Università di Trieste
Corso di Laurea in Geologia

Anno accademico 2018-2019

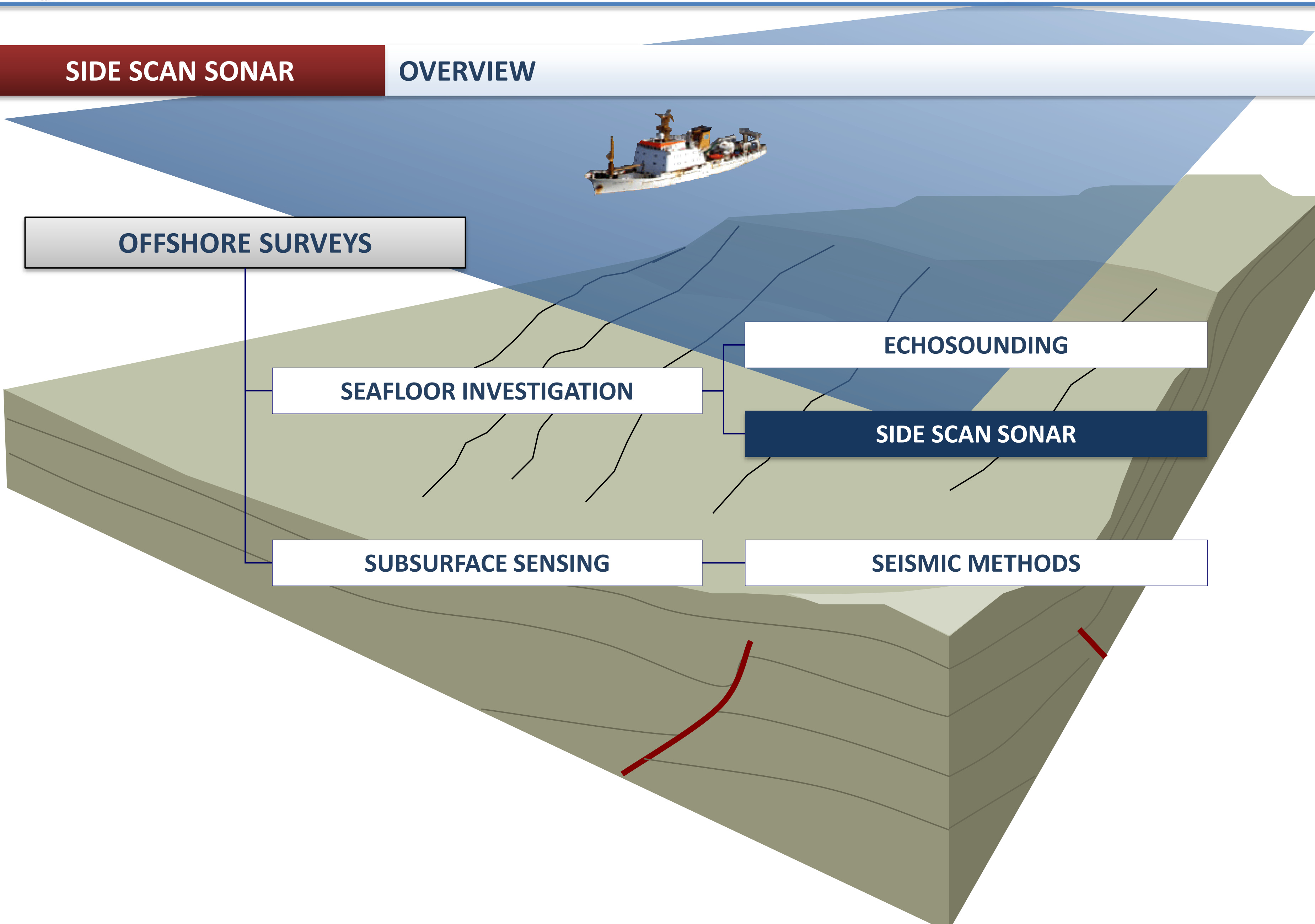
Geologia Marina

Parte I

Modulo 2.1 **S**ide **S**can **S**onar

Docente
Fabrizio Zgur

SIDE SCAN SONAR | OVERVIEW



SIDE SCAN SONAR OVERVIEW

IT IS USED FOR

SSS reveals information about sea floor composition by taking advantage of the different sound **absorbing** and reflecting characteristics of different materials. Strong reflectors (rock, biogenic structures, metals) create strong echoes, while weak reflectors (silt, clay) create weaker echoes. Reporting the **strength of echoes** is essentially what a sidescan sonar is designed to do.

HOW IT WORKS

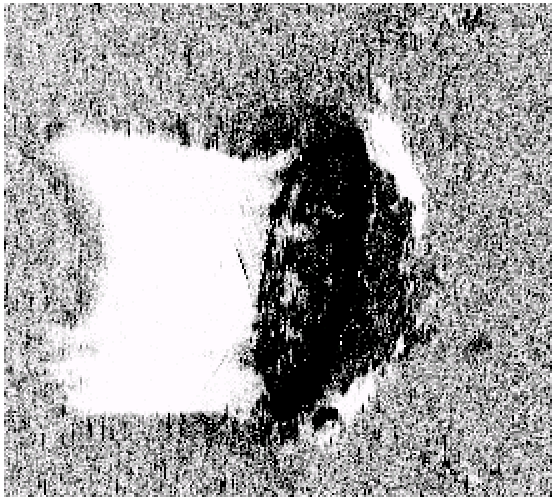
Pulses are transmitted using a projector (or array of projectors), and hydrophones receive echoes of those pulses from the ocean floor and pass them to a receiver system. Where sidescan sonar differs from a depth-sounding system is in the way it processes these returns.

SIDE SCAN SONAR — USES AND OBJECTIVES

ENVIRONMENT AND SOCIETY

Navigation charts

- Objects detection and mapping
  mines, wrecks (ships, aircrafts), pipeline, lost cargos (containers, scientific equipment)
- Search and recovery
- Submarine infrastructures inspection
  wellhead, pipelines, etc.
- Pre / Post dredge surveys



ACADEMIC

Marine Geology and Biology

- Seafloor classification
  rocks, very coarse sediment, coarse and fine sediment.
- Study of benthic habitats

INDUSTRY

Foundation studies for offshore infrastructures

- Cable surveys
- Well site surveys

SIDE SCAN SONAR — USES AND OBJECTIVES

WHAT KIND OF INFORMATION WE CAN (OR CAN NOT) GET

No depth information. Use a single beam or multibeam sonar for that.

Information about targets on the seafloor
position and height above the bottom

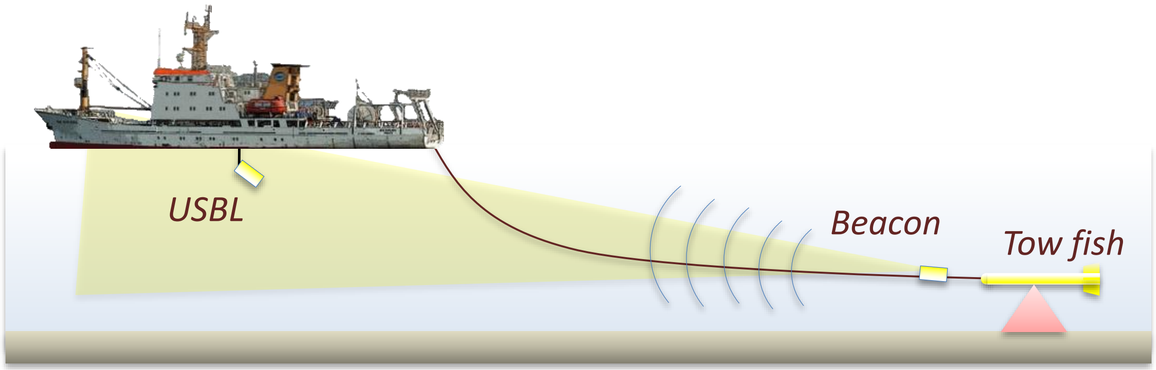
Real time information about the height of the fish above the bottom

It can be used for seafloor classification

It has a swath that is not depth dependent (like a multibeam)

SIDE SCAN SONAR

POSITIONING OF TOWED SYSTEMS

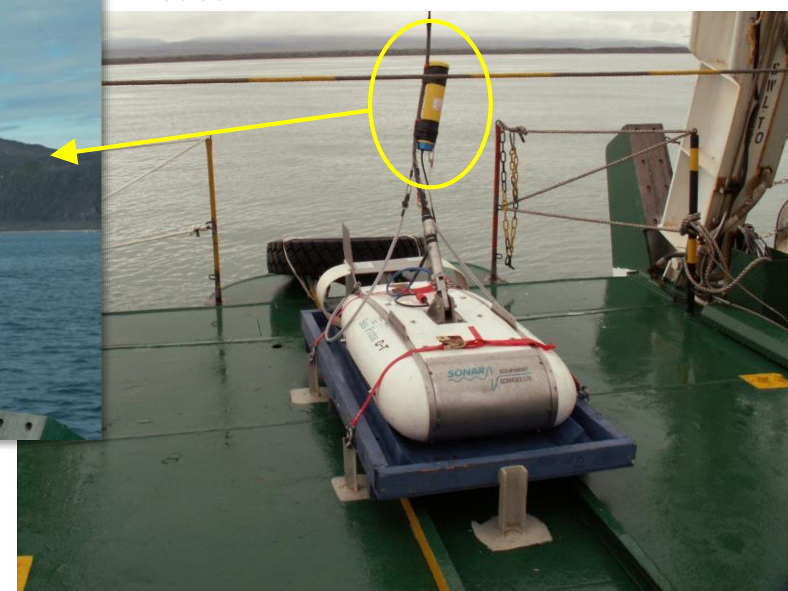


HOW IT WORKS

The beacon (transponder) emits a pulse at constant time interval. The pulse is detected by the USBL (responder) that is mounted on a pole immersed in the water.
The USBL recognizes precisely both the position and the depth.

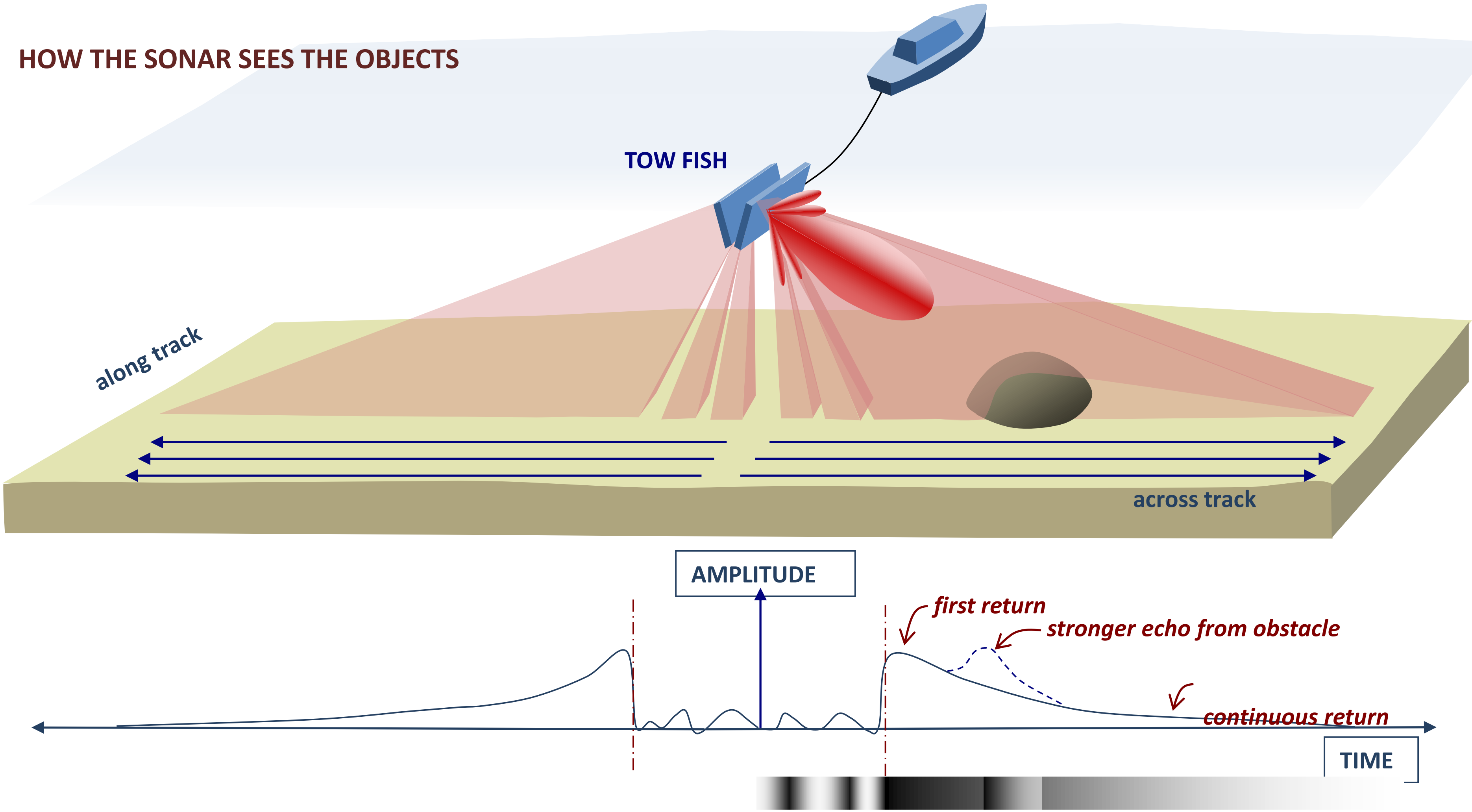
USBL (Ultra Short Base Line)

Beacon



SIDE SCAN SONAR FUNDAMENTALS

HOW THE SONAR SEES THE OBJECTS



SIDE SCAN SONAR | SLANT RANGE CORRECTIONS

Raw SSS data do not represent real distances. Two type of corrections must be applied

ALONG TRACK CORRECTION

Each single beam is represented by an along track direction. The actual distance between beams depend on:

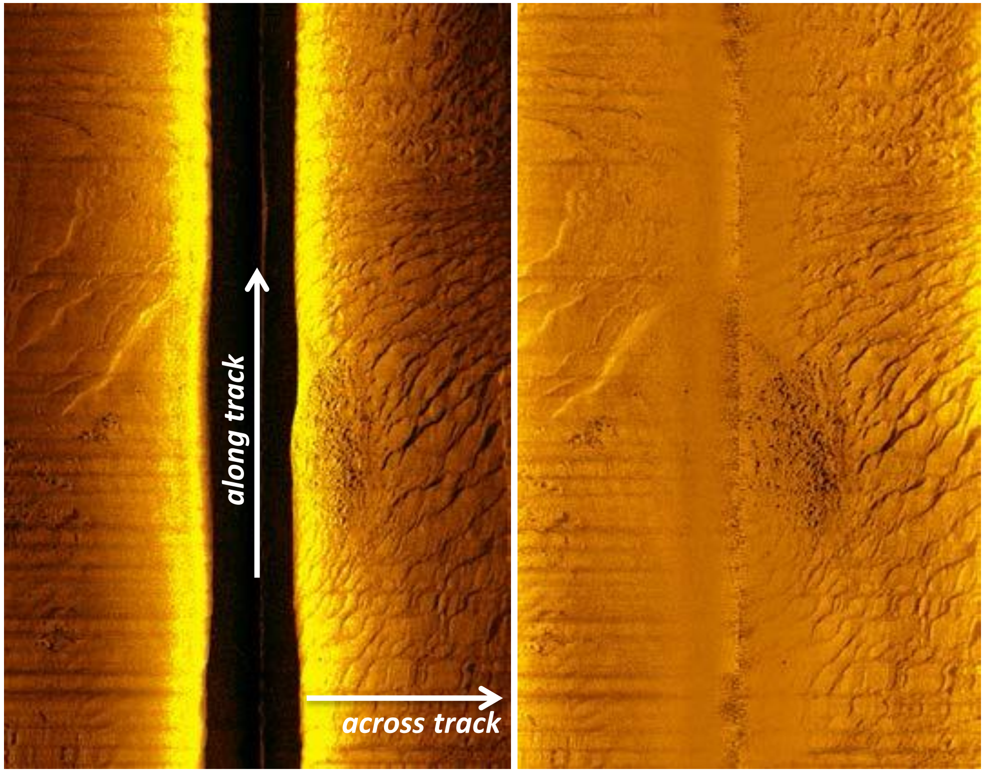
- the speed of the towed fish (or the vessel itself)
- the ping rate (time interval between two pings)

This correction is usually applied automatically by the software, that is interfaced to the navigation system, and is thus provided with real time positioning.

ACROSS TRACK CORRECTION

The system records two way time backscattered data, whose arrival times depend on the sound speed in the water. The objects on the sea bottom result deformed in the across track direction because of travel times increasing with range. The across track correction must thus remove the effect of the different travel times.

BEFORE CORRECTIONS **AFTER CORRECTIONS**



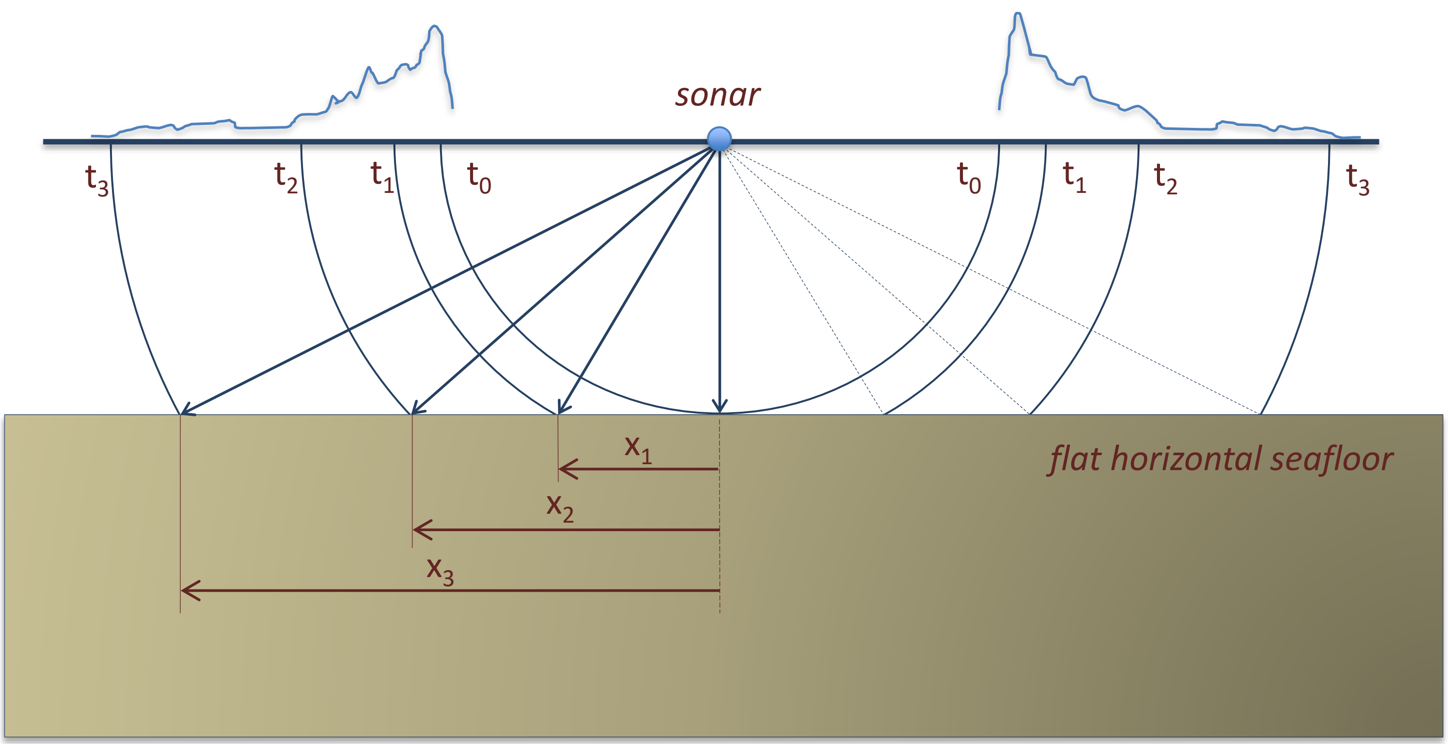
(Pinhero et al. 2011, modified)

SIDE SCAN SONAR

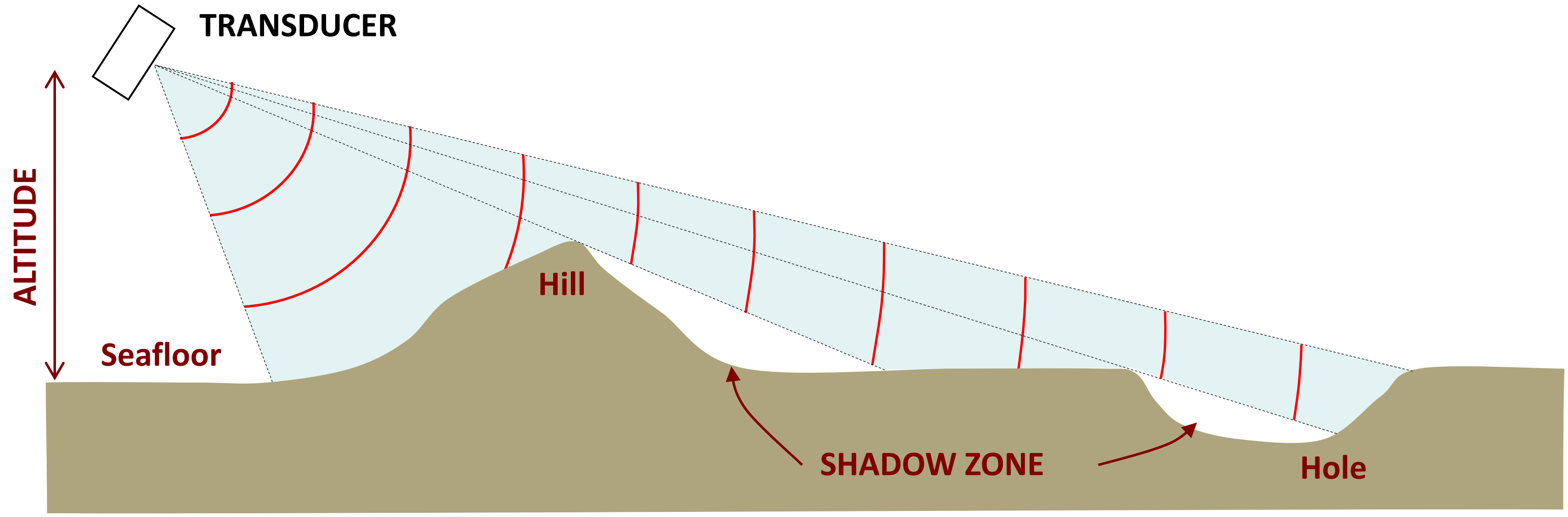
SLANT RANGE TO HORIZONTAL RANGE

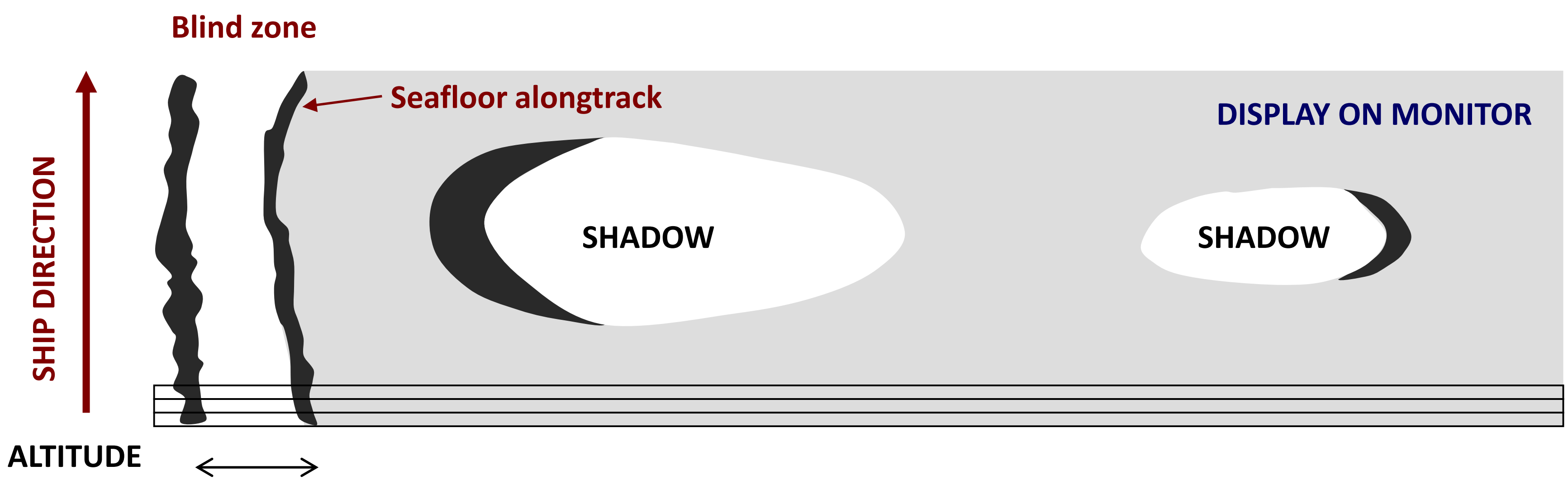
measured one-way travel time t (s) → slant ranges $R_i = c\ t_i$ (m) with c = speed of sound (m/s)

range of first bottom echo $R_0 = c\ t_0$ → horizontal ranges $x_i = c\ (t_i^2 - t_0^2)^{1/2}$



SIDE SCAN SONAR FUNDAMENTALS





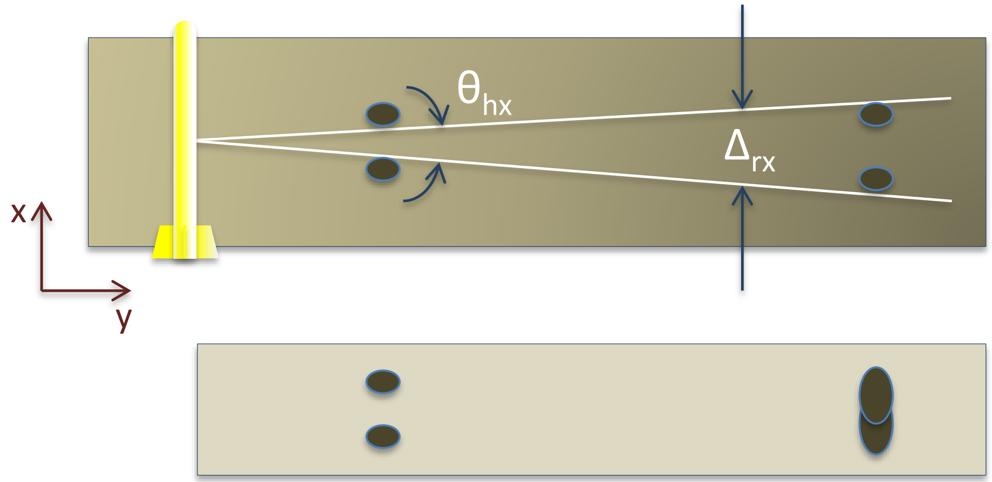
SIDE SCAN SONAR | ALONG TRACK RESOLUTION

DEFINITION

The resolution is defined as the minimum distance between two detected objects that can be distinguished as separated entities in the sonar image.
In the along-track direction, Δ_{rx}, measures the resolution parallel to the line of travel. It is controlled by:

- the azimuthal beamwidth θ_{hx} of the aperture
- the range, R

$$\Delta_{rx} = \theta_{hx} R$$



Seabed display

When targets in the far field are inside the angular resolution of the sonar, they become indistinguishable and look as a single object.
At the near field, these objects can be distinguished.

Δ_{rx} degrades with distance to the transducer

objects in the far field cannot be distinguished

SIDE SCAN SONAR — ACROSS TRACK RESOLUTION

DEFINITION

The across-track resolution is defined as the minimum distance between two objects perpendicular to the line of travel that can be distinguished as separated entities in the sonar image.

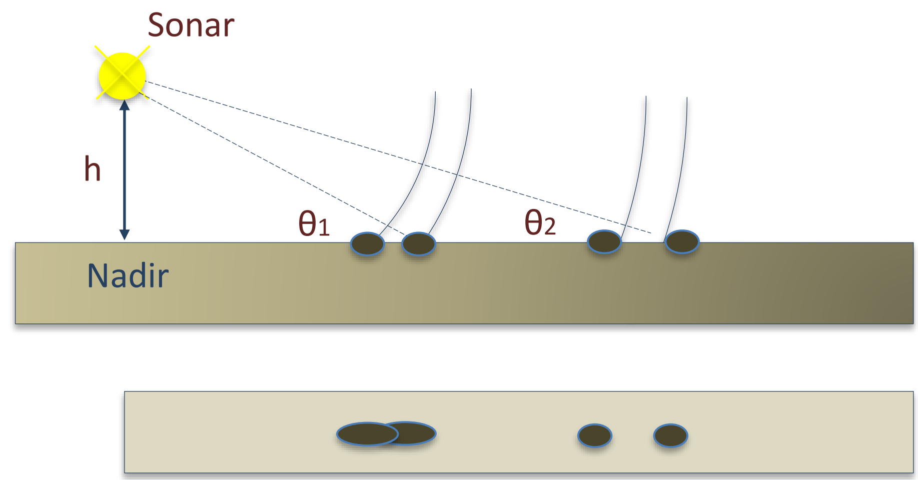
The range resolution is controlled by the signal Bandwidth (Bw = 1 / T)

$$\Delta_{ry} = , (T\ c / 2)\ \sec\theta_n$$

If two objects are too close, they will appear as one on the sidescan record. Getting these objects further apart will show them as independent objects. How close can they be? Half the pulse length.

Example

A 500khz system has a pulse length of 1.5 cm.



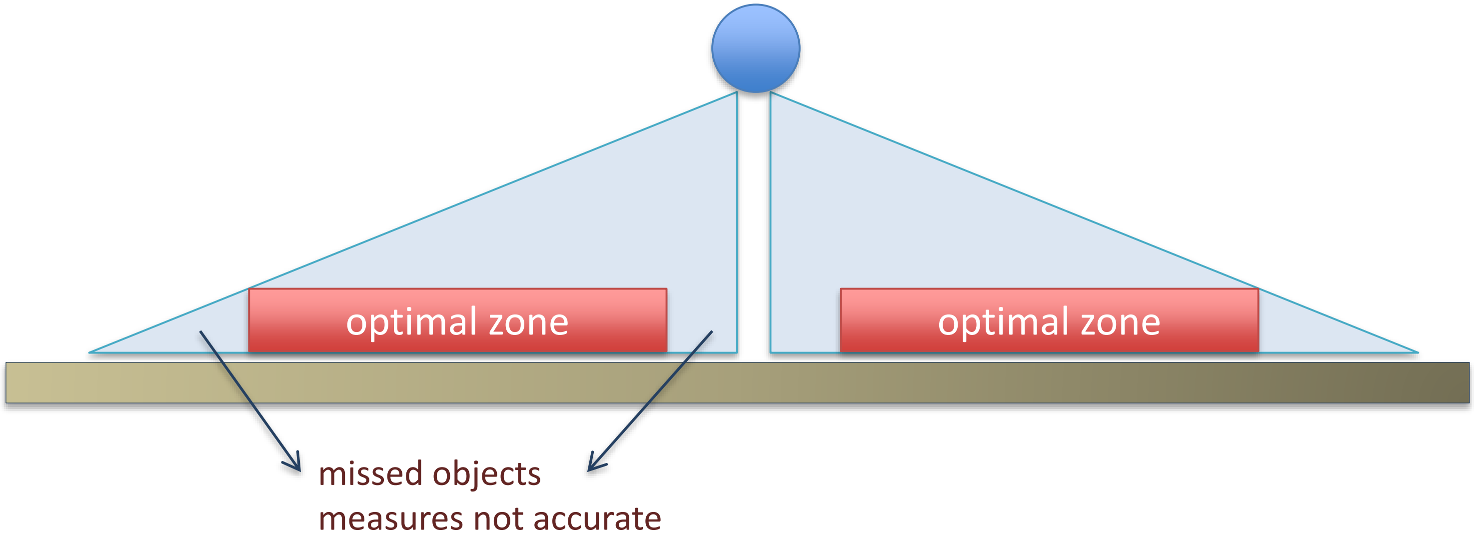
Seabed display

Δ_{ry} degrades approaching the transducer

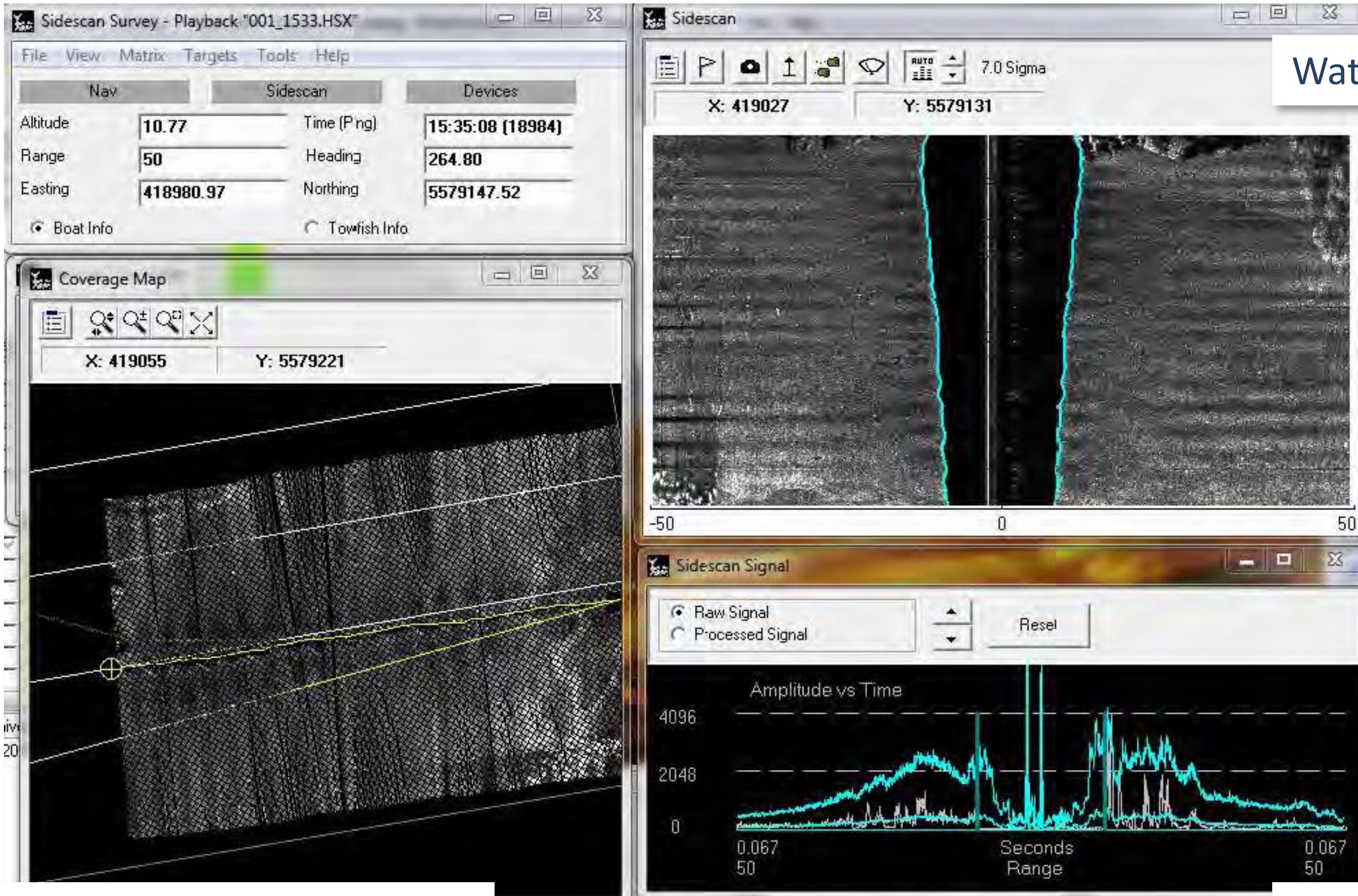
objects in the near field cannot be distinguished

SIDE SCAN SONAR — THE OPTIMAL ZONE OF OPERATION

Looking at both the near field and far field constraints, as well as maximizing the best seen area, the sonar will work best in the region of the Optimal Zone of Operation (OZO)



SIDE SCAN SONAR — AN ACQUISITION SESSION



Waterfall

Coverage map (real time mosaic)

Signal window

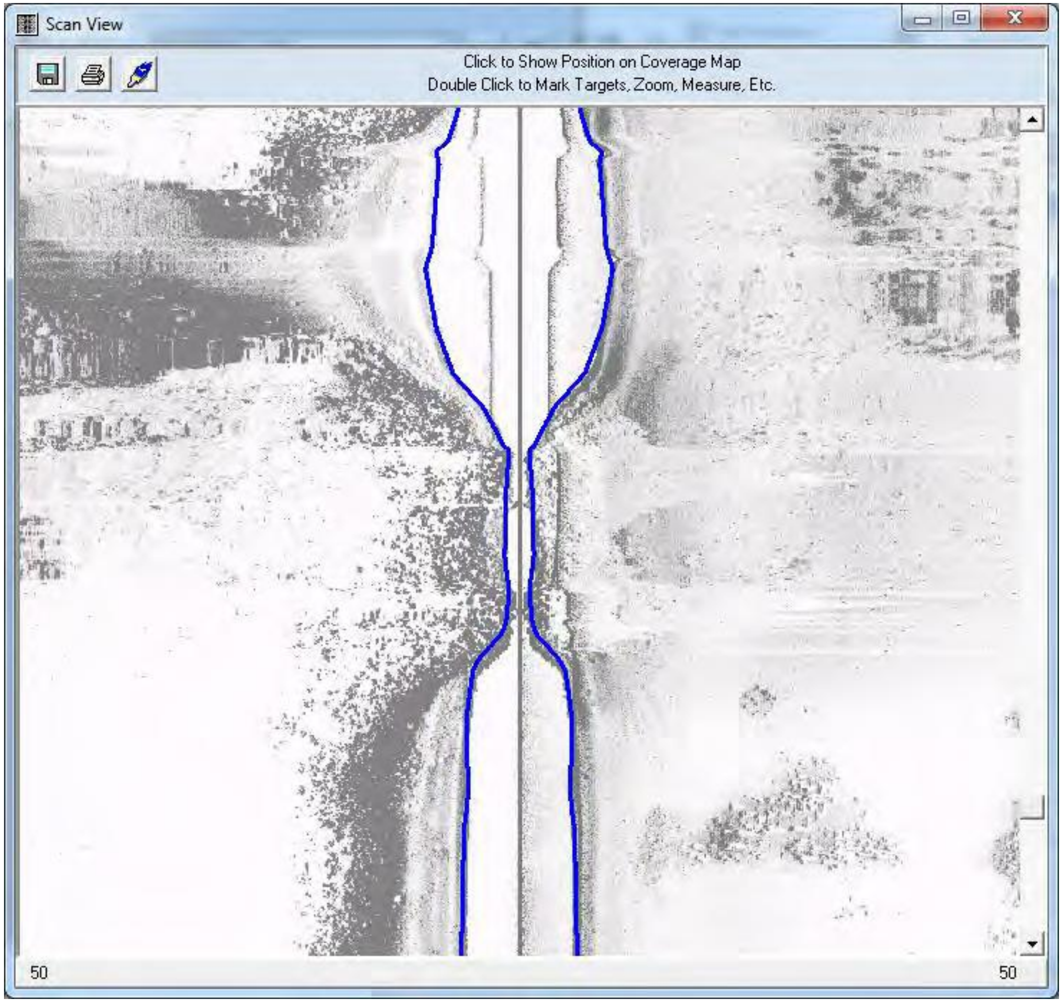
SIDE SCAN SONAR AN ACQUISITION SESSION

BOTTOM TRACK

The bottom track provides
a visual display of how close the towfish is to the bottom.

If the two opposite track get too cloose:

- Speed up the vessel
- Pull the cable in as fast as possible

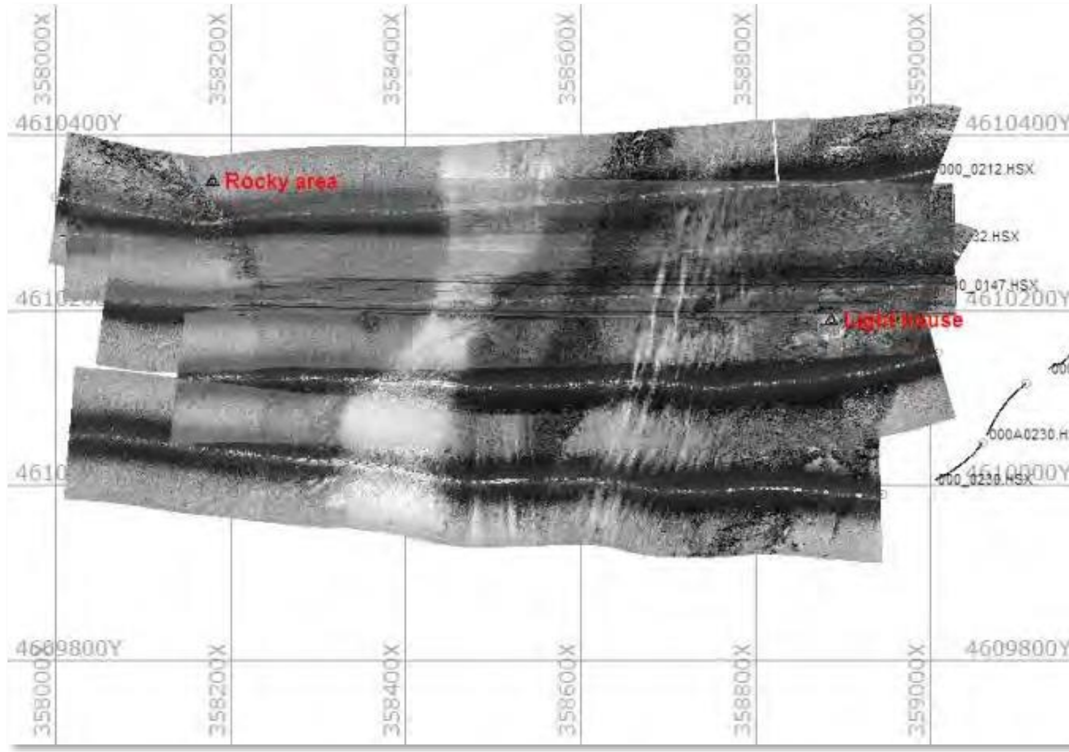


SIDE SCAN SONAR

MOSAIC

Mosaic

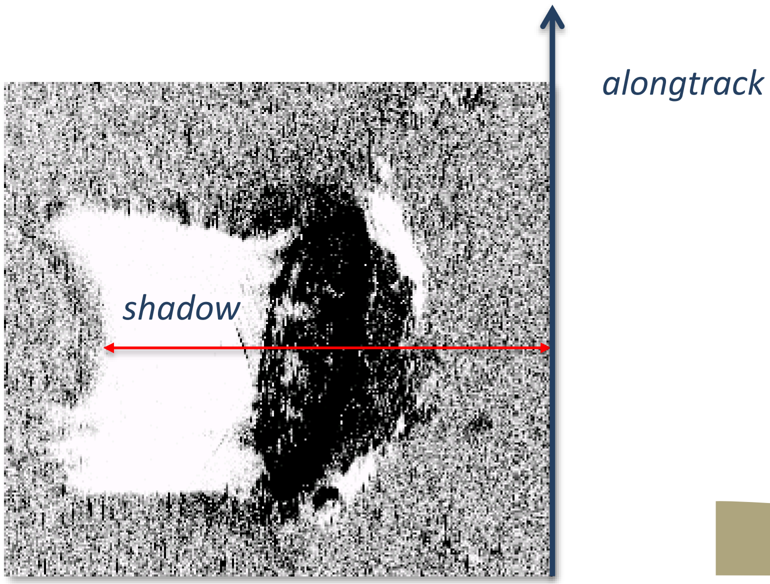
Survey lines can be merged together to provide a 2D representation of the seafloor and saved as a GeoTif file.

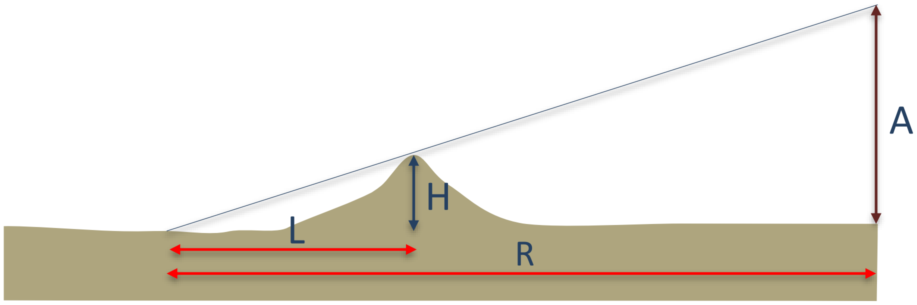


SIDE SCAN SONAR HEIGHT OF A CONTACT

- Altitude (A), from fish
- Shadow length (L), from direct measurement on waterfall view
- Total distance (R), from direct measurement

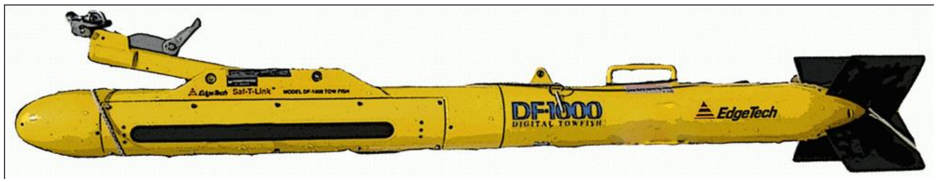
Height of Contact (H) = L * A / R





SIDE SCAN SONAR | **SEABED CLASSIFICATION**

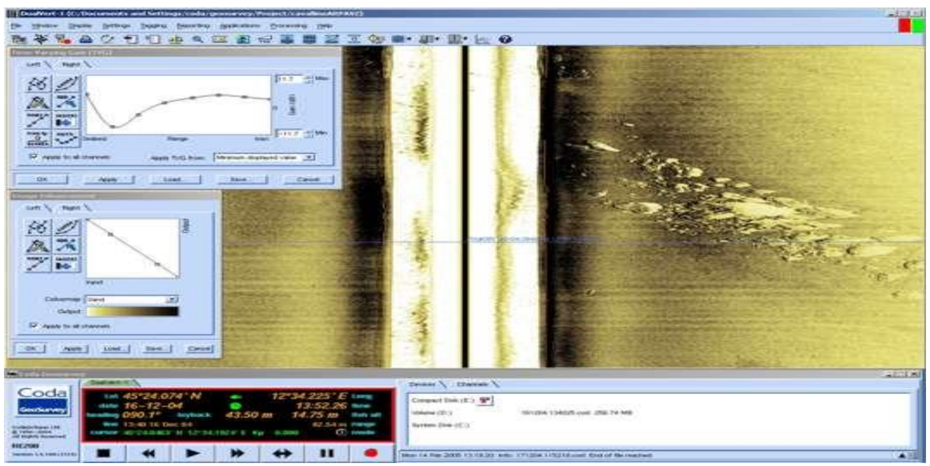
Edgtech DF 1000

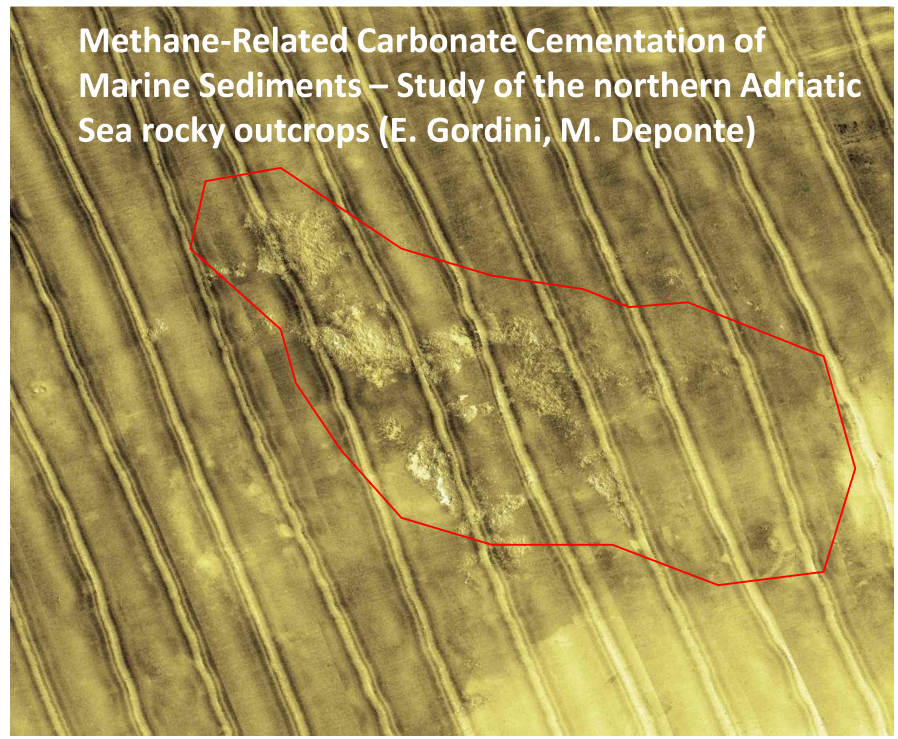


OPERATING FREQUENCY: 100 kHz – 400 kHz

PULSE LENGTH: 0.1 – 0.01 ms

HORIZONTAL BEAM WIDTH: 1.2°- 0.5°





Caorle (northern Adriatic Sea) SSS mosaic. local high backscatter features indicating the occurrence of rock outcrops in a dominant sandy environment.

SIDE SCAN SONAR | MAPPING OF BIOLOGICAL FACIES

IMAGING OF SEAGRASS

Seagrass (foto Ciriaco)

R. Romeo, 2009,PhD thesis.

SIDE SCAN SONAR

EXAMPLE 2