NIWA
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Investigating the relationship between Backscatter Strength and sediment grain size in a dynamic geological environment, Cook Strait, New Zealand

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Outline

- Characterization of the area
- Methods
  - Ship based: Backscatter measurements of multibeam echosounder system
  - Lab based: Grain size analysis
- Combined results
  - Comparison of backscatter and grain size
  - Segmentation
- Summary

Questions

- What is the quantitative relationship between backscatter and grain size?
- How transferable is the derived relationship between backscatter and grain size to other regions?

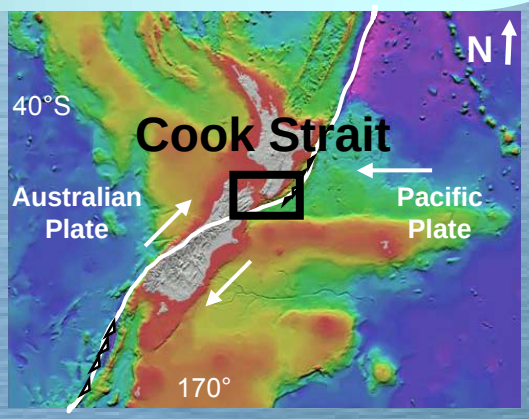
Characterization of the area

Cook Strait, New Zealand:

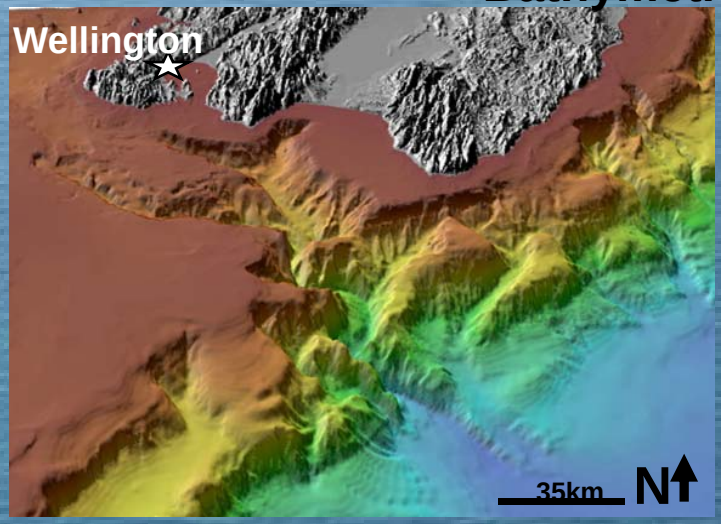
- Part the plate boundary zone of Australian and Pacific lithosphere plates

- Main average depth:
- Northern part/ continental shelf: ~150–350m
- Southern part/ intersection to continental slope: depth to 2500m
- Complex bathymetry
- Strong tides & winds

=>High variety of sediment types



Bathymetry

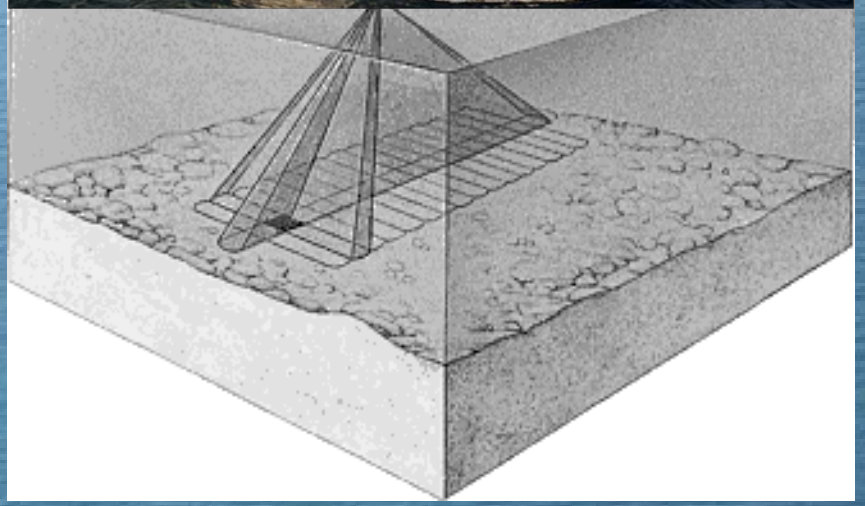


Multibeam system

Backscatter data taken in Cook Strait by:

Simrad EM 300 multibeam system

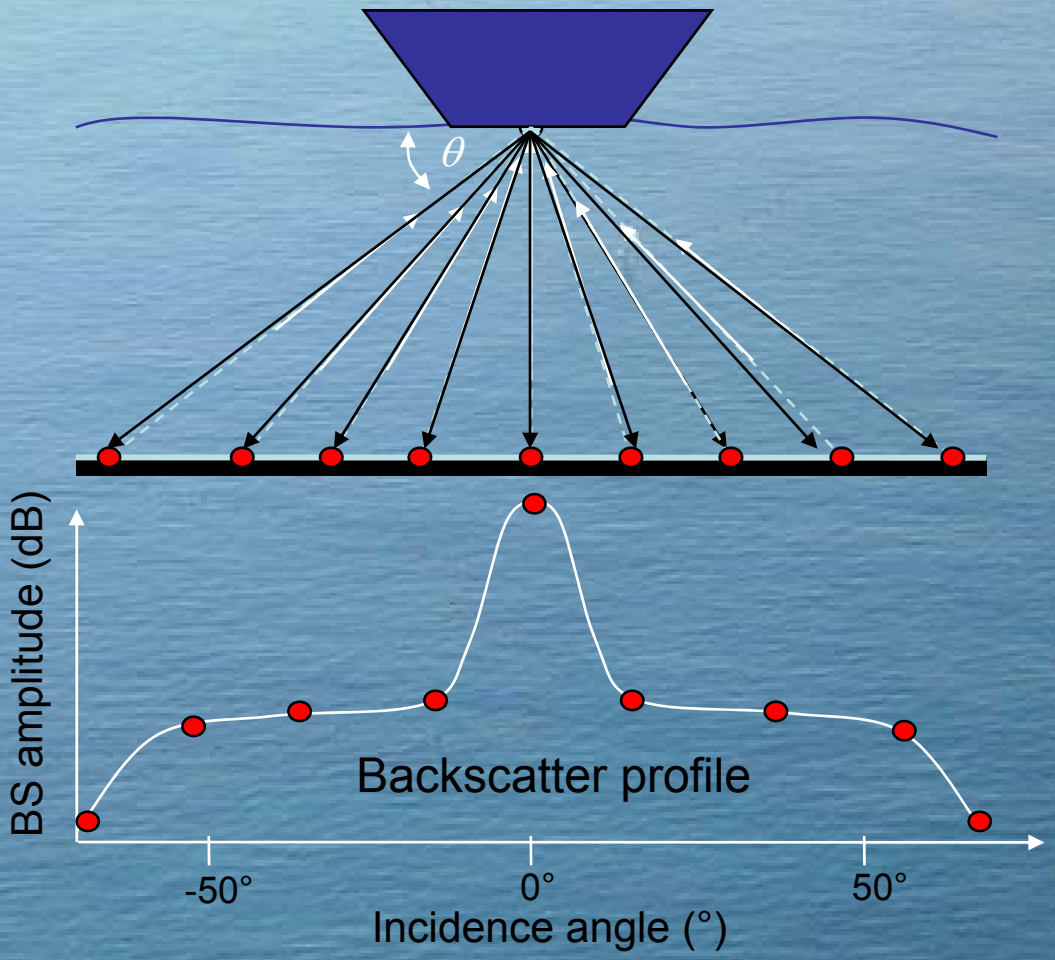
- Mounted on RV Tangaroa
- Frequency of 30 kHz
- Angular coverage of 150°
- 135 beams
- Swath: 4 x water depth



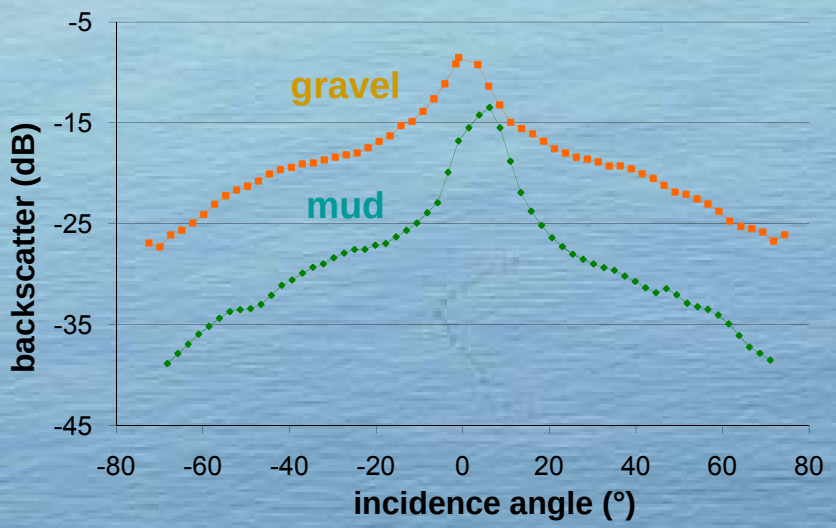
Backscatter

- Backscatter profile across whole insonified area
- Shape of BS in relation to the incidence angle of emitted signal

  =>BS strength
- Grain size
- Sea floor roughness

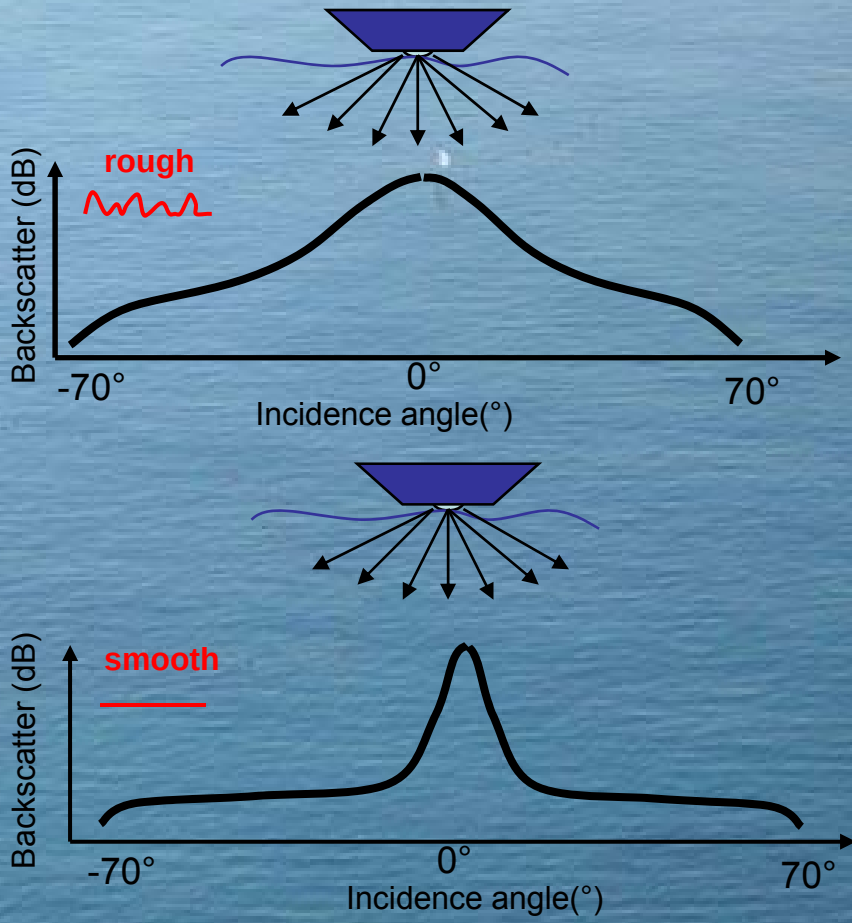


Backscatter



- Coarser material has a higher backscatter (less absorption)
- Finer material has a lower backscatter (more absorption)

Sea floor roughness is important!



Grain size analysis

Cook Strait:

- 250 grab samples
- Several voyages (1950- today)
- Analysed by sieving and divided into seven grain size classes

Grain size analysis

- Wet sieving analysis: - mud (<4Φ) (1Φ= - $\log_2$mm)
- Dry sieving analysis: - five sand classes: v. fine, fine, medium, coarse, v. coarse sand (4Φ to -1Φ)
  - gravel (>-1Φ)

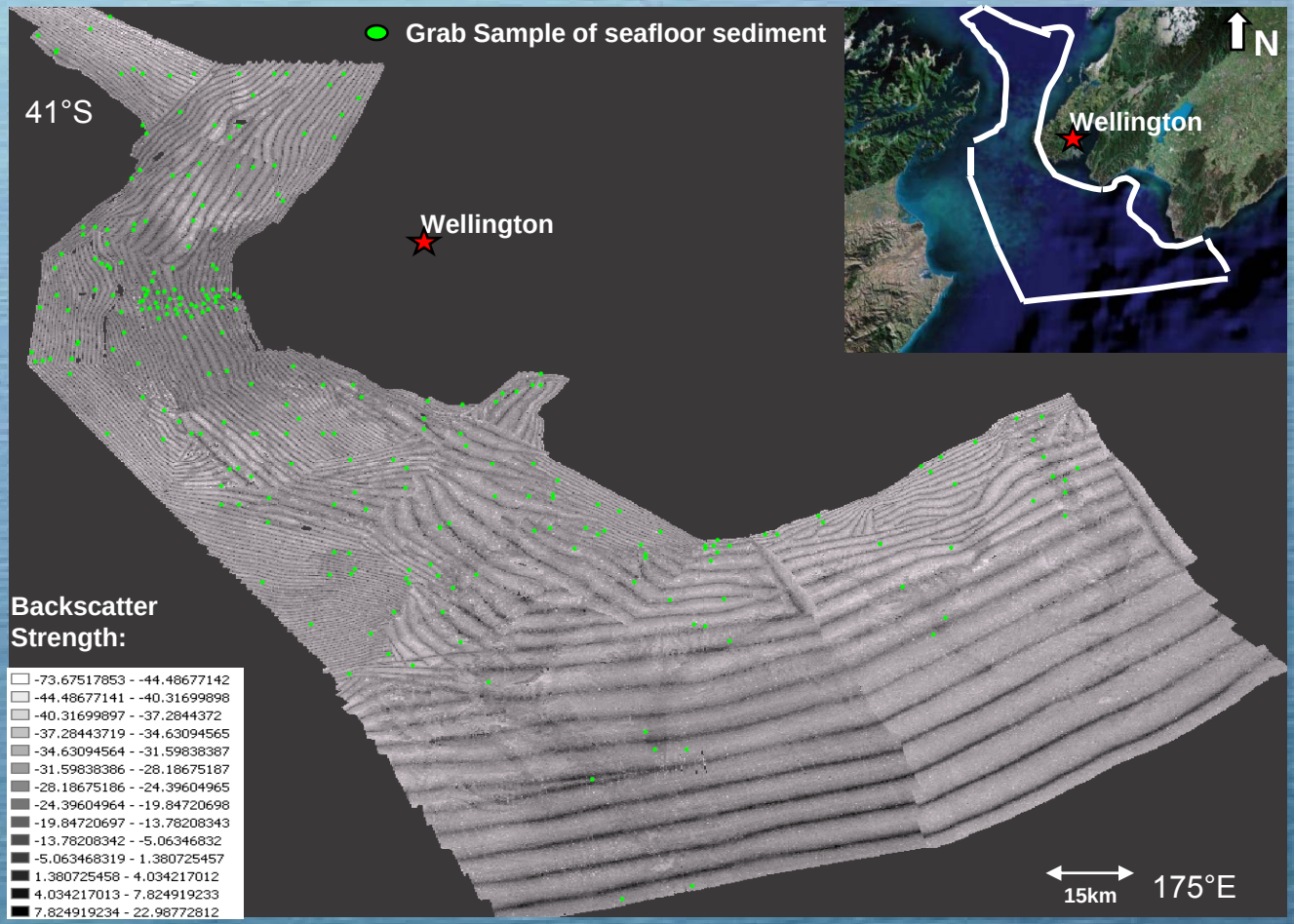
Station	depth	-2 (%)	-0.5	0.5 (%)	1.5 (%)	2.5 (%)	3.5 (%)	5 (%)
C206	174	11.06	7.72	11.78	35.73	23.04	3.21	7.46

- => Calculation: - mean grain size
  - standard deviation
- Compare to backscatter mean

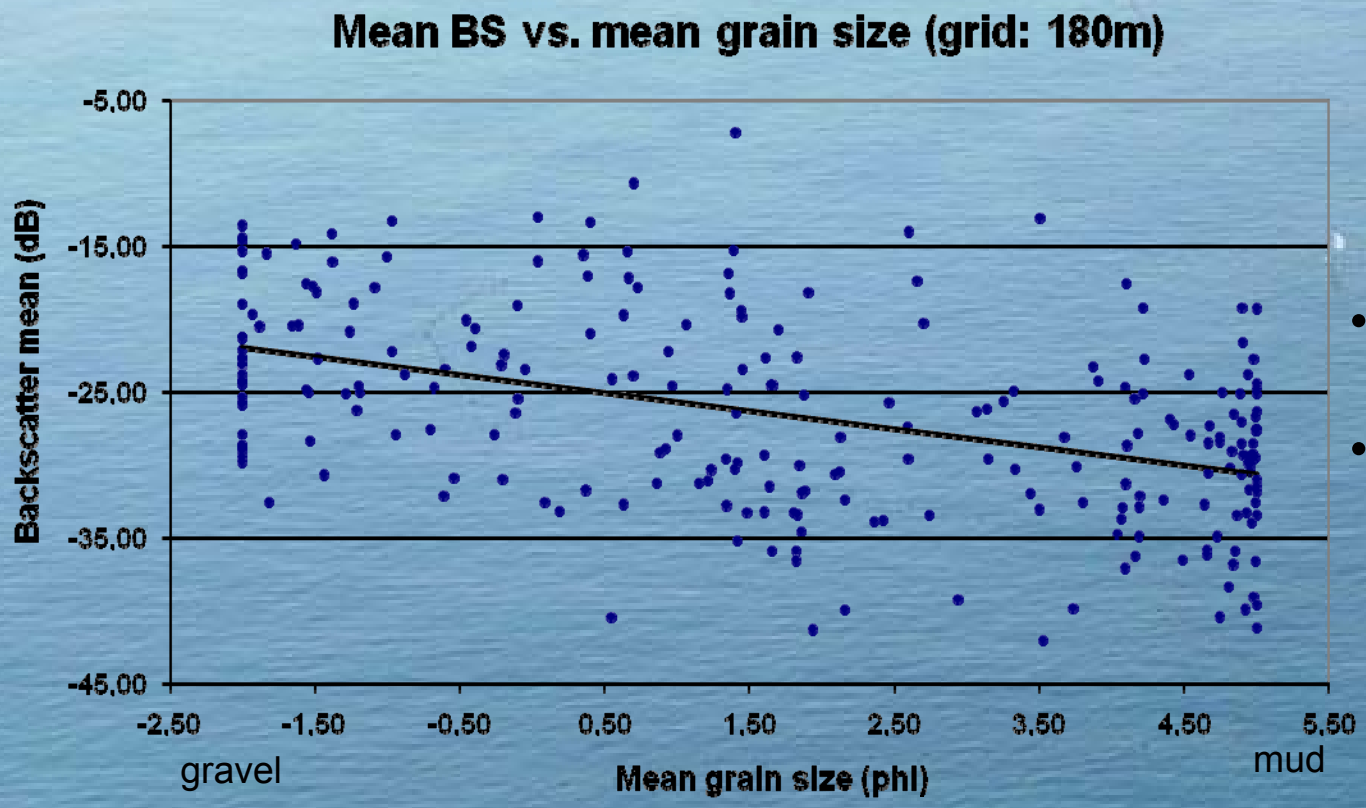
Combined results

Ship based data + Lab based data

- Mosaic of calibrated BS data
- High BS in black
- Low BS in white
- Overly with sample points in GIS
- => Mean BS value around sample point



Backscatter vs. grain size



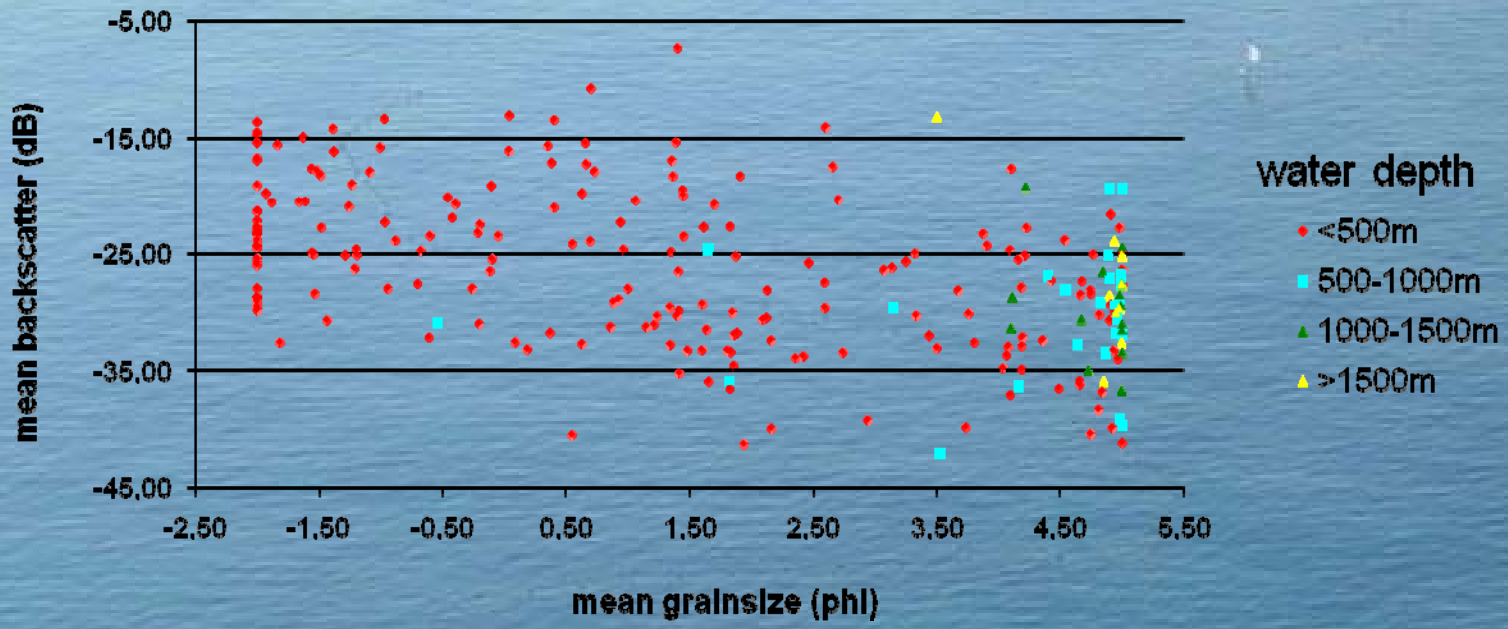
- Low correlation
- $R^2 = 0.21$

- Different grid sizes to see effects of grid resolution (60m, 100m, 180m)

=> Little variation between different grid sizes

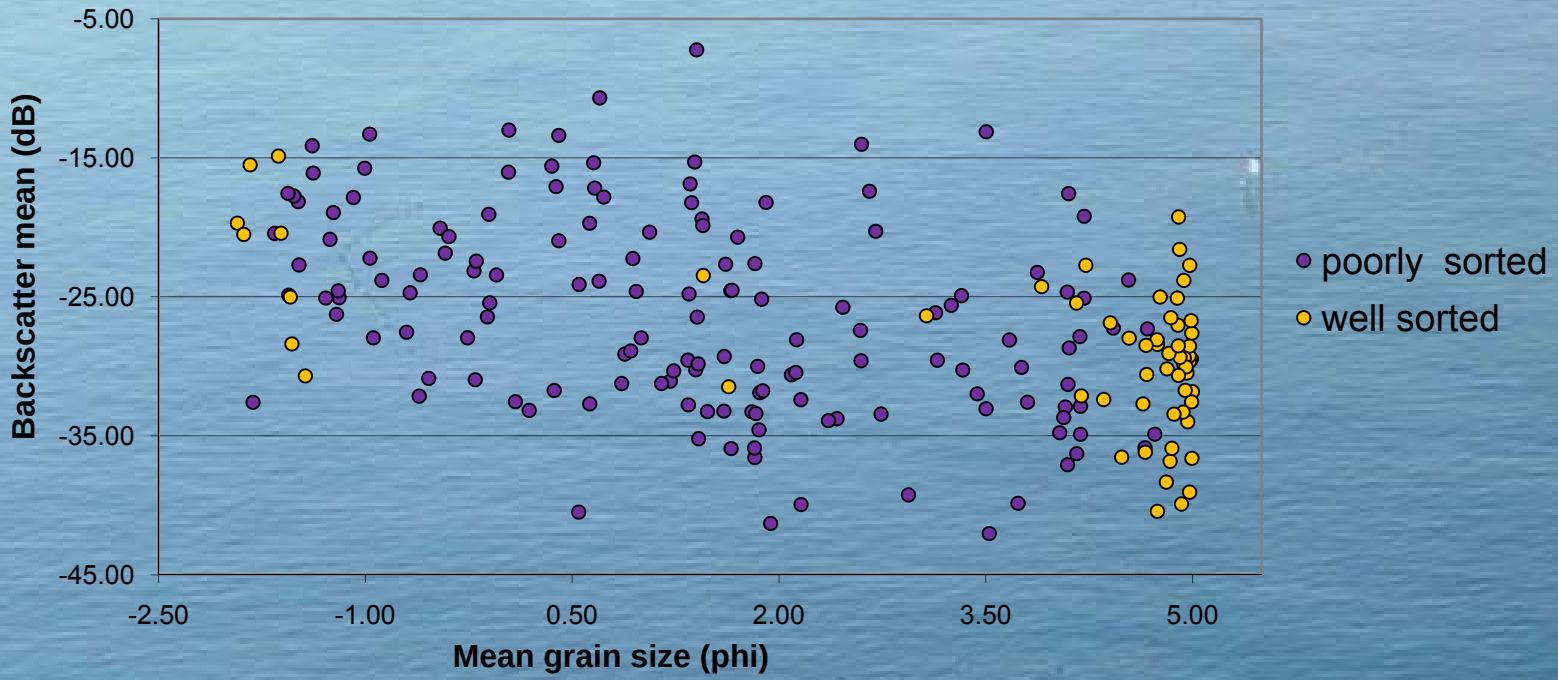
Backscatter vs. grain size (depth)

- Depending on depth?



- No obvious correlation in relation to water depth

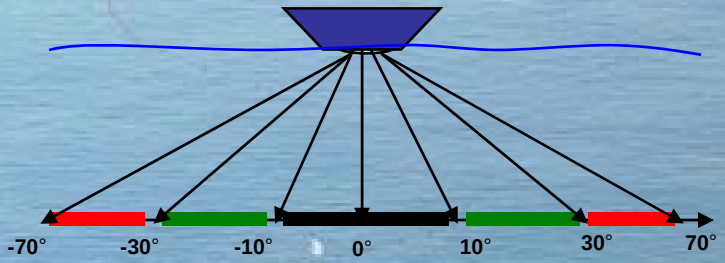
Backscatter vs. grain size (sorting)

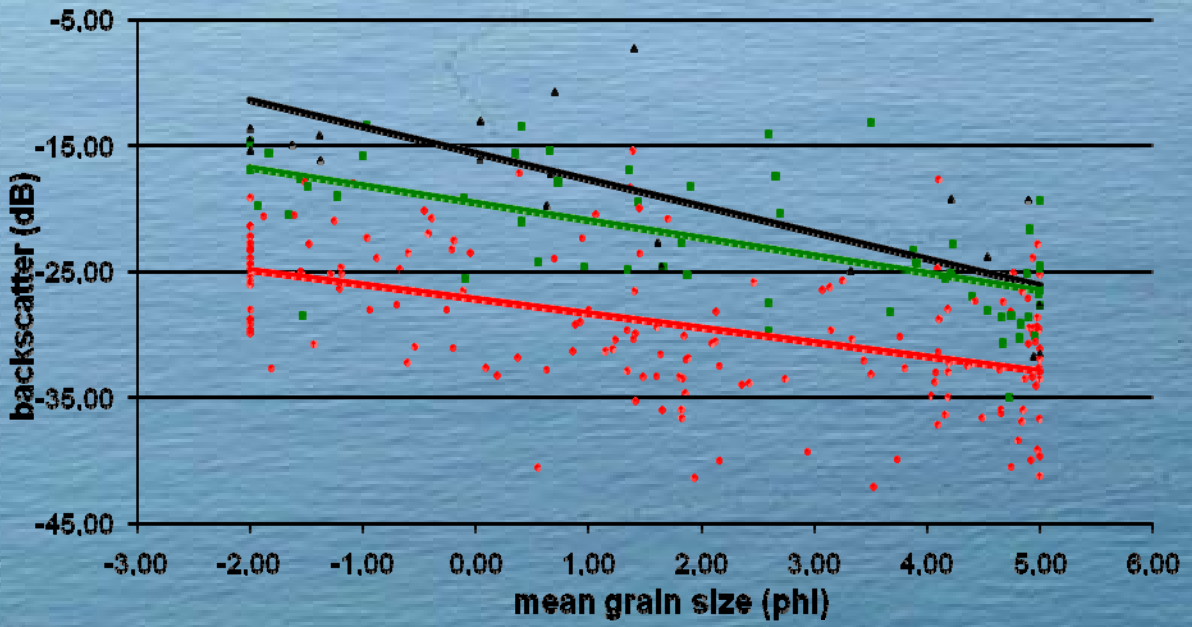


- Poorly sorted (sorting $\delta_\Phi > 1$)
  =>no correlation
  $R^2 = 0.1$
- Well sorted (sorting $\delta_\Phi < 1$)
  Low correlation
  $R^2 = 0.3$

Backscatter vs. grain size (angles)

- Divided into three classes of different angles





70°to 30°: R^2= 0.27

30°to 10°: R^2= 0.41

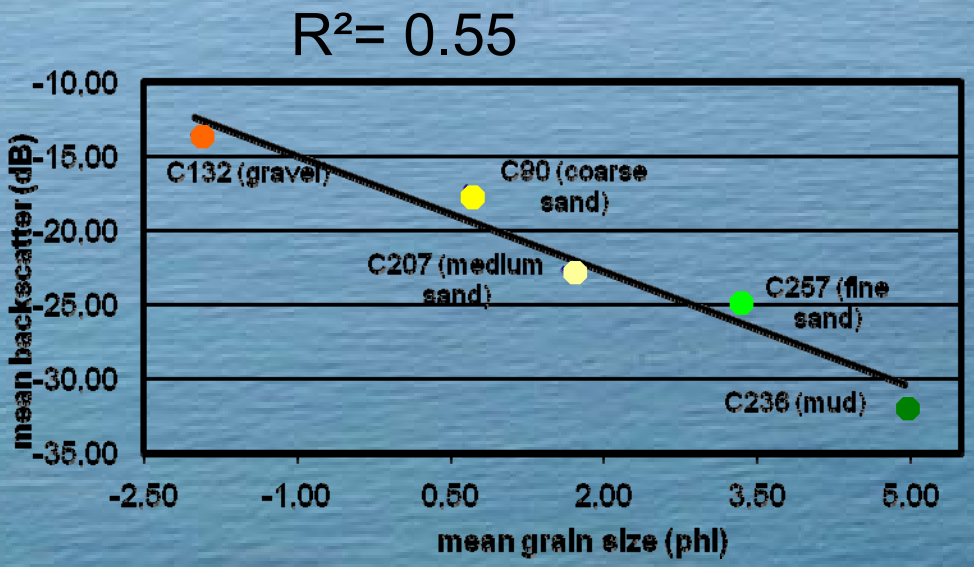
10° to nadir: R^2= 0.55

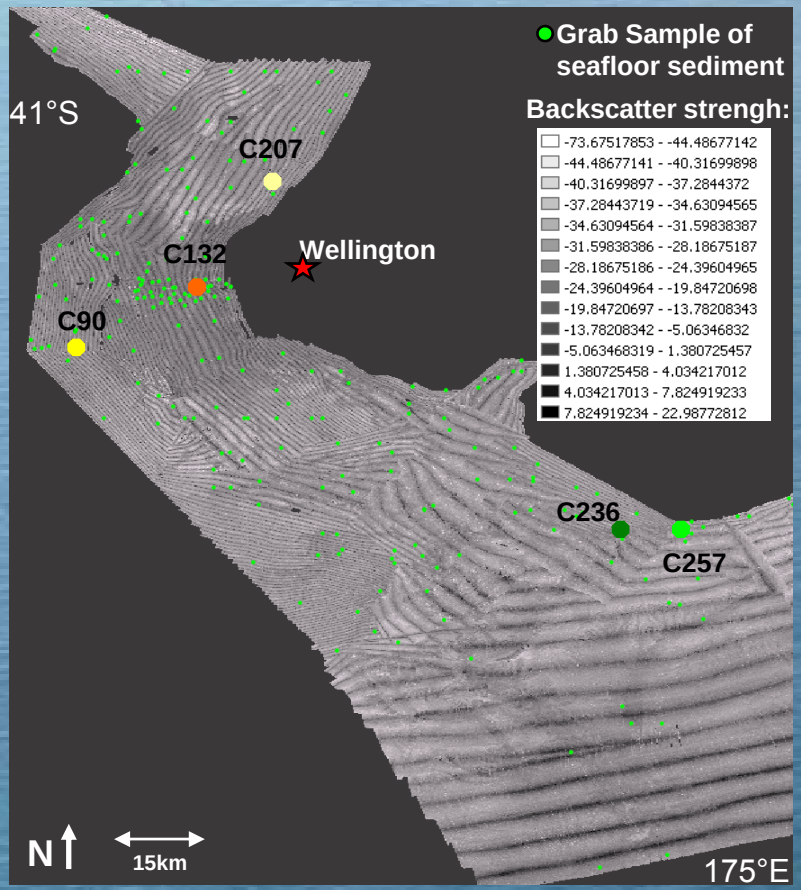
=> accuracy highest for inner part of the swath

Combined results

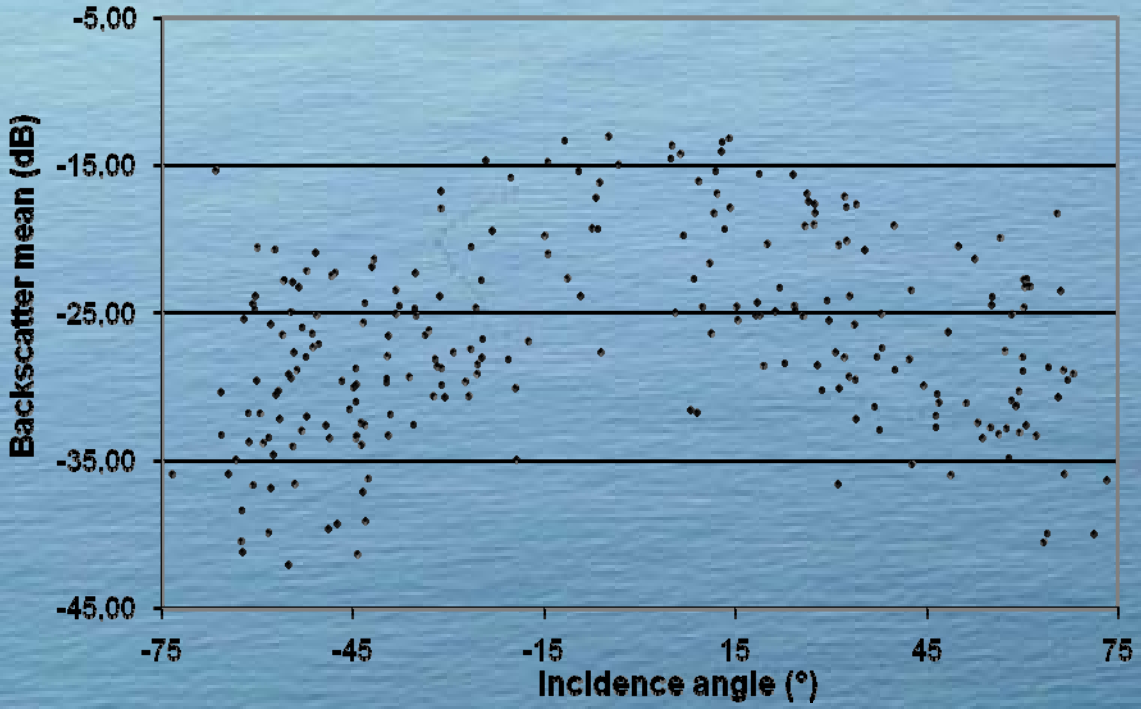
Backscatter vs. grain size (- 10° to 10°)

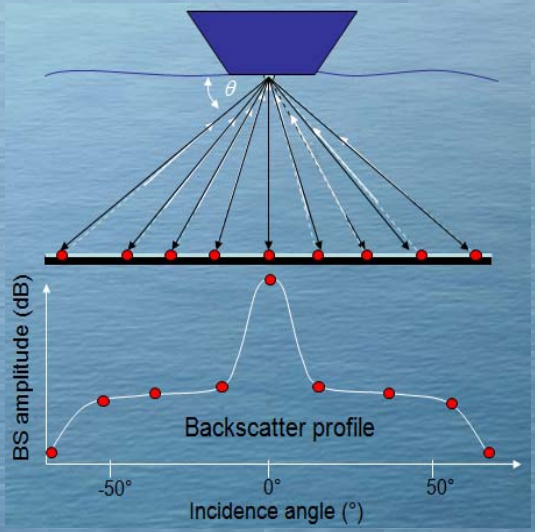
station	Mean grain size (phi)		BS(dB)	Angle(°)
C132	-2.00	gravel	-13.57	5.00
C90	0.66	coarse sand	-17.17	-6.88
C207	1.61	medium sand	-22.65	8.54
C257	3.32	fine sand	-24.92	5.57
C236	4.95	mud	-31.72	8.95





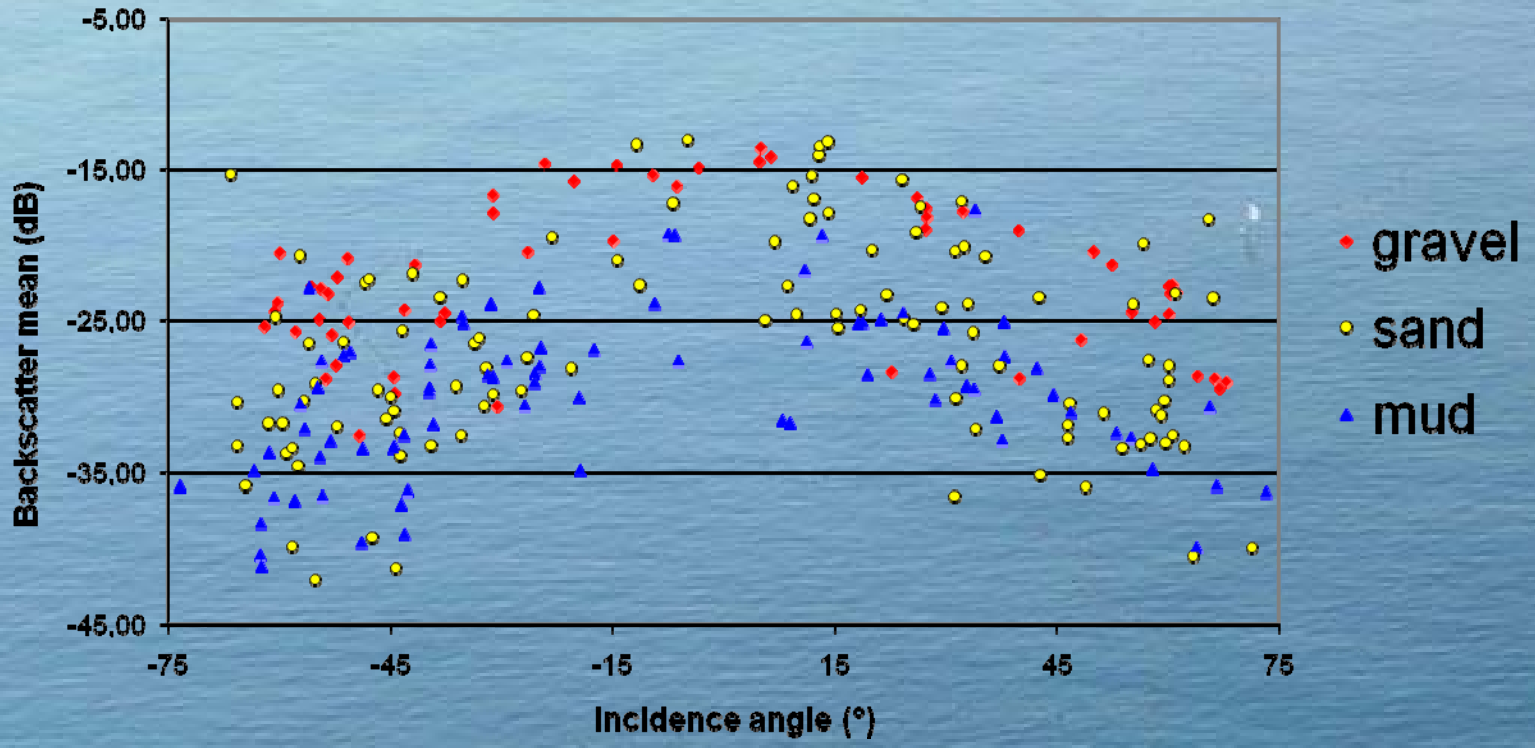
Backscatter vs. grain size (angle)





- Shape of backscatter curve
  - ⇒ lower BS at higher angles
  - ⇒ higher BS at lower angles

Backscatter vs. grain size (angle)



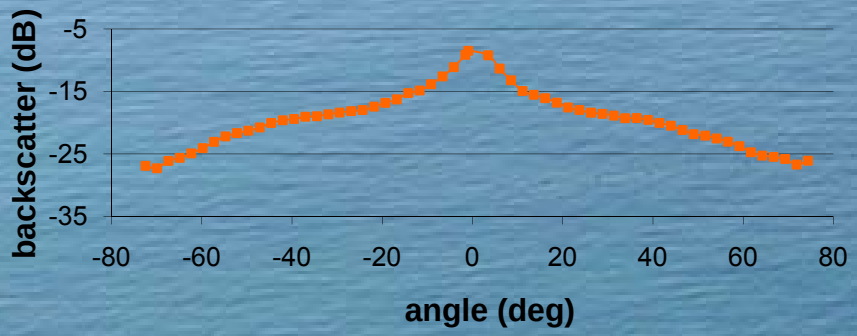
- coarser grain size=> higher BS
- finer grain size=> lower BS

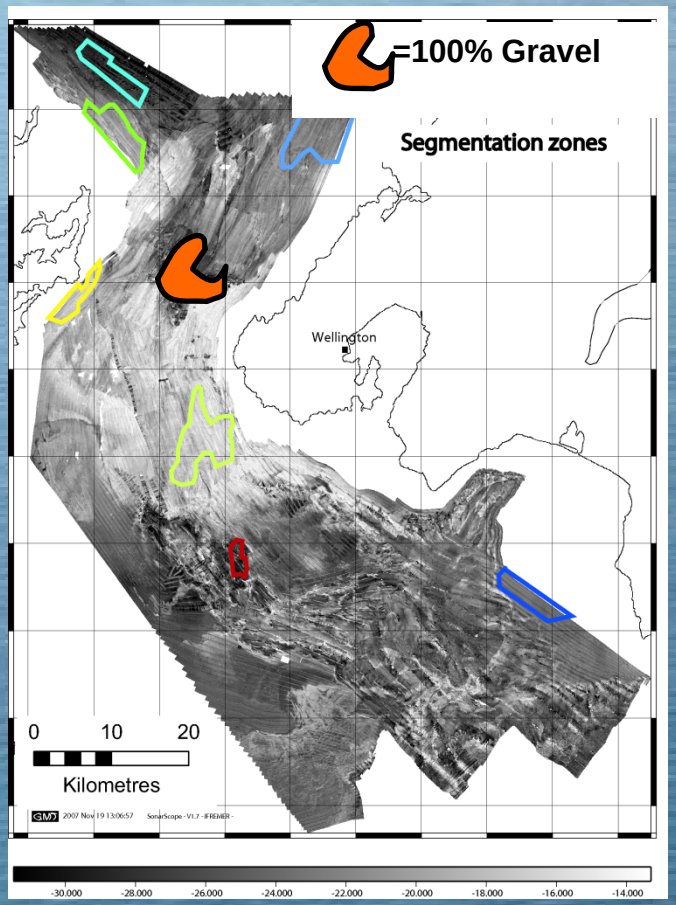
Segmentation

Segmentation

- Acoustically homogeneous areas are defined
- Model of BS profile of each homogenous area

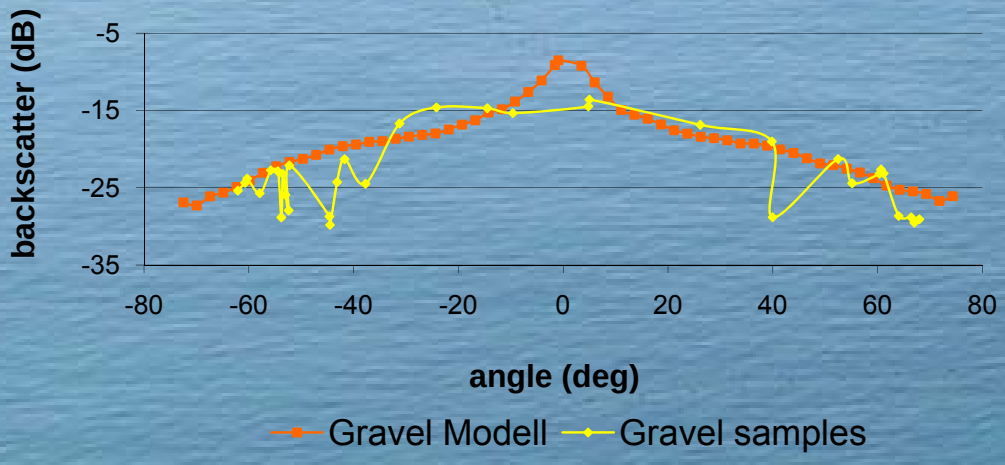
- Example: 100% Gravel
- BS values between -27 and -9 dB

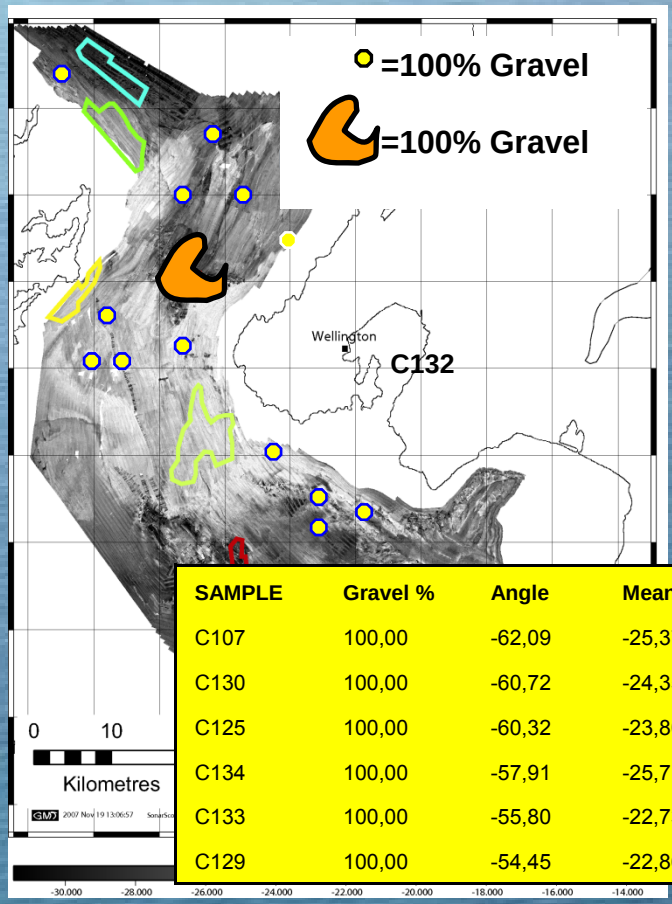




Segmentation

- BS of all samples having the same mean grain size (100% gravel) plotted against the model values





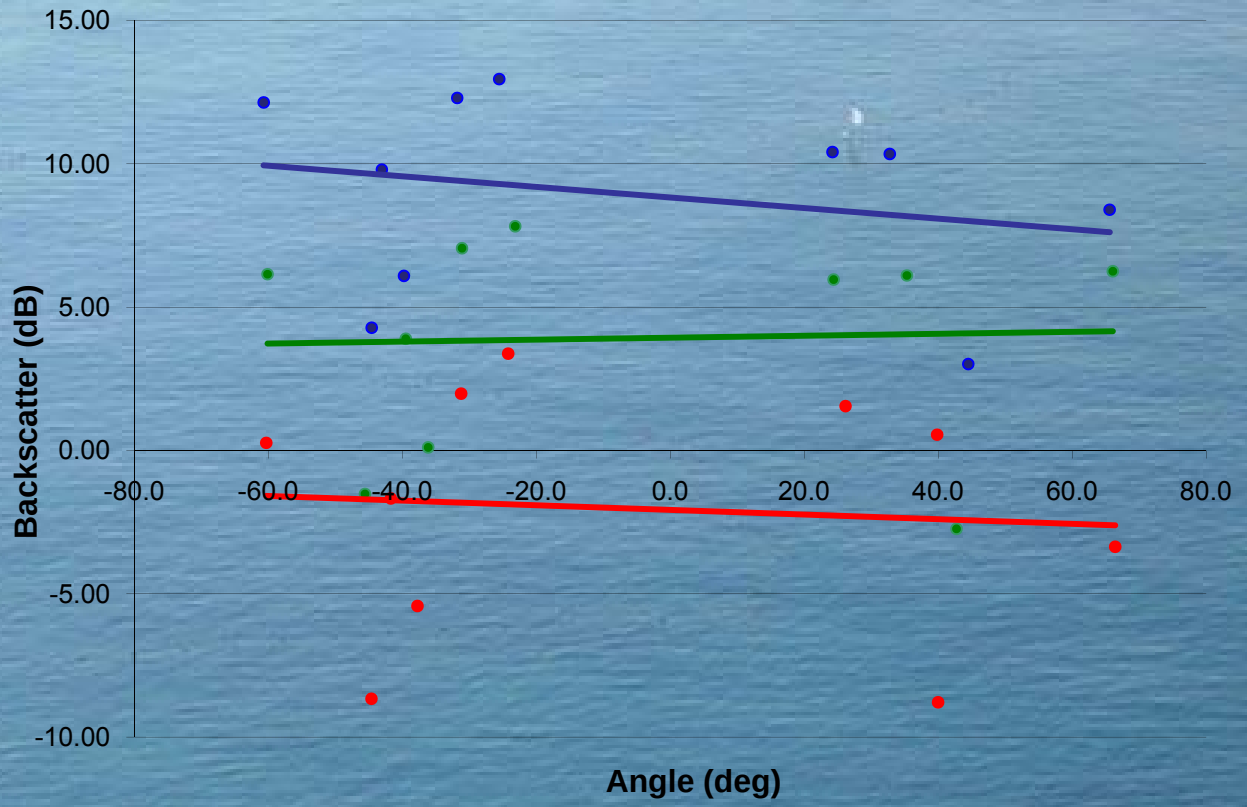
SAMPLE	Gravel %	Angle	Mean BS
C107	100,00	-62,09	-25,37
C130	100,00	-60,72	-24,35
C125	100,00	-60,32	-23,80
C134	100,00	-57,91	-25,71
C133	100,00	-55,80	-22,73
C129	100,00	-54,45	-22,86

- => correlation strength is assessed

Residuals

Difference between samples and model values

- Gravel sample – mud model
- Gravel sample – sand model
- Gravel sample –gravel model



Summary

What is the quantitative relationship between backscatter and grain size?

- Geological information can be extracted from BS
  - Former days: qualitative - strength of signal
  - These days: also quantitative – strength and shape of signal

How transferable is the derived relationship between backscatter and grain size to other regions?

- This question remains to be answered but the approach looks promising