MTT Discussion Papers 1 • 2009

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Abstract

The study uses meta-analysis to provide insights into the value of international marine resources, illustrating the issue with the case of the Baltic Sea. Willingness to pay for water quality improvements varies systematically with factors such as a country's income level, characteristics of the change in water quality, water body type, study year and methodology. The results of the meta-analysis are applied to benefit transfer in order to assess the distribution of the benefits of marine protection measures between the Baltic Sea countries and to compare the results with previous research. The net benefits of protecting the Baltic are positive, but they are asymmetrically distributed between the littoral countries.

Key words: meta-analysis, water quality valuation, marine areas, the Baltic Sea

JEL Classification Codes: Q26, Q51

1 Introduction

Environmental valuation of water resources has been carried out for several decades, and the results of these studies have recently been synthesized and summarized using meta-analysis. This paper focuses on the value of internationally shared marine resources. Previously, Johnston et al. (2006) have used meta-analysis to study the willingness to pay for recreational fishing for both fresh and saltwater species. Our approach to valuing marine amenities is wider in that it includes a variety of recreational activities as well as the non-use values related to water quality in sea areas.

We use the Baltic Sea to illustrate the issues related to the valuation of international marine ecosystems. The Baltic Sea is a small, brackish sea area in Northern Europe with nine littoral countries. The state of the Baltic has been adversely affected by human activities for several decades, and its protection has been called for on many occasions (see e.g. Helcom 1974, 1988 and 2007). In practice, there are still no binding agreements on the protection of the Baltic and the measures implemented have largely been taken without cooperation among the littoral countries. Despite these efforts, significant improvements have not been achieved, for example, in the case of eutrophication.

Where protection of international marine resources is concerned, it is unlikely that the costs and benefits will be symmetrically distributed between the countries involved. As suggested in Turner et al. (1999), this applies also to the Baltic Sea, and some countries will gain and some lose if they participate in joint actions to improve the state of the sea area. The availability of cost and benefit estimates makes it possible to determine the net benefits of different policies, which in turn is crucial for reaching binding agreements on protection measures.

This paper explores the potential of meta-analysis to evaluate the benefits of improving the state of internationally shared marine resources, illustrating the case with the Baltic Sea. We explain the variation in willingness to pay for water quality and also discuss how meta-analysis can be applied to benefit transfer to assess the distribution of benefits between countries. The benefit estimates from the meta-analysis are compared with the costs of protection measures to assess the net benefits of improving the state of the Baltic Sea in terms of reduced eutrophication. The estimates are further compared with the results from the Baltic Drainage Basin Project (Turner et al. 1999).

The present meta-analysis is novel in the sense that it focuses on internationally shared marine resources and uses primarily European valuation studies. The case has broader implications, as the approach employed here provides insights into the applicability of international meta-analyses and can be used for other international marine areas (e.g. the Mediterranean and the Black Sea).

The meta-analytic framework in the present study allows the inclusion of studies that originate from several countries, use different valuation methods and focus on different geographical areas. This implies a rather heterogeneous set of valuation studies. Yet, the willingness to pay for water quality varies systematically according to expectations. The income level of the focal country, represented by its gross domestic product, has a significant effect on willingness to pay, allowing the assessment of benefit distribution among the Baltic Sea countries. In addition, the water body type, the study methodology and the year of the study affect the value of water quality changes.

Meta-analysis proves to be useful for discussing the value of an international good and for providing a more comprehensive understanding of the benefits of improving the state of a sea area in terms of the factors that affect willingness to pay for marine water quality and the magnitude of the benefits. The distribution of the benefits of protecting the Baltic is found to be asymmetric and to differ from that presented in the results of the Baltic Drainage Basin Project (Turner et al. 1999), but the magnitude of total benefits is in line with previous research. The aggregate net benefits of protecting the Baltic Sea are estimated to be positive, an outcome providing an argument for the continuation of protective actions.

The paper is organized as follows. Section 2 presents previous research and the method and section 3 the data for the meta-analysis and how it was collected. Section 4 discusses the variables included in the meta-regression and the expectations regarding their sign. The meta-regression models are presented in section 5 and the results in section 6. Section 7 discusses a model application that uses meta-analysis to assess the distribution of net benefits between the Baltic Sea countries and the comparison of benefits with earlier results. Section 8 presents insights gained and policy implications.

2 Previous research and method

Previous economic studies on the Baltic Sea have focused primarily on evaluating the costs and cost-effectiveness of protection measures in the international context (see e.g. Gren, Elofsson and Jannke 1997; Ollikainen and Honkatukia 2001; Wulff et al. 2001; Elofsson 2003; COWI 2007). The benefits of such measures have been estimated to a lesser extent due to, for example, the difficulties associated with valuation and the complications arising from the international dimension of the issues. The results of the valuation studies and benefit transfers implemented in the Baltic Drainage Basin Project constitute the only available Baltic-wide benefit estimates (see e.g. Gren, Söderqvist and Wulff 1997; Turner et al. 1999 and Markowska and Zylicz 1999). In the project, stated preference surveys were conducted in three Baltic Sea countries – Poland, Latvia and Sweden – and the results were transferred to the other littoral countries[1] to provide a benefit estimate for the entire Baltic Sea region. However, the project results date back to the mid-1990s and might thus be considered outdated, as some Baltic Sea countries and their economies have undergone significant changes during the last decade.

Since the 1990s, no coordinated efforts have been undertaken to value the benefits of water quality improvements and the distribution of those benefits for the entire Baltic Sea region. What information is available is rather fragmented. Valuation studies on the protection of the Baltic have lacked coordination and have typically been context-specific, for example, focusing on single countries and limited geographical areas of the Baltic Sea (see e.g. Frykblom 1998 or Atkins, Burdon and Allen 2007). The present study uses meta-analysis to synthesize the existing information and to obtain a more comprehensive understanding of the benefits of improving the state of the Baltic.

Meta-analysis refers to methods and techniques that review and summarize the results of empirical studies. In the field of environmental valuation, meta-analysis is used for three general purposes: research evaluation and synthesis, hypothesis testing and benefit transfer (Smith and Pattanayak 2002, 277). Meta-regression is the predominant method of analysis, allowing the examination of heterogeneity across studies and the effects of explanatory variables on the value estimates. Meta-regression can also be used to construct a benefit transfer function that provides an alternative to the more common function-based transfer from a primary study (Stapler and Johnston 2009, 228).

Glass (1976) is typically credited with introducing meta-analysis to the social sciences. The first applications in environmental valuation were conducted in the early 1990s (Smith and Kaoru 1990, Walsh, Johnson and McKean 1992). Since then, meta-analyses of environmental amenities have covered a variety of topics, including air quality (Smith and Huang 1995), outdoor recreation (Rosenberger and Loomis 2000), threatened and endangered species (Loomis and White 1996), wetland services (Brouwer et al. 1999; Woodward and Wui 2001; Brander, Florax and Vermaat 2006), recreational fishing (Johnston et al. 2006) and pesticide risk exposure (Florax, Travisi and Nijkamp 2005).

The increasing interest in benefit estimation and the infeasibility of conducting primary studies has prompted a significant number of meta-analyses in the field of environmental valuation. Previous meta-analyses have varied in the procedures used and in quality, raising questions about the reliability of their results (Nelson and Kennedy 2009). For example, the shortcomings criticized include differences in goods valued and in valuation concepts and problems with econometric modeling.

Primary valuation studies have been used to investigate marine and coastal amenities and their value as regards beach protection (Huang, Poor and Zhao 2007, Whitehead et al. 2008) and marine protected areas (Wallmo and Edwards 2008). The meta-analyses of water quality benefits have not, to the best of our knowledge, focused on international marine resources. Previous meta-analyses have covered primarily freshwaters, although estuaries have been included in addition to rivers and lakes. Johnston, Besedin and Wardwell (2003) use meta-regression to model relationships between non-use values for surface water quality improvements and several study-specific attributes, and find a clear empirical relationship between use and non-use values. Johnston et al. (2005) conduct a meta-analysis on aquatic resource improvements to identify systematic patterns in willingness to pay and to evaluate the challenges of using meta-analytic models for benefit transfer. Their results indicate that the variation in willingness to pay can be successfully explained with meta-analysis but that methodological variables pose challenges for the estimation and interpretation of the results. Van Houtven, Powers and Pattanayak (2007) evaluate the results of stated preference studies on water quality and put forward implications for benefit transfer and policy analysis. They argue that meta-analysis provides a reasonable basis for predicting willingness to pay for water quality changes but also highlight the limitations of the method resulting from the unexplained variation in willingness to pay. Liu and Stern (2008) conduct a meta-analysis of coastal and near-shore marine ecosystems and include contingent valuation studies from throughout the world, although most of their data comes from North America.

The earlier meta-analyses of water quality largely deal with the United States, and we are aware of no published meta-analyses focusing mainly on European water quality valuation studies. Most meta-analyses have also limited their scope to one country. Examples of international meta-analyses are Lindhjem (2007), who summarizes the existing valuation studies on non-timber benefits in Norway, Sweden and Finland, and Jacobsen and Hanley (2008), who study the income effects on willingness to pay for biodiversity. Our meta-analysis is novel in the sense that it focuses on internationally shared marine resources and uses primarily European valuation studies. Another distinct feature of our data is its heterogeneity, which derives from the need to include studies from several countries and from the characteristics of the available valuation studies.

Since our data includes studies from several countries and we use benefit transfer to predict country-specific benefits, we have to address issues similar to those encountered in international benefit transfer. Using a set of studies from eight countries introduces additional challenges compared to more common intra-country meta-analyses and benefit transfers. Currency conversion and differences between countries and their populations have to be taken into account. As transfer errors should intuitively be smaller in cases where the sites and their surroundings are more similar, we may expect that international benefit transfers produce higher errors than transfers within a country. However, Ready and Navrud (2006, 433) observe that in general international benefit transfer errors are similar to those found in intra-country transfers.

The empirical results on the performance of meta-analysis in international benefit transfer are somewhat mixed. Shrestha and Loomis (2001) report an average error of 24-30% for international meta-analytic benefit transfer in the case of recreation values, a range which they consider acceptable for many benefit transfer applications. Lindhjem and Navrud (2008) assess the reliability of international value transfer for non-timber benefits. They compare the transfer errors between different benefit transfer techniques and conclude that meta-analytic transfers do not always outperform more simple approaches. The mean transfer errors in their meta-analysis are between 47-126% depending on the model used. We expect a similar error rate in the present case, although the heterogeneity of the data might increase the size of the error.

3 Data selection

Our data complements a set of European valuation studies with research from the United States and applies the findings to the Baltic Sea. Ideally, the data set should include only studies that value water quality changes in sea areas. However, the small number of direct marine studies (13 studies with 18 value estimates) does not make thorough statistical analysis possible; accordingly, we have included studies that either relate to the Baltic indirectly or deal with the drainage basin. The data encompasses not only studies from the Baltic Sea countries, but also comparable research from the United States, which has not previously been included in meta-analyses. The starting point of the search for the primary studies was a review, which compiled information about valuation studies on the Baltic Sea from the littoral countries (Söderqvist and Hasselström 2008). The European data consists of those studies in the review that address water quality. The studies from the United States have been found by conducting exhaustive searches on travel costs studies valuing water quality.

The selection criteria for the data are the following. First, the focus of the study needs to be water quality, not other water-related issues, such as beach protection or visual disamenities from windmills. In the present case, water quality is defined broadly to include effects from eutrophication, the state of fisheries and also other physical factors. Second, the water quality change valued must affect recreational activities and/or biodiversity in water ecosystems. In addition, it is essential that the description of the change be detailed enough to connect it to a common metric, in this case the percentual change in water quality. Third, the valuation methods are limited to stated preference methods (contingent valuation and choice experiment) and the travel cost method. Fourth, it is essential that the study report provide sufficient data for purposes of the analysis.

The criteria for exclusion center on the availability of information from the study reports. The studies that have been excluded do not provide a willingness to pay estimate per person or per household (e.g. Sandström 1996, NAO 2007) and do not contain sufficient information for computing these. The data includes both stated preference and travel cost studies, although it has been argued that meta-analyses should strive for consistency by only including studies that use comparable valuation concepts (Smith and Pattanayak 2002, Nelson and Kennedy 2008). A counter-argument is presented in Stapler and Johnston (2009, 235), who suggest that differences in welfare estimates are less critical if the meta-regression can appropriately predict heterogeneous welfare measures. Hedonic pricing studies have been excluded as they differ considerably in their characteristics from stated preference and travel cost studies.

We include studies from both peer-reviewed publications and the "gray literature", which encompasses sources such as working papers, reports, master's thesis and PhD dissertations. As most of the valuation study reports on the Baltic Sea belong to the gray literature, excluding these would have not been reasonable. It can also be argued that unpublished studies may be as good as published ones (Lipsey and Wilson 2001, 19). Including only published articles might also introduce a publication selection bias in the results, which would reduce the validity and reliability of the meta-analysis for benefit transfer (Rosenberger and Stanley 2006, 375).

The final data consist of 32 studies and 54 observations (see Appendix 1). Some authors recommend using only one value estimate per study (Lipsey and Wilson 2001, 113), but in the present case this approach would have led to a substantial reduction in the sample size of the meta-analysis. In practice, it is more common to include several estimates per study (see e.g. Van Houtven, Powers and Pattanayak 2007; Johnston et al. 2005). The most frequent reason for using multiple observations from a single study is that the study provides value estimates for different water quality change scenarios (Kosenius 2008, Vesterinen et al. 2008, Hasler et al. 2005, Egan et al. 2004, Eggert and Olsson 2003, Parsons, Helm and Bondelid 2003, Needelman and Kealy 1995, Mäntymaa 1993). Toivonen et al. (2004) include value estimates for several scenarios and separately for three Nordic countries. Atkins and Burdon (2006) and Atkins, Burdon and Allen (2007) both provide one estimate for the same scenario but use distinct approaches.

If there are minor differences in statistical procedures that produce multiple mean willingness to pay estimates from the same data, the estimates are averaged into a single observation. It should also be noted that some study reports provide several value estimates that are based on different samples and valuation approaches. These are treated as separate observations. Roughly one-third of the studies provide one value estimate and the remaining multiple estimates (not more than five). Table 1 summarizes the features of the data, and the next section describes the variables used in the meta-regression in detail.

[insert Table 1 here]

4 Variables and hypotheses

The meta-regression aims at explaining the variation in willingness to pay for water quality changes through a set of explanatory variables. The range of possible variables is large and the final set of variables has been chosen based on several factors. First, theoretical assumptions and empirical results of prior meta-analyses have been considered. Second, the purpose of using the meta-regression for predicting the distribution of benefits between countries has affected the variable selection. The availability of detailed information on the studies has also been decisive.

The dependent variable in all meta-regression models is willingness to pay for the water quality change specified in the valuation study. Most value estimates have been reported as annual willingness to pay per person and thus this has been chosen as the base format. Household-specific willingness to pay estimates are divided by 2. To make the willingness to pay estimates comparable, they are first converted to euros using the Eurostat annual purchasing power parities (PPP) of the original country and Finland in the year of the study. The resulting estimates are then adjusted to 2007 euros using country-specific consumer price indices (CPI). Individual indices are employed for each country as the rate of change in CPI differs significantly between countries. PPP is used because it adjusts to differences in price levels between countries and thus measures the differences in purchasing power more accurately than exchange rates do.

The distribution of the willingness to pay estimates is shown in Figure 1, and it has a shape similar to that established in other meta-analyses (Lindhjem 2007, 259). The mean annual willingness to pay for water quality based on the meta-data is 64.2€ per person. The weighted mean, weighted by the number of observations, is similar, 62.9€ per person.

[insert Figure 1 here]

Meta-regression models typically include explanatory variables describing the characteristics of the environmental good, the population studied, the methodology used, the quality of the research and other study-specific features. The variables ultimately included in the present meta-regressions are listed in Table 2. Most explanatory variables are binary, meaning that they may take only the values 0 or 1.

[insert Table 2 here]

The first set of explanatory variables describes the valued environmental good: the variables in the set pertain to the characteristics of the water quality change, the water body type and the geographical scope of the good. The descriptions of the water quality change are inherently diverse due to the heterogeneity of the studies. Our purpose is to control the dissimilarities in the environmental good with a set of explanatory variables. The extent of the change in water quality is captured with the variable WQCPERC. All changes are converted to a common scale ranging from 25 to 230, which is based on the percentual change in water quality. Some percentual changes were provided in the study reports; others had to be inferred from the scenarios. Although we attempted to make the magnitudes of the changes comparable, it is clear that there is room for interpretation. A basic expectation derived from the economic theory is that people's willingness to pay should be responsive to the amount of the good provided: that is, the willingness to pay estimates should be scope sensitive. Thus it is assumed that people are willing to pay more for larger changes in water quality, whereby the sign of WQCPERC is positive.

The dummy variable GAIN is included to indicate whether the study measures the willingness to pay for an improvement in water quality or for preventing the quality from deteriorating. The hypothesis here is that people value losses higher than gains and the expected sign of GAIN is therefore negative (Tversky and Kahneman 1991 or Kahneman, Knetsch and Thaler 1991).

The water quality change is further described by the variables EFFREC and EFFBIO, which capture the dimensions of the good affected by the change. EFFREC describes the changes that are specified as affecting recreation and EFFBIO those affecting biodiversity or habitats. The expectation for both variables is that the sign will be positive, although the relative magnitudes are unknown beforehand. Other variables describing the water quality change, e.g. variables distinguishing changes that are represented in terms of eutrophication, fisheries or water quality in general, were included in the early stages of analysis, but they were not significant in explaining willingness to pay for water quality.

It is interesting to investigate whether the water body type affects people's willingness to pay, especially as our focus is on marine ecosystems and assessing the benefits of protecting the Baltic Sea. The dummy variables SEA, LAKE, RIVER AND SOUND distinguish different water body types, with the base case being several different water bodies. The variable SEA provides a convenient way of assessing the magnitude of the value estimates for the Baltic Sea relative to other water bodies as all these studies deal with the Baltic. There is no prior expectation regarding the sign of the variables for water body type.

The geographical dimension of the good is captured with the dummy variable REGLOC, which indicates whether the valued good is regional or local rather than national. The expectation regarding the sign of REGLOC is ambivalent. The variable can be thought to reflect the spatial scope of the water quality change and therefore have a negative sign. On the other hand, it has been observed that people's willingness to pay decays with distance (Bateman et al. 2006), and thus local water quality improvements may be valued higher per person than national ones.

An indicator for the income level is necessary for assessing the benefit distribution, as the differences in mean willingness to pay between countries originate from the differences in their income and wealth. The ideal indicator of income would be the mean income of the study population, but this is seldom reported. Therefore GDP is used as a proxy. In the present case, GDP gives the country's gross domestic product in purchasing power standards (PPS) for the year of the study. All GDPs are adjusted to the year 2007 using country-specific consumer price indices. There are significant differences in gross domestic product between the countries. Economic theory suggests that willingness to pay is higher in countries with higher GDPs.

The third set of variables describes the methodology used. The valuation method is captured with the dummies CE and TCM for choice experiment and travel cost method respectively; the base case is contingent valuation. A previous meta-analysis has indicated that travel cost studies produce higher value estimates than contingent valuation studies do (Carson et al. 1996). Then again, as the travel cost method is capable of measuring use value only, it can intuitively be expected to produce lower willingness to pay estimates than stated preference methods if stated preference methods are used to measure both use and non-use values. Moreover, the non-use value component is likely to be substantial in the case of water ecosystems (Wilson and Carpenter 1999, 779). There is no strong expectation concerning the use of the choice experiment method compared to contingent valuation for the value estimates, as prior results on the relationships between these methods have varied (see e.g. Adamovicz et al. 1998; Hanley et al. 1998).

The final set of variables consists of the variables PUBLISH and YEAR. PUBLISH is used as a proxy variable for study quality. The expected direction of the effect on value estimates is unclear as prior results have been inconsistent. Rosenberger and Stanley (2006) found that published estimates have been lower than unpublished estimates in several meta-analyses of non-market valuation. On the other hand, in their meta-analysis of water quality Van Houtven, Powers and Pattanayak (2007, 222) report a positive and significant effect on value estimates for published studies.

The variable YEAR is included in the meta-regression to reveal whether there is a systematic trend in willingness to pay over the years. The expected sign is ambivalent, although prior meta-analyses of water quality have found a negative and significant effect on willingness to pay estimates indicating that values for water quality have declined over time (see e.g. Van Houtven, Powers and Pattanayak 2007 and Johnston et al. 2005). One possible reason for the lower willingness to pay estimates in later studies could be that improvements in survey design have reduced biases that previously led to overestimating the true values (Johnston, Besedin and Wardwell 2003, 7).

The variables NUMOBS and ESTW are used as a combined weighting factor in the meta-regression and they are described in detail in section 5.

5 Models

Previous meta-analyses of non-market valuation have employed various statistical methods, and there is no consensus on the appropriate estimation technique for the meta-regression model. However, the heteroskedasticity of the value estimate variances and the correlation between studies need to be addressed in the analyzing stage. These issues are taken into account by using weighted least squares and calculating heteroskedasticity-consistent standard errors.

We present the meta-regression models for two data sets, the first of which comprises all studies and the second of which only European studies. The European subsample has the advantage of being more homogeneous than the overall sample but, on the other hand, has substantially fewer observations, making statistical inferences more challenging. The results for both full and restricted models are reported. There is no standard for the functional form of the meta-regression model, and in the early stages of the analysis three forms (linear, semi-log and log-linear) were used to assess the robustness of the specifications. The results across these were rather similar, and the linear specification was chosen, as it seems to provide the best fit to the data according to the significance of the explanatory variables and the R^2 and adjusted R^2 statistics.

All regressions use weighted least squares (WLS). Two weighting factors are combined in accordance with the approach set out by Van Houtven, Powers and Pattanayak (2007). First, estimates that are based on larger sample sizes are more precise and should therefore be given more weight (Lipsey and Wilson 2001, 36). Ideally, we would weight each value estimate by the inverse of its variance. As standard errors of willingness to pay estimates are generally not reported, we use the number of observations as proxies for the variances. Thus each value estimate is weighted directly using the number of observations (NUMOBS) that the calculation of the mean willingness to pay estimate is based on. For example, if the value estimate is calculated based on a sample of 400 respondents, the estimate is weighted directly with 400. Second, the data contains value estimates that originate from the same study and use the same sample population but differ in some other respect, typically the valuation scenario. Ignoring this would give disproportionate weight to those studies that have produced several value estimates. To address the issue, all observations are given a weight that sums to one for a study (ESTW); that is, if a study has produced two estimates, each is given a weight of 0.5. The combined weighting factor (CWEIGHT) is the product of the two weights, NUMOBS and ESTW.

For all models, both WLS standard errors and White's heteroskedasticity-consistent standard errors are reported for comparison.

6 Meta-regression results

Table 3 reports the results of four different meta-regression models. Both full and restricted models are reported for the whole data set (n = 54) and for the European data set (n = 41). The full models include the variables that are of interest and that were introduced in section 4. The restricted models exclude variables that are not statistically significant in explaining willingness to pay estimates at the 0.10 level or less. However, the variables describing the environmental change – WQCPERC, EFFREC and EFFBIO – are retained in all models due to their importance. The variable SEA is included in all models, as we are especially interested in its influence.

The results of the meta-regressions are fairly robust, as the signs and statistical significances of the variables are consistent across specifications. Understandably, there are differences in the magnitudes of the coefficients across the data sets. All models give a reasonably good fit to the data, the R^2 statistic being between 0.75-0.82 and adjusted R^2 statistics between 0.67-0.72. The variance inflation factors (VIF) were examined to assess the extent of multicollinearity in the models. The higher the VIF, the higher is the degree of multicollinearity. There is no common threshold for the acceptability of the VIF; rather, several rules of thumb have been applied, the most common being a VIF of 10 (O'Brien 2007, 673). In the full model, all variance inflation factors are below 10. For the restricted models, the variance inflation factors are below

5 for all variables other than EFFBIO in both data sets and REGLOC in the European data set.

The willingness to pay for water quality varies in systematic patterns according to our expectations. Importantly, the results indicate that the variables describing the change in water quality are statistically significant in determining the willingness to pay estimates. The value estimates seem to be scope sensitive; that is, they increase as the improvement in water quality increases. WQCPERC is positive and statistically significant in all models but one.

The coefficient of GAIN is negative, as expected, but it is statistically significant only in the models that include all studies. Thus, the variable has been excluded from the restricted models in the European subsample. The variables describing the effects of the water quality change, EFFREC and EFFBIO are positive and consistently significant across the models. The coefficient of EFFREC is larger than that of EFFBIO, indicating that changes that affect recreation are valued higher.

Water body type is found to affect willingness to pay, as the variable LAKE is consistently negative and significant across specifications. Thus water quality changes taking place in a lake or lakes are valued lower than those in other water bodies. The coefficient of SEA is positive, but is statistically significant only in models that include all studies. Other water body types (RIVER and SOUND) have no significant effect on value estimates, and are excluded from the restricted models.

The geographical scope of the good is statistically significant in determining willingness to pay for water quality, as the variable REGLOC is significant in most models. The positive sign of the variable indicates that regional and local goods are valued higher, a finding that may be a result of distance decay of values.

Our models indicate that the income variable, GDP, performs well. GDP is significant and positive in all specifications, indicating that willingness to pay for water quality is higher in countries that have higher gross domestic products. This result is important, as it argues for using the variable in assessing the distribution of the benefits of protection measures among the Baltic Sea countries.

The study methodology is also significant in determining water quality values. Choice experiments produce higher willingness to pay estimates than contingent valuation, as CE is consistently positive and significant across specifications. In contrast to prior findings, travel cost studies seem to give lower value estimates for water quality. The coefficient of TCM is negative and significant in all models.

The variable reflecting study quality, PUBLISH, is not statistically significant in explaining willingness to pay and has been excluded from the restricted models. Thus, our results do not indicate significant differences in willingness to pay estimates between peer-reviewed and other types of study reports. This is promising, as the majority of our observations come from sources other than peer-reviewed journals.

The year of the study also affects water quality values, as the variable YEAR is statistically significant in all specifications. The sign is consistently negative, indicating that recent valuation studies have produced lower willingness to pay values for water quality. There are many possible reasons for this trend: it may reflect the change in environmental attitudes over time or stem from the degradation in the state of the Baltic Sea and other water bodies. Another could be the progress in valuation methodologies which has led to lower estimates.

[insert Table 3 here]

The meta-regression allows predicting the willingness to pay for specific water quality change scenarios. Table 4 presents benefit estimates for a 50% change in water quality affecting either recreation or both recreation and biodiversity. Other variables are set to their mean values. We use both data sets and calculate the estimates for the full and restricted models to compare the willingness to pay estimates.

The willingness to pay estimates are close to each other in the full and the restricted models for the full data set. The European subset produces somewhat higher estimates, but in any case the order of magnitude is similar between all models. The annual mean willingness to pay estimates per person range from 41€ to 53€ for a change that affects only recreation to 98€ to 117€ for a change that affects both recreation and biodiversity. Our results are similar in magnitude to those of other meta-analyses of water quality. Van Houtven, Powers and Pattanayak (2007) report annual willingness to pay estimates of $24-93 for a medium-sized change in water quality.

[insert Table 4 here]

7 Application to assess the benefits for the Baltic Sea

The meta-regression makes it possible to assess the benefits of improving the state of the Baltic Sea. In addition, it is possible to calculate the distribution of the benefits between the littoral countries and to compare the benefits with the costs of protection measures. However, the limitations and drawbacks of the method should be borne in mind. Benefit transfers derived from meta-analyses have been found to produce transfer errors and, given the heterogeneity of our data set, the predicted benefit estimates should be considered only indicative of the value of protecting the Baltic Sea. On the other hand, no up-to-date estimates based on primary valuation studies for each Baltic Sea country are available: the existing results date from the mid-1990s and are for the most part based on benefit transfer.

We estimate both the benefits and net benefits of improving the state of the Baltic Sea and compare them with the results of the Baltic Drainage Basin Project (Turner et al. 1999). Calculating the net benefits requires updated information on both benefits and costs. To make our approach comparable with that in previous studies, we focus on eutrophication, which is considered the most serious environmental problem in the Baltic, and use the same costs as in the Drainage Basin Project (Turner et al. 1999). The population figures for each country represent the share of the adult population living in the drainage basin (Söderqvist and Hasselström 2008). The costs evaluated in the Drainage Basin Project were calculated for a 50% reduction in the total nutrient load flowing into the Baltic Sea. These costs have been adjusted using purchasing power parities and country-specific consumer price indices to reflect 2007 euros.

The benefit figures for the Baltic Drainage Basin Project are from Söderqvist and Hasselström (2008), where updated estimates for the benefits are presented. They use data on income elasticity of willingness to pay, growth in gross domestic product per capita and consumer price indices to adjust the estimates. Söderqvist and Hasselström (2008) report the benefits in 2005 euros, and we adjust them further with country-specific consumer price indices to the year 2007. The population figures and the distribution of costs, benefits and net benefits among the Baltic Sea countries according to the Baltic Drainage Basin Project are presented in Table 5. The variation in benefits between countries reflects the differences in population size and in mean willingness to pay estimates.

The estimates of the benefits derived from the meta-analysis have been calculated using the full model with a data set that includes all studies. The advantages of using the complete data set are that it is based on more observations and produces more conservative estimates compared to the European subsample. The water quality change is specified as a 50% improvement and as affecting both recreation and biodiversity. The benefits are estimated for a change that takes place in a sea area. The other water body type variables are set to zero. Country-specific GDPs are used to evaluate the mean willingness to pay for each country. Other variables (YEAR, PUBLISH, CE, TCM and REGLOC) are set to their mean values. Table 6 presents the country-specific mean willingness to pay estimates, benefits and net benefits based on the meta-analysis. The population figures and costs are identical to those in Table 5. Here, the variation in mean willingness to pay between countries results from the differences in the countries' GDPs and as before, the benefits vary due to different population sizes.

[insert Table 5 and Table 6 here]

The aggregate benefit estimates of the Baltic Drainage Basin Project and the meta-analysis are very similar, both being approximately MEUR 5000 per year. Although total benefits are similar, the distribution of the benefits between countries differs. In general, the meta-regression predicts lower benefits for Denmark, Finland, Germany and Sweden and higher benefits for Estonia, Latvia, Lithuania, Poland and Russia. Contrary to the Baltic Drainage Basin Project results, Germany is now a net loser and Poland a net winner. Overall, both approaches predict positive total net benefits (around MEUR 870 per year) and thus suggest that measures should be implemented to reduce eutrophication in the Baltic Sea.

In the Baltic Drainage Basin Project the benefits are estimated for a plan that decreases eutrophication to a sustainable level, and Turner et al. (1999) note the difficulty in relating the outcome in the valuation scenario to a specific nutrient load reduction. This reflects a common problem in comparing benefits from valuation studies with costs. It is generally very challenging to link the benefit estimates directly to ecological indicators, such as nutrient loads. Additional complications arise because the benefit estimates are inherently subjective as opposed to the cost measures, which are typically assumed objective.

The comparison of the estimates from the Drainage Basin Project and the meta-analysis reveals that the benefits of protecting the Baltic Sea are distributed differently according to the results of these studies. This is interesting from the viewpoint of international negotiations, as net benefits are decisive in determining countries' incentives to adhere to international agreements on protecting shared marine areas. Although total net benefits from the protection measures will be positive, some countries will have to bear costs that are higher than their anticipated gain, and these countries may thus be reluctant to participate in common actions. In this situation, binding agreements are difficult to reach. However, the positive aggregate net benefits noted would allow for compensation to be paid between countries, which might facilitate the conclusion of international agreements on the protection of the Baltic Sea.

8 Conclusions and discussion

Information on the benefits of protecting water bodies is in general fragmented, and this applies also to the Baltic Sea. Meta-analysis can be used to summarize existing information in order to attain a more comprehensive understanding of the value of environmental amenities. Our study represents an attempt to illustrate the potential of meta-analysis in assessing internationally shared marine resources. We also present up-to-date estimates of the benefits of protecting the Baltic Sea and their distribution among the countries involved.

Meta-analysis proves to be useful in assessing the benefits of improvements in water quality also in the case of internationally shared marine resources. In the present study, it has revealed systematic and consistent patterns in willingness to pay for water quality. Value estimates are higher for larger changes in water quality and sensitive to the amenities affected. There is a positive and highly significant relationship between a country's GDP and willingness to pay for water quality, a finding that argues for the estimation of country-specific benefits. More recent studies have in general yielded lower values for water quality. The valuation method also affects willingness to pay, as choice experiments give higher and travel cost method lower estimates than contingent valuation.

The predicted mean annual willingness to pay per person for a 50% water quality change ranges from 40€ to 120€, depending on the dimensions of the good that are affected. In comparison to the results of the Baltic Drainage Basin Project, the present meta-analysis predicts similar aggregate benefits for improvements in the state of the Baltic Sea. The total net benefits are estimated to be positive. The results also indicate that the distribution of the net benefits is somewhat different than reported in earlier studies, which is important, as it is net benefits in particular that are decisive in prompting countries to enter into international agreements.

The main limitation of the present meta-analysis is the heterogeneity of the data, particularly regards to the descriptions of the change in the environmental good. The studies, although having a common focus on water quality, value diverse changes, which has complicated expressing them on a comparable scale. Differing approaches in describing the good being valued between studies is a frequent problem in environmental valuation as there are no common standards. The variation in practices complicates comparisons between valuation studies and also diminishes the reliability of meta-analyses of environmental valuation.

Another limitation stems also from the characteristics of the valuation studies. At present, it is difficult to link the benefit estimates to ecological indicators and therefore to the costs of protection measures. Thus the benefits obtained from valuation studies and the estimated costs are typically not directly comparable. Using such ecological indicators for water quality as nutrient levels, state of fish stocks and sight depth is possible, but in any case it is not evident how people perceive the improvements in terms of the indicators. Thus one of the objectives of future research should be on identifying suitable indicators for monetary valuation which can easily be connected to cost estimates.

The results of the meta-analysis with regard to benefit transfer and the assessment of benefit distribution are subject to transfer errors, which might be exacerbated by the heterogeneity of our data. On the other hand, we have compiled valuation information from a range of studies and included estimates from several countries to increase the reliability of our results. Moreover, separate benefit estimates do not exist for each of the Baltic Sea countries, which makes the use of benefit transfers compelling if we want to estimate the Baltic-wide benefits. As uncertainties related to the benefit estimates remain, further studies are needed to provide more accurate information on the country-specific benefits of protecting the Baltic Sea.

Footnotes

[1] The littoral countries are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden and Russia.

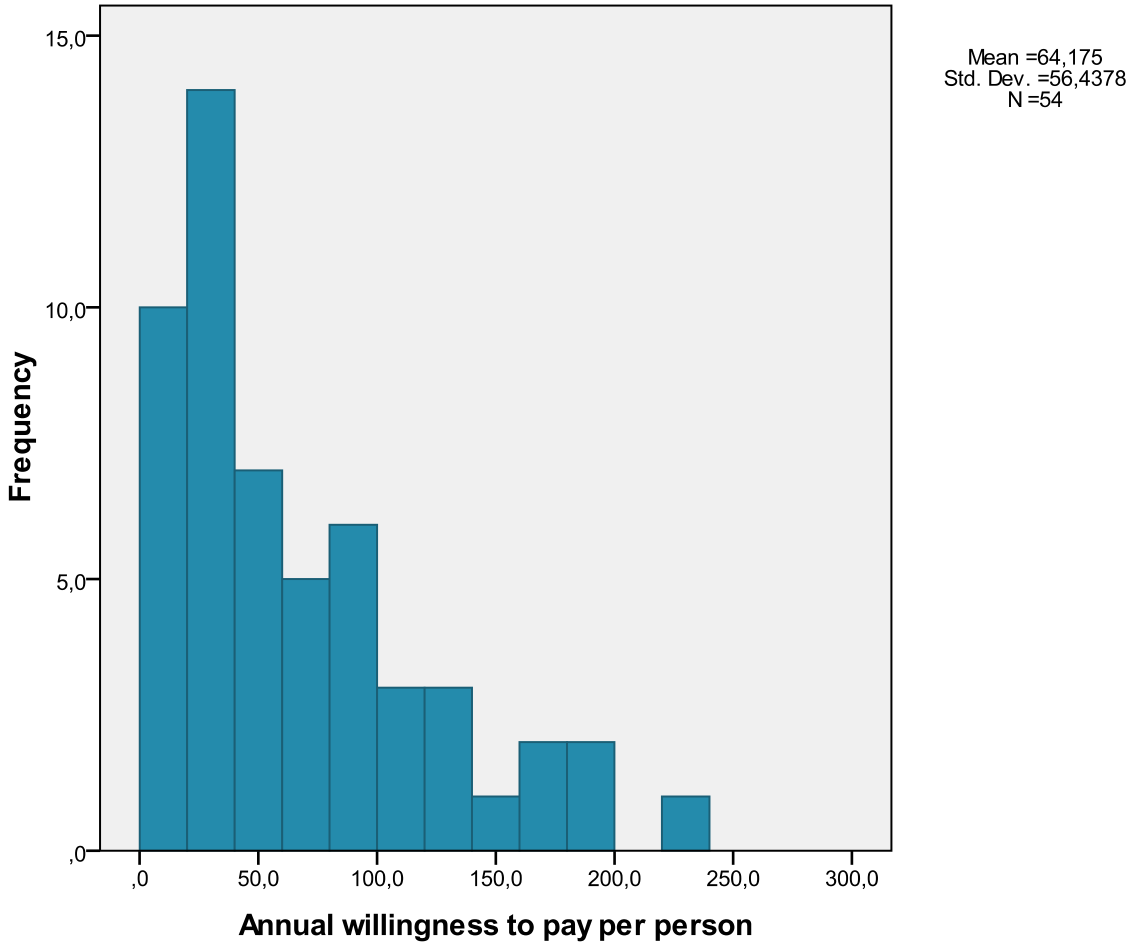

Figure 1. Distribution of willingness to pay estimates (€/person)

Table 1

Summary statistics for the meta-data

	Studies (n=32)		Value estimates (n= 54)	
	Number	Percent	Number	Percent
Type of publication				
Journal article	11	34.4 %	19	35.2 %
Working/discussion paper	8	25.0 %	17	31.5 %
Report	9	28.1 %	14	25.9 %
PhD/master's thesis	4	12.5 %	4	7.4 %
Year of publication				
1990 - 1999	10	31.3 %	15	27.8 %
2000 -	22	68.8 %	39	72.2 %
Country				
Denmark	3	9.4 %	6	11.1 %
Finland	9	28.1 %	16	29.6 %
Germany	1	3.1 %	1	1.9 %
Latvia	2	6.3 %	2	3.7 %
Lithuania	2	6.3 %	2	3.7 %
Poland	3	9.4 %	3	5.6 %
Sweden	7	21.9 %	11	20.4 %
United States	5	15.6 %	13	24.1 %
Type of water body affected				
Sea (area)	13	40.6 %	18	33.3 %
Lake(s)	5	15.6 %	12	22.2 %
River(s)	4	12.5 %	4	7.4 %
Several types of water bodies	8	25.0 %	17	31.5 %
Other (sounds, estuaries)	2	6.3 %	3	5.6 %
Geographic extent of change				
National	13	40.6 %	22	40.7 %
Local/regional	19	59.4 %	32	59.3 %
Connection to the Baltic Sea				
Direct	13	40.6 %	18	33.3 %
Indirect	8	25.0 %	15	27.8 %
Drainage basin	6	18.8 %	8	14.8 %
None	5	15.6 %	13	24.1 %
Focus of the study				
Eutrophication	16	50.0 %	24	44.4 %
Fisheries	5	15.6 %	8	14.8 %
Oil spills	1	3.1 %	1	1.9 %
Water quality in general	10	31.3 %	21	38.9 %
Valuation method				
Contingent valuation (CV)	22	68.8 %	27	50.0 %
Choice experiment (CE)	3	9.4 %	9	16.7 %
Travel cost method (TCM)	6	18.8 %	17	31.5 %
Other (combined CV and TCM)	1	3.1 %	1	1.9 %

Table 2

Variables and summary statistics (for all studies)

Variable	Description	Mean	Std deviation	Min	Max
WTP	PPP and country-specific CPI-adjusted annual willingness to pay per person (in 2007 euros)	64.2	56.4	0.1	237.0
NUMOBS	Number of observations, continuous	789	779	40	3340
ESTW	Estimate weight; sums to one for a study	0.59	0.33	0.20	1.00
CWEIGHT	Combined weight factor, = Estimate weight * Number of observations	469.77	590.46	40.00	3340.00
WQCPERC	Percentual change in water quality, continuous	56.3	43.3	25.0	230.0
GAIN	1 if WTP is asked for an improvement in water quality, 0 if it is asked to prevent deterioration	0.89	0.32	0	1
EFFREC	1 if the water quality change has an effect on recreation, 0 otherwise	0.93	0.26	0	1
EFFBIO	1 if the water quality change has an effect on biodiversity or habitats, 0 otherwise	0.43	0.50	0	1
SEA	1 if the water body is a sea area, 0 otherwise	0.33	0.48	0	1
LAKE	1 if the water body is a lake or lakes, 0 otherwise	0.22	0.42	0	1
RIVER	1 if the water body is a river or rivers, 0 otherwise	0.07	0.26	0	1
SOUND	1 if the water body is a sound or an estuary, 0 otherwise	0.06	0.23	0	1
REGLOC	1 if the good is regional or local, 0 if it is national	0.56	0.50	0	1
GDP	Country's gross domestic product in PPS in the study year, in thousands of 2007 euros, continuous	25.28	6.68	6.90	35.70
CE	1 if choice experiment, 0 otherwise	0.17	0.38	0	1
TCM	1 if travel cost method, 0 otherwise	0.31	0.47	0	1
PUBLISH	1 if the study was published in a peer-reviewed journal , 0 otherwise	0.39	0.49	0	1
YEAR	Study year (minus 1988), continuous	10.65	5.25	1	20

Table 3

Meta-regression results

Linear regression, weighted least squares, dependent variable: WTP in 2007 euros, n = 54 or n = 41)

	All studies (n = 54)								European studies (n = 41)					
	WLS				WLS, heteroskedasticity-consistent covariance matrix				WLS				WLS, heteroskedasticity - consistent covariance matrix	
	Full		Restricted		Full		Restricted		Full		Restricted		Restricted	
Variables	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
CONSTANT	-105.291**	44.383	-119.758***	38.825	-105.291*	55.263	-119.758**	45.649	-114.647**	50.021	-142.592***	42.530	-142.592**	58.614
WQCPERC	0.579***	0.124	0.591***	0.119	0.579***	0.163	0.591***	0.170	0.648	0.493	0.674**	0.255	0.674*	0.396
GAIN	-51.164*	28.001	-56.941**	26.263	-51.164**	23.578	-56.941**	22.859	-35.385	28.042				
EFFREC	112.851***	31.470	111.952***	30.791	112.851***	41.149	111.952**	43.997	128.376***	32.043	103.149***	29.078	103.149*	55.335
EFFBIO	55.501***	19.996	57.078***	15.448	55.501*	30.381	57.078**	21.231	73.060***	21.218	56.800***	19.389	56.800*	31.101
SEA	20.454	12.915	24.689**	10.462	20.454	17.511	24.689*	12.785	4.074	14.904	5.319	11.782	5.319	12.673
LAKE	-54.639***	16.723	-56.151***	16.122	-54.639***	15.427	-56.151***	17.485	-50.026**	22.569	-40.786**	19.767	-40.786**	16.061
RIVER	-8.807	17.641			-8.807	16.992			11.888	26.777				
SOUND	15.515	22.218			15.515	22.118			33.641	78.673				
REGLOC	28.990*	16.470	34.626**	12.926	28.990	25.370	34.626*	18.571	35.748*	19.533	44.455**	16.502	44.455	29.227
GDP	4.602***	1.028	4.720***	0.933	4.602***	1.407	4.720***	1.162	5.793***	1.217	5.273***	1.008	5.273***	1.193
CE	103.647***	23.192	106.471***	22.258	103.647**	46.264	106.471**	43.414	126.149***	25.139	135.923***	24.428	135.923**	55.453
TCM	-64.675***	12.294	-59.025***	11.008	-64.675***	9.307	-59.025***	10.188	-54.685***	14.295	-50.941***	13.914	-50.941***	11.958
PUBLISH	-11.799	18.264			-11.799	28.682			-28.030	20.987				
YEAR	-5.904***	1.769	-5.449***	1.289	-5.904**	2.447	-5.449***	1.754	-10.553***	2.290	-8.728***	1.768	-8.728***	2.387
R^2	0.76		0.75		0.76		0.75		0.82		0.79		0.79	
Adjusted R^2	0.67		0.68		0.67		0.68		0.72		0.71		0.71	
F	8.70		11.40		8.70		11.40		8.43		11.12		11.12	

Individual coefficients are significant at the *** 1 %, ** 5 % and * 10 % level.

Weighted by combined weight factor (Combined weight factor = Estimate weight * Number of observations

Table 4

Predicted willingness to pay for a 50% change in water quality

	All studies		European	
Water quality change	Full model	Restricted	Full model	Restricted
Recreation	43 €	41 €	44 €	53 €
Recreation and biodiversity	99 €	98 €	117 €	109 €

Table 5

Distribution of benefits according to the Baltic Drainage Basin Project

Country	Population (in millions)[a]	Costs per year (millions of 2007 euros)[b]	Benefits per year (millions of 2007 euros)	Net benefits (millions of 2007 euros)
Denmark	3.58	373	952	579
Estonia	1.05	228	67	-161
Finland	3.86	348	628	280
Germany	2.45	495	552	57
Latvia	1.78	286	70	-215
Lithuania	2.42	307	88	-219
Poland	25.85	1357	966	-391
Russia	7.01	114	197	83
Sweden	6.78	653	1507	854
Total	54.78	4160	5027	867

[a] Population figures are the same as in Söderqvist and Hasselström (2008)

[b] Costs are updated from Turner et al. (1999)

Table 6

Distribution of benefits based on meta-regression

Country	Annual mean willingness to pay per person (2007 euros)	Benefits per year (millions of 2007 euros)	Net benefits per year (millions of 2007 euros)
Denmark	147	527	154
Estonia	89	93	-135
Finland	141	544	197
Germany	137	335	-160
Latvia	74	132	-154
Lithuania	78	188	-119
Poland	69	1778	422
Russia	58	408	294
Sweden	151	1026	373
Total		5030	871

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Appendix 1. Summary of studies included in the meta-data (studies=32, value estimates=54)

Study number	Author(s)	Environmental focus	Resource type and area	Baltic Sea connection	Valuation method	Mean of WTP estimates in 2007 € (number)
1	Mäntymaa (1994)	eutrophication	lake Oulujärvi, Finland	in the drainage basin	CV	70.0 (2)
2	Needelman and Kealy (1995)	water quality	lakes in New Hampshire, US	none	TCM	3.70 (5)
3	Söderqvist (1996)	eutrophication	Baltic Sea	direct	CV	124.6 (1)
4	Söderqvist (1996)	eutrophication	Baltic Sea	direct	CV	99.7 (1)
5	Zylicz et al. (1995)	eutrophication	Baltic Sea	direct	CV	151.5 (1)
6	Frykblom (1998)	eutrophication	Laholm Bay, Sweden	direct	CV	94.5 (1)
7	Luoto (1998)	water quality	lake Öjanjärvi, Finland	in the drainage basin	CV	39.5 (1)
8	Markowska and Zylicz (1999)	eutrophication	Baltic Sea	direct	CV	32.1 (1)
9	Markowska and Zylicz (1999)	eutrophication	Baltic Sea	direct	CV	49.0 (1)
10	Markowska and Zylicz (1999)	eutrophication	Baltic Sea	direct	CV	82.7 (1)
11	Söderqvist and Scharin (2000)	eutrophication	Stockholm archipelago, Sweden	direct	CV	83.9 (1)
12	Whitehead, Haab and Huang (2000)	water quality	Albemarle and Pamlico Sounds, North Carolina, US	none	TCM	23.1 (1)
13	Ready, Malzubris and Senkane (2002)	water quality	Gauja River, Latvia	indirect	CV	24.9 (1)
14	Eggert and Olsson (2003)	water quality	Skagerrak and Kattegat off the west coast of Sweden	direct	CE	109.3 (4)
15	Parsons, Helm and Bondelid (2003)	water quality	all waters in the six northeastern states, US	none	TCM	16.2 (3)
16	Arlinghaus (2004)	fisheries	all waters in Germany	indirect	CV	24.2 (1)
17	Egan et al. (2004)	water quality	lakes in Iowa, US	none	TCM	48.6 (3)

18	Kosenius, (2004)	eutrophication	Gulf of Finland	direct	CV	26.0 (1)
19	Toivonen et al. (2004)	fisheries	all waters in Finland	indirect	CV	57.5 (2)
20	Toivonen et al. (2004)	fisheries	all waters in Sweden	indirect	CV	61.4(2)
21	Toivonen et al. (2004)	fisheries	all waters in Denmark	indirect	CV	107.6 (2)
22	Hasler et al. (2005)	water quality	lakes and watercourses in Denmark	in the drainage basin	CE	90.7 (2)
23	Parkkila (2005)	fisheries	Simojoki River, Finland	indirect	CV	53.0 (1)
24	Soutukorva (2005)	eutrophication	Stockholm archipelago, Sweden	direct	TCM	22 (1)
25	Whitehead (2005)	water quality	Neuse River, North Carolina, US	none	combined CV and TCM	47.7 (1)
26	Ahtiainen (2007)	oil spills	Gulf of Finland	direct	CV	28.0 (1)
27	Atkins, Burdon and Allen (2007)	eutrophication	Randers Fjord, Denmark	indirect	CV	115.2 (2)
28	Pakalniete, Lezdina and Veidemane (2007)	eutrophication	river and lake Ludza, Latvia	in the drainage basin	CV	5.8 (1)
29	Sceponaviciute, Monarchova and Semeniene (2007)	water quality	Nevezis river basin, all rivers, Lithuania	in the drainage basin	CV	17.8 (1)
30	Ahtiainen (2008)	eutrophication	Lake Hiidenvesi, Finland	in the drainage basin	CV	29.4 (1)
31	Kosenius (2008)	eutrophication	Gulf of Finland	direct	CE	206.0 (3)
32	Vesterinen et al. (2008)	eutrophication	all lakes and coastal waters in Finland	indirect	TCM	25.8 (4)

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ISSN 1795-5300