

Requirements and results – Experiences from seabed topography mapping in MAREANO

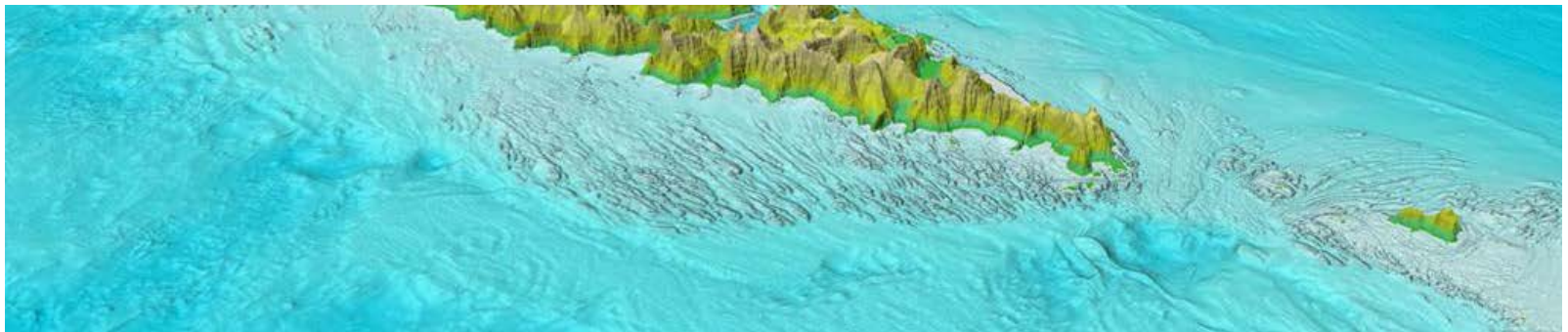


NORWEGIAN MAPPING
AUTHORITY

HYDROGRAPHIC DATA – FOR THE BENEFIT OF SOCIETY



Requirements and results – Experiences from seabed topography mapping in MAREANO



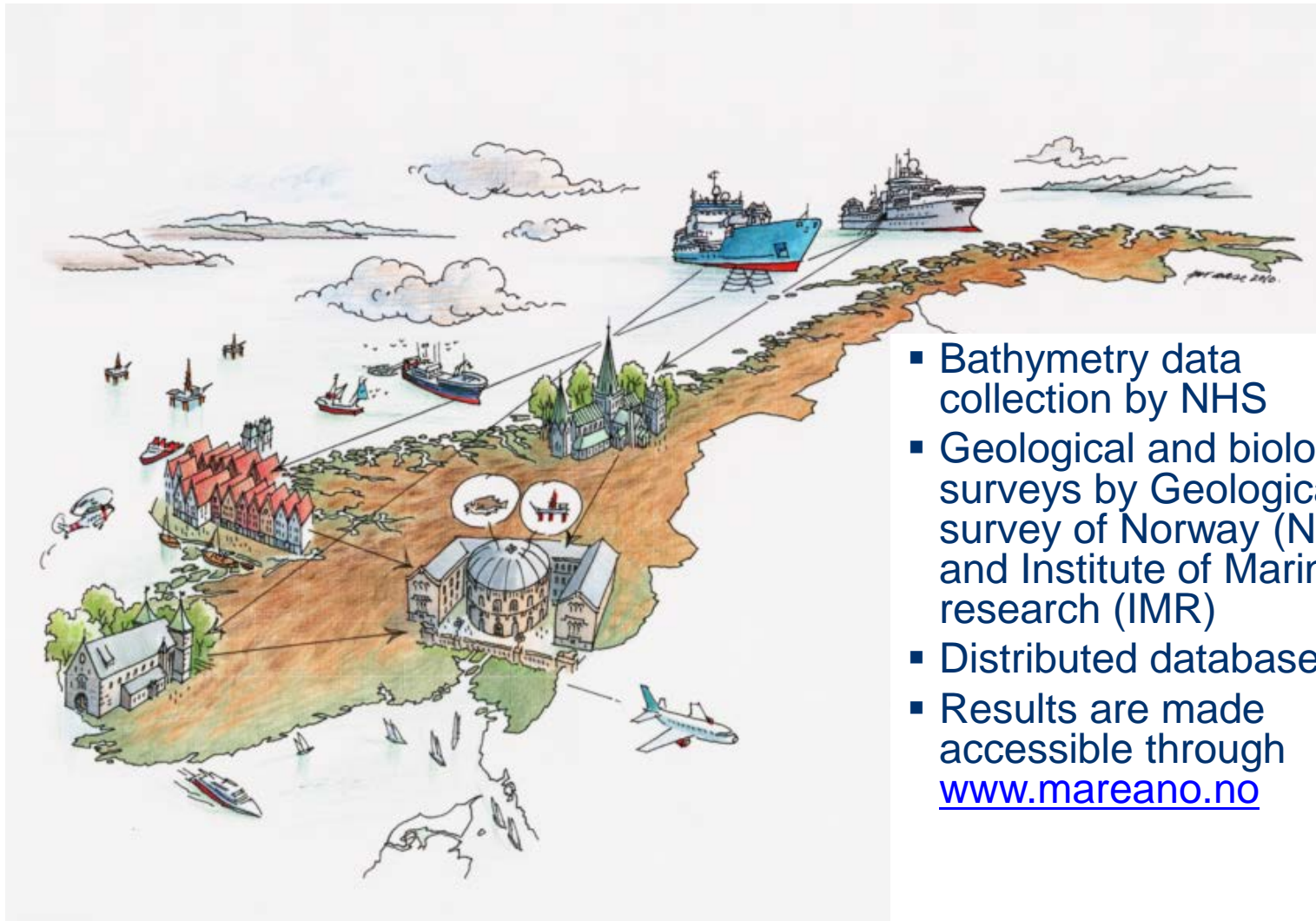
Arne E. Ofstad and Hanne Hodnesdal
Norwegian Mapping Authority Hydrographic Service (NHS)
(Statens kartverk Sjø)

Seabed Mapping and Inspection 2011
Geilo 9-11 February 2011





MAREANO – Dataflow



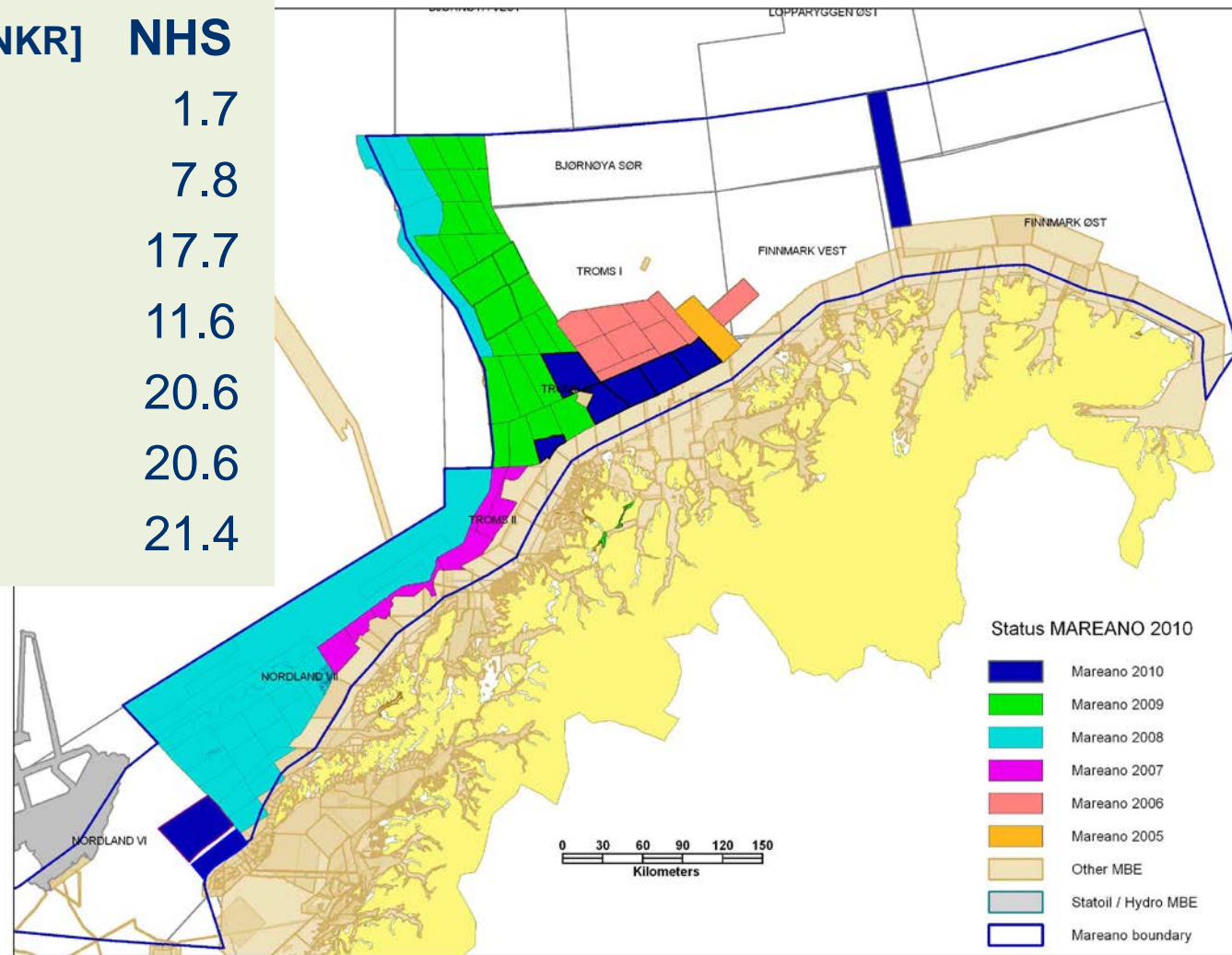
- Bathymetry data collection by NHS
- Geological and biological surveys by Geological survey of Norway (NGU) and Institute of Marine research (IMR)
- Distributed databases
- Results are made accessible through www.mareano.no





FINANCING AND PROGRESS

Year	Granted [NKR]	NHS
2005	5.0 mill	1.7
2006	23.6 mill	7.8
2007	32.6 mill	17.7
2008	32.6 mill	11.6
2009	51.5 mill	20.6
2010	51.5 mill	20.6
2011	52.4 mill	21.4

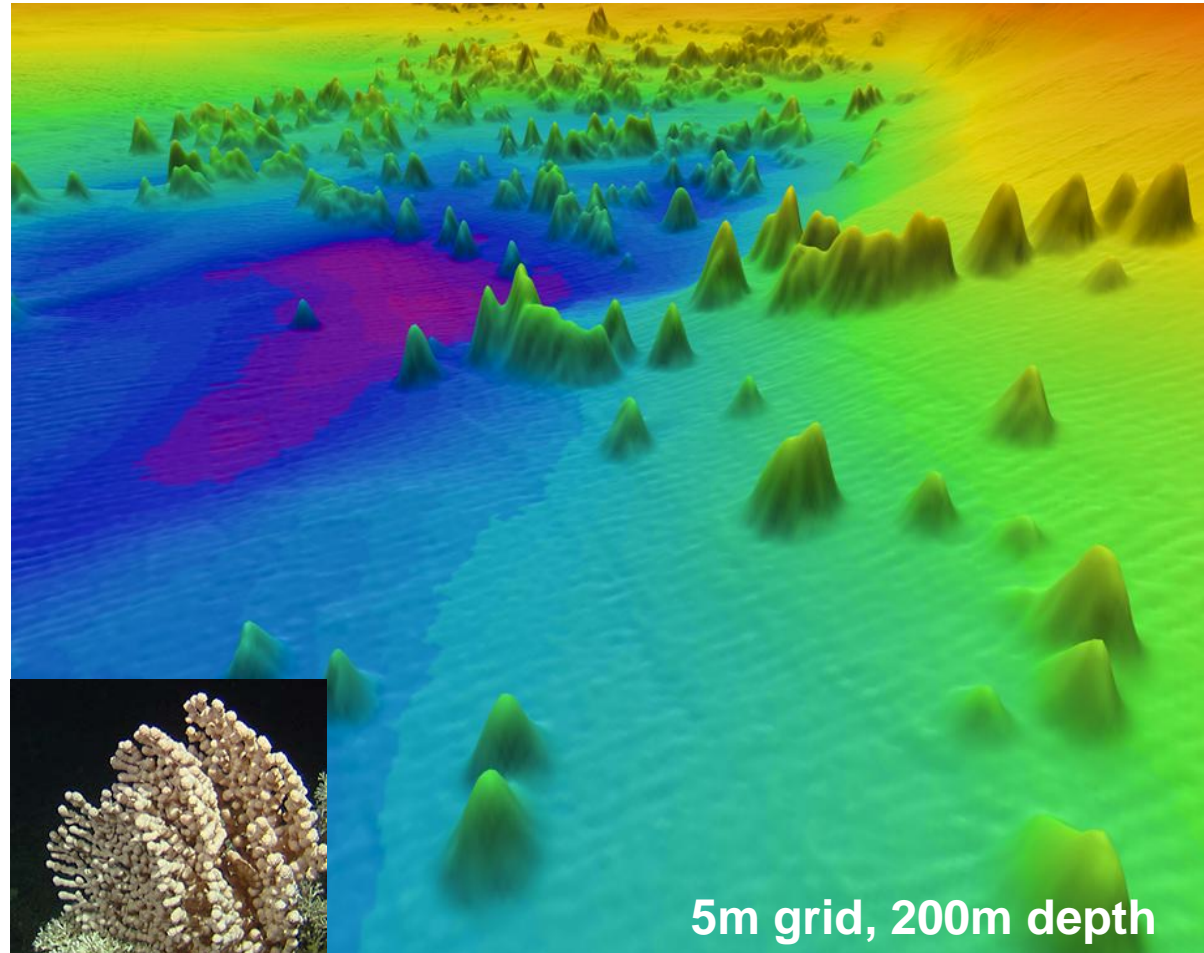




The specification depends on what are we looking for in the seabed topography

Corals

- Depth 40m to 450m
- Height up to 35m
- Reefs can be more than 100m long

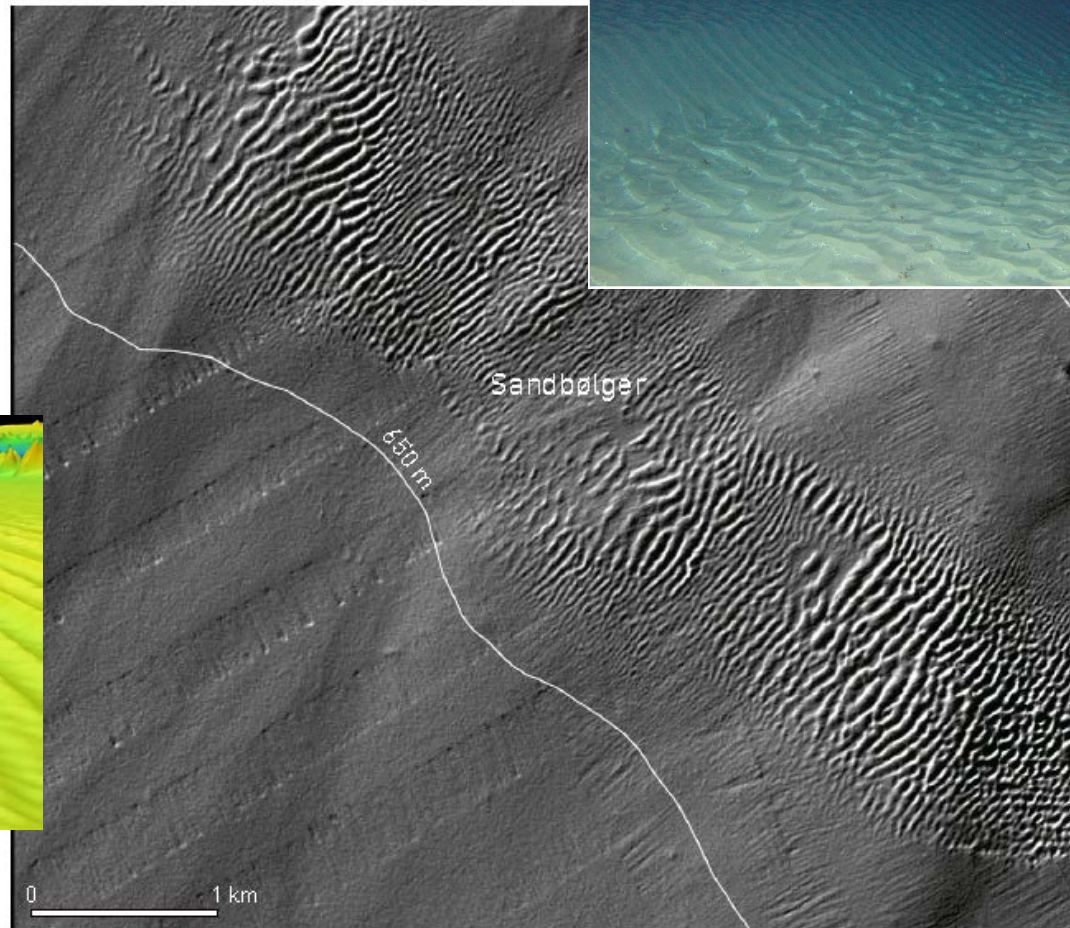
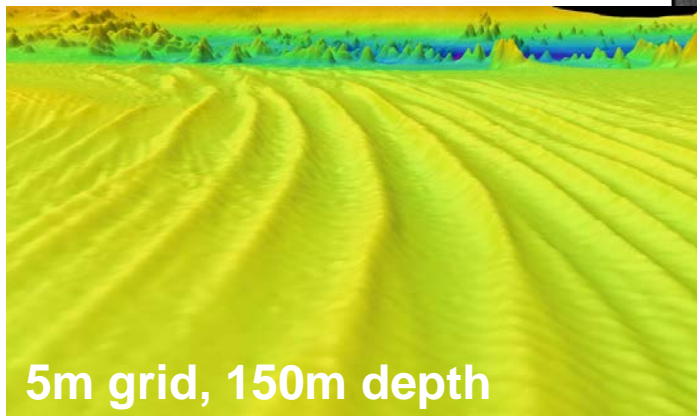




What are we looking for in the seabed topography

Sand waves

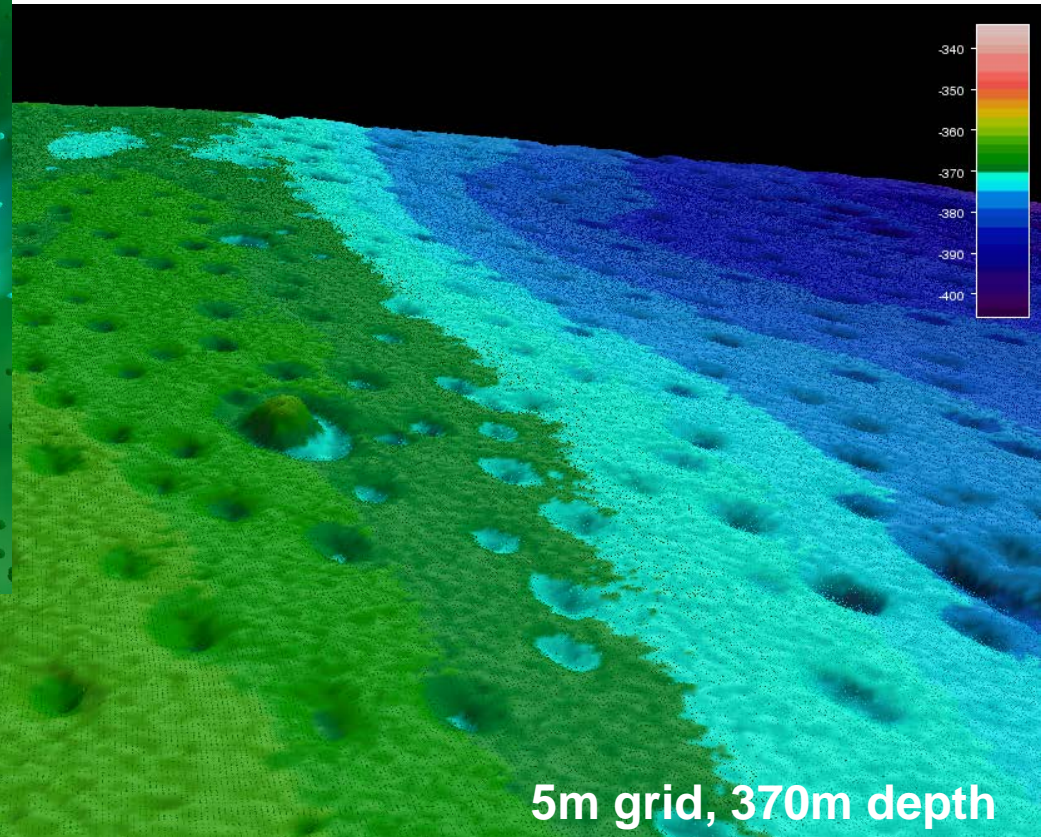
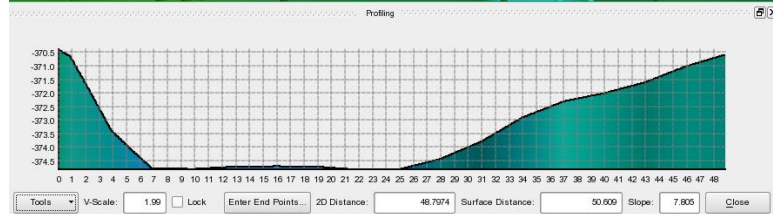
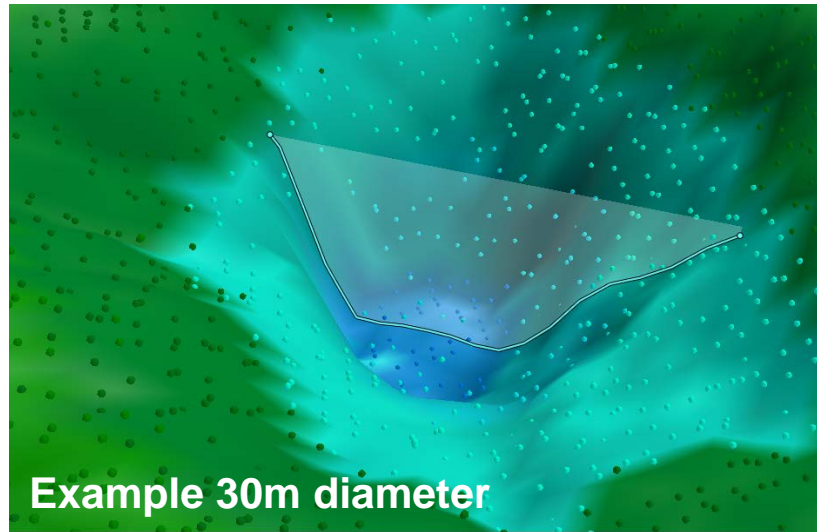
- Sand waves with different dimensions at varying depths
- From ripples with height 10 cm to large waves with height up to 7 m





What are we looking for in the seabed topography

Pockmarks

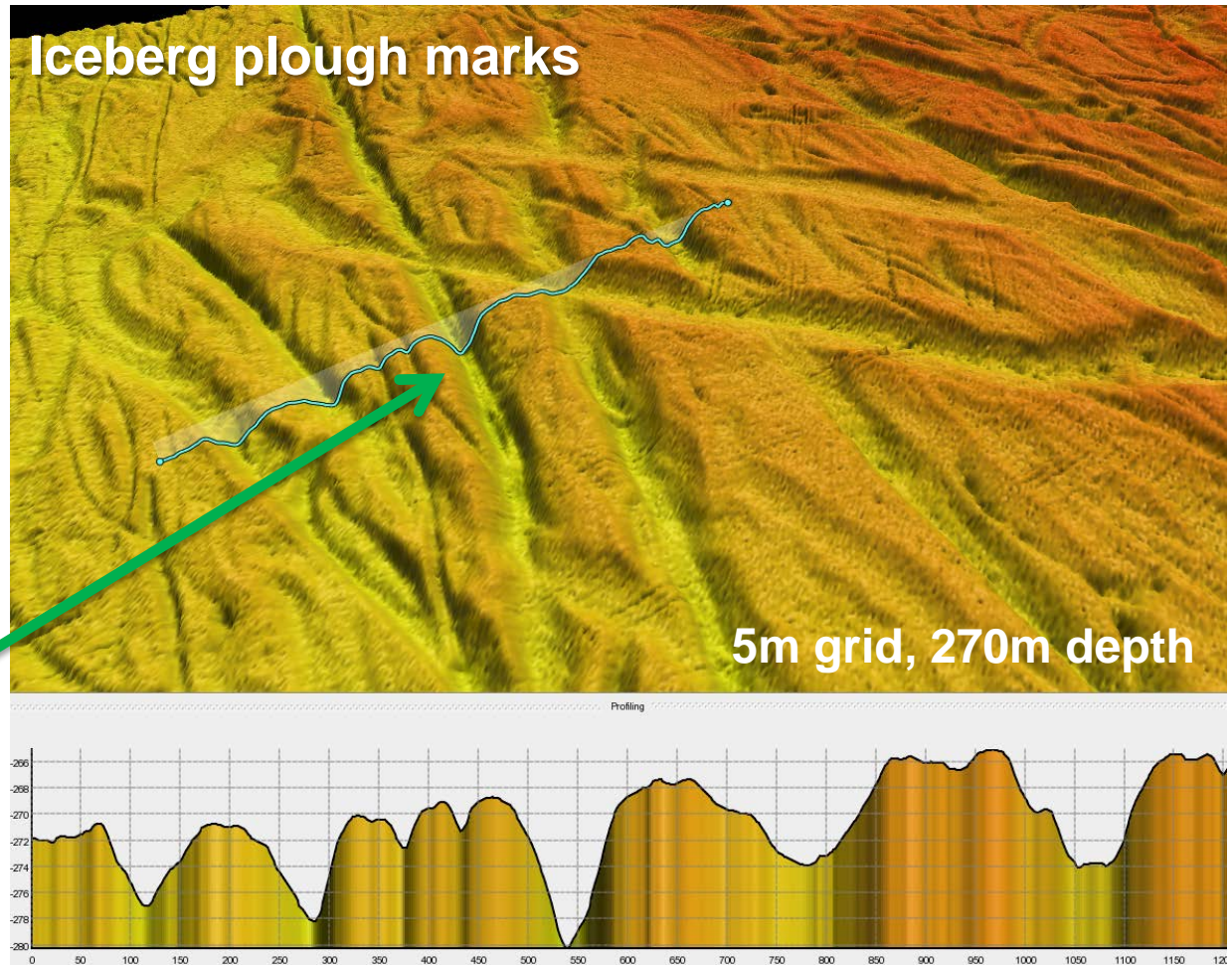




What are we looking for in the seabed topography

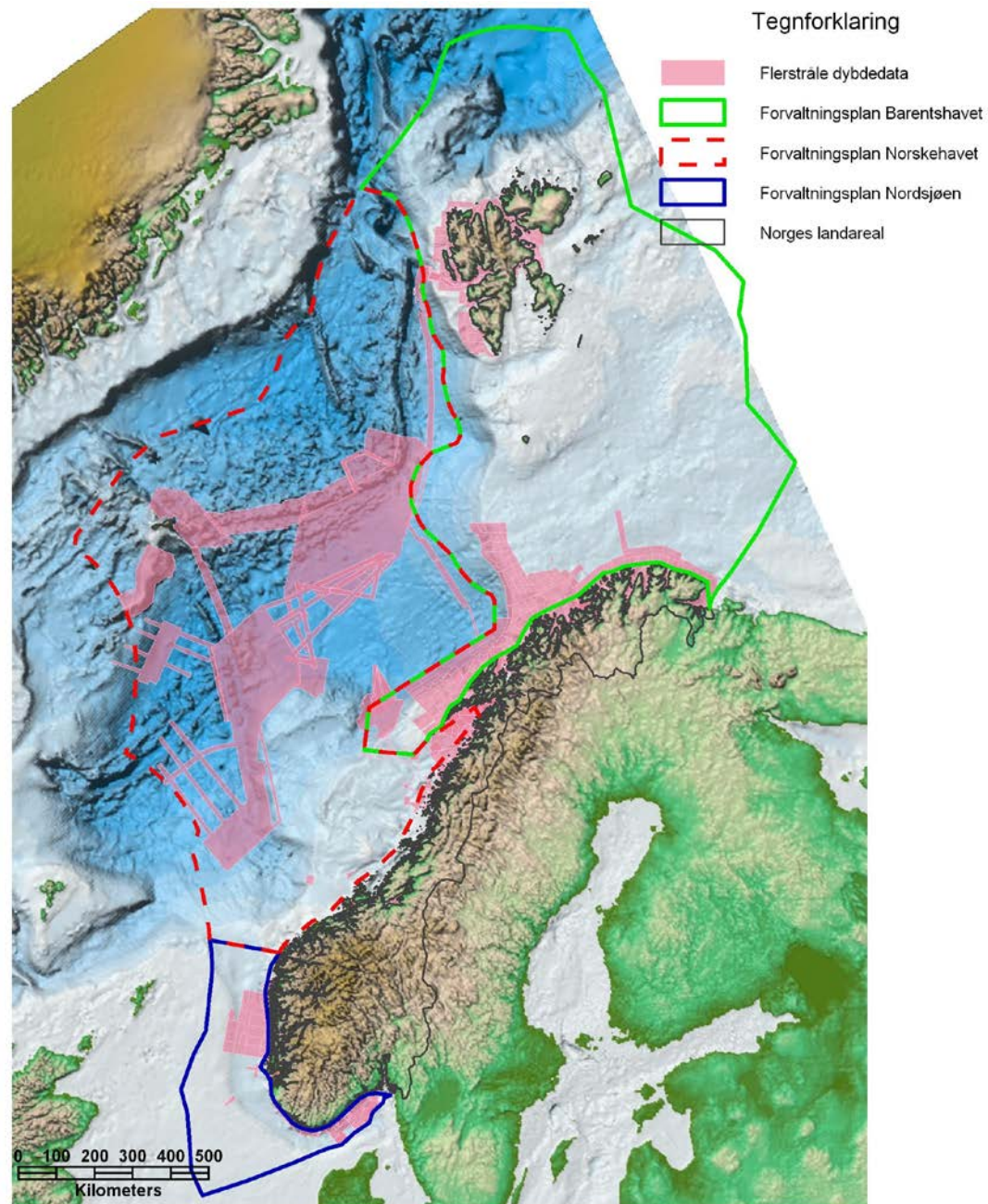
- Iceberg plough marks
- Other terrain details
- General topography

Example 100m wide
and 12 m deep



Norwegian sea areas

- Large areas (2.1 mill km²)
- Only partly covered by MBE data
- Bathymetry data collection is expensive
- Important to use data from other sources: Defence, oil- and gas industry etc.





TECHNICAL SPECIFICATIONS FOR MAREANO SURVEYS

- Challenge

- Cover as large area as possible
- with as detailed data as possible
- at the lowest cost as possible



Seeking the ideal compromise!

- Survey strategy

- Surface vessel with multibeam echosounder
- Satisfactory details down to about 1200m
- The survey strategy may be changed for deeper areas





SPECIFICATION PRINCIPLES

- **Ideally:** Only specify the *survey area*, *resolution* and *accuracy* for delivered data
- **Real life:** Difficult to ensure a sufficient data quality without specifying requirements for *equipment* and *procedures*



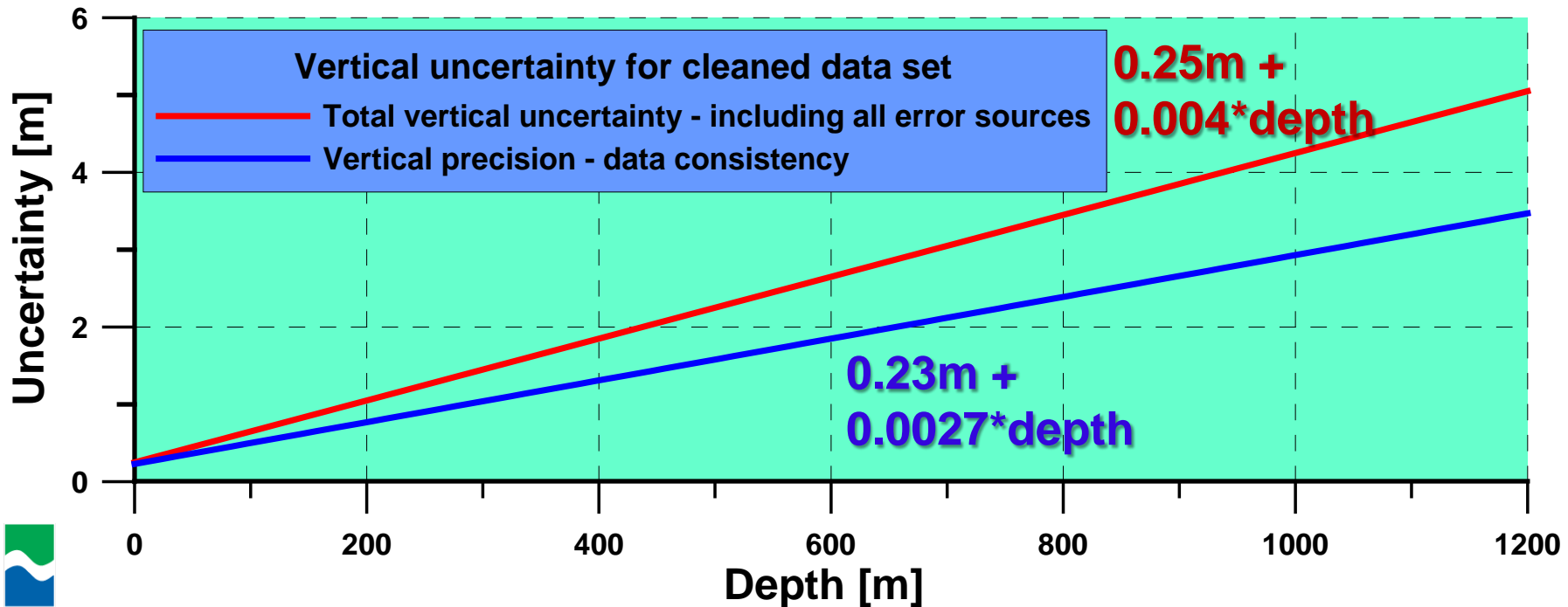
But not “over-specifying”

- At the end it is the *quality* of the *delivered data* that counts
 - Soundings are checked against neighbour data
 - Data from overlapping lines are controlled against each other
 - Identification of artefacts in the dataset
 - Identification of gaps in the dataset
 - Field verification (“patch test”)
 - Control of data against independent data in a test area



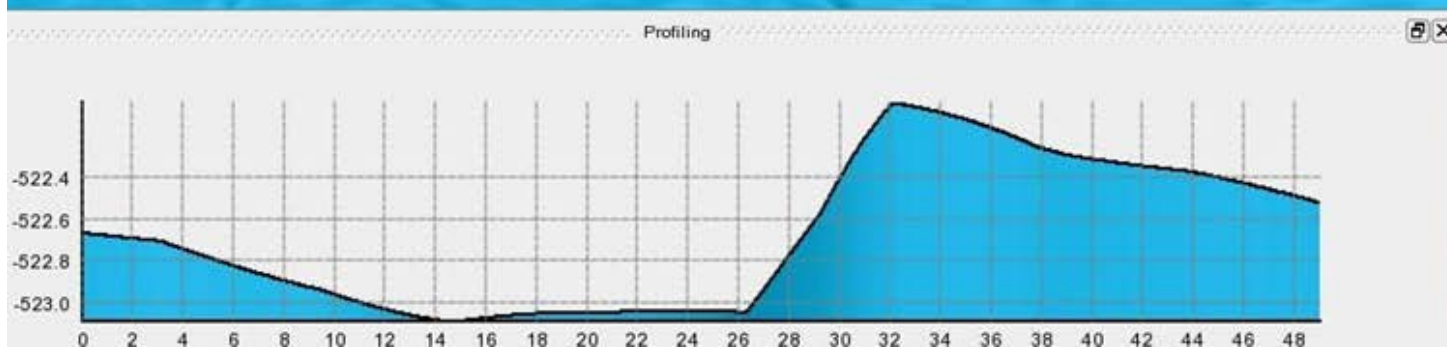
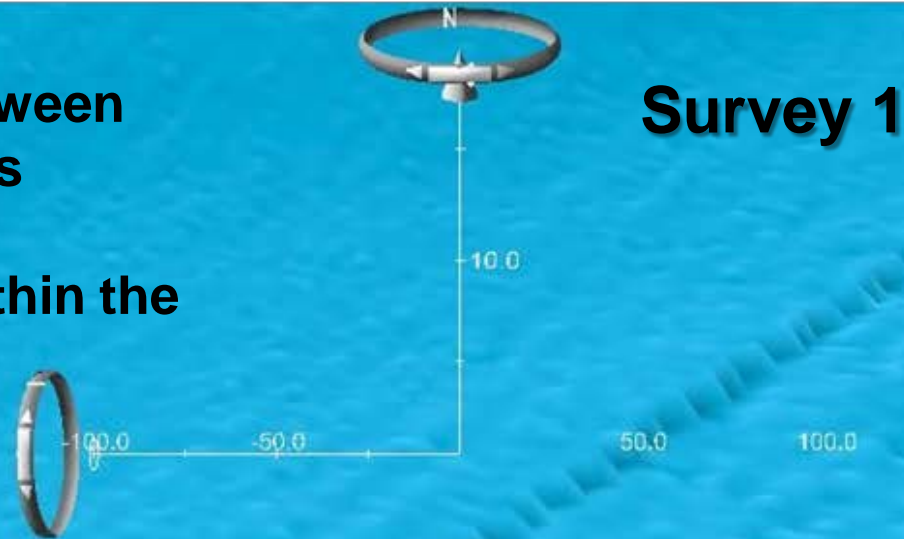
VERTICAL UNCERTAINTY

- Uncertainty values are given for *cleaned data sets*
- *All accepted data shall be within given limits*
- Total vertical uncertainty checked in test patch (bias + noise)
- Data consistency checked in overlaps and neighbouring data



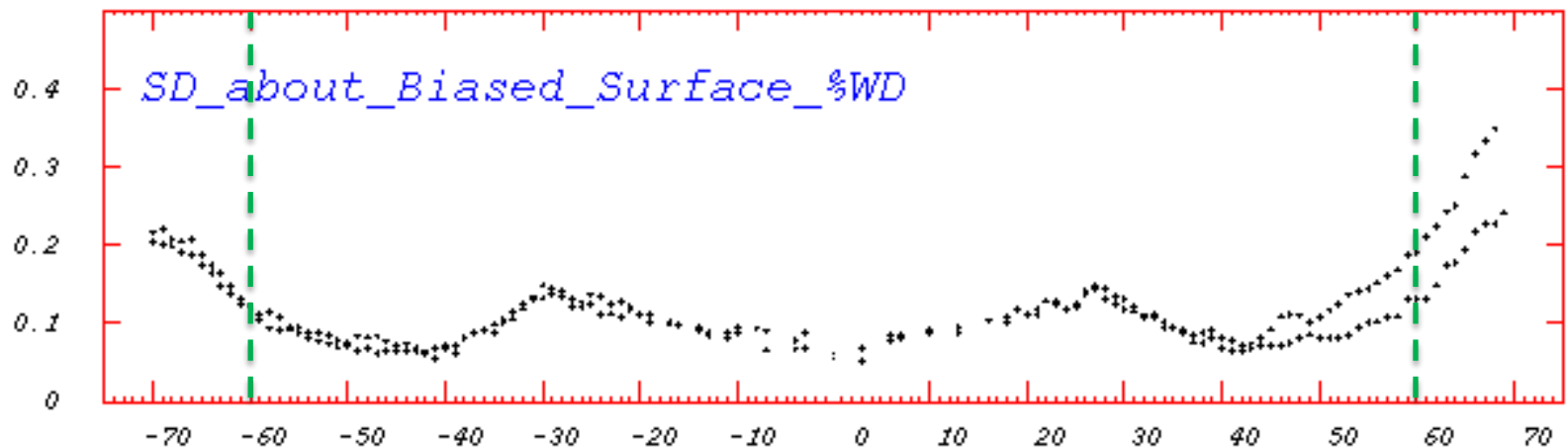
CONSEQUENCES OF REQUIREMENT OF TOTAL VERTICAL UNCERTAINTY AND PRECISION

- Thresholds between surveys are less important than consistency within the survey



TO ENSURE SOUNDING UNCERTAINTY

- Requirement: **The abeam nadir angle shall not exceed 60°**
- The sounding accuracy will degrade significantly (particularly due to sound velocity uncertainties) for nadir angles exceeding 60°



Example of total system accuracy for EM 710 0.5° x 1° . Courtesy of the University of New Brunswick.



SOUND VELOCITY OBSERVATIONS

To ensure sounding accuracy

- Not more than **two** hours between sound velocity profiles
- Not more than **six** hours between profiles to full survey depth
- Absorption coefficient profiles shall be utilized by the MBE without significant delay
- Further specifications of sensor and formulas to be used for calculations...



BUT NO REQUIREMENTS ON HOW TO HANDLE BAD WEATHER CONDITIONS

- Strategies to reduce noise in bad weather conditions:
 - More overlap
 - Logging data in only one direction
 - Narrowing the swath
 - Stop logging, wait for better weather
- It is up to the contractor to decide what to do in these cases

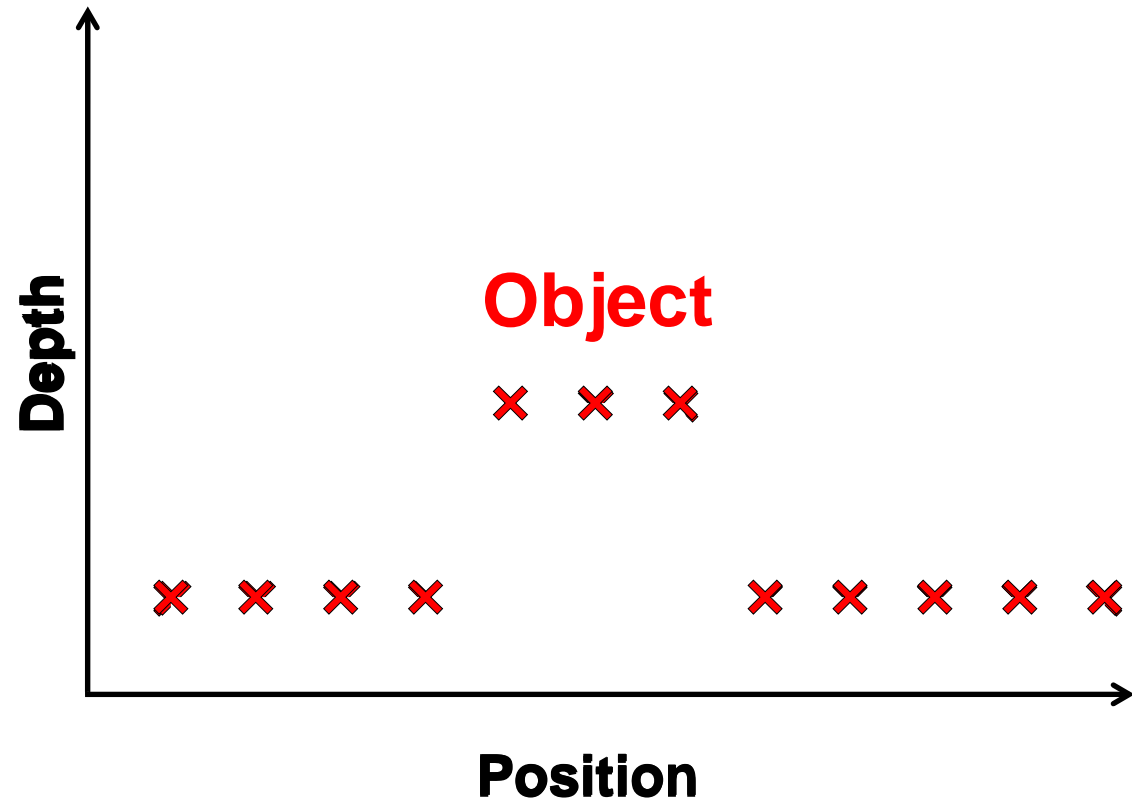


Our requirements for data quality still applies



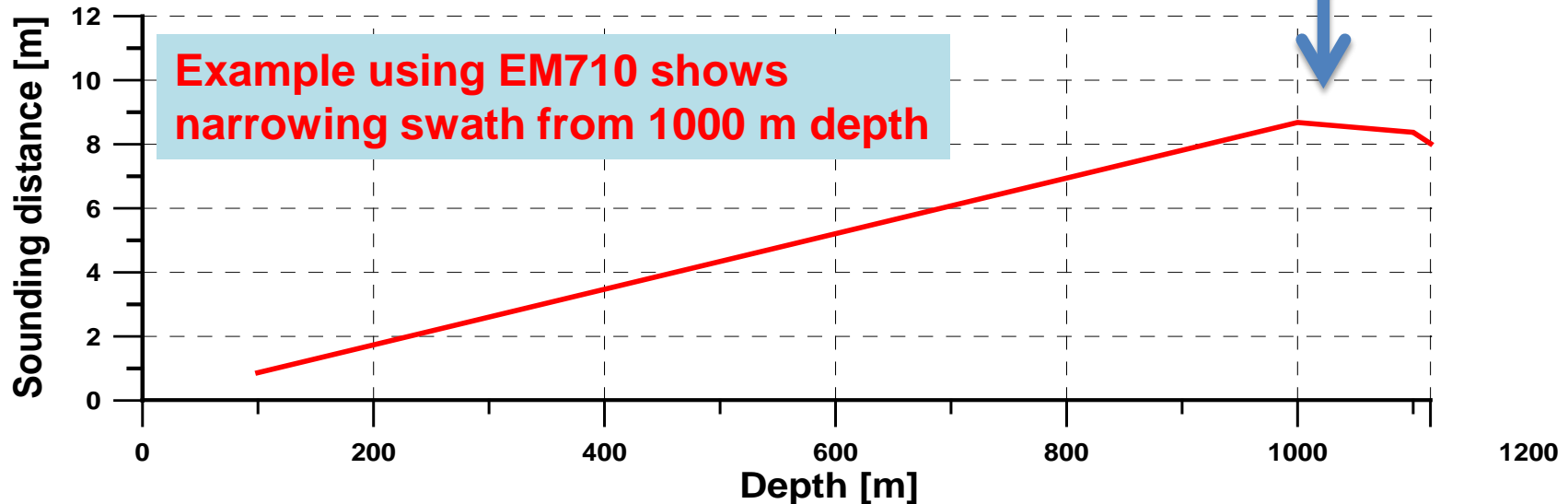
BASIC USER REQUIREMENTS

- Detection of “small” objects on the seabed is a primary objective
- At least 3 soundings on the object is required to distinguish between topographic variations and noise



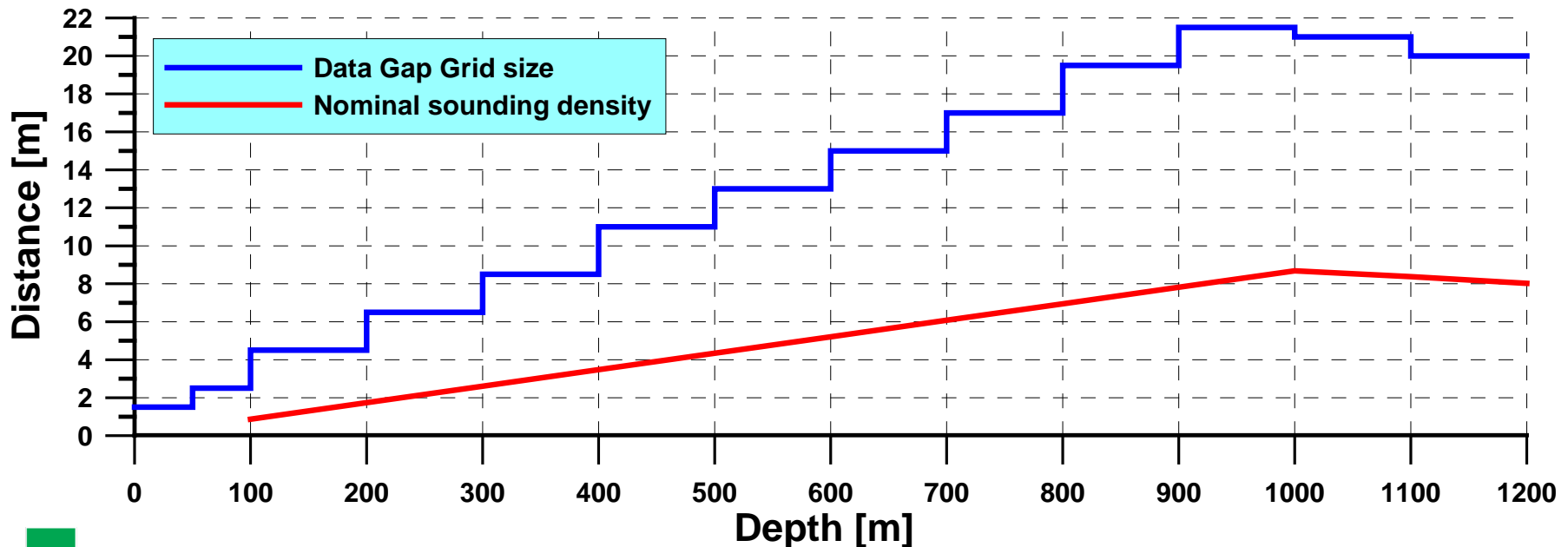
SOUNDING DENSITY

- The abeam nadir angle shall not exceed 60°
- The maximum available sounding density shall be used – i.e. adjusting MBE settings and narrowing the swath for **deep** areas where MBE range is limiting the coverage
- The sounding distance (both along track and abeam) shall not exceed $2 * \text{depth} * \tan(60^\circ) / 399$



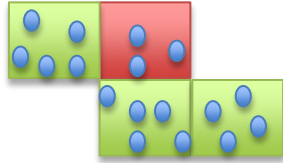
DATA GAPS

- Data gaps are caused by missing soundings or by soundings rejected in the data processing.
- The accepted data shall be checked for data gaps by defining a data gap grid (DGG).
- The DGG grid size is 2.5 times the nominal sounding distance.

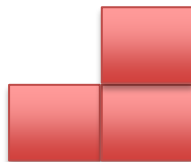


DATA GAPS

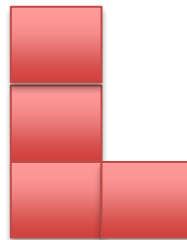
- A DGG cell with less than 4 accepted soundings is defined as a gap.



- More than three adjacent (i.e. cells sharing one side) gaps are not accepted (some exceptions for areas without significant topographical details)



Accepted



Not Accepted

- The total number of gaps shall not exceed 0.1% of the DGG cells.

CALIBRATION AND VERIFICATION

- **Calibration** comprise both the determination of corrections, and the use of these corrections
 - Individual sensor calibration
 - Survey vessel reference frame
 - Sensor alignment
 - MBE installation angles
 - Attitude and heading sensors
- **Field verification** of the survey spread calibration
 - Analysing overlapping hydrographic data (patch test)
 - Check vertical offset and noise level by comparing with previous surveys in a test area

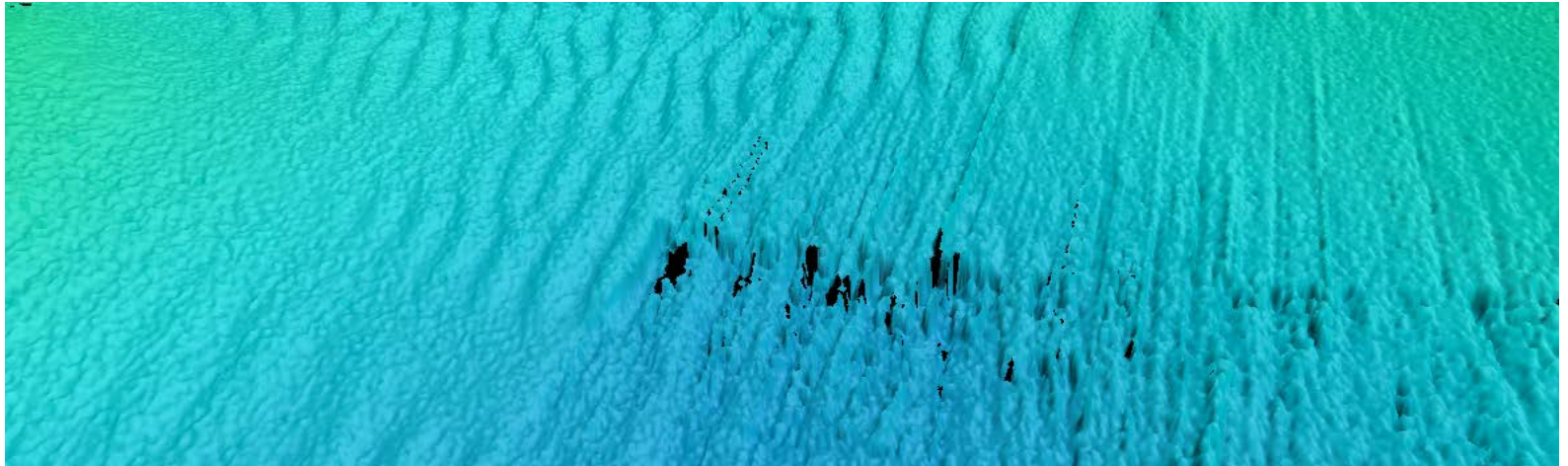


Only verification – not calibration!



PROCESSING

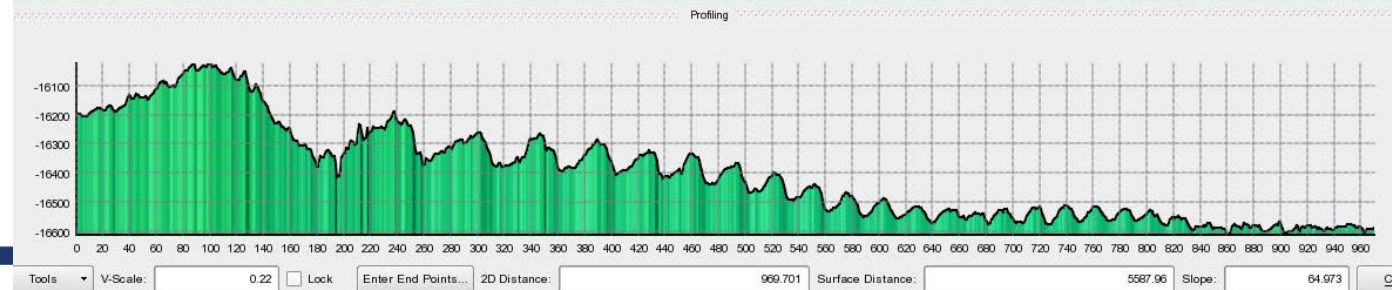
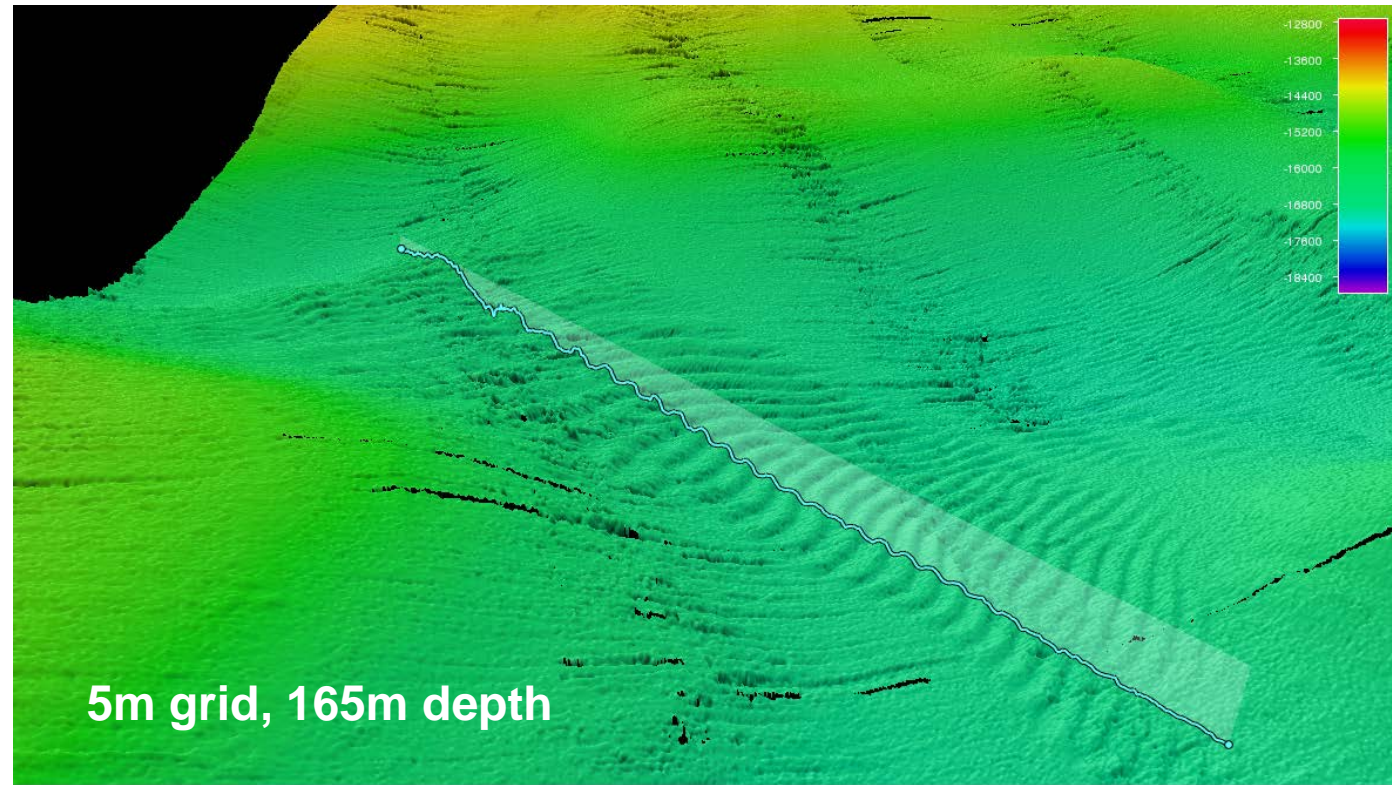
- Removing faulty soundings and preserving seabed feature information
- Artefacts shall be kept at an insignificant level not disturbing the seabed image
- Faulty soundings shall be flagged as rejected (no soundings shall be deleted)
- XYZ-data shall not be smoothed



RESULTS – SAND WAVES IN NOISY DATA

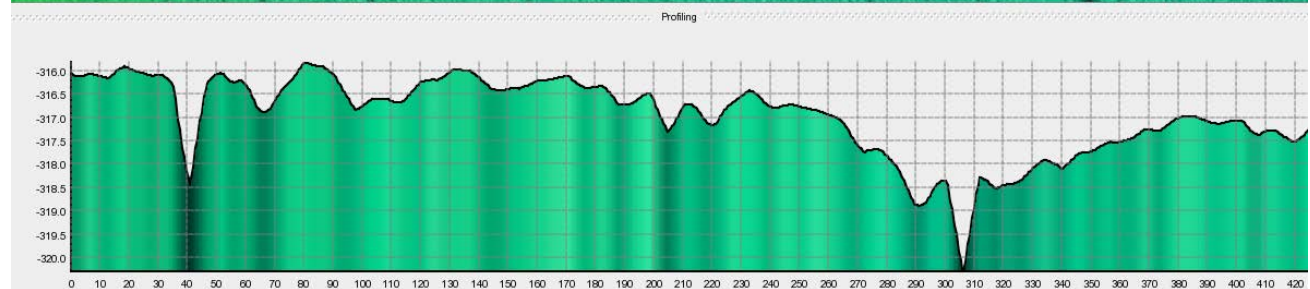
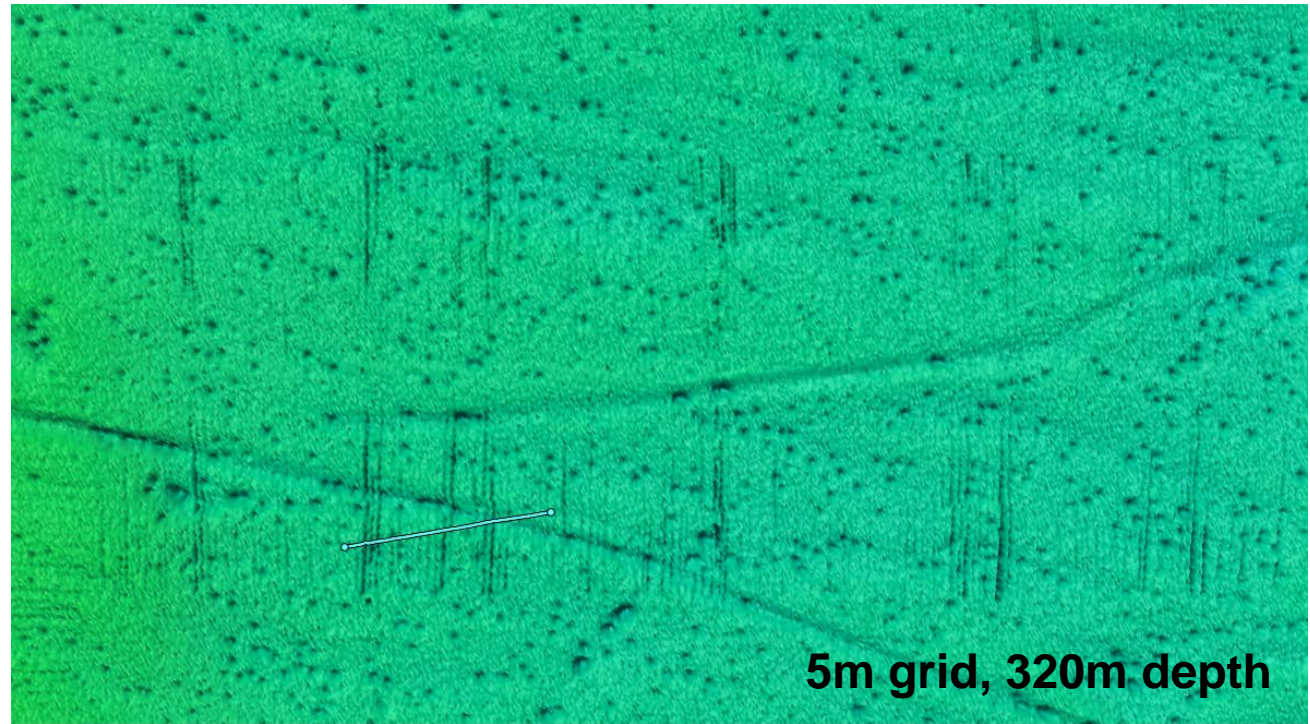
Example

- Wave height 1m
- Wavelength 20 m
- Depth 165 m



RESULTS – POCKMARKS, ICE BERG PLOUGH MARKS

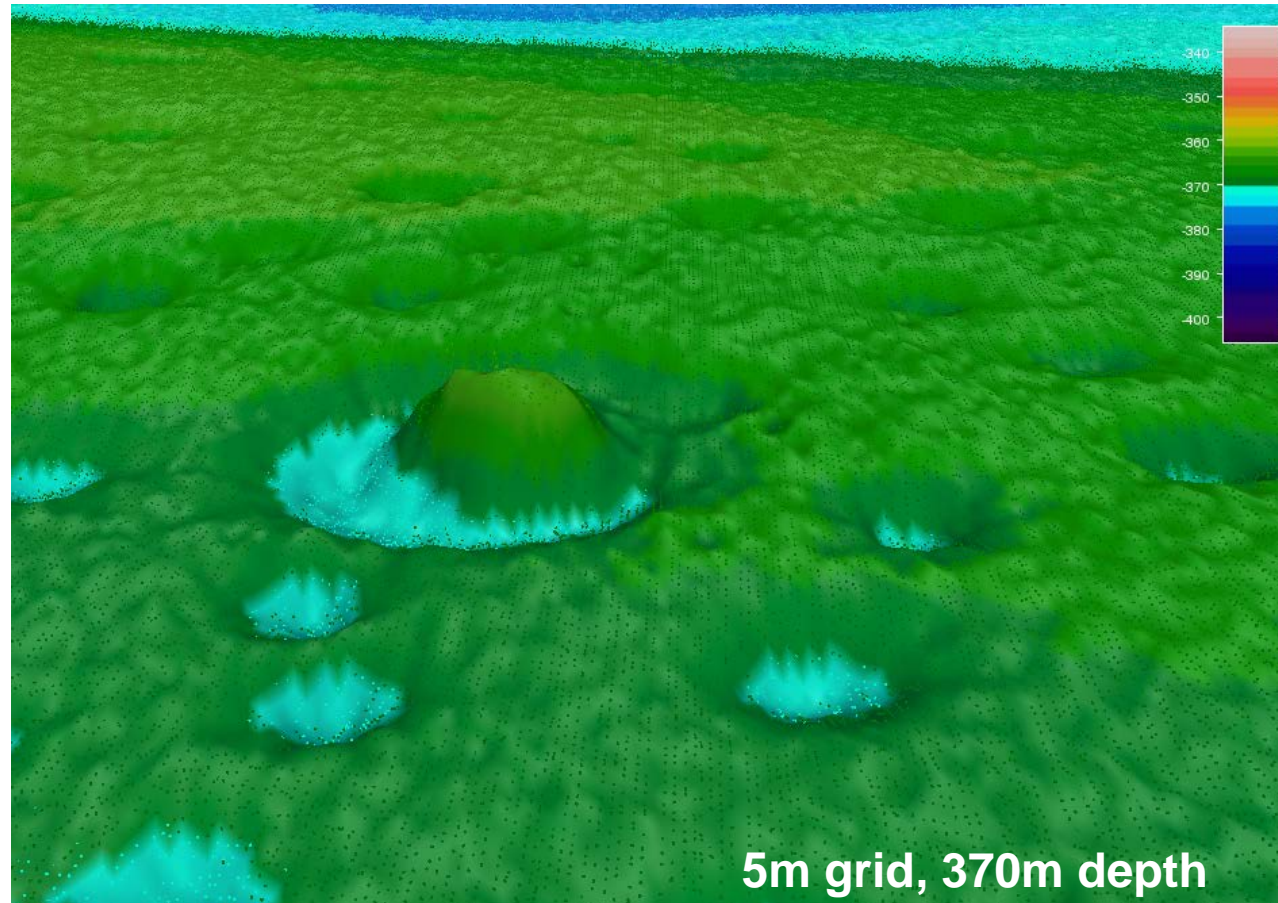
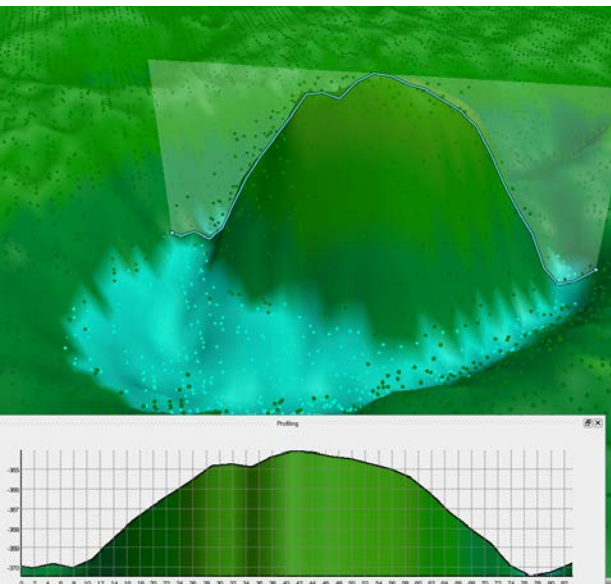
- Example from Barents sea



RESULTS – POCKMARK WITH AN “EYE”

Example from Troms III

- “bump” in a pockmark
- 6m high
- 60m in diameter





Questions?

