

Effect of sediment resuspension on near-bottom mercury dynamics

Insights from a Baltic Sea experiment

Agnieszka Jędruch, Ewa Korejwo, Grzegorz Siedlewicz, Aleksandra Cichecka,
Jacek Bełdowski

Institute of Oceanology Polish Academy of Sciences
Department of Marine Chemistry and Biochemistry
Laboratory of Contemporary Threats to Marine Ecosystems

hyron@iopan.pl



Sediment resuspension

Natural causes

- Waves and currents
- Severe weather events
- Seismic and volcanic activity

Human activities

- Offshore industry (e.g., wind farms, underwater pipelines)
- Dredging
- Sea mining
- Bottom trawling
- Boat traffic
- Clearance of underwater munitions and other hazardous objects



(photo: Adobe Stock)

Marine munitions removal

Techniques

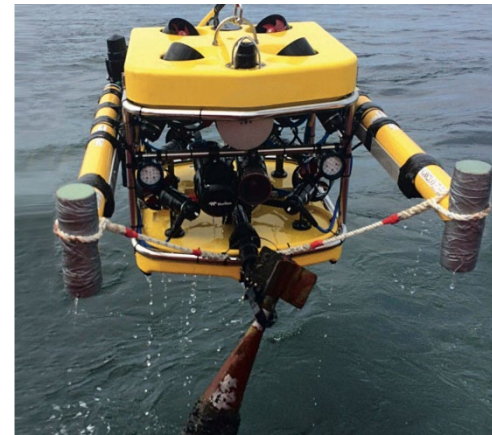
- Surveying and detection
- Excavation and retrieval of munitions from the seabed
- Controlled detonation
- Relocation to a designated disposal site
- Erosion and scouring around the disturbed area

Environmental impacts

- Habitat disruption
- Remobilization of contaminants
- Turbidity increase
- Underwater noise



(photo: Adobe Stock)

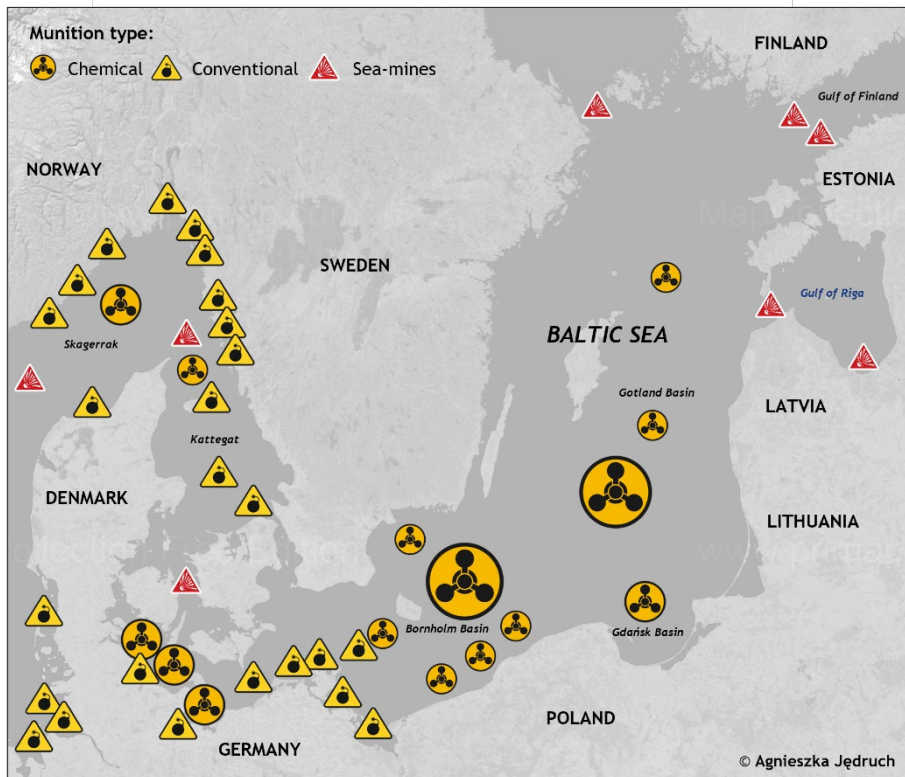


(photo: SeaTerra)

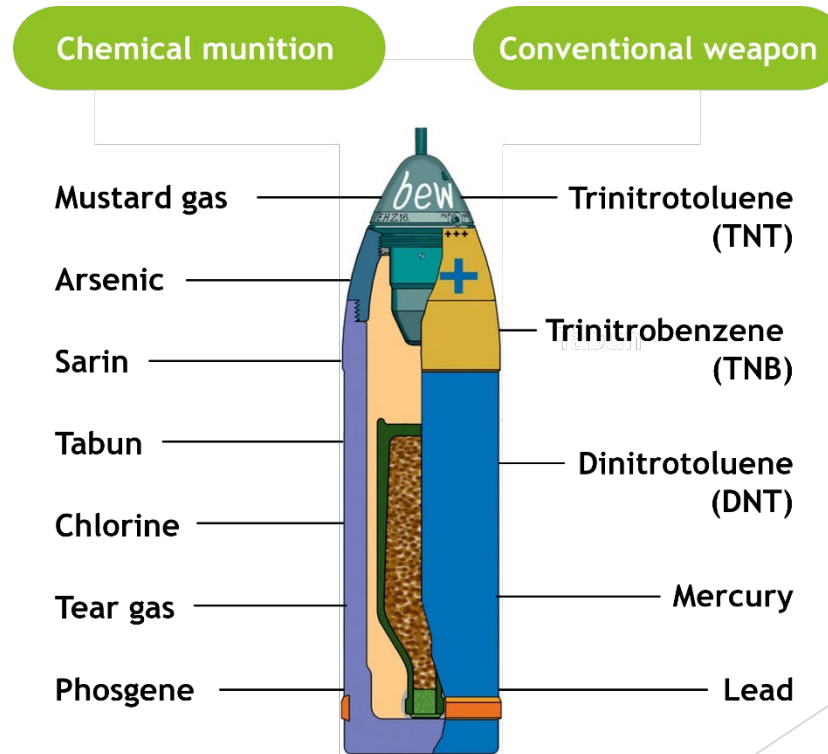


(photo: A. Jędruch)

Marine munitions: Hot spots of pollutants

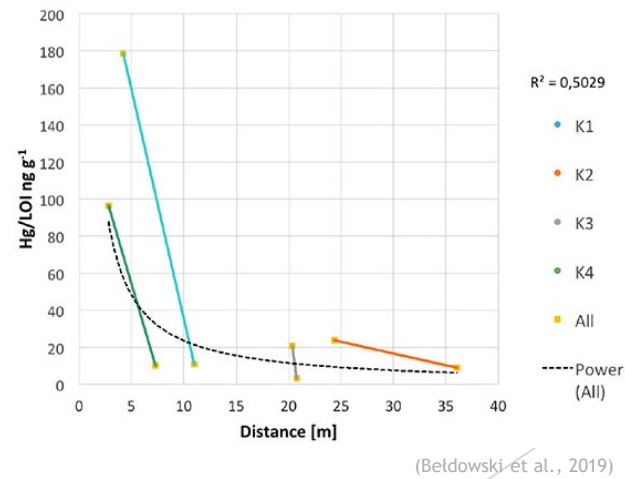
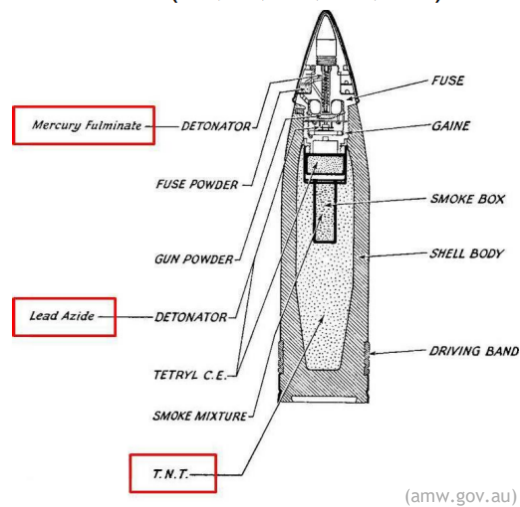


Source: HELCOM (1994, 1995, 2021), Koch and Nehring (2007), CHEMSEA project (2013), EMODnet (2024)

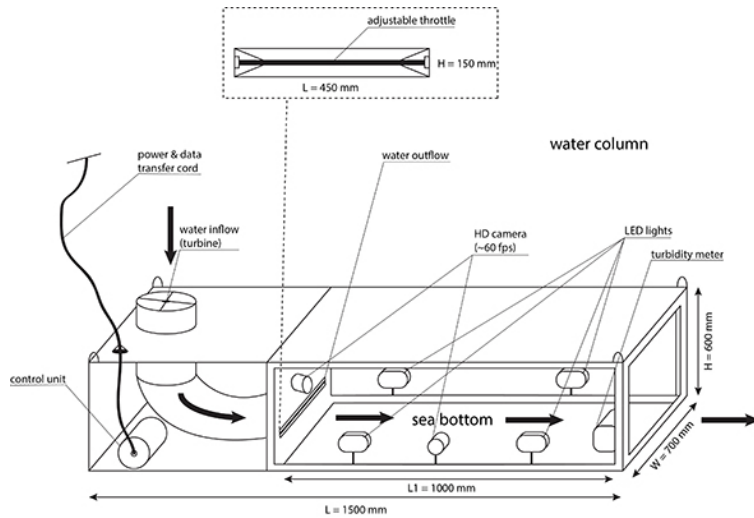


Mercury as a tracer approach

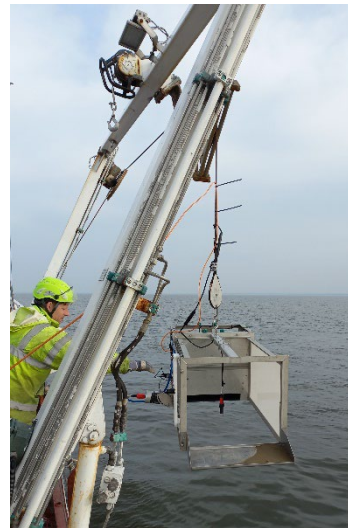
- Mercury (II) fulminate ($\text{Hg}(\text{CNO})_2$) used as a primary explosive material in many types of artillery shells, grenades, and mines
- Dumped munitions in the Baltic Sea contain about 300 t of mercury
- Increased mercury concentration in sediments form chemical and conventional munition dumpsites, especially close to the sunken object



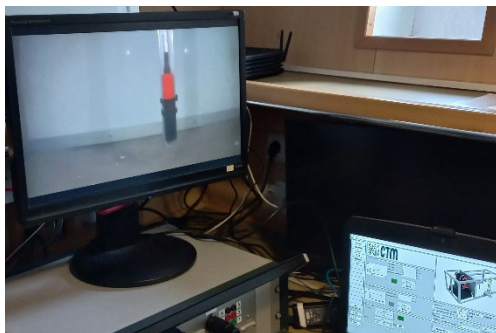
Critical Shear Threshold Device



Source: CTM: Ośrodek Badawczo-Rozwojowy Centrum Techniki Morskiej S.A.



(photo: A. Jędruch)

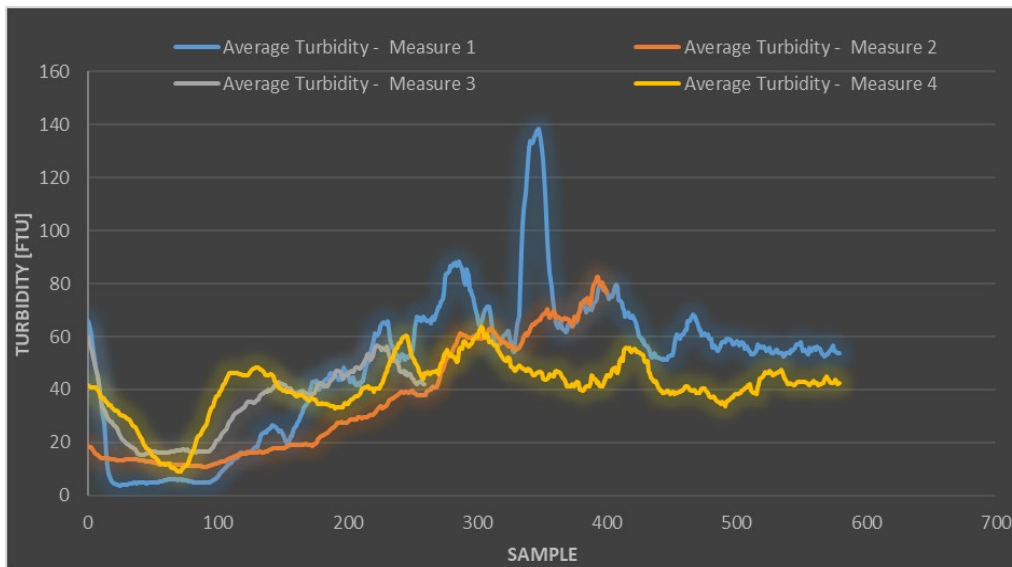
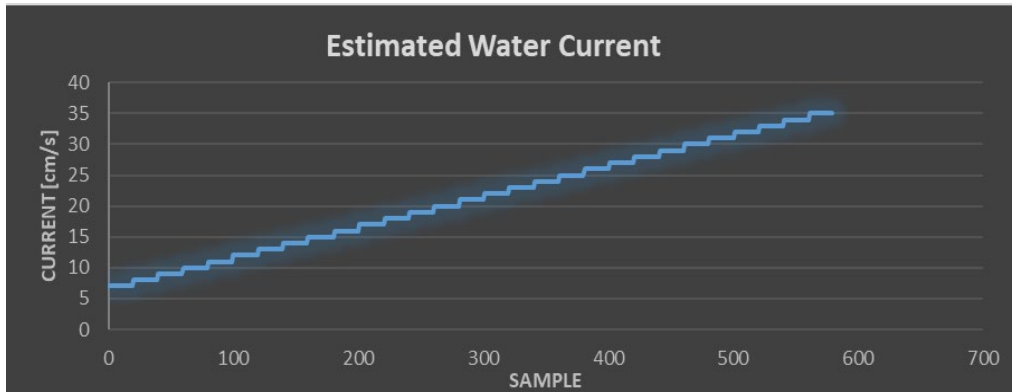


(photo: A. Jędruch)



(photo: A. Jędruch)

Critical shear stress

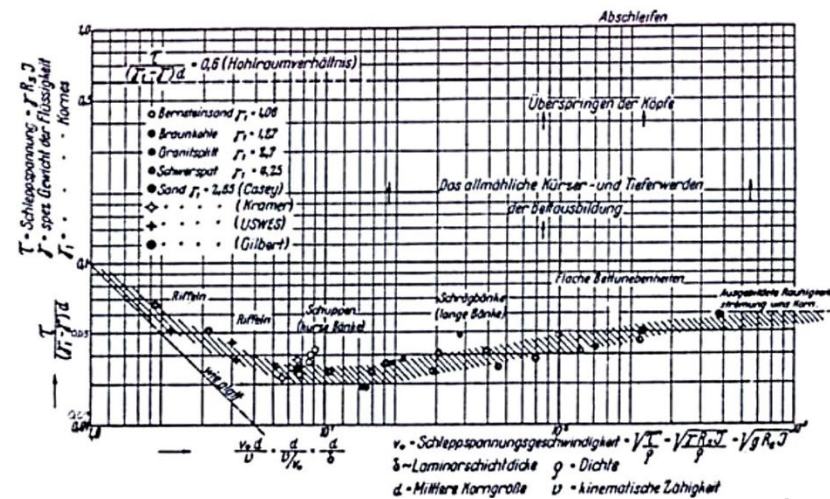


$$\tau_* = \frac{\tau}{(\rho_s - \rho_f)(g)(D)}$$

$$\tau_b = \rho g h S$$

$$\tau_b^* = f(\text{Re}_p^*)$$

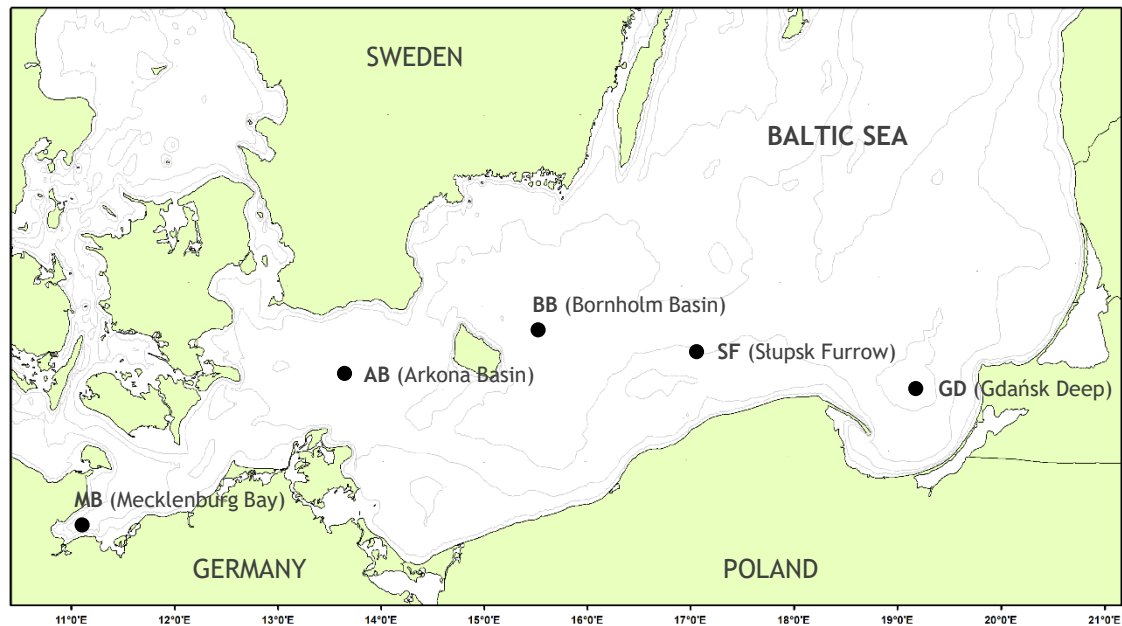
$$u_* = \sqrt{\left(\frac{\tau_b}{\rho}\right)}$$



Experiment

Impact of sediment resuspension on remobilization of mercury into the water

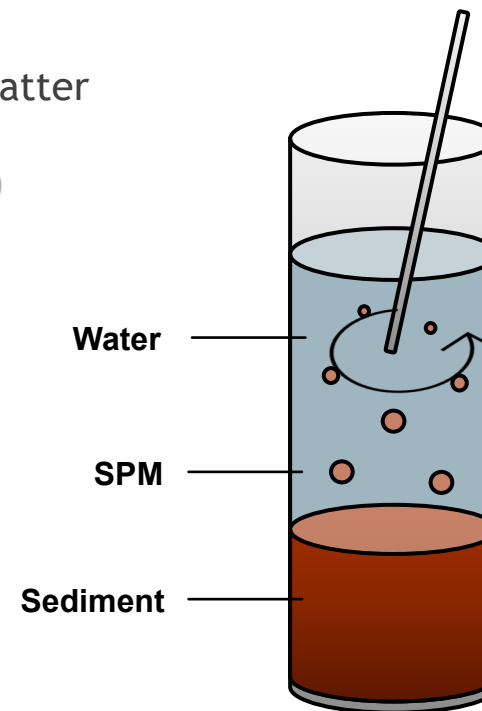
- **Research material:** Sediment cores taken from five different areas of the southern Baltic Sea to study the sediment resuspension and Hg remobilization processes
- **Sampling:** r/v Oceania cruise in October 2022



Experiment

Impact of sediment resuspension on remobilization of mercury into the water

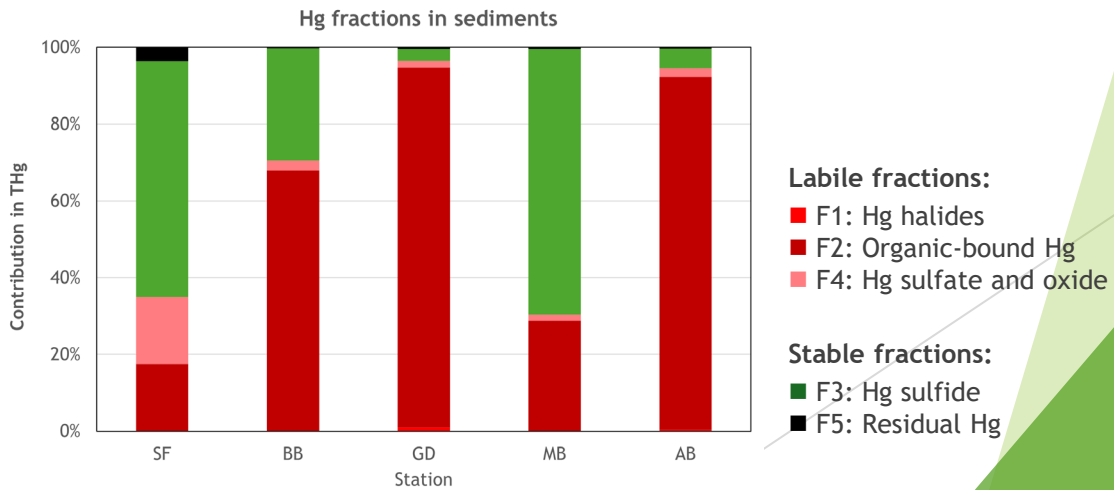
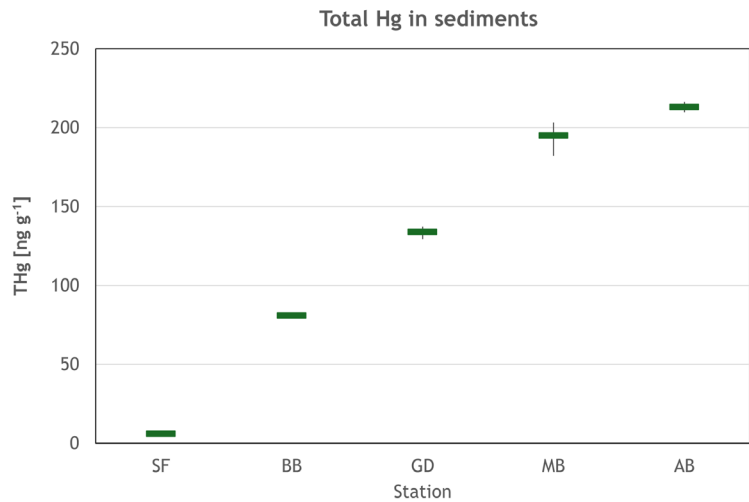
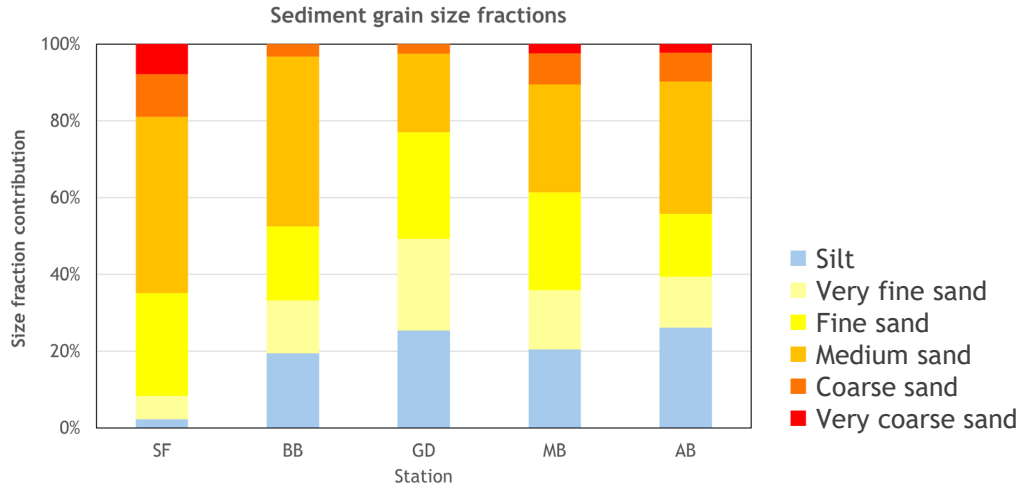
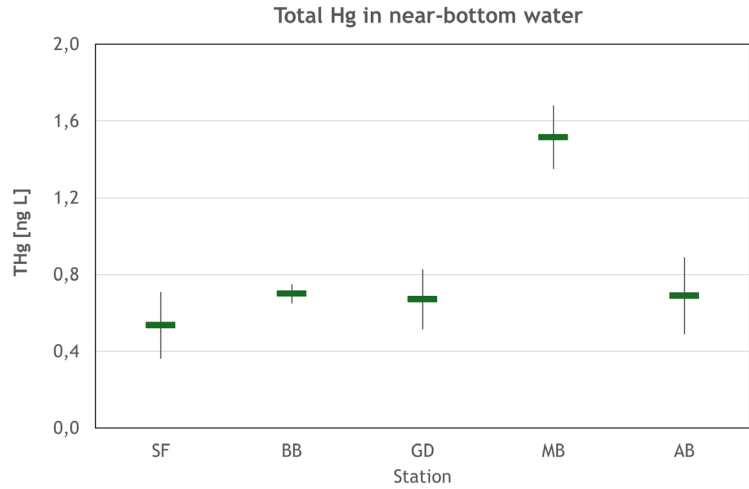
- **Research material:** Sediment cores taken from five different areas of the southern Baltic Sea to study the sediment resuspension and Hg remobilization processes
- **Sampling:** r/v Oceania cruise in October 2022
- **Experiment design:** Sampling of seawater along with suspended matter at defined time intervals after mixing the core with sediment, simulating the resuspension process (Seelen et al., 2018, modified)
- **Analysis:**
Total Hg in water (TEKRAN 2600, CV-AFS),
Total Hg and Hg fractions in sediments (DMA-80, TD-AAS),
Sediment grain size



Source: A. Jędruch

Results

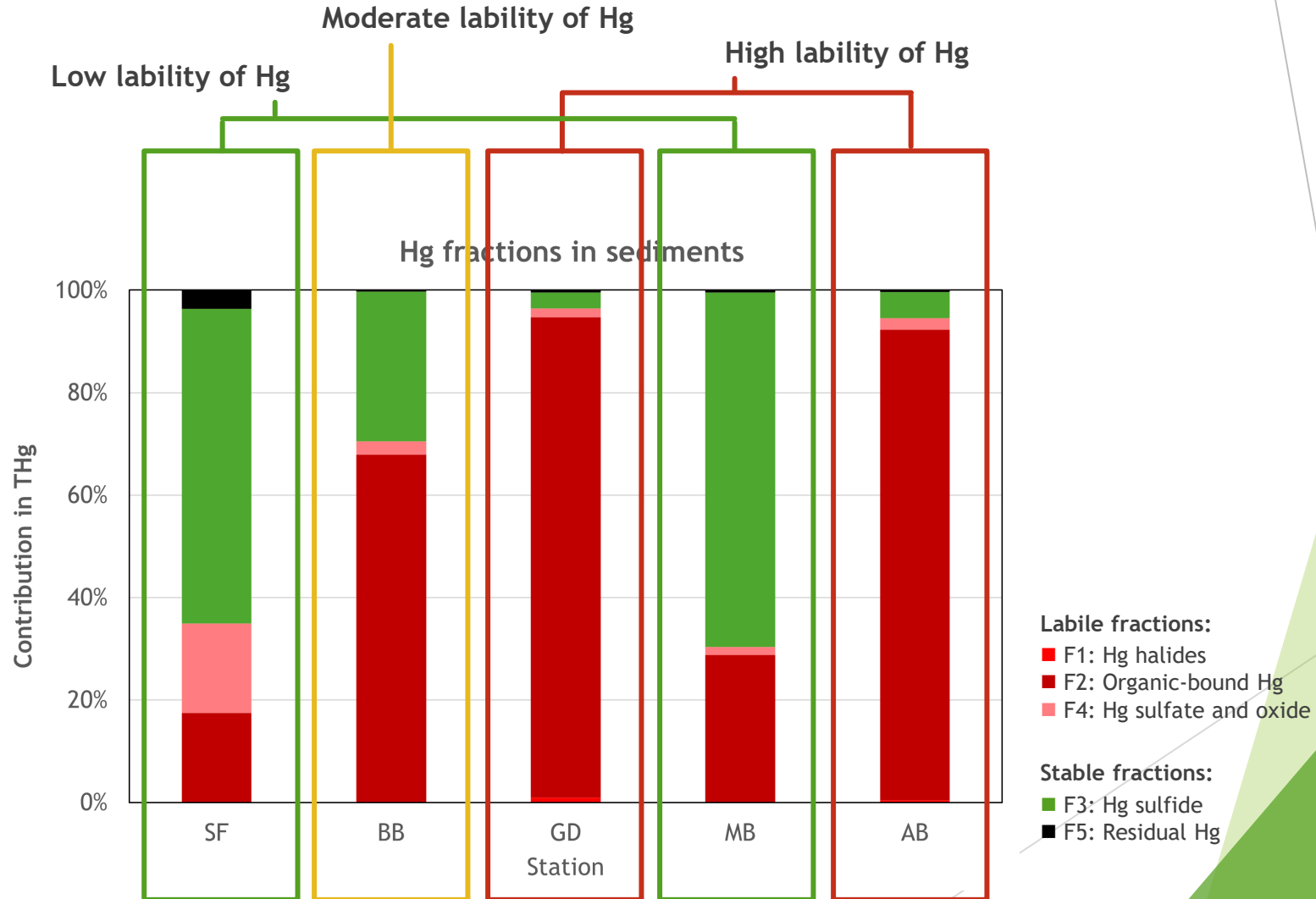
Background information



SF: Słupsk Furrow, BB - Bornholm Basin, GD - Gdańsk Deep, MB - Mecklenburg Bay, AB - Arkona Basin

Results

Background information

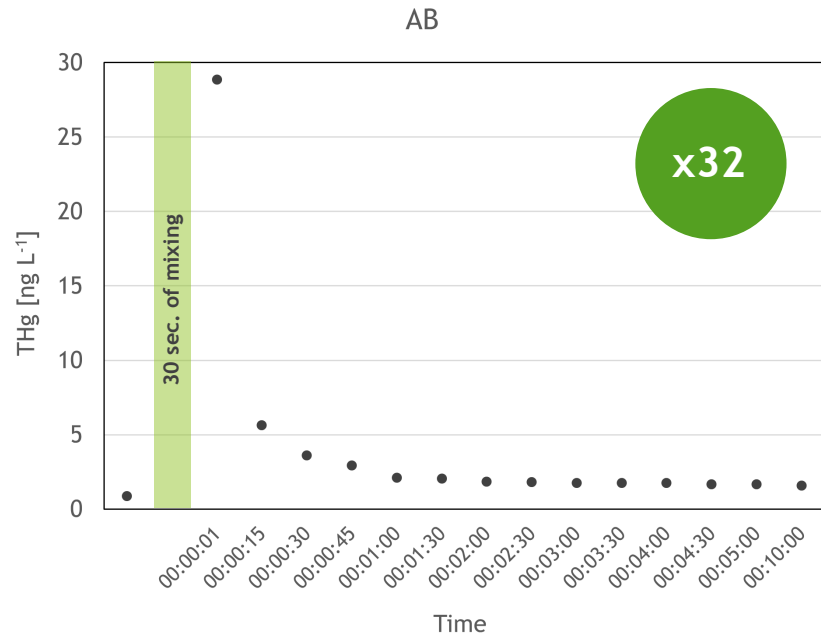


Results

Hg remobilization efficiency

High THg concentration in sediments
& high labile Hg contribution

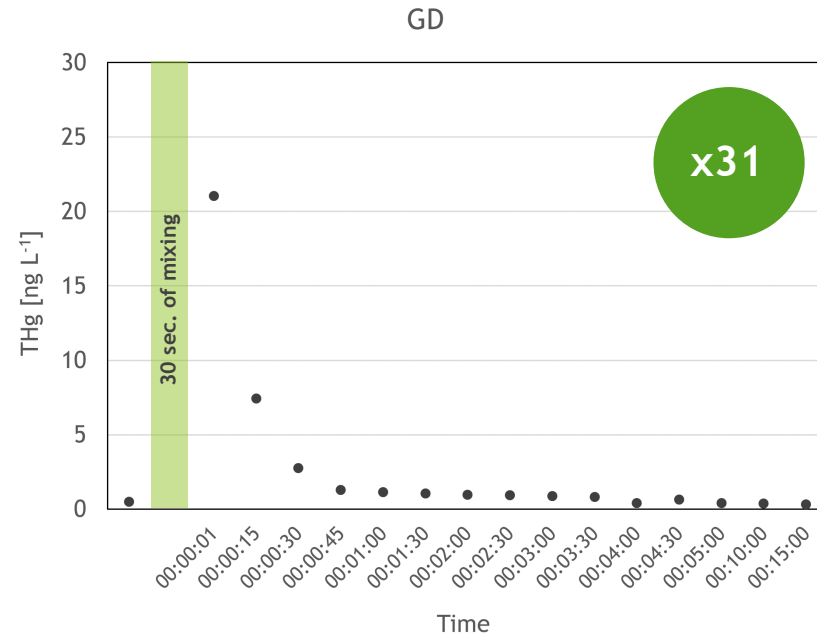
High content of fine sediment fraction



(THg in sediments $\approx 200 \text{ ng g}^{-1}$, labile Hg contribution $\approx 90\%$)

Moderate THg concentration in sediments
& high labile Hg contribution

High content of fine sediment fraction



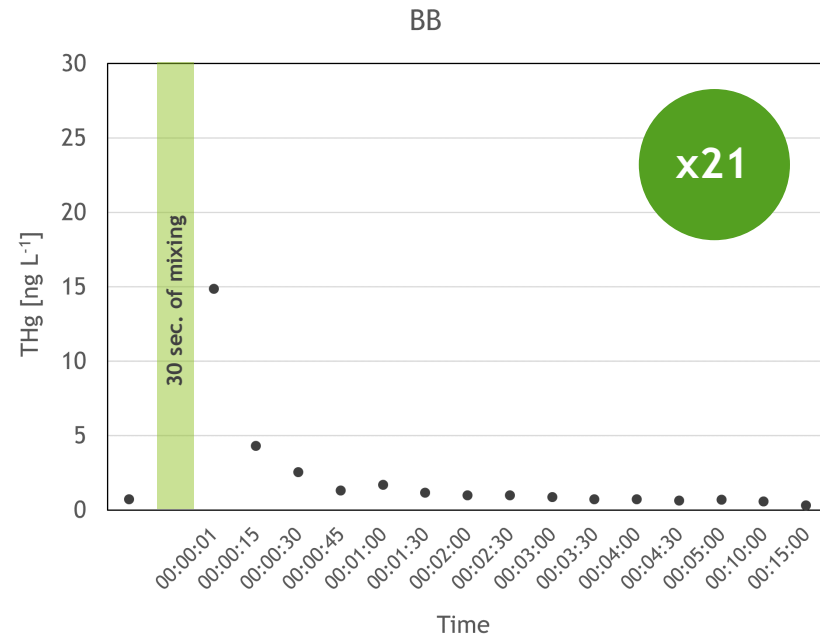
(THg in sediments $\approx 130 \text{ ng g}^{-1}$, labile Hg contribution $\approx 90\%$)

Results

Hg remobilization efficiency

Moderate THg concentration in sediments
& moderate labile Hg contribution

Moderate content of fine sediment fraction



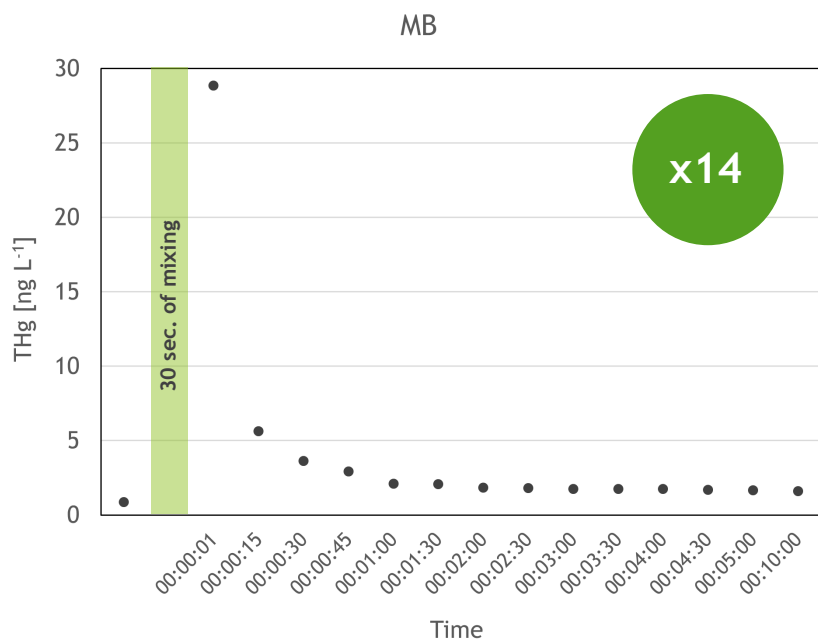
(THg in sediments $\approx 80 \text{ ng g}^{-1}$, labile Hg contribution $\approx 70\%$)

Results

Hg remobilization efficiency

High THg concentration in sediments
& low labile Hg contribution

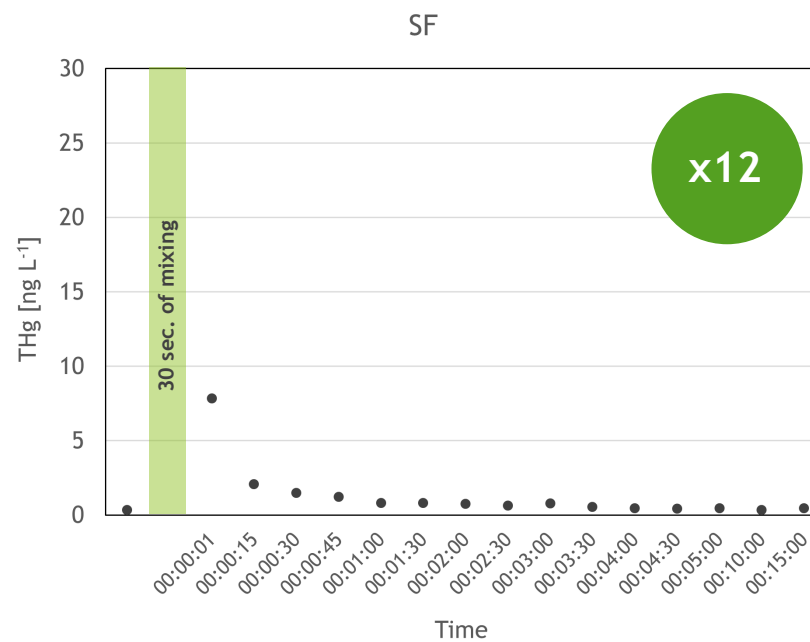
Moderate content of fine sediment fraction



(THg in sediments $\approx 200 \text{ ng g}^{-1}$, labile Hg contribution $\approx 30\%$)

Low THg concentration in sediments
& low labile Hg contribution

Low content of fine sediment fraction



(THg in sediments $\approx 5 \text{ ng g}^{-1}$, labile Hg contribution $\approx 30\%$)

Conclusion

- Mercury release from sediment during a resuspension event is almost instantaneous
- In the presence of sediment surface disruption by currents or other water movements, Hg could be transported outside the resuspension area
- The speciation of Hg is the single most important factor in the release of Hg during sediment resuspension

Thank you!

Funding

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Thank you!

Jacek Bełdowski

Institute of Oceanology Polish Academy of Sciences
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hyron@iopan.pl

