Assessing the impacts of dumping on the seafloor

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Assessment of seafloor integrity and change

- *Marine Strategy Framework* and *Marine Spatial Planning Directives* aim to promote the sustainable use of the seas and conserve marine ecosystems, and to ensure that pressures from human activities are compatible with Good Environmental Status
  - Descriptor 6 (Seafloor Integrity, MSFD) of good environmental status of marine waters is targeted to assess the change of seafloor by natural and anthropogenic processes
  - Development of indicators for determining the seafloor integrity and its change is largely focused on the biological (e.g. macrofauna) and hydrochemical (e.g. dissolved oxygen content) aspects of the seafloor ecosystem
  - There was no indicator for determining the *geological* integrity of a seafloor, or to quantify its change, although that is required by MSFD by 2020
- Metrics of the indicators should be based on seabed parameters that can be routinely collected to promote the establishment of robust, cost effective monitoring programmes
- Discrimination between natural seafloor change and changes resulting from human activities (dredging/dumping, underwater construction etc.)

Seafloor geological integrity – The the capability of seafloor to provide a habitable substrate for indigenous benthic communities

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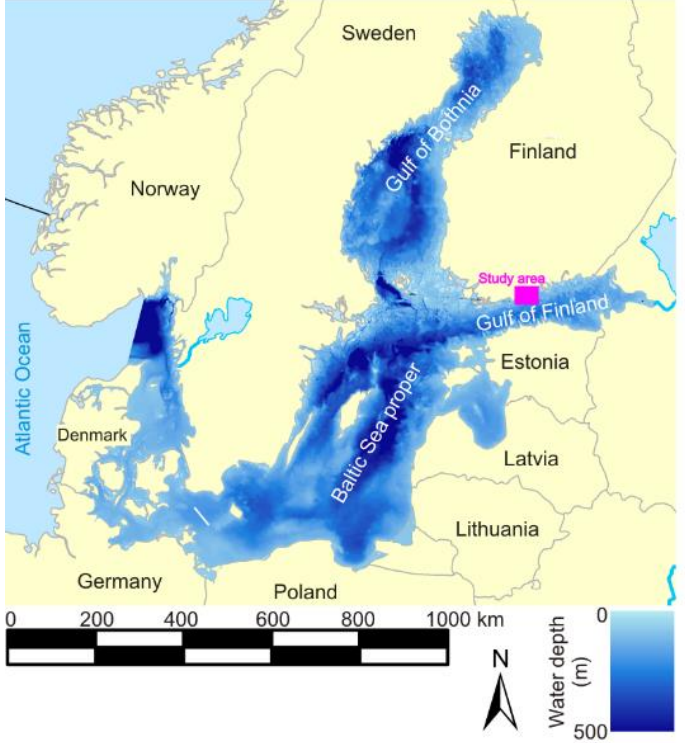
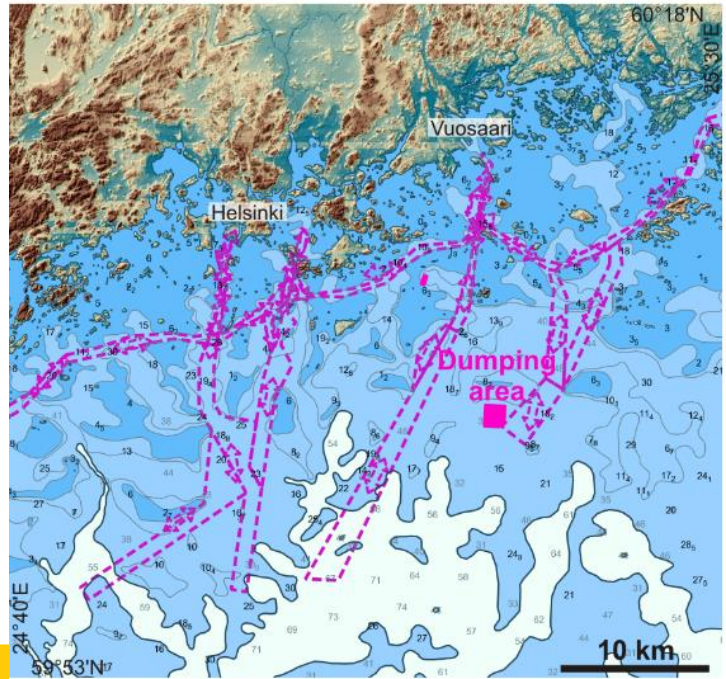
Development of a technique for the assessment of seafloor geological integrity

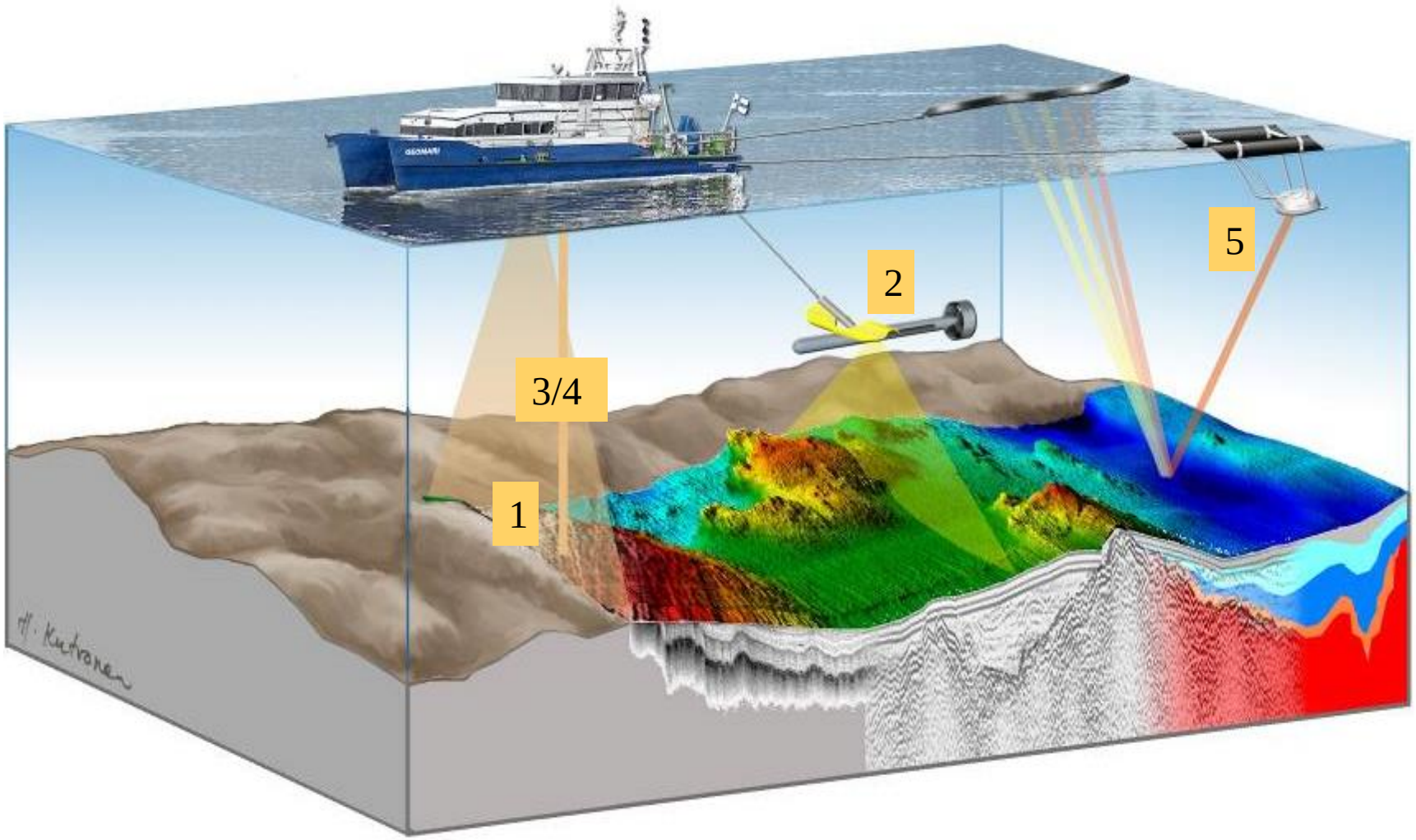
- The Vuosaari offshore dumping area
  - Came into use in 2003, when the construction of the Vuosaari harbor began
  - 1.76 km^2 rectangular area, in the water depths between 50–60 m
  - The most active phase of dumping was 2004–2006
  - Dumping ceased with the completion of the construction works in 2008, when 6.14 million hopper m^3 of dredge spoil had been dumped
  - Dumped material is a mixture of brackish-water mud, glacial lacustrine silt and clay, till, and crushed rock from the necessary demolitions
  - Contaminated sediments were not transported to the offshore dumping area





R/V Geomari

1. Multibeam, 200 kHz Atlas Fansweep 20
2. Sidescan, 100 & 500 kHz Klein 3000
3. Pinger, 28 kHz Meridata
4. Chirp, 3.5 – 8 kHz Massa TR-61A
5. Reflection seismic, 300–1500 Hz ELMA



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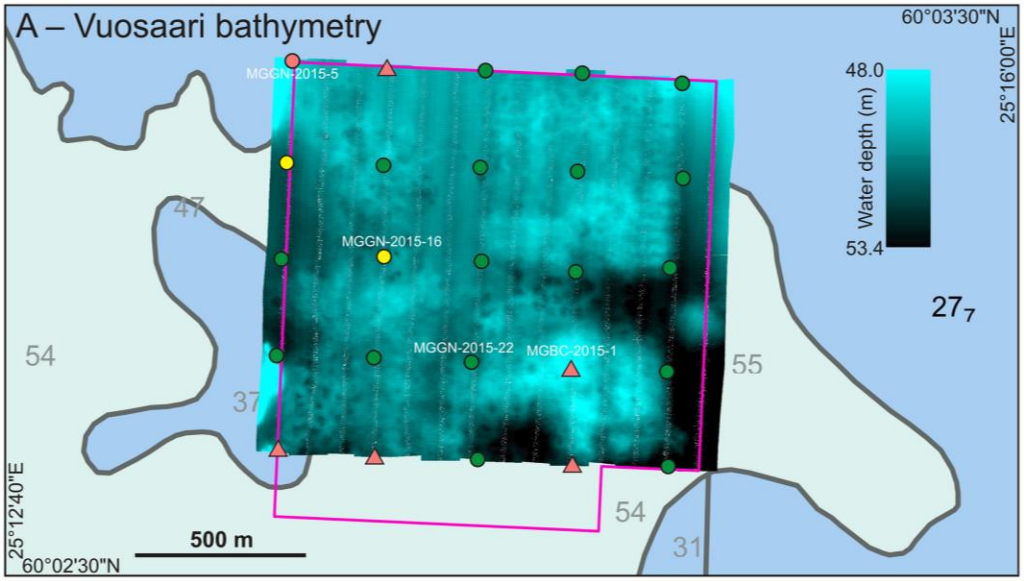
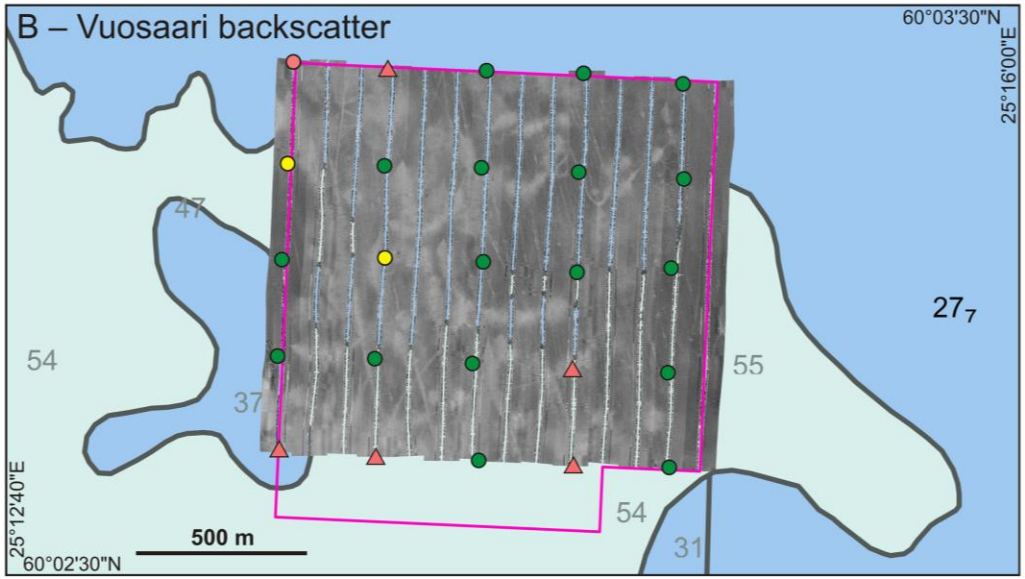
Field work August 2015

- Multibeam surveys of the dumping area
  - 200 kHz Atlas Fansweep 20
- Dumped material shows up as bright patches of harder material in the multibeam relative backscatter image
- 25 sediment cores were collected in a 5×5 grid pattern over the dumping area
  - ^{137}Cs activity was measured at 1 cm resolution for the upper parts of the cores, using an EG&G Ortec ACE™-2K gamma spectrometer equipped with a 4” NaI/Tl detector
  - Weight loss on ignition (LOI) was analyzed at 1 cm resolution for the entire length of the cores
  - Grain size distribution was analyzed for selected 1-cm sediment slices, which were freeze dried prior to sieving. The <63 µm size fraction was further analyzed down to 0.6 µm using a Micromeritics Sedigraph III 5120 sedimentation analyzator. The sieving results were merged with sedimentation data in Sedigraph software. Grain size distribution parameters (mean, sorting, skewness, kurtosis) were calculated according to the geometric Folk and Ward (1957) graphical measures. Clay is grains finer than 2 µm, whereas mud is clay and silt (<63 µm), sand is 63 µm – 2 mm, and gravel is 2–64 mm (Blott and Pye, 2012).





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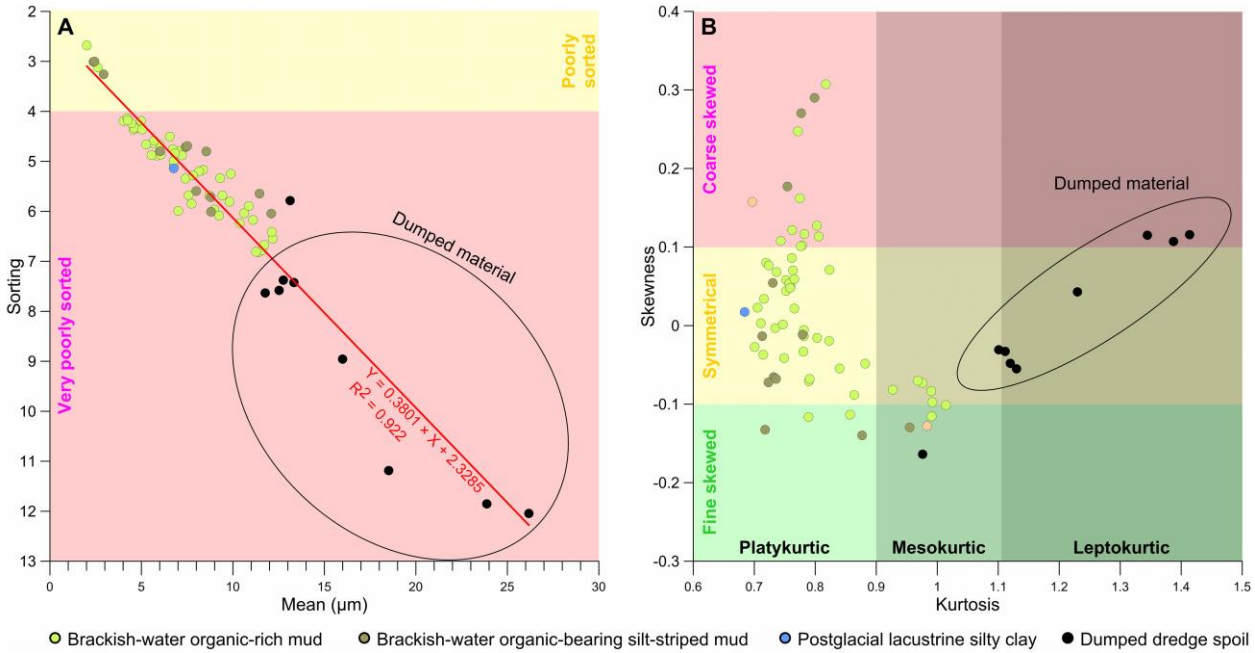
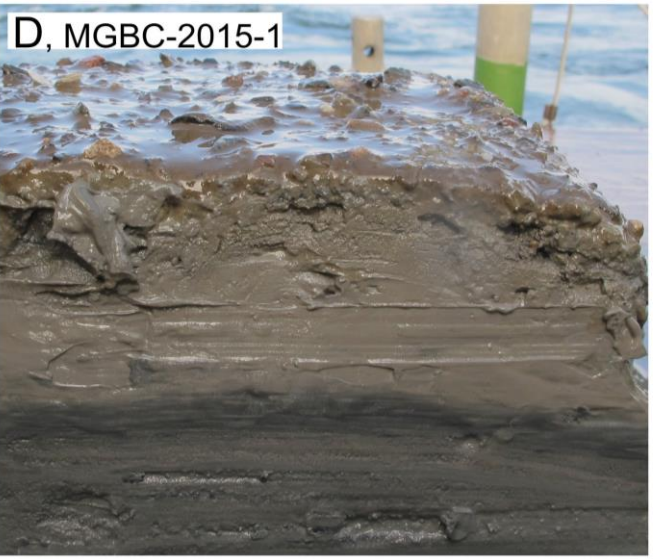
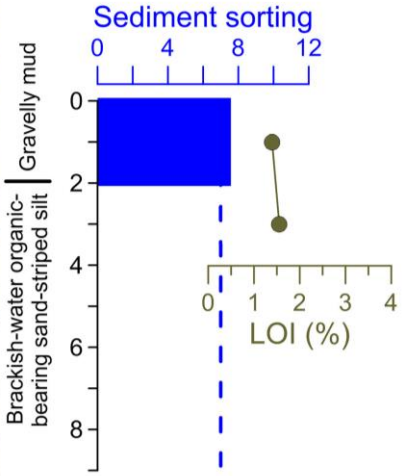
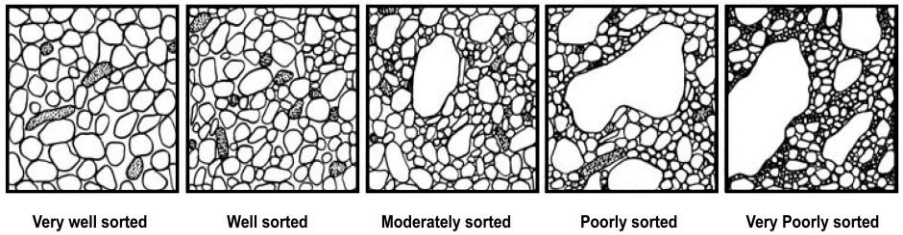
Dumped material in sediment cores

- *Gravelly mud* layer with massive texture and angular coarse grains in sediment cores
- Dumped material is coarser, less sorted and has higher kurtosis compared to natural sediment
  - Admixing of blasted rock during the dredging activities, and limited sorting during fall through the water column upon dumping









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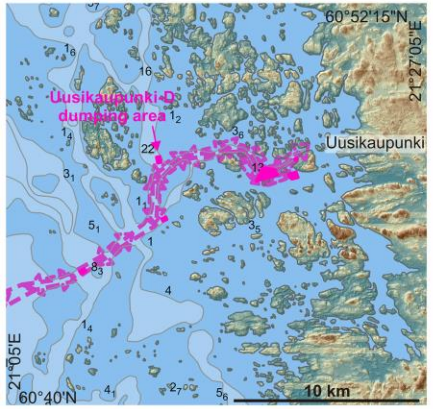
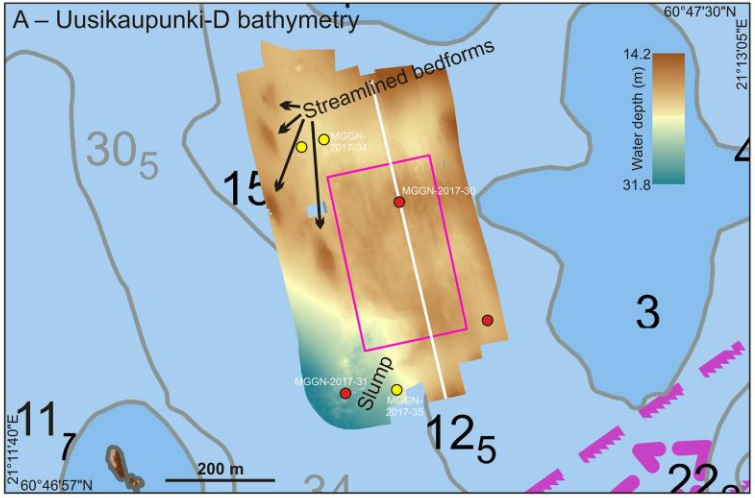
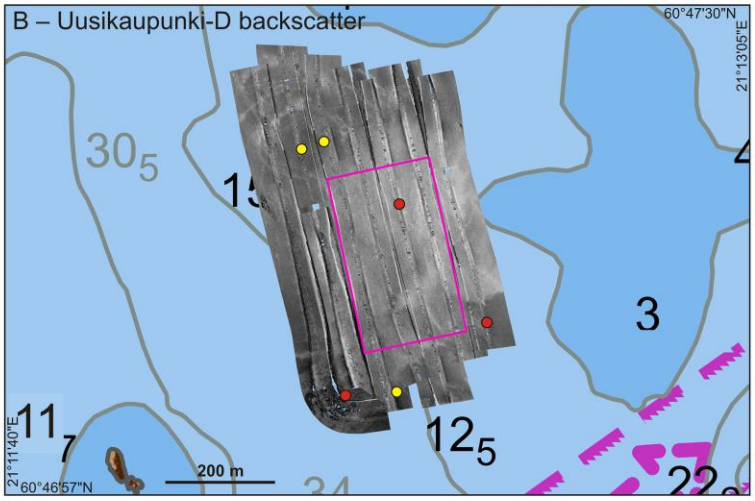
Uusikaupunki-D dumping area

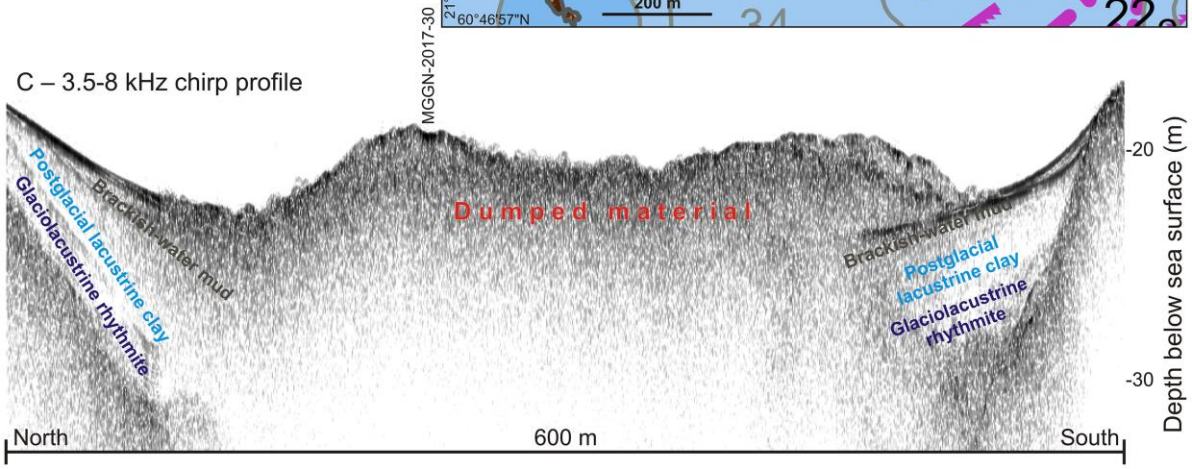
- Used in 2013–2014, when the shipping lane to the Uusikaupunki harbor was deepened to a draft of 12.5 m
- 0.062 km^2 area, in water depths 22–25 m
- 0.563 million hopper m^3 of dredge spoil, mainly silt with minor till and blasted rock
- Contaminated sediments were not transported to the offshore dumping area

- Multibeam surveys of the dumping area
  - 200 kHz Atlas Fansweep 20
- 6 sediment cores were collected
  - ^{137}Cs activity
  - Weight loss on ignition (LOI)
  - Grain size distribution
- Sediment cores with dumped material plot on the bright patches of harder material in the multibeam relative backscatter image
- Dumped material has slumped down to an adjacent channel and is likely being redistributed by near-bottom currents



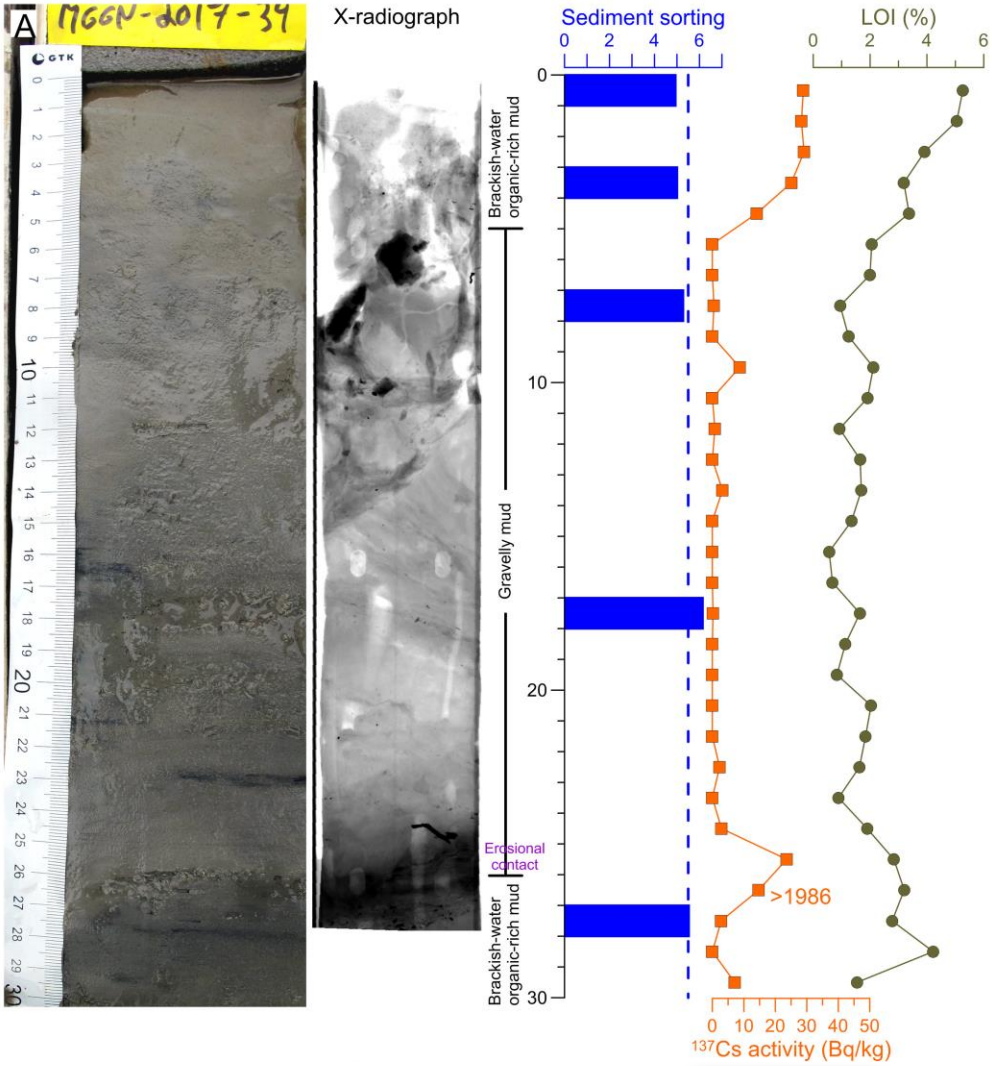






Recovery of seafloor geological integrity

- Gravelly mud layer (dumped material) in MGGN-2017-34 is covered by 5 cm of natural sediment (organic-rich mud)
  - Slow recovery of the seafloor geological integrity is taking place
- Benthic communities in the northern Baltic Sea are dominated by small organisms with shallow burrowing depths (oxygen and salinity stress)
  - Already a relatively thin layer of natural sediment may make the seafloor appear as a natural substrate to the macrofauna
  - Burial of dumped material by 10 cm of natural sediment is proposed as a rule-of-thumb criterion for the recovery of the seafloor geological integrity
- Recovery is possible at depositional dumping areas only, whereas at dispersive sites the dumped material will remain exposed and be redistributed along the seafloor
- Seabed that requires more than 10 years to recover is considered as “physically lost” in the GES assessment of MSFD



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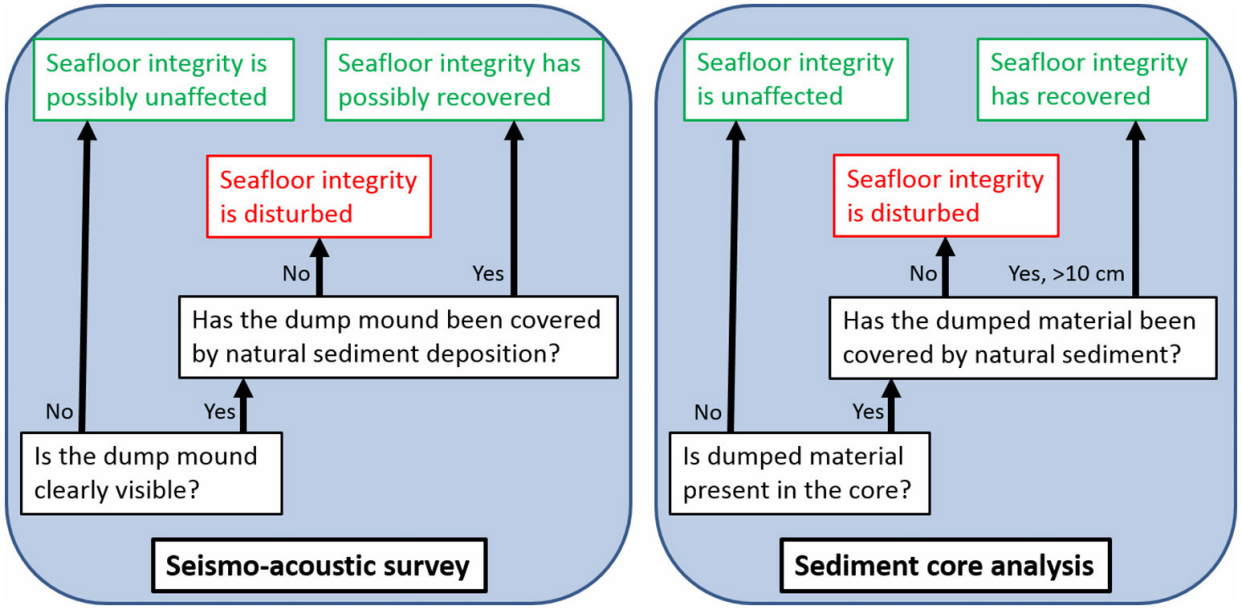
Assessment protocol of the seafloor geological integrity



- *Seismo-acoustic survey* allows quick identification of dumped material mounds and their areal coverage on the seafloor, and repeated surveys permit the assessment of their possible burial
- *Sediment core analysis* permits ground-truthing of seismo-acoustic data, and detailed determination of the thickness and quality of the dumped material layer and its possible burial by natural sediment
- The two methods should be used in parallel with more weight given on the sediment core analysis
- Burial of dumped dredge spoil by natural sediment is considered as a prerequisite for the recovery of the seafloor geological integrity
  - Vuosaari, slow recovery (burial) in progress
  - Uusikaupunki-D, not recovering

Original publication:
Virtasalo JJ, Korpinen S, Kotilainen AT (2018) Assessment of the Influence of Dredge Spoil Dumping on the Seafloor Geological Integrity. Frontiers in Marine Science 5:131. doi:10.3389/fmars.2018.00131

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