

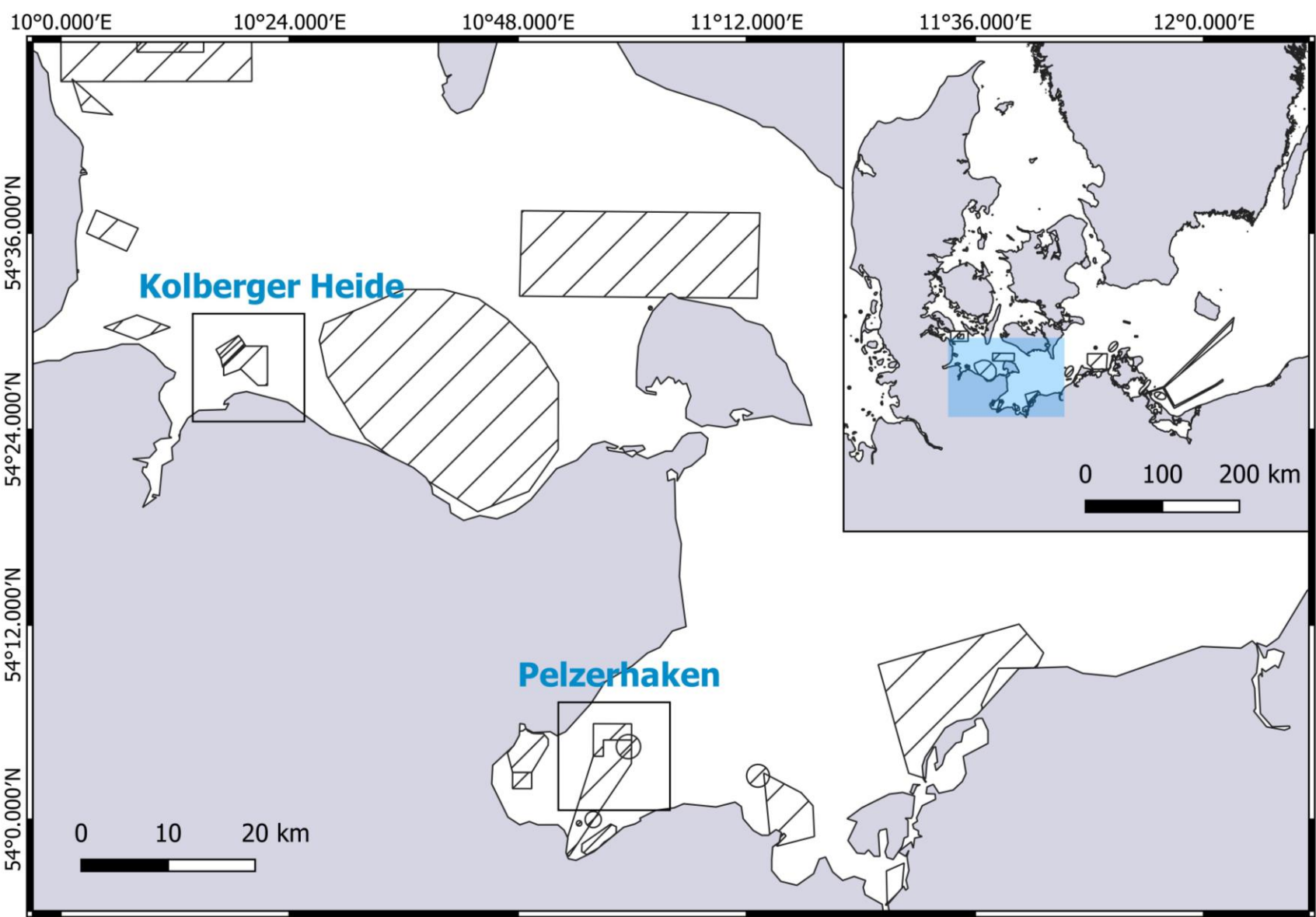
Towards marine munition dumpsite characterization and UXO mass estimations



Mareike Kampmeier, Jens Greinert
GEOMAR Helmholtz Centre for Ocean Research Kiel; mkampmeier@geomar.de

Combined hydroacoustic and high resolution optical mapping providing base data for future remediation

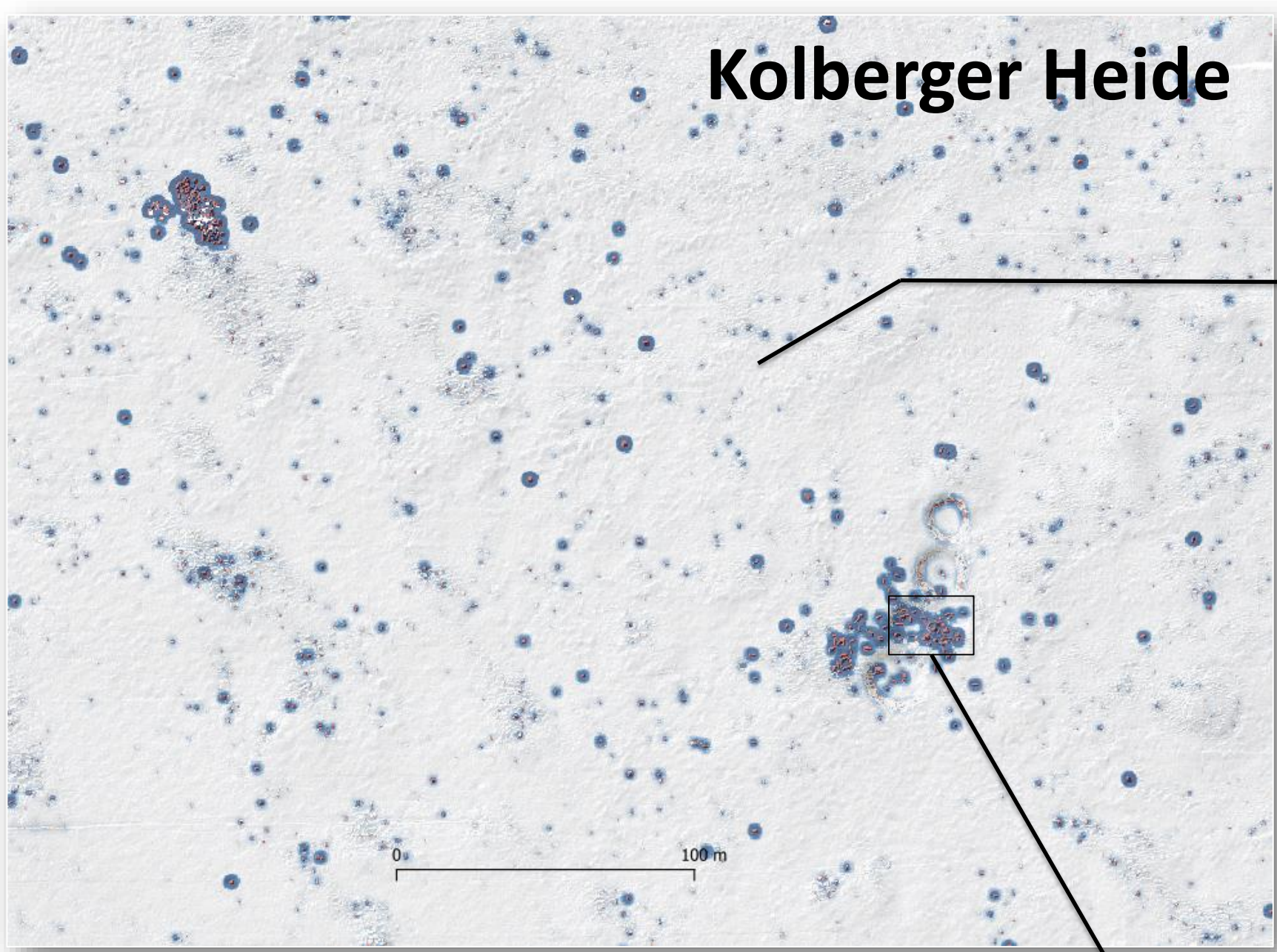
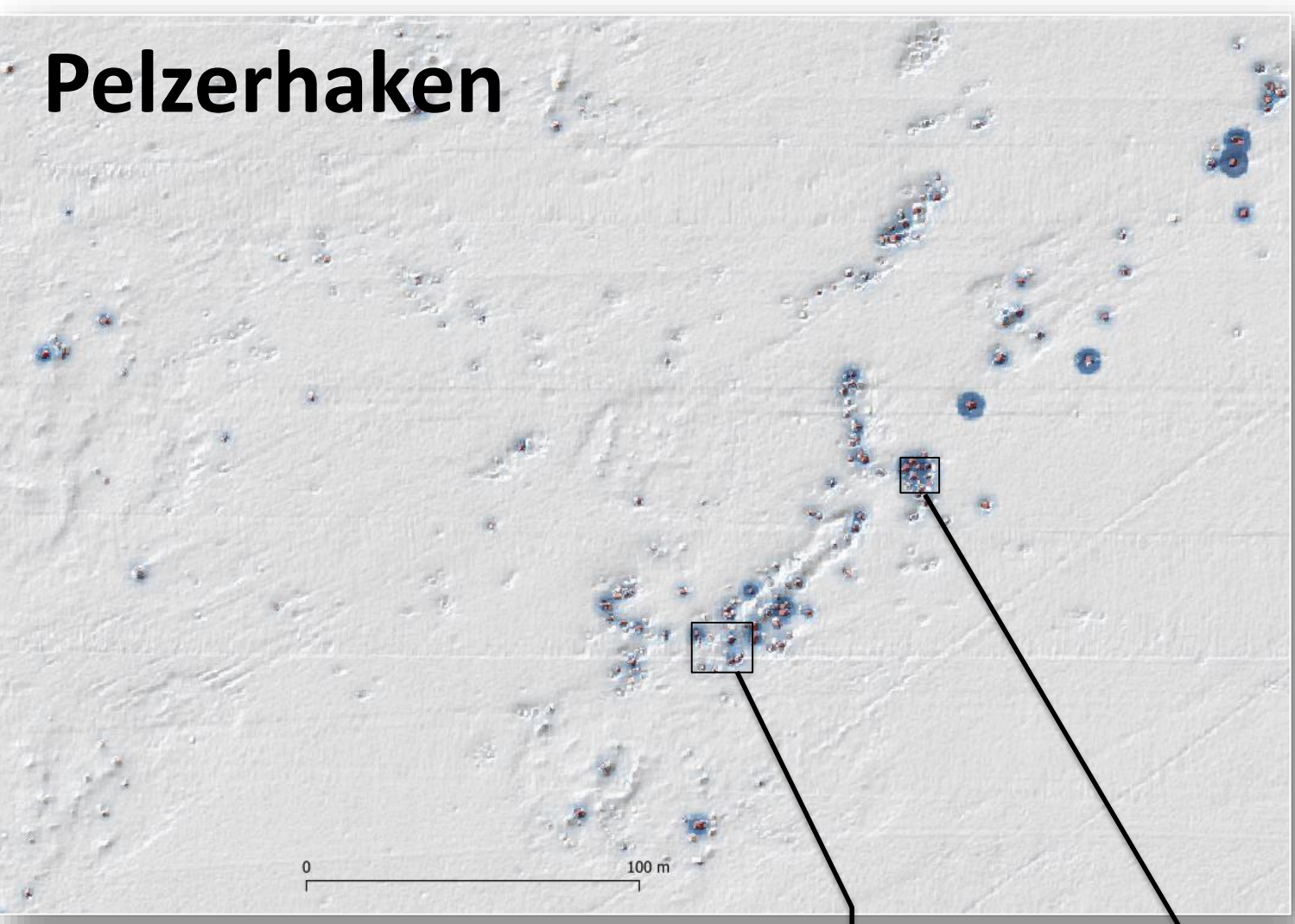
After World War II, large quantities of conventional munition were dumped in the German Baltic Sea. Most of the munition is concentrated in coastal munition dumpsites in water depths between 10 and 25 meters (Kampmeier et al., 2020). Since the explosives and their degradation products pose a threat to the local marine environment (Beck et al. (2021), Strehse, et al. (2020) and Schuster et al. (2021)), remediation plans are needed. Eventhough the dumpsites are officially known, the exact mass of dumped munitions is still not clear. But for future remediation plans, seafloor characteristics and munitions types and numbers will be essential base information.



Map of the munition dumpsites **Kolberger Heide** and **Pelzerhaken** in German Baltic Sea coastal waters. In both sites, munitions were dumped after WW II. Hatched areas indicate munition contaminated sites.

In the following, the UXO content of two munition dumpsites is compared and the workflow towards mass estimations is introduced

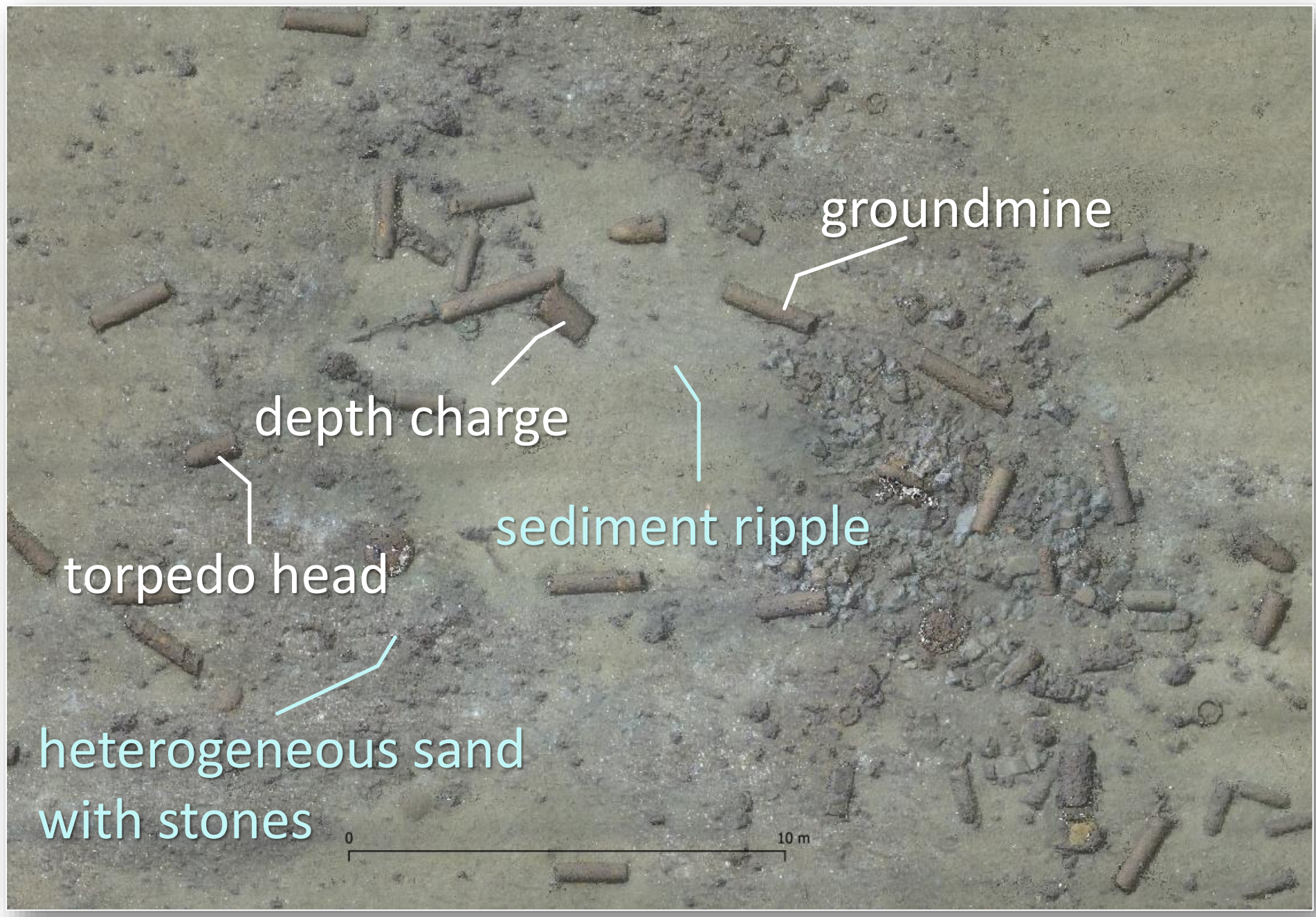
1. Finding UXO in bathymetry



Marine munition dumpsites have been mapped with ship-based high resolution multibeam (400/800kHz). Morphometric derivatives can enhance features on the seafloor and support UXO detection within multibeam data. Here the TPI (topographic positioning index) was calculated as secondary derivative of the real surface area. It reduces data artifacts and background geology of the seafloor.

2. Validate UXO findings

Potential UXO findings are surveyed with a very slow going AUV (autonomous underwater vehicle). Overlapping HD photographs are taken every second.



3. Dumpsite characterization and mass estimation

The AUV camera is calibrated and resulting photos contain geo-information. By finding matching points, photo mosaics, DTMs and 3D models can be created, which allow detailed groundtruth.



Pelzerhaken

- ca 60 % homogeneous sediment
- ca 30 % dumped slag
- ca 10 % stone reefs

UXO detection high
no UXO (buried?)
UXO detection low

1928 contacts / 7 % ground-truthed
172 piles / 30 % ground-truthed

Pile 1:

Area: 500 m²
Content: 45 cluster bombs
1 munition box
5180 grenade cartridges
Mass: ca 14.4 to

Pile 2:

Area: 117 m²
Content: 17 munition boxes
Mass: ca 3.4 to

Kolberger Heide

- ca 50 % homogeneous sediment
- ca 50 % heterogeneous, stony seafloor

UXO detection high
UXO detection low

1136 contacts / 5 % ground-truthed
2 piles / 100% ground-truthed

Pile 1:

Area: 155 m²
Content: 19 torpedo heads
15 groundmines
1 depth charge
Mass: ca 13.5 to

Pile 2:

Area: 193 m²
Content: 76 sea mines
Mass: ca 11.4 to

Conclusion and outlook

- dumpsite content is highly variable
- closed munition boxes with unknown content
- munition detection via MBES is low in stony areas
- training of AI algorithm with ground truthed data to find more objects in MBES data
- more UXO annotations needed
- masses for UXO types need to be defined (min / max weights)
- extrapolate weights per area

