

# Dumped chemical substances as a driver for Earth system changes in the Baltic Sea region

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**Interreg**

Baltic Sea Region



EUROPEAN UNION

EUROPEAN  
REGIONAL  
DEVELOPMENT  
FUND

# Situation of Baltic Sea dumped munitions



**CHEMSEA**  
CHEMICAL MUNITIONS  
SEARCH & ASSESSMENT



**MODUM**  
TOWARDS THE MONITORING  
OF DUMPED MUNITIONS THREAT

**daimon**

Decision Aid for Marine Munitions

 **Interreg**  
Baltic Sea Region

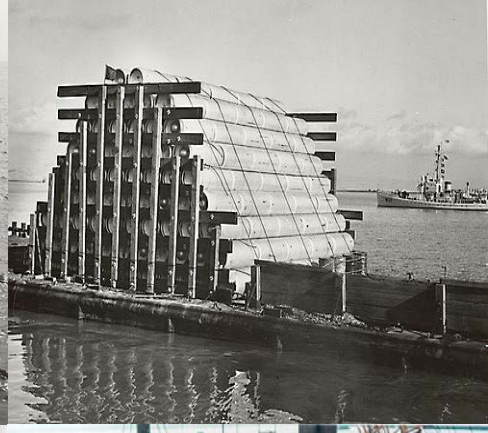
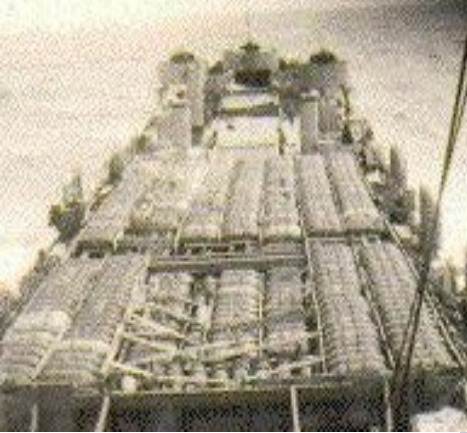


# Chemical munitions sunk at sea

- 40 000 tonnes sunk in Baltic proper, 150 000 tonnes in Skagerrak
- **Natural processes plus enhancing human pressure put environment at risk**



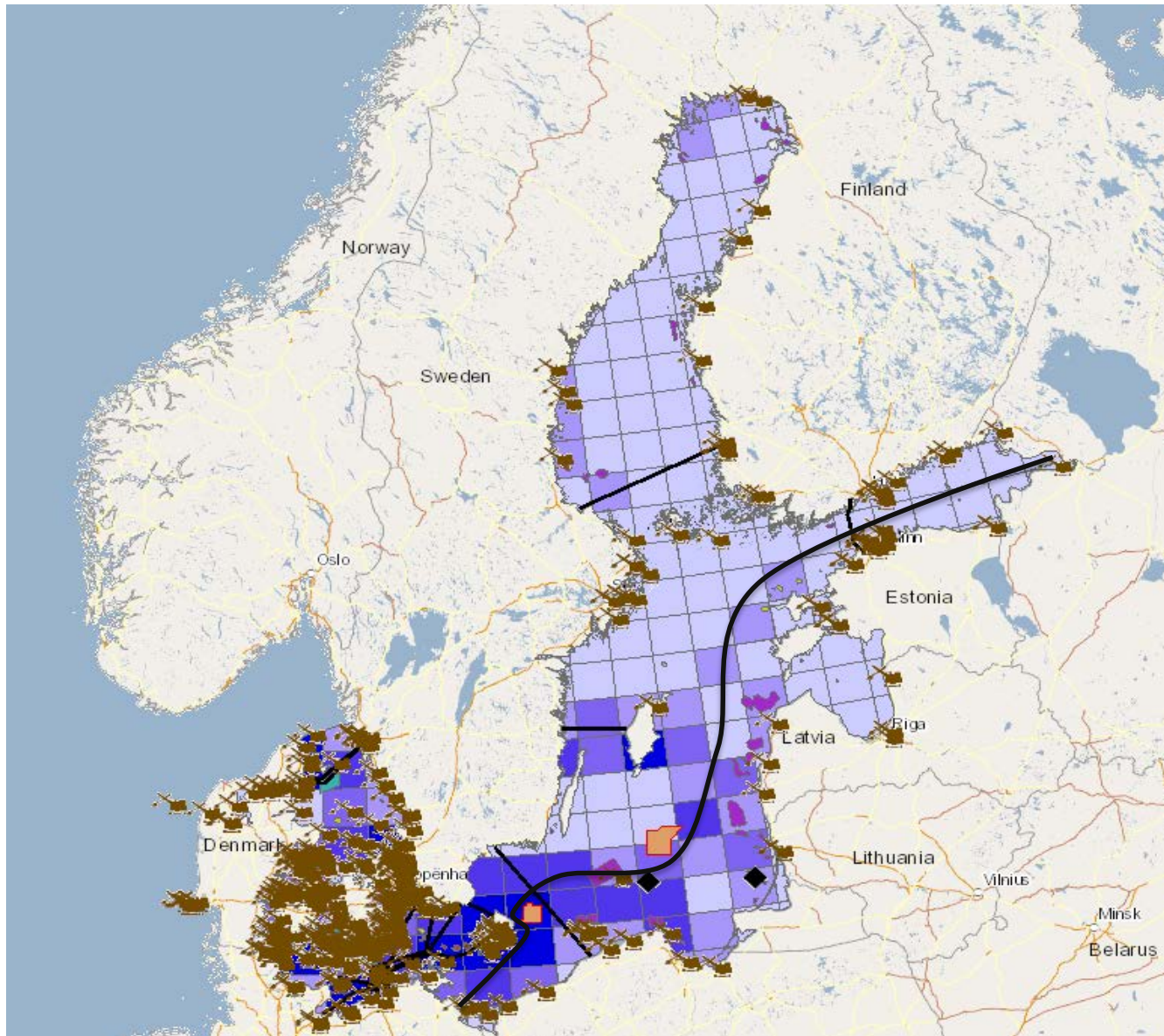




EXPLOSION OF MUNITIONS AT MAGAZINE, NEAR DARTMOUTH, HALIFAX N.S. JULY 16-1914  
PHOTO COPYRIGHT, J. HAYWARD HALIFAX  
Improve

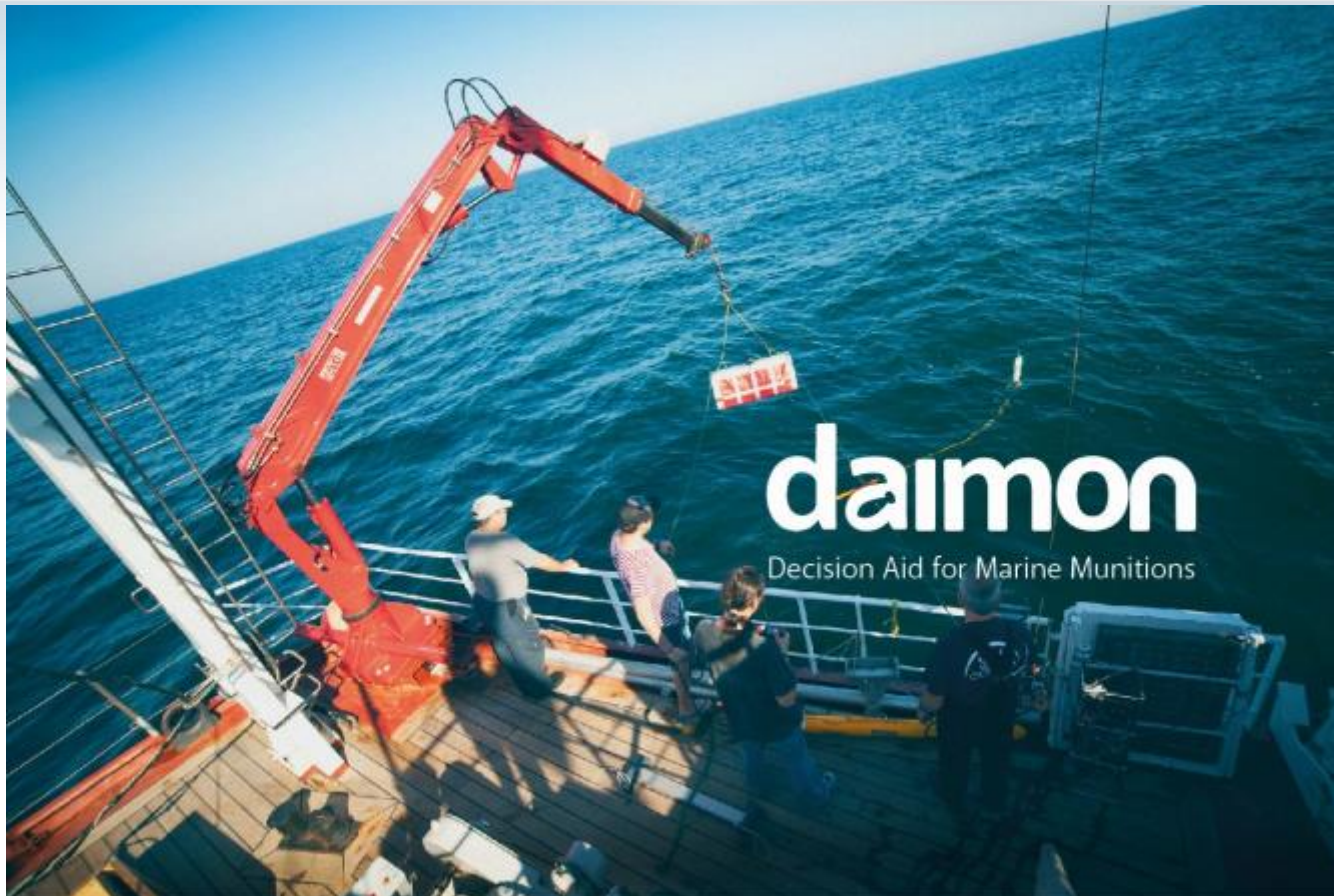






- Legend:
- CWA Dumps
  - Dredge sites
  - Offshore wind farms (planned)
  - Bottom Trawling intensity
  - Pipelines and Cables

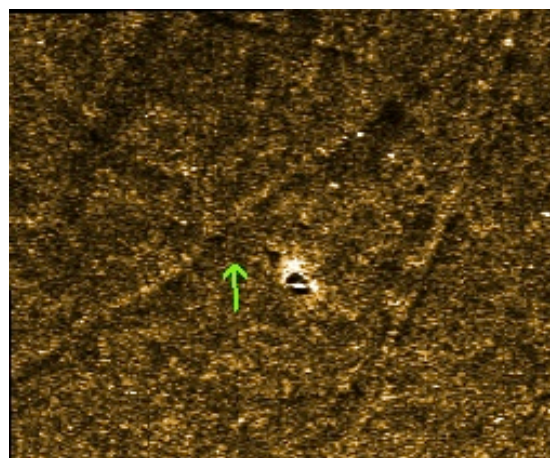
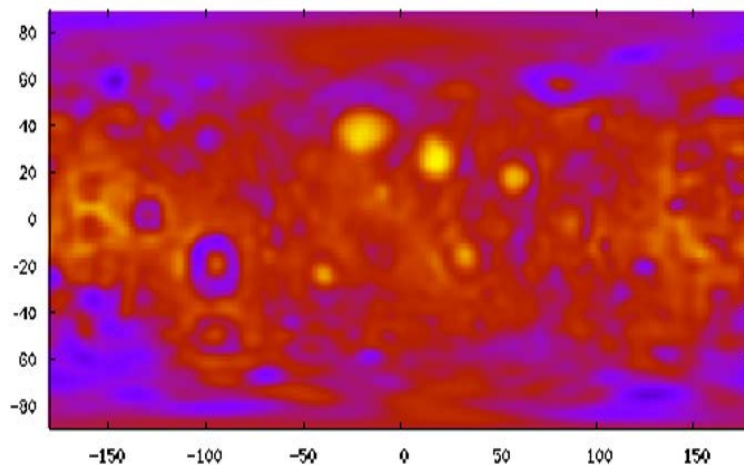
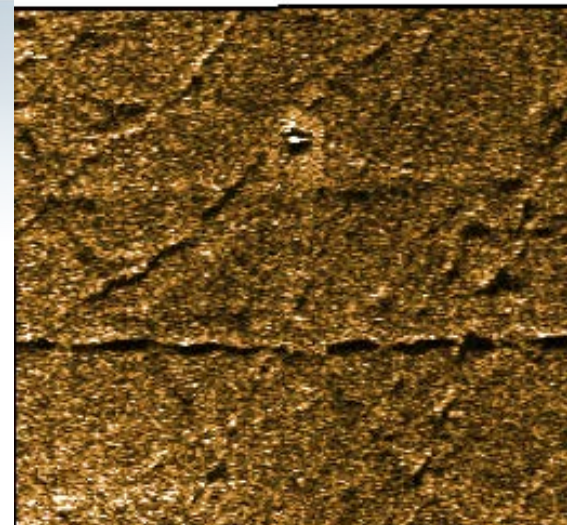
# Decision Aid for Marine Munitions



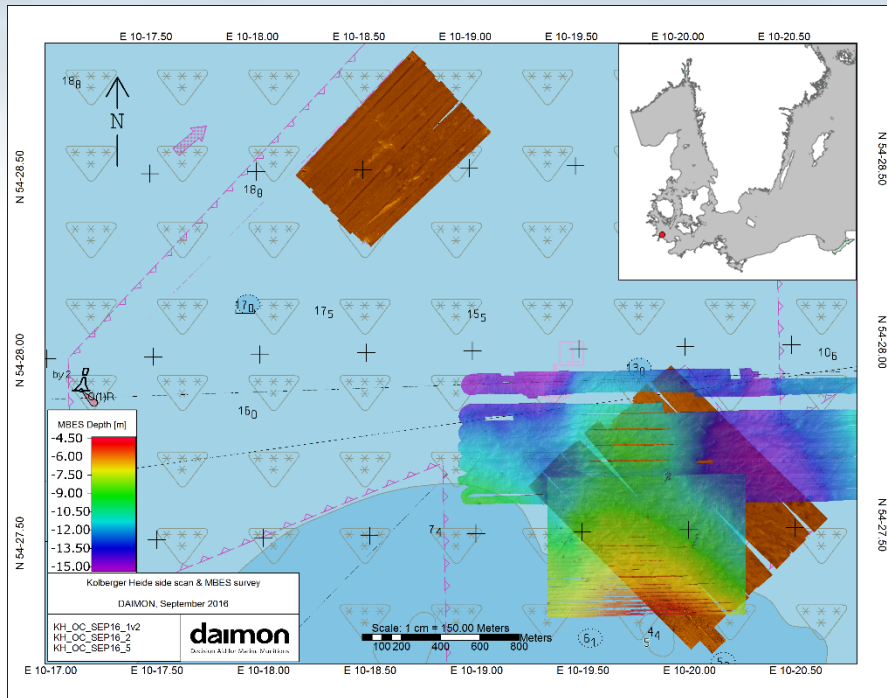


# Survey

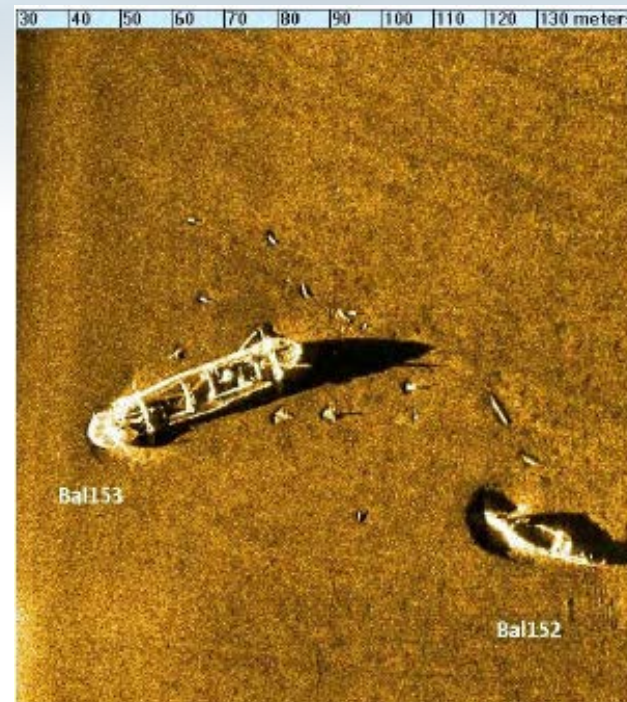
- Side Scan Sonar
- Magnetometr
- Sub-bottom profiler



# Detection



Kiel Bay

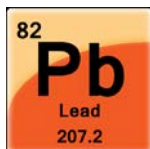
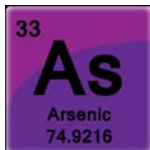
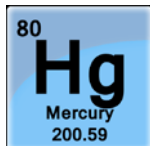


Skagerrak

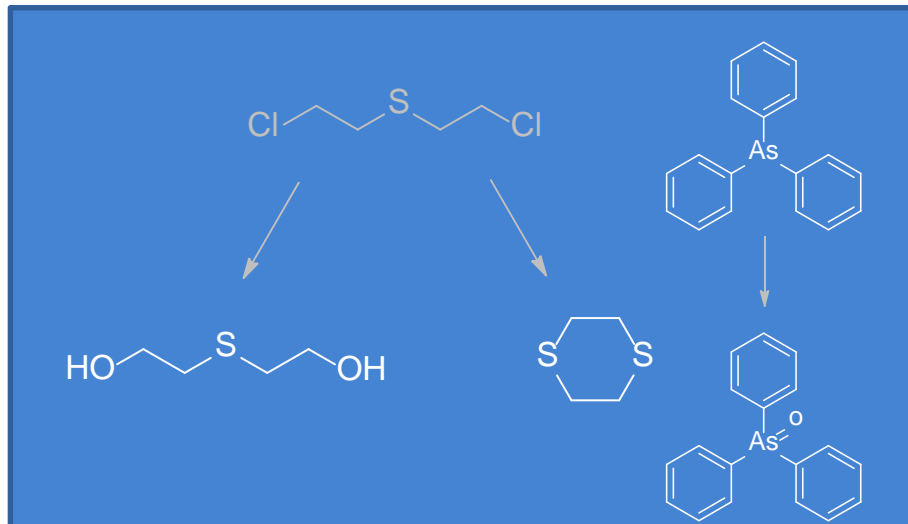


# Pollution of sediments and water

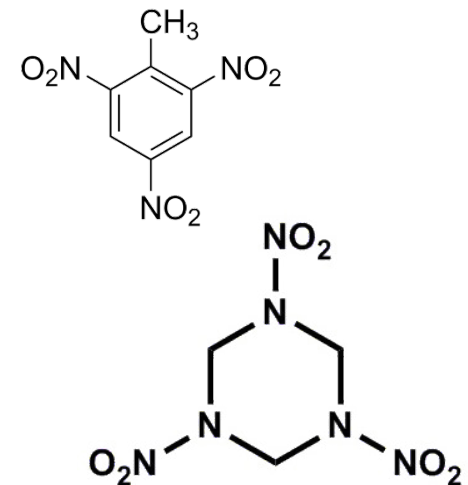
## Metals



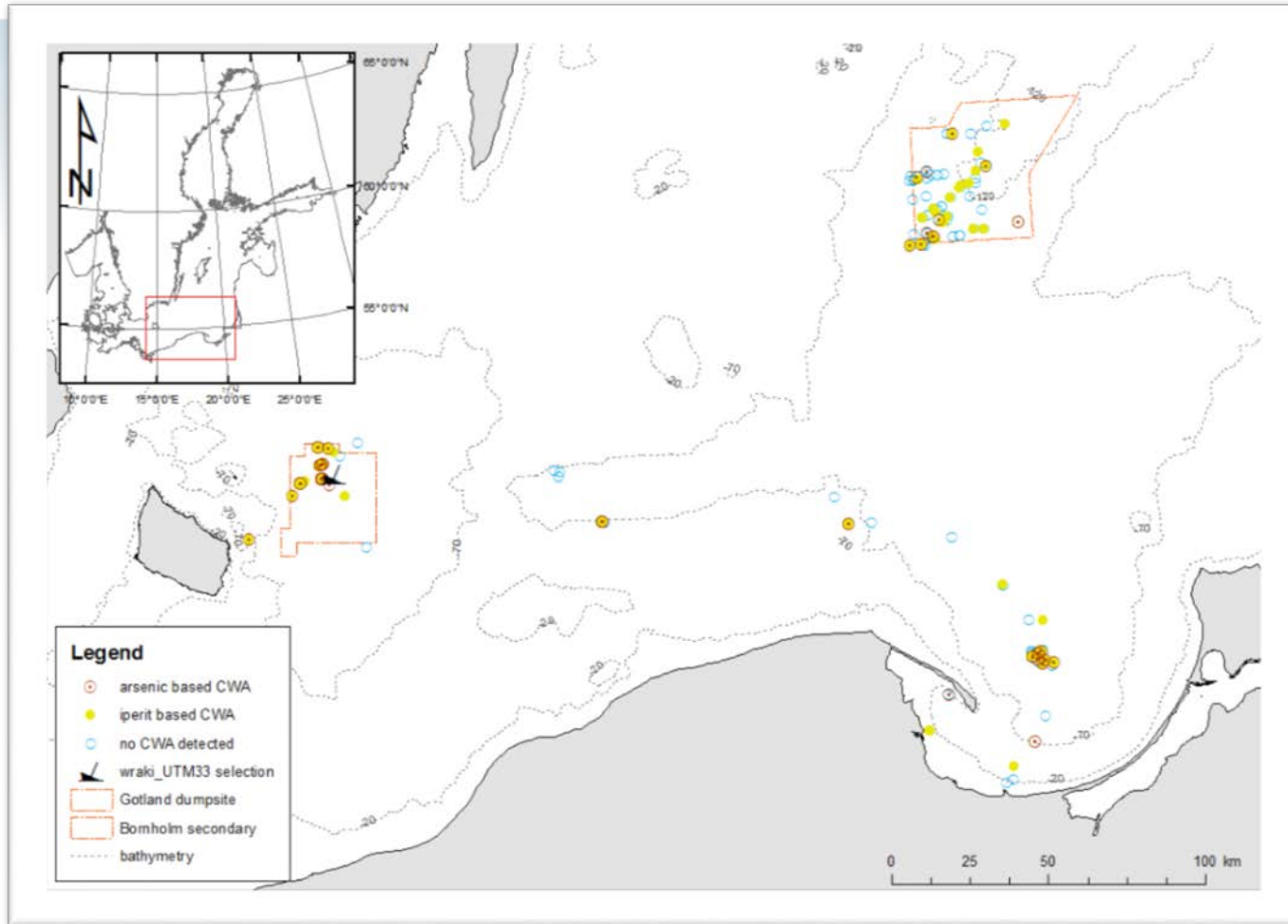
## Chemical Warfare Agents



## Explosives



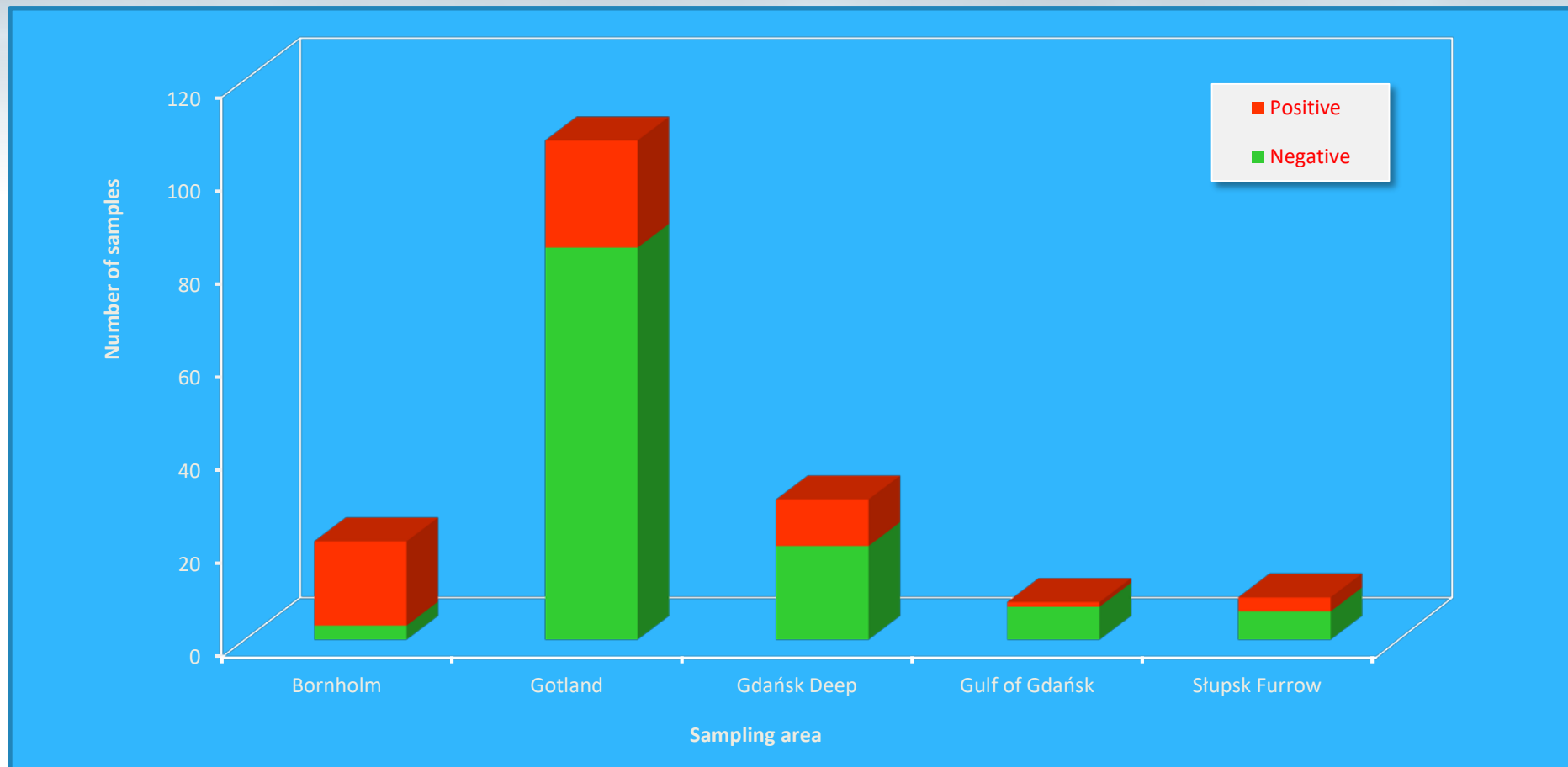
# 3.1 History and Current Status



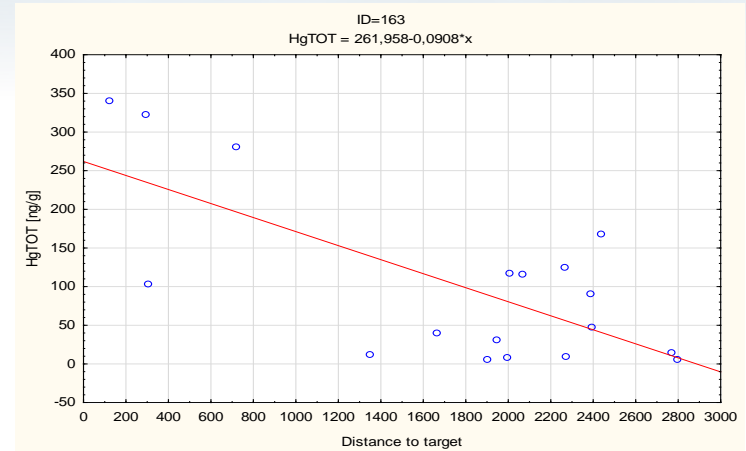
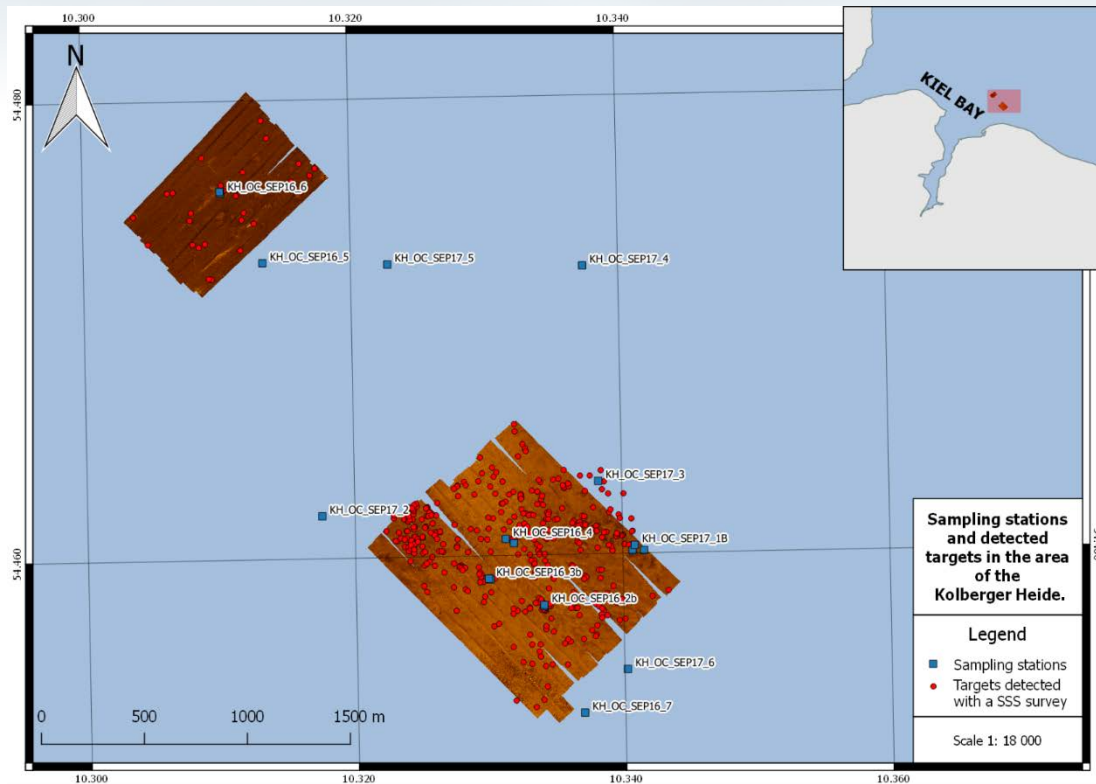
## Degradation Products



# Detection

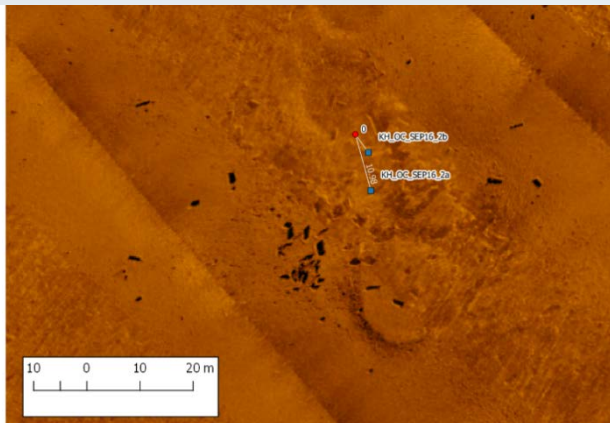


# Overall concentrations

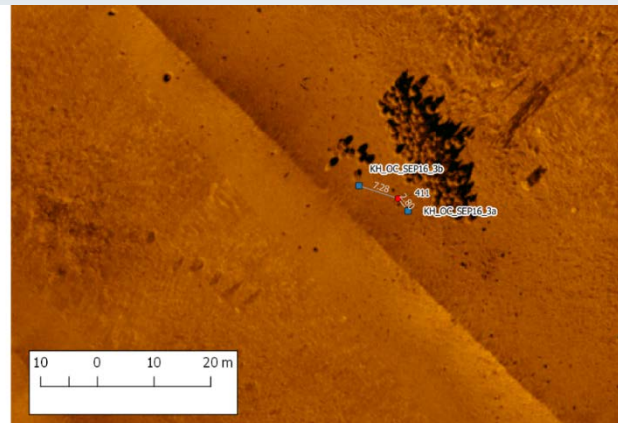
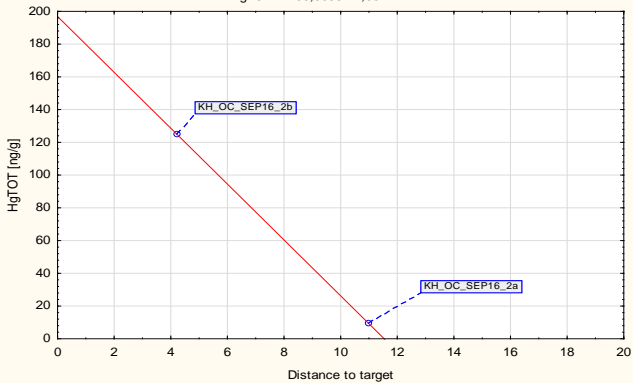




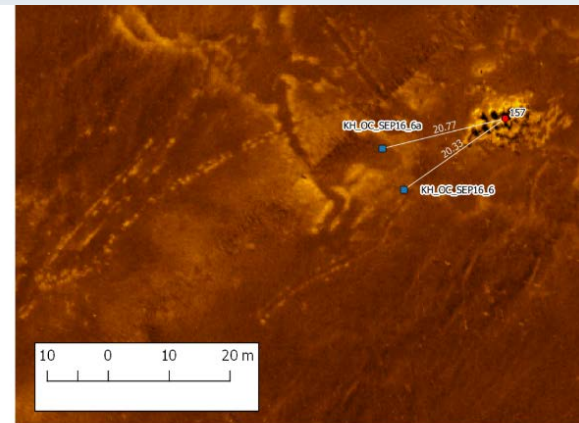
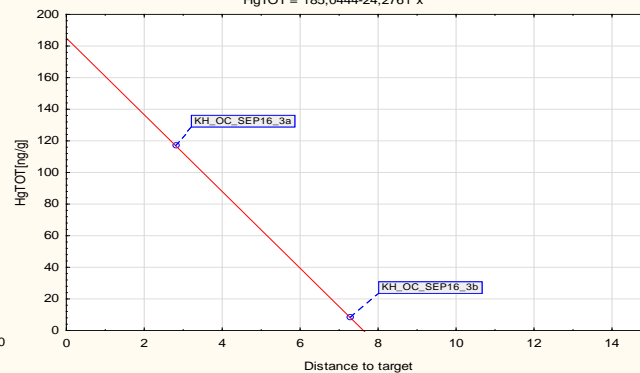
# Object-by-object – drastic drop



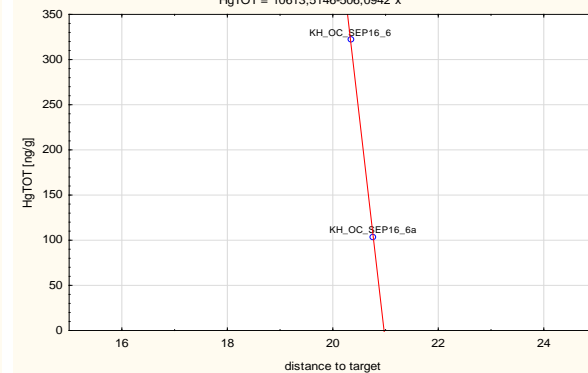
ID=0  
HgTOT = 196,8895-17,0617\*x



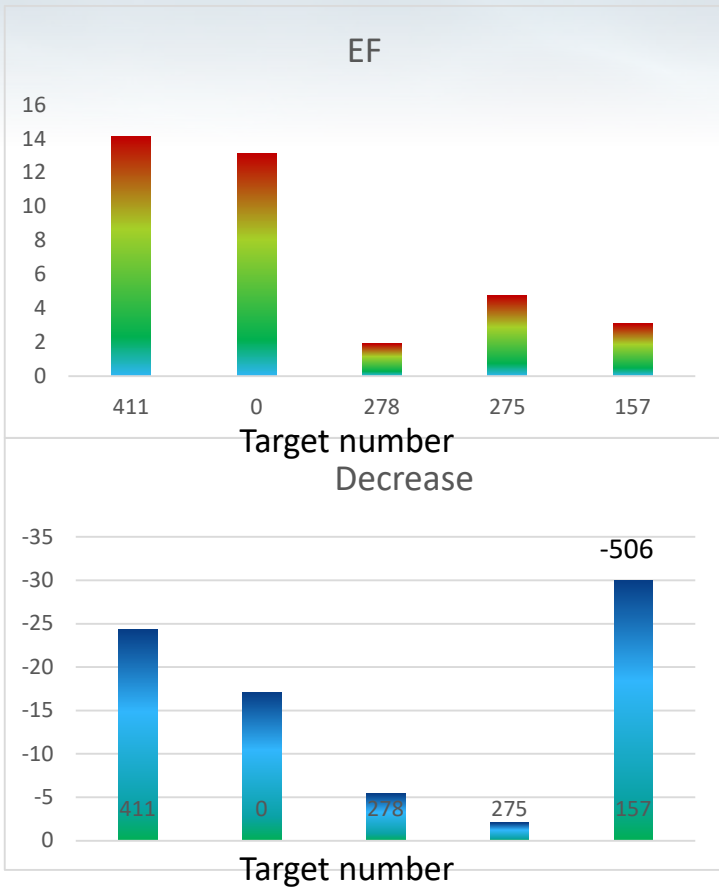
ID=411  
HgTOT = 185,0444-24,2761\*x



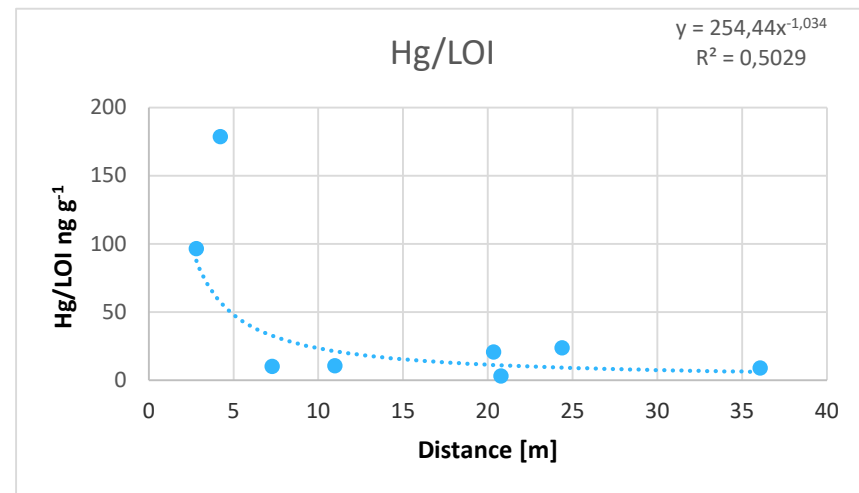
ID=157  
HgTOT = 10613,5146-506,0942\*x



# Enrichment, range

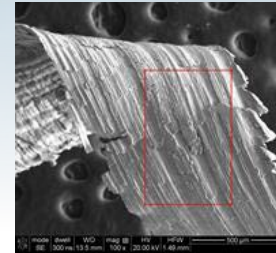
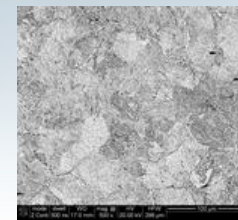
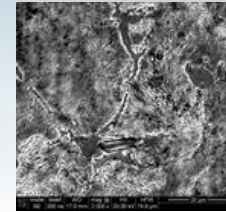


- Large sources predominantly local
- Sharp gradients
- May depend on corrosion
- Range not directly depend on concentration

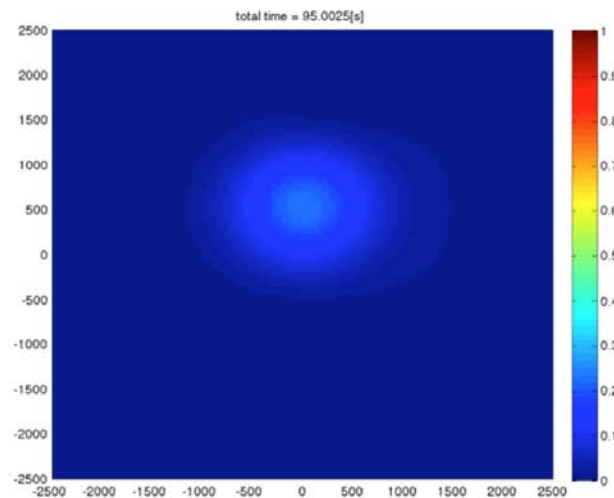
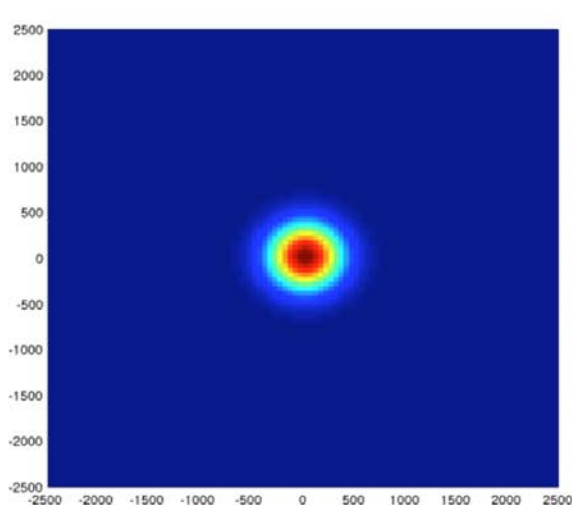




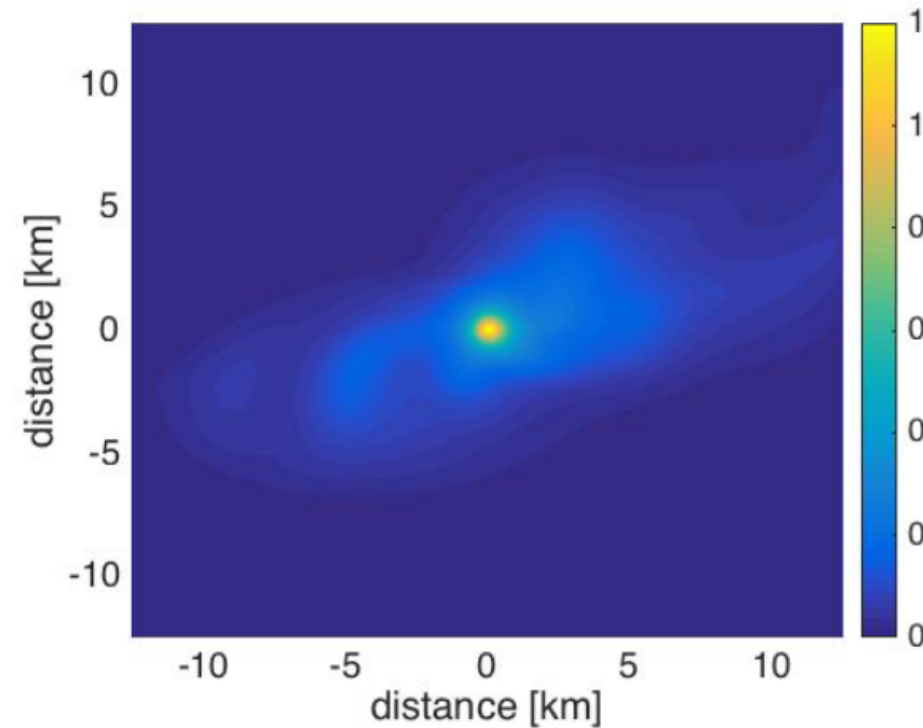
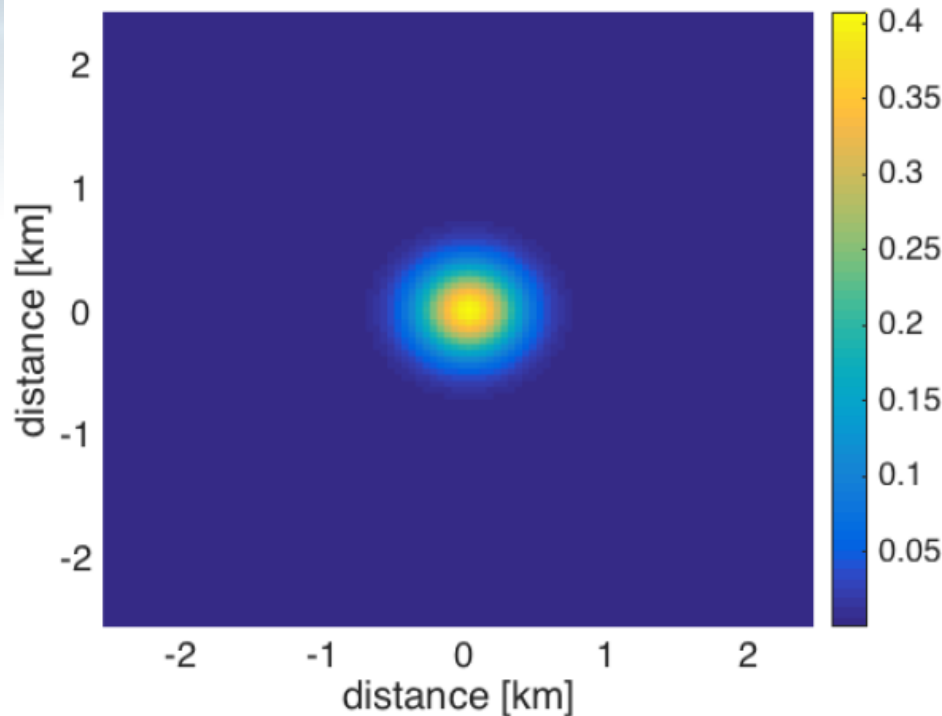
# Modelling release



**Corrosion:**  
**X-ray Energy Dispersive Spectroscopy**  
**Release:**  
**High Resolution Model, NEMO**

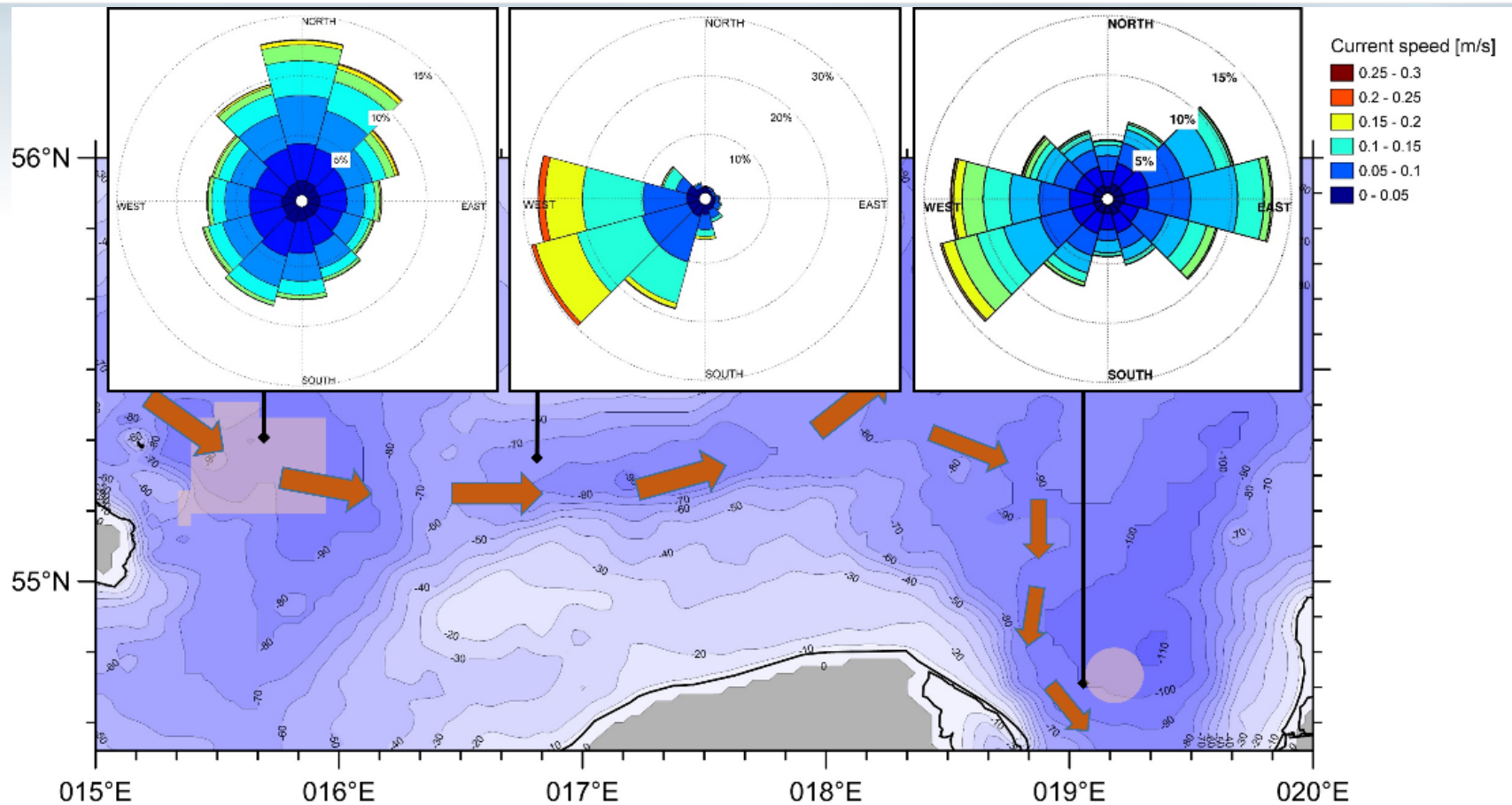


# High Resolution Model (HRM)-Bornholm Deep (constant leakage)



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.

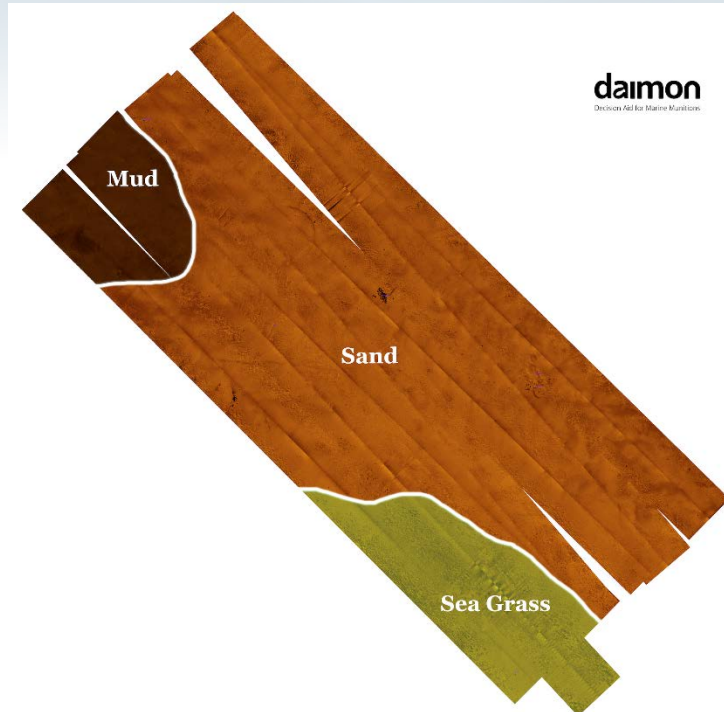
# 3.1 History and Current Status



Bottom Currents



# Impact on biota



- Mussel
- Fish
- Infauna

## Types of habitats

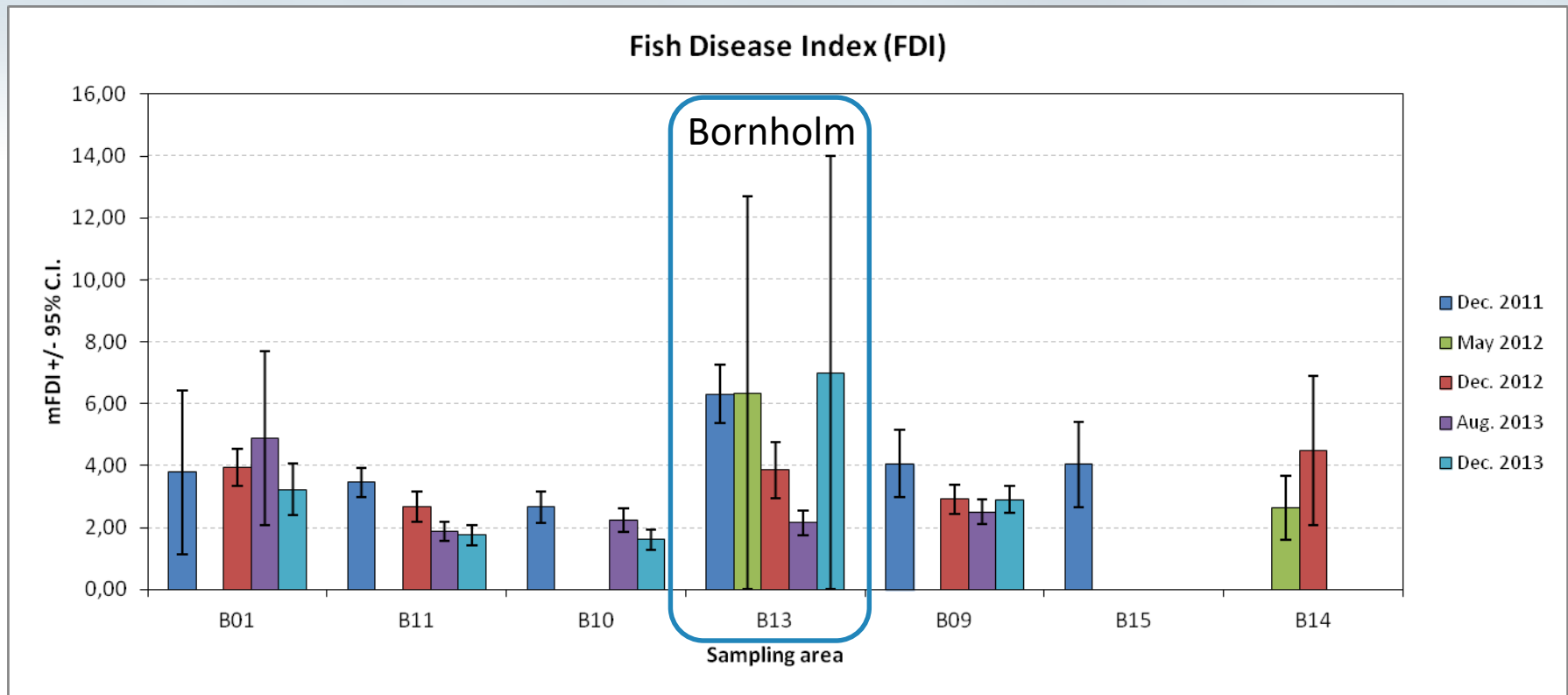
A5.2 - Sublittoral Sands

A5.4 - Sublittoral Mixed Sediments

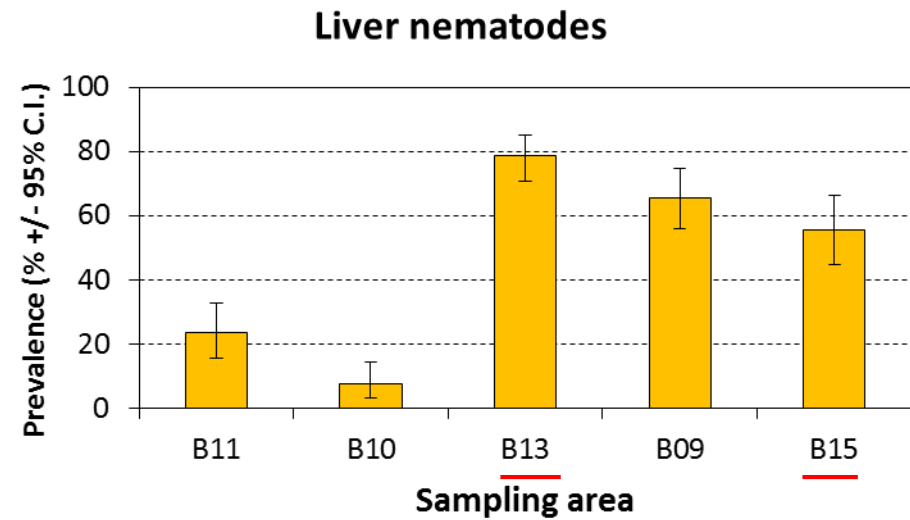
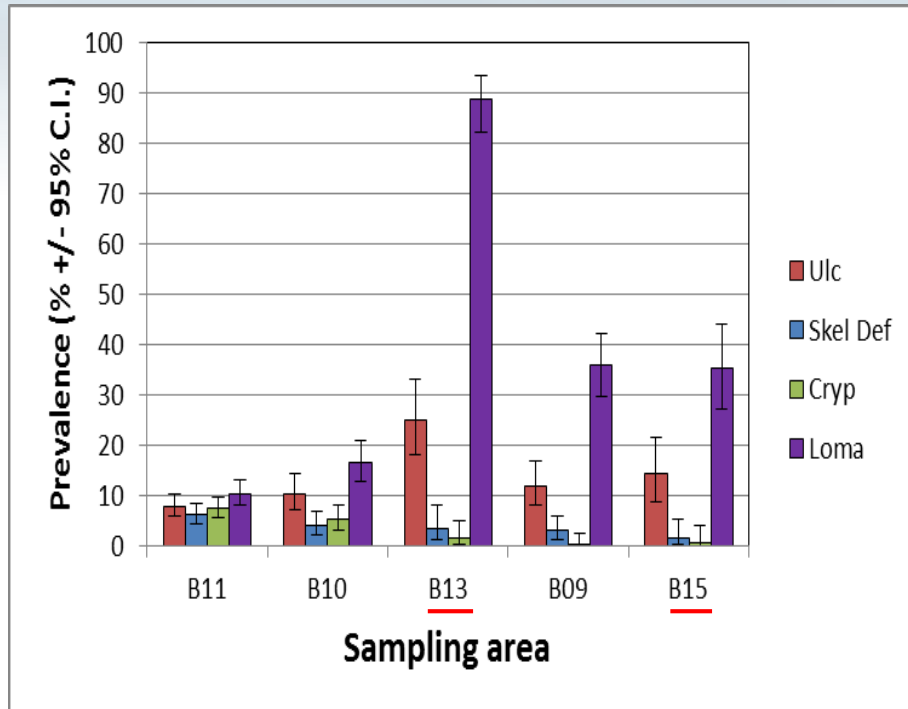
A5.5 - Sublittoral Macrophyte-Dominated Sediment

# 3.1 History and Current Status

Fish Disease Index (FDI)

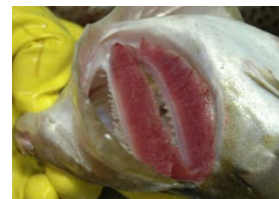


# Diseases/Parasites



## Conclusions

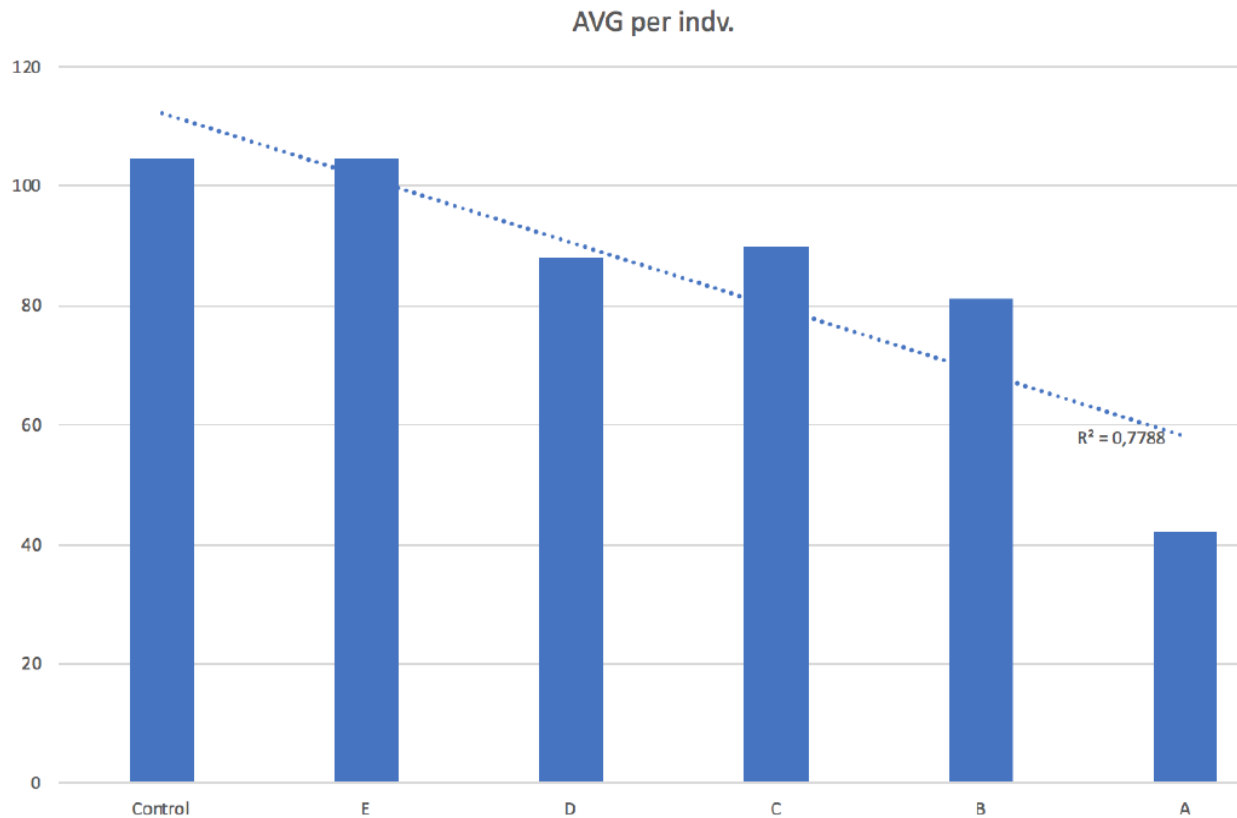
- Significant differences in diseases





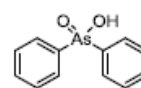
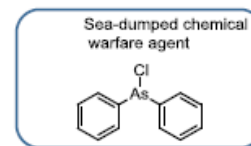
# Toxicity

Clark I chronic – 21 days / micrograms per liter

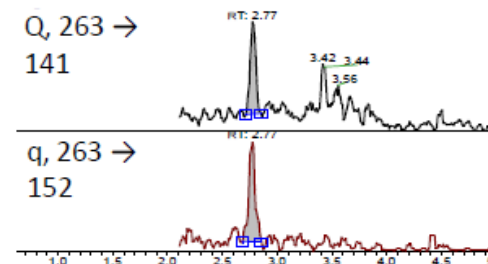


A – 10  
B – 5  
C – 2,5  
D – 1,25  
E – 0,625

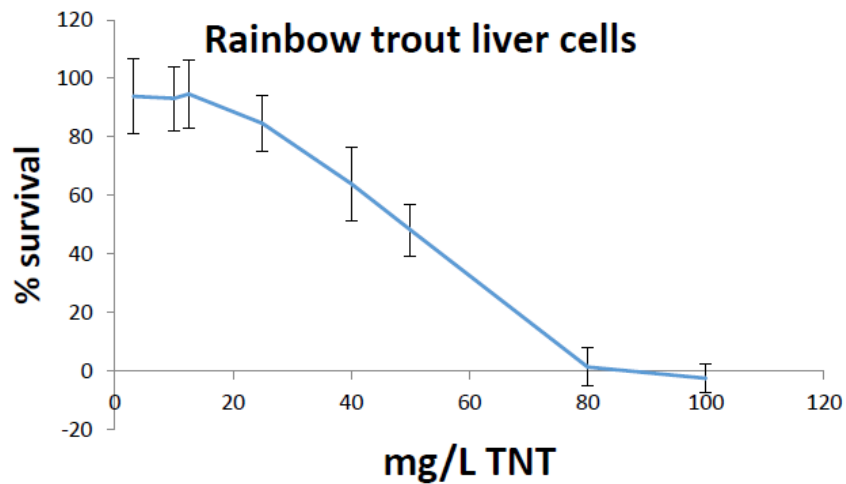
# Biota Impact



Q, 263 →  
141



q, 263 →  
152



# 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



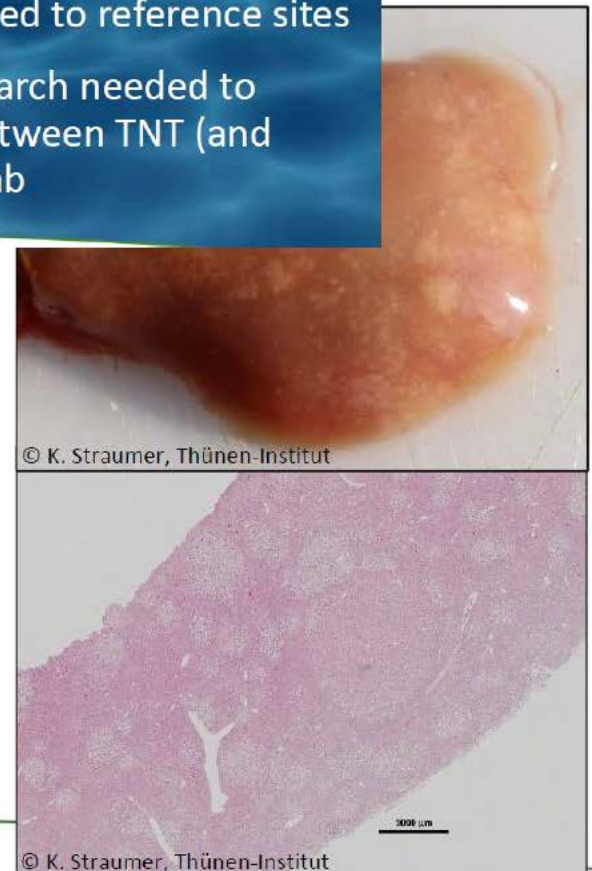
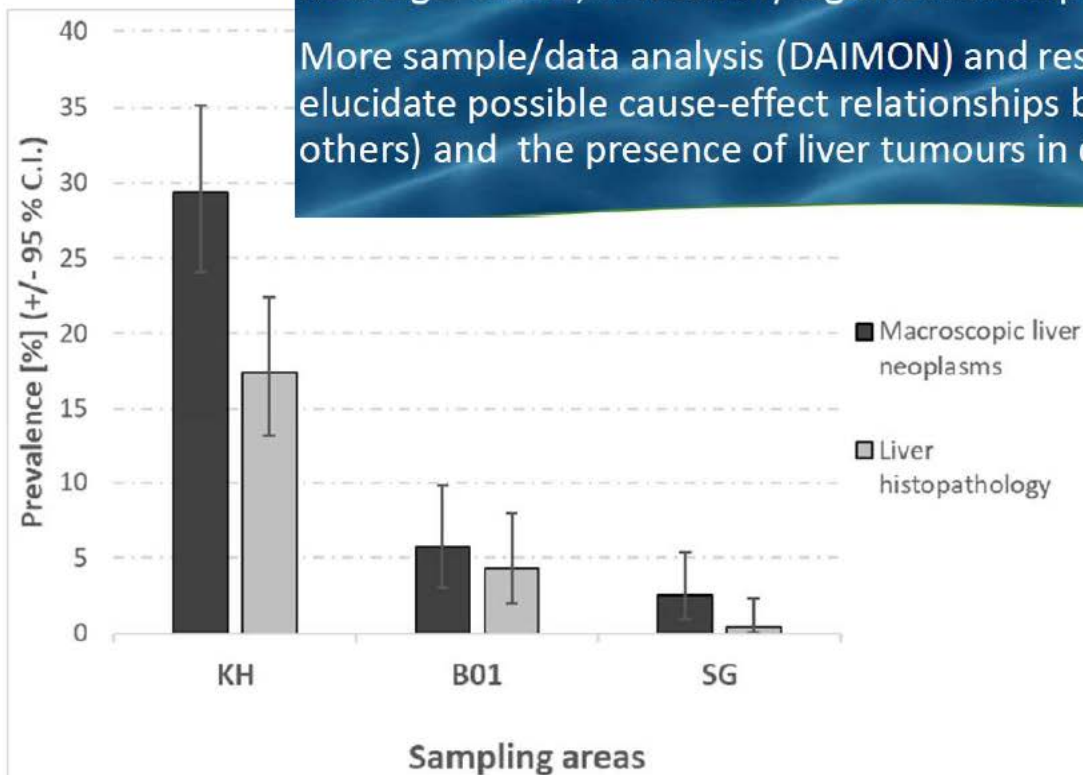
# Biomarkers

## Liver neoplasms and histopathology

DAB

markedly high prevalence of liver tumours in fish from the dumpsite Kolberger Heide, statistically significant compared to reference sites

More sample/data analysis (DAIMON) and research needed to elucidate possible cause-effect relationships between TNT (and others) and the presence of liver tumours in dab



# Food web impact

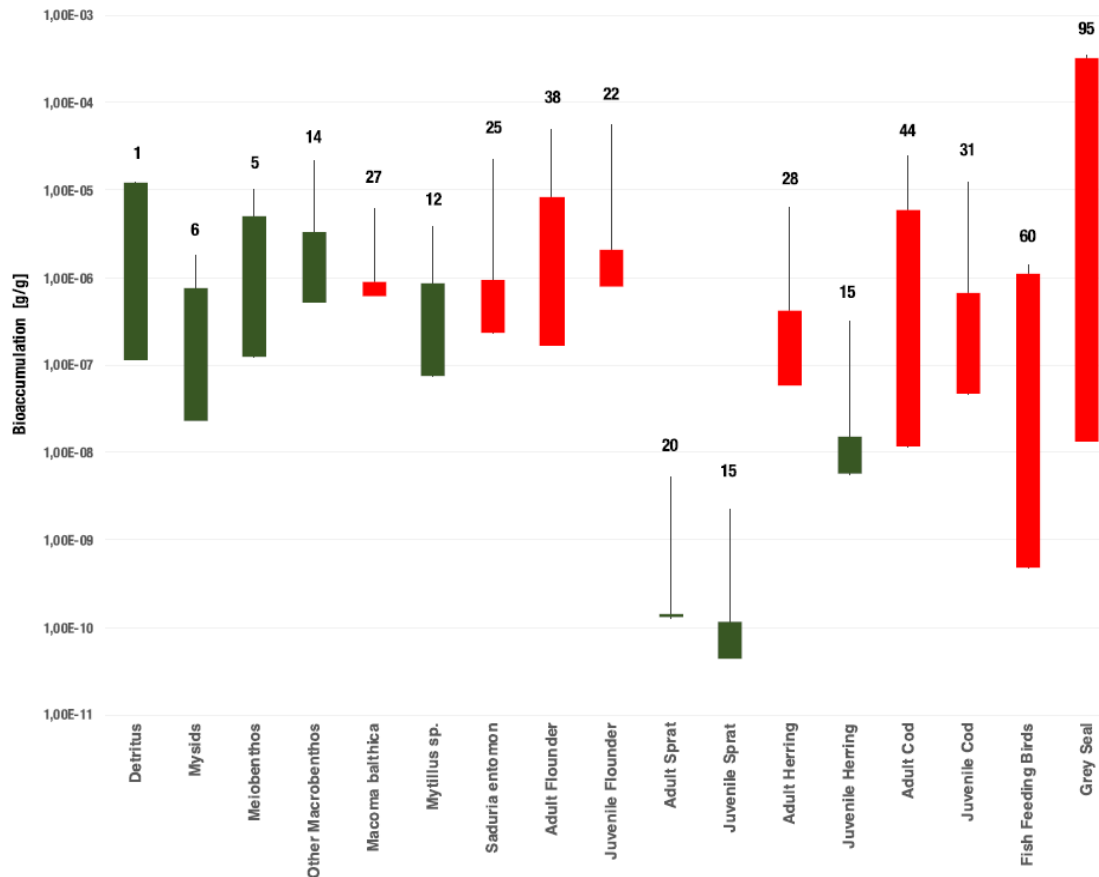


Figure 3.

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.

# DAIMON Outline

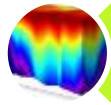
Methods

Risk Assessment  
Tool

Decision support



Munition Status Examination



Modelling of possible release



Pollution of sediments and water



Impact on biota assessment



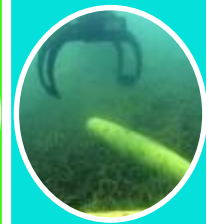
Risk categorization procedure



Monitor



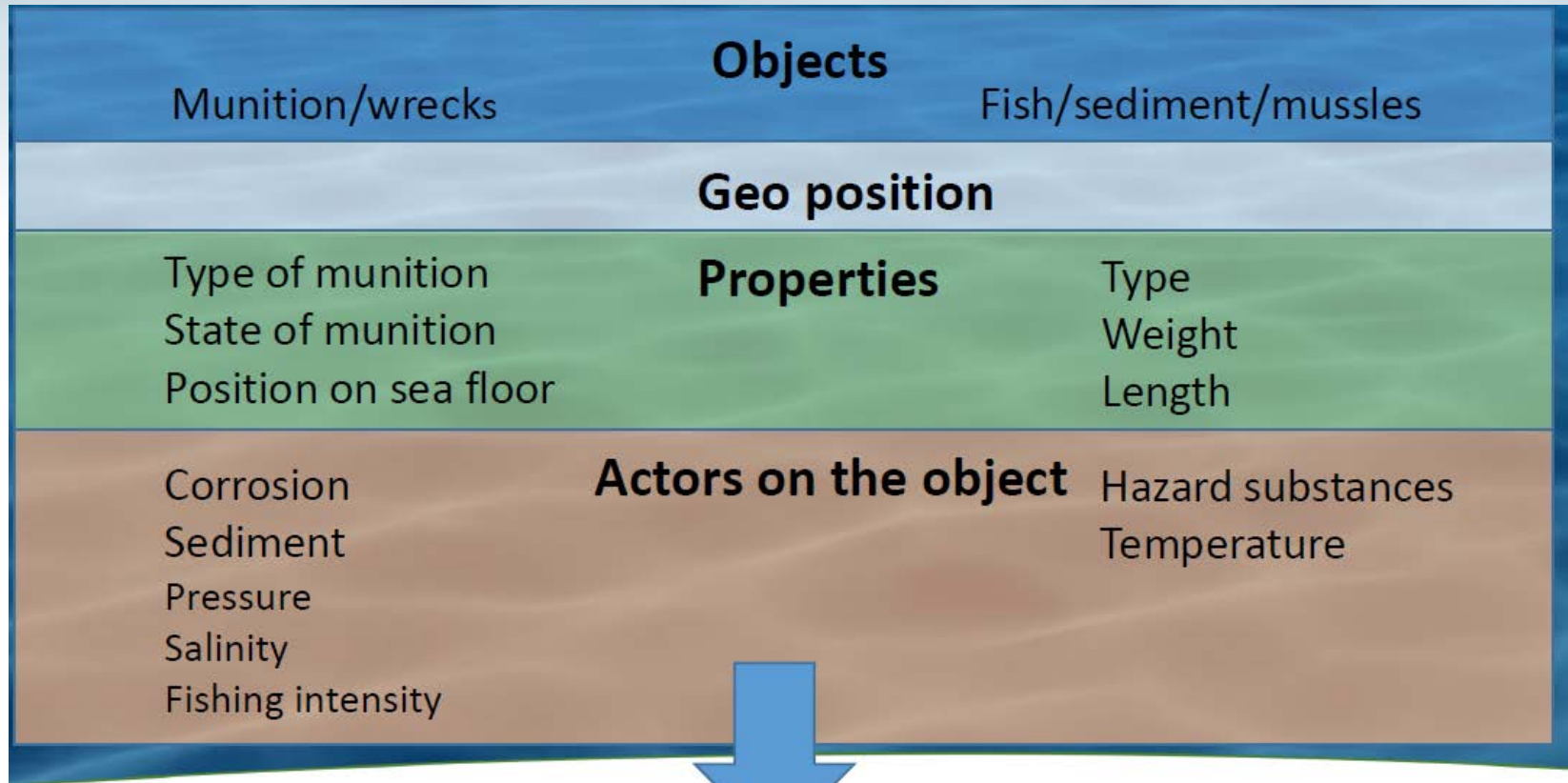
Manage



Remediate

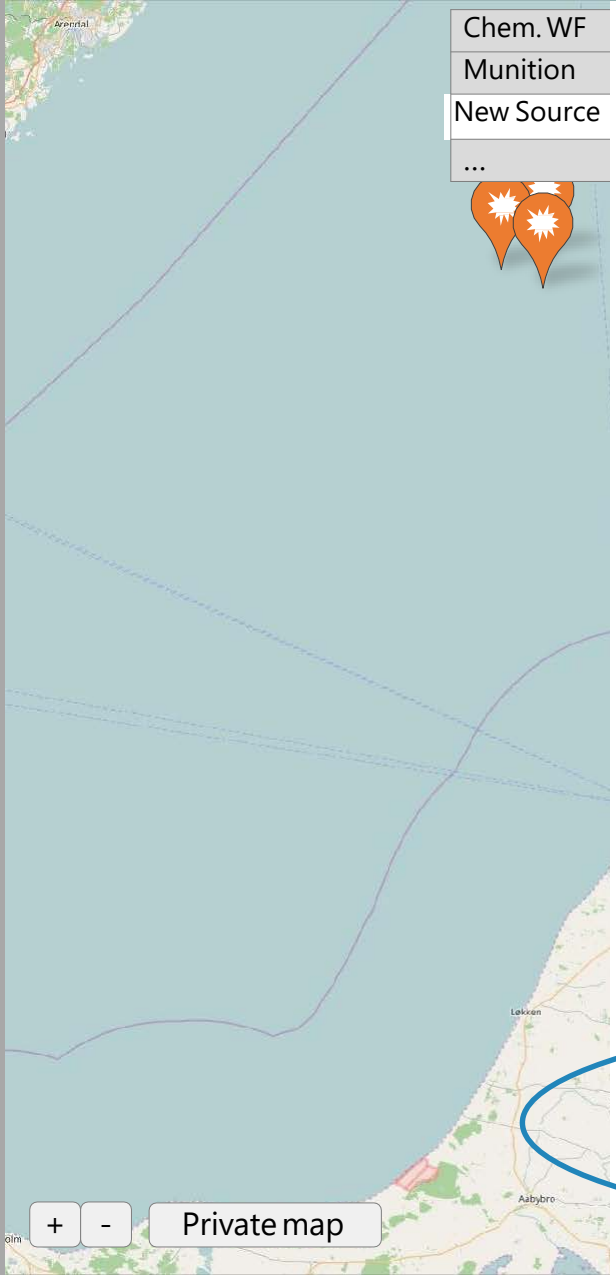


# DSS



State of hazardness





- Chem. WF
- Munition
- New Source
- ...



### Enter data about a new detection of warfare agents

- Chem. WF
- Munition

Date of detection: 16 / 11 / 2018

Place of detection:  GPS Coordinates

What munition was detected: Sea mine  
Land mine

fired  
lost  
dumped  
unkown

Enter new munition type

- How was the munition detected:
- On sea ground
  - adrift
  - fishernet
  - Washed up at the coast
  - other

State of corrosion: 4

Leaks: 0

Calculated ecological hazardousness: (low) (high)

Level of confidence: (low) (high)

Cancel

Save data set and classify munition

# Thank You for attention



1) 'The research work was funded by the European Union (European Regional Development Fund) under the Interreg Baltic Sea Region Programme 2014-2020, project #R013 DAIMON'

2) 'The research work was financed by the Ministry of Science and Higher Education from the 216-2019 science funding allocated for the implementation of international co-financed project'