TOWARDS A BALTIC SEA UNDISTURBED BY HAZARDOUS SUBSTANCES

Draft HELCOM Overview 2007

2nd Stakeholder Conference on
the HELCOM Baltic Sea Action Plan

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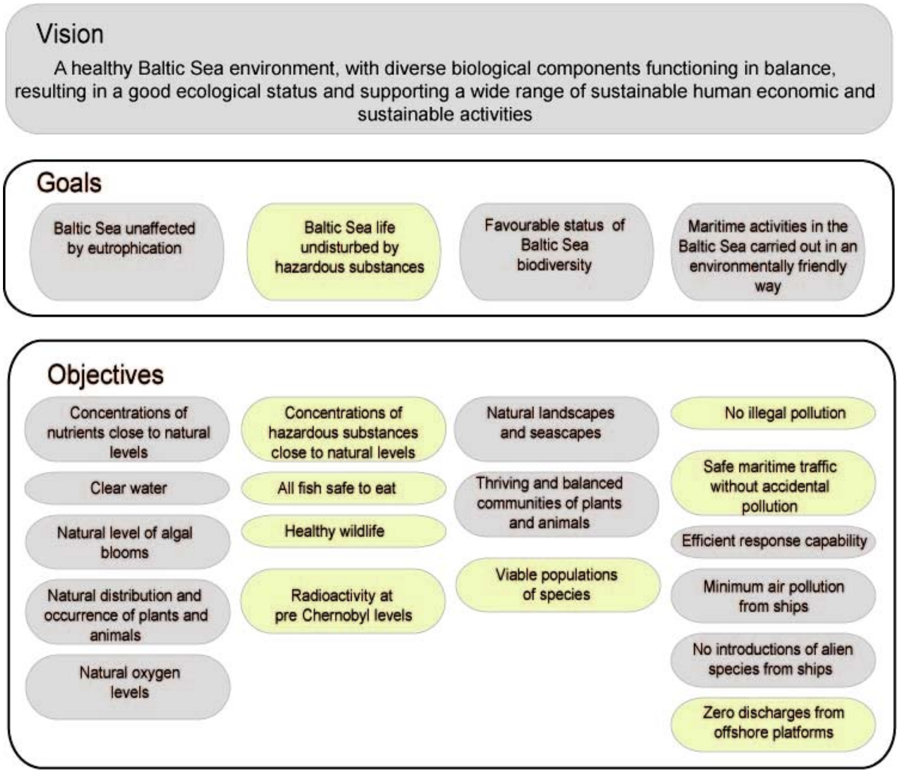
PREFACE

The aim of this concise overview is not to provide a comprehensive assessment on the extent of the impacts of hazardous substance on Baltic Sea environment, but rather, a first attempt to outline an indicator-based assessment that:

- shows how ecological objectives could be used as basic assessment tools when assessing the degree to which the Baltic Sea ecosystem is affected by hazardous substances, and
- stimulates discussion on the development of targets and indicators as well as actions for the HELCOM Baltic Sea Action Plan (BSAP).

For the implementation of the ecosystem approach, HELCOM has adopted a system of vision, strategic goals and ecological objectives. “Hazardous substances” is one of the four thematic areas covered by the HELCOM Baltic Sea Action Plan.



The HELCOM system of vision, strategic goals and ecological

The specific **strategic goal** for hazardous substances is to have a “Baltic Sea life undisturbed by hazardous substances”. The **ecological objectives** related to this goal are reaching concentrations of hazardous substance close to natural levels, having all fish safe to eat, having healthy wildlife and reaching pre Chernobyl levels of radioactivity.

EXECUTIVE SUMMARY

Pollution caused by hazardous substances refers to a substantial number of different substances ending up in the marine environment, including man-made (anthropogenic) substances and naturally occurring substances when their inputs exceed natural levels. Although monitoring activities indicate that the loads of some hazardous substances have been reduced considerably over the past 20–30 years, problems still persist.

Once released into the Baltic Sea, hazardous substances can remain in the water for very long periods and can accumulate in the marine food web up to levels which are toxic to marine organisms. Hazardous substances cause adverse effects on the ecosystem, such as

- Impaired general health status of animals
- Impaired reproduction of animals, especially top predators
- Increased pollutant levels in fish for human consumption.

Certain contaminants may be hazardous because of their effects on hormone and immune systems, as well as their toxicity, persistence and bio-accumulating properties. In particular, substances bio-accumulating in the food web may cause potential hazard to humans.

Goal and objectives for hazardous substances in the HELCOM Baltic Sea Action Plan

The agreed goal of HELCOM on Hazardous substances *Baltic Sea undisturbed by hazardous substances* is described by four ecological objectives:

1. Concentrations of hazardous substances close to natural levels,
2. All fish safe to eat,
3. Healthy wildlife,
4. Radioactivity at pre-Chernobyl level.

In order to have operational ecological objectives, appropriate indicators need to be identified. The agreed objectives will be preliminarily monitored by the state of the environment (State and Impact). The indicators will be represented by selected heavy metals and organic substances in different environmental compartments such as in sediment, fish, white tailed sea eagle and seals.

Target levels for the indicators reflect undisturbed, i.e. good ecological, status. Existing target values, developed e.g. within the EU Water Framework Directive and EEA work, are used as much as possible and existing methodologies should be used when developing new targets.

Further actions

As a result of the EU enlargement and the development of new EU measures, there is a reduced need for corresponding HELCOM measures. There remain, nevertheless, continuing needs for identifying the specific problems in the Baltic marine environment and reviewing whether measures by the various organizations (Global organizations, EU, HELCOM or national) adequately cover the general obligations of the Helsinki Convention and the HELCOM Objective with regard to the cessation target for emissions and discharges of hazardous substances by 2020 in the whole Baltic catchment area. Particular care should be taken that the interests of all HELCOM Contracting Parties are taken into account. This might generate the need for HELCOM to adopt its own Baltic specific measures.

The basic steps for taking action in HELCOM are:

- Identification of threats;
- Identification of fields of action and the need for measures;
- Screening the coverage / implementation efficiency of existing international and national provisions, and
- Deciding whether to develop new measures at international, regional or national level.

HELCOM assessments show that a significant share of both the air- and waterborne inputs to the Baltic Sea originate in non-HELCOM countries. This means that it is of utmost importance that the results of HELCOM assessments are taken into account in other fora.

The information available on inputs and sources for hazardous substances is much scarcer than that on nutrients and does not allow for a comprehensive assessment of the situation in the Baltic at present.

In order for HELCOM to be able to influence the development and to co-ordinate its measures with the European Marine Strategy and other international activities affecting the Baltic Sea, HELCOM has started an activity where all available information on certain hazardous substances is jointly evaluated. The aim is to assess the impacts on the Baltic Sea environment and to also provide input to the development of the HELCOM Baltic Sea Action Plan.

The activity focuses on nine organic hazardous substances, that have already been prioritized by HELCOM and other international for a, for which initial information was available at the start of the activity. The activity also includes hazardous substances, such as brominated flame retardants and perfluoro chemicals, which have not been assessed in HELCOM earlier.

HELCOM has collected information on the use of the selected substances in different sectors from available national registers and other sources. Furthermore information has been collected on their occurrence in discharges/emissions to the Baltic marine environment. This information is also being utilised in a HELCOM project which will identify actions for the HELCOM Baltic Sea Action Plan which also covers other toxic substances. Additional information is intended to be collected in a proposed screening study focusing on the occurrence of selected hazardous substances in the Baltic marine environment.

Based on the outcome from available reports, and the work still to be carried out, the most relevant hazardous substances of specific concern in the various sub-regions, their main uses and their most significant sources will be identified. This information will be the basis for developing input, e.g. a joint position by HELCOM countries, to international, regional or national actions. The actions will be based on substance specific as well as sector specific measures, preferably on a plant by plant basis (“hot spot related measures”).

BALTIC SEA UNDISTURBED BY HAZARDOUS SUBSTANCES

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Concentrations of hazardous substances close to natural levels

Despite reductions in inputs, concentrations of heavy metals (mercury, cadmium & lead) in water of the Baltic Sea are still up to 5 times higher than in the Northern Atlantic (Pohl & Hennings 2007). Also the levels of some organic pollutants are much higher in Baltic marine environment.

On the other hand, the levels of HCH-isomers in both sea water and biota (marine organisms) in the Baltic marine environment have decreased considerably since the mid-1980s. Additionally, the DDT and HCB levels in biota have decreased considerably since the early 1970s and end of 1980s, respectively (HELCOM 2002 & 2003).

The temporal trend analyses (ICES 2006) covering the years 1980-2004, and altogether five Swedish coastal areas from Kattegat to Bothnian Bay and five Finnish coastal areas from Gulf of Finland to Bothnian Bay, found three significant downwards trends for mercury in herring muscle in Swedish and Finnish parts of Bothnian Sea and in Gulf of Finland. For other sites significant trends were not found (Figure 1).

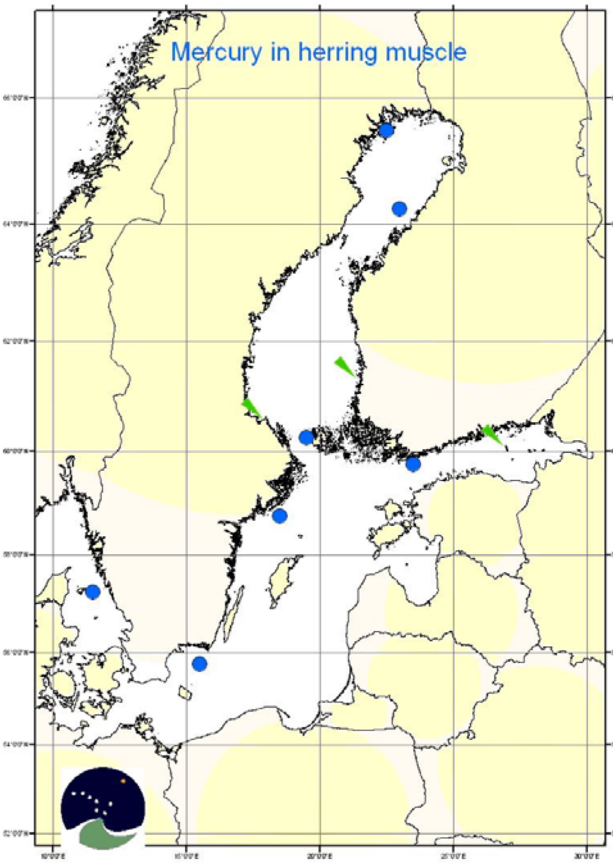

Figure 1. Temporal trends of mercury in herring livers. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend (ICES 2006).

Another temporal trend analyses (Bignert & Nyberg 2006a), covering the years 1981-2005, and altogether five Swedish coastal areas from Kattegat to Bothnian Bay, showed that cadmium levels in herring liver are decreasing in Swedish coastal areas (Bothnian Sea and western Baltic Proper) where increasing concentration trends have been observed during 1980s (Figure 2). However, the recent levels are not significantly lower compared to the concentrations measured at the beginning of the 1980s, despite measures taken to reduce cadmium discharges to the environment. Additionally, cadmium levels in cod liver in south east of Gotland and Kattegat have decreased significantly during 1981-2005.

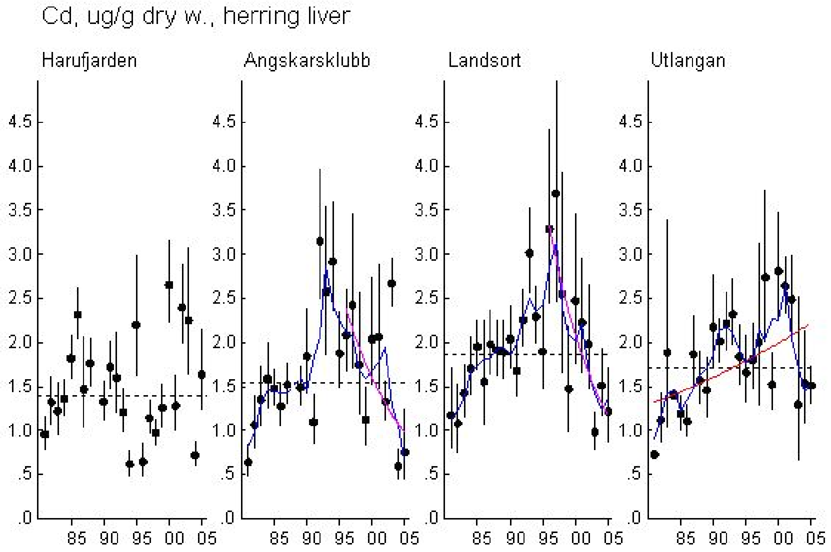

Figure 2. Temporal trends of cadmium level (µg/g dw) in herring liver in Swedish coastal area during 1981-2005 (Bignert & Nyberg 2006a).

Among the positive trends concerning hazardous substances is the clear decrease in lead levels in biota (e.g. herring and perch liver) in most Baltic Sea areas (HELCOM 2002, ICES 2006).

TBT levels are still so high that they have potential biological effects in all parts of the Baltic marine environment, especially in the coastal areas. For many endocrine disrupting substances and other organic contaminants, a comprehensive assessment of their levels or effects is not possible due to the lack of eco-toxicological data (i.e. what is the harmful contaminant level in organisms) and monitoring data (i.e. which contaminant levels occur in the Baltic marine environment or in effluents from e.g. landfills or sewage treatment plants).

Sediments often act as an ultimate sink for many heavy metals (e.g. mercury, Figure 3) and hydrophobic organic substances (e.g. PCBs, Figure 4). Nevertheless, the changes in REDOX potential (oxic/anoxic) may remobilize some heavy metals from sediment to water. Under anoxic conditions, for instance mercury and cadmium concentrations in water (e.g. in Central Baltic Sea, Figure 5) decrease due to the formation of rather insoluble sulphides, which settle down to the sediment (HELCOM 2002, Pohl & Hennings 2007).

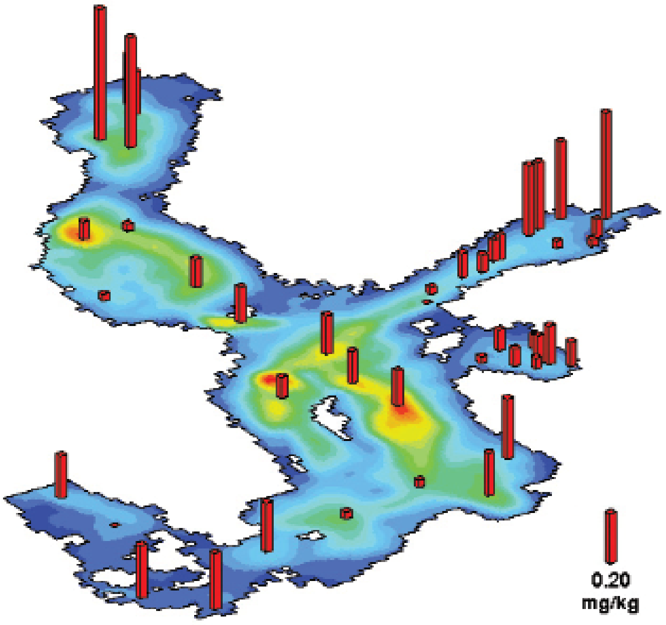

Figure 3. Mercury levels (mg/kg dw) in surface sediment in the Baltic Sea (HELCOM 2002).

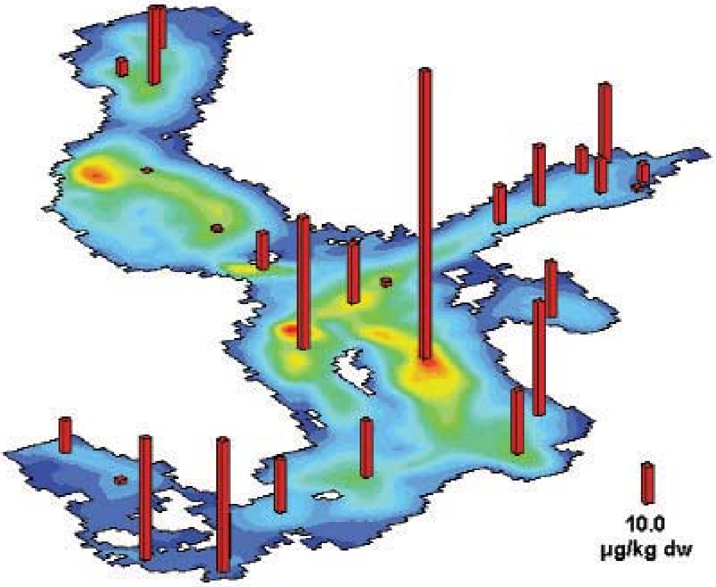

Figure 4. PCB (∑7PCB congeners) levels (range 3.5-55 µg/kg dw) in surface sediment (0-1 cm) in the Baltic Sea (Perttilä et al. 2003).

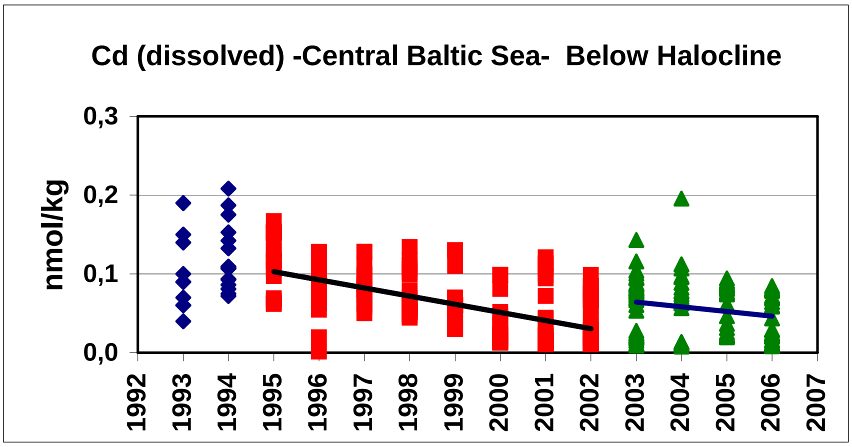

Figure 5. Trend for dissolved cadmium in water below the halocline in the central Baltic Sea during 1993 – 2006 (Pohl and Henning, 2007).

Indicators with targets

As a huge number of different hazardous substances are affecting the Baltic Sea, and as all of them can not be monitored, some representative substances have to be selected for which target values are defined. Traditionally HELCOM has assessed heavy metals (e.g. mercury, cadmium and lead) and some historic organic pollutants such as DDT and PCB.

The partition of hazardous substances among the different compartments of the marine environment (water, sediment, biota) varies depending on the physico-chemical properties of each substance (e.g. water solubility, adsorption, bioaccumulation). Therefore, different compounds are measured in the different environmental compartments but the assessment should consider the whole marine environment as thoroughly as possible.

For many of the HELCOM priority substances, which are defined as so called PBT substances (Persistent, Bioaccumulative, Toxic), biota is considered to be the most relevant matrix. For other types of substances (e.g. endocrine disrupters), biological effect monitoring can be considered to be more practical and of higher value. For substances which do not belong to PBT substances, but give a reason for concern due to their widespread and extensive use, monitoring of concentrations in water is regarded a more valid strategy. In conclusion, the selection of representative substances and the most relevant matrices to monitor in the Baltic Sea is based on substance properties, the extent of use and potential effects.

HELCOM has as a start selected nine organic substances (or substance groups) and surveyed the use and occurrence of these substances in different effluents (from e.g. sewage treatment plants and landfills) and in the Baltic marine environment (Table 1).

Table 1. Substances or substance groups suspected to be highly relevant to the Baltic Sea and subjected to data and information collection by HELCOM Contracting Parties in 2006.
1. Dioxins (PCDD), furans (PCDF) & dioxin-like polychlorinated biphenyls (dilPCB)
2a. Tributyltin compounds (TBT)
2b. Triphenyltin compounds (TPhT)
3a. Pentabromodiphenyl ether (pentaBDPE)
3b. Octabromodiphenyl ether (octaBDPE)
3c. Decabromodiphenyl ether (decaBDPE)
4a. Perfluorooctane sulfonate (PFOS)
4b. Perfluorooctanoic acid (PFOA)
5. Hexabromocyclododecane (HBCDD)
6a. Nonylphenols (NP)

6b. Nonylphenol ethoxylates (NPE)
7a. Octylphenols (OP)
7b. Octylphenol ethoxylates (OPE)
8a. Short-chain chlorinated paraffins (SCCP or chloroalkanes, C_{10-13})
8b. Medium-chain chlorinated paraffins (MCCP or chloroalkanes, C_{14-17})
9. Endosulfan

For most of the selected substances, available information is quite scarce. Nevertheless, the preliminary results of the HELCOM survey indicate that some of the substances need more attention than others. Therefore, the substances and matrixes presented in Table 2 have been chosen at this stage to be developed further as indicators for the ecological objective “Concentrations close to natural levels”.

The ultimate target levels for the indicators reflect undisturbed, i.e. good ecological status. Three kinds of target levels have been defined for the ecological objective “Concentrations close to natural levels”:

- The primary target is a decreasing trend in concentration (concerns all substances)
- The intermediate target levels are relevant at least for certain substances (e.g. mercury as well as dioxins and furans, which are dioxin-like PCBs). EU limit values referring to human health (Table 3) are used as intermediate target levels for mercury & dioxins, furans and dioxin-like PCBs.
- The ultimate target level is to reach near background concentrations for naturally occurring substances (mercury, cadmium as well as dioxins and furans, dioxin-like PCBs) and to reach close to zero concentrations for man-made synthetic substances (TBT and PFOS)

The following tables give a general overview how the favourable status of the Baltic Sea with regards to hazardous substances has been assessed in this document.

The status is categorised using flounder smileys.


indicates a favourable status or a positive trend


an unfavourable status or a negative trend


is neutral or no trend

refers to big gaps in information

Table 2. Chosen indicators for ecological objective Concentrations of hazardous substances close to natural levels

Indicator	**Matrix**	**Target**	**Status**
Cadmium	* Herring or flounder liver as indicator for whole Baltic Sea * Bivalve (Blue mussel or Baltic clam) as indicator for different sub-regions of Baltic Sea	Primary target of decreasing concentration trend Ultimate target level to reach near background concentrations	
Mercury	* Herring or flounder muscle as indicators for whole Baltic Sea * Bivalve (Blue mussel or Baltic clam) as indicators for different sub-regions of Baltic Sea	Primary target of decreasing concentration trend Intermediate target level for fish shown in table 3 Ultimate target level to reach near background concentrations	
Dioxins, furans, dioxin-like PCBs	Herring and salmon muscle	Primary target of decreasing concentration trend Intermediate target level for fish shown in table 3 Ultimate target level to reach near background concentrations	
TBT	Sediment and biota [and imposex in biological effects monitoring]	Primary target of decreasing concentration trend Ultimate target level to reach close to zero concentrations	
PFOS	biota	Primary target of decreasing concentration trend Ultimate target level to reach close to zero concentrations	

Progress towards targets for Concentrations close to natural levels

- Decreasing trends or no trends at all for mercury in herring in Swedish and Finnish coastal waters
- Decreasing trends in cadmium levels in herring and cod in some Swedish coastal areas during very recent years. However, the recent levels are not significantly lower compared the beginning of the 1980s
- TBT levels are still so high that they have potential biological effects all around the Baltic Sea, especially in the coastal areas
- For many organic contaminants, a full assessment of their levels or effects is not possible due to the lack of eco-toxicological and monitoring data

All fish safe to eat

Of the life living in and around the Baltic Sea, people have a special relation to fish. Although birds such as eider duck (*Somateria mollissima*) are hunted for food, the most common Baltic Sea biota ending up at the dinner table are different fish species. Recent news about the alarmingly high levels of various hazardous substances such as tributyl tin (TBT) and dioxins has made the polluted state of the Baltic Sea very concrete for many people. Therefore, the HELCOM Baltic Sea Action Plan has identified the objective “All fish safe to eat” for hazardous substance.

Concentrations of dioxins in marine ecosystems declined in the 1980s but this decrease levelled off in the 1990s. Dioxin levels in fatty Baltic fish (e.g. herring and salmon) still show high levels of contamination (Figure 6, HELCOM 2004).

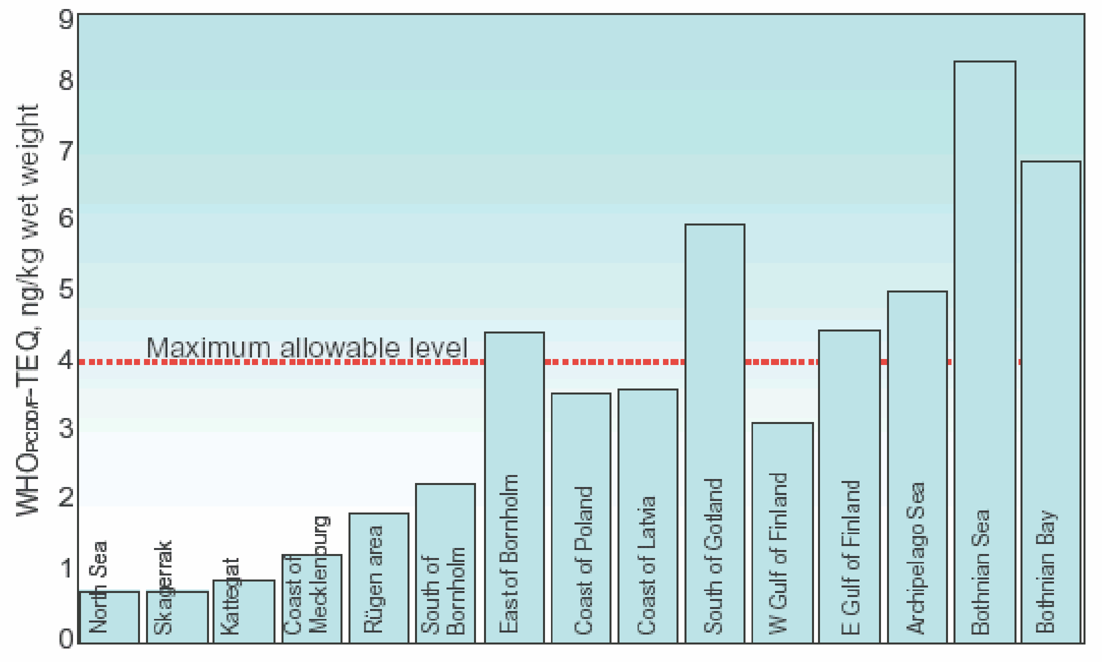

Figure 6. The dioxin content in herring muscle at different fishing grounds (HELCOM 2004).

The polychlorinated biphenyl (PCB) levels in herring muscle in Swedish coastal areas from Kattegat to Bothnian Bay have decreased significantly during the time period 1978/80-2005. The levels are still significantly higher in the Baltic Proper and in the southern Bothnian Sea compared to the Kattegat and the Skagerrak (Figure 7). The two cod liver time-series (1980-2004/05) from southeast of Gotland in the Baltic Proper and Kattegat also show significant decreasing trends of PCB (Bignert & Nyberg 2006b). Note that these PCB congeners are not exactly the same as the dioxin-like PCB congeners. Recently a study (MacKenzie et al. 2004) showed that the standing stock of the most abundant fish species in the Baltic Sea was a sink for 260 kg of PCBs in the late 1980s to early 1990s, and that the fisheries removed 31 kg PCB per year which ended up in the consumers. Fishery removed as much, or even more, PCB as other factors (e.g. degradation in the water).

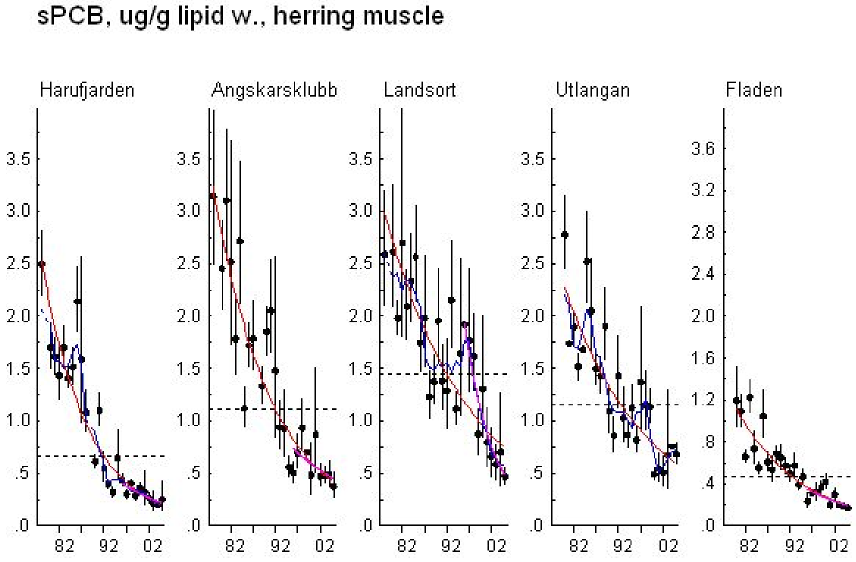

Figure 7. Temporal trends of sPCB concentration (ug/g lipid w.) in herring muscle in Swedish coastal area during 1981-2005 (Bignert & Nyberg 2006b)

Indicators with targets

The EU has adopted regulations concerning limit values on maximum levels for certain hazardous substances in food stuff, including fish. The World Health Organization has also developed recommendations on daily intake of some hazardous substances from fish. In addition, some Contracting Parties recommend limitations in consumption of Baltic herring and salmon for children and women of childbearing age due to dioxins, furan and PCB contamination.

As a pragmatic approach, it is proposed that the EU maximum allowable concentrations of mercury, cadmium as well as dioxins and dioxin-like PCBs in fish meat be used as target levels for fish in the Baltic Sea (Table 3). It is recognised that some wildlife species could be more susceptible to hazardous substances in fish compared to human. It should be noted that the stricter target levels for these substances have been presented in ecological objective “Concentrations of hazardous substances close to natural levels”; namely the ultimate target to reach near background concentrations in some fish species (Table 2).

Table 3. Maximum allowable concentrations of mercury (Hg), cadmium (Cd), dioxins and sum of dioxins & dioxin-like PCBs in fish meat meant for foodstuff as regulated by EC 466/2001 with amendments (e.g. EC 199/2006)

Substance	**Maximum levels in fish meat (µg / kg WW fish (EC 466/2001).** Note that exceptions (in parenthesis) listed include only eel and pike, other species named in the regulation but less common in the Baltic are excluded.
Hg	500 (1 000 in pike *E. lucius,* eel *A. anguilla*)
Cd	50 (100 in eel *A. anguilla*)
Dioxins (WHO-PCDD/F) Teq	$4 * 10^{-3}$
Dioxins (PCDD/F)+PCBs (WHO-TEq)	$8 * 10^{-3}$

Progress towards targets for all fish safe to eat

- Dioxin levels in fish (specially in salmon and herring) exceed the new EU food safety limits in some Baltic Sea areas, particularly further north
- PCB levels in herring in Swedish coastal areas have decreased significantly during 1978/80-2005. The levels are still clearly higher in the Baltic Proper and in the southern Bothnian Sea compared to the Kattegat and the Skagerrak

Healthy wildlife

Taking both concentrations and biological effects of hazardous substances into account in the objectives is important as a large number of hazardous substances have been released to the Baltic Sea, often in low concentrations. Such substances may be possible to observe if special concern for the substance is raised e.g. human health risks. In other cases, the only way to detect the impact of previously unknown substances and especially substance mixtures is through applying biological effects monitoring methods, just like the observations in seal and predatory bird reproductive health indicating pollution by PCBs and DDT during the 1970s. Specific methods to detect biological effects (such as molecular biomarkers) caused by unknown and known substances are presently on the way to reaching maturity.

In addition to being harmful to humans, the hazardous substances found in Baltic Sea animals (as well as plants) cause various health problems to some organisms even at low dosages. Such sub-lethal poisonings endanger the reproduction and viability of many Baltic species.

The monitoring of biological effects of hazardous substances provides information on their adverse effects on marine organisms *in situ*. These effects are visible both as direct physical changes in some animals in the form of sterility and failing breeding among birds but also as physiological changes measurable as biomarkers and other eco-toxicological tools. Detection of biological effects is of strategic importance to the overall monitoring of hazardous substances since many methods reveal the potential presence of substances (or substance groups) that are not feasible to be measured on a regular basis due to their huge number and technical difficulties in analysis.

Generally, the reproductive success of top predators is an indicator of detrimental effects of accumulating hazardous substances. Shell thickness of common guillemot (*Uria aalge*) eggs from Stora Karlsö in the Central Baltic Proper has been monitored in Sweden since the end of 1960s (Figure 8). During 1990s the thickness of guillemot eggshells in the area returned to the dimensions recorded prior to the 1940s. The thin eggshells observed during 1960 were attributable to the severe DDT pollution during that period. Similar effects of, and recovery from, DDT and other substances can also be seen in Swedish time series of white-tailed eagle (*Haliaeetus albicilla*) brood size and nesting success (HELCOM 2002).

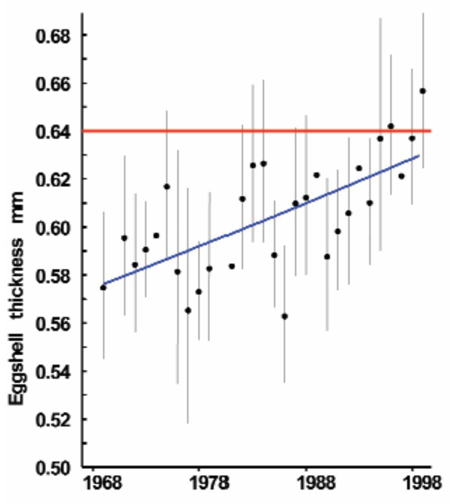

Figure 8. Temporal trends in the thickness of common guillemot (*Uria aalge*) eggshells collected in Stora Karlsö in the central Baltic Proper. The solid red line indicates the thickness prior to 1940 (HELCOM 2002)

The pregnancy rate among female grey seals in the Baltic Sea has increased very significantly in recent years, reflecting the fact that uterine damage is now rare. Intestinal ulcers, on the other hand, are still common, even in young individuals (Figure 9).

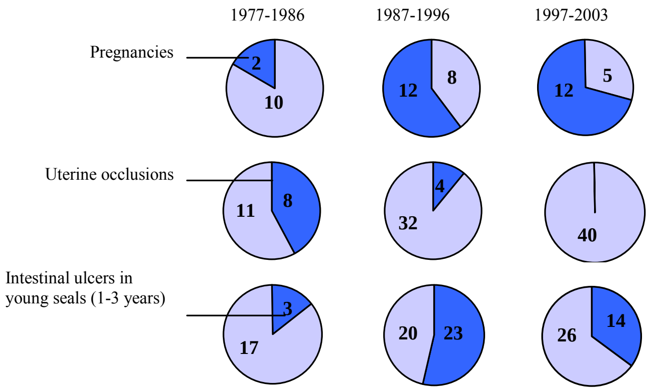

Figure 9. Health status of the grey seals in the Baltic Sea. Numbers in the pie charts are the numbers of seals examined (data from Museum of Natural History, Stockholm, Sweden, Bernes 2005).

The most sensitive reaction of mammals to TBT is linked to the effects on the immune system. It is supposed that TBT could increase the susceptibility of mammals to diseases such as microbial infection. It is possible that TBT acts in a synergistic way with other immune toxicants such as PCBs. The mass die-outs among the Baltic seals, caused mainly by morbilli virus infections, may possibly be attributed to chemical pollutants such as organochlorines, heavy metals and TBT (Ciesielski et al. 2004). Additionally, harbour porpoises from the German area of the North Sea and the Baltic Sea exhibit a higher incidence of bacterial infections compared to whales in less polluted arctic waters. Beineke et al. (2005) found that thymic atrophy and splenic depletion were significantly correlated to increased PCB and polybrominated diphenyl ether (PBDE) levels. This supports the hypothesis of contaminant-induced immunosuppression, possibly contributing to disease susceptibility in harbour porpoises. The potential adverse effects of contaminants such as PCBs and heavy metals on the immune system and the health status of marine mammals are still discussed controversially.

Indicators with targets

Research on health effects caused by hazardous substances is ongoing on different species around the Baltic. However, the data is mostly scarce and limited to a few regions, which at this stage does not seem to allow for developing target levels in the different regions. Most information on long time-series concerns predatory birds, such as the white-tailed eagle as well as seals. Therefore, the following indicator topics (details to be determined) are proposed to be considered for healthy wildlife (Table 4). Target levels for the different sub-regions are to be defined.

Table 4. The proposed indicators for ecological objective “Healthy wildlife”

Indicator	**Target**	**Status**
Predatory bird health: White tailed eagle	Target level need to be defined • proportion of successfully reproducing pairs • mean brood size	?
Fish disease	To be defined	?
Seal health: Grey seal (for entire Baltic) and ringed seal (for northern Baltic)	- rate of pregnancy (CA) with *target* of normal pregnancy rate:	🐟 Grey seal ? Ringed seal
	- rate of fecundity (CL) with *target* of normal fecundity rate	🐟 Grey seal ? Ringed seal
	- occurrence of uterine pathology (occlusion, stenosis, “myoma”) with *target* of normal level	🐟
	- occurrence of intestinal ulcers in 1-3 year old seals with *target* of normal level	🐟

Progress towards targets for Healthy wildlife

- The pregnancy rate among female grey seals has increased very significantly in recent years, reflecting the fact that uttering damage is now rare
- Intestinal ulcers, on the other hand, are still common, even in young individuals
- There is a need to further develop the indicators and targets for Healthy wildlife

Radioactivity at pre-Chernobyl levels

The levels of anthropogenic radionuclides are higher in the Baltic Sea than in other water bodies around the world. Compared to the North East Atlantic and the North Sea the concentrations of caesium-137 in the Baltic Sea are 40 and 10 times higher, respectively. This is due to atmospheric nuclear testing in the 1960s and the Chernobyl accident in 1986. Also discharges of radionuclides into the Irish Sea from Sellafield are traceable in the Baltic Sea. Liquid discharges from nuclear power plants in the Baltic Sea are estimated to be low.

HELCOM has since 1984 collected monitoring data on radioactivity in the Baltic Sea. These data cover both radioactivities in the Baltic marine environment and in discharges from nuclear installations (nuclear power plants and nuclear research facilities) within the catchment area of the Contracting Parties to HELCOM.

Indicators and targets

HELCOM will in the future continue to monitor and follow closely both radioactivity concentrations in the marine environment as well as the level of radioactivity in the discharges from Baltic nuclear installations. This includes both elaborations of annual indicator reports on the trends and levels of artificial radionuclides as well as more thematic assessment reports. The results from the monitoring are also used to assess potential health risk to humans due to radioactive exposure.

The following indicator topics are proposed to be considered for radioactivity (Table 5).

Table 5. Chosen indicators for ecological objective Radioactivity at pre-Chernobyl levels. Target values have been calculated on basis of average concentrations during years 1984-85 which refer to pre-Chernobyl time period (HELCOM MORS 2006).

Indicator	Matrix	Target	Status
Cs-137	Herring muscle	- Primary target of decreasing concentration trend - Ultimate target level to reach pre-Chernobyl level of 2.5 Bq/kg wet weight	
Cs-137	Plaice and flounder muscle	- Primary target of decreasing concentration trend - Ultimate target level to reach pre-Chernobyl level of 2.9 Bq/kg wet weight	
Cs-137	Sea water *	- Primary target of decreasing concentration trend - Ultimate target level to reach pre-Chernobyl level of 14.6 Bq/m^3	
Cs-137	Sediment	- Primary target of decreasing concentration trend - Ultimate target level to reach pre-Chernobyl level - to be defined	

* sampling depth 0-10 m

Together with the information that HELCOM holds and regular updates on sources, emissions and inputs of radioactive material as well as their impacts in the marine ecosystem, the ecological objectives and the associated indicators will provide the basis for HELCOM's sound management decisions.

Progress towards targets for radio-active substances

- Overall the levels of radioactivity in the Baltic Sea water and biota have shown declining trends since the Chernobyl accident in 1986 (cf. Figure 10)
- The amount of caesium-137 in Baltic Sea sediments, however, has remained largely unchanged, with highest concentrations in the Bothnian Sea and the Gulf of Finland

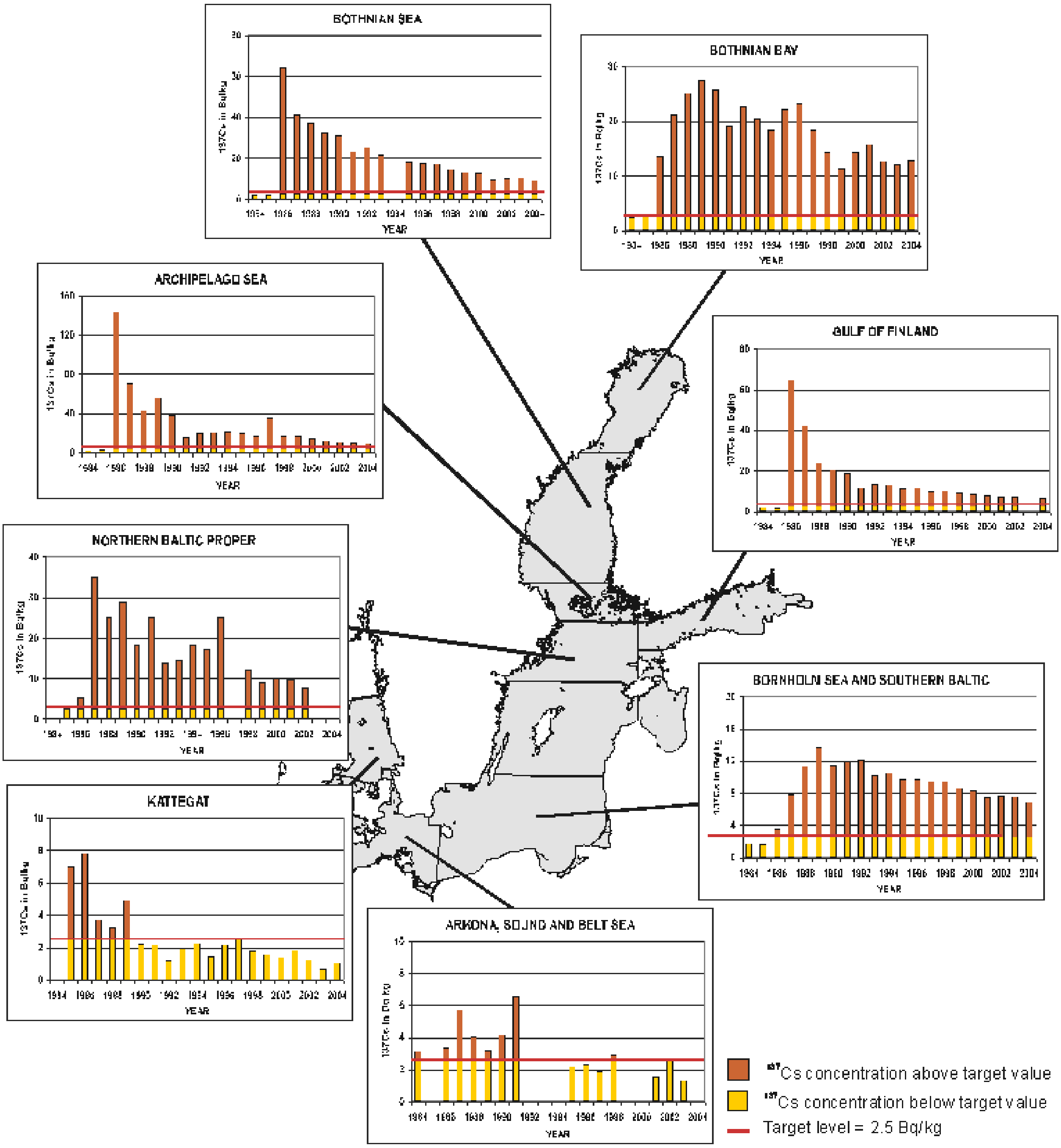

Figure 10. ^{137}Cs concentrations (in Bq/kg) in herring muscle in 1984-2004, as annual mean values by basin. Target values have been calculated as averages of pre-Chernobyl (1984-1985) concentrations. Note: variable scales in the graphs (HELCOM MORS 2006).

INPUTS AND SOURCES

HELCOM monitoring programmes provide regular information on the water- and airborne inputs and sources to the Baltic Sea as well as trends of selected heavy metals and some organic pollutants. Data on sources and inputs of hazardous substances is scarce compared to nutrients.

The loads of some hazardous substances to the Baltic Sea have been reduced considerably over the past 20-30 years. In particular, discharges of heavy metals have decreased although no similar general trend has been observed for heavy metal levels in marine biota since 1990.

For mercury, lead and cadmium, waterborne inputs to the Baltic Sea, via rivers or as direct discharges, are the main source. The remaining share is mainly from atmospheric deposition.

Dioxins are not intentionally produced, but are formed as by-products or impurities of several different industrial processes as well as from most combustion processes, such as chemical, paper and metal industries, incineration of municipal and hazardous waste and small scale burning. Fossil energy production, traffic, and other sources both in Central Europe and in the countries around the Baltic Sea also contribute to their presence. Natural events or processes such as forest or steppe fires and volcanic eruptions can also cause dioxin emissions. Thus, dioxins enter the Baltic Sea as air fallout when transported from land-based sources and via a multitude of waterways. Knowledge about dioxin air emissions has improved to the point where there are relatively accurate measurements or estimations available from some countries. However, it seems that the information concerning dioxin concentrations in waste waters or wastes are not at the same level (HELCOM 2004).

The main pathways of hazardous substances to the marine environment are industrial wastewater, municipal wastewater - discharged directly to the Baltic or transported via rivers - and atmospheric deposition, depending on substance. The main source or pathway to the Baltic marine environment of TBT and TPhT is the anti-fouling use in sea ship hulls and subsequent direct release to sea water. On the other hand, the main pathways of pentaBDPE, octaBDPE and decaBDPE, HBCDD, PFOS, PFOA, SCCP and MCCP to the Baltic Sea are via rivers receiving municipal and/or industrial waste water, direct municipal and/or industrial waste water discharges and via atmosphere. The main pathways of NP, NPE, OP and OPE are via rivers receiving municipal and/or industrial waste water and via direct municipal and/or industrial waste water discharges. The main pathways of endosulfan are via rivers receiving leaching waters from agricultural land and via atmosphere due to the application of agricultural pesticides containing endosulfan. Discharges from landfills and via storm water can be significant for some substances mentioned above. Significant pollution sources of selected organic substances, which have been found based on preliminary assessment results, are presented in more detail in Annex 1.

Quantitative information of emission, discharges and deposition of some heavy metals, lindane and dioxins are presented in the following chapters, but this information is not available for organic substances presented in Table 1. According to a HELCOM evaluation (HELCOM 2001), it can be assumed that the 50% discharge reduction target has been largely achieved for 46 hazardous substances prioritised by HELCOM.

Emissions to air and atmospheric depositions

Heavy metals

The HELCOM monitoring programme annually compiles data on the amount of selected waterborne and airborne pollutants entering the Baltic Sea. Data on cadmium, lead and mercury loads are presented in this chapter. In 2004 total annual emissions to the air by the HELCOM countries amounted to 107 tonnes of cadmium, 38 tonnes of mercury, and 1,124 tonnes of lead (Gusev, 2006a).

Depositions of cadmium and lead show a decrease from south to north, due to the distance from the main emission sources. The total atmospheric depositions of heavy metals into the Baltic Sea during 2004 were over 5.7 tonnes of cadmium, 2.9 tonnes of mercury, and ca. 235 tonnes of lead. The highest levels of heavy metal deposition are experienced in the Belt Sea sub-basin (Gusev, 2006b).

Anthropogenic emission sources, such as industries, energy production and waste incineration, of heavy metals in the HELCOM countries accounted for about 30-50% of the total atmospheric deposition into the Baltic Sea in 2003. Natural and distant sources from outside the Baltic Sea catchment area also contributed significantly. HELCOM assessments also show that the contribution from HELCOM Contracting Parties of the deposition to the Baltic Sea has decreased since 1995, especially with regard to cadmium and lead.

In 2004, HELCOM countries were the source of 48% of airborne cadmium being deposited onto the Baltic Sea and three non-HELCOM countries (United Kingdom, France, and Slovak Republic) were among the top ten contributors (Figure 11). Eleven percent of airborne cadmium deposited on the Baltic Sea originated from other European countries and 40% from other sources (re-emission, natural and global sources). The most significant contributions to total annual cadmium depositions to the Baltic Sea in 2004 were from Poland, Russia and Finland.

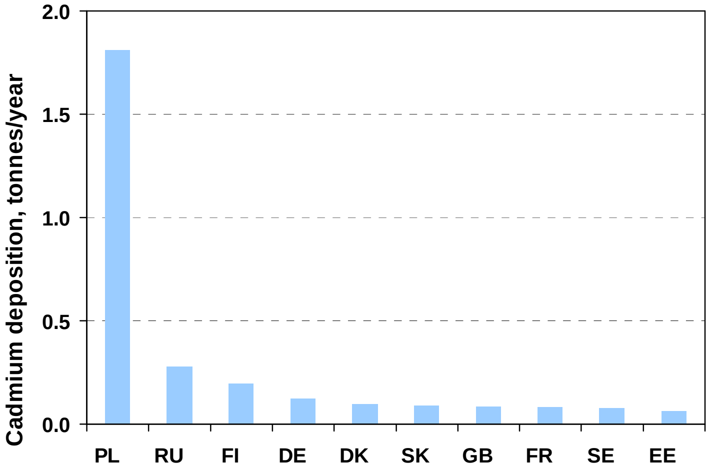

Figure 11. Ten European countries with the highest calculated contribution to the annual deposition of cadmium to the Baltic Sea for 2004 (units: tonnes/year). (EMEP, 2006).

As regards the atmospheric deposition of lead to the Baltic Sea in 2004, HELCOM countries were the source of 19% and five non-HELCOM countries (Belgium, United Kingdom, France, Romania and the Netherlands) were among the top ten contributors. Eight percent of airborne lead deposited on the Baltic Sea originated from other European countries and 73% from other sources (re-emission, natural and global sources). The most significant contributions to total annual lead depositions over the Baltic Sea in 2004 were Poland, Latvia, and Estonia.

For mercury, HELCOM countries were the source of 20% of airborne mercury deposited onto the Baltic Sea in 2004 and three non-HELCOM countries (United Kingdom, France, and Belgium) were among the top ten contributors (Figure 12). Eight percent of airborne lead deposited on the Baltic Sea originated from other European countries and 72% from other sources (re-emission, natural and global sources).The most significant contributions to total annual mercury depositions over the Baltic Sea in 2004 were Poland, Denmark, and the United Kingdom.

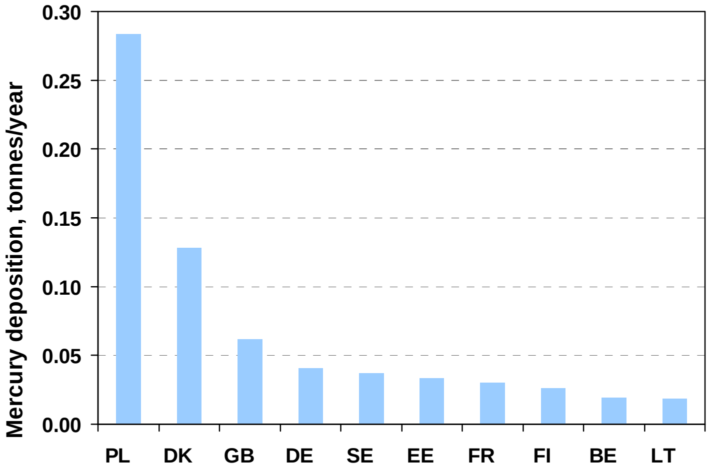

Figure 12. Ten countries with the highest contribution to annual deposition of mercury to the Baltic Sea in 2004 (units: tonnes/year). (EMEP, 2006).

Dioxins and furans

According to the European Dioxin Inventory report, the major industrial sources presented in Table 6 account for about 62% of total dioxin air emissions in Europe. The most important direct source of dioxins to the marine environment is the dry deposition of airborne particle-bound dioxins (HELCOM 2004, OSPAR 2005).

Table 6. The sources of dioxin emissions to air according to the European Dioxin Inventory (HELCOM 2004)

Major industrial air emission sources (62%)	-incinerators for municipal waste -iron ore sinter plants -incinerators for clinical waste -facilities of the non-ferrous metal industry
Other industrial sources and mainly non-industrial sources (38%)	-domestic heating facilities (particularly wood combustion) - accidental fires - traffic (mainly if petrol is used)

Gusev (2006a) found that in 2004, among the HELCOM countries, the largest contributions to total annual PCDD/F emission came from Germany (71%), followed by Russia (14%) and Poland (11%). The highest fractions of emissions deposited to the Baltic Sea belong to Denmark and Sweden (about 20%), and the lowest to Russia (about 0.5%).

Waterborne input

The reported riverine loads, including direct discharges from coastal areas, to the Baltic Sea in 2004 amounted to 6.4 tonnes of mercury, 332.1 tonnes of lead and 35.4 tonnes of cadmium. The riverine inputs of heavy metals are for cadmium, lead and copper highest in the Gulf of Finland, while mercury inputs are highest in the Baltic Proper. A few large rivers account for very large proportions of the total riverine heavy metal loads.

Heavy metals and some hazardous substances end up in the waters from different sources such as industrial activities, urban waste waters, agriculture and waste management.

To a large extent in the past waterway dioxin and furan pollution could be attributed to some chemical and forest industries, where chlorine was used in large amounts for pulp bleaching until the early 1990s. This has now stopped in Finland and Sweden but chlorine gas is still used in some Russian pulp and paper mills. Other water pollution sources of dioxins and furans are e.g. municipal waste waters and residues (solid waste). Wastewater from households and smaller enterprises contain traces of dioxins, the major part of which ends up in sludge produced by sewage treatment plants. Dioxins and furans also eventually end up in residues from air pollution control systems. Residues are mainly disposed of in landfills, from where dioxins and furans may be released via leachate (effluent from landfills) to aquatic environment (HELCOM 2004, OSPAR 2005).

Transboundary pollution

Transboundary pollution loads from Belarus, the Czech Republic and Ukraine are significant also for heavy metals. Although the exact loads of heavy metals originating from upstream countries in the Baltic Sea catchment have not been accurately measured or assessed, a HELCOM project evaluated the proportion of transboundary pollution in 2000 (HELCOM 2005). The project findings suggest that the proportions of the total pollution loads entering the Baltic Sea that originate from these upstream countries are in the range of 5% to 15% for selected heavy metals such as mercury, cadmium and lead. The significance of this transboundary pollution is naturally higher in certain sub-catchments than in the Baltic Sea overall.

Long-term trends in emissions and inputs

Heavy metals

Annual emissions of heavy metals from HELCOM countries to air have decreased during the period from 1990 to 2004 by 44% for cadmium, 42% for mercury, and 86% for lead (cf. Figure 13). The reductions in heavy metal emissions to the air are largely due to the increased use of lead-free fuels, the wider use of cleaner production technologies, the substitution of different production inputs as well as the economic decline and industrial restructuring that occurred in Poland, Estonia, Latvia, Lithuania, and Russia in the early 1990s (Gusev 2006a).

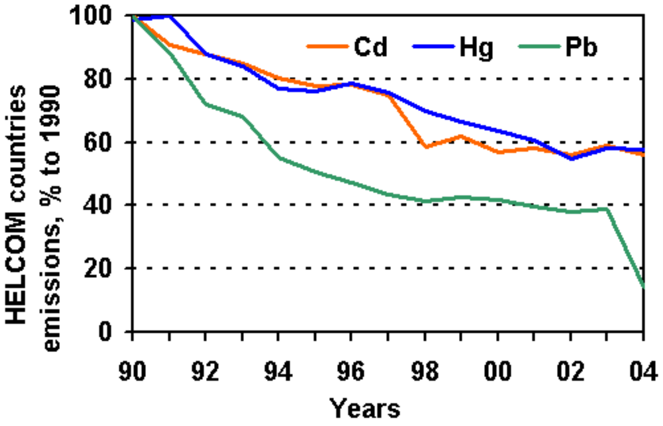

Figure 13. Total annual emissions of cadmium (Cd), mercury (Hg), and lead (Pb) to air from HELCOM countries in period 1990-2004 (% of 1990) (Gusev 2006a).

The annual atmospheric deposition of heavy metals are affected by meteorological conditions, therefore decreases in emissions do not always lead to corresponding reductions in atmospheric deposition rates. Annual deposition rates of heavy metals have halved since 1990 in the Baltic Sea as a whole with reductions of 51% for cadmium, 44% for mercury, and 69% for lead, respectively. On the level of individual sub-basins the most significant reduction in cadmium depositions were calculated for the Gulf of Finland (68%). The most significant decrease for lead were calculated for the Gulf of Bothnia and the Gulf of Finland (73%). The largest decrease in mercury depositions is calculated for the Belt Sea (60%) (Gusev 2006b).

Since the mid-1990s riverine heavy metal loads (notably cadmium and lead) have decreased in several countries.

Dioxins and furans

The total PCDD/F emissions of HELCOM countries in 2004 were 60% higher than emissions in 1990 (Figure 14). The temporal variation is mostly determined by the variation of PCDD/F emissions by Germany, which made up 71% of the total emission from HELCOM countries in 2004 and whose emissions in 2004 were three times higher than in 1990. PCDD/F emissions from Finland have increased from 1990 to 2004 by 7%. Significant increase of emissions can be noted also for Latvia (156%) and Lithuania (92%). The reason of this difference is partly connected to gaps in submitted information on sectoral emissions. In particular, data on emissions from the Petroleum refining sector were reported for 2000-2004 but not estimated for the previous period 1990-1999.

Nevertheless, annual emissions of dioxins and furans have decreased during the period from 1990 to 2004 in some HELCOM countries. The most significant drop of PCDD/F emissions can be noted for Sweden (39%), Estonia (34%) and Russia (34%). Some decrease of emission can also be noted for Denmark (16%) and Poland (9%) (Gusev 2006c).

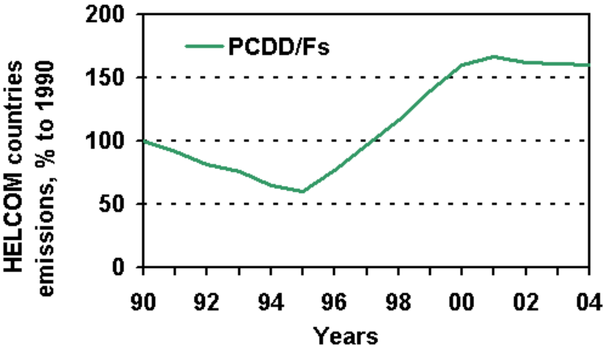

Figure 14. Emissions of PCDD/Fs to air from HELCOM countries in period 1990-2004 (% of 1990) (Gusev 2006c)

Despite substantially increased dioxin and furan emissions from HELCOM countries, the total atmospheric deposition to the Baltic Sea has decreased from 1990 to 2004 by 33% (Figure 15). Following modeling results, only a small percentage of emissions from German sources are deposited to the Baltic Sea. Therefore, when combined with contributions from other sources, the influence of temporal variations in German emissions is not significant to the total deposition over the Baltic Sea (Gusev 2006d).

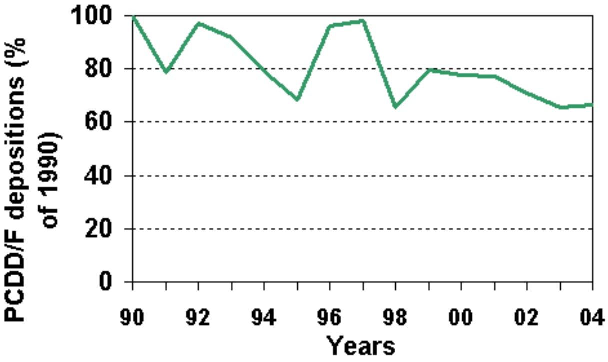

Figure 15. Computed atmospheric depositions of PCDD/Fs to the Baltic Sea in 1990-2004 (% of 1990) (Gusev 2006d)

On the sub-basin level the most significant drop in PCDD/Fs deposition has been in the Belt Sea (40%) and the Gulf of Riga (39%). In spatial distribution of PCDD/Fs depositions on the Baltic Sea, the highest levels can be noted for the Belt Sea. Significant levels of depositions can also be noted for the Kattegat and the Gulf of Riga. PCDD/F deposition is the lowest in the Gulf of Bothnia (Figure 16). Among the HELCOM countries the most significant contributions to deposition over the Baltic Sea belong to Germany, Poland and Russia (Gusev 2006d).

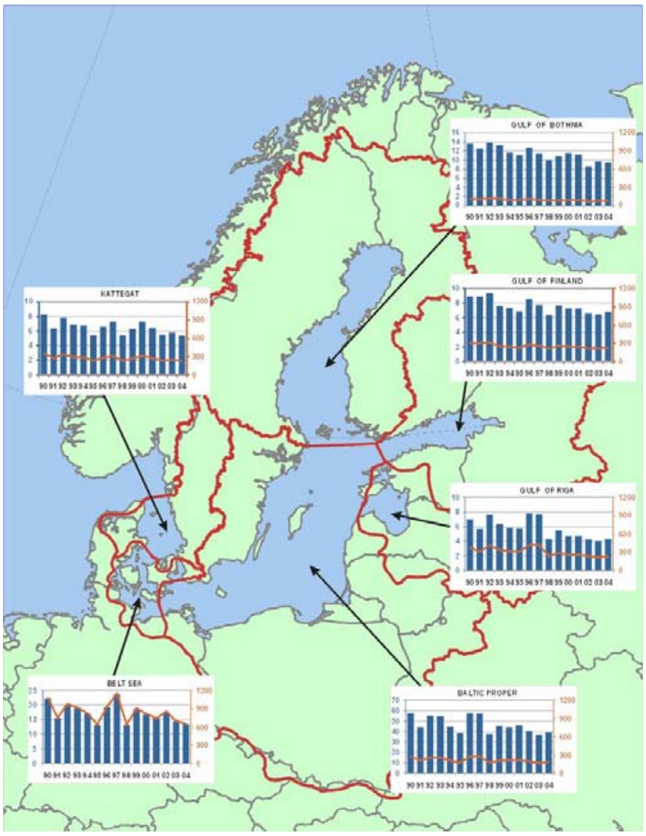

Figure 16: Time-series of computed total annual atmospheric deposition of PCDD/Fs to six sub-basins of the Baltic Sea in 1990-2004 in tons/year as bars (left axis) and total deposition fluxes in mg TEQ/km2/year as lines (right axis). Note that different scales are used for total depositions in g TEQ/year and the same scales for total deposition fluxes (Gusev 2006d).

FURTHER ACTIONS

As a result of the EU enlargement and the development of new EU measures, there is a reduced need for corresponding HELCOM measures. There remain, nevertheless, continuing needs for identifying the specific problems in the Baltic marine environment and reviewing whether measures by the various organizations (Global organizations, EU, HELCOM or national) adequately cover the general obligations of the Helsinki Convention and the HELCOM Objective with regard to the cessation target for emissions and discharges of hazardous substances by 2020 in the whole Baltic catchment area. Particular care should be taken that the interests of all HELCOM Contracting Parties are taken into account. This might generate the need for HELCOM to adopt its own Baltic specific measures.

The basic steps for taking action in HELCOM are:

- Identification of threats;
- Identification of fields of action and the need for measures;
- Screening the coverage / implementation efficiency of existing international and national provisions, and
- Deciding whether to develop new measures at international, regional or national level.

HELCOM assessments show that a significant share of both the air- and waterborne inputs to the Baltic Sea originate in non-HELCOM countries. This means that it is of utmost importance that the results of HELCOM assessments are taken into account in other fora.

The information available on inputs and sources for hazardous substances is much scarcer than that on nutrients and does not allow for a comprehensive assessment of the situation in the Baltic at present.

There is a clear need to efficiently implement already existing regulations concerning hazardous substances, such as implementation of BAT and substitution of hazardous substances in production processes. One particular field with direct impact on the marine environment where implementation of existing HELCOM regulations should be further improved seems to be the dredging and the disposal of dredged spoils. The HELCOM survey shows that TBT concentrations are high in sediments in some areas indicating that disposal of the contaminated material from those areas should be managed in an appropriate way.

In order for HELCOM to be able to influence the development and to co-ordinate its measures with the European Marine Strategy and other international activities affecting the Baltic Sea, HELCOM has started an activity where all available information on certain hazardous substances is jointly evaluated. The aim is to assess the impacts on the Baltic Sea environment and to also provide input to the development of the HELCOM Baltic Sea Action Plan.

The activity focuses on nine organic hazardous substances, that have already been prioritized by HELCOM and other international for a, for which initial information was available at the start of the activity. The activity also includes hazardous substances, such as brominated flame retardants and perfluoro chemicals, which have not been assessed in HELCOM earlier.

HELCOM has collected information on the use of the selected substances in different sectors from available national registers and other sources. Furthermore information has been collected on their occurrence in discharges/emissions to the Baltic marine environment. This information is also being utilised in a HELCOM project which will identify actions for the HELCOM Baltic Sea Action Plan which also covers other toxic substances. Additional information is intended to be collected in a proposed screening study focusing on the occurrence of selected hazardous substances in the Baltic marine environment.

Based on the outcome from available reports, and the work still to be carried out, the most relevant hazardous substances of specific concern in the various sub-regions, their main uses and their most significant sources will be identified. This information will be the basis for developing input, e.g. a joint position by HELCOM countries, to international, regional or national actions. The actions will be based on substance specific as well as sector specific measures, preferably on a plant by plant basis ("hot spot related measures").

The following sections include proposed input/joint positions by HELCOM countries to the international, regional and national actions.

International actions

- EU under relevant Directives/requirements
  - Promote restrictions and bans on use of hazardous substances
  - Influence placing of plant protection and biocides products on the market, if e.g. levels of these substances in the Baltic marine environment are so high that adverse effects on marine organisms are possible
  - Promote substitution with less hazardous substances
  - Develop environmental product labelling (EU flower, Nordic swan, German blue angel) in order to take into account those hazardous substances which have been observed to have harmful effects in Baltic Sea
- Measures under Stockholm POP's Convention (e.g. dioxins, furans)
- Measures UN/ECE framework for hazardous substances

HELCOM / Regional actions

1. Identification of a list of hot spots consisting of plants/sectors among industries and hazardous waste that should be addressed as first priority.

2. Recommendation/introduction of requirements to be adopted in 2007 for:

- Product control measures including substitution with less hazardous substances
- Voluntary agreements with industry
- Modifications of (industrial) processes
- Selection of better quality raw materials
- End-of-pipe solutions (*e.g.* enhanced waste water treatment and reduction of emissions to air)
- Development of more efficient product recycling in order to have less waste
- Demands on industry connected to sewers (e.g. enhanced waste water pre-treatment)
- Amendment of Annex on hazardous substances in convention/Update of HELCOM recommendation for hazardous substances 19/5 concerning substances and actions/requirements

National actions:

- Review of environmental permits for industrial activities, municipal waste water treatment plants and municipal landfill sites in sub-regions prioritizing the activities which have been identified as main uses or sources for these substances
- This includes the actions and timetable proposed at individual plant level identified by the Lead Country activity in cooperation with the Contracting Parties for hazardous substances as well as existing JCP Hot Spots
- Establish and develop national chemical product registers in order to have more reliable substance-specific information on uses and amount of used. It has to be taken into account that existing registers and those under development should be used as much as possible and respective developments under e.g. REACH should be built upon.
- Raising the environmental awareness of consumers/citizens regarding the use of eco-labelled products and the threats of excessive human consumption of limited natural resources to the environment

Other possible actions needed:

- Screening and assessment of further identified sources and effects of selected hazardous substances should be carried out by 200x
- Introduction of the whole effluent assessment approach
- Development of biological effects monitoring
- Development of requirements concerning Import/export of hazardous substances

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ANNEX 1

The estimated significant sources of 8 organic substances presented in Table 1. The industrial sector or professional use has been identified as significant source if the emission factor is relatively high or if it has been identified as risk use in national risk assessment or based on expert judgement. The significance of other activities (e.g. STPs) has been evaluated on the basis of measured effluent concentrations.

Table 1. The estimated significant sources of 8 organic substances

Substance	Sources to aquatic environment	Sources to atmosphere
TBT & TPhT	* anti-fouling use in sea ship hulls (the most significant source for Baltic Sea!) * waste treatment; storm water from waste sorting sites * landfills	considered not important
pentaBDPE	* waste treatment; storm water from waste sorting sites * landfills * STPs * industrial waste water from textile industry & pentaBDPE production	* waste treatment * losses from products during service-life
octaBDPE	* waste treatment; storm water from waste sorting sites * industrial waste water from textile industry & octaBDPE production	* waste treatment * losses from products during service-life
decaBDPE	* industrial waste water from polymer and textile industry * waste treatment; storm water from waste sorting sites	* losses from products during service-life * waste treatment
HBCDD	* industrial waste water from textile industry and laundries * landfills * waste treatment, storm water from waste sorting sites	production of HBCDD
PFOS & PFOS related substances	* landfills * STPs * industrial waste water from metal plating factories, semiconductor and photographic industry, manufacture (and use) of fire fighting foams, paper and packaging protection industry	semiconductor industry
PFOA	* use of PFOA related substances * landfills * STPs * fluoropolymer production	* use of PFOA related substances * fluoropolymer production
NP	* use of NPE-based products, see NPE sources * STPs * landfills * storm water from waste sorting sites and residential area	not considered important
NPE	* industrial waste water from NPE production, pulp and paper industry, paint industry, production (also use) of detergents and cleaning agents, metal working industry,	not considered important

	textile and leather industry, photographic industry and civil and mechanical engineering industry * air transport (anti-icing use) * agriculture * STPs * landfills * storm water from waste sorting sites & residential area	
OP	* use of OPE-based products, see OPE sources * industrial waste water possibly [1] * STPs * landfills * waste treatment; storm water from waste sorting sites	not considered important
OPE	* industrial waste water possibly [1] * STPs * landfills * storm water from waste sorting sites and residential area	not considered important
SCCP	industrial waste water from metal cutting and leather industry and manufacture of fat liquoring products used in textile industry	industrial waste water from metal cutting industry
MCCP	industrial waste water from metal cutting and leather industry	industrial waste water from plastics and rubber industry
endosulfan	agricultural pesticide use	agricultural pesticide use

[1] An assessment is not possible due to lack of information on emission factors