Sediment classification from multibeam backscatter images using simple histogram analysis

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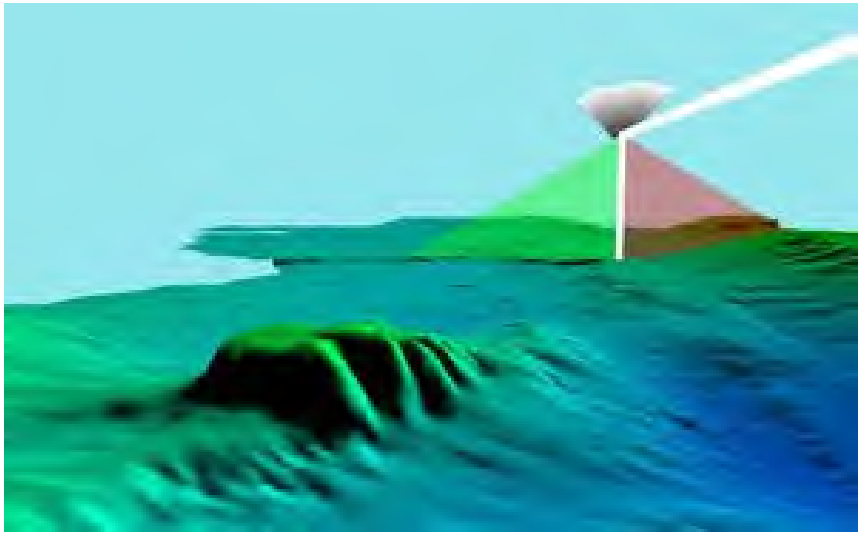
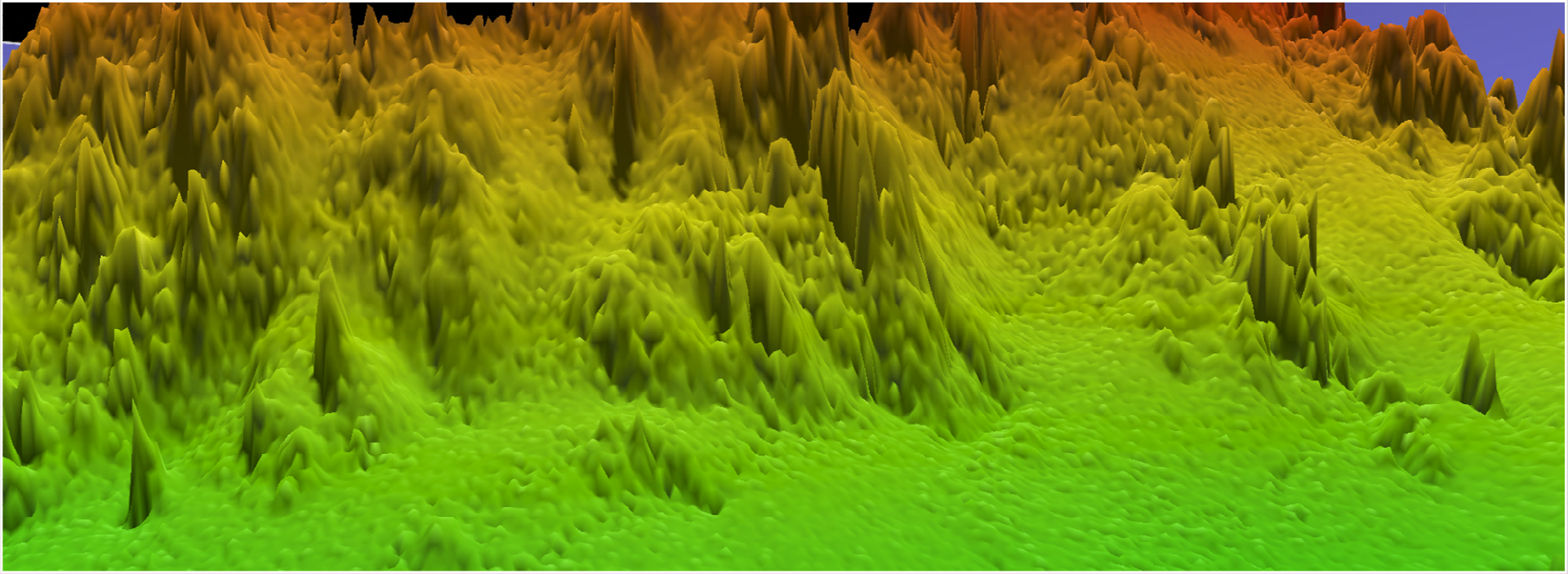
Multibeam echo sounder system

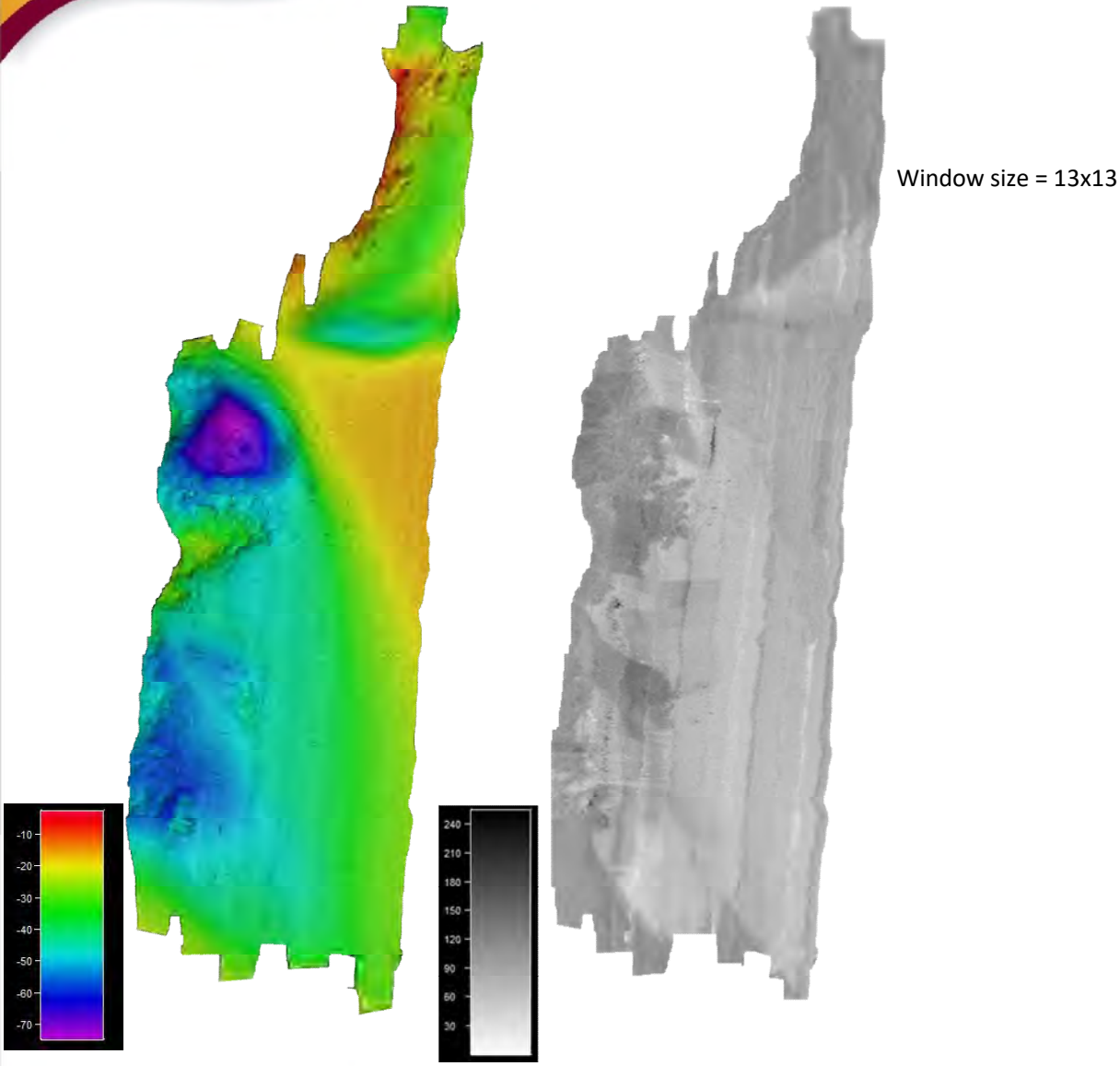
- High spatial resolution dataset – depth + intensity (backscatter)
- Full coverage dataset
- More detail seabed feature



Source: WASSP website



Seafloor hardness (backscatter)



Window size = 13x13

- High intensity returns -> hard surface, e.g. gravel or potentially from hard coral
- Low intensity returns -> soft surface, e.g. fine sand
- Backscatter -> indicator and proxy for sediment types and potentially substrate classes

Backscatter classification

- Ability of backscatter data to characterise/discriminate seafloor types - sediment or benthic habitats
- Technique depends;

1. Types of backscatter data (either mosaic or angular)
2. Existence of other data (e.g. bathymetry and other benthic seascapes – slope, aspect, curvature, benthic terrain model, etc.)
3. Habitat types (e.g. from ground truthing)

How backscatter data is used for sediment classification?

1 – Backscatter mosaic (image) – textural classification, grey level co-occurrence, filtering

2 – Backscatter mosaic + bathymetry (predictive modelling)

3 – Angular backscatter Response (parameter extraction, inversion model-ARA, generic seafloor acoustic backscatter model)

Aim

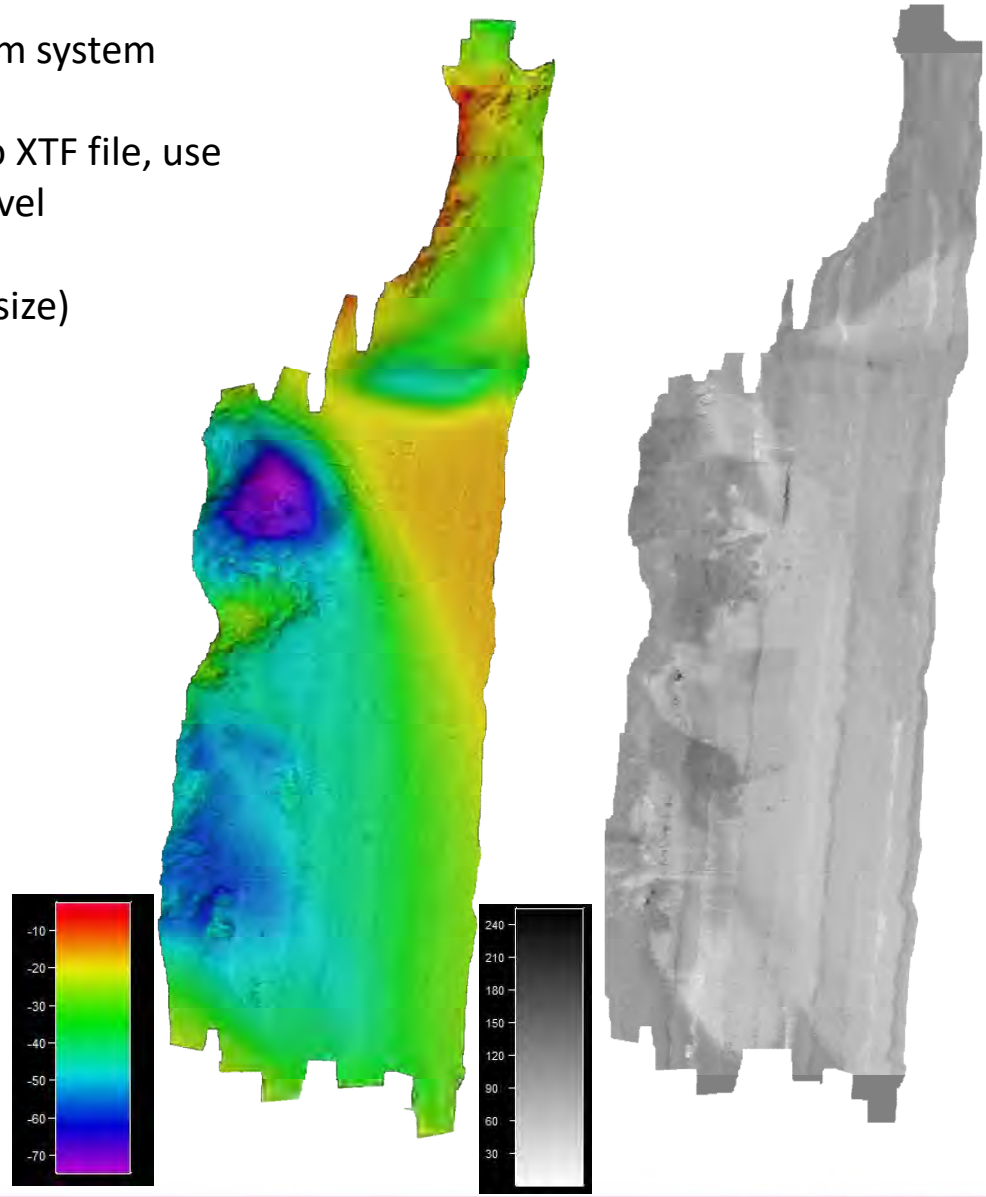
- Attempt to use simple classification from backscatter mosaic
- Method:

- use information from histogram derived from backscatter intensity pixel

- Implement simple data classification in GIS software without complex modelling or advanced machine learning approach

MBES data at Pulau Agas (Kepulauan Sembilan), Perak

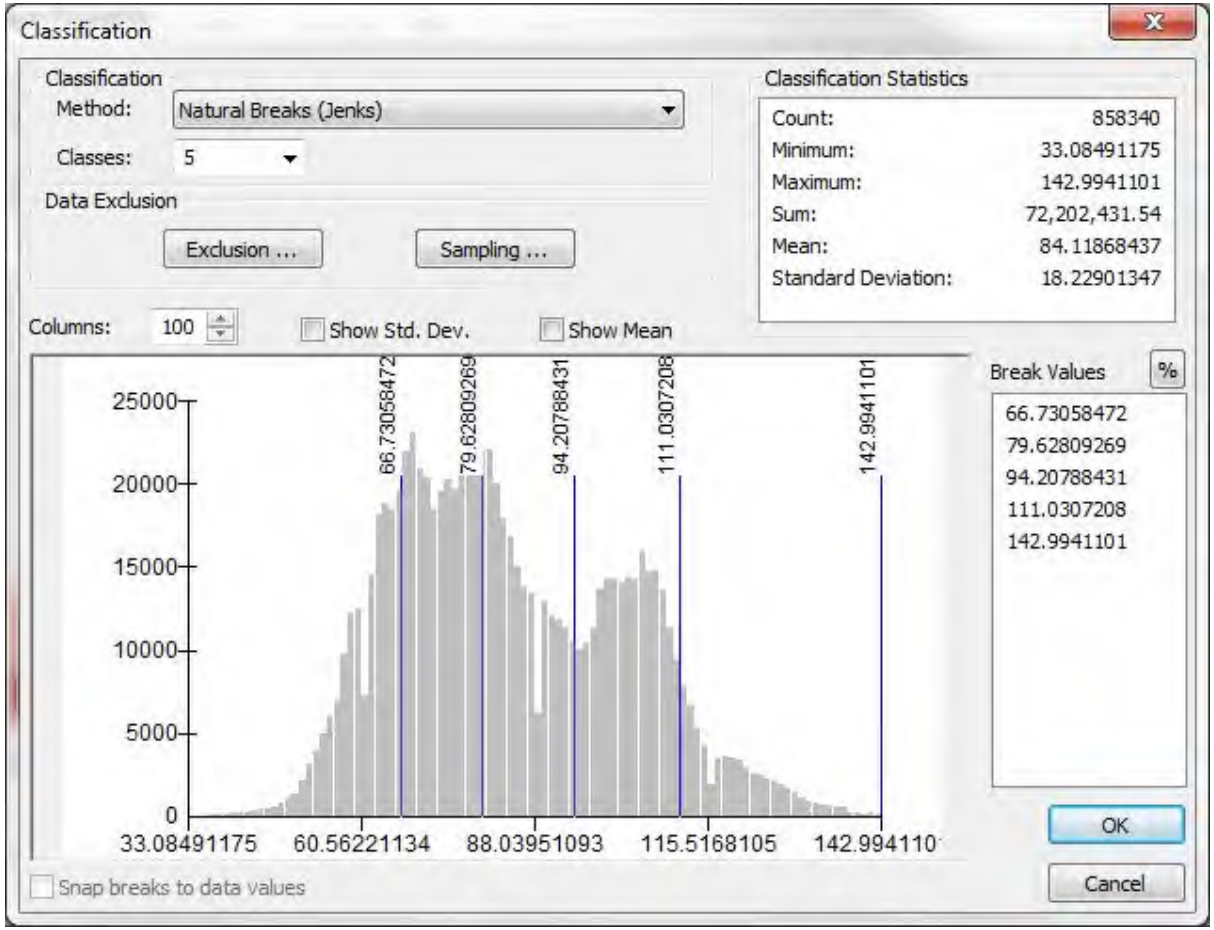
- Acquired using WASSP WMB-3250 multibeam system
- Depth from 2m to 75m
- Backscatter – recorded in QINSY, exported to XTF file, use in-house matlab script to extract intensity level
- Use 8 bit intensity backscatter image
- Compute mean backscatter (13x13 window size)



Ground truthing

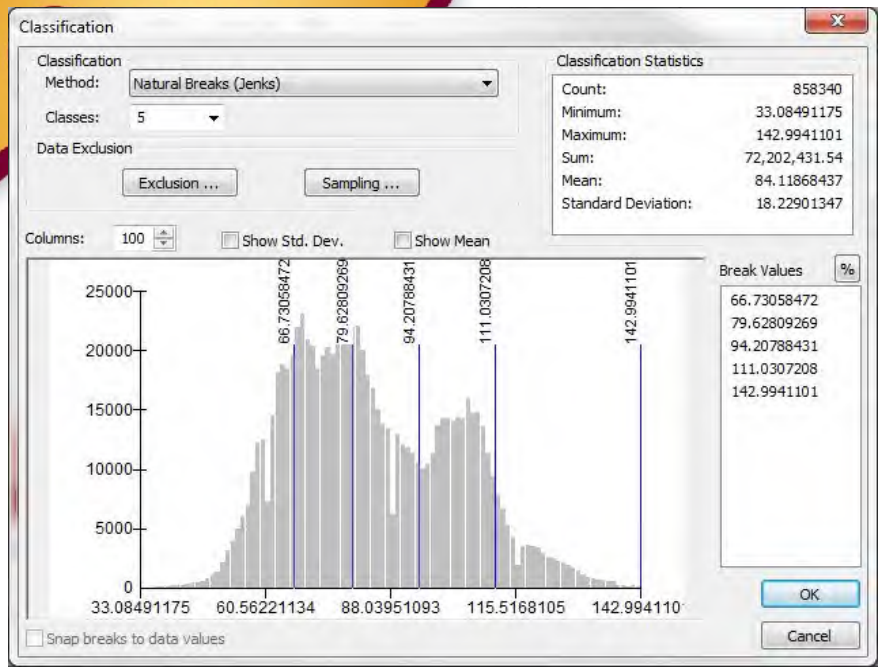
- Use grab sampler and underwater video observation
- Class 1 – Sand
- Class 2 – Silt
- Class 3 – Gravel
- Class 4 – Hard coral
- Class 5 – Soft coral

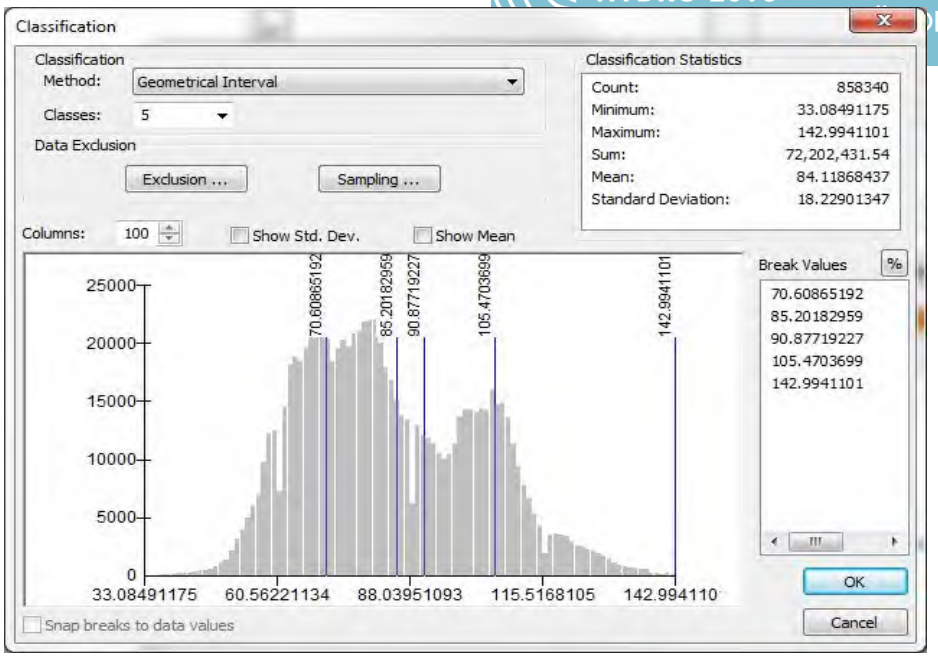
Histogram from mean backscatter image



Data classification techniques in ArcMap

- Classify data using histogram shape and statistics
- Natural breaks - breaks classes are based on natural groupings inherent in the data.
- Geometrical interval - creates class breaks based on class intervals that have a geometric series
- Quantile - well suited to linearly distributed data & assigns the same number of data values to each class
- Equal interval - divides the range of attribute values into equal-sized subranges


Classification
Classification
Method: Natural Breaks (Jenks)
Classes: 5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 858340
Minimum: 33.08491175
Maximum: 142.9941101
Sum: 72,202,431.54
Mean: 84.11868437
Standard Deviation: 18.22901347
Columns: 100
Show Std. Dev.
Show Mean
Break Values
66.73058472
79.62809269
94.20788431
111.0307208
142.9941101
25000
20000
15000
10000
5000
0
33.08491175
60.56221134
88.03951093
115.5168105
142.994110
OK
Cancel
Snap breaks to data values


Classification
Classification
Method: Geometrical Interval
Classes: 5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 858340
Minimum: 33.08491175
Maximum: 142.9941101
Sum: 72,202,431.54
Mean: 84.11868437
Standard Deviation: 18.22901347
Columns: 100
Show Std. Dev.
Show Mean
Break Values
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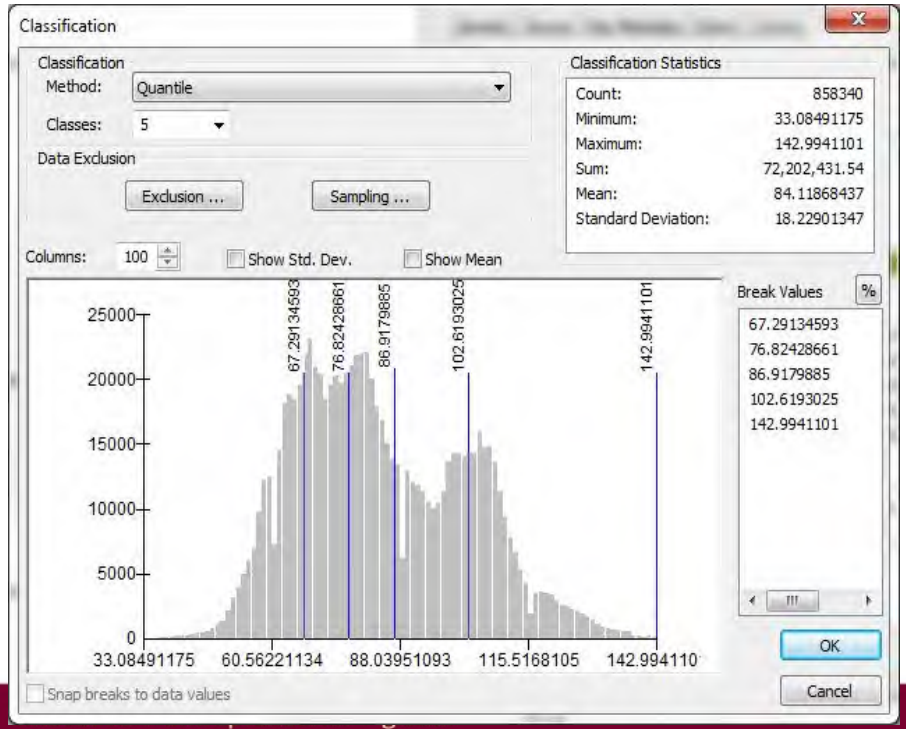
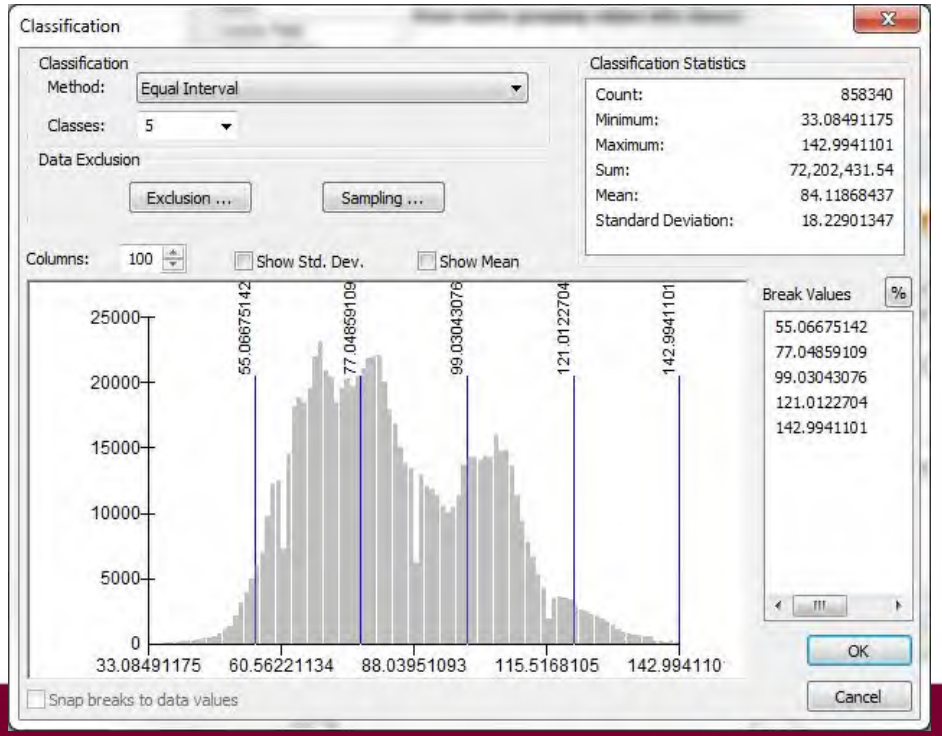
85.20182959
90.87719227
105.4703699
142.9941101
25000
20000
15000
10000
5000
0
33.08491175
60.56221134
88.03951093
115.5168105
142.994110
OK
Cancel
Snap breaks to data values


Classification
Classification
Method: Quantile
Classes: 5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 858340
Minimum: 33.08491175
Maximum: 142.9941101
Sum: 72,202,431.54
Mean: 84.11868437
Standard Deviation: 18.22901347
Columns: 100
Show Std. Dev.
Show Mean
Break Values
67.29134593
76.82428661
86.9179885
102.6193025
142.9941101
25000
20000
15000
10000
5000
0
33.08491175
60.56221134
88.03951093
115.5168105
142.994110
OK
Cancel
Snap breaks to data values


Classification
Classification
Method: Equal Interval
Classes: 5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 858340
Minimum: 33.08491175
Maximum: 142.9941101
Sum: 72,202,431.54
Mean: 84.11868437
Standard Deviation: 18.22901347
Columns: 100
Show Std. Dev.
Show Mean
Break Values
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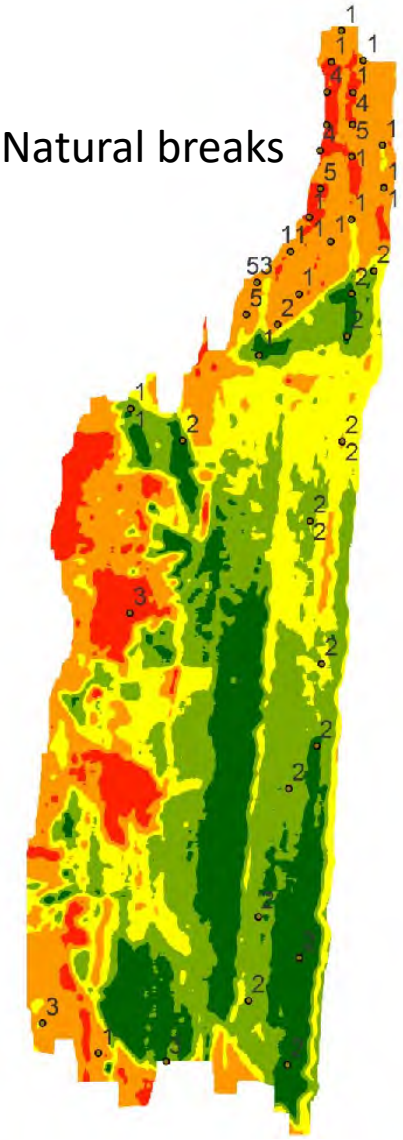
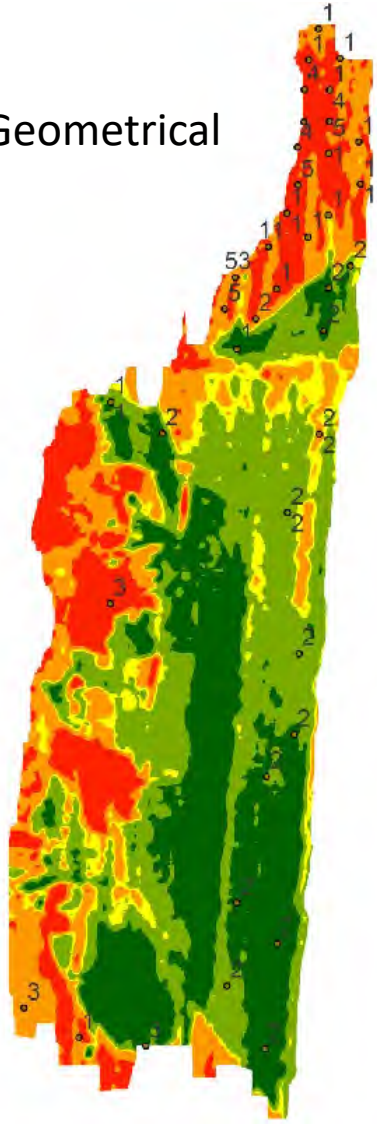
77.04859109
99.03043076
121.0122704
142.9941101
25000
20000
15000
10000
5000
0
33.08491175
60.56221134
88.03951093
115.5168105
142.994110
OK
Cancel
Snap breaks to data values

Class 1 – Sand
Class 2 – Silt
Class 3 – Gravel
Class 4 – Hard coral
Class 5 – Soft coral

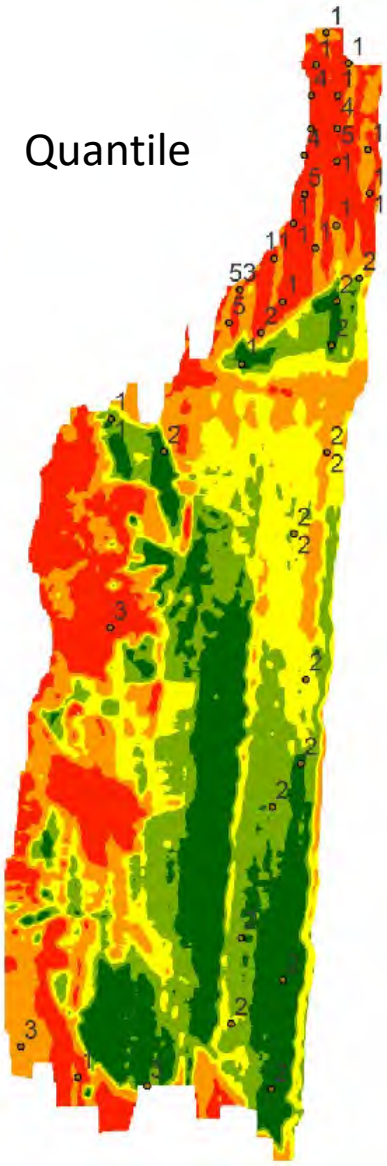
Natural breaks



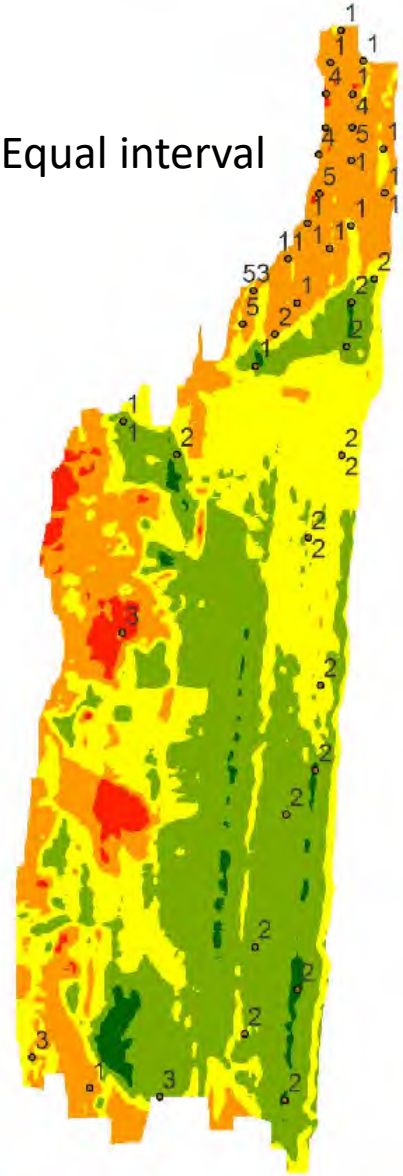
Geometrical



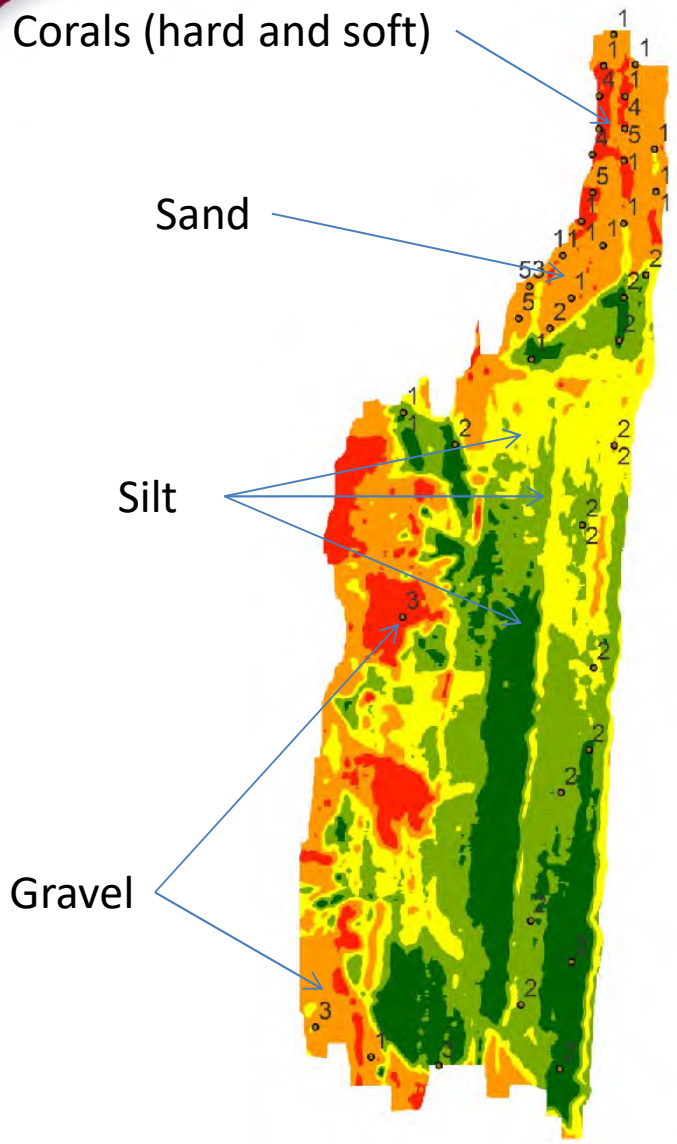
Quantile

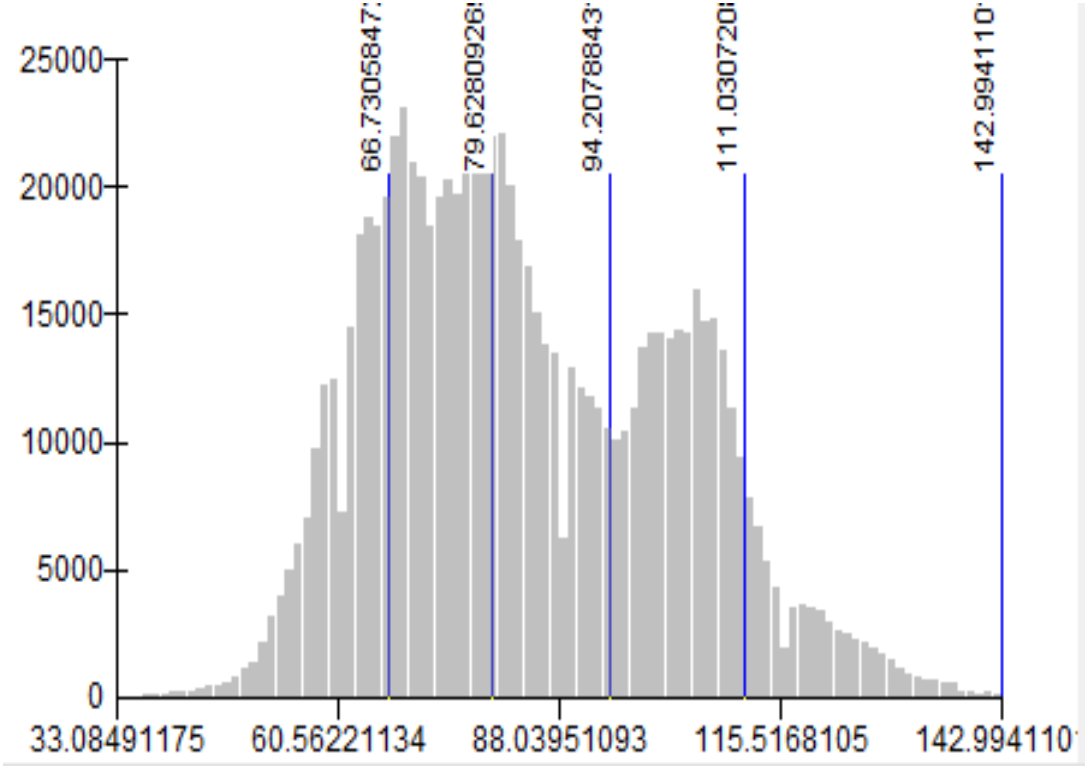


Equal interval



Natural breaks





Intensity (0-255)

Discussion and conclusions

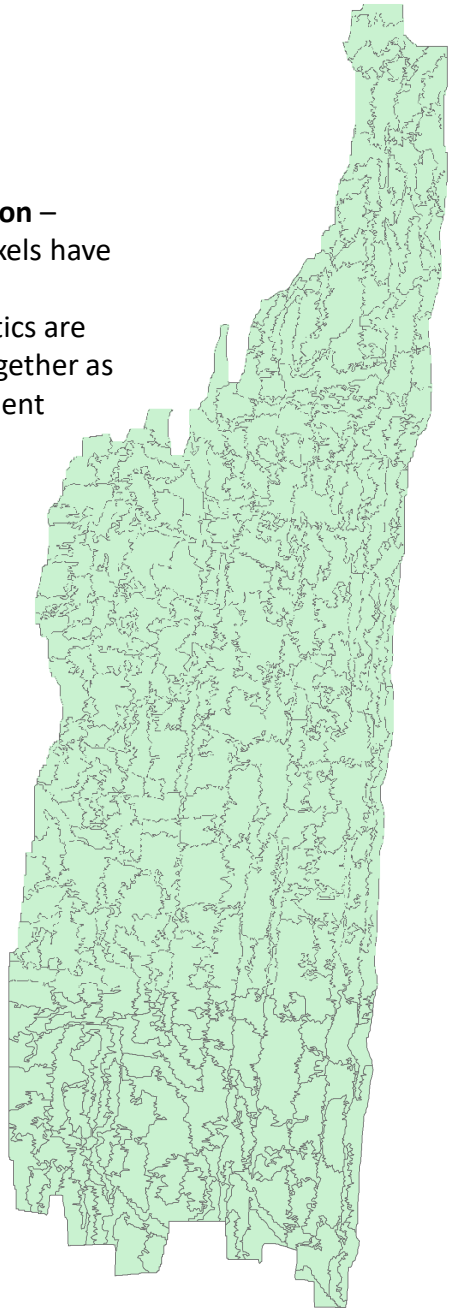
- Histogram analysis found to be a useful technique for backscatter image data classification.
- Advantage – no need to use advance modelling or machine learning technique & works even with only one layer (backscatter)
- Although not exactly correct, but provide general overview of spatial distribution of the sediment types in the areas.
- Misclassifications occurred, most likely due to the low quality of backscatter image (i.e. processing) and noise
- Classification results still need some validation (i.e. compare with ground truthing) to generate final map
- This technique is an unsupervised method, future research will look into on how to applied this in a supervised mode

Thank you!!!

Danke!!!

Terima kasih!!!

Spatial segmentation – adjacent pixels have similar characteristics are grouped together as larger segment



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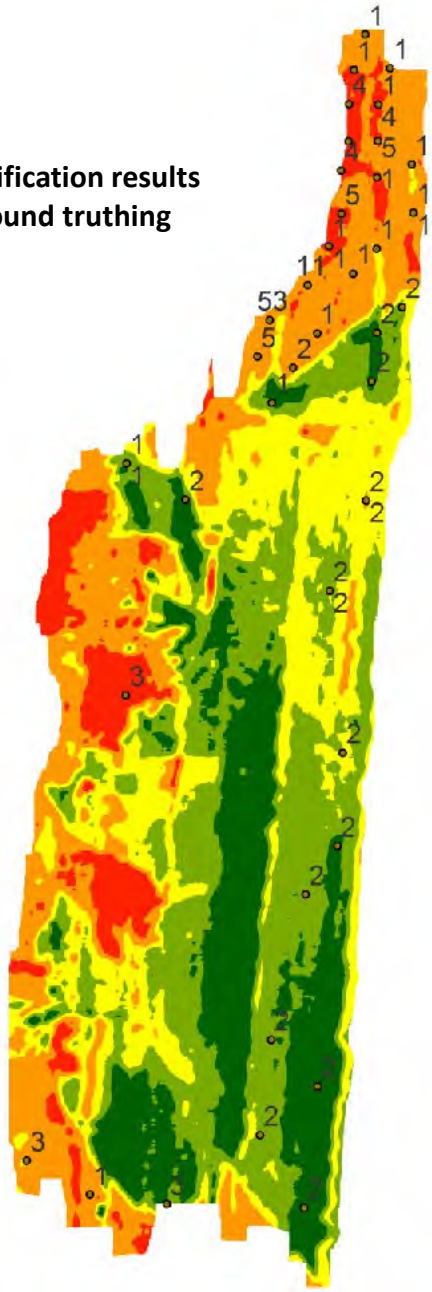
Classification results & ground truthing



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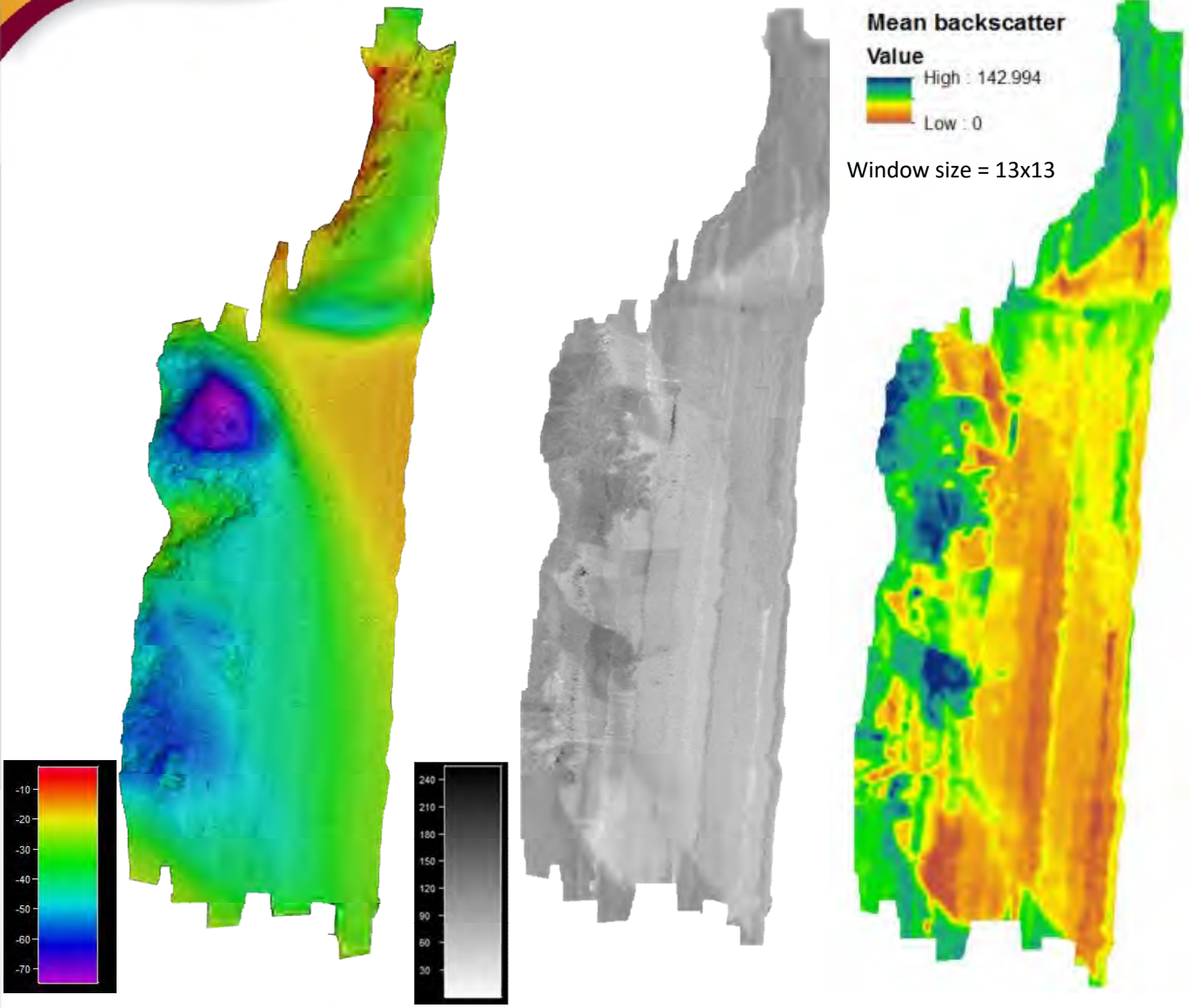
Sediment classification map

Backscatter analysis



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- Low intensity returns -> soft surface, e.g. fine sand
- Backscatter -> indicator and proxy for sediment types and potentially substrate classes
- Other terrestrial applications

-> grey level co-occurrence matrix (GLCMs) (image analysis)

-> Hue-Saturation-Intensity (HSI) – originally developed for radar

Bathymetry seascape derivatives

- Does not provide accurate habitat class, but important as proxy to study coral reef distribution and fish habitats
- Specific habitat class can be predicted using some modelling techniques & if ground truth data available
- Advantage – fine resolution dataset means better spatial scale of mapping benthic habitats