Universität Lüneburg

Warfare-related hazardous sites in the Baltic Sea

Status quo, risk potentials, securing and remediation attempts

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First International Conference „Chemical and Conventional Munitions Dumped at Sea“
Halifax, Canada, 9th/10th of October 2007

AGENDA

- **Arsenals of chemical agents in and their destiny after WW II**
- **Dumping activities of chemical and conventional ammunition**
- **Recent scientific investigations and resulting recommendations**
- **Open questions & risk potentials**
- **Securing- and remediation scenarios and their consequences**
- **Conclusion**

PRODUCTION & DESTINY OF THE ARSENALS (I)

- **Germany produced about 65,000 tons of warfare agents between 1935 – 1945, resulting in about 300,000 tons of chemical ammunition**
- **25,000 tons of it were mustard (about 38,5% of the overall amount)**
- **Based on the non-use of chemical agents in WWII, the Allies found that 300,000 tons in their individual occupation zones and had to get rid of them**
  - the chemical ammunition was partially stored or confiscated as „haul weapons“
  - there were concrete disposal- and destruction plans by the Allies until end of 1947, the weapons were buried, simply poured out or burned based on the lack of appropriate destruction technologies
- **The conventional “destruction” soon turned out to be too costly, dangerous and lengthy**
- **A dumping of the chemical (and conventional) ammunition in the depths of the surrounding seas seemed to be the easiest solution for the problem at that time**
- **After first cost- and logistic considerations that ruled out the dumping in the deep sea areas of the Atlantic (4,000 m), the Baltic Sea remained as the easiest alternative with water depths of 10 – 120 m (exception: the Skagerrak (up to 600 m)**

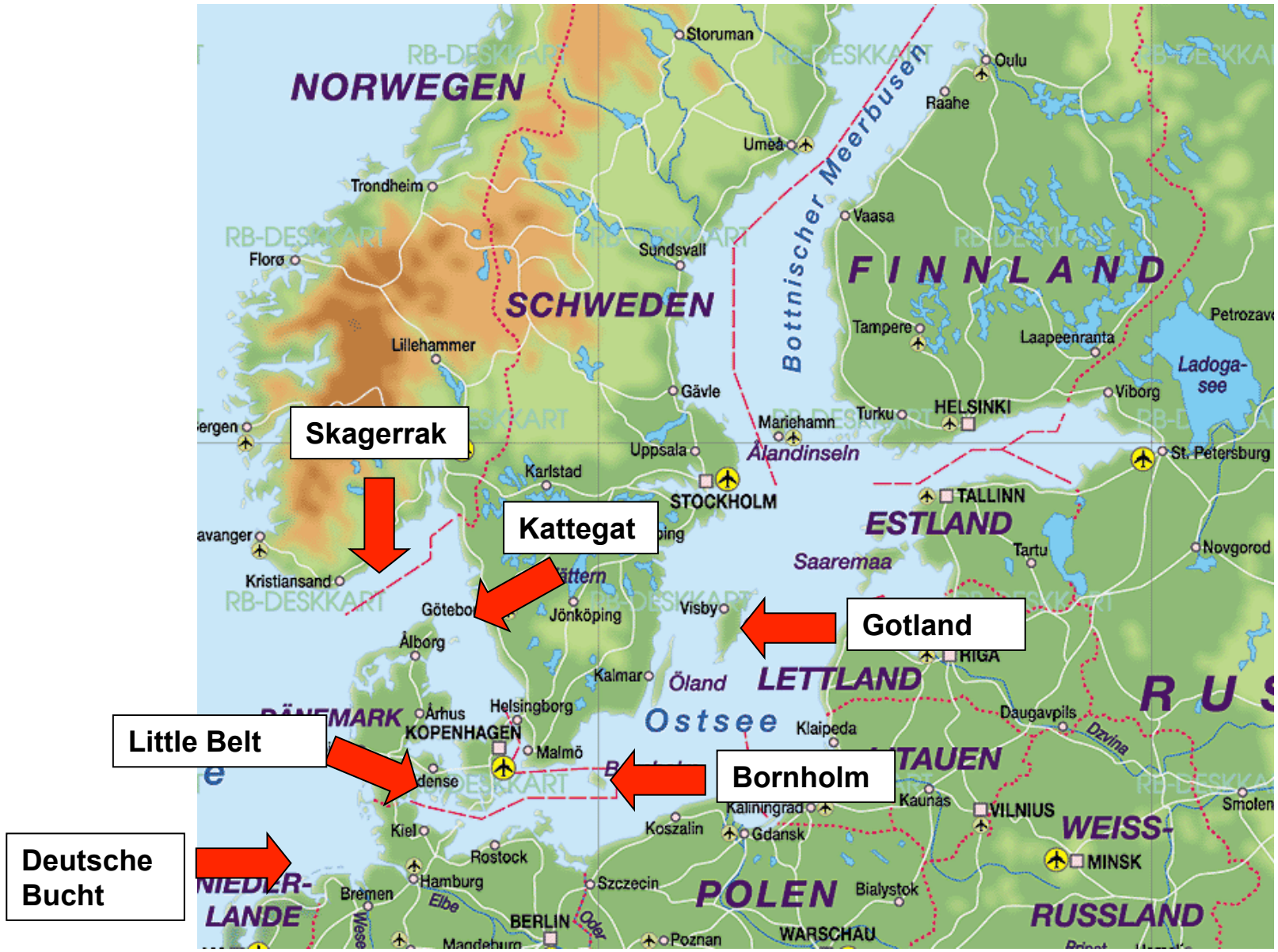
PRODUCTION & DESTINY OF THE ARSENALS (II)

Alliierte Truppen „vernichten“ Tabun-Behälter in einer bayerischen Munitionsanstalt.

DUMPING ACTIVITIES (I)

- **There were dumping activities concerning chemical ammunition already after the WWI; types, amounts and sites are mostly unknown (exception e.g. the Belgian „Paardenmarkt“)**
- **In the last weeks of WWII, the German “Wehrmacht” started to dump significant amounts of conventional and chemical ammunition, the Allies continued with these activities soon after the end of WWII**
- **Huge amounts of both, conventional and chemical ammunition were dumped in the Baltic and North Sea**
- **The main dumping sites for chemical ammunition in the Baltic Sea are: The „Little Belt“, the „Bornholm Basin“, Gotland and the Skagerrak**

DUMPING ACTIVITIES (II)



Karte: RB Deskkart, www.welt-atlas.com

DUMPING ACTIVITIES (III)

Dumped chemical ammunition

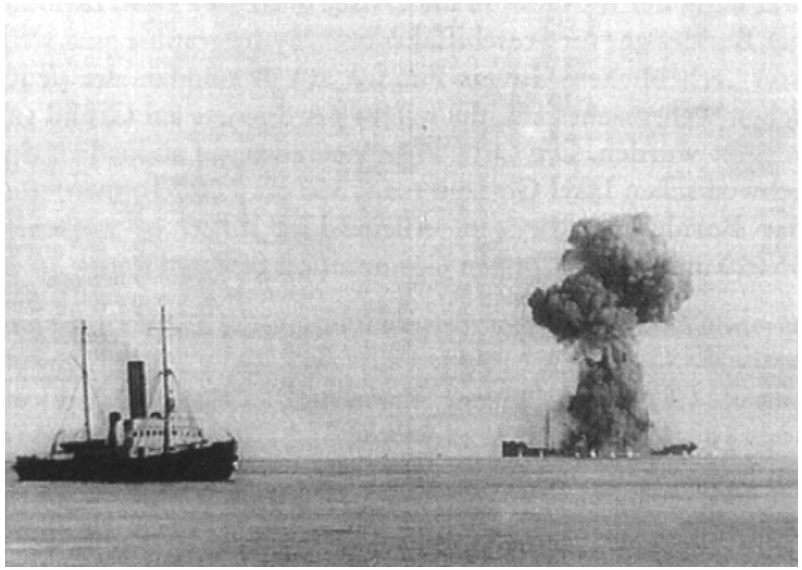
- 5,000 t of bombs and grenades, filled with Taboon and Phosgene in the Little Belt (dumped in 1945)
- 35,000 t of bombs and grenades, filled with S-Lost, Clark I & II as well as Adamsite in the Bornholm Basin (dumped in 1947/1948)
- 2,000 t of unknown ammunition dumped at Gotland (in 1947)
- 23,000 t of unknown chemical ammunition, probably dumped in the Bornholm Basin
- 170,000 t of chemical ammunition dumped in the Skagerrak
- Unconfirmed statements of 300,000 tons of chemical ammunition in the Baltic Sea alone
- “Rumours“ of undeclared dumping activities of Russia until mid/end of the 1980’s (also nuclear and biological material?)
- “Agreement of Discretion“ between the USA & UK first until 1997, then extended in 1997 for further 20 years until 2017 (maybe bearing a quantitative and/or qualitative surprise about their dumping activities?)

DUMPING ACTIVITIES (IV)

Dumped conventional ammunition

- **The situation is quite different from the chemical ammunition related dumping activities: mostly dumped in direct vicinity to the coast in the North Sea**
- **400,000 – 1.3 Mio. tons of conventional ammunition are assumed to be still present in the “Deutsche Bucht” (Heligoland Bay) alone – even after intense recovery activities in the 1950’s**
- **Misleaded bombardments (e.g.: Operation „Hydra“ Peenemünde on the isle of Usedom in the Baltic Sea) did also lead to a significant amount of phosphorus containing bombs in coastal areas, resulting in heavy burns of amber collecting tourists each year**

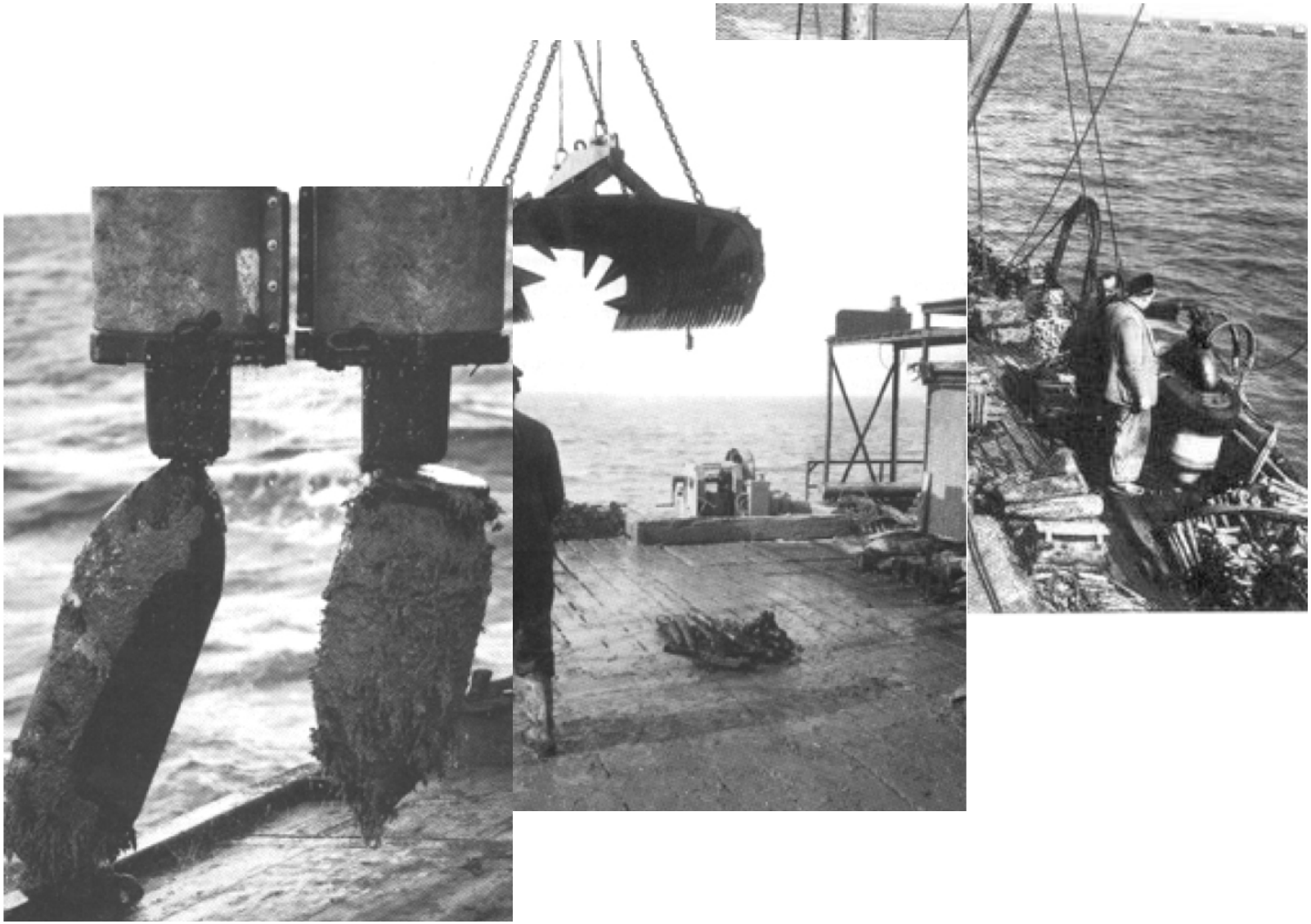
DUMPING ACTIVITIES (V)



DUMPING ACTIVITIES (VI)

- **Intense removal activities by commercial „Munitionsfischer“ between 1947-1958 to gain scrap metals and explosives (TNT)**
- **This lead to the recovery of mainly conventional ammunition in close vicinity to the coast (250,000 – 350,000 t) in the North Sea („Deutschen Bucht“)**
- **In recent times (since 2000): there are increasingly removal activities of conventional „hot spots“ in coastal areas; mainly realised by underwater detonation**

DUMPING ACTIVITIES (VII)



SCIENTIFIC INVESTIGATIONS (exempl.)

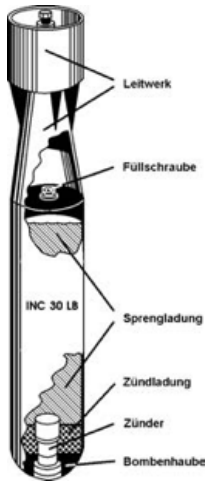
- **Report „Chemische Kampfstoffmunition in der südl. und westl. Ostsee“ of the „Bundesamt für Seeschifffahrt und Hydrographie“ (BSH 1993)**
- **Report „Chemical Munitions Dumped in the Baltic Sea“ of the Helsinki Commission (HELCOM 1994 / revised 1995)**
- **Report „Investigation and risk assessment of ships loaded with chemical ammunition scuttled in Skagerrak“ of the Norwegian Forsvarets Forskningsinstitut (FFI 2002)**
- **Report „Meeresumweltschutz für Nord- und Ostsee“ by the German „Rat von Sachverständigen für Umweltfragen“ (SRU 2004)**
- **Present EU-Research project: „Modelling of ecological risks related to sea-dumped chemical weapons“ (MERCW, since November 2005)**

→ **Recommendations are still not or not adequately fulfilled (e.g. concerning the localisation and determination of dumped ammunition)**

→ **There are still significant lacks of knowledge concerning open questions that were mentioned by the reports (esp. concerning eco- and toxicological effects)**

RISK POTENTIALS (I)

- **Emission of explosives and chemical agents by corrosion (0,1mm/y ?) and resulting leakages**
- **Explosives:**
  - 95 individual substances
  - partially significant loads of heavy metals (esp. lead & mercury)
  - TNT (90% of the used explosive) is toxic for micro organisms and water plants; 0.7 to 3.7 mg/l are lethal for fishes, the water solubility amounts to between 100 to 130 mg/l (!)



Weight percentage
(Bombs, Grenades etc.)

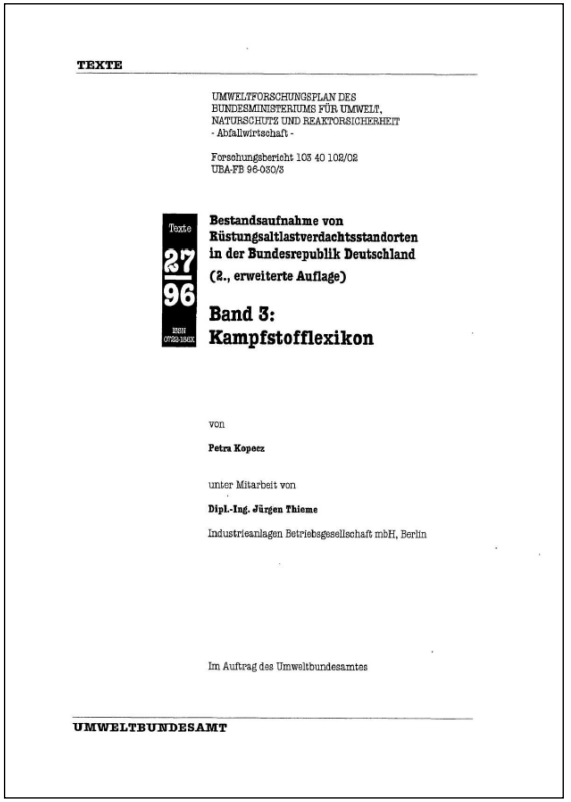
Metal - 25 to 95 %
ø ca. 70 %

Chemical content
- 3 to 88 %
ø ca. 30 %

„Warfare related hazardous sites in the Baltic Sea“

RISK POTENTIALS (II)

- **Chemical agents:**
  - 53 individual substances
  - 9 of 13 main agents represent dangerous water pollutants, of which 6 are heavily to extremely toxic for aquatic organisms
  - 4 of 13 produce arsenic containing break-down products
  - 3 of 13 create mid- or long-term persistent contamination areas in the water column with highly toxic concentrations (based on their high solubility and low velocity of hydrolysis)



TEXTE

UMWELTFORSCHUNGSPLAN DES
BUNDESMINISTERIUMS FÜR UMWELT,
NATURSCHUTZ UND REAKTORSICHERHEIT
- Abfallwirtschaft -

Forschungsbericht 105 40 102/02
UBA-FB 96-060/3

Texte 27/96

Bestandsaufnahme von Rüstungsaltlastverdachtsstandorten in der Bundesrepublik Deutschland
(2., erweiterte Auflage)

Band 3: Kampfstofflexikon

von
Petra Kopecz

unter Mitarbeit von
Dipl.-Ing. Jürgen Thieme
Industrieanlagen Betriebsgesellschaft mbH, Berlin

Im Auftrag des Umweltbundesamtes

UMWELTBUNDESAMT

- **The break-down products are partially even more persistent and more toxic than their initial substances**
- **Long-term toxicological and ecotoxicological effects are mostly completely unknown**
- **The substances have partially carcinogen, teratogen and/or genetically harmful effects**

RISK POTENTIALS (III)

- **Possible effects:**
  - implausible, strongly excessive values for zinc in the sediment as well as accumulation of heavy metals in mussels that are eventually based on ammunition dumpsites (besides others arsenic) in Mecklenburg-Pommerania and at the isle of Sylt
  - values for nitro-aromatics at Heligoland are by 100% higher than in the Elbe estuary
  - Results from a dumpsite in the Adriatic, Italy: excessive concentrations of arsenic in fish compared to the FDA limit values for food and near the LD_{50} for mammals (20 mg/kg weight)! Fishes showed chronic damages of liver and spleen that are most probably based on the here dumped chemical agents!

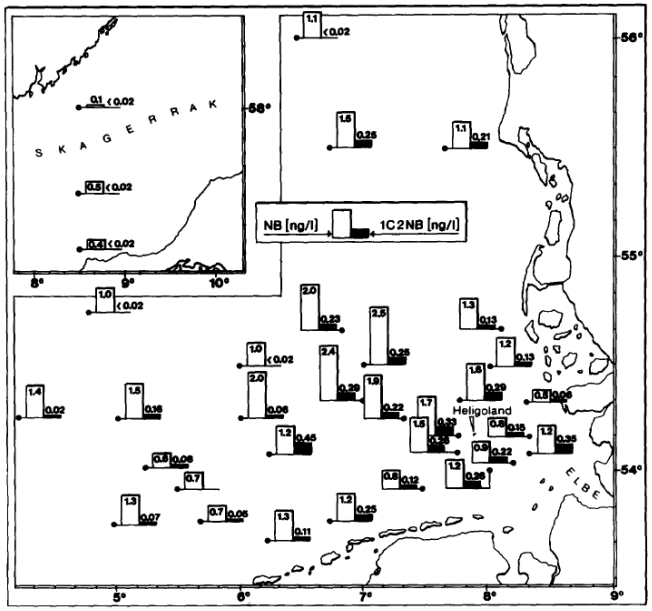


Fig. 5 Distribution of nitrobenzene (NB) and 1-chloro-2-nitrobenzene (1C2NB) in the German Bight (summer 1993).

Source:

The Distribution of Nitrobenzene and other Nitroaromatic Compounds in the North Sea; Marine Pollution Bulletin, Vol. 30, No. 3

RISK POTENTIALS (IV)

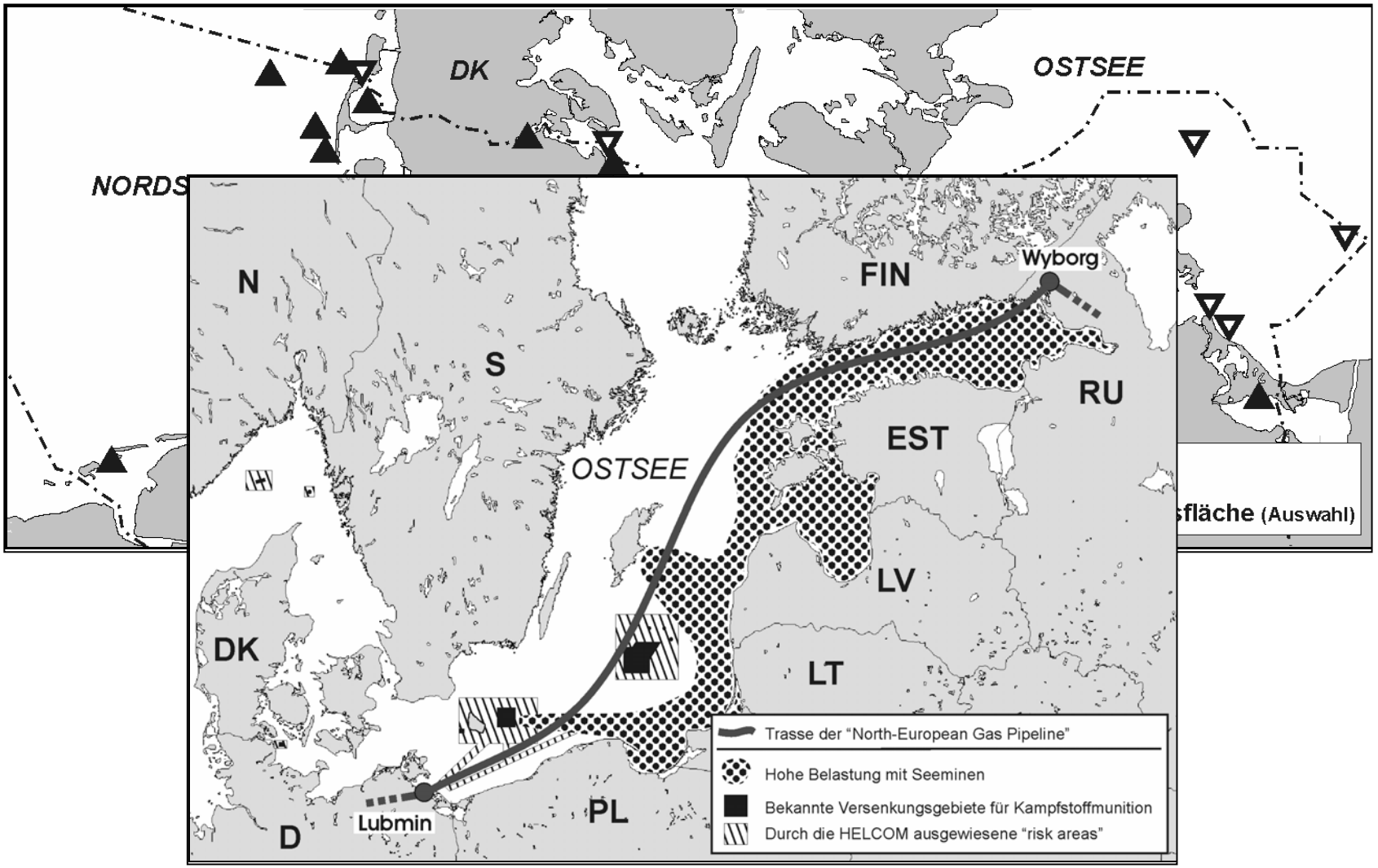
Further risk potentials (exemplarily)

- **Access to ammunition in the context of terrorists' activities (dumping activities even in very low water depths (e.g. Belgian Paardenmarkt 10-15m)**
- **Fishing / contamination of catches and equipment of commercial fishery (danger of explosion / contamination; at least 443 incidents between 1985 until 2005 alone on the part of Danish fishermen at Bornholm; in 2005 three Dutch fishermen were killed by such an incident in the North Sea)**
- **Danger & danger potential of the civil and commercial shipping (anchoring / accidents (e.g. Paardenmarkt Nov. 2001))**
- **Washing ashore of containers and ammunition as well as already washed out contents on coasts and beaches (e.g. the "amber problem")**
- **Sudden release of bigger amounts of contents of ammunition with unassessible consequences**
- **Self detonation (with specific relevance in the context of the planned North European Gas Pipeline in the Baltic Sea)**




RISK POTENTIALS (V)

Risk areas on the German coast based on ammunition dumping



SECURING & REMEDIATION (I)

Potential securing and remediation scenarios

1. **No remediation of ammunition contaminated areas („Permanent disposal-Scenario“)**
2. **Partial remediation of ammunition contaminated sites („By the way-Scenario“)**
3. **Complete remediation of sites with high related risks & amounts of ammunition („Hot Spot-Scenario“)**
4. **Complete remediation of all sites with known contamination with ammunition („Full Clean Up-Scenario“)**

Fotos: Rapsch & Fischer 2000, Meyer 2003, Schories 2005

SECURING & REMEDIATION (II)

1. Permanent disposal-Scenario

- the ammunition stays untouched “in situ” without any securing or remediation attempts
- uncontrolled emission of unknown amounts of partially highly toxic substances
- unknown mechanisms concerning toxicological and ecotoxicological effects
- only very few existing investigations with often contradictory assessments

Fotos: Missiaen & Henriet 2002

SECURING & REMEDIATION (III)

2. By the way – Scenario

- partial remediation by e.g. regular beach collections, by especially equipped fish trawlers and accompanying remediation activities in the context of construction works
- continuous but diffuse remediation- and securing progress
- no prioritisation based on risk assessments
- relatively cost effective solution attempt

Foto: Goldhammer (2005)

Foto: www.spiegel-online.de

SECURING & REMEDIATION (IV)

3. Hot Spot-Scenario

- securing- and remediation activities are based on detailed considerations and resulting risk assessments
- may lead to the so called “drop in the ocean” by only concentrating on “hot spots”
- effective securing and remediation is possible after precedent investigations
- enables relatively cost effective securing- and remediation activities
- „Hot Spots“ might be: pin point dumping sites of e.g. bursters or big ammunition -> big amounts of ammunition on a comparably small area (some sites are as big as a tennis court but covered tall as a man)

Foto: Heinrich Hirdes GmbH

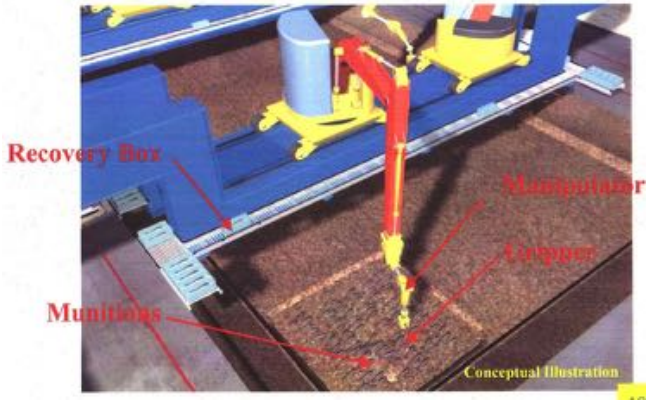


Foto: Niho 2005

SECURING & REMEDIATION (V)

4. Full clean up – Scenario

- ❖ securing- and remediation activities are based on extensive investigations
- ❖ from the emission related point of view the most effective solution based on the tackling of all known sites
- ❖ partially resulting in ineffective activities concerning the related remediation progress
- ❖ enormous financial burden based on the extensive securing and remediation measures

Foto: www.coastguard.se

Foto: Missiaen & Henriet 2002

CONCLUSION “REMEDIATION”

Recommendation: 3. „Hot Spot Scenario“

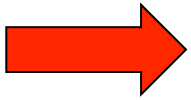
- **e.g. Use of divers in shallow water depths (0-20m WT)**
- **remote controlled roboters in deep zones of the sea (> 20m)**
- **reduced but highly efficient attempt that leads to a significant reduction of related costs**

A remediation or partial remediation of at least the Hot Spots seems to be unavoidable from a ecotoxicological and generally risk related point of view

GENERAL CONCLUSION

Open questions and related risks

- **Still unknown amounts and composition of dumped ammunition**
- **Unclear areas of dumping activities and uncontrolled “en route dumping”**
- **Significant amounts of ammunition are still intact**
- **Continuous accidents with explosives and contents of ammunition**
- **Unclear ecotoxicological and long-term effects for the natural environment**
- **Partially contradictory assessments concerning acute risks and future tackling**



There is still a significant demand for action and scientific investigation concerning most of the related issues especially in responsibility for future generations !!

Thank you very much!

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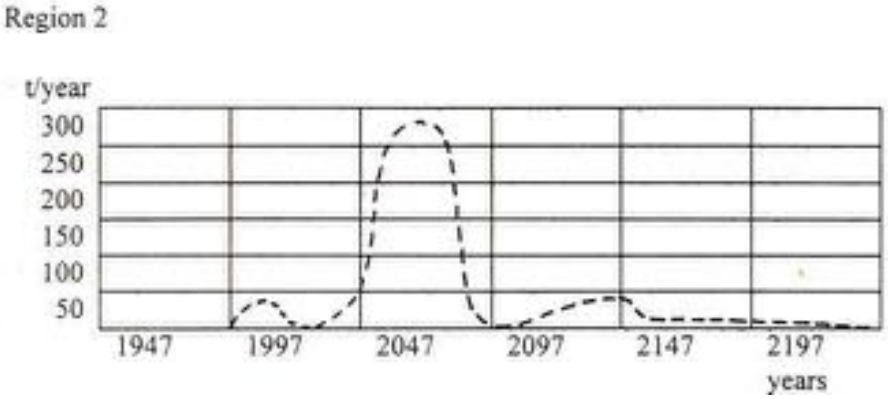
RISK POTENTIALS (III)

❖ Periodical emission of pollutants



Source:

KAFFKA, A. (ED.) (1996): Sea- Dumped Chemical Weapons: Aspects, Problems and Solutions. 170 S.; NATO ASI Series Vol. 7

- ➢ Russian scientist assume three main emission periods in the Baltic Sea:
  - 1997 – 2013 with 43.3 tons of mustard/year
  - 2022 – 2082 with 280 tons of mustard/year
  - 2110 – 2260 with 13 tons of mustard/year

❖ Experts report of the German Environmental Council (2004):

- ➢ the emission situation can not be finally assessed based on the lack of knowledge about the condition of the ammunition and the resulting actual emission processes