Reducing eutrophication in the Baltic Sea: A contingent valuation study across nine littoral countries

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Introduction and background

In this extended abstract we present results from a unique large-scale contingent valuation (CV) study on the benefits of reducing eutrophication in the Baltic Sea, conducted simultaneously in all nine Baltic littoral countries in 2011. Knowledge on the benefits of reducing the nutrients loads to the Baltic is valuable because it provides guidance in determining the economically optimal level of nutrient abatement measures, information regarding the distributional effects of eutrophication and improved water quality as well as information on the scale of social value at stake if the abatement measures undertaken are insufficient to deliver policy objectives. The study and the results are described in more detail in Ahtiainen et al 2012, and we refer to this working paper for further details (http://www.mtt.fi/dp/DP2012_1.pdf).

Eutrophication remains one of the most significant ecological problems of the Baltic Sea, reducing the benefits provided by the marine ecosystem services (HELCOM 2009). The Baltic Sea is particularly sensitive to eutrophication caused by nutrient loads due to limited water exchange, while the effluent loads are high arising primarily from agriculture, sewage and other anthropogenic sources. Most areas of the Baltic Sea are affected by eutrophication, some areas even heavily (HELCOM 2009, 2010). Visible effects of eutrophication on the marine environment are, for example, decreased water transparency, decrease of bladder wrack stands (*Fucus vesiculosus*) (Kautsky et al. 1986), heavy growth of filamentous macro algae, oxygen deficiency in sea bottoms and blooms of blue-green algae (i.e. cyanobacteria) (Pihl et al. 1996; Sundbäck et al. 1996). These effects accumulate over time and affect the functioning of the entire marine ecosystem.

Protection of the Baltic Sea has been called for on many occasions (see e.g. Baltic Sea Action Plan, BSAP; HELCOM 2007, or European Union Marine Strategy Framework Directive, MSFD; 2008/56/EC), and the need for cooperation between the nine littoral countries is evident. The BSAP and the MSFD have a common objective to achieve 'good environmental status' in the Baltic Sea in 2020 (MSFD) and 2021 (BSAP), which – among others – means reducing human-induced eutrophication by controlling nutrient loads. Designing sustainable and socially-optimal management strategies requires country-specific knowledge of the economic costs and benefits of achieving the good environmental status of the Baltic Sea. Substantial research effort has been devoted to identifying cost-efficient measures to reduce nutrient loads to the Baltic Sea (e.g. RECOCA 2011; Gren and Wulff 2004; Elofsson 2003), while the economic benefits of reducing Baltic Sea eutrophication remain to large extent unknown.

There are several previous attempts to assess the benefits of an improved environmental state of the Baltic Sea. A literature review by SEPA (2008c) concluded that most previous valuation studies concerning the Baltic Sea environment have been local case studies, and are hard to link to existing policy targets for various reasons. An often cited earlier large-scale study is the Baltic Drainage Basin Project (BDBP), which is reported in e.g. Söderqvist (1996), Gren et al. (1997), Turner et al. (1999) and Markowska & Zylicz (1999). The study was based on Lithuanian, Polish and Swedish CV surveys, which assessed the WTP for a 50% reduction of nutrient loads to the Baltic Sea. The WTP for the whole population around the Baltic Sea was estimated using benefit transfer (BT). The study showed that a healthy Baltic Sea is a valuable asset – the aggregate WTP was estimated to 5 billion Euros per year[1]. The Baltic Drainage Basin Project provided important information, but new studies are needed because WTP estimates might not be easily transferred between countries, especially if the countries are highly heterogeneous in income levels. This is also concluded in Ready & Navrud (2006), Bateman et al. (2012) and Czajkowski & Ščasný (2010). Furthermore, new studies should allow a clear quantitative link between the benefit estimates and the environmental status predicted by an ecological model. The previous attempts did not provide this link, which makes it hard to use the results in a cost-benefit analysis.

With identical surveys in all nine countries, the present study elicited willingness to pay measures for two future eutrophication scenarios by applying the CV approach for two scenarios where the level of eutrophication is reduced.

The eutrophication scenarios, built on 50% (half) and 100% (full) fulfilment of nutrient load reduction targets set by the HELCOM's BSAP, were based on biogeochemical modelling of open-sea conditions (Ahlvik et al, submitted, Pitkänen et al. 2007). Modelling results were combined to create colour-coded maps illustrating the level of eutrophication in each Baltic Sea basin, and the maps were used to present the scenarios to respondents. Eutrophication was described by a five-step water quality scale in terms of water clarity, blue-green algal blooms, underwater meadows, fish species composition and oxygen conditions in deep sea regions.

The data from the CV study were analysed using a spike model and grouped data model to estimate the mean willingness to pay for the two scenarios, representing the benefits of ecological improvements of the sea in each country. The results provide a valuable input for cost-benefit analyses of reducing the eutrophication of the Baltic Sea, and support decision-

[1] The estimates vary between the studies mainly because of the aggregation methodologies chosen. The figure presented is in 2005 prices and is based on an update of the results to present-day conditions, performed in SEPA (2008).

making by allowing for the calculation of efficient country contributions to the costs of reducing nutrient loads.

In this presentation at the DØRS conference we present the common survey design used in all 9 countries, we give a brief introduction to the results in all countries, while focusing on the Danish results, being most relevant for the audience at this conference.

Survey design and Methods

The common CV study was conducted in all 9 littoral countries at the same period of time in 2011. Face-to-face interviews were used in Latvia, Lithuania, and Russia; and an internet panel was used in Denmark, Sweden, Finland, Germany, and Estonia. In Poland, both internet panel and face-to-face interviews were implemented. Before the main survey was launched, a focus group testing and pilot study were conducted in order to validate the questionnaire.

The final questionnaire contains sex sections which are: 1) description of the Baltic Sea, 2) questions about leisure time spent at the sea, 3) definition of, and questions regarding eutrophication, 4) valuation scenario and willingness to pay questions, 5) follow-up questions in relation to certainty and motivation for willingness to pay, and 6) questions regarding respondents' socio-economic background.

Ecological modelling and the presentation of the effects of eutrophication

The core question in the questionnaire concerned respondents' WTP for reduced eutrophication, and, as a consequence, improved water quality of the Baltic Sea. The reduction in eutrophication was presented to the respondents using eutrophication-level maps which described the predicted condition of the Baltic Sea in the year 2050[2]. Two maps were presented for comparison: (1) a map describing the baseline scenario for eutrophication based on the present nutrient load reduction efforts, and (2) another map illustrating a scenario in which additional measures for reducing nutrient loads in the Baltic Sea has been implemented.

To create the eutrophication scenarios and the maps, we used exogenously given projections on nutrient loads and marine model simulations. As the first step, a dynamic marine model by Ahlvik et al. (2012) was used for projecting the state of the Baltic Sea over the 40 years time horizon 2010 - 2050. This model describes the exchange of water and nutrients across the seven basins of the Baltic Sea, and projects the development of nutrient concentrations as a consequence of the current state and exogenously given load projections. The second step was to use more detailed biogeochemical models to translate the predicted nutrient

[2] The year 2050 is chosen because SYKE's ecological model is used to model when the ecological improvements from reducing nutrient loads will take place (cf Ahlvik et al. 2012).

concentrations from the basin-level marine model into phytoplankton biomass and other attributes of water quality at a spatially detailed level.

The third step in preparing the eutrophication maps was to aggregate the multidimensional outputs describing the state of the Baltic Sea into a single indicator value, the average Ecological Quality Ratio (EQR). This indicator describes the present status in relation to the agreed reference condition for a particular eutrophication indicator (Andersen et al. 2010). In this study, the Ecological Quality Ratio was derived from three core eutrophication indicators, chlorophyll *a*, phosphate-phosphorus and nitrate-nitrogen concentrations and it was categorized according to the HELCOM classification into High, Good, Moderate, Poor or Bad water quality (Andersen et al. 2010). The fourth and the final step in preparing the eutrophication maps was to repeat steps 1-3 for a baseline load scenario and two alternative policy scenarios. The two alternative policy scenarios were constructed based on the projected decrease of the nutrient load as a result of measures carried out within the on-going Baltic Sea Action Plan (BSAP). One scenario was based on the full implementation of the BSAP load reduction targets (the "full BSAP" scenario) and the other was based on a less ambitious load reduction target in which 50% of the BSAP targets are achieved (the "half BSAP" scenario).

The valuation scenarios

The valuation scenario was carefully formulated based on feedback from pre-testing by focus groups and a pilot survey. We presented the change in eutrophication visually on maps to the respondents, using the mentioned EQR and a related water quality colour scale, where each colour was characterised by the previously described ecosystem characteristics. The description also included information on possible measures to reduce eutrophication, specification of the payment vehicle, and a statement clarifying who will have to pay to secure the environmental improvement. Finally, respondents were also asked to note that – if they agreed to pay – they would have to pay every year for the rest of their lives and this would therefore leave less money to spend on other things, and they were also reminded that the eutrophication reduction program would not ameliorate other environmental problems in the Baltic Sea, and that they had the possibility of using alternative water bodies for water recreation (see e.g. Bateman et al. 2002; Bateman et al 2011, Hasler et al 2011).

The payment vehicle used was a special Baltic Sea tax, implemented as a earmarked fixed annual amount specifically for reducing Baltic eutrophication, stated to be collected from each individual and firm in all Baltic Sea countries. Previous results from Söderqvist et al (2010) indicates that ear-marked payments were, in general, preferred by the citizens of the nine Baltic Sea countries in funding actions concerning the sea,, and the tax was deemed both credible and acceptable based on pre-testing. The tax was adjusted to individual differences in tax systems in each of the 9 countries to secure credibility in all countries. In all countries the tax was annual and individual for each person.

The WTP question comprised two separate stages: first - and prior to the actual presentation of the scenarios and maps - the respondent was asked whether s/he would in principle be willing to pay for reducing eutrophication in the Baltic Sea (this type of question is referred to as a *spike question*). If the answer was *yes* or *don't know*, then the respondent was presented with the maps comparing the two policy scenarios with the baseline scenario, together with their associated WTP questions. If the answer to the spike question was *no*, the respondent was directed straight to debriefing questions focused on respondents being unwilling to pay regarding motives for unwillingness to pay. The elicitation format was a payment card, constructed using the approach outlined in Rowe et al. (1996). The payment card was a 4 x 5 matrix, with 18 positive bids, a zero bid and a *don't know*[3]. Monetary amounts presented on the card were country-specific, chosen based on the results of the pilot studies. The WTP question was formulated as follows: "What is the most you would be willing to pay <u>every year</u> to reduce eutrophication in the Baltic Sea as shown in the maps? Please consider your disposable income carefully before answering the question."

Results:

Willingness to pay results for all 9 countries

The following two tables contain the estimated mean Willingness to pay (WTP) values for all littoral Baltic countries. As mentioned, the mean values were estimated using an interval regression model and a spike model. The interval regression model is a generalization of the Tobit model in which the true willingness to pay is assumed to lie in the interval between the lower and the higher bid in the payment card. In our application, the lower value of the lowest interval is zero is zero as respondents were screened for being in the market prior to the valuation question. The upper bound was specified in such a way that it is added with one unit of national currency. Following the approach of Cameron & Huppert (1989) and Lindhjem & Navrud (2011), the WTP estimates were log-transformed to account for the naturally skewed distribution of WTP figures toward lower values. In the spike model, each respondent's mean WTP is modelled directly, i.e. there is no censoring for only those who have positive WTP. Instead, the distribution of WTP is assumed to have a jump-discontinuity (spike) in the probability density function at WTP=0.The spike model incorporates a binary variable reflecting market participation and a variable expressing the interval of respondent's willingness to pay. The payment card allows us to infer the lower and upper bound of each respondent's WTP, provided that the respondent is 'in-the-market'.

The interval regression and spike models yielded similar results after results from the interval regression were adjusted by the share of respondents who are willing to pay positive amounts. The highest mean WTP was found in Sweden followed by Finland and Denmark. For the large reduction of eutrophication, respondents are willing to pay more than for the half reduction. The difference is small for e.g. Denmark (see tables 1&2), and we assume that

[3] In the Russian survey, a 4 x 4 bid matrix was employed due to technical problems. The second column, including low-to-mid range of bids was lost, and thus the WTP figures for Russia have a larger interval between the low values and higher values in the bid vector than originally intended.

this small difference can be explained by the small difference between half and full BSAP for the water quality in the Danish marine areas of the Baltic Sea.

Table 1. Mean annual WTP per person for the ½BSAP eutrophication reduction scenario (in 2011 Euros, PPP-corrected Euros, Euro27=1)

Interval regression				Spike model		
Country	Mean WTP (s.e)	95% CI	Sample mean WTP	Mean WTP (s.e)	95% CI	Spike probability
Denmark	63.68 (3.08)	57.65 – 69.71	34.39	35.15 (2.356)	30.54 – 39.77	0.47 (0.0002)
Estonia	35.71 (3.03)	29.76 – 41.65	19.25	19.95 (1.67)	16.68 – 23.22	0.50 (0.0005)
Finland	54.20 (1.99)	50.31 – 58.09	33.66	32.40 (1.03)	30.38 – 34.42	0.41 (0.0001)
Germany	33.39 (1.39)	30.68 – 36.10	18.26	18.24 (0.44)	17.37 – 19.10	0.48 (0.0001)
Latvia	10.67 (0.82)	9.07 – 12.28	5.24	4.91 (0.08)	4.75 – 5.07	0.54 (0.0003)
Lithuania	13.65 (1.15)	11.39 – 15.92	7.38	12.42 (0.58)	11.28 – 13.56	0.53 (0.0005)
Poland	19.25 (0.78)	17.72 – 20.77	10.45	11.15 (0.13)	10.90 – 11.40	0.49 (0.0001)
Russia	29.58 (2.80)	24.09 – 35.06	9.20	10.65 (0.31)	10.04 – 11.26	0.70 (0.0001)
Sweden	90.72 (4.37)	82.16 – 99.28	67.22	63.06 (4.98)	53.30 – 72.82	0.32 (0.0002)

CI=confidence interval

Table 2. Mean annual WTP per person for the BSAP eutrophication reduction scenario (in 2011 Euros, PPP-corrected Euros, Euro27=1)

Interval regression				Spike model		
Country	Mean WTP (s.e)	95% CI	Sample mean WTP	Mean WTP (s.e)	95% CI	Spike probability
Denmark	67.00 (3.41)	60.31 – 73.67	35.98	36.27 (2.5256)	31.32 - 41.22	0.48 (0.0002)
Estonia	46.20 (3.80)	38.76 – 53.65	26.06	25.76 (2.6407)	20.58 - 30.93	0.48 (0.0005)
Finland	71.56 (2.80)	66.07 – 77.04	45.08	42.49 (1.7542)	39.05 - 45.93	0.40 (0.0001)
Germany	45.66 (2.02)	41.69 – 49.62	25.66	25.15 (0.8019)	23.57 - 26.72	0.46 (0.0001)
Latvia	12.74 (1.06)	10.66 – 14.82	6.34	5.89 (0.1148)	5.66 - 6.11	0.54 (0.0003)
Lithuania	18.60 (1.50)	15.65 – 21.55	10.25	16.51 (0.9441)	14.66 - 18.36	0.51 (0.0004)
Poland	23.90 (0.90)	22.13 – 25.67	13.15	13.39 (0.1761)	13.04 - 13.73	0.48 (0.0001)
Russia	35.97 (2.93)	30.22 – 41.72	11.58	11.67 (0.3613)	10.96 - 12.38	0.69 (0.0001)
Sweden	111.78 (5.75)	100.52 – 123.04	83.39	77.14 (8.2254)	61.01 - 93.26	0.33 (0.0002)

CI=confidence interval

Willingness to pay results from: the Danish part of the survey

In this section of this abstract we focus on the Danish results. As indicated above, Danish respondents were willing to contribute a sizeable amount to implement the program that reduces eutrophication in the Baltic Sea. Therefore, it would be imperative to assess which factors affect the willing to pay, and therefore, we estimated different model incorporating important covariates. For the Danish specific results we have chosen to present the spike model results in more detail. The spike model was applied in order to account for those respondents who were not willing to pay (zero WTP) for reducing eutrophication in the Baltic Sea, i.e. respondents who said “no” to the spike question. This type of model reflects whether the respondent participates in the “market” or not. The spike model was employed with and without covariates.

Table 3: Estimated Parameters of the Spike Model for the half BSAP

	Spike model without covariates		**Spike model with covariates**	
Variable	**Coefficient**	**SE**	**coefficient**	**SE**
			Participation equation	
AGE	-0.0233***	0.0043	-0.0234***	0.0044
HH_SIZE	-0.0162	0.0829	-0.0162	0.0868
FREQ_USER	-0.2878	0.1914	-0.2878	0.1914
HIGHEDUC	0.0385	0.1372	0.0385	0.1376
WORRIED	0.2855	0.2263	0.2855	0.2277
RESPONSIBLE	0.3833***	0.1612	0.3833***	0.1620
NO_SUBSTITUTE	0.4689**	0.2297	0.4689**	0.2307
KIDS	-0.1127	0.1395	-0.1127	0.1436
GENDER	0.2666**	0.1388	0.2666**	0.1393
INC_HIGH	-0.0534	0.2008	-0.0534	0.2014
INC_LOW	-0.0586	0.1489	-0.0586	0.1496
EXPERIENCE	0.8591***	0.1816	0.8591***	0.1824
CLOSER	-0.1087	0.1507	-0.1088	0.1518
KNOWLEDGE	0.9303***	0.1619	0.9303***	0.1622
			Willingness to pay equation	
Constant	1.5997***	0.1217	-0.0914	0.6587
Price	-3.2430***	0.0951	-3.4245***	0.0984
AGE			0.0143**	0.0069
HH_SIZE			0.1477	0.1114
FREQ_USER			0.5131***	0.2076
HIGHEDUC			0.1369	0.1659
WORRIED			0.2764	0.3831
RESPONSIBLE			0.2149	0.2184
NO_SUBSTITUTE			0.0180	0.2203
KIDS			-0.3192*	0.1799
GENDER			-0.1669	0.1651
INC_HIGH			0.1933	0.2256
INC_LOW			-0.3891**	0.1897
EXPERIENCE			0.0413	0.1964
CLOSER			0.2072	0.2007
KNOWLEDGE			0.3490	0.2587
LL	2435.446		2406.854	
N	1049		1049	

*** Significant at 1% level, **Significant at 5% level, *Significant at 10% level

As can be seen from tables 3 and 4 in the participation equation; the age of a respondent (AGE) has a negative impact on the WTP, and older respondents prefer not to pay for reducing eutrophication. However, feeling responsible for the improvement of the Baltic Sea environment (RESPONSIBLE), a variable reflecting that the Baltic sea is the only place for recreation (NO_SUBSTITUE), gender, experiencing the effects of eutrophication (EXPERIENCE) , and having prior knowledge about eutrophication (KNOWLEDGE) have a positive impact on the probability of being willing to pay for reducing eutrophication in the Baltic sea. In line with a priori expectations, any increment in the price leads to a decreasing willingness to pay.

Table 4: Estimated Parameters of the Spike Model for the full BSAP

	Spike model without covariates		Spike model with covariates	
Variable	**Coefficient**	**SE**	**coefficient**	**SE**
			Participation equation	
AGE	-0.0234***	0.0043	-0.02335***	0.0044
HH_SIZE	-0.0162	0.0829	-0.0162	0.0871
FREQ_USER	-0.2878	0.1917	-0.2878	0.1915
HIGHEDUC	0.0385	0.1371	0.0385	0.1378
WORRIED	0.2855	0.2262	0.2855	0.2279
RESPONSIBLE	0.3833***	0.1612	0.3833**	0.1619
NO_SUBSTITUTE	0.4689**	0.2296	0.4689**	0.2307
KIDS	-0.1127	0.1394	-0.1127	0.1443
GENDER	0.2666**	0.1388	0.2666**	0.1393
INC_HIGH	-0.0534	0.2009	-0.0534	0.2016
INC_LOW	-0.0586	0.1487	-0.0586	0.1491
EXPERIENCE	0.8591***	0.1814	0.8591***	0.1821
CLOSER	-0.1088	0.1509	-0.1088	0.1519
KNOWLEDGE	0.9303***	0.1619	0.9303***	0.1624
			Willingness to pay equation	
Constant	1.5414***	0.1228	0.0848	0.6666
Price	-3.0608***	0.0894	-3.2326***	0.0913
AGE			0.0092	0.0071
HH_SIZE			0.1702*	0.1072
FREQ_USER			0.5995***	0.2136
HIGHEDUC			0.1311	0.1700
WORRIED			0.3004	0.3854
RESPONSIBLE			0.1271	0.2195
NO_SUBSTITUTE			0.1153	0.2233
KIDS			-0.2711*	0.1733
GENDER			-0.2769*	0.1672
INC_HIGH			0.2411	0.2287
INC_LOW			-0.3167*	0.1915
EXPERIENCE			0.0559	0.2010
CLOSER			0.1742	0.2106
KNOWLEDGE			0.3422	0.2607
LL	2482.286		2455.008	
N	1049		1049	

*** Significant at 1% level, **Significant at 5% level, *Significant at 10% level

As to the willingness to pay equation for half BSAP; AGE, FREQ_USER, the number of children (KIDS) and lower income group of people (INC_LOW) are significant, and the negative sign of the estimated coefficients of the latter two variables, i.e. KIDS and INC_LOW suggests as the number of children in the household increase, respondents were less likely to pay for reducing eutrophication in the Baltic sea. By the same token, respondents under a lower income group had a lower probability of paying the minimum positive amount on the payment card. The same interpretations hold for full BSAP except that AGE is no longer significant but HH_SIZE and GENDER are. Female respondents were less likely to pay than male respondents.

Conclusions and discussion

The results of the study show that the populations of the nine Baltic Sea littoral states attach great value to achieving the policy targets specified by the BSAP, and for Denmark this conclusion also hold. Notably, the differences between the WTP in various countries are large, with the WTP of Swedes being the highest and the WTP of Latvians being the lowest. The Danish results show a small difference between the two scenarios, and the most likely explanation for that is that the water quality improvement pertaining to the areas close to Denmark in the two scenarios only differs with respect to the Baltic Proper. The Baltic Proper is further away from most Danes compared to the Belts and Kattegat.

The approach used for the study is unique in the sense that the estimates rely on primary data for nine countries, i.e. all relevant countries around the Baltic, and that they are based on extensive ecological models that predict the state of the Baltic Sea under various future scenarios. This makes the results promising for inclusion in future cost-benefit analyses. Further, the use of two scenarios with varying nutrient reductions allow for interpolations and marginal WTP estimations.

Even though we find the above mentioned results for Denmark, the respondents generally seem to care not only for their own area of the sea, but for the whole sea. Further, all types of eutrophication effects seem important to the respondents, not only very 'visible' effects such as cyanobacterial blooms or water clarity. This indicates that the non-use component of the willingness to pay-estimates may be large.

The results provide a strong message to the decision makers about the need for further actions to fulfill the policy targets in the BSAP. An important next step is to compare the WTP estimates with the costs of water protection measures. Cost minimization can be applied to determine cost-effective combinations of nutrient abatement measures to meet some given targets of water protection (see e.g. Hasler et al 2012).

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