Trends in Seabed Mapping Technology

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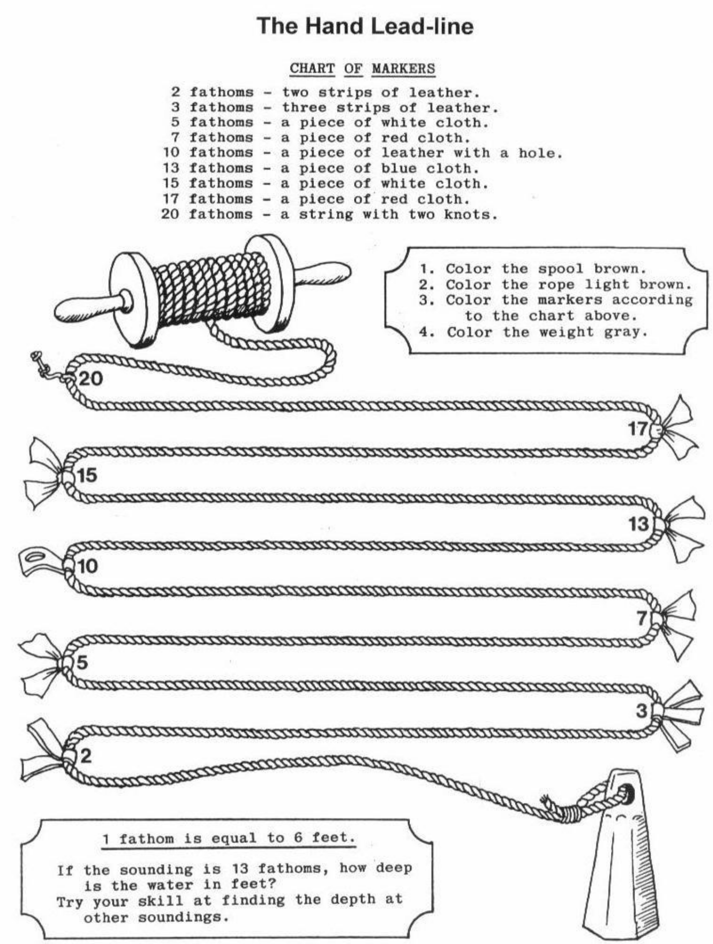
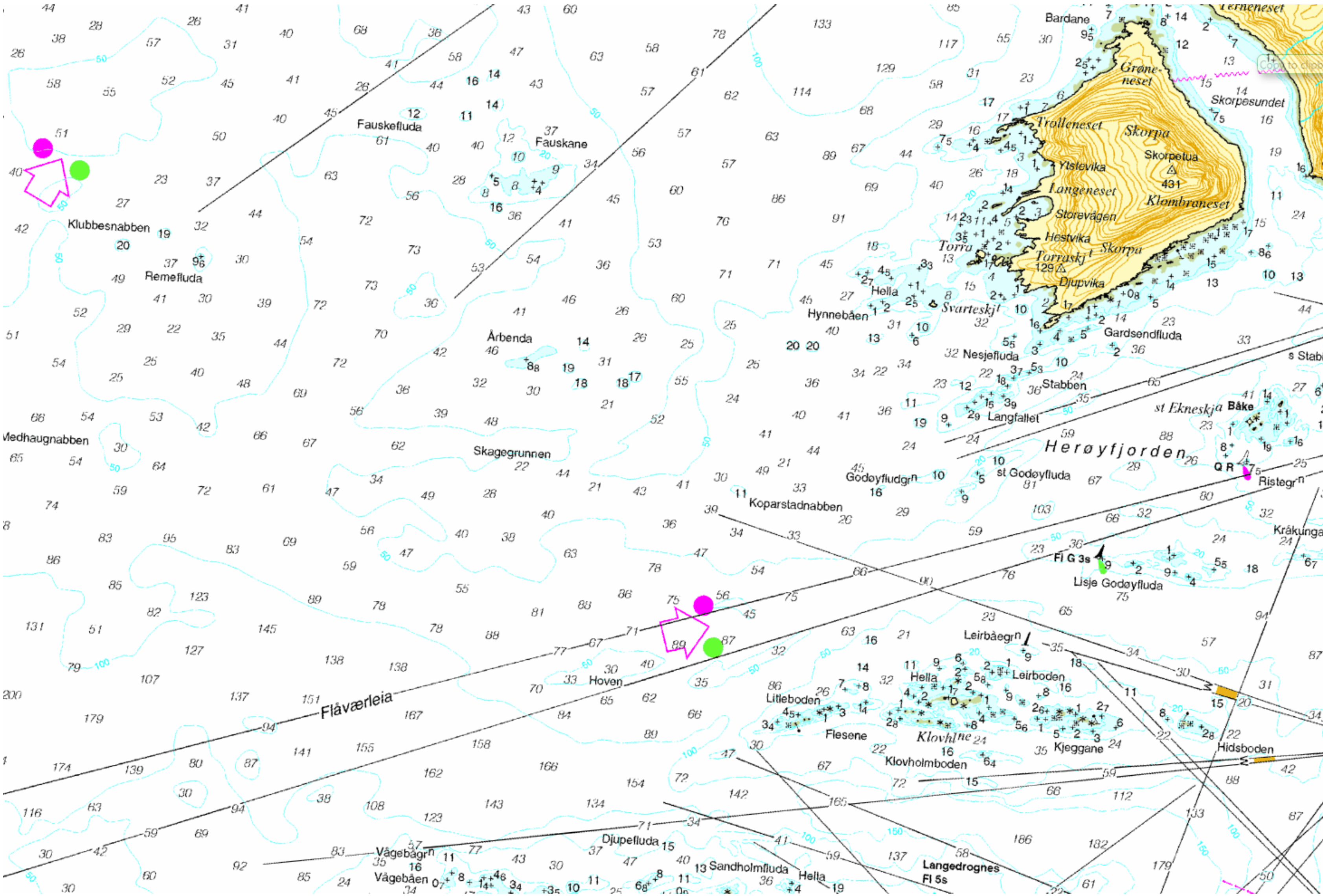
Hand lead-line



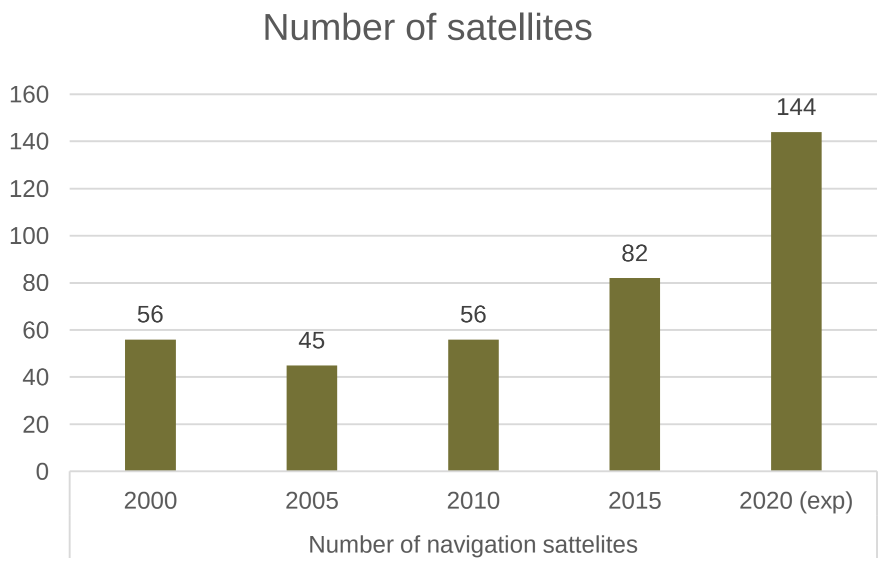
Nautical chart



Global Navigation Satellite System (GNSS)

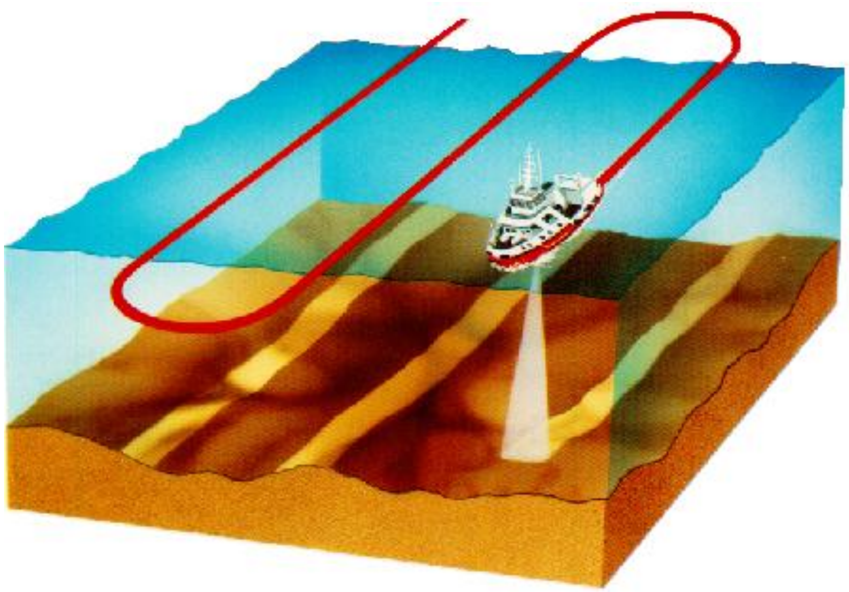
Seapath 1996: Tracked 25 satellites. 1.5 m position accuracy.

Seapath 2016: Tracks unlimited satellites. dm accuracy with differential GNSS and augmentation services. cm accuracy with RTK.

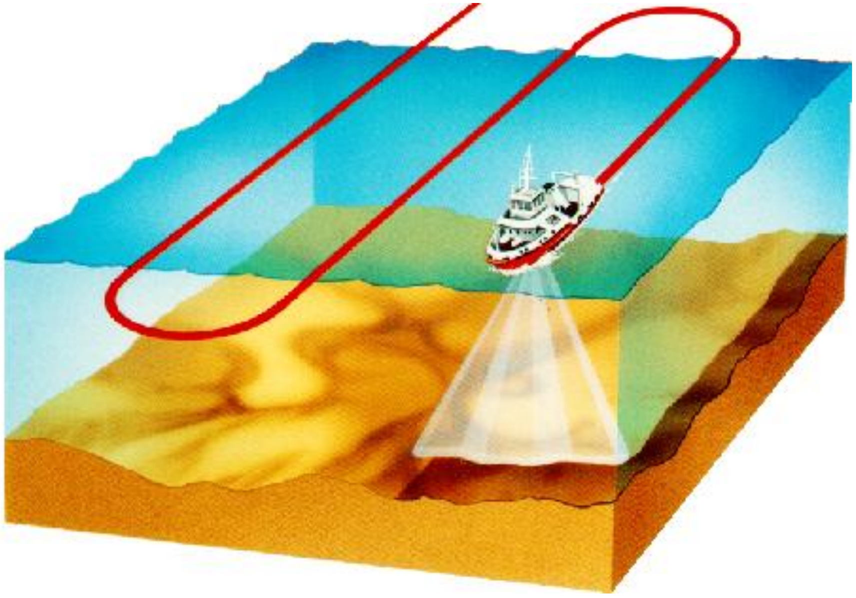


Multibeam versus single beam

Kongsberg introduced its first multibeam echosounder in 1986

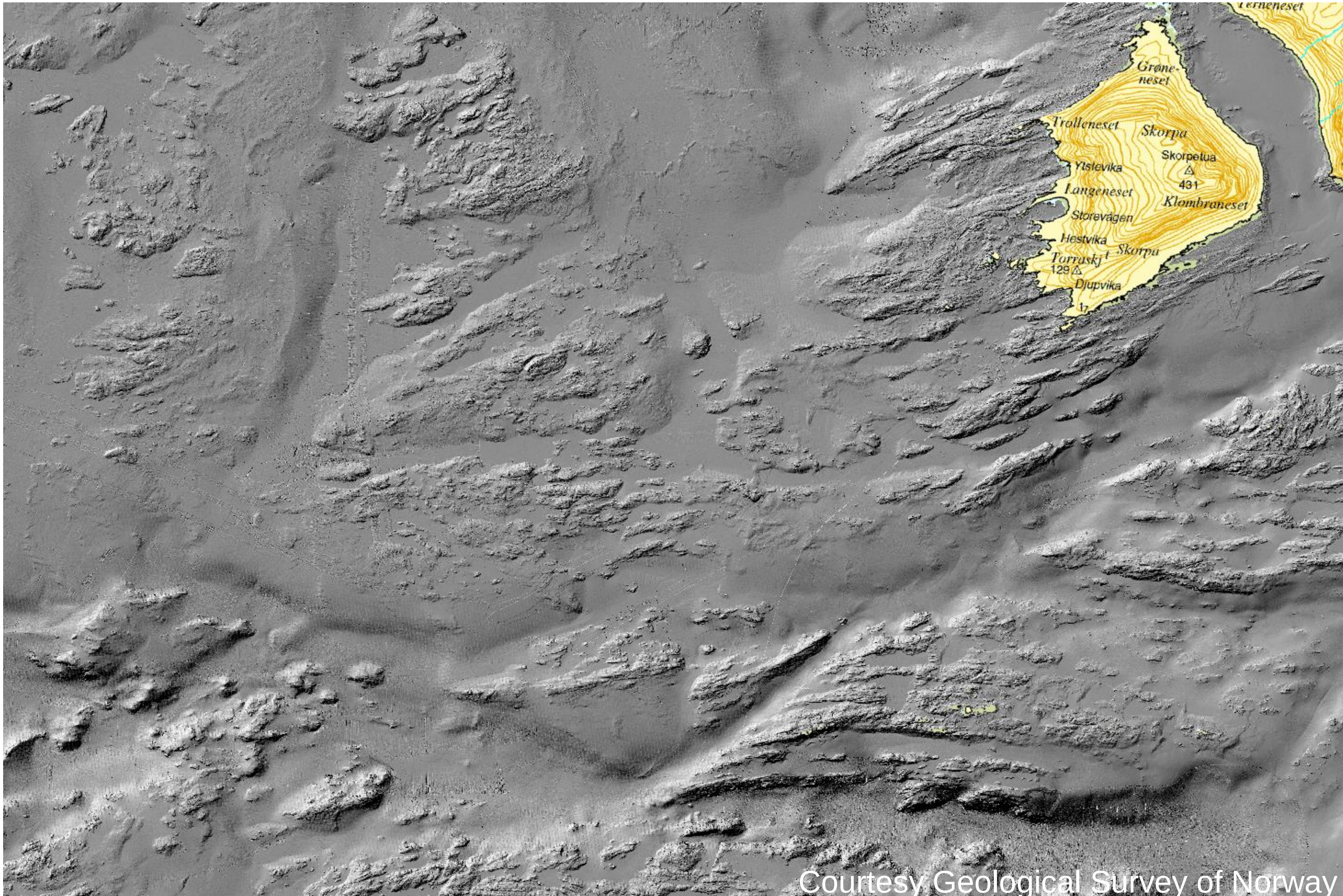


Singlebeam survey:
Large unmapped gaps between lines



Multibeam survey:
100% coverage of seafloor

Resolution matters

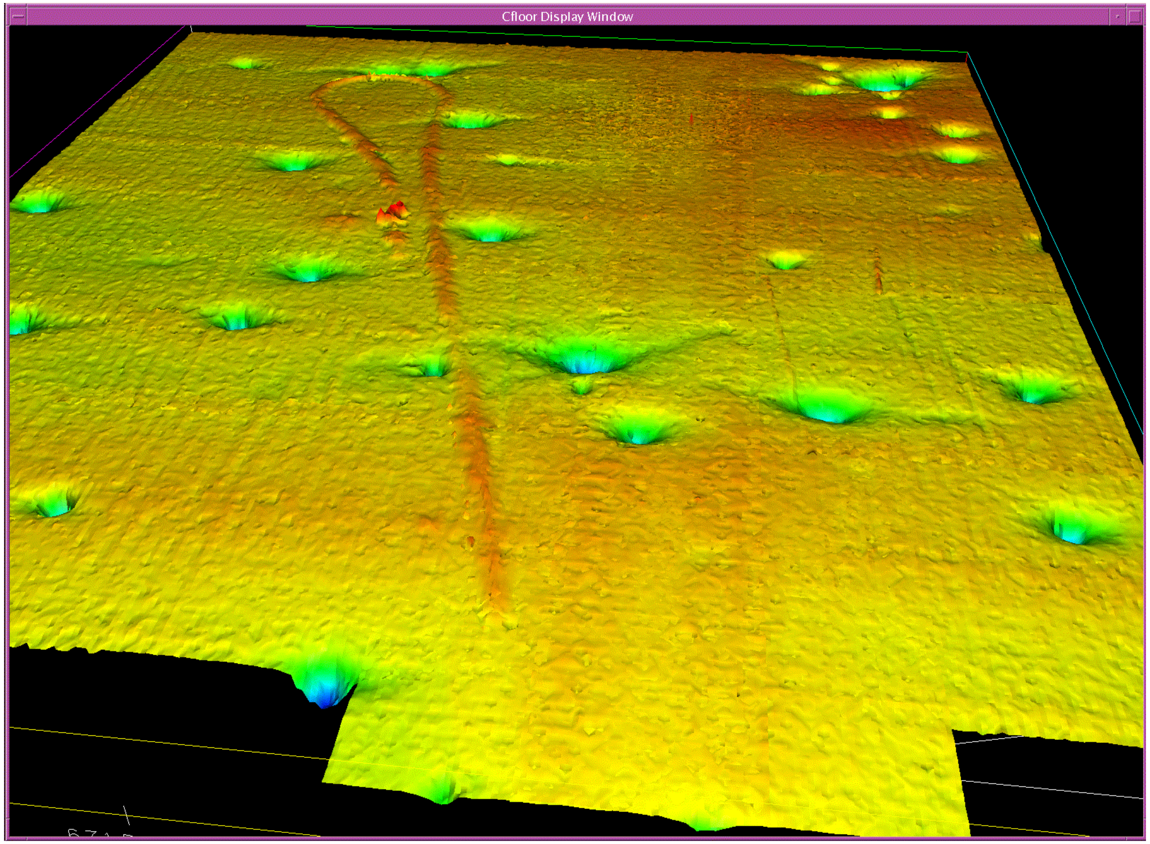


Multibeam echosounder 1986 - EM 100

- 95 kHz frequency
- 27 or 32 receiving beams
- Beam widths:
  - 2 × 3°
  - 2.5 × 3°
  - 5.5 × 3°
- 100° coverage
- Stabilization
  - Roll: electronic
  - Pitch: mechanical

Multibeam echosounder 1999 - EM 1002

- 95 kHz frequency
- 111 receiving beams
- Beam width:
  - 2.0 × 2.3°
- 150° coverage
- Stabilization
  - Roll: electronic
  - Pitch: mechanical



Pock marks at the Troll oil and gas field in the North Sea.

Multibeam echosounder 2016 - EM 712

- 40 to 100 kHz frequency
- 512 receiving beams
  (max 1600 soundings/ping)
- Beam widths:
  - 0.25 × 0.5°
  - 0.5 × 0.5°
- 140° coverage
- Stabilization
  - Roll: electronic
  - Pitch: electronic
  - Azimuth: electronic

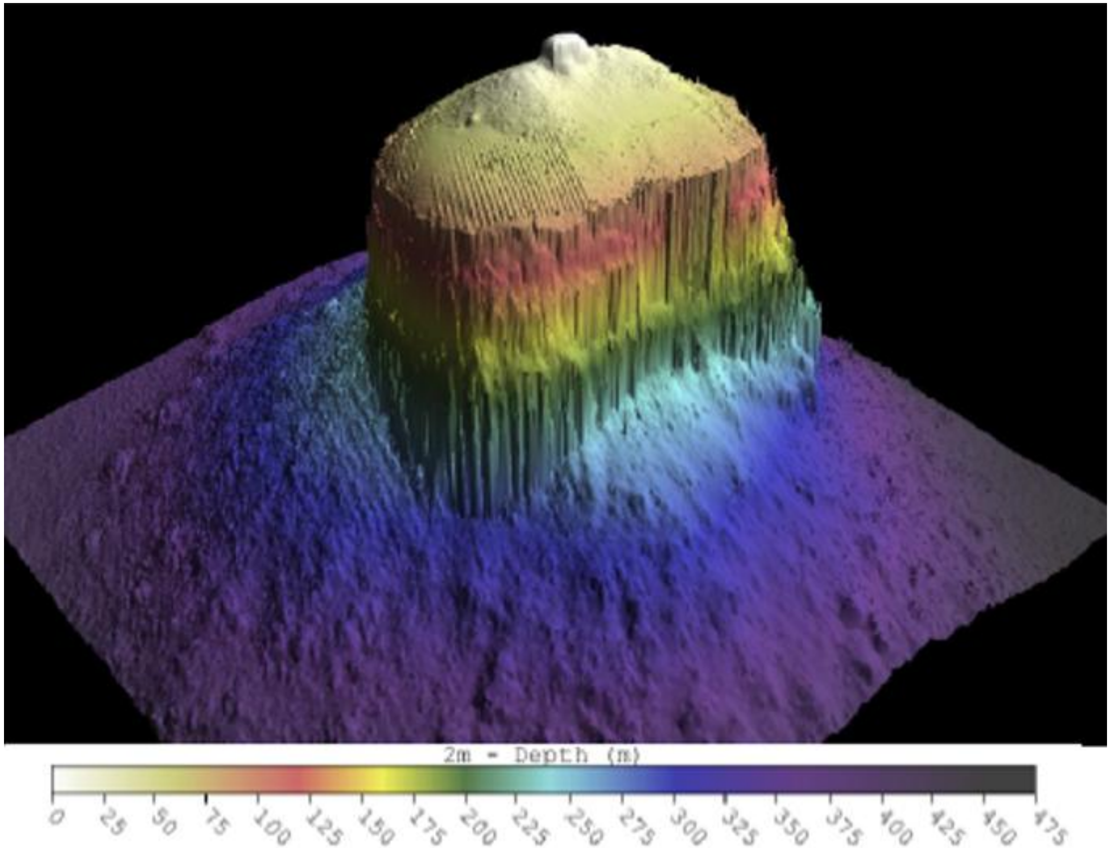
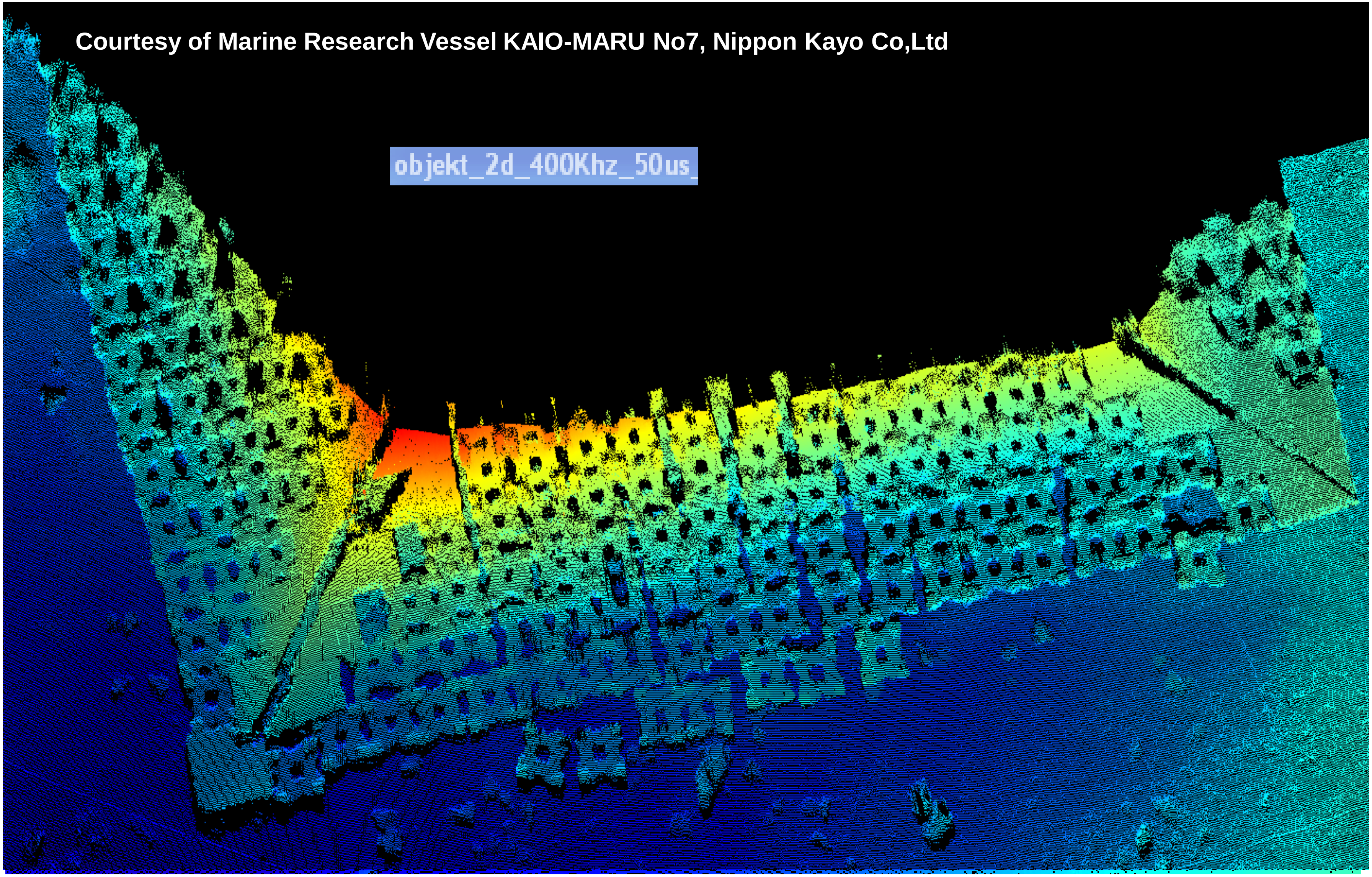


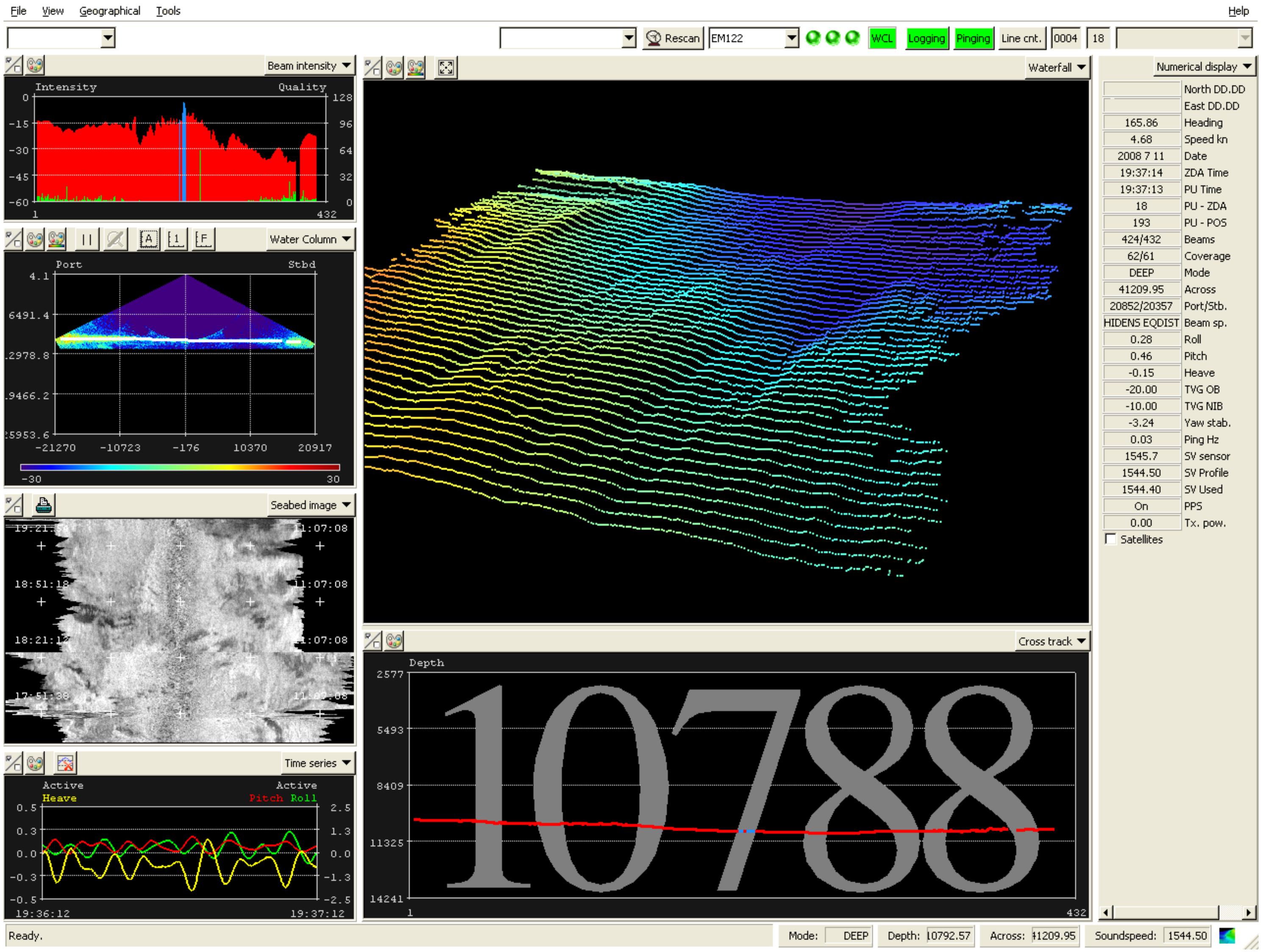
Image provided with permission of Fugro.

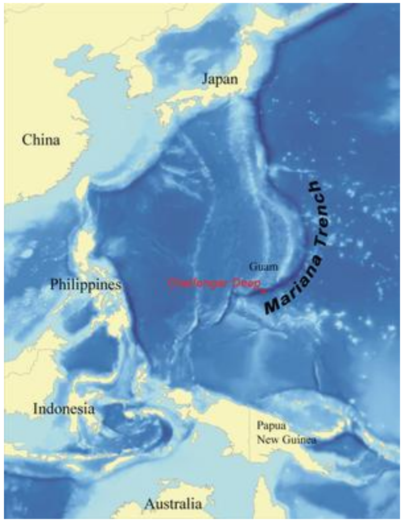
Wideband systems



Shallow to full ocean depth

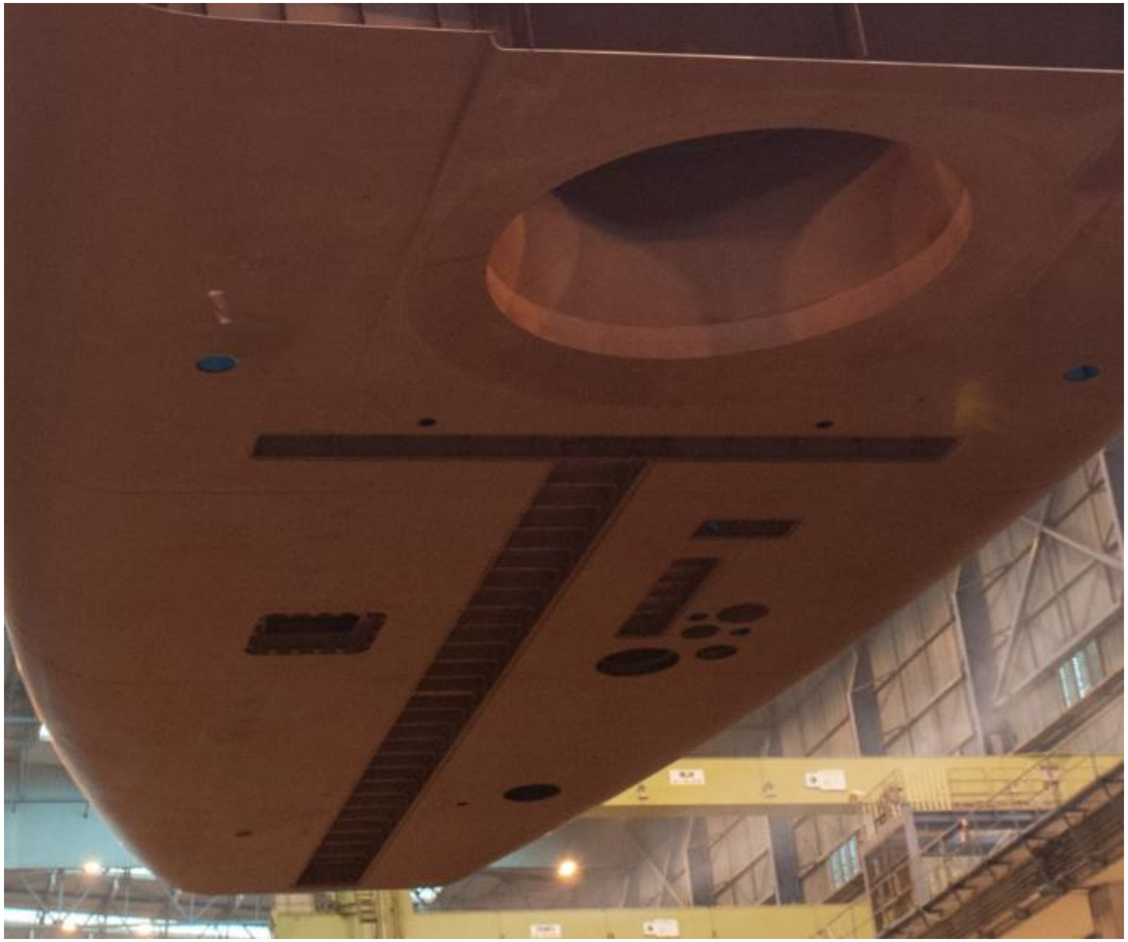
Mapping the Mariana Trench





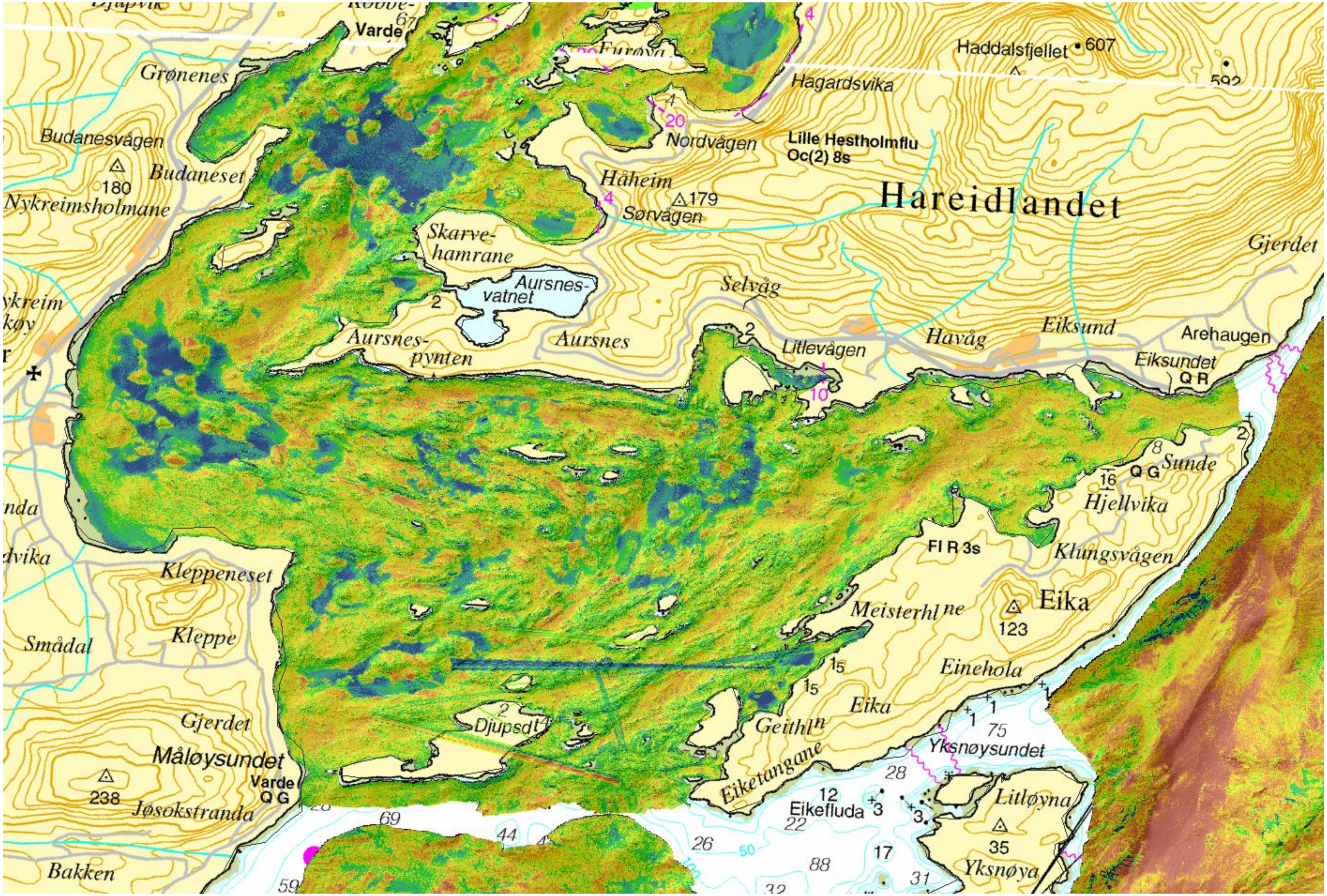
EM 122 data. Courtesy of Naval Oceanographic Office.

EM 122 on RV Sonne



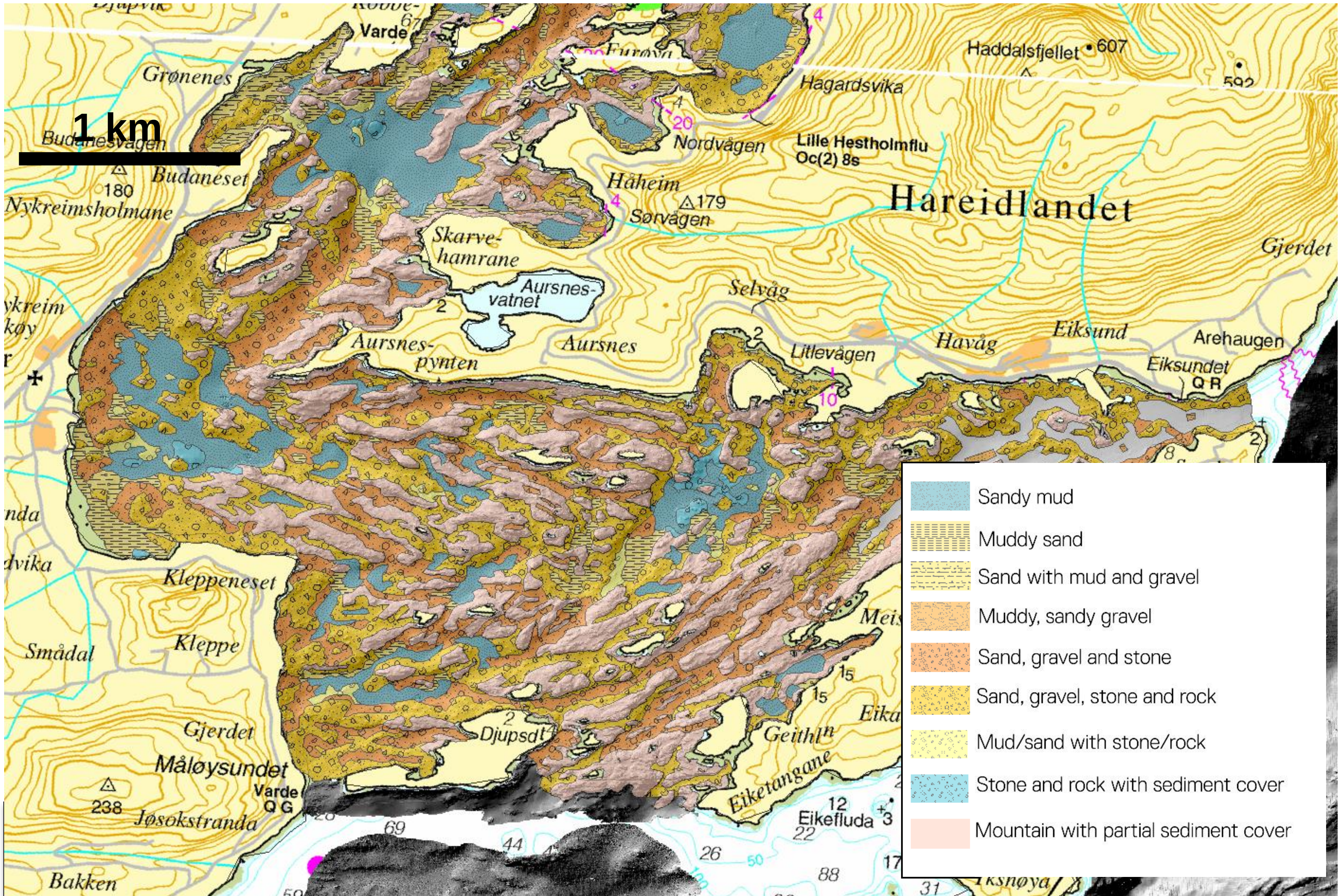
16 m TX frame array, 8 m RX frame array: 0.5° × 1.0° @ 10 kHz

Backscatter



Courtesy Geological Survey of Norway

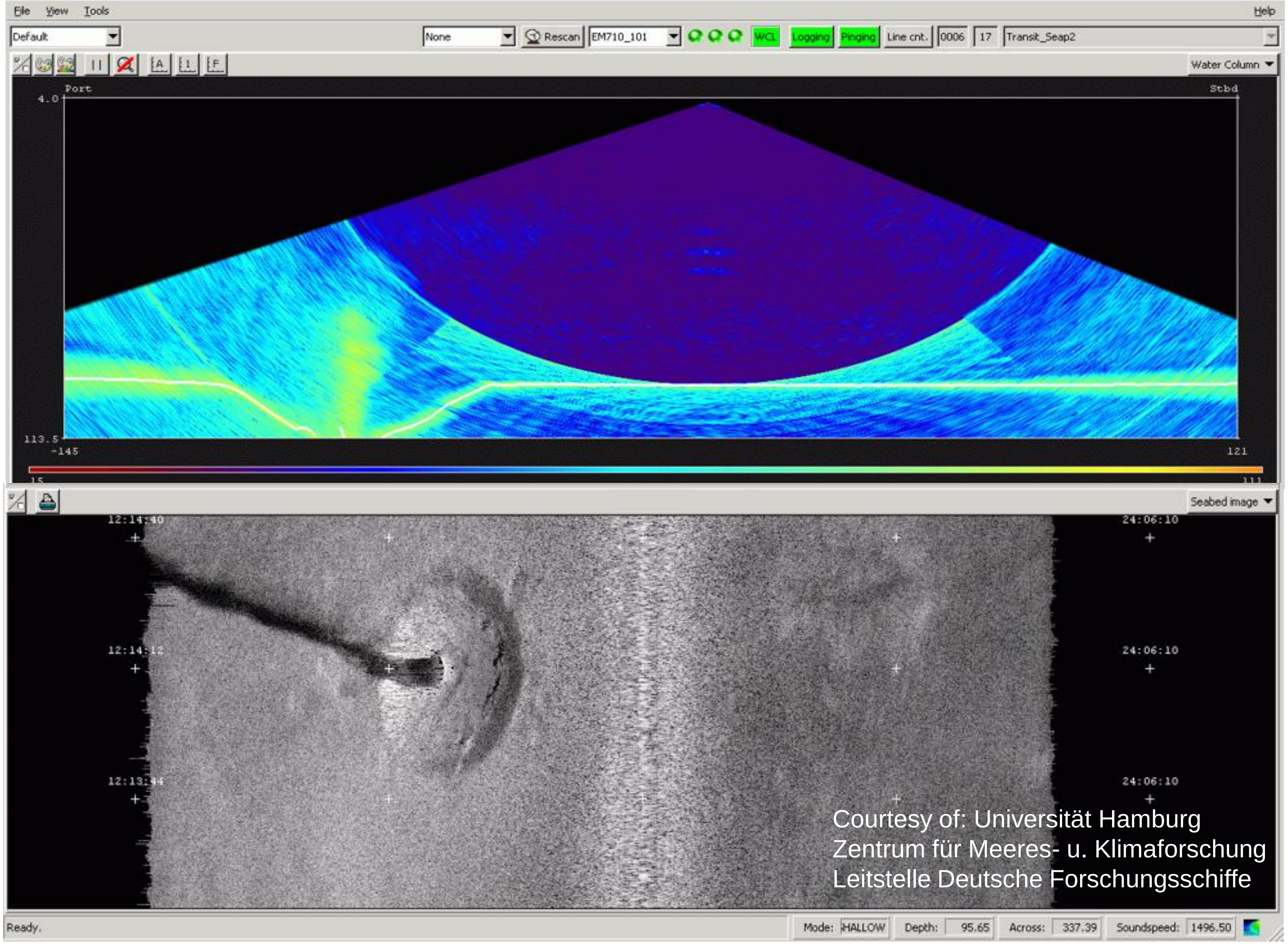
Backscatter interpretation



Interpreted bottom types

Courtesy Geological Survey of Norway

Water column data



Water column data and multiple detections

Courtesy of John Hughes Clarke – Ocean Mapping Group / University of New Brunswick

Trend: Research vessels, hydrographic vessels

Merging shallow and deep water data

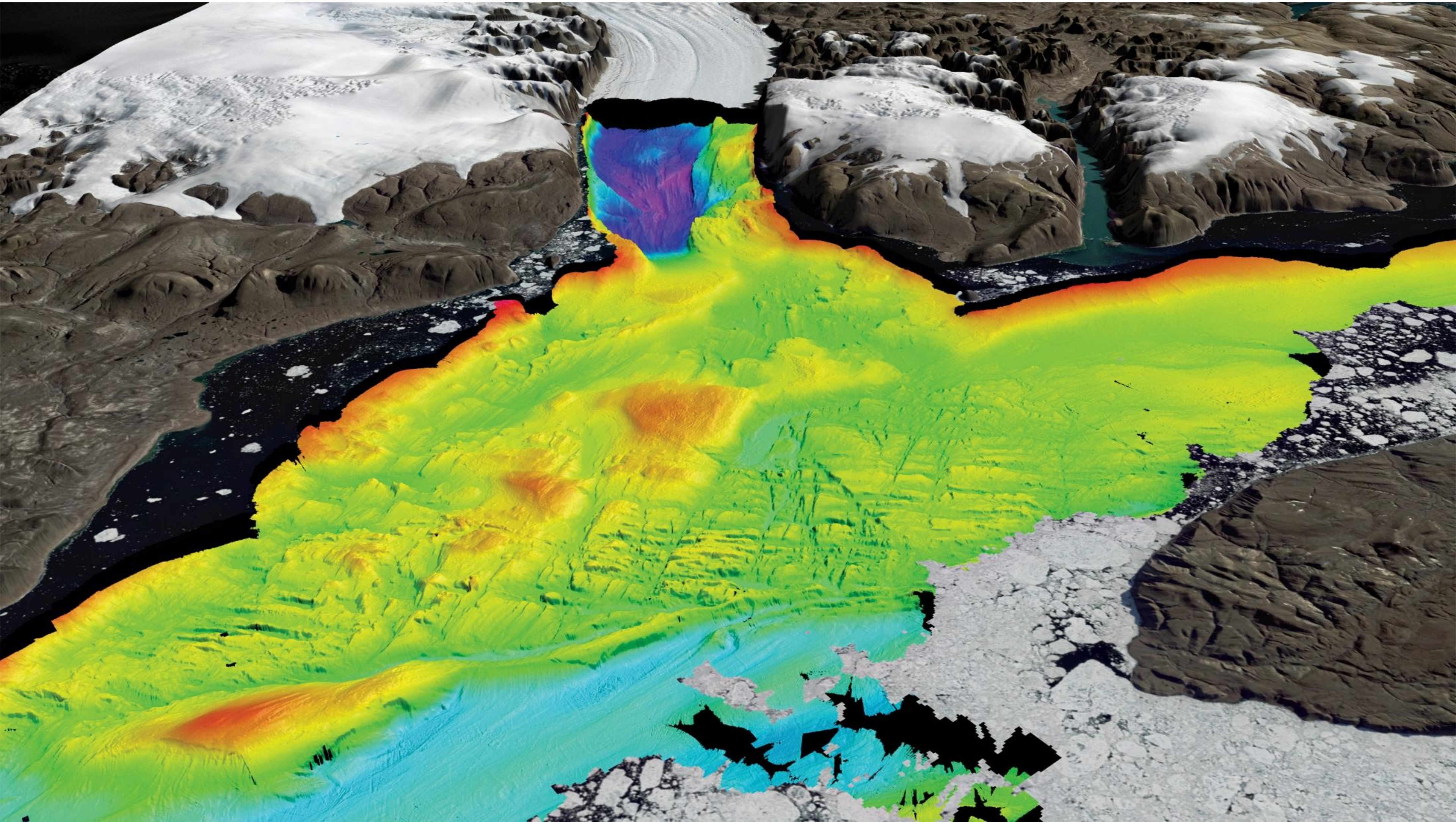
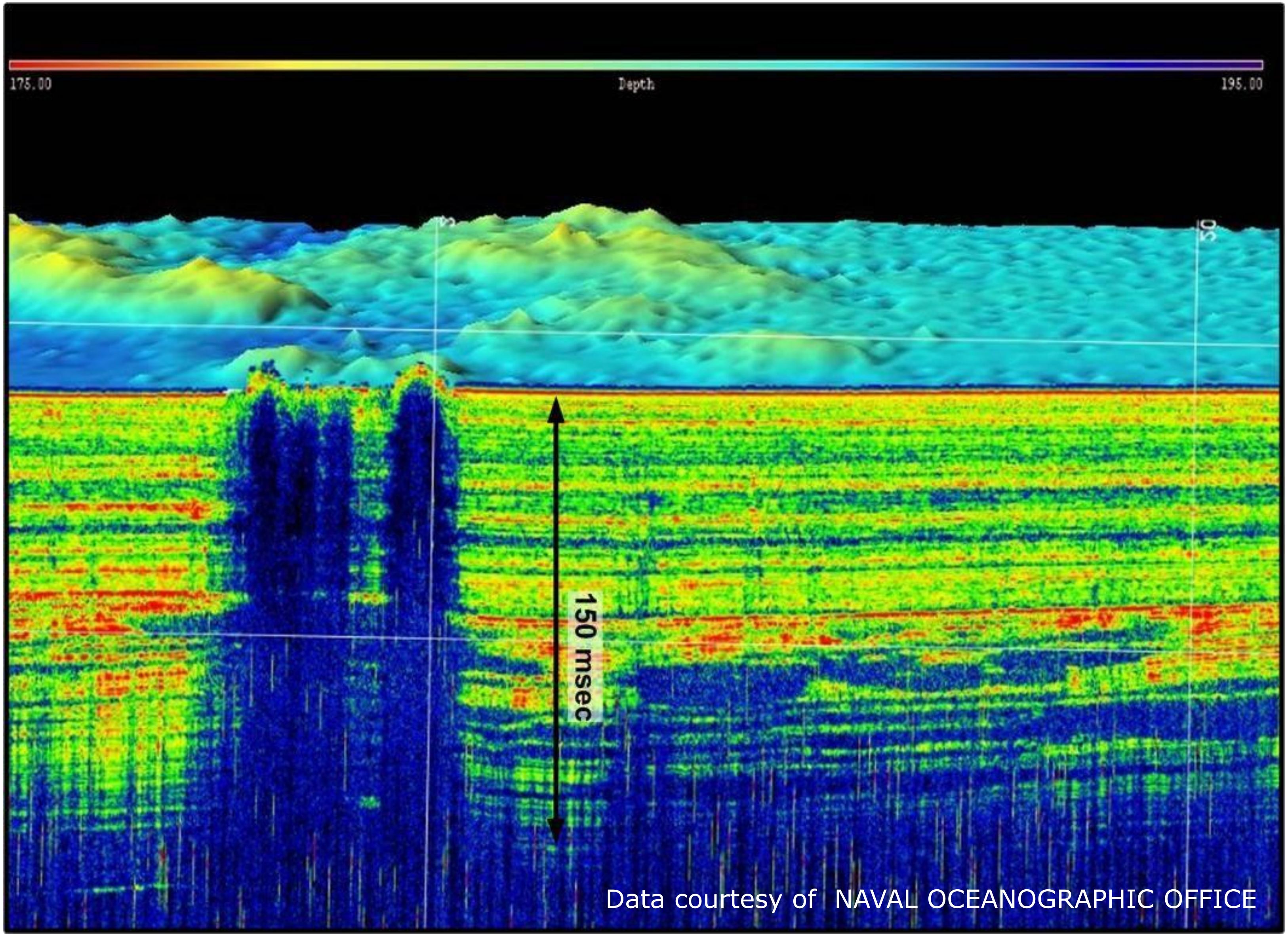
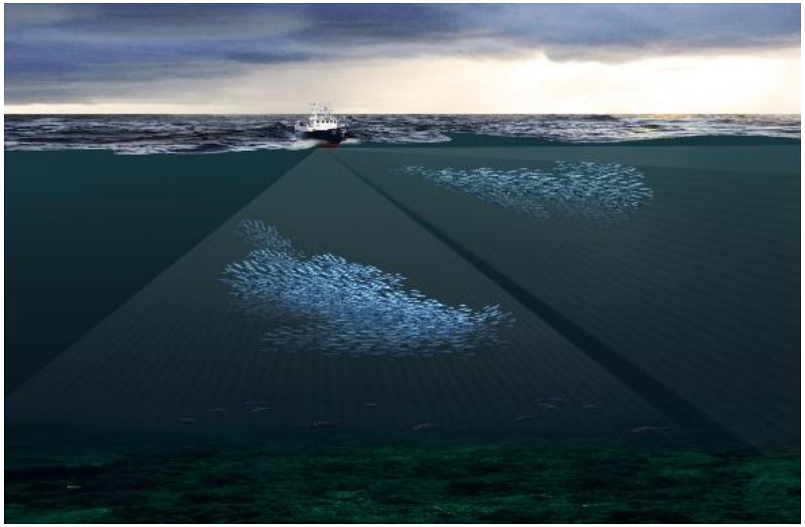


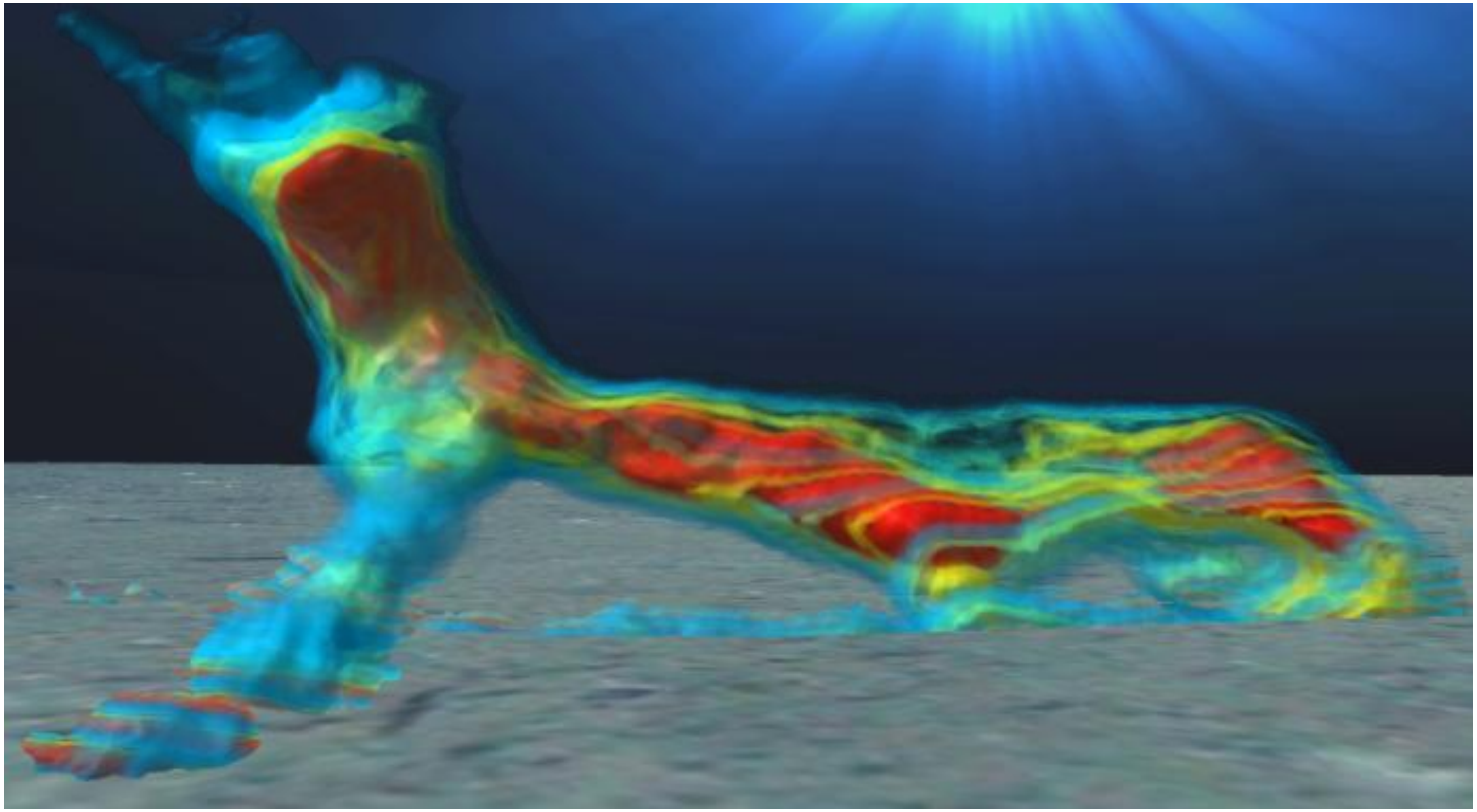
Image courtesy Stockholm University. EM 2040 and EM 122 data.

Sub-bottom profiler





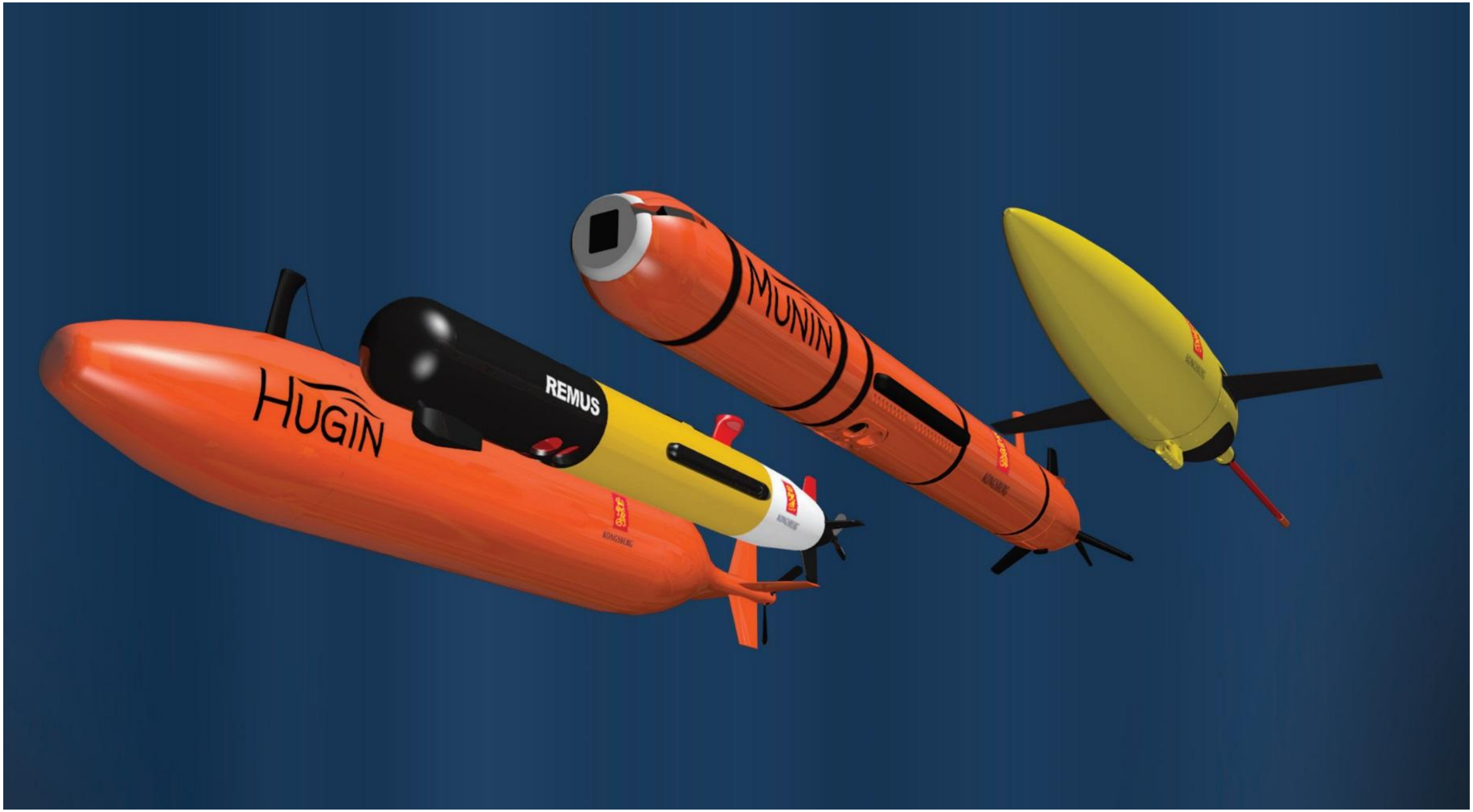
Fishery stock estimation



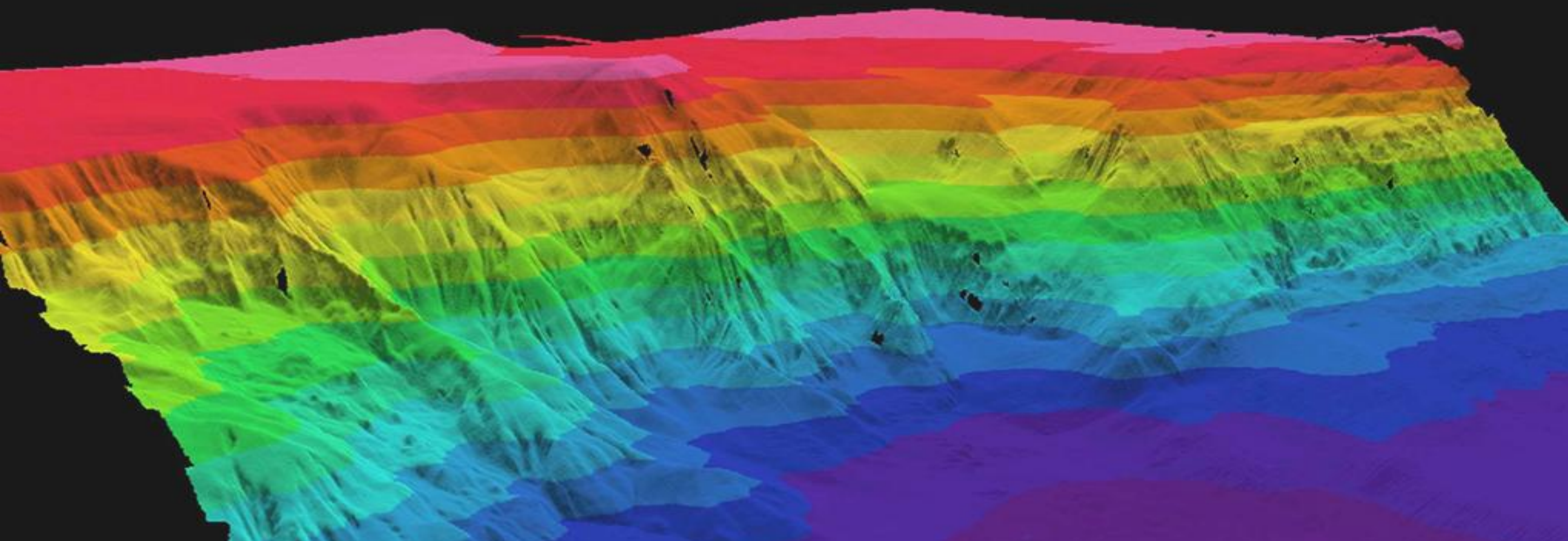
Schooling Sand Eel close to bottom in the North Sea mapped with Simrad ME70 scientific multibeam

Trend: portable systems for shallow water

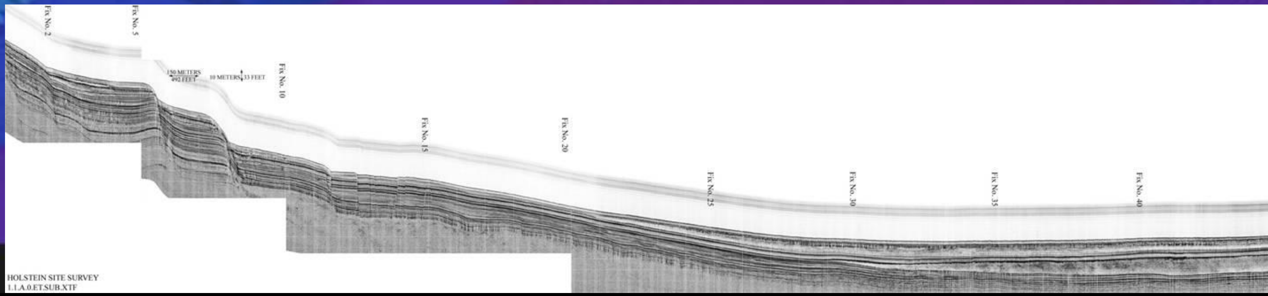
Trend: marine robotics



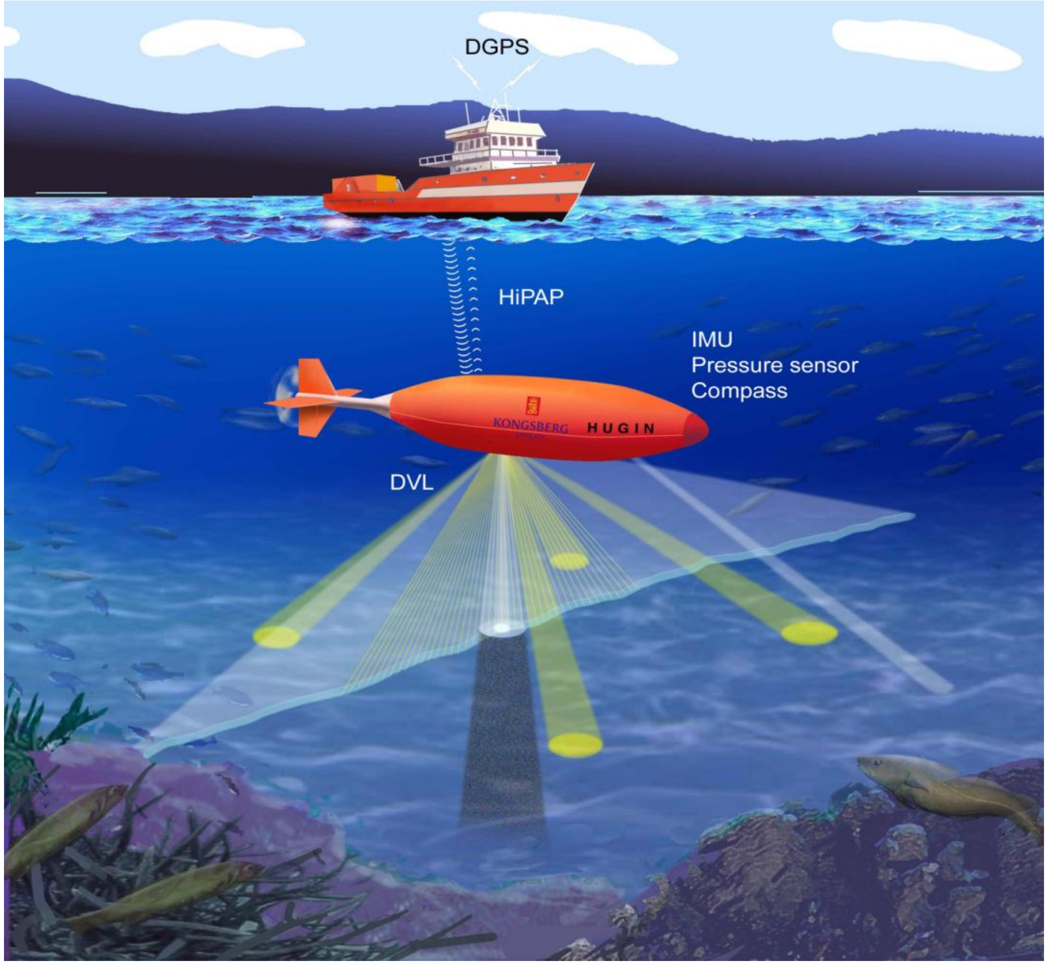
Gulf of Mexico commercial AUV survey 2000 - 2001



Courtesy C & C Technologies



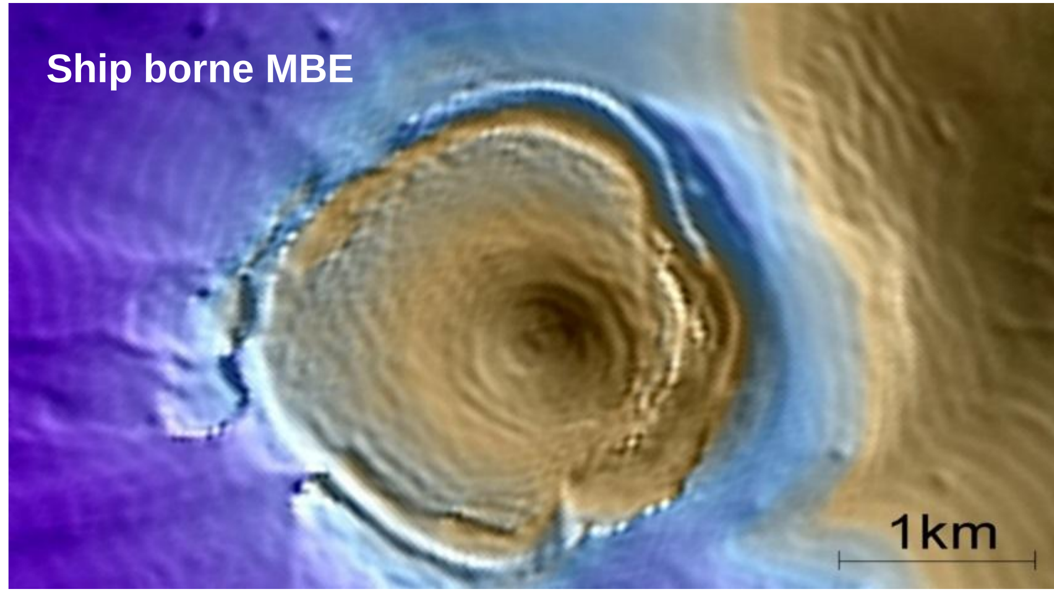
GPS - USBL



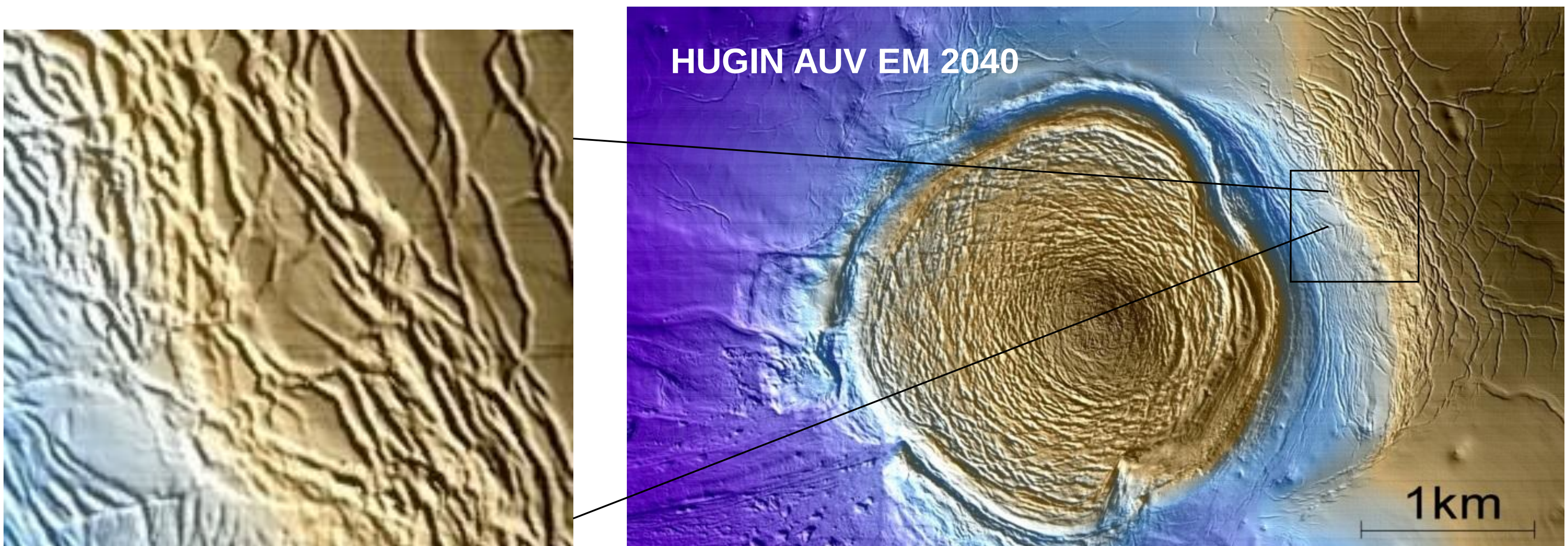
AUV survey position accuracies Gulf of Mexico 2000 / 2001:

- 1300 m: 2 m (1σ)
- 2100 m: 4 m (1σ)

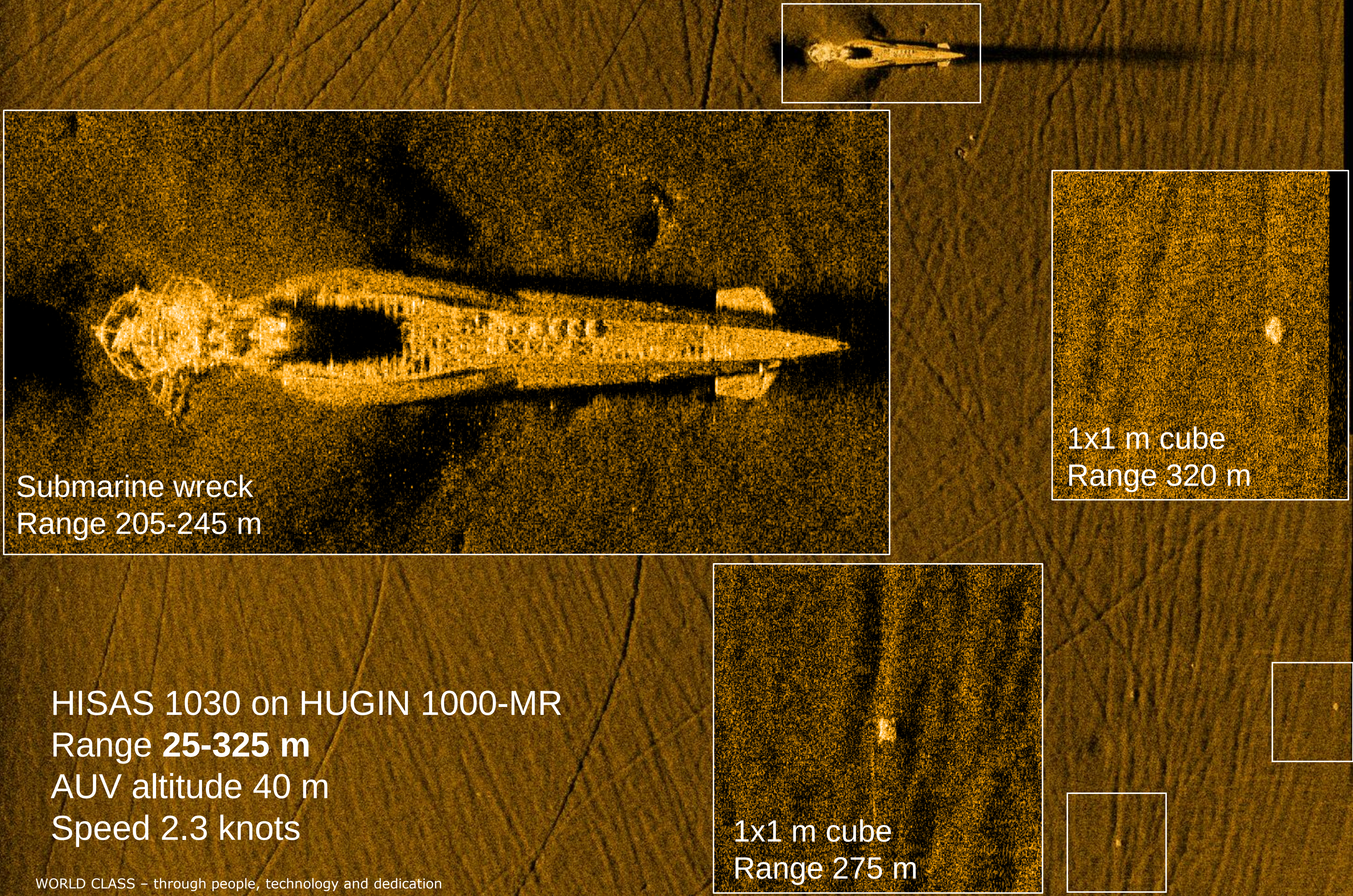
Detailed seabed mapping with AUV



Data courtesy of Fugro

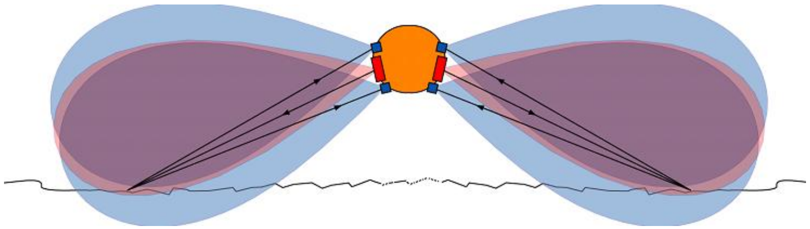


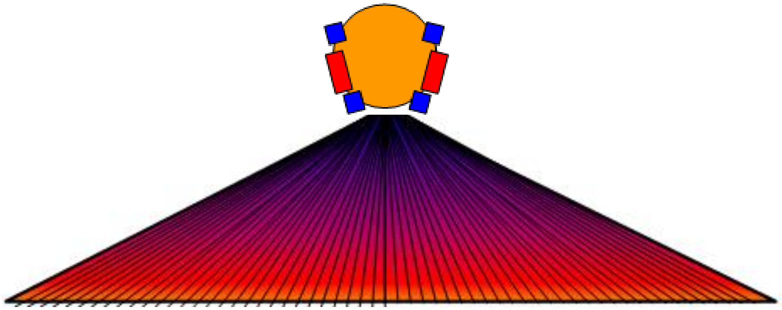
Synthetic aperture sonar long range example



HISAS 1030 on HUGIN 1000-MR
Range **25-325 m**
AUV altitude 40 m
Speed 2.3 knots

Interofermetric SAS and MBE for hydrographic mapping





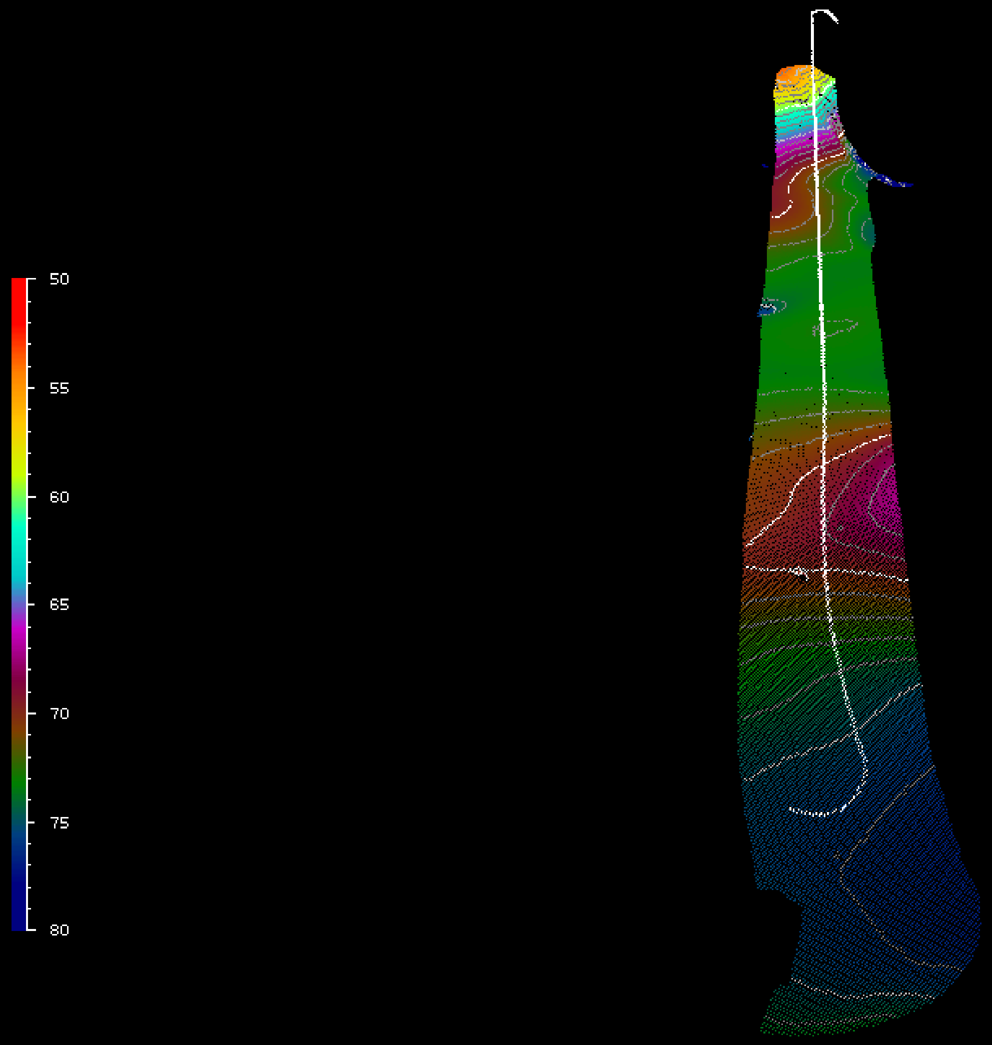
Interferometric SAS

- High area coverage rate, typically 2km^2/hr.
- Blind zone directly below the vehicle (nadir gap)

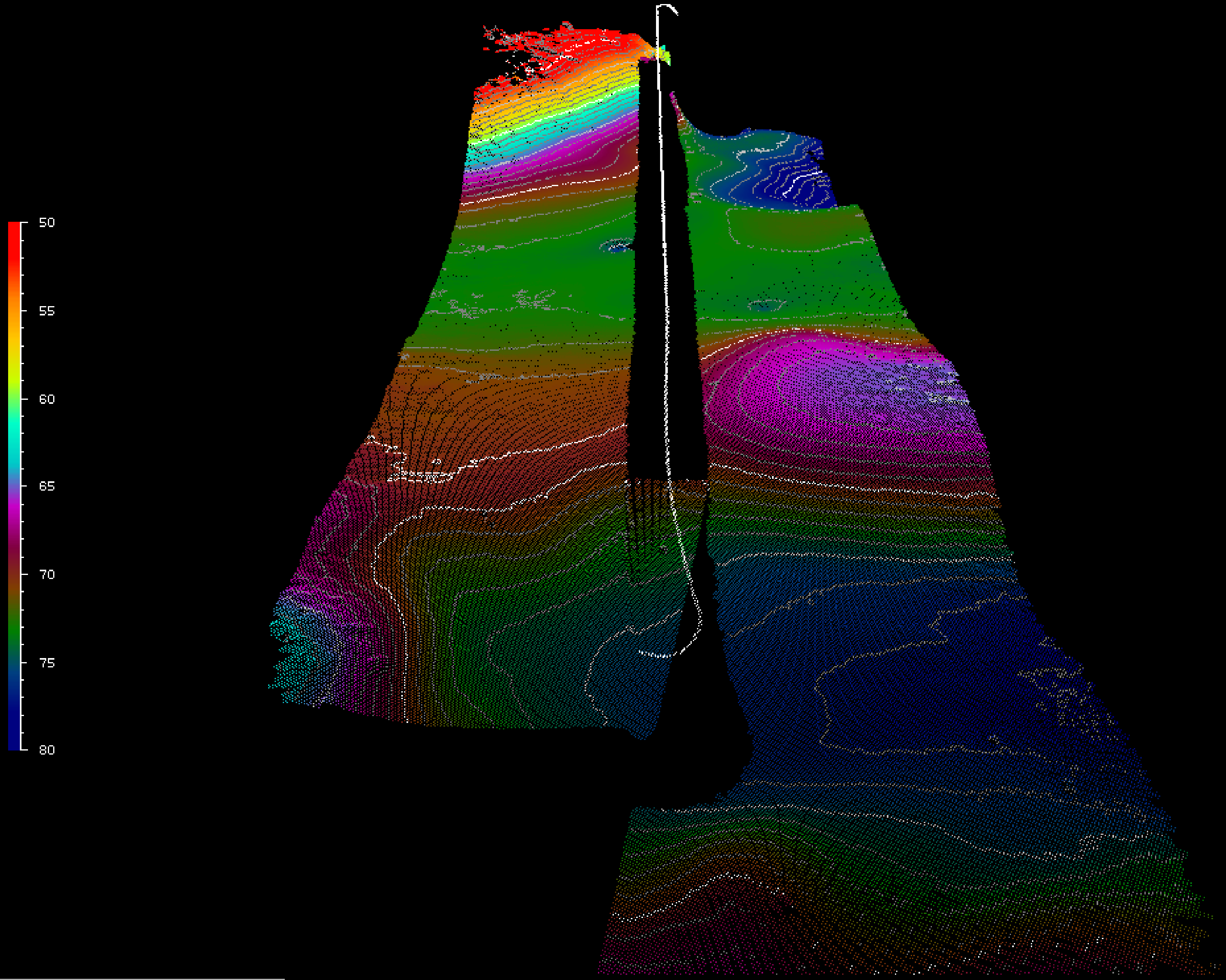
MBE

- Beamformers have advantage at nadir
- Less coverage than interferometric SAS

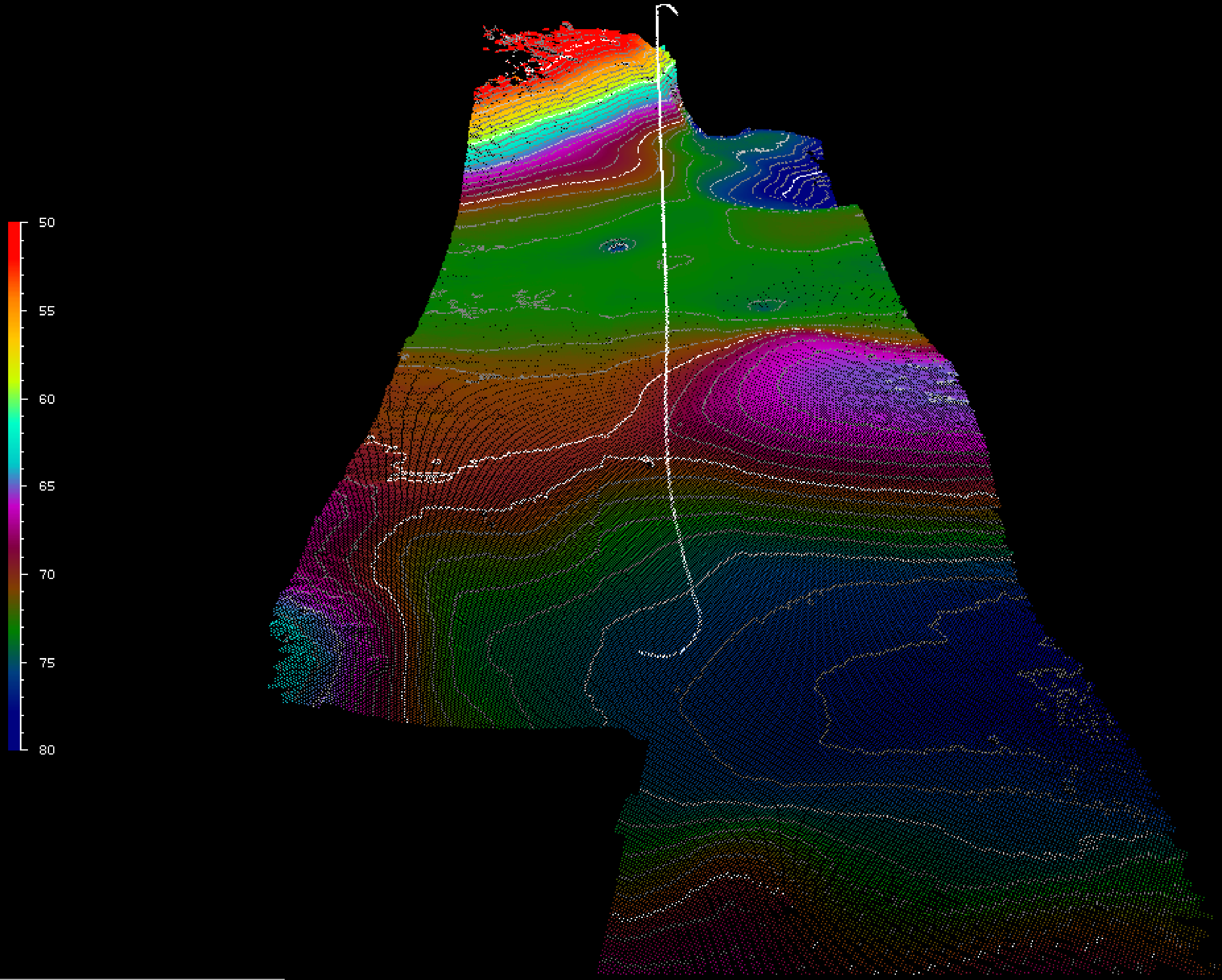
EM 2040 bathymetry (400 kHz)



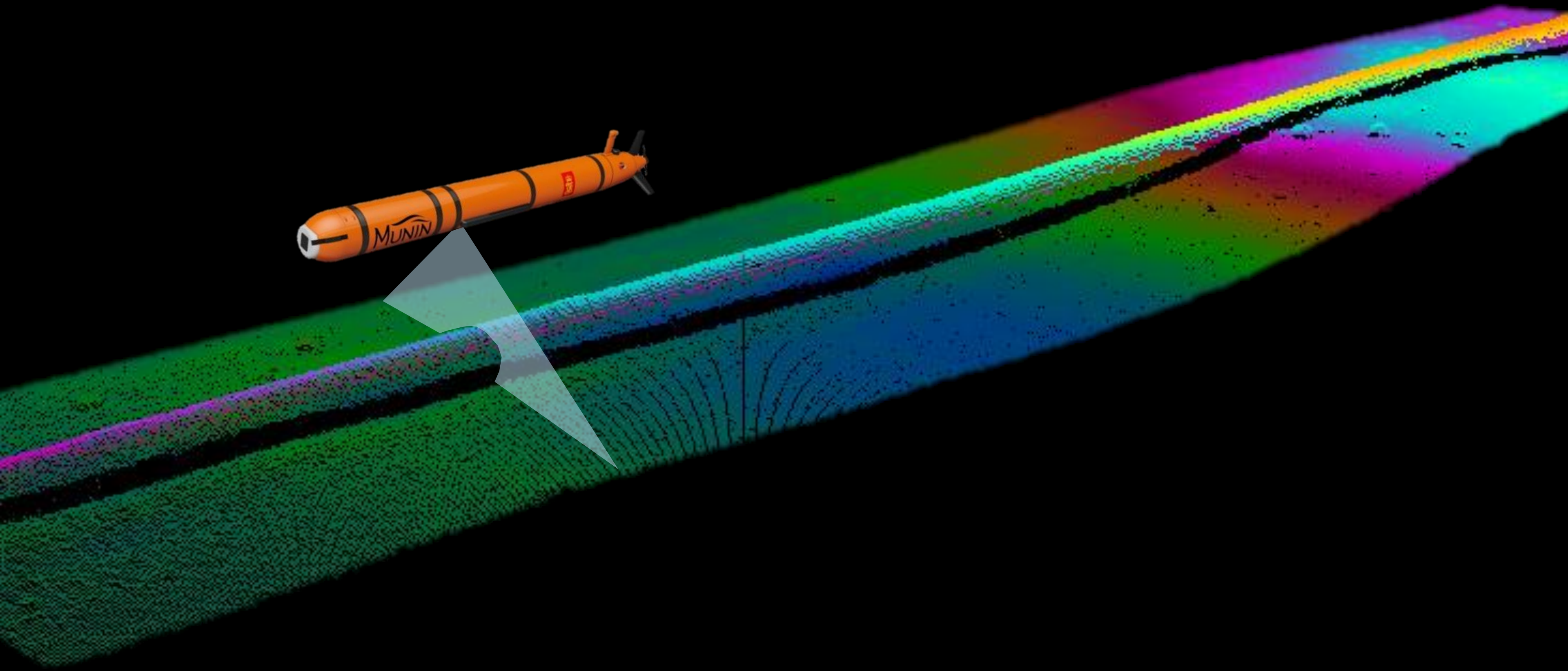
HISAS sidescan bathymetry



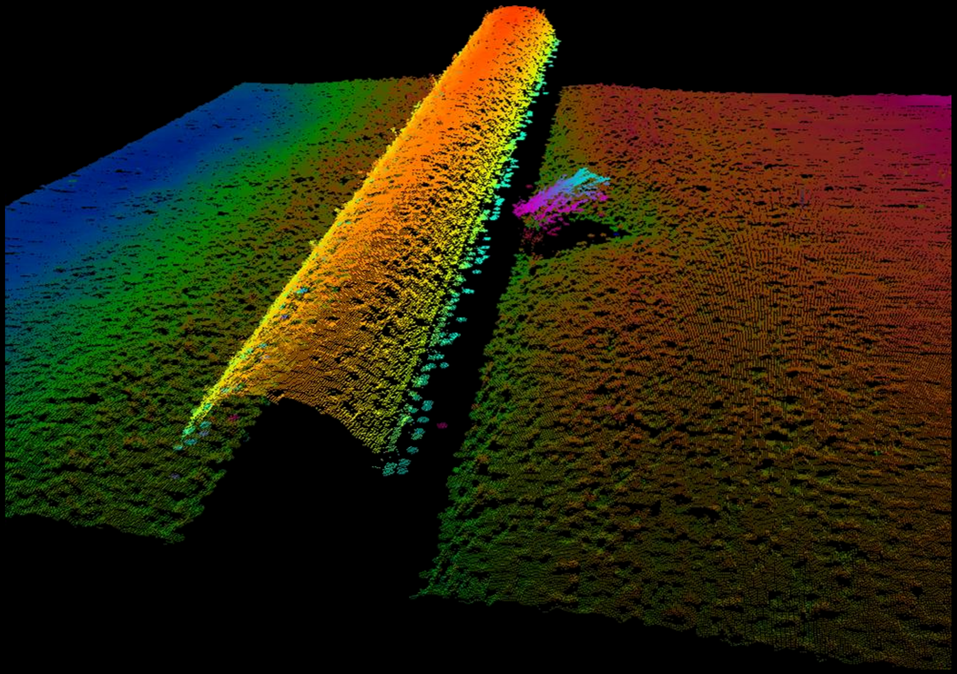
Merged bathymetry



Pipeline survey



Pipeline survey



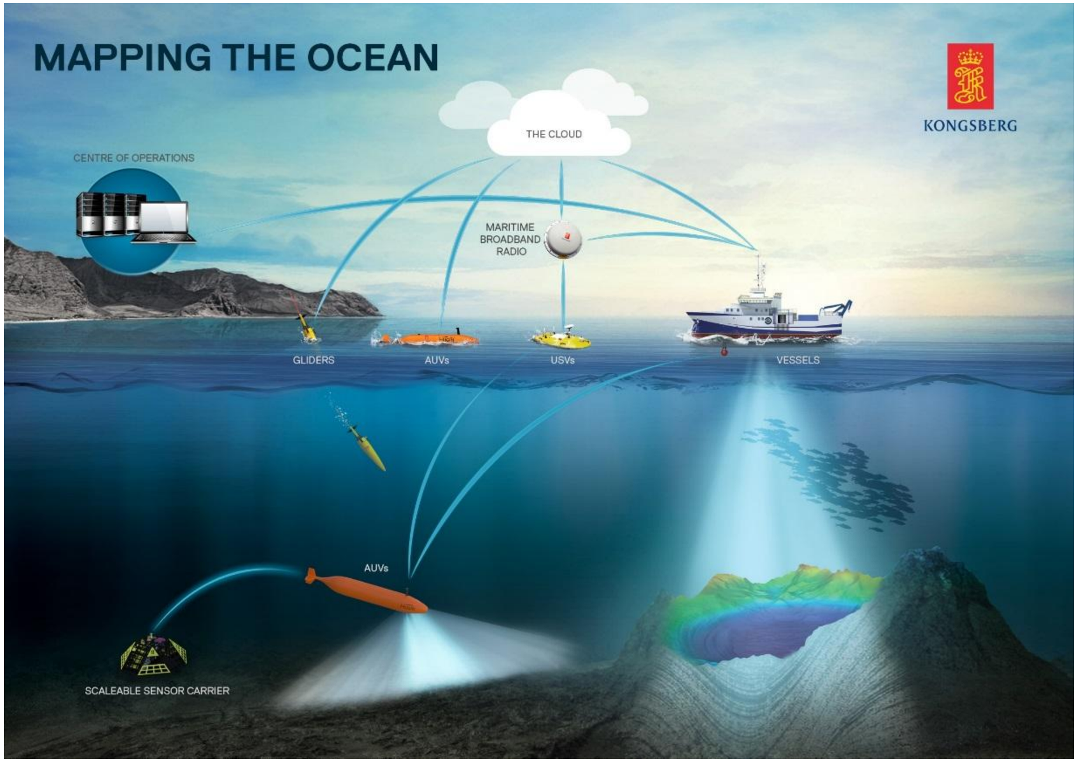
Trends in data processing

- Instruments produce cleaner data
- Higher data density, richer data sets – more processing and data handling
- More automated processing
- Ecosystem on open standards
- Value added services
- Land and ocean mapping meets

Courtesy Geological Survey of Norway

What holds the future?

- Cleaner data
- Improved accuracy
- Multifrequency seafloor classification
- Synthetic aperture sonar
- Continued robotization
- Extending from mapping to monitoring
- Connected operations
- Automated processing
- Open standards



MAPPING THE OCEAN