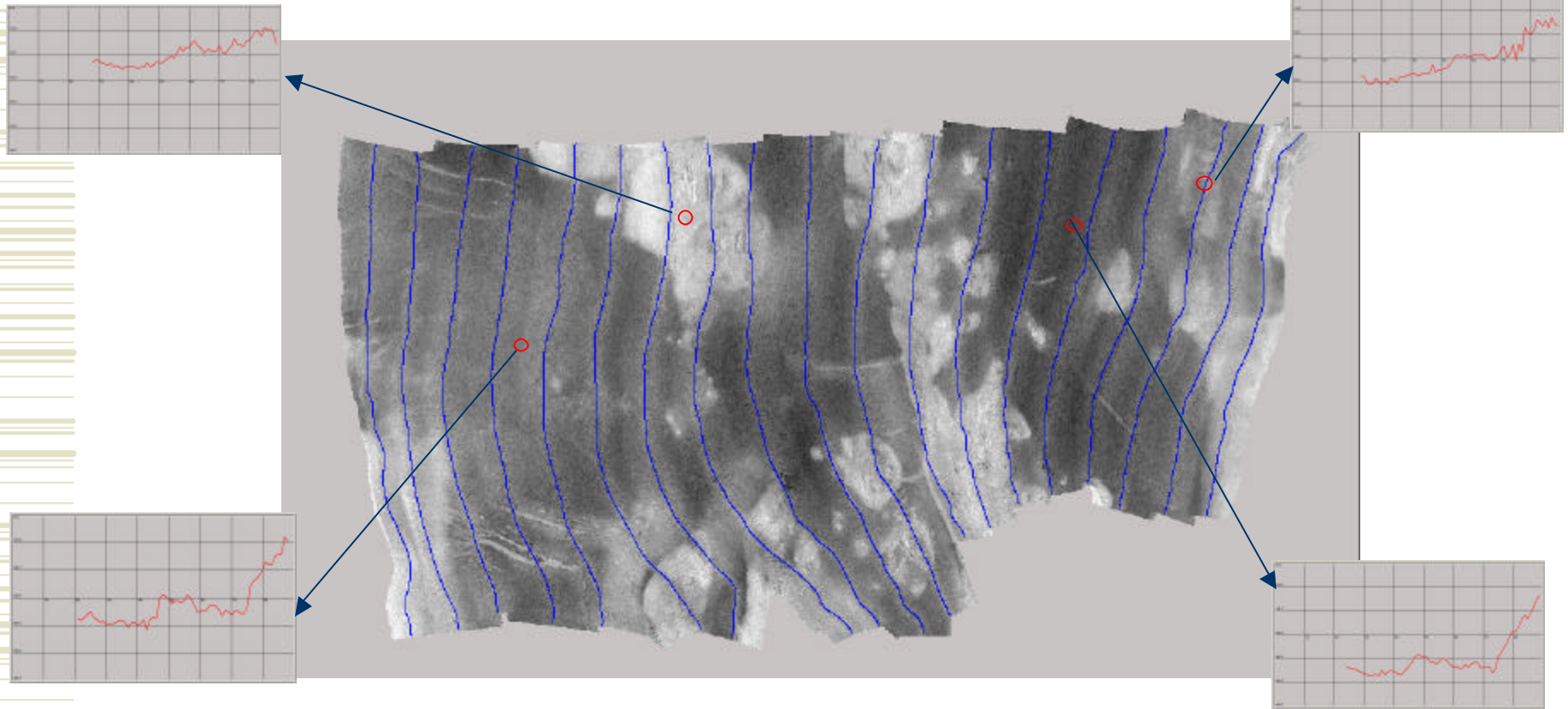




Backscatter Mosaics and Acoustic Seafloor Characterization



Luciano Fonseca
Center for Coastal and Ocean Mapping
University of New Hampshire

10/17/2006

INMARTECH-2006



Acoustic Backscatter Processing

We want:

1- to be able to produce a normalized backscatter mosaic suitable for geologic and habitat interpretation as well as object detection

2- to analyze the acoustic backscatter in as quantitative a way as possible for seafloor characterization and object detection

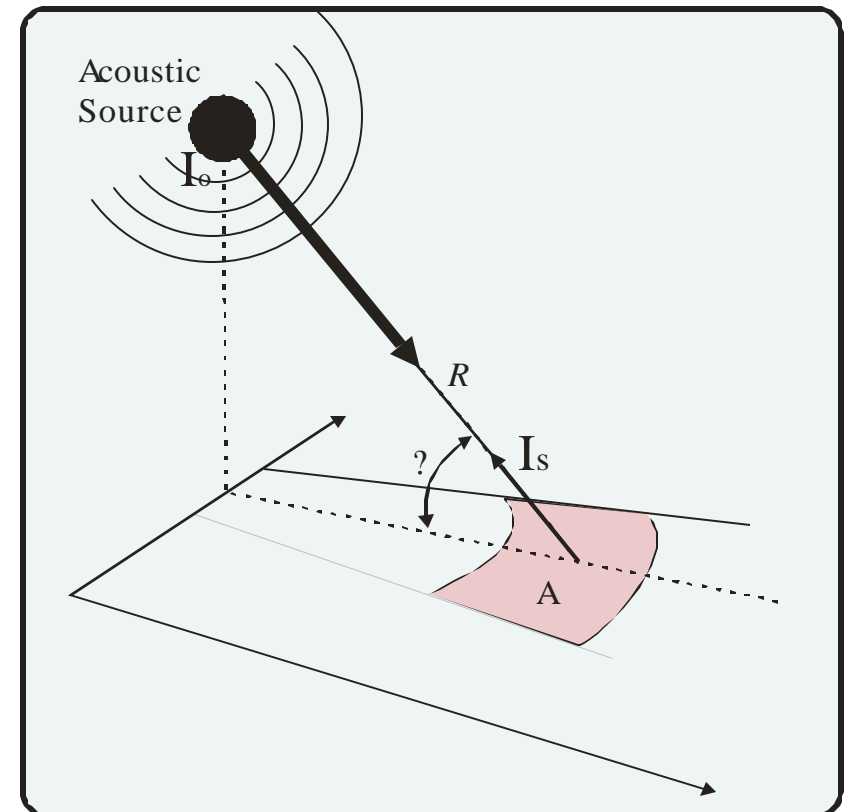


Total Backscattering Cross Section

$\sigma_t(\theta)$ per unit solid angle, per unit area

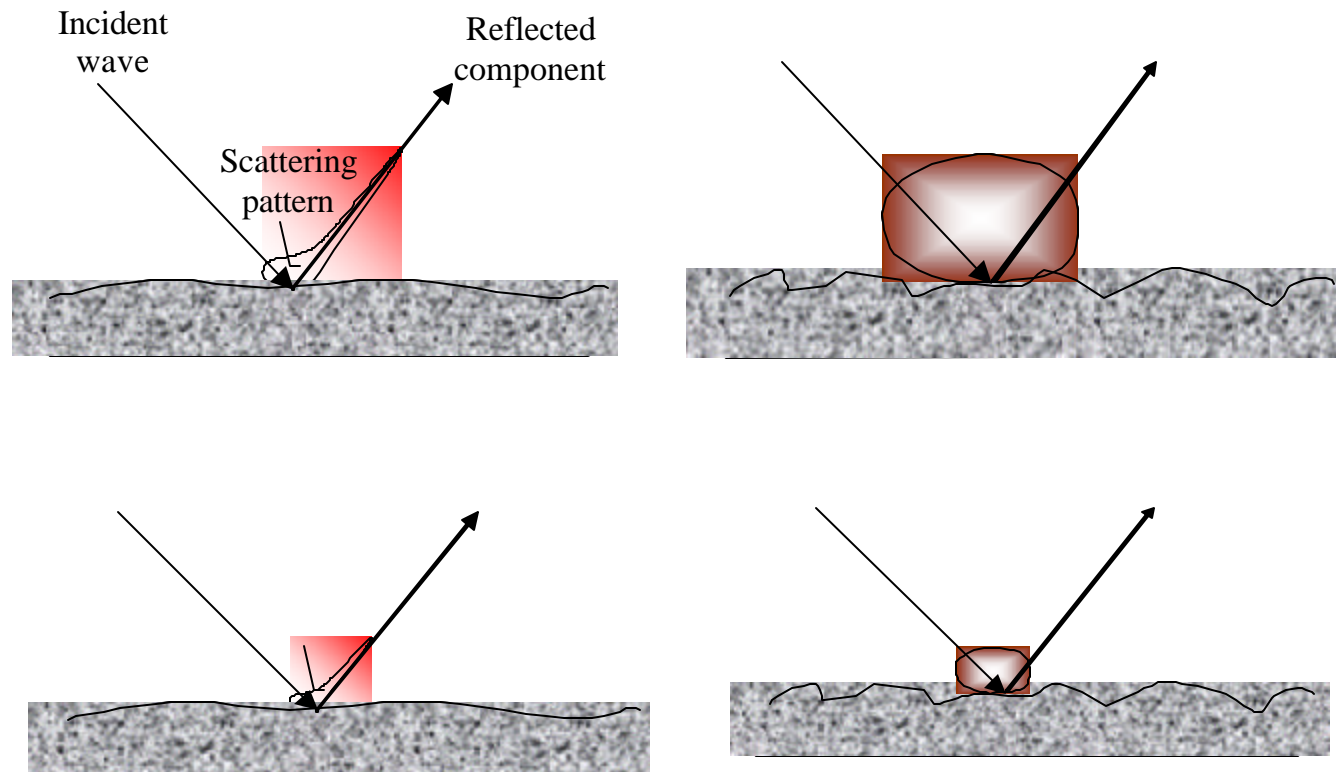
$$\sigma_t(\theta) = R^2 \frac{I_s}{I_0 A}$$

- θ - Grazing angle
- R - Slant range
- I_0 - Source intensity (db re 1 μ Pa/m)
- I_s - Backscattering intensity



Impedance Contrast and Roughness

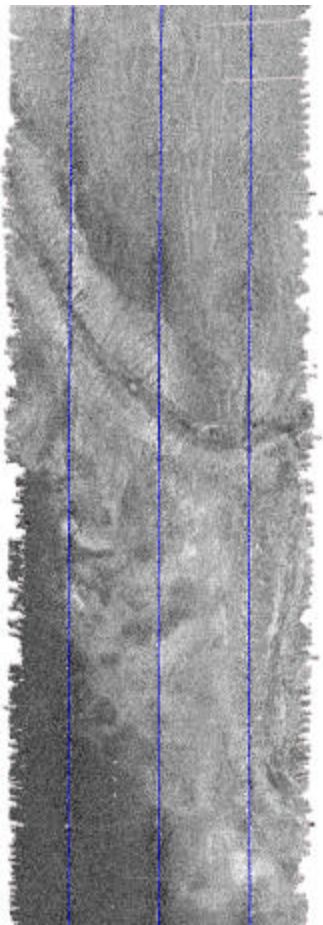
Impedance



Roughness



Sonar Frequency



Simrad EM120
12kHz



Simrad EM300
30kHz



Simrad EM1002
95kHz



Simrad EM3000
300kHz

10/17/2006

INMARTECH-2006



Radiometric and Geometric Distortions

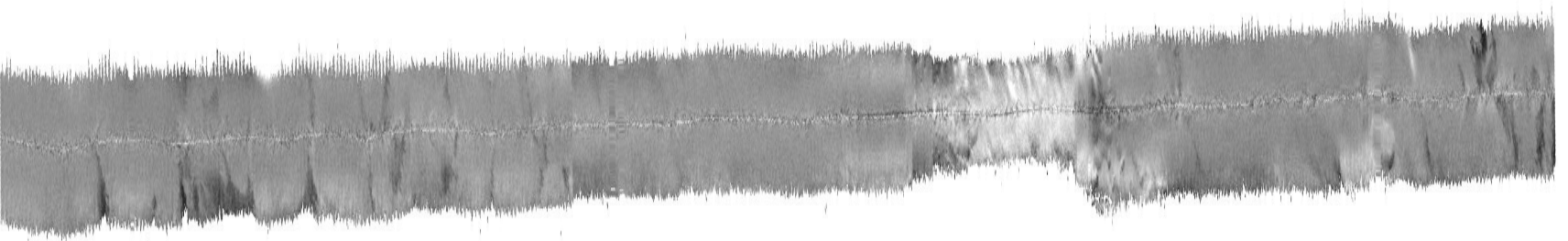
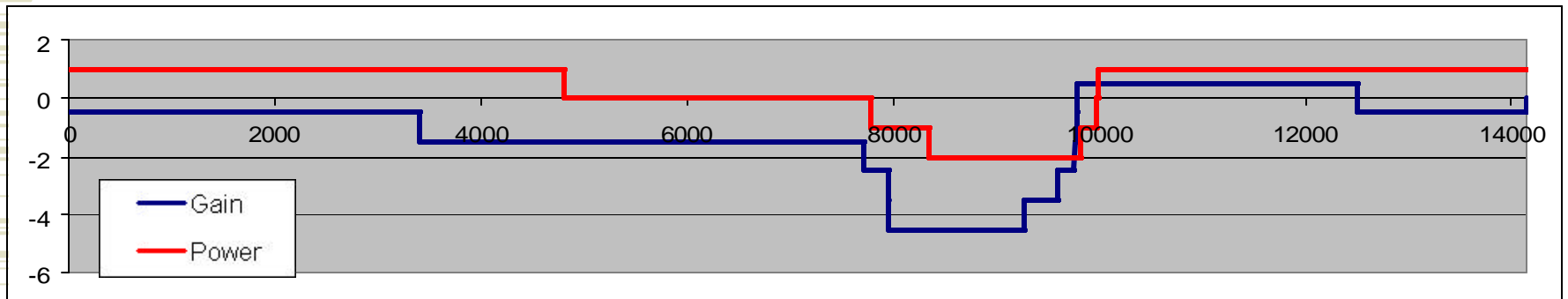
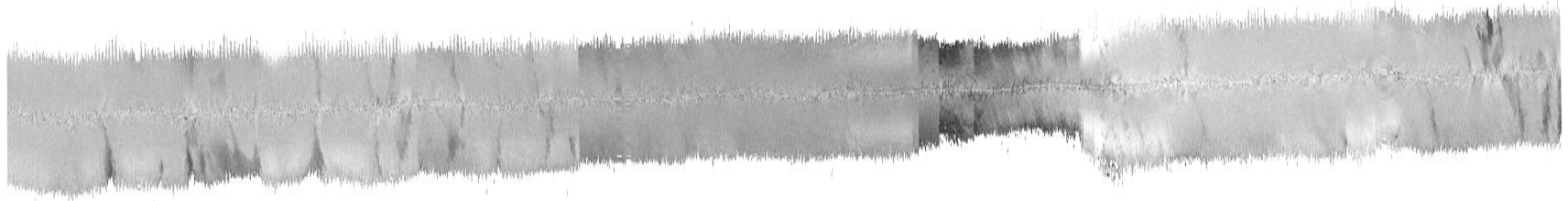
- ✍ Transmit Power
- ✍ Receiver Gain
- ✍ Pulse widths
- ✍ Area of insonification
- ✍ Attenuation in the water column
- ✍ Seafloor Slope
- ✍ Sediment Angular Response
- ✍ Spherical Spreading
- ✍ Beam patterns
- ✍ Speckle noise

- ✍ Slant-range
 - ✍ Refraction in the water column
 - ✍ Foreshortening
 - ✍ layover
- ✍ Positioning
 - ✍ Variations in trajectory
 - ✍ Variations in speed
 - ✍ Variations in attitude



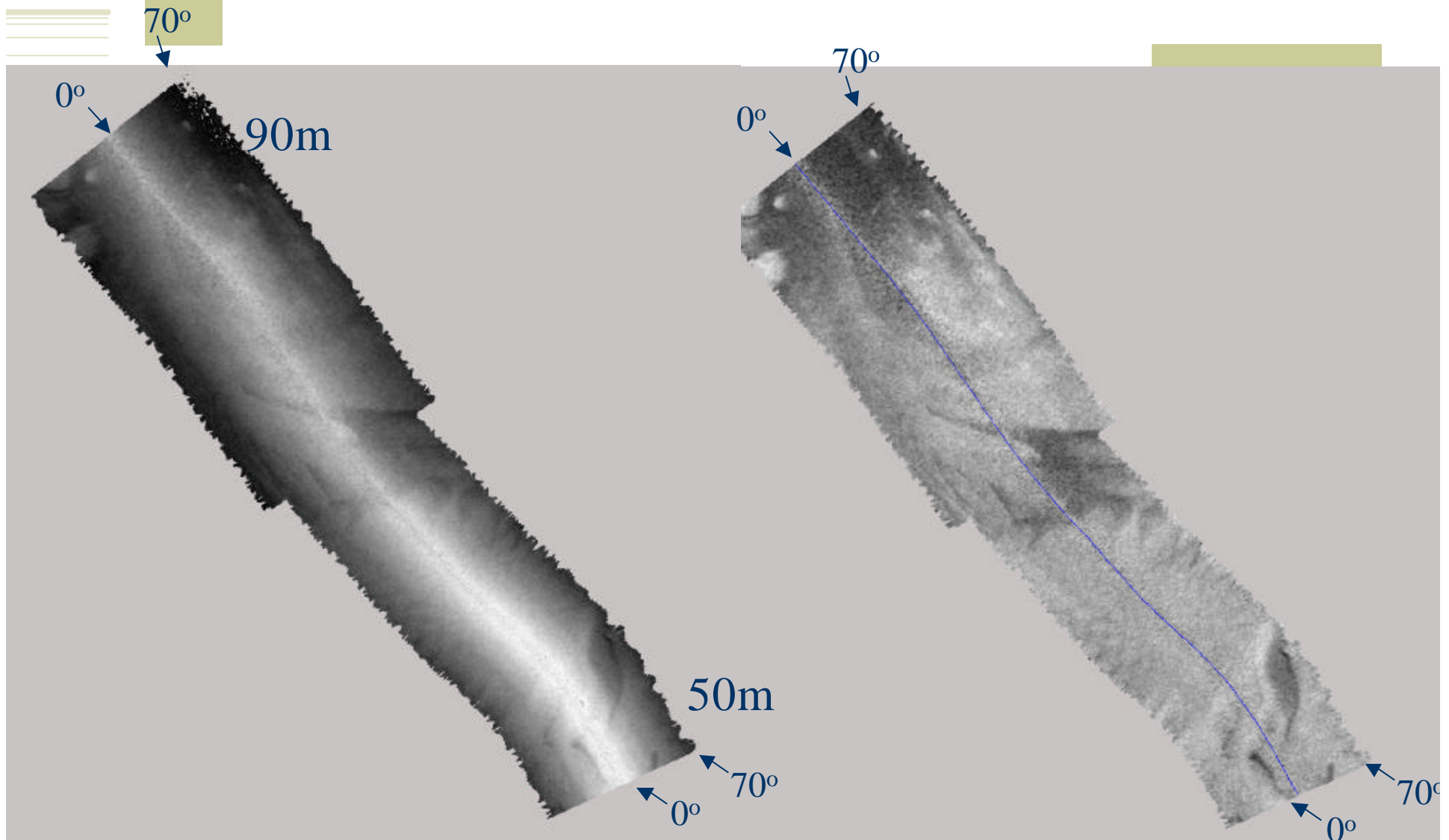
Acquisition Parameters

Transmit Power and Receiver Gain





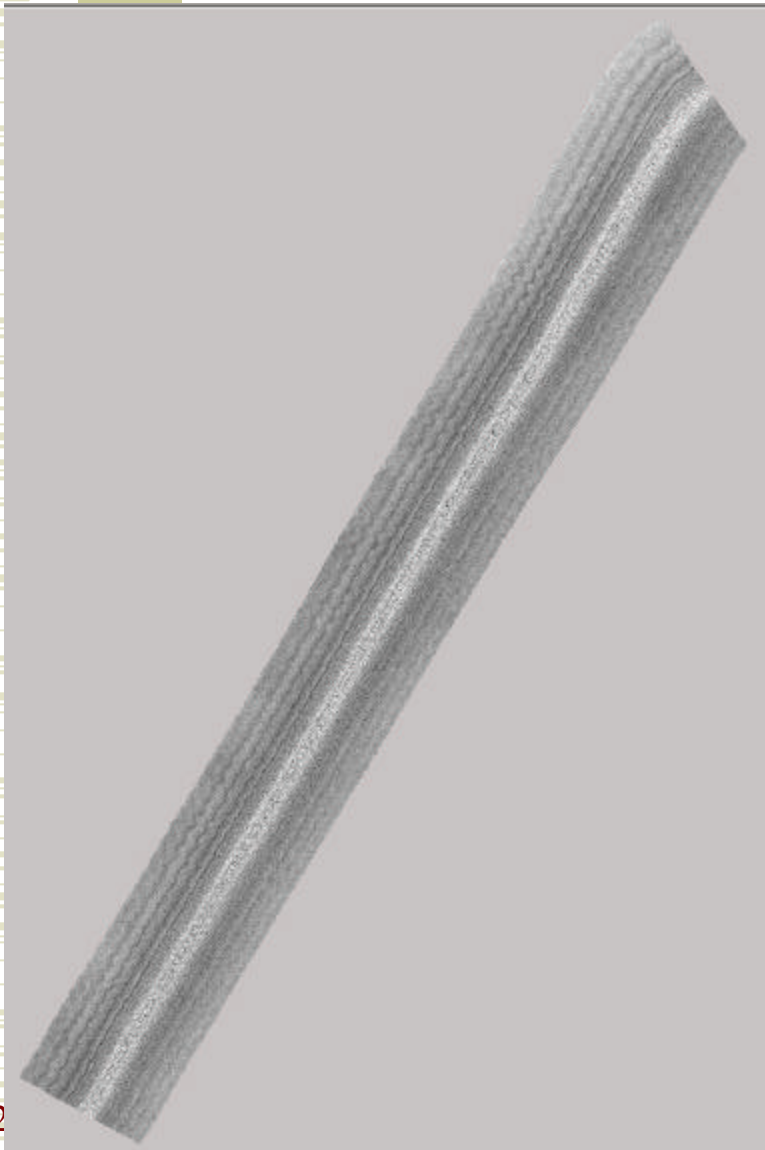
Acquisition Geometry



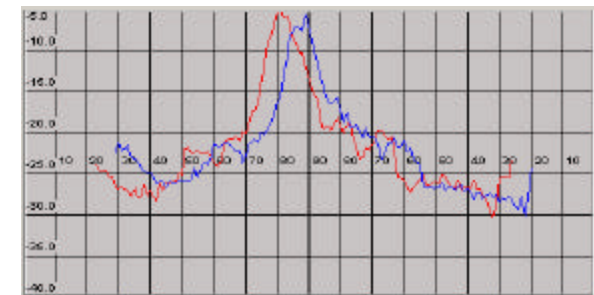
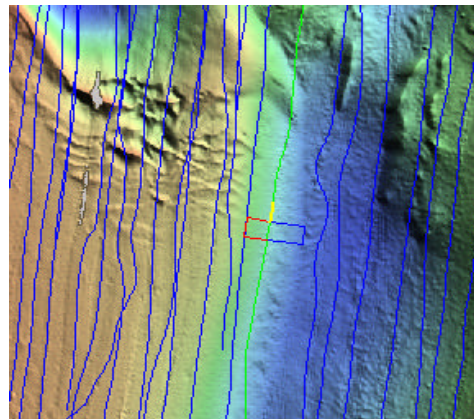
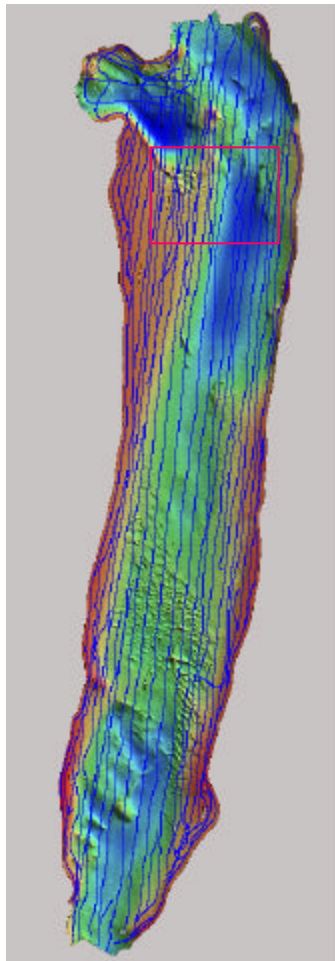


Transducer Properties

TX Beam Pattern

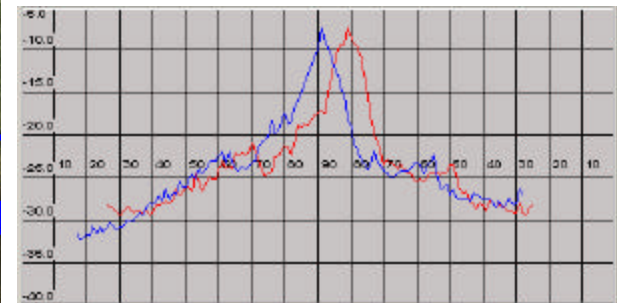
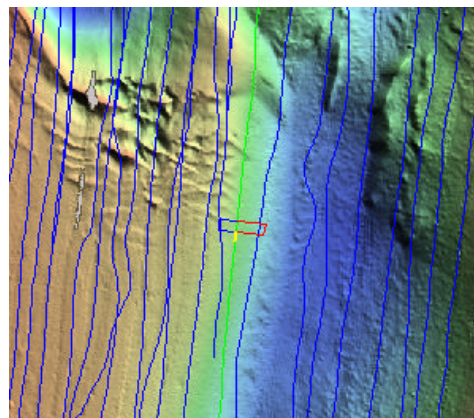


Seafloor Slope



Red - Original Backscatter

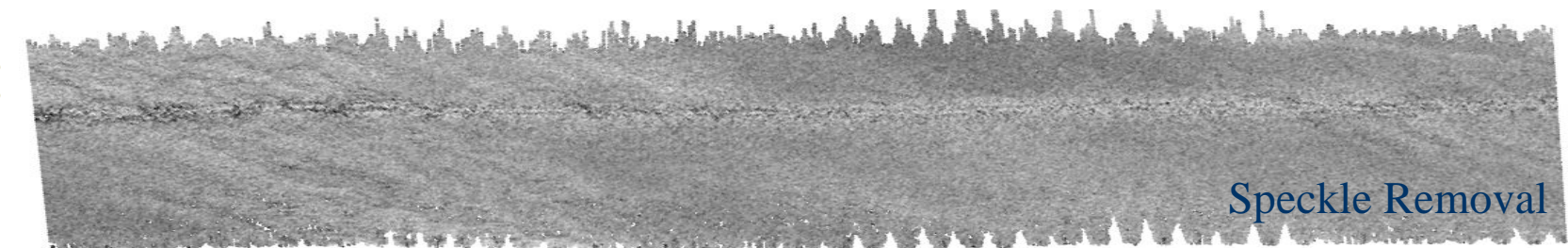
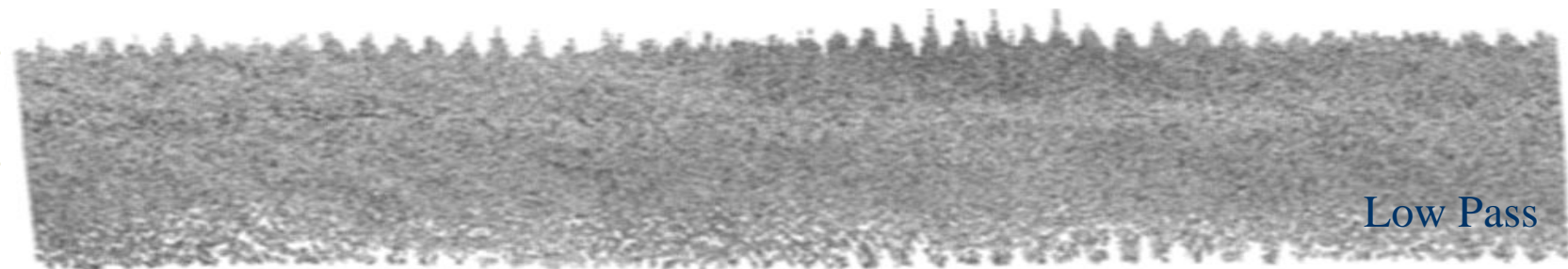
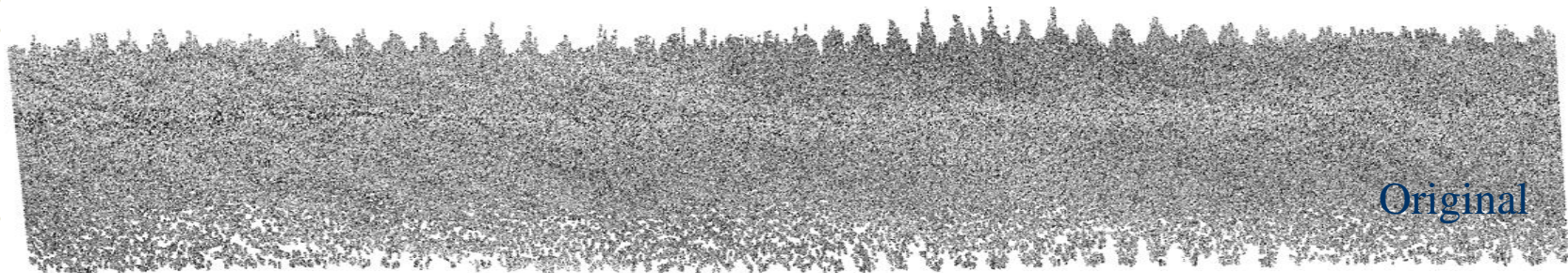
Blue - Slope Corrected Backscatter





Speckle Noise

stochastic fluctuations








Different Backscatter Measurements

Sidescan Sonar

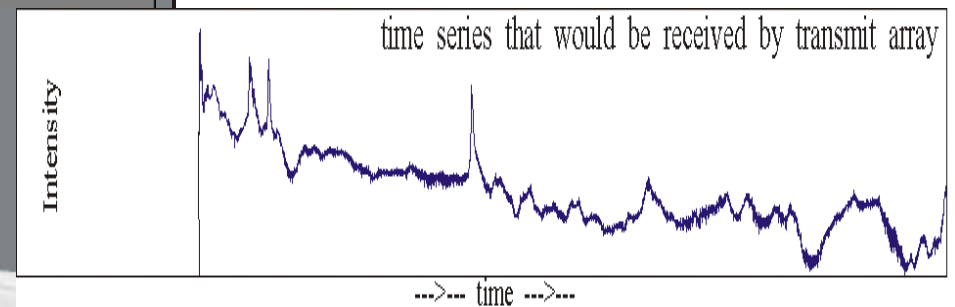
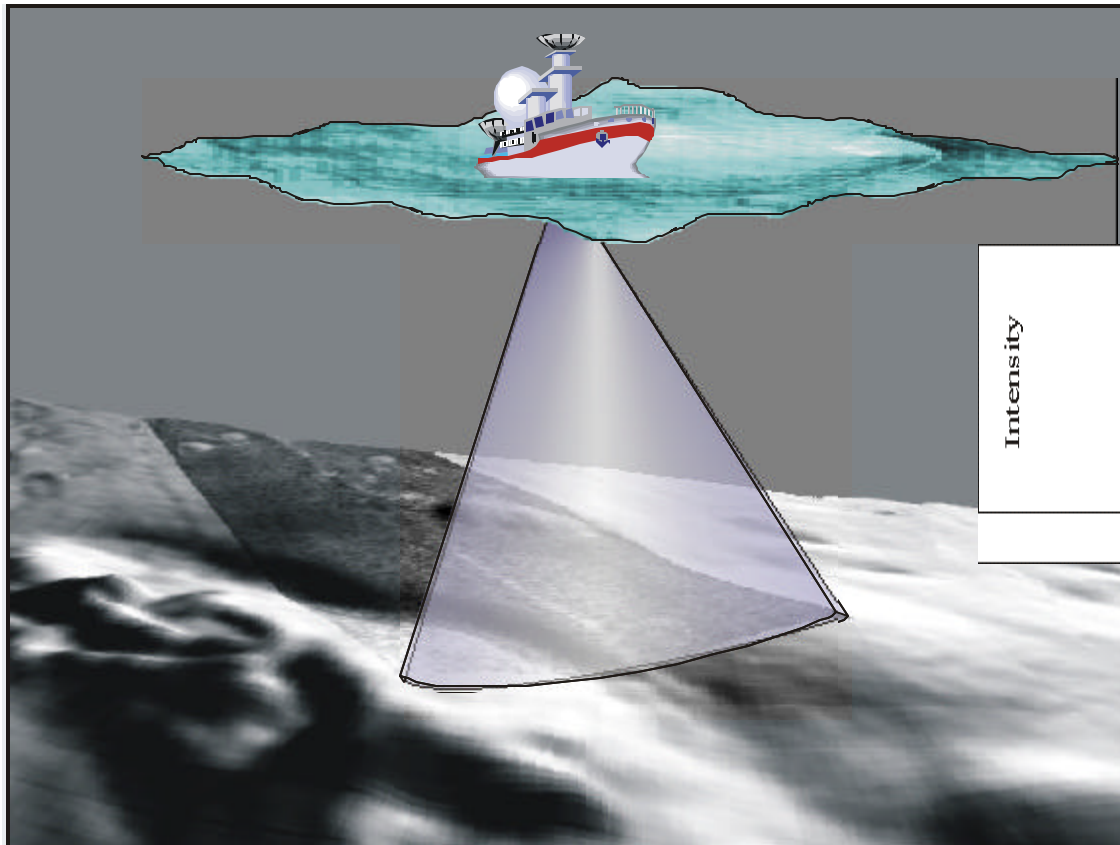
-  two long time series of backscatter strength for each received ping

Multibeam Sonar

-  one value of average backscatter strength per beam
-  one time series of backscatter strength per beam
-  two long time series of backscatter strength for each received ping



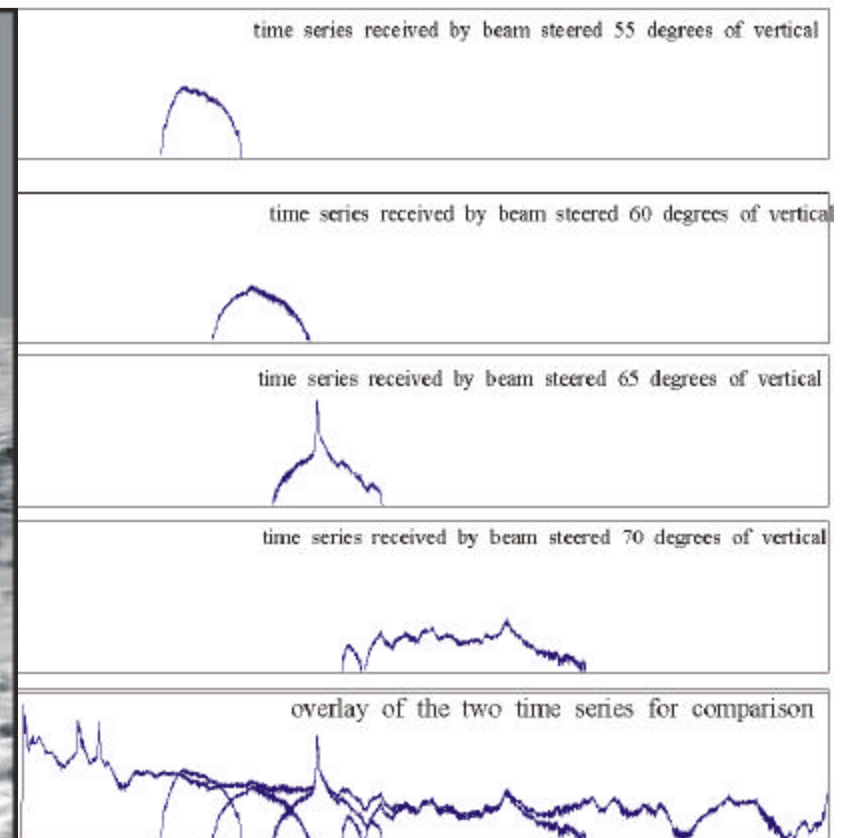
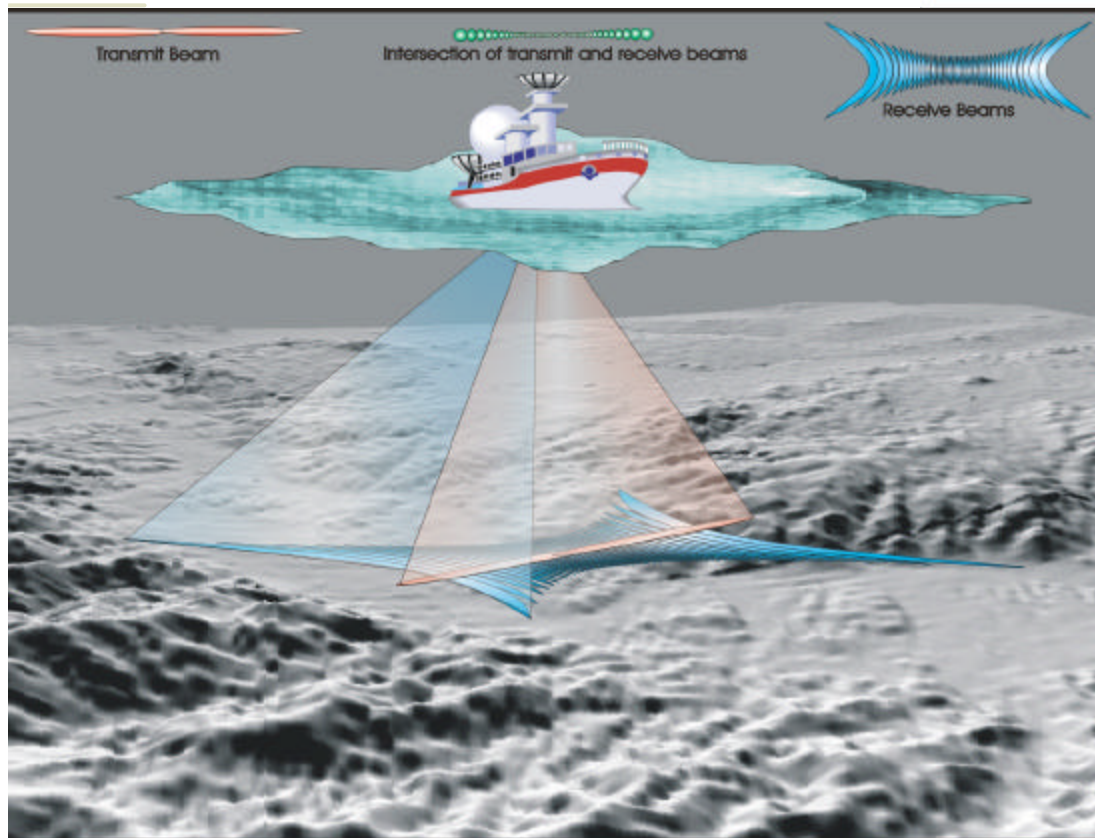
Time series of backscatter strength for each received ping



From JHC



Time series of backscatter strength per beam



Simrad “beam time-series”

From JHC

10/17/2006

Reson “snippet”

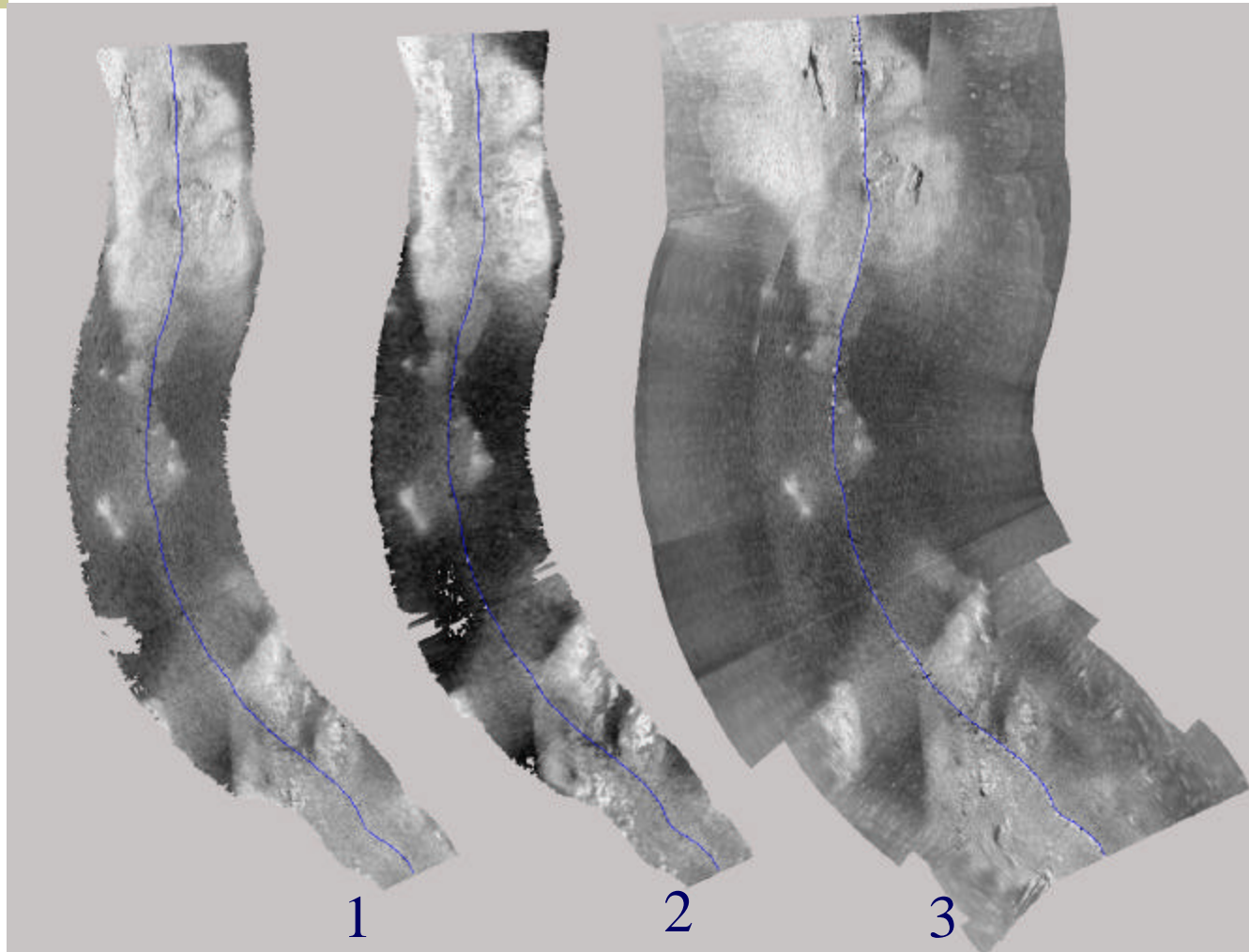
INMARTECH-2006



Sources of Backscatter



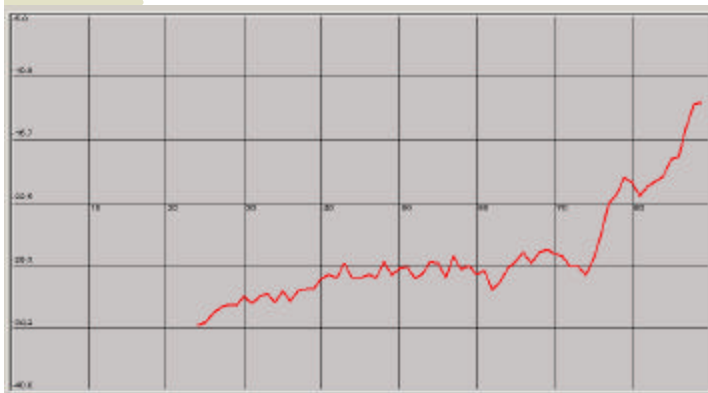
1. Snippets
2. Beam Average Backscatter
3. Sidescan Time Series



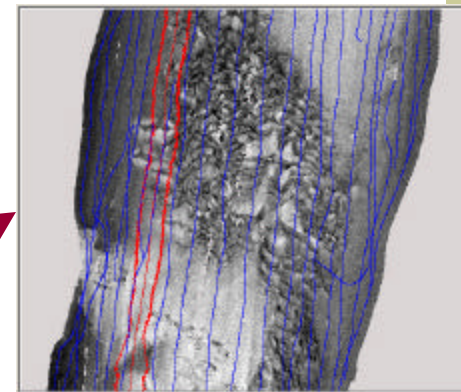


Corrected Backscatter

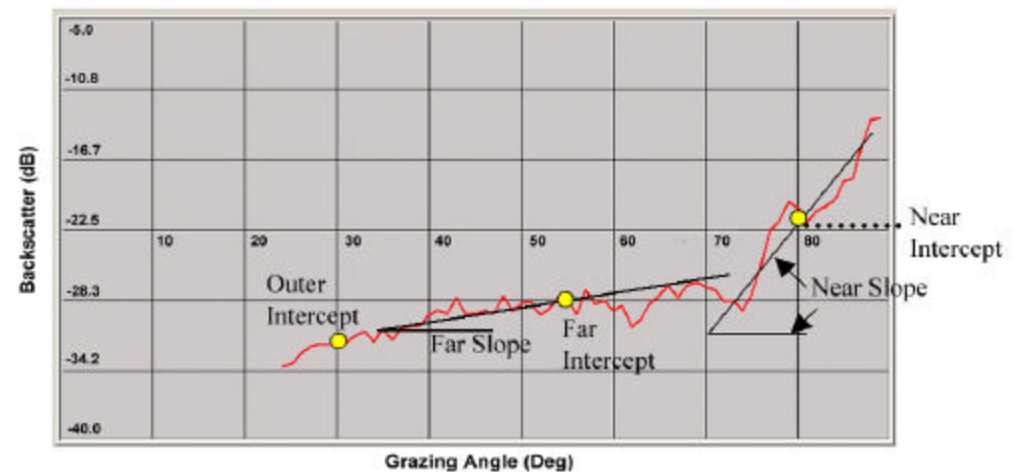
Corrected for Radiometric and Geometric Distortions



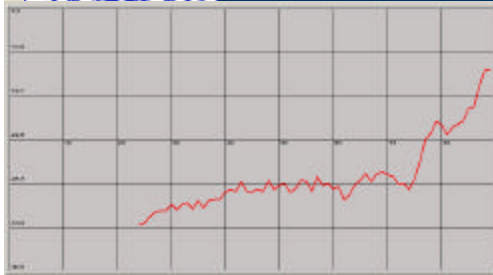
Corrected
Backscatter (half) Swath



1) Mapping and Mosaicking



2) Seafloor Characterization



→ 1) Mapping and Mosaicking

AVG Correction

-  sediment angular response

Homography Mapping

-  Mapping two pings at a time

Anti-Aliasing

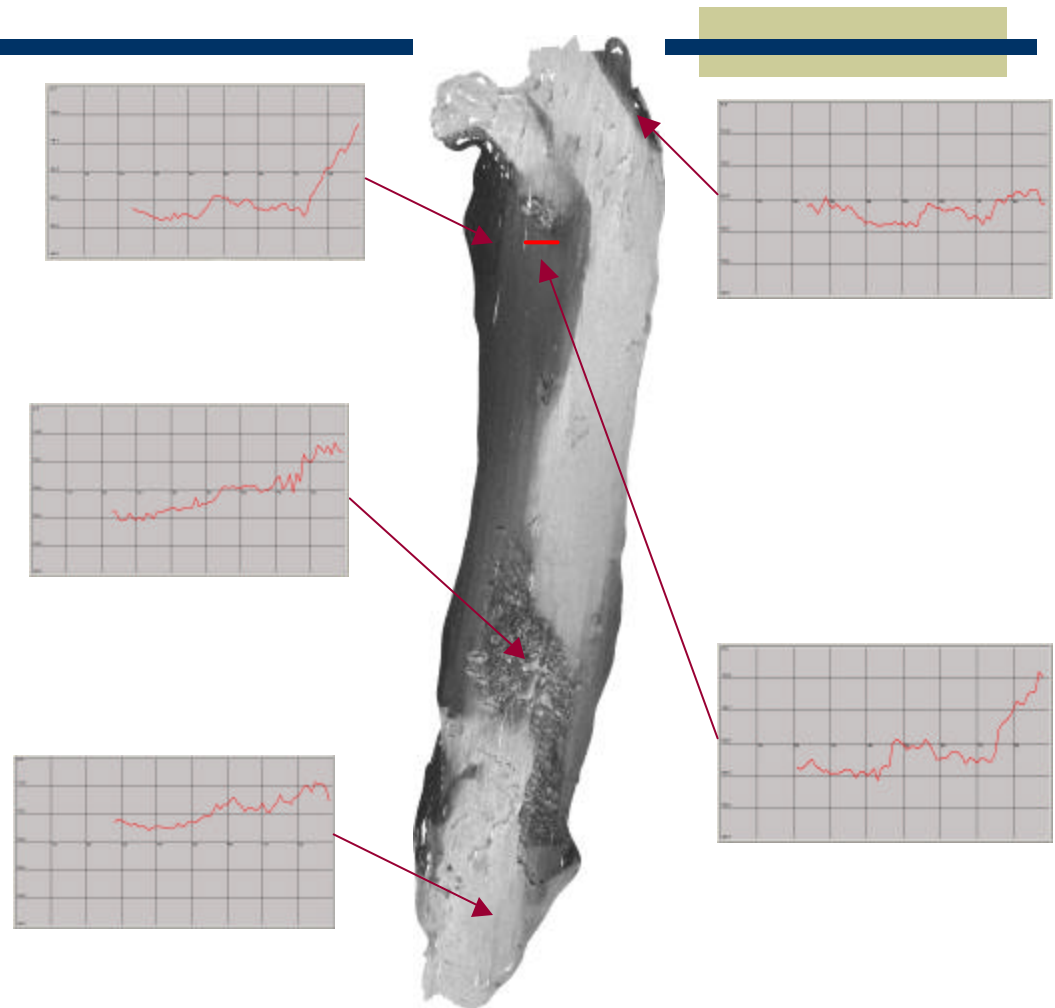
-  Multiple resolutions

Overlap

-  Automatic overlap handling

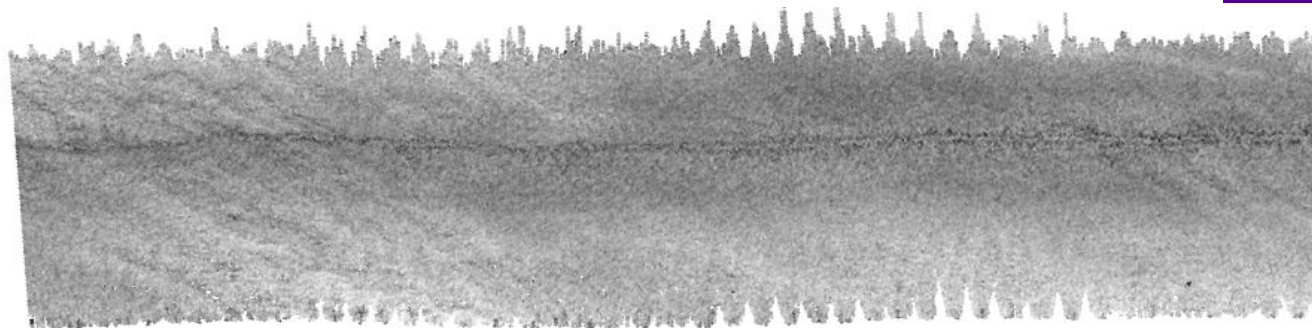
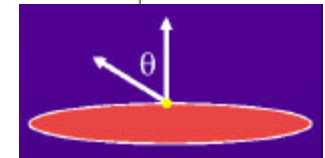
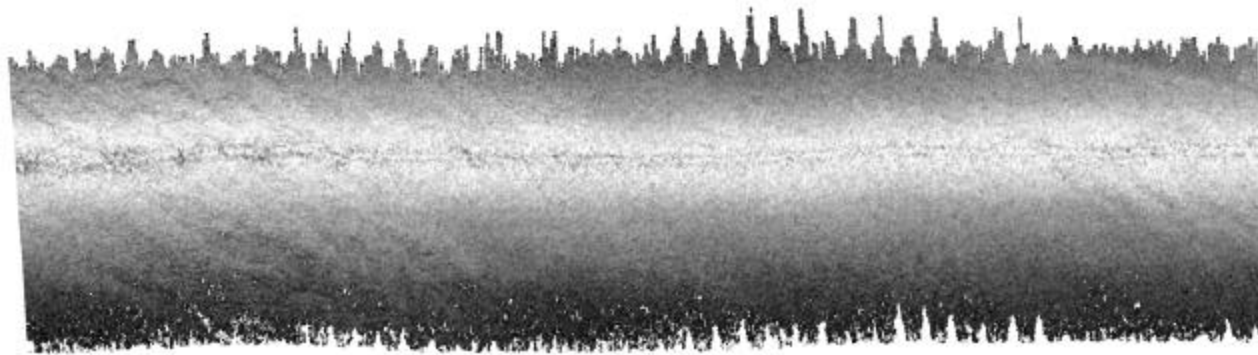
Feathering

-  Reduced seams





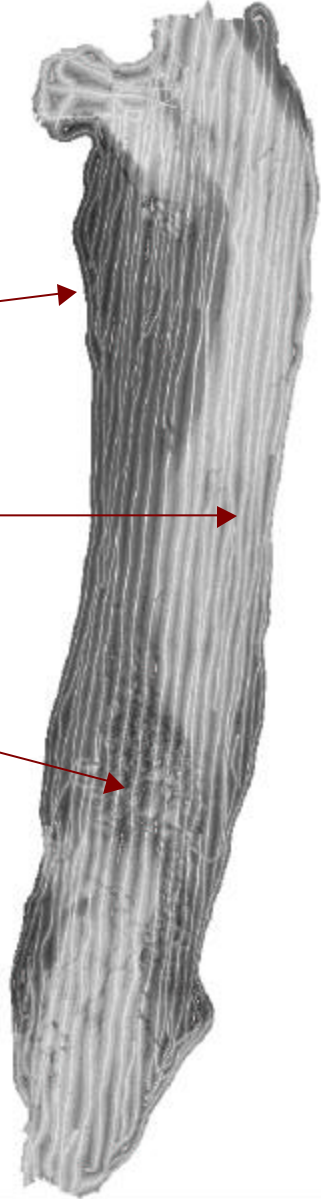
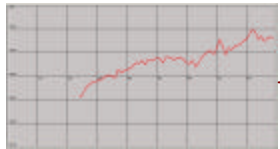
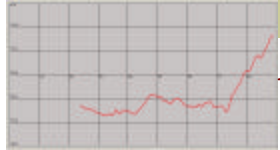
Seafloor Angular Response





Seafloor Angular Response

AVG corrections



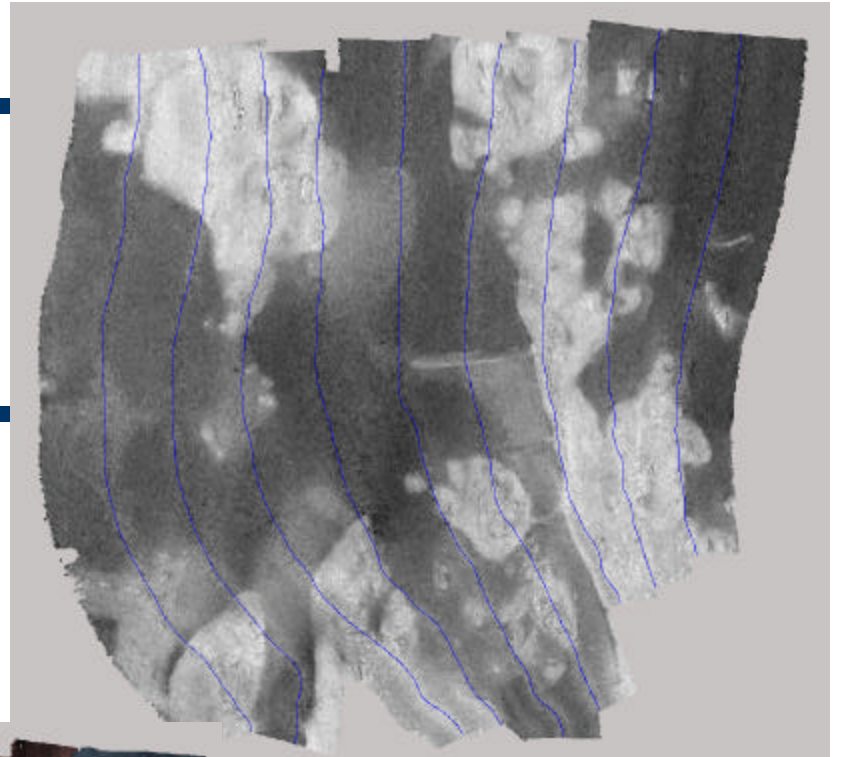
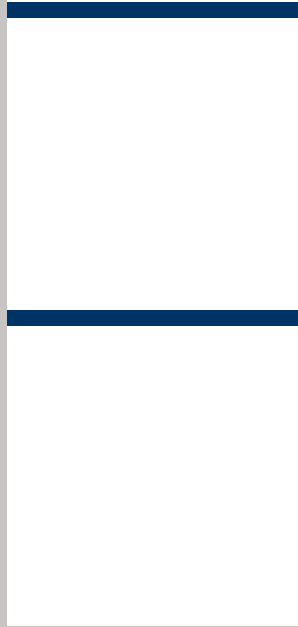
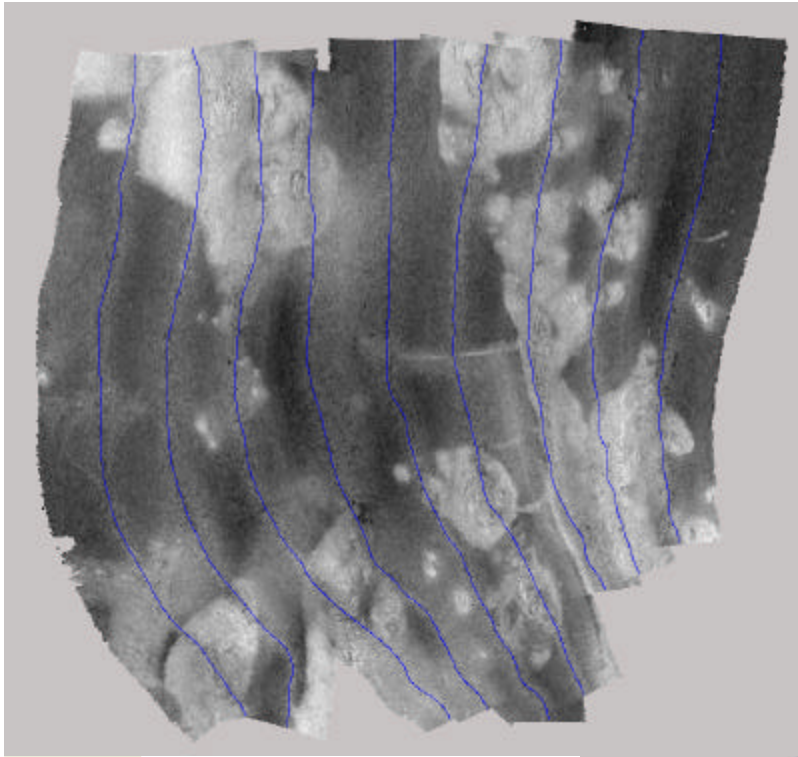
10/17/2006

Original

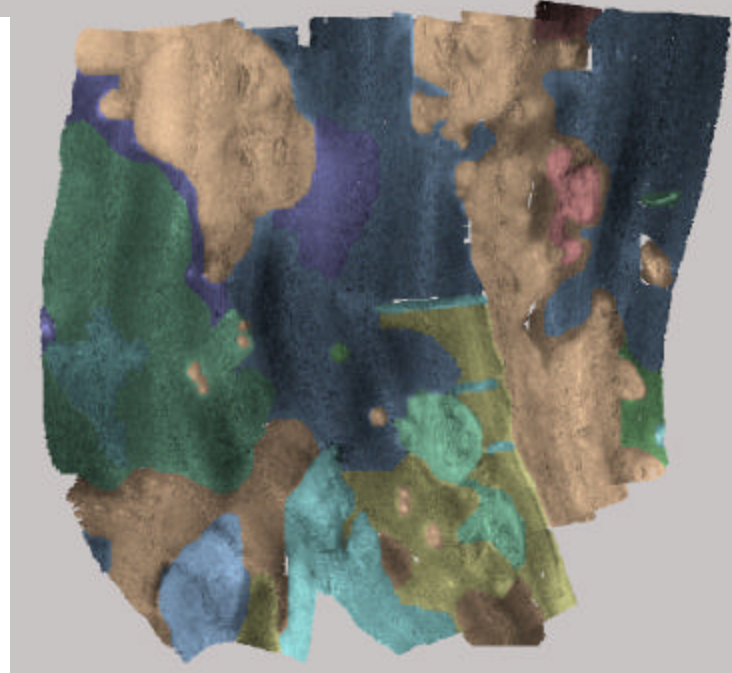
Flat

Trend Adapting

INMARTECH-2006



Backscatter Mosaics



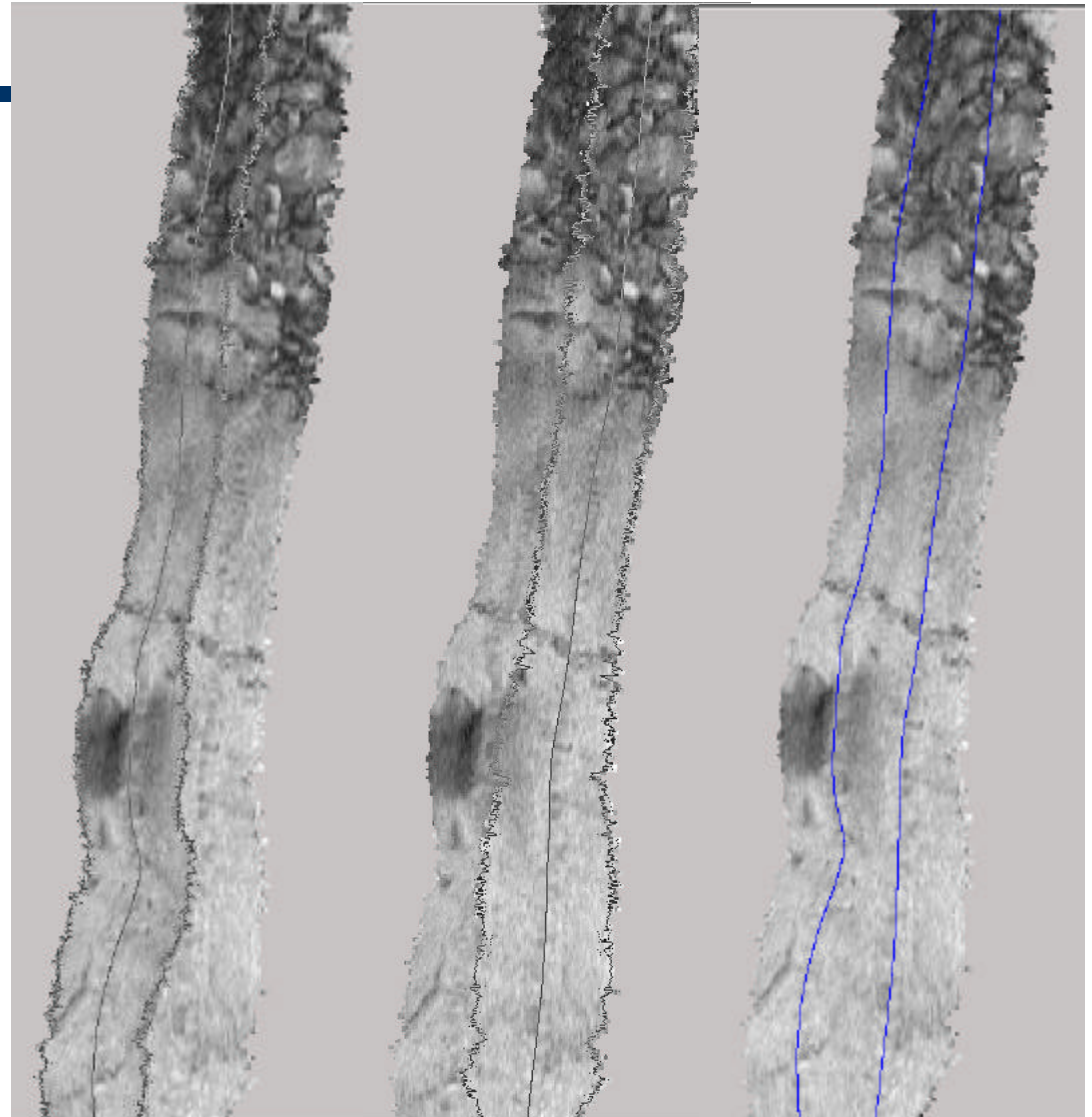
Seafloor Characterization



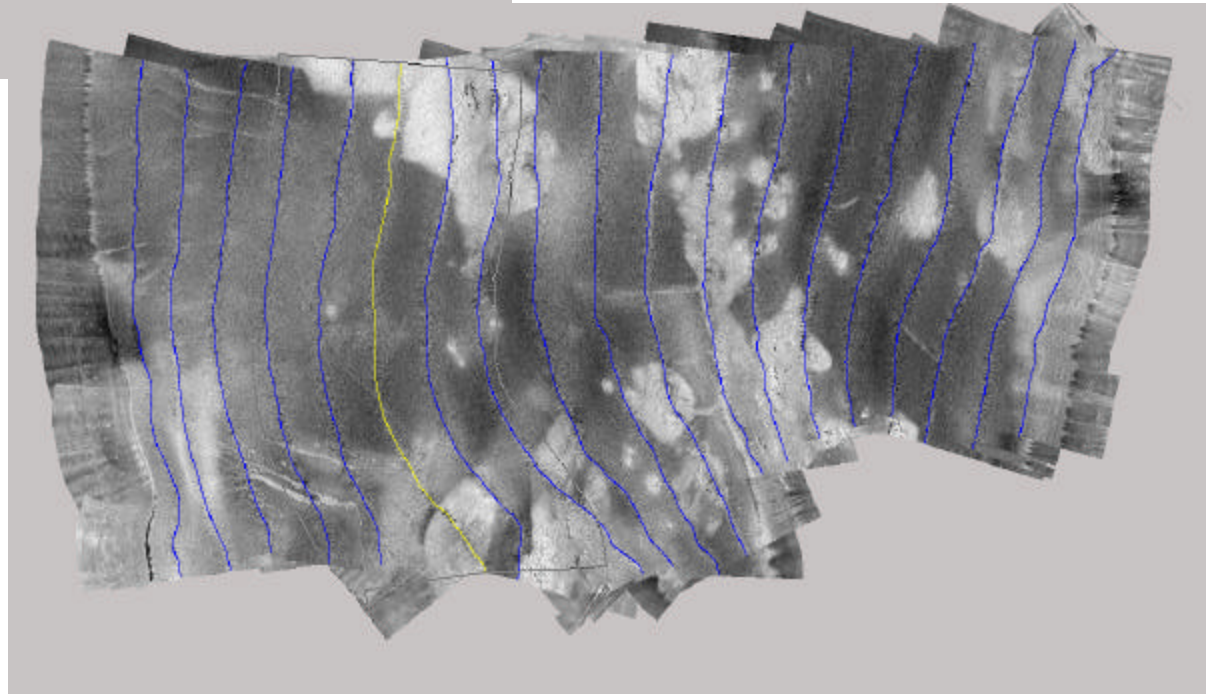
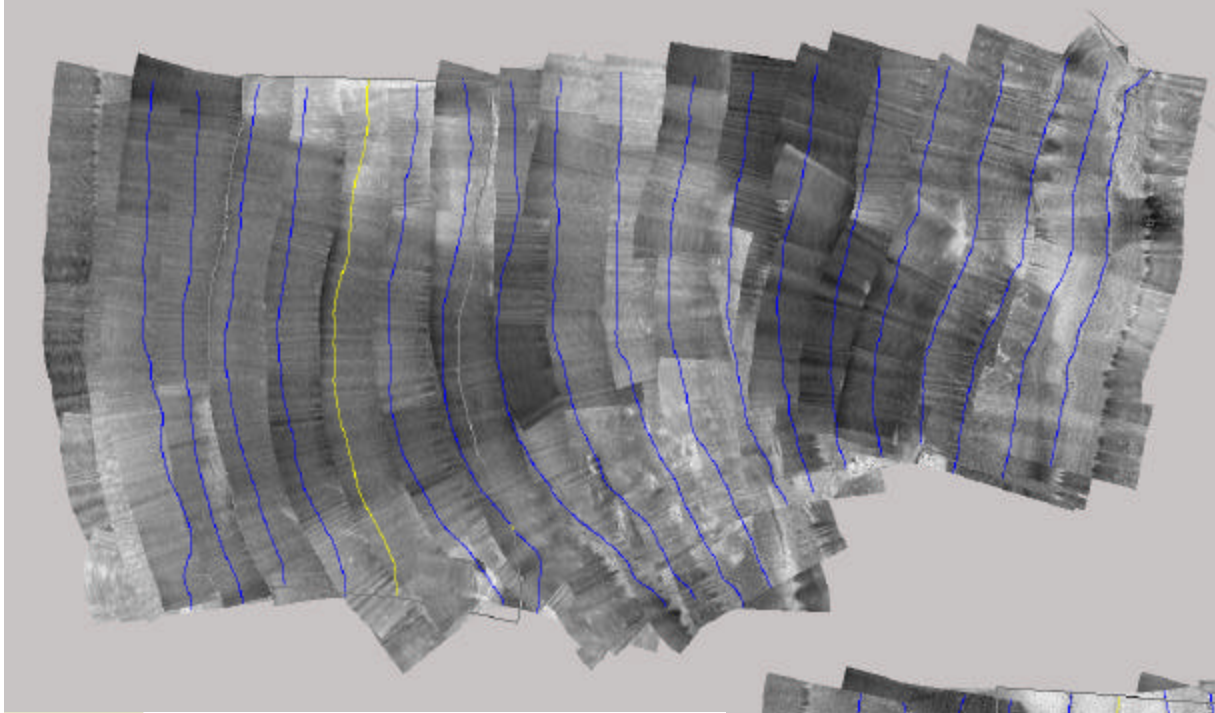
Overlapping and feathering

Reduce seam artifact between overlapping lines

- ✍ Based on a quality factor stored for each sample
- ✍ Buffer zone around the seam



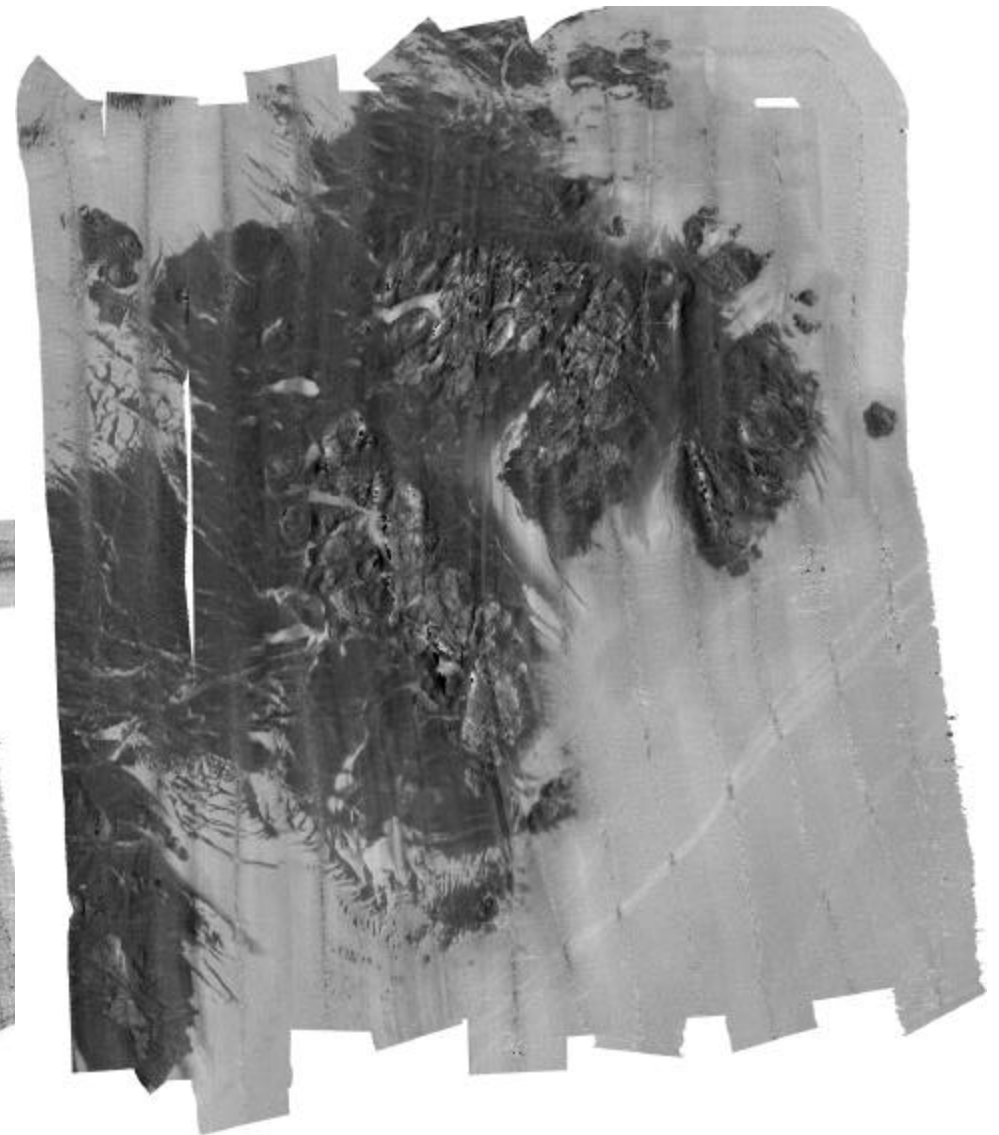
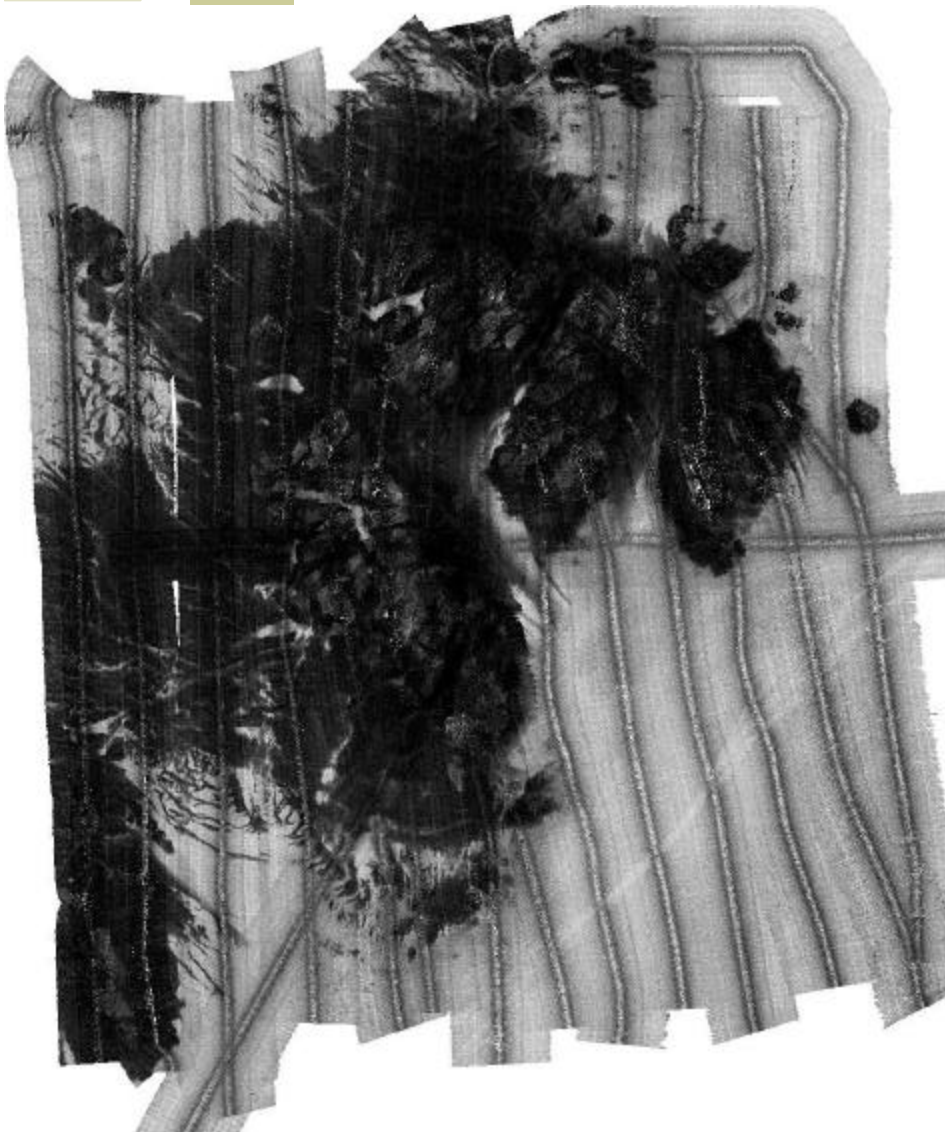
Mosaicking Technique





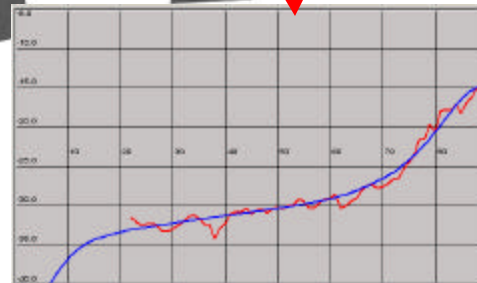
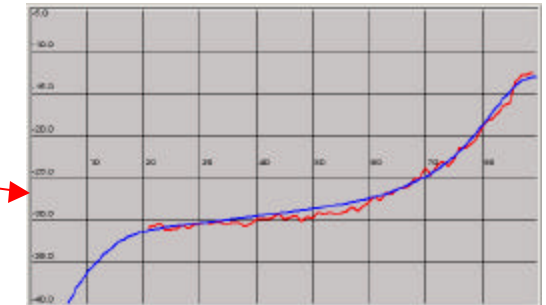
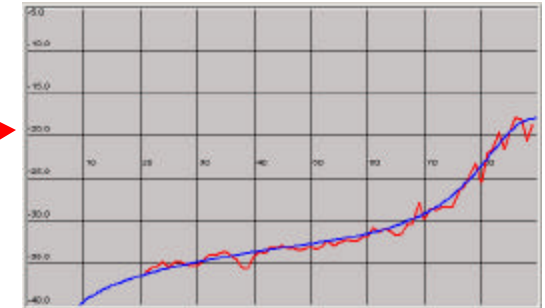
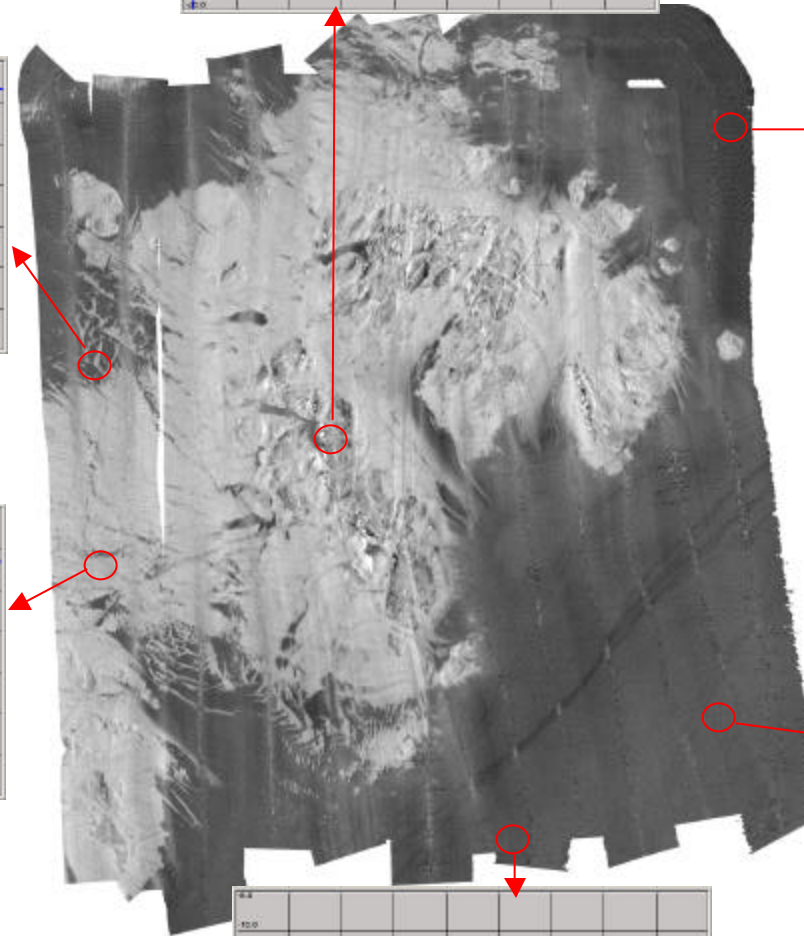
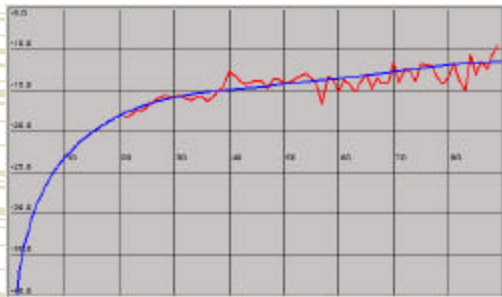
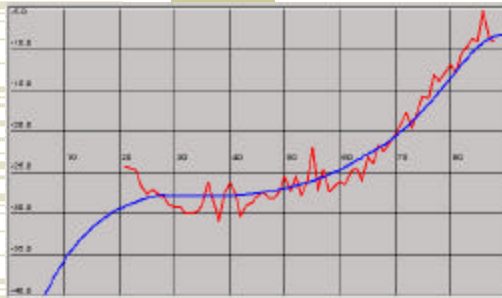
Stanton Bank

Acoustic Backscatter Mosaic



10/17/2006

INMARTECH-2006



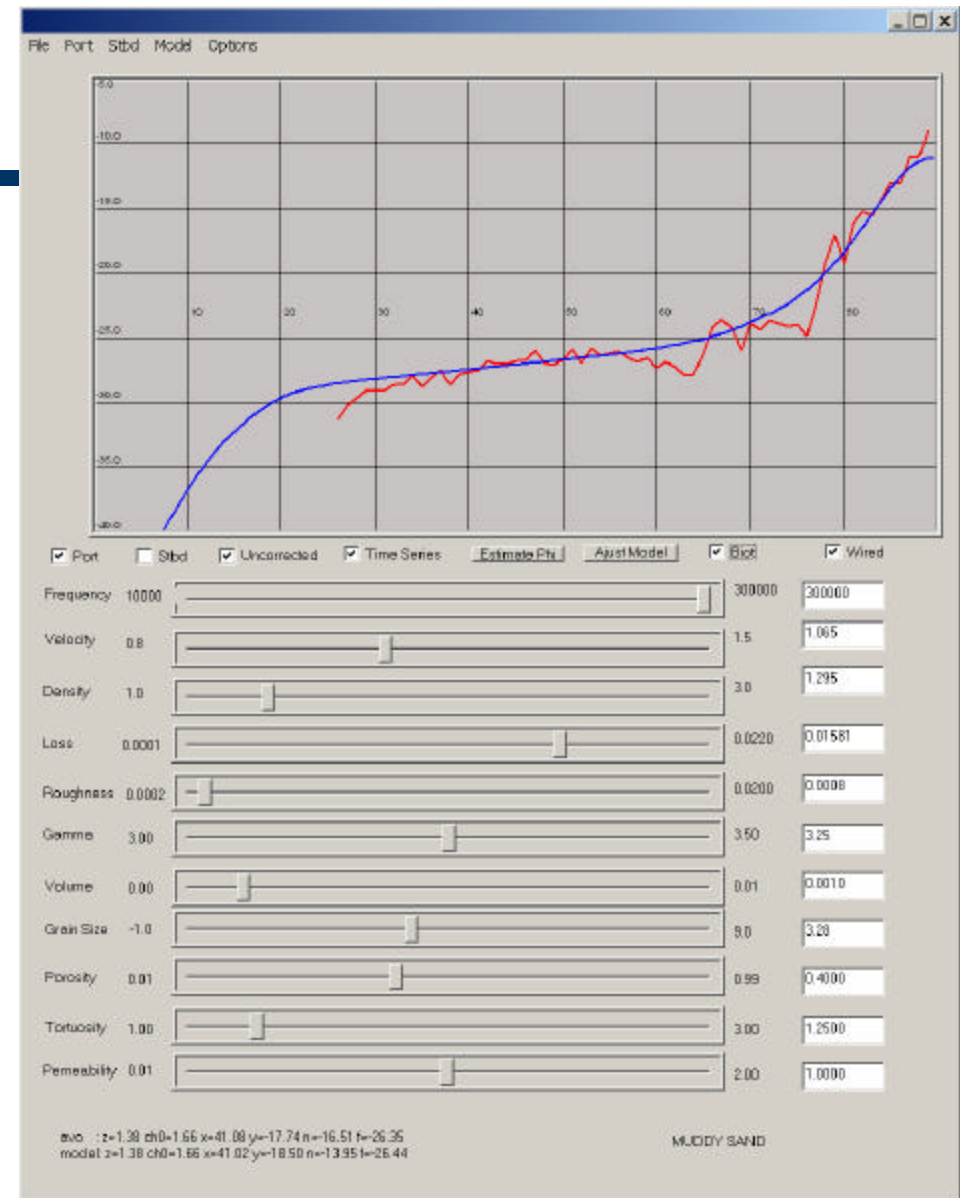
10/17/2006

INMARTECH-2006



2) Seafloor Characterization

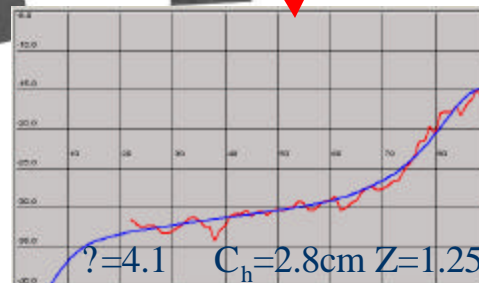
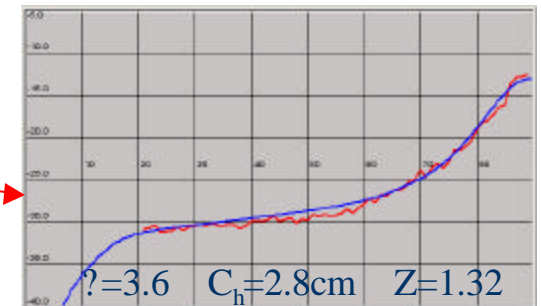
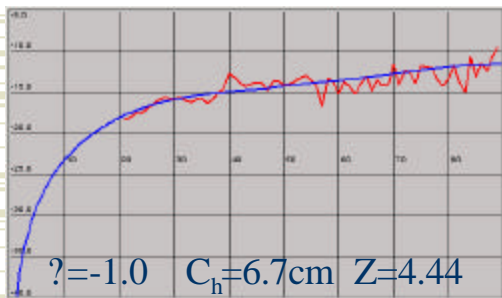
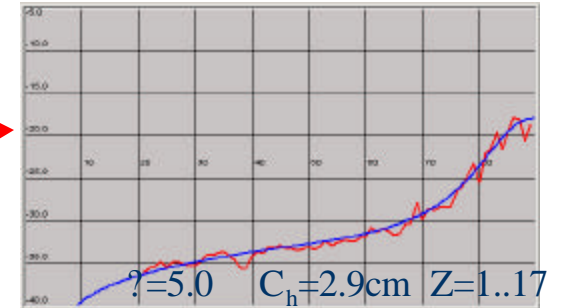
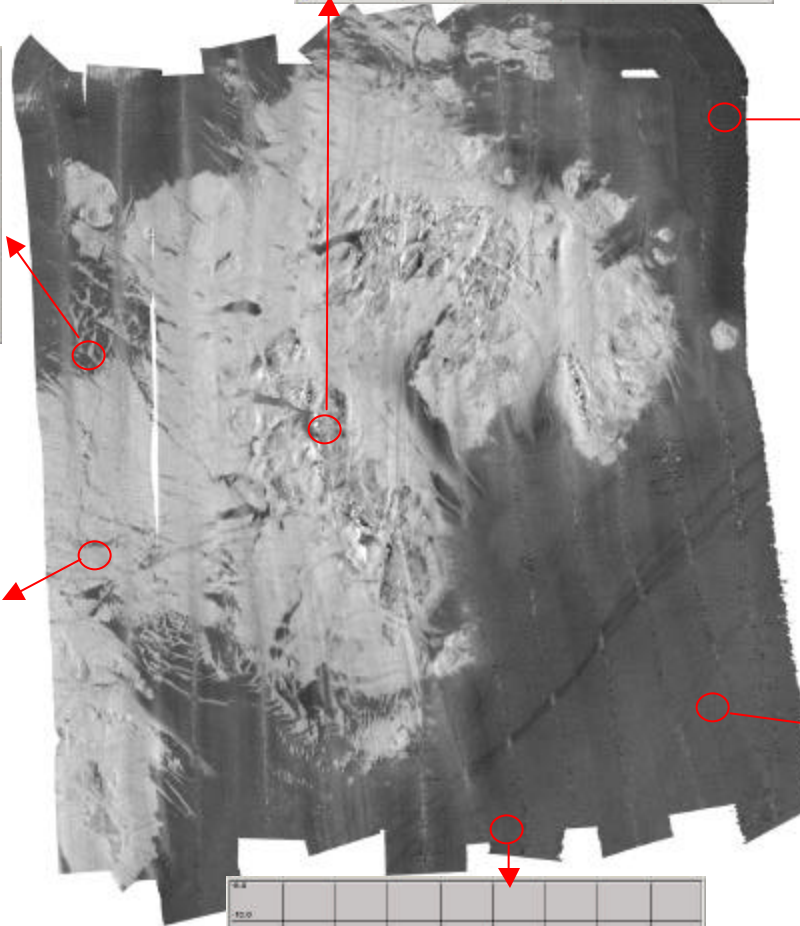
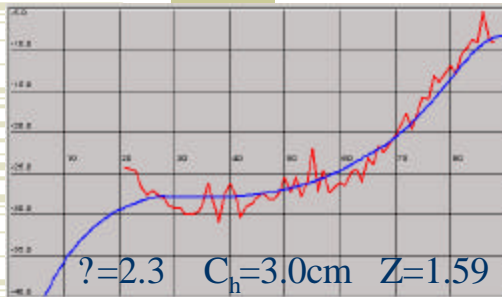
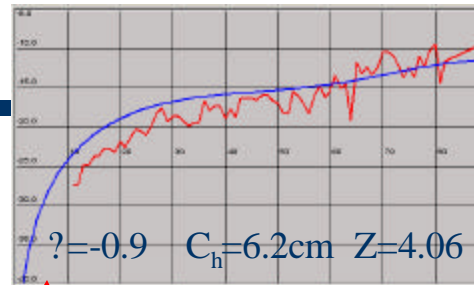
- Based on seismic reflection AVO, Linking the measured angular response to actual seafloor properties.
- Constrained Iterative Inversion of the a mathematical model
- Constraints based on Hamilton relations for sediment physical properties
- The inversion is regularized by the adjustment of the AVO parameters and not by the adjustment of the model parameter,





2) Seafloor Characterization

Modeling

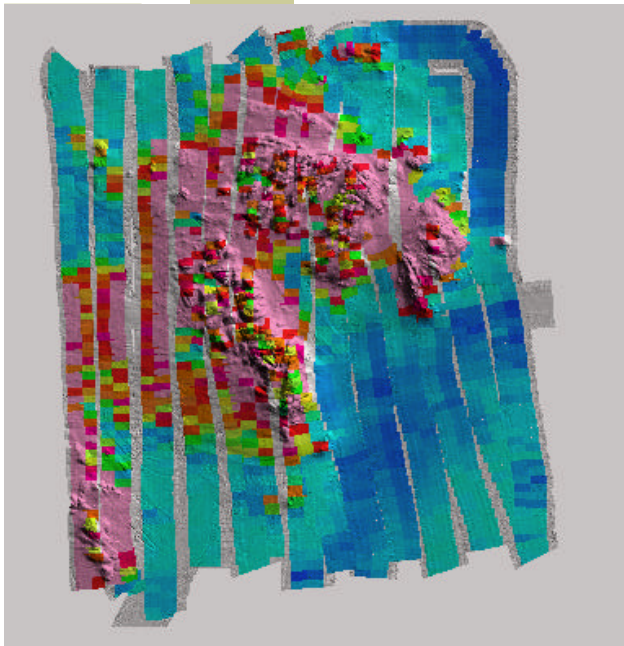


10/17/2006

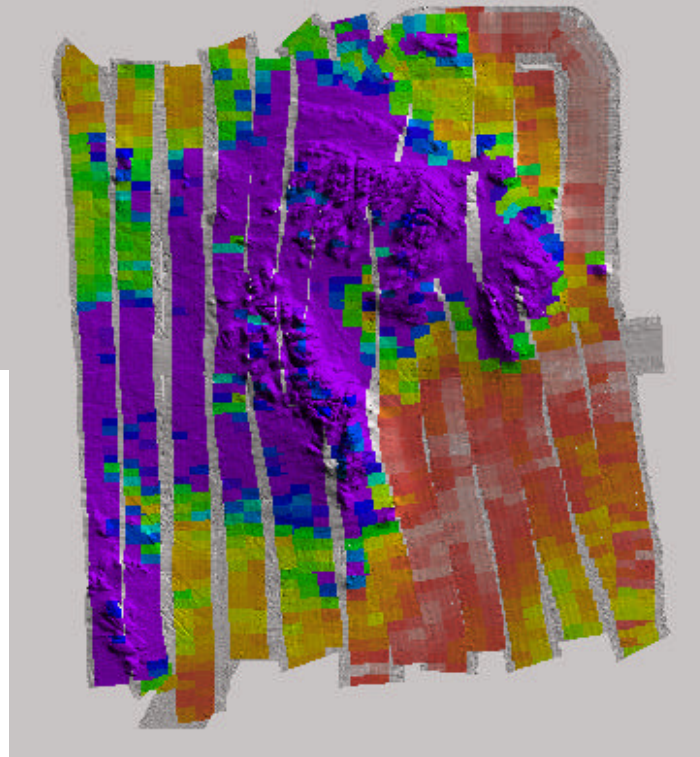
INMARTECH-2006



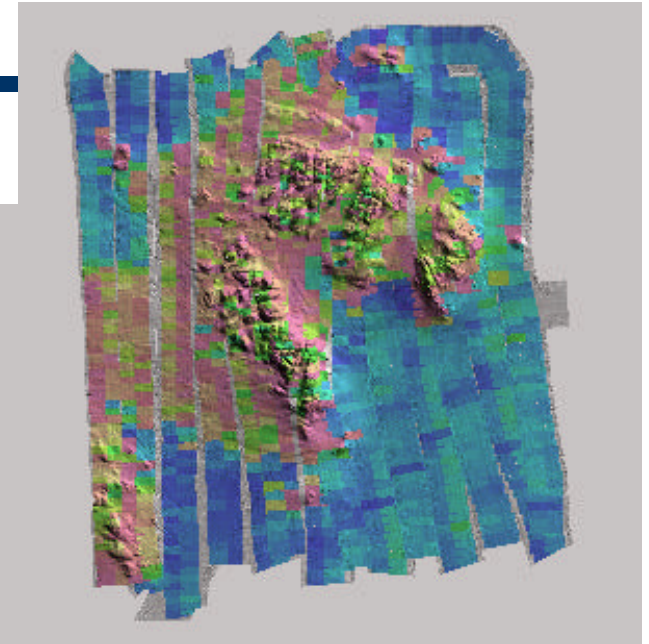
Inverted Properties



Impedance
[-1.08 , 4.46]



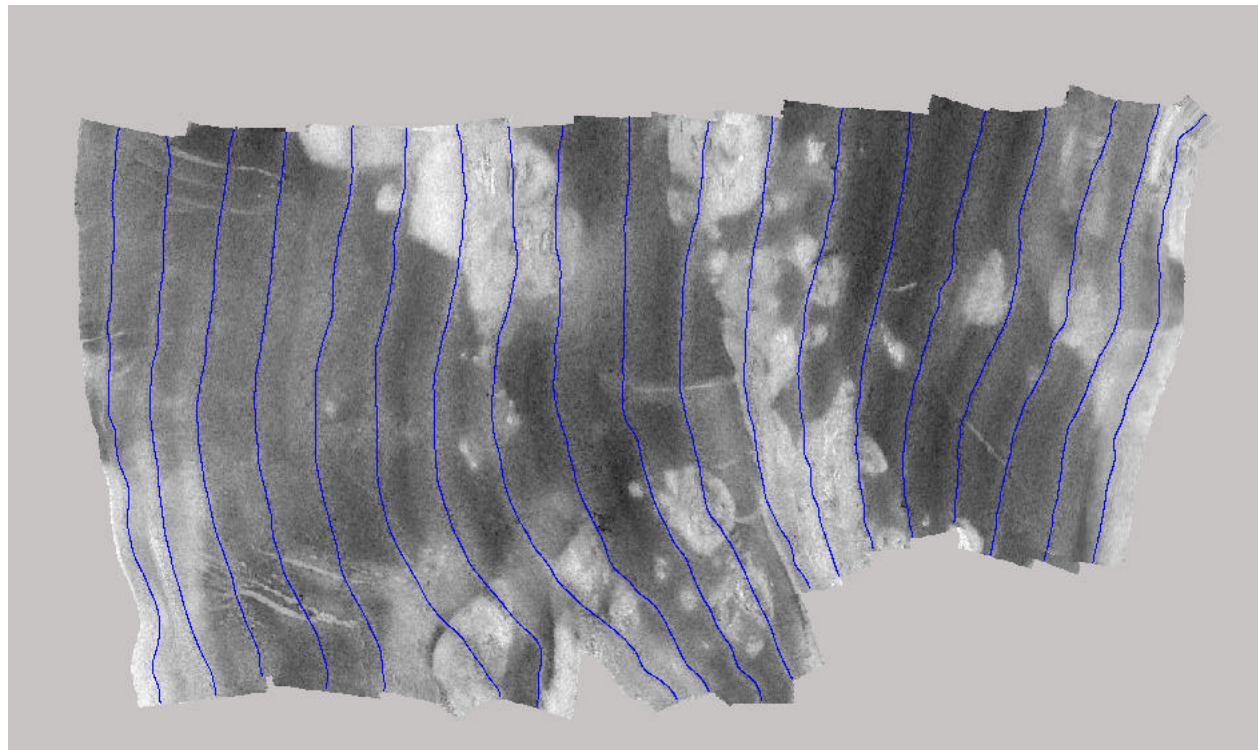
Grain Size (?)
[-1.0 , 5.2]



Roughness (cm)
[2.18, 6.71]



End

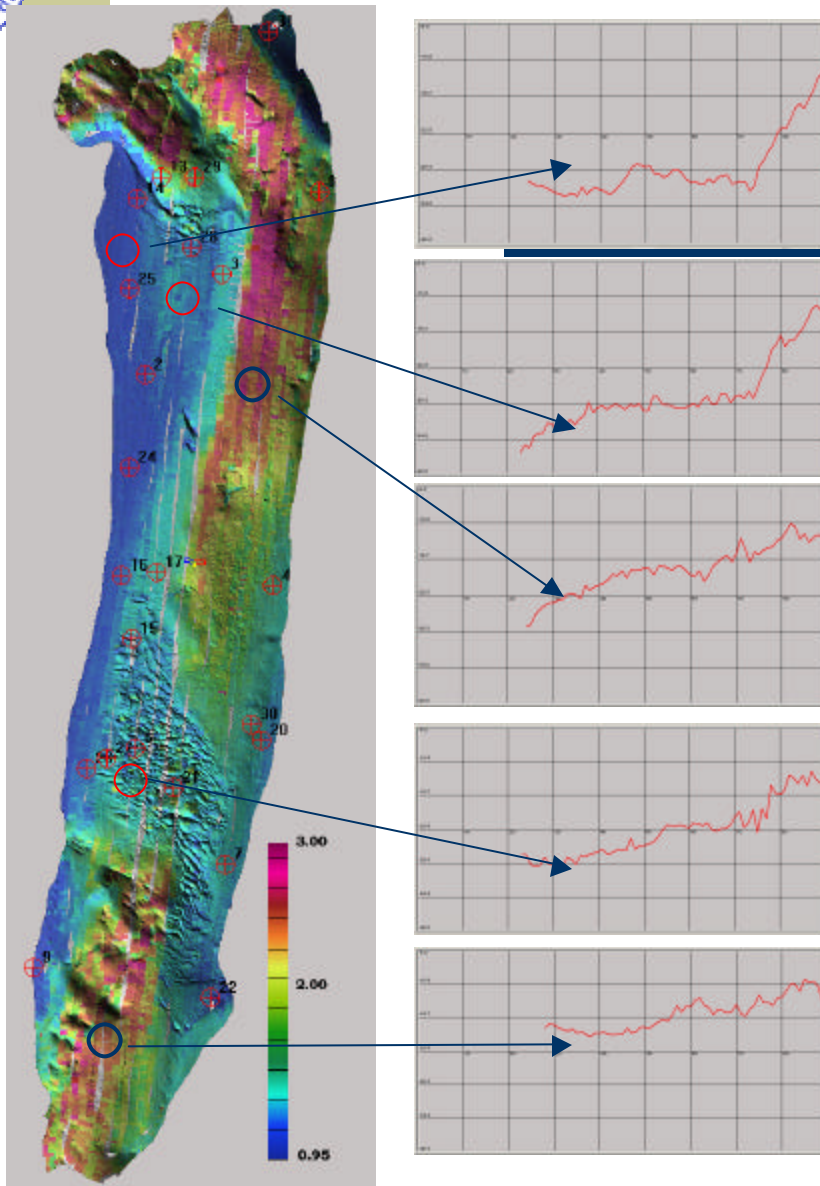




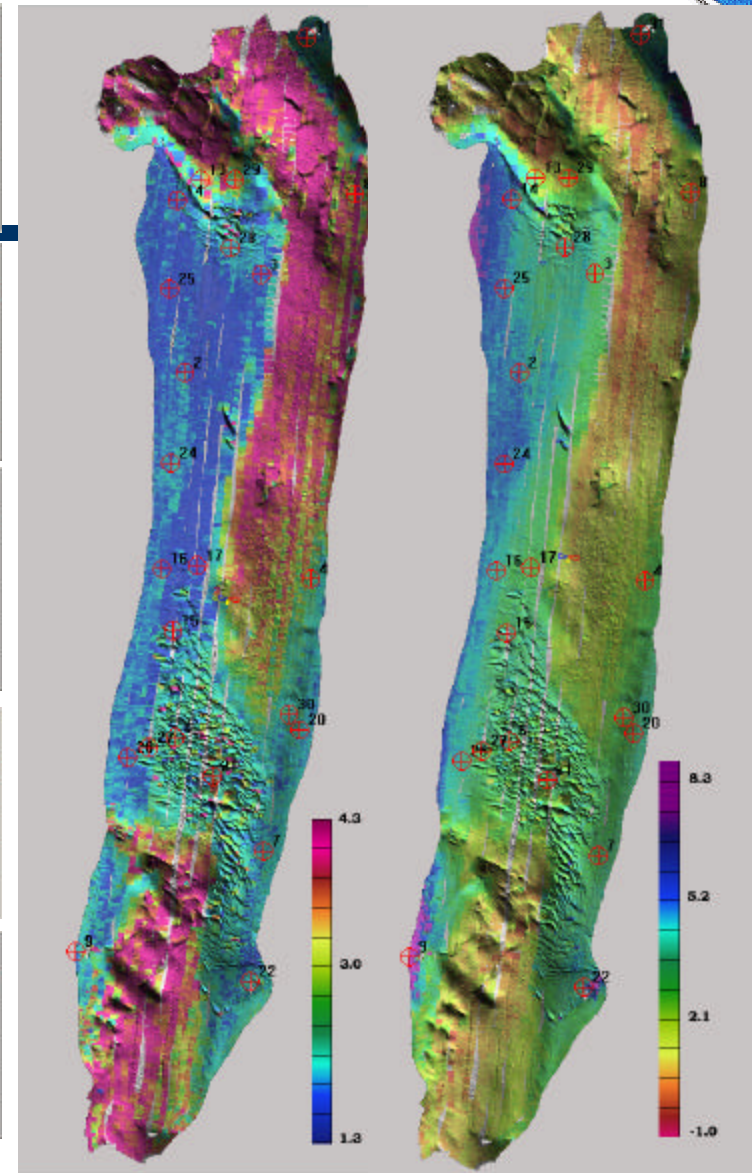
Inverted Properties



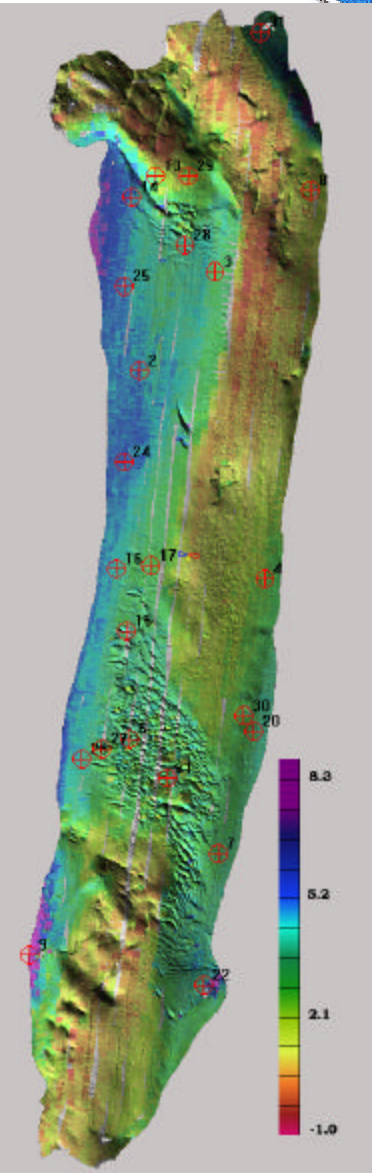
Impedance



Roughness



Grain Size



10/17/200

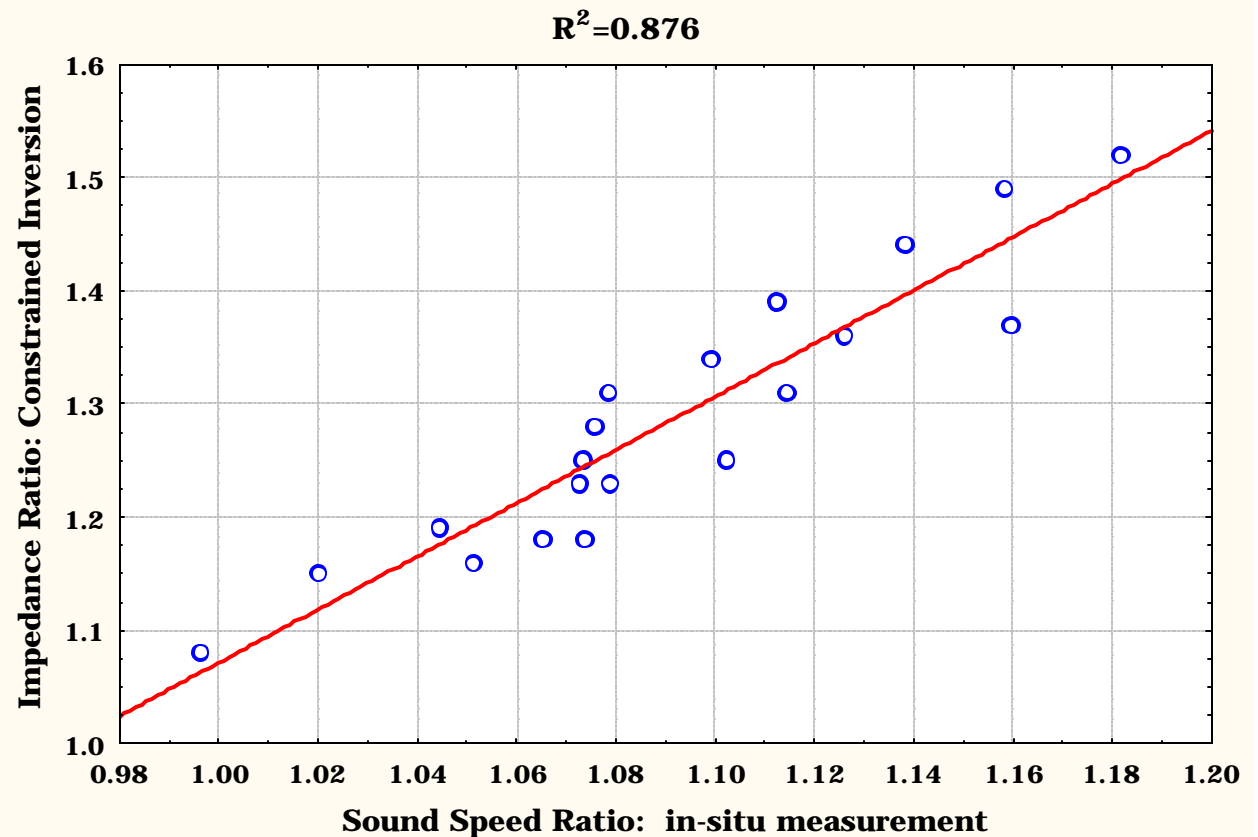
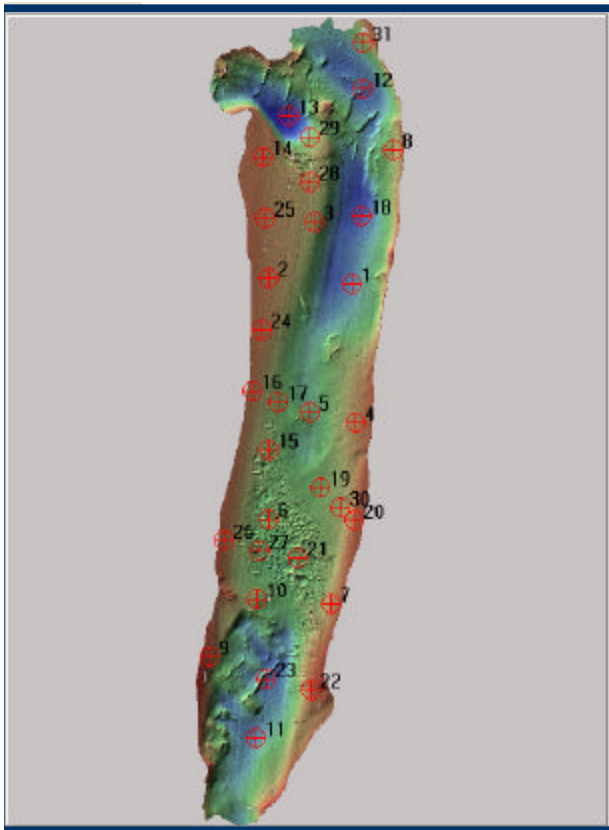
200 0 200 400 Meters

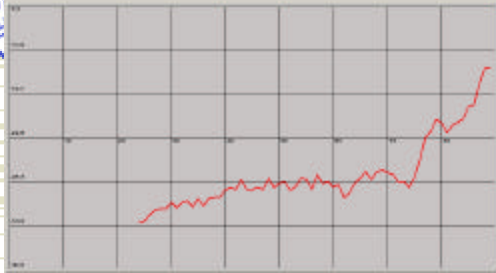


INMARTECH-2006

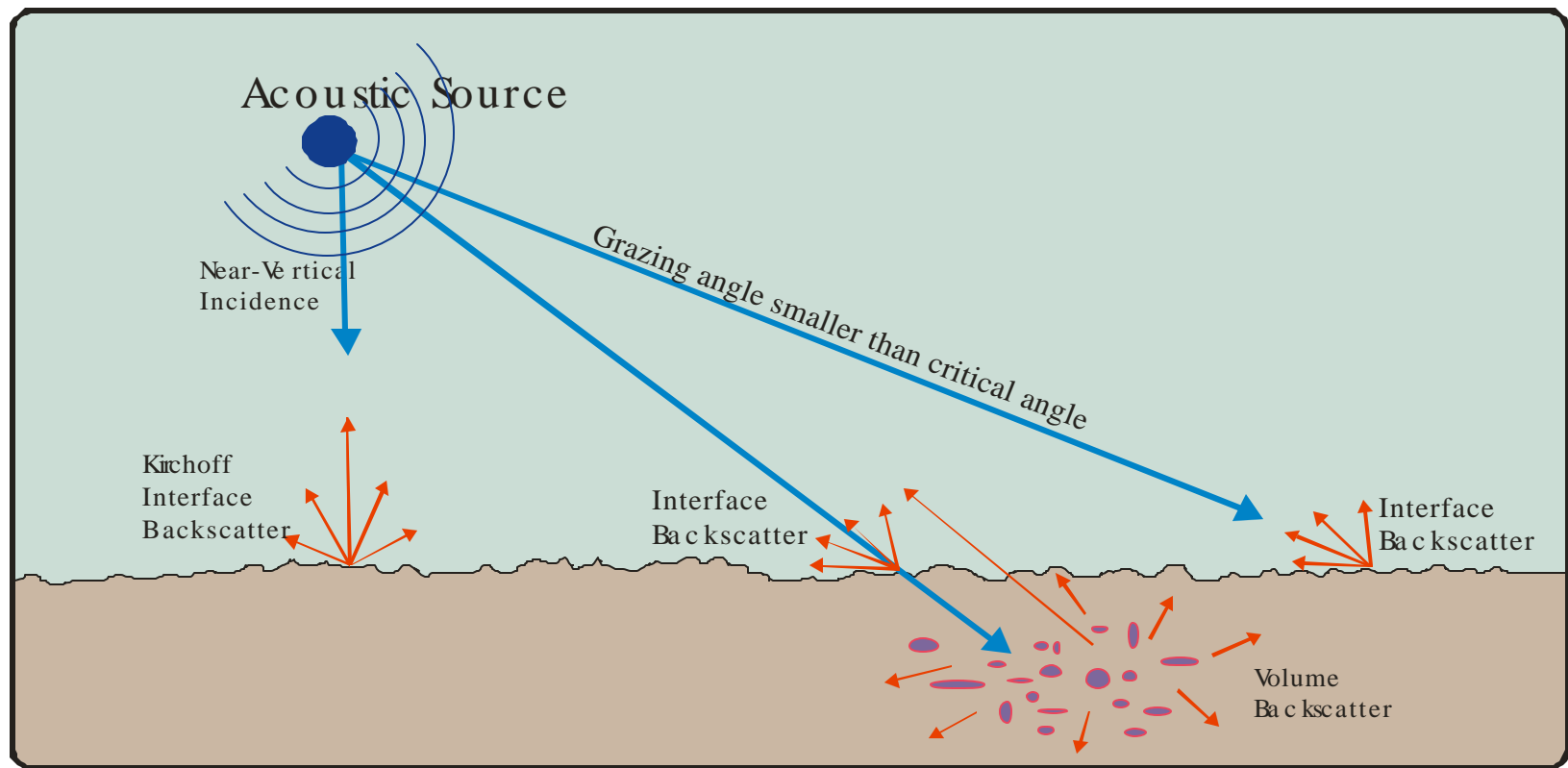


ISSAP In Situ Measurements and AVO Parameter



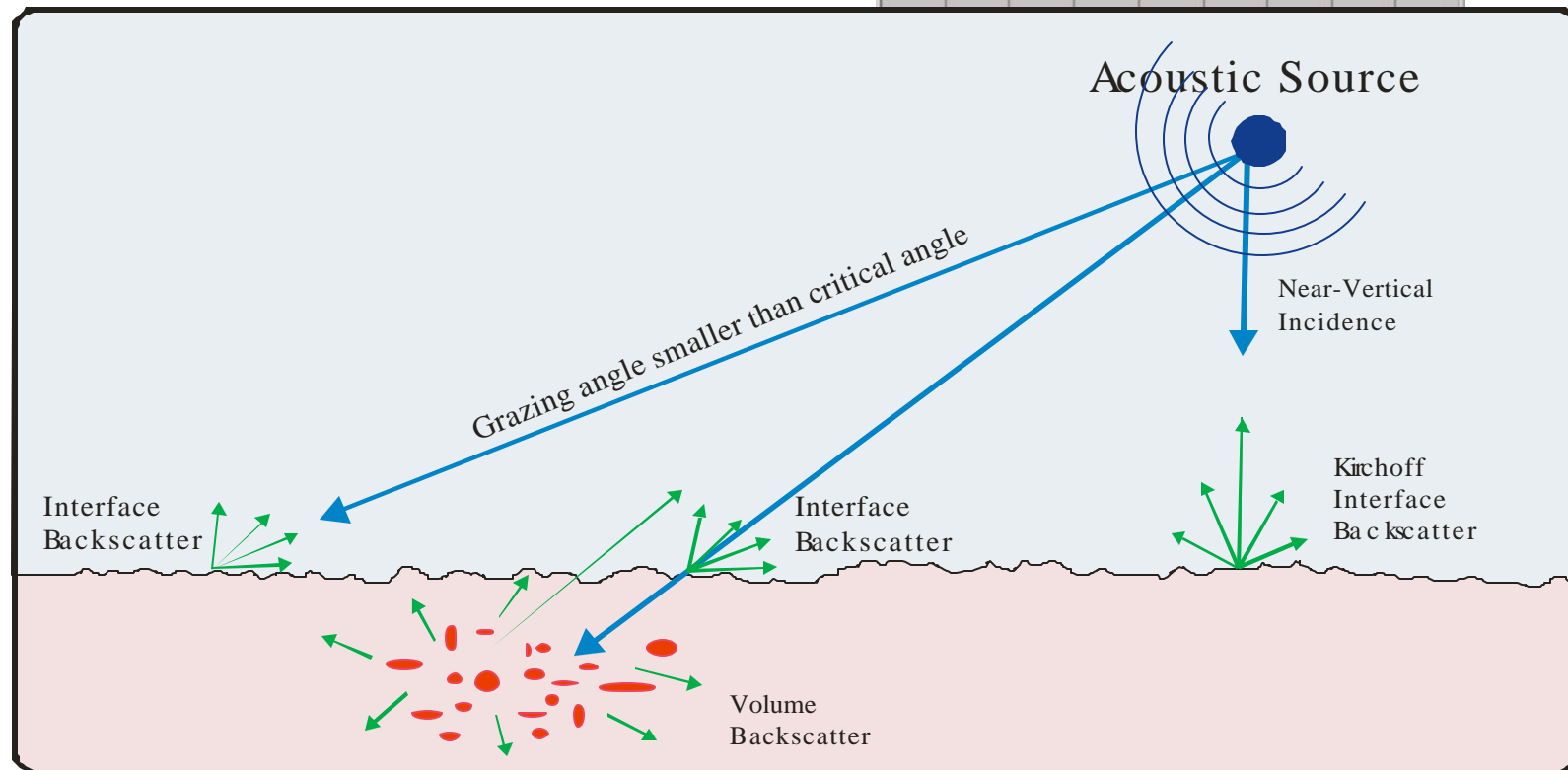
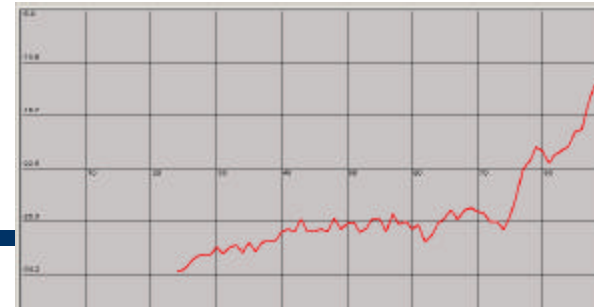


→ Acoustic Backscatter Model



- ✍ *Acoustic Impedance*
- ✍ *Roughness*
- ✍ *Volume Scatter*

Angular Response



✎ *Acoustic Impedance*

✎ *Roughness*

✎ *Volume Scatter*



Total Backscattering Cross Section

$\sigma_t(\theta)$ per unit solid angle, per unit area

$$\sigma_t(\theta) = R^2 \frac{I_s}{I_0 A}$$

θ - Grazing angle

R - Slant range

I_0 - Source intensity (db re 1 μ Pa/m)

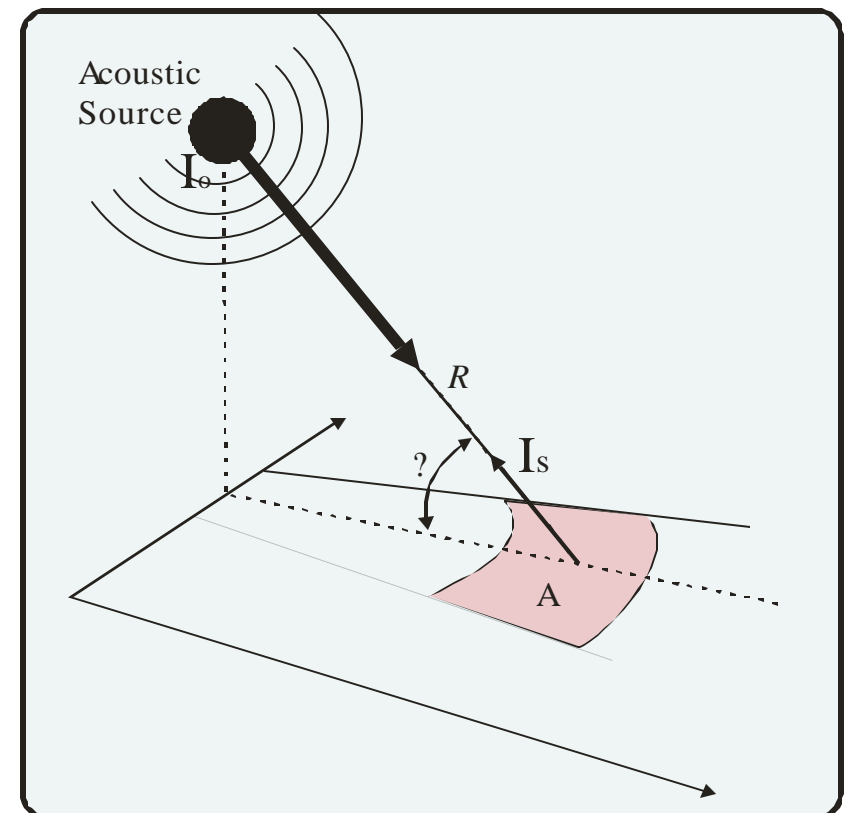
I_s - Backscattering intensity

$$A = \frac{c \cdot \tau \cdot R \cdot \theta_a}{2 \cdot \cos(\theta)}$$

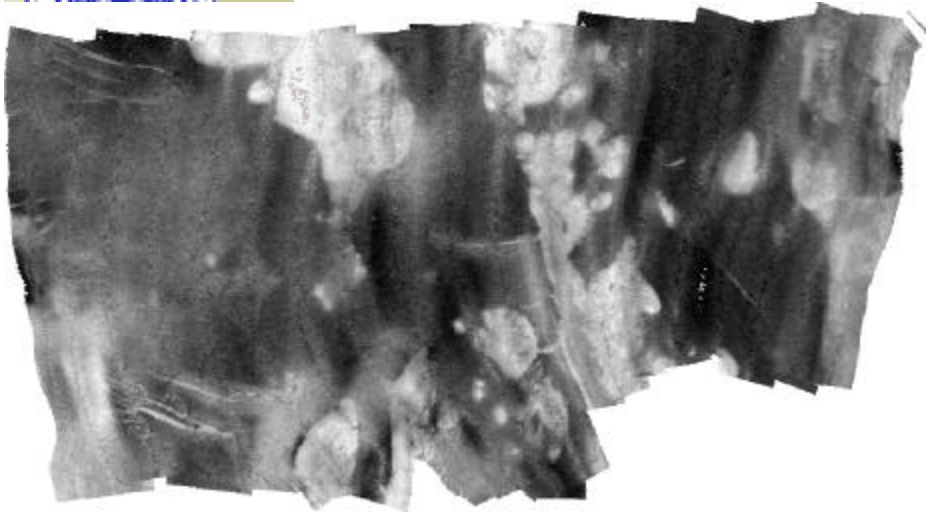
c = Sound speed

τ = pulse length

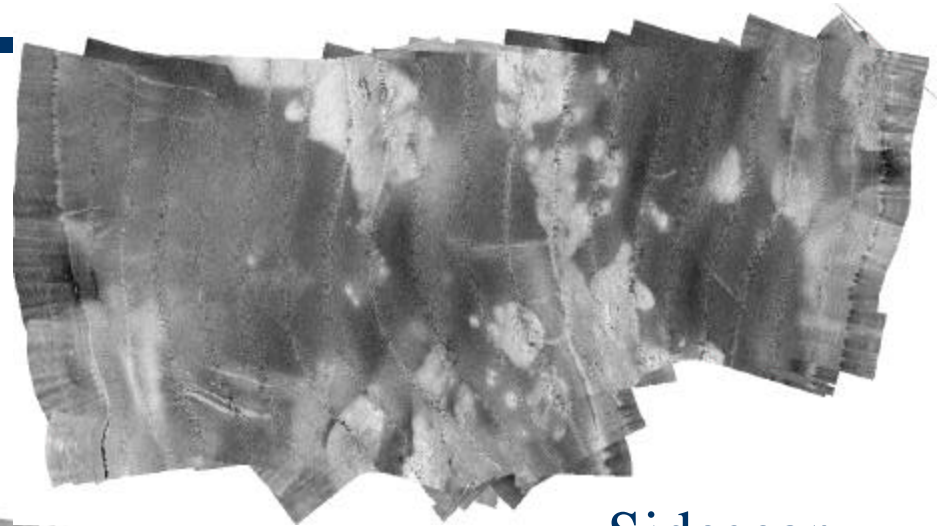
θ_a - Along track beam width



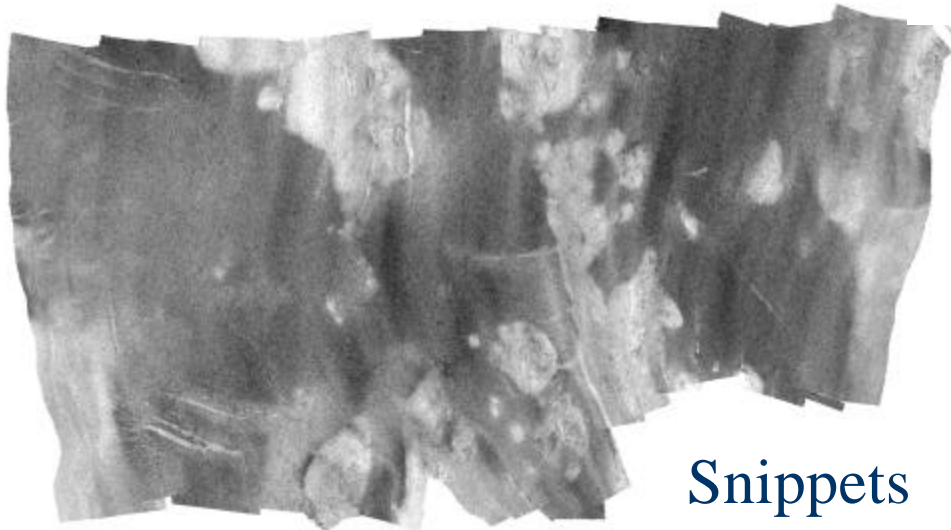
Different Backscatter Measurements



Beam Average



Sidescan



Snippets