Università di Trieste
Corso di Laurea Magistrale in Esplorazione Geologica

Anno accademico 2021 - 2022

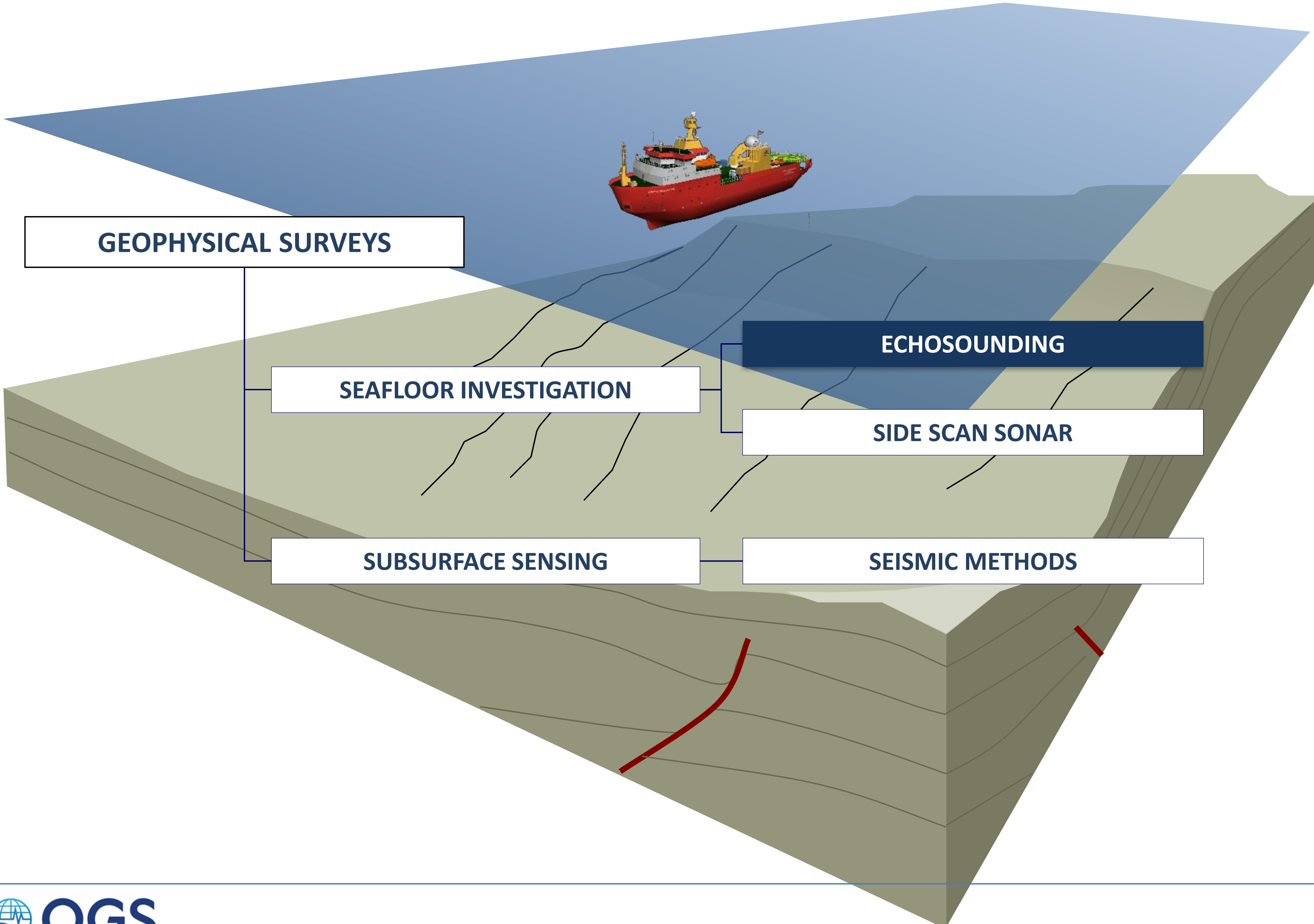
Geologia Marina

Parte II

Modulo titolo: Metodi acustici

Docente
Fabrizio Zgur

MULTIBEAM ECHOSOUNDER OVERVIEW



IT IS USED FOR

Morphobatymetry surveys aim at mapping the seafloor with large areal coverage. The result is a 3D **D**igital **T**errain **M**odel (**DTM**) mad up of a grid of cells whose size depends on the resolution.

HOW IT WORKS

Multibeam echosounders use transducers that produce a fan of pre-formed beams. The fan can vary from 45° to up to 150° depending on the unit. The returns from these beams can be processed with GPS position information and ship motion compensation to give bathymetry as well as the backscatter information that is obtained by conventional sidescans. A single ship's track can map a swath between 2 and 7.4 times water depth, depending on the system. Beam widths fore and aft vary between 1.5º and 4.5º depending on the system.

MULTIBEAM ECHOSOUNDER USES AND OBJECTIVES

ENVIRONMENT AND SOCIETY

Navigation charts

- Bathymetric surveys
- Pre / Post dredge surveys
- Breakwaters, piers, bridges
- Harbor and rivers surveys
- Flood damage assessment
- Underwater inspections

RESEARCH

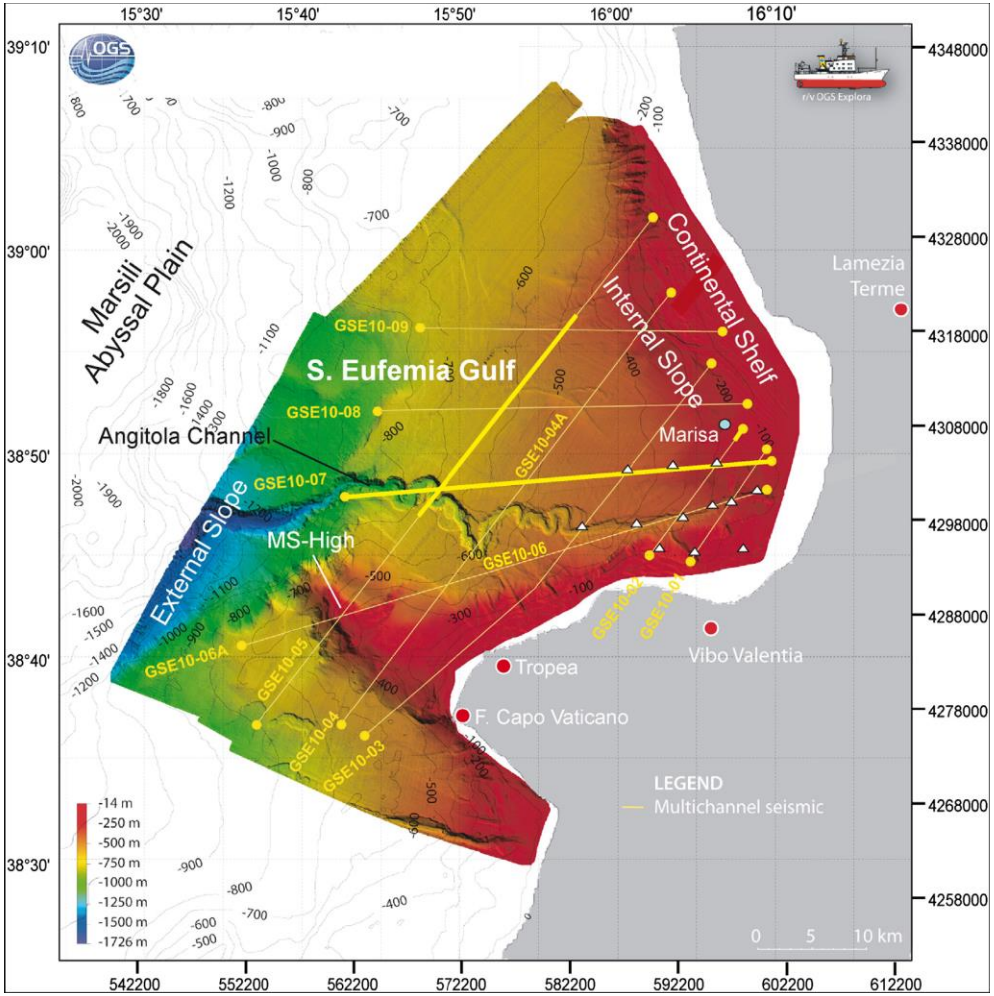
Marine Geology and Biology

- Geomorphology
- Geo hazard (slope stability)
- Fluid escapes (water column)
- Neotectonic related surface expressions
- Study of benthic habitats

INDUSTRY

Foundation studies for offshore infrastructures

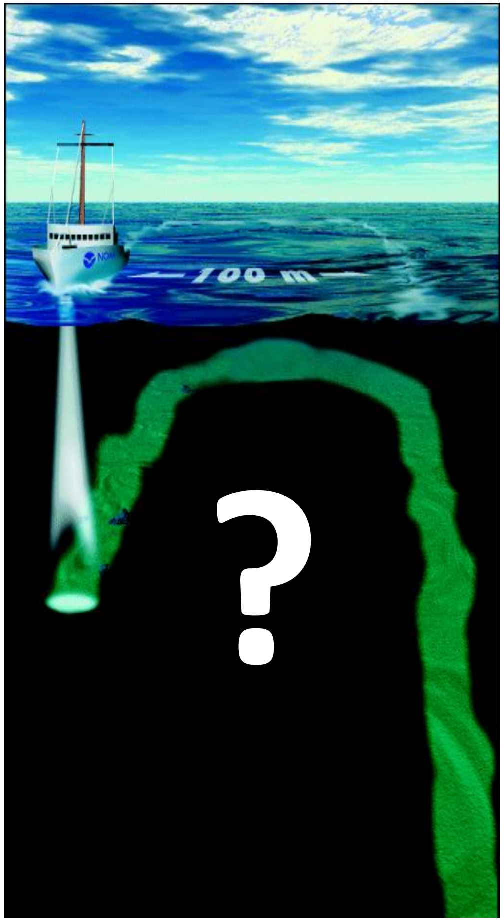
- Cable surveys
- Well site surveys

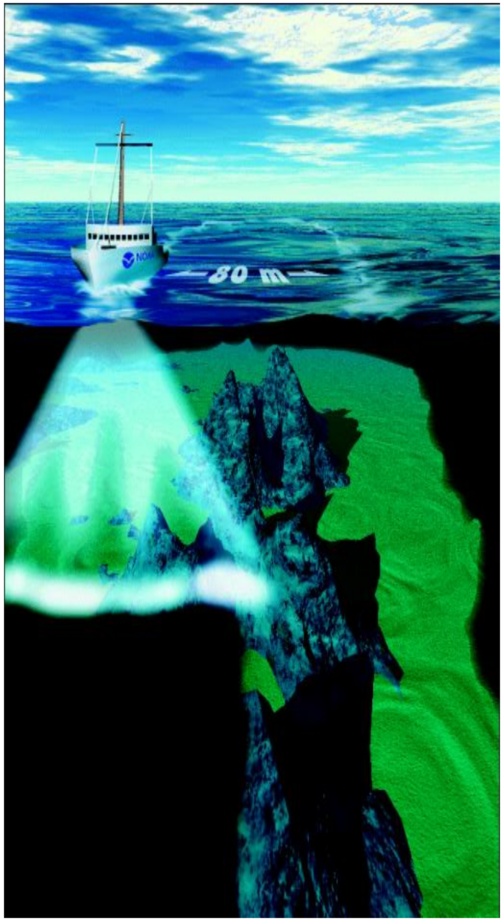


Loreto et al., 2013.Approaching the seismogenic source of the Calabria 8 September 1905 earthquake: New geophysical, geological and biochemical data from the S. Eufemia Gulf (S Italy). Marine Geology 343 (2013) 62–75.

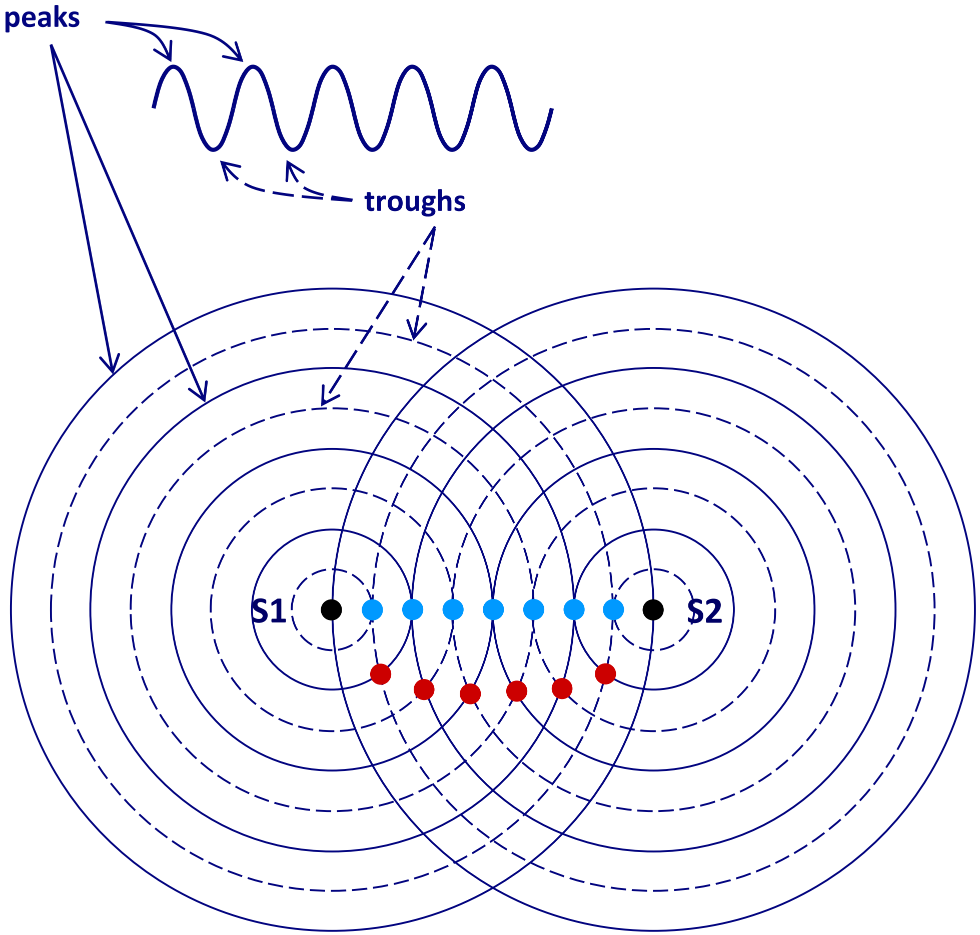
ADVANTAGES OF MBES COMPARED TO SBES

- Wide profile of depths in a line perpendicular
  to the ship's direction of travel.
- Total ensonification of the bottom possible
- Wider coverage in deeper water
- Backscatter imagery for bottom analyses
- Water column recorded

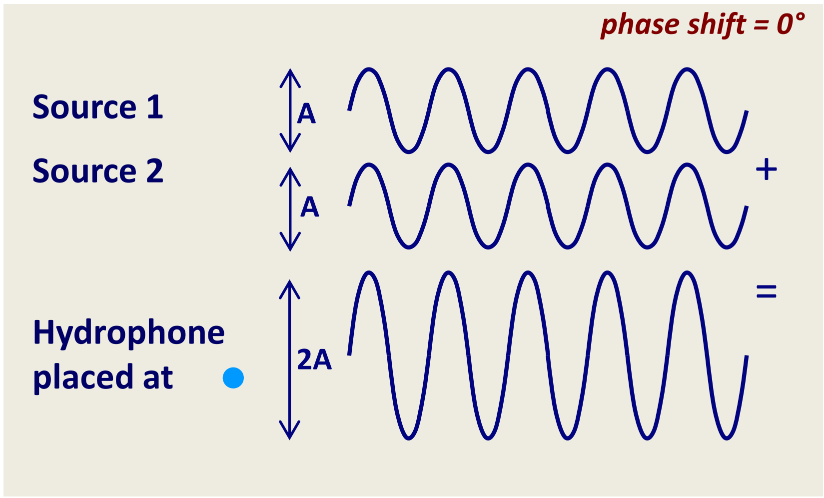




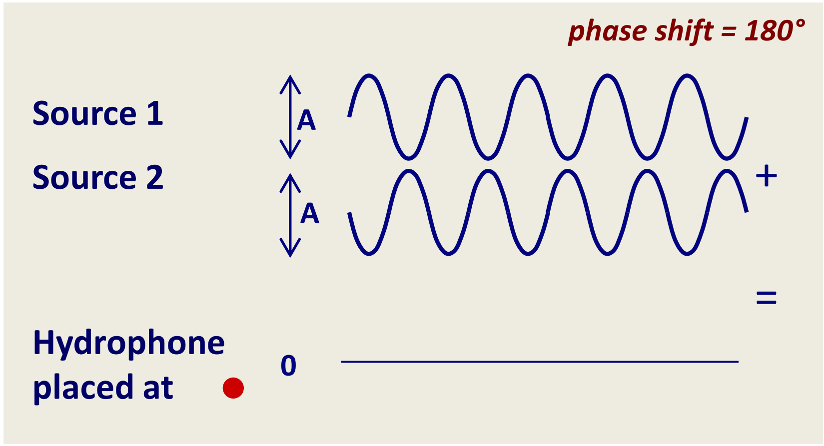
MULTIBEAM ECHOSOUNDER BEAMFORMING



● CONSTRUCTIVE INTERFERENCE



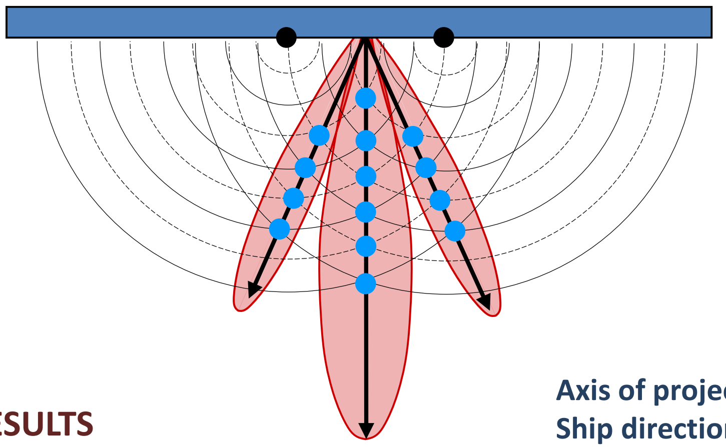
● DESTRUCTIVE INTERFERENCE



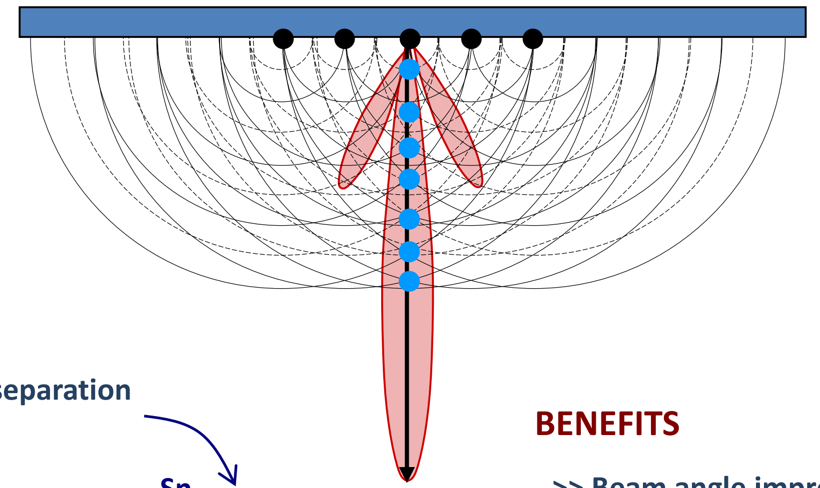
PROJECTORS AND RECEIVERS ARRAYS

FLAT ARRAYS

Two sources activated simultaneosly



Adding more staves

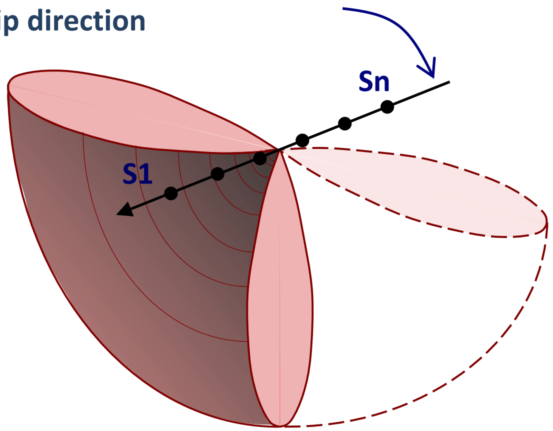


RESULTS

>> Directivity (90°)

>> Sidelobes
(undesirable side effect)

Axis of projector separation
Ship direction



BENEFITS

>> Beam angle improvement

>> Reduced sidelobes

>> Improved directivity

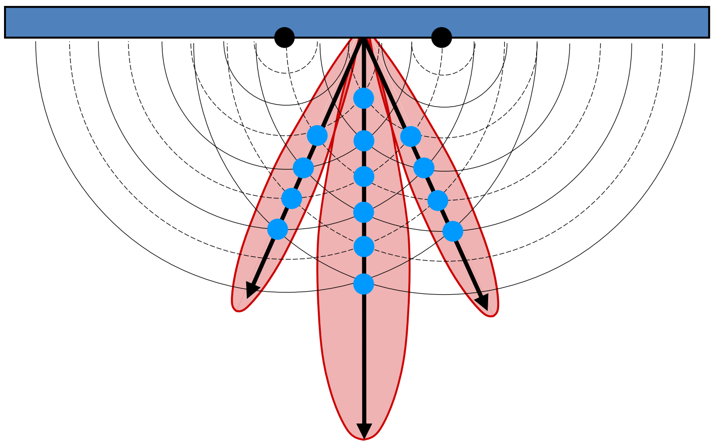
>> Narrower beams > HR

BEAMFORMING APPLIES TO BOTH PROJECTOR AND RECEIVERS ARRAYS

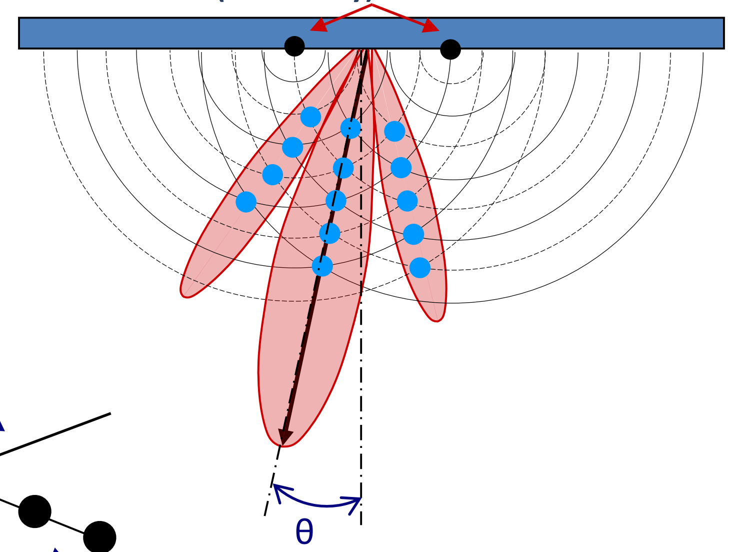
BEAM STEERING: RECEIVERS ARRAYS

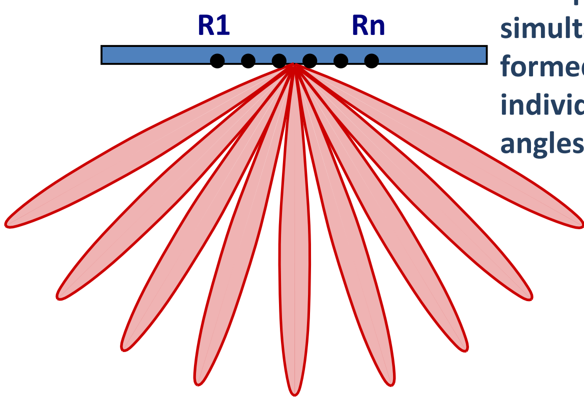
FLAT ARRAYS

Two sources activated simultaneosly

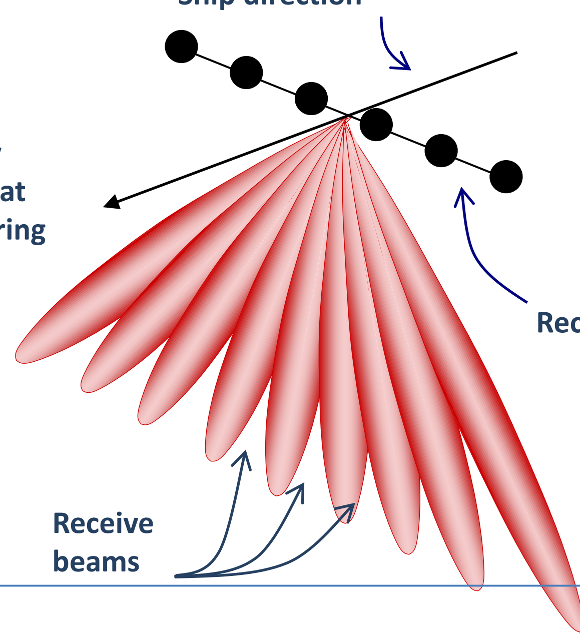


Phase shift (time delay) between staves

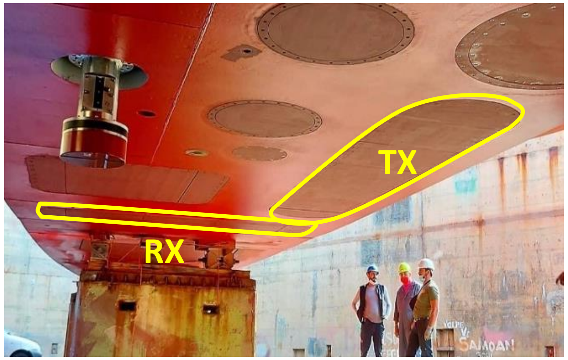


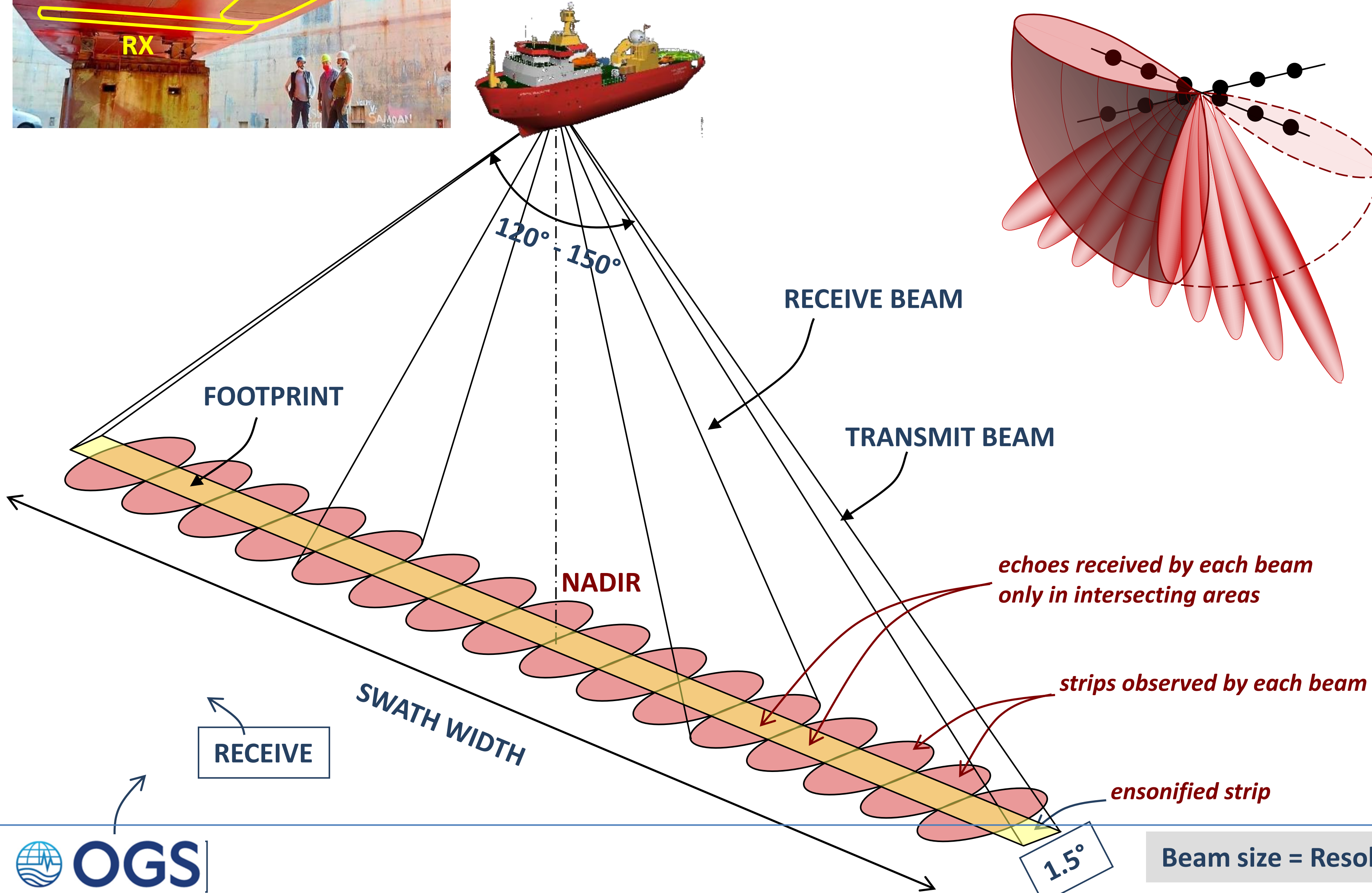


Multiple simultaneously formed beams at individual steering angles



MULTIBEAM ECHOSOUNDER THE T CONFIGURATION

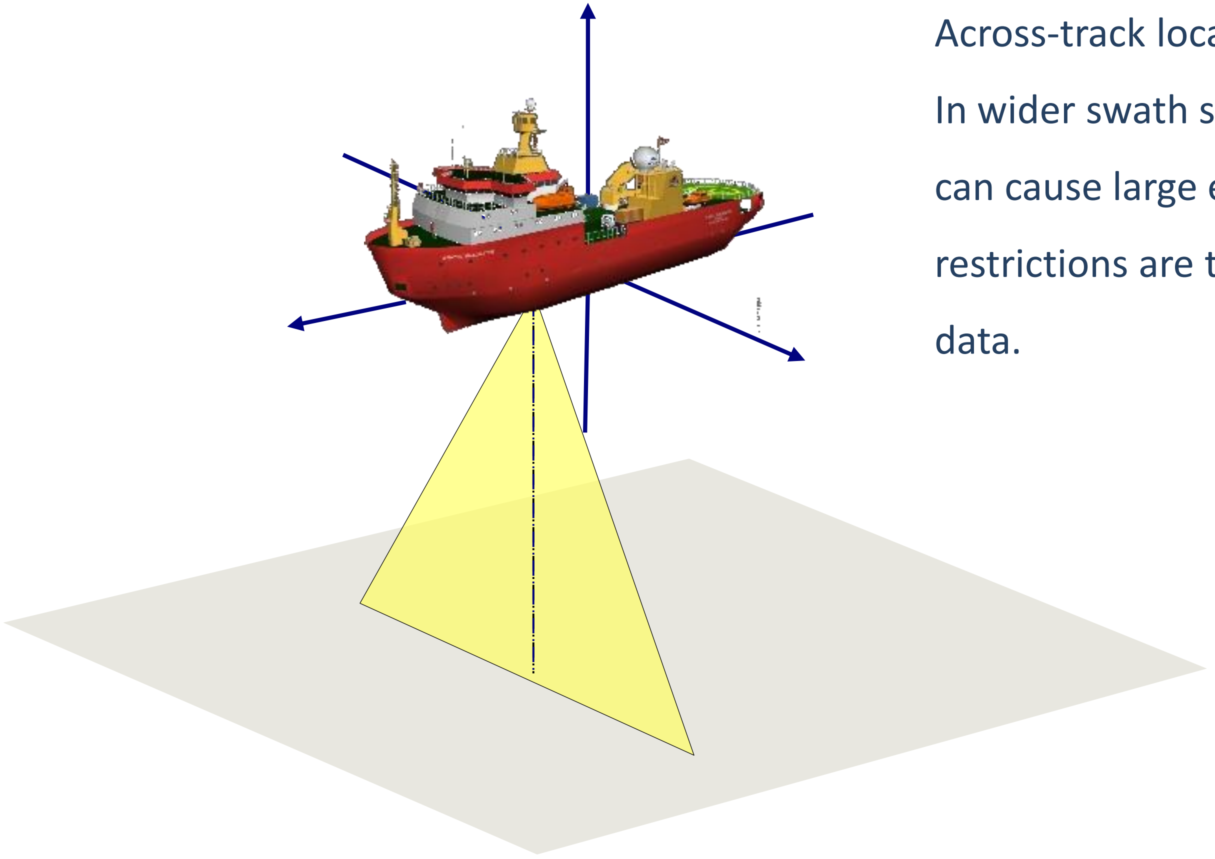




Beam size = Resolution

OGS

DYNAMIC CORRECTIONS



Horizontal positioning accuracy is dependent upon the ability of the system to compensate for pointing errors caused by vessel roll, pitch, and yaw.

Across-track location of each bottom point is critical. In wider swath systems, even a small degree of roll can cause large errors in the outer beams; thus restrictions are typically placed on use of outer beam data.

- **Roll**
- **Pitch**
- **Yaw**
- **Heave**
- **Positioning**

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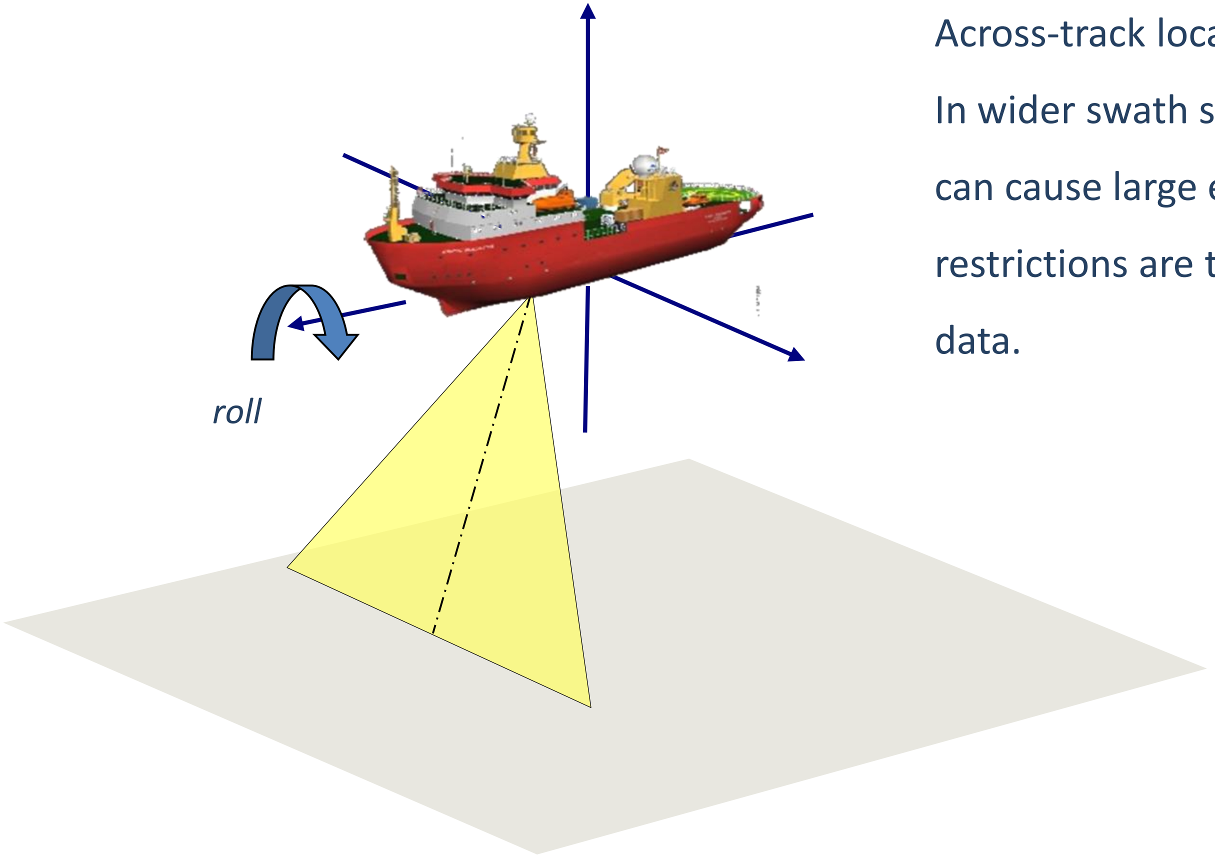

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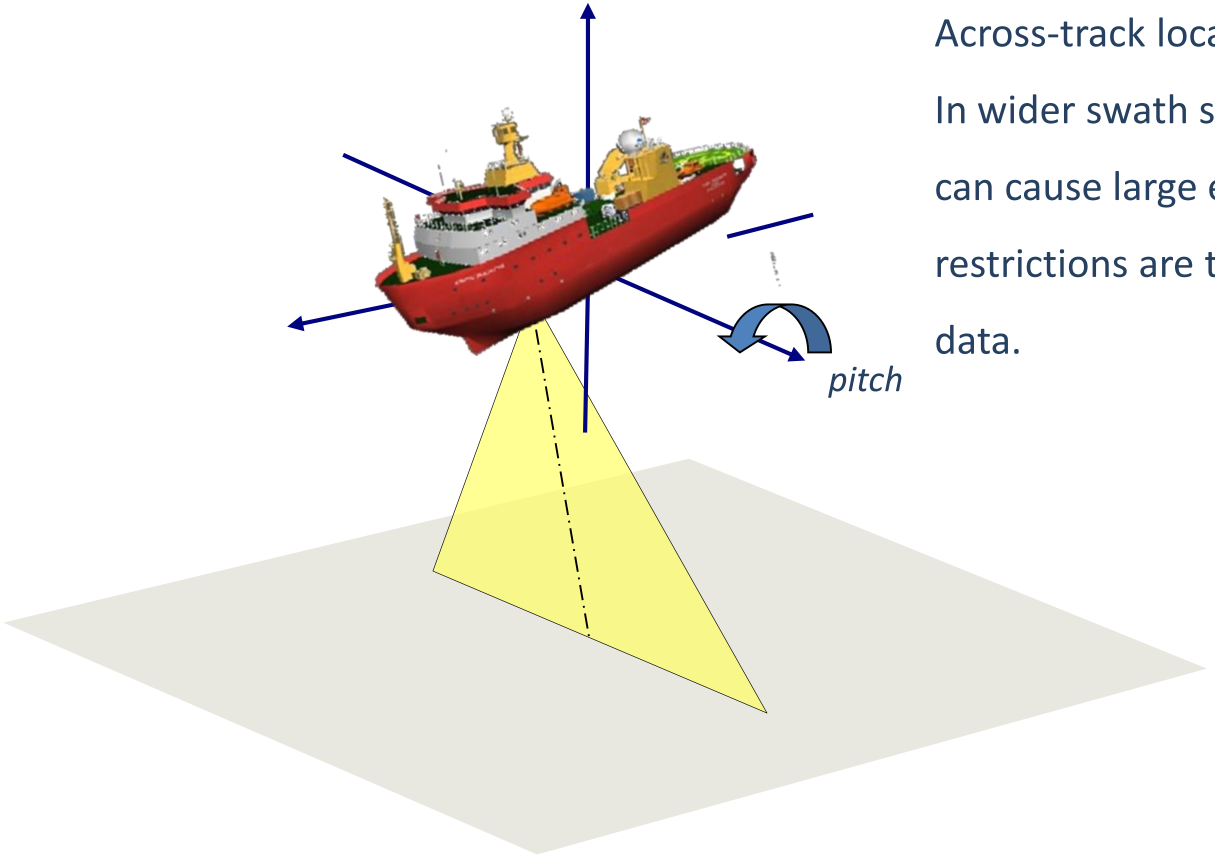

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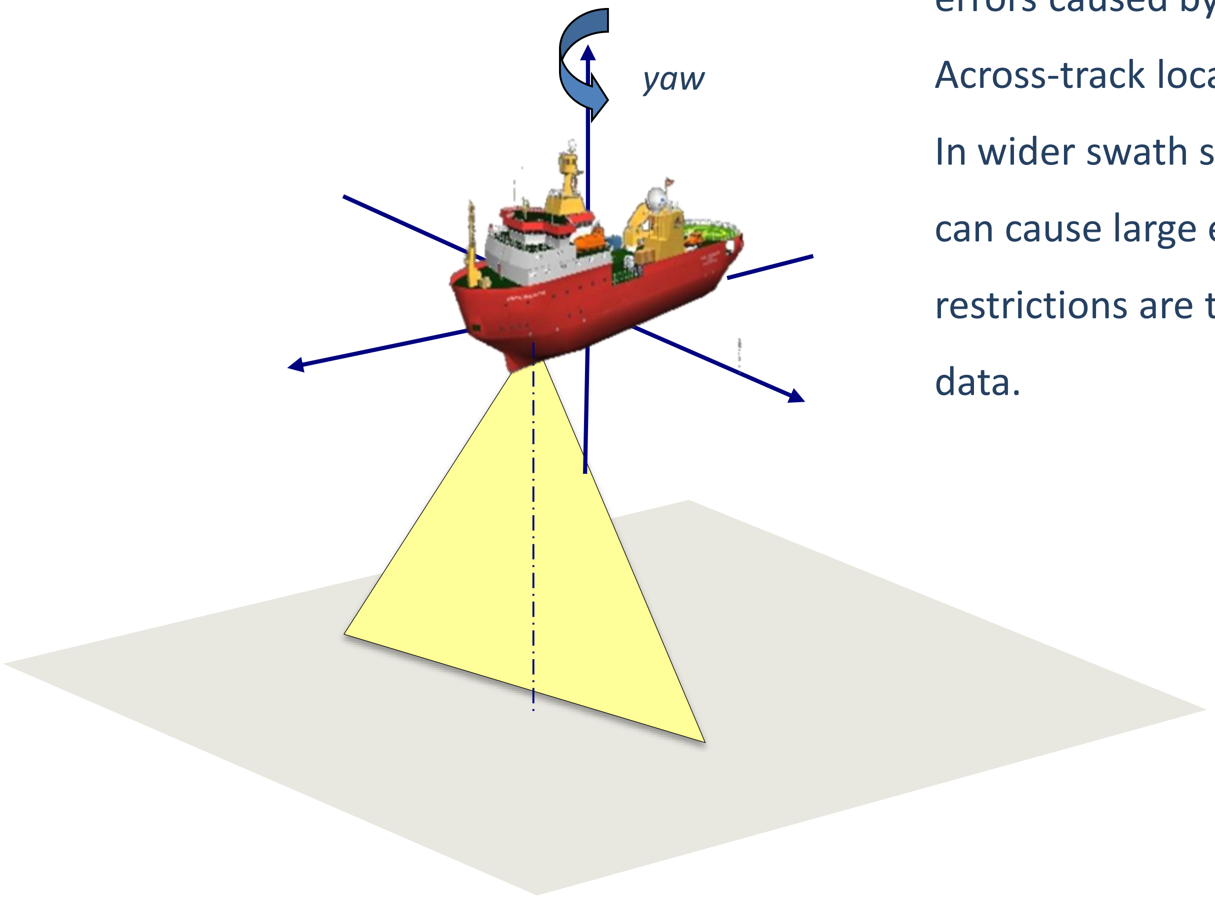

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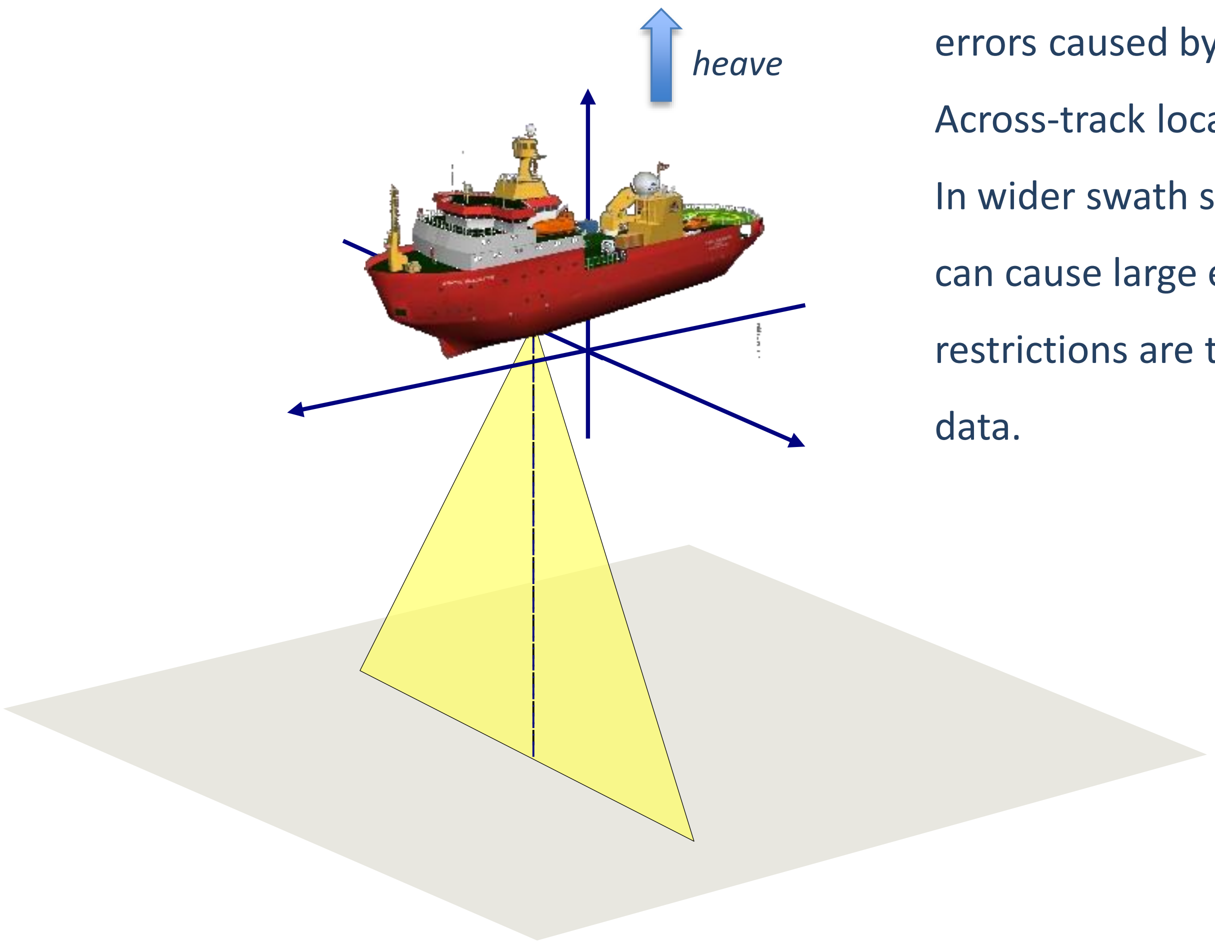

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SOUND VELOCITY

Sound velocity can vary considerably from point to point in the ocean

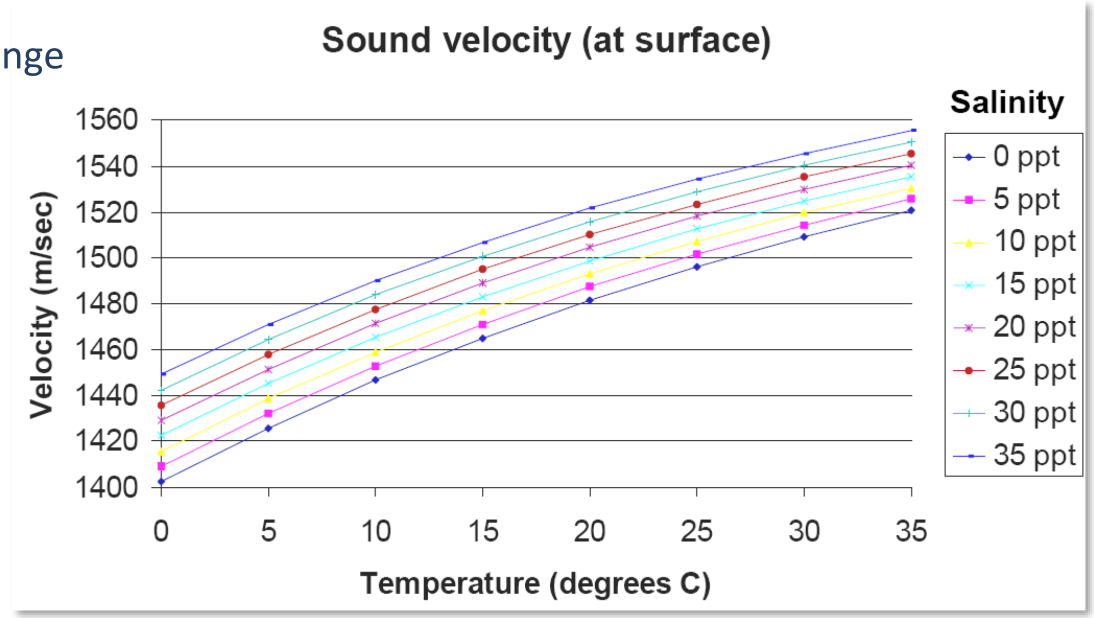
Vs is dependent on three main factors:

SALINITY

- Ranges from 32 - 38ppt (parts per thousand)
- A change in salinity causes a density variation which changes the sound propagation velocity
- Varies geographically (Baltic 7ppt, Dead Sea 300 ppt)
- Change of 1ppt = approx 1.3m/s velocity change

TEMPERATURE

- Temperature usually decreases with depth
- A change of 1ºC will change Vs by 3m/s
- Above 1000m water depth, temperature is the predominant influence on underwater sound velocity



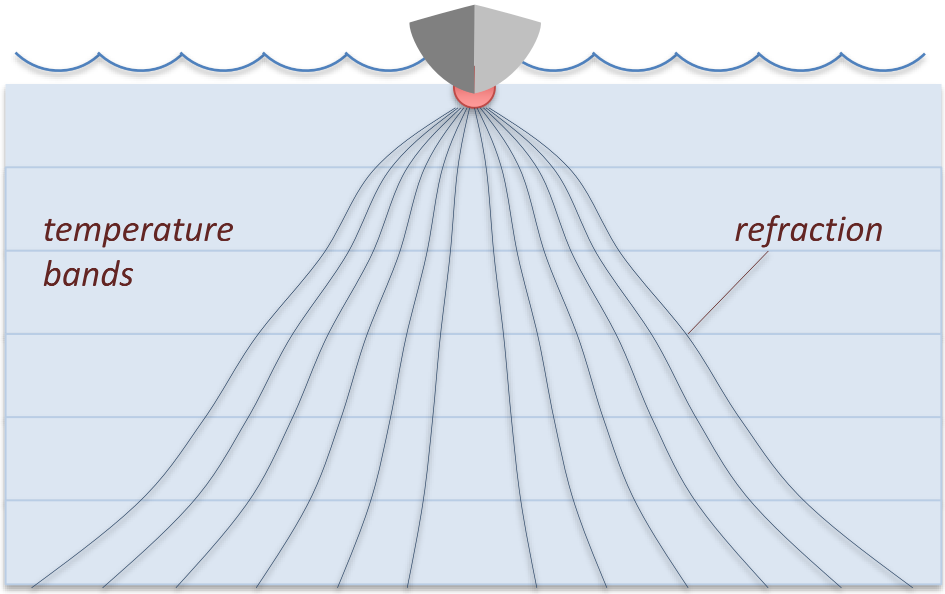
RAY BENDING

• MBES are dependent upon the two-way travel time of sound (i.e. sound velocity) in water

• The value for sound velocity in oceanic water is subject to changes associated with differences in density (primarily a function of temperature)

• Depending on the angle of beam travel, bending (refraction) can cause deviations in the travel path as a result of changes in density

• Generally, the greater the beam direction angle, the more likely the chances are for refraction

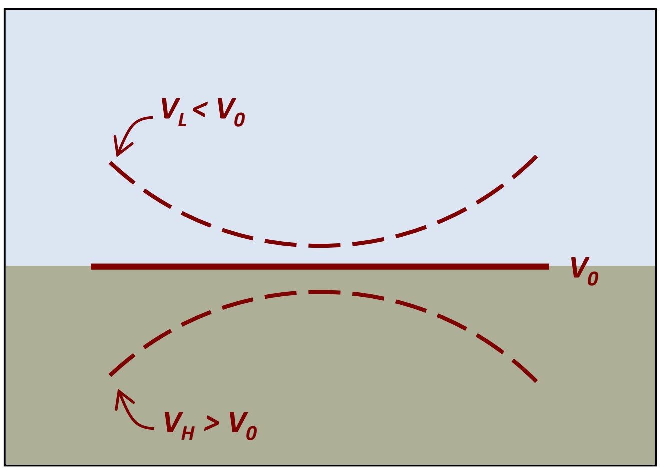


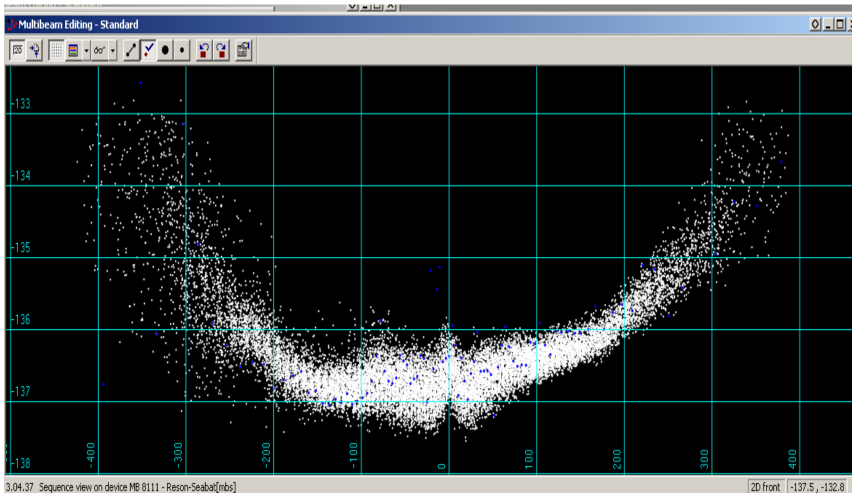
VELOCITY ERRORS

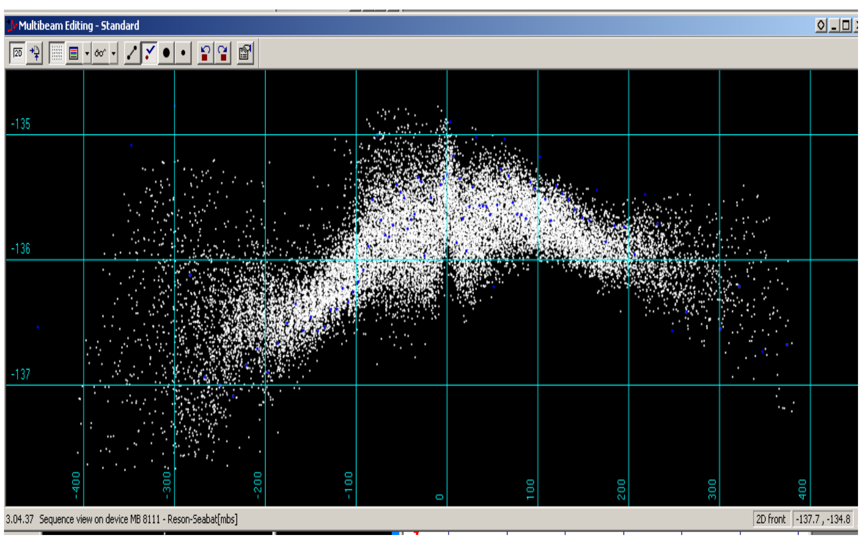
SMILES & FROWNS

Indicates errors in the sound velocity setting

Range $= \frac{1}{2} * V * \Delta t$







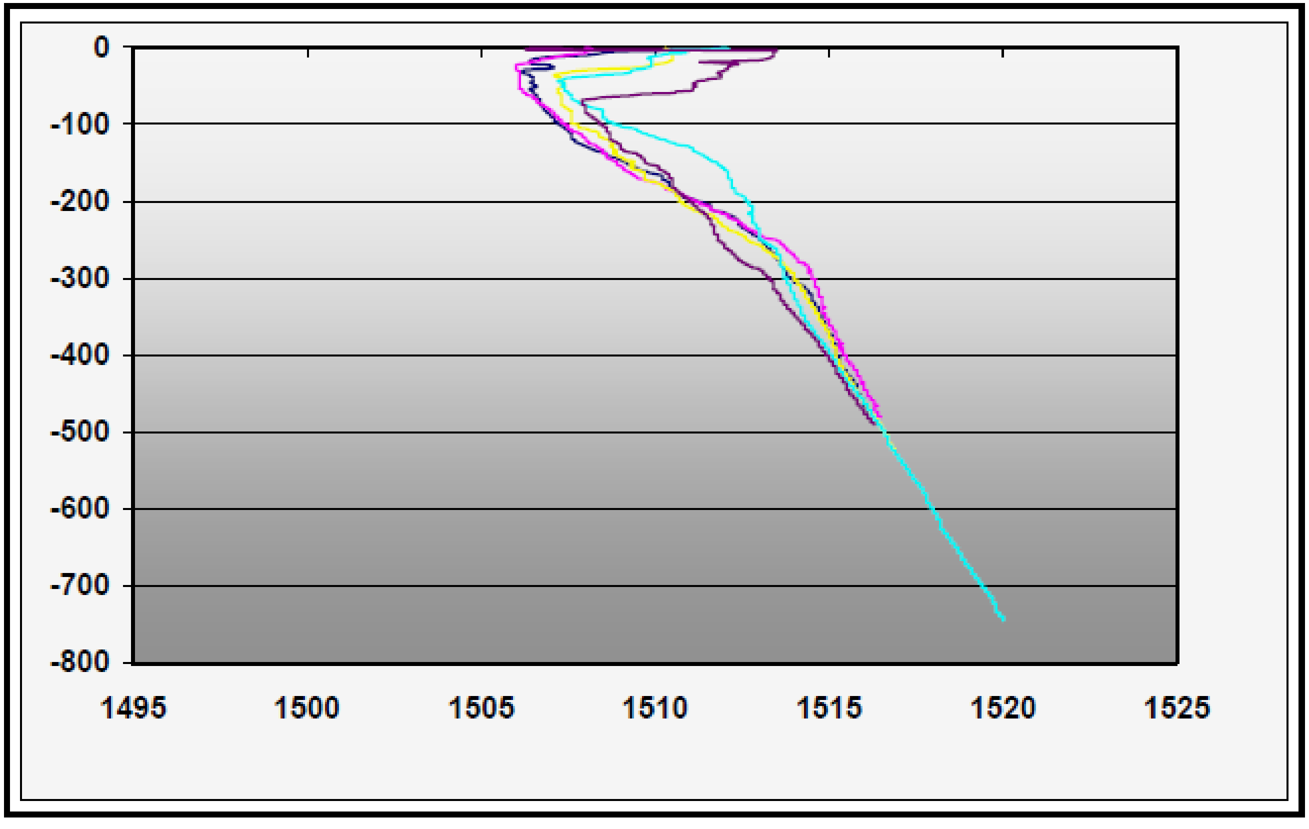
SOUND VELOCITY PROFILES

SOUND VELOCITY PROBE

• Collects a profile of sound velocities at predetermined depth intervals

• Operates autonomously (no electrical cable)

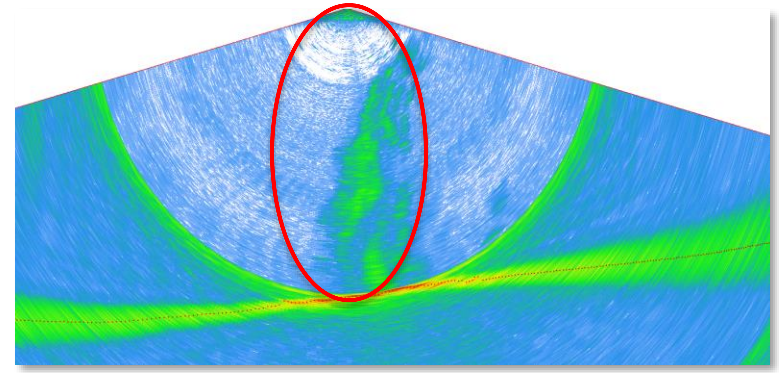
• Data downloaded into computer and uploaded in the acquisition software



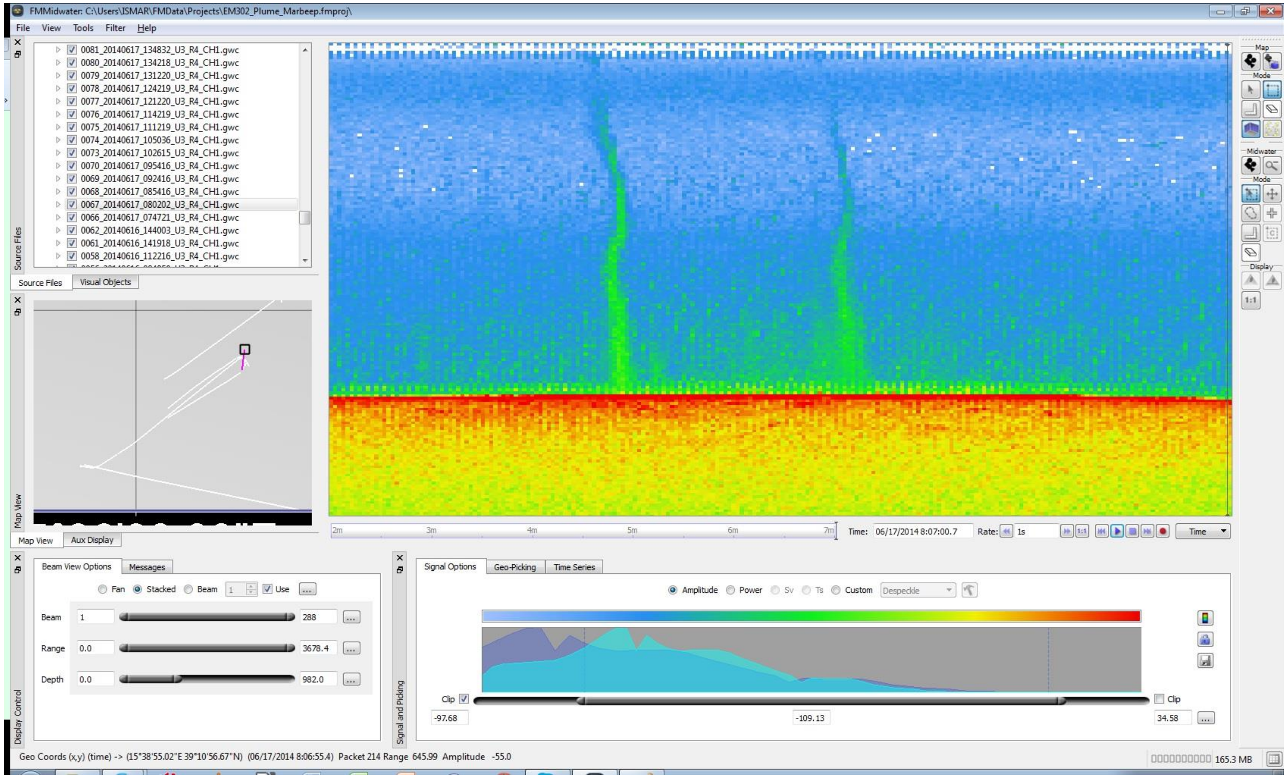
GAS PLUMES DETECTION

Raw sonar data

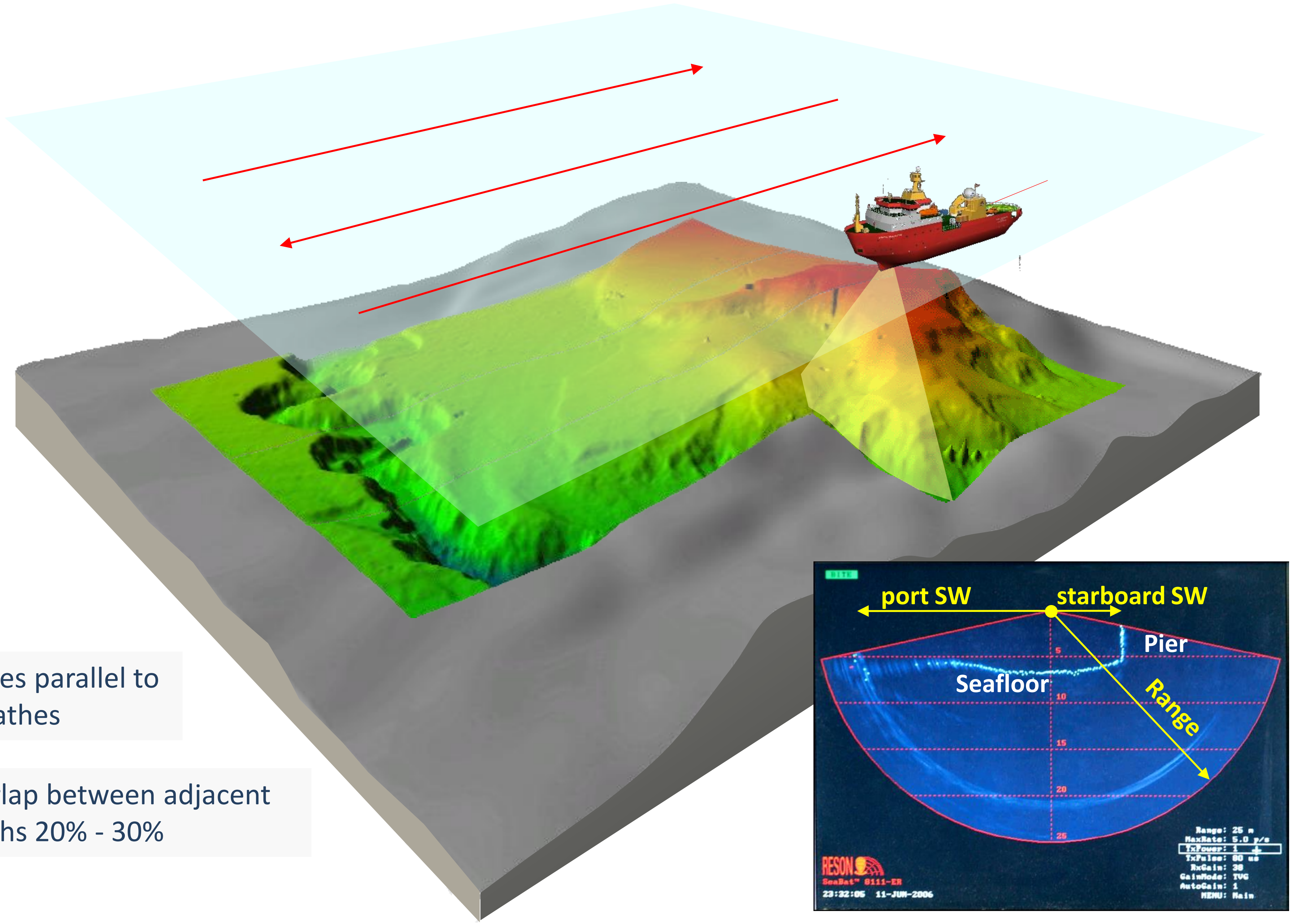
Seafloor



Stacked gas plumes detected in the water column by the EM302 multibeam system along a transect over a mud volcano. Rovere et al., 2014. Normal faults control fluid flow structures at the rear of the Calabrian Arc (Paola Ridge, southeastern Tyrrhenian Sea). GNGTS 2014.



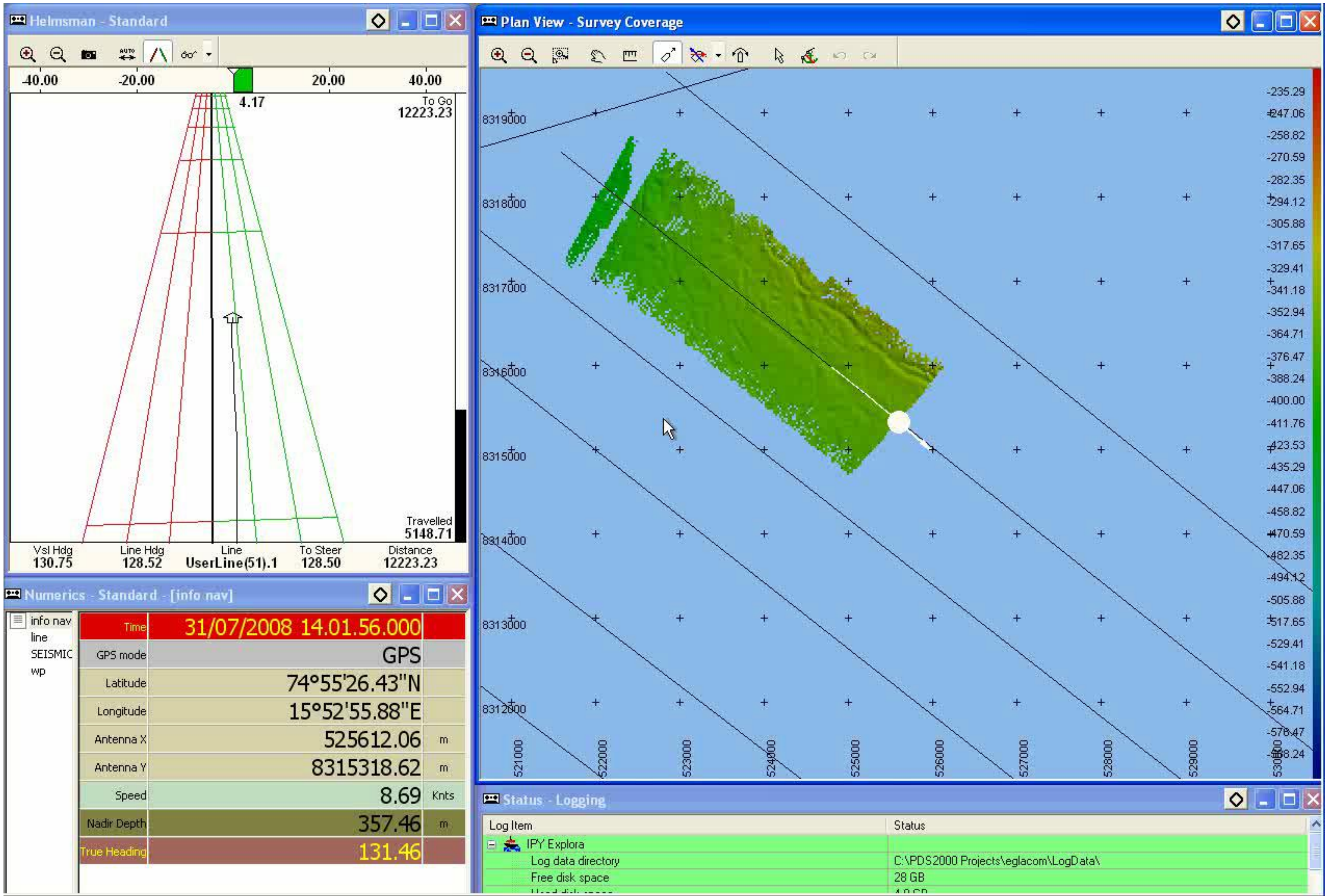
SURVEY PLANNING AND DESIGN



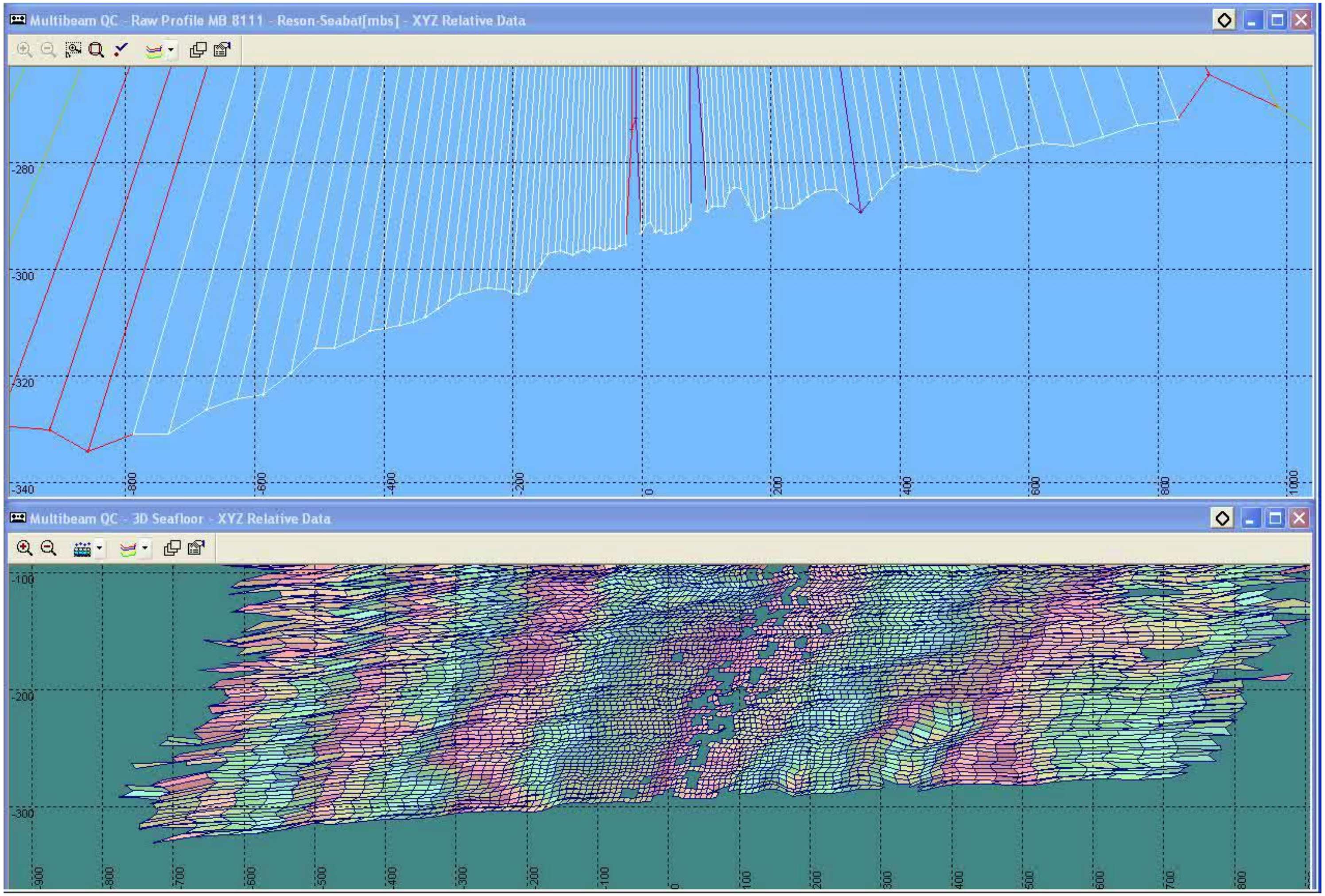
Routes parallel to isobathes

Overlap between adjacent swaths 20% - 30%

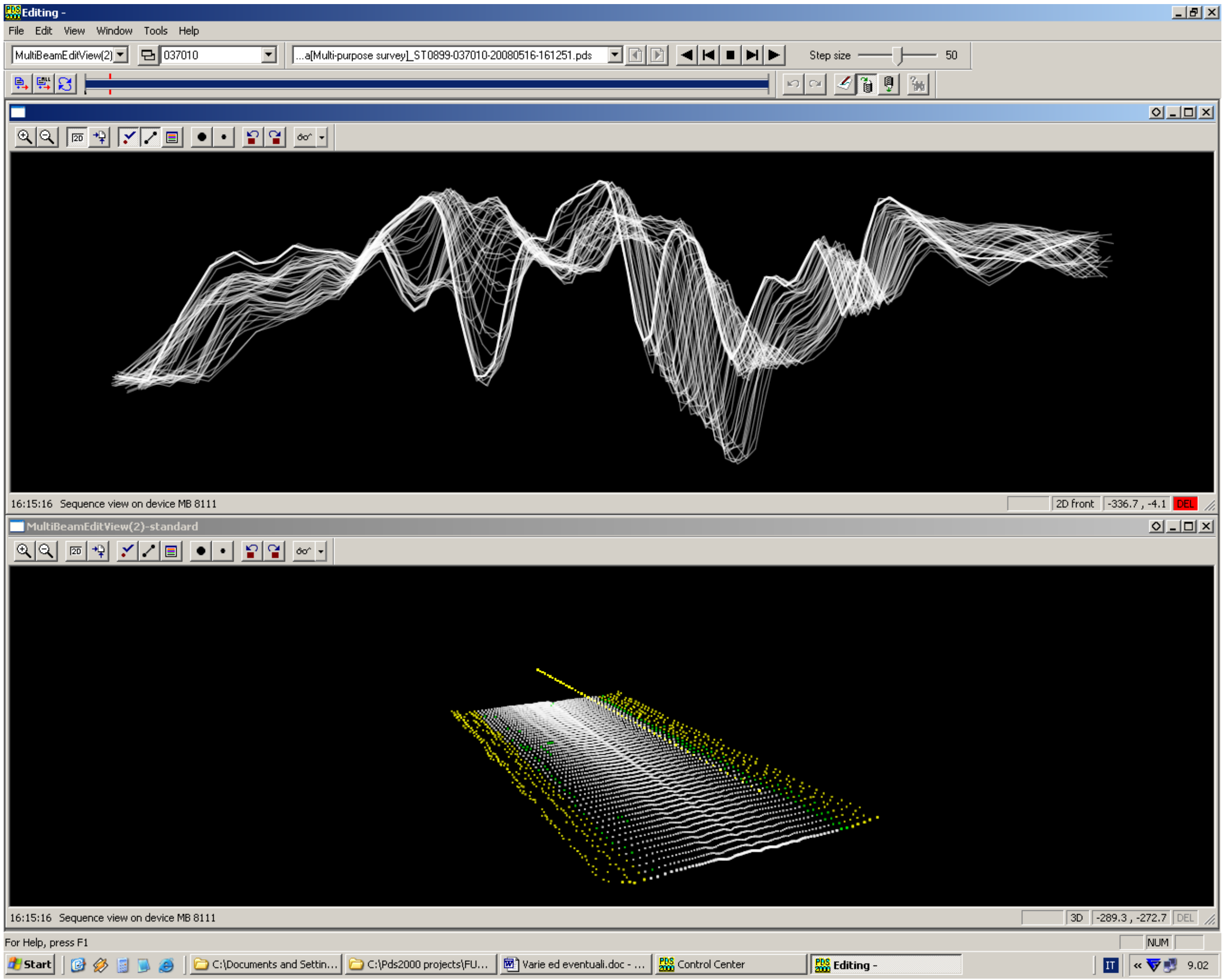
MULTIBEAM ECHOSOUNDER DATA ACQUISITION



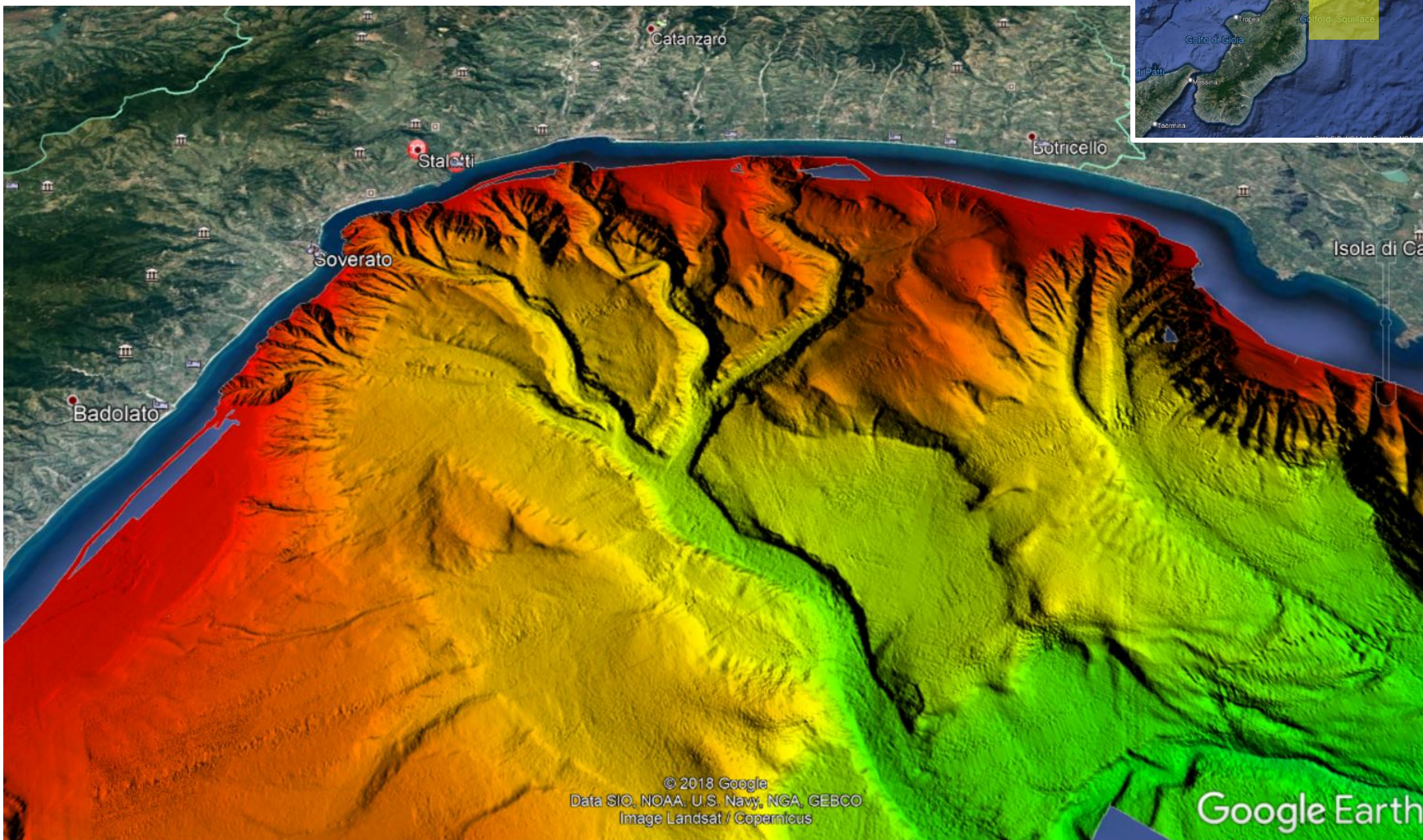
DATA ACQUISITION



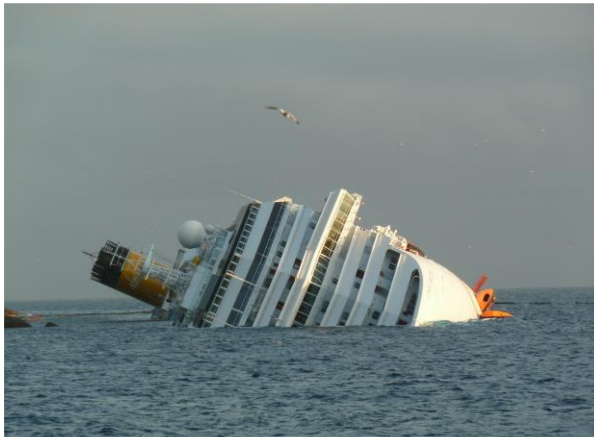
SWATH EDITING

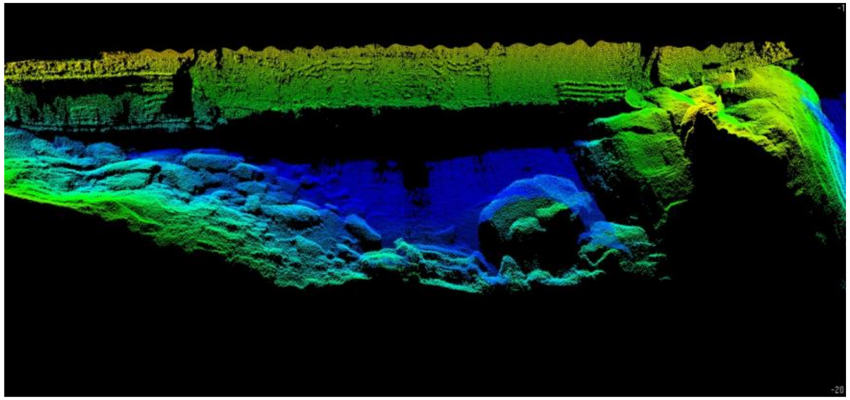


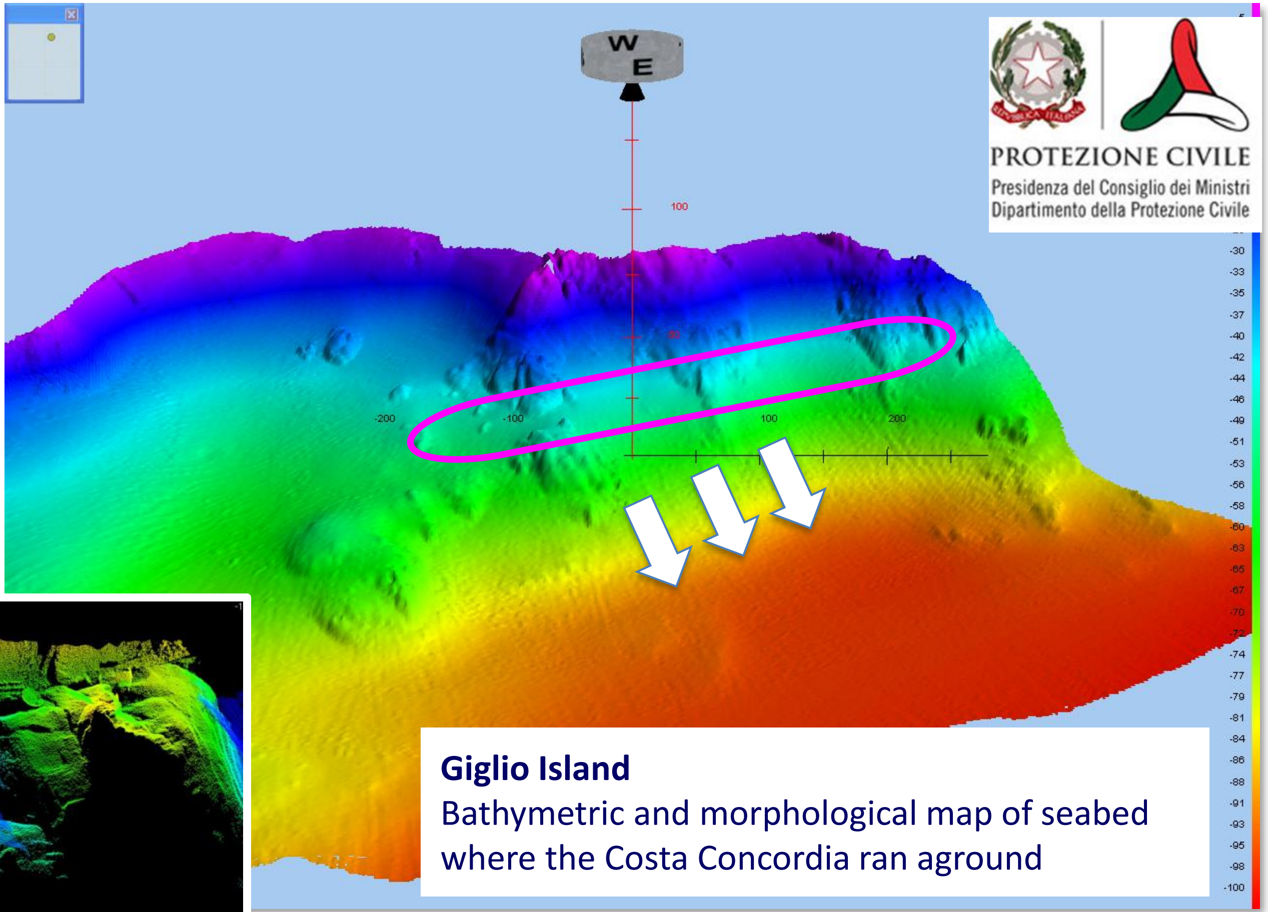
GEO HAZARD: SUBMARINE CANYONS AS A THREAT TO COASTAL INFRASTRUCTURES



CIVIL PROTECTION: SLOPE STABILITY







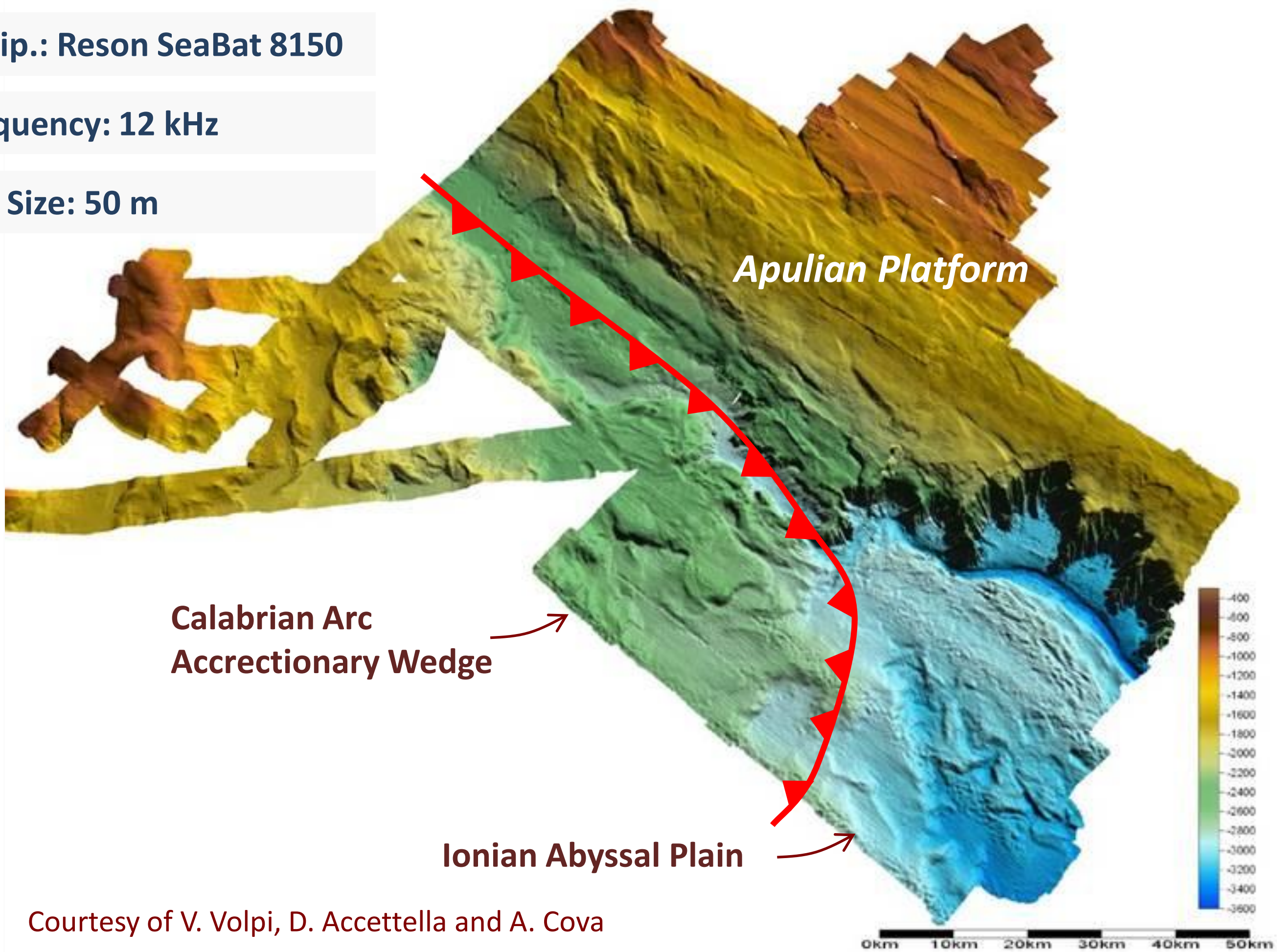
Giglio Island
Bathymetric and morphological map of seabed where the Costa Concordia ran aground

Courtesy of D. Cotterle, E. Gordini, and M. Deponte, OGS, 2012

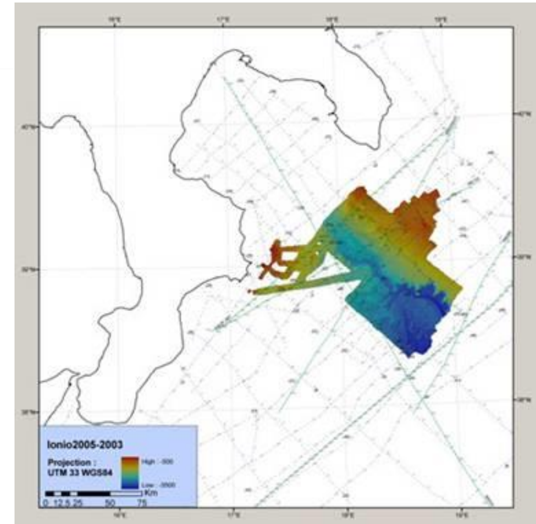
EXAMPLE 3

RESEARCH: GEODINAMIC STUDIES

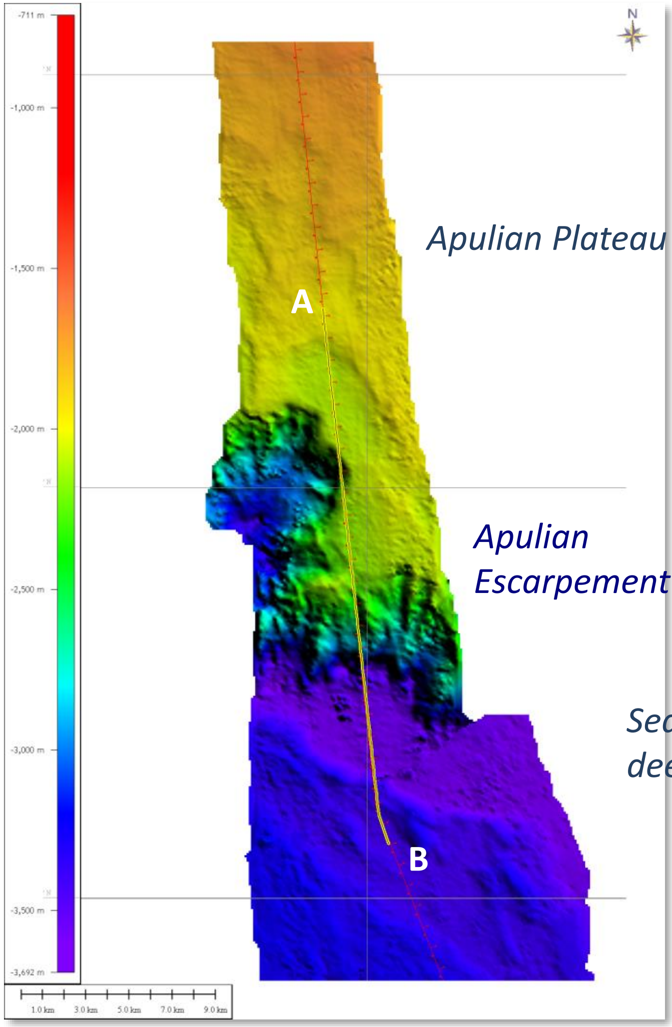
- M/V OGS Explora, 2003
- Equip.: Reson SeaBat 8150
- Frequency: 12 kHz
- Cell Size: 50 m



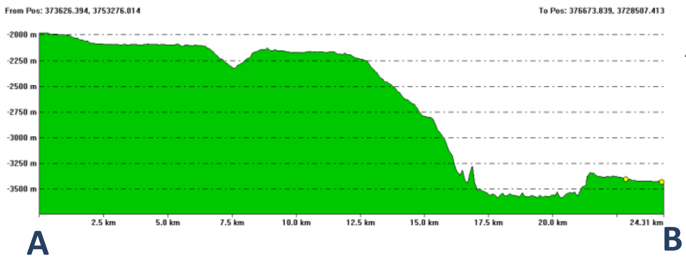
Courtesy of V. Volpi, D. Accettella and A. Cova



MULTIBEAM ECHOSOUNDER CABLE SURVEY



Bathymetric profile



Avg. gradient = 25°
Max gradient >40°