

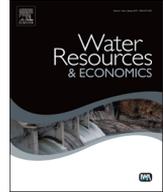


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## Hydro-economic modelling of cost-effective transboundary water quality management in the Baltic Sea



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### ABSTRACT

Helcom's recently revised Baltic Sea Action Plan (BSAP) aims to reduce eutrophication in the Baltic Sea by reducing nutrient loads from all discharging drainage basins. The BALTICOST costminimisation, model, featuring abatement cost and effect functions which utilise spatial data down to,  $10 \times 10 \text{ km}^2$  grid cell resolution, is used to identify a cost-effective distribution of nutrient abatement, measures between drainage basins whilst attempting to achieve specified nutrient load reductions for, separate Baltic Sea regions. Results indicate that the 2013 BSAP load reduction targets for nitrogen and phosphorus can be achieved in most Baltic Sea regions, except for phosphorus into the Baltic Proper, and the Gulf of Finland. The estimated minimum total cost of delivering these reductions is 4.17 billion, Euros annually, with substantial differences in the cost burden between countries and measures.

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Results are strongly influenced by differences in nutrient retention between drainage basins. Detailed, retention modelling and high spatial resolution source data are major novel features of this research.

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## 1. Introduction

Many national and international initiatives have been instituted to improve the quality of inland, coastal and marine waters like the EU Water Framework Directive (WFD) [19] and the EU Marine Strategy Framework Directive (MSFD) ([18]). HELCOM's recently revised Baltic Sea Action Plan (BSAP) [32,33] is a transnational plan to stimulate goal-oriented co-operation across a common sea region to deliver ambitious targets for restoring good ecological status to the shared Baltic marine environment by 2021. In 2013 HELCOM issued a revised set of BSAP nutrient load reduction targets, based on a new and more complete emission load dataset, an improved modelling approach and revised harmonised eutrophication status targets [33]. The revised 2013 BSAP nutrient load reduction targets (approximately 118,000 and 12,000 t for nitrogen (N) and phosphorus (P), respectively, distributed among 7 separate sea regions within the Baltic) were lower than the originals set in 2007 [32] (135,000 and 15,250 t for N and P, respectively) (Table 1, Columns A and B). Their distribution also changed considerably, with substantial decreases in N reduction targets for the Danish Straits and the Kattegat, decreases in P reduction targets for the Baltic Proper and the Gulf of Riga, but an increase in the P reduction target for the Gulf of Finland (Table 1, Columns C and D).

Given the considerable costs which will likely be incurred in delivering these load reductions (see e.g. NEFCO [36], Elofsson [17]), identifying a cost-effective distribution of nutrient abatement measures between Baltic littoral countries is of clear political relevance. A cost-effectiveness analysis

**Table 1**

HELCOM'S original 2007 BSAP load reduction targets (Columns A and B), [33] revision of the BSAP load reduction targets for N and P (Columns C and D), maximum N and P load reduction targets deliverable within the capacity restriction of abatement measures modelled in BALTCOST (Columns E and F), and N and P load reductions actually delivered by the lowest cost combination of drainage basin-specific abatement measures which satisfy the load reduction targets of Columns C and D as completely as possible (Columns G and H).

Sea region ID	A 2007 BSAP N load reduction target (t)	B 2007 BSAP P load reduction target (t)	C 2013 BSAP N load reduction target (t)	D 2013 BSAP P load reduction target (t)	E Maximum N load reduction achievable by BALTCOST (t)	F Maximum P load reduction achievable by BALTCOST (t)	G N load reduction achieved given Column C target (tonnes) [% of BSAP target]	H P load reduction achieved given Column D target (tonnes) [% of BSAP target]
BB	0	0	0	0	32842	295	0	0
BS	0	0	0	0	21804	332	0	0
BP	94000	12500	98920	10959	251581	9294 [85percent] <sup>a</sup>	130152 [132]	9294 [85] <sup>a</sup>
GF	6000	2000	14451	3908	53706	2290 [59percent] <sup>a</sup>	36103 [250]	2290 [59] <sup>a</sup>
GR	0	750	0	307	56255	827	1449 <sup>b</sup>	308 [100]
DS	15000	0	0	0	15953	405	0	0
KT	20000	0	4760	0	29325	679	4761 [100]	0
Total	135000	15250	118131	15174	461466	14115	214131	12503

<sup>a</sup> Denotes percentage of BSAP target when maximum achievable load reduction is lower than the BSAP target.

<sup>b</sup> Denotes nutrient reduction delivered against a load reduction target of 0 t, as a consequence of attempting to achieve a reduction target for the other nutrient.

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