MBARI Marine Operations

Steve Etchemendy, Director - Marine Operations

RV *Western Flyer* / RV *Point Lobos* / RV *Zephyr*

Ocean Observatory Group

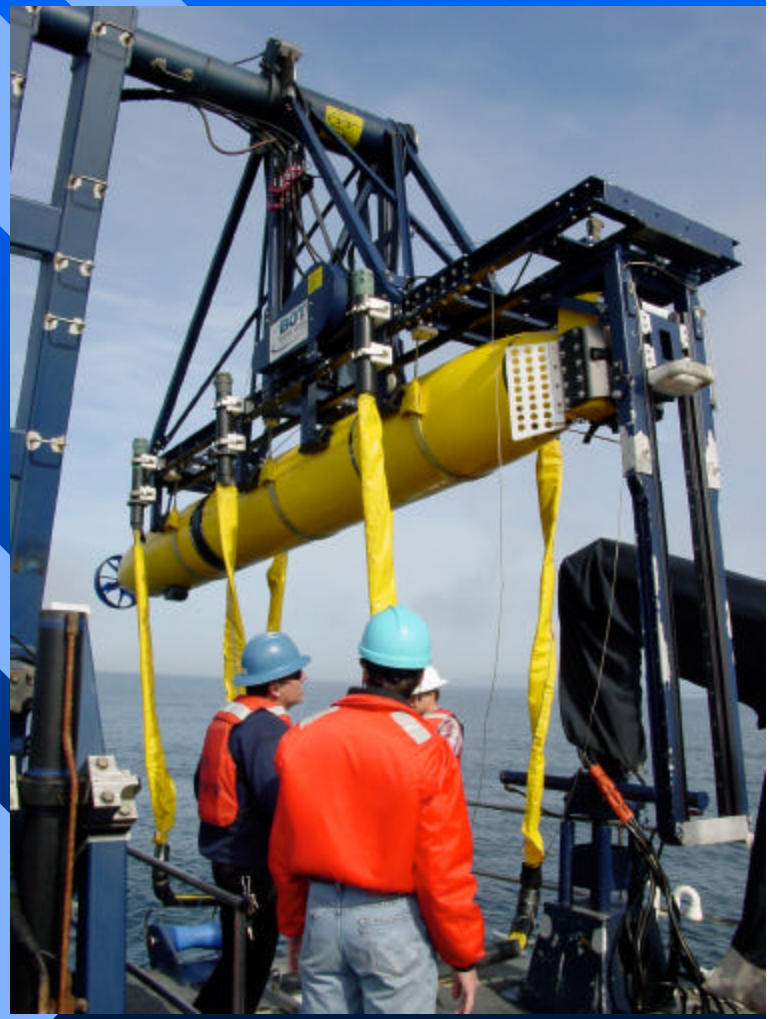
ROV *Tiburon* / ROV *Ventana* / AUV Group

Marine Operations Technicians

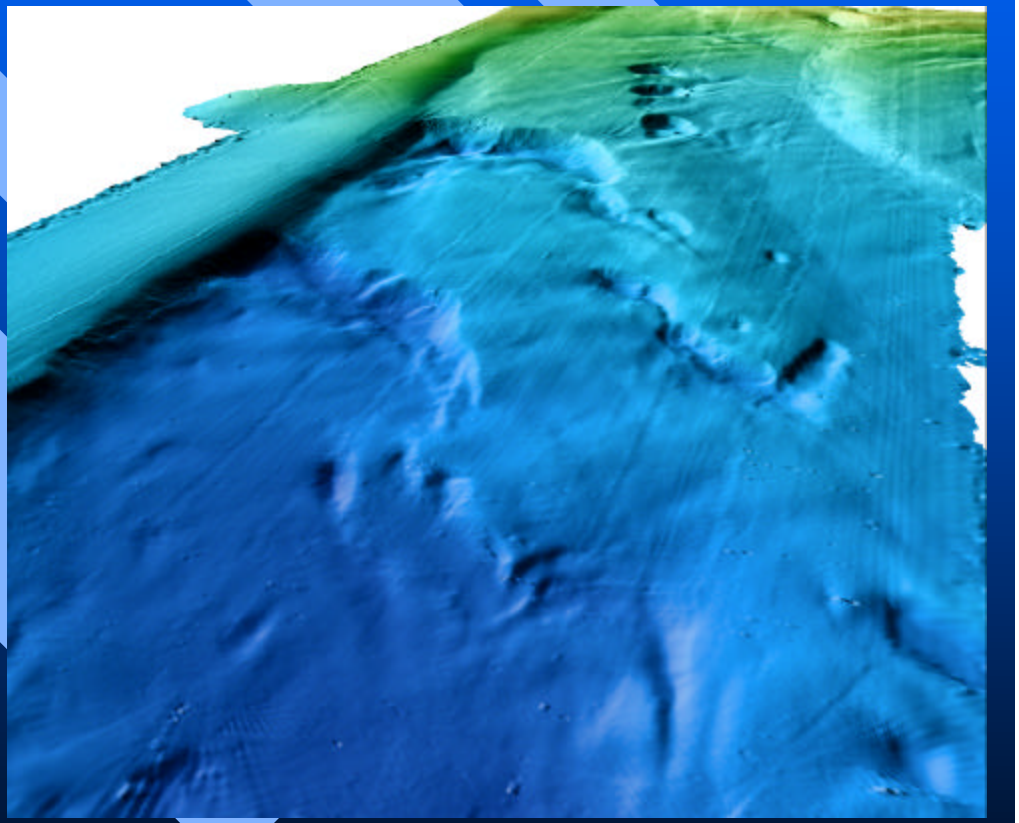
MARS

2007 Missions

- AUVs are now important research platforms at MBARI
  - 92+ days at sea in 2007
  - Planned Missions (Mapping AUV)
    - Monterey Canyon Repeat Mapping
    - Loihi Volcano
    - Rodriquez Seamount
    - San Andreas fault
    - Dana Point
  - Planned Missions (CTD AUV)
    - Gulper development
    - Bioluminescence studies
    - Thin layers
    - Onboard decision making
    - AOSN



High-Resolution Multibeam and Subbottom Surveys Using the MBARI Mapping AUV

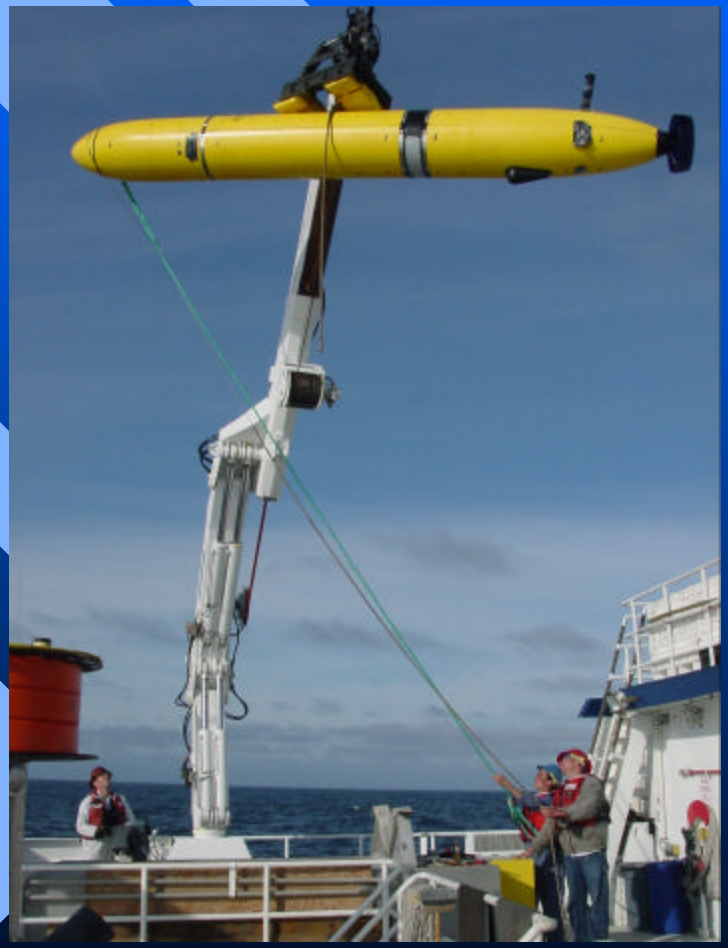


Mapping AUV Specifications

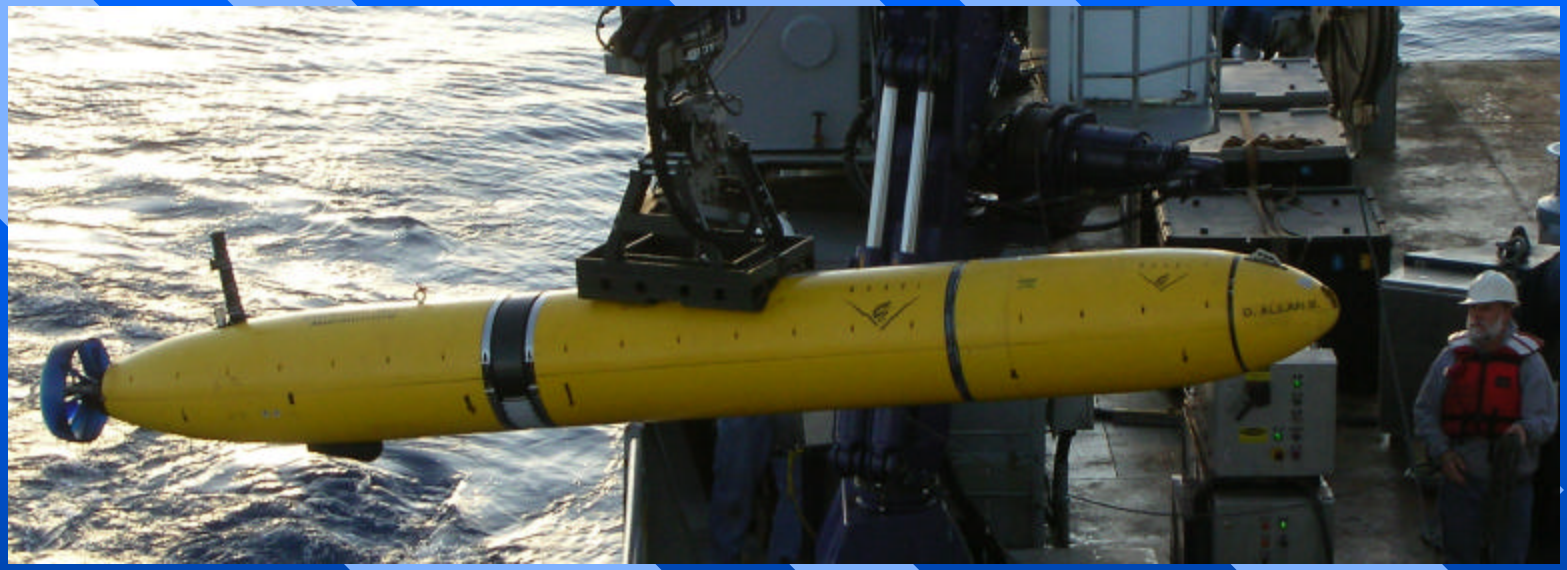
- Dorado-class, modular AUV
- Torpedo shaped ABS plastic structure
- 21-inch diameter, 17.2-ft length
- 6000 m depth rating
- Typical speed 1.5 m/s
- Can be operated from blue-water UNOLS vessels
- Can be carried by ROV Ventana

Mapping AUV Specifications

- Power
  - 5 kWhr Li-ion battery package in 1-atm glass sphere
  - 8.5 hour missions
- Main Vehicle Computer
  - PC-104 running QNX operating system
- Communication
  - Radio modem
  - Benthos acoustic modem
  - Argos and Iridium satellite transmitters



Navigation Systems

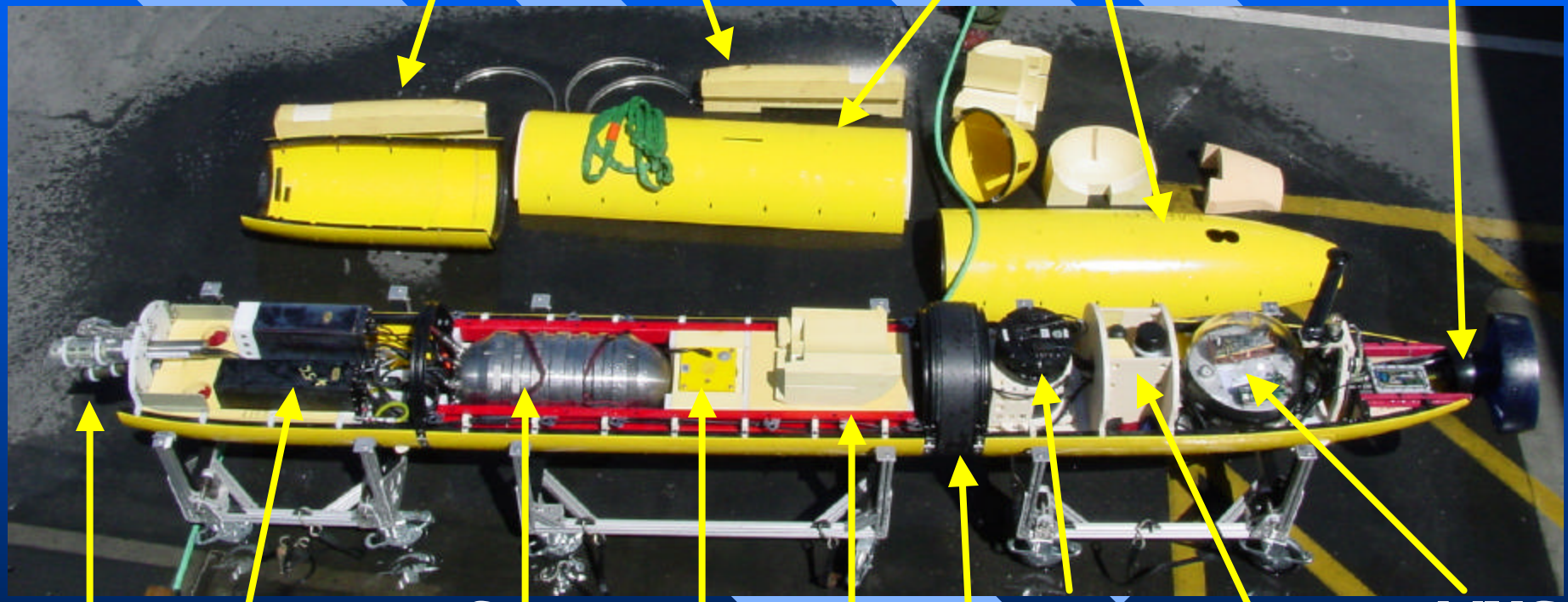


- GPS for surface positioning
- USBL for tracking while submerged
  - Tracking position sent to AUV through acoustic link
- INS and DVL are used during mapping runs
  - Kearfott integrated INS/DVL package
  - Error is 0.05% distance traveled w/DVL bottom-lock

Mapping Payload

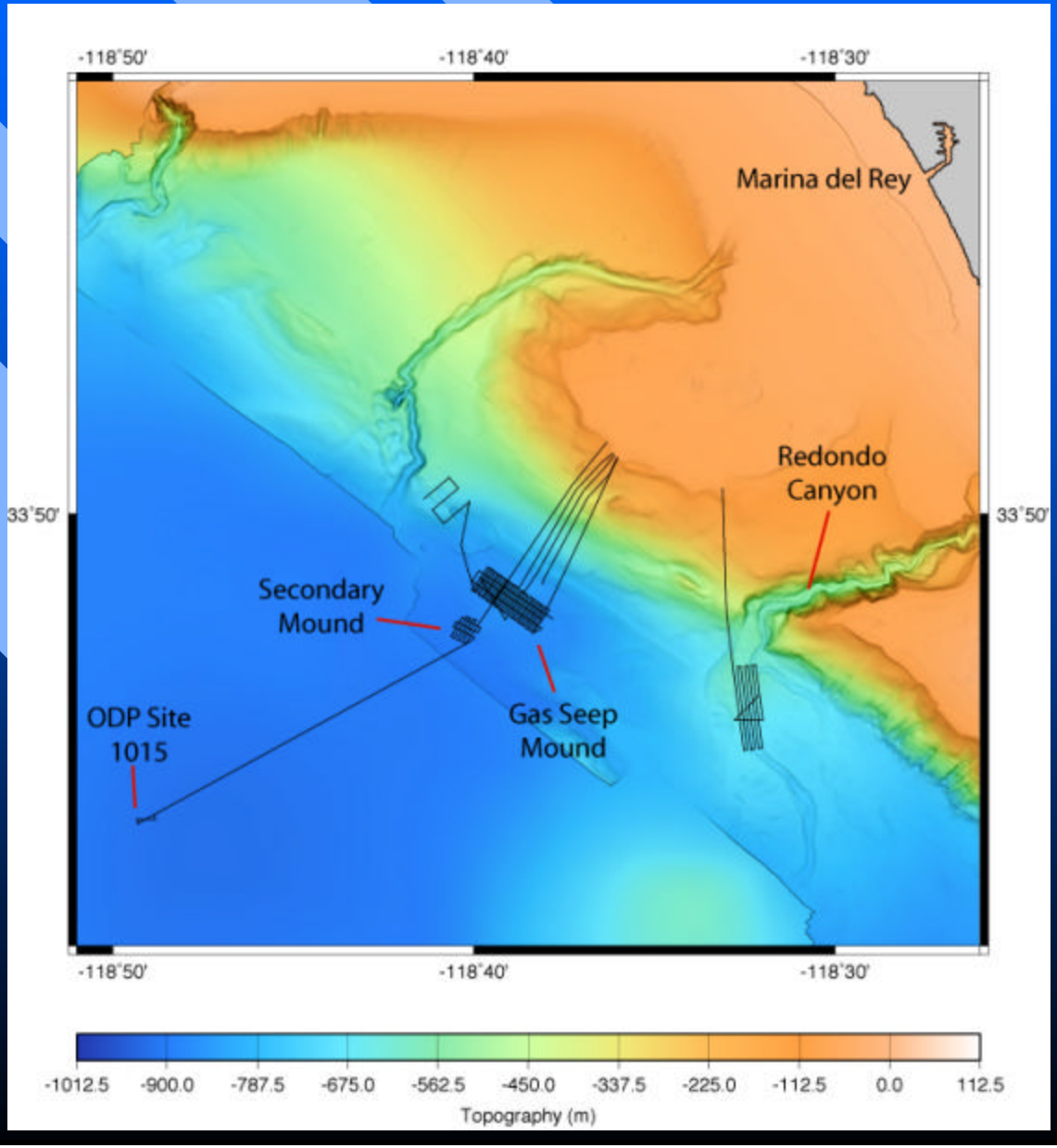
- Reson 7125 200 kHz multibeam sonar
  - 256 1° x 1° beams provide 120-150° swath
- Edgetech chirp sidescan sonar
  - 110 kHz and 410 kHz sonars augment multibeam
- Edgetech subbottom profiling sonar
  - 2-16 kHz chirp to image sub-surface structure
- Sonars coordinated by external computer

Interior of the Mapping AUV



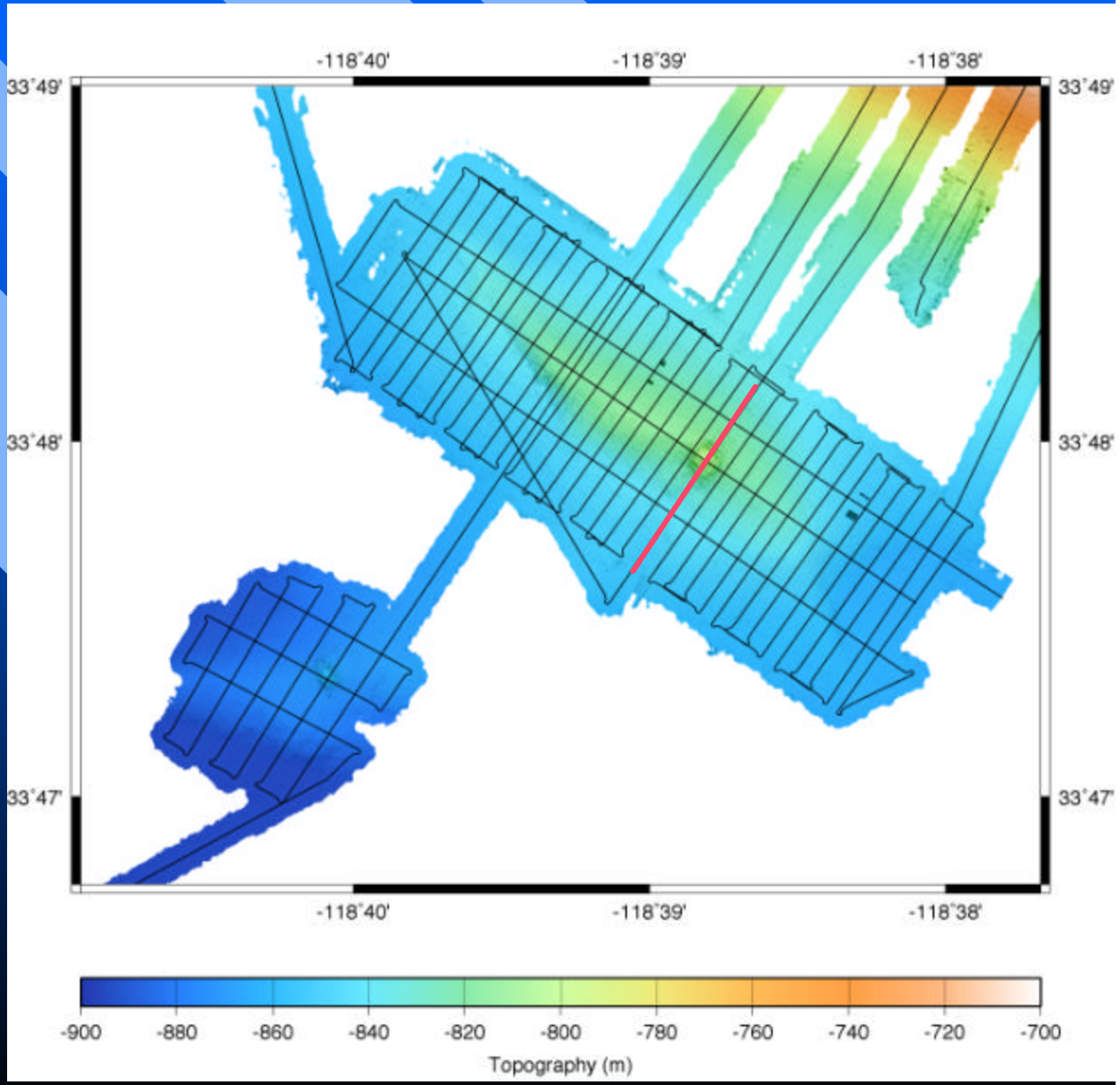
Santa Monica Basin

- From Marina del Rey on *R/V Zephyr*
- Image structure of gas hydrate mounds
- Investigate scour-like features in Redondo Canyon



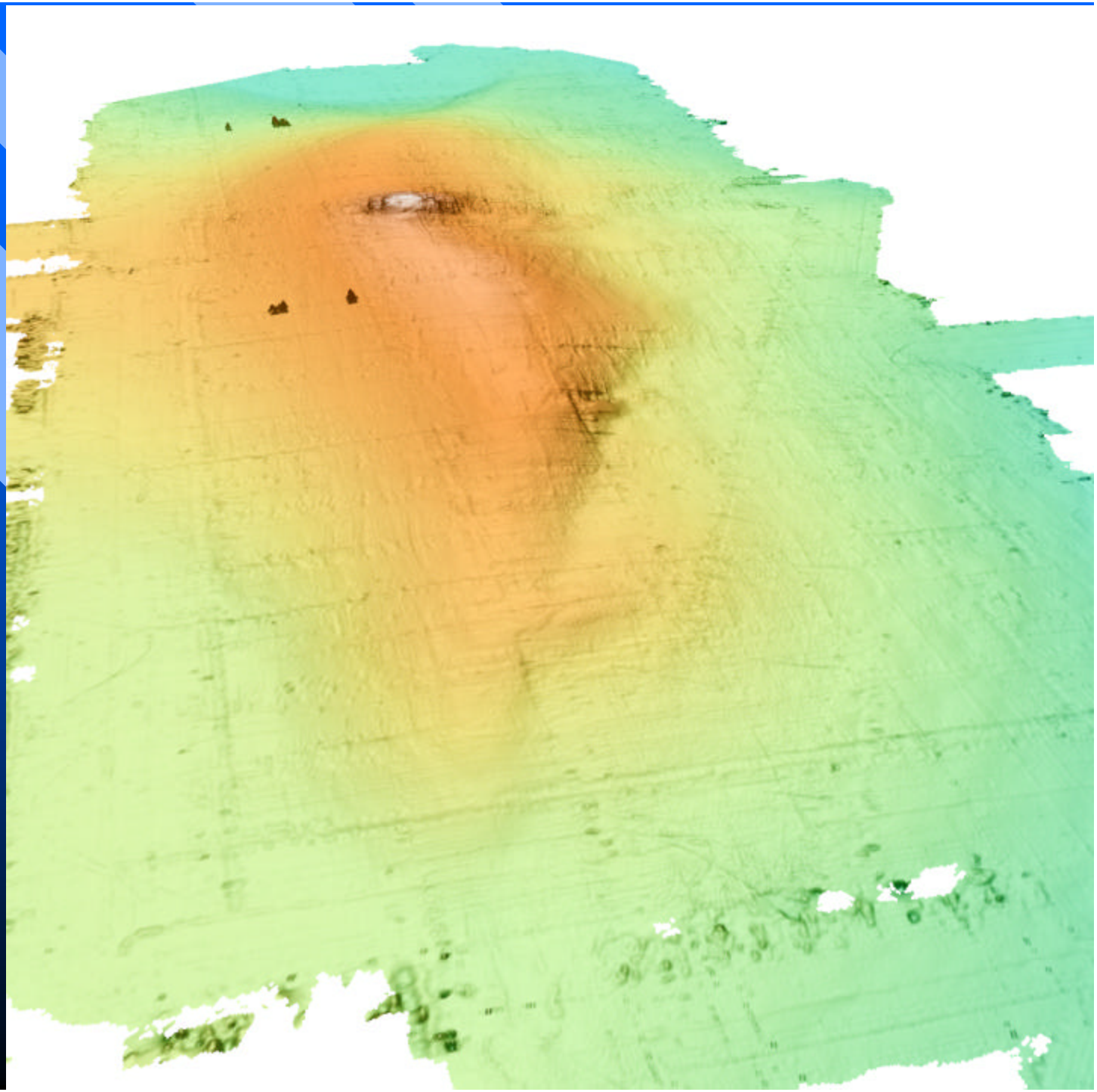
Gas Hydrate Mound Survey

- 100% bathymetry coverage w/2 m lateral resolution
- 100 m spacing over northern mound, 200 m over southern mound
- Subbottom profile track line shown in red



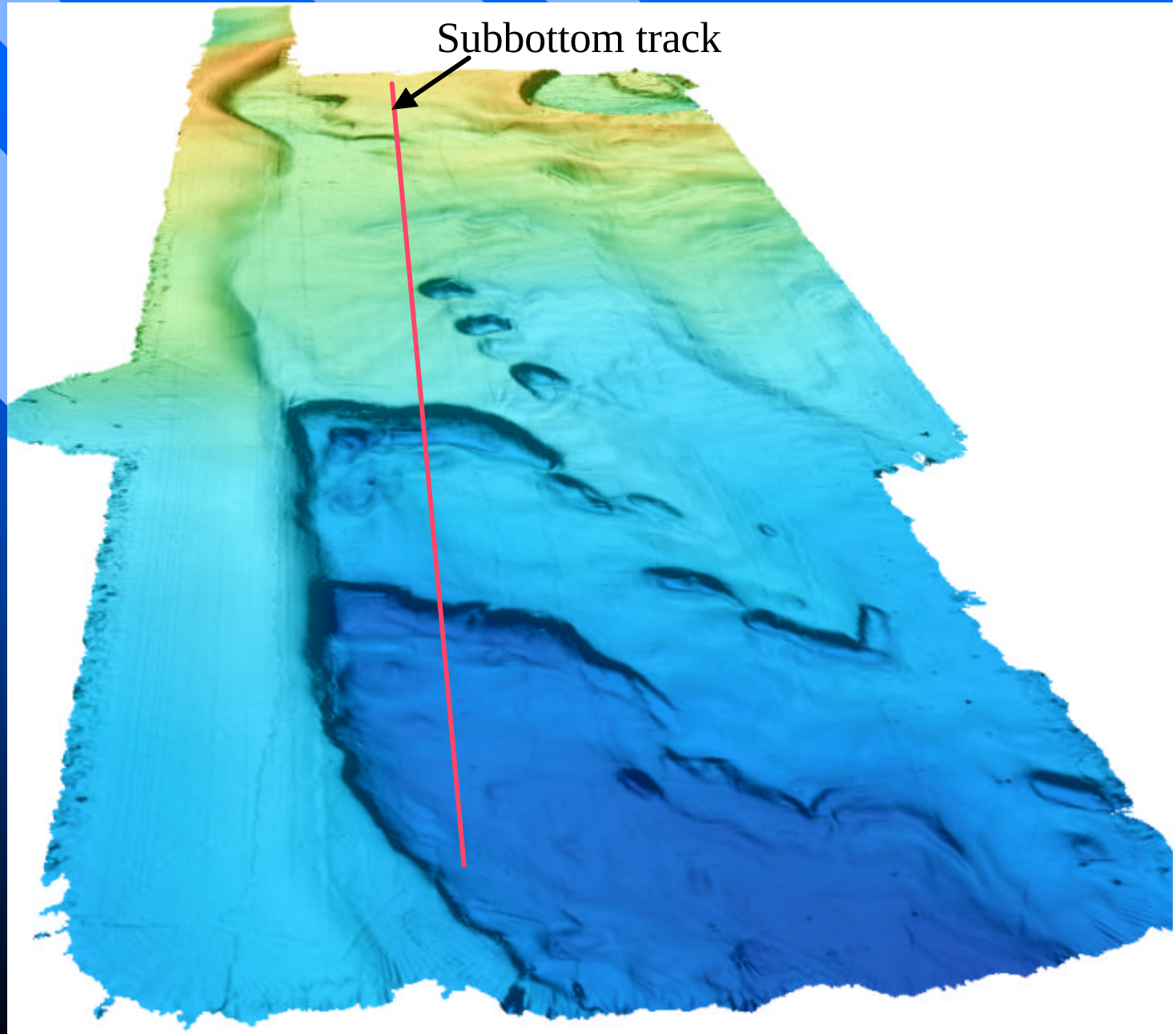
North Mound

- Perspective view of the north mound from the northeast
- Slope shading
- 2 m grid resolution

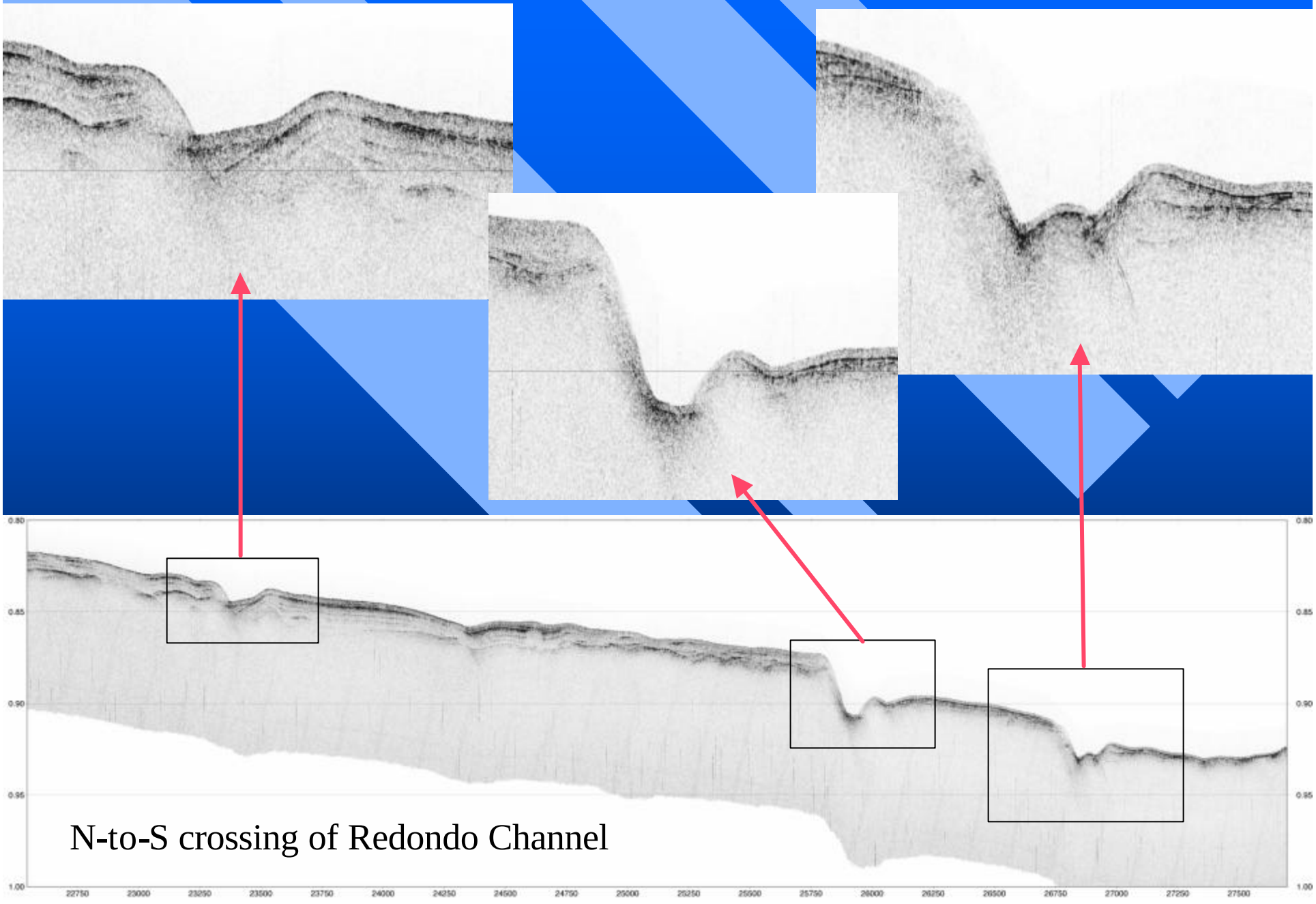


Redondo Channel

- Perspective view of the Redondo Channel survey from the south
- Slope shading
- 2 m grid resolution
- Subbottom data in next slide taken from red line

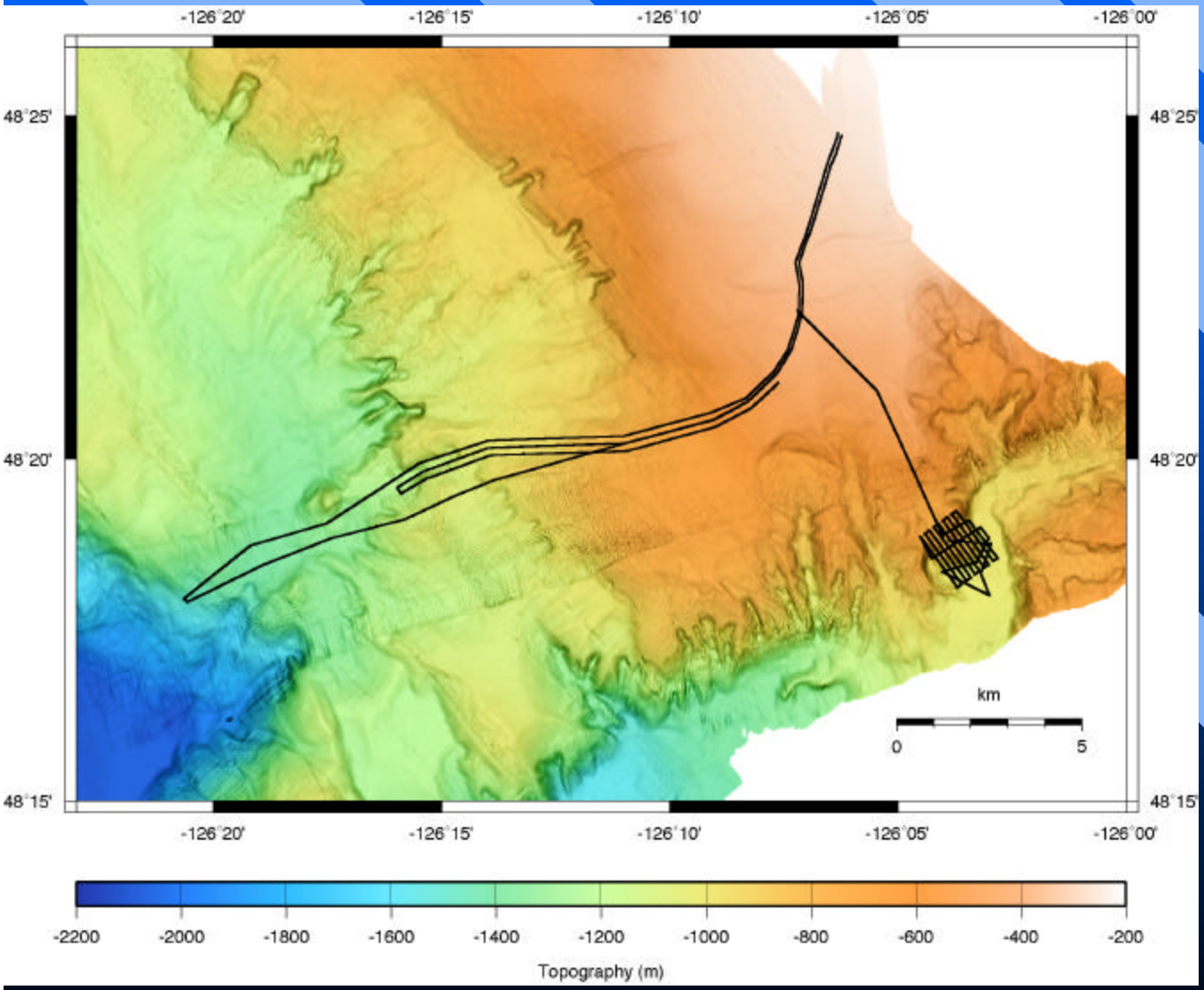


Redondo Channel - Subbottom Profile



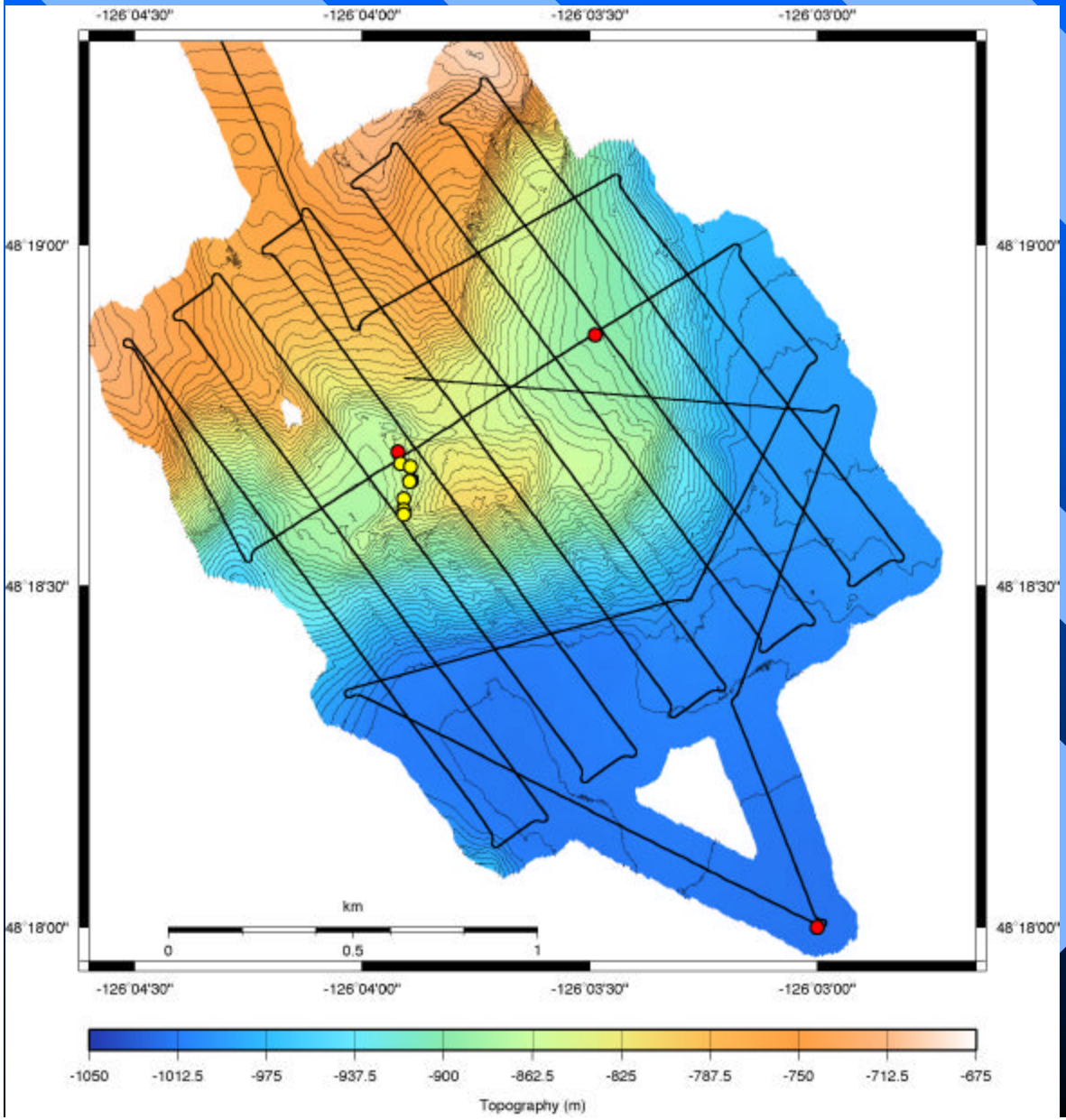
N-to-S crossing of Redondo Channel

Barclay Canyon



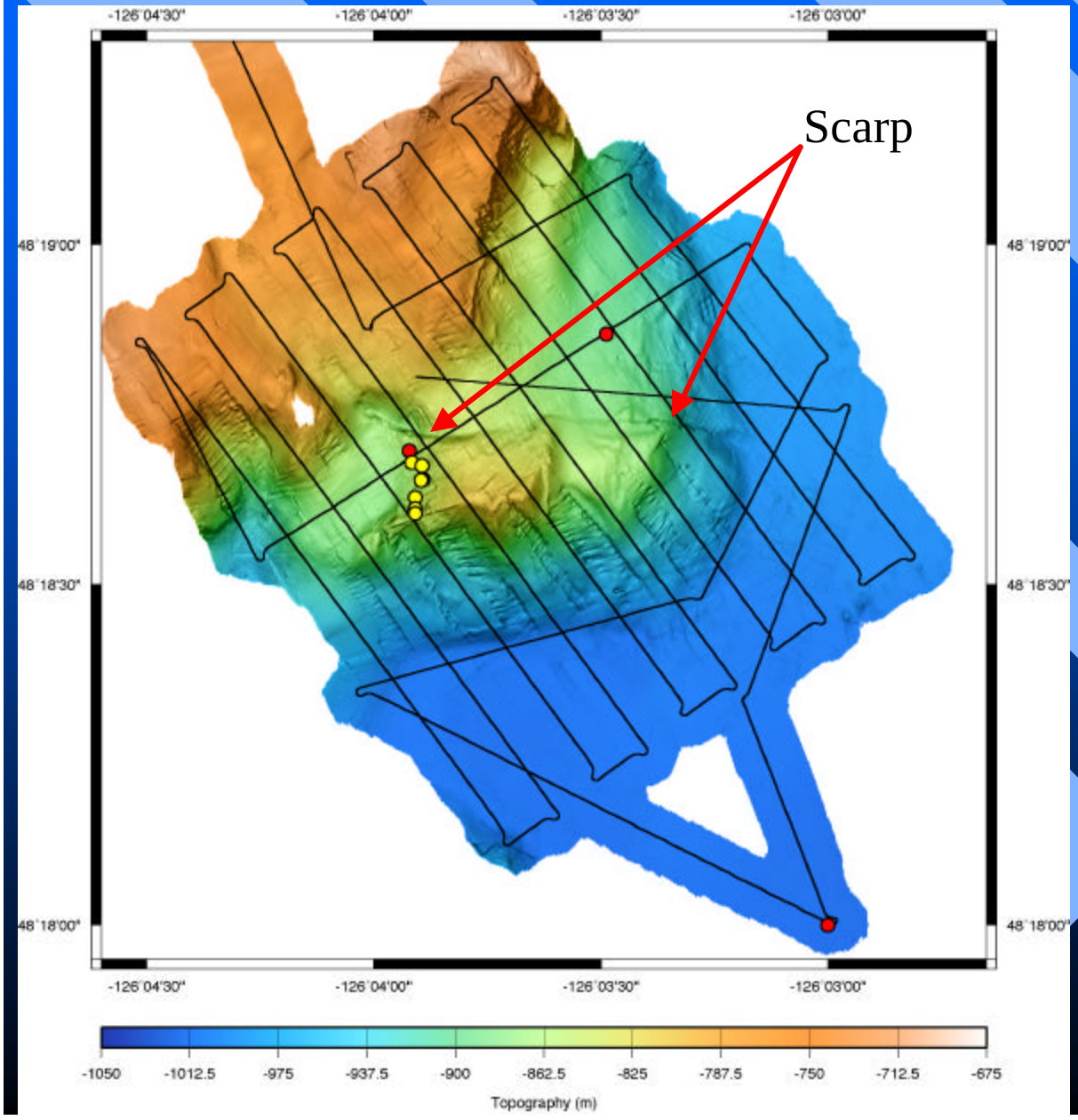
- *R/V Western Flyer*
- Map cable routes for Neptune-Canada
- Map the Barclay Canyon hydrate site (outcrops of massive methane hydrates)

Barclay Canyon Hydrate Survey



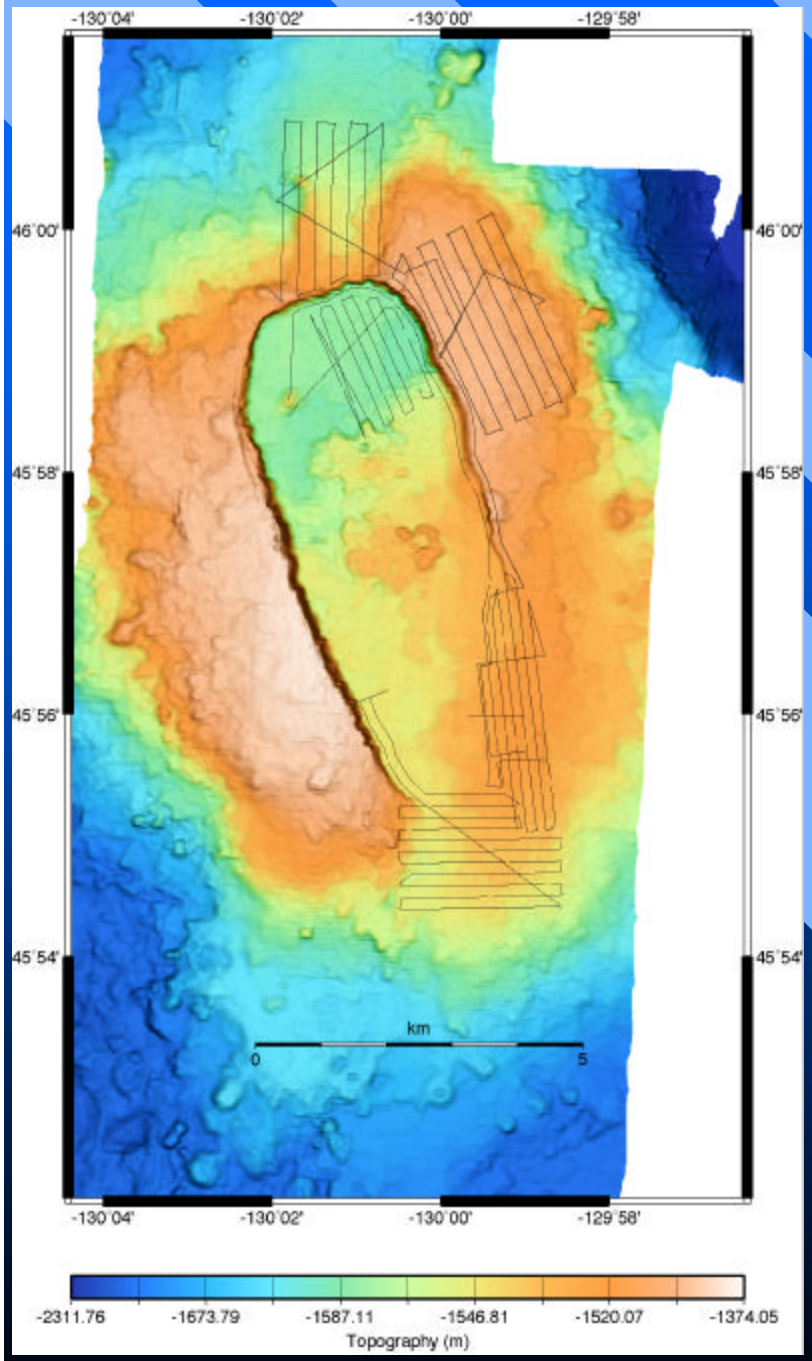
- 50 m altitude
- 150 m spacing
- Hydrate outcrops (yellow dots) perched on plateau 150 m above the canyon floor
- Red dots show planned Neptune-Canada cable nodes.
- 5 m contours

Barclay Canyon Hydrate Survey

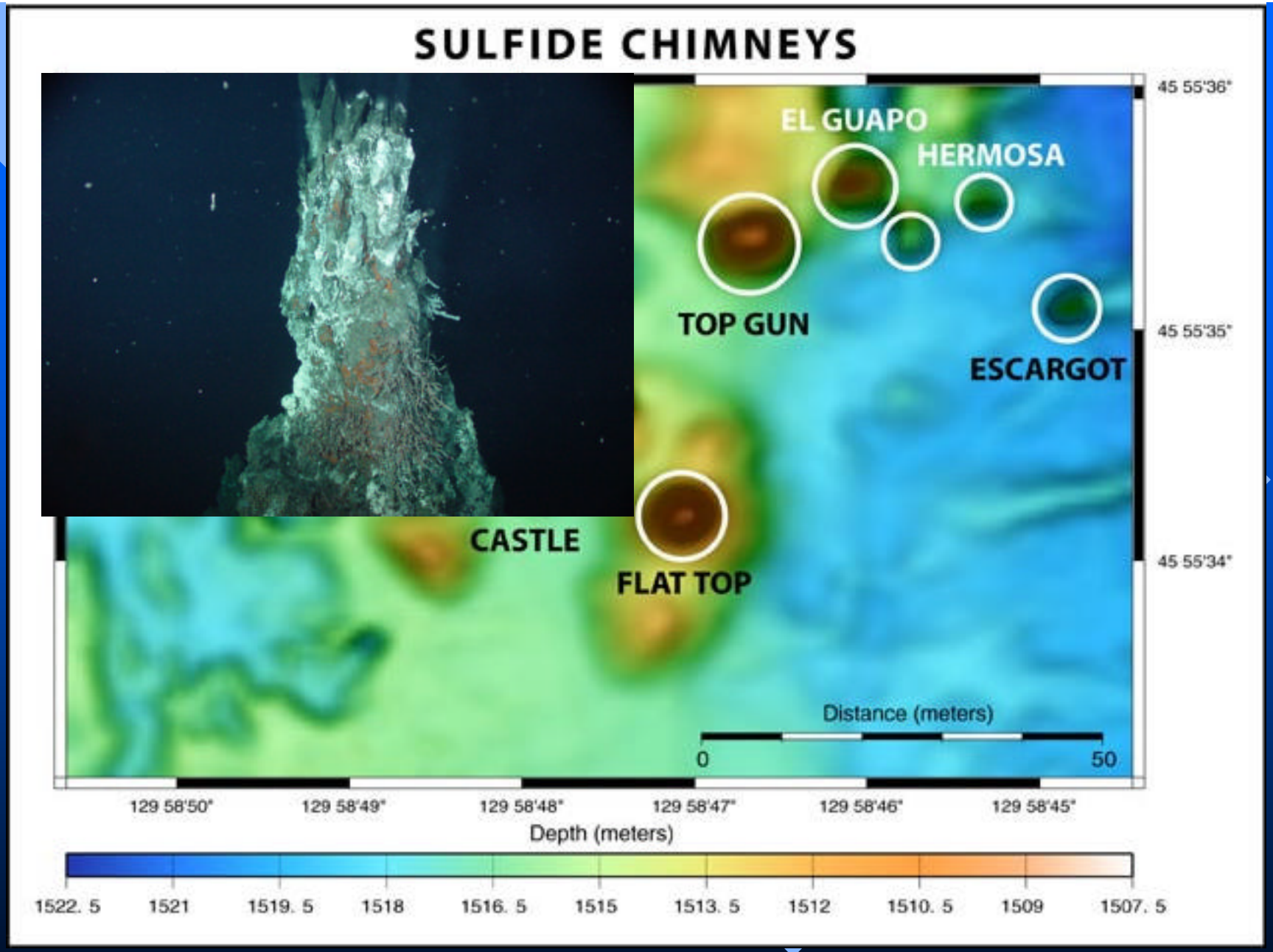


- Slope shading w/1 m lateral resolution reveals a 5-15 m high scarp cutting across the plateau
- Newly discovered feature is apparently an active reverse fault
- Possibly explains the location of the hydrates

Axial Seamount Surveys

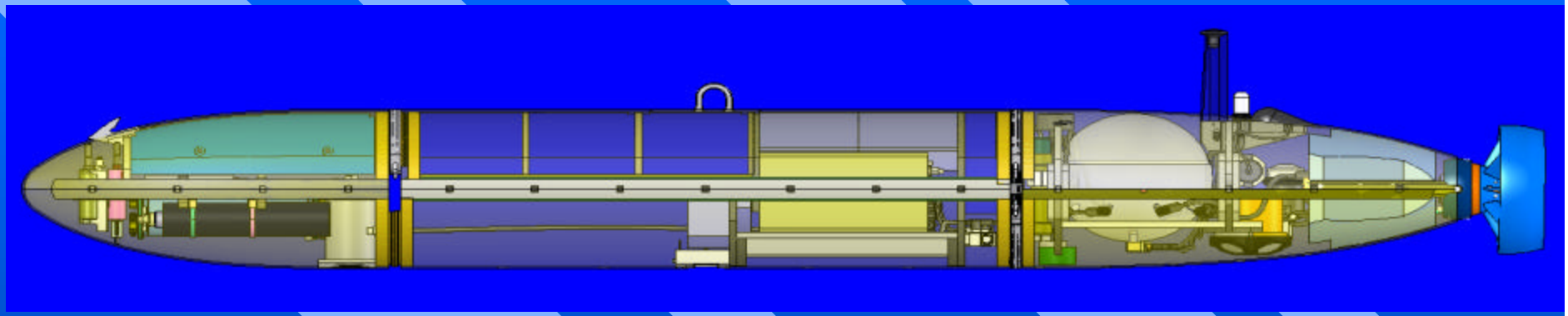


- *R/V Thomas Thompson*
- Map rim and portions of caldera interior
- Image volcanic pillars and known hydrothermal vents
- Unexpected extra features
- Lava channel



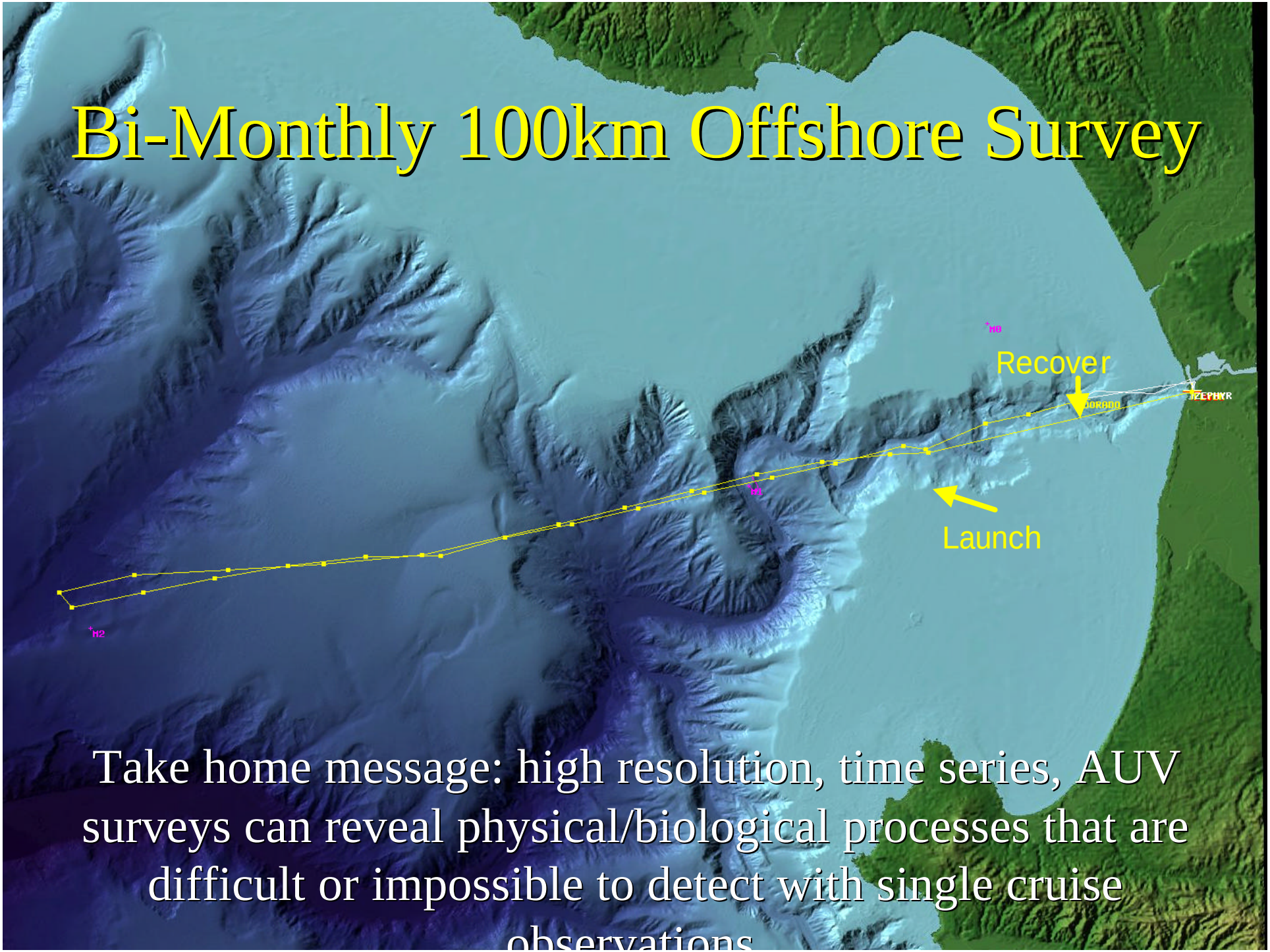
AUV bathymetry showing 7 newly discovered active sulfide chimneys on the east side of caldera. This map guided ROV ROPOS operations.

AUVCTD Vehicle

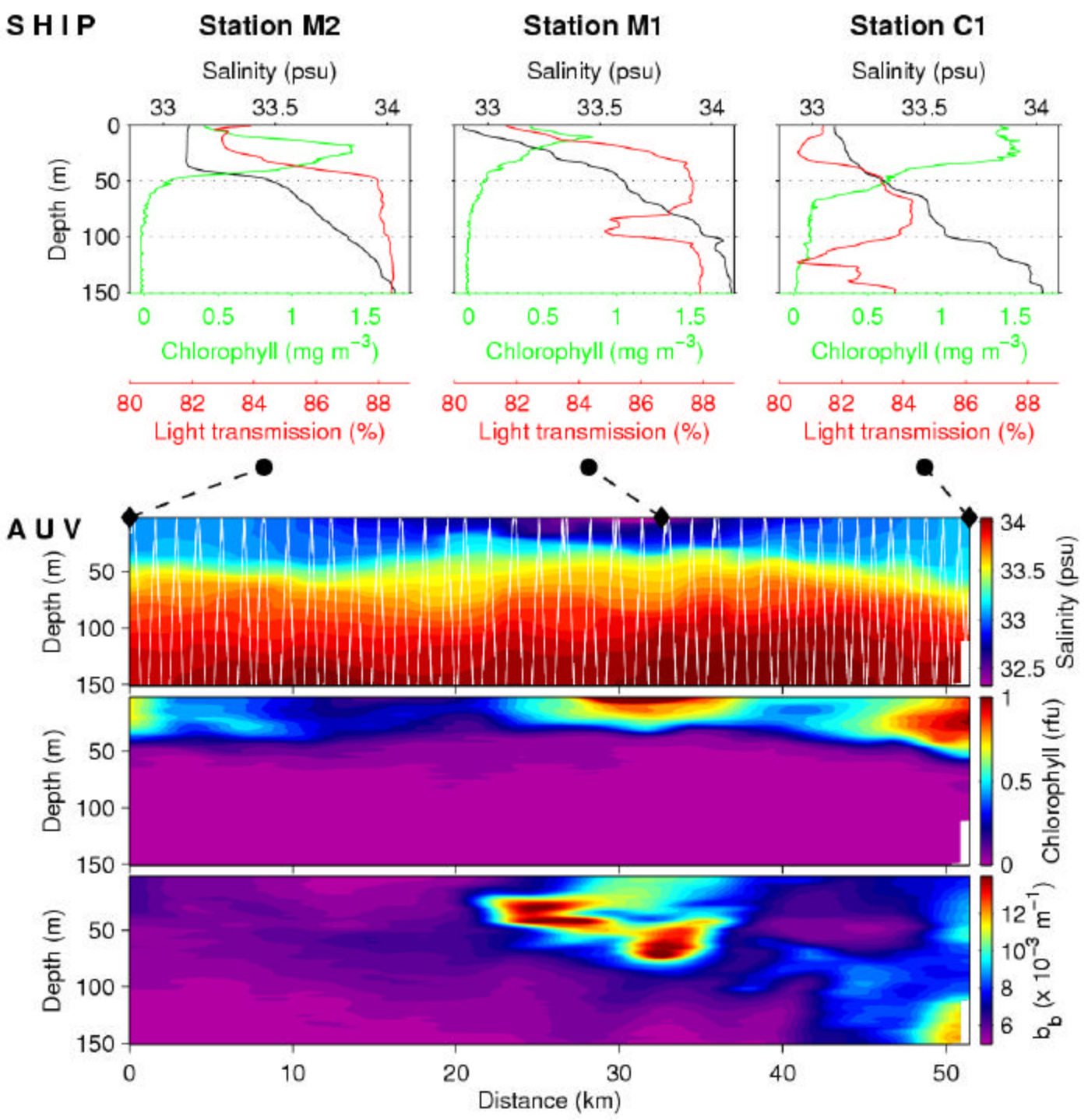


- 4500m Operational Depth (deepest dive 900m)
- 6 kW-Hr/20 Hour Endurance w/ 5 hr recharge
- Core Instruments (Nose)
  - 2 x SBE3/SBE4/SBE5 Pumped CT
  - 1 x SBE43 DO, 1x MBARI ISUS
  - Hobilabs HS2 Fluorescence/Backscatter
  - Networking & Data Acquisition Electronics
- Midbody
  - Large reserve volume/buoyancy for additional instruments
  - Current Payload
    - » UCSB Bathyphotometer, Sequoia Scientific LISST-100

Bi-Monthly 100km Offshore Survey



Take home message: high resolution, time series, AUV surveys can reveal physical/biological processes that are difficult or impossible to detect with single cruise observations


SHIP
Station M2
Station M1
Station C1
Salinity (psu)
33
33.5
34
Depth (m)
0
50
100
150
0
0.5
1
1.5
Chlorophyll (mg m^{-3})
80
82
84
86
88
Light transmission (%)
AUV
Depth (m)
Salinity (psu)
32.5
Chlorophyll (rfu)
b_b (x 10^{-3} m^{-1})
12
10
8
6
0
10
20
30
40
50
Distance (km)

Conclusions

- AUVs are becoming *preferred* tools for certain types of ocean science.
  - High quality systems, subsystems, and instruments now commercially available
  - Gathering high-quality physical/biological/chemical datasets is a complex integration effort
  - Most efficient way to map the deep ocean sea floor
- Major limitations
  - Energy – need higher performance low-rate systems, or better energy scavenging technology
  - Autonomy
    - » current AUVs are limited in ability to react to evolving ocean processes (no deliberative planning/execution capacity in most systems)
    - » Multi-vehicle survey is more energetically efficient, but requires high-level coordination & good ocean modeling to exploit