Report on Chemical Munitions
Dumped in the Baltic Sea

Report to the 15th Meeting of Helsinki Commission

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from

the Ad Hoc Working Group on Dumped Chemical Munition

(HELCOM CHEMU)

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1. SUMMARY

The present report contains information on dumping of chemical munitions until the year 1947 (except for the dumping of 200 tonnes by the former GDR in the 50'ties). Information on the dumpings after World War I and dumpings of conventional ammunition is not included. The information is provided to the Helsinki Commission by the member countries and observers from the United Kingdom, United States of America and Norway as by the end of 1993.

Types and Quantities of Dumped Chemical Munitions
With relatively certainty around 40,000 tonnes of chemical munitions have been dumped in the Helsinki Convention Area. It is estimated that the chemical munitions contained no more than 13,000 tonnes of chemical warfare agents. This figure does not take into account the dilution and degradation which have taken place.

No information on types of hitherto unknown chemical munitions or warfare agents has been revealed.

Dumping Areas
The following dumping areas in the Convention Area were identified: South-east of Gotland (south-west of Liepaja), east of Bornholm and south of Little Belt[1]. There are indications that during transport to the dumping areas east of Bornholm and south-east of Gotland munitions have been thrown overboard while ships were en route. As some munitions were dumped in wooden cases some have drifted outside the area where they were dumped.

Information on other dumping areas in the Helsinki Convention Area has not been verified.

Present Condition of Dumped Chemical Munitions
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 shown that intact munitions and completely corroded casings not containing warfare agents are found.

Behaviour in the Marine Environment
Investigations of 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; details of the rates at which the processes occur are mostly missing.

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. 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, however.

[1] Information on the dumping area off the lighthouse Måseskär west of Sweden, which is situated just outside the Convention Area is included in the report.

Relocation by Currents and Threat to the Coast
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.

Threat to the Marine Environment
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 are known so far.

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

Threat to Fishermen
The crews of fishing vessels operating in the dumping areas or in their immediate vicinities could be in danger from the chemical munitions and chemical warfare agents dumped there, if lumps of viscous mustard gas or chemical munitions are caught in bottom trawls and hauled on board. Crews then risk being contaminated by chemical warfare agents. In some countries fishing activities in those areas are regulated through national legislation, including that fishing vessels have to bring along protective and chemical warfare agents first aid equipment.

Potential Risk 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. With the present knowledge, the chemical warfare agents do not constitute a problem in terms of food toxicology.

2. INTRODUCTION

This report contains a compilation of information on chemical munitions dumped in the Helsinki Convention Area. The information is provided to the Helsinki Commission by all the member countries and observers including observers from United Kingdom, United States of America and Norway as by the end of 1993. It does not contain information on munitions dumped after the World War I, neither does it contain information on dumping of conventional ammunition. At present only information on dumpings up til 1947 is included -apart from information from the former GDR.

The various problems to the environment, arising from dumping of chemical munitions in the Helsinki Convention Area many years before the Helsinki Convention was signed, have been dealt with at several meetings in the Convention. In 1992 the Helsinki Commission decided to convene a special working group designated to deal with problems related to dumped chemical munitions, taking into account that in the beginning of the 90'ties intensive rumors circulated in the press and elsewhere about new dump areas for chemical munitions in the Helsinki Convention Area and that more than 300,000 tonnes of chemical munitions had been dumped in the Convention Area.

It should be mentioned that the Convention of the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction, signed in Paris in January 1993 by all the Baltic States - but not yet entered into force - does not require declaring of chemical weapons dumped in the sea areas prior to 1 January 1985 (paragraph 17 of Article IV).

At the two first meetings of the "Ad hoc Working Group on Dumped Chemical Munition (HELCOM CHEMU)" Contracting Parties presented national reports concerning dumped chemical munitions. Denmark has acted as lead country and compiled the information into the present report which has been discussed by the working group at its 2nd and 3rd meetings.

The information presented has been collected from the following references:

Basic reports:

1. Update of report dated 7 may 1985 concerning environmental, health and safety aspects connected with the dumping of war gas ammunition in the waters around Denmark. HELCOM 14/10/1 (14 January 1993) submitted by Denmark.

2. Chemical Munitions in the Southern and Western Baltic Sea. Compilation, Assessment and Recommendations. Federal Maritime and Hydrographic Agency, Hamburg, Germany. May 1993.

3. Complex Analysis of the Hazard Related to the Captured German Chemical Weapon Dumped in the Baltic Sea. CHEMU 2/2/1/Rev.1 (27 September 1993) as amended 11 October 1993 - submitted by Russia.

Other reports:

4. Report on the availability of correct information on dumped chemical munition on the Swedish continental shelf. CHEMU 1/3 (5 April 1993) submitted by Sweden.

5. National information on dumped chemical munition. CHEMU 1/3/1 (6 April 1993) submitted by Latvia.

6. Information on catches of chemical munitions by fishermen. HELCOM CHEMU 2/2/2 (8 September 1993) submitted by Latvia.

7. National report on war gases and ammunition dumped in the Polish Economic Zone of the Baltic Sea. CHEMU 2/2/4 (17 September 1993) submitted by Poland.

8. Fishing vessel incidents involving dumped chemical munition reported to the Swedish Coast Guard since 1980. CHEMU 2/2/6 (28 September 1993) submitted by Sweden.

9. National information on dumped chemical munition. CHEMU 2/2/7 (28 September 1993) submitted by Lithuania.

Reports from observers:

10. Study of the Sea Disposal of Chemical Munitions. CHEMU 2/2 (8 September 1993) submitted by United States of America.

11. Report on sea dumping of chemical weapons by the United Kingdom in the Skagerrak waters post World War II. CHEMU 2/2/5 (28 September 1993) submitted by United Kingdom.

Reports from meetings of the working group:

12. Report of The First Meeting of the Ad hoc Working Group on Dumped Chemical Munition. CHEMU 1/8. St. Petersburg, Russia, 19-21 April 1993.

13. Report of The Second Meeting of the Ad hoc Working Group on Dumped Chemical Munition. CHEMU 2/8. Vilnius, Lithuania, 28-30 September 1993.

14. Report of the Third Meeting of the Ad hoc Working Group on Dumped Chemical Munition. CHEMU 3/5. Copenhagen, Denmark, 19-21 January 1994.

Other references:

15. Miljøstyrelsens Havforureningslaboratorium; Levnedmiddelstyrelsen; Civilforsvarets Analytisk-Kemiske Laboratorium: "Report on accumulation tests of war gas agents in fish." January 1986. (in Danish).

16. Åsted, A., Darre, E. & H. Chr. Wulf. Mustard Gas: "Clinical, Toxicological, and Mutagenic Aspects Based on Modern Experience."
Annals of Plastic Surgery. Volume 19, Number 4. October 1987.

17. Blanch et al., 1985 "Advanced Hazard Assessment of Arsenic in the Swedish Environment" in L.Landner (Ed) "Chemicals in the Aquatic Environment, Advanced Hazard Assessment", Springer-Verlag.

18. Forsvarets Forskningsinstitutt, 1989:
"Undersøkelse av skipsvrak inneholdende kjemisk ammunisjon senket i norske farvann eter annen verdenskrig." Rapport 89/6007, Kjeller, Norway.
(in Norwegian).

3. TYPES AND QUANTITIES OF DUMPED CHEMICAL MUNITIONS

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 million. Although large amounts of chemical warfare agents were produced and developed during World War II (around 65,000 tonnes 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. See Table 1 below for the quantities of chemical warfare agents produced in Germany.

Table 1. *Important chemical warfare agents produced in Germany between 1935 and 1945 (ref. 2).*

Warfare agent	Quantity [t]
Chloroacetophenone	7100
Clark I	1500
Clark II	100
Adamsite	3900
Arsinic oil[2]	7500
Phosgene	5900
Mustard gas	25000
Nitrogen mustard	2000
Tabun	12000
Lewisite	Production small, but unknown

The chemical warfare agents can be classed in the following groups - based on their effects:

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

[2] Mixture of arsenic containing compounds. Main ingredients: Pffificus (phenyldichloroarsine), and Clark I, and arsenictrichloride and triphenylarsine.

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.

Most of the reports referred to in this report dealing with amounts and types of chemical munitions dumped, date back to the same sources e.g. information from German archives in Koblenz or allied military archives.

The following amounts of chemical munitions and warfare agents were found on German territory between the end of World War II and 1948:

in the American occupation zone (ref. 2)	93,995 t
in the British occupation zone (ref. 2)	122,508 t
in the French occupation zone (ref. 2)	9,100 t
in the Soviet occupation zone (ref. 3)	70,500 t
i.e. a Total of	296,103 t

The records are incomplete concerning details of the amounts that were destroyed or deposited on land or dumped at sea.

It is worth noticing 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.

It will <u>not</u> be possible to specify an accurate net weight of the warfare agents alone because of the following factors:

- the quantity of chemical warfare agents varies for the individual types of munitions, depending on their purpose. The decisive factor is whether the munitions are artillery ammunition, aerial bombs or other containers which consist only of a thin shell and thus contain a larger amount of warfare agents;

- some of the objects were intact munitions filled with chemical warfare agents and some consisted of empty shells with no chemical warfare agents; and

- information about the composition of the various munitions cargoes is highly inadequate.

Taken the above into account, several countries within the Helsinki Convention estimate the content of active chemical warfare agents in an artillery round to be 10%, and 60% for bomb. Consequently, it is assumed that 10-20% of the known quantities of chemical munitions dumped are active chemical warfare agents. In this figure dilution/degradation in sea water is not included.

Around 34,000 tonnes of chemical munitions - containing about 12,000 tonnes of chemical warfare agents - were dumped east of Bornholm and near Gotland in 1947 and 1948 on orders of the Soviet Military Administration in Germany (SMAD) (ref. 3). In Tables 2, 3 and 4 are given the types of chemical munitions and the amounts of chemical warfare agents dumped.

Table 2. *Types of chemical munitions and quantities of warfare agents dumped in the Helsinki Convention Area under control of the former Soviet Union (in tonnes) (ref. 3).*

Types of Chemical munitions	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 3. *Types of chemical munitions and quantities of warfare agents dumped* ***south-east of Gotland*** *(= south-west of Liepaja) under control of the former Soviet Union (in tonnes) (ref. 3).*

Types of Chemical munitions	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
Smoke grenades	-	-	6	-	-	6
Containers	-	80	-	-	-	80
Drums	-	-	2	-	-	2
Total	608	176	124	44	6	958

Table 4. *Types of chemical munitions and quantities of warfare agents dumped **east of Bornholm** under control of the former Soviet Union (in tonnes) (ref. 3).*

Types of CM	Mustard gas	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
Smoke grenades	-	-	65	-	-	65
Containers	-	924	-	-	-	924
Drums	-	-	18	-	-	18
Total	7.027	2.033	1.428	515	74	11.077

Earlier it was estimated that between 36,000 and 50,000 tonnes of munitions have been dumped east of Bornholm 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 an estimation of the quantity of chemical munitions dumped east of Bornholm and south-east of Gotland can be narrowed to around 34,000 tonnes. However, due to the new information (ref. 3) and due to the high share of aircraft bombs the average warfare content was higher than the hitherto assumed 15%. In earlier estimates the quantities of warfare agents have been calculated to app. 6,000 tonnes based on a 15% assumption. Table 5 gives an overview of quantities of chemical munitions and warfare agents dumped in the Helsinki Convention Area.

About 200-300 tonnes of chemical munitions residues, discovered after 1952 in the former GDR, were dumped east of Bornholm (ref. 2).

In addition it should be mentioned that witnesses report that in 1946 4 ships containing around 15,000 tonnes of chemical munitions were dumped south-west of Rønne (Bornholm). Witnesses also report that in 1956 4 decommissioned East German coastal patrol vessels were loaded with chemical munitions (around 50 tonnes) and were sunk south-west of Rønne and unconfirmed reports claim that about 8,000 tonnes of chemical munitions were dumped east of Bornholm in addition to those mentioned in Table 4 (ref. 2). <u>None</u> of these dumpings <u>have been confirmed</u> from other sources.

As explained in chapter 4, in 1960 the tabun shells which were sunk at the southern entrance to Little Belt were raised, leaving about 5,000 tonnes of chemical munitions (phosgene and nerve gas). However, until nowaday 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 degraded rapidly in sea water. In addition, mostly thin-walled bombs whose casings rust through fairly quickly were dumped here (ref. 2).

Table 5. *Quantities of chemical munitions and types and quantities of chemical warfare agents dumped in Helsinki Convention Area (ref 1, 2 & 3), and at Måseskär (west of Sweden) in the southern part of Skagerrak (ref 4).*

Area	**Quantities of munitions (in tonnes)**	**Quantities of warfare agents (in tonnes)**	**Types of warfare agents (in tonnes)**
Bornholm Basin (E of Bornholm)	app. 32,000	app. 11,000	mustard gas, viscous mustard gas, Clark I, Clark II, Adamsite, chloroacetophenone; (less certain: phosgene, nitrogen mustard, tabun)
E of Bornholm	*(8,000 - not verified)*	-	*no information*
Area SW of Bornholm	*(app. 15,000 - not verified)*	-	*no information*
Gotland Basin (= SW of Liepaja)	app. 2,000	app. 1,000	mustard gas, Adamsite, chloroacetophenone
Little Belt	app. 5,000	750 (estimated at 15%)	tabun, phosgene
Måseskär, W of Sweden (outside the Helsinki Convention Area)	app. 20,000 (quantity not verified)	-	mustard gas (other types not verified)

<u>Dumping outside the Helsinki Convention Area:</u>
In 1964 462 tabun shells were recovered from Wolgast harbour (former GDR), set in concrete blocks and dumped in the Norwegian Sea (ref. 2).

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 which were sunk afterwards. Records show that 1 ship was sunk in the Norwegian Sea and 26 named and 6-8 unnamed vessels were sunk in Skagerrak together with an estimated 130,000 tonnes of chemical munitions and conventional ammunition at a position 25 nautical miles south-east of Arendal in the Norwegian Channel (ref. 1,2, 11 and 14).

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 Skagerrak (just outside the Convention Area). The quantity here has been estimated by Swedish authorities to be approximately 20,000 tonnes of chemical munitions containing mustard gas. However, the presence of other types of chemical warfare agents, including nerve gas can not be ruled out (ref. 4). It has been confirmed by United Kingdom (ref. 11 and 14) that ships with chemical munitions were sunk in this area. No information about quantities and types of chemical munitions has been obtained.

Furthermore another 2 vessels with chemical munitions were sunk at a position close to the parellel of the Skaw in 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. 1,500 tonnes of chemical munitions were dumped in connection with this operation (ref. 2).

Summary: With relatively certainty around 40,000 tonnes of chemical munitions have been dumped in the Helsinki Convention Area. It is estimated that the chemical munitions contained no more than 13,000 tonnes of chemical warfare agents. This figure does not take into account the dilution and degradation which have taken place.

No information on types of hitherto unknown chemical munitions or warfare agents has been revealed.

4. DUMPING AREAS

Only dump areas recognised by a member country to the Helsinki Convention either as a fact or as an assumption are dealt with. The areas in the Helsinki Convention Area - and Måseskär (Skagerrak) - where chemical munitions have been dumped are shown in Figure 1. The following three dumping areas have been identified:

- Shortly before the end of World War II, 2 German vessels loaded with nerve agent projectiles (tabun) and other types of chemical and conventional munitions were sunk at the southern entrance to Little Belt, approximately 7 nautical miles south-east of Pøls Huk at the position 54E 48' 22" N, 10E 13' 22" E (ref. 1 & 2).

  In August 1961, the German authorities stated that chemical warfare agents also had been dumped in the sea at the position 54E 50' N - 54E 47' N, 10E 08' E - 10E 15' E, south of Little Belt (ref. 2).

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 between 1 - 2 mm / year. Accordingly, a thickness of around 8 cm is reached after 40 years or so. The munitions can be expected to have sunk into the sediment as it is soft and muddy. The surface current mainly flows north-west and south-east at a speed of 0.3 to 0.5 m/s.

After World War II, Allied forces dumped chemical munitions east of Bornholm and south-east of Gotland in the Helsinki Convention Area and in the Skagerrak area in the Norwegian Channel and West of Måseskär (the two last mentioned dumping areas are outside the area of the Helsinki Convention). The area off Måseskär is situated at 55E07'N and 10E47'E.

- Dumping east of Bornholm in the Bornholm basin was primarily inside a circular area with a radius of 3 nautical miles. The centre of this area is specified on the Danish charts with the coordinates 55E 21'0 N and 15E 37'02 E. 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 (ref. 1, 2 & 3).

The depth of the water ranges between 70 m and 105 m and a 5 - 6 m thick layer of mud covers most of its bottom. The waters in the Bornholm basin can be divided into an upper and a lower layer. The upper layer consists primarily of fresh water flowing in from the Baltic Sea with a salinity of 8l and reaching down to approx. 50 m. This water flows slowly out of the Baltic Sea. The lower layer originates in the North Sea and on its way to the Bornholm basin is mixed with water from the upper layer, resulting in a salinity between 9l and 23l. Incoming currents with a salinity of more than 19l occur in the period August to April with a mean frequency of every 4-5 years.

The surface temperature varies according to the time of year, while variations in the lower layer are small with a mean temperature of 6EC. The oxygen content in the surface layer is determined by the season. The oxygen content in the lower waters is determined by the oxygen content of the incoming water currents and bacteriological consumption. As water near the seabed is rarely renewed, the oxygen content is increased by incoming currents and then decreases until the next incoming current. In the surface layer there is a weak southwesterly current, while in the bottom layer there is an easterly current of 0.05 m/s.

- The dumping operations south-east of Gotland took place in the Gotland basin within the following positions 56E16,0'N 18E39,0'E, 56E16,0'N 18E51,0'E, 56E20,0'N 18E55,0'E, 56E20,0'N 19E31,0'E, 56E07,0'N 19E15,0'E, 55E56,0'N 19E15,0'E, 55E56,0'N 18E39,0'E (= south-west of Liepaja) (ref. 2).

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 Bornholm Basin with very stable stratification of the water masses and only a slight bottom current.

Information from former GDR, obtained recently shows that in addition to the above mentioned dumping areas also an area south-west of Bornholm might have been used for dumping of chemical munitions (ref. 2). This information has never been verified.

The tabun shells sunken south of Little Belt by German authorities were recovered from the ships in 1959 and 1960, set in concrete blocks and subsequently dumped west of the Bay of Biscay (ref. 2).

In 1964, 462 tabun shells, recovered from Wolgast harbour, were set in concrete blocks and dumped in the Norwegian Sea at a depth of 3,100 m (position 64E42'N 01E36'W) (ref. 2).

Although both of the two last above-mentioned dumping operations took place outside the Helsinki Convention area, the examples show how difficult it is to handle remnants from chemical munitions even many years after World War II.

Methods of dumping (ref. 1 & 2)

During transport to the dumping area east of Bornholm, munitions have been partially 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 partially 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. It is stated that in some cases the boxes were washed ashore on Bornholm and on the Swedish coast.

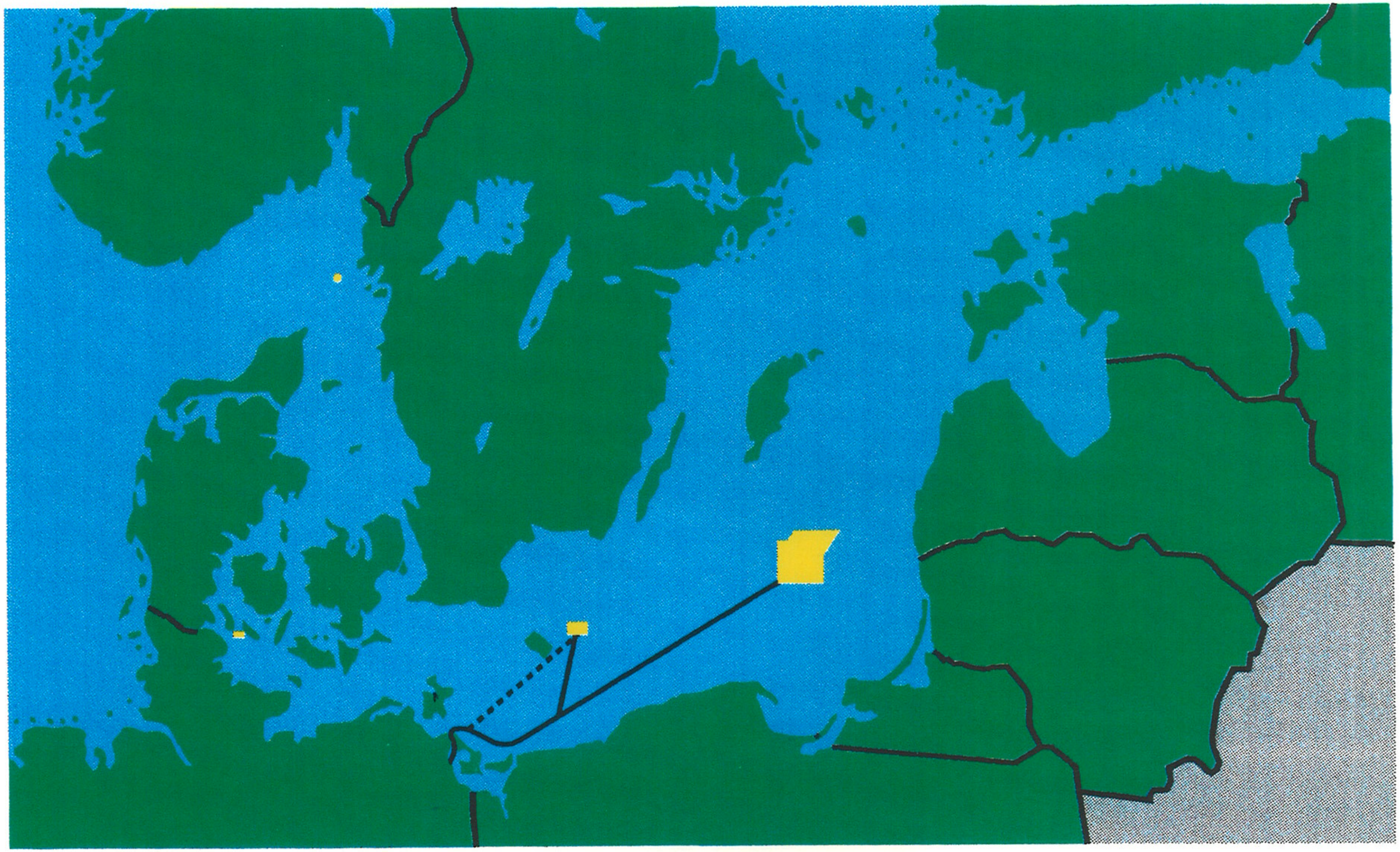
Buoys marking the dumping positions were laid out relatively late. By that time the dumping vessels were only equipped with strictly necessary navigation equipment, therefore in many cases the exact dumping positions are uncertain.

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 Skagerrak and southern Little Belt, where complete ships were sunk. The very nature of the dumping operations has apparently prevented overboard cast outside the area where the ships were sunk. The fact that the warfare agents were inside a ship hull has also prevented further spreading.

Summary: The following dumping areas in the Convention Area are identified: South-east of Gotland (south-west of Liepaja), east of Bornholm and south of Little Belt. There are indications that during transport to the dumping area east of Bornholm and south-east of Gotland munitions have been thrown overboard while ships were en route. As some munitions were dumped in wooden cases some have drifted outside the area where they were dumped.

Information on other dumping areas in the Helsinki Convention Area has not been verified.

Figure 1. Map of dumping areas for chemical munitions in the Helsinki Convention Area (including transport routes) on the next page.



Dumping areas

—— Transport routes (official)
----- Transport routes (short-cut)

Figure 1

5. PROPERTIES OF CHEMICAL AGENTS AND THE PRESENT CONDITION OF DUMPED CHEMICAL MUNITIONS

5.1 Chemical Munitions

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 filled in munitions 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 handling of warfare munitions being dumped in the Helsinki Convention Area, such an incident has never occurred as far as is known.

The condition of the munitions varies since it depends on a number of factors, e.g: The original wall thickness, the material of which the body of the munitions and the igniter is made (iron, aluminium alloys), and the nature of the dumping area such as solid ground (munitions lying exposed in the water) or mud (munitions cut off from oxygen supply).

In autumn 1971 and spring 1972 the German Army raised 28 bombs and 15 shells having 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 (ref. 2).

In 1989, the research institute of the Norwegian Ministry of Defence (Forsvarets Forsknings-institutt) 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 rusted through, although some had (ref. 18).

According to the Danish authorities, mostly greatly corroded munitions and lumps of viscous mustard gas are found off Bornholm.

Summary: 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 shown that intact munitions and completely corroded casings not containing warfare agents are found.

5.2 Chemical Warfare Agents

5.2.1 Physico-Chemical Properties

An overview of the most important physico-chemical properties influencing the behaviour of warfare agents in the environment is given in Table 6.

The melting and boiling points show that most warfare agents are liquid or solid at 20EC; only phosgene is gaseous at temperatures above 8EC. The term "poison gas" is thus misleading. As the warfare agents were often not used in their pure form, but admixed with other substances, the melting points are mostly slightly lower than those given in Table 6.

Vapour pressure is included in Table 6 as the measure showing how easily the warfare agents tend to vaporize - the higher the vapour pressure, the greater the concentration of the substance in the air, the quicker the substance volatizes.

Aqueous solubility is one of the most important parameters for the behaviour of warfare agents in the marine environment. Chemical degradation and dispersion in the sea (drifting, dilution) occur orders of magnitude faster when warfare agents are in the dissolved state. The density of warfare agents determines whether the substances sink to the sea bed or rise to the surface of the water and accumulate there.

With the exception of tabun, all the warfare agents given in Table 6 are much heavier than Baltic Sea water (density: 1.08 g/cm^3). Therefore, warfare agents dumped in the Helsinki Convention Area do not show a tendency to rise to the surface and drift away.

Table 6: Chemical and physico-chemical properties of the chemical warfare agents (ref. 2).

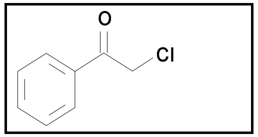
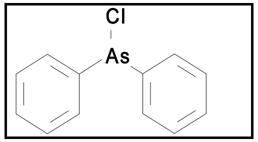
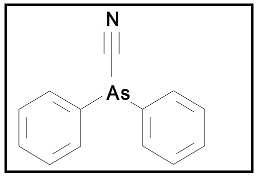
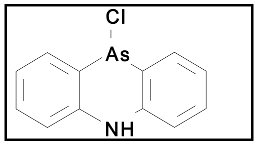
Name	**Synonyms**	**Structure**	**Melting point [°C]**	**Boi-ling point [°C]**	**Vapour Pressure [mm Hg] 20°C**	**Densi-ty [g/-cm^3]**	**Aqueous solubility [g/l]**
<u>Tear Agents</u>							
Chloroacetophenone (2-Chloro-1-phenyletha-none)	CN, Mace,		54 - 56	244	0,013	1,32	1
<u>Nose and Throat Irritants</u>							
Clark I (Diphenyl arsine chlori-de)	Sternite		38 - 44	307 - 333	0,0016	1,422	2
Clark II (Diphenyl arsine cyani-de)	Sternite		30 - 35	290 - 346	0,000047	1,45	2
Adamsite (10-Chloro-5-hydrophe-narsazine(10))	Phenarsazine chloride		195	410	2* 10^{-13}	1,65	0.002

Table 6 (cont.)

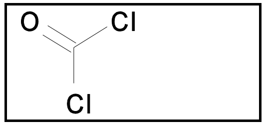
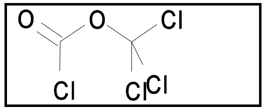
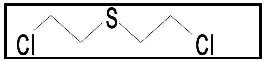
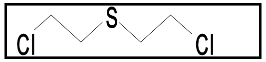
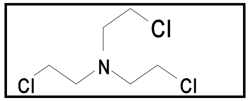
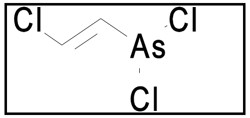
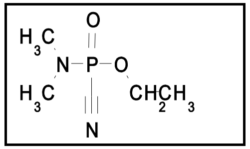
Name	**Synonyms**	**Structure**	**Melting Point [°C]**	**Boiling Point [°C]**	**Vapour Pressure [mm Hg] 20°C**	**Density [g/cm³]**	**Aqueous Solubility [g/l]**
<u>Lung Irritants</u>							
Phosgene (carbon dichloride oxi-de)	Carbonyl chloride, CG,		- 128	7,6	1178	3,4	9
Diphosgene (Trichloromethyl chloro-formate)	*Perstoff*		- 57	127	10,3	1,65	
<u>Blister Gases (Vesi-cants)</u>							
Mustard gas (2,2´-Dichloro-diethyl-sulfide)	*Lost, Schwefel-Lost, Senfgas, Yperit*		14	228	0,72	1,27	0,8
Viscous mustard gas						1,3	<< 0,8
Winter mustard gas		different mix-tures, e.g. 63% mustard gas + 37% Lewi-site	-14	<190		1,66	

Table 6 (cont.)

Name	**Synonyms**	**Structure**	**Melting Point [°C]**	**Boilin g Point [°C]**	**Vapour Pres- sure [mm Hg] 20°C**	**Densi- ty [g/- cm³]**	**Aqueous Solubility [g/l]**
Nitrogen Mustard (2,2´,2´´-Trichloro triet- hylamine)	*Trichlormethin, NH3*		-4	235	0,011	1,24	0,16
Lewisite (dichlor-(2-chlorvinyl)- arsane	L		-18	190	0,35	1,89	0,5
<u>Nerve Gases</u>							
Tabun (P-Cyano-N,N-dimethyl phosphonamid acid ethyl ester)	Trilon 83		-50	246	0,07	1,07	120

5.2.2 Behaviour in the Marine Environment

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 - Baltic Sea water is slightly alkaline (pH 8) - salinity and temperature are the main environmental parameters that influence chemical reactions here. The solubility of the compounds and the speed of reactions both increase with a rise in temperature. With an increase in temperature of 10EC, the speed of reactions generally doubles. Water temperatures in the Baltic Sea vary between 0E and 20EC, i.e. reactions occur 4 times faster at 20EC than at 0EC. However, in the water above the seabed in the Baltic Sea the temperature variation is less, typically between 2E - 12EC.

Dissolution of the chemical warfare agents into the sea is considered as the crucial first step in the degradation of the compunds. Besides a rise in temperature, current in particular speed up the process of dissolution. As Table 6 shows, 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 reaction with water - hydrolysis - new compounds are formed which have different properties from those of the warfare agents. Such reaction products are usually no longer toxic or are less toxic and generally dissolve better in water.

Investigations on 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; details of the rates at which the processes occur are mostly missing.

The behaviour of individual warfare agents in sea water:

<u>Chloroacetophenone</u> hydrolyses only very slowly, if at all, in water, but its chemical structure does indicate that it can be biodegraded. After dehalogenation (removal of the chlorine atom), non-toxic products develop that can easily be fully degraded in sea water.

<u>Clark I</u> reacts very slowly with water and forms tetra-phenyldiarsine oxide and hydrochloric acid. While the latter is neutralized by the sea water, only little is known about the degradative behaviour of tetraphenyldiarsine oxide. As it is hydrolysed very slowly, it still has warfare agent properties and therefore it is not detoxified. Even if it degrades completely, an inorganic arsenical compound persists which is still toxic and cannot be degraded. Such a compound has no longer warfare agent properties, however.

The physico-chemical properties of Clark I give reason to believe that it and its reaction products can be preserved for a long time on the sea bed and that they might possibly accumulate in organisms (bioaccumulation).

Clark II degrades in sea water, initially forming tetra-phenyldiarsine oxide (see Clark I) and hydrogen cyanide. Although the latter is toxic, in the sea it degrades relatively quickly and forms non-toxic formic acid and its sodium salt.

Adamsite is soluble in water only in extremely small quantities. It hydrolyses very slowly and forms phenarsazinic oxide and hydrochloric acid. The same apply as for Clark I and II as which also contain arsenic.

Phosgene is a very reactive compound which in sea water is broken down into carbon dioxide and hydrochloric acid. In slightly alkaline sea water, hydrochloric acid is neutralized. The reaction occurs rapidly - even at 0EC: an 1% watery phosgene solution is completely decomposed after only 20 seconds.

Mustard gas. Hydrolysis of mustard gas in sea water occurs in two stages. Thiodiglycol and hydrochloric acid are formed; the former is non-toxic and the latter is neutralized by sea water.

While mustard gas has a half-life of minutes when it hydrolyses in pure water, hydrolysis in sea water occurs more slowly, especially if water temperatures are low; then half-life is measured in hours. This time scale applies only to dissolved mustard gas, however. Because mustard gas is relatively insoluble, the slower dissolving process becomes the determining factor. The dissolving process itself depends on many parameters such as salinity, temperature, current speed and the extent to which munitions are covered. Degradation of solid mustard gas can thus take weeks or years.

Viscous mustard gas is mustard gas to which thickeners have been added. It has a completely different appearance from ordinary mustard gas and reacts differently in physical terms as well. Its colour ranges from reddish brown / brown green to black and has the consistency of thick paste - something like bee-wax. It is viscous and very sticky. About 20% of the mustard gas produced was processed into viscous mustard gas. Water-insoluble thickening agents such as polystyrene and montan wax have a crucial effect on its behaviour in the marine environment as they prevent the mustard gas from reacting with the sea water. Hydrolysis is possible only after the mustard gas has diffused out of the viscous mustard gas.

The thickening agents remain and form the basis of a developing crust on which fine sand and mud particles can also be deposited. This further hinders diffusion of any remaining active parts of mustard gas. Warfare agent which are contained in lumps of viscous mustard gas can thus be preserved for many years - the bigger the lump of mustard gas, the longer it will be conserved. Crushing by mechanical means in the sea is made more difficult because the lumps are very elastic and are protected by a leather-like crust.

It must, therefore, be assumed that a very long time is needed before viscous mustard gas is broken down into harmless substances. Depending on oceanographic conditions, waves or bottom current can transport lumps of viscous mustard gas, which are heavier than sea water, across the seabed.

Nitrogen mustard gas. Hydrolysis of nitrogen mustard gas is slower than that of mustard gas and occurs in several stages. The half-time of the first stage is around 9 hours. In fresh water, decomposition takes about 3 weeks; no data are available for decomposition in sea water. A number of different products of hydrolysis is formed, probably ethanolamines, which are water-soluble and barely toxic.

Lewisite reacts with water to form chlorovinyl arsine oxide, which in alkaline solution can react further to produce arsenic acid and acetylene. While in this context acetylene is an unproblematic gas, the arsenic acid retains arsenic's typical toxicity.

Tabun dissolves well and is of relatively little resistance. At a temperature of 7EC, its half-life in water is about 5 hours. During hydrolysis non-toxic esters of phosphoric acid and hydrogen cyanide are formed. Toxic hydrogen cyanide is converted relatively easily into non-toxic formic acid or its sodium salt.

Cyclone B consists of salts of hydrogen cyanide which dissolve well. Toxic hydrogen cyanide is converted relatively easily into non-toxic formic acid or its sodium salt.

Summary: Investigations of 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; details of the rates at which the processes occur are mostly missing.

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, 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. 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, however.

6. POTENTIAL HAZARDS

6.1 Relocation by Currents and Threat to the Coast

Two ways of relocation of dumped chemical munitions have been considered in the report: Relocation by hydrographic conditions and relocation by fishing activities (section 6.3.2).

The possibility that chemical munitions or lumps of viscous mustard gas can be washed ashore is extremely unlikely. All of the dumped chemical warfare agents have a density of more than 1. The only exception is tabun which has a density close to 1 (see table 6). 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 cases referred to below, there has not been any confirmed reports of bombs or bomb remains having been washed ashore on Danish, Swedish, Polish or German territories, since the dumped warfare objects were settled on the seabed. Again, except for the cases referred to below, rumours about mustard gas finds on beaches, did not stand up to later investigations.

The only confirmed finds of chemical munitions onshore are the following:

It is reported that five bombs were found along the Polish coast between 1952 and 1954, but it is not known whether they were conventional or chemical munitions. Similarly, their origin is uncertain - possibly they have been dumped en route to the dumping areas (ref. 7).

In 1954, a chemical bomb was found at Selliner Strand on the island of Rügen. The possibility that water currents could have transported this bomb to Rügen from a depth of around 100 m in the Bornholm Basin can be ruled out. It is more likely that the bomb was thrown overboard near Rügen while being transported from Wolgast (ref. 2).

On the 18th of February 1992, a 250 kg bomb containing mustard gas was found at Dueodde beach on Bornholm. Judging from the bomb's condition, Danish experts came to the conclusion that it had not been in the sea for a longer period of time and that it had not been washed ashore. The possibility is also ruled out that the bomb had been buried for a longer period of time in the sand and had only just been uncovered by the tide. Thus, the only possible explanation is that the bomb has been placed at the beach by purpose (ref. 1).

Supporting the conclusion - that warfare agent residues from the dumping areas in the central part of the Baltic Sea area cannot be washed ashore by currents - is the fact that the seabed currents in the area are easterly and weak, and that 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 metres in order to be washed ashore.

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

6.2 Threat to the Marine Environment

The knowledge of ecological effects of the dumped chemical warfare agents to the marine environment in the Helsinki Convention Area is so far limited. Also the knowledge of chemical behaviour of the warfare agents in sea water is not known in detail. Ecotoxicological investigations, both in relation to lethal and sublethal effects towards various types of marine organisms, have almost exclusively been carried out for mustard gas. The results are referred below.

<u>Mustard gas:</u> Marine organisms at various trophic levels have been tested. The tests have been carried out, simulating the physical/chemical conditions in the Baltic Sea. Most investigations have focused on mustard gas and nitrogen mustard, exposed directly in the water column or as lumps of viscous gas in the bottom of the test aquarium. As expected, different organisms react with varying degrees of sensitivity.

In a test series of experiments with marine organisms the following results were obtained: Toxic concentrations of mustard gas in the water column, for planktonic algae such as *Phaeodactylum tricornutum* and *Rhodomonas balthica* were found from app. 1 mg/l (ppm). The effect was 10-20% inhibition of the photosynthesis. At a test concentration of about 10 ppm mustard gas the corresponding photosynthesis inhibition was 80-90%. Hatching rate for eggs of the crustacean *Artemia salina* was inhibited at concentrations varying from 10 to 100 ppm; with almost total inhibition at 100 ppm. The LC 50 concentration for juvenile specimens of plaice tested in 96 hours was app. 3 ppm (ref. 15).

In order to analyze the potential for bioaccumulation of mustard gas in fish, the following tests using flounder as research organism are referred to:

In one research series flounders were exposed to lumps of viscous mustard gas for 42 week in the test aquariums. The concentration of mustard gas in the water was below the detection limit of 0.05 ppb. However, it was possible to detect traces, in the order of 2-5 ppb, of substances normally found associated with the mustard gas. It was not possible to detect mustard gas in the flounders in this research series (ref. 15).

In a second research series pure mustard gas was discharged into an aquarium at an initial concentration of 40 ppb. Due to the very fast hydrolysis of mustard gas in seawater the true concentration in the research aquarium was estimated to be 8-10 times lower. In the outlet from this aquarium mustard gas could not be detected (detection limit 1 ppb). It was not possible to measure mustard gas in the fish (detection limit 1 ppb) (ref. 15).

In a third research series the flounders were exposed in research aquariums where pure mustard gas was discharged at an initial concentration of 400 ppb. Also in these aquariums the true concentration was estimated to be 8-10 times lower. In one of the aquariums from this series it was possible to measure mustard gas in the fish at a concentration of 10-50 ppb. The research series do not indicate that mustard gas is bioaccumulated in fish (ref. 15).

In another test series with fresh water organisms no effects (% death within one day) were found at 1.8 mg/l in experiments with a fish (*Poecelia reticulata*) and a gastropod mollusk (*Lymnaea stagnalis*), whereas 33.3% mortality within 3 days was found for a zooplanktonic crustacean (*Daphnia sp.*) at a concentration of 0.033 mg/l (ref. 3).

Warfare agents containing arsenic: Due to their physico-chemical properties, the possibility cannot be ruled out that Clark and Adamsite can accumulate in biota. This has not been investigated though. However, it has to be taken into consideration that warfare agents containing arsenic, even after complete degradation of the substances, the arsenic still persists as an inorganic arsenic compound. Such inorganic arsenic compounds are less acutely toxic than the warfare agents. Taking into account the mass reduction of the warfare agents, while they degrade (200g of Clark contains 75g of arsenic) and the decrease in the acute toxicity of inorganic arsenic compounds, partial detoxification can be expected following complete degradation. Inorganic arsenic compounds undergo further reaction in algae and fish to form non-toxic organic arsenic compounds.

In a series with fresh water organisms parallel to those with mustard gas no toxic effects were found neither with Adamsit or with chloroacetophenone, probably due to their low solubility (ref. 3).

Monochlorobenzene as an additive to warfare agents is potentially environmentally hazardous due to its stability and ecotoxicity. For mustard gas the additive of monochlorobenzene can be 20 % Tabun may contain up to 50 % monochlorobenzene from the manufacture.

In order to evaluate possible threats to the marine environment one has to combine the data of toxicological effects with the expected concentrations of warfare agents in the sea water. In principle, when warfare agents are leaking out from their containers, local effects may occur in organisms in the immediate vicinity, when higher concentrations are reached for a limited time until the agents are completely dissolved, diluted and/or degraded.

Most warfare agents have only a limited water solubility and degrade more or less rapidly in sea water. Therefore, higher concentrations cannot exist for a longer period of time. Those compounds which show a slow degradability (Clark I and II, Adamsite and viscous mustard gas) have only a very little water solubility, so that only very low concentrations are reached, which according to the present knowledge cause no ecological effects.

However, one has to bear in mind that insufficient data is available for the arsenic containing warfare agents, as well as chlorinated additives. These compounds are often lipid soluble, and therefore, possibly bioaccumulative.

Summary: 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 are known so far.

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

6.3 Threat to Humans

Chemical munitions have an adverse effect only when the warfare agents contained in them are released. This can happen suddenly in an explosion or slowly as the munitions rust.

In the case of an explosion, for instance due to improper handling during a recovery operation, large quantities of warfare agents could be released abruptly and eventually dispersed as a fine aerosol which could be inhaled or could contaminate the whole body. Then the agents would have the same effects as under combat conditions. In the case of handling of warfare munitions being dumped in the Helsinki Convention Area, such an incident has never occurred as far as is known.

All the known injuries, hitherto suffered by fishermen, have occurred because liquid or solid mustard gas or viscous mustard gas escaped from rusted munitions and came into localised contact with the skin. Therefore, only the effects of mustard gas are described below. The description of human effects from other types of warfare agents can be found in the literature. It is stressed that until now only fishermen, who have caught mustard gas in their bottom trawl nets and hauled it to the surface, have been injured.

6.3.1 Clinical Features of Mustard Gas

Mustard gas can easily penetrate materials such as rubber, leather, textiles, wood and concrete. It causes clinical symptoms after penetration through the skin, by vapour inhalation, or absorption from the conjunctiva or the eye (ref. 16).

<u>Skin.</u> Penetration of the skin is symptom free. There is a latent period of 4 to 8 hours before the onset of burning or itching followed by redness eruptions of extremely painful liquid-filled blisters. When the blisters burst, whitish painful ulcers appear. Dangerous secondary diseases often occur in the form of festering bacterial infections, particularly after the blisters are cut, as mustard gas also weakens the cellular resistance to infection. There may be chronic changes, such as hyperpigmentation or depigmentation of the affected skin. Some patients get recurring blister formations and itching of the affected skin, especially in case of exposure to heat.

<u>Eyes.</u> Penetration of the mustard gas causes no symptoms in the beginning, but after 4 to 6 hours later (sometimes less than 1 hour) there is an irritation of the eyes causing severe lacrimation. There may be a severe inflammation and swelling of the upper eyelids, so that they cannot be opened. At this stage the eyes are painful and very sensitive to light (photalgia). Direct contact between mustard gas and the eyes causes corneal clouding, inflammation and corneal ulceration and necroses. In severe cases blindness may occur. Chronic changes, such as changes in the bloodvessels of the eyes, scars of the eyelids, and chronic high sensitivity to light and smoke may occur. Furthermore, late recurrences of keratitis are also described.

<u>Respiratory System.</u> After about 24 hours, inhalation of mustard gas vapours causes coughing, a running nose and bronchitis. Larger doses cause inflammation and necroses of the mucous membrane as well as pulmonary oedema. There are examples of chronic affection of the respiratory system, for instance an affected lung function, bronchitis and emphysema.

<u>Gastrointestinal Tract.</u> The mucous membrane will be damaged causing nausea, vomiting, bloody diarrhoea, and possibly collapse resulting from dehydration.

General Condition. Besides local symptoms of exposure to mustard gas also systemic changes might occur - difficulties in breathing, disorders of the cardiovascular system and damage to the nervous system. Apathy, lingering illness and death are the final stages in cases of severe poisoning.

Mustard gas is an alkylating agent that causes cross links in DNA. This agrees with findings in fishermen which have been exposed to mustard gas. They have increased sister chromatid exchange rates in their lymphocytes. Sister chromatid exchange is a measure of DNA exchange between sister chromatids of chromosomes, and it correlates with mutagenicity and carcinogenicity.

6.3.2 Threat to Fishermen

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 Bornholm. Fishermen operating here do repeatedly find bombs, shells and fragments thereof and lumps of mustard gas in their bottom trawl nets.

There are several explanations to this fact: During transport to the dumping area east of Bornholm, 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 partially 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 unintentional 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 caught munitions have probably been thrown back into the sea, possibly a long way from the position where they were dumped once.

The dumping areas are marked as foul with an "anchoring and fishing not recommended" on nautical charts. Fishing in these areas is not prohibited, and it is allowed to carry on commercial fishing.

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 bring along protective and chemical warfare agents first aid equipment.

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 redispose or bring the munitions ashore.

If the chemical munitions pose a risk of explosion, they will be redisposed 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 examining 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 authoritie has to approve the vessel and gear before fishing is reassumed.

As mentioned above, spreading of dumped chemical warfare material is to some degree caused by fishermen themselves by redisposal of caught chemical warfare equipment, 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 marked "anchoring and fishing not recommended", and on the 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 finds of chemical warfare agents. 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. Discovery of chemical warfare agents around the dumping areas is shown in Figure 2.

Table 7 gives the figures for total amount of chemical munitions caught and registered by Denmark east of Bornholm during the period 1985-1992. The reasons for the increase in 1991 are still unknown. This is probable 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 registered by Denmark in 1993 is less than ten.

Table 7. *Total numbers and weight of chemical munitions caught east of Bornholm and registered by Denmark in the period 1985 - 1992 (ref. 1).*

Year	Number of "catches"	Weight of chemical munitions (in kg)	Landed chemical munitions (in kg)
1985	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	58	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 Bornholm in the area marked "Foul chemical munitions" and "Anchoring and Fishing Dangerous" or in the immediate vicinity (ref. 2). Sweden has reported 4 incidents with mustard gas from this area since 1980 -one involving a fishing vessel from Estonia (ref. 8).

Due to the fact that in the Gotland Basin the composition of the munitions is similar to that in the Bornholm Basin, a similar assessment of the risks to fisheries applies, but at a smaller scale.

Latvia has reported about fishermen's contact with chemical munitions. The contacts have taken place in the 50-ties up to the 70-ties, and in some cases later. The places of discovery are within the dumping area south-east of Gotland. Most findings were in the 50-ties, and in some instances the contacts have caused heavy consequences for fishermen (ref. 6).

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 chloroacetophenone (ref. 4). Likewise Lithuanian fishermen occasionally have had contact with chemical weapons in the area. One episode from 1986 is reported (56E20'N and 19E48'E), where fishermen after contact with a mustard gas bomb were hospitalized (ref. 9).

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 (54E 37'0 N and 15E 39'0 E), this area is on the route which the ships used to the dumping area south-east of Gotland (ref. 7).

The very nature of the dumping operations in the area south of Little Belt has apparently prevented overboard cast 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.

Summary: The crews of fishing vessels operating in the dumping areas or in their immediate vicinities could be in danger from the chemical munitions and chemical warfare agents dumped there, if lumps of viscous mustard gas or chemical munitions are caught in bottom trawls and hauled on board. Crews then risk being contaminated by chemical warfare agents. In some countries fishing activities in those areas are regulated through national legislation, including that fishing vessels have to bring along protective and chemical warfare agents first aid equipment.

Figure 2. Map showing discovery of chemical munitions in the Helsinki Convention Area (including transport routes) on the next page.

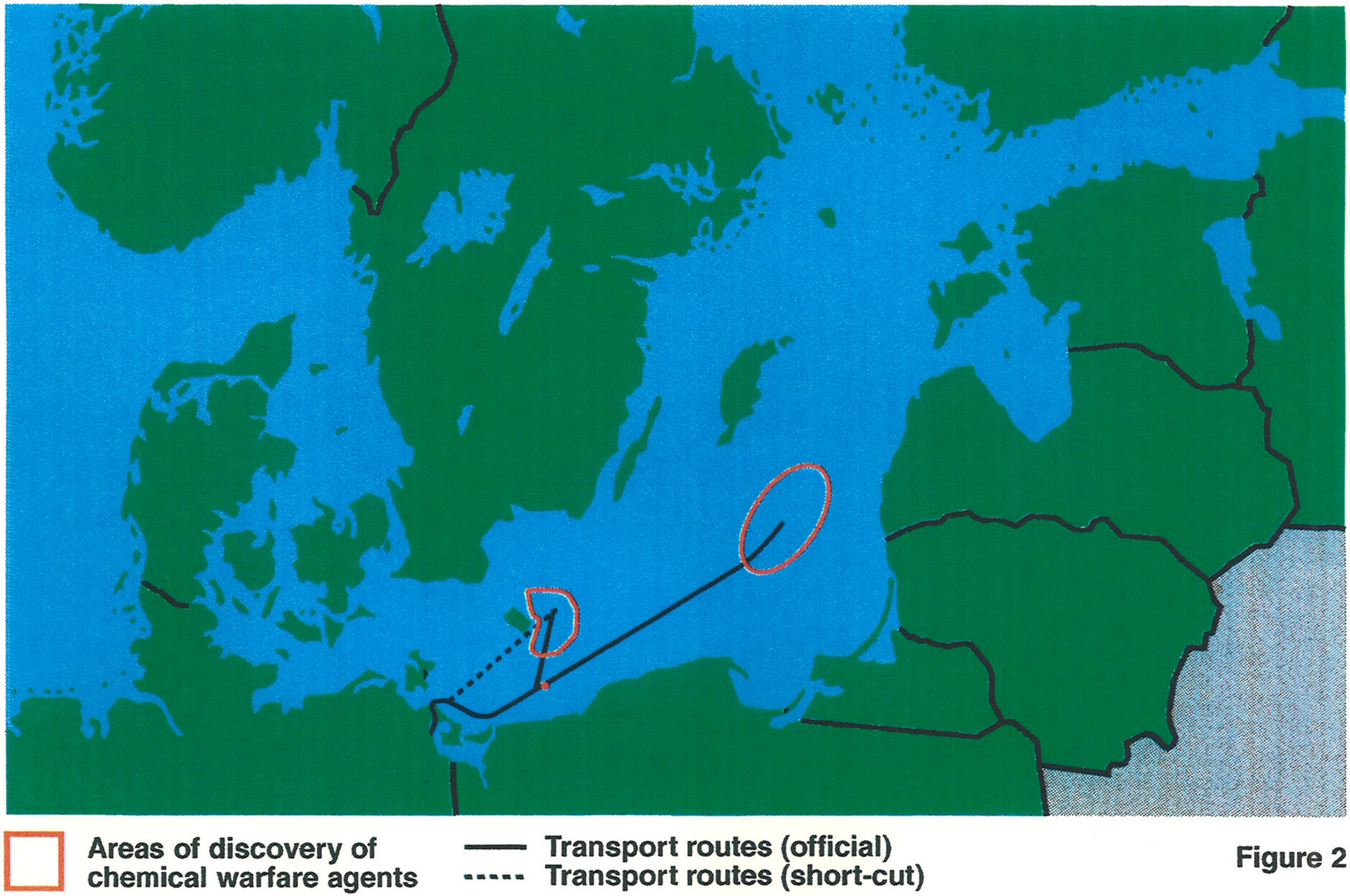

Areas of discovery of chemical warfare agents
Transport routes (official)
Transport routes (short-cut)

Figure 2

6.3.3 Potential Risk to Consumers

If a lump of viscous mustard gas is caught in a bottom trawl net, it can be pressed against the catch either during towing, hauling on board or when the net is emptied. 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. With the present knowledge, the chemical warfare agents do not constitute a problem in terms of food toxicology.

The organic arsenic compounds possess properties which imply that they could be transferred via marine food to comsumers. However, in specific analyses of fish the amounts of arsenic that are absorbed, are so small that they are irrelevant with regard to acute toxicity.

Inorganic arsenic compounds do not have the properties of warfare agents, but they are regarded as carcinogenic in humans. The formation of organic arsenic compounds in algae and fish could, however, also be a link between marine life and human beings.

Summary: 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. With the present knowledge, the chemical warfare agents do not constitute a problem in terms of food toxicology.

7. RESULTS OF INVESTIGATIONS AT OR NEAR DUMPING AREAS

At the dumping area south of the entrance to Little Belt sediment and water samples were taken in 1971/72 by German authorities. During this investigation 28 bombs and 15 shells having contained tabun and phosgene were recovered that had sunk about 50 cm into the mud. An examination revealed that most of the bomb casings had been corroded and no longer contained warfare agents. No traces of warfare agent were found in the sediment and water samples taken in the immediate vicinity (ref. 2).

In connection with video recordings of the seabed in the dumping area east of Bornholm, samples of the seabed sediment were taken in November 1992. Two samples close to one another were taken from the middle of the dumping field. The Civil Defence Analytical-Chemical Laboratory, Denmark found mustard gas in one of the samples and the more stable 1,4-dithiane in both samples. 1,4-dithiane is a by-product of mustard gas production. National Environmental Research Institute, Denmark analyzed the samples for arsenic; and detected an increased content (185 and 210 mg As/kg dry weight) compared to samples taken from other parts of the Baltic Sea. No other traces of chemical warfare agents or chemical compounds related to such agents were found in the sediment samples (ref. 1).

In 1992, the Norddeutscher Rundfunk (North German Radio Station) had 18 sediment samples analyzed. They had been collected at 6 different positions, 5 of them in the Bornholm dumping area. In one sample, a concentration of 10 mg of Clark I per kg of sediment (10 ppm) was found; nothing was found in the other samples from the same area. Likewise, no other warfare agents were found in any other sample. The arsenic concentrations - even in the sample containing Clark - did not exceed the values usually observed in the Baltic Sea area of up to 100 mg per kg of sediment (ref. 2).

Investigations by the German Hydrographic Institute in 1987 showed that the arsenic content of Baltic Sea water, including near-bottom water, does not exceed 1 µg/l (0,001 ppm). Concentrations in the dumping areas were not higher than those measured elsewhere (ref. 2).

In the summer of 1992 investigations were carried out 20 nautical miles west of the lighthouse Måseskär on the Swedish west coast (Skagerrak), where German mine swepers were sunk after World War II. Together with surface ships a remote operated vehicle (ROV) was used. Videofilms were made in the area where five of the ships were sunk. No grenades, bombs or other receptacles, which could have contained chemical agents were observed visually. Biological investigations were carried out by using cages containing crabs and mussels. The cages were placed to leeward of the bottom current in the immediate vicinity of the five wrecks and on a reference station. Sediment samples were collected on six locations in the vicinity of the wrecks (ref. 4).

When the cages were retrieved the specimens were quite normal and no mortality was noted. The crabs which had been placed furthest away from the wrecks showed a somewhat lower activity of the enzyme acetylcholinesterase (AChE), an enzyme which is inhibited by the presence of organic phosphorous compounds (such as in tabun), compared to crabs in the immediate vicinity of the wreck. Although an influence cannot be excluded, the difference is not statistically significant though.

The sediment samples were analyzed for mustard gas and the degradation product thiodiglycol. The detection limit was as low as 0.1 ppt (equals 1 to 10^{12}). At this level of detection the analysis of the sediment has demonstrated very low concentrations of mustard gas at least one kilometre from the wrecks. It has not been possible to detect the presence of nerve gas.

In 1989, the research institute of the Norwegian Ministry of Defence 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 still seemed to be intact, but others were already perforated by corrosion. Water and sediment samples were taken in the immediate vicinity of the bombs and analyzed. No mustard gas, nor tabun or mustard gas decomposition products were found in any sample, although also in this case very low levels for detection limits were achieved (ng/kg and μg/kg range) (ref. 18).

8. CONCLUSIONS

1. On the basis of national reports the Group concludes that there is a good picture on types and amounts of chemical munitions dumped in the Helsinki Convention Area until 1947. It can be stated with relative certainty that around 40,000 tonnes of chemical munitions have been dumped in the Helsinki Convention Area. It is estimated that the chemical munitions contained no more than 13,000 tonnes of chemical warfare agents.

2. The following dumping areas were identified in the Convention Area: South-east of Gotland (south-west of Liepaja), east of Bornholm and south of Little Belt. These are known dumping areas. No information has been obtained on hitherto unknown dumping areas. There are indications that during transport to the dumping area east of Bornholm and south-east of Gotland munitions have been partially thrown overboard while ships were en route. As some munitions were dumped in wooden cases, which may have remained floating for some time, some have drifted outside the areas where they were dumped.

   Further search for location of chemical munitions could be conducted on national basis within the framework of the Helsinki Commission.

3. The Group identifies two possible ways of the dumped munitions being relocated:
   - relocation by hydrographic conditions;
   - relocation by fishing activities.

   A relocation by hydrographic conditions is unlikely. Because of intensive fishing activities in or close to the dumping areas relocation of chemical munitions may take place.

4. *The Group is of the opinion that - when chemical munitions caught by fishermen and possibly representing a risk to human health - they can be redisposed in the sea in accordance with the principles and procedures agreed upon at the Ninth Meeting of the Helsinki Commission. Such redisposal shall be done with great caution following the instructions of the appropriate authorities.*

5. The Group concludes that a threat to the coastal areas of the Helsinki Convention Area from residues of warfare agents or chemical munitions washed ashore is unlikely.

6. Some Contracting Parties have developed guidelines for fishermen with information on the dumping areas and on how to deal with chemical munitions which have been accidentally brought on board with trawl catches.

   The Group recommends the elaboration of Baltic Guidelines for fishermen within the framework of the Helsinki Commission in consultation with the International Baltic Sea Fishery Commission (IBSFC).

7. *In addition the Group recommends that Baltic Guidelines on how the appropriate authorities should deal with incidents where chemical munitions have been caught by fishermen should be elaborated.*

8. Only poorly soluble and poorly degradable warfare agents can persist locally in the sediment at elevated concentrations over a long period of time. Investigations on the chemical processes and ecological effects of warfare agents under Baltic Sea conditions exist only for a few substances. These processes and effects can often only be described qualitatively.

   Further investigation on these processes and effects, especially on poorly soluble compounds such as viscous mustard gas and arsenic compounds, should be undertaken.

9. 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 shown that intact munitions and completely corroded casings not containing warfare agents are found. It is important to examine whether the chemical munitions are embedded in the sediment or are lying on the sediment surface and what is their state of corrosion.

   Therefore, further investigations on these issues should be carried out in selected parts of the dumping areas.

10. The Group notes that there are control procedures in the Contracting Parties for fish before reaching consumers. According to existing knowledge no content of mustard gas or other chemical warfare agents have been found in edible fish or other types of seafood.

11. The Group notes that in some of the Contracting Parties investigations on dumping areas have been carried out.

    The Group is of the opinion that investigations including water, sediment and biota should be conducted in selected dumping areas.

12. The Group is of the opinion that the risks which are connected with recovery of chemical munitions are high.

    The Group recommends not to recover chemical munitions from the Helsinki Convention Area.

13. *The Group recommends the 15th Meeting of the Helsinki Commission to prolong the mandate of the ad hoc Working Group on Dumped Chemical Munition (HELCOM CHEMU) to follow and implement the aforementioned recommendations.*