Nord Stream
The new gas supply route for Europe

Nord Stream Environmental Impact Assessment Documentation for Consultation under the Espoo Convention

Nord Stream Espoo Report: Key Issue Paper
Munitions: Conventional and Chemical

February 2009

English version | Key Issue Paper
Munitions: Conventional and Chemical

ENG

Please note:

The “Nord Stream environmental impact assessment documentation for consultation under the Espoo Convention” will, hereinafter and throughout the entire documentation as submitted hereunder, be referred to as the “Nord Stream Espoo Report” or the “Espoo Report”.

The English version of the Nord Stream Espoo Report has been translated into 9 relevant languages (hereinafter referred to as the "Translations") . In the event that any of the Translations and the English version conflict, the English version shall prevail.

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Abbreviations and definitions

BSH	Federal Maritime and Hydrographic Agency
DHI	Danish Hydraulic Institute
DNV	Det Norske Veritas
DTM	Digital Terrain Modelling
EEZ	Exclusive Economic Zone (EEZ)
EIA	Environmental Impact Assessment
Espoo Convention	Convention on Environmental Impact Assessment in a Transboundary Context, signed in Espoo, 1991
GOFREP	Gulf of Finland Mandatory Reporting System
HELCOM	The Helsinki Commission.
km	Kilometre
m	Metre
NERI	National Environmental Research Institute,Aarhus University, Denmark
PNEC	Predicted No Effect Concentration
ROV	Remotely operated vehicle
VERIFIN	Finnish Institute for Verification of the Chemical Weapons Convention
WWI	World War I
WWII	World War II

Munitions: Conventional and Chemical

1 Introduction

This chapter presents an overview of the munitions issue within the Baltic Sea and its relation with the Nord Stream Pipeline. The chapter has been developed based on information presented in the Espoo Report and Finnish national EIA.

The Baltic Sea is an area with a history of significant strategic naval importance. The legacy of World War I (WWI) and World War II (WWII) is the presence of conventional and chemical munitions. These are of specific relevance to the environment and safe installation and operation of the pipelines. The munitions are categorised as:

- Conventional munitions i.e. deployed sea mines, depth charges, torpedoes and air bombs; and dumped munitions
- Chemical munitions which were mainly disposed of following WWII

This chapter presents the:

- Strategy that was adopted to establish a rigorous baseline of actual conditions. This involved the combination of public domain studies, field surveys, expert review and consultation
- Key results
- Project activities that cause the impact
- Assessment of the impact, considering the methodology and criteria
- Proposed mitigation measures to reduce the environmental risk
- Further studies that are planned during the execution of the Project

2 Baseline for conventional and chemical munitions

2.1 Background

2.1.1 Conventional Munitions

The estimated number of mines laid in the Baltic Sea varies between 100,000 and 150,000. Of these 35,000 to 50,000 mines were swept and have been accounted for. It is estimated that 35,000[1] mines may remain in the Gulf of Finland. **Figure 2.1** shows the known mine deployment areas and dumpsites for chemical munitions in the Baltic Sea.

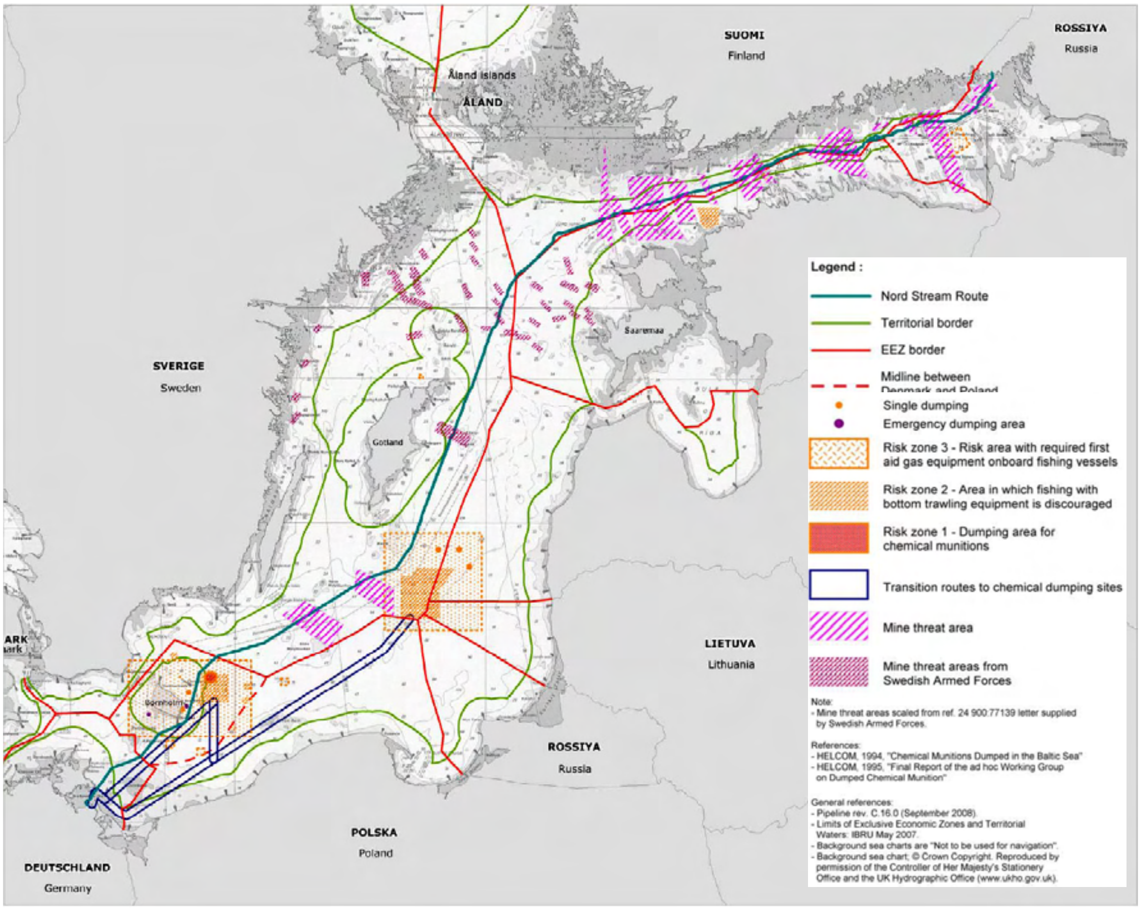

Figure 2.1 Areas of chemical and conventional areas in the Baltic Sea

(1) MMT report. Munitions Identification Expert Review Nord Stream Pipeline Project. ref. G-EN-SUR-RPT-108-UXOC1400

The most common mines deployed are contact mines. There are three types, these being moored, bottom and drifting contact mines. Moored contact mines (**Figure 2.2**) are connected to a release system deployed on the seabed and are designed to float at or near the surface. Mines that are still attached to the anchor as in **Figure 2.2** have failed to release or filled with water on deployment.

The most common methods to detonate the charges of mines are:

- Electromechanical: Horned mines are electromechanical and they are triggered by the Hertz device. When bent the Hertz device creates a simple battery and electric current triggers the detonator

- Mechanical: Mechanical mines are detonated when the mine is moved and a pendulum dislodged.

Figure 2.2 Mine and mine: German WW II ECM moored contact mine, Gulf of Finland

The mines were deployed in lines by various navies. The lines were deployed at various times with the mines designed to float at varying depths thus creating complex curtains (**Figure 2.3**). Databases are available that define the locations of the mine lines but these are incomplete; however, they still provide a guide to areas of elevated risk.

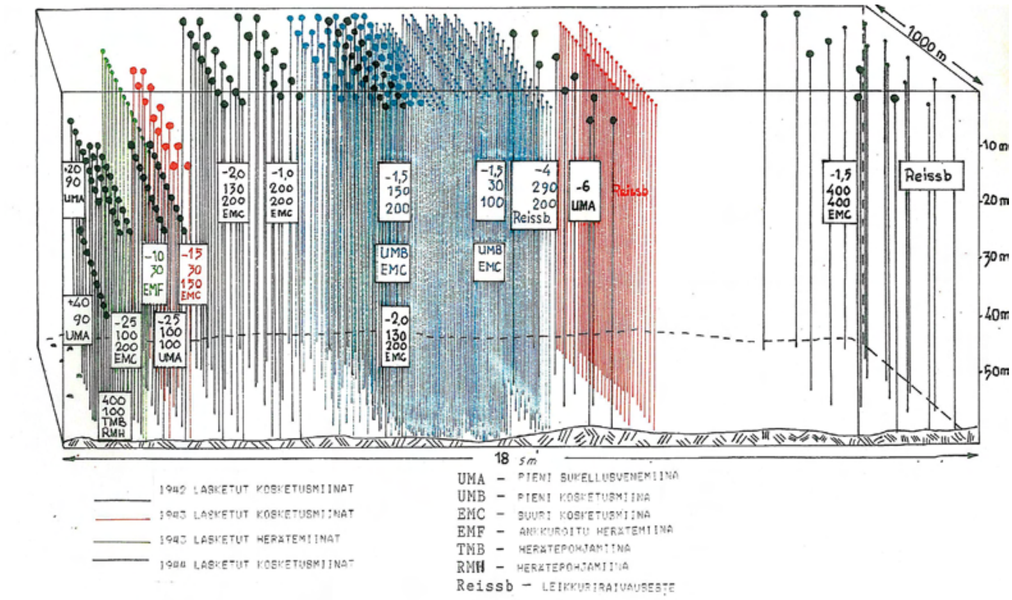

Figure 2.3 Example of a mine curtain, Gulf of Finland(1)

(1) Source: Mine Museum Turku. Finland

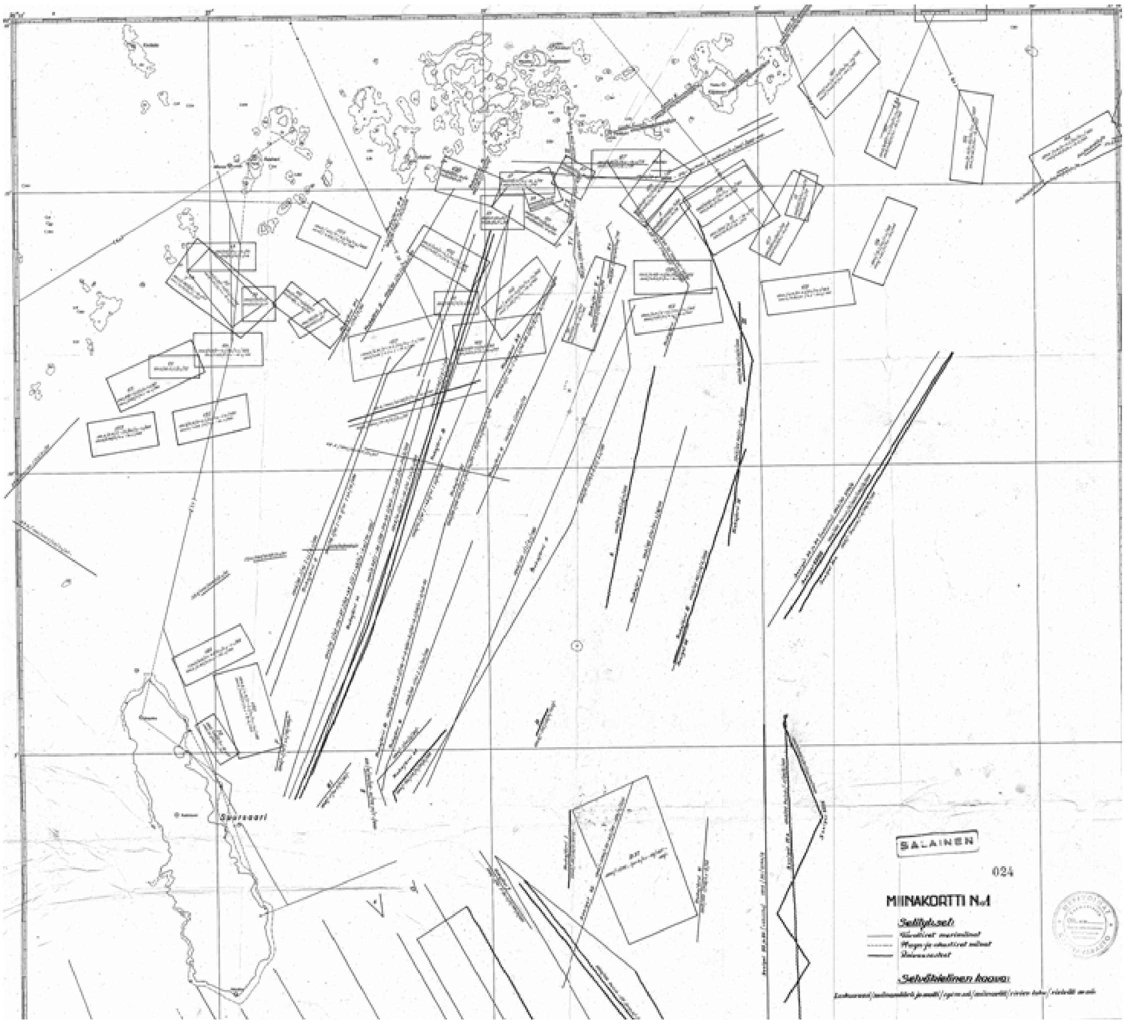

Figure 2.4 Example of mine lines deployed North and East of Gogland during WW II

2.1.2 Chemical Munitions

Chemical warfare agents (CWA[1]) were not used during World War II by either Germany or the Allied Forces. However, together both sides stockpiled between a half-million and one million tonnes of chemical munitions and CWA. At the end of the World War II, Germany was ordered to destroy approximately 65,000 tonnes of stockpiled CWA munitions. Russian forces undertook the bulk of this task during the summer of 1947, using German barges and crews. Due to schedule and financial restrictions, the Bornholm Basin and southeast of Gotland were chosen as they are the deepest locations in proximity to the German harbours (Peenemünde and Wolgast) from which the munitions were shipped out. The dumped munitions were not "live" as the shock-sensitive detonators for the explosives were not inserted.

(1) Chemical warfare agents refer to the chemical compounds used in chemical munitions.

The exact locations of dumpsites and thus associated risk areas are ambiguous[(1)]. The Baltic Marine Environment Protection Commission (Helsinki Commission)[(2)] addressed the issue of chemical weapons and concluded that approximately 40,000 tonnes of chemical munitions, containing approximately 13,000 tonnes of CWA, have been dumped in the Baltic Sea. It was estimated that 11,000 tonnes of CWA were dumped at a site east of Bornholm and 1,000 tonnes were dumped south-east of Gotland. **Figure 2.5** shows the location of the CWA dumping areas, and Atlas Map MU-1 indicates dumping areas of chemical and conventional munitions in the Baltic Sea[(3),(4),(5)].

(1) Brewer PG and Nakayama N, 2008, "What lies beneath: A plea for complete information.", Environ Sci Technol. 42: 1394-1399.

(2) 16th Meeting of the Helsinki Commission, 1995

(3) Helcom, 2002, "Response Manual, Vol. 2 Chapter 6 - Amendment No. 27/02/03".

(4) HELCOM, 1995, "Final Report of the ad hoc Working Group on Dumped Chemical Munition", http://www.helcom.fi/stc/files/Publications/OtherPublications/CHEMUFinalReport1995.pdf , Date accessed: 2008-8-14.

(5) HELCOM, 1994, "Chemical Munitions Dumped in the Baltic Sea", http://www.helcom.fi/stc/files/Publications/OtherPublications/1994Report-ChemicalMunitionsDumpedInTheBalticSea.pdf , Date accessed: 2008-8-14.

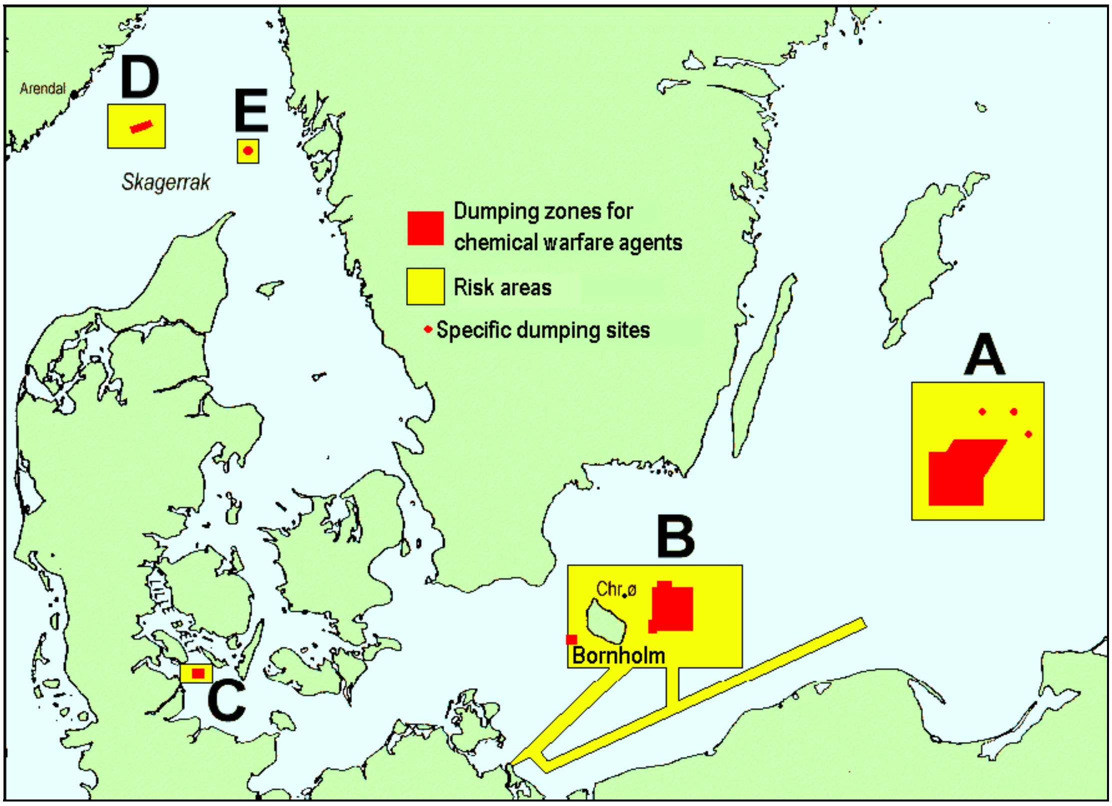

Figure 2.5 **Chemical warfare agent (CWA) dumping areas near Denmark. Site A is the Gotland dumpsite; Site B is the Bornholm dumpsite; Site C is the Lille Belt dumpsite; and Site D and Site E are the Skagerrak dumpsites** [1]

(1) Helcom, 2002, "Response Manual, Vol. 2 Chapter 6 - Amendment No. 27/02/03".

Chemical munitions are believed to have been thrown overboard during the transit to the dumpsites. Therefore, risk areas have been defined around the dumpsites and along sailing routes to the dumpsites. Fishing and anchoring are prohibited at the dumpsites and fishing vessels operating in the risk areas are required to have cleaning and first aid equipment on board in case of exposure to CWA[(1)].

Historical analysis of CWA dumping east of Bornholm

A historical analysis of dumping of CWA east of Bornholm based on news articles and reports from the period 1947 – 2008 has been developed[(2)].

The Russian Navy began dumping of CWA east of Bornholm began around 1 July 1947 and ended 30 December 1947. The dumping took place within a 4 nautical mile radius of a point 55°20’N 15°37’ E. In August 1947 wooden chests containing munitions washed ashore on Bornholm (**Figure 2.6**). Following reports that crates were washed ashore in Bornholm, Sweden and Poland, orders were given to fire upon drifting chests. By September 1947, four ships – three German and one Russian – were dumping munitions. Approximately 200-300 tonnes of chemical munitions were dumped per day.

Figure 2.6 A KC250 aerial mustard gas munitions shell that washed to shore in its original wood chest (Bornholm Museum)

(1) Iver C. Weilbach & Co. A/S, 2007, "The Danish Fishery Yearbook 2007".

(2) Sanderson H and Fauser P, 2008, "Historical and qualitative analysis of the state and impact of dumped chemical warfare agents in the Bornholm basin from 1947 - 2008".

In 1962 the East Germany navy was under Operation Hanno, scuffled an old wooden barge filled with CWA near the primary dumpsite in the Bornholm basin. In the latter part of the 1960s, there were reports of dead fish off the Swedish coast due to released CWA from corroded shells.

In August 1972 the navy reported that all munitions were corroded, broken or empty and that CWA was present as lumps on the seafloor. In 1977, it was reported that more than 500,000 CWA shells had been dumped.

On 27 March 1984, fishing restrictions in the primary dumpsite were established.

In the mid 1980s, the Danish authorities launched Operation Pegasus, to collect and destroy dumped munitions around Bornholm. However this was abandoned due to costs, security risks and public opposition.

In 1992, the European Parliament decided by more than a 93% majority vote that the environmental and human health risks of dumped CWA in the Baltic Sea should be investigated and described in support of deciding further actions relative to potential remediation. HELCOM organised an ad hoc chemical munitions working group (CHEMU) that collected information provided by the Russian authorities in 1993 with regard to the dumping of CWA in 1947. The HELCOM CHEMU (1994) concluded that remediation was unnecessary because the CWA would either be insoluble or degrade and dilute rapidly. In the late 1990s and early 2000s scientific investigations were performed at other dumpsites (Skagerrak and elsewhere), but not at the Bornholm dumpsite. In 2005 the EU Commission, through the 6th Framework Programme, funded the Modelling the Environmental Risks of Chemical Weapons in the Baltic Sea (MERCW) project. Field work was concluded in late 2008, but at the time of writing this document the MERCW report has not been published.

CWA dumped east of Bornholm

The different CWA substances and the amounts dumped east of Bornholm are shown in **Table 2.1**.

Table 2.1. Dumped warfare agents (CWAs) in Bornholm Basin[1,2]

Name	Composition	CAS no.	Dumped (tonnes)
Sulphur mustard gas (Yperite)[1]	$C_4H_8Cl_2S$	505-60-2	7,027
Adamsite[2]	$C_{12}H_9AsClN$	578-94-9	1,428
Clark I[2]	$C_{12}H_9AsCl$	712-48-1	712
Clark II[2]	$C_{13}H_{10}AsN$	23525-22-6	N/A
Triphenylarsine[8]	$C_{18}H_{15}As$	603-32-7	102
Chloracetophenone (CAP)[3]	C_8H_7ClO	1341-24-8	515
Phenyldichloroarsine[8]	$C_6H_5AsCl_2$	696-28-6	1,017
Trichloroarsine[8]	$AsCl_3$	7784-34-1	102
Monochlorobenzene[4]	C_6H_5Cl	108-90-7	1,405
Zyklon B[5]	HCN	94-90-8	74
Possible CWAs dumped east of Bornholm[3]			
Phosgene[6]	CCl_2	75-44-5	-
Nitrogen mustard[1]	$C_5H_{11}Cl_2N$	51-75-2	-
Tabun[7]	$C_5H_{11}N_2O_2P$	77-81-6	-

1: Blister gases (vesicants)	5: Blood agent
2: Nose and throat irritants	6: Lung irritants
3: Tear gases (lachrymatory agent)	7: Nerve gas
4: Additive	8: Arsenic oil: Organoarsenic blister gas

CWA were most often contained in two types of aerial bombs; one of them, the mustard gas Type KC250, is shown in **Figure 2.7**.

(1) HELCOM, 1994, "Chemical Munitions Dumped in the Baltic Sea", http://www.helcom.fi/stc/files/Publications/OtherPublications/1994Report-ChemicalMunitionsDumpedInTheBalticSea.pdf , Date accessed: 2008-8-14.

(2) Sanderson H, Fauser P, Thomsen M and Sørensen P.B, 2007, "Summary of Screening Level Fish Community Risk assessment of Chemical Warfare Agents (CWAs) in Bornholm Basin", A Paper by Sanderson et al. to be submitted to Jour. Haz. Mat. April, 2007.

(3) HELCOM, 1994, "Chemical Munitions Dumped in the Baltic Sea", http://www.helcom.fi/stc/files/Publications/OtherPublications/1994Report-ChemicalMunitionsDumpedInTheBalticSea.pdf , Date accessed: 2008-8-14.

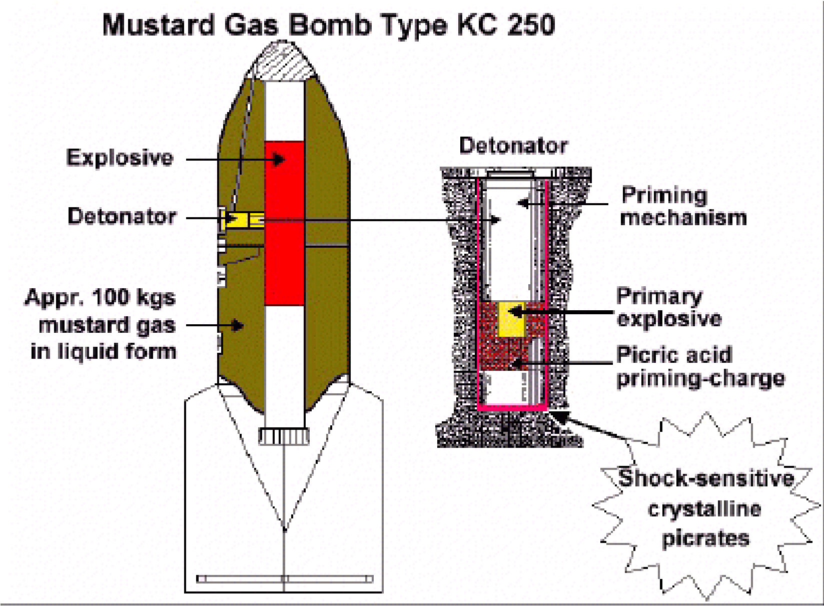

Figure 2.7 The design of the mustard gas bomb Type KC 250

The bomb shells were made of thin steel casing, which is now often fully corroded. Finds of whole bombs are becoming rare[(1)].

Mustard gas constitutes the majority of the dumped chemical warfare agents. Fishermen occasionally find yellow or brown lumps of mustard gas in their fish catch. The lumps vary in size up to 100 kg. They often have a clay-like consistency with the surfaces oxidized to solid state. Therefore lumps of mustard gas can be preserved for many years.

Since 1992, all munitions recovered by fishermen have been either empty or completely corroded. Currently only solid lumps of CWA are found. More than 10 years ago, some CWA remains had liquid content, but this is no longer the case[(2)]. **Figure 2.8** shows examples of munitions caught within the Bornholm dumpsite.

(1) Helcom, 2002, "Response Manual, Vol. 2 Chapter 6 - Amendment No. 27/02/03".

(2) Sanderson H and Fauser P, 2008, "Historical and qualitative analysis of the state and impact of dumped chemical warfare agents in the Bornholm basin from 1947 - 2008".

Figure 2.8 Mustard gas lump (left) and corroded gas bombs (navy personnel in protective ABC suit)

Fishing within the dumpsite east of Bornholm is forbidden. However, fishermen have caught chemical munitions in and around the area the dumpsite as the munitions have spread over a larger area. In Denmark, fishermen are compensated economically if they report catches of munitions to the Bornholm Marine District. Since the 1960s, the Bornholm Marine District has registered catches of munitions from the Bornholm area. **Figure 2.9** shows the numbers of chemical munitions caught by fishermen from 1979-2006.

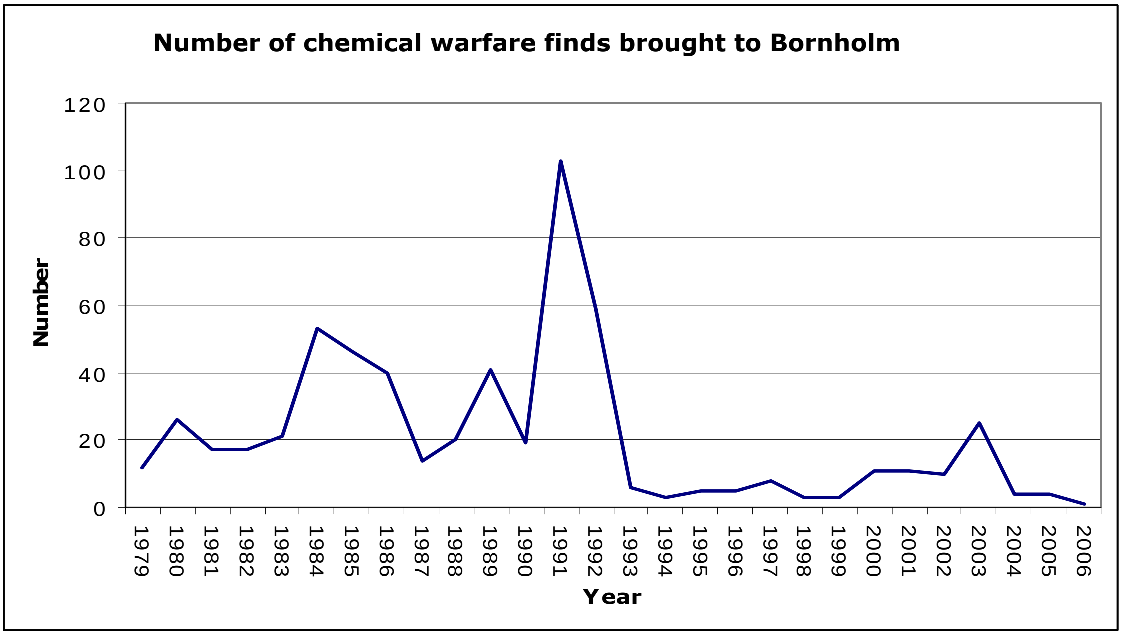

Figure 2.9 Number of chemical munitions finds reported around Bornholm from 1979-2006[1]d

(1) 2007, "Admiral Danish Fleet. The Bornholm Marine District".

2.2 Munitions Screening Surveys

2.2.1 Survey Strategy

The objective of the munitions screening surveys is to perform the necessary field investigations to reduce the risk of encountering munitions to a level that is "as low as reasonably practicable" (ALARP). The assessment of the process to achieve the "ALARP" level is complex and demonstrating that it is challenging.

Normally the process requires that good practice is exercised, but with the munitions issue it is not just a case of referring to existing "good practice". As the munitions issue represents a high hazard with resulting risk to the environment, personnel safety and reputation, the process whilst based on good practice, uses expert judgment, consultation and technological development to establish a "state-of-the-art" approach.

The process adopted for the Nord Stream munitions screening surveys includes the following steps:

- Assessment of the public domain information (background providing the hazard origin)
- Evaluation of prior surveys principally those conducted between 2005 and 2006
- Development of the scope of work, technical requirements and required technological developments
- Execution of the munitions screening survey for the optimised pipeline alignments
- Expert evaluation of survey results
- Consultation and communications with experts from Parties of Origin and Affected Parties
- Development of the scope of work for the anchor corridor survey
- Execution of the anchor corridor surveys to be used for the installation phase of the pipelines (ongoing: commenced November 2008 with completion Q3 2009)
- Munitions clearance (currently in planning phase)

2.2.2 Prior Surveys – 2005 and 2006

Between 2005 and 2006 the Russian engineering and survey contractor Peter Gaz performed two main survey programs. The surveys were supported by the Russian contractor Svarog and Fugro Osae from Germany.

In 2005 the general reconnaissance geophysical survey was performed to support route selection and optimisation. This survey results provided the evaluation of seabed morphology, surficial soils, cultural heritage and other objects located within a nominal 2 kilometre wide corridor. This corridor extends from the landfall Russia to landfall Germany. This scope included approximately 17,000 survey line kilometres.

In 2006 a detailed geophysical survey was performed along a 180 metre wide corridor centred on the selected "conceptual" pipeline route. This survey of approximately 5,000 line kilometres provided more resolute seabed topography (2 by 2 m DTM) and located objects for further inspection. Following the geophysical phase targets were selected for visual inspection by remotely operated vehicle (ROV). The selected objects were within 20 metres of the "conceptual" alignment.

Equipment used during these campaigns included:

- Geophysical Phase: multibeam echosounders to establish seabed morphology, side scan sonar (100/300 kHz) to map the seabed features, sub-bottom profilers to investigate the shallow geology and magnetometers (Caesium and Overhauser) to locate ferrous objects

- ROV Phase: video camera, laser scale and a pulse induction detection to locate buried or exposed conductive material (TSS 340)

- Sub-bottom profiler: 2 to 7 kHz chirp and boomer

2.2.3 Munitions Screening Scope of Work and Technological Developments

Assessment of the results of the 2005 and 2006 surveys concluded that the survey approach was not sufficiently rigorous to reliably assess and document the munitions within the corridor for the Nord Stream Pipeline. Additionally, the ‘conceptual’ route alignment had been developed to minimise the environmental impact associated with the seabed intervention works.

The key development to the 2005 and 2006 survey programme was to implement a four stage approach for munitions screening of the full corridor from Russia to Germany. The survey was designed to increase resolution and target detection reliability. The coverage achieved through steps 1 to 3 is presented in **Figure 2.10**:

- Step 1 Geophysical Phase: increase the resolution of the side scan sonar system to greater than 500kHz
- Step 2 ROV mounted gradiometer: develop a gradiometer array to allow full ferrous detection coverage of the 15 m installation corridor
- Step 3 ROV visual inspection: extend the 'security' corridor to a total width of 50 m. Additional visual inspection of all identified cultural heritage for expert evaluation
- Step 4 Expert evaluation: evaluation of all objects defined for visual inspection to determine the origin, size, location and condition by experts in underwater marine warfare

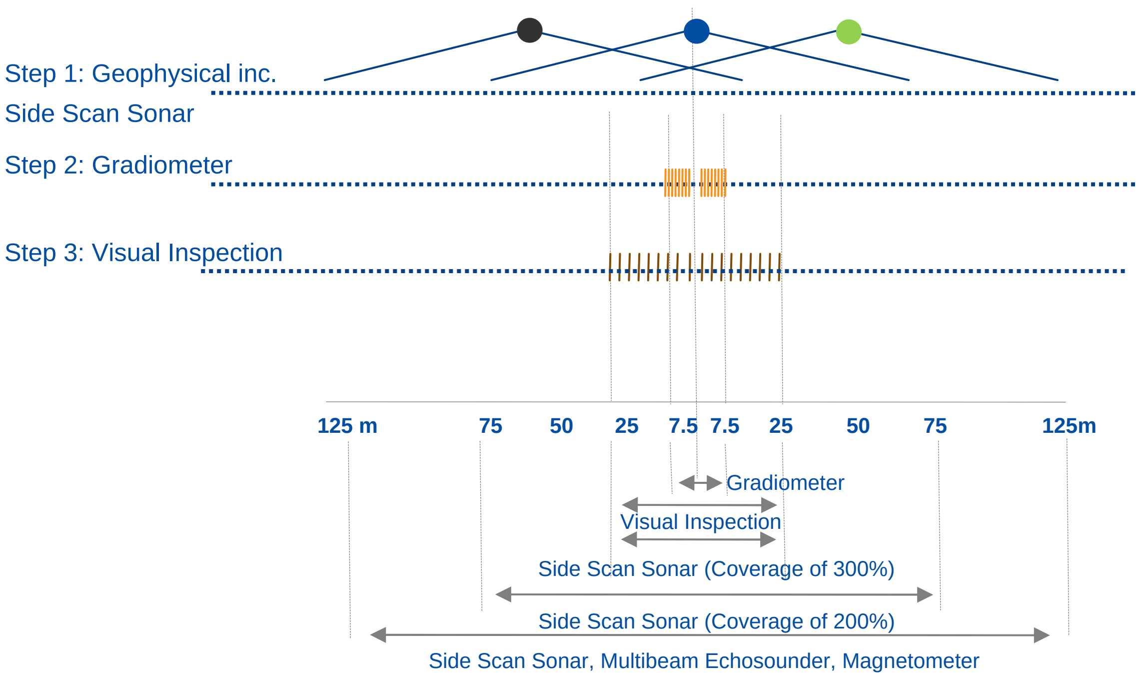

Figure 2.10 Munitions screening survey phases

The width of the defined corridors is based on the following:

- Installation corridor (Step 2) is based on the specified installation tolerance defined in the contract with the installation contractor, i.e. +/- 7.5 m in normal pipelay

- Security corridor (Step 3) is based on the effects of underwater explosion on the pipeline. The 50 m wide (i.e.+/- 25 m either side of the optimised alignment) is based on engineering analyses performed by the design contractor[(1)] and verified by the certifying authority

The ROV mounted gradiometer array with 12 elements (**Figure 2.11**) was developed specifically for Nord Stream to provide a "terrain model" of the magnetic field gradient within the installation corridor. Two passes are required along each route to fully cover the 15 metre installation corridor. The technology was developed by Innovatum and applied to the marine environment by the survey contractor Marin Mätteknik AB. Each gradiometer element comprises two magnetometers (top and bottom) allowing measurement of the magnetic field difference with a precision of 1 nT (nano tesla).

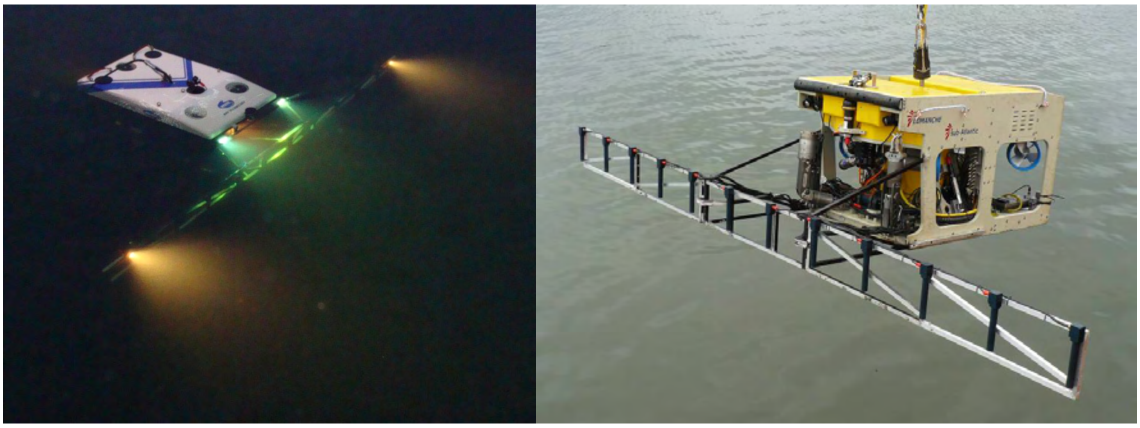

Figure 2.11 ROV-mounted gradiometer array: Russian Sector (left image), Finnish, Swedish, Danish and German Sectors (right image)

System acceptance trials were initially performed on land and once proven ROV trials were performed against known objects placed on the seabed.

(1) SES report Effects of Underwater Explosions. G-EN-PIE-REP-102-00072528

Figure 2.12 Onshore acceptance trails of the gradiometer array

The two day onshore trials program was based on a series of scenarios (with regard to expected orientation and attitude of objects), developed from experience gained from the 2006 ROV operations in the Baltic. The tests demonstrated that the system is able to detect and position metallic objects of varying sizes on or below the seabed **Figure 2.12**. However, the signatures of objects differ with orientation, attitude, construction and elevation, so it is not possible to assign individual magnetic flux signatures to specific objects. Consequently the identification of objects will require visual inspection.

Offshore acceptance trials were conducted against steel rods, containers and actual munitions. In the Russian sector trails were performed on a specific test range operated by the Russian Navy. The test range included 9 items ranging from a 35 mm anti-aircraft type shell to a small mine. The Russian Navy witnessed the trials and approved the system for use in the Russian sector.

Additional Chemical Munitions Screening

In addition to the general munitions screening performed along the full route, a screening survey was designed to investigate background levels of CWA contaminants in the Bornholm area. The survey scope was based around equidistance soil and pore water sampling survey along the section of the route passing to the west of the Bornholm chemical munitions dump site.

2.2.4 Munitions Screening Survey Performance

Due to the constraints imposed by survey permits and permissions, the survey scope was divided into two main parts these being:

- Russian sector
- Combined sectors of Finland, Sweden, Denmark and Germany

Russian Sector

The geophysical phase, Step 1, was performed in 2007 by Peter Gaz with the support of Svarog. The survey comprised approximately 800 line kilometres.

The ROV phase, Steps 2 and 3, commenced in December 2008 and is likely to continue through to mid-2009.

In Russia the expert evaluation (Step 4) is being performed by representatives from State Research Navigational and Hydrographic Institute (GNINGI) under the supervision of the Russian Authorities (Ministry of Defence Russian Federation, Staff Baltic Fleet).

Combined sectors of Finland, Sweden, Denmark and Germany

Marin Mätteknik AB (MMT) of Sweden performed the full survey scope with a short period of support from DoF (Norway). Surveys were conducted over the period from March 2007 to August 2008.

The geophysical phase, Step 1, included both munitions screening and detailed engineering surveys. Approximately 13,300 survey line kilometres were performed.

The survey of the installation corridor included 6,400 line kilometres of ROV based gradiometer survey. In addition the gradiometer array was mounted in a variety of ways (**Figure 2.13**) to allow continuity of the surveys through the shallow water and across the dry section at the German landfall. The corridor width was extended to encompass the full trenching extents.

Figure 2.13 Shallow water and onshore gradiometer deployment methods: German landfall

The visual inspection phase, Step 3, included inspections of all targets located within the installation corridors (15 m), and selected targets potentially of human origin within the security corridor (50 m). In addition all targets of potential cultural interest were also inspected.

Object classification, Stage 4, was conducted in two phases, the initial offshore evaluation of all identified objects and the onshore verification by three marine warfare experts. This final verification stage is where targets are conclusively identified as munitions or not. The video records were independently reviewed by the marine warfare experts. The experts that performed the evaluation are:

- Matti Puoskari Commander ret. (Finnish Navy) – recommendation of the Finnish MOD
- Eugene Charysczak Lt. Colonel ret. (Swedish Navy) – recommendation from the survey contractor MMT
- Lars Møller Pedersen Commander, Head of Danish Fleet Ordnance Demolition

2.2.5 Performance of Chemical Munitions Screening Survey

The soil and pore water sampling survey designed to screen for background levels of CWA contaminants in the Bornholm area was carried out late May 2008. Sediment samples were taken with a Haps core sampler at 35 stations along the planned pipeline route passing east and south of the island of Bornholm (see **Figure 2.14**).

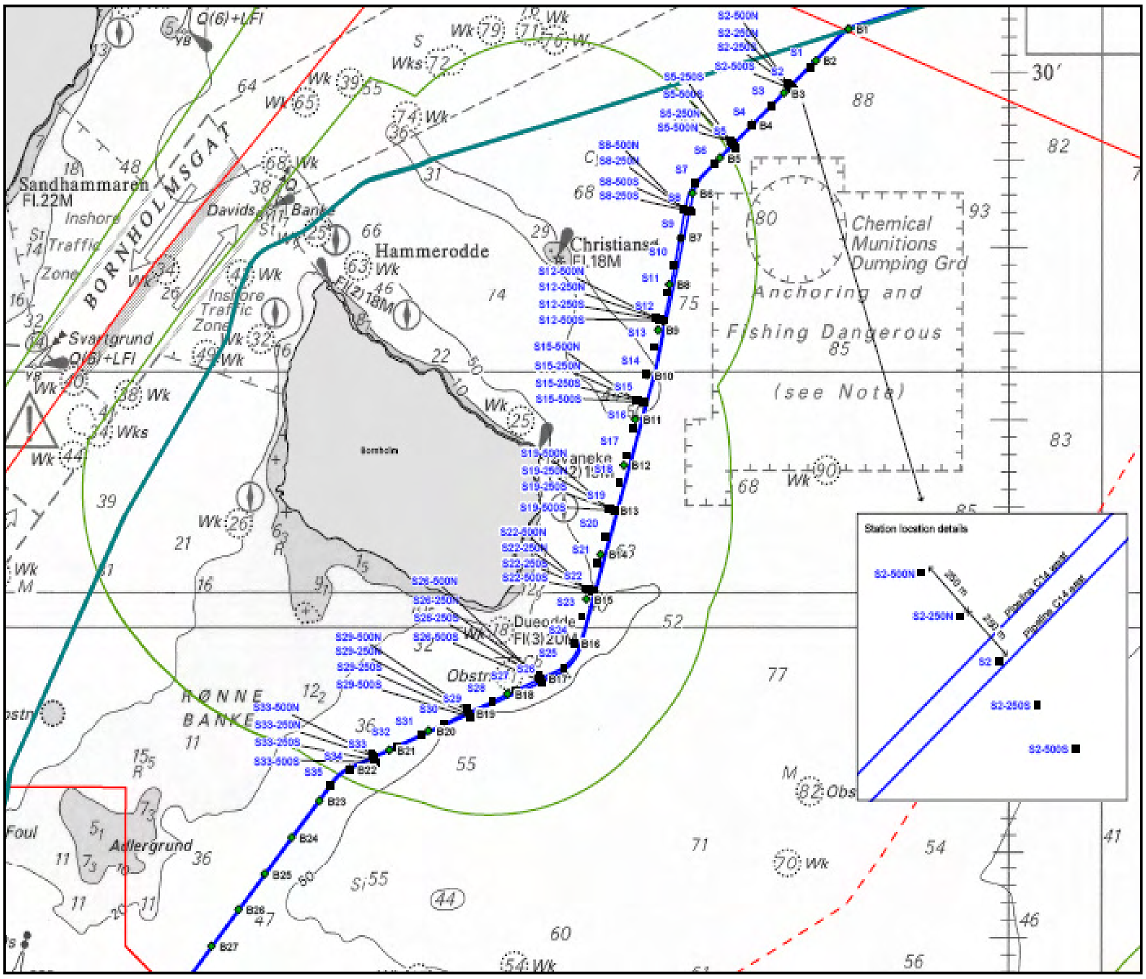

Figure 2.14 Sampling stations along the section to the East of Bornholm

At all station samples were taken from the upper 5 cm, middle and bottom of the core. At 10 positions 4 stations were sampled perpendicular to the pipeline route. The distance of these transect stations was 500 m north, 250 m north, 250 m south and 500 m south of the main station.

A total of 95 sediment and 11 pore water samples have been collected for chemical analyses.

To allow independent verification of results each sample was equally divided in to A and B sub-samples and analysed by two independent laboratories. "A" samples were tested by the Danish National Environmental Research Institute (NERI) and the "B" samples by the Finnish Institute for Verification of the Chemical Weapons Convention Finland (VERIFIN). The laboratories analysed the samples for the chemical substances shown in **Table 2.2**.

Table 2.2 CWA contaminants tested for in sediment and pore water samples [(1),(2)]

Chemical (acronym)	CAS number
Intact chemicals	
Sulphur mustard gas (H)	505-60-2
Adamsite DM)	578-94-9
Clark I (DA)	712-48-1
Triphenylarsine (TPA)	603-32-7
A-Chloroacetophenone (CN)	532-27-4
Tabun (GA)	77-81-6
Lewisite I (L1)	541-25-3
Lewisite II (L2)	40334-69-8
Phenyldichloroarsine (PDCA)	696-28-6
Degradation products and derivatives of DM	
Phenoarsazin-10(5H)-ol	18538-32-4
10-(Phenoarsazin-10(5H)-yloxy)-5,10-dihydropheno-arsazine	4095-45-8
5,10-Dihydrophenoarsazin-10-ol 10-oxide	4733-19-1
Degradation products and derivatives of DA	
Diphenylarsinous acid	6217-24-9
Bis(diphenylarsinic)oxide	2215-16-9
Diphenylarsinic acid	4656-80-8
Degradation products of H	
Thiodiglycol	111-48-8
Thiodiglycol sulfoxide	3085-45-8
Degradation products and derivatives of L1	
Vinylarsinous acid	85090-33-1
2-Chlorovinylarsinic oxide	3088-37-7
2-Chlorovinylarsonic acid	64038-44-4
Dipropyl 2-chlorovinylarsonodithioite	
Degradation products and derivatives of L2	
Dininylarsinic acid	
Bis(2-chlorovinyl)arsenic acid	
Propyl bis(2-chlorovinyl)-arsinothioite	
Degradation products of PDCA	

(1) Finnish Institute for Verification of the Chemical Weapons Convention (VERIFIN), 2008, "Nord Stream Offshore Pipelines through the Baltic Sea. Chemical analysis of Sea-dumped Chemical Warfare Agents in Sediment and Pore Water Samples".

(2) Bossi R, Krongaard T and Christoffersen C, 2008, "Nord Stream Offshore Pipelines through the Baltic Sea. Analysis of arsenic compounds in sediment samples and sediment pore water samples from the Baltic Sea. NERI Technical Report, October 2008".

Chemical (acronym)	CAS number
Phenylarsonous acid	25400-22-0
Phenylarsonic acid	98-05-5
Arsenic compounds	Total arsenic (As_{total}), Sum of arsenite (As(III), Arsenate (As(V), Monomethylar-sonic acid, Dimethylarsonic acid, Trimethyl-arsine oxide, Tetramethylarsonium ion, Arsenobetaine

2.2.6 Munitions Screening Survey Results

The results of the munitions screening survey are deemed confidential and are discussed in detail with the responsible national authorities. Consequently the results are presented in general way to provide an overview of the findings.

Russian Sector

The surveys are currently being conducted. No results are available.

Combined sectors of Finland, Sweden, Denmark and Germany

Munitions, mainly in the form of contact mines, have been identified along the Nord Stream alignment. The highest density as expected from public domain information and previous surveys is in the Gulf of Finland. **Table 2.3** provides an overview of the numbers of munitions and **Table 2.4** presents the number of munitions related items that have been identified during the munitions screening survey in 2007/2008. **Figure 2.15**, **Figure 2.16**, and **Figure 2.18** provide the geographic distribution of the munitions and munitions related items for Finland, Sweden and Denmark respectively. **Figure 2.17** shows the good correlation between the historical mine line data provided by the Swedish Armed Forces and the mine and mine anchors located during the munitions screening survey. No munitions related objects were found in the German sector.

Table 2.3 Munitions identified from the Nord Stream Munitions screening survey

Country	Number of identified munitions	Types of munitions	Pipeline Route/Alternative
Finland	31	26 Mines, 1 possible mine, 2 possible air dropped depth charges and 2 obstructer mines	Nord Stream Pipeline Route [Finnish Alternative 2 (C16)]
Sweden	1 (Note 1)	1 mine 1 corroded bomb(Note 1)	Nord Stream Pipeline Route
Denmark	3	3 chemical munitions	Nord Stream Pipeline Route

Country	Number of identified munitions	Types of munitions	Pipeline Route/Alternative
Germany	0	No munitions finds	Nord Stream Pipeline Route

Note 1: The marine warfare experts (refer to **section 2.2.4**) performed a joint review (08-09 January 2009) and concluded that Target R-32-1974 was a heavily corroded tail-cone for air bomb containing no explosives. Therefore the target should be considered within the munitions related object list.

Table 2.4 Munitions related items identified during the Nord Stream munitions screening survey

Country	Number of munitions related items	Types of items	Pipeline Route/Alternative
Finland	68	Mine anchor/chair (release system), mine sweeping equipment (paravane), wire rope, counter weights	Nord Stream Pipeline Route [Finnish Alternative 2 (C16)]
Sweden	19(Note 1) 14 possible buried	Mine anchor/chair (release system), wire rope, corroded bomb(Note 1)	Nord Stream Pipeline Route
Denmark	0		Nord Stream Pipeline Route
Germany	0		Nord Stream Pipeline Route

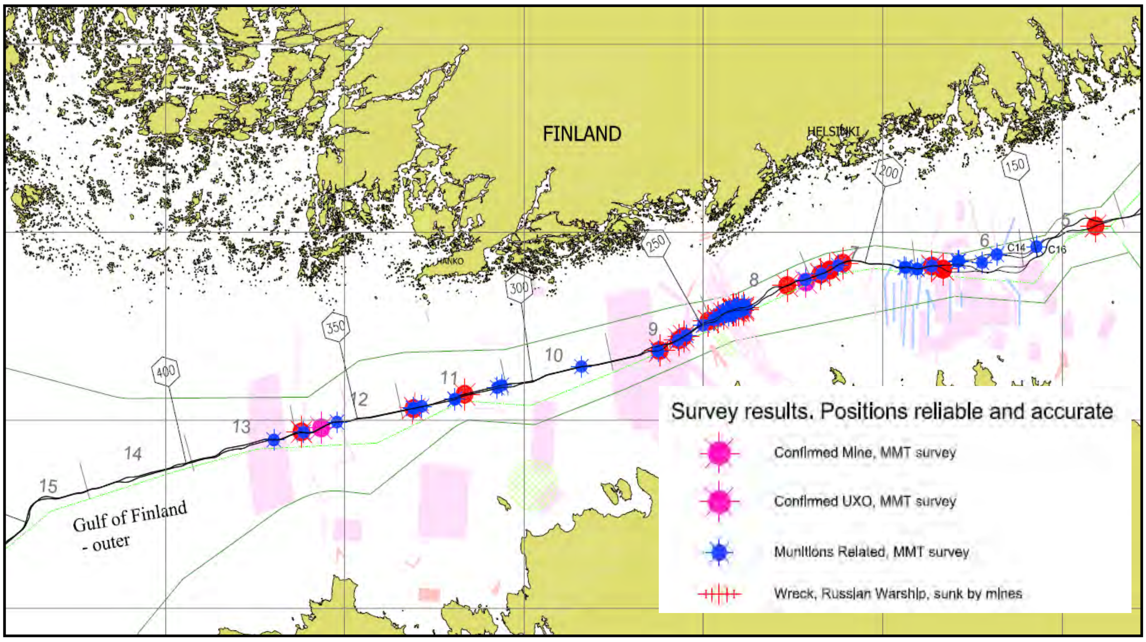

Figure 2.15 Munitions found in the Finnish project Sector within 25 m of the Nord eam pipeline routes (C14 and C16)

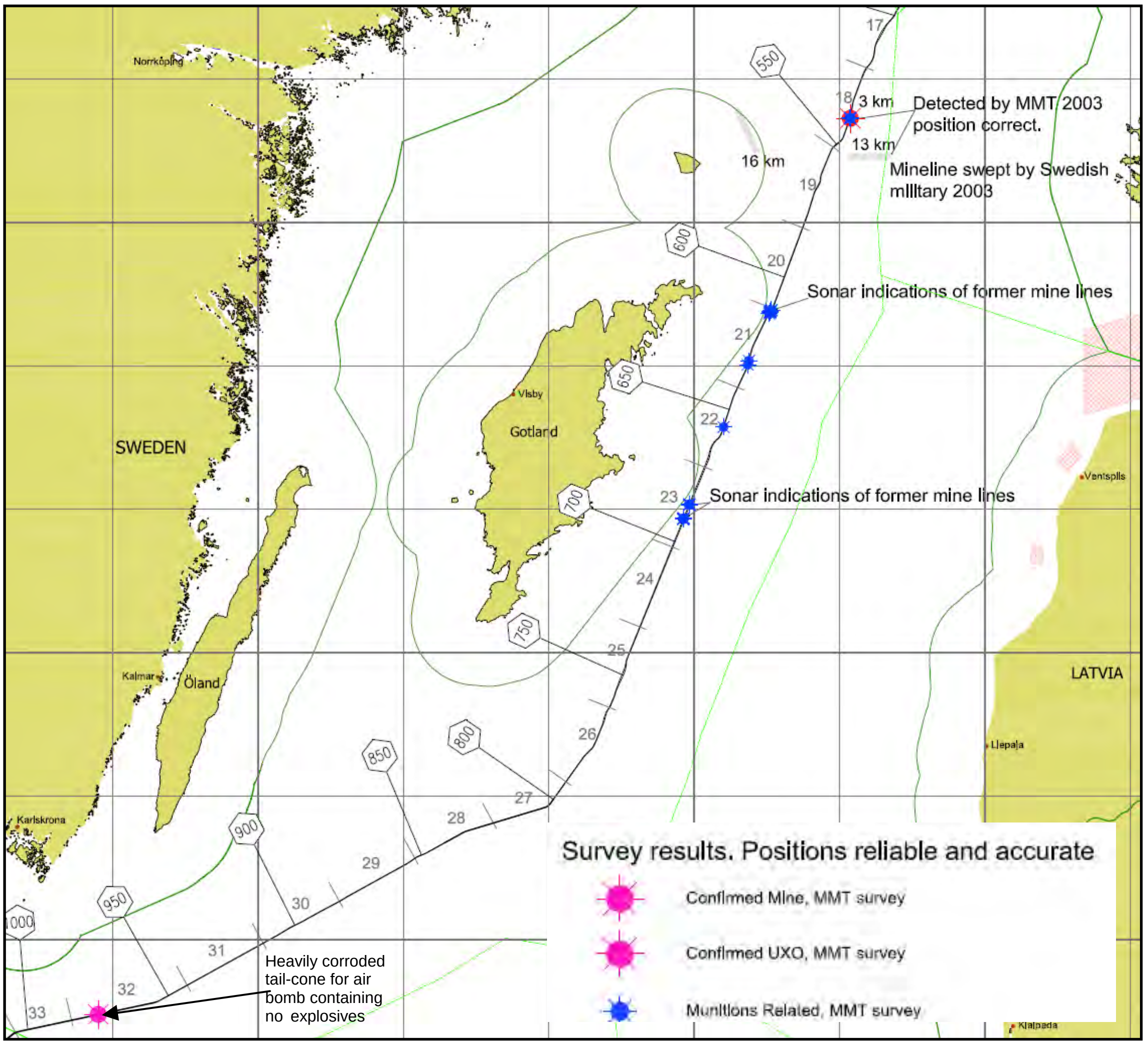

Figure 2.16 **Munitions found in the Swedish project Sector within 25 m of the Nord Stream pipeline routes (C16)**

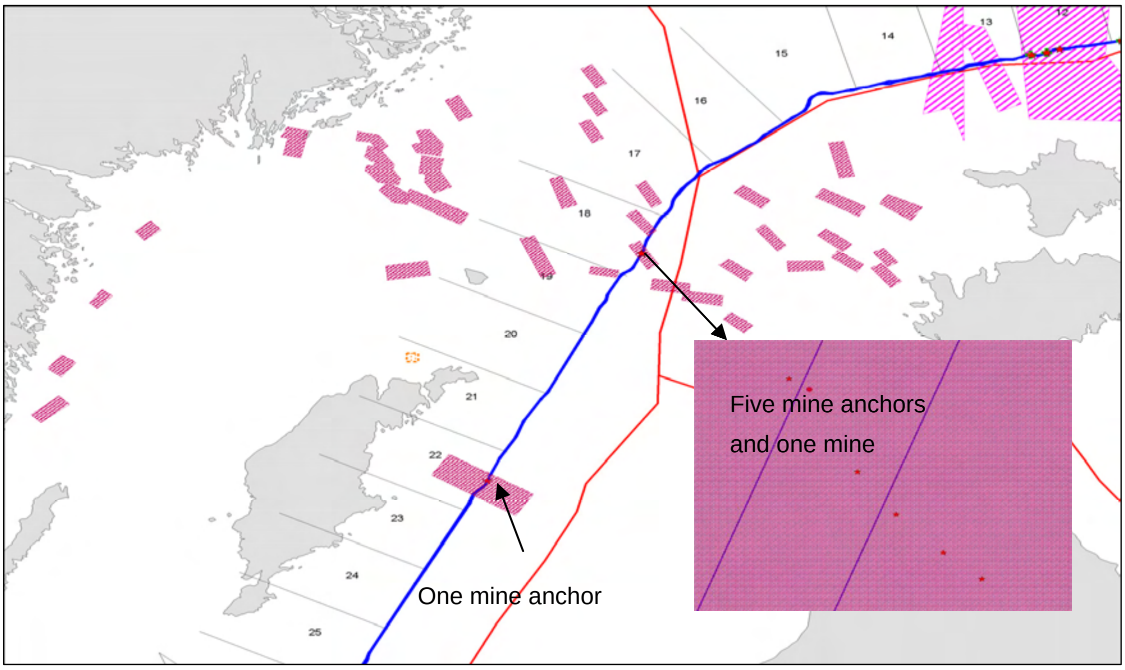

Figure 2.17 Correlation between munitions and munitions related objects and mine line data provided by Swedish Armed Forces

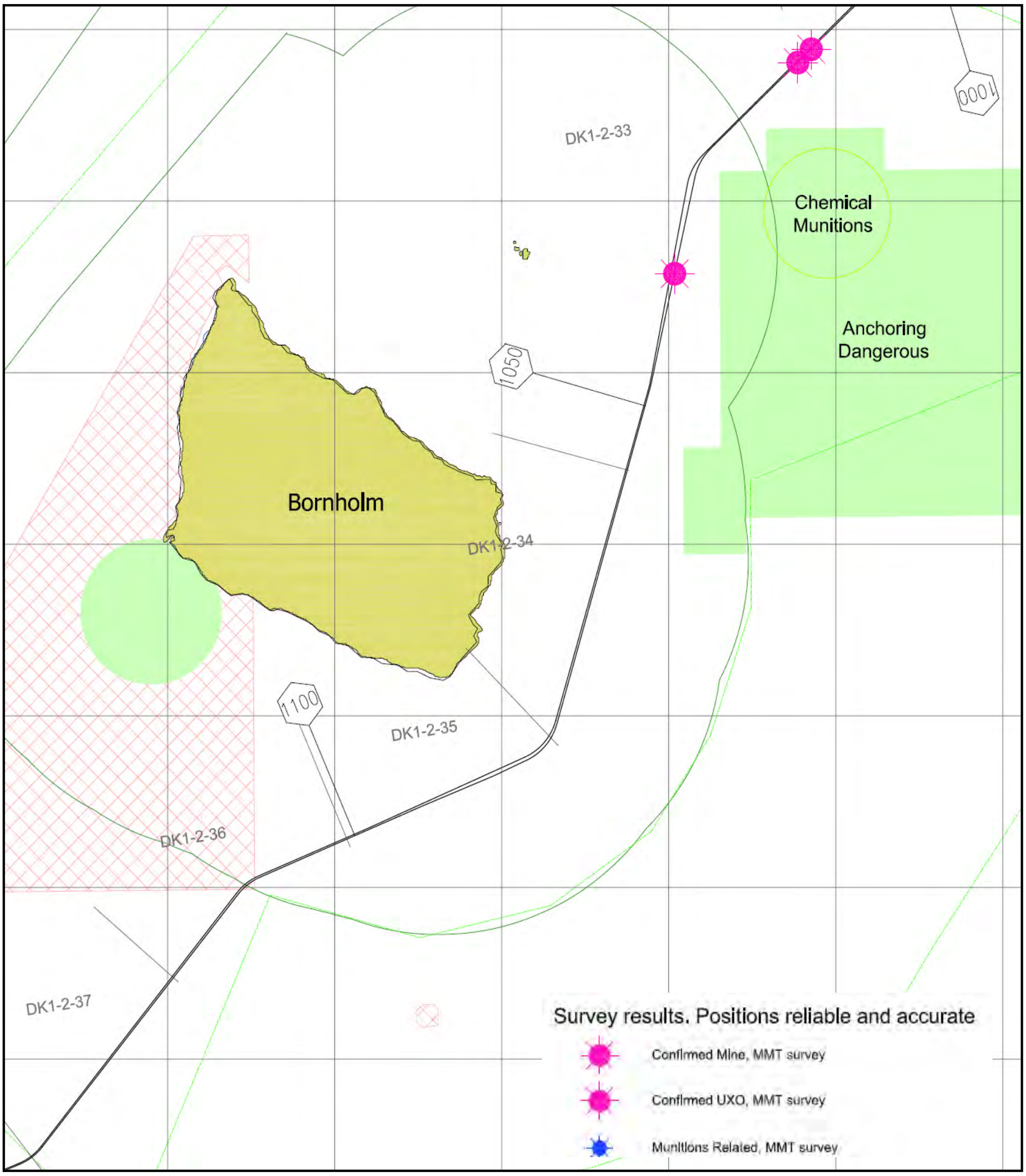

Figure 2.18 Munitions found in the Danish project Sector within 25 m of the Nord Stream pipeline routes (C16)

Extensive correlation has been performed to relate the identified munitions to historical technical documentation. This correlation will be used to support the munitions clearance plan. The following four examples (**Figure 2.19**, **Figure 2.20**, **Figure 2.21** and **Figure 2.22**) present images of the munitions, correlation to historical data, description and the potential explosive charge.

Figure 2.19 **Target R-8AG-W-014, German moored contact mine type EMC. Charge 250/300 kg Hexanite**

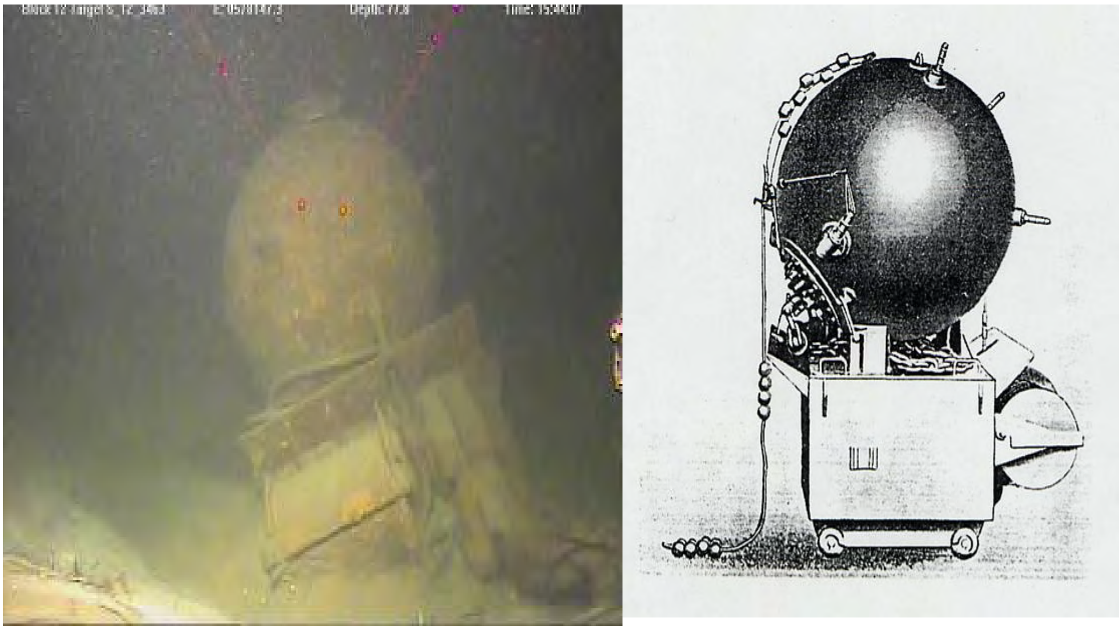

Figure 2.20 **Target R-12-3463, Mine with mine anchor mechanism located in a deep scoured hollow surrounded by a flat seabed of soft gyttja clay. Identification: EMC I + II German WW II moored contact mine, Charge 320 / 250 kg Hexanite**

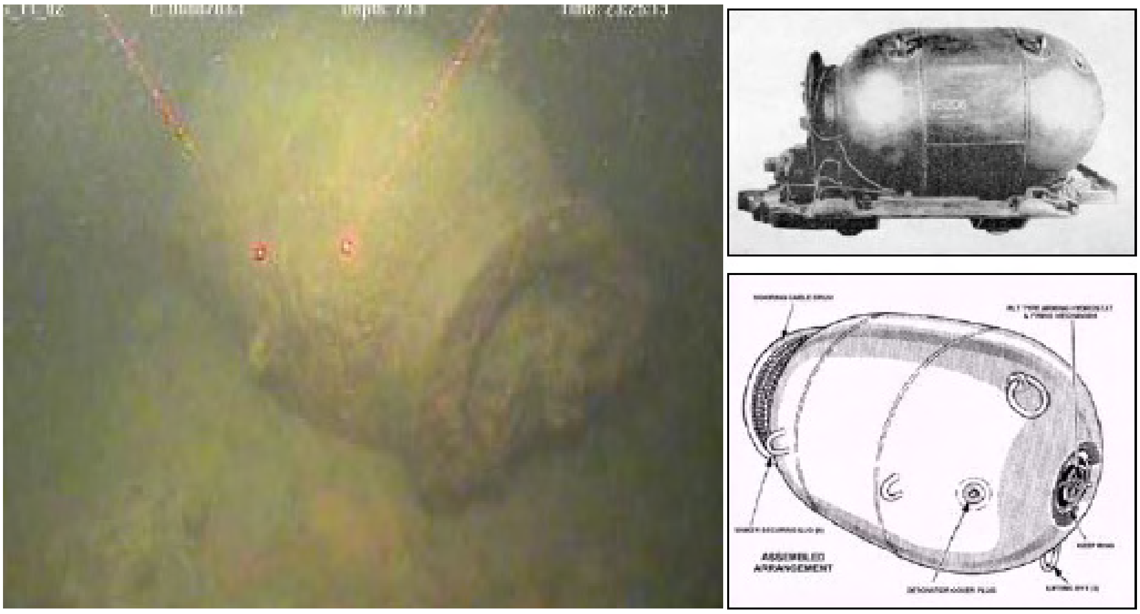

Figure 2.21 **Target R-11-5167, Cylinder with a hemispherical base - Lifting eyes fixed to sides. Russian moored contact mine M26, Pendulum firing mechanism, Charge 240 kg TNT**

Figure 2.22 **Target R-09-04, WWII Mine line anti-sweep explosive device, conical casing with rounded base resting on the possible remains of its deployment system in a scoured hollow on a seabed of sandy clay. Identification: SPB D German Obstructer Mine, Charge 0.8 kg, External features push / drag sensor**

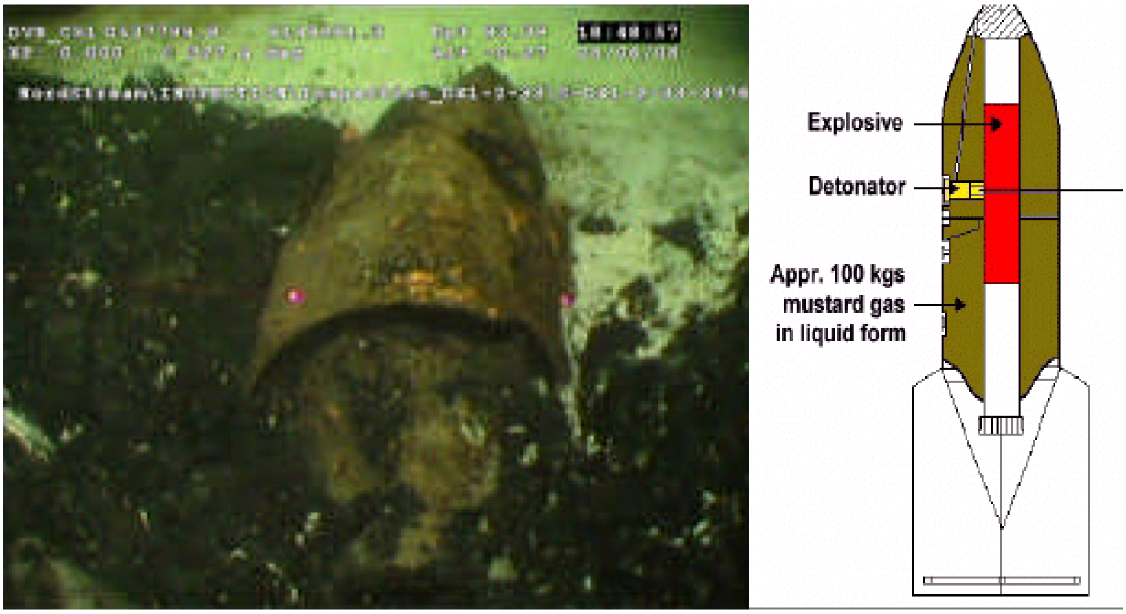

Figure 2.23 DK1-2-33-3976, WWII A German chemical 250 mustard gas bomb. The casing is heavily corroded and the some of the gas is still in the bomb, approx up to 30 kg.

Note that the KC 250 gas bomb (aircraft bomb) constitutes 90-95% of the general findings east of Bornholm. The bomb has an overall length of 1.65m, diameter of 0.37m and contains 8 to 14 kg of explosives and up to 100 kg of mustard gas.

Results from Chemical Munitions Soil and Pore Water Sampling Investigations

The results from the chemical analysis carried out by NERI and VERIFIN show that only very few stations had evidence of contaminants related to CWA (Adamsite, Clark I, Triphenylarsine and Phenyldichloroarsine). Furthermore, the extent of the contamination, where encountered was very low. For all other substances analyses for as shown in **Table 2.2**, the content of CWA contaminants was below the detection limit. The NERI analyses found more samples with content of Clark I, triphenylarsine and phenyldichloroarsine than VERIFIN. Furthermore, NERI found low content of Clark I, triphenylarsine and phenyldichloroarsine (0.002 mg/l) in some of the pore water samples. In general, the chemical content in sediment samples found by NERI was lower than the results from VERIFIN. One reason for the difference between the results between VERIFIN and NERI may be that VERIFIN and NERI used different methodologies in their analyse[(1)].

Overall the CWA content in sediment samples and pore water samples was low.

The results from the analysis are shown in **Table 2.4** and **Table 2.5**.

Table 2.4 Chemical analyses results for sediment samples

Sediment sample[(1)]	Adamsite (mg/kg DM)	Clark I (mg/kg DM)	Triphenylarsine (mg/kg DM)	Phenyldichloroarsine (mg/kg DM)
S5 (250N)	-/-	-/0.029	-/-	-/0.028
S5 (500S)	-/-	-/0.034	-/-	-/0.044
S5 (500N)	-/-	-/-	-/-	-/0.051
S8	-/-	-/-	0.0026/-	-/-
S9	-/-	-/-	-/-	-/0.101
S12	0.010/-	-/-	-/-	-/-
S12 (250N)	-/-	-/-	-/-	-/0.032
S12 (500S)	-/-	-/0.041	-/-	-/0.051
S12 (500N)	-/-	-/0.028	-/-	-/0.027
S13	0.0024/-	-/0.008	-/-	-/0.009
S14	-/-	-/0.008	-/-	-/-
S15	-/-	-/-	-/-	-/0.006
S16	0.0017/-	-/0.013	-/-	0.0023/0.014
S16 (250S)	0.200/-	0.0025/0.051	-/-	0.0096/0.606
S16 (250N)	0.0014/-	-/0.014	-/-	0.00183/0.013
S16 (500S)	-/-	-/0.020	-/0.012	-/0.036
S16 (500N)	-/-	-/0.008	-/0.017	-/0.019
S16 (10-15 cm)	-/-	-/0.007	-/-	-/0.027
S16 (15-20 cm)	-/-	-/0.006	-/-	-/0.006
S17	0.0032/-	-/0.034	-/-	-/0.043
S18	-/-	-/0.023	-/-	-/0.028
S19	-/-	-/0.025	-/-	-/0.046
S19 (250S)	0.0019/-	-/0.026	-/-	-/0.043
S19 (250N)	-/-	-/0.025	-/-	-/0.44

(1) Finnish Institute for Verification of the Chemical Weapons Convention (VERIFIN). 2008. Nord Stream Offshore Pipelines through the Baltic Sea. Chemical Analysis of Sea-dumped Chemical Warfare Agents in Sediment and Pore water Samples. - Discussion of the results presented in report VER-MS-0162.

Sediment sample[(1)]	**Adamsite (mg/kg DM)**	**Clark I (mg/kg DM)**	**Triphenylarsine (mg/kg DM)**	**Phenyldichloroarsine (mg/kg DM)**
S19 (500S)	-/-	-/0.020	-/-	-/0.35
S19 (500N)	-/-	-/0.023	-/-	-/0.028
S20	-/-	-/0.015	-/-	-/0.027
S21	-/-	-/-	-/-	-/0.007
S22	-/-	-/0.009	-/-	-/0.010
S22 (250S)	-/-	-/0.007	-/-	-/0.009
S22 (250N)	-/-	-/0.032	-/-	-/0.098
S22 (500S)	-/-	-/0.010	-/-	-/0.011
S22 (500N)	-/-	-/0.009	-/-	-/0.010
S23	-/-	-/-	-/-	-/0.007
S25	-/-	-/-	-/-	-/0.008
S25 (250S)	-/-	-/0.007	-/-	-/0.008
S25 (250N)	-/-	-/0.007	-/-	-/0.009
S25 (500S)	-/-	-/0.007	-/-	-/-
S26	-/-	-/0.008	-/-	-/0.008
S27	-/-	-/0.008	-/-	-/0.008
S29	-/-	-/0.008	-/-	-/0.010
S29 (250N)	-/-	-/-	-/0.008	-/-
S29 (500S)	-/-	-/0.006	-/-	-/0.007
S30	-/-	-/0.008	-/-	-/0.015
S31	-/-	-/0.007	-/-	-/0.009
S33 (250S)	-/-	-/0.007	-/-	-/0.008
S33 (500N)	-/-	-/0.010	-/0.007	-/-
S33 (9-14 cm)	-/-	-/-	-/0.005	-/-
S34	-/-	-/0.006	-/-	-/-
All other stations/ samples	-/-	-/-	-/-	-/-
DL	0.0008/0.200	0.0012/0.006	0.0021/0.006	0.0011/0.006

1. Surface sediment sample from 0-5 cm depth.
2. 0.0025/0.051: Analysed by Verifin/Analysed by NERI
3. DL: Detection limit
4. -: Below detection limit

S16: Station S16 located at the pipeline route.
S16 (250S): Station S16 located 250 m south of the pipeline route.
S33 (9-14 cm): Station S33, sediment sample analysed from 9-14 m depth

Table 2.5 Chemical analyses results for pore water samples

Pore water sample	Adamsite (mg/l)	Clark I (mg/l)	Triphenylarsine (mg/l)	Phenyldichloroarsine (mg/l)
S22	-/-	-/0.002	-/0.002	-/0.002
S25	-/-	-/0.002	-/0.002	-/0.002
S29	-/-	-/0.002	-/-	-/-
All other stations/samples	-/-	-/-	-/-	-/-
DL	0.016/0.020	0.020-0.023/0.00041	0.020/0.00035	0.020/0.00051

1. -/0.002: Analysed by Verifin/Analysed by NERI
2. DL: Detection limit
3. -: Below detection limit

2.3 Consultations

As previously discussed, the munitions issue represents a hazard and the exchange of information within various fields of expertise is key to develop a sound approach to the issue. The main forms of consultation – expert group meetings, seminars and bilateral meetings – have taken place to facilitate this information and knowledge transfer.

2.3.1 Expert Group Meetings

Two expert group meetings have been conducted under the Espoo process. Both meetings were held in Hamburg and facilitated by representatives from BSH. The first meeting on 7th and 8th of June 2007 and the second on 16th/17th September 2008.

Expert Meeting 7th- 8th June 2007

The expert working group meeting objectives were to develop a common approach to the requirements for field investigations and for the handling of the found munitions.

The key questions raised during the meeting were:

- Are all dumping places and areas in the Baltic Sea known?
- What kind of impact could be caused by the dumped munitions?

There was common agreement that comprehensive and complete information on the areas where munitions could have been dumped in not available.

The munitions screening survey program was presented by Nord Stream AG. Participants agreed that:

- The survey programme as proposed was considered to be of a higher standard than average and could be characterised as "challenging“
- There is no method or measurement available, which guarantees a clear seabed to a depth of two meters below seabed
- The survey programme is in general considered as efficient to serve the purpose

The working group concluded that for the acceptance of the munitions screening survey results the classification of the findings must be described precisely, based on transparent and documented methods.

With respect to the handling of the found munitions it was concluded that thorough assessment is required to assess the impacts; this should consider the difference between chemical and conventional munitions.

Participants agreed on the following circumstances:

- Chemical munitions found in the Baltic Sea have not exploded
- Conventional munitions, especially mines, should be considered as dangerous i.e. likely to explode
- Common standards for handling munitions findings cannot be established as the necessary actions depend on different national rules and standards

In addition to Nord Stream and Ramboll attendees included representatives from:

- Germany: BSH
- Denmark: Bornholms Marinedistrikt
- Sweden: Swedish Armed Forces - COM Mine Warfare Data Center (MWDC)
- Finland: Finnish Institute of Marine Research, Defence Forces, Geological Survey

- Russia: Representative of the Russian Federation
- Estonia: Ministry of Environment, University of Tartu, Est. Marine Institute
- Latvia: Ministry of Environment - Data and Marine Environment Policy Branch

Expert Meeting 16th- 17th September 2008

The expert working group meeting objectives were to present the survey results, describe the munitions classification methodology in a transparent way and have open discussion.

Key clarifications included the:

- Survey corridor definition i.e. installation corridor, security corridor and overall screening corridor
- Planned anchor corridor survey scope of work which will be developed based on a risk assessment founded on the results of the munitions screening survey. Whilst extensive survey works will be performed there is no 100% certainty that all munitions will be located
- Planned munitions clearance, i.e. clearance will only be conducted for those munitions located in the security corridor. Munitions in the anchor corridor will be cleared if necessary otherwise they would be monitored and avoided during construction
- Soil and pore water sampling programme for contaminants associated with the degradation of CWA
- Use of a dynamically positioned pipelay vessel i.e. a lay barge that does not use anchors. It was noted that there is only one such vessel that could install the Nord Stream Pipeline, this is the "Solitaire". Consequently the surveys and assessments assume use of an anchored lay barge (worst case scenario)
- Reliability of the survey results and classification which was provided by onshore verification by three independent marine warfare experts (refer to **2.2.3**)
- Data confidentiality i.e. detailed survey data is provided only to the respective authorities of the countries where the surveys have been conducted. Generalised data will be presented in the respective environmental impact assessments

Discussions on the munitions clearance focused on the environmental impact which included the:

- Affects to fish: fish in the immediate proximity will die, however the majority of clearing at depths where there are low oxygen conditions

- Affects to marine mammals
- Mitigation measures to minimise impacts to fish and marine mammals

In addition to Nord Stream, Ramboll and ERM, attendees included representatives from:

- Germany: BSH, University Kiel
- Denmark: The Viking Ship Museum, Roskilde
- Sweden: Ministry of Environment, Swedish Armed Forces - COM Mine Warfare Data Centre (MWDC)
- Finland: Finnish Institute of Marine Research, Defence Forces, National Board of Antiquities, Uusimaa Regional Environmental Centre
- Poland: Sea Fisheries Institute
- Lithuania: Ministry of Environment, Centre of Marine Research

2.3.2 Seminars

To address the Espoo working group's recommendation that the survey methods and classification of results must be based on transparent methods, two munitions seminars were hosted by Nord Stream AG. These were held in Gothenburg, Sweden at the start of the munitions screening survey in 2007 and then approximately one year later in Turku, Finland on completion of the survey campaign.

Seminar 1: 27-28 September 2007 Gothenburg, Sweden

Nord Stream AG hosted the first munitions seminar held in Gothenburg, Sweden on September 27th and 28th 2007. The purpose of the seminar was to present Nord Stream's survey program, both the past surveys and the scope for the munitions screening surveys, to determine and circumvent the potential risks caused by munitions in the Baltic Sea.

Presentations informed on:

- The project history and prior surveys (2005 and 2006 survey campaigns) which included an introduction to the details of the 2006 underwater inspections demonstrating resolution of side scan imagery, under water video sequences and classification of objects found
- Route selection philosophy
- Survey scope for the 2007/2008 munitions screening survey and the adopted survey procedure

- Target interpretation and correlation between the various sensors and across the present and past survey campaigns
- Object classification by experts with marine ordnance experience

Participants also volunteered to share their particular knowledge of munitions in the Baltic.

- Representative from Swedish Navy presented an overview of the history of mine deployment in the Baltic Sea which included examples of maps of mine lines, types of munitions and mine clearance
- The Danish Navy representative (Bornholm's Marinedistrikt) gave an overview of the Danish explosive ordnance demolition service including the disposal of chemical munitions
- Representative from the Russian Federation provided an overview on potential risks posed by chemical munitions during the construction of the pipeline

In addition to Nord Stream, Ramboll and MMT attendees included representatives from:

- Germany: BSH
- Denmark: Bornholms Marinedistrikt
- Sweden: Swedish Armed Forces - COM Mine Warfare Data Center (MWDC)
- Finland: Finnish Institute of Marine Research, Defence Forces, Geological Survey
- Russia: Representative of the Russian Federation
- Estonia: Ministry of Environment, University of Tartu, Est. Marine Institute
- Latvia: Ministry of Environment - Data and Marine Environment Policy Branch
- UK: Innovatum International Ltd – developer of gradiometer array

Seminar 2: 23-24 October 2008 Turku, Finland

This seminar was developed as a continuation of the first munitions seminar. The munitions screening survey findings were addressed and the proposed clearance method presented. The objective was to demonstrate that the survey objectives presented during the first seminar have been met and that a rigorous and detailed baseline for the Baltic Sea had been established.

Presentations informed on:

- Survey techniques, located conventional munitions, expert evaluation of the located objects and related aspects for pipeline installation
- Munitions clearance methodology for conventional munitions
- Survey techniques for chemical munitions screening to the east of Bornholm
- An assessment of various aspects of risk posed by chemical munitions disposed within the dump sites

The invitation list was directed to the ESPOO national focal points to nominate representatives from military and/or maritime authorities, attendees of the first seminar conducted in Gothenburg, authority contacts within the national permitting process in Finland and individual experts.

In addition to Nord Stream, Ramboll and MMT attendees included representatives from:

- Denmark: Bornholms Marinedistrikt
- Sweden: Swedish Armed Forces - COM Mine Warfare Data Center (MWDC)
- Finland: Ministry of Environment and Defence Forces
- Latvia: Ministry of Environment - Data and Marine Environment Policy Branch
- UK: Saipem – installation contractor

2.3.3 Bilateral Meetings

Finnish Authorities

Bilateral meetings have been conducted with the Finnish Authorities on the national level to address the munitions issue. These meetings were attended by the Ministry of Defence in addition other authority representatives.

During 2008 the Ministry of Defence attended the following meetings:

- 9th January 2008, Munitions screening meeting in the Ministry of Foreign Affairs
- 12th February 2008, Presentation and discussion of the EIA-report draft (authority workshop) in Ramboll Espoo office

- 20th May 2008, Munitions findings and munitions clearance plan meeting in the Ramboll Espoo Office
- 2nd July 2008, Maritime Safety meeting in Finnish Border Guard
- 26th September 2008, Presentation and discussion of the EIA-report draft (authority.workshop) in Ramboll Espoo office

Swedish Authorities

In Sweden bilateral meetings were held on:

- 22nd February 2007 when the methodology and available survey results were presented and discussed
- 12th January 2009 when the clarifications raised by the Swedish Armed Forces during the Administrative Referral were discussed

Danish Authorities

In Denmark no specific bilateral meetings were held to discuss the munitions issue. Munitions have been discussed as part of the general the "application preparation meetings" on:

- 20th February 2006
- 04th July 2007
- 31st March 2008

German Authorities

In Germany, bilateral meetings with authorities regarding the issue of munitions have been held on Federal level, as well as on the level of the Land Mecklenburg-Vorpommern:

- 16th November 2007, Meeting with the BSH and BA (Federal Maritime and Hydrographic Agency / Mining Office)
  - Discussions regarding how to present a concept regarding the presentation of potential munitions findings in the application documents
  - Agreement to invite a representative of the Munitions Recovery Institute Mecklenburg-Vorpommern to discuss the issue of munitions discoveries for the next meeting

- 18th December 2007, Meeting with BSH and BA (Federal Maritime and Hydrographic Agency / Mining Office)
  - Presentation of the survey level of detail of and the procedure in the event munitions are found
  - Agreement that studies concerning munitions carried out by Nord Stream are very detailed and cover the full requirements of the scoping
  - Representative of the Munitions Recovery Institute Mecklenburg-Vorpommern was present and stated that the Institute expects no munitions findings on the Nord Stream route in Germany
- 22nd January 2008, Meeting with Umweltministerium MVP (Ministry of the Environment of Mecklenburg-Vorpommern)
  - Presentation on status and results of munitions surveys

3 Project Activities that Cause Impact

3.1 Planned Activities

3.1.1 Construction Phase

The pipelines will be installed from a pipelay barge. There are two principle means for the pipelay barge to maintain position, these being the use of anchors or dynamic positioning i.e. the use of computer controlled propulsion. To ensure the safe installation of the pipeline all areas where there is the potential for seabed disturbance are surveyed to locate potential munitions. Munitions that cannot be avoided will be cleared in a controlled operation i.e. "planned activity".

Seabed disturbance occurs in the following areas:

- Where the seabed will be trenched prior to pipeline installation (landfalls)
- Where rock will be placed to support the pipelines in areas of freespans
- Where the pipeline will be laid on the seabed
- Where anchors will be placed on the seabed
- Where anchor wires will sweep the seabed

3.1.2 Operational phase

To ensure the safe operation of the pipeline in the Russian, Finnish and Swedish sectors munitions need to be cleared from the security corridor. These are munitions that if they detonate may cause structural damage to the pipelines. The width of this security corridor is defined as extending 25 m either side of each pipeline (refer to **section 2.2.3**).

There is no evidence to suggest that the movement of munitions by fishing activity or seabed currents or that munitions have ‘self’ detonated in the Gulf of Finland. However; during the operational life of the pipelines there is a possibility that munitions may be found within the security corridor during the regular pipeline inspection surveys. In the event such munitions are located, the situation will be analysed by marine warfare experts and an action plan will be developed in conjunction with the national authorities.

3.1.3 Munitions Clearance

The main objective of the clearance operations is to clear ordnance that pose a threat to pipeline installation. It is envisaged that the clearance will be performed in two phases, firstly along the security corridor, followed by selected munitions within the anchor corridor.

Munitions clearance requires the safe detonation of the munitions. Physically removing the ordnance from the pipeline route has been addressed by the munitions experts and they have concluded that this option would incur greater risk than detonation (leading to an unplanned event, refer to **section 3.2**).

Safe and proven clearance methods will be used which are similar to those previously used to dispose of munitions in the Baltic Sea. Over the last decade or so, the collective navies of the Baltic States have developed methods that are both safe and effective for the clearance of mines and other explosive underwater ordnance. These methods have also been used by other national navies around the world to dispose of ordnance.

The clearance will be conducted in accordance with a clearance plan that will be developed in conjunction with relevant national authorities. The clearance plan will include clear risk assessed procedures for the technical performance of the work, together with the mitigation measures to minimise impact to marine mammals, fish and birds, and a monitoring plan.

The technical procedure of the munitions clearance will address:

- Identification and implementation of exclusion zones to assure safe shipping movements for all vessels in the surrounding area

- Pre-detonation inspections: ROV based verification survey using high resolution cameras to record the seabed conditions and the surrounding environment including presence of existing infrastructure, cultural heritage, anthropogenic debris (e.g. barrels) and other munitions

- Munitions classification verification: where the classification of all munitions will be verified (type, model and amount of explosive material based on historical data)

- Disposal: where the proven method involves placing a small charge on the identified live or suspected live ordnance on the seabed using a small ROV. The charge is then detonated acoustically from a surface support ship located at a safe distance from the target

- Post detonation survey: to verify successful detonation and if necessary remove any remaining large residual items of metal that are still present in the area and which could create further pipeline installation difficulties. ROV utilising manipulators and special baskets will also carry out this operation

3.1.4 Chemical Munitions

Three items were located in the Danish sector that are related to chemical munitions. These items are not deemed to be explosive as the detonators were removed when dumped. These are:

- Chemical 250 mustard gas bomb offset 17 m from the pipeline route

- Fuse from chemical bomb offset 16 m from the pipeline route

- Bomb tail from chemical mustard gas bomb offset 19 m from the pipeline route

As the objects do not pose an explosive risk Nord Stream has advised that it intends:

- Not to move or recover the objects

- Install the pipeline no closer that 10 m from identified objects

Guidance is awaited from the Danish Admiralty Fleet and specific additional precautions or actions may be implemented following consultation with the Danish authorities.

3.2 Unplanned Events

3.2.1 Construction Phase

Munitions will be detected through the extensive survey programs that have been and will be conducted by Nord Stream AG. However, it is not possible that all conventional munitions will be located during these surveys. In the event that unforeseen munitions are encountered, for example when anchors are placed on the seabed or where the anchor wires sweep the seabed, munitions may detonate causing an "unplanned event".

As with the conventional munitions it is not possible that all items related to chemical munitions will be located. However soil sample chemical testing results (refer to **section 2.2.6**) indicate only low contamination as would be expected given the history of the area. In the event that unforeseen chemical munitions are encountered, for example when anchors are placed on the seabed or where the anchor wires sweep the seabed, then the items may be moved and potentially the anchor wires could become contaminated with the residue of the degradation of chemical munitions.

Pipeline installation and anchoring procedures will be the subject of detailed risk assessments. The necessary precautions will be developed and discussed with the relevant authorities to ensure the safe installation of the pipeline.

4 Impact of Munitions Clearance

4.1 Physical Environment – Water Column

The clearance of munitions has the potential to cause the re-suspension and spreading of sediments and the release of contaminants. The sediment released into the water column through munitions clearance is related to the size of the depression created i.e. crater size. The assessment of the depression size is based on an empirical calculation which has been correlated against information and experience received from the Finnish navy (**Figure 4.1**). The variety of soil types encountered along the pipeline corridor; i.e. soft clay, sand or hard bedrock, are accommodated through a resistance factor. The depth of the crater is assumed to be half of the radius.

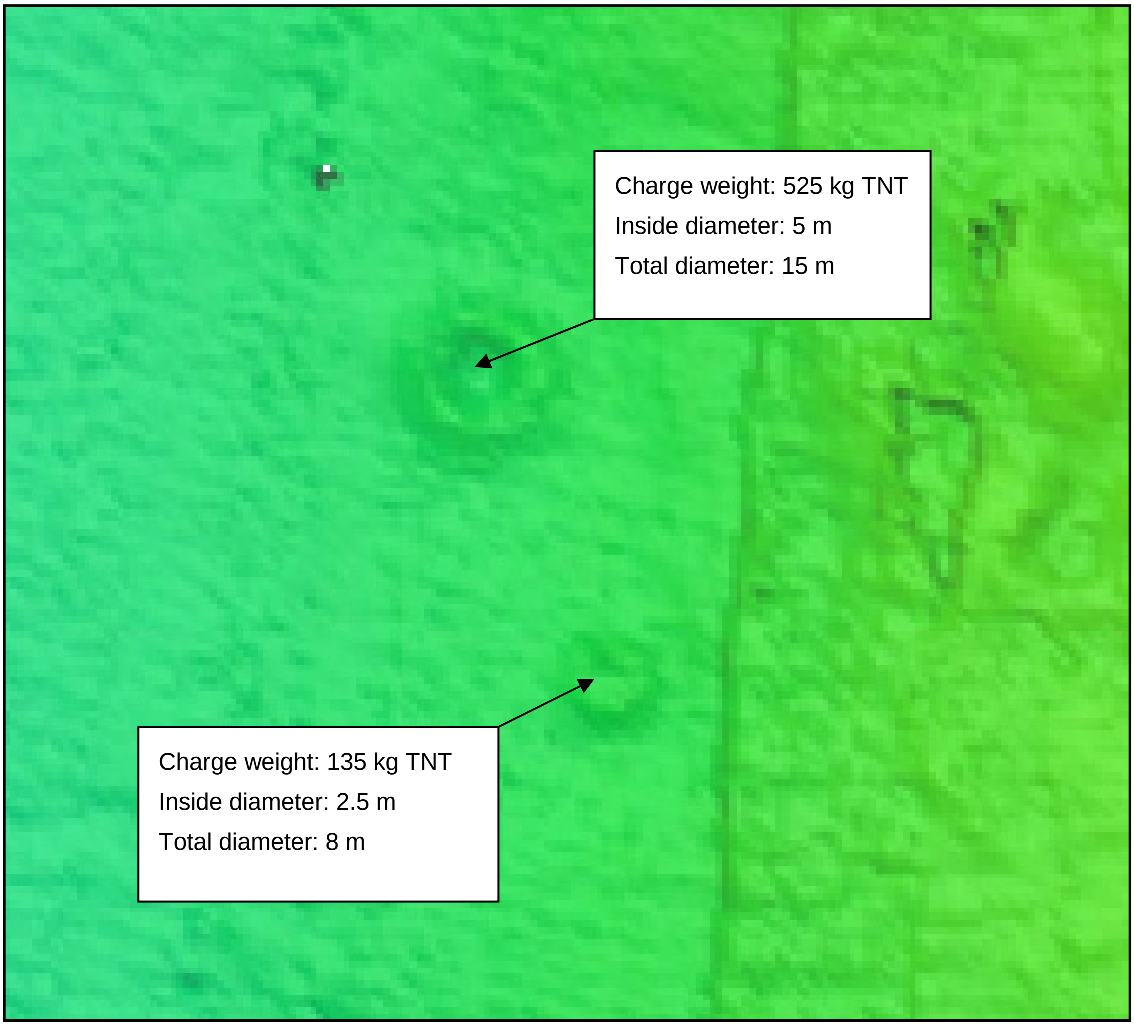

Figure 4.1 Bathymetric image of two depressions caused by seabed mine detonations (w.d. approx. 25m) – Soils hard clay underlain by soft clay (Finnish Navy)

The assessment of the spreading of sediments and contaminants released into the water column, transported by currents and then re-deposited during munitions clearance, is made by combining computer modelling and expert opinion. The extent of the re-sedimentation is assessed using the three dimensional computer flow model MIKE 3 in combination with the particle spreading model MIKE 3 PA (developed by DHI Water-Environment-Health).

The modelling of sediments released due to munitions clearance considers calm weather conditions as munitions will only be cleared in calm weather due to observation constraints (refer to **section 5.3**).

4.1.1 Increase in Turbidity

The clearance of munitions is expected to result in the formation of a crater on the seabed and the re-suspension of sediment throughout the water column.

On average, munitions clearance results in re-suspended sediment with a concentration above 1 mg/l within 1-2 km, with a maximum in some locations of 5 km, of the disturbance area for 13 hours. A concentration above 10mg/l is expected to last for 4 hours on average and close to the clearance site. Sedimentation is limited and rarely exceeds 0.1kg/m^2. Therefore, due to the limited extent and duration of increased turbidity levels and the fact that munitions clearance will only occur at specific points (Swedish, Finnish and Russian EEZ) on the pipeline routes it is expected that the impact (**negative** and **direct**) on the water column will be of **regional** scale (above background levels) and of **short-term** duration (sedimentation rate). Impacts will be **reversible** within a few days as sediment settles to the seabed. Intensity is **low** as no major change in structure and function is expected. Impact magnitude is **low**. Therefore impact significance is expected to be **minor**.

4.1.2 Release of Contaminants

Munitions clearance will result in the release of contaminants into the water column. Modelling has been performed for munitions clearance locations in the Finnish EEZ [(1)]. However, as the number, and locations, of munitions that require clearance in the Russian sector has not been confirmed no modelling of the release of contaminants has taken place. As such, the Project has considered the modelling performed in Finland and has used it as a basis for assuming that similar impacts would occur in the Russian and the Swedish EEZ.

For munitions clearance locations in the Finnish EEZ, dissolved copper is modelled and predicted to exceed the Predicted No Effect Concentration (PNEC) (>0.02 µg/l) up to a distance of 1-3 km from the source during normal weather. The duration for which copper concentrations are expected to be greater than the PNEC is 6 hours. Dissolved poly aromatic hydrocarbons (PAHs) are expected to exceed the PNEC (>0.000009 µg/l) up to a maximum distance of 1-3.5 km from the source during normal weather. The duration for which PAH concentrations are expected to be greater than the PNEC is 7 hours.

Therefore, due to the limited extent and duration of increased contaminant concentration levels and the fact that munitions clearance will only occur at specific points on the pipelines' route it is expected that the impact (**negative** and **direct**) of the release of contaminants is expected to be **regional** (above the PNEC), of **short-term** duration due to the expected settling of suspended sediment bound contaminants and of **low** intensity as no change is expected in the structure

(1) Nord Stream AG & Ramboll. 2008. Memo 4.3A-12 Spreading of sediment and contaminants from clearing of munitions.

and function of the water column. Impacts will be **reversible** within a few days. Impact magnitude is therefore **low**. As both the impact magnitude and receptor value/sensitivity are **low**, impact significance is expected to be **minor**.

4.1.3 Physical Environment – Alteration of the Seabed

The clearance of munitions has the potential to cause physical alteration of the seabed through altering the structure of the seabed directly and through the re-suspension and spreading of sediments. Crater size is dependent on the charge size which range between 0.8 kg to 320 kg TNT and the soil type. Based upon the munitions clearance modelling performed in the Finnish EEZ craters been estimated to range from several decimetres for the smallest charges up to a maximum of approximately 10– 15 m, with average radii of 4.5 meters.

This will result in a **negative** and **direct** impact on a **local** scale (<500 m) and of **low** intensity as no major change in structure or function of the seabed is expected. Impacts will be of **short-term** duration and **reversible** as the craters will, overtime, be filled. The magnitude of the impact is **low**. The seabed is generally of **low** sensitivity in the areas identified for munitions clearance and therefore the impact on the seabed is considered to be **minor.**

4.2 Biological Environment – Marine Benthos

Munitions clearance is expected to impact marine benthos through an increase in turbidity, release of contaminants, increase in noise and vibration and physical loss of seabed habitats.

4.2.1 Increase in Turbidity

The clearance of munitions has the potential to increase the re-suspension of sediments leading to smothering of benthos. The **negative**, **direct** impacts will act on a **regional** scale, impacting benthos in the **short-term** to **long-term** as recovery of the community is dependent on recruitment from the surrounding areas. Most benthic fauna, including non-burrowing species, would be expected to be able to survive even high levels of deposition and therefore the impact would be **reversible.** The intensity of the impact is expected to be **low** as a localised group of individuals will be affected with many individuals expected to survive a certain degree of smothering. The magnitude of the impact is also expected to be **low**. As described above, the sensitivity of the benthos communities along the pipelines' route within Finland, Sweden and Russia are considered **low** to **medium** for all communities. The impact significance due to munitions clearance is therefore predicted to be **minor**.

4.2.2 Release of Contaminants

In areas where the sediments are contaminated with heavy metals and organic contaminants there is a potential for these contaminants to be released into the water column. These contaminants have the potential to cause toxic effects to fauna on the seabed upon direct contact and may have an indirect effect on the benthos from contamination of the water column, particularly on suspension feeders. The residual impact from contaminants released from disturbed sediments to the benthos once mitigation measures have been implemented is expected to be **negative**, **direct** to the seabed and **indirect** through the water column. The concentration of contaminants in the water column will decrease with time reducing the potential for harmful levels of contaminants to accumulate within the organisms. The impact will be **local, long-term** and **reversible** as particle-bound contaminants will be present in the surface layers of the sediment for many years but the population will eventually recover once the contaminants become increasingly immobilised and toxicity of the sediment is reduced. The impact of contaminants on **low** value/sensitivity benthic flora and fauna will have a **low** intensity, as changes are expected to be at the limit of detection and will affect a group of localised individuals. The impact will be of **low** to **medium** magnitude. The impact significance is expected to be **minor**.

4.2.3 Noise and Vibration

During munitions clearance, a shockwave will result, originating from the location of the device that is cleared. The shockwave may disrupt sensitive benthic fauna, particularly large mobile species. Information on the distance a shockwave can travel as a result of munitions clearance is not available but is likely to have a **local** impact. The effect is expected to be **direct**, **negative** and **reversible**. The impact would be likely to be **temporary** as the shockwave will quickly lose power with distance and time. This is likely to lead to a **low** to **medium** intensity impact since benthos is expected to receive low level tissue damage. As the size of the resulting shockwave from munitions clearance is unknown, it is difficult to assess the magnitude of the impact; however it is considered likely to be a **low** magnitude impact, which would affect a **low** to **medium** value/sensitivity receptor. The overall significance of the impact of noise and vibration from munitions clearance on marine benthos is therefore expected to be **minor**.

4.2.4 Physical loss of Seabed Habitats

Munitions clearance will result in physical disturbance to the seabed and loss of benthos habitats that will be **negative** and **direct**. The impacts are likely to affect an area within 500 m of the pipelines' corridor and it will therefore be **local** impact. The loss of habitat from the munitions clearance is likely to be **short-term** and **reversible.** The intensity of the impact is **medium** as localised habitat and associated benthos will be destroyed but not to the extent that the whole population will be affected. The magnitude of the impact will be **low** as only a small proportion of the benthic community is expected to be affected. As marine benthos is of **low** to **medium** value/sensitivity, overall this impact is expected to be of **minor** significance.

4.3 Biological Environment – Fish

Munitions clearance activities may result in tissue damage and death to fish as well as behavioural changes such as the displacement of fish from their usual spawning grounds during the spawning season.

4.3.1 Release of Contaminants

Munitions clearance will result in increased noise and vibration and subsequently fish will move away from the areas of increased turbidity due to increased noise levels.

The impact of munitions clearance resulting in the release of contaminants on fish species during the construction phase is expected to be **negative** and **direct,** on a **local** scale and of **short-term** duration. Impacts are **reversible**. The value/sensitivity of fish is **low** to **high**. However as the re-suspension of sediments and release of contaminants are less likely to affect the upper layers of the water column, these impacts will be of **low** intensity with a **low** magnitude. Impact significance is expected to be **minor** where mitigation measures are applied. In the unlikely event that diadromous species (fish that regularly migrating between freshwater and seawater) are in close proximity to the pipelines during migratory periods, an increase in contaminants could result in an impact of **moderate** significance, as these fish are highly sensitive at this time. As there are no specific important spawning grounds located in the vicinity of the proposed route in the Gulf of Finland impacts of munitions clearance resulting in the exposure of fish to contaminants is expected to be **insignificant**.

4.3.2 Noise and Vibration

Predictions exist regarding fish mortality due to the detonation of munitions during clearance operations. Based on these published regression lines for "probability of mortality"(1) the following plots have been developed for charge weights of 50 kg, 150 kg and 300 kg (**Figure 4.2**). The coloured circles represent probability levels of mortality at horizontal distances from the source, for example, that the probability of mortality is 25%-35% at a horizontal distance of approximately 200 m for a charge weight of 150 kg.

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(1) Baxter, I., Hays, E., Hampson, G. and Backus, R. 1982. Mortality of fish subjected to explosive shock as applied to oil well severance on Georges Bank. Woods Hole Oceanographic Institution. Ch. WHOI-82-54.

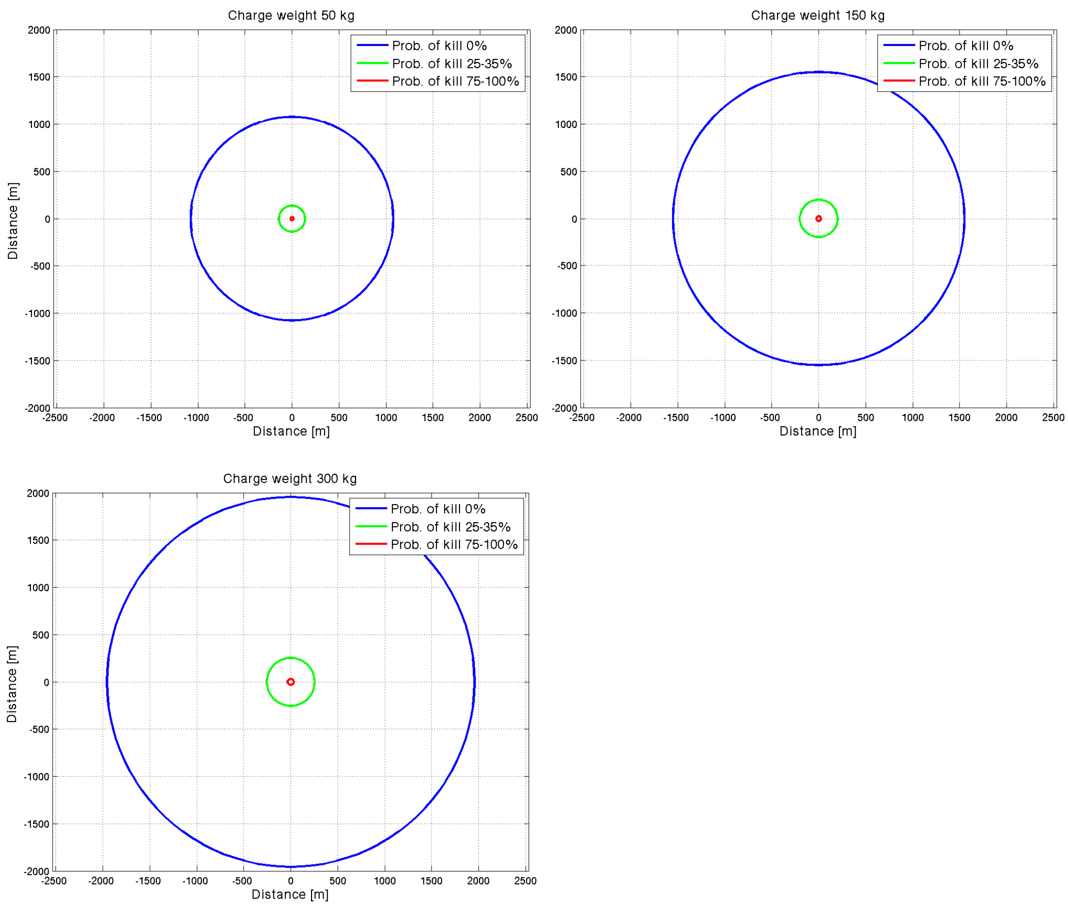

Figure 4.2 Probability of fish mortality as a function of the horizontal distance and charge weight

As loud noise usually initiates an avoidance response, some fish will move away from the areas of disturbance from vessels associated with munitions clearance and return once munitions clearance has completed. However, displacement of fish away from their usual spawning grounds during the spawning season could have a significant impact on recruitment to the adult population.

The impacts of noise generated as a result of munitions clearance on fish will be **negative** and **direct** and of **temporary** duration. The impact will be on a **regional** scale around the clearance site. Impact intensity is expected to be **medium** to **high** depending on the fish present in the area impacted from the detonation. Impact magnitude is **medium** and the value/sensitivity ranges from **low** to **high** depending on the species impacted. Impacts may be irreversible at an individual level if tissue damage or hearing loss occurs, however at a population level the impacts are considered to be **reversible**. Therefore, impact significance is expected to be **minor** to **moderate**. It should be noted that munitions clearance is a common activity in the Baltic Sea. Impacts will act on the individual rather than operating at the population level.

As mitigation measures fish spawning times will be considered in the planning phase (refer to **section 5.2**) and for fish that swim in shoals within the impact area that acoustic survey will be used (refer to **section 5.3**) to check the area before detonation.

4.4 Biological Environment – Sea Birds

4.4.1 Increase in Turbidity

Visual and physical disturbance due to munitions clearance is predicted to impact on sea birds in the Russian EEZ. Impacts from increased turbidity due to munitions clearance will be **regional**, of **short-term** duration and of **low** intensity. Impact magnitude is therefore **low**. Birds in the Russian EEZ are highly sensitive during the breeding season and spring/autumn migration period due to the large numbers of internationally protected species present during these periods. However, increased turbidity will not affect the long-term distribution and abundance of sea birds in this area. The value/sensitivity of species ranges from **low** to **high**. The majority of affected species forage over large ranges and will return once re-suspended sediment has settled, therefore the impact will be **reversible**. Increased turbidity may result in **moderate** significant impacts on foraging terns as these species are listed in Annex I of the EC Birds Directive, and **minor** significant impacts on the majority of gulls, auks and cormorants.

Many species of diving sea birds including those of high ecological value such as divers (*Gavia* spp.) are known to feed by eye sight and increased turbidity may have a **direct negative** impact upon foraging success of these species. Re-suspended sediments are expected to remain throughout the water column for munitions clearance.

Munitions clearance within the Gulf of Finland and Sweden has the potential to impact upon piscivorous species of birds (i.e. habitually feeding on fish). As the distance to the nearest area of importance for birds is at least 25 km from the munitions clearance, works this activity is unlikely to pose a risk to sea birds at the colonies. Although it is possible that some birds may still forage underwater closer to the pipelines' route and may be at risk, impacts are considered to be **insignificant** as only single individuals will be temporarily displaced and will return once sediment has settled.

4.4.2 Noise and Vibration

Munitions clearance will result in increased underwater noise levels and above surface noise levels. The greatest level of disturbance is expected to affect birds foraging underwater in the immediate vicinity. The shallow water of the Russian coastline may at times support large numbers of staging birds, especially during the spring/autumn migration. A number of highly sensitive species of waders are known to occur in the local area, including ruff and bar-tailed godwit. The clearance of munitions will be carried out outside the breeding and migration period and will also be carried out during daytime hours because the eastern part of the Gulf of Finland supports night-time roost sites for migrating birds. Increased noise levels may cause the temporary displacement of a small number of birds which will return once these construction activities have ceased. Impacts are therefore **insignificant**.

Munitions clearance within the Gulf of Finland and Sweden has the potential to impact upon piscivorous species of birds. The stand off areas of birds foraging under water is, however, largely unknown and the scale of direct effects on birds can therefore not be exactly identified. However, the distance to the nearest area of importance for birds is at least 25 km from the munitions clearance works and therefore is not likely to pose a risk to sea birds at the colonies, due to the distance of these dense populations of sea birds from the detonation point. Although it is possible that some birds may still be foraging underwater closer to the pipelines' route and may be at risk, impacts are considered to be **insignificant**.

4.4.3 Loss of Seabed Habitat

The loss of seabed habitat may cause negative impacts on benthic feeding species such as diving ducks and auks, especially within the area of Dolgy Reef, Bolshoy Fiskar Archipelago and the Ingermanlandsky islands due to their close proximity to the pipelines' route. Diving ducks comprise the most numerous group of sea birds within the area of Beryozovyye Island, supporting several hundred thousand long-tailed ducks (*Clangula hyemalis*), black scoter (*Melanitta nigra*) and velvet scoter (*Melanitta fusca*) during the spring/autumn migration period. Smew, a species protected under the EC Birds Directive, is also present although in smaller numbers.

The impact on sea birds due to loss of seabed habitat will be **direct** and **negative** and will affect a 15 m corridor on each side of the pipelines within the offshore areas and within 500 m of the pipelines along the dredged sections at the Russian landfall. Destruction of seabed habitat may also be caused by increased turbidity. Impacts on benthic feeding sea birds are **local** in scale and will not affect the long-term distribution of species of sea birds in the Russian EEZ. The loss of benthic habitat is **reversible** and **short-term** and will affect only small numbers of foraging sea birds during the spring/autumn migration period and also during the breeding season. Long-term impacts on sea birds will not result and the impact will not affect the long-term distribution and abundance of sea birds in this area. Impact intensity is **low**. Impact magnitude is **low**. The sensitivity of sea birds is **low** to **high,** being high during the spring/autumn migration period and also during the breeding season due to the large number of protected species. The loss of seabed habitat will primarily affect common birds, especially during autumn migration when, amongst others, large numbers of long-tailed ducks, common scoter and velvet scoter migrate through this area. However, the loss of seabed habitat is small in comparison will recover rapidly. The impact significance is **minor** to **moderate**.

Munitions clearance within the Finland and Sweden will not be located close to the shallow waters that are regularly inhabited by waterfowl species such as diving ducks and waders. A minor proportion of seabed habitat within areas of shallower water may, however, be lost during the construction of the pipelines affecting a small proportion to the south of Itäinen Suomenlahti National Park. However, the seabed habitat is expected to recover rapidly and the localised loss of seabed habitat is not expected to impact significantly upon benthic-feeding species of birds. Impacts are therefore considered to be **insignificant**.

4.4.4 Visual/Physical Disturbance

Munitions clearance is expected to cause physical disturbance to birds rafting or feeding on the water surface, as well as those foraging underwater in the Russian EEZ. The greatest level of disturbance is expected to affect birds foraging underwater in the immediate vicinity of the clearance site. Bird populations in this area are particularly sensitive during the breeding season and the spring/autumn migration period, as high numbers of internationally protected species are present at these times and a large number of diving ducks migrate through this area during the spring/autumn migration (primarily long-tailed ducks, tufted ducks, black scoter and velvet scoter). These species forage underwater and may be affected by munitions clearance activities. The impact of munitions clearance, which will be **negative** and **direct**, is expected to act on a **local** scale and be **temporary** in duration. The intensity varies between **low** and **medium** depending on the distance between the bird and the detonation point. The careful timing of munitions clearance activities is very important, and these activities will be carried out during daytime hours, in agreement with government and non-governmental organisations relevant to bird conservation, in order to ensure that the level of physical disturbance to sea birds will be kept to a minimum. With these mitigation measures in place, the impact magnitude is considered to be **low**. The sensitivity of species ranges from **low** to **high**. Impacts will be **reversible**. The impact will therefore be of **minor** to **moderate** significance, affecting small numbers of diving ducks. Although still moderate, the impact may be slightly higher if velvet scoter are affected as this species is listed as rare and/or declining in the Baltic Sea. However, if timed carefully, the clearance of munitions will not affect the long-term abundance and distribution of protected or rare birds.

A lower risk of significant impacts is identified for species foraging on the water surface, such as terns and gulls. These species may be disturbed for a very short period of time and will return immediately. The impact of physical disturbance from munitions clearance on these species is therefore expected to be **insignificant**.

Munitions clearance may, however affect, single individuals of piscivorous sea birds diving in the vicinity of the detonation. As the likelihood that birds are diving in close vicinity to the detonation is very low impacts are considered to be **insignificant** in Sweden. In Finland, as the munitions are located in areas of deeper water (below 50 m depth) and the likelihood that diving sea birds may be impacted is therefore very low.

4.5 Biological Environment – Marine Mammals

4.5.1 Increase in Turbidity

An increase in turbidity due to the re-suspension and spreading of sediments during construction may result from munitions clearance. As marine mammals use their hearing ability for navigation, as well as for hunting, an increase in turbidity is expected to yield an **insignificant** impact on individuals. Other marine fauna, on which marine mammals would feed, may vacate the construction area due to noise and an increase in turbidity. As the water column near the seabed in most areas of the Finnish and Swedish EEZ goes through periods where oxygen is present and through periods of hypoxia, a halocline may be present. The halocline would affect the abundance of marine fauna in close proximity to the seabed. During periods where oxygen is present high and thus marine fauna will be abundant. An increase in turbidity may result in short term reduction in marine fauna close to the seabed which may affect marine mammal feeding areas. This is expected to have an **insignificant** impact on marine mammals in these areas as they would more than likely avoid the construction area due to noise and vibration and would hunt elsewhere. During periods of hypoxia oxygen levels would be low and thus marine fauna will be scarce in close proximity to the seabed. No significant impacts are expected.

4.5.2 Release of Contaminants

An increase in contaminant concentration in the water column due to the release of contaminants from the re-suspension and spreading of sediments during munitions clearance could theoretically raise the concentration of contaminants in the food chain and subsequently in mammal tissue. However, it is expected that any contaminants that may be released will remain above the Predicted No-Effect Concentration (PNEC) for **short** periods of time in the immediate (2-4 km) vicinity to seabed intervention sites. In general, marine mammals are expected to vacate the construction area due to noise and thus impacts related to the release of contaminants are deemed to be **insignificant** and are not assessed further.

4.5.3 Noise and Vibration

Sensitivity of marine mammals to the emission of underwater noise and pressure waves is relatively high. Noise can cause behavioural responses or even injuries and death, depending on the level and other properties of the noise[(1),(2)].

Five zones of impact from noise are defined, depending on the distance between the source and recipient[(3)]:

- Zone of audibility: the area within which the animal is able to detect the sound
- Zone of masking: the region within which noise is strong enough to interfere with the detection of other sounds, such as communication signals or echolocation clicks. Noises that mask important sounds, such as calls, may have an indirect impact on marine mammals by postponing reactions to calls. Although there are many indications that marine mammals might have the ability to change their natural sound in order to counteract the masking effect, confirming studies are scarce
- Zone of behaviour: the zone in which the animal reacts behaviourally or physiologically. Noise that causes behavioural changes such as reduced time at the surface or swimming away from the source of noise may affect individual mammals
- Zone of hearing loss: the area in which the received sound level is high enough to cause hearing loss (temporary or permanent)
- Zone of tissue damage: the area closest to the noise source where the noise is strong enough to damage tissue surrounding the lungs

Munitions clearance has the potential to cause considerable noise and vibration that would impact negatively on marine mammals. Noise generated during clearing takes the form of an initial shock pulse followed by a succession of oscillating bubble pulses.

(1) Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. 2006. Effects of offshore wind farm noise on marine mammals and fish.

(2) Southall, B. L., Bowles, A. E., Ellison W.T., Finneran, J. J., Gentry, R. L., Greene, C. R., Kastak, D., Ketten, D. R., Miller, J. H, Nachtigall, P. E., Richardson, W. J., Thomas, J.A. and Tyack, P. 2007. Marine mammal noise-exposure criteria: initial scientific recommendations. Aquat. Mammals. Vol. 33. 411- 521.

(3) Richardson, W. J., Greene Jr., C. R., Malme, C. I. and Thomson, D. H. 1995. Marine Mammals and Noise. Academic Press. London.

Literature[1] suggests that:

- Close to the detonation the peak pressure of the shockwave is the major parameter in estimating the effect of underwater explosions on marine life

- Further away from detonations (in lower pressure zone) the impact is considered to be caused by the negative (under) pressure pulse, which follows high pressure front and can be strengthened by the reflected wave front from water-air surface. This negative pressure causes gas embolism, gas bubbles in blood

- Injured mammals may not be able to swim to the surface at normal speed. Thus depth where mammals meet pressure waves is an important factor of survival

Predictions regarding safety distances for mammals due to the detonation of munitions during clearance operations have been developed[2, 3] The charts have been developed on charge weights of 50 kg, 150 kg and 300 kg (**Figure 4.3**). The coloured circles represent probability levels of damage at horizontal distances from the source. The coloured circles represent horizontal safety distances where mammals are predicted:

- To die if they are within the red circle

- To be severely injured if they are between the red and green circle

- To suffer minor injuries if they are between the green and blue circle

- To safe outside the blue circle

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(1) Lewis, J. A. 1996. Effects of underwater explosions on life in the sea. AR No. AR-009-629. DSTO-GD-0080. DSTO Aeronautical and Marine Research Laboratory. Melbourne. Australia.

(2) Goertner, J. F. 1982. Prediction of underwater explosion safe ranges for sea mammals. Final Report NSWC TR 88-114. Naval Surface Warfare Center. Dahlgren Division. White Oak Detachment Silver Spring. Maryland USA.

(3) Parvin, S. J., Nedwell, J. R., and Harland, E. 2-2-2007. Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring. http://www.subacoustech.com/information/downloads/reports/565R0212

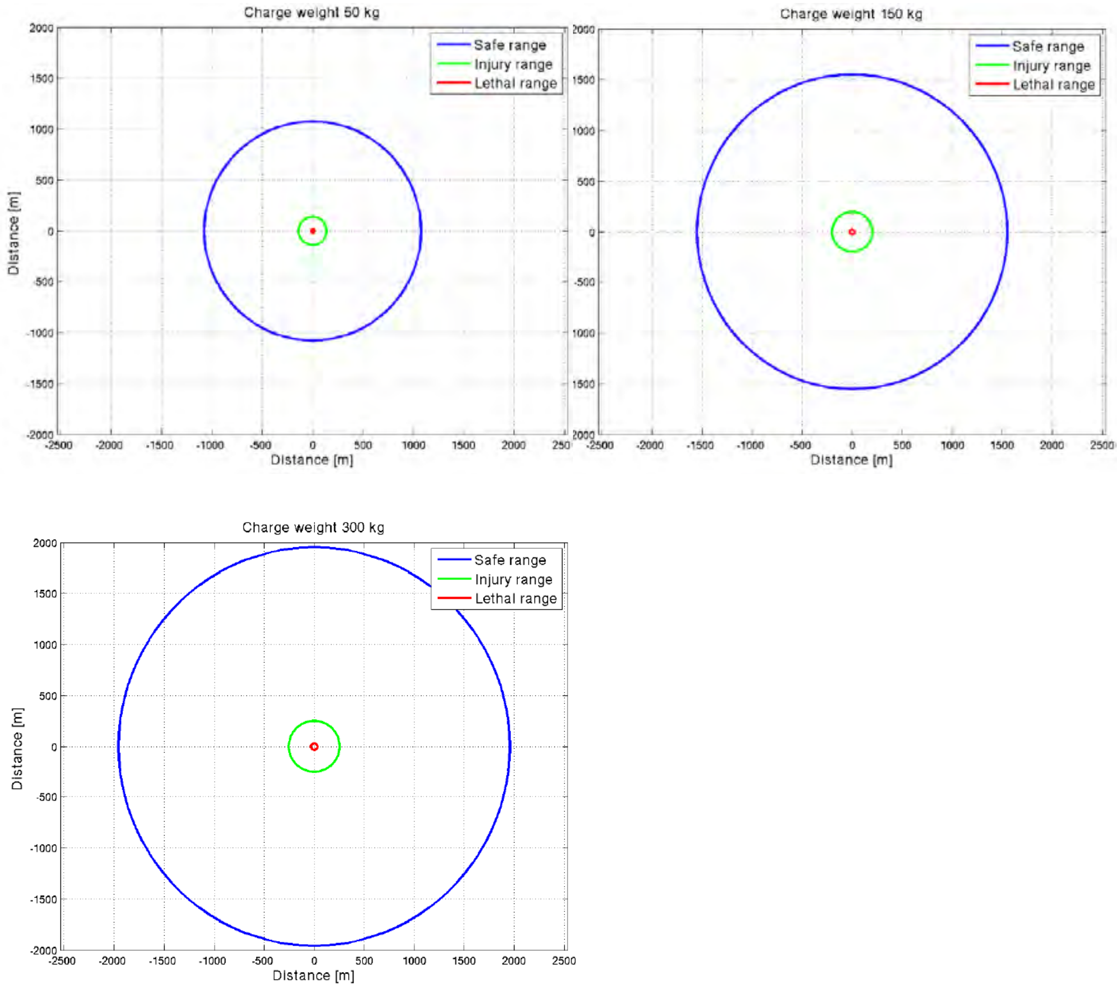

Figure 4.3 Probability of marine mammal damage as a function of the horizontal distance and charge weight

The safety distances for the majority of the charges (between 50 kg and 300 kg) are between 1 and 2 km from the detonation point. However, behavioural reactions of mammals and masking might occur at distances greater 2 km.

The expected level of noise and vibration generated would be dependent on the amount of explosive used as well as the residual explosive within the device. As the impact (**negative** and **direct**) is of **temporary** duration, a slight behavioural change (recognition of the sound and / or swimming away) is expected in individual seals that are present within 2-3 km of the clearance site. The impact will be on a **regional** scale. Impact intensity is expected to be **medium** to **high** depending on marine mammal presence. Impacts may be irreversible at an individual level if tissue damage or hearing loss occurs, however at a population level the impact is considered to be **reversible**. Impact magnitude is **medium** and value/sensitivity ranges from **medium** to **high** depending on the seasonal breeding habits. Therefore, impact significance is expected to be **moderate**. It should be noted that munitions clearance is a common activity in the Baltic Sea.

For mitigation it is necessary to make sure that no marine mammals are within a 2 km safety zone (exclusion zone) from the detonation location (refer to **section 5.3**). Acoustic harassment devices will be employed combined with observational monitoring to reduce the possibility that marine mammals will be present in close proximity to the clearance site.

4.6 Biological Environment – Nature Conservation Areas

4.6.1 Increase in Turbidity

Munitions clearance has the potential to result in an increase in turbidity due to the re-suspension and spreading of sediments during a blast, the extent of which will depend on the amount and type of explosives used and the amount of residual explosives present in the device. The impact of an increase in turbidity on nature conservation areas will depend on the proximity of the clearance site to the protected area and its designated habitats and species. Where the munitions clearance is to take place within 20 km of the a conservation site, impacts of increased turbidity on these important habitats for the species for which the conservation areas are designated are expected to be **negative** and **direct**, but are **short-term** and on a **regional** scale. Impact intensity is expected to be **low** to **medium** and consequently magnitude is expected to be **low** to **medium** as in a worse case scenario, the structures and functions of the conservation areas are affected but their basic structure/function is retained depending on the proximity of the munitions clearance to the nature conservation areas and its protected species. Impacts are **reversible** as sediment settles over a few days. As the overall value/sensitivity of nature conservation areas is **high**, the overall significance of munitions clearance is expected to be **moderate.**

Where conservation areas are greater than 20 km from the nearest munitions location the impact of increased turbidity is expected to be **insignificant.**

4.6.2 Noise and Vibration

Impacts to conservation areas designated as a result of protected species such as marine mammals present that lie within 20 km of the munitions clearance site are expected to be **negative** and **direct**, but **temporary**. Impacts will occur on a **regional** scale. Impact intensity is expected to be **low** to **medium**, depending on the proximity of the designated fauna to the munitions clearance areas. Similarly, impact magnitude may be **low** to **medium**, depending on the number of individuals affected as the structures and functions of these conservation areas may affected but their basic structure/function is retained. Impacts will be **reversible** as the conservation areas and their associated species will revert to their pre-impact state. As the sensitivity of nature conservation areas (and their protected species) is **high**, impact significance is predicted to be **moderate**.

However, where the nature conservation areas are situated at least 20 km from munitions clearance sites, the impact of noise and vibration is expected to be **insignificant**.

4.7 The Social and Socioeconomic Environment

4.7.1 Fisheries

A restriction on navigation for fishing vessels will apply during munitions clearance. An exclusion zone will put into affect around each munitions clearance site. The radius of the exclusion zone is expected to be in the order of 2 nautical miles (approximately 3.5 km). This exclusion zone will result in a limited **direct** and **negative** impact on the fishing vessel navigation. The duration of impact at any single clearance site is predicted to be **short-term** (a few hours) and the scale of the impact will be **regional** as the exclusion zone will have a radius in excess of 500 m. The impact will be **reversible** since there will be no noticeable effect once munitions clearance is complete. The intensity of the impact is considered to be **low** as there will be no permanent change in passage and most fishing vessels will be able to avoid the exclusion zone without significant deviation from their passage. The magnitude is therefore considered to be **low**. Taking into consideration that the value/sensitivity of the fishing industry in the Baltic Sea is **medium,** the imposition of the proposed munitions clearance exclusion zone is expected to have a **minor** impact on fishing vessel navigation.

The disruption of current fishing patterns would be related to the shock waves associated with munitions clearance. The probability of mortality is 25%-35% at a horizontal distance of approximately 200 m for a charge weight of 150 kg, decreasing to zero at 1.5 km from detonation. This has resulted in impacts to fish from munitions clearance events being assessed to be of minor to moderate significance. However, these impacts will be restricted to the discrete location of the clearance site. In each case the affected area will be dependent on the charge size, and up to a maximum of 1.5 km radius of the detonation event (150 kg charge) and fish are expected to return to the area following the event. Fishermen will therefore be able to resume normal fishing activities in the area soon after the event. The effect on catches is not expected to be significant. The impact of munitions clearance on fishing patterns is therefore assessed to be **insignificant**.

4.7.2 Shipping and Navigation

A restriction on navigation for shipping vessels will apply during munitions clearance. An exclusion zone will put into affect around the munitions clearance site which is expected to be in the order of 2 nautical miles from the detonation point. There is the potential, particularly in the Gulf of Finland, for this short duration exclusion zone to impact on shipping lanes, thereby requiring ships to divert their routes to avoid the exclusion zone. The exclusion zones and deviations to shipping routes will be coordinated through the Gulf of Finland Mandatory Reporting System (GOFREP). The imposition of an exclusion zone will result in a limited **direct** and **negative** impact on the shipping vessel navigation. The duration of impact at any single clearance site is predicted to be **short-term** (a few hours) and the scale of the impact will be **regional** as the exclusion zone will have a radius in excess of 500 m. The impact will be **reversible** since there will be no noticeable effect once munitions clearance is complete. The intensity of the impact is considered to be **low** as there will be no permanent change in passage and most vessels will be able to avoid the exclusion zone without significant deviation from their passage. The magnitude is therefore considered to be **low**. Taking into consideration that the value/sensitivity of shipping in the Baltic Sea is **medium** to **high** (Gulf of Finland), the imposition of the proposed munitions clearance exclusion zone is expected to have a **minor** to **moderate** impact on shipping vessel navigation.

4.8 Impacts Arising from Unplanned Events

In addition to the impacts associated with normal Project activities, which are carefully planned and tightly controlled, the potential exists for accidental or unplanned events to occur. Some of these could result in significant environmental and social/socioeconomic impacts. Unplanned events are less predictable and may be damaging to the receiving environment when they occur. The concepts of probability and consequence have been included in the assessment to determine the overall significance of potential impacts arising from unplanned events. The disturbance of munitions has the potential to give rise to significant impacts.

4.8.1 Chemical Munitions

Dumped chemical munitions (chemical warfare agents) maybe encountered throughout the Baltic Sea. Along most of the Nord Stream Pipeline route the probability of disturbing chemical munitions (warfare agents) is **low**, however the route does cross Risk Zone 3 dumping areas around Bornholm and to the south of Gotland and the probability of disturbing warfare agents here is higher (Refer to **section 2.1.2**) Disturbance of chemical munitions may occur during the construction (Refer to **section 3.2.1**) and operational (highly unlikely) phases of the Project. An interaction with chemical munitions could result in toxic chemicals being released into the water column. This could result in impacts of **minor** consequence on the water column and sea birds and of **moderate** consequence on fish, marine mammals and conservation areas. Impact consequence may extend from **minor** to **major** for marine benthos. Taking into consideration the **low** probability of disturbing chemical munitions along the pipelines' route, the overall significance on these resources/receptors is **low** for the water column, fish, sea birds, marine mammals, conservation areas and sea birds but extends to **moderate** for marine benthos. Disturbance of chemical munitions will have an overall **insignificant** impact on the social/socioeconomic environment.

4.8.2 Conventional Munitions

Conventional munitions found in the Baltic Sea include depth bombs, aerial bombs, submarine combating rockets, grenades and naval mines. As the Nord Stream Pipeline route will be cleared of conventional munitions prior to construction, the probability of accidental disturbance to conventional munitions is low (refer to **section 3.2.1**). If conventional munitions were to be accidentally disturbed during the construction phase, this could result in impacts similar to those assessed for normal munitions clearance. This would result in impacts of **minor** consequence on the water column and seabed, of **minor** to **moderate** consequence on fish, sea birds and marine mammals, of **moderate** consequence on marine benthos, and of **moderate** to **major** consequence on conservation areas. Taking into consideration that the accidental disturbance and detonation of conventional munitions is **low**, the overall impact significance on these resources/receptors is **low** extending to **moderate** for conservation areas. Accidental disturbance of conventional munitions will have an **insignificant** impact on each of the social/socioeconomic receptors described.

5 Mitigation measures for munitions clearance

5.1 Introduction

Although the impact of munitions clearance on marine mammals, fish, and seabirds is assessed to be low to moderate, there is a risk that they are affected by munitions clearance activities. To mitigate the risk to marine mammals, fish and seabirds measures to minimise the impact can be implemented during two phases: the planning and execution phase.

5.2 Planning Phase

In the planning phase, where possible the schedule for munitions clearance should consider the seasonal variations in the environment. All work should be carried out during the ice-free period and away from important timings and areas for fish spawning and marine mammal migration.

5.3 Execution Phase

In the execution phase expert observations are preferred as the primary mitigation method. The use of unproven and complex technology, such as bubble curtains, is not recommended. The standard method used by the navies in the Baltic will be used to reduce the safety risk during the performance of the work.

Observational monitoring should be made to assess whether:

- Marine mammals are within the risk area; if present the mammals should be frightened away acoustically. This could include the use of acoustic harassment devices ("pingers"), both for seals and harbour porpoises, since they have proven to be effective in driving the animals away from the source. However, the avoidance zone around a pinger might be small (500 m or less are reported for porpoises). Thus, it might be necessary to deploy several pingers at different distances from the munition site

- Fish shoals are in the risk area; if shoals are identified through acoustic survey then the munitions disposal should be delayed

- Diving seabirds (such as sea-ducks and auks) are in the risk area; if diving birds are identified then the munitions disposal should be delayed

The radius of the exclusion will be adjusted according to type of munitions, sound propagation conditions and subject of protection.

As the mitigation measures focus mainly on visual and acoustic observations and monitoring, the observation conditions shall be considered. These relate to the effectiveness of the observations due to light and sea conditions, such as:

- Limiting the clearance to calm to slight sea conditions and daylight hours (between one hour after sunrise and one hour before sunset)
- Ensuring observations commencing at least 30 minutes before each detonation
- Ensuring observations for marine mammals and birds commence no earlier than 20 minutes after sunrise

6 Further Studies

6.1 Russian Sector: Munitions Screening

The geophysical field work has been completed for the pipeline route Step 1 (refer to **section 2.2.3**) and the anchor corridor survey. The reporting and interpretation phase is ongoing.

The ROV based phases of munitions screening survey in the Russian sector are ongoing. The scope of work is divided into the following main phases

- Phase 1: Gradiometer survey of installation corridor (ongoing)
- Phase 2: Visual inspection of targets within the construction corridor
- Phase 3: Visual inspection of targets within the anchor corridor
- Phase 4: Munitions clearance and receipt of certificate of approval from Russian Authorities

The objective of the work is to ensure that:

- All munitions within the pipeline security corridors have been located and cleared to allow the safe installation and operation of the Nord Stream Pipelines

This requires that:

- All targets (potential munitions) within the anchor corridor identified during previous geophysical surveys have been verified by ROV
- Where necessary munitions are cleared to allow safe installation of the Nord Stream Pipelines
- A certificate is issued by Russian Authorities confirming that the installation corridor has been adequately surveyed and cleared of munitions to allow the safe installation of the Nord Stream Pipelines

The survey works and clearance works are reviewed, monitored and supervised by the Russian Authorities (Ministry of Defence Russian Federation, Staff Baltic Fleet). Through their approval at various key stages prior to, during and on completion of the work, a certificate is issued by Russian Authorities confirming that corridor is suitable for the safe installation of the Nord Stream Pipelines.

The following time schedule (**Figure 6.1**) is envisaged for the performance of the overall scope of work:

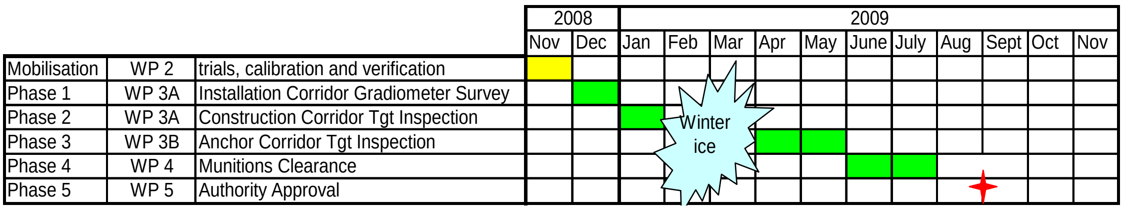

Figure 6.1 Proposed time schedule for the munitions screening surveys and clearance in the Russian sector

6.2 Anchor Corridor Survey

Prior to pipeline installation an anchor corridor survey is required to identify, verify and catalogue all probable obstructions that could impact safe pipe lay, anchoring of the lay barge and/or lead to an adverse impact to the environmental. The corridor will extend 1,000 m either side of each pipeline route in water depths greater than 100 m and 800 m in water depths of less than 100 m.

The survey was commenced on 15 November 2008 and is planned continue through to the third quarter of 2009. The scope of work was developed from the detailed munitions screening survey which has established a highly detailed baseline of potential obstructions and hazards. In addition to establishing the seabed topography across the complete corridor, the survey will focus on locating and assessing cultural heritage and potential hazards (such as munitions) to pipeline installation and its long term integrity.

The anchor corridor survey scope will include four phases as follows:

- Phase 1: Geophysical survey, multibeam, side scan sonar, magnetometer
- Phase 2: ROV visual inspection
- Phase 3: ROV based gradiometer surveys in critical sections
- Phase 4: Expert evaluation of objects

The results of the anchor corridor survey will be input to a formal risk assessment to determine the risks of anchoring during pipeline installation. As required measures will be implemented such as additional munitions clearance to reduce the risk posed by munitions to an acceptable level.

6.3 Munitions Clearance Plan

Within the Nord Stream Pipeline security corridors for the two pipelines 32[(1)] conventional munitions at 31 locations have been identified. It is estimated that during the anchor corridor survey in the region of 600 munitions will be located within the Finnish Sector. Of these indentified munitions within anchor corridor selected munitions will require clearance to allow safe anchoring of the pipe lay-barge.

All munitions will be assessed to ensure that they do not pose any risk during construction and operation of the pipelines.

Clearance of munitions will only be conducted with risk assessed technical procedures developed in conjunction with relevant national authorities. These procedures will address the technical performance of the work, mitigation measures and monitoring requirements.

To support the environmental assessment an additional literature study being performed by Swedish Defence Institute to:

- Assess the effects of underwater explosions on biota living in water

(1) The marine warfare experts (refer to section 2.2.4) performed a joint review (08-09 January 2009) and concluded that Target R-32-1974 was a heavily corroded tail-cone for air bomb containing no explosives. Therefore the target should be considered within the munitions related object list.

- Assess toxicological effects of underwater blasts as regards to combustion products, residue content and combustion processes iwhen explosives detonate under water
- Theoretical evaluation of the possibilities to use thermite charges for clearing munitions

6.4 Reference List

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