SPECIAL PROBLEMS

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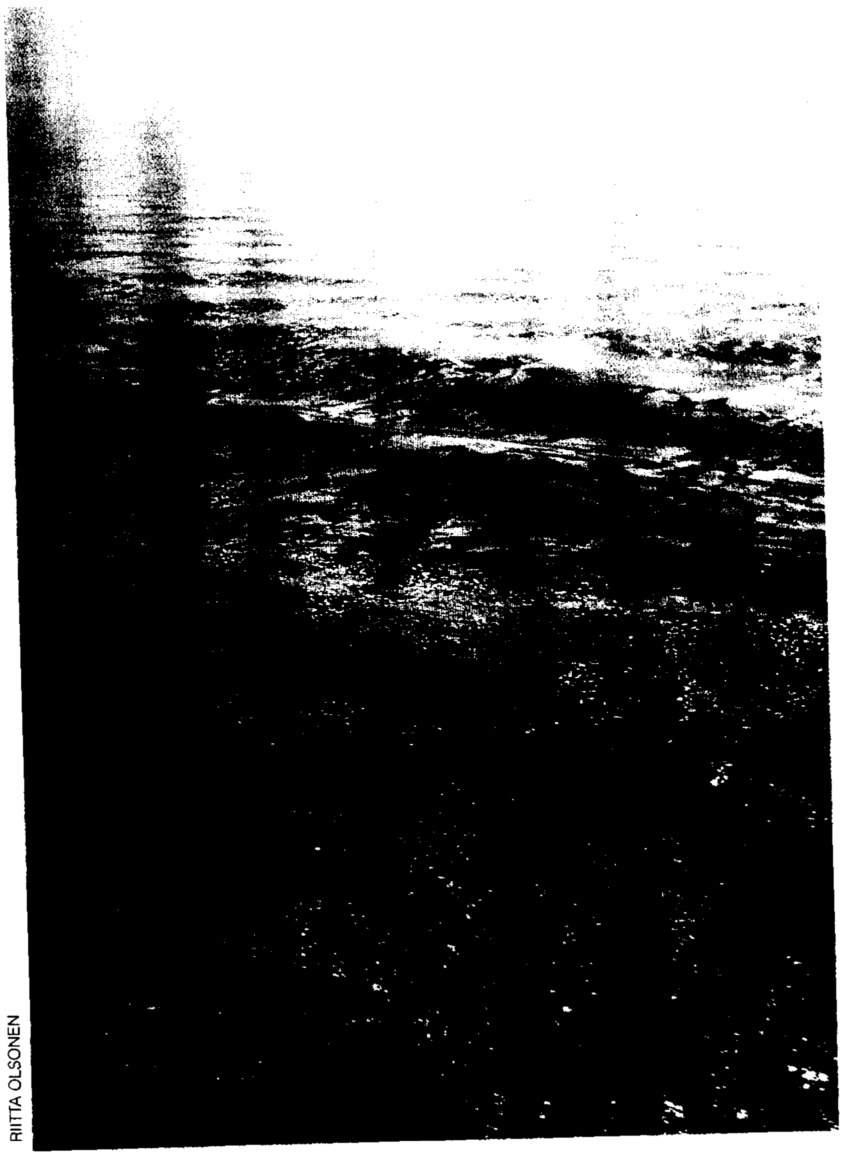

RIITTA OLSONEN

HELCOM

8.1 HARMFUL ALGAE

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8.1 .1 General overview

Among the approximately 5,000 species of marine phytoplankton, 75 to 150 may be harmful. They may be harmful by contaminating marine organisms used for human consumption, resulting in human poisoning. They may kill marine organisms, such as wild and cultured fish, as well as birds and land-based wild and domestic animals. They develop such a high biomass that the recreational value of coastlines is jeopardized, and are as aerosols along the coast which may threaten human health. They may also be harmful without producing toxic substances, by the clogging of fish gills, and develop into such quantities that oxygen depletion, resulting in bottom animal and fish mortality, is caused during their decomposition.

The threats from harmful algae can thus be summarized as
* human health problems,
* poisoning of land-based wild and domestic birds and animals,
* poisoning and mortality of marine organisms.
* ecosystem damage,
* threats to the biodiversity of the sea, and
* economic losses.

Blooms of phytoplankton are common in the sea on a world-wide basis. In recent years, harmful algal blooms or events have become an increasing problem in coastal waters around the world. It is generally agreed that the increased frequency of blooms and harmful events, as well as increased spatial distribution of phytoplankton blooms and indigenous species all over the world is real [*19,626,627*]. At many places, this increase has been linked to the increase of the anthropogenic impact on coastal waters.

The Intergovernmental Oceanographic Commission is presently attempting to evaluate the economic impact of the harmful algal events on a world-wide basis. This, however, is extremely difficult, as many intoxications are never reported. Moreover, much of the impact of harmful algae is difficult to estimate in economic terms. For instance, human intoxication due to toxic algae is considerable. It is roughly estimated that there are 50,000-150,000 cases of human poisoning every year.

Over the last few decades, harmful algal events have extended into areas where toxic or harmful phytoplankton species, or events, were never previously observed. Such spreading has been documented both on a trans-oceanic and regional scale. The spreading of species may arise in several different ways, e.g., natural spreading with currents, shipping of living mariculture products as fish and shellfish, and the transfer of alien phytoplankton in the ballast water of ships. Independent of the mechanism of species transfer, this problem is also increasing in the Baltic Sea.

In the Baltic Sea, problems of harmful algae also occur. In fact, considerable phytoplankton blooms during summer are a characteristic feature of the Baltic Sea. In the Baltic Sea, there are about 30 different species of phytoplankton which have proved to be harmful in the Baltic Sea and elsewhere. Among these, the blue-green algae are most common, forming spectacular blooms nearly every summer. These blooms may result in mortality of domestic animals, mainly cattle, dogs and ducks, through the drinking of water. Very large blue-green algal blooms have been reported from the Baltic Sea since the middle of the last century. Satellite imagery shows that areas up to 60,000 km^2 of the Baltic Sea may be covered by blue-green algal blooms during the summer [*325*].

Toxic events and poisoning caused by blue-green algae in the Baltic Sea have been reported since the beginning of the 1960s (Table 8.1.1, [*152,313,337*]). In addition to ducks, cattle and dogs dying from intoxication, there are also reports that people swimming in the sea during blue-green blooms have suffered from stomach complaints, headaches, eczema and inflammation of the eyes. In some years, there has also &en prohibition of swimming along certain shores where blue-green algae have accumulated [*420*].

Small phytoplanktonic flagellates, e.g.. ***Ptymnesium parvum,*** have caused fish kills in coastal areas of the Baltic Sea, such as the Stockholm Archipelago [*30,711*], along the Finnish coast [*342*], at the island of Rügen and in Danish waters [*314,526*]. There are indications, that some of these blooms were caused by exceptional nutrient conditions. In 1988, an extremely large algal bloom hit the Kattegat, Skagerrak and Sound, covering an area of 75,000 km^2. The small flagellate ***Chrysochromulina polylepis,*** which was responsible for the bloom produced a toxin which killed or affected all sorts of marine organisms, ranging from other phytoplankton and zooplankton to seaweeds, mussels and wild and cultured fish. There was also some indication that the ***Chrysochromulina*** bloom had a direct or indirect negative effect on the survival of eider ducklings. The economic impact due to the bloom was considerable, especially for the fish-farming industry.

There are indications that a mass mortality of sea birds in the Gulf of Finland in 1992 may have been caused by algal toxins, although so far no definite link has been established. A special group of phytoplankton, the dinoflagellates, contains many toxic species. Several of them occur regularly in the Baltic Sea, especially in the Kattegat. Some of the toxins produced by these dinoflagellates have been found in the Baltic Proper, but toxic effects have not been reported. In the Kattegat and Skagerrak, however, mussels accumulate the

Table 8.1.1 Toxic plankton events reported from the Baltic Sea Area [338] (SBP - Southern Baltic Proper)

Year	Location	Species	Affected animals	Reference
1900-33	Waterneversdorf (SBP)	*Prymnesium parvum*	fish	*[250]*
1963	Rügen (SBP)	*Nodularia spumigena*	~400 ducks	*[313]*
1970	Darß (SBP)	*Prymnesium parvum*	fish	*[314]*
1975	Fehrmarn (Belt Sea)	*Prymnesium parvum*	fish	*[250]*
1975	Danish coast	*Nodularia spumigena*	30 dogs sick, 20 died	*[420]*
1982	Swedish coast	*Nodularia spumigena*	9 dogs	*[152,414,430]*
1983	Genan coast	*Nodularia spumigena*	16 young cattle	*[338]*
1984	Finnish coast	*Nodularia spumigena*	1 dog, 3 puppies	*[538]*
1988	Skagerrak Kattegat, Sound	*Chrysochromulina polylepis*	large-scale effects	*[338]*
1990	small coastal inlet, Finland	*Prymnesium parvum*	fish	*[419]*
1990	Rügen (SBP)	*Prymnesium saltans*	fish	*[330]*
1991	shallow coastal lake	*Prymnesium parvum*	sea birds	*[256]*
1992	Eastern Gulf of Finland			*[326]*

[1] see ANNEX 11.3 for addresses of authors

toxins almost every year, causing economic loss following the harvest ban. Other dinoflagellates in the Kattegat occasionally form blooms with such a high biomass, that oxygen deficiency develops, when they sink to the deep water and consume oxygen during their decomposition. Since the beginning of the 1980s, oxygen deficiency in the Kattegat during the early autumn is a recurrent phenomenon which is spreading over larger areas.

8.1.2 Species distribution

Species distribution in 1993 - In the unattended monitoring system [*409*], 22 potentially toxic phytoplankton species were found. The material, covering 1993, shows the spatial and temporal distribution of the species. In 1993, ***Aphanizomenon flos-aquae*** was present in all sea areas during the growth season. Other blue-green algal species were more concentrated in the late summer and autumn. Many potentially toxic dinoflagellates were encountered in most areas of the Baltic Sea, and ***Chrysochromulina*** species were almost constantly present in all areas. The material clearly indicated differences in the distribution patterns.

The analysis of the distribution of harmful species material was based on information in the HELCOM database and on data gathered from national sources. The results are presented as species-distribution maps (Fig. 8.1.1).

Diatoms and other chrysophytes - A number of potentially harmful diatoms were found in the Kattegat, Belt Sea and Arkona Basin (Fig. 8.1.1). Only *Chaetoceros* ***dunicus*** has been reported from the whole Baltic Sea. For some reason, ***Chaetoceros borealis*** was mainly reported from samples taken between 1979 and 1985. Since then it has been identified as ***C. dunicus*** **and** thus the earlier reports may be false. For the Gulf of Finland, the misidentification of ***C. dunicus as C. decipiens*** is also possible as the distribution pattern of ***C. decipiens*** appears to be rather unique, i.e., with plenty of reports just from the Kattegat and the Gulf of Finland, and no reports from other areas of the Baltic Sea. ***Pseudonitzschia-pungens*** has been a permanent part of the phytoplankton community in the Kattegat, Belt Sea and Arkona Basin. Possibly **because** its identification started only in 1990, *P. pseudodelicatissima* was reported only from 1986 to 1993.

Two potentially toxic small flagellated chrysophytes have been reported, ***Chrysochromulina polylepis*** and ***Prymnesium parvum. C. polylepis*** had a widely distributed bloom in 1988. However, it is not likely that the present material can give a full picture of the distribution of these two species, as their positive identification requires electron microscopy. A toxic strain of the sihco-flagellate ***Dicryocha speculum*** caused fish kills in Danish waters in the 1980s. This species has been present in the area during the last ten years.

Dinoflagellates - Dinoflagellates are a group of phytoplankton with potential harmful effects on Baltic Sea ecosystems. Several genera of dinoflagellates consist of toxic species. Two widely distributed genera can be found over **most of** the Baltic Sea. These are ***Dinophysis*** **and** *Prorocentrum*. From the three ***Dinophysis*** **species,** ***D.*** *acuminata* may be found over the whole Baltic Sea and ***D. norvegica*** from all other areas except the Bothnian Bay. ***D.*** *acuta* is lacking from the Gulf of Bothnia. The distribution patterns of ***D.*** *acuminata* and ***D. norvegica*** showed no changes, but ***D.*** *acuta* has changed its distribution by expanding into the Baltic Proper and the **Gulf** of Finland during 1986-93. However, this should be subjected to a more detailed analysis as such a drastic change could also be due to problems in the taxonomy of the genus.

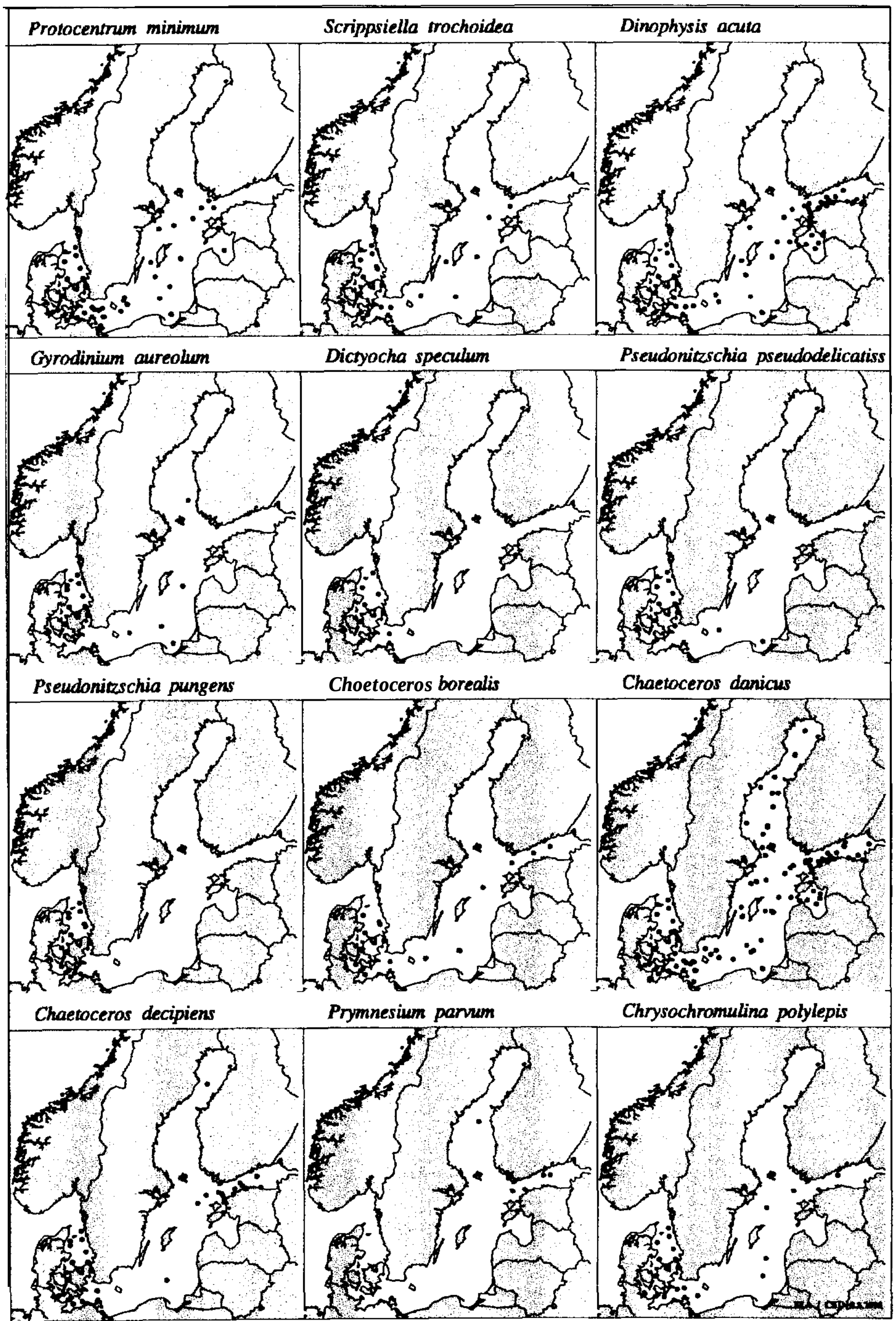

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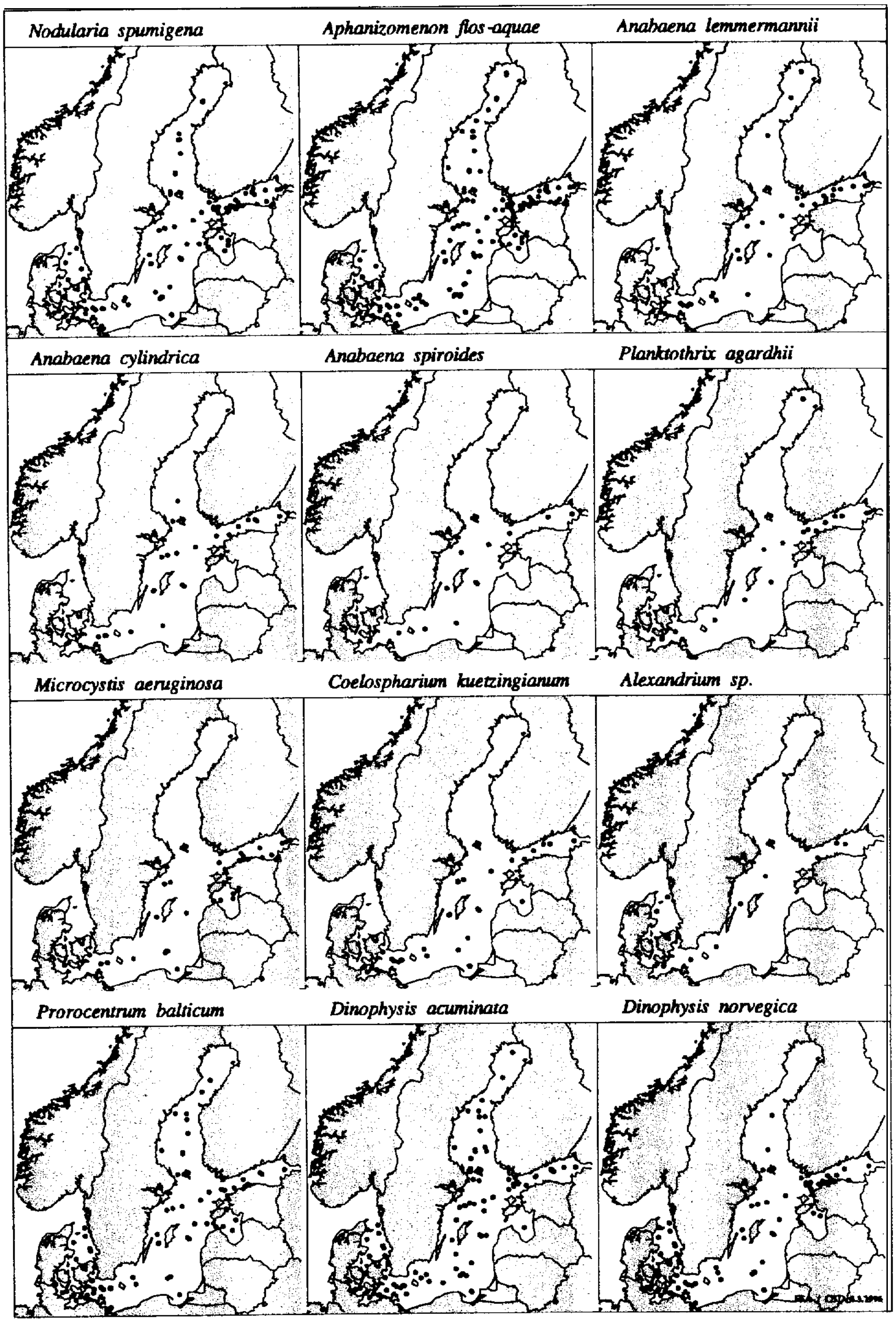
Fig. 8.1.1 ***Species-relatedoccurrence of harmful algal blooms in the Baltic Sea***



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Prorocentrum** balticum* has been a common species throughout the monitoring period, but it seems that ***P. minimum was more common in the Central Baltic Proper in 1986-93.

Another group of potentially harmful dinoflagellates includes marine species found more frequently from the Kattegat during 1986-93. These species include ***Alexandrium*** spp., ***Gyrodinium aureolum*** and ***Scrippsiella trochoidea.***

Blue-green algae - Blue-green algal blooms are a common part of the Baltic Sea ecosystem. Although the heaviest blooms are not common in the Bothnian Bay, bloom-forming species can be found throughout the Baltic Sea. The species ***Anabaena lemmermannii, Aphanizomenon jlos-aquae*** and ***Nodularia spumigena*** have a wide distribution (Fig. 8.1.1). Anabaena lemmermannii seems to occur over most of the Baltic Sea. However, no clear changes in the distribution of blue-green algae can be observed. Another component of the Baltic Sea blue-green algal community are species favouring fresh- or diluted brackish-water environments. These species include Coelosphaerium kuetzingianum, Microcystis aeruginosa and Planktothrix agardhii. In the assessed material, these three species showed the same distribution pattern. They were reported from the whole Baltic Sea except the Gulf of Bothnia. Two other species, Anabaena cylindrica and Anabaena spiroides, were more frequently encountered during the period 1986-93. However, the material lacks information on coastal waters, in which they are commonly found.

8.1.3 Summary

The assessment has shown that potentially harmful algae are present in all parts of the Baltic Sea. Thus concern on their distribution and the monitoring of their abundance is highly justified. Most of the potentially harmful species appear to be found mainly in the Kattegat, Belt Sea and Arkona Basin, but clear cases of distribution northwards have been documented.

The nature of the material restricts detailed analysis of certain species. However, some recommendations are possible:

- The identification of some species requires special techniques. If the distribution of small flagellates, e.g., ***Chrysochromulinapolylepis*** and *Prymnesium* ***parvum,*** is to be monitored, their identification must be based on electron microscopic analysis. Also the species analysis of many dinoflagellates requires special techniques. A quality-controlled system should therefore be established for the analysis of taxa requiring special techniques.
- Some species have been reported to the database only for a certain period, e.g., from 1979 to 1985, and not later. This may be due to changes in the identification and/or taxonomy. However, when these changes occur, the existing database should be critically evaluated and corrected. A critical evaluation should also be made if a taxon is divided into two separate taxa, or if two or more are joined to one taxon.
- All records of potentially harmful species should be reported annually to an expert group which should confirm the records.

8.2 SANITARY CONDITIONS IN COASTAL WATERS

The hygienic quality of the beaches is of great importance for general recreational purposes, tourism and other uses. There are national as well as international standards and recommendations for control of the bacteriological quality of water. Among international guidelines can be mentioned those of the European Community (EC). One of the first directives within the EC in the environmental field was adopted in December 1975 (76/160/EEC).

The systems **used** for the determination of the sanitary conditions, e.g., for bathing and swimming, are generally based on examinations of bacteria, such as coliforms, streptococci, salmonella and enteroviruses in the waters. This control is often combined with analyses of physical and chemical parameters, in addition to visual inspections. The faecal coliforms, often being the key parameter in the assessments, have a limited survival in marine waters. This directs the problems to near-shore areas and especially to the mixing zone between fresh water and sea water.

All countries reporting on sanitary conditions have pointed out that the conditions at some beaches are particularly dependent on meteorological conditions, mainly the directions of wind or, e.g., a temporary cleaning of the beach during a storm. In these cases, the period for prohibition of a beach is dependent on the frequency of regular controls or initiatives taken by local authorities. Within a wide archipelago, where the isolation and temporary stagnation of water exchange is frequent, the beaches are especially sensitive.

The various control routines, the application of standards and the categorisation of conditions differ between the countries. It is therefore necessary, to present and comment data on an individual national basis. The text presented here is compiled by ***Eeva-Liisa Poutunen,*** Environment Secretary of HELCOM, on the basis of information provided by the countries.

Denmark

The classification of water quality for bathing mainly follows the EC directive, with the exception of the number of faecal coliforms, 1,000 per 100 cm^3, which is half the value accepted by EC. This limit must not be exceeded for more than 5 % of the bathing season.

For 1995, the data were presented together with a detailed bathing-water map. The situation in Denmark as a whole, including the western and inland waters, showed improved conditions compared to 1994. In 1995, there were 1,301 (1994: 1,288) monitoring stations, of which 1,225 (1994: 1,232) met the water quality requirements. Based on the results obtained at 22 (1994: 23) monitoring stations, the number of banned sites was 20 (1994: 21), but there were 52 (1994: 33) sites with doubtful bathing water quality.

A calculation of figures relating to the Convention Area for 1995 gives a coastline of approximately 6,000 km, of which about 4,000 km are suitable for bathing. Taken together, the sites, where bathing is prohibited, cover a coastline of 10 km in length.

The data presented in Table 8.2.1 show that 22 monitoring stations have prohibited bathing, which corresponds to 20 banned sites, while the number of sites with doubtful bathing water quality is 52, including a total of 54 monitoring stations with doubtful quality.

Table 8.2.1 ***National reports on total number of beaches controlled mainly during 1995, and decisions taken for bans on bathing***

Country	Total number controlled	Doubtful quality	Bathing prohobited
Denmark *	990	33	19
Estonia	33	2	4
Finland	100	1	0
Germany	306	1 **	0
Latvia	36	9	0
Lithuania	20	1	4
Poland	82	15	4
Sweden	500	30	1

* - monitoring stations (Denmark without the western and inland waters)
** - Schleswig/Holstein

Estonia

Health protection authorities control the sanitary conditions at 100 bathing places, including 24 larger beaches. Although, bathing conditions have been improved during the last years, improvement has been faster at the beaches of lakes and rivers than at the marine beaches. ***The Coli-index*** has been in a range of lO,OOO-70,000, with a pathogenic microflora being absent in most of the cases. Conditions at the former most polluted area, the Pärnu Bight, have been improved.

In July 1995, ***Chloreae inaba*** and ***Chloreae ogava*** were found on the northern coast at the Aa beach. After identification of the non-pathogenic character of the vibrions, the beach was re-opened. ***The Heiberg vibrio*** pathogens were only detected in occasional cases at the Aa beach and the Pärnu beach, but rather frequently at the beaches of the western coast of the Estonian mainland.

The Paralepa beach in Haapsalu Bight and the Stroomi beach (not listed for bathing) were closed during the summer of 1995. All the other beaches were opened for bathing.

Finland

The national classification of the Finnish beaches is based on the number of thermotolerant coliform bacteria and faecal streptococci per 100 cm^3. Values below 100 indicate good conditions, IOO-1,000 moderate, while those exceeding 1,000 indicate poor quality.

The first national review concerning the hygienic quality of bathing waters in 1995 was recently published. 73 % of all beaches were in excellent condition according to the Finnish standards and only 1 % were poor. One hundred individual coastal beaches are included in the EU Bathing Water Directive reporting system. The quality criteria were met by 80 of them, while only one did not fulfil the obligatory requirements (although the poor quality of this beach was just temporary).

A short compilation of the hygienic status of 50 beaches of the five largest coastal cities was done in 1993. In general, the hygienic quality of water was good on most study occasions, and occasionally poor quality occurred in inlets with poor water exchange. During the last 4-5 years (from 1992), bans have been imposed on only two beaches in these towns (once because of the breakdown of a pumping station). The water protection measures conducted are reflected in the hygienic status of bathing water. For example, a third of beaches of Helsinki were repeatedly classified as poor in the 1960s. Since then, in the 1970s and 1980s, only a few similar occasions have been reported, and during recent years, more than half of the beaches are classified as good in Helsinki.

Germany

Almost 200 bathing sites along the 340 km of coastline of Mecklenburg-Vorpommem and 21 sites on the banks of Bodden areas have been investigated by government laboratories in Greifswald and Rostock, once a fortnight during the bathing season (15 May to 10 September) in 1990-95. Since 1990, investigations and assessments have been based on the EC guideline from 8 December 1975 for the quality of bathing water. The guideline states, how bathing waters are to be judged in accordance with hygienic criteria. Total colifonn bacteria and faecal coliform bacteria, facultatively ***Streptococcusfuecalis*** and, where justified, salmonella and intestinal viruses, are regularly investigated (cf. Table 8.2.2).

From a sanitary standpoint, chemical investigations are of secondary importance. They are carried out specifically only when a 'tendency towards eutrophication of bathing waters' exists.

The site of each sample was visited and an appraisal made of its standard hygiene with the following result:
a) Bathing sites found to be very suitable for bathing, i.e., no contamination was found: 1993 - 113, 1995 - 133;
b) Bathing sites found to be suitable for bathing, i.e., slight contamination was occasionally found: 1993 - 20, 1995 - 3;
c) Bathing sites found still suitable for bathing,

Table 8.2.2 Results of studies on the sanitary conditions at about 200 beaches at the shores of Mecklenburg-Vorpommern (Germany), 1993 and 1995

Parameter	Number of studies		Samples <Guide value		Samples >Guide value & <Imperative value		Samples >Imperative value	
	1993	1995	1 9 3	1995	1993	1995	1993	1995
Total coliform bacteria	1,625	1,604	1,457	1,458 (90.0 %)	152 (9.3 %)	126 (7.8 %)	16 (1 %)	20 (1.2 %)
Faecal coliform bacteria	1,625	1,604	1,363 (83.9 %)	1,456 (90.8 %)	238 (14.6 %)	148 (9.2 %)	24 (1.5 %)	16 (1 %)
Faecal streptococci	23	150	13	148	10	2		

Guide values: total coliform bacteria per 100 cm^3 <500; faecal coliform bacteria per 100 cm^3 <100; *Streptococcus faecalis* per 100 cm^3 <100;

Imperative values: total coliform bacteria per 100 cm^3 <10,000; *faecal coliform* bacteria per 100 cm^3 <2,000

i.e., contamination was found:
1993 - 11, 1995 - 3.

Storms and strong accumulations of algae deposited on the beach impeded the collection of samples and occasionally influence the results in a negative way. No bathing sites were closed.

The tendency for the microbial contamination to decrease could possibly be explained by the installation of, or improvements in waste-water treatment plants (Greifswald, Stralsund, Bergen, Kühlungsborn, Wismar, island Poel).

Twenty one bathing sites on the banks of the 'boddens' (Dar8 Bodden Chain, Achterwasser /Usedom) have permanently a transparency <1 m, caused by eutrophication.

Latvia

The water quality at beaches is monitored from May to September. Bathing is not prohibited if the lactose-positive coliform bacteria (LPCB) content does not exceed 5,000 cells per liter, *E. coli* <1,000, staphylococci <100, coliphages <100, and no pathogenic microflora are found.

Beaches of good quality exist in the north-western part of the Gulf of Riga. Most polluted beaches were from the mouth of the river Daugava to the Estonian border, and bathing in this territory is prohibited. The water quality of Liepaja City beaches occasionally does not meet the requirements, and bathing was prohibited for several weeks.

A tendency for microbial contamination to decrease is also observed at Jürmala beaches. This could be explained by the recent *opera*tion of the Riga water treatment installations, as well as by a decrease in the number of visitors to the area. Bathing in Jürmala was prohibited only in some cases in year 1993.

Lithuania

According to the 1988 requirement, the ***Coli-index*** was 500 per 100 cm^3. After 1992, this standard was changed to 100-500. The hygienic service permits beach activities (e.g., bathing) when the *Coli-index* does not exceed 2,500/100 cm^3 and there is an absence of pathogens.

During 1992-93, beaches in the vicinity of Klaipeda were periodically closed. In 1994, this happened only on two occasions, but in 1995, there were no closures. The sanitary conditions are affected by discharges from the town and by the direction of the wind. Maximum mean values for the season, 10,000/100 cm^3, were reported from beaches at Melnrage during 1991. Via the Klaipeda Strait, the mixture of river water and waste products closely follows the coastline, moving mainly northwards. The best water quality for bathing is reported from the Neringa beaches which are located along the coast south of Klaipeda, facing the Baltic Proper.

Poland

The faecal coliform index is used as the key parameter of bacterial pollution level. Waters are classified into four quality groups, according to the value of this index, with the number of faecal coliform bacteria per 100 cm^3 increasing in a logarithmic scale, i.e., water class

- *I* -5100,
- [illegible] - 100-1,000,
- *III* - 1,000-10,000, and
- IV - >10,000.

In compliance with legal regulations, only the water quality groups ***I*** and ***II*** are allowed to be used for bathing and water sports.

The frequency of collecting water samples, the length of the research period and the method of determining bathing usability are regulated by the Ministry of Health and Social Care. According to them, the examination of beaches needs to be continued for a period of 9 months (March-November), and only at those sites, where at least 70 % of the results comply with the criteria for the water quality groups ***I*** and II, are allowed to be used for bathing.

On the basis of the examination results and the above mentioned method for estimating sanitary conditions of sea water, all controlled bathing beaches are classified as either
a) very clean (if all results comply with the criteria for groups ***I*** and ***II***),
b) clean (if at least 70 % of the results comply with the criteria for groups I and ***II***),
c) uncertain (in case of minimal excess of the item b) requirements),
d) polluted (if more than 10 % of the results comply with the citeria for group ***IV,*** but if there have been also results complying with the quality groups I and ***II***), or
e) seriously polluted (if more than 10 % comply with the citeria for group ***IV,*** and there have not been results complying with the criteria for groups ***I*** and ***II***).

Irrespective of the level of faecal colifortn bacteria pollution, the finding of the *Salmonella* sp. classifies the bathing beach as polluted or seriously polluted.

At the majority of stations, the highest level of pollution was observed in 1992, and the lowest one in 1995. Increasing numbers of clean bathing beaches were noted in the Slupsk, Gdansk and Elblag voyvodships. It is worth stressing, that the increase at Elblag voyvodship was particularly high, i.e., from 35 % to 71 %. Positive changes noted since 1995 are the results of efforts made by local authorities to decrease the pollution load discharged into the sea. The scale of the improvement recorded in 1995 is compared with the results of the four-year research cycle (1992-95) and presented in Figure 8.2.1.

Generally, the sanitary state of the water at the Polish coastal zone in 1992-95 may be described as 'satisfactory' based on the fact that 72 % of all bathing beaches were 'very clean' and 'clean', 16 % 'uncertain', 9 % 'polluted', and only about 3 % 'seriously polluted'. The sanitary state of the bathing beaches, situated near the open sea is considerably better than those situated in Gdansk Bight. This is shown below in percentage of the total number of bathing beaches for each category.

	very clean and clean	uncertain	polluted	seriously polluted
open sea	84	14	2	0
Gdansk Bight	42	21	27	10

A permanent improvement of the sanitary state of the Polish bathing beaches has been recorded for the last three years.

Sweden

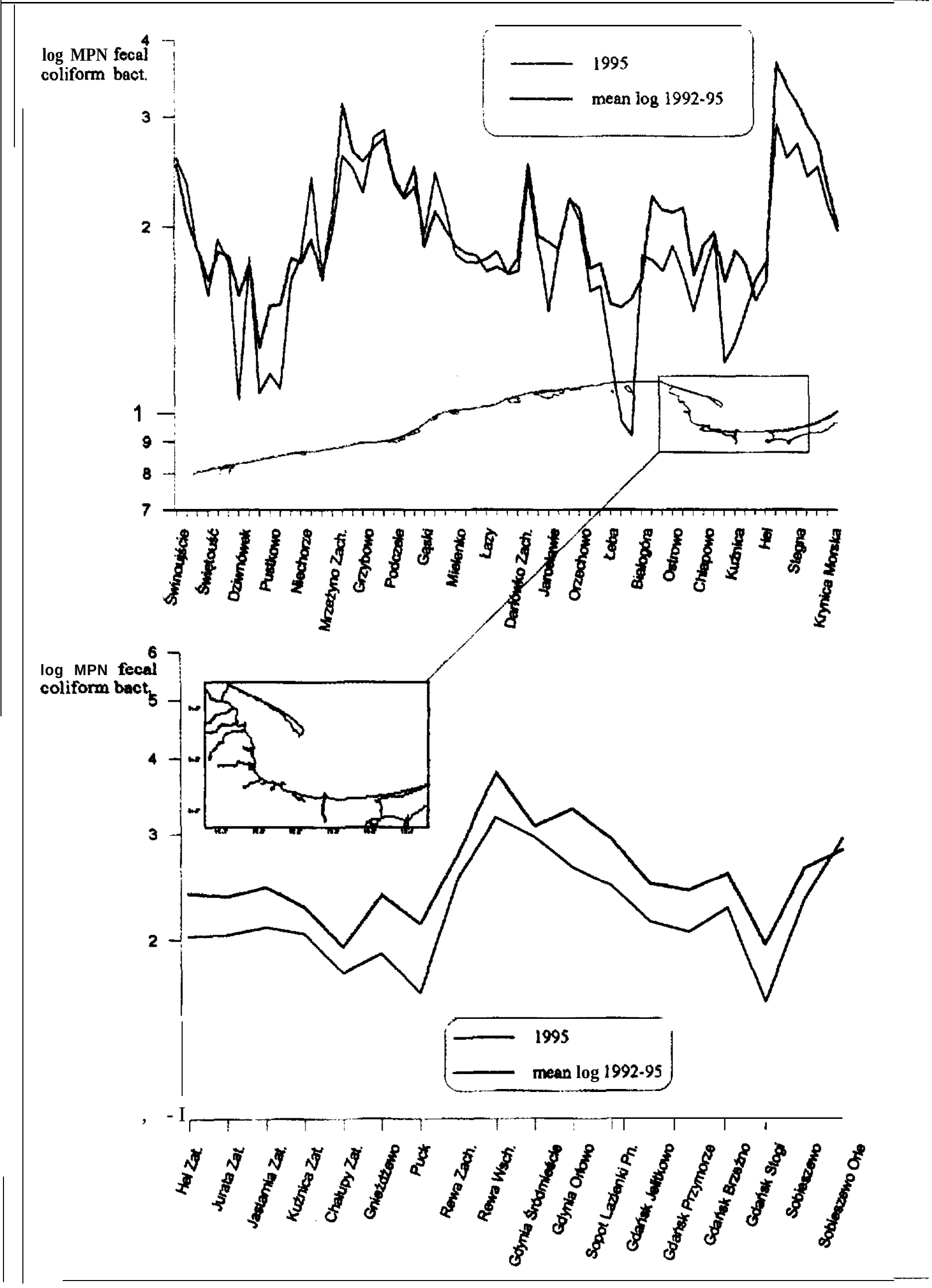
A summary of the bacteriological quality of the Swedish bathing areas has been done for 1993-95, and bathing maps for each county were produced. During that period, the EC directive was not followed and no chemical analyses were done. The frequency of sampling varies considerably, from once a week to once a year. The recommendation is, that the samples should be taken twice a month during the bathing season.

The limits for classification of Swedish beaches are given in numbers per 100 cm^3:

	Suitable	Suitable with reservations	Unsuitable
Presumptive E. coli	<100	100-1,000	>1,000
Presumptive faecal streptococci	<30	30-300	>300
Coliform bacteria 35 °C		>1,000	

Around 500 beaches are controlled along the Swedish coast. Generally, the water quality is very good, but there are a few places with higher amount of faecal bacteria, especially along the most southern part of Sweden. This happens occasionally, and often in connection with heavy rain. During the period 1993-95, 30 beaches have had doubtful quality during oneormoreyears. Only one beachisclassified as not suitable for bathing.

Fig. 8.2.1 Sanitary conditions of coastal waters along the Polish shore of the Baltic Sea, and of the Gdansk Bight in more detail, 1995, compared to the mean value during the period 1992-95



8.3 DUMPING OF CHEMICAL MUNITION

8.3.1 Introduction

The various problems to the environment, arising from dumping of chemical munitions in the Baltic Sea Area many years before the Helsinki Convention was signed, have been dealt with at several meetings in the framework of the Convention. In 1992, the Helsinki Commission decided to convene a special working group to deal with problems related to dumped chemical munitions, taking into account that, in the beginning of the 1990s, intensive rumors circulated in the press and elsewhere about new dump areas for chemical munitions in the Helsinki Convention Area, and that >300,000 t of chemical munitions had been dumped in the Convention Area.

Information on the chemical munitions dumped in the Baltic Sea was compiled by the special working group (*ad hoc* Working Group on Dumped Chemical Munition, HELCOM CHEMU), under the leadership of Denmark, on the basis of national reports provided to the Helsinki Commission by all the Contracting Parties and observers, including from United Kingdom, United States of America and Norway, as by end of 1993. The 'Report on Chemical Munitions Dumped in the Baltic Sea' was submitted for approval by the Commission in 1994 [*239*].The report does not contain information on munitions dumped after World War I, neither does it contain information on dumping of conventional ammunition. Information on dumpings up to 1947 is included in the report (except for the dumping of 200 t by the former GDR in the 1950s).

The mandate of the working group was prolonged by the Commission in 1994, with a request, to follow and implement the substantial recommendations provided in the report. All the Baltic Sea States were requested to provide the Commission by 1995 with information and official documentation concerning chemical munitions dumped after 1947.

Following the decision by the Commission, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden subsequently reported that there were no dumping activities of chemical munitions by their respective countries after 1947. Information on the dumping activities by the former GDR after 1947 was already included in the report to the Commission [*239*]. Russia confirmed that the

Russian national report submitted to HELCOM contained all available information on dumping activities by the former USSR [*230*].

The 16th meeting of the Commission endorsed the final report of the working group [*242*] and agreed on several proposals for further actions, which mainly dealt with studies and investigations of the chemical processes of warfare agents and ecological effects of such processes. Furthermore, the Commission confirmed that, according to existing knowledge, dissolved warfare agents are not a wide-spread risk to the marine environment.

8.3.2 Types, quantities and properties of dumped munition

Chemical warfare agents are chemical compounds which through chemical or biochemical reactions interfere with the physiological functions of the human organism in such a way, that the combat capability of soldiers is impaired or that death is caused. Chemical warfare agents are gaseous, liquid or solid substances for anti-personnel use, they are mostly contained in shells and bombs. They are released in the air or sprayed.

Chemical weapons were used in World War I and caused the deaths of around 100,000 men and disabled about 1.2 10^6. Although large amounts of chemical warfare agents were produced and developed during World War II (around 65,000 t of warfare agents in Germany), they were never used in Europe. Mustard gas was the most widely produced, accounting for around 39 % of total production. In Table 8.3.1, the quantities of chemical warfare agents produced in Germany are shown.

Based on their effects, the chemical warfare agents can be classified into
- tear gases (lachrymators): chloroacetophenone (CAP),
- nose and throat irritants: Clark I, Clark II, Adamsite,
- lung irritants: phosgene, diphosgene,
- blister gases (vesicants): sulphur mustard, nitrogen mustard, Lewisite,
- nerve gases: tabun, and
- additives, such as monochlorobenzene, are made to the warfare agents in order to change their physico-chemical properties.

Furthermore, the dumped chemical munitions might also contain certain amounts of explosives. Leaching of persistent and bioaccumulable substances (N-compounds) from this material might occur. It is worth noting, that most specified quantities of the dumped chemical warfare materials referred to in this chapter are gross weights based on the weight specifications for the material when it was dumped.

Around 34,000 t of chemical munitions, containing about 12,000 t of chemical warfare agents, were dumped east of Bomholm and near Gotland in 1947 and 1948, on orders of the Soviet Military Administration in Germany (SMAD) [*230*]. In Tables 8.3.2 to 8.3.4 are given the types of chemical munitions and the amounts of chemical warfare agents that were dumped.

Earlier, it was estimated that between 36,000 t and 50,000 t of munitions have been dumped east of Bomholm and south-east of Gotland (south-west of Liepaja). These munitions contained chemical warfare agents of the types blister-, vomiting-, tear agents and phosgene. Based on the information currently available, the estimate of the quantity of chemical munitions dumped east of Bomholm and south-east of Gotland can be reduced to around 34,000 t. However, due to the new information [*230*] and the high proportion of aircraft bombs, the average chemical agent content was higher than the 15 % hitherto assumed. In earlier estimates, the quantities of chemical agents have

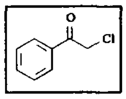
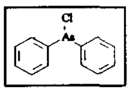
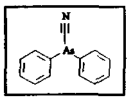
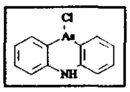
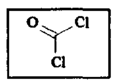
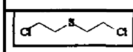
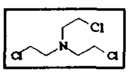
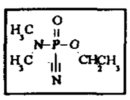
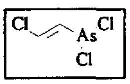
Warfare agent	Quantity [t]	Structure	Melting point [°C]	Boiling point [°C]	Vapour pressure [mmHg] 20 °C	Density [g cm^{-3}]	Aqueous solubility [g dm^{-3}]
Chloroacetophenone (2-Chloro-1-phenylethanone)	7,100		54-56	244	13x10'3	1.32	1
Clark I (Diphenyl arsine chloride)	1,500		36-44	307-333	16×10^{-4}	1.422	2
Clark II (Diphenyl arsine cyanide)	100		30-35	290-346	47×10^{-6}	1.45	2
Adamsite (10-Chloro-5-hydrophenarsazine(10))	3,900		195	410	2×10^{-13}	1.65	2x1 0^{-3}
Arsinic oil*	7,500						
Phosgene (carbon dichloride oxide)	5,900		-129	7.6	1,178	3.4	9
Mustard gas (2,2'-Dichlorodiathyl-sulfide)	25,000		14	228	0.72	1.27	0.8
Nitrogen mustard (2,2',2"-Trichloro triethylamine)	2,000		-4	236	11×10^{-3}	1.24	0.16
Tabun (P-Cyano-N,N-dimethyl phosphonamid acid ethyl ester)	12,000		-50	246	0.07	1.07	120
Lewisite (dichlor-(2-chlorvinyl)-arsane)	Production small, but unknown		-18	190	0.35	1.89	0.5

Table 8.3.1 Important chemical warfare agents produced in Germany between 1935 and 1945 [229]

'Mixture of arsenic-containing compounds with the main ingredients being *Pfiificus* (phenyldichloroarsine), Clark I, arsenic trichloride and triphenyl-arsine been calculated to be about 6,000 t based on a 15% level of chemicals in the munitions. Table 8.3.5 gives an overview of quantities of chemical munitions and warfare agents dumped in the Helsinki Convention Area.

About 200-300 t of chemical munitions residues, discovered after 1952 in the former GDR, were dumped east of Bomholm [229]. In addition, it should be mentioned that witnesses reported that four ships containing around 15,000 t of chemical munitions were dumped south-west of Rønne (Bomholm) in 1946. Witnesses also reported that, in 1956. four decommissioned East German coastal patrol vessels were loaded with chemical munitions (around 50 t) and were sunk south-west of Rønne, and unconfirmed reports claim that about 8,000 t of chemical munitions were dumped east of Bomholm in addition to those mentioned in Table 8.3.4 [229]. None of these dumpings have been confirmed by other sources.

In 1960, the tabun shells, which were sunk at the southern entrance to the Little Belt, were raised, leaving a residue of about 5,000 t of chemical munitions (phosgene and nerve gas). However, to date, no catch or findings of chemical munitions or parts thereof have been registered in the specific area. Only phosgene and tabun munitions were dumped, and these substances are rapidly degraded in sea water. In addition, mostly thin-walled bombs, whose casings rust fairly quickly, were dumped at this location [229].

Types of chemical munitions and quantities of warfare agents dumped in the Helsinki Convention Area under control of the former Soviet Union -in t- [230]

	Mustard gas	As-cont.	Adamsite	CAP	Others	Total
Aircraft bombs	6,432	984	642	520	.	8,578
Artillery shells	729		66	39	-	834
High-explosive bombs	341					341
Mines	46					46
Encasements	87	221	753		80	1,141
Smoke grenades	.		71			71
Containers		1,004	.			1,004
Drums			20			20
Total	7,635	2,209	1,552	559	80	12,035

Table 8.3.2 **Total amounts**

	Mustard gas	As-cont.	Adamsite	CAP	Others	Total
Aircraft bombs	512	78	51	41		682
Artillery shells	58	.	5	3		66
High-explosive bombs	27	.				27
Mines	4	.				4
Encasements	7	18	60	-	6	91
Smokegrenades	.	.	6	.		6
Containers		80	.	-		80
Drums			2	.		2
Total	608	176	124	44	6	958

Table 8.3.3 **Southeast of Gotland (southwest of Liepaja)**

	Mustardgas	As-cont.	Adamsite	CAP	Others	Total
Aircraft bombs	5,920	906	591	479	.	7,896
Artillery shells	671	.	61	36	-	768
High-explosive bombs	314	-	-			314
Mines	42	.				42
Encasements	80	203	693	-	74	1,050
Smokegrenades	.	.	65	.		65
Containers		924	.	.		924
Drums			18	.		18
Total	7,027	2,033	1,428	515	74	11,077

Table 8.3.4 **East of Bomholm**

	CMs (t)	WAS (t)	WA type
Bornholm Basin (East of Bornholm)	~32,000	~11,000	mustard gas, viscous mustard gas, Clark I, Clark II, Adamsite, chloroacetophenone; (less certain: phosgene, nitrogen mustard, tabun)
East of Bomholm	(n.v.)	8,000	no information
Area SW of Bornholm	~15,000 (n.v.)	.	no information
Gotland Basin (SW of Liepaja)	~2,000	~1,000	mustard gas, Adamsite, chloroacetophenone
Little Belt	~5,000	750*	tabun, phosgene
Måseskär, w of Sweden (outside the Helsinki Convention Area)	~20,000 (q.n.v.)	.	mustard gas (other types n.v.)

** (estimated at 15%)*
n.v. - not verified
q.n.v. - quantity not verified

Table 8.3.5 Quantities of chemical munitions (CMs) and types and quantities of chemical warfare agents (WAs) dumped in the Helsinki Convention Area [228-230], and at Måseskär (west of Sweden) in the southern part of Skagerrak [231]

Dumping outside the Helsinki Convention Area- - In 1964, 462 tabun shells were recovered from Wolgast harbour (former GDR), set in concrete blocks and dumped in the Norwegian Sea [229]. From 1945 to 1948, on the orders of the British and American occupation forces, confiscated German merchant ships were loaded with large quantities of chemical munitions and these were subsequently sunk. Records show, that one ship was sunk in the Norwegian Sea and 26 named and 6-8 unnamed vessels were sunk in the Skagerrak, together with an estimated 130,000 t of chemical munitions and conventional ammunition, at a position 25 nautical miles south-east of Arendal in the Norwegian Trench [228,229,232,241].

In addition, the wrecks of eight rather small naval vessels and a medium-large cargo vessel were sunk at a depth of 200 m at a position west of Måseskär lighthouse in the Skagerrak, i.e., just outside the Convention Area. The quantity here has been estimated by Swedish authorities to be approximately 20,000 t of chemical munitions containing mustard gas. However, the presence of other types of chemical warfare agents, including nerve gas, can-

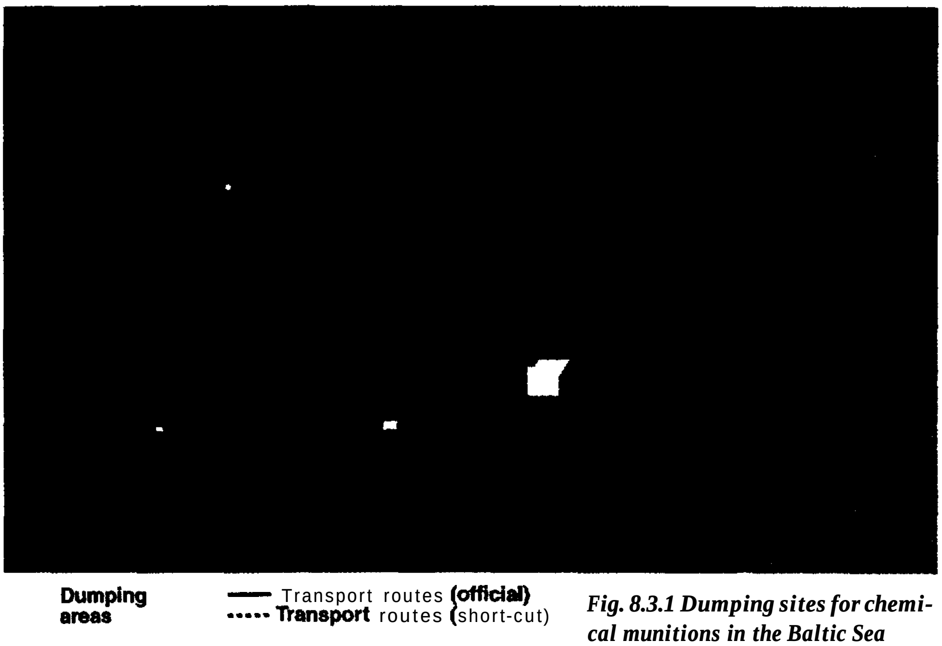


Fig. 8.3.1 Dumping sites for chemical munitions in the Baltic Sea

not be ruled out [231]. It has been confirmed by United Kingdom [232,241], that ships with chemical munitions were sunk in this area. However, no information about quantities and types of chemical munitions has been obtained.

Furthermore, another two vessels with chemical munitions were sunk at a position close to the parallel of the Skew in the Skagerrak, close to the border of the Helsinki Convention Area. These are probably the ships, which were sunk on the orders of the French occupation authorities, and 1,500 t of chemical munitions were dumped in connection with this operation [229].

In summary, it can be stated that with relative certainty around 40,000 t of chemical munitions have been dumped in the Helsinki Convention Area. It is estimated, that the chemical munitions contained no more than 13,000 t of chemical warfare agents. This figure does not take into account the dilution and degradation which have subsequently taken place. No information on types of hitherto unknown chemical munitions or warfare agents has been revealed.

8.3.3 Dumping areas

Dumping areas in the Helsinki Convention Area were identified at locations south-east of Gotland (south-west of Liepaja), east of Bomholm and south of the Little Belt (Fig. 8.3.1). In the Little Belt, the water depth is around 30 m, and the sea bed is covered with mud up to 8 m thick. The rates of sedimentation here are l-2 mm yr^{-1}. Accordingly, a thickness of up to 10 cm may be reached after 50 years. Therefore, the munitions can be expected to have sunk into the soft and muddy sediments. The surface current mainly flows north-west and south-east at a speed of 0.3-0.5 m s^{-1}.

Dumping east of Bomholm in the Bomholm Basin was primarily inside a circular area with a radius of 3 nautical miles. However, it must be assumed that the chemical munitions were spread over a considerably larger area during dumping. Several factors indicate this, e.g., the positions where fishermen have caught munitions in their nets and the circumstances of the dumpings [228-230].

The dumping operations south-east of Gotland took place in the Gotland Basin within several positions as specified in [239]. The water depth in the dumping area is between 70 m and 120 m. In general, the hydrographic conditions are similar to those in the Bomholm Basin, with very stable stratification of the water masses and only a slight bottom current.

8.3.4 Dumping methods

During transport to the dumping area east of Bomholm, munitions were sometimes thrown overboard while the ships were en route. Therefore, warfare agents are assumed to be spread over a considerable area along the transport routes. Furthermore, the actual dumping of munitions may have taken place while the vessels were either drifting or underway. The first dumping operations took place while the munitions were still packed in wooden boxes, which sometimes were observed to drift around before sinking to the bottom of the sea. It is stated, that in some cases the boxes were washed ashore on Bomholm and on the Swedish coast.

Buoys marking the dumping positions were laid out relatively late, i.e., after the dumping had been completed. At that time the dumping vessels were only equipped with strictly necessary navigation equipment, therefore in many cases the exact dumping positions are uncertain.

The chemical warfare agents in the eastern part of the Helsinki Convention Area were mainly dumped in the form of munitions or contained in containers. This is in contrast to the method used in the Skagerrak and southern Little Belt, where complete ships were sunk. The very nature of this latter dumping operation has apparently prevented munitions being dumped outside the area where the ships were sunk. The fact that the warfare agents were inside a ship hull has also prevented further spreading.

8.3.5 Present conditions of the dumped chemical munition

The chemical warfare agents in the Helsinki Convention Area were mainly dumped in munitions, mostly in bombs and shells. In addition, warfare agents that had not been loaded into bombs were dumped in containers.

The munitions pose a threat only when the warfare agent inside is released. This can occur suddenly in an explosion, e.g., caused by mechanical stress during a recovery operation, or slowly as the walls of the shells corrode. In the case of the handling of warfare munitions, that had been dumped in the Helsinki Convention Area, such an explosion has never occurred as far as is known.

The condition of the munitions varies since it depends on a number of factors. These factors include the original wall thickness, the material of which the body of the munitions and the igniter is made, i.e., iron or aluminium alloys, and the nature of the dumping area such as solid ground, where munitions lie exposed to the water or mud, where munitions lying buried in the sediment are cut off from an oxygen supply.

In autumn 1971 and spring 1972, the West German Army raised 28 bombs and 15 shells, which contained phosgene and tabun, from the southern Little Belt. The recovered munitions had sunk about 50 cm into the mud. An examination revealed, that most had been corroded and no longer contained warfare agents. No traces of warfare agents were found in the sediment and water samples taken in the immediate vicinity [229].

In 1989, the research institute of the Norwegian Ministry of Defence (Forsvarets Forskningsinstitutt) undertook an extensive investigation of the ships loaded with munitions that had been sunk in the Skagerrak. Most of the bombs found in the wrecks or nearby had not yet completely rusted through, but some were found in this condition [*167*]. Off Bomholm, according to the Danish authorities, greatly corroded munitions and lumps of viscous mustard gas were mainly found.

In conclusion, due to the large number of parameters, theoretical considerations or calculations cannot be used to comment on the condition of the munitions in a particular dumping area. Investigations so far have found either intact munitions and completely corroded casings, which do not contain warfare agents.

8.3.6 Behaviour in the environment

An overview of the most important physico-chemical properties, influencing the behaviour of warfare agents in the environment, is given in [*239*]. The behaviour of chemical substances in the marine environment depends both on the chemical and physico-chemical properties of the substances and on environmental factors, such as temperature, salinity and the pH value of the water. As the pH value of sea water is rather constant around 8, salinity and temperature are the main environmental parameters that influence chemical reactions here. The solubility of the compounds and the speed of chemical reactions both increase with a rise in temperature. With an increase in temperature of 10 °C, the speed of reactions generally doubles. Water temperatures in the Baltic Sea vary between 0 and 20 °C, i.e., reactions occur 4 times faster at 20 °C than at 0 “C. However, in the water above the seabed in the Baltic Sea, the temperature variation is much less, typically between 2 and 12 °C.

Dissolution of the chemical warfare agents into the sea is considered as the crucial first step in the degradation of the compounds. Besides a rise in temperature, the process of dissolution is increased by current movement. The solubility of the various chemical warfare agents varies from good (tabun) to very poor (Adamsite, viscous mustard gas). However, it should be noted, that poor solubility retards the process of degradation.

The behaviour of warfare agents in the marine environment is additionally influenced by the physical properties of the agents. For instance, a warfare agent in viscous or highly viscous form, or in lump form, can be caught in nets. This cannot happen to substances in liquid or powder form. This is one reason why most accidents with warfare agents so far have involved viscous mustard gas. Because of the admixture of thickeners, viscous mustard gas is the only warfare agent occuring in large lumps that are mechanically relatively stable. Other warfare agents are also resistant to sea water, e.g., Clark and Adamsite.

All warfare agents react with sea water, but reaction rates can vary enormously depending on the chemical structure of the different agents. Through hydrolysis, new compounds are formed which have different properties from those of the original warfare agents. Such reaction products are usually no longer toxic or are less toxic and generally dissolve better in water. Investigations on the behaviour of warfare agents under Baltic Sea conditions exist only for a few substances. For this reason, their behaviour can often only be described qualitatively, as details of the rates at which the processes occur are not available.

Almost all warfare agents are broken down at varying rates into less toxic, water-soluble substances. Some compounds, however, show an extremely low solubility and slow degradability (viscous mustard gas, Clark I and II, and Adamsite). These, however, cannot occur in higher concentrations in the water, therefore a wide-scale threat to the marine environment from dissolved chemical warfare agents can be ruled out. However, elevated levels of sparingly soluble Clark, Adamsite or mustard gas in viscous form might occur in the sediment in the immediate vicinity of dumped munitions.

***Relocation** by **currents** and threat to the coast* - Two ways of relocation of dumped chemical munitions have been considered by the working group [*239*], i.e., relocation by hydrographic conditions and relocation by fishing activities. The possibility, that chemical munitions or lumps of viscous mustard gas can be washed ashore, is extremely unlikely. Almost all of the dumped chemical warfare agents have a density >1. The only exception is tabun with a density close to 1. Near-bottom currents in the dumping areas are too weak to move the heavy munitions, which are mostly covered by mud, or to force them into upper layers of water. Likewise, lumps of viscous mustard gas, which have a density of about 1.3-1.5 g cm^{-3}, will not be shifted far by the currents. Except for the few cases referred to in [*239*], there have not been any confirmed reports of bombs or bomb remains being washed ashore on Danish, Swedish, Polish or German territories, since the dumped warfare objects were settled on the seabed. Again, except in a few cases, rumours about mustard gas finds on beaches did not stand up to later investigation.

The conclusion, that warfare agent residues from the dumping areas in the central part of the Baltic Sea cannot be washed ashore by currents, is supported by the fact that the seabed currents in the area are rather weak and mainly easterly. Material released from the seabed will thus move into the Baltic Sea. In addition, the dumped material needs to be moved upwards from a depth of up to 100 m in order to be washed ashore.

A relocation by hydrographic conditions is unlikely. Therefore, a threat to coastal areas of the Helsinki Convention Area from residues of warfare agents or chemical munitions washed ashore is unlikely.

8.3.7 Threats

Based on present knowledge, a widespread risk to the marine environment from dissolved warfare agents can be ruled out. Elevated levels of sparingly soluble Clark, Adamsite or viscous mustard gas may, however, occur in the sediment in the immediate vicinity of dumped munitions. Because of the very limited extent of the agents, however, no threat is posed to marine flora and fauna according to current information. No detrimental effects on the marine environment due to warfare agents have so far been observed.

Insufficient ecotoxicological data is available for most of the chemical warfare agents. Further investigations should be carried out with a special emphasis on mustard gas, chlorinated additives and arsenic compounds.

Discoveries of warfare agents during fishery outside the dumping areas happen from time to time. The problem is recognised especially in the area east of Bomholm. Here, fishermen operating repeatedly find bombs, shells and fragments thereof, and lumps of mustard gas in their bottom-trawl nets. There are several explanations for the spread of munitions. During transport to the dumping area east of Bomholm, munitions have been thrown overboard while the ships were en route. Warfare agents are assumed to be spread over a considerable area along the transport routes. Furthermore, the munitions have sometimes been thrown overboard from drifting or sailing vessels. The first dumping operations took place while the munitions were still packed in wooden boxes, which sometimes were observed to drift around before sinking to the bottom of the sea. However, spreading of the chemical munitions are also done unintentionally by fishing vessels when trawling. In this way, chemical munitions can be dragged about in the trawl over the sea bed without being caught. Furthermore, on some occasions munitions recovered by fishermen have probably been thrown back into the sea, possibly a long way from the position where they were initially dumped.

The dumping areas are pronounced as foul with an "anchoring and fishing not recommended" on nautical charts. However, since fishing in these areas is not prohibited, commercial fishing can occur. In order to avoid problems, considerably larger areas encircling the dumping grounds have been designated as risk areas on the nautical charts. In Denmark and Sweden, rules have been laid down for fishing in these areas through various legislations. For example, it is obligatory for the vessel to carry protective clothing and first aid for chemical warfare agents.

The detailed regulations on the handling of caught chemical munitions include the designation of appropriate authorities to, among other things, assess the chemical munitions caught and to advise fishermen whether to re-dump or bring the munitions ashore. If the chemical munitions pose a risk of explosion, they will be re-dumped after consultation with the appropriate authorities. This is done in accordance with the decision at the 9th Meeting of the Helsinki Commission in 1988 (HELCOM 9/16, Paragraph 8.12). On the other hand, if, after close examination of the material caught, experts do not find that it poses any risk of explosion, it will be brought ashore and deposited in special depots, until it can be transported to a destruction facility. Afterwards, the vessel and its gear will be decontaminated following specialized procedures, and the appropriate authority has to approve the vessel and gear before fishing is re-commenced.

As mentioned above, spreading of dumped chemical warfare material is to some degree caused by fishermen re-dumping chemical warfare equipment which had been caught in fishing nets,' possibly a long way from the position where it was dumped originally. Fishermen from Denmark, Greenland and the Faroe Islands have access to *ex gratia* compensation from the Danish State, but only when chemical warfare agents are caught outside the areas pronounced "anchoring and fishing not recommended', and on condition that the catch of fish, contaminated by chemical warfare agents, is destroyed. It should be added, that of 103 cases of chemical warfare material catches registered by Denmark in 1991, only 5 cases involved "foreign" fishermen.

It is generally accepted that since Denmark compensates its fishermen if they destroy contaminated catches, fairly reliable Danish statistics exist about reported finds of warfare agents. Fishermen from other nations bordering the Helsinki Convention Area are not obliged to notify the authorities of such findings. Accordingly, only incomplete figures exist on warfare agent finds by fishermen from other countries. Information has been provided by Germany, Latvia, Lithuania, Poland and Sweden.

Table 8.3.6 gives the figures for total amount of chemical munitions caught and registered by Denmark east of Bomholm during the period 198592. The reasons for the increase in 199 1 are still unknown. This is probably due to a combination of different factors, like the spreading of dumped munitions, and increased fishing as a result of decreased cod stocks in the Baltic Sea. It should be mentioned that the number of catches of munitions registered by Denmark in 1993 is less than ten.

Table 8.3.6 Total numbers and weight of chemical munitions (CMs) caught east of Bomholm and registered by Denmark in the period 1985-92 [228]

	Number of "catches"	CM mass (kg)	Landed CMs (kg)
1935	46	2,695	585
1986	41	1,830	370
1987	14	582	175
1988	19	1,044	115
1989	42	1,966	120
1990	19	979	182
1991	103	5,378	269
1992	50	2,597	100
total	342	17,072	1,917

Germany has reported 13 cases. Only the incidents in which crews were injured are known, so far with no major fatalities. All 13 incidents occurred east of Bomholm in the area pronounced "Foul chemical munitions" and "Anchoring and Fishing Dangerous", or in the immediate vicinity [*229*]. Sweden has reported 4 incidents with mustard gas from this area since 1980, one involving a fishing vessel from Estonia [*233*]. Due to the fact that in the Gotland Basin the composition of the munitions is similar to that in the Bomholm Basin, a similar assessment of the risks to fisheries applies, but on a smaller scale.

Latvia has reported fishermen's contact with chemical munitions. The contacts took place from the 1950s to the 1970s, and in some cases later. The locations of these catches were within the dumping area south-east of Gotland. Most findings were in the 1950s, and in some instances the contacts have led to fishermen being injured [*234*].

Sweden has reported 4 fishing vessel incidents involving dumped chemical warfare agents south-east of Gotland since 1980. Two incidents involved mustard gas and the others Clark I and CAP [*231*]. Likewise, Lithuanian fishermen occasionally have had contact with chemical weapons in the area. One episode from 1986 is reported (56°20' N / 19°48' E), where fishermen after contact with a mustard gas bomb were hospitalized [*235*].

In the Polish exclusive economic zone, there have been 16 identified findings of outdated ammunition and weapons. Chemical munitions have occurred in one of those areas. Judged from the coordinates given (54°37' N / 15°39' E), this area is on the route which the ships used to the dumping area south-east of Gotland [*236*].

The very nature of the dumping operations in the area south of the Little Belt has apparently prevented accidental or deliberate dumping of munitions outside the area where the ships were sunk. The fact that the chemical munitions were inside a ship hull, has also prevented further spreading. In this area, only easily degradable warfare agents (tabun and phosgene) were dumped.

Potential risks to consumers - Contracting Parties have control procedures for fish and other types of seafood, before they reach consumers. According to the existing knowledge, no content of mustard gas or other chemical warfare agents have been found in edible fish or other types of seafood. Given the present knowledge, the chemical warfare agents do not constitute a problem in terms of food toxicology.