SURVEY REPORT

WARATAH SEARCH, PORT ST JOHNS

MULTIBEAM, SUB-BOTTOM PROFILER & MAGNETOMETER SURVEYS

OUR REF: SUR18-033D

Final Report

9 March 2018

REVISION 01

CONFIDENTIAL REPORT

Submitted to:

Andrew Van Rensburg

Prepared by:

SUBTECH GROUP

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ACRONYMS

CD	Chart datum
CDP	Chart datum port
EOL	End of line
GNSS	Global navigation satellite system
GPS	Global positioning system
IHO	International Hydrographic Organisation
KTS	Knots (Nautical miles per hour)
MBES	Multibeam echo sounder
MRU	Motion reference unit
MSL	Mean sea level
SBES	Single beam echo sounder
SBP	Sub bottom profiler
SOL	Start of line
SSS	Side scan sonar
SV	Sound Velocity
SVP	Sound velocity profile
THU	Total horizontal uncertainty
TPU	Total propagated uncertainty
TVU	Total vertical uncertainty

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1 INTRODUCTION

Subtech joined Andrew Van Rensburg on the first campaign for 2018.

As a result of feedback received from Hypack in the States and other information gleaned from previous surveys, a number of sites were identified from magnetometer data. It was suggested to use multibeam to survey the seabed for possible debris trace and sub-bottom profiler to determine if there was signed of buried debris.

The survey search area is offshore of Port St Johns in various locales.

The team mobilised from Subtech Warehouse, Durban on Sunday 11th February, and returned to same on Saturday 17th February 2018.

Surveys were conducted from the Monday 12th February to Friday 16th February inclusive.

Post-processing of all data sets were completed in Durban. A final report and A0 plots were compiled and submitted to the Client on 9th March 2018.

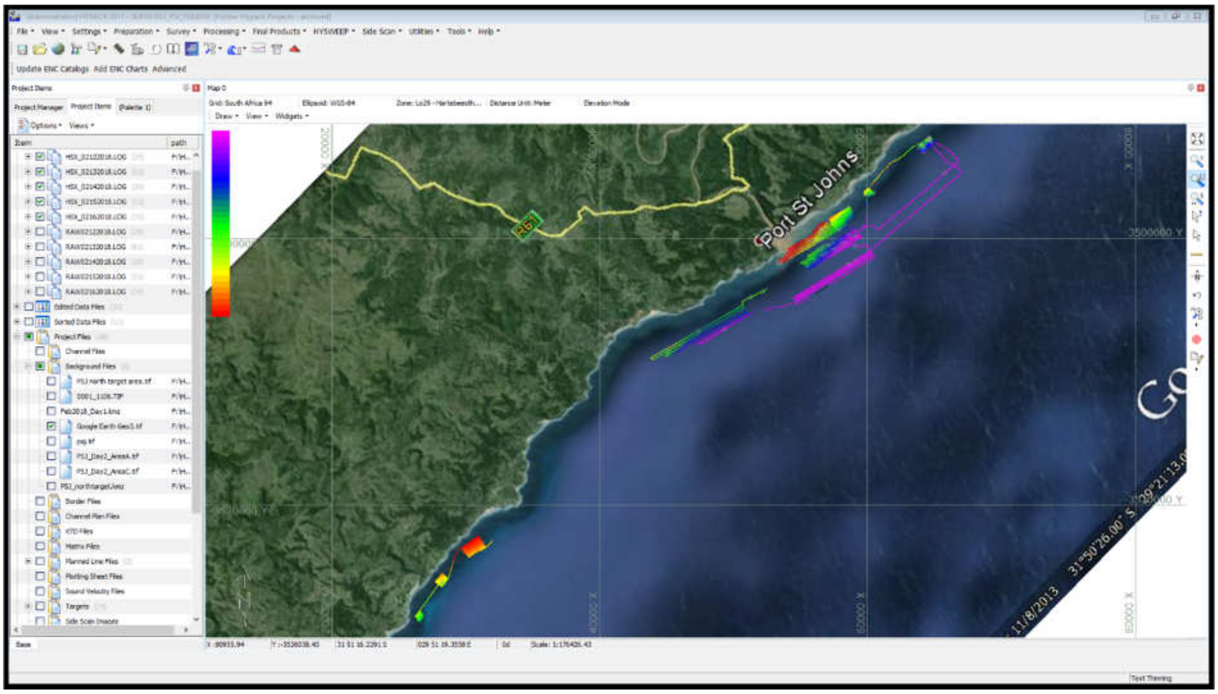

Figure 1 – February 2018 Survey Area

2 SURVEY AREA

The survey search area is offshore of Port St Johns in various locales.

Survey search sites were pre-determined on a daily basis based on the identified targets and daily feedback of preliminary data processed.

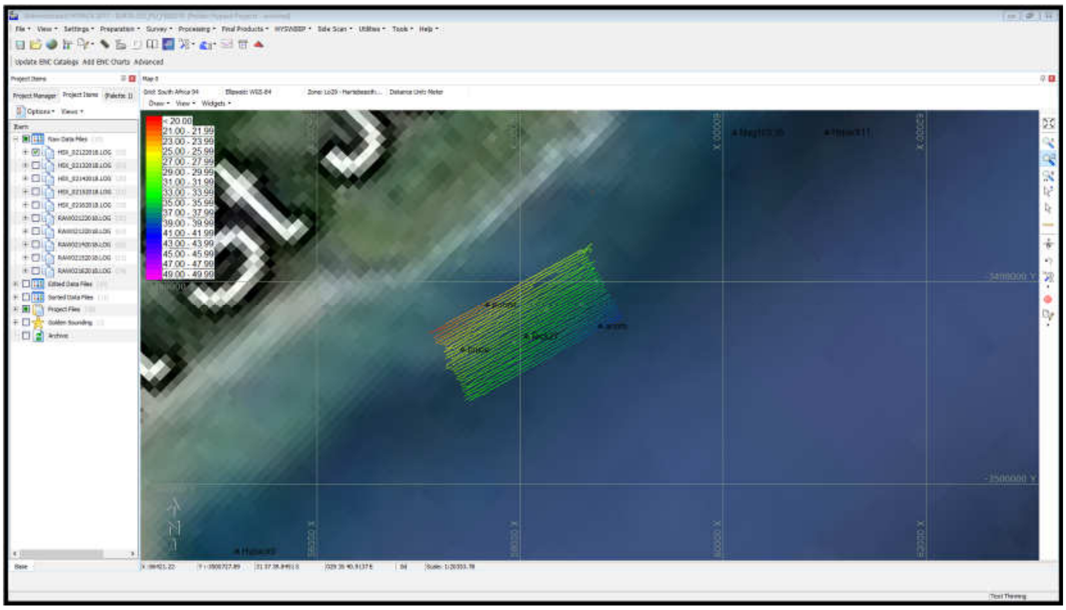

Figure 2 - Day 1, 1 site immediately off Port St Johns

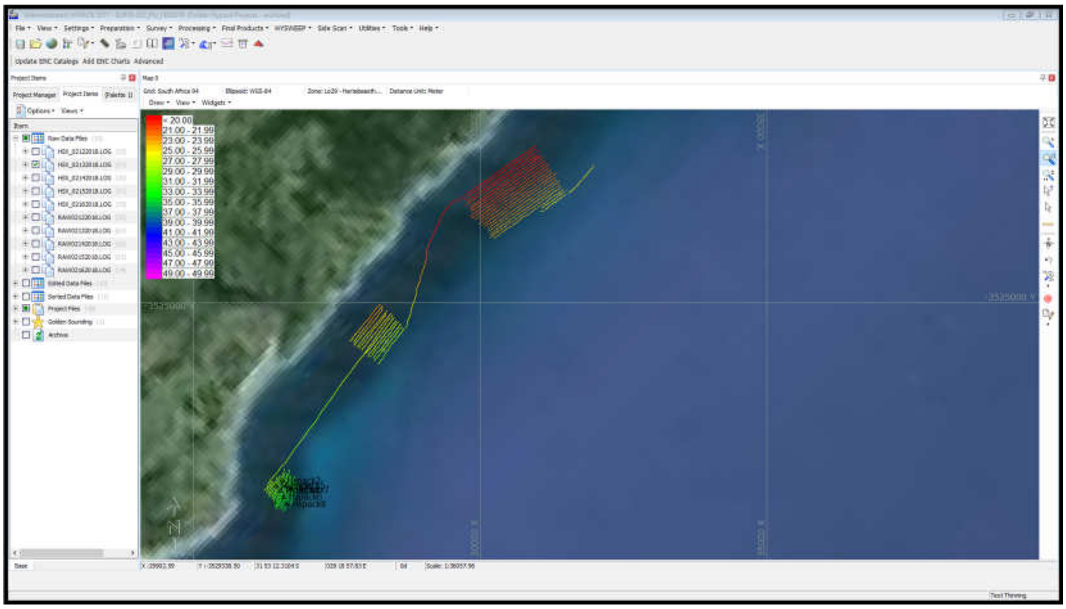

Figure 3 - Day 2, three sites to the south of Port St Johns

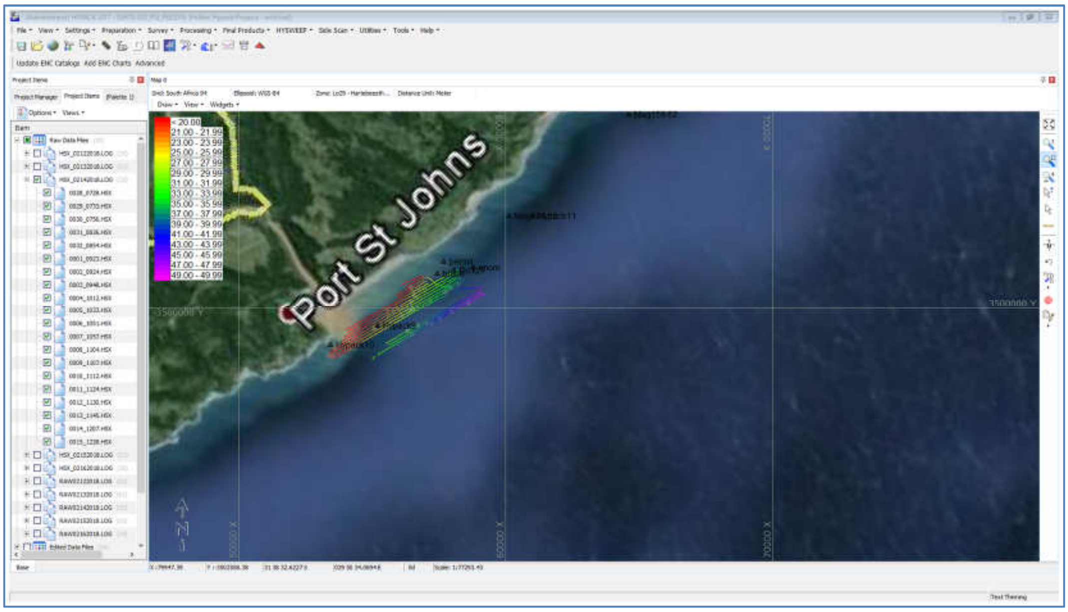

Figure 4 - Day 3, site offshore of Port St Johns

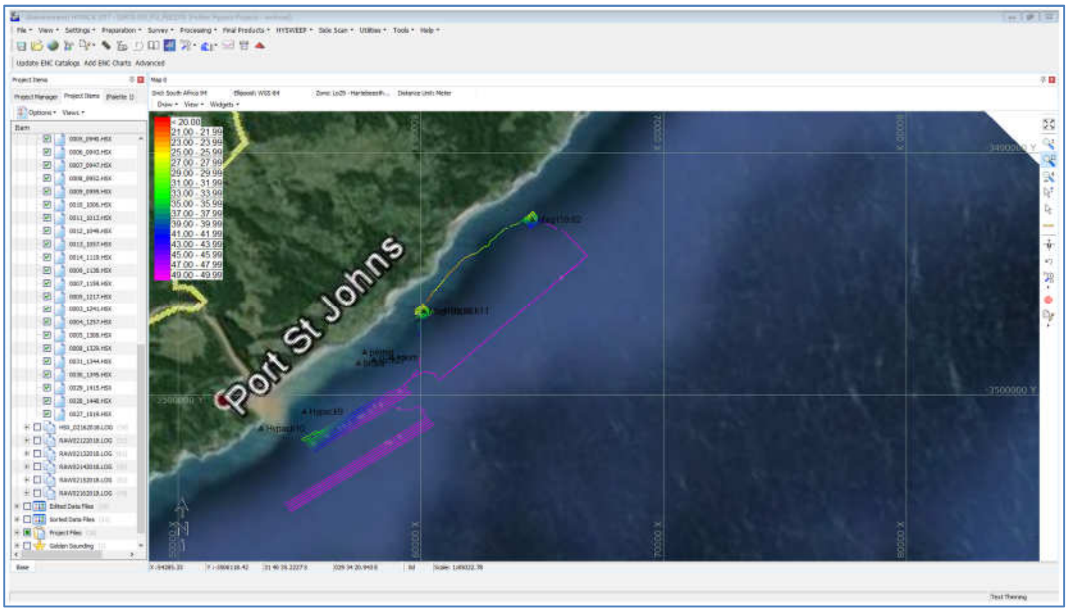

Figure 5 - Day 4, offshore Port St Johns

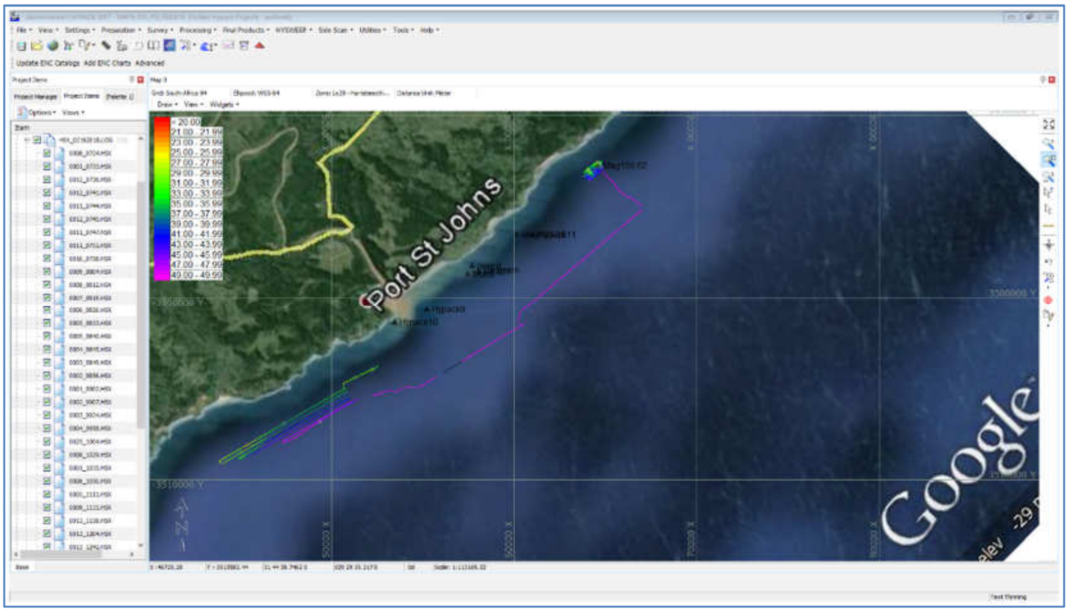

Figure 6 - Day 5, offshore Port St Johns

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3 POSITIONING

3.1 Geodetic Parameters

Positions were acquired on Hartebeeshoek94, Lo 29 coordinate system which is based on the WGS84 ellipsoid.

The projection was Transverse Mercator.

NTRIP RTK tides are used to determine vertical elevations / depths. A base station was established in Port St Johns and RINEX data collected for post-processing purposes.

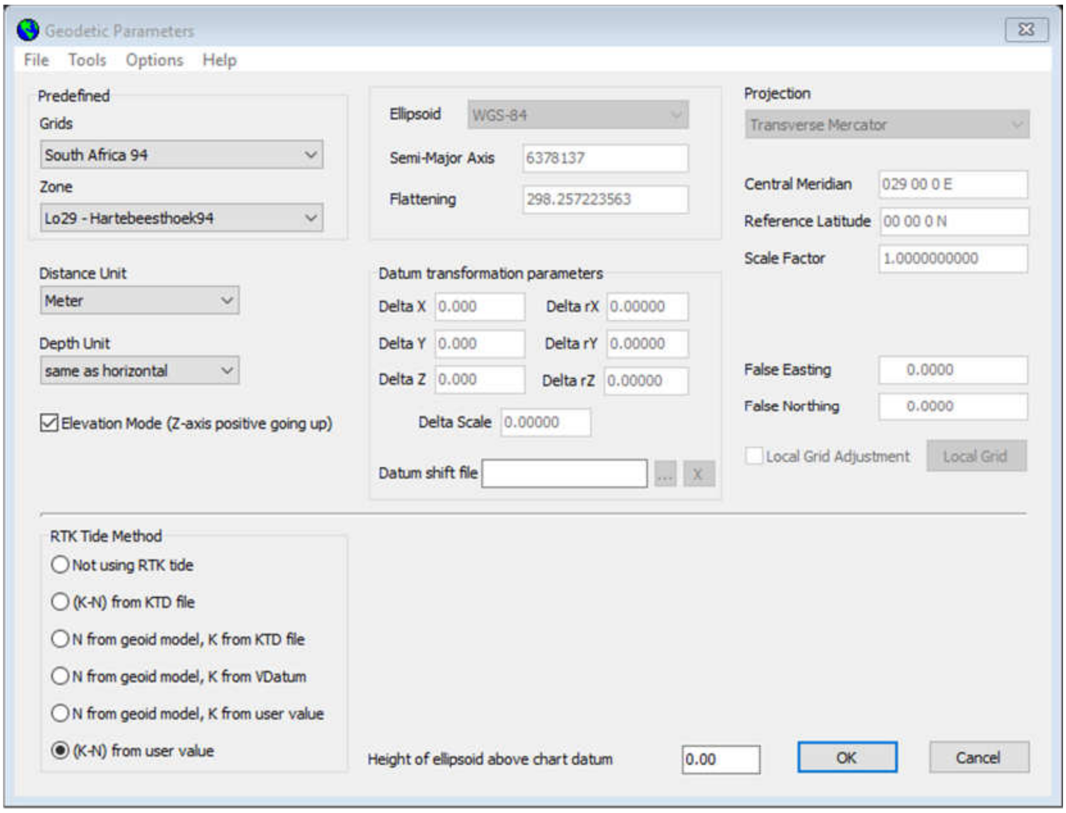


Figure 7 - HYPACK Geodetic Parameters

3.2 Horizontal & Vertical Positioning

The primary method of positioning was a GNSS generated position corrected using the NTRIP correction service.

RTK Tides was used to determine tide heights.

All objects depths recorded are relative to CD.

4 HARDWARE

4.1 Vessels

4.1.1 Survey vessel

A vessel was supplied by the Client for the purposes of the survey. The multibeam and sub-bottom were fitted to a wooden structure sitting athwart ships.

4.2 Equipment

4.2.1 Satellite positioning systems

The Survey Team utilised an NTRIP signal correction, the survey vessel was fitted with a Trimble SPS851 RTK GPS unit receiving RTK corrections from the NTRIP signal.

One of the benefits to using NTRIP in areas where available is we are capable of achieving centimetre RTK accuracies. RTK accuracy allows for a level of repeatability over a large area such as a harbour where it is difficult to establish RTK base stations to cover the entire area.

Code differential GPS positioning[2]	
Horizontal accuracy	0.25 m + 1 ppm RMS (0.8 ft + 1 ppm RMS)
Vertical accuracy	0.50 m + 1 ppm RMS (1.6 ft + 1 ppm RMS)
SBAS (WAAS/EGNOS/MSAS) positioning[3]	
Horizontal accuracy	Typically <1 m (3.3 ft)
Vertical accuracy	Typically <5 m (16.4 ft)
OmniSTAR positioning	
VBS service accuracy	Horizontal <1 m (3.3 ft)
XP service accuracy	Horizontal 0.2 m (0.66 ft), Vertical 0.3 m (1.0 ft)
HP service accuracy	Horizontal 0.1 m (0.33 ft), Vertical 0.15 m (0.5 ft)
Real-Time Kinematic (RTK) positioning	
Horizontal accuracy	10 mm + 1 ppm RMS (0.032 ft +1 ppm RMS)
Vertical accuracy	20 mm + 1 ppm RMS (0.065 ft +1 ppm RMS)
Initialization time	
Regular RTK operation with base station	Single/Multi-base minimum 10 seconds + 0.5 times baseline length in km, up to 30 km
RTK operation with Scalable GPS infrastructure	Typically <30 seconds anywhere within coverage area (SPS751 Max and SPS851 only)
Initialization reliability[4]	>99.9%

Figure 8 - Trimble RTK GPS system specifications and illustration

The Trimble GPS receiver was configured with an 8 degree masking (i.e. not use satellites less than 8 degrees above the horizon).

NTRIP was used to acquire RTK differential corrections for both the Topographic and Hydrographic surveys. (**NTRIP**-Network Transport of RTCM via Internet Protocol) and CORS (Continuously Operating Reference Station) are forms of RTK differential correction that are done through the use of a cellular modem and base station network.

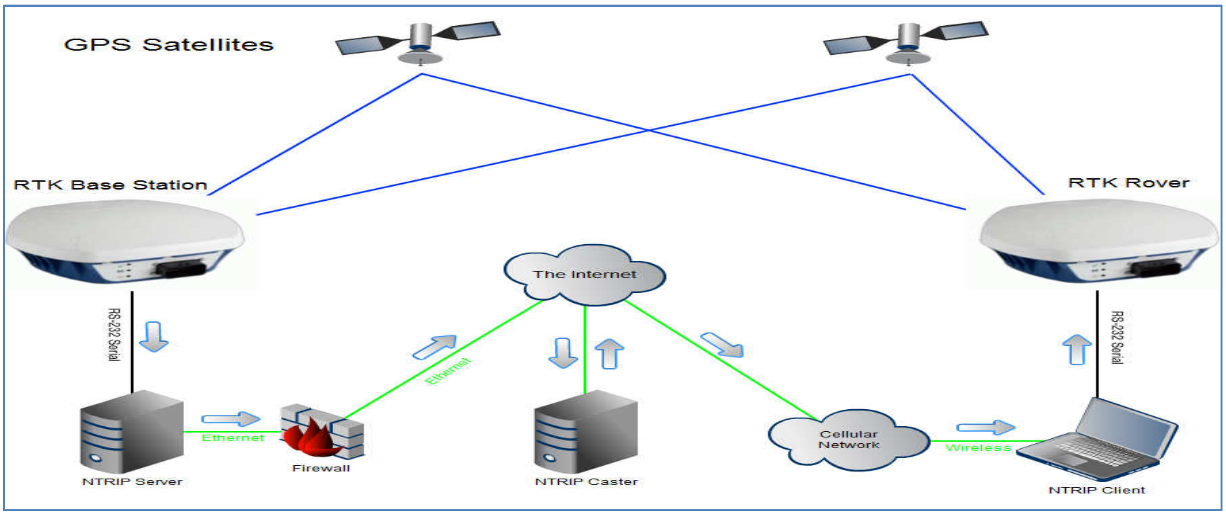
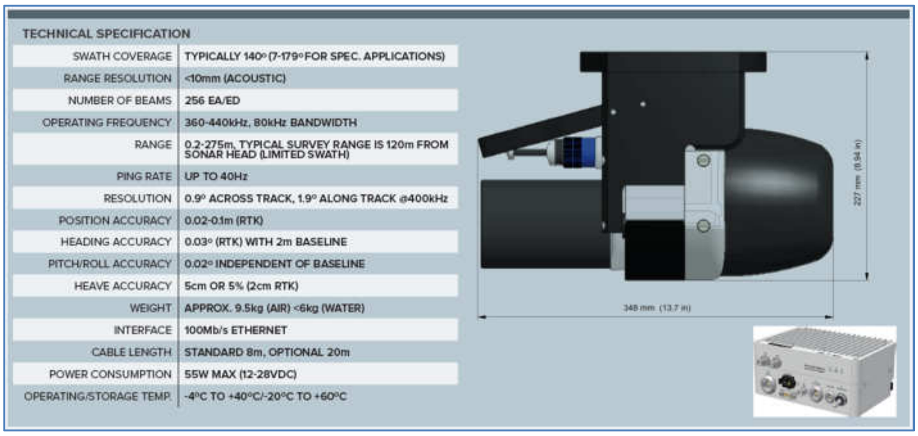


Figure 9 – Picture Showing How NTRIP Signal Correction works

4.2.2 *Multibeam systems*

The 400 kHz integrated multibeam solution offers high resolution in conjunction with the preferred inertial navigation system from surveyors around the world – the PosMV 220 Wavemaster. Having the inertial navigation system GNS/INS integrated into the sonar, ensures fast and reliable mobilization.

The WBMS-series are based on a flexible sonar platform that utilizes the latest in analogue and digital signal processing.



TECHNICAL SPECIFICATION

SWATH COVERAGE	TYPICALLY 140° (7-179° FOR SPEC. APPLICATIONS)
RANGE RESOLUTION	<10mm (ACOUSTIC)
NUMBER OF BEAMS	256 EA/ED
OPERATING FREQUENCY	360-440kHz, 80kHz BANDWIDTH
RANGE	0.2-275m, TYPICAL SURVEY RANGE IS 120m FROM SONAR HEAD (LIMITED SWATH)
PING RATE	UP TO 40Hz
RESOLUTION	0.9° ACROSS TRACK, 1.9° ALONG TRACK @400kHz
POSITION ACCURACY	0.02-0.1m (RTK)
HEADING ACCURACY	0.03° (RTK) WITH 2m BASELINE
PITCH/ROLL ACCURACY	0.02° INDEPENDENT OF BASELINE
HEAVE ACCURACY	5cm OR 5% (2cm RTK)
WEIGHT	APPROX. 9.5kg (AIR) <6kg (WATER)
INTERFACE	100Mb/s ETHERNET
CABLE LENGTH	STANDARD 8m, OPTIONAL 20m
POWER CONSUMPTION	55W MAX (12-28VDC)
OPERATING/STORAGE TEMP.	-4°C TO +40°C/-20°C TO +60°C

Figure 10 - technical specifications Norbit iWBMS

4.2.3 *Attitude sensors*

4.2.3.1 *Inertial Navigation Sensor*

This is integral to the Norbit iWBMS multibeam system

4.2.3.2 *Heading*

GPS Azimuth Measurement System, This is integral to the Norbit iWBMS multibeam system

4.2.4 *Sub-bottom Profiler*

In general, sub-bottom profiling (SBP) systems are single-channel systems used for shallow reflection seismic profiling. These sub-bottom profilers operate at different transmit frequencies and this has an effect on the depth of acoustic penetration into the seabed and the resultant resolution. Lower frequency sound sources produce more acoustic penetration into the seabed.

Sub-bottom profilers work by transmitting sound energy in the form of a short pulse towards the seabed. This sound energy is reflected from the seabed and the sub-surface sediment layers. The reflected energy intensity depends on the different densities of the sediments, the denser (harder) the sediments, the stronger the reflected signal. The reflected signal then travels back through the water to the receiver (either a towed hydrophone or transducer). The received signals are then amplified, processed and displayed in the acquisition system.

▶ Performance
- water depth range: 0 – 400 m
- penetration: up to 40 m depending on sediments and frequency
- range resolution: up to 5 cm, depending on pulse settings
- HRP compensation: heave, depending on sensor data
- beam width @ 3dB: ± 2 ° / footprint < 7 % of water depth for all frequencies

4.2.5 *Sound velocity equipment*

The multibeam sonar head is fitted with a sound velocity probe.

Base•X is a rugged, shallow water logging instrument. Designed for profiling in coastal waters, the instrument includes a shackle, a sensor cage, and an LED status indicator to simplify deployment preparation. High-speed 25Hz sampling ensures excellent data resolution. Base•X's compact size and compatibility with AML's Xchange sensor-head architecture make it the ideal companion for the shallow water hydrographic surveyor.

4.2.6 *Acquisition Software and Hardware*

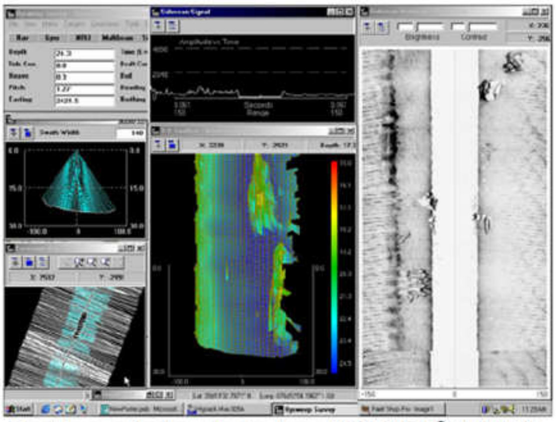
4.2.6.1 HYPACK2017/HYSWEEP2017 Hydrographic Survey Software

HYSWEEP® is an optional module of HYPACK® that integrates multibeam and multiple transducer sonar systems. It provides programs for:

- System alignment and calibration
- Multibeam data collection and review
- Multibeam data editing
- QC and performance testing

System Alignment: Using the integrated 'Patch Test' in HYSWEEP®'s MULTIBEAM EDITOR, you can quickly determine the exact mounting angles and time delays for both single and dual-head multi-beam sonar systems. Your system calibration takes hours, not days.

Data Collection and Review: HYSWEEP® SURVEY runs simultaneous with the HYPACK® SURVEY program. It performs all data collection, logging and time tagging while providing graphics for data visualization, bottom coverage and quality control.



Real time collection display from HYSWEEP® SURVEY.

4.2.7 *Tidal Observations*

The survey was conducted using NTRIP corrections applied as RTK tides.

These were verified using the SA Hydrographic office predicted tide tables for the Port of East London.

4.3 System Calibrations and Accuracy Checks

SUBTECH undertook the following industry standard Hydrographic Survey Quality Control Quality/Assurance Calibrations and Checks as described elsewhere in this document.

- Horizontal GNSS Position Check and Vertical Datum Verification
- Rub-test of Sonar head
- Patch test and GAMS calibration
- Sound Velocity Calibration

System	Manufacturer quoted accuracies
Trimble 851 SPS with NTRIP corrections	Real Time data is provided using the Networked Transport of RTCM via Internet Protocols (NTRIP): • DGPS (~0.35m accuracy) countrywide; • RTK (~0.05m accuracy) within 30 – 40 kms of each station using a single base technology; and • Network RTK (~0.03m accuracy) within the Gauteng, Western Cape and KwaZulu Natal clusters.
Norbit iWBMS – PosMV 220 Wavemaster GNSS/INS	Real-Time Kinematic (RTK) positioning • 0.02-0.1m (RTK)
Norbit iWBMS 400kHz multibeam	Range resolution: <10mm (acoustic) 0.9O ACROSS TRACK, 0.9O ALONG TRACK @400kHz Accuracy: • IHO Special Order • U.S. Army Corps of Engineers Special Order
Norbit iWBMS – Wavemaster motion reference and heading	Pitch/roll accuracy 0.02O INDEPENDENT OF BASELINE (2m baseline) Heave accuracy 5cm OR 5% (2cm RTK) Heading accuracy 0.03O (RTK) WITH 2m BASELINE
AML Base X SV-change sound velocity probe	Accuracy • ±0.25 m/sec

Table 1- - Manufacturers' quoted system accuracies

5 MOBILIZATION

The relevant vessel offsets were measured using a tape measure and recorded on a vessel offset diagram.

Measurements were taken a minimum of three times and a standard deviation was be used.

The following offsets were measured on the vessel:

- Reference point to the DGNSS antenna.
- Reference point to the waterline.
- Reference point to multibeam reference point
- Reference point to the sub-bottom profiler
- Reference point to the magnetometer tow point

5.1 Equipment Installation Configuration

Figure 11 – *Norbit iWBMS multibeam* equipment flow diagram

6 PERSONNEL

Data acquisition was conducted on site in the Port Of Durban by Subtech survey personnel.

Post-processing of the data was conducted in the Subtech offices by Subtech personnel in Durban.

Compilation of the Final report and plotting of charts was completed in Durban by Subtech personnel.

Name	Position	Qualifications & Experience
Field Survey Team		
Gaynor Deacon	Survey Division Manager	IHO Cat A BSc Hon, PgDip, MSCC - 25 years
Andrew Watermeyer	Surveyor	Professional Land and Hydrographic Surveyor – 40 years
Client representative		
Rick & Nathan		
Marine Crew		
Greg & Grant		
Office Support Team		
Riaan Venter	Draughtsman	15 years
Professor Andrew Green	UKZN; Marine Geologist and geophysicist	

Table 2 –Personnel involved in the field acquisition, post-processing and interpretation

7 SURVEY METHODOLOGY

7.1 Multibeam Surveys

1. Mobilization of equipment and personnel to the search area
2. Perform the multibeam survey to acquire data
   - Set Norbit swath to 120 degrees
   - Minimum gate 1m, maximum gate 75m
   - Equiangular
   - Automatic detection
   - Snippet and water column data enabled
3. Survey equipment and personnel return to shore.
4. Post-process acquired data
   - Apply patch test
   - Apply sound velocity cast
   - Grid to 0.25 matrix
   - Apply filters and masks
   - Step through profiles, sweeps
   - CUBE
   - Save as HSX2x
   - Save as non-gridded all points
   - Save as gridded median reduced file
5. Present findings to Client
6. Generate survey report

7.2 Sub-bottom Surveys

1. Mobilization of equipment and personnel to the search area
2. Perform the SBP survey to acquire data
3. Survey equipment and personnel return to shore.
4. Post-process acquired data
   - Apply sound velocity value
   - Digitise bottom
   - Apply filters and masks
   - Step through profiles
   - Save as segy edited files
   - Identify all reflectors
   - Export
5. Present findings to Client
6. Generate survey report

7.3 General Work Flows

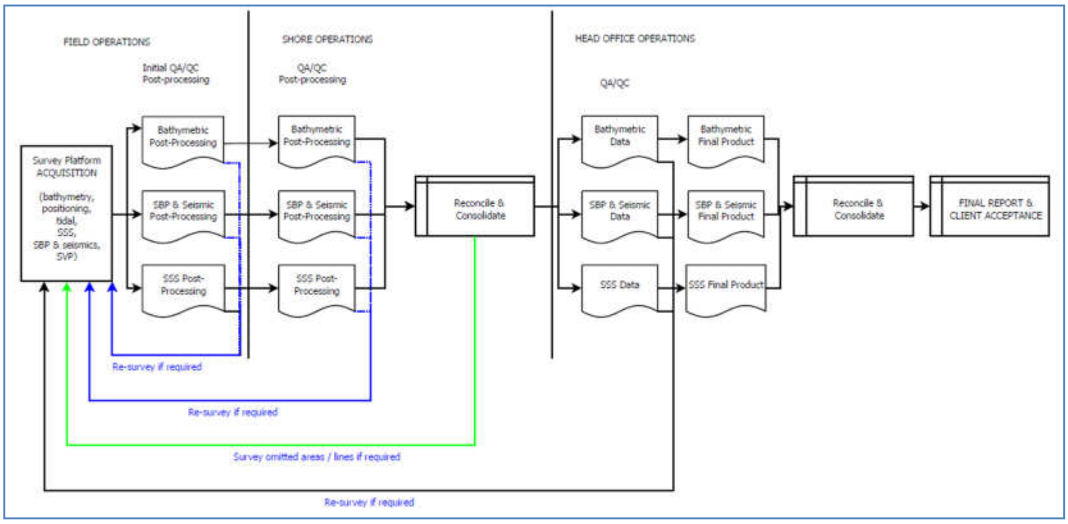


Figure 12 - Survey Projects General Workflow

8 QUALITY CONTROL AND ASSURANCE

8.1 IHO Standards for Hydrographic Surveys

SUBTECH is cognizant of and surveys to the following international hydrographic survey standards:

IHO Standards for hydrographic surveys, Special Publication S-44, 5th Edition Feb 2008 (http://www.iho.int/iho_pubs/standard/S-44_5E.pdf).

The measurement criteria for IHO survey minimum standards is TPU or total **propagation of uncertainty** the result of uncertainty propagation, when all contributing measurement uncertainties, both random and systematic, have been included in the propagation. Uncertainty propagation combines the effects of measurement uncertainties[3]

Irrespective of surveying to Client specification or IHO specification, the following contributing factors remain the same and the procedures to mitigate remain the same.

The component of TPU calculated in the horizontal plane (or Total Horizontal Uncertainty – THU) has a 2-dimensional quantity, quoted as a single figure.

The component of TPU calculated in the vertical direction (or Total Vertical Uncertainty – TVU) has a 1-dimensional quantity.

IHO THU/TVU Standards for hydrographic surveys are as follows.

Survey Classification	Maximum Allowable TVU at 95% Confidence Level	In 10m of water…	In 20m of water…
Special Order	A = 0.25m B = 0.0075	0.26m	0.29m
Order 1A	A = 0.5m B = 0.013	0.51m	0.56m
Order 1B	A = 0.5m B = 0.013	0.51m	0.56m
Order 2	A = 1.0m B = 0.023	1.03m	1.10m

Max TVU = $[A^2 + (B \times Depth)^2]^{0.5}$

Survey Classification	Maximum Allowable THU at 95% Confidence Level	In 10m of water…	In 20m of water…
Special Order	2m	2m	2m
Order 1A	5m + 5% of Depth	5.5m	6m
Order 1B	5m + 5% of Depth	5.5m	6m
Order 2	20m + 10% of Depth	21m	22m

Figure 13 - maximum allowable THU and TVU asper IHO Standards 2008

[3] IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44) 5th Edition February 2008 http://www.iho.int/iho_pubs/standard/S-44_5E.pdf

Contributing Factors to the THU include	Procedures in place to mitigate risk
• Positioning System Errors • Range and Beam Errors • Ray Path Errors • Errors in Vessel Heading • Transducer Misalignment Errors • Sensor Location Errors • Vessel Motion Errors (roll and pitch) • Time Synchronization/Latency Errors	• Sound Velocity Calibration • Horizontal GNSS Position Check • Multibeam System Alignment/Orientation Tests (e.g., Latency/Patch Test)
Contributing Factors to the TVU include	**Procedures in place to mitigate risk**
• Vertical Datum Errors • Ellipsoidal/Vertical Datum Separation Errors • Vertical Positioning System Errors • Vessel Motion Errors, (Roll, Pitch & Heave) • Tidal Measurement Errors • Vessel Draft • Instrument Errors • Vessel Settlement and Draft • Sound Speed Errors • Seabed Slope	• Sound Velocity Calibration • Horizontal GNSS Position Check • Vertical Datum Verification • Local Tide Gauge Check (CD verification) • Multibeam System Alignment/Orientation Tests (e.g., Latency/Patch Test)

Table 3 - factors contributing to the THU & TVU together with procedures to mitigate the risk

8.2 Total Propogated Uncertainty

The measurement criteria for IHO survey minimum standards is TPU or total propagation of uncertainty the result of uncertainty propagation, when all contributing measurement uncertainties, both random and systematic, have been included in the propagation. Uncertainty propagation combines the effects of measurement uncertainties.

HYPACK provides a utility which enables the surveyor to load the equipment parameters and system configuration. Estimation graphs are produced which indicate the achieved TPU versus the IHO minimum standards.

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Vessel	Survey System Configuration	Water Depths relevant to survey areas	IHO Order level		
			Depth Uncertainty (m)	Positioning Uncertainty (m)	Target Detection (m)
VOO	Norbit iWBMS with PosMV and RTK	0-100m	Special Order achieved	Special Order achieved	Special Order achieved

Table 4 - Subtech multibeam system configuration and achievable IHO Order levels showing that the survey with the current system configuration met all IHO standards to Special Order TPU standards

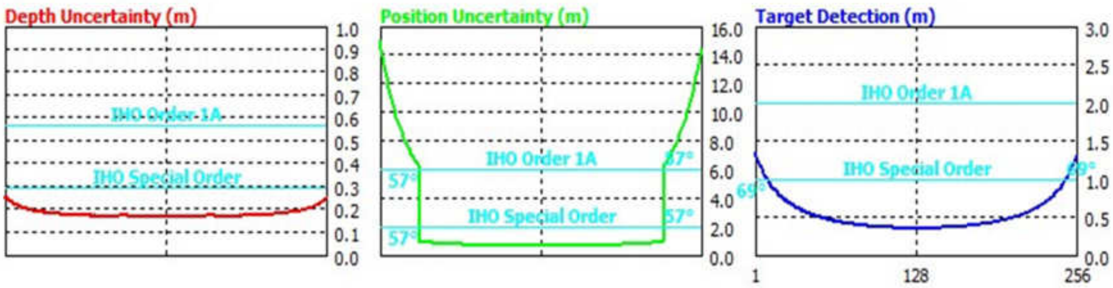


Figure 14 - report generated using the TPU utility showing *Odin* fitted with the Norbit iWBMS and RTK positioning system achieves the minimum IHO standards.

8.3 Real-time Quality Control and Quality Assurance

Continual QA/QC checks are undertaken and monitored real time using HYPACK / HYSWEEP's TPU (Total Propagated Uncertainty) Utility.

Total Propagated Uncertainty (TPU) calculations attempt to account for all possible causes of error in your survey data and how they affect each other.

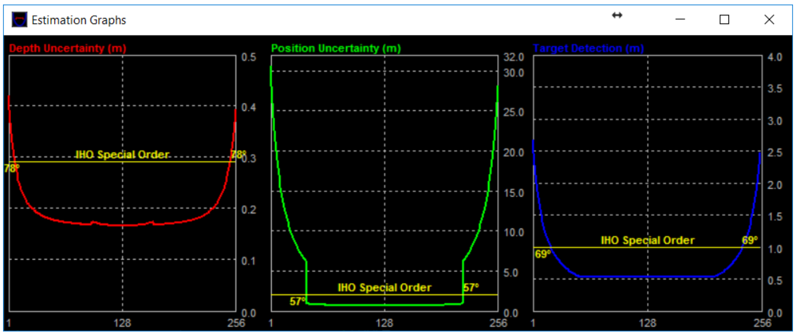
Based on the general, environmental and sensor specific data entered in the TPU EDITOR and real-time sounding data, HYSWEEP® SURVEY calculates and displays three uncertainty values:

- Total Vertical Uncertainty (TVU): Level of confidence in the depth value, calculated based on Depth 1 in dual frequency surveys and on the nadir beam of multibeam surveys.
- Total Horizontal Uncertainty: Level of confidence in the horizontal positioning of the sounding.
- Target Size Limit Value: Minimum size object likely to be found given the sounding and positioning uncertainties.

Subtech's online acquisition team compared each uncertainty display against the following IHO specifications in the HYSWEEP® TPU windows.

- IHO Special Order Requirements

During post-processing we recalculate the TPU (Total Propagated Uncertainty) i.e. Total Horizontal Uncertainty (THU) and Total Vertical Uncertainty (TVU) values and displays them in the Survey Information window.



Continual QA/QC checks are undertaken and monitored real time using HYPACK / HYSWEEP's positioning Utility to ensure that the positioning remained in FIXED solution.

8.4 GNSS Verification and Postioning Quality Assurance

Position and tides were calculated in real time using the SA Trignet corrections, additional Post Processing allowed for a much tighter and accurate solution.

A base station was established at the Cremorne Resort and data logged daily. This data was utilised in the post-processing process.

The data was logged in 2 hour increments and submitted to the AUSPOS GPS Online Processing service to compute precise coordinates.

3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/.

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
0106	-31 35 52.13047	29 31 52.88768	-5.307	-36.030
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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8.5 Project Data Analysis and Quality Control

SUBTECH provided continuous data collection, processing and preliminary interpretation throughout survey operations. Digital data file formats of survey coverage and daily logs were captured and saved.

Preliminary processing of survey data ensured data quality during survey operations.

Processing of sidescan data was done using Hypack's HYSCAN 64-bit software.

Any data omissions were recorded and reruns were undertaken by the field team to ensure full coverage of the survey area.

9 SURVEY OPERATIONS AND ACQUISITION

9.1 Area Coverage

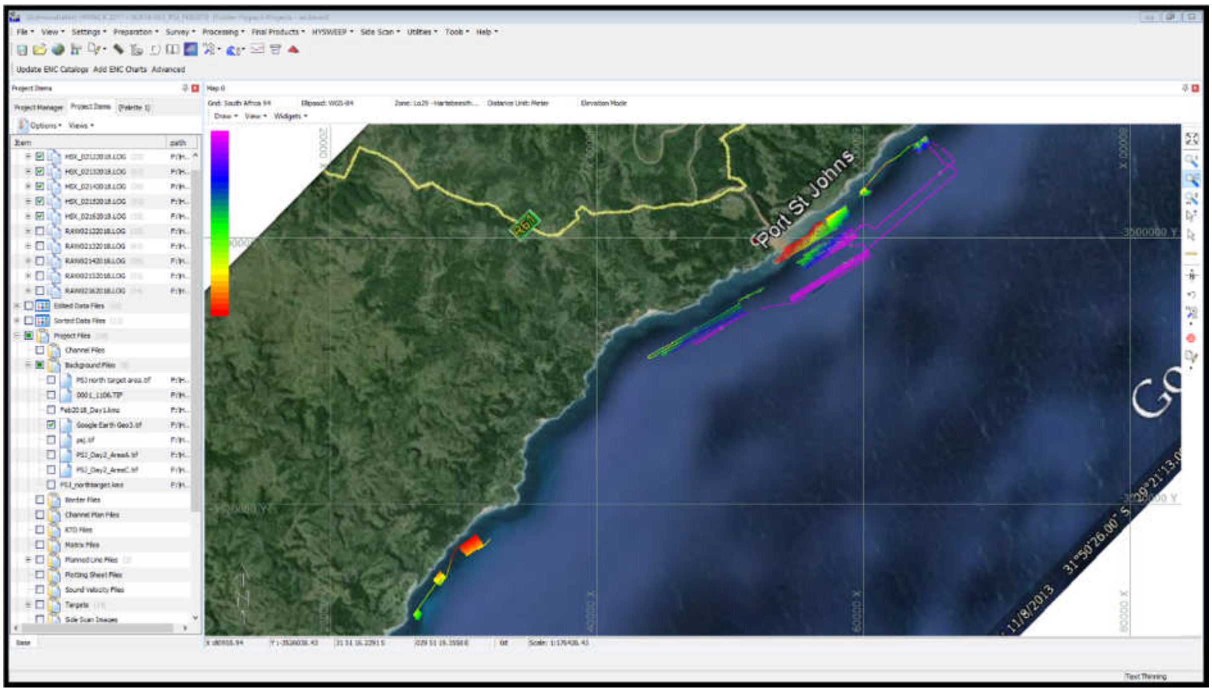


Figure 15 – multibeam, magnetometer and sub-bottom survey lines

All operations were conducted parallel to the coastline at line spacing 50/100 or 200m spacing. Survey speed averaged at 6.7 knots.

9.2 Daily Production

Table 5 - daily production summary

Day	Line Kilometres	Duration	
Sub 11 Feb		Survey kit	Depart Durban 11h00 Arrive PSJ 16h30 Mob equipment Plan Day 1 of Survey, load all Hypack targets End of day 22h00
Mon 12 Feb	46.7km	Start 12h23 End 16h09	Start of Day 06h00 Continue mobilisation Set up and establish base station Launch boat, basic wet tests in river Team depart 11h30 Survey area 1 with identified mag readings from 2017 Team Return to Cremorne Estate 17h00 Prelim MB & SBP analysis End of day 23h00 Decision to survey Hypack targets to the south, line plans setup for the next day
Tues 13 Feb	56.5km	Start 08h47 End 13h25	Launch boat 06h00 Set up and establish base station Team travels to southern area approx. 38km Prelim MB & SBP analysis Fix positioning data interface to SBP Mobilise magnetometer Setup lines for Day 3 End of day 22h00
Wed 14 Feb	61.3km	Start 07h28 End 12h28	Launch boat 06h00 Set up and establish base station Setup lines for Day 4 Prelim MB, SBP & Mag analysis End of day 21h30
Thurs 15 Feb	101.7km	Start 07h14 End 15h19	Launch boat 06h00 Set up and establish base station Prelim MB, SBP & Mag analysis Setup lines for Day 5 End of day 22h00
Fri Sat Feb	79.9km	Start 07h33 End 14h06	Launch boat 06h00 Set up and establish base station Prelim MB, SBP & Mag analysis End of day 23h00
Sat 17 Feb			Depart PSJ 04h00 Arrive Durban 09h50 Unpack survey kit Crew leaves warehouse 10h55
	346.1km survey kilometres (excluding travel kilometres)	27.9 hrs logging online acquisition (excluding transmit time)	

9.3 Site Safety

Safety was generally in accordance with the 'Marine Geophysical Operations Safety Manual'

Safety was generally in accordance with the 'Marine Geophysical Operations Safety Manual' (International Association of Geophysical Contractors, Ninth Edition, 2004) and per the guidelines and requirements of the Client

Site safety was assured by adopting the following measures:

- Survey teams were inducted to work and operate offshore
- Only experienced licensed personnel were used to man the vessel
- Only SAMSA certified vessels were used. All certified vessels were operating within class and fitted with all prescribed safety equipment.
- Daily safety talks and job safety analysis was undertaken.
- All personnel were inducted and aware of Subtech and Client safety policies and requirements
- All personnel utilised necessary safety gear as required, for example life jackets, safety boots and reflective jackets
- All relevant Subtech and Client specific safety policies and procedures were adhered to.

10SURVEY RESULTS & INTERPRETATION

A total of 84 hours of multibeam, backscatter and sub-bottom profiling data was gathered (28 hours of each) and 20 hours of magnetometer data. Preliminary post-processing of multibeam was conducted on site, and basic analysis of the other daily logged data to assist with the daily report back and planning for the following day.

Final processing of all data sets was conducted off site once the team returned to Durban and Cape Town. Over 120 hours of man hours have been spent on the post processing, analysis and interpretation by the surveyors and Professor Green.

The survey results and findings here in the report are to illustrate the findings of this process and highlight any items of interest.

The basic trend of the survey area was a homogenous sandy surface with isolated rocky features close to the shore. These outcrops appear to continue directly out from regional geological features visible on the shore.

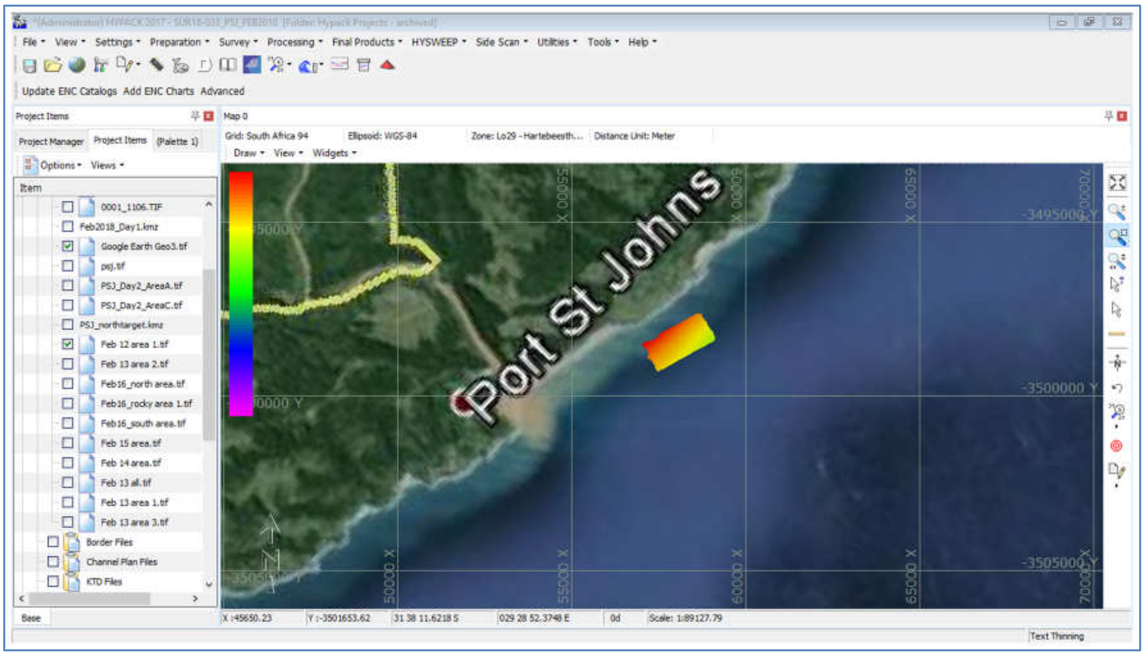
There were no specific sightings or targets of possible debris or other items of man-made nature spotted in the multibeam, backscatter, sub-bottom nor magnetometer data.

10.1 Day 1

The search area on Day 1 was focussed on the targets identified in November 2017, and other points provided by the Client. This area had been dived on but nothing seen. The multibeam also showed nothing of significance, and neither did the SBP on the day. There does appear to be a layer of sand in this area, and these mag readings may correspond with rocky outcrops which have been silted over by the sand from the river.

Day 1 survey area was conducted north of PSJ River mouth and beaches. A total of 35 survey lines totalling 46km lines were surveyed using multibeam, backscatter and sub-bottom profiler at 30m line spacing for high definition.

Nothing of significance was seen on this day. Seabed is homogeneous sand and drops from 18.5m CD to 40.5m CD.



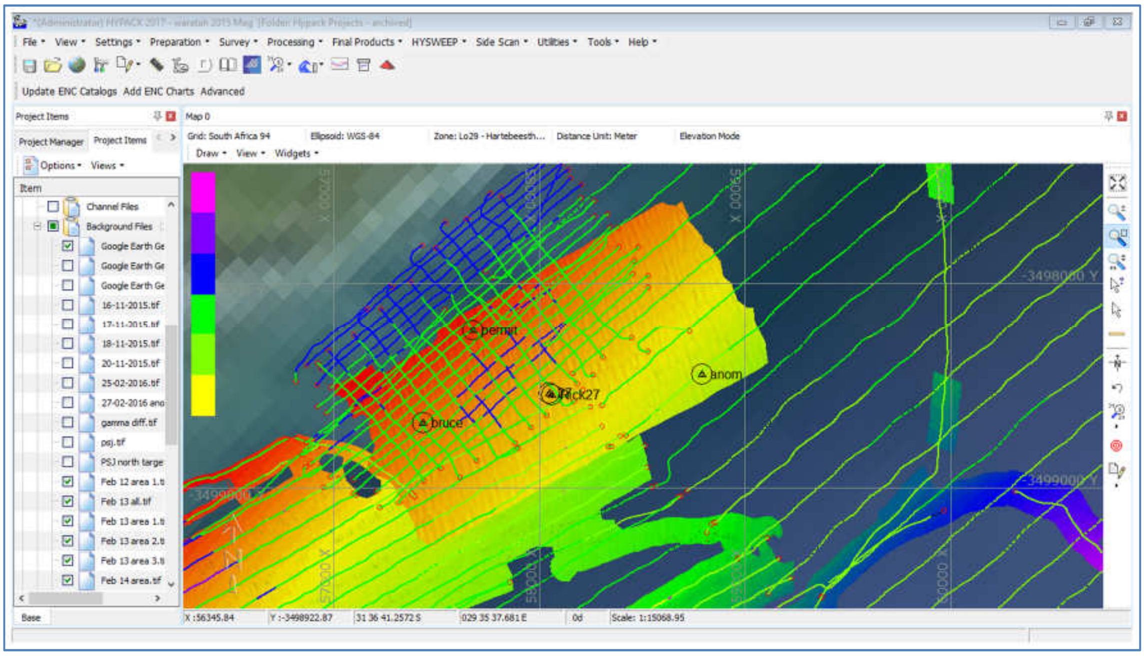


Figure 16 - previous and latest magnetometer readings in the first search area. Sub-bottom did not pick up any anomalies.

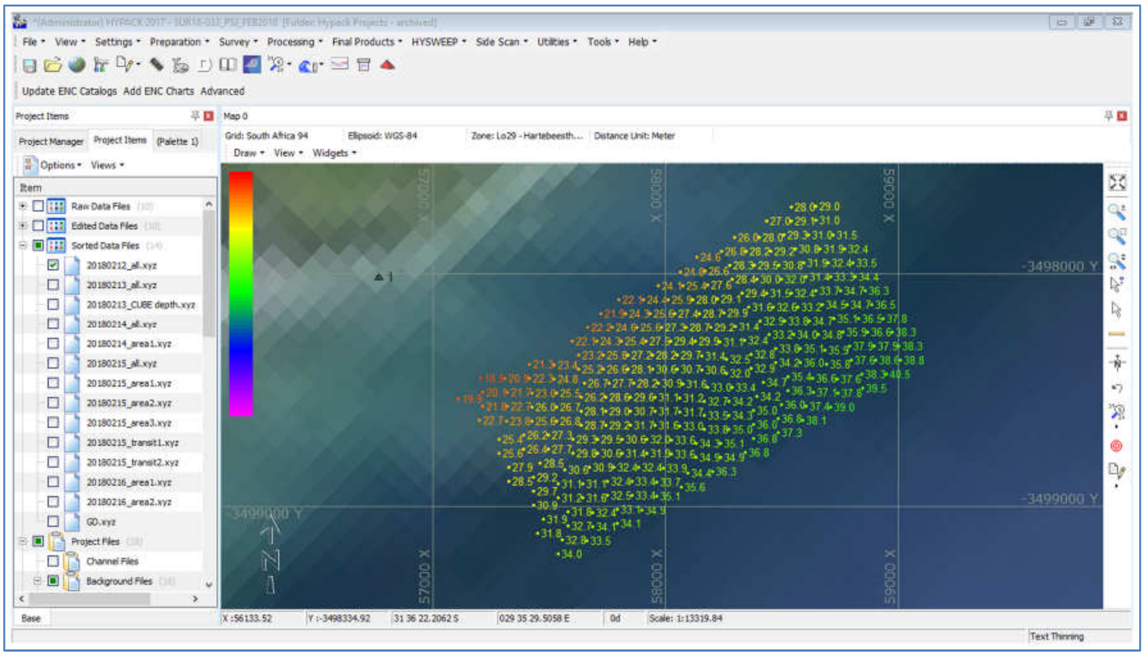


Figure 17 - soundings in search area 1

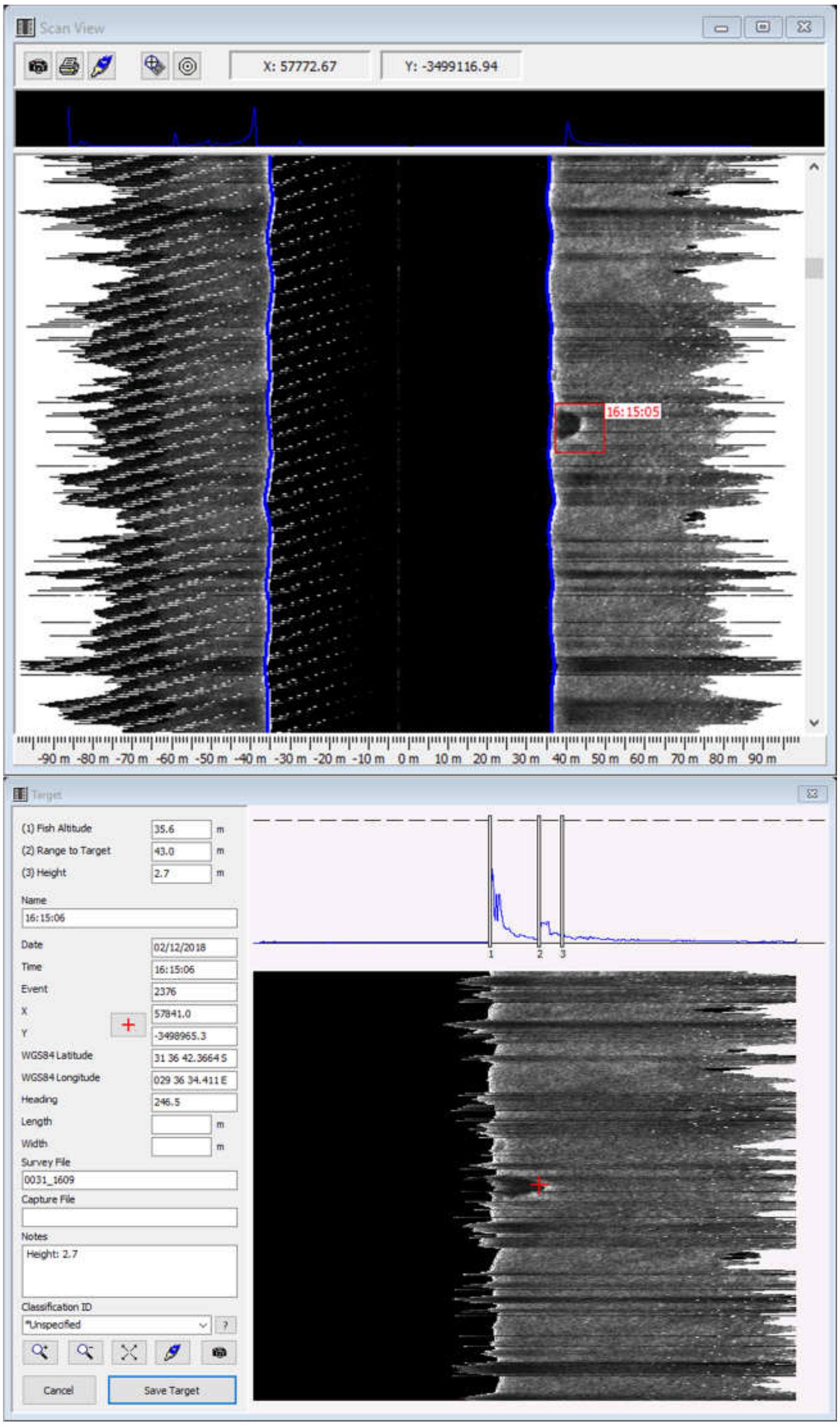


Figure 18 - an otherwise bare seabed, one shallow indentation in the sandy bottom

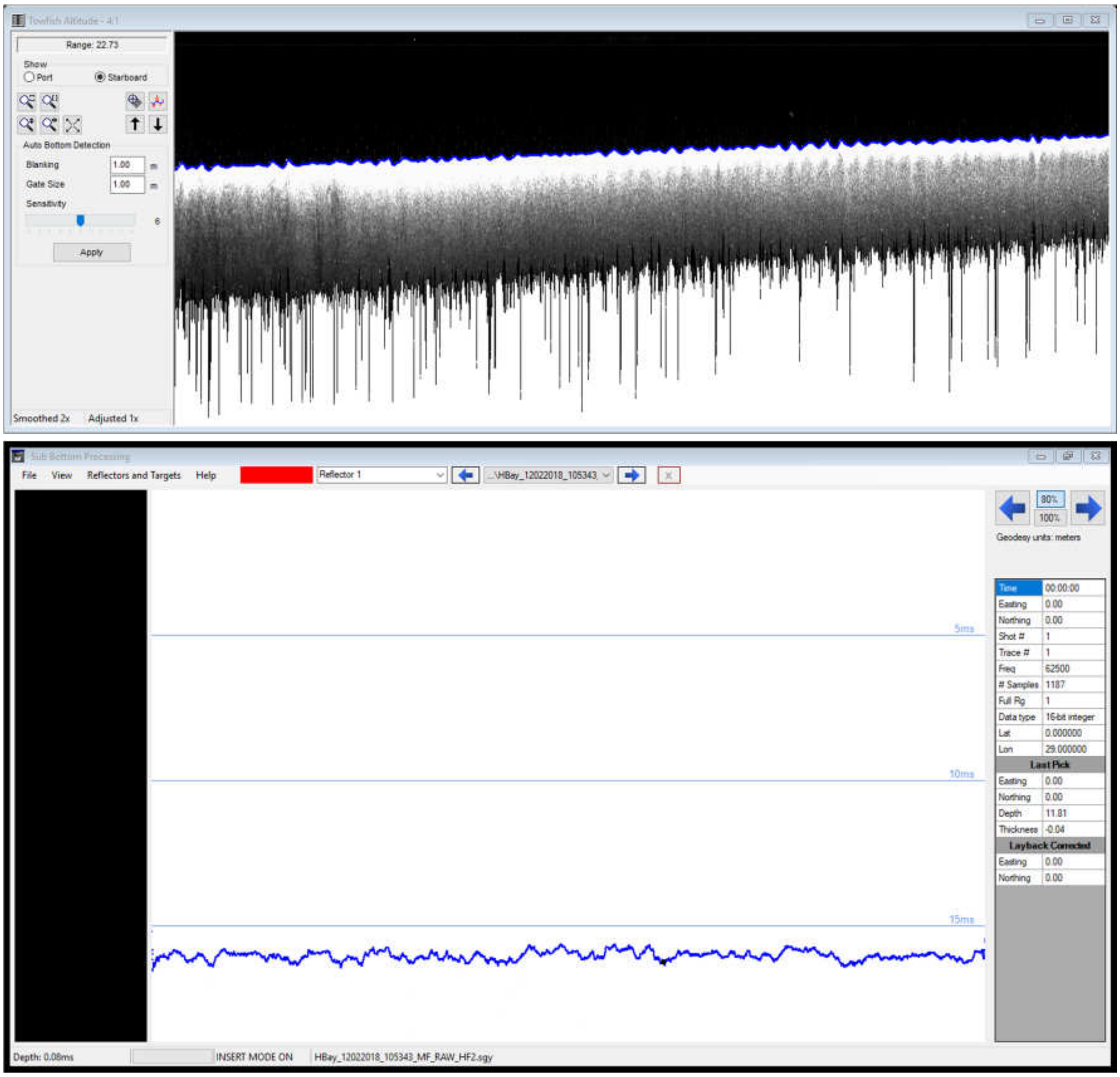


Figure 19 - sub-bottom and backscatter of the same survey line - sandy bottom

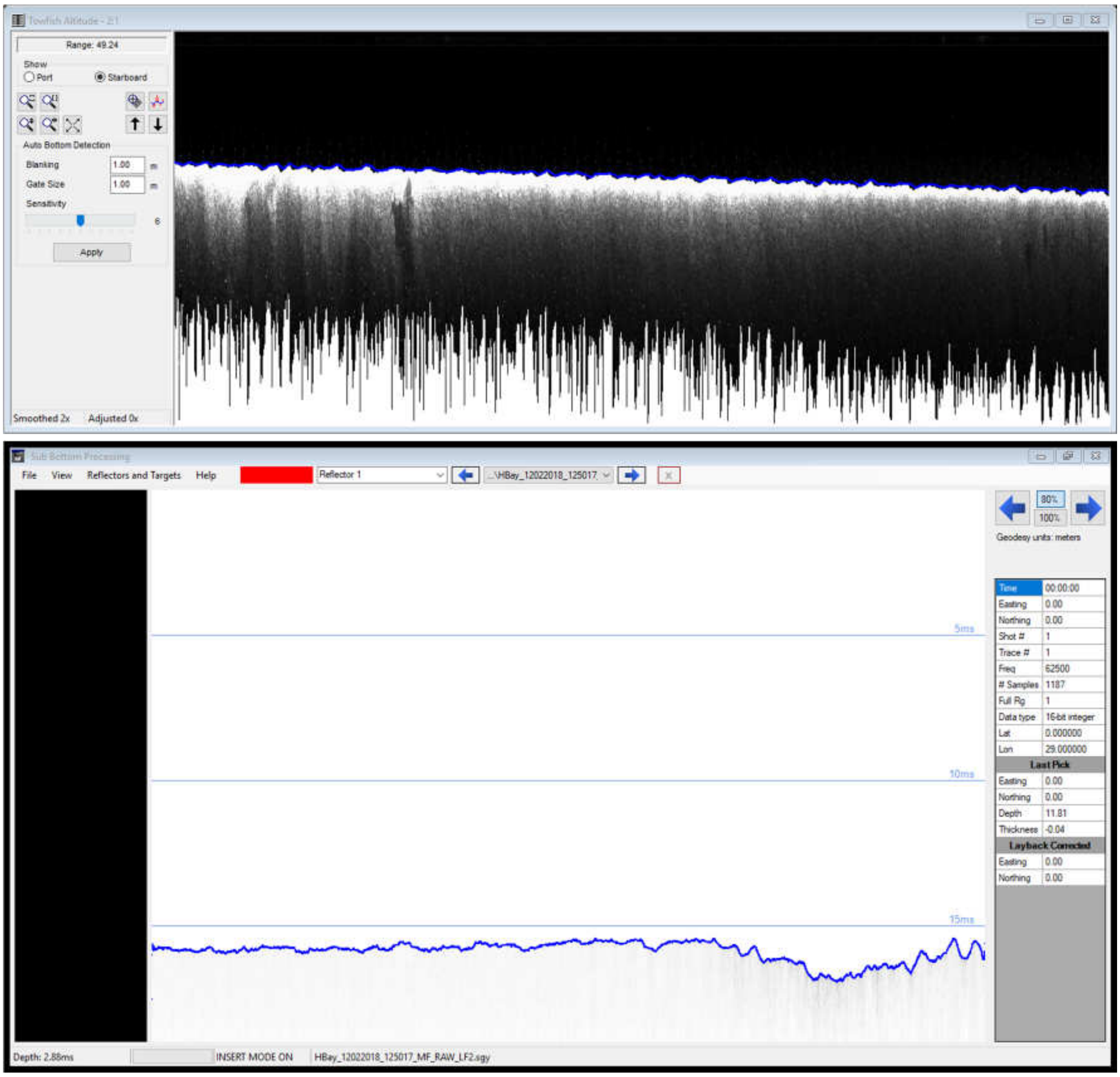


Figure 20 - examples of sub-bottom and multibeam backscatter profiles over lines where search targets were located. No notable features or geology to note. Seabed surface was sandy.

10.2 Day 2

Day 2 survey area was conducted approximately 30km south of PSJ in an area where there were multiple possible target identified by Hypack.

A total of 61 survey lines totalling 56km lines were surveyed using multibeam, backscatter and magnetometer.

Nothing of significance was identified for further investigation

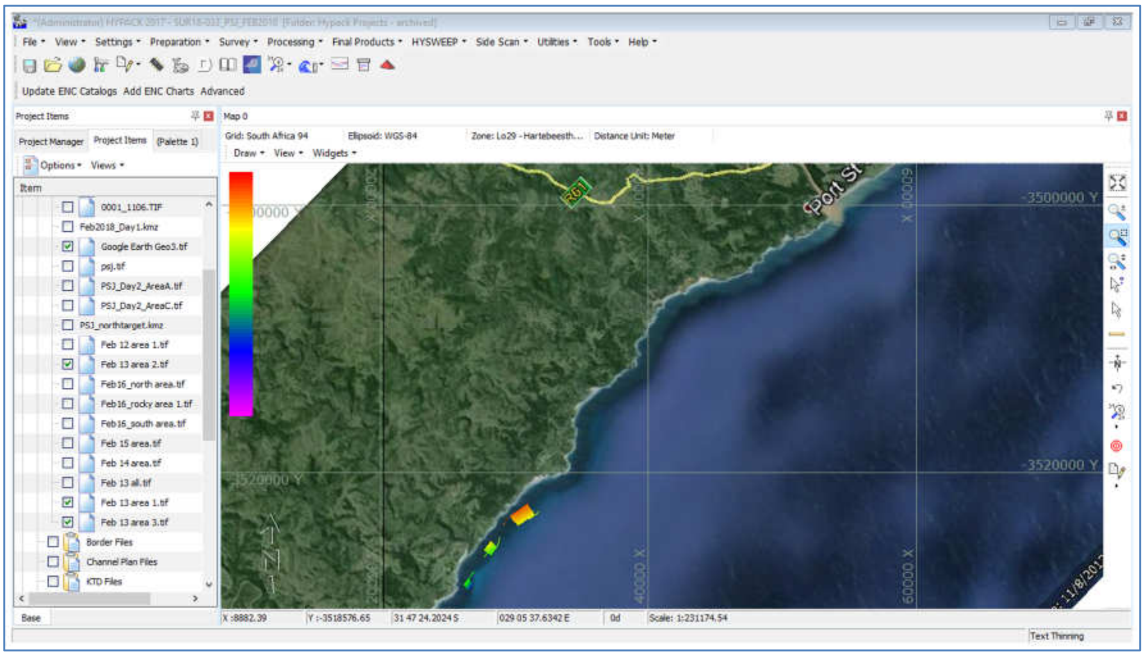


Figure 21 - search areas Day 2

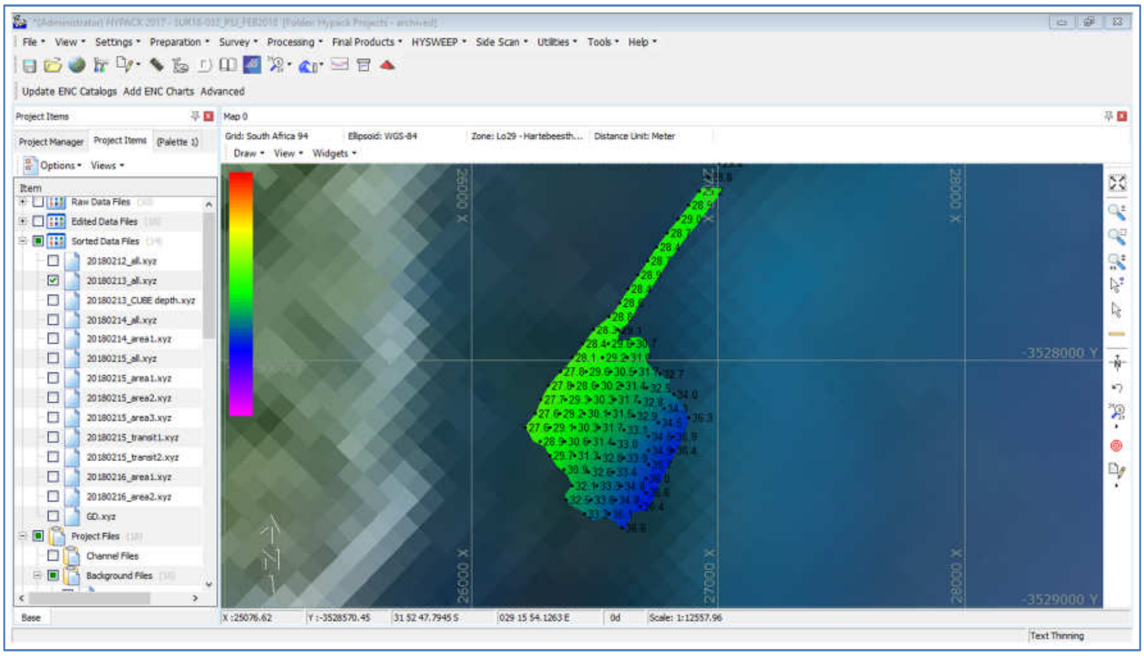


Figure 22 - Search area 1 on day 2. Area was selected due to targets by the Hypack magnetometer identified by Hypack USA. Nothing of any significance was seen. Area ranged from water depths 27.6m CD to 36.6m CD

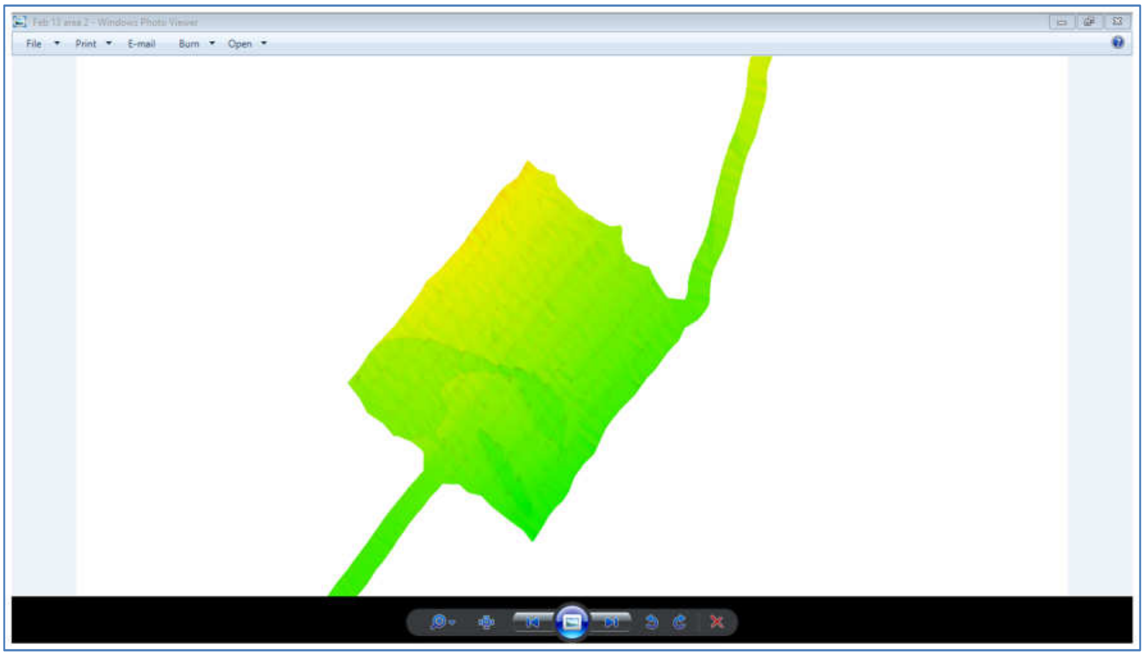


Figure 23 - feature showing a possible old river channel offshore – very shallow or marginal difference in elevation – less than 50cm step in channel.

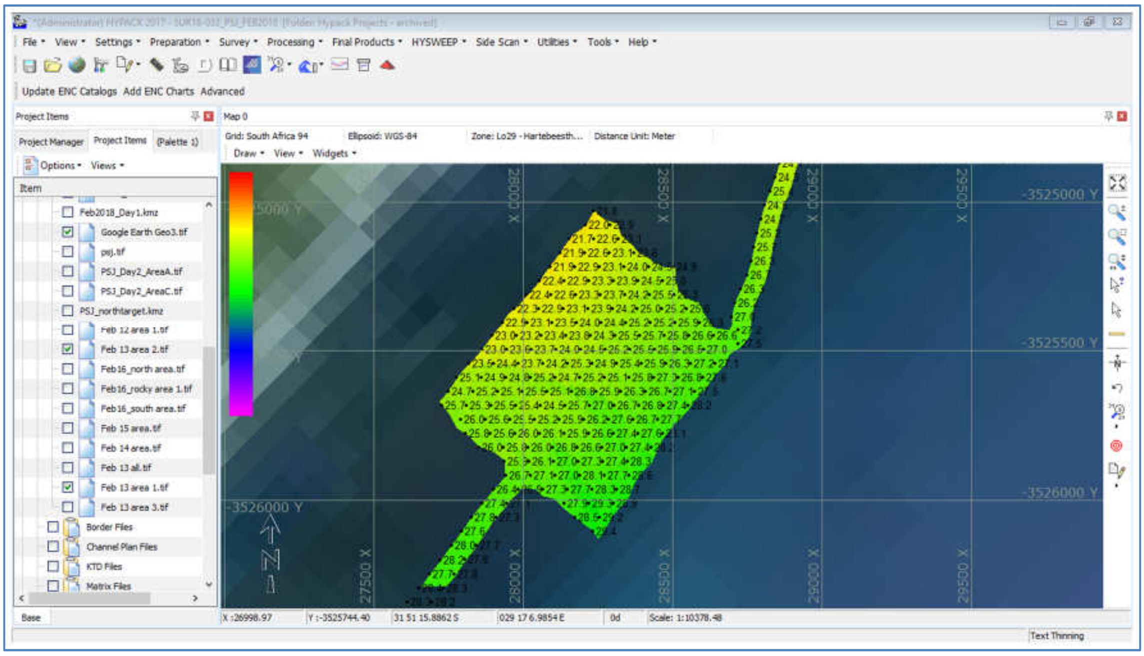


Figure 24 - area 2 searched on day 2. Nothing of significance seen. Area had been previously search with a magnetometer. Geological features present – what appears to be harder gravel areas either side of a sandy "river" running through the area perpendicular to the coastline. Seabed water depths range from 21.8m CD to 29.4m CD.

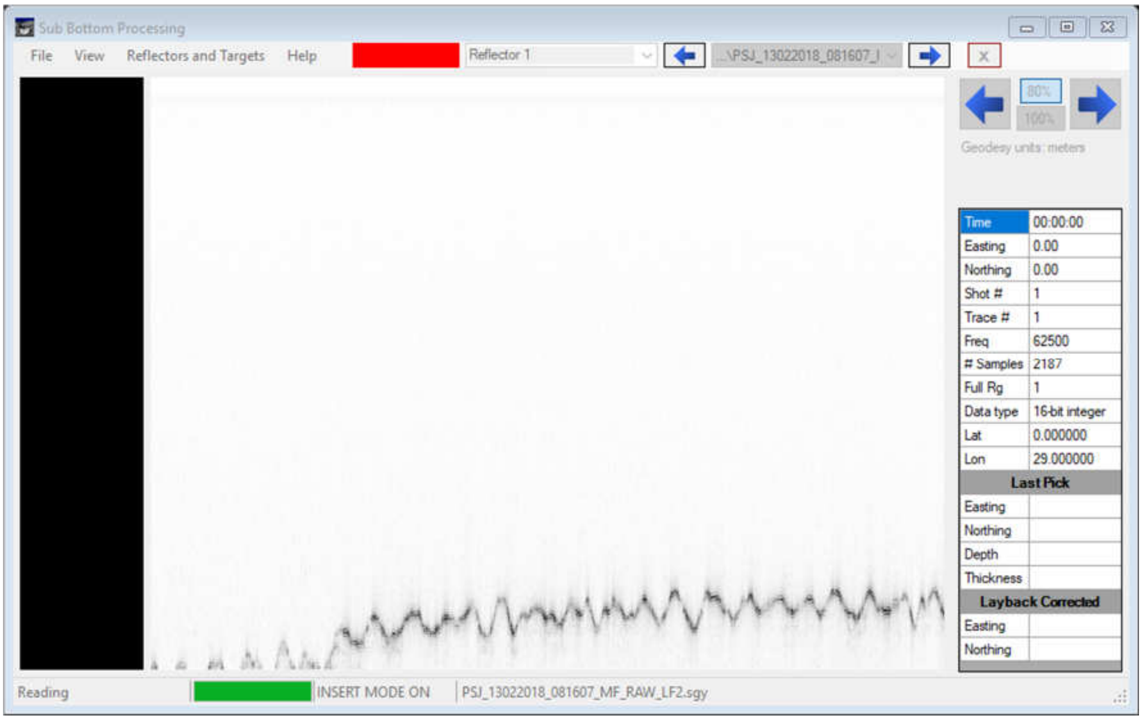


Figure 25 - sub-bottom did not function as favourably in this area and suggestion is that the parametric system is not suited to this type of geology and sedimentology. Professor Green suggests the Transkei coast is better surveyed with a lower frequency towed boomer system

and an 8-element hydrophone. This is a larger system and would not fit an 8m RHIB but requires a more permanent installation and a larger generator as a power source.

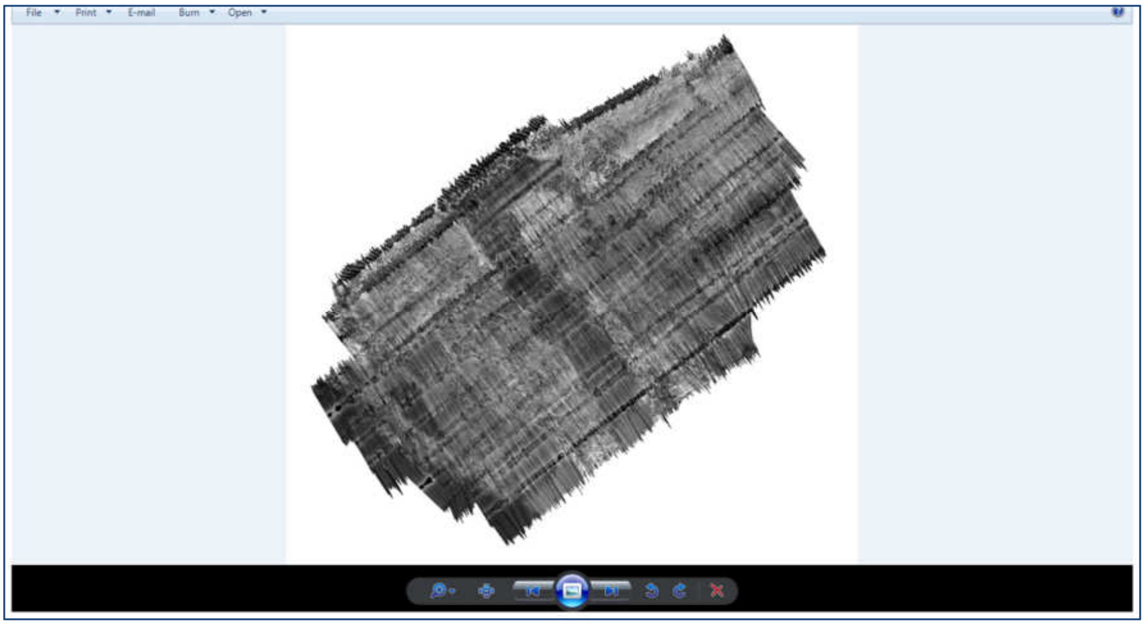


Figure 26 - mosaicked backscatter image of survey area. Appears to be a patch of different sediment running through the middle of the area - darker colour indicates it is a finer material or sandier than the two areas either side. Geological samples would confirm sediment particulate size and mineral make-up

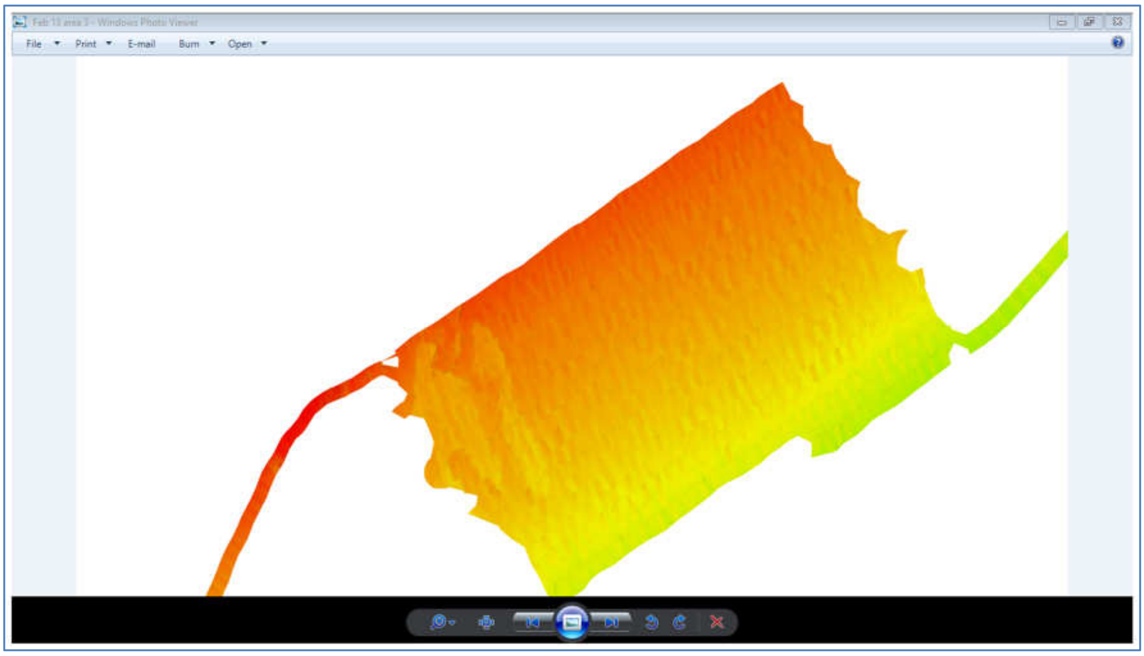


Figure 27 - rocky outcrop (dark red) on the line leading into he larger survey area indicated a zone of irregular rocky seabed standing higher than adjacent areas

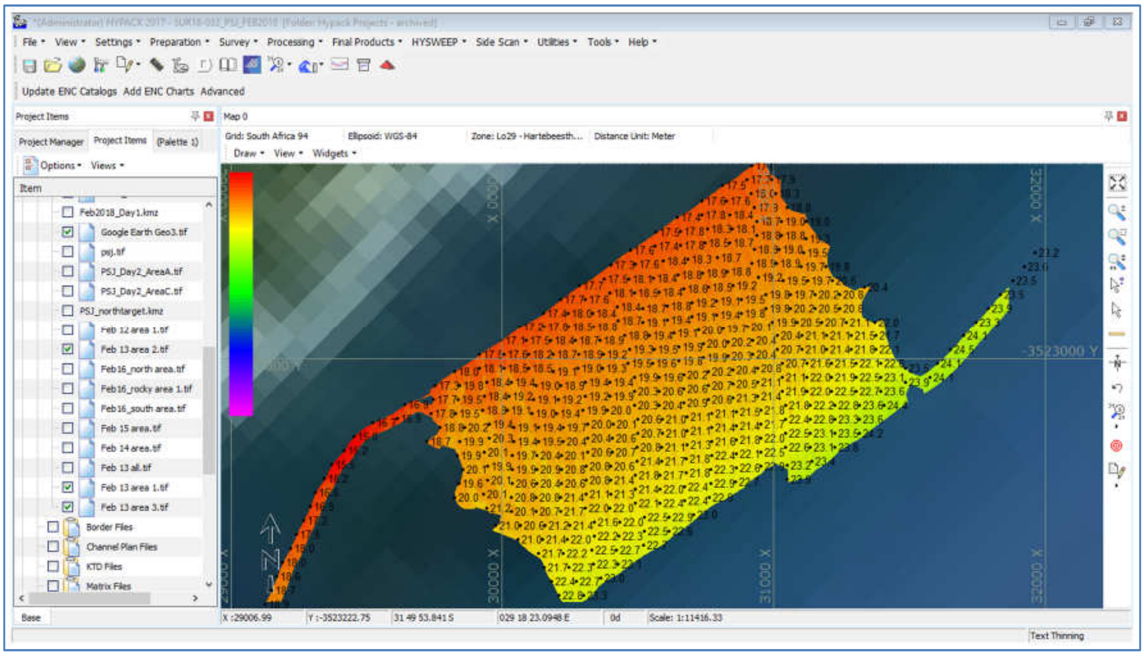
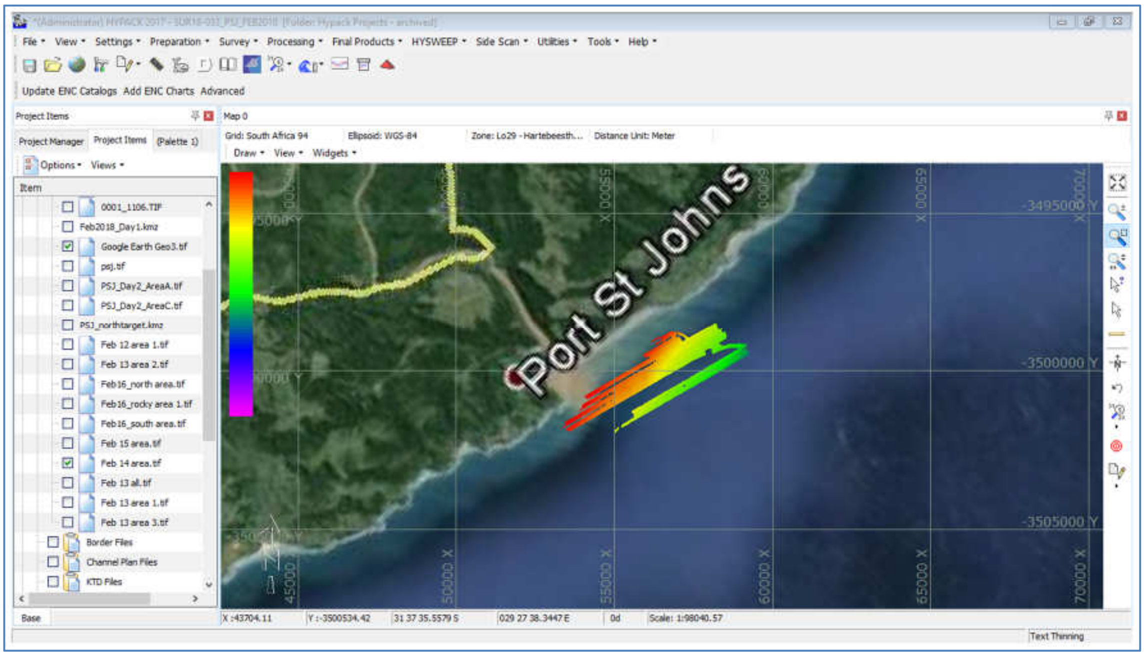


Figure 28 - area 3 surveyed on Day 2. Nothing of significance seen, except geological features in the western approach to the search area and the western quadrant. Seabed ranges from 15.0m CD over the rocky outcrop to 24.5m CD in the eastern extremity.

10.3Day 3

Day 3 survey area was conducted near the PSJ River mouth and beaches. A total of 18 survey lines totally 61km lines were surveyed using multibeam, sub-bottom profiler and magnetometer. Nothing of significance was identified for further investigation.



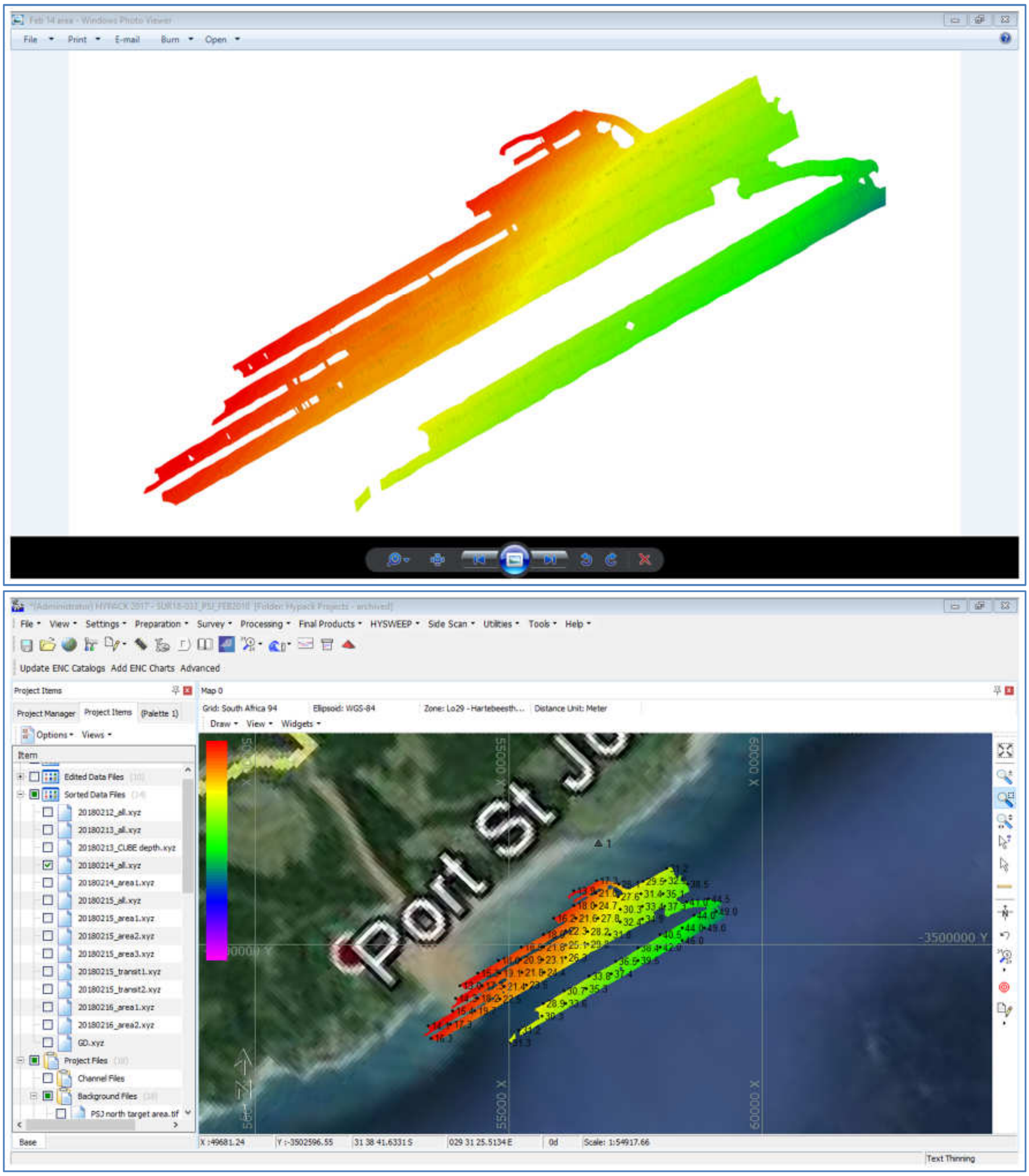


Figure 29 - Day 3 search area off the mouth of Port St Johns. Nothing was seen. Survey area ranged from 13.0m CD in the western area off the PSJ lighthouse to 49.5m CD offshore.

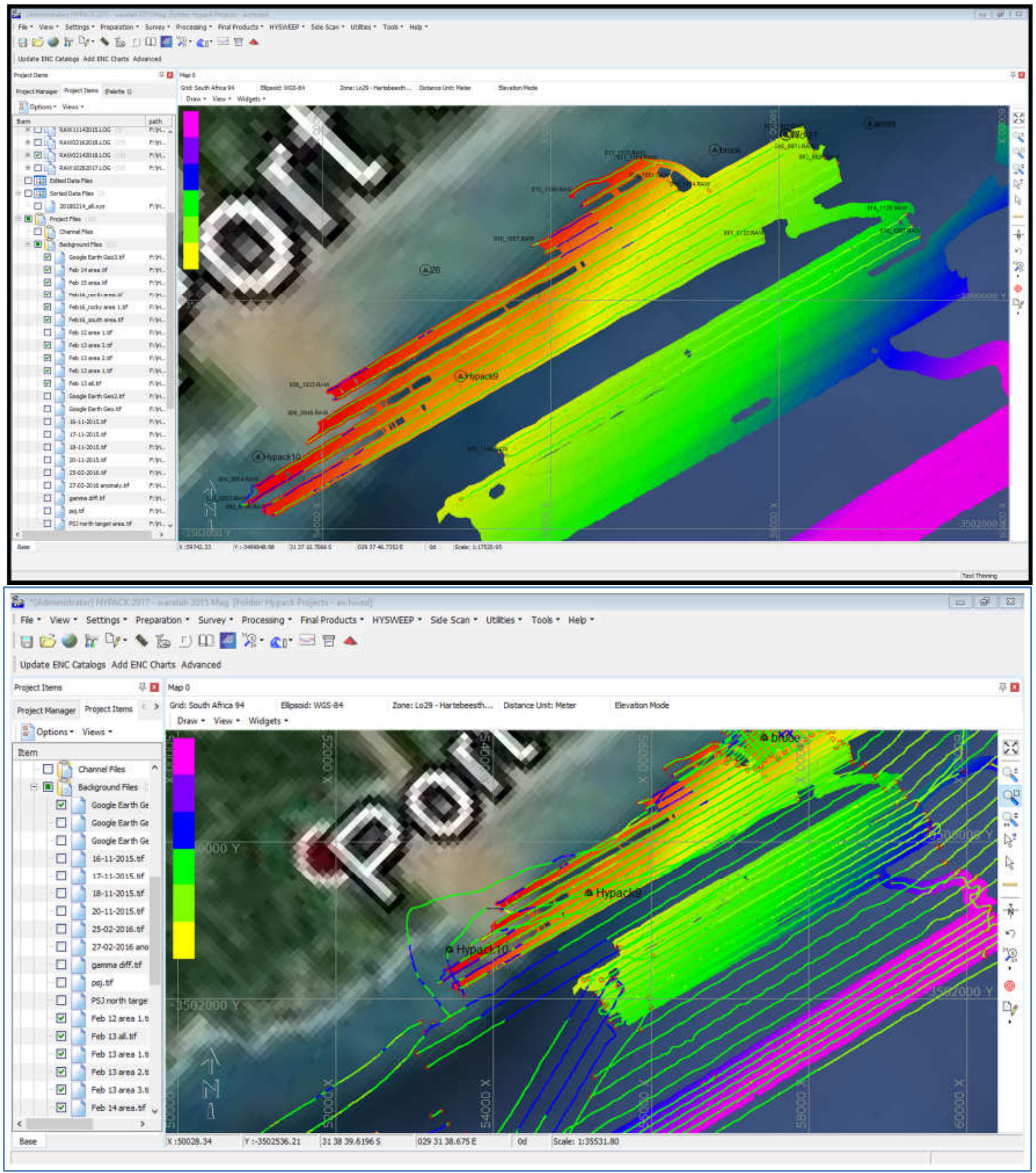


Figure 30 – Magnetometer data – top data from day in question, second image showing tie-in with adjacent historical data. Regional trends evident which leads conclusion that this is geological in nature.

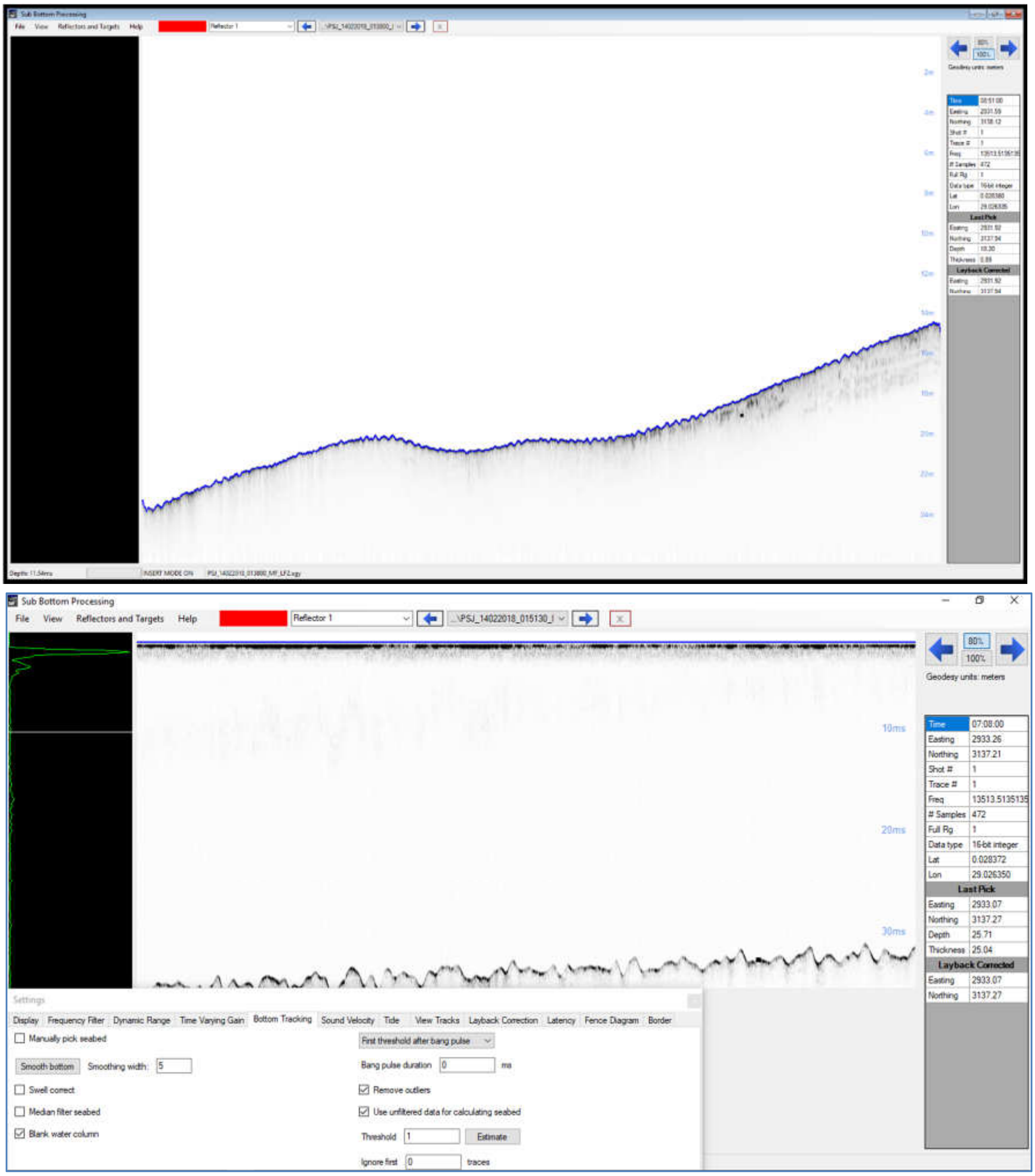


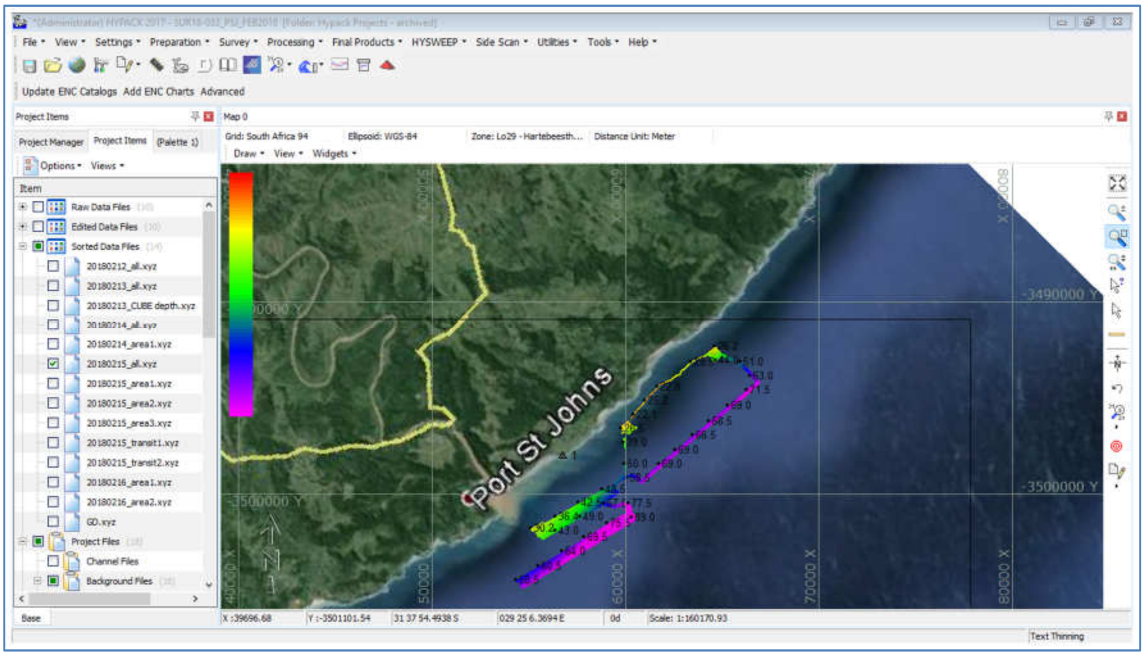
Figure 31 – sample SBP profiles showing tracked seabed along entire survey lines. No significant non-geological reflectors or targets identified in the SBP profiles.

10.4 Day 4

Day 4 was split into 2 main search areas to cover the final Hypack USA magnetometer targets, and then a continued seabed survey to complete the offshore area off the mouth at Port St Johns

Day 4 survey area included a total of 51 survey lines totalling 101km lines surveyed using multibeam, backscatter, sub-bottom profiler and magnetometer.

The northern survey area showed some interesting real-time magnetic behaviour, and due to the magnetic readings and the rugged nature of the preliminary multibeam data processed it was decided to extend this survey area on the last day of the project.



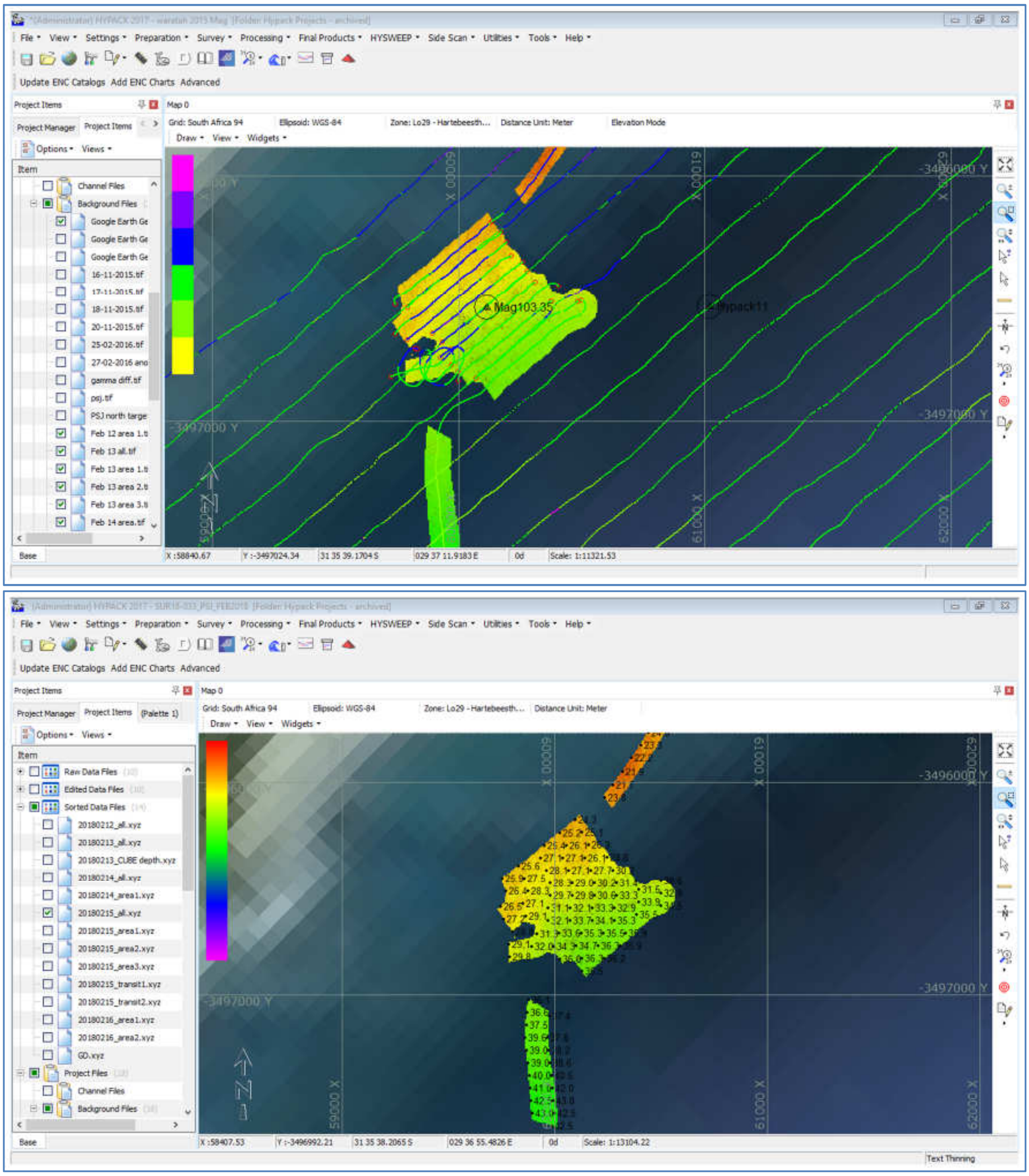


Figure 32 - Area 1 searched on Day 4 corresponded with the mag target identified by Hypack USA. Area was fairly flat and homogenous with some rocky features present. Seabed ranged from 24.3m Cd in the north to 35.9m on the southern extremity. The seabed slopes parallel to the shoreline.

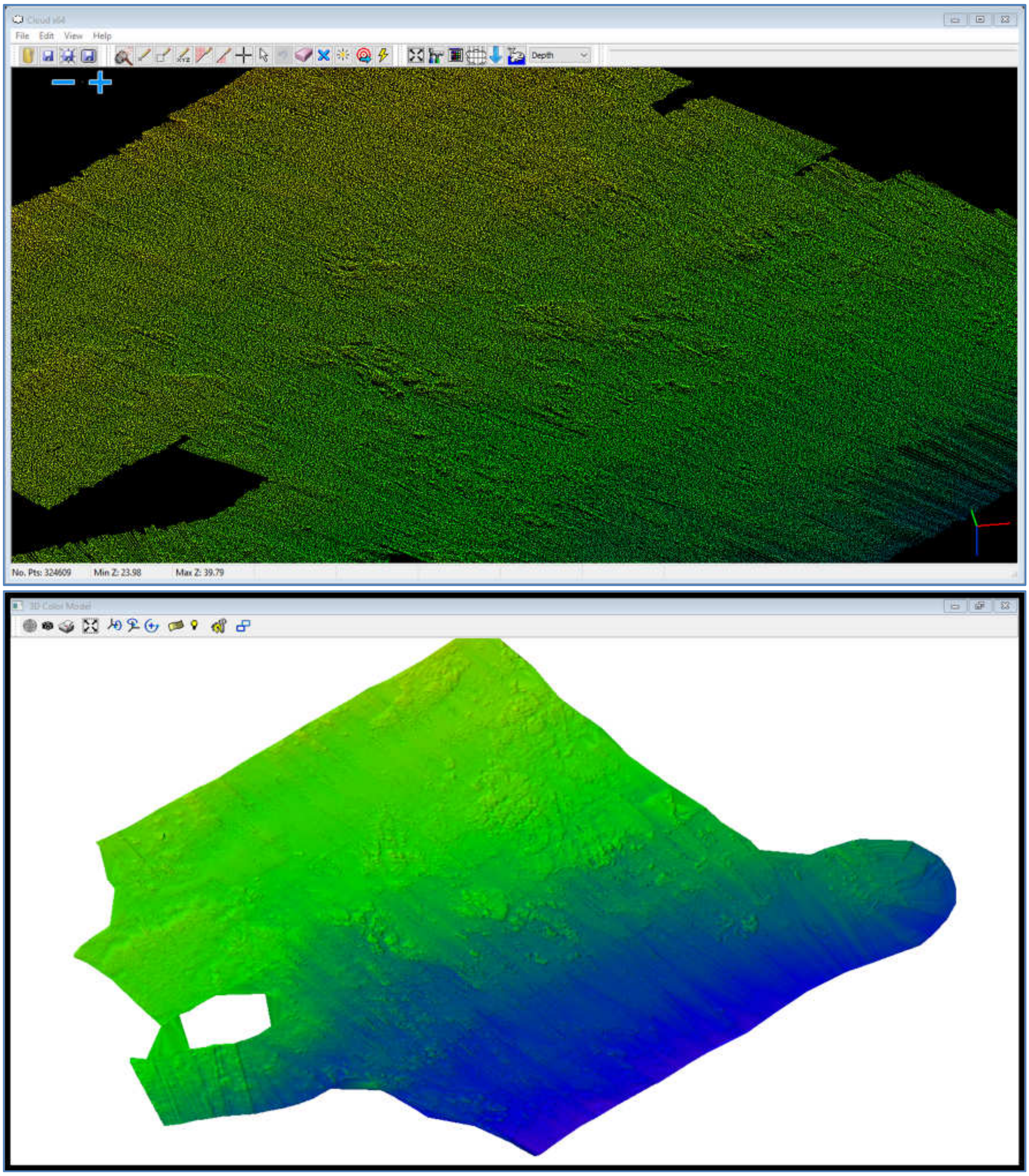


Figure 33 - isolated and scattered rocky outcrops and reefs in the first of the two survey areas. The Hypack target was dead centre of this survey area. The magnetometer on the closer line spacing behaved in the same manner, and this correspond with the seabed geology.

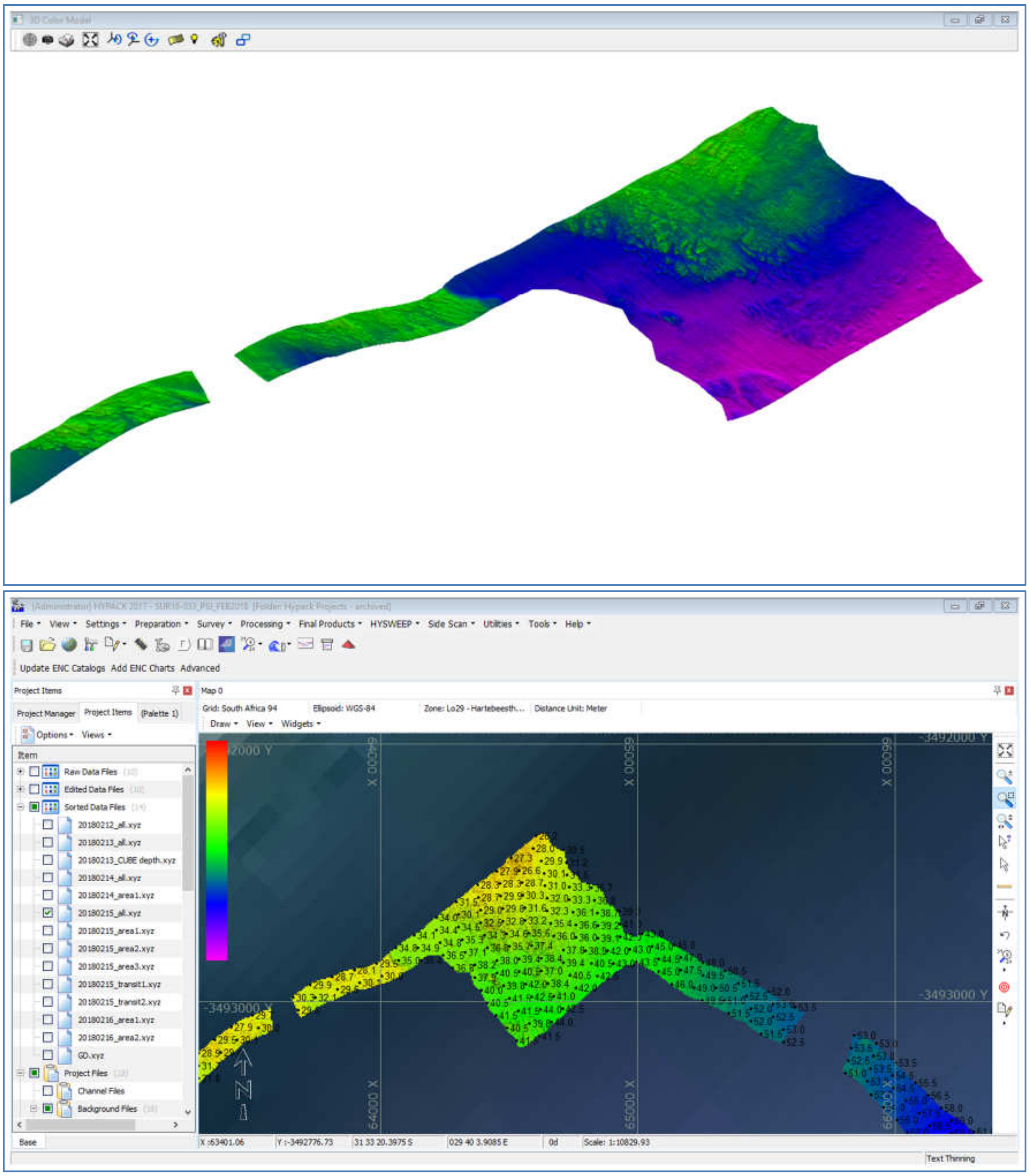


Figure 34 – Area 2 Day 4 - this area was the final and largest of the magnetometer readings from Hypack USA. Once again as the team towed the mag over this area the magnetometer readings were high in value especially to the northern eastern quadrants. The results of this area are discussed in Day 5 feedback.

10.5 Day 5

Day 5 was focussed on one main search area which showed interesting features in the preliminary post-processing. Though strongly suspected to be geological in nature, a larger search area was defined to investigate the features further.

Day 5 survey area included a total of 34 survey lines totalling just short of 80km lines surveyed using multibeam, backscatter, sub-bottom profiler and magnetometer.

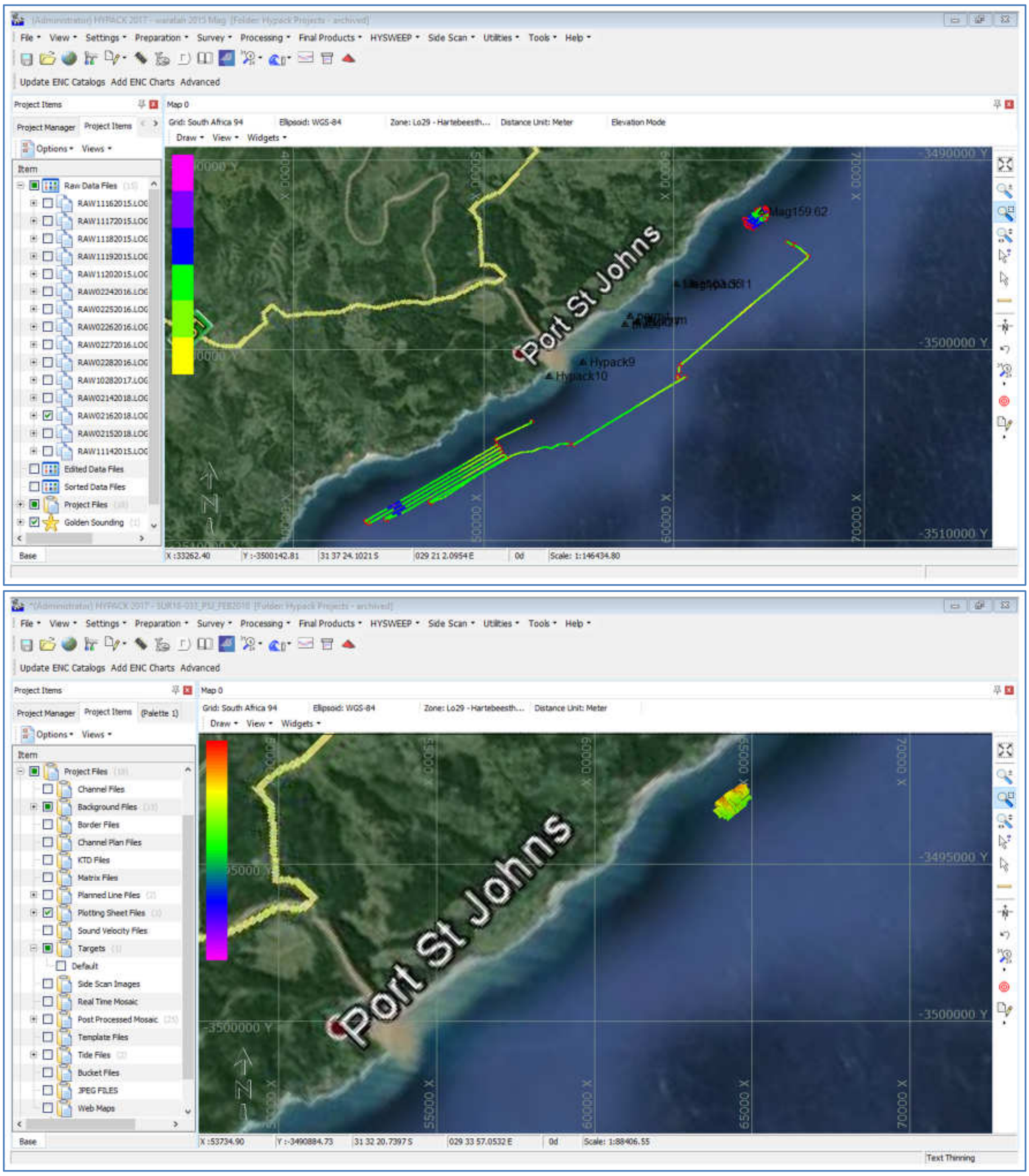


Figure 35 - search areas Day 5

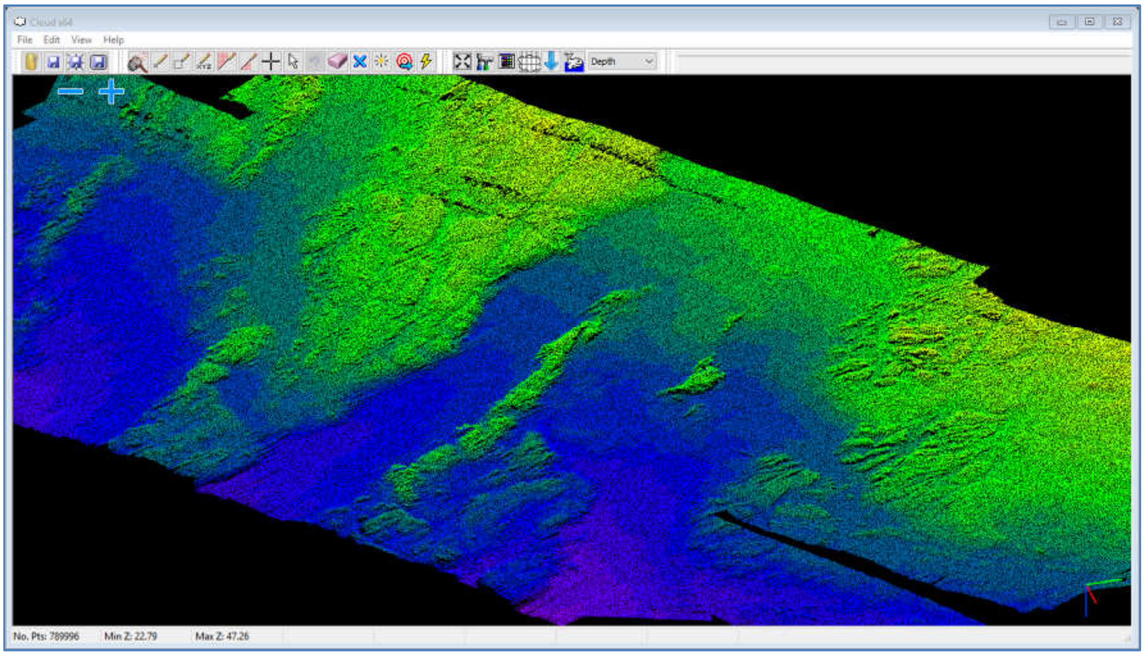


Figure 36 - rocky features most likely dolomite extrusions, on top of possible sandstone features. The middle ridge running through the survey area rises over 9m off the seabed and is the most significant geological feature witnessed in the survey.

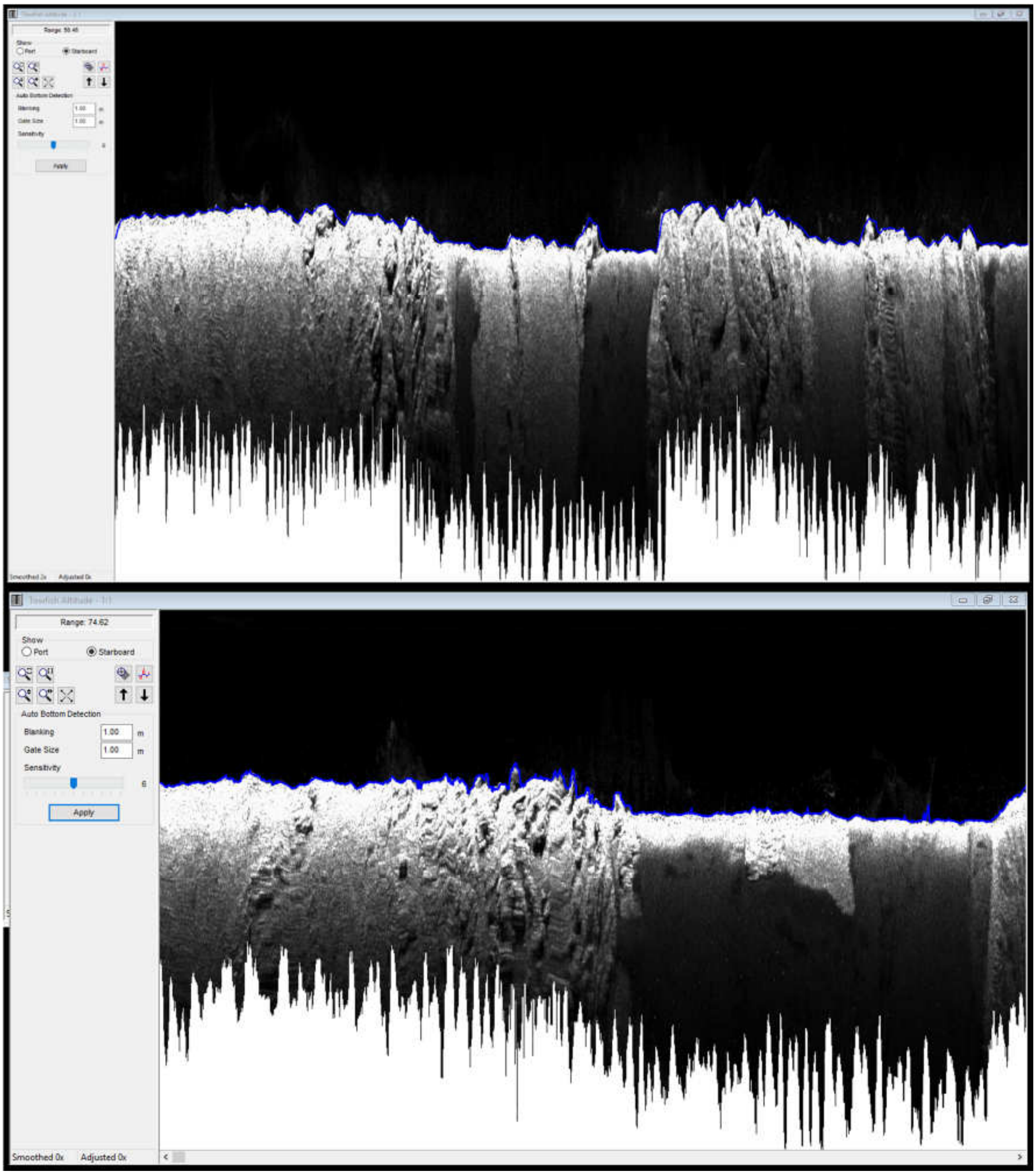


Figure 37 - Multibeam backscatter showing geological typography. Darker colours represent sand or softer material. Lighter texture is hard surfaces like rock. Shadow features are outcrops, steps or pinnacles on the seabed. Length of shadow is indicative of the height of the object on the seabed.

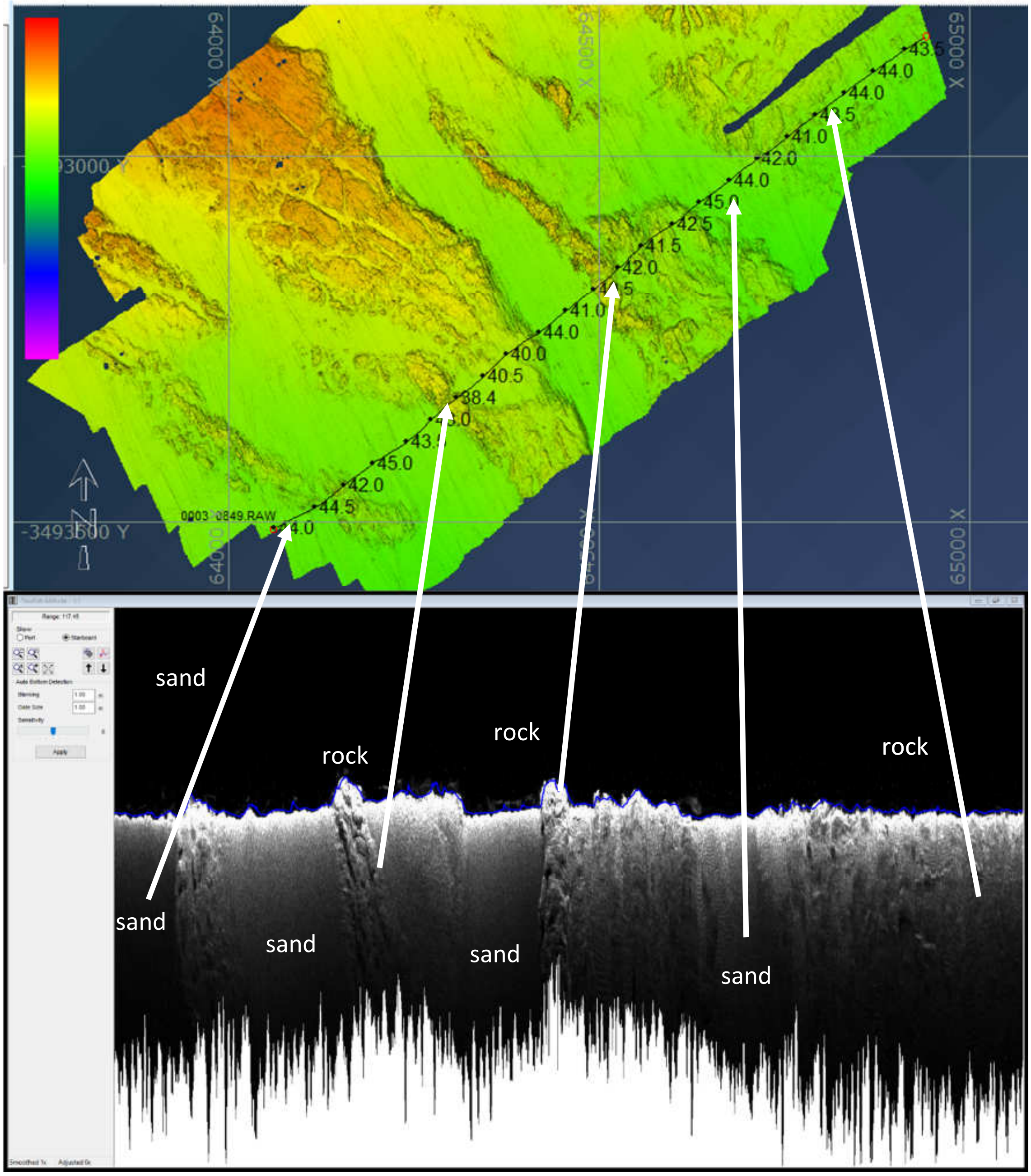


Figure 38 - Day 5 - line 08h49. Illustration of multibeam and backscatter comparison.

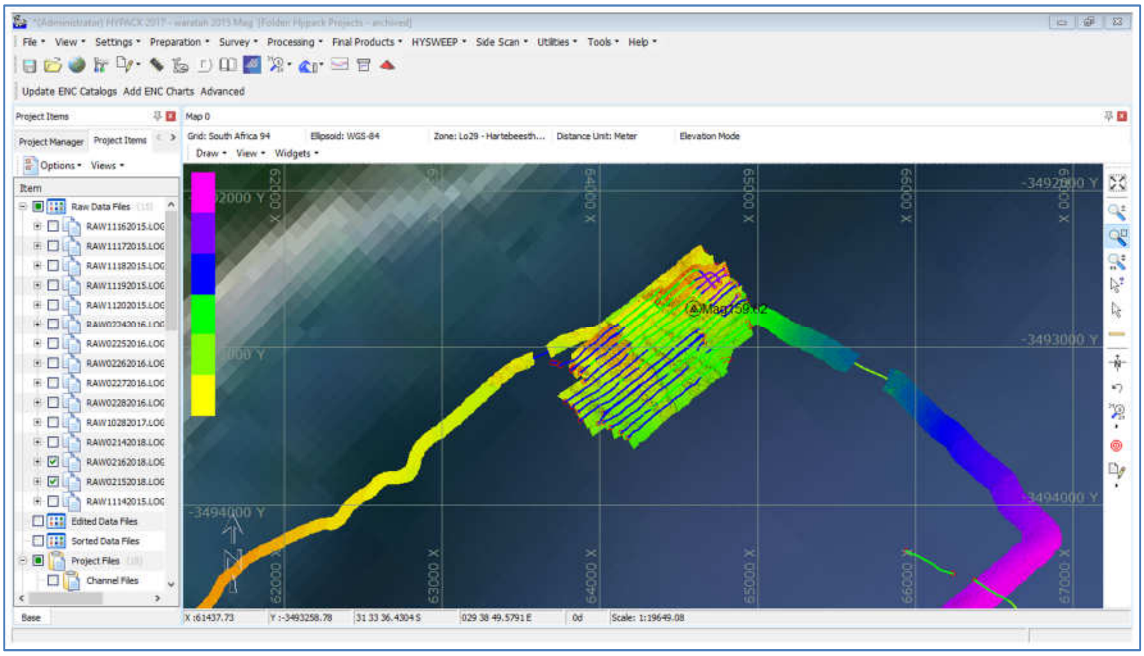


Figure 39 - there appears to be correlation with the geological features and the higher mag reads. This area is known for dolomite outcrops which has a higher magnetic signature. There is also sandstone which appears more weathered.

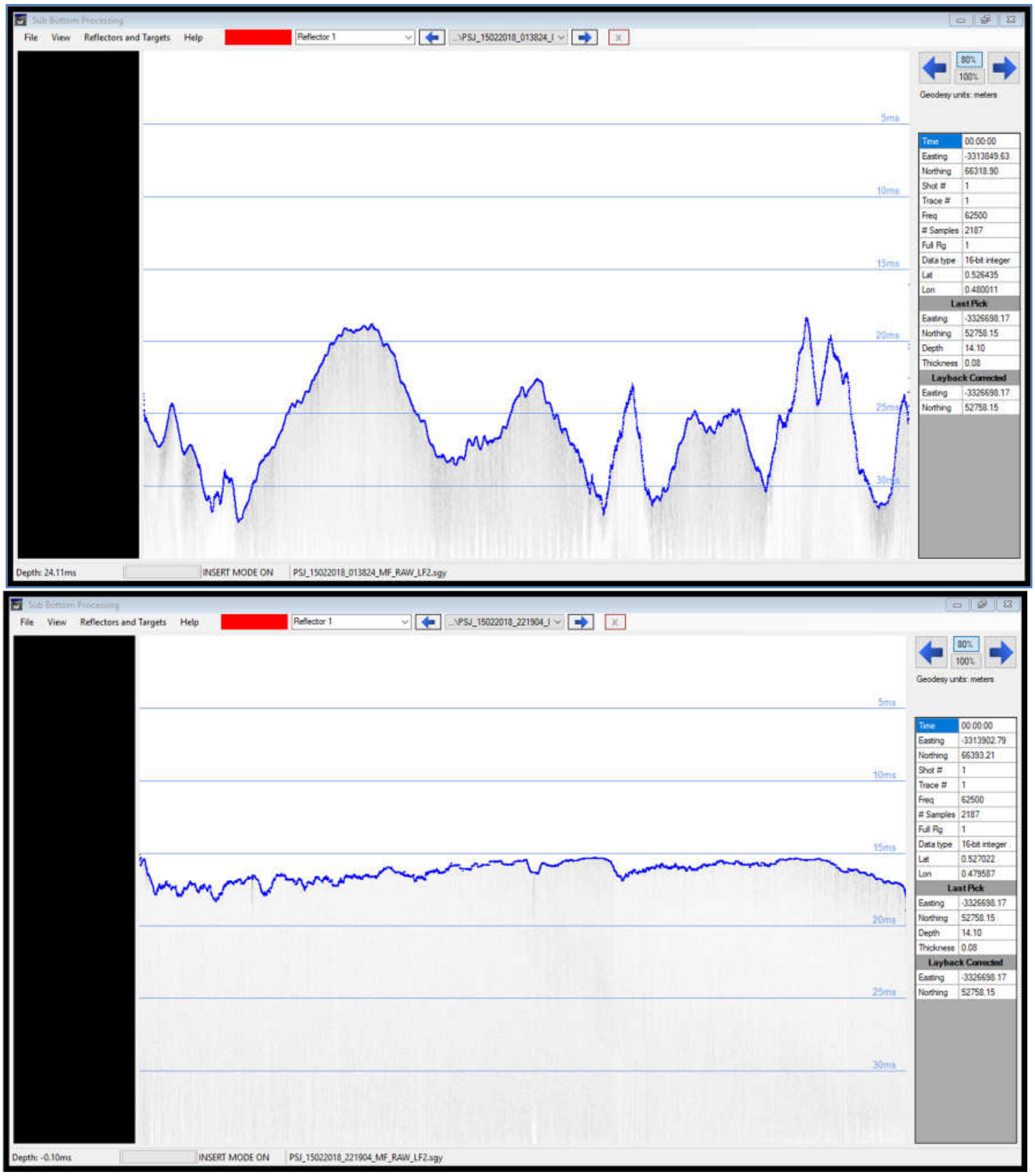
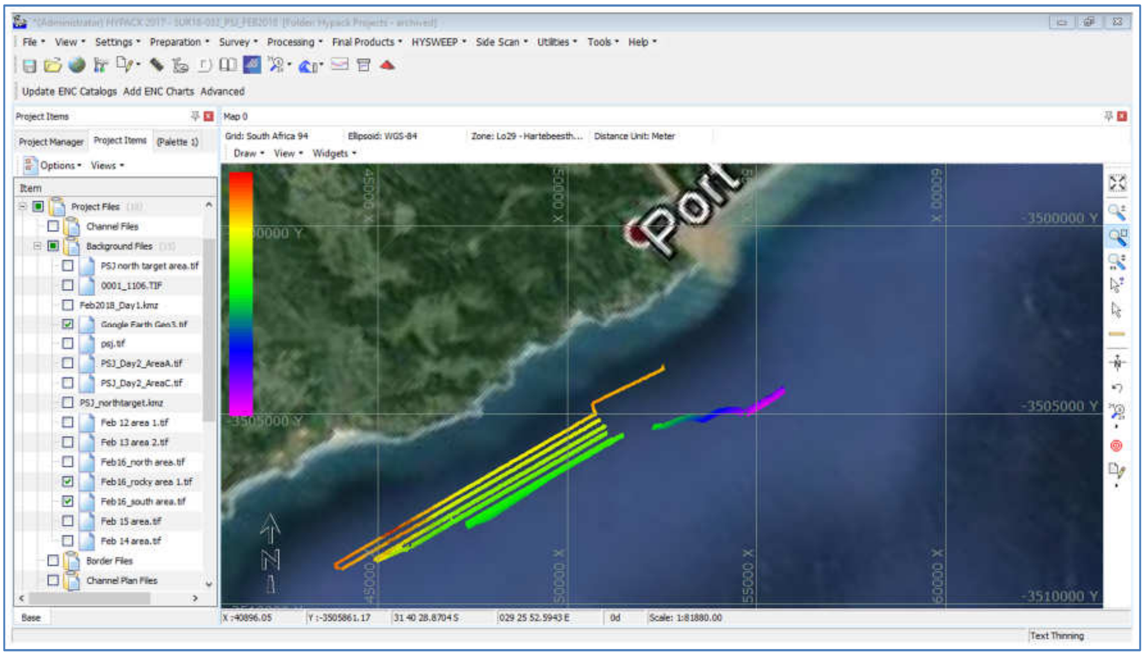


Figure 40 - examples of SBP survey lines - top image is travelling over the rocky outcrops visible in the multibeam images. The jagged nature of the formation leads the geologist to believe this is dolomite outcrops. Lower image is a more homogeneous sandy seabed with some heave artefact present. Nothing of non-geological significance was noted.



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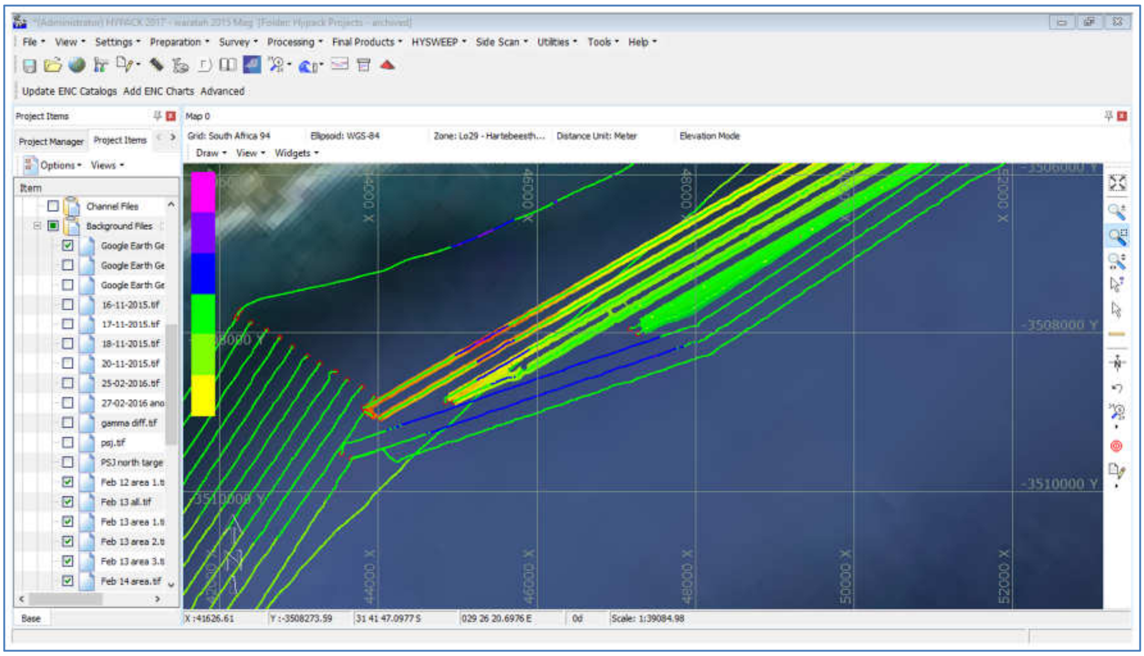

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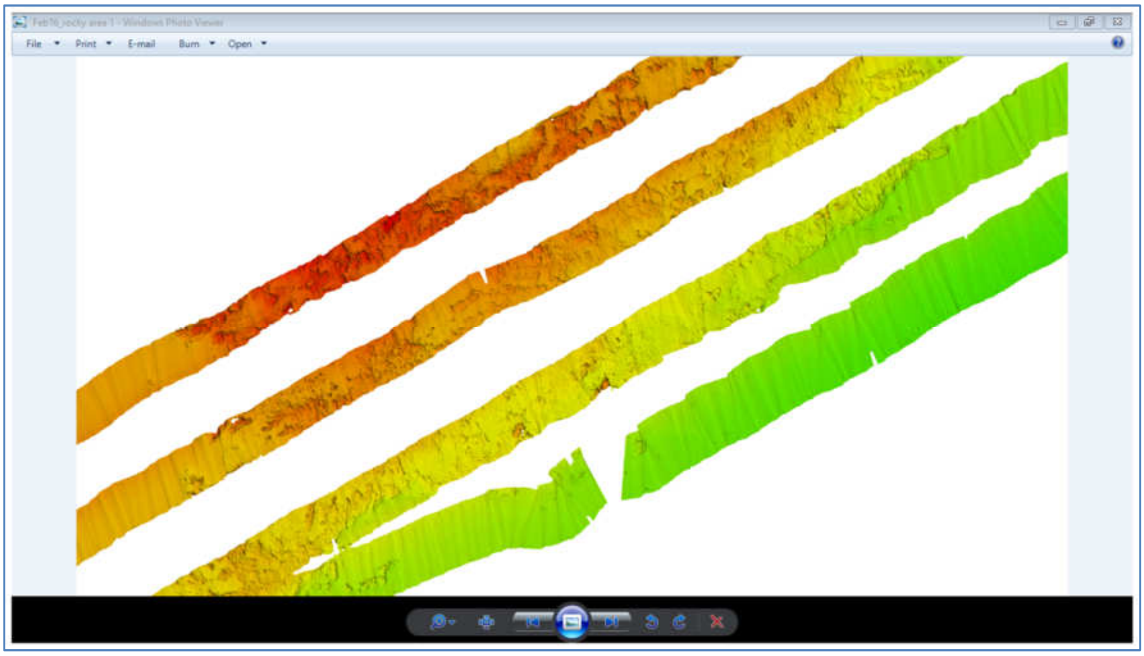

Figure 41 - high magnetometer reading in the southern sections (blue) appears to correspond with the rocky geological features visible in the multibeam (orange and red areas visible in third image

10.6 Combined Magnetometer data 2015 to date

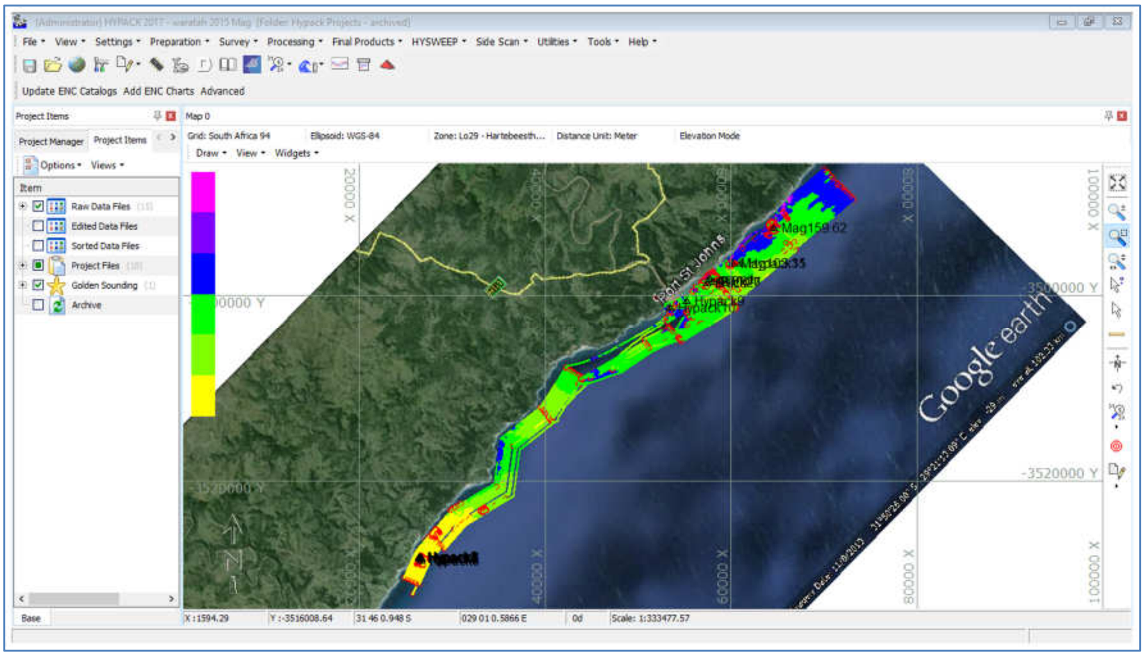

Figure 42 - Above image represents all magnetometer data from 2015 to date. Data prior to 2011 has not been compiled or consolidated as yet. The blue areas are regional areas of higher magnetic values and due to their large expanse, Professor Green is of the opinion these are indicative of the dolomitic geology which sits on and extrudes in the sandstone along this coastline. Further geological studies could be undertaken to confirm this.

11 Conclusion & Recommendation

Subtech believes that the multibeam and backscatter has proven invaluable in this exercise. The visible geology has shown a strong correlation with the magnetometer findings.

Further interpretation of the sub-bottom profiler has indicated that this particular parametric type is not suited for the entire region, and that a low frequency seismic boomer system would be better suited.

This requires additional power (5kVa generator), a larger heavier sled, a towed hydrophone element and a qualified operator. This system will not fit the current RHIB and a purpose-built vessel would be necessary.

We would recommend that a multibeam be used in the following campaigns. Due to the nature of the system and the overall value of the equipment, Subtech does not hire out their multibeam without a Subtech surveyor present.

We do feel that future surveys would benefit have both a multibeam and a magnetometer running simultaneously, and log all data through the Hypack system. This will provide spatially corrected data real-time and would eliminate the need of inspection dive surveys if possible targets are spotted in the mag data or on the multibeam screens.

As a result of all the data acquired in the week commencing 12th Feb, especially that on the 15th and 16th Feb, and combined with the magnetometer data from the past three years, it may be beneficial to survey the area to the north east of the last survey area.

Historical data shows high mag readings in this region but it should be noted that these are over a large area (650m x 500m). There are no significant spikes within this to indicate any other anomalies (i.e. ferrous metal lying on top of the outcrops), however a survey with the multibeam will provide a visual of what is on the seabed and will either confirm the extension of the dolomite outcrops or the presence of other structure or debris.

Subtech looks forward to working with Andrew Van Rensburg in the future on this project.

Professor Green has expressed his thanks for the data which is adding to the University's geological database of the Transkei to Durban coastline and is also excited to work with Andrew Van Rensburg if the opportunity arises again and when his boomer system is fixed is willing to work with Andrew, university schedule allowing.

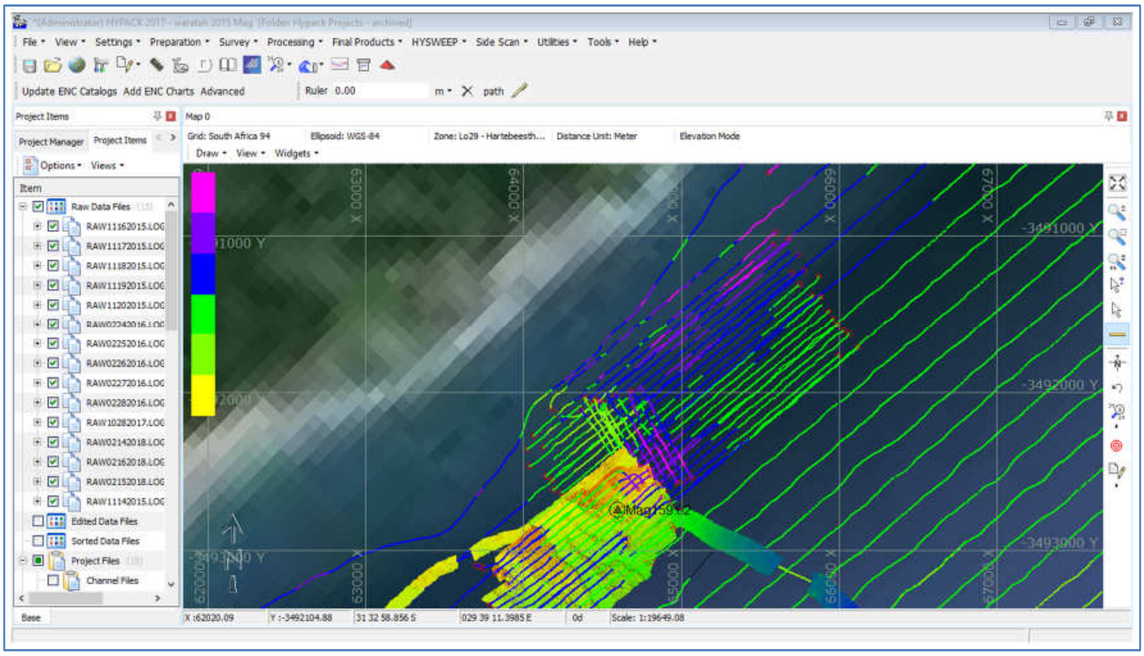

Figure 43 - Day 4 and Day 5 mag data combined with previous magnetometer data. The multibeam survey data is a backdrop to the south west in the image. It is suggested that should Andrew Van Rensburg return to PSJ to search further, that the area to the north parallel to the coastline be extended and surveyed to determine the source of the high magnetometer readings (pink areas).

12 REFERENCES

Publications:-

Websites:-

13 APPENDIX

- A0 plots of survey data
  - All track lines 12-16 February 2018
  - Multibeam bathymetry
  - Multibeam bathymetry with Hypack and other targets superimposed
  - Magnetometer data 2015 to 2018
  - Magnetometer data overlaid onto bathymetry and targets superimposed