APPENDIX A-1

GEOPHYSICAL SURVEY REPORT

CHANNEL NAVIGATION IMPROVEMENTS FEASIBILITY STUDY, DUTCH HARBOR, ALASKA

VOLUME 1 – REPORT

VOLUME 2 - DRAWINGS

FINAL SUBMITTAL
REVISION 1

GEOPHYSICAL SURVEY REPORT

CHANNEL NAVIGATION IMPROVEMENTS
FEASIBILITY STUDY
DUTCH HARBOR, ALASKA

VOLUME 1 OF 2
REPORT

CONTRACT NO. W911KB-17-D-0001
DELIVERY ORDER NO. 0005

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5 JULY 2017

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July 5, 2017 R&M No. 2440.05

Mr. Doug Bliss, P.E., P.G.
Contracting Officer's Representative
U.S. Army Corps of Engineers, Alaska District
VIA EMAIL: Douglas.A.Bliss@usace.army.mil
JBER, Alaska 99506

RE: Final Geophysical Survey Report
Channel Navigation Improvements Feasibility Study, Dutch Harbor, Alaska
IDIQ Contract for Geotechnical Design and Related Services
Contract No. W911KB-17-D-0001, Delivery Order No. 0005

Dear Mr. Bliss:

Enclosed find our final geophysical survey report prepared for the above referenced project. This work has been completed in accordance with Contract No. W911KB-17-D-0001, Delivery Order No. 0005. This final submittal incorporates review comments of the draft geophysical survey report made within ProjNet and distributed June 21, 2017.

We trust that this final report is found to be responsive to your requirements. Should you have any questions or desire additional information, please do not hesitate to contact us. It has been a pleasure to be of service to the USACE, Alaska District on this effort.

Sincerely,

R&M CONSULTANTS, INC.

Charles H Riddle, C.P.G.
Senior Vice President

GEOPHYSICAL SURVEY REPORT

CHANNEL NAVIGATION IMPROVMENTS FEASIBILITY STUDY

DUTCH HARBOR, ALASKA

The following report presents the results of R&M and eTrac's marine geophysical survey completed to support the Channel Navigation Improvements Feasibility Study at Dutch Harbor, Alaska. The report includes discussion and results associated with the geophysical survey, geologic reconnaissance, sediment sampling, and laboratory testing. The report also includes conclusions and recommendations regarding general dredging considerations, hydrology and hydrogeology considerations, and recommendations for future investigations. The marine geophysical survey services performed by R&M Consultants, Inc. and eTrac Inc. were authorized by the USACE-AD under Contract No. W911KB-17-D-0001, Delivery Order No. 0005.

Geophysical surveys performed as part of this investigation may or may not successfully detect or delineate any or all features present. Locations, depths and scale of submarine and subsurface features mapped as a result of this investigation are a result of geophysical interpretation only, and should be considered as confirmed, actual, or accurate only where recovered by excavation or drilling.

This report includes both factual and interpretative information and is intended to provide the project designers with a summary of the geotechnical conditions expected at the site. This report is intended solely for use by USACE and its contractors directly involved with the channel navigation improvements feasibility study; contingent upon the reader possessing basic understanding of geophysical and geotechnical terminology and principles, as well as the referenced documents.

R&M Consultants, Inc. has performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. R&M's services for the project were performed by, or under the responsible charge of the individuals listed below.

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ACRONYMS AND ABBREVIATIONS

°	degree(s)
°F	degree(s) Fahrenheit
3D	three dimensional
AEC	Architecture, Engineering and Construction
ARA	angle range analysis
ASP	Alaska State Plane
ASTM	ASTM International
CAD	Computer Aided Drawing
CD	compact disc
cm	centimeter
CMR	compact measurement record
COR	contracting officers representative
DTON	danger to navigation
.dwg	AutoCAD Drawing File Format
.dxf	AutoCAD Drawing Exchange Format
EM	engineering manual
EP	exploration plan
eTrac	eTrac, Inc.
GFI	government furnished information
GNSS	global navigation satellite system
GPS	global positioning system
HPU	hydraulic power unit
Hz	hertz
ID	identification
IHO	International Hydrographic Organization
JSF	java server faces
kHz	kilohertz
LPCP	local project control point
m	meter
MBES	multibeam echosounder system
MEC	munitions and explosives of concern
MLLW	mean lower low water

ACRONYMS AND ABBREVIATIONS (CONTINUED)

MMS	mobile mapping suite
NAD83	North American Datum 1983
NAVFAC	Naval Facilities Engineering Command
NGS	National Geodetic Survey
NI	National Insturments
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OPUS	Online Positioning User Service
pdf	Adobe Portable Document Format
POSMV	position and orientation system for marine vessels
PPCP	primary project control point
PPS	pulse per second
R&M	R&M Consultants, Inc.
ROV	remotely operated vehicle
RTK	real time kinematic
SBET	smoothed best estimate of trajectory
SEG	Society of Exploration Geophysicists
TM	Technical Manual
TVG	transverse gradient
USM	universal sonar mount
USACE	U.S. Army Corps of Engineers
USBL	ultra-short base line
USC&GS	U.S. Coast and Geodetic Survey
UXO	unexploded ordinance
VOOP	vessel of opportunity
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, Alaska District (USACE) has conducted a marine geophysical survey investigation to provide design information for the construction of a proposed dredge channel at the entrance to Iliuliuk Bay. This channel is intended to increase harbor operation efficiency at Dutch Harbor for deep draft ships and to provide a port of refuge for vessels requiring emergency anchorage while en route to the Arctic Ocean, Asia, and Europe via the Northern Sea Route. R&M Consultants, Inc. (R&M) under contract with the USACE, subcontracted eTrac, Inc. (eTrac) to perform a marine geophysical survey investigation at the site from the period of April 10th through May 2nd 2017. A vessel of opportunity (the Miss Alyssa), provided by the City of Unalaska, was utilized as the platform to perform the survey activities. Additionally, two USACE representatives were on-site throughout applicable portions of the project to provide marine mammal observation services. This report and the attached eTrac Geophysical Survey Report present a summary of results from the marine geophysical survey and our interpretation of site conditions.

The project area is located at the entrance to Iliuliuk Bay and is situated between Amaknak Island and Unalaska Island. Water depths in this area have been surveyed at depths as shallow as -42 feet. It is understood that in order to assure safe passage for deep draft vessels making routine or emergency stops in Dutch Harbor, the USACE wishes to establish a dredged channel to about -60 feet in elevation.

A combination of marine sediment sampling, bathymetric surveying, subbottom seismic reflection profiling, gradiometer surveying and terrestrial geologic reconnaissance was accomplished during this investigation. The main purpose of the investigation was to define the nature of the shallow shoal structure and to delineate both surface and buried submarine objects and debris within the defined geophysical survey area.

Interpreted geophysical findings indicate that the shoal structure is most likely glacial in origin and has experienced some post depositional consolidation resulting in a dense structure with dredging characteristics similar to some weaker rocks. Materials within the shoal are expected to consist of a consolidated, unsorted and unstratified heterogeneous mixture of clay, silt, sand, gravel and cobbles and boulders ranging widely in size and shape. Construction is expected to be difficult at best and a high degree of risk should be anticipated with this project.

The survey area was analyzed for surface and subsurface features larger than 1 foot by 1 foot. They were classified into several groups based on their geophysical signatures and further refined as to their location being either within the inner box or within the outer box of areas investigated. Of particular concern to the feasibility study is whether or not any potential UXOs may be present within the inner box. Thirty-eight (38) objects with a ferrous return, which could not be discounted as something innocuous like a crab pot, were identified within the inner box.

Based on bathometric survey results, observed surface sediment and interpreted subsurface sediment depositional environments, it is likely that the shoal acts as a natural breakwater. The shoal appears to reduce the impacts from wave action from the open sea and likely acts as a natural sediment dam retarding the deposition of the highly mobile sandy sediments located within the outer shoal area to within the inner shoal area.

The combination of dense material, open-water, and the potential for rough seas will make construction dredging difficult at best. Hydraulic cutterhead or mechanical backhoe dredging may be capable of excavating the material to the desired depths. However, both of these methods may be limited by their ability to work in rough water. It is likely that blasting will be necessary followed by mechanical dredging to remove the loosened material.

The dense shoal material is expected to have a high in-situ strength. If undisturbed, the material would be expected to be stable at slopes of 2:1 (horizontal:vertical). Flatter slopes may be necessary if the material is loosened by blasting. The dredge slope angle should be re-evaluated if additional soil property data becomes available.

1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Army Corps of Engineers, Alaska District (USACE) is presently conducting a channel navigation improvements feasibility study at the entrance to Iliuliuk Bay, between Amaknak Island and Unalaska Island (see Vicinity and Location Maps, Figure 1-1). A shoal which crosses the channel limits access to Dutch Harbor by deep draft vessels. The Government's feasibility study will evaluate the benefits of channel dredging to alleviate the harbor access limitations. This report presents the results of geologic reconnaissance, geophysical surveys, bathymetric surveys and our interpretation of site conditions.

R&M retained eTrac, Inc. (eTrac) to provide marine geophysical survey and bathymetric survey services. A vessel of opportunity (the Miss Alyssa), provided by the City of Unalaska, was utilized as the platform to perform the survey activities. Additionally, two USACE representatives were on-site throughout applicable portions of the project to provide marine mammal observation services.

This report is comprised of two volumes, Volume 1 (Report) summarizes the results of the field and office programs along with methods and procedures used to complete the work. Volume 1 also presents our conclusions and recommendations regarding dredging methods and activities. Volume 2 (Drawings) contains various maps and graphical presentation of geophysical survey data.

In conjunction with the geophysical investigation, a bathymetric survey was also conducted which required separate delivery specifications. This bathymetric survey deliverable was provided under separate cover from Volume 1 and 2 of this Geophysical Survey Report.

Site descriptions and submarine conditions presented herein are based on our current understanding of the project and location as outlined within and illustrated on the drawings included in Volume 2 of this report. Any deviation from the proposed location would necessitate further evaluation of submarine conditions.

1.2 CONTRACT AUTHORIZATION

This study has been conducted under the terms of Contract No. W911KB-17-D-0001 between the USACE and R&M. This report is in specific fulfillment of Delivery Order No. 0005 of the contract. Measurements and weights presented in this report are generally shown as U.S. Customary Units.

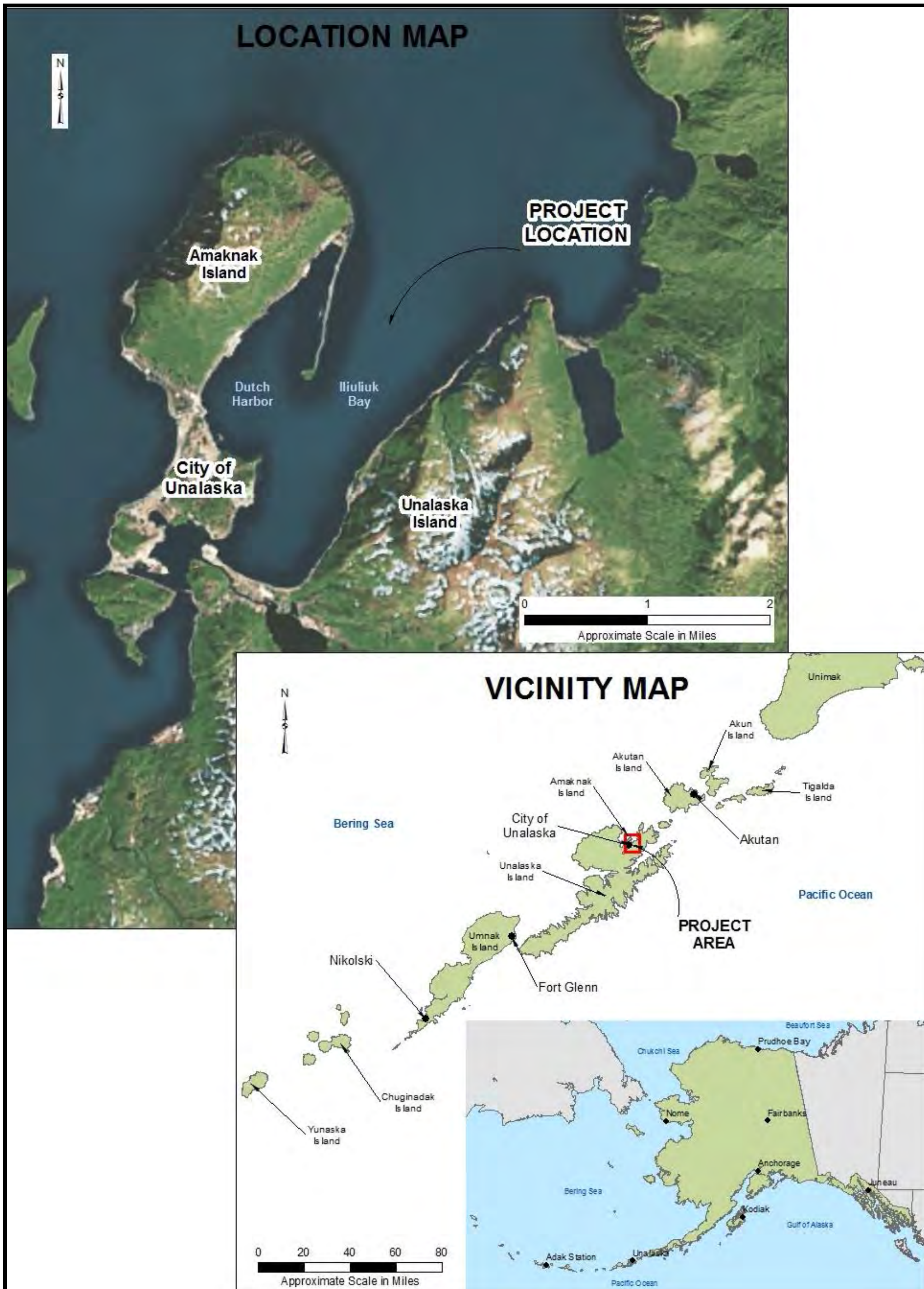
1.3 INVESTIGATION OBJECTIVES

This marine geophysical and bathymetric survey was intended to provide sea-floor bathymetry, subbottom stratigraphy, and submarine debris target information. The geophysical investigation specifically focused on the following objectives:

- Stratigraphic and geologic characterization of sediment, soil, and/or bedrock underlying the defined geophysical survey area.
- Description of the nature of the shallow shoal structure.

- Definition of the relevant engineering properties of sea floor material expected within and adjacent to the planned dredge limits.
- Delineation of surface and buried submarine objects and debris within the defined geophysical survey area.

FIGURE 1-1: DUTCH HARBOR VICINITY AND LOCATION MAPS



1.4 PURPOSE AND SCOPE-OF-WORK

The geophysical survey area consists of an outer rectangular box (3,500-feet by 2,500-feet) and an inner rectangular box (1,500-feet by 1,000-feet). The inner box defines an area that more closely encompasses the planned area to be dredged. The location of these boxes and relation of them to the shallow shoal is presented in Volume 2 on Sheets 2 through 6. A Statement of Work prepared by the USACE, dated January 27, 2017, summarizes the Scope-of-Work for this project. The work performed within the outer and inner boxes by the R&M and eTrac team is detailed as follows:

Outer Box Geophysical Survey (includes inner box except as noted):

- GPS surveying and other vessel tracking procedures were performed to accurately establish vessel position and movement while acquiring geophysical survey data.
- Geophysical methods, as detailed within the Geophysical Site Activities description (Section 3.0), were employed to delineate stratigraphic units to a depth of at least 30 feet below the sea floor and to identify surface or buried submarine object/debris larger than 1 foot by 1 foot within the geophysical survey area. The data density and resolution of the equipment was deemed acceptable in having the ability to detect an object over 1 foot by 1 foot. For all equipment used for object detection more than 1 data point was achieved every 1 foot. The equipment used has been proven to provide the position of objects both buried at the surface that are 1 foot by 1 foot or larger.
- Multibeam sonar sounding with snippets data collection was performed to accurately establish precise bathymetry and surface geomorphology for stratigraphic analysis and object/debris detection purposes. There was a 200% survey coverage of the area, with swath width varying dependent on sea floor depth. The density of soundings per grid node in the multibeam data varied by depth. The density ranged from 2 pings per 1 foot by 1 foot grid in the deepest areas to over 40 soundings per node in the shallow areas. The mean sounding density was 10 soundings per node.
- Chirp subbottom profiling across the survey area was performed to delineate the presence of fine-grained sediments and aid in the detection of buried objects. For the outer box area, excluding the inner box area, survey lines were spaced 50 feet apart with cross lines every 175 feet.
- Seismic reflection profiling across the survey area was performed to delineate the presence of coarse-grained sediment deposits and/or bedrock. For the outer box area, excluding the inner box area, survey lines were spaced 50 feet apart with cross lines every 175 feet.
- Ponar® grab samples of surface sediment were retrieved on a grid spacing of 500 feet.

Additional geophysical survey within the inner box:

- For the chirp subbottom profiling system performed across the inner box area, survey lines were spaced on a 5-foot grid pattern.
- A magnetometer (gradiometer) survey was performed across the inner box area for the detection of surface or buried objects, using the same 5-foot grid pattern as the subbottom profiling.
- As detailed for the outer box area, the objective was to identify any object/debris larger than 1 foot by 1 foot within the inner box area.

1.5 PREVIOUS INVESTIGATIONS

Several previous investigations including Preliminary Assessments (NAVFAC, 2013), Site Inspections (NAVFAC, 2016), Reconnaissance Studies (Tryck Nyman Hayes, 1995) and Underwater Surveys (Jacobs, 1999) have been performed within the Dutch Harbor and Unalaska Island area. Results from these studies document that the U.S. Navy established a significant presence in the Unalaska-Dutch Harbor area during the World War II era, from approximately 1940 through 1944. Dutch Harbor is currently the operations center for commercial fishing in the Bering Sea, servicing both the large domestic fleet and foreign vessels fishing for ground-fish and crab.

1.6 WORK PLAN DEVIATIONS

Five (5) deviations from the approved work plan occurred and are described below.

- A semi-permanent remote RTK base station was established on the spit near the moorage location of the project vessel. This deviation was proposed to eliminate the need for daily set-ups and to minimize the likelihood of the base station being shifted or knocked over during the extended survey period. Approval of this deviation was granted by the USACE Geomatics Section on April 11, 2017. To accomplish setting up the new control location, horizontal and vertical control were transferred via Static GNSS Network, following USACE standards.
- Three sediment sampling locations were added to the 500-foot sampling grid in order to further characterize the crest of the shoal.
- Twelve sieve analyses were deleted from the laboratory testing suite due to lack of recovery from sediment samples collected from the shoal area.
- Four Atterberg limits tests were added to the laboratory testing suite. This was done to further characterize the fine-grained sediments.
- In the northwest corner of the survey area, the narrow band subbottom profile and chirp subbottom profile lines were re-routed away from a limited shallow area with less than 30 feet of water due to safety concerns and the potential loss of towed systems.

2.0 REGIONAL SETTING AND GENERAL SITE CONDITIONS

2.1 REGIONAL SETTING

2.1.1 LOCATION

The geophysical survey area is located at the entrance to Dutch Harbor located between Amaknak Island and Unalaska Island, Alaska. The area is bounded on the northwest by an exposed marine spit that extends into the harbor approximately 6,500 feet and is bounded on the southeast by steep bedrock walls rising from the ocean surface. To the northeast lies the expansive Bering Sea, while to the southwest, lies Dutch Harbor proper and the City of Unalaska.

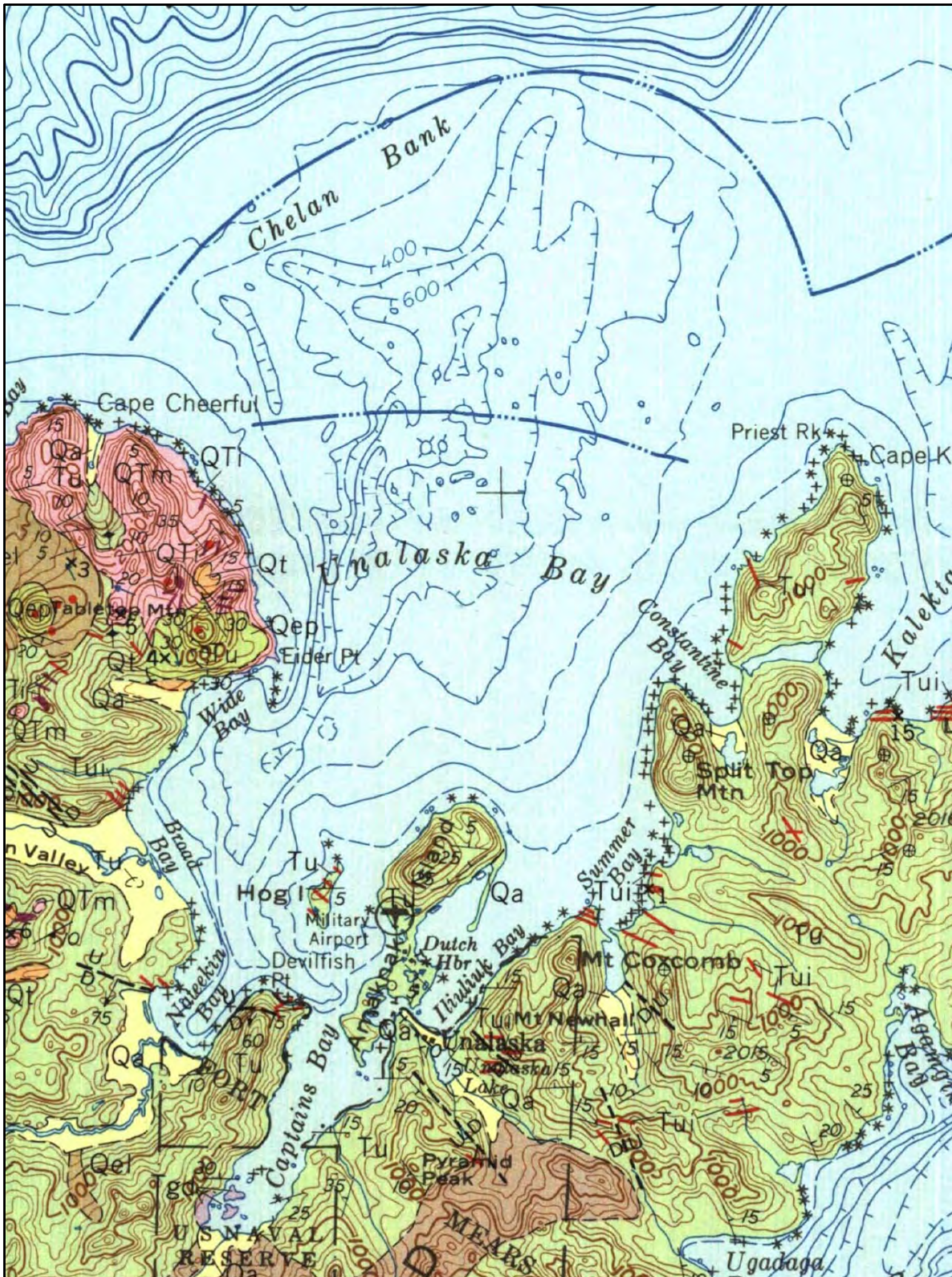
2.1.2 GENERAL GEOLOGY

The project area lies in the Aleutian Islands physiographic province. These islands are a chain of islands surmounting the crest of a submarine ridge 1,400 miles long, 20 to 60 miles wide, and 12,000 feet high above the sea floor on either side. The linear chain of volcanos on the north side of the islands is of constructional origin and late Cenozoic age and includes many calderas. The remaining islands appear to be emerged parts of tilted fault blocks consisting chiefly of faulted and folded Cenozoic volcanic rocks, locally mildly metamorphosed; granitic intrusions of Cenozoic age are present on Unalaska, Sedenka, Ilak and other islands (Wahrhaftig, 1965).

During the late Pleistocene, glaciers covered much of Unalaska Island, excluding the Makushin Volocano cone. The entirety of Dutch Harbor proper is inferred to have been glaciated up to 13 miles offshore based on submarine topography (Drewes et al., 1961 and Coulter et al., 1965). Submarine moraines have been mapped north of Unalaska Bay and are interpreted to form the Chelan Bank as shown on Figure 2-1. The upland areas at the project region are considered to generally be free of permafrost (Ferrians, 1965).

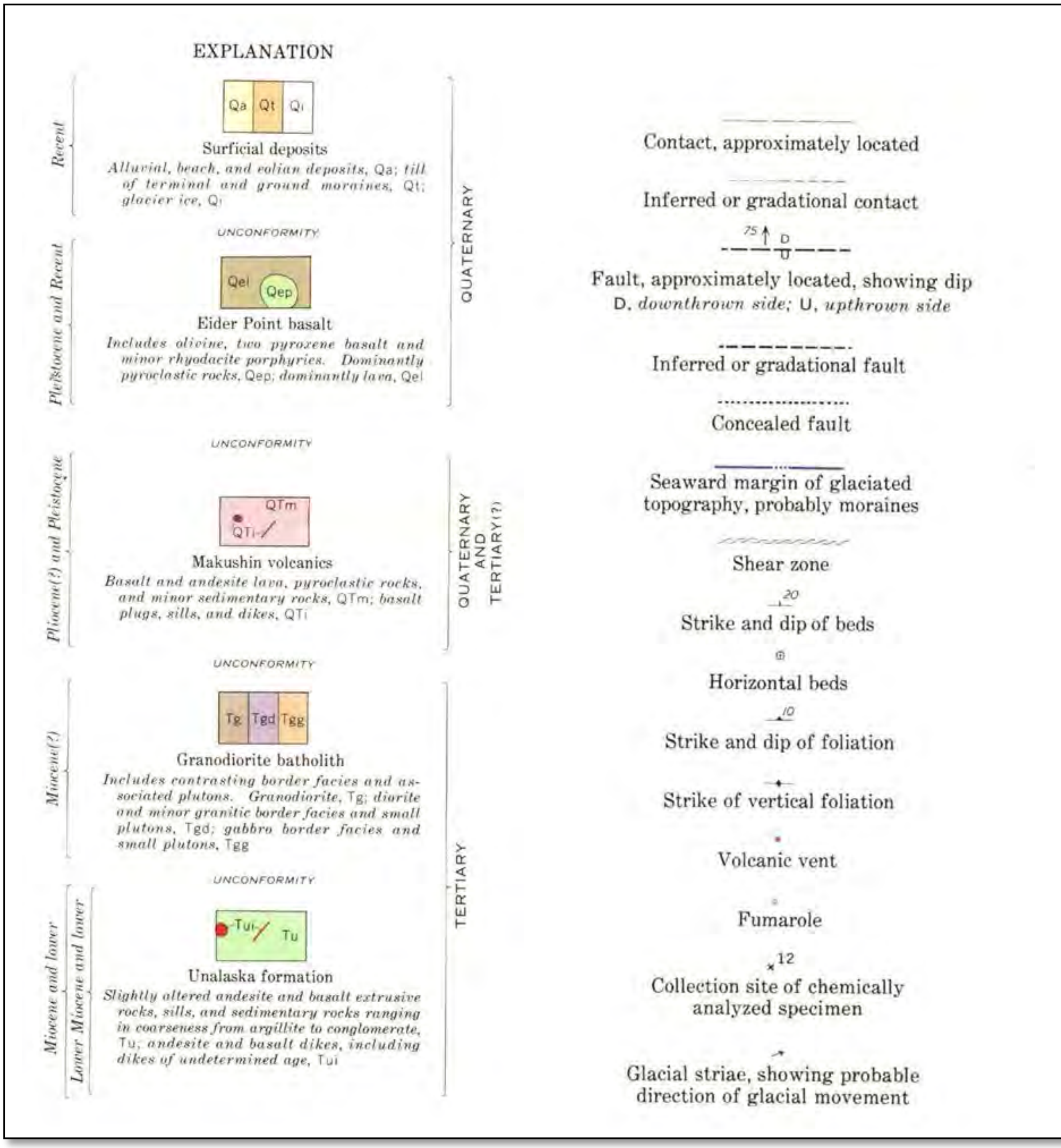
Much of Unalaska Island is discontinuously veneered by a thin mantle of glacial till, volcanic ash, humus and soil. The project area lies within an area mapped as containing the oldest rocks on the island, the Unalaska formation. This formation consists of altered andesitic intrusive and extrusive rocks and sedimentary rocks derived from similar rocks. Conglomerates and coarse breccias are the dominant sedimentary rocks in the northern and eastern part of the island (Drewes et al., 1961).

FIGURE 2-1: UNALASKA ISLAND REGIONAL GEOLOGIC MAP



(after Drewes et al., 1961)

FIGURE 2-1: UNALASKA ISLAND REGIONAL GEOLOGIC MAP (CONTINUED)



2.1.3 GENERAL SEISMICITY

Unalaska Island is located about midway along the Aleutian Arc, a 1,900-mile long arcuate chain of mountain ranges extending from the Russian Kamchatka Peninsula to Cook Inlet, Alaska. The Aleutian Arc forms the northern rim of the Pacific Ocean basin, where the Pacific and North American lithospheric plates are converging at an average rate of about 3.3 to 3.5 inches per year. This on-going convergence results in southern Alaska and the Aleutian Arc being one of the most seismically active regions in the world. This region has experienced the largest magnitude earthquakes and largest measured co-seismic deformations recorded in North America.

2.1.4 CLIMATE

Unalaska and Dutch Harbor are subject to a Maritime climate regime, characterized by heavy precipitation, moderate winters, and cool summers. Storms are frequent and violent williwaws are experienced with southerly gales and winds from the southeast, southwest and northeast sometimes attaining hurricane velocity (Tryck Nyman Hayes, 1995).

The weather is usually characterized by wind, rain, fog, and overcast skies. Based on climate data recorded at the Dutch Harbor weather station from 1951 to 2006: the mean annual air temperature is approximately 40.9 °F, with mean monthly averages ranging between approximately 32.2 °F (February) and 53.5 °F (August); and the area received an average of about 62.7 inches of precipitation per year, with about 88.5 inches of snow (WRCC, 2017).

A summary of climatological data obtained from the Dutch Harbor recording station is presented in Table 2-1.

TABLE 2-1: DUTCH HARBOR CLIMATOLOGICAL DATA

Weather Station Parameter	Dutch Harbor (Station No. 502587)
Period of Record	1951 to 2006
Mean Annual Temperature (°F)	40.9
Mean Max. Daily Temperature (°F)	46.0
Mean Min. Daily Temperature (°F)	35.8
Record High Temperature (°F)	79 (13 August 2001)
Record Low Temperature (°F)	-8 (22 January 1986)
Mean Annual Precipitation (in.)	62.71
Mean Maximum Monthly Precipitation (in.)	8.18 (December)
Maximum Daily Precipitation (in.)	4.8 (20 July 2003)
Mean Annual Snowfall (in.)	88.5
Mean Maximum Monthly Snowfall (in.)	23.0 (January)
Maximum Monthly Snowfall (in.)	93.0 (January 2000)

NOTES:
After Western Regional Climate Center (www.wrcc.dri.edu)

2.2 GENERAL SITE CONDITIONS

2.2.1 SEAFLOOR TOPOGRAPHY

Seafloor topography at the site is dominated by an underwater shoal trending northwest-southeast. Within the project area, the shoal rises to a maximum elevation of approximately 6.75 fathoms (40 feet) within the center of the survey area and 3.5 fathoms (21 feet) near the marine spit adjacent to the northwestern extent of the survey area. Maximum water depths within the survey area are approximately 17 fathoms (102 feet) on the harbor-side of the shoal within the west-central portion of the survey area. Water depths on the exposed ocean-side of the survey area range from 8 fathoms (48 feet) in the southeast to 12 fathoms (72 feet) in the northeast.

2.2.2 TIDE AND CURRENTS

During our field investigation, the mean tide range at Dutch Harbor was about 1.9 feet and the maximum diurnal range is about 4.1 feet (NOAA, 2017). Tides are mixed semi-diurnal with two highs and lows generally occurring daily. Currents are estimated to generally be less than one knot.

3.0 INVESTIGATION METHODS

3.1 VESSEL OF OPPORTUNITY

The City of Unalaska supplied a vessel of opportunity; the Miss Alyssa, for hydrographic and geophysical survey operations throughout the duration of our investigation. The Miss Alyssa is a 43-foot all fiberglass twin diesel powered commercial fishing/dive support and charter vessel.

Installation of geophysical survey equipment, computer systems and tow winch were accomplished at the Miss Alyssa's permanent slip located at the Carl E. Moses boat harbor on the southern end of the City of Unalaska. Once the systems were installed, the Miss Alyssa transited around Amaknak Island, through the entrance of Iliuliuk Bay, and was moored at the Dutch Harbor boat harbor to allow for more expeditious transit times between the moorage location and the project site. A photograph of the Miss Alyssa is provided in Appendix A.

3.2 MULTIBEAM SONAR OPERATIONS

Multibeam broadband high frequency sonar data was collected with the objective of obtaining bathymetry, surface sediment characterization, and object detection. Multibeam data was collected so as to achieve 200% bottom coverage, i.e. lines were run to ensure the full extents of the boundary (3,500-feet by 2,500-feet) was covered with multibeam sounding data at least twice.

A detailed description of the multibeam equipment and methods is provided in the attached eTrac, Geophysical Survey Report. Quality Assurance and Quality Control procedures implemented to ensure that data quality objectives were met are detailed in the Mobilization Report provided as Appendix A within the attached eTrac, Geophysical Survey Report.

3.3 SEDIMENT SAMPLING

A WILDCO Ponar® Grab sampler was utilized to collect sediment from the sea floor to aid in the classification of surface sediment types. The grab sampler is a "clamshell" type stainless steel sampler with a volume of approximately 500 cubic inches and measures 9 inches wide by 9 inches long. The system was deployed and retrieved via the onboard hydraulic winch. All recovered soil samples were handled, characterized and logged in accordance with R&M's Standard Procedure for "Soil Classification, Logging, and Sampling".

It should be noted that while sampling along the shoal, there were several instances when the grab sampler was unable to retrieve a sample. This lack of recovery is due to the limitations of the Ponar® Grab sampler in gravelly conditions or in areas of cobbles and boulders. When in gravelly conditions, it is common for clamshell type samplers to fail to fully close due to a gravel particle becoming lodged between the two halves of the sampler and thereby washing the remainder of the sample out upon retrieval. In areas of cobbles and boulders, the grab sampler is limited simply due to its size.

Collected soil samples were returned to R&M's materials testing laboratory for further characterization and analysis. Photographs of each sample were obtained. Selected representative photographs of each sediment type are presented in Appendix A of this report.

3.4 GEOPHYSICAL SURVEY OPERATIONS

3.4.1 NARROW BAND SUBBOTTOM PROFILER SYSTEM OPERATIONS

In order to obtain an understanding of the deep, subsurface stratification in the wider survey area, a Falmouth HMS-620 Bubble Gun with dual acoustic source was employed. The system is a narrow band, low frequency bubble gun capable of penetrating coarse sand and gravel sediments. Subbottom profile lines were run across the wider survey area (3,500-feet by 2,500-feet). These were run at 50-foot spacing across the box width and 175-foot spacing along its length. This resulted in 71 lines across the shoal and 15 along the shoal feature.

A detailed description of the narrow band subbottom profiler equipment and methods is provided in the attached eTrac, Geophysical Survey Report. Supporting documentation presenting the Quality Assurance and Quality Control procedures implemented to ensure that data quality objectives were met are detailed in the Mobilization Report provided as Appendix A within the attached eTrac, Geophysical Survey Report.

3.4.2 CHIRP SUBBOTTOM PROFILER SYSTEM OPERATIONS

For imaging the near surface sediments at a higher resolution and thus greater detail, and detecting surface objects, a Chirp subbottom system was implemented. An Edgetech 216S with a 3200 topside unit was used. Subbottom profile lines were run across the wider survey area (3,500-feet by 2,500-feet) at 50-foot spacing across the box width and 175-foot spacing along its length. This resulted in 71 lines across the shoal and 15 along the shoal feature. Within the Inner Box survey area (1,000-feet by 1,500-feet) lines were run in a 5-foot grid across and along the shoal feature. This resulted in an additional 250 lines across the shoal and 180 along the shoal feature

A detailed description of the chirp subbottom profiler equipment and methods is provided in the attached eTrac, Geophysical Survey Report. Quality Assurance and Quality Control procedures implemented to ensure that data quality objectives were met are detailed in the Mobilization Report provided as Appendix A within the attached eTrac, Geophysical Survey Report.

3.4.3 TVG GRADIOMETER SYSTEM OPERATIONS

To detect possible Unexploded Ordinances (UXOs) a Transverse Gradient (TVG) Magnetometer system was employed. This system can detect ferrous materials below and at the seabed surface. A G-882 TVG was used for this project. Data was acquired on the same grid patterns as the Chirp subbottom profiler in the smaller box (1,500-feet by 1,000-feet). This resulted in 301 lines run across the feature and 201 lines along the feature. In order to maintain accurate navigation and quality data, the gradiometer was run independently of the Chirp subbottom profiler but on the same grid pattern.

A detailed description of the TVG Gradiometer system equipment and methods is provided in the attached eTrac, Geophysical Survey Report. Quality Assurance and Quality Control procedures implemented to ensure that data quality objectives were met are detailed in the Mobilization Report provided as Appendix A within the attached eTrac, Geophysical Survey Report.

3.5 TERRESTRIAL GEOLOGIC RECONNAISSANCE

Onshore terrestrial geologic reconnaissance was performed adjacent to the project area on both the western and eastern shore of Iliuliuk Bay and along the Dutch Harbor Spit. This reconnaissance was conducted at locations of particular geologic interest and consisted of making field observations regarding the characteristics of regional bedrock conditions and Quaternary soil conditions. Photographs of representative regional geologic conditions were also collected and are presented within Appendix A of this report.

3.6 MARINE MAMMAL OBSERVATION

Marine mammal observation activities were administered by two USACE observers in accordance with the approved marine mammal monitoring plan. It was understood that some marine mammals may be disturbed by certain marine geophysical survey activities including the chirp subbottom profiler and bubble gun systems. Should any marine mammals have approached the vessel to within approved shutdown distances, the geophysical survey collection activities for the chirp subbottom profiler and bubble gun would have been suspended. Geophysical survey activities would have resumed after approval from the USACE observers that marine mammals have exited the established shutdown distances.

Established marine mammal shutdown distances were as follows:

- 50 meters for the EdgeTech 216S Chirp Subbottom Profiler.
- 75 meters for the HMS-620 Bubble Gun.

During the period; from April 18, 2017 to April 24, 2017; when the chirp subbottom profiler and bubble gun systems were deployed, no marine mammal sighting were reported by the USACE marine mammal observers.

4.0 LABORATORY TESTING PROGRAM

The laboratory testing program was developed in order to characterize the various sediment samples obtained during the field investigations. Laboratory testing was performed in accordance with the following ASTM procedures (ASTM, 2017).

TABLE 4-1: LABORATORY ANALYSIS METHODS

Test Procedure	ASTM Designation
Classification of Soils for Engineering Purposes	D 2487
Description and Identification of Soils (Visual-Manual Procedure)	D 2488
Particle-Size Analysis of Soils (Standard sieve analysis which includes percent passing No. 200 sieve)	D 422
Liquid Limit, Plastic Limit and Plasticity Index of Soils	D 4318

Samples were assigned a Unified Soil Classification System (USCS) symbol which is presented on the laboratory data summary and gradation curves for those respective samples tested. When the USCS symbol was estimated, the estimated classification symbol is followed by an asterisk (*) on the laboratory data summary and gradation curves.

The Unified Soil Classification Symbol is presented in Appendix B on Drawing B-01. A summary of laboratory test results is provided on Drawing B-02, Gradation curves are presented on Drawings B-03 through B-10, and a plot of plasticity (Atterberg limits) testing results is presented on Drawing B-11.

5.0 FINDINGS

5.1 TERRESTRIAL GEOLOGIC CONDITIONS

Bedrock within the immediate Dutch Harbor area was observed to consist of altered andesite and basalt extrusive rocks, sills, and sedimentary rocks ranging in coarseness from argillite to conglomerate and consisting of the Unalaska Formation (Drewes et al., 1961). The overwhelming majority of bedrock exposures were observed to have been subjected to both regional and cataclastic metamorphism resulting in a tilted, fractured, and warped assemblage with little consistent regional structure.

Along the southeastern shore of Iliuliuk Bay, numerous exposed shelfs consisting of bedrock were observed within the intertidal zone. Immediately southeast of and in line with the longitudinal axis of the underwater shoal of interest, an exposed bedrock shelf was observed. This shelf was measured to be approximately 230 feet in width and extended about 150 feet into the bay. It was observed to consist of a gray, very hard, faintly to slightly weathered aphanitic andesite. This shelf exhibited consistent structure and its primary joint set was measured to strike in a northwest/southeast trend (≈160°/340°) and dip about 60° to 70° towards the northeast. A photograph of this shelf is presented on Page A-06 of Appendix A.

Much of the intertidal zone along the southeastern shore of Iliuliuk Bay was armored with a layer of rounded to subrounded cobbles and boulders generally consisting of gray to gray-green andesite and averaging about one to three feet in diameter.

Situated along the northwestern shore of Iliuliuk Bay is the Dutch Harbor marine spit. It is mapped as consisting of Quaternary alluvial beach deposits (Drewes et al., 1961). This spit was observed to be armored with a layer of gray, gray-green and brown mixture of andesitic and basaltic cobbles and boulders averaging about one to three feet in diameter. Average particle size of these cobbles and boulders was observed to decrease from the spit-toe, in the north, to the spit-head, in the south. This particle size sorting may indicate that long-shore current deposition contributed to the formation and southward propagation of the marine spit.

Although no evidence of glacial drift, till or moraines were observed on land in the immediate vicinity of the project site, they are mapped in numerous terrestrial locations. Particularly in the vicinity of present glaciers and upon the flanks of Makushin Volcano. Even with the lack of terrestrial glacial deposits in the vicinity of the project site, the potential for submarine glacial drift, till, and moraine deposits should not be discounted as significant and widespread glaciation of Unalaska Island is well documented.

5.2 SUBMARINE SHOAL AND DREDGE PRISM GEOLOGIC CONDITIONS

The area under consideration for potential dredging activities consists of the 1,000-foot by 1,500-foot "inner box" area shown on Sheet 2 of Volume 2 of this report. It is understood that the maximum proposed depth of dredging is about -60 feet. Within the dredge prism, the submarine geomorphology is dominated by a shoal which rises to a maximum elevation of about -42 feet.

Based on results from the geophysical investigation, the shoal is interpreted to consist of a dense, consolidated, glacial moraine deposit overlying bedrock. Although the exact nature of this glacial moraine deposit is unable to be determined without further geologic investigation, it is possibly a recessional moraine created during a temporary halt of the glaciers retreat which deposited the moraine structures forming the Chelan Bank (Figure 2-1).

Materials within the shoal are expected to consist of a consolidated, unsorted and unstratified heterogeneous mixture of clay, silt, sand, gravel and cobbles and boulders ranging widely in size and shape.

Thickness of the glacial moraine deposit was interpreted to vary significantly and is mainly a function of the highly irregular bedrock surface interpreted to underlie it. A maximum thickness of about 100 feet was interpreted from the sub-surface sectional profile lines EW 03 and EW 07 as presented in Volume 2 of 2 on Sheets 11 and 12, respectively.

To estimate consolidation of the shoal, a single channel velocity test was calculated on a single line of seismic reflection data running along the crest of the shoal. Results of this test produced a maximum seismic refraction velocity of about 9,800 feet per second. This seismic refraction velocity is similar, but even higher than published velocities of saturated glacial moraine deposits (about 5,000 to 7,000 feet per second) and is on the lower end of published velocities of basalt (about 9,000 to 14,000 feet per second) (Redpath, 1973). Due to these elevated velocities, the shoal has likely experienced some additional consolidation during deposition or post deposition. In comparing the interpreted seismic refraction velocity to published rippability values of glacial till, the shoal would be considered to be non-rippable by a Caterpillar D9R bulldozer in a terrestrial setting (Caterpillar, 2000).

The shoal is interpreted to be armored with a layer of subrounded to subangular cobbles and boulders of varying thickness. This armor layer was most likely formed from the erosion of fines (sands and silts) due to wave action transporting the fines off the shoal, into deeper surrounding waters, and leaving the cobbles and boulders remaining on the shoal. Evidence of these cobbles and boulders was observed during sediment sampling operations both in recovered samples and in limited underwater video collected along the shoal. These cobbles and boulders are estimated to generally range from 3-inch particle size up to about 3-foot particle size and were observed to consist generally of subrounded to subangular; tabular to blocky clasts. It should be noted that particles greater than 3 feet in diameter may present on any portions of the shoal.

Based on interpreted geophysical sub-surface profiles, presented in Volume 2, Sheets 8 through 12, bedrock is not expected to occur at elevations shallower than -90 feet within the proposed dredge prism. Graphical representations and sectional profiles of the aforementioned conditions are provided in Volume 2 of this report.

Sea floor sediment sampling results within this area were predominately visual-manual and based on the reaction of the sediment sampler. The overwhelming majority of sampling attempts within this area resulted in low recovery (a few gravel particles) or no recovery. This lack of recovery is due to the limitations of the Ponar® Grab sampler in gravelly conditions or in areas of cobbles and boulders. One soil index testing result from this area revealed that the matrix of the coarse gravelly bottom consisted of a fine to medium grained poorly graded sand (USCS = SP). Tested percent of material passing the No. 200 sieve was 1.2 percent. No visual or olfactory evidence indicated the presence of environmental contamination at sampling locations.

5.3 OUTER SHOAL GEOLOGIC CONDITIONS

Areas located northeast of the shoal and open to the sea are considered the "outer shoal". Interpreted geologic conditions within this area consist of a sandy bottom overlying a homogenous unit interpreted to consist of sandy materials ranging in thickness from about 10 to 50 feet with an average thickness of about 40 feet. Deposition of this unit is interpreted to have occurred along with and shortly after deposition of the shoal materials. The sea floor in this area is currently situated in a high energy environment dominated by wave action generated from the open sea to the northeast.

Underlying the homogeneous sand unit is a heterogeneous unit of indeterminate materials which exhibit distinguishable layers of sedimentation. These layers indicate that the unit may be glacimarine in origin and were likely deposited along with and shortly after the shoal materials. The heterogeneous unit has a maximum thickness of about 60 feet and averages about 20 to 30 feet in thickness.

Underlying both the homogenous unit and heterogeneous unit is bedrock at depth. Graphical representations and sectional profiles of the aforementioned conditions are provided in Volume 2 of this report.

Sea floor sediment sampling results within this area reveal a sandy bottom consisting of a fine to medium grained poorly graded sand (USCS = SP). Tested percent of material passing the No. 200 sieve ranged from 0.7 to 2.1 percent. No visual or olfactory evidence indicated the presence of environmental contamination at sampling locations.

5.4 INNER SHOAL GEOLOGIC CONDITIONS

Areas located southwest of the shoal and shielded from sea by the shoal are considered the "inner shoal". Interpreted geologic conditions within this area are similar to those described in the outer shoal area, however the current submarine environment is considered to be lower energy due to the shoal acting as a natural breakwater from the sometimes violent wave activity experienced in areas open to the sea.

Towards the northern and southern extent of the bar, a homogenous sand unit was interpreted in discrete areas. This unit may have been deposited through glacimarine processes along with or shortly after deposition of the shoal materials. This homogeneous sand unit has a maximum thickness of about 80 feet and averages about 30 to 40 feet in thickness.

In deeper waters further west of the shoal, a homogenous unit consisting of silty materials was interpreted. These finer particles were likely deposited by dropping out of suspension upon reaching the lower energy environment of the inner shoal. This homogenous silty unit has a maximum thickness of about 15 feet and averages about 10 feet.

Interpreted as underlying both the homogenous sand and silt unit is a heterogeneous unit of indeterminate materials which exhibit distinguishable layers of sedimentation. These layers indicate that the unit may be glacimarine in origin and were likely deposited along with or shortly after the shoal materials. The heterogeneous unit has a maximum thickness of about 70 feet and averages about 35 to 45 feet in thickness.

Underlying both the homogenous unit and heterogeneous unit is bedrock at depth.

Within the extreme southwestern extent of the inner shoal area, is an area interpreted as a gas unit. This gas severely limited the Chirp subbottom profiler system and created a blind spot where no energy penetration could be achieved. Energy from the narrow band Bubble Gun subbottom profiler system was able to penetrate this gas unit and provide data on the underlying bedrock contact. Although the source and characteristics of this subsurface gas unit is indeterminable, it is most likely biologic in nature and caused by the decay of organic detritus possibly being washed around the southern tip of the shoal and being deposited in the low energy deep waters of this distinct area.

Graphical representations and sectional profiles of the aforementioned conditions are provided in Volume 2 of this report.

Sea floor sediment sampling results within this area reveal a sandy and silty bottom ranging from a fine to medium-grained poorly graded sands (USCS = SP) to a non-plastic to low-plasticity sandy silt (USCS = ML). Tested percent of material passing the No. 200 sieve ranged from 0.9 to 61 percent. No visual or olfactory evidence indicated the presence of environmental contamination at sampling locations.

5.5 UXO FINDINGS

The survey area was analyzed for surface and subsurface features larger than 1 foot by 1 foot. Features were classified into several groups based on their geophysical signatures and further refined as to their location being either within the inner box or within the outer box. Of particular concern to this feasibility study is whether or not any potential UXOs may be present within the inner box. Thirty-eight (38) objects with a ferrous return, which could not be discounted as something innocuous like a crab pot, were identified within the inner box. These objects fell into three distinct categories as described below.

- Twenty-three (23) surface objects with a ferrous return were detected by the multibeam sonar and gradiometer survey within the inner box.
- Six (6) subsurface objects with a ferrous return were detected by the chirp subbottom profiler and gradiometer survey within the inner box.
- Nine (9) surface or subsurface objects, not detected by the chirp subbottom profiler or the multibeam sonar survey, were identified by the gradiometer survey as having a ferrous return.

Locations of these objects are shown on Sheet 6 and are listed on Sheet 13 within Volume 2 of this report. Further discussion of these objects and a general description of their interpreted physical characteristics is provided within the attached eTrac Geophysical Survey Report. Although several of these objects may be discounted as potential UXO, based on their interpreted physical characteristics, many of these objects should be considered likely UXOs until further evaluation.

Potential UXOs identified as being located on the surface may be further characterized by certified UXO identification experts using visual analysis methods employed from submarine remotely operated vehicles (ROVs) with video capability. Potential subsurface UXOs will require further analytical analysis of geophysical raw data by certified UXO identification experts such as the Naval Facilities Engineering Command (NAVFAC).

Should further evaluation of potential UXO targets within the inner box confirm the presence of UXOs, these objects may be handled prior to or concurrently with construction activities by certified UXO experts. It is understood that typical methods of handling surface UXOs within a dredge prism may include removal of the objects, or blow-in-place methods. Any targets identified as being subsurface UXOs within a dredge prism may be limited to blow-in-place methods.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Our conclusions and recommendations regarding future dredging operations are presented in the following paragraphs. These recommendations are based on our understanding of the geophysical data obtained from the field program and of the proposed construction. It is emphasized that our understanding of the planned dredging at the time of writing this report was limited in many cases to only very general information. Additionally, dredge material disposal considerations were not included within our Scope-of-Work. It is understood that future dredging endeavors will require full agency participation.

6.1 GENERAL DREDGING CONSIDERATIONS

Various planning, design and construction references for dredging include: USACE (2015), Bray (1979), Bruun (1981), Herbich (1992) and Herbich (1975). Three different dredging methods are presented: 1) Hydraulic (suction) dredging, 2) Mechanical dredging, and 3) Blasting. Our comments regarding these dredging methods are presented within the following paragraphs.

6.1.1 HYDRAULIC (SUCTION) DREDGING

Hydraulic dredge systems are normally classified as either plain-suction, draghead or cutterhead types. The plain-suction type has no external means to dislodge materials so they are not considered appropriate for anything other than very soft or loose materials. The draghead type intakes are normally used on hopper type dredges with their design varying considerably depending on the type material being dredged. However, to achieve high production rates, considerable pressure would normally be exerted from the surface to the draghead or rakes which would then dislodge material before suction through the system. While draghead systems can dredge denser material than a plain-suction dredge, they are not considered appropriate for very dense glacial deposits. Also, a system of this type may not be economically productive in moderately rough water.

The third type of hydraulic dredge is the hydraulic cutterhead. This system generally consists of the basic hydraulic suction pipe equipped with a rotating bit (or cutterhead) which is mounted ahead of the suction pipe. Various cutterhead systems include a boom type system fixed to the surface vessel, and also submersible type equipment mounted on underwater tracked crawlers. These systems are capable of cutting through very dense materials and soft rock at depth exceeding 65 feet (USACE, 2015). However, cutterhead dredges have limited capability of working in open-water areas. High sea states can break discharge pipelines, and can make adding or removing pipeline sections more dangerous.

6.1.2 MECHANICAL DREDGING

Mechanical dredging includes bucket (clamshell) and backhoe dredging. Clamshell excavation is one of the simpler mechanical methods of dredging. The clamshell bucket is generally best suited in very soft underwater deposits, even with the addition of hydraulic closures. Due to the apparent high density of the shoal material, clamshell dredging is not expected to be effective for this project in Unalaska. However, clamshell dredging may be useful in removing material that has been loosened by blasting.

Backhoe dredging equipment may be capable of excavating the dense soils at the Unalaska site. A large backhoe dredge can remove bottom materials consisting of clay, hard-packed sand, glacial till or blasted rock material to depths up to 85 feet (USACE, 2015). However the limiting factor for this method may be the ability to work in open-water during high sea states.

6.1.3 BLASTING

In areas where bedrock or very dense glacial deposits are encountered, the material to be removed may need to be broken and displaced by explosive charges before dredging equipment can effectively remove it. At locations where a minimal thickness of rock needs to be removed, consideration could be given to utilizing surface or lay-on charges. Depending on conditions and explosives, depths on the order of up to 3 or 4 feet may be realized by this method (DuPont, 1969). However, in larger areas or locations with a thicker volume of rock removal, patterned drill holes for explosives may be required. The amount of explosives required to ensure proper fragmentation depends greatly on the degree of fragmentation required, dimensions of the free face, dimension of the excavation, and type of rock (Bruun, 1981). Once the material is loosened it can then be removed by mechanical means.

The use of explosives will necessarily involve environmental restrictions (fisheries areas and time of season) in addition to special safety concerns related to the shipping traffic and the use of underwater explosives.

6.2 DREDGE SLOPES

The apparent dense glacial material is expected to have a high in-situ strength. If undisturbed, the material would be expected to be stable at slopes of 2:1 (horizontal:vertical). Flatter slopes may be necessary if the material is loosened by blasting. The dredge slope angle should be re-evaluated if additional soil property data becomes available.

6.3 HYDROLOGY AND HYDROGEOLOGY CONSIDERATIONS

Based on bathometric survey results, observed surface sediment and interpreted subsurface sediment depositional environments, it is likely that the shoal acts as a natural breakwater. The shoal appears to reduce the impacts from wave action from the open sea and likely acts as a natural sediment dam retarding the deposition of the highly mobile sandy sediments located within the outer shoal area to within the inner shoal area.

6.4 RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

It is our understanding that the project is still in the feasibility phase and bidding documents (plans and specifications) are not yet available for the proposed Dutch Harbor Channel Navigation Improvements dredging project. Therefore, it is difficult for us to make a thorough assessment of what type, if any, of future investigation may be required. However, we offer the following general comments in regards to both soil and bedrock.

We are not aware of any borehole data available for the project site other than that from previous investigations performed in and around Dutch Harbor which are not relatable to the project site. Should the USACE desire to further define anticipated dredging conditions and minimize risk, it is our impression that a series of shallow test borings along the shoal structure may be appropriate.

Local landing craft or barges based out of Dutch Harbor have proven to be acceptable drilling platforms for auger test borings.

Standard penetration testing could be performed inside hollow-stem augers or drill casing. Laboratory tests (ASTM, 2017) could then be performed on selected samples. Testing could be conducted to derive the soil properties within the shoal structure and surrounding areas. Soil samples may also be obtained by specialized underwater samplers such as gravity corers or vibratory corers.

Should bedrock be encountered within the dredge prism, rock samples could also be obtained as diamond cores. Typical rock testing may include the following: bulk density, porosity, surface hardness, unconfined compressive strength, grain size, etc. In addition to the above standard tests, point load testing and the Protodyakanov drop test are often used to assess dredgability and drillability, respectively.

Based on geophysical findings within the project area and on-shore geologic reconnaissance, it is interpreted that the shoal structure likely extends underneath the adjacent Dutch Harbor marine spit. Should a more economical and convenient drilling method be preferred, land based drilling techniques may be employed to further characterize material underlying the spit which could then be extended to the submarine shoal structure.

7.0 REFERENCES

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APPENDIX A
PHOTOGRAPH LOG

Vessel of Opportunity Photograph

Charter vessel Miss Alyssa moored at the Carl E. Moses boat harbor; 15 April 2017

Vessel of Opportunity Mobilization Photograph

Installation of geophysical survey equipment and systems at the Carl E. Moses boat harbor; 17 April 2017

Geophysical Control Center Photograph
Onboard geophysical data collection control and command center; 24 April 2017

Iliuliuk Bay Photograph 1
Overview of Iliulliuk Bay; Survey area is located center of frame and slightly north of the container crane; Facing north; 15 April 2017

Iliuliuk Bay Photograph 2

Overview of Iliulliuk Bay; Shoal crest is orientated parallel along viewers line of sight and the Miss Alyssa and headland located center of frame; Facing northwest; 13 April 2017

Sediment Sampling Photograph

Ponar grab sample deployment and retrieval operations; 14 April 2017

Sand (SP) Surface Sediment Photograph
Representative sand surface sediment; Grab sample No. 46; From 45-foot depth; 14 April 2017

Silt (ML) Surface Sediment Photograph
Representative silt surface sediment; Grab sample No. 25; From 105-foot depth; 13 April 2017

Hard Bottom Surface Sediment Photograph
Representative low-recovery conditions from “hard bottom” surface sediments; Grab sample No. 51; From 50-foot depth; 13 April 2017

Boulder Surface Sediment Photograph
Representative sample of cobbles and boulders interpreted to armor the shoal; Boulder is 0.9 feet by 1.3 feet; Grab sample No. 10; From 59-foot depth, 14 April 2017
NOTE: The size of recoverable particles was limited by the size of the sampling system. Larger particles than grab sample No. 10 are interpreted to armor the shoal.

Onshore Exposed Bedrock Photograph
Representative exposed bedrock conditions onshore and off the southern end of the shoal; Facing northwest; 15 April 2017

Dutch Harbor Spit Conditions Photograph
Representative cobble and boulder armor layer conditions along the spit toe off the northern extents of the shoal; Average size 2 to 3 feet, Facing northeast; 16 April 2017

Onshore Geologic Conditions Photograph 1
Representative onshore geologic conditions off the southern end of the shoal; Facing southeast; 15 April 2017

Onshore Geologic Conditions Photograph 2
Representative onshore geologic conditions off the southern end of the shoal; Facing northeast; 15 April 2017

APPENDIX B
LABORATORY TESTING RESULTS

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Group Name [B]
Coarse-grained Soils More than 50% retained on the No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]	GP	Poorly-graded gravel [F]
		Gravels with Fines More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]	SP	Poorly-graded sand [I]
		Sands with Fines More than 12 % fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 and plots below "A" line [J]	ML	Silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic Clay [K, L, M,N] / Organic Silt [K, L, M,O]
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic Clay [K, L, M,P] / Organic Silt [K, L, M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravel with 5 to 12 % fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly-graded gravel with silt
- GP-GC poorly-graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly-graded sand with silt
- SP-SC poorly-graded sand with clay

[E] $Cu = D_{60} / D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add "with sand " to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains $\geq$ 30% plus No. 200, predominantly sand, add "sandy" to group name.

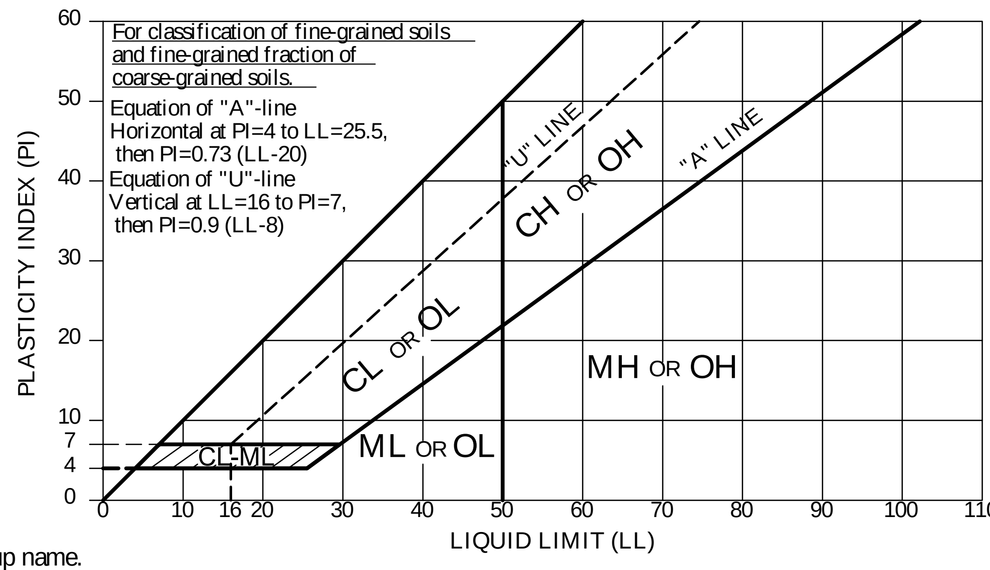
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI $\geq$ 4 and plots on or above "A" line.

[O] PI $<$ 4 and plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DWN:	B.M.M.
CKD:	C.H.R.
DATE:	GENERAL
SCALE:	NONE

R&M CONSULTANTS, INC.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES ASTM D 2487

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-01

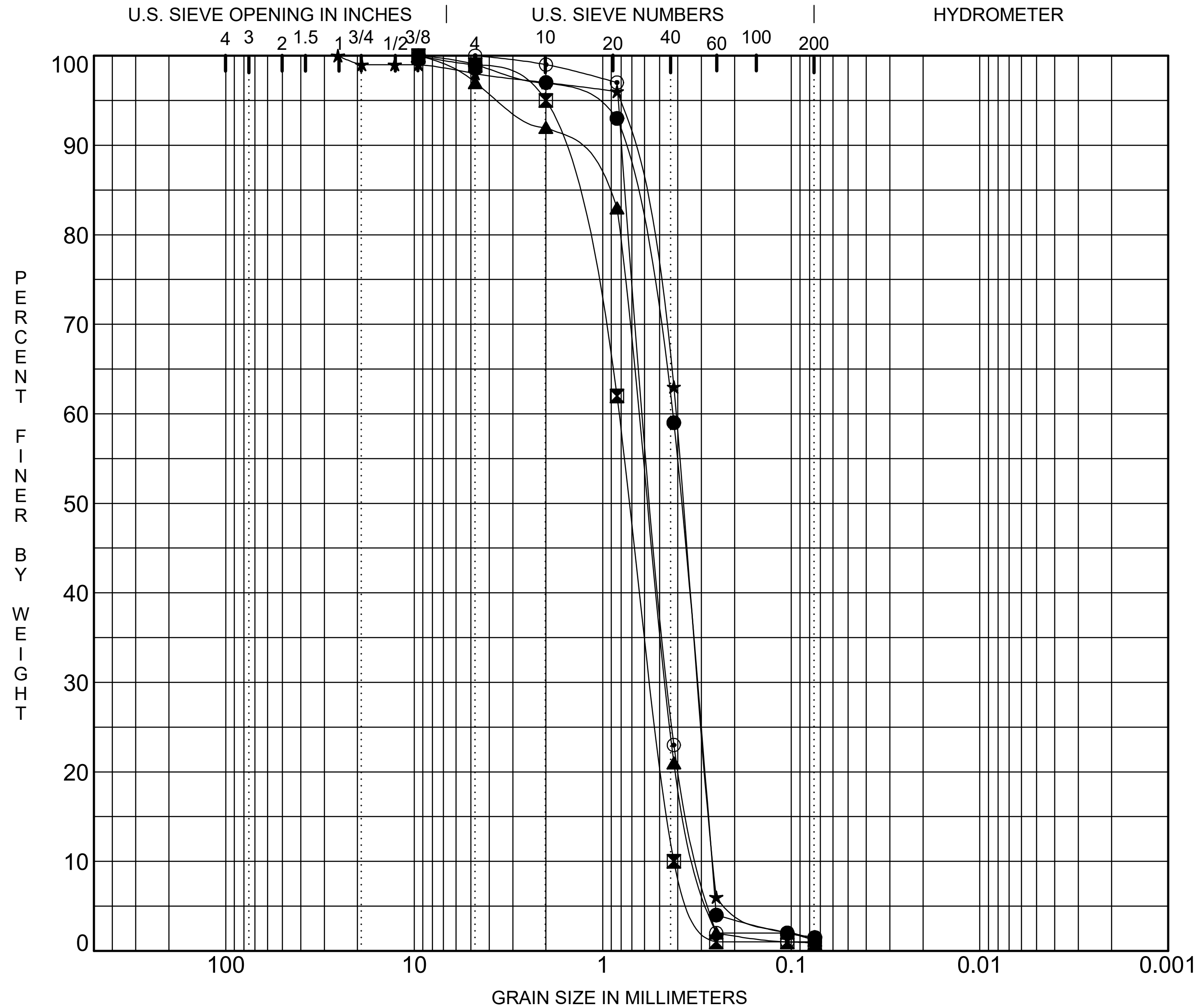
SUMMARY OF LABORATORY SOILS DATA
GEOPHYSICAL SURVEY REPORT
CHANNEL NAVIGATION IMPROVEMENTS FEASIBILITY STUDY
DUTCH HARBOR, ALASKA

SAMPLE IDENTIFICATION		PARTICLE SIZE ANALYSIS (% FINER) STANDARD SIEVE SIZE													ATTERBERG LIMITS			ASTM CLASS.
GRAB SAMPLE NO.	WATER DEPTH (FT.)	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140**	#200**	LL	PL	PI	
1	26						100	99	97	93	59	4	1	1.5				SP
2	38						100	99	95	62	10	1	1	0.9				SP
3	41						100	97	92	83	21	2	1	1.2				SP
4	62									No Analysis								
5	77			100	99	99	99	98	97	96	63	6	1	1.1				SP
6	79						100	100	99	97	23	2	1	1.0				SP
7	44						100	100	99	98	84	16	3	2.5				SP
8	37									No Analysis								
9	46									No Analysis								
10	59									No Analysis								
11	75						100	99	99	98	71	8	2	1.1				SP
12	77						100	99	96	89	23	2	2	1.1				SP
13	62	100	96	96	95	94	94	93	91	79	38	4	1	0.9				SP
14	67						100	99	97	61	15	4	2	1.5				SP
15	55									No Analysis								
16	60									No Analysis								
17	74			100	99	98	97	95	90	71	39	5	1	1.1				SP
18	73			100	99	99	99	98	94	78	21	3	2	1.1				SP
19	83						100	100	99	89	9	8	4	3.2				SP
20	102						100	100	99	98	90	69	18	8.7				SP-SM*
21	58									No Analysis								
22	55									No Analysis								
23	69						100	100	99	77	25	2	1	0.9				SP
24	69						100	100	99	83	18	2	1	0.7				SP
25	105						100	100	100	98	92	86	74	61	45	37	8	ML
26	105						100	100	99	99	96	92	75	53				ML*
27	57									No Analysis								
28	58									No Analysis								
29	64						100	100	99	80	23	3	1	0.9				SP
30	63						100	100	99	75	10	1	1	0.7				SP
31	103						100	100	100	98	92	87	74	56	40	34	6	ML
32	105						100	100	100	99	97	94	77	47				SM*
33	61									No Analysis								
34	58					100	99	98	95	69	20	3	1	1.2				SP
35	58					100	99	99	96	70	15	2	1	0.7				SP
36	57						100	100	99	77	8	2	1	0.7				SP
37	102						100	100	100	100	96	93	77	53	37	NV	NP	ML
38	82					100	99	98	93	73	18	10	6	4.1				SP
39	52									No Analysis								
40	52						100	99	98	83	24	2	1	0.9				SP
41	51		100	99	98	97	97	96	92	67	10	2	1	0.9				SP
42	51						100	100	100	73	5	2	1	0.7				SP
43	102						100	100	100	99	92	86	62	44	42	36	6	SM
44	54				100	93	91	86	81	75	43	14	4	2.2				SP
45	56	100	99	99	99	99	99	99	98	89	24	4	1	1.0				SP
46	45						100	100	98	86	16	2	1	0.7				SP
47	46		100	99	99	99	99	98	95	66	4	1	1	0.7				SP
48	42						100	100	100	99	94	91	12	2.1				SP
49	47									No Analysis								
50	44									No Analysis								
51	50									No Analysis								

* Soil Plasticity was estimated following ASTM D 2488.

** Per ASTM, the #140 sieve is rounded to the nearest whole number and the #200 sieve is rounded to the nearest 0.1 when <10.

(green) = Shoal sample results
(blue) = Inner shoal sample results
(pink) = Outer shoal sample results



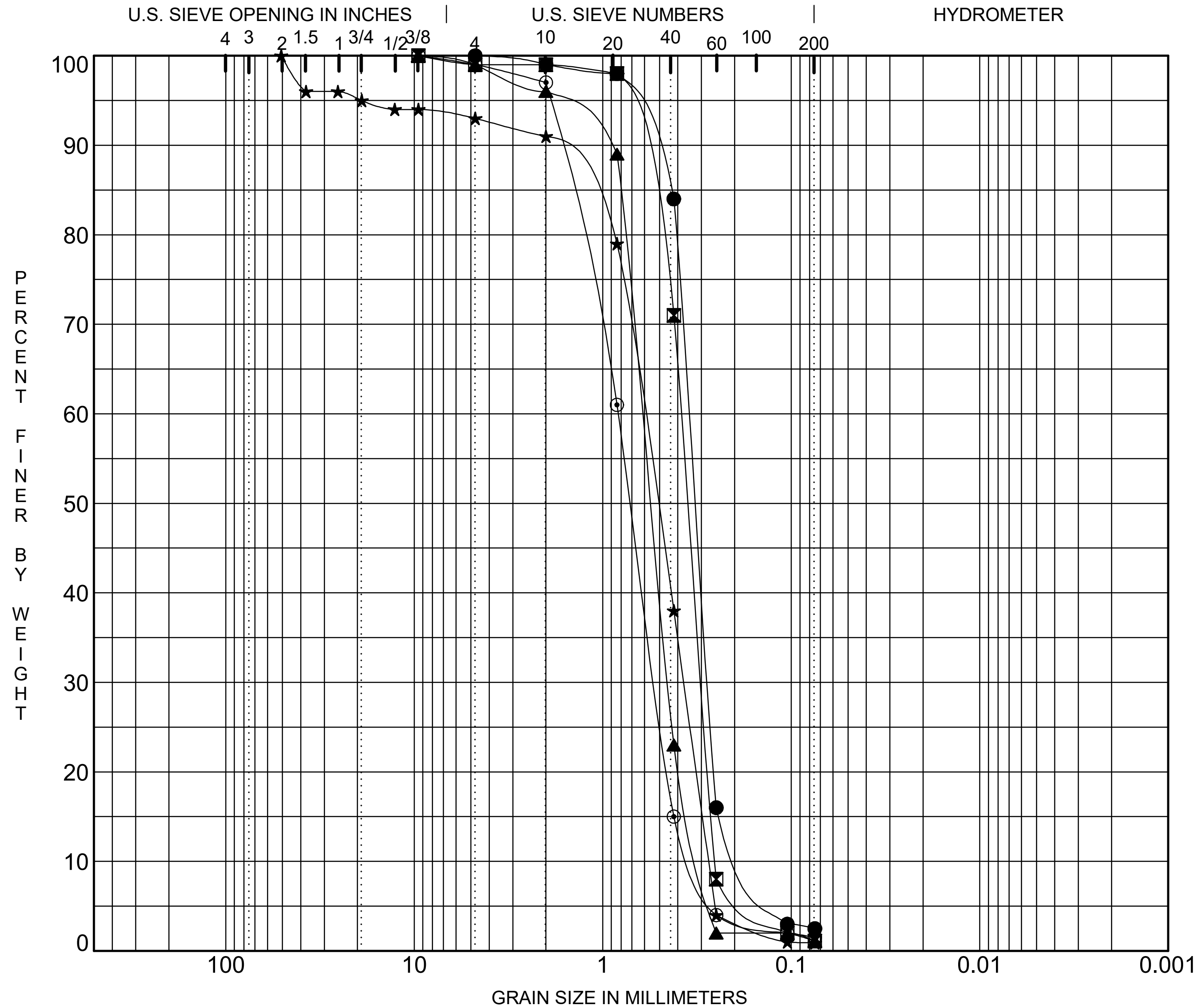
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-01	1	26	SP						0.90	1.62
⧗	GS-02	1	38	SP						0.88	1.95
▲	GS-03	1	41	SP						1.07	2.09
★	GS-05	1	77	SP						0.91	1.58
⊙	GS-06	1	79	SP						1.11	1.95

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-01	1	9.500	0.429	0.319	0.265	1	98	1.5	
⧗	GS-02	1	9.500	0.819	0.549	0.42	1	98	0.9	
▲	GS-03	1	9.500	0.65	0.465	0.311	3	96	1.2	
★	GS-05	1	25.400	0.409	0.311	0.259	2	97	1.1	
⊙	GS-06	1	4.750	0.594	0.449	0.305	0	99	1.0	

*Estimated Classification

DWN:	A.T.B.	R&M CONSULTANTS, INC.	CHANNEL NAVIGATION IMPROVEMENTS	FB:	NA
CKD:	C.H.R.		DUTCH HARBOR, AK	GRID:	UNALASKA
DATE:	JUL. 17		GRADATION CURVES	PROJ.NO:	2440.06
SCALE:	N.T.S.			DWG.NO:	B-03



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-07	1	44	SP						1.32	2.09
⊠	GS-11	1	75	SP						0.92	1.51
▲	GS-12	1	77	SP						1.08	2.03
★	GS-13	1	62	SP						0.83	2.23
⊙	GS-14	1	67	SP						1.01	2.50

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-07	1	4.750	0.35	0.278	0.168	0	98	2.5	
⊠	GS-11	1	9.500	0.384	0.3	0.254	1	98	1.1	
▲	GS-12	1	9.500	0.62	0.452	0.305	1	98	1.1	
★	GS-13	1	50.800	0.61	0.372	0.274	7	92	0.9	
⊙	GS-14	1	9.500	0.828	0.527	0.332	1	98	1.5	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

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PROJ.NO:	2440.06
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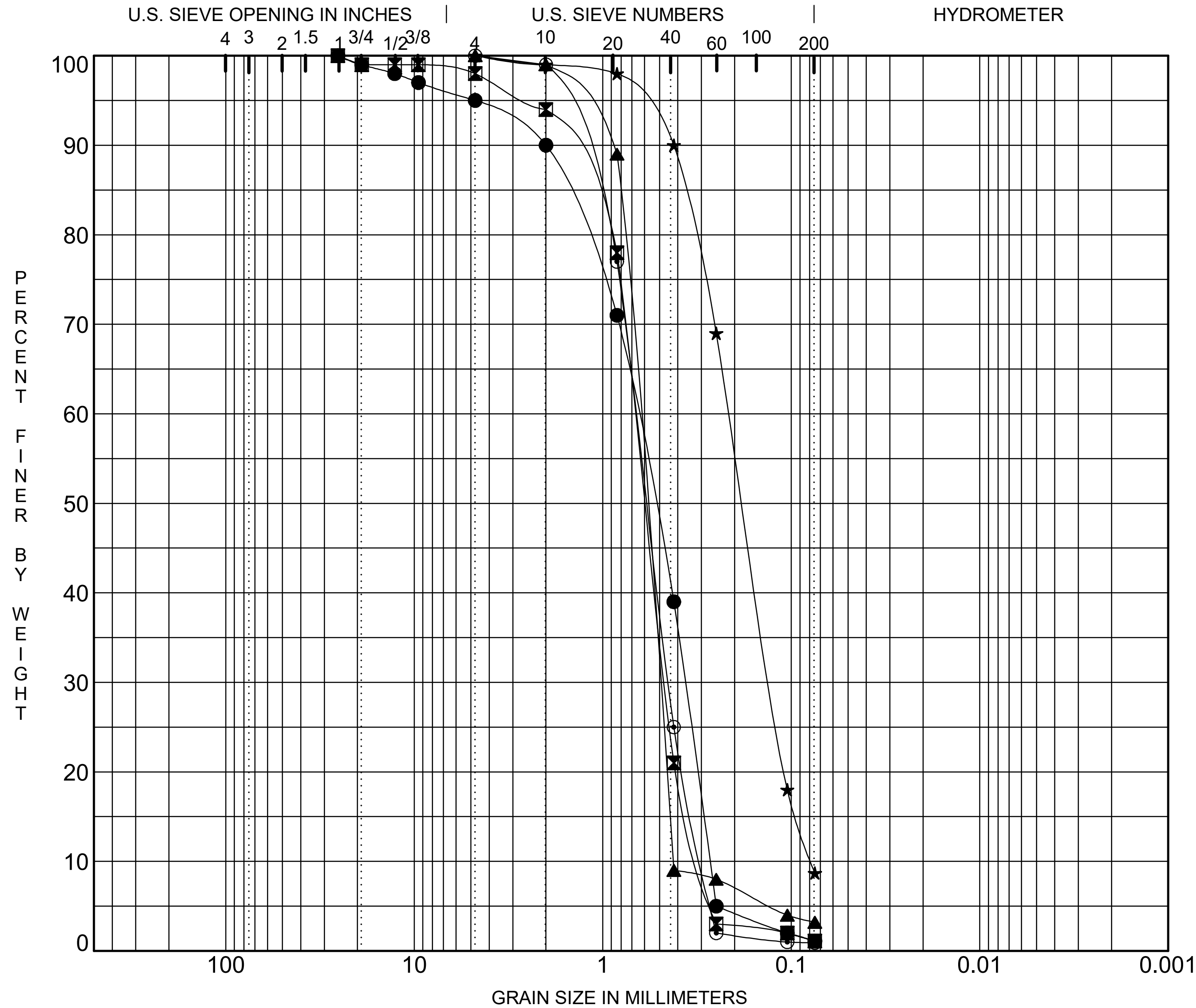

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-17	1	74	SP						0.75	2.46
⊠	GS-18	1	73	SP						1.06	2.21
▲	GS-19	1	83	SP						0.92	1.54
★	GS-20	1	102	SP-SM*						0.98	2.73
⊙	GS-23	1	69	SP						1.00	2.24

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-17	1	25.400	0.662	0.366	0.27	5	94	1.1	
⊠	GS-18	1	25.400	0.675	0.469	0.306	2	97	1.1	
▲	GS-19	1	4.750	0.654	0.504	0.424	0	97	3.2	
★	GS-20	1	4.750	0.215	0.129	0.079	0	91	8.7	
⊙	GS-23	1	4.750	0.67	0.449	0.299	0	99	0.9	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

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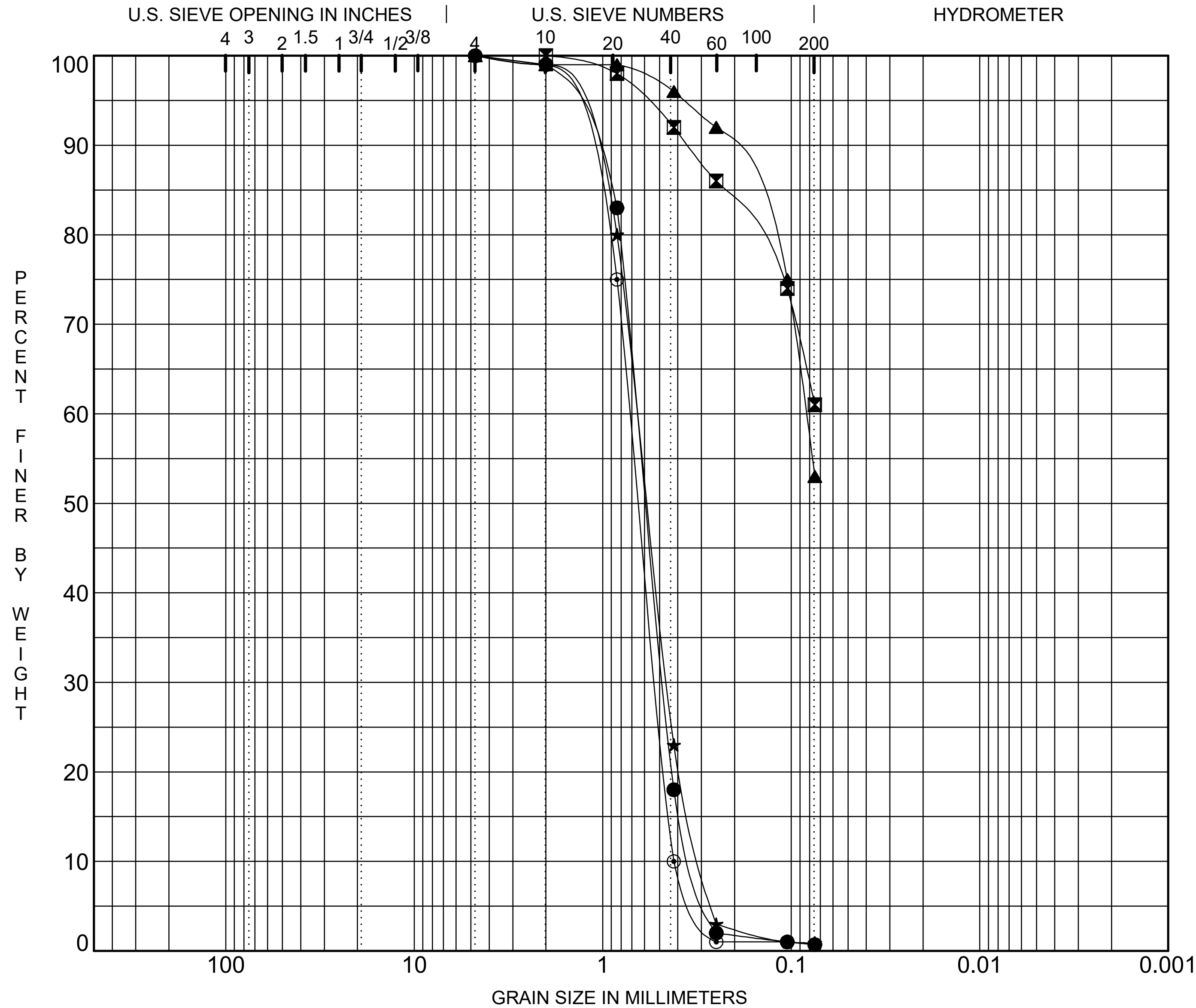

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-24	1	69	SP						1.07	2.03
⧗	GS-25	1	105	ML			45	37	8		
▲	GS-26	1	105	ML*							
★	GS-29	1	64	SP						1.06	2.20
⊙	GS-30	1	63	SP						0.90	1.71

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-24	1	4.750	0.658	0.477	0.324	0	99	0.7	
⧗	GS-25	1	2.000				0	39	61	
▲	GS-26	1	4.750	0.083			0	47	53	
★	GS-29	1	4.750	0.659	0.457	0.3	0	99	0.9	
⊙	GS-30	1	4.750	0.716	0.52	0.42	0	99	0.7	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

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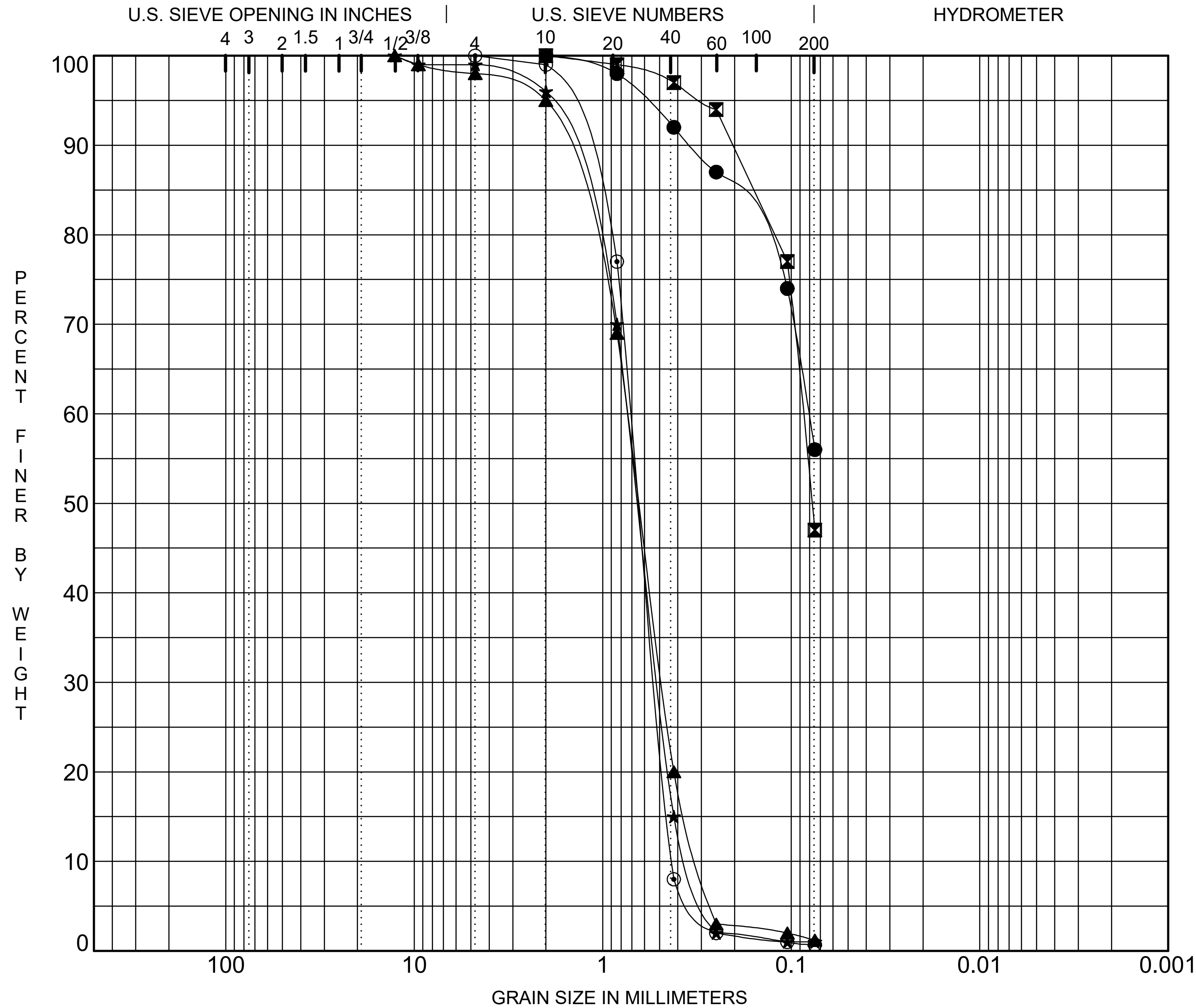

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-31	1	103	ML			40	34	6		
⧗	GS-32	1	105	SM*							
▲	GS-34	1	58	SP						1.02	2.39
★	GS-35	1	58	SP						1.01	2.15
⊙	GS-36	1	57	SP						0.90	1.65

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-31	1	2.000	0.081			0	44	56	
⧗	GS-32	1	2.000	0.087			0	53	47	
▲	GS-34	1	12.700	0.74	0.484	0.31	2	97	1.2	
★	GS-35	1	12.700	0.741	0.508	0.344	1	98	1.0	
⊙	GS-36	1	4.750	0.709	0.524	0.429	0	99	0.7	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

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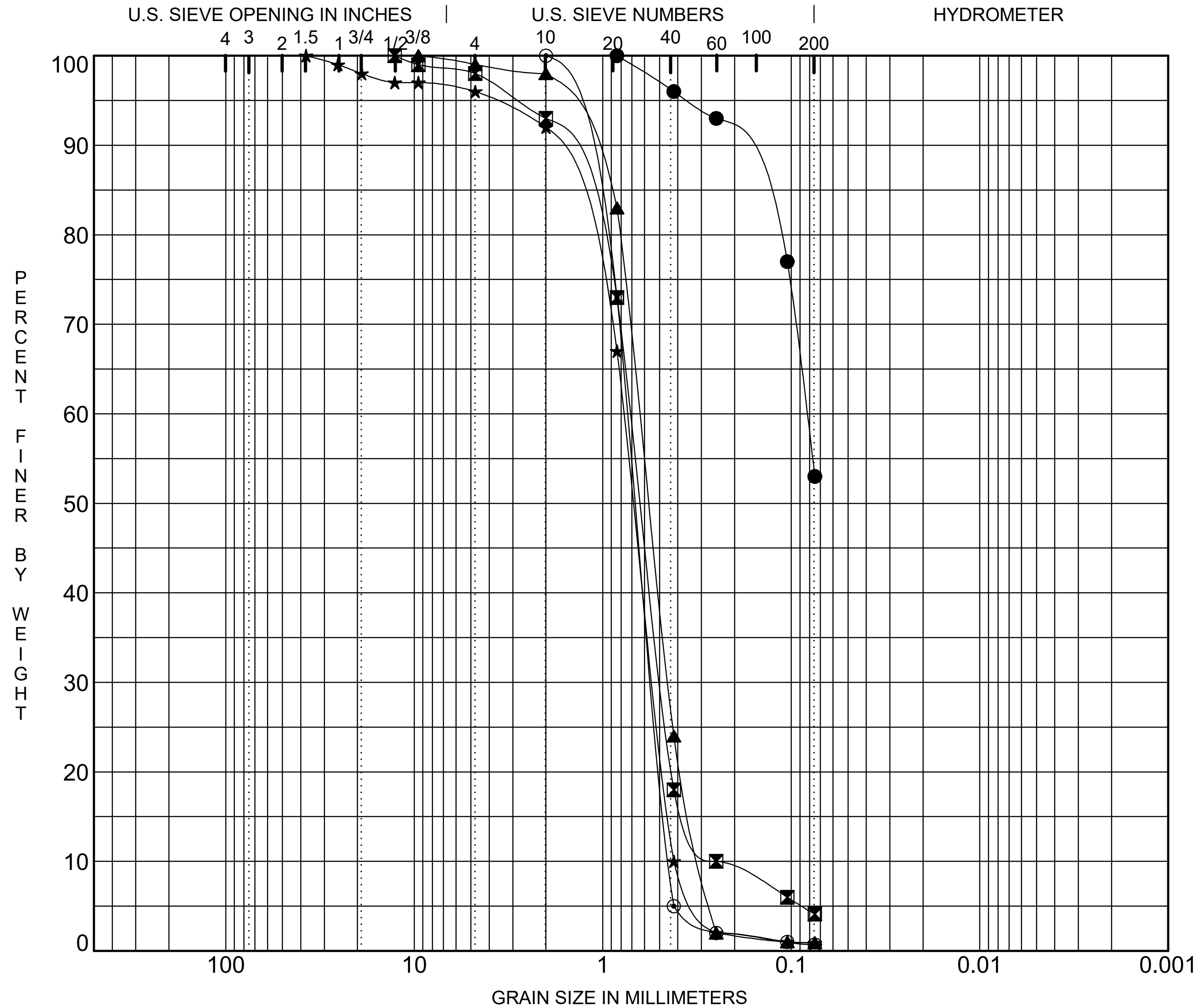

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-37	1	102	ML			37	NP	NP		
⧗	GS-38	1	82	SP						1.34	2.85
▲	GS-40	1	52	SP						1.05	2.13
★	GS-41	1	51	SP						0.89	1.84
⊙	GS-42	1	51	SP						0.90	1.67

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-37	1	0.841	0.083			0	47	53	
⧗	GS-38	1	12.700	0.714	0.489	0.25	2	94	4.1	
▲	GS-40	1	9.500	0.642	0.451	0.302	1	98	0.9	
★	GS-41	1	37.500	0.772	0.536	0.42	4	95	0.9	
⊙	GS-42	1	2.000	0.736	0.542	0.442	0	99	0.7	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

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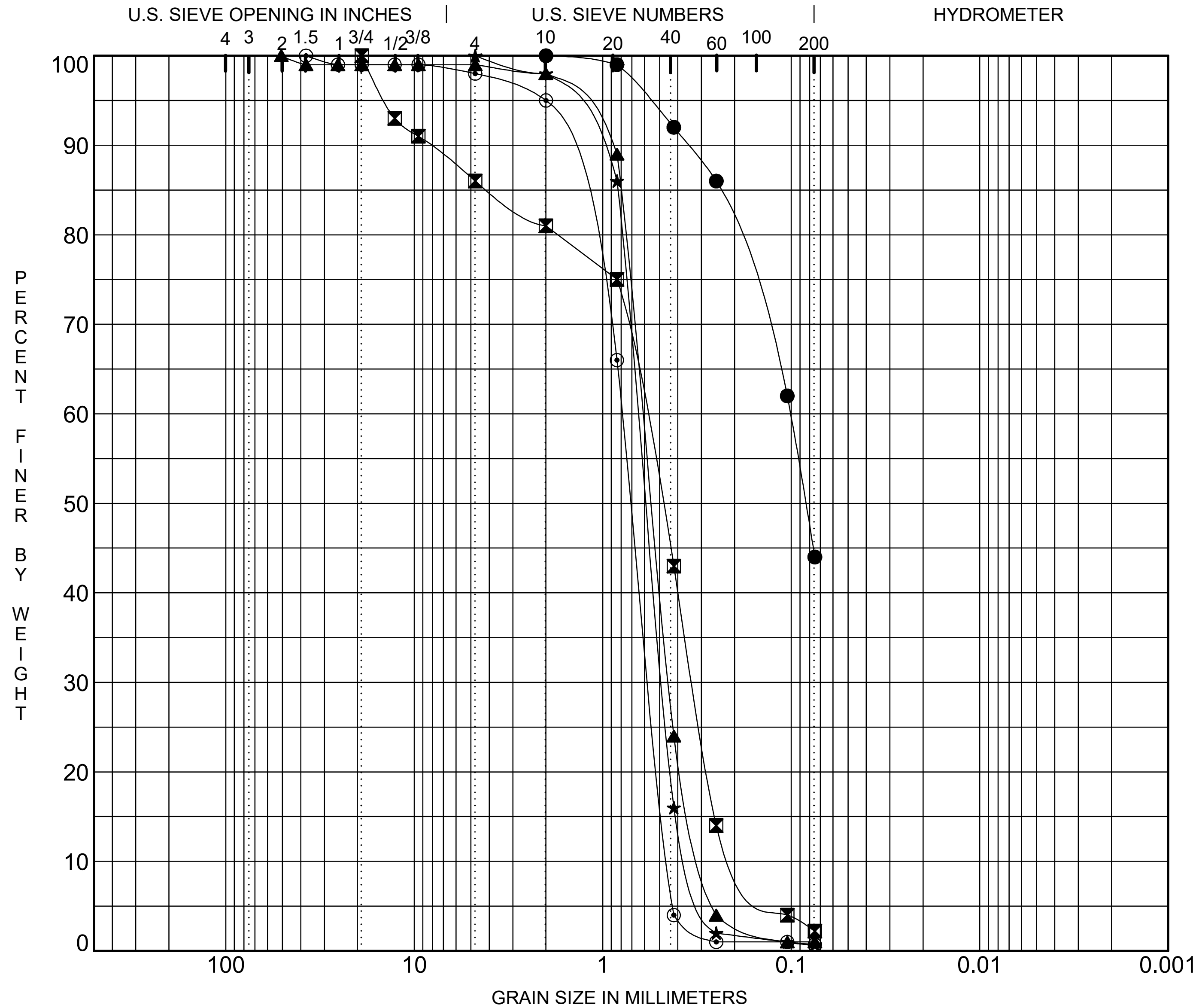
DWG.NO:	B-08



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-43	1	102	SM			42	36	6		
⧗	GS-44	1	54	SP						1.03	3.44
▲	GS-45	1	56	SP						1.11	2.11
★	GS-46	1	45	SP						1.07	1.93
⊙	GS-47	1	46	SP						0.89	1.75

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-43	1	2.000	0.101			0	56	44	
⧗	GS-44	1	19.000	0.607	0.333	0.177	14	84	2	
▲	GS-45	1	50.800	0.617	0.448	0.292	1	98	1.0	
★	GS-46	1	4.750	0.65	0.483	0.336	0	99	0.7	
⊙	GS-47	1	37.500	0.786	0.562	0.449	2	97	0.7	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

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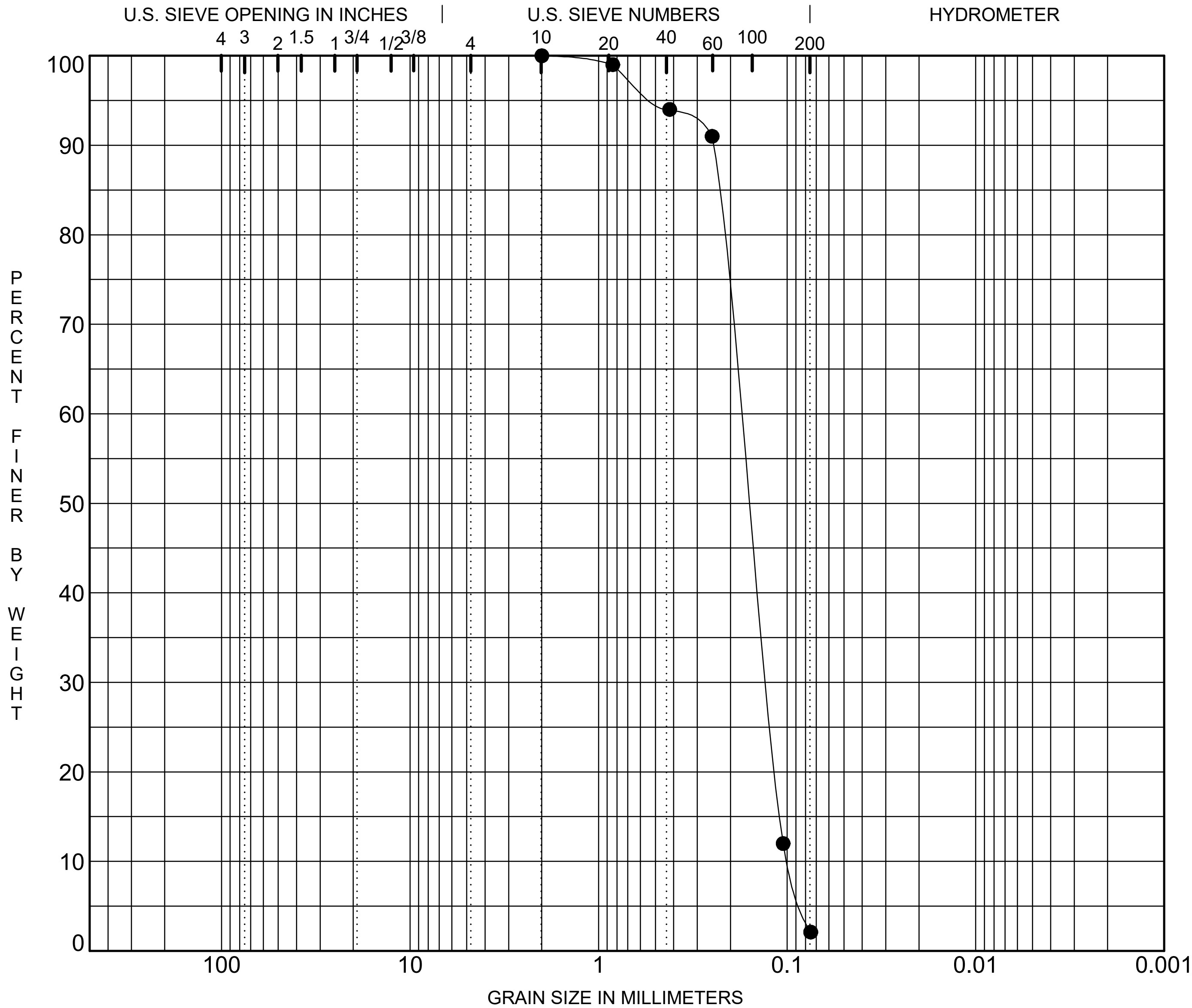

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Depth	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	GS-48	1	42	SP						0.94	1.81

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	GS-48	1	2.000	0.178	0.128	0.098	0	98	2.1	

*Estimated Classification

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	JUL. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

GRADATION CURVES

FB:	NA
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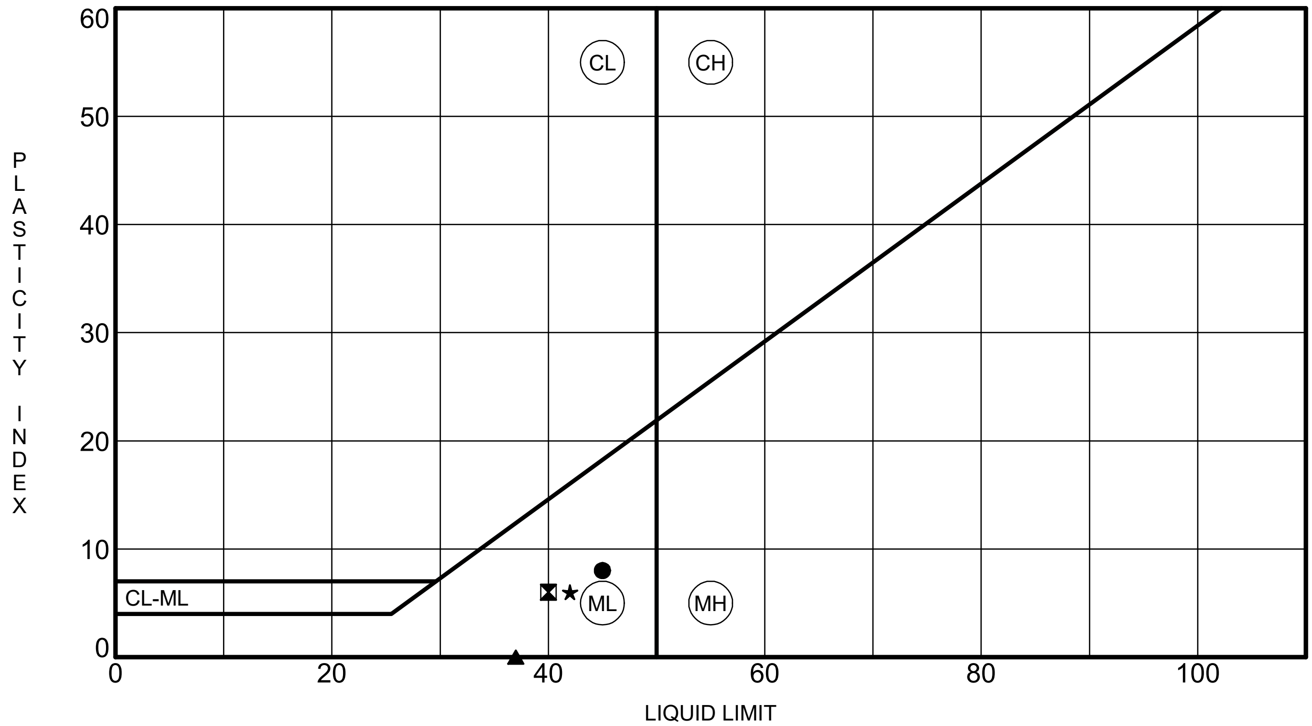
PROJ.NO:	2440.06
DWG.NO:	B-10



Specimen Identification	Depth	LL	PL	PI	Fines	Classification
● GS-25	105.0	45	37	8	61	SANDY SILT (ML)
⧗ GS-31	103.0	40	34	6	56	SANDY SILT (ML)
▲ GS-37	102.0	37	NV	NP	53	SANDY SILT (ML)
★ GS-43	102.0	42	36	6	44	SILTY SAND (SM)

DWN:	A.T.B.
CKD:	C.H.R.
DATE:	MAY. 17
SCALE:	N.T.S.

R&M CONSULTANTS, INC.

CHANNEL NAVIGATION IMPROVEMENTS
DUTCH HARBOR, AK

ATTERBERG PLOTS

FB:	NA
GRID:	UNALASKA
PROJ.NO:	2440.06
DWG.NO:	B-11

ATTACHMENTS

GEOPHYSICAL SURVEY REPORT

CHANNEL NAVIGATION IMPROVEMENTS

FEASIBILITY STUDY

DUTCH HARBOR, ALASKA

CONTRACT NO. W911KB-17-D-0001

DELIVERY ORDER NO. 0005

Contractor Document No: USACE_R&M_DUTCH_HARBOR_GEOPHYSICAL_FINAL_REPORT

07/05/2017	A3	Final	NPJG	IK		07/05/2017
05/30/2017	A2	Issued to client	NPJG	IK		06/20/2017
05/26/2017	A1	Issued to client	NG	AB		05/27/17
Date	Revision	Description of Revision	Prepared	Checked	Approved	Client

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Table of Contents

APPENDICES

Volume 2 o f 2 - Drawings

Acronyms and Abbreviations

°	degree(s)
°F	degree(s) Fahrenheit
3D	three dimensional
ACSM	American Congress on Surveying and Mapping
cm	centimeter
CMR	compact measurement record
Ft	feet
eTrac	eTrac Inc.
GLONASS	global navigation satellite system
GNSS	global navigation satellite system
GPS	global positioning system
Hz	hertz
ID	identification
IHO	International Hydrographic Organization
JSF	java server faces
m	meter
MBES	multibeam echosounder system
MLLW	mean lower low water
NAD83	North American Datum 1983
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration

OPUS	Online Positioning User Service
pdf	Adobe Portable Document Format
POSMV	position and orientation system for marine vessels
PPK	Post Processed Kinematic
QPS	Quality Positioning Systems
R&M	R&M Consultants, Inc.
RTK	real time kinematic
SBET	smoothed best estimate of trajectory
THSOA	The Hydrographic Society of America
TVG	transverse gradient
USM	universal sonar mount
USACE	U.S. Army Corps of Engineers
USBL	ultra-short base line
UXO	unexploded ordinance
VOOP	vessel of opportunity

EXECUTIVE SUMMARY

Between April 10th 2017 and May 2nd eTrac Inc. completed a full geophysical and bathymetric survey of an area located at the entrance to Dutch Harbor, between Amaknak Island and Unalaska Island, Alaska in support of the Dutch Harbor Channel Improvements Feasibility Study. The survey area consists of an outer rectangular box (3,500 ft by 2,500 ft) and an inner rectangular box (1,500 ft by 1,000 ft).

The bar structure was found to be a glacial moraine. The feature is consolidated, and constructed of a uniform, hard deposited material. Velocities through the feature are similar to those observed in lithified rock. The entire moraine feature is made up of the bar running across the harbor entrance as well as extending to the northwest of the survey area towards a spit which is visible above the waterline.

Several unknown objects with high ferrous return were identified on and close to the bar feature. These features have similar shapes and sizes to UXOs noted as possibly being in the area. Other objects of interest were identified in both the inner and outer box.

1. INTRODUCTION

1.1 Contract and Scope

This report is prepared for R&M Consultants, Inc. (R&M) by eTrac Inc. (eTrac) under the U.S. Army Corps of Engineers (USACE) contract W911KB-17-D-0001, to perform a marine geophysical and bathymetric survey for the Channel Navigation Improvements Feasibility Study in Dutch Harbor, Alaska. This study is in support of proposed dredging operations of a shallow bar structure at the entrance of Dutch Harbor Channel by providing seafloor-bathymetry, subbottom stratigraphy, and submarine debris target information.

1.2 Survey Area

The survey area is located at the entrance to Dutch Harbor located between Amaknak Island and Unalaska Island, Alaska. The area is bounded on the northwest by an exposed marine spit that extends into the harbor. A shallow bar structure is located at the entrance of the harbor and was the main focus of the survey. Figure 1 shows the project area location.

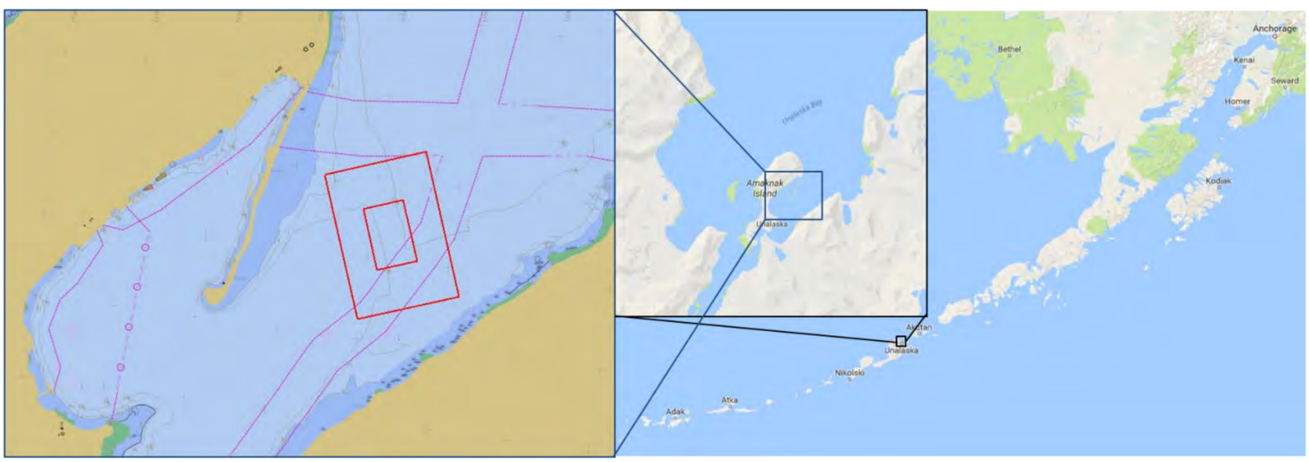


Figure 1 Survey Area Location

The survey area for the project consists of an outer rectangular box (3,500 ft by 2,500 ft) and an inner rectangular box (1500 ft by 1000 ft). The inner box defines the intended area to be dredged. Figure 2 below shows the defined survey boxes.

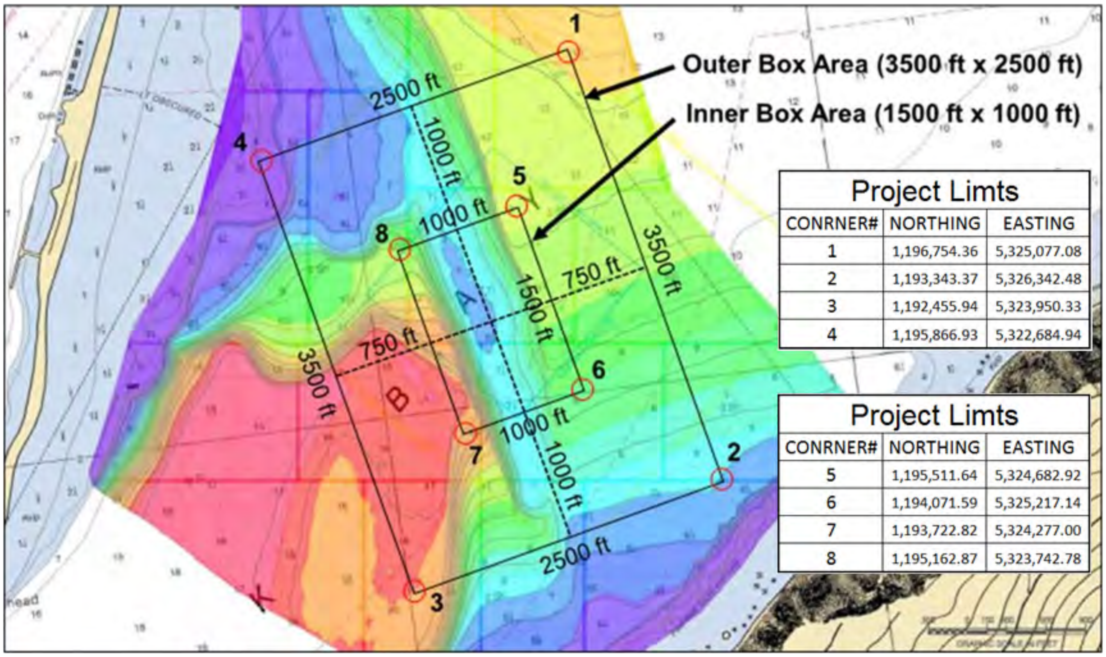


Figure 2 Defined Survey Area Boxes (background bathymetry from NOAA 2011 dataset from GFI-5 for Dutch Harbor Marine Geophysical-Bathymetric Survey.pdf)

The outer box survey area (including the inner box) required 200% coverage with multibeam echosounder (MBES). Sediment grab samples would be retrieved on a grid spacing of 500 feet. Simultaneous Chirp Subbottom Profiler and Narrow Band Seismic Refraction Profiler lines were required to be run spaced 50 feet apart with cross lines every 175 feet. The inner box survey area was required to be covered with chirp subbottom profiler lines spaced on a 5ft grid pattern. Gradiometer lines would be run on the same 5ft grid pattern. The objective of the inner and outer box survey area was to identify objects/debris larger than 1 ft by 1 ft. The layout of surveys completed in the inner and outer boxes is shown below in Figure 3.

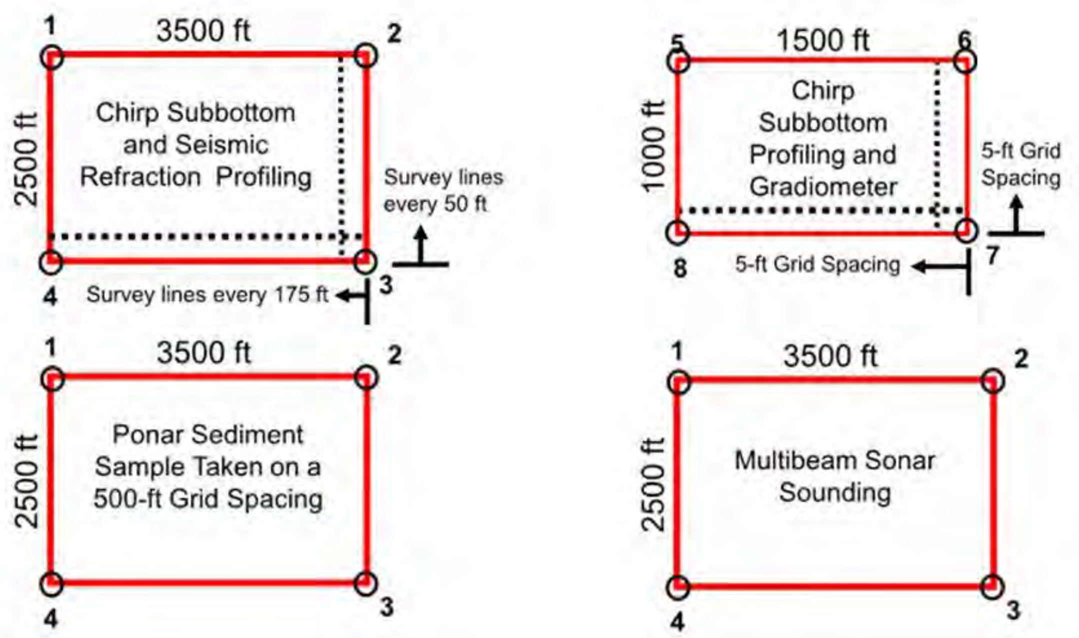


Figure 3 Survey descriptions of inner and outer boxes

1.3 Company Overview

eTrac Inc. was established in 2003 as a hydrographic and geophysical surveys, vessel positioning and instrumentation firm. eTrac has several offices along the US West Coast including San Francisco, Seattle and Anchorage. The firm has earned a strong reputation among many sectors of the hydrographic industry, including government agencies and private industry. Its equipment fleet has also grown to include 8 aluminum geophysical survey vessels as well as several ultraportable, shallow water survey craft. eTrac's role has grown over the years to include a strong group of full-time staff as well as several localized vessels to support the work required by the USACE, marine construction, engineering firms and petroleum industry contractors on the West Coast. eTrac is committed to continual re-investment in industry leading equipment and knowledgeable staff to complete multibeam, singlebeam, sidescan, mobile LiDAR, subbottom, and water-level surveys required by our clients. Staffed with professionally licensed land surveyors and ACSM/THSOA (American Congress on Surveying and Mapping/The Hydrographic Society of America) certified hydrographers, eTrac's projects are performed at the highest level of quality and detail that the industry demands.

2 OBJECTIVES

eTrac completed a bathymetric and geophysical survey in support of proposed dredging operations of a shallow bar structure at the entrance of Dutch Harbor Channel. The requirement of the project is to provide sea-floor bathymetry, subbottom stratigraphy, and identification of submarine debris targets that are larger than 1 ft x 1 ft.

The objectives of this survey are as follows:

- Determine the stratigraphic and geologic characterization of sediments, soil, and bedrock underlying the survey area
- Define and describe the nature of the shallow bar structure
- Identify and analyze surface and subsurface submarine objects and debris larger than 1 ft x 1 ft within the survey area.

3 SURVEY CALENDAR

The survey began on April 10th 2017 with the mobilization of the multibeam and positioning systems. The final day was May 2nd when all systems were demobilized from the vessel. The survey activities calendar is below in Table 1.

Table 1 Survey Activates Calendar

April 10, 2017	Mobalization MBES and Vessel Positioning System
April 11, 2017	Mobalization MBES and Vessel Positioning System
April 12, 2017	Aquire MBES
April 13, 2017	Aquire MBES and Sediment Samples / Land Survey
April 14, 2017	Aquire MBES and Sediment Samples / Demobalization of MBES
April 15, 2017	Mobalization USLB, Bubble Gun Subbottom and Chirp Subbottom / Land Survey
April 16, 2017	Winch Instalation
April 17, 2017	USBL Calibration / Winch Instalation / Transit
April 18, 2017	Aquire Stratification Survey Bubble Gun and CHIRP Subbottom Data
April 19, 2017	Aquire Stratification Survey Bubble Gun and CHIRP Subbottom Data
April 20, 2017	Aquire Stratification Survey Bubble Gun and CHIRP Subbottom Data / Demobalize Bubble Gun Subbottom
April 21, 2017	Aquire Subsurface Object Detection Survey CHIRP Subbottom Data
April 22, 2017	Aquire Subsurface Object Detection Survey CHIRP Subbottom Data
April 23, 2017	Aquire Subsurface Object Detection Survey CHIRP Subbottom Data
April 24, 2017	Aquire Subsurface Object Detection Survey CHIRP Subbottom Data / Demobalize Chirp Subbottom / Mobalize Grad
April 25, 2017	Aquire Gradiometer Data
April 26, 2017	Aquire Gradiometer Data
April 27, 2017	Aquire Gradiometer Data
April 28, 2017	Aquire Gradiometer Data
April 29, 2017	Aquire Gradiometer Data
April 30, 2017	Aquire Gradiometer Data
May 1, 2017	Demobalization Gradiometer and Vessel Positioning System
May 2, 2017	Demobalization Vessel Positioning System

4 METHODOLOGY

4.1 Survey Vessels

eTrac Inc. used charter vessel Miss Alyssa for hydrographic and geophysical survey operations for the Channel Navigation Improvements Feasibility Study in Dutch Harbor, Alaska. Vessel Miss Alyssa is a 43 foot all fiberglass twin diesel powered commercial fishing/dive support and charter vessel (see Figure 4 for an image of the mobilized vessel). A positioning and motion detection system was installed on the vessel with a long antenna base allowing maximum heading accuracy. A multibeam system and USBL system were mounted with a Universal Sonar Mount (USM) – Vessel of Opportunity (VOOP) kit. The sediment sampler was deployed and retrieved via the onboard hydraulic winch. The narrow band subbottom system was towed from two tie points off the stern of the vessel. The Chirp subbottom system and the Gradiometer were towed using a sheave with a block and winch off the stern of the vessel.

Figure 4 Vessel Miss Alyssa

4.2 Equipment

A base station was set-up next to the survey area with a baseline no longer than 1 mile to any point in the survey area (see Figure 7). This base was constantly logging and broadcasting correction data. The base position was transferred from and checked in to the project benchmarks to within 0.03 ft in horizontal and vertical. The system provided RTK corrections for GLONASS and GPS satellites for optimal performance. Precise positioning and motion systems, a high resolution multibeam sonar, a sediment grad sampler, a bubble gun subbottom sonar system, a USBL system, a CHIRP subbottom sonar system, and a gradiometer were installed for this project and are described below.

4.2.1 Positioning System

The vessel was positioned and motion accounted for using an Applanix POS MV5 Oceanmaster. The system allows high accuracy real time kinematic (RTK) positioning as well as a post processed kinematic (PPK) solution. All tidal stages are accounted for in real-time through the RTK or PPK vertical position. Details of the system are below in Figure 5.

Applanix POS MV V5 Oceanmaster

- Position Accuracies PPK: Horizontal: +/ (8 mm + 1 ppm x baseline length)3 Vertical: +/ (15 mm + 1 ppm x baseline length)
- Motion Accuracies, Roll and Pitch: 0.008° in PPK
- Heading Accuracies: 0.01° (4 m baseline)
- Real time Heave 5cms and Trueheave Solutions available increasing to 3 cms
- With POSPac Processing allows PPK solution with GLONASS AND GPS satellites.

Figure 5 Applanix POS MV Oceanmaster

The system was set-up with POS View Software and offsets to GPS antenna from the reference point entered in to the system. Images from the software are shown in Figure 6.

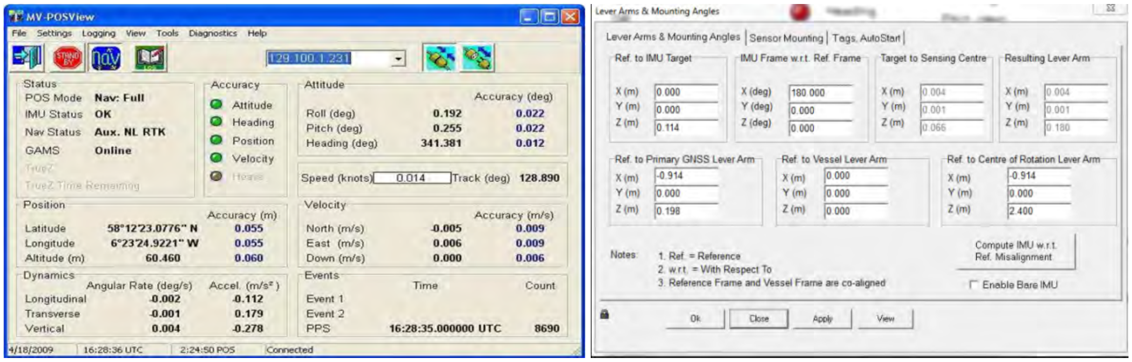


Figure 6 POS View Screens Online and Lever Arm Offsets

The base station used was a Trimble 855 with radio for broadcasting CMR correction to the vessel. The system as set-up on point "SPIT" is shown below in Figure 7.

Mobilization details the QC methods for the POS MV Positioning system can be found in Appendix A – Mobilization Report.

Trimble 855

- Broadcasting RTK CMR+ and CMR 94 corrections
- Logging data with NetR5
- GPS and GLONASS

Figure 7 Trimble SP 855 RTK base station "SPIT" GNSS & VHF Antennas set-up for the project

4.2.2 USBL

A LinkQuest Tracklink 1500 USBL system was used to position the Chirp subbottom system and gradiometer along with the POSMV which positioned the vessel on which the USBL was mounted. Listed below are the details of the USBL used (see Figure 8).

USBL

•Positioning Accuracy: 3 degrees (better than 5% of slant range)
•Slant Range Accuracy: 0.20 meters
•Targets Tracked: 16
•Operating Frequency: 31.0 to 43.2 kHz
•Operating Beamwidth: 120 to 150 degrees
•Transmit Mode Power Consumption: 10 Watts
•Receive Mode Power Consumption: 1.6 Watts
•Working Range With Ship Noise: 1000 m
•Maximum Transponder Depth: 1500 m

Transponder 1505B
•Dimensions: 30 cm x 6.4 cm
•Battery Storage Time: 3 years
•Battery Operation Time: 1 year
•Active Responding Time: 8 x 10 hours
•Weight in Water: 0.86 kg
•Weight out of water: 1.77 kg
•Input Voltage 18 to 24 v

Figure 8 LinkQuest Tracklink 1500 USBL Details

The system was set-up and controlled using the TrackLink navigator software. This showed the relative position of the Beacon along an X and Y axis as well as the depth of the beacon. An image from the TrackLink software is seen in Figure 9.

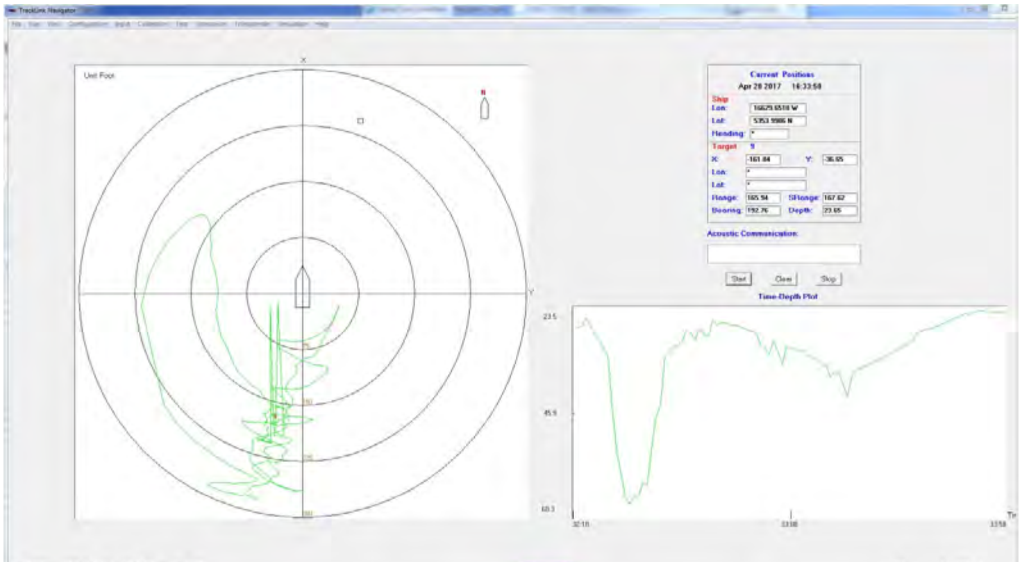


Figure 9 Tracklink Navigator Software

As described in Appendix A – Mobilization Report, the top center of the IMU was chosen as the RP and an offset to the acoustic center of the USBL and thus the reference point of the USBL was measured and used to position the system. This offset was added into QINSy as well as the offset results from the calibration tests and position was calculated and recorded in real-time. The USBL position is displayed in the QINSy shell as a node.

Details of the system calibration can be found in Appendix A - Mobilization Report.

4.2.3 Cable Counter

A Hydrographic Survey Products cable counter was used as a secondary positioning system for the chirp and gradiometer systems. The cable counter was set-up as a separate computation in QINSy and the computed solution from the cable counter would be used during USBL dropouts. Details of the system can be seen below in Figure 10.

•Power: 8 to 24V dc @ 1amp
• Max Count: 99999.9 meters (10kM)
•Min Count: 00000.0 meters
•Resolution 10 cm (determined by magnet spacing)

Figure 10 HSP Cable Counter Details

As described in Appendix A - Mobilization Report during Chirp and Gradiometer acquisition as a quality control measure between the primary positioning (USBL) and secondary positioning (cable counter), a comparison was made between the two systems. Each time the winch was used to lower or raise the Chirp or Gradiometer the mark set for the exact amount of cable out (at 5m and 10m) was checked against the cable out calculation from the cable counter. This data was used by QINSy to estimate the position of the instrument towed behind the boat. In the QINSy shell the position resulting from the cable counter and the position resulting from the USBL was compared. There was good agreement between the two positioning systems.

Further details of this system can be found in Appendix A - Mobilization Report in.

4.2.4 Multibeam Sonar

R2Sonic 2024 Multibeam Echo sounder

- 400 kHz
- 256 discrete 0.5° x 1.0° beams (0.5° 700 kHz)
- 1 to 500 meter minimum/maximum range
- 1.25 cm range resolution

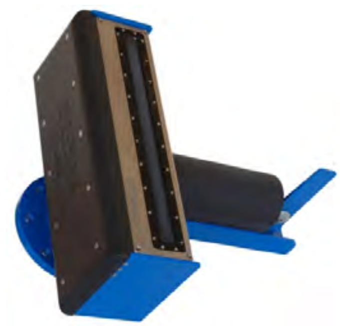


Figure 11 R2 Sonic 2024 Multibeam Echosounder System

An R2 Sonic 2024 multibeam system was used for all bathymetry data acquisition (see Figure 11 for image and details). The system used is capable of running at 400 kHz to get the highest resolution dataset.

The system is controlled using the R2 sonic controller (seen below in Figure 12). The setting changes that can be made include the range, gain, power, pulse width, absorption and saturation. These are monitored and adjusted accordingly. Swath width is also adjusted using the R2 sonic controller. Swath width varied but was always between 90° and 110°.

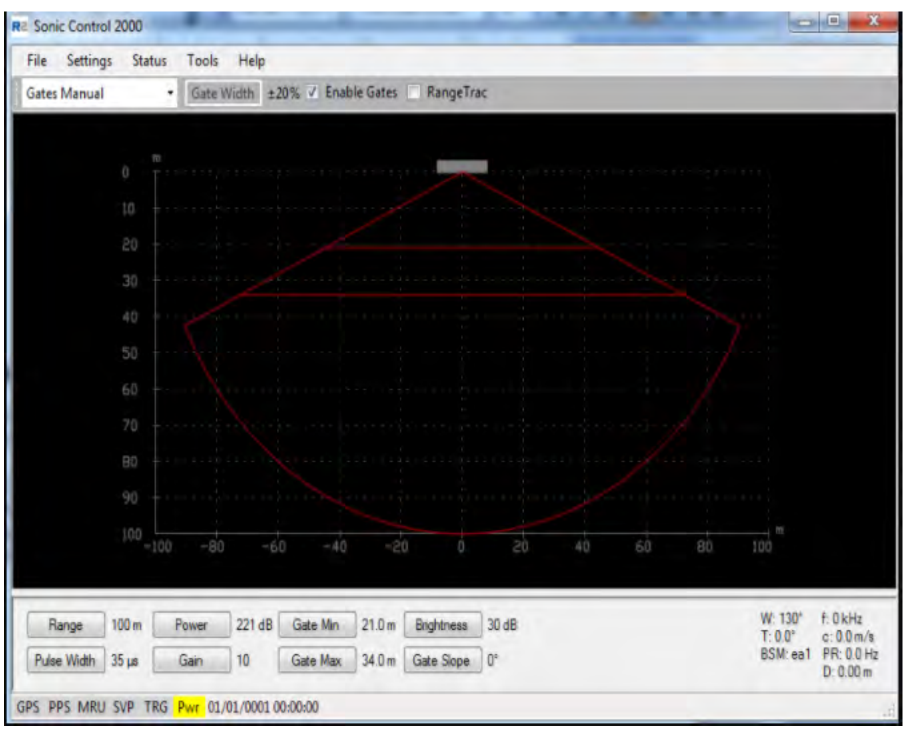


Figure 12 R2 Sonic Control 2000

Data was logged in QINSy as .DB files containing bathymetry, intensity and snippets data.

As described in Appendix A – Mobilization Report, the top center of the IMU was chosen as the reference point and measurements were taken in the x, y, and z direction between the RP and the R2 Sonic Acoustic Center and used to position the system. These offsets were applied in the vessel Database in QINSy and position was calculated and recorded in real-time. The R2Sonic position is displayed in the QINSy shell as a node.

Further details of the calibration and QC methods for multibeam system can be found in Appendix A - Mobilization Report.

4.2.5 Sound Velocity

Sound velocity profiles were obtained at pre-planned intervals during all surveys to adjust the computation of MBES sonar, subbottom sonar, or gradiometer refraction and ranging of data due to speed of sound variation in the water column.

AML Base X 2 Sound Velocity Profiler

- Depth Range: up to 500 meters
- Sound Velocity Range: 1375 to 1625 m/s
- Sound Velocity Precision (+/-): 0.006 m/s
- Sound Velocity Accuracy (+/-): 0.025 m/s
- Sound Velocity Resolution: 0.001 m/s
- Pressure Range: Up to 6000 dBar

Figure 13 AML Base X 2 Sound Velocity Profiler

An AML Base X 2 Profiler (See Figure 13 for image and details) was used as the sound speed profiler due to its high accuracy time of flight sound speed sensor, which is capable of measuring sound speed in depths up to 500 meters. The AML Base X 2 is capable of transferring data via WiFi. AML SeaCast software was run on the acquisition computer to facilitate the data transfer and profile formatting.

AML Micro X Sound Velocity Profiler

- Depth Range: up to 500 meters
- Sound Velocity Range: 1375 to 1625 m/s
- Sound Velocity Precision (+/-): 0.006 m/s
- Sound Velocity Accuracy (+/-): 0.025 m/s
- Sound Velocity Resolution: 0.001 m/s

Figure 14 AML Micro X Sound Velocity Profiler

During MBES survey an AML Micro X (see Figure 14 for image and details) was utilized by the R2Sonic 2024 for the surface sound speed measurement. The AML Micro X is a time of flight SV sensor and is powered through the R2Sonic topside unit via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

Details of the sound velocity profiler systems can be found in the Mobilization Report in Appendix A.

4.2.6 Grab Sampler

WILDCO Ponar Grab

Figure 15 WILDCO Ponar Grab Sampler

A WILDCO Ponar grab sediment sampler system was used for all sediment collection (shown in Figure 15). The Ponar grab is a self closing stainless steel grab sampler and has a sample volume of 500 Cubic Inches and measures 9'Wx9'L. A full mobilization report for the grab sampler system can be found in Appendix A.

4.2.7 Subbottom Profilers

Two subbottom profiler systems were used to image deep and shallow subsurface stratigraphy as well as buried objects. The low frequency acoustic signal penetrates surface sediments and reflections from the subsurface layers and objects are recorded. Strong amplitude returns represent harder materials below the surface. Areas where there is a strong return but nothing below can be considered too hard to penetrate. Changes in amplitude return are detected which represents a change in the sediment type below the surface. Objects appear in the data as parabolas where the return of the echo is dispersed. A narrowband subbottom system was used for general stratigraphy while the FM Chirp system has reduced penetration but offers greater resolution and ability to decipher buried objects.

4.2.7.1 Narrow Band Boomer Subbottom System

Falmouth HMS620 Bubble Gun

Figure 16 Falmouth HMS-620 Bubble Gun

The Falmouth HMS-620 Bubble Gun (shown in Figure 16) was used to determine the deep subsurface stratification (up to 300 feet below the seabed). The system is a narrow band low frequency boomer subbottom profiler capable of penetrating course sand and gravel sediments. This system can differentiate bedrock from other geological environments. The Bubble Gun has frequency of 400 kHz. The Bubble Gun system is designed to be flown at the surface.

The narrowband subbottom Digital SEG Y data was acquired using Chesapeake 2-channel NI Analog SB real-time server and SonarWiz Subbottom Acquisition. QPS QINSy was used for navigation and a layback set-up allowed the navigator to see the position of the Bubble Gun relative to the vessel. The system was controlled using the SonarWiz subbottom analog server. The range and frequency settings as well as the DC offset and AC range can be adjusted. The controller is shown below in Figure 17. Data was logged in SonarWiz as .SEGY files.

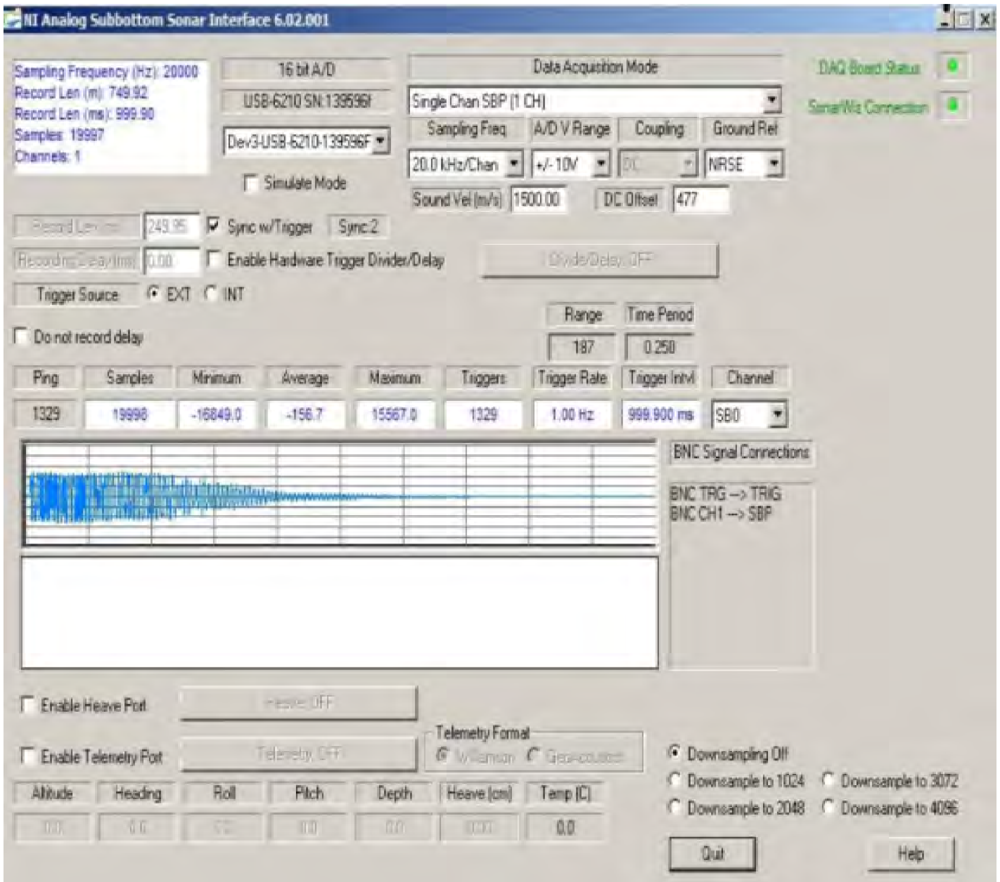


Figure 17 SonarWiz Analog Subbottom Interface

A full mobilization report for the Bubble Gun system can be found in Appendix A.

4.2.7.2 Chirp Subbottom System

Edge Tech Chirp 216S

Figure 18 Edgetech 216s

To understand the shallow subsurface stratification (up to 30 feet below seabed) and subsurface object detection an Edgetech 216S Chirp Subbottom profiler with a 3200 topside was used. The system is shown in Figure 18 above. The system has a frequency modulated pulse and can be set-up to 2-16 kHz at 5 m/s. The Chirp system has an optimal range of flight between 5 – 10 meters about the seafloor.

Edgetech Discover software was used to control the system. The frequency settings and range can be adjusted. Data was logged as native, raw .jsf files with navigation embedded. Chirp subbottom JSF data was acquired in Edgetech Discover software. The raw jsf files were recorded to eliminate any loss in fidelity. As described in Appendix A – Mobilization report, QPS QINSy was used for navigation and the USBL and layback set-up allowed the navigator to see the position of the towfish relative to the vessel in real-time. All Chirp data was processed in SonarWiz software.

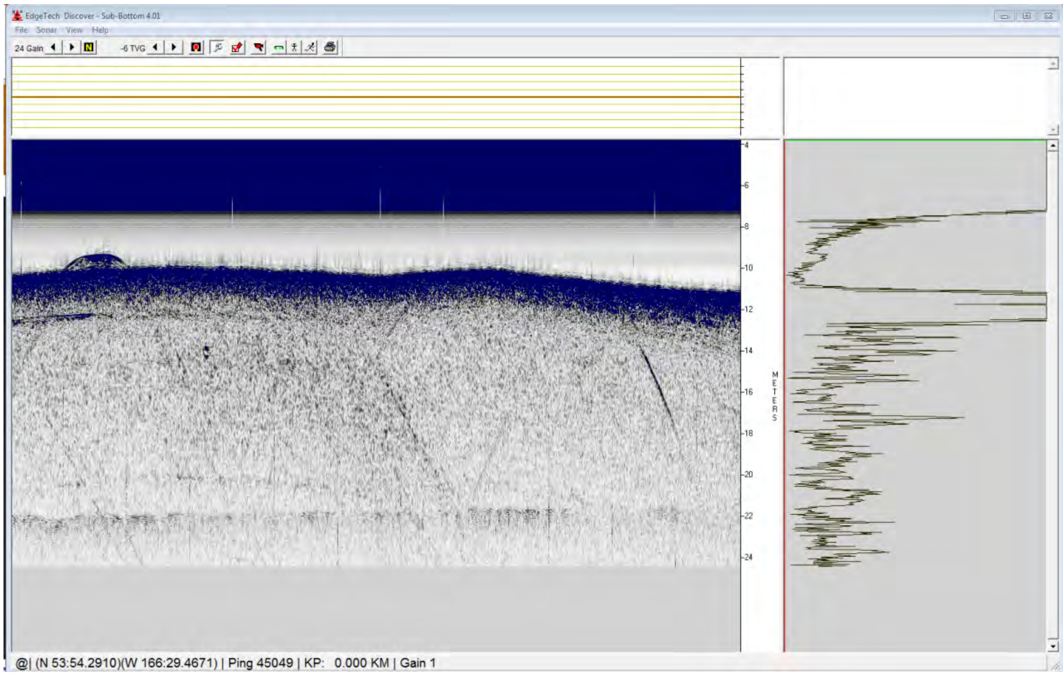


Figure 19 Discover Software

A full mobilization report for the Chirp subbottom system can be found in Appendix A.

4.2.8 Gradiometer System

Geometrics G-882 TVG

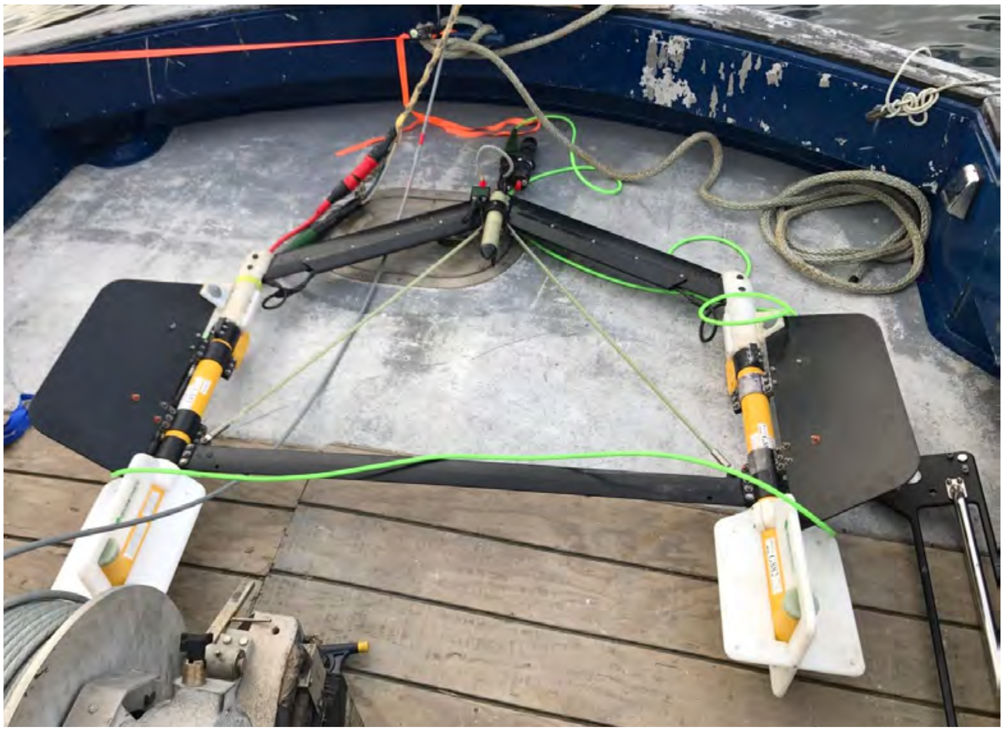


Figure 20 Geometrics G-882 Gradiometer

A Geometrics G-882 Cesium-Vapor marine Gradiometer (Transverse gradient magnetometer) was used to detect possible Unexploded Ordinances (UXOs) (seen above in Figure 20). This system detects ferrous objects below and at the surface of the seabed. The gradiometer system is made of two magnetometers mounted on a frame in parallel. The Gradiometer system compared to a single magnetometer system is able to detect smaller ferrous objects and is better at accounting for surrounding magnetic disturbance. A Quasi-Analytic signal can be produced based on the transverse gradient of the magnetic detection from the two systems. The gradiometer has an optimal range of flight between 5 – 10 meters above the seafloor.

Gradiometer acquisition was completed in MagLog. As described in Appendix A – Mobilization report, QPS QINSy was used for navigation and the USBL and cable counter set-up allowed the navigator to see the position of the gradiometer relative to the vessel. MagLog software was used to log data and set-up the system. An image of the software in use is shown below in Figure 21.

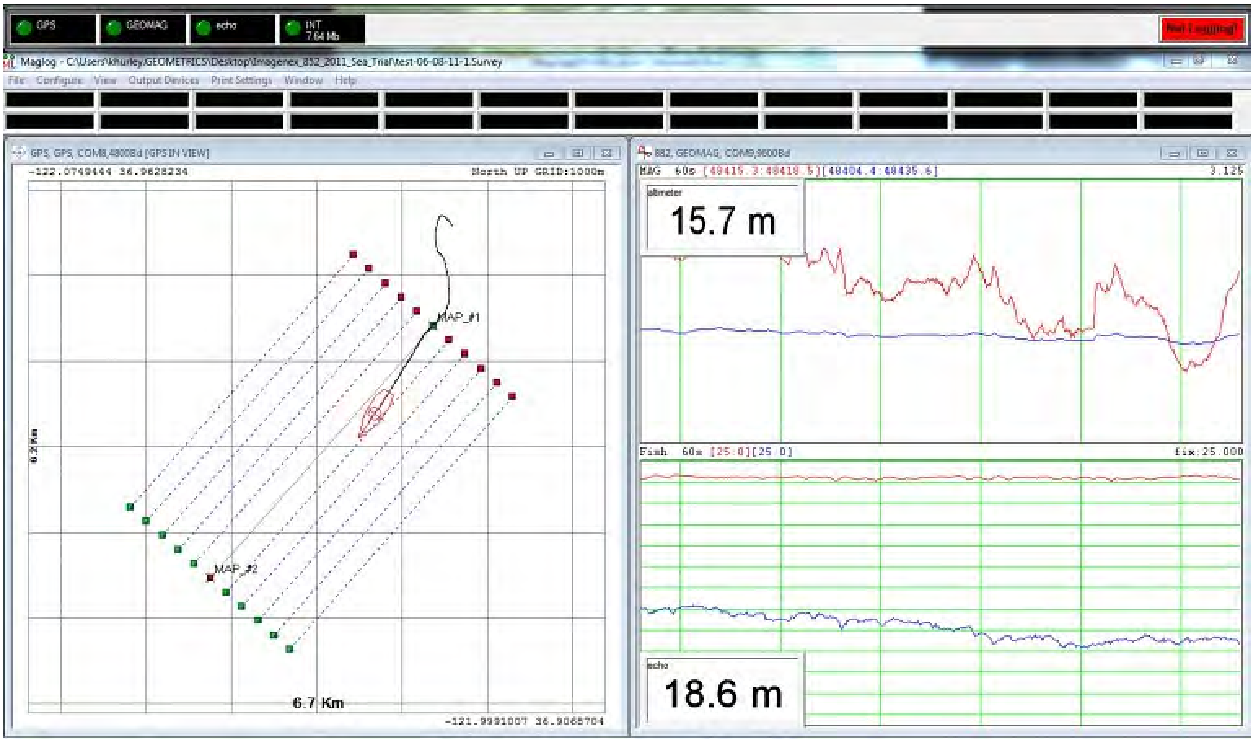


Figure 21 MagLog Software used to set-up and log gradiometer data

Further details of this system can be found in the mobilization report in Appendix A.

4.3 Data Acquisition

4.3.1 Multibeam Bathymetry

All multibeam data was acquired as outlined in the Channel Navigation Improvements Feasibility Study, Dutch Harbor Alaska, Marine Geophysical and Bathymetric Work plan dated 23 March 2017, activities plan section under multibeam sonar operations and in accordance with eTrac's related standard operating procedures. The combined POSMV and R2 Sonic multibeam system were used to acquire all multibeam bathymetry data. All RTK position data was successfully collected and applied in real-time in the QPS QINSy online shell. All tidal stages were accounted for in real-time through our RTK position. The R2 system was run at 400 kHz to allow hi-res data. The system was run with no gates or filters to enable imagery of all potential objects in the entire water column. The R2 Sonic 2024 was set to collect intensity data (snippets) concurrently with the bathymetry. Snippets data packets were acquired and stored in the QINSy database files and used in addition to the sediment samples to determine the sediment characterization of the survey area. Sonar saturation was monitored throughout the survey to maintain a consistent signal to noise ratio

As described in section 4.2.5 of this report, for all multibeam data the sound speed both at the sonar head and through the water column was accounted for with two sound velocity probes. An AML micro X and an AML Base X2 were used. During mulitbeam acquisition sound velocity profiles were acquired every 2 – 3 hours and applied in real-time in QINSy using the echosounder settings utility in the online QINSy shell. As described in Appendix A – Mobilization Report, the AML Base X2 sound velocity profile and the AML micro X sound velocity at the head were compared.

As described in Appendix A – Mobilization Report, multibeam data was collected to achieve 200% bottom coverage with object detection of any object larger than 1ft by 1ft. This achieved coverage is further explained in section 4.4.1 of this report.

4.3.2 Sediment Sampling

Grab samples were completed as described in the Channel Navigation Improvements Feasibility Study, Dutch Harbor Alaska, Marine Geophysical and Bathymetric Work plan dated 23 March 2017 activities plan section under sediment sampling and in accordance with R&Ms related standard operating procedures. More details on the sediment sampling can be found in the R&M Geophysical Survey Report. Sediment samples were analyzed in the field as well as sent for laboratory testing. Samples were positioned by creating a fix at each drop location using the winch as the reference point. The sample results were used to ground truth the snippets multibeam data in order to create a surface classification.

4.3.3 Subbottom Systems

4.3.3.1 Bubble Gun Subbottom

Bubble Gun data was acquired as described in the Channel Navigation Improvements Feasibility Study, Dutch Harbor Alaska, Marine Geophysical and Bathymetric Work plan dated 23 March 2017 activities plan section under Geophysical Survey Operations - Stratification Detection and in accordance with eTrac's related standard operating procedures.

As described in Appendix A – Mobilization Report, the Falmouth HMS Bubble Gun system was towed from two tie points on port and starboard sides of the stern (one for the source, one for the streamer). The tow cables were marked and extended to the same point each time to maintain layback consistency and allow consistent accurate positioning of the system. The Bubble Gun was flown at the surface towed at 25m cable from the tow point at the stern of the vessel. The cable towing the source was measured and marked to maintain a 25m distance each time the system was deployed. The streamer was set to be 10 meters behind the source. Although at the surface, due to the distance of 25m behind the stern of the vessel, prop wash did not interfere with the system. The POS MV with an offset to the stern tow point was used to position the system at the tow point node. The resulting tow point position data string was fed from QINSy to the SonarWiz data acquisition system. A layback value to fully position the system was calculated in processing.

The system was set to 20 kHz sampling frequency with a trigger rate of 0.125 seconds and the range at a maximum to sync with the trigger rate. The AD range was set to +-10v. A low frequency filter set to 50 and a high frequency filter set to 200 were set to filter any chirp noise. Gain was set to 18db so the overload indicator remained off. A real- time profile data display was monitored for penetration and signal attenuation through the subsurface.

4.3.3.2 Chirp Subbottom

Chirp Subbottom data was acquired as described in the Channel Navigation Improvements Feasibility Study, Dutch Harbor Alaska, Marine Geophysical and Bathymetric Work plan dated 23 March 2017 activities plan section under Geophysical Survey Operations - Stratification Detection as well as the Subsurface Object Detection section and in accordance with eTrac's related standard operating procedures.

As described in Appendix A – Mobilization Report, the Chirp system was towed on an armored 6-string cable from a sheave with a block off the stern of the vessel. The system was positioned using the USBL System beacon allowing consistent accurate positioning. A cable counter was used as a secondary positioning system. The resulting position of the Chirp subbottom system was output to the Edgetech Chirp subbottom acquisition system. This position was logged with the raw JSF data files. The fish was flown at the optimal height for data resolution and coverage of 5 to 10 meters above the seafloor. The system was lowered and raised using the winch to enable this set height. Prop wash did not interfere with the system as it was flown below any disturbance.

As described in Appendix A – Mobilization Report, the 2-16 kHz WB 10 ms setting was used consistently throughout the survey. The maximum range was set to 22 m and the top 4 m was blanked. This allowed a consistent ping rate of up to 19.6 Hz and never lower than 18 Hz. At 4knots there is an average of 3 pings every 1 ft which results in 3 possible detection points every 1ft. allowing for the detection of objects 1 ft x 1 ft or greater along the 5ft grid lines. Given the system footprint at the depth flown, objects within the 5ft grid pattern would also be detected.

At this setting the beam width is 17° and at the towing height of 20 ft gives a footprint of 6 ft. The first return is directly below the system and therefore it is understood that the object has to be directly below the system to be detected, but objects up to 6ft away can cause disturbance. The vertical resolution is 0.2 ft at this setting.

During the stratification detection survey the Chirp system was run concurrently with the FalmouthHMS-630 Bubble Gun.

4.3.4 Gradiometer System

Gradiometer Subbottom data was acquired as described in the Channel Navigation Improvements Feasibility Study, Dutch Harbor Alaska, Marine Geophysical and Bathymetric Work plan dated 23 March

2017 activities plan section under Geophysical Survey Operations - Subsurface Object Detection section and in accordance with eTrac's related standard operating procedures.

As described in Appendix A – Mobilization Report, the Gradiometer system was towed on a cable from a sheave with a block off the stern of the vessel. The system was positioned using the USBL System beacon allowing consistent accurate positioning. A cable counter was used as a secondary positioning system. The system was lowered and raised using the winch in order to fly as flat as possible while maintaining a height above the seafloor of 5 m to 10 m. Prop wash did not interfere with the system as it was flown below any disturbance. The resulting position of the system as calculated using the USBL was output to the gradiometer acquisition system running MagLog. MagLog was set-up for this type of gradiometer system with two systems, two depth sensors and one altimeter on a frame 1.5 m wide. The update rate (sample rate) for the system was set to 0.1 seconds. At 4 knots survey speed this rate resulted in 1.5 samples every 1 ft. allowing for the detection of objects 1 ft x 1 ft or greater along the 5ft grid lines. In addition, the system footprint created by having two detection units in a 1.5m frame allowed for object detection within the 5ft grid spacing.

Survey Areas and Lines

The project included an inner and outer survey area. Exact line spacing was required for each of these survey areas. These lines and areas are described below.

4.4.1 Multibeam

The multibeam survey was performed in the outer box (including the inner box) boundary (3,500 feet by 2,500 feet). As described in Appendix A – Mobilization Report, multibeam data was collected to achieve 200% bottom coverage with object detection of any object larger than 1ft by 1ft. Lines were run to ensure the full extents of the boundary were covered with multibeam sounding data at least twice (at least 2 soundings per node). Line spacing was determined by depth. The density (soundings per node) or our 1x1 ft grid ranges from at least 2 soundings per node to over 40 soundings per node with a mean sounding density of 10 soundings per node. The ability to detect objects larger than 1 ft x1 ft was achieved with our sounding density of at least 2 soundings per 1x1ft node.

4.4.2 Sediment Samples

The sediment samples were collected by R&M in the outer box (including the inner box) boundary (3,500 feet by 2,500 feet). 51 sediment grab samples were taken on a 500 ft x 500 ft grid spacing. Three additional grab samples were collected for the crest of the bar to increase sample coverage within that area. Figure 22 below shows the approximate orientation of the collected sediment grab samples.

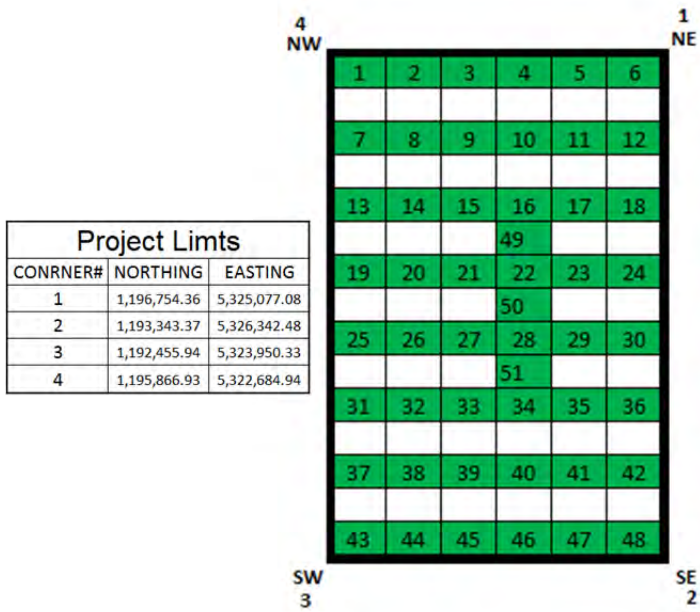


Figure 22 Sediment Grab Sample Orientation

4.4.3 Subbottom

Initial testing lines were run for both the Falmouth HMS-620 Bubble Gun and the Edgetech 216S Chirp subbottom profilers. The first testing lines were the layback calibration lines to determine the exact position of the subbottom system relative to the positioning system. Lines were run over the bar. A second set of lines were run in different geology types and depths to determine the optimal subbottom settings. All lines were run a set speed between 2-4 knots both to maintain data density while maintaining the system flying above the seafloor.

4.4.3.1 Narrowband Subbottom Profiler

The narrowband subbottom profiler survey was performed in the outer box (including the inner box) boundary (3,500 feet by 2,500 feet). Survey lines were run parallel to the bar feature spaced 50 feet apart and across the bar feature spaced 175 feet apart. This spacing resulted in 51 survey lines running parallel to the bar and 21 survey lines running across the bar.

4.4.3.2 Chirp

The Chirp subbottom profiler survey had different line requirements in the outer box boundary and the inner box boundary.

In the outer box (including the inner box) boundary (3,500 feet by 2,500 feet) the Chirp subbottom profiler survey was performed simultaneously with the narrowband seismic refraction profiler survey. Survey lines were run parallel to the bar feature spaced 50 feet apart and across the bar feature spaced

175 feet apart. This spacing resulted in 51 survey lines running parallel to the bar and 21 survey lines running across the bar.

In the inner box boundary (1,500 feet by 1000 feet) the Chirp survey lines were run parallel to and across the bar in a 5 ft x 5 ft grid spacing. This grid spacing resulted in 201 survey lines running parallel to the bar and 301 survey lines running across the bar.

4.4.4 Gradiometer

The gradiometer survey was performed in the inner box boundary (1,500 feet by 1000 feet). Survey lines were run parallel to and across the bar in a 5 ft x 5 ft grid spacing. This grid spacing resulted in 201 survey lines running parallel to the bar and 301 survey lines running across the bar. All lines were run a set speed between 2-4 knots so that the system flew at the same offset length behind the vessel throughout the survey.

4.5 Geodesy

4.5.1 Project Coordinates

The project coordinates used for the survey were NAD83 U.S. State Plane Alaska Zone 10 in US Survey feet.

4.5.2 Vertical Datum

The vertical datum used for the survey was MLLW.

4.5.3 Horizontal and Vertical Control

Local Project Control is based on NGS (OPUS) and NOAA published values for NOAA Tidal Station “946 2620 Unalaska, Dutch Harbor, Alaska”. Tidal bench mark “946 2620 TIDAL 19” was held as the primary control point. Differential Leveling was conducted between “946 2620 TIDAL 19” and three other bench marks from the same station: “946 2620 TIDAL 16”, “946 2620 M”, and “946 2620 P”. A Static GNSS survey was conducted in order to compute the position of semi-permanent RTK Base Station “SPIT” established near the project site. The location of benchmarks and the semi-permanent RTK Base Station “SPIT” as well as an image of “SPIT” are displayed in Figure 23 and Figure 24 below.

Figure 23 Semi-Permanent RTK Base Station "SPIT" established near project area

Figure 24 Semi-Permanent RTK Base Station "SPIT" GNSS & VHF Antennas installed at weather station

Differential Leveling was carried out between “TIDAL 19” and three other NOAA bench marks using a Leica DNA03 digital level. A collimation test was performed prior to conducting two level loops, each starting at and holding “TIDAL 19” as fixed. Table 2 below lists the results of the differential leveling.

Table 2 Benchmarks used for Differential Leveling

Bench Mark	Published Elevation (NOAA 10/24/2011)	Measured Elevation (eTrac 04/18/2017)	Δ
946 2620 TIDAL 19	16.427	16.427*	*0.000
946 2620 TIDAL 16	18.366	18.365	0.001
946 2620 M	10.974	10.965	0.009
946 2620 P	11.726	11.718	0.008

*946 2620 TIDAL 19 held as fixed for differential leveling. All values in USft.

A Static GNSS network was carried out over two days, 4/13/17 and 4/15/17 using a combination of Trimble R8-2 and SPS 855 receivers logging at 5-second intervals. Observations times are listed in Table 3 and Table 4 below.

Table 3 Static GNSS network Observation Times 4/13/17

4/13/2017

Bench Mark	Receiver S/N	Antenna Height	Measured To	Start Time	Stop Time	Duration
TIDAL 19	4329	1.5 m	Bottom of Mount	10:07	18:21	8:14
2620 M	9246	1.5 m	Bottom of Mount	10:29	19:03	8:34
SPIT	5165	0.0 m	Bottom of Mount	10:52	19:20	8:28

Table 4 Static GNSS network Observation Times 4/15/17

4/15/2017

Bench Mark	Receiver S/N	Antenna Height	Measured To	Start Time	Stop Time	Duration
TIDAL 19	9246	1.5 m	Bottom of Mount	8:44	17:09	8:25
2620 M	5165	1.5 m	Bottom of Mount	8:55	17:43	8:48
SPIT	4329	0.0 m	Bottom of Mount	7:31	18:09	10:38

Logged data for “TIDAL 19” and “2620 M” were submitted to OPUS for publication. The Static GNSS network was processed using Trimble Business Center, in which the published OPUS coordinates for “TIDAL 19” and “2620 M” were held as fixed for the horizontal adjustment. The NOAA published MLLW elevation of “TIDAL 19” (5.007 m) was held as fixed for the vertical adjustment.

The final coordinates for “SPIT” (NAD 83 (2011) 2010.00 AKSP Zone 10) are:

Northing: 1195075.54 USft

Easting: 5321164.69 USft

MLLW: 23.97 USft

Although commonly subject to ground movement these benchmarks were found to be continuously stable. An OPUS solution of TIDAL 19 has been published 5 times since 2006 and each solution differs minimally. Our published OPUS solution compared to the 2006 OPUS solution differs 0.044m in Northing, 0.025m in Easting, and 0.007m in Ortho Height.

The following supplemental horizontal and vertical control reports can be found in Appendix B

- GNSS Baseline Processing Report
- Fully Constrained Network Adjustment Report
- Minimally Constrained Network Adjustment Report
- GNSS Loop Closure Network Adjustment Report
- Level Report
- OPUS Shared Solution: 946 2620 TIDAL 19
- OPUS Shared Solution: 946 2620 M

4.6 Acquisition and Safety

All data was collected from April 12th 2017 to April 30th 2017. Data was collected in a safe and efficient manner. All personnel involved with the project are OSHA certified. All personnel completed a Project Safety Orientation and Vessel Safety Briefing before being operations. At the start of the day and before any activity change a full toolbox talk was completed. The main risk involved was deploying and retrieving the towed survey instruments (Bubble Gun, Chirp, and Gradiometer). Two people were always on deck during these operations and retrieval and it was always done at periods during which ample time could be allowed for the process to be done in a safe manner.

4.7 Processing and Software

4.7.1 Multibeam Data

All multibeam data acquisition was completed in QPS QINSy hydrographic data acquisition and navigation software package. All online data was acquired in RTK Fixed mode. Logging was stopped if the position went to Float or accuracies in the vertical were over 0.1ft. This was monitored using online alarms in QINSy, reading qualify output data from the POS MV. In addition an online, real-time 95% confidence, standard deviation grid of soundings were displayed. All position data was logged for an eventual PPK solution. Changes in the sound speed environment were monitored and appropriate actions in terms of further measuring of the water column sound speed were taken.

All multibeam data was processed in QPS Qimera software. Firstly, a post processed kinematic solution, smooth best estimate of trajectory (SBET) for the horizontal and vertical position of the vessel was created in Applanix POSPAC software and applied in Qimera to replace all online navigation and motion. This allowed the implementation of the full PPK motion accuracy and position solution with the high 200hz data rate. The application of the highly accurate SBET allowed for processing of vertical data using the GPS antenna height. This nullifies any variation due to tide. Qimera allows for the pure processing of the accurate and high frequency GPS height rather than applying a GPS tide as other programs use. Therefore, the affect of heave or squat discrepancies , which are common in hydrographic surveys was negated. Additional checks and processing of sound velocity was completed in the software. Data was cleaned and analyzed on a 1ftx1ft dynamic surface (grid) in Qimera. Data was cleaned using slice sections and 3D point cloud views. Spurious sounds were deemed to be those which did not agree with the general surface and points which were not detected by two lines. In addition plumes of noise that can be recognized as sonar disturbance due to their shape were cleaned. Data was analyzed in the 3D point viewer of Qimera to locate and understand objects on the seafloor. When objects were found, the shoalest point was classified that the location was exported into a points file.

Snippets backscatter data was processed in QPS FM Geocoder. QPS FM Geocoder Toolbox (FMGT) was used to visualize and analyze the backscatter from the snippets data. The raw beam data was positioned and corrected with processed data from the QINSy multibeam project to create a normalized backscatter signal. The processing accounts for range and angle in the signal return from all the beams within the multibeam swath. In addition a gridded reference surface is input into the project to reduce the signal loss from steep slopes and changed in elevation.

A simple backscatter intensity mosaic was produced based on understanding of the sonar settings used during acquisition. This is an indexed grid from 1-255 of return intensity. This was used to discern between harder and softer sediment types of the seafloor. The stronger returns were assumed to be a harder surface. In addition statistical analysis was run on the beams returns within a grid. These signal return statistics were used to identify changes in sediment and thus sediment type extents. The final step was to produce an angle range analysis grid of sediment characterization. This is programmed into FMGT and is based off the work of Luciano Fonseca at the University of New Hampshire to relate the beam pattern to a sediment type. Initially this was used to detect changes in the sediment types as with the statistical grid. The data was then trained with grab sample data in order to discern similar sediment types across the survey area.

Sediment samples were used to ground truth data and for beam pattern correction to enhance the created mosaic. Intensity and angle range analysis (ARA) calculations were used to create a seafloor characterization which was then analyzed in comparison to the sediment samples. Layers of gridded datasets (multibeam depths, intensity and statistics) were brought into a GIS program and the extents of sediment regions were digitized. Using the intensity, the grab samples and the sediment characterization (ARA) the sediment groups were categorized. The grab sample data was held as the dataset with the strongest confidence and sediment classification was based on the type of sediments identified across the samples

4.7.2 Bubble Gun Subbottom Data

Bubble Gun single channel SEGY data was processed in SonarWiz software. Position data was cleaned and interpolated where the position was found to be unrealistic. Data was bottom tracked and gain corrected. Time varying gain was applied to enhance buried features. On key lines amplitude correction, swell filtering and de-multiplying completed in order to reveal subsurface layering that would be otherwise hidden. An example of a line where this processing route was completed is shown in Figure 25.

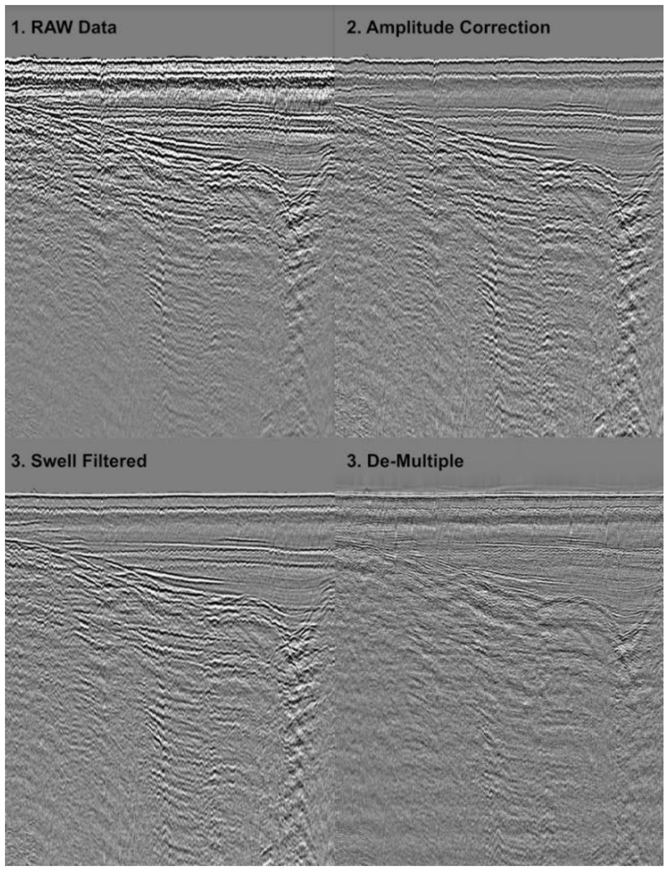


Figure 25 Image showing the processing routine on key data lines

Bottom tracked data was then aligned with the multibeam dataset in order to reduce it to the vertical datum (MLLW). Aligning the data to the more accurate multibeam bathymetry dataset greatly improved the dataset positional accuracy. The corrected data was then analyzed by digitizing stratification horizons. The average, measured velocity of sound in the water column of 4796.5 ft/s was used for the digitized lines for all files. A constant sound velocity of 5085 ft/s was used for layers below the sediments outside of the bar feature. This is in line with studies such as Pinson et al. (2002)[1] in similar glacial environments. Below the harder surface of the bar feature and rocky surfaces a sound velocity of 8202 ft/s was used to convert the two way time SEGY data to depths for the digitized lines. 3D surface interpolated across the horizons were exported to create 3D views and cross sections.

[1] Pinson et al. (2002) Deglacial history of glacial lake Windermere, UK: implications for the central British and Irish Ice Sheet

4.7.3 Chirp Subbottom Data

Chirp JSF data was imported into SonarWiz. The position was cleaned and interpolated to eliminate spikes of data jumps. Data was bottom tracked, gain corrected and then aligned with the multibeam to reduce data to the project datum (MLLW). Subsurface seismic units were identified and digitized in the chirp data. As with the Bubble Gun data, a water column speed of sound of 4796.5ft/s was used and a sound speed of 5058 ft/s below the surface. Data was analyzed for parabolas in order to identify buried targets. Various time varying gain settings were used to enhance buried features. Contacts were picked by looking for parabolas and disturbance. Cross line intersections were viewed to confirm the presence of an object on multiple lines.

4.7.4 Gradiometer Data

Interpolator data files logged in MagLog were brought into MagPick using a specific template for the gradiometer with two depth sensors and an altimeter on the 2nd magnetometer. Position data was filtered with a tight spline in order to eliminate position jumps. Data was processed in two separate ways in order to QC each dataset against each other.

Firstly, a Quasi-Analytic signal was produced. This used the built in Geometrics calculations for a transverse gradiometer (shown below in Figure 26). A Quasi-Analytic signal was used because it simplifies detection as it is always a positive value. In addition, the calculation offers the ability to position the detected feature based on the estimated center of the maximum of the anomalies[2]. A gridded dataset can be added to a map to compare horizontal positions to other datasets. It was noted that the center of the feature as detected by the Quasi-Analytic maximum was different to an object detected by the multibeam and also a position as detect by dipole analysis. Profiles of calculated Quasi-Analytic signal were gridded using spline gridding to a 5 ft x5 ft "heat map" grid. The Quasi-Analytic signal map has all the features of an Analytic signal analysis map that requires more magnetometer sensors and a complicated deployment scenario. Unlike an Analytic signal map the Quasi-Analytic signal map does not require diurnal correction or filtering and provides a cleaner view of the local anomalies[3].

[2] Tchernychev, M., Johnston, J., Johnson, R. 2008 Transverse Total Magnetic Field Gradiometer Marine Survey in Hawaii: The Quasi-Analytic Signal Approach and Multi-Channel Total Field dipole modeling. SAGEEP proceedings.
[3] M. Tchernychev, J. Johnston, R. Johnson (2010) Total Magnetic Field Transverse Gradiometer as UXO locating tool: case study. EGM 2010 International Workshop.

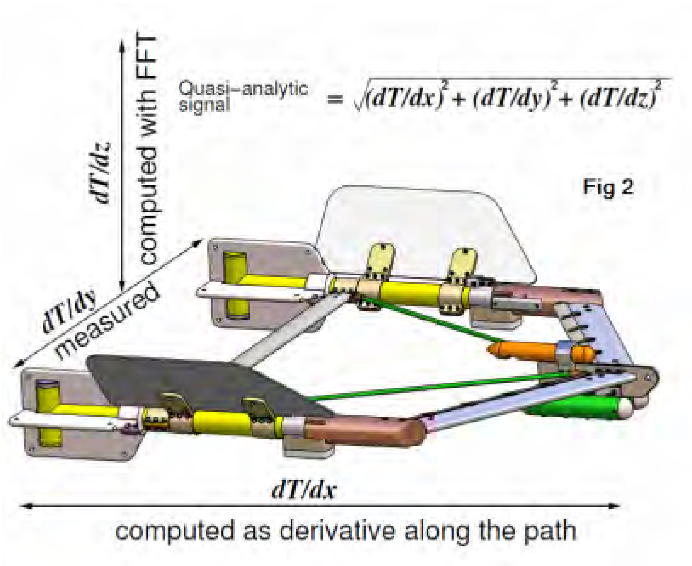


Figure 26 Quasi-Analytic Signal Calculations

The second processing regime took each magnetometer as an individual system and the total analytic signal was analyzed in order to QC the quasi analytic signal. Single profiles were analyzed for dipole wave forms. Large spikes were "cleaned" out of the data. The difference between the cleaned data and original data was then calculated and plotted. The profiles of the difference were then gridded into a "heat map" 5 ft x5 ft grid using a spline vector to raster conversion.

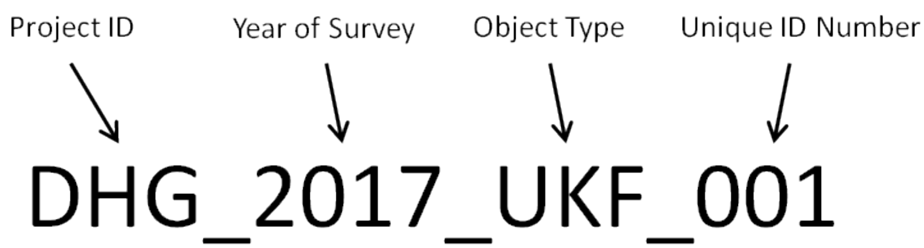
The background magnetism vs. anomalous magnetic responses were viewed by calculating the statistics of the grid. Data was then colored using these statistics looking for equal intervals. Targets were then made from the heat map looking at strong returns. The target database of the gradiometer data was compared and used with subbottom and multibeam data to create a final target database.

A magnetic base station was not established for this project as it was deemed unnecessary for sufficient coverage. This is due to the fact that the gradient was being calculated and the data was collected over a short period of time.

4.8 Geodatabase

A geodatabase was made to store all the findings. These are referenced by year and type of object found. Each feature was given a unique ID code. An example of the geodatabase naming convention is shown below in Figure 27.

Objects



UKF – unknown surface object with ferrous return
UKI – unknown surface object non ferrous Inner Box
UKO – unknown surface object non ferrous Outer Box
ISUKF – Inner Box subsurface unknown object with ferrous return
ISUKNF - Inner Box subsurface unknown object non ferrous
OSUK - Outer Box subsurface unknown likely rock
OSUKO - Outer Box subsurface unknown object
FA- ferrous object with no other surface or subsurface detection

Figure 27 Geodatabase Unique IDs

4.9 Stratification, Quality Control and Velocity Estimate

In order to understand the structure of the bar feature, stratification layers were analyzed and digitized in the subbottom datasets. Changing amplitude represented a change in sediment. In addition high amplitude returns were interpreted as strong returns and therefore hard surfaces. The amount of penetration was also analyzed. Based on knowledge of the systems used sediment type would be determined by penetration. All cobbles and gravel would be penetrated by the Bubble Gun, but hard rock surfaces would not. The Chirp system would penetrate sand and silt but not gravel. A continuous surface with a high return and zero penetration would be considered bedrock. Layers that could be penetrated, would be considered deposited material.

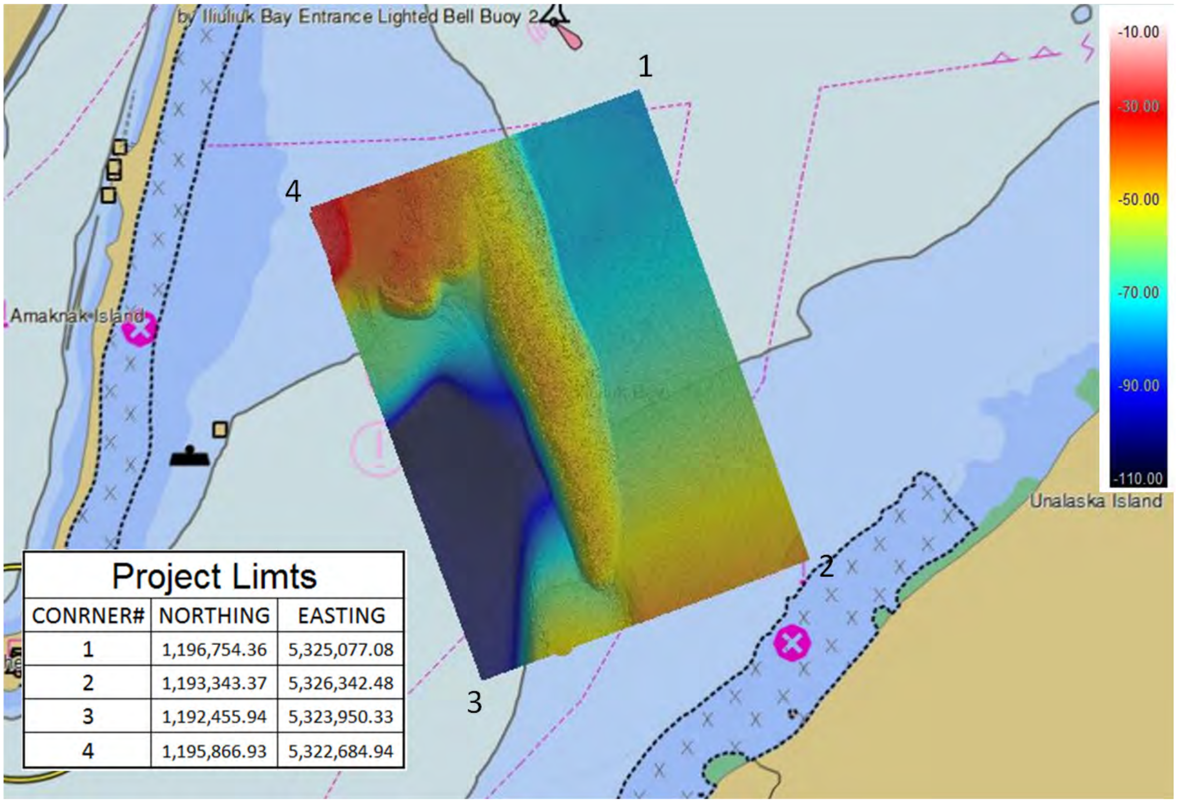
All interpretations completed by eTrac were sent to an independent team of geophysicists for quality control through a secondary, combined opinion.

Along one line across the bar feature a velocity value through the bar was estimated. The diffraction shapes of the bedrock surface below the bar were used to estimate a speed of sound through the structure. Though this is an estimate it gave a relative idea of consolidation of the deposit.

5 RESULTS

5.1 Multibeam

200% multibeam coverage was achieved through the entire survey area. Data density was highest in the shallow areas and conversely least in the deepest. A density of at least 2 pings in each 1x1ft grid was achieved in the deepest sections. The average density was 10 pings per node and a maximum of 40 pings in a grid cell in the shallow areas. The 200% coverage allows spurious soundings to be identified where two pings from different passes were not in agreement. All position data was successfully collected and applied in processing to achieve horizontal and vertical accuracies of better than 0.1ft. The antenna height was used for all vertical positioning. The frequency and accuracy of the SBET PPK data was sufficient to create a vertical solution only using the antenna height. This negated the use of tide. As explained in the Appendix A- Mobilization report. The processed data was compared to a 2011 NOAA survey. The data agreement was within the tolerance of the accuracy of the individual surveys. The data density and coverage of the multibeam data allowed the creation of a 1x1ft grid with multiple pings. Objects larger than 1ftx1ft would be imaged by more than one sounding. As described in Appendix A – Mobilization Report and section 4.4.1 of this report, the high resolution multibeam imagery detected objects larger than 1 ft x 1 ft. Depth in the survey area ranges between 24 ft to 104 ft below MLLW. MBES depth coverage is displayed below in Figure 28.



Project Limts

CONRNER#	NORTHING	EASTING
1	1,196,754.36	5,325,077.08
2	1,193,343.37	5,326,342.48
3	1,192,455.94	5,323,950.33
4	1,195,866.93	5,322,684.94

Figure 28 Multibeam Coverage

Backscatter intensity data (snippets) was successfully collected and used to create a sediment characterization map of the survey area. Sediment characterization is achieved based upon statistical analysis and the intensity return of backscatter data. MBES backscatter statistical data which shows clearly defined areas of contiguous sediment can be seen in Figure 29. MBES backscatter intensity which shows variation in the intensity of the acoustic return from hard and soft sediment n is displayed below in Figure 30. The Angle Range Analysis grid helped further determine similar sediment types and whether they were hard or soft. Even with the beam pattern correction from the sediment samples the ARA did not classify the sediment consistently when compared to the grab samples. This was used as a guide and as part of the interpretation rather than being a standalone final dataset. As the ARA algorithms were originally based on a different sonar system, this mismatching was expected[4].

[4] Fonseca, Luciano; Mayer, Larry A.; and Kraft, Barbara J., "Seafloor Characterization Through the Application of AVO Analysis to Multibeam Sonar Data" (2005). Center for Coastal and Ocean Mapping. Paper 340

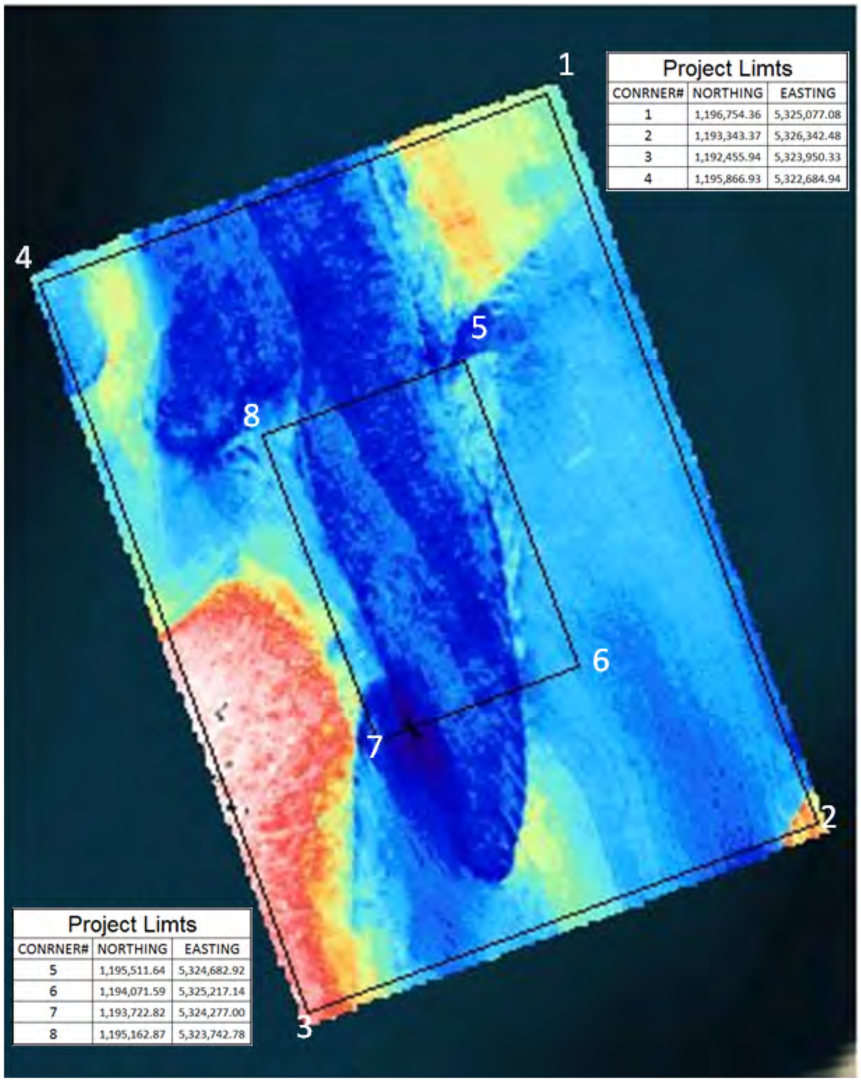


Figure 29 MBES Backscatter Statistical Regions Color Map

Figure 30 MBES Backscatter Intensity Return Map

A detailed plot of the bathymetry dataset can be seen in Volume 2 of 2, Drawings - Sheet 2 - Bathymetric Survey Contours and Soundings and Sheet 3 - Bathymetric Survey Contours and Color Relief.

5.2 Sediment Samples

R&M collected 51 sediment grab samples in the survey area on a 500 ft x 500 ft grid spacing. All sediment samples were logged and analyzed in accordance with R&M's Standard Procedure for "Soil Classification, Logging, and Sampling". After in-field analysis sediment samples were submitted to R&M's Materials Laboratory for further analysis. Analysis of sediment samples can be found in R&M's Geophysical Report. Sediment sample locations are displayed below in Figure 31.

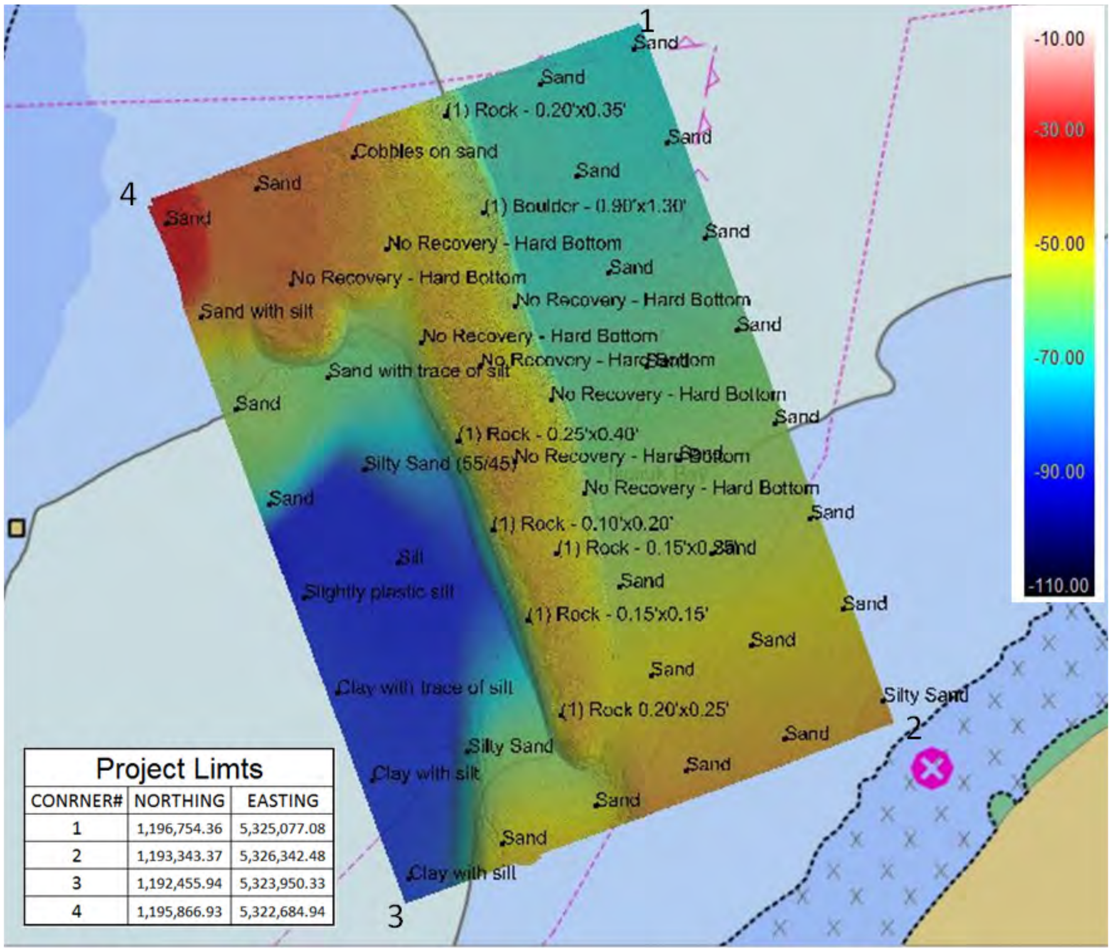


Figure 31 Sediment Grab Sample Locations

As mentioned in section 4.7.1 of this report the sediment samples collected by R&M were used by eTrac in association with the MBES backscatter data to create a sediment characterization map of the survey area. Sediment samples were used to ground truth data and for beam pattern correction to enhance the created mosaic. Table 5 below shows the comparison of sediment sample recovery and backscatter intensity in each sample location. Sediment samples are displayed on the MBES backscatter intensity map below in Figure 32.

Table 5 Sediment Sample Recovery and MBES Backscatter Intensity

Sediment Sample Recovery and Backscatter Intensity Comparison				
			NAD 83 US State Plane AK Zone 10	
ID	Sediment Sample Recovery	Backscatter Intensity	Northing	Easting
1	Sand	22.25	1195807	5322734
2	Sand	21.26	1195982	5323189
3	Cobbles on sand	26.19	1196143	5323674
4	(1) Rock - 0.20'x0.35'	20.67	1196348.44	5324133.92
5	Sand	22.25	1196512.25	5324610.55
6	Sand	21.66	1196685.75	5325076.33
7	Sand with silt	21.07	1195341	5322906
8	No Recovery - Hard Bottom	14.97	1195509	5323361
9	No Recovery - Hard Bottom	17.72	1195682	5323841
10	(1) Boulder - 0.90'x1.30'	18.31	1195867.27	5324325.36
11	Sand	27.76	1196045.25	5324788.35
12	Sand	26.97	1196213.78	5325245.64
13	Sand	27.17	1194878	5323082
14	Sand with trace of silt	19.17	1195042	5323547
15	No Recovery - Hard Bottom	18.51	1195217	5324017
16	No Recovery - Hard Bottom	15.56	1195398	5324485
17	Sand	20.08	1195560.94	5324953.72
18	Sand	23.63	1195740.78	5325434.29
19	Sand	26.58	1194404	5323251
20	Silty Sand (55/45)	22.84	1194577	5323726
21	(1) Rock - 0.25'x0.40'	15.95	1194724	5324195
22	No Recovery - Hard Bottom	19.49	1194925	5324663
23	Sand	21.46	1195091.79	5325137.95
24	Sand	21.26	1195274.19	5325593.9
25	Slightly plastic silt	32.49	1193936	5323423
26	Silt	31.89	1194107	5323897
27	(1) Rock - 0.10'x0.20'	17.13	1194277	5324368
28	No Recovery - Hard Bottom	17.52	1194456	5324830
29	Sand	22.05	1194629.34	5325302.6
30	Sand	21.26	1194811.28	5325782.98
31	Clay with trace of silt	35.04	1193456	5323590
32	Silt	30.56	1193163	5324247
33	(1) Rock - 0.15'x0.15'	17.72	1193824	5324544

34	Sand	17.52	1193991	5325009
35	Sand	17.92	1194156.58	5325470.06
36	Sand	13.39	1194333.46	5325961.67
37	Clay with silt	28.55	1193026	5323768
38	Silty Sand	23.04	1193163	5324247
39	(1) Rock 0.20'x0.25'	16.15	1193344	5324709
40	Sand	20.67	1193547.47	5325161.4
41	Sand	19.3	1193695.03	5325663.23
42	Sand	20.28	1193876.14	5326123.59
43	Clay with silt	29.93	1192527	5323952
44	Sand	21.66	1192703	5324417
45	Sand	20.08	1192892	5324885
46	Sand	20.28	1193071	5325340
47	Sand	20.87	1193225	5325833
48	Silty Sand	25.54	1193418	5326326
49	No Recovery - Hard Bottom	13.59	1195097	5324309
50	No Recovery - Hard Bottom	19.1	1194615	5324479
51	(1) Rock - 0.15'x0.25'	18.51	1194156	5324691

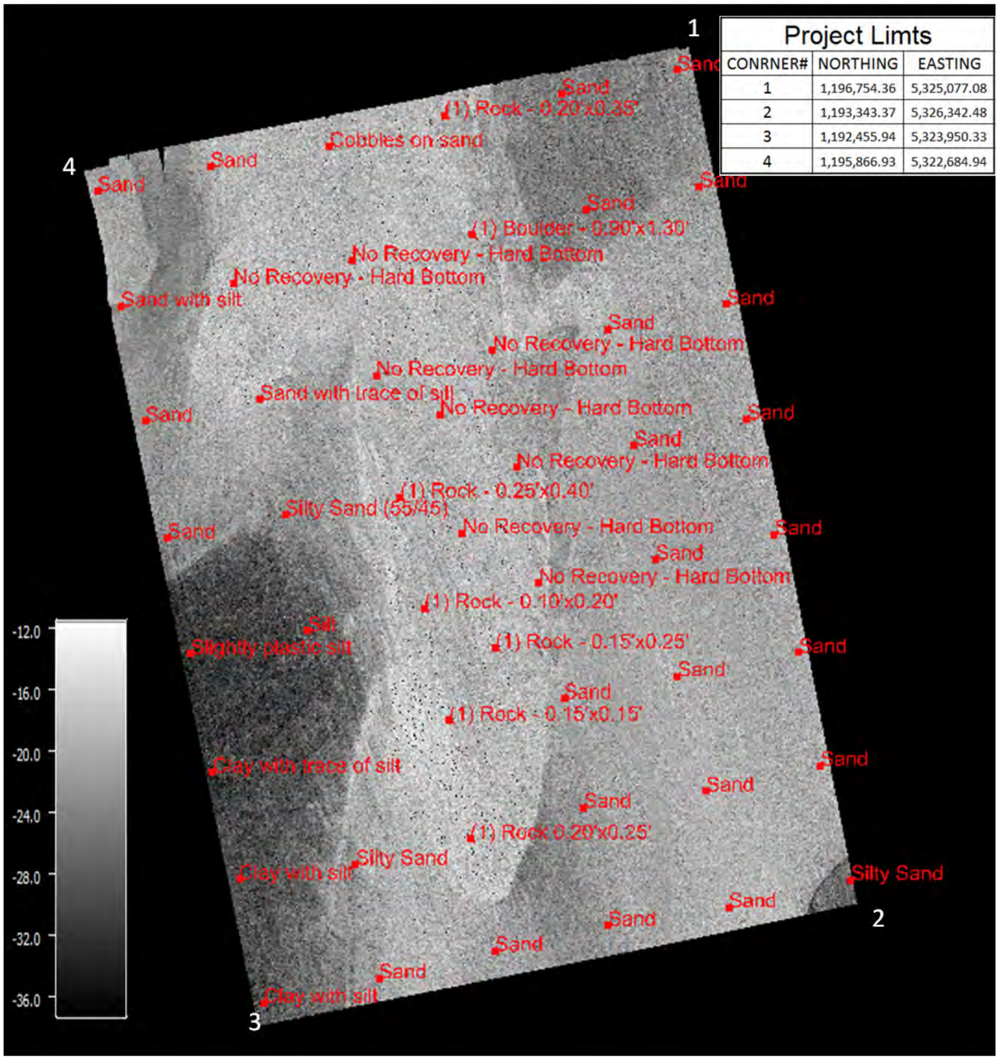


Figure 32 Sediment Grab Samples and Backscatter Intensity

A detailed map with sediment sample locations can be found in Volume 2 of 2, Drawings, Sheet 4 - Surface Classification Map.

5.3 Subbottom

5.3.1 Narrow Band Subbottom

100% of planned survey lines were run. In the northwest corner of the survey area, lines were rerouted away from shallow areas with less than 30 ft depth due to safety concerns of towed systems. 79 narrow band subbottom profile lines were run with the Bubble Gun to complete seismic refraction profiling, including 2 lines used for layback calibration. The measured offset of the cable and tow point of the source and streamer allowed the position of the system to be accurate and consistent throughout the entire survey. The layback calibration was confirmed over the bar feature and compared to the multibeam surface. RTK data was consistent throughout the survey with no lines having to be stopped due to alerts that the accuracy tolerances described above in Section 4.7.1.

All data was successfully aligned to the project datum using the multibeam surface. Data was processed with optimal gain settings and filtering applied. Further amplitude filtering along with de-ghosting and multiple filtering was successfully applied on selected data across the bar.

Data was clear and the narrow band, low frequency of the system allowed for deep subsurface stratification through cobble, sand, silt, and bedrock. Penetration of up to 100 ft below the surface was achieved throughout the entire survey hitting bedrock. Distinct sediment stratification was observed across the region and bedrock was able to be identified below the bar and sediment stratification layers. Some penetration of the bar structure was achieved. The bar structure is evident in the data both above and below the surface. Interpreted Bubble Gun data along sample lines as designated in the project GFI 6 is included in Appendix E - Seismic Profiles. Units of strata were able to be identified in the data. 3D surfaces using the digitized horizons, corrected for sound speed changes in the water column and sediment were created across the entire survey area.

A surface artifact was noted in the Bubble Gun data. This artifact distorted the first 15ft of data below the seafloor. The surface artifact was deemed unavoidable, common to the particular system and consistent with other datasets. The surface artifact is assumed to be caused by the long pulse width of the system. It is for this reason that the higher frequency Chirp system, which would allow greater resolution in the shallow subsurface, was also employed. Figure 33 shows a dataset from the user manual of the Falmouth HMS-620 Bubble Gun. This dataset exhibits the same surface artifact. All processed Bubble Gun seismic profiles will be included in the final project files report.

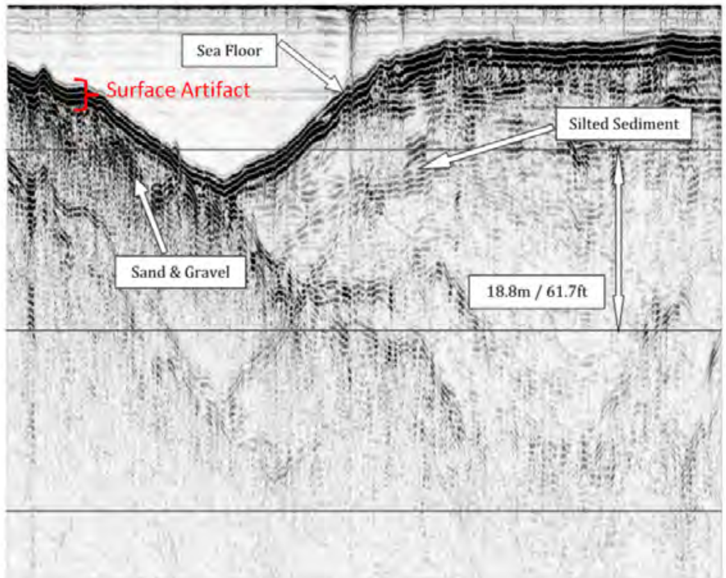


Figure 33 Example of a surface artifact in a Bubble Gun Profile Record

Based on work completed by the National Oceanographic Center in the Southampton, UK a single channel velocity test on a single line of data across the bar was completed to determine the speed of sound through the bar feature. The test was run by Dr. Mark Vardy at SAND geophysics. The test is based on the idea that in common-offset seismic reflection profiles, the shape of diffraction hyperbolae (specifically, the rate at which the arrival time increases away from the apex) from small, discrete targets is controlled by the RMS velocity between the source/receiver and reflection point. By modeling the shape of several diffraction events at the base of the moraine unit, an RMS velocity between the water surface and the base of the moraine can be estimated. This can be combined with the known water column velocities from the sound velocity profiles taken. This velocity would in turn suggest the consolidation of the material making up the bar.

The single velocity test was successful in being able to estimate the sound velocity through the moraine unit. Several diffraction events were able to be modeled and an RMS velocity between the water surface and the base of the moraine was estimated to be between 8202 ft/s and 9186 ft/s. This was combined with the water column velocity of 4796.5 ft/s to give an average velocity for the moraine unit estimated as in the region of 9842.5 ft/s.

Figure 34 below shows the narrow band subbottom data lines completed in the survey area. The multibeam data displayed in this image is a combined surface of multibeam data collected by eTrac during this project and multibeam data collected in 2011 by NOAA. Figure 35 shows an example of deep stratification achieved in bubble gun subbottom data.

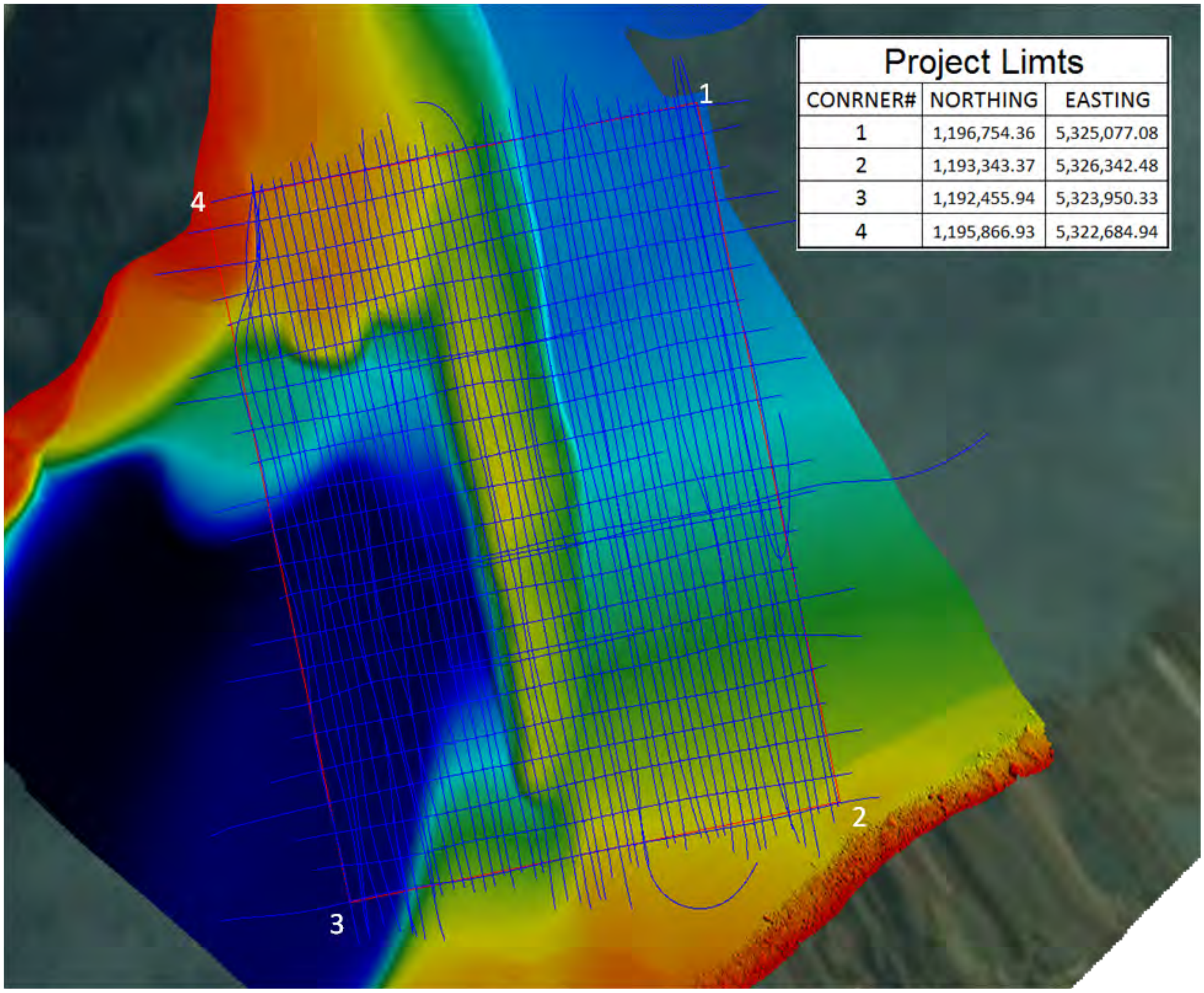


Figure 34 Bubble Gun Subbottom lines run

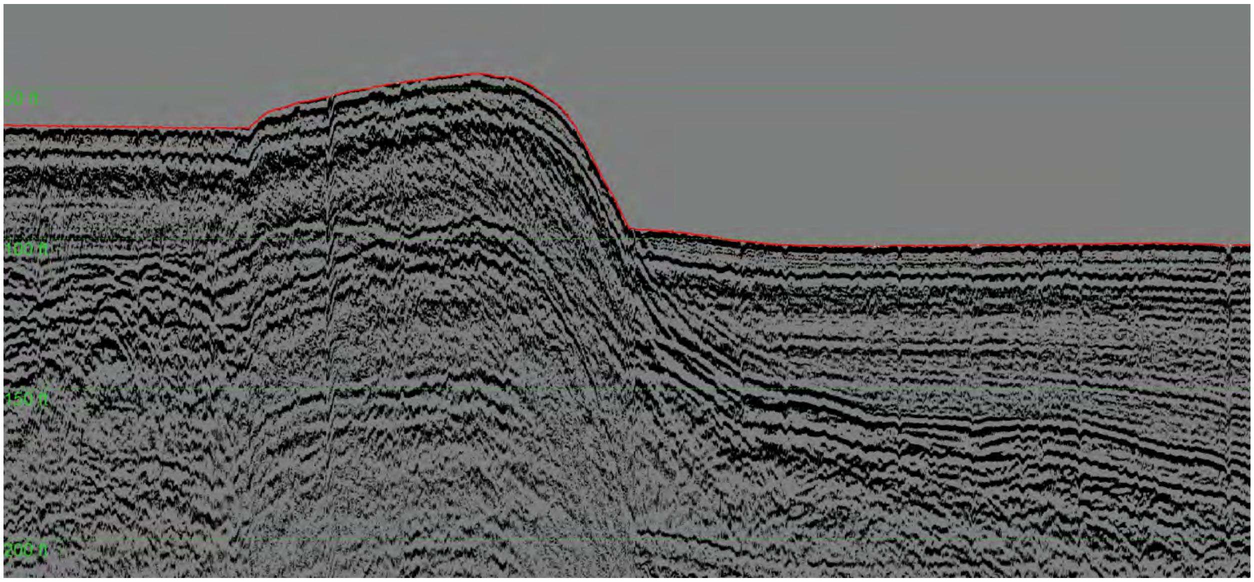


Figure 35 Stratification layers in Bubble Gun Subbottom data

5.3.2 Chirp Subbottom

In the stratification survey area (outer & inner box) 100% of planned survey lines were run. In the northwest corner of the survey area, lines were rerouted away from shallow areas with less than 30 ft depth due to safety concerns of towed systems. 79 chirp subbottom profile lines were run to complete stratification detection including 4 lines used for layback calibration and quality control.

The vessel was positioned for the entire survey within the tolerances described in section 4.7.1 and RTK was consistent. The USBL calibration and the measured offset of the value and tow point allowed the position of the Chirp Subbottom system to be accurate and consistent throughout the entire survey. All data positioning was successfully QCed against the multibeam surface.

Data was clear and as described in Appendix A – Mobilization Report and section 4.3.3.2 of this report the high frequency allowed for good determination of shallow subsurface stratification. Penetration of up to 50 ft below the surface was achieved in silt and clay throughout the entire survey. Penetration of up to 30 ft below the surface was achieved in sand. On the bar structure there was zero penetration. Along one line the bedrock was imaged at 30ft below the surface through a sediment unit where the surface layer was sand. Interpreted Chirp data along sample lines as designated in the project GFI 6 is included in Appendix E - Seismic Profiles. Stratification horizons were able to be indentified and units of common strata were digitized. 3D surfaces from the digitized strata which were sound velocity corrected were successfully created.

Figure 36 below shows the Chirp subbottom data lines completed in the survey area during the stratification survey. The multibeam data displayed in this image is a combined surface of multibeam data collected by eTrac during this project and multibeam data collected in 2011 by NOAA. Figure 37 shows an example of stratification achieved in the Chirp subbottom data.

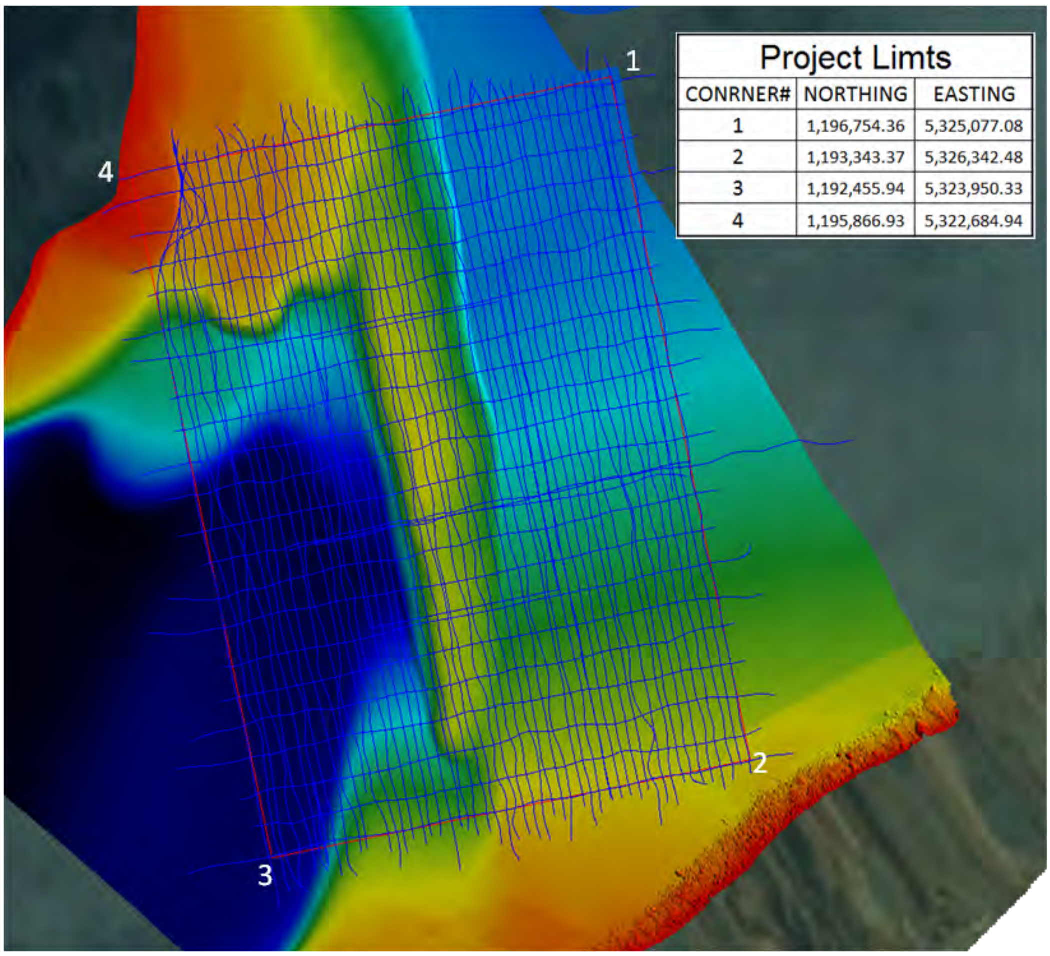


Figure 36 Chirp Subbottom lines run for stratification survey

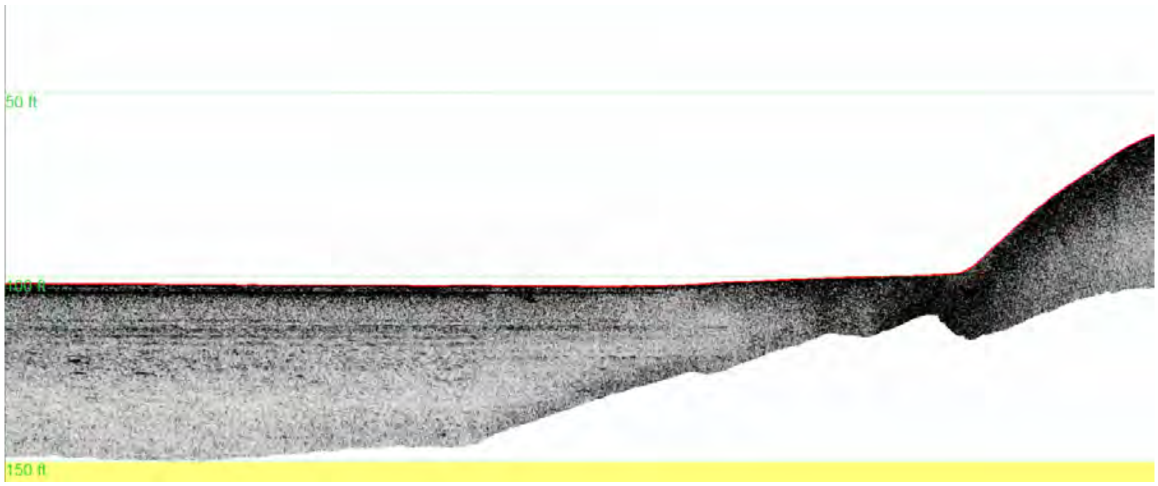
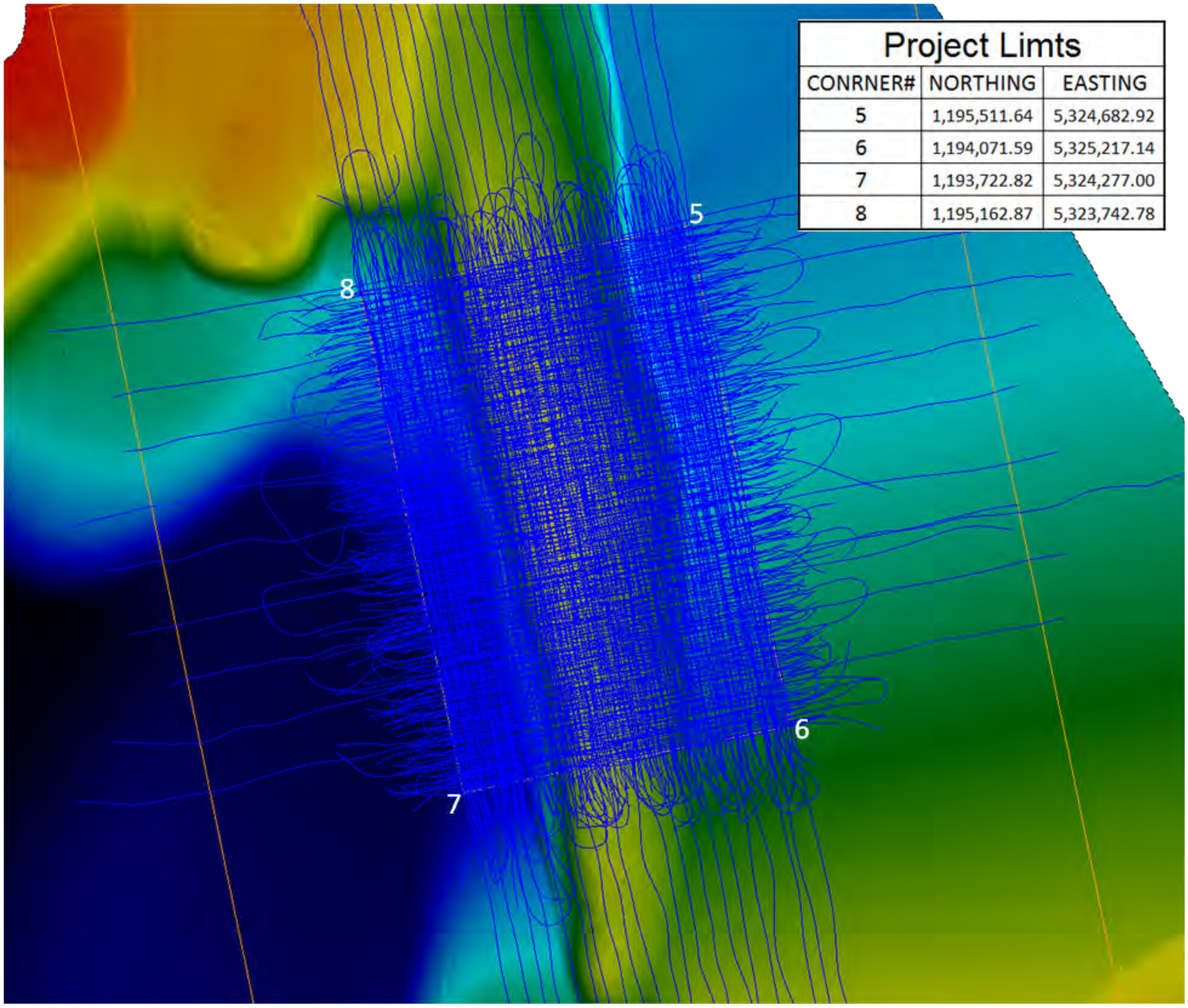


Figure 37 Stratification layers in Chirp Subbottom data

In the object detection survey area (inner box) 100% of planned survey lines were run. 510 chirp subbottom profile lines were run to complete focused object detection near the bar, including 8 lines from the outer box.

Data was clear and as described in Appendix A – Mobilization Report and section 4.3.3.2 of this report the high frequency ping rate of 20 Hz of the system allowed for shallow subsurface stratification and detection of objects larger than 1 ft x 1 ft along the 5ft survey lines. The survey speed allowed for up to 3 pings to detect every 1ft object. Depths of buried objects were well determined. Objects were detected down to 30 ft below the surface and created clear parabolas in the data. Over 60 subsurface targets were identified.

Figure 38 below shows the Chirp subbottom data lines completed in the survey area during the object detection survey. The multibeam data displayed in this image is a combined surface of multibeam data collected by eTrac during this project and multibeam data collected in 2011 by NOAA.



Project Limts		
CONRNER#	NORTHING	EASTING
5	1,195,511.64	5,324,682.92
6	1,194,071.59	5,325,217.14
7	1,193,722.82	5,324,277.00
8	1,195,162.87	5,323,742.78

Figure 38 Chirp Subbottom lines run for object detection survey

The two subbottom systems could be QCed against each other in one region where the bedrock was close enough to the surface to be detected by the Chirp subbottom. Both systems imaged the bedrock with similar geometry and at depths that were not more than 2 ft apart. This is shown below Figure 39.

Figure 40 shows an object detected in the Chirp Subbottom data.

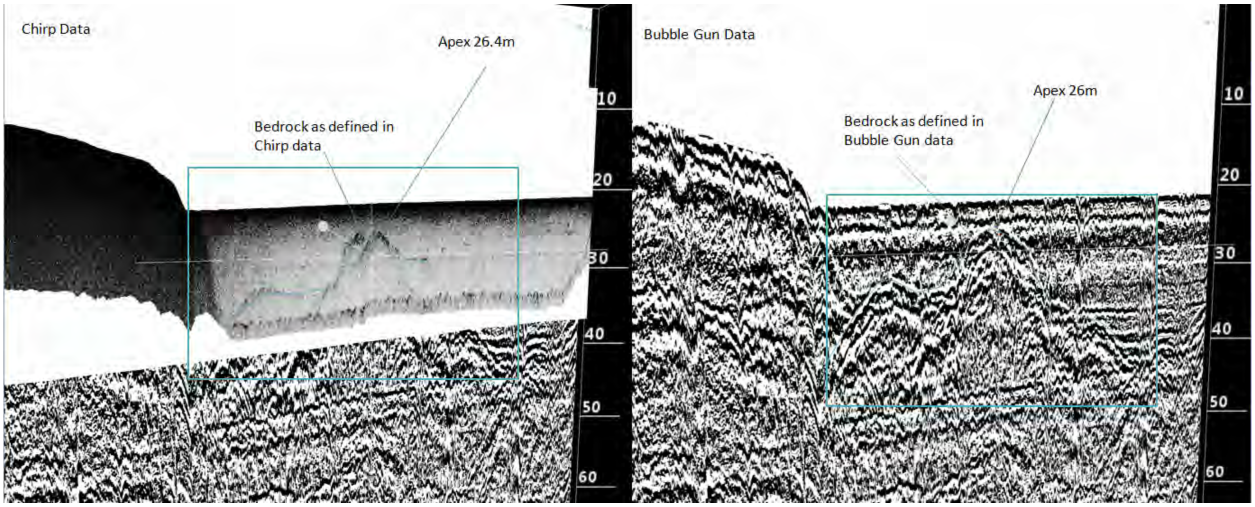


Figure 39 Image showing agreement in the definition and elevation of bedrock in both the Chirp and Bubble Gun data

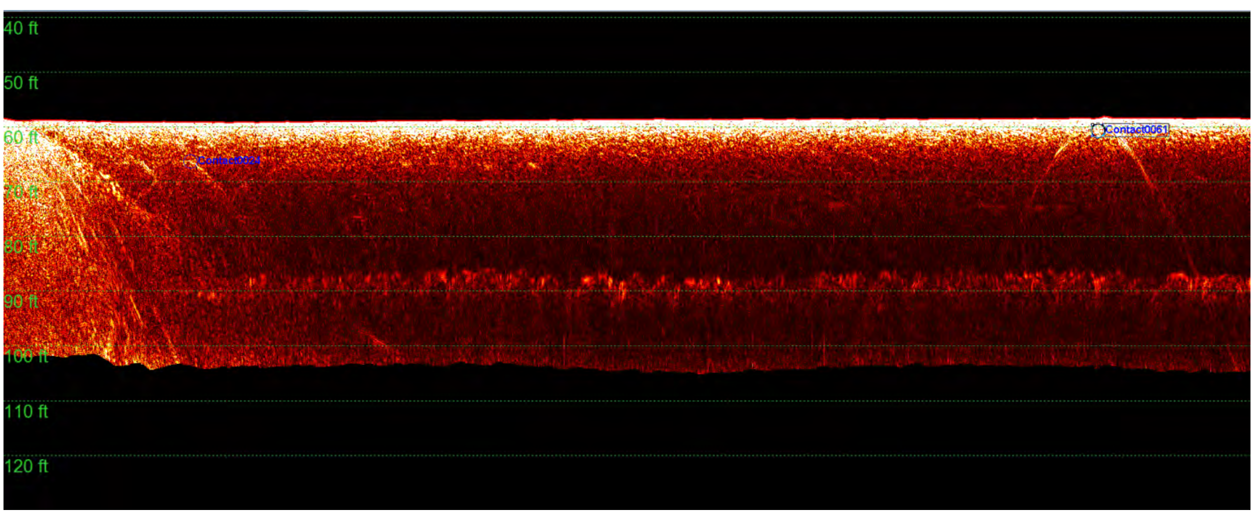


Figure 40 Objects targeted in Chirp Subbottom data

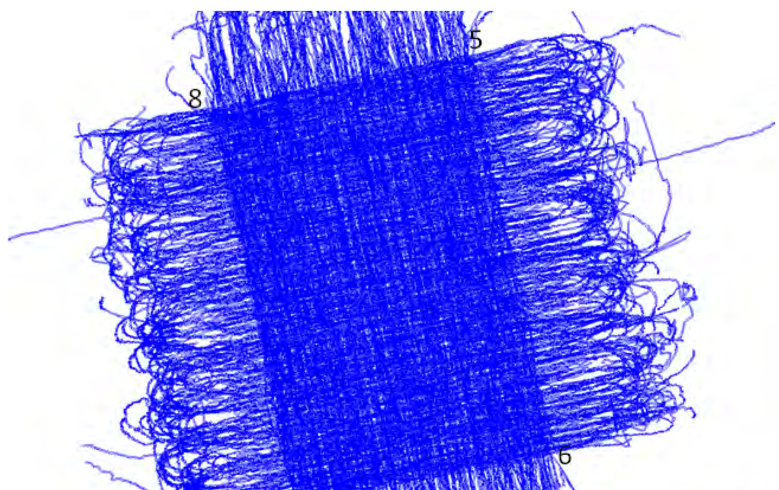
5.4 Gradiometer

100% of planned survey lines were run. 540 gradiometer lines were run to complete detection of possible Unexploded Ordinances (UXOs) including 6 lines used for quality control. The USBL calibration and the measured offset of the value and tow point allowed the position of the gradiometer system to be accurate and consistent throughout the entire survey. The gradiometer heat map was overlaid with subbottom and multibeam data to allow comparison and combined targets to be made.

Figure 41 below shows the gradiometer lines completed in the survey area. Figure 42 below shows the heat map created from the gradiometer data. Ferrous objects and areas appear as a bright high return ranging from blue as medium return, green and yellow has high return, and purple as extreme high return.

The gradiometer was able to pick out ferrous objects and areas above and below the seabed. There is a clear distinction in the data between background magnetic response and the response from an object. The statistics of the final Quasi Analytic grid are shown in (Figure 43) which demonstrates the background "normal" magnetism as a discernible value. These responses were tested by comparing the magnetic return of a confirmed ferrous object (crab pot) and a confirmed non ferrous object (tire) in the survey area. As described in section 4.3.4 of this report the system is able to detect objects larger than 1ftx1ft along the 5ft search lines. The smallest above surface ferrous object detected and confirmed with multibeam was approximately 1.7 ft x 2.3ft.

For the majority of objects there was good agreement between the position of the object detected by the multibeam data and the highest magnetic return. This made understanding the ferrous area easier (see Figure 44). In some instances, the center of the strongest magnetic response recorded did not always match the center of the object in the multibeam surface. The distance off center was not consistent as to be an offset in the gradiometer but required some level of analysis and interpretation to distinguish the ferrous area or object. Figure 45 below shows and example of the inconstant offset between the center of gradiometer hit and ferrous object in multibeam surface.



Project Limts		
CONRNER#	NORTHING	EASTING
5	1,195,511.64	5,324,682.92
6	1,194,071.59	5,325,217.14
7	1,193,722.82	5,324,277.00
8	1,195,162.87	5,323,742.78

Figure 41 Gradiometer lines run

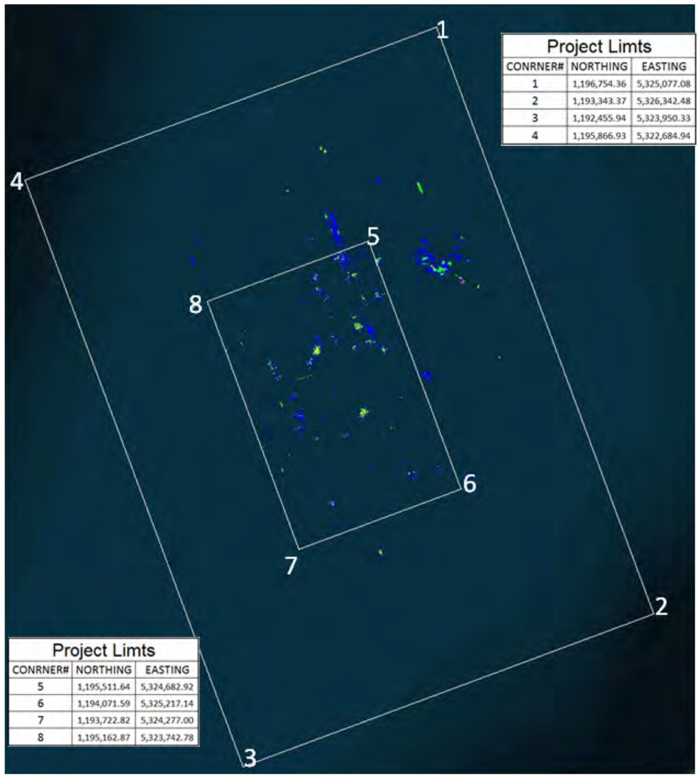


Figure 42 Heat map created from gradiometer data

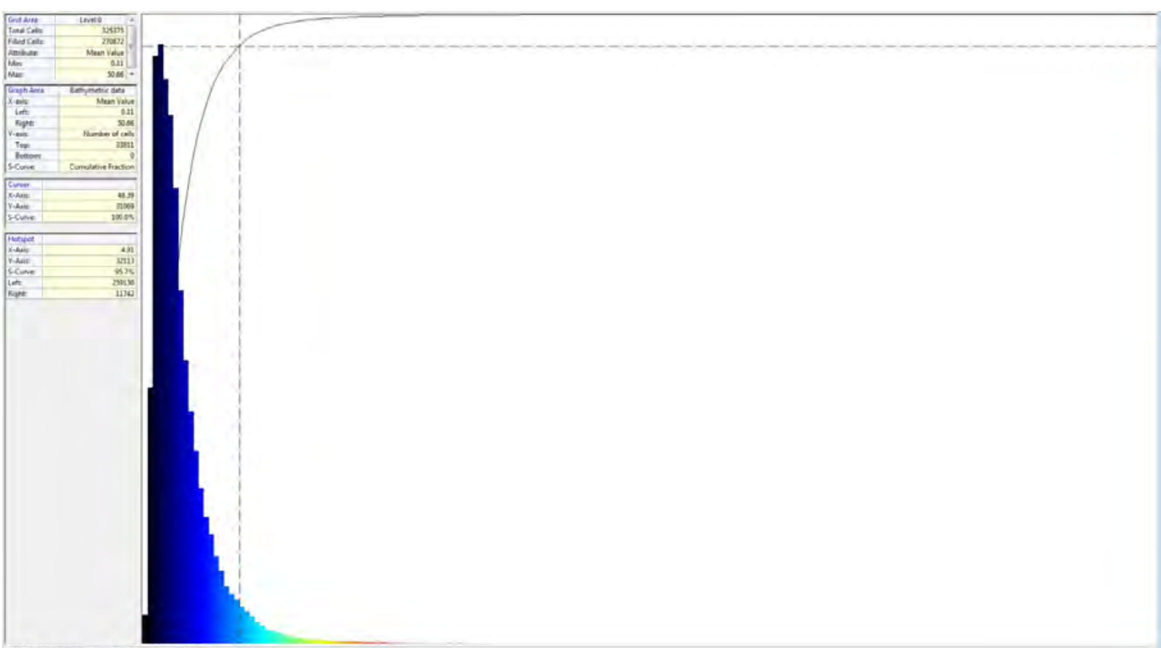


Figure 43 Statistical Analysis of the heat map grid showing "normal"/background magnetic return as values less than 5

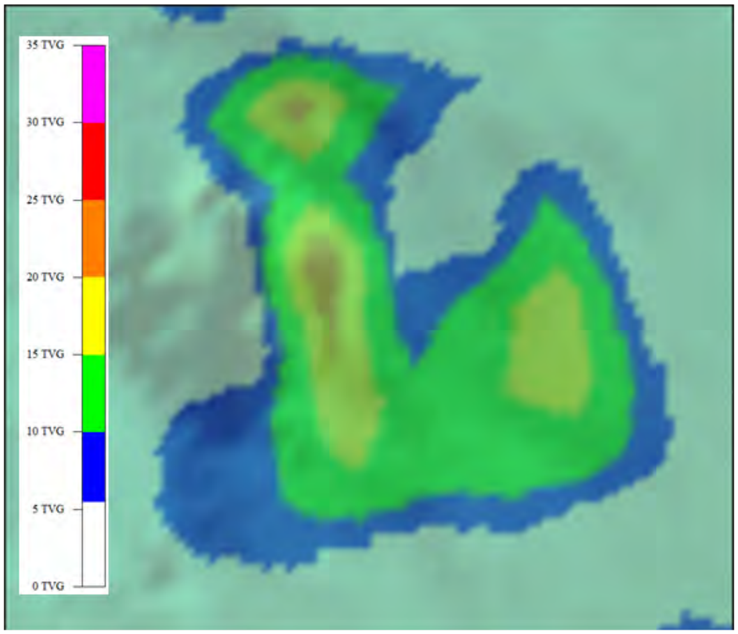


Figure 44 Strong Ferrous Quasi-Analytic Return directly over the object

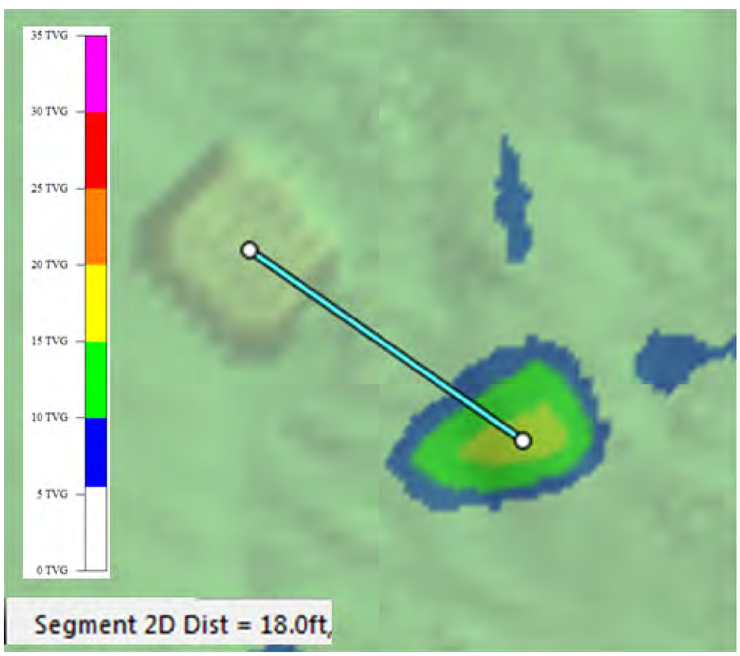


Figure 45 Location of Quasi-Analytic gradiometer return of known ferrous object (crab pot) compared to multibeam surface

5.5 Overview

In the inner box boundary, surface and subsurface objects and debris larger 1 ft x 1 ft in size were detected including ferrous objects. The inner box focused on the area where proposed dredging of the bar is to occur. In the outer box boundary (including the inner box) the depth and thickness of stratification was determined. Each sediment layer and bedrock were classified and differentiated for each other. Sediment classification was also determined by sediment grab samples acquired ever 500 ft within the outer box boundary (including the inner box). eTrac's interpretations of the subsurface features agreed with, and were confirmed as accurate by the independent geophysicists.

6 ANALYSIS

This section will describe the As Surveyed positions of surface and subsurface objects and the classification of sediment layers and areas. Surface and subsurface objects were categorized based on object type, location, and magnetic return. The Geodatabases for all objects can be found in Appendix C - Geodatabases. In addition, images of all noted objects can be seen in Appendix D - Feature Images. Detailed drawings of surface and subsurface objects can be found in Volume 2 of 2, Drawings - Sheet 5 - Geophysical Survey Detected Objects - All and Volumes 2 of 2, Drawings - Sheet 6 - Geophysical Survey Detected objects - Ferrous.

6.1 Features

6.1.1 Above surface features

The survey area was analyzed for surface features larger than 1 ft x ft. Features were classified into the following groups; unknown objects with ferrous return, unknown objects in outer box, unknown objects in inner box without ferrous return, crab pots, and tires.

6.1.1.1 Unknown Ferrous Surface Objects

31 unknown objects with ferrous return were found in the survey area. Many of these objects could be defined as not likely to be UXOs due to the fact that they were either obviously another feature, or they have a shape such as flat top not associated with UXO[5]. Objects with rounded shapes and high ferrous return, that could not be explained as something else are seen as potential UXOs. In Table 6 below, whether an object can be considered a potential UXO is listed. The size and depth of surface objects with ferrous return was determined using the MBES data.

The majority of surface objects with a ferrous return were found in the required survey area of the inner box. The ferrous objects detected in the outer box were found during gradiometer quality control and calibration lines acquisition. A full list of the objects is below in Table 6.

[5] NAVTEC Site Inspection Report 28 July 2016 - Naval Defensive Sea Area Unalaska Island, Alaska Don 0716.503 used as a guide to size and shape of UXO.

Table 6 List of surface unknown objects with ferrous return

Surface Unknown Objects with Ferrous Return							
		NAD 83 US State Plane AK Zone 10			Dimensions in USft		
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Max Dimensions (HeightxWidthxLength)	Description	Potential UXO
800001	DHG_2017_UKF_001	1195283.384	5324951.773	69.00	0.7'x5.2'x5.5'	Round Mound (Outer Box)	NO
800002	DHG_2017_UKF_002	1195180.919	5324646.649	67.73	3'x7.2'x7.5'	Irregular shaped objects	YES
800003	DHG_2017_UKF_003	1195868.950	5324753.357	72.65	1'x8'x8'	Mound with some structure. Likely netting or cable	NO
800004	DHG_2017_UKF_004	1195767.379	5324408.551	55.08	5'x4.9'x5.3'	Large sphere feature (Outer Box).	YES
800005	DHG_2017_UKF_005	1195405.909	5324743.219	70.36	1.25'x7.3'x11.5'	Large semi buried object (Outer Box).	YES
800006	DHG_2017_UKF_006	1195404.047	5325247.361	67.55	2'x7.5'x8.5'	Object with straight lines and flat sides (Outer Box).	NO
800007	DHG_2017_UKF_007	1195365.618	5324554.875	70.61	2'x2'x4.5'	Small egg shaped object at base of slope.	YES
800008	DHG_2017_UKF_008	1195276.463	5325252.245	65.43	3'x4.5'x8'	Irregular structure with some linear features and other features that rise up.	NO
800009	DHG_2017_UKF_009	1195167.334	5323888.933	63.34	1.5'x2.5'x3.6'	Irregular object that leaves a shadow and has some flat faces possibly an anchor and chain.	NO
800010	DHG_2017_UKF_010	1194984.774	5323969.268	66.03	4'x5.5'x8'	Large rounded object	YES
800011	DHG_2017_UKF_011	1194907.125	5323956.488	70.96	3'x6'x8'	Object with shadow flat side angled into bottom some straight edges	NO
800012	DHG_2017_UKF_012	1194786.951	5324119.340	60.14	2.5'x5.8'x8.3'	Two straight parallel objects off the bottom with shadows	NO
800013	DHG_2017_UKF_013	1194564.882	5324160.519	80.96	4'x1.8'x4'	Tall structure with few soundings and sounding beneath it.	YES
800014	DHG_2017_UKF_014	1194415.305	5324241.720	79.87	2.5'x5'x7'	Irregular object	YES
800015	DHG_2017_UKF_015	1194157.450	5324928.236	57.92	1.5'x4'x11'	Debris	NO
800016	DHG_2017_UKF_016	1194149.039	5324965.196	58.10	1'x2'x2.5'	Round small object	YES

800017	DHG_2017_UKF_017	1194141.074	5324199.316	84.28	15'x10'x18'	Large Object Possible buoy with chain	NO
800018	DHG_2017_UKF_018	1194878.858	5323835.015	70.09	3'x7.5'x7.5'	3 parallel line structures (Outer Box)	NO
800019	DHG_2017_UKF_019	1193986.100	5324470.330	60.69	0.63'x1.7'x2.3'	Round Feature	YES
800020	DHG_2017_UKF_020	1194364.480	5324382.130	47.73	1'x2.7'x5.7'	Round Feature	YES
800021	DHG_2017_UKF_021	1194428.240	5324821.510	54.96	1.82'x2.8'x8.52'	Round feature with flat angled side	YES
800022	DHG_2017_UKF_022	1194865.120	5324773.130	66.62	0.73'x1.5'x3.3'	Round Feature	YES
800023	DHG_2017_UKF_023	1195007.020	5324619.550	53.28	2.67'x3.7'x13.35'	Round Feature	YES
800024	DHG_2017_UKF_024	1194088.150	5324493.890	49.88	1'x1.8'x3.6'	Small narrow oblong mound	YES
800025	DHG_2017_UKF_025	1194195.650	5324684.620	49.15	0.5'x3.2'x6.7'	Shallow oval shaped mound	YES
800026	DHG_2017_UKF_026	1195231.190	5324382.130	48.92	1'x2'x2.5'	Small square with flat top	NO
800027	DHG_2017_UKF_027	1195307.890	5324591.130	70.26	1'x2.7'x3.6'	Small mound at edge of bar that has large depression around it	NO
800028	DHG_2017_UKF_028	1193840.197	5324263.386	96.28	2.5'x6.3'x6.5'	Square flat top object	NO
800029	DHG_2017_UKF_029	1194229.000	5324898.920	58.90	1.2'x3.8'x7.1'	Rounded object on edge of bar	YES
800030	DHG_2017_UKF_030	1195516.860	5323708.700	42.92	1.2'x3'x3.5'	Oval shaped object (Outer Box)	YES
800031	DHG_2017_UKF_031	1194200.670	5324211.370	97.10	1'x4'x13'	3 egg shaped mounds	YES

The ferrous return unknown objects range in size from 2.3 ft to over 10 ft and were found to be a variety of shapes including round, oblong, egg shaped, and square. The majority of objects are 1 ft to 3 ft in height from the seafloor. The ferrous unknown objects are displayed on the multibeam surface and gradiometer return imagery below in Figure 46.

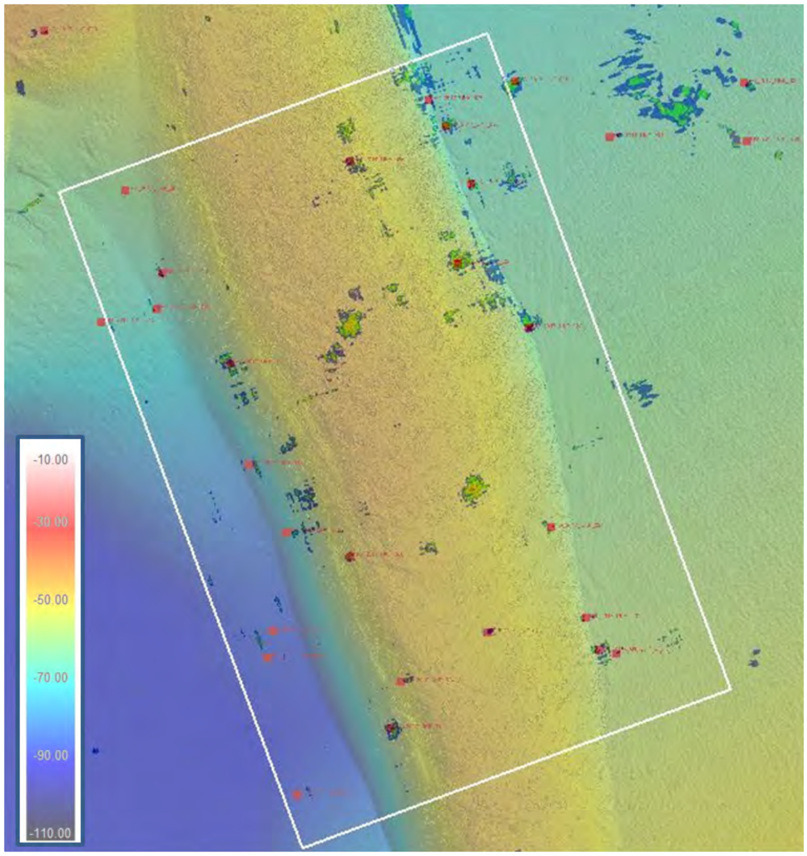


Figure 46 Ferrous Unknown Objects

The largest object found (DHG_2017_UKF_017) has dimensions of 15 ft tall, 10 ft wide and 18 ft long. This object has a strong gradiometer return surrounding it is clearly visibly in the multibeam data. Images of this object are displayed below in Figure 47 and Figure 48.

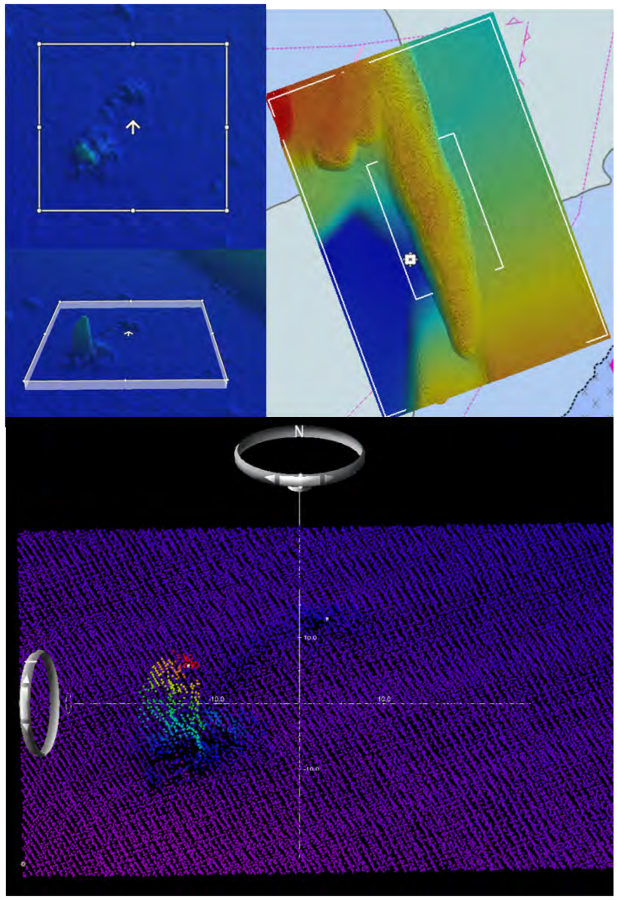


Figure 47 Object DHG_2017_UKF_017 2d and 3d Plan view (upper left) Overview (upper right) and 3d view (lower)

Figure 48 Object DHG_2017_UKF_017 3d imaging with gradiometer return

Oblong, egg shaped and rounded objects with ferrous return were scattered through the survey area. The largest of these objects (DHG_2017_UKF_005) has dimensions of 1.25 ft tall, 7.3 ft wide and 11.5 ft long. Images of this object and other examples are displayed below in Figure 49, Figure 50, Figure 51, and Figure 52.

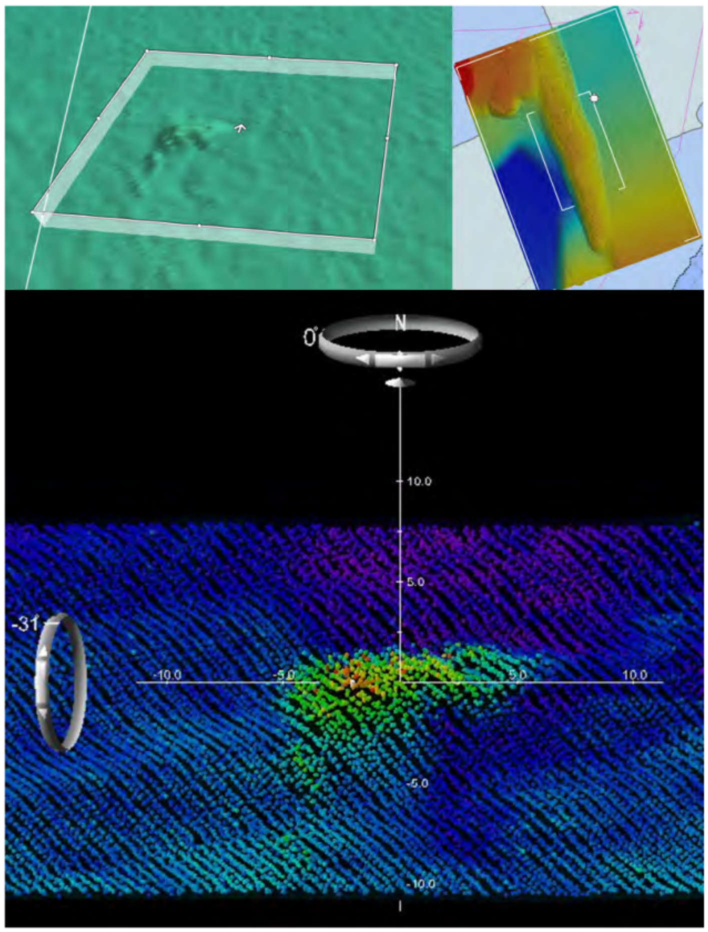


Figure 49 Large egg shaped object DHG_2017_UKF_005 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

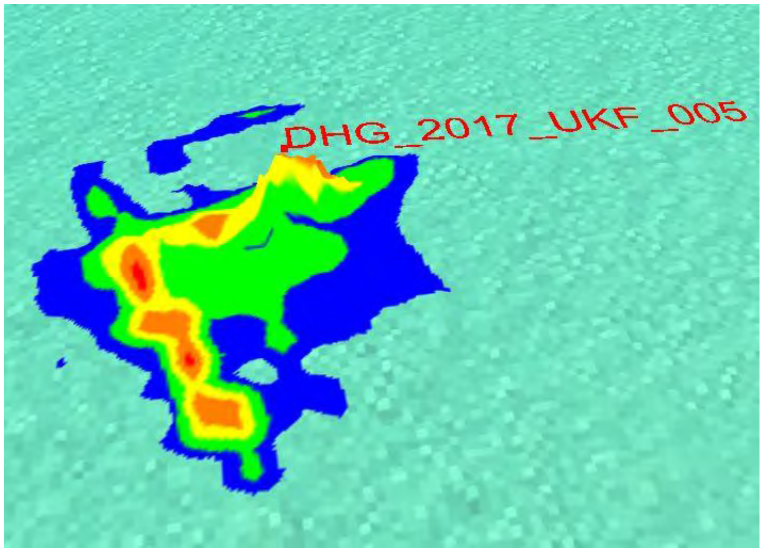


Figure 50 Object DHG_2017_UKF_005 3d imaging with gradiometer return

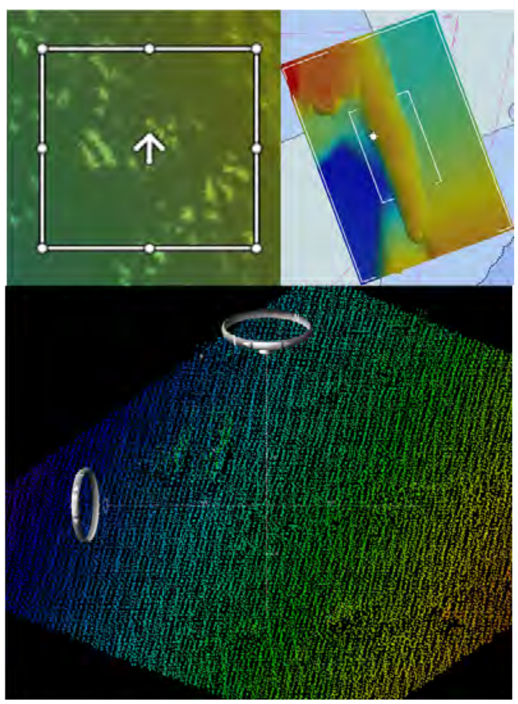


Figure 51 Object with two parallel oblong structures DHG_2017_UKF_012 Plan view (upper left) Overview (upper right) and 3d view (lower)

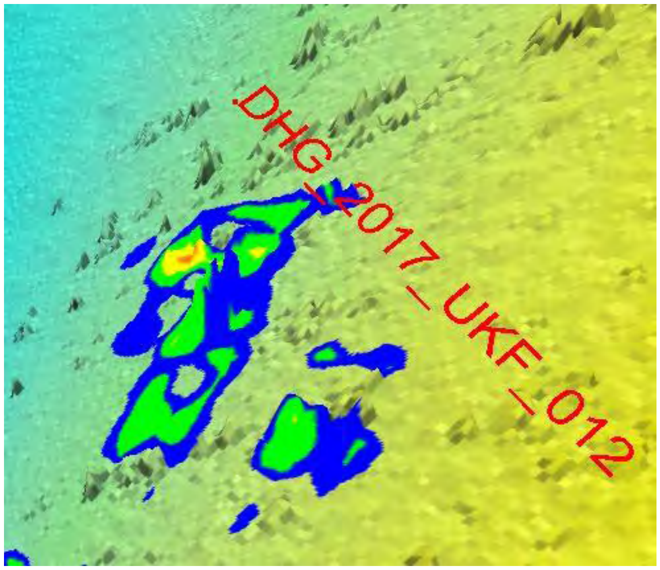


Figure 52 Object DHG_2017_UKF_012 3d imaging with gradiometer return

Other ferrous objects in the survey area had flat or angled features. Some examples of these objects are displayed below in Figure 53, Figure 54, Figure 55, and Figure 56.

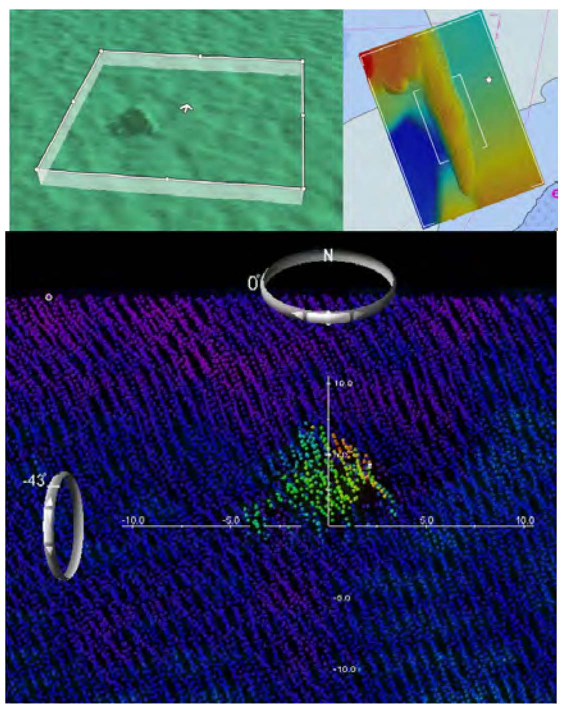


Figure 53 Object with angled and flat sides DHG_2017_UKF_006 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

Figure 54 Object DHG_2017_006 3d imaging with gradiometer return

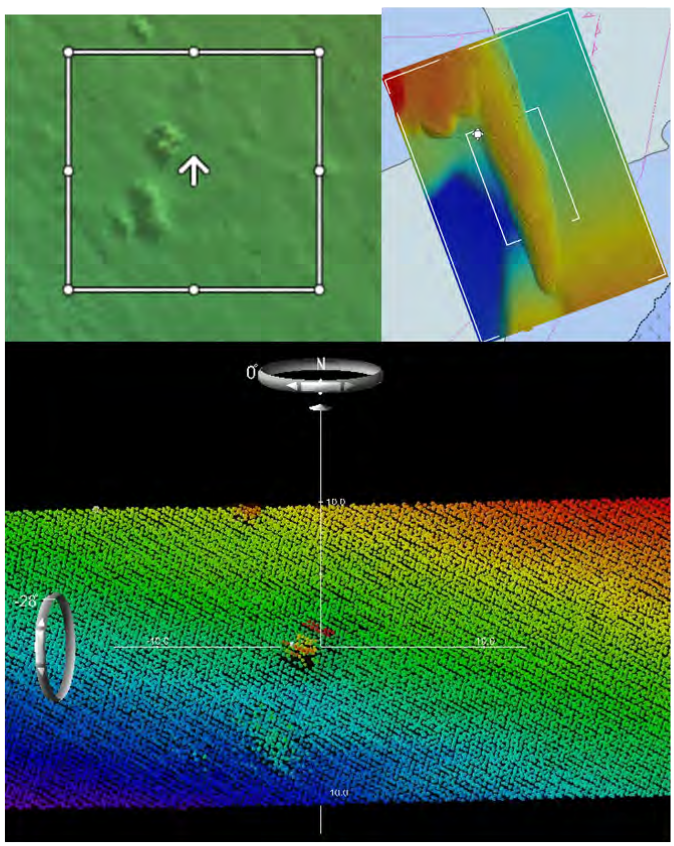


Figure 55 Object with flat faces DHG_2017_UKF_009 Plan view (upper left) Overview (upper right) and 3d view (lower)

Figure 56 Object DHG_2017_009 3d imaging with gradiometer return

6.1.1.2 Unknown Non Ferrous Surface Objects Inner Box

8 non-ferrous unknown objects were found in the inner box survey area. Surface objects with no ferrous return are considered likely not a UXO. A full list of the objects is below in Table 7.

Table 7 List of surface unknown non ferrous objects in inner box

		NAD 83 US State Plane AK Zone 10			Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Max Dimensions (HeightxWidthxLength)	Description
9900001	DHG_2017_UKI_001	1195302.784	5324680.136	69.60	1.5'x4.5'x5.2'	structure with uneven top and round shape
9900002	DHG_2017_UKI_002	1195241.676	5324602.917	69.88	1.5'x2.5'x2.5'	small object with flat top
9900003	DHG_2017_UKI_003	1194506.525	5324880.144	61.94	1.5'x3.5'x4.5'	not well defined object may be net or other soft object
9900004	DHG_2017_UKI_004	1194389.773	5324177.090	93.19	1.4'x4'x6'	oval shaped
9900005	DHG_2017_UKI_005	1195043.552	5324005.982	59.52	2'x1.7'x3.3'	flat top object
9900006	DHG_2017_UKI_006	1194064.884	5324211.894	98.07	2.5'x4.5'x8'	irregular debris
9900007	DHG_2017_UKI_007	1193782.425	5324259.207	96.16	1'x1.2'x3'	small object
9900008	DHG_2017_UKI_008	1195060.890	5324685.760	68.39	1'x3.5'x9.6'	egg shaped object at edge of bar

The non-ferrous unknown objects found in the inner box range in size from 2.5 ft to over 9 ft and were found to both rounded and angular in shape. The objects range from 1 ft to 2.5 ft in height from the seafloor. The non ferrous unknown objects in the inner box are displayed on the multibeam surface below in Figure 57.

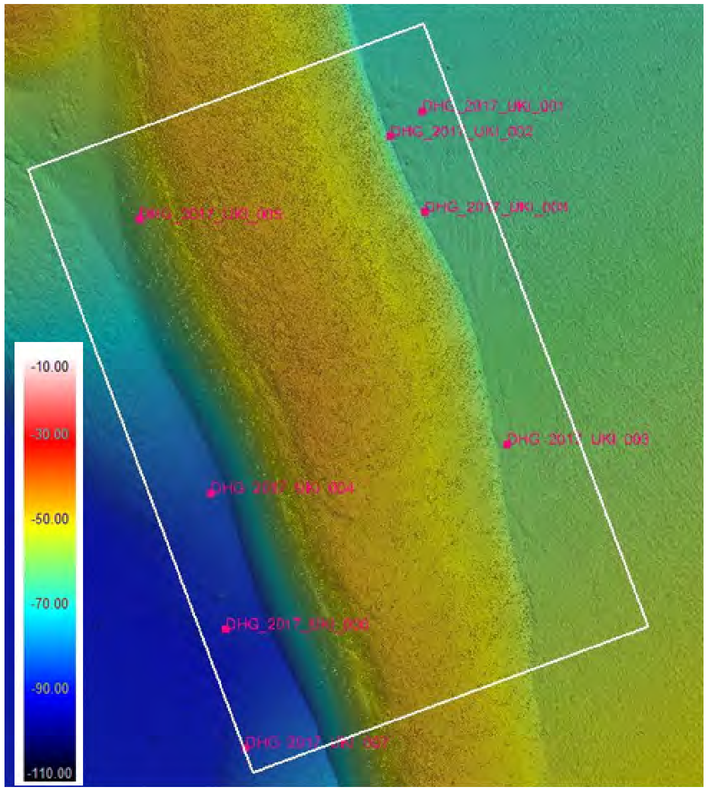


Figure 57 Non Ferrous unknown objects in inner box

The largest object found (DHG_2017_UKI_006) has dimensions of 2.5 ft tall, 4.5 ft wide and 8 ft long. This object is irregular in shape and was recorded in multiple multibeam lines. Images of this object and other examples are displayed below in Figure 58, Figure 59 and, Figure 60.

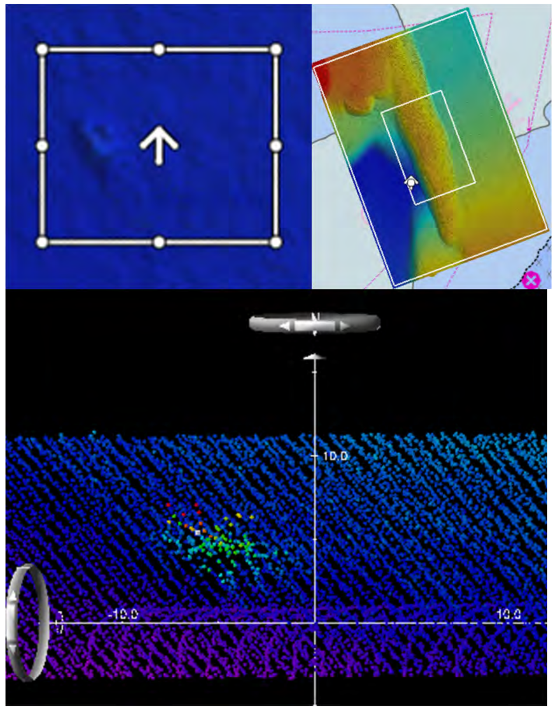


Figure 58 Irregular debris object DHG_2017_UKI_006 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

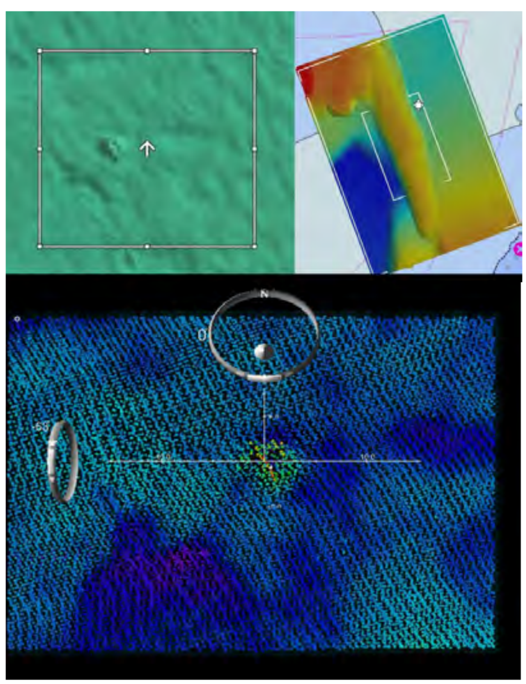


Figure 59 Object with round shape and uneven top DHG_2017_UKI_001 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

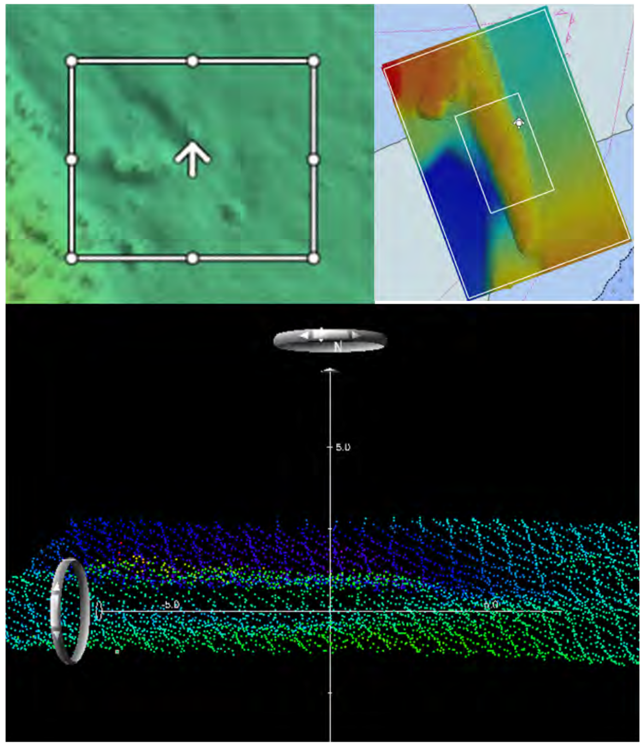


Figure 60 Egg shaped object DHG_2017_UKI_008 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

6.1.1.3 Unknown Surface Objects Outer Box

109 unknown objects were found in the outer box survey area. Objects found in the outer box are unable to be categorized as ferrous or non ferrous. As stated in the Marine Geophysical and Bathymetric Survey Work Plan, gradiometer survey was not executed in the outer box survey area. A full list of the objects is below in Table 8.

Table 8 List of surface unknown objects in outer box

		NAD 83 US State Plane AK Zone 10			Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Max Dimensions (HeightxWidthxLength)	Description
66001	DHG_2017_UKO_001	1196189.194	5324857.468	72.06	2'x6.5'x7.5'	jagged object
66002	DHG_2017_UKO_002	1195955.194	5324390.054	67.81	2.5'x4.5'x6.2'	irregular structure on edge of bar
66003	DHG_2017_UKO_003	1195923.377	5324624.051	70.37	2.5'x5.5'x5.5'	loose square object with raised rail over a mound
66004	DHG_2017_UKO_004	1195575.794	5323292.736	35.14	1.75'x3.5'x4'	very rounded
66005	DHG_2017_UKO_005	1195318.515	5325292.932	67.89	0.7'x5.5'x5.5'	very rounded
66006	DHG_2017_UKO_006	1194870.606	5323575.943	66.88	1.5'x4'x4'	round object with flat top
66007	DHG_2017_UKO_007	1193371.633	5324081.185	98.99	2'x4.7'x5.5'	flat top object

66008	DHG_2017_UKO_008	1194066.828	5323901.428	100.44	2.5'x8'x8'	irregular structure
66009	DHG_2017_UKO_009	1193985.624	5324101.948	100.30	3.5'x7'x8'	irregular structure
66010	DHG_2017_UKO_010	1193659.240	5323774.057	96.48	6'x6.5'x8.6'	irregular structure
66011	DHG_2017_UKO_011	1193360.338	5324569.616	66.37	2.5'x6.5'x7.2'	three parallel lines of a frame next to bar
66012	DHG_2017_UKO_012	1193062.825	5323818.630	94.75	5'x11'x13'	irregular shape
66013	DHG_2017_UKO_013	1193514.336	5323655.171	95.43	6'x8'x10'	large debris
66014	DHG_2017_UKO_014	1192663.479	5324177.136	88.86	4'x8.7'x9.5'	mound with some structure
66015	DHG_2017_UKO_015	1193049.681	5324327.749	63.50	2'x2'x5'	irregular structure
66016	DHG_2017_UKO_016	1193814.282	5326070.595	49.06	1'x2'x4.3'	egg shaped
66017	DHG_2017_UKO_017	1193820.314	5325205.247	53.03	1'x5'x10'	egg shaped
66018	DHG_2017_UKO_018	1193921.175	5324092.483	97.36	5'x6'x11'	irregular debris with not much structure
66019	DHG_2017_UKO_019	1193898.987	5324053.294	99.63	3'x2'x8'	debris protruding at an angle
66020	DHG_2017_UKO_020	1193802.189	5324089.752	99.74	4'x8'x10'	irregular object
66021	DHG_2017_UKO_021	1193588.468	5323875.727	98.73	3'x6.5'x10'	mound with debris
66022	DHG_2017_UKO_022	1193622.602	5323714.785	94.85	6'x7'x14'	debris with flat surfaces
66023	DHG_2017_UKO_023	1193508.730	5323832.379	100.17	1'x2'x5'	cylindrical object
66024	DHG_2017_UKO_024	1194683.682	5325709.140	59.60	1'x4'x6'	low oval mound
66025	DHG_2017_UKO_025	1194646.714	5325691.680	58.83	1.8'x3.5'x5.6'	egg shaped object with a protruding feature on one side
66026	DHG_2017_UKO_026	1194050.154	5323706.629	100.46	2'x3.6'x7.5'	oval shaped
66027	DHG_2017_UKO_027	1194007.386	5323919.604	100.66	2'x2'x8'	irregular object
66028	DHG_2017_UKO_028	1194005.667	5323832.889	100.33	2.5'x7'x10'	frame or netting
66029	DHG_2017_UKO_029	1193979.053	5323789.366	99.51	3'x7'x13'	oval shaped object with soundings below it on bottom
66030	DHG_2017_UKO_030	1194094.169	5323671.957	100.29	3'x2'x10'	thin linear structure with small debris next to it
66031	DHG_2017_UKO_031	1194099.967	5323510.253	100.76	1'x5'x7'	three short round mounds
66032	DHG_2017_UKO_032	1194148.507	5323639.914	100.84	2'x4.5'x4.5'	small round object
66033	DHG_2017_UKO_033	1194156.019	5323560.350	101.26	1'x3.3'x6.3'	flat debris in a depression
66034	DHG_2017_UKO_034	1194140.618	5323782.126	100.97	1'x2.8'x5'	oval debris with good return and shadow
66035	DHG_2017_UKO_035	1196356.142	5324291.449	72.23	1'x4.8'x9.5'	long and tear drop shaped object
66036	DHG_2017_UKO_036	1196457.627	5324577.031	70.79	2.5'x9.5'x7'	irregular object
66037	DHG_2017_UKO_037	1196606.239	5324943.494	74.75	1'x8'x8'	irregular object
66038	DHG_2017_UKO_038	1196320.632	5324326.721	71.94	1.2'x3.5'x3.5'	flat object with sloped top
66039	DHG_2017_UKO_039	1196283.085	5324526.643	71.57	1.25'x5.5'x6.5'	egg shaped object with somewhat flat surface
66040	DHG_2017_UKO_040	1196324.269	5324685.895	72.74	1'x7'x7.5'	mound with structure
66041	DHG_2017_UKO_041	1196202.746	5324545.071	70.26	2.3'x6.5'x6.5'	straight line structure
66042	DHG_2017_UKO_042	1196099.325	5324786.329	70.20	3'x8'x11.5'	frame like structure

66043	DHG_2017_UKO_043	1196034.375	5325157.268	72.73	1.2'x7.5'x8'	short mound with short soft object protruding up
66044	DHG_2017_UKO_044	1195967.726	5324791.670	71.36	2'x5'x7'	object with shadow
66045	DHG_2017_UKO_045	1195830.476	5324480.380	71.88	1'x7.8'x9.5'	multiple long objects
66046	DHG_2017_UKO_046	1195706.579	5324791.497	70.70	3.5'x1.5'x3.5'	small structure
66047	DHG_2017_UKO_047	1195526.723	5324827.916	68.70	4'x4'x8'	mound with a structure rising 4 ft above bottom
66048	DHG_2017_UKO_048	1195481.029	5324956.113	69.36	2.5'x3.2'x6'	low square mound with structure that rises 2.5ft up
66049	DHG_2017_UKO_049	1195128.490	5325061.892	65.95	2'x2.5'x2.5'	round object with a flat top
66050	DHG_2017_UKO_050	1194900.892	5325428.019	63.72	0.5'x7.5'x7.5'	irregular shaped mound
66051	DHG_2017_UKO_051	1194694.779	5323446.356	67.64	2.5'x3.5'x5.5'	object with angled flat surface and straight lines
66052	DHG_2017_UKO_052	1194684.336	5323863.972	79.09	3'x5.5'x7.5'	object with angled flat surface and straight lines
66053	DHG_2017_UKO_053	1194517.440	5323662.017	98.03	3'x6.4'x8.3'	irregular shaped debris
66054	DHG_2017_UKO_054	1194516.843	5323627.087	94.46	7.5'x5'x10'	stacked flat objects looks like shelves
66055	DHG_2017_UKO_055	1194451.446	5323935.347	91.89	3'x4.8'x10'	irregular mound
66056	DHG_2017_UKO_056	1194396.623	5323589.181	101.35	1'x2'x7'	straight object with an angled flat surface
66057	DHG_2017_UKO_057	1194212.935	5323520.674	100.41	2'x8'x8.7'	clustered debris
66058	DHG_2017_UKO_058	1194197.429	5323419.862	101.50	1'x4'x9'	long oval object
66059	DHG_2017_UKO_059	1193944.021	5323541.453	100.72	1'x3'x7'	oval shaped mound with some structure
66060	DHG_2017_UKO_060	1193844.597	5323802.432	99.64	5'x9'x10'	angular object with protruding features
66061	DHG_2017_UKO_061	1193406.769	5323722.516	99.26	1'x1.5'x7.5'	long object in a depression
66062	DHG_2017_UKO_062	1193400.753	5323778.977	99.60	1'x1.5'x5.3'	small egg shaped object
66063	DHG_2017_UKO_063	1196619.190	5324685.730	73.29	1.75'x14'x11'	large irregular mound
66064	DHG_2017_UKO_064	1196379.357	5325155.115	72.31	3'x6'x6.5'	debris
66065	DHG_2017_UKO_065	1196278.861	5325229.339	73.90	1'x8.5'x13'	cone shaped object with some flat surfaces and a mound at end of cone
66066	DHG_2017_UKO_066	1196172.032	5324392.300	72.03	0.8'x1.3'x6.5'	flat object laying on the bottom with soft shadow
66067	DHG_2017_UKO_067	1196160.912	5324686.467	71.81	1'x3.5'x5'	egg shaped object
66068	DHG_2017_UKO_068	1196120.995	5324399.551	71.86	0.75'x3'x8'	cylindrical object
66069	DHG_2017_UKO_069	1196160.547	5325235.616	73.96	0.75'x7.5'x8'	short egg shaped mound in a flat area
66070	DHG_2017_UKO_070	1196113.839	5325254.144	73.17	1.2'x4.6'x8.5'	oval shaped object with a depression in the middle
66071	DHG_2017_UKO_071	1195994.113	5324930.546	73.54	0.75'x3.5'x6.8'	short egg shaped mound in a flat area with small depression
66072	DHG_2017_UKO_072	1195719.615	5325491.673	70.18	0.7'x4'x16'	low oval mound
66073	DHG_2017_UKO_073	1195666.955	5325305.962	70.46	0.75'x1.5'x1.5'	very small object
66074	DHG_2017_UKO_074	1195663.234	5325260.344	70.02	1.5'x2.5'x4'	egg shaped object
66075	DHG_2017_UKO_075	1195539.736	5325464.646	68.37	1.5'x2'x4'	oval mound

66076	DHG_2017_UKO_076	1195456.143	5325425.255	68.43	1'x3'x3.5'	small egg shaped mound
66077	DHG_2017_UKO_077	1195449.248	5325383.027	67.94	1.3'x1'x2'	small object
66078	DHG_2017_UKO_078	1195166.413	5325503.475	64.09	2'x2.5'x5.5'	small object protruding from bottom
66079	DHG_2017_UKO_079	1195081.313	5325653.530	64.25	0.6'x4.5'x4.5'	round object
66080	DHG_2017_UKO_080	1193121.191	5323943.169	98.04	2'x4'x6'	irregular object
66081	DHG_2017_UKO_081	1192853.760	5324012.360	98.34	0.3'x2.6'x5.4'	oval object
66082	DHG_2017_UKO_082	1192835.980	5323850.670	99.30	0.3'x2.2'x5.1'	oval object
66083	DHG_2017_UKO_083	1193157.062	5323692.353	97.43	2'x4'x8'	oval flat top object with hard return and shadow
66084	DHG_2017_UKO_084	1193283.561	5323957.832	100.43	0.6'x7.5'x7.8'	object protruding from round mound
66085	DHG_2017_UKO_085	1193318.219	5324038.265	99.36	0.7'x8.3'x13.2'	oval object
66086	DHG_2017_UKO_086	1193409.270	5324102.800	100.59	0.4'x3.4'x5.5'	irregular object
66087	DHG_2017_UKO_087	1193451.380	5323934.770	100.47	0.5'x3.3'x9.6'	egg shaped object
66088	DHG_2017_UKO_088	1193437.100	5323792.480	100.26	0.4'x2.8'x5.3'	oval with flat top
66089	DHG_2017_UKO_089	1193525.150	5324097.580	100.61	0.75'x2.6'x7.5'	oval shaped object
66090	DHG_2017_UKO_090	1193729.508	5324409.792	88.77	0.75'x2.5'x2.5'	low round object with flat top
66091	DHG_2017_UKO_091	1193707.075	5323984.459	100.82	1'x5'x7'	low round mound in depression
66092	DHG_2017_UKO_092	1193721.780	5324165.870	101.08	0.6'x2.5'x4.9'	small flat top object
66093	DHG_2017_UKO_093	1193714.540	5323915.000	100.86	1'x8.1'x12.1'	large egg shaped mound
66094	DHG_2017_UKO_094	1193680.820	5323497.764	97.84	2.5'x2.8'x3.5'	debris
66095	DHG_2017_UKO_095	1194069.060	5324054.320	102.29	0.7'x5.1'x12.3'	oval mound in depression
66096	DHG_2017_UKO_096	1193865.130	5324106.810	101.97	0.5'x10.2'x12.4'	two round irregular objects
66097	DHG_2017_UKO_097	1194796.962	5323649.223	73.89	0.7'x2'x4'	debris
66098	DHG_2017_UKO_098	1194482.740	5323636.840	101.58	0.5'x7.6'x13.7'	irregular debris
66099	DHG_2017_UKO_099	1194442.480	5323612.730	101.50	0.55'x6.1'x2.4'	oval mound
66100	DHG_2017_UKO_100	1193908.860	5323880.460	101.87	0.5'x7.05'x8.02'	debris
66101	DHG_2017_UKO_101	1192557.000	5324122.460	95.37	0.3'x5.4'x13.2'	collection of debris
66102	DHG_2017_UKO_102	1192889.618	5323775.426	98.91	0.75'x2.7'x3.8'	small flat top object in depression
66103	DHG_2017_UKO_103	1194564.186	5323577.800	99.56	1'x2'x5'	short oval mound
66104	DHG_2017_UKO_104	1194433.840	5323431.753	98.40	2'x5'x5'	round mound with some structure
66105	DHG_2017_UKO_105	1194389.367	5323412.156	100.45	1'x5'x5'	debris mound
66106	DHG_2017_UKO_106	1194319.208	5323489.003	101.24	1'x7'x8'	irregular debris
66107	DHG_2017_UKO_107	1194468.143	5323681.756	101.44	0.75'x2'x4'	short small oval mound
66108	DHG_2017_UKO_108	1194423.000	5323702.270	102.04	0.35'x6.2'x10.1'	irregular shaped debris
66109	DHG_2017_UKO_109	1194439.480	5323776.080	101.49	0.5'x4.2'x6.2'	egg shaped mound

The unknown objects found in the outer box range in size from 1.5 ft to 14 ft and were found to be a variety of shapes including round, oblong, egg shaped, square, and angular. The objects range from less than 1 ft to over 7 ft in height from the seafloor. The unknown objects in the outer box are displayed on the multibeam surface below in Figure 61.

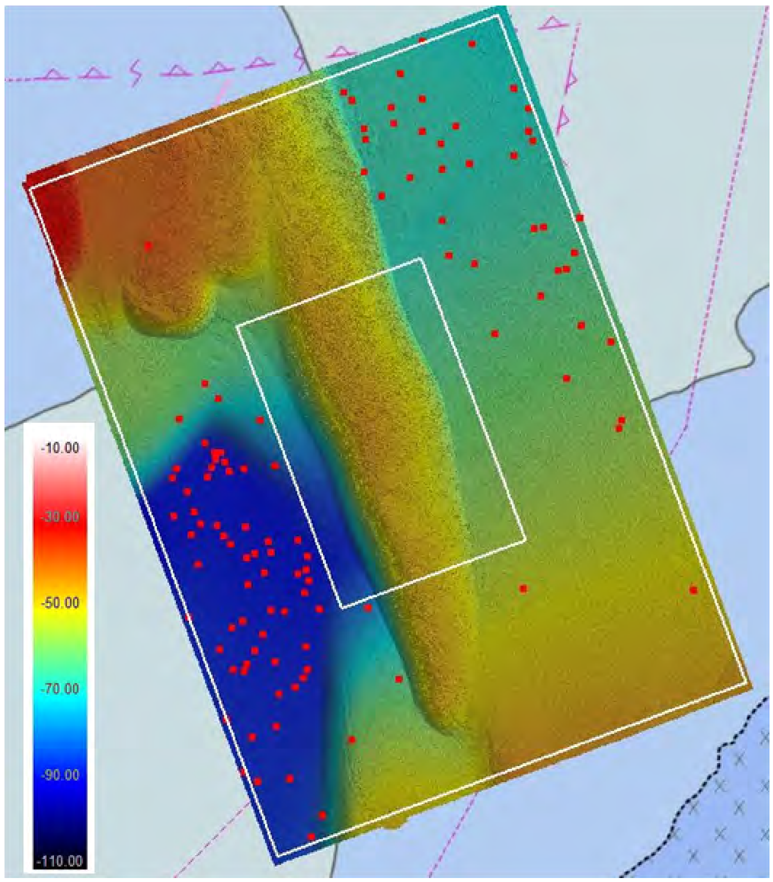


Figure 61 Unknown objects in outer box

The largest object found (DHG_2017_UKO_012) has dimensions of 5 ft tall, 11 ft wide and 13 ft long. This object is irregular in shape. Images of this object are displayed below in Figure 62.

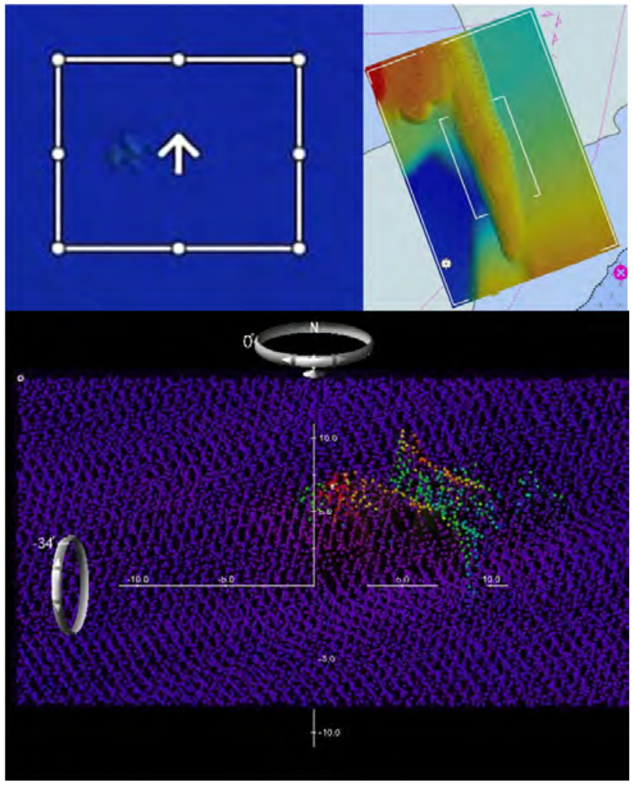


Figure 62 Large irregular shaped object DHG_2017_UKO_012 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

Many of the objects found in the survey area were rounded oblong, oval, or egg shaped. An example of this shape object is shown below in Figure 63.

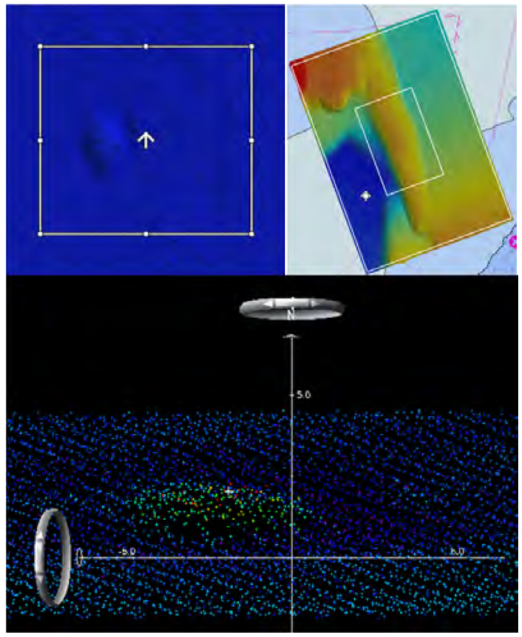


Figure 63 Large egg shaped object DHG_2017_UKO_093 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

Other unique objects found in the outer box survey area are displayed below in Figure 64, Figure 65, Figure 66, and Figure 67.

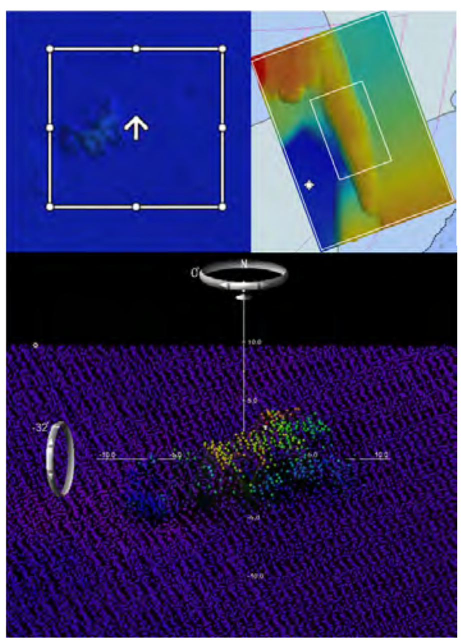


Figure 64 Debris object with flat surfaces DHG_2017_UKO_022 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

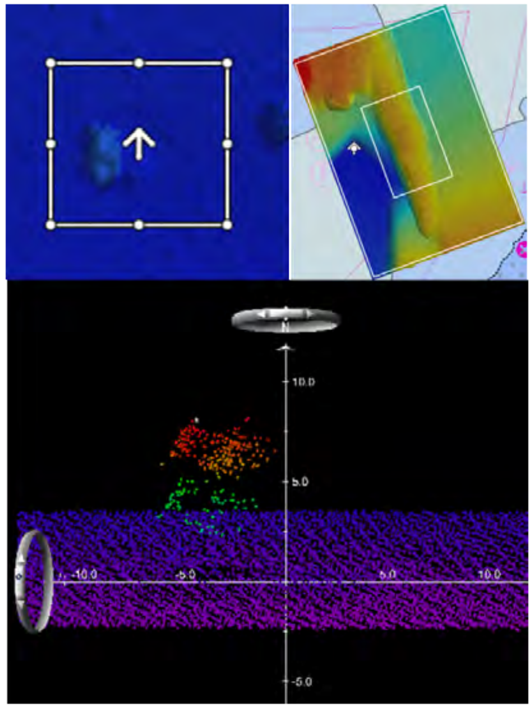


Figure 65 Stacked flat objects DHG_2017_UKO_054 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

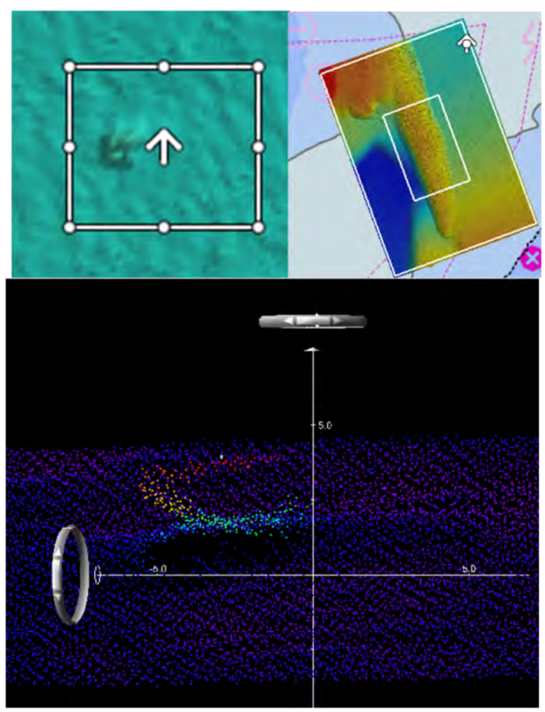


Figure 66 Large coil debris object DHG_2017_UKO_064 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

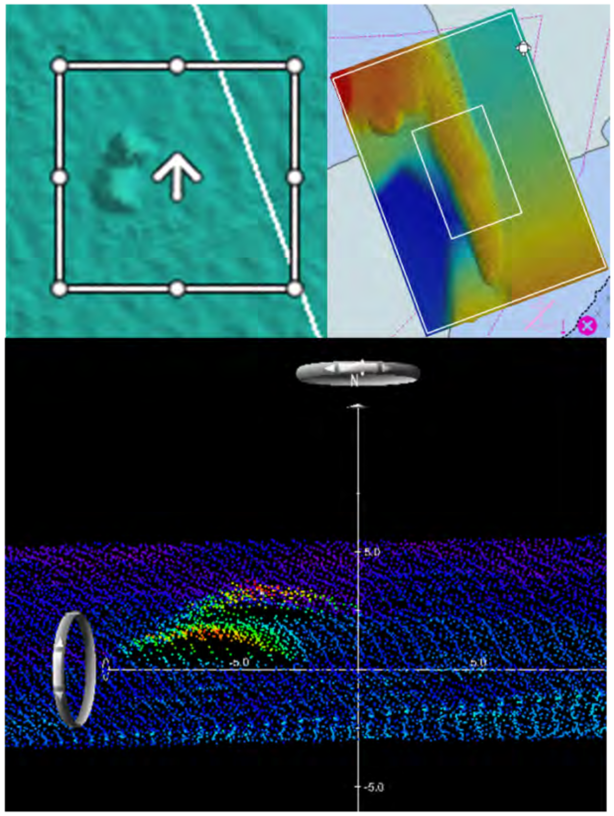


Figure 67 Cone shaped objects DHG_2017_UKO_065 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

6.1.1.4 Crab Pots

Crab pots had a high magnetic response and were visible on the surface. There were listed in order to discount them as an object of interest. 48 crab pots were found in the survey area. Crab pots in the gradiometer survey area had high magnetic returns. A full list of the objects is below in Table 9.

Table 9 List of crab pots

		NAD 83 US State Plane AK Zone 10			Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Max Dimensions (HeightxWidthxLength)	Description
550001	DHG_2017_CRB_001	1196575.113	5324564.058	71.65	2.8'x7'x7'	partial crab pot structure
550002	DHG_2017_CRB_002	1196569.277	5325010.539	72.96	3'x8'x8'	crab pot
550003	DHG_2017_CRB_003	1196322.217	5325025.044	72.22	2.5'x7.5'x8.5'	crab pot
550004	DHG_2017_CRB_004	1196315.251	5325047.852	72.05	2'x7.5'x7.7'	crab pot
550005	DHG_2017_CRB_005	1196272.758	5324252.020	64.10	3'x7'x7'	flat top frame structure along edge of bar
550006	DHG_2017_CRB_006	1196201.965	5324657.250	69.09	5'x8'x8'	frame
550007	DHG_2017_CRB_007	1196200.076	5324309.389	69.45	2'x6.5'x7'	flat top with some frame along edge of the bar

550008	DHG_2017_CRB_008	1196084.394	5323556.543	36.05	2.5'x6'x6'	square top crab pot frame
550009	DHG_2017_CRB_009	1196051.640	5324879.359	71.60	2.5'x7'x7.5'	square top structure
550010	DHG_2017_CRB_010	1196043.896	5324414.942	70.27	2.5'x6.5'x7.3'	crab pot with protruding object
550011	DHG_2017_CRB_011	1195965.678	5325053.294	72.45	1.8'x5'x5'	square top structure sitting at angle
550012	DHG_2017_CRB_012	1195939.119	5325312.569	70.20	2.5'x6.5'x7.2'	square top structure sitting at angle
550013	DHG_2017_CRB_013	1195901.963	5325052.672	69.95	3'x7'x7'	square with frame
550014	DHG_2017_CRB_014	1195883.018	5325346.869	69.87	3'x7.5'x7.5'	crab pot
550015	DHG_2017_CRB_015	1195869.575	5324739.260	71.05	2.5'x7'x7'	crab pot sitting at angle
550016	DHG_2017_CRB_016	1195844.170	5324978.882	70.00	3.5'x6.5'x6.5'	crab pot
550017	DHG_2017_CRB_017	1195802.710	5324443.162	70.45	3'x6.5'x7.3'	crab pot
550018	DHG_2017_CRB_018	1195515.613	5325439.171	67.43	2.2'x6'x6'	crab pot
550019	DHG_2017_CRB_019	1195471.715	5325003.355	68.24	3'x5.5'x6.5'	frame structure
550020	DHG_2017_CRB_020	1195414.035	5324500.169	58.53	3.5'x6.5'x7'	crab pot
550021	DHG_2017_CRB_021	1195343.700	5323788.460	56.81	2.5'x7.5'x7.5'	square structure with flat top
550022	DHG_2017_CRB_022	1195331.084	5325428.482	66.43	2'x5'x5'	round crab pot with flat top
550023	DHG_2017_CRB_023	1195199.441	5324744.847	67.37	3'x7.2'x7.2'	crab pot
550024	DHG_2017_CRB_024	1194713.713	5325015.288	61.69	3'x7'x7'	crab pot
550025	DHG_2017_CRB_025	1194680.335	5323712.556	81.85	2.5'x8'x8'	flat square top crab pot
550026	DHG_2017_CRB_026	1194636.123	5323773.160	84.85	2.5'x8'x8'	flat square top crab pot
550027	DHG_2017_CRB_027	1194612.647	5324858.227	61.68	3'x7'x7'	crab pot
550028	DHG_2017_CRB_028	1194541.124	5323402.358	78.33	3'x8.5'x8.5'	crab pot
550029	DHG_2017_CRB_029	1194398.647	5324773.664	51.12	3.5'x5'x5'	crab pot
550030	DHG_2017_CRB_030	1194375.428	5324550.905	43.68	3'x7.5'x7.5'	crab pot
550031	DHG_2017_CRB_031	1194321.724	5325435.072	57.25	1.3'x4.4'x5.2'	crab pot
550032	DHG_2017_CRB_032	1194314.272	5324058.405	95.91	2.5'x8'x8'	crab pot
550033	DHG_2017_CRB_033	1194256.783	5323683.424	99.59	3'x8.2'x8.2'	crab pot
550034	DHG_2017_CRB_034	1194180.916	5325089.036	56.44	2.5'x6'x6'	crab pot
550035	DHG_2017_CRB_035	1194175.045	5324153.055	97.31	2.5'x7.3'x7.3'	crab pot
550036	DHG_2017_CRB_036	1194149.204	5325269.550	54.57	2.5'x6.5'x6.5'	crab pot
550037	DHG_2017_CRB_037	1194148.810	5324930.946	56.56	2.5'x6.5'x6.5'	crab pot
550038	DHG_2017_CRB_038	1193879.652	5324999.169	53.97	2'x4'x4'	Small crab pot near bar
550039	DHG_2017_CRB_039	1193860.197	5323780.523	99.41	2.5'x9.5'x10'	flat top structure
550040	DHG_2017_CRB_040	1193784.184	5324033.648	99.36	3'x8'x9'	flat top structure
550041	DHG_2017_CRB_041	1193699.928	5324750.820	43.53	2.5'x6.3'x7.5'	corroded crab pot
550042	DHG_2017_CRB_042	1193610.459	5325607.941	47.16	2.5'x6'x6'	crab pot
550043	DHG_2017_CRB_043	1193518.800	5323544.412	97.57	3'x7'x7'	crab pot
550044	DHG_2017_CRB_044	1193012.009	5324763.336	55.45	2'x5.5'x6'	Small crab pot near end of bar

550045	DHG_2017_CRB_045	1193009.568	5324167.392	94.42	2.9'x7'x7'	crab pot
550046	DHG_2017_CRB_046	1192688.626	5324222.805	77.92	2.5'x8'x8'	crab pot
550047	DHG_2017_CRB_047	1192634.459	5324151.317	90.63	3'x7.5'x8.5'	crab pot
550048	DHG_2017_CRB_048	1192605.923	5324175.533	89.24	1.5'x4.5'x5'	crab pot

The crab pots range from 4 ft to 10 ft in size and 1 ft to 5ft in height from the seafloor. The crab pots are displayed on the multibeam surface below in Figure 68. Images of a crab pots are shown below in Figure 69 and Figure 70.

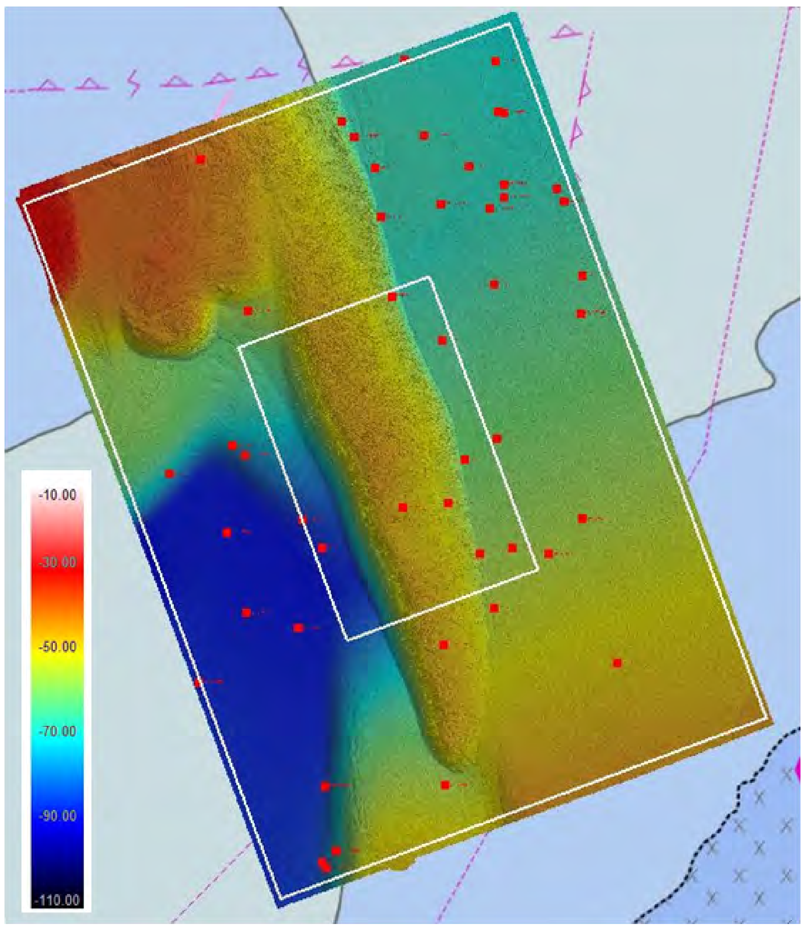


Figure 68 Crab pots

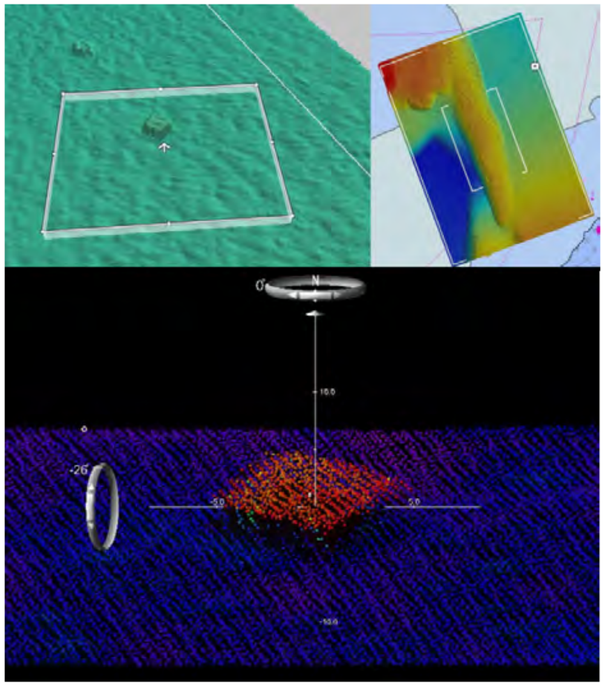


Figure 69 Crab Pot DHG_2017_CRB_014 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

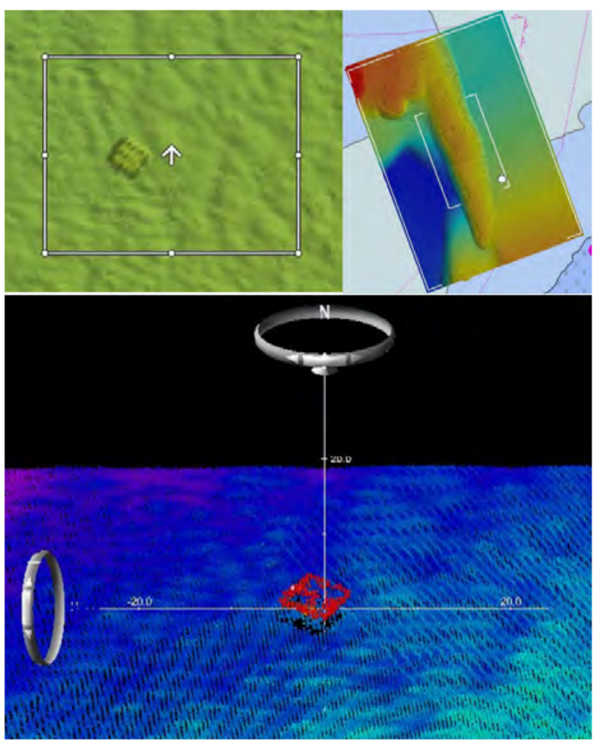


Figure 70 Crab Pot DHG_2017_CRB_034 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

6.1.1.5 Tires

Tires were surface objects with no magnetic response. These were noted in order to discount them as objects of interest. 4 tires were found in the survey area. A full list of the objects is below in Table 10.

Table 10 List of tires

		NAD 83 US State Plane AK Zone 10			Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Max Dimensions (HeightxWidthxLength)	Description
710001	DHG_2017_TR_001	1193635.975	5323565.454	100.05	0.5'x7.5'x7.5'	Tire
710002	DHG_2017_TR_002	1193460.241	5323628.958	99.33	1'x8'x8'	Tire
710003	DHG_2017_TR_003	1196111.272	5324932.141	72.84	1.2'x6'x6'	Tire
710004	DHG_2017_TR_004	1195356.390	5323693.740	58.10	0.5'x6.3'x6.3'	Tire

The tires range from 6 ft to 8 ft in size and 0.5 ft to over 1 ft in height from the seafloor. The tires are displayed on the multibeam surface below in Figure 71. Images of a tire are shown below in Figure 72.

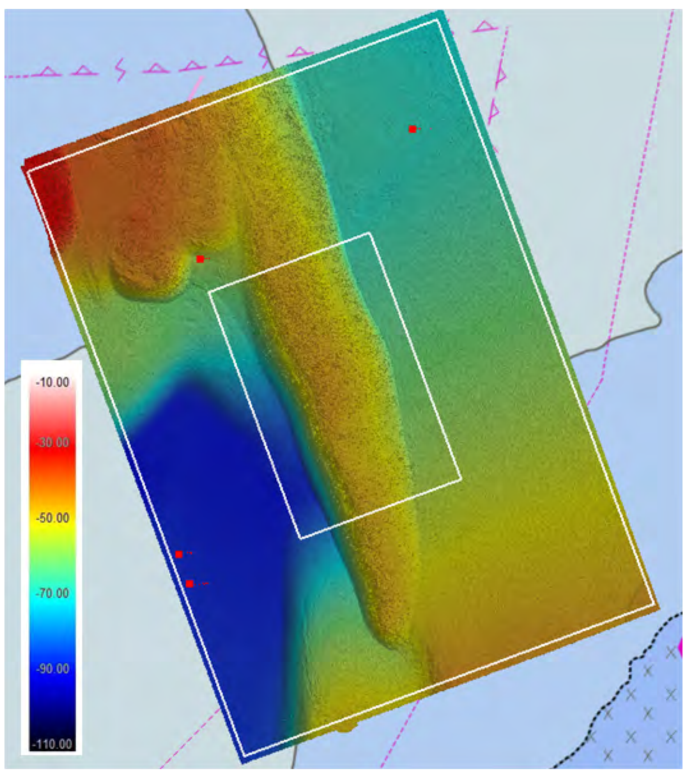


Figure 71 Tires

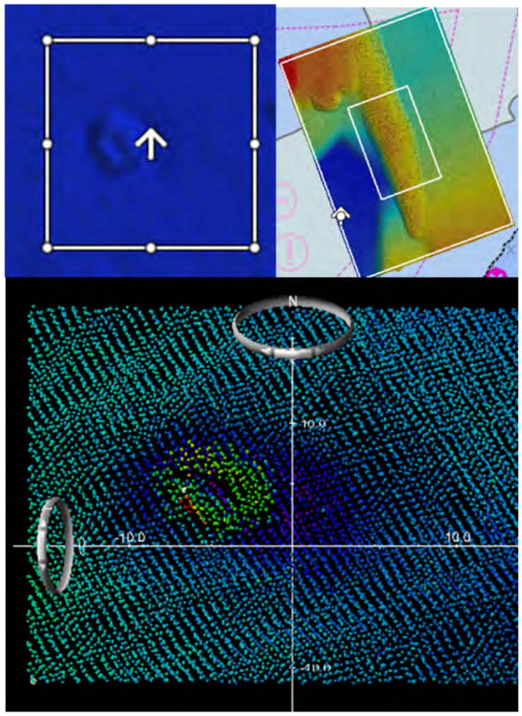


Figure 72 Tire DHG_2017_TR_002 2d Plan view (upper left) Overview (upper right) and 3d view (lower)

6.1.2 Subsurface Features

The survey area was analyzed for subsurface features larger than 1 ft x 1 ft. Features were classified into the following groups; unknown objects with ferrous return in the inner box, non ferrous unknown objects in inner box, unknown objects in the outer box that are likely boulders, and unknown objects in the outer box that are unnaturally shaped.

6.1.2.1 Unknown Ferrous Subsurface Objects Inner Box

6 ferrous unknown objects were found in the inner box survey area. A full list of the objects is below in Table 11. The subbottom data is able to detect the object and give an idea of size, but does not provide enough information to be able to determine with any accuracy if a buried object is a UXO or not. The size and depth of subsurface objects with ferrous return was determined using the Chirp data.

Table 11 List of unknown ferrous subsurface objects

		NAD 83 US State Plane AK Zone 10				Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Depth of burial (surface depth - object depth)	Estimated Size (largest dimension)	Description
62001	DHG_2017_ISUKF_001	1194201.12	5325090.44	61.37	2.31	4-8ft	Unknown large buried object with high ferrous return

62002	DHG_2017_ISUKF_002	1194185.62	5324179.55	102.64	3.48	2-4ft	Unknown object with ferrous return
62003	DHG_2017_ISUKF_003	1194178.63	5324966.44	66.49	7.18	2-4ft	Unknown object with ferrous return
62004	DHG_2017_ISUKF_004	1194151.79	5324955.46	64.78	5.74	2-4ft	Unknown object with ferrous return
62005	DHG_2017_ISUKF_005	1194382.10	5324422.64	55.99	9.64	2-4ft	Unknown object with ferrous return
62006	DHG_2017_ISUKF_006	1195271.37	5324645.72	73.56	2.38	4-8ft	Unknown debris with ferrous return

The ferrous unknown subbottom objects in the inner box are displayed on the multibeam surface with gradiometer return imagery for location reference in Figure 73 below.

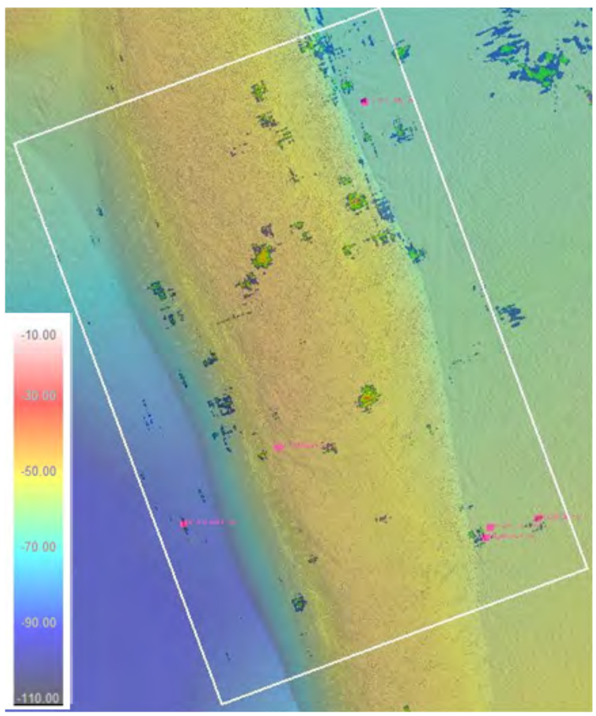


Figure 73 Locations of subbottom ferrous unknown objects

The ferrous subsurface objects range between 2 ft to 8 ft in size and 2 ft to 10 ft in depth of burial. The largest and least burred object (DHG_2017_ISUKF_001) has an estimated size of 48 ft and a burial depth of 2.3 ft. Images of this object and other ferrous subbottom objects displayed on the multibeam surface with the gradiometer return imagery and in the subbottom profile are shown below in Figure 74, Figure 75 and Figure 76.

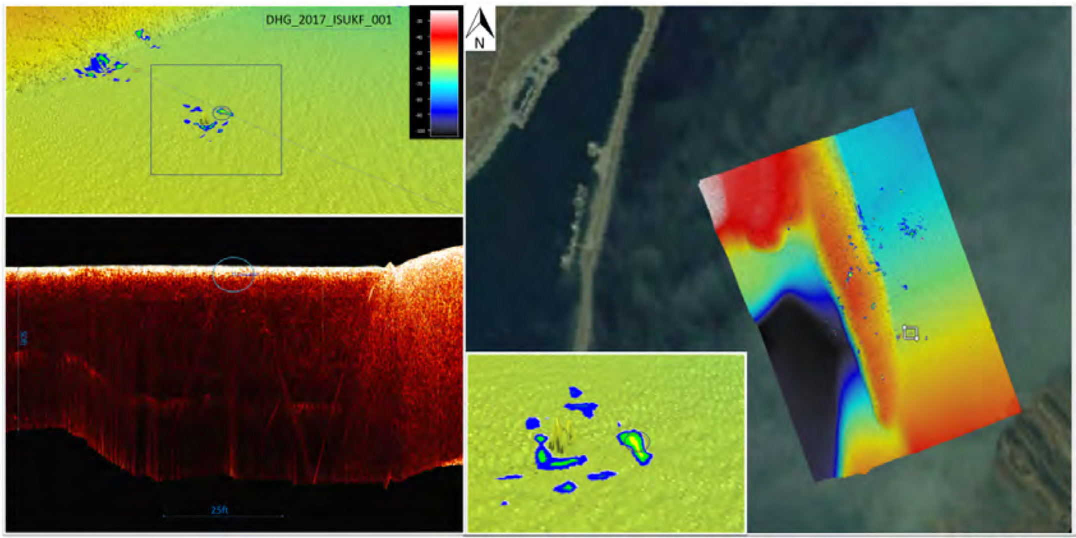


Figure 74 Subbottom Ferrous Object DHG_2017_ISUKF_001 Plan view (upper left) Subbottom profile (lower left) 3d view (center) Overview (right)

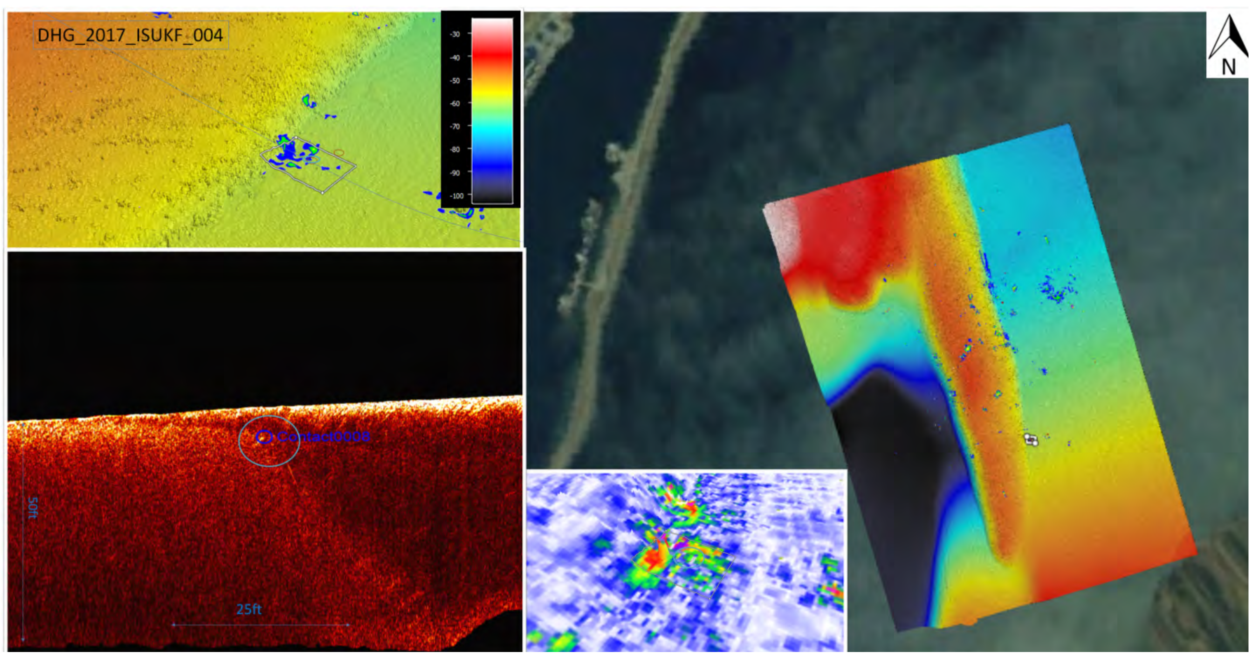


Figure 75 Subbottom Ferrous Object DHG_2017_ISUKF_004 Plan view (upper left) Subbottom profile (lower left) gradiometer return (center) Overview (right)

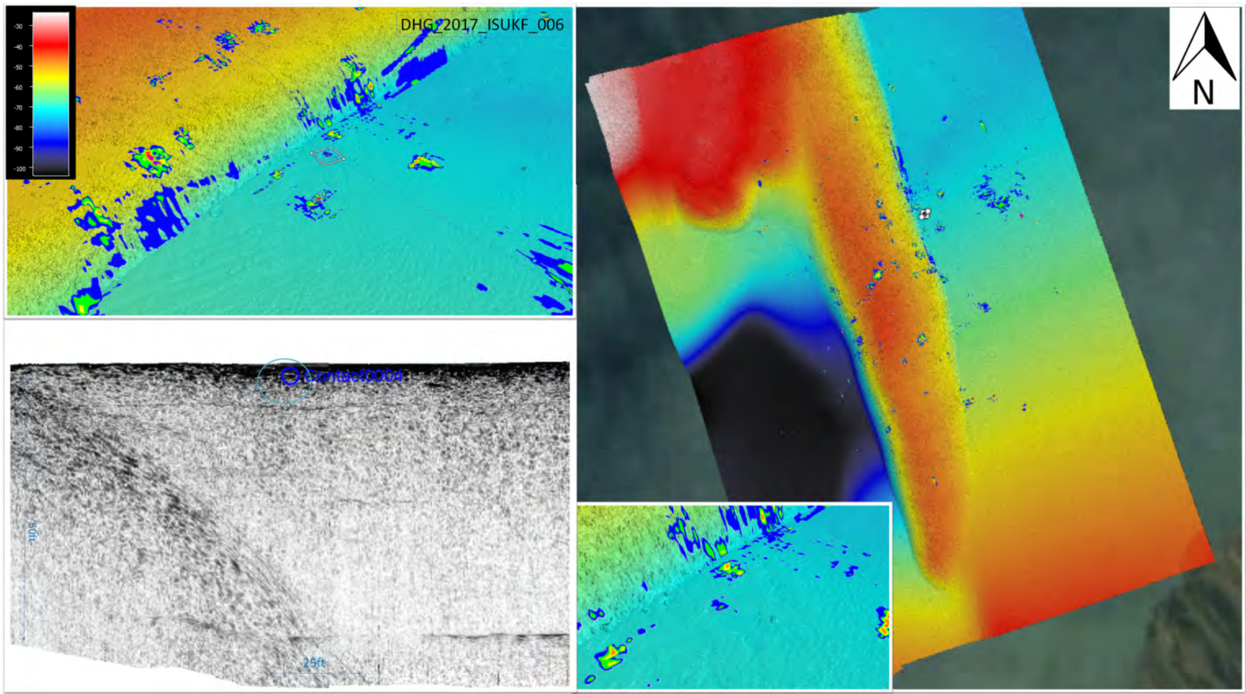


Figure 76 Subbottom Ferrous Object DHG_2017_ISUKF_006 Plan view (upper left) Subbottom profile (lower left) 3d view (center) Overview (right)

6.1.2.2 Unknown Non Ferrous Subsurface Object Inner Box

52 non ferrous objects were found in the inner box survey area. A full list of the objects is below in Table 12.

Table 12 List of unknown non ferrous subsurface objects in inner box

		NAD 83 US State Plane AK Zone 10				Dimensions in USFt	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Depth of burial (surface depth - object depth)	Estimated Size (largest dimension)	Description
156001	DHG_2017_ISUKNF_008	1195519.55	5324650.73	86.56	13.13	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156002	DHG_2017_ISUKNF_009	1194138.59	5325102.70	79.46	21.20	8-12ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156003	DHG_2017_ISUKNF_010	1194216.68	5325080.88	78.89	19.63	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156004	DHG_2017_ISUKNF_011	1194211.08	5325082.23	75.50	16.32	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder

156005	DHG_2017_ISUKNF_012	1194225.80	5325075.59	81.95	22.60	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156006	DHG_2017_ISUKNF_013	1194145.35	5325107.70	68.61	10.29	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156007	DHG_2017_ISUKNF_014	1194194.25	5325128.80	78.77	20.07	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156008	DHG_2017_ISUKNF_015	1194655.81	5323969.16	106.15	21.95	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156009	DHG_2017_ISUKNF_016	1194661.72	5323972.91	106.86	22.96	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156010	DHG_2017_ISUKNF_017	1194201.27	5325134.98	82.35	23.57	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156011	DHG_2017_ISUKNF_018	1194183.96	5325042.72	79.79	20.65	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156012	DHG_2017_ISUKNF_019	1193878.35	5324294.38	113.56	14.90	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156013	DHG_2017_ISUKNF_020	1194522.42	5324942.06	76.01	12.73	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156014	DHG_2017_ISUKNF_021	1195609.96	5324589.88	95.42	21.62	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156015	DHG_2017_ISUKNF_022	1194307.86	5325104.56	92.29	32.23	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156016	DHG_2017_ISUKNF_023	1194157.66	5325007.20	66.41	7.37	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156017	DHG_2017_ISUKNF_024	1193885.79	5324347.01	102.07	4.76	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156018	DHG_2017_ISUKNF_025	1194153.35	5325008.85	67.33	8.35	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156019	DHG_2017_ISUKNF_026	1195174.73	5324690.41	74.43	4.23	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156020	DHG_2017_ISUKNF_027	1195198.56	5324712.70	76.10	5.84	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156021	DHG_2017_ISUKNF_028	1193886.57	5324298.04	106.42	7.71	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156022	DHG_2017_ISUKNF_029	1194436.43	5324991.61	70.78	8.62	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156023	DHG_2017_ISUKNF_030	1194353.75	5325062.90	63.56	2.73	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156024	DHG_2017_ISUKNF_031	1195378.06	5324599.34	78.88	6.93	1-3ft	Unknown Non Ferrous Object in Inner Box -

							Likely a boulder
156025	DHG_2017_ISUKNF_032	1194343.00	5325082.68	77.85	17.24	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156026	DHG_2017_ISUKNF_033	1195458.15	5324681.27	83.09	10.53	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156027	DHG_2017_ISUKNF_034	1194365.18	5325059.35	76.81	15.85	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156028	DHG_2017_ISUKNF_035	1194311.07	5324155.98	117.92	21.15	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156029	DHG_2017_ISUKNF_036	1194130.69	5324997.30	75.69	16.90	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156030	DHG_2017_ISUKNF_037	1194321.43	5324152.37	123.18	26.62	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156031	DHG_2017_ISUKNF_038	1194035.09	5325001.26	83.38	25.62	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156032	DHG_2017_ISUKNF_039	1194247.09	5325078.46	60.91	1.37	2-4ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156033	DHG_2017_ISUKNF_040	1194353.39	5325086.45	72.92	12.27	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156034	DHG_2017_ISUKNF_041	1194387.51	5325048.77	91.62	30.40	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156035	DHG_2017_ISUKNF_042	1194110.33	5324985.99	71.19	12.50	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156036	DHG_2017_ISUKNF_043	1193881.17	5324337.35	105.23	7.72	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156037	DHG_2017_ISUKNF_044	1194170.83	5325029.51	64.41	5.27	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156038	DHG_2017_ISUKNF_045	1194101.66	5325036.69	66.14	7.84	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156039	DHG_2017_ISUKNF_046	1194555.08	5324910.82	71.29	7.64	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156040	DHG_2017_ISUKNF_047	1194982.48	5324759.20	72.18	3.85	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156041	DHG_2017_ISUKNF_048	1194980.65	5324751.68	76.22	7.82	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156042	DHG_2017_ISUKNF_049	1194089.77	5325126.34	65.80	8.16	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156043	DHG_2017_ISUKNF_050	1194589.12	5324027.69	111.76	24.38	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder

156044	DHG_2017_ISUKNF_051	1194167.26	5324475.18	55.29	5.56	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156045	DHG_2017_ISUKNF_052	1194135.38	5324175.22	101.99	1.95	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156046	DHG_2017_ISUKNF_053	1194131.31	5324919.28	60.19	2.22	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156047	DHG_2017_ISUKNF_054	1194192.68	5325151.49	90.90	32.33	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156048	DHG_2017_ISUKNF_055	1194132.50	5324914.64	66.20	8.70	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156049	DHG_2017_ISUKNF_056	1195670.29	5324562.67	92.38	18.96	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156050	DHG_2017_ISUKNF_057	1194554.02	5324889.63	82.76	19.07	3-6ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156051	DHG_2017_ISUKNF_058	1194235.70	5324221.00	103.45	5.64	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder
156052	DHG_2017_ISUKNF_059	1194169.04	5325058.28	60.50	1.53	1-3ft	Unknown Non Ferrous Object in Inner Box - Likely a boulder

The non ferrous unknown subbottom objects in the inner box are displayed on the multibeam surface for location reference in Figure 77 below.

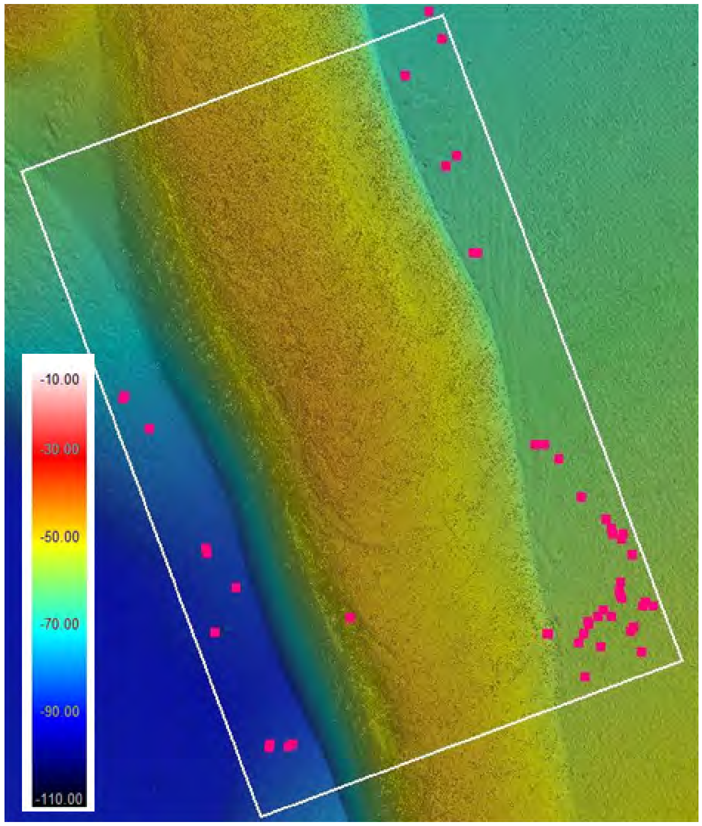


Figure 77 Locations of subbottom non ferrous unknown objects in Inner box

The non-ferrous subbottom objects in the inner box range between 1 ft to 12 ft in size and 1 ft to over 32 ft in depth of burial. The largest and least buried object (DHG_2017_ISUKNF_009) has an estimated size of 8-12 ft and a burial depth of 21.2 ft. Images of this object and other inner box non ferrous subbottom objects displayed on the multibeam surface and in the subbottom profile are shown below in Figure 78, Figure 79, and Figure 80.

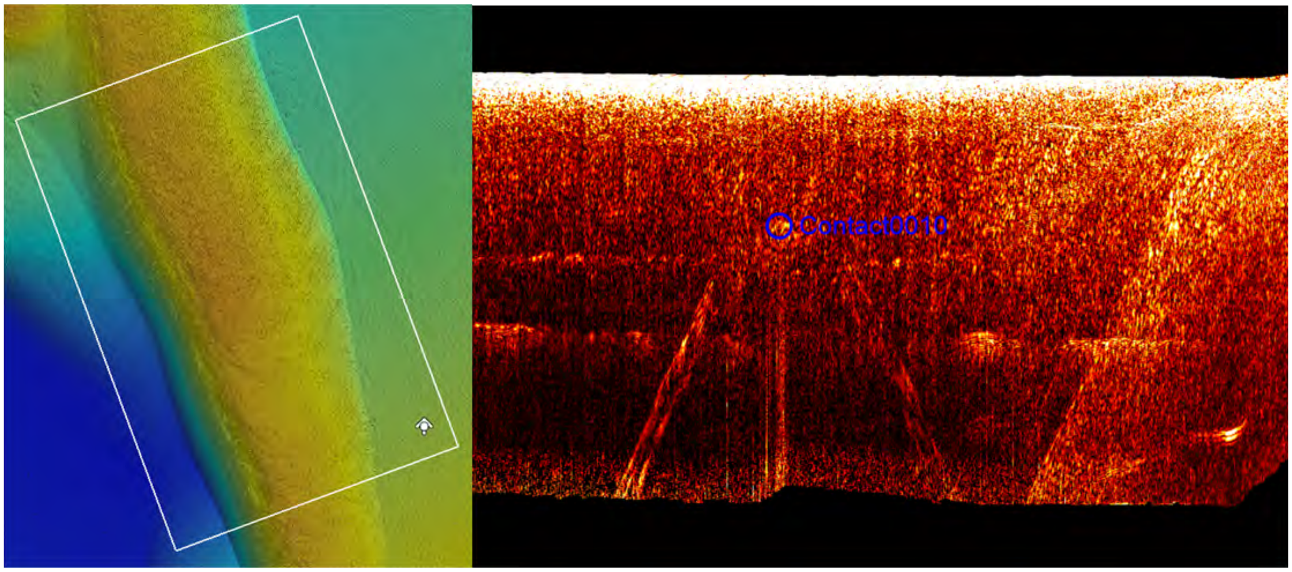


Figure 78 Large subbottom non ferrous object DHG_2017_ISUKNF_009 Overview (left) Subbottom profile (right)

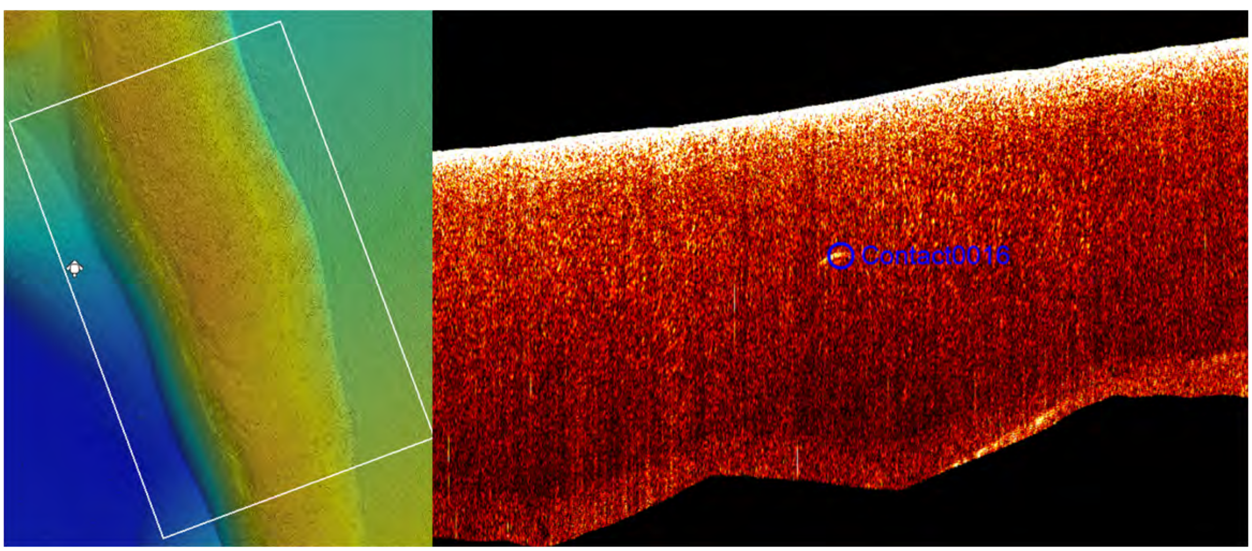


Figure 79 Subbottom non ferrous object DHG_2017_ISUKNF_015 Overview (left) Subbottom profile (right)

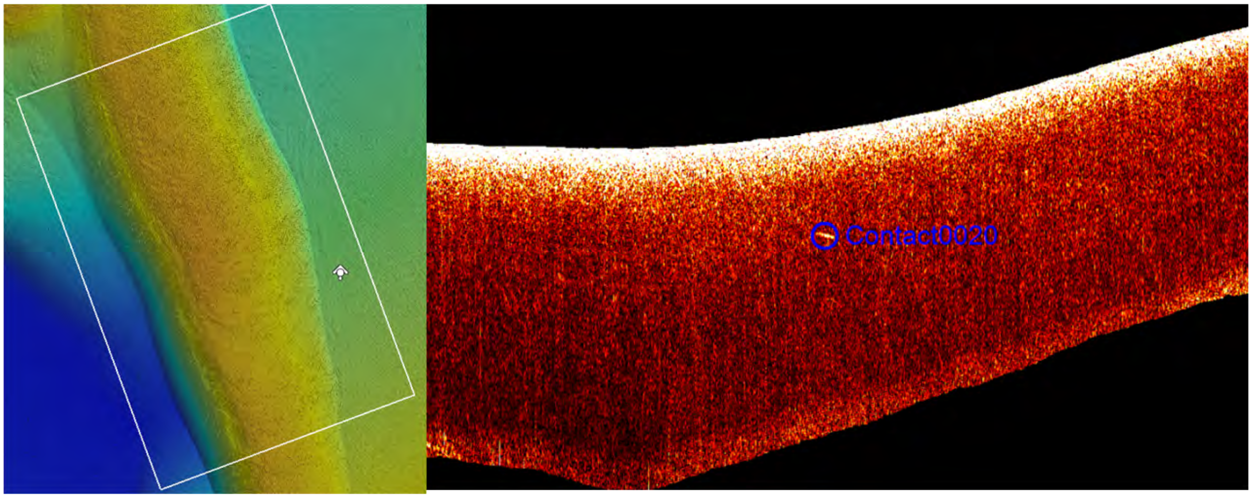


Figure 80 Subbottom non ferrous object DHG_2017_ISUKNF_019 Overview (left) Subbottom profile (right)

6.1.2.3 Unknown Subsurface Objects Outer Box Likely Boulders

42 unknown objects were found in the outer box boundary. These objects are most likely boulders. Objects found in the outer box are unable to be categorized as ferrous or non-ferrous. As stated in the Marine Geophysical and Bathymetric Survey Work Plan, gradiometer survey was not executed in the outer box survey area. A full list of the objects is below in Table 13.

Table 13 List of unknown subsurface objects in outer box likely boulders

		NAD 83 US State Plane AK Zone 10				Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Depth of burial (surface depth - object depth)	Estimated Size (largest dimension)	Description
181300	DHG_2017_OSUK_060	1195395.80	5325213.17	83.94	14.46	4-6ft	Unknown Object in Outer Box - Likely a boulder
181301	DHG_2017_OSUK_061	1194834.25	5325420.56	85.19	21.62	4-6ft	Unknown Object in Outer Box - Likely a boulder
181302	DHG_2017_OSUK_062	1195402.59	5325271.64	74.71	5.32	4-6ft	Unknown Object in Outer Box - Likely a boulder
181303	DHG_2017_OSUK_063	1195078.46	5324887.96	87.34	18.73	2-4ft	Unknown Object in Outer Box - Likely a boulder
181304	DHG_2017_OSUK_064	1196081.58	5324641.09	83.69	10.88	2-4ft	Unknown Object in Outer Box - Likely a boulder
181305	DHG_2017_OSUK_065	1195314.09	5325404.6	81.35	13.36	2-4ft	Unknown Object in Outer Box - Likely a boulder
181306	DHG_2017_OSUK_066	1194640.66	5325086.89	77.45	13.96	2-4ft	Unknown Object in Outer Box - Likely a boulder
181307	DHG_2017_OSUK_067	1194647.86	5325115.68	77.33	13.92	2-4ft	Unknown Object in Outer Box - Likely a boulder
181308	DHG_2017_OSUK_068	1195095.82	5324903.82	85.81	17.18	2-4ft	Unknown Object in Outer Box - Likely a boulder
181309	DHG_2017_OSUK_069	1194862.28	5324966.28	82.36	16.16	2-4ft	Unknown Object in Outer Box - Likely a boulder
181310	DHG_2017_OSUK_070	1194836.14	5325022.69	75.91	10.32	2-4ft	Unknown Object in Outer Box - Likely a boulder
181311	DHG_2017_OSUK_071	1195166.50	5325035.78	85.49	17.10	2-4ft	Unknown Object in Outer Box - Likely a boulder
181312	DHG_2017_OSUK_072	1194893.48	5324972.05	79.97	13.55	2-4ft	Unknown Object in Outer Box - Likely a boulder
181313	DHG_2017_OSUK_073	1193957.37	5325016.04	77.05	20.23	2-4ft	Unknown Object in Outer Box - Likely a boulder
181314	DHG_2017_OSUK_074	1195068.60	5324924.15	73.27	5.03	2-4ft	Unknown Object in Outer Box - Likely a boulder
181315	DHG_2017_OSUK_075	1195518.32	5325475.33	82.46	12.92	2-4ft	Unknown Object in Outer Box - Likely a boulder
181316	DHG_2017_OSUK_076	1194585.35	5325127.06	72.10	9.43	2-4ft	Unknown Object in Outer Box - Likely a boulder
181317	DHG_2017_OSUK_077	1193044.67	5325537.18	52.39	9.35	2-4ft	Unknown Object in Outer Box - Likely a boulder
181318	DHG_2017_OSUK_078	1194111.78	5325875.38	61.95	7.72	2-4ft	Unknown Object in Outer Box - Likely a boulder
181319	DHG_2017_OSUK_079	1195369.75	5325302.34	76.60	7.65	2-4ft	Unknown Object in Outer Box - Likely a boulder
181320	DHG_2017_OSUK_080	1196273.77	5324473.75	105.40	32.79	2-4ft	Unknown Object in Outer Box - Likely a boulder
181321	DHG_2017_OSUK_081	1196265.80	5324469.9	104.27	31.68	2-4ft	Unknown Object in Outer Box - Likely a boulder
181322	DHG_2017_OSUK_082	1192956.82	5324343.88	63.57	2.39	1-2ft	Unknown Object in Outer Box - Likely a boulder
181323	DHG_2017_OSUK_083	1194631.54	5325055.87	75.23	11.76	1-2ft	Unknown Object in Outer Box - Likely a boulder
181324	DHG_2017_OSUK_084	1194637.64	5325149.31	74.87	11.84	1-2ft	Unknown Object in Outer Box - Likely a boulder
181325	DHG_2017_OSUK_085	1195055.25	5324915.74	77.89	9.69	1-2ft	Unknown Object in Outer Box - Likely a boulder

181326	DHG_2017_OSUK_086	1195144.21	5325083.09	79.18	11.18	1-2ft	Unknown Object in Outer Box - Likely a boulder
181327	DHG_2017_OSUK_087	1195441.70	5324720.51	85.51	13.39	1-2ft	Unknown Object in Outer Box - Likely a boulder
181328	DHG_2017_OSUK_088	1195517.73	5325710.72	93.36	25.05	1-2ft	Unknown Object in Outer Box - Likely a boulder
181329	DHG_2017_OSUK_089	1196093.77	5324692.75	89.45	16.45	1-2ft	Unknown Object in Outer Box - Likely a boulder
181330	DHG_2017_OSUK_090	1195662.82	5324544.14	74.79	1.35	1-2ft	Unknown Object in Outer Box - Likely a boulder
181331	DHG_2017_OSUK_091	1194926.11	5323828.94	99.38	27.94	1-2ft	Unknown Object in Outer Box - Likely a boulder
181332	DHG_2017_OSUK_092	1195109.35	5323021.68	61.41	3.29	1-2ft	Unknown Object in Outer Box - Likely a boulder
181333	DHG_2017_OSUK_093	1194819.39	5323850.67	105.53	30.18	1-2ft	Unknown Object in Outer Box - Likely a boulder
181334	DHG_2017_OSUK_094	1193811.52	5325562.96	62.96	10.84	1-2ft	Unknown Object in Outer Box - Likely a boulder
181335	DHG_2017_OSUK_095	1192972.52	5324290.48	72.88	5.29	1-2ft	Unknown Object in Outer Box - Likely a boulder
181336	DHG_2017_OSUK_096	1194916.18	5325009.3	72.73	6.30	1-2ft	Unknown Object in Outer Box - Likely a boulder
181337	DHG_2017_OSUK_097	1193765.75	5324119.49	108.80	6.93	1-2ft	Unknown Object in Outer Box - Likely a boulder
181338	DHG_2017_OSUK_098	1194144.06	5325321.68	68.01	10.85	1-2ft	Unknown Object in Outer Box - Likely a boulder
181339	DHG_2017_OSUK_099	1194436.56	5323741.72	109.46	7.20	1-2ft	Unknown Object in Outer Box - Likely a boulder
181340	DHG_2017_OSUK_100	1195380.40	5325330.11	85.86	16.94	1-2ft	Unknown Object in Outer Box - Likely a boulder
181341	DHG_2017_OSUK_101	1194702.61	5324983.76	67.88	3.27	2-4ft	Unknown Object in Outer Box - Likely a boulder

The unknown subbottom objects in the outer box that are likely boulders are displayed on the multibeam surface for location reference in Figure 81 below.

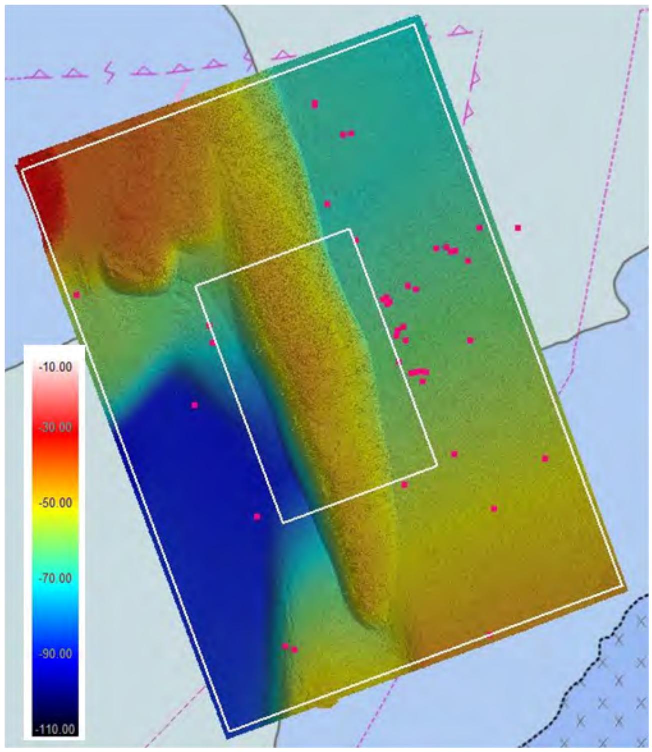


Figure 81 Locations of subbottom unknown objects in outer box likely to be boulders

The subbottom objects in the outer box likely to be boulders range between 1 ft to 6 ft in size and 3 ft to over 32 ft in depth of burial. Images of two of these objects are displayed on the multibeam surface and in the subbottom profile are shown below in Figure 82 and Figure 83.

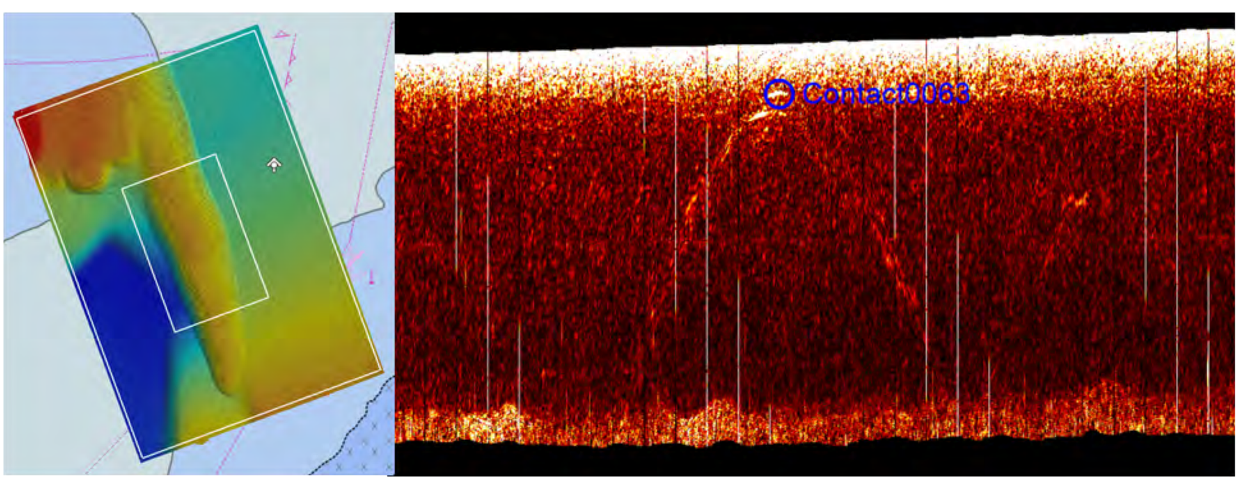


Figure 82 Subbottom object likely boulder DHG_2017_OSUK_062 Overview (left) Subbottom profile (right)

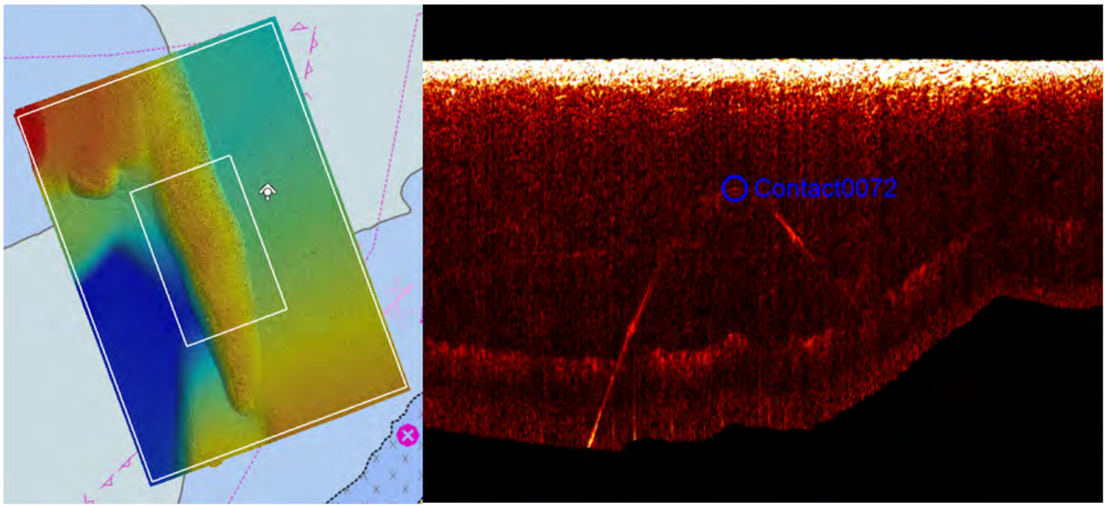


Figure 83 Subbottom object likely boulder DHG_2017_OSUK_071 Overview (left) Subbottom profile (right)

6.1.3 Unknown Subsurface Objects Outer Box

When analyzing the chirp data where no ferrous return was evident, every effort was made to use just the chirp data to determine if an object was natural (boulder, sediment feature) or non natural (potential obstruction). A unnatural feature was determined based on it being isolated from other contacts (in areas where rocks are evident at the surface contact subsurface would be deemed rock or boulders and therefore not unnatural), being shallow buried (it is assumed that obstructions would be relatively recent and therefore not buried more than 10ft) and/or having multiple returns rather than a single parabola.

13 unknown objects with unnatural shape were found in the outer box boundary. Objects found in the outer box are unable to be categorized as ferrous or non ferrous. As stated in the Marine Geophysical and Bathymetric Survey Work Plan, gradiometer survey was not executed in the outer box survey area.

A full list of the objects is below in Table 14.

Table 14 List of unknown subsurface unnatural objects in outer box

		NAD 83 US State Plane AK Zone 10				Dimensions in USft	
ID	Object ID	Northing	Easting	Depth (shoal point on object)	Depth of burial (surface depth - object depth)	Estimated Size (largest dimension)	Description
191000	DHG_2017_OSUKO_101	1194317.48	5325394.35	78.80	6.17	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191001	DHG_2017_OSUKO_102	1193823.50	5326111.18	70.61	6.22	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191002	DHG_2017_OSUKO_103	1193798.76	5326078.85	55.36	1.61	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191003	DHG_2017_OSUKO_104	1194845.26	5325382.91	65.77	0.59	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191004	DHG_2017_OSUKO_105	1196156.57	5324657.70	79.72	2.06	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191005	DHG_2017_OSUKO_106	1195449.35	5325337.44	72.07	0.80	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191006	DHG_2017_OSUKO_107	1195671.48	5325247.51	74.78	1.03	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191007	DHG_2017_OSUKO_108	1193820.77	5326055.52	52.28	0.57	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191008	DHG_2017_OSUKO_109	1195661.60	5325273.76	73.23	0.62	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191009	DHG_2017_OSUKO_110	1193693.69	5325152.18	54.82	0.58	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191010	DHG_2017_OSUKO_111	1193523.81	5325529.04	51.59	0.82	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191011	DHG_2017_OSUKO_112	1194749.14	5325008.71	67.61	0.83	2-4ft	Unknown Object in Outer Box - Non Natural Feature
191012	DHG_2017_OSUKO_113	1195553.94	5325295.13	71.28	0.28	2-4ft	Unknown Object in Outer Box - Non Natural Feature

The unknown subbottom objects in the outer box that are unnatural in shape are displayed on the multibeam surface for location reference in Figure 84 below.

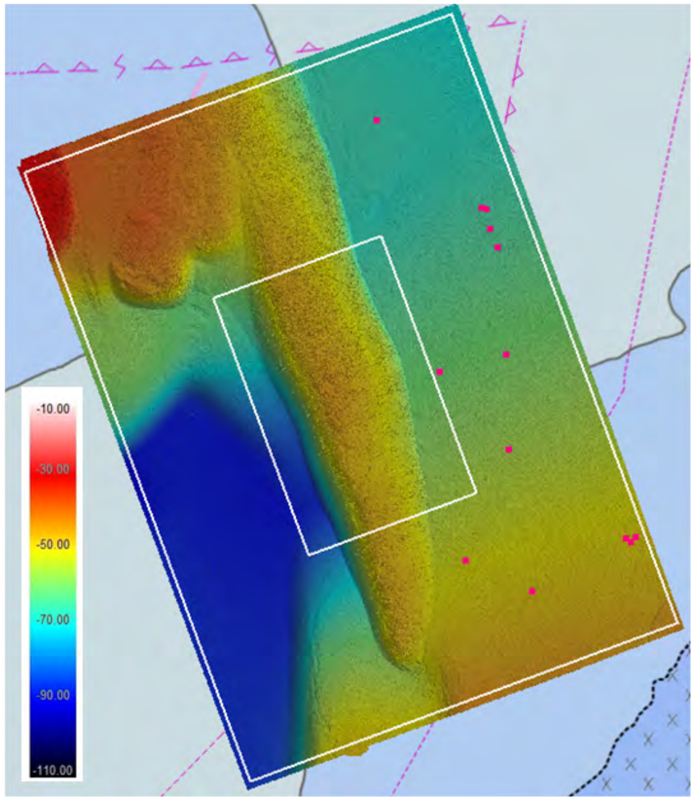


Figure 84 Locations of subbottom unnaturally shaped unknown objects in outer box

The subbottom objects in the outer box that are classified as non natural range between 2 ft to 4 ft in size and less than 0.5 ft to over 6 ft in depth of burial. Images of two of these objects are displayed on the multibeam surface and in the subbottom profile are shown below in Figure 85 and Figure 86.

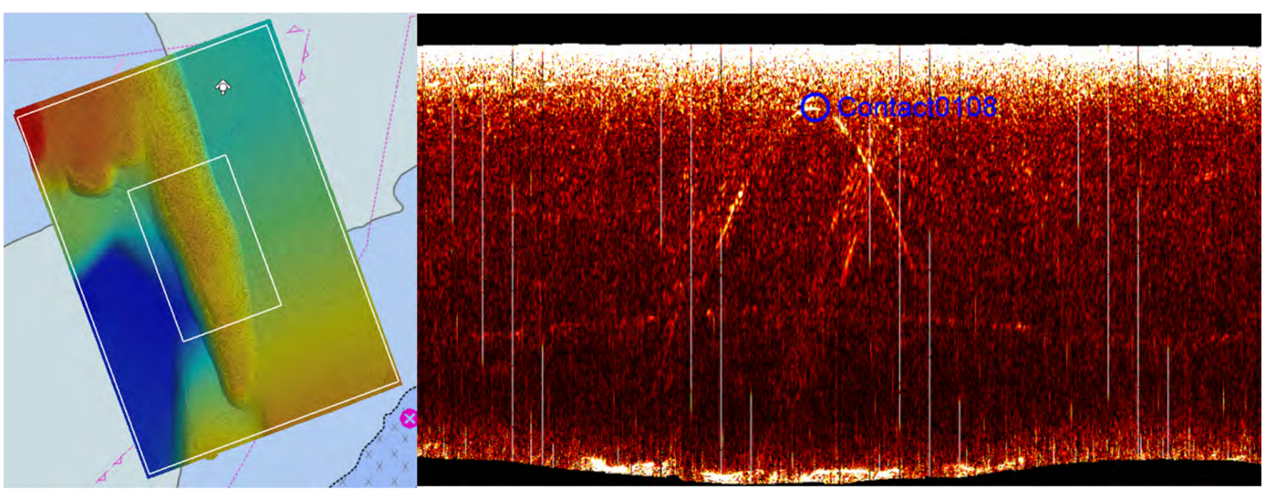


Figure 85 Unnatural subbottom object DHG_2017_OSUKO_105 Overview (left) Subbottom profile (right)

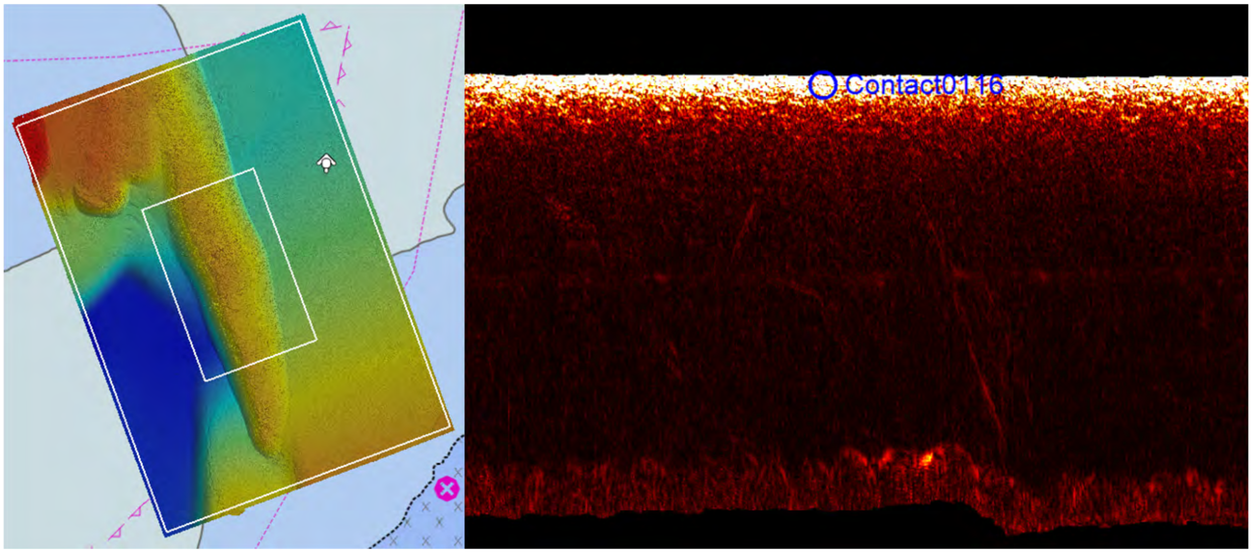


Figure 86 Unnaturally shaped subbottom object DHG_2017_OSUKO_113 Overview (left) Subbottom profile (right)

6.1.4 Ferrous Areas

In the survey area there were 9 locations that had strong gradiometer returns that were unable to be paired with a surface or subsurface object. These high returns were located in both flat and rocky areas on the bar. A full list of the areas is below in Table 15.

Table 15 List of Ferrous Areas

		NAD 83 US State Plane AK Zone 10		
ID	Object ID	Northing	Easting	Description
660001	DHG_2017_FA_001	1194510.21	5324658.88	rocky area
660002	DHG_2017_FA_002	1194495.51	5324283.06	flat area
660003	DHG_2017_FA_003	1194600.33	5324245.35	flat area
660004	DHG_2017_FA_004	1195302.14	5324372.54	rocky area
660005	DHG_2017_FA_005	1194894.35	5324602.00	mixed rocky and flat area
660006	DHG_2017_FA_006	1194923.75	5324692.12	rocky area
660007	DHG_2017_FA_007	1194868.78	5324378.29	rocky Area
660008	DHG_2017_FA_008	1194919.28	5324491.42	small rocks in flat area
660009	DHG_2017_FA_009	1194707.08	5324291.37	rocky area

The ferrous areas without a surface or subsurface object are displayed on the multibeam surface with gradiometer return imagery below in Figure 87. Examples of these areas on the multibeam surface and in the subbottom data are shown in Figure 88 and Figure 89 below.

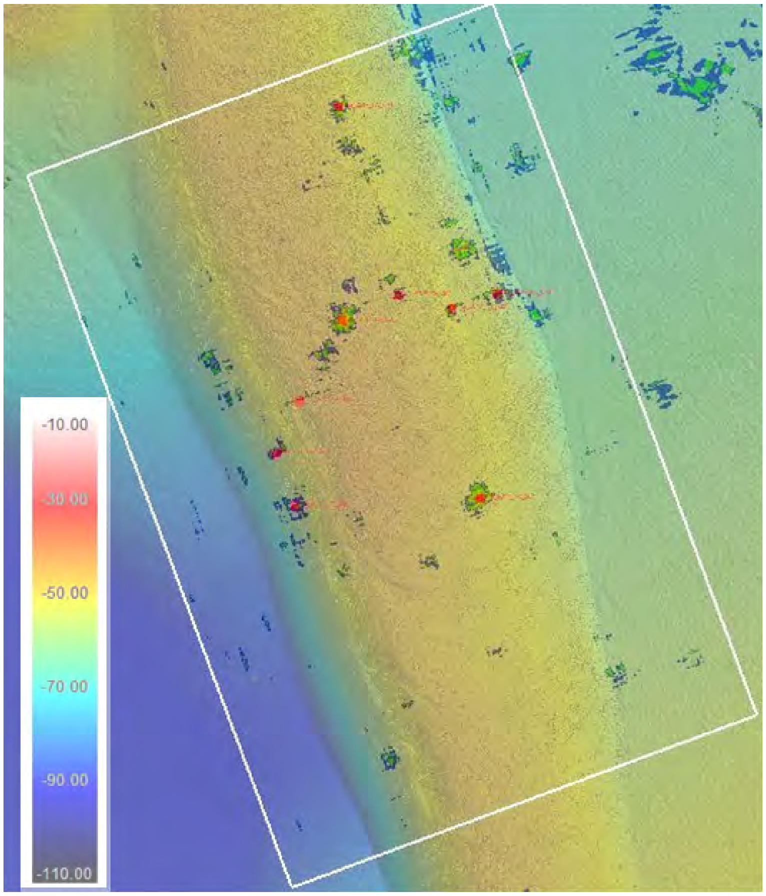


Figure 87 Ferrous Areas without objects

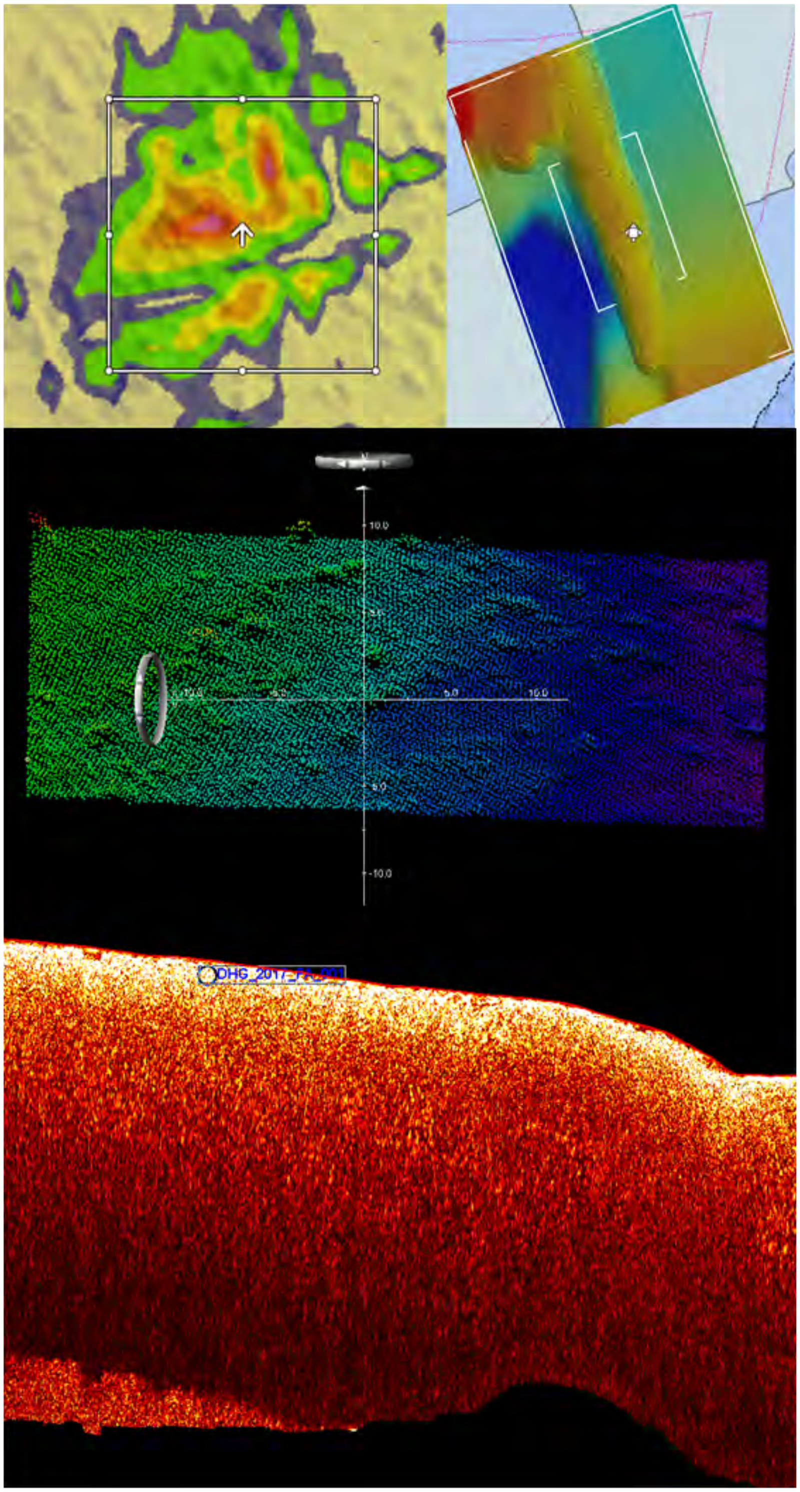


Figure 88 Rocky area with ferrous return DHG_FA_001 2d Plan view (upper left) Overview (upper right) 3d view (middle) and Subbottom profile (lower)

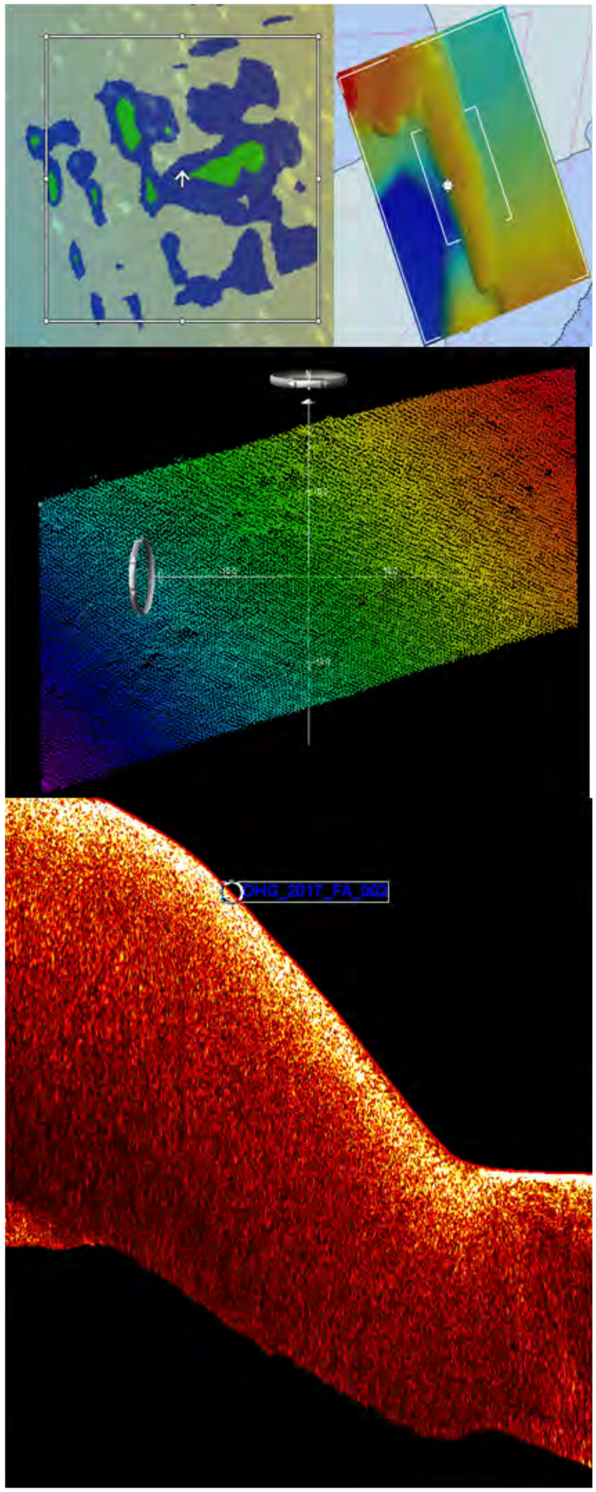


Figure 89 Flat area with ferrous return DHG_FA_002 2d Plan view (upper left) Overview (upper right) 3d view (middle) and subbottom profile (lower)

6.1.5 Overview

Several objects were noted at the surface and near subsurface with strong ferrous returns. Some surface objects could not determined as being be crab pots or other known objects. Due to the known presence of UXOs in the area (Navy 2016)[6] certain objects on the seafloor are considered a potential UXO. These are listed in Table 6. Subsurface objects with a ferrous return could be UXOs but it is not possible to decipher buried metallic debris from a UXO. Several objects outside of the survey area where the gradiometer was not run and could not be explained as being a known object such as a crab pot. Further investigation would be required on these objects to determine if these are UXOs.

[6] NAVTEC Site Inspection Report 28 July 2016 - Naval Defensive Sea Area Unalaska Island, Alaska Don 0716.503

6.2 Surface Classification

Surface classification was determined through multibeam backscatter and sediment sample analysis. The bar surface, trending northwest to southwest, is hard bottom, boulders, and rocks. The area east of the bar is sand. The sand moves into the channel (east to west) and wraps around the bar. The bar blocks larger sediment from transporting west, so the western survey area surface is clay and silt. The surface classification map is displayed below in Figure 90. Striation features, boulders, pockmarks, and erosion features were all identified using the multibeam surface. Volume 2 of 2, Drawings – Sheet 4 Geophysical Survey - Sediment Classification Map is a detailed plot of the surface sediment classification.

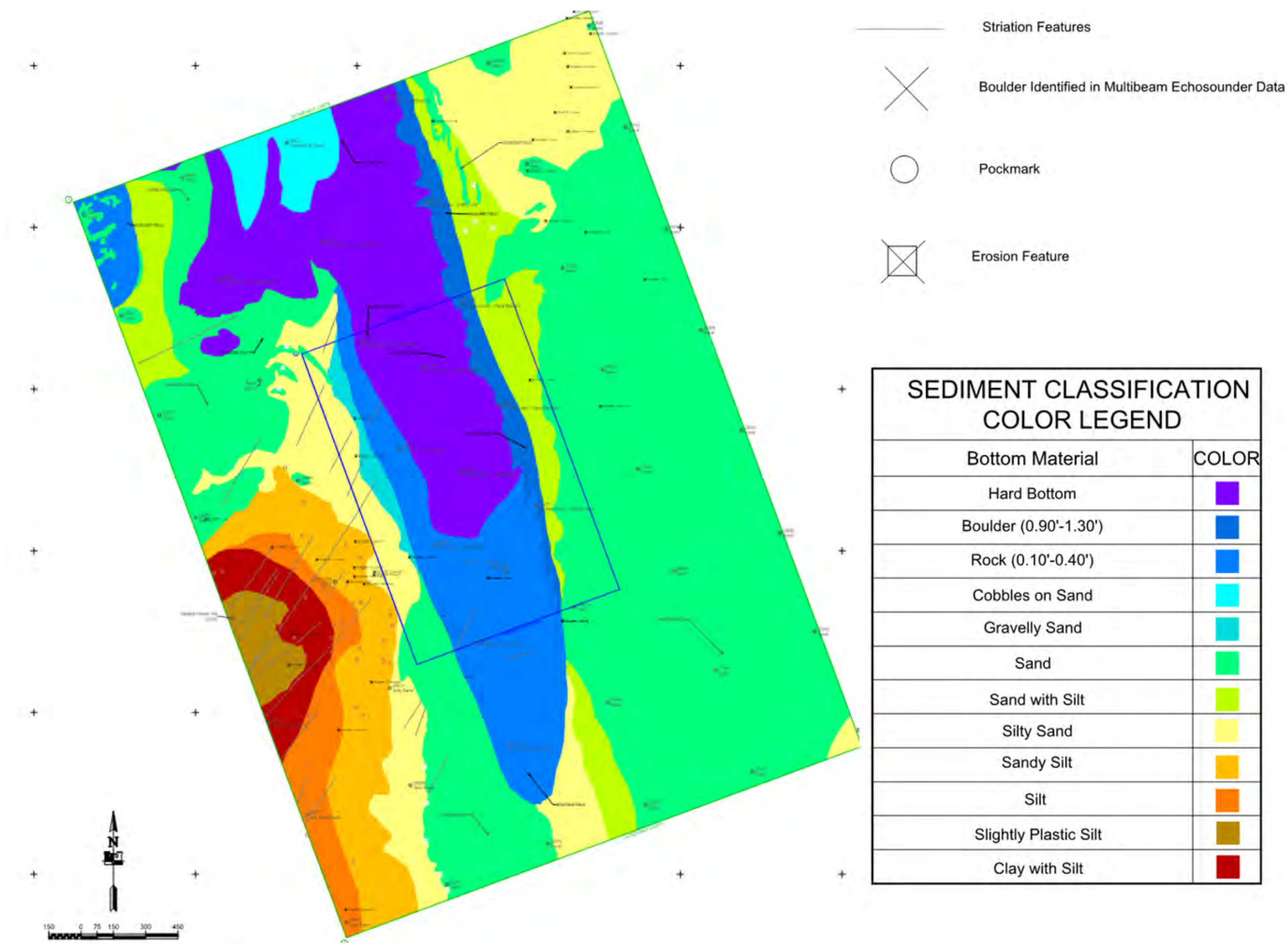


Figure 90 Surface Classification

6.2.1 Bar Feature

The bar extends approximately 3,225 feet from the northern border of the survey area towards the southern end of the survey area. The center area and shallowest point of the bar is hard bottom. The southern end of the bar, approximately 1,300 feet in length from the southern tip to the center of the bar is rocky.

The western side of the bar is generally straight across the channel from the north end of the survey area to the tip. The eastern side of the bar is straight and then curves slightly towards the tip creating a slight westward bend in eastern side of the bar. (See Figure 91 for a surface profile across the bar)

Length wise, the bar gradually slopes down from the center to the north and the south. Depths lengthwise along the top of the bar range from 49 to 42 feet in depth. Length wise, in the center of the bar where the hard bottom surface changes into a rock field there is a depth change of 1 ft. (see Figure 92 for a long profile of the bar).

The bar width wise is an un-centered mound with the apex closer to the western side. The eastern side of the bar rises steeply from the sandy flat bottom and then gradually rises to the apex. The western side of the bar rises steeply from the silty, flat bottom to the apex. At the widest point where the bar is across the harbor entrance, the width of the structure is 730 ft across. The shallowest point along this part of the bar is 42 ft. The steepest slope on the western side of the bar is 20° with an average of 14°. On the eastern side the maximum slope is 8° with an average of 6°.

On the eastern side of the bar there is a 90 ft wide section of boulders from the north end of the bar down to the start of the curve roughly 2/3 down the inner box boundary. Where the eastern side of the bar starts to curve there are few to no boulders. The flat surfaces surrounding the rocky tip end of the bar on the eastern and western sides are sand, sand with silt, and silty sand. Along the western edge of the bar at the foot of the slope are gravelly deposits. Within this area are multiple large boulders.

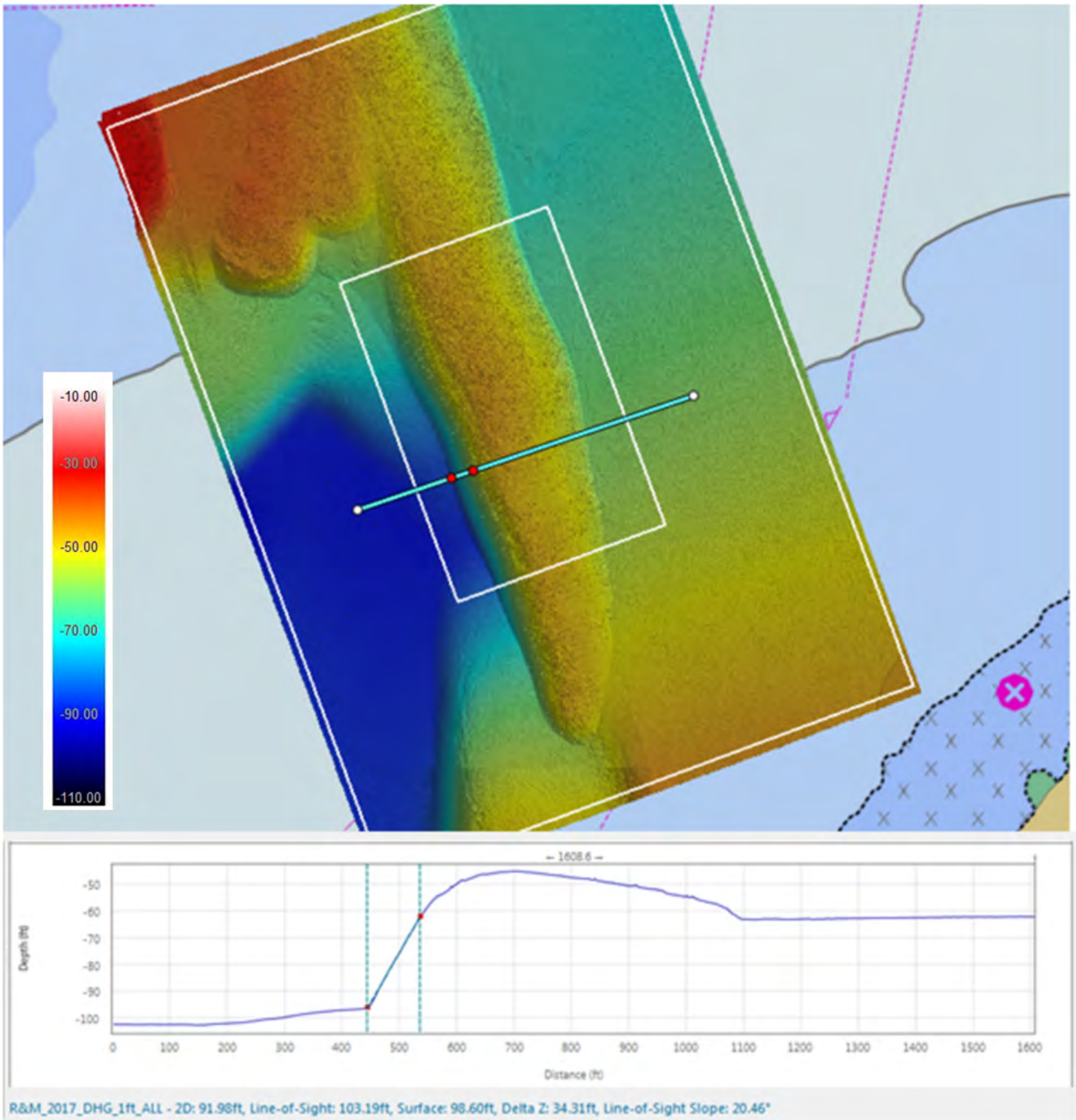


Figure 91 Surface profile across the bar feature

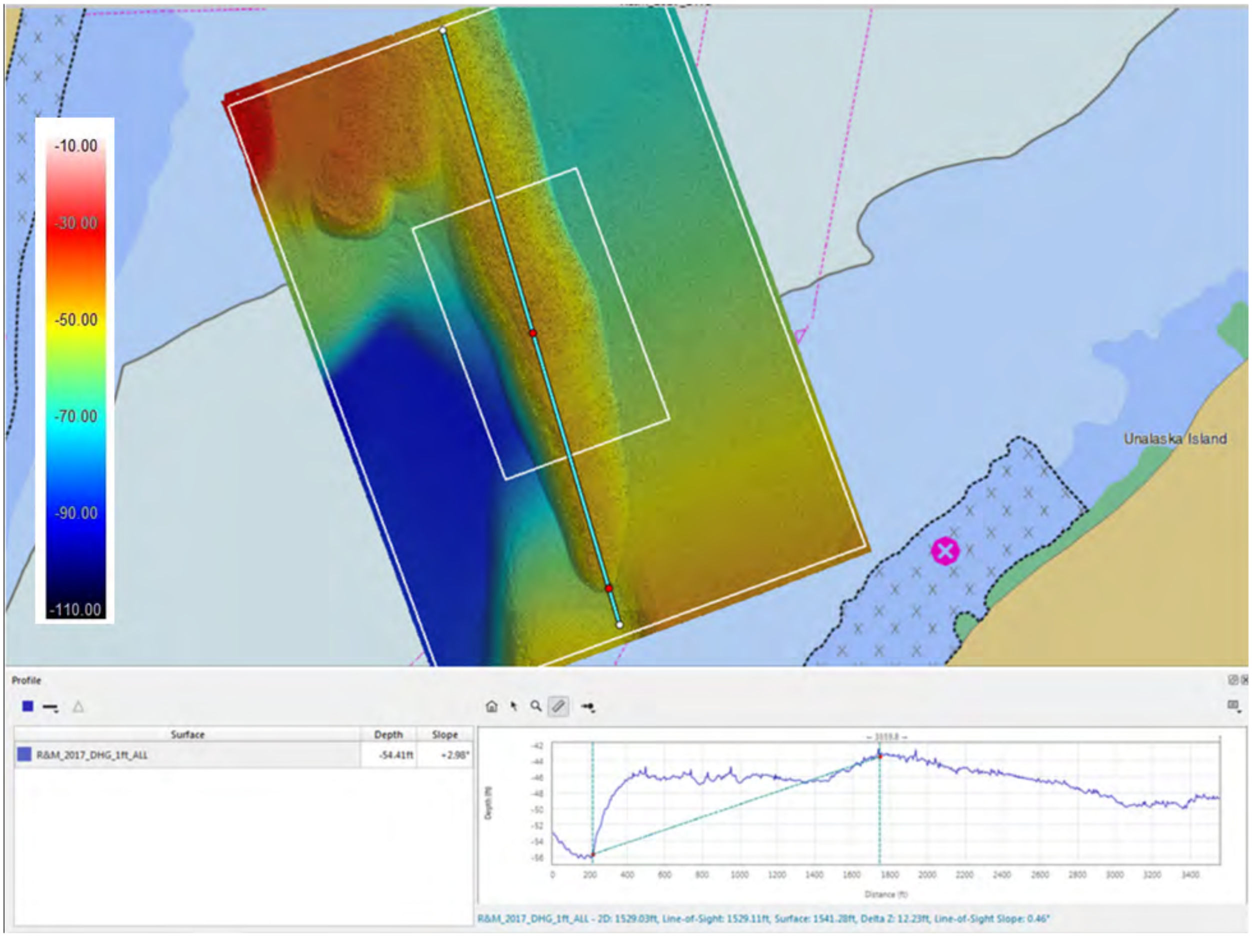


Figure 92 Surface profile along the bar feature

6.2.2 Surrounding Surface Sedimentation

The eastern section of the survey area is sand with silty, sand in the upper north eastern corner and the edge of the southeastern corner. The eastern edge of the bar is sand with silt. The bar is hard bottom, rocks and boulders. The western edge of the bar is sand and gravelly sand. The lower half of the survey area on the western side of the bar transitions east to west from silty, sand to clay with silt and slightly plastic silt. The upper half of the survey area on the western side of the bar is hard bottom that transitions to sand with silt. The northeastern corner of the survey area is rocks and sand.

6.2.3 Boulder Fields, Pockmarks, Striations and Sandwaves

Several surface sediment features were noted in the survey area. Boulders fields were located on top of the main bar feature, but also to the northwest and west of the feature. Boulders observed in the areas were up to 2 ft wide with a density such that little space between individual boulders were evident. An example of the boulder field north west of the bar is shown in Figure 93 and the boulder field on top of the bar is below in Figure 94.

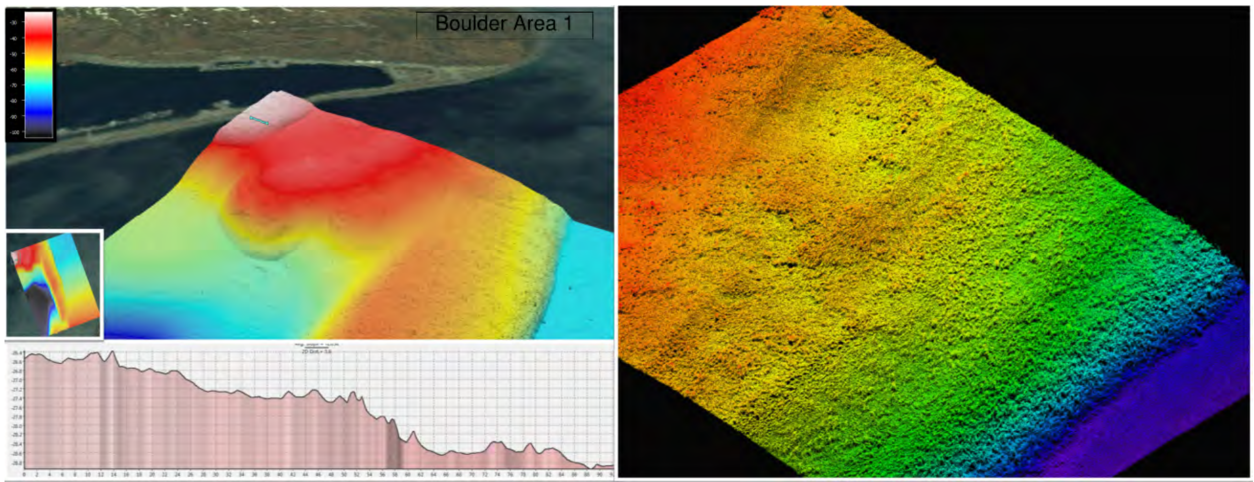


Figure 93 Boulder field to the north west of the bar feature

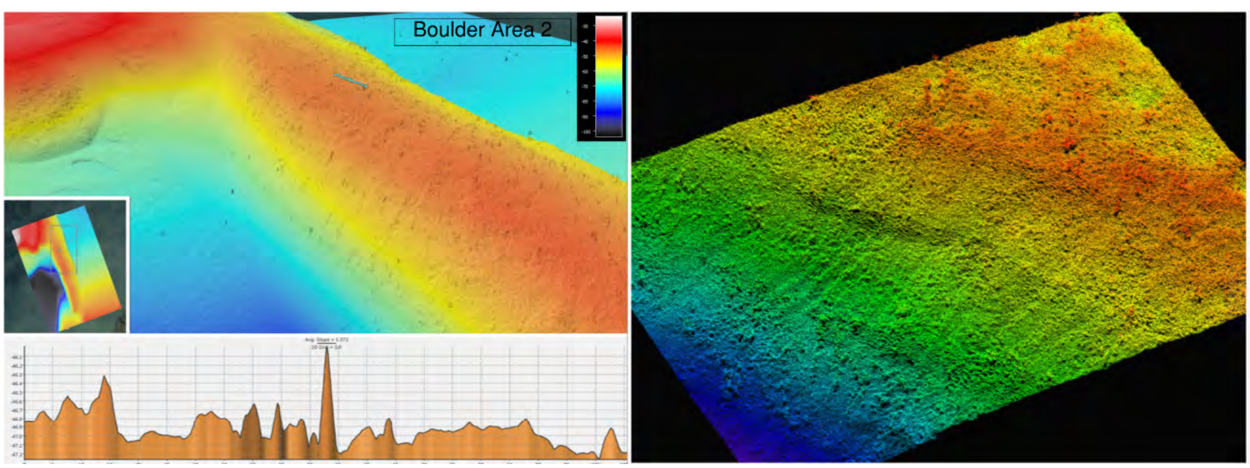


Figure 94 Boulder field along the top of the bar

Large areas of sandwaves are located to the south, east, and northwest of the bar. Differences in the wavelength the sandwaves were observed in each area. Wavelengths ranged from 18 ft in the east to 5 ft in the northwest. The sandwave heights were all similarly 0.3 ft. The largest sandwave area to the east of the bar is shown below in Figure 95.

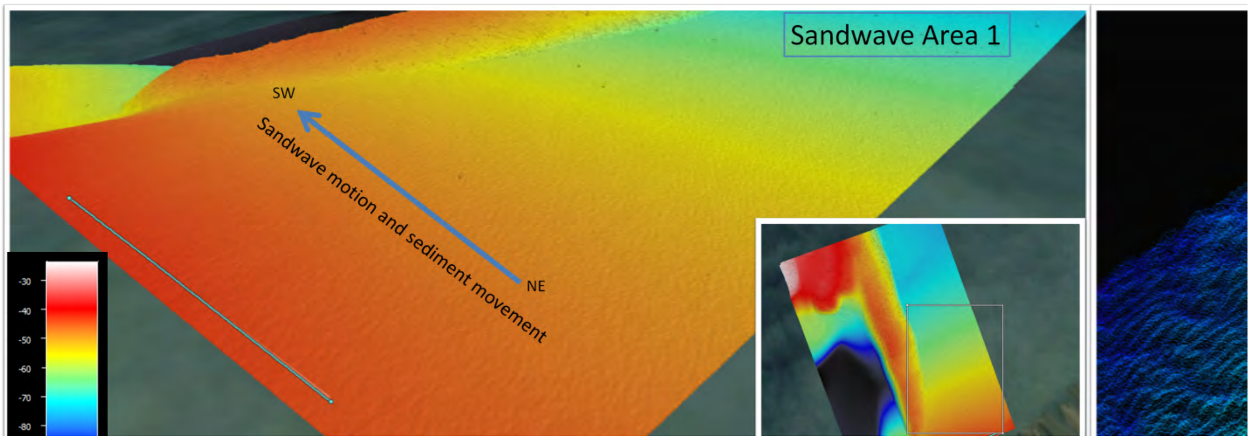


Figure 95 Large area of sandwaves to the south east of the bar

To the west in the silt and clay areas, pockmarks were noted. Several of the pockmarks are associated with a deposited boulder, however, in many there is no associated deposit. An example of these pockmarks is shown in Figure 96. The features range from being 7 ft to up to 18 ft wide.

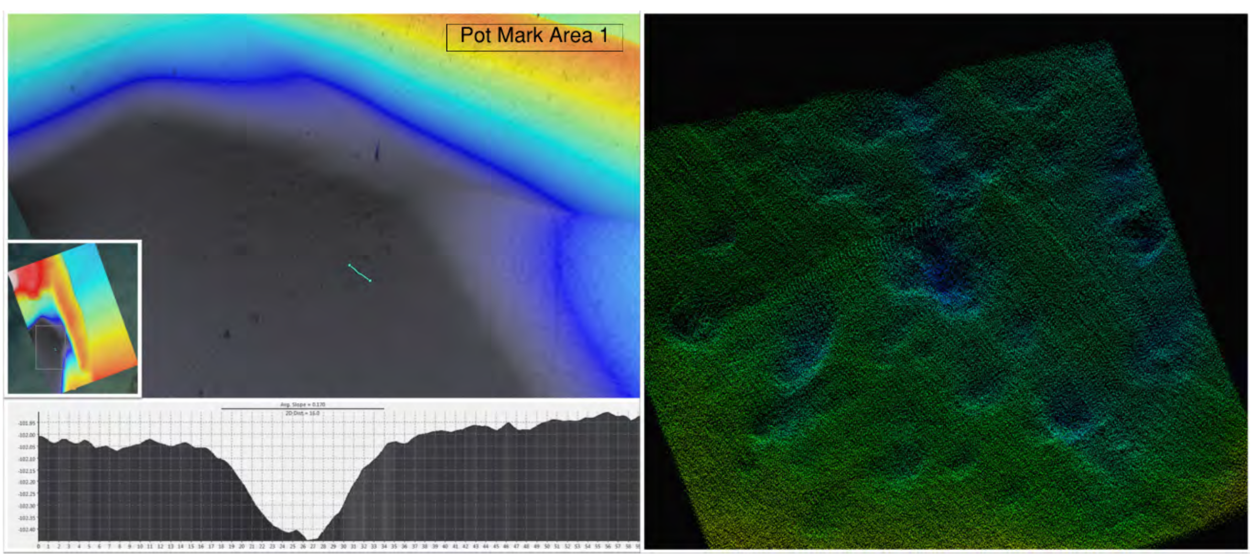


Figure 96 Example of a pockmark to the west of the bar

Several striations running along the northeast southwest axis were visible at the surface. It is not known if these are manmade or natural. The striations are noted along the west side of the bar. The features are up to 25 ft wide and 0.5 ft deep. The entire length of the striations was often outside of the survey area were at least 1,000ft long. An example of one of the features is shown below in Figure 97.

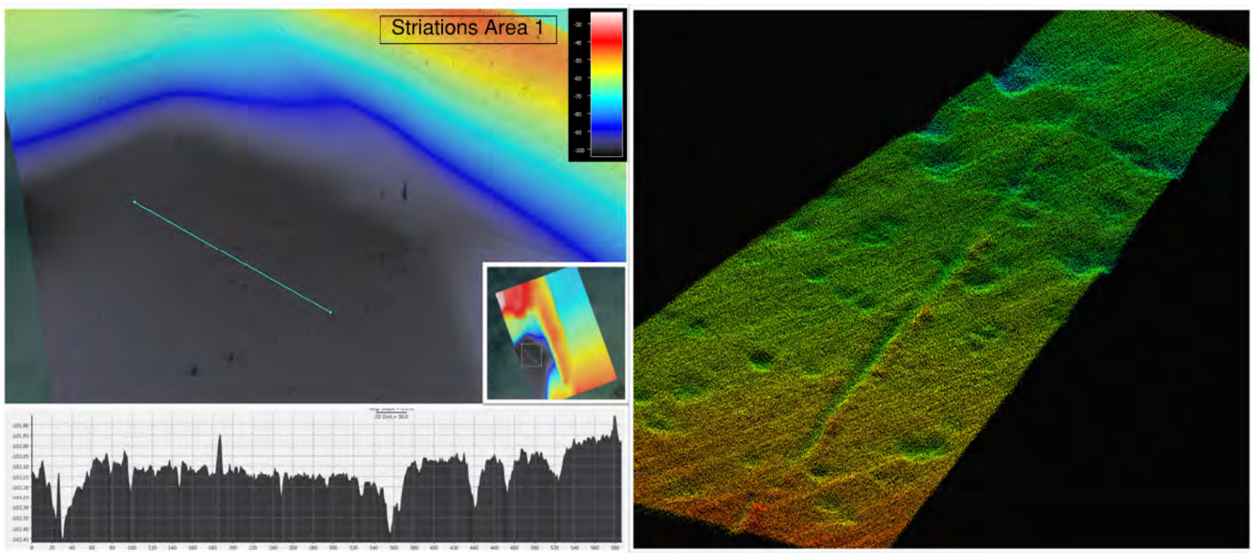


Figure 97 Example of Striation Feature to the west of the Bar

Curved features that form scarp formations where sand was deposited on top of silt and clay were noted across the survey area. These features were found with dimensions up to 30 ft wide and 0.5 ft deep. One of these features, to the west of the bar is shown below in Figure 98.

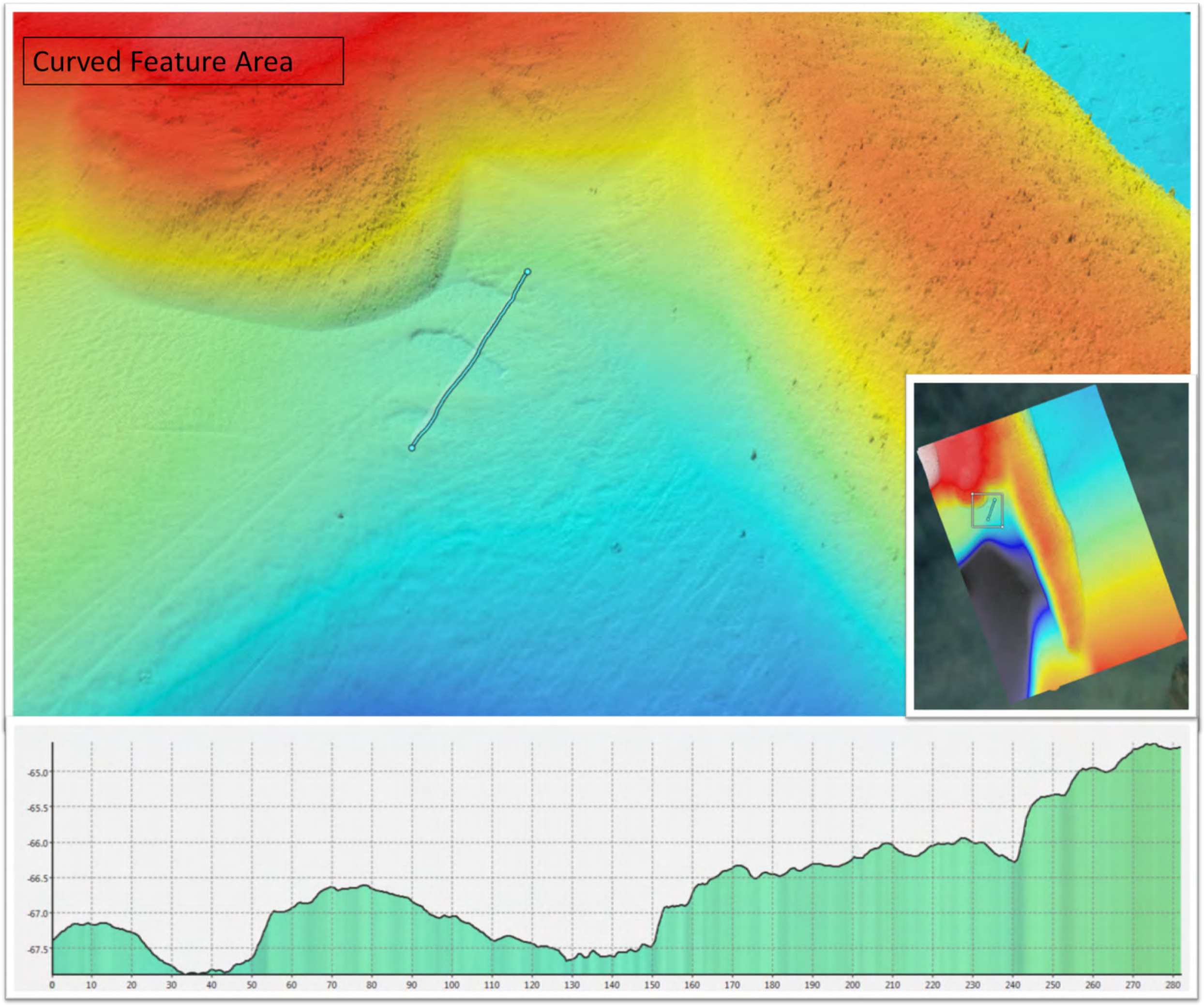


Figure 98 Curved feature with scarp formation, sand on top of silt and clay

6.3 Subsurface Classification

Distinct regions of subsurface stratification were identified. These are described below in turn. An overview over the subsurface stratification is shown in Figure 99. Volume 2 of 2, Drawings – Sheet 7 - Geophysical Survey Sub-Surface Overview & Profile Lines is a detailed plot of the subsurface strata and Volume 2 of 2, Drawings - Sheets 8 to 12 show the designated cross section profiles. The profiles are based on the 3D surface model created from the sound velocity corrected, digitized horizons. Interpreted seismic profiles of both Bubble Gun and Chirp data can be found in Appendix E - Seismic Profiles. The Appendix in PDF form has layers where interpretations over the seismic profile image can be viewed or turned off.

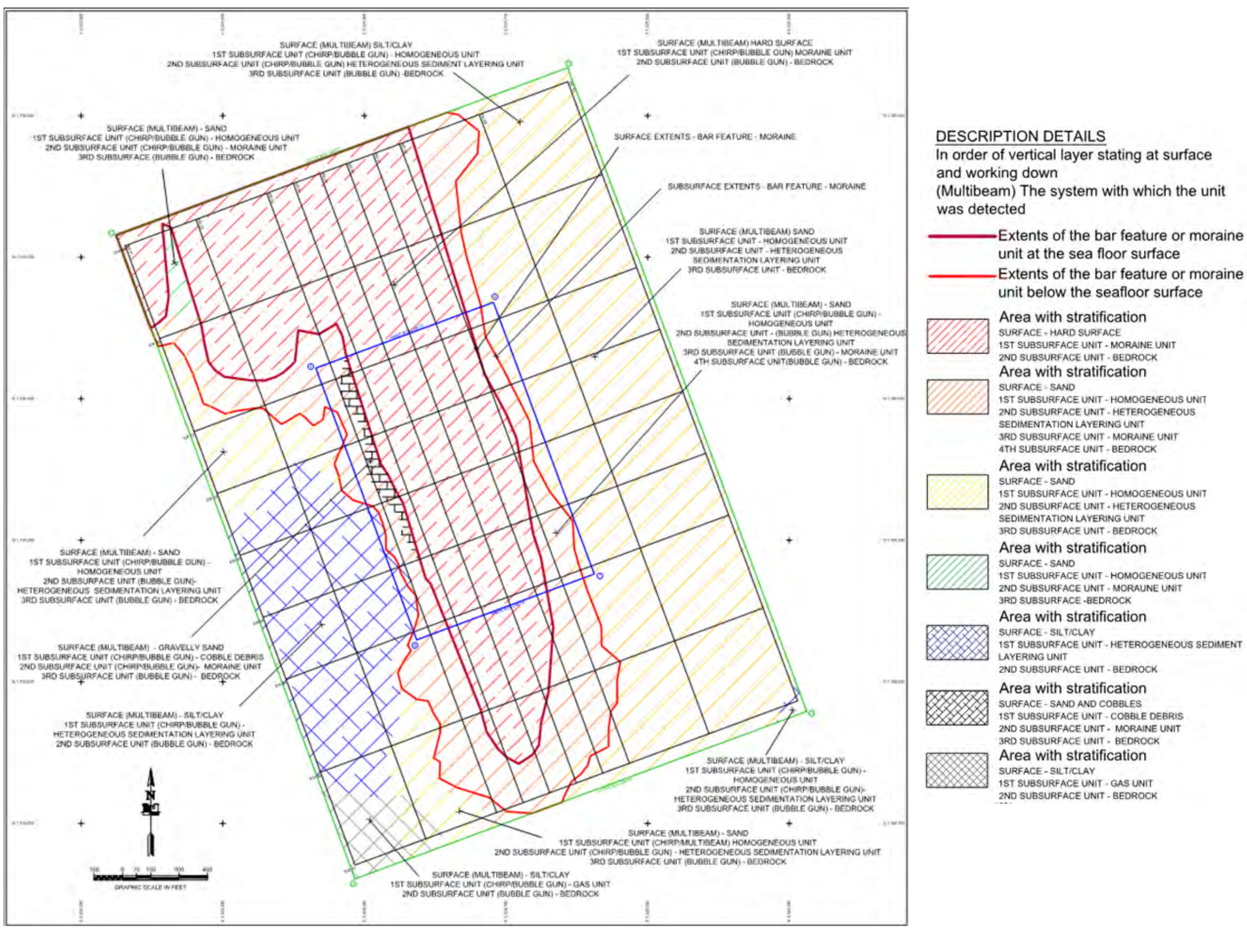
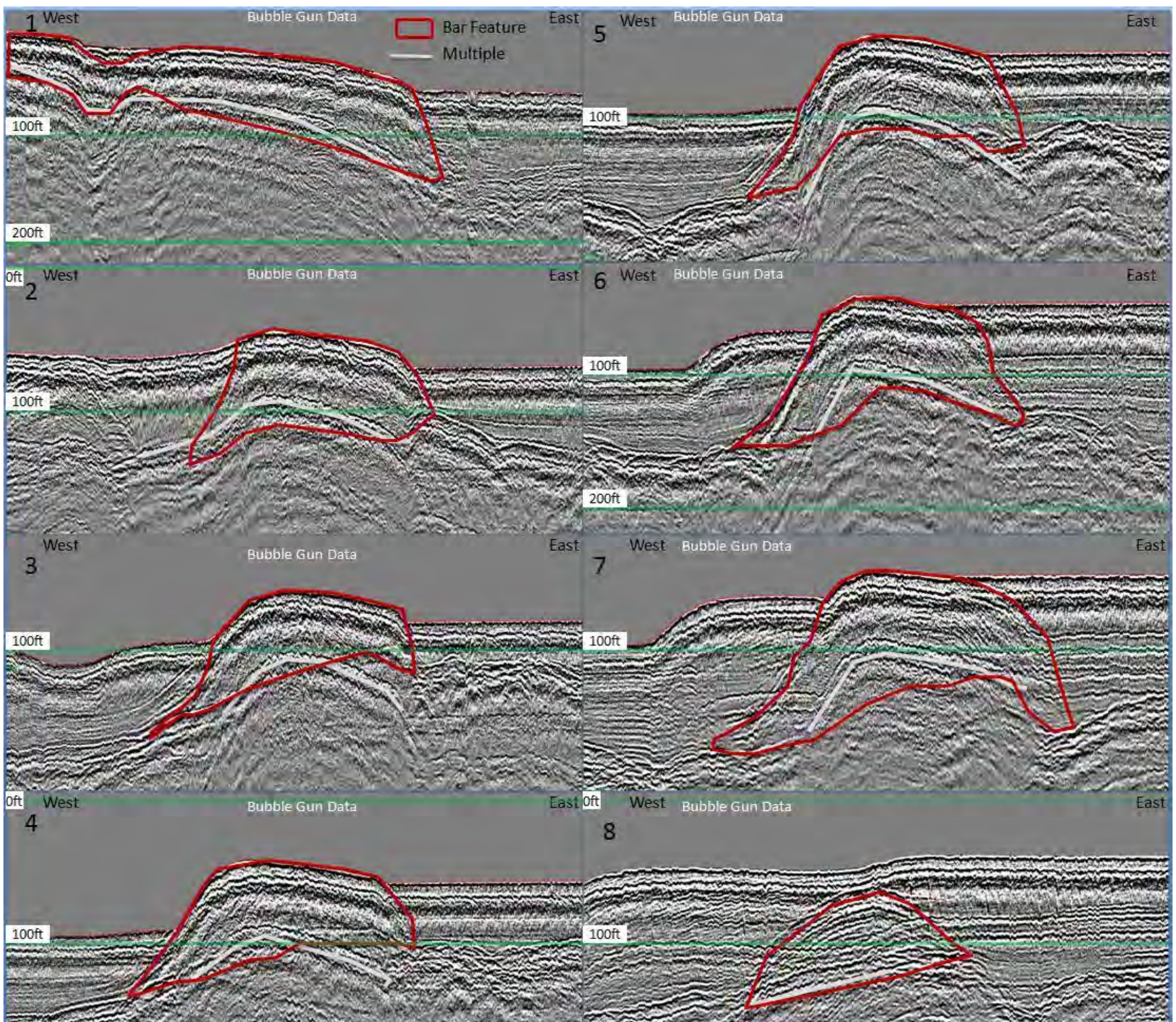


Figure 99 Subsurface Classification Overview

6.3.1 Bar Feature

The bar feature was a consistent structure with little penetration below. However, there was enough penetration to discern it from the bedrock that it overlies. The surface across the bar feature is hard and rocky. This surface structure appears to continue to the subsurface. Within both the Bubble Gun and Chirp datasets there is no evidence of material change across the bar. The return is similar across and along the feature. In addition, the structure is considered consistent and consolidated. There is no evidence of harder features within a less consolidated deposit material. Figure 100 shows profiles centered on the top of the bar feature. These show a similar acoustic signature in the bar feature along all profiles. A strong return is evident at the surface and then a diffusion of the amplitude below the surface. The multiple returns are much stronger showing the loss of energy. Within the bar structure the unit is homogeneous. There is no change of sediment within the structure.



Profiles all running West to East across bar. Feature. Line 1 is most northern and line 8 most southern. Depth below MLLW based on a constant sound speed of 5085ft/s

Figure 100 Profiles across the top of the bar

Lines run north to south along the bar structure show similar consistency in that axis. The hard surface diffuses energy and there is little in the way of a return below the bar along the entire line. This is shown below in Figure 101.

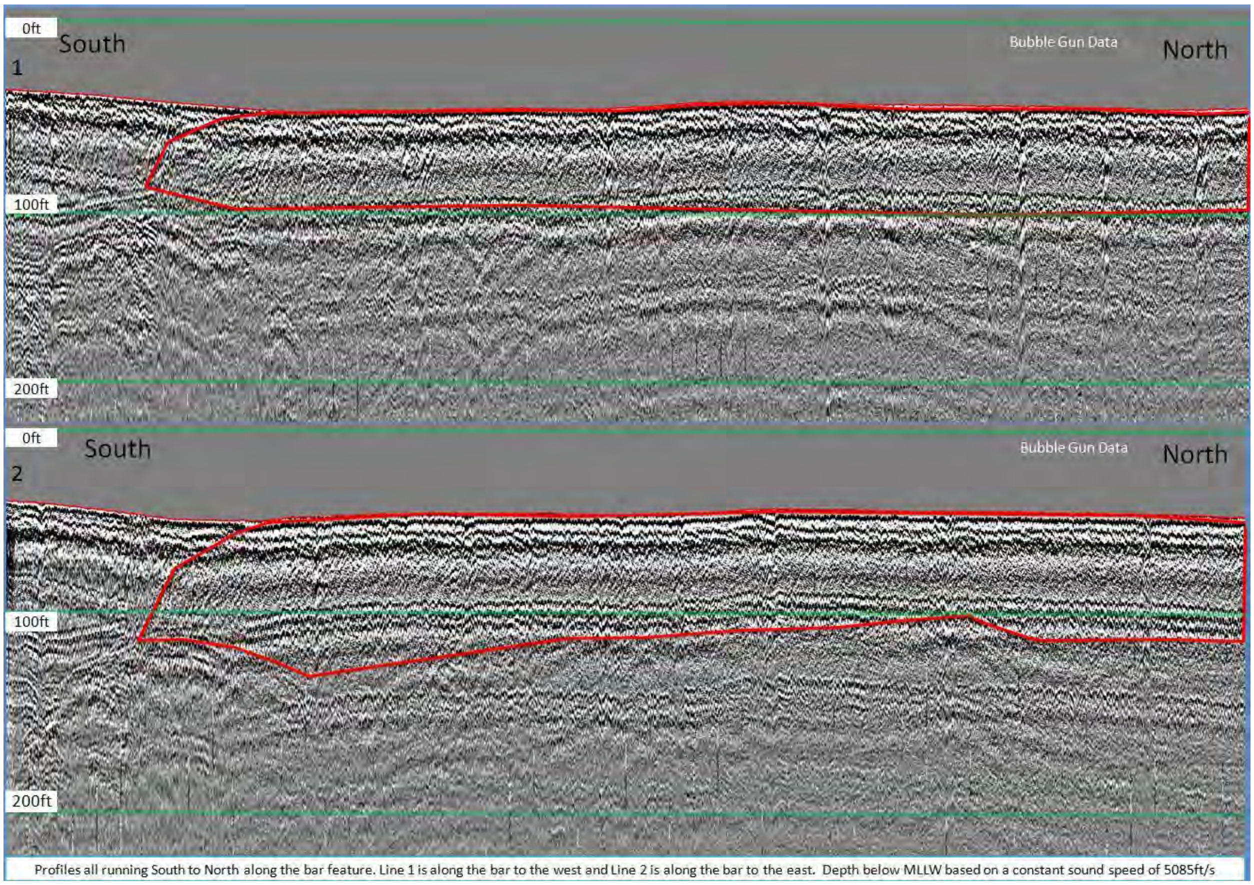


Figure 101 Profile along the top of the bar

The consistency of the material making up the bar feature could be considered bedrock. However, this theory was seen as incorrect for two main reasons. Firstly, across the profiles, while there was not clear penetration, there was some penetration below the bar feature to the bedrock below. This was particularly evident on a profile at the end of the bar and one in the middle of the feature. These are shown below in Figure 102. Penetration was reduced at the apex of the bar, but at the edges there was clear return from the bedrock below the bar feature.

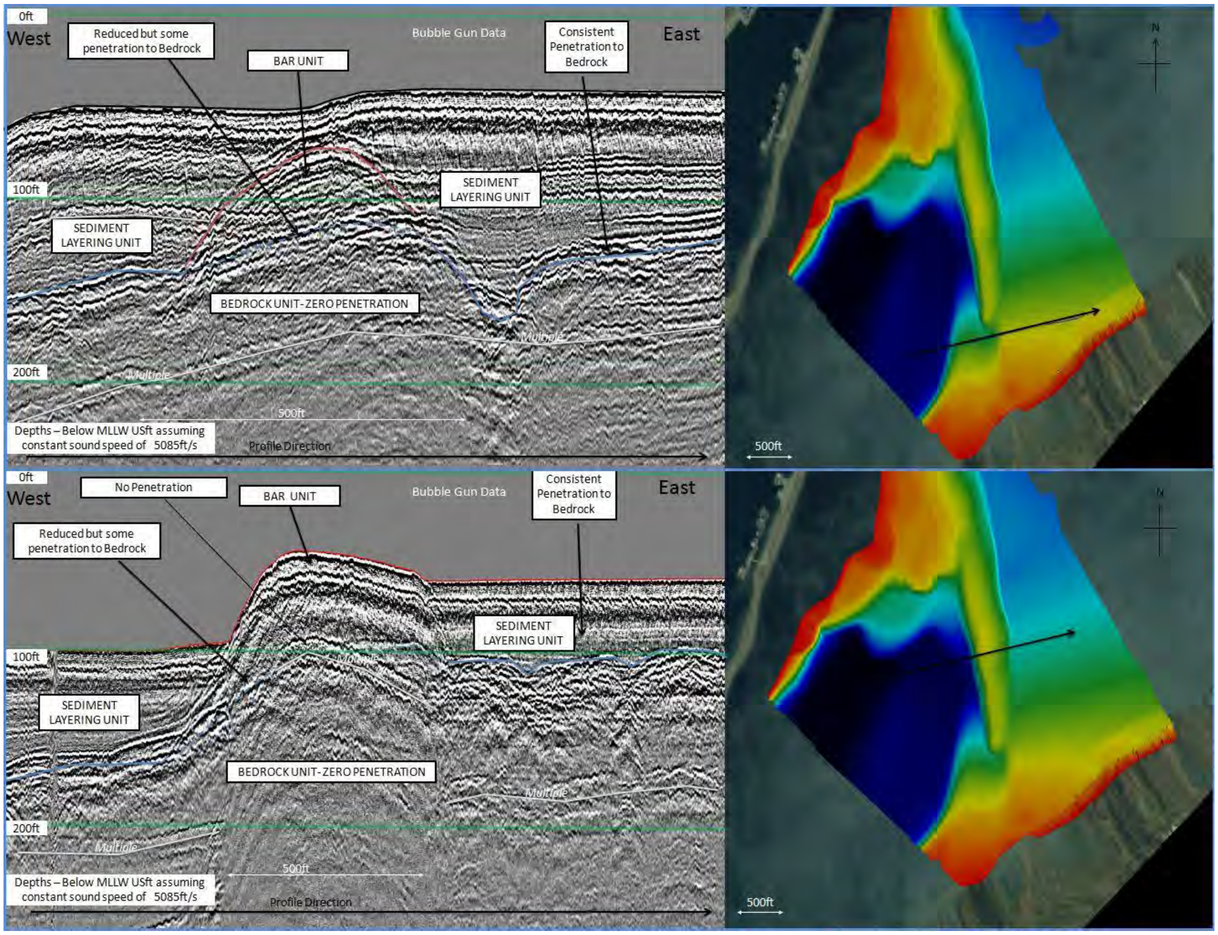


Figure 102 Profiles across the bar showing examples of penetration below the bar feature to bedrock

Secondly, when mapping the bedrock across the survey area and comparing it to the bar feature the bar feature is distinctly different from the surrounding bedrock. It is anomalous to the shape and size of the bedrock formations. This is shown below in Figure 103 . The figure is the complete bar structure digitized and modeled above and below the surface, and overlies the surrounding bedrock. The bar structure possesses steep slopes, change in elevation and curvature that is distinctly different to the bedrock.

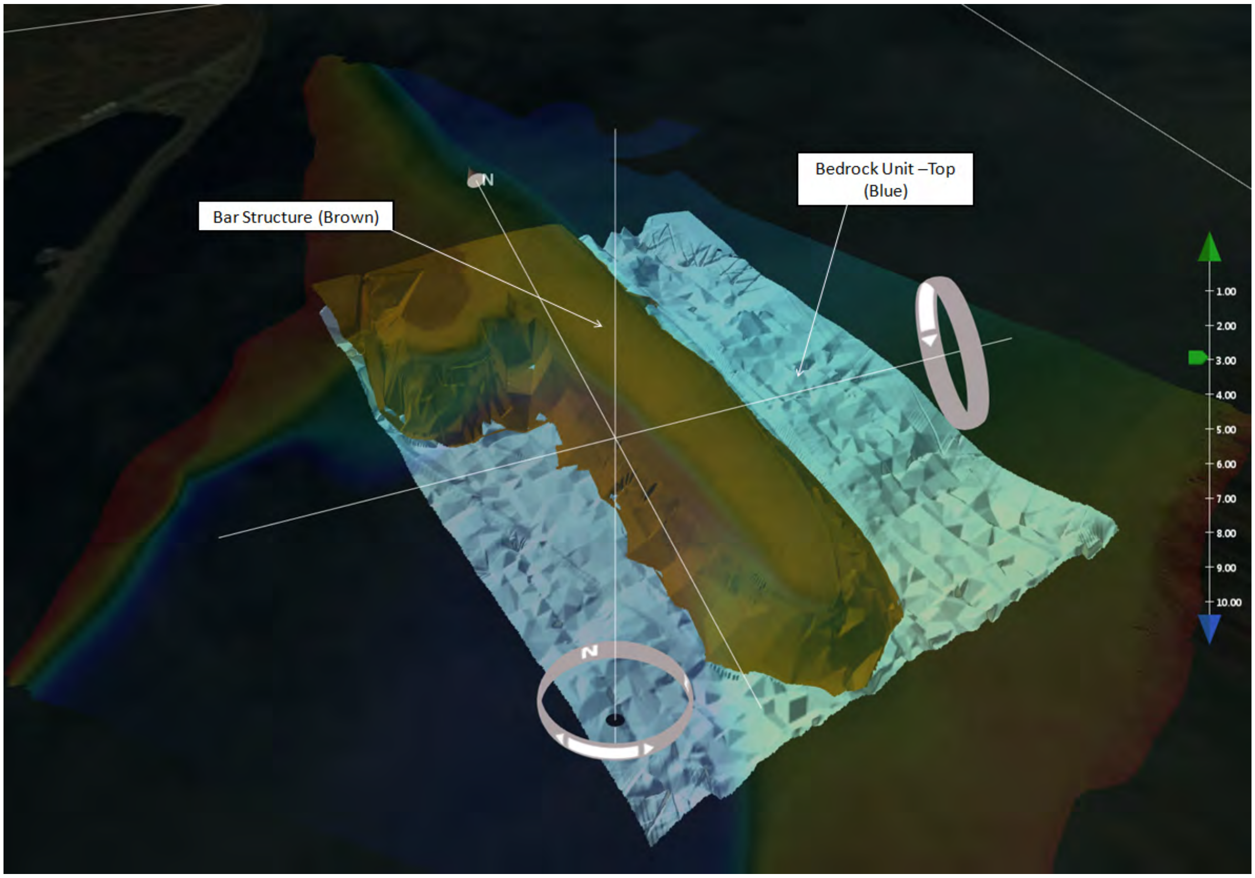


Figure 103 Modeled bar structure at surface and subsurface with surrounding bedrock

The estimated velocities through the bar structure across the central line, calculated using the diffraction shapes, produced a value of ~9,800 ft/s. This speed of sound is close to that observed in lithified rock. It is similar but even faster than typical, highly compacted, recessional glacial moraine features consisting of consolidated, hard boulders and rock material (Pinson et. al 2002)[7]. Glacial activity is known to have been prevalent in Dutch Harbor, with several documented glacial movements. (Dewes et al. 1961)[8]. The bar feature is therefore concluded to be a glacial moraine deposit.

The feature across the entrance to the harbor referred to as the bar is actually part of a larger stretching contiguous, structure consisting of hard, consolidated material. The acoustic signature across the most northern line shows a continuous, similar return with little or no penetration. This is shown in Figure 104 and the extents of the feature at the surface shown in Figure 105.

[7] Pinson et al. (2002) Deglacial history of glacial lake Windermere, UK: implications for the central British and Irish Ice Sheet

[8] Dewes et al. (1961) Geology of Unalaska Island and Adjacent Insular Shelf, Aleutian Islands, Alaska

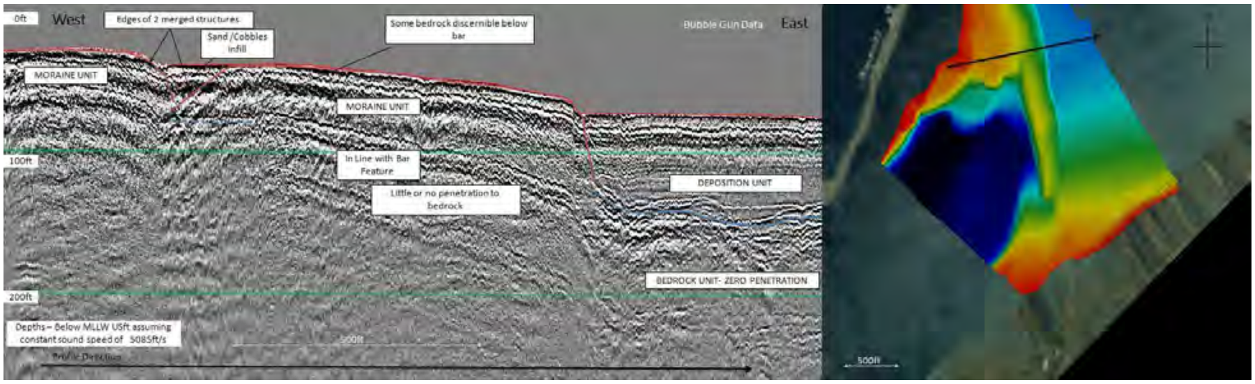


Figure 104 The northern most cross line showing the bar feature as part of a large structure

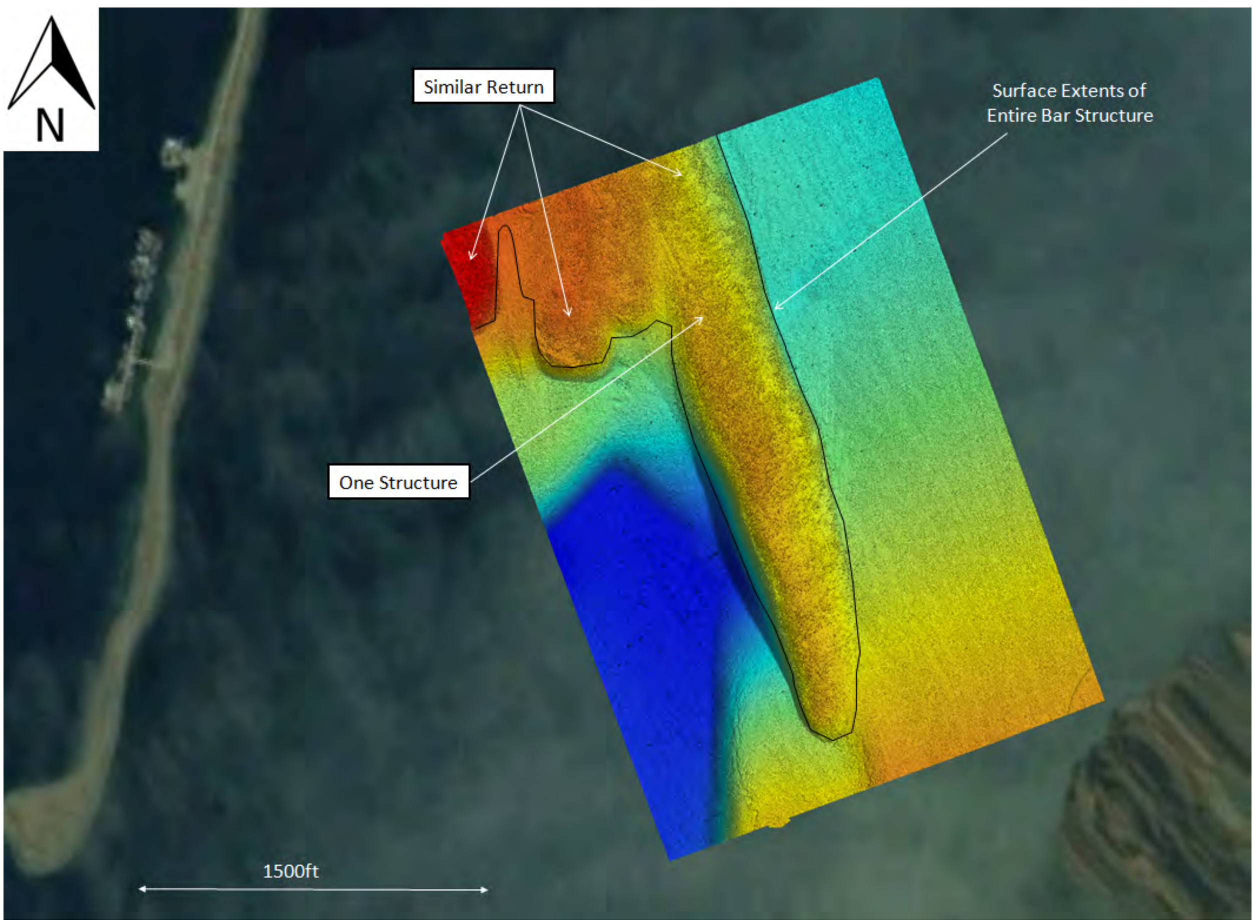


Figure 105 Image showing the surface extents of the bar structure using the subsurface data

The horizontal, subsurface extents of the feature referred to as the bar are up to 300 ft from the surface extents. The bar feature, is a consistent feature that creates a surface impression but is also submerged below the sea floor surface. The deepest the transition horizon between the bar feature and the bedrock on which it sits, was imaged at -180 ft elevation. The maximum thickness of the bar observed was 105 ft (assuming a sound speed of 8202ft/s).

6.3.2 Bedrock

The bedrock was evident as a consistent unit of zero penetration and relatively high amplitude initial response when hitting the bedrock surface. The bedrock return is high amplitude return with an uneven surface occurring below the homogeneous or well-stratified units. The bedrock was mapped across the entire survey area. Below the bar, where penetration was reduced the modeled bedrock was interpolated. The bedrock structure showed peaks that averaged 300 ft across, with an elevation difference from the foot to the peak of a maximum 40 ft and average 20 ft. The minimum depth of the bedrock in the survey area was 87 ft. This was to the east of the bar feature. Examples of bedrock as seen in the Bubble gun data as below in Figure 106.

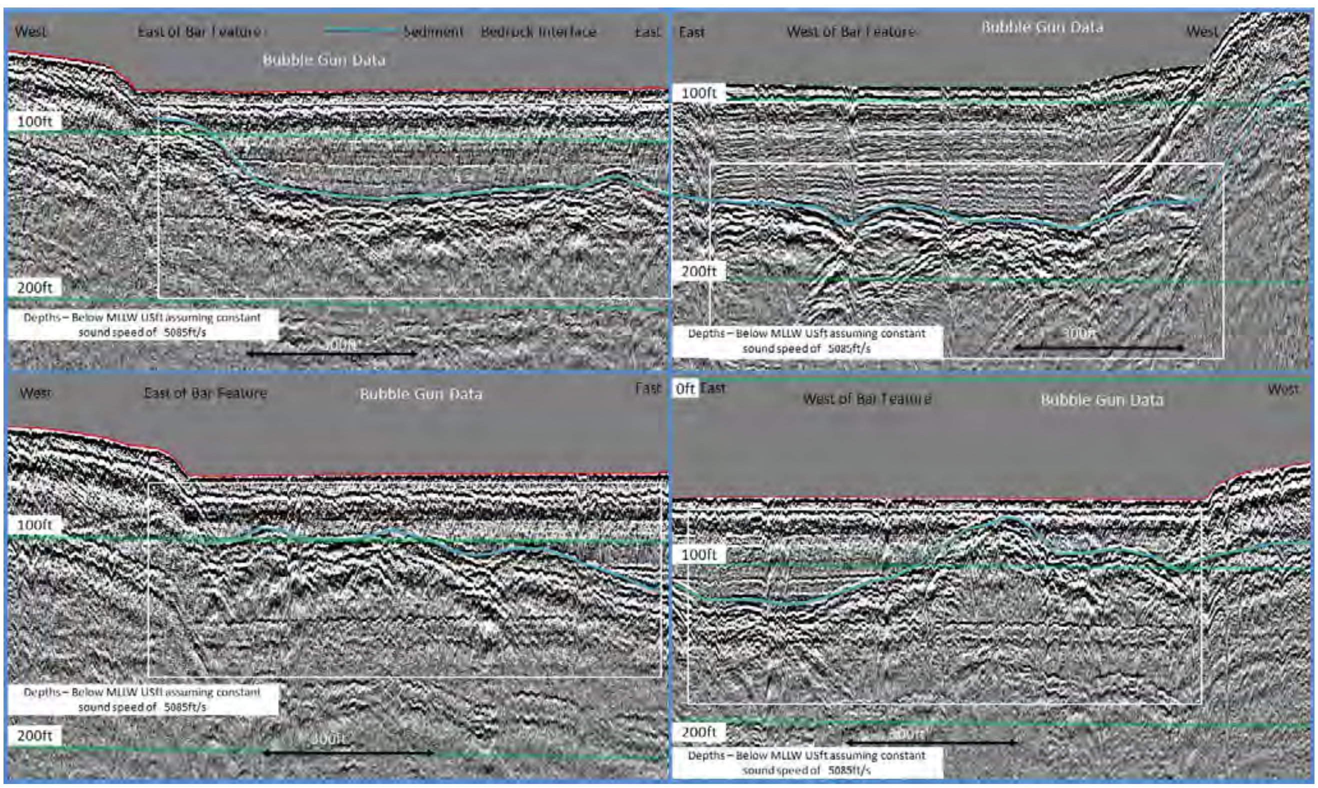


Figure 106 Examples of bedrock in the Bubble Gun data

The images below show the modeled bedrock (Figure 107) and the modeled bar on top of the bedrock (Figure 108). The images show that the bedrock and bar geometries are different and that the bar is founded on bedrock.

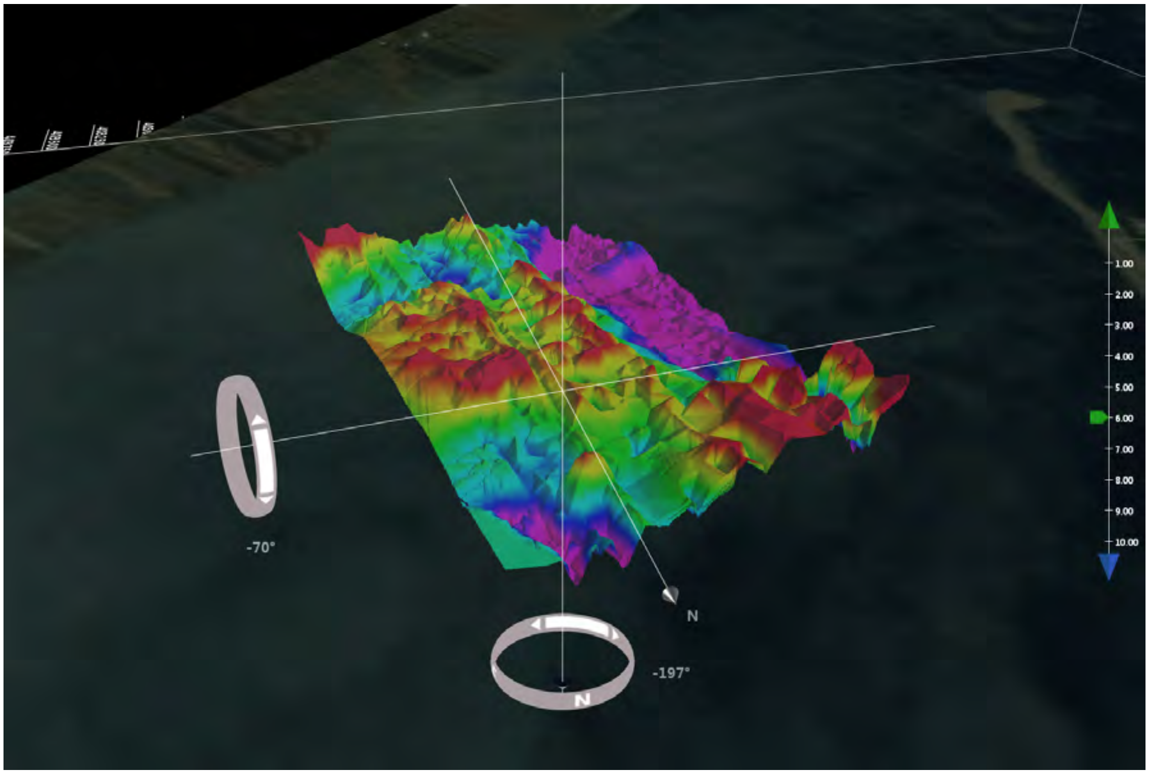


Figure 107 Bedrock model Colored by height (red shallow depth and purple deep)

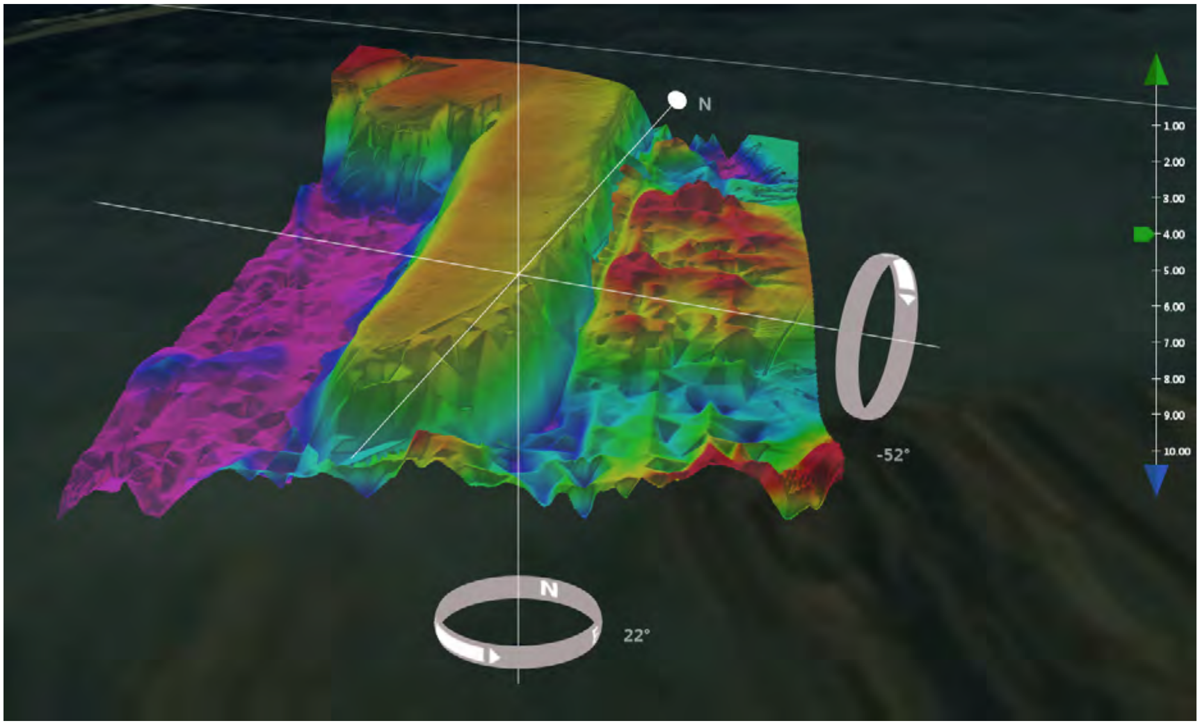


Figure 108 Bedrock and Bar Structure Colored by Height

6.3.3 Surrounding Geology

To the east and west of the bar and above the bedrock are heterogeneous sediment layering units and units of a what is classified as a homogeneous deposit. The heterogeneous layering unit shows clear stratification and sediment change vertically. In the homogeneous unit there is little or no stratification or amplitude change. To the east, the predominant surface sediment is sand. There is no clear distinction in the chirp data between the surface sand layer and those below the surface. The homogeneous unit to the east has a thickness of up to 60 ft with an average thickness of 50 ft. The minimum thickness of the unit is the point where the bedrock reaches a maximum elevation. At this point the unit above the bedrock is 10 ft thick. The heterogeneous unit below the homogenous unit has a maximum thickness of 40 ft but is more consistently between 10 ft and 20 ft thick. An example of the sediment layering and homogeneous units to the east are shown below along one profile line (Figure 109).

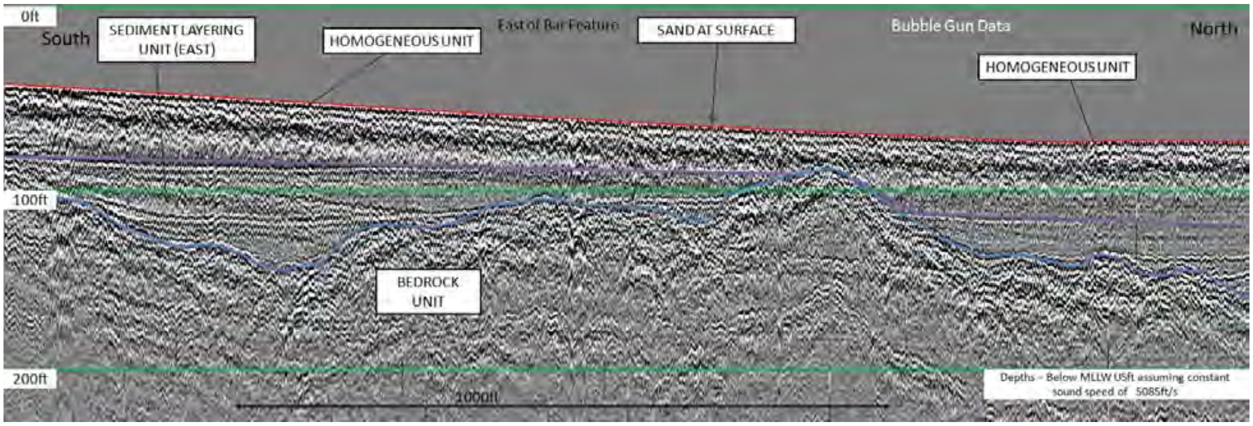


Figure 109 Profile to the east of the bar showing the sediment layering unit below the homogeneous unit

To the west of the bar the same homogenous unit observed to the east was seen, but only in discreet areas to the north and south. This homogenous unit creates a formation that is evident at the surface. These features are shown in Figure 110 and Figure 111. The homogenous unit is up to 55 ft thick in places.

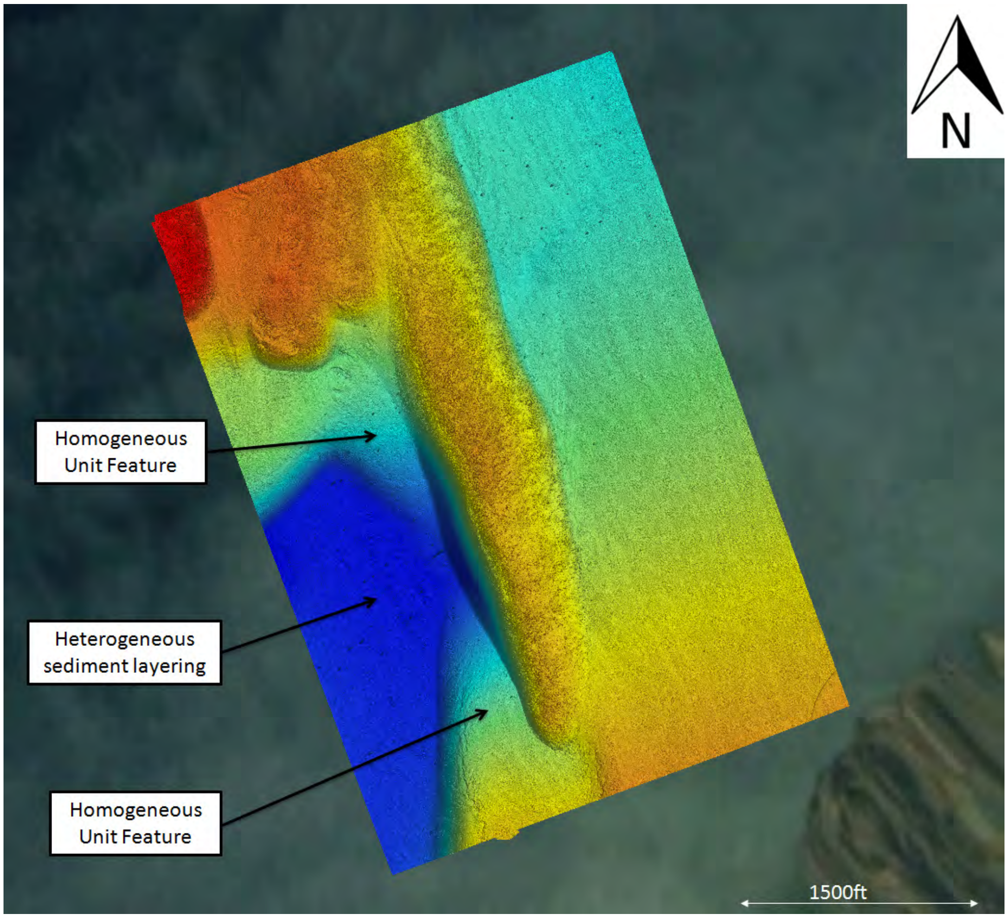


Figure 110 Homogeneous Unit to the west, evident at the surface

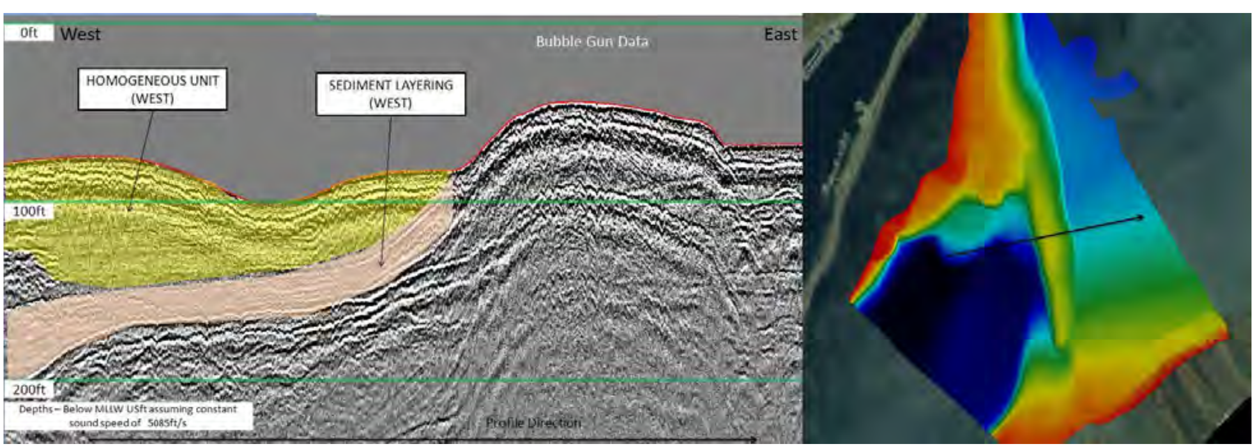


Figure 111 Profile showing the homogeneous unit above the heterogeneous sediment unit

The predominant subsurface stratification to the west is a clay/silt/sand layering unit. This was imaged in both the Chirp and Bubble Gun data. The unit was only seen at depths of below 90 ft. The unit is up to 60 ft thick and sits above the bedrock. A profile is seen in Figure 112 showing the unit in both the Chirp and Bubble Gun data.

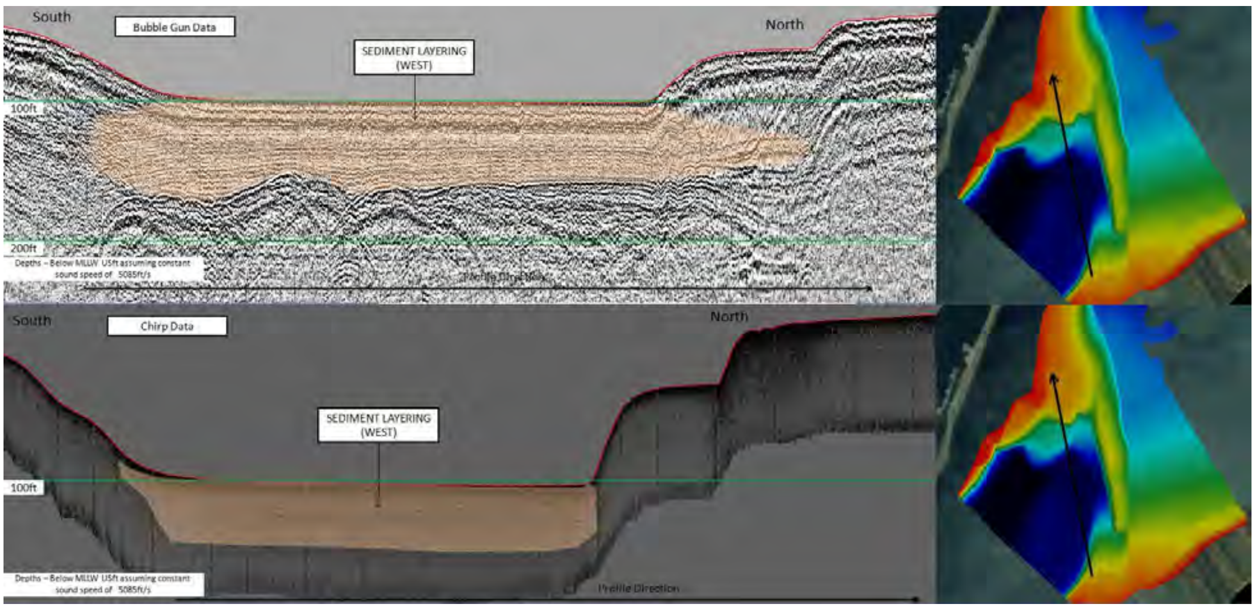


Figure 112 Heterogeneous Unit to the west of the bar in the Bubble Gun and Chirp Data

To the west of the bar a gas unit was also imaged at the south western corner of the survey area. The gas severely distorts both datasets. In the chirp data the gas creates blanking where no penetration can be achieved. The Narrow band Bubble Gun system is able to achieve some penetration through the gas layer, but the data is still distorted. This is shown below in the chirp and bubble gun datasets. This gas is interpreted to be biological in nature due to decaying organic detritus often associated with clay pelagic sediments (Hsu and Jenkyns, 1974[9])

[9] Hsu, KJ, Jenkyns, H (eds) (1974) Pelagic sediments on land and under the sea. Special Publication International Association of Sedimentology Journal

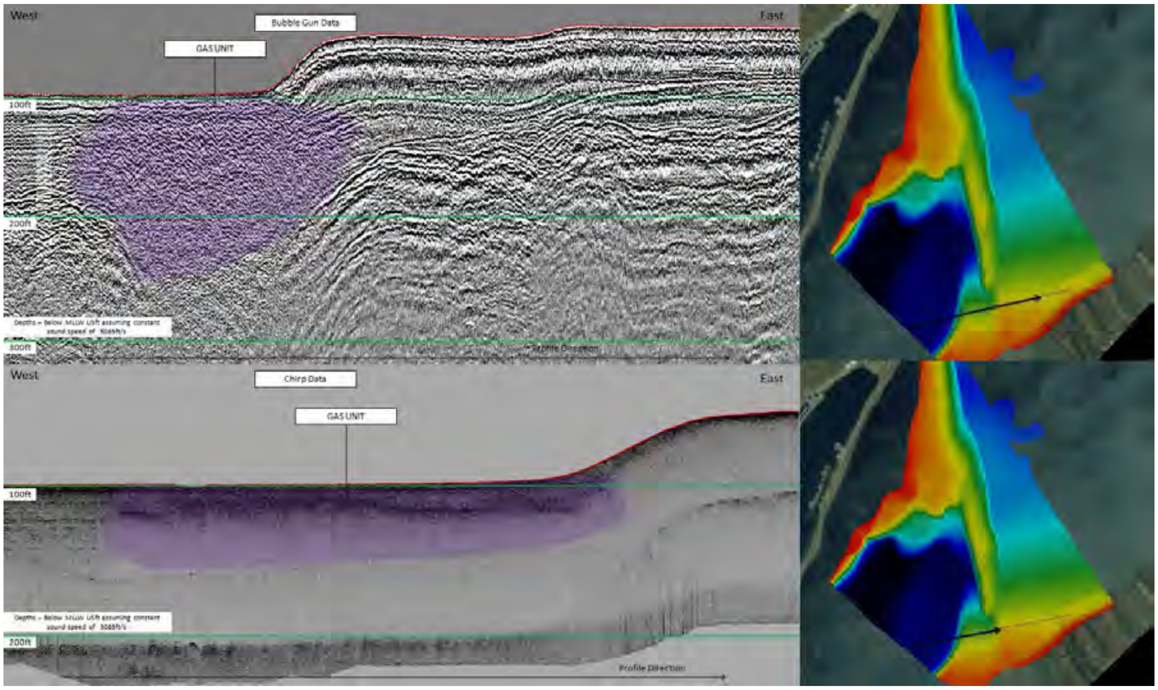


Figure 113 Gas Blanking in the Bubble Gun and Chirp data

To the west of the bar, buried and surface boulders are common. While there are sporadic buried boulders and infrequent surface boulders to the east, to the west, boulders are markedly more prevalent. At the foot of the bar slope to the west are large gravel deposits with occasional buried rocks. The deposit is made of much larger features than observed anywhere else aside from to the north where the surface sediment is cobbles on sand.

6.3.4 Overview

The bar is interpreted as a glacial moraine deposit. The material is highly consolidated. It is distinct from the bedrock which has a different geometry and is evident below and surrounding the bar. The moraine unit accounts for the entire bar feature evident at the surface. In addition the unit is below the surrounding sand and silt sediments at the surface. The bar feature can be considered a larger feature than the mounded ridge that stretches across the harbor entrance. The moraine unit that makes up the entire bar feature is also to the north and the north west of the surface feature.

The fence diagram in Figure 114 shows the various strata units and how they relate to each other. Figure 115 shows the subsurface strata modeled in a 3D environment.

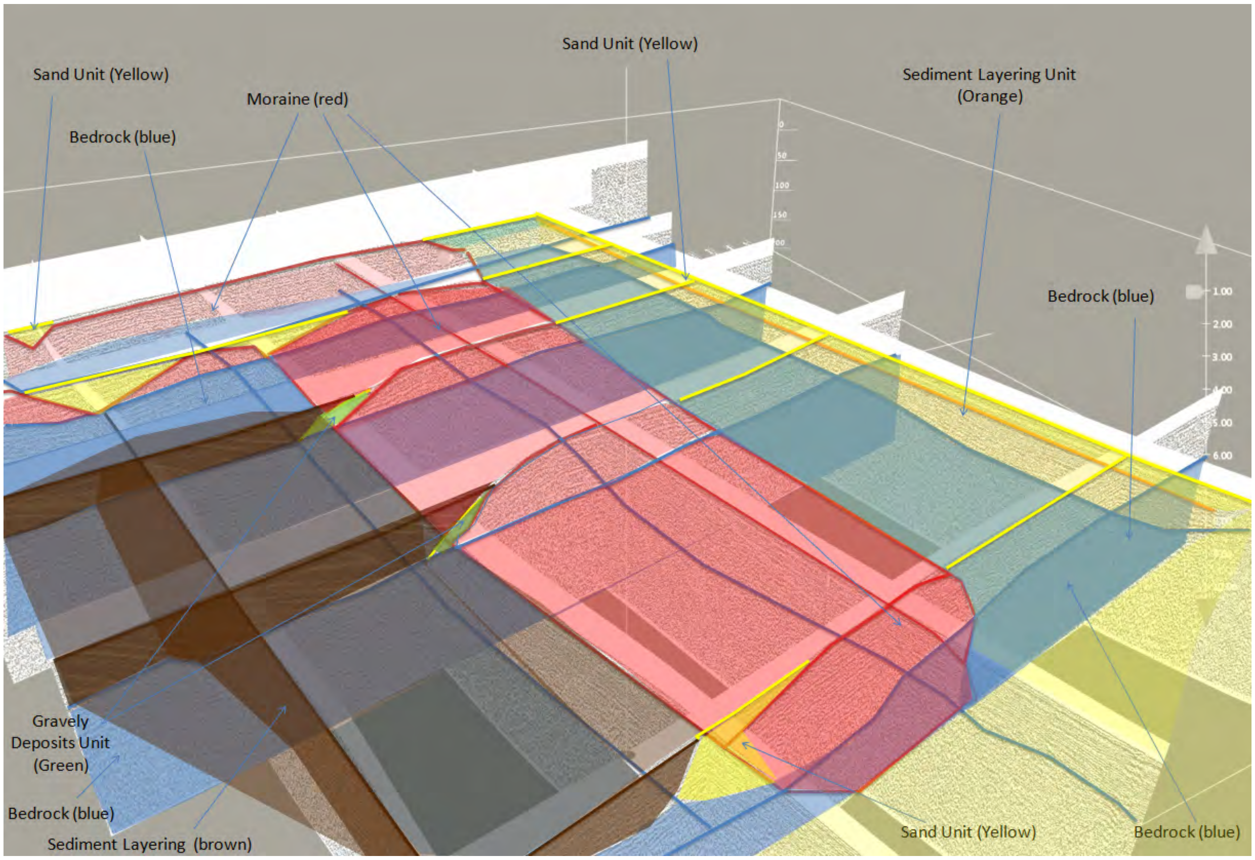


Figure 114 Fence Diagram of the subsurface strata units

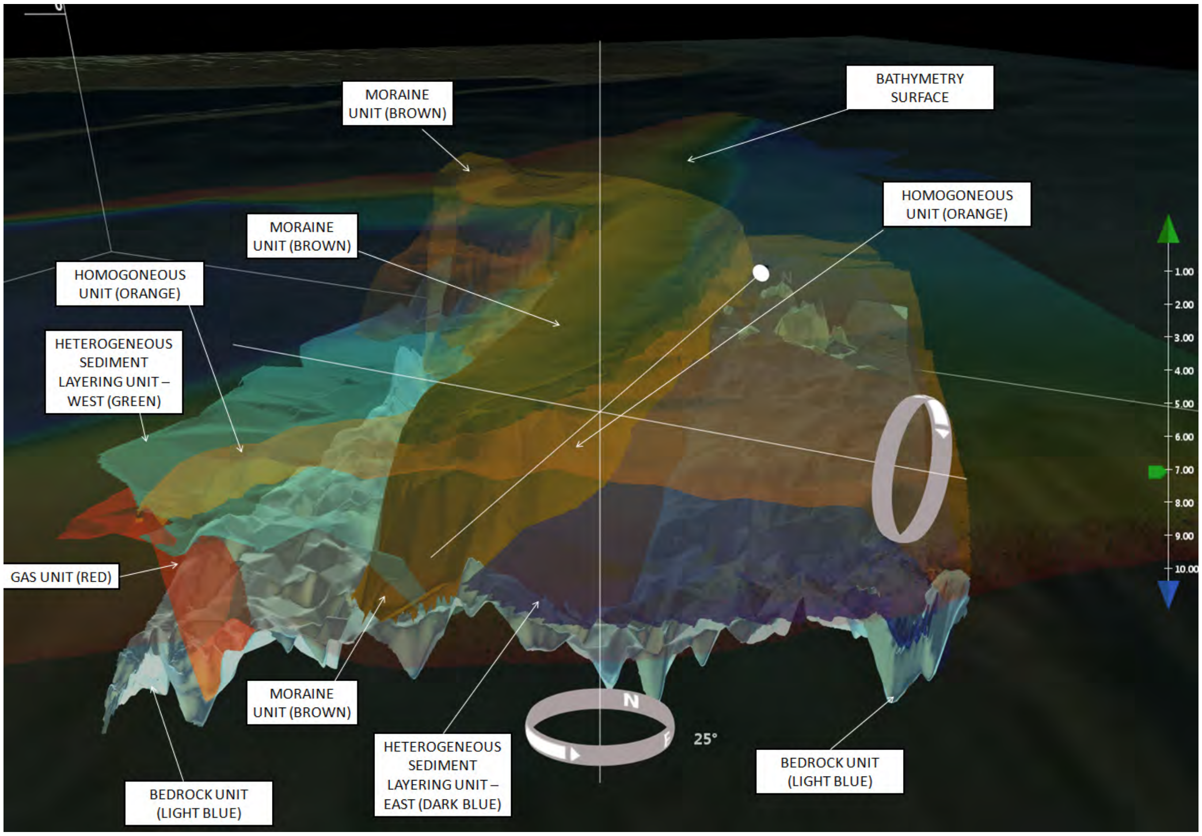


Figure 115 3D Image of the subsurface strata units

A detailed plot of the subsurface strata is shown in Volume 2 of 2, Drawings – Sheet 7 Geophysical Sub-Surface Overview and Profile Lines. Volume 2 of 2, Drawings – Sheets 8 to 12 show the cross sections along the designated sample lines.

6.3.5 Bar Extents and Further Thoughts

The entire bar structure can be extrapolated past the lines surveyed using the NOAA 2011 data. The structure as seen in the NOAA data, related to the subsurface data is shown on a map below in Figure 116.

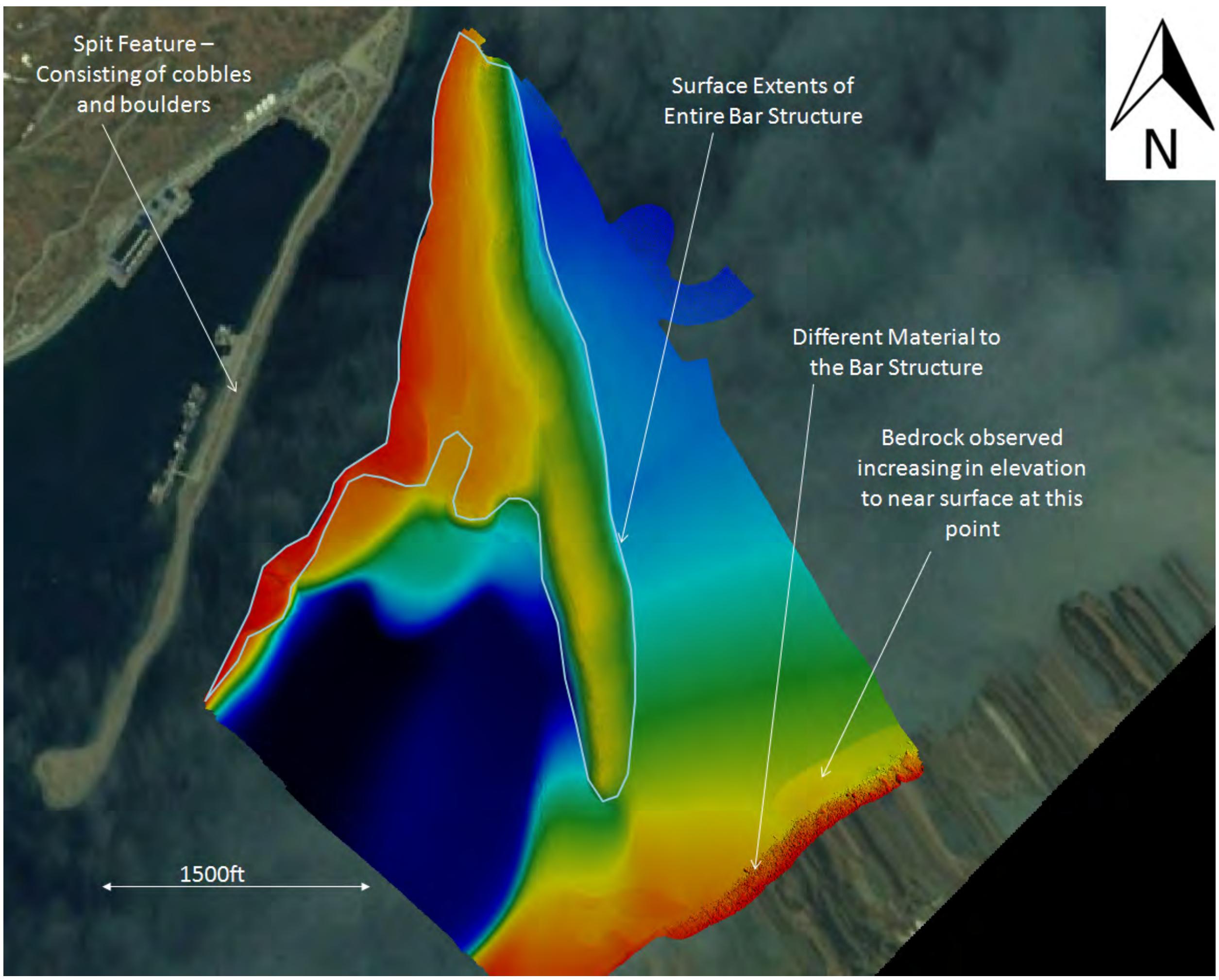


Figure 116 The estimated extents of the bar structure using NOAA 2011 bathymetry data to extrapolate from the subsurface data collected

The modeled bar structure from the subbottom data when compared to the NOAA bathymetry data further suggests this continuation. Images in Figure 117 and Figure 118 show the bar structure in 3D with the bathymetry in the background and foreground respectively. There is a continuation of a similar depth to the north and west past where the bar was imaged.

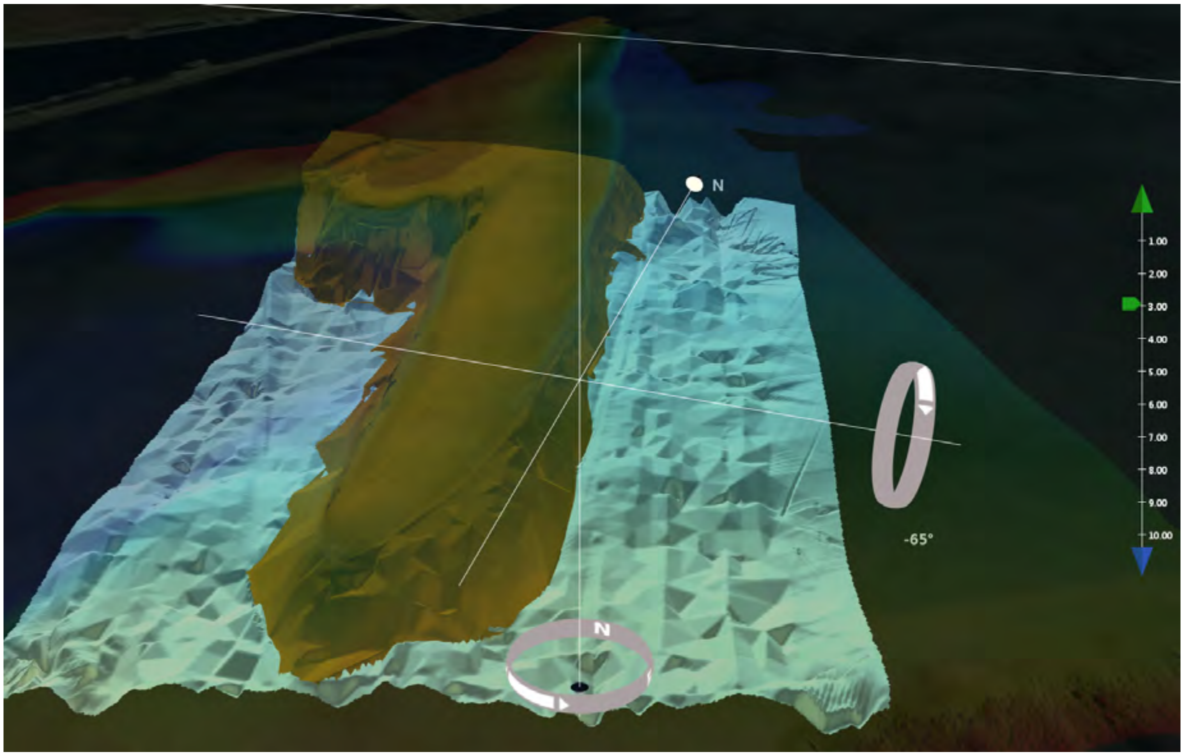


Figure 117 Bar feature modeled in 3D above the bedrock with the bathymetry from NOAA 2011 survey in the background following the same depths as the bar feature

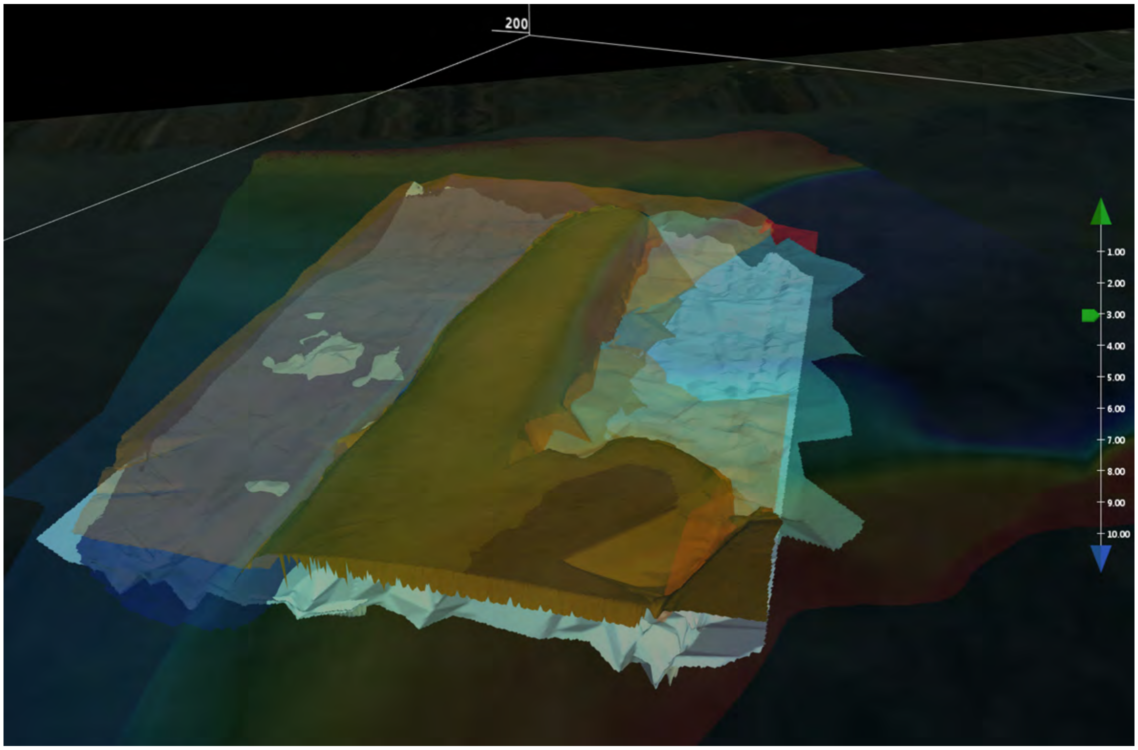


Figure 118 Bar feature modeled in 3D above the bedrock with the bathymetry from NOAA 2011 survey in the foreground following the same depths as the bar feature

During field investigation activities, field work photos were taken to document activities and conditions. All images can be found in Appendix F - Field Photos. Images of the terrestrial geology just above the waterline surrounding the survey area are included.

7 CONCLUSIONS

The bar feature that crosses the harbor entrance is part of a larger structure stretching to and along the north side of the Illiuliuk Bay. The feature comprises of highly consolidated, hard deposited material. Velocities recorded through the feature are close to those observed in lithified rock. The feature is however, distinctly different from the surrounding bedrock on which the feature has been deposited. Due to the consolidation and hardness of the deposited material little penetration below the features was observed. However, limited penetration occurred and the bedrock was imaged below and as distinct from the bar feature. Glacial activity is known to have occurred in the area. Therefore, glacial deposition is the suggested explanation for the feature.

Due to the known military activity in the area and observations of UXOs in surrounding area, several features that had strong ferrous returns which could be discounted as crab pots or other known objects should be considered likely to be UXOs.

8 RECOMMENDATIONS

All data collected for this project was remotely sensed. This allowed the entire area to be covered and objects across the project site identified. Every effort to fully analyze targets was taken. However, remotely sensed data lacks the confirmation gained from visual identification. Based on experience with marine geophysical surveys and the identification of objects, eTrac recommends the use of an ROV to visually inspect the targets identified to gain full confirmation of the object type. An ROV with a camera and positioning system could be controlled to the targets and produce video footage (live and processed) of each target. Most of the potential UXOs indentified in the dredge area are at the surface where visual inspection is possible. eTrac owns and operates a Deep Trekker DTG2 ROV. The instrument has an internal camera with 330 ° field of view, forward speed of 2.5 knots and depth rating of 100 m. This system is low cost and portable. The ROV would be applicable and usable in the conditions observed in Dutch harbor during this project. eTrac has used this effectively to inspect exposed marine cables, underwater obstructions and the underside of bridges for vegetation growth.

Due to safety concerns and the sensitive nature of the data to be collected, all work to be undertaken for the inspection of UXO targets would be done with authorized, specialized, trained personnel from organizations with experience and clearance to undertake detailed UXO inspection.

In addition to visual inspection, eTrac will make all raw and processed data available for further analysis by organizations that specialize in UXO detection. eTrac uses a range of software packages and has the ability to convert data to many different formats.

Accompanying Deliverables

Geophysical Survey Deliverables

Volume 2 of 2 - Drawings are 13 sheets of paper plots. These include bathymetry data, surface classification maps, sub-surface classification maps, located objects and profiles showing strata.

Bathymetric Survey Deliverables

The additional bathymetry survey deliverables include

- One set of plots of surveyed area at a horizontal scale of 1 inch =50feet with contour interval of one foot

- Point files of the bathymetry data - 3-foot, 6-foot and 12-foot gridded x,y,z field both mean and shoal

- Control data excel spreadsheet

- AutoCAD Civil 3D drawing format

- Land XML files

Disclaimer

All geophysical data analysis, interpretations, conclusions, and recommendations in this document are based upon sound scientific principles, using appropriate technology, and have been completed by qualified and experienced geophysicists. A geophysicist's certification of interpreted geophysical conditions comprises a declaration of his/her professional judgment. It does not constitute a warranty or guarantee, expressed or implied, nor does it relieve any other party of its responsibility to abide by contract documents, applicable codes, standards, regulations, or ordinances. eTrac inc. cannot be held liable or responsible for consequences arising from the use of the information presented in this report. All bathymetry data is valid for the time in which the survey was conducted