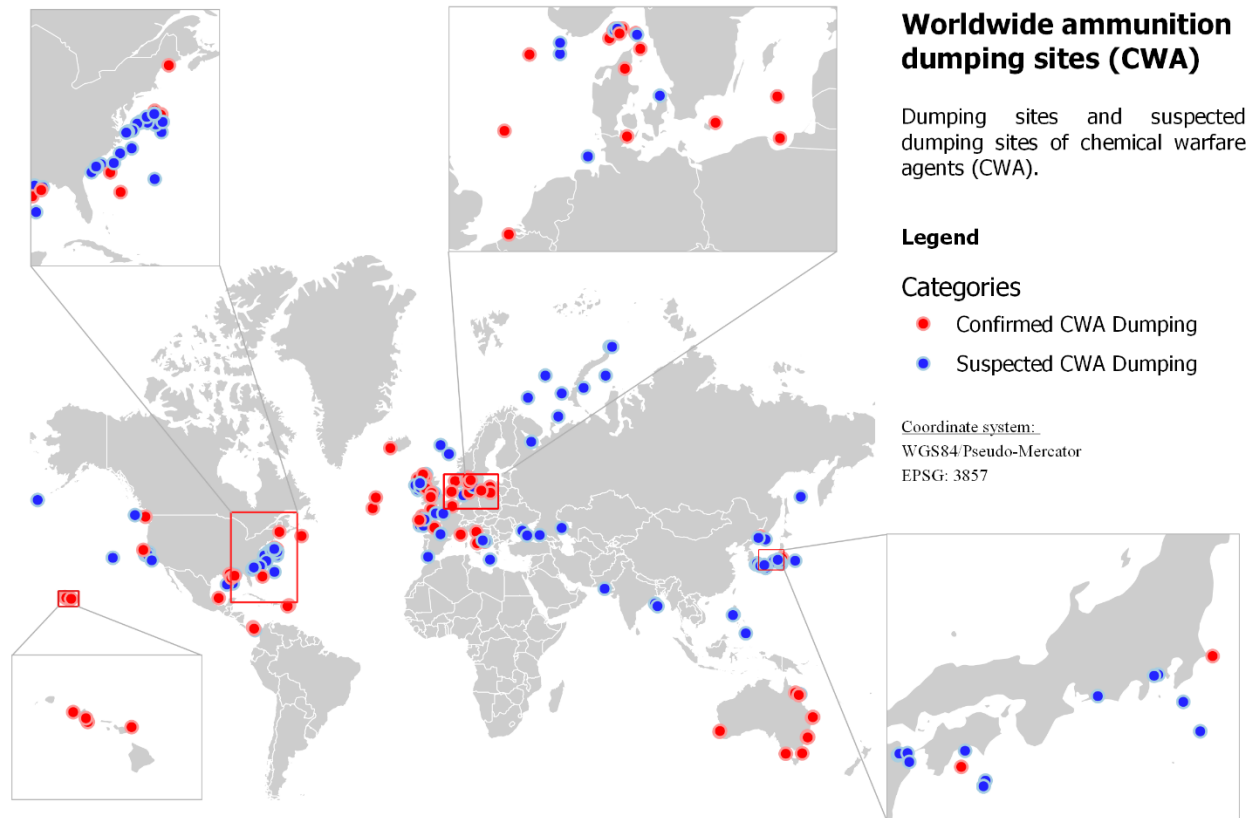# A Decade of Chemical Munitions Studies in the Baltic Sea and New Perspectives

JACEK BEŁDOWSKI

INSTITUTE OF OCEANOLOGY POLISH ACADEMY OF SCIENCES
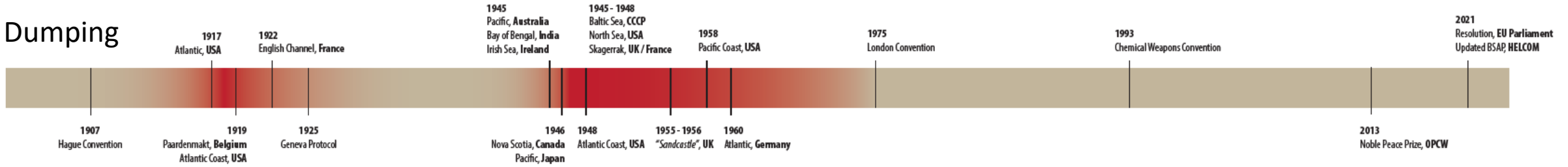
Dumped CWs

Worldwide ammunition dumping sites (CWA)

Dumping sites and suspected dumping sites of chemical warfare agents (CWA).

Legend

Categories

- 🔴 Confirmed CWA Dumping
- 🔵 Suspected CWA Dumping

Coordinate system:
WGS84/Pseudo-Mercator
EPSG: 3857

Source: International Ammunition Cadastre - AmuCad.org (2022/05/09)

Timeline

Dumping

- 1907 — Hague Convention
- 1917 — Atlantic, **USA**
- 1919 — Paardenmakt, **Belgium** / Atlantic Coast, **USA**
- 1922 — English Channel, **France**
- 1925 — Geneva Protocol
- 1945 — Pacific, **Australia** / Bay of Bengal, **India** / Irish Sea, **Ireland**
- 1945 – 1948 — Baltic Sea, **CCCP** / North Sea, **USA** / Skagerrak, **UK / France**
- 1946 — Nova Scotia, **Canada** / Pacific, **Japan**
- 1948 — Atlantic Coast, **USA**
- 1955 – 1956 — "Sandcastle", **UK**
- 1958 — Pacific Coast, **USA**
- 1960 — Atlantic, **Germany**
- 1975 — London Convention
- 1993 — Chemical Weapons Convention
- 2013 — Noble Peace Prize, **OPCW**
- 2021 — Resolution, **EU Parliament** / Updated BSAP, **HELCOM**

Incidents

- WW I
- WW II
- 1955 | Baltic Sea, **Poland** — Injury to 102 kids on a beach from a barrel
- 1972 | Baltic Sea, **Denmark** — Mustard Gas burns Danish Fisherman
- 1984 | Baltic Sea, **Denmark** — Twelve Danish Fishermen hurt by Mustard Gas
- 1997 | Baltic Sea, **Poland** — Eight Polish Fishermen exposed to Mustard Gas

Studies

- CLASSIFIED US ARMY R&D REPORTS*
- 1971 – 1975 | CHASE X, **US NAVY** — Five Post-Dump Surveys of the Chase X Disposal Site
- 1985 – 1993 | HELCOM **CHEMU** — Helsinki Commision ad hoc Working Group
- 2010 – 2013 | HELCOM **MUNI** — Helsinki Commision Expert Group
- 2013 – 2021 | HELCOM **SUBMERGED** — Helsinki Commision Working Group
- 2022 – 2026 | HELCOM EG **SUBMERGED** — Helsinki Commision Expert Group
- 1991 — Skagerrak **FFI**
- 1999 — Adriatic Sea **ACAB**
- 2005 — North Sea **PAARDENMARKT**
- 2005 — Baltic Sea **MERCW**
- 2011 — Baltic Sea **CHEMSEA**
- 2012 — Hawai'i **HUMMA**
- 2013 — Baltic Sea **MODUM**
- 2016 — Baltic Sea **DAIMON** / **DAIMON 2**
- 2020 — Baltic Sea **WARTOX**

1900   1925   1950   1975   2000   2025

HELCOM involvement

CHEMU	MUNI	SUBMERGED	BSAP	CBSS

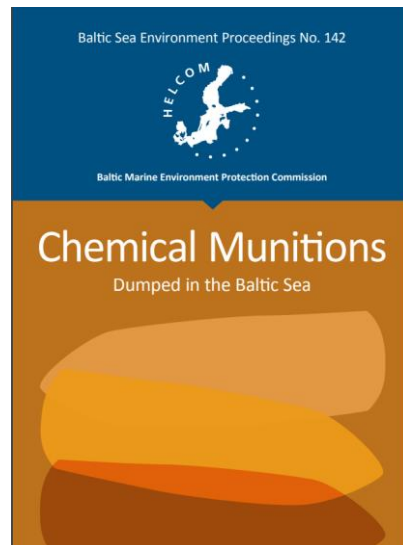- 1993
- 2010
- 2016
- 2020
- 2022
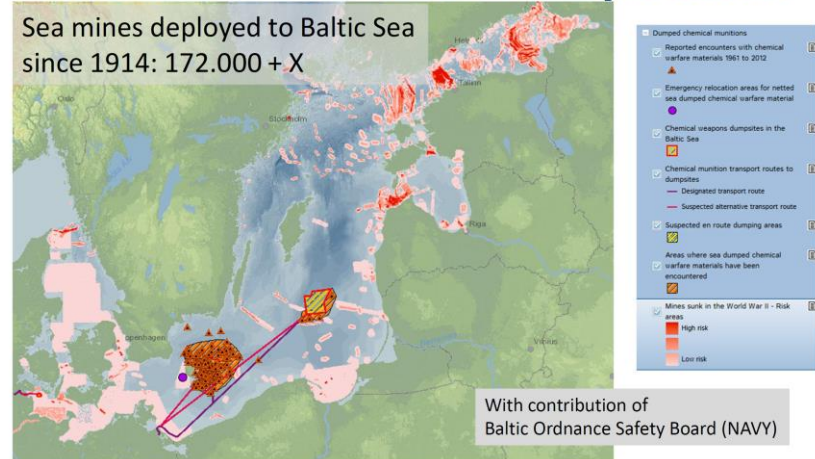
Baltic Sea Environment Proceedings No. XX

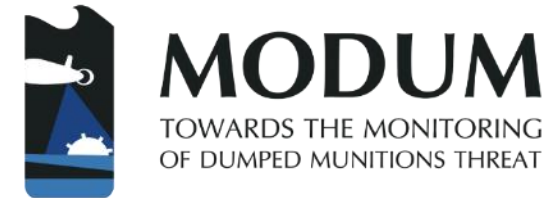**Chemical Munitions Dumped in the Baltic Sea**

Report of the *ad hoc* Expert Group to
Update and Review the Existing Information on Dumped Chemical
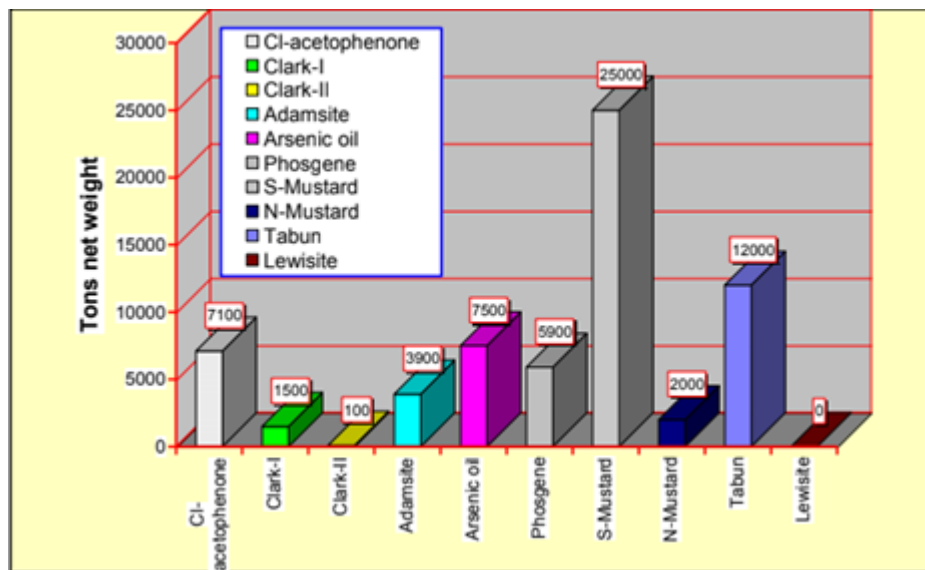Munitions in the Baltic Sea (HELCOM MUNI)

Helsinki Commission
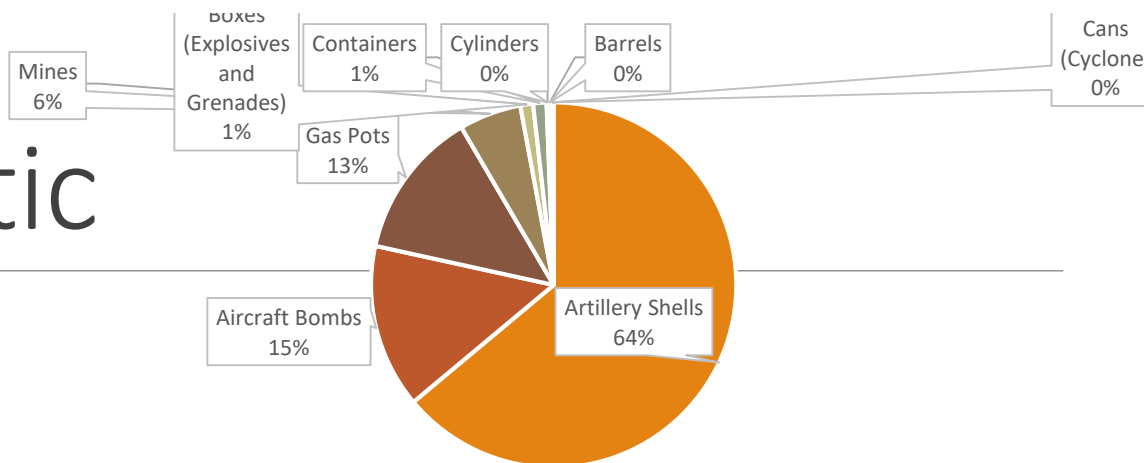Baltic Marine Environment Protection Commission

Baltic Sea Environment Proceedings No. 142

Chemical Munitions
Dumped in the Baltic Sea

Baltic Marine Environment Protection Commission

Online: Map & Data Service
Chemical Munitions & Risk-Layer Mines

Sea mines deployed to Baltic Sea
since 1914: 172.000 + X

With contribution of
Baltic Ordnance Safety Board (NAVY)

Situation of Baltic Sea dumped munitions

Munitions in the Baltic

Stocks of German chemical warfare (CW) agents produced and accumulated before and during WW-II

Types and compounds dumped in the Baltic [%]

Mines 6%
Boxes (Explosives and Grenades) 1%
Containers 1%
Cylinders 0%
Barrels 0%
Cans (Cyclone 0%
Gas Pots 13%
Aircraft Bombs 15%
Artillery Shells 64%

- Artillery Shells
- Aircraft Bombs
- Gas Pots
- Mines

Cl-acetophonone 5%
Serie1 Arsenic Subst.
Others 1%
Adamsite 13%
S-Mustard 63%
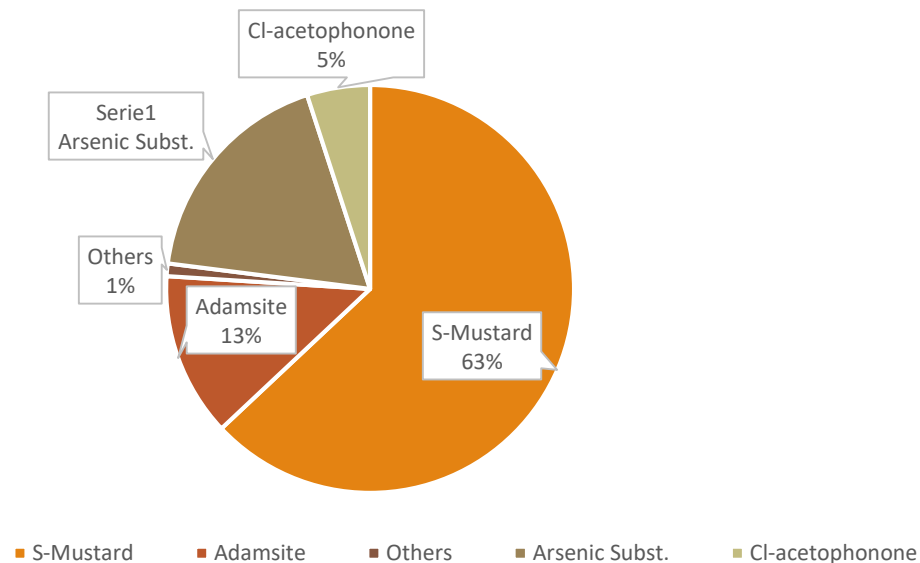
- S-Mustard
- Adamsite
- Others
- Arsenic Subst.
- Cl-acetophonone

Munition Status

- Detection
- Identification
- Corrosion
- Threat
- Leakage

Sonar quality

2011

2018

Width: 0.7 m

Lenght: 3.8 m
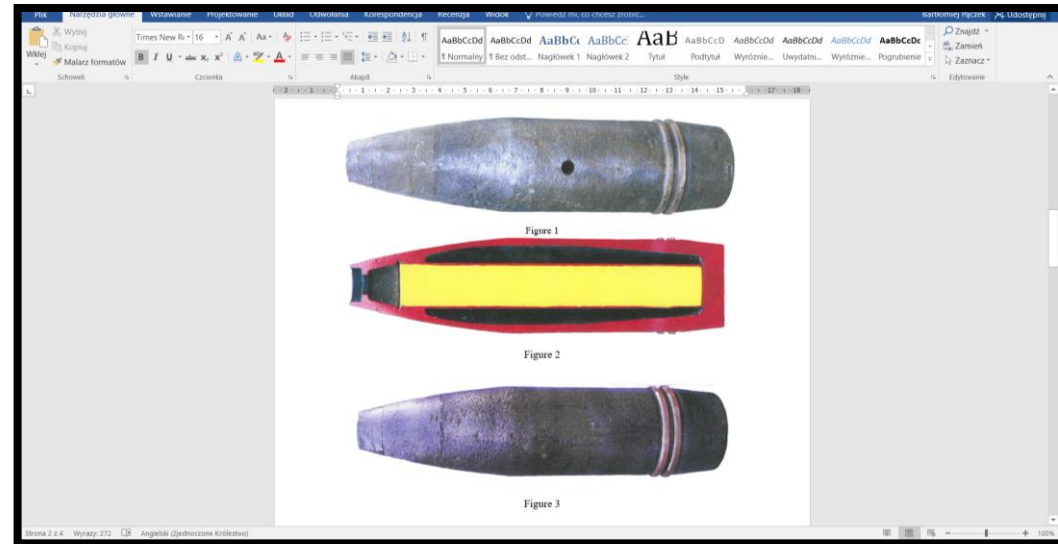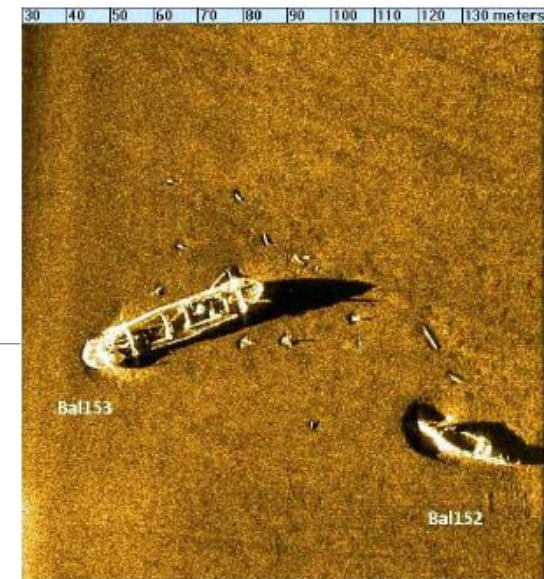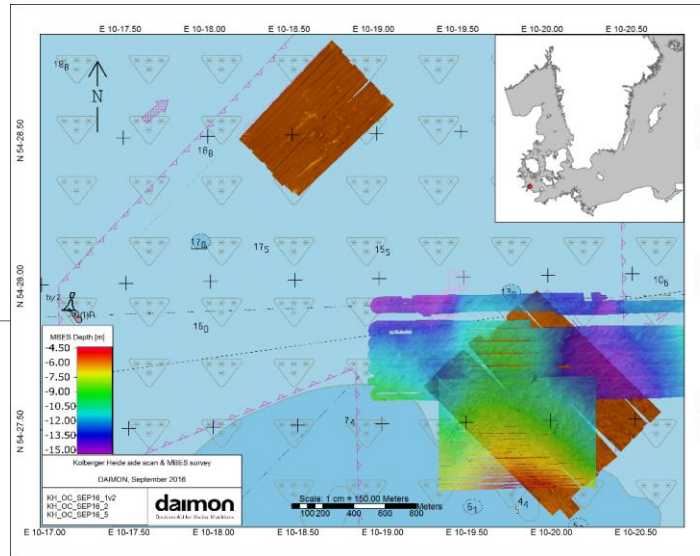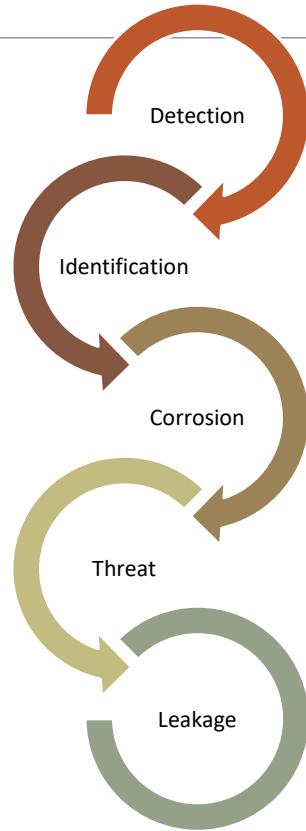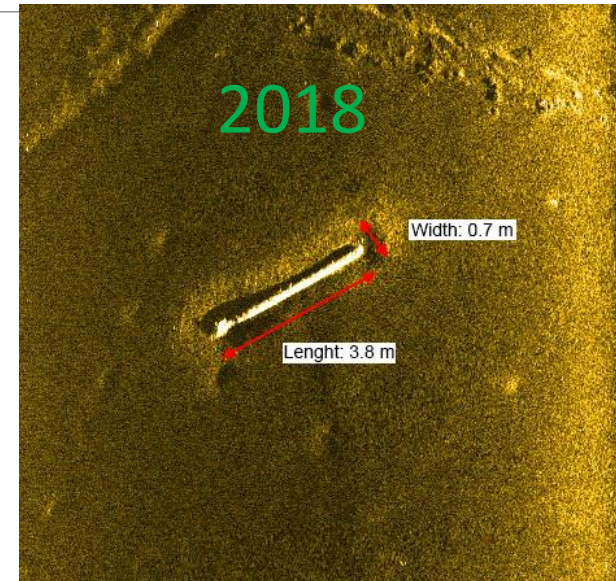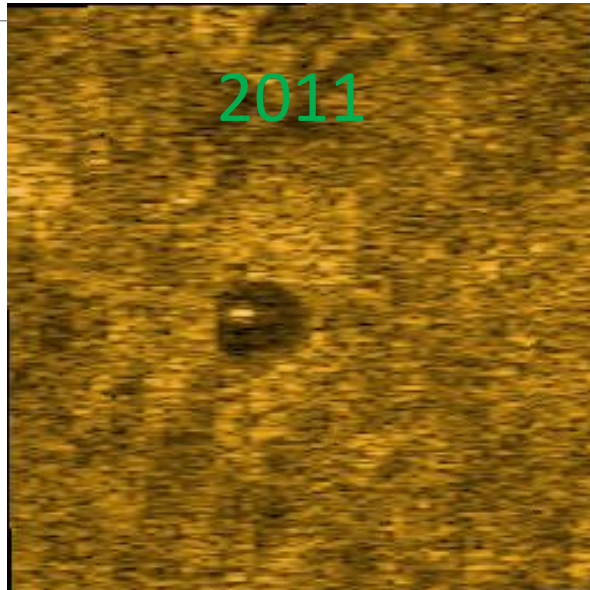
Detection – Gotland Deep
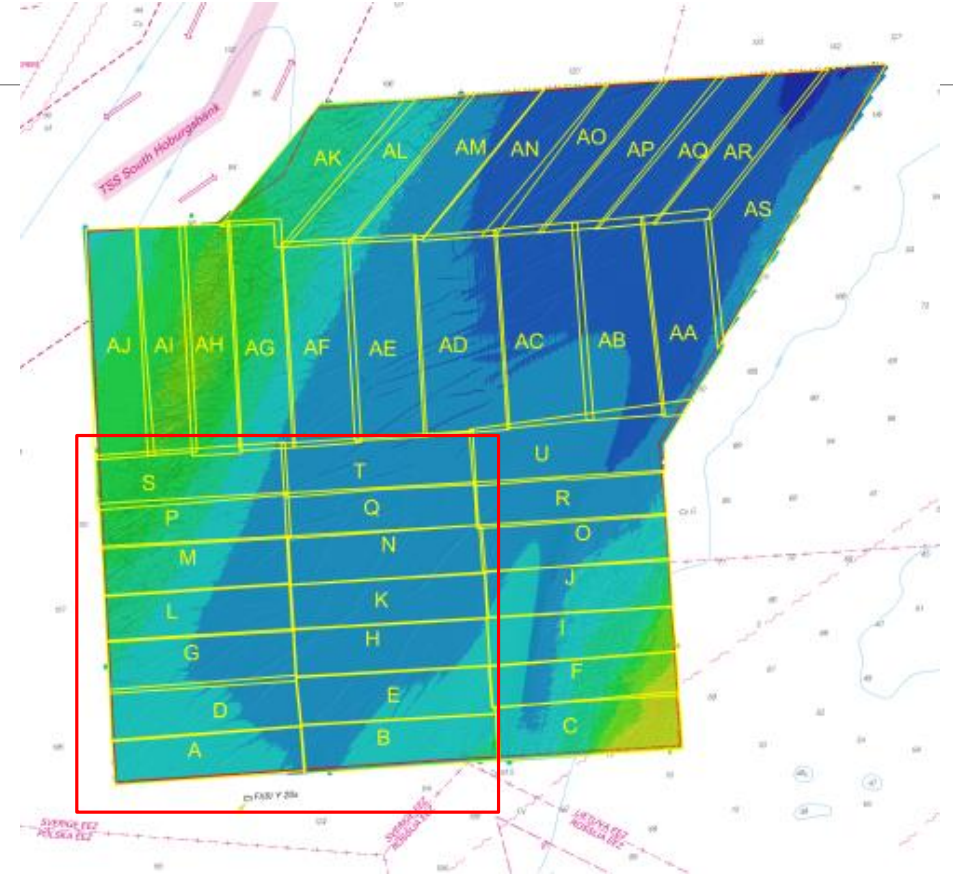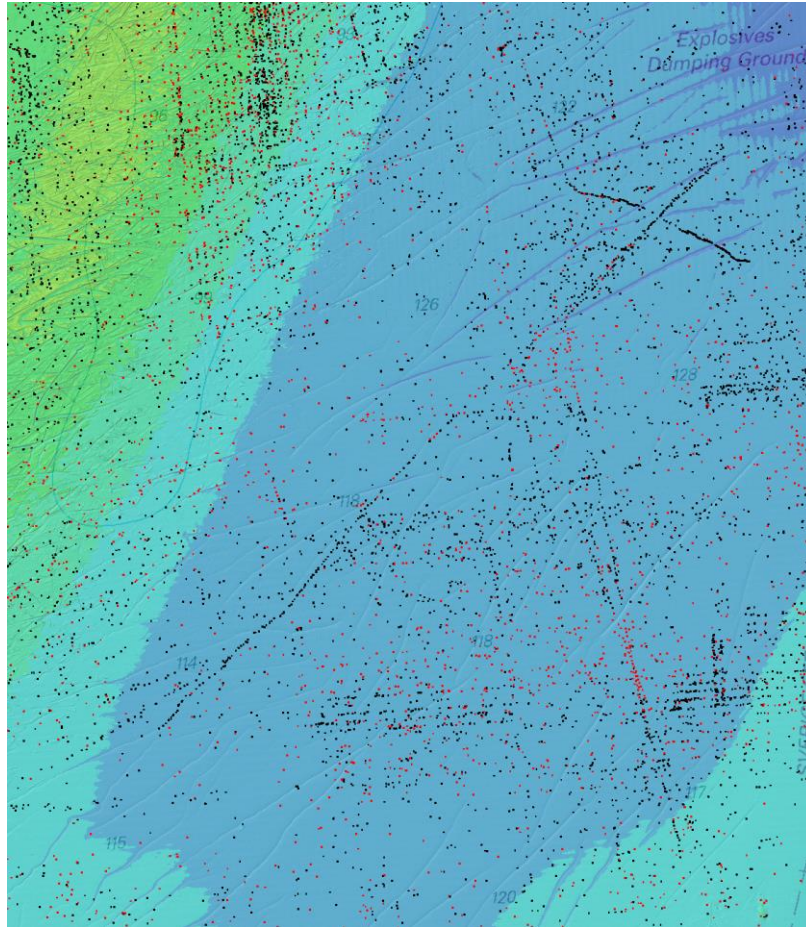
Density of objects
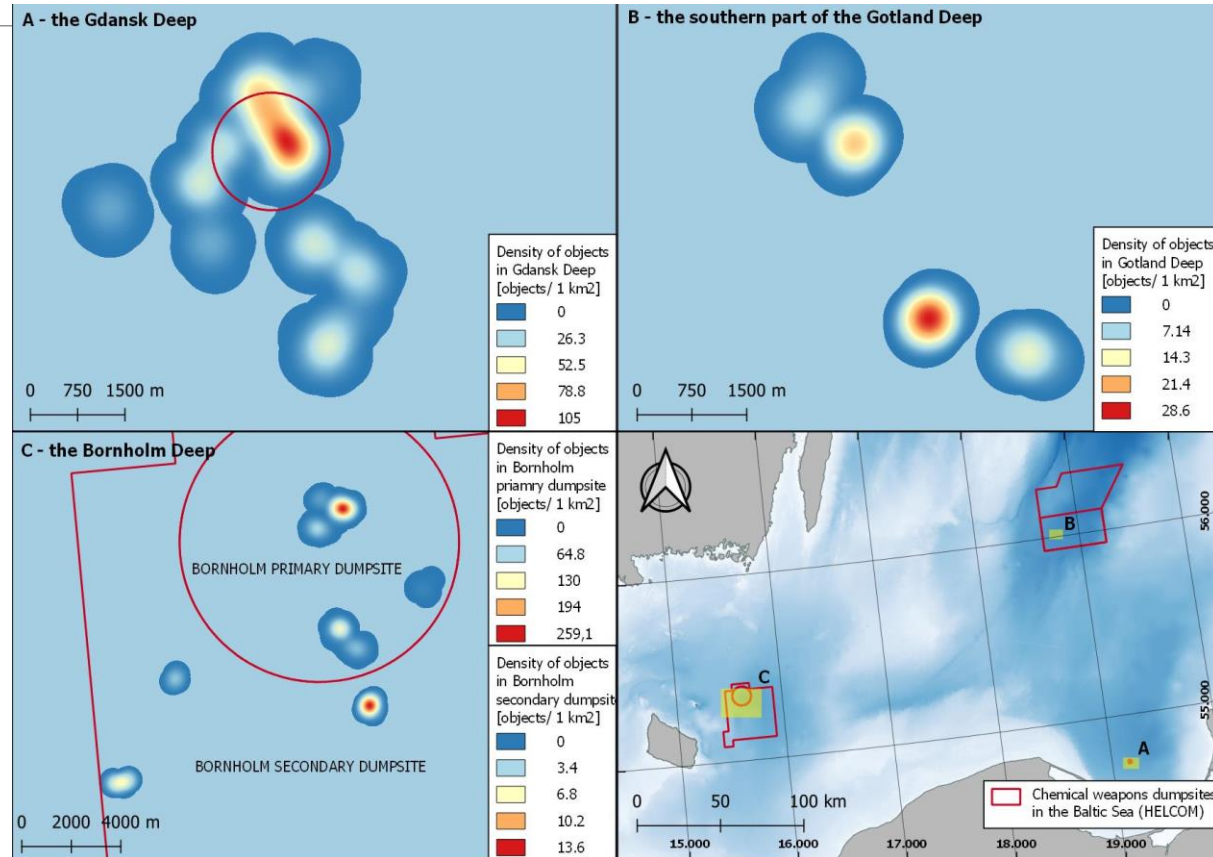
Identification
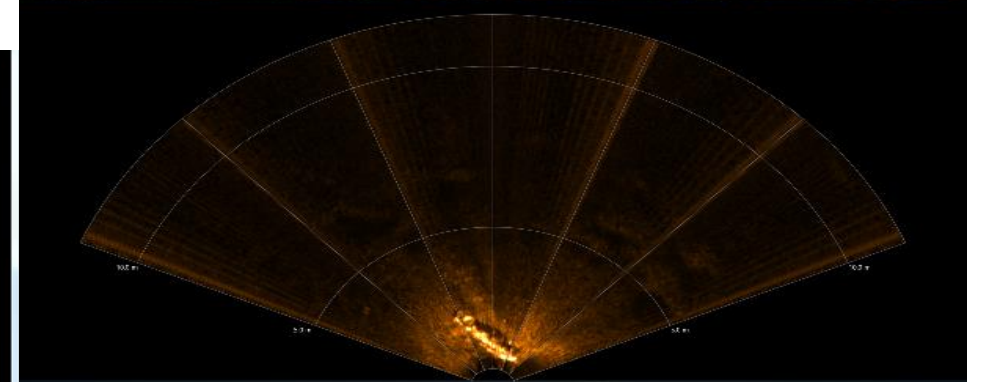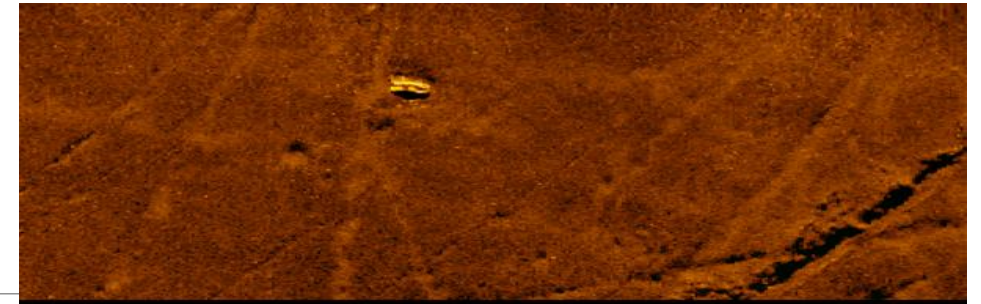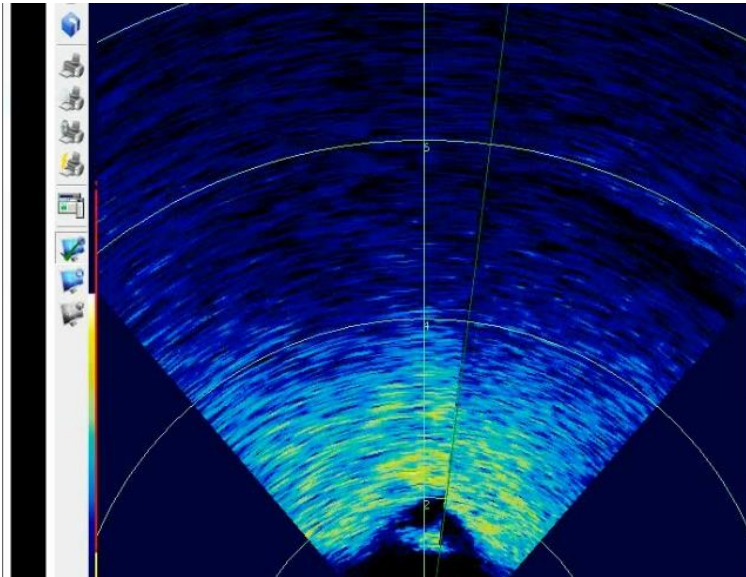
Corrosion
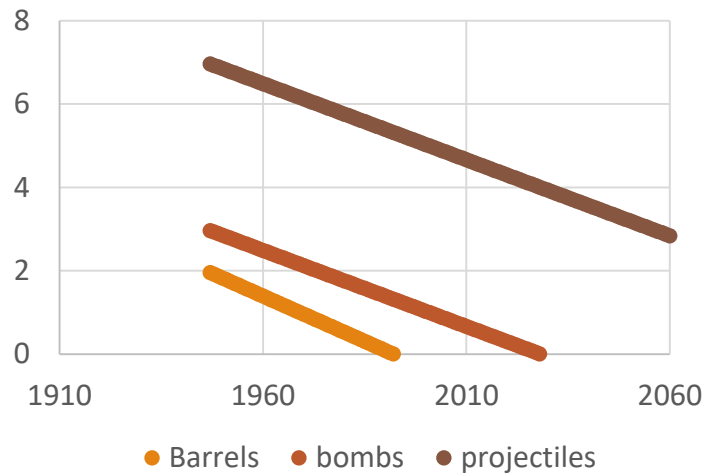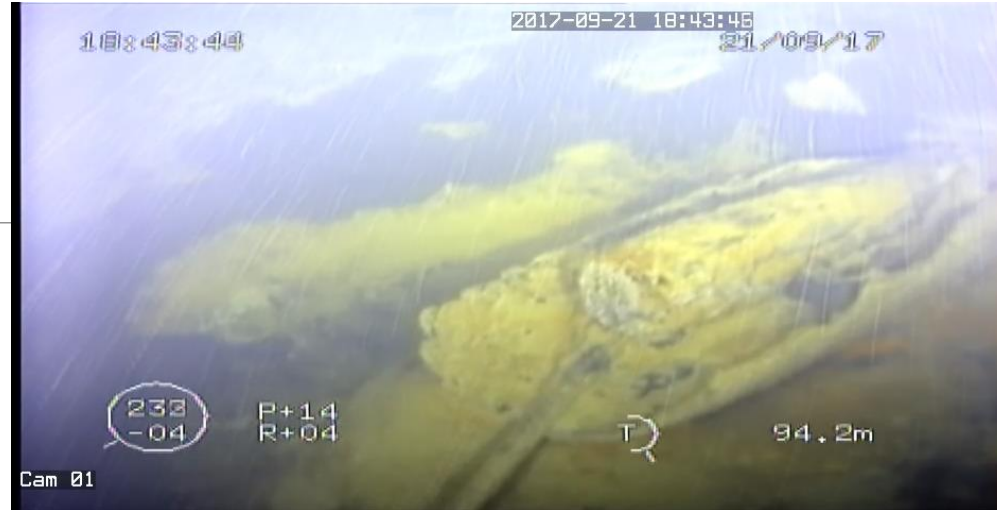
Barrels V_k=0,0434 mm/rok
Bombs V_k=0,0365 mm/rok
In sediments V_k=0,0313 mm/rok

Wall thickness:
Barrels 1.5 do 2 mm
Bombs 3 mm
Projectiles 5-7 mm

Transport

High Resolution Model (HRM)-Bornholm Deep (constant leakage)
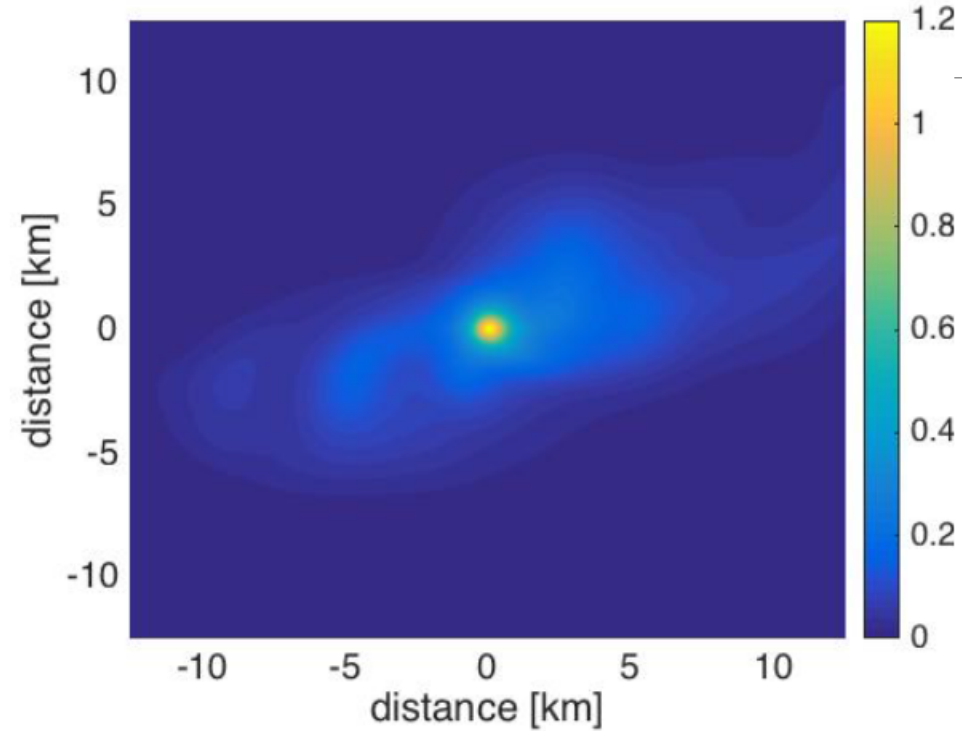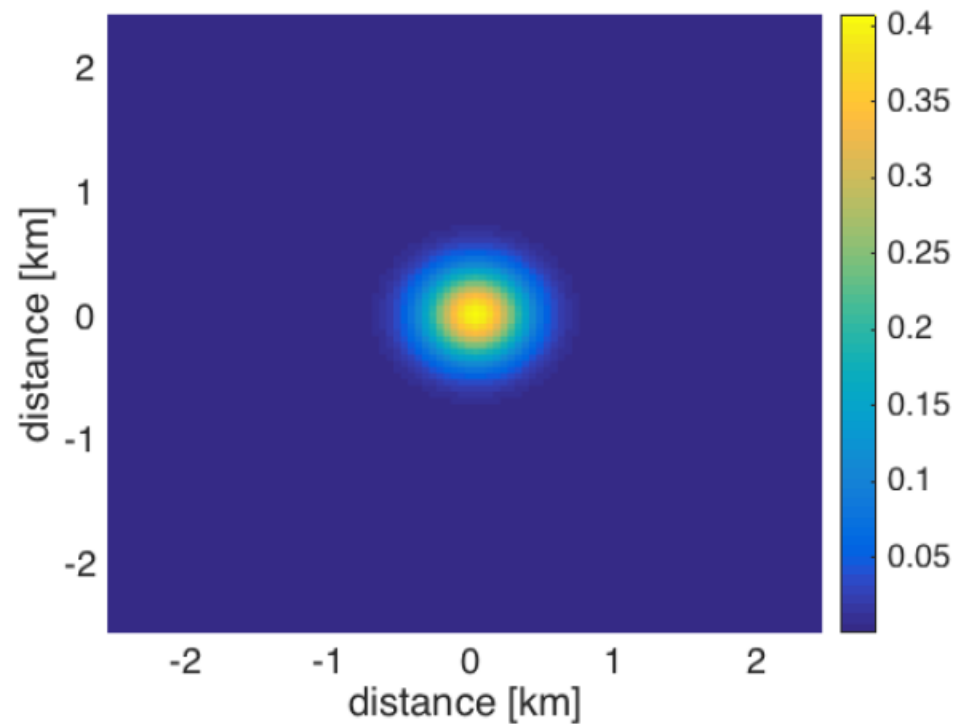
Initial state and situation after 5 days of estimated potential leakage. Horizontal and vertical axes represent distance in relative units. Color scale can be interpreted as the level of contamination.

Pollution of sediments and water

Metals
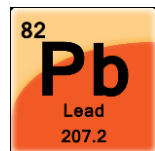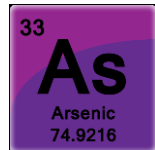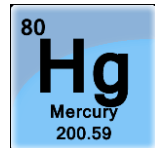
Chemical Warfare Agents
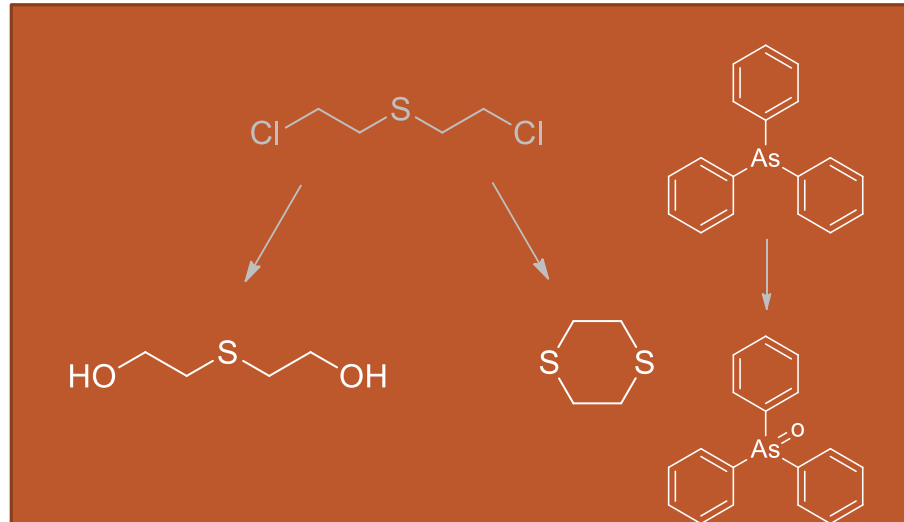
Explosives
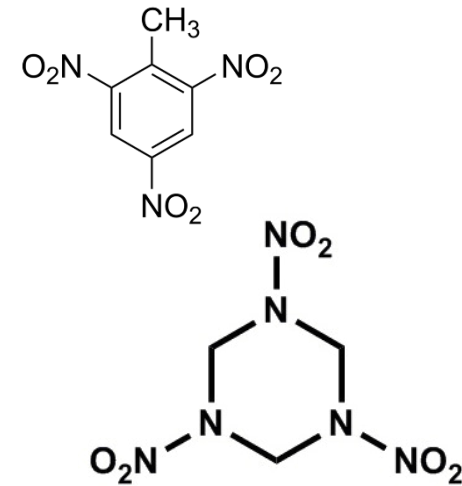
CWA and explosives
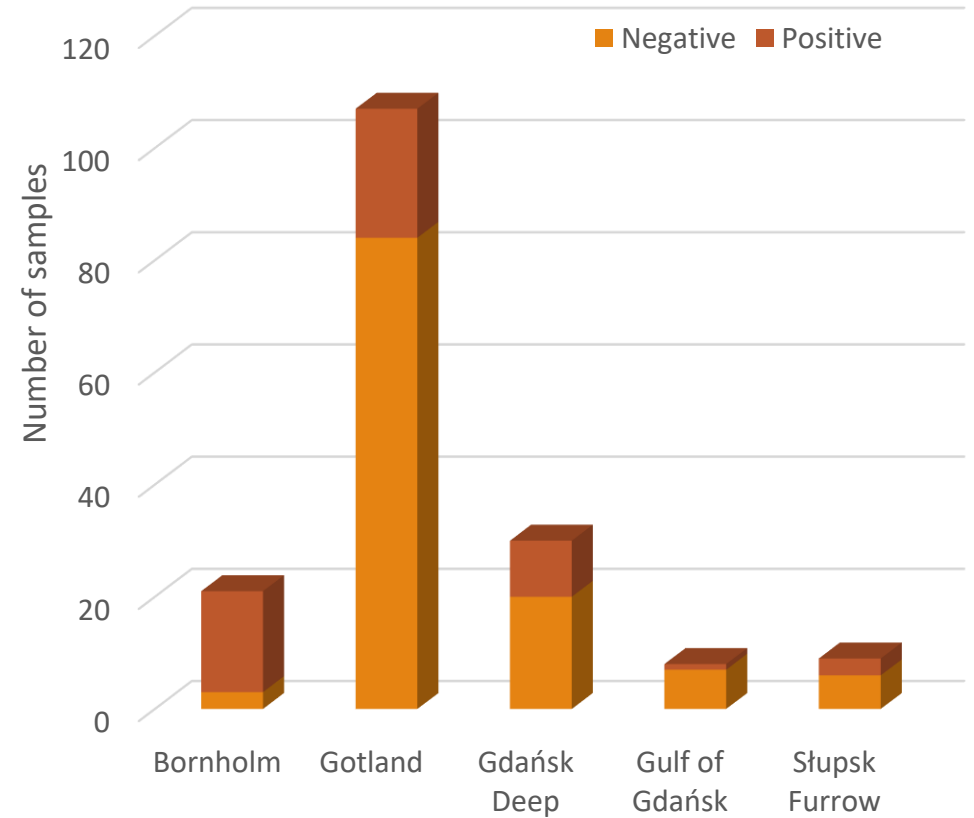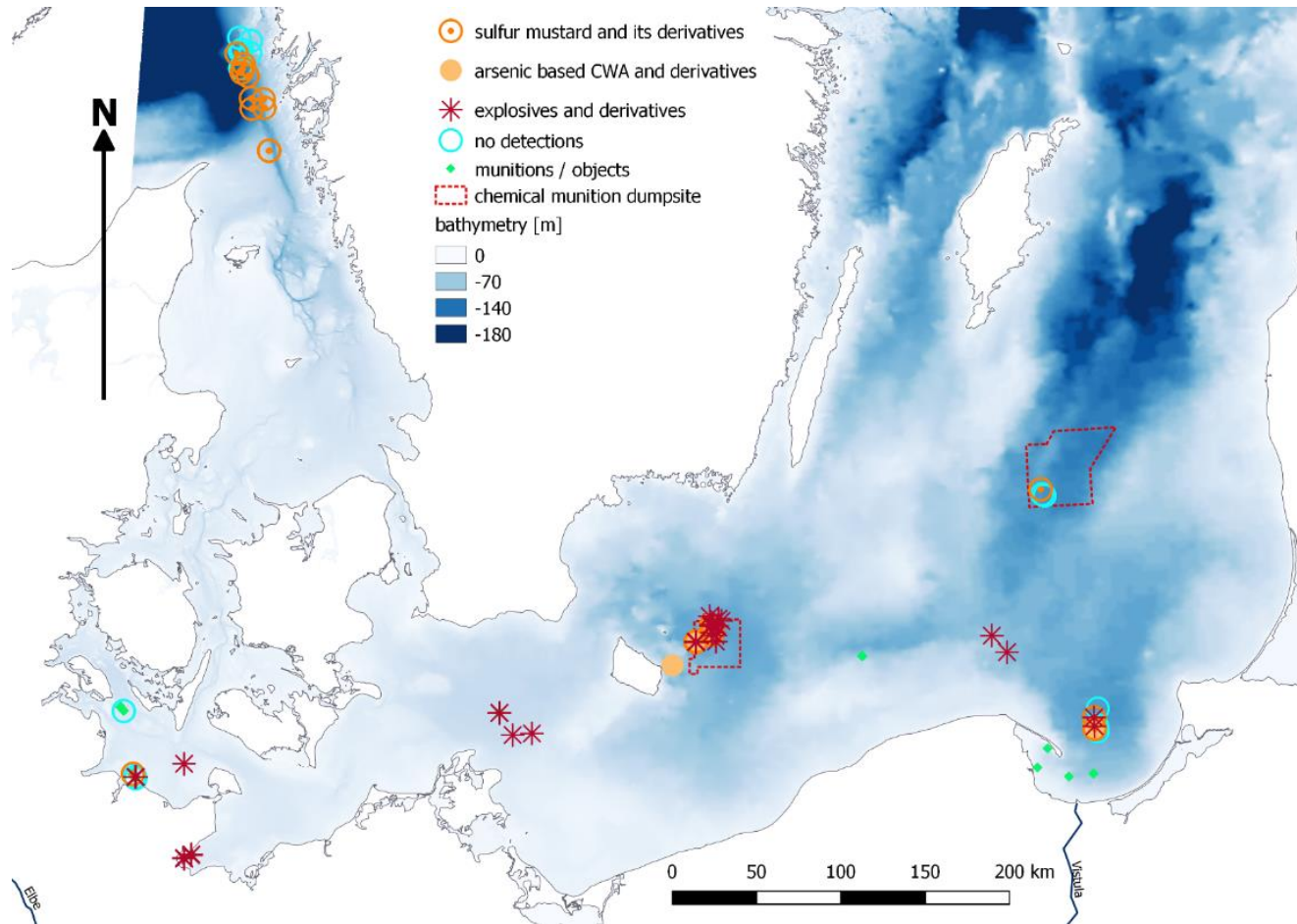
Positive CWA detections after 10 years
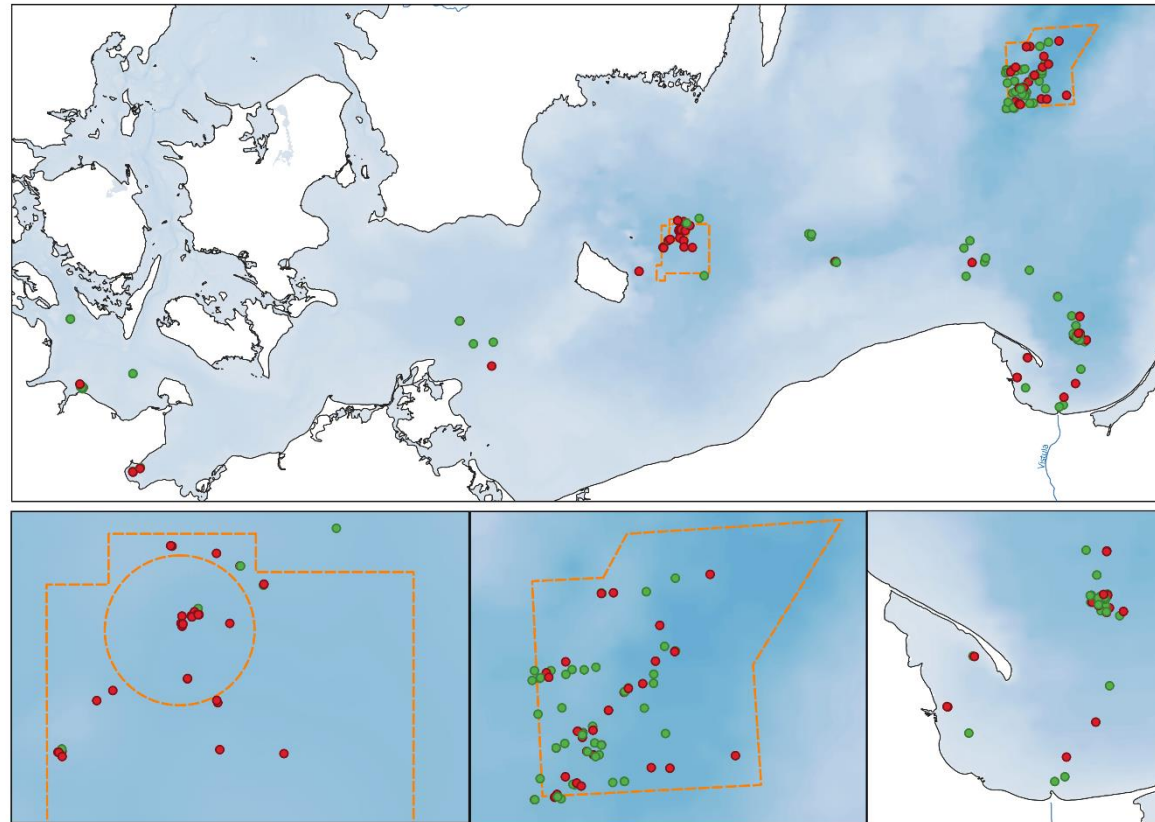
Bornholm Deep
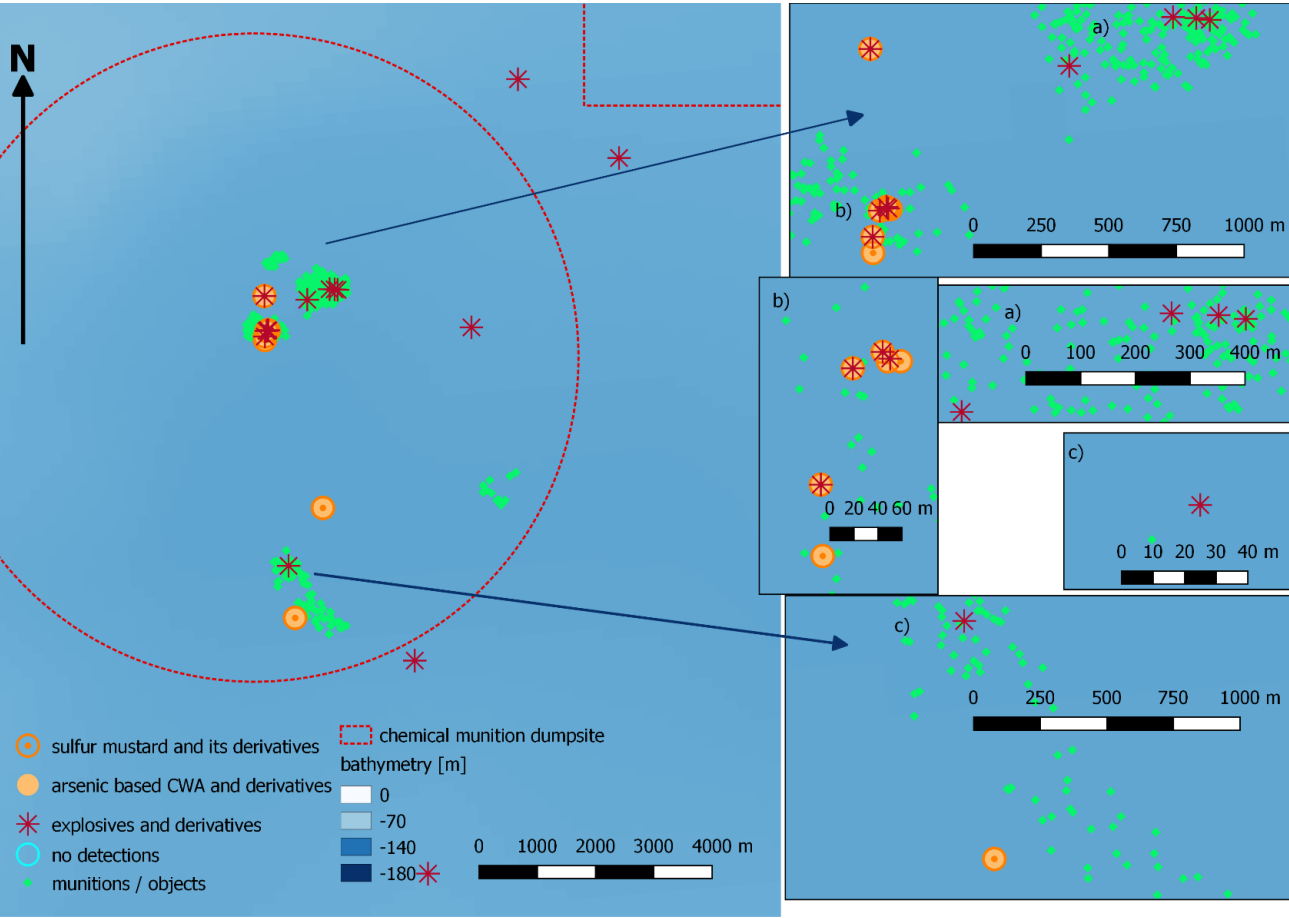
Legend:
- sulfur mustard and its derivatives
- arsenic based CWA and derivatives
- explosives and derivatives
- no detections
- munitions / objects
- chemical munition dumpsite
- bathymetry [m]: 0, -70, -140, -180

Enrichment, range

ID=163
HgTOT = 261,958-0,0908*x

$y = 254,44x^{-1,034}$
$R^2 = 0,5029$

Hg/LOI

Impact on biota

Fish Disease Index (FDI)

Impact

Toxicity

Rainbow trout liver cells
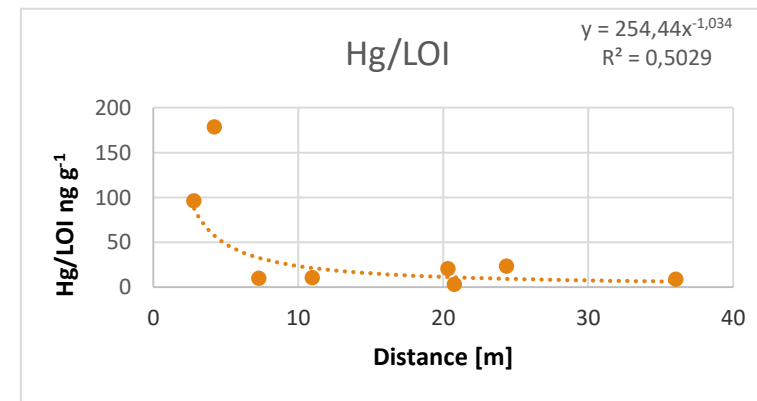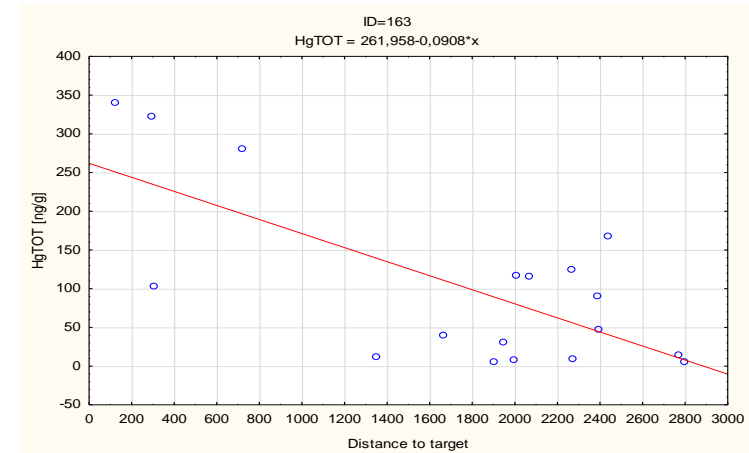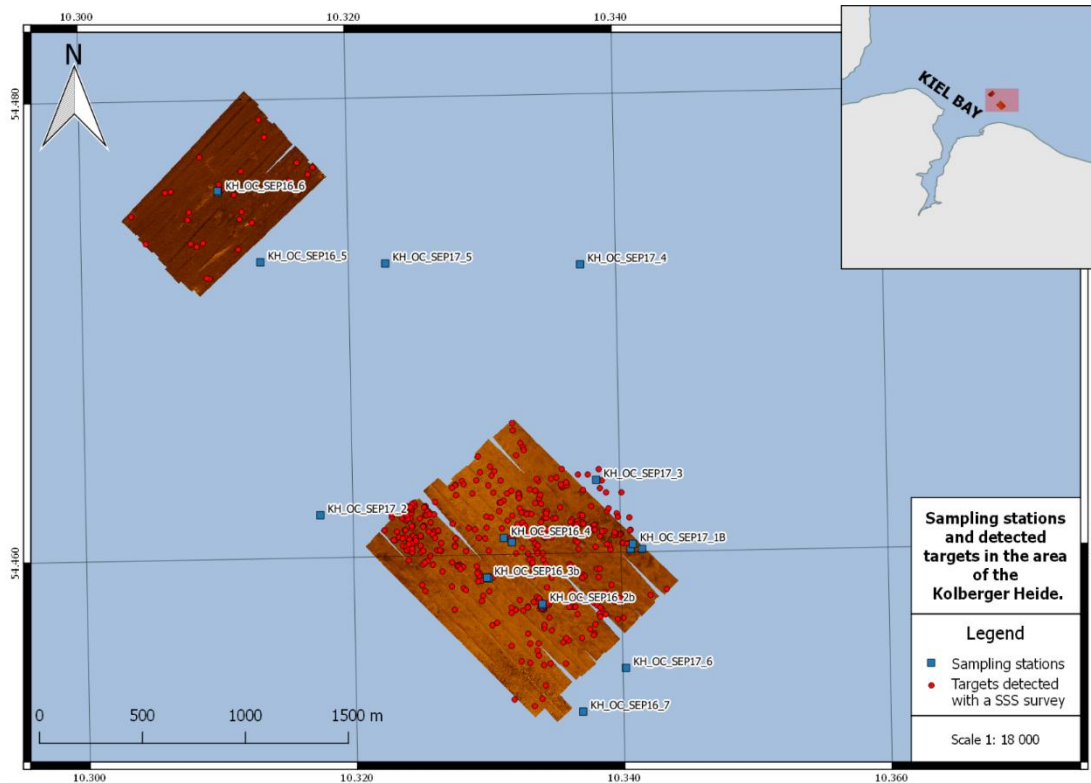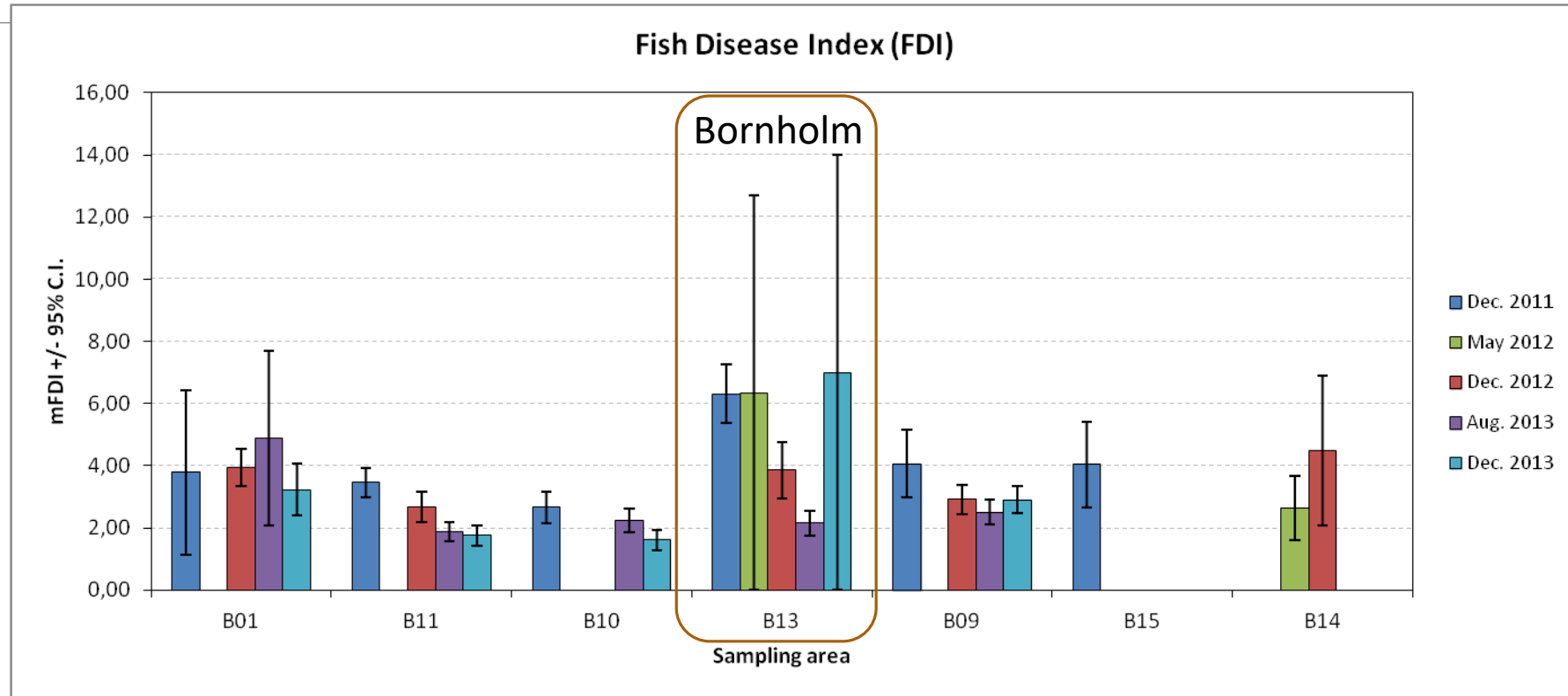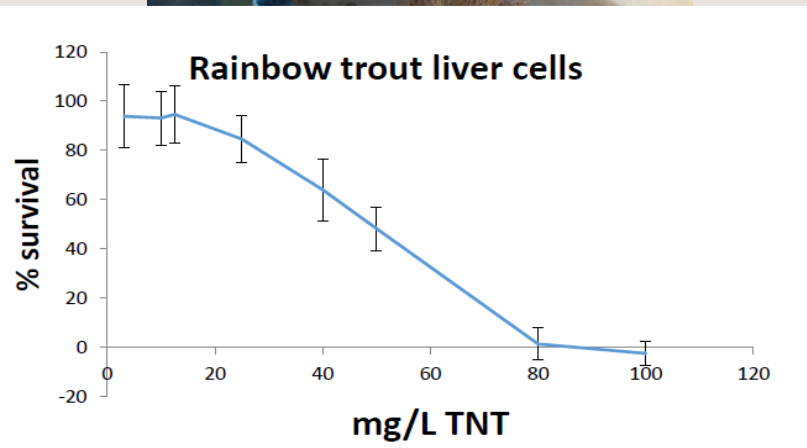
Bio accumulation
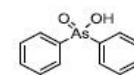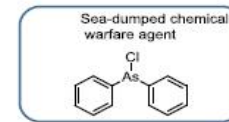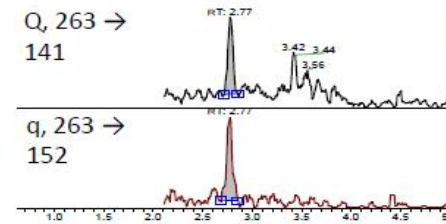
Fish results

- 3 out 100 reference cod muscle contained TPAox
- No DPA detected from Bornholm reference area
- 13 % of studied cod muscle samples collected from Bornholm dumpsite have contained arsenic CWAs
  - 20 % analysed cod liver samples have contained TPAox

Species	Sampling area	Number of samples	Muscle		Liver	
			DPA	TPAox	DPA	TPAox
Cod	Bornholm reference site B09	100	-	3/100	0/10	0/10
Cod	Bornholm dumping site B13	120	9/120	10/120	0/10	3/15
Saithe	Måseskär	9	NA	NA	0/9	0/9
Hagfish	Skagerrak (wreck 13)	20	10/20	19/20	NA	NA

Food web impact
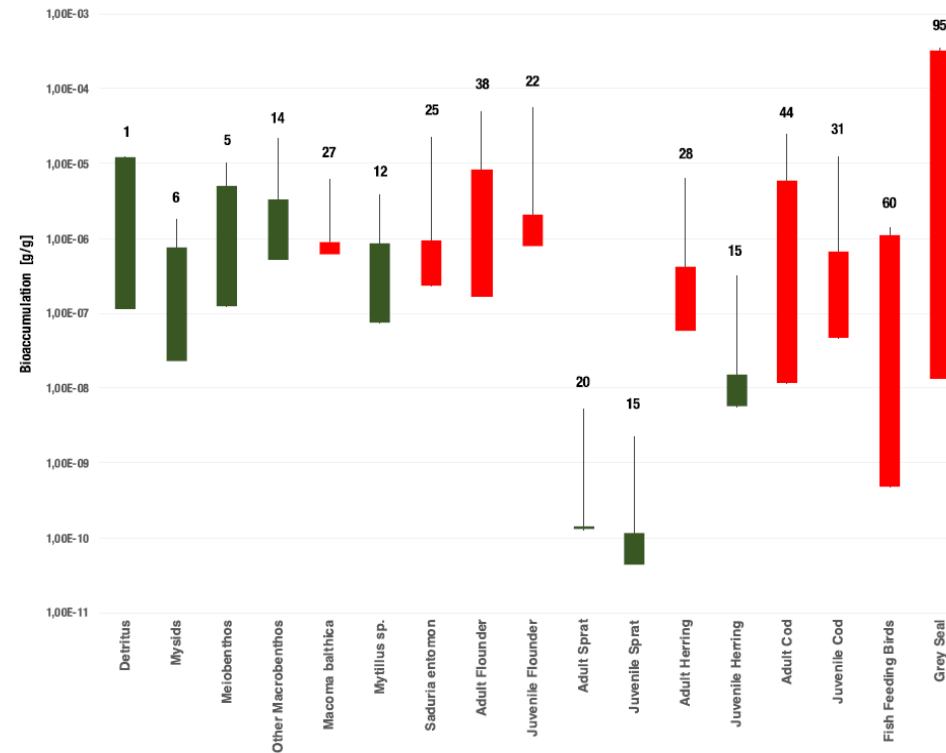
Figure 3.

Modelled t_0, t_{end} and maximum concentrations of Clark I + degradation products in biota and detritus per 1 gram of biomass. Green color represents a decrease and red color an increase of concentration during 10 years from leakage. Numbers above each box represent the months when maximum concentrations occurred.
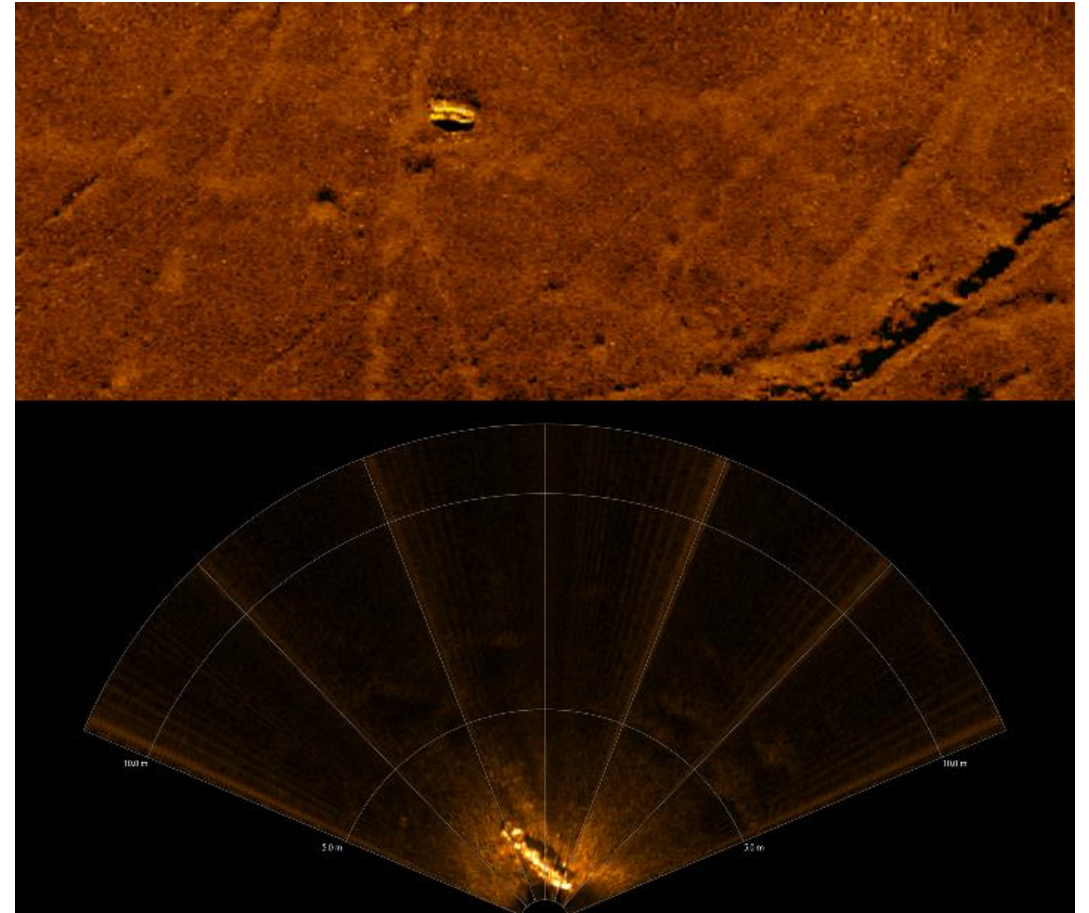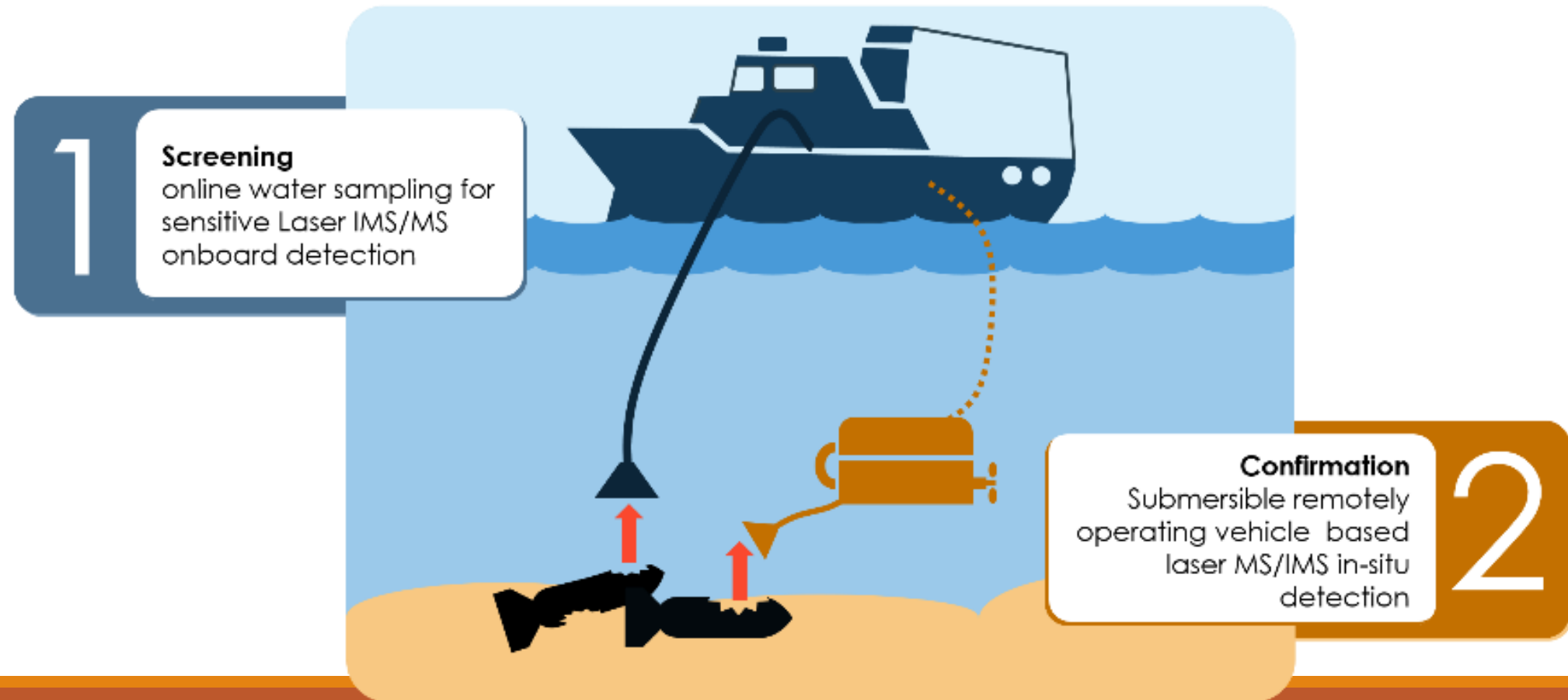
DSS

Models and reports

Complete Scene recognition

- Object modeling
- Bottom image
- Bottom properties
- Bayesian AI for best remediation

AMMOTRACE

AMMOTRACe – Marine ammunition dump site exploration by surface- and underwater-based laser mass spectrometric tracing technology

1 **Screening** online water sampling for sensitive Laser IMS/MS onboard detection

Confirmation Submersible remotely operating vehicle based laser MS/IMS in-situ detection **2**

EROVMUS- Enhanced ROV for Munition Studies

Better ROV

Improved control

Easier piloting

Partners:

- IOPAN
- OceanTech
- GEOECOMAR
- CUTEC (Claustahl)
- QVITEC
- VLIZ
- Harbor of Oostende

MAMON

mooring platform – inteligent buoys

Biota based indicators

In situ Mass Spec

Passive samplers

Flux chambers

Environmental sensors

Water and sediment transport

SEE YOU SPACE COWBOY...