An overview of the use of acoustic data for geology and habitat mapping in MAREANO

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Geological Survey of Norway (NGU)

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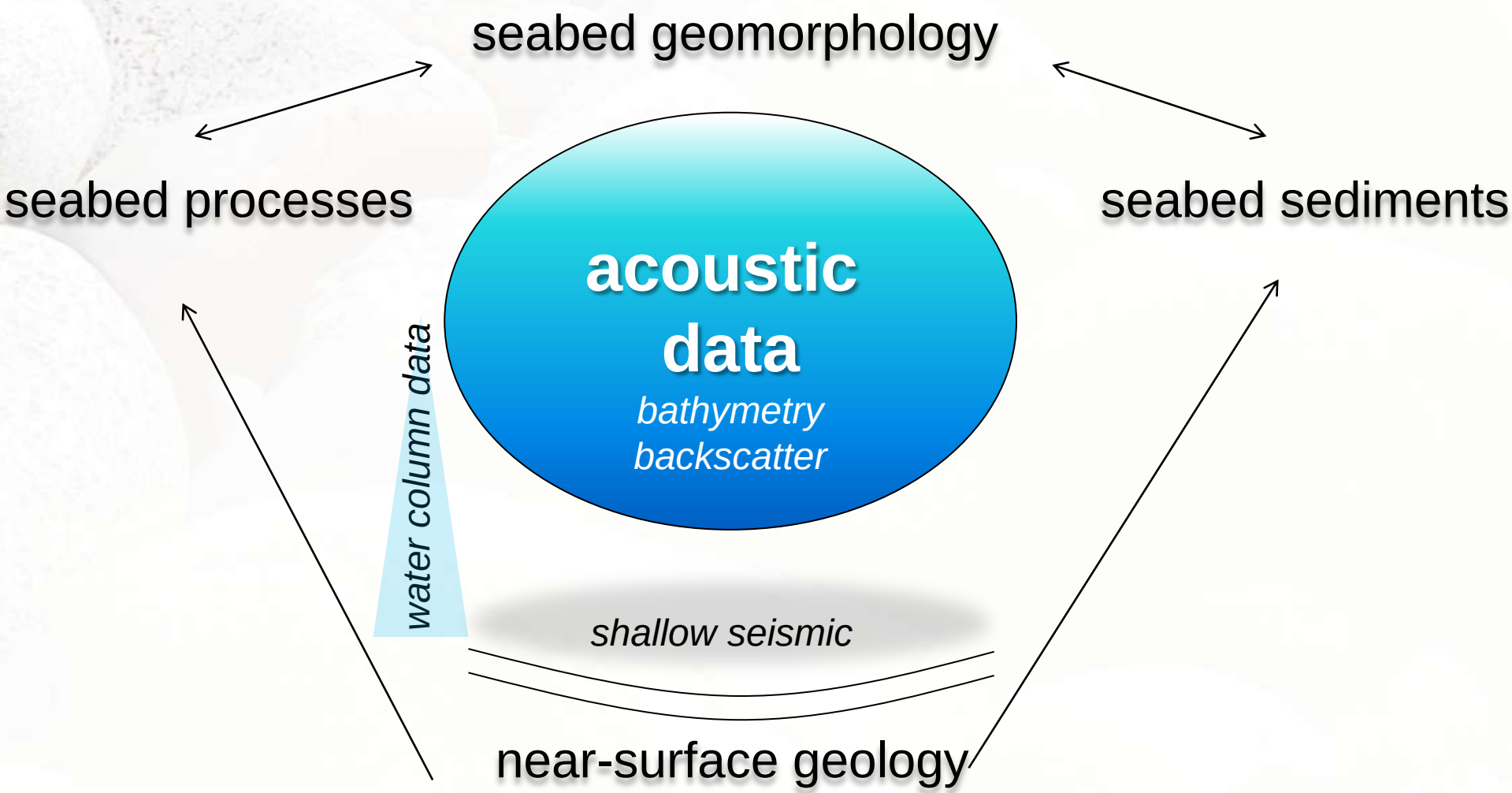
NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Core information for geology and habitat mapping



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Basis for geological and habitat map development

ACOUSTIC DATA

bathymetry
backscatter

shallow seismic

Bathymetry and backscatter maps

Terrain variables for habitat mapping +

Landscape *(broad-scale geomorphic features)*

Landforms *(local seabed geomorphic features)*

Sediment grain size

Sedimentary environment

Sediment genesis (formation)

+ ESSENTIAL BASIS FOR BIO/GEO CRUISE PLANNING

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Bathymetry data processing and analysis

Gridded data (NHS)

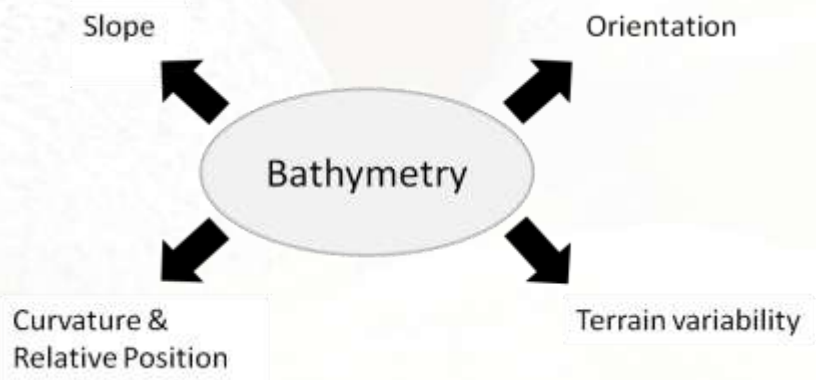
Raster bathymetry and hillshade (ArcGIS)

Quantitative terrain analysis (GIS)

Landscape map

Terrain variables for habitat mapping

Sediment interpretation



Summary of the types of terrain variables that can be derived from bathymetry data. From Dolan et al. 2012 NGU report 2012.045 (Geo-Seas)

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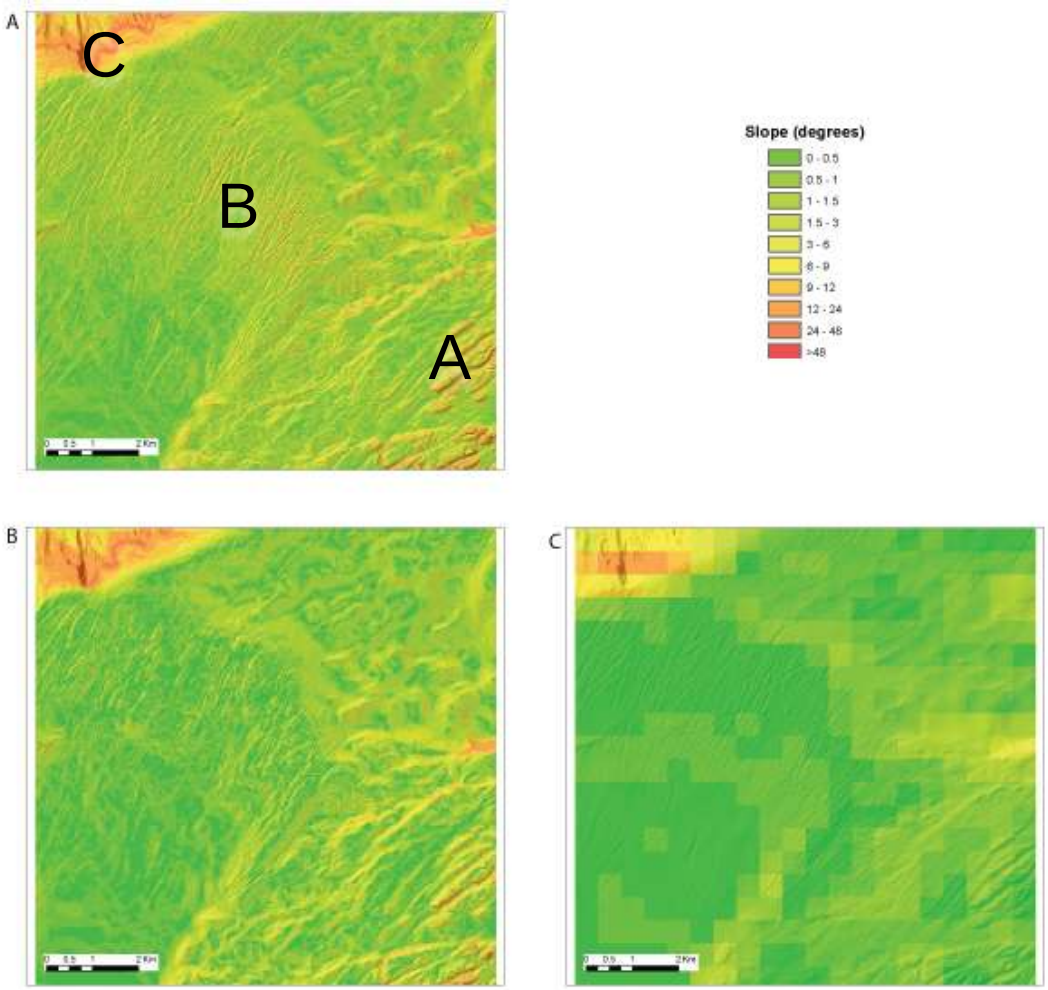
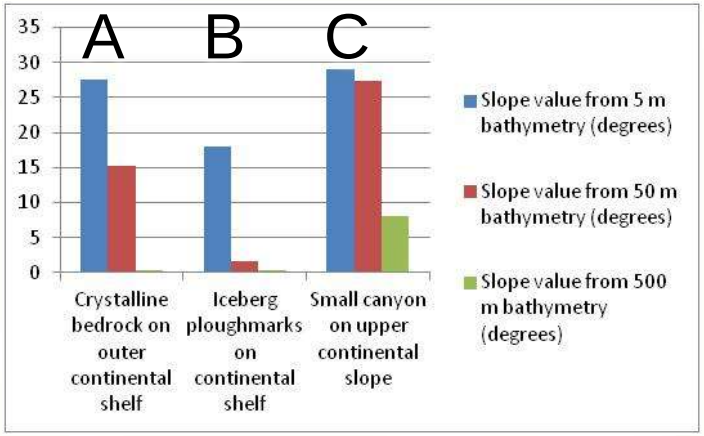
Geomorphic and ecological relevance of different types of terrain parameters

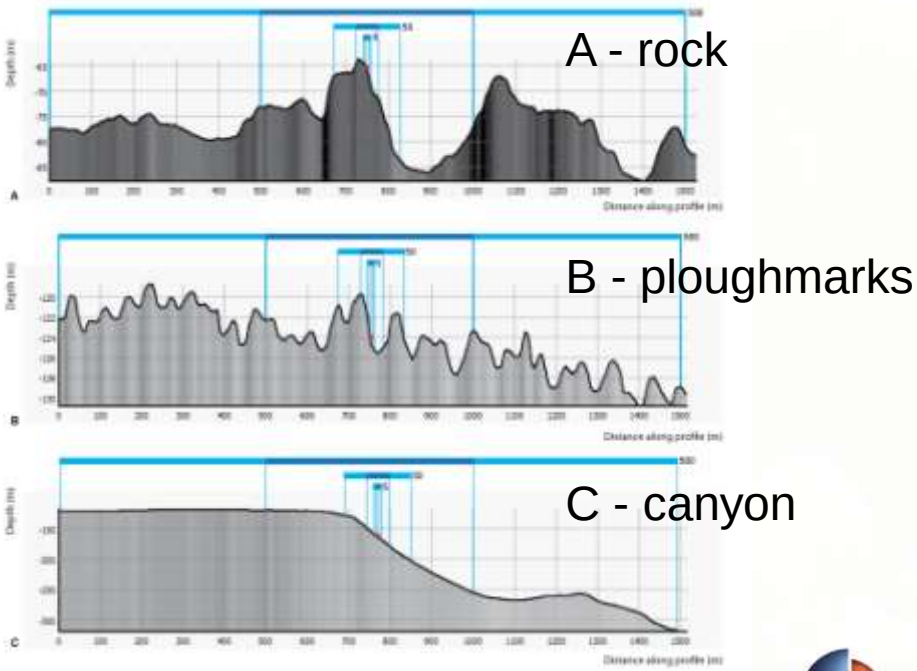
From Dolan et al. 2012. NGU report 2012.045 (Geo-Seas)

	Slope	**Orientation**	**Curvature and Relative Position**	**Terrain Variability**
Ecological relevance	Stability of sediments (ability to live in/on sediments) Local acceleration of currents (food supply, exposure, etc.).	Exposure to dominant and/or local currents from a particular direction (food supply, larval dispersion etc.)	Index of exposure/shelter e.g. on a peak or in a hollow (food supply, predators etc.)	Index of degree of habitat structure, shelter from exposure/predators (link to life stages). Structural diversity linked to biodiversity
Geomorphic relevance	Stability of sediments (grain size). Local acceleration of currents (erosion, movement of sediments, creation of bedforms).	Relation to direction of dominant geomorphic processes.	Flow, channelling of sediments/currents, hydrological and glacial processes. Useful in the classification of landforms.	Terrain variability and structures present reflect dominant geomorphic processes.

Terrain variables - scale, resolution and computation methods matter

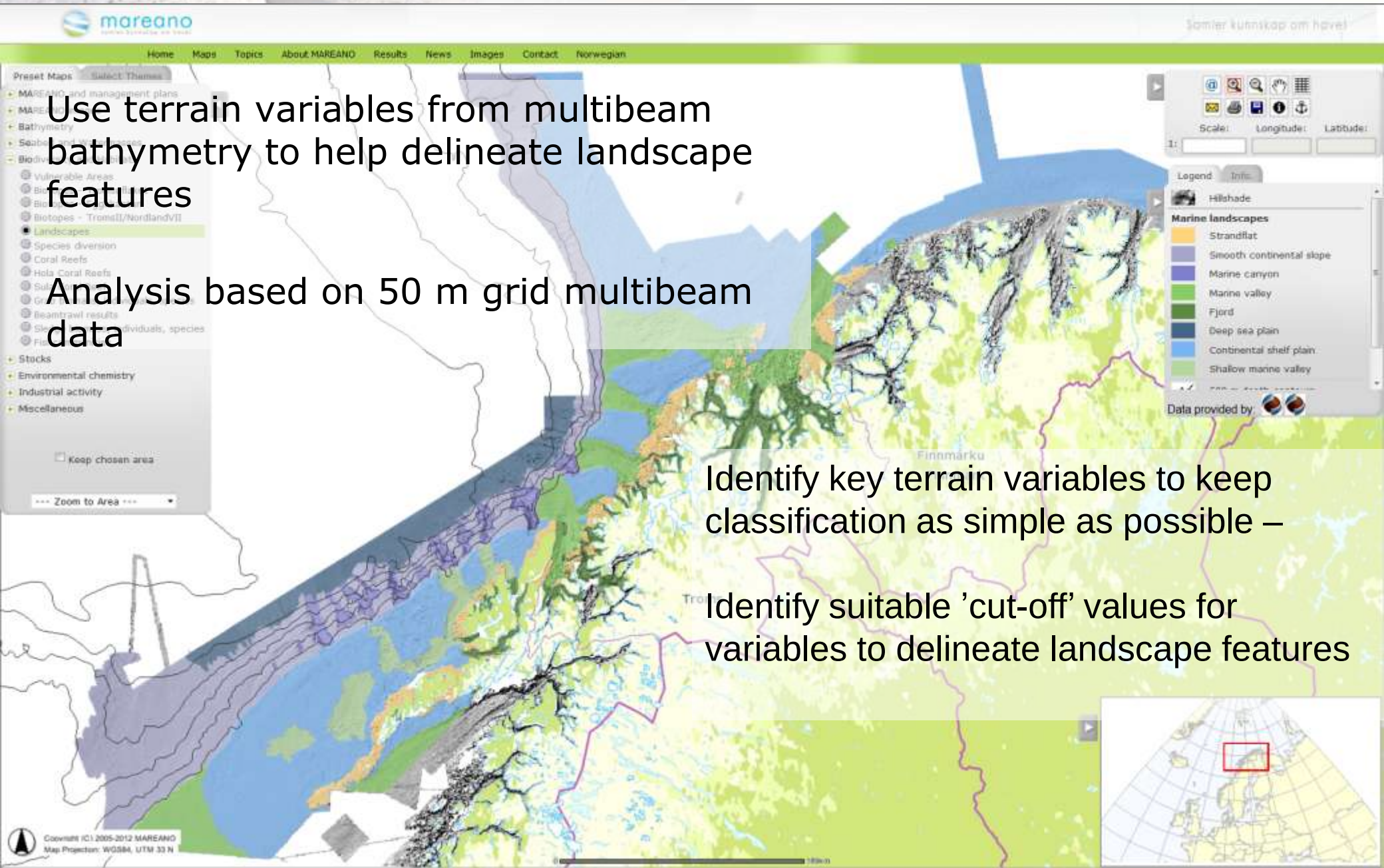






Example of single-scale (3x3 analysis window) slope at three different cell sizes (a) 5 m, (b) 50 m, (c) 500 m. The same colour scale is used for slope values across each cell size. From Dolan 2012. NGU Report 2012.041

Landscape maps



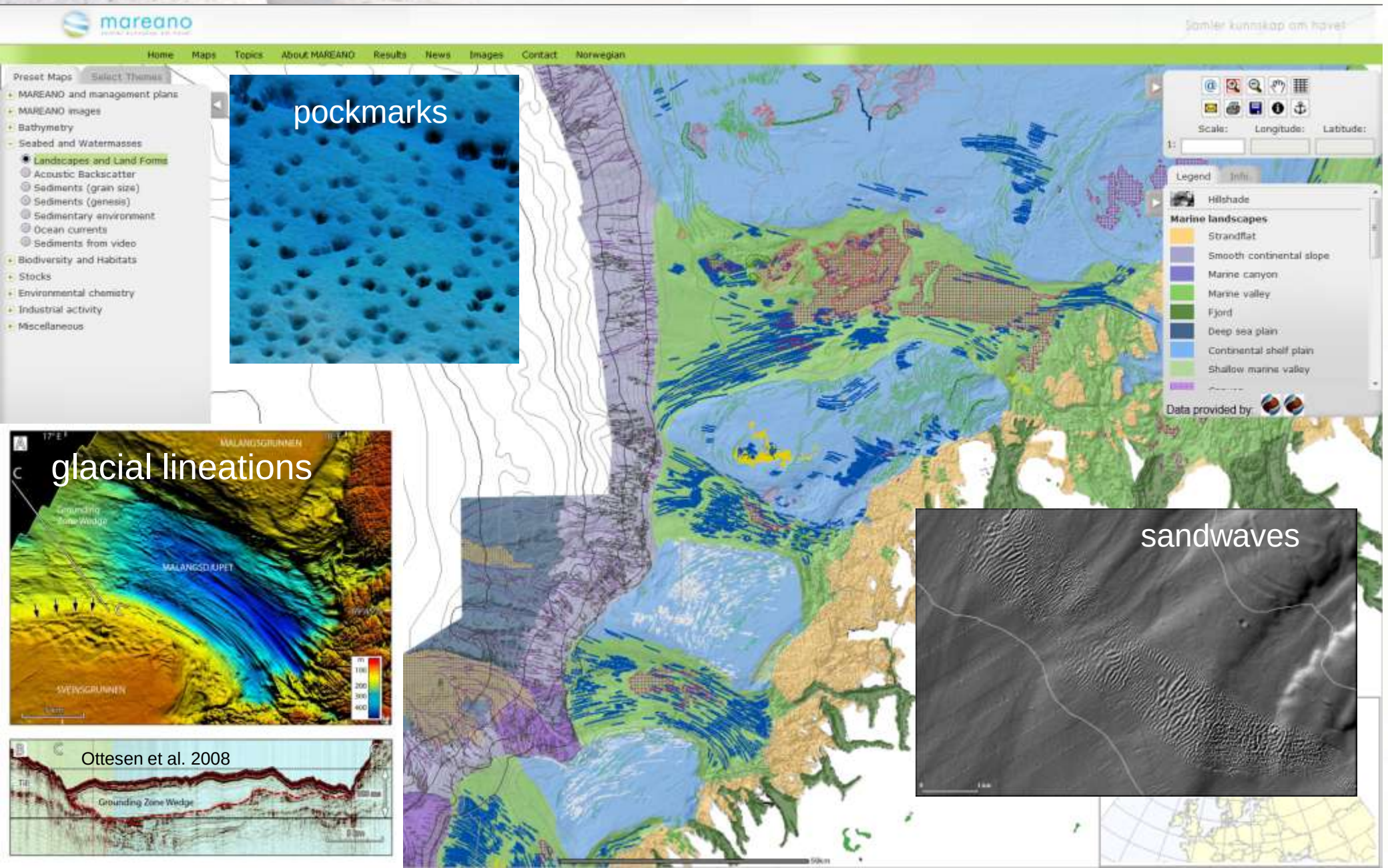
Use terrain variables from multibeam bathymetry to help delineate landscape features

Analysis based on 50 m grid multibeam data

Identify key terrain variables to keep classification as simple as possible –

Identify suitable 'cut-off' values for variables to delineate landscape features

Landscape and landform maps

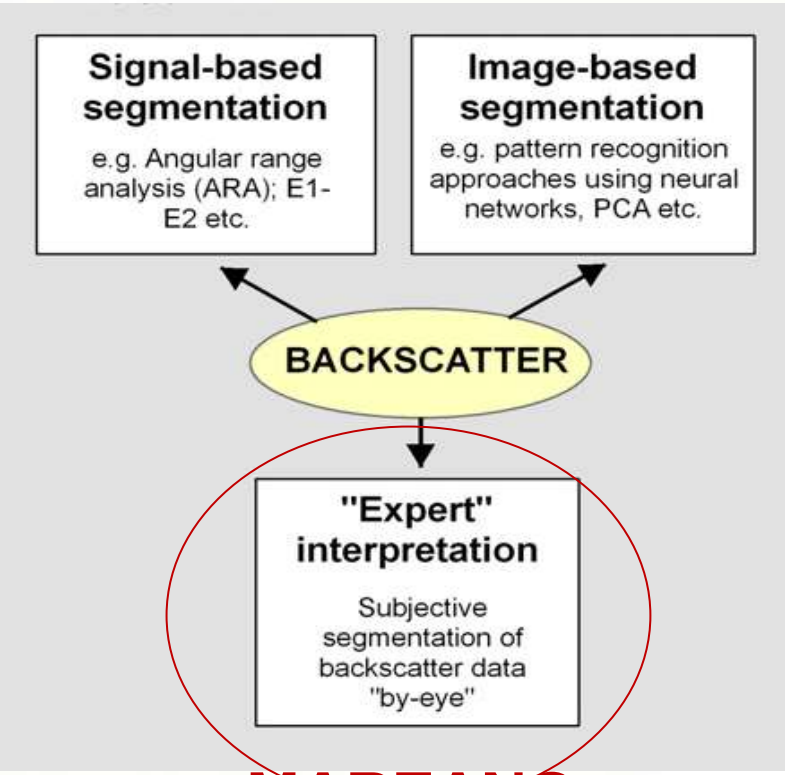


Backscatter data processing and analysis

Raw data → FMGT → Raster mosaic (ArcGIS)

GSC, (Poseidon)

MAREANO tested ARA in FMGT, limited use in geo-workflow to date



Tested QTC – limited use with large data volumes.

Part of figure from Brown C.J., et al. (2011) ECSS 92

MAREANO + FMGT mosaic statistics

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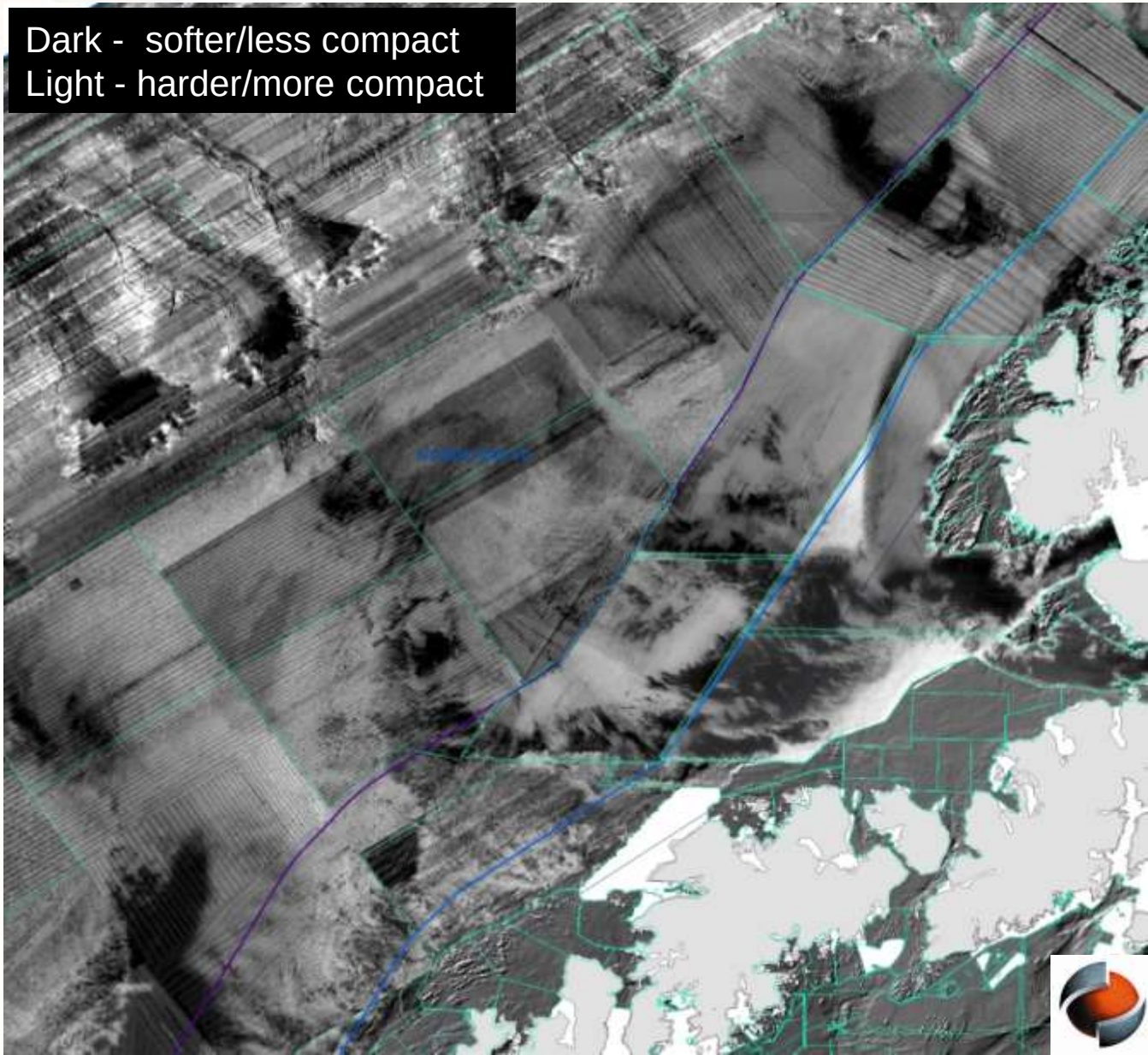
Backscatter data – unlevelled, ’patchwork’

Acoustic reflectivity – indicates the nature of the seabed (grain size/ roughness/compactness)

- Different years
- Different boats
- Different multibeam systems
- Different contractors
- Different depths - resolution

Data require harmonisation…



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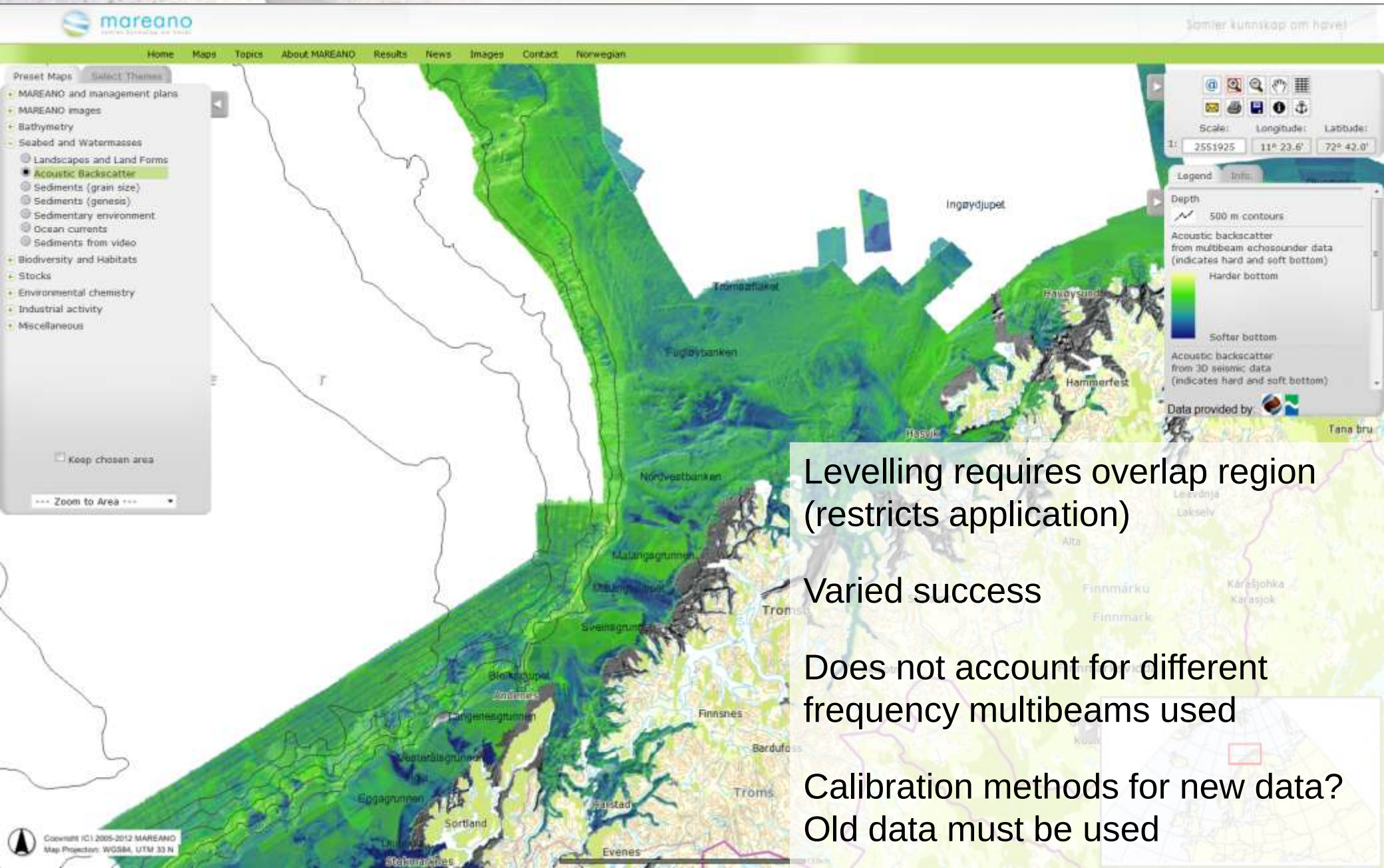
Backscatter data after arithmetic levelling



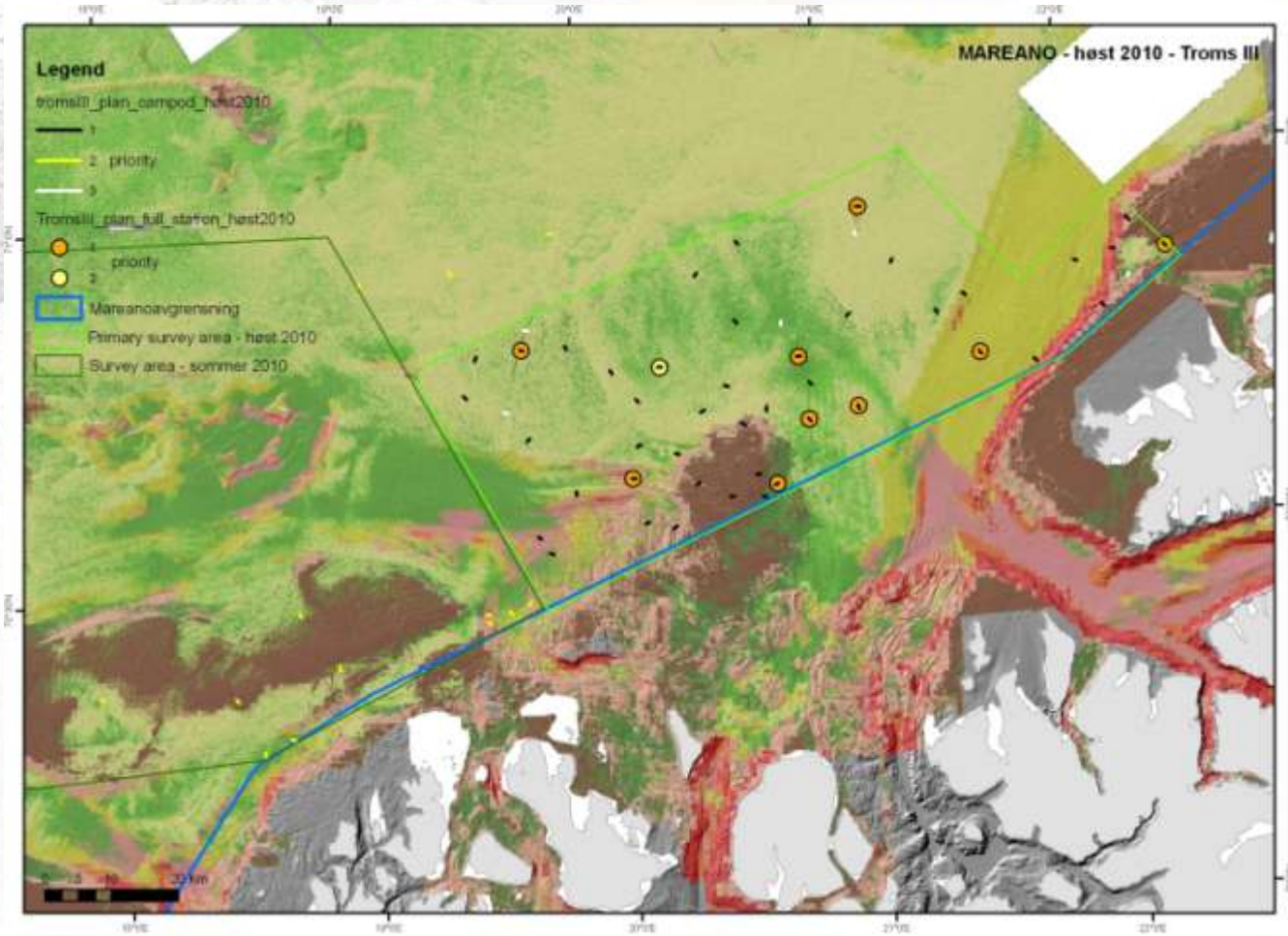
Levelling requires overlap region (restricts application)

Varied success

Does not account for different frequency multibeams used

Calibration methods for new data? Old data must be used

Unsupervised classification for bio/geo cruise planning (video & sampling)



ISOCLUSTER/MLC classification using simple combination of fine/broad scale terrain variables + backscatter

Physically different areas shown in contasting colours

Help objective cruise planning

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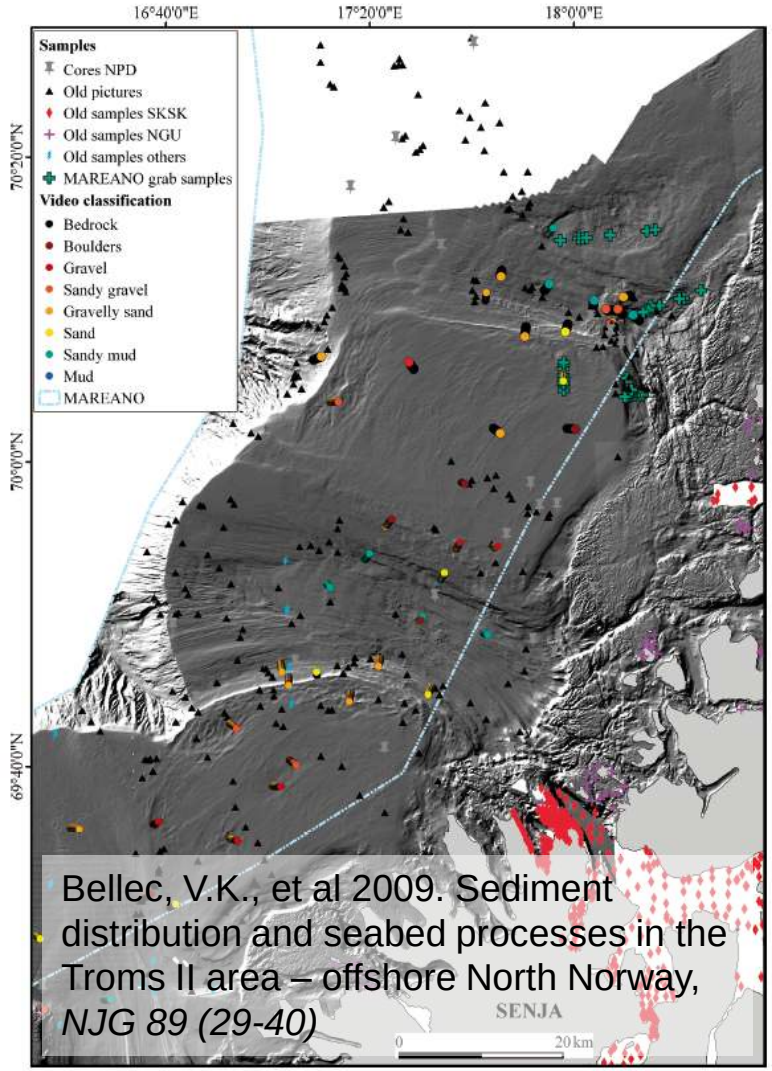
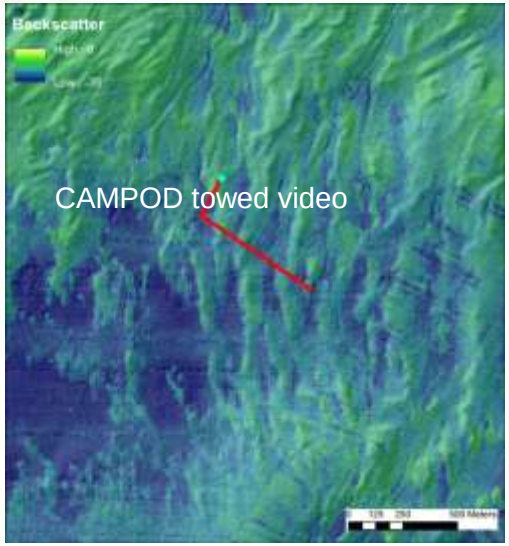
Acoustic data for sediment interpretation

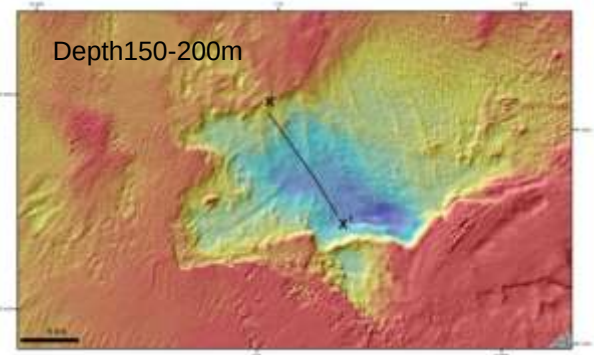
– *integrating datasets, assimilating knowledge*



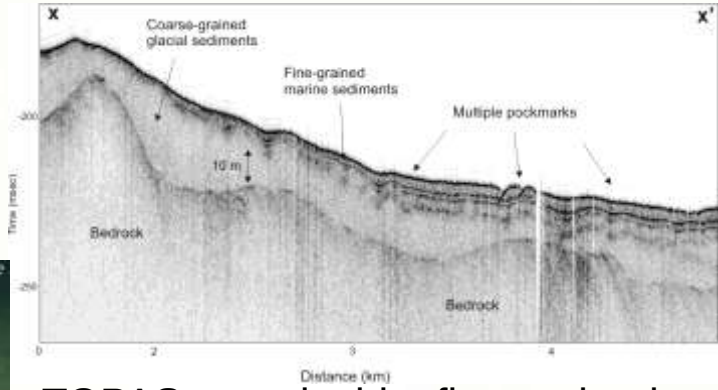
Bellec, V.K., et al 2009. Sediment distribution and seabed processes in the Troms II area – offshore North Norway, *NJG 89 (29-40)*



Often backscatter gives clear indication of sediment which matches video observations. e.g. moraine ridge



Sometimes backscatter here shows less variation but TOPAS reveals the geolgical history and gives further info on sediments



TOPAS reveals thin, fine grained surface layer underlain by glacial sediments. All draping over deeper bedrock. Not moraine ridge.

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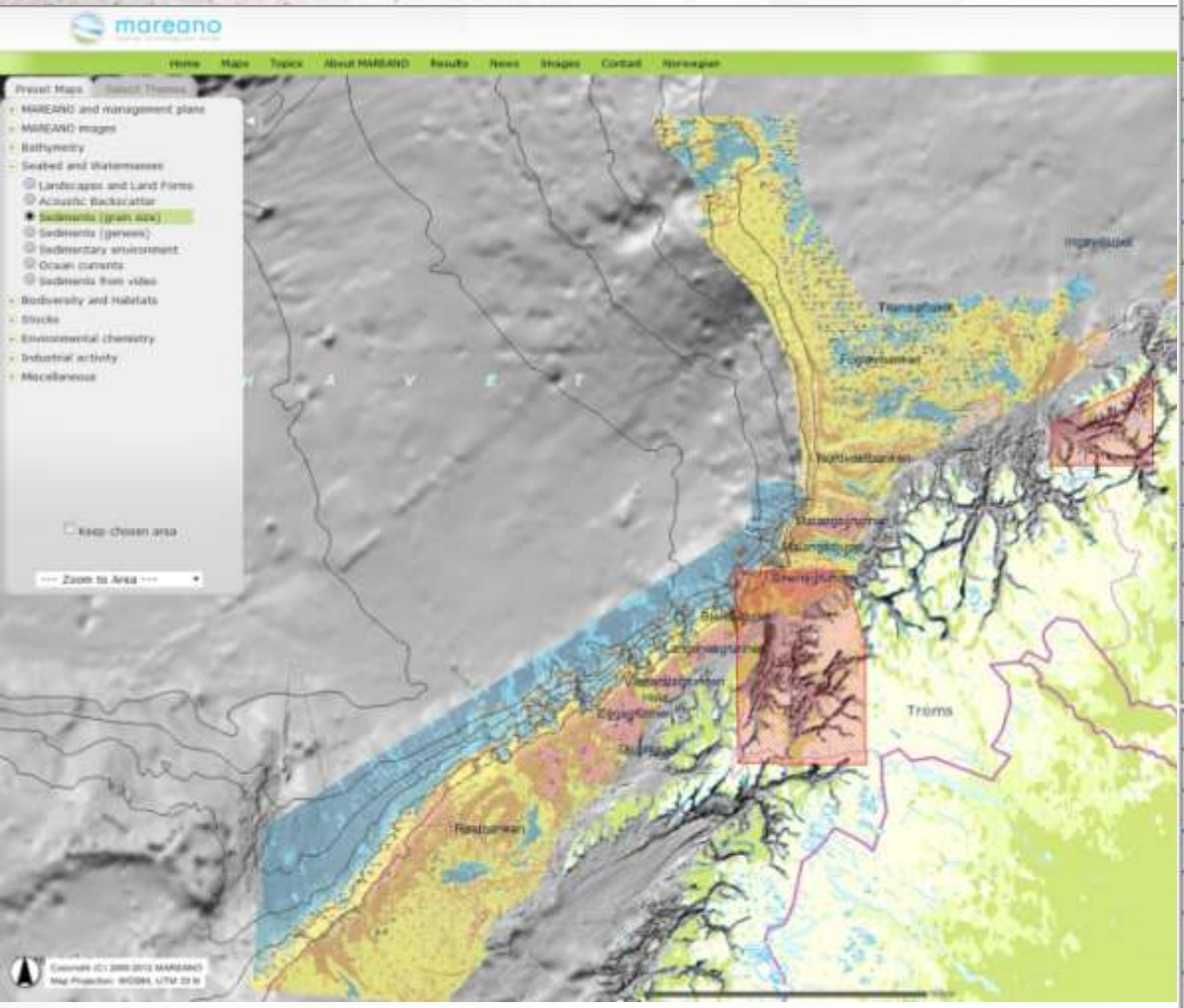
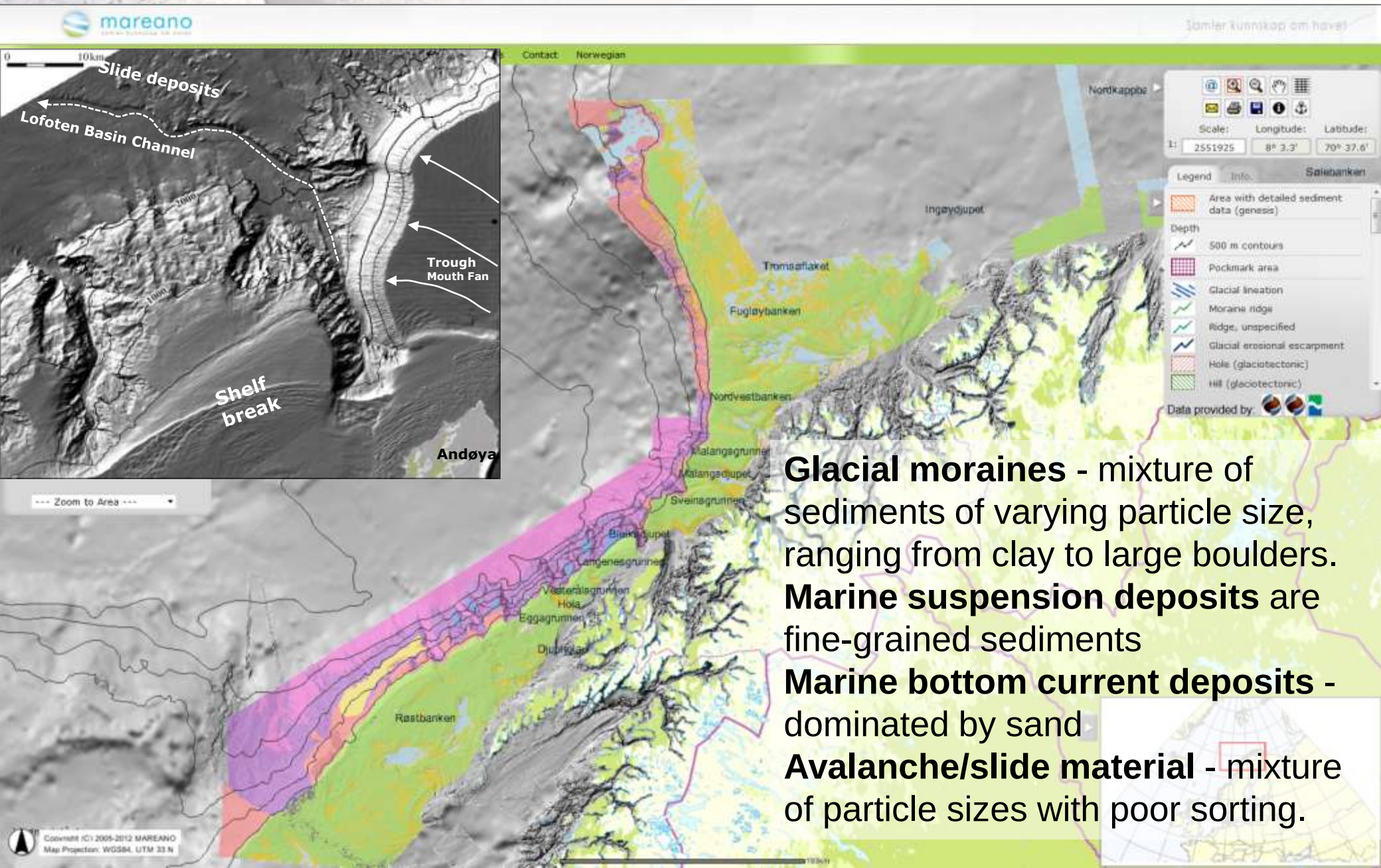
Sediment grain size



Symbol	Grain size	Abbr.	Definition/description	Code	CAMPOD logger code
	Clay	C	Clay:silt ratio >2:1 and clay+silt >90%, sand <10%, gravel <2%	10	1 - Mud
	Organic mud	-	Clay:silt ratio from 1:2 to 2:1 and clay+silt >90%, sand <10%, gravel <2%. High content of organic material.	15	
	Mud	M	Clay:silt ratio from 1:2 to 2:1 and clay+silt >90%, sand <10%, gravel <2%	20	
	Sandy clay	sC	Clay:silt ratio >2:1 and clay+silt >50%, sand <50%, gravel <2%	30	2 - Sandy mud
	Sandy mud	sM	Clay:silt ratio from 1:2 to 2:1 and clay+silt >50%, sand <50%, gravel <2%	40	
	Silt	Z	Clay:silt ratio <1:2 and clay+silt >90%, sand <10%, gravel <2%	50	
	Sandy silt	sZ	Silt:clay >2:1 and clay+silt >50%, sand <50%, gravel <2%	60	
	Clayey sand	cS	Sand >50%, clay:silt ratio >2:1 and clay+silt <50%, gravel <2%	70	3 - Muddy sand
	Muddy sand	mS	Sand >50%, clay:silt ratio from 1:2 to 2:1 and clay+silt <50%, gravel <2%	80	
	Silty sand	zS	Sand >50%, silt:clay ratio >2:1 and clay+silt <50%, gravel <2%	90	
	Fine sand	-	Sand >90%, includes fine and very fine sand (Wentworth, 1922)	95	4 - Sand
	Sand	S	Sand >90%, clay+silt <10%, gravel <2%	100	
	Coarse sand	-	Sand >90%, includes medium, coarse and very coarse sand (Wentworth, 1922)	105	
	Gravelly mud	gM	Sand:silt+clay ratio <1:9, gravel 2-30%	110	5 - Gravelly sandy mud
	Gravelly sandy mud	gsM	Sand:silt+clay ratio from 1:9 to 1:1, gravel 2-30%	115	
	Gravelly muddy sand	gmS	Sand:silt+clay ratio from 1:1 to 9:1, gravel 2-30%	120	6 - Gravelly muddy sand
	Gravelly sand	gS	Sand:silt+clay ratio >9:1, gravel 2-30%	130	*7 - Gravelly sand
	Muddy gravel	mG	Sand:silt+clay ratio <1:1, gravel 30-80%	140	8 - Muddy sandy gravel
	Muddy sandy gravel	msG	Sand:silt+clay ratio from 1:1 to 9:1, gravel 30-80%	150	
	Sandy gravel	sG	Sand:silt+clay >9:1, gravel 30-80%	160	9 - Sandy gravel
	Gravel	G	Gravel >80%	170	A - Gravel
	Gravel, cobbles and boulders	GB	Dominant grain sizes are gravel, cobbles and boulders.	175	
	Cobbles and boulders	B	Dominant grain sizes are cobbles and boulders.	180	B - Cobbles and boulders
	Sand, gravel and cobbles	SGB	Dominant grain sizes are sand, gravel and cobbles.	185	
	Sand and boulders	SB	Dominant grain sizes are sand and boulders.	190	C - Sand and boulders
	Diamicton	D	Sediment containing particles of a wide range of sizes. Unsorted or very poorly sorted.	200	
	Compacted sediments or sedimentary bedrock	-	Submarine outcrop of compacted sediments or sedimentary bedrock.	200	D - Compacted sediments
	Thin or discontinuous sediment cover on bedrock. Sediments with varying grain size.	-	Lateral variation of small basins with sediments and exposed bedrock, and/or bedrock with thin/discontinuous sediment cover. Sediments in small basins may have varying grain size.	1	
	Exposed bedrock	-	Areas without sediment cover.	5	E - Exposed bedrock
	Unspecified	-	Grain size is not specified.	0	F - No observation

Sediment genesis (formation)



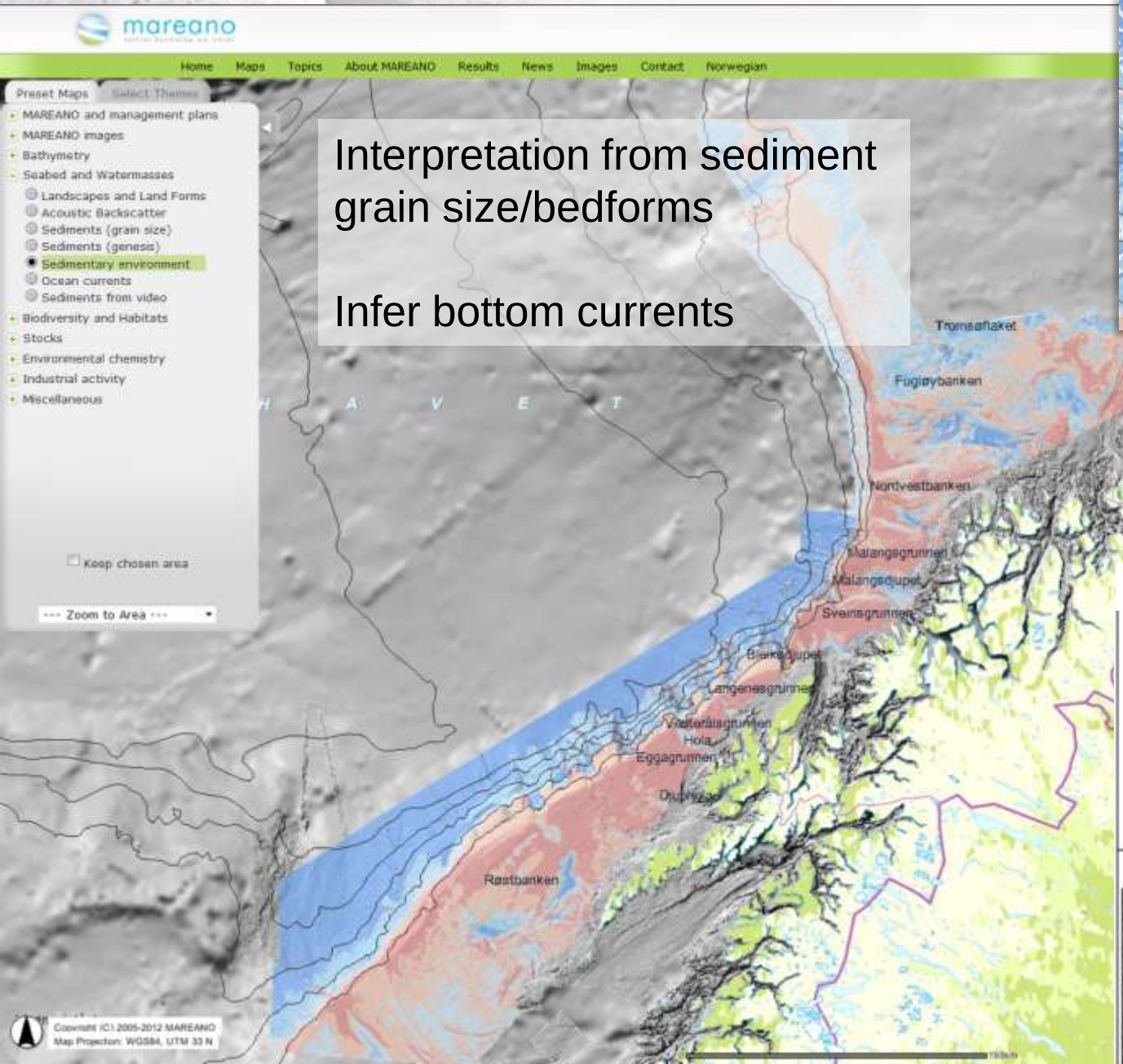
Glacial moraines - mixture of sediments of varying particle size, ranging from clay to large boulders.

Marine suspension deposits are fine-grained sediments

Marine bottom current deposits - dominated by sand

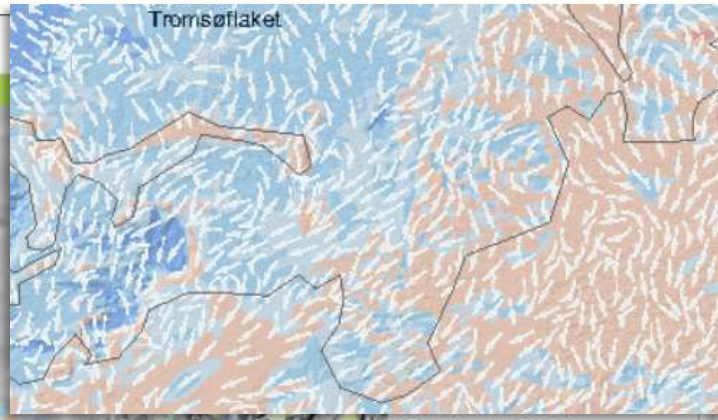
Avalanche/slide material - mixture of particle sizes with poor sorting.

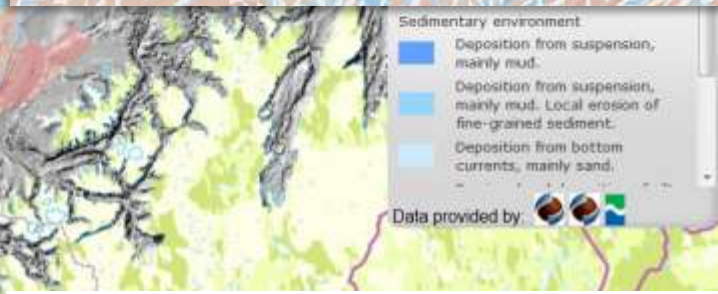
Sedimentary environment (deposition/erosion areas)



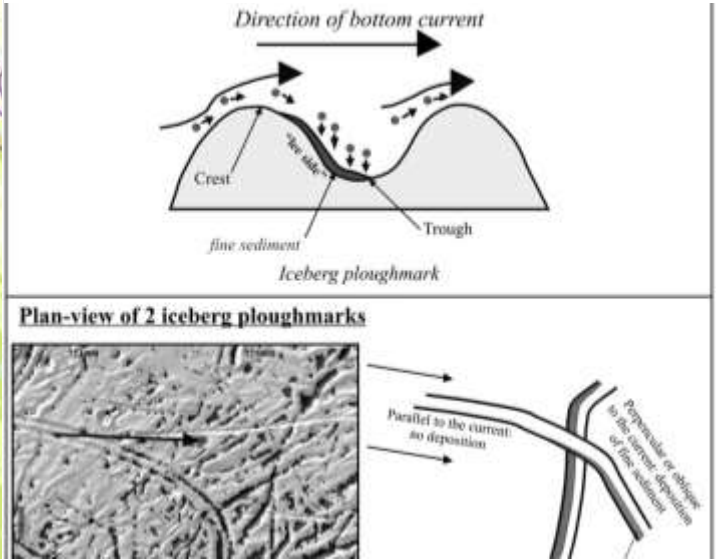
Interpretation from sediment grain size/bedforms

Infer bottom currents

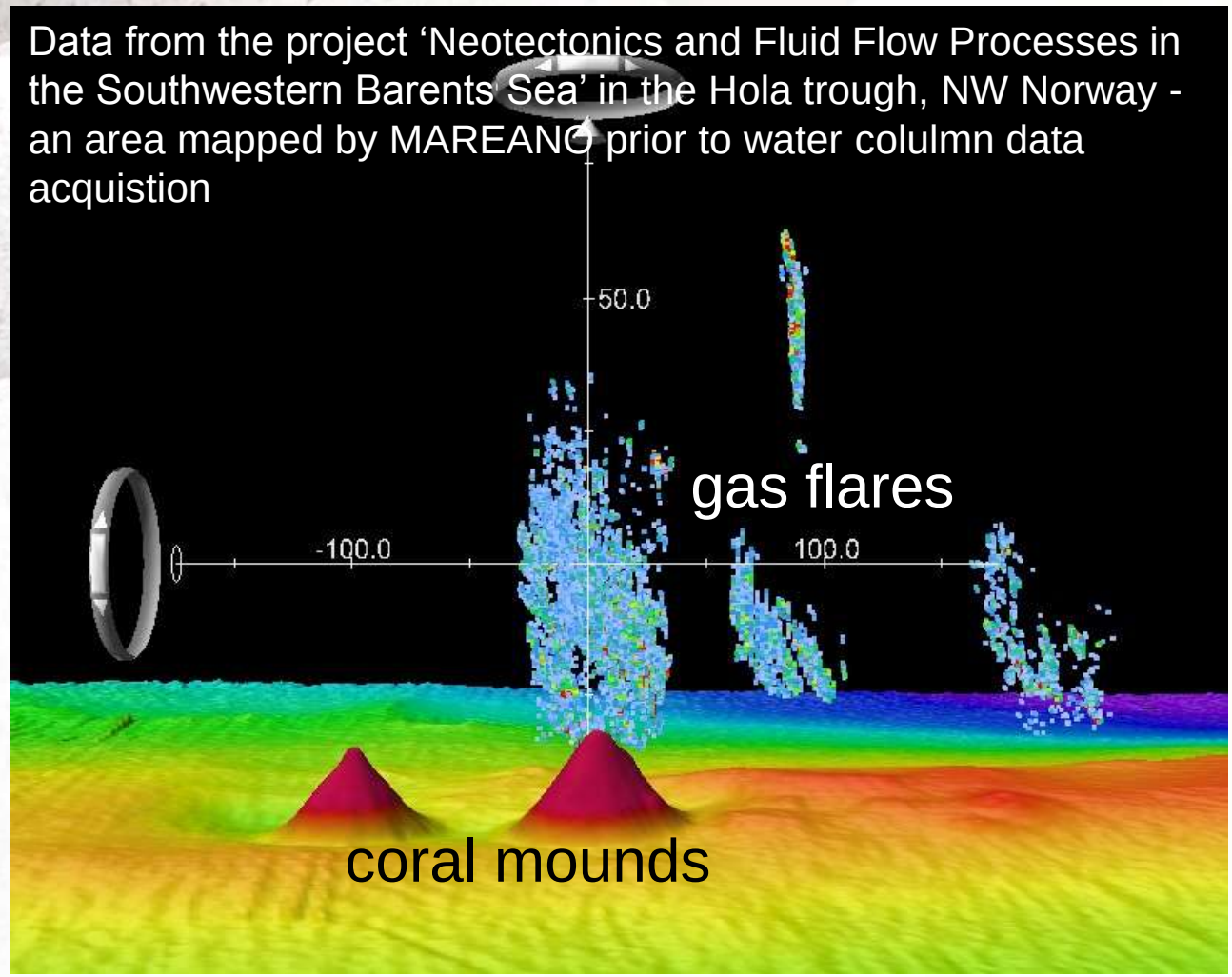




Bellec et al. 2008. Mar Geol. 249(257-270)



Multibeam water column data



Now part of MAREANO multibeam data acquisition

Large data volumes but useful data

- gas flares
- fish/mammals
- more?

See also S. Chand, T. Thorsnes, L. Rise, H. Brunstad, D. Stoddart, R. Bøe, P. Lågstad, T. Svolsbru 2012. Multiple episodes of fluid flow in the SW Barents Sea (Loppa High) evidenced by gas flares, pockmarks and gas hydrate accumulation. Earth and Planetary Science Letters 331-332 (2012) 305–314)

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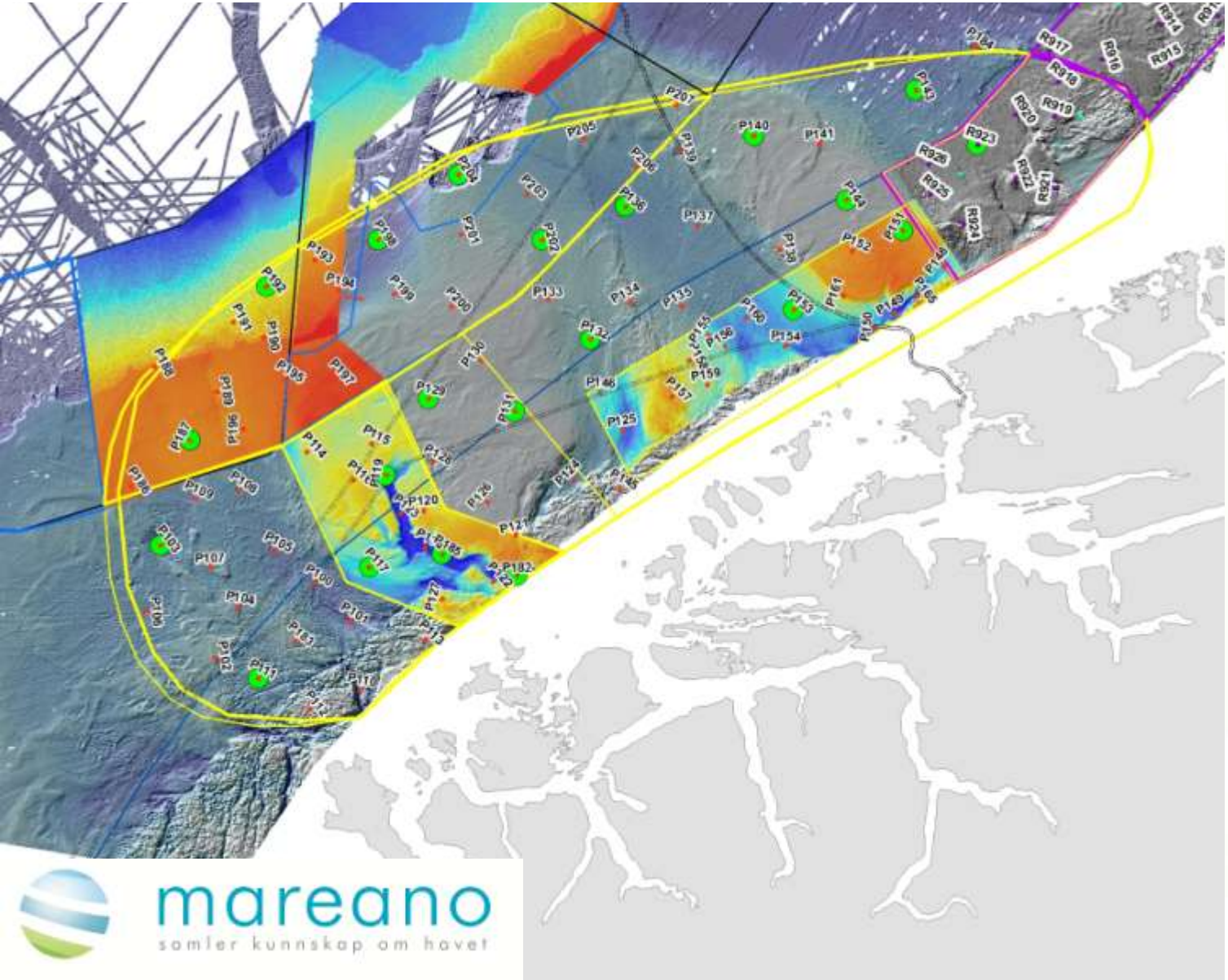
MAREANO - Integrating alternative bathymetry data



Simulation study for sediment biotope mapping using Olex & Multibeam data

Elvenes, Buhl-Mortensen & Dolan (2012) NGU report 2012.030

Olex and multibeam data used from video/sampling cruise planning Autumn 2012

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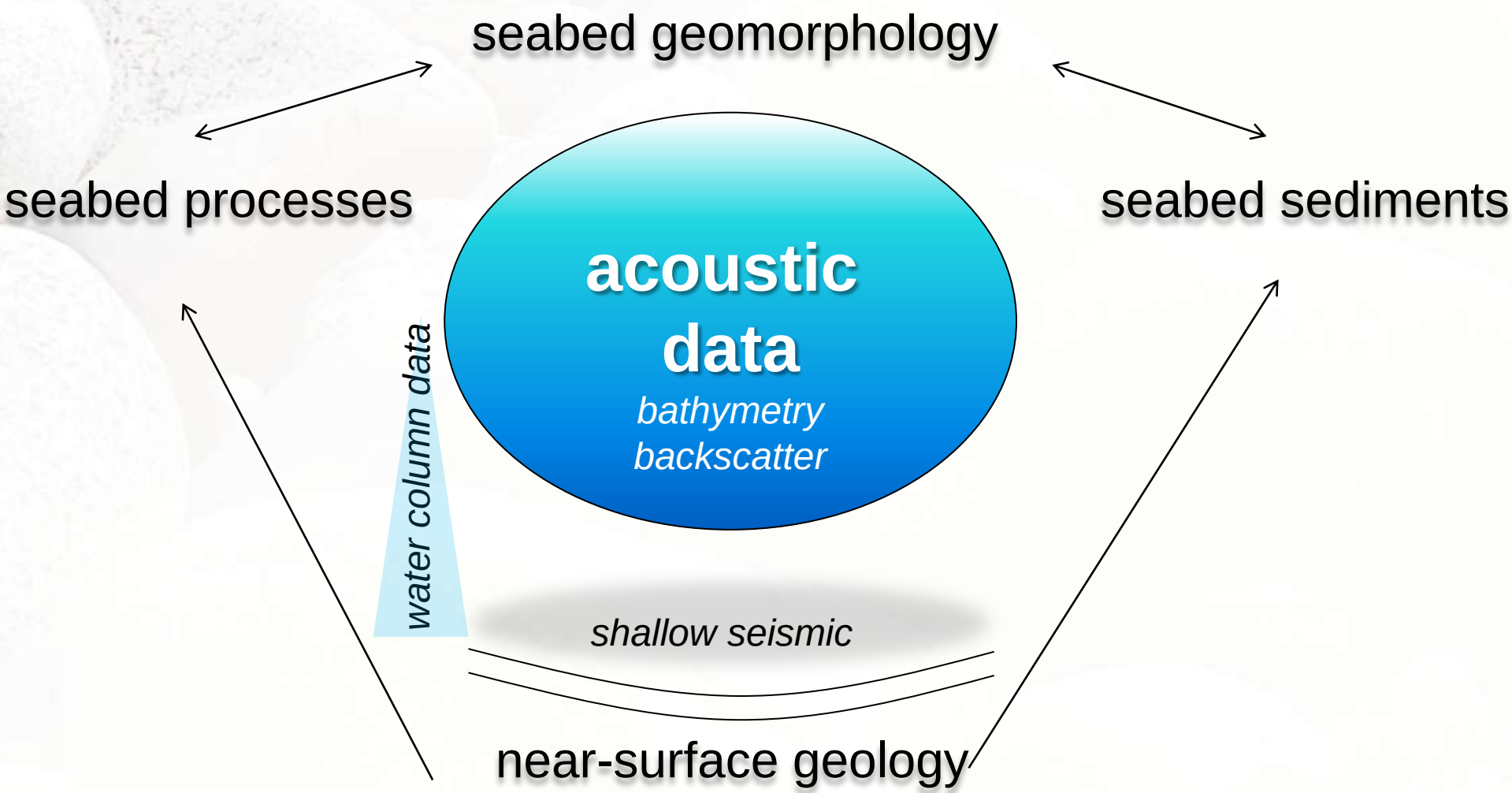
Lessons learned and potential for future use of acoustic data in MAREANO…



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Lessons learned and potential for future use of acoustic data in MAREANO…

- Acoustic data also means managing a huge volume of data
- Challenge to harmonise data, especially backscatter
- Easy to under-use data + too easy to ignore limitations w.r.t. acoustics
- Scale, resolution, method important w.r.t. terrain variables
- Semi-automated interpretation of sediments? Automated feature detection? *corals, pockmarks, glacial features*
- Integration of TOPAS, ground truth + existing knowledge is vital for geo- interp
- Additional ground truth opportunities (eyeball camera etc.)
- Potential for integration with datasets at other resolution – high (UUV based MBES, SAS etc.) and low (Olex, regional bathy), other seismic