Recent Scientific and Political Developments Regarding Sea-Dumped Chemical Weapons in the Baltic Sea

by
John Hart (SIPRI)
and
Thomas Stock (Dynasafe)

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I. Introduction

Scientists, government officials and others continue to consider periodically historical, legal, political and technical aspects associated with chemical weapons (CW) dumped in the Baltic Sea following the end of World War II.[1] It has been estimated that 30–40 000 tonnes of CW have dumped in the Baltic Sea.[2] Fishing vessels in the region continue inadvertently to recover CW (usually sulphur mustard) every year or so.[3] Consideration of what, if anything, should be done with dumped munitions (including CW), has continued. Some ambiguity will always remain regarding the extent and nature of the dumpings mainly because of poor record keeping and a failure to dump at designated coordinates. The high probable financial cost (and possible political uncertainties) associated with any recovery or remediation effort may inhibit the willingness and ability of states to take action. Technical specialists have generally recommended that dump sites not be disturbed until or unless there is a compelling reason to do so.[4]

However, at least three factors may increase the likelihood that action will be taken to recover or treat munitions *in situ*. First the technical feasibility and options for doing so are increasing. Second there is longstanding concern that the slow, yet progressive, corrosion of the munitions bodies and the deterioration of scuttled ships may result in a sudden release of toxic agents into the environment with measurable effects. Should this occur, the level of public awareness and political interest in dumped CW may result in pressure for a recovery and remediation effort. Finally, understanding of the desirability and feasibility of recovering or remediating dump sites is evolving as further surveys and fundamental research (e.g. through the use of Environmental Geo-Informatics) are carried out and the environmental processes of the Baltic Sea become better known.

Any recovery or remediation of dumped CW will also have to take into consideration the provisions of the 1993 Convention on the Prohibition of the Development, Stockpiling and Use of Chemical Weapons and on Their Destruction (Chemical Weapons Convention, CWC). The CWC does not require the recovery CW dumped in territorial waters if the dumping occurred prior to 1 January 1985. However, any CW that is recovered (either from land or water) must not be re-disposed of through dumping, burial or open-pit burning and its recovery and disposal should be reported to the Organisation for the Prohibition of Chemical Weapons (OPCW), based in The Hague. Finally, the OPCW, national defence research establishments, industry, environmental scientists and those involved in archaeological studies and the survey of shipwrecks should be consulted periodically regarding various aspects connected with any proposed recovery or remediation of CW.

[1] The authors' contact details are: John Hart (hart@sipri.org) and Dr Thomas Stock (thomas.stock@dynasafe.de). The views expressed are those of the authors and do not necessarily reflect those of Dynasafe or SIPRI.

[2] See, for e.g., Missianen, T., Paka, V. and Emalyanov, E., *Modelling of Ecological Risks Related to Sea-Dumped Chemical Weapons, MERCW*, p. 5,
<http://www.fimr.fi/en/tutkimus/muututkimus/mercw/news.html>; and Beddington, J. and Kinloch, A. J., *Munitions Dumped at Sea: a Literature Review* (Imperial College: London, June 2005). In general such estimates probably combine the weight of the agent and munitions body. During the negotiations of the 1993 Chemical Weapons Convention (CWC) parties began to distinguish between the two and often referred to agent weight only, except when considering 'munitions and devices'. See CWC, Article II, para. 1.

[3] See Walij, A., *Dumpade C-stridsmedel i Skagerrak och Östersjön en Uppdatering* [Dumped Chemical Warfare Material in the Skagerrak and the Baltic Sea An Update], Report no: FOI-R-0148-SE (Swedish Defence Research Agency (FOI): Umeå, Sweden, Sep. 2001); Advisory Committee on Protection of the Sea, *Maritime and Coastguard Agency Research Project no: 488, Coastal Survey of Packaged Chemical and Other Hazardous Items 2002/2003* (London, Oct. 2003); and Swedish Coast Guard, *Kemiska Stridsmedel till Sjöss: Information och Vägledning för Svensk Fiskare* [Chemical Warfare Material at Sea: Information and Guidance for Swedish Fishermen] (21 May 2003).

[4] E.g. this has been the general view of participants of HELCOM meetings.

II. Overview

The Baltic Sea is famous for its many well-preserved shipwrecks, perhaps 200 000 or more, and has been called 'an archaeological paradise'.[5] Objects located in these waters tend to remain in good condition because of the sea's low salinity and temperature. While the cost of recovering or remediating dumped CW is uncertain, the Baltic Sea has special characteristics that more readily allow for salvage operations. It has an average depth of 55 meters. Although its maximum depth is 459 meters, it is usually not deeper than about 130 meters—even in areas where no land is visible. It also has generally weak currents. This means that it is readily accessible to divers and is well within the operating limits of remote operated vehicles (ROVs).[6] In addition, the Baltic Sea is one of the best studied bodies of water by scientific researchers thanks in part to the work of the Helsinki Commission (HELCOM).

Scientists and technical experts continue to study options for the recovery and disposal of dumped CW, such as at the annual chemical weapons demilitarisation (CWD) conferences organised through the UK Ministry of Defence's Defence Science and Technology Laboratory (DSTL). Participants at these meetings have, for example, periodically considered the work of a major recovery operation of dumped World War II-era CW that has been carried out since 2004 at Kanda Port in south-western Japan where dredging operations are underway in preparation for the construction of an airport. This work involves the use of magnetometers and divers who have recovered more than 1200 chemical munitions from a survey area totaling approximately 650 hectares. The munitions are destroyed using a mobile explosive containment chamber in the dock area. The use of the magnetometer has greatly increased the number of point detections (totaling more than 150 000) of metal of which approximately 92 per cent have been found to be scrap metal. Divers have been able to find fewer point detections of metal (more than 2600). However, of these detections, approximately 15 per cent have turned out to be munitions.[7]

Information on the technical challenges experienced during other munition recovery operations generally more limited. Shortly before the end of World War II, Germany dumped 69 000 tabun-filled (GA) artillery shells at a depth of between 20–30 meters in an area called 'Little Belt' located between the Danish islands of Als and Fys. In 1959–1960, the Federal Republic of Germany raised two ships containing the GA shells and repackaged the munitions before redisposing of them in the Bay of Biscay at a depth of 2 km.[8]

[5] The low temperature and low oxygen and salt (*c*. 3.5 per cent) content assist in the preservation of wood, partly because naval shipworm (*Teredo navalis*) cannot thrive in low salt waters. Thus, for example, a 17 meter mast of a 18th century carvel in the Oxelö archipelago in Swedish waters remained standing when it was surveyed starting in the mid-1990s. An 18th century Dutch warship was found in 2007 in similar condition by a Swedish submarine crew while carrying out routine survey work.

[6] For insight into the role of divers for surveying and recovery of military wrecks, including dangers posed by ordnance, see Lenihan, D., *Submerged: Adventures of America's Most Elite Underwater Team* (Newmarket Press: New York, 2002).

[7] Takashi, W. and Ryusuke, K., 'Destruction of old chemical bombs using DAVINCH™ at Kanda, Japan', Presentation at CWD2007, Brussels, 14–18 May 2007, available at 'Chemical Weapons Demilitarisation Conferences', <http://www.dstl.gov.uk/conferences/cwd/index.php>.

[8] Ministry of the Environment, Environmental Protection Agency (Denmark), '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', Paper presented at the 14th meeting of the Baltic Marine Environment Protection Commission (Helsinki Commission), HELCOM 14/10/1, 14 Jan. 1993, p. 10; and Chemische Kampfstoffmunition in der südlichen und westlichen Ostsee: Bestandsaufnahme, Bewertung und Empfehlungen, Bericht der Bund/Länder-Arbeitsgruppe Chemische Kampfstoffe in der Ostsee [Chemical munitions in the southern and western Baltic Sea: compilation, assessment and recommendations, Report by the Federal/Länder Government Working Group 'Chemical Munitions in the Baltic Sea'] (Federal Maritime and Hydrographical Agency: Hamburg, May 1993), p. 1.

Finally, contemporary underwater explosive clearance can be used to help inform the possible recovery or remediation of sea-dumped CW.[9]

III. Search and recovery techniques

A number of techniques can be used to survey dump sites, including through the use of magnetometers, side scan sonar and sub bottom profilers. Sub bottom profiling systems, for example, typically entail the use of an air gun which is towed behind a ship. The gun produces a loud sound that penetrates the sea floor and is reflected at different times back to a hydrophone—also towed behind the ship as part of an array. The differences in the sound reflections reveal the layers of material along the sea floor. Archaeologists and recreational divers sometimes tow side scan sonar 'fish' to locate shipwrecks.[10] ROVs and, possibly, divers can then be used to visually inspect objects of interest. Geophysical samples can also be taken. Finally, all such information can be loaded into a computer-integrated system that includes geographical coordinates and the precise physical characteristics of any number (e.g. thousands) of objects.

Relevant characteristics of dumped CW that should be taken into account during any search and recovery include: (*a*) the munitions often have their fuses, (*b*) the munitions were usually packed into boxes or containers, but they may have also been dropped into the water individually (i.e. the munitions are 'loose'), (*c*) the records on the location, munitions type and fill are incomplete, (*d*) the current state of the munitions (i.e. stability) is uncertain, (*e*) dump sites may consist of a mix of CW agents and munitions type, (*f*) some of the agents may be completely decomposed or heavily degraded, while others may remain largely viable and (*g*) some states may be reluctant to fully share their information on sea dumping.[11]

IV. Recent activity

Perhaps most of the authoritative information on CW dumped in the Baltic have been made available through the work of the 1992 Ad Hoc Working Group on Dumped Chemical Munitions of the Baltic Marine Environmental Protection Work (Helsinki Commission, HELCOM). The papers tabled during these meetings have served as standard references.[12]

Nord Stream

Nord Stream AG, a German–Russian business consortium, currently plans to operate, starting in 2010, a 1200-kilometre gas pipeline, worth an estimated €5 billion, which will link Viborg, Russia, and Greifswald, Germany.[13] The consortium is currently screening the sites over which the pipeline would run to ensure that it does not disturb munition dump sites and sites of historical importance. Three Swedish survey vessels belonging to Marin Mätteknik AB and some

[9] See Underwater Ordnance Recovery, Inc., <http://www.uwuxo.com/documentation.html>; and Albright, R. D., *Cleanup of Chemical and Explosive Munitions: Locating, Identifying Contaminants, and Planning for Environmental Remediation of Land and Sea Military Ranges and Ordnance Dumpsites* (William Andrew, Inc.: Norwich, New York, 2008).

[10] See <http://www.ukdiving.co.uk/wrecks/>.

[11] Based on Heaton, H. and Stock, T., 'Recovered sea-dumped chemical weapons—possibilities for on– and off–shore treatment', First International Conference of Chemical and Conventional Munitions Dumped at Sea, Halifax, Nova Scotia, Canada, 9–11 Oct. 2007, presentation slides, p. 5.

[12] Helsinki Commission, Baltic Marine Environment Protection Commission, <http://www.helcom.fi/home/en_GB/welcome/>. See also Eds. Stock, T. and Lohs, K., *The Challenge of Old Chemical Munitions and Toxic Armament Wastes*, SIPRI Chemical & Biological Warfare Studies no. 16 (Oxford University Press: Oxford, 1997).

[13] For general background on European—Russian political developments regarding oil and energy, see Goldman, M. I., *Petrostate: Putin, Power, and the New Russia* (Oxford University Press: Oxford, 2008).

90 investigators have carried out a seabed survey to collect sediment samples and screen for submerged objects along a 2 km wide corridor. More detailed screening, down to 10 cm, has been carried out in a 15 metre wide installation corridor.[14] Nord Stream has a three stage approach to conducting its survey. The first involves the use of a multi-beam echo sounder, a high resolution side scan sonar and a sub-bottom profiler. The second stage involves using a magnetometer array and electronic induction sensors[15] fitted to a specially constructed frame that is towed at 1–2 knots approximately 5 metres above the seabed. During the third stage, sensor readings of interest, including suspect munitions, are further investigated using a ROV equipped with scanning sonar and video equipment.[16]

On 18 August 2008 Nord Stream announced that it will, in cooperation with the Bureau for Culture and Care and Preservation of Ancient Monuments and Artefacts of the state of Mecklenburg–Western Pomerania, raise a ship off the coast of Rügen in order to help clear a 60 meter corridor for the gas pipeline. The ship, which is approximately 12.8 metres long and 3.5 meters wide, will be re-sunk in a gravel lake for further study.[17] It is one of approximately 20 which the Swedish Navy sank in 1715 in shallow water in order to create a 980 meter wall to prevent entry by the Danes into the Bay of Greifswald. The ships were discovered in 1990.

The initial proposed route, which was to run down the middle of the Baltic Sea and pass off the southeast side of Gotland, will be modified. On 2 September 2008 the consortium announced that it will adopt an 'optimised' route around Bornholm along the southern, rather than northern, route (the so-called S-route). It took the decision partly on the basis of about 100 soil samples which were taken in Danish waters and tested by the Danish Hydraulic Institute (DHI) and the Finnish Institute for Verification of the Chemical Weapons Convention (VERIFIN). Denmark's National Environmental Research Institute (NERI) will shortly issue a final report on these test results and Nord Stream will issue a detailed assessment of the S-route in accordance with the provisions of the 1991 Convention on Environmental Impact Assessment in a Transboundary Context (Espoo).[18]

There is concern that the detonation of a single munition may be sufficient to rupture the pipeline. At least 100 wrecks have been charted the waters off the island, while historical records indicate that up to 2,500 ships may be sunk around the island over the past 250 years.[19] According to one estimate, some 100 000 tonnes of unexploded World War II munitions lie in the path of the projected pipeline.[20] There is concern that any disturbance of the site could

[14] Munitions survey in Gulf of Finland currently underway', *Facts About the Natural Gas Pipeline Across the Baltic Sea*, no. 5 (Jan. 2008), p. 2.

[15] Electronic induction sensors are sensors that consist of an induction loop. Electric current generates a magnetic field which collapses after the current is cut. Because metal is an effective inductor, its presence increases the current flowing through the loop.

[16] 'Strategy for the handling of munition finds developed', *Facts About the Natural Gas Pipeline Across the Baltic Sea*, no. 1 (Apr. 2007), p. 2.

[17] 'Nord Stream to raise historic shipwreck near German Rügen island', 18 Aug. 2008, <http://www.nord-stream.com/en/news-list/news/news-detail/article/nord-stream-to-raise-historic-shipwreck-near-german-ruegen-island-1.html?no_cache=1&tx_ttnews[backPid]=1&cHash=bce2fdc02a>.

[18] 'Nord Stream presents optimised route in Bornholm Area', 2 Sep. 2008, <http://www.nord-stream.com/en/news-list/news/news-detail/article/nord-stream-presents-optimised-route-in-bornholm-area.html?no_cache=1&tx_ttnews[backPid]=1&cHash=3e4766d5ce>. See also United Nations Economic Commission for Europe, <http://unece.org/env/eia/>.

[19] MACHU (Managing Cultural Heritage Underwater)', 13 Aug. 2008, <http://www.machuproject.eu/news/news-27.htm>.

[20] 'MACHU, (note 19).

damage adjacent ships.[21] It is possible that munitions or munitions-filled ships may also be resting in the area.

Helsinki Commission

HELCOM is the governing body of the 1992 Convention on the Protection of the Marine Environment of the Baltic Sea Area (the convention entered into force in 2000). The Ad Hoc Working Group on Dumped Chemical Munitions of the Baltic Marine Environmental Protection Work began in 1992 a series of meetings among countries with an interest in chemical weapons (CW) that have been dumped in the Baltic Sea. The group, more informally known as the Helsinki Commission (HELCOM), agreed terms of reference for its work in February 1993.[22] HELCOM's final report identified five locations where fishing vessels were advised not to anchor or fish with bottom tackle (see table 1). It also recommended continued information collection and study of the issue and concluded that the state of recovered munitions ranged from some which were intact to others that were completely corroded and contained no CW agent. The report also contains guidelines for contracting parties to the convention on how to deal with CW.[23] The commission continues to monitor the sea dumping issue.

Table 1. Areas identified by the Helsinki Commission where fishing vessels should not anchor or use bottom tackle

	Parallels	Meridians
A.	55° 50' north and 55° 40' north	18° 30' east and 20° 00' east
B.	54° 50' north and 55° 30' north	14° 30' east and 16° 30' east
C.	54° 45' north and 54° 52' north	10° 00' east and 10° 20' east
D.	58° 10' north and 58° 25' north	09° 10' east and 09° 50'east
E.	58° 07' north	10° 47' east

Source: 'Final report of the ad hoc Working Group on Dumped Chemical Munition (HELCOM CHEMU) to the 16th meeting of the Helsinki Commission', Mar. 1995, p. 13.

Modeling of Ecological Risks Related to Sea-dumped Chemical Weapons

In October 2008 the Modelling of Ecological Risks Related to Sea-dumped Chemical Weapons (MERCW), worth €2 250 000, is scheduled to be completed. The purpose of this project has been to study CW munition dump sites in the Baltic Sea and Skagerrak area in order to assess the environmental risks posed by them to humans and the environment.[24] The project developed an

[21] MACHU, (note 19).

[22] See 'Helsinki Commission, Baltic Marine Environment Protection Commission', <http://www.helcom.fi/>.

[23] 'Final report of the ad hoc Working Group on Dumped Chemical Munition (HELCOM CHEMU) to the 16th meeting of the Helsinki Commission', Mar. 1995.

[24] The institutes involved are: (*a*) the Finnish Institute of Marine Research (Finland), (*b*) the Shirshov Institute of Oceanology, Atlantic Branch (Russia), (*c*) the Saint Petersburg Scientific Research Centre of Ecological Safety (Russia), (*d*) the Scientific and Production Association 'Typhoon' (Russia), (*e*) the Renard Centre of Marine Geology, University of Gent (Belgium), (*f*) G-tec (Belgium), (*g*) the Rheinische Friedrich-Wilhelms Universität, Bonn (Germany), (*h*) NERI (Denmark), and (*i*) VERIFIN (Finland). See 'Finnish Institute of Marine Research, <http://www.fimr.fi/en_GB/>; Ocean.ru, <http://ocean.ru/eng/>; Russian Federal Service for Hydrometeorology and Environmental Monitoring (RosHydroMet), 'Typhoon' scientific and production association, <http://www.typhoon.obninsk.ru/english/main.htm>; Renard Centre of Marine Geology, <http://www.rcmg.ugent.be/>; G-tec, <http://www.gtec.be/>; NERI, <http://www.dmu.dk/>; and Finnish Institute for Verification of the Chemical Weapons Convention, <http://www.helsinki.fi/verifin/VERIFIN/english/>.

integrated geophysical, geo- and hydro-chemical, hydrographical and hydro-biological site investigation. It aimed to model the release, migration and degradation of toxic compounds and their degradation products. The project, which is funded under the European Commission Framework Programme 6, began in mid-2006 when a geophysical and hydrographical survey was carried out in the Bornholm Basin. The first half of the MERCW project took magnetometric readings, while the second part took acoustic readings. Researchers have also carried out hydrographic measurements and sediment sampling throughout the exercise.

In 2006 MERCW issued an interim report which assessed three dump sites: (*a*) the Bornholm Basin, (*b*) the Southern Gotland Basin and (*c*) Eastern Skagerrak.[25] Citing HELCOM reports, the study stated that approximately 13 000 agent tonnes of CW (more than 35 000 tonnes including munition weight) of CW was dumped in the Bornholm Basin at depths between 80–100 meters; that at least 2 000 tonnes had been at depths between 80–100 meters in the Southern Gotland Basin; and that at least nine ships (carrying 20–50 000 tonnes of 'toxic agents') were scuttled at about 200 meters in the Eastern Skagerrak.[26] While the organophosphorus nerve agents hydrolyze to relatively non-toxic products, sulphur mustard develops a crusty exterior at sea water temperatures while the interior remains viscous (HD hydrolyses readily at 90 degrees celsius). In addition, the fate of arsenic (both in organic and inorganic form) is a longstanding concern. Russian researchers have reported a 'high dispersion and sharp anomalies' of arsenic levels reaching up to 200 mg/kg at the Måseskår dumpsite in the Eastern Skagerrak region. This could imply that arsenic CW agents are the source.[27]

Managing Cultural Heritage Underwater

Finally, the Managing Cultural Heritage Underwater (MACHU) project is developing an international global information system (GIS) and database of ship wrecks and other objects of archaeological interest on the seabed.[28]

V. Chemical Weapons Convention

As of September 2008 184 countries have ratified or acceded to the CWC. The Technical Secretariat (TS) of the Organisation for the Prohibition of Chemical Weapons (OPCW), located in The Hague carries out onsite inspections at military and civilian chemical facilities and processes declarations from states parties to the CWC. Short notice challenge inspections of sites where illicit activities are suspected may be carried out by international inspection teams.

The CWC requires every party to destroy all chemical weapons it 'owns or possesses, or that are located in any place under its jurisdiction or control'.[29] Declaration and destruction requirements for chemical weapons are located in Articles III (Declarations) and IV (Chemical Weapons) and Part IV(A) of the Verification Annex (Destruction of Chemical Weapons and its Verification Pursuant to Article IV). The Convention requires that chemical weapons be destroyed in 'an essentially irreversible way to a form unsuitable for production of chemical

[25] Missianen, T., Paka, V. and Emalyanov, E., *Modelling of Ecological Risks Related to Sea-Dumped Chemical Weapons, MERCW*, <http://www.fimr.fi/en/tutkimus/muututkimus/mercw/news.html>. Missiaen works for the Renard Centre of Marine Geology at the University of Gent, while Paka and Emalyanov work at the Shirshov Institute of Oceanology in Kaliningrad.

[26] Missianen, T., Paka, V. and Emalyanov, E., (note 25), p. 6,

[27] Missianen, T., Paka, V. and Emalyanov, E., (note 25), p. 46.

[28] 'MACHU (Managing Cultural Heritage Underwater)', <http://www.machuproject.eu/>.

[29] CWC, Article I, para. 2. There is one exception to the general obligation to destroy chemical weapons. Chemical weapons which were buried before 1 Jan. 1977 and which remain buried or chemical weapons dumped at sea before 1 Jan. 1985 are not, at the discretion of the State Party, subject to the CWC's declaration and destruction provisions. CWC, Article III, para. 2; and Article IV, para. 17.

weapons'.[30] Any destruction technology must destroy a given amount of CW agent up to a certain percentage. No quantitative minimum threshold of destruction efficiency, referred to as 'completeness of destruction', has apparently been agreed.[31] But it would seem that four nines (i.e. 99.99 per cent) is the minimum acceptable level of destruction efficiency for which there is consensus among delegations.[32] A party may not destroy chemical weapons by dumping in any body of water, land burial or open–pit burning.[33] States Parties are also required to 'assign the highest priority' to ensuring the protection of people and the environment during transportation, sampling, storage, and destruction of chemical weapons.[34]

During the course of negotiations in the Preparatory Commission (PrepCom) for the OPCW, the term 'chemical weapon' has been frequently understood to mean either (*a*) a chemical weapon produced between 1925 and 1946 which has been determined to be usable, or (*b*) a chemical weapon produced on or after 1 January 1946. The Convention defines a 'chemical weapon'—in the broader sense of the term—as consisting of one or more of the following: (*a*) toxic chemicals and their precursors which are in a type or quantity not consistent with the object and purpose of the Convention; (*b*) munitions and devices which are specifically designed to cause harm or death through the use of toxic chemicals and their precursors; or (*c*) any equipment which is specifically designed to be used directly in connection with the munitions and devices as defined in (*a*) or (*b*).[35] An 'old chemical weapon' is defined as a chemical weapon which was produced before 1925 or one which was produced between 1925 and 1946 which has been determined to be 'unusable'.[36] The level of verification corresponds to the level of risk the weapon poses to the Convention. Thus chemical weapons produced (*a*) after 1 January 1946 or (*b*) produced between 1925 and 1946 which have been determined to be usable are subject to full and systematic verification. Chemical weapons which the Technical Secretariat has confirmed as having been produced before 1925, however, are to be destroyed as 'toxic waste'.[37]

Burial or dumping of CW

The Convention allows State Parties the option of declaring and/or destroying chemical weapons buried on its territory before 1 January 1977 and which remain buried or chemical weapons 'dumped at sea' before 1 January 1985.[38] The relevant text of the CWC is as follows:

(*a*) 'The provisions of this Article and the relevant provisions of Part IV of the Verification Annex shall not, at the discretion of a State Party, apply to chemical weapons buried on its territory before 1 January 1977 and which remain buried, or which had been dumped at sea before 1 January 1985.' (para. 2, Article III (Declarations));

[30] CWC, Verification Annex, Part IV(A), para. 12.

[31] During the Preparatory Commission's (PrepCom) work, the Expert Group on Chemical Weapon Destruction Facilities considered the issue but was unable to reach consensus on a quantitative threshold. See, Expert Group on Chemical Weapons Destruction Facilities, Interim Report, PrepCom document PC-V/B/WP.17, 3 Dec. 1993, para. 13, p. 8. The issue has almost certainly been revisited, at least informally, since entry into force of the CWC. There is no formal obligation unless the OPCW takes a formal decision.

[32] See, Expert Group on Chemical Weapons Destruction Facilities, Interim Report, PrepCom document PC-V/B/WP.17, 3 Dec. 1993, para. 13, p. 8.

[33] CWC, Verification Annex, Part IV(A), para. 13.

[34] CWC, Article IV, para. 10.

[35] CWC, Article II, para. 1.

[36] CWC, Article II, para. 5.

[37] CWC, Verification Annex, Part IV(B), para. 6.

[38] CWC, Article III, para. 2; and Article IV, para. 17.

(*b*) 'The provisions of this Article and the relevant provisions of Part IV of the Verification Annex shall not, at the discretion of a State Party, apply to chemical weapons buried on its territory before 1 January 1977 and which remain buried, or which had been dumped at sea before 1 January 1985.' (para. 17, Article IV (Chemical Weapons)).

Decisions

A State Party is obligated to declare CW buried on its territory on or after 1 January 1977 or CW 'dumped at sea' on or after 1 January 1985.[39] Such declarations 'could include any additional information, if available, that could facilitate the Technical Secretariat's evaluation of the information, *inter alia*: (*a*) the exact date when the chemical weapons were buried or dumped; (*b*) how the chemical weapons were buried or dumped, e.g. inside crates, individual items, etc.; (*c*) the present condition of the buried and dumped chemical weapons; and (*d*) possible environmental risks posed'. If CW buried on the territory of a State Party before 1 January 1977 should subsequently become uncovered, then the State Party is obliged to declare this CW.

On 13 February 1997, the Expert Group 1 on Chemical Weapons Issues recommended that Working Group B submit for adoption to the 16th Plenary of the PrepCom the following understanding of the declaration and destruction requirements for chemical weapons 'buried by a State Party on its territory' and 'dumped at sea':

'*(a)* the term 'buried by a State Party on its territory' in Article III, paragraph 2 and Article IV, paragraph 17, shall be understood to cover chemical weapons buried on the land territory of a State Party or in its internal waters;

(b) the term 'dumped at sea' in the same paragraphs shall be understood to cover chemical weapons dumped at all parts of sea, including territorial sea of a State Party.'

The recommendation also states that chemical weapons dumped in archipelagic waters should be considered as having been 'dumped at sea' and that borders between territorial sea, land territory and internal waters should be determined in accordance with relevant international law. The concept of 'territory' includes a State Party's internal waters.

The recommendation was considered and approved by the 16th Plenary of the PrepCom.[40] Following the entry into force of the CWC on 29 April 1997, these decisions were then formally adopted by the First Conference of States Parties.[41] In November 1998 the Third Conference of States Parties further decided that the TS 'shall inspect chemical weapons buried on the territory of a State Party after 1976 or dumped at sea after 1984 on the basis of declarations submitted to this effect, taking into consideration that *such weapons have to be accessible in terms of identification* thereof as required in Article IV and the relevant provisions of Part IV of the Verification Annex'. [emphasis added][42] This decision also formally removed the issue of 'all

[39] 'Expert Group 1 on Chemical Weapons Issues, First Report', PrepCom document, PC-XVI/B/WP.4, 13 Feb. 1997, p. 4.

[40] 'Report of the Commission', PrepCom document PC-XVI/36, 15 Apr. 1997, para. 10.2.

[41] 'Decision, Declaration Requirements for Chemical Weapons Buried by a State Party on its Territory after 1976 or Dumped at Sea after 1984', OPCW document C-I/DEC.30, 16 May 1997 and 'Decision, Understanding with Respect to the Terms "Buried by a State Party on its Territory" and "Dumped at Sea"', OPCW document C-I/DEC.31, 16 May 1997.

[42] 'Decision, All Aspects of the Issue of Chemical Weapons Buried by a State Party on Its Territory after 1976 or Dumped at Sea after 1984, Including a Possible Challenge Inspection, and Its Implications for the Technical Secretariat's Responsibilities', OPCW document C-III/DEC.12, 20 Nov. 1998.

aspects of the issue of chemical weapons buried by a State Party on its territory after 1976 or dumped at sea after 1984, including a possible challenge inspection, and its implications for the Technical Secretariat's responsibilities' from the list of issues still not resolved by the OPCW.

It is still not entirely clear to what extent the provisions of paragraph 1(a) of Article III apply in practice to (*a*) chemical weapons buried on the territory of a State Party on or after 1 January 1977 and which remain buried, and (*b*) for chemical weapons dumped at sea on or after 1 January 1985. How these decisions are or will be implemented is not well documented by information in the public domain. Thus far, however, no formal declarations of dumping of CW in the high seas or in territorial waters have been submitted to the OPCW.

Finally, information relevant to the dumping of CW may be contained in information provided to the OPCW under paragraph 5 of Part IV(A) of the Verification Annex which requires States Parties to declare any chemical weapons which it has 'transferred or received' since 1 January 1946 as long as the total transferred exceeds '1 tonne per chemical per year in bulk and/or munition form'.[43]

Financing

Under the CWC, the direct costs of verification are borne by the inspected State Party under the general principle that 'the possessor pays'. Costs not incurred as a direct result of an inspection are covered by the OPCW as a whole. In the case of abandoned CW, the Abandoning State Party (ASP) pays for the direct costs of international verification.[44] In cases where there is no State Party or Territorial State Party (TSP) (the State Party which has had ACW left on its territory), the direct costs of international verification would probably have to be borne by the all OPCW States Parties according to the UN scale of assessment (some of the costs could perhaps be offset by the establishment of a special fund). Such a situation could result in cases where CW has been dumped in the high seas.

Analysis

During the CWC negotiations the issue of dumped CW presented challenges with uncertain, yet significant implications. While dumping has been carried out throughout the world on a very large scale, much of the detail on where and how it was carried out remains uncertain and will remain so. An important principle reflected in the provisions of the CWC is the proper allocation of rights and responsibilities of the States Parties. However, determining who is responsible for the destruction of dumped CW is potentially problematic. In the case of the Baltic Sea most of the munitions (conventional and chemical) appear to be of German origin. However the weapons were not under the jurisdiction or control of Germany when they were dumped. Moreover it would not be reasonable to place too many financial and administrative burdens on those states in the region that might wish to participate in the recovery or remediation of dumped CW. Any such activity should be carried out in a reasoned and balanced manner. Nor should any state be compelled to participate in such operations.

VI. Environmental factors

From the practical recovery experience of old chemical munitions on land it is clear that high safety precautions must be applied. For such weapons the munition bodies have corroded over a

[43] CWC, Verification Annex, Part IV(A), para. 5.

[44] 'Abandoned Chemical Weapons' are defined as CW or old CW 'abandoned by a State after 1 January 1925 on the territory of another State without the consent of the latter'. CWC, Article II, para. 6.

period of decades, the agents and explosives inside might have been partially degraded or decomposed and the condition of fuse and burster charges are unpredictable. Handling these old munitions must be done with the greatest care and under special safety procedures.

Sea conditions and processes

Dumped chemical munitions present an additional element of unpredictability. This is because the potential impact that seawater might have on these old munitions is still not clearly understood. Despite previous scientific investigations, a comprehensive understanding of the nature of corrosion at various depths in seawater is not available. These specific conditions might have an impact on decomposition of CW agents and the associated explosive material.

When considering the possible environmental behaviour of old dumped chemical munitions, it is important to distinguish the different scenarios for these weapons. There should be a clear understanding that a chemical warfare agent itself can undergo decomposition/degradation over the years (i.e. autonomous degradation/decomposition) and the degradation/decomposition can be triggered by external factors (e.g. the collapse of the integrity of a ship). In addition, it is necessary to define the condition of the munitions shell body. From a practical point of view, it may be desirable to distinguish the following possibilities:

(*a*) the chemical munition shell is still more or less an intact steel body;
(*b*) the chemical munition shell is partly corroded and the inner agent and explosive components are partially in contact with sea water;
(*c*) the chemical munitions is more or less without a munition casing and the agent and explosive components are in direct contact with the seawater.

Finally, in addition to the agent and the munitions shell bodies, one must also consider the explosive parts: the fuses and burster charges. These may: (*a*) have been degraded/decomposed over the years, (*b*) be in contact with the chemical warfare agent fills and have undergone different chemical degradation/decomposition processes, (*c*) remain active or (*d*) have partially reacted with the shell bodies.

Taking into account the chemical warfare agents present in the munitions being dumped after WWII into the Baltic Sea (these have been mainly S-mustard, arsine-oil, phosgene/diphosgene, Clark I and Clark I, Adamsite, chloroacetophenone (CAP), tabun and N-mustard, and small amounts of lewisite), there is a need to examine the chemistry and physicochemical properties of these agents for a further assessment (in addition to evaluating the behaviour of the munitions body).

The long-term behaviour, degradation or detoxification of these agents in general and in munitions in particular is dependant on: (*a*) temperature, (*b*) pH-value, (*c*) salinity, (*d*) pressure, (*e*) current velocity and (*f*) chemical composition and corrosive activity. The last factor can be regarded as an internal one, all the others are clearly external factors. Furthermore, if looking into the chemical agent itself, there are additional factors such as: (*a*) solubility, (*b*) purities or impurities, (*c*) stability and (*d*) reactivity.

Table 2. Physico–chemical properties of select CW agents

Substance	Chemical formula	Density (g/cm^3)	Mp in ºC	Bp in ºC
Phosgene	$COCl_2$	0.0044	-127.9– -118	7.5–8.2
Diphosgene	$C_2Cl_4O_2$	1.636	-57	127
Clark I	$C_{12}H_{10}AsCl$	1.422	41–44.5	333 (dec.)
Clark II	$C_{13}H_{10}AsN$	1.45	28–35	290–340 (dec.)
Chloroacetophenone	C_8H_7ClO	1.321	54–60	245–247
Adamsite	$C_{12}H_9AsClN$	1.648	195	410
Sulphur Mustard	$C_4H_8Cl_2S$	1.27–1.28	13.5–14.4	216–227.8
Nitrogen Mustard	$C_6H_{13}Cl_2N$	1.0861 (23 ºC)	-34	85 (at 15 mm Hg)
Lewisite 1 (cis)	$C_2H_2AsCl_3$	1.886	-18– -13	190 (dec,)
Lewisite 1 (trans)	$C_2H_2AsCl_3$	1.8598	-1.2	196.6 (dec.)
Tabun	$C_5H_{11}N_2O_2P$	1.077	-50– -48	235–246

Source: Kopecz, P., *Review of Suspected Warfare-Related Environmental Damage in the Federal Republic of Germany, Part 3: Chemical Agent Dictionary*, texte 32/96, Research Project No. 103 40 102/02, UBA-FB 96-030/3e, Umweltbundesamt 1997; Martinetz, D. and Rippen, G., *Handbuch Rüstungsaltlasten*, 1996, Ecomed Verlagsgesellschaft, Landsberg; and Compton, J. A. F., *Military Chemical and Biological Agents: Chemical and Toxicological Properties* (Telford Press: Caldwell, N.J., 1987); and M. Koch, Nehring, S. and Ruck, W., *Chemical and conventional ammunition in the Baltic Sea – Status quo, related risk potentials, possible securing and remediation attempts at ENCORA*, <http://www.encora.eu/coastalwiki/Chemical_and_conventional_ammunition_in_the_Baltic_Sea>, 2008.

Baltic Sea environment

Salinity

The Baltic Sea presents an eco-system which is characterized by a slightly alkaline pH value around pH 8. This value is influenced mainly by the salinity. The Baltic Sea's salinity is much lower than that of ocean water, as a result of abundant freshwater runoff from the surrounding land. The runoff contributes roughly one-fortieth its total annual volume. The open surface waters of the central basin have salinity of 6–8 per cent. At the semi-closed bays with major freshwater inflows, such as the head of the Finnish Gulf with Neva mouth and the head of Bothnian gulf with close mouths of Lule, Tornio and Kemi, the salinity is considerably lower. Below 40–70 meters, the salinity is between 10 and 15 per cent in the open Baltic Sea, and more than this near Danish Straits. The flow of fresh water into the sea from approximately two-hundred rivers and the introduction of salt from the South builds up a gradient of salinity in the Baltic Sea. Near the Danish straits the salinity is close to that of the Kattegat, but still not fully oceanic, because the saltiest water that passes the straits is still already mixed with considerable amounts of outflow water. The salinity steadily decreases to the north and east. At the northern part of the Gulf of Bothnia the water is no longer salty.

Temperature

Another factor influencing chemical reactions, including decomposition, is temperature. Solubility and reaction speed increase if temperature increases.[45] In addition, the temperature is important in order to ascertain the behaviour of agents regarding their melting and boiling points. Only phosgene is a gas at normal sea-water temperatures. All other above listed agents are solid or liquid.

Density

The density of sea-water is approximately 1.08 g/cm^3 (for Baltic Sea water). With exception of tabun and phosgene (this is a gas anyway) all other above listed agents do have a higher density than the Baltic Sea water. This means nothing more that these agents will not rise to water surface automatically.

Dissolution/Solubility

In reviewing the decomposition of CW agents under water conditions, the dissolution is most probably the important step, because dispersion will be much faster if the agent is already dissolved in water. The following table presents an overview on solubility of CW agents.

Table 3. Solubility of CW agents

Agent	Solubility in water [g/l]
Chloroacetophenone (CAP)	1
Clark I	2
Clark II	2
Adamsite	negligible
Phosgene	9
Sulphur Mustard	0.8
Nitrogen Mustard	0.16
Lewisite	0.5
Tabun	120

Source: Stock, T., 'Sea-dumped chemical weapons and the Chemical Weapons Convention', in Kaffka, A. V. (ed.), *Sea-Dumped Chemical Weapons: Aspects, Problems and Solutions* (Kluwer Academic Publishers: Dordrecht, 1996), p. 55.

As regards solubility, the reaction of chemical warfare agents with water depends on hydrolysis as the main reaction.

VII. Implications

CW destruction activities have thus far been conducted only on land, not at sea. Specialized salvage, analytical and destruction equipment would have to be developed for use on the high seas before any significant offshore remediation efforts could be seriously contemplated. Some CW-dumped munitions were sealed into concrete or steel containers and may be located in poorly accessible areas within the interior of the scuttled ship. Raising the ship or ships may not be feasible. CW munitions could disintegrate if raised causing short term, high level CW exposure to the environment. The throughput of any destruction operation would be low, perhaps a couple of dozen per day. One would have to consider whether remediation or destruction

[45] E.g. if the temperature increases by 10°C, the speed of chemical reaction doubles.

efforts could or should be carried out at sea over a period of months or years. Removal of CW to shore, on the other hand, would increase the number and scope of problems (legal, political and technical). Furthermore, any remediation effort would have to include procedures for dealing with conventional explosives, either conventional munitions or as part of the CW munitions themselves (i.e. burster charges, fuse mechanisms, and propellant). It would be risky to bring thousands of fused munitions directly on board a ship. One or more would certainly explode. A possible alternative could be to handle all munitions on an underwater platform removed from the ship and at a depth low enough to be unaffected by surface wave action. One must then consider how analytical and destruction equipment could be adapted to underwater destruction operations in a relatively safe and effective manner. In short, the technological and financial challenges of any attempted remediation would be very high and probably questionable.

If a dump site were found to be releasing agent into surrounding environment at a dangerously high rate, a possible response could be to pour concrete over the site to slow the rate at which the agent is reintroduced into the environment. This is clearly a technically feasible option. A Soviet nuclear submarine, the *Komsomolets*, which sank in 1989 in the western approaches to the Barents Sea, for example, was subsequently encased in concrete.

VIII. Recommendations and conclusions

As already identified by HELCOM CHEMU more than 10 years ago, the following topics require further thorough investigation:[46]

(*a*) locations of dumped munitions;
(*b*) ecological and eco-toxicological effects of chemical warfare agents;
(*c*) presence of chemical warfare agents in various marine compartments, especially the presence of the more persistent and poorly soluble agents in sediment and biota;
(*d*) elaboration of national guidelines for fishermen on how to deal with chemical munitions;
(*e*) guidelines on how to deal with incidents[47]; and
(*f*) compilation of information on the state of corrosion of munitions.

The literature on dumping of munitions should be further integrated with the literature on shipwrecks. An extensive recreational and professional diving community exists in the Baltic Sea region and its members may be familiar with the nature and type of ships and degree of accessibility.[48] Scientists and marine archeologists sometimes use submersibles and ships with salvage equipment in their work. Those involved in any recovery or remediation effort should therefore take into consideration the experience of such groups.

It is possible that the entire seabed of the Baltic Sea will be completely surveyed and the information made available through a single, integrated data system.

[46] For a more actual overview see also: OSPAR Commission, 2005, 'Overview of Past Dumping at sea of Chemical Weapons and Munitions in the OSPAR Maritime Area'. (OSPAR: Convention for the Protection of the Marine Environment of the North-East Atlantic was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 Sep. 1992. The Convention entered into force on 25 Mar. 1998.

[47] See also HELCOM, 1995, 'Final Report of the ad hoc Working Group on Dumped Chemical Munitions. Attachment III HELCOM Guidelines to be used by the Contracting Parties when elaborating National Guidelines for fishermen on how to deal with caught chemical weapons—Fisheries and Warfare Agents, Preventive Measures and First Aid'. (HELCOM CHEMU) HELCOM 16/10/1.

[48] Divers using normal air (as opposed to special mixtures) typically dive to a maximum depth of 40 meters. Special air mixtures, such as by replacing some nitrogen with helium, can be used to extend the effective normal diving range to approximately 120 meters.

Sea dumped CW has recently received increased attention because of various pipeline projects. In addition to the Nord Stream project, a pipeline from a Norwegian gas field to the UK is currently underway which might also pass through sensitive dumping areas. Such projects will continue to prompt debate on how to best preserve aquatic systems, the long term responsibility of states that have carried out dumping and the proper role of the CWC.

The knowledge and understanding of the behaviour and possible threats resulting from sea-dumped CW have been increasing over the last 10 years. Quite intensive examinations on corrosion of munitions and degradation of chemical agents in aquatic media have led to better insight into possible threats resulting from sea-dumped CW.[49]

There are certain aspects resulting from the definition of a chemical weapon under the CWC and the special treatment for sea-dumped CW under the Convention which should result in the application of the following basic principles for dumped CW:

(1) Any recovered sea-dumped CW should remain under the responsibility of the State Party having recovered it. Thus it is irrelevant whether such munitions are recovered in territorial waters or international waters;

(2) Technically the sea-dumped weapons material, if recovered, might be so heavily corroded that any further processing, including transportation, would be quite dangerous and should be under responsibility of the State Party having recovered the material;

(3) A State Party recovering dumped CW from both international and territorial waters should make a general declaration to OPCW on the recovery by reporting relevant and available information on the quantities, type of material, etc.

(4) With recovering sea-dumped CW a State Party should not be regarded as a CW possessor State Party, as per definition under the CWC.

(5) The disposal of recovered sea-dumped chemical weapons material should be performed under the same principles as applied for 'toxic wastes', if this material meets the non-usability criterion, as outlined under Verification Annex IV (B), Paragraph 6 for 'old chemical weapons' before 1925.

It should also be noted that the CWC allows for multiple solutions for recovery and destruction of sea-dumped CW.

The first ten years of the CWC have shown that the approach applied for sea-dumped CW has been practical. No major recovery operations have been performed. If there should be real need to conduct such recovery operations on sea-dumped CW in the future, the concerned states should clarify all necessary aspects before starting the recovery and destruction operation, including technical approach, cost and legal aspects.

Barring a compelling case of dumped munitions being discovered and a party to the CWC expressing its intention to recover or remediate them, the OPCW as an organization will

[49] *E.g.* OSPAR CONVENTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT OF THE NORTH-EAST ATLANTIC, A framework for developing national guidelines for fishermen on how to deal with encounters conventional and chemical munitions, (Reference number 2004-9); Adopted by BDC 2004 (BDC 2004 Summary Record—BDC 04/, §§ 5.15–5.19) and endorsed by OSPAR 2004; Annica Waleij, "Dumpade C-stridsmedel i Skagerrak och Östersjön en uppdatering", FOI-R--0148—SE, Sep. 2001, ISSN 1650-1942, FOI, TOTALFÖRSVARETS FORSKNINGSINSTITUT.

probably remain hesitant to become involved with the dumping issue. This is partly because of a broader background desire by most of the parties to limit the cost, scope and level of intrusiveness of the convention. Onsite inspections by the OPCW could be understood by some parties to imply that a ship would have to be procured. The methodology for the elaboration of the direct costs of inspection might also have to be modified to cover sea-borne activities. Doing so may create possibilities for disagreement (e.g. concern over the setting of precedents) or opportunities for cross linkage with non-dumped CW issues.

Enhancing co-operation among concerned states and seeking practical solutions are necessary in order to cope with the possible threats resulting from dumped CW in certain territorial/international waters.

Dumped CW have already lain in the sea for many decades. Raising them will increase the potential dangers and threats these remnants from war might still pose. The longer the dumped material remains at the bottom, the greater the deterioration.

Without having the resources available to destroy recovered sea-dumped CW material immediately a state should not perform such recovery operations. Storage of the recovered material is not a practical solution because it creates more problems that pose further threats to human and environmental safety.

A fundamental difficulty is whether doing ‘nothing’ is preferable to doing ‘something’. Some public opinion will always support some type of action to be taken. A public wish for a solution to clearing areas of sea-dumped CW, without the practical tools available, will not contribute constructively to the process.