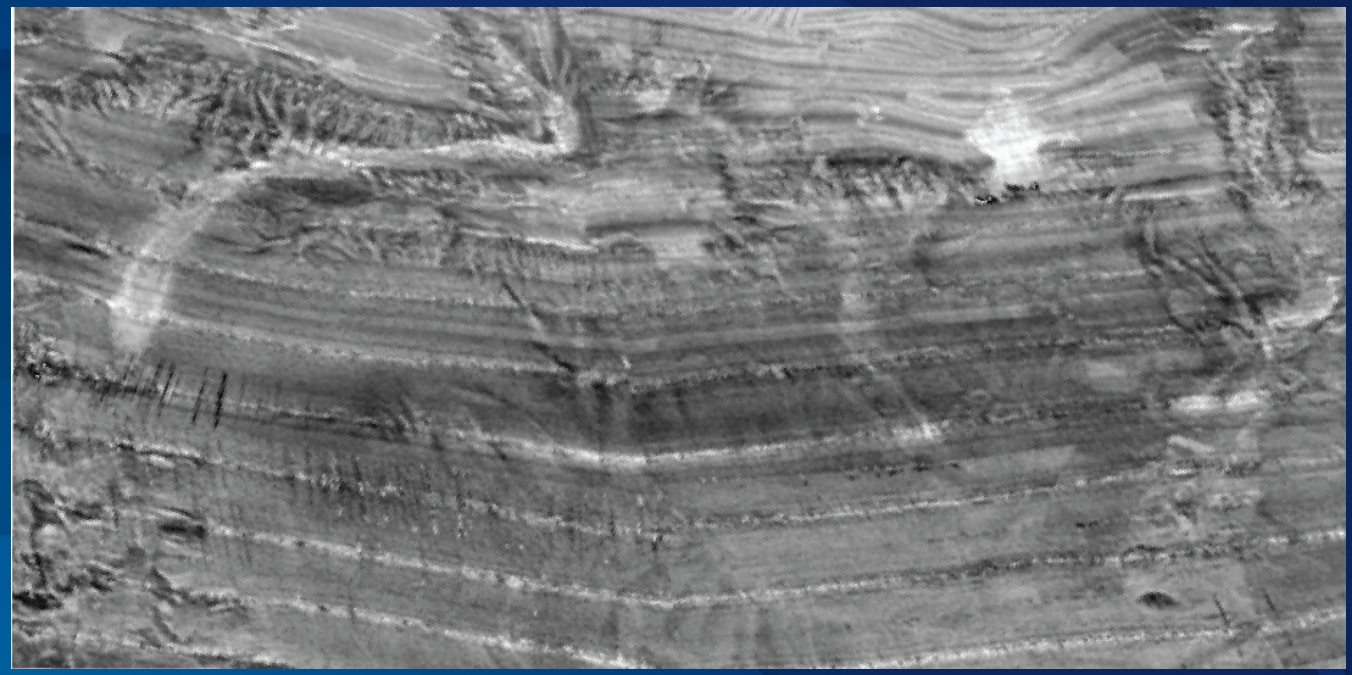

Backscatter data - the indispensable complementary data to bathymetry

Geoffroy Lamarche
NIWA – University of Auckland

Climate, Freshwater & Ocean Science

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

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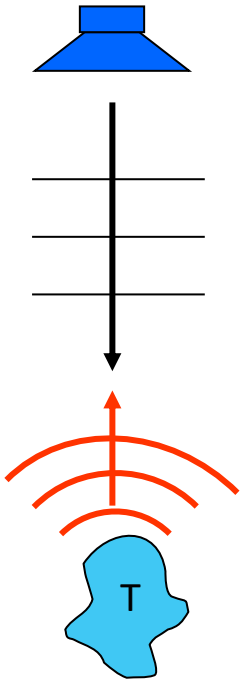
From the same received echo…

Reflection data vs Backscatter data

Arrival time

Time domain - Coherent signal
Geometry – miror-like reflection
Low-frequency vertical beams
Quantified by a reflection coefficient

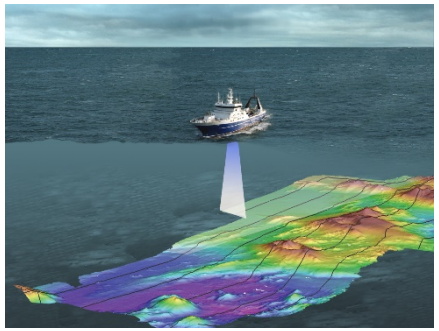
➢Range measurement
➢Target localisation
➢Seafloor mapping

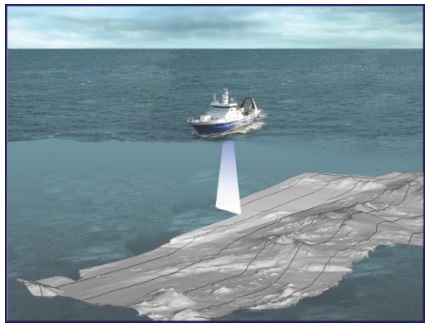


Echo amplitude

- Amplitude – incoherent intensity
- Depends on physical properties of medium
- High-frequency systems
- Quantified by a Target Strength

➢Biomass estimation
➢Seafloor characterisation
➢Water column

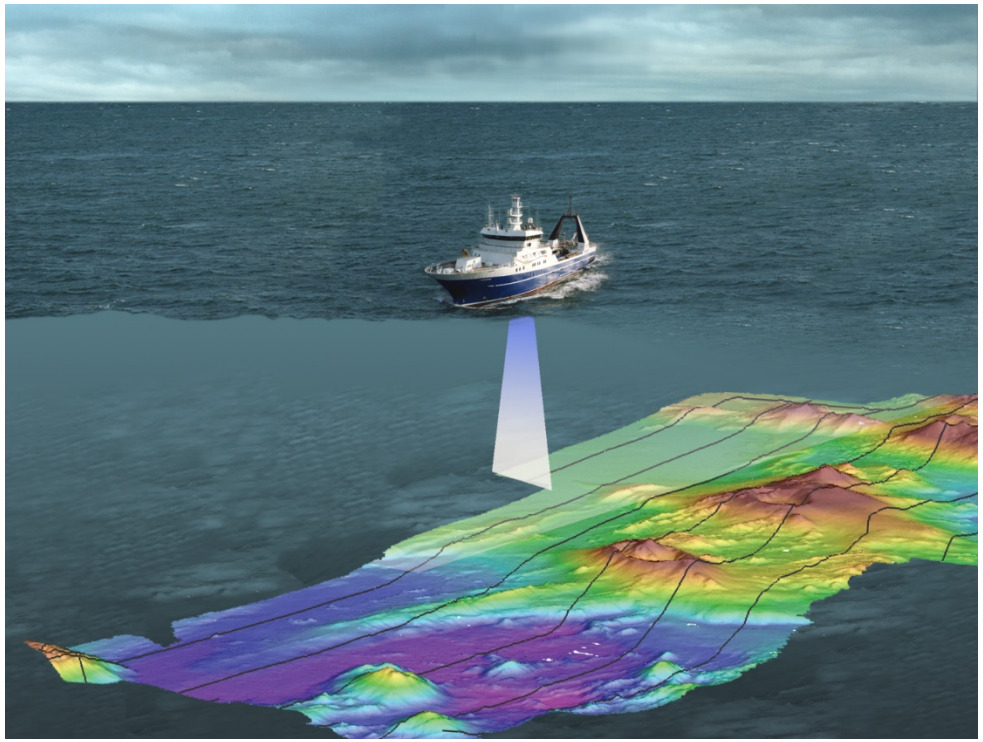




From the same received echo…

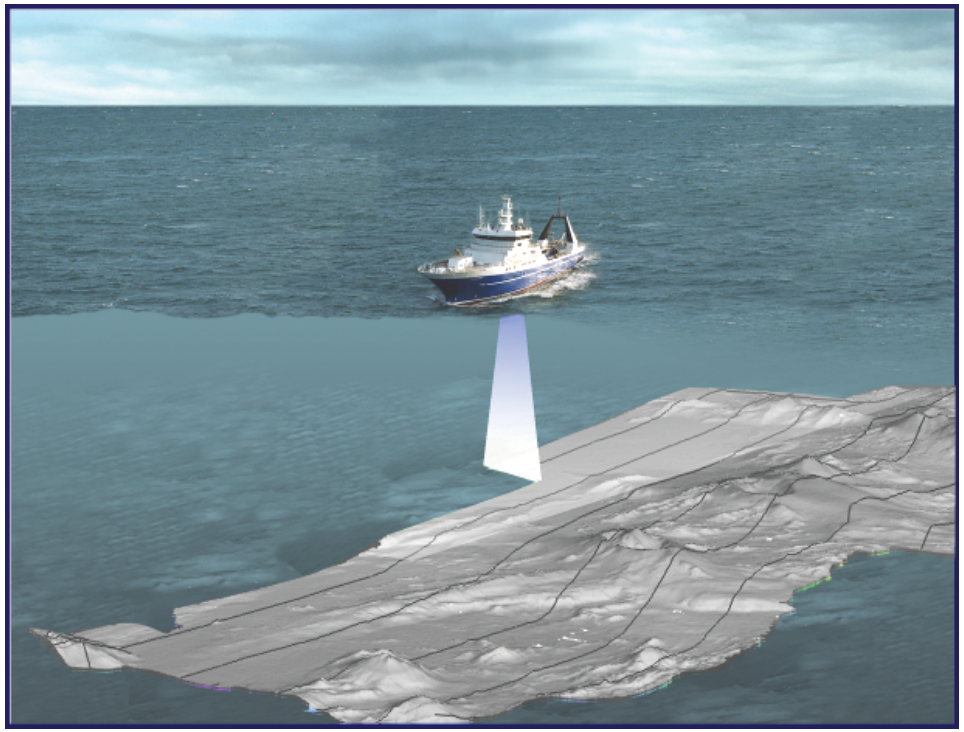
Increased interest in using **seafloor sonar backscatter in** Geoscience, fisheries, environment, hydrography, naval…

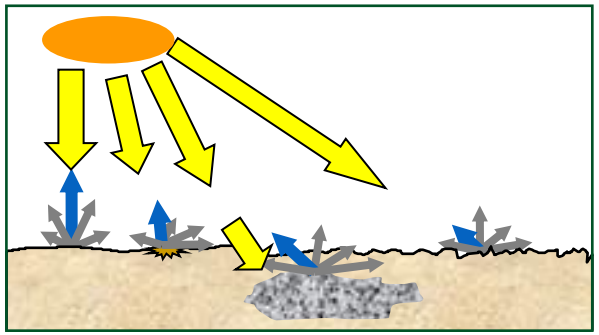
Reflection data



vs

Backscatter data





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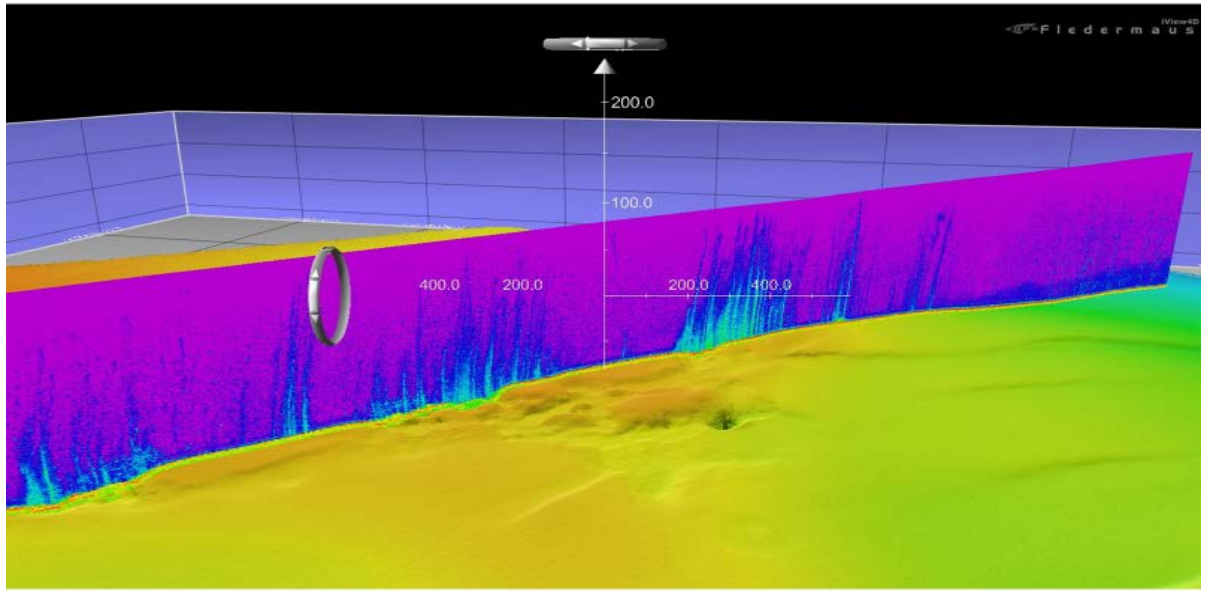
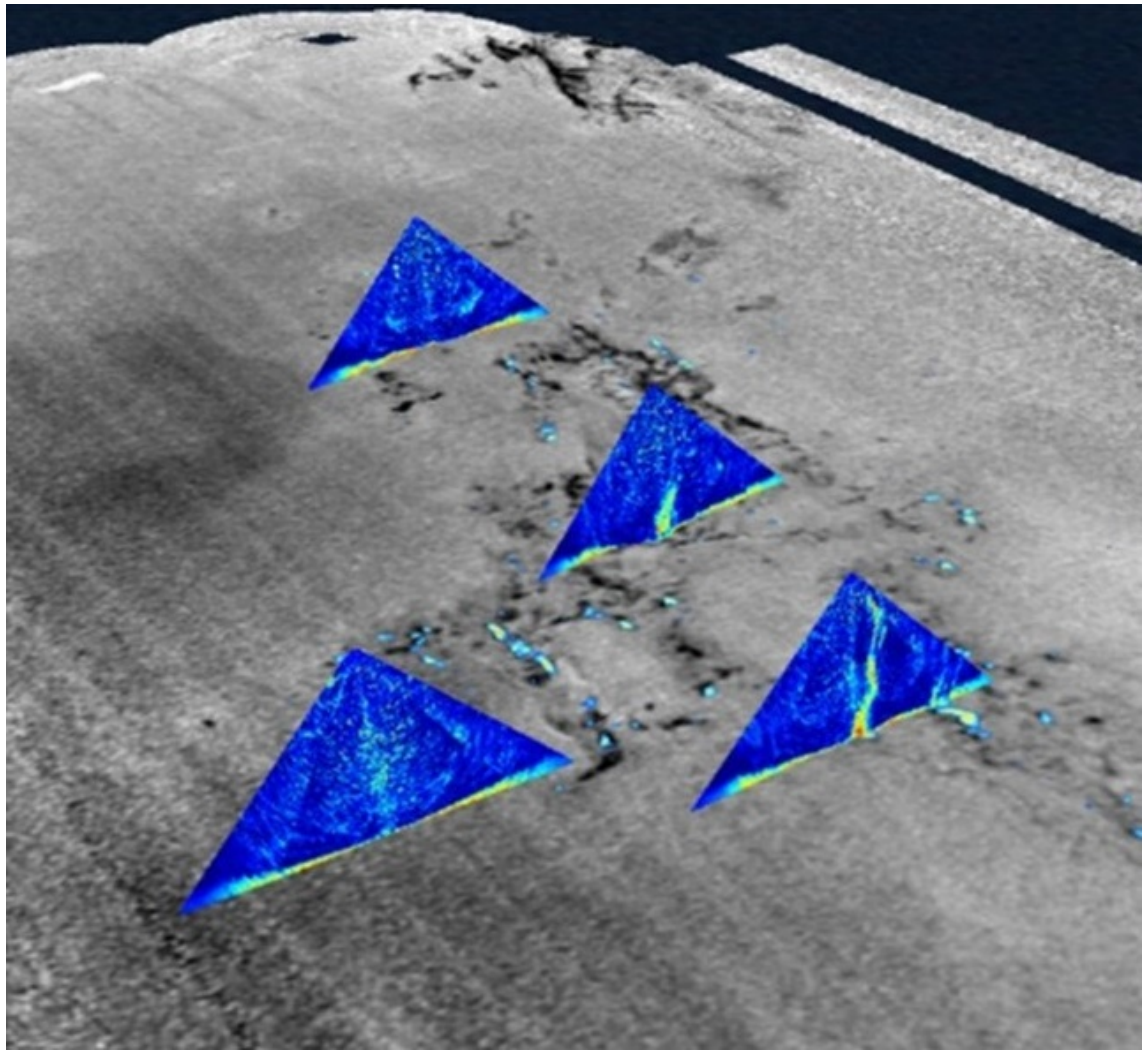
And water column

- Gas bubbles
- Biomass
- Fresh water
- Sediment Particulate matter





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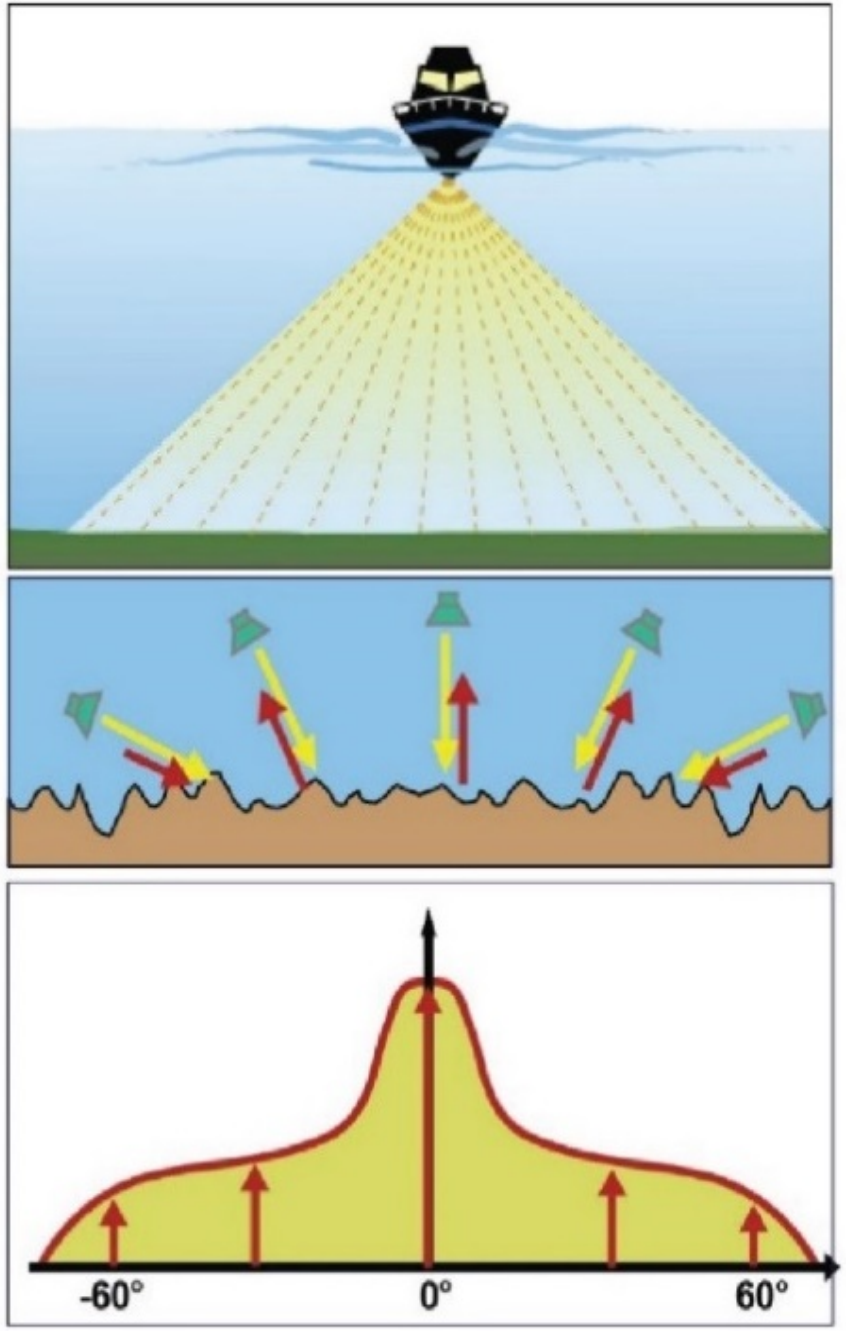
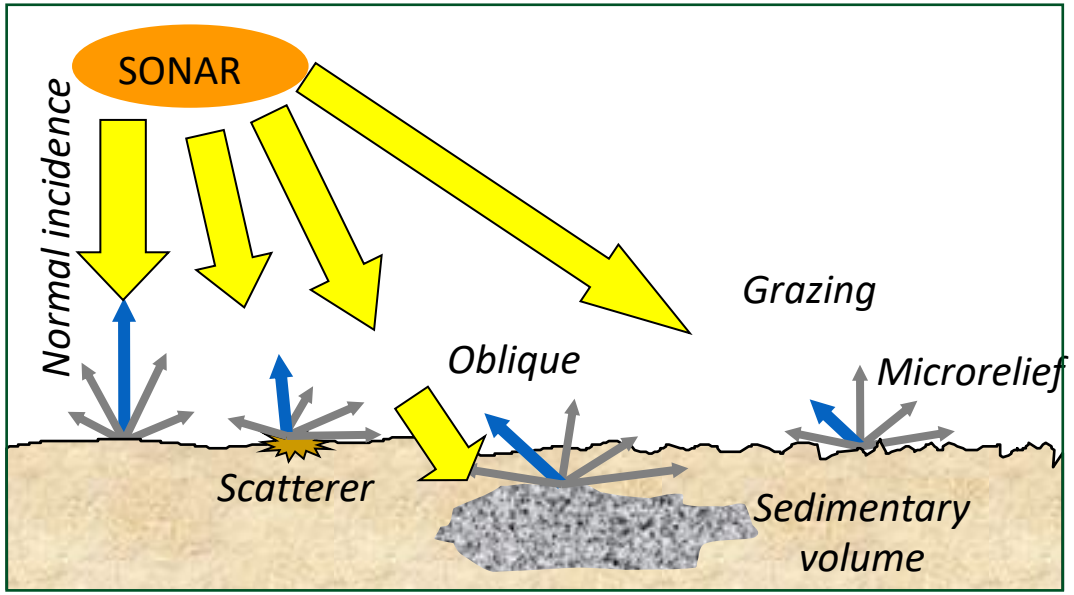


Backscatter Data

- Collected routinely alongside bathymetry data
- Associated with the signal **amplitude** (strength)
- Relates to grain-size & volume scattering
- Provides **qualitative** and **quantitative** information on substrate & water-column
- Strong signal **angular dependence**
- Well adapted to predictive resource mapping



- living organisms
- mineral inclusions
- Seaweeds
- gas bubbles
- man-made objects

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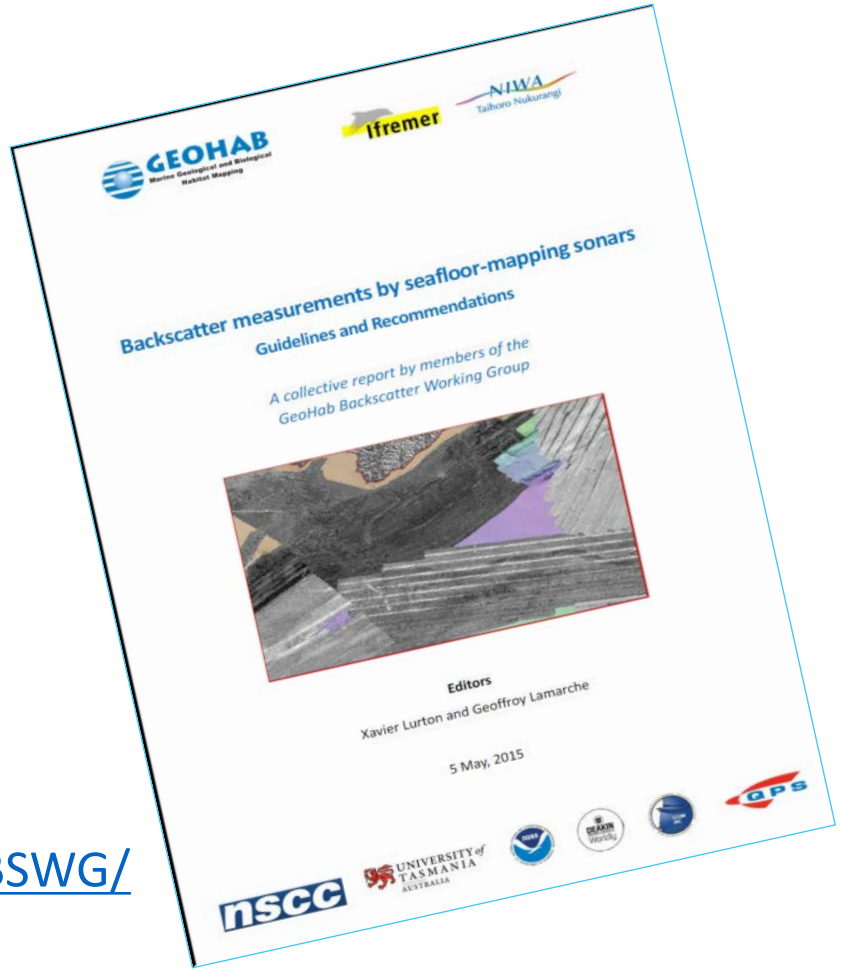
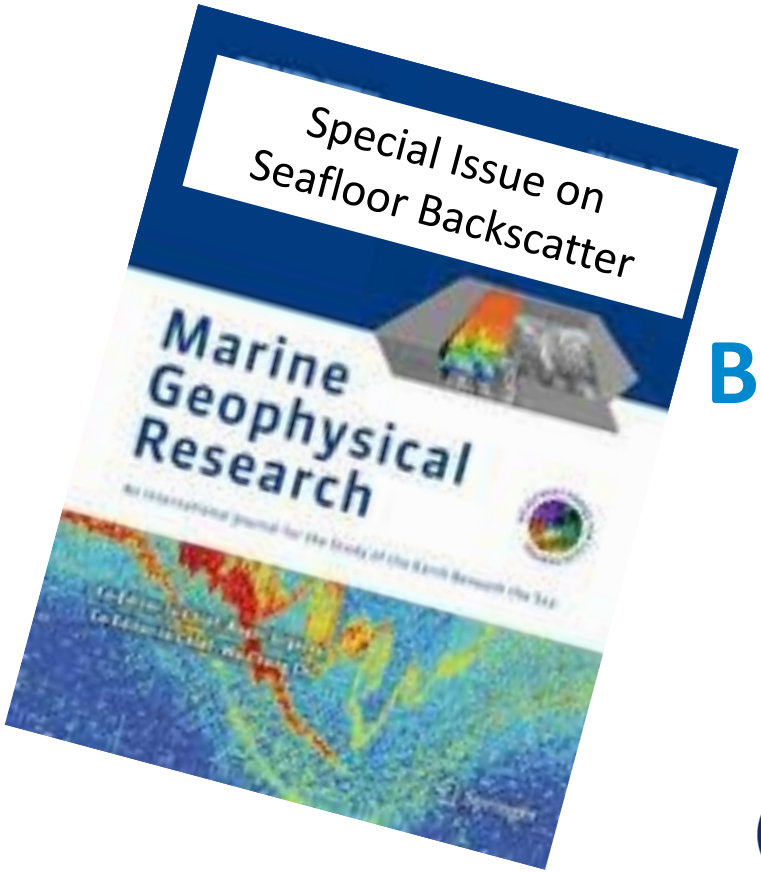
The *Backscatter Working Group*

GEOHAB
Marine Geological and Biological Habitat Mapping

Born May 2013 Rome, Italy!

BSWG.1



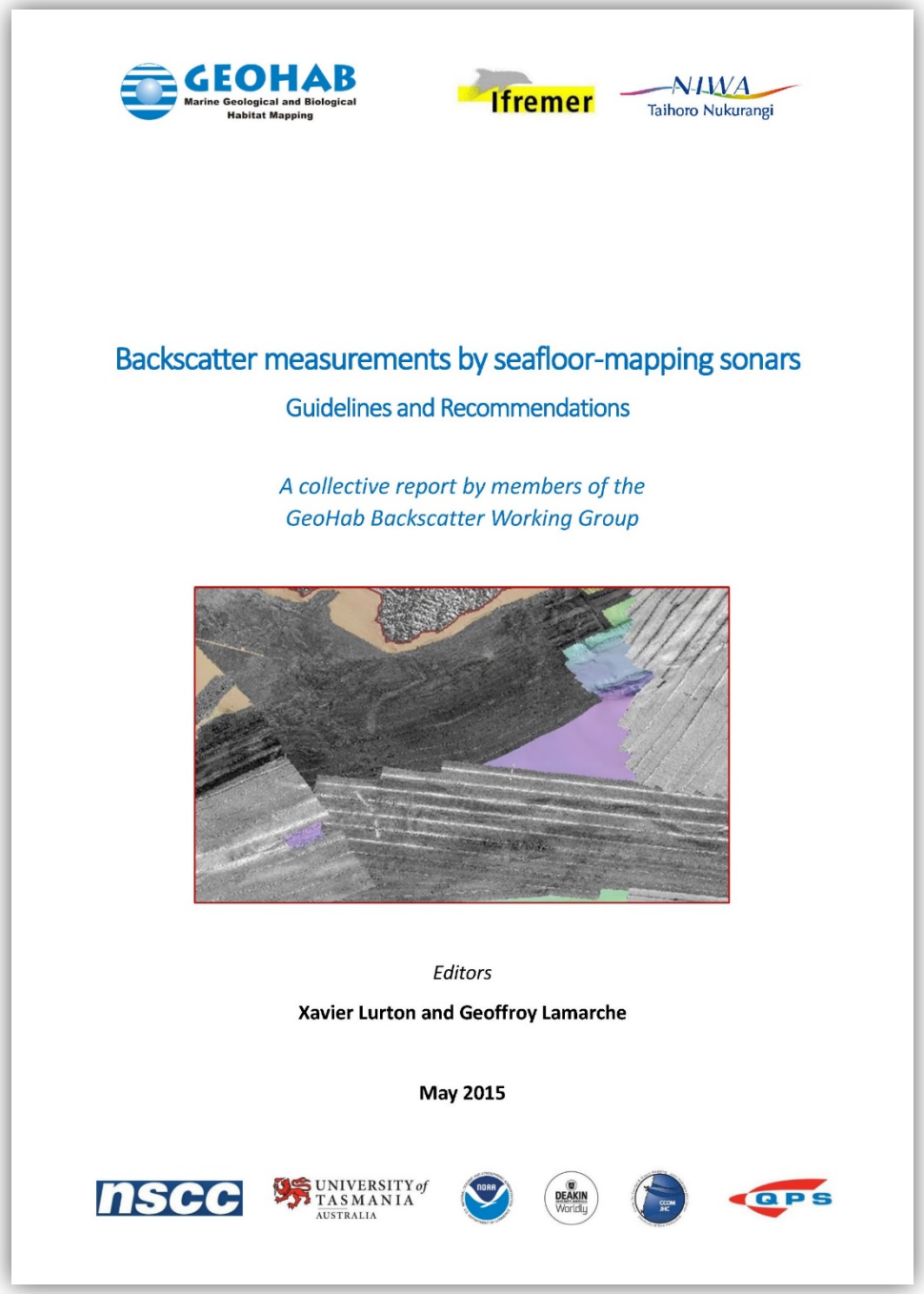


BSWG.2

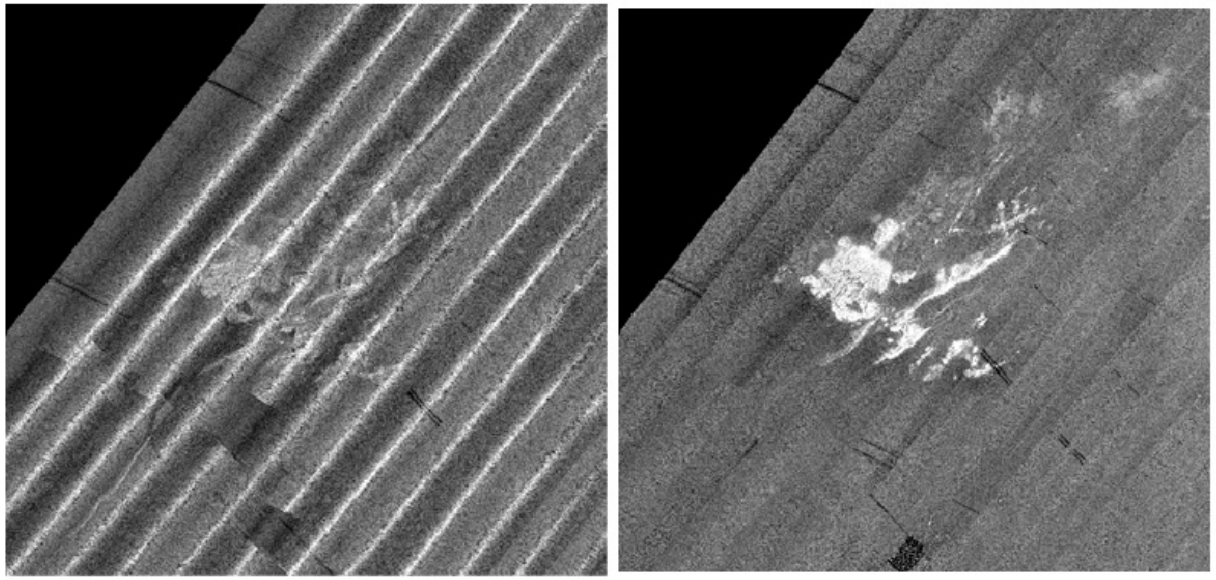
http://geohab.org/BSWG/

BSWG Guidelines

- Five thematic chapters
  - *Fundamentals*
  - *User needs*
  - *BS Sonar measurement*
  - *At-sea acquisition*
  - *Data Processing*
- Five Teams, with
  - 5 coordinators leading,
  - > 20 co-authors/contributors
- **Publication**
  - Freely available
  - Citable
  - In discussions with IHO for final publication



Recommendations



to operators

- Dedicate surveys to backscatter;
- Calibrate MBES
- Define adapted settings
- Keep setting stables
- Reproduce conditions and settings for monitoring

to constructors

- Improve technical information
- Improve calibration process
- Develop & incorporate calibration tools
- Design specific modes for backscatter

to Users

- Calibration areas & ground-truthing
- Databases & mutualize
- Keep HW and SW stable
- Do not over-interpret your data

Calibration of MBES for backscatter

- **Exploration**

➢ Map seafloor types

➢ Classify / identify / characterize / model

➢ **BS absolute levels** are needed

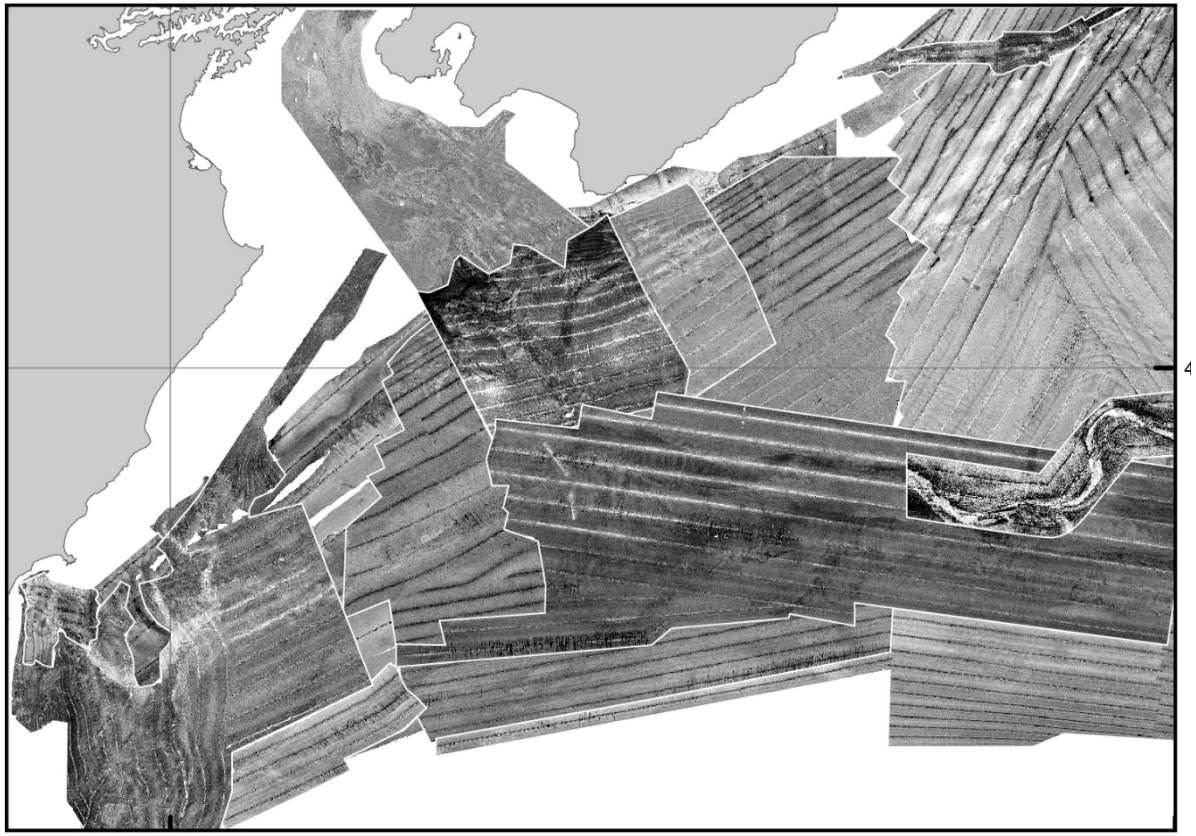
➢ Compensate for Gain & Directivity

- **Monitoring**

➢ Objective observation of seafloor changes

➢ **BS relative levels** may be enough (for data consistency)

➢ Sensor biases may be acceptable (if stable enough)

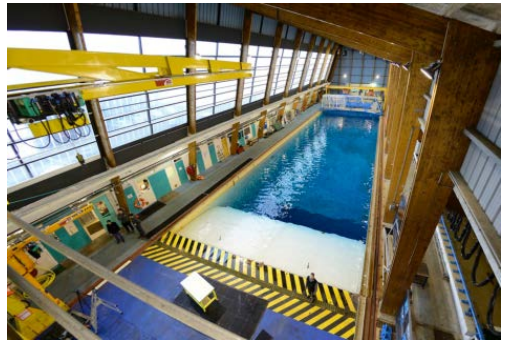


Data NIWA (Kongsberg EM300 - Cook Strait, NZ)

An error magnitude of ±1 dB ➔ both acceptable (by users), feasible (by engineers) & reachable (by operators)

MBES backscatter calibration: 4 ways

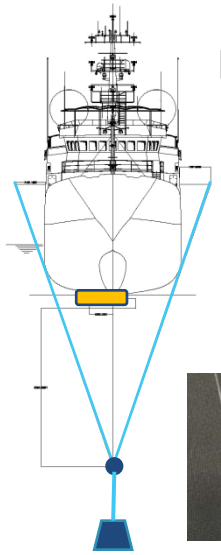
Metrological (factory, test tank)

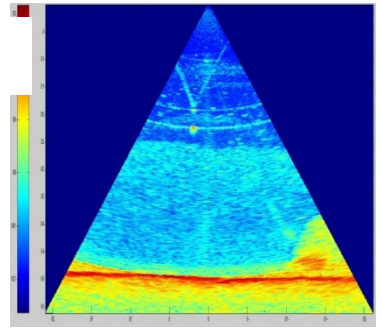


Electroacoustical measurements:

➔ SL/Receiver sensitivity/Gains/ Directivity…

Reference Target



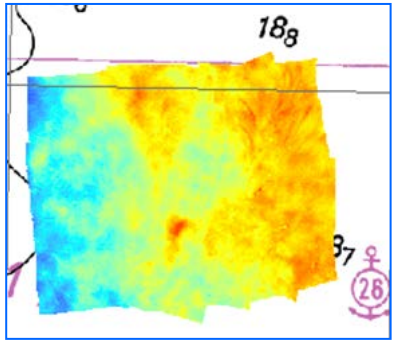


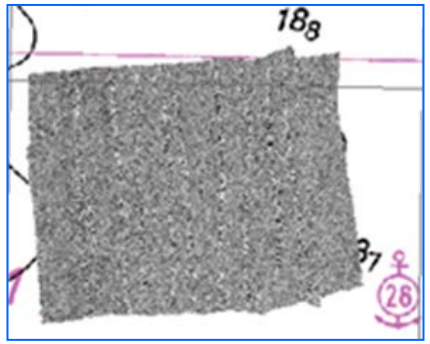
➔ Quay-side or test-tank

➔ Classical for fisheries SBES

➔ Practical difficulties for MBES

Reference seafloor area





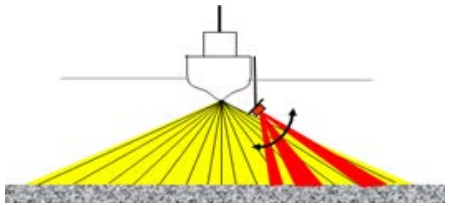
Survey conditions

➔ Direct comparison w/ local reference data

➔ Find, validate & monitor specific areas

Cross-calibration

(vs a reference sounder, at sea)



Survey conditions

➔ Adjust data w/other calibrated echosounder

➔ No specific area needed

Nomenclature of backscatter processing

A – Raw or TVG applied
- A0. Echo level, raw – no TVG
- A1. Manufacturer TVG for TL
- A2. Manufacturer TVG for TL & FE
- A3. Customized RVG for TL & FE
- A4. Modeled TL & parameters

B - Array directivity compensation
- B0. No compensation
- B1. Pattern model
- B2. Statistical average modulation
- B3. Customized model

C - Seafloor Angular compensation
- C0 – C4

D –Level of reference
- D0 – D4

E – Incident angle at the seafloor
- E0 – E6

F – Resolution in time (or range)
- F0. Fundamental raw signal resolution
- F1. Undersampled time signal
- F2. Filtered time signal
- F3. Customized resolution / Other

G - Geo-referencing
- G0-G2

H - Mosaicking
- H0-H3

I - Interpolation
- I0-I3

J - Representation
- J0-J4

K - Reference angle
- H0-H3

BSWG.3 – born Santa Barbara, CA - May 8th 2018

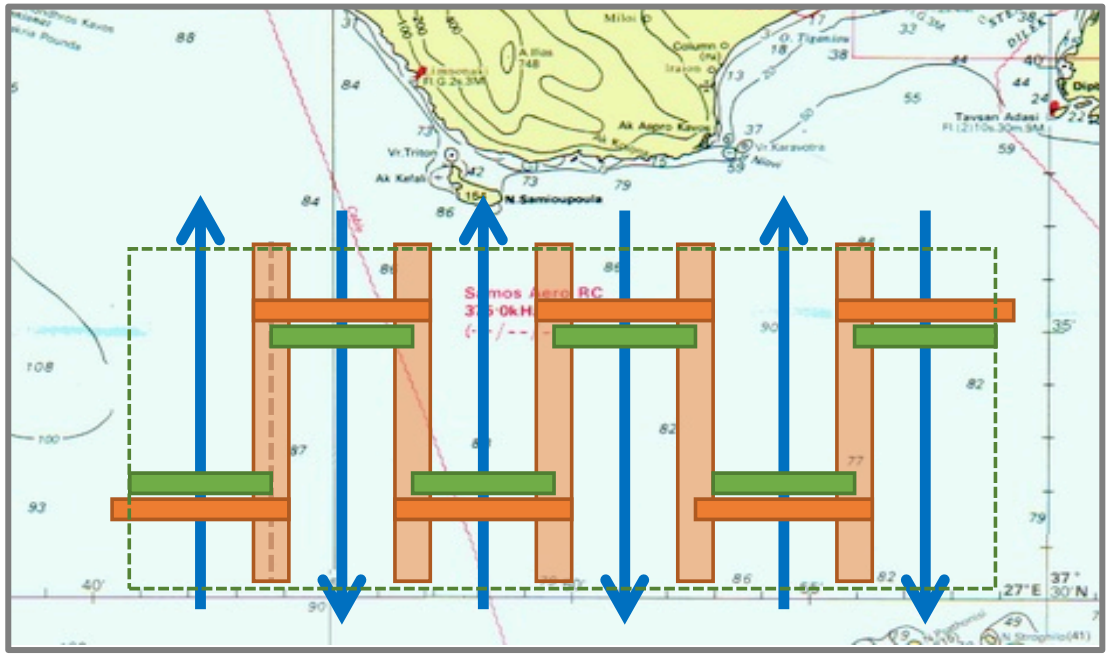
1. Acquisition standards & recommendations
2. Multi-frequency
3. Backscatter processing software comparison
4. Seafloor Backscatter Variability
5. Seafloor backscatter resolution and accuracy
6. Library of seafloor backscatter responses

1 – Acquisition standards & recommendations

Facilitator : Margaret Dolan (NGU) *Margaret.Dolan@ngu.no*

- Equal status for MBES backscatter data cf. bathymetry data.
- Monitoring, QC and post-processing of backscatter data.
- Increased focus on oceanographic measurements and other environmental factors influencing backscatter data.
- Follow-up of BSWG guidelines with practical specifications/protocols.

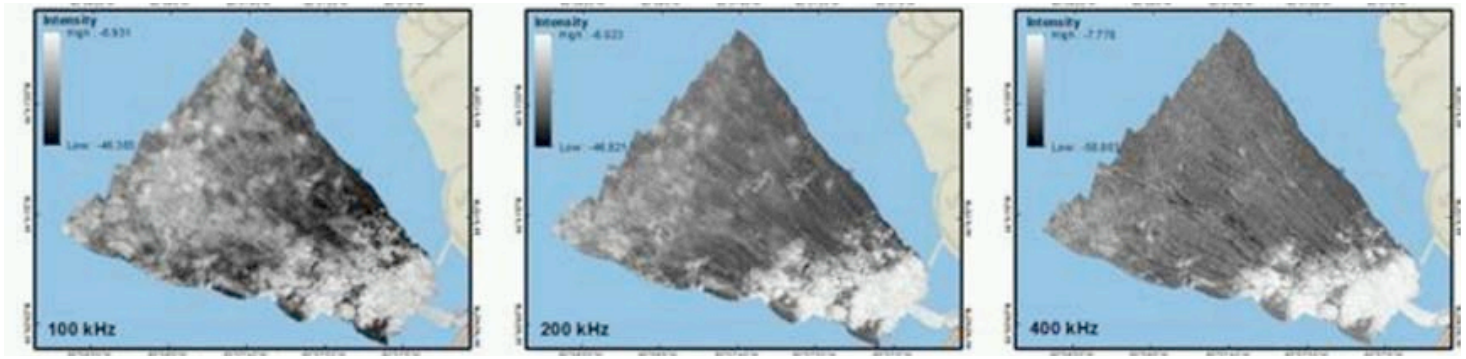
- source good practice from the entire community (survey industry, hardware/software manufacturers, government agencies, academia etc.).
- work towards development of generic specifications for common survey types which can provide a starting point for those writing project-specific specifications.

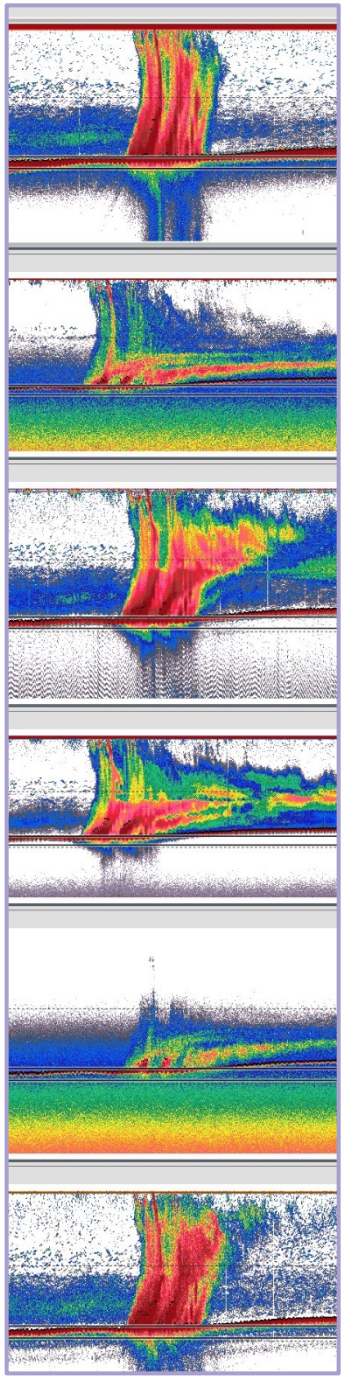


2 – Multi-frequency

Facilitator : Jens Schneider von Deimling (Univ.Kiel, Germany)

- Backscatter is dependent on the pulse length as well as the **frequency**.
- Different frequencies cover different reality
- Influence if system response and of environmental parameters.
- Objective: build a spectral response catalogue for key habitats defined by biology (macrobenthos, microbial, macrophytes) and geology (grain size, compositions).

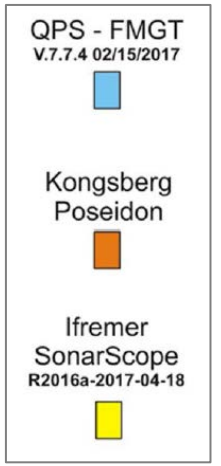


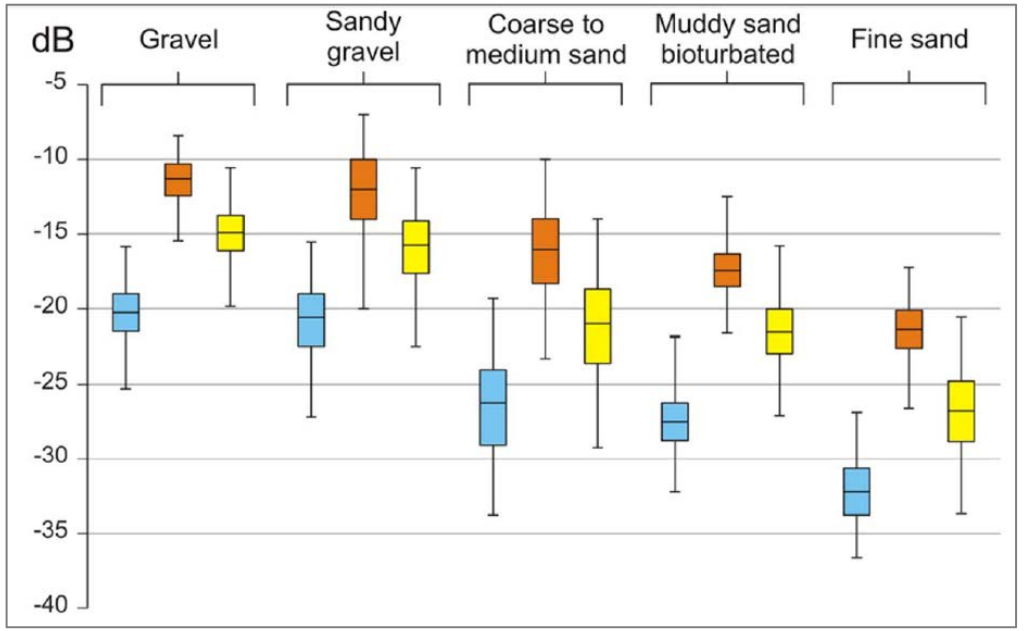


3 – Backscatter processing software comparison

Facilitator : Mashkoor Malik (NOAA)

- Comparison of processing corrections from different processing software
- Validation of backscatter processing steps
- Using same data set, may result in different final products
- Need input from developers to document the processing chain better



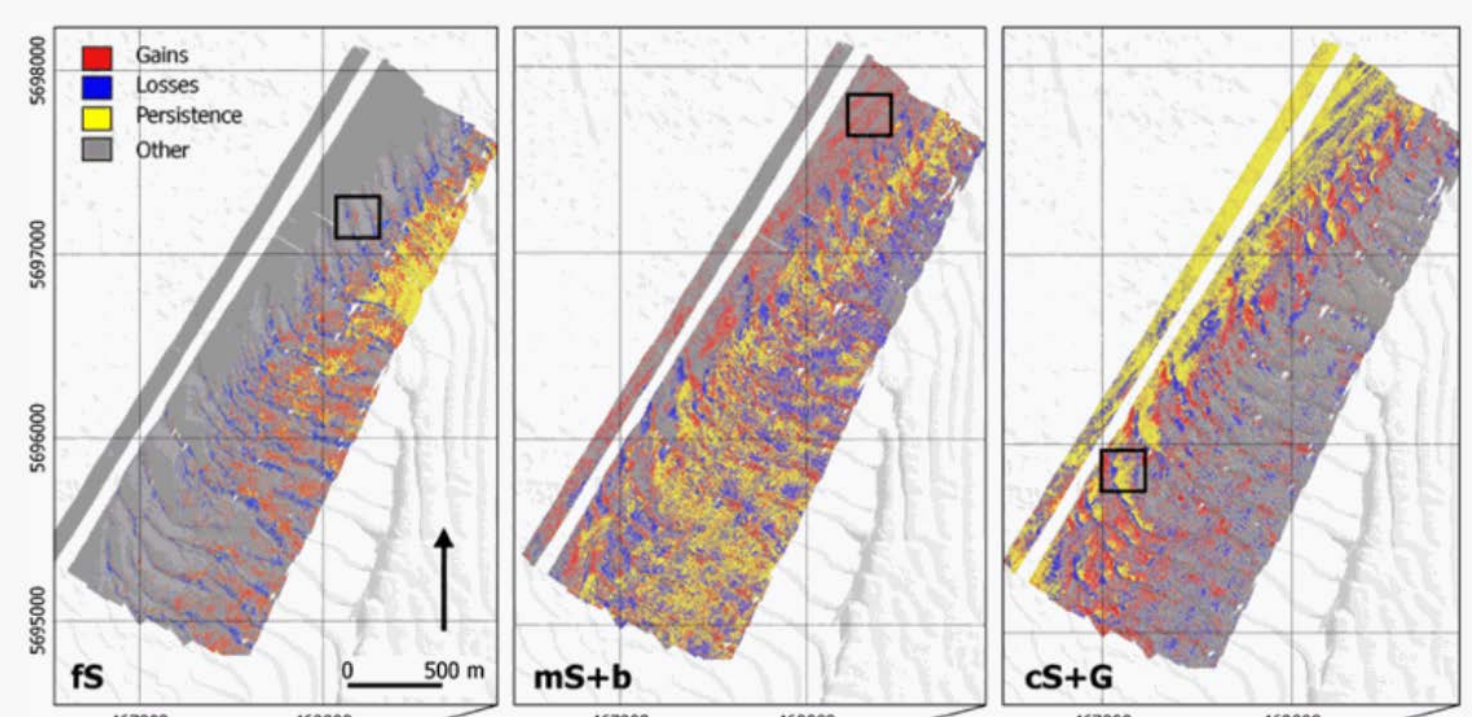


- 1: Collectively come to an agreement over **processing stages**
- 2: Identify **discrepancies in the processing chain**;
- 3: Develop consensus among software developers about adopting a **standard nomenclature and metadata.**

4: Seafloor Backscatter Variability

- Why variability and What kind -

- Monitoring → Temporal comparability → **Change** assessments
- **Intra & Inter** platform & institutions **comparability** → Merging data (spatial comparability)
- Important to control **factors** that could introduce **bias in the measurements**



Facilitator: Giacomo Montereale-Gavazzi (Ghent University, B)

Montereale-Gavazzi et al. 2017

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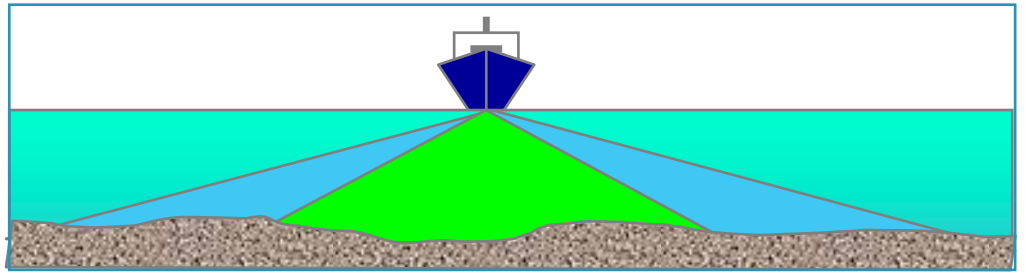
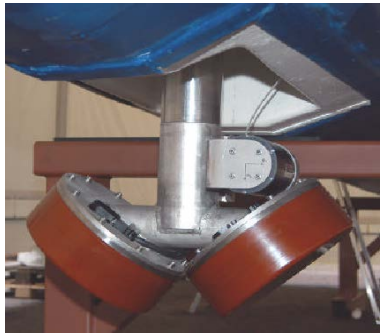
5: Seafloor backscatter resolution and accuracy

Facilitator: Xavier Lurton

- Define horizontal resolution and level accuracy of measured and processed BS;
- Find compromise between users' needs and system characteristics;
- Promote application of backscatter level calibration for swath-bathymetry sonars;
- Define post-processing operations to optimized grids;
- Change current systems to obtain lower-resolution/higher-accuracy data

Frequency	Domain	Swath width	Horiz. Resol.
12 kHz	Deep water	20 km	100 m
30 kHz	Continental slope	10 km	50 m
100 kHz	Continental shelf	1 km	10 m
> 200 kHz	Shallow water	100 m	1 m

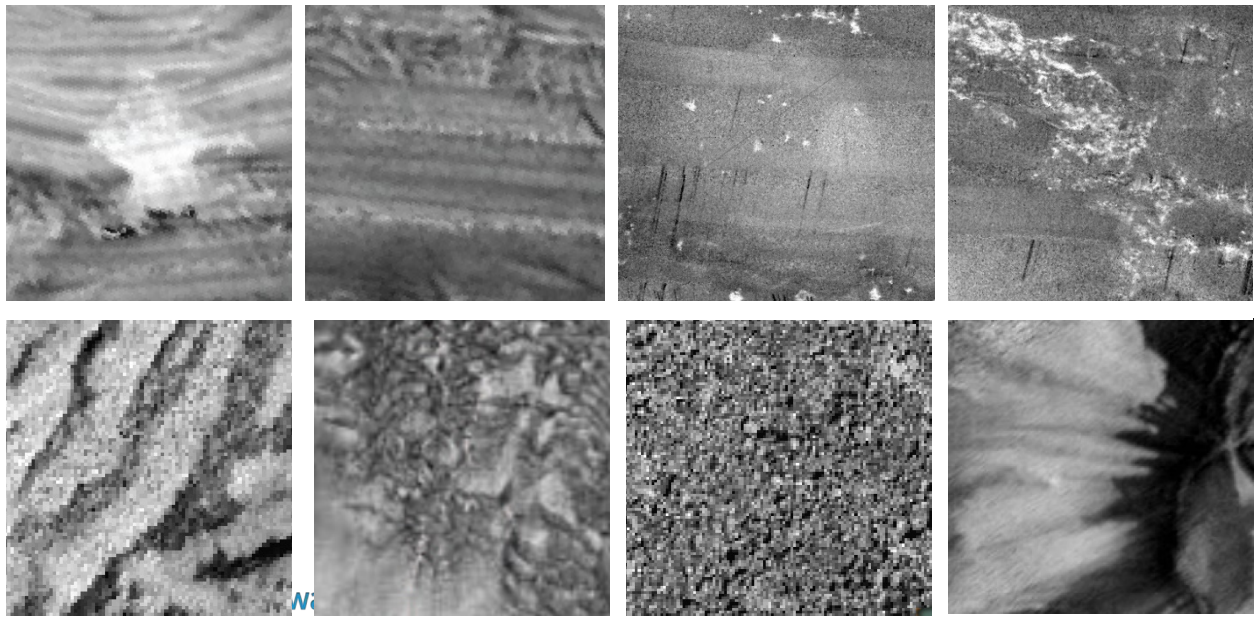




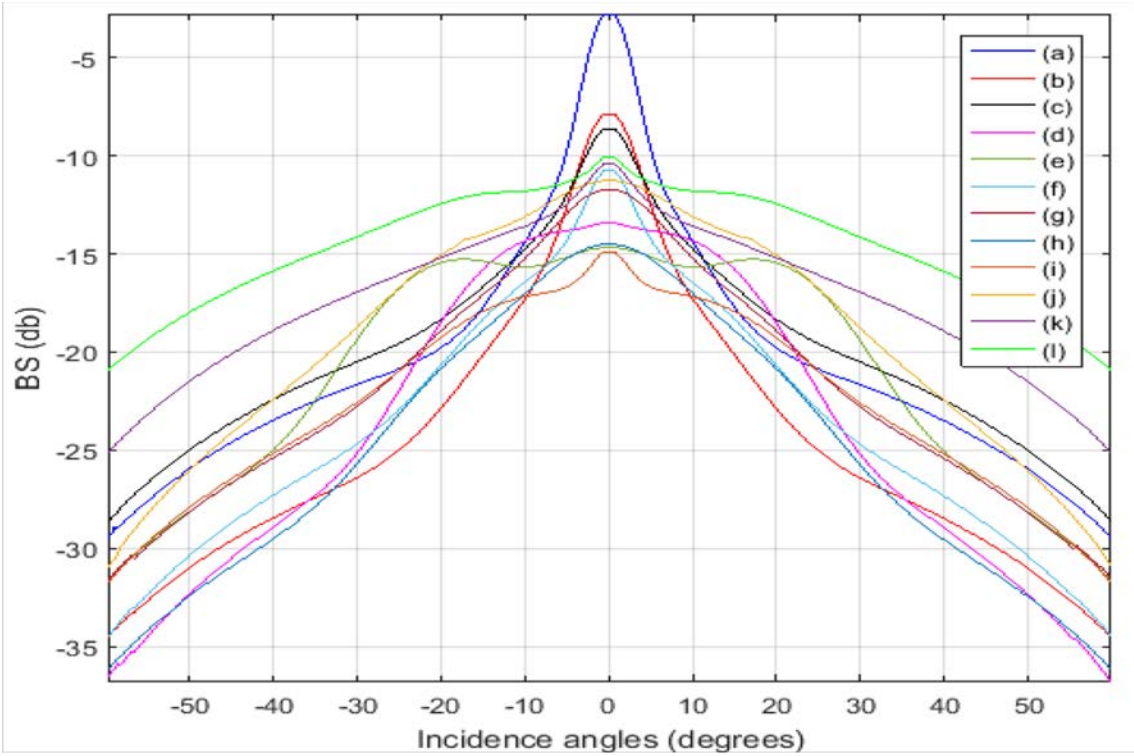
6: Library of seafloor backscatter responses

Luciano Fonseca (Federal University of Brasilia, Brazil)

- Absolute backscatter strength
- Dependence on incident angle - building a library of angular responses for documented seafloors
- Indication of frequency
- Acquisition parameters (pulse length, attenuation, footprint extent, various processing steps).
- Groundtruthing



Fonseca and Calder, 2006

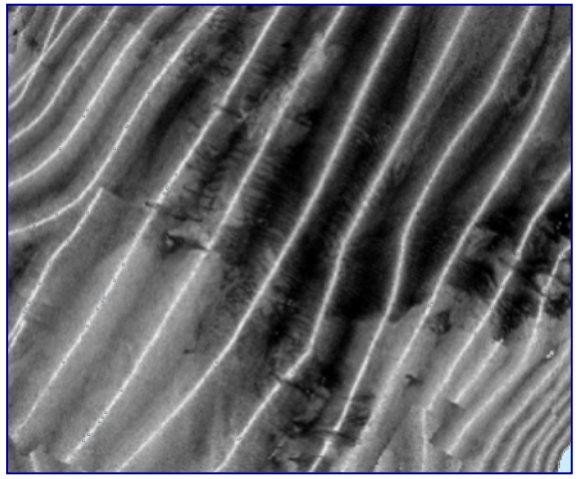


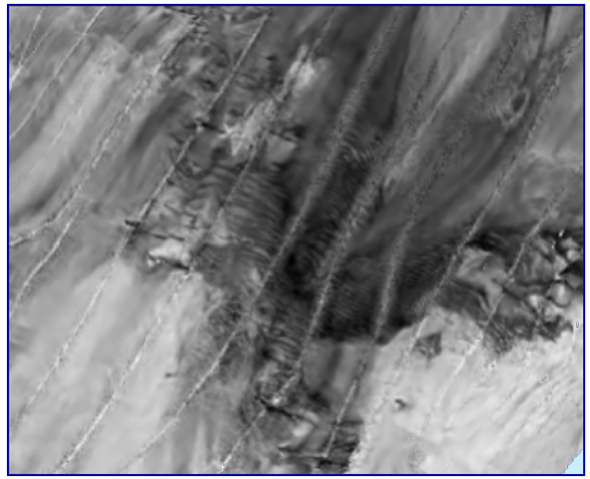
All other images NIWA

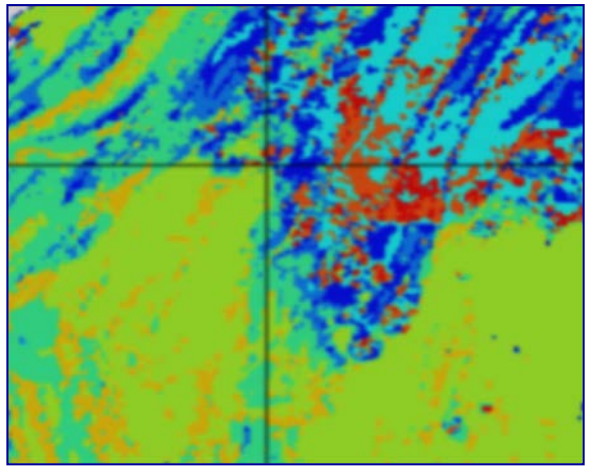
Take home message

- Mean backscatter level is a powerful descriptor of **seafloor types at regional scale**
- Multi-frequency offers a new potential – to be explored
- **Calibration is crucial** – at least sensor consistency
- Need for more BS calibration tools:

In short : read and follow the BSWG Guidelines and Recommendations !







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I have a dream!

Wouldn't it be great to capitalise on the Seabed 2030 Project and systematically collect seafloor and water column backscatter so that the entire ocean is really mapped!

Thank you

Geoffroy Lamarche
+64 21 1895 732
Geoffroy.lamarche@niwa.co.nz

Climate, Freshwater & Ocean Science

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Taihoro Nukurangi