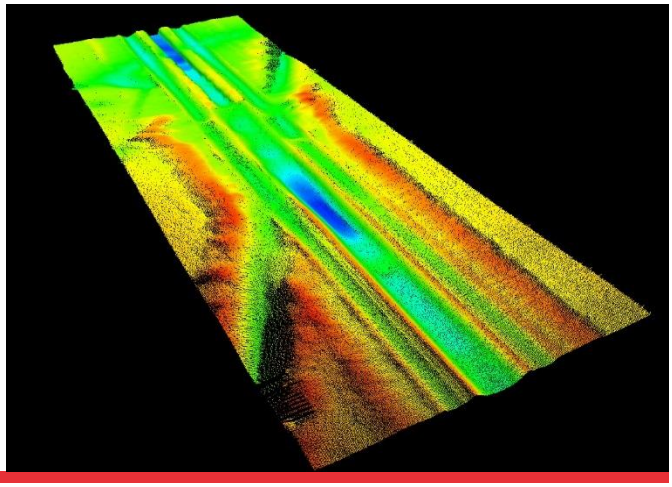
104002-USV-MMT-SUR-REP-SURVEYRE
REVISION 02 | FOR CLIENT REVIEW
FEBRUARY 2022

MARINE SURVEY REPORT

PROJECT SEAGRASS



USV REACTIVATION & SEAGRASS

MOBILISATION & GEOPHYSICAL SURVEY

SOLENT, UK
DECEMBER 2021

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AN OCEAN INFINITY COMPANY

REVISION HISTORY

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REVISION LOG

DATE	SECTION	CHANGE

DOCUMENT CONTROL

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Check	Reporting Quality Controller	Rebecca Österberg
Approval	Project Manager	Stina Palmeby

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ABBREVIATIONS AND DEFINITIONS

BEA	Beaulieu survey area
BEM	Bembridge survey area
EMODnet	European Marine Observation and Data Network
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
HAM	Hamstead survey area
m	meter
MBES	Multibeam Echo Sounder
NM	Nautical Mile
POS MV	Position and Orientation System for Marine Vessels
POSPac	Position and Orientation System Package
PPS	Pulse Per Second
SBET	Smoothed Best Estimated Trajectory
SOW	Scope of Work
SSS	Side Scan Sonar
TOT	Totland survey area
UTC	Coordinated Universal Time
USV	Unmanned Surface Vessel

1 | INTRODUCTION

1.1 | PROJECT INFORMATION AND SURVEY AREA

The Seaworker 8 Unmanned Surface Vessel (USV) had been lying idle and was to be tested. Following completion of the test, a survey was performed along nearshore areas of the Solent, collecting data for Project Seagrass. Figure 1 shows the location of the areas and the survey priority order, 1 to 4. These are referred to as; Hamstead (HAM), Beaulieu (BEA), Bembridge (BEM), Totland (TOT) respectively.

Update: The Bembridge area (number 3 in Figure 1) was removed from the scope.

Project Seagrass is an environmental charity devoted to the conservation of seagrass ecosystems. In the Solent, the goal is to establish locations suitable for seagrass restoration. In this project Ocean Infinity, acting as a partner to Project Seagrass, will support by collecting data of seabed morphology which can be used for evaluating biological suitability.

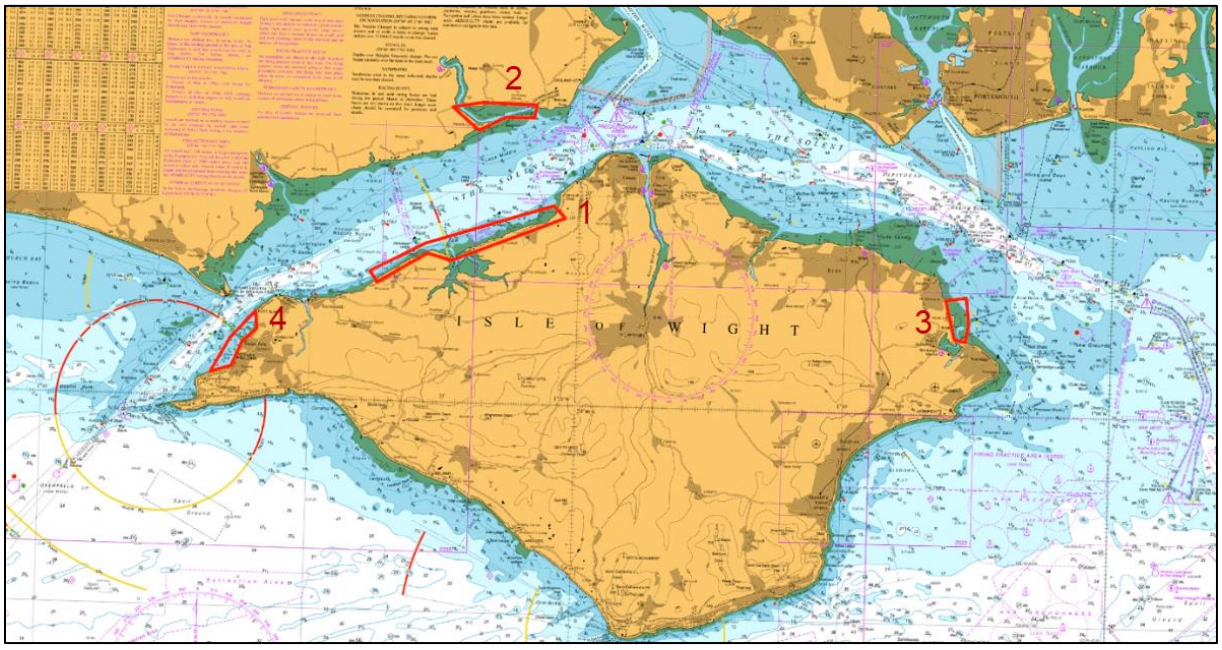


Figure 1 Overview images of the survey areas and priority order.
(Number 3 removed from the scope).

The project details are summarised in Table 1.

Table 1 Project details.

PROJECT:	USV Reactivation & Seagrass
MMT PROJECT NUMBER:	104002
SURVEY TYPE:	Geophysical
AREA:	Solent, UK
CATEGORY OF WATER:	Category C and D waters (between Needles and Bembridge) (Workboat Code and MSN 1837)
SURVEY PERIOD:	December 2021
SURVEY VESSEL:	Seaworker 8 USV
MMT PROJECT MANAGER:	Stina Palmeby

1.2| SCOPE OF WORK (SOW)

A larger mobilisation was performed, as the vessel has been idle for some time. After this mobilisation, which included verification tests, a survey task for Project Seagrass was performed.

Project Seagrass require data to determine suitable sites for the introduction of seagrass. Bathymetry, backscatter and side scan sonar (SSS) data was collected, processed and interpreted.

Survey was run as close to shore as possible, running to a maximum depth of 5 m below LAT.

Locations for ground truthing were selected from the acquired survey data. Video sampling of these selected locations was undertaken.

1.3| PURPOSE OF DOCUMENT

This document presents a summary of the operations, processing and interpretation performed during the project and briefly reports the results. The report will accompany data deliverables.

1.4| REPORT STRUCTURE

The report provides the results of the geophysical survey of the Hamstead, Beaulieu, and Totland areas. The report also includes project information, SOW, a brief summary of the survey performance and information and specifications for the project. Digital data deliverables accompany the report.

The following appendices are provided alongside the report:

- Equipment Specifications
- Ground Truthing Locations

2| SURVEY PARAMETERS

2.1| GEODETIC DATUM AND GRID COORDINATE SYSTEM

The geodetic and projection parameters are detailed in Table 2 and Table 3.

Table 2 Geodetic parameters.

DATUM PARAMETERS	
Datum	World Geodetic System 1984 (6326)
Ellipsoid	World Geodetic System 1984 (7030)
Prime Meridian	Greenwich (8901)
Semi-major axis	6 378 137.000 m
Semi-minor axis	6 356 752.3142 m
Inverse Flattening (1/f)	298.257223563
Unit	International metre

Table 3 Projection parameters.

PROJECTION PARAMETERS	
Projection	UTM
Zone	30 N
Central Meridian	03° 00’ 00’’ W
Latitude origin	0
False Northing	0 m
False Easting	500 000 m
Central Scale Factor	0.9996
Units	metres

2.2| VERTICAL DATUM

The vertical reference parameters used for processing and reporting are presented in Table 4.

Table 4 Vertical reference parameters.

Vertical Reference Parameters	
Vertical reference	LAT
Height model	VORF

FOR USE ON HULL-MOUNTED MBES SYSTEMS

Global Navigation Satellite System (GNSS) tide was used to correct the bathymetry data to the defined vertical reference model UKHO VORF LAT (Figure 2). The GNSS tide was generated from post-processing of the GNSS data collected by the Applanix PosMV Elite system. The GNSS data was post-processed using the Applanix software POSPac MMS. POSPac MMS outputs ellipsoidal heights with an accuracy of 0.05 m RMS, corrected for motion and referenced to the MBES reference point. All heights were referenced to the same vertical height model by incorporating the model of the defined

vertical datum into the process. Comparisons with the closest water level station were performed to ensure that the data was levelled correctly.

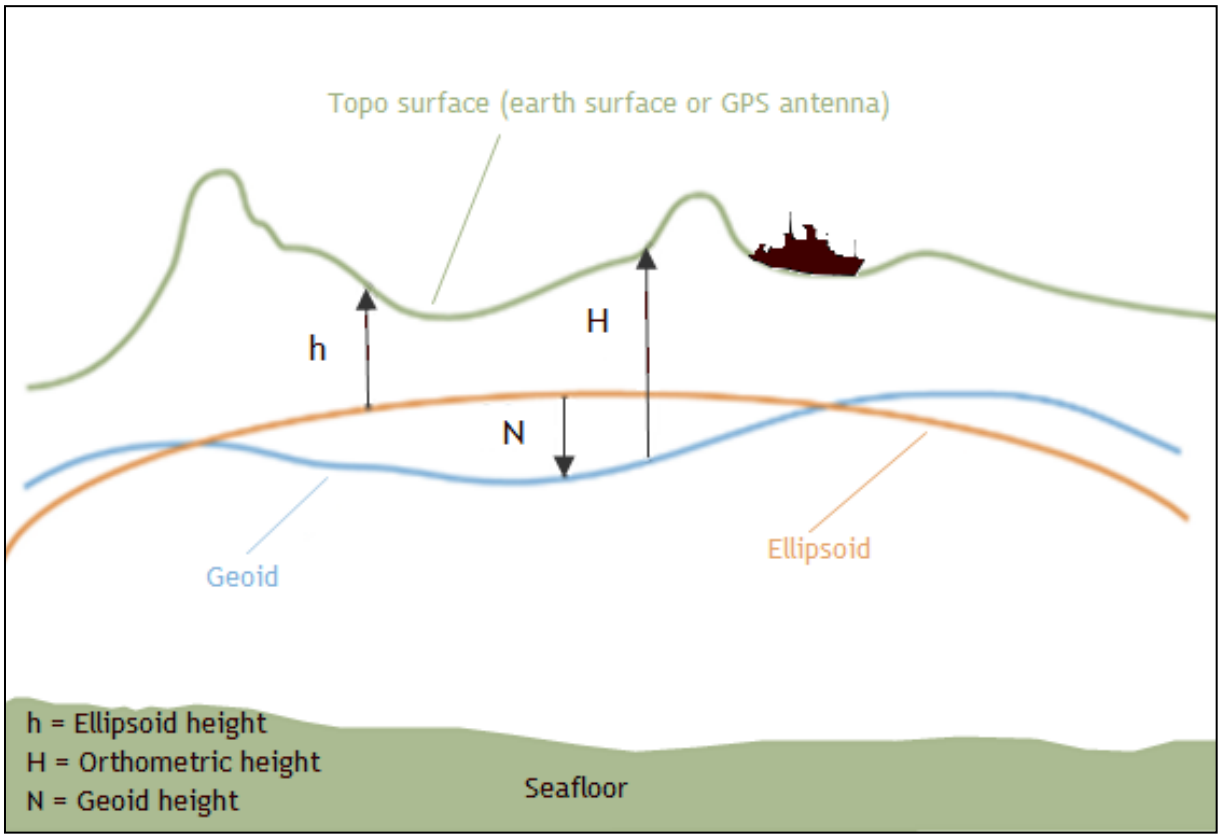


Figure 2 Overview of the relation between different vertical references.

The tidal reduction methodology encompasses all vertical movement of the vessel, including tidal effect and vessel movement due to waves and currents. The short variations in height are identified as heave and the long variations as tide.

This methodology is very robust, since it is not limited by the filter settings defined online and provides very good results in complicated wave and swell patterns as well as accounts for any changes in height caused by changes in atmospheric pressure, storm surge, squat, loading or any other effect not accounted for in a tidal prediction. The vessel navigation is exported into a post-processed format, SBET (Smoothed Best Estimated Trajectory), and applied to the MPES data.

2.3| TIME DATUM

Coordinated universal time (UTC) was used on all survey systems on board the vessel. The synchronisation of the vessel's on-board system was governed by the pulse per second (PPS) issued by the primary positioning system. All displays, overlays and logbooks were annotated in UTC.

3| OPERATIONS

The survey operations were performed in three (3) sections; mobilisation and calibration, geophysical survey and video camera ground truthing.

3.1| SURVEY TASKS

A summary of the survey tasks are presented in Table 5.

Table 5 Survey tasks.

TASK	DATE	DESCRIPTION
Mobilisation and Calibration	2021-12-02 to 2021-12-06	Mobilisation was performed alongside at Woolston, UK. Calibrations were performed at sea.
Geophysical Survey	2021-12-06 to 2021-12-15	The acquisition of bathymetry, backscatter and side scan sonar data by USV, Seaworker 8.
Video Camera Ground Truthing	2021-12-13 to 2021-12-15	Deployment of video camera at pre-determined locations, recording short videos to assist interpretation.

3.1.1| MOBILISATION AND CALIBRATION TEST

Mobilisation of the Seaworker 8 USV and the support vessel Rebel Anchorman was completed alongside at Woolston, UK, between 2nd December 2021 and 6th December 2021.

MBES and SSS offshore calibration tests were performed on 6th December 2021 over a chosen contact, a well-defined boulder approximately 1.5 m in diameter. Six verification lines were run with 75 m range, the selected contact was positioned approximately 60 m from the nadir and the water depth at the calibration location was approximately 20 m.

The mobilisation was successful and the performance of the equipment was accepted.

3.1.2| GEOPHYSICAL SURVEY

Geophysical survey began after satisfactory verifications on 6th December 2021 and continued until 15th December 2021.

The Seaworker 8 USV ran pre-set survey lines, acquiring bathymetry, backscatter and SSS data. This was supported by the manned vessel, Rebel Anchorman.

Seasonal, marginal weather resulted in a reduction of the SSS range for part of the TOT area, in order to increase the motion tolerance and therefore, reduce stretching in the data.

Coverage reports were produced while survey was ongoing, consequently, infills were run where necessary to achieve coverage of the survey areas. Note, full coverage of all systems was not fulfilled due to the priority of SSS coverage over bathymetry and backscatter.

3.1.3| VIDEO CAMERA GROUND TRUTHING

27 locations for ground truthing were selected in the HAM and BEA areas. A GoPro video camera was deployed from the support vessel Rebel Anchorman at each of these locations, recording short videos to get an idea of the seabed conditions and check for potential seagrass presence.

This took place alongside survey between the 13th December 2021 and the 15th December 2021. In most instances, clear videos were achieved, however, at three locations that were located in deeper

waters the light levels were too low to see the seabed conditions and murky water in the estuary area (BEA) resulted in some unclear footage.

3.2| SURVEY VESSEL

The survey was performed from the USV Seaworker 8, Figure 3, accompanied by the manned support vessel Rebel Anchorman, a 10 m Multi Role Catamaran, Figure 4, from which the survey was monitored.

Figure 3 USV Seaworker 8.

Figure 4 Support vessel Rebel Anchorman.

3.3| SURVEY EQUIPMENT

The vessel equipment is presented in Table 6.

Equipment specifications can be found in Appendix A|.

Table 6 Vessel-mounted and towed positioning/geophysical/geotechnical equipment.

Instrument	Name
Primary Positioning System	Applanix POS MV Elite with SBAS corrections. Post processing using RINEX data.
Secondary Positioning System	Fugro Seastar 9205
Primary Gyro and INS System	Applanix POS MV Elite
Survey Navigation System	QPS QINSy
Multibeam Echo Sounder	Edgetech 6205 (540 kHz)
Side Scan Sonar	Edgetech 6205 (230/540 kHz)
Sound Velocity Sensor	Valeport SVX2, deployed over the side
Video Camera	GoPro 4 Hero Black

4| DATA QUALITY AND PROCESSING

4.1| MULTIPHASE ECHO SOUNDER

The MPES system used for Project Seagrass was selected on the basis of its capability to record bathymetry, backscatter and SSS data from a single unit. Additionally, interferometric systems such as these are able to achieve greater swath widths in shallow depths compared to a MBES. However, the usable range of each data type acquired is actually different with SSS having the greatest coverage, Backscatter next and the bathymetry the shortest. Prioritising the SSS coverage meant that there are substantial gaps in the bathymetry and backscatter coverage which proved problematic during data processing since the competing aims of removing poor quality outer beam data needed to balanced with not reducing the overall coverage where possible. This resulted in a lot of manual cleaning and reinstating data after outer-beam filtering had been performed.

The effect is for the survey to result in a series of transects across the shallowest parts of each area which still gives a good understanding of depths within the sites and allowed greater areas to be surveyed which would not have been achieved if 100% bathymetric coverage was required.

Excessive wave motion caused oscillations within the bathymetry of up to 20cm which were common in the Totland survey area, especially towards the southern end.

4.2| BACKSCATTER

The backscatter data acquired for Project Seagrass was generally of good quality with excellent performance in deeper areas and during calmer weather conditions. Excessive vessel motion translated into the data as an oscillation of grey tones which were most noticeable within the Totland survey area which was the most exposed of the 3 areas (Figure 5). Despite the appearance it did not affect the usability of the dataset for sediment classification or supporting the SSS for interpreting the locations of Seagrass habitat.

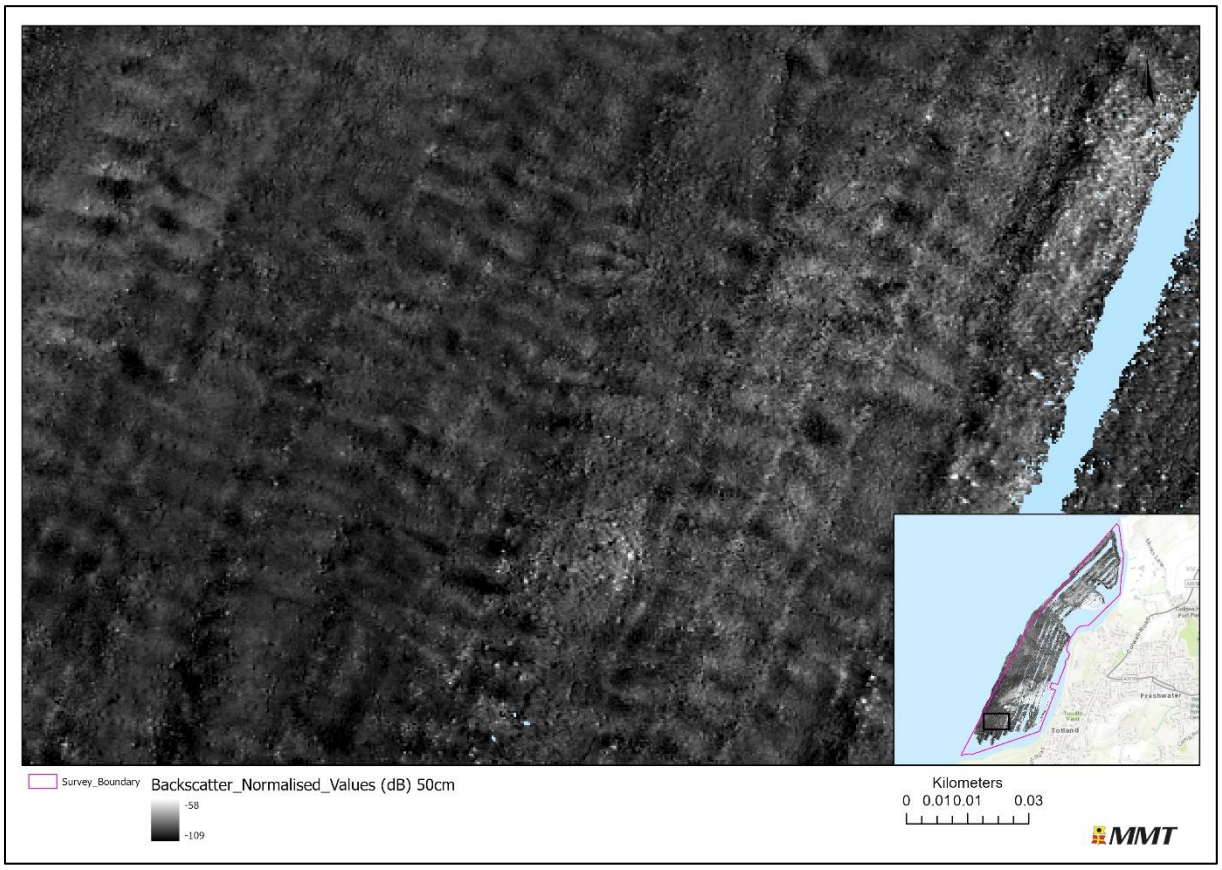


Figure 5 Oscillating backscatter data due to vessel motion in the Totland survey area.

BACKSCATTER - HABITAT CLASSIFICATION

The Backscatter (floating point) in this dataset was gridded at a 0.5 m cell size and the intensity decibel value interval varied from -48 dB (white, high reflectivity, hard) and -109 dB (black, low reflectivity, soft) for the exported mosaic. Intensity intervals between -48 dB and -56 dB were excluded from the process as the values represent edges of data and/or no data.

The backscatter image was imported into ArcGIS and a raster image was created based on the measured intensity values for each cell.

Within ArcGIS, a secondary image was created through the calculation of the average cell value with the Focal Statistics tool which creates a new average value for each input cell based on the neighbouring cell values. The mean value output was gridded in a 2 x 2 m (4x4 cell) raster image, Table 7.

With the collected ground truthing data, the intensity values were ground-truthed and grouped to provide indicative trends with regards to seagrass presence.

There were limiting factors due to the morphologically different ripple features in the area as well as the heterogenic substrates identified. The difficulties imposed on backscatter data are due to changes in elevation and angle of the seabed. These affect the amount of reflected sound, resulting in values indicating too hard or too soft of a substrate.

The potential errors are partially mitigated for by using the Focal Statistics tool in ArcGIS, as the interpolation used in the tool averages out the overestimated and underestimated values from the backscatter.

Table 7 Backscatter Intensity colour schema for each area (intensity is presented in dB).

DEFAULT	HAM	BEA	TOT
	-94.3 - -82.9	-95.4 - -84.4	-109 - -84.2
	-82.8 - -80.7	-84.3 - -80.5	-84.2 - -82.6
	-80.6 - -78.9	-80.4 - -76.5	-82.6 - -80.6
	-78.8 - -77.3	-76.4 - -73.4	-80.6 - -78.6
	-77.2 - -75.8	-73.3 - -69.9	-78.6 - -74.6
	-75.7 - -72.8	-69.8 - -57.1	-74.6 - -70.6

4.3| SIDE SCAN SONAR

The SSS data was of good quality with regards to the detection of seabed sediment, seabed features, and marine growth habitats. However, weather-induced motion affected the data in some instances. Roll in excess of 15 degrees was experienced in the HAM and TOT areas due to swell, resulting in stretched data. Marginal weather during the acquisition of the TOT area resulted in a reduction of the SSS range from 75 m to 30 m, in order to increase motion tolerance.

Suspended sediment in the water column is visible in some SSS lines, which affected smooth bottom tracking.

The positioning of the SSS was good in relation to the MBES and the desired resolution was achieved for the full swathe range.

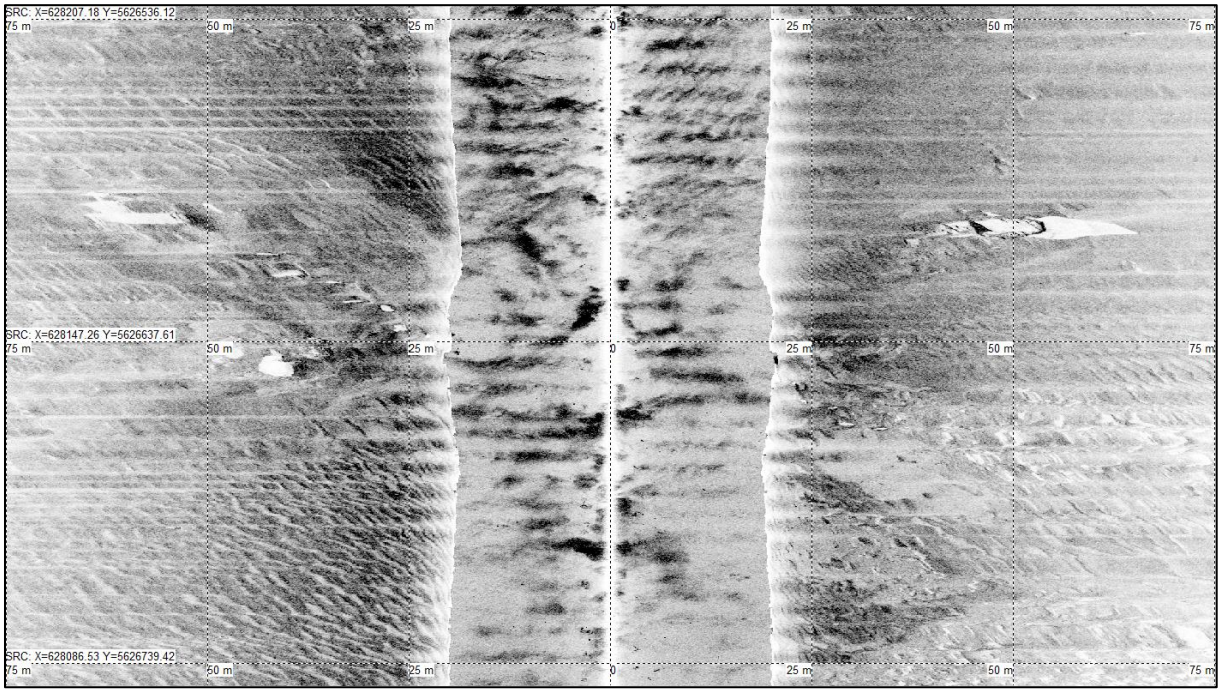


Figure 6 Data example of high frequency SSS data.
Showing 'banding' due to motion and acoustic reflections in the water column, but good resolution for the full 75 m swathe and clear feature detection.

4.4| VIDEO CAMERA

Generally, the quality of video footage recorded was very good, the seabed substrate and presence of seagrass was easily identifiable, see Figure 7.

Three of the ground truthing locations in the HAM area were in deeper waters, where low light levels resulted little-to-no visibility of the seabed.

The water column in the BEA area appeared to have a greater sediment load, which created a murky appearance in some of the videos, however the presence/absence of seagrass was still clearly visible, see Figure 8.

Please refer to Appendix B| for ground truthing locations.

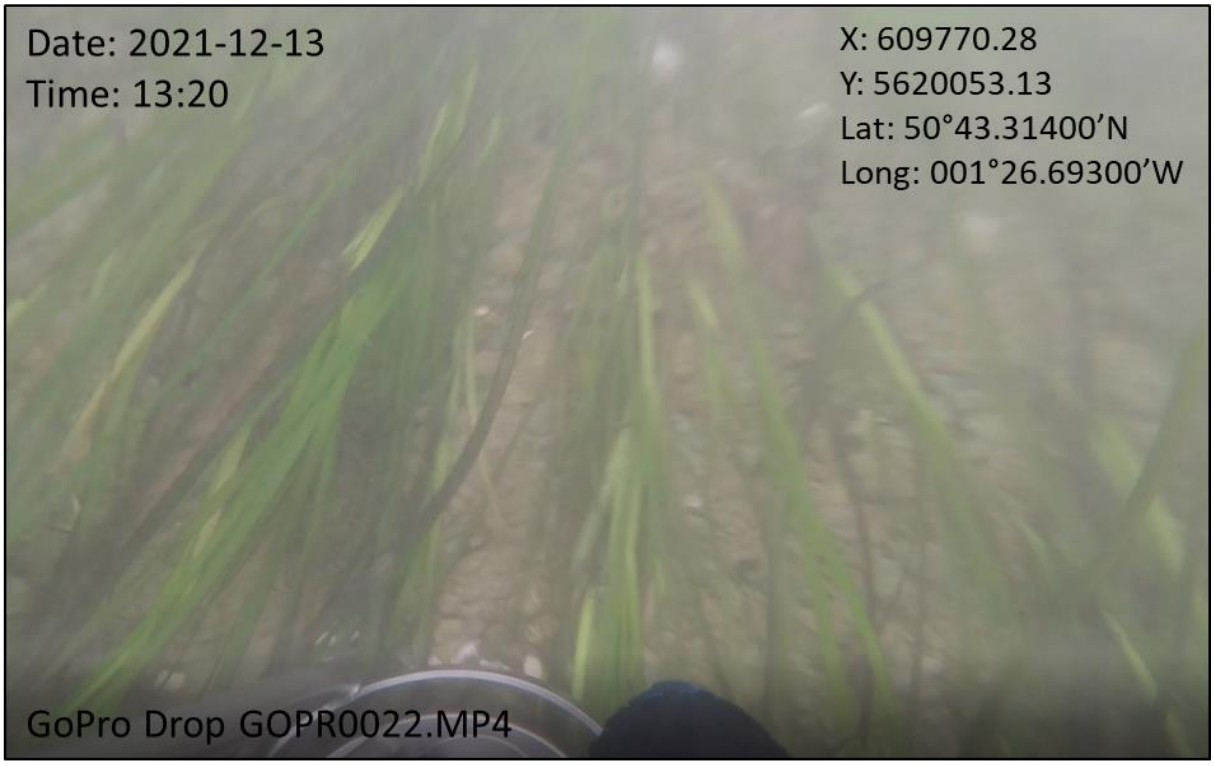


Figure 7 Example of video footage quality from a shallow ground truthing location in the HAM area.

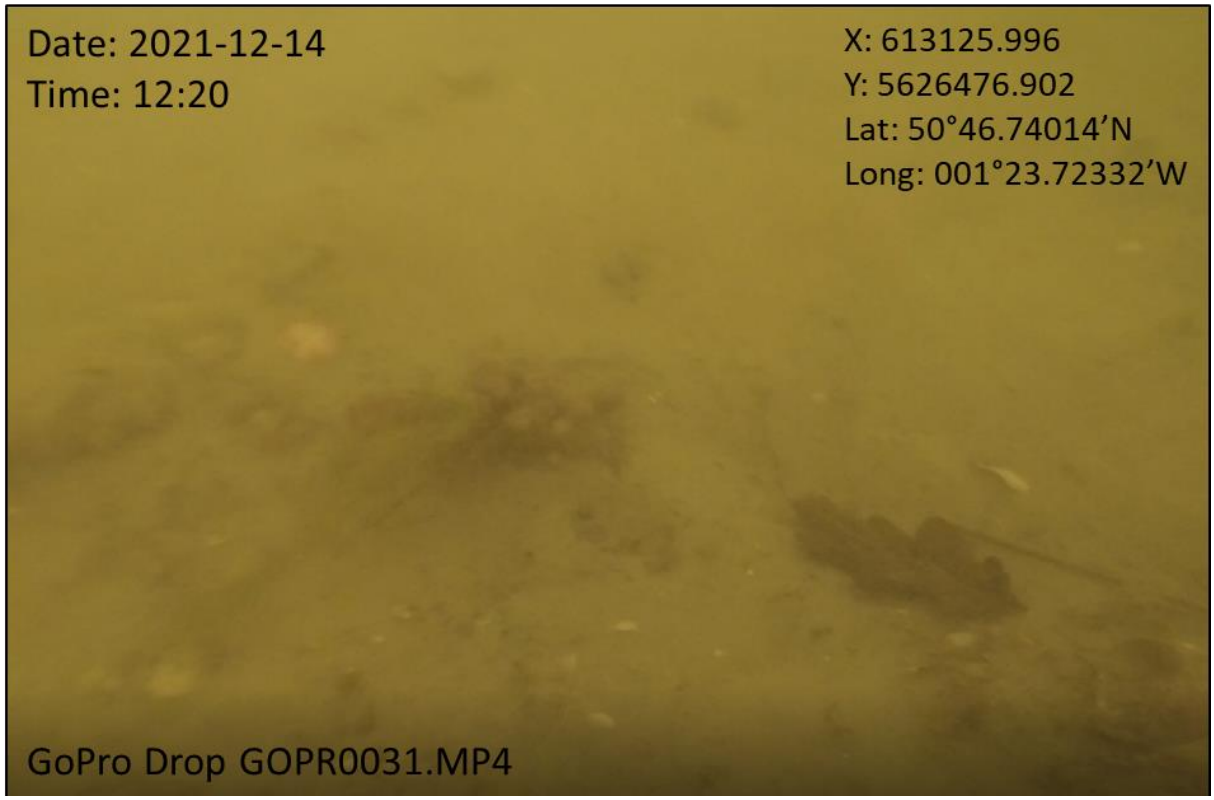


Figure 8 Example of video footage quality from a typical ground truthing location in the BEA area.

5| BACKGROUND DATA AND CLASSIFICATIONS

5.1| BACKGROUND INFORMATION

Background data from EMODnet; the European Marine Observation and Data Network, was used in supporting interpretation. This included a composite database of habitat and sediment types from numerous ground truthing projects in European waters as well as locations of known *Zostera* detection.

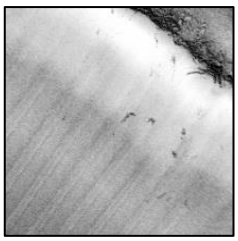
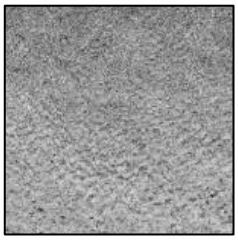
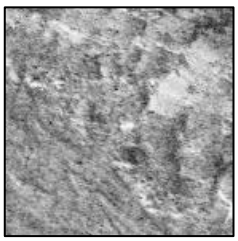
5.2| SEABED CLASSIFICATION

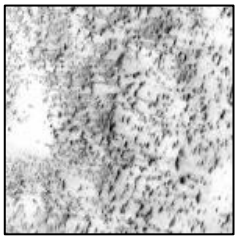
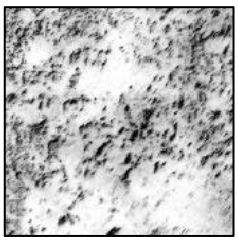
Sediment classifications assigned within the three survey areas are listed in Table 8. The interpretation of sediment boundaries was derived using the acoustic character of the SSS and backscatter data, correlated with the general seafloor morphology and respective MBES DTM. EMODnet substrate maps and corresponding habitat point observations were used during the assignment of sediment classifications to boundaries interpreted from the datasets.

The ID column in Table 8 defines the colour used in the report images for the specific sediment type. All particle sizes refer to the soil classification in ISO 14688-1 (2002).

Seabed feature classifications have been applied according to Table 9. These were mapped and classified according to the criteria specified in the project manual. Seabed features found within the survey areas exhibit a height of less than 1 m and are therefore classified as ripples.

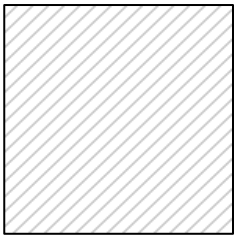
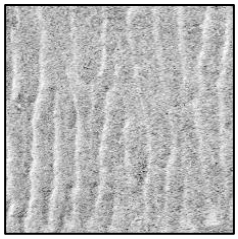
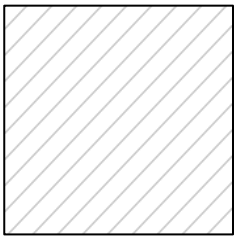
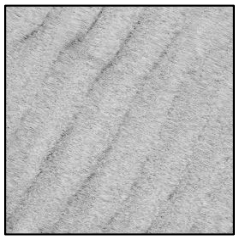
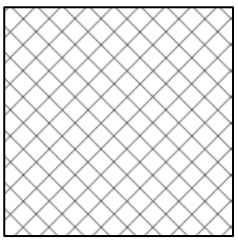
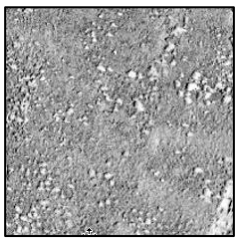
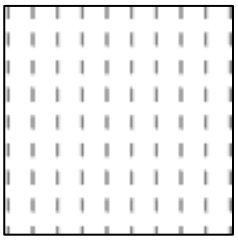
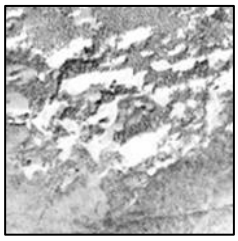
Table 8 Sediment classification.

ID	SSS IMAGE	ACOUSTIC DESCRIPTION	LITHOLOGICAL INTERPRETATION
		Low acoustic reflectivity, relatively smooth texture.	**CLAY** Predominantly Clay, may have minor fractions of silt, and shell fragments.
		Medium acoustic reflectivity, slightly grainy texture.	**SAND** Predominantly Sand, may have minor fractions of silt, clay and/or gravel.
		Medium to high acoustic reflectivity. Slightly grainy to grainy texture, coarse texture in places.	**Gravelly SAND** Predominantly sand. With coarser sediment and gravel in varying proportions. Some degree of sorting seen in high current areas.

ID	SSS IMAGE	ACOUSTIC DESCRIPTION	LITHOLOGICAL INTERPRETATION
		Medium to high acoustic reflectivity. Grainy to coarse texture in places.	**GRAVEL** Predominantly gravel. May have sand and pebbles in varying proportions.
		Medium to high acoustic reflectivity. Exhibits relief and texture.	**BEDROCK**

The ID column in Table 9 defines the pattern in the charts for the specific feature type.

Table 9 Seabed features classification.

ID	SSS IMAGE	SEABED FEATURE	CRITERIA
		Ripples	Wavelength <5 m Height <0.2 m
		Large Ripples	Wavelength 5-15 m Height 0.2-1.5 m
		Boulder Field Numerous	Concentration of ≥20 boulders within a maximum area of 100 m^2
		Eroded Depressions	Area of eroded seabed. With no clear indication of current direction.

5.3| SEABED GRADIENT CLASSIFICATION

The seabed gradient has been classified according to Table 10.

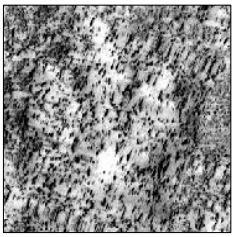
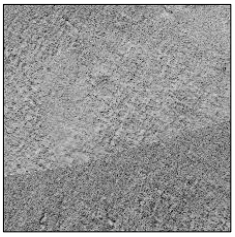
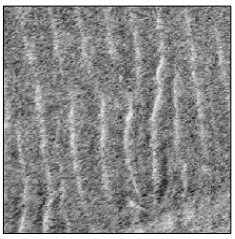
Table 10 Seabed gradient classification.

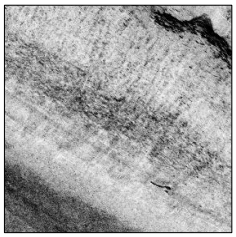
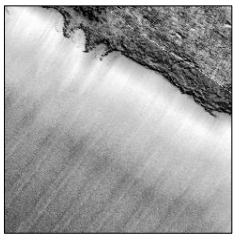
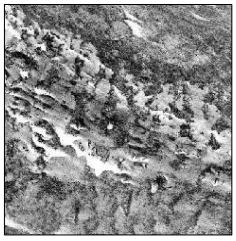
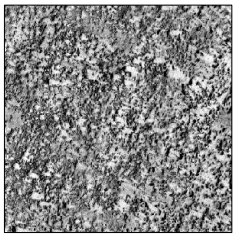
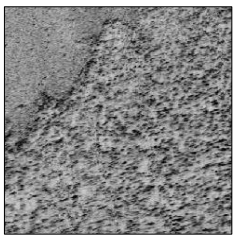
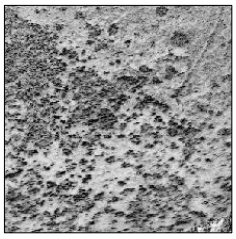
CLASSIFICATION	GRADIENT
Very Gentle	< 1°
Gentle	1° - 4.9 °
Moderate	5° - 9.9°
Steep	10° - 14.9°
Very Steep	> 15°

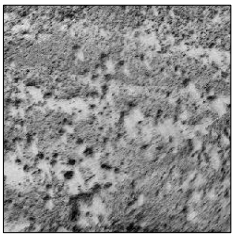
5.4| HABITAT CLASSIFICATION

The Biotope classification are based on the European Nature Information System (EUNIS) classification (EEA, 2019), Table 11.

Table 11 Habitat classification.

ID		EUNIS CODE	DESCRIPTION
		A3	Infralittoral rock and other hard substrata
		A4.23	Communities on soft circalittoral rock
		A5.13	Infralittoral coarse sediment
		A5.2	Sublittoral sand

ID		EUNIS CODE	DESCRIPTION
		A5.22	Sublittoral sand in variable salinity (estuaries)
		A5.32	Sublittoral mud in variable salinity (estuaries)
		A5.42	Sublittoral mixed sediment in variable salinity (estuaries)
		A5.43	Infralittoral mixed sediments
		A5.5	Sublittoral macrophyte-dominated sediment
		A5.53	Sublittoral seagrass beds

ID		EUNIS CODE	DESCRIPTION
		A5.53 A4.23	Sublittoral seagrass beds Communities on soft circalittoral rock
	-	-	Sublittoral seagrass beds

6| RESULTS

6.1| HAMSTEAD (HAM), ISLE OF WIGHT

6.1.1| BATHYMETRY AND BACKSCATTER

The bathymetric survey in the Hamstead area encountered depths ranging between +1.83 m and -17.42 m LAT. The shoal depth is located at the far eastern end of the survey area on seabed with an irregular texture.

The maximum depth is located along the offshore side of the survey area to the northwest of the Newtown River mouth. This point lies within a basin with megaripples and ripples and is bounded on the nearshore side by seabed with very steep gradients.

The backscatter data acquired within the Hamstead survey area was of a sufficient quality to facilitate seabed interpretation and assist in the identification of seagrass habitats. An overview image showing the backscatter for the full site is shown in Figure 10 and images zoomed in over areas identified as bearing Seagrass are shown in Figure 11 to Figure 14.

Figure 9 Bathymetric overview of the Hamstead survey area.

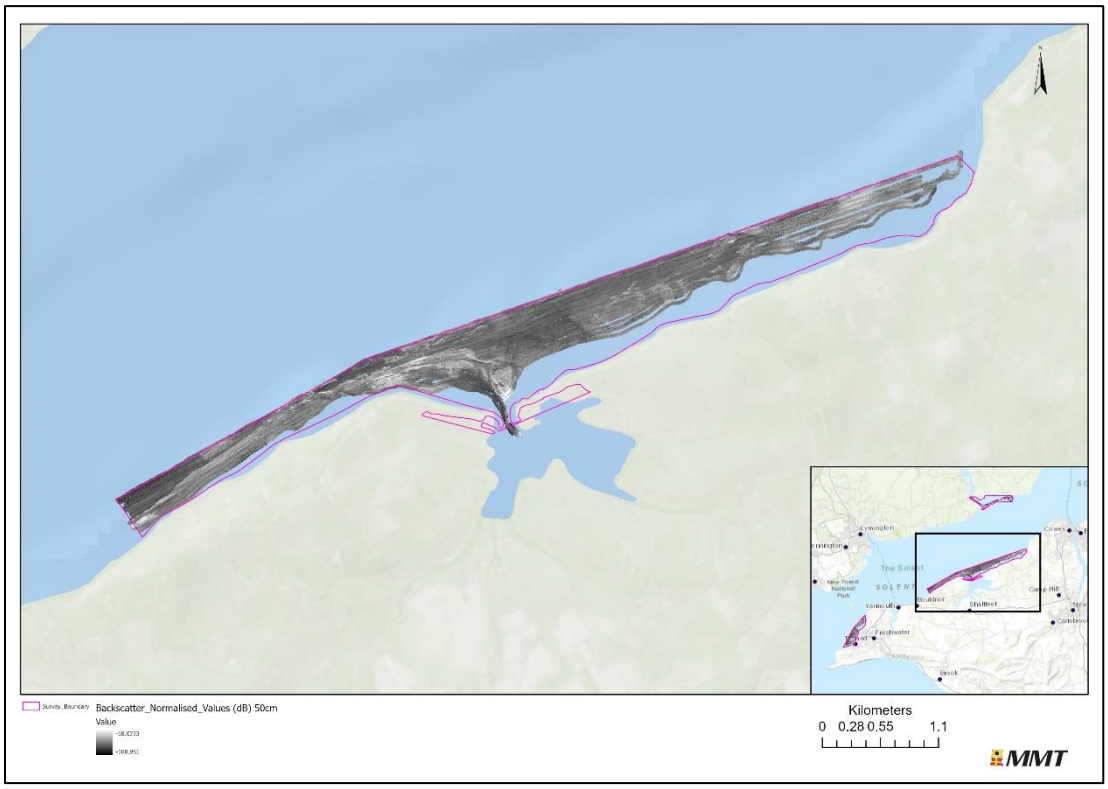


Figure 10 Overview of the backscatter normalised values for the Hamstead survey area.

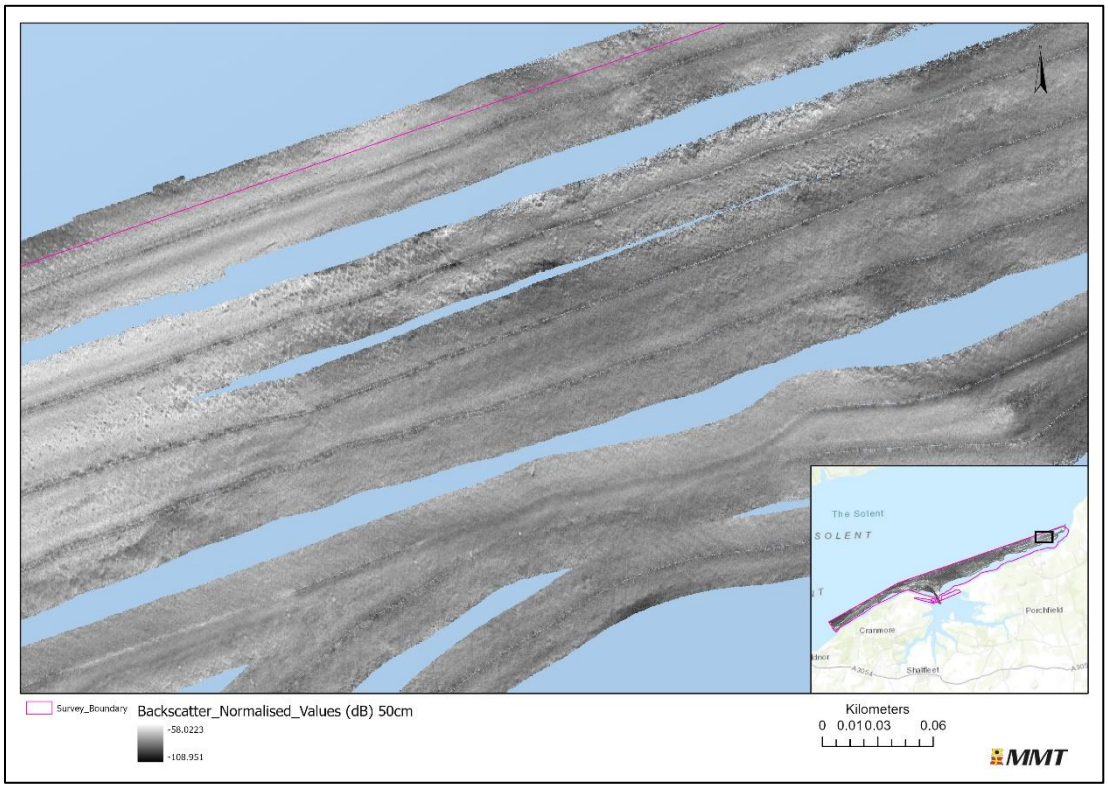


Figure 11 Backscatter normalised values for a location at the eastern end of the Hamstead survey area identified in the habitat map as containing seagrass.

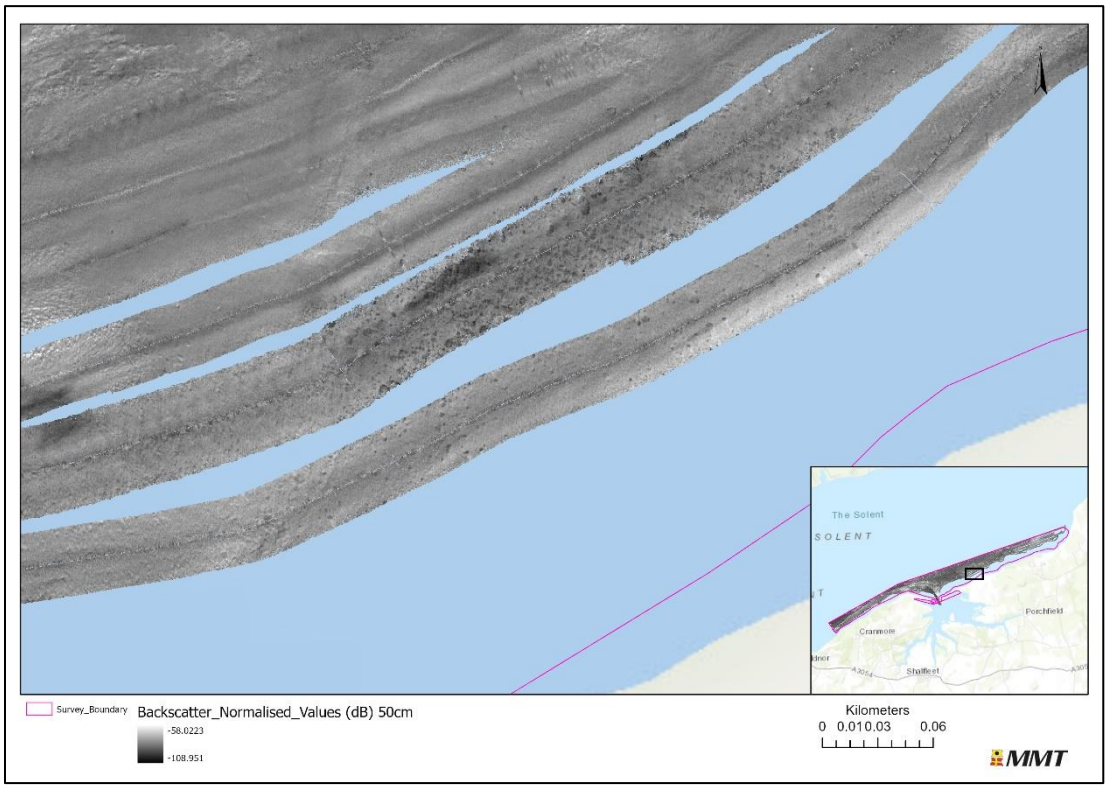


Figure 12 Backscatter normalised values for a location at the middle-eastern end of the Hamstead survey area identified in the habitat map as containing seagrass.

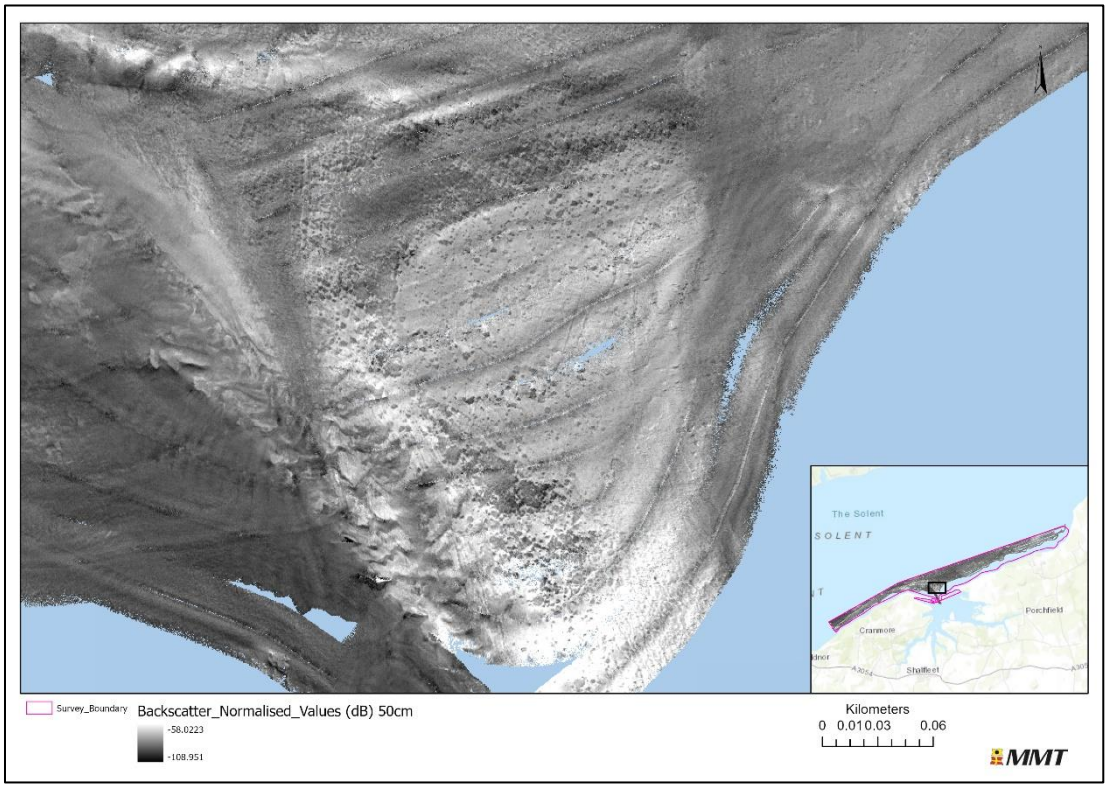


Figure 13 Backscatter normalised values for a location within the Hamstead survey area near the Newtown River mouth identified in the habitat map as containing seagrass.

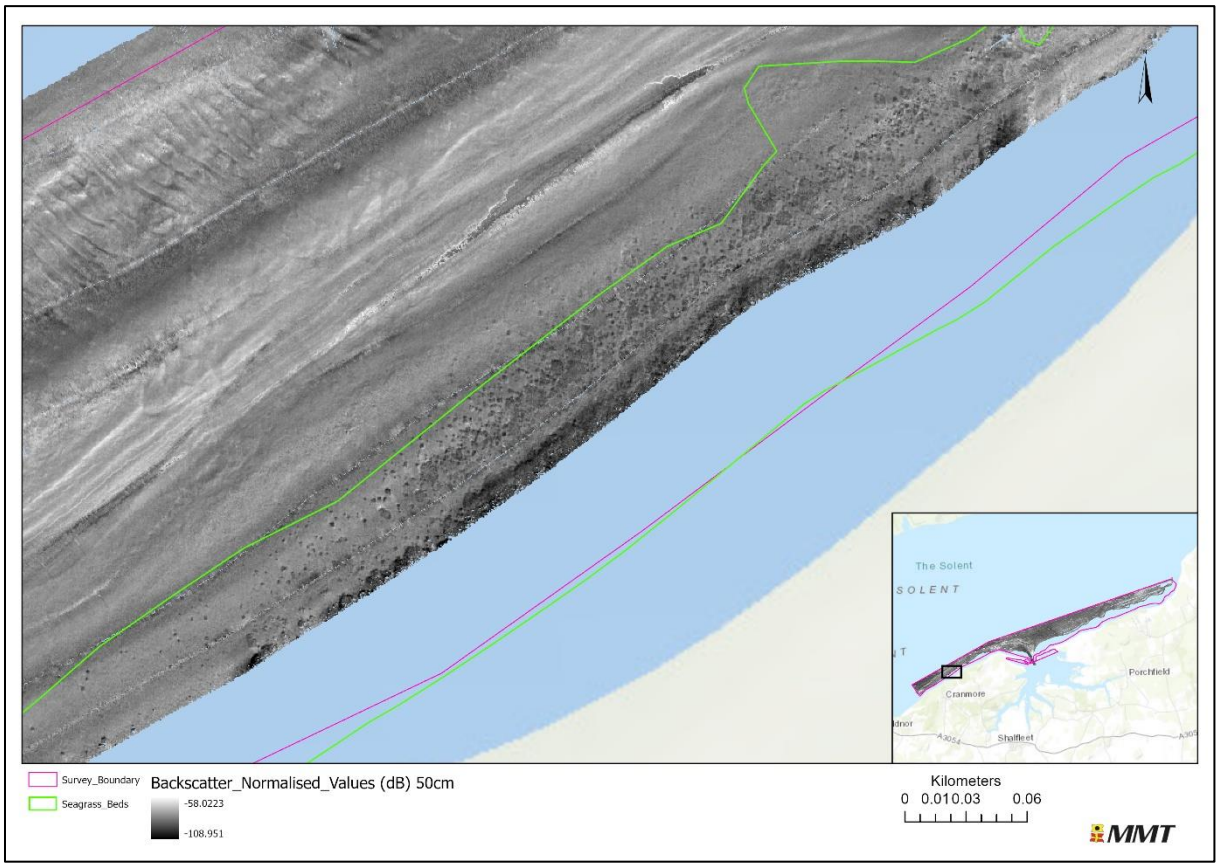


Figure 14 Backscatter normalised values for a location towards the southwest of the Hamstead survey area identified in the habitat map as containing seagrass.

6.1.2| SURFICIAL GEOLOGY AND SEABED FEATURES

The majority of the Hamsted area is dominated by sediments of SAND, with localised areas of GRAVEL and BEDROCK. The seabed sediment classifications and boundaries were identified using a combination of the bathymetry, backscatter and SSS data (LF and HF), as well as the ground-truthing video footage and EMODnet background information. See Figure 15 for an overview of the Hamstead area interpretation.

Close to Hamstead Point we see what appears to be features in the SSS data, typically 10 m to 30 m wide and over 200 m long, orientated in a roughly 100° orientation which is broadly perpendicular to the coastline, see Figure 16. This orientation follows that of the underlying bedrock strata which can be seen from satellite images of the coastline and is mapped on local topographical maps. On the SSS data this looks very distinctive, and could be interpreted as CLAY, however we can see in the bathymetry and backscatter data that this is all a smooth continuation of SAND. It is therefore inferred that the large white areas in the SSS data are in fact patches of missing data caused by changing slope angles in the seabed morphology, a result of a relatively thin layer of sediment covering sub cropping bedrock, creating a lineated topography.

The outlet of the Newtown River in the centre of the Hamstead area is interpreted to be the cause of the large ripples imaged in Figure 17. These ripples have an uneven, convex appearance with large wavelengths of between 7 m and 15 m. They are orientated broadly parallel to the coastline which agrees with the outward flow of the Newtown River being the cause.

To the northeast of the Hamstead area there is interpreted to be a patch of exposed BEDROCK within GRAVEL, approximately 200 m by 100 m in diameter. However, part of the texture seen in the SSS data could be attributed to marine growth, see Figure 18. We also see evidence of a subsea structure in this area with a possible cable crossing the BEDROCK.

Large areas of ripples can be observed in the SAND within the deeper parts of the Hamstead area. The ripples range in height from <0.05 m to 1.4 m and are sub-divided into ripples (height <0.2 m) and large ripples (height 0.2-1.5 m). The wavelength ranges from an average of 3 m for smaller ripples to an average of 7 m for the large ripples. The ripples most commonly have a crest orientation between 130° and 170°, indicating a current direction of broadly east-west, through the Solent.

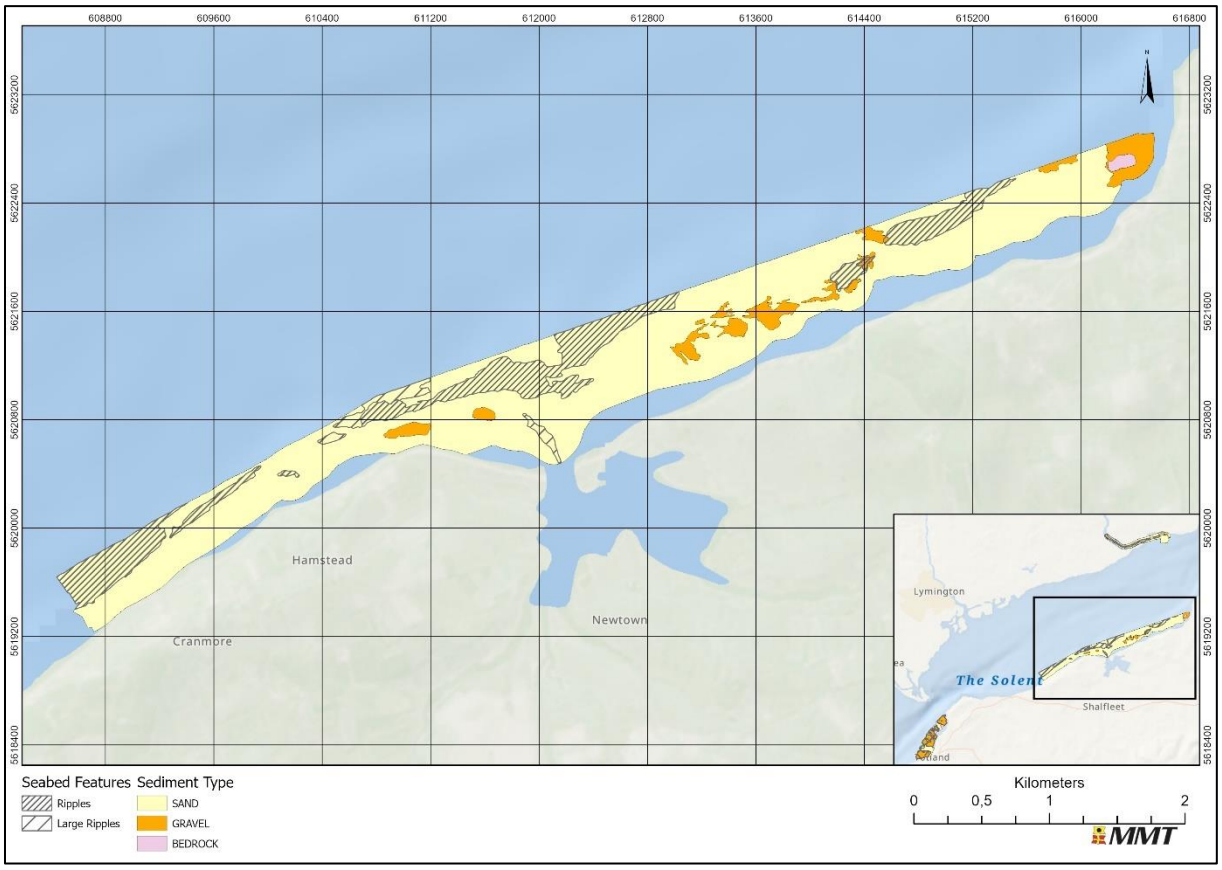


Figure 15 Overview of the surficial geology and seabed features interpretation for the HAM area.

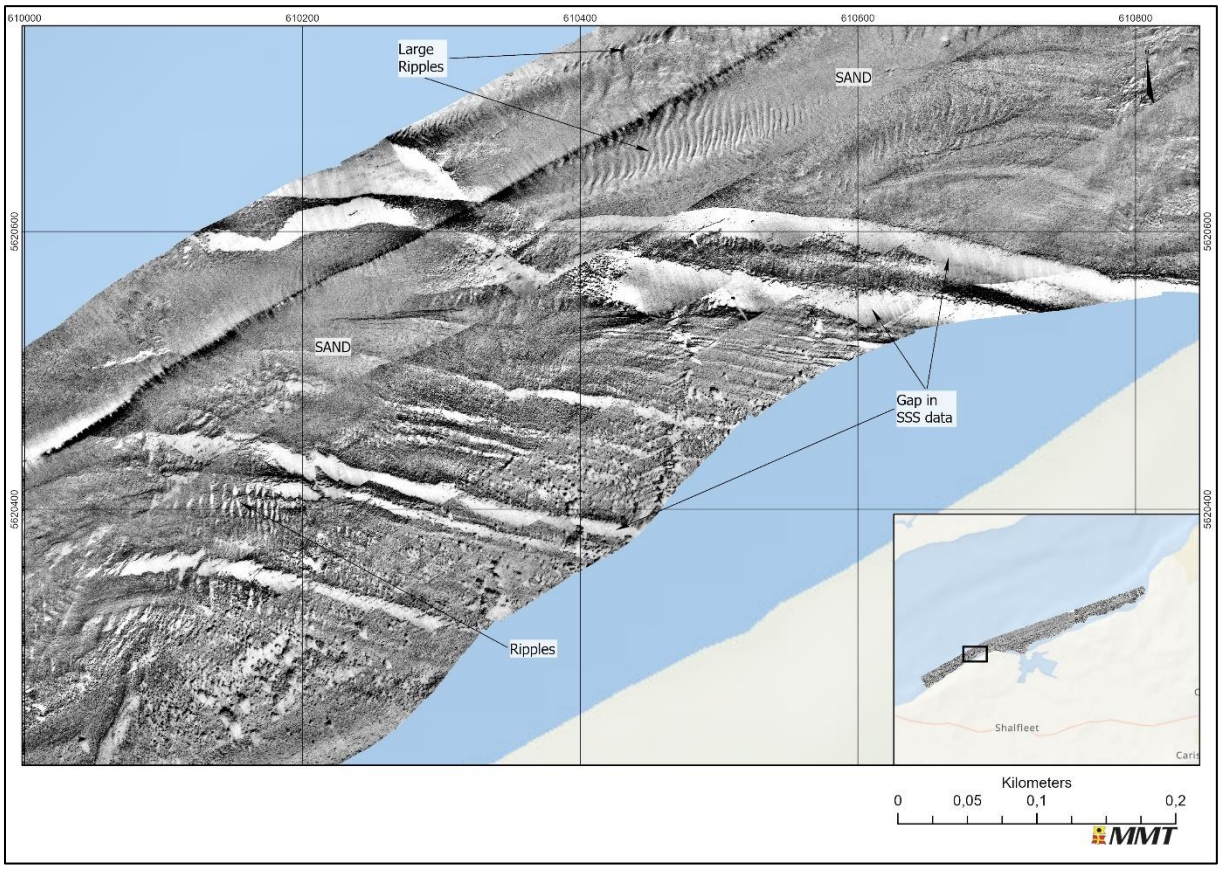


Figure 16 SSS image of surficial geology and seabed features in part of the HAM area. Showing elongate areas of shadow (i.e., missing data) caused by changing seabed morphology within the typical SAND of the HAM area, also visible are localised areas of large ripples within the SAND.

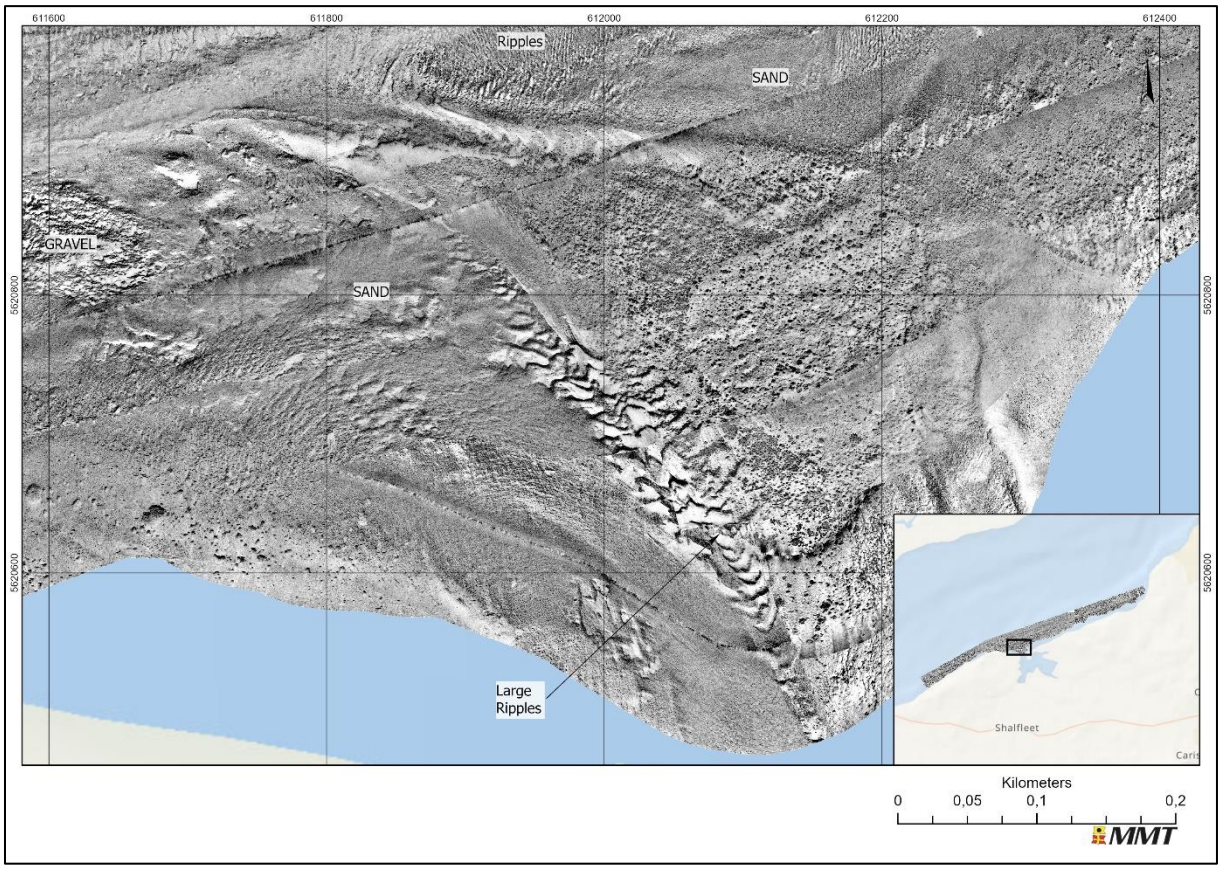


Figure 17 SSS image of surficial geology and seabed features in part of the HAM area.
Showing Large Ripples formed at the outlet of the Newtown River, ripples to the north formed in SAND and an area of GRAVEL to the west.

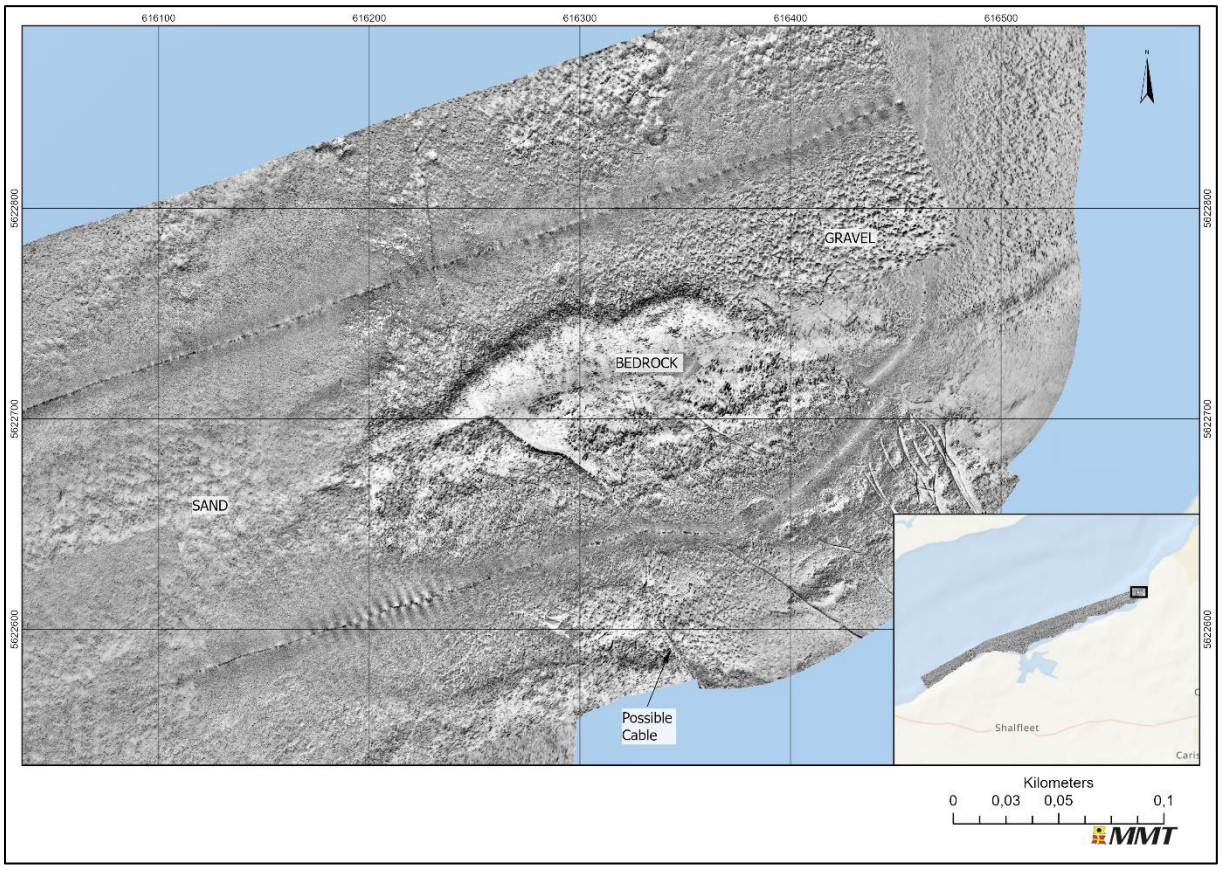


Figure 18 SSS image of surficial geology and seabed features in part of the HAM area. Showing an area of exposed BEDROCK within GRAVEL and SAND at the eastern extent of the HAM area.

6.1.3| SEAGRASS AND HABITAT MAPPING

Hamstead is interpreted to comprise predominantly coarse sands and muddy mixed sediments, Figure 19. Habitat A5.53 - Sublittoral seagrass beds, comprising commonly *Zostera spp*., occur closest to and along the entire coastline within the current survey area. The areas comprising seagrass beds are separated by muddy mixed sediments as well as areas of soft chalk classified as A4.23 - Communities on soft circalittoral rock. The A4.23 is predominantly interpreted to be present in the central to western most sections of the Hamstead area.

The areas classified as A5.5 - Sublittoral macrophyte-dominated sediment are dominated by various red, green, and brown seaweeds.

The backscatter data, in areas interpreted as seagrass beds, details a higher reflectivity (between -77 and -72dB), than the surrounding seabed, which indicates that the substrates comprise slightly silty sand/ coarse clean sand (Figure 20) as would be expected for seagrass beds.

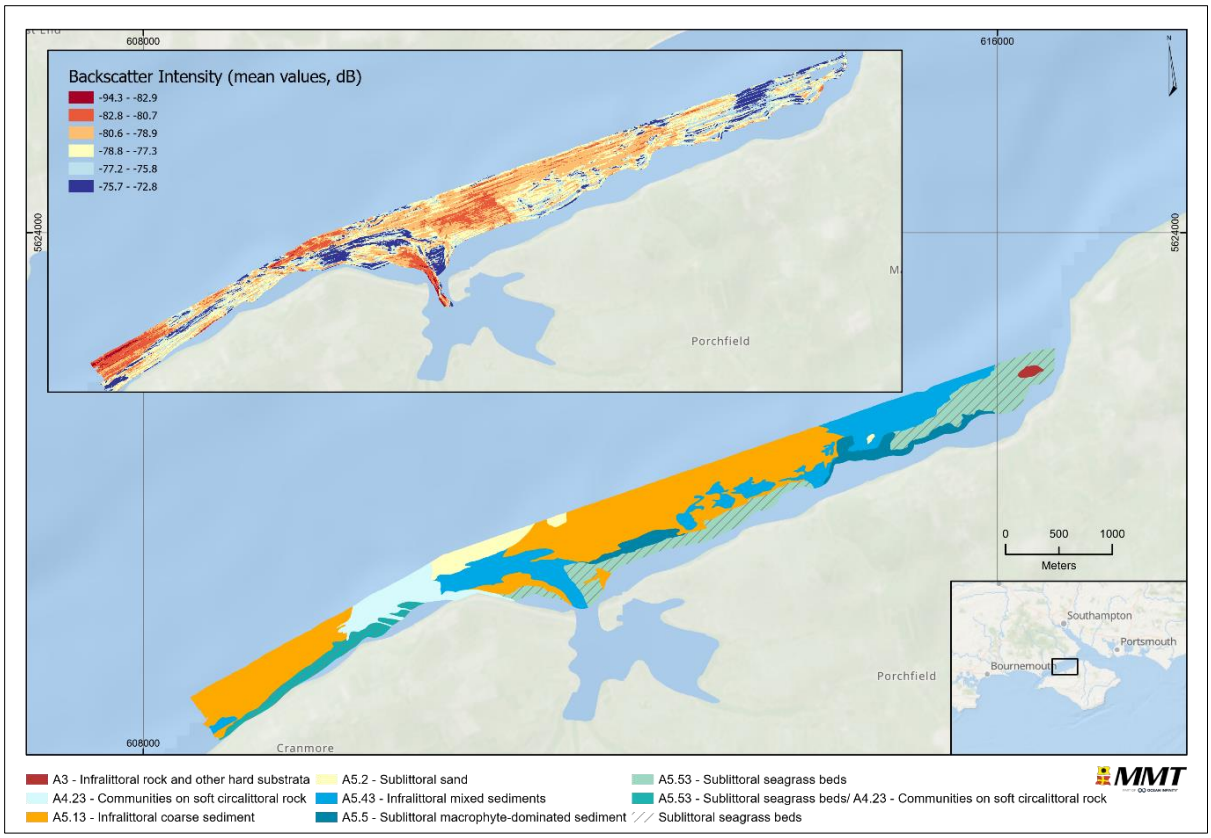


Figure 19 Habitat classification at Hamstead with backscatter data overview.

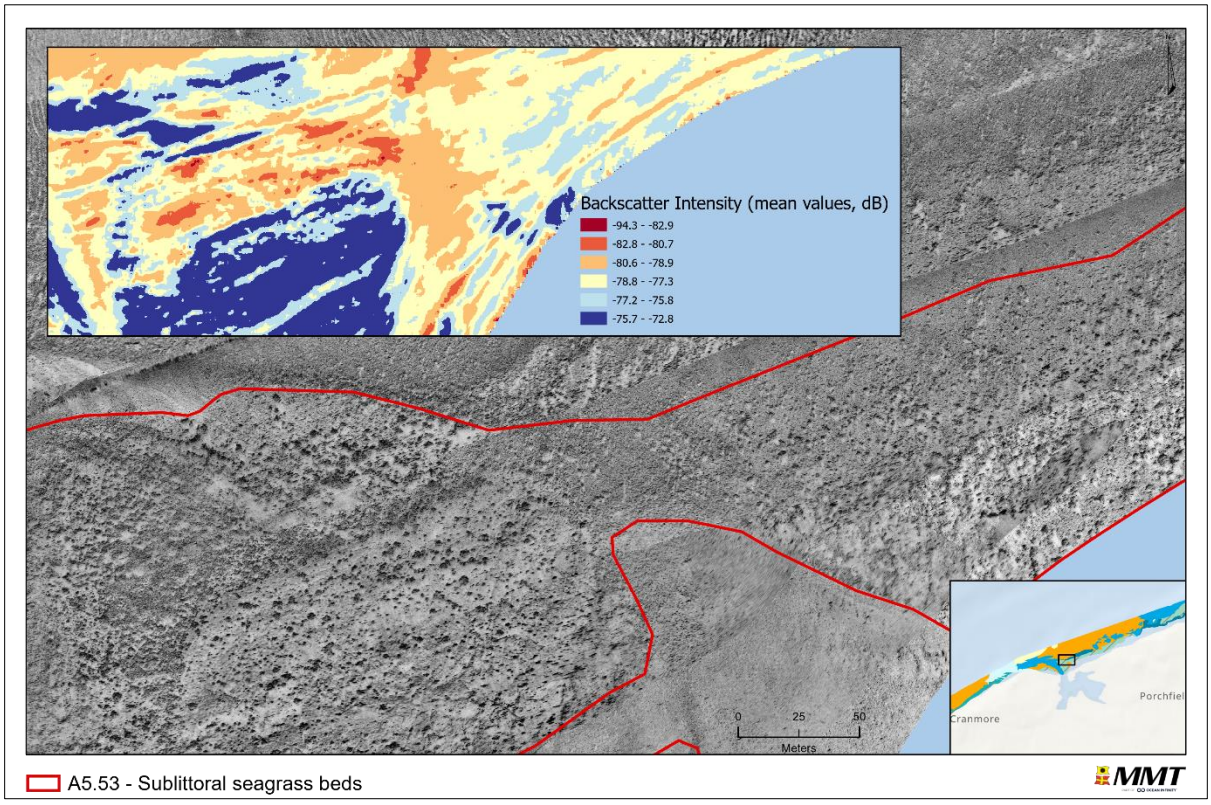


Figure 20 Seagrass beds at Hamstead with backscatter and SSS data overview.

6.2| BEAULIEU (BEA), MAINLAND

6.2.1| BATHYMETRY AND BACKSCATTER

Water depths within the Beaulieu dataset range between +1.77 m and -9.01 m LAT (Figure 21). The minimum depth recorded was located within a zone of incomplete bathymetric coverage at the eastern end of the site over the Beaulieu Spit. The maximum depth is located within the river channel at the head of the spit.

Data was acquired within the channel and captures the steep flanks with some coverage over the edges of the adjacent flats. Some navigational hazards were encountered within this area which limited the USV's ability to capture a full dataset along the flanks of the channel.

Along much of the length of the channel megaripples and ripples are visible within the bathymetry with the flanks and flats comprised of smooth seabed.

The backscatter data acquired within the Beaulieu survey area showed variations relating to sediment types and seabed textures and was of a sufficient quality to facilitate seabed interpretation and assist in the identification of seagrass habitats. An overview image showing the backscatter for the full site is shown in Figure 22. An image showing the backscatter variability within the river channel is shown in Figure 23 and an image showing an area identified as bearing Seagrass is shown in Figure 24.

Figure 21 Bathymetry overview for the Beaulieu survey area.
Depths represented in Navimodel as positive down.

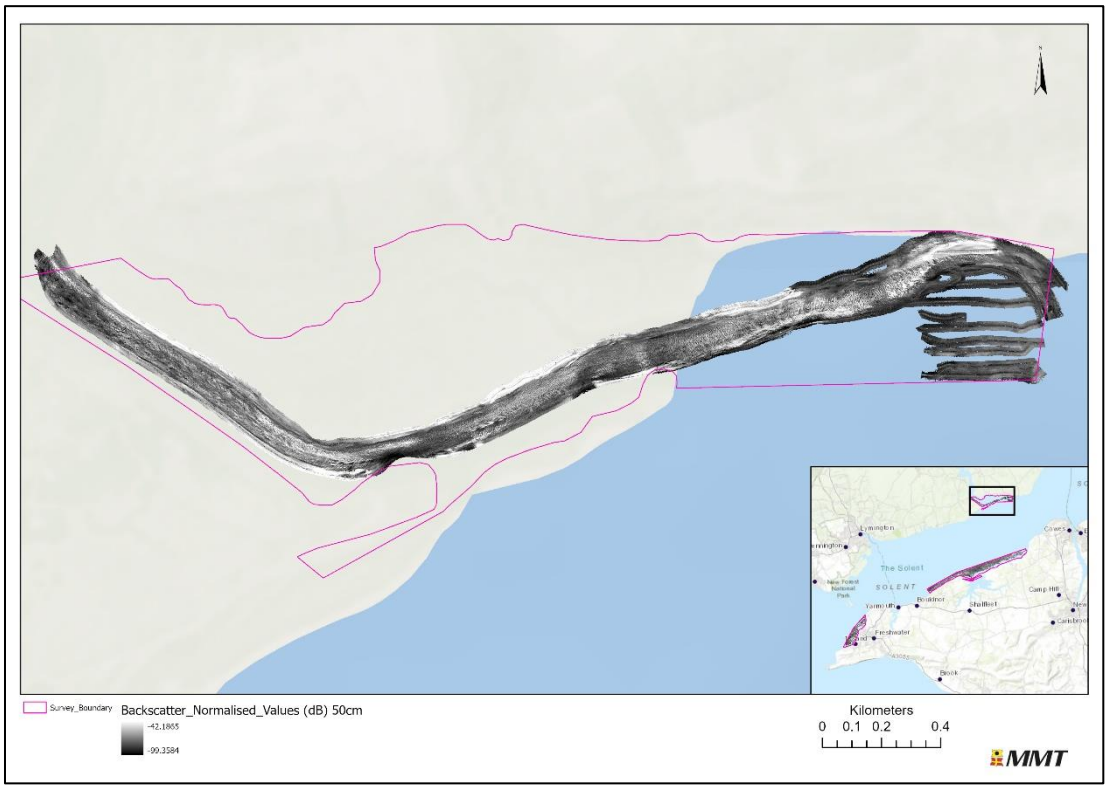


Figure 22 Overview of the backscatter normalised values for the Beaulieu survey area

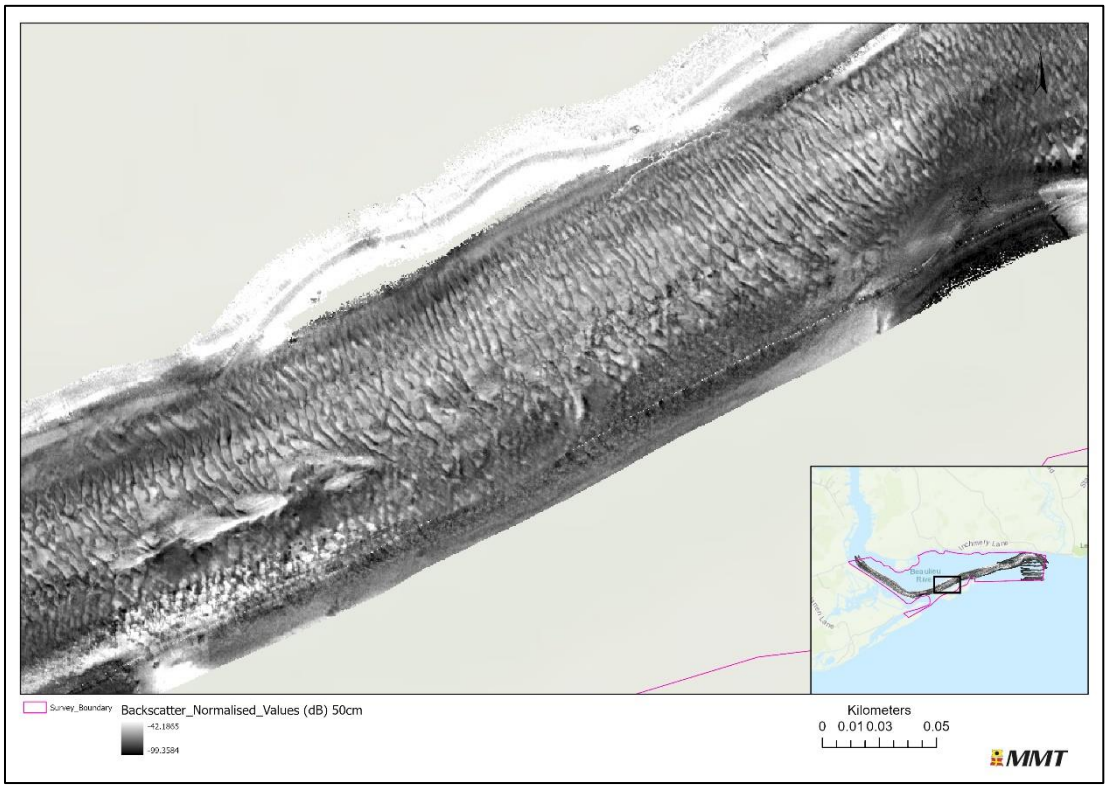


Figure 23 Backscatter normalised values for a region of the Beaulieu survey area showing variation caused by the presence of sorted bedforms within the base of the river channel.

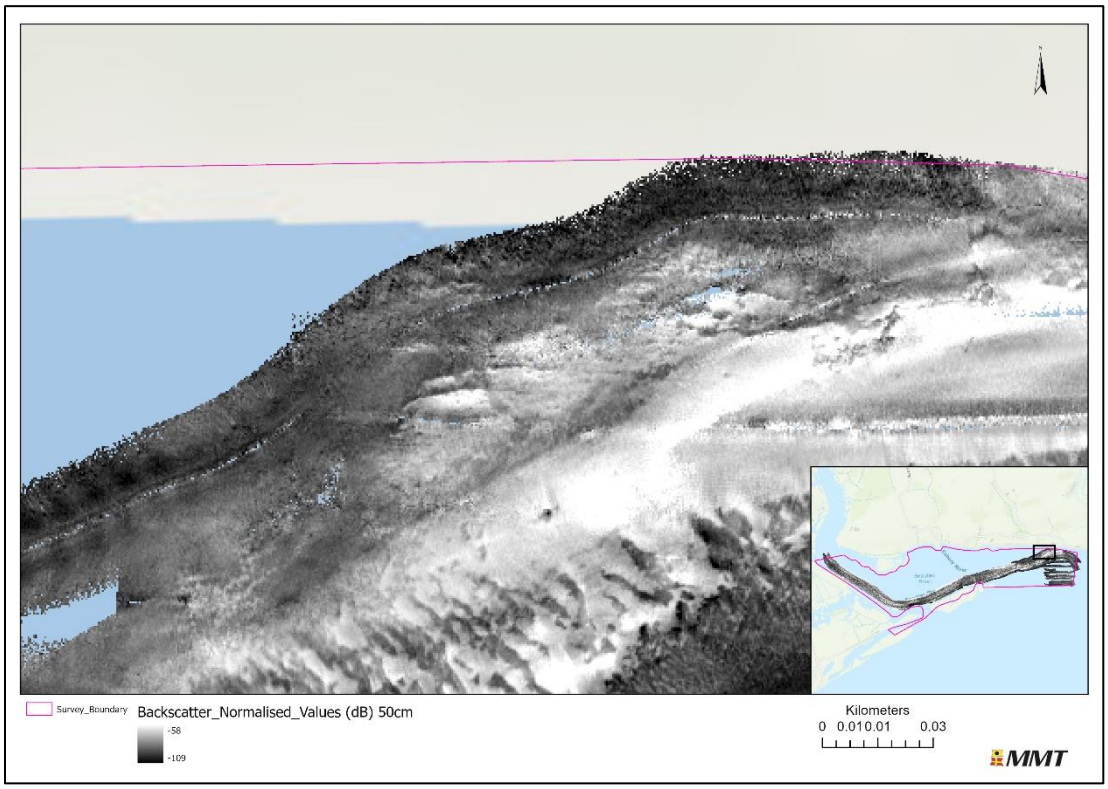


Figure 24 Backscatter normalised values for a location towards the eastern end of the Beaulieu survey area identified in the habitat map as containing seagrass.

6.2.2| SURFICIAL GEOLOGY AND SEABED FEATURES

The surficial geology of the Beaulieu area appears to mirror the morphology of the estuary, see Figure 25. With the edges forming banks of CLAY, deepening through SAND to gravelly SAND in the central area of the channel. This is interpreted to represent varying energy environments, and hence sediment carrying capabilities across the estuary, with the greatest flow velocities being in the centre.

Within the deeper, central channel of the estuary there are distinct eroded depressions. These are possibly generated by turbulent bottom currents, part of the river flow process, Figure 26. The scours typically have random shapes, however some show an elongate teardrop shape, narrowing in the down-stream direction, to the southeast.

Further seaward, ripples become the dominant bedforms in the central channel with an orientation between 140° and 200°, see Figure 27. These ripples have the appearance of sorted bedforms, with the contrasting acoustic character of finer SAND and coarser gravelly SAND. Sorted bedforms form when waves create turbulence over a poorly sorted seabed which leads to the selective concentration of coarser grained sediments.

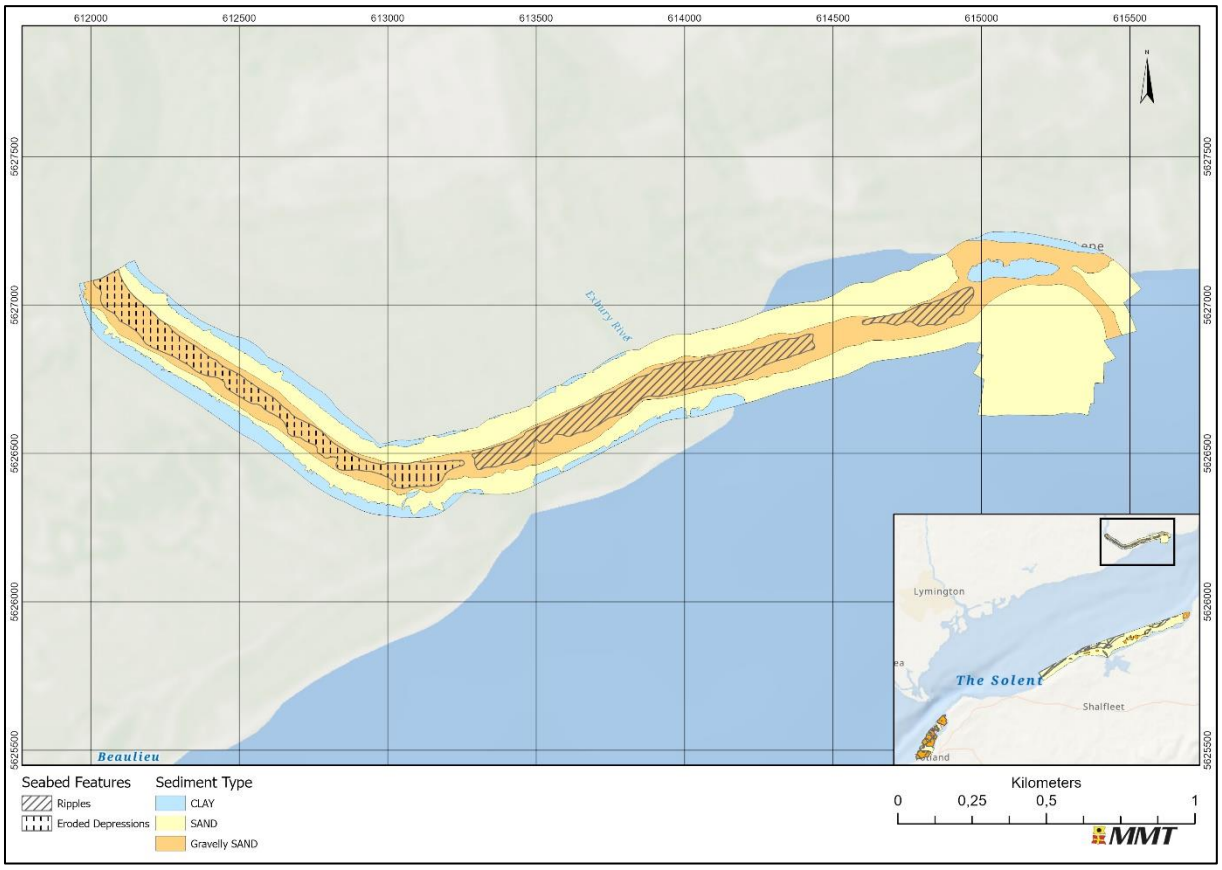


Figure 25 Overview of the surficial geology and seabed features interpretation for the BEA area.

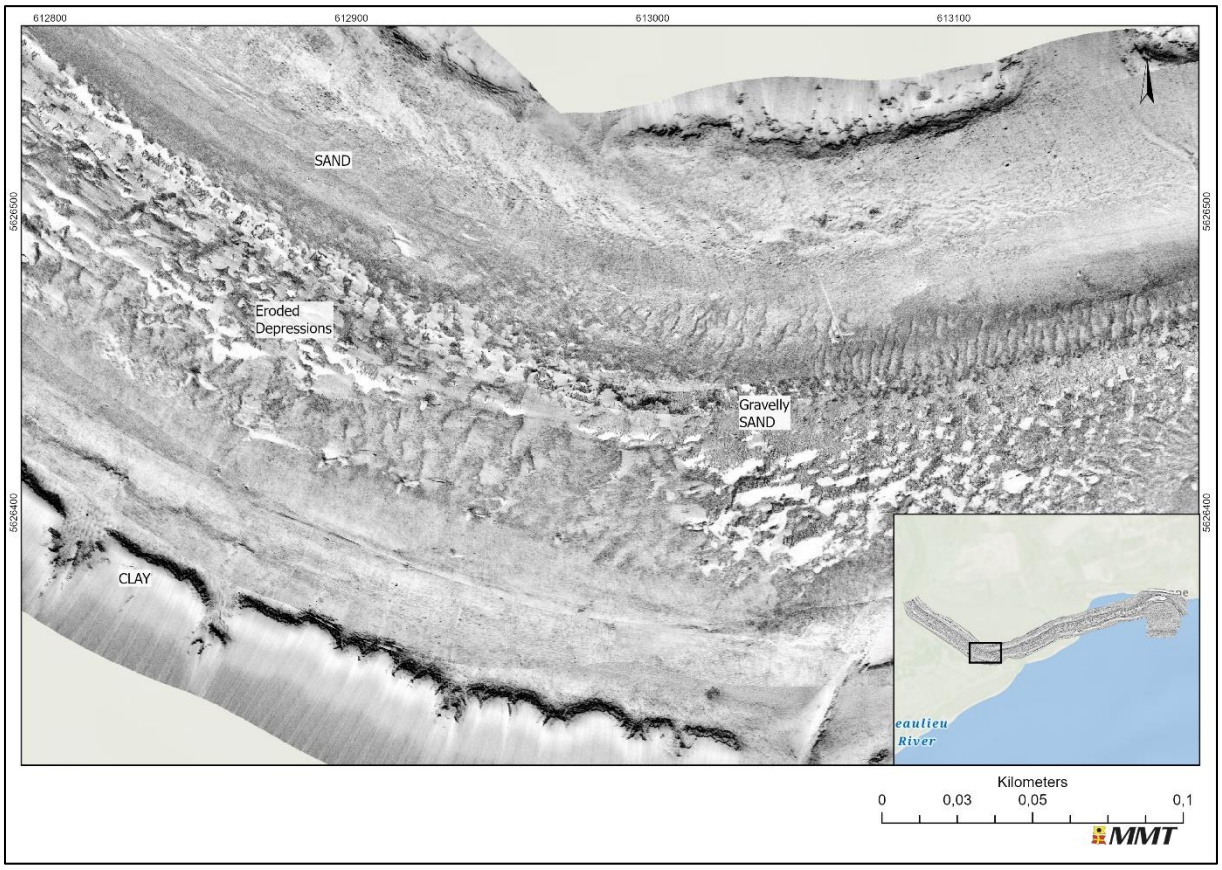


Figure 26 SSS image of surficial geology and seabed features in an up-stream part of the BEA area. Showing the transition from CLAY on the banks, through SAND to gravelly SAND in the centre. Distinct eroded depressions are seen in the gravelly SAND.

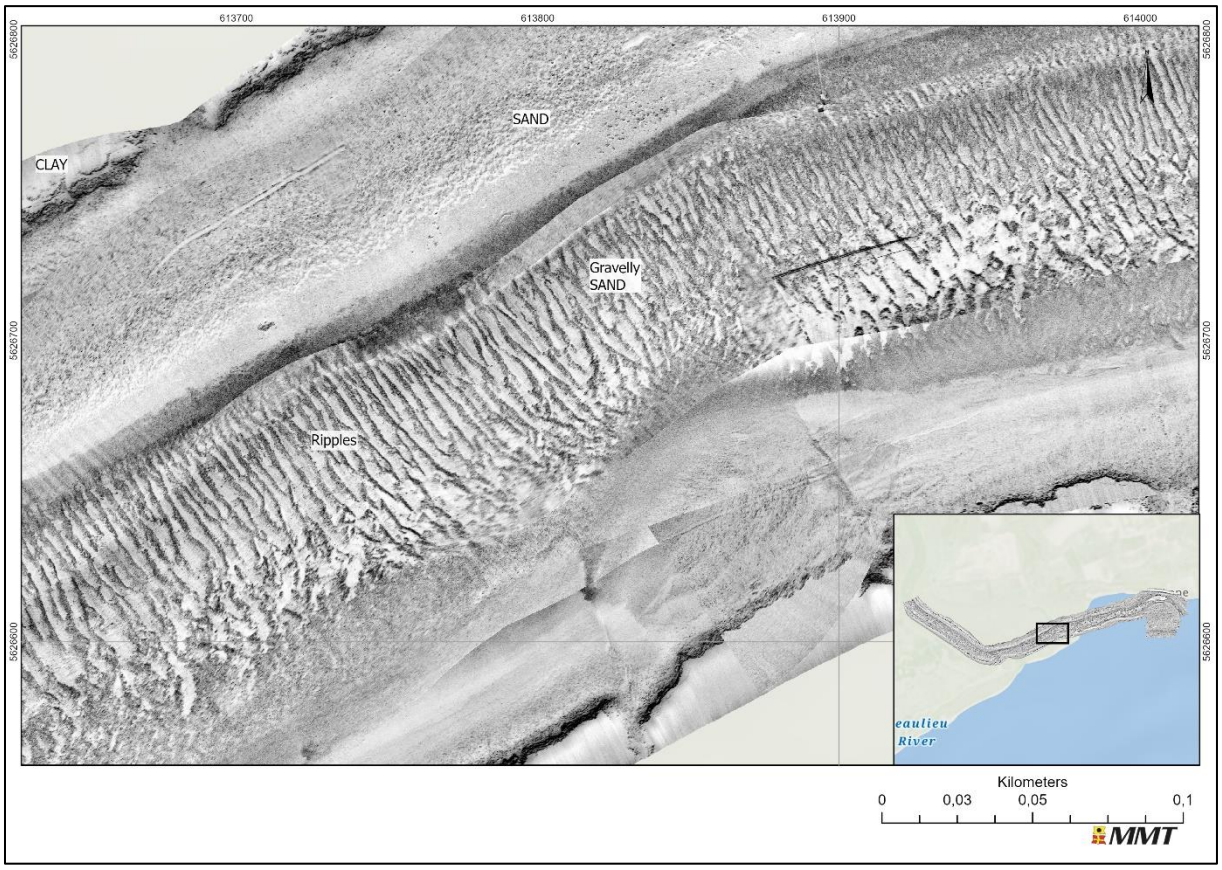


Figure 27 SSS image of surficial geology and seabed features in a down-stream part of the BEA area. Showing the transition from CLAY on the banks, through SAND to gravelly SAND in the centre. Distinct ripples are seen in the gravelly SAND, highlighted by the contrasting sonar reflectivity of sorted sediment.

6.2.3| SEAGRASS AND HABITAT MAPPING

The seabed within the Beaulieu River estuary comprises primarily muddy mixed sediments with areas of sand/muddy sand followed by mud with these substrates traversing as a gradient from the central parts of the survey corridor to outer edges bordering the shores, Figure 28.

Habitat A5.53 - Sublittoral seagrass beds, is interpreted to be potentially present at the outer most sections towards the Solent.

The backscatter data, in areas interpreted as seagrass beds, details a lower reflectivity (-95 dB to -80 dB), than the surrounding seabed and compared to seagrass in Hamstead and Totland, which indicates that the substrates comprise a higher mud component, Figure 29.

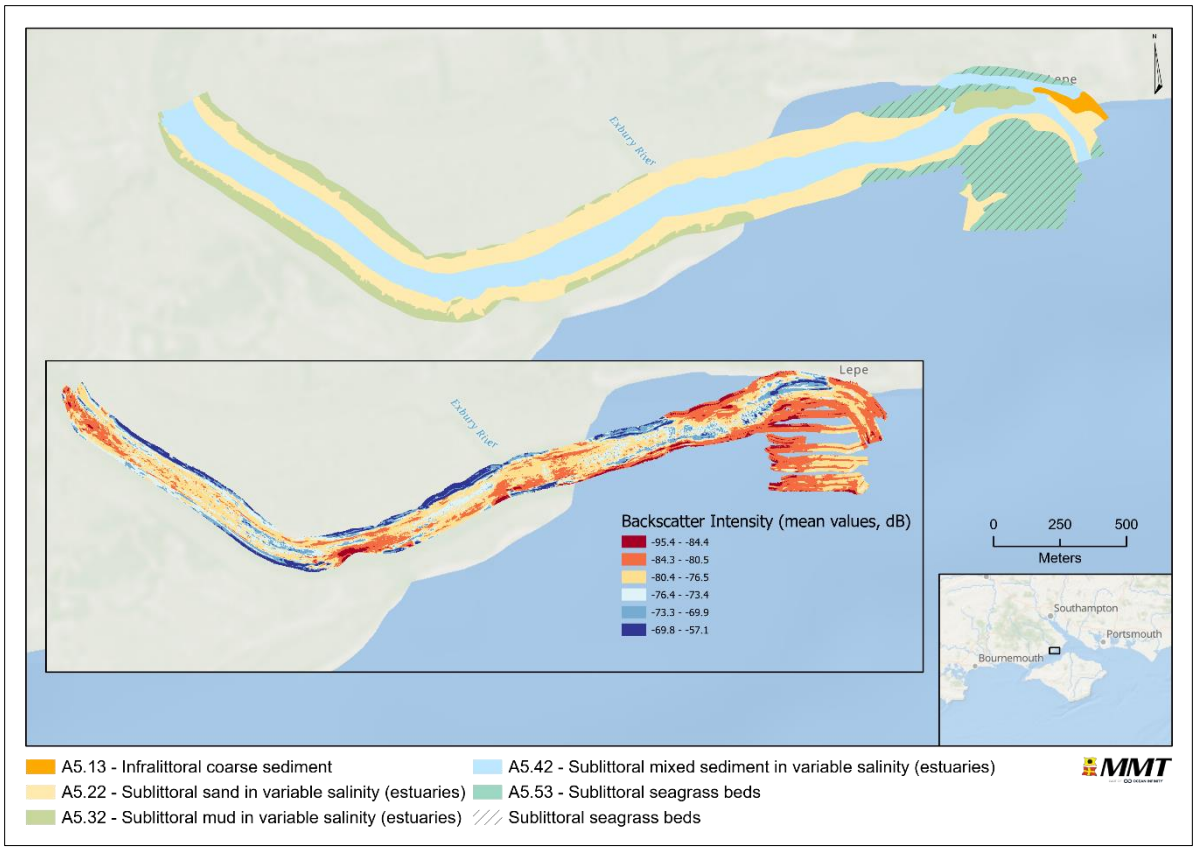


Figure 28 Habitat classification at Beaulieu with backscatter data overview.

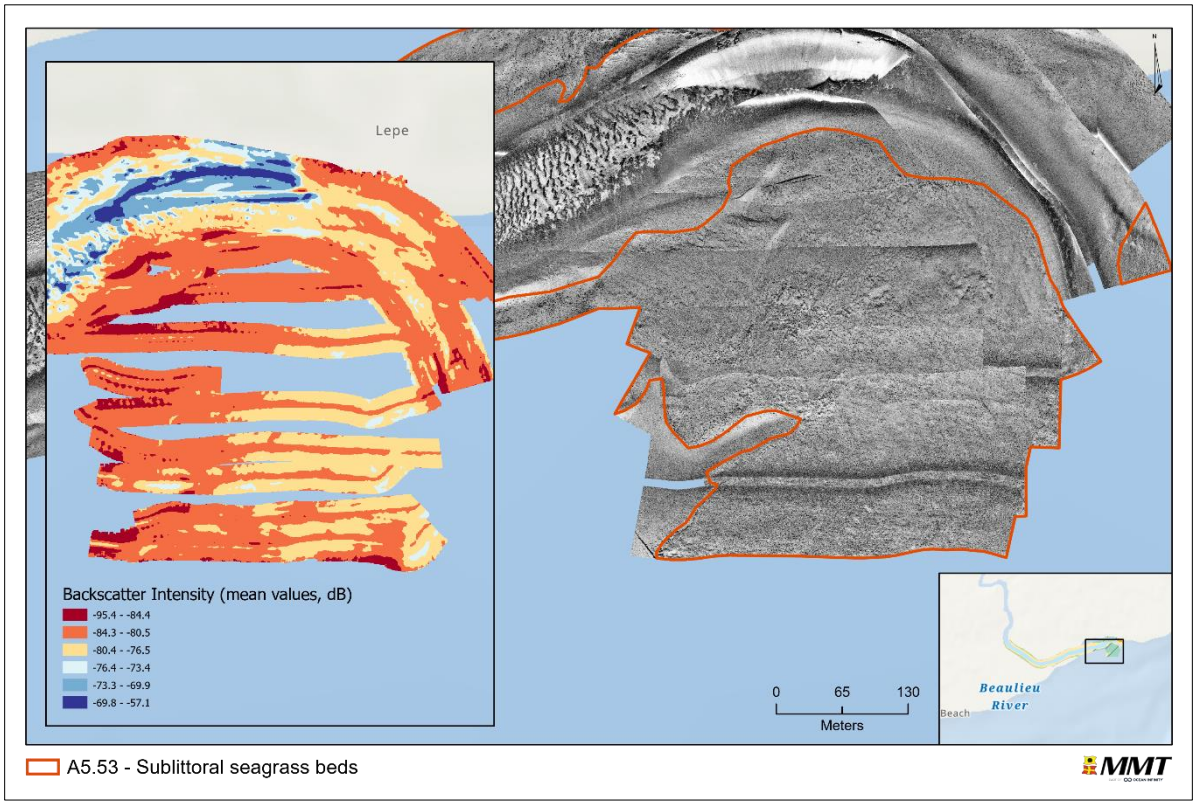


Figure 29 Seagrass beds at Beaulieu with backscatter and SSS data overview.

6.3| TOTLAND (TOT), ISLE OF WIGHT

6.3.1| BATHYMETRY AND BACKSCATTER

The bathymetry within the Totland dataset ranged from +0.04 m to +7.96 m LAT. In this bay the minima and maxima are found within 400 m of each other with the shoal depth lying on the top of a band of bedrock, called How Reef, towards the northern end of the survey area in Colwell Bay. Another band of bedrock called Warden Point extends from the shoreline across the site becoming Warden Ledge at depths that do not dry. The maximum depth is located within a smooth, basin between these rocky outcrops.

South of Warden Point, in Totland Bay, the seabed is varied with steeper slopes relating to ledges covered by sediment, areas of rocky seabed and expanses of seabed with numerous boulders. These are most prevalent towards the southern limit of the MPES coverage.

Totland was the most exposed site surveyed during Project Seagrass and the USV was exposed to significant wave motion that caused roll artefacts to be present within the data. These could not be removed during post-processing as the movements experienced by the vessel could not be accurately captured by the Inertial Motion Unit. The depth variations caused by the motion (up to 20cm) do not impact on the suitability of the data for habitat mapping purposes.

An overview of the backscatter acquired at the Totland survey area is shown in Figure 31. The backscatter shows bright tones (higher values) associated with areas of clean sand in Colwell and Totland Bays. More generally across the site the subtle gradations of greys indicates the presence of more mixed sediments with noisey signatures located over the rock outcrops and boulders.

The excessive vessel motion is apparent in areas of smoother, more consistent seabed but this could not be removed during processing in Sonarwiz.

Figure 30 Bathymetry overview for the Totland survey area.
Depths represented in Navimodel as positive down.

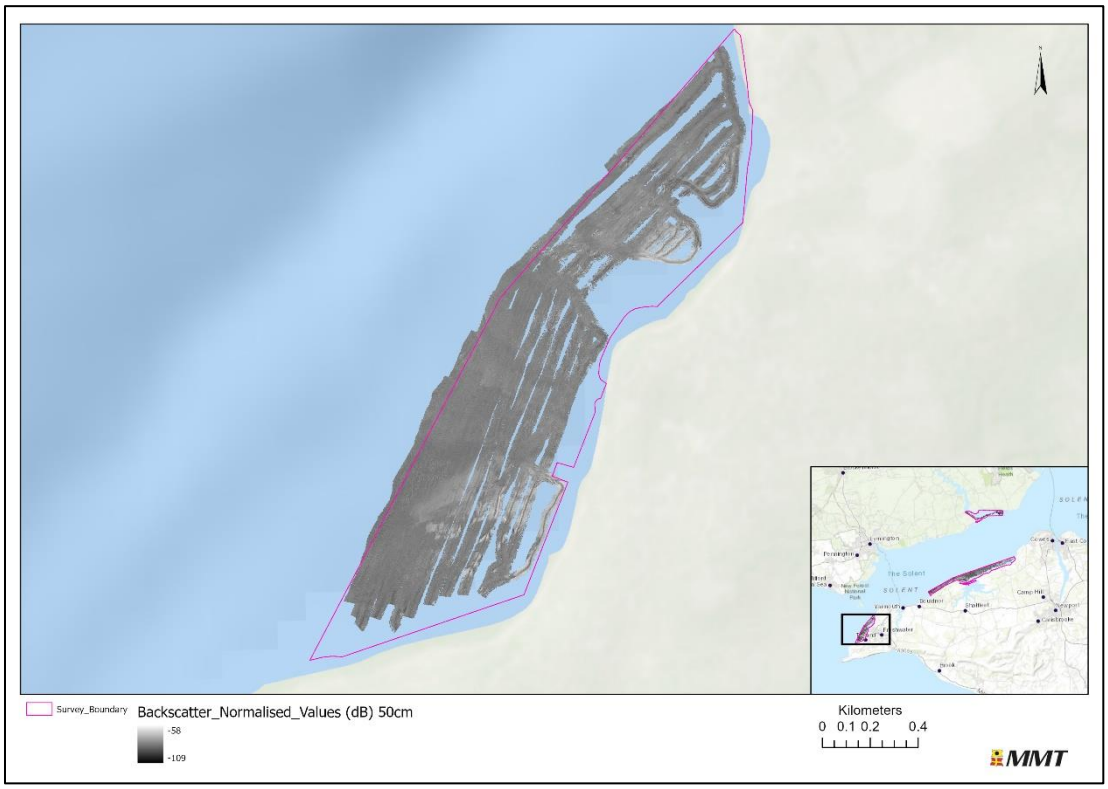


Figure 31 Overview of the backscatter normalised values for the Totland survey area.

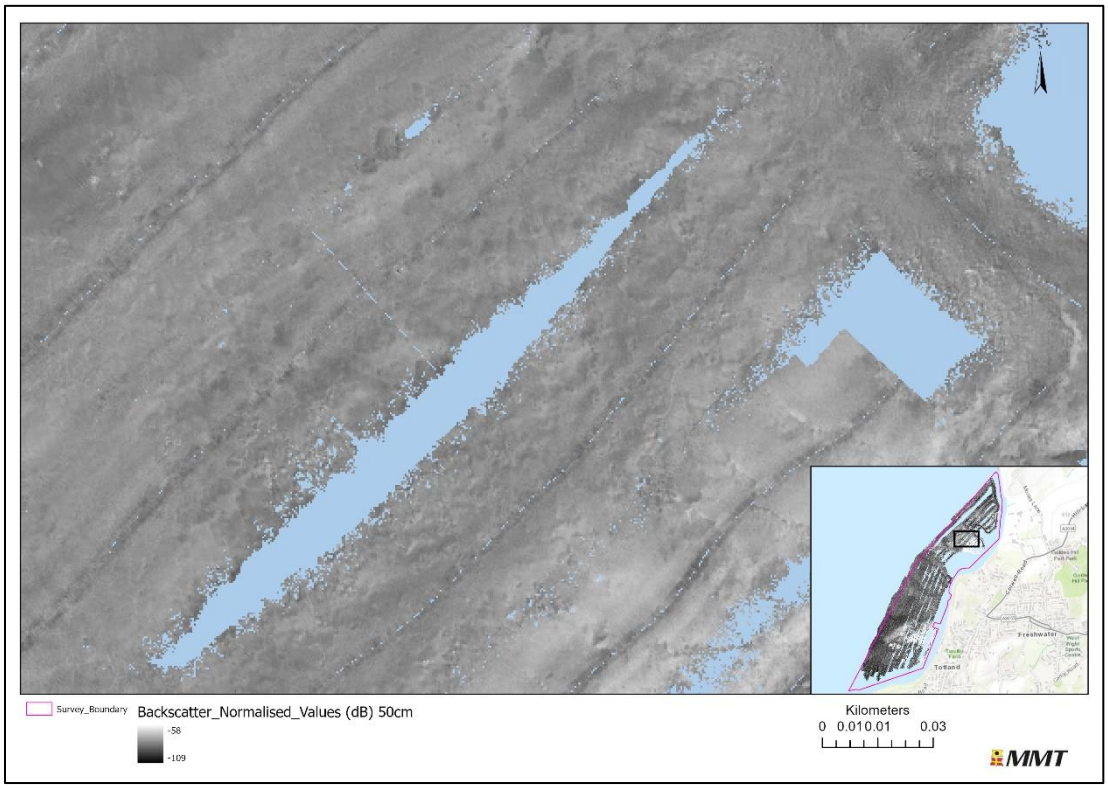


Figure 32 Backscatter texture within the northern part of the Totland survey in an area identified to contain Seagrass.

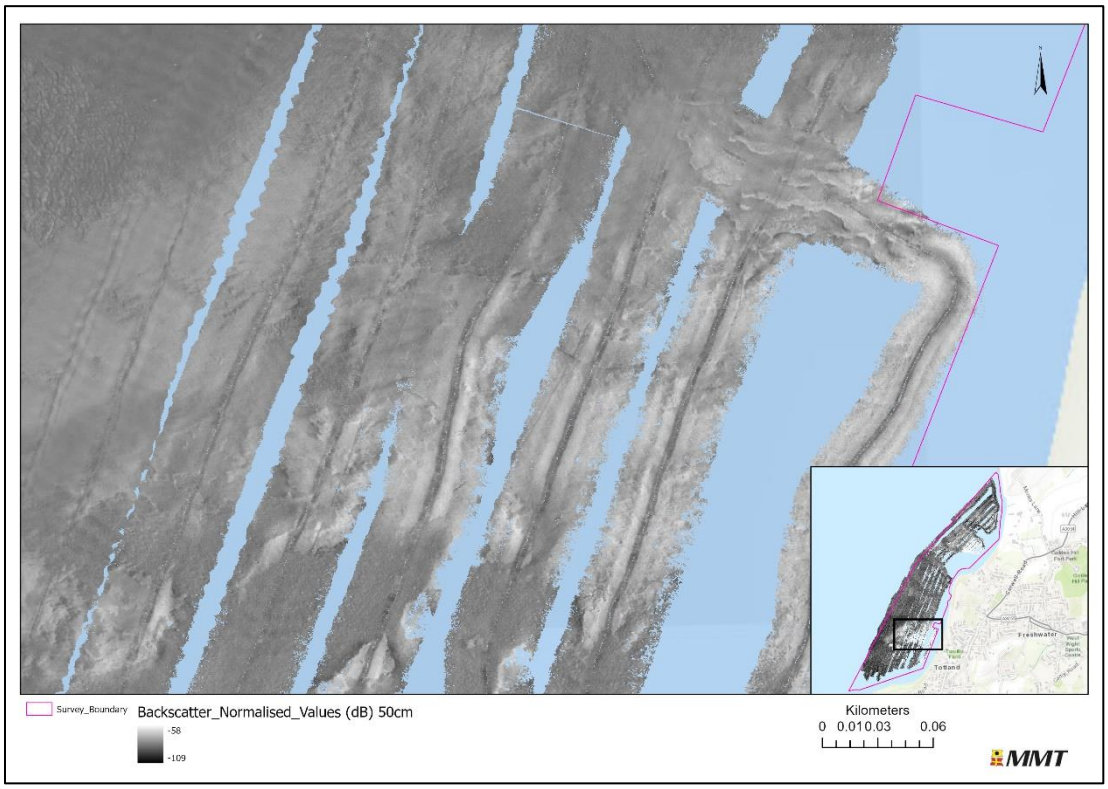


Figure 33 Backscatter texture within the southern part of the Totland survey in an area identified to contain Seagrass.

6.3.2| SURFICIAL GEOLOGY AND SEABED FEATURES

The Totland survey area is dominated by SAND and GRAVEL with distinct areas of exposed BEDROCK, Figure 34. Most of the site is composed of predominately GRAVEL which is interpreted to be quite coarse material with numerous boulders, forming large, high-density, boulder fields. The boulders average approximately 1 m in diameter and are densely concentrated with well over 20 boulders per 100 m^2, see Figure 35. Very few isolated boulders are seen outside of the boulder fields.

In the centre and to the north of the area there are elongate areas of exposed BEDROCK, roughly perpendicular to the coastline. These produce higher reflectivity, relatively homogeneous textures in the SSS data compared to that of the surrounding SAND, GRAVEL, and boulder field areas, see Figure 37.

There is one pronounced area of undulatory ripples within the Totland area, shown in Figure 36. These show a broad orientation of 165° (parallel to the coastline) but with a slight chaotic appearance suggesting, potentially being the result of tidal currents. Due to many ripples being elliptical in shape they show varying wavelengths, which can be up to 3.5 m.

The support frame for the Totland Pier can be seen in the SSS data, marked as 'subsea structure' in Figure 34.

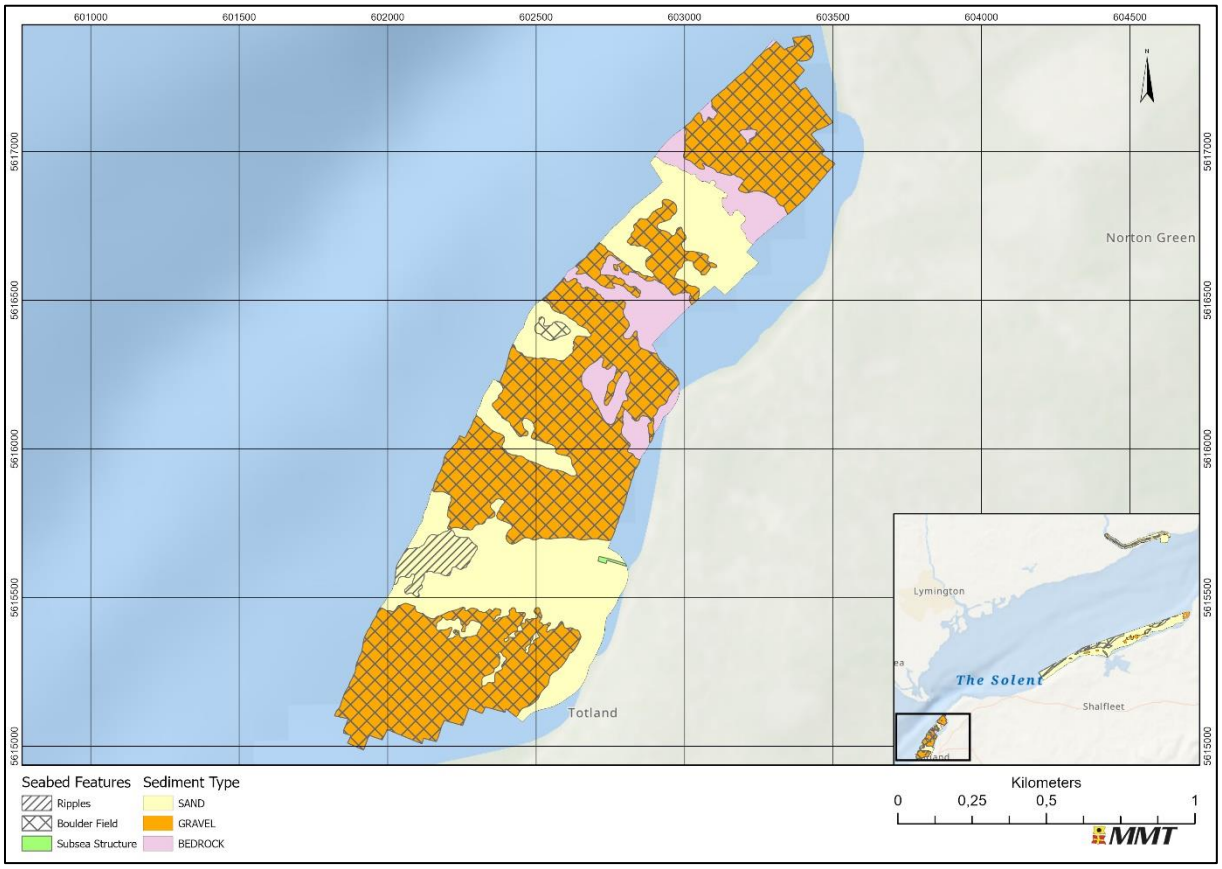


Figure 34 Overview of the surficial geology interpretation for the TOT area.

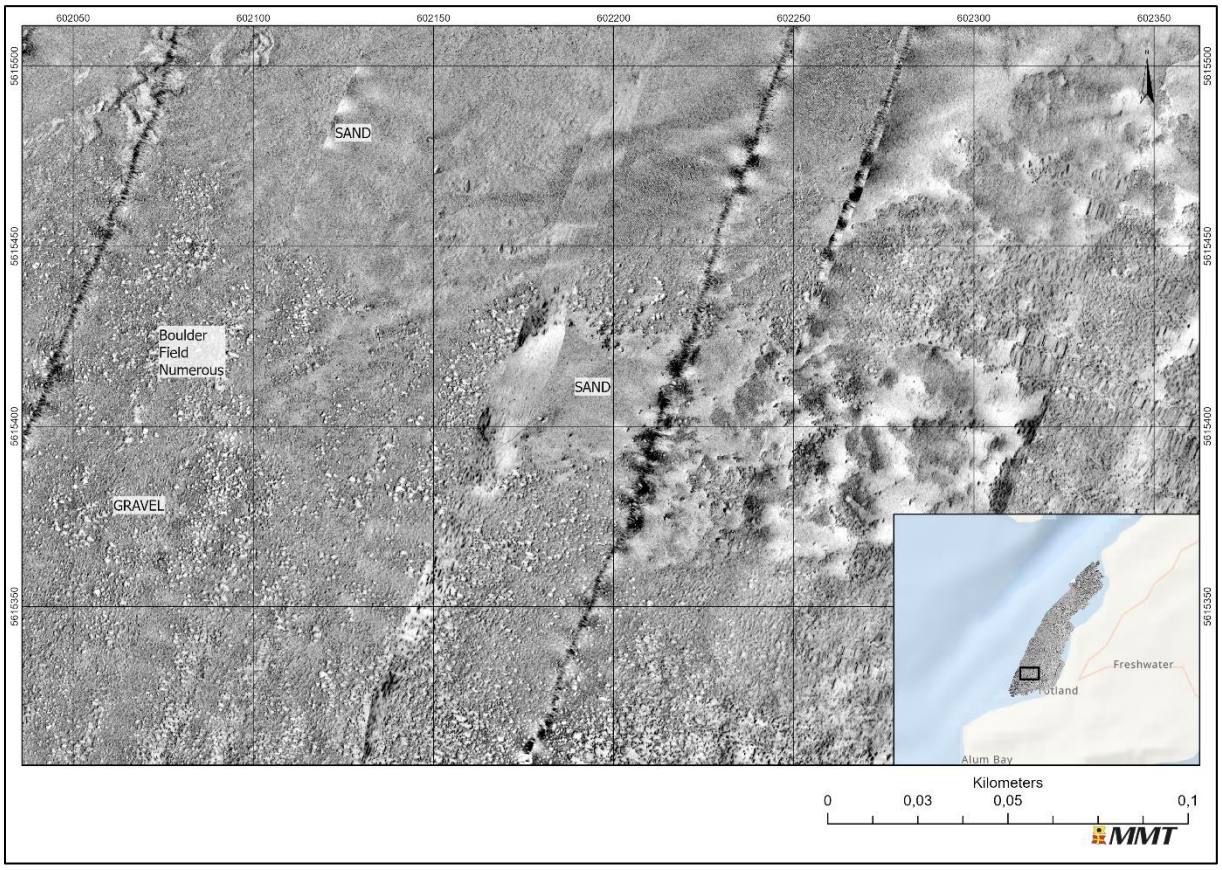


Figure 35 SSS image of surficial geology and seabed features in part of the TOT area. Showing GRAVEL, SAND and a boulder field in the south-eastern part of the TOT area.

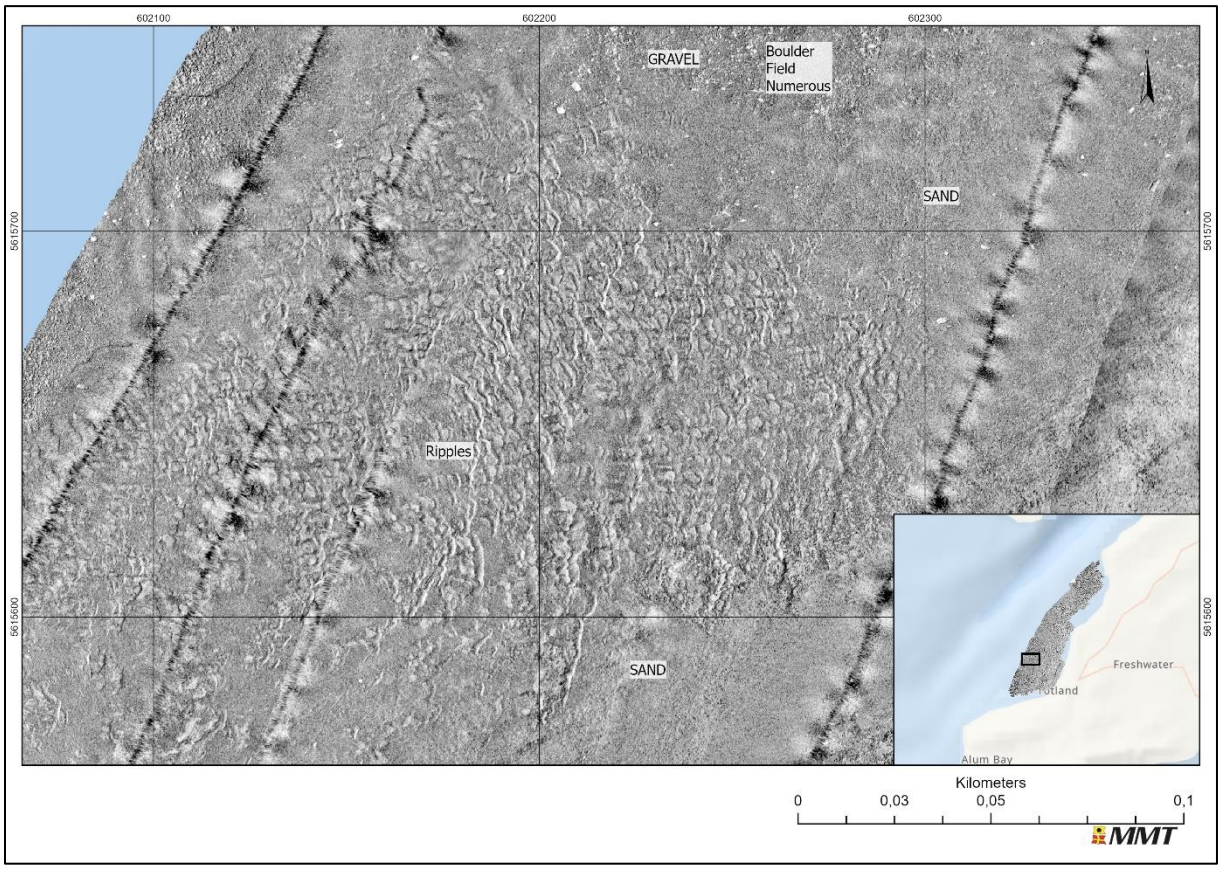


Figure 36 SSS image of surficial geology and seabed features in part of the TOT area. Showing ripples within SAND, as well as a GRAVEL and boulder field area to the north.

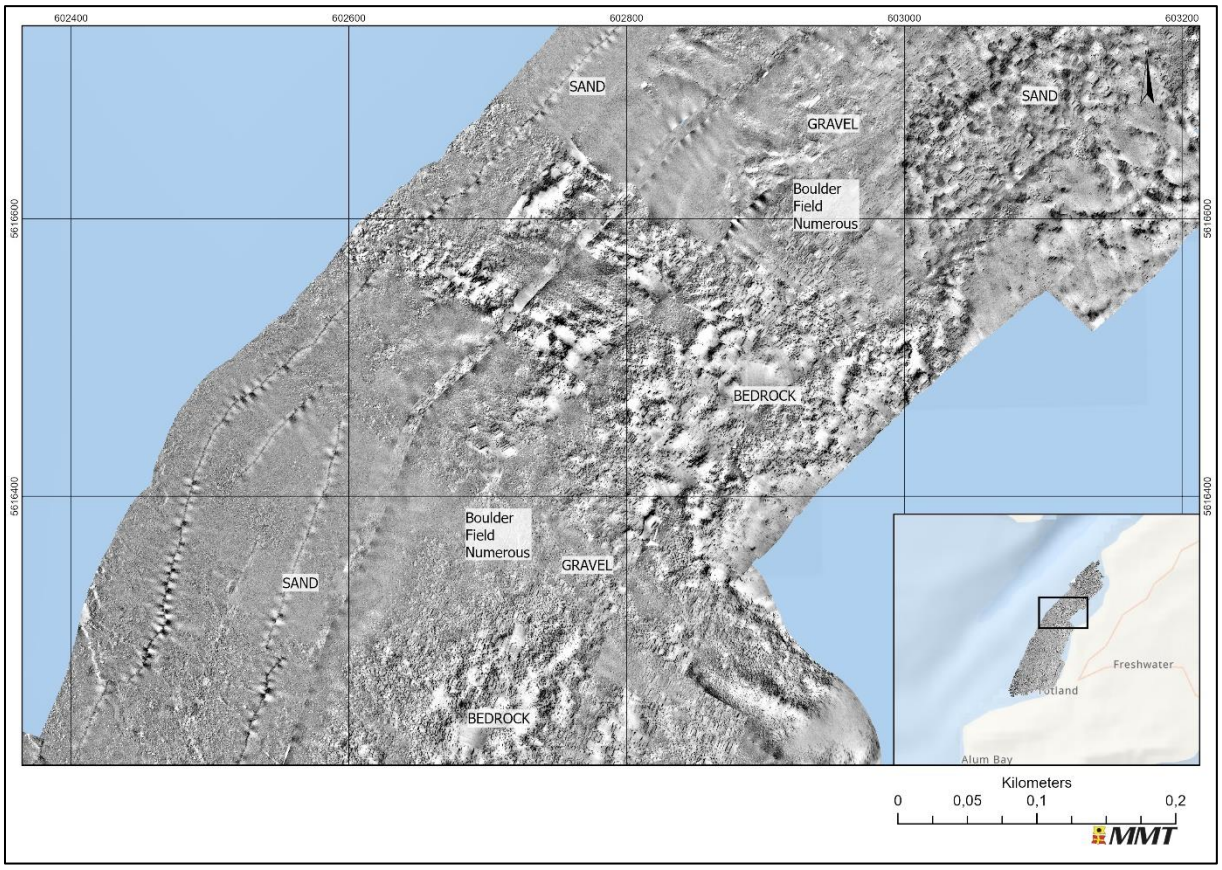


Figure 37 SSS image of surficial geology and seabed features in part of the TOT area. Showing SAND and the higher reflectivity, homogenous texture of exposed BEDROCK within GRAVEL.

6.3.3| SEAGRASS AND HABITAT MAPPING

Totland is interpreted to comprise coarse and heterogenic muddy mixed sediments as well as boulder fields and bedrock classified as A3 - Infralittoral rock and other hard substrata, Figure 38.

Three separate areas were identified as A5.53 - Sublittoral seagrass beds and comprise most likely *Zostera spp*. commonly occurring in this area. These areas are situated closest to the coastline and separated by areas of coarse/ muddy mixed as well as rocky sediments which are likely dominated by A5.5 - Sublittoral macrophyte-dominated sediment. The areas classified as A5.5 - Sublittoral macrophyte-dominated sediment likely comprise various red, green and brown seaweeds.

The backscatter data, in areas interpreted as seagrass beds, details a higher reflectivity (between -78 dB and -70 dB), than the surrounding seabed, which indicates that the substrates comprise slightly silty sand/ coarse clean sand (Figure 39) as would be expected for seagrass beds.

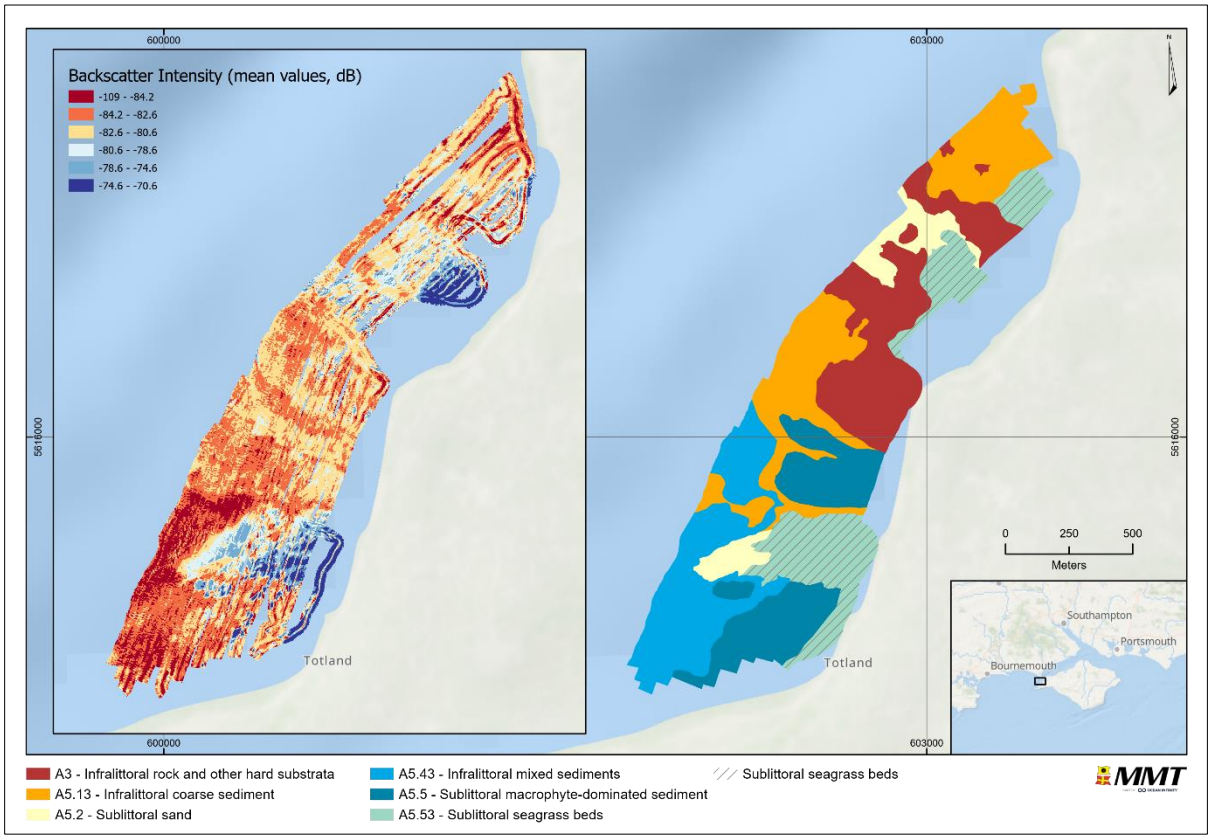


Figure 38 Habitat classification at Totland with backscatter data overview.

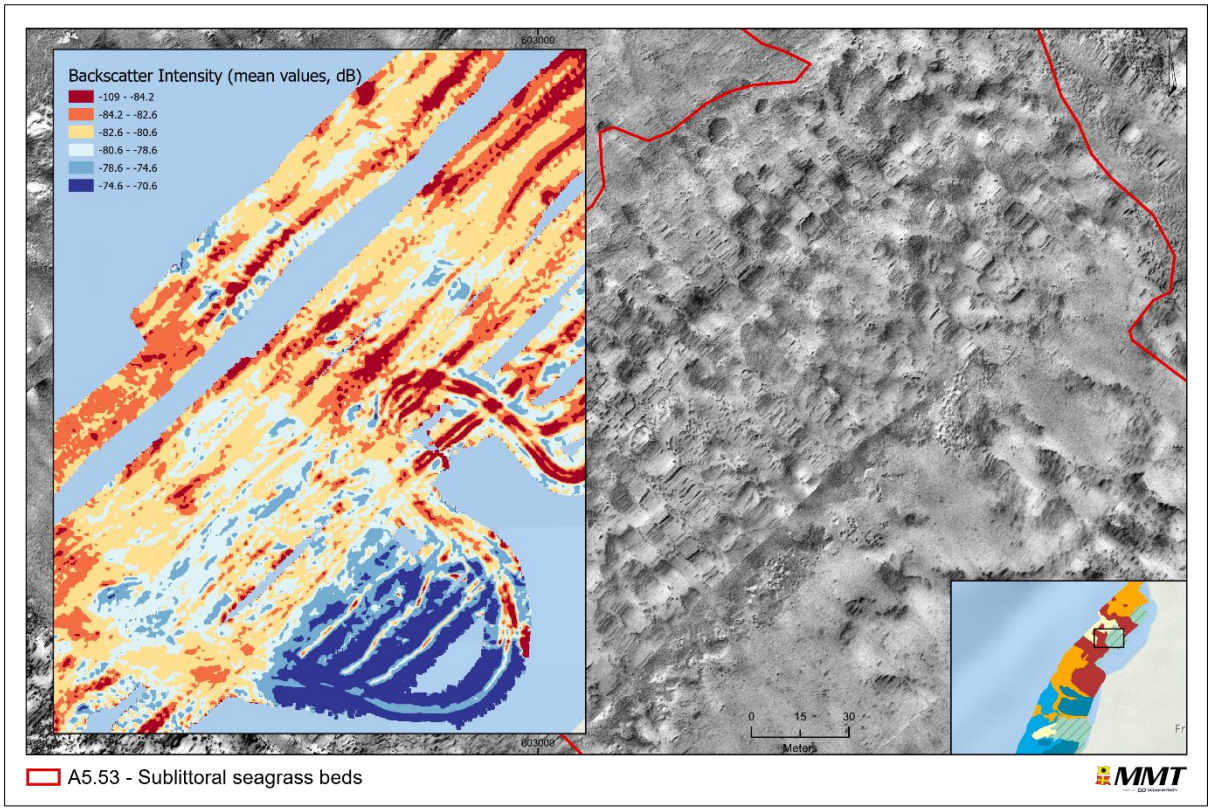


Figure 39 Seagrass beds at Totland with backscatter and SSS data overview.

7| CONCLUSIONS

HAMSTEAD (ISLE OF WIGHT)

Water depths in the Hamstead survey area ranged between +1.83 m and -17.42 m LAT.

The surficial geology of the Hamstead area is dominated by SAND with local areas of GRAVEL and a potential area of exposed BEDROCK to the northeast. Near Hamstead Point, lineated sub cropping BEDROCK creates a sloping topography on the seabed which is not disguised by the overlying sand, and therefore is seen in the SSS and bathymetry data. Large areas of ripples within the SAND of the Hamstead area indicate a current flow direction of east-west through the Solent and the Newtown River has created large convex ripples where it outflows into the Solent.

BEAULIEU (MAIN LAND)

Water depths within the Beaulieu dataset ranged between +1.77 m and -9.01 m LAT.

The geophysical data displays a typical morphology for an estuary in the Beaulieu area. With CLAY banks, deepening through SAND to gravelly SAND in the centre where the sediment load carrying ability of the river discharge is greater. Currents in this higher-energy central channel have created eroded depressions which turn to fairly regular ripples of sorted sediment down-stream.

TOTLAND (ISLE OF WIGHT)

The bathymetry within the Totland dataset ranged from +0.04 m to +7.96 m LAT.

The surficial geology of the Totland area is dominated by SAND and GRAVEL with areas of exposed BEDROCK. Most of the site can be classified as boulder fields, with a high density of approximately 1 m boulders. Within the SAND in the southwest of the site, there is an area of chaotic ripples which suggests possible tidal currents operating perpendicular to the coast.

SEAGRASS

Seagrass beds were noted in all three surveyed areas. The quality and density, as far as can be assessed from the geophysical data and the ground-truthing video, indicates that the seagrass beds which would qualify as in good condition are located primarily in Totland and Hamstead.

APPENDIX A | EQUIPMENT SPECIFICATIONS

APPENDIX B | GROUND TRUTHING LOCATIONS