Integrated Management of the Baltic Sea

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THE ECOSYSTEM

The Baltic Sea area is situated in Northern Europe and is surrounded by seven countries, clockwise: Sweden, Finland, the Soviet Union (USSR), Poland, German Democratic Republic (GDR), the Federal Republic of Germany (FRG) and Denmark (see figure 1).

The Baltic Sea, with a surface area of about 400.000 square kilometres and a volume of 21.000 cubic kilometres, is one of the largest brackish water areas in the world. It is shallow, with an average depth of 55 m and a maximum depth of 459 m. The Baltic Sea is a very peculiar ecosystem because of its relatively high brackishness and almost permanent stratification. The key to the peculiar character of the area is the extremely shallow, narrow Danish Straits which allow only a very slow water exchange between the Baltic and the North Sea. As a result, the water in the Baltic Sea has a long residence time, in the order of 35 to 40 years, leading to accumulation in water, sediments and biota of discharged pollutants. This is important because the Baltic Sea is one of the most severely polluted sea areas in the world and serious adverse effects of currently discharged pollutants into the ecosystem will be felt several generations from now.

The coastline, with an abundance of inlets, bays and fjords on the Northern side, has a length of 7.000 km. Thousands of small islands are situated in the area, but only a number of these are inhabited. The North-Western side of the Baltic has a rocky, fjord-like coastline, whereas ths South-Eastern side has a soft, sandy coast.

The water of the Baltic Sea is brackish with a variable salinity at the surface from about 15 g/l in the Belt Sea to about 3 g/l in the Bothnian Bay (compared with about 35 g/l in the oceans). The drainage area is about four times the water area (1.6 million square kilometres) and the average annual flow of riverwater into the Baltic is approximately 430 cubic kilometres, or about 2 % of the volume of the Baltic Sea.

The Northern part of the Baltic is covered with ice for 4 to 5 months of the year. The cold, stagnant and stratified basins in the Baltic proper act as traps for organic matter. In the lower water layers, which do not receive oxygen from the surface due to the stratification, decomposition of the organic material can lead to anoxic conditions, rendering these layers virtually life-less. The main source of oxygen for the deep waters of the Baltic Sea is the periodic - but irregular - inflow from the North Sea.

URBAN AREAS

Urban areas contribute approximately 25 % of the land based sources of nutrient inputs into the Baltic. Figure 2 presents an overview of the concentration of urban areas along the coast. In 1980 about 20 million people lived immediately adjacent to the Baltic Sea, about half in urban areas, of a total of 60 million inhabitants within the drainage basin. Cities such as Copenhagen, Leningrad and Warsaw (through the Vistula River) contribute significant amounts of pollution to the Baltic Sea.

During the '70s and '80s, ambitions have more and more shifted towards removal of nutrients to reduce or prevent eutrophication. Removal of nutrients requires at least a biological treatment system (secondary treatment) which removes organic material and, to some extent, nitrogen and phosphorous. The installation of biological treatment systems is expected to dominate the investments in municipal treatment systems around the Baltic Sea for a long period of time. Further reduction of phosphate concentrations in the effluent of waste water treatment plants (tertiary treatment) is currently being (or, has already been) undertaken at great cost in some countries. In Sweden, the share of municipal wastes in the total discharges of nitrogen and phosphorous to the sea has declined noticeably over the last several decades. In fact, most possible measures affecting the phosphorous concentration in municipal

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effluent have been taken in Sweden, and further reduction of phosphorous loads will have to approach other sources.

MINING AND INDUSTRY

Industrial activities in the countries around the Baltic Sea (see Figure 3) are largely based on the local availability of raw materials: ore, timber and phosphate rock. Related industrial activities, which are well developed in the countries around the Baltic area include: paper and pulp processing, mining, steel and metal manufacture and fertilizer production.

The **pulp and paper processing** is particularly strongly represented. The countries in the drainage basin are producing about 25 percent of the world production of pulp, paper and board. The pulp and paper industry in Sweden and in the USSR is mainly situated along the coast. In Finland and Poland the industry is located throughout the country. Pulp mills have earlier been a major source of mercury discharges and bleaching plants at pulp mills are by far the dominant source of organochlorine compounds in Sweden and Finland. The industry in Sweden and Finland is responsible for the major part of the pollutant load to the Baltic, as regards chlorinated organic compounds even though the industry generally uses the best available technology to reduce discharge of pollutants.

Mining and steel and metal manufacture activities are primarily undertaken in the west of Sweden and in the south of Poland near the border with Czechoslovakia. Some mining activities also take place in Finland (where the metallurgic industry is very well developed). Sweden is the largest producer of iron ore in the region: in 1986 20.490.000 tonnes was mined in Sweden. A lot of the iron ore is exported by sea to other European countries; the remainder is processed in Sweden into all kinds of steel products. A considerable amount of zinc is also mined in Sweden, and is used mainly in the domestic steel industry.

Poland is a major producer of copper ore at a global scale. In 1986, 29.581.000 ton was mined in the Lublin region. Lead and zinc ore are also mined. The iron ore deposits are virtually exhausted.

In Finland, iron ore and a small amount of zinc and silver are mined. The metallurgy industry in Finland accounts only for about 10 percent of the total manufactured output. It is, however, a major exporting sector.

Fertilizer production in Poland, Finland, Sweden and the USSR is a major component of the chemical industry in the region. The presence of phosphate rock in these countries has led to a specialisation in production of sulphuric acid. In the Baltic countries both nitrogenous and phosphate fertilizers are produced in large quantities. This activity has caused heavy discharges of phosphate and nitrogen salts and cadmium into the environment.

AGRICULTURE

Agriculture is important in all the countries around the Baltic Sea. The agricultural sector uses high levels of artificial fertilizers and produces more manure than can be comfortably handled locally. Growing concerns over eutrophication have placed agriculture at the top of the list of polluting activities in recent years. This also implies a shift in emphasis from point sources to non-point sources.

The most important emissions from agriculture are nutrients, which form a very significant component of the total nutrient emissions transported by the rivers into the Baltic.

THE INTERNATIONAL SITUATION

We share our surrounding sea areas with many other countries. Rivers and water sheds flowing into the Baltic are the dominating sources for inputs of pollutants to this area.

Sweden's part of the inputs of pollutants to the Baltic is comparatively small. This is due in part to our small population (8.5 million inhabitants) but also in part because we have carried out a lot of measures limiting discharges of pollutants in our country. The measures that we now are planning will thus have only small effects upon the situation in the open sea areas. In our own coastal areas the effects may be considerable, however.

An important part of the international work against the pollution of the Baltic is concentrated to the Helsinki Convention. In spring 1988, a major break-through in the work of this convention happened. Environmental ministers of all countries concerned took a joint decision to reduce the inputs of the most serious types of pollutents into the Baltic over a period of ten years

This agreement means that contracting parties undertake to use the best avaible technology to achieve a substantial reduction, of the order of 50 %, of the input to the sea area of stable organic substances which are toxic and liable to bioaccumulate, toxic metals and nutrients.

VARYING CONDITIONS

The marine areas surrounding Sweden differ from each other a great deal. Salinity varies sharply from the Bay of Bothnia's river-diluted water to the Skagerak's purely marine character. Different areas also have different levels of sensitivity to environmental effects. The retention time of the water varies from several decades for the Baltic to a few months for the Öresund. The time it takes for various pollutants to disappear ("turnover time") depends on the water's own retention time, as well as factors such as rate of degradation, sedimentation, evaporation etc.

Model studies from the Baltic show that there is a very long time lapse between the cessation of the load input and the beginning of a measurable decrease in concentrations in the sea. This delay is due to the fact that land, rivers, lakes and seas contain large quantities of both natural substances (eg nutrients and metals) and non-natural substances (stable organic substances). It takes a long time before a new equilibrium between input, concentrations and disappearance is achieved. Even if all countries bordering the Baltic were to reduce their discharges by 50 percent tomorrow, it would take at least 10 to 15 years before a measurable reduction in concentrations occurred. Remedial measures are thus a matter of urgency.

The input of pollutants varies from one part of the marine environment to another. The northern Swedish coast, dominated by the pulp and paper industry, suffers from a different type of pollution load as compared with the southern Swedish coast. The Bay of Bothnia is relatively nutrient-poor and particularly sensitive to an increase in toxic substances and metals.

Eutrophication is the most pronounced problem in the Baltic proper, although the markedly higher concentrations of toxic organic substances constitute an ever greater threat to the environment in the long term. Pollution input comes from several countries around the Baltic, particularly via large discharges of inadequately treated waste water from cities and industrial plants in the eastern European drainage basin. As a result of the relatively severe eutrophication of the Baltic, the toxic substances are diluted in a large biomass. This means that the programme of remedial measures to reduce the nutrient input must be combined with an effective programme of measures to deal with the toxic substances.

ENVIRONMENTAL GOALS

Overall long-term goals for Swedish and bordering marine areas should be that it should be possible in these areas to:

- maintain vigorous, balanced populations of naturally occurring species;
- achieve a natural zoning of flora and fauna;

- prevent the occurrence of sea bottom areas suffering from harmful oxygen deficiency;
- carry on regular, long-term fishing;
- consume fish and shellfish from the areas without risk to health
- ensure that pollution of and in the water does not constitute a restriction of the recreational value of the marine areas.

Eutrophication of the sea and the input of stable organic substances is regarded as being without doubt the major threat to the marine environment over the next few decades. (See below).

Of the metals, it is primarily cadmium and mercury, and in some areas zinc and arsenic, which constitute a continuing threat to the marine environment, even if such threat is not of the same overall magnitude as that posed by nutrients and stable organic substances. More progress has been made in Sweden in respect of measures to combat discharges and emissions of metals than with regard to stable organic substances. The overall strategy for remedial measures to combat toxic metals is therefore to follow the programme of measures which has already started to be implemented.

In the case of oil pollution, it is also mainly a question of completing the programme of measures which has been initiated, the emphasis being on international cooperation. Oil entering the marine environment via rivers and atmospheric deposition must continue to be the subject of concern. As far as the Baltic is concerned, a further serious threat may be posed by future offshore extraction. If such drilling does begin, then extremely extensive environmental protection measures will be necessary. Recommendations in this direction have been adopted by the Helsinki Commission.

Agriculture is still responsible for the majority of nutrients entering our marine areas from Sweden. The demands which have already been made of agriculture are now being fulfilled. There is considerable evidence that the effect in the long term may be substantially greater than the 15-20 percent reduction which was originally expected. The National Board of Agriculture estimates that the remedial measures which have already been decided upon and those now proposed will facilitate a reduction well on the way to the 50 percent goal.

The main concern for municipal treatment plants is to implement the existing programme. A detailed review has been made of 85 coastal treatment plants, serving a population equivalent of around 4.5 million people. The need for practical trials to establish suitable treatment techniques for nitrogen and the great need for increased construction and capacity may make it difficult to carry out the whole programme by 1995. Furthermore, analyses of the problems involved indicate that more urgent considerations for the future are to do something about leaking piping and to install overflow systems in the network, rather than sharpen the treatment requirements at the plants themselves.

NUTRIENTS

This century, the load of nitrogen and phosphorus on the Baltic has increased four-fold and eight-fold respectively. Up to 1950 the load of both nitrogen and phosphorus had doubled. From 1950 up to the present day the nitrogen load has doubled again, whereas the phosphorus load has increased by four times. This means that, compared with the original state of affairs, there is a surplus in the supply of phosphorus. Increased nitrogen fixation via nitrogen-fixing algae in the Baltic suggests that the nitrogen being supplied via the external load is not sufficient for all the phosphorus to be utilised for production. Not only is the total nutrient load too high, it is also in a state of imbalance.

It may also be the case that many of the well high inexplicable algal blooms which we see in our marine areas are die to the fact that the supply of growth factors other than nitrogen and phosphorus varies from year to year. After a winter with a great deal of precipitation the leaching of many substances from agricultural and forest land is substantial. It is also known that acidification increases the quantity of certain metals entering the sea. We do not at present know the extent to which such fluctuations influence algal blooms in the marine environment.

Notwithstanding the fact that many factors contribute to algal blooms in marine areas, our view is that the increased supply of nutrients is the fundamental cause of the problem we have today and that measures must be taken to limit the quantity of these nutrients entering the sea.

The large-scale distribution of sources of nutrients is shown in the table below. Around half of the total load of nitrogen on the Baltic may be attributed to land areas, including coastal discharges, 40 percent is attributable to direct deposition on the sea surface and a little bit more than 10 percent to nitrogen fixation in the Baltic. Sweden accounts for 20 percent of the nitrogen load from land areas, putting it in third place among the countries bordering the Baltic.

Land areas are responsible for 90 percent of the phosphorus load, while atmospheric deposition accounts for the other 10 percent. The Swedish share of this load is 10 percent.

Table   Nutrient load on the Baltic from land areas, including coastal discharges, direct deposition on the sea surface and nitrogen fixation.

Country	tonnes N/yr	%	tonnes P/yr	%
Sweden	98,800	21	4,380	10
Finland	70,400	15	4,520	10
USSR	130,300	27	5,880	13
Poland	109,900	23	19,100	43
East Germany	3,600	1	380	1
West Germany	16,400	3	2,370	5
Denmark	51,000	10	7,860	18
Total	480,400	57	44,490	89
Deposition	369,000	43	5,430	11
Total	849,400	87	49,920	
N-fixation	130,000	13		
Total	979,400			

STABLE ORGANIC SUBSTANCES

Today, about ten million organic substances have been described in litterature. Only a small fraction of these have, however, come to a practical use. About three hundred thousand new substances are added each year. It can be estimated that between fifty thousand and one hundred thousand different chemical substances are in more general use around the world. Most of these are organic substances.

PCB:s, DDT, dioxins and dibenzofuranes are examples of substances which have been very much in focus in the past debate. Against the background of the very big number of existing substances, one can assume that the above mentioned examples are only the top of the iceberg.

The development within this field can very briefly be summarized by saying that the old and known problems are decreasing, but not vanishing completely. At the same time new problems are rising at an alarming rate. With the help of the vastly improved analytical techniques, new substances are discovered in the environment.

Organic substances which are not degraded in the environment, or which are degraded at the lower rate than corresponding to the inputs, are beeing enriched in the environment. Most stable organic substances are soluble in fat, and are thus enriched in living material. Sooner or later, many more such substances than those we know about today will reach concentrations that somewhere in the echological systems will cause negative effects. We must calculate with further serious environmental hazards from presently unknown toxic substances.

The only way to be safe from such environmental surprises is to reduce the input of manmade stable organic substances to virtually zero.

In general terms, the organic substances with the largest proven or expected environment risks are today found within the group chlorinated organic substances. The major source for inputs to the environment of such substances is the pulp and paper industry. The chemical industry and other industries using a lot of chemicals such as the textile industry, the tanning industry, the plastic and rubber industry, the mining industry and the graphical industry, can also give rise to considerable inputs of such substances.

One large source, and certainly the most difficult one to handle, is the general use and distribution in our society of stable organic substances in constructions (e.g. asbestos), consumer goods (e.g. cadmium in pigments) and chemical products (e.g. chlorinated solvents). It is becoming more and more obvious that potentially hazardous substances are beeing incorporated into social structures through the products we use; in much larger amounts than they leave the active society in the shape of waste of different types. Sooner or later also these substances will reach the environment, but we are today loosing control of their ultimate fate.

The Swedish policy to reduce the risks caused by discharges of stable organic substances is built upon the precautionary principle. The discharge of such substances from the chemical industry is beeing inventorized. The use of chemical products within certain industrial sectors is also beeing investigated. In this effort the principle of substitution is central. This principle means that anyone who uses a chemical product shall all the time strive to switch into substitutes which are potentially less hazardous.

A quite considerable effort has been made to reduce the inputs of stable organic substances from the Swedish pulp and paper industry. This program has been developed jointly between the authories and the industrial sector itself and has so far cost a lot of research and invest money.

The first face of the cleaning-up is well under way, and within a few years all pulp and paper industries with bleacheries in Sweden will have reduced their discharges of chlorinated organic material with about 50 percent, compared to 1988. The total discharge of such material, measured as total organically bound chlorine TOCl is expected to bee around 6.300 tonnes per year after phase one.

Phases two and three will further reduce the discharges over the next decade. The total investments for this environmental effort is estimated to about 500 million US dollars. It should be noted that sufficient technology is not yet in existence in order to fully carry out the whole program.

NEW PROBLEMS

Experience of the problems we have had with various stable organic substances should already have led to greater care when introducing new substances. Unfortunately this does not always seem to have been the case. Instead we are still discovering new groups of substances out in the environment.

Those which are of most current interest are brominated aromatic substances (principally polybrominated diphenyl ethers, PBDE), which have been increasingly used as flame-proofing agents. They have been found in all biological samples, including seals from the northern Arctic Ocean. Besides this, analyses of laminated sediments from the Baltic Sea suggests that the concentrations of these compounds are rising rapidly. In order not to risk creating a new PCB problem we must reduce the use of these substances. This may give rise to a conflict between environmental demands and fire safety requirements if it is not possible to develop substitute products which are less harmful to the environment.

In the Netherlands biological material from the Rhine is now being found to contain high concentrations of chlorinated benzyl toluenes (PCBTs), substances which are used as a substitute for PCB in hydraulic systems in coal mines. The concentrations found in fish in the Rhine are, surprisingly enough, even higher than correnponding PCB levels.

We must therefore clearly do more, than to-day, in order to prevent future harm to the environment. We cannot simply wait until effects are discovered. One reason for this is that when an effect has actually been discovered, it often takes a very long time to link this effect to a substance or a combination of substances.

We experience obvious problems when it comes to identifying (with chemical and biological methods) those substances which constitute a threat. It is essential to try to find other methods of predicting the danger to the environment posed by a substance.

And, above all, we must learn to apply the precationary principle much more stringently, and especially to man-made organic substances, in order to safeguard the marine environment. We will often, in the future, have to ask ourselves if the introduction, or continued or increased use, of an organic substance is environmentally safe. When in doubt, we must say No.

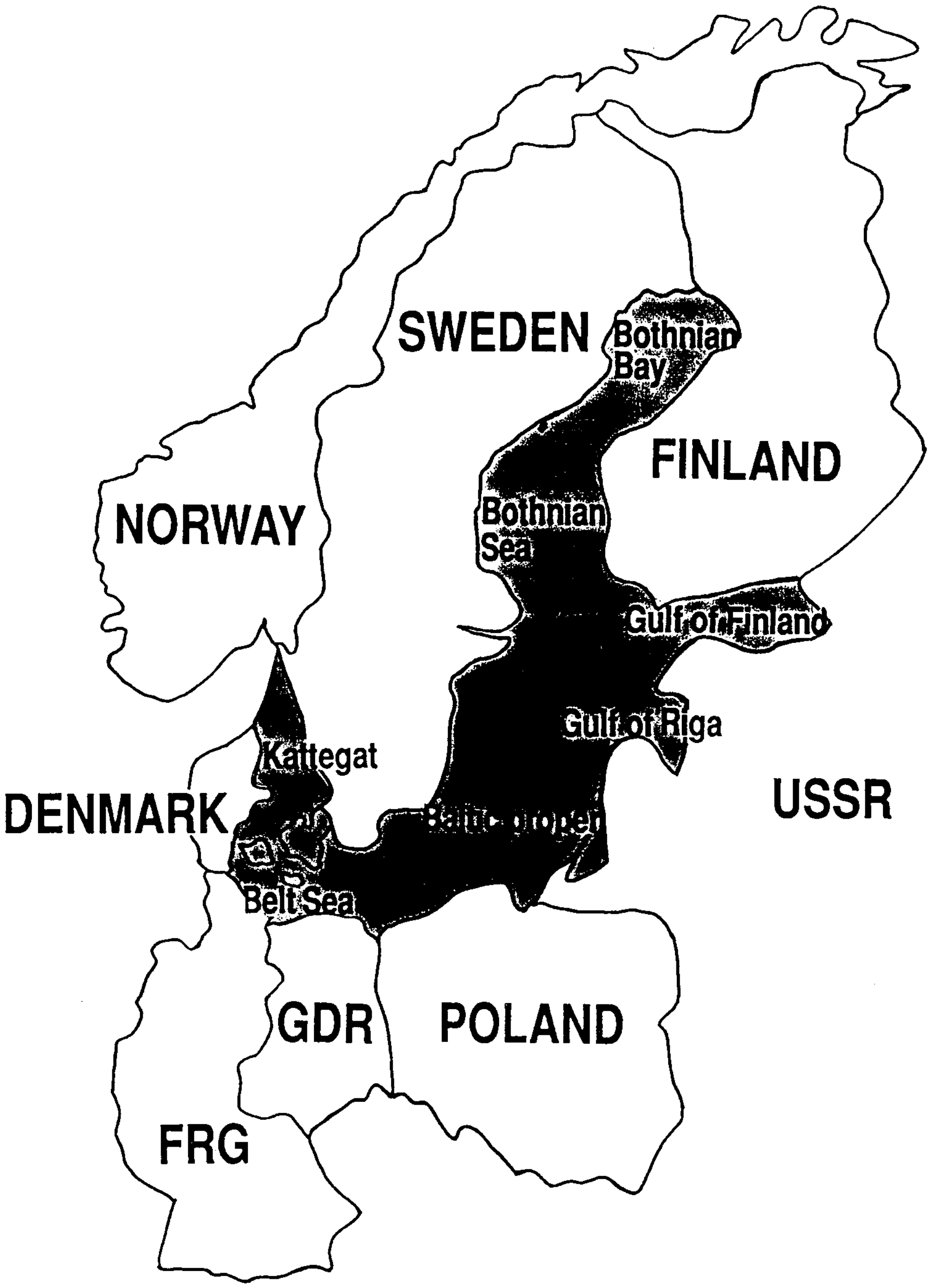

Figure 1

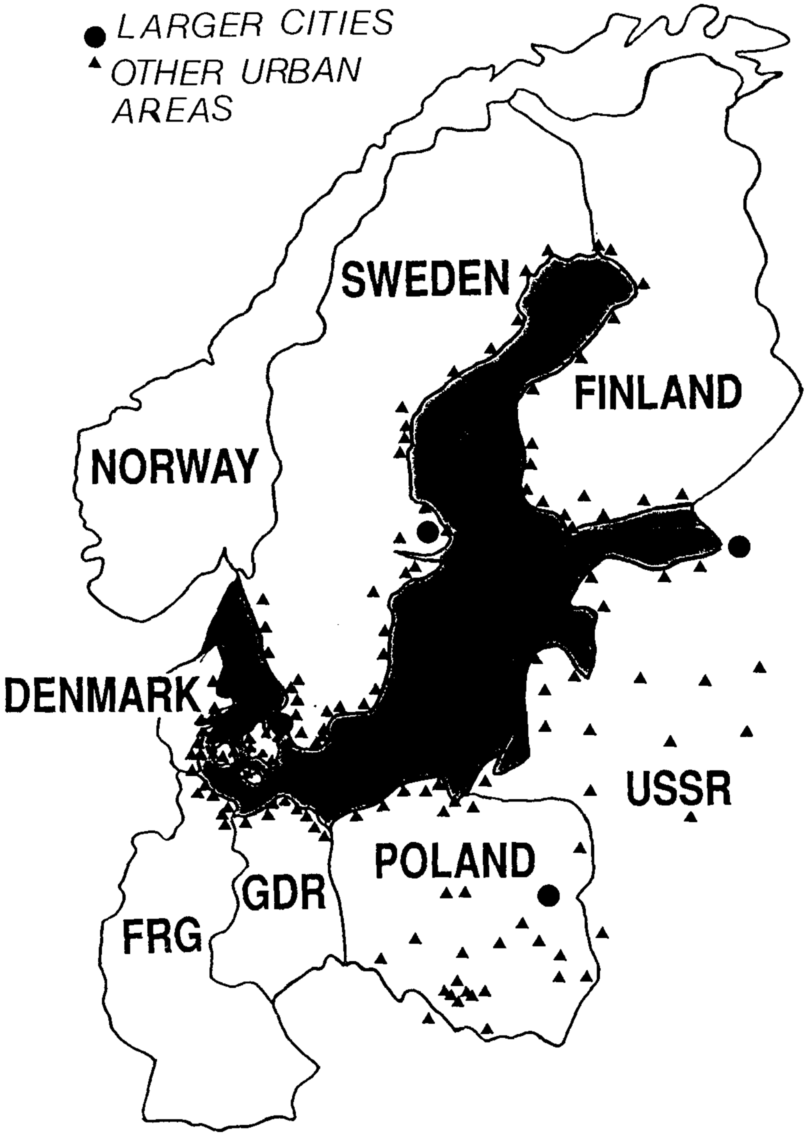

Figure 2

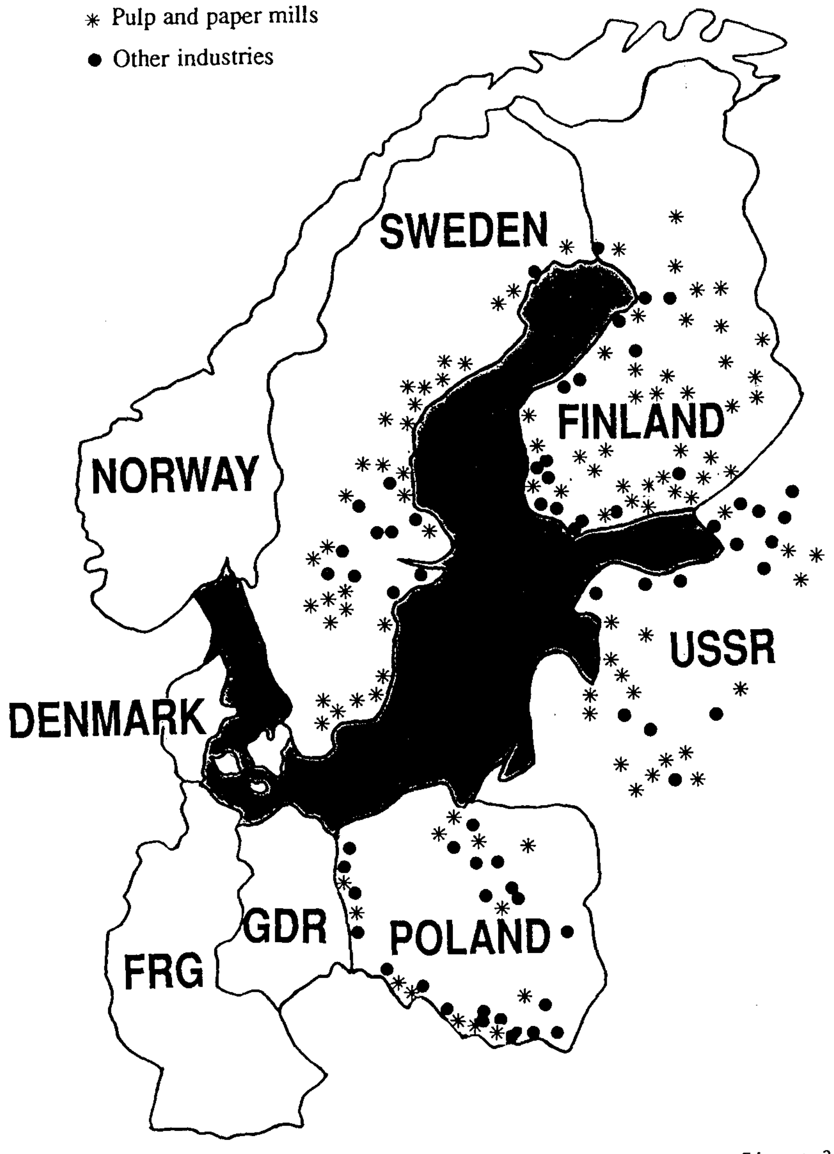

Figure 3