and III. Essay II also differs from Essay I in terms of control for coastal residence and coastal summer cottage ownership. No control was necessary because the aim of Essay II was to study the effect of respondent uncertainty on the WTP, and the individual-specific impacts on the WTP were not of specific interest. The same reason applies to the lack of control of socio-demographics in Essay III in addition to the fact that the data were found to be representative of the Finnish population. The impact of these decisions on willingness to pay estimates is discussed in section 6.3.

5 Summaries and primary results of the essays

I. Heterogeneous preferences for water quality attributes: the case of eutrophication of the Gulf of Finland, the Baltic Sea

This essay examines the heterogeneity of the preferences of the general public regarding water quality attributes and provides welfare estimates (willingness to pay, WTP) for three nutrient reduction scenarios that would improve the water quality in the Gulf of Finland, which is part of the Baltic Sea. In the choice experiment (CE), the improvement is described in terms of four water quality attributes: water clarity, the abundance of coarse (non-attractive) fish, the status of the bladder wrack (a type of seaweed), and mass occurrences of blue-green algae blooms.

The attributes reflect multiple consequences of eutrophication as well as several dimensions and values of the Gulf of Finland for which the preferences of the respondents are expected to vary. The data are analysed with three models: the Multinomial Logit (MNL) model, the Random Parameters Logit (RPL) model, and the Latent Class Model (LCM). While the MNL and RPL models reveal the sources of heterogeneity in relation to the contribution to water quality improvement in general, the LCM reveal preference heterogeneity for particular attributes.

On average, the respondents are willing to contribute to the improvement of the water quality of the Gulf of Finland. The probability for this increases with residential or recreational contact with the gulf, higher than average income, younger than average age, and the absence of dependent children in the household. On average, for the respondents the relatively most important characteristic of water quality is water clarity followed by the desire for fewer occurrences of blue-green algae.

The LCM reveals a group with a tendency to choose a business-as-usual option. The probability of belonging in this group increases with non-coastal residence and lower than average income. Non-coastal residence is a significant determinant for membership in a group for which no other attributes except price affected the choice. Age, household income, coastal residence, and summer cottage ownership explain the opinions about the order of relative importance of the attributes.

For three nutrient reduction scenarios of different intensities, the annual mean household willingness to pay estimates range from €271 to €448 and the present values range from 28 billion euros to 54 billion euros. The present values are calculated using the mean welfare estimates and discounted for perpetuity with a 2 percent rate.

II. Respondent uncertainty in choice experiment: causes and implications for WTP estimation

This essay empirically tests the impact of accounting for respondent uncertainty on WTP estimation in the CE context in order to provide more information on this novel issue. Another aim is to examine the sources of response uncertainty with the focus on price, the utility difference within the alternatives of the choice set, several sociodemographic characteristics, and the acceptance of scenario elements. As a way to increase the acceptance of the scenario, the essay investigates the introduction of outcome uncertainty in the valuation scenario.

After the choice sets, the respondents are asked to state their certainty of their choice of preferred alternative. The determinants of respondent certainty are analysed with the ordered logit model. To examine the impact of respondent uncertainty on model performance, Mixed Logit analyses of original and respondent-uncertainty-adjusted data are compared. Three treatments of the information about respondent uncertainty are tested, namely, the elimination of uncertain responses and two alternative recoding approaches using either the BAU choice or the best available alternative, which is determined using the individual parameter estimates from the Mixed Logit model.

Both recoding approaches reduce the model fit and the efficiency of the WTP estimates, whereas the elimination of uncertain choices from the analysis leads to a slightly better model fit and has a minor decreasing impact on the efficiency of the estimates.

The causes of response certainty are in accordance with the findings of previous studies. The response certainty decreases with an increase in the price of the chosen alternative and increases with a positive attitude towards the scenario, prior free time visits to the area, high education, and male gender. In addition, a large within-choice-set utility difference increases the likelihood of stating certainty, implying a rational reason for response uncertainty. The introduction of outcome uncertainty in the scenario increased the acceptance of the scenario, which may indicate an increase in the credibility of a proposed scenario.

III. Does accounting for discontinuous preferences improve the willingness to pay estimates for reduced eutrophication in the Gulf of Finland?

This essay examines the incidence of discontinuous preferences in a discrete choice experiment, their underlying causes, and the implications for the efficiency of WTP estimates for reduced eutrophication in the Gulf of Finland. In the experiment, water quality improvement resulting from the reduction of nutrients is described in terms of four attributes.

Preference discontinuity refers to the violation of the continuity axiom of neoclassical consumer theory. In the choice task, the respondent may consider only some of the attributes due to either behavioural relevance or the simplification of a difficult task, instead of making trade offs based on all the attributes. The respondents expressing discontinuous preferences are identified with the help of two follow-up questions. Two approaches to how to treat these respondents in analyses are tested: the introduction of the scale parameter and the elimination of less important attributes.

Out of 307 respondents resulting from a random sample of 943 residents, one tenth (10.4%) are identified as potentially having discontinuous preferences. The probability for preference discontinuity increases with younger than average age, female gender, higher income, non-coastal residence, and haste in answering the questionnaire. The tax attribute is most often perceived as more important than other attributes, followed by the blue-green algae, water clarity, bladder wrack, and fish attributes. The introduction of the uncertainty of achieving either the outcome of a policy implementation or the future state of the Gulf of Finland without new policies does not affect perceptions of the attributes' importance.

The preference discontinuity is accounted for with the Error Component Multinomial Logit model. Both the introduction of the scale parameter and the elimination of less important attributes according to the respondents improve the model's performance. The impact on the efficiency of WTP estimates for water quality improvement in the Gulf of Finland depends on the model specification. Contrary to expectations, the scale parameter does not reveal a larger unobserved variance in the utility of the respondents with discontinuous preferences.

6 Discussion and conclusions

The thesis consisted of three essays on the monetary valuation of the benefit from reduced eutrophication in the Gulf of Finland. In addition to producing information on the benefits of water quality improvement in the Gulf of Finland, the thesis demonstrated the use of the following econometric models: the Random Parameters Logit model, the Latent Class Model, and the Error Component Multinomial Logit model. While standard, these models are flexible enough to reveal and account for features beyond the homogeneous Multinomial Logit analysis of discrete choice data. The thesis aimed at contributing to the benefit estimation of the protection of the Gulf of Finland and to the discussion of the implications for the welfare estimation of two anomalies that are common in the stated preference studies: respondent uncertainty and preference discontinuity.

6.1 Findings

Heterogeneity of preferences is significant for improvement in general and for water quality attributes. The analysis reveals that, on average, Finns are in favour of protecting the Gulf of Finland, which indicates the importance of the study area to the general public. However, some citizens do not experience any benefit from water quality improvement. Another important aspect related to heterogeneity of preferences is that not all the attributes are behaviourally relevant to all the respondents. The statistically significant difference in WTP estimates owing to the socio-demographic characteristics of the respondents suggests that differences in tastes must be accounted for in the analysis.

Essay I provides an example of linking qualitative attribute levels to objective water quality measures (biomasses of algae species). This linking has been much discussed in the field of stated preferences valuation. In the definition of the good being valued, there is a trade-off between the respondents' ability to understand the good, but, at the same time, the good's applicability for decision makers. In general, the technical measures of eutrophication used by the environmental administration are not usable in the stated preferences questionnaires as such due to the layperson's difficulty in understanding them, and therefore some link must be specified.

For the protection of the Gulf of Finland, WTP estimates of water quality improvement are important because no studies on the valuation of the Gulf of Finland exist. These estimates may also serve as an input for benefit transfer in the entire Baltic Sea area because information on the benefits of protecting the Baltic Sea are needed, but the literature concerning the valuation of water quality improvement is not extensive.

The incidence of respondent uncertainty and discontinuous preferences in the data as well as the improvement in the model performance and potentially also in the efficiency of WTP estimates when accounting for anomalies in the analysis underline the importance of identifying and paying attention to these anomalies. Successful consideration of the deviations from standard preference ordering and of respondent uncertainty concerning the choice process in the analysis of the CE data can increase the credibility of the method among policy planners and those who distrust stated preference valuation methods.

An interesting finding is that, concerning the credibleness of the scenario, the comparison across questionnaire versions implies that introducing the uncertainty of future states of the Gulf of Finland resulting from the policy implementations increases the acceptance of proposed scenario. That is, increasing the uncertainty in the response of the marine ecosystem to nutrient reductions decreases the uncertainty in the respondents' choices. Another finding related to uncertainty is that the aspect of uncertain achievement of the future state described in the choice task is more relevant with respect to uncertainty related to the policy implementations than to the business-as-usual option.

Evidence that the respondent uncertainty partly stems from the valuation exercise itself and that, in some cases, the adjustment for respondent uncertainty improves the model and the efficiency of the estimates motivates researchers to account for respondent uncertainty both in the design of the stated preference surveys and in the analysis of valuation data. Knowledge of the causes of heterogeneous as well as discontinuous preferences and respondent uncertainty is relevant for the planning phase of future experiments.

Without understating the importance of careful planning of the scenario and the questionnaire in order to decrease the number of uncertain responses, it is important to know how to handle uncertain respondents in the analysis. The same applies to respondents with discontinuous preferences. Following the procedures of accounting for uncertainty used in the contingent valuation applications, the thesis shows, in accordance with previous studies, that the chosen approach of treating uncertain responses affects model performance and WTP estimation. The reduction in the model fit and the efficiency of WTP estimation results from the recoding of uncertain choices either as a BAU choice or the best of the available alternatives. Instead, a slightly better model fit and only a minor negative impact on the results result from eliminating uncertain choices from the analysis. However, the superiority of the elimination approach is likely to be traded-off when the share of uncertain responses is large. Besides the problem of uncertain respondents, the elimination approach serves as the best approach to treat preference discontinuity when measured in terms of model performance. In terms of the efficiency of the WTP estimates, the superiority of one model over another is not a clear case.

Common to all three analyses performed (Essays I-III) is that no straightforward suggestions for the best model or the best treatment of non-standard responses can be given. In the policy-oriented analysis aiming at estimating the WTP for water quality improvement, the priority of the weighting required for the aggregation of the WTP estimates is traded off for different relative orders of the importance of the attributes. The latter is only revealed by the Latent Class Model, which does not allow for weighting of the responses.

6.2 Validity of the results

The evaluation of the validity of results can be done from viewpoints of content (or internal) validity and construct validity. The latter includes convergent validity and expectation-based validity (Bateman et al. 2002). The model and the results passed several formal tests of internal validity. In all the models, the parameter estimates had the expected signs. According to the likelihood ratio test for the contribution of a particular set of attributes, the null hypotheses that all parameter values were equal to zero were rejected, indicating that the variables of the model were important predictors of the choice. As a statistical measure of model fit, the likelihood ratio indexes (the pseudo R^2) of the models, which ranged from 0.12 to 0.66, indicated that the models, except for the worst ones, were quite good: values of 0.3-0.4 indicate good model fit. The IIA test conducted for the Multinomial Logit model in Essay I implied that the use of more advanced models is necessitated. In all three essays, the predictive validity of the results improved with more flexible models by providing better behavioural realism.

Another aspect of internal validity is the formulation of the questionnaire and how well the respondents understood the good being valued. The definition of the good started with focus group interviews. The good was described to the respondents with the help of pictures of blue-green algae blooms and bladder wrack on the cover of the questionnaire. However, in the choice situations, only text was used for the description of the qualitative attribute levels, which may have impeded some of the respondents from understanding the attribute levels. In order to familiarize the respondents with the attributes, they were asked to state their perceptions of the current water quality in terms of the attributes before the actual choice tasks. Maps of the Gulf of Finland as well as its catchment area in Finland were presented in the questionnaire. In addition, while introducing the scenario, the respondents were asked questions regarding the credibility of an opt-out option, the acceptability of tax as a payment vehicle, and their perception of international co-operation in order to give the respondents time to think and process information. The answers to these questions showed that the scenario was accepted reasonably well.

The convergent validity of the results cannot be assessed due to the lack of other data, such as revealed preference data of water quality improvement in the Gulf of Finland. Likewise, the validity of the results cannot be tested through a comparison to real market behaviour, which is a common disadvantage of stated preference studies. One interesting aspect of evaluating the results is reliability, which refers to the stability of willingness to pay estimates over time. This is especially interesting due to the uncertainty related to combating eutrophication, as this uncertainty may be solved over time.

Apart from convergent validity, expectation-based validity can be assessed. The results meet the theoretical expectations: both a close connection to the Gulf of Finland and higher income have a positive effect on the willingness to pay. Concerning the causes of respondent uncertainty, likewise previously found in several studies, the results showed that a prior familiarity with the good increased the likelihood of expressing certainty about the choices. Also, high education and male gender were important determinants of respondent certainty found in other studies. Out of the questionnaire-related aspects, a positive attitude towards the scenario and the large utility difference within the choice task increased the likelihood of expressing certainty. In this respect, the results of the thesis confirm the existing knowledge on the factors behind respondent certainty.

6.3 Approaches and analysis

Although the tests discussed in the previous section indicate the validity of the results, it is necessary to discuss the effect on the accuracy of WTP estimates of several issues regarding data collection and analysis, such as experimental design, sampling and weighting, control of uncertainty treatments, and endogenous attitudinal variables.

The experimental design posed several problems in the analysis and in the interpretation of the results. First, as the respondents may have considered the water quality attributes somewhat correlated (although no protest answers were seen in the pilot phase), in order to avoid strange combinations of attribute levels, attribute level combinations were restricted. The business-as-usual levels appeared only in the business-as-usual option, while the policy alternatives consisted of two higher attribute levels. This prevented the estimation of a fully specified model. In addition, qualitative attributes are not as informative as quantitative characteristics in descriptions of water quality, and they behave less smoothly than continuous variables in the model. Second, using two experimental designs which are then pooled in the same analysis may not be the best practice. Third, although the design with the highest statistical efficiency was chosen, it is not clear whether this random design was the most efficient design possible.

Due to the inability to fully identify the model, the WTP estimates must be interpreted with caution. As the WTP estimates measure changes with respect to the business-as-usual level, while the middle levels of attributes had to be ignored in the model estimation, the effect of mid-levels on the choice is thus reflected in the alternative-specific constant in addition to other effects not explained by the variables in the model. When estimating the WTP, a high-level attribute is assumed to refer to a change from the business-as-usual level to the high level. In the WTP calculation of the scenarios, the attribute is assumed to be linear by multiplying the coefficient of the high-level attribute by 0.5. This estimation procedure is likely to yield overestimations of the WTP estimates for the scenarios associated with middle attribute levels.

In addition to the bias associated with the variables in the model, two other problems need to be considered when interpreting the results in Essay I, namely, the non-respondents and the non-random sample. As presented in Appendix V, the effects of these problems on WTP estimations are parallel. Proximity to the Gulf of Finland was found to increase the WTP as well as the willingness to respond to the survey. Because non-respondents and respondents were assumed to have the same WTP distribution, and the data likely consisted of too many respondents having higher WTP, the reported WTP estimates are upwards biased. On the other hand, the three-step non-random sampling procedure was not the most appropriate as it resulted in a non-representative sample. This problem was corrected by including the socio-demographic variables, with respect to which the sample was not representative, and by weighting the estimates of the population means WTP after the parameter estimation.

However, the comparison of the resulting WTP estimates in Essay I to the estimates derived from the random Finnish sample (Appendix V) revealed that the results reported in Essay I likely are upwards biased. Based on these two tests, we may conclude that the WTP estimates in Essay I likely overstate the WTP of the Finnish population. The standard model in Essay III produced more precise population WTP estimates in terms of a more conservative assumption on the WTP of non-respondents, but still, in addition to not being weighted for representativeness of the population, the estimates were based on the average household WTP, which may not reflect the aggregate population WTP with the same accuracy as the average individual WTP estimates. Concerning the calculation of the confidence intervals of WTP estimates, according to the delta method and the Krinsky-Robb procedure, both methods resulted in variances of almost similar size.

Additionally, pooling different design sets without controlling for uncertainty treatments in the analysis may result in additional bias. Uncertainty treatments were controlled for with the dummy variables in Essay II, while in Essays I and III, the impact of outcome uncertainty is reflected in the (random) alternative-specific constant. The concern is that pooling different design sets without controlling may result in upwards biased estimates of the mean WTP because the WTP in the case of an uncertain policy is higher. Whether or not pooling is harmless was tested, although not reported elsewhere in the thesis, by running the MNL model with only the data from the base questionnaire version and with the data containing all questionnaire versions. The comparison of the WTP estimates for each attribute (WAT, ROA, BLW, and BGA) and for the three scenarios revealed that, in most cases, the pooling was safe. According to the t-test, the estimates from different samples were not statistically different from each other with one exception. At a 95% confidence level, the WTP estimates from the base version were significantly lower for the blue-green algae and for scenario 2 (in which the blue-green algae was at a higher level), and higher for the water clarity attribute. Out of these, only the lower WTP for the blue-green algae applied at a 90% confidence level. This comparison implies that the WTP estimates in Essay I could be slight overestimations with respect to the blue-green algae, as the uncertainty seems to favour the preferences for the blue-green algae at the expense of water clarity. However, this test was only run for the MNL model as the data set from the base version is too small for the more advanced model to estimate. Thus, unfortunately, no safe conclusions can be made about the bias in the estimates obtained from the RPL model.

One further issue to be discussed, especially in relation to Essay II, is the use of attitudinal variables in estimations. These variables may not be independent of the error term of the linear model, but rather reflect the same factors as the dependent variable or other explanatory variables, thus being endogenous. This poses a problem of potentially biased and inaccurate estimation of choice probabilities when attitudinal factors are used as explanatory variables in the choice model. Although not discussed in the essay, a similar issue may arise in Essay I. The socio-demographic variables in the choice model may not be fully independent of each other, e.g., as well known, households living on the southern coast of Finland and owning a summer cottage on the coast most likely, on average, have a higher income than average in Finland. This was controlled for before introducing the explanatory variables in the model by examining the correlations in order to avoid variables that are too correlated. With regard to the endogenous attitudinal variables, their introduction to choice modelling certainly requires more advanced methods than those applied in this thesis.

6.4 Conclusion and possible future research directions

In conclusion, this study contributes to the estimation of the benefits of water quality improvement by providing new WTP estimates for selected nutrient reduction scenarios in the Gulf of Finland. However, when considering the seemingly valid WTP estimates produced in this thesis, the restrictions stemming from the decisions concerning approaches and analyses, as discussed in this section, should be borne in mind.

Looking to the future, some interesting extensions related to the analysis can be described. First, the random parameters in the RPL model were assigned a normal distribution, which is the most common approach in earlier literature. Studying the suitability of other distributions would be important (see, e.g., Hensher & Greene 2003, Siikamäki & Layton 2007). Second, this thesis analysed the choice data in the "preference space" with coefficients of utility, using a random parameters logit (RPL) model. Recently, multinomial choice models with random tastes have been analysed in "WTP space" (Train & Weeks 2005, Sonnier et al. 2007, Scarpa et al. 2008), which is an extension of the expenditure function approach in the analysis of contingent valuation data (Cameron & James 1987). In comparison to the approach used in this thesis, the advantage of the WTP space approach is that it may provide more reasonable WTP distributions because they can be directly specified and estimated instead of being derived from the distributions of the coefficients of the utility function.

Concerning the anomalies common in the stated preference studies and how to cope with them, this thesis provides new information. An interesting challenge for future research is to extend the analysis of respondents' attendance to attributes also to account for the effect of attribute levels. This would better account for potential differences in attitude-attending strategies between the choice tasks. In future explorations of anomalies, the analysis could be improved by applying the methods recently developed in the field of transportation and marketing research, such as the Integrated Choice and Latent Variable model, which is free of the problem of endogenous variables in estimations (see, e.g., Walker & Ben-Akiva 2002, Temme et al. 2008). All in all, as the ability to generalize the results concerning anomalies requires more than one data set, the methodological research questions of this PhD thesis can be further developed and analysed with many data sets.

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APPENDIX I. The English translation of the questionnaire version "base".

(The original questionnaire versions in Finnish and Swedish are in colours.)

SURVEY

Eutrophication of the Gulf of Finland in the Year 2030

Bladder wrack – a reproduction environment for fish and small marine animals

Blue-green algae on the open sea

University of Helsinki
Department of Economics and Management
May 2006

YOUR CONNECTIONS TO THE GULF OF FINLAND

in English:

Suomi = Finland
Suomenlahti = the Gulf of Finland
Viro = Estonia
Venäjä = Russia

1. The Finnish coast of the Gulf of Finland reaches from Hanko to Virolahti (see the illustration above). In which of the following ways are you connected to the Gulf of Finland? (Please check yes or no, and if needed, fill in the answer on the appropriate line.)

		Yes	No
A	Have you ever visited the coast of the Gulf of Finland?	1☐	0☐
B	Have you cruised on the Gulf of Finland (for example, to Stockholm, Tallinn)?	1☐	0☐
C	Have you heard or read about the Gulf of Finland in the media? If yes, which media? ______________________________	1☐	0☐
D	Have you spent free time on the coast of the Gulf of Finland? If yes, where mostly? ______________________________	1☐	0☐
E	Do you now live on the coast of the Gulf of Finland (within 1 km of the coast)?	1☐	0☐
F	Have you earlier lived on the coast of the Gulf of Finland? If yes, where? ____________________________________	1☐	0☐
G	Do you or any of your family members have a vacation home on the Gulf of Finland? If so, where? ________________________	1☐	0☐
H	Do you or any of your family members have a boat on the Gulf of Finland? If yes, what kind of boat? ____________________	1☐	0☐
I	Does your occupation or work have a close connection to the Gulf of Finland?	1☐	0☐
J	Does the Gulf of Finland have any other connection to your life? If yes, in what way? ______________________________	1☐	0☐

Even if you answered ’No’ to each question, please continue.

CURRENT STATE OF THE GULF OF FINLAND

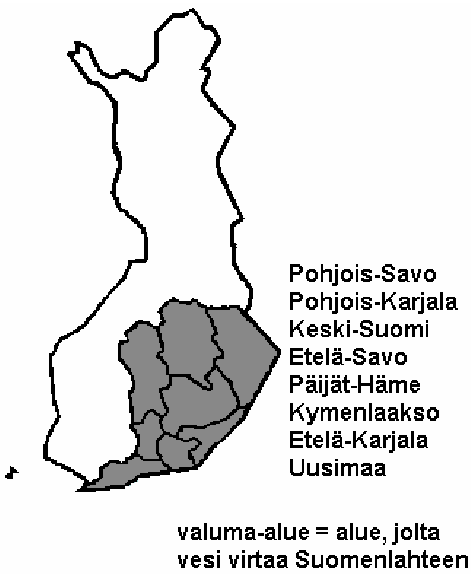
Eutrophication refers to an accumulation of phytoplankton caused by excessive nutrient flow (nitrogen and phosphorous). Although nutrients flow to the Gulf of Finland from Estonia and Russia, runoff from <u>the catchment area in Finland</u> as shown on the map is the most important cause of eutrophication in <u>the coastal waters</u> of the Gulf of Finland. <u>The open sea,</u> however, is mostly affected by the nutrient loading from other countries than Finland. Finnish nutrient sources are (in alphabetical order in Finnish):

- the fish industry
- ship sewage
- air deposits (from traffic)
- vacation and scattered settlements
- agriculture and forestry
- coastal towns
- inland towns
- industry

in English:

List of regions in the catchment area

valuma-alue = catchment area = the area from which the water flows to the Gulf of Finland



2. Eutrophication is causing, for example, the following changes in the Gulf of Finland:

- the water becomes more turbid (sight depth decreases)
- the number of Cyprinids (coarse fish) increases
- the vitality of the bladder wrack decreases (the bladder wrack is a reproduction environment for fish and small marine animals)
- blue-green algae mass occurrences form in the open sea (blue-green algae disturb the growth of young fish and are a health risk to humans and animals, since part of the algae is poisonous)

Have you experienced harmful effects from the consequences of eutrophication in <u>the Gulf of Finland</u>?

Yes	No
1☐	0☐

3. (Answer this question only if you have experienced harmful effects from consequences of eutrophication in the Gulf of Finland; otherwise go to question 4.)

How harmful for <u>yourself</u> have you experienced any of the following consequences of eutrophication that can be noticed in the Gulf of Finland? (one check per line)

		Not at all harmful	Somewhat harmful	Harmful	Very harmful	Cannot say
A	Turbid sea water	0☐	1☐	2☐	3☐	e☐
B	Increased numbers of Cyprinids	0☐	1☐	2☐	3☐	e☐
C	Fishing gear fouled by algae	0☐	1☐	2☐	3☐	e☐
D	Beaches and rocks fouled by algae	0☐	1☐	2☐	3☐	e☐
E	Dead or dying sea bottoms	0☐	1☐	2☐	3☐	e☐
F	Smell of rotting algae	0☐	1☐	2☐	3☐	e☐
G	Decreased incidence of bladder wrack (reproduction environment for fish and small marine animals)	0☐	1☐	2☐	3☐	e☐
H	Blue-green algae mass occurrences floating on the open sea	0☐	1☐	2☐	3☐	e☐
I	Small amounts of blue-green algae drifting along the coast	0☐	1☐	2☐	3☐	e☐
J	Large amounts of blue-green algae drifting along the coast	0☐	1☐	2☐	3☐	e☐
K	Health risk caused by poisonous blue-green algae	0☐	1☐	2☐	3☐	e☐
L	Other? Please specify ______________________	0☐	1☐	2☐	3☐	e☐

4. **Water quality in the Gulf of Finland differs locally. In <u>your opinion</u>, what is the current condition of the Gulf of Finland in general?** (please check one)

Excellent	Good	Moderate	Bad	Very bad	Cannot say
1☐	2☐	3☐	4☐	5☐	0☐

5. **The severity of eutrophication in the Gulf of Finland can be described, for example, with the following water quality characteristics: *water clarity, the number of Cyprinids, the vitality of the bladder wrack, and the number of blue-green algae mass occurrences*. How would you evaluate the current quality of the Gulf of Finland using the following characteristics of water quality?** (Please check only one box for each characteristic.)

WATER CLARITY	When you stand in water up to your waist, the sea bottom can be seen			
	clearly	hardly	not at all	cannot say
	1☐	2☐	3☐	0☐
NUMBER OF CYPRINIDS	The number of Cyprinids is			
	small	rather large	large	cannot say
	1☐	2☐	3☐	0☐
VITALITY OF THE BLADDER WRACK	The bladder wrack population on the coast is			
	good	a bit weakened	weakened a lot	cannot say
	1☐	2☐	3☐	0☐
NUMBER OF MASS OCCURRENCES OF BLUE-GREEN ALGAE	Mass occurrences of blue-green algae in the summer are seen for			
	1–4 days	5–21 days	22–60 days	cannot say
	1☐	2☐	3☐	0☐

STATE OF THE GULF OF FINLAND IN THE YEAR 2030

6. **According to forecasts, by the year 2030, the Gulf of Finland will develop to the following state (in terms of the following characteristics) <u>unless new</u> measures are taken to reduce eutrophication:**

In waist-deep water, the sea bottom cannot be seen at all.
The number of Cyprinids is large.
The bladder wrack population has weakened a lot.
Blue-green algae mass occurrences form in summertime for 22–60 days

In your opinion, how likely is it that this forecast will come true for the Gulf of Finland by the year 2030?

Very likely	Quite likely	Not at all likely	Cannot say
1☐	2☐	3☐	e☐

7. **These developments could be prevented if new measures for reducing eutrophication were implemented. Imagine that Russia, Estonia, and Finland were to make an agreement for this purpose. Beginning in 2010, this binding agreement would require each signatory to decrease, <u>first of all</u>, its own nutrients, because no country alone is responsible for eutrophication.**

   In your opinion, how important is it to make such an international agreement?

Very important	Important	Rather important	Not important	Cannot say
1☐	2☐	3☐	4☐	e☐

8. **In Finland, decisions about pinpointing the measures to different sources of nutrients would be made according to the latest research. Depending on which measures are adopted, the condition of the Gulf of Finland could be one of several possibilities by the year 2030. The idea would be to monitor the Gulf and implement appropriate measures as needed. Because combating eutrophication is not free, a tax would be introduced, to be collected <u>from every household</u> in Finland <u>for 20 years</u>. What do you think of such a tax?**

Very good	Good	Bad	Very bad	Cannot say
1☐	2☐	3☐	4☐	e☐

9. **In this question, we want <u>your opinion about developments in the condition of the Gulf of Finland from now until the year 2030</u>. In the following six choice situations, please choose the one that is the closest to your opinion from three alternatives (A, B, or C).**

   Alternatives **A** and **B** represent agreements that would improve the condition of the Gulf of Finland by the year 2030. Alternative **C**, “No Agreement”, stands for the condition of the Gulf of Finland without international agreements and without implementing any measures to reduce eutrophication.

   The alternative conditions of the Gulf of Finland are described by means of the following <u>characteristics of water quality</u>:

   - THE BOTTOM CAN BE SEEN clearly, hardly, or not at all
   - THE NUMBER OF CYPRINIDS is small, rather large, or large
   - THE BLADDER WRACK POPULATION is good, a bit weakened, or weakened a lot
   - BLUE-GREEN ALGAE MASS OCCURRENCES in the summer are seen for 1–4 days, 5–21 days, or 22–60 days

A special tax to be collected from each household for a 20-year period is included in alternatives **A** and **B.** In alternative **C**, no special tax would be collected.

In each choice situation, please compare alternatives **A**, **B**, and **C** regarding the special tax and the water quality measures projected for the year 2030.

In each choice situation, please choose the alternative that best describes your opinion of the preferred development of the condition of the Gulf of Finland from now until the year 2030.

Please think through each choice situation separately. Do not compare them.

Please consider how your household would prefer to spend money: to combat eutrophication in the Gulf of Finland or for something else. When you make your selection, please consider the disposable income of your household after necessary expenses (such as food, rent, and so on) have been met.

Please check one box in each choice situation.

CHOICE SITUATION 1

	AGREEMENT A	**AGREEMENT B**	**NO AGREEMENT (C)**
TAX FOR THE HOUSEHOLD	€70 / year	€30 / year	€0 / year
SEA BOTTOM CAN BE SEEN	hardly	clearly	not at all
NUMBERS OF CYPRINIDS	small	rather large	large
BLADDER WRACK IS	a bit weakened	good	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	1–4 days	22–60 days
The best alternative is … **(please check one)** →	**A** ☐	**B** ☐	**C** ☐

CHOICE SITUATION 2

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€150 / year	€350 / year	€0 / year
SEA BOTTOM CAN BE SEEN	clearly	clearly	not at all
NUMBERS OF CYPRINIDS	rather large	rather large	large
BLADDER WRACK IS	a bit weakened	good	weakened a lot
BLUE-GREEN ALGAE OCCURS	5–21 days	5–21 days	22–60 days
The best alternative is … (please check one) →	**A** ☐	**B** ☐	**C** ☐

CHOICE SITUATION 3

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€70 / year	€30 / year	€0 / year
SEA BOTTOM CAN BE SEEN	clearly	hardly	not at all
NUMBERS OF CYPRINIDS	small	rather large	large
BLADDER WRACK IS	good	a bit weakened	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … (please check one) →	**A** ☐	**B** ☐	**C** ☐

CHOICE SITUATION 4

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€350 / year	€5 / year	€0 / year
SEA BOTTOM CAN BE SEEN	clearly	hardly	not at all
NUMBERS OF CYPRINIDS	small	rather large	large
BLADDER WRACK IS	a bit weakened	good	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … (please check one) →	**A** ☐	**B** ☐	**C** ☐

CHOICE SITUATION 5

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€350 / year	€150 / year	€0 / year
SEA BOTTOM CAN BE SEEN	hardly	clearly	not at all
NUMBERS OF CYPRINIDS	rather large	small	large
BLADDER WRACK IS	a bit weakened	good	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … **(please check one)** →	**A** ☐	**B** ☐	**C** ☐

CHOICE SITUATION 6

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€5 / year	€30 / year	€0 / year
SEA BOTTOM CAN BE SEEN	hardly	hardly	not at all
NUMBERS OF CYPRINIDS	small	small	large
BLADDER WRACK IS	a bit weakened	good	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … **(please check one)** →	**A** ☐	**B** ☐	**C** ☐

BACKGROUND INFORMATION ABOUT ANSWERING THE QUESTIONS

10. How would you characterize your confidence in answering the choice questions?
(one check per row)

I was…	certain	quite certain	quite uncertain	uncertain
… in choice situation 1	1☐	2☐	3☐	4☐
… in choice situation 2	1☐	2☐	3☐	4☐
… in choice situation 3	1☐	2☐	3☐	4☐
… in choice situation 4	1☐	2☐	3☐	4☐
… in choice situation 5	1☐	2☐	3☐	4☐
… in choice situation 6	1☐	2☐	3☐	4☐

11. When choosing the preferred alternative, did you consider every part of each alternative?

Yes ☐ No ☐

12. Were some characteristics more important than others? Yes ☐ No ☐

Which? _______________________

13. If you chose alternative C in <u>all</u> six choice situations, which of the following describes your reasons? (you can check as many alternatives as you wish)

A	I don’t care about eutrophication in the Gulf of Finland.	☐
B	It’s not my responsibility to pay for improving the condition of the Gulf of Finland.	☐
C	I don’t believe that the agreement would result in any improvement in the Gulf of Finland.	☐
D	Other countries should take care of protecting the Gulf of Finland.	☐
E	I am in favour of protecting of the Gulf of Finland, but the tax is too high.	☐
F	Other, specify. ______________________________	☐

14. What do you think of the following statements? (one check per row)

		I fully agree	I partly agree	I partly disagree	I fully disagree
A	I believe that eutrophication in the Gulf of Finland can be reduced by the year 2030.	1☐	2☐	3☐	4☐
B	I am in favour of protecting the Gulf of Finland if I do not have to pay for it.	1☐	2☐	3☐	4☐
C	I am in favour of protecting the Gulf of Finland even if I have to pay for it.	1☐	2☐	3☐	4☐
D	The tax should only be collected from those Finns who live in the catchment area of the Gulf of Finland.	1☐	2☐	3☐	4☐
E	The tax should be collected from all Finnish citizens.	1☐	2☐	3☐	4☐
F	Finnish money could be invested abroad in projects for combating eutrophication of the Gulf of Finland.	1☐	2☐	3☐	4☐
G	I believe that all countries (Finland, Estonia, Russia) are able to reduce their own nutrient loads.	1☐	2☐	3☐	4☐
H	I believe that the collected money will be used to improve the Gulf of Finland.	1☐	2☐	3☐	4☐
I	The polluters should pay for at least half of all costs.	1☐	2☐	3☐	4☐
J	I will visit the Gulf of Finland in the future.	1☐	2☐	3☐	4☐
K	I plan to enjoy recreational activities on the coast of the Gulf of Finland in the future.	1☐	2☐	3☐	4☐
L	I like the lake environment more than the sea environment (I am a lake person).	1☐	2☐	3☐	4☐
M	I like the sea environment more than the lake environment (I am a sea person).	1☐	2☐	3☐	4☐
N	I would call myself an environmentalist.	1☐	2☐	3☐	4☐

BACKGROUND INFORMATION ABOUT YOU (for generalization of the results)

15. Year of birth _______ **16. Gender** ☐ male ☐ female

17. Which newspapers do you read daily or almost daily? ________________________

18. Living environment
☐ settlement in the countryside
☐ population center or small town (under 20,000 inhabitants)
☐ town (20,000 – 100,000 inhabitants)
☐ city (over 100,000 inhabitants)

19. Education
☐ lower elementary school
☐ elementary school
☐ vocational school
☐ high school
☐ vocational college
☐ polytechnic institution
☐ university or other higher education
☐ other; specify ___________

20. Occupational status
☐ farmer
☐ entrepreneur
☐ upper-level employee
☐ lower-level employee
☐ manual worker
☐ pensionnaire
☐ unemployed
☐ student
☐ other; specify ____________

21. There are ___ persons living in my household, of whom ___ are 0–6 years old and ____ are 7–16 years old.

22. The yearly <u>net</u> income of my <u>household</u> in 2005 was:

☐ under €10,000
☐ €10,001–€20,000
☐ €20,001–€30,000
☐ €30,001–€40,000
☐ €40,001–€50,000
☐ €50,001–€60,000
☐ €60,001–€70,000
☐ €70,001–€80,000
☐ €80,001–€90,000
☐ over €90,000

23. Recreation along the coast: how many days in the year 2005 did you participate in any of the following recreational activities on <u>the Gulf of Finland or its coast</u>? (Please check one box per row.)

		Not at all	1–5	6–15	Over 15
A	Vacation home living	0☐	1☐	2☐	3☐
B	Touring with a mobile home	0☐	1☐	2☐	3☐
C	Sailing or boating	0☐	1☐	2☐	3☐
D	Cruising	0☐	1☐	2☐	3☐
E	Fishing; specify type___________	0☐	1☐	2☐	3☐
F	Observing coastal and marine nature	0☐	1☐	2☐	3☐
G	Swimming	0☐	1☐	2☐	3☐
H	Sunbathing	0☐	1☐	2☐	3☐
I	Walking on the beach	0☐	1☐	2☐	3☐
J	Walking on ice, skiing, skating	0☐	1☐	2☐	3☐
K	Water sports (such as kayaking, water skiing)	0☐	1☐	2☐	3☐
L	Diving with equipment	0☐	1☐	2☐	3☐
M	Other; specify _____________	0☐	1☐	2☐	3☐

24. What kind of personal experience of the following consequences of eutrophication on the Gulf of Finland do you have? (one check per row)

		No personal observations	Some observations yearly	Several observations yearly	Continuous observations
A	Turbid sea water	0☐	1☐	2☐	3☐
B	Increased number of Cyprinids in catch	0☐	1☐	2☐	3☐
C	Fishing gear fouled by algae	0☐	1☐	2☐	3☐
D	Beaches fouled by algae	0☐	1☐	2☐	3☐
E	Decreased incidence of bladder wrack	0☐	1☐	2☐	3☐
F	Blue-green algae mass occurrences floating on the open sea	0☐	1☐	2☐	3☐
G	Small amounts of blue-green algae drifting along the coast	0☐	1☐	2☐	3☐
H	Large amounts of blue-green algae drifting along the coast	0☐	1☐	2☐	3☐
I	Health risk caused by poisonous blue-green algae for my close friends and family and for me	0☐	1☐	2☐	3☐
J	Anything else? Specify_________________	0☐	1☐	2☐	3☐

25. How did you fill in the questionnaire? (one check per row)

		Yes	No	Can't say
A	I filled in the questionnaire in order starting from the first question.	1☐	0☐	e☐
B	I might have answered in a bit of a hurry.	1☐	0☐	e☐
C	Some questions seemed difficult to answer.	1☐	0☐	e☐
D	In many places I felt answering was too difficult.	1☐	0☐	e☐
E	I think I understood all the questions rather well.	1☐	0☐	e☐

Thank you for your answers! Date _____/_____ 2006

If you wish, you can write your opinions here about this questionnaire and about protecting the Gulf of Finland.

____

____

____

____

Appendix II. The questionnaire version "policy uncertainty"

Only questions 6 and 9 differed from the base questionnaire version. Question 6 in the base version stated "According to forecasts". In the policy uncertainty version, the wording was "According to recent research" in order to underline the certainty of alternative C. In this appendix, different (question 6) or additional (question 9) information given to the respondents in the policy uncertainty version is written in *italics* (unlike in the original questionnaires).

6. According to *recent research*, by the year 2030, the Gulf of Finland will develop to the following state (in terms of the following characteristics) unless new measures are taken to reduce eutrophication:

In waist-deep water, the sea bottom cannot be seen at all.
The number of Cyprinids is large.
The bladder wrack population has weakened a lot.
Blue-green algae mass occurrences form in summertime for 22–60 days.

In your opinion, how likely is it that this forecast will come true for the Gulf of Finland by the year 2030?

Very likely	Quite likely	Not at all likely	Cannot say
1☐	2☐	3☐	e☐

(Questions 7 and 8 as in the base version.)

9. In this question, we want your opinion about developments in the condition of the Gulf of Finland from now until the year 2030. In the following six choice situations, please choose the one that is the closest to your opinion from three alternatives (A, B, or C).

Alternatives **A** and **B** represent agreements that would improve the condition of the Gulf of Finland by the year 2030. Alternative **C**, "No Agreement", stands for the condition of the Gulf of Finland without international agreements and without implementing any measures to reduce eutrophication.
The alternative conditions of the Gulf of Finland are described by means of the following characteristics of water quality:

- THE BOTTOM CAN BE SEEN clearly, hardly, or not at all
- THE NUMBER OF CYPRINIDS is small, rather large, or large
- THE BLADDER WRACK POPULATION is vigorous, a bit weakened, or weakened a lot
- BLUE-GREEN ALGAE MASS OCCURRENCES in the summer are seen for 1–4 days, 5–21 days, or 22–60 days

*With our current knowledge, the outcome of an agreement (**A** or **B**) and the following actions are impossible to describe with full certainty, because, in addition to the actions, the future state of the Gulf of Finland will be affected by, among other factors, temperature, salinity, and fisheries.*

*Due to this, THE STATES OF THE GULF OF FINLAND IN 2030 described in alternatives **A** and **B** would be achieved with either 80% or 60% certainties. The state could also be worse than those described. In alternative **C**, eutrophication would proceed with 100% certainty.*

A special tax to be collected from each household for a 20-year period is included in alternatives **A** and **B.** In alternative **C**, no special tax would be collected.

In each choice situation, please compare alternatives **A**, **B**, and **C** regarding the special tax and the water quality measures projected for the year 2030.

In each choice situation, please choose the alternative that best describes your opinion of the preferred development of the condition of the Gulf of Finland from now until the year 2030.

Please think through each choice situation separately. Do not compare them.

Please consider how your household would prefer to spend money: to combat eutrophication in the Gulf of Finland or for something else. When you make your selection, please consider the disposable income of your household after necessary expenses (such as food, rent, and so on) have been met.

Please check one box in each choice situation.

CHOICE SITUATION 1

	AGREEMENT A	**AGREEMENT B**	**NO AGREEMENT (C)**
TAX FOR THE HOUSEHOLD	€40 / year	€100 / year	€0 / year
CERTAINTY OF ACHIEVING THE STATE IN 2030	60 % (the state can also become worse)	80 % (the state can also become worse)	100 %
SEA BOTTOM CAN BE SEEN	hardly	clearly	not at all
NUMBER OF CYPRINIDS	rather large	small	large
BLADDER WRACK IS	a bit weakened	vigorous	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … (please check one) →	**A** ☐	**B** ☐	**C** ☐

Appendix III. The questionnaire version "business-as-usual (BAU) uncertainty"

Only question 9 differed from the base questionnaire version. In this appendix, the additional information given to the respondents in the business-as-usual (BAU) uncertainty version is written in *italics* (unlike in the original questionnaires).

9. In this question, we want your opinion about developments in the condition of the Gulf of Finland from now until the year 2030. In the following six choice situations, please choose the one that is the closest to your opinion from three alternatives (A, B, or C).

Alternatives **A** and **B** represent agreements that would improve the condition of the Gulf of Finland by the year 2030. Alternative **C**, "No Agreement", stands for the condition of the Gulf of Finland without international agreements and without implementing any measures to reduce eutrophication.
The alternative conditions of the Gulf of Finland are described by means of the following characteristics of water quality:

- THE BOTTOM CAN BE SEEN clearly, hardly, or not at all
- THE NUMBER OF CYPRINIDS is small, rather large, or large
- THE BLADDER WRACK POPULATION is vigorous, a bit weakened, or weakened a lot
- BLUE-GREEN ALGAE MASS OCCURRENCES in the summer are seen for 1–4 days, 5–21 days, or 22–60 days

*With our current knowledge, it is impossible to describe with full certainty the state of the Gulf of Finland in 2030 without an agreement (alternative **C**) because, in addition to the amount of nutrients, the future state of the Gulf of Finland will be affected by, among other factors, temperature, salinity, and fisheries. The future state described with the characteristics of sea water quality will become true with an 80% certainty, but the state could also be better. In alternatives **A** and **B**, the actions can be adjusted, which is why in alternatives **A** and **B**, THE STATES OF THE GULF OF FINLAND IN 2030 would be achieved with 100% certainty.*

A special tax to be collected from each household for a 20-year period is included in alternatives **A** and **B.** In alternative **C**, no special tax would be collected.
In each choice situation, please compare alternatives **A**, **B**, and **C** regarding the special tax and the water quality measures projected for the year 2030.
In each choice situation, please choose the alternative that best describes your opinion of the preferred development of the condition of the Gulf of Finland from now until the year 2030.
Please think through each choice situation separately. Do not compare them.
Please consider how your household would prefer to spend money: to combat eutrophication in the Gulf of Finland or for something else. When you make your

selection, please consider the disposable income of your household after necessary expenses (such as food, rent, and so on) have been met.
Please check one box in each choice situation.

CHOICE SITUATION 1

	AGREEMENT A	**AGREEMENT B**	**NO AGREEMENT (C)**
TAX FOR THE HOUSEHOLD	€40 / year	€100 / year	€0 / year
CERTAINTY OF ACHIEVING THE STATE IN 2030	100 %	100 %	80 % (the state can also become worse)
SEA BOTTOM CAN BE SEEN	hardly	clearly	not at all
NUMBER OF CYPRINIDS	rather large	small	large
BLADDER WRACK IS	a bit weakened	vigorous	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … (please check one) →	**A** ☐	**B** ☐	**C** ☐

Appendix IV. Design matrices for treatments

The design matrix used in the treatments in the base questionnaire (no explicit (un)certainty) and in the BAU uncertainty questionnaire (uncertain business-as-usual). In the latter, the information on uncertainty was added later in the choice tasks.

Version	Choice task	Tax for household PRICE	Water clarity WAT	Number of Cyprinids ROA	Bladder wrack BLW	Blue-green algae BGA
1	1	70	1	2	1	2
		30	2	1	2	2
		0	0	0	0	0
	2	150	2	1	1	1
		350	2	1	2	1
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	350	2	2	1	2
		5	1	1	2	1
		0	0	0	0	0
	5	350	1	1	1	2
		150	2	2	2	1
		0	0	0	0	0
	6	5	1	2	1	2
		30	1	2	2	1
		0	0	0	0	0
2	1	350	1	1	2	2
		70	2	2	1	1
		0	0	0	0	0
	2	30	2	2	2	1
		30	1	2	1	2
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	5	2	1	1	2
		70	1	2	2	1
		0	0	0	0	0
	5	150	1	1	2	2
		30	1	1	1	1
		0	0	0	0	0
	6	150	2	1	1	1
		500	1	2	2	2
		0	0	0	0	0
3	1	70	2	2	1	1
		500	2	1	2	2
		0	0	0	0	0
	2	70	1	1	2	1
		150	2	2	2	2
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	30	1	1	1	2
		350	2	2	1	2
		0	0	0	0	0
	5	5	2	1	2	1
		70	2	2	1	2
		0	0	0	0	0
	6	30	1	2	1	2
		5	2	1	1	1
		0	0	0	0	0
4	1	350	1	2	2	2
		30	2	1	1	1
		0	0	0	0	0
	2	5	1	2	1	1
		70	1	1	2	2
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	350	2	2	1	1
		500	1	2	2	2
		0	0	0	0	0
	5	150	2	1	1	2
		30	1	1	2	1
		0	0	0	0	0
	6	150	2	2	1	2
		70	1	1	2	1
		0	0	0	0	0
5	1	5	2	2	2	1
		30	1	1	1	2
		0	0	0	0	0
	2	70	2	1	2	2
		5	1	2	1	1
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	5	2	1	1	2
		30	1	2	2	1
		0	0	0	0	0
	5	500	2	2	1	1
		150	1	2	1	2
		0	0	0	0	0
	6	150	1	1	1	2
		350	2	1	2	1
		0	0	0	0	0
6	1	500	2	1	2	2
		70	1	2	2	1
		0	0	0	0	0
	2	5	2	1	2	1
		350	1	2	2	2
		0	0	0	0	0
	3	70	2	2	2	2
		30	1	1	1	1
		0	0	0	0	0
	4	500	1	1	1	2
		30	2	2	1	1
		0	0	0	0	0
	5	70	1	1	2	2
		350	2	1	1	1
		0	0	0	0	0
	6	30	2	1	1	1
		150	2	2	2	2
		0	0	0	0	0

The design matrix used in the treatment in the policy uncertainty questionnaire (uncertain policy alternatives).

Version / Choice task		Tax for household PRICE	Likelihood of state CER	Water clarity WAT	Number of Cyprinids ROA	Bladder wrack BLW	Blue-green algae BGA
1	1	5	80	1	1	1	2
		70	60	2	2	2	1
		0	100	0	0	0	0
	2	30	60	1	1	2	1
		50	80	2	2	1	2
		0	100	0	0	0	0
	3	150	60	2	1	1	2
		500	80	1	2	2	1
		0	100	0	0	0	0
	4	500	60	1	1	1	2
		350	80	2	2	2	1
		0	100	0	0	0	0
	5	150	80	2	1	2	1
		70	60	2	2	2	2
		0	100	0	0	0	0
	6	350	60	1	2	1	2
		30	80	1	2	1	1
		0	100	0	0	0	0
2	1	30	60	2	1	2	2
		70	80	2	1	1	1
		0	100	0	0	0	0
	2	70	80	1	2	2	2
		500	80	2	1	1	1
		0	100	0	0	0	0
	3	70	60	1	2	1	2
		350	60	2	1	2	1
		0	100	0	0	0	0
	4	150	80	1	2	2	1
		5	60	2	1	1	2
		0	100	0	0	0	0
	5	350	80	1	1	2	2
		500	60	1	2	1	1
		0	100	0	0	0	0
	6	30	80	2	1	2	2
		30	80	2	2	1	2
		0	100	0	0	0	0
3	1	5	60	1	1	2	1
		150	60	2	2	1	2
		0	100	0	0	0	0
	2	150	80	2	2	2	2
		70	60	2	1	1	1
		0	100	0	0	0	0
	3	500	60	2	2	2	2
		150	80	1	1	1	1
		0	100	0	0	0	0
	4	350	60	2	2	1	1
		70	80	1	1	1	2
		0	100	0	0	0	0
	5	500	80	1	2	2	2
		500	60	2	1	2	1
		0	100	0	0	0	0
	6	70	60	2	2	1	1
		30	80	1	1	2	2
		0	100	0	0	0	0
4	1	70	80	2	1	2	2
		5	60	1	2	1	1
		0	100	0	0	0	0
	2	5	80	2	2	1	1
		350	60	1	1	2	2
		0	100	0	0	0	0
	3	30	60	1	2	1	2
		350	80	2	2	1	2
		0	100	0	0	0	0
	4	70	80	2	2	2	1
		150	60	1	1	2	2
		0	100	0	0	0	0
	5	350	80	2	1	1	2
		150	60	1	2	2	2
		0	100	0	0	0	0
	6	5	60	2	1	1	1
		70	80	1	2	2	1
		0	100	0	0	0	0
5	1	30	80	2	2	1	1
		5	60	1	2	2	2
		0	100	0	0	0	0
	2	30	60	2	1	1	1
		500	80	1	2	1	2
		0	100	0	0	0	0
	3	350	80	1	1	2	2
		150	60	2	2	2	1
		0	100	0	0	0	0
	4	500	80	2	1	1	1
		70	60	1	2	1	2
		0	100	0	0	0	0
	5	5	80	1	2	2	1
		70	60	2	2	2	2
		0	100	0	0	0	0
	6	150	80	1	1	1	1
		30	60	1	2	2	2
		0	100	0	0	0	0
6	1	5	80	2	1	1	2
		30	60	1	1	2	1
		0	100	0	0	0	0
	2	500	60	2	2	1	2
		150	60	2	1	2	1
		0	100	0	0	0	0
	3	70	80	1	1	1	2
		500	80	1	2	2	1
		0	100	0	0	0	0
	4	30	60	1	1	1	1
		150	80	2	2	2	2
		0	100	0	0	0	0
	5	350	60	1	2	2	2
		500	80	2	1	1	2
		0	100	0	0	0	0
	6	350	60	2	1	2	1
		70	60	1	2	1	1
		0	100	0	0	0	0

Appendix V. Notes on the precision of the WTP estimates in Essay I

Table V-1 presents the descriptive statistics of the sample used in the analysis in Essay I (N=726), of the Finnish population (N=5255580), and of the original “citizens” subsample (N=307) in comparison to the Finnish population data. The representativeness of the original “citizens” subsample of the Finnish population is tested with a two-tailed t-test for the variables age (OLD) and income (HINC) and with the Pearson Chi squared test for the rest of the variables: dependent children in a household (DEPCH), coastal residence (COA), and vacation home ownership (VAC).

Table V-1. Descriptive statistics of the data used in the analysis and the corresponding data on the Finnish population as well as data on the original “citizens” sample based on random sampling of the Finnish population.

	Essay I sample average	**Finnish average[1]**	**"Citizens" sub-sample average**	**Test statistics[2]**
Sample size	726	5255580	307	
Socio-demographic characteristics				
Age (OLD)	51.48	45.88	48.32	**-0.61**
Dependent children in the household (% with dep.ch.) (DEPCH)	12.32	41.18	17.26	**71.74*** **
Income (net, thousand € / year) (HINC)	37.8	31.0	33.71	**-0.59**
Coastal residence (% living in coastal municipalities) (COA)	63.09	23.47	26.06	**1.16**
Vacation home ownership (% of owners on the coast of the Gulf of Finland) (VAC)	32.78	2.44	3.91	**3.66***

*[1]) The data for the Finnish population are from Statistics Finland (2006). [2]) The test statistics are t-test statistics for the variables OLD and HINC, and Pearson chi squared statistics for the variables DEPCH, COA, and VAC. For the latter, ***(*) refers to the 1(10)% significance level.*

The null hypothesis for the t-test is that the means are equal, that is, the mean of the “citizens” subsample is neither lower nor higher than the population mean. Based on the t-test statistics in the rightmost column, the “citizens” subsample represents the Finnish population well at a 95% confidence level for the variables OLD and HINC. The statistic is clearly less than 1.96.

The null hypothesis for the Pearson Chi squared test is that, for the variables, the observed proportion (the “citizens” subsample) equals the expected proportion (calculated based on the Finnish population). The Chi squared value for variable DEPCH is statistically significant at a 1% level, indicating that the “citizens” subsample differs significantly from the Finnish population in terms of the proportion of households with dependent children. The same applies at a 10% level for variable VAC, indicating that the proportions of vacation home owners in the samples are significantly different. However, the Pearson Chi squared test suggests no statistically significant difference in terms of the proportion of coastal residents (COA) in the samples.

These tests suggest that the WTP estimates calculated based on solely the "citizens" sample may not be representative of the Finnish population and that weighting of the WTP estimates is required. Thus, similarly to the estimates in Essay I, the WTP estimates for the "citizens" subsample are weighted for the variables DEPCH, COA, and VAC, and for the dummy variables OLD (1 if the respondent is older than average) and HINC (1 if the household income is higher than average), a weight of 0.5 is used. This is due to a lack of detailed information on the proportions of the population above the average values.

Table V-2 presents the results of the MNL and RPL models estimated using the sample in Essay I and the "citizens" subsample, and table V-3 presents and compares the WTP estimates based on the models. According to the t-test statistics, the WTP estimates reported in Essay I are statistically significantly different from the results estimated using the data representative of the Finnish population, except for scenario 1. This indicates that weighting the parameters after estimation could have been more successful.

Based on the MNL results, the scenario WTP estimates in Essay I are biased upwards, except for scenario 1, for which the difference is not statistically significant according to the t-test. The same applies, at the 5% significance level, to the RPL results. However, the closeness of the estimates for scenarios 1 and 2, probably stemming from the small number of observations (N=307) and the large random variation in the preferences for the blue-green algae attribute, may make comparison based on the RPL model slightly questionable. The coefficients of the attributes in the models indicate that the marginal WTP estimates for the attributes decrease when using the "citizens" subsample. This is consistent with the assumption that the proximity to the environmental resource increases the WTP and with the fact that the data used in Essay I included too large proportions of coastal residents and coastal vacation home owners compared to the Finnish population due to the non-random sampling. The aggregated WTP estimates are reported in table V-4.

Table V-2. The results of the MNL and RPL models based on the data used in the analysis in Essay I and on the “citizens” subsample data.

Variable / Model	MNL Essay I	MNL "Citizens"	RPL Essay I	RPL "Citizens"
BAU	-1.302 (0.119)[a]	-1.679 (0.150)[a]	-3.679 (0.453)[a]	-4.103 (0.558)[a]
St. Dev. BAU	-	-	*3.399 (0.229)* [a]	*3.720 (0.375)* [a]
BAU*COA	-0.295 (0.106)[a]	-0.231 (0.171)	-0.005 (0.386)	-0.474 (0.686)
BAU*VAC	-0.379 (0.123)[a]	-2.050 (0.756)[a]	-1.144 (0.444)[b]	-2.718 (2.066)
BAU*OLD	0.211 (0.109)[c]	0.382 (0.145)[a]	0.541 (0.393)	0.276 (0.555)
BAU*DEPCH	0.474 (0.129)[a]	0.371 (0.184)[b]	0.785 (0.469)[c]	0.955 (0.731)
BAU*HINC	-0.793 (0.102)[a]	-0.662 (0.147)[a]	-1.707 (0.364)[a]	-1.454 (0.585)[b]
PRICE	-0.007 (0.000)[a]	-0.007 (0.000)[a]	-0.012 (0.001)[a]	-0.013 (0.001)[a]
Water clarity WAT	0.318 (0.045)[a]	0.214 (0.070)[a]	0.606 (0.081)[a]	0.390 (0.120)[a]
St. Dev. WAT	-	-	*1.071 (0.118)* [a]	*1.065 (0.174)* [a]
Coarse Fish ROA	0.212 (0.045)[a]	0.135 (0.070)[c]	0.271 (0.071)[a]	0.137 (0.113)
St.Dev ROA	-	-	*0.631 (0.146)* [a]	*0.821 (0.182)* [a]
Bladder wrack BLW	0.095 (0.043)[b]	0.038 (0.066)	0.153 (0.072) [b]	0.007 (0.102)
St.Dev. BLW	-	-	*0.889 (0.119)* [a]	*0.602 (0.218)* [a]
Blue-green algae BGA	0.232 (0.043)[a]	0.051 (0.066)	0.375 (0.090)[a]	0.101 (0.123)
St. Dev BGA	-	-	*1.660 (0.119)* [a]	*1.300 (0.173)* [a]
Number of obs	*3946*	*1687*	*3946*	*1687*
Log likelihood	*-3222.325*	*-1392.644*	*-2680.221*	*-1140.596*
Log likelihood (0)	*-4335.124 *)*	*-1853.359*	*-4335.124*	*-1853.359*
Pseudo R	*0.25670 *)*	*0.18168*	*0.38174*	*0.38458*
Correct predictions	*51.14%*	*50.50 %*	*51.40%*	*50.80 %*

*Standard errors are in parentheses. [a] ([b]) [c] significant at the 1(5)10% level. *) These are the corrected values of LL(0) and PseudoR2. The values in Essay I are incorrect.*

Table V-3. Comparison of the WTP estimates: the weighted population mean WTP (Essay I) and the weighted mean WTP based on the random sampling (the “citizens” sample). The values are in euros.

SCENARIO			MNL			RPL		
No	Reduction in biomass	Attribute levels	Essay I (n=726)	"Citizens" (n=307)	t-test stat	Essay I (n=726)	"Citizens" (n=307)	t-test stat
1	Other: <15 % Cyano: <15 %	WAT mid ROA mid BLW mid BGA mid	271.1 *(10.7)*	273.9 *(12.2)*	-0.59	392.8 *(11.3)*	385.1 *(17.7)*	1.43
2	Other: <15 % Cyano: >15 %	WAT mid ROA mid BLW mid BGA best	287.6 *(11.1)*	277.2 *(12.8)*	2.13	405.2 *(12.1)*	384.7 *(18.6)*	3.70
3	Other: >15 % Cyano: >15 %	WAT best ROA best BLW best BGA best	332.0 *(12.0)*	302.3 *(14.0)*	5.82	448.1 *(12.9)*	402.8 *(19.4)*	7.97

Table V-4. Aggregated WTPs (in millions of euros).

Scenario	MNL		RPL	
	Essay I	**"Citizens"**	**Essay I**	**"Citizens"**
1	32,600 *(30,078-35,122)*	32,936 *(30,061-35,812)*	47,234 *(44,571-49,897)*	46,308 *(42,137-50,480)*
2	34,584 *(31,968-37,200)*	33,333 *(30,316-36,350)*	48,725 *(45,873-51,577)*	46,260 *(41,876-50,644)*
3	39,923 *(37,095-42,751)*	36,352 *(33,052-39,651)*	53,884 *(50,844-56,924)*	48,437 *(43,864-53,009)*

*PV=WTP/r*2.405. The constant discount rate r= 2% refers to the growth rate of the GDP. The number of Finnish households is 2.405 million. 95% CIs in parentheses.*

An additional remark is needed about the precision of the WTP estimates in Essay I. They are calculated based on the assumption of equal WTP distributions of the respondents and the non-respondents. Thus the WTP estimates are likely to be overestimated because the data shows that proximity to the Gulf of Finland increases both the WTP and the response rate. However, the WTP estimation in Essay III assumes conservatively that the non-respondents have a zero WTP. Thus, although based on the same “citizens” subsample, the results in Essay III and in this appendix are not fully comparable. Another reason for the inability to compare the results is that the sociodemographic characteristics interacted with the alternative-specific constant (BAU) are not included in the models in Essay III because the specific interest of Essay III is to study the preference discontinuity.

Another issue for discussion related to the WTP estimations is the inclusion of the constant BAU. This unexplained part of the WTP is assumed to reflect, in addition to many other factors not explained by water quality attributes, the utility from the increase in the water quality from the business-as-usual level to the middle level in terms of all attributes because the middle levels are not included in the model due to the identification problem. For this reason, the BAU utility is included in the WTP estimation. However, the calculation of the scenario WTP estimates accounts for the middle levels also by multiplying the coefficients of the higher levels of attributes by 0.5. This may be considered as double-counting the utility associated with the middle levels of attributes. On the other hand, the utility derived from the constant (BAU) comprises a great proportion of the scenario WTP, and the impact of the actual water quality change seems to have rather little impact on people’s willingness to pay for reduced eutrophication in the Gulf of Finland.