Monitoring environmental effects of a deep-sea mining test in shallow water, Bay of Málaga

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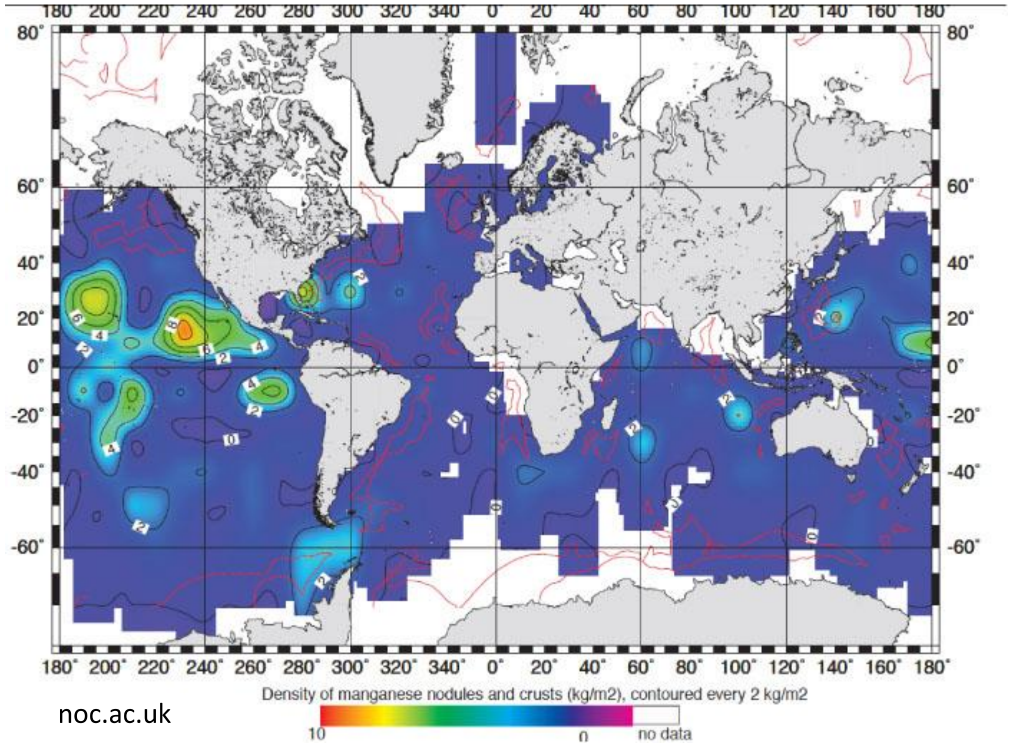
Royal NIOZ is part of the institutes organisation of NWO, in cooperation with Utrecht University

Introduction – Why deep-sea mining?

- Interest in deep-sea mineral resources to reduce dependency on land-based raw materials
- Polymetallic nodules, mineral concretions composed largely of iron and manganese hydroxide, have relatively high concentrations of nickel, copper and cobalt
- Mainly found in the Pacific Ocean in the Clarion-Clipperton Zone (CCZ)



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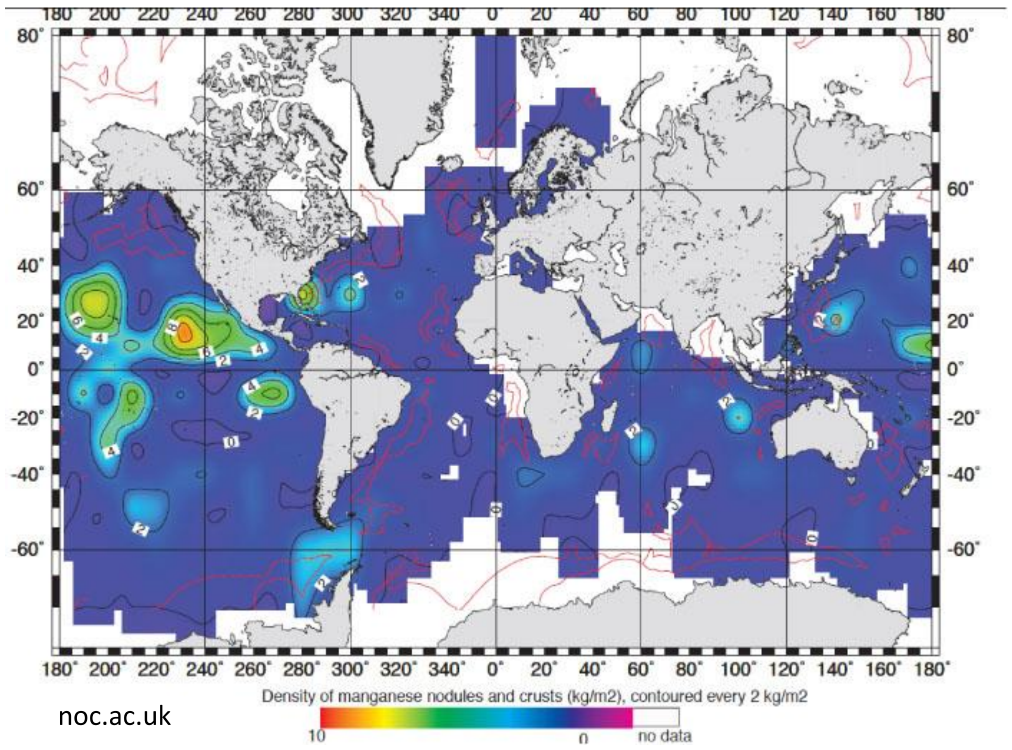
Introduction – Why deep-sea mining?

- No commercial mining is happening yet

- Potential environmental impacts have to be studied before mining takes place as many questions exist about the environmental sustainability of deep-sea mining



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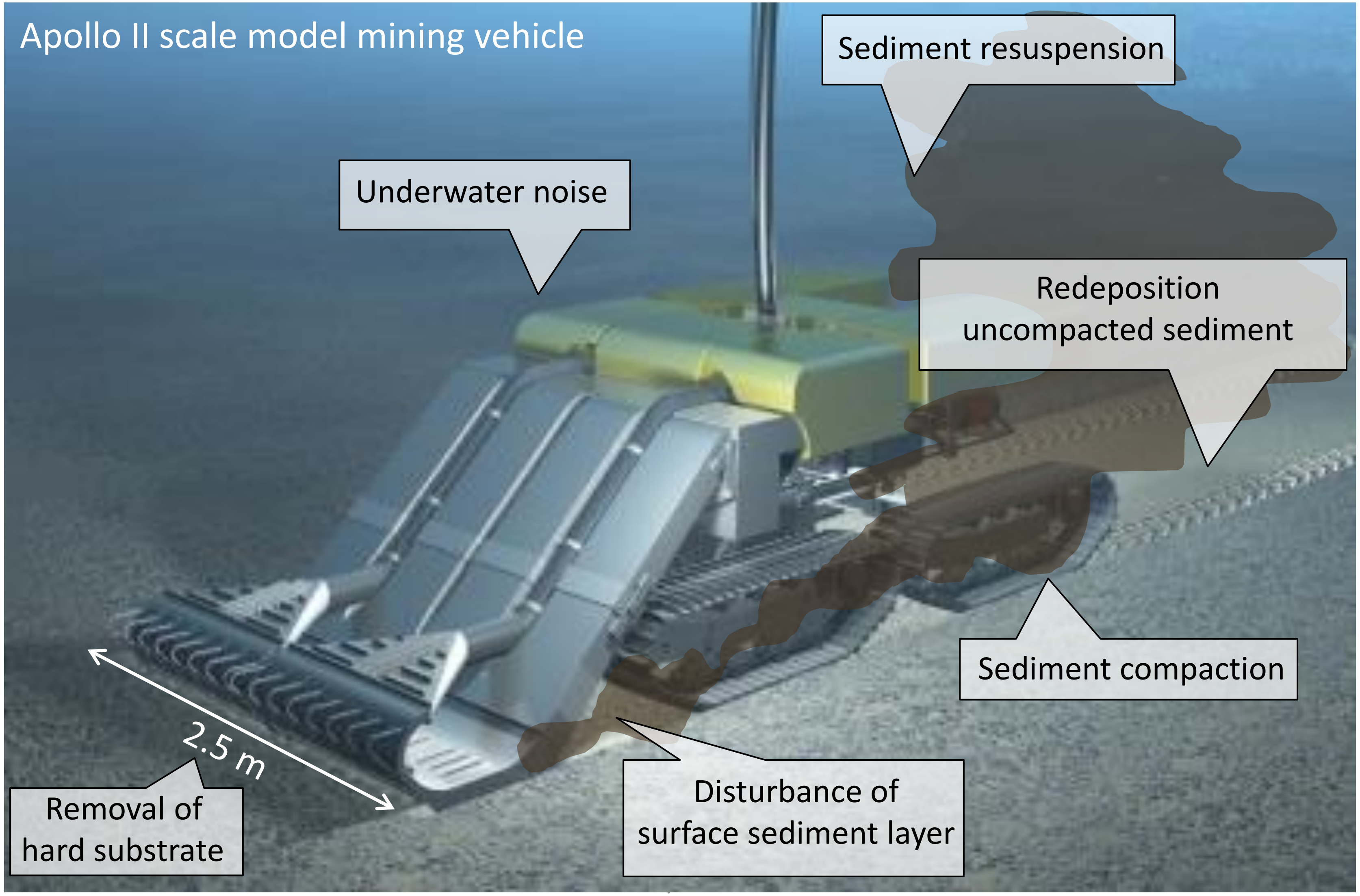
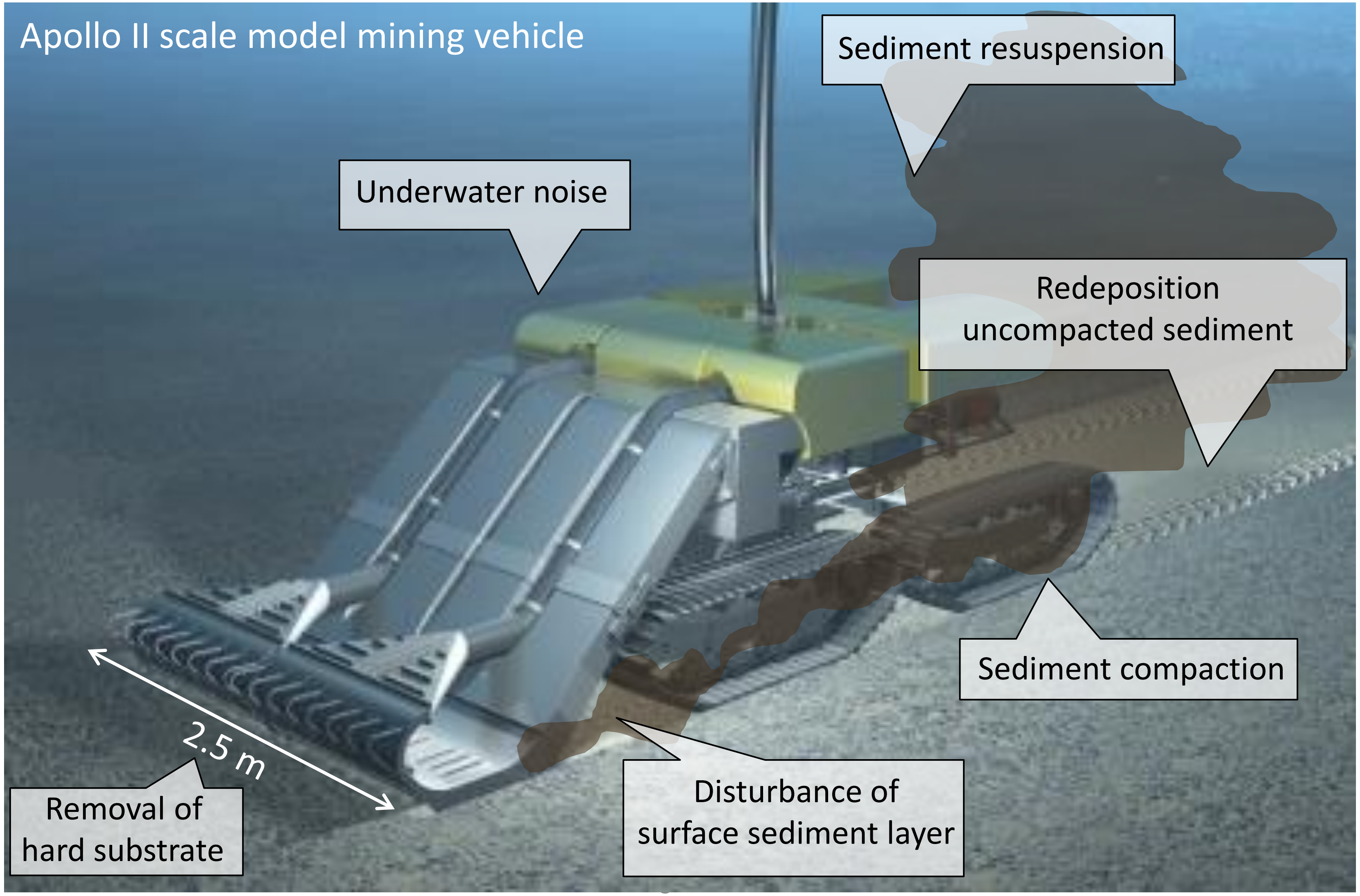
Introduction – Possible impacts

- Plume of suspended sediment mobilised by the mining vehicle is considered to represent a major environmental pressure which may extend far beyond the actual mining area



Introduction – Possible impacts

- Removal of nodules, mobilisation and compaction of surface sediment, redeposition of sediment from the plume will have long-term impacts on benthic ecosystems



Introduction

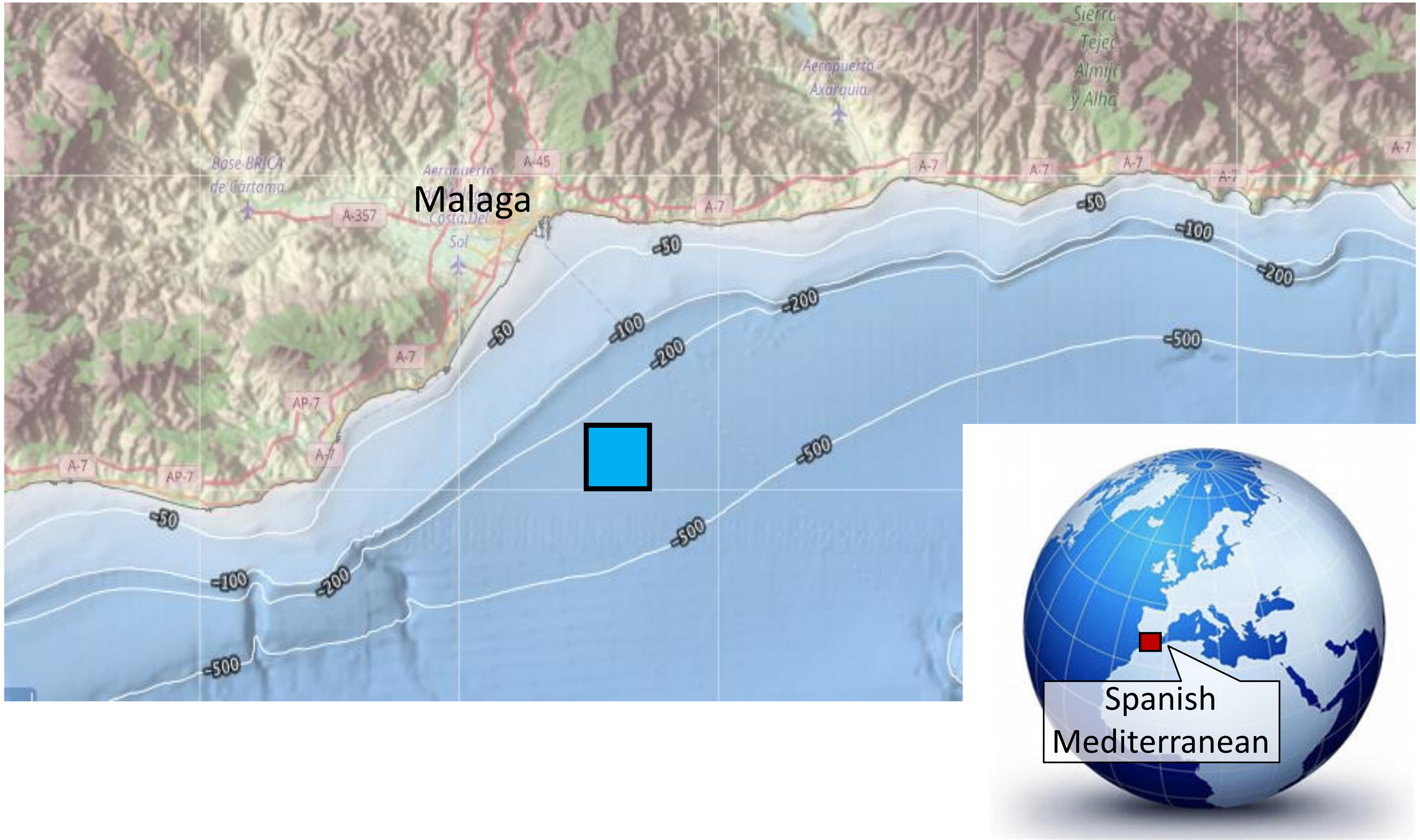
Aim:

Use a deep-sea mining test in shallow water to establish methods for monitoring plume dispersion and seabed substrate alteration, which could be applied for future deep-sea mining in e.g. the CCZ

Setting field test – Bay of Málaga

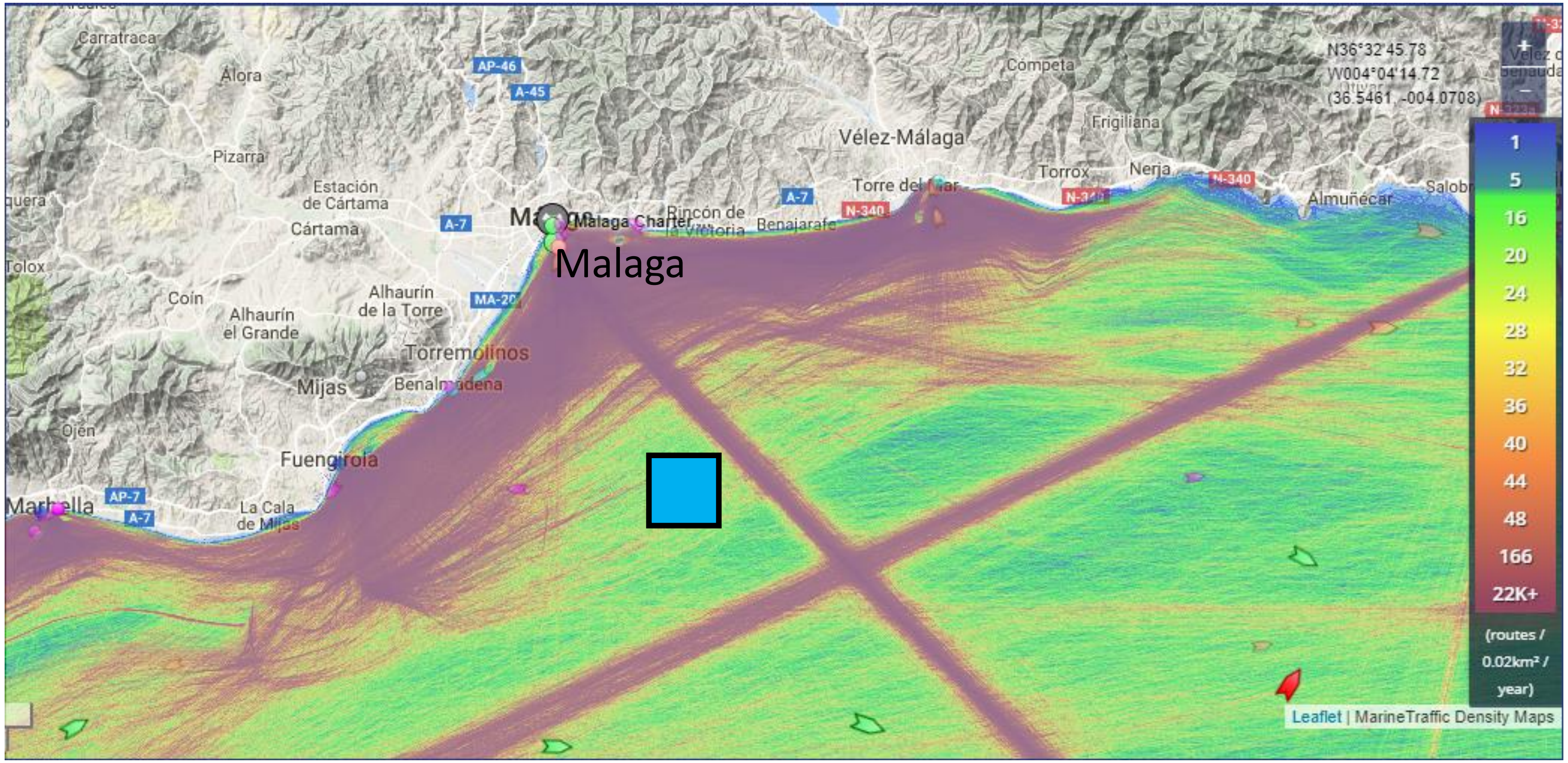
- Relatively shallow water (300 m)
- Gently sloping seabed covered with fine muddy sediment
- Tide-dominated weak near-bottom currents (5-10 cm s^{-1})

→ Physical seabed conditions similar to CCZ



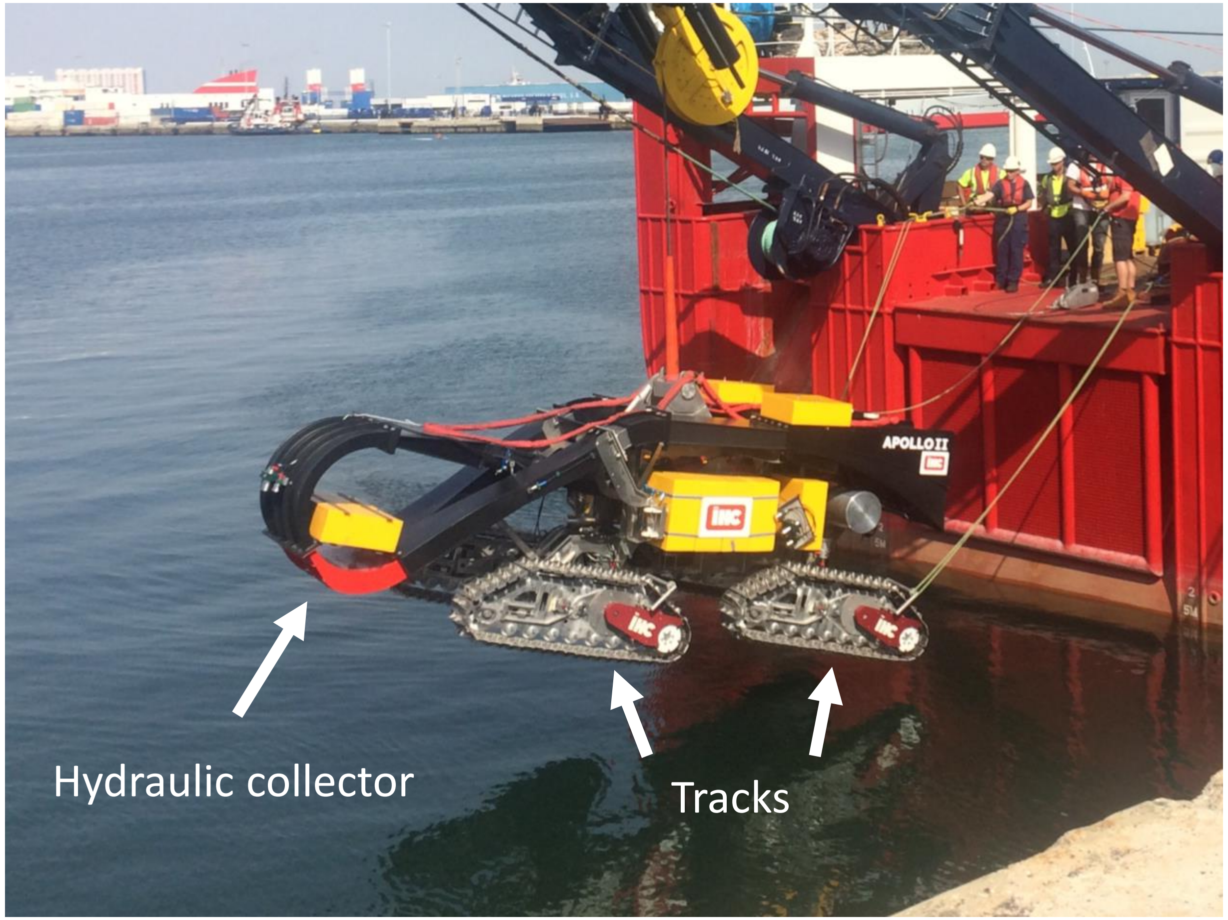
Setting field test – Bay of Málaga

- Field test area outside of main marine traffic routes
- Bottom trawling on the continental shelf and slope



Methods – IHC *Apollo II* mining vehicle

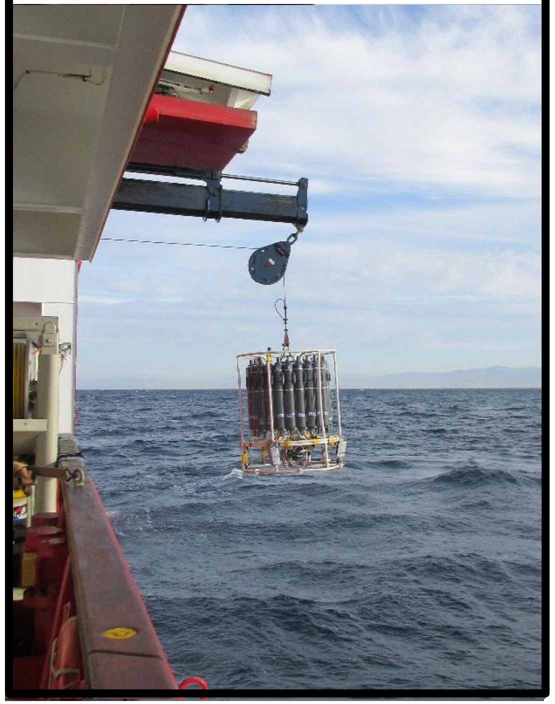
- Scaled pre-prototype hydraulic collector
- 5.6 x 2.5 x 2.3 m in size
- Weighs 3800 kg in air, 850 kg in water
- Average speed during field test: 0.25 cm s^{-1}
- Turbidity sensor mounted at rear of vehicle



Methods – Monitoring equipment

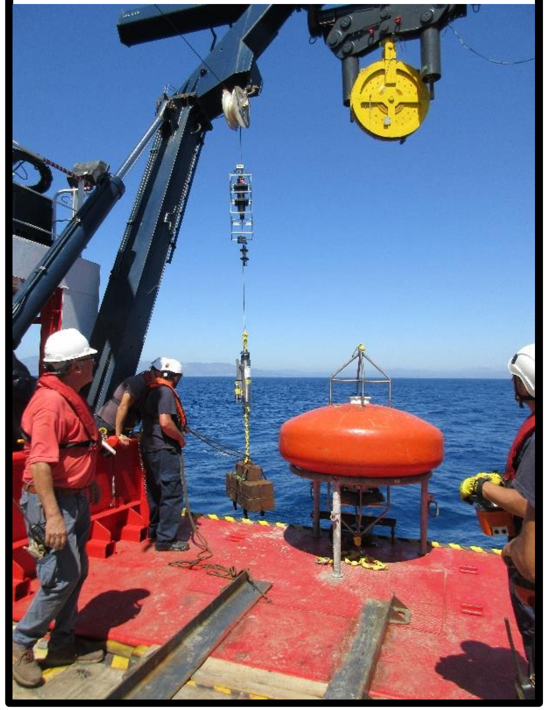
CTD

- Profiling water column properties
- Water sampling



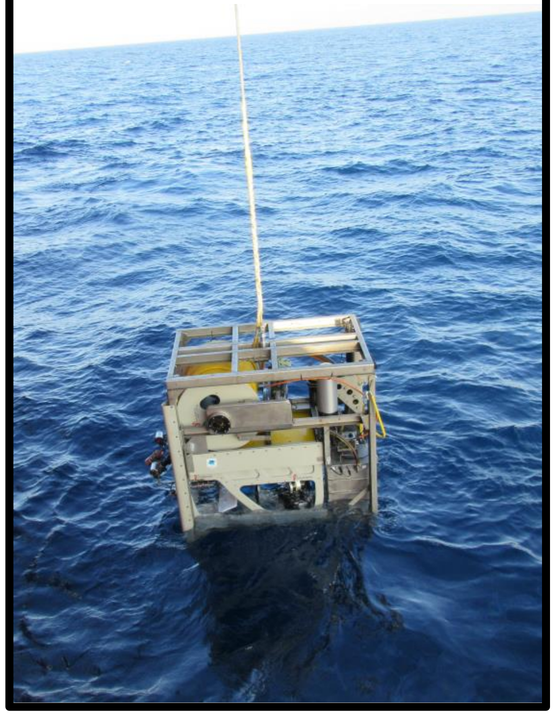
Moorings

- Temporal data on current regime and turbidity



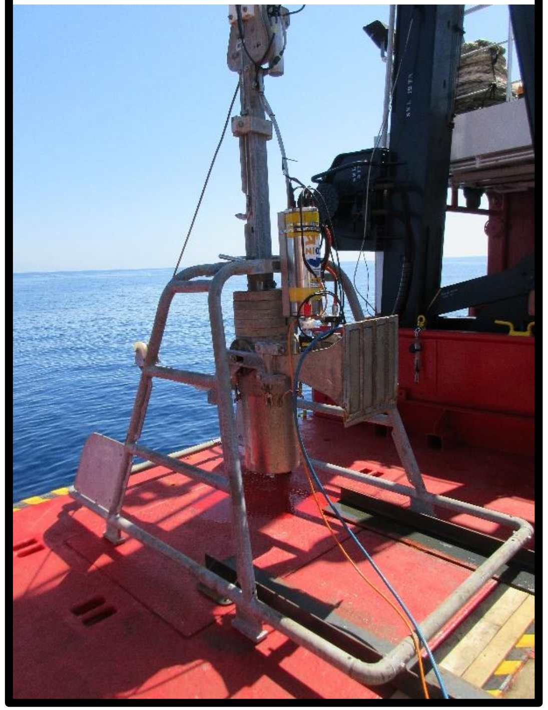
ROV

- Visual control of plume and seabed alteration



Box corer

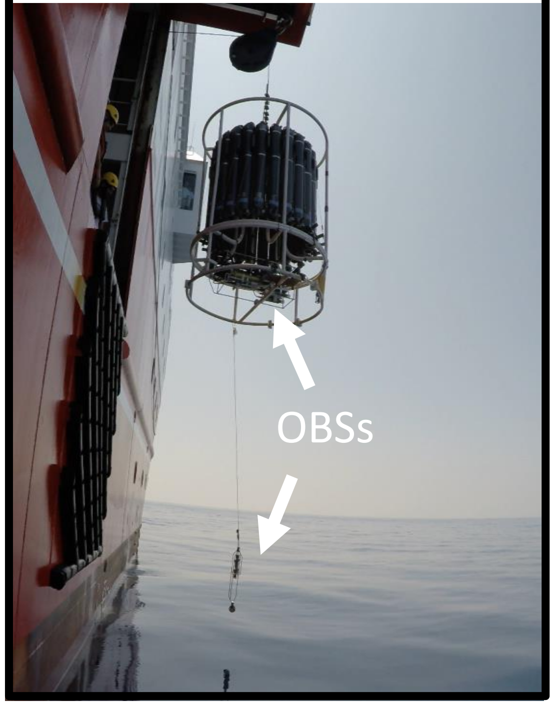
- Sediment samples before and after disturbance



Methods - CTD

CTD

- Profiling water column properties
- Water sampling

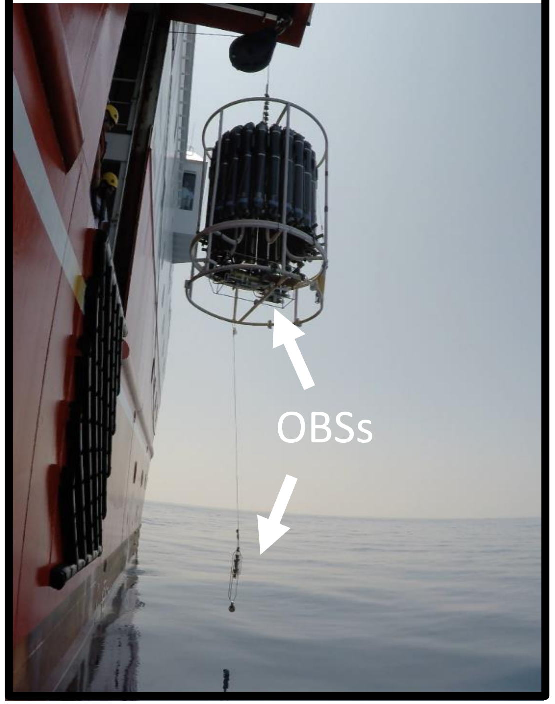


- Multiple turbidity sensors
  - One optical backscatter sensor (OBS) suspended below the CTD frame

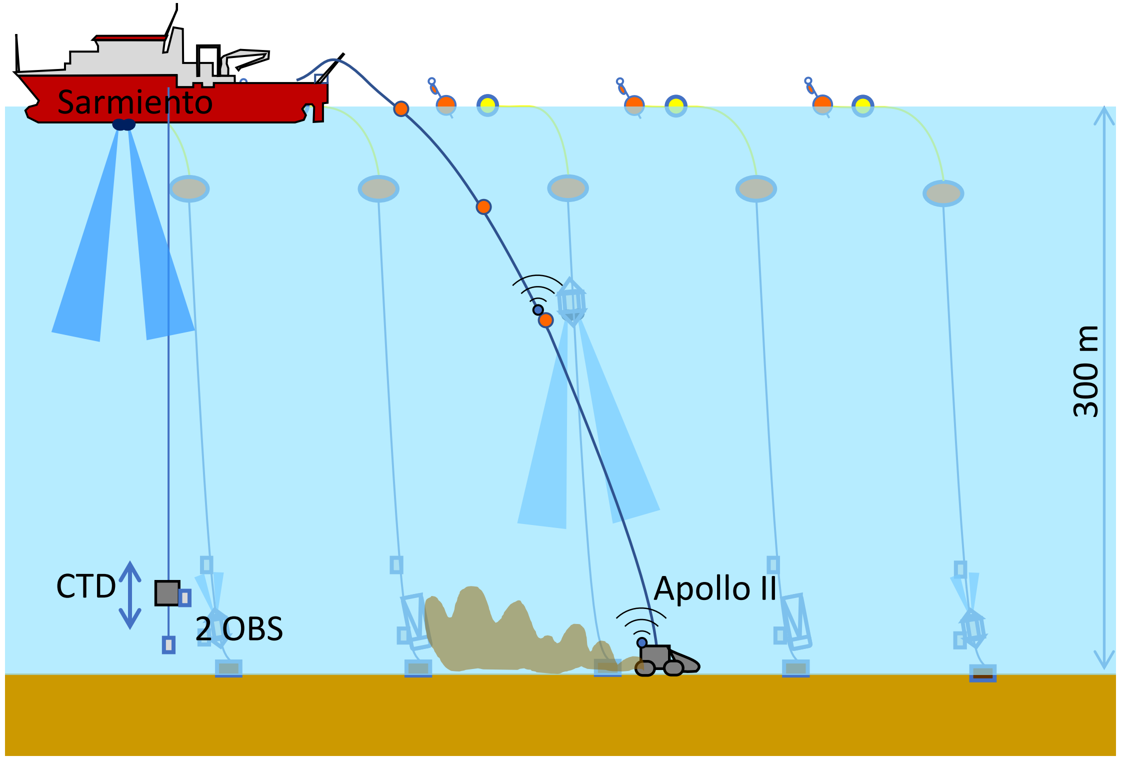
Methods - CTD

CTD

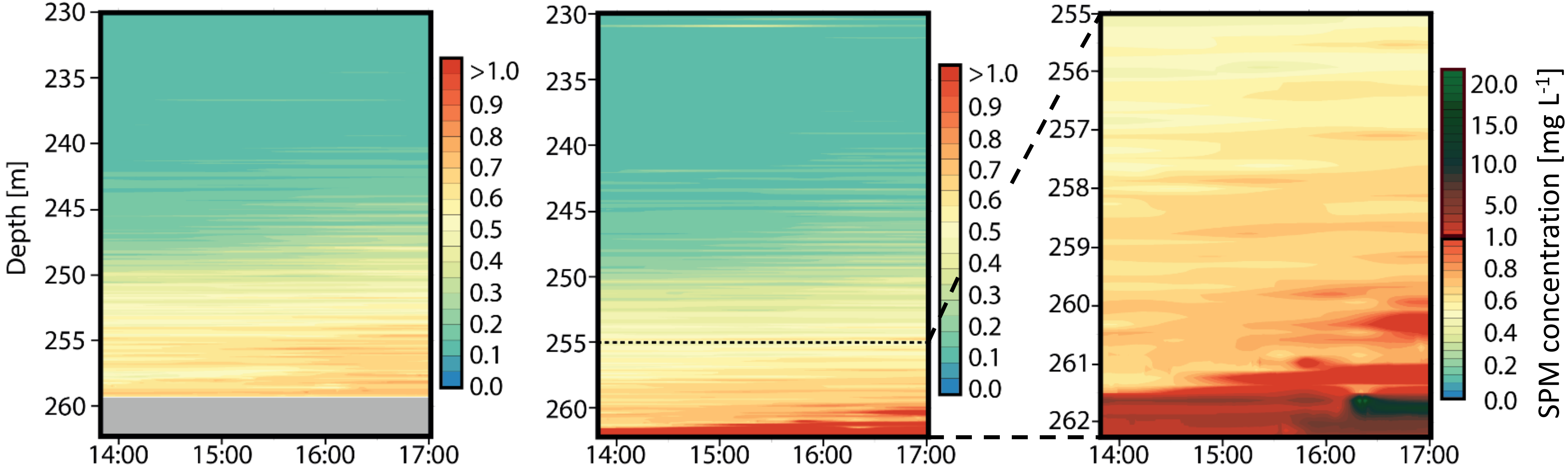
- Profiling water column properties
- Water sampling



- Yo-yo and tow-yo CTD casts through generated sediment plume at approximately 100 m distance behind the *Apollo II* mining vehicle



Results - CTD



OBS on frame

- Increased turbidity in lower 10 m
- Hardly any sign of sediment plume, only natural background turbidity

OBS below frame

- Sediment plume present in lower few meters

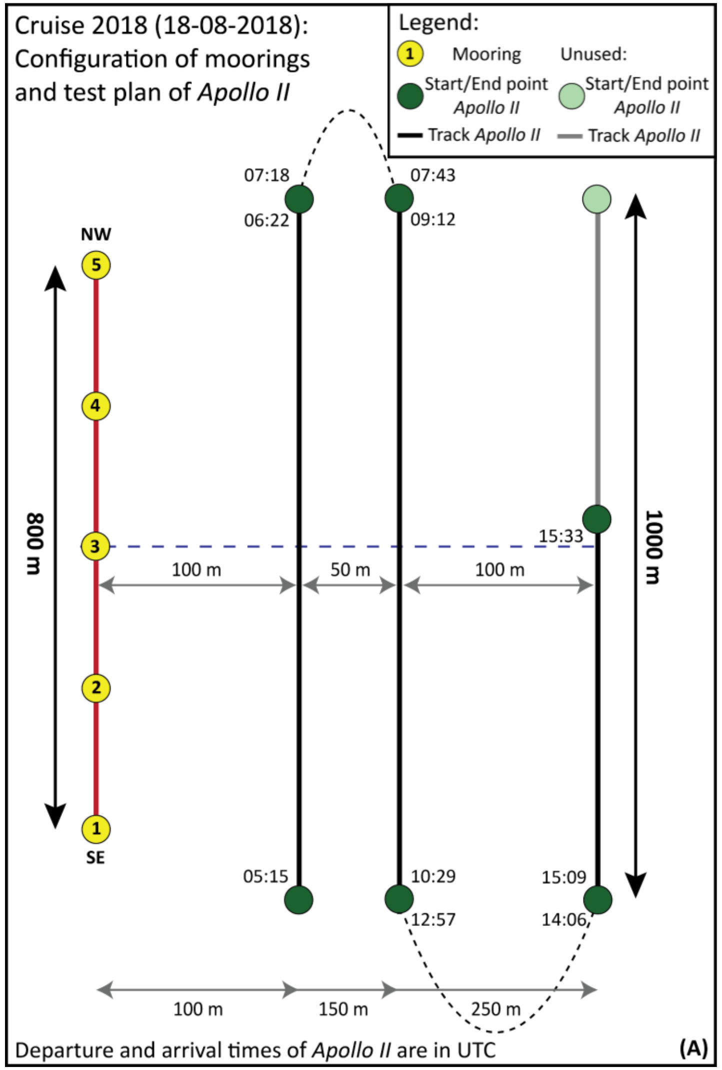
OBS below frame

- Strong presence of a sediment plume with concentrations up to 100 times background turbidity

Methods – Configuration mooring arrays

Moorings

- Temporal data on current regime and turbidity

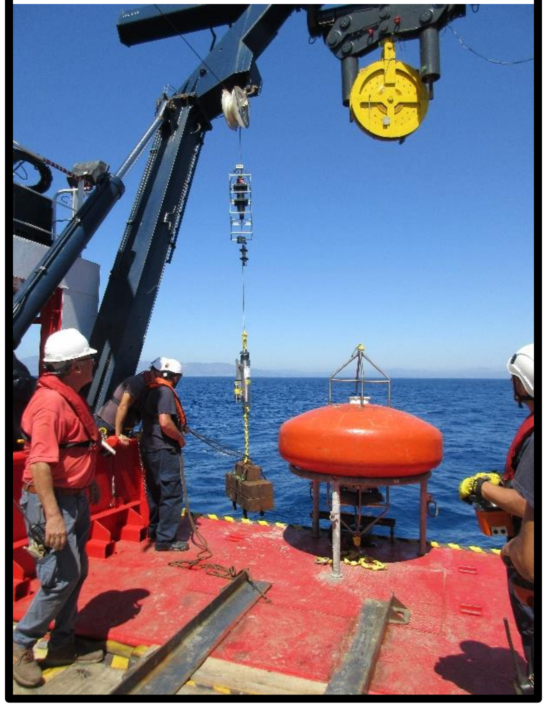


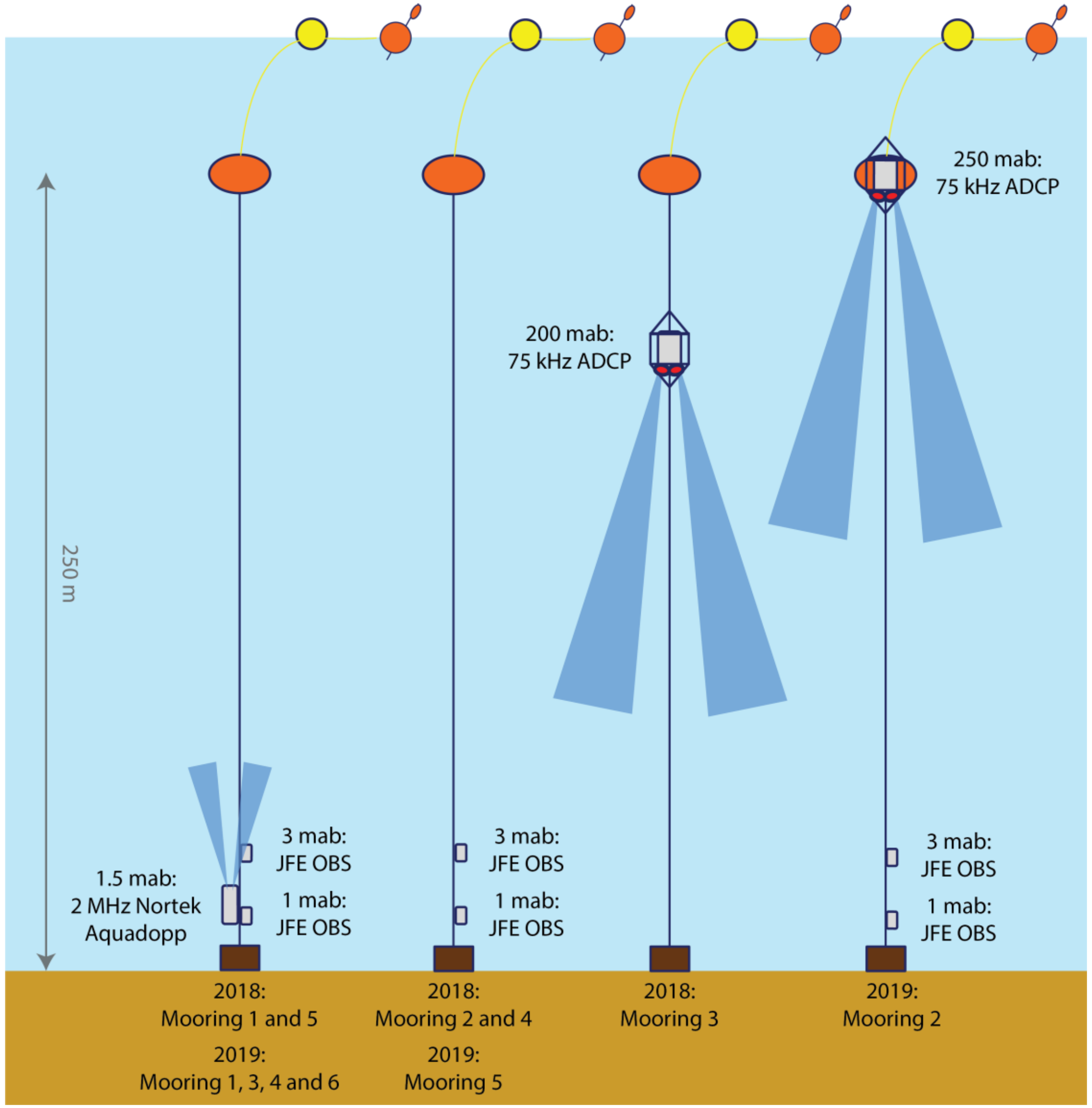
- *Apollo II* drove three lines in front of the mooring array
  - Line 1: 100 m
  - Line 2: 150 m
  - Line 3: 250 m

Methods – Configuration moorings

Moorings

- Temporal data on current regime and turbidity

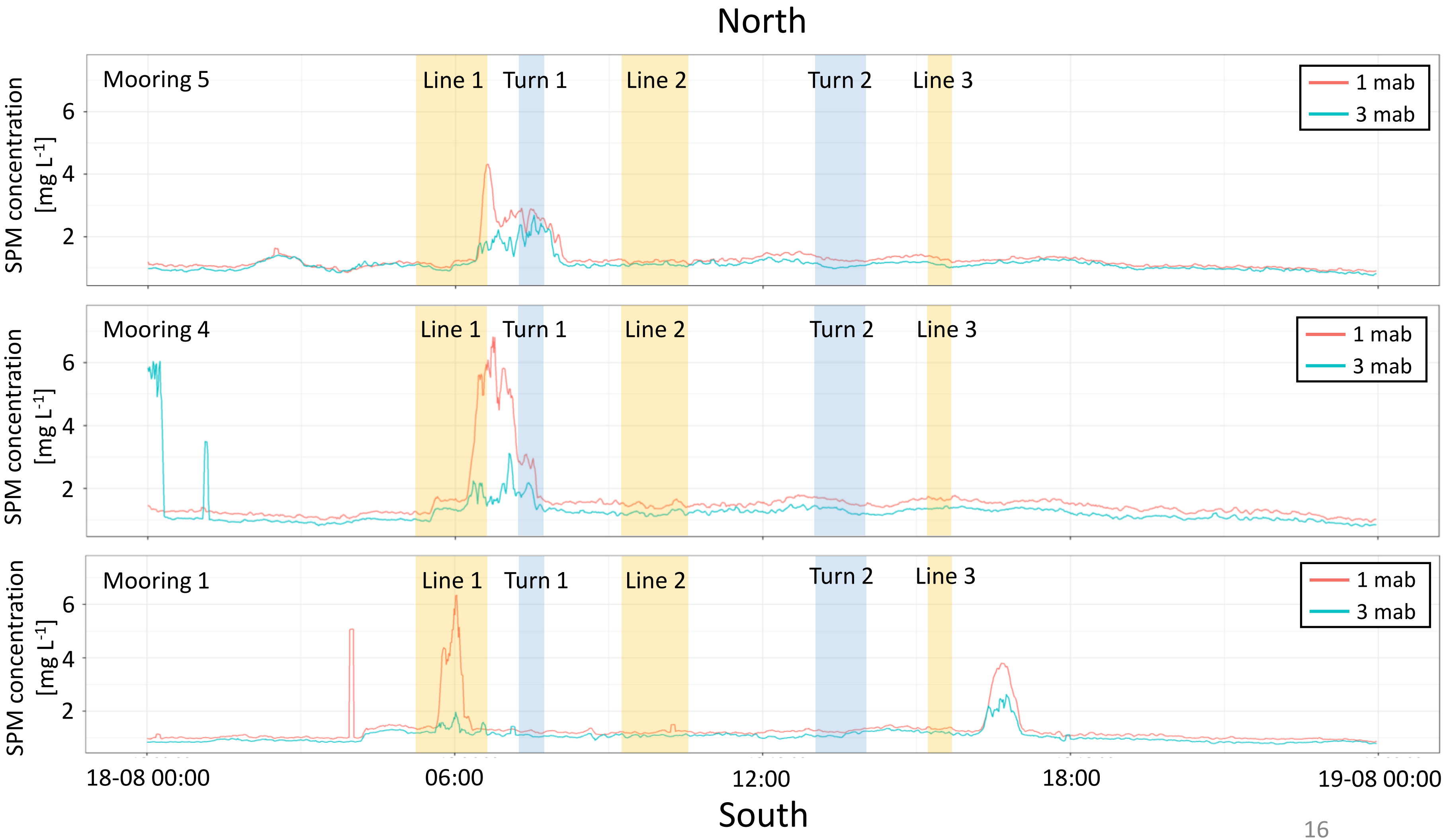




- Moorings equipped with several turbidity sensors (OBSs) and current profilers

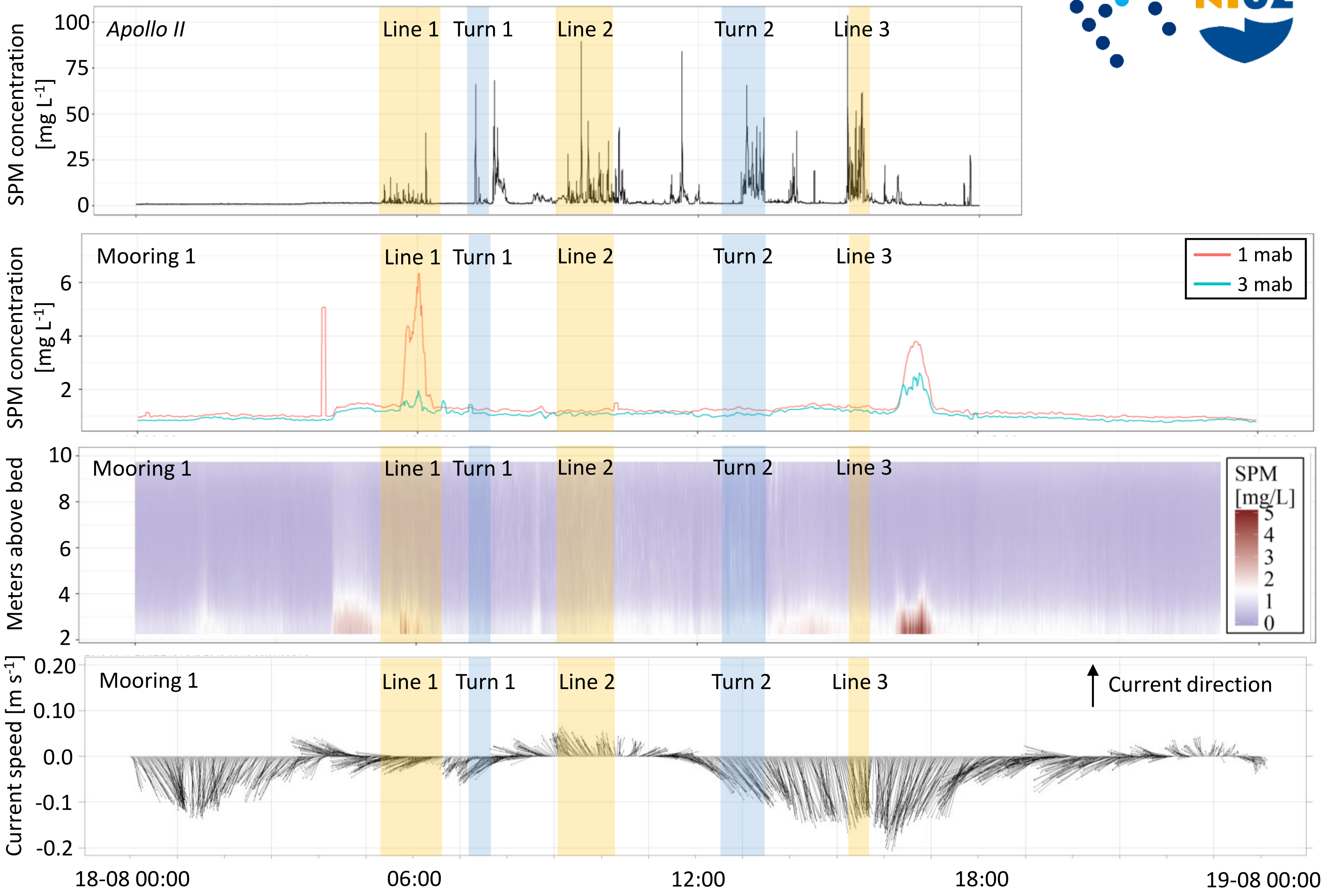
Results
Moorings

- Lines and turns: Activity of *Apollo II*
- Plume generated during line 1 recorded at all moorings
- Plume generated during line 3 only at mooring 1



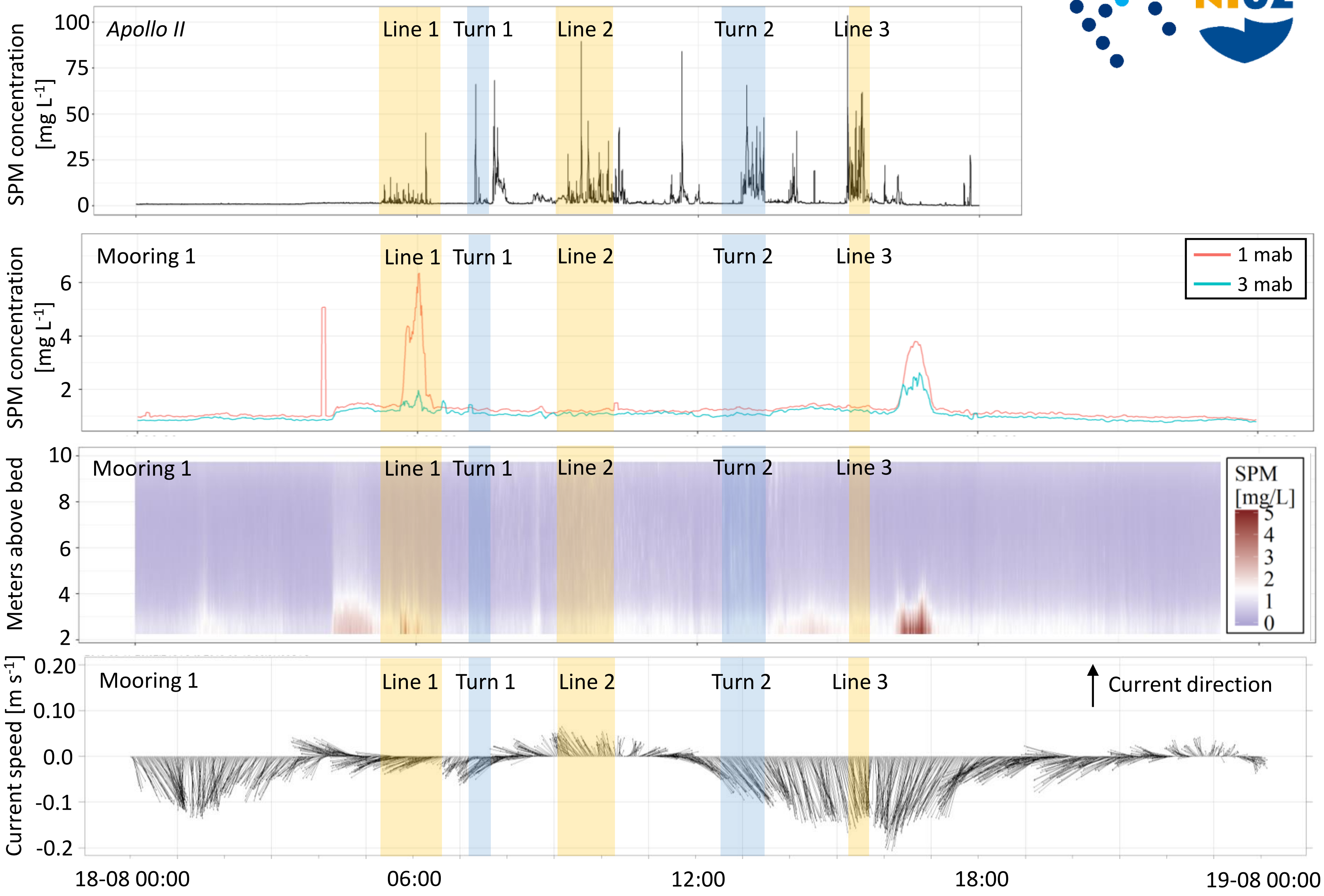
Results
Moorings

- SPM concentration recorded at mooring 1 order of magnitude lower than recorded at *Apollo II*



Results
Moorings

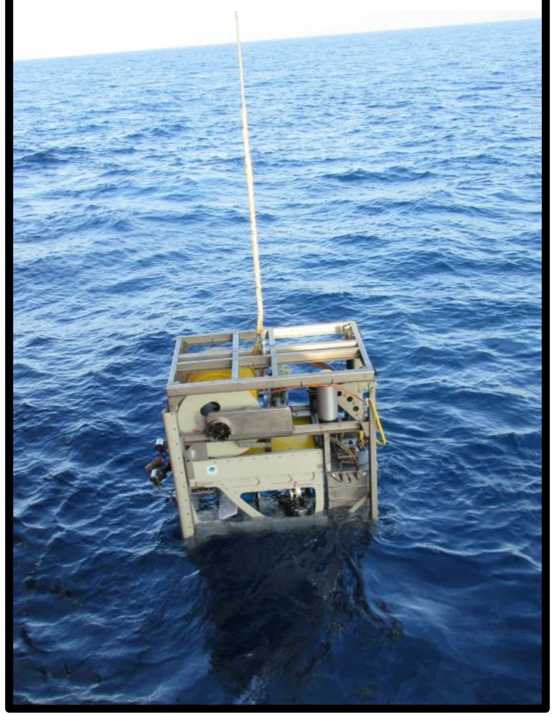
- Absence of plumes generated during line 2 and 3 explained by change in current direction



Methods – ROV *Zonnebloem*

ROV

- Visual control of plume and seabed alteration

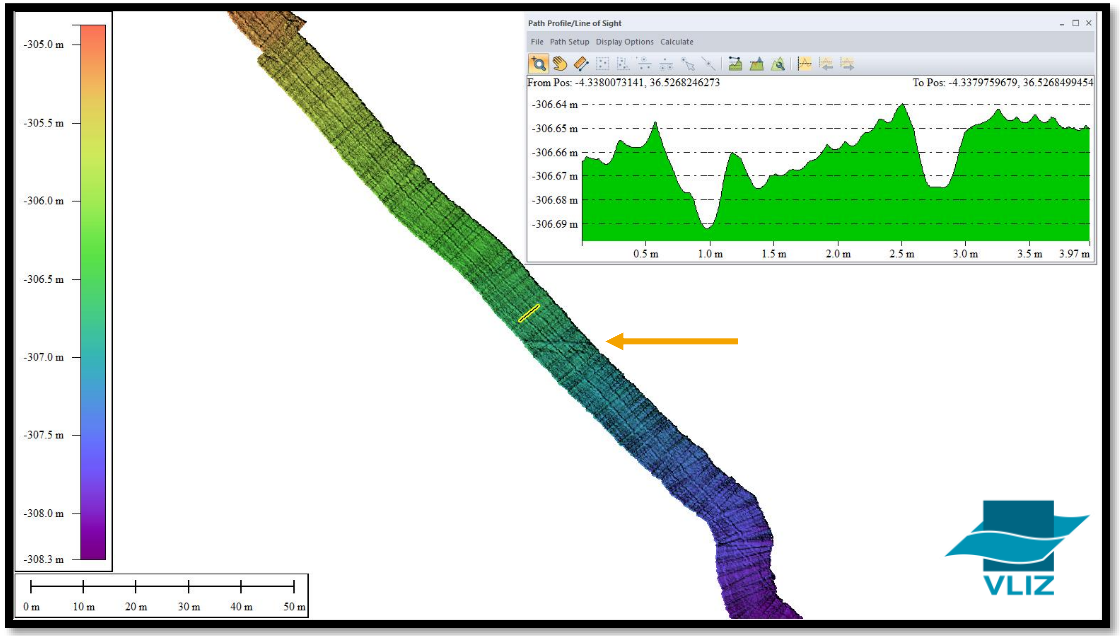


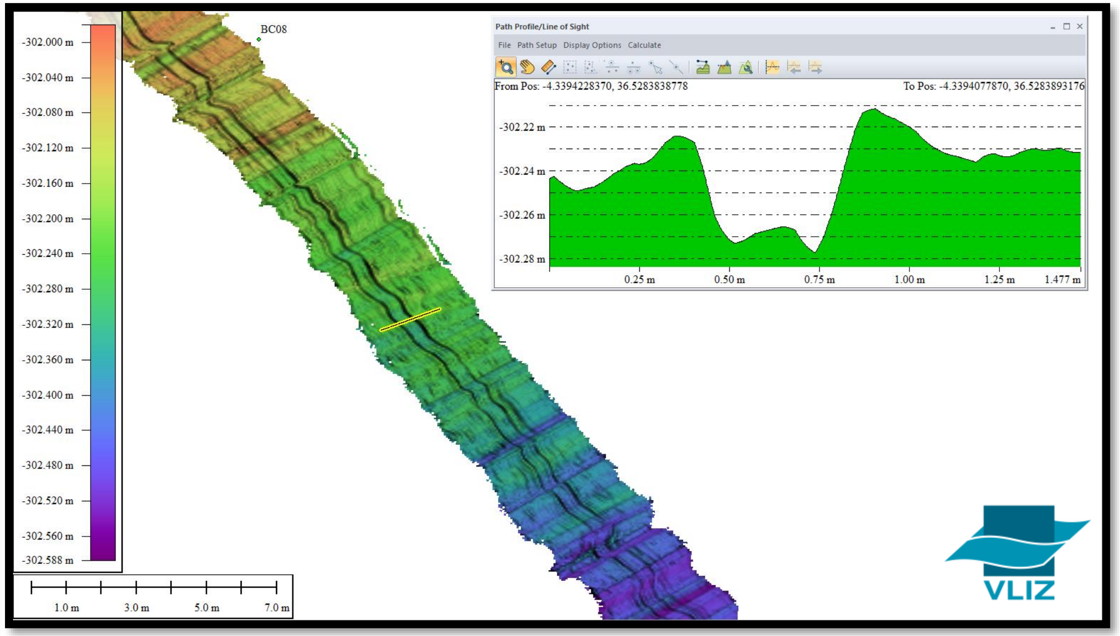
- Visual control of plume and seabed alteration
- Data on depth of incision *Apollo II* tracks by BlueView multibeam system
  - Dual frequency: 900 & 2250 kHz
  - Acquisition software: Qinsy
  - Accuracy
    - Vertical: <1cm
    - Horizontal: ±5 cm

Results – ROV BlueView system

- ROV at 2.5m above seabed
- 10 cm horizontal resolution
- 2 tyres tracks at once
- Dredging mark (arrow)

- ROV at 1m above seabed
- 5 cm horizontal resolution
- 1 tyre track





Methods – Box coring

Box corer

- Sediment samples before and after disturbance

- Box cores inside and outside of the disturbed area
- Shear strength measured using a hand vane shear probe
- Bearing capacity measured using a penetrometer
- Subcores taken for analysis of density and porosity

Results – Box cores

- Undisturbed:
  - Pit and mound structure
- Disturbed:
  - Tracks of *Apollo II*

Undisturbed

Disturbed

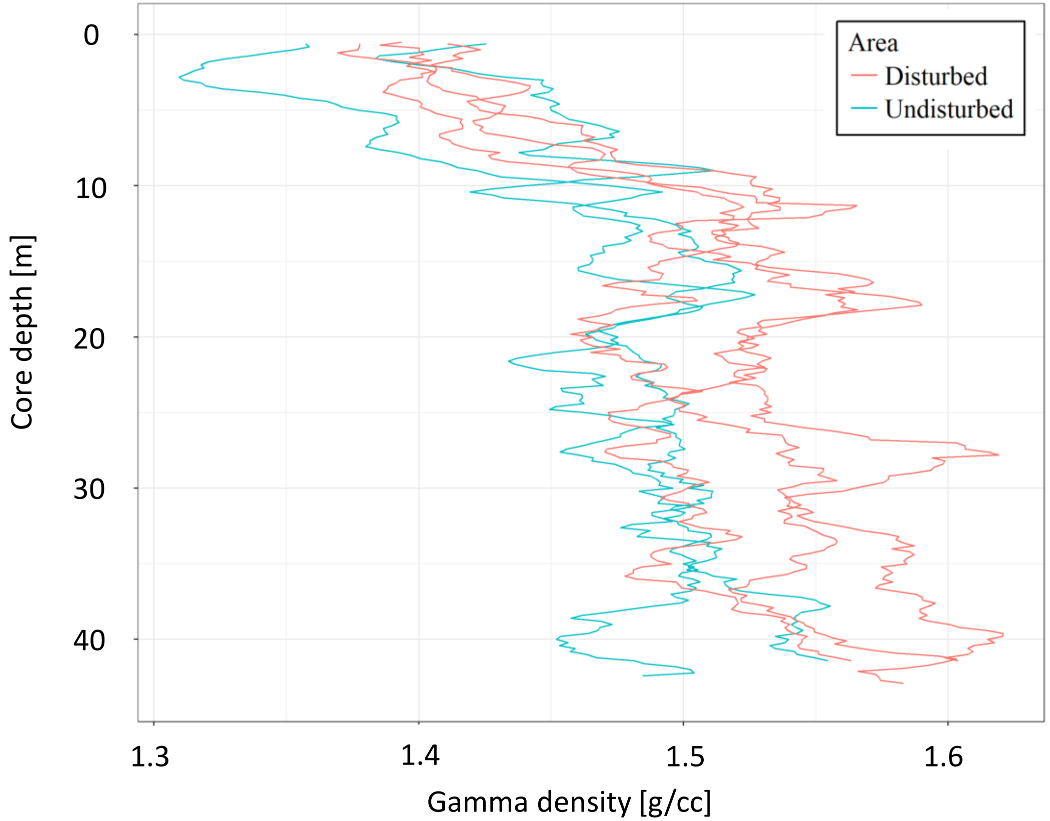
Results – Box cores

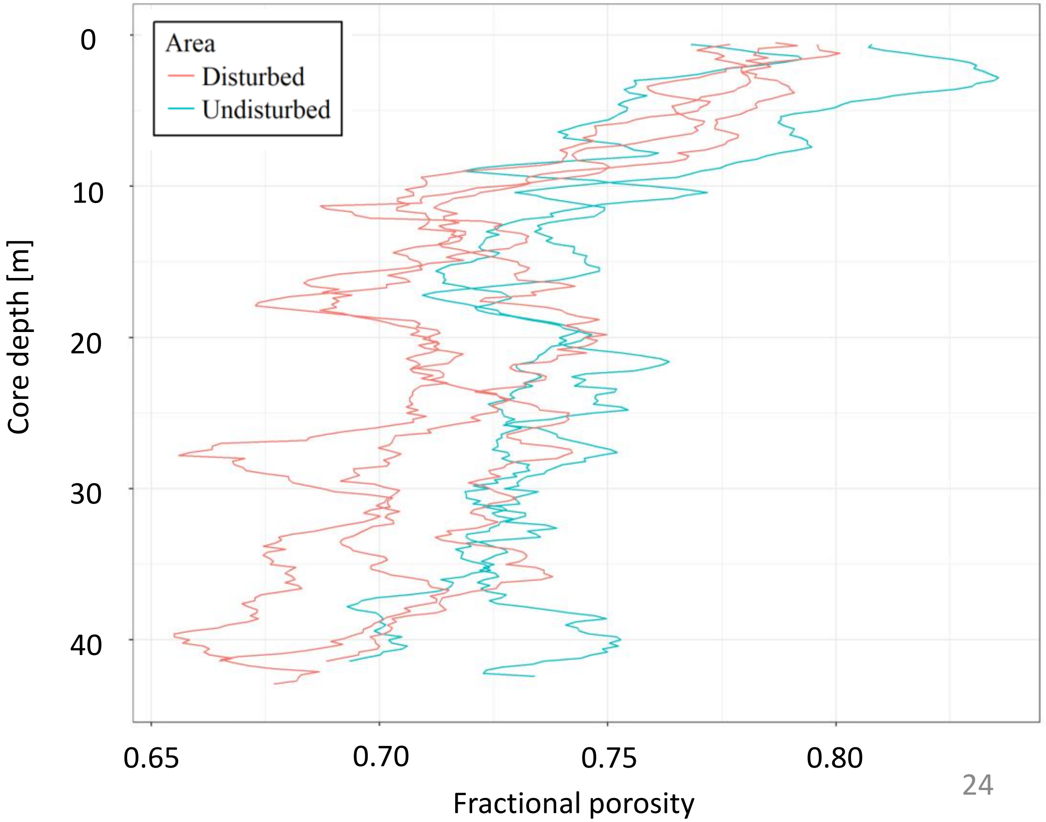
- Undisturbed:
  - Pit and mound structure
- Disturbed:
  - Tracks of *Apollo II*

Undisturbed | **Disturbed**

Results – Box cores

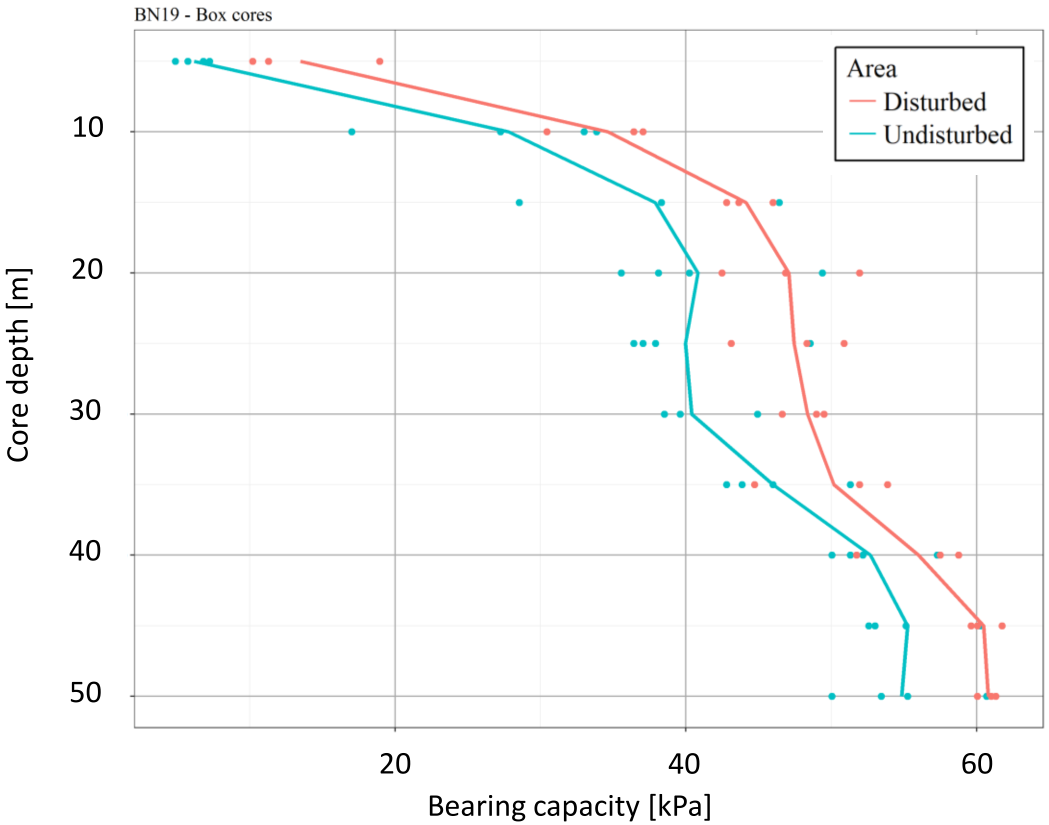
- Increase in density and decrease in porosity over complete depth range when comparing cores from undisturbed to disturbed sites

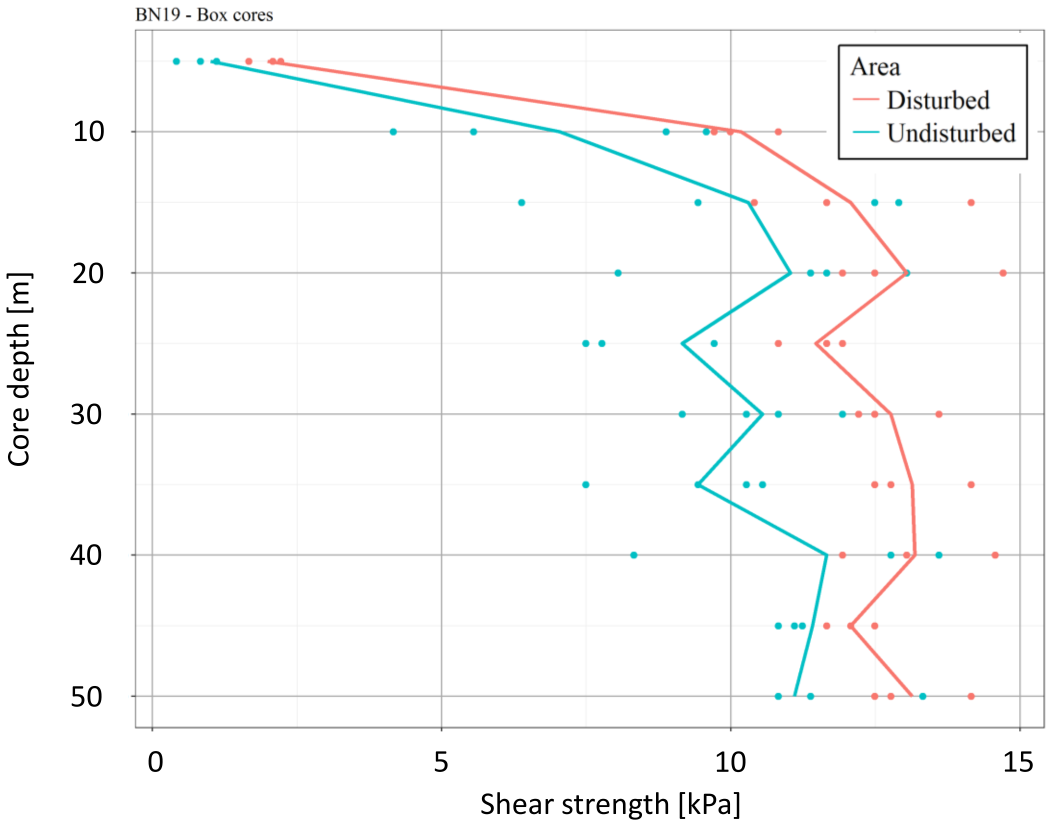




Results – Box cores

- Increase in both bearing capacity and undrained shear strength over complete depth range





Resumé and conclusion
Plume monitoring

- Generated sediment plume extended not more than 2 m above the seabed close to the disturbance (< 100 m), but increased in height with distance away from the disturbance site
- Turbidity decreased rapidly with increasing distance from the source, but a distinct signal could still be distinguished above background turbidity at 250 m away from the source

- Currents are highly variable over time, making ‘catching’ the plume rather difficult
- Different monitoring setups were tried. For a proper monitoring both the horizontal and vertical dispersion should be covered

Resumé and conclusion
Seabed alteration

- Seabed surveys with ROV-based video and scanning sonar showed that the tracks of the test vehicle, left marks of 4 ± 0.8 cm deep in the surface sediment
- Surveys revealed ubiquitous signs of bottom trawling in the area, including furrows of approximately 10 cm deep produced by trawl doors
- In sediment cores collected from the path of the vehicle, decreased porosity and increased sediment density, undrained shear strength and bearing capacity indicate compaction of sediment under the tracks of the mining vehicle

End of presentation

Industry

Research Institutes

Service Supplier

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