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THE BALTIC DRAINAGE BASIN REPORT:

SUMMARY FINAL REPORT

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I. OBJECTIVES

The overall objective of this interdisciplinary project was to identify the significant environmental pressures that have been changing the state of the Baltic sea and to analyse appropriate (efficient and environmentally effective) response options.

The overall objective was decomposed into six interrelated intermediate goals:

a) A quantification of the regional (i.e. Baltic Sea and linked coastal regions and drainage basins) resource system and carrying capacity. The aim was to provide as comprehensive and rigorous a profile of the Baltic ecological resource base as was feasible, and to further relate this resource inventory to socio-economic activities, pressures and trends.

b) A quantification of the nutrient loading trends for the Baltic region (subdivided into individual drainage basin areas) which have led to changes in the trophic state of the Baltic Sea and its sub-systems.

c) To develop a model for predicting the concentration of nutrients in the different drainage basin areas.

d) To estimate the costs of various strategies designed to reduce the nutrient loading of the Baltic Sea; and in particular to try to identify cost-effective nutrient abatement options.

e) To explore the feasibility of estimating in monetary terms the social benefits of nutrient reduction strategies. In particular, to deploy household production function, travel cost, hedonic pricing and contingent valuation methods in a small number of case-study contexts. In addition, the problem of benefit estimates transfer and aggregation was explored.

f) To simulate basin-wide net benefit outcomes and investigate their institutional implications.

II. METHODOLOGY

The changes that the Baltic Sea and its surrounding coastal zone have experienced since the 1950s are an example of the much more extensive Global Environmental Change (GEC) Process that has been gathering pace over roughly the same time period. The research undertaken has therefore been set in an analytical framework appropriate for an investigation of GEC phenomena. The GEC process is a complex flux of factors, the impacts of which can manifest themselves at a number of different spatial and temporal scales. It is, however, possible to identify a group of interrelated socio-economic trends and pressures which both contribute significantly to the Baltic's environmental change impacts, as well as to an increasing degree of environmental risk to the marine ecosystem and the surrounding drainage basins' biophysical and socio-economic systems. We have therefore analysed the problems of the Baltic region in terms of a 'pressure-state-response' (P-S-R) model.

An increasing degree of environmental impact pressure has been felt in the Baltic region as a result of the following socio-economic drivers:

- - population growth;
- - increasing rate of urbanisation;
- - increasing industrialisation and intensification of agriculture;
- - increasing emphasis on economic growth maximisation policy;
- - increasing rate of altitudinal and lifestyle changes across all sectors of different economies and societies.

The result has been that the Baltic Sea and coastal zone resources (including the waste assimilative capacity) have come under severe pressure from a range of, often competing, usage demands. In this research particular attention was paid to nutrient (nitrogen and phosphorus) pollution of the Baltic Sea and its consequences. Evaluating the importance (in human welfare terms) of the various environmental impacts requires that their effects be measured in biophysical and then in monetary terms. This gives some measure of the state of the Baltic environment and the importance of the environmental degradation that has taken place. Finally, the research sought to identify priorities for action, causes of the problem and cost-effective policy instruments for correction.

Given the interdisciplinary nature of the research question and contributing research teams there was no further overarching research method, beyond the P-S-R model and an emphasis on the use of quantitative methods. Different specific research methods have been deployed within the sub-projects related to the intermediate study goals (a to f) outlined in section III. Sub-project (a) has utilised a Geographical Information System (GIS) in order to produce baseline data, and to assist with "appropriate ecosystem area analysis" which has sought to quantify the "ecological footprint" relating to urban areas and other intensive land use activities. Sub-projects (b) and (c) have required the further development of models from systems ecology and in particular nutrient budget and transport models. Sub-projects (d) and (e) have relied on standard economic cost analysis, as well as on market and non-market monetary valuation methods and techniques. These economic costs and value estimates have then been combined together in an economic cost-benefit assessment model in order to forecast potential net benefits from basin-wide nutrient abatement strategies.

III. MAIN RESULTS

The research team believed that it demonstrated that it was possible to conduct an extensive interdisciplinary research project that has generated a range of important and policy-relevant results. One novel feature of the project was the combination of natural science models and economic cost-benefit models which have allowed the investigation of a number of realistic environmental management response options. The P-S-R analytical framework proved to be a very appropriate approach for interdisciplinary research teams.

The primary achievement of the research was not so much in terms of theoretical advances (in the science or the social science of the project), but in terms of significant empirical findings. These findings underpin a more environmentally effective and economically efficient future Baltic resources conservation strategy. The analysis supported the proposition that such a marine and coastal zone management strategy must be conducted on a Baltic basin-wide scale and in an integrated fashion. It was possible to aggregate the seven sub-drainage basin areas into three meaningful general drainage basins - Bothnian Bay, Bothnian Sea and the Baltic proper - at least in the context of nutrient (nitrogen (N) and phosphorus (P) flows) loading, transport and environmental impacts -

Environmental Pressure

A great deal of new information on the Baltic region's ecological support systems and land use and population distribution patterns has been generated by this project, and organised in a GIS system. The aim was to gain a better insight into the region-wide environmental pressures that have been building up over time, and to relate these pressures to the capacity of the Baltic's ecosystems to respond to such stress and shock, i.e. system resilience. In this context use was made of "appropriated ecosystem area (AEA)" analysis, i.e. an estimation of the amount of land and water area required to support a region for a given population and level of resource consumption - the so-called "ecological footprint".

A comparison of regional AEAs and currently available region resource bases might highlight potentially unsustainable resource consumption trends. Thus the results indicated that the current level of resource consumption generated by the 85 million inhabitants of the Baltic region is well within the supply capacity of the region's agricultural and forestry systems, but not the marine system. Baltic region seafood demand requires an appropriate area six to seven times the area of the Baltic Sea (9% of the global shelf sea area).

These calculations do not, however, represent precise estimates of regional carrying capacity. They are static measures based on current levels of technology and current cost/price conditions. They do nevertheless provide some indication of the pressure that growing socio-economic systems exert on the underpinning ecological support systems. In particular, waste assimilation services provided by the environment are a cause for concern in the Baltic and elsewhere.

Good N and P load estimates were calculated for the three drainage basin areas. The indications were that the overall load entering the Baltic has not changed greatly over the last 20 to 25 years. The major increase in N and P inputs into the Baltic system occurred during the 1950s and 1960s. Only atmospheric nitrogen inputs continued to increase (because of the expansion of intensive livestock farming regions and road traffic volumes) through the 1980s.

That part of the drainage basin within the territory of Poland was found to be a key area, both in terms of nutrient loading and reduction strategies. This area contains some 45% of the population of the entire drainage basin and around 40% of intensive arable and intensive livestock areas.

Overall the Baltic region has also suffered a major loss of wetland ecosystems. Wetlands now cover only about eight percent of the drainage basin and are most extensive in the Northern regions. Wetlands are capable of providing effective nutrient sinks or traps and their existing distribution pattern has important pollution abatement policy relevance. The remaining extensive wetland areas (mostly in the Northern Baltic regions) are remote from major centres of population and/or intensive agriculture. Wetland creation and/or restoration in the more Southern regions is therefore a significant potential pollution abatement option.

Baltic Environmental State and Response Measures

This research project has allowed the further development of a model which is capable of providing good predictions of the concentrations of N and P in the three major drainage basins areas of the Baltic. This modelling indicates that loads of N and P into the Baltic basin have a differential environmental impact on the Baltic sea, depending on their spatial location. The Northern Baltic areas still possess effective N and P traps (e.g. wetlands) and their inputs have a relatively small effect on the ambient quality status of the Baltic Sea because of limited transportation into the Baltic proper. The opposite is the case for the Southern Baltic areas.

Analysis in the Gulf of Riga area has shown that a policy of regulating just one nutrient in one area may well make eutrophication problems worse elsewhere in the wider basin area. It is also the case that there is a significant ‘soil nutrient trap’ effect present, such that a policy directed at nutrient load reduction through reduced agricultural fertiliser usage will not have any noticeable effect on riverine nutrient loadings into the Baltic sea for between 5 and 15 years.

There has been a tendency for policy-makers and the public to focus most of their attention on nitrogen loads and impacts in the Baltic. Nitrogen inputs reduction has become a prime policy target because of the links to blue/green algae episodes and related public perceptions and concerns. In general, nitrogen inputs are more difficult and costly to reduce, but once a reduction has been achieved the time lag before an ambient state change is experienced is relatively short (up to 10 years). Phosphorus inputs, on the other hand, can be reduced more effectively and cheaply but there is a long time lag before environmental improvement occurs (up to 25 years). Some 13 N-reduction measures and 8 P-reduction measures were analysed in economic cost terms in the research project.

The simultaneous regulation of both N and P inputs is both more environmentally effective and more cost-effective than single inputs regulatory measures. It is around ten times more expensive to reduce nitrogen inputs (because of their more diffuse sources across whole drainage basins) than it is to reduce phosphorus inputs (e.g. point sources at sewage treatment works) for the same percentage load reduction. The marginal costs of abating phosphorus inputs increase sharply at high levels of reduction, so it seems more cost-effective to concentrate abatement measures in areas with currently low sewage effluent treatment levels. If these areas are also located in the southern Baltic region (and therefore the effect of their nutrient loading on the quality of the Baltic proper is more pronounced) then they should be considered as top priority target areas for pollution control policy.
A concerted attempt was made to estimate the economic benefits of environmental improvements in the Baltic. Some fourteen individual pilot and full monetary valuation studies (using the contingent valuation and travel cost methods) were undertaken across three countries, Poland, Sweden and Lithuania. The studies in Poland and Lithuania represent, as far as we are aware, the first deployment of environmental benefits valuation methods in the context of ‘transition’ economies. Both use and non-use economic (willingness-to-pay) value estimates were derived for marine and coastal resources, Table 1 presents some basin-wide results based on the benefits transfer method i.e. mean WTP estimates for Sweden SEK 2100 pa and for Poland SEK 870 pa were ‘transfered’ to other developed and transition economies in the Baltic region in order to calculate an aggregate benefits estimate. The mean WTP estimates were derived from a similar questionnaire survey on Baltic Clean up policy which was administered in both Poland and Sweden. The clean up target illustrated in the survey was equivalent to the 50% N and P reduction target which was used to determine the cost-effective pollution abatement package of measures.

Basin Wide Benefit Estimates

Country	Annual WTP per person (SEK)	National WTP[a] year 1[b] (MSEK)	National WTP present value[c] (MSEK)	National WTP, present value per year (MSEK)
Transition economies				
Belarus	1,100	3,111	32,960	1,648
Czech Republic	1,046	1,174	12,440	622
Estonia	1,165	1,313	13,907	695
Latvia	778	1,502	15,916	796
Lithuania	502	1,314	13,922	696
Poland	870	22,742	240,924	12,046
Russia	901	6,515	69,016	3,451
Slovakia	728	113	1,201	60
Ukraine	847	1,086	11,510	575
Market economies				
Denmark	2,269	7,829	82,938	4,147
Finland	1,638	6,150	65,150	3,257
Germany	2,000	4,861	51,497	2,575
Norway	2,204	56	591	30
Sweden	2,100	13,925	147,525	7,376
TOTAL		71,692	759,496	37,975

[a] For the transition economies, the Polish WTP estimate of SEK 870 was multiplied by thr ratio between each country's GNP per capita and Poland's GNP per capita. For the market economies, the Swedish WTP estimate of fSEK 2100 and Sweden's GNP per capita were used correspondingly. The total national economic value figures were found by multiplying the WTP estimates per person by the number of adults of the Polish and the Swedish population respectively. The WTP estimates are those given in section 7.4.2, i.e. $116 and 613 for Poland and Sweden respectively. The Polish estimates are assumed to be representative for the nine transition economies of the Baltic drainage basin. The Polish population constitutes 59.8% of the basin population of these nine countries, which gives an aggregate factor of 1.672. The Swedish estimates are used for the remaining five countries. The Swedish population constitutes 40.1% of the basin population of these five countries, which gives an aggregation factor of 2.494. See Sweitzer et al. (1994) for detailed population data.

[b] The annual WTP estimates per person multiplied by the (adult) population in the Baltic drainage basin part of each country.

[c] Time horizon: 20 years (specified in the CVM studies). Discount rate: 7 per cent.

The benefits transfer method, together with an aggregation procedure were used to quantify basin-wide benefits relating to environmental improvement. Table 2 brings together both the costs of pollution abatement and related economic benefit estimates in a cost-benefit analysis framework. It is clear that there are net benefits available to a number of Baltic countries. While the economic benefit calculations are far from precise point estimates they are indicative of the range or order of magnitude of clean-up benefits in the Baltic i.e. annual aggregate net benefit of some SEK 4,000 million.

Costs and benefits from reducing the nutrient load to the Baltic Sea by 50%, millions of SEK/year

Country	Reduction in %	Costs	Benefits
Sweden	42	5,300	7,376
Finland	52	2,838	3,357
Denmark	51	2,962	4,147
Germany	39	4,010	2,575
Poland	63	9,600	12,046
Russia	44	586	3,451
Estonia	55	1,529	695
Latvia	56	1,799	796
Lithuania	55	2,446	35,039
Total	50	31,070	35,039

Poland faces the largest cost burden because of its relatively high pollution loading contribution and the modest levels of efficient treatment that it currently has in place.

IV. SCIENTIFIC INTEREST AND POLICY RELEVANCE

There is considerable merit in the adoption of a basin-wide approach to pollution abatement policy in the Baltic and therefore in the implementation of an integrated coastal zone management strategy. It is clear that the ambient quality of the Baltic Sea is controlled by the coevolution of both biophysical and socio-economic systems throughout the macro-scale drainage basin. Land use change and population increase trends (especially since the 1950s) have served to markedly increase the environmental pressure exerted on the Baltic's natural resource base and carrying capacity. The waste assimilation function provided by the Baltic's ecosystems is under the most intense relative pressure.

Despite the pioneering nature (i.e. in the 'transition' economies) of some of the economic benefits research, there seems to be little doubt that a pollution abatement strategy roughly equivalent to fifty percent nutrients reduction target adopted by the Helsinki Commission would generate significant positive net economic benefits (benefits minus costs). Sweden, Denmark, Russia and Poland would all gain net welfare benefits from the implementation of such a policy. In fact these countries could potentially gain sufficient net benefits to be able to also pay for clean-up measures in the Baltic Republics and still remain better off than they were prior to the implementation of such a pollution abatement policy. The research into the monetary valuation of environmental benefits also indicated that the public's and experts' perception of environmental quality and quality decline are not necessarily synonymous.

A policy of uniform pollution reduction targets is neither environmentally nor economically optimal. Rather what is required is a differentiated approach with abatement measures being concentration on nutrient loads entering the Baltic proper from surrounding southern sub-drainage basins. The northern sub-drainage basins possess quite effective nutrient traps and contribute a much smaller proportionate impact on the Baltic's environmental quality state. The countries within whose national jurisdiction these southern sub-basins lie are also the biggest net economic gains from the abatement strategy.

Although there are a range of feasible individual N-reduction and P-reduction measures available, our research indicates that the simultaneous reduction of both N and P loadings into the Baltic is more environmentally effective as well as cost-effective. The increased deployment of N-reduction measures within existing sewage effluent treatment works, combined with coastal wetland creation/restoration schemes would seem to be a particularly effective option set.

The marginal costs of nutrient reduction measures increase sharply towards the full works treatment end of the spectrum. This finding suggests that the greatest environmental and economic net benefits are to be gained by an abatement policy that is targeted on areas which lack treatment works on an acceptable standard, rather than on making further improvements to treatment facilities that already provide a relatively high standard of effluent treatment. This finding combined with our findings relating to the importance of the spatial location of nutrient loading, suggests that nutrient reduction measures in the Polish and Russian coastal zone areas would be more than proportionately effective.