GEOLOGICAL RESULTS FROM SEAMBOTH-PROJECT

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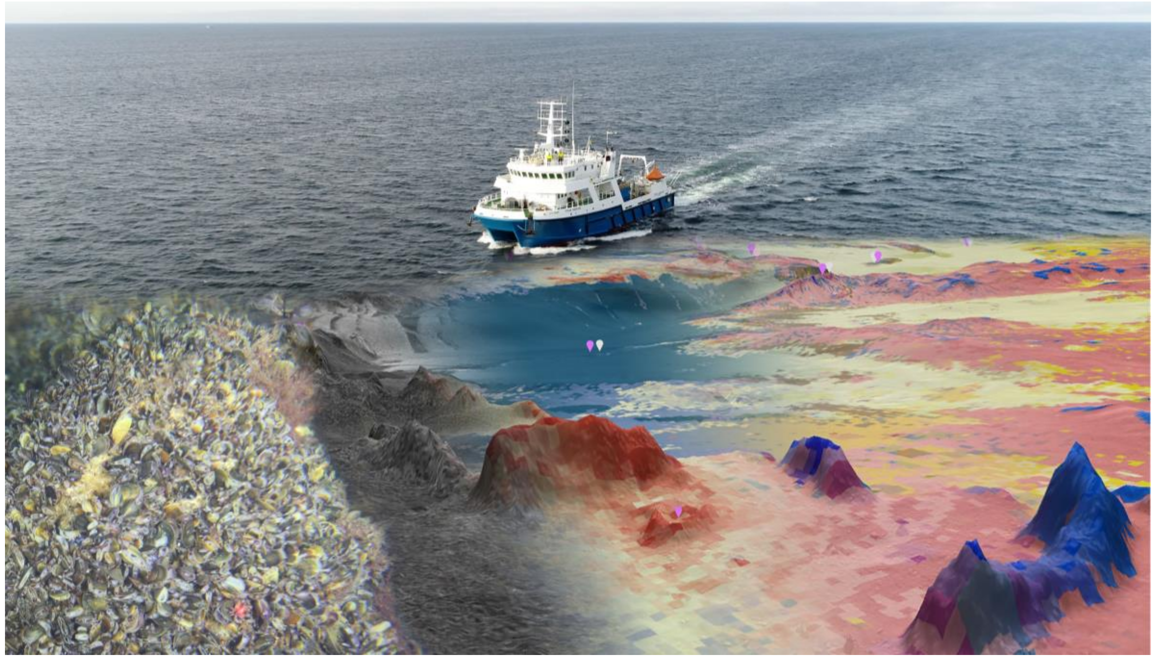
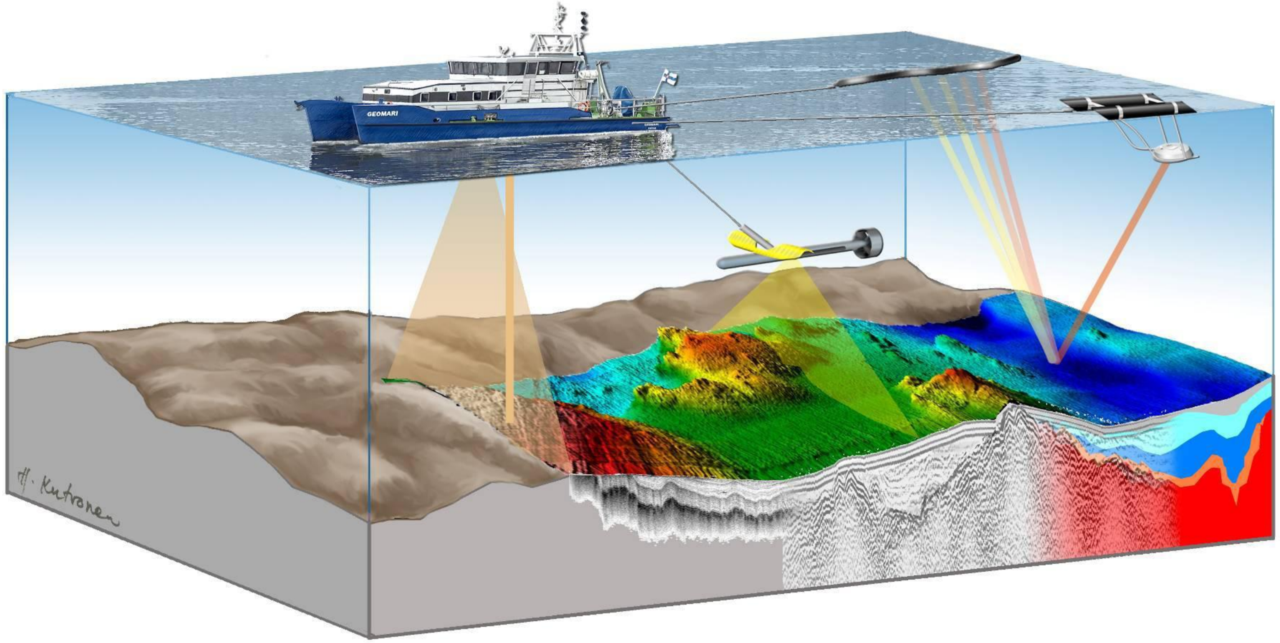
Gustav Kågesten - Geological Survey of Sweden

2020-02-20





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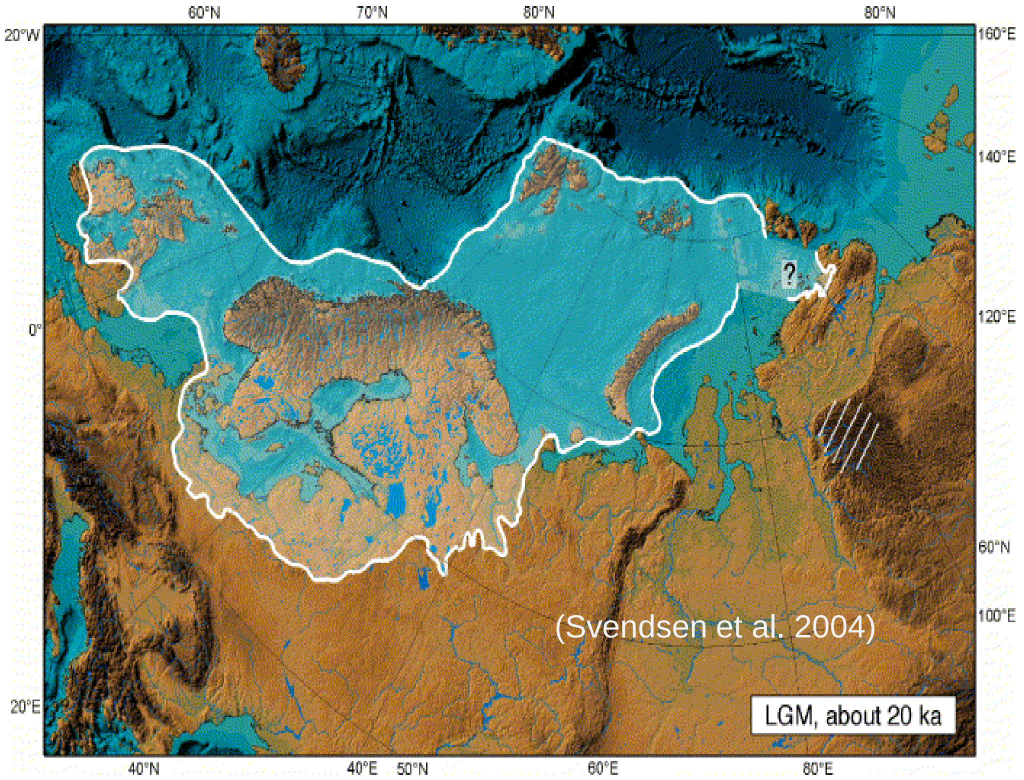
LONG-TERM ENVIRONMENTAL CHANGES IN THE BOTHNIAN BAY – GEOLOGICAL RECORDS

THE YOUNG BOTHNIAN BAY

- The Bothnian Bay and the entire Baltic Sea basin was covered up to 3 km thick ice sheet during the latest ice age, around 20,000 years ago (Svendsen et al., 2004).

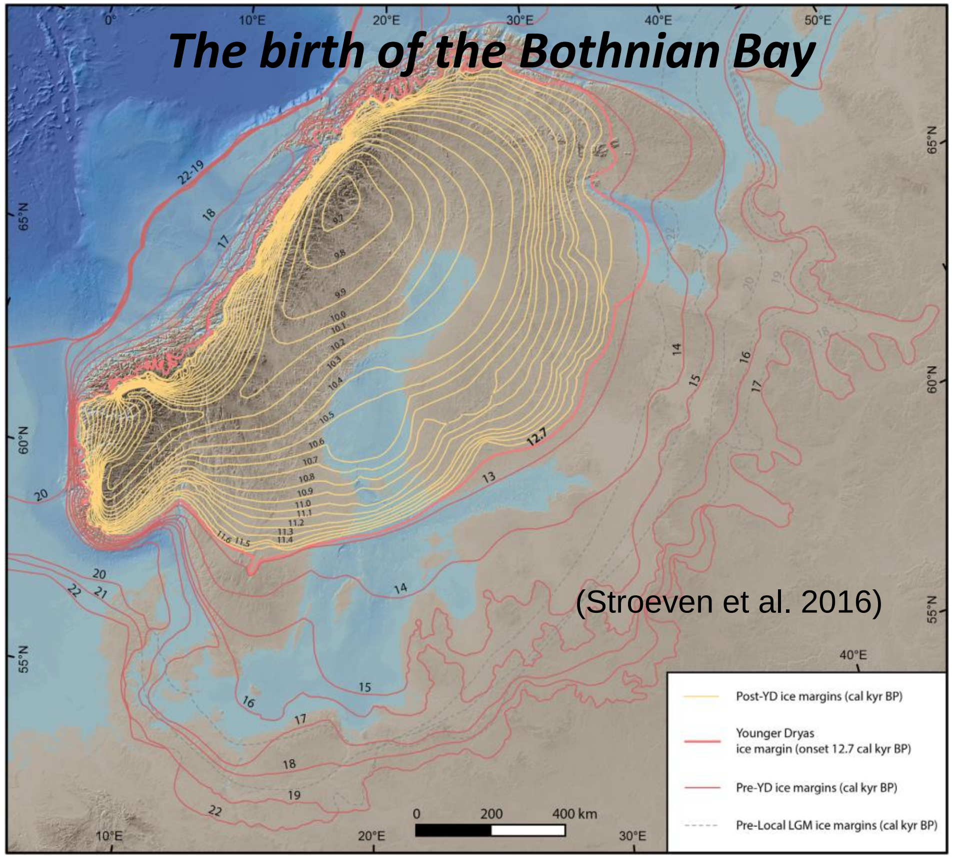


THE YOUNG BOTHNIAN BAY

- The Bothnian Bay and the entire Baltic Sea basin was covered up to 3 km thick ice sheet during the latest ice age, around 20,000 years ago (Svendsen et al., 2004).

- The Bothnian Bay was deglaciated around 10,000 years ago (Stroeven et al. 2016).

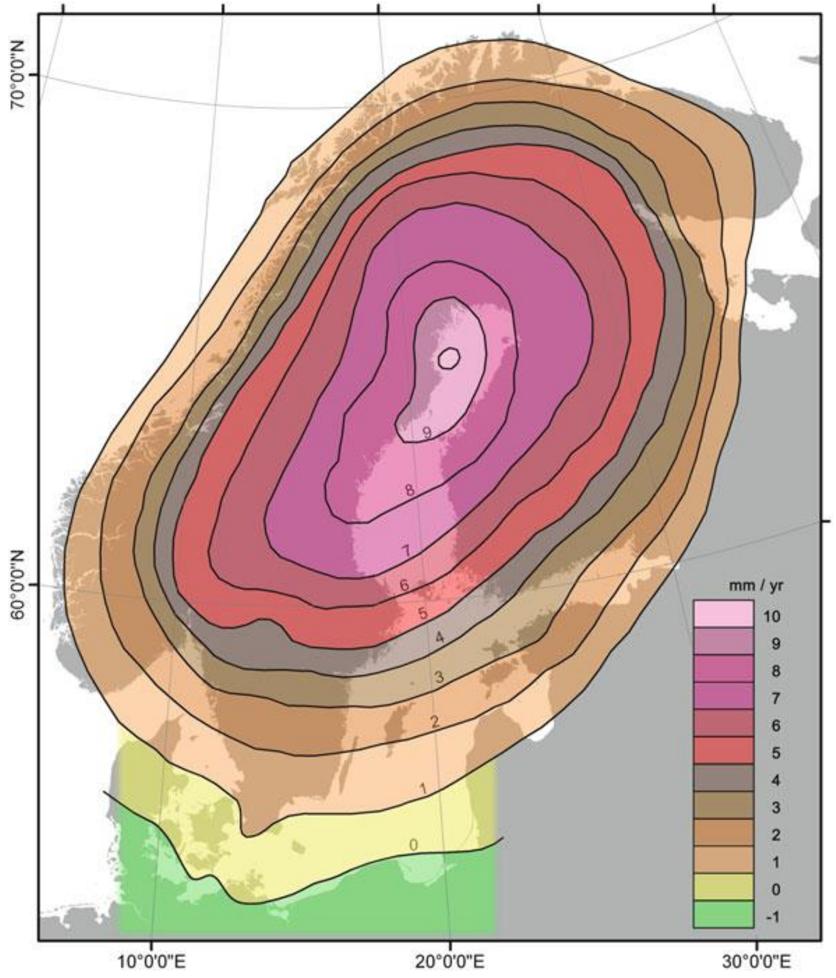
- The Bothnian Bay is geologically very young. It is the youngest part of the Baltic Sea, and probably the youngest sea (area) of our planet.



THE LAND UPLIFT

- The melting of the ice sheets lead to the increase of the global sea level, and triggered local glacio-isostatic adjustment, which is still taking place in the Baltic Sea today.
- In the Bothnian Bay the land uplift rate is up to 1 cm/year (Ekman, 1996; Lidberg et al. 2010; Kakkuri, 2012). If the current sea level rise is taken into account, the land uplift rate (relative to sea level) is smaller (7 – 9 mm/v) (Poutanen and Steffen 2014).
- In the Bothnian Bay, the land uplift rate is one of the largest in the world.

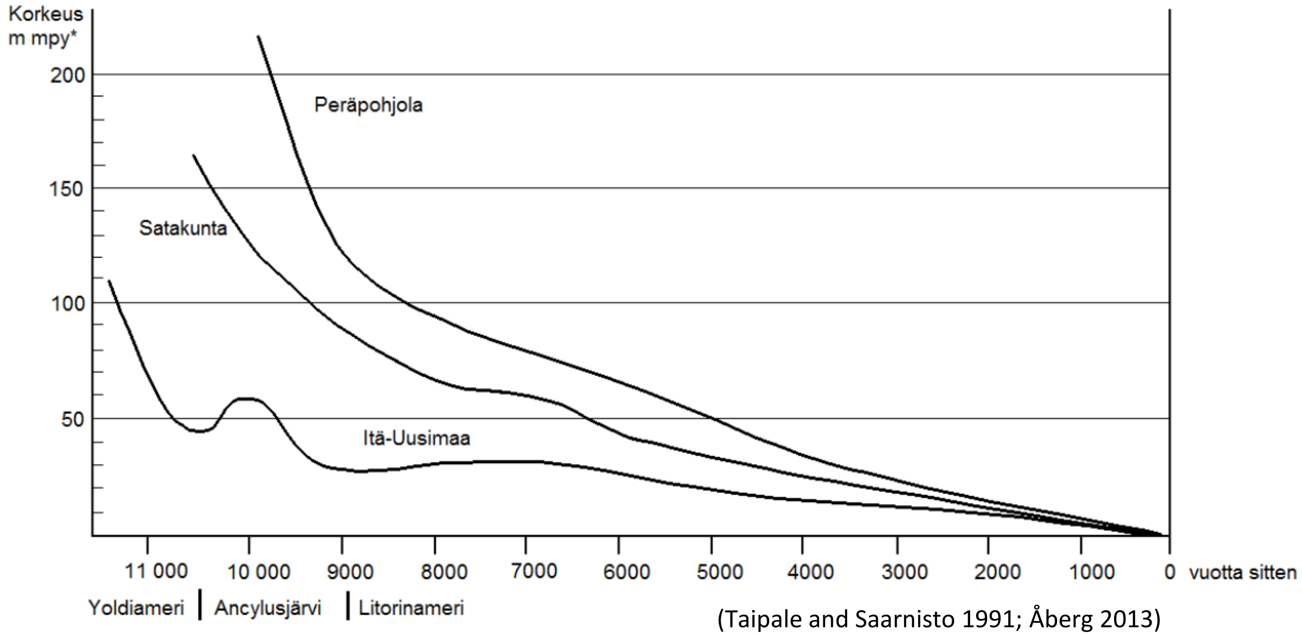
Land uplift (mm/year)



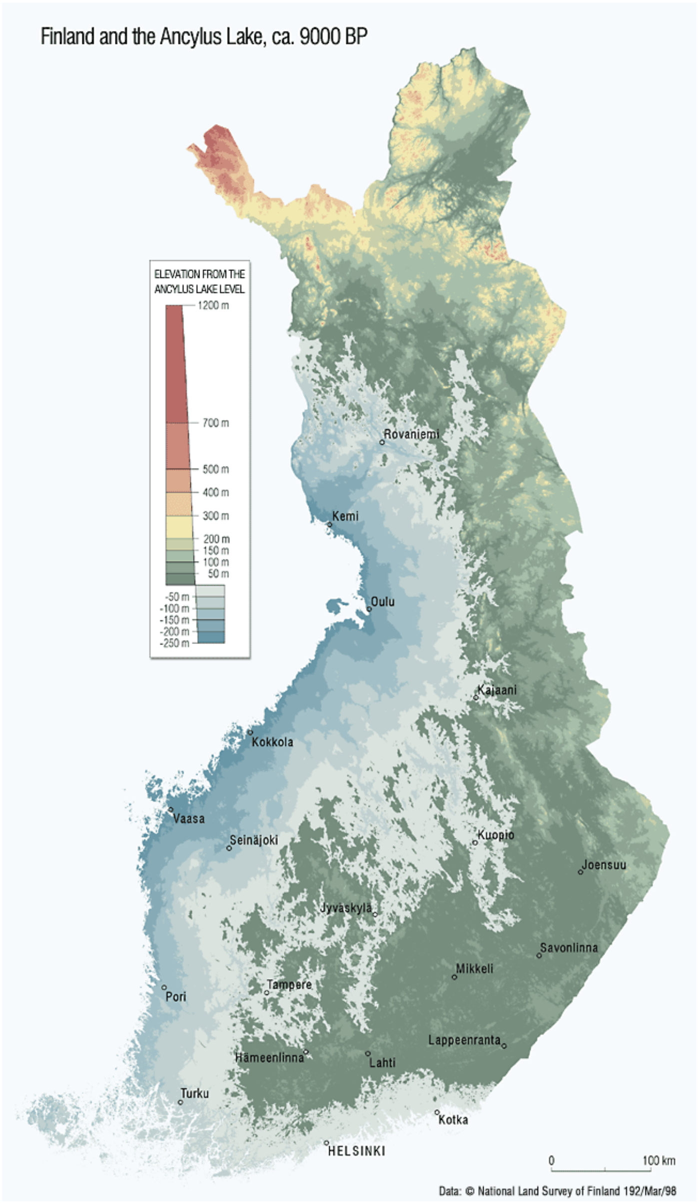
(Harff and Meyer 2011)

SHORE DISPLACEMENT

- Just after the deglaciation (ca 10 ka) the Gulf of Bothnia was up to 300 m deeper than today (Berglund 2004, 2012).



(Taipale and Saarnisto 1991; Åberg 2013)



(Tikkanen and Oksanen 2002)

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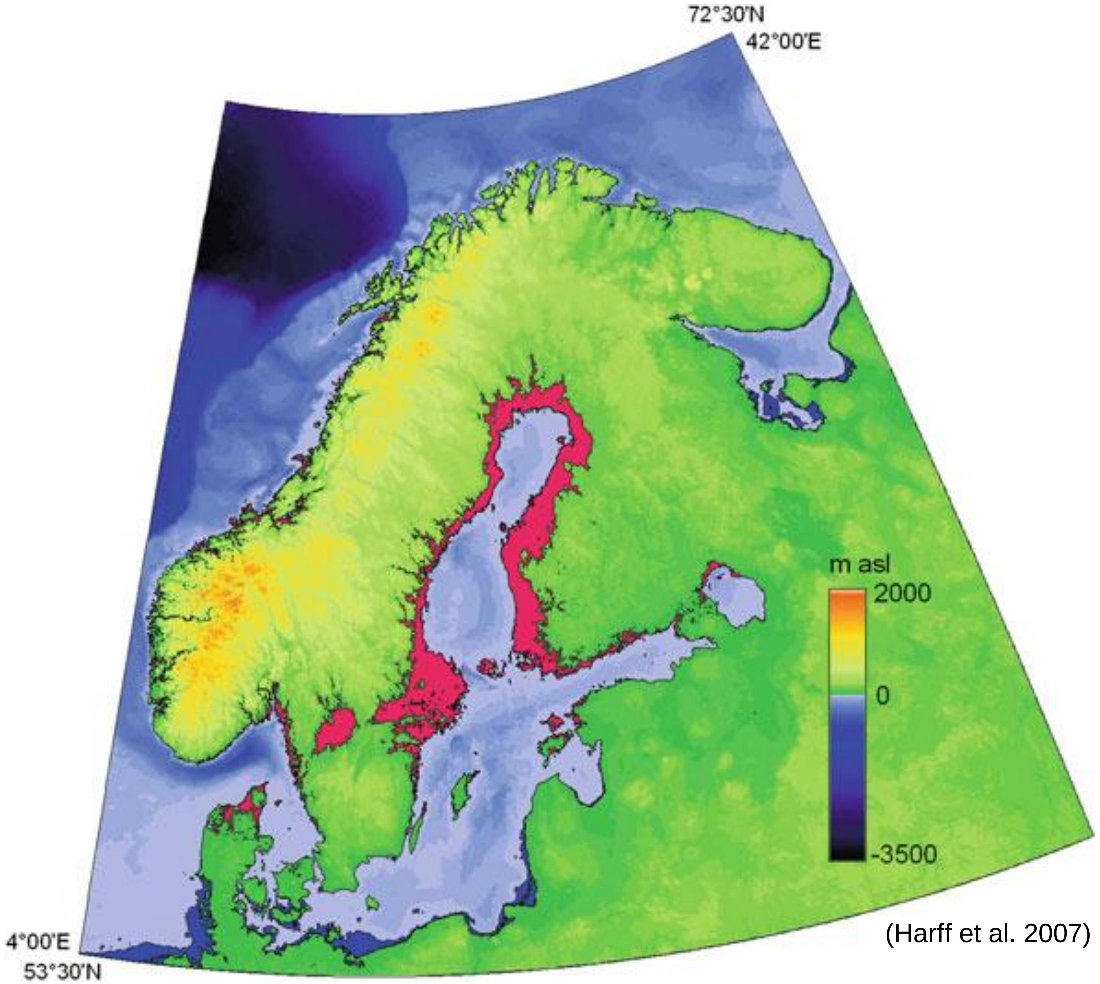
THE LAND UPLIFT

- Today, the new land is born/rising from the sea about 700 hectares per year (Poutanen and Steffen 2014) (GoB).

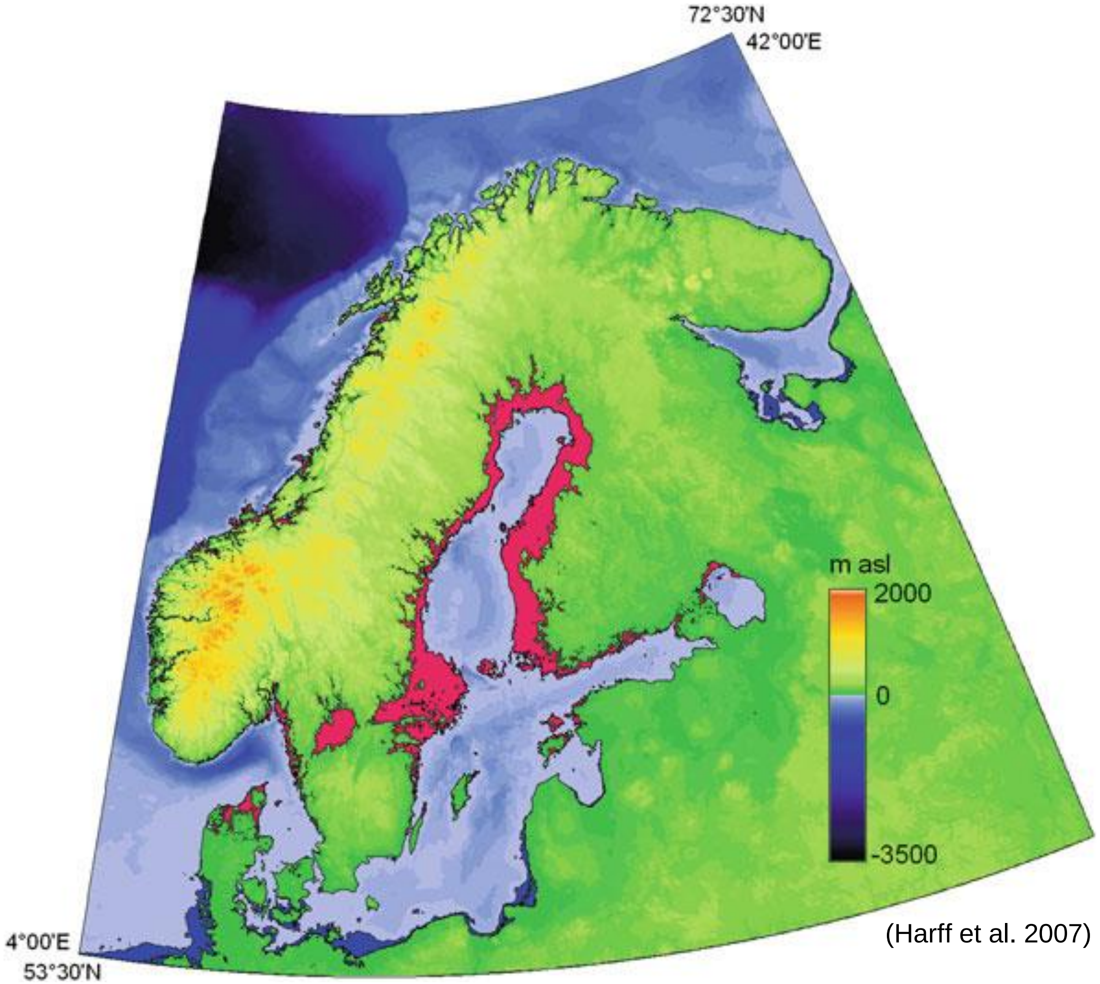


The shore displacement of the Baltic Sea over the past 8000 years (Harff et al. 2007). *Red area* uplifted land and *blue area* transgression.

WATER VOLUME

- Over the last 8000 years, the Baltic Sea area has decreased by ~ 30% and the Baltic Sea volume has declined by ~ 47%(e.g. Meyer & Harff 2005).

- In the Bothnian Bay, the changes have been relatively even higher due to faster land uplift.

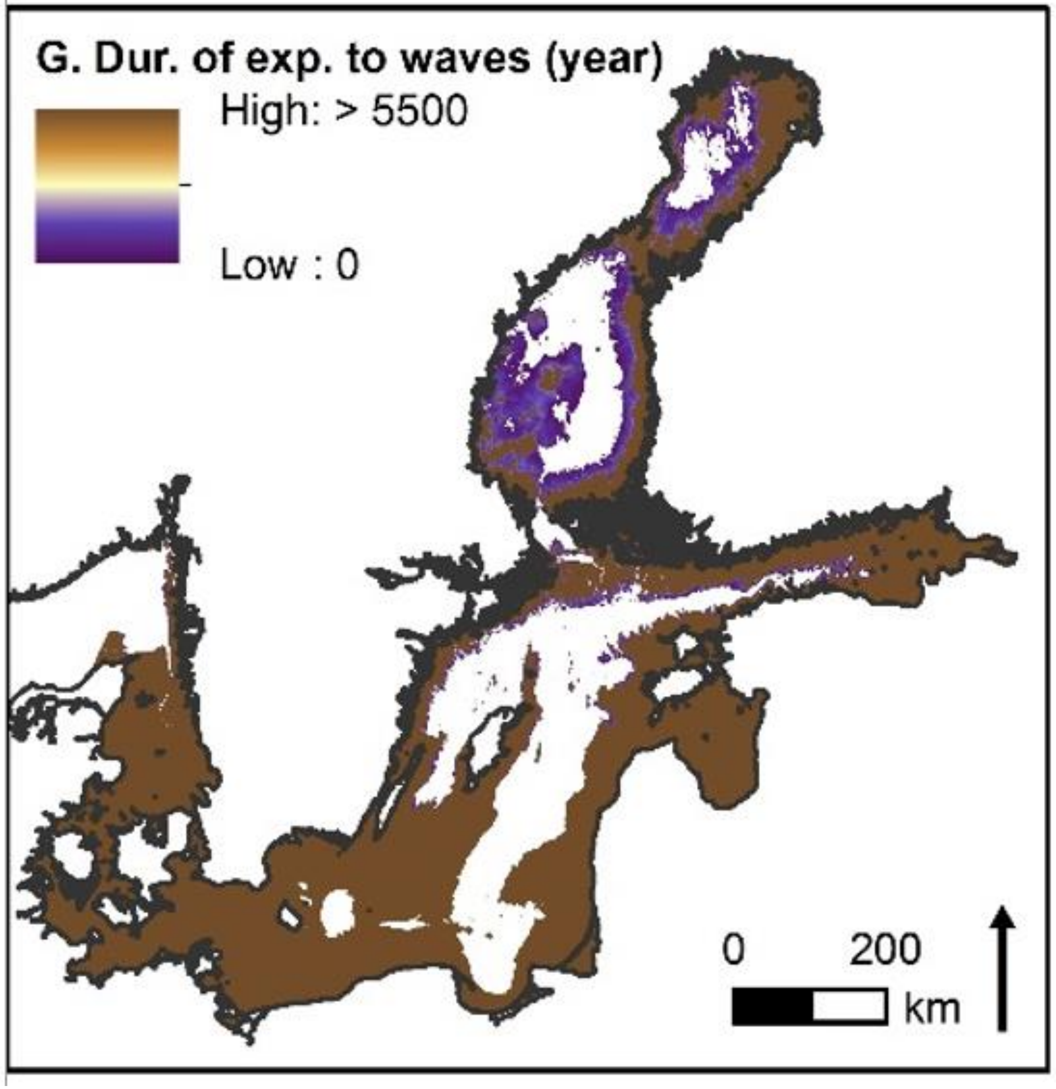


The shore displacement of the Baltic Sea over the past 8000 years (Harff et al. 2007). *Red area* uplifted land and *blue area* transgression.

SEABED EROSION

- Over the past thousands of years, large areas of the seabed in the Bothnian Bay have been subjected to potential erosion (wave erosion).

- This is particularly the case on the Finnish coast, where the coastal area is shallow, and the seabed is deepening gently towards the west.



(Kaskela ja Kotilainen 2017)

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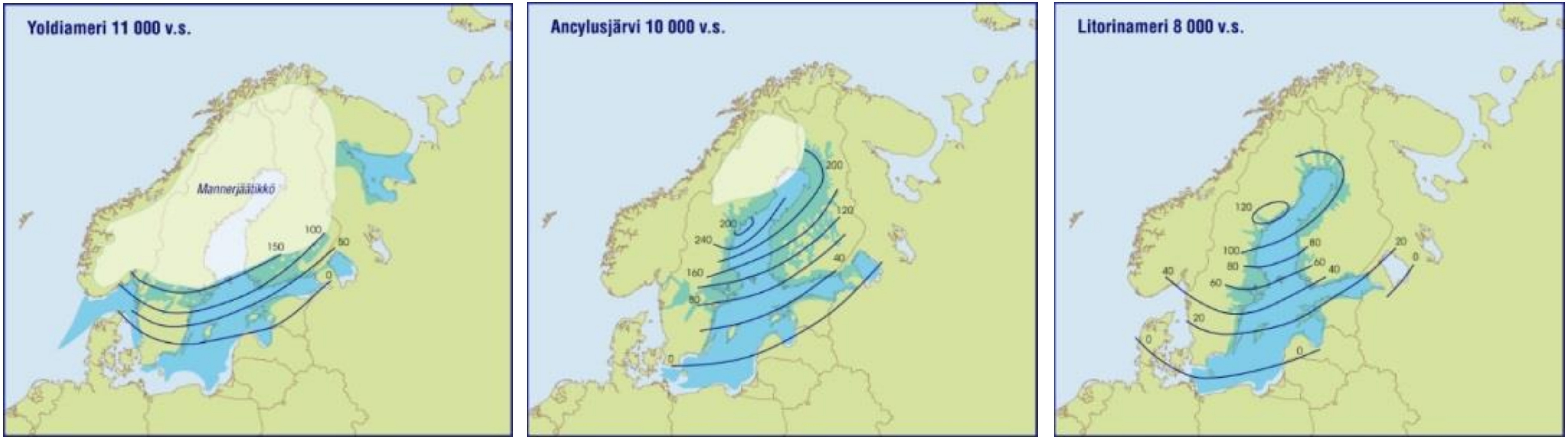
SALINITY

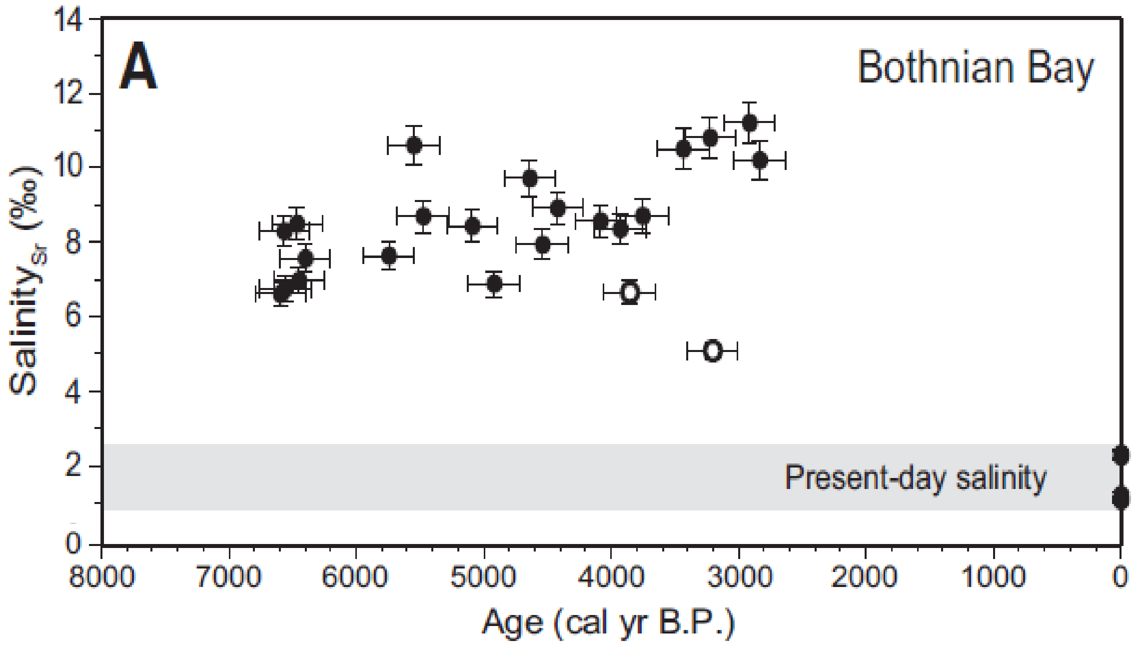
- Salinity has fluctuated during the various phases of the Baltic Sea.



(www.geologia.fi)

SALINITY

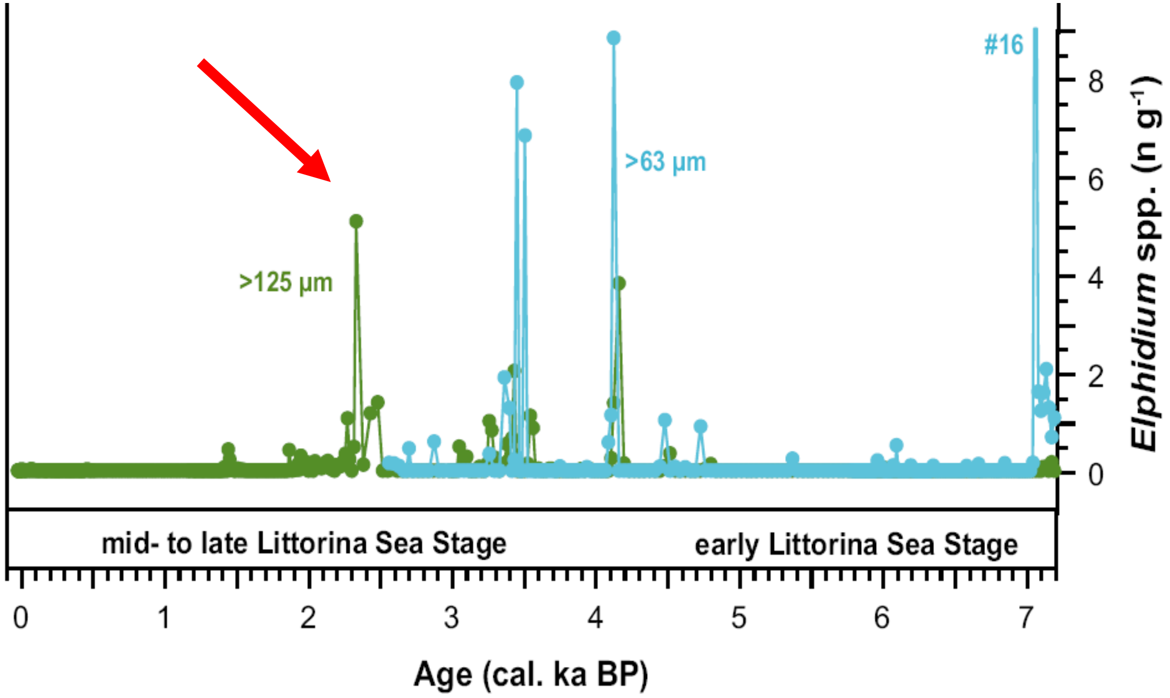
- Palaeosalinity reconstructions, based on Sr isotope analysis of the mollusks shells, indicate the maximum surface salinity (10 – 11 ppt) in the Bothnian Bay about 7000 – 3000 years ago.



(Widerlund & Andersson 2011)

SALINE WATER PULSES

- The occurrence of benthic foraminiferas (*Elphidium* spp.) indicate the last inflow of large saline pulses into the Gulf of Bothnia ca 2300 years ago.



(Häusler et al. 2017)

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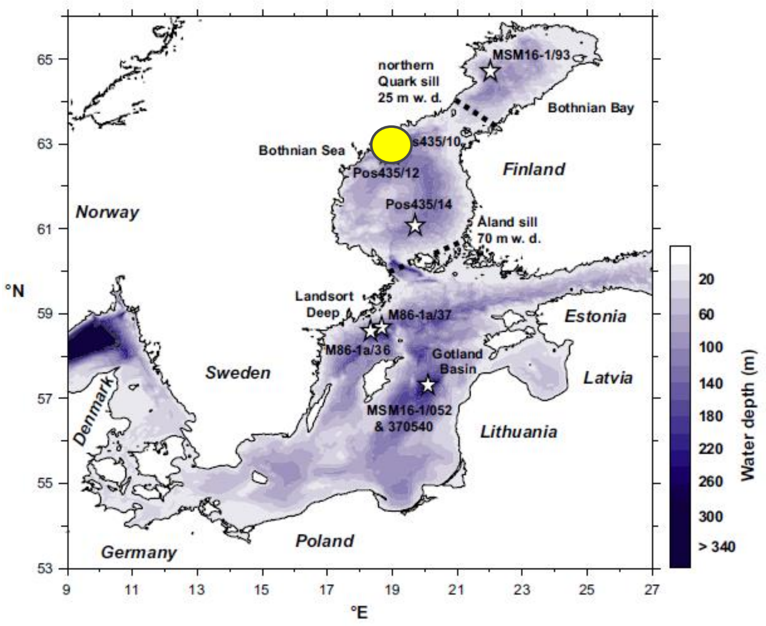

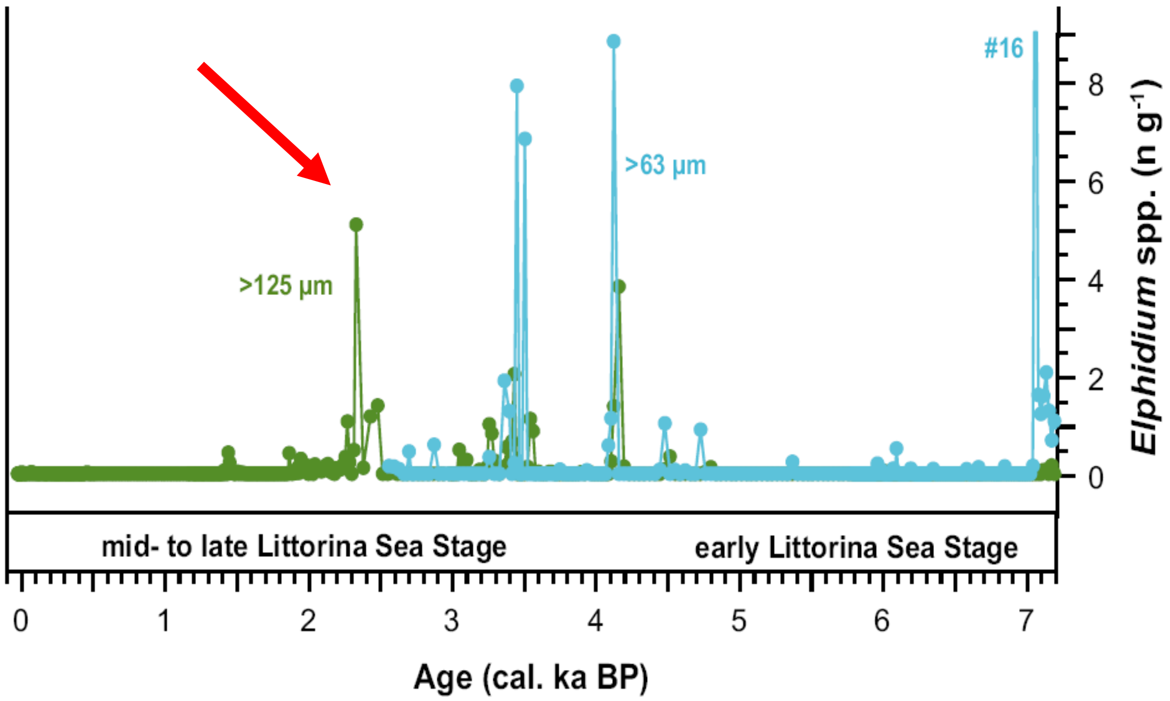

(Häusler et al. 2017)

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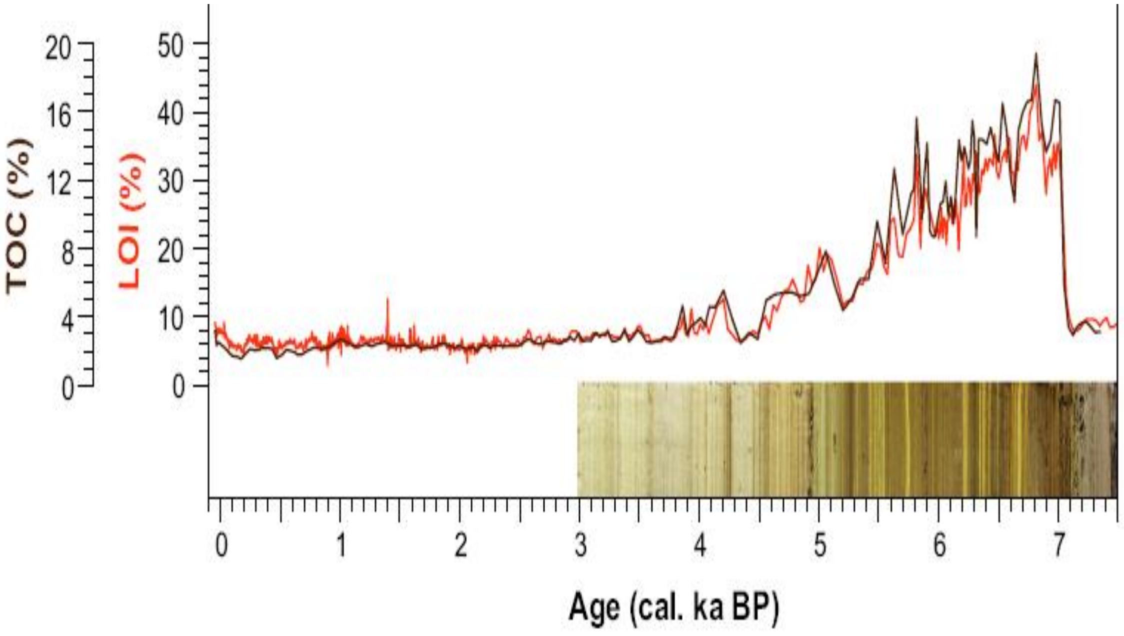
PRIMARY PRODUCTION

- Increased primary production and sedimentation of organic matter in the past warm phases, such as the Holocene Thermal Maximum, around 7000 – 4000 years ago.

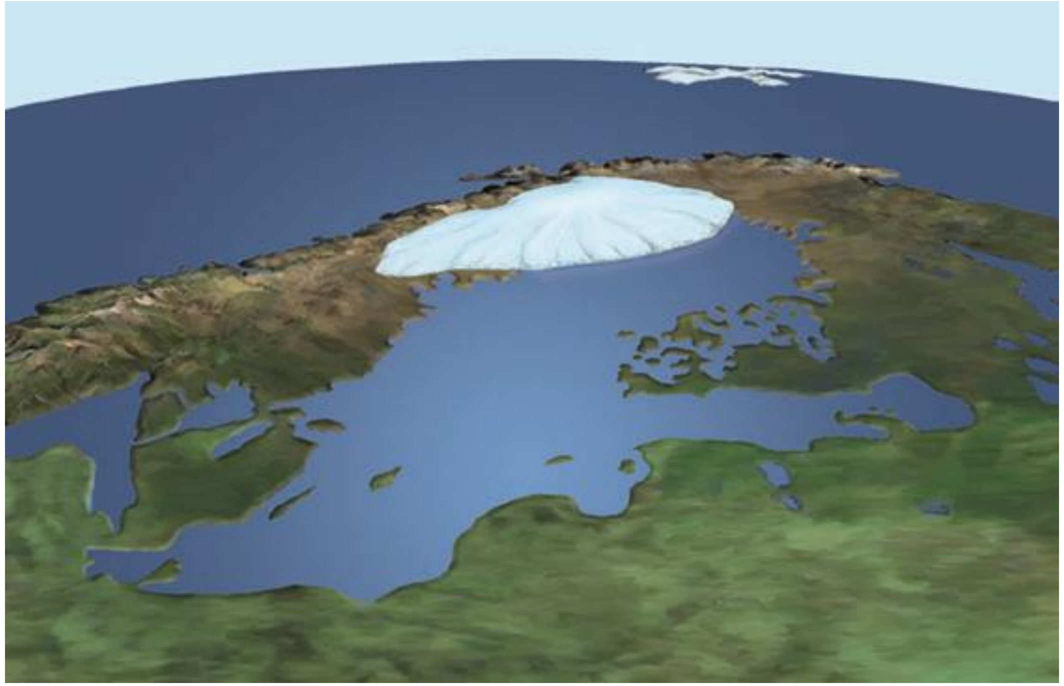


(Häusler et al. 2017)

CONCLUSIONS

- The Bothnian Bay has experienced significant changes after the ice age; e.g. its
  - *sea level/shoreline,*
  - *bathymetry,*
  - *water volume,*
  - *salinity,*
  - *sea surface temperature,*
  - *primary production, and*
  - *seabed hypoxia*

  have changed abundantly.



The Ancylus Lake, *circa* 10,000 years ago.
Figure: Matti Saarnisto, Olli Sallasmaa ja Harri Kutvonen / Geologian tutkimuskeskus.

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CONCLUSIONS

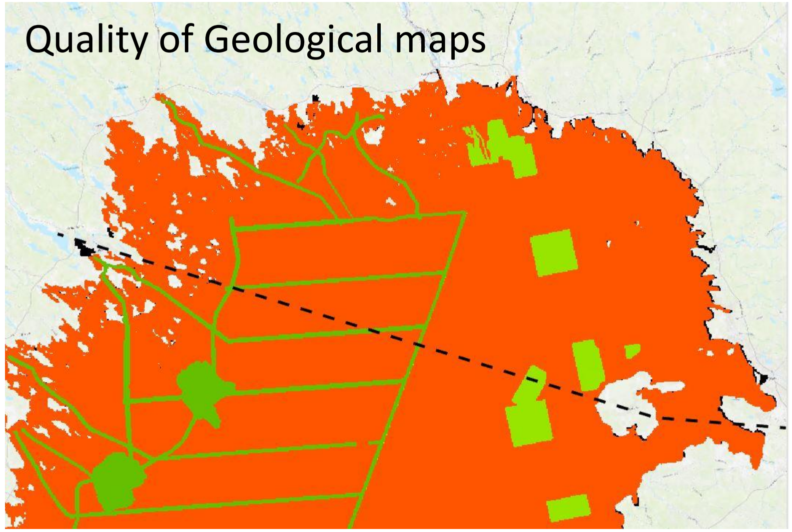
- Ongoing land uplift modifies the seabed and the coast slowly, but steadily

→ **seabed is under a constant change.**

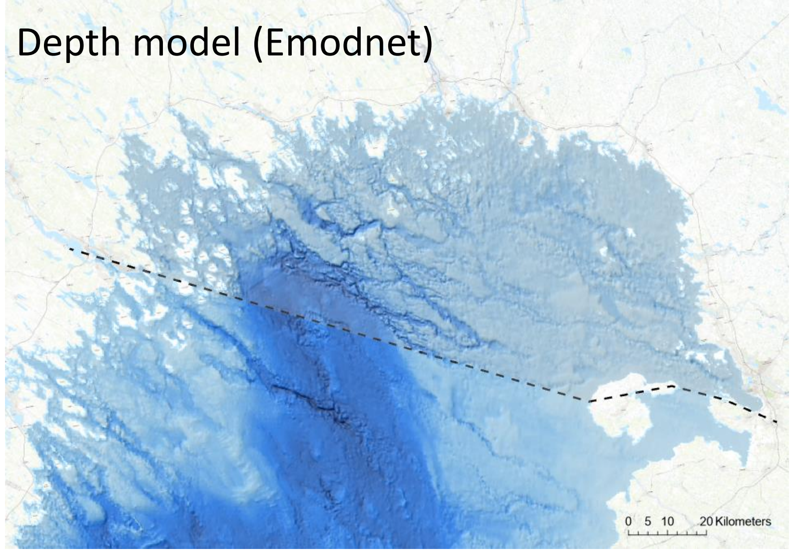
Photo *by Suvi Saarnio, Metsähallitus.*

GEOLOGY IN THE SEAMBOTH AREA
– THE MAPS AT THE START OF THE PROJECT

Quality of Geological maps

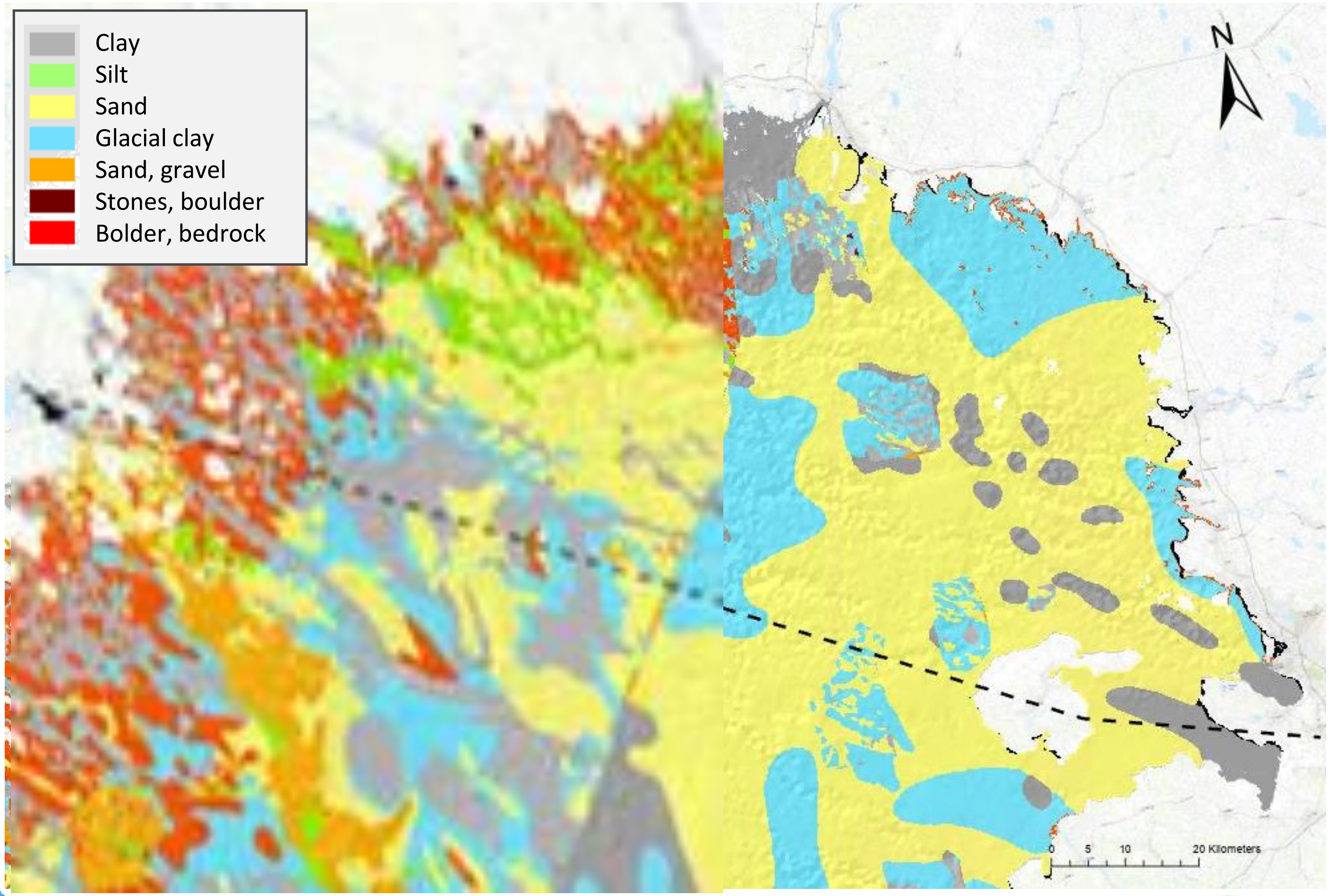


Depth model (Emodnet)



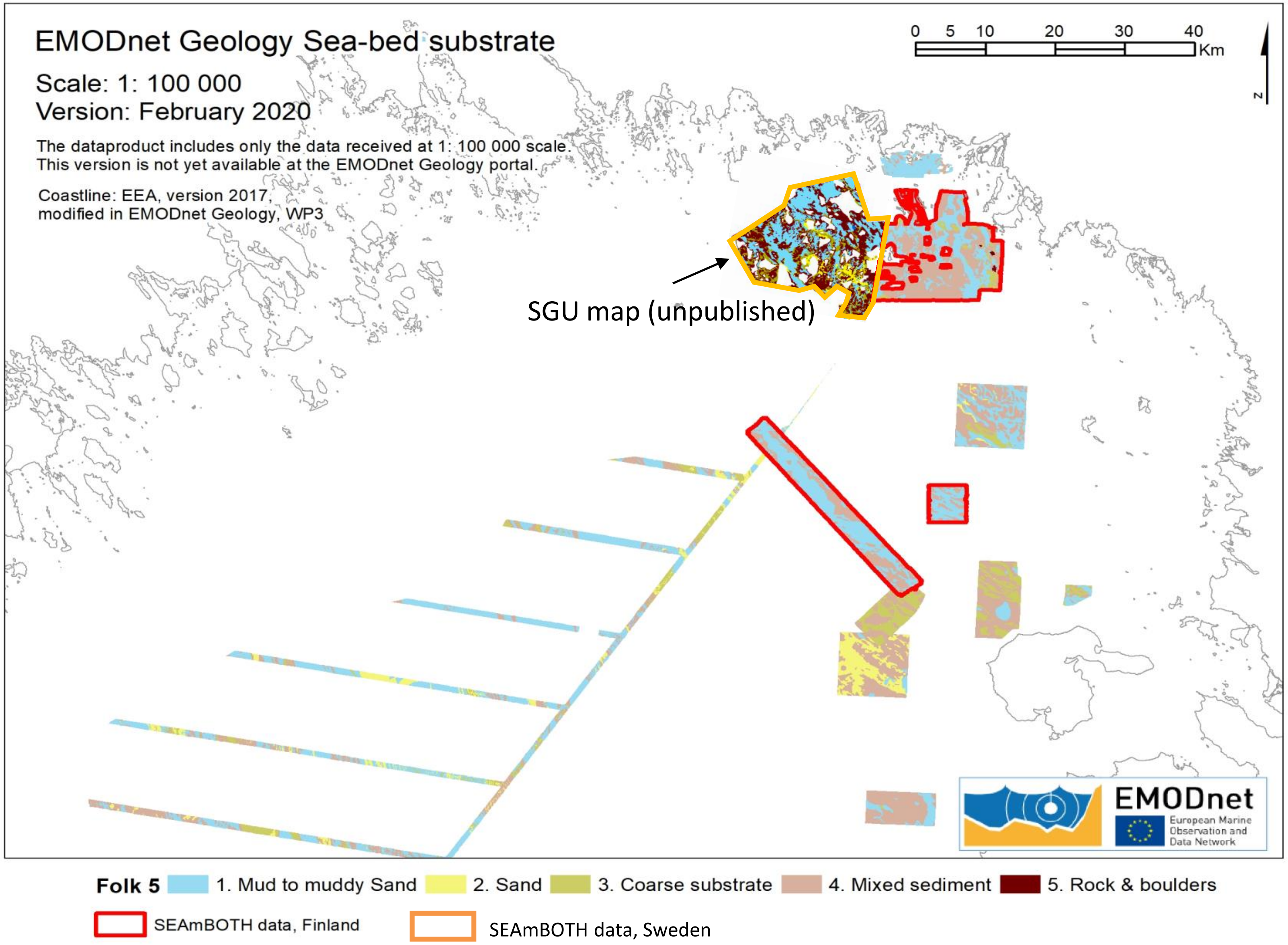
The maps available at the starts of the project

Combination of GTK and SGU geological maps (1:100k – 1:1000k scale)



New Geological Surveys in the northern Bothnian Bay

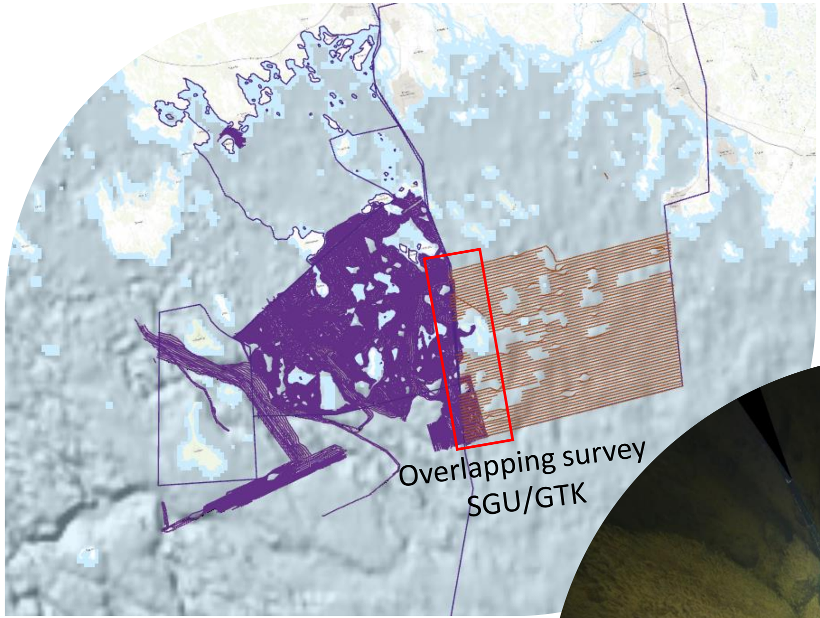
a window to the unknown

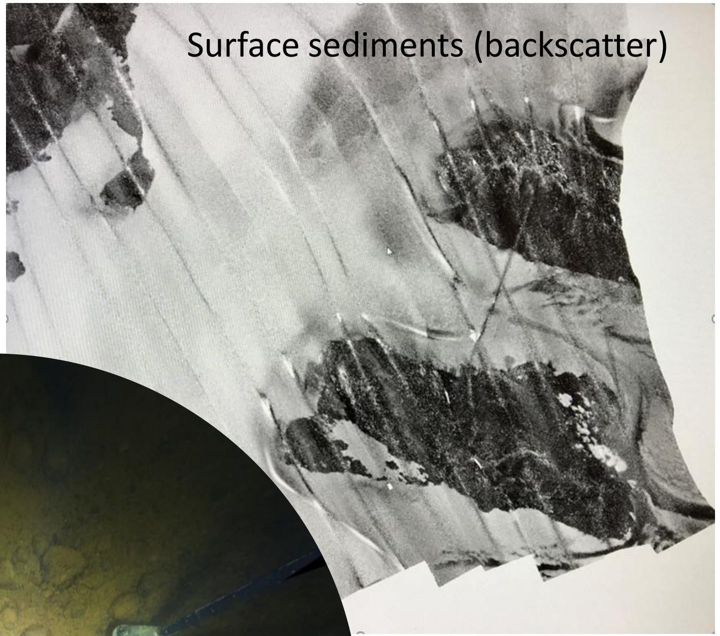


Pilot areas

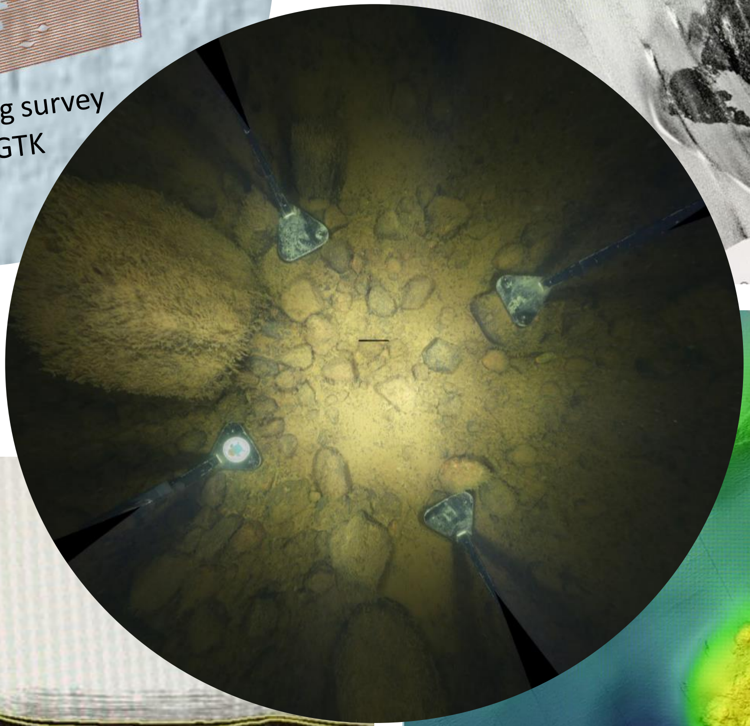
a window into the unknown

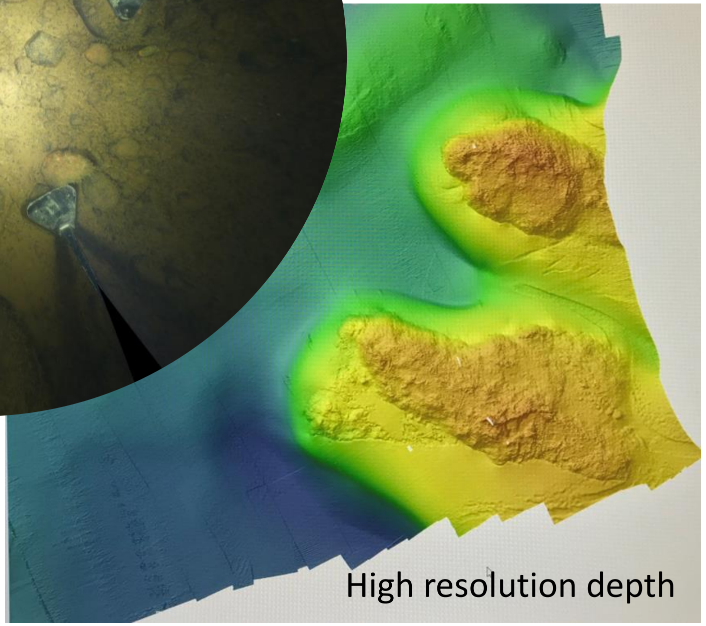
- Replacing historical soundings with high resolution surveys
- Seamless maps cross the border area
- Geological & biological features mapped
- High resolution maps highlight limits and possibilities with coarser models in the Seamboth study area





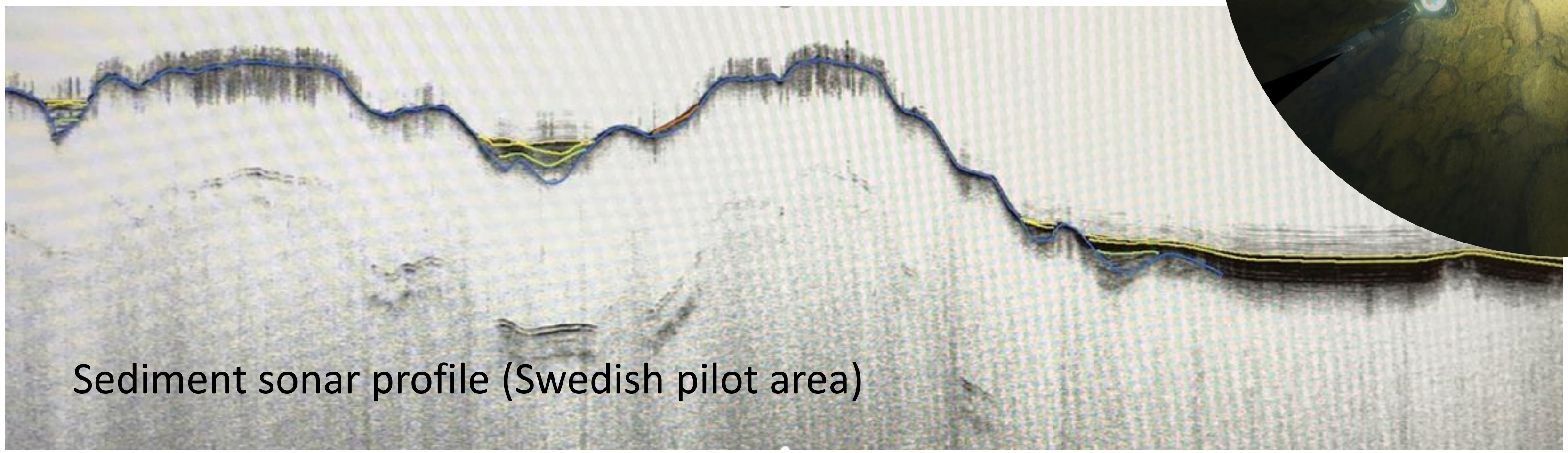
Surface sediments (backscatter)





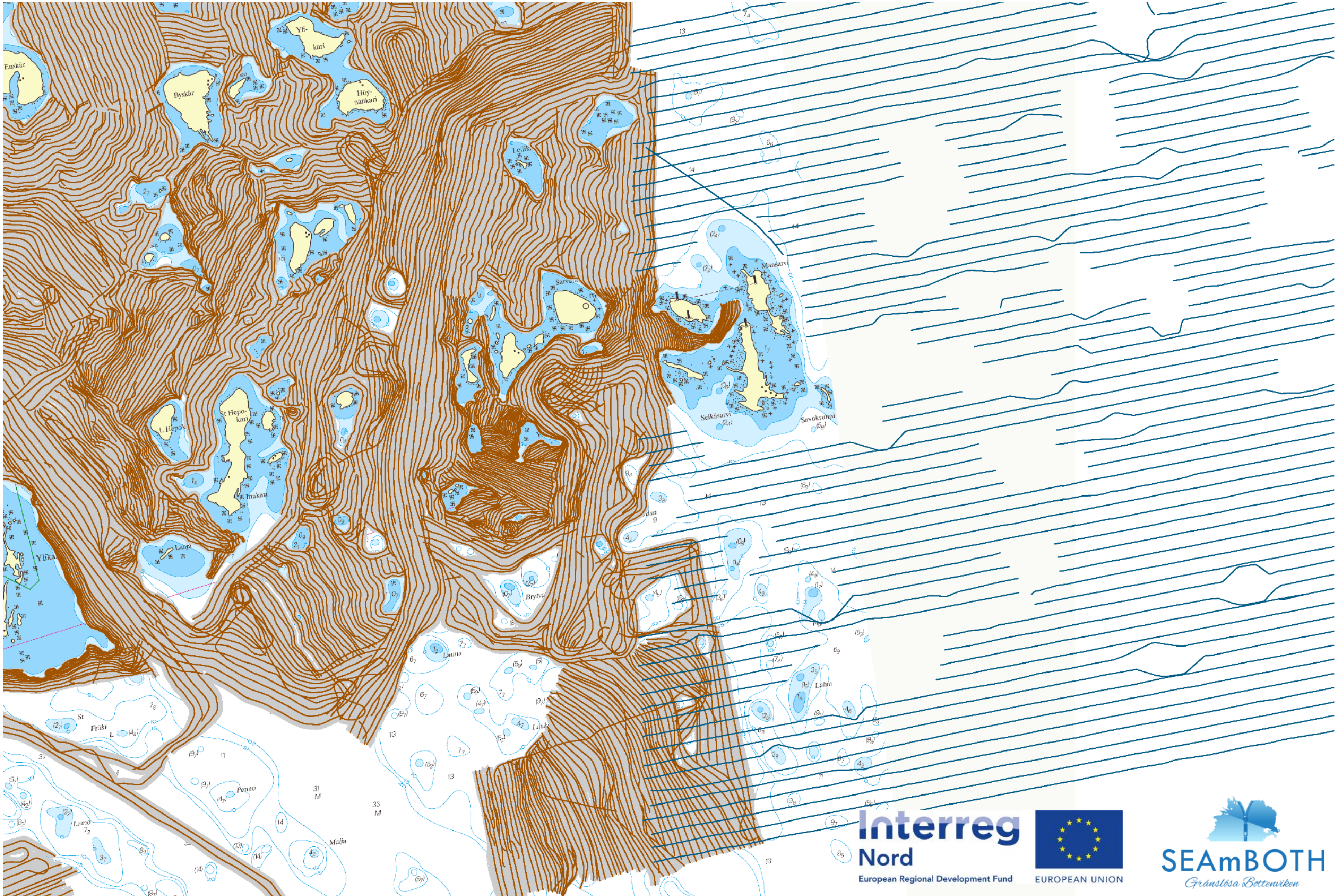
High resolution depth

Sediment sample



Sediment sonar profile (Swedish pilot area)

OVERLAPPING GEOLOGICAL FIELDWORK SWEDEN-FINLAND



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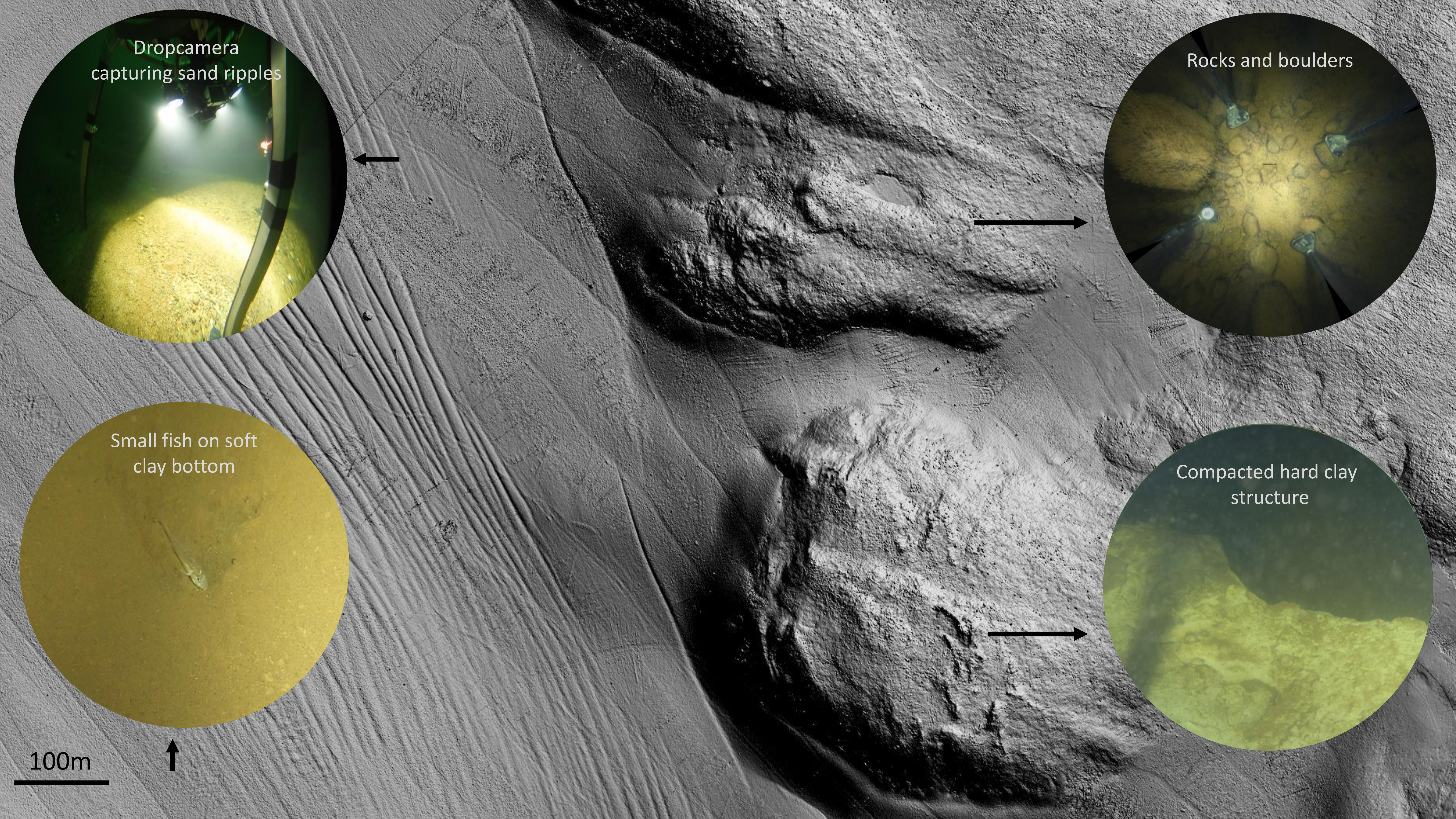
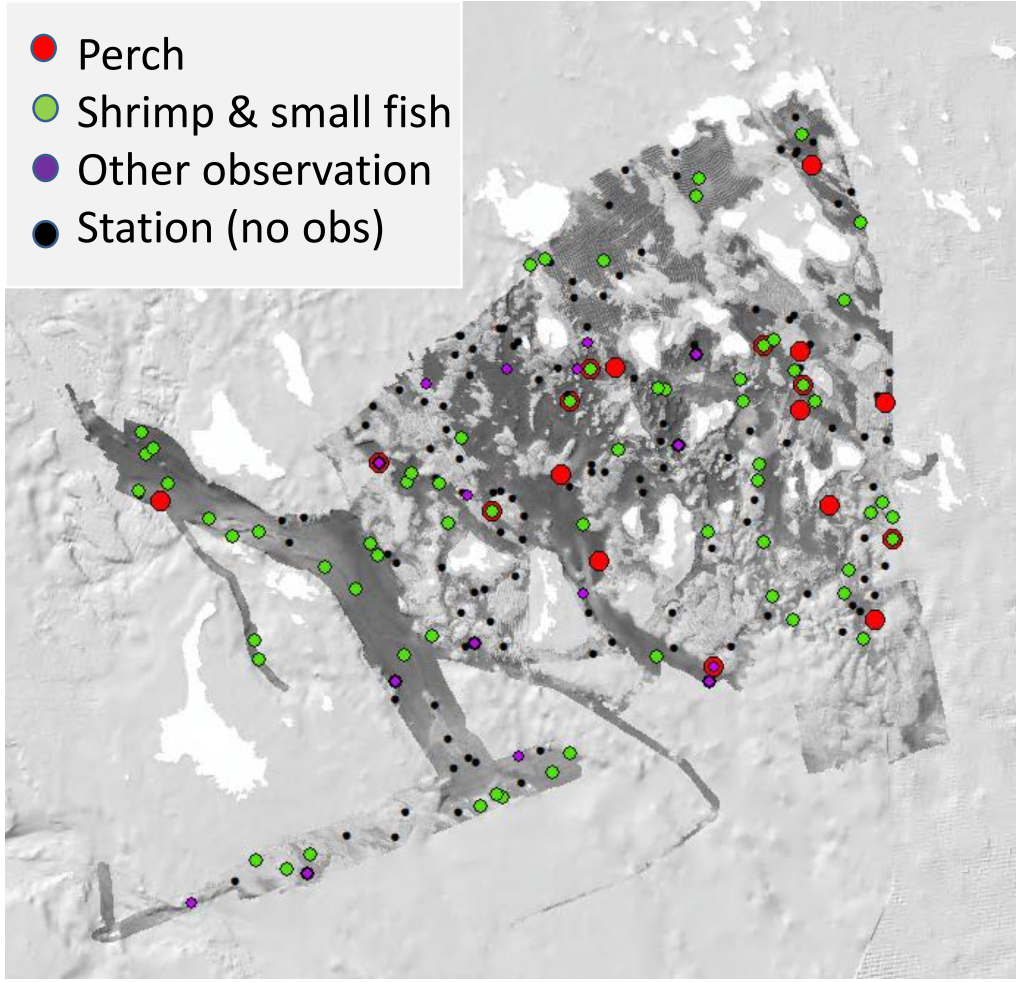
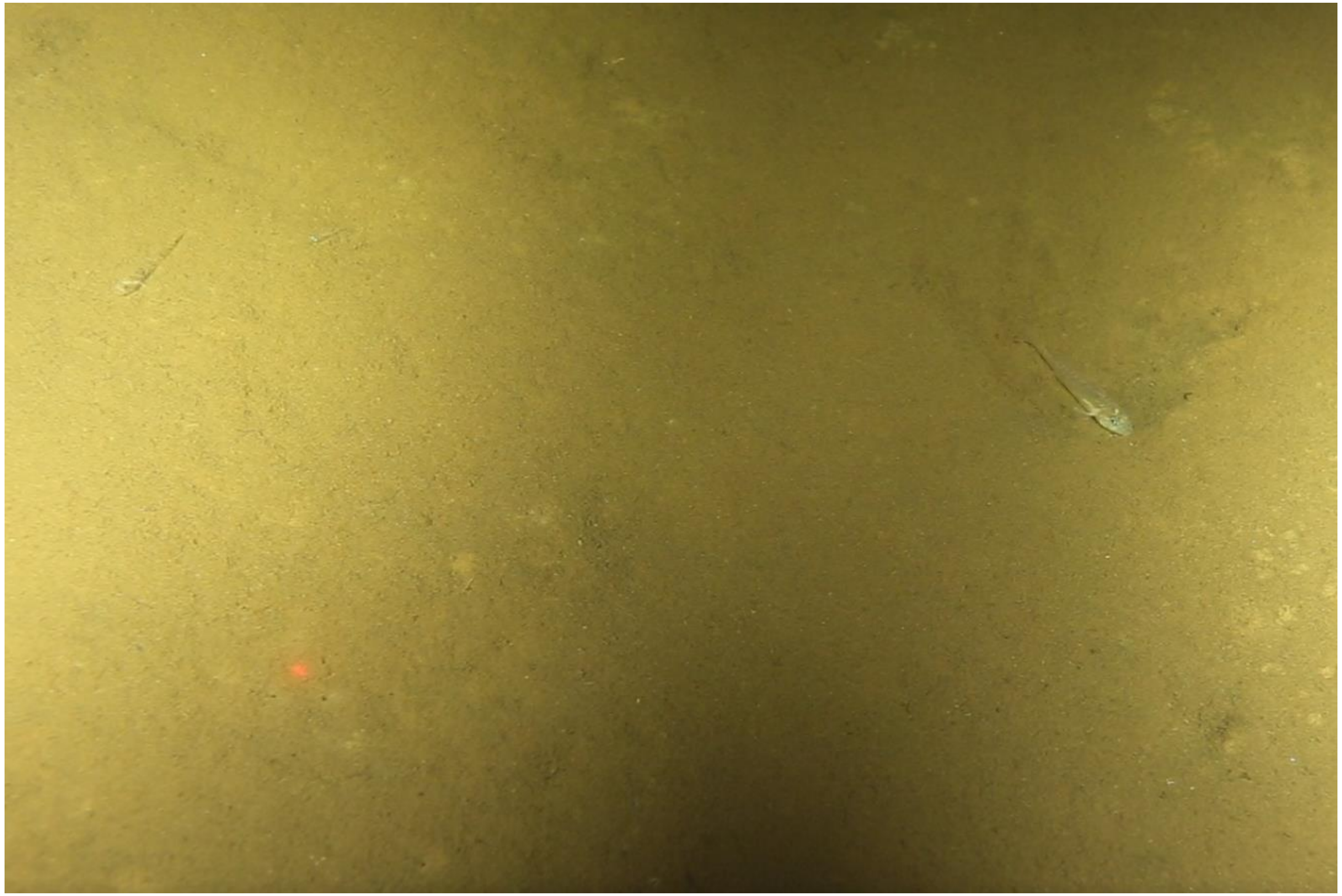
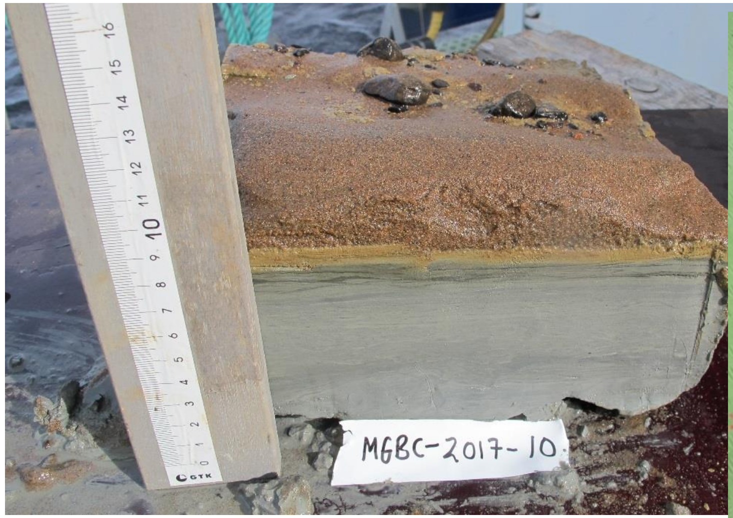

Dropcamera
capturing sand ripples
Rocks and boulders
Small fish on soft
clay bottom
Compacted hard clay
structure
100m

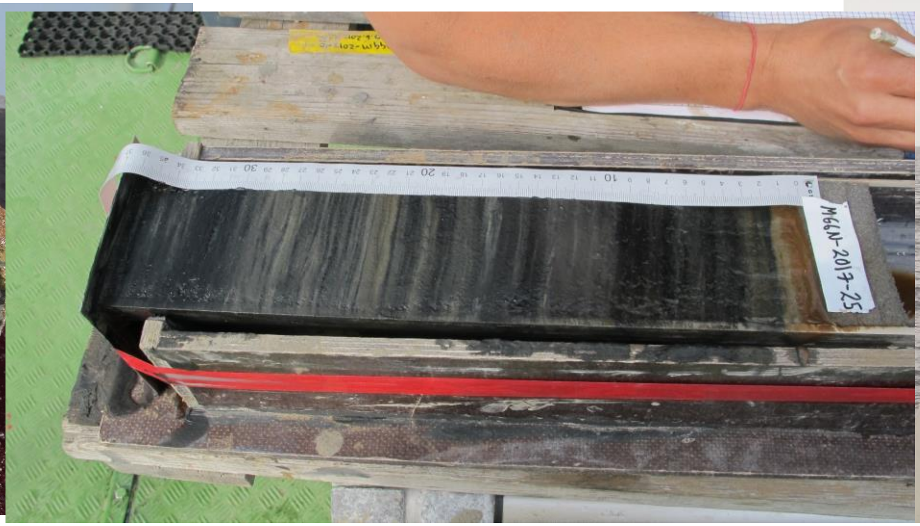
Even geologists finds the living…



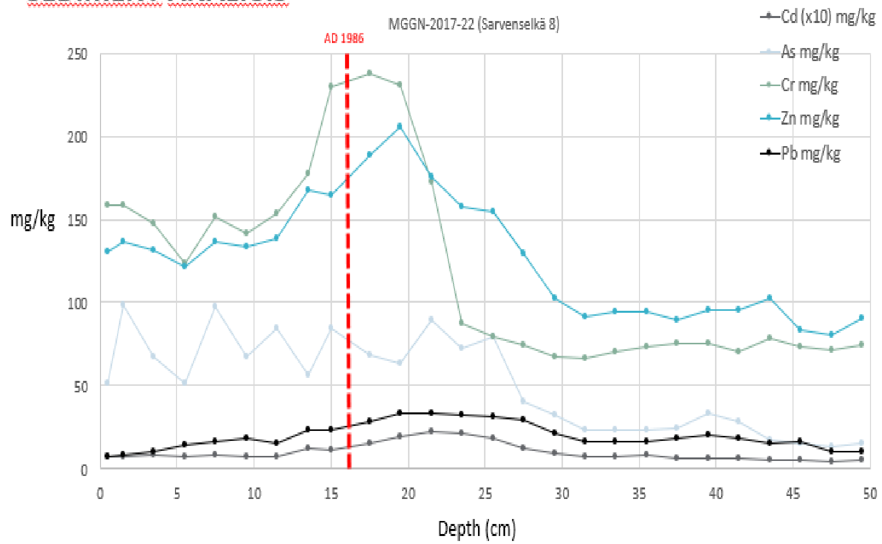


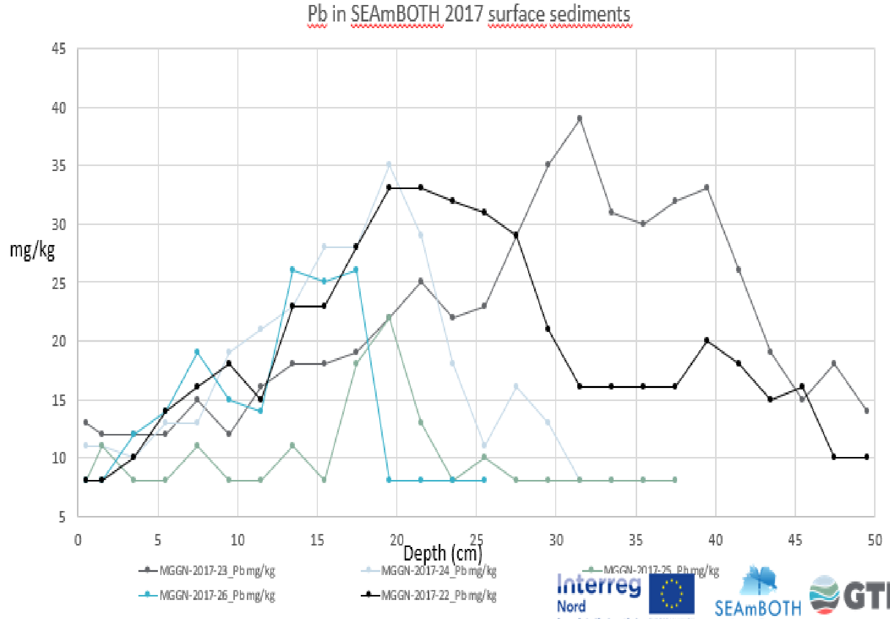
SEDIMENT ANALYSIS – WHAT HIDES IN THE MUD?

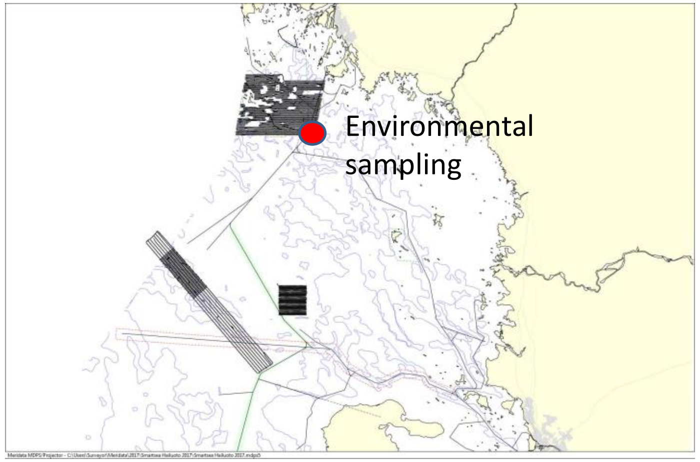




SEDIMENT ANALYSIS







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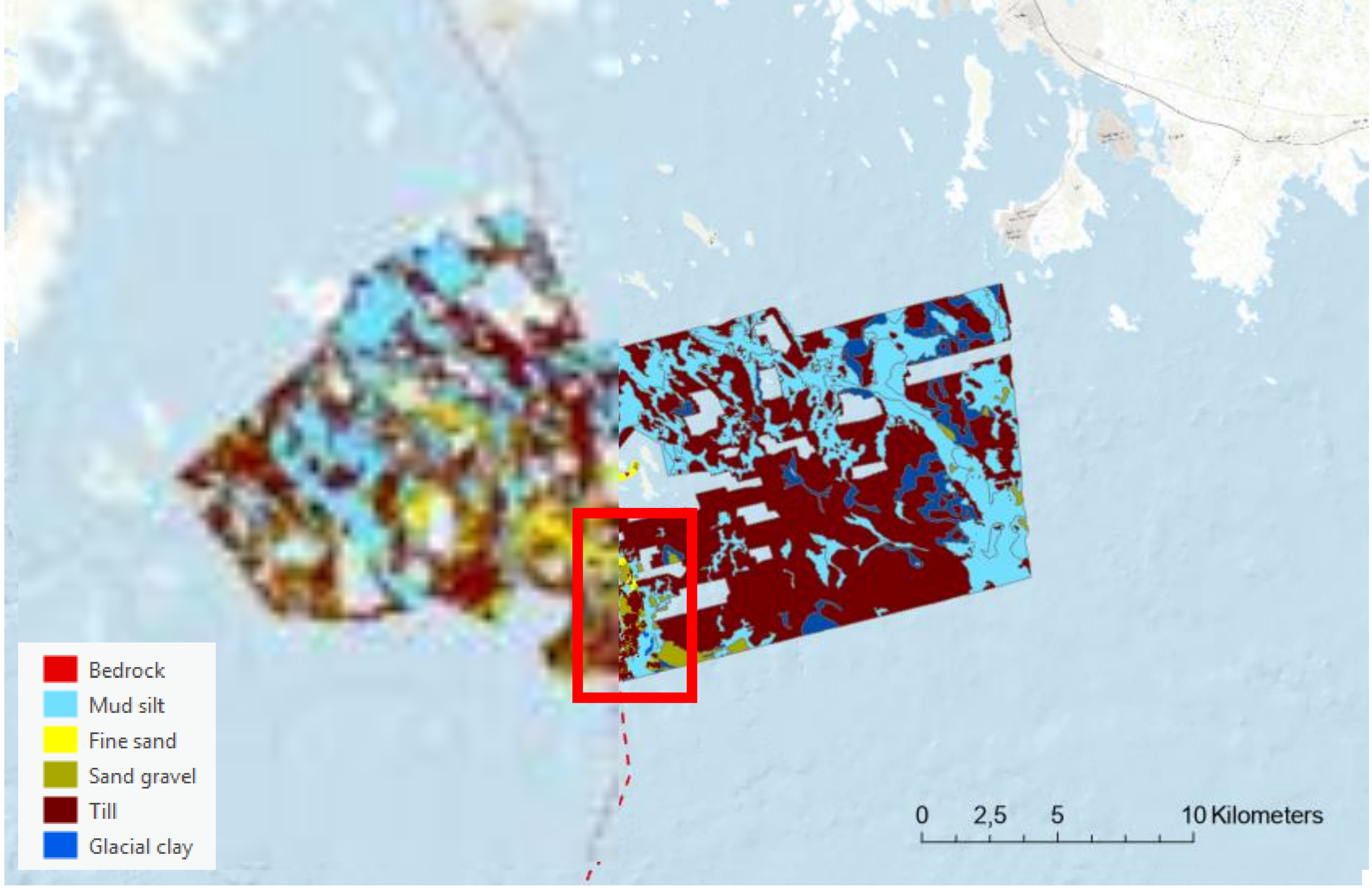
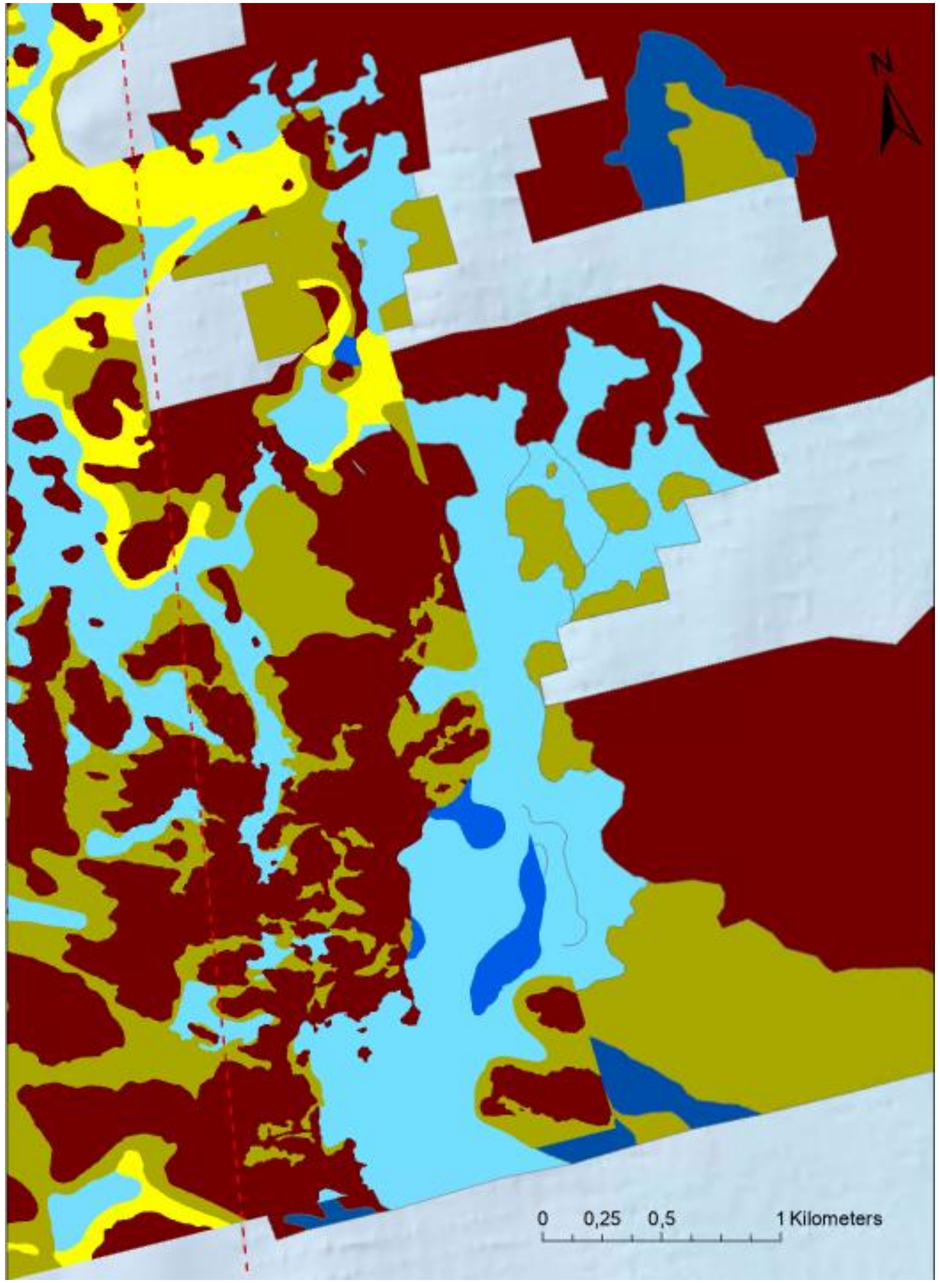
Seamless geological maps GTK/SGU

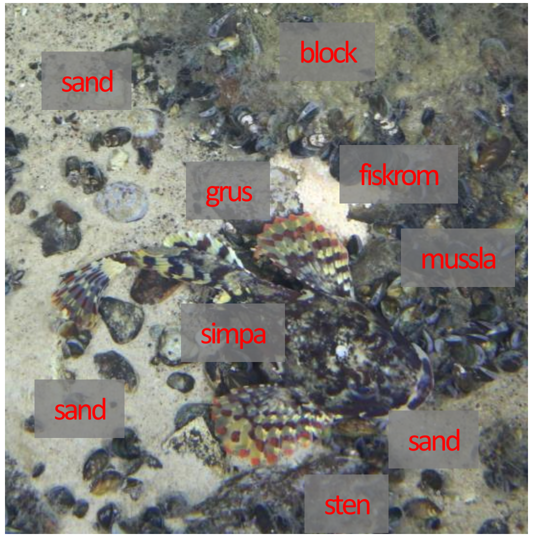
Combined geological maps in the Haparanda/Tornio region covering ~350 km^2

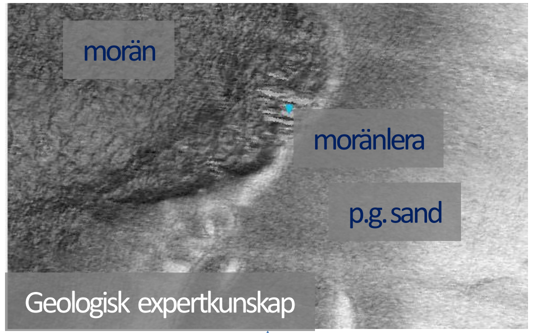




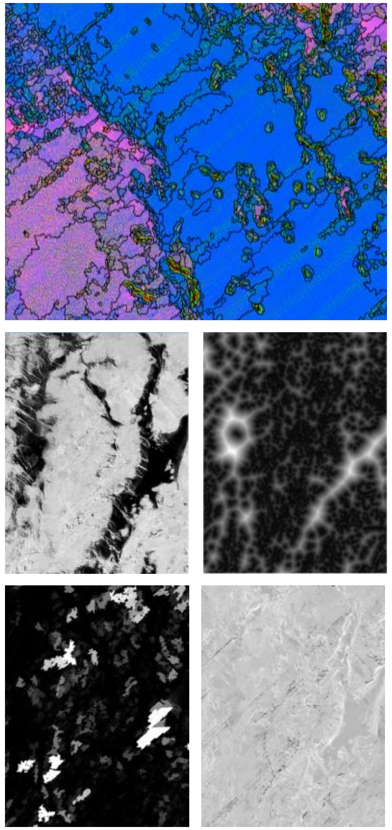
MODELLING SEABED HABITATS USING HIGH RESOLUTION DATA

Trainingdata
Sampels, observations
& expert interpretation

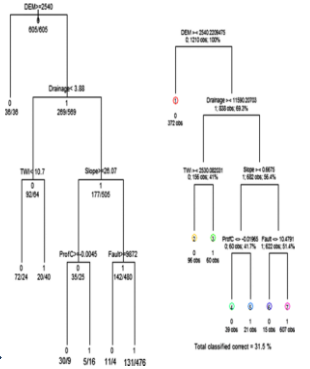




Environmental data
Depth, sonar mosaics,
remote sensing…

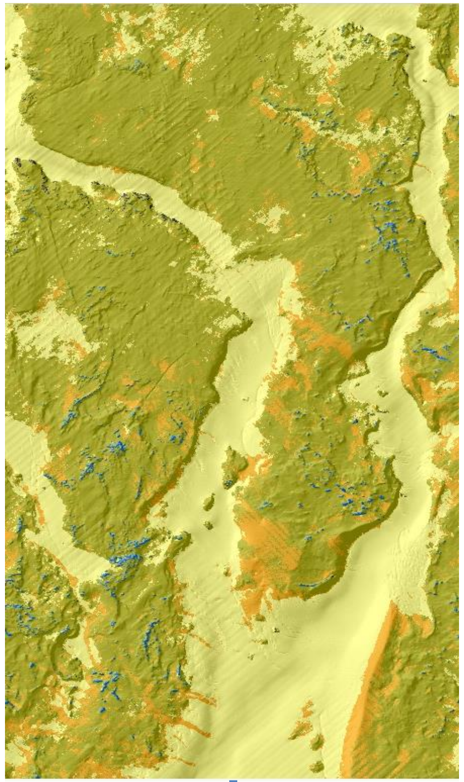


Machine learning
Thematic,
continuous or
presence model



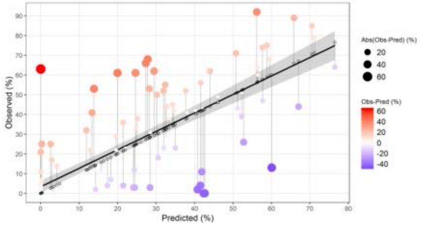
For example using ”Boosted regression trees” connecting trainingdata with environmental data to make prediction

Predicted maps
New version when better source data becomes available



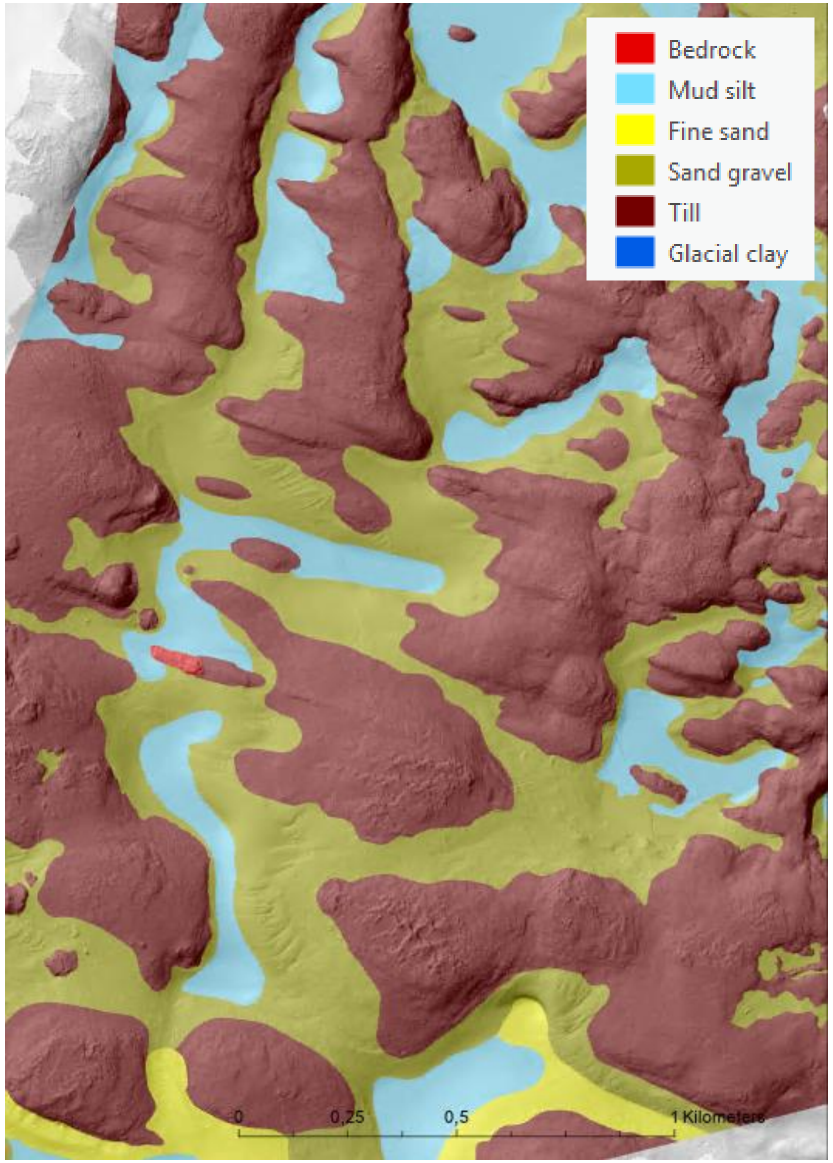
Uncertainty
How good is the map?

Independent testdata from observations

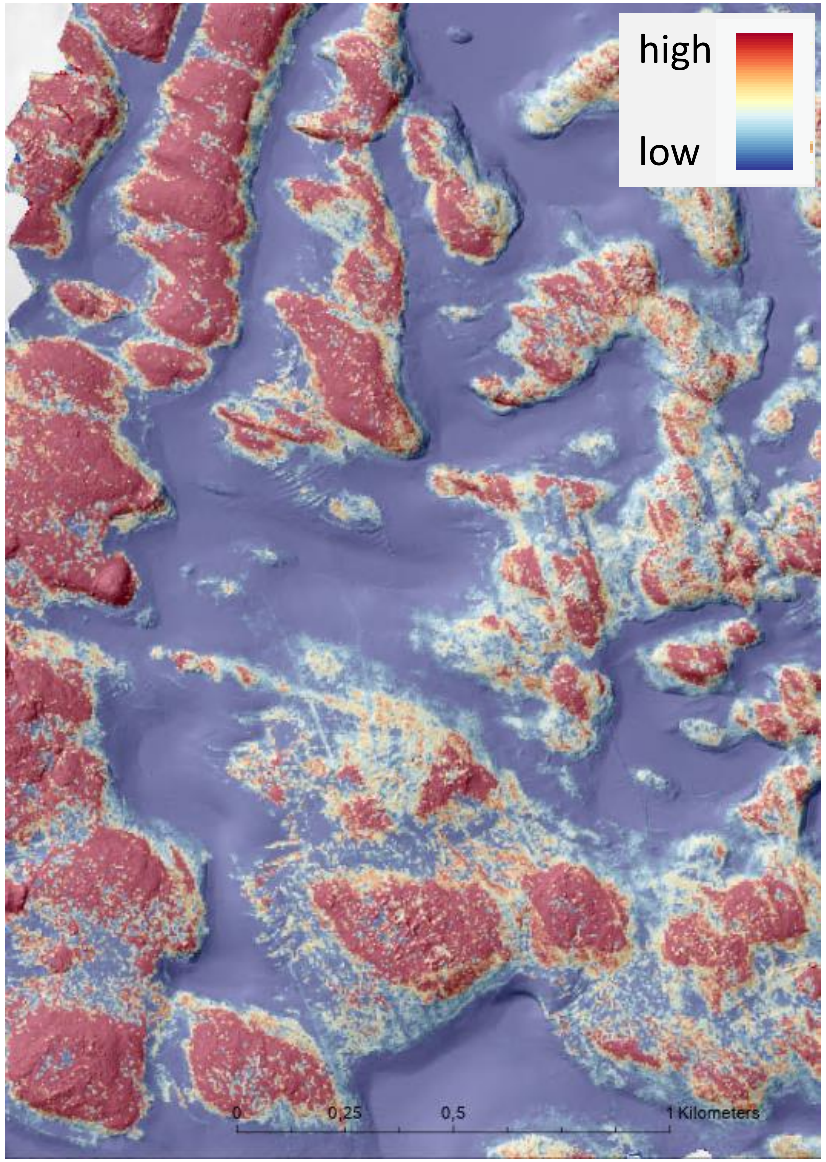


Expert validation (geology) – more trainingdata – new model

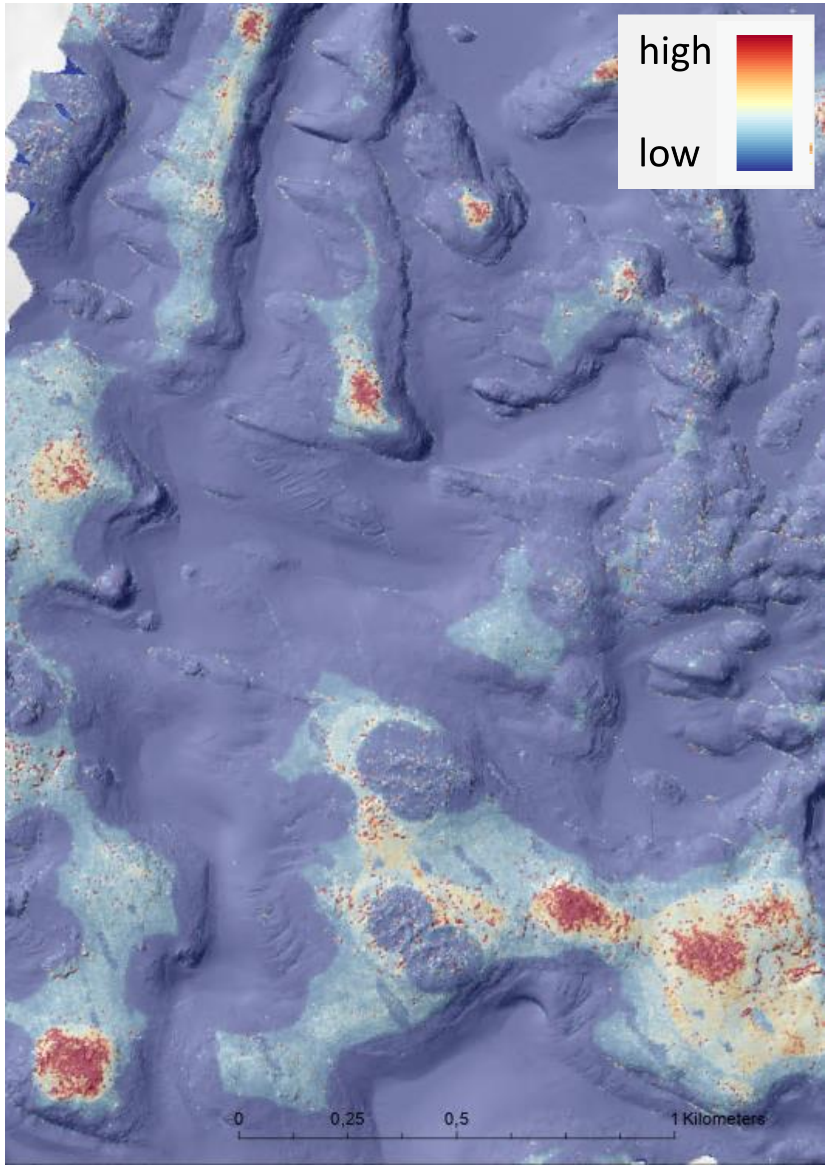
Geological interpretation
Bottom material (upper 1m)



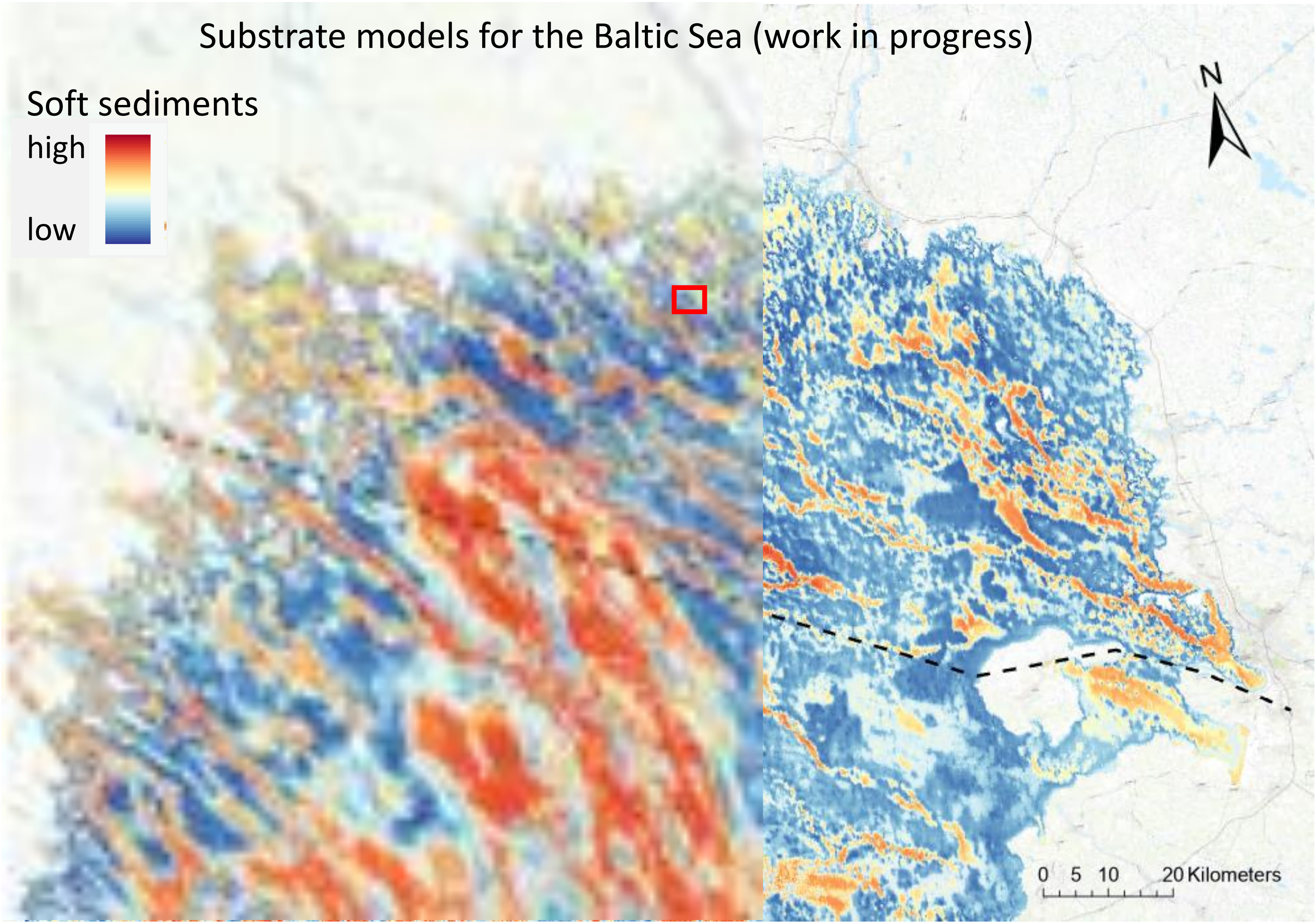
Surface substrate models
% cover hardbottom



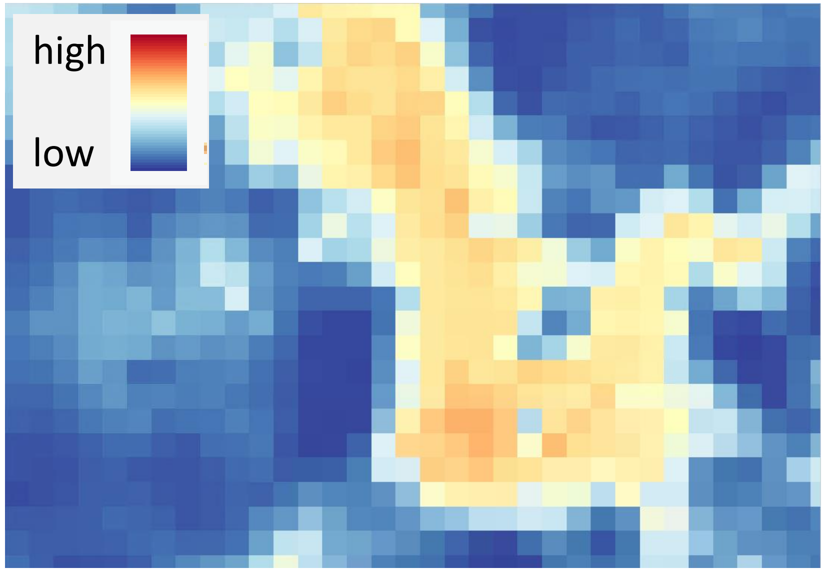
Biological cover models
% cover freshwater hydroids



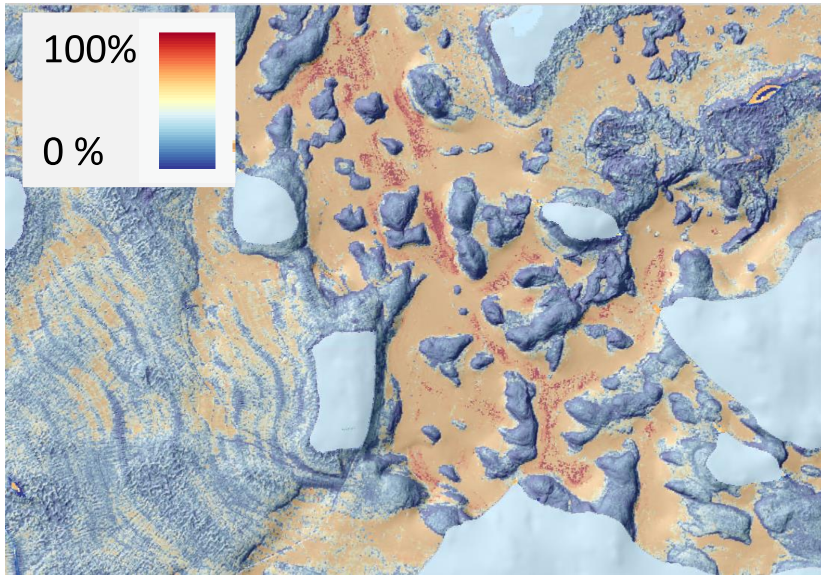
A seamless Bottnian Bay…



100m resolution soft sediment model



5m soft sediment model Seamboth



Existing geological maps - new substrate models

Significant progress has been made! - lots of work remaining