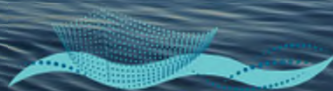


AMM TRACe

Marine **AMM**unitiOn dump site exploration
by surface- and underwater-based laser
mass spectrometric **TRAC**ing technology

Björn Raupers



MarTERA
ERA-NET COFUND



Funded by the
European Union

Project number: 728053

<https://www.ammotrace.eu>

Scientific partners



Coordinator, offline analytic



spectroscopy, MS design



membrane tech, MS design



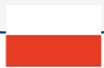
pore water sampling, ROV



Industrial partners



laser design



ROV housing and implementation



Demonstration, geophysical techniques



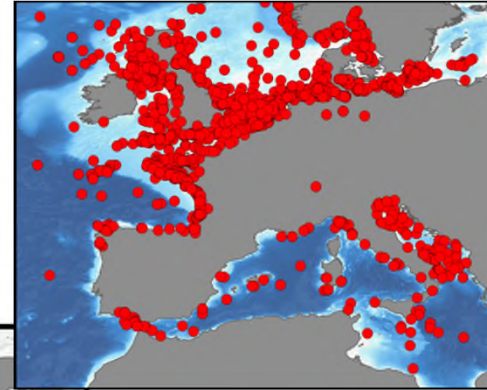
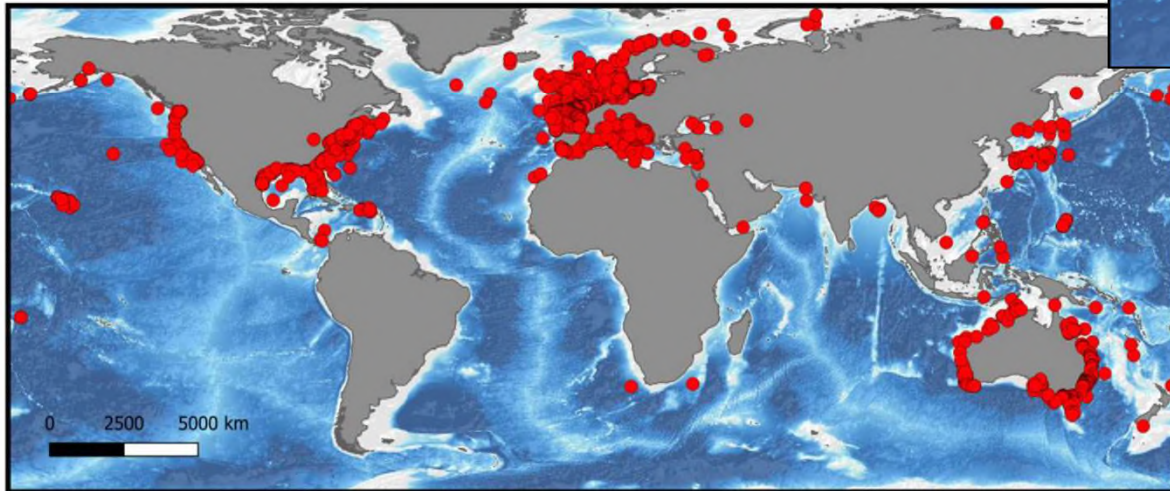
MS design, software

Project duration: 3 years

10/21 – 08/24

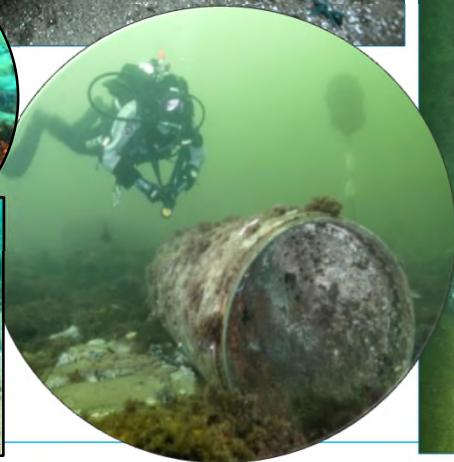
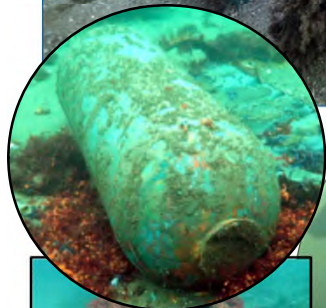
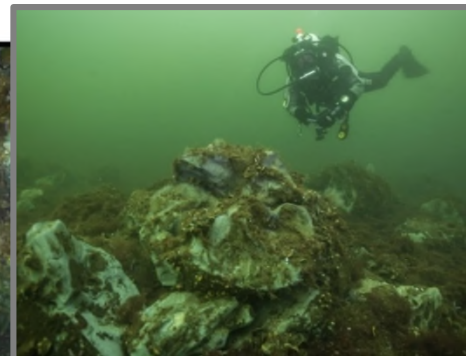
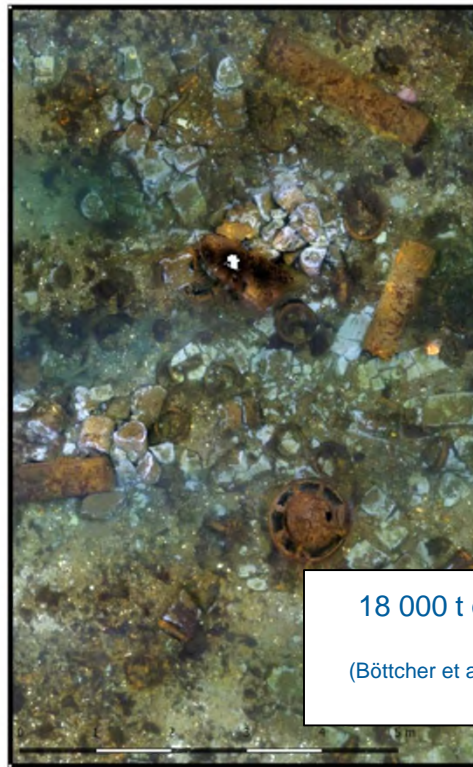
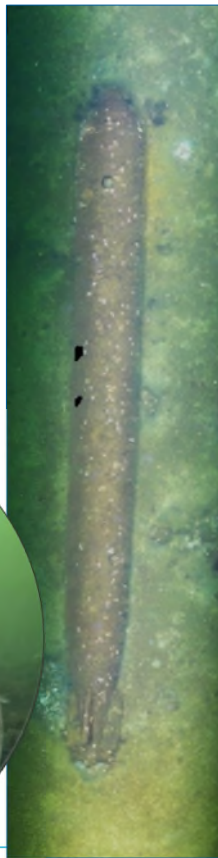
Munition in coastal waters – a global problem

- Baltic Sea (Germany): 300 000 t of munition & 5 000 t of chemical warfare agents (Böttcher et al., 2011)
- North Sea (Germany): 1 300 000 t of munition & 9 000 t of chemical warfare agents (Böttcher et al., 2011)



Images: A. Beck, J. Ulrich

Impressions from the sea floor

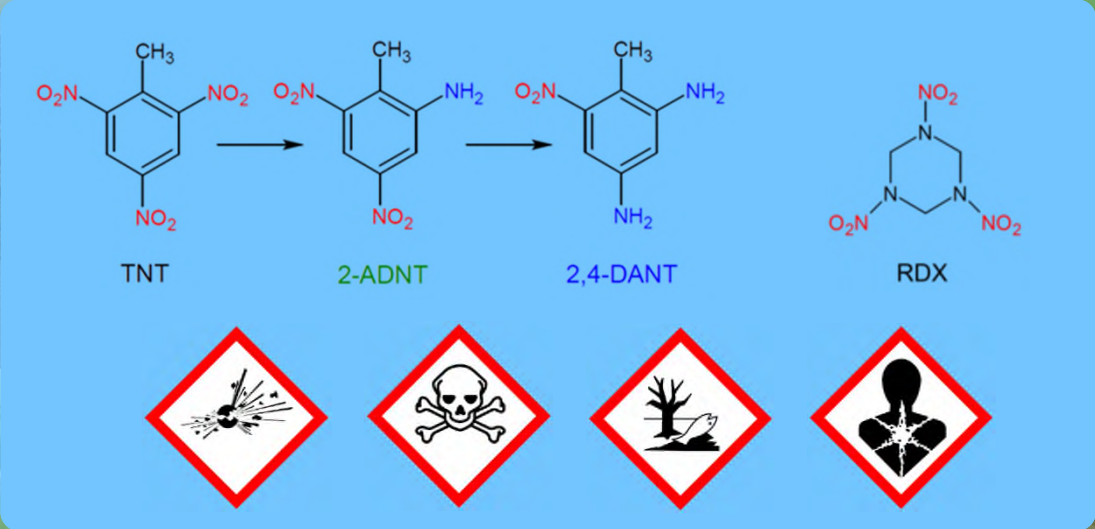
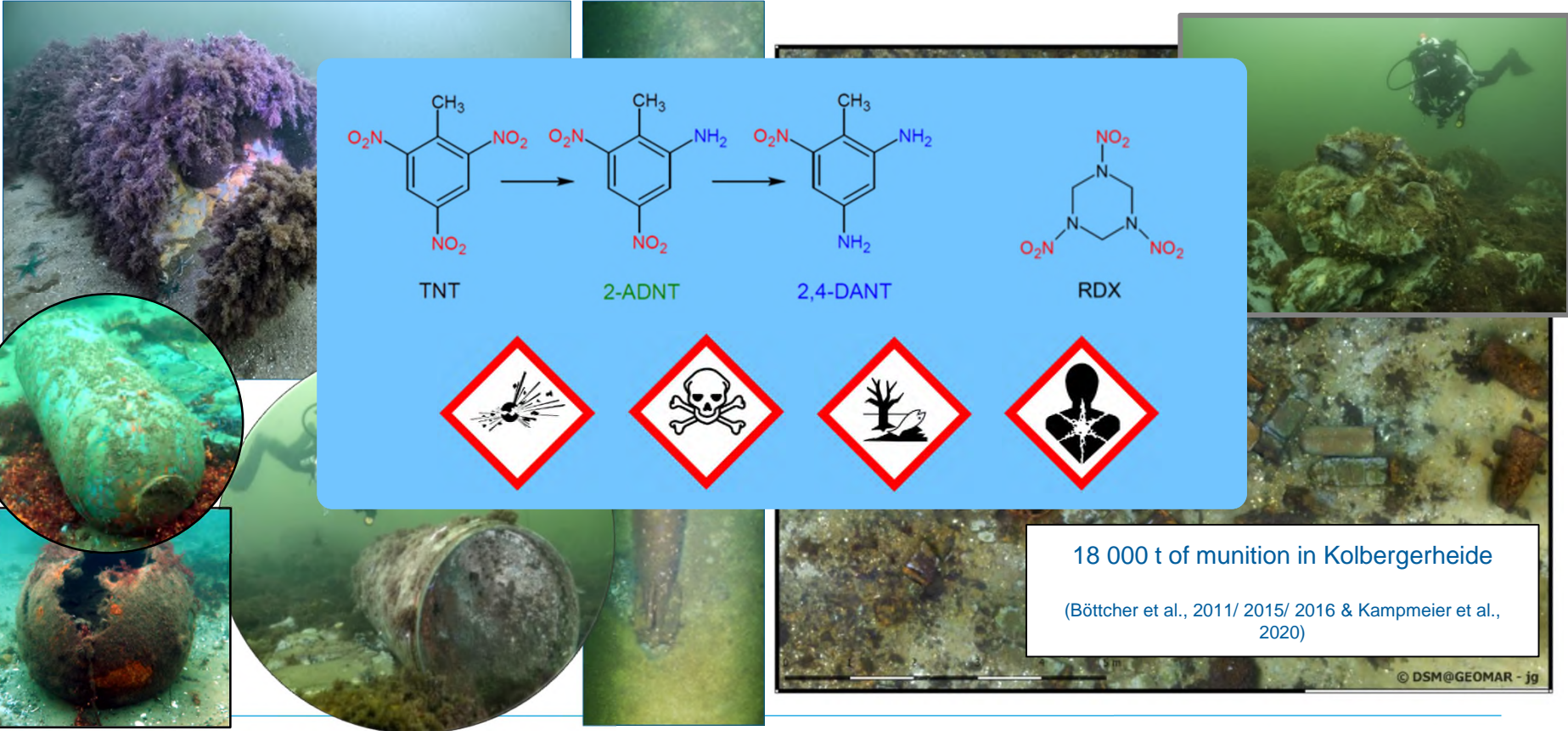


18 000 t of munition in Kolbergerheide

(Böttcher et al., 2011/ 2015/ 2016 & Kampmeier et al., 2020)

© DSM@GEOMAR - jg

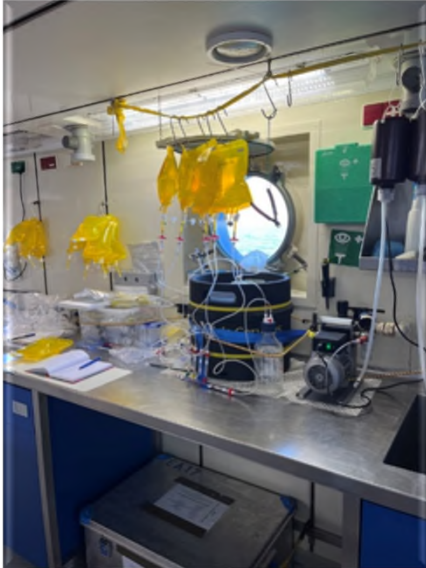
Impressions from the sea floor



18 000 t of munition in Kolbergerheide
(Böttcher et al., 2011/ 2015/ 2016 & Kampmeier et al., 2020)

State of the art

Laboratory approach



1

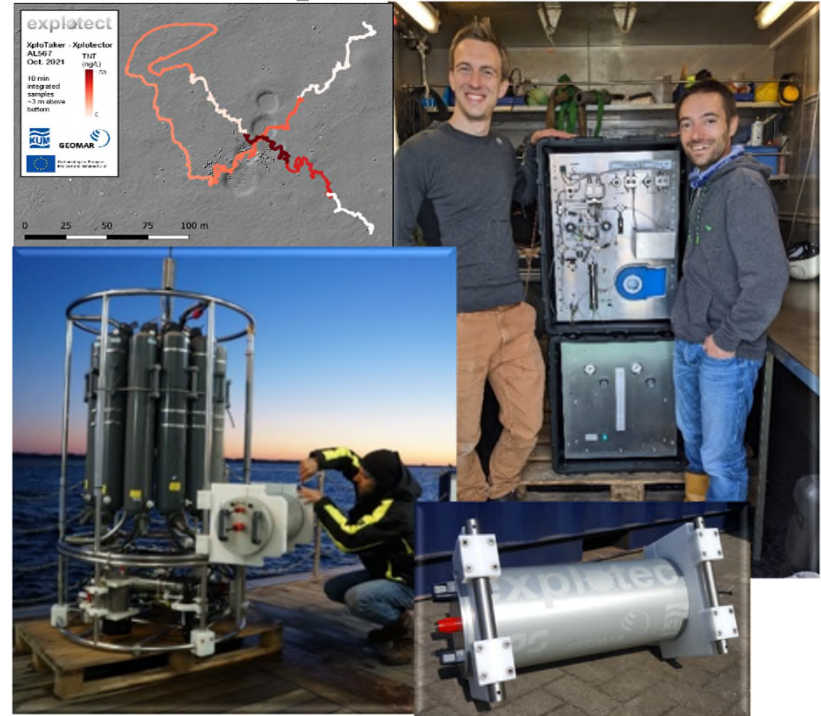


2

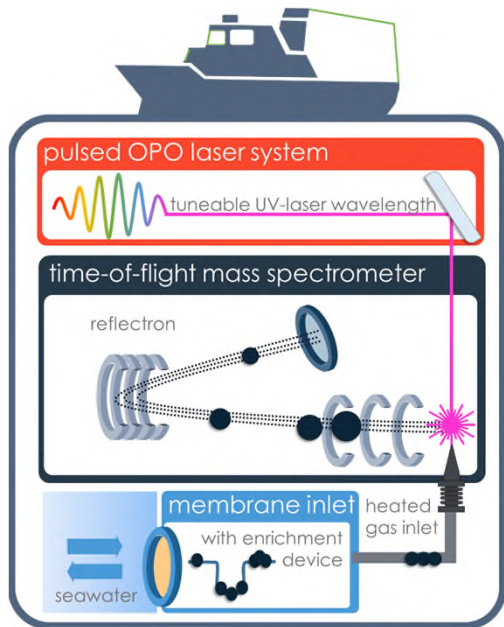


- Laboratory LOD of TNT in seawater 0.02 ng/L

explotect

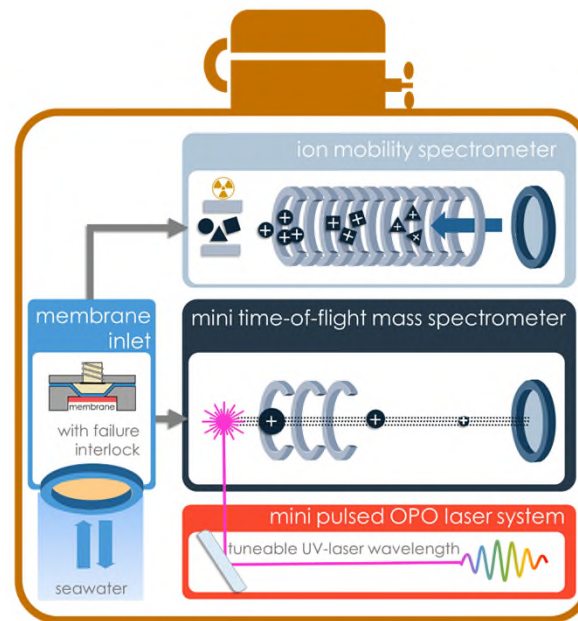


Ship-based sensor



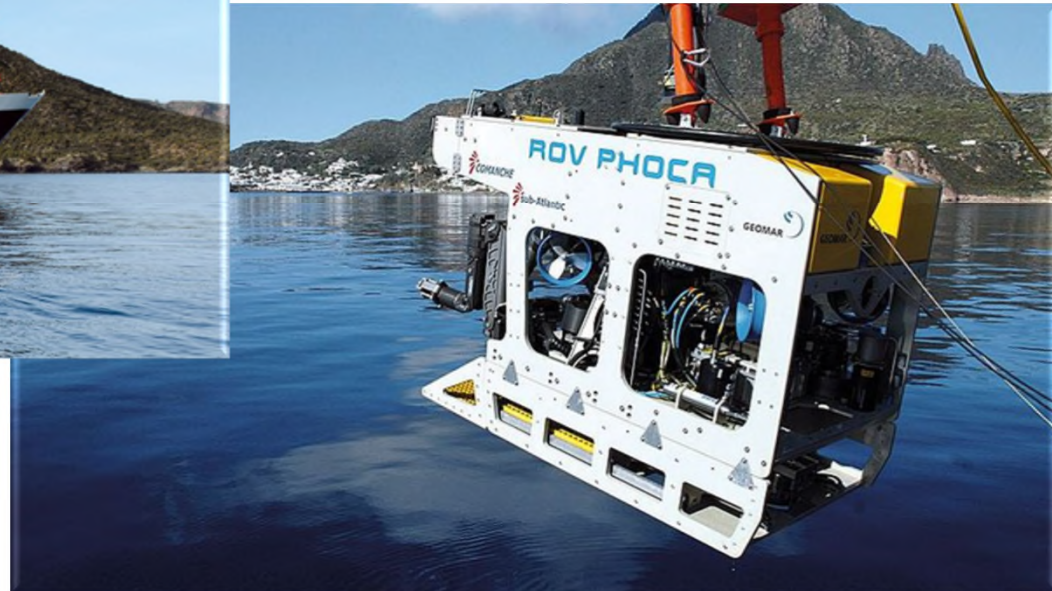
- sensitive detection of munition compounds
- rough localization

ROV-based sensor



- fast detection of munition compounds
- exact localization and confirmation

The operating platform



Ship-based laser



- Field tested tested Oktober 2023 on GEOMAR vessel



ROV-based sensor

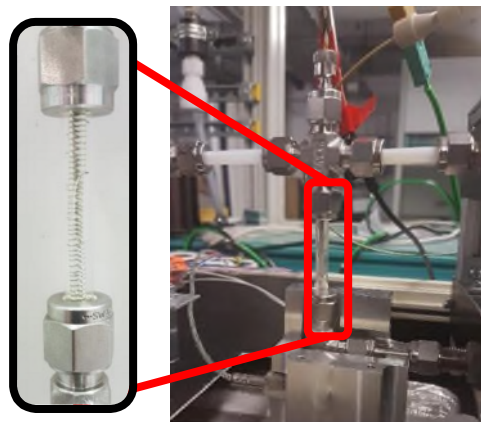
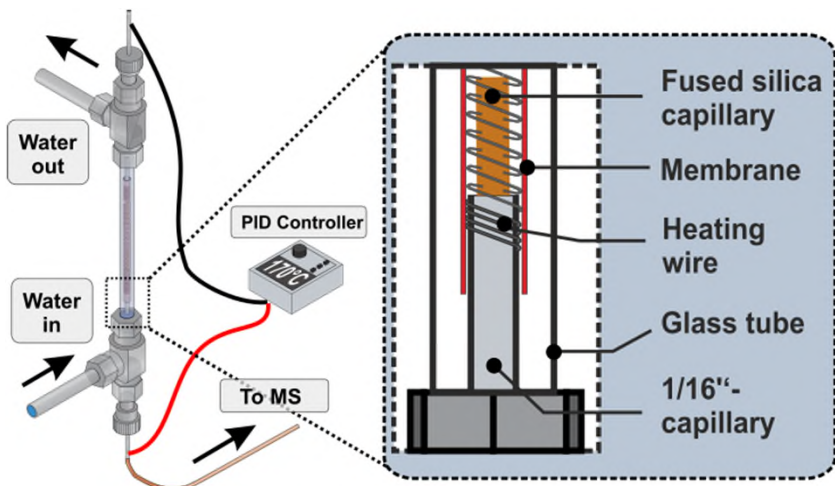


- First tests starting in March 2024

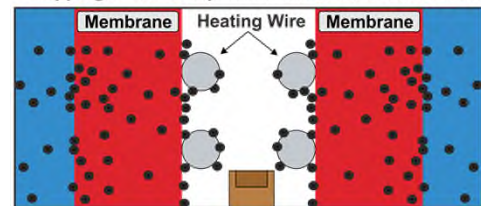
Work in Progress

- Software development
- Power supply development for ROV setup

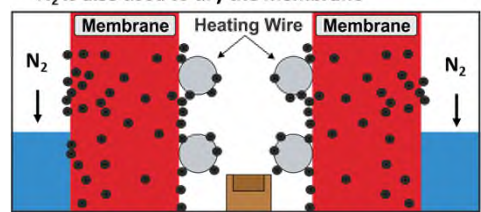
Membrane inlet



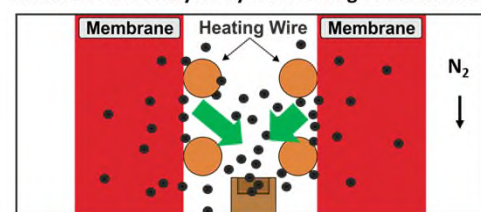
Trapping of the analytes on cold membrane surface



Water is pressed out of the glass tube by N₂; N₂ is also used to dry the membrane



Release of the analytes by fast heating of the membrane

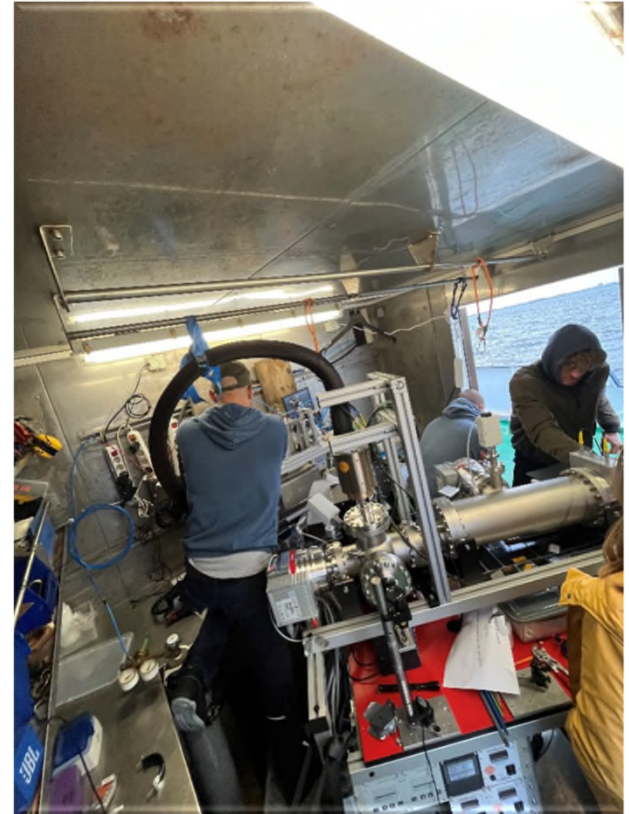
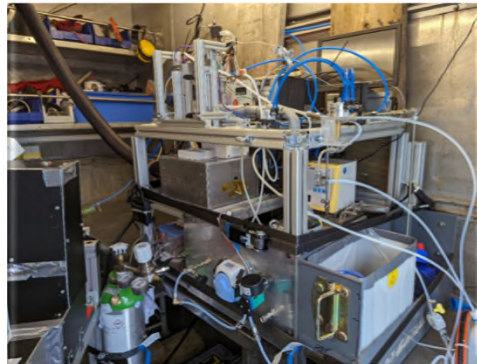


- Hollow fiber membrane (250 μm wall thickness) on 1/16'' stainless steel capillaries
- Ni heating wire is used to heat the membrane's inner surface

Test cruise on Littorina (L23-15)

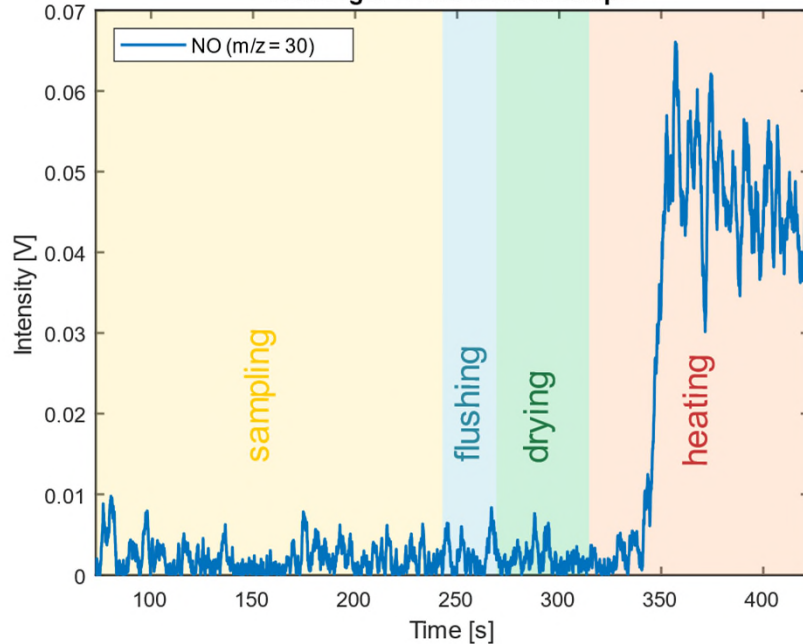


AMMOTRACe – Field test fall 2023



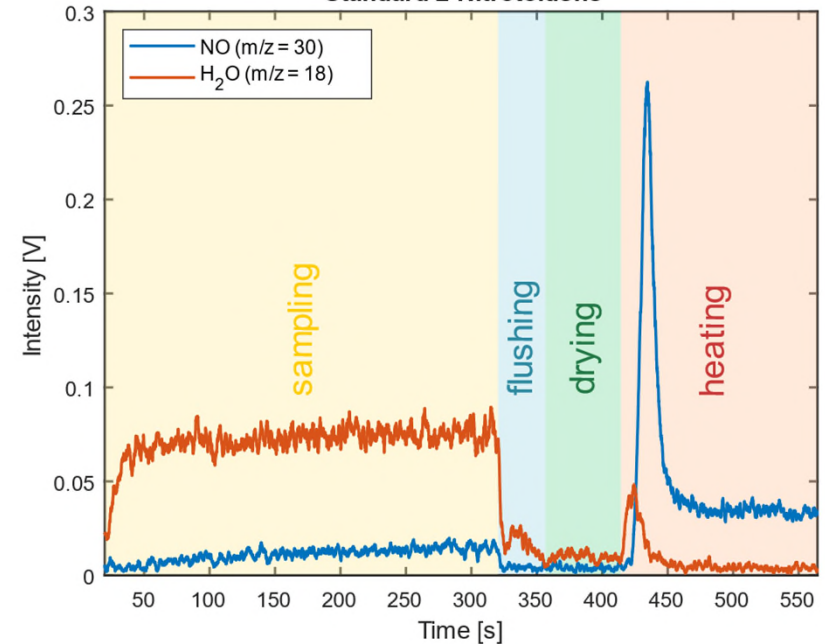
AMMOTRACe – Field test fall 2023

Kolberger Heide bottom sample



- Kolberger Heide bottom sample (blank subtracted) (≈ 30 ng/L)
- Membrane temp. 200 °C
- Water temp. 80 °C
- Wavelength: 226 nm

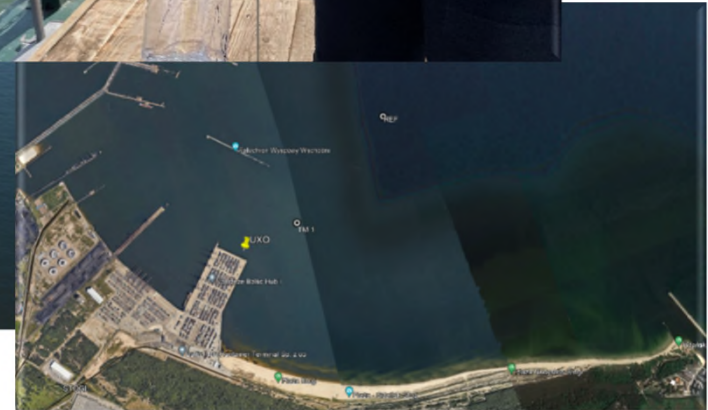
Standard 2-Nitrotoluene



- Standard 2-NT (46,4 $\mu\text{g/L}$)
- Membrane temp. 200 °C
- Water temp. 80 °C
- Wavelength: 226 nm

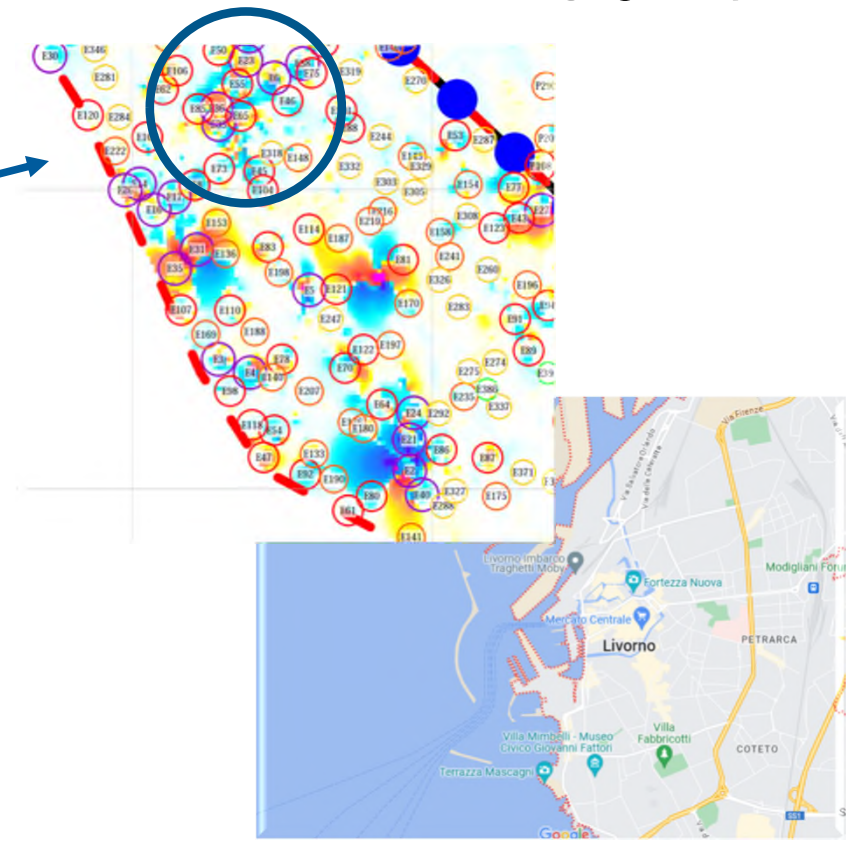
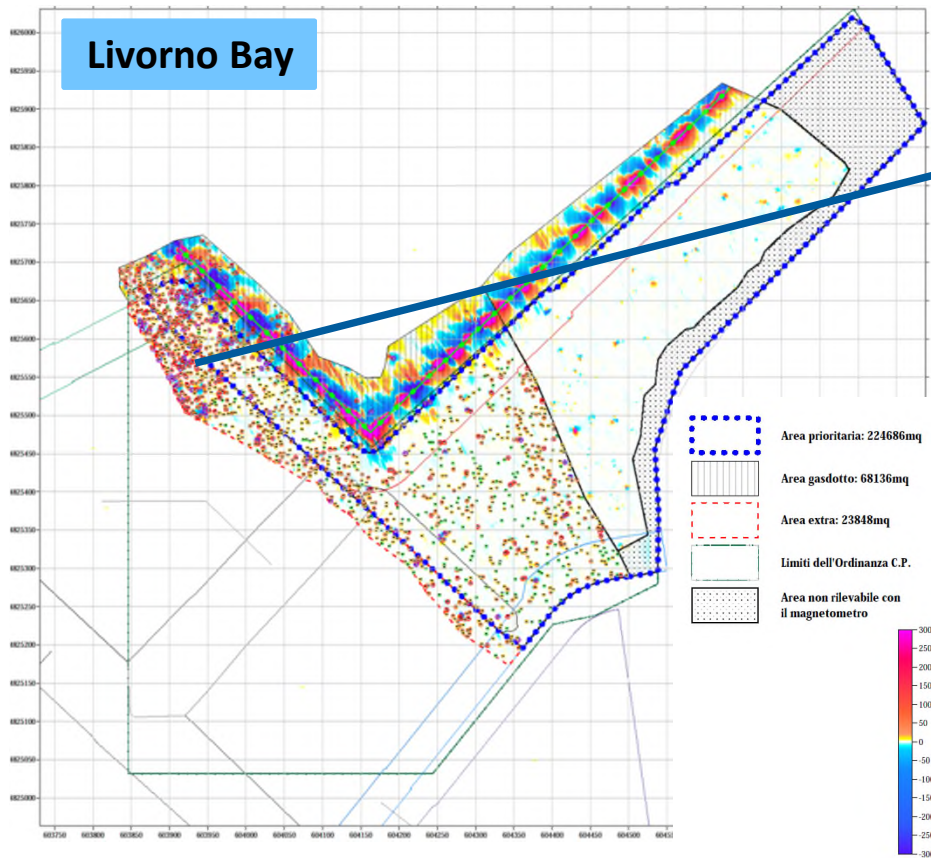
DEME Cooperation – Poland – Summer 2023

Gdansk Bay



DEME Cooperation – Italy – Fall 2023

Livorno Bay



Thank you for your attention




TrAC Trends in Analytical Chemistry




Volume 163, June 2023, 117084



In situ detection of munition compounds in coastal waters

[Björn Raupers](#)^a, [Johannes Passig](#)^{b c}, [Christian Gehm](#)^{b d}, [Aaron J. Beck](#)^a, [Mario Esposito](#)^a,
[Martha Gledhill](#)^a, [Ralf Zimmermann](#)^{b c}, [Eric P. Achterberg](#)^a  

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