Survey Report for
US Wind, Inc.

Title:
High Resolution Geophysical, Geotechnical, and Environmental Survey Report

Project:
US Wind Export Cable Route Survey Offshore Maryland and Indian River Bay, Delaware

Survey Date:
August - November 2016
September-October 2017

Project Number:
1783

Report Status:
FINAL

SURVEY OVERVIEW

Alpine Ocean Seismic Survey, Inc. (Alpine) carried out a marine survey investigation on behalf of US Wind, Inc. (US Wind) to undertake High Resolution Geophysical (HRG), Geotechnical and Environmental surveys on the Outer Continental Shelf (OCS), in the Maryland Wind Energy Area (WEA). The surveys were conducted to support development of renewable wind energy by providing necessary data for linear siting of an export cable route, as well as supplying pertinent information and permitting and regulatory purposes.

The marine surveys covered an approximate 35 km long export cable route from mainland Delaware out to Outer Continental Shelf Lease numbers OCS-A 0489 and OCS-A 0490. The lease areas have been designated for development of renewable wind energy.

Survey operations were conducted in accordance with a Survey Plan developed to satisfy Bureau of Ocean Energy Management's (BOEM) "Guidelines for Providing Geophysical, Geotechnical, and Geohazard Information Pursuant to 30 CFR Part 585", and "Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585", both dated July 2015.

Offshore HRG data acquisition was carried out on board the RV *Shearwater*, which sailed to Ocean City, Maryland on 25-August-2016 with operations continuing until completed on 1-September-2016. Inshore HRG data acquisition was carried out from 10-October-2016 to 4-November-2016 with an additional reroute HRG survey being conducted from 20-September-2017 to 4-October-2017.

Bathymetric and geophysical data were collected aboard the RV *Shearwater* using a multibeam echosounder (MBES), side-scan sonar (SSS), shallow penetration sub-bottom profiler and a marine magnetometer. The inshore section of the cable route utilized a combined SSS and swathe bathymetry system, the Edgeteech 6205. The 6205 is a multiphase echosounder (MPES) and can be pole-mounted for shallower survey work.

An environmental and geotechnical survey was conducted on both the inshore and offshore sections of the cable route to gather underwater photography and video, benthic grab samples and vibracores. These combined data sets provided seafloor and sub-surface characterization needed to determine site suitability for installation of a submarine cable. The geotechnical survey aboard the RV *Shearwater* was conducted from 1-September-2016 to 14-September-2016 and the inshore geotechnical survey aboard the MV *George* was conducted 5-October-2017 to 14-October-2017.

Surveyed seafloor elevations across the offshore section (KP 0+000 to KP 44+050) of the export cable route ranged between approximately -2.8 and -31.1 m (MLLW). The seafloor generally dips in the offshore direction with an average slope of approximately 1.0˚. The seabed alternates between a relatively smooth surface, and in other areas takes on a more irregular appearance. Prominent sand ridges occur along the offshore section of the export cable route between KP 25+000 and KP 27+000. Surveyed elevations across the inshore section (KP 0+000 to KP 15+850) of the export cable route ranged between approximately 0.7 and -9.3 m (MLLW). The seafloor is relatively flat within the bay but exhibits areas of tidal scour near the cut banks along the Indian River as well as in areas west of Indian River Inlet. The seabed is moderately smooth along the survey corridor with sand ripples being observed along the tidal scour areas just west of the Indian River Inlet.

After analysis of the side scan sonar data set in the offshore route, a total of 271 sonar contacts were identified, 49 of which exhibited greater than 0.5m relief and 9 with more than 1m relief. Forty-four contacts are of apparent man-made origin - possibly related to debris, tires and fishing gear. The remaining contacts were classified as possible geology with most representing isolated coarse substrate areas (gravel and cobbles). Sonar contacts classified as geological were included in final contact reports per client request. The seabed along the route was mapped by analyzing sonar backscatter intensity. A variety of seabed sediments characterizes the route, ranging from silt-clay, sand, gravel, cobbles and possible small boulders. Sand ripple formation is common along the route, with distinct areas near the Delaware landing, as well localized areas further offshore.

The inshore cable route survey revealed a total of 356 contacts in addition to the 271 contacts identified in the offshore section of the cable route. A total of 23 of the observed targets exhibited relief greater than 0.5m and 3 were observed with relief greater than 1m. A large majority of the contacts are possible debris or fishing gear with a few contacts classified as possibly geological in origin. Most of the geological contacts are isolated rocks or possible boulders. Of the 356 side scan targets, 59 of them could be associated with magnetic anomalies. A large majority of these associations are likely fishing gear and a few possible geological contacts.

A total of 178 magnetic anomalies were identified during the export cable route survey. Of these, 134 anomalies are 25 nT or less and 29 are between 25 – 50 nT. Fifteen anomalies were greater than 50 nT, eight of which are over 75 nT in magnitude. A total of 1,756 magnetic anomalies were identified throughout the inshore portion of the export cable route in addition to the 178 anomalies identified in the offshore section of the cable route. Of all the targets, a total 384 magnetic anomalies exhibited amplitude values above 100 nT and 256 anomalies exhibited amplitude vales between 50 nT and 100 nT. All other anomalies had an amplitude of less than 50 nT.

In the offshore section of the route, the shallow penetration Chirp sub-bottom profiler was able to penetrate the seabed 10m or more in the majority of the survey area. The deepest regional reflector resolved occurs approximately 7 – 10 m below the seabed, and is mapped on the Alignment Sheets as the U1 Reflector. The next regional reflector identified occurs in the upper 1 – 3 m of the seabed, or is locally absent, and is mapped as the U2 Reflector. Figure 9.2 presents a comparison of sub-bottom profiles, the top profile collected by Alpine in 2016, and the bottom profile from Wells (1994). The comparison shows the similarity between the U2/A1 and U1/M2 reflectors. Paleochannel surfaces were also identified incising into the U1 and U2 reflectors, and were resolved down to depth of approximately 15 m below the seabed. The larger paleochannels typically display internal reflectors from depositional and erosional processes during recent sea level variations. Along the inshore cable route, the sub-bottom profiler was able to penetrate the seabed 4-6 m in most areas. Two different acoustic reflectors were mapped along the inshore portion of the export cable route corridor. The reflectors were identified as biogenic gas layers and internal reflectors. Many of the internal reflectors matched up well with vibracore samples taken along the route.

A total of 14 grab samples were acquired along the offshore section of the export cable route. The samples recovered primarily sandy sediments (fine to coarse grained), with some gravel and occasional cobbles. Fine-grained silt-clay was also recovered. A total of 17 grab samples were acquired along the inshore section of the export cable route. The samples recovered primarily silty-sandy sediments with some medium and coarse sand. Trace shell fragments and gravel were also recovered in select samples.

A total of 34 Vibracore locations were investigated along the export cable route. Core samples recovered a range of sediments including silt, clay sand and gravel. In some locations peat and other organic material was encountered. A total of 18 Vibracore locations were investigated along the inshore section of the export cable route. All 18 locations were sampled twice, one for physical analysis and one for chemical analysis. Sixteen locations were sampled a third time for thermal resistivity analysis excluding VC-IRB-16 and VC-IRB-17. The inshore core samples recovered a wide range of sediments and material including silt, clay, peat, organics, and sand. All core samples provided ground truthing of the sub-bottom data and generally correlate well with the sub-bottom interpretation.

SERVICE WARRANTY

USE OF THIS REPORT

This report has been prepared with due care and diligence and with the skill reasonably expected of a reputable contractor experienced in the types of work carried out under the contract and as such the findings in this report are based on an interpretation of data which is a matter of opinion on which professionals may differ and unless clearly stated is not a recommendation of any course of action.

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ALIGNMENT SHEETS

Offshore Route

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Alignment Sheet	1:5000	1	0+000	3+884
Alignment Sheet	1:5000	2	3+664	8+574
Alignment Sheet	1:5000	3	8+374	13+263
Alignment Sheet	1:5000	4	13+063	17+953
Alignment Sheet	1:5000	5	17+753	22+642
Alignment Sheet	1:5000	6	22+442	26+927
Alignment Sheet	1:5000	7	26+727	31+414
Alignment Sheet	1:5000	8	31+214	35+099
Alignment Sheet	1:5000	9	21+517	26+037
Alignment Sheet	1:5000	10	24+211	26+514

Inshore Route

Alignment Chart	Scale	Chart Number	Start KP	End KP
Alignment Sheet	1:5000	1	0+000	3+802
Alignment Sheet	1:5000	2	3+675	8+565
Alignment Sheet	1:5000	3	8+369	13+258
Alignment Sheet	1:5000	4	12+306	15+845

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GLOSSARY OF ABBREVIATIONS

Abbreviation	Meaning
AB	Acoustic Basement
cfm	Cubic feet per minute
CHIRP	Compressed High Intensity Radar Pulse
CORS	Continuously Operating Reference Station
DE	State of Delaware
DGPS	Differential Global Positioning System
DPR	Daily Progress Report
DTM	Digital Terrain Model
E&G	Environmental and Geotechnical
ft.	Feet
G&G	Geophysical and Geotechnical
GAMS	GPS Azimuth Measurement System
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
HRG	High Resolution Geophysical
Hz	Hertz
IMU	Inertial Measurement Unit
IRB	Indian River Bay
kHZ	Kilohertz
KP	Kilometer Post
kts	Knots
Lat	Latitude
Long	Longitude
m	Meter
MAG	Magnetometer
MBES	Multibeam Echosounder
MD	State of Maryland
nT	nanotesla
MV	Motor Vessel
NA	Not Applicable
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
PDOP	Position Dilution of Precision
PPK	Post Processing Kinematic
PPS	Pulse Per Second
psi	Pounds per Square Inch
RTK	Real Time Kinematic
QA/QC	Quality Assurance/Quality Control
RV	Research Vessel
SBP	Sub-bottom Profiler
SOW	Scope of Work
SSS	Side-Scan Sonar
SVP	Sound Velocity Profile
USCG	United States Coast Guard
USGS	United States Geological Survey
UTM	Universal Transverse Mercator Projection
VERTCON	North American Vertical Datum Transformation
WGS84	World Geodetic System 1984
XTF	eXtended Triton Format
ybp	Years before present

DEFINITIONS

Terminology	Definition
Acoustic basement	The deepest acoustic reflector able to be resolved in the sub-bottom profiler data, generally represents the upper surface of bedrock or coarse glacial till.
Acoustic penetration	The ability of acoustic waves to travel through the subsurface.
Acoustic reflector	A subsurface that causes the velocity of seismic waves to change and partial reflection of the acoustic energy.
Bedding/Layering	A stratified or layered feature associated with sedimentary rocks and/or loose sediments.
Bedform	Any oscillatory topographic deviations from flat bedding, produced by fluid movement including wave and current activity, such as sand ripples, mega ripples and sand waves.
Bedrock	The solid rock lying beneath superficial material such as silt, clay, sand, gravel or soils.
Boulder	A separated rock mass larger than a cobble, having a diameter greater than 200 mm. It is rounded in form or shaped by abrasion.
Clay	A complex mineral assemblage with particle size <0.002 mm
Coarse sediment	Sediment composed mainly of sand and gravel.
Cobble	A clast of rock defined as having a particle size of 64 mm to 256 mm
Cohesive sediment	Sediments, typically clay and/or silty clay that resist separation due to nature of bonds between fine-grained particles.
Debris	Unknown sonar contacts attributed to human activity.
Fine sediment	Sediment composed mainly of fine sand, silt, and clay.
Gravel	An unconsolidated accumulation consisting of particles larger than sand (diameter 2 mm – 60mm).
Loose sediment	Not cemented sediment, either cohesive or not.
MLLW	Tidal datum that is the arithmetic mean of the lower low water heights of each tidal day observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observational comparisons are made with a control tide station to derive the equivalent of the National Tidal Datum Epoch. MLLW has been designated for use in lieu of MLW as the adopted reference NOS chart and sounding datum in most coastal tidal waters per the National Tidal Datum Convention of 1980.
Ridge	A long narrow raised portion of the seafloor, relative to its surroundings.
Rock outcrop	Rock that is exposed at the seafloor.
Sand	A detrital particle larger than a silt grain and smaller than a gravel, having a diameter in the range of 0.062 mm to 2 mm.
Very coarse sediment	Sediment composed mainly of cobbles and boulders.

1 INTRODUCTION

Alpine Ocean Seismic Survey, Inc. (Alpine), on behalf of US Wind, Inc. (US Wind) performed High Resolution Geophysical (HRG), Geotechnical and Environmental surveys adjacent to the Maryland Wind Energy Area (WEA) located on the Outer Continental Shelf (OCS). The project consisted of an offshore scope of work completed on Alpine's 110' survey vessel, the RV *Shearwater*, and an inshore scope of work completed with Alpine's smaller survey vessels, the MV *William M* and the MV *George.* The surveys were performed to support development of an export cable extending from the site of a proposed wind farm, westward through Indian River Bay and terminating at the Indian River Power Plant near Millsboro, Delaware. The Offshore scope of work included bathymetric, high-resolution geophysical, environmental, and geotechnical surveys along a 300 meter wide cable corridor. The inshore scope of work consisted of bathymetric, high-resolution geophysical (HRG) and environmental and geotechnical (E&G) surveys in a 500 meter wide cable corridor within Indian River Bay. The overall route for both offshore and inshore survey can be seen in Figure 1.1. All survey procedures were conducted in accordance with lease requirements (OCS-A 0489 and OCS-A 0490) as modified by the US Wind Survey Plan that was approved by the Bureau of Ocean Energy Management (BOEM) on 3-June- 2015. This report covers the survey operations and data results for the US Wind export cable survey, as carried out by Alpine, for the offshore, inshore and reroute sections of the route.

The surveys included protected species mitigation measures as detailed in the lease and described in the Marine Mammal Mitigation Plan submitted to BOEM prior to the onset of survey activities. The offshore surveys were conducted during 24-hr operations with continuous visual observations by qualified Protected Species Observers (PSO). In addition to visual monitoring, a Passive Acoustic Monitoring system (PAMS) was installed on the survey vessel with trained personnel operating the equipment at all times during survey operations, ramp ups, and during shut downs. For more information on protected species mitigation, refer to Appendix N of this report, which includes a detailed PSO report for each phase of survey operations.

The RV *Shearwater* conducted the offshore surveys, and was mobilized in Ocean City, MD during the period 23-August-2016 to 15-September-2016. The MV *William M* Conducted the main inshore HRG survey from the 10-October-2016 to 04-November-2016 and surveyed a reroute section from the 20-September-2017 to 04-October-2017. The MV *George* completed E&G operations from the 05-October-2017 to 14-October-2017.

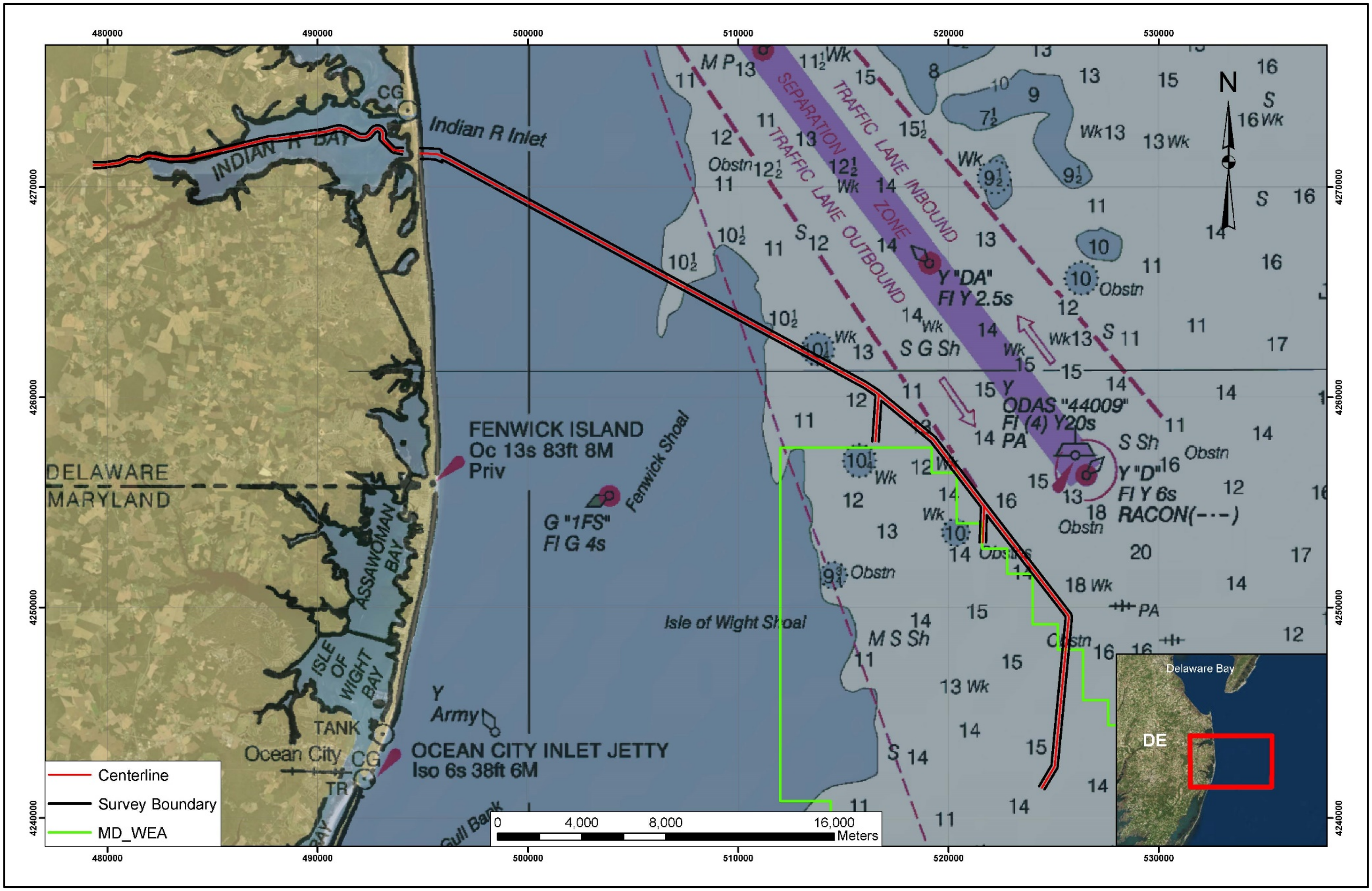


Figure 1.1 Survey location map – Export Cable Survey Route

The surveys were in line with lease requirements and according to specifications described in BOEM's "Guidelines for Providing Geophysical, Geotechnical, and Geohazard Information Pursuant to 30 CFR Part 585", and "Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585", both dated July 2015.

1.1 Purpose

US Wind contracted Alpine Ocean Seismic Survey, Inc. (Alpine) to undertake the bathymetric, marine high-resolution geophysical (HRG), environmental, and geotechnical surveys for the export cable that extends from the proposed wind farm lease block offshore Maryland and terminates at the Indian River Power Plant.

The project consisted of the following scope of work:

1. Perform bathymetric, HRG, geotechnical, and environmental surveys for the offshore section of the 300 meter wide export cable corridor using the RV *Shearwater*
2. Perform bathymetric and HRG surveys for the 500 meter wide cable corridor within Indian River Bay using Alpine's shallow draft vessel, the MV *William M* (report to be updated under separate cover)
3. Perform a geotechnical and environmental survey for inshore locations using Alpine's shallow water coring platform, the MV *George*.

This report presents the results for all HRG and E&G phases of survey.

1.2 Fieldwork Summary

Table 1.1 Field work summary – Offshore Phase

Fieldwork Summary – Offshore Phase			
Program	Survey Vessel	Task	Dates
Mobilization	RV *Shearwater*	Travel to Ocean City, Maryland, Mobilize survey equipment, perform calibrations	23-Aug-2016 to 25-Aug-2016
Offshore Bathymetric and HRG Surveys	RV *Shearwater*	Survey using multibeam bathymetry, side scan, sub-bottom, and marine magnetometer	25-Aug-2016 to 01-Sept-2016
Offshore E&G Surveys	RV *Shearwater*	Sample sediments using vibracore and day grab; perform underwater video and camera investigation	01-Sept-2016 to 14-Sept-2016
Demobilization	RV *Shearwater*	Demobilize all equipment and travel back to Norwood, NJ	14-Sept-2016 to 16-Sept-2016

Table 1.2 Field work summary – Inshore Bathymetry and HRG Survey

Fieldwork Summary – Inshore Bathymetry and HRG Phase			
Program	Survey Vessel	Task	Dates
Mobilization	MV *William M*	Travel to Indian River Bay, Delaware, Mobilize survey equipment, perform calibrations	10-Oct-2016 to 13-Oct-2016
Inshore Bathymetric and HRG Surveys	MV *William M*	Survey using multibeam bathymetry, side scan, sub-bottom, and marine magnetometer	13-Oct-2016 to 03-Nov-2016
Demobilization	MV *William M*	Demobilize all equipment and travel back to Norwood, NJ	03-Nov-2016 to 04-Nov-2016

Table 1.3 Field work summary – Inshore Bathymetry and HRG Re-route

Fieldwork Summary – Inshore Bathymetry and HRG Re-route			
Program	Survey Vessel	Task	Dates
Mobilization	MV *William M*	Travel to Indian River Bay, Delaware, Mobilize survey equipment, perform calibrations	20-Sept-2017 to 22-Sept-2017
Inshore Bathymetric and HRG Surveys	MV *William M*	Survey using multibeam bathymetry, side scan, sub-bottom, and marine magnetometer	22-Sept-2017 to 03-Oct.-2017
Demobilization	MV *William M*	Demobilize all equipment and travel back to Norwood, NJ	04-Oct.-2017

Table 1.4 Field work summary – Inshore Geotechnical and Environmental

Fieldwork Summary – Inshore Geotechnical Phase			
Program	Survey Vessel	Task	Dates
Mobilization	MV *George*	Travel to Indian River Bay, Delaware, Mobilize survey equipment	5-Oct.-2017

Fieldwork Summary – Inshore Geotechnical Phase			
Inshore Environmental and Geotechnical survey operations	MV *George*	Survey using a vibracore, day grab sampler and underwater camera.	6-Oct.-2017 to 13-Oct-2017
Demobilization	MV *George*	Demobilize all equipment and travel back to Norwood, NJ	14-Oct-2017

1.3 Time Breakdown by Phase

The offshore bathymetric, HRG, geotechnical, and environmental phase of the project totaled 486:10 hours, with 224:27 being operational survey hours.

Table 1.5 Time Breakdown – Offshore Survey RV *Shearwater*

Activity	Project Hours	Percentage of Total
Operational Survey	224:27:00	46.17%
Calibrations	2:45:00	0.57%
Standby (weather)	163:50:00	33.70%
Survey Downtime	1:15:00	0.26%
Mobilization / Demobilization	87:00:00	17.90%
Vessel Downtime	1:35:00	0.32%
MMO Shutdown	5:18	0.32%
Total	**486:10:00**	100.00%

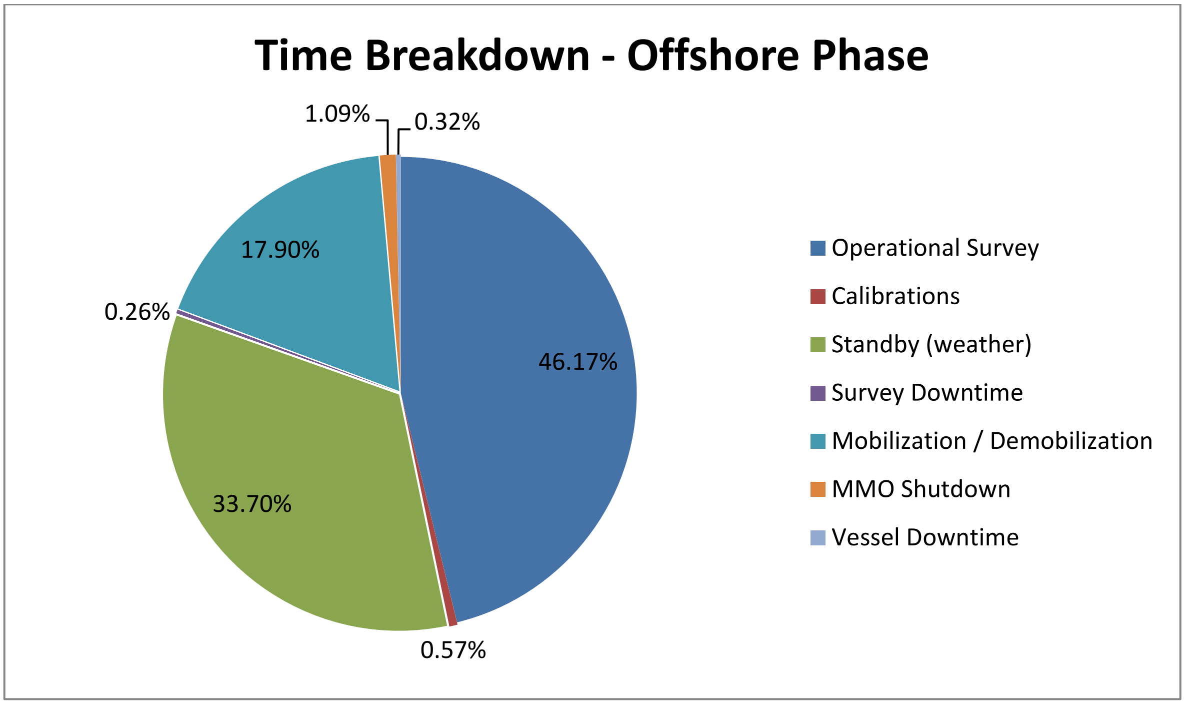


Figure 1.2 Time breakdown for offshore HRG, environmental, and geotechnical phase

The inshore IRB HRG project scope totaled 538:32 hours, with 360:12 being operational survey hours.

Table 1.6 Time breakdown inshore IRB HRG survey

Activity	Project Hours	Percentage of Total
Operational Survey	360:12:00	66.89%
Standby (weather)	65:30:00	12.16%
Standby on Client	36:00:00	6.68%
Mobilization / Demobilization	72:20:00	13.43%
Vessel Downtime	4:30:00	1.73%
Total	**538:32:00**	100.00%

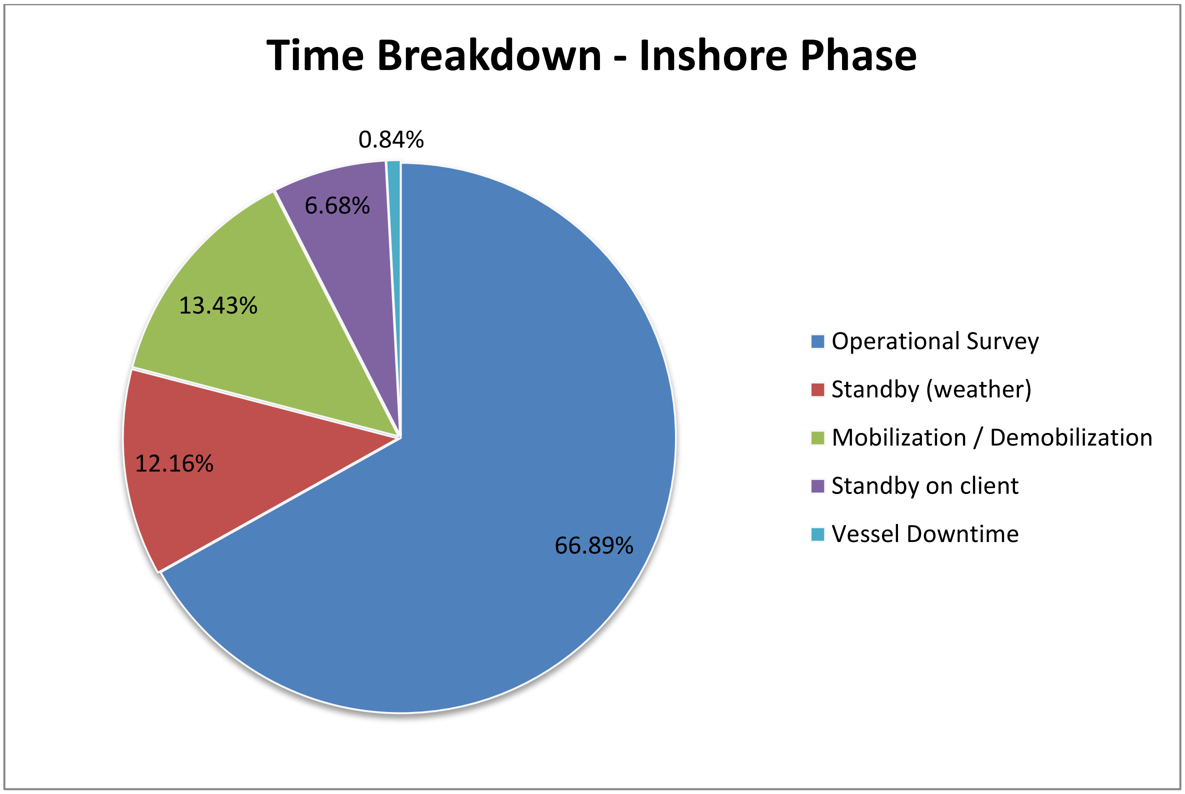


Figure 1.3 Time breakdown for inshore IRB, HRG, environmental and geotechnical phase

2 VESSEL SUMMARY

2.1 Offshore Scope – RV *Shearwater*

The RV *Shearwater* was used for the HRG, environmental, and geotechnical survey work along the offshore portion of the US Wind Export Cable route. The RV *Shearwater* is a multi-purpose survey vessel with capabilities to perform bathymetric and high-resolution geophysical surveys, geotechnical investigations, and environmental studies. The *Shearwater* has two fast-action hydraulic winches and a heavy-duty (S.W.L. 8,000 lbs) overhead crane for heavy operations.

Table 2.1 Vessel Specifications – RV *Shearwater*

RV *Shearwater* Vessel Specifications	
Class	Multi-Role Survey
Flag	USA
Built	1981 (reconfigured 2011)
Length OA	33.5m
Breadth OA	11.9m
Draft	2.7m
GT	198t
Endurance	21 days (nominal)
Main Engine	2 x 526 HP John Deere Model 6125AFM
Bow thrust/Stern Thrust	Thrustmaster 100 HP / Hydraulically Driven “Z” Drives
Accommodation	20 Berths

Figure 2.1 Vessel RV Shearwater

2.2 Inshore IRB HRG Survey – MV *William M*

The MV *William M* was used for the bathymetric and geophysical survey work in Indian River Bay. The MV *William M* is 22 ft. long by 8 ft. wide, and is equipped with dual outboard engines. The shallow draft vessel is custom fitted to perform efficient, safe, and repeatable surveys. The vessel features a cabin and back deck with side davit, dedicated side-mount and bow-mount brackets for equipment installation, and a winch.

Table 2.2 Vessel Specifications – MV *William M*

MV *William M* Vessel Specifications		Performance	
LOA	22 ft.	Top Speed	30 kts
Beam	8 ft.	Cruise	25 kts
Draft	2 ft.	Range	100 nm
Fresh Water Capacity	N/A	Generator	3kW
Power	Twin Yamaha 115	Fuel Capacity	60 Gal

Figure 2.2 Vessel MV *William M*

2.3 Inshore IRB Environmental and Geotechnical Survey – MV *George*

The MV *George* was used for the environmental and geotechnical survey work in Indian River Bay. The MV *George* is 24 ft. long by 8 ft. wide, and is equipped with a single 115 HP engine. The pontoon boat is custom fitted to perform geotechnical and environmental surveys. The vessel features a covered area, a pilot's seat and a large A-frame and winch.

Table 2.3 Vessel Specifications – MV *George*

MV *George* Vessel Specifications		Performance	
LOA	24 ft.	Top Speed	20 kts
Beam	8 ft.	Cruise	15 kts
Draft	2.5 ft.	Range	50 nm
Fresh Water Capacity	N/A	Generator	3kW
Power	Mercury 115 HP	Fuel Capacity	20 Gal

Figure 2.3 Vessel MV *George*

3 SAFETY

Safety standards and procedures on board all Alpine vessels adhere to company policy which operates under the guidance of Alpine's Health and Safety Manual for Marine Geophysical Operations and is administered by the company's Health and Safety Officer. Every crew member is given a safety induction upon joining the vessel and regular toolbox meetings are also conducted prior to back deck operations, equipment deployment and recovery.

During the offshore scope of operations, a total of 45 toolbox meetings were completed. During the inshore HRG and E&G operations, a total of 21 toolbox meetings were completed.

Start of day and end of day check-ins were completed by the Party Chief with the designated onboard client representative.

3.1 Exposure Hours – Offshore HRG and E&G Scope of Work

The survey and marine crew averaged 18 persons for the majority of the survey operations. The total numbers of exposure hours from onsite mobilization on 23-August-2016 to survey completion on 15-September-2016 was 8646 hours during which there were no lost time incidents, no injurious incidents and no occurrences that resulted in damage to the environment.

3.2 Exposure Hours – Inshore IRB HRG Scope of Work

The survey and marine crew totaled 3 persons for the majority of the survey operations. The total number of exposure hours from onsite mobilization on 10-October-2016 to survey completion on 03-November-2016 was 867 hours during which there were no lost time incidents, no injurious incidents and no occurrences that resulted in damage to the environment.

3.3 Exposure Hours – Inshore IRB HRG-Reroute Scope of Work

The survey and marine crew totaled 3 persons for the majority of the survey operations. The total number of exposure hours from onsite mobilization on 20-September-2017 to survey completion on 04-October-2017 was 516 hours during which there were no lost time incidents, no injurious incidents and no occurrences that resulted in damage to the environment.

3.4 Exposure Hours – Inshore IRB E&G Scope of Work

The survey and marine crew totaled 3 persons for the majority of the survey operations. The total number of exposure hours from onsite mobilization on 06-October-2017 to survey completion on 14-October-2017 was 396 hours during which there were no lost time incidents, no injurious incidents and no occurrences that resulted in damage to the environment.

4 CREW LIST

4.1 Crew List – Offshore Surveys

The following personnel were present on board the survey vessel during mobilization, calibration and survey operations on the offshore scope of the US Wind project.

Table 4.1 Field Personnel – Offshore Scope of Work

Personnel – Offshore Scope of Work			
Bathymetry and HRG Survey		**Period**	
Party Chief	Daniel Whitesell	23-Aug -2016	15-Sept-2016
Navigation/Hydrographic Surveyor	Dario Manchia	23-Aug -2016	02-Sept-2016
Navigation/Hydrographic Surveyor	Marcus Kwasek	23-Aug -2016	02-Sept-2016
Geophysical Surveyor	Mitchell Kennedy	23-Aug -2016	15-Sept-2016
Geophysical Surveyor	Ben Manze	23-Aug -2016	02-Sept-2016
Processor	Cameron Morissette	23-Aug -2016	03-Sept-2016
Processor	Brent Johnston	23-Aug -2016	03-Sept-2016
Captain	Wayne Porter	23-Aug -2016	15-Sept-2016
Captain	Mike Masek	23-Aug -2016	15-Sept-2016
Captain	Nick Jurich	23-Aug -2016	15-Sept-2016
Deckhand	Sean Kelleher	23-Aug -2016	07-Sept-2016
Deckhand	Joe Scotch	23-Aug -2016	15-Sept-2016
Cook	Bobby Lamton	23-Aug -2016	15-Sept-2016
US Wind Representative	Keir Miller	23-Aug -2016	15-Sept-2016
Marine Mammal Observer	Sharon Doake	23-Aug -2016	15-Sept-2016
Marine Mammal Observer	Jack Allum	23-Aug -2016	15-Sept-2016
Marine Mammal Observer	Crystal Lee Shaw	23-Aug -2016	26-Aug -2016
Marine Mammal Observer	Felix Smith	23-Aug -2016	02-Sept-2016
Marine Mammal Observer	Sian Ponting	29-Aug -2016	15-Sept-2016
Environmental & Geotechnical Survey		**Period**	
Party Chief	Bill Rottner	30-Nov-2016	15-Sept-2016
Geotechnical Engineer	Ovidio Hernandez	30-Nov -2016	15-Sept-2016
Geotechnical Engineer	Mitchell Kennedy	23-Aug -2016	15-Sept-2016
Protected Species Observer	Sharon Doake	23-Aug -2016	15-Sept-2016
Protected Species Observer	Sian Ponting	29-Aug -2016	15-Sept-2016
Surveyor	Robert Vietri	03-Dec-2016	15-Sept-2016
Environmental Scientist	Jack Allum	23-Aug -2016	15-Sept-2016
ESS Representative	Stephanie Martin	23-Aug -2016	09-Sept-2016
ESS Representative	Mike Phillips	06-Sept -2016	09-Sept-2016
US Wind Representative	Keir Miller	06-Sept -2016	15-Sept-2016

4.2 Crew List – Inshore Surveys

The following personnel were present on board the MV *William M* and MV *George* during mobilization, calibration and survey operations on the inshore IRB HRG phase as well as the E&G phase of the US Wind project.

Table 4.2 Field Personnel – Inshore HRG and E&G Survey

Personnel– Inshore Scope of Work			
Geophysical Survey		**Period**	
Party Chief / Vessel Master	Cameron Morissette	10-Oct-2016	03-Nov-2016
Navigator/Hydrographic Surveyor	Phil Morton	10-Oct-2016	03-Nov-2016
Navigator/Hydrographic Surveyor	Ralph Morris	19-Oct-2016	03-Nov-2016
Geophysical Surveyor	Mitchell Kennedy	10-Oct-2016	19-Oct-2016
Geophysical Surveyor	Ben Manze	19-Oct-2016	24-Oct-2016
Client Representative	Laurel Gionet-Kenyon	13-Oct-2016	19-Oct-2016
Geophysical-Reroute Survey		**Period**	
Party Chief	Matt Slusher	20-Sept-2017	4-Oct-2017
Surveyor	Dennis Wilson	20-Sept-2017	4-Oct-2017
Surveyor	Mitchell Kennedy	25-Sept-2017	30-Sept-2017
Surveyor	Phil Morton	1-Oct-2017	4-Oct-2017
Environmental and Geotechnical		**Period**	
Party Chief	William Rottner	5-Oct-2017	9-Oct-2017
Party Chief	Mitchell Kennedy	10-Oct-2017	14-Oct-2017
Surveyor	Mitchell Kennedy	5-Oct-2017	9-Oct-2017
Surveyor	Dario Manchia	10-Oct-2017	14-Oct-2017
Environmental Scientist	David Reynolds	5-Oct-2017	14-Oct-2017

5 SURVEY PARAMETERS

5.1 Project Geodetics

Table 5.1 Project Geodetics

Datum and Projection Parameters:		
Geodetic datum	NAD83	
Ellipsoid	GRS-1980	
	semi-major axis (a)	6,378,137.000 m
	Semi-minor axis (b)	6,356,752.314 m
	inverse flattening (1/f)	298.257222101
	eccentricity (e)	0.0818191910435
Projection	Universal Transverse Mercator Zone 18N	
	origin latitude	0°
	origin longitude	-75°
	origin false easting	500000.00
	origin false northing	0.00
	Scale factor	0.9996
	grid unit	meters

5.2 Vertical Datum

A post-processed GNSS solution was used to relate the bathymetry to the project tidal datum, Mean Lower Low Water (MLLW), using the VDATUM vertical datum transformation model.

Tidal elevations were derived by post-processing GNSS and motion data logged throughout the survey period to produce a highly accurate vessel position and to recover the full spectrum of motion – heave, squat, settlement and tide. The raw GNSS/IMU data is post-processed using Applanix PosPac 7.2 software to achieve a tightly-coupled PPK/INS solution.

The post-processed GNSS/IMU positions were reported in NAD83(2011) reference frame, referred to the GRS80 reference ellipsoid, and exported from PosPac as the Smoothed Best Estimate of Trajectory (SBET) file, typically at 100 Hz.

Tidal reduction was carried out within Caris HIPS software. The SBET file was applied to data on a line by line basis. This element of the processing essentially removes the measured heave from the bathymetry and substitutes the processed SBET GNSS altitude. Application of an extracted VDATUM MLLW surface was applied as the reference data for the tidal reduction. This stage of the process uses a network of points with the ellipsoid to MLLW separation bounding the survey area, to transform the height reference of the bathymetry to project datum.

6 SURVEY EQUIPMENT AND PROCEDURES

6.1 Offshore HRG Survey

6.1.1 General

The offshore scope of the US Wind export cable HRG survey involved a hydrographic and geophysical investigation of the seafloor along a 300 meter wide cable corridor. The cable corridor extends from lease blocks OCS-A 0489 and OCS-A 0490 to the coastal zone south of Indian River Inlet and was surveyed to minimum water depths of 5 m for vessel safety. Horizontal drilling technology will be incorporated at a later time in order to extend the export cable under the beach and into Indian River Bay, where it will extend approximately 15 kilometers eastward to the Indian River Power Plant.

All data were acquired in accordance to Alpine standard operating procedures and in line with industry standard practices.

6.1.2 Summary of Offshore HRG Survey Design

The survey design was based on the US Wind Survey Plan that was approved by BOEM prior to the beginning of survey operations. The US Wind Export cable corridor is 300 meters in width for the offshore section between the wind farm area and the three nautical mile line (boundary between state and federal waters). Primary line spacing in this offshore section was 30 m. From the three nautical mile line landward the line spacing changed to 15.24 m (50 ft). The survey corridor expanded to 500 m between the Delaware shoreline to a point 1,000 m from the offshore (Figure 6.1) Tie lines, or lines run perpendicular to the primary lines, were run at a 500m spacing throughout the entire offshore survey. A survey of a 500 m wide corridor was conducted in the Indian River Bay in 2016 and a reroute was added in 2017. Primary line spacing was 15.24 m (50 ft.) for this phase and the line plan can be seen in Figure 6.2. Survey parameters for all areas of the export cable route can be seen in Table 6.1.

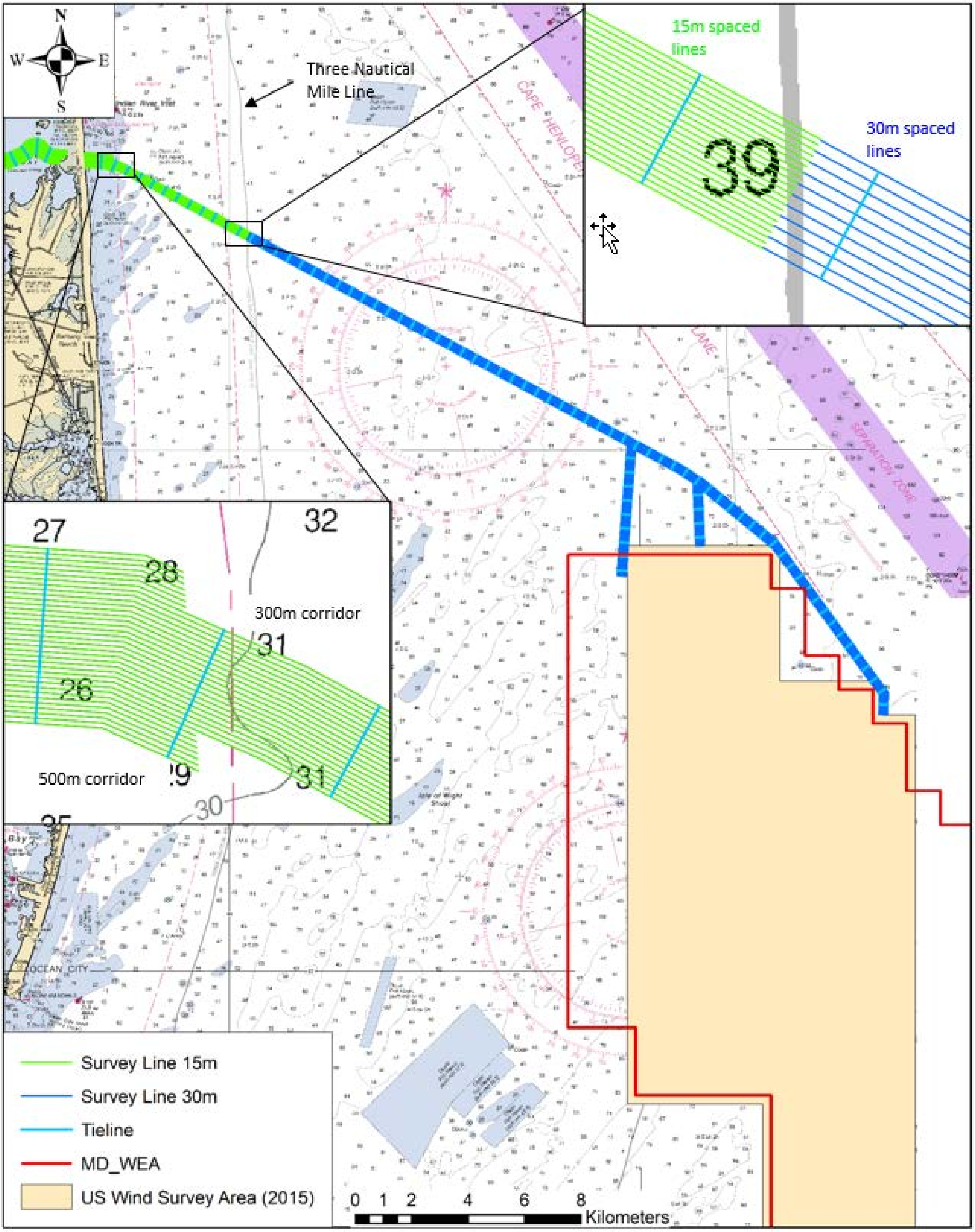


Figure 6.1 Offshore export cable survey line plan

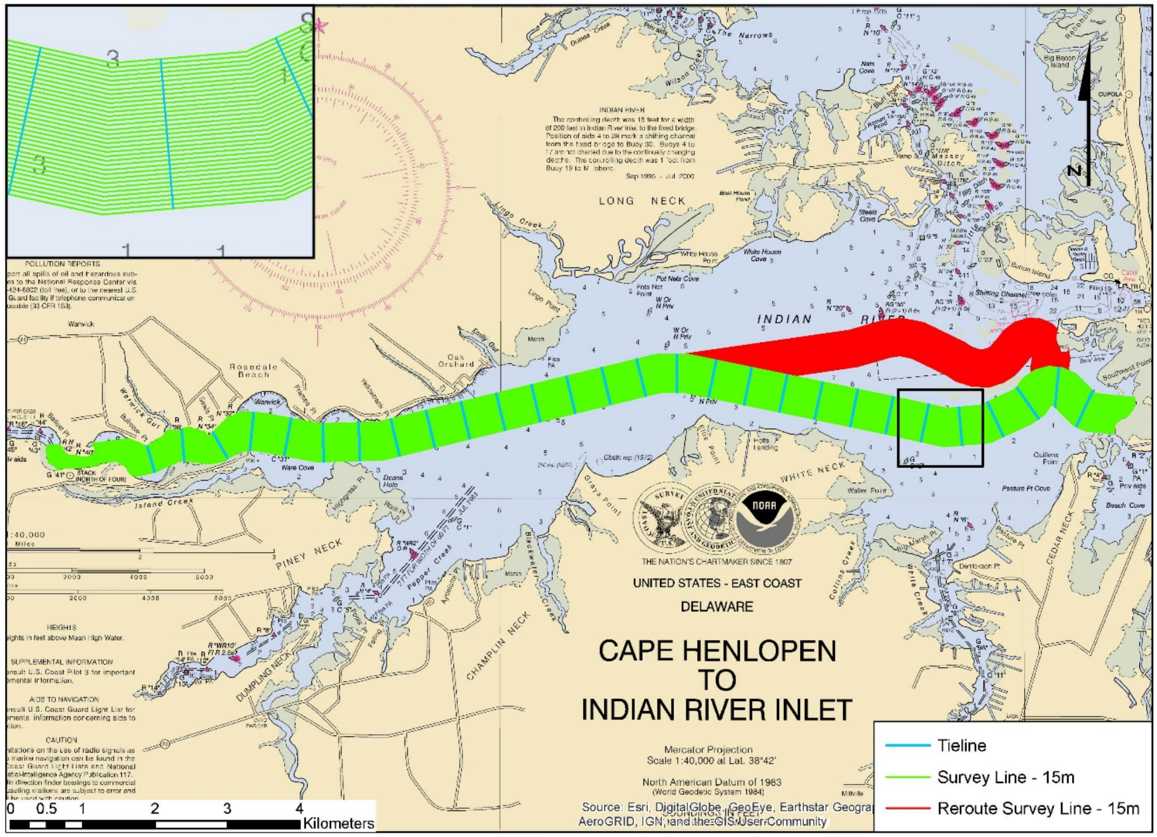


Figure 6.2 Inshore export cable survey line plan with reroute

Table 6.1 Survey Design Parameters

Offshore Section	Corridor Width	Line Spacing
Delaware Shoreline – 1,000 m offshore	500 m	15.24 m (50 ft)
1,000 offshore to three nautical mile line	300 m	15.24 m (50 ft)
Three nautical mile line to wind farm area	300 m	30 m

Alpine collected multibeam bathymetry, SSS, high-resolution CHIRP SBP, and MAG data within the offshore section. Bathymetry and side scan data are required to provide an understanding of seafloor depths, morphologies, and characteristics, while shallow-penetration sub-bottom data will help engineers understand the subsurface geologic structures that may be encountered during cable laying procedures. The marine magnetometer was used in order to detect any ferrous/magnetic targets that may exist along the planned cable route.

Multibeam bathymetry provided greater than 100% coverage for the entire offshore export cable route. Side scan sonar range was set to 75 meters for the duration of the offshore survey, providing greater than

200% coverage for the entire corridor.

6.1.3 Survey Equipment and Methods

6.1.3.1 Vessel Configurations

The RV *Shearwater* provided the survey platform to conduct the bathymetric and geophysical investigation on the offshore phase of the route. The RV *Shearwater* provides a large aft deck, winch, and cabin space for topside survey electronics. The SSS and MAG towfish were deployed from the aft A-frame, through an electronic cable counter pulley, and connected to a hydraulic winch. The MBES transducer was hull mounted in the forward section of the ship, and the sub-bottom (CHIRP) and USBL transducers were mounted in the starboard moonpool approximately amidships. Details of equipment calibrations are included in Appendix E.

Table 6.2 Vessel Offsets and Equipment – RV *Shearwater*

VESSEL: RV Shearwater				
Offsets from Reference Point in Meters		+ forward/ - backward	+ right/ - left	+ up/ - down
Primary GPS Antenna (P)	○	0.978	-1.591	5.043
Secondary GPS Antenna (S)	○	-0.974	1.808	5.042
Internal Measurement Unit (IMU)	□	0.000	0.000	0.000
Waterline	—	---	---	-3.959
Multibeam Echosounder Transducer (MBES)	■	3.037	-0.729	-6.070
USBL Transceiver	●	-0.780	4.206	-6.551
Chirp Sub-bottom Transducer	■	-0.628	3.825	-6.286
Side-scan Block Sheave		-16.810	0.005	-3.959
Magnetometer Offset from SSS (MAG)		-10.000	---	---

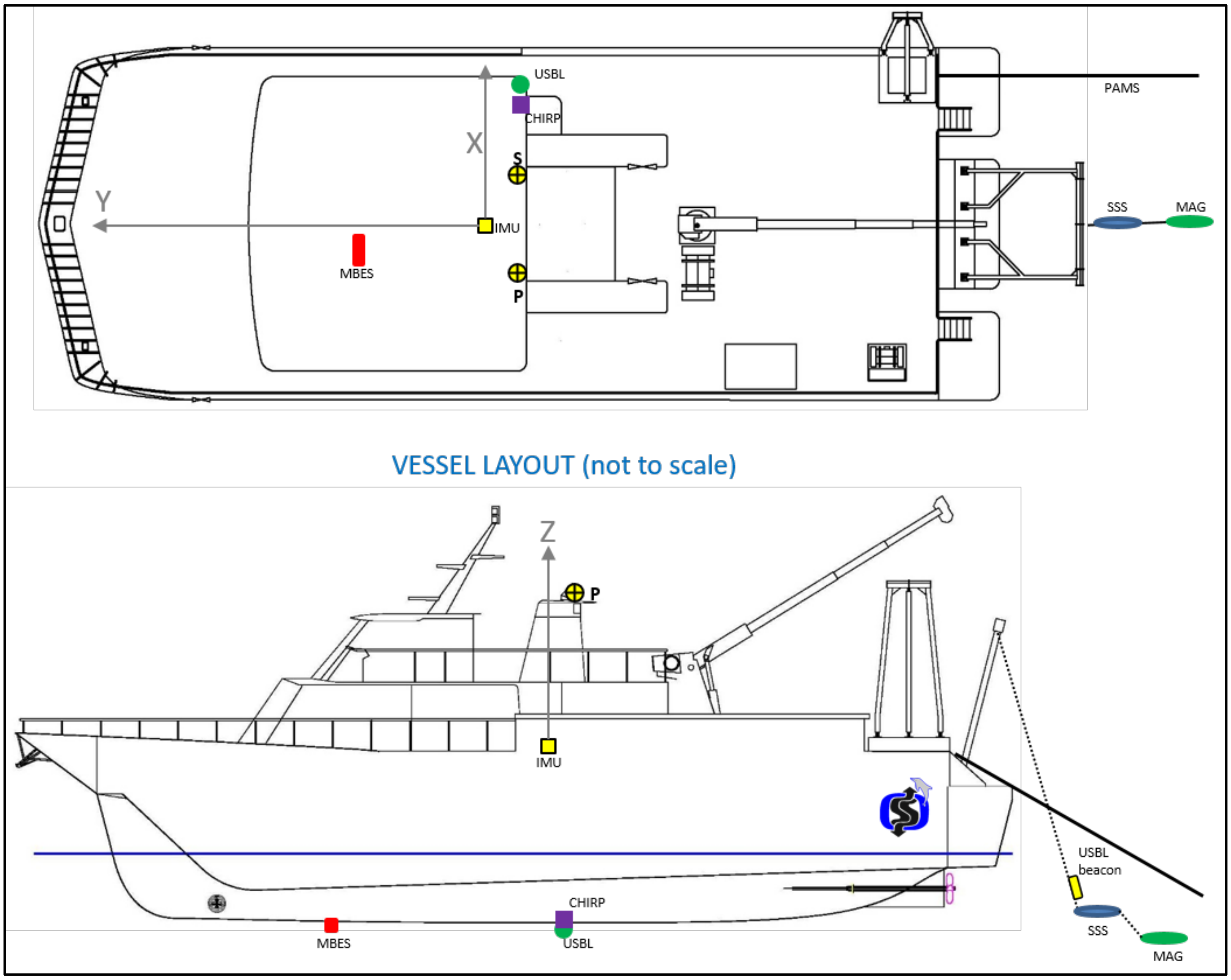


Figure 6.3 RV *Shearwater* HRG Offset Diagram

Table 6.3 RV *Shearwater* HRG Survey Equipment

Equipment Type	Equipment Model
Primary GNSS	Applanix POS MV
Heading Sensor / Motion Sensor	Applanix POS MV
Multi-beam Echosounder (MBES)	RESON 7125
Side Scan Sonar (SSS)	Klein 3900
Sub-bottom Profiler (SBP)	Benthos CHIRP III
Magnetometer (MAG)	Geometrics G882 cesium vapor magnetometer
Ultra-Short Base Line (USBL)	Sonardyne Scout Pro
Sound Velocity Probe (SVP)	Sontek CastAway CTD
Navigation, Multi-beam, Side Scan Sonar, Sub-bottom and Magnetometer Data Acquisition software	QPS QINSy, Klein SonarPro, CTI SonarWiz, Geometrics' MagLog

6.1.3.2 Vessel and Equipment Navigation

The Applanix POS MV 320 DGNSS was used for navigation control during the survey. The POS MV was interfaced with a Trimble NavBeacon beacon receiver which uses the local USCG reference station in order to calculate a differential correction for a vessel's location. Differential corrections were received from the USCG station in Annapolis, MD. This system, which includes a GPS aided Inertial Measurement Unit (IMU), provided precise real-time dynamic sub-meter positioning including heading, heave, pitch and roll.

Aboard the RV *Shearwater* the IMU was mounted on the floor of the survey laboratory near the vessel's center of rotation/gravity. The GPS antennas were mounted above ship's bridge roof, aligned normal to the longitudinal axis of the vessel. Offsets between the GPS antennas, IMU and all other fixed mounting points for the other geophysical sensors were precisely measured before conducting onsite calibrations.

6.1.3.3 Ultra-short Baseline (USBL) Acoustic Positioning System

A Sonardyne Scout Pro USBL acoustic positioning system was used to calculate towfish position (SSS & MAG) in real-time on board the RV *Shearwater.* The system utilizes a hull mounted transceiver (installed on the starboard side moon pool next to the CHIRP transducer) and a transponder (beacon), which is fixed to the armored cable just above the SSS towfish. The USBL transceiver was tilted aft approximately 30 degrees in order to improve system range and performance in shallow water. The USBL system was interfaced to the QINSy navigation software, which exported corrected sensor positions to the SSS and MAG logging computers.

The USBL system was calibrated using QINSy's calibration routine in approximately 25m water depth. The USBL system is interfaced with QINSy software and the Applanix POS MV which provides precise positioning, heave, pitch and roll values. Upon locating a site with a suitable water depth for calibration, a series of calibration lines were established and run. The calibration results are presented in **Error! Not a valid bookmark self-reference.** below and detailed calibration procedures are presented in Appendix E.

Table 6.4 USBL Calibration Results

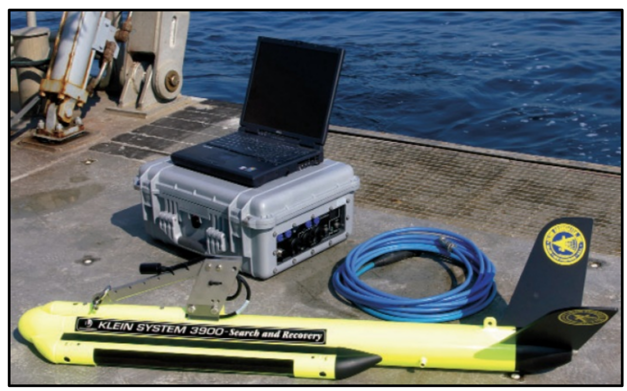
Roll Angle	Pitch Angle	Heading Angle
-2.83°	-28.82°	4.15°

6.1.3.4 High-resolution CHIRP Sub-bottom Profiler

A Teledyne Benthos CHIRP III Profiler system was used to generate the sub-bottom acoustic signal, which was transmitted through a set of four transducers mounted on the starboard-side moon pool of the vessel. The transducers were wired in parallel for maximum transmit power and optimum signal reception.

Each pulse consists of a swept frequency (2 - 7 kHz) operated at a 15ms pulse length. The system was operated using a 125ms sweep length, providing for greater than 90m of recorded data. The signals were received and digitized using the CHIRP topside unit. The CHIRP system received positioning information from the QINSy software so that all the data were continuously geo-referenced. Real-time bottom tracking and display gains were applied to the data in the field using Chesapeake Technologies' SonarWiz software for quality control, and the data were recorded in SEGY format. SonarWiz also provides post-processing capability where the user can perform seafloor tracking, adjust gains and map and export sub-surface reflectors or features.

6.1.3.5 Side-scan Sonar System



A Klein model 3900 dual-frequency (455/900 kHz) SSS system was used to collect the side scan data during the survey. The system was interfaced with the QINSy navigation and all data were continuously geo-referenced. Sonar XTF files were recorded using Klein's SonarPro software platform. With SonarWiz the XTF files can be corrected for pitch, roll, slant range, gains and generation of a sonar mosaic at a user specified resolution. Sonar contacts can be picked, measured, saved and exported in a contact report.

Aboard the RV *Shearwater* the towfish height off seafloor was maintained at 10-20% of the sweep range using a deck mounted hydraulic winch and armored cable. The towfish position was calculated in real-time using the USBL system. A backup positioning system was also used, utilizing a digital cable counter sheave to measure cable out from the stern of the vessel.

The sweep range was set to 75m per channel resulting in a 150m total swath. The system was operated and recorded using a frequency of 455 kHz. All data were displayed in a waterfall format on a high definition LCD monitor during the survey work so that the operator could note any significant targets in the field.

The Klein 3900 Side Scan Sonar system was wet tested and data were collected to ensure proper acoustic imagery acquisition. The data were processed in SonarWiz to generate a mosaic and verify object detection and positioning.

6.1.3.6 Marine Magnetometer System

A Geometrics G-882 cesium vapor marine magnetometer was towed directly behind the SSS towfish using an umbilical cable. This towing configuration was ideal for controlling the altitude of the MAG, which was flown at the optimal distance (less than six meters) from the seafloor, where possible. The MAG data were viewed in real time on board the survey vessel, and recorded in MagLog at 10 Hz along all survey lines. The position of the magnetometer was determined using a fixed layback behind the USBL calculated position of the SSS towfish.

6.1.3.7 Multibeam Echosounder (MBES)

A RESON 7125 multibeam echosounder system was used to collect the bathymetric data. On the RV *Shearwater* the transducer was hull-mounted on the forward section of the vessel. Once appropriate settings of power and gain were determined, the system was calibrated for pitch, roll, and yaw by running a patch test. This data were then run through a series of calibrations in a post-processing software package (Caris) to determine the calculated calibration values for pitch, roll, and yaw. Calibration results for the MBES are included in Table 6.5. Detailed calibration procedures and results are included in Appendix E.

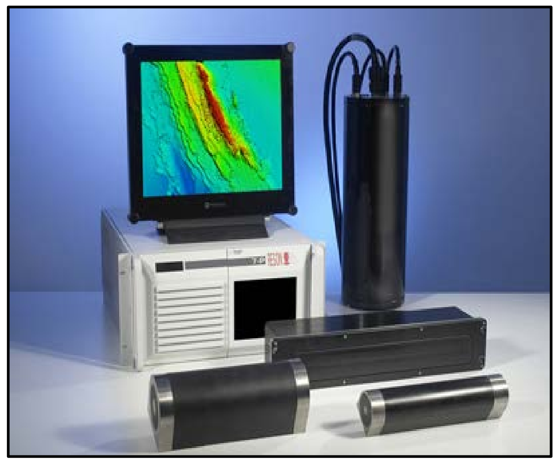


Table 6.5 MBES calibration values

Motion	Correction
Pitch	1.17°
Roll	-1.99°
Yaw	0.90°

Data were collected using a signal transmitted at a frequency of 400 kHz and variable settings were used for range/pulse-length and gain for optimal data quality. The speed of sound in water was determined using a Castaway CTD Sound Velocity Profiler (SVP). The SVP sensor data were used to generate a profile of the speed of sound, which was then applied in QINSy to calculate corrected water depths. SVP casts were conducted at a minimum of every four hours during the MBES portions of the survey. Heading, heave, pitch and roll output from the Applanix POS MV system was recorded with the bathymetry data in the survey acquisition software (QINSy), with final post-processing and DTM generation performed using Caris.

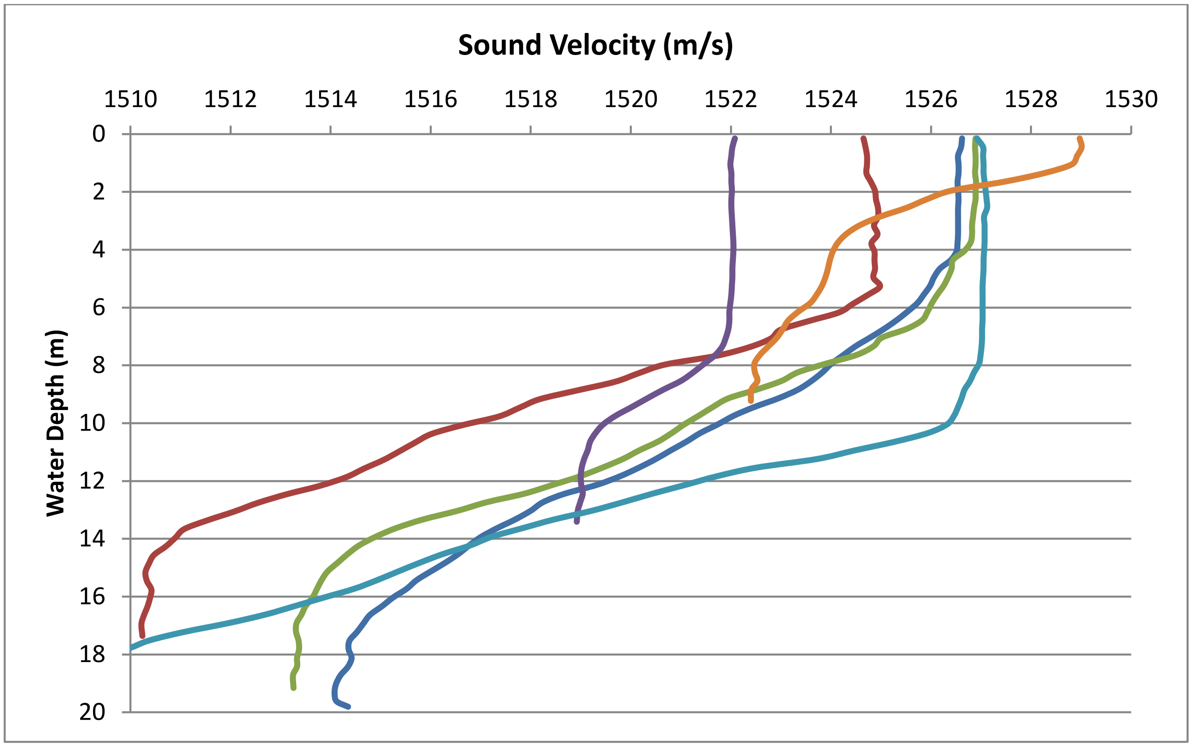


Figure 6.4 Example of SVP profiles collected during the offshore HRG survey

6.1.3.8 PSO Observation Equipment

Monitoring of marine mammals and sea turtles occurred during all phases of the US Wind Export Cable surveys. The survey was run in accordance with the mitigation requirements stipulated in the lease (OCS-A 0489 and OCS-A 0490) and mitigation plan submitted to the Bureau of Ocean Energy Management (BOEM). Mitigation measures covered mitigation for vessel strike avoidance and for the avoidance of disturbance and harm from geophysical and geotechnical survey activities.
Watches for marine mammals and sea turtles occurred throughout the 24 hour operations of the HRG survey, and Passive Acoustic Monitoring Systems (PAMS) were implemented as additional efforts for monitoring and acoustic detection. All appropriate distances and avoidance measures were maintained and implemented during the survey.

A full PSO Report for both the HRG and Geotechnical scopes of work can be found in Appendix N.

6.2 Offshore Environmental and Geotechnical Survey

6.2.1 General

The scope of the investigation also included environmental and geotechnical sampling surveys along the export cable route. Sampling plans were developed by US Wind and Alpine, and were submitted and approved by BOEM prior to any commencement of work.

6.2.2 Summary of Environmental and Geotechnical Survey Design

Environmental work was undertaken for the purpose of assessing the presence, or absence of seabed conditions that may support potentially sensitive benthic habitats, including shellfish areas, submerged aquatic vegetation (SAV) or hard bottom conditions.

Geotechnical grab and vibracore sampling was undertaken along the cable route to provide further insight into surficial and shallow sub-surface geology, and to ground truth the geophysical data interpretation. Sampling was conducted at a spacing of 2000 meters within federal waters and 1600 meters within state waters. In areas where there were sudden changes in soil conditions a smaller spacing was required.

Vibracore sampling depths were set to a minimum 3.6 meters where the cable burial depth was 3 meters, allowing for an additional 20% investigation below the planned depth limit. Soil samples were taken from every vibracore sediment layer thicker than 0.5 meters, except in the case of homogenous soil, in which one soil sample was taken every 1 meter of depth. Geological descriptions, layer thicknesses, soil type (obtained from lab samples), and soil strength (obtained from laboratory tests), were the information being collected. Laboratory tests were selected based on geological assessment.

6.2.3 Survey Equipment and Methods

6.2.3.1 Vessel Configuration

The RV *Shearwater* provided the survey platform to conduct the environmental and geotechnical operations. The vessel provides a large aft deck, starboard winch and A-frame, and an overhead crane for heavy lifting. In general, sediment grabs and underwater camera capture were done as a separate procedure from sediment coring. The Modified Day Grab sediment sampler was deployed and recovered with a hydraulic winch from the starboard A-frame. The underwater camera rig was deployed and recovered with the ship's crane on the starboard aft quarter, near the A-frame. The vibracoring rig was deployed from the starboard a frame and recovered onboard with the ship's crane and winch. The equipment offsets are presented below.

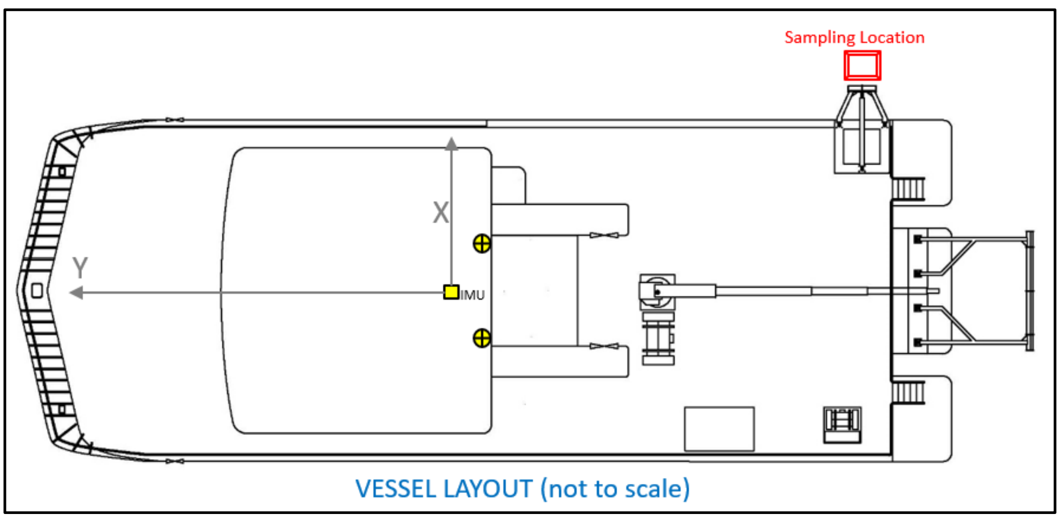


Figure 6.5 Sampling equipment configuration

Table 6.6 Offshore Environmental and Geotechnical Equipment

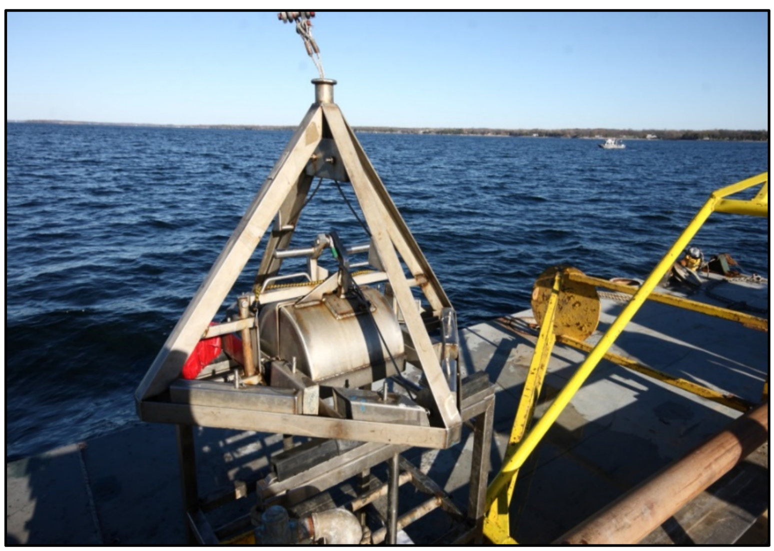
Equipment Type	Equipment Model
Primary GNSS	Applanix POS MV
Heading Sensor / Motion Sensor	Applanix POS MV
Navigation Software	Hypack 2015
Sediment Grab	Modified Day Grab
Underwater Camera	Kongsberg/Simrad Shallow Water Video/Camera System
Sediment Corer	Alpine Model P Pneumatic Vibracorer
PSO/MMO Equipment	Gardline Environmental Ltd Passive Acoustic Monitoring System
Core Logging Software	Alpine Corelog

6.2.3.2 Vessel and Equipment Navigation

Vessel navigation was controlled by an Alpine surveyor using Hypack software interfaced to the Applanix POS MW DGNSS system. An engineering drawing of the RV *Shearwater* was input within the software, and offsets from the vessel reference point to the each piece of equipment were measured. The vessel tracking point was set to the pulley on the starboard A-frame, and the vessel captain monitored this tracking point and used it to position the equipment over each planned station. The forward thruster and aft props were used to keep the RV *Shearwate*r on station during coring, grab sampling, and underwater camera operations.

6.2.3.3 Sediment Grab

A modified day grab was used to collect seabed benthic samples - a total of 14 samples were collected. In the case that there was not a sufficient amount of sample recovered another deployment was made. Once an adequate amount of sample was retained it was then run through a 500 µm sieve to collect epifauna. All specimen collected was then put into a wide mouth jar with a formaldehyde preservative. A small amount of Rose Bengal dye was also added to each sample to assist in detecting the microfauna.



6.2.3.4 Underwater Camera and Video Capture

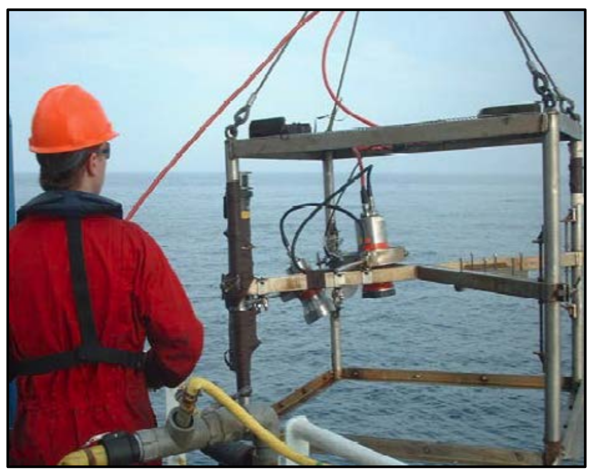
Kongsberg/Simrad Underwater Digital Camera/Video system was used for the real-time observation of the seafloor. The main instrumental and acquisition details are listed in Table 6.7.

Table 6.7 Underwater Digital Camera/Video System

Equipment Type	Equipment Model
Manufacturer	Kongsberg/Simrad
Model	OE14-208
Pixels	5.0 M
Standard Lens	f 7.2 – 28.8 (35mm format equivalent to 38 – 140mm)
Focus Control	Automatic or manual 50mm to infinity
Trigger	Remote from deck
Height Control	USBL Beacon and Video footage
Video Overlay	Oceantools HDO

Environmental seabed images were taken by means of a digital stills camera system with a dedicated strobe and video lamp, mounted within a stainless steel frame. All positions of the underwater camera were referenced to the A-Frame, where an accurate measurement was taken and recorded into our navigation software.

Footage was viewed in real time via an umbilical, which assisted in the control of the digital stills camera. This allowed for shot selection in the event that the system recorded a sediment change or feature at the seafloor.



A minimum of 10 seabed photographs were taken, separated by a time gap of approximately 5-10 seconds at each station, using a hover and drift technique. This technique allowed the frame to move progressively along the seabed as the vessel traversed the work area on its thrusters or drifted. The images were captured remotely using the surface control unit and stored on the camera's internal memory card. Video footage was overlaid with time, position, and depth, and recorded directly onto VHS video and DVD. On completion, photographs were downloaded onto a PC via a USB download cable and copied onto CD-ROM. All CDs, DVDs and videos were labelled with the relevant job details, write-protected and stored.

6.2.3.5 Sediment Coring

Alpine's model P pneumatic Vibracore system, configured to collect cores to 6 m in length, was used to collect core samples during the project. This system uses a pneumatically powered vibratory hammer to advance the core pipe into the sediments. Cores were collected for physical description and sampling at each site. Originally there were 24 sites for sampling, but an additional ten sites were added by the client representative, based on his infield analysis of the geophysical data. These additional ten sites were used to confirm stratigraphy at potential points of concern, such as buried channels which appeared to contain clay. At selected sites a separate core was collected for chemical analysis of the sediments. In addition, at several sites selected by the client representative, a third core was collected for use in conducting laboratory thermal resistivity testing of the sediment sample.

The Vibracore was equipped with the Alpine CoreLog system which monitors and records the rate and depth of penetration of each core at one foot intervals. The data were then used to develop a graph of the penetration, as shown in Figure 6.6, which is used by the project geologist to assist in logging the stratigraphy of the core. The slower rate of penetration correlates with the depth to denser sediments. The penetration graphs of all the physical cores are included in Appendix J. Each graph has a header which includes the core number, date and time of collection, the water depth at the site and location of the core in both project grid coordinates and Latitude-Longitude.

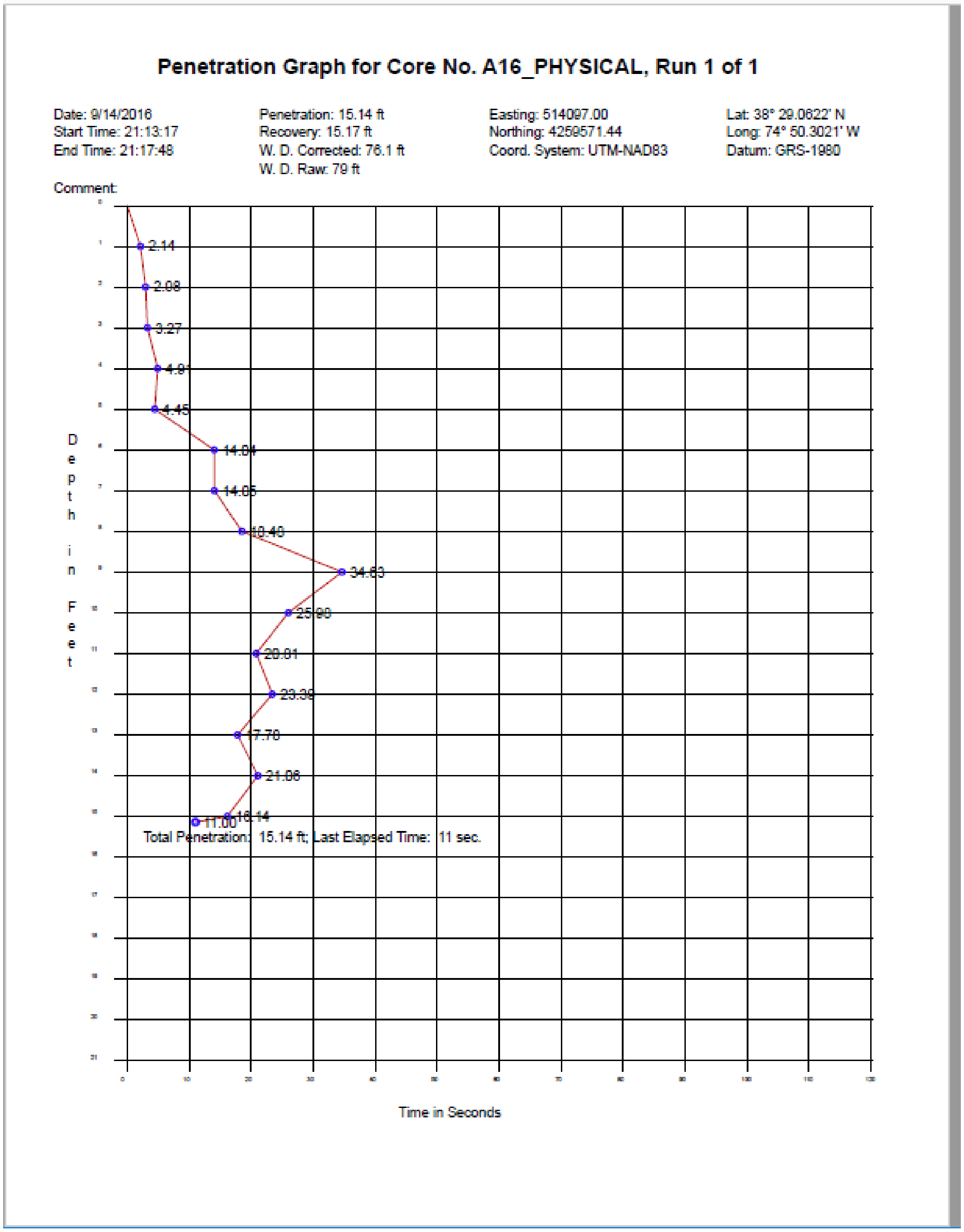


Figure 6.6 Example of a Penetration Graph

6.3 Inshore Indian River Bay HRG Survey

6.3.1 General

The inshore scope of the US Wind export cable high-resolution geophysical survey comprised an investigation of the bathymetry, seabed features, and shallow geology along a 500 meter wide cable corridor extending from Indian River Inlet in the east to the Indian River Power Plant in the west. The following section discusses the Inshore HRG survey.

All data were acquired in accordance to Alpine standard operating procedures and in line with good industry standard practices.

6.3.2 Summary of Survey Design

The vessel MV *William M.* conducted the HRG phase on the inshore section of the export cable route. The MV *William M*. had the MPES system bow-mounted with the CHIRP SBP side-mounted on the port and the MAG towed from the port stern cleat. The equipment offsets for the MV *William M* are presented in Figure 6.6

The survey design was based on the US Wind Survey Plan that was approved by BOEM prior to the beginning of survey operations. The US Wind Export cable corridor is 500 meters in width for the inshore section and 300 meters for the reroute section surveyed in 2017. Line spacing was 15.24 m (50 ft.) within the whole corridor except within an 80 meter corridor around the centerline which required 7.6 m line spacing to gain full coverage.

Alpine collected swath bathymetry, side scan sonar, high-resolution CHIRP sub-bottom, and MAG data within this inshore section. Bathymetry and side scan data are required to provide an understanding of seafloor depths, morphologies, and characteristics, while shallow-penetration sub-bottom data will help engineers understand the subsurface geologic structures that may be encountered during cable laying. The marine magnetometer was used in order to detect any ferrous iron targets that may exist along the planned cable route.

6.3.3 Survey Equipment and Methods

6.3.3.1 Vessel Configuration

The MV *William M* provided the survey platform to conduct the bathymetric and geophysical investigation. The vessel provides an aft deck for equipment and deployment and cabin space for topside survey electronics. The MPES, which provided SSS and swath bathymetry was bow-mounted in front of the vessel while the MAG was towed from the starboard stern cleat by a polyurethane data cable. The Edgetech 216 CHIRP system was side-mounted on the port stern of the vessel and secured by a safety line. The equipment offsets for the MV *William M* are presented below.

Table 6.8 Vessel Offsets and Equipment – MV *William M*

VESSEL :	MV William M					
OFFSET from Ref.Point	☒ meter	☐ feet		+ forward/ - backward	+ right/ - left	+ up/ - down
Reference Point (RP)			■	0.000	0.000	0.000
Primary GPS Antenna (P)			●	-0.375	-0.743	2.213
Secondary GPS Antenna (S)			●	-0.375	0.741	2.213
Auxillary Antenna (A)			●	-0.375	-0.184	2.213
Inertial Measurement Unit (IMU)			■	0.000	0.000	0.000
Multiphase Echosunder (MPES)			■	3.660	0.090	-1.010
Sub-bottom Profiler (SBP)			■	-1.300	-1.660	-1.900
Magnetometer Towpoint (TP)			●	-3.53	1.200	0

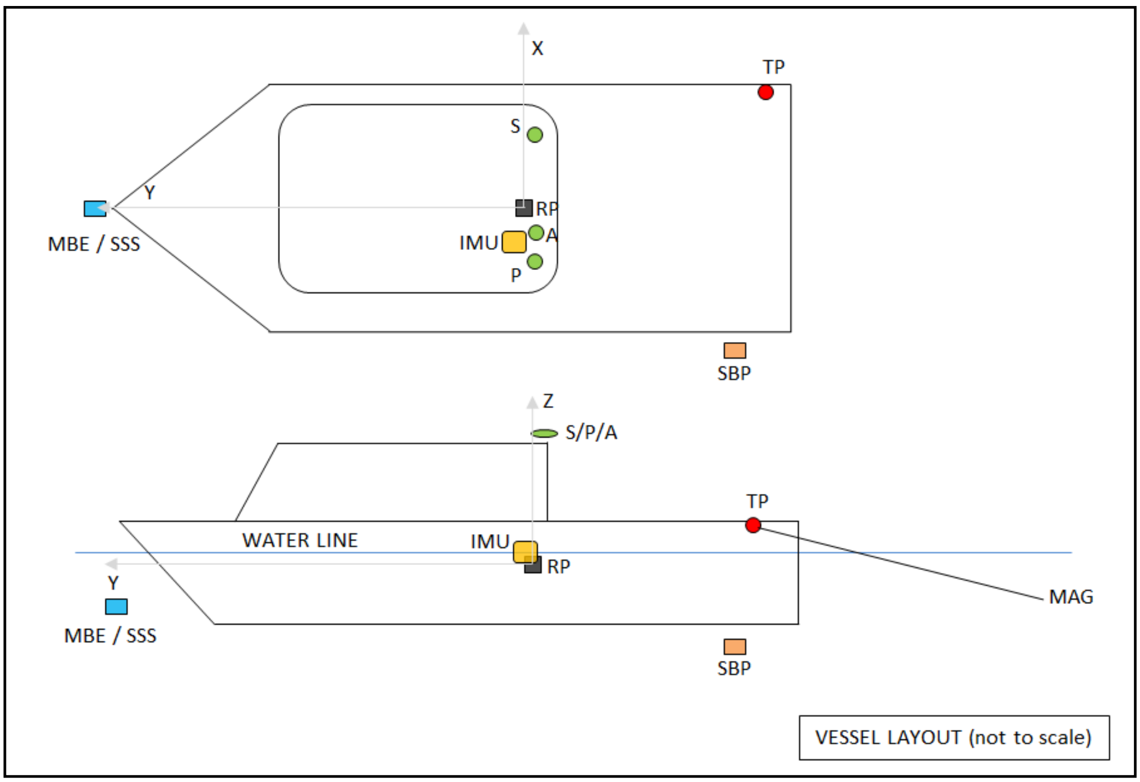


Figure 6.7 MV *William M* Offset diagram

Table 6.9 Marine Geophysical Survey Equipment

Equipment Type	Equipment Model
Primary GNSS	Applanix POS MV
Heading Sensor / Motion Sensor	Applanix POS MV
Multi-beam Echosounder (MBES)	Edgetech 6205
Side Scan Sonar (SSS)	Edgetech 6205
Sub-bottom Profiler (SBP)	Edgetech 3100P w/ 216s towfish
Magnetometer (MAG)	Geometrics G882 cesium vapor magnetometer
Sound Velocity Probe (SVP)	Sontek CastAway CTD
Navigation, Multi-beam, Side Scan Sonar, Sub-bottom and Magnetometer Data Acquisition software	QPS QINSy, Discover Bathymetric, Discover Sub-bottom, Geometrics' MagLog

6.3.3.2 Vessel and Equipment Navigation

The Applanix POS MV 320 DGNSS was used for navigation control during the survey. The POSMV was interfaced with a Trimble NavBeacon USCG beacon receiver which uses local USCG reference stations in order to calculate a differential correction for a vessel's location. Differential corrections were received from the USCG station in Virginia Beach, VA. This system, which includes a GPS aided Inertial Measurement Unit (IMU), provided precise real-time dynamic sub-meter positioning including heading, heave, pitch and roll.

Aboard the MV *William M* the IMU was mounted on the floor of the wheelhouse near the vessel's center of rotation/gravity. The GPS antennas were mounted above the cabin, aligned normal to the longitudinal axis of the vessel. Offsets between the GPS antennas, IMU and all other fixed mounting points for the other geophysical sensors were precisely measured before conducting onsite calibrations.

After the navigation system was installed and configured on the survey vessels, the following steps were taken to calibrate the POS MV:

1. The GPS Azimuth Measurement Subsystem (GAMS) Solution was calculated as follows:

   - GAMS calibration began when the number of satellites in view exceeded 5 and PDOP was less than 3.0.
   - The vessel was maneuvered through moderately aggressive turns (figure eights or S-turns) incorporating changes of speed and direction.
       - The operator then waited for the heading accuracy to be below the threshold value entered (0.5 degree) and for the GAMS Status to read Ready Offline.
       - Vessel motion was then stopped and the vessel held to a constant heading.
       - GAMS calibration was started.
       - Once GAMS calibration was complete the values were saved into the system, and were used for the remainder of the survey.

2. Summary of Navigation Data Accuracy

- The result of the GAMS solution indicated that the azimuth or heading of the vessel was accurate to within 0.25 degrees. This result shows a very high degree of accuracy of the heading data being generated by the navigation system. In the same way, the accuracy of the navigation fix data were determined to be within one meter.

The positioning data from the POS MV was output to a computer equipped with QINSy navigational software, which transmitted continuous navigation data to all systems requiring geo-referencing. Instruments receiving positioning from QINSy included the CHIRP sub-bottom acquisition system, the Interferometric sonar, and the MAG. The POS MV system output was also directly interfaced to the MPES system using a PPS (pulse per second) device to avoid any latency delays. All offsets from the reference point for the navigation system to the various geophysical instruments were measured and recorded in QINSy. The QINSy navigation software converted the latitude and longitude data to Universal Transverse Mercator Zone 18N projection, NAD83 datum, which was used for survey control.

As part of the mobilization procedure, a control point was established on a quayside structure near the bow of the vessel dockage. A PK nail was installed on a marina piling at Rehoboth Bay Marina. This survey point was used to check vessel positioning. A position verification was conducted on 25-August-2016 alongside the control point in Rehoboth Bay Marina, Rehoboth, DE.

To verify vessel positioning accuracy a comparison was made between the multibeam echosounder node and the survey benchmark established dockside. The distance between the benchmark and the MBES was measured physically with a measuring tape, while logging the computed position. The geodetic distance between the MBES node and benchmark was calculated and compared to the hand-measured distance. Results of this comparison are presented in the table below. The results are within the expected stated accuracies of the DGNSS system.

Table 6.10 DGNSS Position Verification

DGNSS Positioning Verification			
	Benchmark	**Real Time Position**	**Difference**
Latitude	38 41 14.73065 N	38 41 14.74260 N	0.1195
Longitude	75 4 34.96503 W	75 04 34.94460 W	0.2043
Easting	493357.192	493357.69	-0.498
Northing	4282093.518	4282093.89	-0.372

6.3.3.3 Interferometric Side Scan Sonar and Multibeam Echosounder System

Bathymetry and side scan sonar data were collected using a bow-mounted EdgeTech 6205 system. The Edgetech 6205 is an Interferometric Phase Differencing Swath Bathymetry System, which is capable of recording a multibeam swath of 8 – 10x water depth while simultaneously recording dual frequency (220/550 kHz) side scan sonar data.

The Edgetech 6205 is particularly useful in shallow settings such as Indian River Bay, because the system can acquire larger swath coverage than most conventional MBES. In addition to greater efficiency, the collection of side scan sonar within the same system eliminates positioning errors that are common when surveying in shallow locations.

The sonar was installed on a custom hydraulic bow mount that was specifically designed for use as an echosounder mount. The bow mount can be recovered quickly when faster transit times are desired, but also deploys in the same exact position consistently, allowing for repeatable recovery and deployment without the need to perform additional multibeam calibrations. The bow mount is positioned along the longitudinal axis of the vessel, and accurate offset measurements to the transducers were made and checked prior to data collection.

An Applied Microsystem sound velocity sensor, installed in the Edgetech transducer body and directly interfaced with the EdgeTech system, provided the continuous sound velocity readings used by the EdgeTech system to generate the correct beam steering.

The EdgeTech System directly received position and motion data from the Applanix POSMV Oceanmaster. Time synchronization was accomplished using a PPS string via a split BNC connection from the Applanix Wavemaster to EdgeTech and QINSy.

The EdgeTech data were generated and visualized using EdgeTech's Discover Bathymetric software. Edgetech's proprietary JSF files were saved in Discover which included the positioning, motion, bathymetry, and side scan data. The data were also passed on to QINSy through an Ethernet connection, where the positioning, motion, bathymetry and side scan data were saved as QINSy database files. These files were collected as back-up and were able to be converted to XTFs to use in the case that the JSF files were corrupted or unusable.

A patch test was conducted on 13-October-2016 to establish the correct mounting offset angles for the MBE system. The patch test consisted of setting the mounting angle values in the acquisition software to 0.00, and running a standard set of patch test lines for a dual-head multibeam system to determine roll, pitch and yaw calibration values.

A calibration site was chosen in the channel between Rehoboth Bay and Indian River Bay. The data were acquired in QINSy Version 8.10. Data were processed in QINSy Processing Manager in NAD83 UTM Zone 18N meters.

Three navigation lines were designed to run over a navigation channel slope as well as an area of flat seafloor. All three lines were run in both directions to ensure enough coverage to allow for proper calibration, and a third cross line (perpendicular to the first two lines) was run for a QA/QC check. A secondary patch test was chosen outside the Indian River Marina and was conducted on 24-October-2016 to better adjust for motion artifacts. The secondary patch test was used for final motion values as the pitch calibration was determined to have improved. The patch test results were keyed into the multibeam acquisition software for the survey. The results of the patch test are shown in Table 7.6 below. For a detailed summary of the patch test, see Appendix E.

Table 6.11 Patch test values for IRB HRG Phase

Patch test values for Inshore IRB survey	
Motion	Correction
Pitch	3.40°
Roll Port	-2.50°
Roll Stbd	-1.66°
Yaw	-0.50°

Table 6.12 Patch test values for IRB HRG reroute Phase

Patch test values for Inshore IRB reroute survey	
Motion	Correction
Pitch	2.20°
Roll Port	1.25°
Roll Stbd	-1.80°
Yaw	1.70°

The Edgetech 6205 side scan system was wet tested and data were collected to ensure proper acoustic imagery acquisition. The data were processed in SonarWiz version 6.0 to generate a mosaic and verify object detection and positioning. The specification for this project is to collect SSS at range scales in which 100% overlap is obtained in the all sections of the export corridor. Side scan imagery showing detection of sand ripples can be seen below

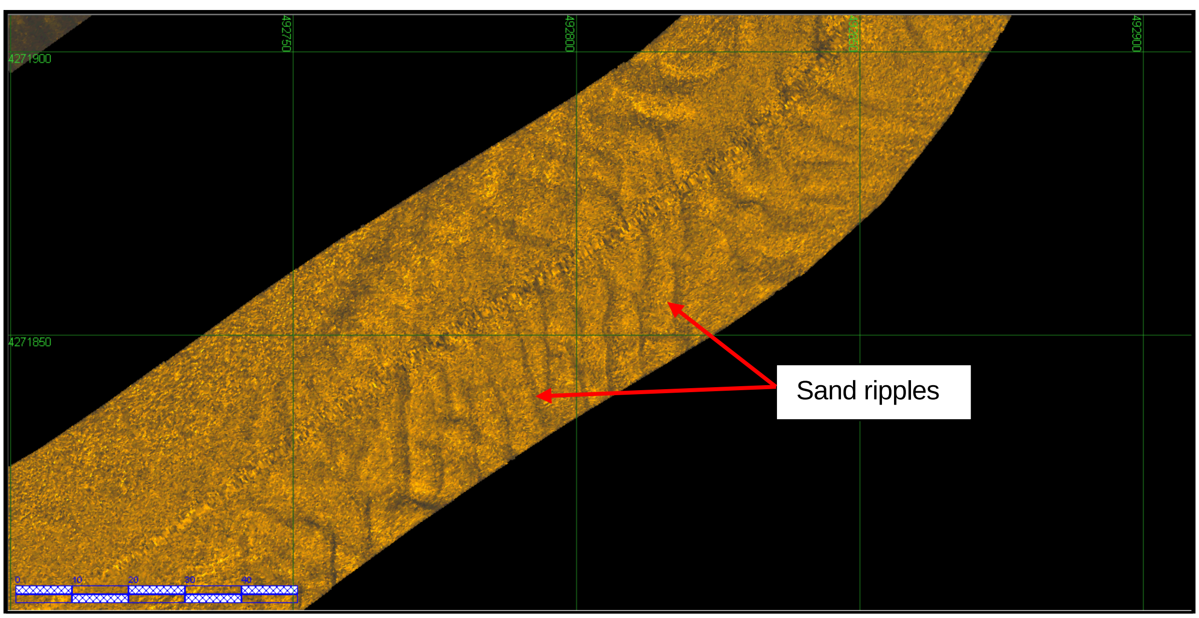


Figure 6.6 Edgetech 6205 SSS Data Example

6.3.3.4 High-resolution CHIRP Sub-bottom Profiler

An Edgetech 3100P Profiler system was used to generate the high-resolution sub-bottom acoustic signal, which was transmitted through an Edgetech 216s towfish that was towed from a davit arm located at the aft port side of the vessel. The towfish was deployed at the same depth and distance for the entirety of the survey.

Each pulse consists of a swept frequency (2 - 16 kHz) operated at a 15 ms pulse length. The signals were received and digitized using the CHIRP 3100 portable topside unit. The CHIRP system received positioning information from the QINSy software so that all the data were continuously geo-referenced. Real-time bottom tracking and display gains were applied to the data in the field using Edgetech's Discover software for quality control, and the data were recorded in SEGY and JSF format. SonarWiz software provided post-processing capability where the user can perform seafloor tracking, adjust gains and map and export sub-surface reflectors or features.

On 13-October-2016 the system was tested to ensure proper penetration and acoustic transmission. The sub-bottom system was powered on and the vessel moved underway to verify for acoustic transmission, receiving and for interfacing with the navigation system. A profile of collected data below shows approximately 3-5 meters of penetration.

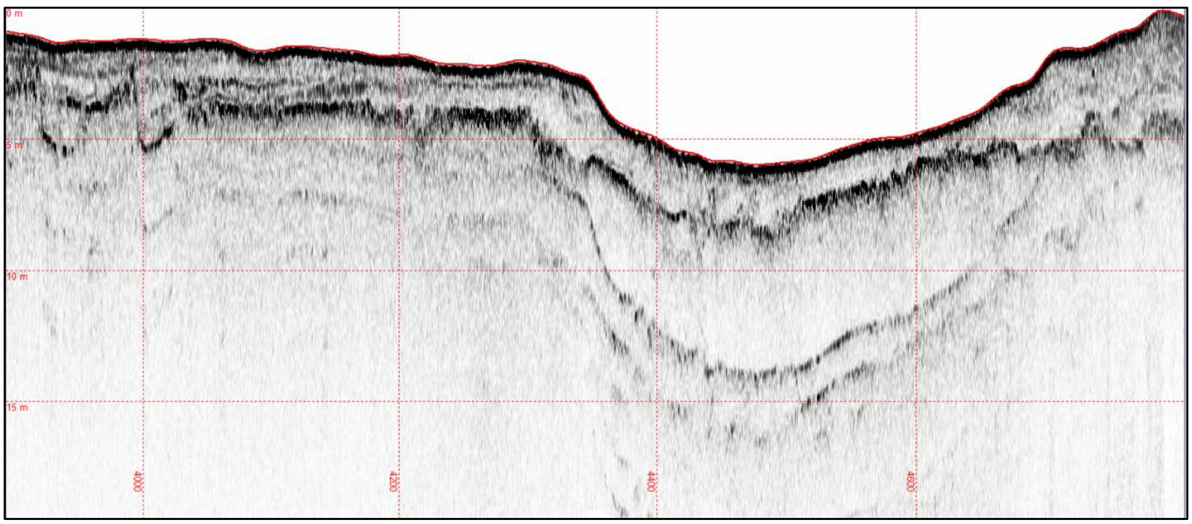


Figure 6.7 Edgetech 3100P data example showing seafloor penetration

6.3.3.5 Marine Magnetometer System

A Geometrics G-882 cesium vapor marine magnetometer was towed from the vessel's starboard aft cleat throughout the survey. Due to the shallow nature of Indian River Bay, the magnetometer was attached to a Norwegian buoy so at to maintain a safe distance from the seabed. This towing configuration was optimal because a majority of the IRB survey area was less than 6 meters depth, and thus "floating" the magnetometer allowed for safe acquisition within specification (<6 meters). The MAG data were viewed in real time on board the survey vessel, and recorded in MagLog at 100ms intervals along all survey lines. The position of the towfish was determined using a fixed layback of 10 meters behind the vessel. The MAG data were post-processed using Geometrics' MagPick software platform. Figure 16 below shows a 140 nanotesla (nT) magnetic "hit" acquired in the survey area during mobilization.

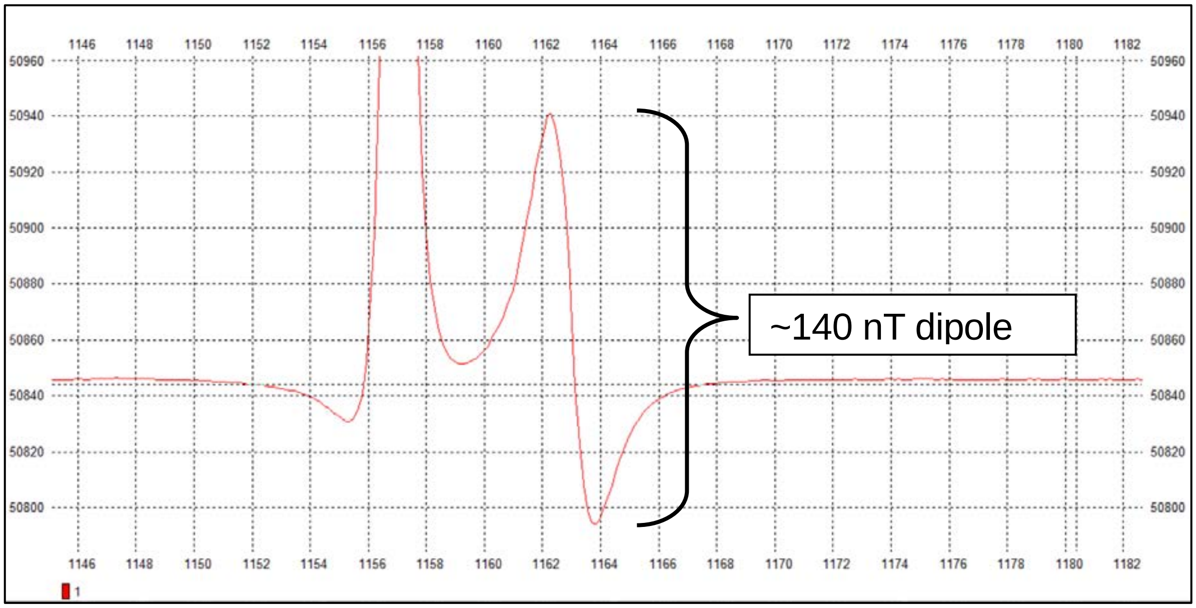


Figure 6.8 Geometrics G-882 Magnetometer Data Example

6.4 Inshore Environmental and Geotechnical Survey

6.4.1 General

The scope of the cable route survey included environmental and geotechnical sampling surveys along the inshore portion of the export cable route. Sampling plans were developed by US Wind and Alpine, and were submitted and approved by BOEM prior to any commencement of work.

6.4.2 Summary of Environmental and Geotechnical Survey Design

Environmental work was undertaken for the purpose of assessing the presence, or absence of seabed conditions that may support potentially sensitive benthic habitats, including shellfish areas, submerged aquatic vegetation (SAV) or hard bottom conditions.

Geotechnical grab and vibracore sampling was undertaken along the cable route to provide further insight into surficial and shallow sub-surface geology, and to ground truth the geophysical data interpretation. Sampling was conducted at approximately 1600 meters on the inshore cable route but in areas where there were noticeable changes in sediment, a smaller spacing was required.

Vibracore sampling depths were maximum 3.0 m in shallow water locations inshore even where the cable burial depth was 3.0 m. Sediment samples were taken from every vibracore sediment layer thicker than 0.5 m, except in the case of homogenous sediment, in which one sediment sample was taken every 1 meter of depth. Geological descriptions, layer thicknesses, soil type (obtained from lab samples), and sediment strength (obtained from laboratory tests), were the information being collected. Laboratory tests were selected based on geological assessment. Any sections containing clay or peat were sampled even if less than 0.5 m.

6.4.3 Survey Equipment and Methods

6.4.3.1 Vessel Configuration

The MV *George* was used to conduct the environmental and geotechnical operations on the inshore section of the export cable route. The vessel provides a large deck with a winch and forward A-frame for deploying the environmental and geotechnical equipment. Sediment grabs, underwater camera capture and sediment coring were all done separately. The Modified Day Grab sediment sampler, the underwater camera rig and the vibracoring rig were all deployed and recovered using the forward winch and A-frame.

6.4.3.2 Vessel and Equipment Navigation

Vessel navigation was controlled by an Alpine surveyor using Hypack software interfaced to the Applanix POS MW DGNSS system. An engineering drawing of the MV *George* was input within the software, and offsets from the vessel reference point to the each piece of equipment were measured. The vessel tracking point was set to the pulley on the stern A-frame, and the vessel captain monitored this tracking point and used it to position the equipment over each planned station.

6.4.3.3 Sediment Grab

A modified day grab was used to collect seabed benthic samples. This is built within a pyramid frame, deployed on dual, stainless-steel warp wires that retain the sample buckets in the open position. Low-slung pad feet trigger the instrument when in contact with the seabed. On retrieval (once triggered) the weight of the instrument is transferred along the warp wires, closing the jaws of the grab. This ensures that the sample recovery does not rely on the inertia of the instrument during impact, thereby avoiding sediment disturbance. A total of 17 grab locations were sampled along the inshore cable route. In the case that there was not a sufficient amount of sample recovered another deployment was made. Once an adequate amount of sample was retained it was then run through a 500 µm sieve. All epifauna collected was then put into a wide mouth jar with a formaldehyde preservative. A small amount of Rose Bengal was also added to each sample to assist in detecting the microfauna.

6.4.3.4 Underwater Camera and Video Capture

A Kongsberg/Simrad Underwater Digital Camera/Video system, similar to the kit used on the offshore section was used to complete transects on the IRB inshore section of the route. The main instrumental and acquisition details are listed in Table 6.7.

Table 6.13 Underwater Digital Camera/Video System

Equipment Type	Equipment Model
Manufacturer	Kongsberg/Simrad
Model	OE14-208
Pixels	5.0 M
Standard Lens	f 7.2 – 28.8 (35mm format equivalent to 38 – 140mm)
Focus Control	Automatic or manual 50mm to infinity
Trigger	Remote from deck
Height Control	USBL Beacon and Video footage
Video Overlay	Oceantools VO1

Equipment Type	Equipment Model
Scale Bar	Green line lasers with 100mm separation between lines.

Environmental seabed images were taken by means of a digital stills camera system with a dedicated strobe and video lamp, mounted within a stainless steel frame. All positions of the underwater camera were referenced to the A-Frame on the bow of the vessel, where an accurate measurement was taken and recorded into our navigation software.

Footage was viewed in real time via an umbilical, which assisted in the control of the digital stills camera. This allowed for shot selection in the event that the system recorded a sediment change or feature at the seafloor.

A minimum of 10 seabed photographs were taken, separated by a time gap of approximately 5-10 seconds at each station, using a hover and drift technique. This technique allowed the frame to move progressively along the seabed as the vessel traversed the work area on its thrusters or drifted. The images were captured remotely using the surface control unit and stored on the camera's internal memory card. Video footage was overlaid with time, position, and depth, and recorded directly onto VHS video and DVD. On completion, photographs were downloaded onto a PC via a USB download cable and copied onto CD-ROM. All CDs, DVDs and videos were labelled with the relevant job details, write-protected and stored.

6.4.3.5 Sediment Coring

Alpine's model M pneumatic Vibracore system, configured to collect cores to 3 m in length, was used to collect core samples during the inshore section of the project. This system uses a pneumatically powered vibratory hammer to advance the core pipe into the sediments. Cores were collected for physical description and sampling at each site as well as chemical analysis. A total of 18 core sites were chosen for sampling along the inshore route. In addition, at several sites selected by the client representative, a third core was collected for use in conducting laboratory thermal resistivity testing of the sediment sample. Physical and chemical cores were collected at all 18 sites and thermal cores were collected at 16 of the 18 locations.

7 BACKGROUND GEOLOGY

7.1 Physiographic Setting

The Maryland coast is part of a regional feature known as the Delmarva Peninsula. The Delmarva Peninsula is bounded to the north by the Delaware Bay, to the west by the Chesapeake Bay and to the east by the Atlantic Ocean. The Delmarva Peninsula and surrounding features are characterized by three geologic provinces, the Piedmont Plateau, the Coastal Plain, and the Atlantic Continental Shelf. The Piedmont Plateau and Coastal Plain provinces are separated by a "Fall Line". The Fall Line separates the Coastal Plain on the east, from metamorphosed rocks of the Piedmont province to the west - the remnant core of the ancestral Appalachian Mountains. From the time the ancestral Appalachian Mountains were uplifted between 250 – 450 million years ago they began to erode. Rivers and streams flowing down from the mountain tops carried the eroded material to be spread out and deposited in deltas and outwash plains on the Coastal Plain. East of the Coastal Plain lies the Atlantic Continental Shelf, the submerged continuation of the Coastal Plain extending eastward another 75 miles where sediments exhibit a maximum thickness of 40,000 feet (Maryland Geological Survey, 2015).

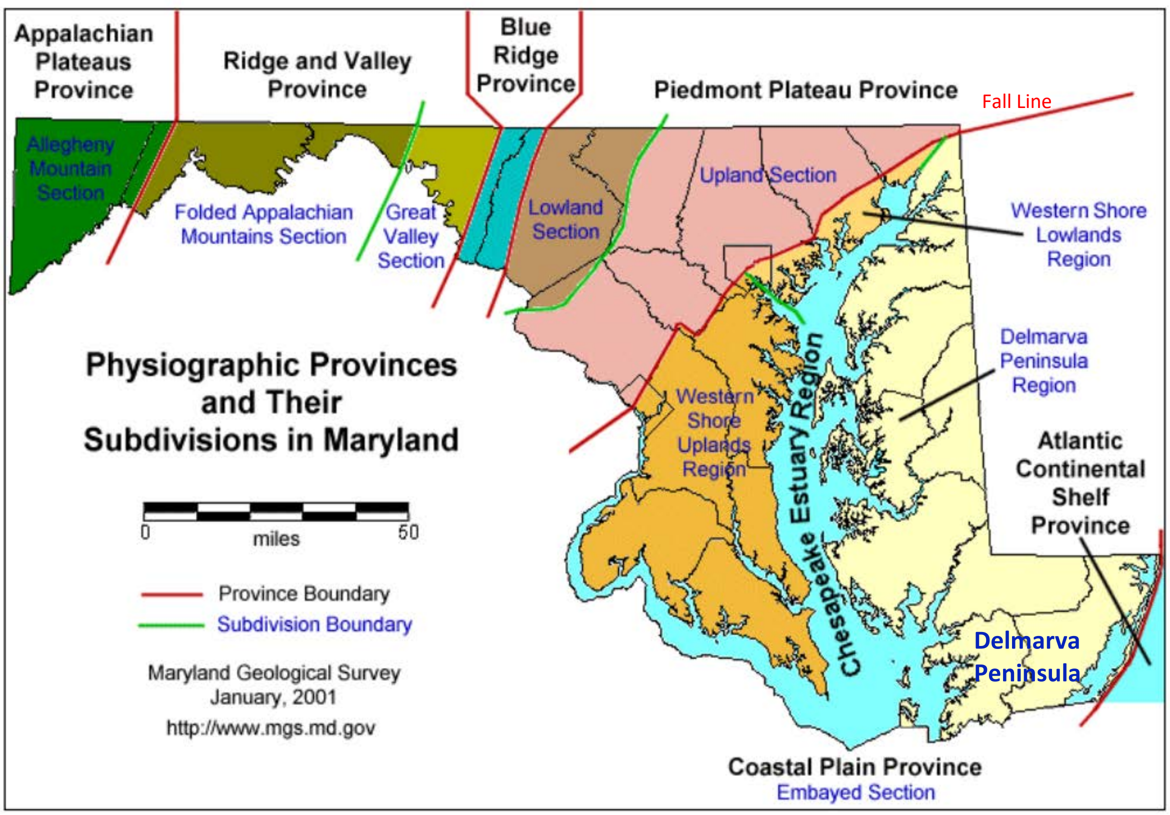


Figure 7.1 Maryland Physiographic Provinces (modified from the USGS)

7.2 Stratigraphy

The sediments of the Coastal Plain dip eastward at a low angle, generally less than one degree, thicken eastward and range in age from Triassic to Quaternary.

Linear shoals or sand ridges are among the largest, most pervasive, and enigmatic bedforms on the Delaware-Maryland continental shelf (Figure 8) (Conkwright, and Williams, 1996). Numerous scientists have investigated the seafloor geomorphology and the surficial stratigraphy of the Atlantic shelf to understand the origins and morphology of these linear shoals. Comprehensive reviews of these works have been published by Duane and others (1972), Field (1976, 1980), Toscano (1989), McBride and Moslow (1990), and Wells (1994). As a group, linear shoals share several common features. Duane and others (1972) characterized these features:

1. Linear shoal fields occur in clusters, or fields, from Long Island, New York to Florida.
2. Shoals exhibit relief up to 30ft, side slopes of a few degrees, and extend for tens of miles.
3. The long axes of linear shoals trend to the northeast and form an angle of less than 35° with the shoreline.
4. Shoals may be shoreface-attached, or detached. Shoreface-attached shoals may be associated with barrier island inlets.
5. Shoal sediments are markedly different from underlying sediments. Shoals are composed of sands and generally overlay fine, occasionally peaty, sediments.

With so many common characteristics, early researchers assumed a common origin for these features. Generally, it was assumed that linear ridges represented relict barriers or subaerial beaches, developed at a lower sea level stand, and preserved with sea level rise. (Veatch and Smith, 1939; Shepard, 1963; Emery, 1966; Kraft, 1971; and many others). Improvements in seismic data collection and reexamination of earlier data led to a new hypothesis of shoal evolution: linear shoals are post-transgressive expressions of modern shelf processes. In particular, Field's (1976, 1980) work on the Delmarva shelf could find no support for the theory of relict, submerged shorelines. Many investigators (including Field 1980; Swift and Field, 1981) concluded that ridge and swale topography developed by the interaction of storm-induced currents and sediments at the base of the shoreface. As the shoreface retreated during transgression, shoreface-attached shoals became detached, and isolated from their sand source. Once detached, the shoals continued to evolve within the modern hydraulic regime.

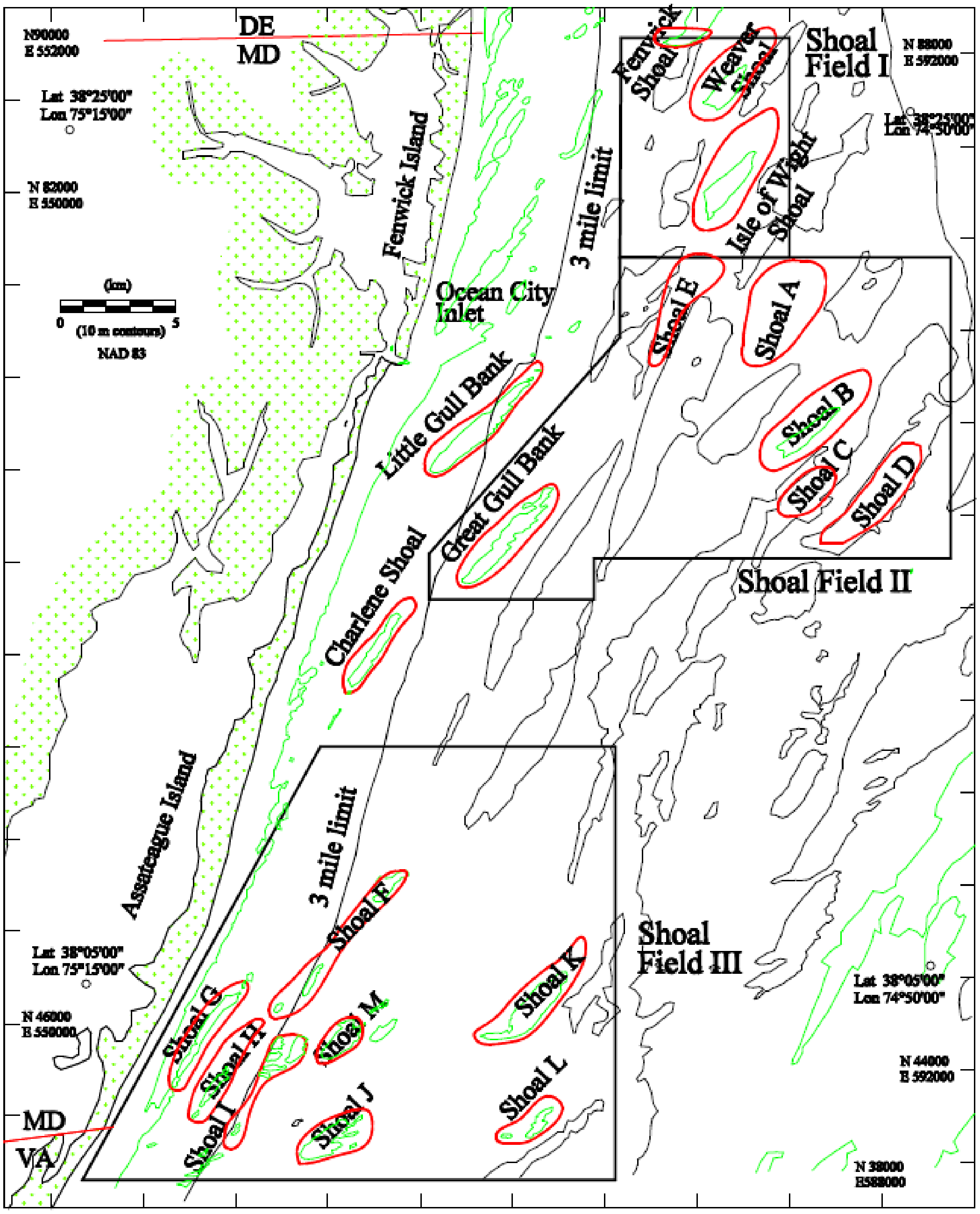


Figure 7.2 Index of Shoal fields Offshore Maryland

Several shallow geophysical reflectors were mapped in the area in and around a series of sand shoals located offshore of Ocean City, MD. The reflectors described represent the Quaternary geologic sequence for the work area developed by the Maryland Geological Survey between 1987 and 1992 during work conducted as part of the Minerals Management Service Continental Margin Program.

The figure below illustrates the sedimentary sequence described by Wells (1994).

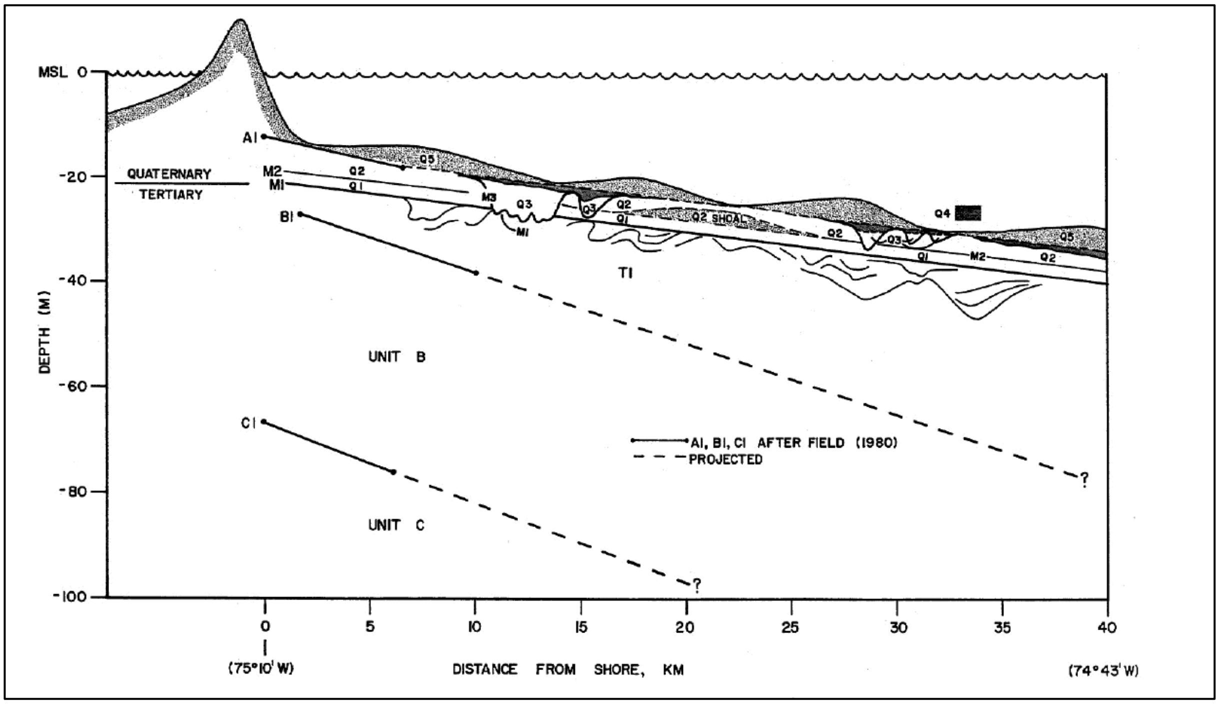


Figure 7.3 Maryland's Inner Continental Shelf Stratigraphy (from Toscano et al. 1989)

The reflectors and depositional units are described as follows (Wells, 1994):

The M1 reflector is correlated to the Tertiary-Quaternary unconformity and is generally present at a depth of 21 to 36m below MSL within 10 miles of the shoreline.

The Q1/Q2 depositional unit immediately overlies the M1 reflector and is characterized by parallel to sub-parallel internal reflectors. A weak reflector, M2, separates the Q1 and Q2 sediments and is generally present at an elevation of 5-6m above M1, interpreted to represent an erosional surface. The Q1 sediments have been described as sands and gravelly sands containing shells where that unit was penetrated by Vibracore samples. The Q2 unit consists primarily of dewatered fossiliferous mud, with rare lenses of sand. This sequence was deposited during a 50,000 year long lower stand of the sea, correlated with an earlier portion of the Pleistocene.

During a low stand of sea level following deposition of the Q1 and Q2 sediments, a series of river channels were incised across the Maryland continental shelf and infilled with sediments. The most prominent of these is referred to as the St. Martin River paleochannel, which extends to the southeast offshore of Ocean City, MD. Unit Q3 represents fluvial fill deposits of the ancestral St. Martin tributary system. Other shallower more recent channels are occasionally present on the geophysical data, but these are generally discontinuous due to post-depositional erosion.

The A1 reflector is usually planar and marks the base of the shoals. It represents the boundary between the ravinement surface formed by shoreface erosion and modern trailing edge shelf deposits.

Both the Q4 and Q5 depositional units are Holocene in age. The Q4 is interpreted to be transgressive leading edge deposits (lagoonal/swamp deposits) and overlaps Q3 and Q2 depositional units. Unit Q5 represents modern shelf shoal deposits.

8 DATA PROCESSING AND METHODOLOGY

8.1 Bathymetry

The bathymetry data collected with the RESON 7125 Seabat and the Edgtech 6205 systems were processed using CARIS HIPS 9.1.9 software. Data were cleaned, tide and datum corrected and exported as a 0.5m binned ASCII XYZ sounding file. The MBES processing flow used to complete final bathymetry products in CARIS software can be seen in Figure

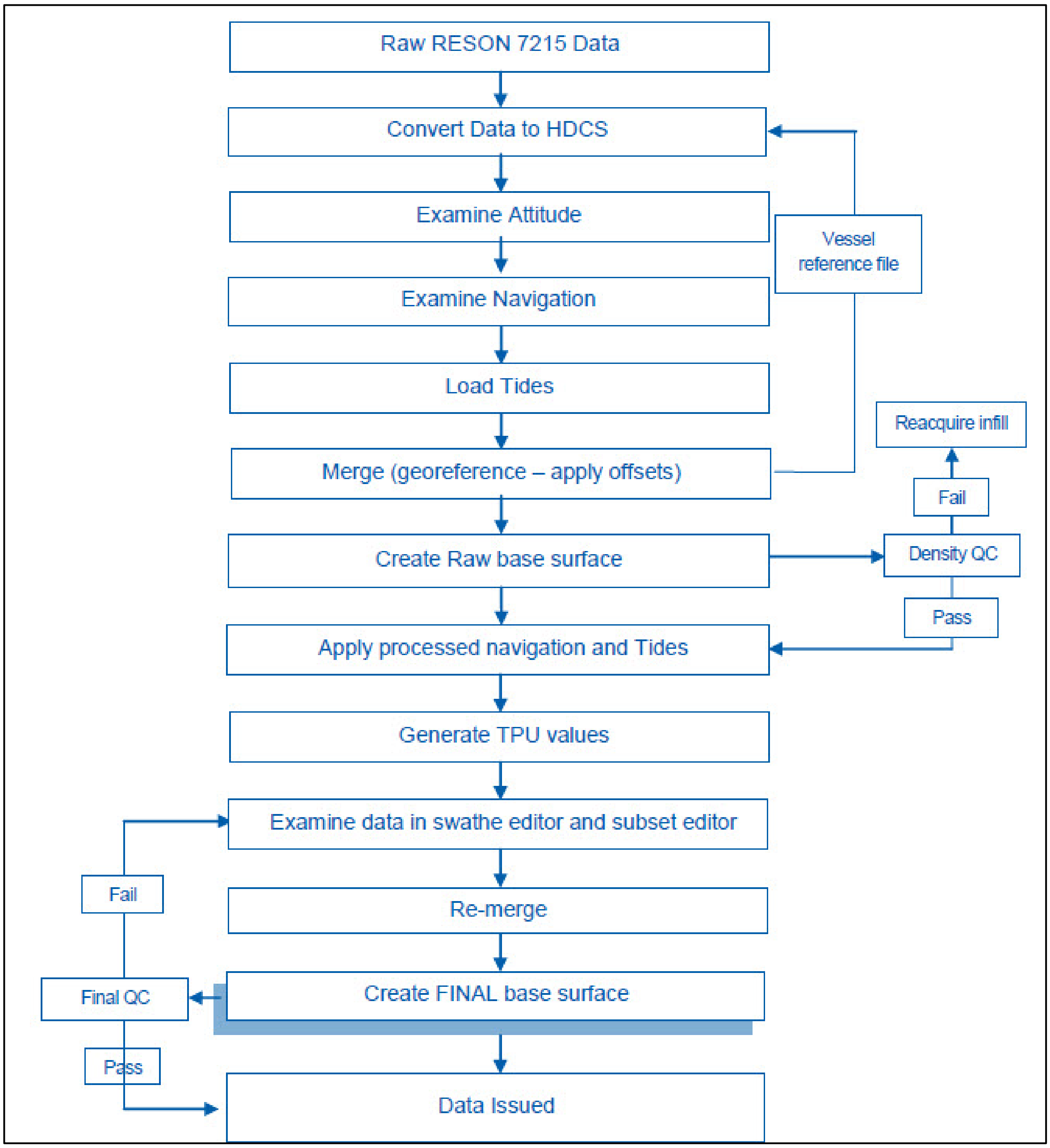


Figure 8.1 MBES processing flow diagram for bathymetry data

Raw position and attitude records were supplemented through Applanix POSPac 7.2 GNSS/IMU processing. The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service, manages a network of Continuously Operating Reference Stations (CORS) that provide Global Navigation Satellite

System (GNSS) data consisting of carrier phase and code range measurements in support of three dimensional positioning, meteorology, space weather, and geophysical applications throughout the United States. The POSPac processing includes the use of reference data from these CORS stations along with a tightly coupled PPK/INS solution to yield greater positional and motion accuracy.

8.2 Side Scan Sonar

Side-scan sonar XTF data were collected using SonarPro and imported into Chesapeake's SonarWiz processing software. SonarWiz was used to apply navigation smoothing, seafloor tracking, gain adjustments and slant range correction. A mosaic was created for each survey line file, as well as a mosaic for the overall survey area. If identified, sonar contacts are chosen, mapped, measured and exported in a contact report. The interpreted seafloor features are presented on Panel 2 of the Alignment Sheets included with this report. The alignment sheets include sediment type classification, bedform, magnetic anomaly, side scan sonar contact and environmental station locations.

8.3 Magnetometer

Magnetometer data collected with Geometrics' MagLog software were post-processed using Geometrics' MagPick program. The individual magnetic profiles from each survey line were examined for any data and navigation spikes. All significant spikes were removed using range filtering and manual rejection. To remove the Earth's total field values and reduce all magnetic data to anomalous values, a residualization process was applied. Residualization of all magnetic data involved applying a third order, non-linear, cubic b-spline function to reduce the data to anomaly values only. Magnetic anomalies were then manually picked and exported in a tabular format as targets.

8.4 Shallow Penetration Sub-bottom

Sub-bottom profile data collected with the CHIRP III system was processed in Chesapeake's SonarWiz software program. Each profile was bottom tracked, swell corrected and applied with a time varying gain. Any significant reflectors identified were mapped, and along the cable centerline exported as an ASCII XYZ thickness file for inclusion on the Profile Panel of the Alignment Sheets.

8.5 Grab Samples

When a significant amount of sample was retained in the grab, the sediments were then described, logged and run through a 500 µm sieve. All epifauna collected was then put into a wide mouth jar with a formaldehyde preservative. A small amount of Rose Bengal dye was also added to each sample to assist in detecting the microfauna. All samples were handled by ESS for processing and laboratory analyses.

8.6 Vibracores

8.6.1 Chemical Cores

ESS had representatives onboard the Shearwater during core collection. These personnel were responsible for all onboard processing of the cores collected for chemical analyses. They split the core longitudinally, developed a geological log of the core and then removed representative sediment samples and placed the samples in containers appropriate for the proposed analyses. All sample jars were labeled by ESS with the core number and depth below sea floor to the sample interval. The jars were then placed in coolers and ice was added to keep the temperature of the samples around 4 C°. Upon arrival in port the coolers were unloaded at the dock and forwarded to the chemical analysis facility under chain of custody.

8.6.2 Physical Cores

The cores collected for physical analysis of the sediments were marked with the core number and depth below sea floor at five foot intervals. The cores were then cut, capped and stored onboard until the end of the project, at which time they were taken to the Alpine office in Norwood, New Jersey for processing as described below.

Sampling procedures were conducted at the Alpine office under the supervision of a client representative, who determined what sample analyses were to be conducted on each core. Prior to opening a core, the basic stratigraphy in the core was determined by visual analysis of end cuts and review of the penetration graph for the core. Where a section of a core was suspected to contain cohesive sediments, such as silts and clays, sample analysis required submitting an un-split core section to the lab. Some analyses of non-cohesive sediments, such as density testing, also required submitting an un-split section of the core to the lab. Where other uncut core sections were required for analysis, such as thermal resistivity testing, the core was marked at the proper depth and one foot sections were cut, capped and labeled with the core number and depth below sea floor.

The remaining sections of the core were then split longitudinally and place in order on a table for description, photography and sediment sampling. A measuring tape with zero at the sea floor was placed next to the split core and a white board with the core number was placed next to the tape. Each foot of each core was then photographed. The core photographs are presented in Appendix L of this report. One half of each split core was wrapped in a plastic tube, marked with core number and depth below sea floor and put aside for future review if needed.

Where a second core had been collected at a site, due to need for thermal resistivity analyses, two sets of samples were collected from some cores. One set was kept in the unsplit core liner, as described above, while a second set was removed from one half of the core section and placed in a plastic bag, which was labeled with the core number and depth below sea floor. All the capped core sections and bagged samples were recorded on a spread sheet along with the laboratory analyses to be conducted on the sample. These spread sheets served as a Chain of Custody for the transfer of the samples to the laboratory.

9 OFFSHORE SURVEY RESULTS

The following results describe the findings of the bathymetric and geophysical investigation during the offshore export cable route surveys conducted in August-September, 2017. Near real-time data processing was conducted on board the RV *Shearwater* during survey operations. All final data processing and analysis was completed at Alpine's office in Norwood, NJ.

9.1 General Data Discussion

Section 9.1.1 through Section 9.1.6, below, provide a broad summary of the survey data sets along the entirety of the export cable route. A more detailed discussion of the data is presented along individual KP sections of the route in Section 9.2.

9.1.1 Bathymetry

Surveyed water Depths across the offshore section of the export cable route ranged between approximately -2.8 and -31.1 m (MLLW). The seafloor generally dips in the offshore direction with an average slope of approximately 1.0˚. The seabed alternates between a relatively smooth surface, and in other areas takes on a more irregular appearance with localized variations of 1 m or more over short horizontal distances. The irregular seabed is typically at lower elevations than the surrounding smooth seabed and may represent areas of scouring. Prominent sand ridges occur along the offshore section of the export cable route between KP 25+000 and KP 27+000.

9.1.2 Side Scan Sonar Data

After analysis of the side scan sonar data set, a total of 271 contacts were identified, 49 of which exhibited greater than 0.5m relief and 9 with more than 1m relief.

Forty-four contacts are of apparent man-made origin - possibly related to debris, tires and fishing gear. The remaining contacts are classified as possible geologic in origin, most representing isolated coarse substrate areas (coarse gravel and cobbles). All identified sonar contacts are mapped on the Alignment Sheets accompanying this report.

Four targets have corresponding magnetic anomalies; S-23 (M-8), S-55 (M-41), S-134 (M-51) and S-217 (M-124).

A tabular listing and report of all sonar contacts, including thumbnail images, is included in Appendix C.

A seabed classification scheme was also developed after review of the sonar data, categorizing the seabed sediments into four types based on backscatter intensity (seabed reflectivity) and/or character:

1. **Variable Reflectivity** – mixed sediments consisting of silt-clay, fine-coarse sand and gravel, with areas of sand ripples common.
2. **Medium Reflectivity** – fine-coarse grained sand with gravel, some areas of sand ripples, isolated patches of silt-clay
3. **Medium to High Reflectivity** – fine-coarse grained sand with gravel, cobbles and possible small boulders
4. **Sand Ripples** – well defined area of sand ripples located near the Delaware shoreline, orientation 360˚,180˚, wavelength = 1 m, ripple height = 0.2 m

Variable Reflectivity seabed is mapped on the middle panel of the Alignment Sheets in light blue, and was delineated from the side scan sonar mosaic as areas of low, medium and high backscatter intensity, indicating a mixture of sediments. These areas are characterized by a variable, irregular seabed composed of sand and gravel, with localized areas of sand rippling and isolated patches of muddy sediment.

Medium Reflectivity is mapped on the Alignment Sheets in light yellow, and represents an overall featureless seabed composed of sand and gravel, with isolated patches of muddy sediments.

Medium to High Reflectivity areas are mapped in red on the Alignment Sheets and are characterized by coarse grained sediments, including pebbles, cobbles and small boulders.

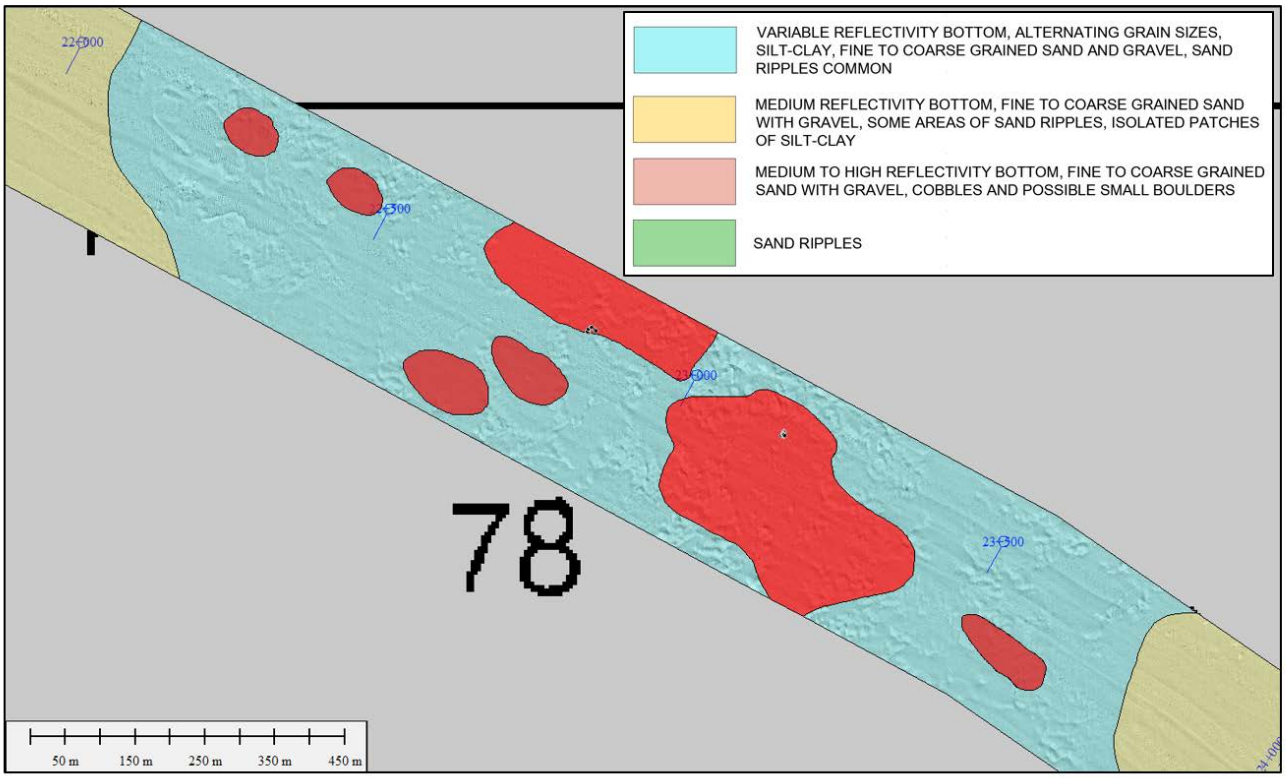


Figure 9.1 Side Scan Sonar Mosaic with Seabed Classification

9.1.3 Magnetometer Data

The magnetometer data set was reviewed and all anomalies greater than or equal to 5 nT were identified, listed and added to the Alignment Sheets. A tabular listing of all identified magnetic anomalies is included in Appendix D.

A total of 178 magnetic anomalies were identified during the export cable route survey. Of these, 134 anomalies are 25 nT or less and 29 are between 25 – 50 nT. Fifteen anomalies were greater than 50 nT, 8 of which are over 75 nT in magnitude. Four anomalies have corresponding side scan sonar targets, as listed above in 9.1.2, and likely represent man-made objects/debris on the seabed.

9.1.4 Shallow Penetration Sub-bottom Data

The shallow penetration Chirp sub-bottom profiler was able to penetrate the seabed 10 m or more in the majority of the survey area. Several shallow acoustic reflectors were mapped along the export cable route corridor. The reflectors identified are consistent with the Quaternary geologic sequence for offshore Maryland/Delaware as developed by the Maryland Geological Survey, described in Section 7.2. The deepest regional reflector resolved occurs approximately +/-7 m below the seabed, and is mapped on the Alignment Sheets as the U1 Reflector. This U1 reflector correlates to the M2 reflector as described by Wells (1994), interpreted to represent an erosional surface from a Pleistocene sea level low stand (> 100,000 ybp). The next regional reflector identified occurs typically in the upper 1 – 3 m of the seabed, or is locally absent, and is mapped as the U2 Reflector which correlates to the A1 reflector described by Wells (1994). Similar to the character as described by Wells, the U2 reflector is usually planar and marks the base of the shoals, in which case it can occur +/- 5 m below the seabed. It is interpreted as the ravinement surface formed by shoreface erosion and modern trailing edge shelf deposits during the late Pleistocene/early Holocene, and is the boundary between late Pleistocene deposits below and recent marine sediments above.

Figure 9.2 below presents a comparison of sub-bottom profiles, the top profile collected by Alpine in 2016, and the bottom profile from Wells (1994). The comparison shows the similarity between the U2/A1 and U1/M2 reflectors.

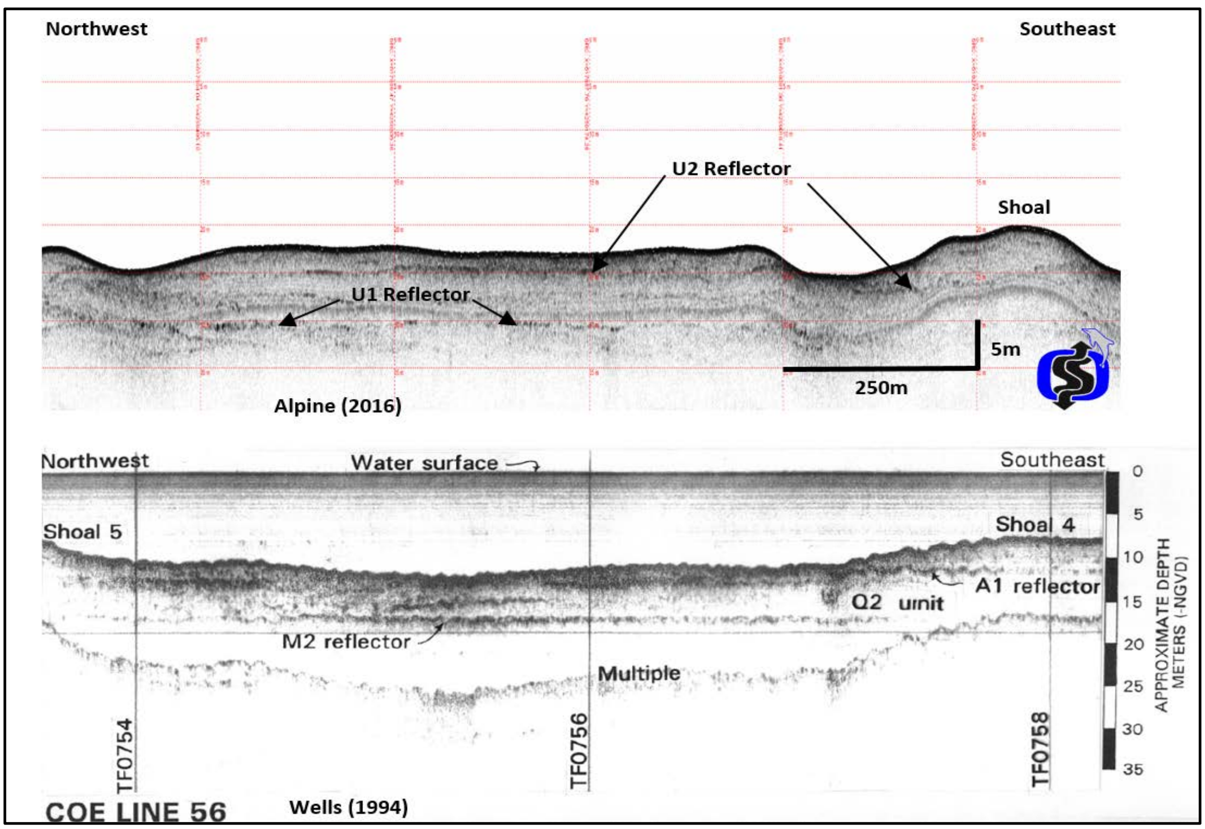


Figure 9.2 Comparison of Sub-bottom Reflectors

Paleochannel surfaces were also identified incising into the U1 and U2 reflectors, and were resolved down to depth of +/- 15 m below the seabed, the most pronounced occurring between KP 1+500 and KP 3+500. The larger paleochannels typically display internal reflectors from depositional or erosional processes occurring during changes in sea level.

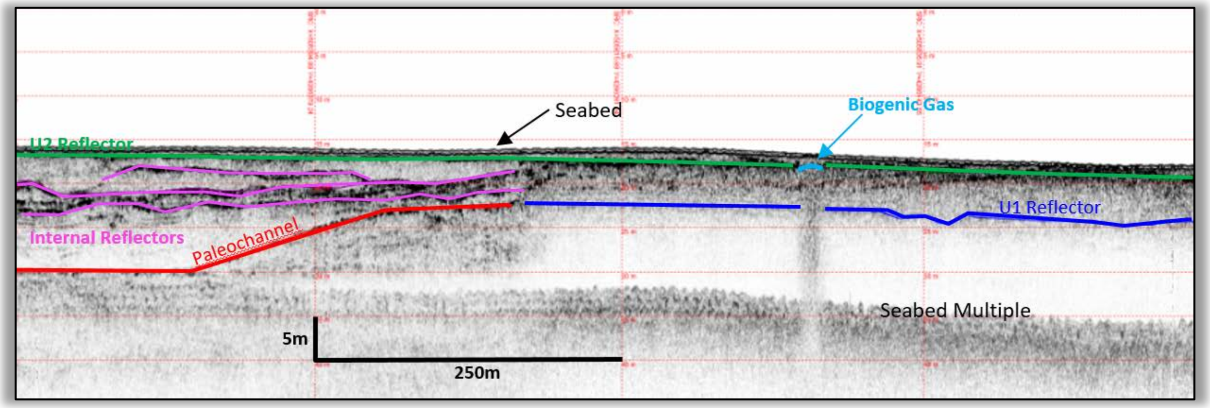


Figure 9.3 Sub-bottom Profile with Mapped Reflectors

9.1.5 Grab Samples

A total of 14 grab samples were acquired along the offshore section of the export cable route. The samples recovered primarily sandy sediments (fine to coarse grained), with some gravel and occasional cobbles. Fine-grained silt-clay was also recovered. Upon recovery all samples were handed over to ESS for processing and benthic analysis. Coordinates for each sample location are provided in Appendix G.

9.1.6 Vibracores

A total of 34 Vibracore locations were investigated along the export cable route. Twenty-four locations (A1 – A24) were sampled twice, one for physical analysis and one for chemical analysis. All chemical cores were handed over to ESS for processing and analysis. An additional 10 locations were investigated for physical analysis only (P1 – P10). All physical samples were brought back to Alpine headquarters in Norwood, NJ for splitting, logging and sampling. Core samples recovered a wide range of sediments and material including silt, clay, peat, organics, sand and gravel. The core samples provide ground truthing of the sub-bottom data and generally correlate well where they penetrated deep enough to sample the sediments at and below the U2 reflector (ravinement surface) and within the paleochannel features. Coordinates of each vibracore location are listed in Appendix H and core logs are presented in Appendix I. Penetration graphs are also provided in Appendix J.

9.2 Detailed Route Discussion

Stationing for the offshore export cable route has been generated beginning at the planned HDD area located approximately 335 m seaward from the Delaware shoreline. KP 0+00 begins at the HDD and extends offshore along the proposed IR-Offshore-3 cable route to KP 35+100, where the route intersects the boundary of the WEA HRG survey completed by Alpine in 2015. A total of eight alignment sheets have been generated along this route for presentation of the survey data. Two additional alignment sheets have been generated for the IR-Offshore-1 and IR-Offshore-2 cable routes, starting at Station 0+00 near the HDD and extending to the boundary of the WEA HRG survey conducted in 2015. The following subsections provide detailed discussions of the survey data along the export cable corridors.

9.2.1 KP 0.000 to 7+500

Alignment Sheet Charts 1 – 2 present the survey results between KP 0+000 – 7+500.

9.2.1.1 Bathymetry

Surveyed water depths between KP 0+00 – 7+500 range between -3.6 and -15.3 m (MLLW). The seafloor slants gently offshore with an average slope of approximately 1.2˚. The seabed surface alternates between relatively smooth and somewhat irregular, with the irregular seabed typically occurring at lower elevations than the surrounding smooth seabed and may represent areas of scouring. Figure 9.4 presents the bathymetry data in this section and shows an example of irregular bottom adjacent to a smooth seabed surface.

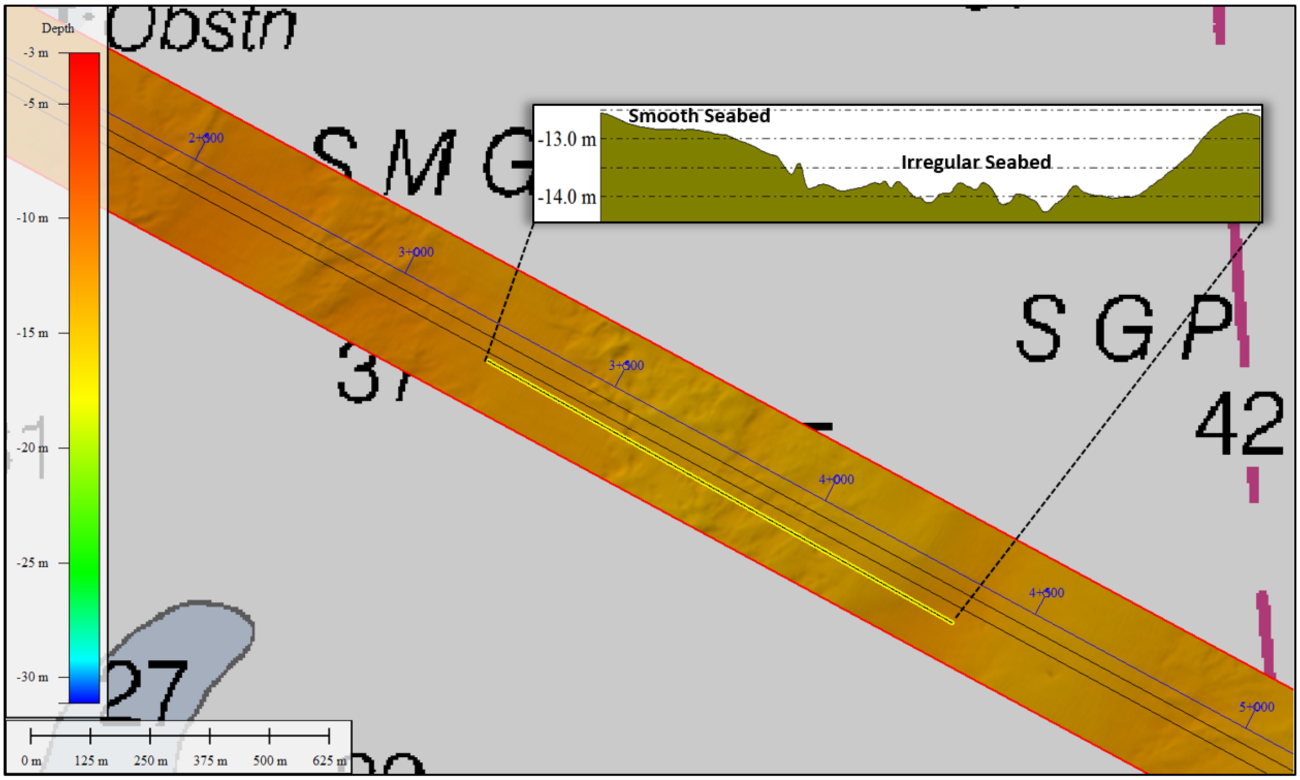


Figure 9.4 Bathymetry between KP 3+000 – 4+500 Showing Transition From Smooth to Irregular Bottom

9.2.1.2 Side Scan Sonar Data

A total of 73 sonar contacts were identified between KP 0+000 – 7+500. Most are relatively small objects related to geology (cobbles/small rocks) or debris. Twenty-seven displayed relief of greater than 0.5 m above the seabed. Three of these are interpreted as debris on the seabed (S-179, S-186 and S-220), as shown in Figure 9.5 below.

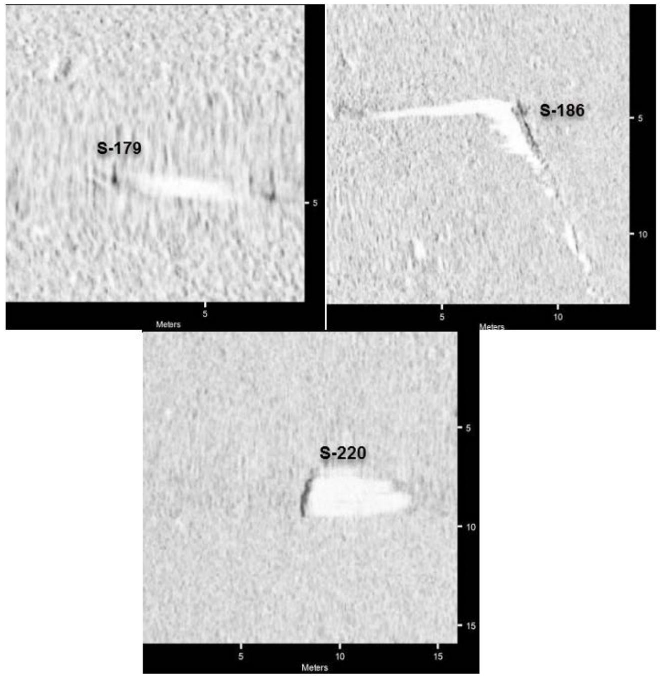


Figure 9.5 Side Scan Sonar Contacts Identified as Debris between KP 0+000 – 7+500

Each of the four seabed classification types described in Section 9.1.2 are mapped throughout this section of the route. Distinct areas of sand rippling are mapped between KP 0+000 – 0+500. Average ripple height is 0.25 m and wavelength is approximately 1.0 m. Ripple orientation is generally 0˚/180˚ (Figure 9.6 Sand Ripples between KP 0+000 – 0+500).

The predominant seabed type between KP 0+000 – 7+500 is fine to coarse sand with some gravel; mapped as Medium Reflectivity (yellow hatch) on the middle panel of the Alignment Sheets. Several extensive areas of Variable Reflectivity occur along this section as well, representing a mixture of sediments (silt-clay and fine sand to coarse sand and gravel). These areas correlate to the irregular seabed areas as seen in the bathymetry data, with apparent scouring and sediment re-working occurring along these sections of the route.

A few small areas of coarse sand, gravel and cobbles are mapped along this section. These are located near KP 1+750 (intersecting RPL), KP 3+225 (offset 140 m from RPL), KP 3+990 (intersecting RPL) and KP 5+285 (intersecting RPL). The coarsest sediments in these areas along this section of the route appear to be large pebbles or cobbles and not expected to have a significant impact on cable installation.

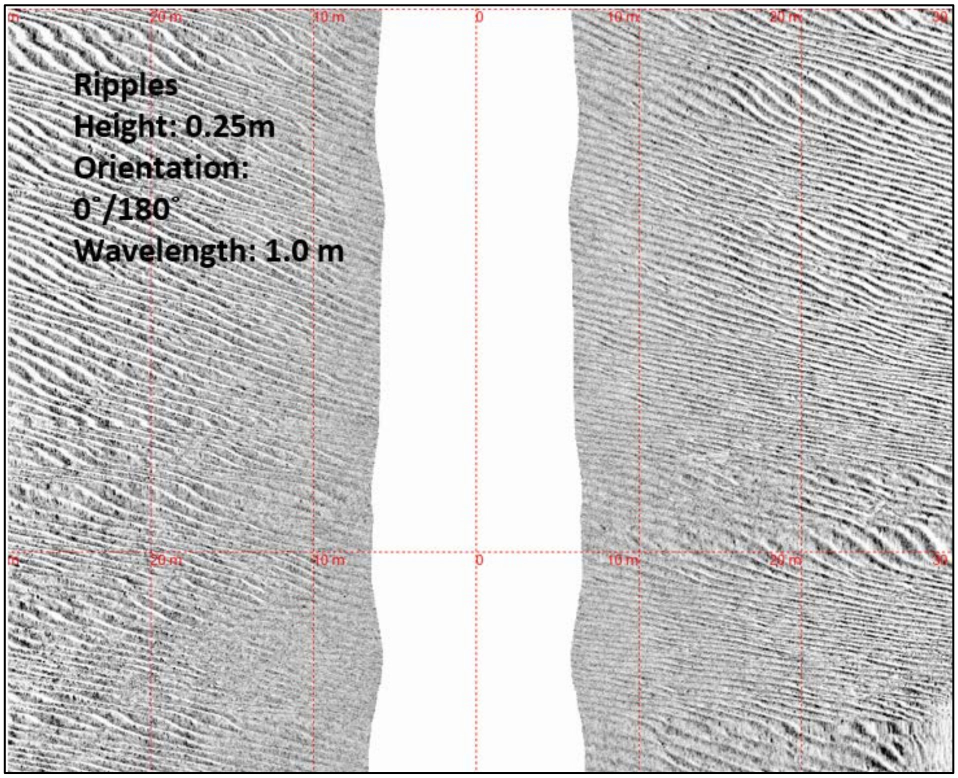


Figure 9.6 Sand Ripples between KP 0+000 – 0+500

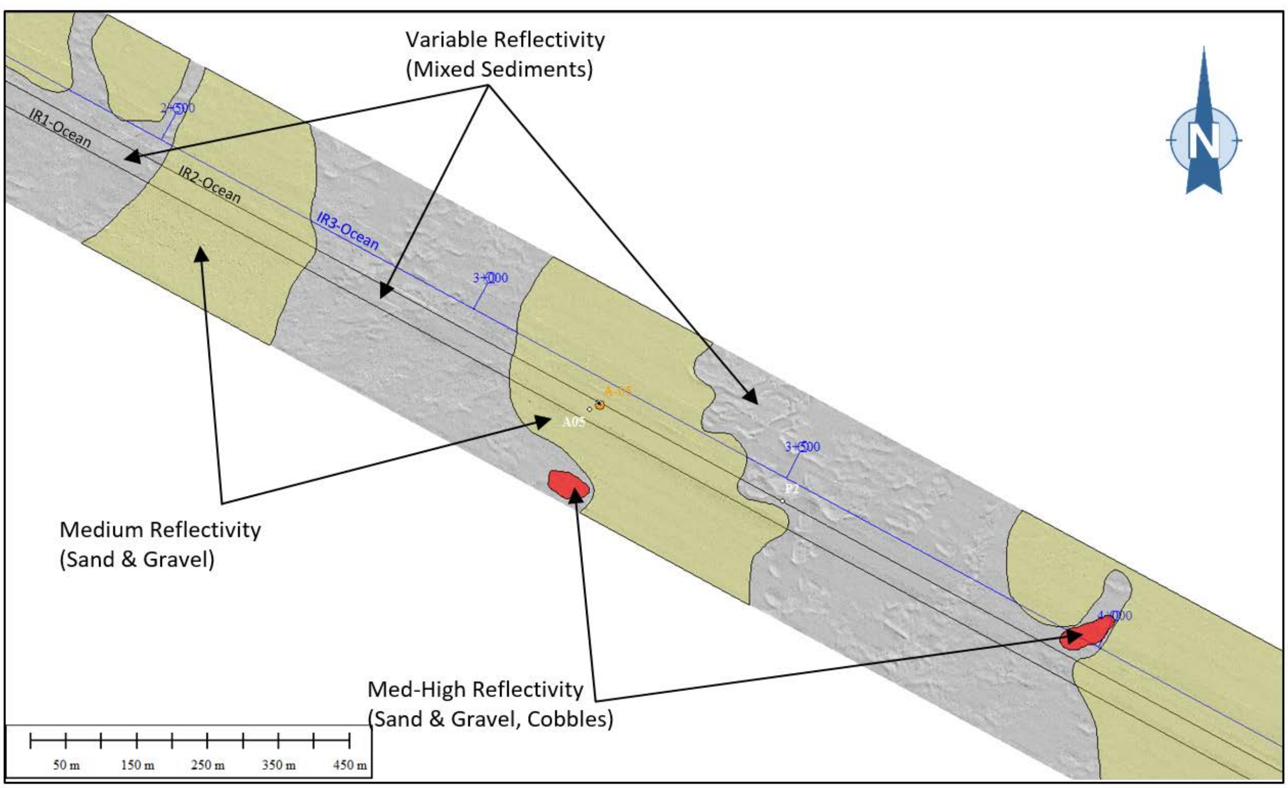


Figure 9.7 Side Scan Sonar Mosaic with Seabed Classification, KP 2+500 – 4+300

9.2.1.3 Magnetometer Data

Seventeen magnetic anomalies are located between KP 0 – 7+500. Three anomalies have greater than 75 nT magnitude (M-63, M-66 and M160) but none correspond with any sonar contacts and may represent buried objects. Seven anomalies ranged between 25 – 50 nT and seven were less than 25 nT, none of which have a corresponding sonar contact.

9.2.1.4 Shallow Penetration Sub-bottom Data

Both the U1 and U2 reflectors were identified along the majority of the route between KP 0+000 – 7+500. The U1 reflector was not resolved between KP 0+000 – 0+500, but has been mapped along the entire extent of the route form KP 0+500 to 7+500 at an approximate depth of +/- 7 m below the seabed. The U2 reflector is mapped along most of this section of the route within the upper 1 – 2 m of the seabed.

A weak reflector was identified as a small paleochannel near KP 1+600, approximately 85 m wide along the RPL with a maximum depth of approximately 5.5 m below the seabed. The feature occurs in the sub-surface between the U1 and U2 reflectors, with no apparent internal stratification was observed. A larger paleochannel was identified between KP 2+750 – 3+300 with a maximum depth of 6.7 m below the seabed.

9.2.1.5 Grab Samples

Five surficial grab samples were recovered between KP 0+000 – 7+500. Grab A-02 and A-04 were recovered within or near the Variable Reflectivity seabed as mapped with the side scan sonar data. Both samples recovered fine sand. Grabs A-05, A-06 and A-07 were all recovered within the Medium Reflectivity seabed and recovered coarse sand. Gravel was also recovered in A-06 and A-07.

9.2.1.6 Vibracores

A total of 9 vibracores were taken between KP 0+000 – 7+500 for physical analysis (A-01 – A-07, P-1 and P-2). Most recovered sandy sediments at the seabed surface, locally with trace gravel or silt (recent marine sediments). A more detailed description of vibracore operations can be seen in Appendix I.

- Vibracore A-04 recovered a thin layer (0.2 m) of sand at the seabed over silt, changing to clay at 1.4 m - this transition correlates to the U2 reflector mapped in this area (ravinement surface).
- Vibracore A-05 recovered approximately 1.5 m of sandy sediments before encountering clay. This correlates to the mapped U2 ravinement surface.
- Vibracore A-06 recovered sandy gravel at the surface down to 5.5 m below the seabed.
- Vibracore P-2 recovered clay in the upper 1 m of the seabed. This correlates to the sub-bottom profiler analysis which shows the U2 ravinement surface truncated at the seabed near core P-2, exposing the late Pleistocene clay sediments on the bottom.

9.2.2 KP 7+500 to 18+000

Alignment Sheet Charts 3 – 5 present the survey results between KP 7+500 – 18+000.

9.2.2.1 Bathymetry

Water depths range between -13.7 and -20.5 m (MLLW) between KP 7+500 – 18+000. The seabed dips gradually offshore with an average slope of 0.7˚. The seabed alternates between a smooth bottom and irregular type bottom, similar to that observed along the previous section of the route discussed in Section 9.2.1.1.

9.2.2.2 Side Scan Sonar Data

Thirty-four side scan sonar contacts were identified between KP 7+500 – 18+000, most related to small objects and geology (cobbles) with less than 0.5 m in relief above the seabed. Fourteen of these have relief greater than 0.5 m above the seabed, 3 of which are related to small debris on the seabed (S-208, S-215 and S-228).

Contact S-143 is located just south of the 300 m wide survey corridor near KP 12+750 and is likely a large boulder (> 1m diameter) on the seabed.

Contact S-217 has a corresponding magnetic anomaly (M-124; 100 nT), and may represent a boulder on the seabed greater than 1 m diameter. It is located near the northern edge of the survey corridor near KP 12+700.

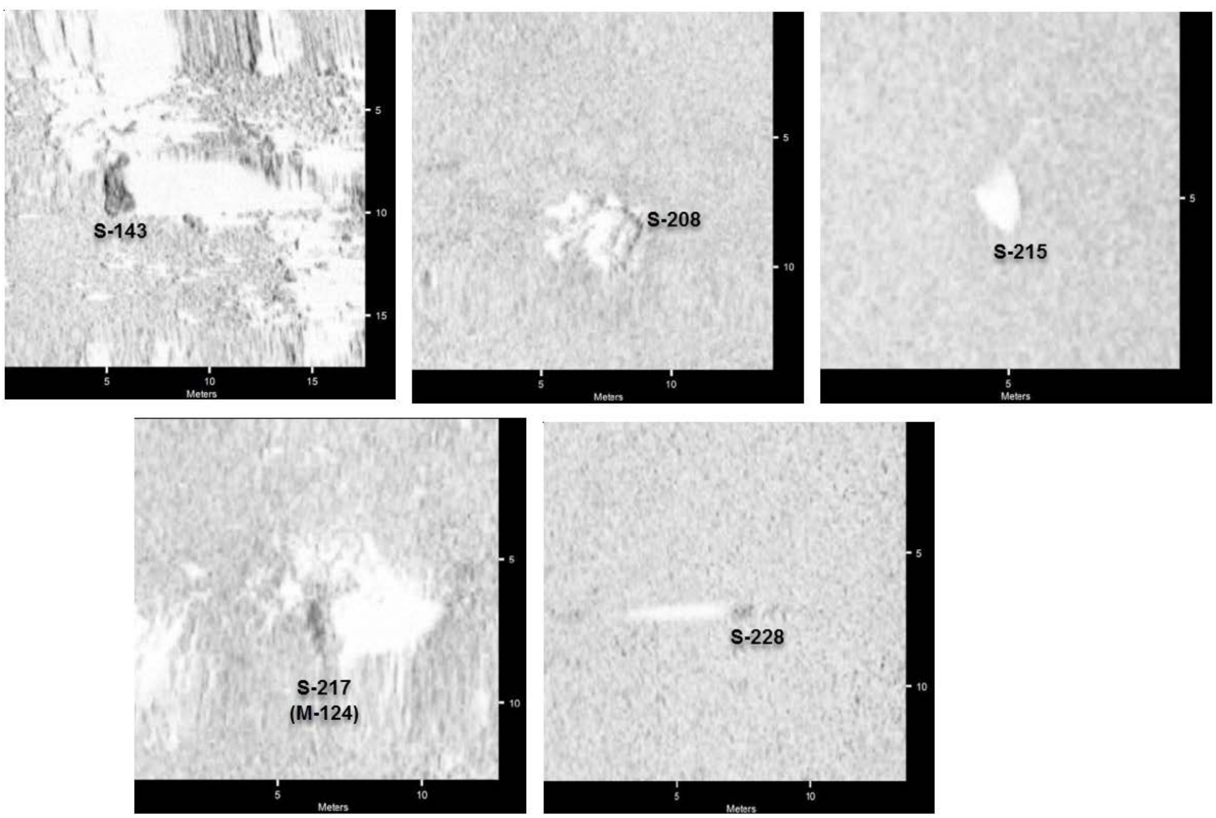


Figure 9.8 Significant Side Scan Sonar Contacts Identified between KP 7+500 – 18+000

The seabed between KP 7+500 – 18+000 alternates between fine to coarse sand with some gravel (Medium Reflectivity) and mixed sediments (silt-clay to sand and gravel; Variable Reflectivity). These areas again correlate to the irregular seabed areas as seen in the bathymetry data, with apparent scouring and sediment re-working occurring along these sections of the route.

Small areas of coarse sand, gravel and cobbles are also mapped along this section. These are located near KP 10+300 (approximately 30 m south of IR3-Ocean RPL; intersecting IR1-Ocean RPL). Between KP 11+900 – 13+200 there are three areas, offset 80 - 150 m south from IR3-Ocean RPL, that have apparent boulders (> 1m diameter) in addition to coarse sand, gravel and cobbles.

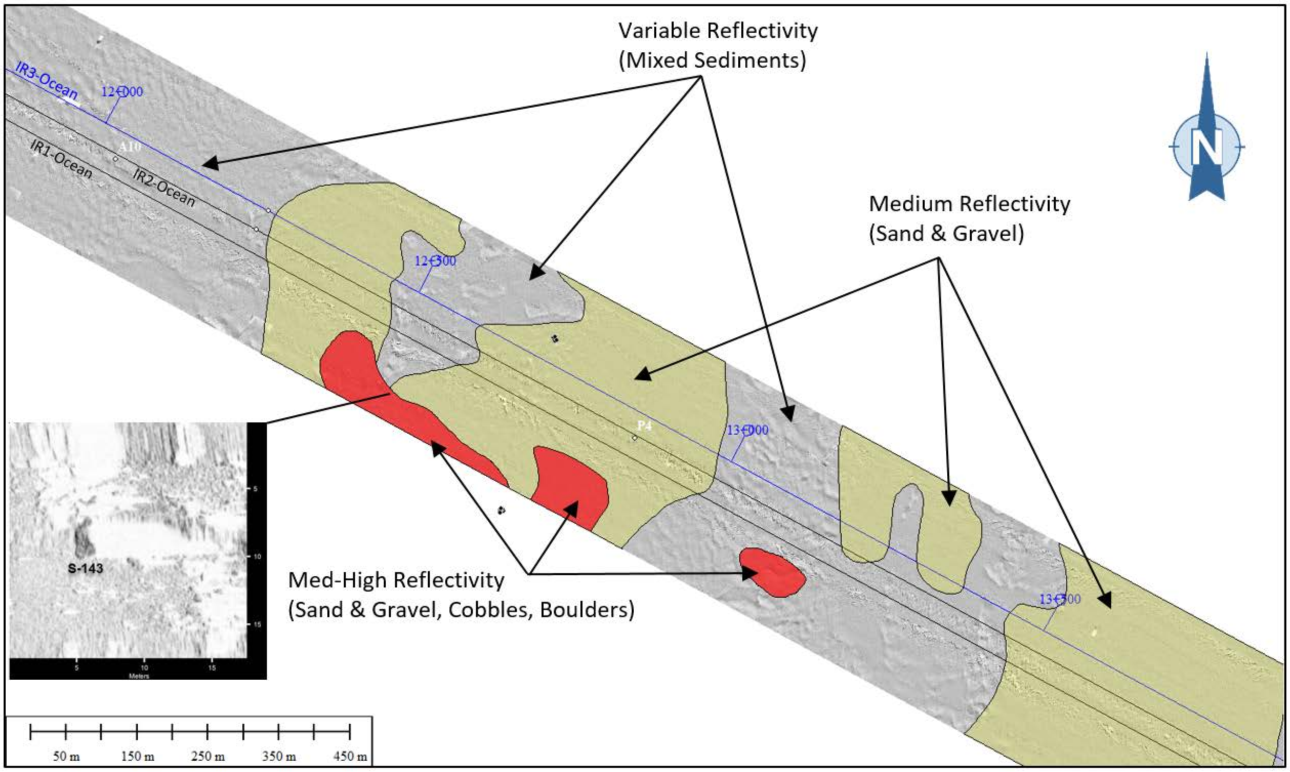


Figure 9.9 Side Scan Sonar Mosaic with Seabed Classification, KP 12+000 – 13+800

9.2.2.3 Magnetometer Data

Eleven magnetic anomalies were identified between KP 7+500 – 18+000. Anomaly M-124 was the largest (100 nT) and has a corresponding sonar contact (S-217). Two anomalies have magnitudes of 25 – 50 nT (M-125 and M-147) and the rest are all less than 25 nT.

9.2.2.4 Shallow Penetration Sub-bottom Data

Sub-bottom data between KP 7+500 – 18+000 reveal this to be the most geologically complex section of the route. Both the U1 and U2 reflectors were identified as well as large and distinct paleochannel features. Similar to the previous section of the route, the U1 reflector is mapped at an approximate depth of +/- 7 m below the seabed, and the U2 reflector is mapped within the upper few meters of the seabed.

Evidence of a large paleochannel occurs between KP 9+000 – 11+700, displaying a width of over 2.5 kilometers. The channel banks can be resolved in the sub-surface to a maximum depth of approximately 15 m, which was the extent of penetration of the sub-bottom system. The depth below the seabed to the channel axis was not able to be resolved, but is greater than 15 m. Many internal reflectors occur within the paleochannel feature, and are interpreted to consist of layered fine grained sediments (silts-clays). The northwest flank of this paleochannel is shown in Figure 9.10. The southeast flank is presented on Figure 9.3 in Section 9.1.4.

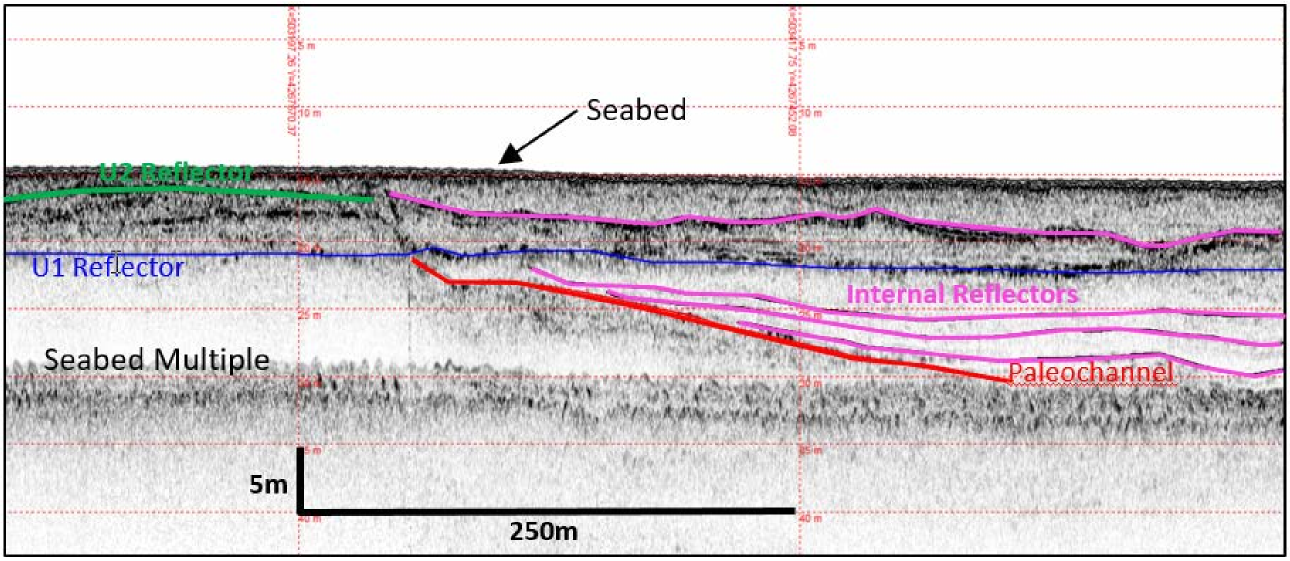


Figure 9.10 Northwest Flank of Paleochannel near KP 9+000

Another paleochannel feature occurs between KP 12+800 – 13+900, with a maximum depth of approximately 11.5 m below the seabed. The paleochannel is infilled with well layered sediments similar to the paleochannel observed between KP 9+000 – 11+700, interpreted as mostly silt-clay layers, and confirmed by vibracore P-4 discussed below.

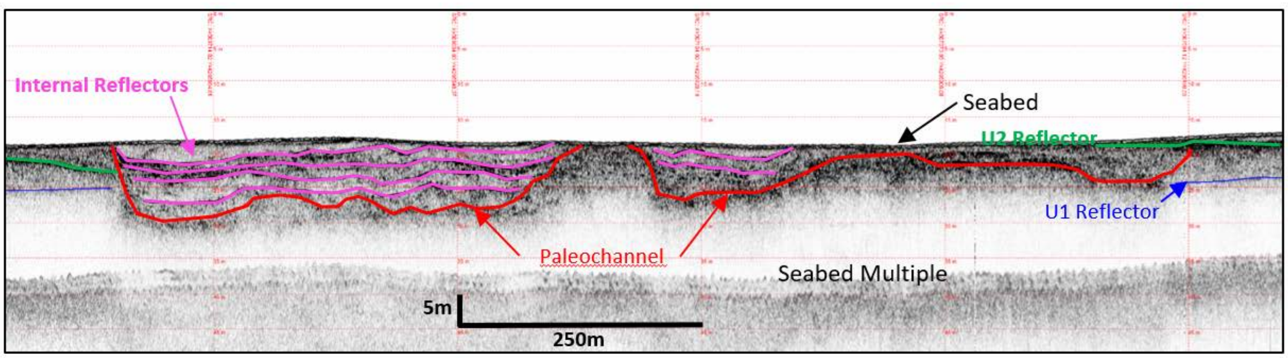


Figure 9.11 Paleochannel between KP 12+800 – 13+900

Intermittent areas of biogenic gas accumulation in the shallow seabed sediments occurs along this section, however only for very short horizontal distances (20 m or less). Biogenic gas results from the breakdown of organic matter in the sub-surface and the accumulation of the resultant gasses in the sediments. These gas-rich sediments act as a barrier to acoustic wave propagation and prevent deeper reflectors from being resolved. These areas are extremely limited along the cable route and did not adversely impact the ability to map and interpret the sub-bottom data.

9.2.2.5 Grab Samples

Two grab samples were acquired between KP 7+500 – 18+000.

- Grab A-09 was taken near KP 10+100 in an area mapped as Medium Reflectivity (sand and gravel) and recovered medium-coarse sand and gravel.
- Grab A-11 was taken near KP 14+100 in an area mapped as Variable Reflectivity (mixed sediment) and recovered fine-medium sand with gravel.

9.2.2.6 Vibracores

A total of 8 vibracores were acquired between KP 7+500 – 18+000 (A-08 – A-12; P-3, P4 & P9). A more detailed description of vibracore operations can be seen in Appendix I.

- Vibracore A-08 was located northwest of the paleochannel features and recovered sands and gravels.
- Vibracore P-9 was located near the northwest flank of the paleochannel near KP 9+500. The core recovered sand and gravel in the upper section with a sharp transition to silty clay at 2.5 m.
- Vibracore A-09 recovered sand and gravel throughout.
- Vibracore P-3, located on the southeast flank of the large paleochannel near KP 11+500, recovered a thin layer of sand and gravel in the upper section, with a transition to clay below 0.8 m, correlating to the U2 ravinement surface mapped in the sub-bottom data. Peat was also recovered at the bottom of the core – approximately 3.2 m below the seabed.
- Vibracore A-10 recovered mostly sand and gravel with a thin (0.2 m) layer of clay between 0.4 – 0.6 m.
- Vibracore P-4 was located in the paleochannel feature near KP 12+800 and recovered a thin upper layer of sand and gravel, approximately 0.3 m thick, underlain by clay down the bottom of the core. Interbeds of peat were observed between 3 – 3.2 m.
- Vibracore A-11 recovered sand and gravel, with a 0.3 m thick layer of loose dark gray gravel between 1.2 – 1.5 m, correlating to the mapped U2 ravinement surface.
- Vibracore A-12 recovered mostly sand with some interlayers of finer grained silts and clays.

9.2.3 KP 18+000 to 24+500

Alignment Sheet Charts 5 – 6 present the survey results between KP 18+000 – 24+500.

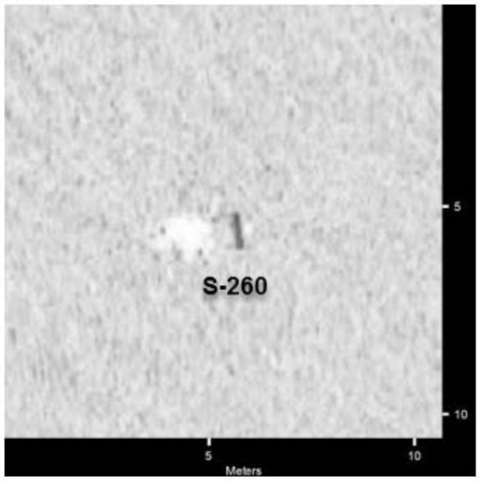
9.2.3.1 Bathymetry

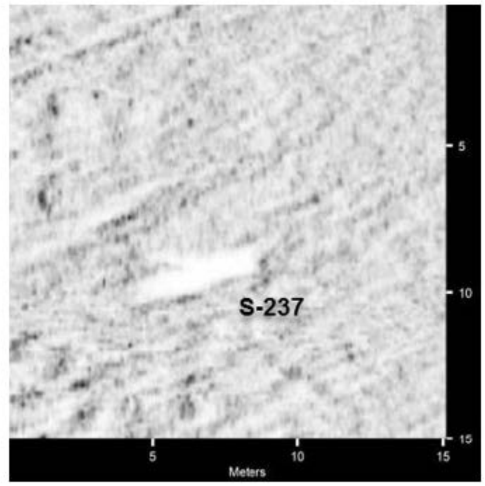
Water depths range between -18 and -27.1 m (MLLW) between KP 18+000 – 24+500. The seabed continues with a gently seaward slant with an average slope of 1.0˚. Between KP 18+000 – 22+000 the seabed is characterized by a mostly smooth bottom, and between KP 22+000 – 24+500 the bottom takes on a more irregular shape.

9.2.3.2 Side Scan Sonar Data

Fifty-four sonar contacts were identified between KP 18+000 – 24+500, most of which are related to small objects and geology (cobbles) with less than 0.5 m in relief above the seabed. Seven contacts have relief greater than 0.5 m above the seabed. Five of these may represent isolated cobbles or small boulders (S-

214, S-222, S-234, S-235 and S-236. Two of these contacts (S-237 & S-260) may represent debris on the seabed.





The seabed between KP 18+000 – 22+000 is predominantly fine to coarse sand with some gravel (Medium Reflectivity). From KP 22+000 – 24+500 the bottom is characterized by mixed sediments (silt-clay to sand and gravel; Variable Reflectivity), with several areas of Medium-High Reflectivity (coarse sand, gravel, cobbles and possible boulders). The Variable Reflectivity areas again correlate to the irregular seabed areas as seen in the bathymetry data.

The areas of Medium-High Reflectivity (coarse sand, gravel, cobbles with possible small boulders) are concentrated between KP 22+000 – 23+700 (Figure *9.12*).

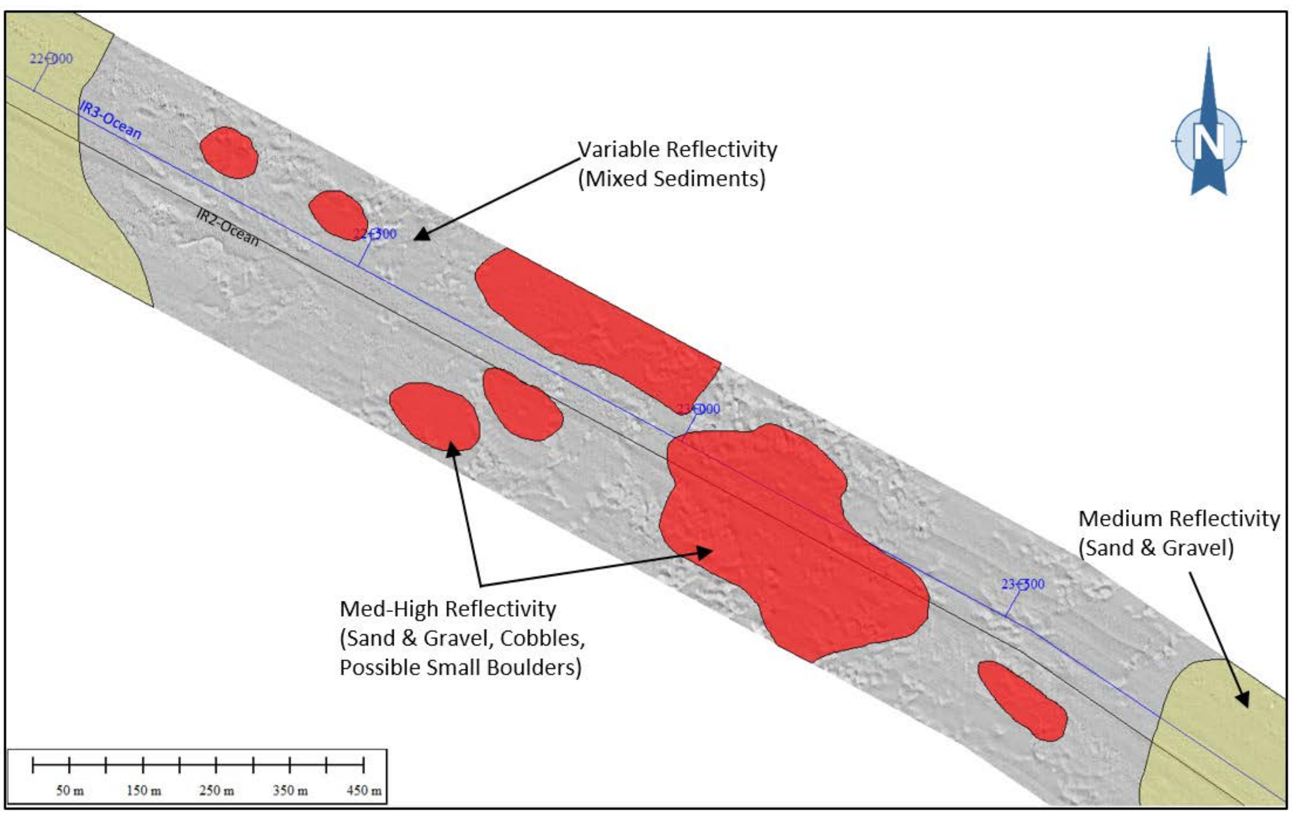


Figure 9.12 Side Scan Sonar Mosaic with Seabed Classification, KP 22+000 – 23+900

9.2.3.3 Magnetometer Data

Thirty magnetic anomalies were identified between KP 18+000 – 24+500. Anomaly M-11 was the largest (93 nT), however it has no corresponding sonar contact and may be a buried object. Two anomalies are greater than 25 nT (M-10 and M-178) and the remaining are less than 25 nT.

A series of small magnitude anomalies were identified near KP 24+300, all less than 25 nT. They occur in a linear arrangement and may represent a buried chain or cable – no features were observed on the seabed in the side scan sonar imagery (Figure 9.13).

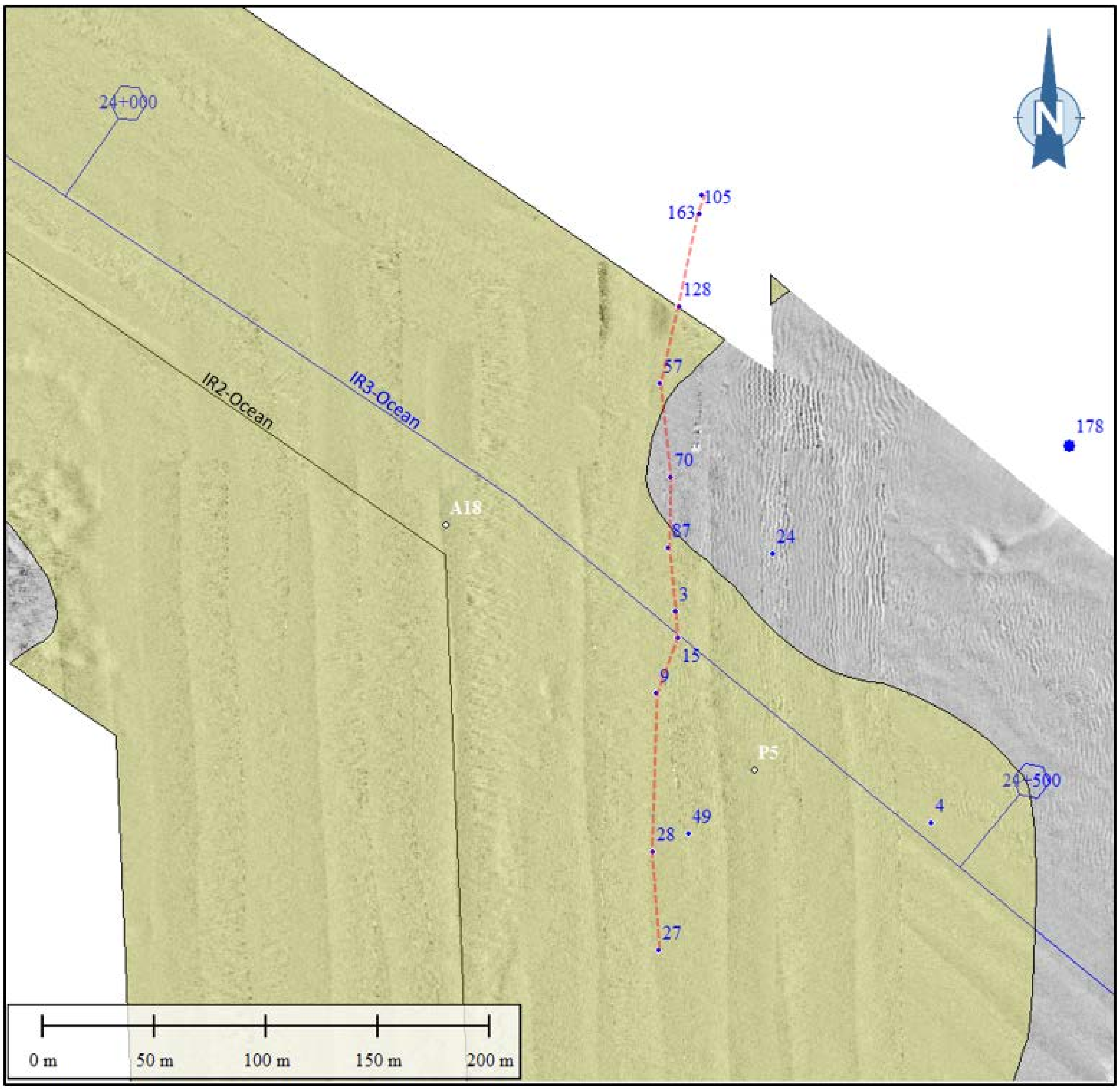


Figure 9.13 Linear Arrangement of Magnetic Anomalies near KP 24+300

9.2.3.4 Shallow Penetration Sub-bottom Data

The only sub-surface features identified between KP 18+000 – 24+500 were the U1 and U2 reflectors, which were identified and mapped along this entire section. The U2 reflector is truncated at the seafloor for a short distance near KP 23+200 and KP 24+500. Similar to the previous sections of the route, the U1 reflector is mapped at +/- 7 m below the seabed, and the U2 reflector within the upper 1 – 2 m.

9.2.3.5 Grab Samples

Two grab samples were acquired between KP 18+000 – 24+500.

- A-13 recovered fine sand with some silt in an area mapped as Medium Reflectivity (sand and gravel).
- A-15 recovered silt-clay with sand and gravel in an area mapped as Variable Reflectivity (mixed sediments).

9.2.3.6 Vibracores

Five vibracores were acquired from KP 18+000 – 24+500 (A-13, A-14, A-15, A-18 and P-5). Vibracore A-13 and A-14 recovered mostly sand with some gravel. A more detailed description of vibracore operations can be seen in Appendix I.

- Vibracore A-15 recovered a thin veneer of coarse sand and gravel at the surface over clay down to 0.76 m. Between 0.76 – 1.2 m the sediments are fine sand, transitioning to silt between 1.2 – 1.5 m, which correlates to the mapped U2 surface.
- Vibracore A-18 recovered a thin veneer of sand and gravel over a thin lens of clay in the near-surface. The clay occurs between 0.13 – 0.2 m and may correlate to the U2 surface which truncates at the seabed nearby. Sand and gravel was recovered throughout the lower sections.
- Vibracore P-5 was located along a section of the route where the U2 ravinement surface is absent and recovered silt in the upper 3.3 m, with sand between 3.3 – 4.7 m.

9.2.4 KP 24+500 to 35+100

Alignment Sheet Charts 6 – 8 present the survey results between KP 24+500 – 35+100.

9.2.4.1 Bathymetry

Water depths range between -21.9 and -31.1 m (MLLW) between KP 24+500 – 31+500. The seabed maintains its gentle seaward dip with an average slope of 1.5˚. The seabed is generally more irregular and variable along this section of the route. A series of sand ridges occur between KP 25+000 – 27+000, with maximum relief of over 5 m from the surrounding seabed (Figure 9.14).

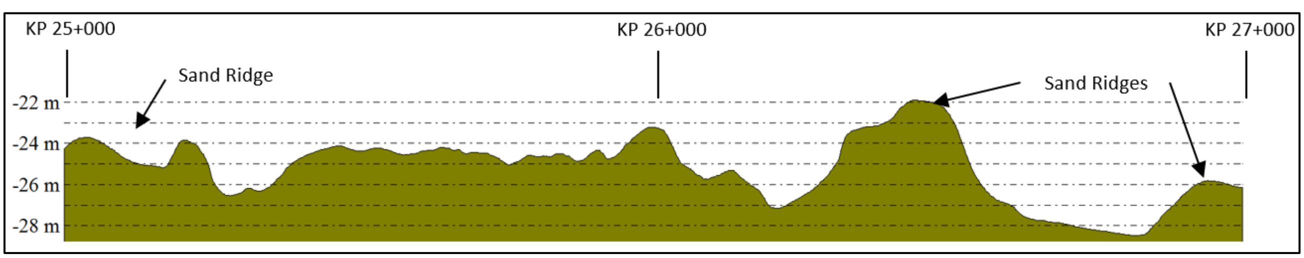


Figure 9.14 Sand Ridges between KP 25+000 – 27+000

9.2.4.2 Side Scan Sonar Data

Forty-four sonar contacts were identified between KP 24+500 – 35+100, only one of which has relief greater than 0.5 m (S-139, height = 0.57 m). The remaining contacts are likely related to small objects and geology.

The majority of this section is characterized by mixed sediments (silt-clay to sand and gravel; Variable

Reflectivity), with lesser areas of sand and gravel (Medium Reflectivity). This section is absent of any areas of Medium-High Reflectivity (coarse sand, gravel, cobbles and possible boulders).

9.2.4.3 Magnetometer Data

Ninety-two magnetic anomalies were identified between KP 18+000 – 24+500. Three anomalies are over 75 nT in magnitude (M-7 [192 nT], M-54 [186 nT], and M-174 [79 nT]), none having a corresponding sonar contact. M-174 was detected on a cross line (tie line) and is located outside the boundary of the 300 m wide survey corridor. Six anomalies ranged between 50 – 75 nT in magnitude, and 15 anomalies are between 25 – 50 nT. The remaining anomalies are all less than 25 nT.

9.2.4.4 Shallow Penetration Sub-bottom Data

Similar to the previous section of the route, the only sub-surface features identified between KP 24+500 – 31+100 were the U1 and U2 reflectors, which were identified and mapped along this entire section.

Similar to the previous sections of the route, the U1 reflector is mapped at +/- 7 m below the seabed. The U2 reflector within the upper 1 – 2 m along the majority of this section, however it is deeper in the area of sand ridges between KP 25+000 – 27+000. The U2 surface occurs at up to 5 m below the seabed directly under the ridges, and generally marks the base of these features (Figure 9.15).

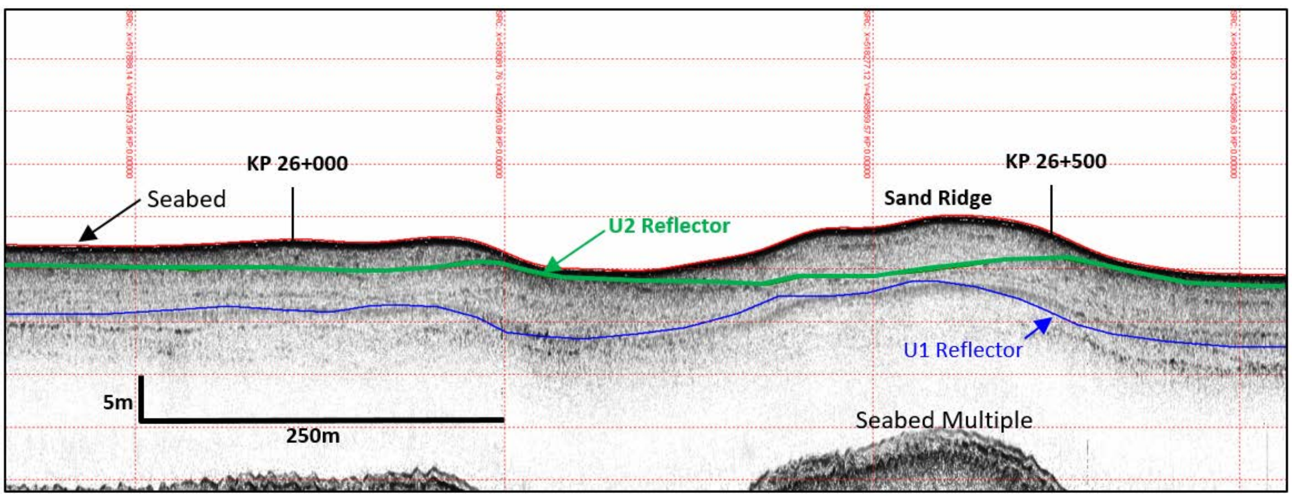


Figure 9.15 Sub-bottom Profile showing Sand Ridge

9.2.4.5 Grab Samples

Two grab samples were acquired between KP 24+500 – 35+100.

- Grab A-21 recovered fine to coarse sand with trace silt.
- Grab A-23 recovered fine to medium sand with trace silt.

9.2.4.6 Vibracores

Nine vibracores were acquired between KP 24+500 – 35+100.

- Vibracore P-6 is predominantly sand, however a layer of silt occurs below 1.35 m, which correlates to the U2 ravinement surface.

- Vibracore P-7 was located in a swale adjacent to the sand ridge between KP 26+000 – 26+500, and recovered fine sand throughout.
- Vibracore A-21 recovered all sandy sediments.
- Vibracore P8 recovered sand down to 2.5 m at which point soft silt was encountered down to approximately 3m – this correlates to the mapped U2 ravinement surface.
- Vibracore A-22 recovered sands down to approximately 2 m before silts were encountered through the lower extent of the core. The mapped U2 ravinement surface occurs near 2 m at this transition.
- Vibracore A-23 recovered sand down to 1.8 m, with silt encountered deeper in the core down to 2.3 m. This correlates to the mapped U2 ravinement surface.
- Vibracore A-24 recovered sand with gravel down to 0.9 m before encountering clay throughout the deeper portion of the core. This transition correlates to the U2 ravinement surface.
- Vibracore P-10 recovered sands and silts in the upper 3 m, with sands from 3 m to the bottom of the core.

9.2.5 IR1-Ocean Extension

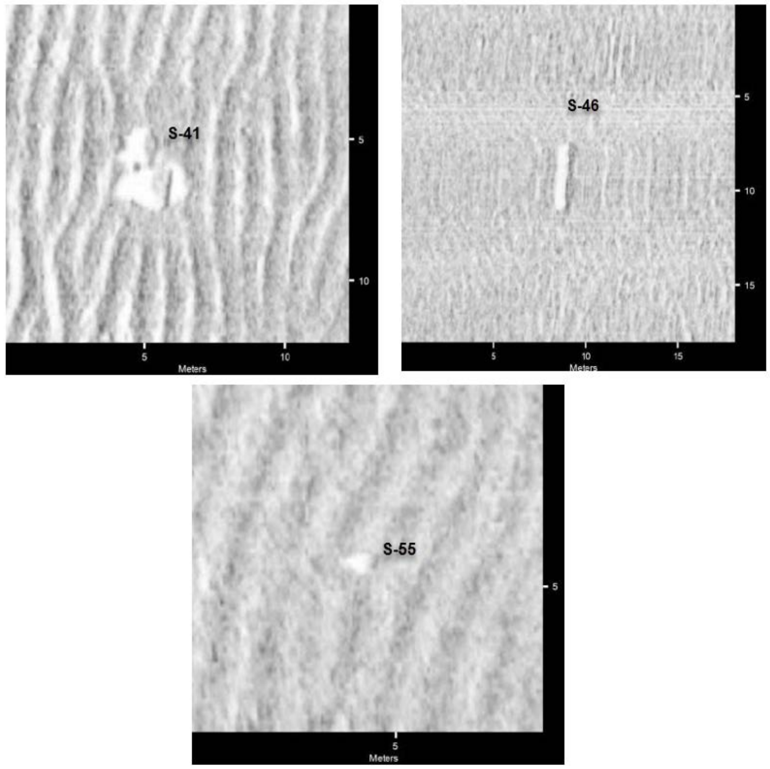
Alignment Sheet Chart 9 presents the survey results for the IR1-Ocean RPL from KP 21+517 to KP 26+037. KP stations along this leg of the route originate at the IR1-Ocean turning point, where the route diverges from the IR3-Ocean RPL and heads southward to the wind farm area surveyed in 2015.

9.2.5.1 Bathymetry

The seabed is relatively flat and elevations range between -21.8 and -24 m (MLLW) along the IR1-Ocean RPL extension into the wind farm area. Locally the bottom undulates up and down +/- 0.5 – 1 m, and has an overall average slope of 1.5˚.

9.2.5.2 Side Scan Sonar Data

A total of 23 sonar contacts were identified along the IR1-Ocean extension, none of which exceeded 0.5 m in relief above the seabed. Two contacts appear to be debris on the seabed; S-41 is 1.3 x 3 m, and S-46 is a linear object 3.6 m long and 1 m wide. The remaining contacts are relatively small and related to possible geology. Sonar contact S-55 has a corresponding magnetic anomaly (M-41; 69 nT).



The majority of the seabed along the IR1-Ocean extension is mapped as fine to coarse sand with some gravel (Medium Reflectivity). From KP 21+517 – KP 24+100 a large area is characterized by mixed sediments (silt-clay to sand and gravel; Variable Reflectivity), with significant areas of sand ripple formation. The Variable Reflectivity coincide with seabed areas displaying a more irregular surface in the bathymetry data.

9.2.5.3 Magnetometer Data

Eighteen magnetic anomalies were identified along the IR1-Ocean extension, only one exceeding 50 nT (M-41). This anomaly also has a corresponding sonar contact (S-55). Four anomalies ranged had magnitudes of 25 – 50 nT (M-40, M-42, M-43 and M-155) and the rest were less than 25 nT.

Several anomalies appear to be in a linear arrangement, however no linear features were observed on the seabed in the sonar data, and they may therefore represent a buried chain or cable.

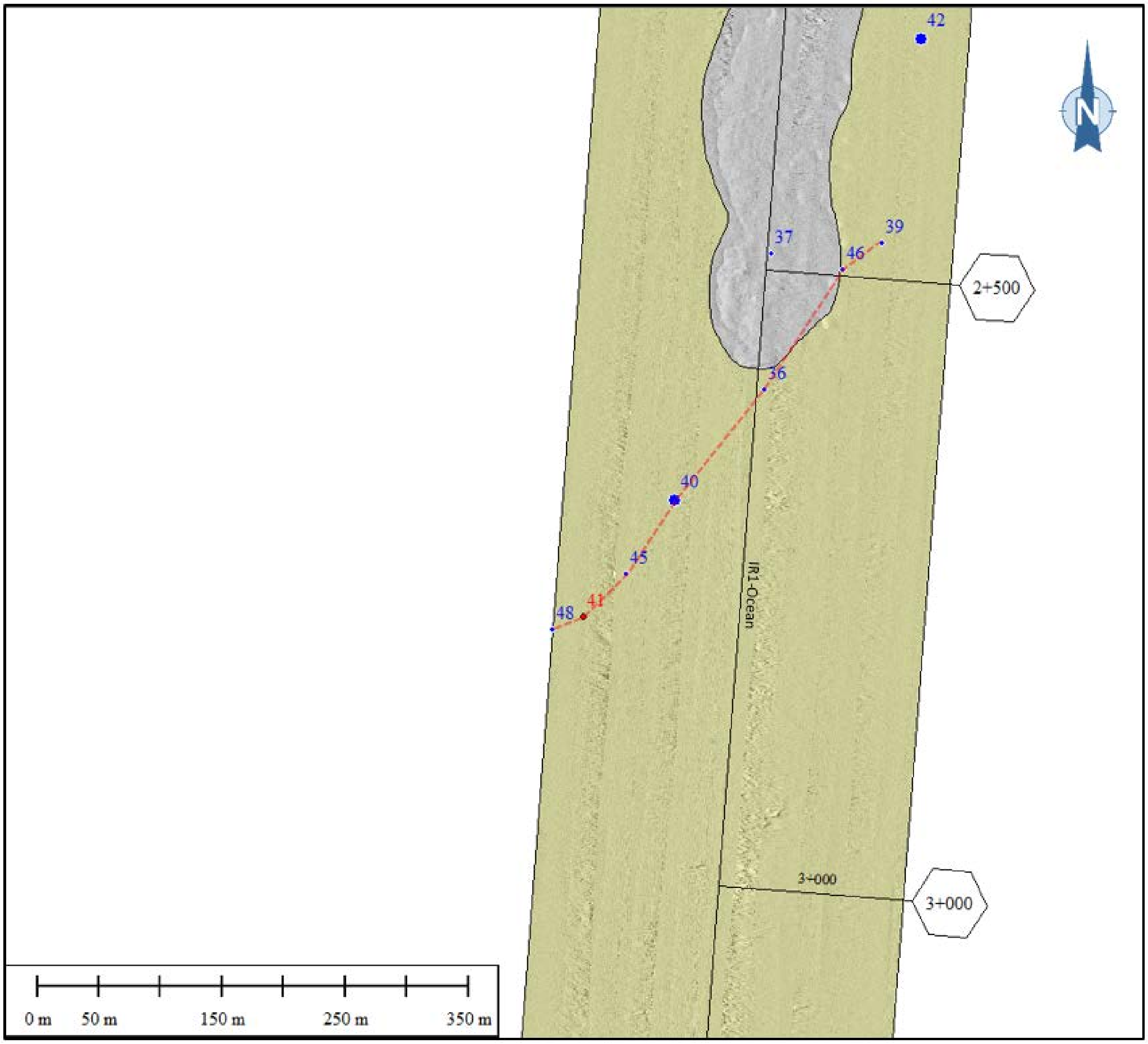


Figure 9.16 Linear Arrangement of Magnetic Anomalies along IR1-Ocean Extension

9.2.5.4 Shallow Penetration Sub-bottom Data

The only sub-surface reflectors identified along the IR1-Ocean Extension were the U1 and U2 reflectors, which were identified and mapped along this entire section. Consistent with previous sections of the offshore route, the U1 reflector is mapped at +/- 7 m below the seabed, and the U2 reflector within the upper 1 – 2 m.

9.2.5.5 Grab Samples

Two grab samples were acquired along the IR1-Ocean Extension.

- Grab A-16 recovered fine sand in an area mapped as mixed sediments (Variable Reflectivity).
- Grab A-17 recovered fine to medium sand with silt, from an area mapped as fine to coarse sand with gravel (Medium Reflectivity).

9.2.5.6 Vibracores

Two vibracores were acquired along the IR1-Ocean Extension.

- Vibracore A-16 recovered a thin veneer of sand at the surface, with interlayered sand/silt-clay down to 1.1 m. Beyond 1.1 m down to the bottom of the core at 4.6 m recovered fine to medium sands.
- Vibracore A-17 recovered interlayered sand and silt in the upper 0.7 m, with a soft silt layer occurring between 0.7 – 1.7 m. Below this the core recovered fine to medium sand to the bottom at 4.65 m.

9.2.6 IR2-Ocean Extension

Alignment Sheet Chart 10 presents the survey results for the IR2-Ocean RPL from KP 24+211 to 26+514. KP stations along this leg of the route originate at the IR2-Ocean turning point, where the route diverges from the IR3-Ocean RPL and heads southward to the wind farm area surveyed in 2015.

9.2.6.1 Bathymetry

Seafloor elevations range between -22.8 and -27.4 m (MLLW) along the IR2-Ocean Extension. The seabed displays a somewhat irregular surface along most of this section, with small undulations of up to +/- 1 m, and an average seabed slope of 1.4˚

9.2.6.2 Side Scan Sonar Data

Fifty-two sonar contacts were identified along the IR2-Ocean Extension, none of which exhibited greater than 0.5 m relief above the seabed. The identified contacts are likely related to geology (cobbles or small rocks) or small debris.

The seabed along the first 500 m of the IR1-Ocean extension is mapped as fine to coarse sand with some gravel (Medium Reflectivity). Most of the remaining section of this route is characterized by mixed sediments (silt-clay to sand and gravel; Variable Reflectivity). The west edge of the survey corridor is mapped as Medium Reflectivity from KP 25+750 – KP 26+514. The Variable Reflectivity areas coincide with seabed areas displaying an irregular surface in the bathymetry data.

9.2.6.3 Magnetometer Data

Seventeen magnetic anomalies are located along the IR2-Ocean Extension. Only one anomaly exceed 25 nT in magnitude (M-151; 30 nT), however it was detected on a cross line (tie line) and is located approximately 100 m outside of the 300 m wide survey corridor.

9.2.6.4 Shallow Penetration Sub-bottom Data

Similar to the IR1-Ocean Extension, the only mappable sub-surface reflectors identified along the IR2-Ocean Extension were the U1 and U2 reflectors. The U1 reflector is mapped at +/- 7 m below the seabed, and the U2 reflector within the upper 1 – 2 m.

9.2.6.5 Grab Samples

One grab sample was acquired along the IR2-Ocean Extension (A-19) and recovered coarse sand with pebbles, located in an area mapped as mixed sediments (Variable Reflectivity)

9.2.6.6 Vibracores

Two vibracores were acquired along the IR2-Ocean Extension.

- Vibracore A-18 recovered a thin veneer of sand and gravel over a thin lens of clay in the near-surface. The clay occurs between 0.13 – 0.2 m and may correlate to the U2 surface which truncates at the seabed nearby. Sand and gravel was recovered throughout the lower sections.
- Vibracore A-19 recovered predominantly sand throughout, with clay lenses occurring between 1.3 – 2.8 m, which correlates to the mapped U2 ravinement surface mapped in the sub-bottom data.

10 INSHORE SURVEY RESULTS

The following results describe the findings of the bathymetric and geophysical investigation during the inshore export cable route surveys conducted in August-September, 2017. All data processing and analysis was completed at Alpine's office in Norwood, NJ.

10.1 General Data Discussion

Section 9.1.1 through Section 9.1.6, below, provide a broad summary of the survey data sets along the entirety of the export cable route. A more detailed discussion of the data is presented along individual KP sections of the route in Section 9.2.

10.1.1 Bathymetry

Surveyed elevations across the inshore section of the export cable route ranged between approximately 0.7 and -9.3 m (MLLW). The seafloor is relatively flat within the bay but exhibits areas of tidal scour near the cut banks along the Indian River as well as in areas west of Indian River Inlet. The seabed is moderately smooth along the survey corridor with sand ripples being observed along the tidal scour areas just west of the Indian River Inlet. The sand ripples can be seen in the bathymetry data from KP 15+000 to KP 12+000 with amplitudes ranging from 20 cm to 100 cm.

10.1.2 Side Scan Sonar Data

After analysis of the side scan sonar data set, a total of 356 contacts were identified on the inshore cable route. These contacts are in addition to the 271 contacts identified in the offshore section of the cable route. A total of 23 of the observed contacts exhibited relief greater than 0.5m and 3 were observed with relief greater than 1m.

A large majority of the contacts are possible debris or fishing gear with a few contacts classified as possibly geological in origin. Most of the geological contacts are isolated rocks or possible boulders. All identified sonar contacts are mapped on the Alignment Sheets accompanying this report.

Of the 356 side scan contacts, 59 of them could be associated with magnetic anomalies. A large majority of these associations are likely fishing gear and a few possible geological contacts.

A tabular list and report of all sonar contacts, including thumbnail images, is included in Appendix C.

A seabed classification scheme for the inshore portion of cable route was developed after review of the sonar data, categorizing the seabed sediments into three types based on backscatter intensity (seabed reflectivity) and/or character:

1. **Variable Reflectivity** – mixed sediments consisting of silt-clay, fine-coarse sand and gravel, with areas of sand ripples common.
2. **Medium Reflectivity** – fine-coarse grained sand with gravel, some areas of sand ripples, isolated patches of silt-clay
3. **Sand Ripples** – well defined area of sand ripples located near the Delaware shoreline, orientation 360˚,180˚, wavelength = 1 m, ripple height = 0.2 m

All inshore seabed classifications area marked on the alignment sheets in the same format as the offshore classifications as seen in section 9.

10.1.3 Magnetometer Data

The magnetometer data set was reviewed and all anomalies greater than or equal to 5 nT were identified, listed and added to the Alignment Sheets. A tabular listing of all identified magnetic anomalies is included in Appendix D.

A total of 1,756 magnetic anomalies were identified throughout the inshore portion of the export cable route. These anomalies are in addition to the 178 anomalies identified in the offshore section of the cable route. Of all the targets, a total 384 magnetic anomalies exhibited amplitude values above 100 nT and 256 anomalies exhibited amplitude vales between 50 nT and 100 nT. All other anomalies had an amplitude of less than 50 nT. Due to high fishing activities and boating in the survey area as well as the low flying altitude of the magnetometer due to shallow water, a large quantity of anomalies were observed in the survey corridor. The large quantity of magnetic anomalies made it difficult to distinguish any linear patterns from possible cables or pipelines in most of the survey except for one area along the reroute between KP 12+500 and KP 13+000. Of the 1,756 magnetic anomalies, a total of 59 could be associated with SSS targets. The majority of these anomalies were identified as possible fishing gear or geological objects.

10.1.4 Shallow Penetration Sub-bottom Data

Along the inshore cable route, the sub-bottom profiler was able to penetrate the seabed 4-6 m in most areas. Two different acoustic reflectors were mapped along the inshore portion of the export cable route corridor. The reflectors were identified as biogenic gas layers and internal reflectors (Figure 10.1). Due to the dynamic environment within the river and bay and sediment shifting, there are many internal reflectors observed at different depths below the seafloor. Correlating all of these reflectors to specific geological boundaries would prove difficult so they were grouped as internal reflectors and compared to cores when possible. Biogenic gas layers are identified in the presence of acoustic blanking where all sound from the sub-bottom source is reflected at the layer of gas and no penetration occurs below that. The biogenic gas layer was observed as deep as 6 m and as shallow as 0.2 m throughout the survey route.

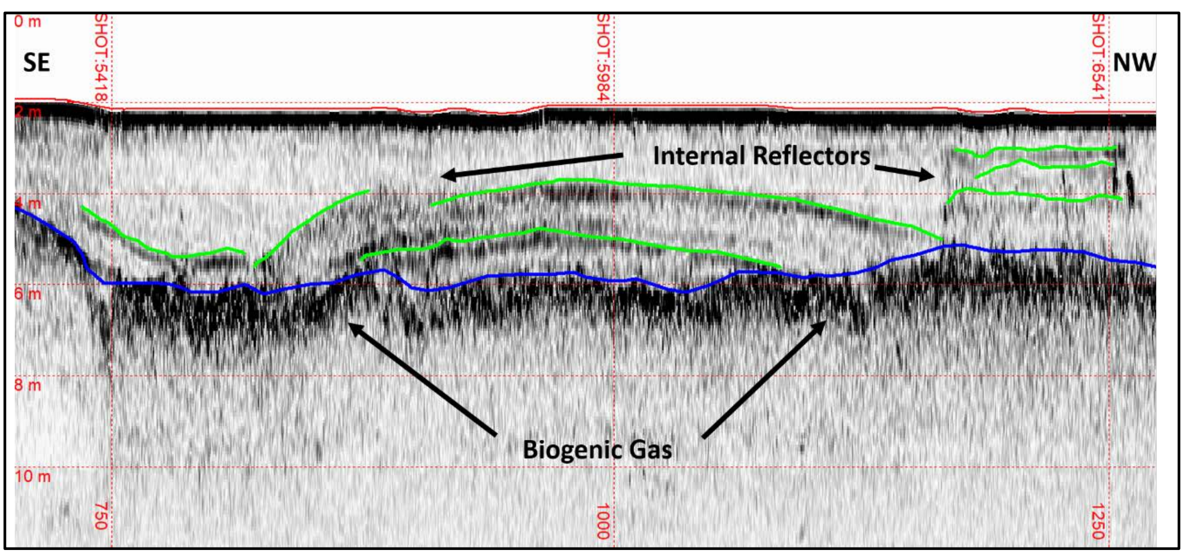


Figure 10.1 Sub-bottom profile showing reflector types on inshore cable route

10.1.5 Grab Sample Data

A total of 17 grab samples were acquired along the inshore section of the export cable route. The samples recovered primarily silty-sandy sediments with some medium and coarse sand. Trace shell fragments and gravel were also recovered in select samples. The majority of these samples were taken from areas mapped as medium reflectivity (fine to coarse sand with gravel), which generally correlates well with the sediment that was recovered. Upon recovery all samples were handed over to ESS for processing and benthic analysis. Coordinates for each sample location are provided in Appendix G.

10.1.6 Vibracore Data

A total of 18 Vibracore locations were investigated along the export cable route. All 18 locations were sampled twice, one for physical analysis and one for chemical analysis. Sixteen locations were sampled a third time for thermal resistivity analysis with VC-IRB-16 and VC-IRB-17 being excluded from the thermal resistivity investigation. All chemical cores were handed over to ESS for processing and analysis. All physical and thermal samples were brought back to Alpine headquarters in Norwood, NJ for splitting, logging and sampling. Core samples recovered a wide range of sediments and material including silt, clay, peat, organics, and sand. The core samples provide ground truthing of the sub-bottom data and generally correlate well where they penetrated deep enough to sample the sediments at and below observed internal reflectors and biogenic gas (BG) reflectors. Coordinates of each vibracore location are listed in Appendix H and core logs are presented in Appendix I. Penetration graphs were not required for the inshore survey locations.

10.2 Detailed Route Discussion

10.2.1 Survey results from KP 0.000 to 9+000

10.2.1.1 Bathymetry

Surveyed elevations from KP 0+000 to KP 9+000 ranged between approximately 0.7 and -6.8 m (MLLW). The survey area consists of a smooth, flat seafloor except for a few areas of tidal scour (Figure 10.2) between KP 0+000 and KP 4+000 where sediment has occurred around the curves of the river possibly due to tides and currents. The scour areas average about 300 m long and increase in depth by approximately 3 m.

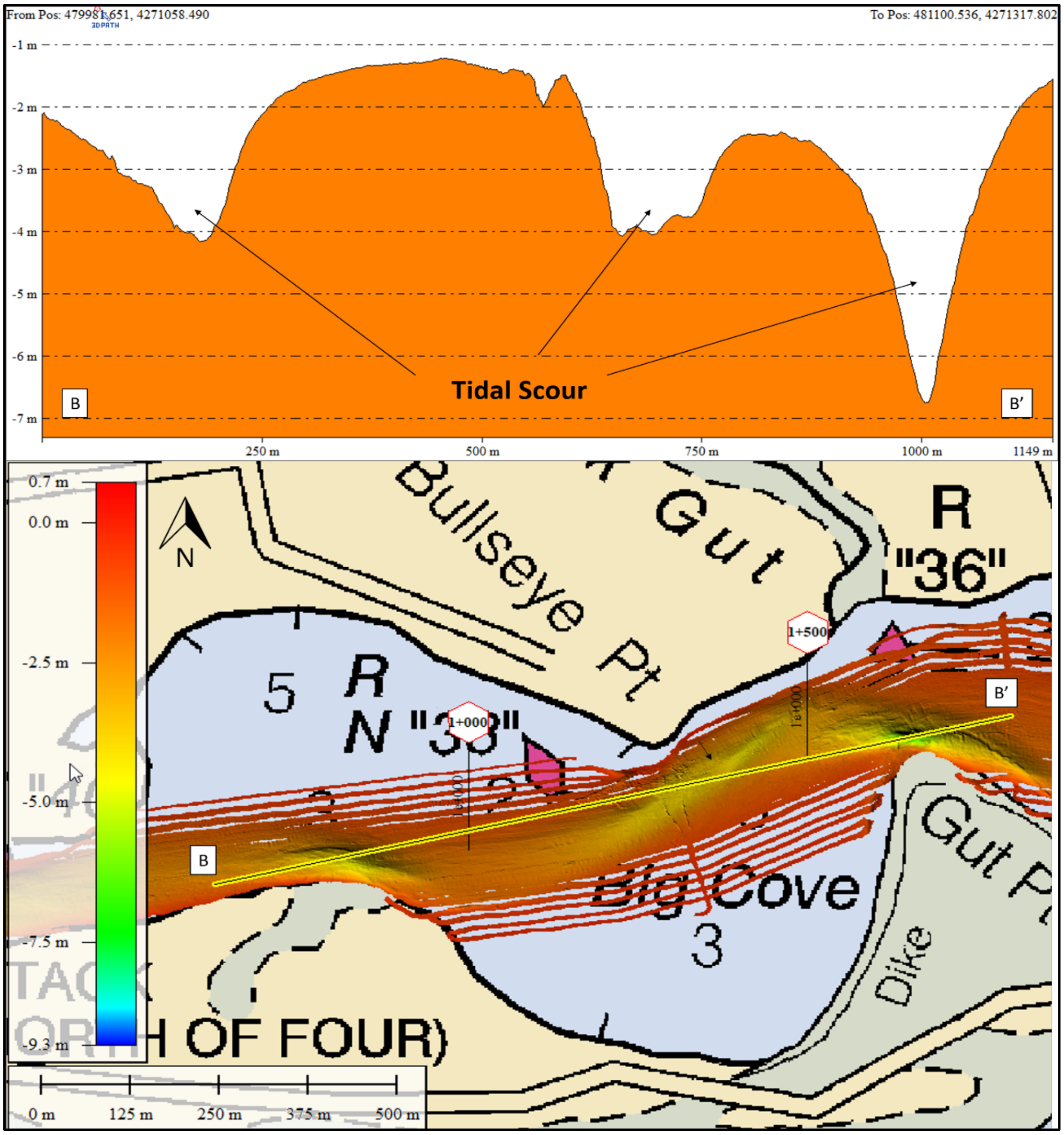


Figure 10.2 Bathymetry data illustrating tidal scouring along the Indian River

10.2.1.2 Side Scan Sonar Data

A total of 249 side scan sonar contacts were identified from KP 0+000 to KP 9+000. Of the 249 contacts, two of them have relief greater than 1 m (S-355 and S-377) and 11 have relief greater than 0.5 m. Contact S-355 and S-377 appear to be possible fishing gear (Figure 10.3). They are both rectangular objects with approximately 1 m x 1 m shape with what appears to be an acoustic shadow from line extending up through the water column. A majority of the sonar contacts with heights of 0.5 m to 1 m appear to be fishing gear and is not uncommon in this area along the route due to a high level of fishing activity. The remaining contacts are smaller objects and may be possible geology or small debris.

A total of 51 of the 249 observed sonar contacts from KP 0+000 to KP 9+000 can be associated with magnetic anomalies. Most of these appear to be possible fishing gear or small debris.

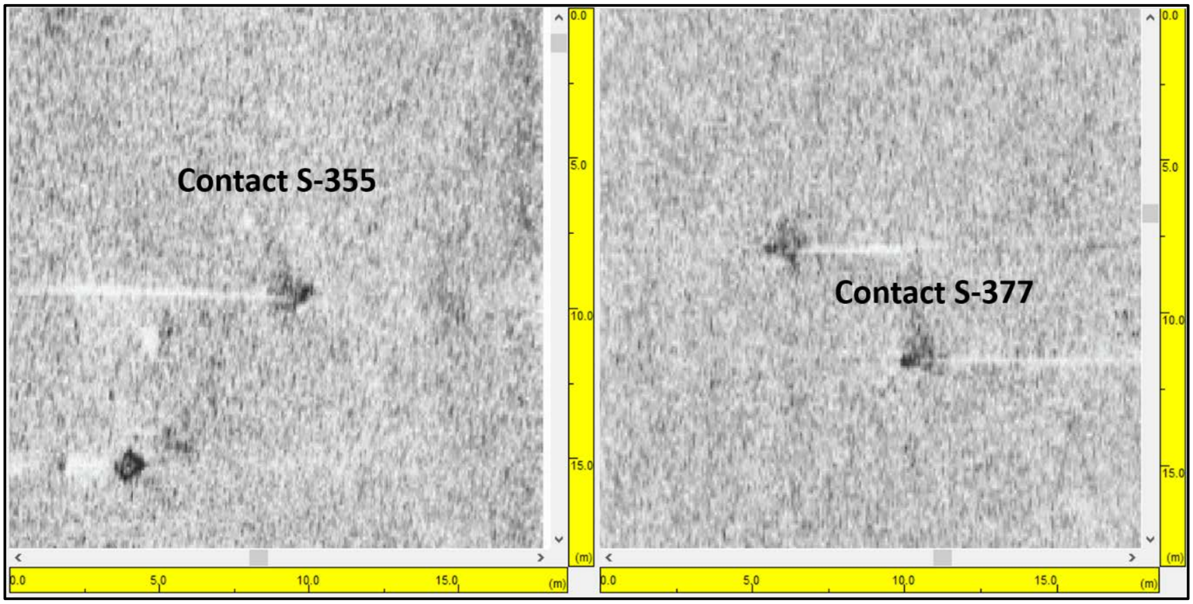


Figure 10.3 Side scan Imagery of two sonar contacts with greater than 1 m relief between KP 0+000 and KP 9+000

From KP 0+000 to KP 9+000 the seafloor was characterized by two sediment types, medium reflectivity and variable reflectivity. An example of both sediment types was observed between KP 8+000 and KP 8+500 and can be seen in Figure 10.4. A large majority of the variable reflectivity was observed outside the corridor. No sand ripples were seen in this area of the cable route.

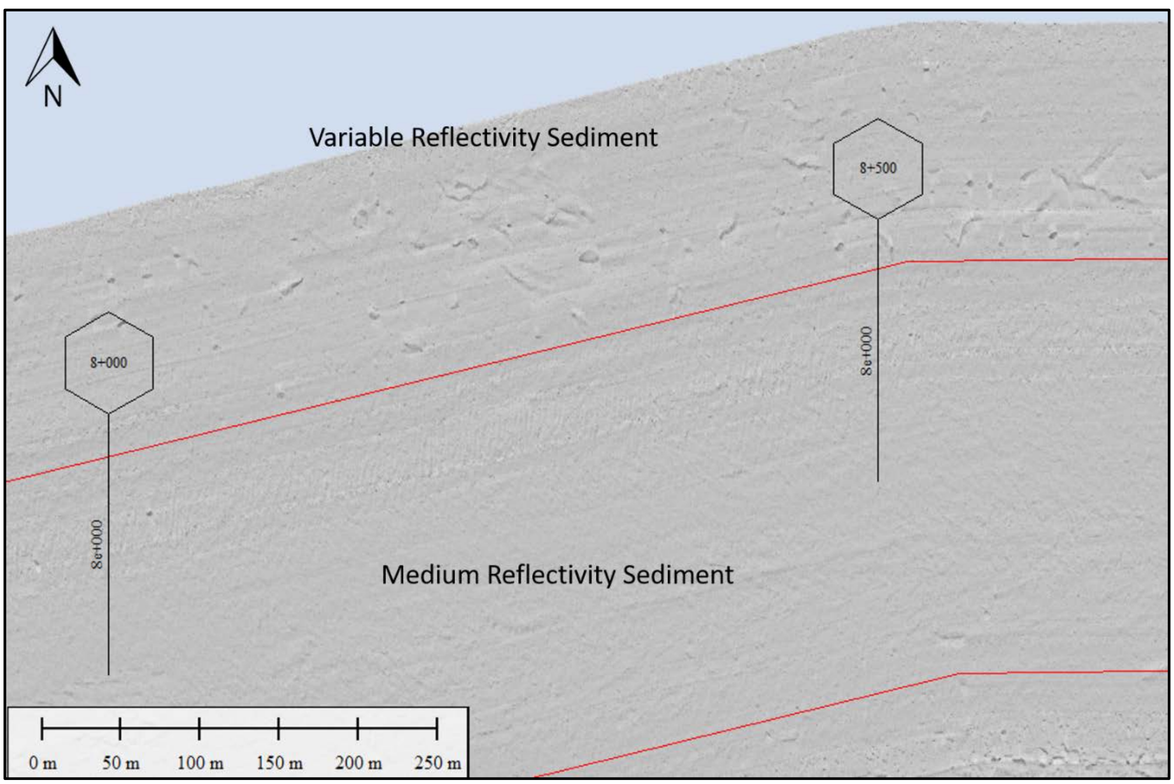


Figure 10.4 Section of the sonar mosaic showing sediment characterization between KP 8+000 and KP 8+500

10.2.1.3 Magnetometer Data

A large majority of the magnetic anomalies observed along the route were located between KP 0+000 and KP 9+000. A total of 18 anomalies had amplitude values above 1,000 nT and two of the anomalies above 1,000 nT can be associated with side scan contacts. Magnetic anomalies M-1679 (1328 nT) and M-925 (3605 nT) are associated with side scan sonar contacts S-522 and S-378 respectively. It appears that both targets are possible fishing gear based on size and showed high amplitude anomalies due to the magnetometer being acquired at low altitude, closer to ferrous targets.

The remaining targets in section KP 0+000 to KP 9+000 are most likely related to fishing and boating activities in the river. Smaller amplitude anomalies may be buried ferrous objects that cannot be associated with any side scan sonar contacts. Please note that due to an abundance of magnetic anomalies in this section, the identification of any linear patterns is very difficult. Therefore, the detection of any submarine utilities would prove unlikely.

10.2.1.4 Shallow Penetration Sub-bottom Data

Both biogenic gas layers and internal reflectors were identified along the inshore route between KP 0+000 and KP 9+000. The biogenic gas reflector is prevalent along the entire section but appears at different depths below the seafloor. In the Indian River the biogenic gas layer is much shallower and begins to deepen as the route approaches the Bay. It can be seen as shallow as 20 cm near KP 0+000 and as deep as 4 m near KP 7+500. Internal reflectors can be seen throughout this section of the route above the biogenic gas layer. An area near KP 7+000 revealed multiple internal reflectors in the sub-bottom profile and a vibracore was collected to ground truth the data. Three layers and two distinct reflectors were identified in the core as matching up with the sub-bottom data. The first reflector at 0.9 m matches the bottom of the clay layer seen in VC-IRB-08-ALT and the second reflector at 1.6 m matches the bottom of the peat layer seen in VC-IRB-08-ALT (Figure 10.5). No other distinguishable reflector types were observed from KP 0+000 to KP 9+000.

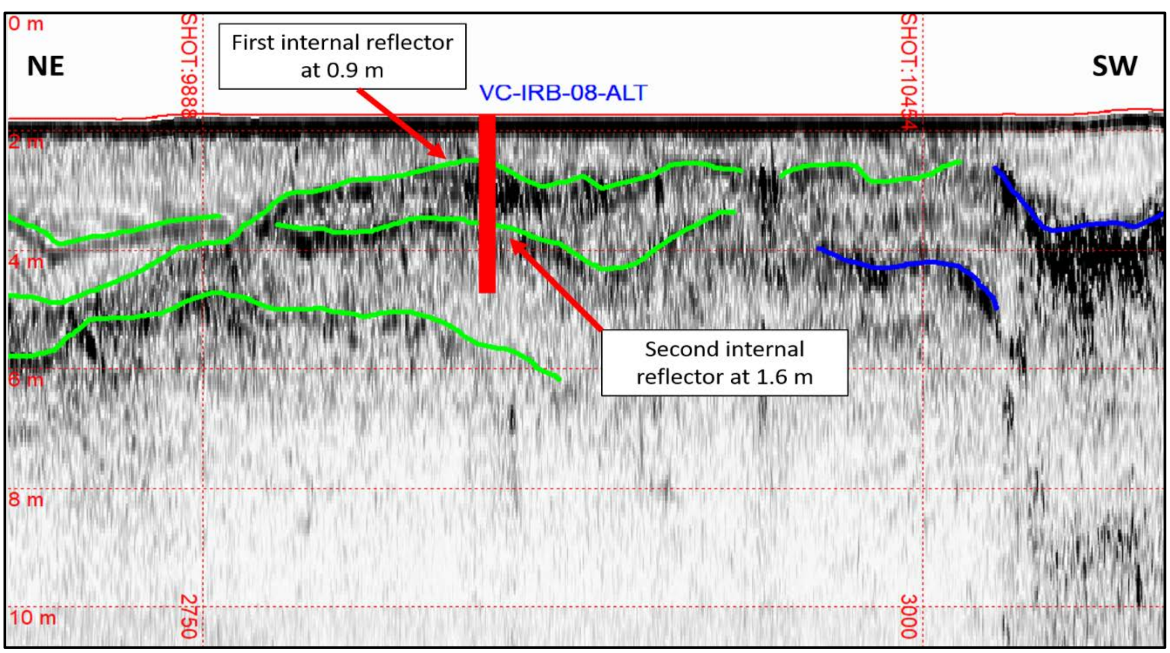


Figure 10.5 Sub-bottom profile showing internal reflectors near core location VC-IRB-08-ALT

10.2.1.5 Grab Sample Data

Ten grab samples were acquired between KP 0.000 and KP 9+000. Nine of the ten vibracores were taken in areas mapped as medium reflectivity in the sonar data. Only one core (BG-IRB-19) was located in an area mapped as variable reflectivity in the sonar data.

- BG-IRB-02-ALT was located near KP 0.000 and recovered silty fine sand.
- BG-IRB-04 was located near KP 1+600 recovered silty coarse sand with large shells overlaying a peatier sediment.
- BG-IRB-05, BG-IRB-06, BG-IRB-07-ALT, and BG-IRB-08-ALT were located between KP 3+150 and KP 7+550. These samples recovered silty fine to medium sand.
- BG-IRB-17 was located near KP 0+650 and recovered silty fine sand.
- BG-IRB-18 was located near KP 1+250 and recovered medium sand with some shell fragments overlaying siltier sediment.
- BG-IRB-19 was located south of KP 7+450 and recovered silty fine sand.
- BG-IRB-24 was located near KP 8+850 and recovered silty fine sand overlaying siltier sediment.

10.2.1.6 Vibracore Data

Vibracores were acquired at ten locations between KP 0.000 and KP 9+000. The majority of the vibracores recovered clay and peat along with sand. Correlations can be made to the biogenic gas reflector in the western portion and to internal reflectors in the eastern portion of this section.

- VC-IRB-01-ALT recovered clay in the upper 1.6 m over a small layer of fine sand in an area where both reflectors are absent.
- VC-IRB-02-ALT recovered clay in the upper 2.35 m over a small layer of silty clay with peat.
- VC-IRB-03-ALT recovered clay with some fine to medium sand in the upper 0.9 m over clay with peat and a small section of silty clay at the bottom. Both reflectors are absent at this location.
- VC-IRB-04 recovered sandy clay with little peat in the upper 0.8 m over clay with trace peat, which correlates with the BG reflector.
- VC-IRB-05 recovered clay down to 1.7 m over peat, which correlates with the BG reflector.
- VC-IRB-06 recovered clay along with trace organics below the top meter.
- VC-IRB-07-ALT recovered silty clay in the upper half meter over a layer of peat extending to 1.2 m. Fine to medium sand was recovered in the remainder of the core with a layer of sandy clay from 1.8-2.0 m and trace roots and gravel from 2.0-2.2 m. The change from peat to sand at 1.2 m may correlate with observed internal reflectors.
- VC-IRB-08-ALT recovered clay in the upper 0.6 m, interbedded clay and peat from 0.6-0.9 m, transitioning to peat until 1.6 m. Medium sand was recovered in the remainder of the core, which correlates with observed internal reflectors.
- VC-IRB-17 recovered clay and silt in the upper two meters over silty sand and fine sand with trace organics and gravel.
- VC-IRB-24 recovered clay in the upper 1.3 m with trace peat from 1.1-1.3 m. Interbedded clay and peat was recovered in the remainder of the core.

10.2.2 Survey results from KP 9+000 to 15+845

10.2.2.1 Bathymetry

Surveyed elevations from KP 0+000 to KP 9+000 ranged between approximately 0.7 and -9.3 m MLLW. From KP 9+000 to KP 12+000 the seafloor is generally flat and smooth but from KP12+000 to KP 14+500 there is a large tidal scour area with superimposed sand ripples (Figure 10.6). The tidal scour deepens to approximately -8 m MLLW between KP 13+000 and KP 13+500.

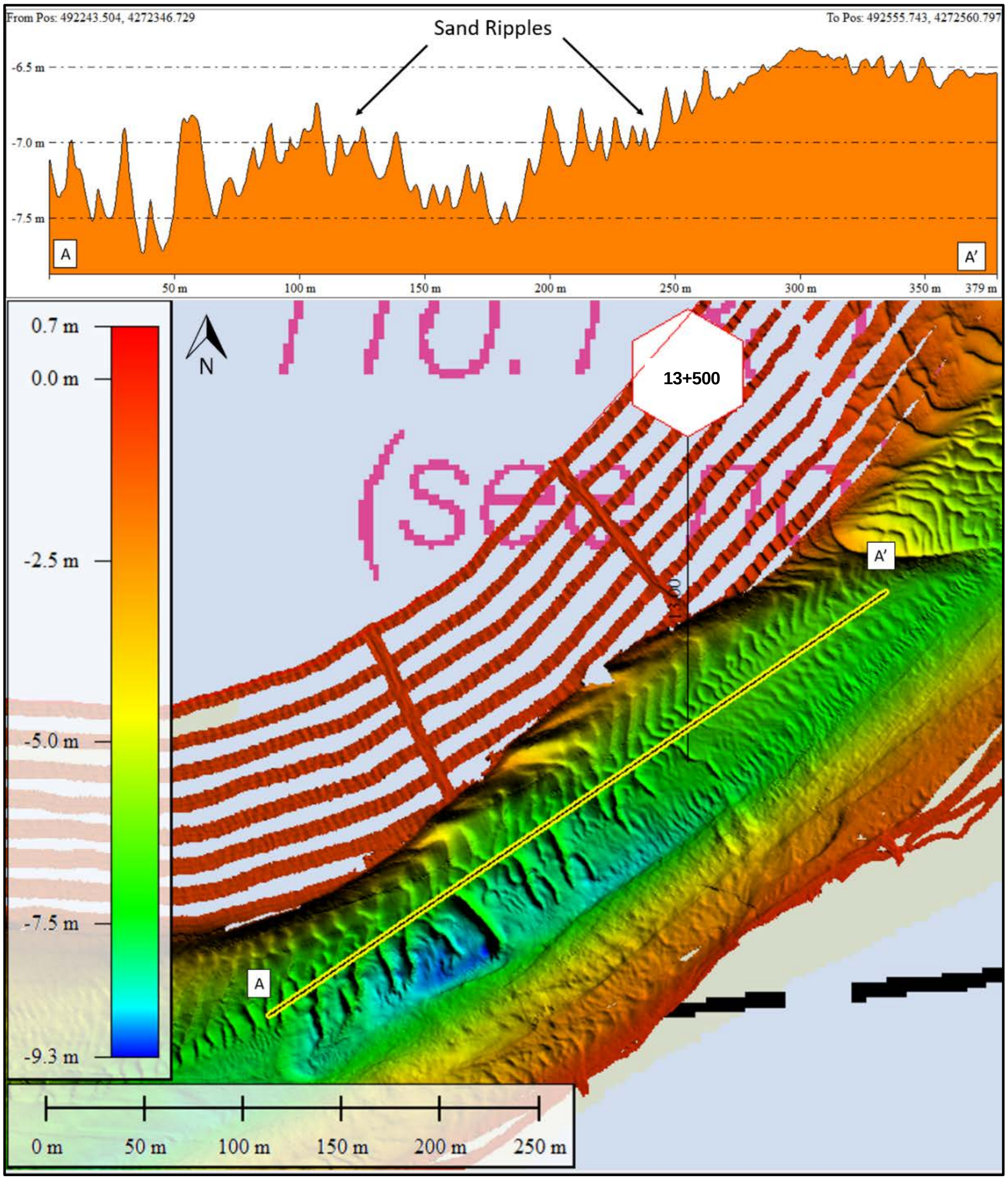


Figure 10.6 Bathymetry data showing sand ripples near Indian River bay Inlet

10.2.2.2 Side Scan Sonar Data

A total of 107 side scan sonar contacts were identified from KP 9+000 to KP 15+845. Only 58 of the 107 contacts were observed within the rerouted section of the cable corridor and the remaining 49 contacts were observed on the southeastern section of the original route. One of the 58 contacts observed along the reroute section had relief greater than 1 m (S-599) and three additional sonar contacts had relief between 0.5 m and 1 m (S-595, S-605 and S-507). Sonar contact S-599 (Figure 10.7) appears to be a rectangular object with approximately 0.5 m x 0.5 m shape with what appears to be an acoustic shadow from line extending up through the water column and is possibly fishing gear or debris. The remaining contacts are smaller objects and may be possible geology or small debris. Only 2 of the 58 observed sonar contacts from KP 9+000 to KP 15+845 can be associated with magnetic anomalies. Contacts S-608 and S-586 were identified as small pieces of debris and most likely containing ferrous components.

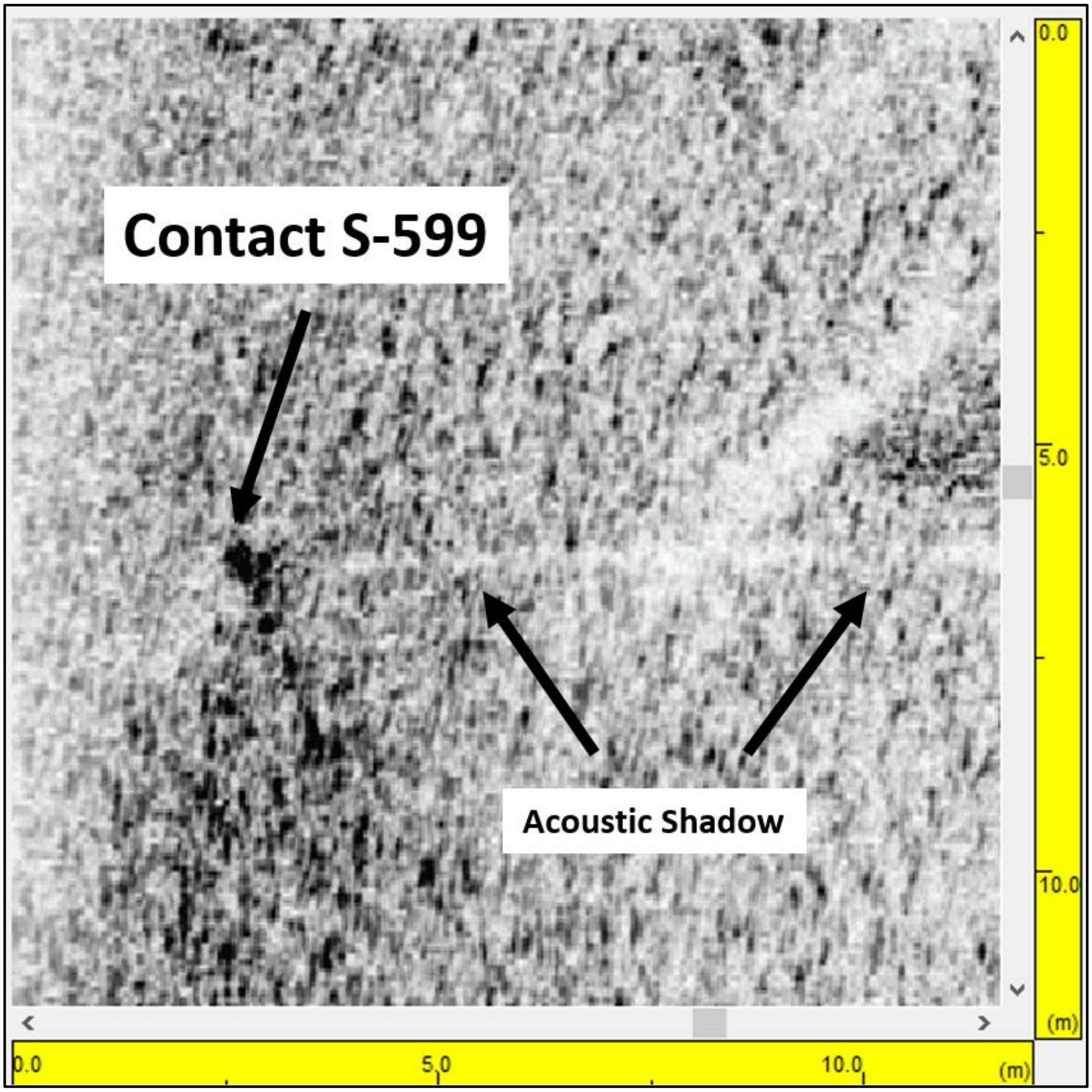


Figure 10.7 Sonar imagery showing contact S-599

From KP 9+000 to KP 15+845 the seafloor was characterized by the same two sediment types seen from KP 0+000 to KP 9+000 which consisted of medium reflectivity and variable reflectivity. The geomorphology was more dynamic towards the eastern side of the survey corridor near the inlet exhibiting areas of sand ripples and tidal scour. An example of sand ripples along the survey route was observed between KP 12+500 and KP 13+000 and can be seen in Figure 10.8. The sand ripples were observed within tidal scour areas from KP 12+000 to 15+000.

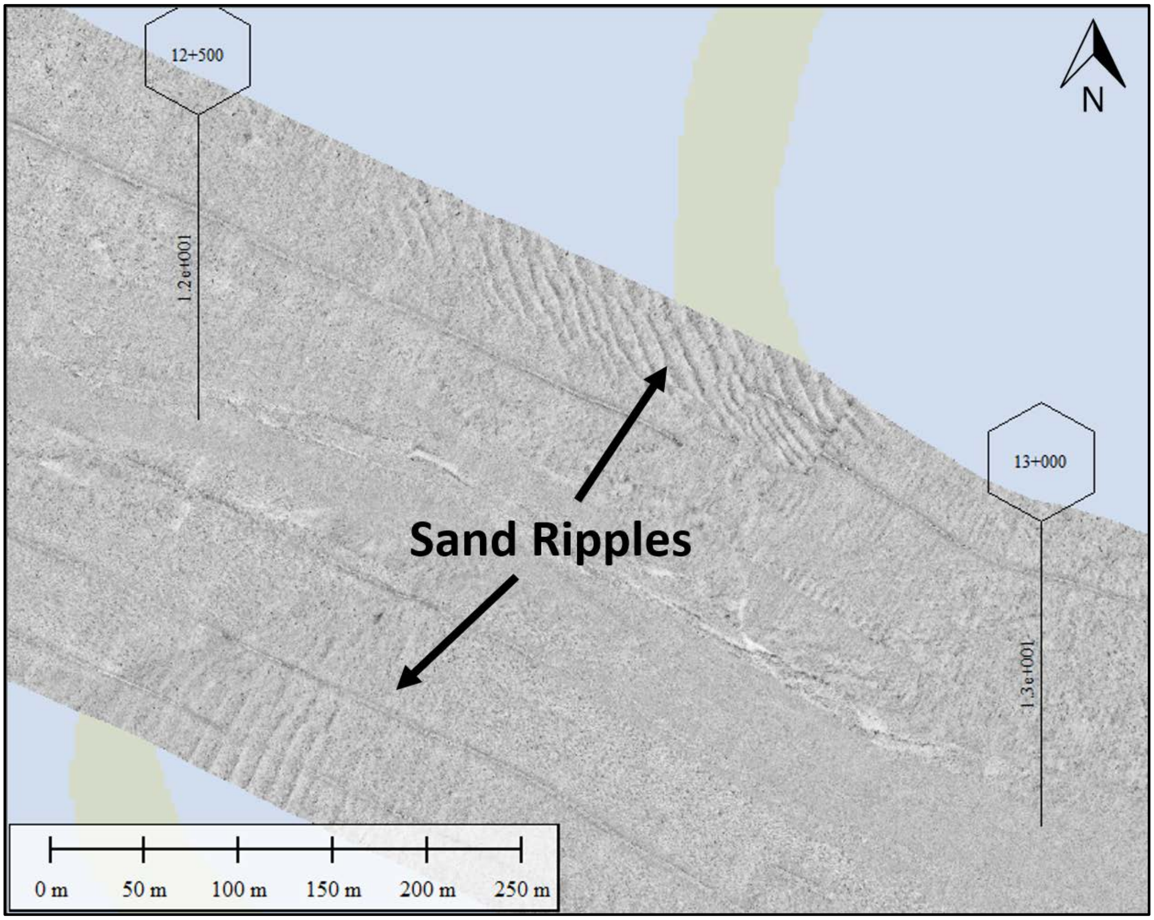


Figure 10.8 Section of the sonar mosaic showing sand ripple areas between KP 12+500 and 13+000

10.2.2.3 Magnetometer Data

A total of 379 magnetic anomalies were observed along the route between KP 9+000 and KP 15+845. None of the anomalies between KP 9+000 and KP 15+84 are above 1,000 nT and only 15 anomalies have amplitude values between 100 nT and 1,000 nT. Three of the largest anomalies observed were M-1877, M-1527 and M1588 which had amplitude values of 600 nT, 950 nT and 812 nT respectively. The three larger targets could not be associated with any sonar contacts and may be buried ferrous objects. Please note that there are more observed anomalies that have amplitude values above 100 nT but they exist along the southeastern portion of the original route which was rerouted. The 15 anomalies noted are in the rerouted section of the cable corridor.

Between KP 9+000 and KP 15+845, two magnetic anomalies observed, M-1841 and M-1844 could be associated with side scan sonar contacts S-608 and S-586 respectively. Both targets were identified as small ferrous objects or possible debris.

Though there were less targets in section KP 9+000 to KP 15+845 most of the anomalies are likely related to fishing and boating activities in the bay area. Smaller amplitude anomalies may be buried ferrous objects that cannot be associated with any side scan sonar contacts. The presence of a lower number of anomalies on this part of the route revealed a few linear trends of approximately 100 m to 200 m in length in the magnetic anomaly data between KP 12+500 and 13+000 (Figure 10.9). While there is no evidence of any cables or pipeline utilities marked on the charts, it is still recommended that these features be investigated further.

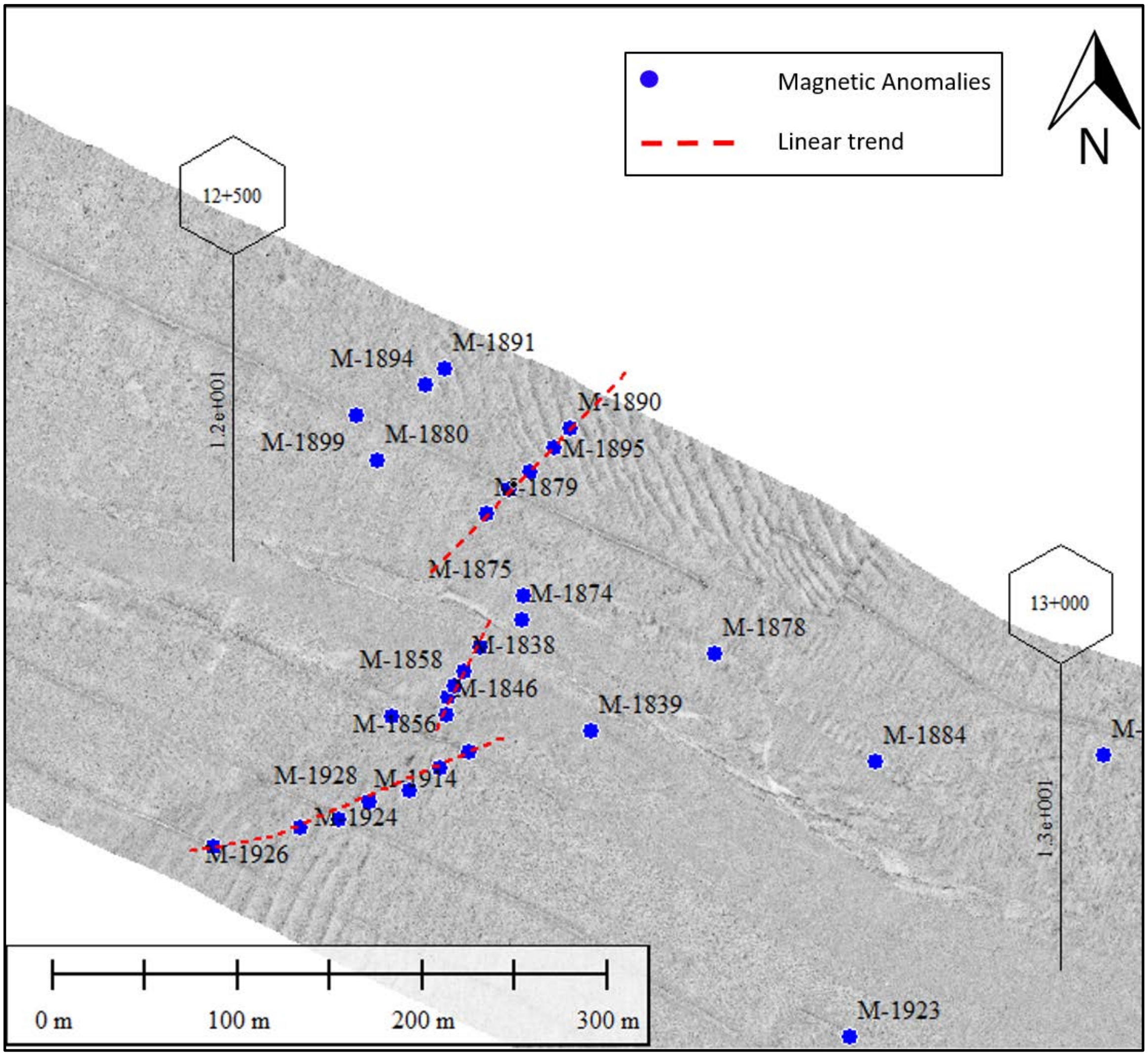
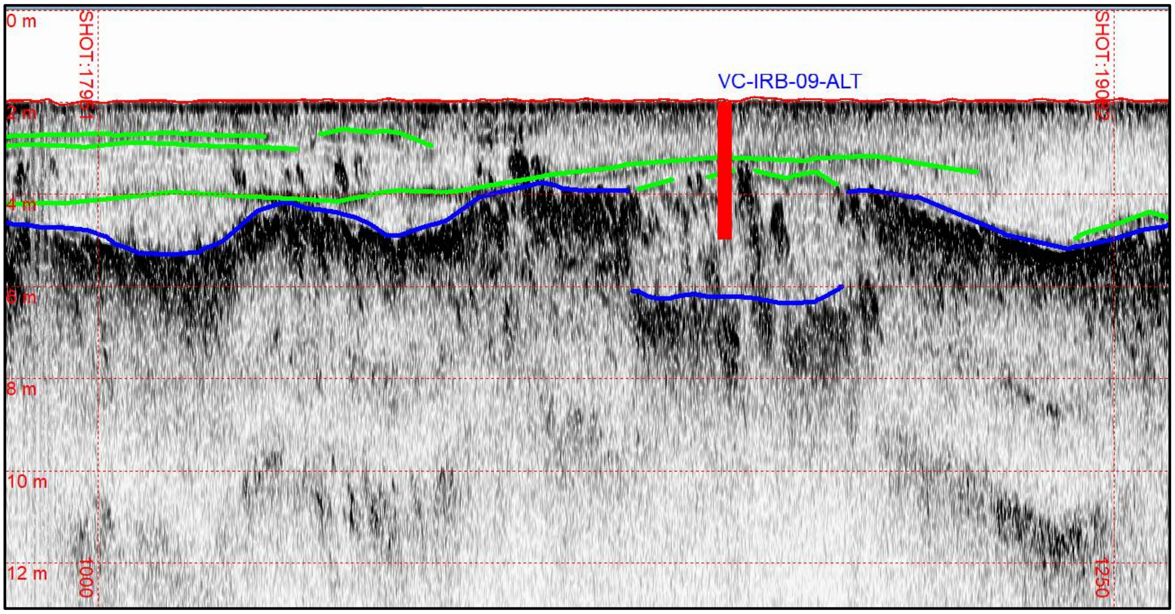


Figure 10.9 Image showing linear trends in magnetic anomalies between KP 12+500 and KP 13+000

10.2.2.4 Shallow Penetration Sub-bottom Data

Two reflectors, biogenic gas and internal were identified along the inshore route between KP 9+000 and KP 15+845. Similar to the previous section, the biogenic gas reflector is prevalent along the entire section but appears at different depths below the seafloor. In the Indian River Bay the biogenic gas layer is much deeper becoming shallower near KP 12+000 as the route approaches the Bay Inlet. The biogenic gas layer was observed as deep as 6.3 m near KP 7+500 and as shallow as 0.5 m near KP 14+150.

Internal reflectors can be seen throughout this section of the route above the biogenic gas layer. An area near KP 9+500 revealed multiple internal reflectors in the sub-bottom profile and a vibracore was collected to ground truth SBP data. Three layers and two distinct reflectors were identified in the core as matching up with the SBP data. The first reflector at 1.1 m matches the bottom of the clay layer seen in VC-IRB-09-ALT and the second reflector at 1.5 m matches the bottom of the peat layer seen in VC-IRB-08-ALT (Figure 10.10). No other distinguishable reflector types were observed from KP 0+000 to KP 9+000.



10.2.2.5 Grab Sample Data

Seven grab samples were acquired between KP 9+000 and KP 15+845. All were taken from areas mapped as medium reflectivity excluding BG-IRB-12, which was located in an area mapped as sand ripples.

- BG-IRB-09-ALT was located near KP 9+950 and recovered silty fine sand overlaying siltier sediment.
- BG-IRB-10-ALT was located near KP 11+300 and recovered silty fine to coarse sand.
- BG-IRB-11-ALT was located near KP 13+100 and recovered silty medium to coarse sand with shell fragments and fine gravel.
- BG-IRB-12 was located near KP 14+950 and recovered medium sand.
- BG-IRB-14-ALT was located near KP 15+800 and recovered silty fine sand.
- BG-IRB-22 and BG-IRB-23 were located on the original route, about one kilometer south of the reroute between KP 12+000 and KP 12+500. These samples recovered silty fine sand.

10.2.2.6 Vibracore Data

Eight vibracores were acquired between KP 9+000 and KP 15+845. These vibracores recovered mostly silty clay and sand along with some layers of peat.

- VC-IRB-09-ALT recovered silty clay with a layer of peat from 1.0-1.5 m, which may correlate with observed internal reflectors. The remainder of the core consisted of soft silty clay with organics
- VC-IRB-10-ALT recovered silty clay with trace peat.
- VC-IRB-11-ALT recovered medium to coarse sand in the upper meter over sandy and silty clay in the remainder of the core with peat beneath 1.9 m. The transition from sandy and silty clay to silty clay with peat correlates with the BG reflector.
- VC-IRB-12 recovered fine sand over a layer of silty sand with trace peat in the upper half meter. Clayey silt and silty clay was recovered in the remainder of the core with trace peat.

The layer of silty clay beginning at 1.2 m penetration may correlate with observed internal reflectors.

- VC-IRB-13-ALT recovered fine sand in the upper 1.1 m over silty clay in an area where both reflectors are absent.
- VC-IRB-14-ALT recovered fine sand in the upper 1.4 m over sand with silt until 1.8 m, transitioning to silty clay.
- VC-IRB-15-ALT recovered fine sand in the upper 1.2 m over silty clay in an area where both reflectors are absent.
- VC-IRB-16 recovered silty sand over a thin layer of fine sand. Recovery past 0.8 m was not possible at this location.

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APPENDICES

APPENDIX A ROUTE POSITION LIST

APPENDIX B EQUIPMENT SPECIFICATION SHEETS

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