Worth it: Benefits outweigh costs in reducing eutrophication in the Baltic

BalticSTERN Summary Report for HELCOM 2013 Ministerial Meeting

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Abstract: This summary report reviews the findings of BalticSTERN, an international research network conducting economic analysis of the ongoing and prospective efforts to reduce eutrophication in the Baltic Sea. The network has undertaken surveys exploring the benefits to be realized by citizens of countries on the Baltic from improved water quality and estimated cost-effective combinations of nutrient abatement measures which would fulfil the targets of the Baltic Sea Action Plan (BSAP). The cost-benefit analysis reported here evaluated the long-term net benefits and ecological consequences of the BSAP. The results indicate that the overall benefits of pursuing the proposed nutrient reductions clearly outweigh their aggregate cost, suggesting that the BSAP is an economically sound plan for solving the transboundary eutrophication problem. The cost of inaction - not implementing the objectives of the BSAP - would be significant. The research tools developed in BalticSTERN may aid decision making and inform processes related to the planning, design and evaluation of future international and national water management plans and policies for the Baltic Sea.

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1 INTRODUCTION

The coastal countries of the Baltic Sea have undertaken significant efforts since the 1970s to reduce nutrient loads to inland waters and the sea. Testifying to the efficacy of the measures taken, recent statistics suggest that nutrient loading peaked around the end of the 1980s and early 1990s and nutrient loads have been declining since.

However, the Baltic is still alarmingly eutrophicated, for there are long lags between the adoption of abatement measures and measurable improvements in water quality and its waters are subject to the impacts of internal loading of phosphorus and yet undetected point sources. Future projections show that serious efforts and additional measures will be required to reach what has been defined as a good environmental status for the sea in a reasonable amount of time.

Environmental improvements such as reducing eutrophication require public intervention. Yet, public resources are scarce and a number of sectors - healthcare, education and defence, for example – compete for them. This scarcity gives the impetus for economic analyses that guide decision makers on the societal impacts of planned public projects across different sectors.

An economic analysis of on-going and future efforts to reduce eutrophication in the Baltic might include evaluation of:

a) how to improve the state of the sea in a cost -effective manner, that is, in a way that the target is reached at the lowest cost; and

a) how large the societal benefits of improved water quality and increased ecosystem services are.

This report reviews the main findings of BalticSTERN, an international research network conducting cost-benefit analysis on the environmental problems of the Baltic Sea (Ericsdotter et al. 2013, Swedish Agency for Marine and Water Management 2013). The main focus of the network's recent research has been eutrophication, analysing costs and benefits of planned efforts to reduce nutrient loads to the Baltic Sea, and identifying cost-effective measures.

In describing uses of the sea, as well as people's attitudes and values regarding improvement of the marine environment, the present report evaluates the benefits of meeting the HELCOM Baltic Sea Action Plan (BSAP) targets agreed on in 2007. The benefits are then compared to the costs of meeting these targets. The report also discusses some of the most salient uncertainties pertaining to the results and evaluates how the results and future research might support societal decision making.

2 THE ECONOMICS OF NUTRIENT ABATEMENT: CURRENT RESEARCH KNOWLEDGE

2.1 Benefits of improving the state of the Baltic Sea

The Baltic Sea marine ecosystem provides many services that contribute to our well-being. In addition to market-valued benefits such as the sea's role as a transport route and source of nutrition (fish stocks), there are many benefits that we enjoy but pay no price for. While the most obvious have to do with recreational use of the sea, there are others - known as non-use benefits. One such benefit is the value given to future generations inheriting the sea in good condition. It is important to recognize the important role such benefits play in our well-being, because eutrophication impairs our possibilities to enjoy them. An estimate of the societal impacts of nutrient abatement is also needed to justify costly nutrient abatement measures.

The importance of use and non-use benefits is a particularly applicable consideration in the case of eutrophication in the Baltic, as it affects a unique ecosystem and there§ are long lags between abatement measures and their impacts on the water quality.

As non-use values cannot be observed directly, environmental economists use survey-based methods that can assess both use and non-use values, one well-established method being contingent valuation (CV), which was used, for example, to assess the damage from the Exxon-Valdez oil spill in Alaska. Currently, CV is a standard method in cost-benefit analyses and is used in litigation in the United States. Contingent valuation elicits individuals' willingness to pay for a well-defined environmental change, with willingness to pay repre-

senting the benefits of a change in monetary terms. With a sufficiently large sample, estimates of willingness to pay can be aggregated to provide an estimate of the total benefits at the national and international scale.

BalticSTERN used contingent valuation to assess the benefits of reaching the eutrophication targets of the current BSAP. Identical valuation surveys were carefully tested and conducted in all of the nine countries bordering on the Baltic Sea. Changes in the state of the sea were described verbally and with maps to help respondents understand how changes in eutrophication would affect water quality (Figure 1). The findings of the survey indicate that the total benefits of reaching the BSAP eutrophication targets would be in the range of 3 600-4 000 million euros annually.

It is not surprising that people in coastal states attach considerable value to efforts to mitigate eutrophication, as they frequently use the sea and are concerned about the marine environment. This is shown in the valuation study (BalticSUN), which was based on, and confirmed the results of, an earlier BalticSTERN survey (BalticSurvey) on the use of and attitudes regarding the Baltic Sea (Ahtiainen et al. 2012, 2013; Swedish EPA 2010a, b).

More than 80 per cent of the people living in the nine coastal countries use the sea for leisure activities. Common activities are walking along the beach, swimming, fishing, boat excursions and cruises. There is also high general awareness and concern over eutrophication and other environmental problems in the Baltic. About 40 per cent

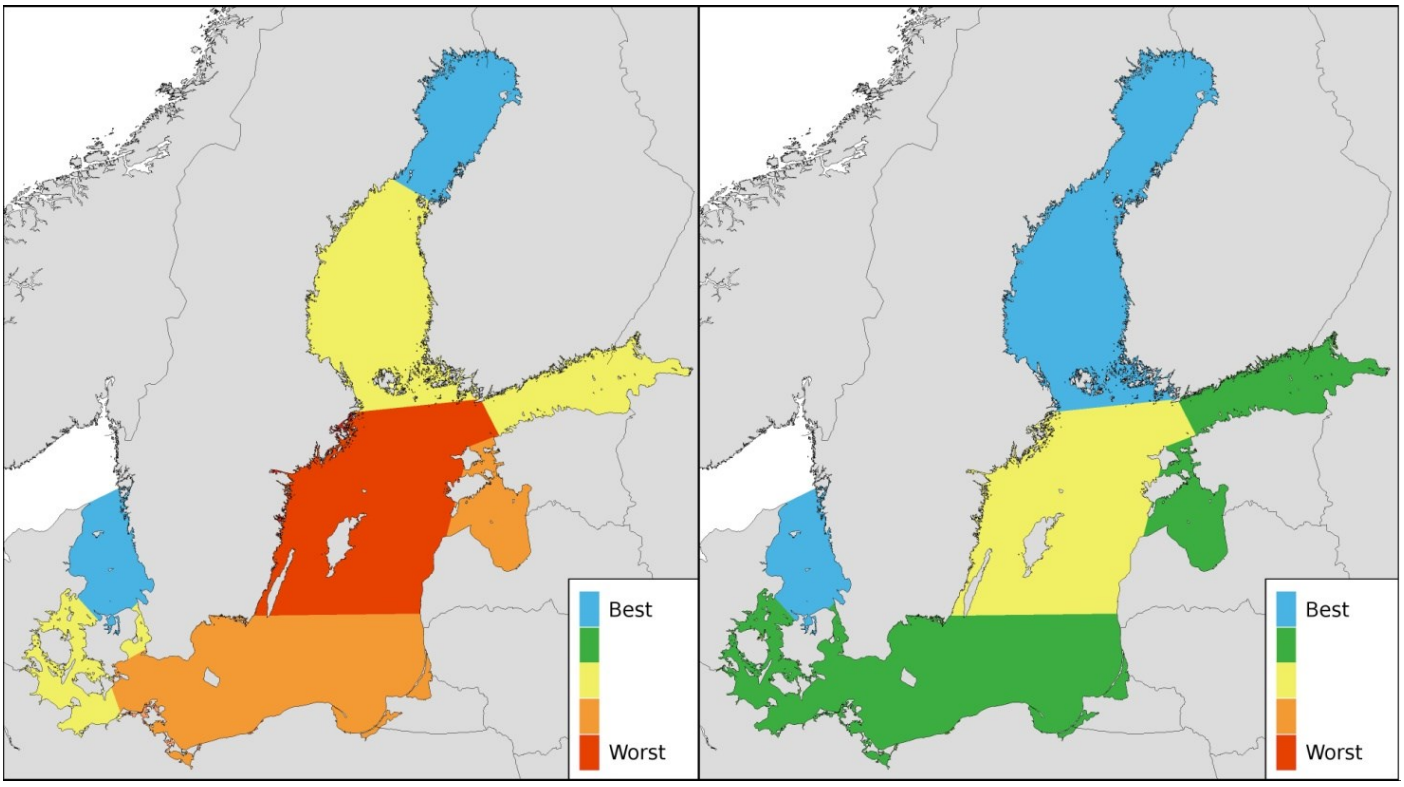

Figure 1. Water quality (on a five-step scale) in the Baltic Sea in 2050 with baseline development (left) and fulfilment of BSAP targets (right).

of respondents had personally encountered the effects of eutrophication, mostly in the form of decreased water clarity and algal blooms. Most people not only care about their local areas, but value having the entire Baltic in a healthier state. Interestingly, research indicates that distance from one's home to the sea generally does not determine willingness to pay for improvements, a result suggesting a sense of common cause.

To conclude, a healthy Baltic is of great value to the people living in the nine coastal countries. Recreation on its shores and waters is popular in all countries and many are worried about the marine environment.

2.2 Costs of nutrient abatement

Eutrophication can be reduced by controlling and reducing the flows of nitrogen and phosphorus into the sea. BalticSTERN conducted cost-effectiveness analyses to identify least-cost combinations of nutrient abatement measures and to ascertain the extent to which these measures should be implemented and where. Since loads have evolved from their 1997-2003 level – the basis for the BSAP 2007 targets - the analysis proceeded from current loads, calculated with reference to the reductions reported in the Fifth Baltic Sea Pollution Load Compilation (Helcom 2011).

In our analysis, the load reduction target per year for nitrogen was 102 624 tonnes and for phosphorus 10 555 tonnes. The costs of achieving these targets were estimated using two models, one developed in Finland as part of the PROBAPS project, the other in Denmark as part of the work of the Baltic Nest Institute. Both models are based on detailed data on land-use in the Baltic Sea catchments, the application of nutrients, the retention of nitrogen and phosphorus in soil and freshwater within the catchments, existing wastewater treatment capacity and the potential for improving wastewater treatment. They also take into account the potential of reducing nutrient loads by using phosphorus-free detergents, undertaking agricultural measures and restoring wetlands.

The maximum implementation capacities for the various abatement measures and nutrient retentions in each drainage basin were modelled in more detail than in previous studies. Analysis of the results obtained with two parallel economic modelling frameworks also provided insights into the level of uncertainties relating to the cost estimates (see Ericsdotter et al. 2013 for description of the approaches and models).

Costs were estimated for achieving load reduction targets for each sea region (Figure 2) and country according to the schemes specified in the BSAP. The total costs of achieving the remaining targets of the BSAP were estimated to be between 1400 and 2800 million euros annually. This range is in line with the findings of earlier studies (see Elofsson 2010 for review).

Figure 2. The Baltic Sea and its catchment area (Sub-basins: 1. Bothnian Bay, 2. Bothnian Sea, 3. Baltic Proper, 4. Gulf of Finland, 5. Gulf of Riga, 6. Danish straits, 7. Kattegat)

Nine relevant large-scale measures were considered for nutrient abatement. The cost-effective mix of measures to reduce nitrogen loads included construction of more wetlands, increased cultivation of catch crops, improved wastewater treatment capacity and reductions in nitrogen fertilization. Reductions in livestock production turned out to be the most expensive measure. The cost-effective combination of measures included improving wastewater treatment in the Baltic states (Estonia, Latvia and Lithuania) and Poland and reducing phosphorus fertilization, particularly in areas with high soil phosphorus levels, that is, parts of Finland, Germany and Denmark. Other low-cost measures included constructing sedimentation ponds and banning phosphorus in laundry detergents.

Measures implemented upstream were in general more costly due to retention of nutrients in the catchments, which reduces the initial effect of the measures on the loads to the sea. On the other hand, nutrient reductions upstream improve the quality of inland waters. As the focus of the study was the Baltic, however, benefits from inland environmental improvements were not assessed.

The present country- and basin-wise load reduction targets, as defined in the BSAP, are based on the "polluter pays" principle. Following this principle neglects spatial variability in the availability, unit costs and effectiveness of nutrient abatement measures across regions and countries. Cost-and-effect models, however, suggest that there is considerable variation in the costs and capacity of the measures across coastal countries. Thus, significant cost savings can be achieved if the measures are implemented in locations where they are the most cost-effective. Modelling results show that the total

costs of implementing a country-wise scheme of the BSAP are approximately 500 million euros higher than the costs of implementing sub-basin targets alone.

2.3 Cost-benefit analysis

Cost-benefit analysis is a method to evaluate the desirability of public projects, investments and policies. It provides an economic criterion for ranking alternative projects. Cost-benefit analysis identifies all the major pros and cons of a proposed project or policy, quantifies them in monetary terms, and weighs them to ascertain if and by how much the overall benefits outweigh the costs.

Cost-benefit analysis is a routine process in many countries when evaluating large public projects, such as building roads and harbours, but it is also used and asked for in evaluating large-scale, transboundary environmental projects as well. The Stern review on climate change (Stern 2007), which estimates the societal costs of climate change, is probably the best-known environmental cost-benefit analysis in the literature.

The BalticSTERN cost-benefit analysis evaluated the long-term benefits and costs of reducing eutrophication in the Baltic Sea and took the view of a social planner looking at the sea and its catchment as a whole. The analysis was conducted by integrating catchment, marine and economic models.

The results of the analysis indicate that the overall benefits of implementing the BSAP (M€ 3600 - 4000 annually) clearly outweigh the costs (M€ 1400 - 2800 annually) provided that the measures to meet the country- and basin-wise load reduction targets are implemented cost-effectively. Accordingly, implementing the BSAP can be considered an economically sound transboundary project. Its positive impacts on the welfare of the citizens of the coastal countries clearly outweigh the total costs of additional nutrient abatement in the agricultural sector and improved wastewater treatment. In other words, the results indicate that the cost of inaction – not implementing the BSAP and thus maintaining the present level of water protection – would be significant.

The beneficiaries of improved water quality in the Baltic Sea are the citizens, industries and businesses (such as tourism) that enjoy and utilize the services and products the sea provides in all coastal countries. Their possibilities to enjoy a healthy marine environment with all ecosystem services intact would clearly be improved.

However, one challenge for the implementation of the BSAP is that the benefits and costs of nutrient abatement are unevenly distributed across different stakeholders, economic sectors, regions and countries. The aggregated benefits are highest in highly populated regions, while the aggregated costs are highest in regions that drain into the sub-basins that are presently in the most alarming ecological state - in particular the Baltic Proper - and thus are subject to the most ambitious nutrient abatement targets.

The costs of nutrient abatement are covered by citizens in the form of increased water charges (investments in waste water capacity), by farmers (uncompensated agricultural measures) and by tax payers (environmental support payments). International financial instruments, such as the Cohesion and Structural Funds of the EU, and joint international projects involving private and public actors as financers have been another way to share the costs of nutrient abatement between different stakeholders.

2.4 Interpretations and caveats

While we can anticipate with some confidence the future consequences of our present day actions through scenarios, simulations and projections, the future is ultimately uncertain. Thus, the results of a cost-benefit analysis, like the results of any other quantitative study that looks into the future, must be interpreted with caution.

The most serious omission of our cost-benefit analysis is probably that it does not quantify the positive impacts of nutrient abatement on the provision of ecosystem services and benefits in inland waters. Nutrient abatements conducted in upstream regions of the catchment area reduce nutrient loads to the Baltic, but may have an even more pronounced impact on the water quality of

lakes and rivers. In addition, measures such as wetland construction may improve the biodiversity of agricultural lands and the scenic value of landscapes. In this light, the benefit estimate is only a partial representation of the true societal benefits of nutrient abatement.

Costs of nutrient abatement may be overestimated or underestimated depending on the relative importance of different caveats and uncertainties. Overestimation may result from the coarse spatial resolution of the applied model, the limited number of measures examined and the exclusion of possible future innovations and technological developments.

The cost of cost-effective nutrient abatement could be reduced by including more optional measures and developing nutrient abatement plans tailored to each catchment or sub-catchment. There is also room for technological innovations that would provide more effective nutrient reductions in wastewater treatment, agriculture, forestry, industries, shipping and other relevant sectors causing nutrient emissions.

On the other hand, transaction costs, including the administrative costs of planning and enforcing the implementation of agri-environmental policies, were omitted. On balance, it is likely that the costs are overestimated rather than underestimated.

To summarize, the true welfare gains to be expected from future investments in water protection are likely to be clearly higher than indicated by the numbers presented in this report.

3 RESEARCH RESULTS AS POLICY SUPPORT

The BSAP is a major international policy guiding water protection in the Baltic Sea. The plan for nutrient load reductions is an iterative process and is periodically revised based on the latest advances and research information on the need for new actions. Economic research, such as the results from the BalticSTERN research network presented here, can help assist HELCOM in identifying economically efficient ways to improve the state of the Baltic as a unique and jointly managed natural resource.

Economic models, if developed at adequately detailed spatial resolution and with reliable data, may help to identify cost-effective combinations of nutrient abatement measures between sectors and locations. Socio-economic research on the present or desired uses of the Baltic Sea and its importance to people's welfare can, together with ecological criteria, be used to set the future target levels for water protection.

The EU Marine Strategy Framework Directive poses a serious challenge for socio-economic research on marine areas by requiring member states to conduct cost-effectiveness and cost-benefit analyses related to the programmes of measures aimed at improving the state of the European regional seas. The integrated assessment framework developed within BalticSTERN for analysing the costs and benefits of nutrient abatement provides one tool to address one specific Good Environmental Status (GES) descriptor, eutrophication, but also addresses other descriptors that depend on the eutrophication status of the Sea. The framework can be adjusted to and applied in relevant parts of other European regional seas where eutrophication is considered an environmental problem. It might also be able to accommodate other GES descriptors provided that research information and models describing the causal interactions between the marine ecosystem and the society are in place.

The EU Water Framework Directive is another major international water policy guiding the management of inland and coastal waters and nutrient abatement in EU countries. The Water Code of the Russian Federation is an equivalent policy in Russia. The cost-and-effect models developed in BalticSTERN may also serve as tools when evaluating and revising the management plans for river basins.

4 MAIN INSIGHTS

Economic research on water resource management can serve as a salient tool when planning, designing and evaluating international and national water management plans and policies. In this regard, the three most important conclusions from BalticSTERN's research are:

1. The overall ambition of the Baltic Sea Action Plan to reduce eutrophication in the sea is economically viable. The expected societal benefits from improved water quality clearly outweigh the total costs of nutrient abatement.

2. The citizens in the Baltic Sea region attach considerable value to improved health for the sea. More than 80 per cent of the people living in the area have spent leisure time at or on the sea. Many of them are deeply concerned about the Baltic.

3. Collaboration across coastal countries and sectors and acknowledging spatial variability in the costs and effectiveness of nutrient abatement are the keys to cost-effective nutrient abatement.

The BalticSTERN study *BalticSurvey* is the first coordinated survey of comparable information in all Baltic Sea countries regarding public use of the Baltic Sea and people's attitudes towards the marine environment and responsibilities for improving it. The research was carried out between April and June 2010 in all nine Baltic Sea countries and included over 9000 interviews.

In *BalticSUN* people in all nine coastal countries were asked for the first time how much they would be willing to pay for a healthier Baltic. More than 10 000 people were interviewed for the survey on the Internet or in face-to-face interviews, making it one of the most extensive international valuation studies to date. The interviews were conducted simultaneously in each country in the autumn of 2011.

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