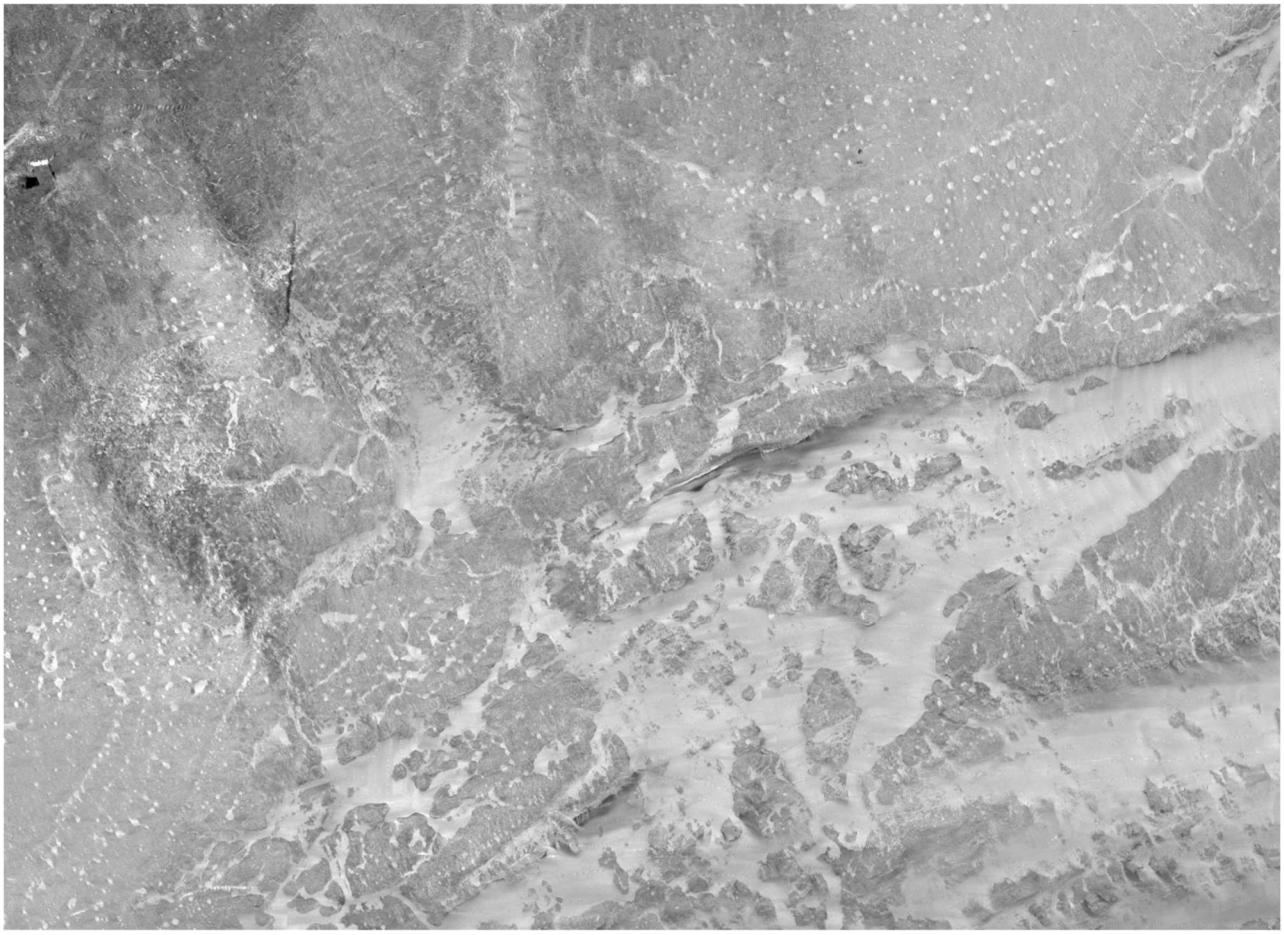
NORBIT

Description of NORBIT Backscatter Mode Outputs

November 2022



NORBIT Snippets-Sidescan Backscatter 50cm resolution Mosaic data from 30m water depth

NORBIT Backscatter

Multibeam sonars are required to record two types of information: bathymetry and backscatter, at the same time without prioritizing one or another. However, achieving these two objectives with adequate level of quality is still an issue for many manufacturers. Generally, users need to choose whether to focus on bottom detection quality or backscatter quality. NORBIT removes that issue and brings data collection to the highest level achieving both types of information at the same time without reducing their quality.

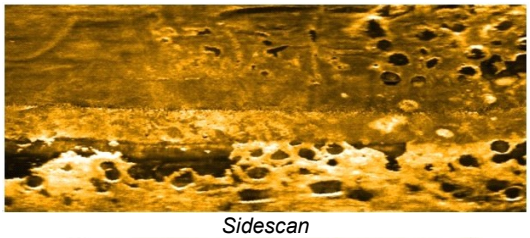
Background

Backscatter is representation of acoustic energy reflected from the seafloor (surface backscatter) or any target in the water column (volume backscatter) and registered by sonar. Backscatter data can be used to aid characterisation of objects which are not evident in bathymetry or in case of seabed classification where different acoustic reflectivity is related to bottom geomorphology and sediment type.

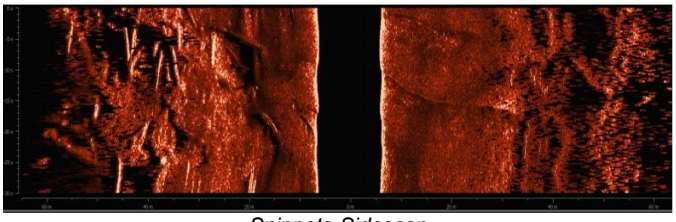
Overview

As standard, NORBIT WINGHEAD, WBMS and WBMS STX systems can output a number of different Backscatter Modes. Each mode reflects different data characteristics and are used to optimise various operational scenarios. All modes are produced over the full frequency band of NORBIT systems from 160kHz to 700kHz that allows further multispectral analysis.

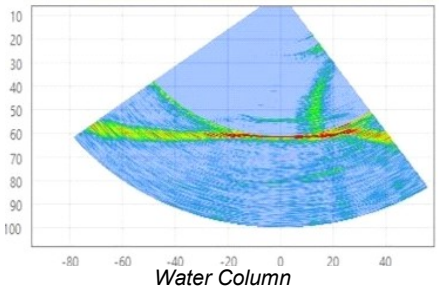
- Water Column (WC)
- Bathy Intensity (Bathy, Bathy echo Intensity at bottom detection point)
- Sidescan (SS)
- Snippets (SN)
- Snippets-Sidescan (SN-SS)
- Backscattering Strength Output (BSO), optional on calibrated systems



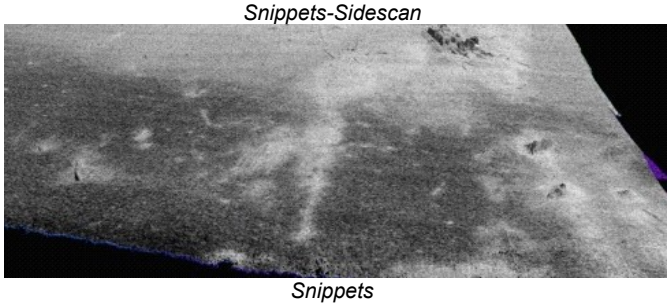
Sidescan



Snippets-Sidescan

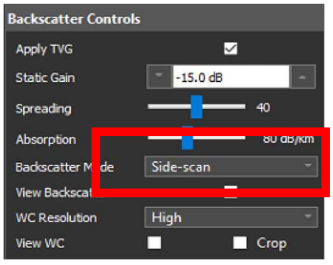


Water Column



Snippets

The desired mode is selected from the onscreen GUI, through a pull down menu highlighted below.



Reference may be made to the system manual regarding user setup for each respective output mode, as well as the recording over network or within the GUI.

The NORBIT GUI clearly indicates what mode is being logged.

File Format

With all NORBIT sonars there are two data formats to consider:

- WBM (*.wbm) - This is the native NORBIT file format. This format is logged when data recording is enabled in the NORBIT GUI. Required for replaying raw data files. May be converted to s7k.
- s7K (*.s7k) – A well-known, open format that is supported by all hydrographic data acquisition and processing software. NORBIT converts all WBM data to s7k for real time network output. When raw data recording is enabled in the GUI, with v10.4 or later, the system generates WBM files and converts them to s7k automatically. The s7k files contain full motion and navigation data, including delayed heave, with integrated NORBIT systems.

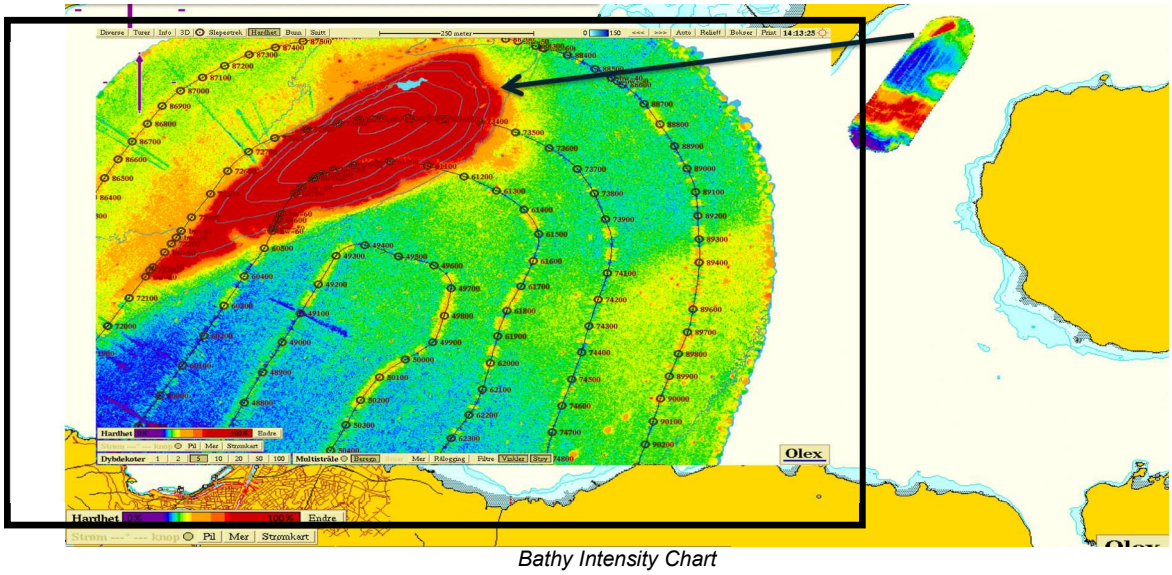
GUI recorded data are, by default, stored at: C:\Users\<user>\Norbit\WBMS\

Backscatter Mode Selection	View Backscatter Checkbox	View Water Column Checkbox	Recorded Data Types in WBM file	7k records in s7k file
None	☐	☐	✓ Bathymetry ✗ Compressed Water Column ✗ Sidescan ✗ Snippets	✓ 7027 ✗ 7042 ✗ 7007 ✗ 7028
None	☐	☑	✓ Bathymetry ✓ Compressed Water Column ✗ Sidescan ✗ Snippets	✓ 7027 ✓ 7042 ✗ 7007 ✗ 7028
Sidescan	☑	☑	✓ Bathymetry ✓ Compressed Water Column ✓ Sidescan ✗ Snippets	✓ 7027 ✓ 7042 ✓ 7007 ✗ 7028
Snippets-Sidescan	☑*	☑	✓ Bathymetry ✓ Compressed Water Column ✓ Snippets-Sidescan ✓ Snippets	✓ 7027 ✓ 7042 ✓ 7007 ✓ 7028
** is not required to log 7k records. This will only help visualise the imagery in the GUI*				

Bathy Intensity at Detection Point

As well as depth information, each NORBIT bathymetry datagram contains a backscatter intensity value at the bottom detection point. This value reflects the echo signal level at the bottom detection point (single sample per beam), which is a rather simplistic but practical type of backscatter.

Bathy Intensity is output automatically with bathymetry data, so no configuration steps are required. Known in HYPACK® as “Beam-Average” and can be processed using HYPACK® Sidescan and Targeting Mosaic tool.



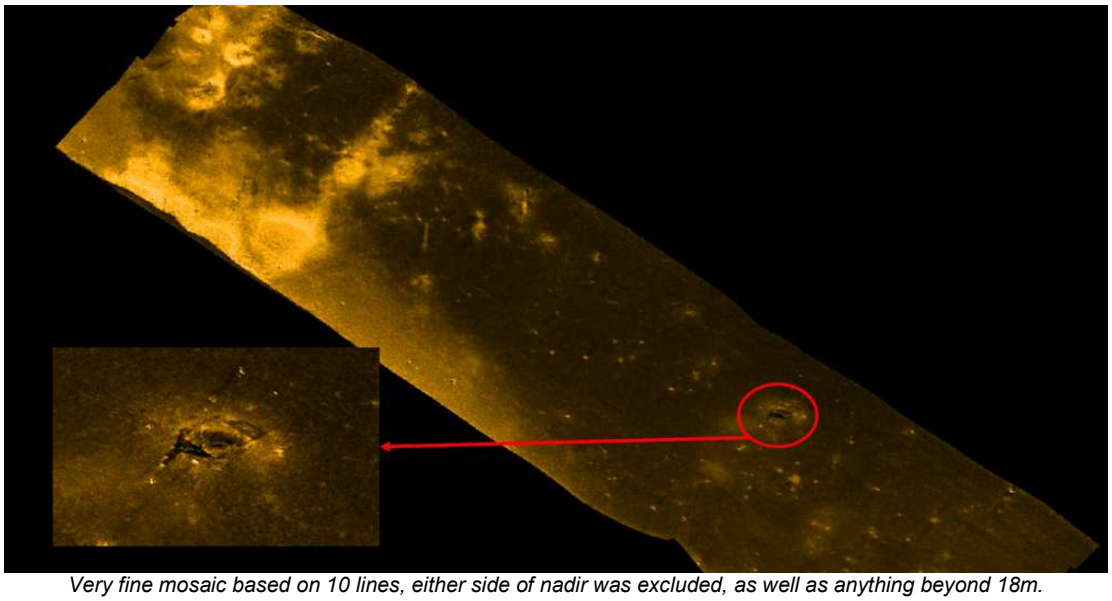
Bathy Intensity Chart

Sidescan

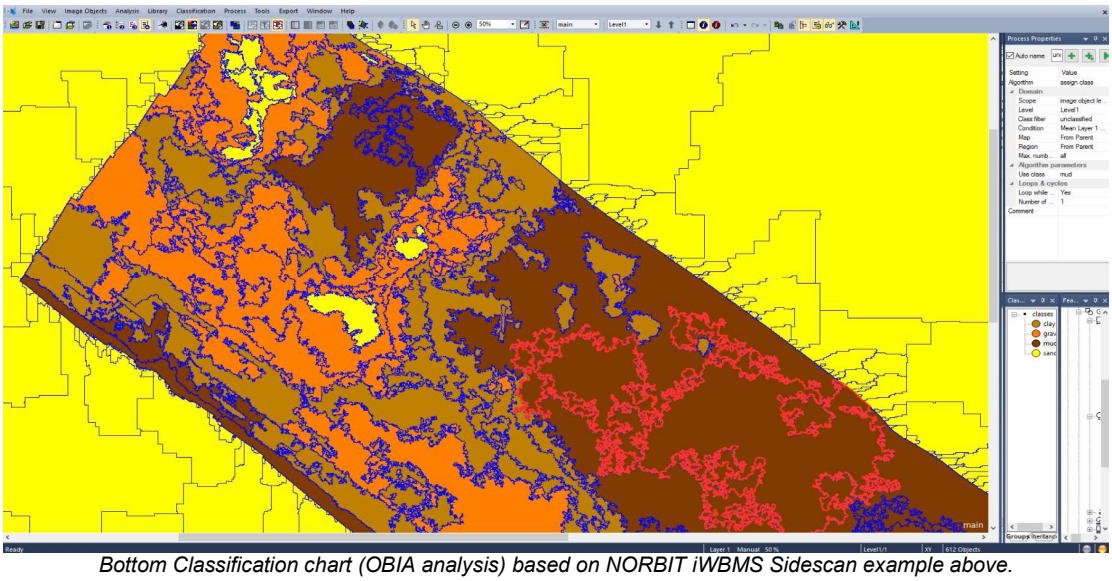
Sidescan images of the seafloor are created from echo signal time series for each half of the sonar wedge. Port and Starboard sidescan image is created ping by ping using amplitudes of the strongest echo for each range of the return signal.

Conventional towed sidescan has low grazing angles, casting long shadows on targets to aid feature detection. Multibeam sidescan works on the same and can be presented as a mosaic or draped over bathymetry. It is important for users to ensure that the outer beams overlap slightly more than the nadir region of adjacent lines to create seamless mosaics. A benefit of Sidescan is a lower data volume compared to Snippets but due to bottom geometry objects and bedforms might not be properly georeferenced.

Along-Track Resolution: Same as multibeam Tx beam width.
Across-Track Resolution: Determined by bandwidth with industry highest 80kHz, it can reach 0.9cm.



Very fine mosaic based on 10 lines, either side of nadir was excluded, as well as anything beyond 18m.



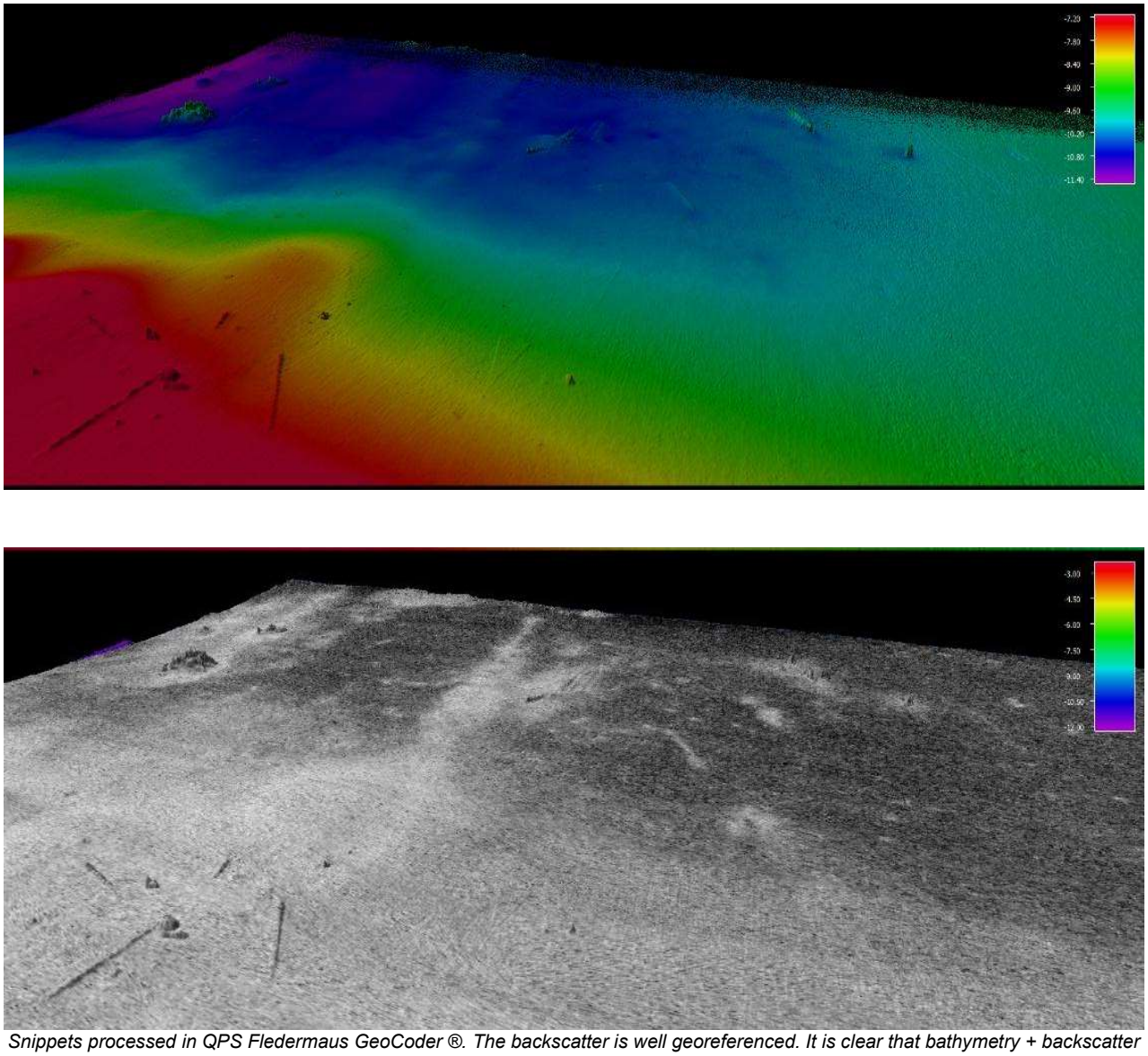
Bottom Classification chart (OBIA analysis) based on NORBIT iWBMS Sidescan example above.

Snippets

Snippets examines a window of samples (a “snippet”) around the bottom detection point. A window size is defined in the data acquisition software and beam intensity samples are recorded before and after the bottom detection point for each beam.

Snippets data is well georeferenced and eases the creation of area mosaics comprised of multiple survey lines when data is post processed.

Snippets produce large file sizes, and good Snippets data quality requires good bathymetry data!

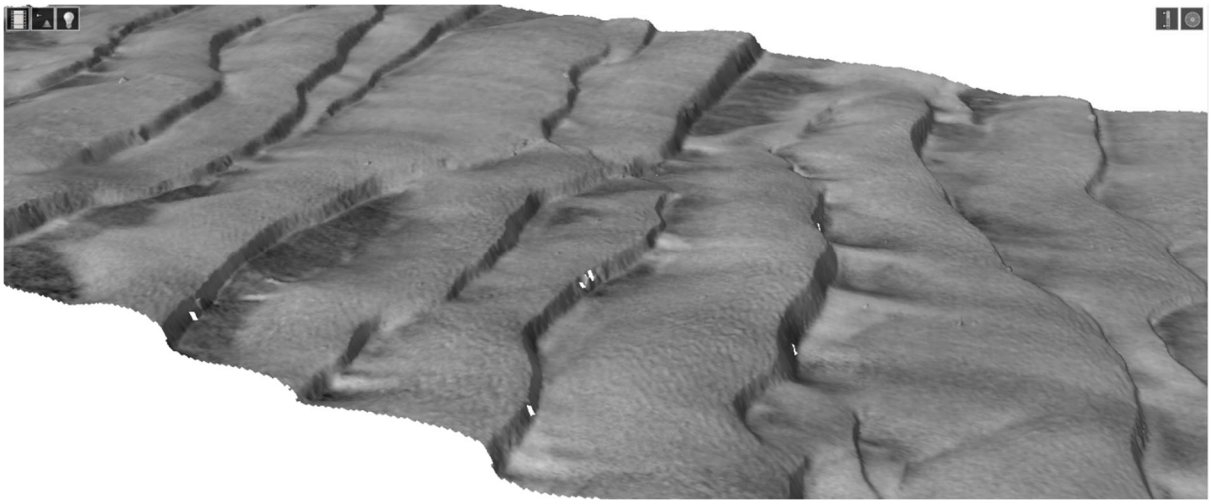


Snippets processed in QPS Fledermaus GeoCoder ®. The backscatter is well georeferenced. It is clear that bathymetry + backscatter provides more information than bathymetry alone, or Sidescan.

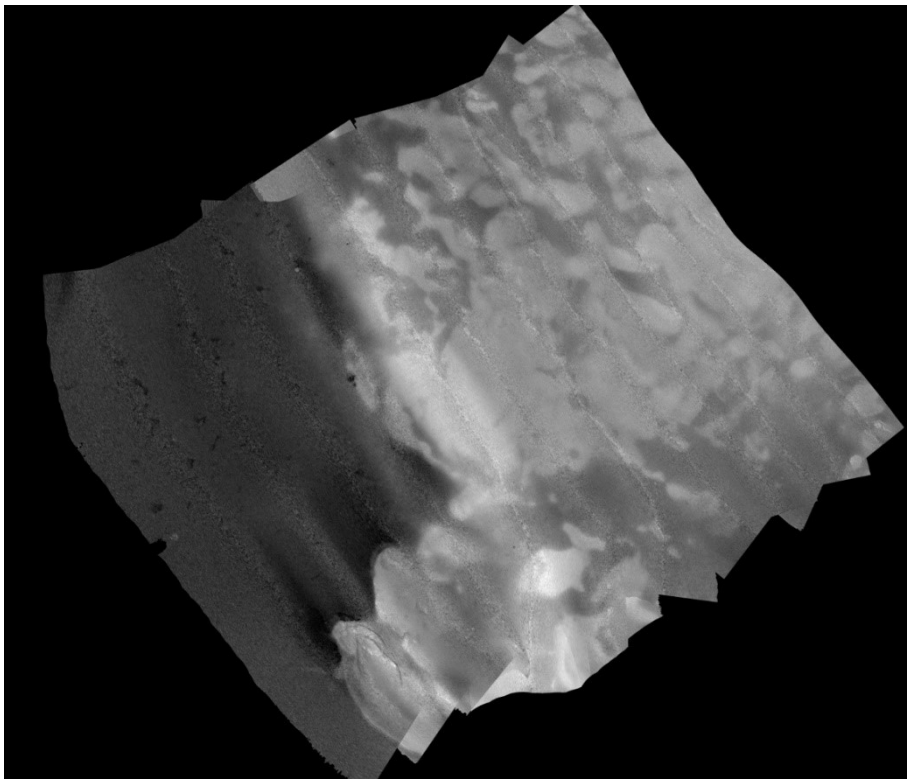
Snippets-Sidescan

When the Snippets-Sidescan option is selected in the GUI (but Sidescan is requested by the acquisition software) a Sidescan composed of Snippet data (“Snippets-Sidescan”) is generated.

Sometimes for visualisation purposes, snippets on port and starboard sides are combined into single waveforms. These time-series backscatter amplitudes create an image similar to sidescan sonar output.



Mosaic of ripples on riverbed (Snippets – Sidescan)



Mosaic of backscatter on seabed site survey (Snippets – Sidescan)

Backscattering Strength Output (BSO)

The Backscattering Strength Output (BSO) from NORBIT sonars provides calibrated echo level, demonstrating how strong, in absolute form, the bottom reflects the acoustic signal that was sent from the multibeam sonar. It provides physical information related to the geological nature and the composition of the seafloor. It gives full transparency for environmental and hardware parameters, therefore providing fully comparable survey results done at different times as well as compatibility with physical models.

NORBIT systems can switch to Backscattering Strength Output mode once calibrated in the NORBIT factory. The calibration contains a series of acoustic measurements done with laboratory equipment in a test tank. After the calibration is performed, the system will output the calibrated data (records 7058 of the s7k stream) for both real time streaming and file recording.

How and why BSO?
Backscatter is used mostly to bring more information about surveyed seabed. Bathymetry layer based on bottom detection data from acoustic echoes reflects mostly seafloor topography, where is flat, rough or slope structure and only from shapes we can assume which bottom type we see: sand (with ripple marks), stones, big rocks with their characteristic patterns. But if it is flat, or composed of different substrate, how can we say what kind of substrate that is? Is it flat sand, mud or maybe shells detritus covering seabed? In many situations answering this question is essential for mission objectives.

Most of survey types are provided on purpose, to understand not only the morphology of the bottom but also geological nature of the seafloor. Is it hard or soft? Is sediment sand or rather clay, till or maybe mud? This is the information that is crucial for dredging, construction works, scientific and environmental studies as well as for management and planning authorities and it is more and more often part of hydrographic scope of work.

NORBIT systems record complex information for each beam in each ping. Bottom detection points together with all geometrical data (motion, angles, heights, beam shape) stored together with echo intensity data. To create a backscatter image (mosaic) users historically use snippets, they are series of intensity values cut around bottom detection points for each beam. Though we must remember that the received echo is a combination of acoustic and geophysical processes, considering both transmitting and recording electronics of the sonar and complex physical phenomenon happening both in the water and at the bottom interface. To bring the data from raw backscatter to seafloor characterisation (calibrated backscatter or BSO) we must correct the returned signal (echo) for all environmental and geometrical losses (e.g. absorption, spreading) as well as for system settings (e.g. frequency, beam geometry, signal bandwidth, transmitted energy) and hardware based variables so that the backscatter reflects only interaction of acoustic wave with seabed.

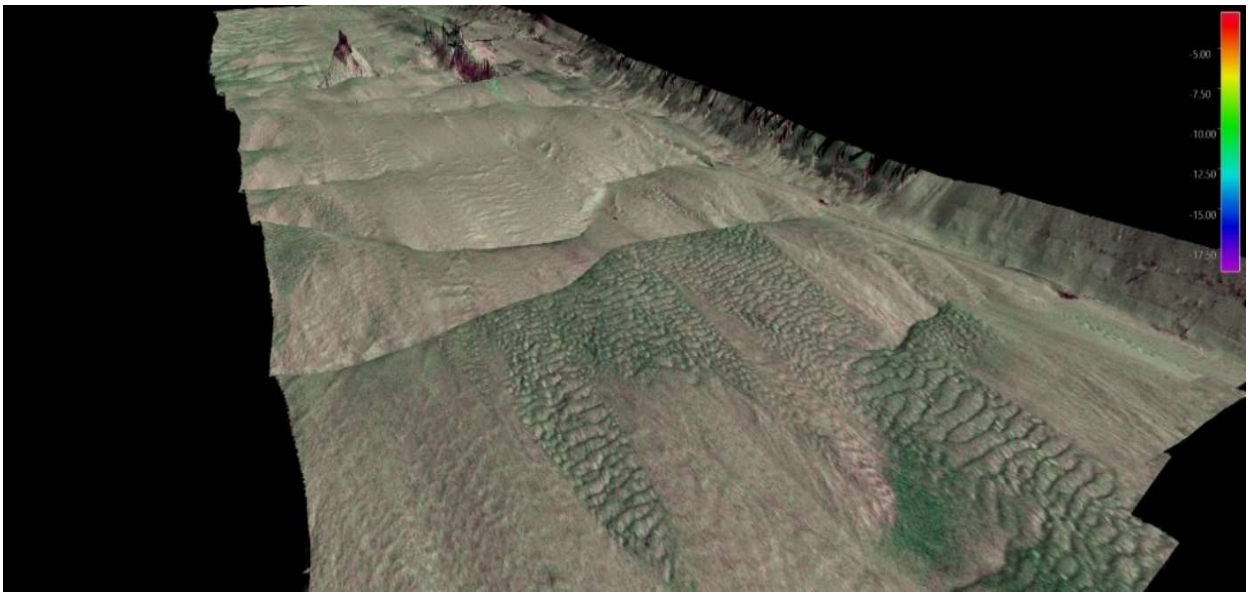
To calculate these corrections NORBIT performs multidimensional calibration in laboratory tank for every unit per customer request. As a result, user receives a multibeam with accurately known acoustic response with special calibration file that is applied to the data recorded during acquisition. This way BSO output is obtained, which is related only to signal-bottom interaction and expressed in absolute dB values giving bottom backscattering strength. The BSO can be used for further seabed characterization and gives repeatable results. It is also directly comparable with different surveys and other calibrated instruments.

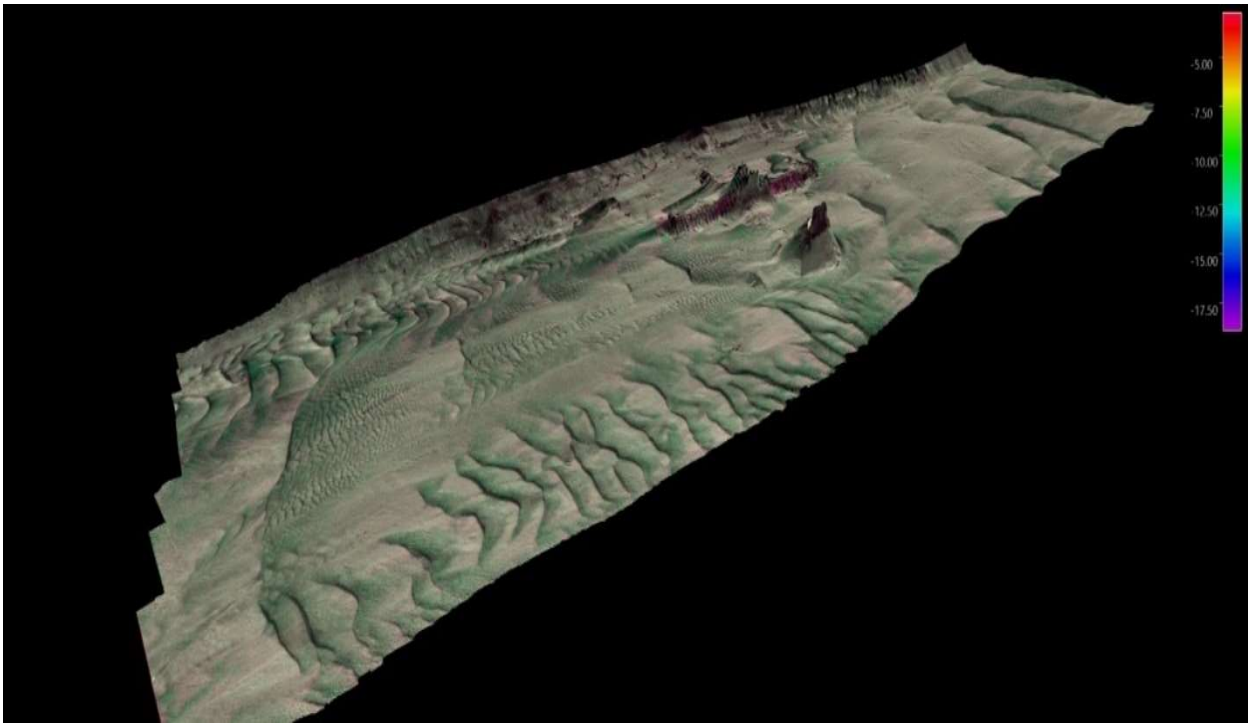
BSO is based on Snippets data but brings backscatter output to a new level. Using non calibrated multibeam the users are often instructed to keep all sonar parameters intact during the survey, so the data does not show artifacts related to changes of these parameters. On the other hand, each survey is different and to promote high bathymetry quality the sonar parameters may need to be adjusted, albeit automatically, yet impacting the backscatter output. That leads to a conflicting objective, one is to promote bathymetry quality and one to promote backscatter quality.

Calibrated backscatter option allows to address this very issue and provide results that are absolute, comparable in time and between devices and more over ensure both in the same time: high quality bathymetry and backscatter results

Multi-Spectral Backscattering (MSB)

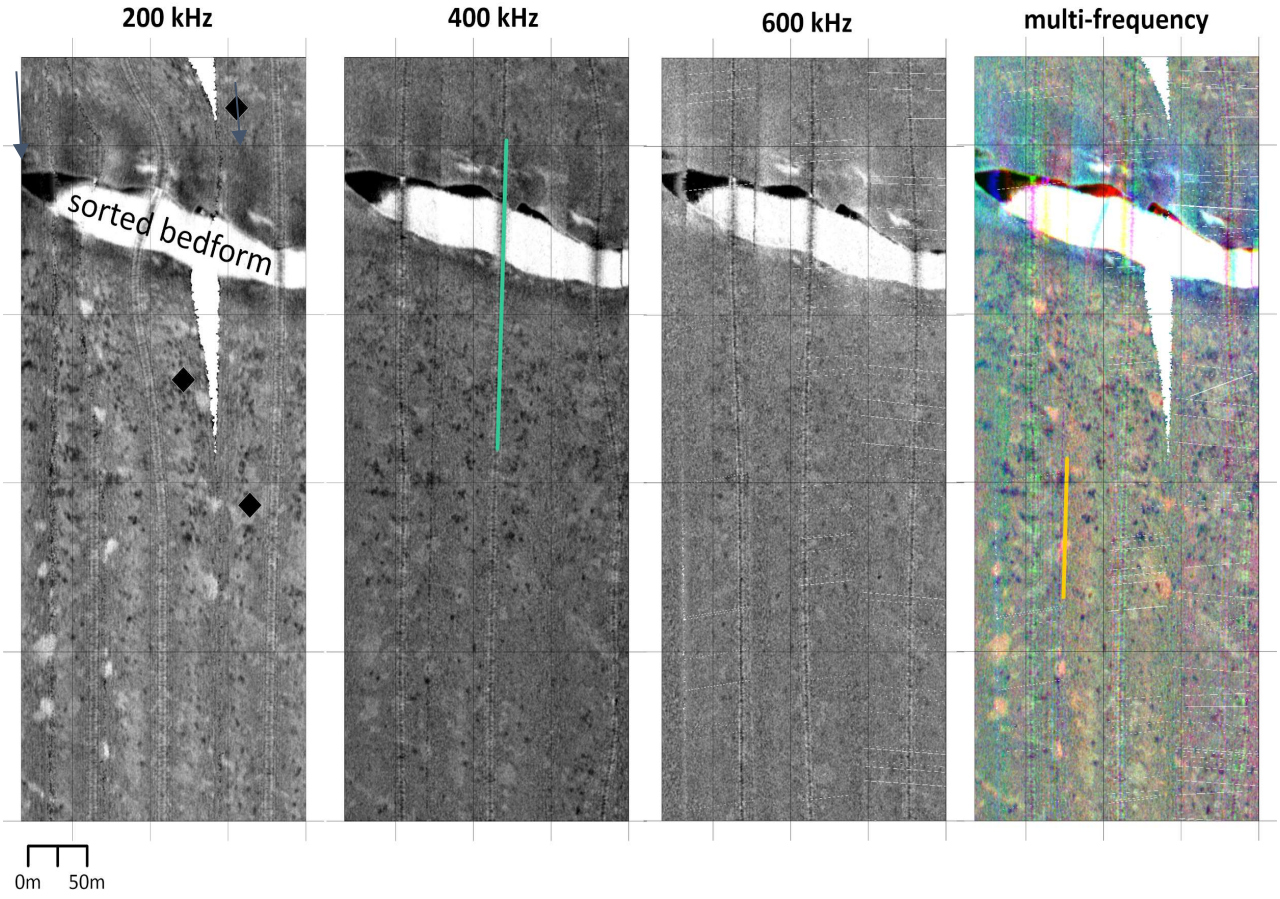
Multi-Spectral Backscattering (MSB) utilizes an ultrawide-band frequency operation by a signal which derives two properties of the backscatter at low-end of the spectrum and high-end of the spectrum simultaneously. This facilitates the determination of backscatter response from the sea bottom at different frequencies and better characterize the seabed by obtaining high contrasts mosaics. At the same time high resolution bathymetry maps are obtained. Example below.





NORBIT has been working with multispectral backscatter feature over the last few years during the EU funded project ECOMAP. The calibrated backscatter concept was heavily used by project partners where multiple frequencies between 150kHz and 600kHz were used allowing to obtain the multi-frequency backscatter response of the seabed.

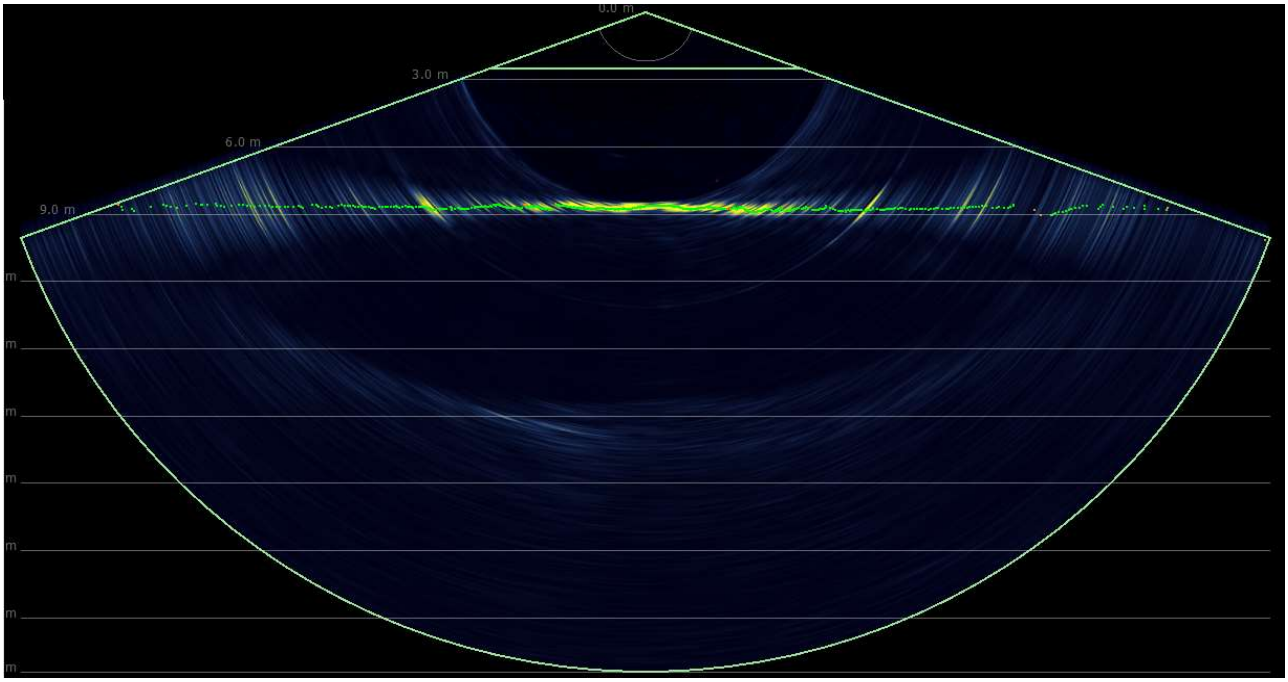
In the example below courtesy of Dr. Jens Schneider Christian-Albrechts-University zu Kiel, Germany, demonstrates the flexibility in use of all NORBIT systems for the ability to collect a form of backscatter at multiple frequency settings. Seabed changes it's acoustic response for acoustic signals at different frequencies, so comparison of these data gives more information about bottom characteristics.



Water Column

Water column data contains beamformed magnitude data for each beam. After acoustic transmission, signal is reflected from everything in the water column, for example: marine life (fish schools, zooplankton layers); sediment; floating particles; bubbles and the seafloor. The strength of the return echo depends on the target type. Water column data contains all of these signals, and is therefore useful for analysing gas plumes, leakage detection, etc.

Historically water column data was impractical to record due to large file sizes, however NORBIT offers compressed water column data, easing the data flow and increasing processing efficiencies. Users can also choose water column data resolution that is recorded (Low->Very High) depending on purpose.



NORBIT Raw water column data

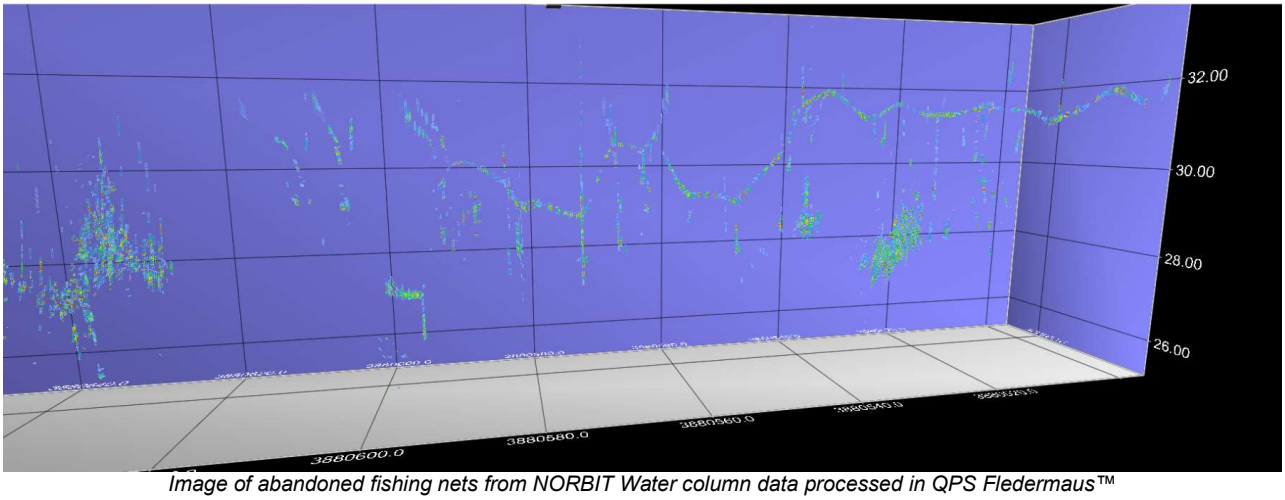


Image of abandoned fishing nets from NORBIT Water column data processed in QPS Fledermaus™