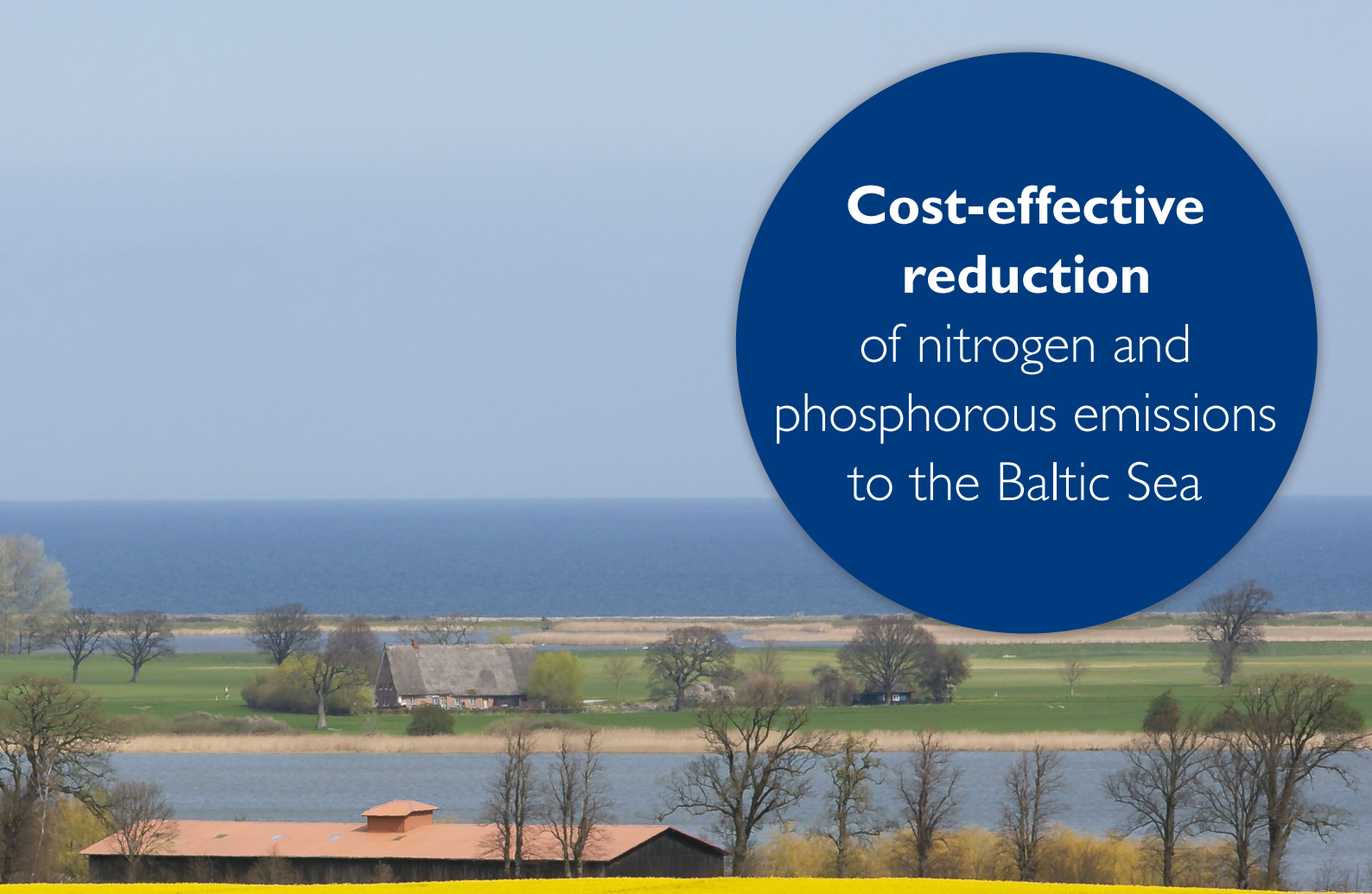


Cost-effective reduction of nitrogen and phosphorous emissions to the Baltic Sea

Eutrophication is destroying the unique Baltic Sea ecosystem. To improve water quality, emissions of the nutrients nitrogen and phosphorous must be radically reduced. As considerable costs are associated with reducing nutrient emissions while resources are scarce, it is crucial to consider cost effectiveness when designing nutrient reduction targets. Finding the solution that gives the most nutrient abatement to the least cost for society is also likely to increase the political feasibility of restoring the sea to a healthy state.

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

BONUS TOOLS2SEA | Policy tools for Baltic Sea nutrient management

Our policy briefs are summaries of scientific knowledge produced in TOOLS2SEA, connected to current management and policy actions concerning the Baltic Sea. The briefs engage in and respond to important issues that support long-term sustainability of ecosystem goods and services of the Baltic Sea.

The state of the Baltic Sea

The Baltic Sea is one of the few brackish seas in the world, creating a unique marine environment. However, human activity has created environmental problems, which threaten the functioning of its ecosystem. One of the more pressing environmental issues is eutrophication due to past and continued excessive inputs of nutrients. Today, almost the entire sea is classified as eutrophied.

Reduction targets

The nine littoral countries of the Baltic Sea have agreed through the intergovernmental body the Helsinki Commission (HELCOM) to restore the sea to good environmental status by 2021 through the Baltic Sea Action Plan (BSAP). The BSAP is a concrete tool to improve water quality and includes specific nutrient reduction targets for the seven Baltic Sea basins. The reduction targets are ambitious and based on what science estimates is needed to restore the ecosystem. Targets are set for each country per basin. When designing the targets, cost-effectiveness was not one of the parameters taken into consideration.

Why cost effectiveness matters

An action is cost effective when it gives the most effect to the least cost. In relation to the BSAP reduction targets, the cost-effective solution is the cheapest way to reach the agreed upon targets. Cost effectiveness is important because society's resources are limited. Society constantly needs to prioritise between different sectors and justify spending of taxpayers' money. Spending on inefficient policy measures can be seen as irresponsible and will reduce the chances of reaching the reduction targets since money can run out before the targets are reached. Hence, it is of both economic and political relevance to investigate how nutrient abatement can be achieved in the most cost-effective way.

Using models to estimate costs

Costs of achieving nutrient reduction targets are generally analysed using cost-minimisation models. The models combine biological and economic data to find the least costly combination of abatement measures that achieves a reduction target. The estimated total cost depends on many factors such as the data used, abatement measures included in the model, reduction target(s), and design of the model. It is important to keep in mind that the model simulations do not evaluate measures actually implemented, but provide cost estimates for potential allocations of measures. Although an estimate can never provide an exact answer to what abatement will actually cost, it is a qualified assessment based on the knowledge and data that is presently available. The development of this literature has been driven by the policy goals of the HELCOM countries. The launch of the BSAP in 2007 and its update in 2013 have inspired a large number of studies of what it would cost to achieve them. We have reviewed results from all Baltic-wide model-based cost-effectiveness studies and summarise their main results below.

Total costs of reducing nutrient emissions to the Baltic Sea

We have identified 16 studies, published between 1997 and 2018, that use model simulations to estimate the costs of achieving specific nutrient reduction targets for the Baltic Sea. Due to the many differences between studies, it is difficult to compare cost estimates, which also vary greatly. For example, cost estimates of achieving the 2013 BSAP reduction targets range from 2000 to 4000 million Euros per year. However, it is clear that the estimated costs of achieving the BSAP targets have decreased over time. This has mainly two explanations:

1. Historical nutrient abatement reduces the present abatement need. Studies using the latest available data on nutrient loads therefore estimate lower total abatement costs.

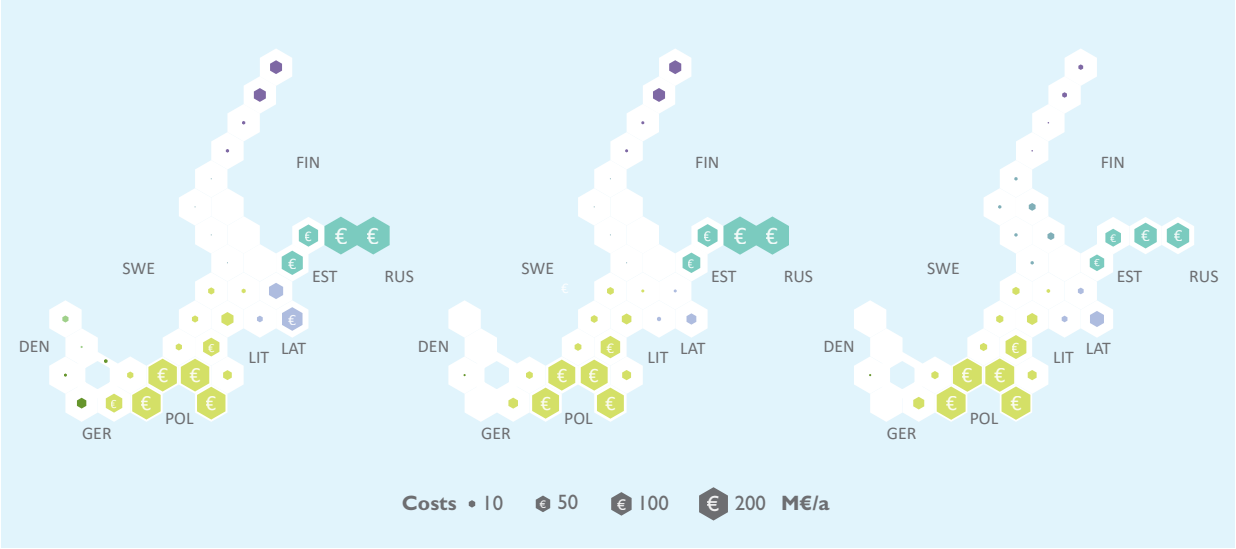
2. Achieving the updated BSAP targets from 2013 is generally cheaper than achieving the original BSAP targets from 2007. This is primarily because the updated targets no longer require costly nitrogen abatement in the Danish Straits and Kattegat.

The costs of reducing nutrient emissions to the Baltic Sea for three different interpretations of BSAP 2013

Country & basin targets

Basin targets only

Flexible basin targets



Current BSAP 2013 targets forces countries to implement many cost-ineffective abatement measures.

Costs would decrease, if countries discharging into the same basin would cooperate and choose abatement measures with the lowest marginal costs.

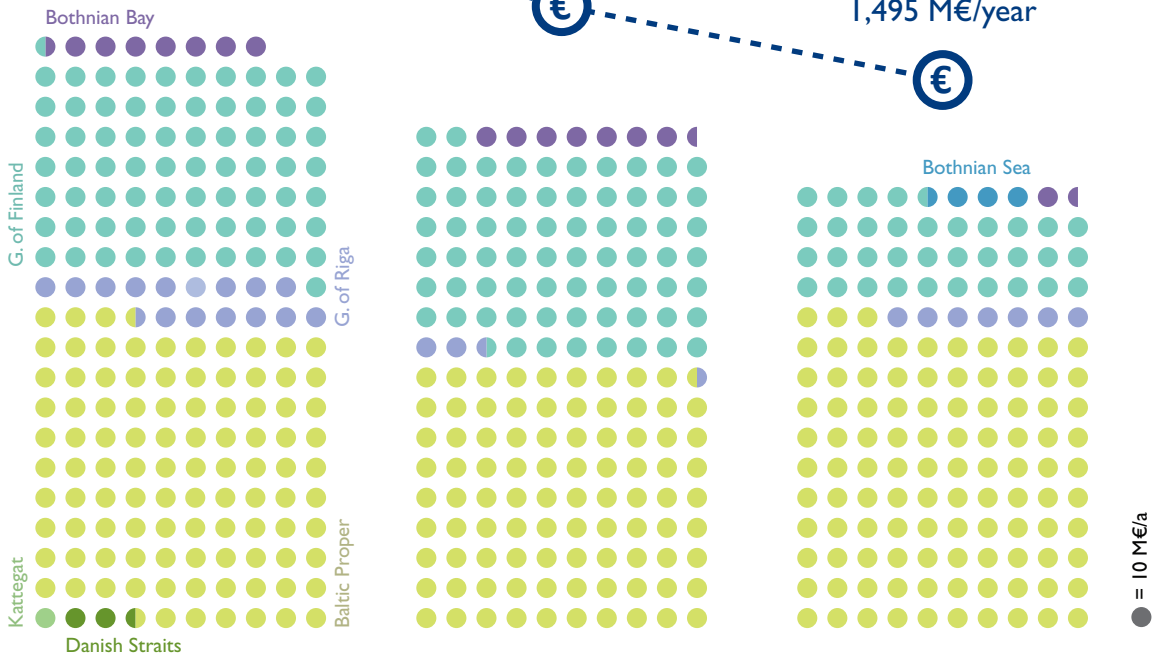
Cost-efficitiveness would further improve, if abatement could be targeted to any basin.

Also, more flexible arrangements would allow the selection of measures that avoid unnecessarily costly N or P reductions.

1,978 M€/year

1,696 M€/year

1,495 M€/year



The number of abatement measures included in the cost-minimisation models affects outcomes and cost estimates. The fewer the measures included, the higher the total cost of abatement is likely to be higher as there is a greater risk that expensive measures must be used to achieve the target. It is possible that the estimated cost of abatement can be reduced if more abatement measures were included in the simulation models, particularly improved manure management and buffer zones.

Reduction targets allowing for flexible abatement save money

Rules specifying how the reduction targets should be achieved has a large impact on total costs. If the rules are restrictive in the sense that a particular country must reduce nutrient emissions by a particular amount to a particular basin, costs will be unconditionally higher than necessary. If more flexible abatement strategies are allowed, i.e., if countries were to cooperate and find the least-costly abatement strategy for a particular basin, the same overall reduction can be achieved at substantially lower cost. In short, nutrient abatement that is expensive and has little effect on water quality can be avoided. When targets are designed in a restrictive way, avoiding these ineffective measures may be impossible. Increased flexibility and better coordination of abatement increases the possibility to use low-cost abatement measures. The current BSAP reduction targets are not cost effective as the same overall nutrient reduction could be achieved at lower cost if more flexible abatement strategies were used. The literature shows that as much as 500 million Euros can be saved annually if targets allowed for more flexible abatement.

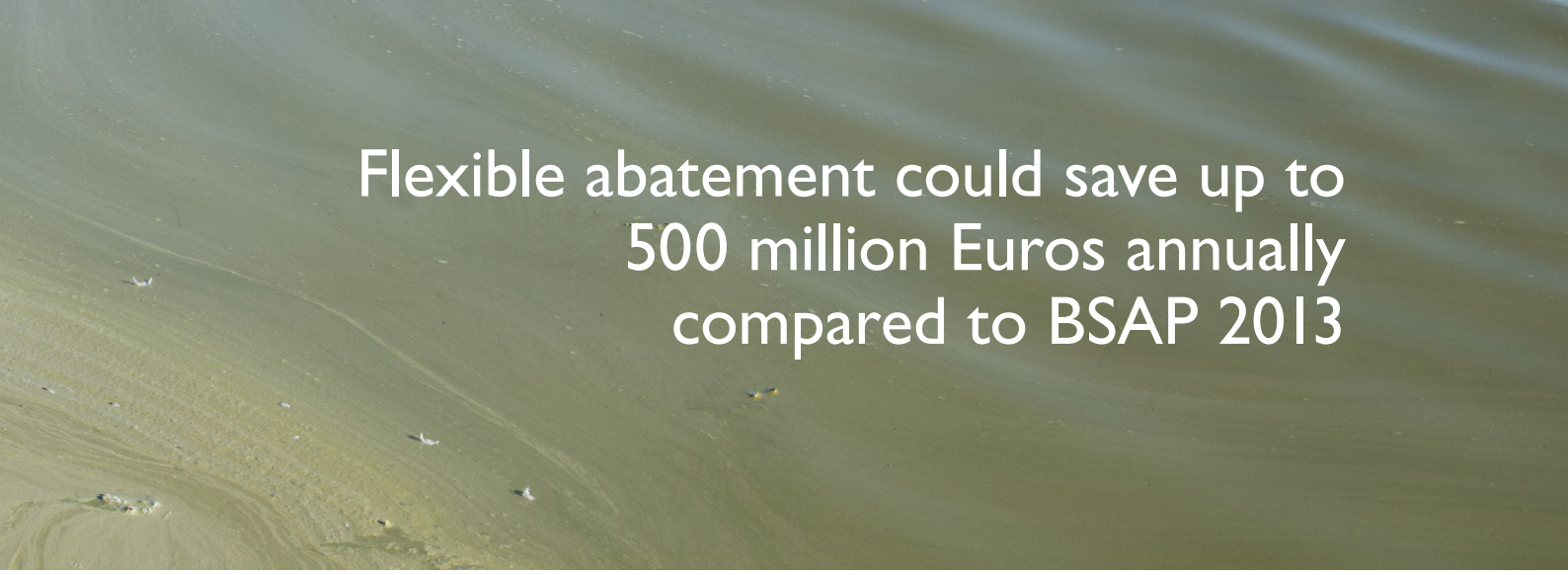
Nutrient abatement measures

The Baltic-wide model-based literature aims at finding the combination of abatement measures that achieves a reduction target to the least cost. Hence, the literature identifies abatement measures that are considered especially important for cost-effective nutrient abatement among the measures included in the simulation models. The following abatement measures are included in all reviewed studies: wastewater treatment, reductions in livestock, cultivation of catch crops, reduction in fertilizer application, and construction of wetlands. Some studies include one or more additional measures, including: changing the spreading time of manure from autumn to spring, cultivation of energy forests, cultivation of grass, buffer zone, construction of sedimentation ponds, catalysts on cars (or ships or trucks), installation of de-NOx units at power plants, private sewers, P-free detergent, and mussel farming.

Cost-effective nitrogen abatement

When it comes to nitrogen abatement, the literature mainly recommends agricultural measures. In particular, the following measures are deemed as cost-effective nitrogen abatement measures:

- construction of wetlands
- reduction of nitrogen fertilisation
- cultivation of catch crops.



Flexible abatement could save up to 500 million Euros annually compared to BSAP 2013

Reduction of livestock is, on the other hand, an expensive measure that is recommended for neither nitrogen nor phosphorous abatement. Note that the review of cost-effective abatement measures only includes the above listed measures used in the cost-minimisation models. Hence, there may be other cost-effective measures that are not included in this review, such as improvements in manure storage facilities.

Cost-effective phosphorous abatement

The cost-effectiveness studies generally include relatively few phosphorous abatement measures. Given this limitation, only improved urban wastewater treatment is found to be a cost-effective measure for phosphorous abatement (i.e., in areas where investments have not already been made). At the same time, phosphorous abatement dominates the model solutions, as it tends to be more difficult to reach the phosphorous targets than the nitrogen targets for the Baltic Sea. There are even examples of studies where the model solutions do not reach the phosphorous targets in all basins. The importance of phosphorous reduction is therefore emphasised in several studies. Important is also that phosphorous reduction may also reduce nitrogen concentrations, meaning that even if one focuses on phosphorous reduction, nitrogen would be reduced simultaneously. This suggests that investment in relatively cheap abatement measures focusing on phosphorous reduction but that also reduce nitrogen is desirable. Identifying cost-effective measures not presently included in the model studies due to data constraints, phosphorous measures in particular, is an important task for future research.

Recommendations

- Cost effectiveness should be the guiding principle when designing nutrient abatement plans.
- Coordination of abatement among countries and hence flexibility in spatially allocating measures is essential to achieve Baltic Sea reduction targets cost-effectively.
- Additional measures that focus on phosphorus abatement should be included in cost-minimisation models.
- Improve the data on costs and effects of abatement measures in order to increase the precision of cost-minimisation models.
- Prioritize cost-effective abatement measures such as wastewater treatment, construction of wetlands, cultivation of catch crops, and reduction of nitrogen fertilisation.

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BONUS TOOLS2SEA is a synthesis project of the BONUS research program.

It will summarize research results and insights from a broader array of studies, projects and publications available in the international literature, as well as in national languages of the Baltic Sea region.

It will synthesize potentials and practical experiences with specific policy instruments designated for nutrient management, while placing and analysing these in context of the domestic and regional governance institutions in place in Baltic Sea countries and beyond.

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Cost-effective reduction of nitrogen and phosphorous to the Baltic Sea

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