Sustainable management of oil polluting wrecks and chemical munitions dump sites

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Abstract*— Dumped chemical weapons that are corroding and exposed to the marine environment can cause contamination and health risks for marine fauna and humans. This paper describes some of the work that is done in the EU-DAIMON (Decision Aid for Marine Munitions) project including the development of a decision support method and previous field results that indicate that bottom trawling re-suspend sediments and spread contaminants and that recently caught fish at the Maseskar dump site contains detectable concentrations of chemical weapons from World War II.

Keywords—dumped chemical weapons; decision support tool; trawling; sediment re-suspension; contaminant spreading; Clark I+II in fish; bottom lander

I. INTRODUCTION

After World War II, the German armed forces had a massive arsenal of chemical and conventional grenades and bombs that the Allies wanted to dispose.

The easiest way to do this was to strip non-functional vessels and stuff them full of weapons and sink them offshore. It is estimated that around 100 000 tons chemical warfare agents were dumped this way outside Bornholm and south of Gotland, in the Baltic Sea, outside Maseskar on the Swedish west coast and outside Arendal, Norway.

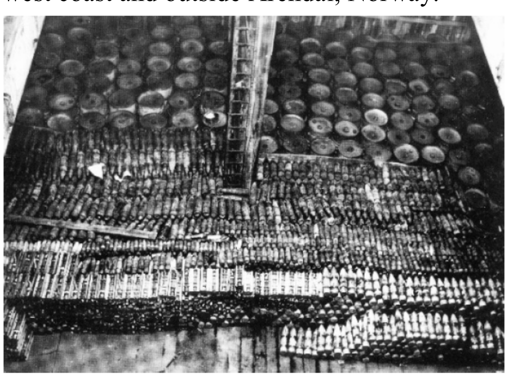

Figure 1: The cargo room of a ship filled with grenades & containers during loading. With permission from Lindsey Arison III.

The dumping was not well documented and often occurred outside designated areas. As time goes, ships and grenades / containers corrode and are broken and the poison is exposed to the marine environment. This conference papers talks about the EU-Daimon project in which decision support methods are developed for well funded management of this environmentally hazardous Word War II heritage.

II. VRAKA: A DECISION SUPPORT METHOD FOR OIL FILLED WRECKS ADAPTED TO CHEMICAL VEAPONS

At the Chalmers University of Technology an ISO 31000 decision-support method, originally developed for contaminated soils on land, was developed for sunken oil-filled wrecks in the frames of a national project.

The method resulted in software that is called “Vraka” and it is now being adapted to the special conditions that apply to dumped chemical weapons.

The method combines measurable facts such as temperature, salinity and oxygen content at the location of the wreck, with expert inquiries.

By organizing elicitations with experts in subsea technology, biology, chemistry, toxicology it is possible to put well-founded numbers on risks that you cannot directly measure.

Experts will, for example, assess the risk that wreck divers or anglers or a gas pipeline construction or trawling break grenades and expose/spread their content into the environment. Once figures have been obtained for the un-measurable risks, specific to each area, these numbers are used in a mathematical model that calculates the likelihood that there will be an emission within the next year.

In the next step, there will be methods to evaluate the environmental and health consequences of an emission.

III. EU-DAIMON PROJECT SHALL GIVE ADVICE ON WHAT ACTIONS TO TAKE

DAIMON (Decision Aid for Marine Munitions) is an EU, Interreg Baltic Sea Region, Flag Ship project coordinated by Dr. Jacek Bełdowski at the Institute of Oceanology of the Polish Academy of Sciences. The project has participants from most Baltic countries and Norway.
http://www.daimonproject.com

In this project extensive laboratory experiments, field studies, field sampling and mapping with advanced technology is carried out.

The work in DAIMON builds on experiences from previous projects such as CHEMSEA (Chemical Ammunition Search and Assessment). The main question is what should be done with identified dumped weapons?

If no action is taken how important is the risk that contaminants will spread in the environment and contaminate the water, sediments and marine fauna and finally end up in our food?

From which areas is the risk of contamination spreading the highest and what methods are there to limit spreading / to recover objects / to cover objects in the areas that are judged to be the most important risk zones?

Stakeholder and decision-makers from environmental authorities participate in the project and the goal is to develop well-funded decision support tools that are based on the leading expertise in this field.

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IV. IN-SITU MEASUREMENTS AT DUMP SITES: FREQUENT TRAWLING RESUSPEND SEDIMENTS

To estimate corrosion potential of gun shells and ship wrecks along with sediment re-suspension and transport, multi-parameter instruments are deployed at the dump sites, see figure 2. Parameters measured include Currents, Salinity, Temperature, Oxygen, Depth, Waves and Suspended particles.

One mooring was deployed in the middle of the Maseskar chemical munitions dumpsite off the West Coast of Sweden. The intention was to leave the instrument on the bottom for about 6 months but after 3 weeks it was trawled up and returned.

Figure 2: Two SeaGuard II instrument moorings prepared for deployment. Ballast weight at bottom, chain, acoustic release (thin grey cylinder), instrument, and two floats (white & orange) with lines.

The recorded data gave evidence of frequent trawling right through the dumpsite with important sediment re-suspension, up to 40 m above bottom, as a result (Fig. 3, below).

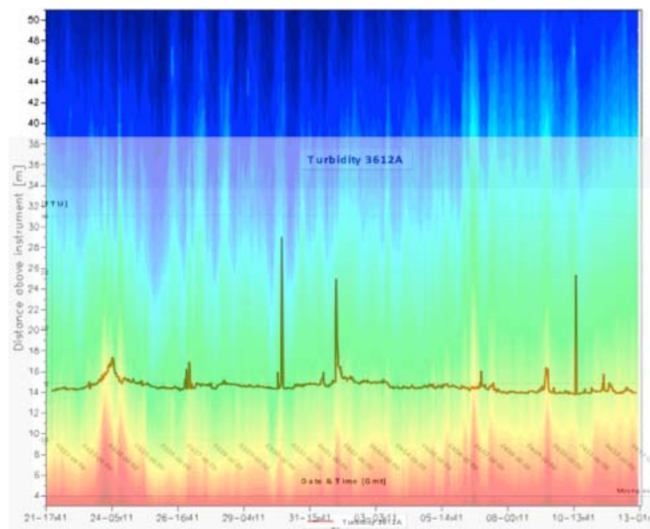


Figure 3: Overlay plot of turbidity measured about 1.5 m above bottom (black line) and acoustic from the bottom up to 50 m above (color plot) from the Maseskar dumpsite. The occasional peaks in turbidity and backscatter correlate with each other and are all related to identified trawlers that fish in the area. No events of natural re-suspension due to high currents were detected. The trawlers re-suspend particles up to 40 m above bottom. These particles are transported downstream with the currents before they settle. If the contaminants are bound to the sediment particles they will be spread.

Since most trawlers have active AIS (Automatic Identification System) transmitters on-board it is possible to track how frequent the trawling is in the Maseskar wreck area. Analyzing such data give evidence of at least 100 passages of trawler that fish per year.

Both AIS data and trawl tracks, from side scan sonar, give demonstrate that the trawler crews know where the large structures are and avoid them (Fig. 4, below).

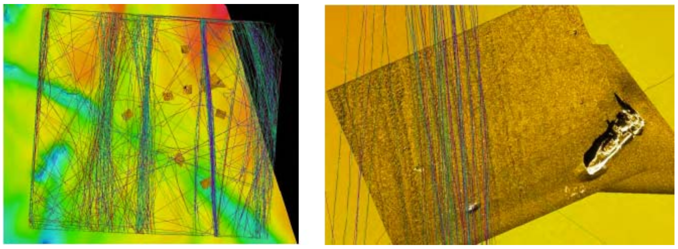


Figure 4: To the left are AIS tracks from trawlers that have been fishing at the Maseskar dumpsite. The brown marked areas are locations with identified wrecks and spread out objects on the bottom. To the right is a zoom in, using side scan sonar, of on one of the brown marked areas. Trawling tracks are clearly visible.

V. ELEVATED ARSENIC CONCENTRATIONS IN SEDIMENTS DOWNSTREAM OF DUMP SITE

Surveys in the area from more than 20 years ago by the Geological Survey of Sweden have shown very elevated arsenic concentrations downstream of the dumpsite. The dominant current direction in the lower 50 m is northwest and arsenic is an important constituent of mustard gas.

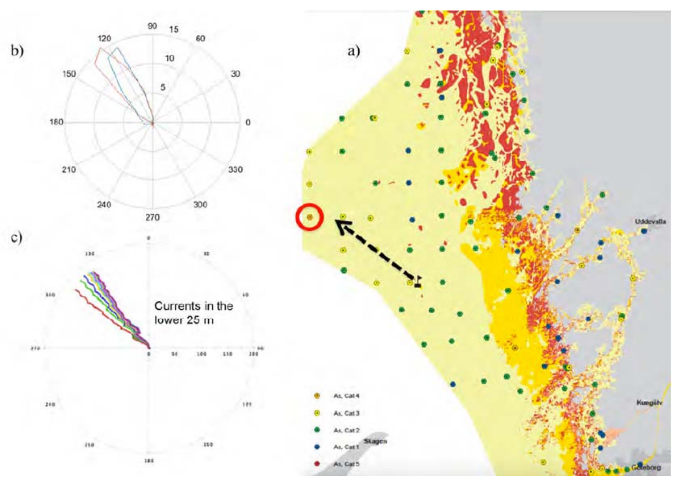


Figure 5a) Geological map from the Geological Survey of Sweden (SGU) with arsenic-concentrations in the surface sediments from sampling done more that 20 years ago. The highest measured concentrations on the Swedish West coast are found NW of the Maseskar wrecks, which is the main direction of transport in the lower 50 m both according to the UGOT-KASK circulation model (b) and the measurements done with the moored instrument (c).

It is likely that trawling contributes greatly to the spreading of arsenic. Still it is not prohibited to trawl. The effects on ecosystems and human health, if consuming seafood, make it questionable if trawling is suitable at dumpsites.

VI. TRACES OF OTHER CHEMICAL WARFARE AGENTS IN SHELLFISH AND FISH

Traces of other chemical warfare substances have recently been found, for the first time, in fish and shellfish around the Maseskar wrecks. The substances in question are Clark 1 and Clark 2 (analyzed by the Finnish Institute for Verification of the Chemical Weapons Convention, VERIFIN) that are also part of chemical weapons.

Of the 20 animals that were examined trails of Clark 1 and 2 was found in three of them. The concentrations ranged from 5 to 30 nanograms per gram meat, which is just above the levels that are measurable.

These are indeed low levels, but these substances do not exist naturally and should not be present in fish and shellfish.

Now the Swedish Agency for Marine and Water Management wants to see a fishing ban in the area in question.

VII. COMING FIELD WORK AND COLLABORATION WITH SHIRSHOV INSTITUTE OF OCEANOLOGY

Within the frames of the Daimon project there will be extensive field campaigns at dumpsites during 2017 and 2018.

At the Maseskar wreck site the plan is to repeat the sampling that was done in that area by SGU more than 20 years ago. Surface sediment samples will be taken for total Arsenic and other metals. The sampling will be expanded with pore water extraction and analyzing to gain more knowledge about dissolved fractions.

For the coming fieldwork the research vessel R/V Academic Nikolay Strakhov (Fig. 6) will be used in an expedition organized by the Shirshov Institute of Oceanology (SIO), Atlantic Branch (Kaliningrad, Russia).

Figure 6: R/V Academic Nikolay Strakhov that will be used during coming expeditions to the Maseskar wreck site area.

SIO is an associated partner of Daimon and their participation is financed by the Swedish Institute.

A group of experts at SIO has more than 20 years of experience from working at dump sites and has developed special sampling equipment and associated modelling tools that focus on spreading of contaminants from chemical weapons and dump sites.

In 2018 the plan is to use autonomous bottom landers (Fig. 7) from Gothenburg to measure sediment-water fluxes at dumpsites. The landers have been used on contaminated fibre bank sediments before but this will be the first time ever that such measurements are done at chemical weapons dumpsites.

The landers are released from the ship and descend by themselves to the seafloor where they insert 2-4 incubation chambers into the sediment to estimate the solute exchange between the sediment and the overlying water. The landers have been deployed about 230 times during the past 10 years in water depths ranging from 5-5600 m. The number of successful incubations has been 663 out of 730 possible which gives a success rate of 91 %.

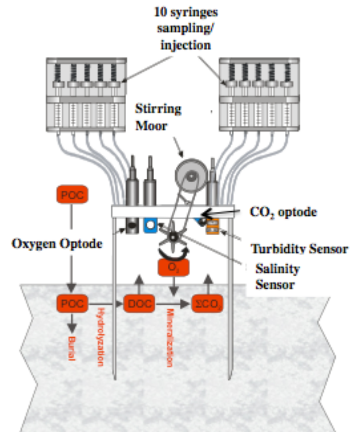
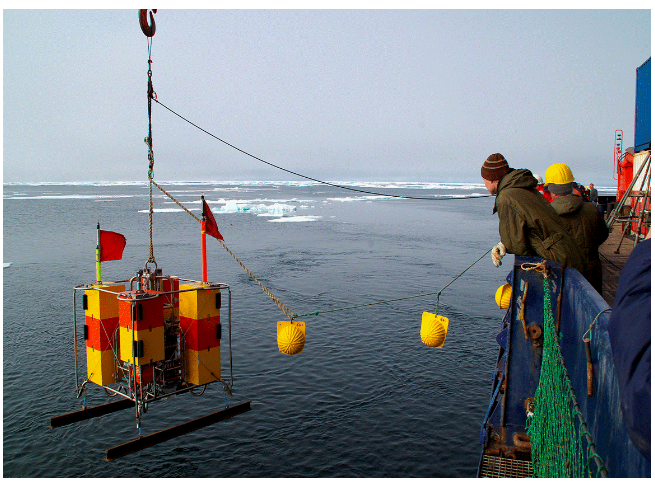


Figure 8: Schematic drawing of one of the incubation chambers. With sensors, syringes, and stirring motor that can simulate sediment re-suspension *in-situ*.

Figure 7: One of the Gothenburg landers being deployed in the Arctic at 5600 m water depth in 2007 from R/V Polarstern.



Around 15 sensors are measuring inside and outside the incubation chambers and 40 water samples are taken during each deployment for later analysing (Fig. 8).

Oil leaking wrecks and dumped munitions, both chemical and conventional, are not unique to the Baltic Sea region. I many areas of the world similar dumping activities have been routinely used as a method to dispose of weapons and toxic waste. Therefore similar methods should be applicable to other areas as well.

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