FINAL REPORT

Wide Area Assessment (WAA) For Marine Munitions and Explosives of Concern

ESTCP Project MR-200808

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14. ABSTRACT

The objective of this demonstration was to address the lack of effective and proven approaches for conducting wide area assessment (WAA) of sites potentially containing underwater MEC. The WAA demonstration was performed at the South Beach Site off the south coast of Martha's Vineyard, MA. Tetra Tech developed and implemented an approach that utilizes multiple customized geophysical detection and mapping technologies and processing methods. These systems and methods include the use of multibeam, sidescan, and subbottom profiling sonars and a gradiometer array. The towfish platform used for collection of magnetometer data was the Marine Gradiometer Array (MGA), a custom designed seven sensor 4m wide true 3-D gradiometer, utilizing Overhauser magnetometers. The Overhauser sensor has been demonstrated to be effective for the location of MEC in marine and freshwater environments. The MGA, depth rated to 300m, successfully operated in 1-35m water depth while exceeding survey production rate estimates. Field survey costs were demonstrated to be as low as $2450 per hectare inclusive of all four geophysical data sets.

15. SUBJECT TERMS
UXO, MEC, Munitions, MGA, marine gradiometer array, magnetics, gradiometer, multibeam, sidescan, sonar, subbottom, profiling, WAA, wide area assessment, FUDS, hydrography, geophysics

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ABBREVIATIONS AND ACRONYMS

2D	two-dimensional
3D	three-dimensional
AUV	autonomous underwater vehicle
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
CSM	conceptual site model
CTD	conductivity, temperature, and depth
DoD	Department of Defense
DTM	digital terrain map
DVL	Doppler velocity log
EM	Electromagnetic
ESTCP	Environmental Security Technology Certification Program
GAMS	GPS Azimuth Measuring System
GIS	Geographic Information System
GPS	Global Positioning System
Hz	hertz
IHO	International Hydrographic Organization
IMU	inertial measurement unit
IVS	instrument verification strip
kHz	kilohertz
LBL	long base line
MBE	multibeam echo sounder
MD	munitions debris
MEC	munitions and explosives of concern
MGA	Marine Gradiometer Array
MRU	motion reference unit
MTMGR	Moving Target Machine Gun Range
NAVD	North American Vertical Datum
nT	nanoTesla
QA	quality assurance
QC	quality control
RF	radio frequency
RTK	real-time kinematic

SBE	Sea-Bird Electronics
SBP	sub-bottom profiler
SSS	sidescan sonar
TtEC	Tetra Tech EC, Inc.
USACE	U.S. Army Corps of Engineers
USBL	ultra short base line
UXO	unexploded ordnance
WAA	Wide Area Assessment
WP	work plan

EXECUTIVE SUMMARY

There are well-developed methodologies and approaches for assessment of terrestrial munitions and explosives of concern (MEC); however, there are currently no standardized approaches for wide area assessment (WAA) of MEC in fresh water or marine environments.

The objective of this demonstration was to address the lack of a standardized approach for detecting and locating underwater MEC over large areas. To accomplish this objective, Tetra Tech EC, Inc. (TtEC) developed an approach that utilizes multiple underwater detection and mapping technologies and instruments to acquire data sets which are used to evaluate ordnance-related conditions and geophysical features that represent potential underwater MEC. A comprehensive data set and data fusion enables the development of appropriate and effective remediation strategies for underwater ordnance. The towfish platform which was used for collection of magnetometer data was TtEC's Marine Gradiometer Array (MGA), which houses instrumentation demonstrated to be effective for the location and identification of MEC in marine or freshwater environments.

Quantitative and qualitative objectives were developed to assess system performance. As detailed in Section 3.0, these included:

- Ability to detect underwater features of interest–measures the system's ability to effectively detect targets of interest with magnetic signatures representative of MEC at water depths from 0.5 to 35 meters.

  Results: The MGA met the data quality metrics as verified by IVS results and the successful operation in all water depths (demonstrated at this and other sites)

- Timely initial data processing and mapping–provides a qualitative and quantitative assessment of processing times for MBE data, which is needed to map site bathymetry, locate debris proud of the bottom, and guide MGA data acquisition.

  Results: Survey technicians were able to process the MBE data onboard the vessel and generate draft charts in near real time. On some survey days, MBE data were collected in the morning, processed, and then used in the afternoon to guide MGA data acquisition. We consider this level of efficiency to be quite successful.

- Good production rate–measure of the system's capability to meet established hourly/daily production rates while meeting data quality objectives.

  Results: Quantitative goals set forth in the work plan, which were derived from previous experience and theoretical production rates based on survey speed and number of operational hours possible in a day, were met and exceeded. TtEC was able to exceed our projected MBE production rate by more than 50 percent.

- Ease of use–this qualitative objective assesses the ease of implementing the WAA survey for both data collection and data processing.

  Results: Customizations to the support vessel have been made to create a platform well suited to performing underwater MEC surveys anywhere in the continental U.S. MGA data processing objectives were exceeded due in part to software development funded in part by ESTCP. While our data processing methods are complex, it is relativity easy to execute and can be taught within a few days to a data processor having previous geophysical survey experience.

- When used in combination with the data collection and processing tools and methods used in this demonstration project, the MGA system is highly cost competitive with existing technologies. This competitive cost is provided while detecting MEC over large areas and achieving reliable anomaly locations (approximately 89% of checks on IVS were located to within 2 meters and approximately 47% were located within 1 meter).

Use of the MGA system for WAA of MEC has several benefits, including:

- The MGA system is modular and can be disassembled and shipped via FedEx or other freight carrier to any location in the world.
- The modular configuration allows the system to be used in shallow (1 meter and less), medium (1 meter and greater to 35 meters) and deep water (greater than 35 meters up to 300 meters) by altering the systems setup and tow method.
- Rugged with weak link allowing for safe detachment from the tow cable while maintaining tracking with ultra short baseline acoustic positioning system (USBL) should the towfish contact the bottom. (note: this functionality performed successfully during the demonstration project survey with no damage to towfish and only minutes of lost survey production).
- The Overhauser magnetometers used in the TtEC MGA have several advantages, including (1) clear, strong proton precession signals using a very small amount of power, (2) power for proton polarization in the Overhauser sensor is applied at a frequency that is far out of the bandwidth of the proton precession signal. As a result, the sensor can be polarized concurrently, rather than sequentially, with precession signal measurement. This effectively doubles the amount of information available from the sensor, allowing faster sampling rates, (3) very sensitive to changes in the geomagnetic field

(approximately 0.08 nanoTesla [nT] at a sampling rate of 4 hertz [Hz]) and are not influenced by a phenomenon termed "heading error", (4) sensor measurements are temperature independent; therefore, there is no system drift, (5) processing and data analysis is simplified because correction for sensor drift, orientation, and heading error is eliminated, (6) the design of the MGA allows the total magnetic field for each magnetometer to be measured, as well as up to 10 two-dimensional (2D) magnetic gradients, and 3 three-dimensional (3D) measured analytic signal vectors that are automatically calculated from the total field and gradient measurements. This system is unique in that it provides both total field and vector data.

While use of the MGA has several advantages, there are some limitations, including:

- Maximum update rate of 4 Hz limits survey speeds to approximately 4 knots (2m/sec) (a 10 Hz version is currently in development).
- Current maximum system depth rating is 300 meters, limiting MEC surveys to this depth and less (greater depth ratings possible by changing pressure housings for 3000-meter version. This would be a significant modification, but 3000-meter systems have been made).
- Current swath width is 5 meters and the system is configured to expand to 7 meters. A wider the swath would survey a larger area per transect.
- Towfish flight altitude control not automated. This requires a skilled operator dedicated full time to towfish flight control. (Note: an automated flight control system is currently in final development/testing.)

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Mr. Herb Nelson and Peter Knowles and the entire ESTCP program for selecting, funding and supporting the WAA for Marine MEC throughout the demonstration effort.

The United States Army Corps of Engineers, including Carol Charette and Bob Selfridge for allowing and coordinating for the use of the South Beach site for this demonstration.

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1.0 INTRODUCTION

The Environmental Security Technology Certification Program (ESTCP) awarded a contract to Tetra Tech EC, Inc. (TtEC) to demonstrate an effective methodology for conducting wide area assessments (WAA) for munitions and explosives of concern (MEC) in the marine and freshwater environments. It is intended that the methodology presented can be used as a basis for standardization of methods for performing underwater MEC assessments. The ultimate goal was to develop standardized and effective data collection methods to acquire comprehensive, high-quality data for underwater MEC investigation.

1.1 BACKGROUND

More than 6 million terrestrial hectares of land are estimated to be impacted by MEC as a result of historical military operations. The underwater regions (marine and fresh water) impacted by MEC may be even larger. The Department of Defense (DoD) is responsible for assessment and remediation of underwater areas impacted by MEC but there is currently no standard approach for underwater WAA for MEC. In short, there are no industry standards for performing the assessment, no standard data collection systems, and no standard data processing techniques, and therefore there is no way to ensure consistency, comparability, and quality from project to project.

A conceptual site model (CSM) (Figure 5-1) was developed prior to the survey based on historical data and known environmental factors, such as currents that could enable redistribution of MEC. This CSM was used to guide the development of the investigation and assists in the discrimination of MEC from other cultural artifacts or natural features.

To develop a "standardized" methodology for underwater MEC work, it is necessary to identify the most effective and reliable technologies for MEC detection and classification. It is also critical to demonstrate that the selected technologies can be combined into a data collection system that can be deployed and obtain accurate and repeatable results. For this demonstration project TtEC combined state-of-the art survey technologies, including multibeam sonar, magnetometry, sidescan sonar (SSS), and sub-bottom profiling sonar (SBP). These technologies were coupled with positioning systems, including real-time kinematic (RTK) Global Positioning System (GPS), a motion reference unit (MRU) to measure vessel dynamics, and an ultra short baseline (USBL) acoustic positioning system for underwater positioning of towed sensors. All of these systems were mobilized aboard a research vessel and configured to function as a synergetic data collection system optimized for WAA of MEC.

The selected technologies must be tested to verify that the most appropriate system configurations have been established for the specific test site. While a methodology can be "standardized," site-specific details must be considered when configuring the data collection system to ensure good system performance. The survey area encompassed variable environmental conditions that included a range of currents, waves, water depths and a variety of submerged geomorphic features that could have impacted system operation. The systems aboard the survey vessel were monitored in real time to ensure consistent and accurate data acquisition.

The final aspect of the demonstration project was visual verification of the survey area. This verification was planned to confirm the findings of the geophysical surveys and guide an effective remedial action, if necessary, at a future date. Trained unexploded ordnance (UXO) divers hired by the USACE conducted operations to evaluate the nature of ferrous anomalies and items of interest identified during analysis of the MBE, MGA, SSS and SBP data. However, at the time of preparation and submittal of this report to ESTCP the results of diver surveys had not been released to TtEC and a delivery date was unknown.

1.2 PURPOSE AND OBJECTIVES

The objective for this project was to demonstrate systems and methods for performing WAA for munitions and explosives of concern in the marine and freshwater environments. The site selected for this demonstration was the former Moving Target Machine Gun Range (MTMGR) at South Beach, Martha's Vineyard, Massachusetts, hereafter referred to as South Beach.

The objectives for the WAA were to:

- Demonstrate the effectiveness of the MGA at detecting and positioning seeded underwater MEC via an Instrument Validation Strip (IVS).
- Demonstrate a practical approach to detecting and locating underwater MEC and munitions debris (MD) in real world conditions as part of a site investigation.
- Integrate supplemental sensor information with the gradiometer data ("data fusion") to aid in discrimination of MEC from non-MEC in the underwater environment. And also to use this supplemental sensor information to refine the CSM.

1.3 REGULATORY DRIVERS

The DoD has responsibility for assessment and cleanup of hundreds of historical in-water (marine and fresh water) munitions use sites (ranges, munitions piers, disposal sites, etc.) throughout the United States. There are a number of regulatory drivers that may apply to munitions response sites; however, two frequent primary drivers are the Base Realignment and Closure Act and Formerly Used Defense Sites processes involving the transfer of DoD property to other government agencies or to the civilian sector. When former DoD property is transferred to non-DoD users, MEC assessment and cleanup operations fall under the compliance requirements of the Superfund (also known as the CERCLA) statutes. Section 2908 of the 1993 Public Law 103-160 requires that the work be performed in accordance with CERCLA provisions. This requirement centers on issues of assumption of liability for ordnance contamination on sites previously controlled by DoD. The technologies and system configurations demonstrated during this project will provide a basis for beginning the process of standardizing in-water MEC assessment and remediation methodologies for marine and fresh water sites. This work will support DoD in the development of CERCLA-compliant MEC remediation strategies for underwater areas.

2.0 TECHNOLOGY

2.1 TECHNOLOGY DESCRIPTION

A multifaceted approach was used to conduct surveys for marine MEC at South Beach. This approach included the use of acoustic imagery to aid in the location and identification of materials at least partially above the sediment surface. Sub-bottom profiler (SBP) data were used to evaluate sub-surface stratigraphy and identify areas were sediment deposition has or is occurring and as a result determine where buried MEC items are likely to be present. Lastly but most importantly, TtEC's MGA was used to locate magnetic anomalies caused by ferrous debris on and below the sediment surface. The MGA comprises a three-dimensional (3D) array of sensitive magnetometers and is capable of measuring the 3D gradient of the magnetic field. The MGA is integrated with high accuracy RTK GPS and USBL positioning systems for the precise location of detected targets.

Table 2-1 contains a summary of the various technologies used, their land-based equivalent and the purpose of their use. Figure 2-1 shows the various sensor and positioning systems used for the South Beach demonstration, and Figure 2-2 provides a schematic of the configuration of the instrumentation utilized. The components that made up the survey system for this project are described in detail in the following sections.

Table 2-1. Summary of Technologies

Technology	Terrestrial Equivalent	Purpose
Multibeam Echosounder (MBE)	LiDAR	Used to map site bathymetry in high resolution. Allows identification of larger (approx. $0.5m^{2,}$ depth dependent) cultural debris, as well as natural geomorphic features that pose a risk to the MGA while being flown at a low altitude.
Marine Gradiometer Array (MGA)	Terrestrial/Aerial Magnetometer Arrays	Measures magnetic field strength and 3D magnetic field gradient that allows for the identification of anomalies that may be MEC.
Sidescan Sonar (SSS)	B&W Aerial Photography	Uses low grazing angle sonar beams that create shadows used to identify smaller items proud of the bottom. Higher frequency and closer proximity to the bottom increases the quality of the bottom image.
Sub-bottom Profiling (SBP)	Seismic Reflection	Used to evaluate stratigraphy and locate areas of sediment deposition where buried MEC items may be present. Aids in the identification of the sediment/bedrock interface which would be the maximum depth to MEC items may be buried.
Positioning Equipment	Terrestrial Positioning Equipment	Two components: RTK GPS with MRU for positioning the vessel and measuring vessel motion. USBL for underwater acoustic positioning.

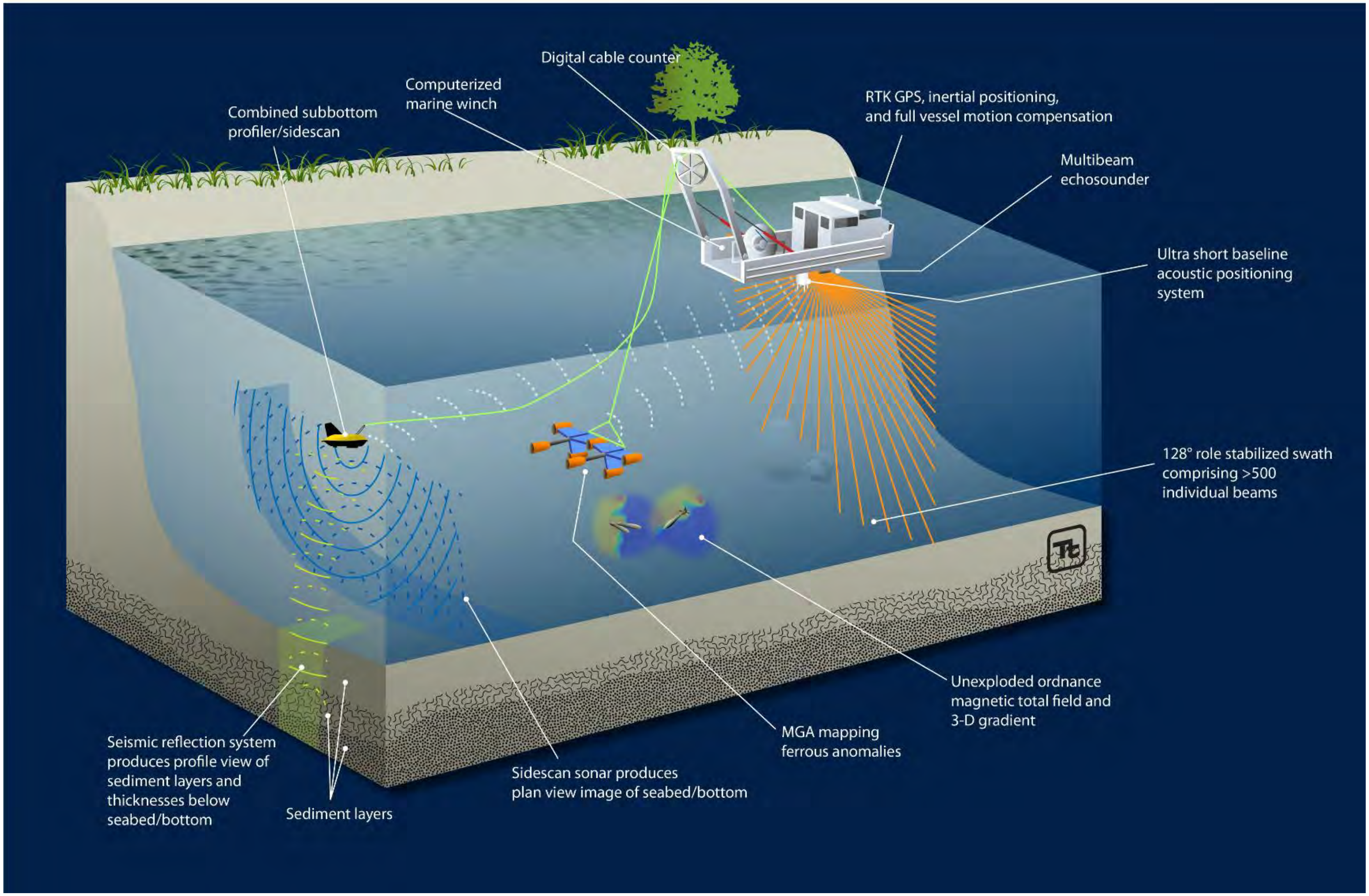


Figure 2-1. Wide Area Assessment Survey System Deployed at South Beach

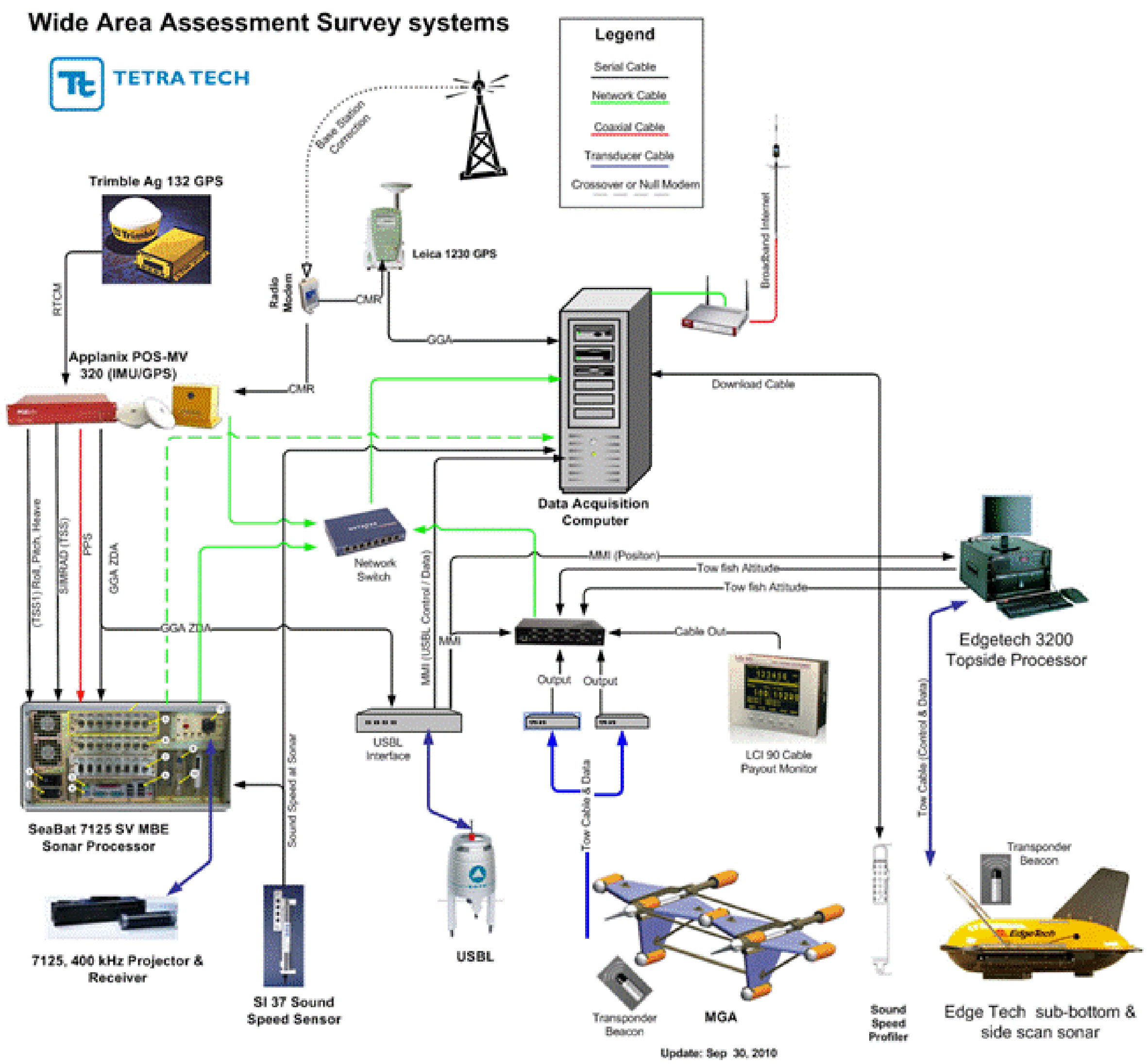


Figure 2-2. Wide Area Assessment Survey Systems

2.1.1 High-Resolution Multibeam Echosounder (MBE)

Prior to conducting the MGA survey operations, the site was surveyed using the high-resolution MBE to:

1. Map site bathymetry.
2. Identify cultural debris.
3. Identify obstructions that could interfere with maintaining MGA low altitude flight.

The RESON SeaBat 7125 SV multibeam sonar was used for this project. This system is among the highest resolution systems available for detailed mapping of the seafloor. The multibeam sonar transmits acoustic pulses in a fan-shaped pattern. These pulses reflect back from the seafloor or items on the seafloor. The reflections are measured from different angles across the swath with 256 or 512 narrow receiver beams, as shown in multibeam illustrations in Figure 2-2. The angles and travel times of each beam can be combined to determine the size and shape of features on the seafloor and the distance to those features. Many factors affect the resolution of the bathymetric map generated by the MBE, including sonar frequency, beam width and angle, water depth, ping rate and vessel speed. Figure 2-3 shows an example of a terrain model and feature detail that can be created using high resolution MBE data.

The strength of the return signal of the MBE pulse is a function of the physical properties of the seafloor and can assist in characterizing features of the study area. Materials, such as metals, boulders, gravel or recently extruded volcanic rock are very efficient at reflecting acoustic pulses whereas finer sediments like clay and silt absorb more of the acoustic energy. Data analysis software, which can import and classify these characteristics, can be used to assist in delineating the areas with similar seafloor physical and geologic properties along the surveyed transects.

For the WAA demonstration the multibeam sonar projector and receiver were mounted on a rigid pole deployed over the port side of the survey vessel. The pole was affixed to the vessel and thus subject to the same motions as the vessel itself. The MBE was used in conjunction with inertial navigation and a vessel heading and attitude sensor to measure the vessel's motion. Position (x, y) and height (z) data were provided using a RTK GPS with corrections from a terrestrial RTK GPS base station set up on shore near the survey area (Figure 2-4).

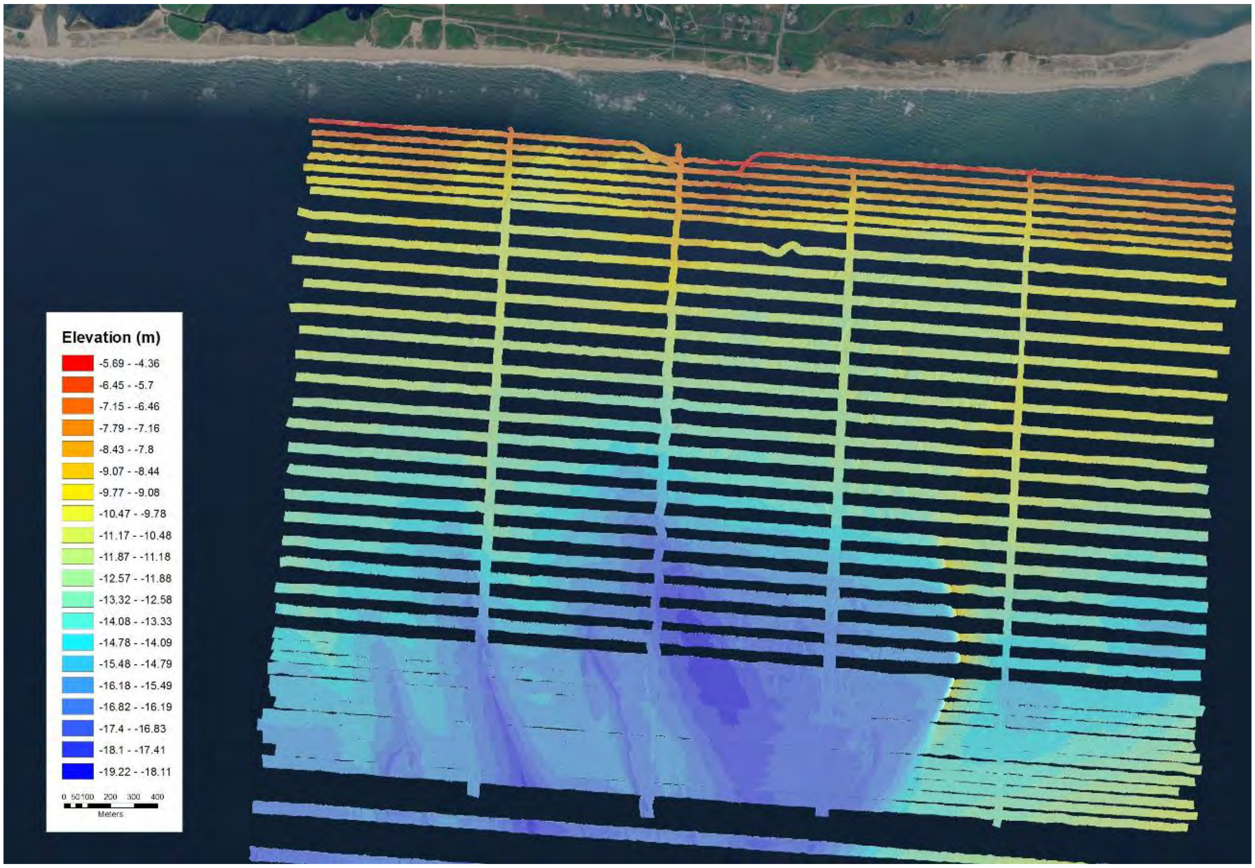


Figure 2-3. Example of Gridded MBE Data, Showing Geomorphic Features

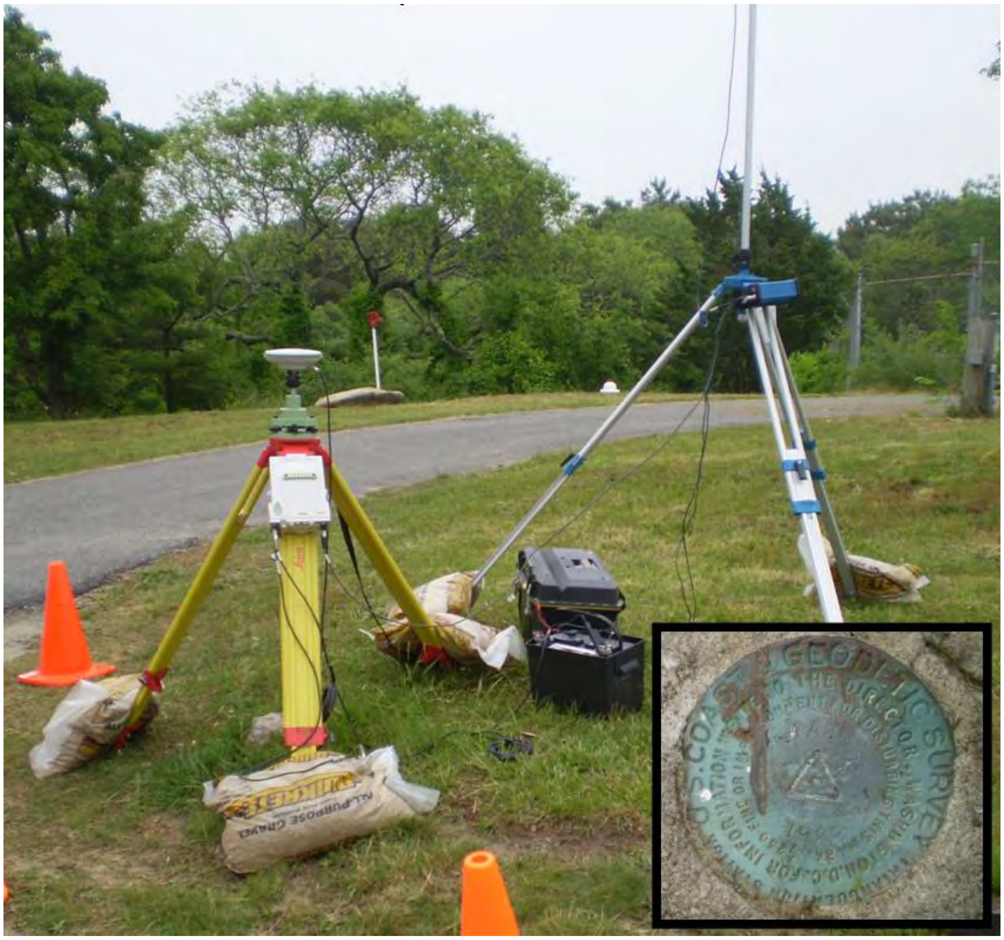


Figure 2-4. Edgartown RTK GPS Base Station

Using the RTK GPS for vessel positioning, together with appropriate data quality checks, provided both horizontal and vertical accuracies of approximately 0.02 meter. Because RTK GPS provides such high accuracy height data there is no need to measure changes in the vessel draft due to crew and material loading as these changes are taken into account automatically in data processing. Heading was obtained from an integrated inertial system (Applanix POS MV 320). This high performance system measured vessel pitch, roll, and heave, which was used by the acquisition and processing software (HYPACK / HYSWEEP and CARIS) to correct the bathymetry data. Roll data were provided directly to the MBE which compensated for roll in real time, thus eliminating the need to apply this correction in post processing. Real time roll compensation is advantageous as it results in a more predictable coverage area and eliminates "scalloping" of the data coverage.

A Seabird Microcat 37 sound speed sensor, mounted adjacent to the multibeam sonar, was used to measure changes in conductivity and temperature and provide sound speed data to the sonar to aid in beam forming. A Seabird 19 was used to measure conductivity, temperature, and depth (CTD) in the water column to calculate the sound speed profile. Data from the CTD were entered into HYSWEEP and CARIS software to model the refraction and path length effects and to apply the appropriate corrections in calculating the positions of the soundings on the seafloor. The frequency and location of the CTD casts were determined by the local water conditions at the survey site; generally CTD casts were taken once per day.

The hydrographic methods utilized to conduct the site bathymetry survey were conducted in general accordance with applicable sections of the USACE Hydrographic Survey Manual (USACE 2002).

2.1.2 Marine Gradiometer Array

This MGA system combines a gradiometer with support sensors to accurately detect and locate magnetic targets on and below the sediment surface. The base gradiometer module consists of four Overhauser magnetometers, and can be expanded by adding up to two additional gradiometer modules containing three magnetometers each. A two gradiometer module consisting of seven magnetometers with a swath width of 4 meters was used for this demonstration (Figure 2-5). The MGA is reconfigurable allowing for individual magnetometers to be removed or reoriented. Furthermore, the addition of floats or weights allows the MGA to operate in water depths from about 1 meter (floated) to 300 meters.

The MGA used for this project measured the ambient magnetic field using a phenomenon called the Overhauser effect. Like proton precession magnetometers (spin magnetometers), Overhauser magnetometers contain a hydrogen based proton rich liquid such as kerosene or methanol. Both types of magnetometers also function by polarizing the protons in the liquid and then measuring the precession rate to the normal spin state of the protons. However, the Overhauser magnetometers achieve proton polarization using an electron-proton coupling known as the "Overhauser Effect," which polarizes the protons without the use of the large magnetic fields generated in the spin magnetometers. The proton rich liquid in the Overhauser magnetometers contains a special chemical with free electrons. These free electrons, which are dissolved in the liquid, are excited by a radio frequency (RF) power source and pass on their energy to the nuclei of the hydrogen atoms (protons) in the liquid, altering their spin states. This transfer of energy from electrons to the protons is called the Overhauser Effect named after the American physicist Albert Overhauser who discovered it in the early 1950s. Once the protons are polarized, the RF power source is de-energized, and the protons spiral back to their original alignment. The frequency of their spiraling (precession), which is dependent on a known constant called the "gyromagnetic ratio" and the total geomagnetic field, is measured with a coil. If the RF is

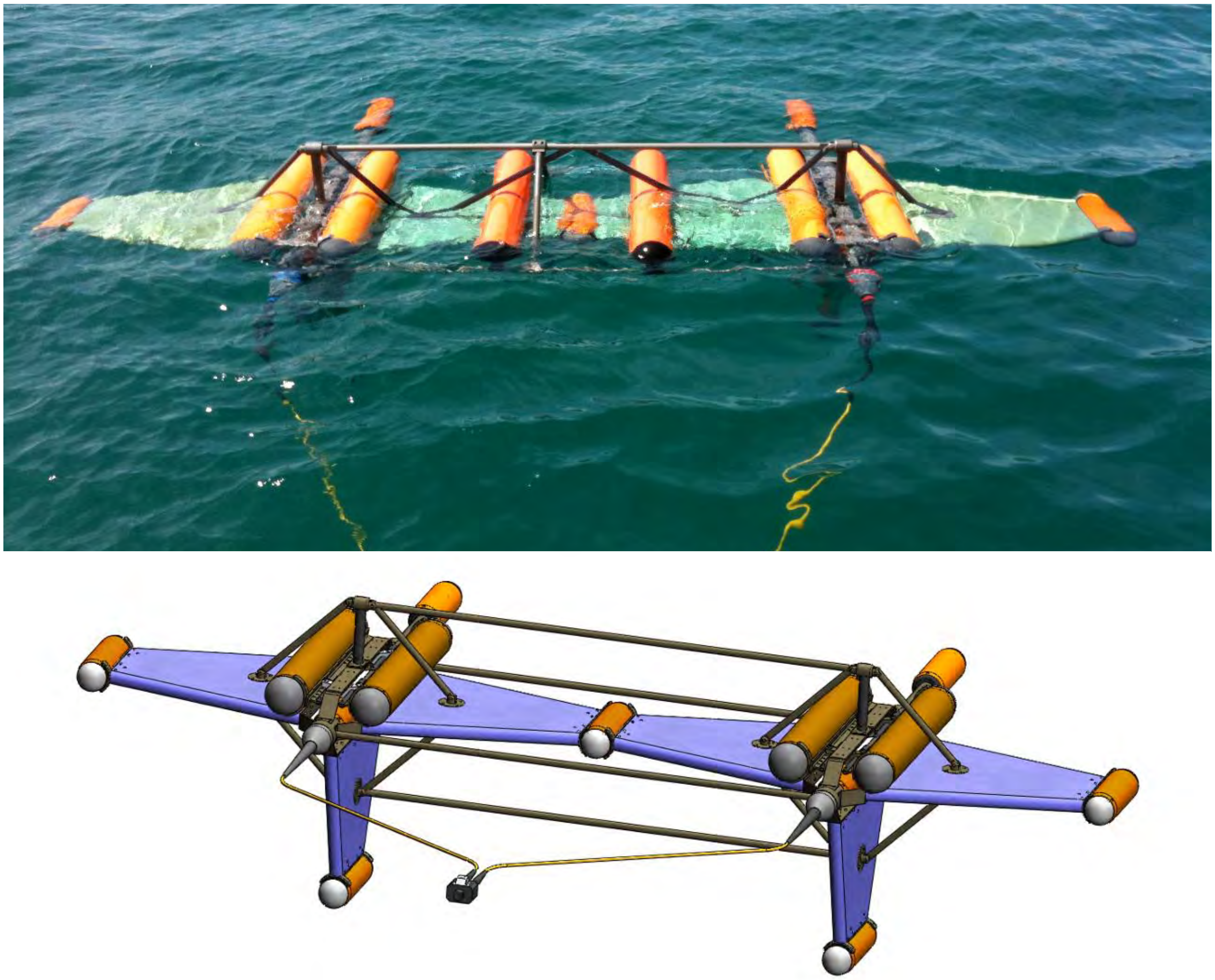


Figure 2-5. MGA Configured for the South Beach Survey with Seven Magnetometers

measured, and the gyromagnetic ratio is known, the total geomagnetic field can be calculated. Aberrations in the geomagnetic field can be used to identify ferrous anomalies on the seafloor and in the sediments below.

The Overhauser magnetometers used in the TtEC MGA have several advantages:

- Overhauser sensors produce clear, strong proton precession signals using a very small amount of power.
- The power needed for proton polarization in the Overhauser sensor is applied at a frequency that is far out of the bandwidth of the proton precession signal. As a result, the sensor can be polarized concurrently with precession signal measurement. This effectively doubles the amount of information available from the sensor, allowing faster sampling rates.

- Overhauser sensors are very sensitive to changes in the geomagnetic field (~ 0.08 nanoTesla [nT] at a sampling rate of 4 hertz [Hz]) and are not influenced by a phenomenon termed "heading error." Heading error is defined as changes in the measured magnetic field based on the direction of travel and orientation of the magnetic sensor. When creating 2D maps, heading error can cause offsets between detections from successive survey lines and small anomalies can be obscured in the data. In general, magnetic sensors that are not affected by heading error have an increased probability of accurately delineating small intensity anomalies without the need to perform full coverage surveys in different directions. Anomalies of this intensity are common in underwater applications due to the required separation of the deployment platform (or towfish) and the seafloor to avoid snagging the towfish on objects and/or features on the seafloor.
- Overhauser sensor measurements are temperature independent; therefore, there is no system drift due to temperature changes.
- Processing and data analysis is simplified because correction for sensor drift, orientation, and heading error is eliminated.

The design of the MGA allows the total magnetic field for each magnetometer to be measured, as well as up to 10 two-dimensional (2D) magnetic gradients and three 3D measured analytic signal vectors that are automatically calculated in real-time from the total field and gradient measurements. This system is unique in that it provides both total field and vector data.

Underwater positioning of the MGA was achieved using a USBL acoustic tracking system and an electronic cable counter. The USBL is more accurate than the cable counter and was the primary method for tracking the MGA. The IXSEA GAPS USBL used for this survey has an accuracy of 0.2 percent of the slant range. This level of performance is unmatched by any other USBL and provided exceptional performance. Table 2-2 shows the expected positioning uncertainty of the USBL for water depths up to 40 meters assuming a 3 to 1 layback typical of towing operations.

Table 2-2. USBL Positioning Uncertainty

Water Depth (m)	Slant Range (m)	Approx. USBL Uncertainty (m)
5	15	0.03
10	30	0.06
15	45	0.09
20	60	0.12
30	90	0.18
40	120	0.24

The IXSEA GAPS USBL has an internal INS thus the USBL requires no calibration to determine angle offsets between the systems hydrophones and an auxiliary INS. This makes the USBL very quick to mobilize onto vessels of opportunity and to begin using at that start of a WAA. A LCI-90 electronic cable counter was used to measure the cable payout to the MGA. The LCI-90 is coupled with an instrumented sheave which the tow cable passes through; the distance resolution on the sheave is 0.06 meter (Figure 2-6). These data from the LCI-90 are provided to the acquisition software where the position of the towfish is calculated in real-time based on vessel position, speed, heading, and cable catenary.

Figure 2-6. Instrumented Sheave for Measuring Cable Payout

Having the cable counter as a redundant positioning system was also beneficial as it provides a method for quality control assessment of the USBL positioning. In real time the survey technician was able to monitor the reported position of the towfish based on both the USBL and the cable counter. Figure 2-7 shows the real time navigation display, note that the distance between adjacent lines is 10 feet (3.05 meters) and the towfish symbols are 13.1 feet (4 meters) wide. Careful observation reveals two towfish in nearly identical locations.

2.1.3 Sidescan Sonar

To provide high quality imagery and to augment the MBE data, high-resolution SSS data were collected with an EdgeTech 2000-DSS combination SSS and SBP towfish with a 100/600 kilohertz (kHz) dual frequency CHIRP SSS. The DSS towfish has an integrated pressure sensor

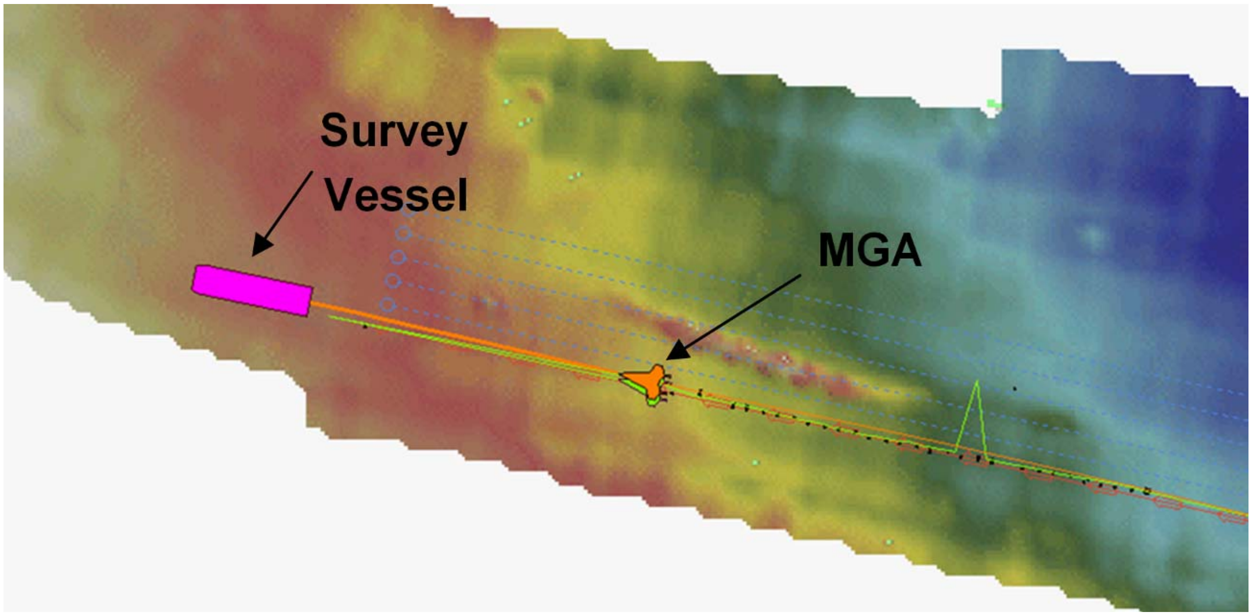


Figure 2-7. Real-Time Navigation Display Track the Vessel and Towfish Using the USBL (orange towfish) and Cable Counter (green towfish). The ~10 meter survey vessel and 4 meter wide MGA are sized to scale.

and altimeter for monitoring submersion depth and height above the seafloor. The positioning methodology used to track the SSS/SBP was identical to that used to track the MGA (refer to Section 2.1.2). The SSS transmits a narrow, fan-shaped acoustic pulse (ping) perpendicular to the direction of travel. As the pulse travels outward from the sonar unit, the seafloor and other objects reflect some of the sound energy back in the direction of the unit. This reflected energy is known as backscatter. The signal strength or amplitude of the reflected acoustic data and it associated travel time are analyzed to generate an image of the seafloor. One advantage of SSS is the low grazing angle of the transmitted beams. The low angle results in distinctive shadows being cast behind objects on the seafloor, making smaller objects more visible and providing greater detail on larger (0.5m^2, range dependent) objects. While SSS does not measure the depths of features, the imagery can provide reasonable size estimates for features, it is efficient for finding small features and it can often provide a sufficiently high-resolution picture to enable identification of some features in the water column and on the sediment surface. These characteristics make it a very good complement to MBE, MGA, and SBP because it can be used to help discriminate features of interest from background clutter. Like the MBE resolution of the SSS data is a function of the operating frequency, number of beams, beam width, pulse rate, beam angle and vessel speed. An example of SSS imagery is presented in Figure 2-8.

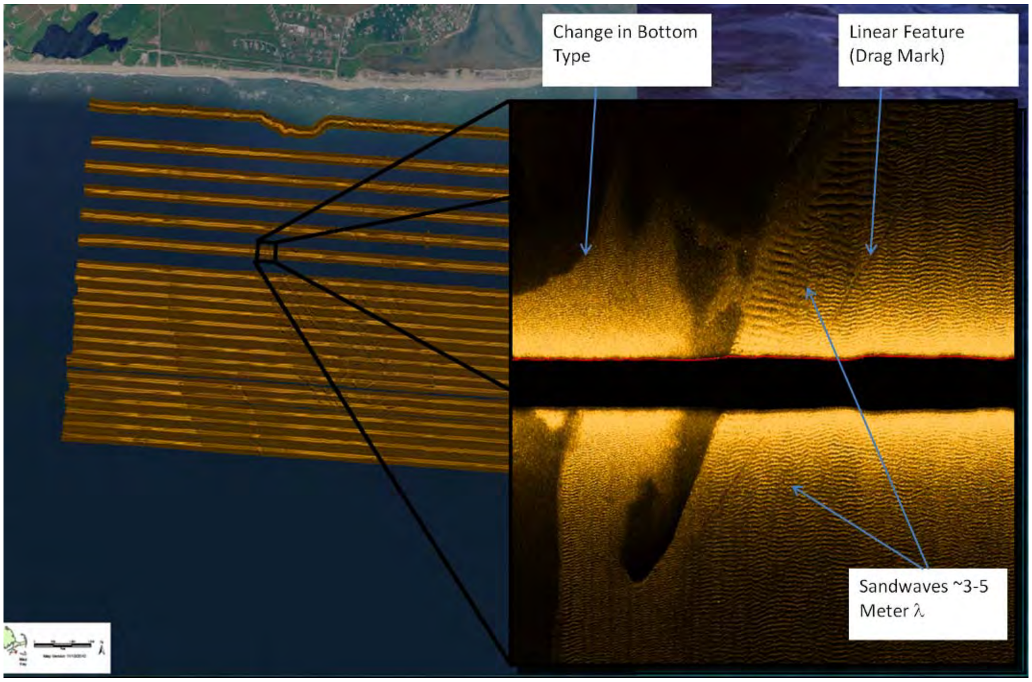


Figure 2-8. Sidescan Sonar Data at South Beach Showing Both Large and Small Geomorphic Features

2.1.4 Sub-Bottom Profiler

Sub-bottom profiler data were collected to provide information on sediment type and stratigraphy in the surveyed areas. Profiling data were used to help define areas of soft sediments and identify depositional areas where MEC may be buried, rather than on the surface. While there is no assurance that a sub-bottom profiler can resolve and delineate individual MEC items, it can detect buried debris fields and large background debris items. These data were helpful in determining the location, boundaries, and nature of anomalies detected during the MBE, SSS and MGA surveys.

The system used to acquire SBP data was the EdgeTech 2000-DSS combination SSS and SBP towfish with a 2 to 16 kHz sub-bottom profiler (Figure 2-9). Positioning was achieved in the same manner as for SSS since a combined SSS/SBP towfish was used.

Figure 2-9. EdgeTech 2000 DSS Combined SSS and SBP

Sub-bottom profilers are acoustic systems that function in a manner similar to echosounders. A sound pulse (ping) is emitted vertically downward toward the seafloor and a receiver records the return signal that is reflected. When the pulse encounters boundaries between two layers that have different acoustic properties (acoustic impedance), part of the pulse is reflected. However, depending on the nature of the pulse, a portion of the signal penetrates through the boundary and is reflected when it encounters another, deeper boundary. Using the strength of the reflected signals and the travel times, it is possible to evaluate the thickness and density of layers in the bottom substrates. These data can be geo-referenced and matched to the bathymetry surface data, as shown in Figure 2-10, to provide a more complete definition of site conditions.

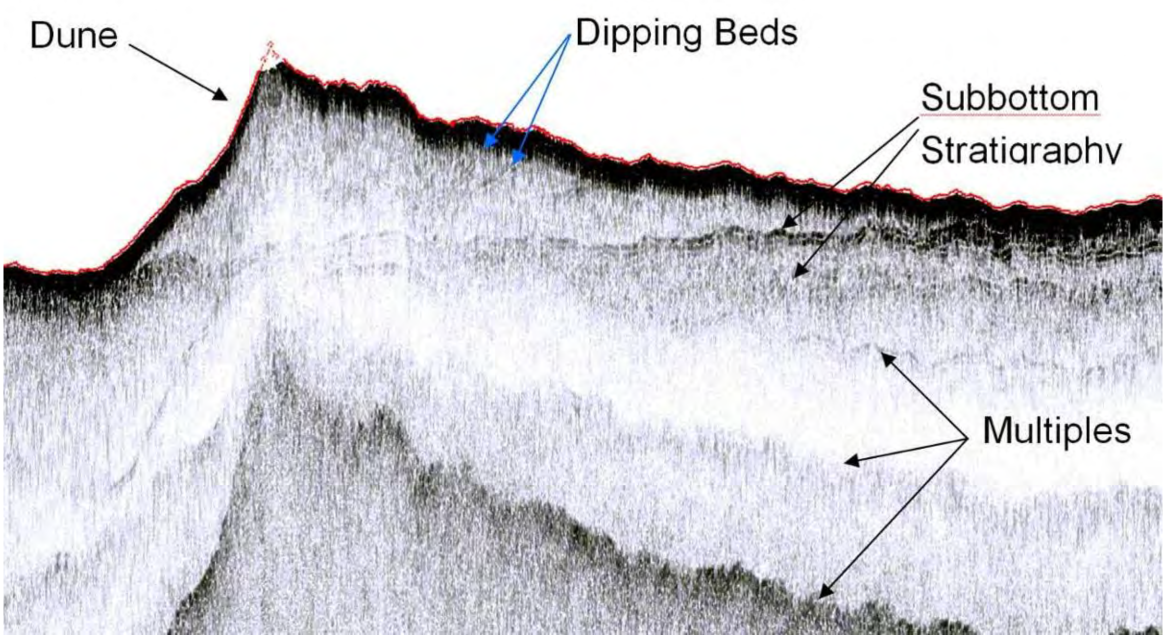


Figure 2-10. South Beach Sub-Bottom Profile Data

The 2000-DSS towfish provides SBP at frequencies between 2 and 16 kHz. This frequency range is appropriate for project sites with sandy bottom substrate such as that found at South Beach. High frequency output will generally provide penetration into the subsurface layers. If the bottom substrate is very hard or is thin, however, the signal may be reflected back from the seafloor and then reflected off the sea water surface, leading to multiple reflections and "noise" in the data.

Signal frequency also has an effect on system performance. Lower frequency systems will typically penetrate farther into the bottom and provide data at greater depths. Higher frequency systems tend to have more usable bandwidth and correspondingly greater range resolution. For example, the Edgetech SB-216S has an operating frequency of 2 to 16 kHz, and a specified penetration of 80 meters in clay, with a best resolution of 6 centimeters (cm). The model SB-424 operates at 4 to 24 kHz, with a maximum penetration of 40 meters in clay and a best resolution of 4 cm.

2.2 TECHNOLOGY DEVELOPMENT

The technological development for this project was not so much individual physical components as much as the methodologies for acquiring and processing data from multiple geophysical instruments. Advanced technologies for underwater positioning, magnetic field measurement and acoustic imaging were integrated into a mobile survey platform for the specific task of locating underwater MEC anywhere in the nation in water depths up to 40 meters. It is this level of system integration seen in Figure 2-11 that is the technological achievement of the WAA survey.

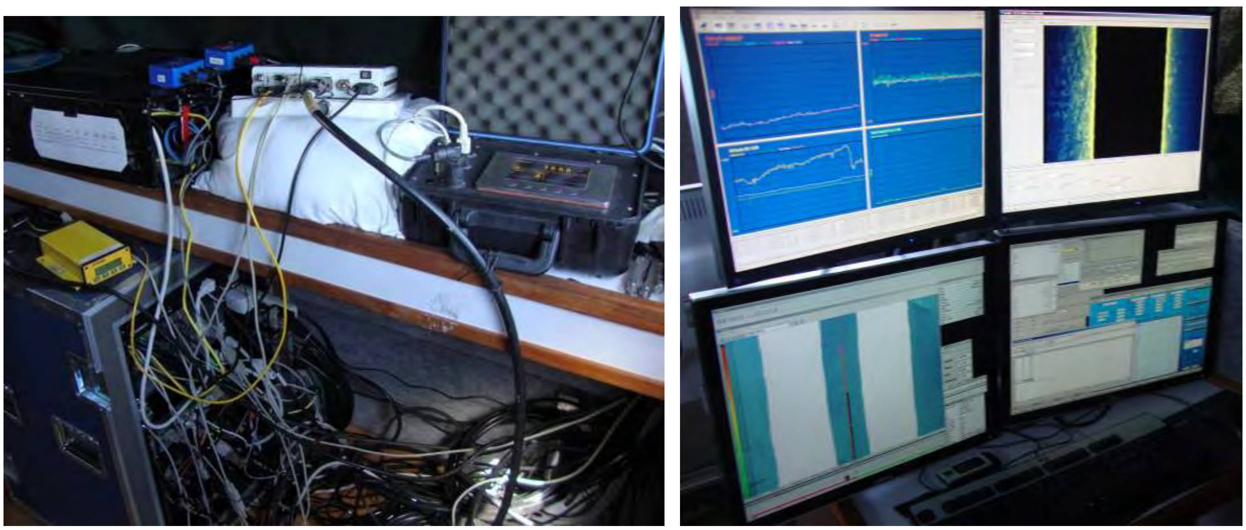


Figure 2-11. Photos from Inside the Survey Vessel Showing Physical Systems Integration and Data Acquisition and Monitoring Station

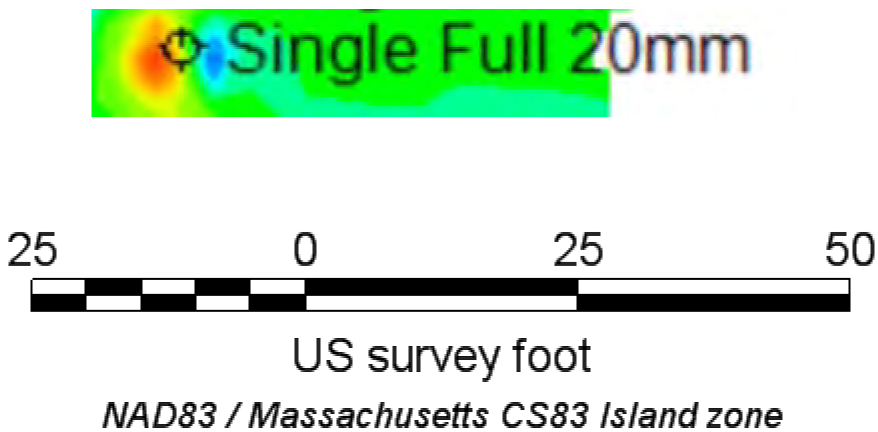
The second component of development for this ESTCP project was the software and work flow for data processing. We refined software to provide quick and efficient processing of the MGA data into a useable format that could then be analyzed in Oasis Montaj. In Oasis Montaj we developed methodologies for further processing and analyzing both the total field and analytic signal data so as to extract meaningful information. Further detail in this regard can be found in Section 6.2.1.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

2.3.1 Advantages

The WAA approach developed by TtEC for underwater MEC WAA combines true 3D analytic signal measurements from the MGA with data from other advanced survey instrumentation and high accuracy vessel and towfish positioning to provide high accuracy MEC detection. The survey system used for this project has several advantages over existing systems.

- The MGA is unique in that it measures both total field and vector data and accurately measures 3D magnetic gradients, rather than 2D gradients collected by other systems. The measurement of 3D gradients over 2D reduces background environmental noise from the dataset, reducing the number of false positives while retaining high sensitivity for detecting small (e.g., full 20mm/40mm round) MEC and providing highly accurate positioning of anomalies.



Example total field data for a single 20mm round from the IVS detected within 0.5 meter of the seeded location.

- Positioning of the MGA and other in water systems is provided by a high accuracy, USBL positioning system which has an accuracy of 0.2 percent of the slant range.
- The TtEC MGA system was successfully deployed and operated in up to Sea State 3 conditions. This is higher than any other known MEC detection platforms developed thus far.
- The TtEC WAA approach integrates magnetometer data with acoustic survey data. The multibeam sonar, SSS, and SBP provide valuable data for discerning the pattern of magnetic anomalies and assessment of in water MEC sites. In some cases the acoustic data can provide additional information about a specific target such as whether the target is buried or the shape of the target.

2.3.2 Limitations

The limitations of the WAA system are the limitations of the individual technologies. For instance, all magnetometers operation is limited when working in locations with complex geology or in close proximity to large ferrous bodies such as bridges or piers or when working near high voltage electrical sources. Since the MGA measures gradients it can in some cases compensate for these large and undesirable magnetic field sources.

Thus far the MGA has been tested in depths up to 35 meters; however, it is rated to 300 meters and could be modified for work in water up to 6,000 meters. TtEC expects that terrain following will become proportionally more difficult as depths increase which will in turn require an increased flight height, automated flight capabilities, and/or integration into an autonomous underwater vehicle (AUV).

As depth increases, so does the inaccuracies of USBL positioning, although sub-meter accuracy should be retained up to survey depths exceeding 100 meters. If higher accuracy is required at greater depths it is possible to integrate the MGA with a Doppler velocity log (DVL) and subsea INS and to utilize a long base line (LBL) acoustic positioning system. Additionally post-processing software can be used to improve the DVL, USBL and/or LBL positioning accuracy.

For the demonstration survey all required systems were mobilized on the R/V Ugle Duckling. While this vessel outperforms the survey platforms utilized by other underwater MEC detection surveys funded by ESTCP, it does have an operational sea state limitation (sea state 4). Fortunately all components of our WAA survey are capable of operation in higher sea states and are easily mobilized to a larger research vessel when operations in greater sea state are required.

3.0 PERFORMANCE OBJECTIVES

The qualitative performance standard for this project was to demonstrate a practical approach to conducting WAA for MEC survey in marine and freshwater environments. Since there was not a specific problem to solve during this demonstration project (e.g., reduce false positives, improve detection probability) the quantitative performance objectives were based upon observed and anticipated system capabilities rather than specific parameters. Although meeting the identified quantitative performance goals for individual system components did not ensure the success of the demonstration, it did ensure that system components were functioning within their performance specifications. In addition, the application of data quality objectives ensured that high quality data were obtained which provided a sound basis for measuring the success of the demonstration.

Success of a practical approach for WAA was also a function of the capability of the approach and selected technologies to locate and delineate features of interest at the project site. The features of interest for a munitions response site are typically munitions use areas such as impact areas (ranges), range safety fans, or disposal areas identified by developing a CSM based on historical data. In the case of this project site, aerial bombing targets, range safety fans and potential disposal sites have been identified in the CSM, which is discussed in more detail in Section 5. Performance objectives for the WAA demonstration incorporated expectations with respect to location of features of interest for the site. Table 3-1 lists the identified performance objectives for the demonstration along with the data needed to evaluate successful achievement of the objectives. Table 3-2 provides the data quality metrics which needed to be achieved to ensure the project objectives for the demonstration were met.

Table 3-1. Performance Objectives

Performance Objective	Metric	Data Required	Success Criteria	Results
Quantitative Performance Objectives				
Detection of underwater features of interest potentially representing MEC	System functionality	• Data from all systems over the instrument verification strip (IVS) • Data from all systems at the demonstration site • Target dig list • Data from the diver investigation • IVS items list with coordinates	• Instruments detect all representative items in IVS • Instrumentation meets quality goals in Table 3-2 • Features of interest are observable in data • All systems performs reliably (no data dropouts, equipment malfunctions)	• As described in section 5.7, the MGA detected all representative items placed in the IVS, including many smaller munitions. Larger items were identified in the SSS, No IVS items mapped with MBE however MBE was successfully used to map site bathymetry and verify a clear path for MGA low altitude flight • Instrumentation met the quality goals in Table 3-2 • At the demonstration site ferrous objects detected with MGA but most were not seen with the SSS. • After the initial shake down all survey/detection systems performed with minimal breakdown. This is with the exception of the survey vessel which experienced mechanical failures. • Diver-based target verification data were not available of the demonstration site at the time of this report.
Timely initial data processing & mapping	Creation of draft data products (processed image data) for MBE & MGA data, mosaics for SSS, vertical imagery curtains for SBP	• raw multibeam soundings • raw MGA data files • raw side-scan files • raw sub-bottom data	• "near real time" on-board and preliminary post processing of all data within 2 day of collection	• Preliminary post processing of MGA, SSS and SBP data was complete within 1 to 2 days of collection. • MBE data were processed in near real time on the vessel.

Table 3-1. Performance Objectives (continued)

Performance Objective	Metric	Data Required	Success Criteria	Results
Good production rate	Number of line kilometers (km) of data collection per day	• Log of field work and all data files time tagged or stamped	• MGA Survey: ~16 line km/day (approximately 3.5 acres/hr; 15-20 acres per day) • MBE Survey: ~ 32 line km/day • SSS/SBP: ~ 32 line km/day	• Production goals were met and in some cases exceeded. • MGA with MBE: ~ 33 line km/day • MBE: ~ 50 line km/day • SSS/SBP: ~ 42 line km/day
Qualitative Performance Objectives				
Ease of use		• Feedback from technicians on usability of technology and time required to setup and operate. Feedback regarding difficulty in data processing	• Technicians indicate that they are able to deploy the system efficiently and in a consistent manner. • Data processing is a smooth workflow • Data analysis techniques allow for quick and accurate target identification.	• Field operations encountered routine minor technical difficulties but operation was otherwise only limited by survey vessel maintenance, adverse weather and/or sea state. • Software development and methodologies allowed incoming data to be processing rapidly • Target picking from the gradiometer data was simple but full integration with acoustic data not completed.

Table 3-2. Data Quality Metrics

Technology Type	Measurement Data Quality Indicator	QC Sample and/or Activity to Assess Measurement Performance	Measurement Performance Criteria	Frequency
Hydrographic Surveys and Marine Geophysical Mapping – Multibeam	Precision/ Repeatability	Cross line data	Data points common to both survey lines and cross lines will have x,y,z coordinates that are repeatable within specified International Hydrographic Organization (IHO) standards (refer to Appendix 1 of the standard, Table 1). Hydrographic survey data shall meet or exceed special order standards.	Minimum one cross line per 10 transects
	Completeness	Visual evaluation of data real-time for verification that intended coverage goals are met	Real-time coverage plots (matrix fill) will be used to monitor coverage completeness. Total linear kilometers of data acquired will not be less than 98% of that indicated by the plan.	Continuous visual monitoring during data collection
	Sensitivity	Real-time monitoring and use of gains and gate filters, software quality flags	Data collection depth range is optimized to reduce anomalous reflections and provide high quality data, gains are set to provide appropriate bottom tracking. Internal testing is done by the data acquisition software to check the validity of each ping based on co-linearity and brightness and each ping is tagged with a quality flag of 0-3 based on the these tests. During processing the pings are filtered based on the quality flags to eliminate all but the data with a quality of 3 unless conditions warrant acceptance of lower quality pings (such as where there are topography discontinuities such as wrecks or piles).	Continuous visual monitoring during data collection, sonar system quality flags
	Accuracy	1. GPS Positioning - Survey crew will check selected terrestrial control points with RTK GPS rover. 2. Water level check – Use RTK GPS rover to check water surface elevation. Compare to survey system navigation reported tide level. 3. Bar check and/or lead line check vs. water surface relative depth from sonar.	1. RTK GPS measurements will match published position to within 0.1 meters x, y and z. 2. RTK GPS water level and survey system tide level will match to within 0.1 meters. 3. Nadir bathymetry depths relative to surface, corrected for draft and attitude matches to within 0.1 meters.	1. Daily 2. Daily 3. At start of MBE operations

Table 3-2. Data Quality Metrics (continued)

Technology Type	Measurement Data Quality Indicator	QC Sample and/or Activity to Assess Measurement Performance	Measurement Performance Criteria	Frequency
Marine Geophysical Mapping, Magnetic Anomaly Mapping. (Marine Gradiometer Array) MGA	Precision Accuracy, precision	Static Test Static Response Test	Standard deviation of readings ≤ 5 nT for each of the seven magnetometers. The test is performed over a 1-2 min period performed in a "background" free of magnetic anomalies while the platform is in motion. Each sensor within +- 20% using a standard item placed in the IVS (baseline response for each sensor will be determined during testings at beginning of project)	Daily during mapping operations.
	Completeness	Visual evaluation of data real-time for verification that intended coverage goals are achieved (re: Figure 3-1). Daily instrument checks serve as QC metrics to calculate completeness during field activities.	Sample distance ≤ 1.3 meters for 90 % of measurements for each 30 linear meters of data assessed (assess minimum of 3% of transect length per day) or as determined during initial data collection effort at Instrument Verification Strip (IVS). 90% of the sensor measurements will be at a platform height of ≤ 2 meters above the bottom. Total linear meters of data acquired will not be less than 98% of that indicated in the plan.	Daily
	Sensitivity	IVS	Instrumentation detects 98% of items in IVS and positions items (x-y) within ± 1 meter of actual position or as determined during initial data collection effort at IVS (*accuracy*). Response from test strip items ≥4 nT peak amplitude or as determined during initial data collection effort at ITS *(sensitivity)*. NOTE: The IVS design and installation are discussed below.	Prior to beginning data collection and daily for all collection days
	Accuracy	Instrument function verification on the test strip	Detect the largest ISO (4 x12 inch per standard) with signal strength above industry standard, physics-based model curve	Calculation performed once

3.1 DETECTION OF UNDERWATER FEATURES OF INTEREST

This performance objective evaluates the fundamental success of the demonstrated WAA system. The objective is to demonstrate a practical method for effectively detecting underwater MEC, particularly over a wide area. Specifically, the MGA must be capable of detecting targets with magnetic signatures representative of those generated by real MEC at water depths ranging from 1 to 120 feet (0.3 to 37 meters). Practical methods of effectively detecting underwater MEC, particularly over a wide area, are a function of the ability to efficiently deploy multi-component data collection systems, which provide accurate, useful, high-quality data.

3.1.1 Metric

The efficiency of the demonstration was measured quantitatively and qualitatively using the performance objectives provided in Tables 3-1 and 3-2. It was also measured qualitatively via the experience of the field and management team. Overall success was a subjective measure.

3.1.2 Data Requirements

To fully evaluate the effectiveness of the data collection system and the success of the demonstration, the team needed to collect geophysical data to identify potential underwater munitions, as well as observational data to evaluate the effectiveness of the system as a whole. The geophysical data were collected using the multiple sensors and processed in a variety of software programs. These data were evaluated quantitatively. The observational data were in the form of survey logs and notes from field technicians. The final evaluation also incorporated the team perspectives on field operations, including any difficulties encountered in configuring or deploying the selected data collection system.

3.1.3 Success Criteria

As a whole, the WAA survey was a success. All of the data quality metrics of Table 3-2 were met and magnetic anomalies that potentially represent MEC were found in the demonstration area. While diver verification was not available for the demonstration area we were able to make many qualitative and quantitative observations from our IVS survey. Section 5.7 provides details regarding the IVS survey. The selected acoustic systems provided additional data that aided in the success of survey operation. The MBE and associated navigational systems were used to generate a detailed bathymetric map, which was in turn used for terrain following and obstacle avoidance when towing the MGA and 2000-DSS. The bathymetric map was also used to augment and evaluate the CSM. In the case of the South Beach survey, no cultural features were identified with the multibeam sonar, however other MEC wide area assessment surveys performed by TtEC have shown that the multibeam sonar can identify cultural features.

The SSS provided detailed images of the seafloor and seafloor geomorphology. This instrument can detect MEC that lay proud of the bottom although its performance depends on the size of the target and distance to the sonar. Because software for full data integration between the SSS and MGA has yet to be developed, TtEC was unable to analyze the SSS data as thoroughly as would be necessary to identity all of the individual MEC. Although tedious in nature, TtEC was able to use MGA data to guide us to a specific region of the SSS data where a magnetic anomaly had been detected. In a few cases, the SSS full resolution waterfall data revealed "bright spots" or a few highly reflective acoustic returns that indicated the magnetic anomalies were generated from a target that lays proud of the bottom. However, these bright spots would not have been very anomalous had they not been associated with magnetic anomalies. Perhaps with software development the SSS data could be more useful. TtEC would also recommend that SSS operations be performed with higher frequency sonar for greater image resolution. Perhaps a combination 600 & 900 kHz system would be more appropriate than the 100 & 600 kHz system operated at South Beach. Furthermore, the success of the SSS will depend of the survey environment. For sites where the MEC are likely to be buried under sediments, the SSS will be less useful.

The SBP provided 2D along-track profiles of the seafloor stratigraphy. Although this was not useful for locating individual MEC, it did provide additional data for the CSM. Specifically the SBP imaged sand dunes that are migrating through the survey area eroding and depositing sediments as they move. For some WAA surveys the sub-bottom survey may not be necessary, however with the use of the 2000-DSS towfish, which is both a SBP and SSS, there is no loss of efficiency in collected the sub-bottom data.

3.2 TIMELY INITIAL DATA PROCESSING AND MAPPING

This performance objective measured our ability to generate data products quickly. Quickly generated products are necessary because it allows decision makers to make sound decisions related to the modification of the survey design and line plan as the survey progresses.

3.2.1 Metric

The metric for this performance objective is the draft data products generated from the raw data.

3.2.2 Data Requirements

Data required for timely initial data processing were the raw data files from the individual geophysical instruments. These data were then processed such that they could be displayed and interpreted with ease.

3.2.3 Success Criteria

For each type of data the processing and interpretation was different and required different software and various amounts of effort.

The MBE data has by far the most individual data points and requires the most computational time. To generate a final MBE data product that has been thoroughly processed requires almost as many hours to process as it does to collect. MBE data processing is explained in Section 5.5. In contrast draft MBE data can be generated in near real time as the data is collected. This allowed the survey technicians to process the MBE data onboard the vessel and generate draft charts in near real time. On some survey days, MBE data were collected in the morning, processed, and then used in the afternoon to guide MGA data acquisition. We consider this level of efficiency to be quite successful.

By the end of the project processing MGA data had become a streamlined processes. Because the MGA data files for each survey line were relatively small (4 megabytes compressed for 4 kilometers of survey) the survey technicians would e-mail the files as they were collected to the data processing lab on land. In the lab, a geophysicist would first examine and edit the navigation data to remove any positional fliers generated by the USBL. The raw file would then be run through MagProc to generate two files: georeferenced analytic signal data file and a georeferenced total field data file. These files could then be run through a script to import the data into the active Oasis Montaj project. This entire process would take less than twenty minutes and was considered a success by the field team. The realized efficiency could only be possible through innovative software and methodology development.

It was not as critical to process the SBP and SSS data in a timely manner, however it was desirable to do so prior to demobilization to ensure coverage and project objectives has been achieved. Both the SBP and SSS data sets were processed to a draft level within two days of collection. No addition software development was necessary for this to be possible. Chesapeake Sonar Wiz was used to process both the SBP and SSS data.

3.3 GOOD PRODUCTION RATE

The objective here was to document that data could be collected with a good production rate.

3.3.1 Metric

The metric for this performance objective is the quantity of data or distance of survey collected each day or each hour.

3.3.2 Data Requirements

Required to asses to performance objective were the time stamped data and survey logs.

3.3.3 Success Criteria

Success in this category was based on performance goals set in the work plan. The quantitative goals were based on previous experience and theoretical production rates based on survey speed and number of operational hours possible in a day. Despite the long transit from the harbor in Edgartown to the survey area at South Beach (approximately two hours each way), TtEC was able to meet or exceeded our success criteria. This was possible through a combination of increased survey speed, decreased turn time, and minimal equipment malfunctions. TtEC was able to exceed our MBE projection rate by more than 50 percent. This was possible because of the greatly increased survey speed during the initial survey due to the extremely stable and well positioned MBE pole mount. While this increased speed did result in a decrease in data density and sometimes quality (bubble wash over the transducers in rough seas) it was inconsequential as a secondary MBE survey was performed while the same lines were rerun during MGA surveying which were collected at slower speeds.

3.4 EASE OF USE

This is a qualitative performance objective to assess the ease of implementing the WAA survey. This objective is subdivided into data collection and data processing.

3.4.1 Metric

The metric for this performance objective is the qualitative feedback from the technicians and geophysicists who collected and processed the data.

3.4.2 Data Requirements

Data requirements for this performance objective are simply the experience of the authors and feedback from other geophysicist and technicians.

3.4.3 Success Criteria

Through many iterations of development and implementation, the MGA and associated systems are now relatively easy to deploy and operate from our survey vessel. Many customizations have been made to the vessel to create a platform that is well suited for performing underwater MEC surveys anywhere in the nation. These customizations include fabrication and addition of vessel side pole mounts which were designed and built for attaching the MBE and USBL. An A-frame was built with integrated hydraulic winches and cradles for picking and transporting the MGA. An electric winch was selected and installed making it possible to fly the MGA at a fixed altitude above the bottom. These designs coupled with experience and methodologies made launching, towing and recovering the MGA a trivial exercise to Sea State 2, with operations possible in Sea State 3. Towing is possible in Sea State 4, but safe retrieval becomes a problem.

In regards to ease of data processing, only the MGA data will be discussed here, as processing MBE and SSS data is not unique to this project. Thanks to software refinement funded in part by ESTCP, the MGA data are now relatively easy to process. The raw MGA data are in the form of American Standard Code for Information Interchange text relaying the total field measurements and ancillary attitude, altitude, and depth measurements. During acquisition the MGA data are recorded with the USBL position data. These raw files are then processed using Tetra Tech's software "MagProc" where the 3D analytic signal is calculated and the position of all the sensor measurements at the time of measurement is calculated based on the USBL transponder location and towfish attitude. MagProc generates an analytic signal and total field file for each of the raw files. These processed files are then read into Geosoft Oasis Montaj software for smoothing gridding and final processing. While this may seem like many steps, it is relativity easy to execute and can be taught to a new data processor with some previous geophysical data processing experience in a few days.

4.0 SITE DESCRIPTION

The site selected for this demonstration project is the former Moving Target Machine Gun Range (MTMGR) at South Beach, Martha's Vineyard, Massachusetts (refer to Figure 4-1). The site is located along the southern shoreline of Martha's Vineyard south of the town of Edgartown, Massachusetts.

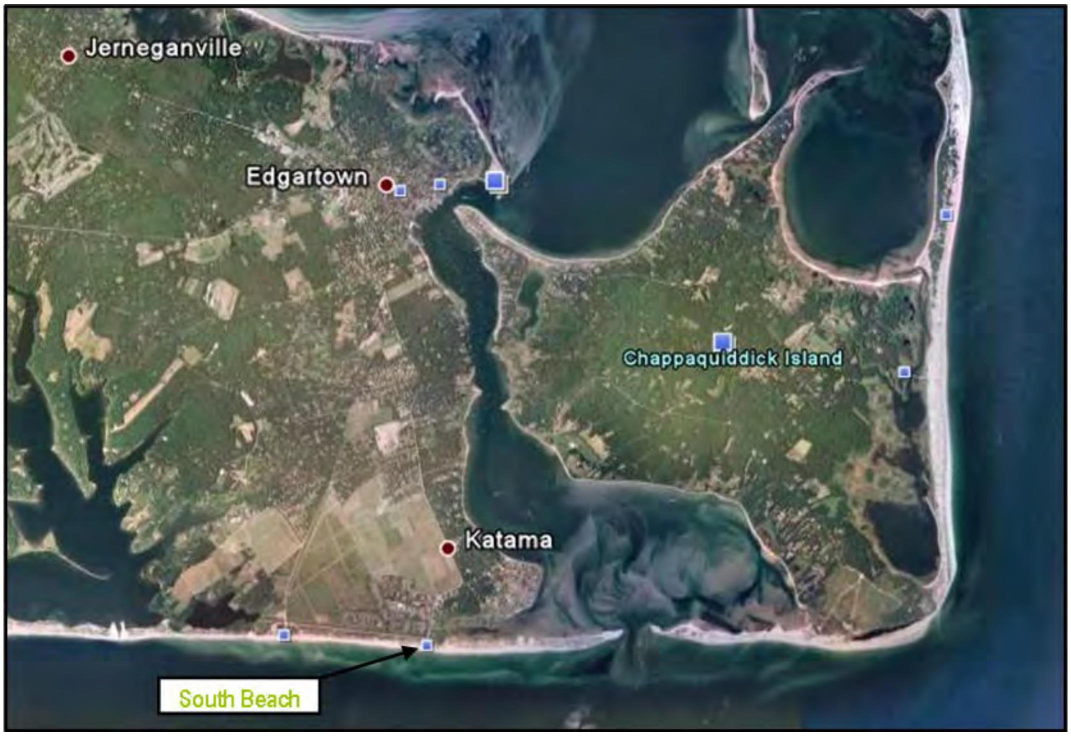


Figure 4-1. South Beach, Martha's Vineyard, Massachusetts

The specific survey area for the demonstration extended approximately 4.3 kilometers along South Beach, beginning approximately 200 to 375 meters off shore at a water depth of approximately 3 meters and continuing out approximately 4.6 kilometers off shore to a water depth of approximately 20 meters. The length of this area along the shoreline corresponds to the terrestrial and surf zone area previously investigated as part of a Preliminary Assessment/Site Investigation conducted by EOD Technology, Inc. as well as areas to the east where munitions have been found in the past. The data from this investigation were used to help determine the likely areas for deposition in the marine environment beyond the surf zone. The approximate demonstration area is shown on Figure 4-2.

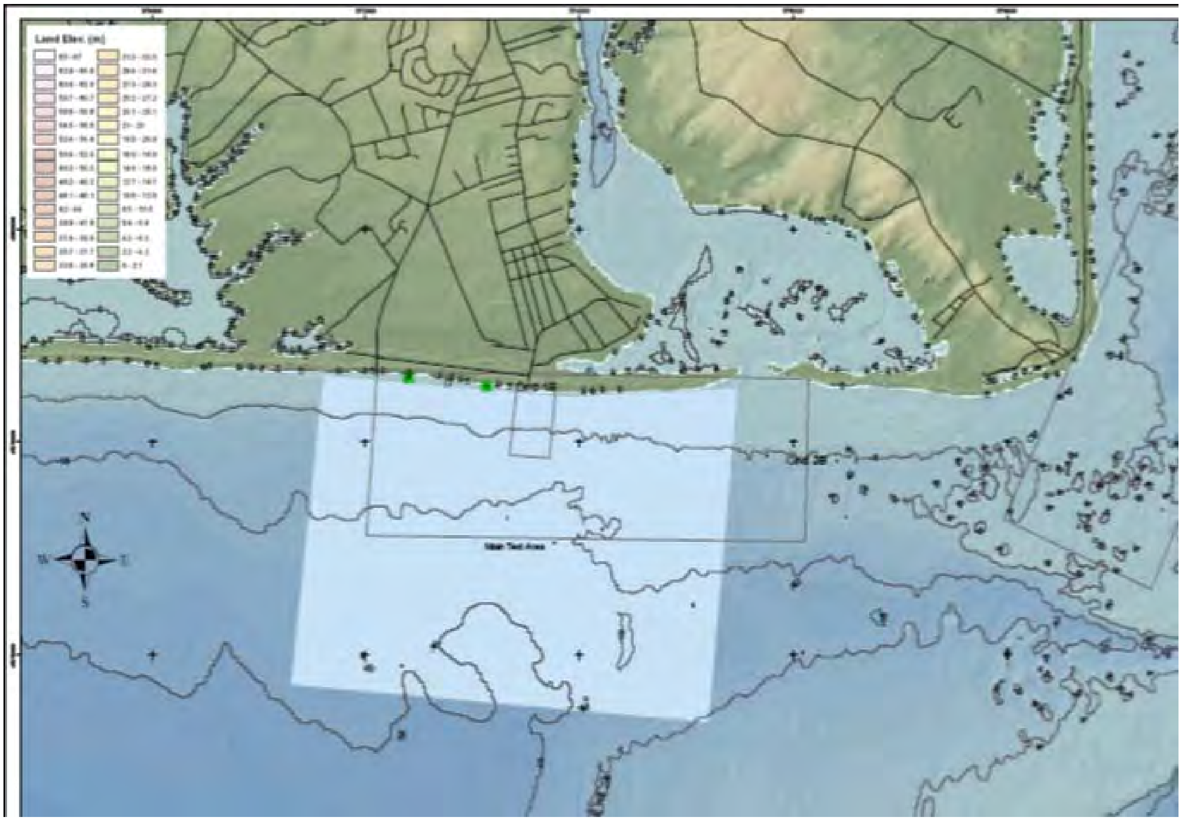


Figure 4-2. Approximate Demonstration Area

4.1 SITE SELECTION

The former MTMGR at South Beach was selected for the WAA assessment based upon a number of factors. First, the site has physical features which were conducive to the demonstration; the bottom area is sandy and there is a range of water depths within the in the project area (3 to approximately 17 meters in the primary survey area). Secondly, and perhaps more importantly, the former MTMGR is typical of many project sites where the technology will commonly be applicable. The area is currently a high-profile beach heavily used by tourists and locals alike. Practice munitions and occasional live bombs have continued to wash ashore over the years from an unidentified offshore source or sources perpetuating the hazard to public. Because Martha's Vineyard is a very popular summer time destination resort, the site has substantial regulatory interest. The U.S. Army Corps of Engineers (USACE) previously conducted a Site Investigation for MEC at South Beach which provided an opportunity to both demonstrate the capability of technology and to enhance the results of the previous investigation. An extra benefit of this site is the historical use of the site as a test bed for laying an underwater gasoline supply pipeline under the English Channel to support the Normandy invasion during World War II. As a result, very long lengths of pipe were laid on the seafloor roughly perpendicular to the shoreline. Since there was no indication that the pipelines were ever removed, these structures would ensure that metallic features were present in the survey area for potential use in calibration of the data interpretation and analysis process (i.e., provide data about the type of response anticipated from large, linear metallic features or debris).

4.2 SITE HISTORY

In 1943, the Department of the Navy leased approximately 264 acres for training purposes, including the South Beach area. South Beach was known as the MTMGR for the U.S. Naval Air Station at Quonset Point, Rhode Island. This range was used for land-based training utilizing a machine gun emplacement and by aircraft for machine gun and rocket target practice. The Navy constructed an oval-shaped rail track to transport the moving targets used on the range and a small observation/spotting bunker. At some point prior to 1946, the oval rail track was substantially destroyed by a hurricane. The Navy constructed new stationary targets at each end of the former track and began using the site for aerial bombing practice. Between 1946 and 1948, the Navy relinquished control of the site back to the prior owners.

While the range was originally constructed near the shoreline, it is now located approximately 150 yards seaward of the beach due to extensive erosion that has occurred since the range was built in the 1940s. A 1952 aerial photograph (refer to Figure 4-3) shows the remnants of the oval track along the shoreline and the effects of the erosion which had already erased the southern edge of the track. Figure 4-4 shows modern day aerial image of the south beach area. In this image the oval-shaped track is only partially visible.

4.3 SITE GEOLOGY

The relatively flat ocean bottom at South Beach made this area appropriate for the demonstration. The geology of this area was also expected to be relatively benign and not produce excessive interference (such as magnetic volcanic rocks). Furthermore, the sandy bottom was forgiving to the magnetometer array when a winch operator error resulted in a sub-sea collision with a sand dune.

4.4 MUNITIONS CONTAMINATION

Little is known about the actual types of ammunition fired and munitions fired or dropped at the former range. Assumptions regarding the potential MEC items present have been derived from the nature of the items found along the beach over time as reported in historical documents provided by USACE. In 1988 the U.S. Army and Navy conducted clearance operations in the former range area. More than 1,650 potential MEC items were found.

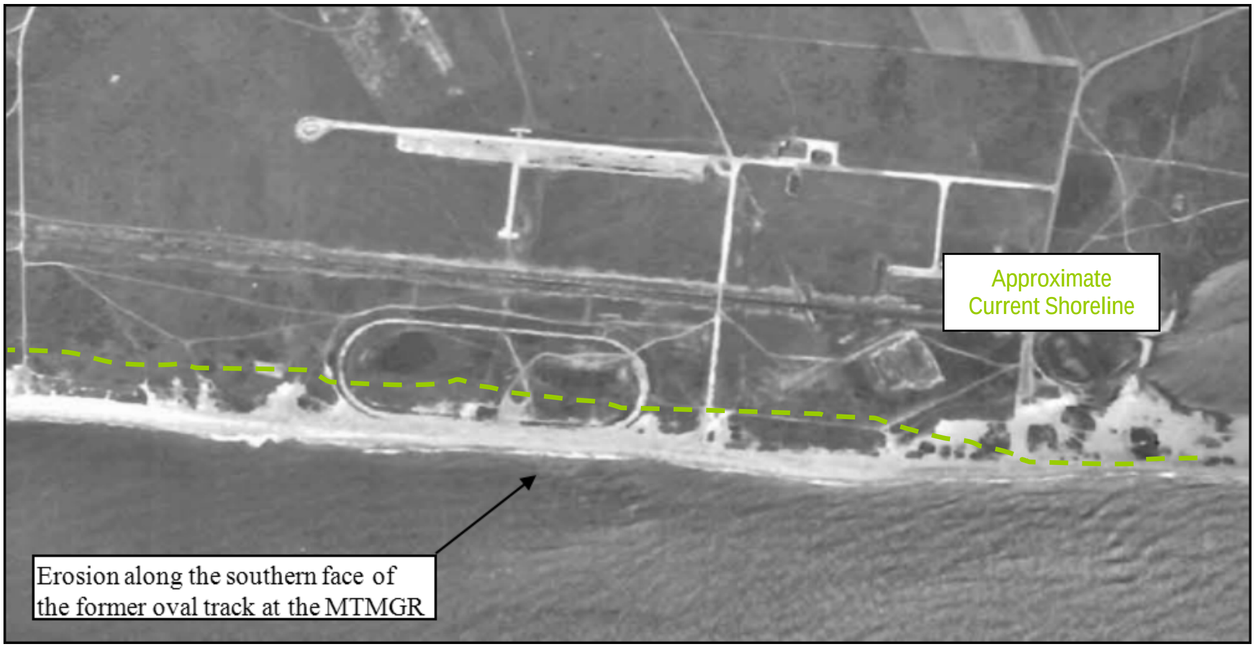


Figure 4-3. 1952 Aerial Photograph Showing Remnants of the Oval Target Track at the Former MTMGR at South Beach

Figure 4-4. Modern Day Aerial Image of South Beach Showing Substantial Beach Erosion and New Housing Development

Most items were MD in the form of shell debris ranging in size from 2.5 to 5 inches in diameter and from 6 to 18 inches in length. Ninety-nine items were inert warheads. Although at the time of the MATEC report in 2003, no ordnance had been reported since the clearance, a representative of the Edgartown Parks Department indicated that he generally observes up to a dozen pieces of MD (target rockets are approximately 5 inches in diameter and range from 3 to 5 feet in length) every year along the beach. In addition, MEC has been found at both South Beach and at Wasque, located to the east, since 2003. It is not known whether this MEC is related to historical operations at the MTMGR. No specific marks or mods are available for the MEC/MD found, as the items have been highly weathered in the marine environment and no firing orders for the range are available.

5.0 TEST DESIGN

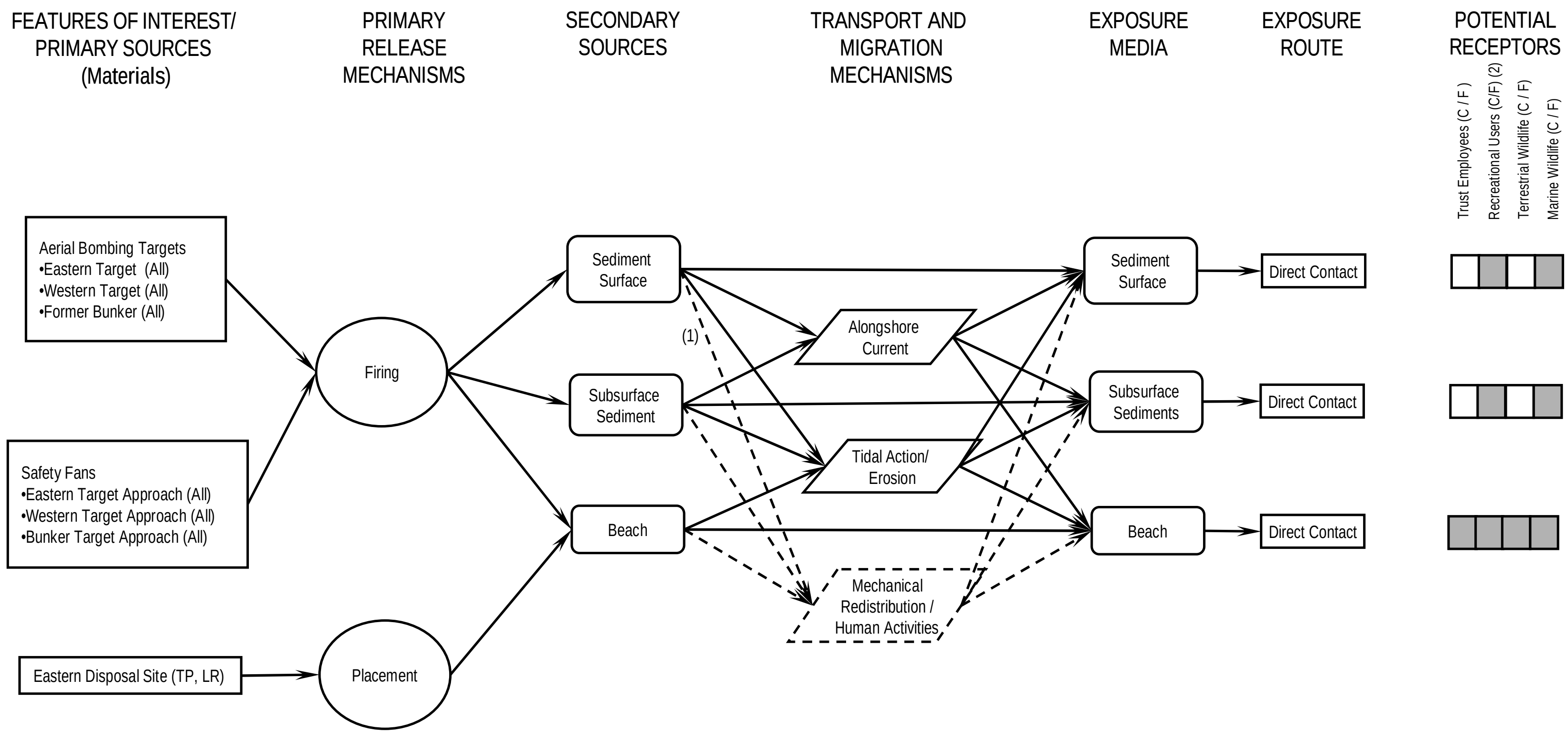
5.1 CONCEPTUAL EXPERIMENTAL DESIGN

Development of the demonstration design was initiated with the preparation of a preliminary CSM (Figure 5-1) that identified the site features of interest, primary sources, secondary source areas, and the types of MEC anticipated. The CSM was based on available historical evidence and mechanisms that may have shifted MEC within the survey area or to areas outside of the survey area boundaries.

Features of interest included the locations where MEC or related materials were most likely deposited as a result of firing or disposal. Secondary sources were the areas where MEC or related materials may have been deposited by the primary release mechanisms or as a result of movement via tides and currents based upon the documented history of the site and available oceanographic data. The types of MEC potentially present in specific areas were established based upon the results of the shoreline/surf zone removal action conducted by VRHabilis under contract to the USACE in the summer of 2009, as well as historical documents provided by the USACE. The CSM, which is a graphic, allows visual evaluation of the "life" of the ordnance materials from use through final deposition. Figure 5-2 shows the location of the potential sites of interest identified in the survey area. During the site inspection or remedial investigation phase of a CERCLA project, one of the objectives would be to verify or invalidate the preliminary CSM. If necessary the CSM would then be modified to reflect actual conditions in the project area and used as a guide in the development of follow-on activities such as remediation or institutional controls.

The WAA evaluation strategy was developed based upon the types of MEC potentially present in the study area, the amount of MEC anticipated and the potential location and distribution of residual MEC.

The initial data collection pattern for the WAA demonstration was based on the information contained in the CSM and the operational limitations of the survey. Since it is typical to use a CSM for this purpose on munitions response projects, the use of a CSM in the design of the demonstration highlighted the practicality of application under typical project conditions. As for many munitions response projects, a phased approach was used to promote efficiency and focus resources in the potential higher hazard areas. At the most basic level, the demonstration survey was designed to delineate the general area of impact associated with historical munitions activities at the former MTMGR. However, the work was also designed to demonstrate the



NOTES:
(1) Dashed boxes or lines indicate a potential source area or linkage that requires further verification.
(2) Examples would be beach combers, divers and swimmers.

C = Current Receptor
F = Potential Future Receptor

MATERIALS ASSOCIATED WITH AREAS:
(TP) Target Practice Rockets
(LR) Live Rockets
(PB) Practice Bombs
(LB) Live Bombs
(All) Potentially all materials listed

Figure 5-1. Conceptual Site Model for South Beach

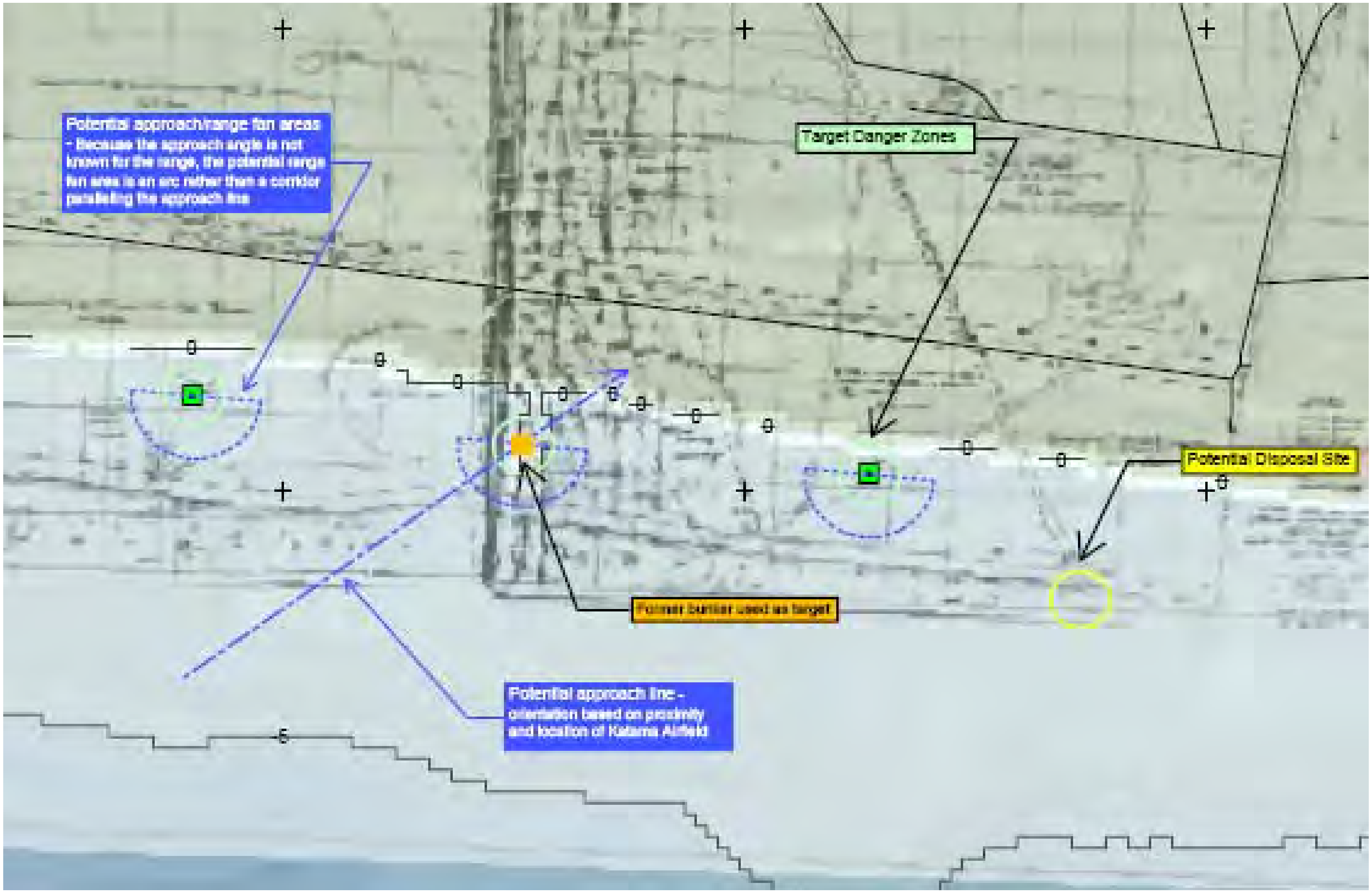


Figure 5-2. Location of Features of Interest in the CSM

capability of the methodology for use in the identification of higher hazard areas where characterization and remediation efforts should be focused for maximum benefit. This effort is termed footprint reduction.

All phases of the demonstration used the MBE, MGA, SSS and SBP technologies, with the exception of Phase 3 where SSS and SBP data was not collected. Detailed instrument specifications are discussed Section 5.3.

The first phase of the demonstration consisted of collecting data along a series of transects oriented approximately parallel to the shoreline within the established project boundaries. Cross line transects were run at a rate of 1 per 10 regular data collection transects for quality purposes. The Phase 1 transects are shown on Figure 5-3.

During the second phase of the data collection, areas with higher magnetic anomaly densities were identified and a second series of transects was used to further evaluate these areas. The Phase 2 transects bisected the region between the initial transects. Data from existing cross lines were used to evaluate the quality of the supplemental data; new cross lines were not necessary. The Phase 2 transects are shown on Figure 5-3.

At the end of Phase 2 the MGA data indicated that the extent of metallic debris in the seaward direction from South Beach had not yet been determined. Instead of further bisecting identified high density areas, supplemental transects were surveyed seaward of the initial site boundary to evaluate the potential seaward limit of the metallic debris. The Phase 3 transects are shown on Figure 5-3.

The first element of each phase was a high-resolution bathymetry survey. The bathymetry data collected were primarily used to locate any obstructions that might pose a hazard to the MGA. The data were also used to generate a detailed bathymetric map while looking for cultural features proud of the bottom.

The initial bathymetry survey was followed by a combined MGA and MBE survey. The MGA provided magnetic field strength and magnetic field gradient data which was analyzed to identify potential MEC. The incorporation of a second MBE survey provided a higher density multibeam data set with no reduction in efficiency or quality of magnetometer data acquired.

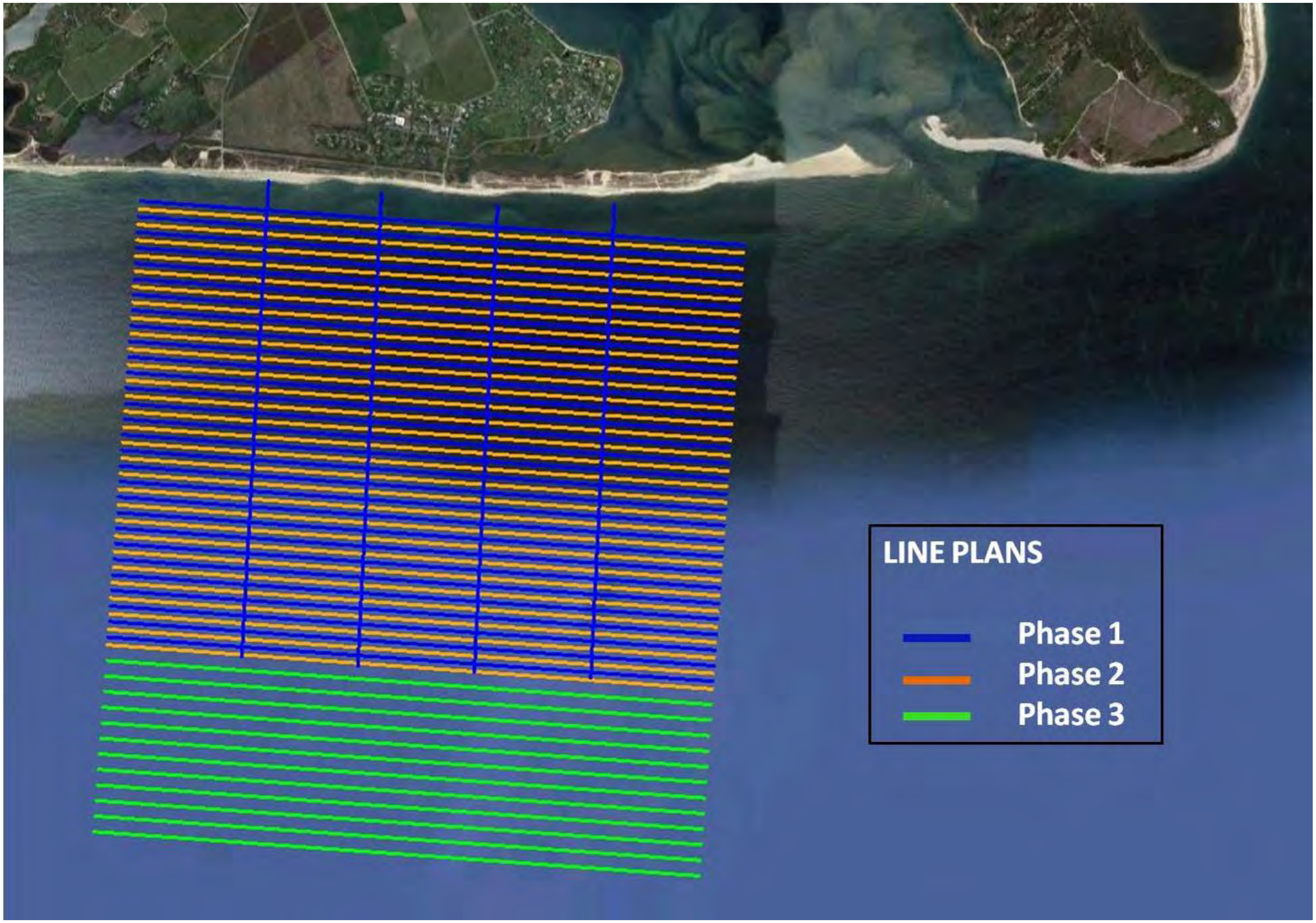


Figure 5-3. Transects Layout for Marine Surveys

The final element of Phases 1 and 2 was a combined SSS and SBP survey. This survey provided data used to evaluate stratigraphy and potentially identify depositional areas where MEC items have become buried under shifting sediment. It also provided low grazing angle sonar data that produces longer, more distinct shadows behind objects proud of the sediment surface and allows identification and more detailed evaluation of smaller features. Following data acquisition, initial data processing and draft product development was performed within 48 hours. Final data processing was performed after all data had been acquired and demobilization from the project site had occurred.

The project goal was to evaluate the overall success of the demonstration to locate underwater MEC or related materials. UXO-qualified divers under contract to the USACE were used inspect a representative sample of the detected anomalies. This data was intended to assess the effectiveness and accuracy of the detection and discrimination efforts. An absolute number of anomalies were selected for verification rather than a percentage of the detected anomalies because a finite budget was available to USACE for this work. The site had a large number of magnetic anomalies, as well as a variety of water depths and conditions which could impact diving safety, production rates and costs. While diving has occurred the USACE has not, at the time this document was prepared and submitted, released the results to Tetra Tech. Figure 5-4 is a Gantt chart showing the schedule of each phase of the survey and how the various phases were related.

Task Name	Duration	Start	Finish
Field Survey	29 days	Fri 5/28/10	Tue 7/6/10
Travel & Mobilization	8 days	Fri 5/28/10	Tue 6/8/10
Verification Over IVS	2 days	Mon 6/14/10	Tue 6/15/10
Data Collection	17 days	Tue 6/8/10	Tue 6/29/10
MBE Survey	17 days	Tue 6/8/10	Tue 6/29/10
Side Scan Survey	2 days	Mon 6/21/10	Tue 6/22/10
Magnetometer Survey	13 days	Mon 6/14/10	Tue 6/29/10
Demobilization & Travel	5 days	Wed 6/30/10	Tue 7/6/10

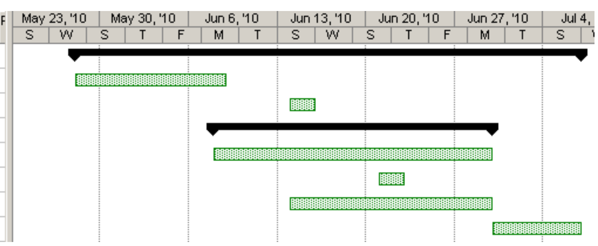


Figure 5-4. Schedule for Field Data Collection (May – June 2010)

5.2 SITE PREPARATION

Field operation preparation for this project included the installation of an IVS for use in system function tests. The IVS was installed near the Edgartown Harbor rather than at the project site, as the harbor provided a more protected environment for both placement and survey of the IVS. Since the survey vessel was moored in Edgartown Harbor nightly, placing the IVS just outside the harbor (location shown in Figure 5-11) allowed confirmation of system function while transiting to or from the survey area. The IVS was designed using a number of inert items found at South Beach as well as smaller UXO and surrogate targets.

The IVS location was selected to be representative of the project survey area. The selected location was first mapped with the MBE and MGA to evaluate the bathymetric conditions and identify any pre-existing objects in the data (metal debris, rocks. etc.). Inert ordnance items resembling the ordnance items of interest were then systematically placed in the IVS at a variety of orientations. Items placed in the IVS were attached to a length of rope that was anchored at both ends. Some items were attached individually to the rope and others were attached to rigid plastic boards to simulate clusters of small munitions items arranged in a non-linear pattern. The number of items placed was sufficient for evaluation of the performance of the data collection and processing systems. Additional information regarding the results of the IVS analysis is available in Section 5.6.

The terrestrial RTK GPS base station used for the WAA was set up near the town of Edgartown and was checked daily. The control point utilized is documented by the National Geodetic Survey with the Point ID "LW4271". The RTK GPS base station correction was verified daily utilizing a control point with published coordinates located near the harbor. All survey data and control were referenced to the following in metric units:

Horizontal Datum

- North American Vertical Datum (NAVD) 83 MA Island
- U.S. survey feet
- Vertical Datum NAVD 88 or Mean Lower Low Water, Epoch 1993-2001

5.3 SYSTEM SPECIFICATIONS

Each component of the WAA survey system is described in detail in Section 2.1. To avoid redundancy, Section 5.3 will focus solely on the operational specifications of each subsystem and including one additional section to document the multiple positioning systems. Please refer to Figure 2-2 for a system integration diagram.

5.3.1 MBE

A RESON SeaBat 7125 multibeam echosounder with a single head was used for this project. The sounder was rigidly fixed to the survey vessel using a pole mounted on the port side of the vessel (Figure 5-5). The sonar head was vertically oriented and the total angular coverage of the system was approximately 130 degrees across track. Individual sonar beams from the MBE, approximately +/- 60 degrees from nadir after roll compensation; were used to map the bottom (outer beams were clipped during post processing). The RESON MBE system transmits 512

Figure 5-5. Pole-Mounted Multibeam Echo Sounder Head

focused 0.5° x 1.0° beams at 400 kHz. The 400 kHz sonar used for the survey provides a range resolution of approximately 6 mm. The system was configured to collect samples at the maximum rate of 50 Hz however, the pulse rate decreases with water depth as the pulses require longer increments of time to reach the seafloor and return. The system received data from the IMU which allowed for real time roll stabilization of the sonar's soundings. Also integral to the multibeam sonar system was the Sea-Bird Electronics (SBE) Microcat 37. This CTD sensor was used to adjust the sonar's beam launch angles. The SBE 37 samples at 1Hz and measures conductivity with a resolution of 0.00001 Siemens per meter and temperature with a resolution of 0.0001^{o}C. A Seabird 19 CTD profiler was also used to measure the changes in sound velocity at depth. Sound velocity profiles were used in post processing to correct for sonar beam refraction. The Seabird 19 has the same specifications as the SBE 37 with the addition of measured depth with a resolution of 0.015 of the systems full depth scale.

5.3.2 Magnetometer Array

Magnetometer surveys were performed using the MGA, a scalable, modular array containing seven sensors and having a physical swath width of 4 meters. The array was configured using 1-meter horizontal spacing between each of the four lateral magnetometers, with 0.75-meter vertical and 1.2-meter along track separation. The array was towed at an altitude of approximately 2 meters above the seafloor. The MGA was set to sample at 2 Hz which provides somewhat reduced noise and improved small target detection relative to the 4 Hz setting. The MGA was operated from and towed with a 34-foot aluminum-hulled survey vessel (the R/V Ugle Duckling) configured with a winch and A-Frame (Figure 5-6). The MGA was fitted with an acoustic transponder and was tracked with a vessel mounted USBL. For redundancy the position of the MGA was also calculated using layback with data provided from an instrumented sheave.

Figure 5-6. MGA Mounted on TtEC Vessel

5.3.3 Sidescan Sonar

The SSS data were collected using an EdgeTech 701-DL processor coupled with the EdgeTech 2000-DSS combination 100/600 kHz SSS and 2-16 kHz SBP system.

Like the MBE data collection operations, the number of data points collected per second during the SSS survey was dependent on water depth, range setting and vessel speed; however, the system was operated at the maximum data collection rate for the high frequency SSS with the low-frequency SSS synchronized to the previous. The shallow water in the survey area resulted in high density sampling and high-resolution data.

The SSS system incorporated an altimeter, pressure sensor and attitude sensor to monitor the towfish flight. Towfish altitude determination was accomplished through a combination of altimeter readings and sonar bottom tracking. The 2000-DSS also incorporated an acoustic transponder that was tracked from the vessel with the GAPS USBL.

5.3.4 Sub-Bottom Profiler

The primary system for Sub-Bottom Profiling was the EdgeTech 701-DL processor coupled with the EdgeTech 2000-DSS combination 100/600 kHz SSS and 2-16 kHz SBP system. The SBP system was operated with a frequency and power level that obtained the high quality data without compromising the quality of the simultaneously recorded sidescan data.

5.4 CALIBRATION

Several functional calibration procedures were performed to ensure proper operation of the instrumentation in the selected configurations. These calibration procedures are discussed in the following sections. All calibration processes relate to systems installation offsets and performance validation.

5.4.1 Vessel Survey and Verification

Spatial offsets were precisely measured for the multibeam sonar, GAPS USBL and GPS antennas with respect to the inertial measurement unit (IMU) of the Applanix POS MV 320 (Table 5-1). These offsets are used by the HYPACK®/HYSWEEP® acquisition software to combine and convert the sonar and support sensor data into real-world coordinates in real time. These offsets were also used to establish a vessel configuration file for data processing in CARIS software. The vessel configuration file serves the purpose of spatially integrating sonar and ancillary sensor data and in doing so, converts the raw sonar data into real world coordinates as defined by the project coordinate system. Verification of measured offsets was obtained via the use of the POS MV's GPS Azimuth Measurement Subsystem (GAMS) calibration and through assessing targets in data processing (refer to Section 5.5.2).

Table 5-1. Survey Vessel Equipment Offsets

Meters	Forward	Starboard	Vertical
Summary	X	Y	Z
POS to MB Sonar	-1.45	-1.64	0.40
POS to Leica Ant.	-1.42	-1.64	-3.20
POS to GAPS	-1.42	1.64	1.03
POS to Primary Ant.	0.36	-1.00	-2.85
POS Ant. Sep	0.00	2.00	0.00
POS to Sheave	6.65	0.00	-3.00

5.4.2 GPS Azimuth Measurement Subsystem (GAMS) Calibration

Prior to performing a multibeam system installation calibration test (the "patch test" [refer to Section 5.5.3]), and whenever necessary as automatically determined by the Applanix software (POSView), an alignment calibration of the Applanix motion and heading sensor was performed. This procedure, which Applanix refers to as a GAMS calibration, utilizes software integrated into the motion sensors. The GAMS calibration procedure is initiated while the survey vessel maneuvers in a figure eight pattern. This calibration procedure allows the POSView software to calculate offsets between the motion sensor's two GPS antennas and align the measured heading with the vessel, resulting in achievement of the specified heading accuracy of 0.02^{o}.

5.4.3 Patch Test

A standard patch test, also known as an installation calibration test, was carried out prior to the MBE survey to calculate the angular offsets between the multibeam echo sounder and the Applanix POS MV IMU. The patch test was also used to determine any time latency in the positioning equipment. The sonar and acquisition computers are time synchronized therefore no latency is data communication was expected or found.

The patch test was conducted over an area where multiple distinct features with significant changes in depth occurred over short distances along track. Pitch, roll, and yaw were measured using areas with the following characteristics:

- Roll – reciprocal lines surveyed over a flat bottom
- Pitch – reciprocal lines surveyed over a sloping bottom, or a distinct linear feature
- Yaw – offset lines surveyed over a sloping bottom, or a distinct linear feature

5.5 DATA COLLECTION AND PROCESSING PROCEDURES

5.5.1 MBE Survey

MBE Data Collection

Bathymetry survey operations for South Beach began on June 4, 2010. The initial multibeam survey was performed while transiting at 6 to 7 knots and provided bathymetric data for terrain following and obstacle avoidance during the magnetometer survey operations. Bathymetric data from each phase was recollected concurrently with the magnetometry surveys to provide higher density bathymetric data. The survey was conducted in general accordance with the most recent USACE Hydrographic Surveying Engineering Manual (EM1110-2-1003 and appendices; USACE 2002) for an acoustic survey, as modified by the project-specific technical specifications provided in the approved *Work Plan, Wide Area Assessment (WAA) for Marine Munitions and Explosives of Concern* (Work Plan) (TtEC 2010).

The bathymetry survey was performed by navigating along parallel survey transects. The multibeam sonar mapped a swath of bathymetry while ancillary systems tracked the 3D movement of the vessel in real time. HYPACK hydrographic software was the primary acquisition software for the survey. This software recorded data from the various devices and displayed it in real-time for QC analysis by the system operator. The software also provided real-time vessel navigation information to the helmsman. The planned transects and vessel tracks were displayed with the bathymetric data during the survey to allow hydrographers and/or geophysicists conducting the survey to continuously assess data quality and coverage.

Initially a set of 31 transects (Phase 1) was established for survey covering the overall project area (refer to Figure 5-3). These transects were oriented roughly parallel to the shoreline at South Beach and were spaced at approximately 100 meters. The survey transects were approximately 4.25 kilometers long. Water depths and sea state at the time of the demonstration prevented data collection on the two transects nearest the beach, resulting in data collection along 29 transects beginning between 200 and 375 meters offshore and extended to a distance of 3,000 to 3,375 meters off shore.

After the initial bathymetric survey was completed the magnetometer survey with concurrent MBE bathymetric mapping was performed over the same transect lines. Data from the magnetometer revealed regions warranting further investigation. Supplemental transects (Phase 2) was established at this point to obtain more detailed data in these areas. Two high density areas were identified; one near the shoreline (between transects 4 and 6) and one near the seaward limit of the initial project area (between transects 25 and 31). The seven supplemental transects were established to bisect the area between previously mapped transects, producing an effective transect spacing of 50 meters.

For the final survey phase (Phase 3) five transects were surveyed seaward of the original project area boundary to support determination of the seaward extent of metallic debris that may be associated with past operations at the former MTMGR. These transects began approximately 3,375 to 3,725 meters offshore and were spaced at about 250 meters. This spacing was considered sufficient to evaluate the general nature of bottom conditions with respect to metallic debris.

MBE survey data were processed in accordance with the methodology described in Section 6.1 to yield a gridded data set. The final data were input into a Geographic Information System

(GIS) where all data could be analyzed as a whole to identify potential MEC and make other determinations regarding site conditions. Final deliverables are presented on the maps and figures in this report.

MBE Quality Checks

Quality control for marine surveys is primarily process quality control, although some product QC is applied during data processing and analysis. Proper operation and function of the equipment and software are the most important factors in achieving data quality. Prior to the survey, all applicable pre-survey calibration and QC tasks discussed in Section 5.4 were completed to ensure detection and positioning systems were functioning properly. In addition, a series of physical checks were routinely conducted on the data collection system prior to beginning the survey work each day or periodically during the survey, as appropriate. The final component of QC was the performance of real-time monitoring and review by system operators and automatic monitoring by software modules used for data collection (Figure 5-7).

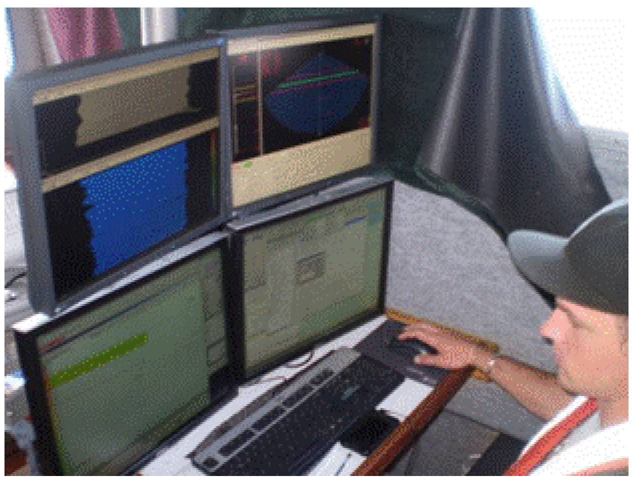


Figure 5-7. Operator Monitoring MBE Data Collection

Physical quality control checks for the MBE survey included water level checks, which were conducted daily during the bathymetry survey operations to ensure that the sonar equipment was functioning properly. The bar check which was performed at the onset of survey operations is a consistency check. An aluminum plate on a calibrated line was manually lowered to a known depth below the sonar head. The depth of the plate below the water surface was recorded and compared to the value reported by the HYSWEEP software Bar Check Utility. Water level checks compared the water level reported by the HYPACK acquisition software to the value measured at the same time by a field technician using a Leica 1230 RTK GPS rover identical to the model installed on the survey vessel. This test verified proper installation offsets on the vessel, and that the GPS was configured properly and was receiving accurate real time corrections from the terrestrial base station.

Data review and monitoring methods used for measuring data quality during the survey operations began with position accuracy. At the completion of each survey line, the lead acquisition hydrographer reviewed the positions of identifiable features in the on-line HYPACK/HYSWEEP coverage plots. This software allowed the hydrographer to compare the results of the measured positions for consistency within the lines and against external references. In this case, the external references were the cross lines which were mapped. Data points co-incident to both data sets were compared to ensure that the data were consistent. Lines that contained positions that exceeded the established quality parameters were flagged for complete or partial re-mapping as appropriate.

Motion data were also scrutinized in HYSWEEP. These data are more difficult to QC than vessel position because there is only one system and it cannot be checked against itself. Consequently, the heave component of the motion data set was merged with the soundings from the vertical beam. A timing error in either of these systems will result in a residual oscillation in the measured depth. Amplitude errors in the heave record will have a similar effect.

Sounding data from the multi-beam echo sounder were subject to interpretive and quantitative measurements of data quality. During acquisition, sonar operators monitored data quality on the multi-beam monitor and HYPACK acquisition screens. The general noise level of the soundings and useable swath width are visible on the SeaBat monitor. Custom screens in HYPACK and HYSWEEP allowed the operator to view a digital terrain map (DTM) of average depths, waterfall displays, and individual profiles. These displays require interpretation and are used as the first quality check on multi-beam data.

Product quality control was applied during the data processing operations. The data were reviewed a second time as they were cleaned (flagged for exclusion from the final data set) and edited. In CARIS SIPS lines were examined for obvious errors. By this time, however, the multi-beam data were bundled with all their ancillary data elements: sound velocity profile (SVP), tide, dynamic draft, heave, pitch, and roll.

The final quality assessment for the data sets was conducted with Fledermaus Pro software. Production line data were compared to a DTM created from a cross line. Differences between the soundings and the surface were tabulated for each beam and evaluated with respect to an accuracy standard, in this case, an IHO specification. Compliance with the specification exceeded 95 percent.

The visualization tools available in the processing software provide clear indications of any problems in the motion sensor data or in the time correlation of the echo sounder and motion data. Any errors in these areas will result in identifiable data artifacts. Conducting preliminary processing of the bathymetry data on the vessel allowed problems to be caught and corrected, and ensured that a complete, high quality data set was collected.

5.5.2 MGA Survey

MGA Data Collection

Magnetometer survey operations for South Beach were conducted beginning on June 11, 2010. Prior to the survey, all pre-survey calibration and QC operations were completed to ensure collection of consistent, high-quality data. The survey was conducted in accordance with the project-specific technical specifications provided in the approved Work Plan (TtEC 2010).

The MGA geophysical survey was performed in much the same manner as the bathymetry survey by navigating along the same transects established for the bathymetry survey and allowing the MGA to collect data while ancillary systems tracked the boat and MGA in real time. The major difference between the two survey processes is that the MGA was not mounted on the vessel, but rather is towed astern. The position of the MGA was tracked using a USBL acoustic tracking system. The position of the MGA was provided to the HYPACK software where the navigation and sensor data were integrated, recorded, and displayed in real time. For positioning redundancy an instrumented sheave was used to monitor cable payout and calculate the towfish layback.

Marine Magnetic SeaLink software was used to configure and monitor the MGA. At the start of each survey session, sensors were time synchronized and configured to sample at 2 hertz (Hz). After deploying the MGA, manual tuning was applied to the sensors to obtain the highest sensitivity within the earth's ambient magnetic field strength at the survey location. For the South Beach survey, a tuning value of 54,000 nT was applied. SeaLink provided a real- time graphical display of the magnetic field strength data as well as multi-axis gradients between the MGA sensors and the analytic signal. The raw MGA data were also recorded in SeaLink as a backup to the data stored by HYPACK, because it contains additional information for debugging the system, if needed.

The survey area for the MGA including transect placement is the same as that used for the bathymetry survey. The transect layout and spacing is described in Section 5.5.1. The swath width for the MGA survey is approximately 4 meters, resulting in substantially less coverage as compared to the MBE. Table 5-2 contains a summary of the data quantities for each phase of the

MGA survey, along with the average vessel speeds and data densities which will be discussed in the following section.

Table 5-2. Data Collection Summary for the MGA Survey

Survey Phase	Transect Distance Surveyed (km)	Average Swath Width (m)	Area Surveyed (sq. km)	Hectares	Average Vessel Speed (kph)	Mean Sampling Distance (m)
1	236	5	1.18	118	6.3	0.88
2	29.6	5	0.14	14	7.0	0.98
3	20.1	5	0.10	10	6.3	0.87
Cross Lines	11.4	5	0.06	6	6.3	0.87
Total 29	**7.1**	**5**	**1.48**	**148**		

The mean sample separation distances for the MGA survey during the various phases of work are presented in Table 5-2 above. The number of samples collected per meter varied in relation to vessel speed and was consistently within the parameters established in the Work Plan.

MGA survey data were collected over a total area of approximately 1.48 square kilometers. These data were processed in accordance with the methodology described in Section 6.1 to yield 761 anomalies with analytic signal anomalies 3 nT or greater. The final data were input into a GIS where all data could be analyzed as a whole to identify potential MEC and make other determinations regarding site conditions.

MGA Quality Checks

Prior to the survey, all applicable pre-survey calibration and QC operations discussed in Section 5.4 were completed to ensure detection and positioning systems were functioning properly. In addition, a series of physical checks were routinely conducted on the data collection system prior to beginning the survey work each day or periodically during the survey, as necessary. The final component of QC was the performance of real-time monitoring by system operators and automatic monitoring by software modules used for data collection.

Figure 5-8a. Preparing to Tow the MGA

Figure 5-8b. MGA Being Towed

Quality control checks for the MGA included static tests, and daily testing over the IVS. A static test was conducted daily to evaluate the MGA for system and external noise sources while the array was at being towed in a background area free of metal. The system was allowed to collect data for 1 minute. The test data were then reviewed to ensure the standard deviation of the measurements about the mean was not excessively large (not greater than 1 to 2 nT).

Daily during data collection activities, the MGA was towed over the IVS to or other stationary magnetic targets to evaluate function, accuracy, and repeatability. The data collected were promptly processed and analyzed in accordance with the procedures described in Section 6. Each day's IVS data were compared to other data sets and a confirmation was made that quality data were being collected.

Data review and monitoring methods used for measuring data quality during the MGA survey operations were similar to those described for the MBE survey. Real-time monitoring by operators, automatic monitoring by software modules and data review procedures were all used to ensure proper equipment performance. Because the data is towed astern of the vessel it was critical that the operator monitor the USBL acoustic positioning equipment to ensure proper operation. Real time quality assessment was performed by comparing the USBL reported position to that calculated by the acquisition system using data from the vessel and instrumented sheave. The position of the towfish should usually agree between these two systems within a few percent of the layback, except where cross currents occur. The lateral offset between the instrumented sheave layback and the USBL positions can be many meters in these cross current conditions as the instrumented sheave calculated layback position assumes that the towfish will follow directly astern of the vessel, while the USBL yields the true position of the towfish.

Product quality control was applied during the data processing operations. The data were reviewed a second time as they were processed and edited. The final quality assessment for the data sets was conducted with Oasis Montaj.

5.5.3 Sidescan Sonar Survey

Sidescan Sonar Data Collection

Sidescan sonar (SSS) survey operations for South Beach were conducted beginning on June 21, 2010. Prior to the survey, all pre-survey calibration and QC operations were completed to ensure collection of consistent, high-quality data. The survey was conducted in accordance project-specific technical specifications provided in the approved Work Plan (TtEC 2010).

The SSS survey was performed by towing the SSS instrumentation along the planned transects in the project area. In reality, the towfish was towed slightly abreast to the transect line thus ensuring ensonification of the region surveyed by the MGA. Positioning was provided using a USBL acoustic positioning system and instrumented sheave identical to MGA operations. HYPACK hydrographic software was the primary navigation software for the survey, while EdgeTech Discover was the software used for controlling the sonar, monitoring, and recording the SSS data (Figure 5-9).

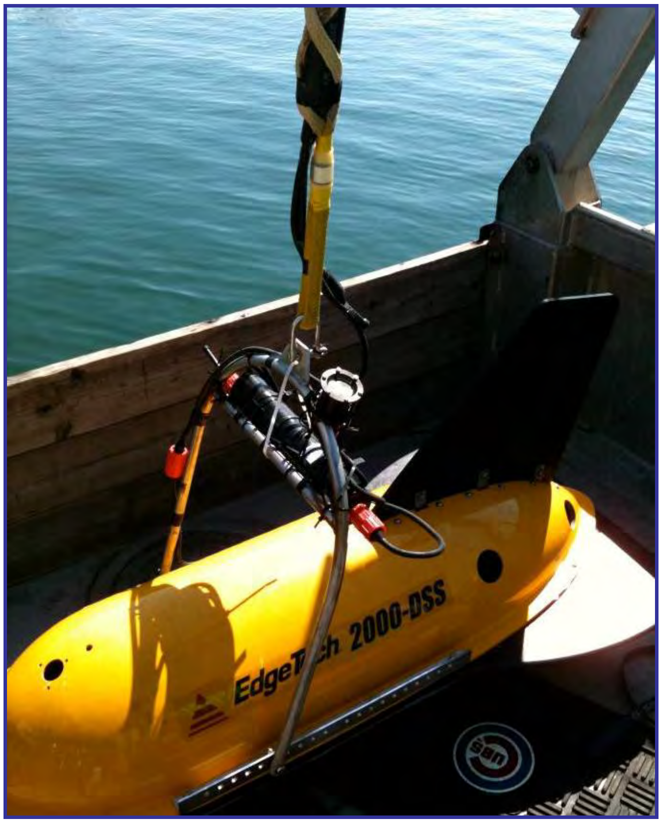


Figure 5-9. Sidescan/Sub-Bottom Towfish

The area for the SSS survey was the same as that for the bathymetry and magnetic surveys. The transect layout and spacing is described in Section 5.5.1. The average swath width for the SSS survey was approximately 98 meters.

Average data densities for the SSS survey are summarized in Table 5-3. The densities varied in relation to vessel speed and water depth; however, data densities were higher than estimated in the work plan, due to the shallow water in the demonstration area. The data densities achieved provided high-resolution data.

Table 5-3. Data Collection Summary for the Sidescan Sonar Survey

Transect Distance Surveyed (km)	Average Swath Width (m)	Area Surveyed (sq. km)	Hectares	Average Vessel Speed (kph)	Average Sample Rate (Hz)	Average Along Track Sample Distance (m)
83.5	98	8.14	814	9.03	13.2	0.19

SSS survey data were collected over a total area of approximately 8.14 square kilometers. These data were processed in accordance with the methodology described in Section 6.1 to yield a final high resolution geotiff. The final data were displayed in a GIS where all data could be analyzed as a whole to identify potential MEC and make other determinations regarding site conditions. The processed data points were used to produce images of the sediment surface for visual evaluation of features of interest and potential MEC. Final deliverables are presented as figures and charts in this report.

Sidescan Sonar Quality Checks

The SSS instrumentation is factory calibrated and requires no field calibration. Quality assurance (QA)/quality control (QC) of the side-scan sonar data was performed in real-time by observing the quality in the acquisition software. The digital data was reviewed during processing, along with the navigation data, to verify the data quality and assure that the requirements for coverage and resolution have been met.

5.5.4 Sub-Bottom Profiling

Sub-Bottom Profile Data Collection

Sub-bottom profiling operations for South Beach were conducted beginning on June 21, 2010. Prior to the survey, quality control checks were completed to ensure collection of consistent, high-quality data. The survey was conducted in accordance with project-specific technical specifications provided in the approved Work Plan (TtEC 2010).

SBP operations were identical to the SSS operations as they were performed coincidentally with the same towfish. The only difference between the SSS survey and the SBP survey was that SBP data were collected with EdgeTech's Discover SBP software. The SBP data generate a 2D depth profile along the track it is towed (Figure 5-10). Thus, a table regarding coverage area is not applicable. Data generated from the subbottom were used to assess the stratigraphy and geomorphology of the site aiding in understanding the CSM.

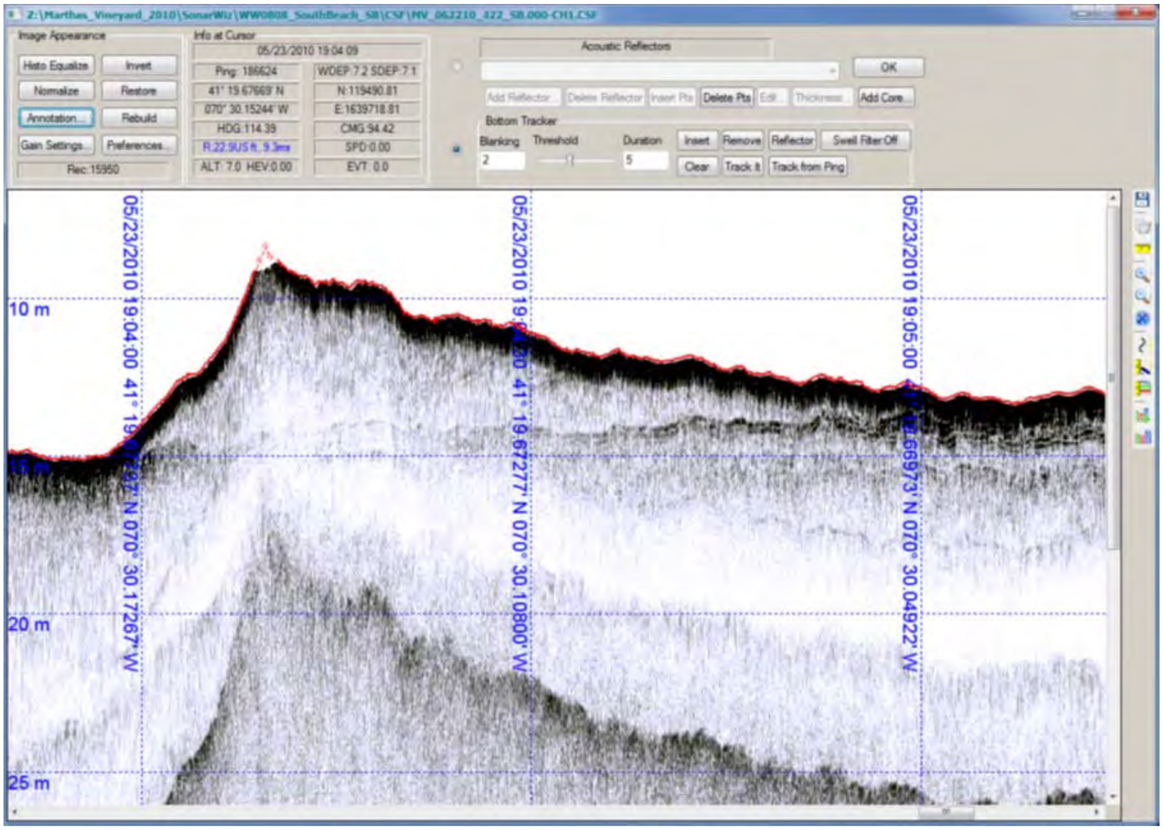


Figure 5-10. Screen Shot of SB Data

Quality Checks

The SBP instrumentation is factory calibrated and the operator only needs to determine appropriate operational frequency and power settings for the survey area. QA/QC of the sub-bottom data was performed in real-time by observing the data on the computer monitor. The SBP reviewed the data during acquisition to optimize bottom penetration without over saturation that would reduce the image quality. The digital data was reviewed during data processing, along with the navigation data, to verify the data quality and ensure that the requirements for coverage have been met.

5.6 PERFORMANCE VALIDATION

The survey was planned to include validation of selected targets by UXO-trained divers who would physically locate the detected item on the sea floor, and perform visual inspection of the object which created the magnetic anomaly. If objects were located, the divers would identify the objects, determine whether or not they were MEC, and record their findings.

Unfortunately, at the time of this report no data is available regarding the diver investigation which was performed by VRHabilis LLC divers and managed by UXB International Inc., the USACE New England District contractor performing RIFS work on Martha's Vineyard. As a result our performance validation relies on the results of the Instrument Verification Strip (IVS).

5.7 INSTRUMENT VERIFICATION STRIP

The IVS was deployed on June 15 and was installed northeast of Edgartown, MA, in a location that was in route to the South Beach survey area (Figure 5-11). Prior to the deployment of the IVS, an area was selected for its location and a pre-survey was conducted on June 7. As a result of permitting delays two days of MGA survey were performed at South Beach prior to the deployment of the IVS. The quality assurance and quality control QA/QC measures for these days consisted of resurveying the IVS deployment area which contained multiple magnetic anomalies. Figure 5-12 shows the pre-IVS survey and the two "IVS" surveys, which consistency mapped out the same magnetic anomalies thus verifying the functionality and repeatability of the instrumentation.

Figure 5-11. IVS Location Map

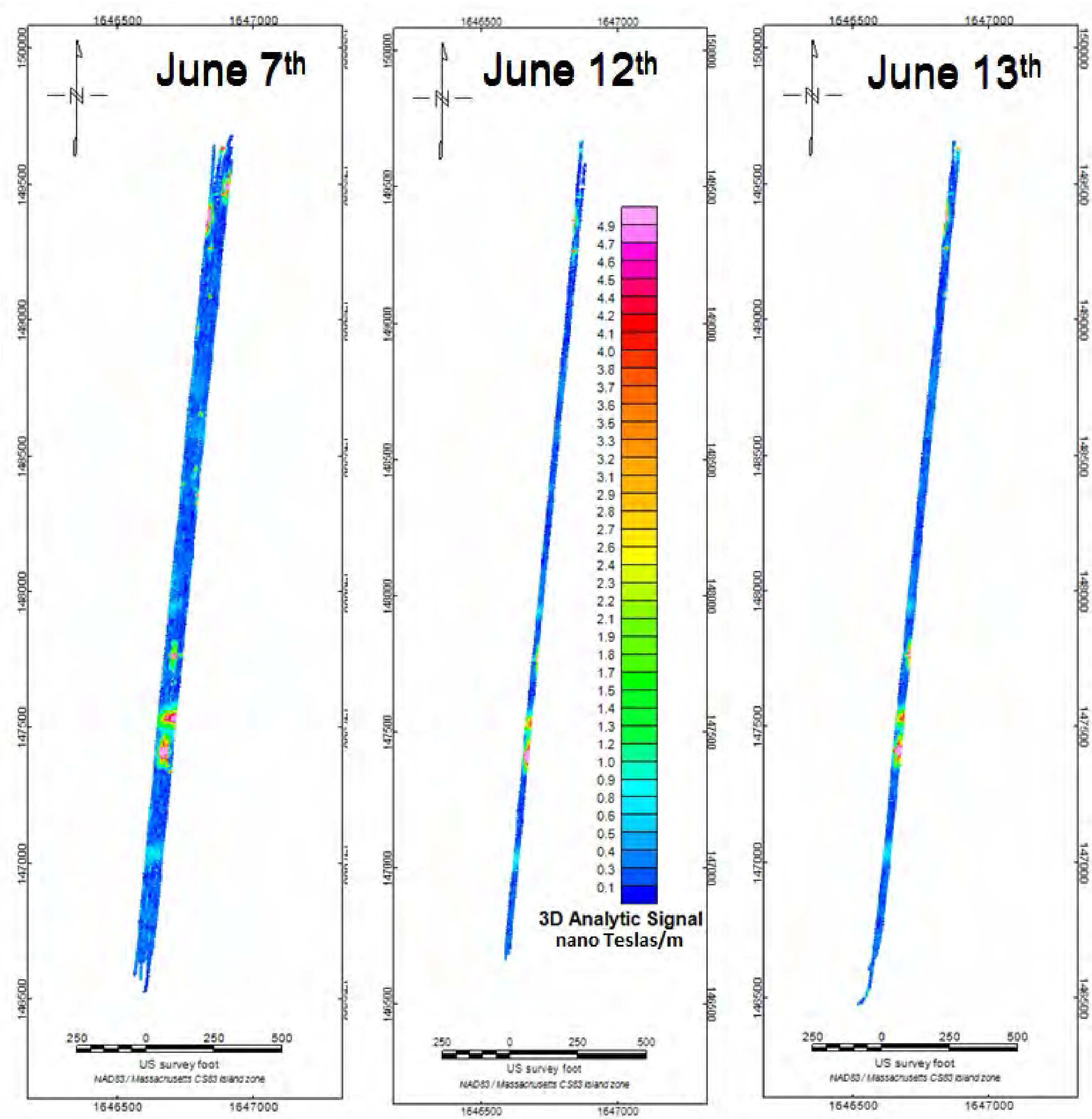


Figure 5-12. Pre-IVS Survey and Subsequent QA/AC Repeat Surveys

The pre-IVS survey was relatively long at over 3,200 feet when compared to the deployed IVS which was 320 feet in length. The large pre-survey allowed for the selection a region free of magnetic anomalies for placement of the IVS. During the pre-survey multiple magnetic anomalies were detected. Repeat surveys of the IVS area pre-deployment were performed on June 12 and 13. Table 5-4 summarizes the specifics of these three Pre-IVS surveys.

Table 5-4. Pre-IVS Quality Control Survey and Summary Statistics

Survey Date	Survey Purpose	Average Flight Height (m)	Number of Passes	Survey Duration	Sample Rate	Average Along Track Sample Distance (m)	Survey Distance (m)	Survey Area (Hectcres)
June 7, 2010	IVS Selection	2.08	7	1:29:00	2Hz	0.75	13011	1.98
June 12, 2010	QA/QC	2.13	2	0:38:00	2Hz	0.83	3681	0.57
June 13, 2010	QA/QC	2.2	3	1:07:00	2Hz	0.83	5593	0.85

Table 5-4a. Pre-IVS Installation Quality Control Targets Separation

	7th to 12th	7th to 13th	12th to 13th
Peak Separation North QC point (m)	0.61	2.52	2.44
Peak Separation South QC point (m)	0.61	2.51	2.18

Table 5-4b. Pre-IVS Installation Quality Control Target Amplitudes

	7th	12th	13th
North QC Point Peak nT/m	18.49	20.15	36.49
North QC Point Peak nT/m	28.05	27.3	26.2

Three large magnetic anomalies were identified in the southern half of the IVS pre-survey on June 7 and the subsequent surveys on June 12 and 13. These anomalies are shown in more detail in Figure 5-13. The MGA located the magnetic anomalies consistently each day and the magnitude of the anomaly response was similar (refer to Figure 5-13).

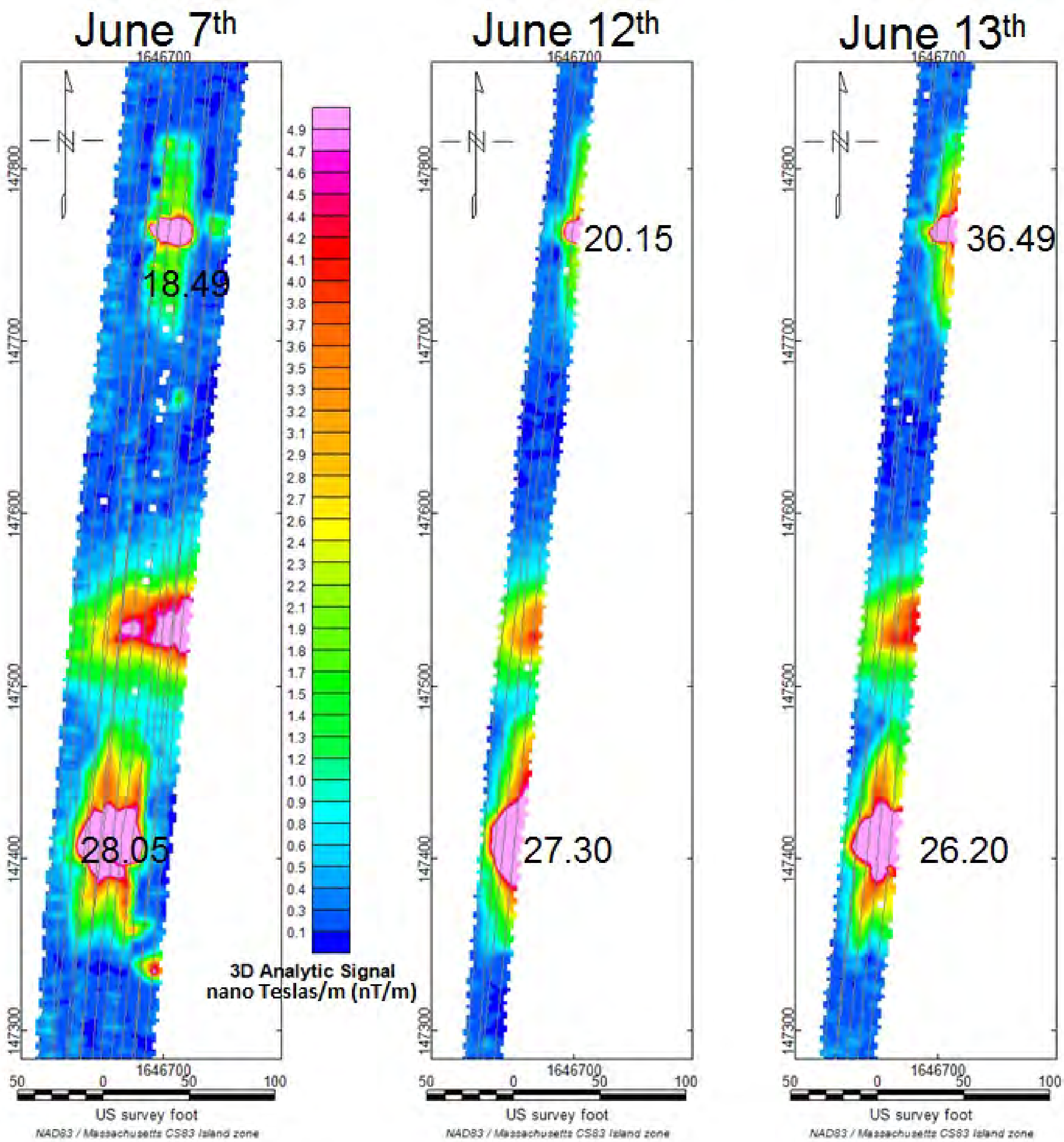


Figure 5-13. Subset Region of the IVS Pre-Survey and Subsequent QA/QC Surveys. Maximum Analytic Signal Response for the Southern and Northern Anomaly in nT/m

On June 15, the IVS was deployed by divers. Due to limited visibility and the design of the IVS the divers failed to place the entire IVS within the bounds of the pre-surveyed area. Fortunately a survey with the MGA after the IVS was removed revealed that the IVS targets were not placed atop any major pre-existing magnetic anomalies. After the deployment of the IVS, a diver carrying a USBL transponder was used to determine the location of each IVS item. The diver moved from item to item stopping at each item for approximately one minute. Table 5-5 lists the IVS items and their positions based on the USBL survey. Figure 5-14 shows images of each IVS item.

Table 5-5. IVS Item Summary Table

ID #	ITEM	Easting (ft)	Northing (ft)
1	Single 80mm Mortar	1646700.5	148090.2
2	Single 60mm Mortar	1646698.2	148097.8
3	Surrogate Cluster of 3 Small NPT	1646695.1	148109.8
4	Cluster of 2 40mm Proj	1646692.2	148117.7
5	Single 40mm Proj	1646689.4	148126.9
6	Single Full 40mm	1646686.8	148137.5
7	Cluster of 10 20mm	1646685.0	148146.0
8	Cluster of 8 20mm	1646682.9	148157.6
9	Cluster of 4 20mm	1646681.0	148167.2
10	Single 20mm	1646679.4	148176.1
11	Single Full 20mm	1646677.1	148187.4
12	Surrogate Small NPT	1646675.5	148195.1
13	Surrogate Medium NPT	1646672.7	148209.2
14	Surrogate Large NPT	1646671.8	148215.8
15	Pipe	1646668.5	148231.7
16	3" Roc with 3" warhead	1646665.1	148255.5
17	Practice Bomb	1646667.9	148288.9
18	2.25 Rock Motor	1646668.1	148322.6
19	3" Rocket Motor	1646668.9	148358.0
20	5" Warhead	1646672.7	148390.0
21	5" Warhead with 3" motor	1646673.8	148427.1

The IVS was surveyed once per day on each day MGA data were collected. In total the IVS was surveyed seven times, although not all components of the IVS were surveyed each day. Figure 5-15 shows a compilation of these seven surveys with the IVS items displayed as circles with their positions based on the diver transported USBL survey. Figure 5-16 shows the post-IVS MGA survey. Note that the anomalies from the IVS items are absent yet a few magnetic anomalies remain in the northern region, fortunately none of the IVS items were placed directly on any of the preexisting anomalies.

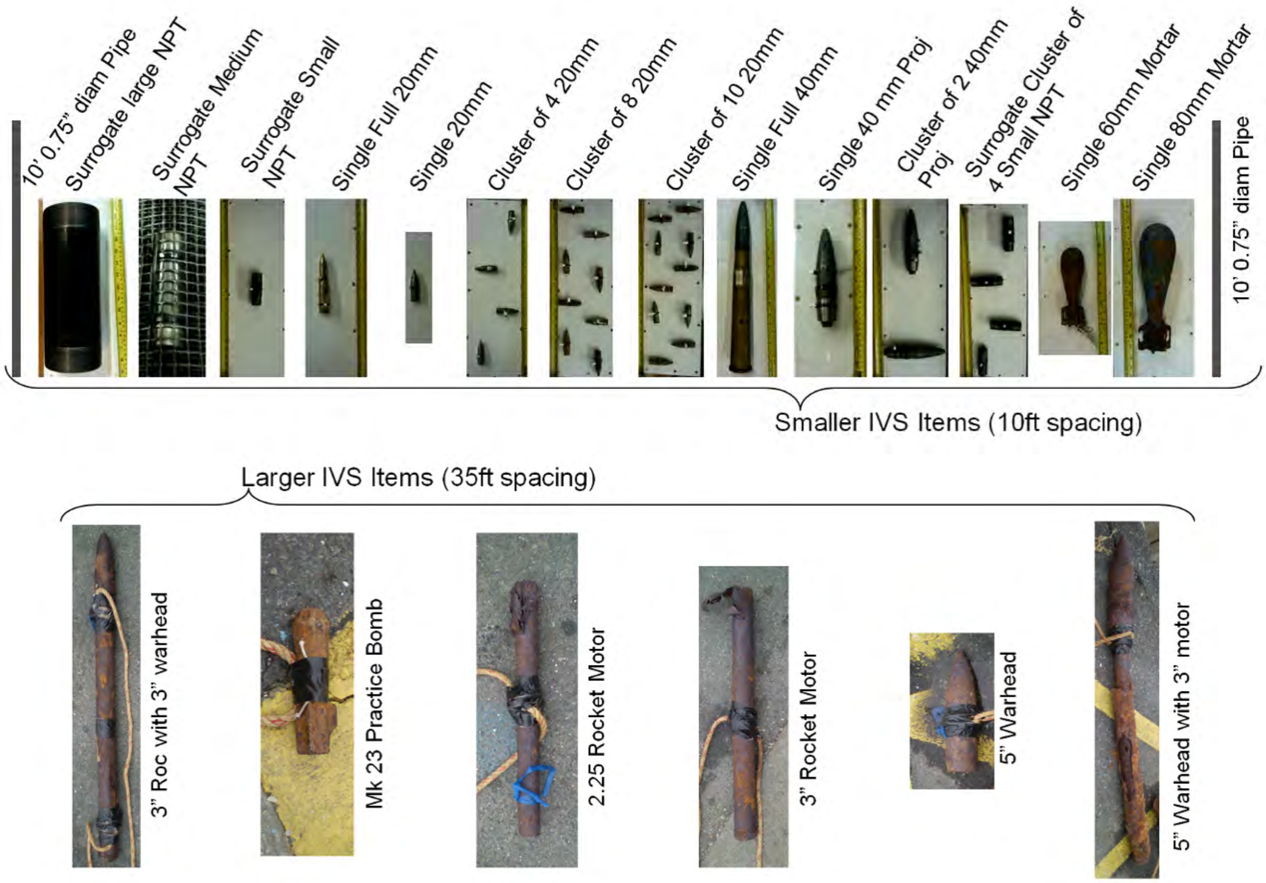


Figure 5-14. IVS Items

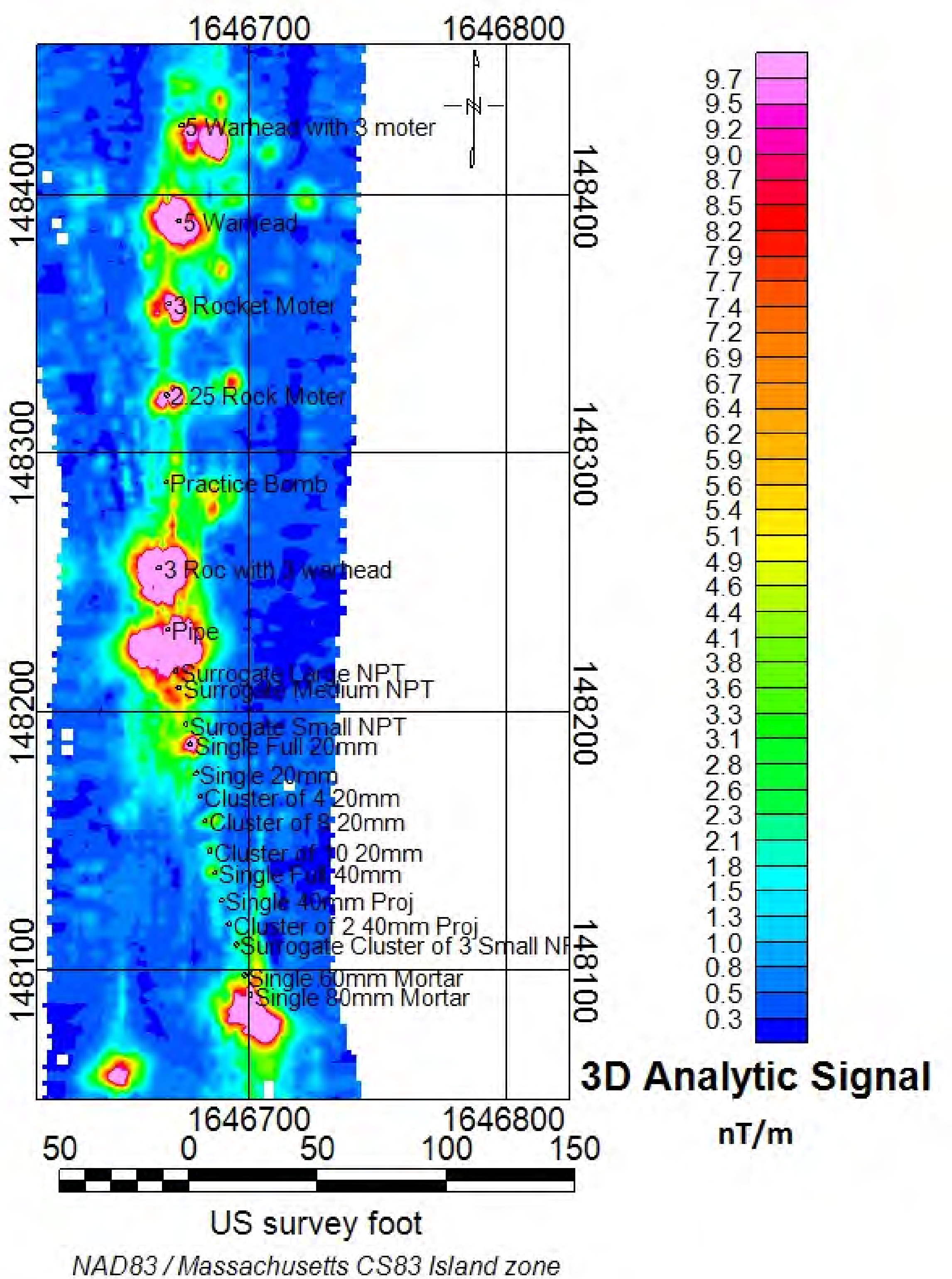


Figure 5-15. MGA Analytic Signal IVS Complication Map June 15 to 28

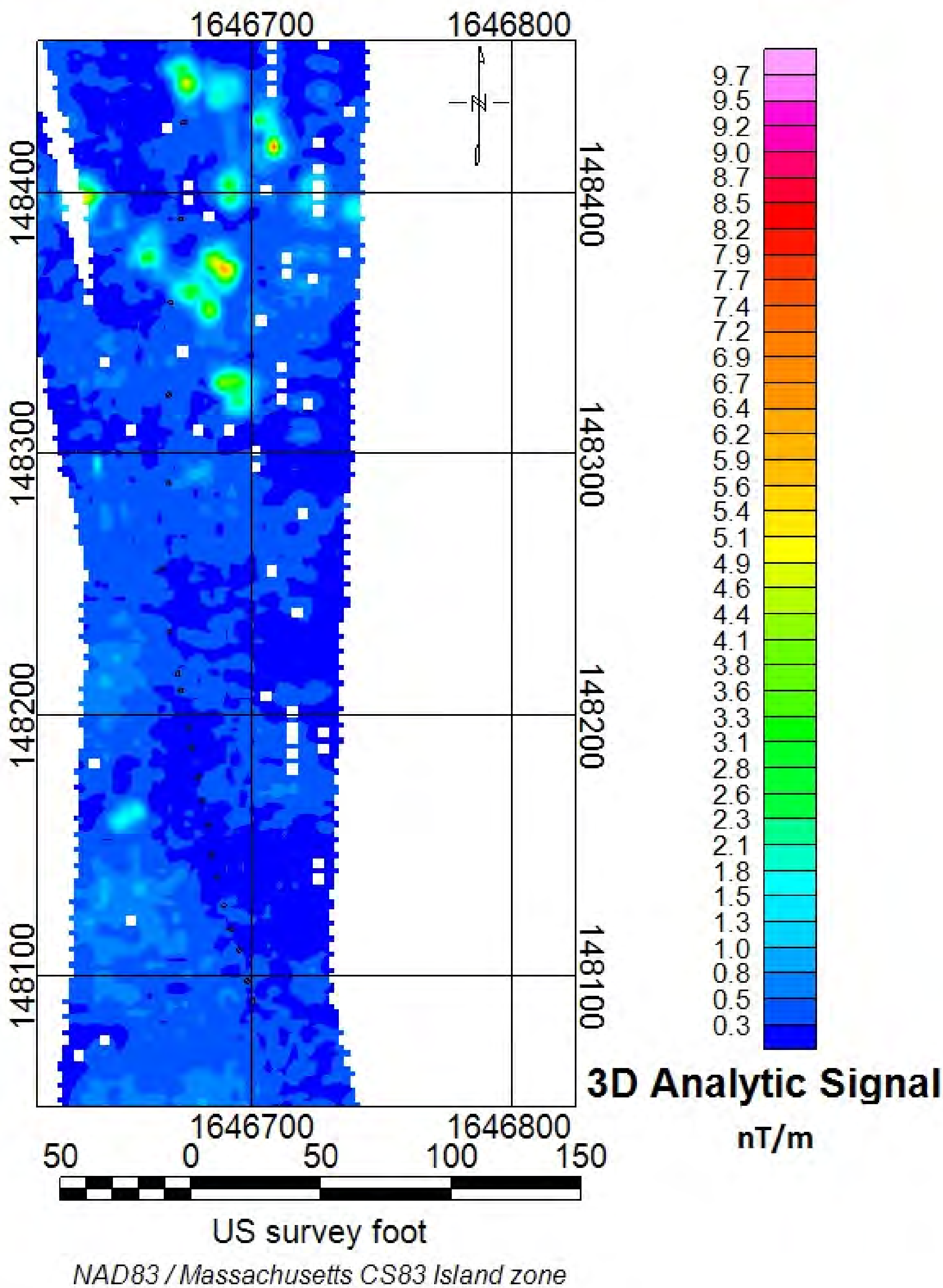


Figure 5-16. Analytic Signal Map of the Post IVS Removal Survey

5.7.1 IVA Data Analysis (Small Target Detection)

The ability to detect small targets largely depended on the proximity of the sensor to the item. With limited ability to laterally guide the MGA precisely over individual IVS items the items cannot be equally examined outside of a lab environment. Figure 5-17 shows a subset of the IVS survey compilation map with the track lines of the port and starboard arrays displayed as thin gray lines. Clearly some IVS items were surveyed more extensively thus had a greater chance of being more closely interrogated, which would generate a larger anomaly response. This likely explains some of the non-intuitive results such as a greater response from a group of eight 20mm projectiles (8.36 nT) versus a group of ten 20mm projectiles (5.59 nT). Sample distance also plays a part of this, a variable that again cannot be as precisely controlled outside of a lab environment. Each day's IVS survey is presented in Appendix A.

Additional analysis was performed on the IVS data by examining individual survey passes of the MGA. The track of the starboard array on line 506_1407 on June 28 is shown in bold in Figure 5-18. The perpendicular ticks denote the sample locations taken every 0.5 second. The array passes close to three of the IVS targets and has a measurable response to each. The along track magnetic response profile is shown in Figure 5-19. It is interesting to note that the maximum magnetic anomaly for the cluster of ten 20mm projectiles is less than that measured of the cluster of eight 20mm. This is likely the result of the proximity of the MGA to the target at the time of the measurement. This observation is also true for the single 40mm projectile (full round with casing), one might expect this projectile to have a larger response than observed here, had the MGA flown directly over the item.

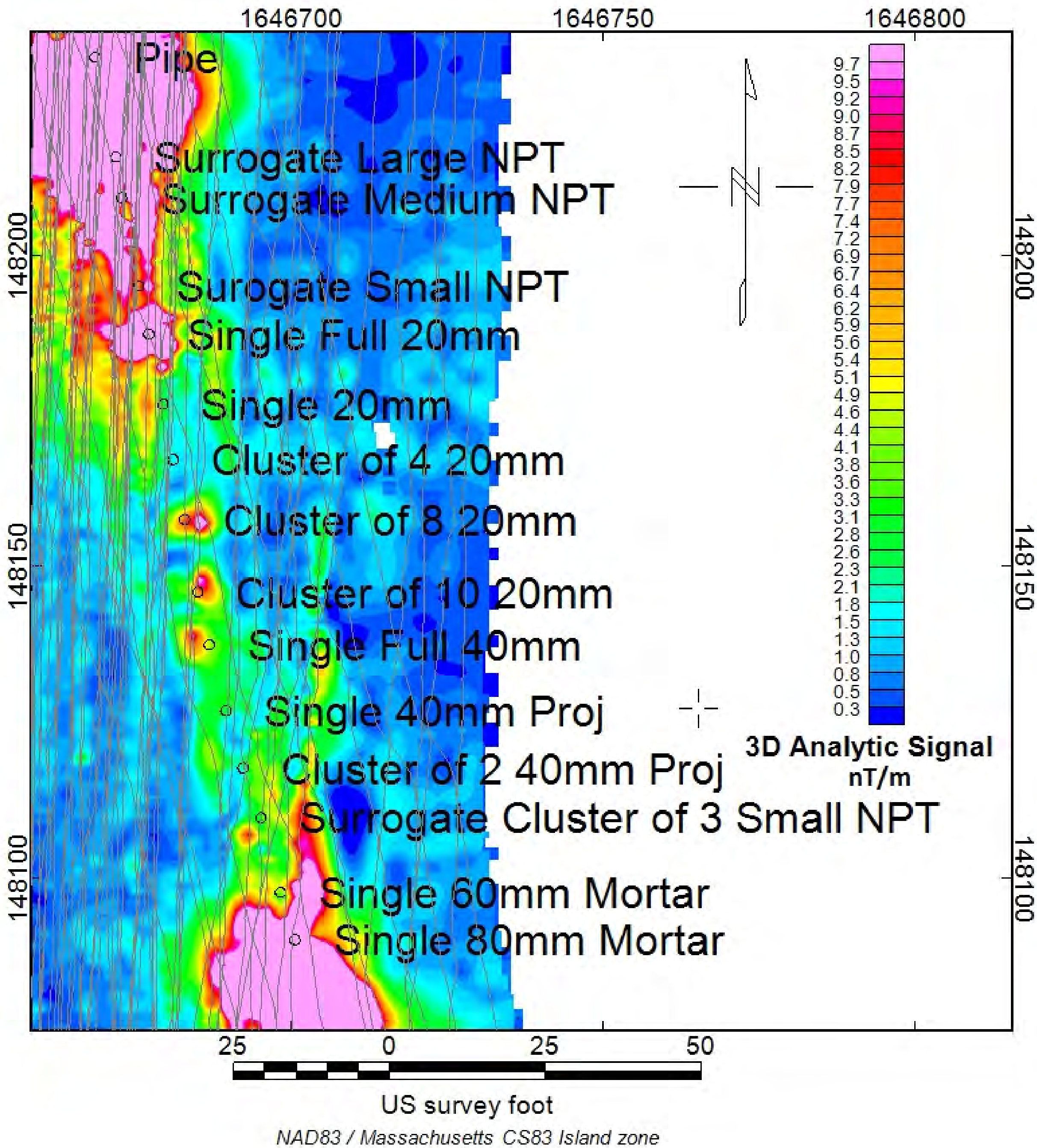


Figure 5-17. Subset Map of the Small Target Region of the Analytic Signal Compilation Map

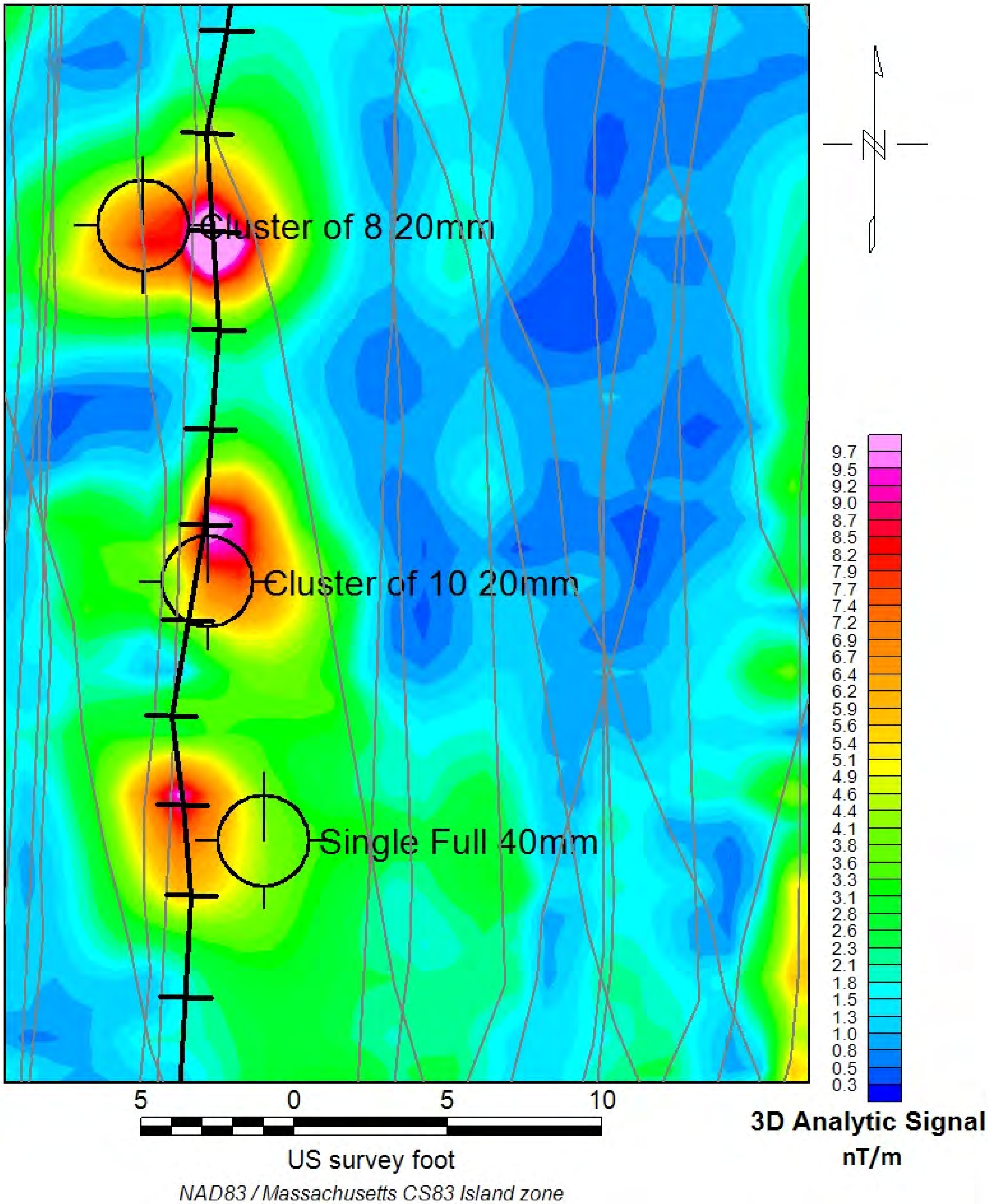


Figure 5-18. Close Examination of Three Small IVS Items

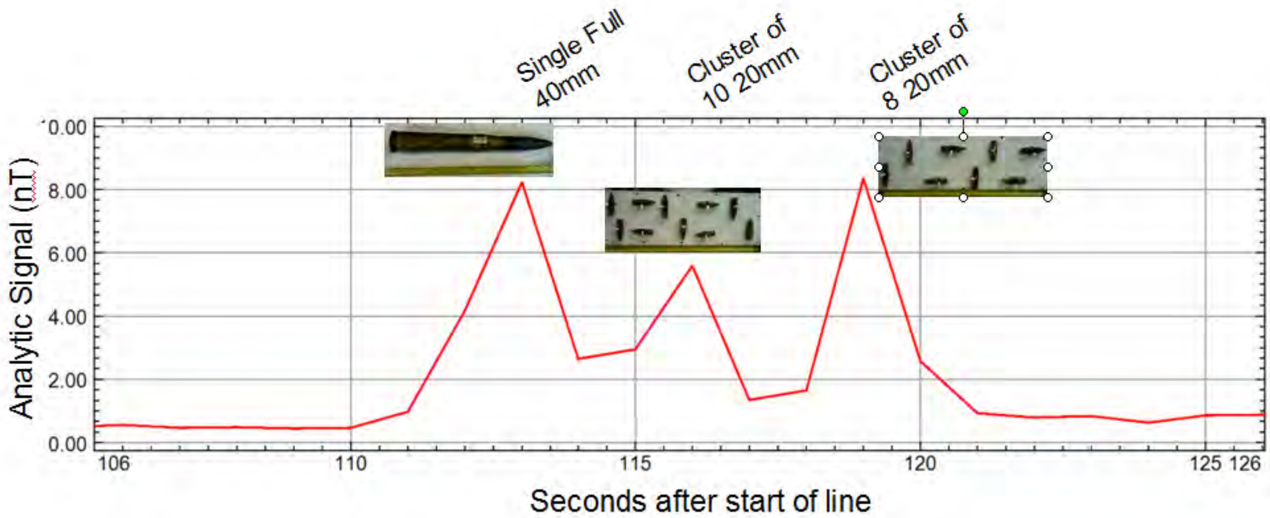


Figure 5-19. Profile of Line 506_1406 Passing Three Small IVS Items

Additional non-project specific analysis of the IVS data was performed for the smaller IVS items that were emplaced in the IVS in addition to six inert items that were recovered from the South Beach site during the time critical removal. The design of the small item IVS was flawed in that many of the items were too close together to be resolved individually. This was especially true for the pipes at the ends of the IVS which were used to anchor the string to the bottom. The small item string was only completely surveyed twice, on June 15 and 28 in order to save time and maximize data collection out at the South Beach site. The results for the 15 and 28 as well as the subset of items surveyed during the other days that the IVS was surveyed are included in Figure 5-6.

Table 5-6. IVS Target Summary Table – Small Items

Date	15th			16th			18th			19th			26th			27th			28th					
Parameter	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Average Max Grid Peak (AS)	Minimum Max Grid Peak (AS)	Maximum Max Grid Peak (AS)
Surrogate Large NPT	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	15.17	1.14	2.45	13.91	1.00	2.00	14.5	13.9	15.2
Surrogate Medium NPT	NR	NR	NR	NR	NR	NR	DP	0.79	2.15	NR	NR	NR	ND	ND	ND	8.84	0.79	2.25	12.09	1.17	2.00	10.5	8.84	12.1
Surrogate Small NPT	NR	NR	NR	ND	ND	ND	NR	NR	NR	NR	NR	NR	ND	ND	ND	ND	ND	ND	4.32	0.35	2.05	4.3	4.32	4.32
Single Full 20mm	10.5	0.84	2.05	5.9	0.46	2.20	11.7	0.88	2.05	5.23	0.91	2.35	16.3	0.29	2.05	11.88	0.91	2.25	12.88	0.13	2.10	10.6	5.23	16.3
Single 20mm	ND	ND	ND	ND	ND	ND	NS	NS	NS	ND	ND	ND	NS	NS	NS	NS	NS	NS	ND	ND	ND	NA	NA	NA
Cluster of 4 20mm	ND	ND	ND	BT	BT	BT	NS	NS	NS	ND	ND	ND	NS	NS	NS	NS	NS	NS	ND	ND	ND	NA	NA	NA
Cluster of 8 20mm	3.12	0.23	2.05	1.3	0.96	2.30	NS	NS	NS	1.87	1.22	2.15	NS	NS	NS	NS	NS	NS	4.97	0.92	1.80	2.8	1.3	4.97
Cluster of 10 20mm	1.5	0.43	1.95	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.11	0.62	2.05	2.8	1.5	4.11
Single Full 40mm Proj	2.32	0.40	2.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.58	0.67	1.70	4.5	2.32	6.58
Single 40mm Proj	ND	ND	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	NA	NA	NA
Cluster of 2 40mm Proj	ND	ND	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	NA	NA	NA
Surrogate Cluster of 4 Small NPT	ND	ND	ND	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	NA	NA	NA
Single 60mm Mortar	NR	NR	NR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	7.34	1.22	2.05	7.3	7.34	7.34
Single 80mm Mortar	NR	NR	NR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NR	NR	NR	NA	NA	NA
Average		0.47	2.03		0.71	2.25		0.84	2.10		1.07	2.25		0.29	2.05		0.95	2.32		0.76	1.97			
Min		0.23	1.95		0.46	2.20		0.79	2.05		0.91	2.15		0.29	2.05		0.79	2.25		0.13	1.70			
Max		0.84	2.05		0.96	2.30		0.88	2.15		1.22	2.35		0.29	2.05		1.14	2.45		1.22	2.10			

Notes: 1) Targets picked manually based on the grid of the analytic signal data.
2) A threshold of 1 nT/m analytic signal was used for IVS target picking
NR - Not individually resolvable due to proximity to anchor pipe
NS- Item location not surveyed on the subject date
DP - Item seen as dipole in total field data
ND - Not Detected
BT - Detected below target picking amplitude threshold
NA - Not Applicable

5.7.2 IVS Data Analysis (Daily Variation)

Additional IVS analysis was performed to examine the day to day variation of IVS target signal strength and also explore the relationship between signal strength and sensor to target proximity.

The northern region of the IVS consisted of six relatively large munitions items and was surveyed seven times on seven separate days (Figure 5-14). Table 5-6 shows a summary of these surveys. The surveys consisted of 2 to 15 passes over the IVS and were all collected with a sample rate of 2 Hz. Gridded MGA data from each survey can be found in Appendix A.

Table 5-6. IVS Survey Summary Statistics

Survey Date	Average Flight Height (m)	Number of Passes	Survey Duration (h)	Average Along Track Sample Distance (m)
61510	2.17	9	1.73	0.74
61610	2.18	3	0.26	0.76
61810	2.2	2	0.16	0.78
61910	2.33	3	0.3	0.78
62610	2.22	2	0.13	0.87
62710	2.4	3	0.28	0.86
62810	2.24	15	1.84	0.90

In Geosoft Oasis Montaj, the analytic signal data from each day was gridded with a 0.6-meter cell size. From this gridded data the peaks of the grid were selected using the "UXPKNESS" utility. This utility mathematically analyzes the peaks of the grids and writes the coordinate of peaks to a database. The magnitude of the grid at these points was also written to the selected database. In Oasis Montaj the distance was measured from the grid peak to the "known" position of the target based on the USBL survey (refer to Table 5-5). The database was further augmented with the altitude of the MGA at the target pick location. Table 5-7 summarizes the results of the IVS target analysis. Using this data we were able to plot the maximum analytic signal strength (grid peak) for each target for each day (Figure 5-20).

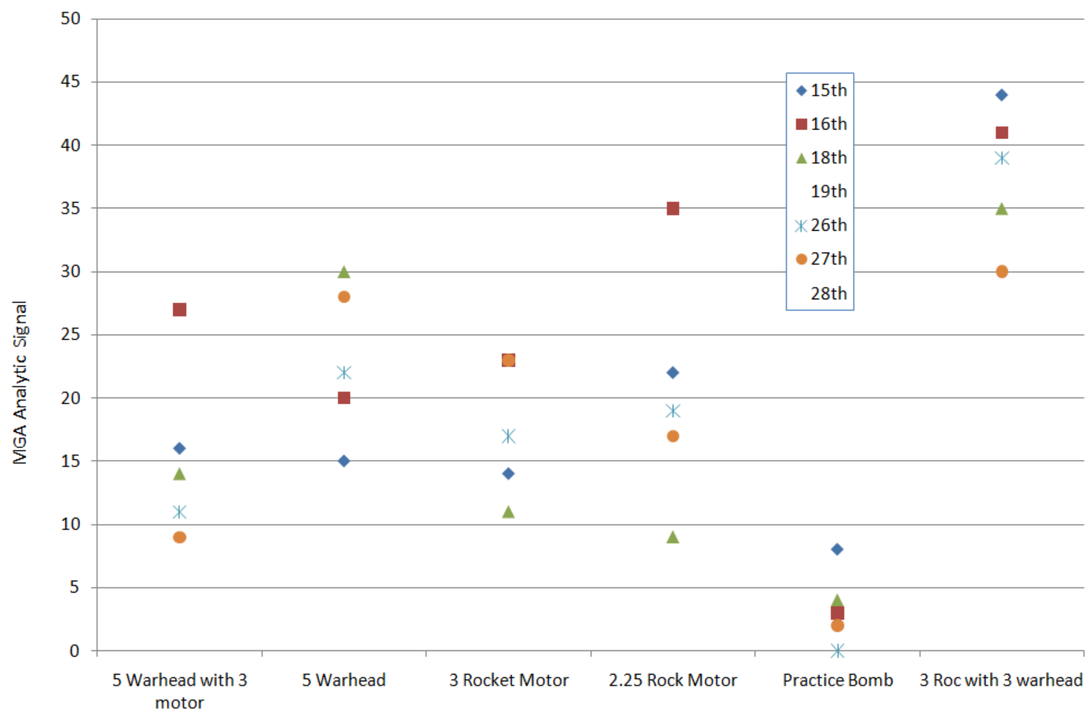


Figure 5-20. Daily Comparison of IVS Target Signal Strength

Table 5-7. IVS Target Summary Table – Large Items

Date	15th 16th			18th						19th			26th			27th 28th					
Parameter	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)	Max Grid Peak (AS)	Peak to Target (m)	Flight Height (m)
(1) 5" Warhead w/ 3" motor	16	2.93	2.14	27	3.81	1.93	14	1.58	2.20	13	1.16	2.43	11	1.16	2.44	9	1.68	2.37	19	4.60	2.01
(2) 5" Warhead	15	0.21	2.15	20	0.70	1.98	30	2.13	2.21	22	0.82	2.43	22	0.70	2.00	28	0.67	2.31	29	1.46	1.95
(3) 3" Rocket Motor	14	1.16	2.12	23	1.13	2.04	11	0.85	2.19	10	0.70	2.40	17	0.73	2.18	23	0.37	2.17	17	0.37	2.15
2.25" Rocket Motor only	22	0.79	2.27	35	0.61	2.25	9	0.18	2.22	9	0.61	2.37	19	1.01	2.30	17	0.21	2.19	17	0.67	1.94
(4) Practice Bomb	8	1.31	2.21	3	1.16	2.26	4	1.13	2.25	3	0.73	2.38	ND*	NA	NA	2	2.04	2.26	4	0.34	2.35
(5) 3" rocket w/ 3" warhead	44	1.55	2.18	41	1.95	2.22	35	1.37	2.25	16	0.37	2.31	39	0.52	2.23	30	1.55	2.31	25	1.62	2.20
Average	20	1.33	2.18	25	1.56	2.11	17	1.21	2.22	12	0.73	2.39	22	0.82	2.23	18	1.09	2.27	19	1.51	2.10
Min	8	0.21	2.12	3	0.61	1.93	4	0.18	2.19	3	0.37	2.31	11	0.52	2.00	2	0.21	2.17	4	0.34	1.94
Max	44	2.93	2.27	41	3.81	2.26	35	2.13	2.25	22	1.16	2.43	39	1.16	2.44	30	2.04	2.37	29	4.60	2.35
Statistics without Item 1, 5" Warhead w/ 3" motor																					
Average		1.01			1.11			1.13			0.65			0.74			0.97			0.89	
Min		0.21			0.61			0.18			0.37			0.52			0.21			0.34	
Max		1.55			1.95			2.13			0.82			1.01			2.04			1.62	

Notes: 1) Targets picked automatically based on the grid peak for the analytic signal data.
2) A threshold of 1 nT/m analytic signal was used for IVS target picking
3) The 5" Warhead w/ 3" motor was a long item that was oriented perpendicular to the IVS and attached to the ground line at the warhead, which puts the motor off to the east side of the IVS item string. The USBL position collected was for the warhead, so the reported position is over a meter from the end of the rocket motor. This increased the distance between the grid peak picks and the reported target position for this item.

Noticeable grouping is seen between targets but signal strength is variable for each target day to day. This variation is caused by a number of factors, most importantly is the proximity of the MGA to the actual target. As discussed above proximity of the MGA is a function of its altitude, cross track position and along track sample rate. No two passes over the same target will be identical, not because the MGA makes inconsistent measurements but rather because the flight path will not be precisely repeatable. On the other hand, assuming that flight height and line spacing are reasonably consistent, gridded data from multiple passes over a target one day should produce the same target anomaly as gridded data from multiple passes on another day.

Another factor that influences the shape and size of the target anomaly is the number of survey passes and size of the anomaly. If a target is inadequately surveyed its magnetic anomaly will not be well defined and thus the peak location and size of the anomaly will have some uncertainty. An example of this would be surveying a target that generated a magnetic anomaly 10 to 15 meters in diameter but only passing over the target with two 4-meter-wide swaths.

Figure 5-21 shows a plot of the distance between each targets location and its magnetic anomaly peak for each day. Clearly the distribution of target vs. anomaly position is greater for the first and last items in the IVS. We suspect this is due to the large size of these two targets. These two IVS items are the largest of all items and their anomalies often extended beyond the limits of the survey resulting in a poorly defined anomaly with a miss located peak position. Figure 5-22 shows a subset of one of these magnetic anomalies extending beyond MGA survey bounds.

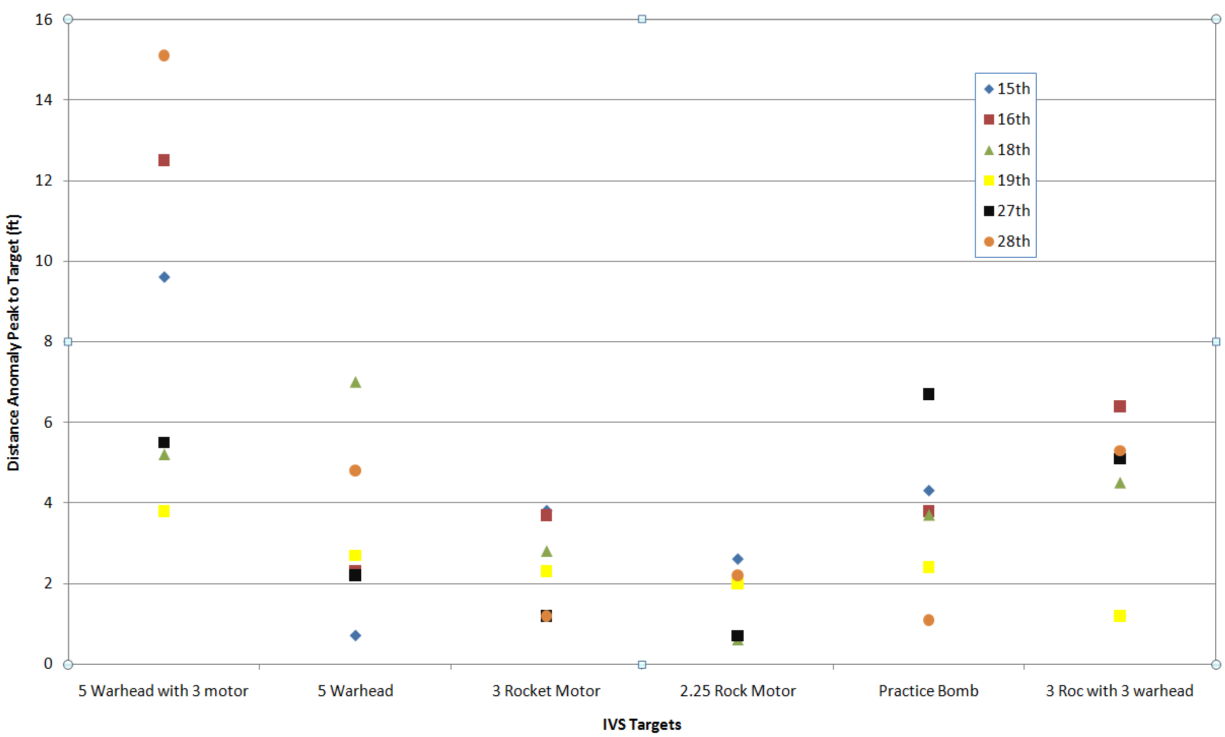


Figure 5-21. Target Location vs. Peak Value Location for Each IVS Target for Each Day

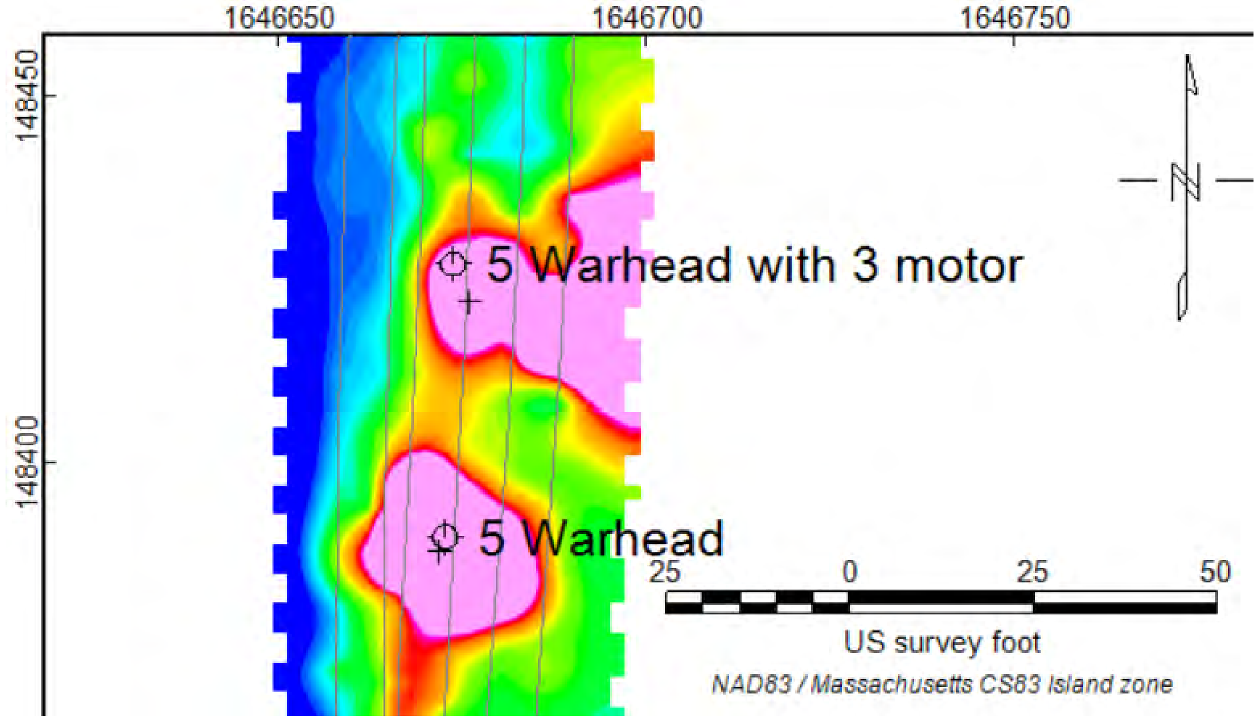


Figure 5-22. IVS Survey on June 19. Magnetic Anomaly for the 5-Inch Warhead with 3-Inch Motor Is Not Fully Captured

The relation between proximity and signal strength is also seen in analyzing the altitude data. Figure 5-23 shows this inverse relationship by plotting the average altitude over each target vs. the average signal strength for all targets that day. Each point on the scatter plot represents a different day's survey.

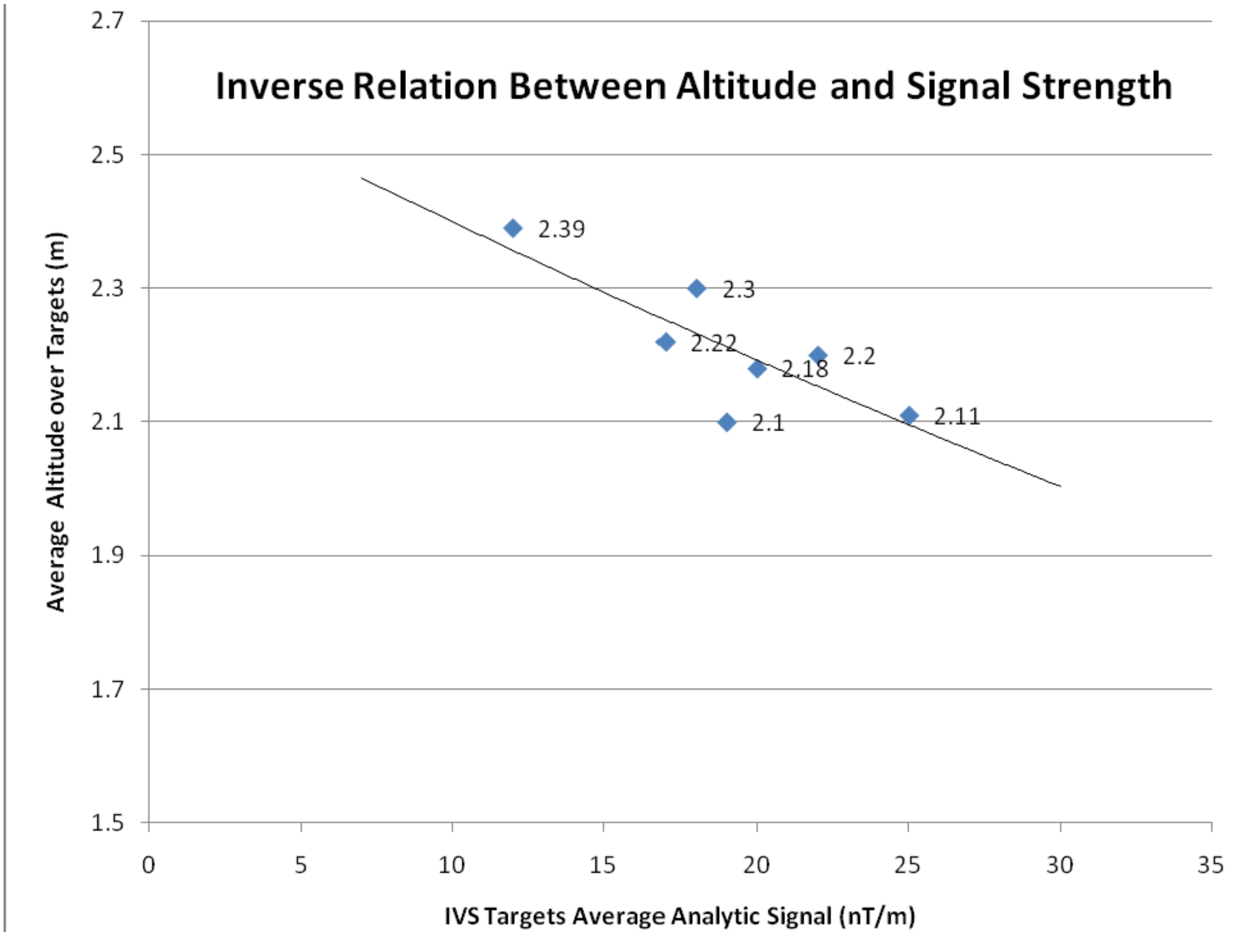


Figure 5-23. Inverse Relationship between Altitude and Signal Strength

6.0 DATA ANALYSIS, AND PRODUCTS

6.1 MBE DATA

6.1.1 MBE Data Processing

The HYSWEEP Multi-beam Software, published by HYPACK Inc., and CARIS HIPS software were used to process and convert sounding data into elevations. During post processing, the multi-beam data were corrected for heave, pitch, roll, and speed of sound, and anomalous data were removed. Multi-beam calibration offsets from patch test results were also applied during the editing process. During editing and processing, each survey line was individually reviewed. This review consisted of visual and automated inspection of speed of sound data, RTK tides, RTK GPS position data, motion sensor data, and sounding data. Anomalous data that are obvious system errors or "noise" within the water column, such as air bubbles, suspended particles and fish, or bottom multiples, were filtered from the final data set. Manual editing was based on a comparison of data outliers with surrounding data points, and file notes.

Automated editing of the data consisted of removing all data points that were not flagged as being "quality three" data points. Data flagged as "quality three" are data that have passed the Sonar processor's brightness and co-linearity quality assessment. The co-linearity test compares the bottom return of each beam with returns from surrounding beams and verifies that it is within the range specified. The brightness test compares the brightness of the center bottom detect from each beam with the surrounding beams. Use of these criteria for automated removal of erroneous soundings reduces the number of points that required manual inspection and removal. These points were not deleted from the original data files; instead they were marked for exclusion from the final data set used to generate a DTM for the site. Rejected data points can be viewed, re-evaluated, and returned to the data set if necessary. Data points that were soundings from surface obstructions were noted for the safety of the following magnetometer survey and for chart production. Initial data processing was performed in near real time aboard the survey vessel allowing for rapid transition to MGA survey.

6.1.2 MBE Data Analysis

Preliminary bathymetry charts of near final quality were ready within 2 to 3 days of data collection. Visual analysis of these preliminary products was used to as a quality control tool and to track project progress. Final editing of the survey data was performed after demobilization from the site.

Initial analysis of the MBE data was performed via visual examination of the terrain plots to identify any features that might interfere with the MGA survey, or potentially damage the MGA. No cultural features of this type were found. Analysis of the plot revealed that the sediment surface throughout the surveyed area was relatively flat with the exception of one 6- to 7-meter-tall steep sided sand wave in the southeast region of the survey area. Figure 6-1 is a subset from the terrain plot showing gently sloping bathymetry with intermittent sand waves including one large amplitude wave in the lower right. The MBE data plot also shows four troughs oriented NNE-SSW near the south-central of the project site. The strong tidal currents and large geomorphic features in the survey area indicate a high energy environment that experiencing both areas of erosion and deposition. The orientation of the sand waves indicates an active transport of sediments in a westward direction. Additional study would be necessary to fully understand the transport mechanisms of the site as this brief analysis is based on only one moment in time and does not account for seasonal variation. On Figure 6-2 the troughs areas appear as dark blue or purple areas. Figure 6-3 is a multi-perspective view of the large sand dune located in the southeast region of the survey area.

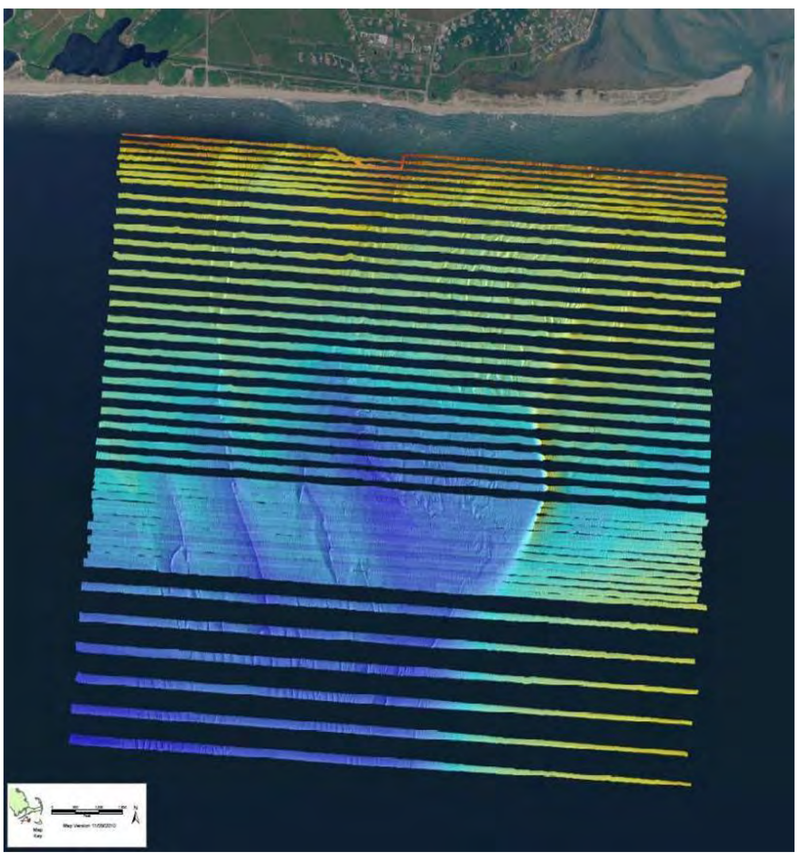


Figure 6-1. South Beach MBE Data

Note: this figure is an example subset of the data provided on Plate 1, Sheet 1 of 6 in Appendix B

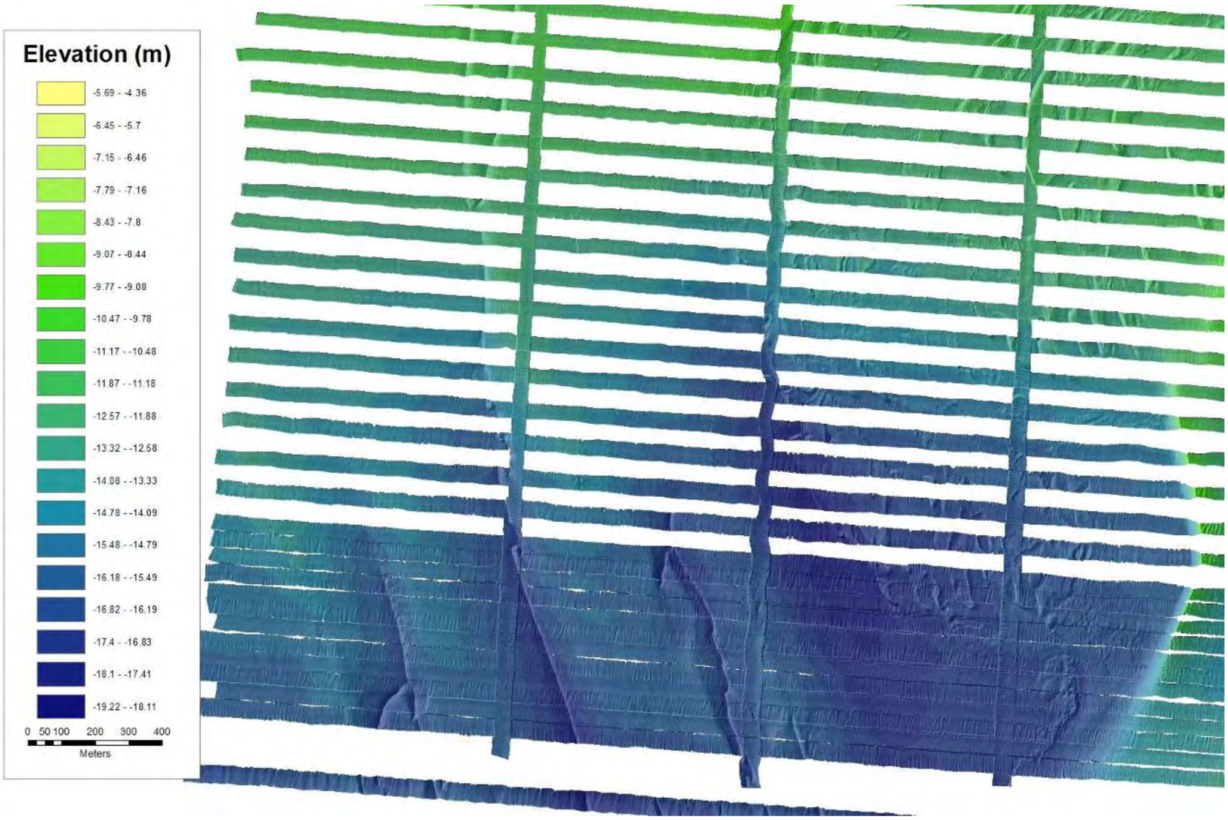


Figure 6-2. Excerpt From MBE Data Showing "Ravine" Areas

Note: this figure is an example subset of the data provided on Plate 1, Sheet 1 of 6 in Appendix B

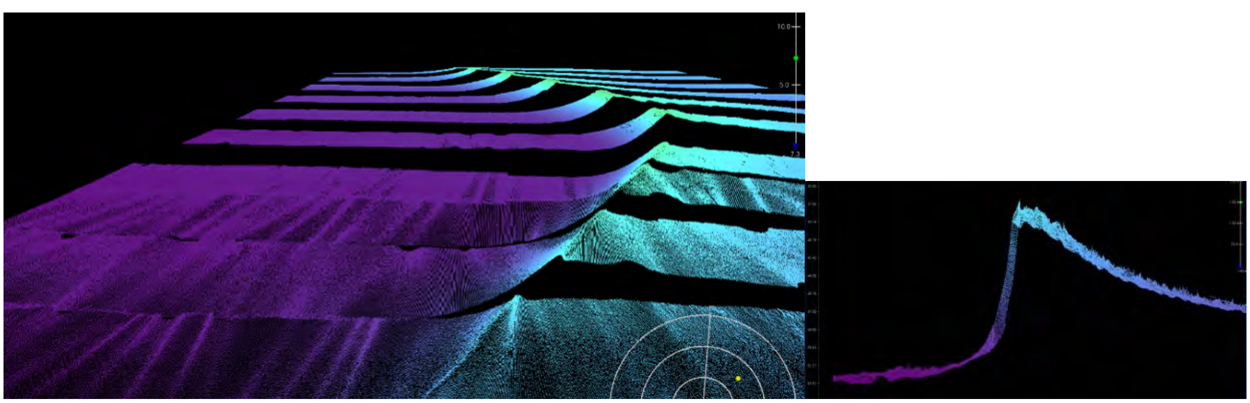


Figure 6-3. Oblique View and Profile of Sand Dune Located within the Survey Area

Final analysis of the MBE data with respect to locating underwater munitions and understanding the distribution pattern of magnetic anomalies was performed in Oasis Montaj. The MBE data were used as base image on top of which the MGA target picks were displayed, thus making it possible visually inspect correlation between the geomorphic features and the target distribution. The MBE data itself did not identify of any MEC or other cultural features in the survey area. The multibeam data chart is presented in Appendix B, Plate 1 Sheet 1.

6.2 MGA DATA

6.2.1 MGA Data Processing

Recall that the MGA is composed of two three-axis gradiometers. In total, the MGA has seven magnetometers and the two gradiometers share the central magnetometer. In data processing the MGA is treated as two separate gradiometers that are flown side by side. The MGA generates time stamped total field measurements (one for each of the seven magnetometers in the array) along with a set of ancillary measurements for each of the two gradiometers (altitude, depth, roll, pitch and heading). These data are processed to extract sets of difference values, or gradients, between selected pairs of sensors. Each array can be processed to derive vertical, horizontal, and longitudinal gradients, which can be combined to form a 3D analytic signal. The gradient and analytic signal data provide improved resolution and positioning of targets of interest when compared to positions derived from total field alone.

The .raw files collected in Hypack contain all of the separate time stamped components of the MGA survey and are first processed with TtEC's MagProc software. MagProc merges the total field data with time coincident attitude, altitude, heading, and position data to determine the XYZ position of each sensor at the time of measurement. If necessary the USBL positions recorded in Hypack are edited in an additional TtEC's application called NavEdit prior to their merger with the magnetometer readings. The MagProc software projects the MGA's sensor measurements into the local coordinate system. The program also computes and georeferences the gradient and analytic signal data for each of the two arrays. A screen shot of MagProc is shown in Figure 6-4, total field readings from each sensor and all three axis gradients are shown in profile. MagProc outputs two file types, one with the total field and positional data for each sensor, and one that includes the calculated gradient and analytic values and corresponding array positions (Figure 6-5).

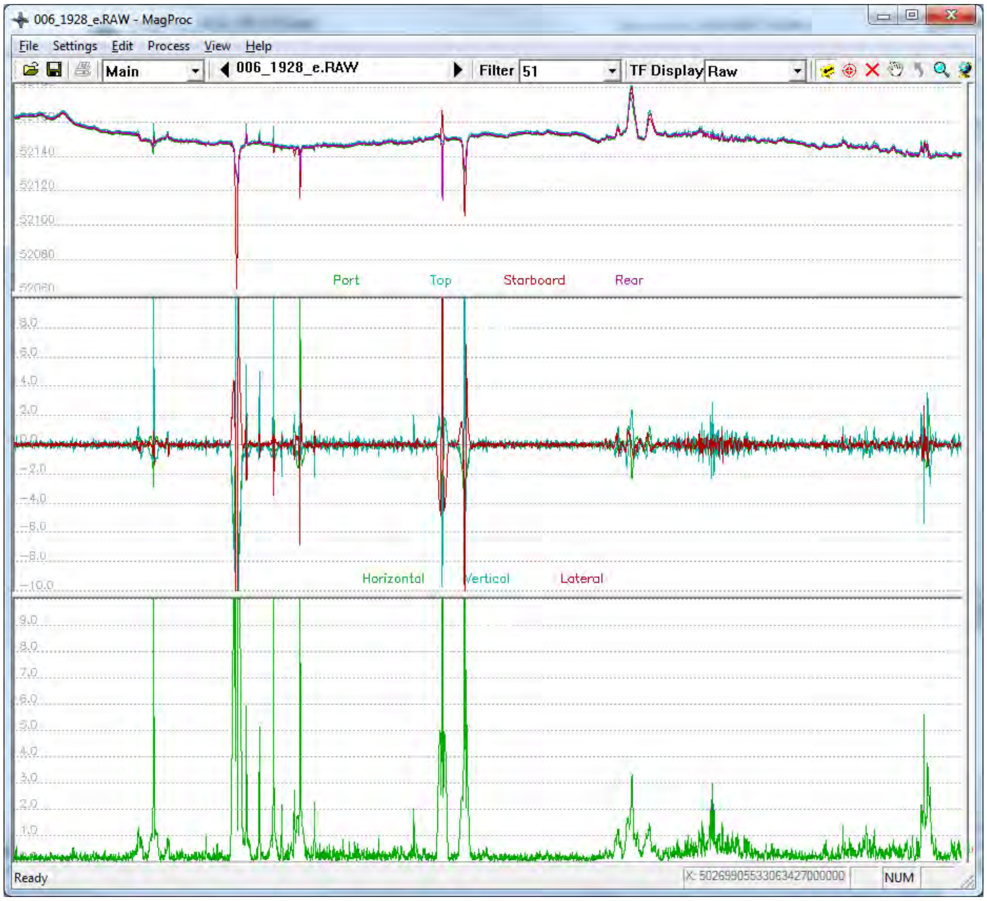


Figure 6-4. MagProc Software Screen Shot

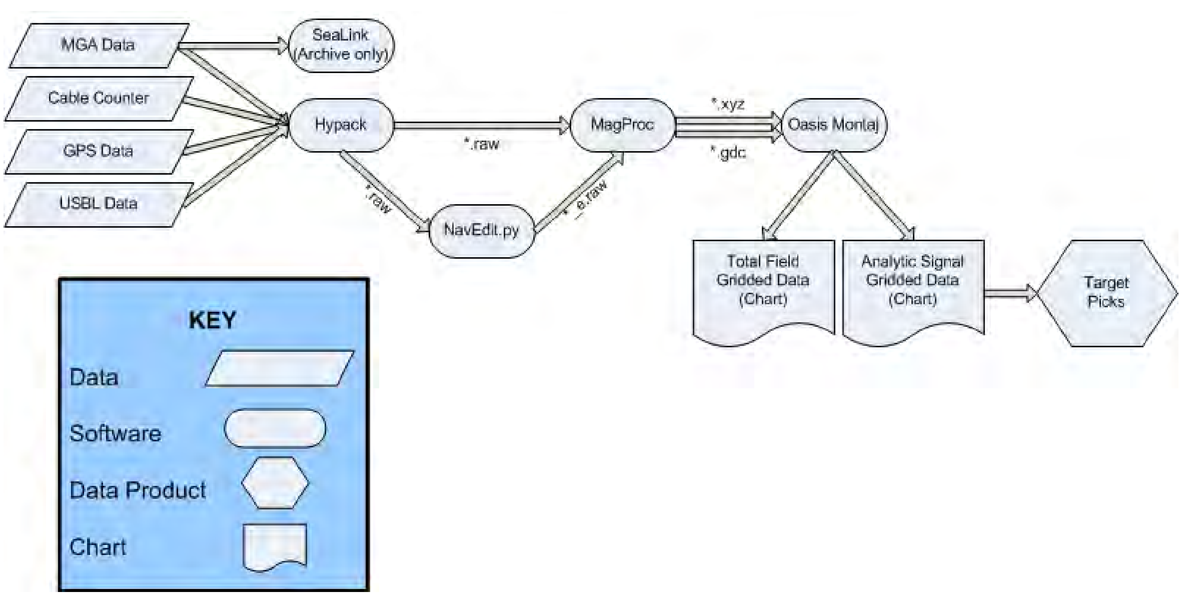


Figure 6-5. MGA Data Processing Workflow

The MagProc output files are then processed using Geosoft's Oasis Montaj software. The data is filtered using a moving box car filter to eliminate magnetic field drift caused by diurnal variation. The data is then gridded to generate a color image of the data highlighting regions with anomalous magnetic field strength, or in case of the analytic data regions with anomalously high magnetic field gradients. Oasis Montaj provides a set of tools for automatic selection of magnetic dipoles as well as other tools for manual and automatic detection and processing of targets. The automatic target picking algorithms can be set with thresholds that are representative of the targets of interest. Results from the IVS survey provided the necessary guidance for the target picking algorithm.

6.2.2 MGA Data Analysis

The MGA was data analyzed visually to identify anomalies based upon dipole reading, size and shape. The visual analysis results were compared to the automated target picks obtained during data processing with the Oasis Montaj software (refer to Section 6.2.1). After target selection was complete, the selected targets were plotted and the distribution of anomalies was visually inspected. The distribution of anomalies can provide clues as to their origin. For example a linear string of anomalies located along the western edge of the survey area and oriented perpendicular to the shoreline, is interpreted to be a non-hazardous cultural feature such as a communications cable. A second cluster of anomalies located in southeastern portion of the demonstration area is semi-linear and angled with respect to the shoreline. These anomalies are interpreted as potential MEC along an approach lane for the western historical aerial target. The magnetic anomalies may also represent cultural debris that has been redeposited by currents and shifting sands. This debris may or may not include MEC. MEC and fragmented cables or pipes have potentially similar transport and redepositional characteristics. The ferrous targets are larger is size and high in density than the sand, these physical properties could results in sorting mechanism where the items are "trapped" in topographically low features and transported away from their original point of deposition through the forces of gravity and water currents.

Figure 6-6 shows the MGA analytic signal data. Hot colors represent magnetic anomalies. Both the total field magnetic data and the 3D analytic signal data charts are presented in Appendix B, Plate 1 Sheet 2 and sheet 3 respectively.

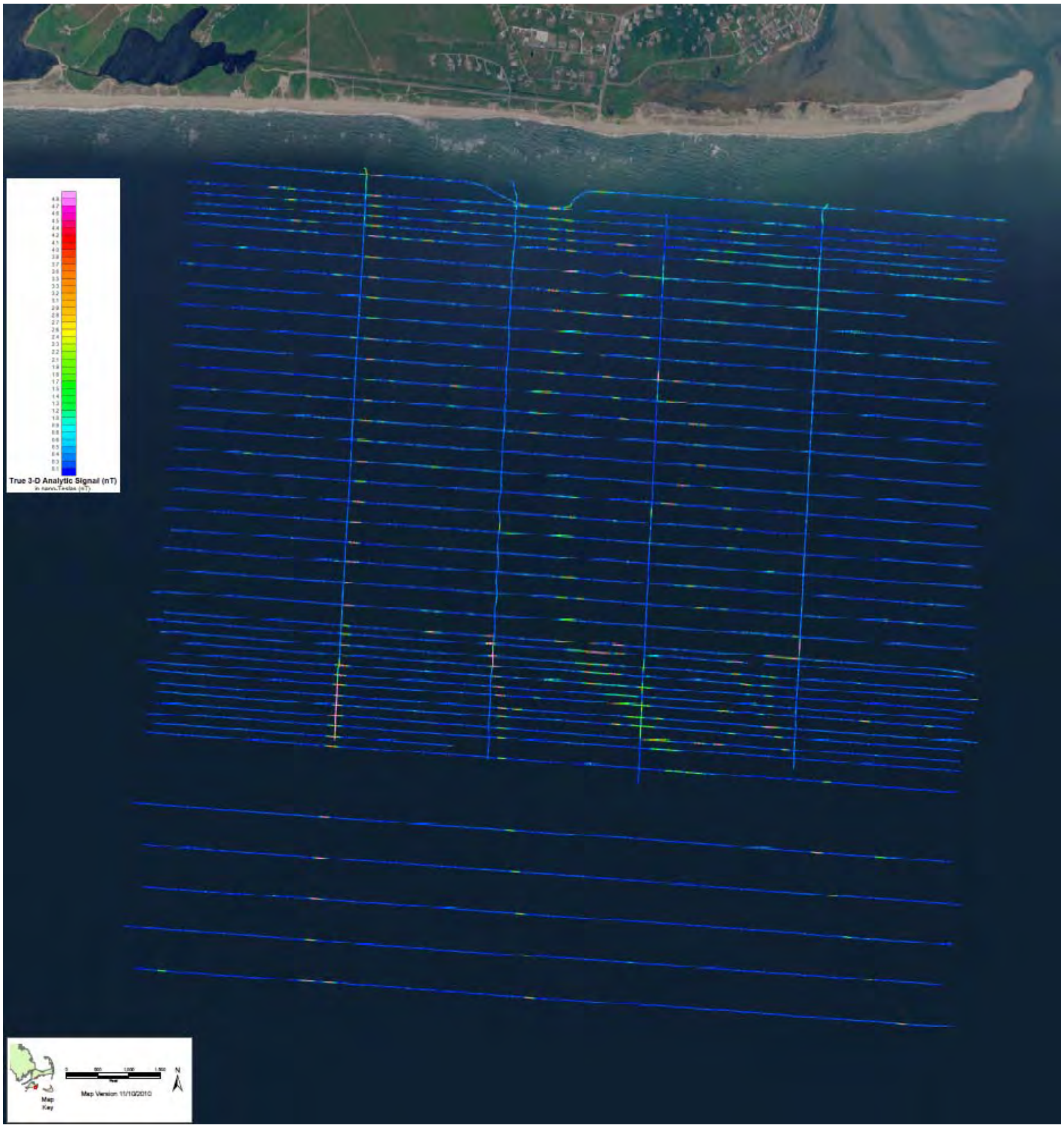


Figure 6-6. MGA Analytic Signal Data

Note: this figure is an example subset of the data provided on Plate 1, Sheet 3 of 6 in Appendix B

6.3 SIDESCAN SONAR DATA

6.3.1 Sidescan Sonar Data Processing

SSS data processing was performed in Chesapeake Technologies SonarWiz 5. Each SSS data file was bottom tracked to remove the water column from the data to allow for the application of slant range and time-varied gain corrections. The SSS data were georeferenced at the time of collection. Each swath of imagery was combined in SonarWiz to generate a nearly continuous mosaic of the survey area. Final data presentation materials were generated using a combination of SonarWiz and ArcGIS.

6.3.2 Sidescan Sonar Data Analysis

Like MBE data, SSS data are plotted and compared to locations of interest (anomalies) in the MGA data to identify if the target is proud of the sediment surface. If the target is proud of the bottom the geophysicist may be able to discrimination MEC from other metallic debris based on the size and shape or more likely identify the item as something other than MEC. The SSS also provides information regarding the sediment surface morphology (Figure 6-7). A mosaic of the sidescan sonar data is presented in Appendix B, Plate 1 Sheet 4.

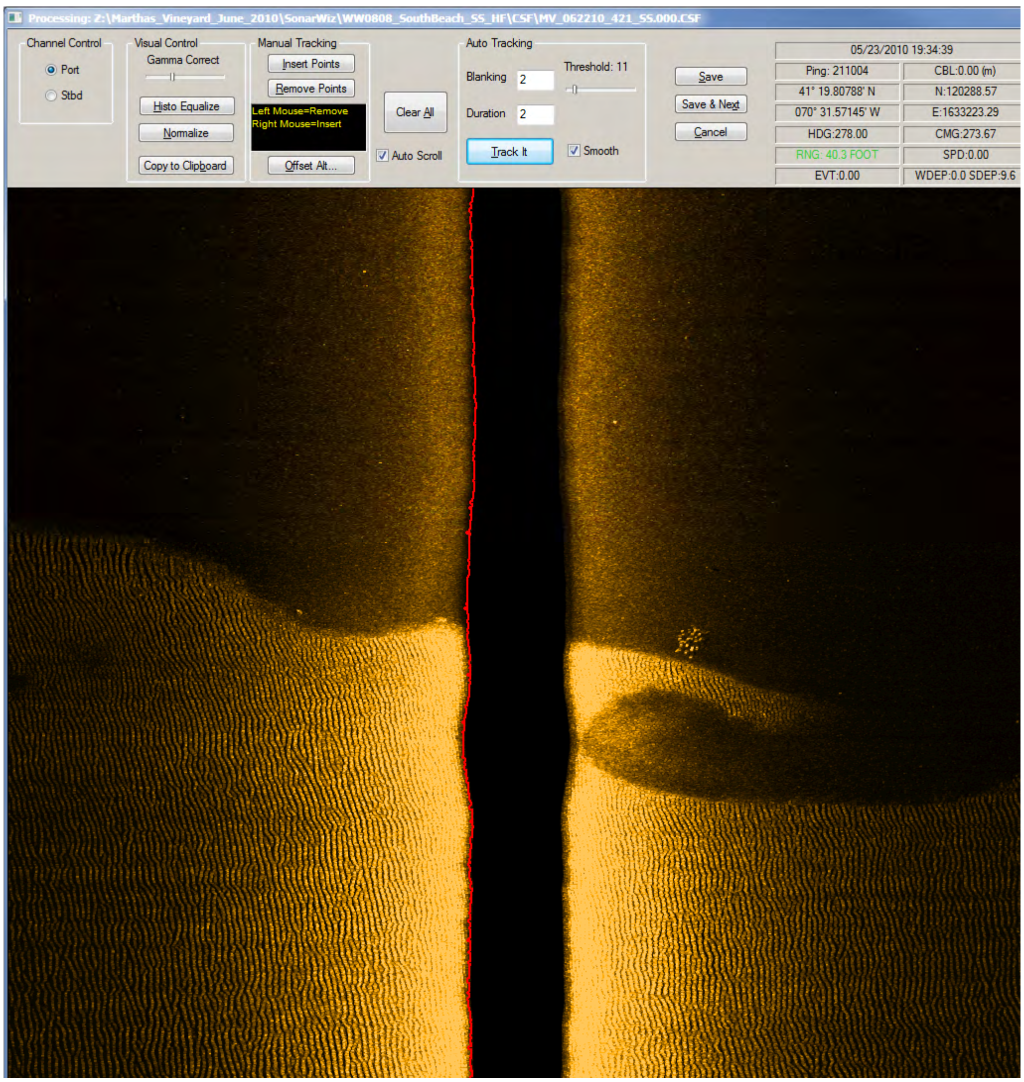


Figure 6-7. SSS Data Showing a Transition from Rippled to Smooth Bottom, along with Some Other Unidentified Feature on the Starboard Side

6.4 SUB-BOTTOM PROFILING DATA

6.4.1 Sub-Bottom Profile Data Processing

SBP data were post-processed using Chesapeake Technology's SonarWiz 5 software. Raw sonar files, recorded in EdgeTech's JSF file format, were imported into a SonarWiz project. Towfish positioning, provided via the USBL acoustic tracking system and recorded within the raw sonar file, was plotted and checked for erroneous data points. Each file was then bottom tracked and signal processing methods were applied to adjust gain and filters to obtain the best possible image. Following bottom tracking and filtering, distinguishable features, primarily the first two substantial subsurface reflectors, were identified where seabed conditions allowed. Reflectors were not always present in the sub-bottom record because the subsurface material was homogenous to the depth of signal penetration.

6.4.2 Sub-Bottom Profile Data Analysis

SBP data were visually analyzed to assess the acoustic reflections. The data were also compared with SSS and MBE data to assess the correlation of sub-bottom features with sediment surface features such as sand shoals or dunes. Figure 6-8 is a plot showing how a sediment surface dune correlates with sub-surface stratigraphy.

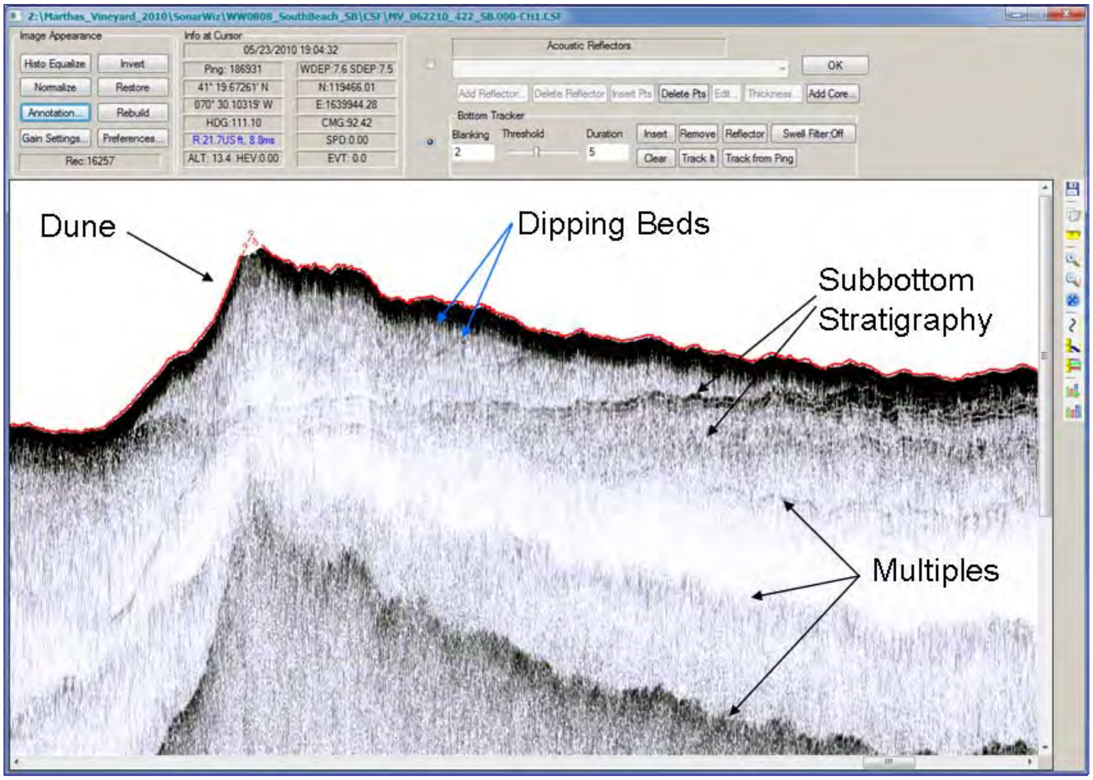


Figure 6-8. Sub-Bottom Cross-Section of a Large Sand Wave Showing Underlying Stratigraphy

6.5 TARGET SELECTION FOR INSPECTION

Anomalies that are potentially MEC were selected by evaluating magnetometer data and corresponding MBE and SSS data. Targets were initially selected using the UXO Detect module in the Oasis Montaj software. Magnetic anomalies having a signature that was 3 nT or more above the background readings were selected. A threshold of 3 nT was based on magnetic anomalies measured in the IVS. A geotiff for the MGA analytic signal data and a dxf file of the MGA target picks was imported into SonarWiz for further investigation. In SonarWiz the sidescan image was examined in full resolution at the location of the magnetic anomaly. A subset image of the sidescan image was extracted at each magnetic anomaly location. At this point the geophysicist carefully reviewed the sidescan data to look for anomalous features that were not detected by the MGA. All anomalies whether magnetic, acoustic or both were denoted as contacts in SonarWiz (Figure 6-9). A color coded system was implemented to denote the characteristics of the contacts (Table 6-1).

Table 6-1. Target Icon Key

Icon	Anomaly Type
Blue Circle	Co-located MGA and SS Anomaly

Pink Circle	Magnetic Anomaly Only
Salmon Circle	Sidescan Anomaly Only
Yellow-Green Cross-Box	Specific linear N-S magnetic anomaly in western survey area believed to be a cable.

SonarWiz is capable of generating a target report based on the selected contacts and includes subset images of the sidescan data in the vicinity of the anomaly. To further augment this report subsets of the gridded MGA data and an along track profile of the magnetic anomaly were included for all contacts where there was a magnetic anomaly. From this target report informed decisions could be made regarding the further investigation of targets. For example magnetic anomalies that lay proud of the bottom (i.e., visible in the sidescan data) could be selected for diver or remotely operated vehicle based investigation. Figure 6-9 shows a color coded contact map in SonarWiz denoting the location of magnetic or acoustic anomalies, and overlays a high resolution mosaic of the high frequency sidescan data. The target report for all phase one lines where quality MGA and sidescan data were available is included in Appendix C.

A large linear magnetic anomaly located in the western survey region oriented perpendicular to shore is most likely a non-hazardous cultural feature such as a telecommunications cable and was assigned a specific color during target picking. Targets from this feature were included in the contact report to ensure that no anomalies were accidentally disregarded.

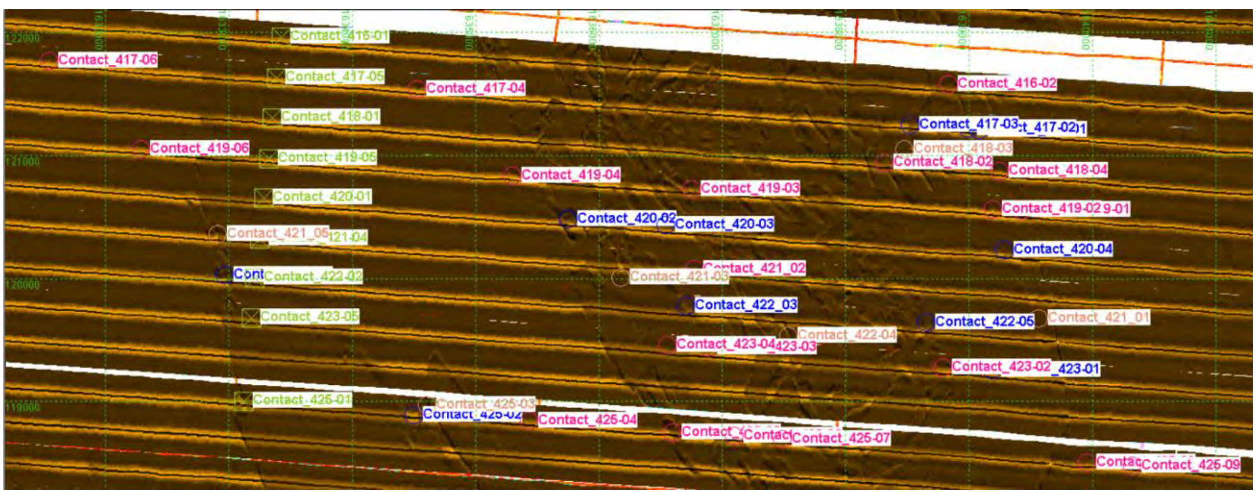


Figure 6-9. Contact Map of Sidescan and Magnetic Anomalies

A set of targets that exhibit characteristics most similar to MEC were selected for visual inspection by UXO-trained divers following the generation of the target report. At the time of this report there are no results from the diver investigation.

6.6 PARAMETER ESTIMATES

Parameter estimation was not performed as part of this demonstration survey. The magnitude of the magnetic anomaly is a function of its size, shape, orientation, and exact distance from the sensors, none of which are known. When performing a wide area assessment survey the MGA is not likely to pass directly over the target generating the magnetic anomaly and thus the actual target location may have some unknown lateral offset from the track of the MGA. Furthermore the target may be buried at some unknown depth that is not compensated for even when corrected for flight height. While some type of mathematical inversion maybe possible by utilizing the multiple gradients that can be calculated from the MGA, this was not attempted.

A small number of targets were visible in the sidescan data. For these targets their length, width, and height above the bottom were measured when possible using the available tools in SonarWiz.

6.7 CLASSIFICATION

6.7.1 Target Classification

Target classification is primarily a process of target reduction. The MGA detects all ferrous objects, all of which potentially represent MEC. By plotting the pattern of magnetic anomalies and utilizing the MGA and SSS data the data analyst was able to classify some percentage of the magnetic anomalies as non-hazardous cultural debris. No confirmation of target classification was available.

6.7.2 Bottom Type Classification

Bottom type classification was performed on the sidescan and MBE snippet data using Quester Tangent's QTC SWATHVIEW™ software. QTC SWATHVIEW™ processes raw backscatter data from multibeam and SSS systems to generate maps of seabed type. This image-based seabed classification software segments the seabed into discrete classes based on the characteristics of the acoustic backscatter. These areas of acoustically similar seabed correspond with variations in material type (sand, gravel, mud, etc.) as well as features (ripple marks, bedrock, seagrass, etc.). Because physical samples and/or visual analyses are required as training data for the acoustic classes to have more meaning, and we did not collect sediment samples from the survey area, we were unable to relate acoustic classes to real world bottom types. Figure 6-10 and 6-11 show examples of seabed classification from the sidescan and snippet data, respectively. The sidescan sonar derived bottom type chart and the multibeam snippet derived bottom type charts are presented in Appendix B, Plate 1 Sheets 5 and 6 respectively.

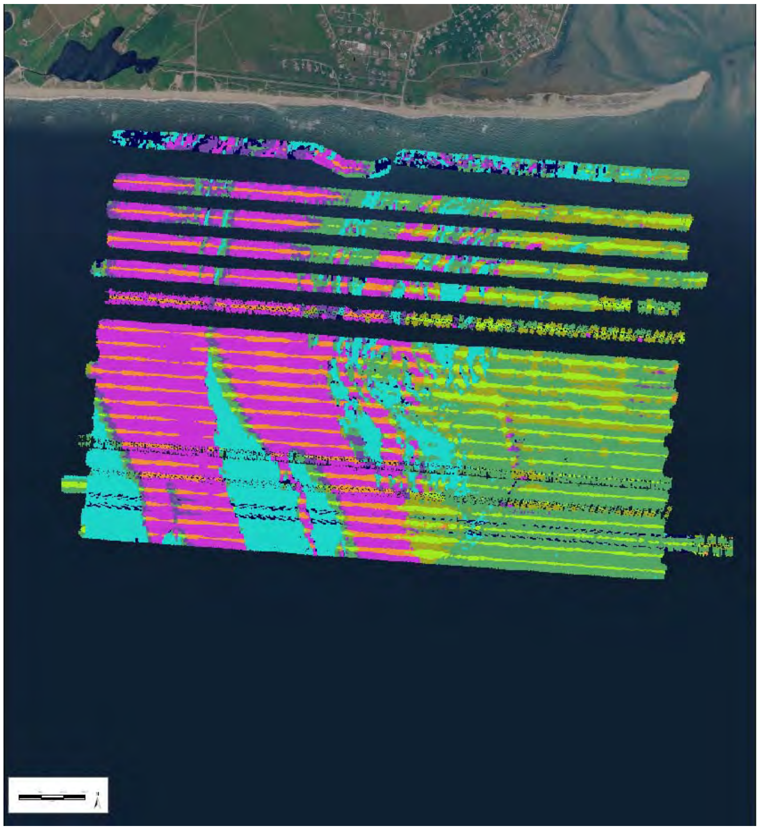


Figure 6-10. Eight Class Seabed Classification Map Derived from Sidescan Data

Note: this figure is an example subset of the data provided on Plate 1, Sheet 5 of 6 in Appendix B

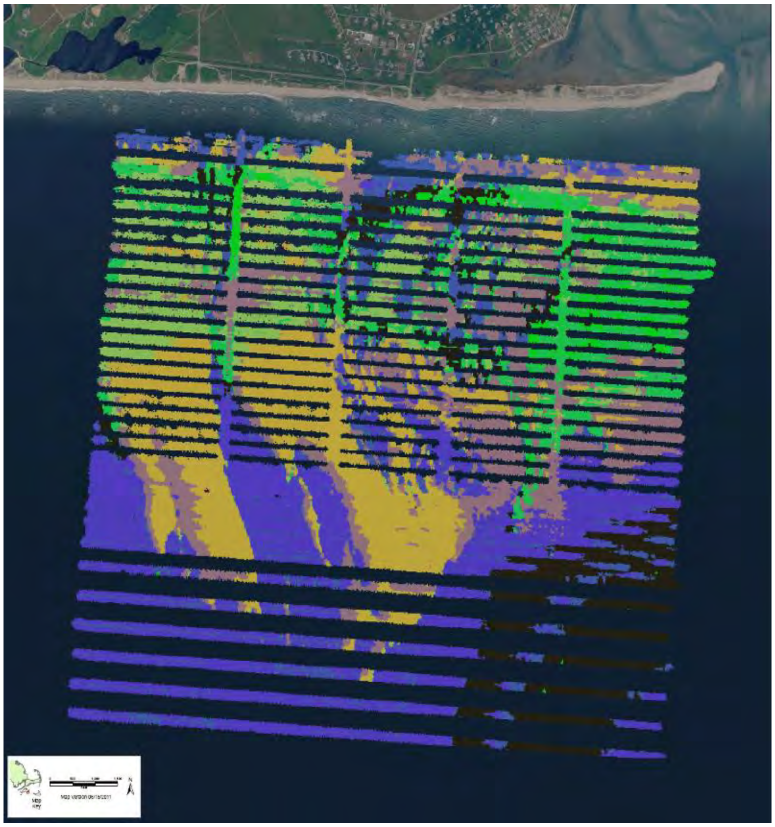


Figure 6-11. Eight Class Seabed Classification Map Derived from MBE Snippet Data

Note: this figure is an example subset of the data provided on Plate 1, Sheet 6 of 6 in Appendix B

6.8 DATA PRODUCTS

6.8.1 MBE Data Products

A combination of Caris, GIS, was used to generate final data products and to down-sample the high-resolution multi-beam data into a digital terrain model which was based on a 1-meter grid (or less). The minimum number of points required per grid was one, ensuring that all data collected would be represented. Any grid cell without a sounding was not assigned a depth and displays with the background color. Charts displaying the site bathymetry and mapped features were generated in the project datum. Appendix B contains the figures generated from the MBE data.

6.8.2 MGA Data Products

The magnetometer data were used to create a raster image that is GIS compatible. All MGA data and documentation are included in this report. Appendix B contains the figures generated from the MGA data.

6.8.3 Sidescan Sonar Data Deliverables

The side-scan sonar data and interpreted results have been provided in this report. Appendix B contains the figures generated from the SSS.

6.8.4 Sub-Bottom Profile Data Deliverables

The interpreted sub-bottom data were reviewed and examples provided in the report.

7.0 PERFORMANCE ASSESSMENT

7.1 DETECTION OF FEATURES OF INTEREST IN THE CSM

Features of interest for the project site are shown in the CSM in Figure 5-1. These features include the aerial bombing targets (east, west, and old bunker), the range safety fans for the targets (east, west, and old bunker) and a potential disposal site on the eastern edge of South Beach. During the demonstration it was determined that these features were primarily located in very shallow water areas that could not be mapped without re-configuration of the detection and location systems. The areas could also only be surveyed during flat calm conditions due to complex sand bars within the near shore area. Since the intent was to demonstrate a WAA methodology, time and effort were not spent in adapting the systems for these very shallow water areas.

7.2 TIMELY INITIAL DATA PROCESSING AND MAPPING

Initial data processing and mapping was consistently conducted in a timely manner and in accordance with the performance specifications for the project. Initial analyses and plots were preliminary in nature and were used for the purpose of planning follow-on work (i.e., identifying features that might damage the MGA using data from the MBE) and for evaluating general quality of performance. Initial quality evaluations supported slight adjustments to equipment configuration or operation that ensured the performance objectives were met.

7.3 GOOD PRODUCTION RATE

Production rates for the demonstration were very good and in general exceeded the performance criteria for the project. Table 7-1 contains a summary of production rates for the various surveys. Although production rates can be greatly influenced by sea state and site conditions, the rates achieved during this demonstration illustrate the tremendous capability of the systems used in the performance of wide area assessment for underwater munitions.

Table 7-1. Summary of Production Rates

Survey Phase	Average Production Rate (km/hr)	Average Production (hectares/day) assuming ~6 hours survey	Comments
MBE	6-10	50-600 (4-30-meter water depth)	Hectares per day - depends largely on water depth.
MGA	6.3	~22	Swath width is a fixed 5 meters
SSS	9	~260	Swath width for this survey was ~100 meters
SBP	9	NA	SBP generate 2D profiles thus area calculations are not applicable. Production is ~ 72 line km

7.4 EASE OF USE

The detection and positioning systems used for the demonstration proved to be relatively easy to deploy and operate by an experienced field team. TtEC staff had developed efficient deployment methods and necessary launch and recovery equipment (such as a hydraulic A-frame used to deploy the towed systems and custom rotating poles for the MBE and USBL) on previous projects. One key contributor to our success is the use of a custom survey vessel that can easily be transported between sites. Our survey vessel has custom mounting brackets for all of the necessary geophysical equipment and travels ready for survey, requiring minimal mobilization time on site. Because the vessel is only 8.5 feet wide and 34 feet long, it can be transported on its trailer anywhere in the nation without wide load permits with relative ease and minimal cost.

The MGA disassembles and can be packaged into rugged cases that ship on two pallets. When assembled, the MGA is 4 meters wide and weighs just over 230 kilograms in air. Because the MGA is 1.5 meters wider than the survey vessel, custom mounts on the A-frame were developed to cradle the MGA during transit from moorage to the survey site; this allows the vessel to transit at its maximum speed. The A-frame is equipped with two hydraulic winches for lifting the MGA. The MGA can be launch and recovered with just two people, although three provide for a quicker and smother operation, especially in higher sea states. Figure 7-1 shows the sequence of recovering the MGA onboard the vessel.

Figure 7-1. MGA Sequence of Recovery

a) Attach 2 hydraulic winch lines to MGA pick points (top left)

b) With a-frame tilted out raise MGA to appropriate height (top right)

c) Tilt a-frame forward allowing the MGA to sit in the cradle (bottom left)

d) Secure MGA to a-frame with straps for high speed transit (bottom right)

8.0 COST ASSESSMENT

8.1 COST ELEMENTS

As required by the project work plan the cost assessment for this demonstration is based upon instrument costs, mobilization/demobilization, site preparation, survey costs, and data detection and discrimination costs. Table 8-1 summarizes these cost elements, how they were tracked, and the results of that tracking during the demonstration. A description of the costs elements are provided in Section 8.1 through 8.3.

Table 8-1. Summary of Cost Tracking Elements

Cost Element	Data Tracked	Demonstration Costs ($k) and Other Details
Instrumentation Cost	Equipment Development, In-House pre-ESTCP Demonstration (estimated)	$150
	Capital Equipment Purchases (MBE, SBP, SSS, MRU, RTK GPS, USBL, MGA, survey vessel, tow winch, acquisition/processing software, etc.)	$1,200
	Lifetime estimate for electronic equipment	3-5 years
	Lifetime estimate for survey vessel	5+ years
	Lifetime estimate for electronic equipment	3-5 years
Mobilization and Demobilization	Cost to mobilize and demobilize equipment and personnel to/from site, as well as costs to setup instrumentation and prepare and install/remove the IVS. Derived from actual demonstration costs	$95
Site Preparation	Establishment of Survey Control. Note IVS installation costs are included with mob/demob costs.	N/A – Provided by USACE
Field Survey Costs	Hectares surveyed – Derived from actual MBS/SSS/SBP/MGA area surveyed	MBE = 738 hectare SSS = 814 hectare SBP=N/A, 2-D profile MGA = 148 hectare
	Cost per hectare – Derived from actual demonstration field survey costs and includes workplan preparation, mobilization/demobilization, data processing, and reporting costs	MBE = $0.8/hectare SSS = $0.9/hectare SBP=N/A, 2-D profile MGA = $2.1/hectare MBE/SSS/SBP/MGA = $2.5/hectare
	Hours per hectare – Derived from actual demonstration production rates	MBE = 0.02 hrs per hectare SSS = 0.02 hrs per hectare MGA = 0.27 hrs per hectare SBP=N/A, 2-D profile MBE/SSS/SBP/MGA = 0.31 hrs per hectare

Table 8-1. Summary of Cost Tracking Elements (continued)

Cost Element	Data Tracked	Demonstration Costs ($k) and Other Details
Field Survey Costs (cont'd)	Personnel required	MBE = 2 hydrographers plus vessel captain SSS/SBP = 2 geoscientist plus vessel captain MGA = 2 geoscientist plus vessel captain
Detection and Discrimination Data Processing and Reporting Costs	Total Processing and Reporting Cost – Derived from actual demonstration processing and reporting costs to date. Cost per hectare as function of anomaly density	$33
	Processing Time required	120 hours
	Personnel required	Experienced (1) midlevel hydrographer and/or geophysicist to edit MBE/SSS/SBP/MGA data. Senior level (1) hydrographer and/or geophysicist MBE/SSS/SBP/MGA to review processing results, final data and anomalies. Principal/Senior level hydrographer and/or geophysicist with programming experience to develop custom scripts.

8.1.1 Instrumentation cost

Instrumentation costs for this demonstration include equipment development costs which were invested prior to funding being provided by ESTCP. These costs are estimated and include capital costs, including TtEC labor costs, for development and field testing of the MGA. These costs do not include Marine Magnetic's costs to modify their commercially available SeaQuest that was adapted to create the custom designed MGA which was used for the demonstration. The capital cost of the demonstrated software, sonar, positioning, and geophysical systems and 34-foot research vessel are approximately $1.2 million.

8.1.2 Mobilization/demobilization cost

These costs are based on actual demonstration costs and include mobilization and demobilization of equipment and personnel from their point of origin (primarily Seattle, Washington) to/from the project site on Martha's Vineyard. This category also summaries costs associated with the setup and preparation of instrumentation, including initial onsite RTK GPS QA/QC, and support of the USACE diving contractor to install and remove the IVS at Martha's Vineyard.

8.1.3 Site Preparation Cost

No costs were incurred under this category because the USACE established the survey control points which were used as control for the RTK GPS base station and QC of the RTK GPS rover.

8.1.4 Field Survey Cost

The costs and production rates associated with MBE, SSS, SBP, and MGA assessment methods are summarized by total hectares surveyed, cost per hectare, and hours required to survey a single (1) hectare. Each cost and production rate is summarized by assessment system (i.e., MBE, SSS, SBP, and MGA). Cost per hectare are based actual total costs incurred during the duration of the field survey which includes daily IVS survey costs, survey production time costs, vessel maintenance costs, weather downtime cost and onsite preliminary data processing costs. Hours per hectare are calculated using only hours in which MBE, SSS, SBP and MBE data was acquired at the South Beach site.

8.1.5 Detection and Discrimination Data Processing Costs

A summary of data processing methods and data products are described in detail in Sections 5.0 and 6.0. These costs are based on actual processing and reporting costs.

8.1.6 Ground Truthing Cost

A full marine wide area assessment should also include sampling to support and verify sediment type classification and diver or remotely operated vehicle (ROV) sampling of selected sensor targets. The cost of these operations will vary significantly with the site and specific methodology employed.

Bottom type classification may be performed with some combination of sediment sampling (e.g. Van Veen, box corer, petite ponar, power grab, vibracorer, etc.), visual inspection by drop camera or ROV, or the use of data from other sources. In the case of this survey, sampling for seabed classification was not included in the scope of work, so no actual costs can be provided.

The cost of diving operations can vary widely depending on water depth, with greater depths requiring both more time to get the diver to the target and much less available bottom time due to nitrogen intake. Dive operations in support of WAAS ground truthing at Martha's Vineyard were conducted and paid for by the USACE. Actual costs for these operations were not provided to Tetra Tech.

8.2 COST DRIVERS

Cost drivers for underwater munitions assessment performed with the systems and methods described in this report are highly site-specific. This site and project specific items and conditions may include, but are not limited to, the following:

- Access to the work area (nearby boat ramps or marinas, cranes and slings, etc.).
- Distance required to transit from marina or daily launch site to project area on a daily basis.
- Weather and time of year at which WAA will be conducted.
- Water conditions including tidal range, currents, flow rates (rivers) and sea state.
- Range of water depths within survey area.
- Bottom conditions such as rocks, coral, vegetation, and man-made features (intake structures, dams, piers, piling, etc.).
- The presence of endangered or threatened species.
- Satellite coverage for navigation.
- Size and type of vessel required (sea-going vessel vs. small boat).
- Pre-configured vessel mobilization/demobilization or vessel of opportunity charter and mobilization/demobilization.
- Size, quantity, and anticipated distribution and data quality objects of munitions.

While the technology is adaptable and applicable at most project sites, site conditions may make the technology more or less expensive for application at some sites. Sites that have a wide range of water depths will require that the systems be re-configured during the survey operations to allow data collection in very shallow water, as well as deeper water areas. Sites with many hazardous bottom features such as rocks or man-made piers and pilings will be less accessible for survey and pose a greater hazard to the equipment, vessel, and personnel. As a result, survey operations at these sites may be slower and less fluid than at other sites.

8.3 COST BENEFIT

The systems and methods demonstrated combined multiples types of sonar and magnetometer technologies which simultaneously acquired geophysical data along a common survey transect. This method consolidates mobilization/demobilization efforts and survey teams and reduces the total number of survey passes necessary to acquired common datasets, resulting in a reduction in overall cost. Since cost is always an important consideration and factor in the design and execution of a MEC WAA, this provides a substantial benefit to projects.

When compared to other similar MEC survey approaches and technologies, the demonstrated production rates, as presented in Table 8-1, exceeded terrestrial man-portable carts, vehicle-towed array, and marine-towed array production rates. These production rates were provided at a cost substantially less per hectare than these types of terrestrial and marine survey methods. The per hectare cost and production rates for the sonar systems were similar to those achieved by helicopter array survey methods. The MGA acquires data with a detection sensitivity that exceeds helicopter arrays (isolated BDU-33 or 2.75-inch warheads were the expected lower detection limit for the airborne MTADs system). Analysis of seed items (105mm, 81mm and 60mm) showed 100 percent detection of 105mm items, 85 percent of 81mm items and 66 percent of 60mm items (MacDonald et al. 2005) and is near, as determined by IVS (see Table 5-6), the vehicle-towed arrays. (The MGA did detect a single full 20mm round repeatedly in the IVS as well as the 40mm. The TtEC vehicle-towed array can detect 20mm rounds to 6-inch depths reliably, and other systems even deeper as the sensors are placed closer to the ground surface). Terrestrial MEC systems can collect up to four hectares a day at a cost of $5,000 to $7,400 per acre. Further data that is comparable to aerial LiDAR, black-and-white aerial photogrammetry, and seismic reflection data, were also provided within the per-hectare price for the WAA.

9.0 IMPLEMENTATION ISSUES

There were few implementation issues for the demonstration. Since the mapping and imagery work is non-intrusive there was no disturbance of habitat.

One of the most difficult activities for the demonstration was installation of an IVS. While TtEC has developed several methods for placing seed items in the IVS and for maintaining their installed position, currents, tides, and even curious boaters make it difficult to install and maintain an IVS throughout the life of a project. Better methods for anchoring the IVS seeds and markers will need to be developed, or the IVS process will need to be replaced with other QC procedures such as re-mapping of transects or grids to demonstrate system performance. Other specific types of implementation issues are discussed in the following paragraphs.

9.1 REGULATIONS AND PERMITS

In the state of Massachusetts, any marine geophysical data collection requires a permit from the Massachusetts Board of Underwater Archaeological Resources. The special use permit for the Remedial Investigation/Feasibility Study at various locations at Martha's Vineyard (Chilmark, Edgartown, and West Tisbury), Massachusetts was issued as Special Use Permit No. 10-003 for the RIFS and this demonstration. No other permits were required.

9.2 END USER CONCERNS

End user concerns are primarily related to the survey technology and methods. Underwater surveys for munitions are relatively new and end users are awaiting definitive proof that the new technologies and methods are effective. The South Beach demonstration provided dependable evidence that the types of systems used and the data collected are reliable and provide consistent useful data for remedial planning at underwater munitions sites. The ability of the various systems to detect and accurately position targets and features of interest was verified by the IVS survey. In addition, data from various surveys collectively supported the conclusions drawn from individual surveys. Sand dunes and shoals observed in the MBE data were also noted in the SSS and SBP data. Each survey supported and strengthened the findings of the other surveys. Finally, the QC checks and calibrations performed during the demonstration clearly showed that the systems were reliable and accurate. Points on cross lines correlated well with corresponding points on the survey transects and data from re-mapped lines compared favorably with the original data.

9.3 CURRENT AVAILABILITY OF THE TECHNOLOGY

All the systems proposed used in the demonstration are off-the-shelf commercial products or were crafted by making modifications to commercial products to make them better suited and/or more cost efficient for the task of finding underwater munitions. System integration and software development are ongoing; however, the systems employed for the demonstration have now been used at multiple project sites for assessment of underwater munitions and are at a relatively mature state at the present time.

9.4 SPECIALIZED SKILLS AND TRAINING

The general mechanics of system deployment and operation do not require a high level of training. System tracking and data collection require education in the technical principles of each system and real-time experience with system set-up and operation in order to acquire good quality data. Education, training, and experience are also necessary for data processing and interpretation, particularly for the MGA data. Manual interpretation of this type of data is art as well as science—qualitative as well as quantitative. The size and shape of anomalies, and the relationship of those criteria to known criteria for munitions of interest, play as big a part in the selection of targets as does the nT readings recorded by the magnetometers.

10.0 REFERENCES

IHO (International Hydrographic Organization). 1998. International Hydrographic Organization Special Publication No. 44, 4th Edition.

McDonald, J.R., D. Wright, N. Khadr, and H.H. Nelson. 2005. Airborne MTADs Demonstration at Aberdeen Proving Ground. NRL Report NRL/MR/6110--05-8855. January 12, 2005.

TtEC (Tetra Tech EC, Inc.). 2010. Final Work Plan, Wide Area Assessment (WAA) for Marine Munitions and Explosives of Concern. Version 3. ESTCP Project MM-2000808. February 4.

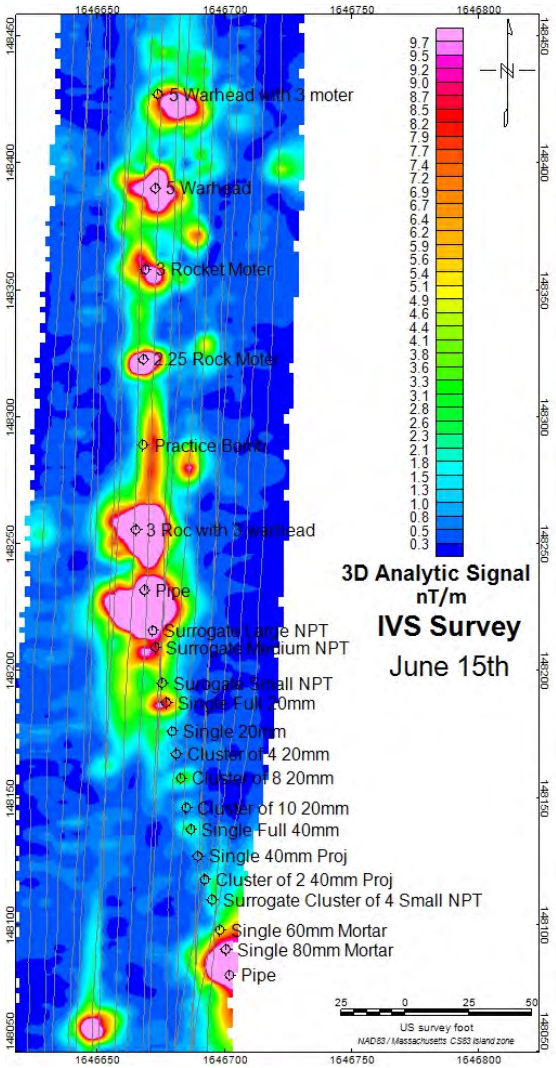
USACE (U.S. Army Corps of Engineers). 2002. Hydrographic Surveying Engineering Manual (EM 1110-2-1003 and appendices)

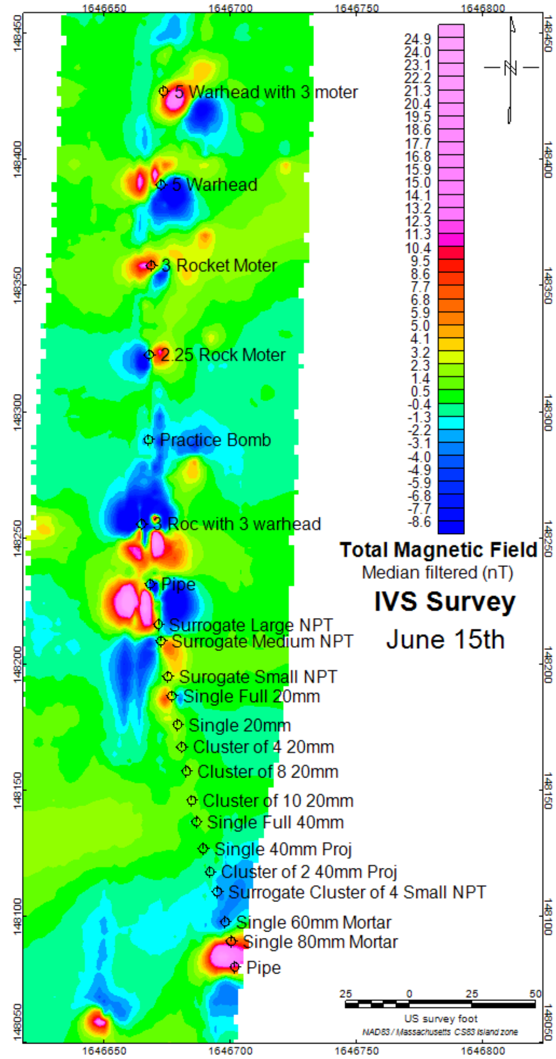
11.0 POINTS OF CONTACT

Table 11-1. Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Richard L. Funk	Tetra Tech EC, Inc. 19803 N Creek Pkwy Bothell, WA 98011	(425) 482-7629 (425) 482-7652 Richard.Funk@tetratech.com	Principal Investigator
Robert J. Feldpausch	Tetra Tech EC, Inc. 19803 N Creek Pkwy Bothell, WA 98011	(425) 482-7629 (425) 482-7862 Robert.Feldpausch@tetratech.com	Co-Principal Investigator
Burton Bridge	Tetra Tech EC, Inc. 19803 N Creek Pkwy Bothell, WA 98011	(425) 482-7859 (425) 482-7652 Burr.Bridge@tetratech.com	Co-Principal Investigator

Appendix A
Daily IVS Surveys


5 Warhead with 3 moter
5 Warhead
3 Rocket Moter
2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
Surrogate Large NPT
Surrogate Medium NPT
Surrogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
3D Analytic Signal
nT/m
IVS Survey
June 15th
US survey foot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2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
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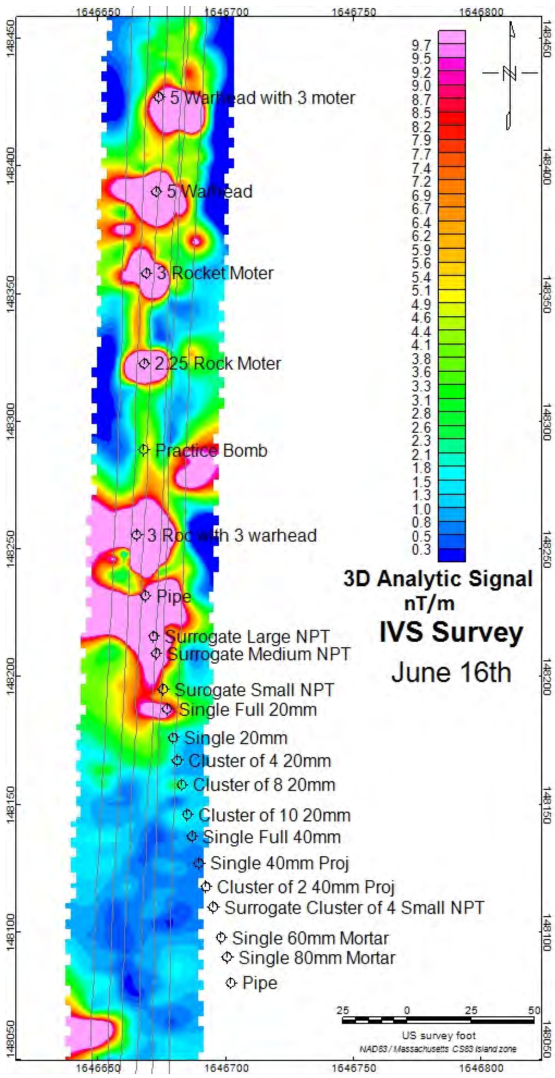
Surrogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
Total Magnetic Field
Median filtered (nT)
IVS Survey
June 15th
US survey foot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1646750
1646800
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148400
148350
148300
148250
148200
148150
148100
148050
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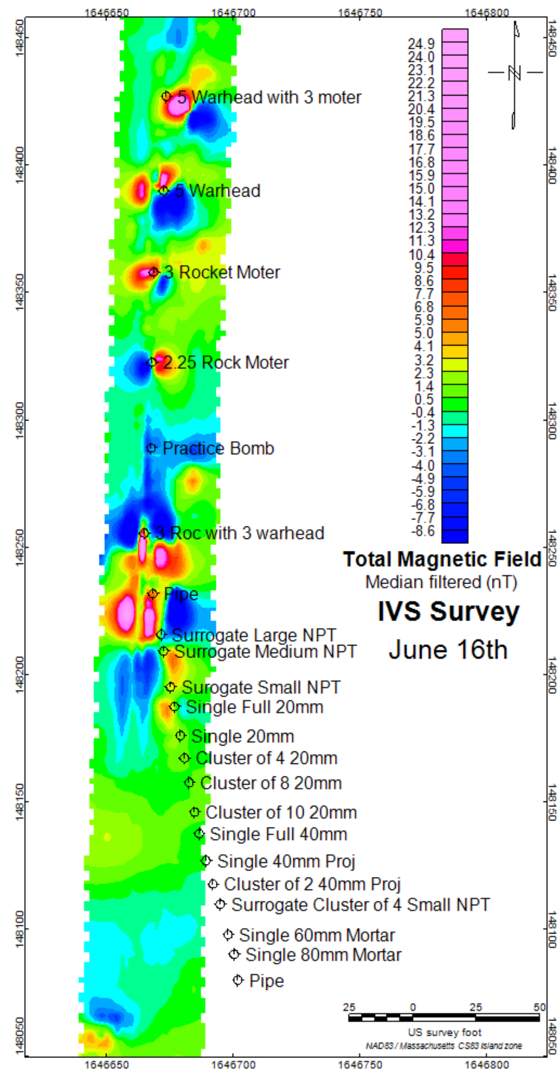
5 Warhead
3 Rocket Moter
2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
Surrogate Large NPT
Surrogate Medium NPT
Surogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
9.7
9.5
9.2
9.0
8.7
8.5
8.2
7.9
7.7
7.4
7.2
6.9
6.7
6.4
6.2
5.9
5.6
5.4
5.1
4.9
4.6
4.4
4.1
3.8
3.6
3.3
3.1
2.8
2.6
2.3
2.1
1.8
1.5
1.3
1.0
0.8
0.5
0.3
3D Analytic Signal
nT/m
IVS Survey
June 16th
25
0
25
50
US survey foot
NAD83 / Massachusetts CS83 island zone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5 Warhead
3 Rocket Moter
2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
Surrogate Large NPT
Surrogate Medium NPT
Surogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
24.9
24.0
23.1
22.2
21.3
20.4
19.5
18.6
17.7
16.8
15.9
15.0
14.1
13.2
12.3
11.3
10.4
9.5
8.6
7.7
6.8
5.9
5.0
4.1
3.2
2.3
1.4
0.5
-0.4
-1.3
-2.2
-3.1
-4.0
-4.9
-5.9
-6.8
-7.7
-8.6
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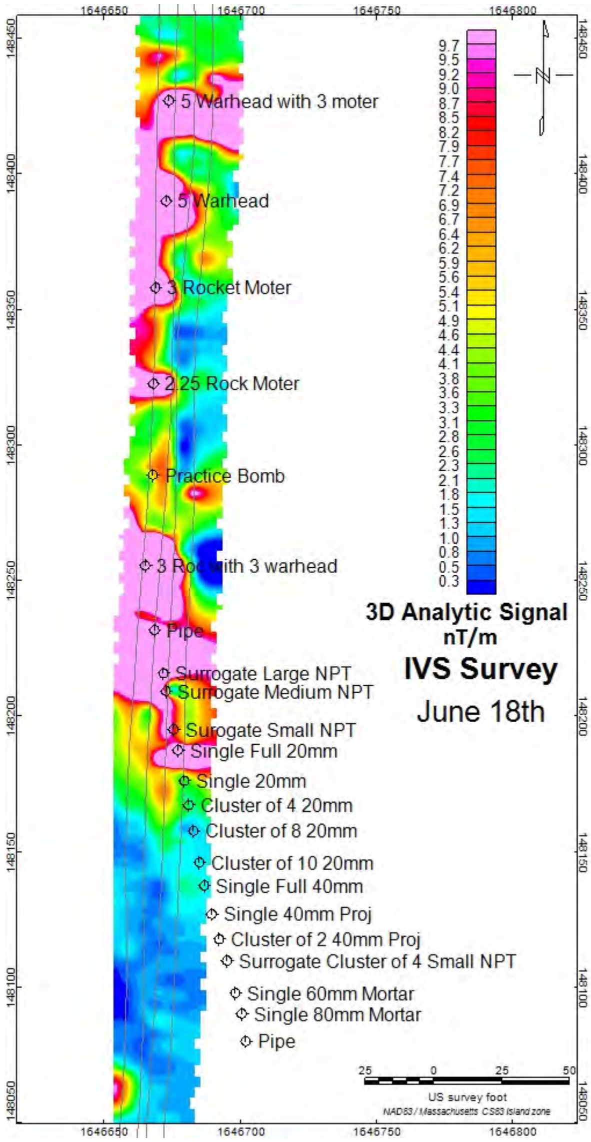
Median filtered (nT)
IVS Survey
June 16th
25
0
25
50
US survey foot
NAD83 / Massachusetts CS83 island zone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nT/m
IVS Survey
June 18th
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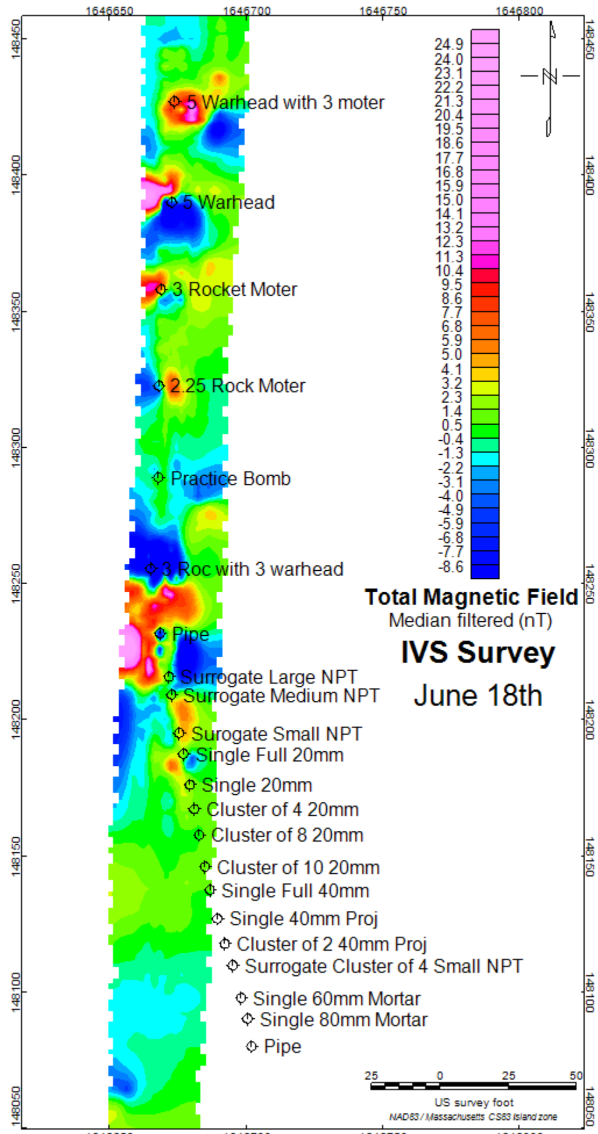
2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
Surrogate Large NPT
Surrogate Medium NPT
Surogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
US survey foot
NAD83 / Massachusetts CS83 island zone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Median filtered (nT)
IVS Survey
June 18th
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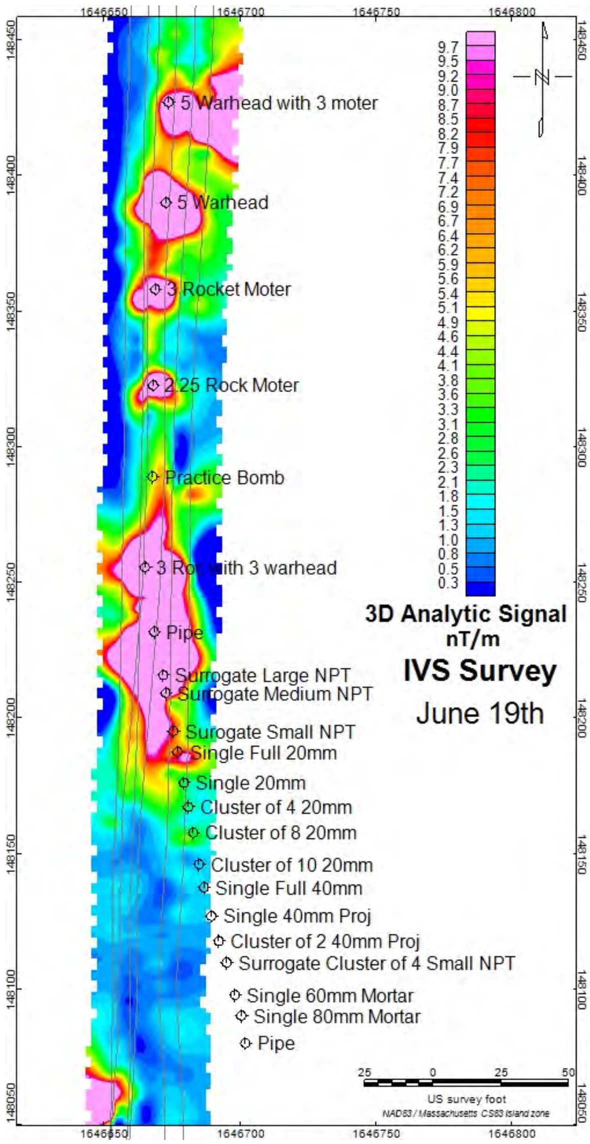
5 Warhead
3 Rocket Moter
2.25 Rock Moter
Practice Bomb
3 Roc with 3 warhead
Pipe
Surrogate Large NPT
Surrogate Medium NPT
Surogate Small NPT
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
US survey foot
NAD83 / Massachusetts CS83 island zone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Practice Bomb
3 Roc with 3 warhead
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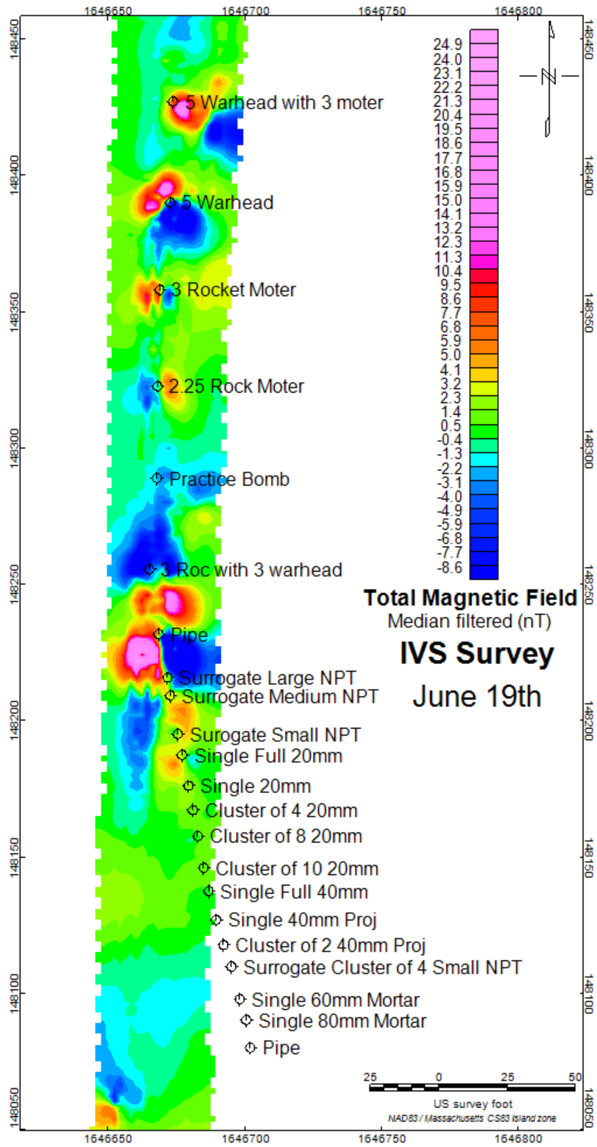
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
3D Analytic Signal
nT/m
IVS Survey
June 19th
US survey foot
NAD83 / Massachusetts CS83 Island zone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Practice Bomb
3 Roc with 3 warhead
Pipe
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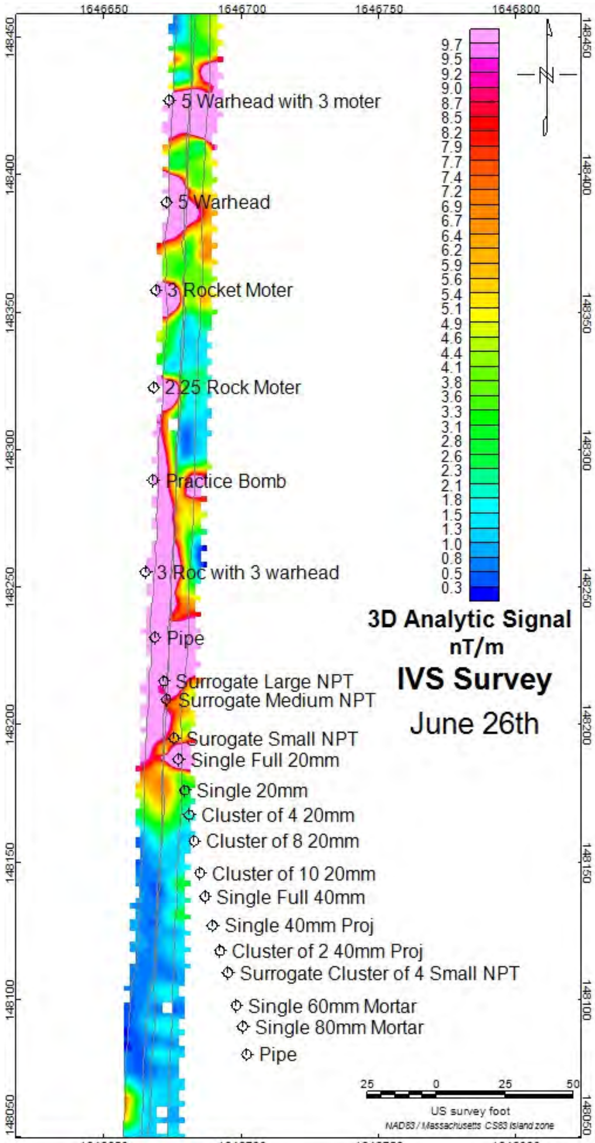
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
Total Magnetic Field
Median filtered (nT)
IVS Survey
June 19th
US survey foot
NAD83 / Massachusetts CS83 Island zone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Practice Bomb
3 Roc with 3 warhead
Pipe
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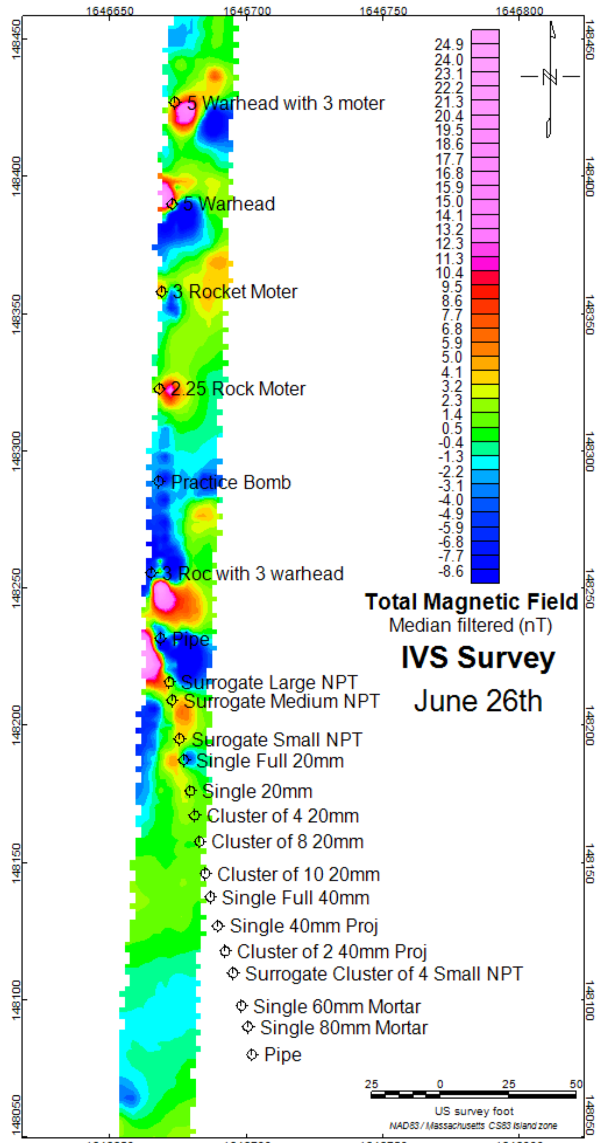
Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
3D Analytic Signal
nT/m
IVS Survey
June 26th
US survey foot
NAD83 / Massachusetts CS83 island zone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Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
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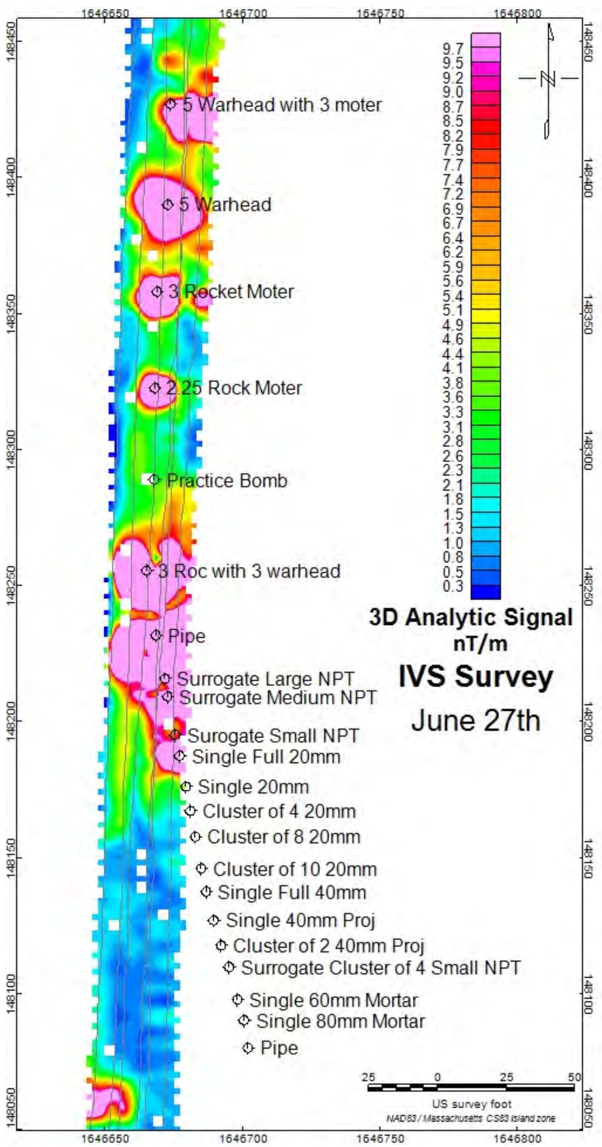
Pipe
Total Magnetic Field
Median filtered (nT)
IVS Survey
June 26th
US survey foot
NAD83 / Massachusetts CS83 island zone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Single Full 20mm
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Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
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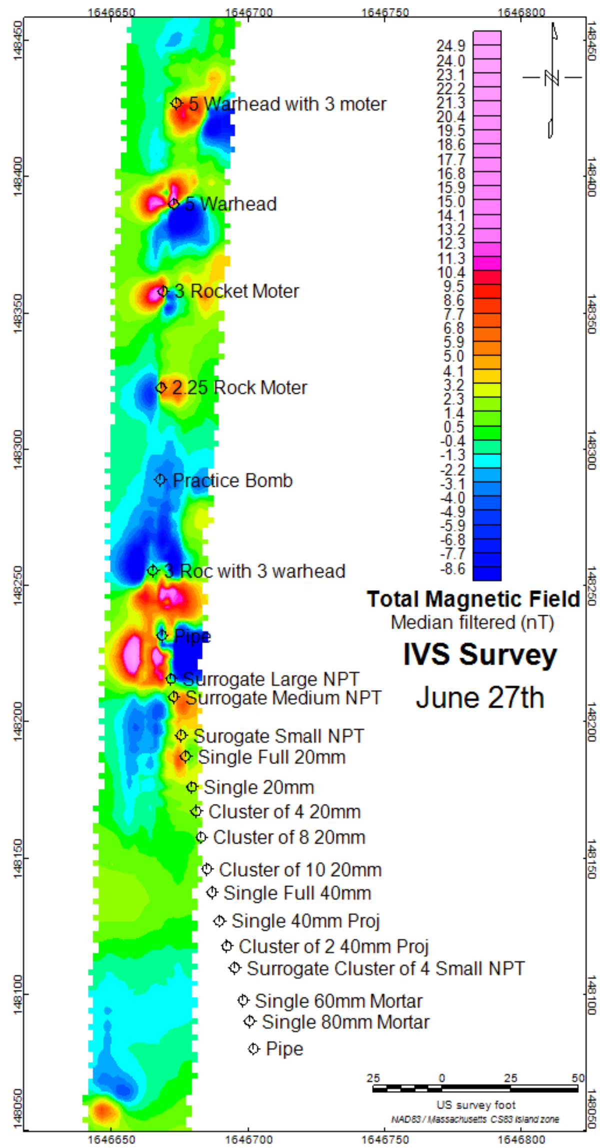
3D Analytic Signal
nT/m
IVS Survey
June 27th
US survey foot
NAD83 / Massachusetts CS83 island zone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Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
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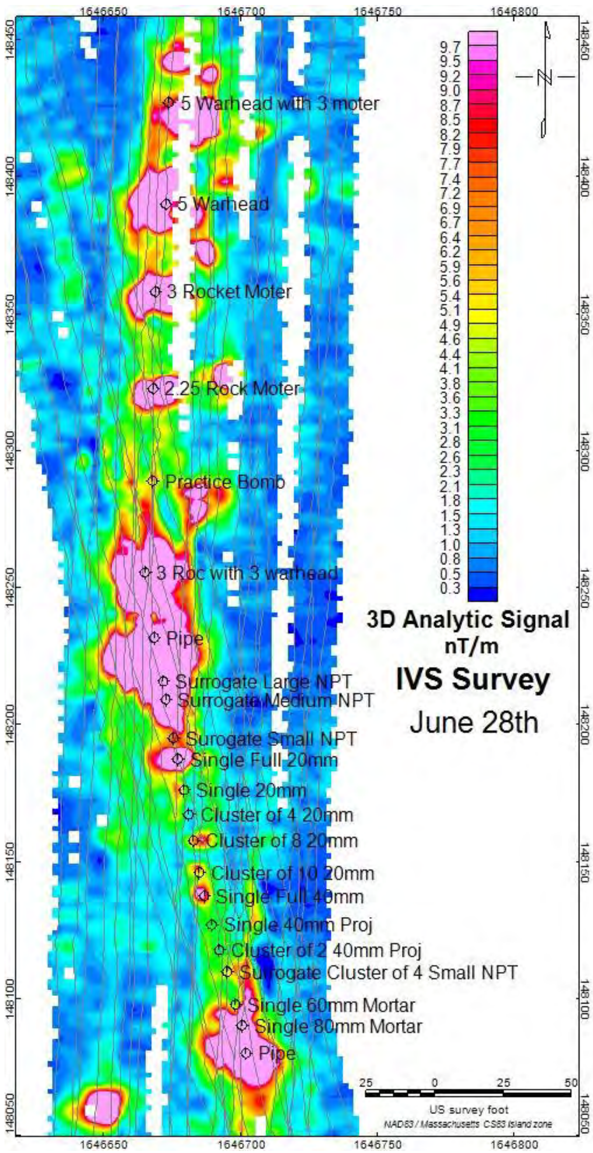
Total Magnetic Field
Median filtered (nT)
IVS Survey
June 27th
US survey foot
NAD83 / Massachusetts CS83 island zone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Practice Bomb
3 Roc with 3 warhead
Pipe
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Single Full 20mm
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Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
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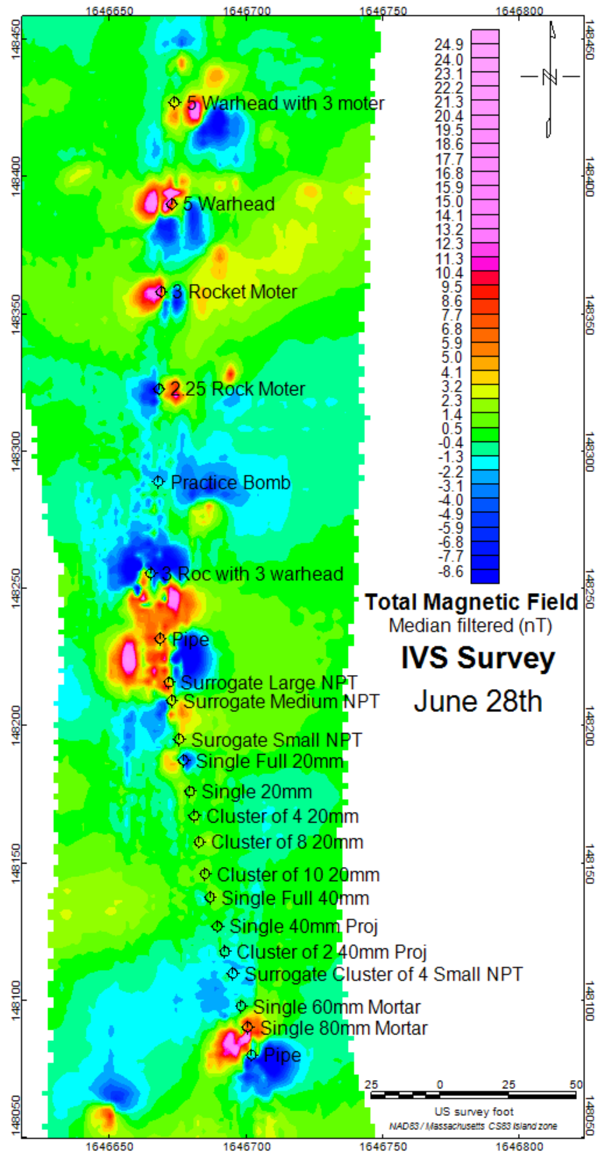
Single 60mm Mortar
Single 80mm Mortar
Pipe
9.7 9.5 9.2 9.0 8.7 8.5 8.2 7.9 7.7 7.4 7.2 6.9 6.7 6.4 6.2 5.9 5.6 5.4 5.1 4.9 4.6 4.4 4.1 3.8 3.6 3.3 3.1 2.8 2.6 2.3 2.1 1.8 1.5 1.3 1.0 0.8 0.5 0.3
3D Analytic Signal
nT/m
IVS Survey
June 28th
US survey foot
NAD83 / Massachusetts CS83 island zone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Single Full 20mm
Single 20mm
Cluster of 4 20mm
Cluster of 8 20mm
Cluster of 10 20mm
Single Full 40mm
Single 40mm Proj
Cluster of 2 40mm Proj
Surrogate Cluster of 4 Small NPT
Single 60mm Mortar
Single 80mm Mortar
Pipe
24.9 24.0 23.1 22.2 21.3 20.4 19.5 18.6 17.7 16.8 15.9 15.0 14.1 13.2 12.3 11.3 10.4 9.5 8.6 7.7 6.8 5.9 5.0 4.1 3.2 2.3 1.4 0.5 -0.4 -1.3 -2.2 -3.1 -4.0 -4.9 -5.9 -6.8 -7.7 -8.6
Total Magnetic Field
Median filtered (nT)
IVS Survey
June 28th
US survey foot
NAD83 / Massachusetts CS83 island zone

Appendix B
Survey Charts

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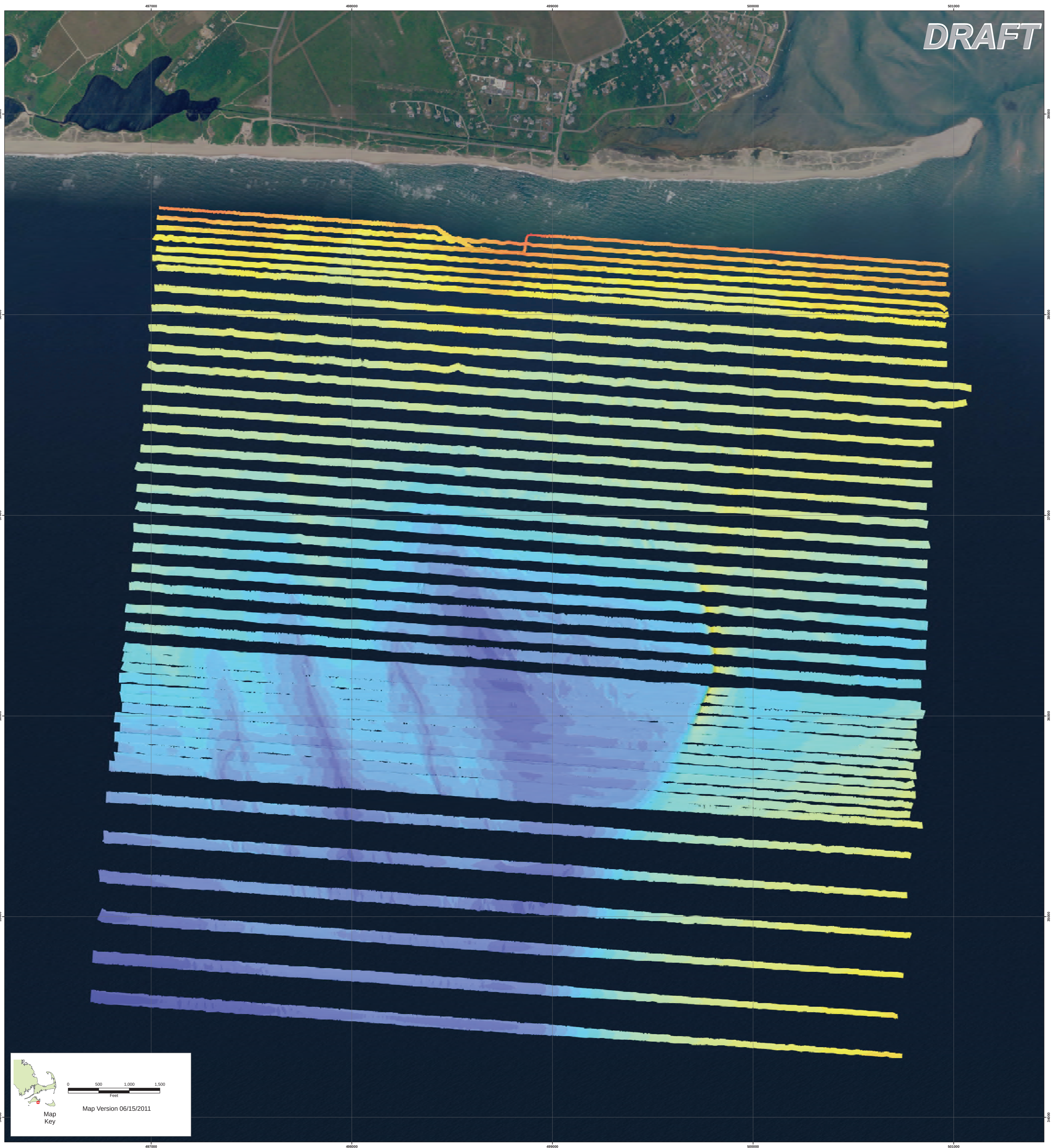

Notes:

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2. 2010 data processing software Caris v7.0 sp2 hf3
3. 2010 data gridded at 1/2 foot resolution
4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
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Legend

Elevation (US Survey Foot, NAVD88)

-13.9 - -12	-31.9 - -30	-49.9 - -48
-15.9 - -14	-33.9 - -32	-51.9 - -50
-17.9 - -16	-35.9 - -34	-53.9 - -52
-19.9 - -18	-37.9 - -36	-55.9 - -54
-21.9 - -20	-39.9 - -38	-57.9 - -56
-23.9 - -22	-41.9 - -40	-59.9 - -58
-25.9 - -24	-43.9 - -42	-61.9 - -60
-27.9 - -26	-45.9 - -44	-62.9 - -62
-29.9 - -28	-47.9 - -46	

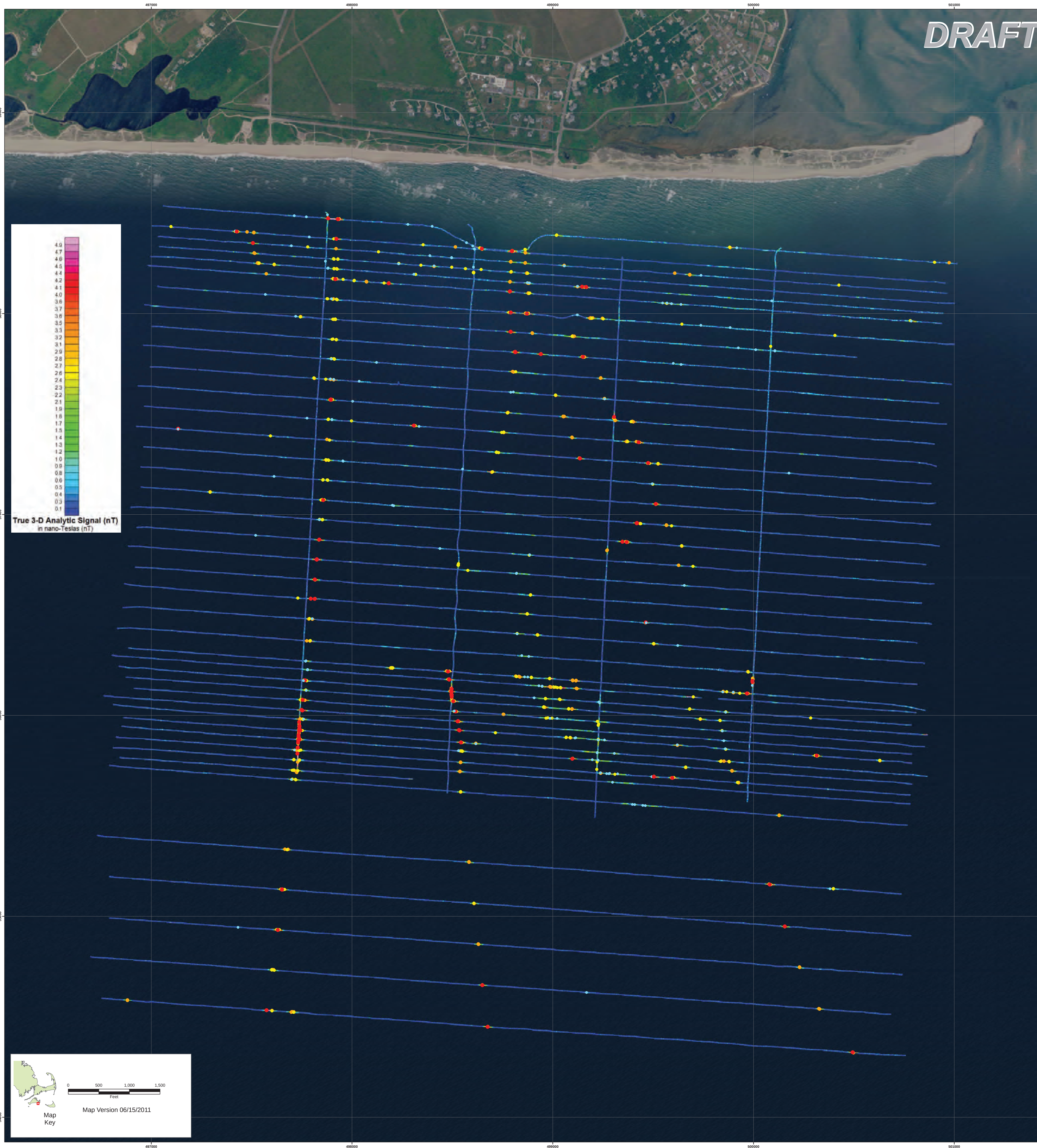
Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Mutilbeam Sonar	Reson 7125 SV
Projection	Lambert Conformal Conic	Primary Position, Motion & Heading Sensor	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	Secondary Position Sensor	Leica 1200
Horizontal Units	US Survey Feet	Sound Speed Profilers	Seabird 37, Seabird 19
Vertical Units	US Survey Feet		
Vertical Datum	NAVD-88		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 7-27, 2010

Martha's Vineyard
2010 Multibeam

Martha's Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
Bothell, WA 98011
1(425) 482 7600

Survey Technicians:	R. Cross, B. Schwartz	Plate 1
Drafted by:	W. Watson	
Checked by:	B. Bridge	Sheet: 1 of 6
Reviewed by:	R. Funk	



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4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
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Magnetometer Target

Analytic Signal

- 3.1 - 5.0
- 5.1 - 10.0
- 10.1 - 25.0
- 25.1 - 40.0

Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Gradiometer	Tetra Tech/Marine Magnetics MGA
Projection	Lambert Conformal Conic	Vessel Positioning	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	MGA Positioning	IXSEA GAPS USBL
Horizontal Units	US Survey Feet		
Vertical Units	US Survey Feet		
Vertical Datum	NAVD-88		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 11-27, 2010

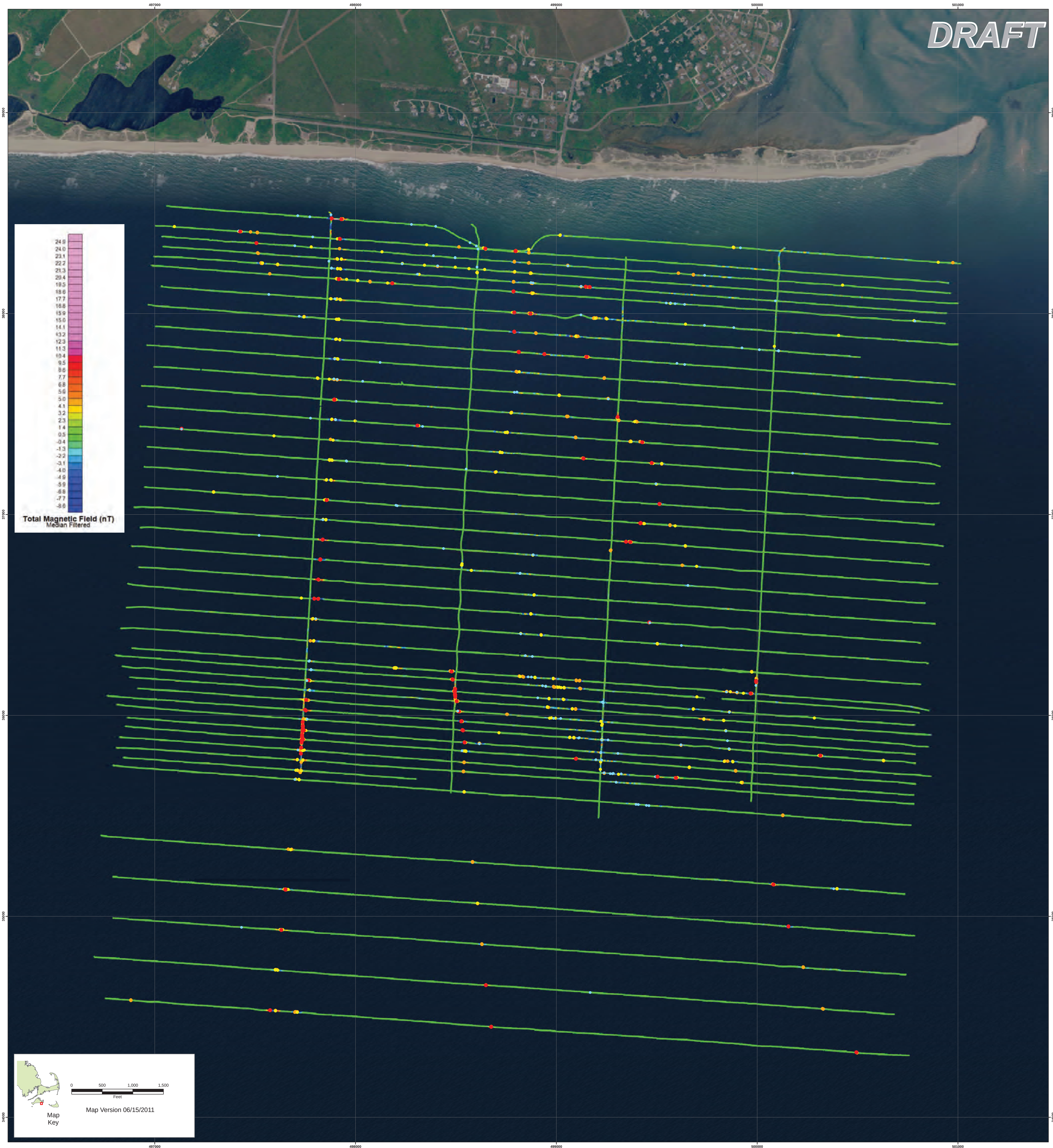
Martha's Vineyard
2010 Analytic Signal Magnetometer

Martha's Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
Bothell, WA 98011
1(425) 482 7600

Survey Technicians:	R. Cross, B. Schwartz	Plate
Drafted by:	W. Watson	1
Checked by:	B. Bridge	Sheet:
Reviewed by:	R. Funk	2 of 6

\\ecimmgfile\project\Marthas_Vineyard_2010\ArcGIS\Marthas_Vineyard\maps\Magnetometer2010_Charting\MarthasVineyard_2010Magnetometer_ver5.mxd Date: 08/05/2011



Notes:

1. 2010 data collection software Hypack 2010 sp1
2. 2010 data processing software Oasis Montaj V7.2.1
3. 2010 data gridded at 2 foot resolution
4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
   WAT1932, LAT = +41 22 41.60758, LONG = -70 31 9.06091, ELEV HGT = -9.649(m), ORTHO HGT = 19.136(m)

Magnetometer Target

Analytic Signal

- 3.1 - 5.0
- 5.1 - 10.0
- 10.1 - 25.0
- 25.1 - 40.0

Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Gradiometer	Tetra Tech/Marine Magnetics MGA
Projection	Lambert Conformal Conic	Vessel Positioning	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	MGA Positioning	IXSEA GAPS USBL
Horizontal Units	US Survey Feet		
Vertical Units	US Survey Feet		
Vertical Datum	NAVD-88		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 11-27, 2010

Martha's Vineyard
2010 Analytic Signal Magnetometer

Martha's Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
Bothell, WA 98011
1(425) 482 7600

Survey Technicians:	R. Cross, B. Schwartz	Plate
Drafted by:	W. Watson	1
Checked by:	B. Bridge	Sheet:
Reviewed by:	R. Funk	3 of 6

\\ecmmgfile\project\Marthas_Vineyard_2010\ArcGIS\Marthas_Vineyard\maps\SideScanSonar\2010_Charting\MarthasVineyard_2010SideScan_ver5.mxd   Date: 08/05/2011

Notes:

1. 2010 data collection software Hypack 2010 sp1
2. 2010 data processing software Sonar Wiz V5.01.0023
3. 2010 data gridded at 1 foot resolution
4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
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Legend

Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Sidescan Sonar	EdgeTech 2000-DSS
Projection	Lambert Conformal Conic	Vessel Positioning	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	Sidescan Positioning	IXSEA GAPS USBL
Horizontal Units	US Survey Feet		
Vertical Units	US Survey Feet		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 17-23, 2010

Martha's Vineyard
2010 Sidescan Sonar

Martha's Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
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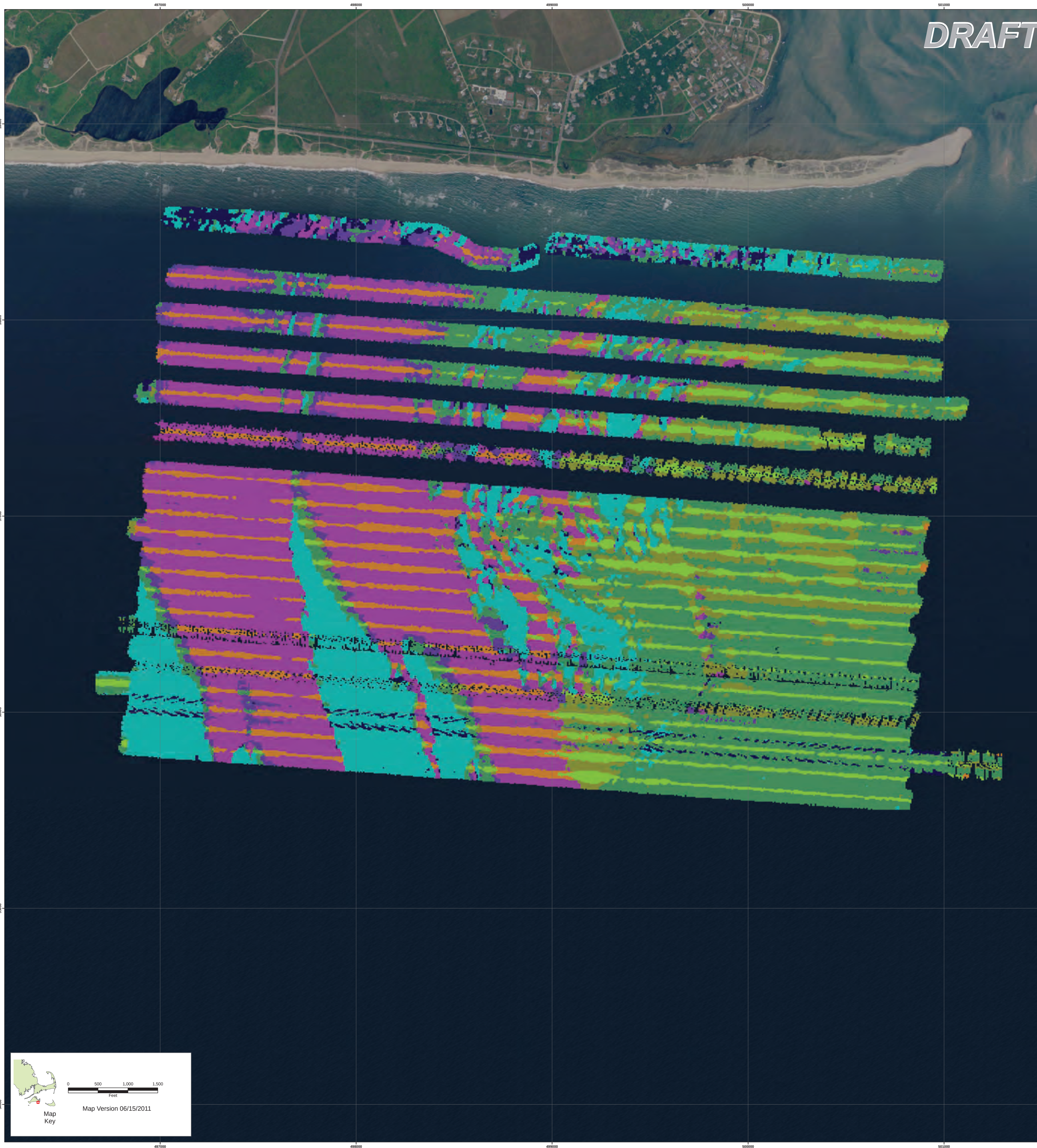
Survey Technicians:	R. Cross, B. Schwartz	Plate
Drafted by:	W. Watson	1
Checked by:	B. Bridge	Sheet:
Reviewed by:	R. Funk	4 of 6

\\ecmmgfile\project\Marthas_Vineyard_2010\ArcGIS\Marthas_Vineyard\Images\SideScanSonar\2010_Charting\MarthasVineyard_2010SideScan_bottom_ver5.mxd Date: 08/05/2011



Notes:

1. 2010 data collection software Hypack 2010 sp1
2. 2010 data processing software Sonar Wiz V5.01.0023
3. 2010 data gridded at 1 foot resolution
4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
   WAT1932, LAT = +41 22 41.60758, LONG = -70 31 9.06091,
   ELEV HGT = -9.649(m), ORTHO HGT = 19.136(m)

Legend

Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Sidescan Sonar	EdgeTech 2000-DSS
Projection	Lambert Conformal Conic	Vessel Positioning	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	Sidescan Positioning	IXSEA GAPS USBL
Horizontal Units	US Survey Feet	Bottom Type Classification Software	Quester Tangent s QTC SWATHVIEW
Vertical Units	US Survey Feet		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 17-23, 2010

Martha s Vineyard 2010 Sidescan Sonar Based Bottom Type Classification

Martha's Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
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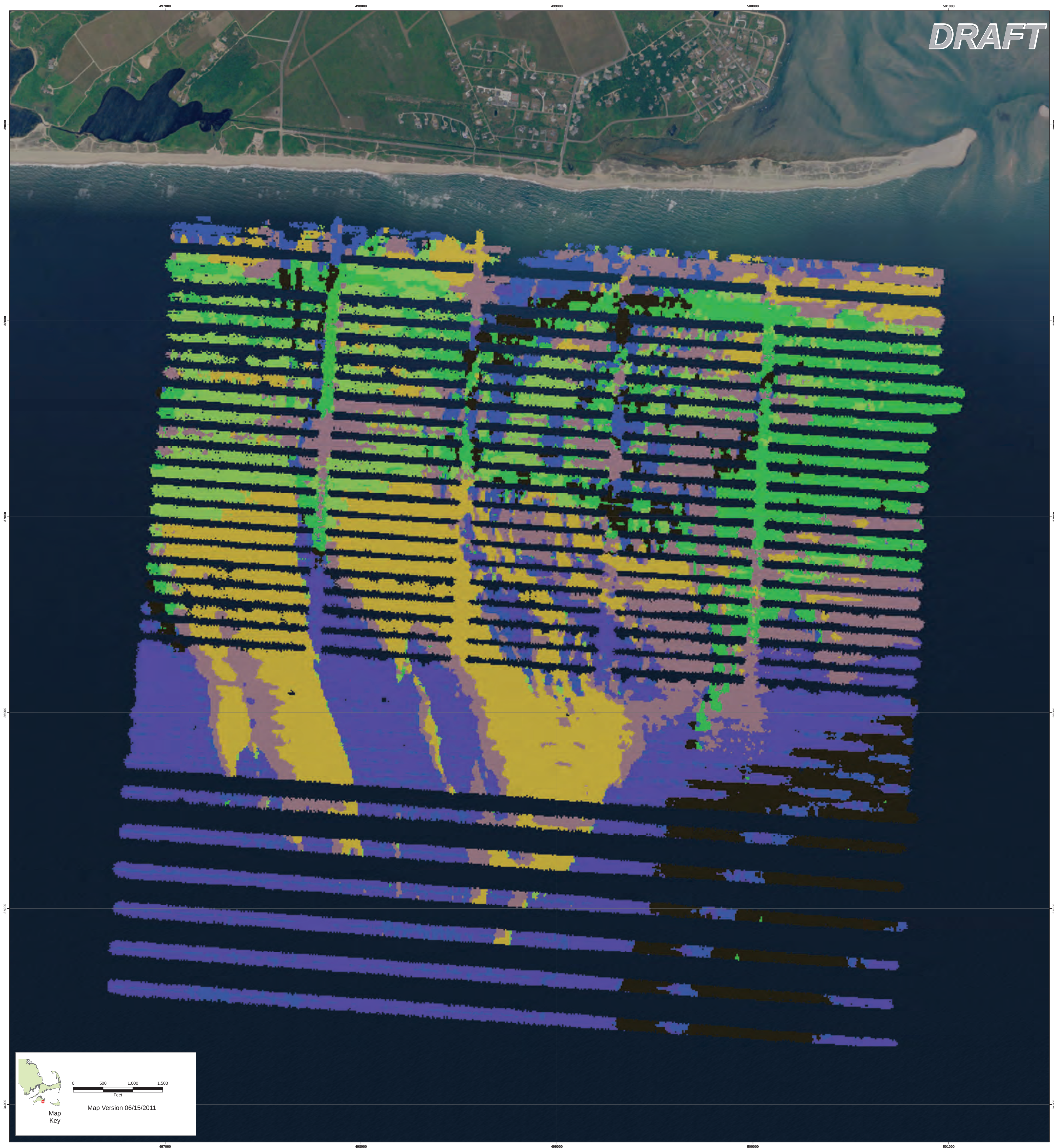
1(425) 482 7600

Survey Technicians:	R. Cross, B. Schwartz	Plate
Drafted by:	W. Watson	1
Checked by:	B. Bridge	Sheet:
Reviewed by:	R. Funk	5 of 6

\\ecimmgfile\project\Marthas_Vineyard_2010\ArcGIS\Marthas_Vineyard\maps\Bathy2010_Charting\MarthasVineyard_2010Bathy_bottom_ver5.mxd Date: 08/05/2011



Notes:

1. 2010 data collection software Hypack 2010 sp1
2. 2010 data processing software Caris v7.0 sp2 hf3
3. 2010 data gridded at 1/2 foot resolution
4. Charting software ArcGIS v9.3
5. Aerial photo - 1999 Satellite Imagery from ESRI Online
6. Control Point:
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   ELEV HGT = -9.649(m), ORTHO HGT = 19.136(m)

Legend

Geodetic Settings		Survey Equipment	
Horizontal Datum	NAD-83/91 with 1998 Adjustment	Mutilbeam Sonar	Reson 7125 SV
Projection	Lambert Conformal Conic	Primary Position, Motion & Heading Sensor	Applanix POS/MV 320
Coordinate System Name	Massachusetts State Plane Island Zone	Secondary Position Sensor	Leica 1200
Horizontal Units	US Survey Feet	Sound Speed Profilers	Seabird 37, Seabird 19
Vertical Units	US Survey Feet	Bottom Type Classification Software	Quester Tangent s QTC SWATHVIEW
Vertical Datum	NAVD-88		
Horizontal/Vertical Control Point	RTK GPS Base Station Point (see bullet #6 in notes)		
Horizontal Control	U.S. Coast and Geodetic Survey	Dates Surveyed	June 7-27, 2010

Martha s Vineyard 2010 Multibeam Snippets Based Bottom Type Classification

Martha’s Vineyard Island, Massachusetts, USA

Tetra Tech EC, Inc.
19803 North Creek Parkway
Bothell, WA 98011
1(425) 482 7600

Survey Technicians:	R. Cross, B. Schwartz	Plate 1
Drafted by:	W. Watson	
Checked by:	B. Bridge	Sheet: 6 of 6
Reviewed by:	R. Funk	

Appendix C
Contact Report

TARGET SELECTION FOR INSPECTION

Anomalies that are potentially MEC were selected by evaluating magnetometer data and corresponding MBE and SSS data. Targets were initially selected using the UXO Detect module in the Oasis Montaj software. Magnetic anomalies having a signature that was 3 nT or more above the background readings were selected. A threshold of 3 nT was based on magnetic anomalies measured in the IVS. A geotiff for the MGA analytic signal data and a dxf file of the MGA target picks was imported into SonarWiz for further investigation. In SonarWiz the sidescan image was examined in full resolution at the location of the magnetic anomaly. A subset image of the sidescan image was extracted at each magnetic anomaly location. At this point the geophysicist carefully reviewed the sidescan data to look for anomalous features that were not detected by the MGA. All anomalies whether magnetic, acoustic or both were denoted as contacts in SonarWiz (Figure 6-9). A color coded system was implemented to denote the characteristics of the contacts (Table 6-1).

Table 6-1. Target Icon Key

Icon	Anomaly Type
Blue Circle	Co-located MGA and SS Anomaly
Pink Circle	Magnetic Anomaly Only
Salmon Circle	Sidescan Anomaly Only
Yellow-Green Cross-Box	Specific linear N-S magnetic anomaly in western survey area believed to be a cable.

SonarWiz is capable of generating a target report based on the selected contacts and includes subset images of the sidescan data in the vicinity of the anomaly. To further augment this report subsets of the gridded MGA data and an along track profile of the magnetic anomaly were included for all contacts where there was a magnetic anomaly. From this target report informed decisions could be made regarding the further investigation of targets. For example magnetic anomalies that lay proud of the bottom (i.e., visible in the sidescan data) could be selected for diver or remotely operated vehicle based investigation. Figure 6-9 shows a color coded contact map in SonarWiz denoting the location of magnetic or acoustic anomalies, and overlays a high resolution mosaic of the high frequency sidescan data. The target report for all phase one lines where quality MGA and sidescan data were available is included below.

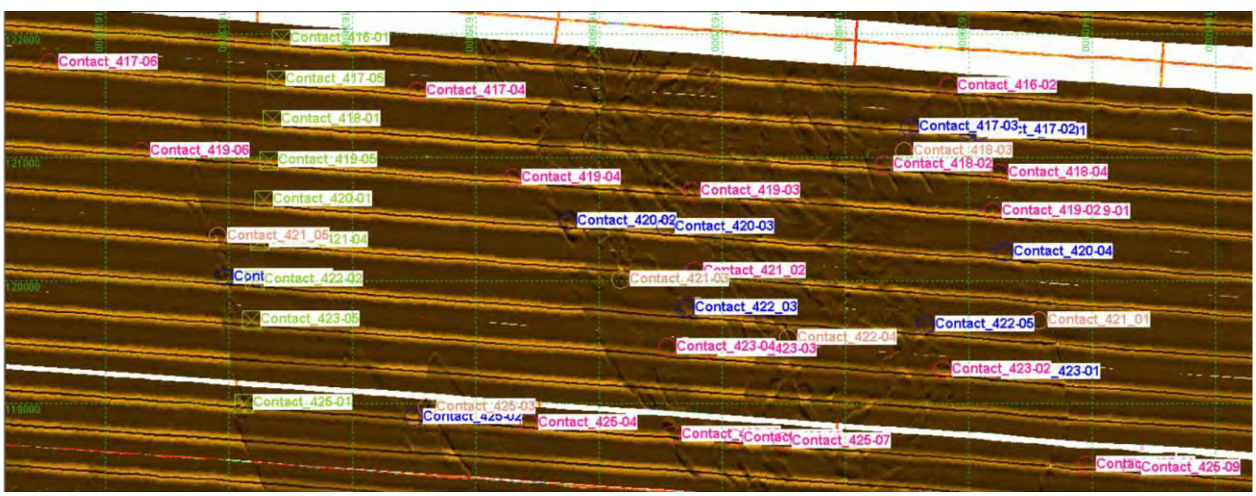


Figure 6-9. Contact Map of Sidescan and Magnetic Anomalies

Appendix C Contact Report

Report file: Contact_Report.doc

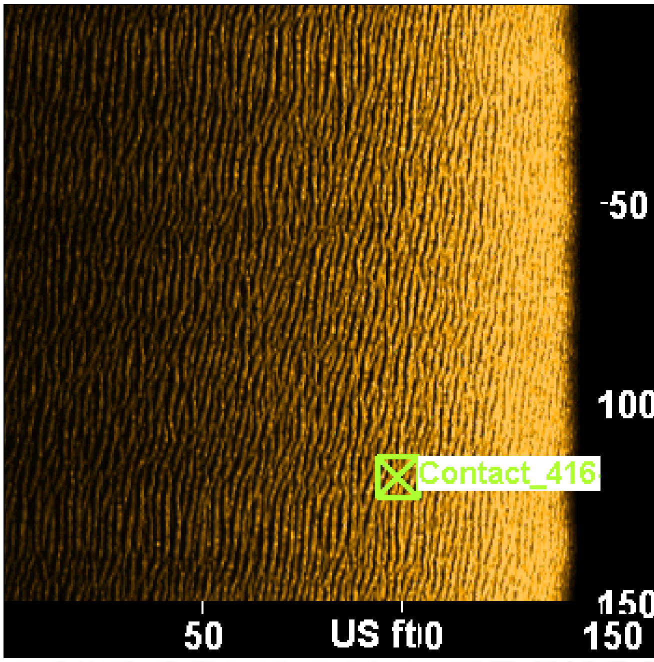
Generated on: 02/02/2011 02:08:48 PM

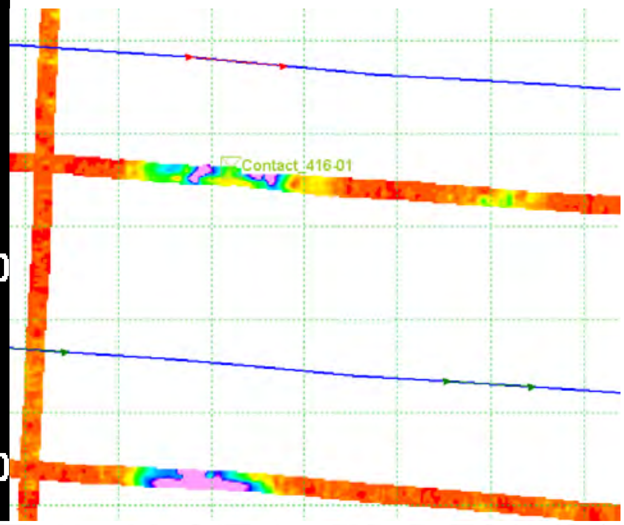
By: targetReportGen2 V3.12.01

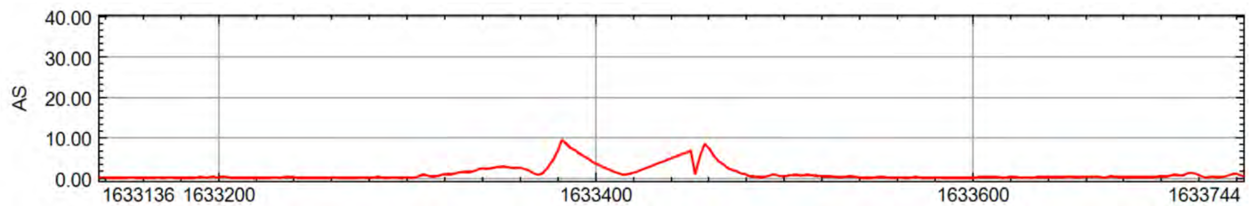
Contacts in this report:

Contact_416-01	05/23/2010 21:38:19	41.3347282410 Lat	-70.5254745483 Lon
Contact_416-02	05/23/2010 21:47:49	41.3336639404 Lat	-70.5057373047 Lon
Contact_417-01	05/23/2010 21:12:43	41.3326377869 Lat	-70.5048599243 Lon
Contact_417-02	05/23/2010 21:12:55	41.3326911926 Lat	-70.5051803589 Lon
Contact_417-03	05/23/2010 21:13:53	41.3327522278 Lat	-70.5068969727 Lon
Contact_417-04	05/23/2010 21:21:54	41.3335609436 Lat	-70.5214614868 Lon
Contact_417-05	05/23/2010 21:24:06	41.3338165283 Lat	-70.5256042480 Lon
Contact_417-06	05/23/2010 21:27:42	41.3341751099 Lat	-70.5323104858 Lon
Contact_418-01	05/23/2010 20:42:58	41.3329315186 Lat	-70.5257339478 Lon
Contact_418-02	05/23/2010 20:51:50	41.3319129944 Lat	-70.5076370239 Lon
Contact_418-03	05/23/2010 20:52:05	41.3322105408 Lat	-70.5070571899 Lon
Contact_418-04	05/23/2010 20:53:24	41.3317451477 Lat	-70.5042572021 Lon
Contact_419-01	05/23/2010 20:17:21	41.3308639526 Lat	-70.5035858154 Lon
Contact_419-02	05/23/2010 20:17:48	41.3308906555 Lat	-70.5044403076 Lon
Contact_419-03	05/23/2010 20:22:19	41.3313331604 Lat	-70.5133209229 Lon
Contact_419-04	05/23/2010 20:24:55	41.3316268921 Lat	-70.5186462402 Lon
Contact_419-05	05/23/2010 20:28:15	41.3320198059 Lat	-70.5258407593 Lon
Contact_419-06	05/23/2010 20:30:03	41.3322105408 Lat	-70.5296020508 Lon
Contact_420-01	05/23/2010 19:48:57	41.3311386108 Lat	-70.5259780884 Lon
Contact_420-02	05/23/2010 19:53:42	41.3306541443 Lat	-70.5169906616 Lon
Contact_420-03	05/23/2010 19:55:09	41.3305282593 Lat	-70.5140914917 Lon
Contact_420-04	05/23/2010 20:00:00	41.3299713135 Lat	-70.5040893555 Lon
Contact_421_01	05/23/2010 19:22:09	41.3284301758 Lat	-70.5030975342 Lon
Contact_421_02	05/23/2010 19:27:56	41.3295555115 Lat	-70.5132598877 Lon
Contact_421-03	05/23/2010 19:29:05	41.3293533325 Lat	-70.5154418945 Lon
Contact_421-04	05/23/2010 19:34:35	41.3302345276 Lat	-70.5260925293 Lon
Contact_421_05	05/23/2010 19:35:14	41.3303298950 Lat	-70.5273361206 Lon
Contact_422-01	05/23/2010 18:50:20	41.3294105530 Lat	-70.5271301270 Lon
Contact_422-02	05/23/2010 18:50:50	41.3293685913 Lat	-70.5262374878 Lon
Contact_422_03	05/23/2010 18:58:14	41.3287124634 Lat	-70.5134963989 Lon
Contact_422-04	05/23/2010 18:59:55	41.3280525208 Lat	-70.5104751587 Lon
Contact_422-05	05/23/2010 19:02:07	41.3283386230 Lat	-70.5064163208 Lon
Contact_423-01	05/23/2010 18:24:02	41.3272781372 Lat	-70.5044784546 Lon
Contact_423-02	05/23/2010 18:24:49	41.3273468018 Lat	-70.5059127808 Lon
Contact_423-03	05/23/2010 18:28:36	41.3277854919 Lat	-70.5128479004 Lon
Contact_423-04	05/23/2010 18:29:16	41.3278312683 Lat	-70.5140380859 Lon
Contact_423-05	05/23/2010 18:35:58	41.3284568787 Lat	-70.5263366699 Lon
Contact_425-01	05/23/2010 17:51:06	41.3266029358 Lat	-70.5265655518 Lon
Contact_425-02	05/23/2010 17:54:18	41.3262786865 Lat	-70.5215377808 Lon
Contact_425-03	05/23/2010 17:54:33	41.3265075684 Lat	-70.5211639404 Lon
Contact_425-04	05/23/2010 17:56:26	41.3261528015 Lat	-70.5181655884 Lon
Contact_425-05	05/23/2010 17:59:06	41.3258972168 Lat	-70.5138854980 Lon
Contact_425-06	05/23/2010 18:00:12	41.3258285522 Lat	-70.5120697021 Lon
Contact_425-07	05/23/2010 18:01:02	41.3257522583 Lat	-70.5106506348 Lon
Contact_425-08	05/23/2010 18:06:24	41.3252334595 Lat	-70.5016708374 Lon
Contact_425-09	05/23/2010 18:07:15	41.3251609802 Lat	-70.5003433228 Lon

Contact_416-01







Contact Info: Contact_416-01

- Sonar Time at Target: 05/23/2010 21:38:19
- Click Position (Lat/Lon Coordinates)
  41.3347282410 -70.5254745483 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633421.38 (Y) 121963.85
- Map Proj:
- Acoustic Source File:

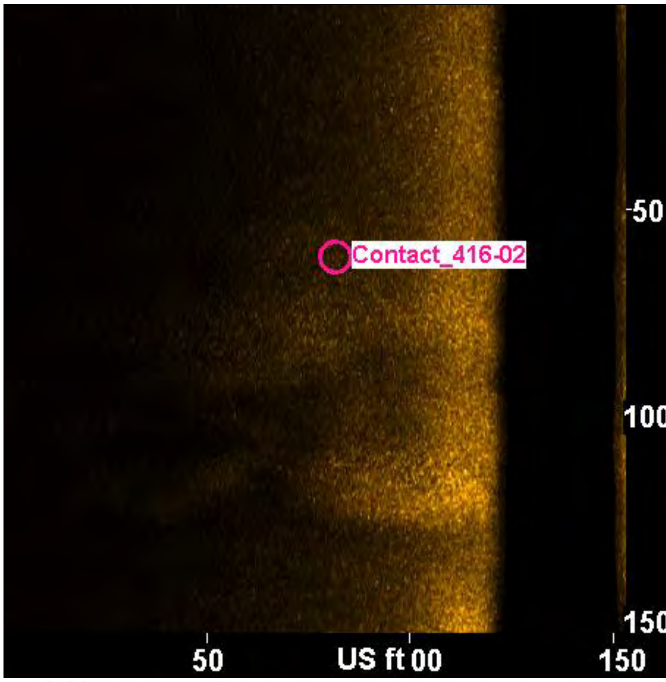
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_416_SS.000.jsf

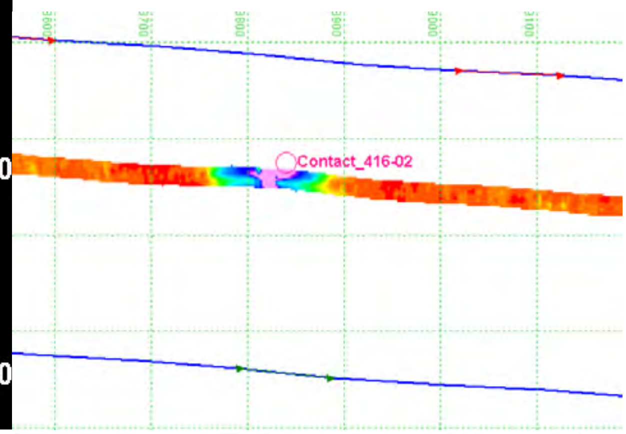
- Ping Number: 309826
- Range to Target: -15.61 US Feet
- Fish Height: 4.86 US Feet
- Event Number: 0
- Line Name: MV_062210_416_SS.000

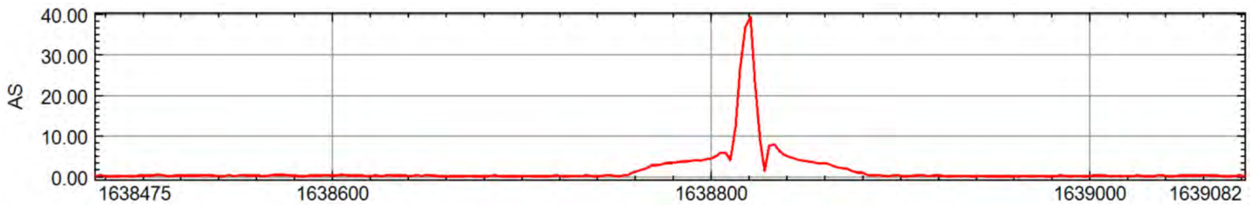
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1: cable
Classification 2:
Area:
Block:
Description: Linear Mag Target non visable in SS

Contact_416-02







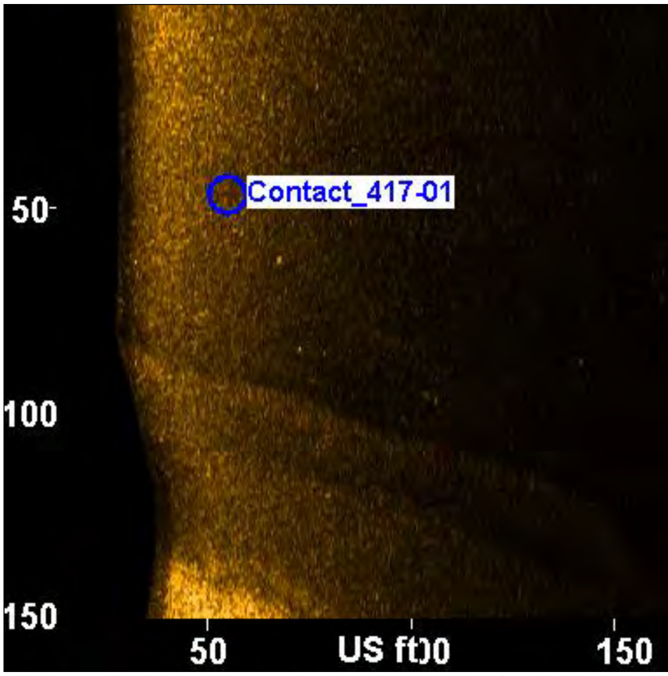
Contact Info: Contact_416-02

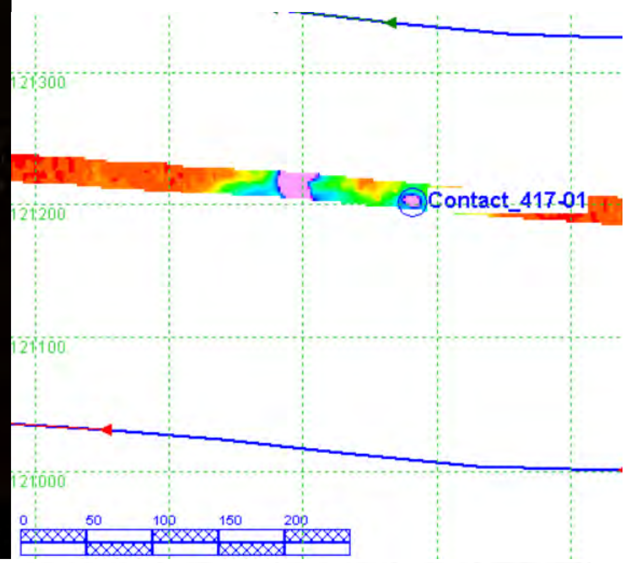
- Sonar Time at Target: 05/23/2010 21:47:49
- Click Position (Lat/Lon Coordinates)
  41.3336639404 -70.5057373047 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1638840.50 (Y) 121574.64
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_416_SS.000.jsf
- Ping Number: 317425
- Range to Target: -16.89 US Feet
- Fish Height: 4.37 US Feet
- Event Number: 0
- Line Name: MV_062210_416_SS.000

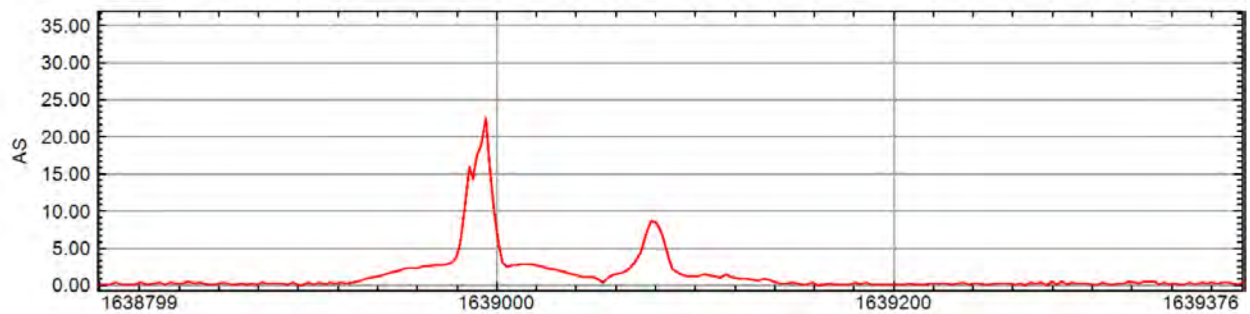
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Mag Target Not Visable on surface

Contact_417-01







Contact Info: Contact_417-01

- Sonar Time at Target: 05/23/2010 21:12:43
- Click Position (Lat/Lon Coordinates)
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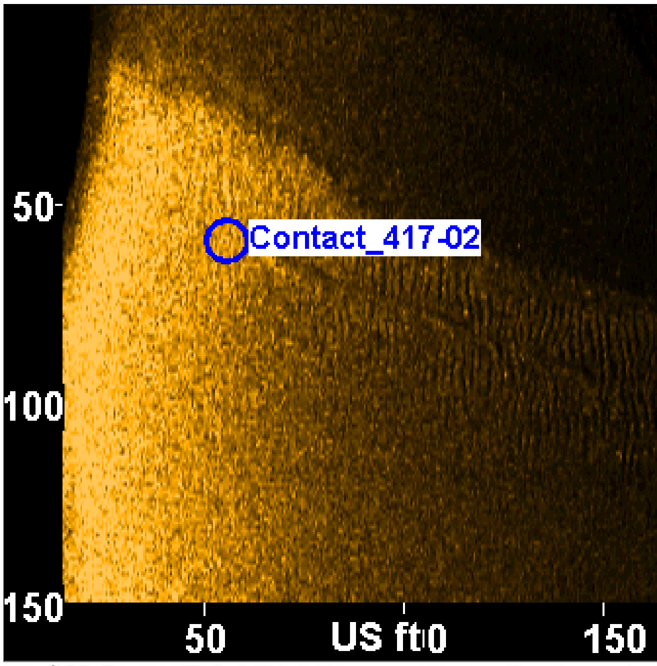
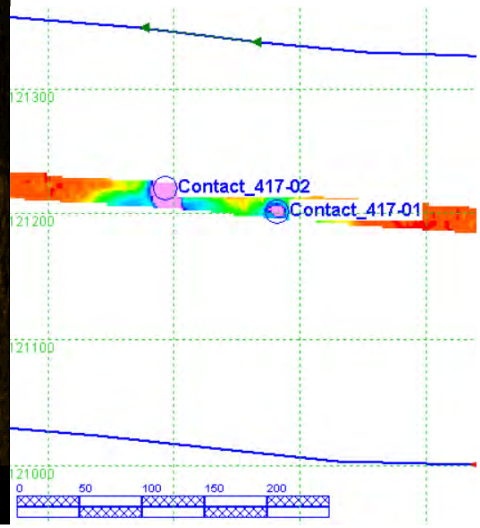
- Click Position (Projected Coordinates)
  (X) 1639081.88 (Y) 121201.10
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_417_SS.000.jsf
- Ping Number: 289375
- Range to Target: 10.05 US Feet
- Fish Height: 4.62 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

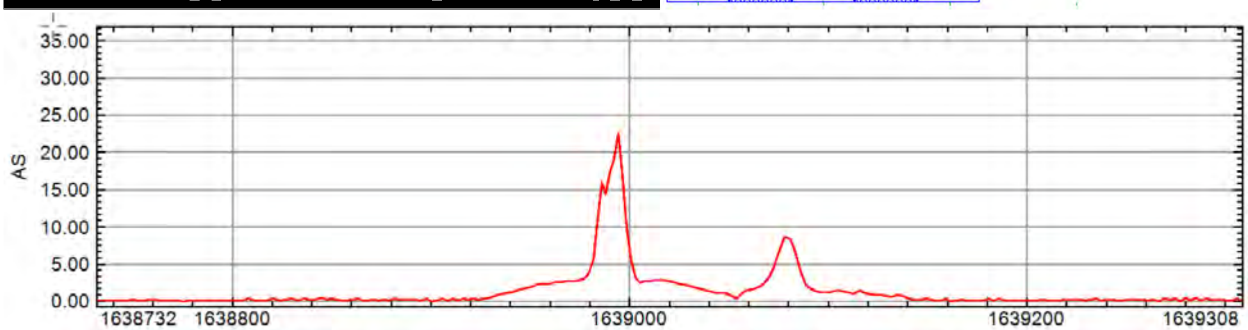
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Suspicious features in SS in close proximity to mag anomalie. Mag anomalie is distrubuted along track

Contact_417-02







Contact Info: Contact_417-02

- Sonar Time at Target: 05/23/2010 21:12:55
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- Click Position (Projected Coordinates)
  (X) 1638993.38 (Y) 121220.05
- Map Proj:
- Acoustic Source File:

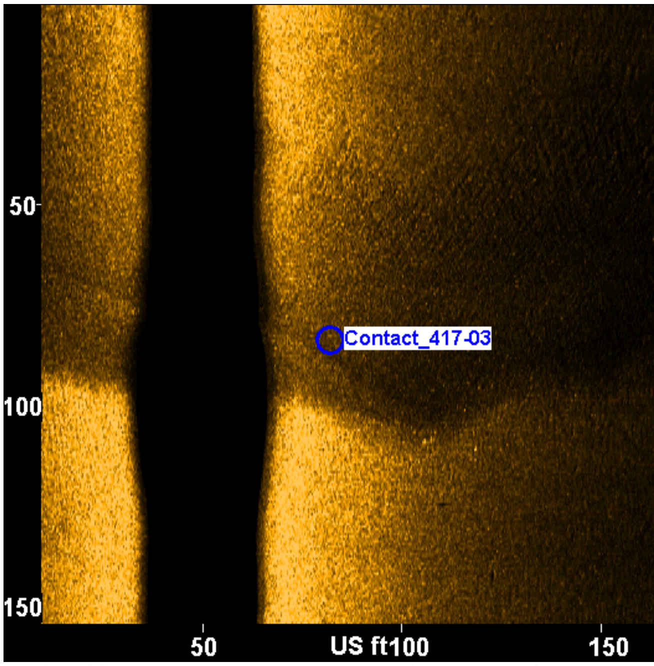
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_417_SS.000.jsf

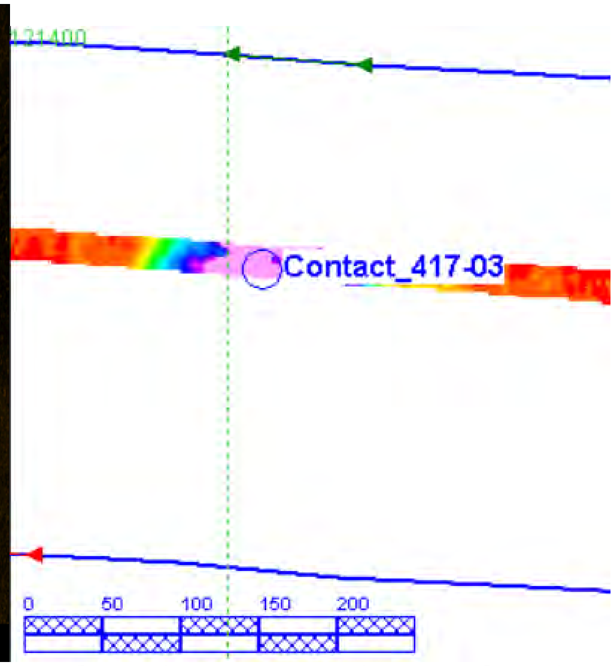
- Ping Number: 289526
- Range to Target: 12.49 US Feet
- Fish Height: 4.98 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

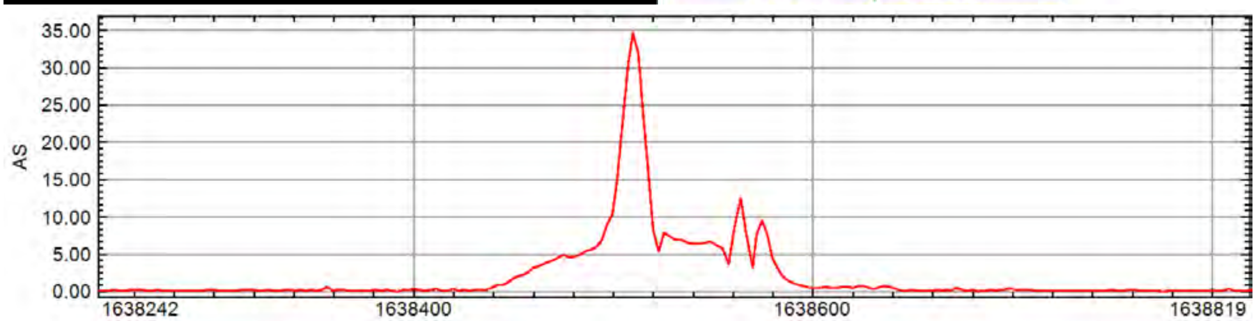
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Something linear cross-cutting sandwaves in SS image

Contact_417-03







Contact Info: Contact_417-03

- Sonar Time at Target: 05/23/2010 21:13:53
- Click Position (Lat/Lon Coordinates)
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- Click Position (Projected Coordinates)
  (X) 1638523.00 (Y) 121242.04
- Map Proj:
- Acoustic Source File:
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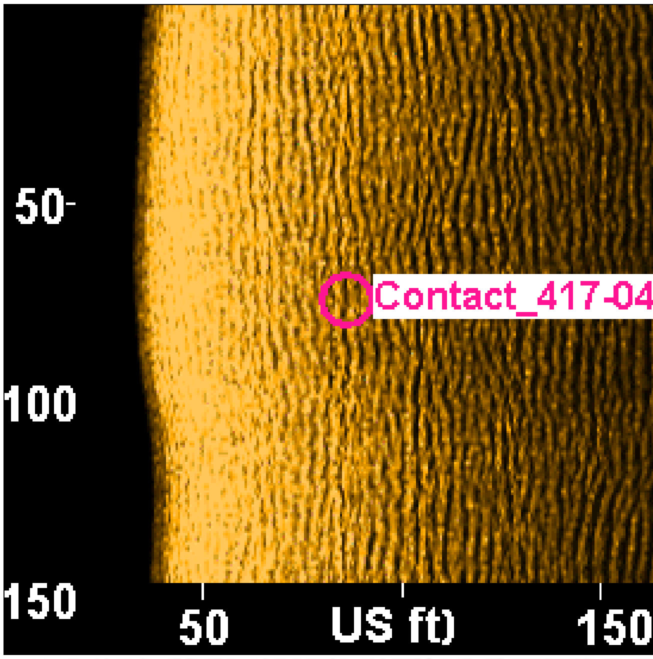
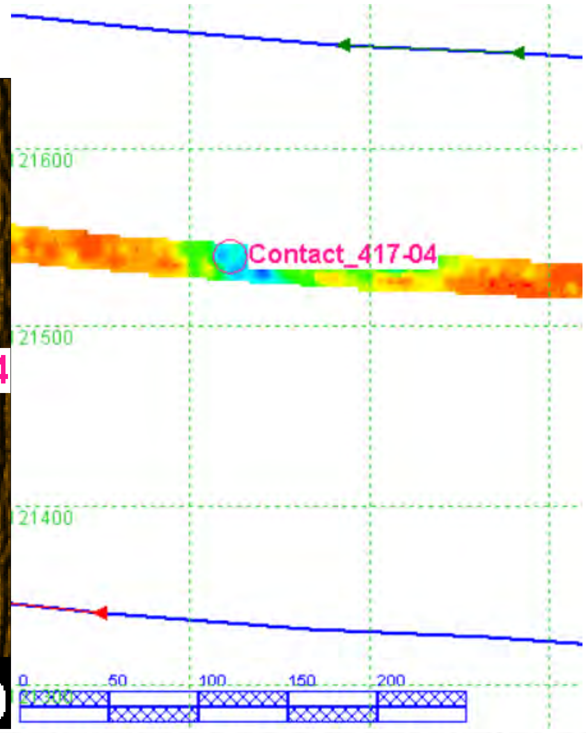
- Ping Number: 290305
- Range to Target: 9.76 US Feet
- Fish Height: 4.75 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

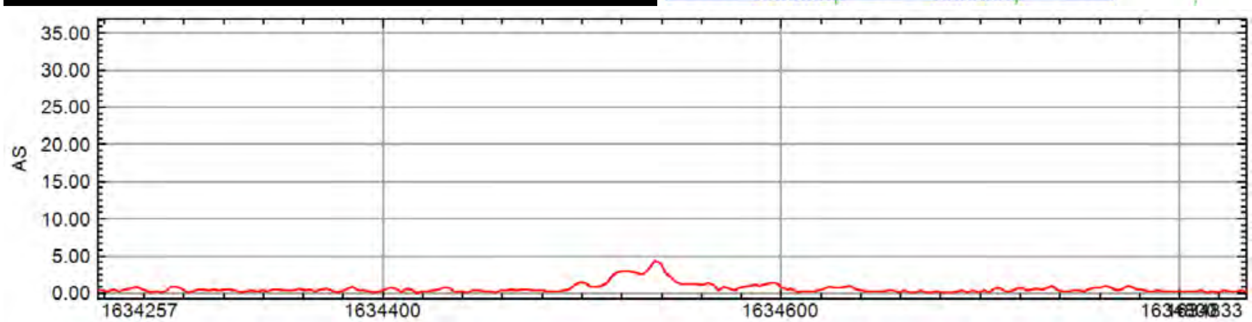
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Something linear in SS image

Contact_417-04







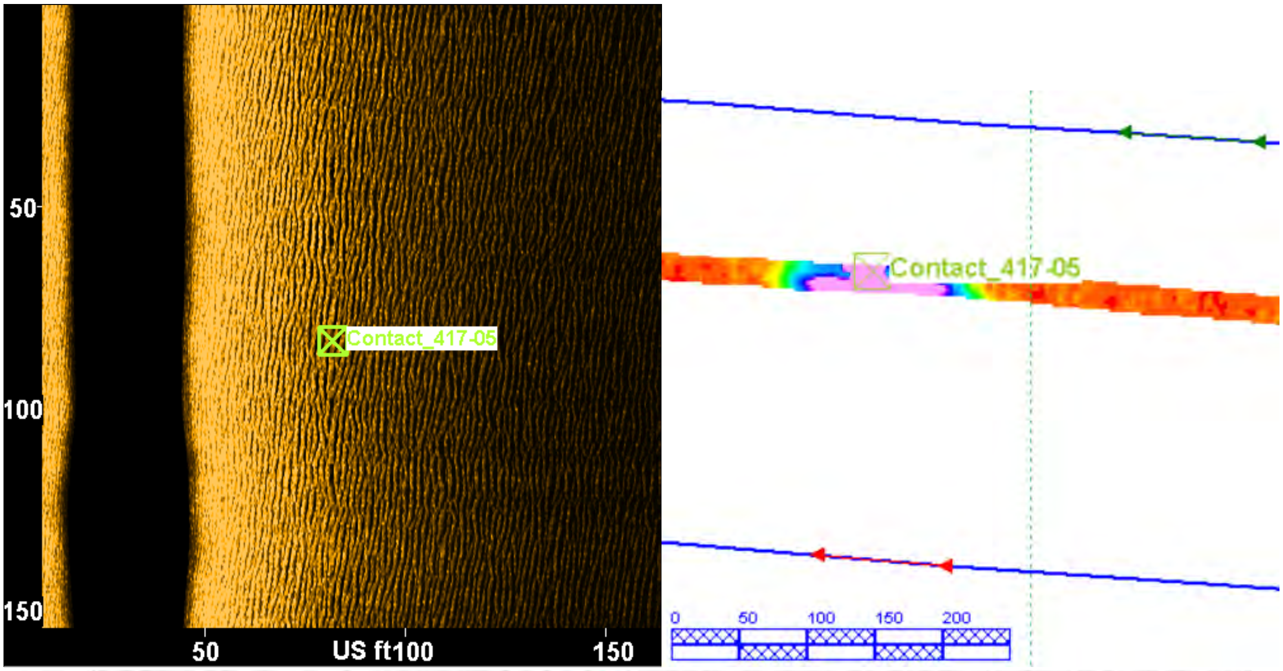
Contact Info: Contact_417-04

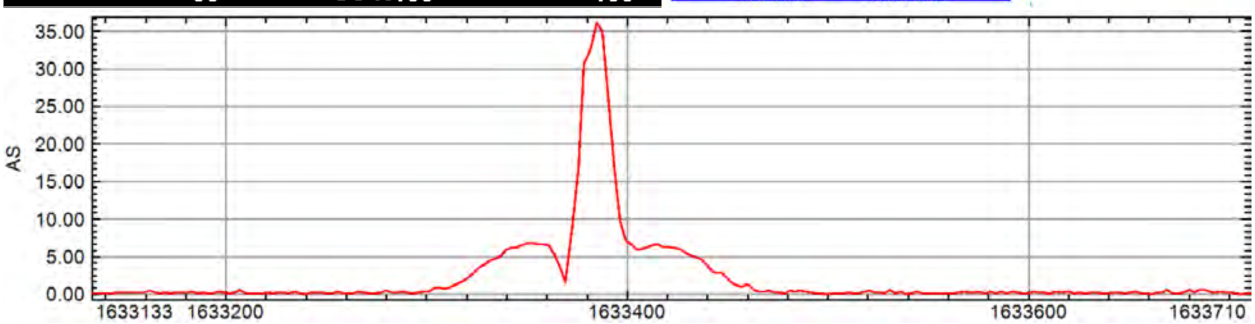
- Sonar Time at Target: 05/23/2010 21:21:54
- Click Position (Lat/Lon Coordinates)
  41.3335609436 -70.5214614868 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1634523.00 (Y) 121537.95
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_417_SS.000.jsf
- Ping Number: 296706
- Range to Target: 12.78 US Feet
- Fish Height: 3.99 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Not visable in SS, small mag target

Contact_417-05





Contact Info: Contact_417-05

- Sonar Time at Target: 05/23/2010 21:24:06
- Click Position (Lat/Lon Coordinates)
  41.3338165283 -70.5256042480 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633383.88 (Y) 121631.81
- Map Proj:
- Acoustic Source File:

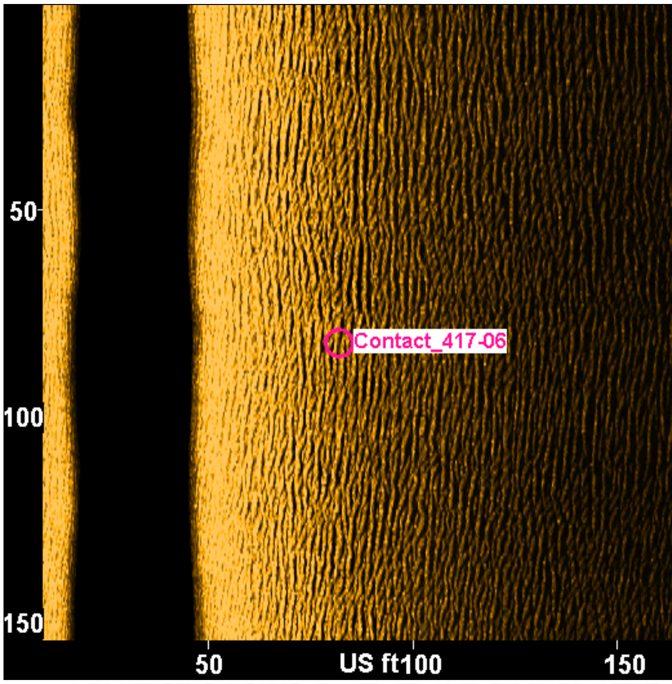
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_417_SS.000.jsf

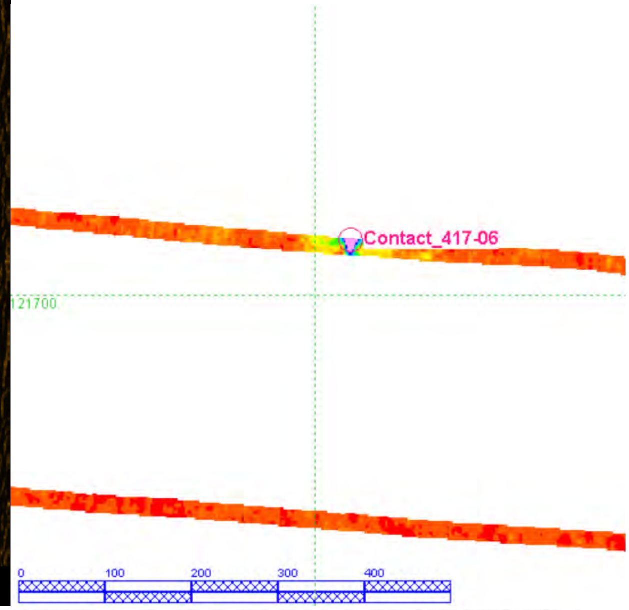
- Ping Number: 298462
- Range to Target: 15.42 US Feet
- Fish Height: 4.18 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

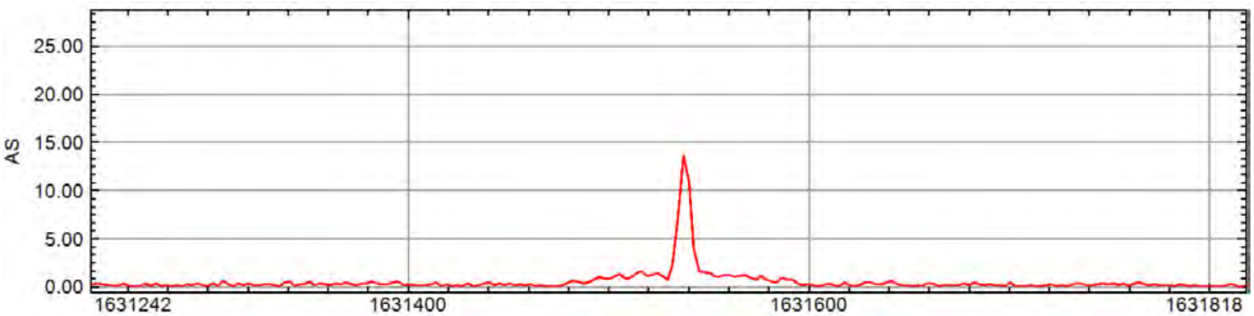
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1: cable
Classification 2:
Area:
Block:
Description: Linear mag, not visable in SS

Contact_417-06







Contact Info: Contact_417-06

- Sonar Time at Target: 05/23/2010 21:27:42
- Click Position (Lat/Lon Coordinates)
  41.3341751099 -70.5323104858 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1631542.25 (Y) 121763.05
- Map Proj:
- Acoustic Source File:

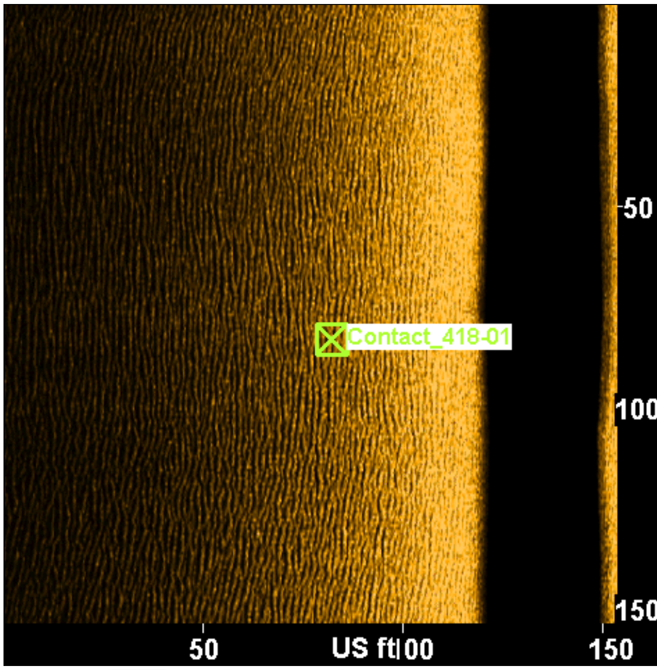
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_417_SS.000.jsf

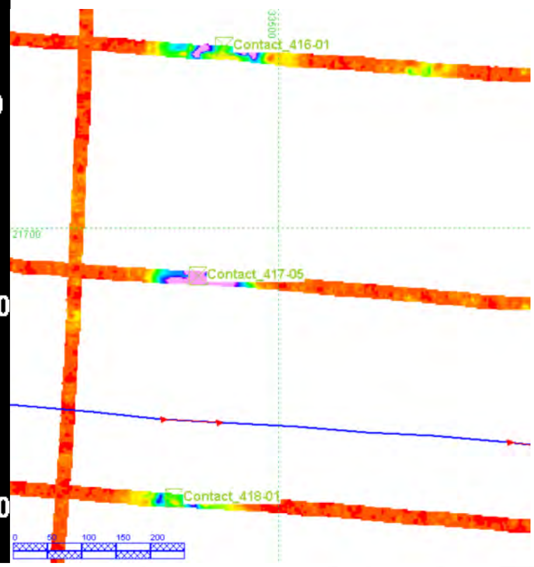
- Ping Number: 301342
- Range to Target: 15.22 US Feet
- Fish Height: 4.61 US Feet
- Event Number: 0
- Line Name: MV_062210_417_SS.000

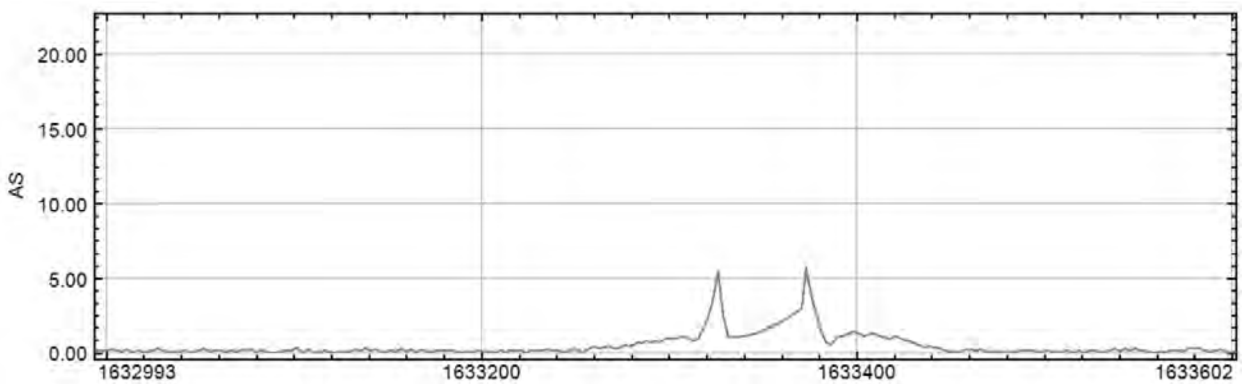
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Not Visable in SS

Contact_418-01







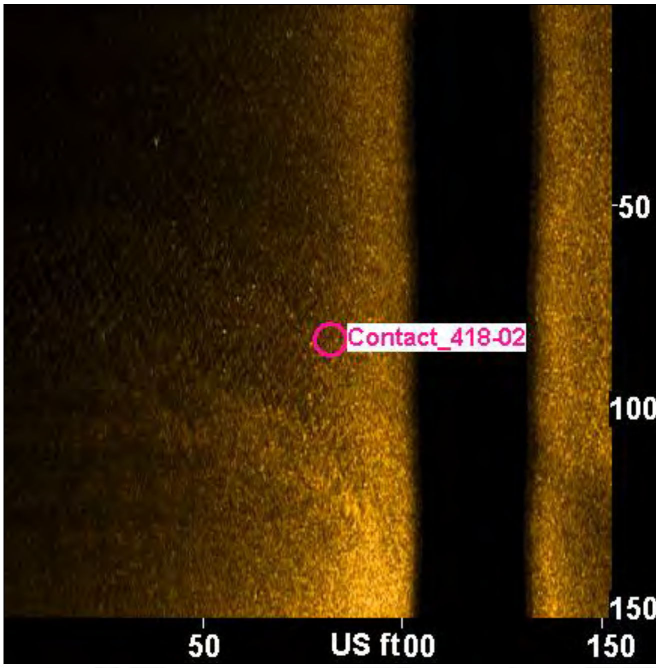
Contact Info: Contact_418-01

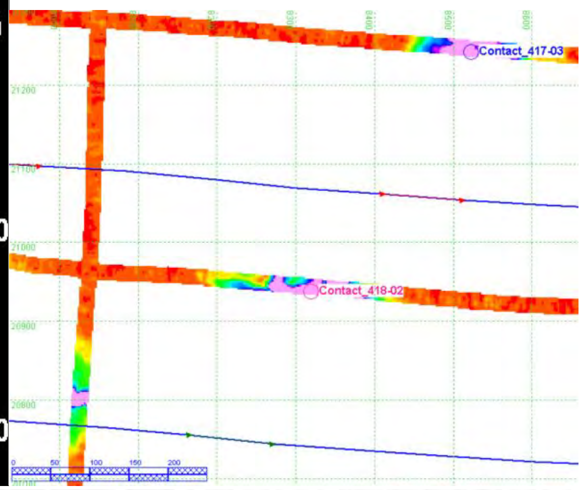
- Sonar Time at Target: 05/23/2010 20:42:58
- Click Position (Lat/Lon Coordinates)
  41.3329315186 -70.5257339478 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633349.13 (Y) 121308.43
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_418_SS.000.jsf
- Ping Number: 265595
- Range to Target: 16.20 US Feet
- Fish Height: 4.54 US Feet
- Event Number: 0
- Line Name: MV_062210_418_SS.000

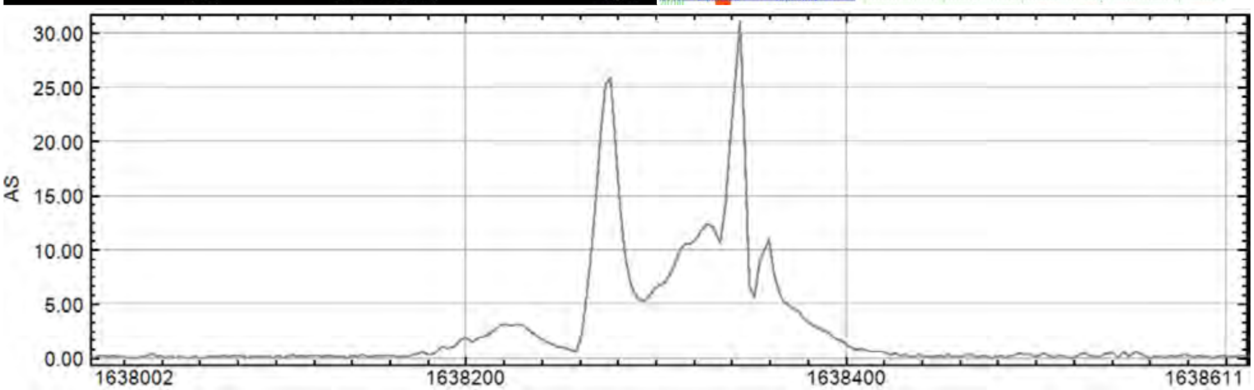
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1: cable
Classification 2:
Area:
Block:
Description: Large linear mag. No SS anomaly

Contact_418-02







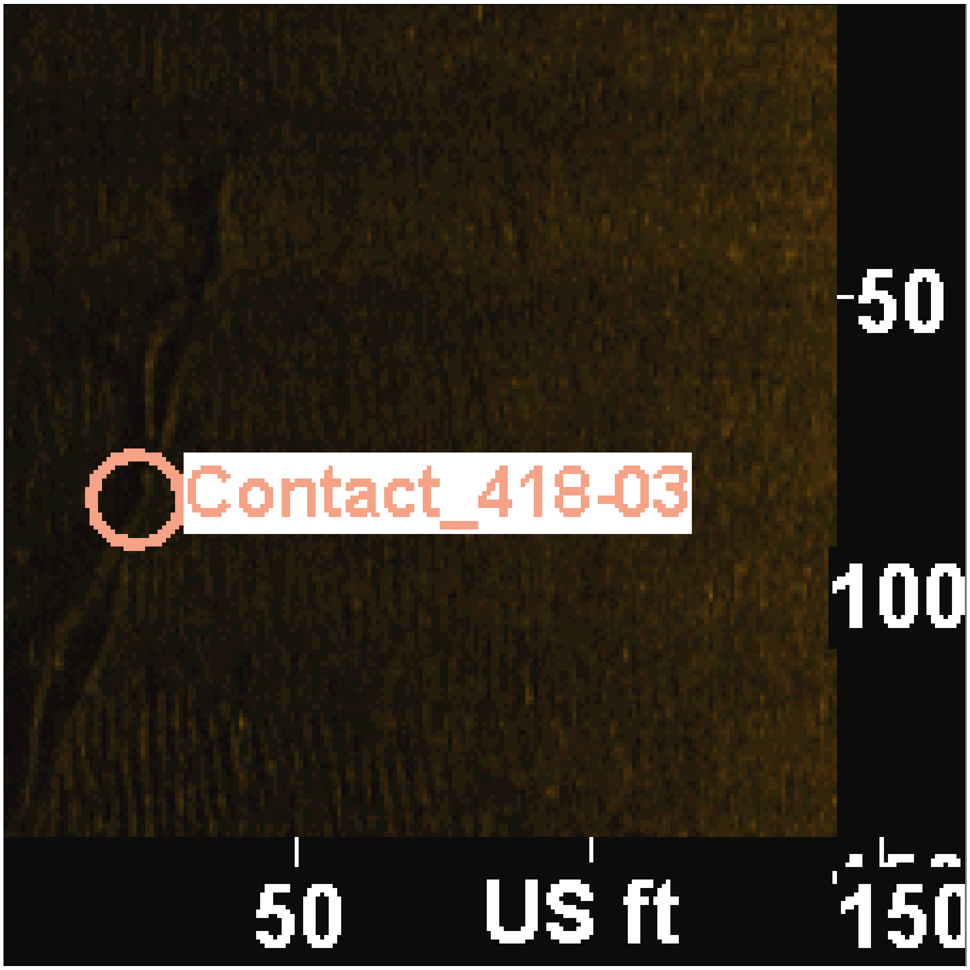
Contact Info: Contact_418-02

- Sonar Time at Target: 05/23/2010 20:51:50
- Click Position (Lat/Lon Coordinates)
  41.3319129944 -70.5076370239 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1638319.75 (Y) 120937.23
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_418_SS.000.jsf
- Ping Number: 272677
- Range to Target: 10.93 US Feet
- Fish Height: 4.29 US Feet
- Event Number: 0
- Line Name: MV_062210_418_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Lage Mag anamaly, not visable in SS

Contact_418-03



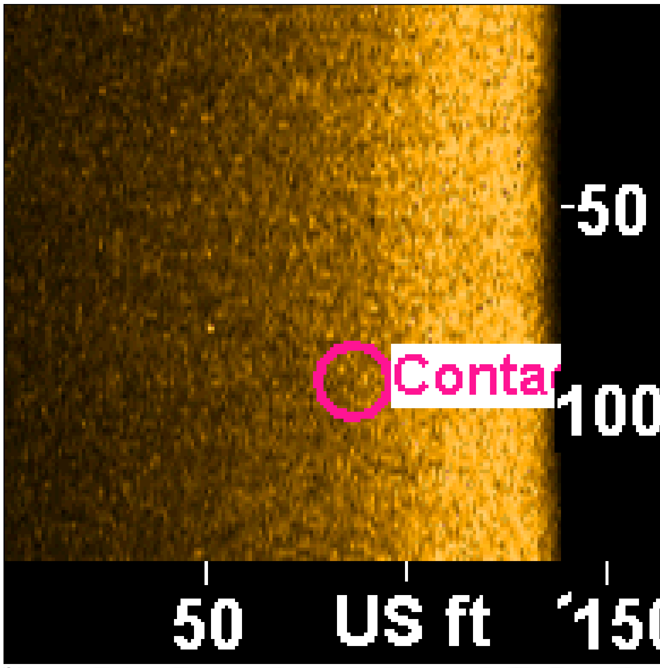
Contact Info: Contact_418-03

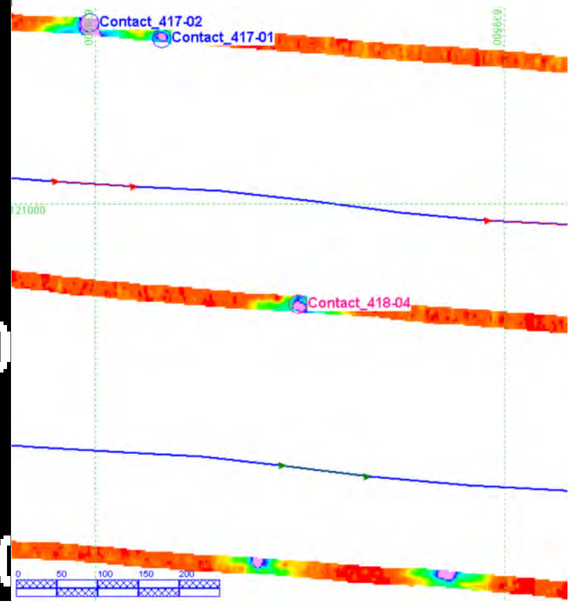
- Sonar Time at Target: 05/23/2010 20:52:05
- Click Position (Lat/Lon Coordinates)
  41.3322105408 -70.5070571899 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1638479.25 (Y) 121045.66
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_418_SS.000.jsf
- Ping Number: 272878
- Range to Target: 46.45 US Feet
- Fish Height: 4.61 US Feet
- Event Number: 0
- Line Name: MV_062210_418_SS.000

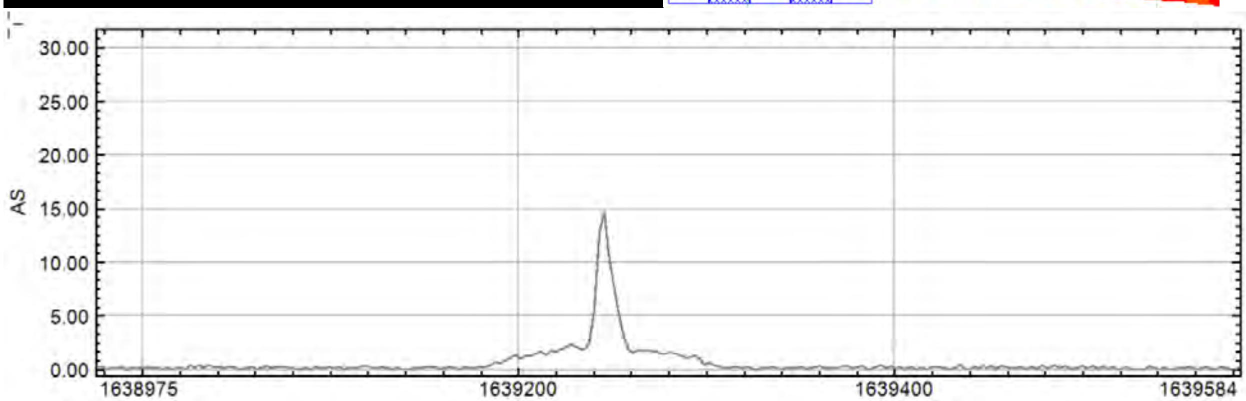
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Not in the path of the MGA survey

Contact_418-04







Contact Info: Contact_418-04

- Sonar Time at Target: 05/23/2010 20:53:24
- Click Position (Lat/Lon Coordinates)
  41.3317451477 -70.5042572021 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639248.25 (Y) 120875.16
- Map Proj:
- Acoustic Source File:

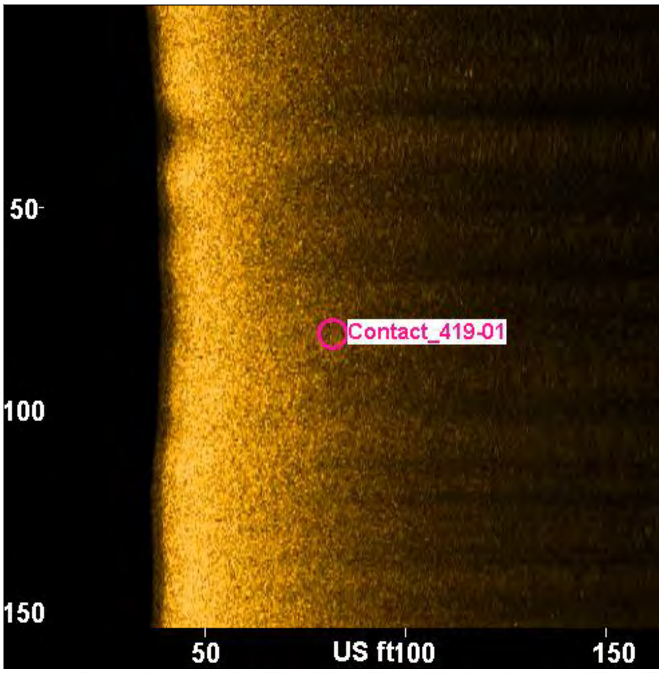
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_418_SS.000.jsf

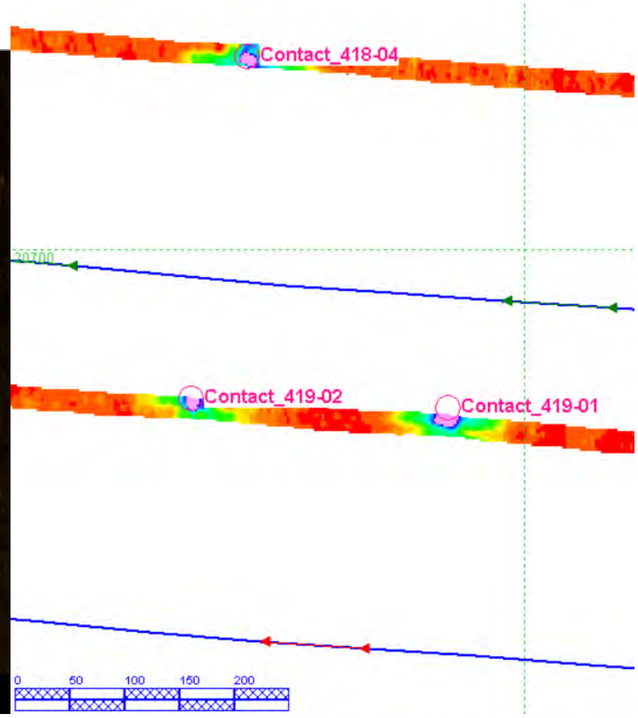
- Ping Number: 273935
- Range to Target: 11.22 US Feet
- Fish Height: 4.31 US Feet
- Event Number: 0
- Line Name: MV_062210_418_SS.000

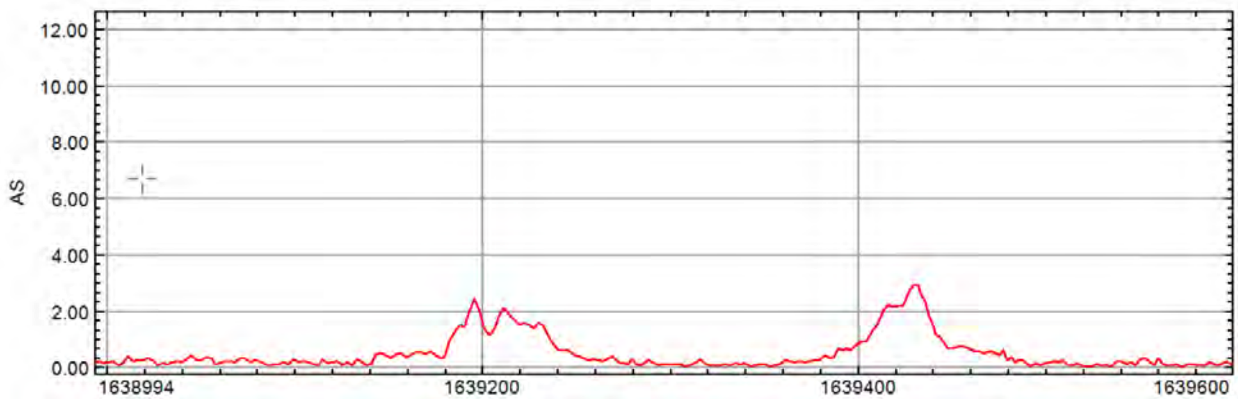
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Mag but not ss anomaly

Contact_419-01







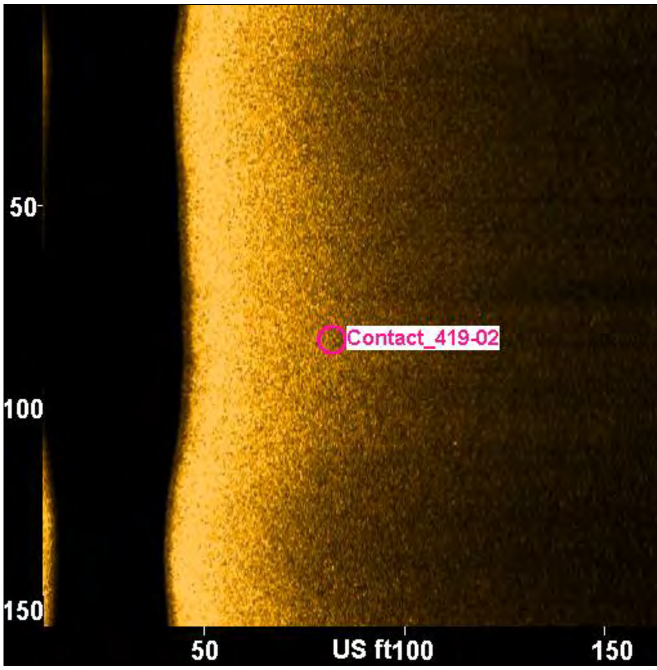
Contact Info: Contact_419-01

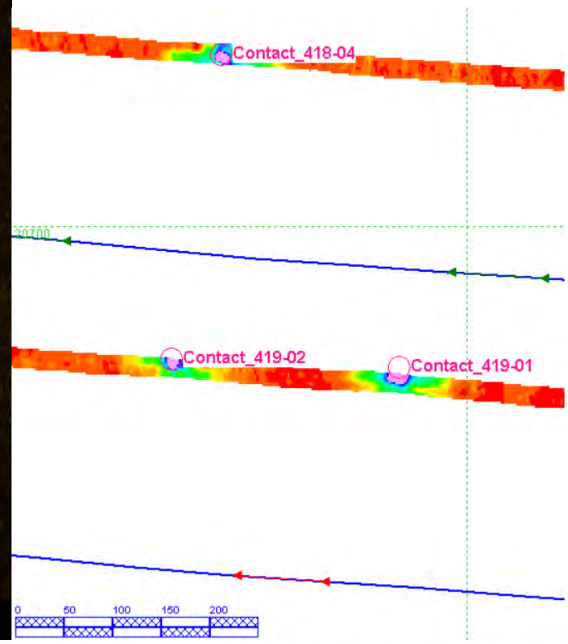
- Sonar Time at Target: 05/23/2010 20:17:21
- Click Position (Lat/Lon Coordinates)
  41.3308639526 -70.5035858154 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639431.50 (Y) 120554.97
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 245117
- Range to Target: 19.61 US Feet
- Fish Height: 6.66 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

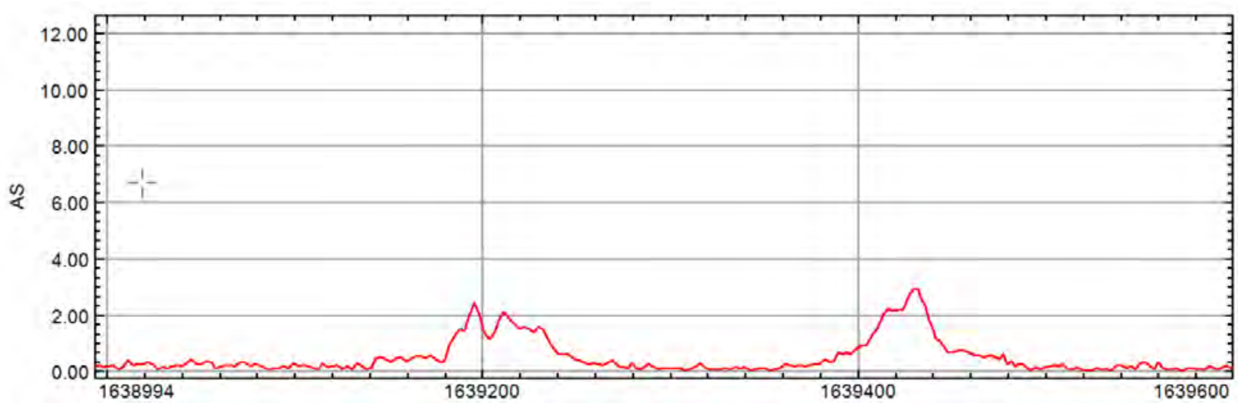
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_419-02







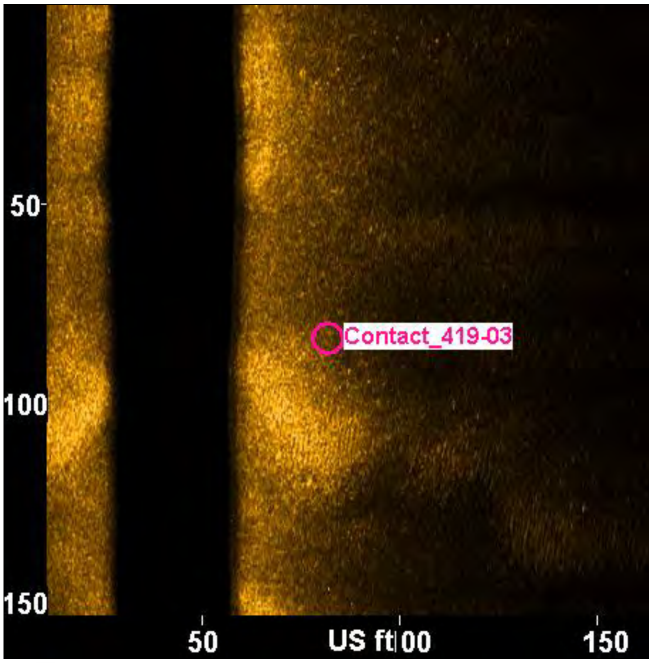
Contact Info: Contact_419-02

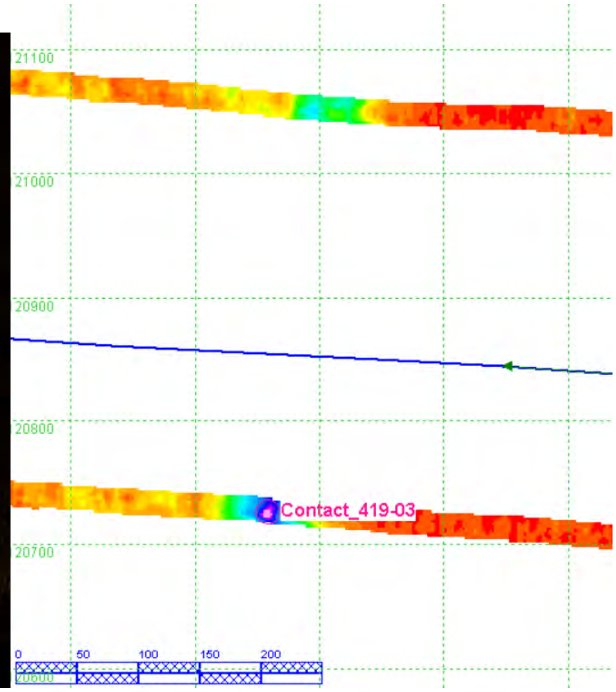
- Sonar Time at Target: 05/23/2010 20:17:48
- Click Position (Lat/Lon Coordinates)
  41.3308906555 -70.5044403076 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639197.63 (Y) 120563.49
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 245482
- Range to Target: 16.78 US Feet
- Fish Height: 5.46 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

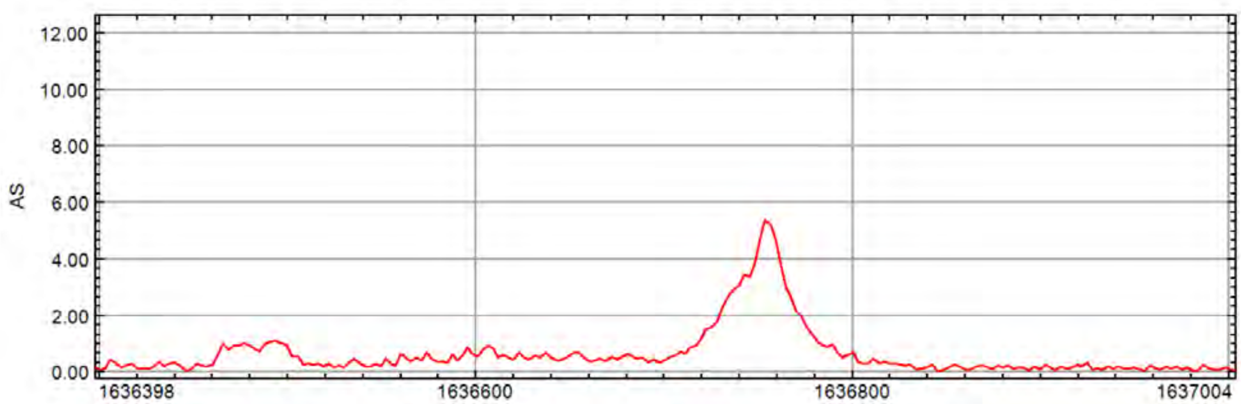
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_419-03







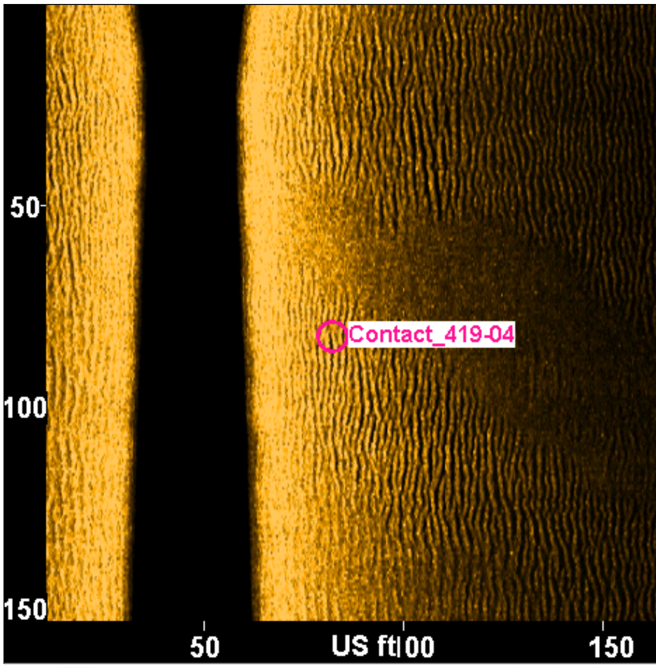
Contact Info: Contact_419-03

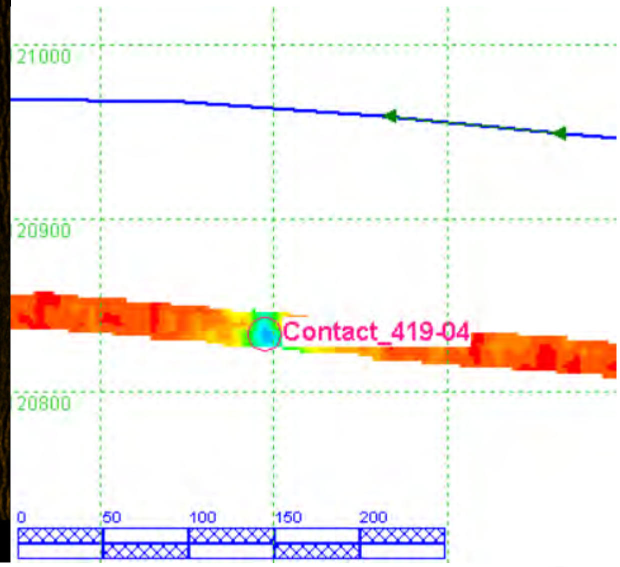
- Sonar Time at Target: 05/23/2010 20:22:19
- Click Position (Lat/Lon Coordinates)
  41.3313331604 -70.5133209229 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636759.00 (Y) 120726.18
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 249096
- Range to Target: 11.90 US Feet
- Fish Height: 4.59 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

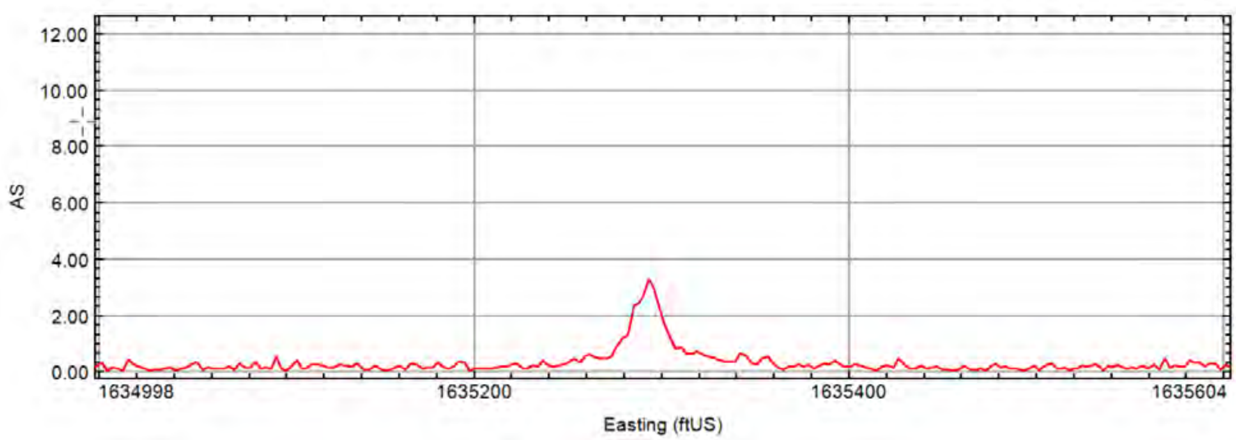
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_419-04







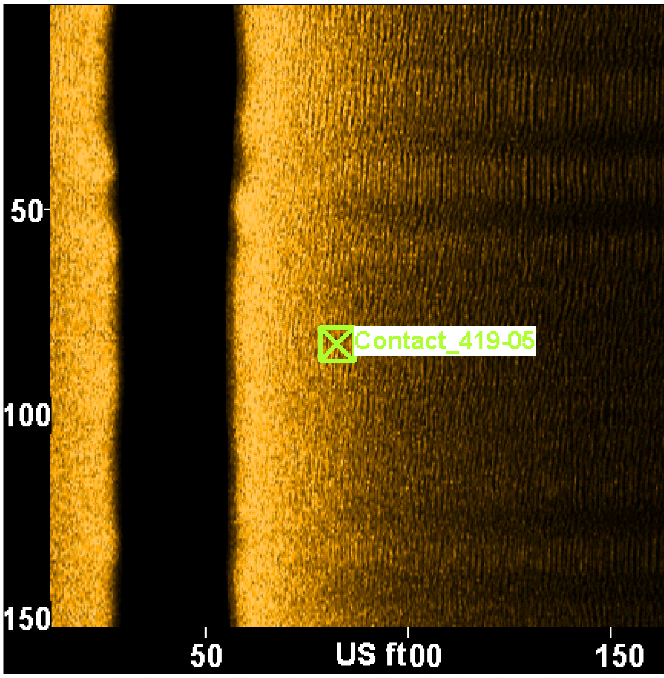
Contact Info: Contact_419-04

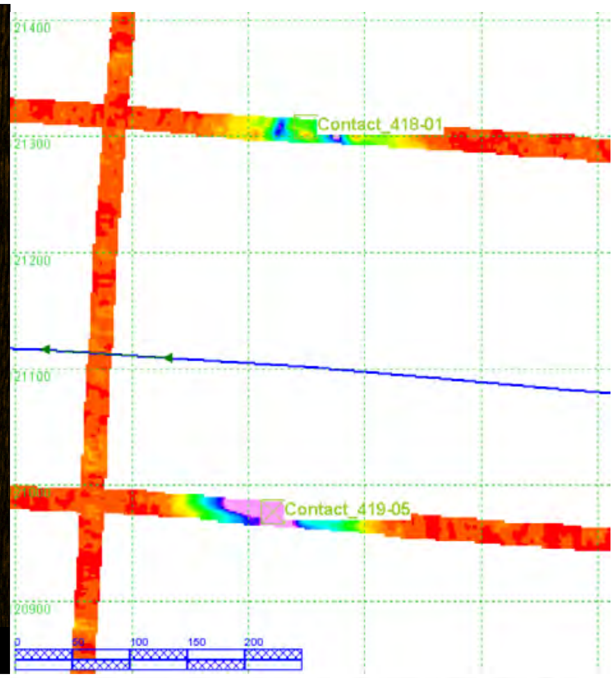
- Sonar Time at Target: 05/23/2010 20:24:55
- Click Position (Lat/Lon Coordinates)
  41.3316268921 -70.5186462402 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1635295.50 (Y) 120833.24
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 251175
- Range to Target: 10.73 US Feet
- Fish Height: 4.02 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

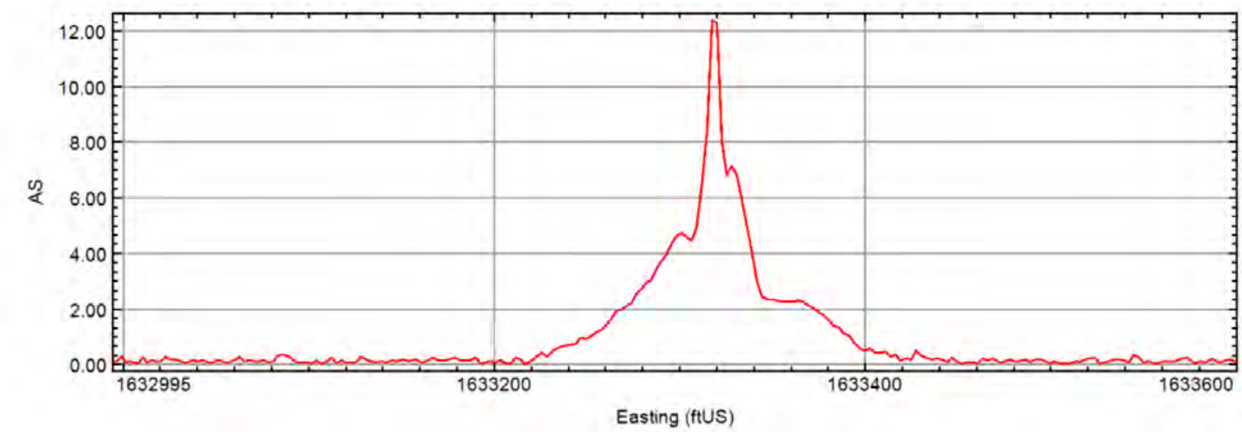
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_419-05







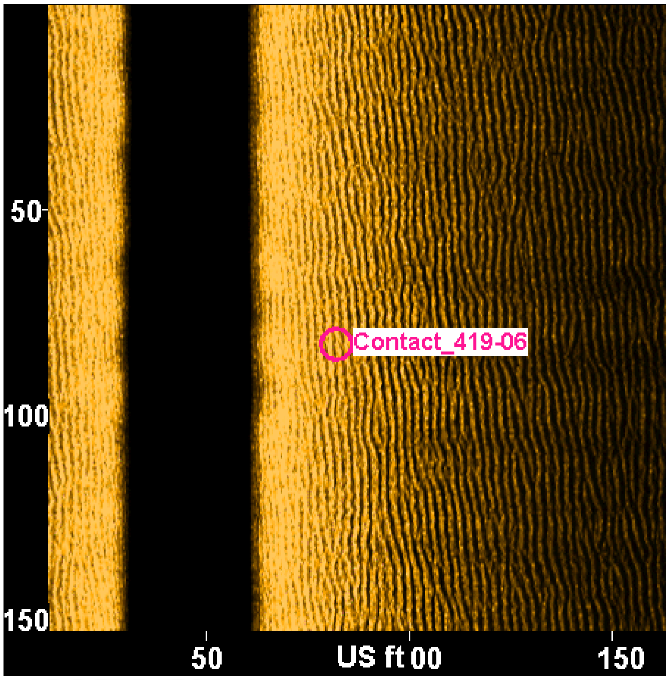
Contact Info: Contact_419-05

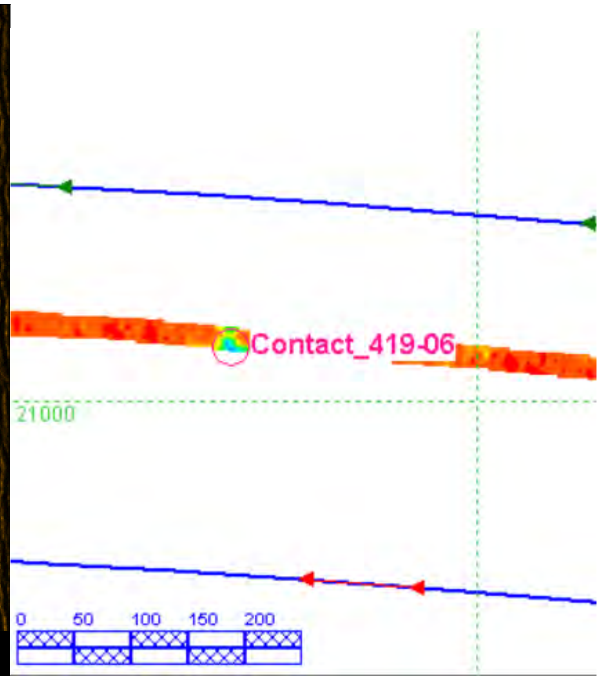
- Sonar Time at Target: 05/23/2010 20:28:15
- Click Position (Lat/Lon Coordinates)
  41.3320198059 -70.5258407593 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633320.50 (Y) 120977.20
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 253840
- Range to Target: 12.20 US Feet
- Fish Height: 4.03 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

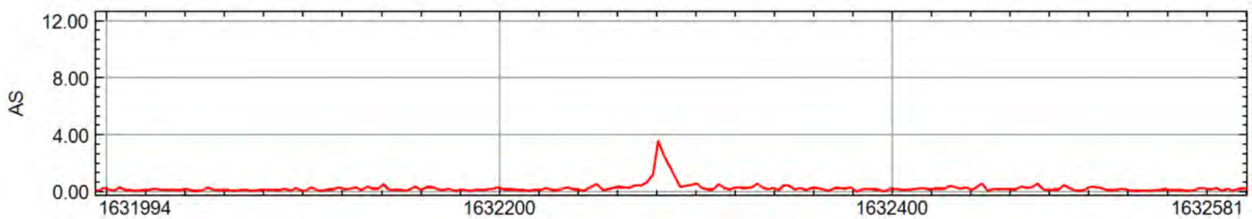
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: large linear mag, no ss anomaly

Contact_419-06







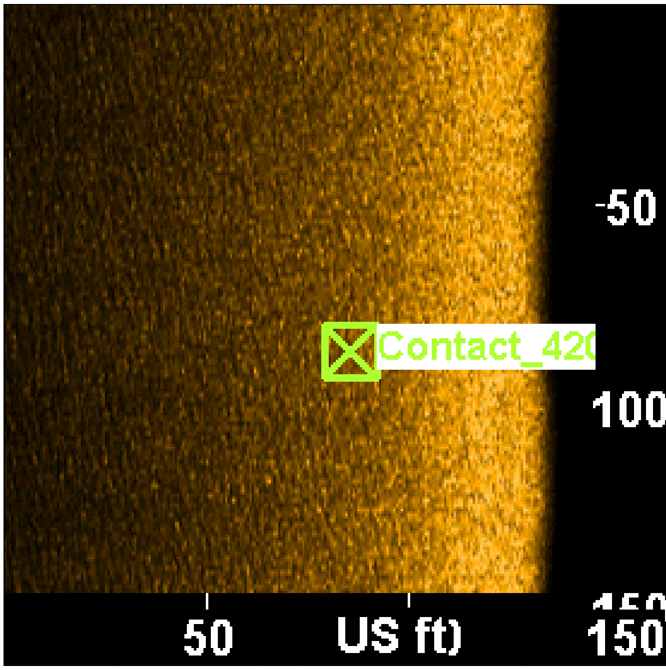
Contact Info: Contact_419-06

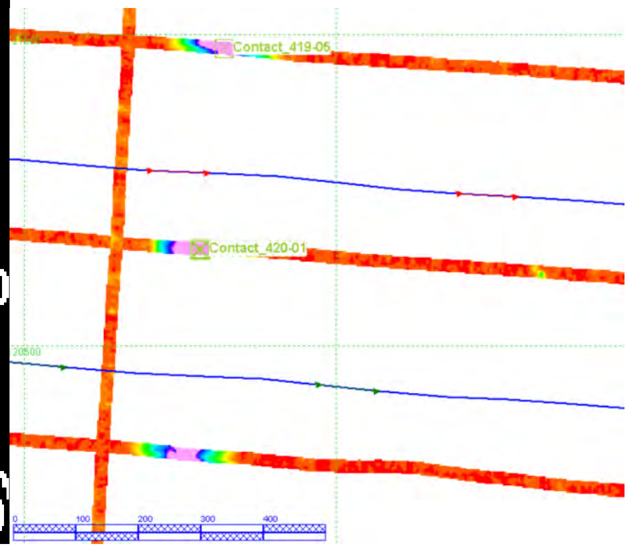
- Sonar Time at Target: 05/23/2010 20:30:03
- Click Position (Lat/Lon Coordinates)
  41.3322105408 -70.5296020508 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1632287.13 (Y) 121045.96
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_419_SS.000.jsf
- Ping Number: 255276
- Range to Target: 11.03 US Feet
- Fish Height: 4.76 US Feet
- Event Number: 0
- Line Name: MV_062210_419_SS.000

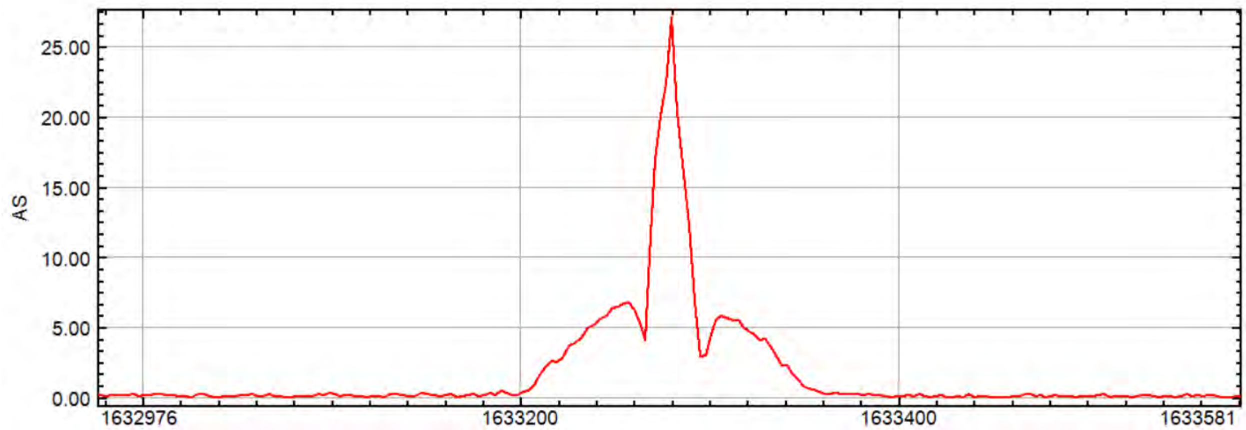
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_420-01







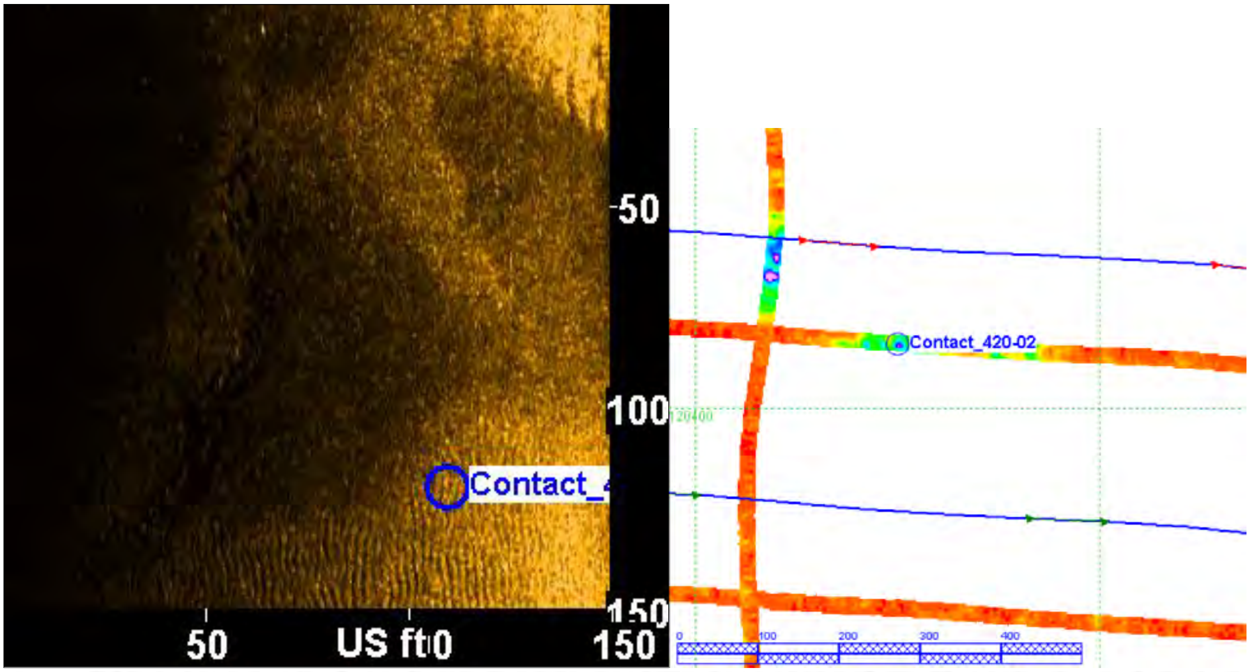
Contact Info: Contact_420-01

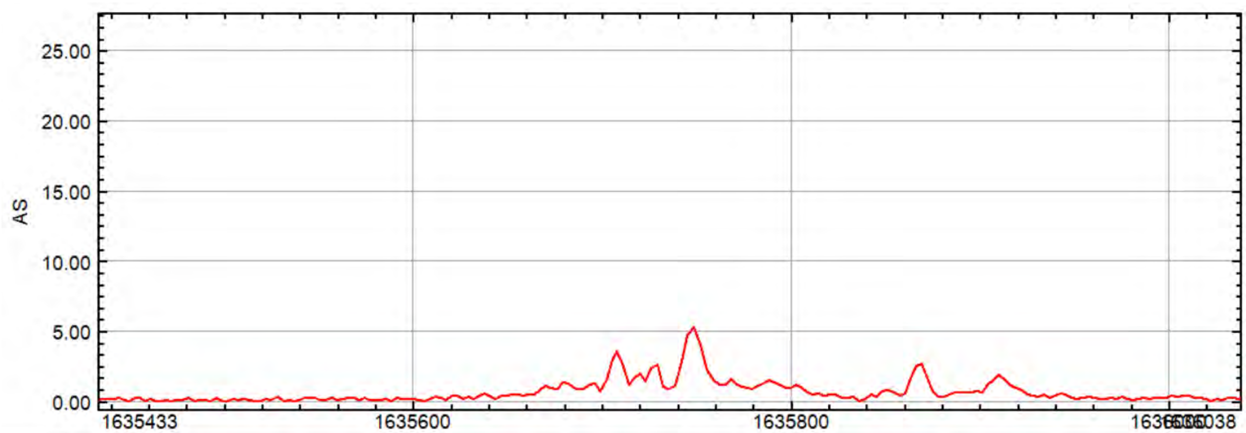
- Sonar Time at Target: 05/23/2010 19:48:57
- Click Position (Lat/Lon Coordinates)
  41.3311386108 -70.5259780884 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633281.13 (Y) 120656.03
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_420_SS.000.jsf
- Ping Number: 222426
- Range to Target: 13.27 US Feet
- Fish Height: 4.41 US Feet
- Event Number: 0
- Line Name: MV_062210_420_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Western area N-S linear mag anamaly with not SS anamaly

Contact_420-02





Contact Info: Contact_420-02

- Sonar Time at Target: 05/23/2010 19:53:42
- Click Position (Lat/Lon Coordinates)
  41.3306541443 -70.5169906616 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1635750.25 (Y) 120479.16
- Map Proj:
- Acoustic Source File:

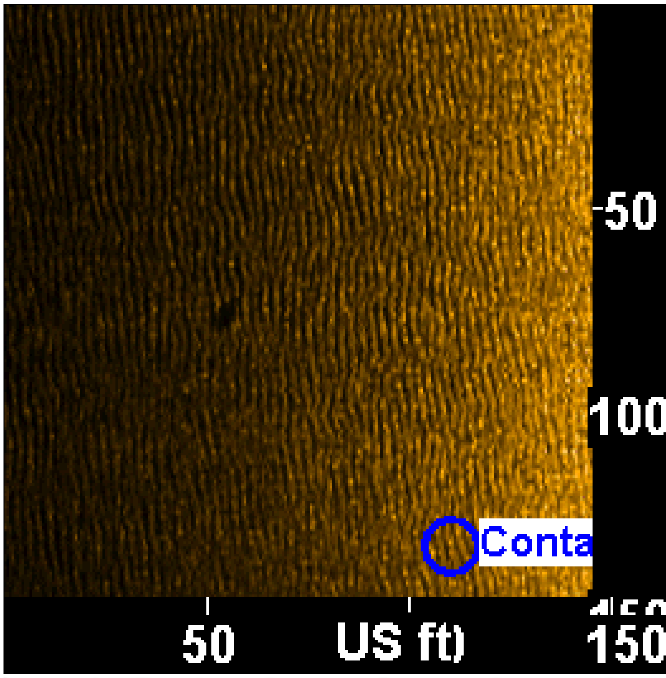
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_420_SS.000.jsf

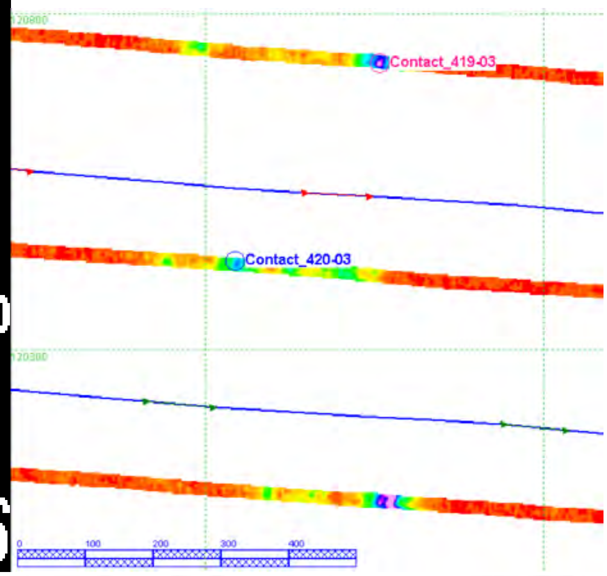
- Ping Number: 226224
- Range to Target: 13.76 US Feet
- Fish Height: 4.20 US Feet
- Event Number: 0
- Line Name: MV_062210_420_SS.000

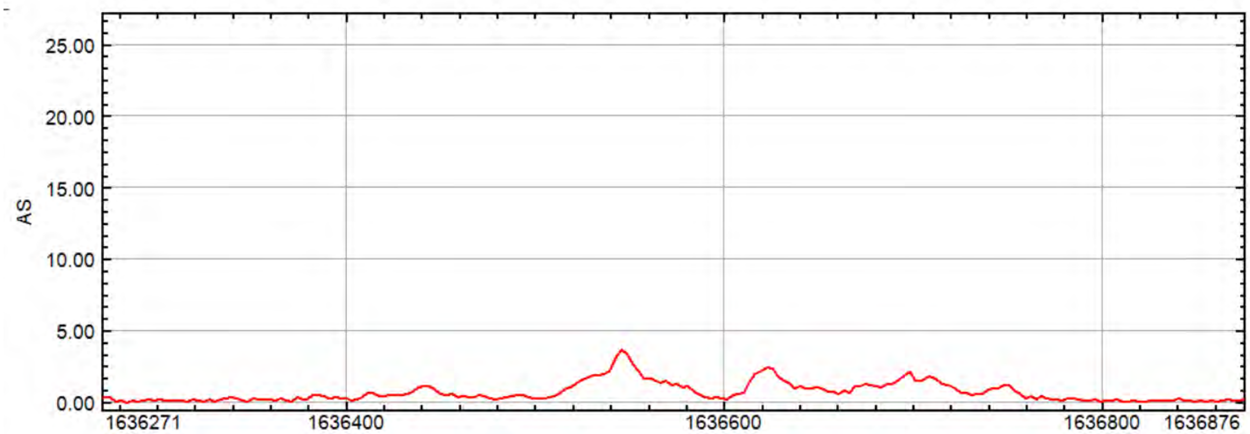
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Distributed Mag Anamaly, Possible SS Targets in vacinity.

Contact_420-03







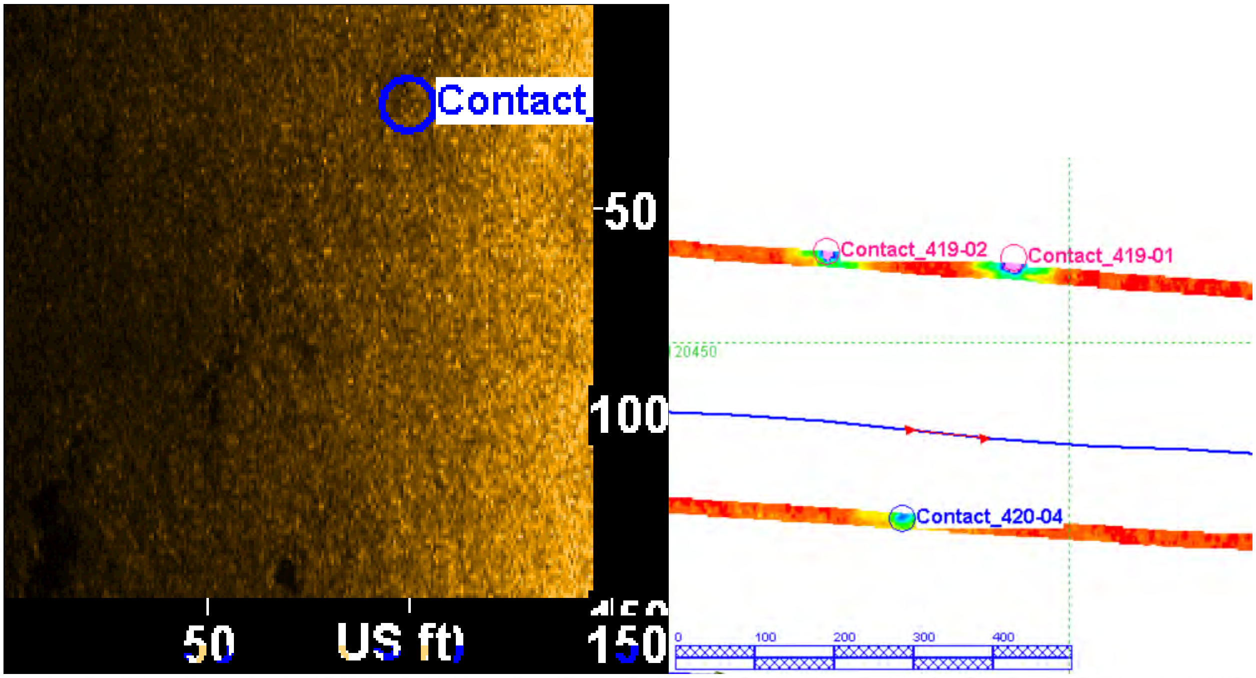
Contact Info: Contact_420-03

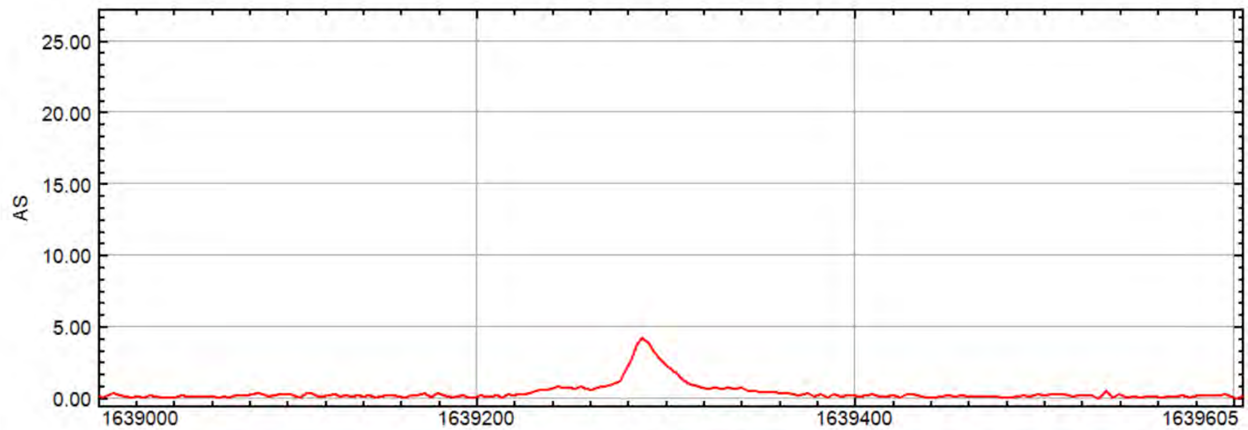
- Sonar Time at Target: 05/23/2010 19:55:09
- Click Position (Lat/Lon Coordinates)
  41.3305282593 -70.5140914917 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636546.00 (Y) 120432.91
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_420_SS.000.jsf
- Ping Number: 227387
- Range to Target: 17.37 US Feet
- Fish Height: 4.93 US Feet
- Event Number: 0
- Line Name: MV_062210_420_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_420-04





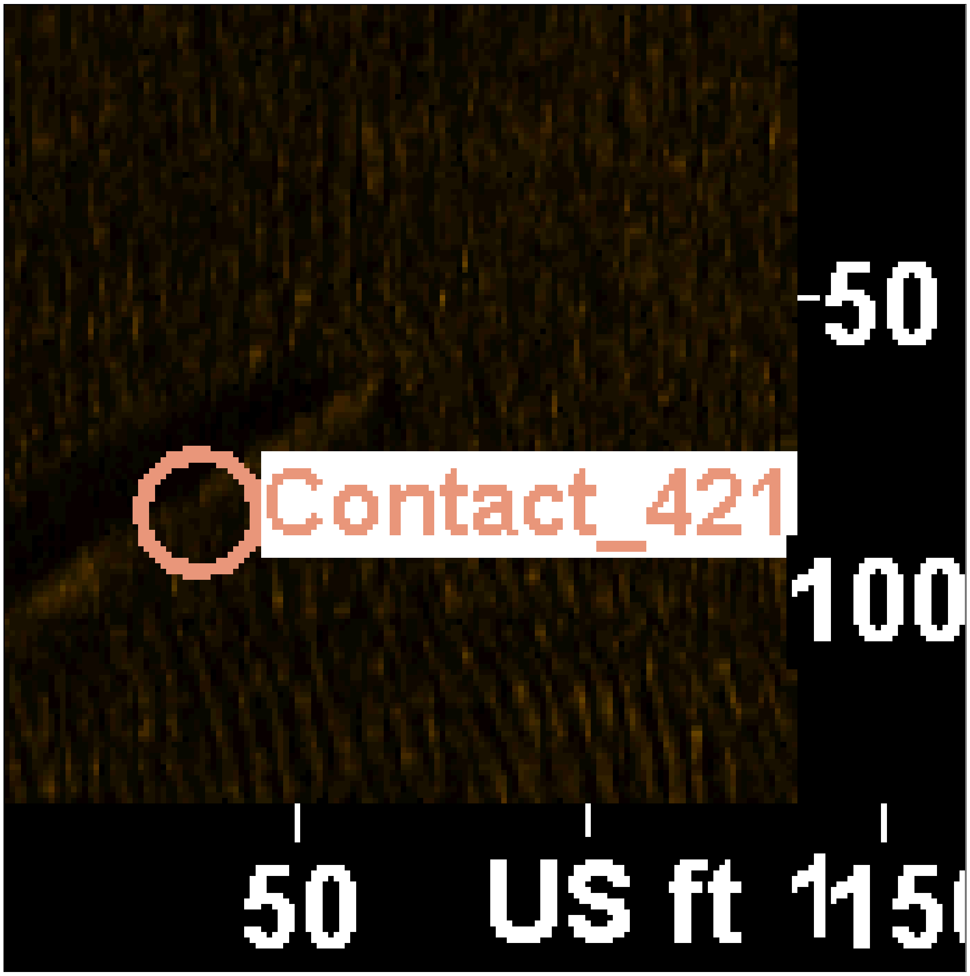
Contact Info: Contact_420-04

- Sonar Time at Target: 05/23/2010 20:00:00
- Click Position (Lat/Lon Coordinates)
  41.3299713135   -70.5040893555 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639292.63 (Y) 120229.90
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_420_SS.000.jsf
- Ping Number: 231264
- Range to Target: 16.30 US Feet
- Fish Height: 4.42 US Feet
- Event Number: 0
- Line Name: MV_062210_420_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Intersting textures/patterns in SS image near this mag anamaly

Contact_421_01



Contact Info: Contact_421_01

- Sonar Time at Target: 05/23/2010 19:22:09
- Click Position (Lat/Lon Coordinates)
  41.3284301758 -70.5030975342 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639566.13 (Y) 119667.05
- Map Proj:
- Acoustic Source File:

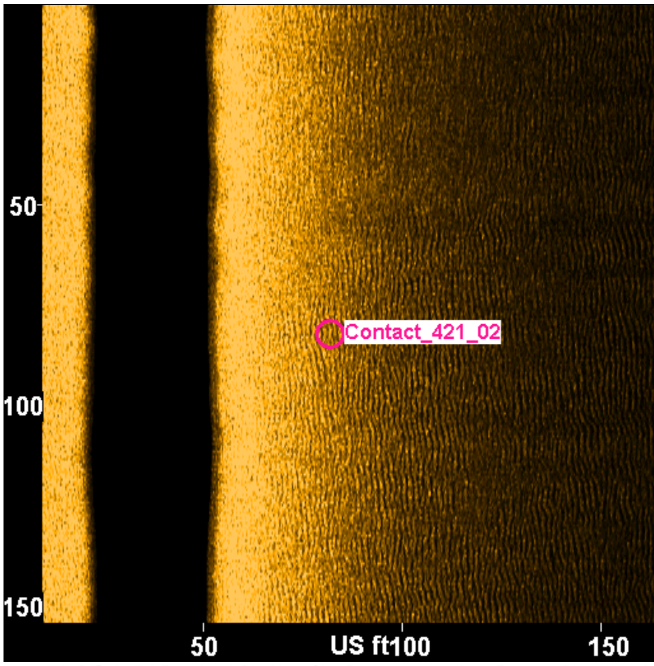
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_421_SS.000.jsf

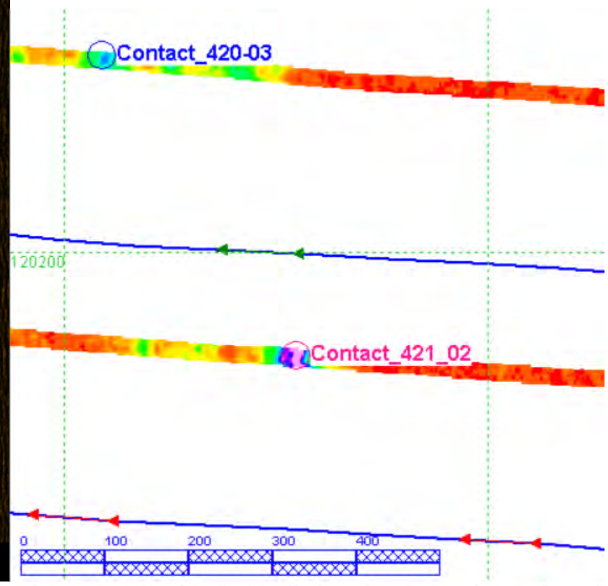
- Ping Number: 201008
- Range to Target: 47.03 US Feet
- Fish Height: 4.87 US Feet
- Event Number: 0
- Line Name: MV_062210_421_SS.000

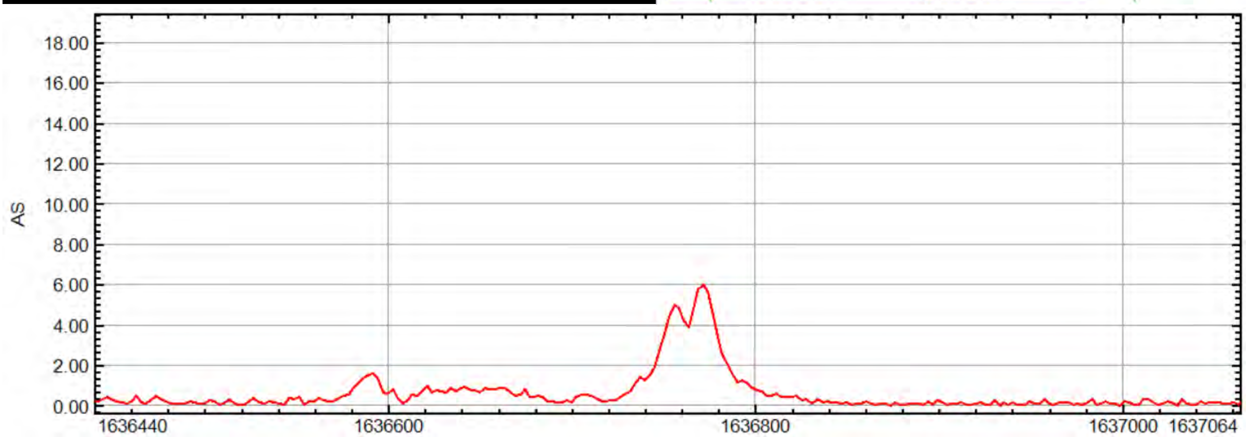
User Entered Info

Target Height >= 0.68 US Feet
Target Length21.5 US Feet
Target Shadow:6.81 US Feet
Target Width:2.5 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: SS target, not in the path of the MGA

Contact_421_02







Contact Info: Contact_421_02

- Sonar Time at Target: 05/23/2010 19:27:56
- Click Position (Lat/Lon Coordinates)
  41.3295555115 -70.5132598877 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636774.75 (Y) 120077.98
- Map Proj:
- Acoustic Source File:

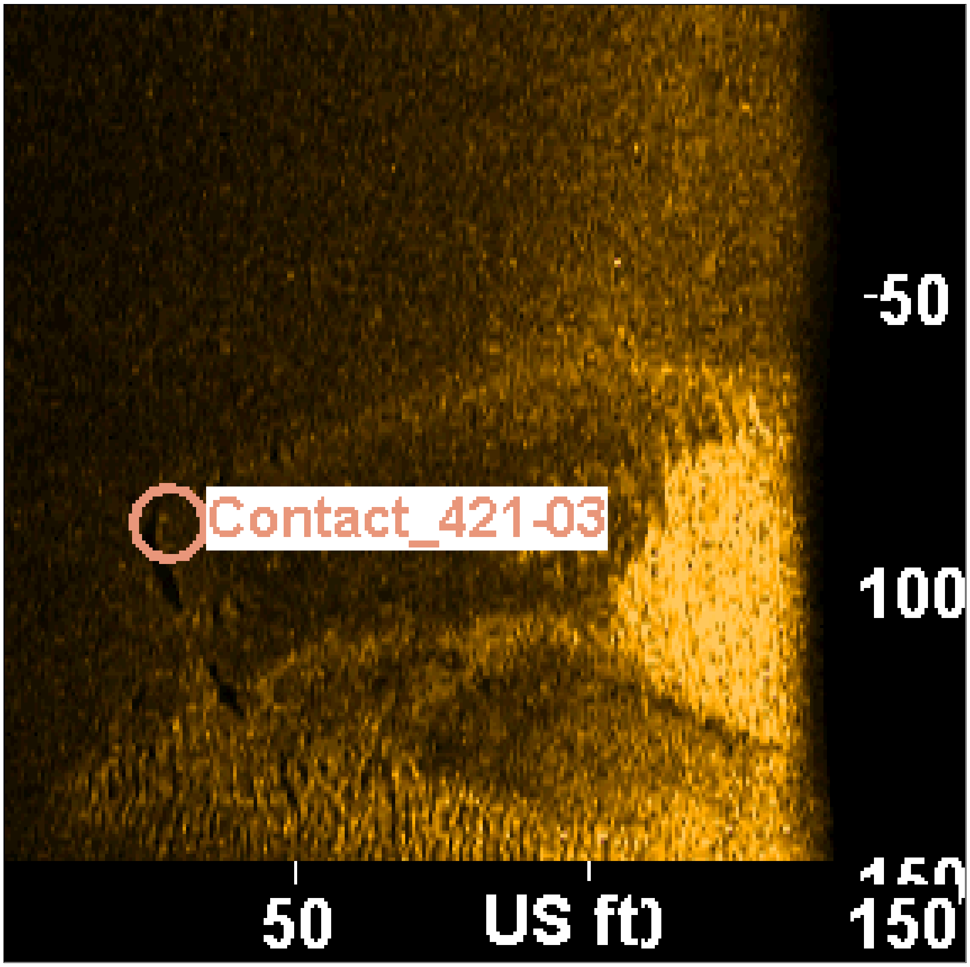
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_421_SS.000.jsf

- Ping Number: 205626
- Range to Target: 13.66 US Feet
- Fish Height: 4.45 US Feet
- Event Number: 0
- Line Name: MV_062210_421_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_421-03



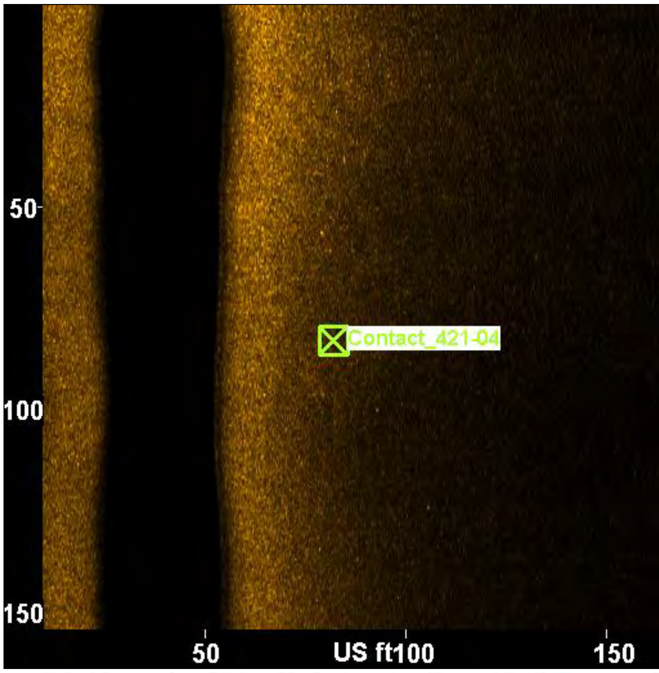
Contact Info: Contact_421-03

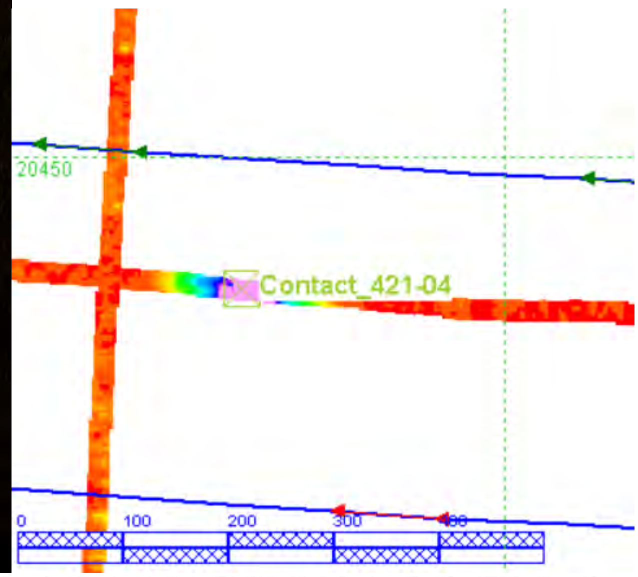
- Sonar Time at Target: 05/23/2010 19:29:05
- Click Position (Lat/Lon Coordinates)
  41.3293533325 -70.5154418945 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636174.88 (Y) 120004.95
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_421_SS.000.jsf
- Ping Number: 206556
- Range to Target: 22.54 US Feet
- Fish Height: 5.00 US Feet
- Event Number: 0
- Line Name: MV_062210_421_SS.000

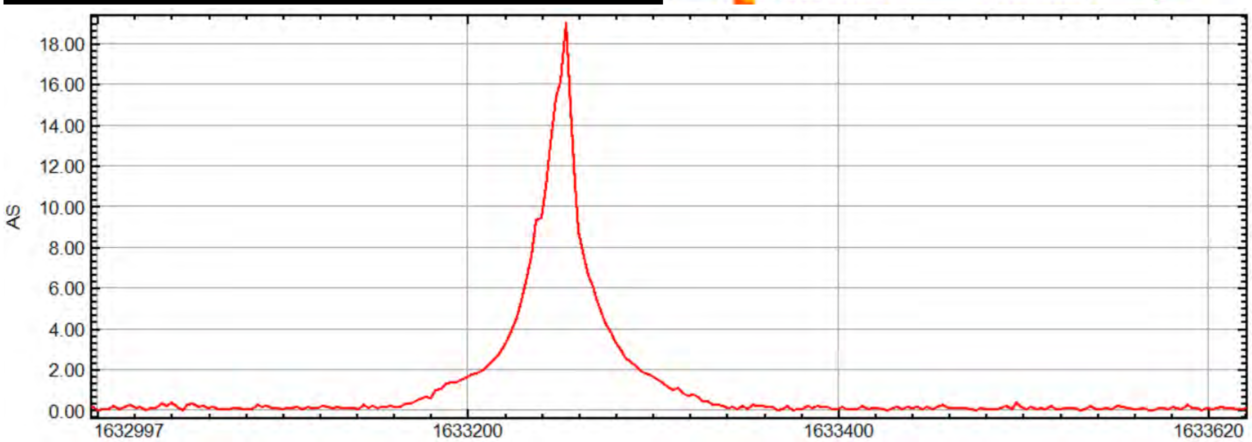
User Entered Info

Target Height >= 0.0 US Feet
Target Length36.3 US Feet
Target Shadow:0.0 US Feet
Target Width:17.8 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1: cable
Classification 2:
Area:
Block:
Description: Thin object with apparent 90deg bend. Out side of MGA coverage

Contact_421-04







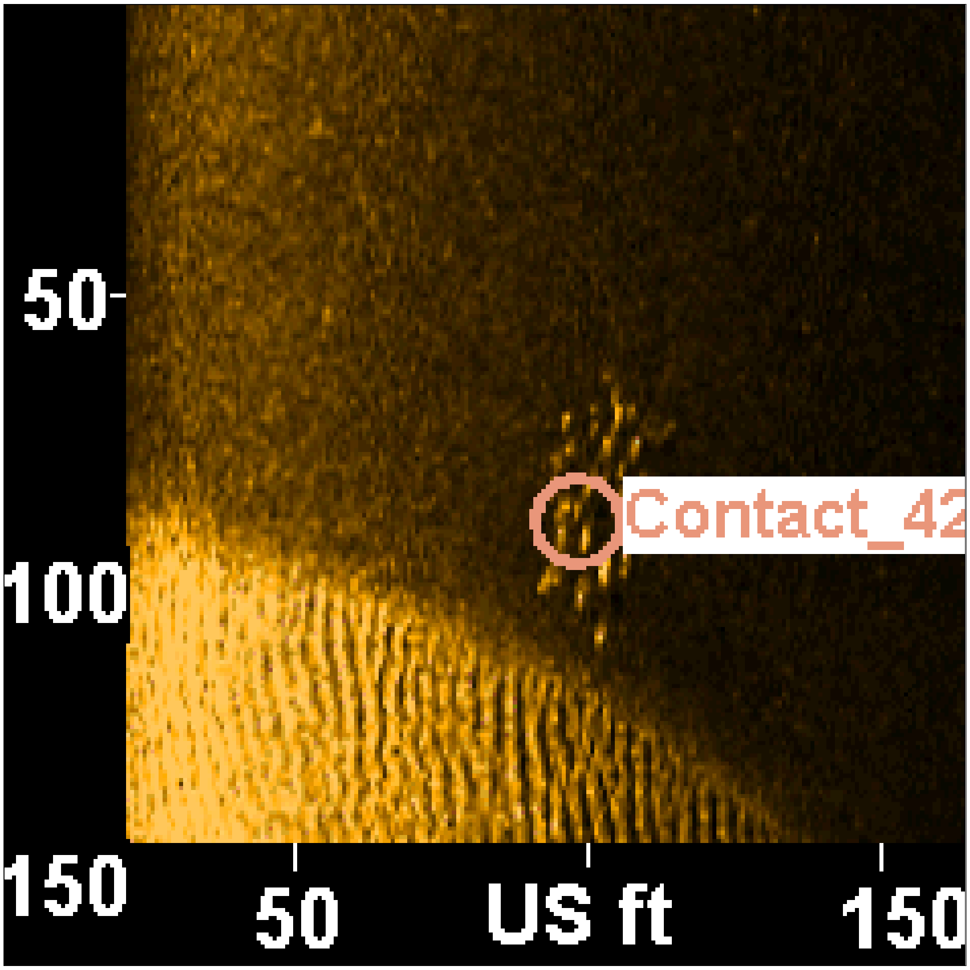
Contact Info: Contact_421-04

- Sonar Time at Target: 05/23/2010 19:34:35
- Click Position (Lat/Lon Coordinates)
  41.3302345276 -70.5260925293 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633251.38 (Y) 120326.50
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_421_SS.000.jsf
- Ping Number: 210944
- Range to Target: 12.98 US Feet
- Fish Height: 4.15 US Feet
- Event Number: 0
- Line Name: MV_062210_421_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1: cable
Classification 2:
Area:
Block:
Description:

Contact_421_05



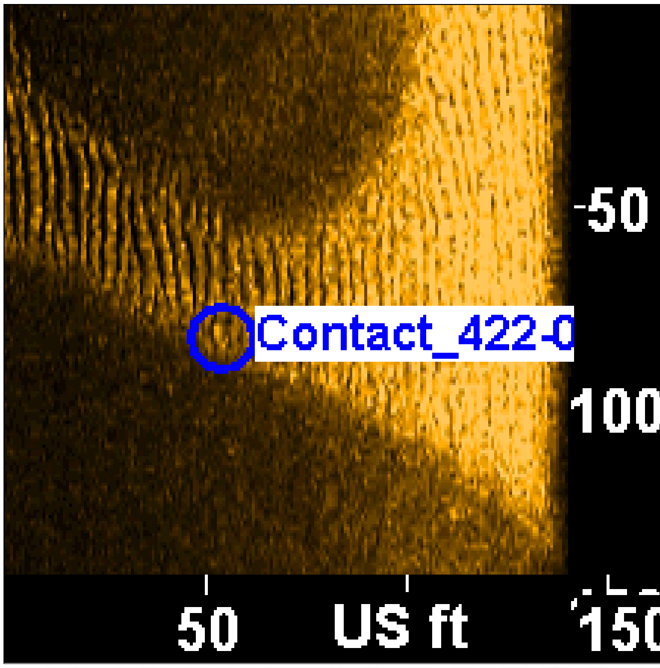
Contact Info: Contact_421_05

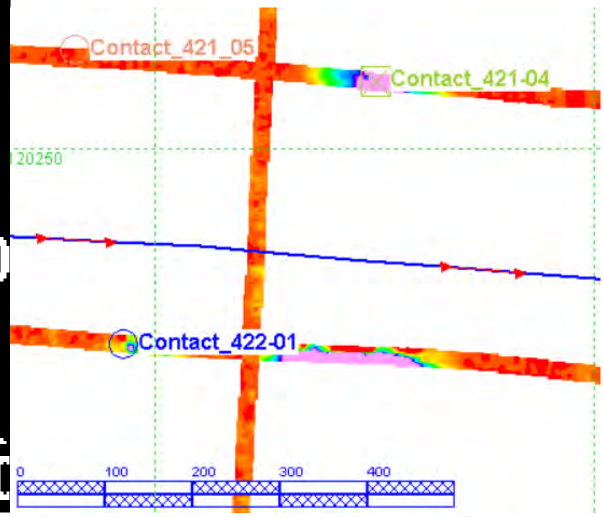
- Sonar Time at Target: 05/23/2010 19:35:14
- Click Position (Lat/Lon Coordinates)
  41.3303298950 -70.5273361206 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1632909.50 (Y) 120361.03
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_421_SS.000.jsf
- Ping Number: 211463
- Range to Target: 16.49 US Feet
- Fish Height: 4.81 US Feet
- Event Number: 0
- Line Name: MV_062210_421_SS.000

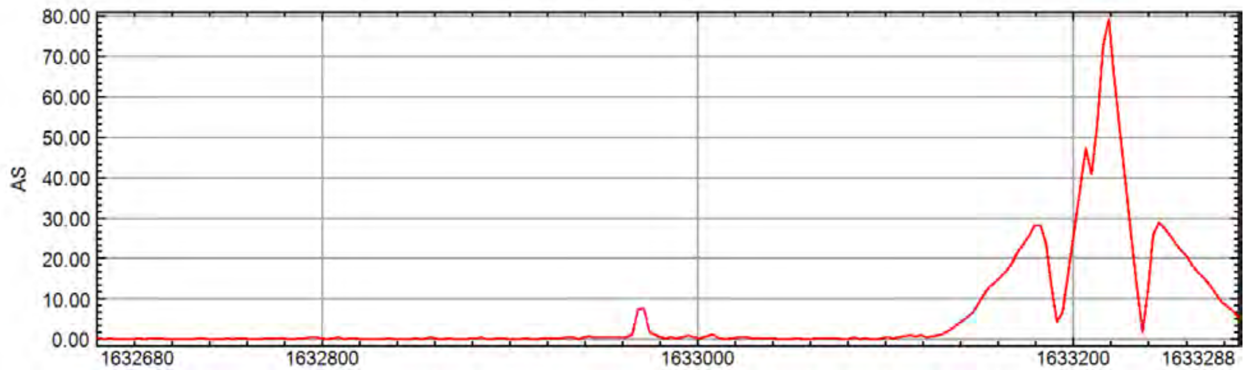
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Was in path of MGA but has no magnetic signature.

Contact_422-01







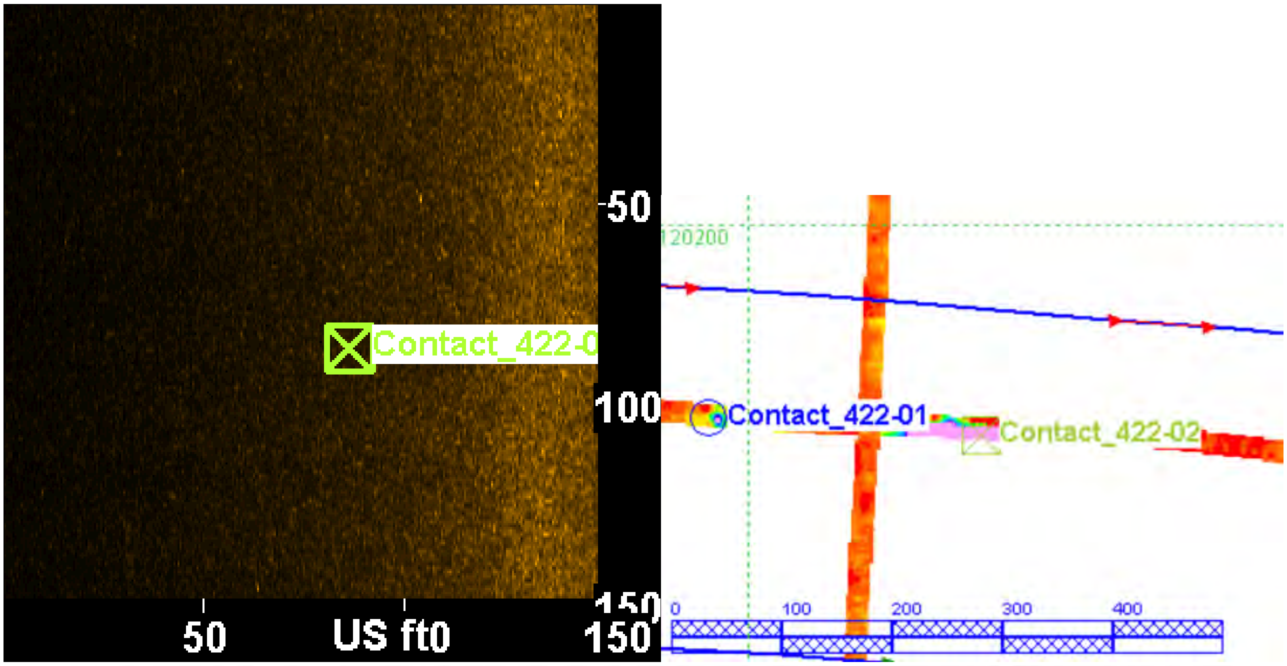
Contact Info: Contact_422-01

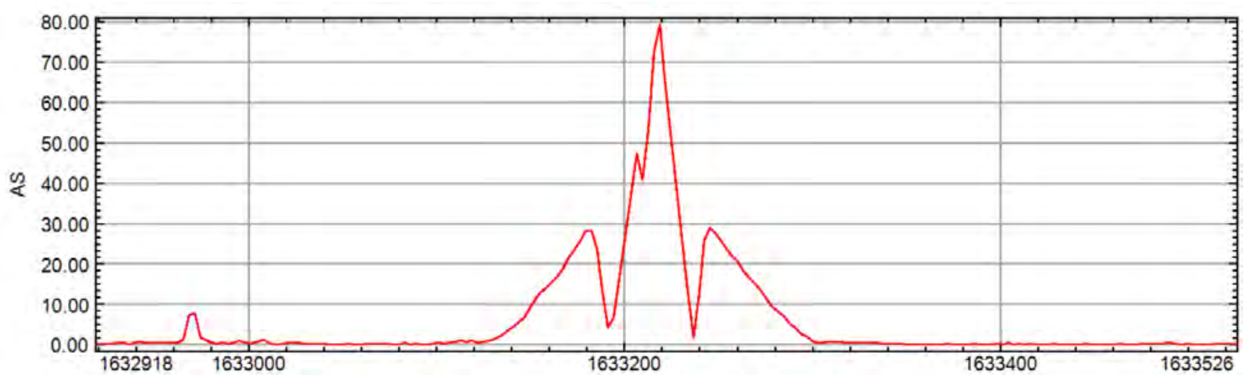
- Sonar Time at Target: 05/23/2010 18:50:20
- Click Position (Lat/Lon Coordinates)
  41.3294105530 -70.5271301270 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1632965.75 (Y) 120026.29
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_422_SS.000.jsf
- Ping Number: 175580
- Range to Target: 14.83 US Feet
- Fish Height: 4.40 US Feet
- Event Number: 0
- Line Name: MV_062210_422_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length1.8 US Feet
Target Shadow:0.0 US Feet
Target Width:0.6 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Small mag and ss anomaly

Contact_422-02





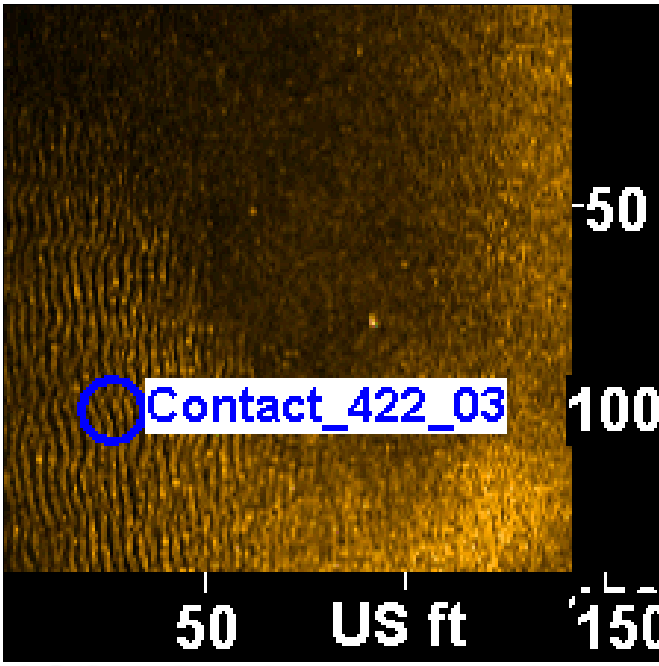
Contact Info: Contact_422-02

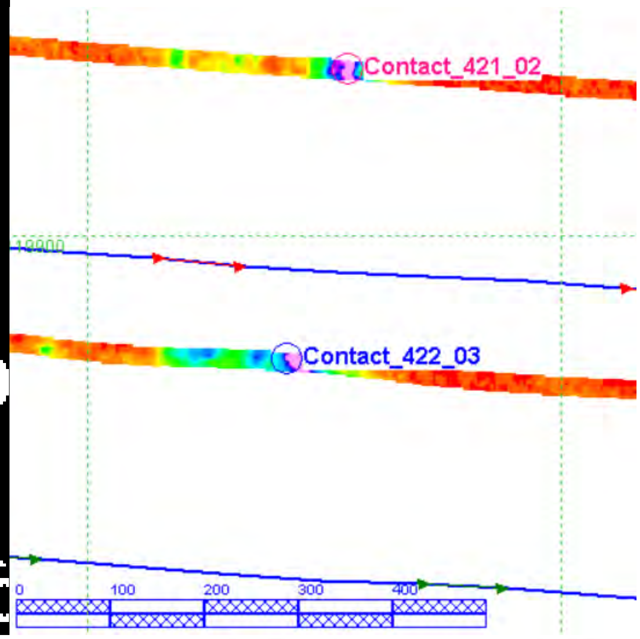
- Sonar Time at Target: 05/23/2010 18:50:50
- Click Position (Lat/Lon Coordinates)
  41.3293685913 -70.5262374878 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633209.63 (Y) 120010.44
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_422_SS.000.jsf
- Ping Number: 175985
- Range to Target: 15.71 US Feet
- Fish Height: 4.29 US Feet
- Event Number: 0
- Line Name: MV_062210_422_SS.000

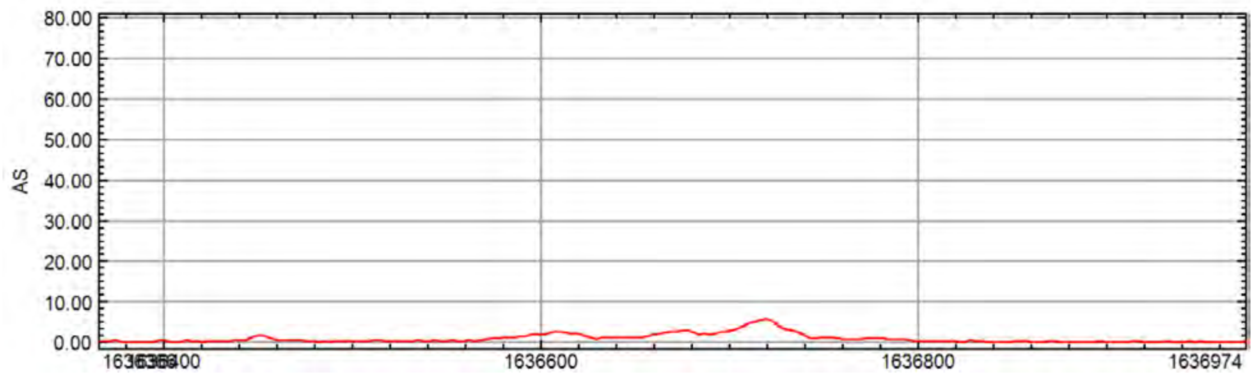
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_422_03







Contact Info: Contact_422_03

- Sonar Time at Target: 05/23/2010 18:58:14
- Click Position (Lat/Lon Coordinates)
  41.3287124634 -70.5134963989 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636710.50 (Y) 119770.38
- Map Proj:
- Acoustic Source File:

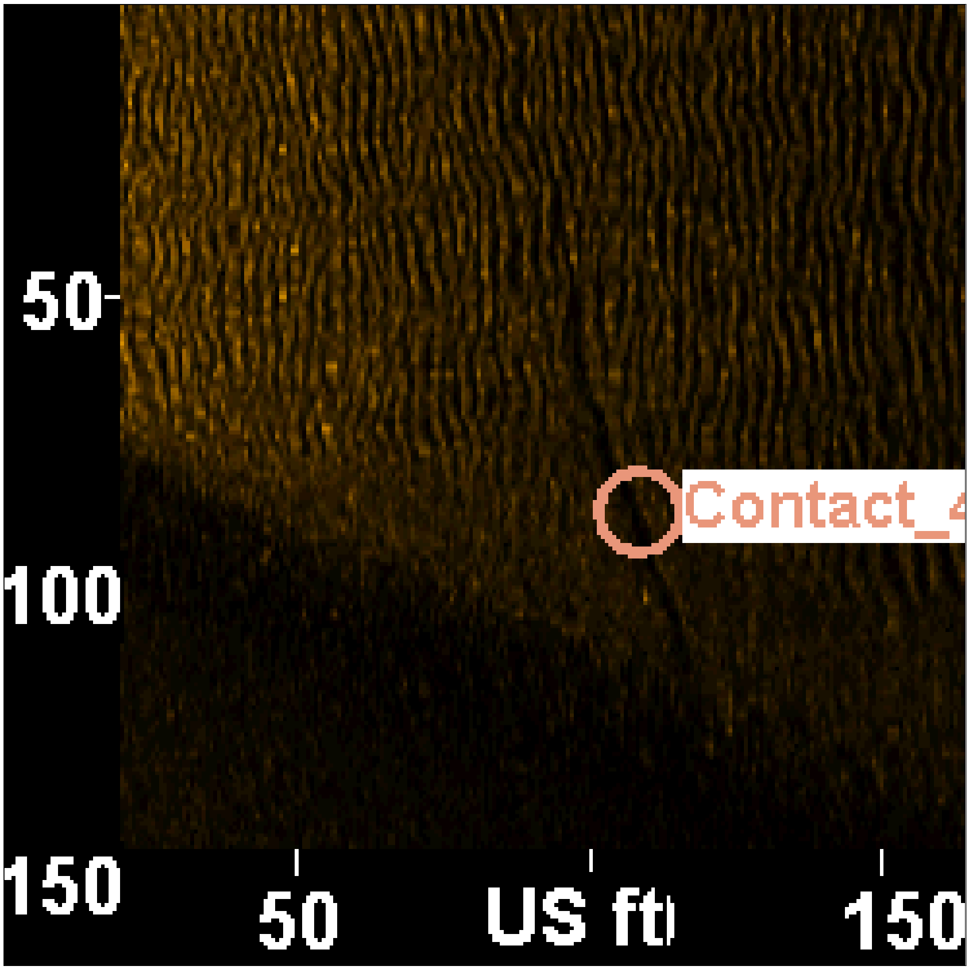
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_422_SS.000.jsf

- Ping Number: 181895
- Range to Target: 21.56 US Feet
- Fish Height: 4.40 US Feet
- Event Number: 0
- Line Name: MV_062210_422_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length1.3 US Feet
Target Shadow:0.0 US Feet
Target Width:0.7 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: SS Anomalies in area

Contact_422-04



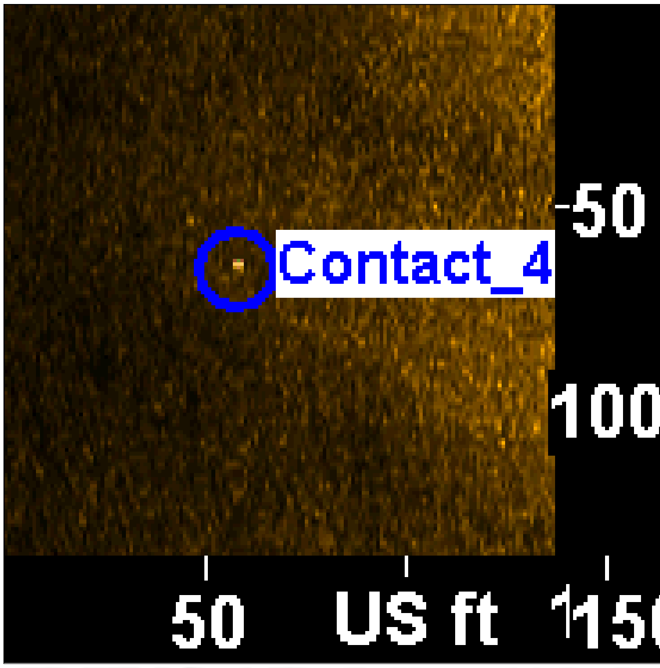
Contact Info: Contact_422-04

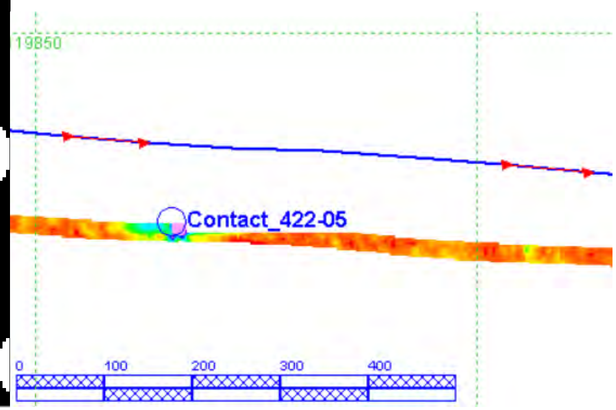
- Sonar Time at Target: 05/23/2010 18:59:55
- Click Position (Lat/Lon Coordinates)
  41.3280525208 -70.5104751587 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1637539.50 (Y) 119529.66
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_422_SS.000.jsf
- Ping Number: 183238
- Range to Target: 34.64 US Feet
- Fish Height: 4.23 US Feet
- Event Number: 0
- Line Name: MV_062210_422_SS.000

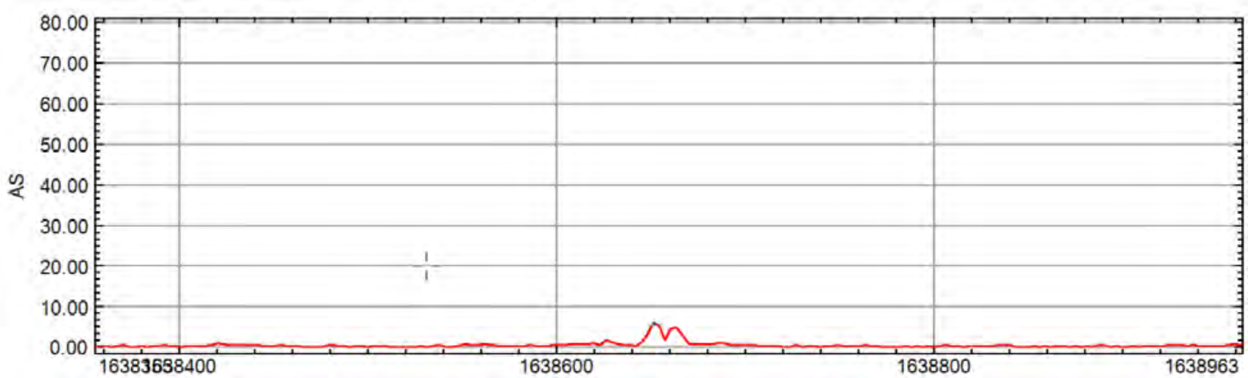
User Entered Info

Target Height >= 0.0 US Feet
Target Length37.0 US Feet
Target Shadow:0.0 US Feet
Target Width:1.1 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: In location not surveyed with MGA

Contact_422-05







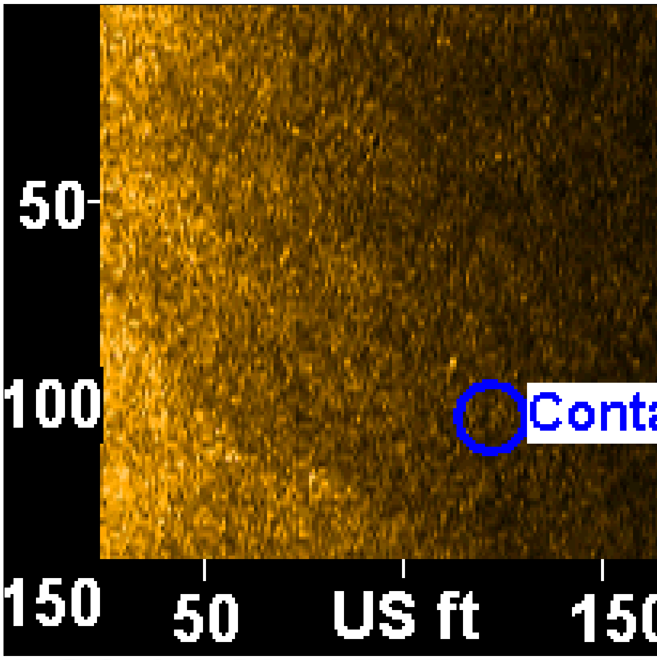
Contact Info: Contact_422-05

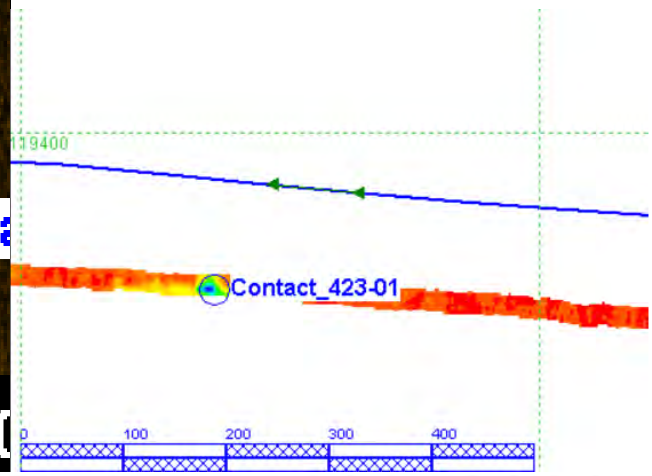
- Sonar Time at Target: 05/23/2010 19:02:07
- Click Position (Lat/Lon Coordinates)
  41.3283386230 -70.5064163208 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1638655.38 (Y) 119634.83
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_422_SS.000.jsf
- Ping Number: 184996
- Range to Target: 23.13 US Feet
- Fish Height: 4.40 US Feet
- Event Number: 0
- Line Name: MV_062210_422_SS.000

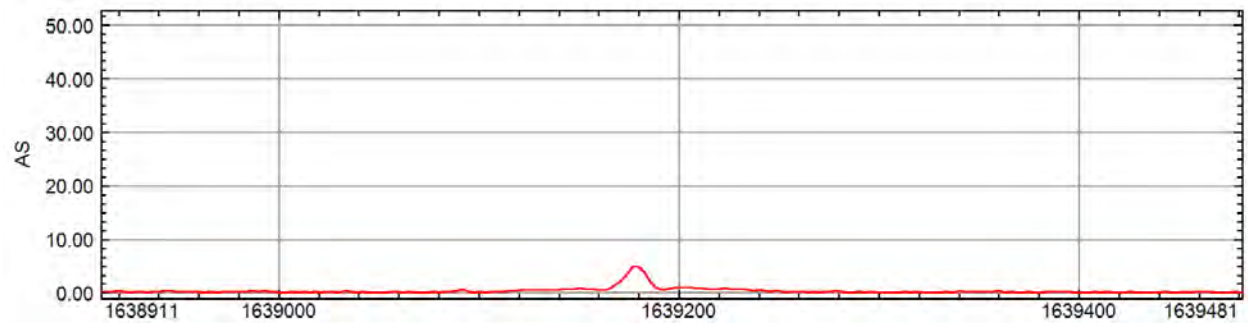
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Good mag and ss anomaly alignment

Contact_423-01







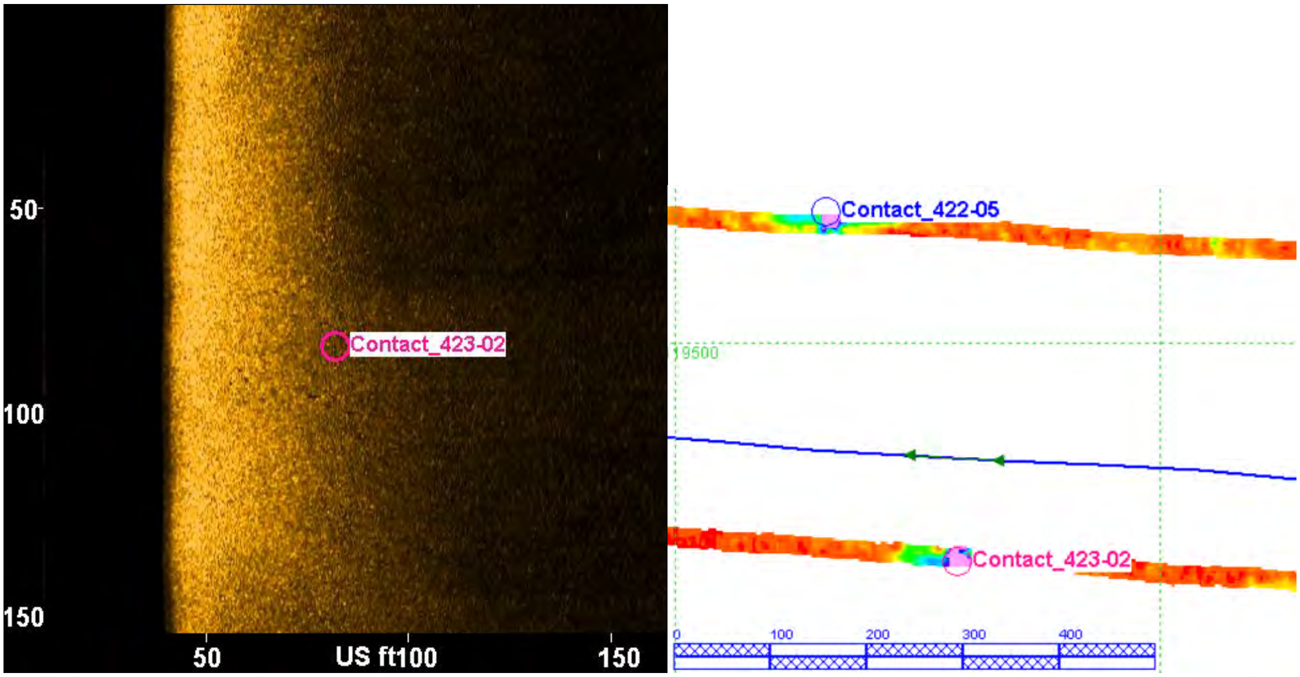
Contact Info: Contact_423-01

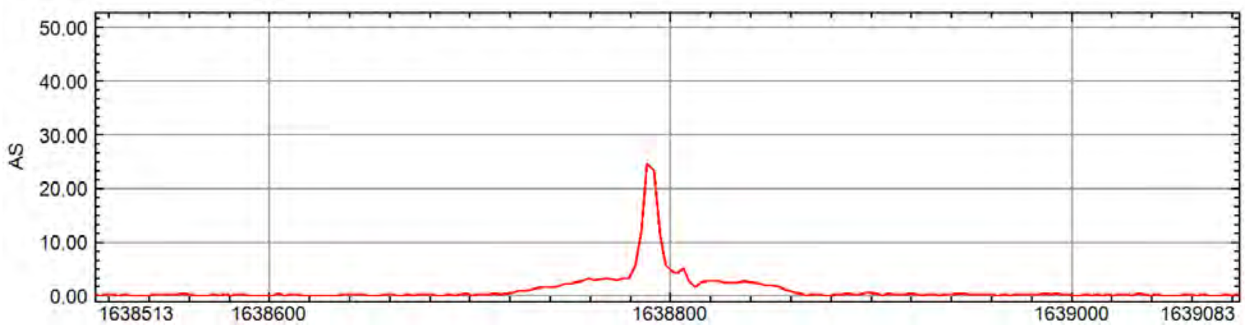
- Sonar Time at Target: 05/23/2010 18:24:02
- Click Position (Lat/Lon Coordinates)
  41.3272781372 -70.5044784546 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639187.50 (Y) 119248.33
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_423_SS.000.jsf
- Ping Number: 154570
- Range to Target: 18.25 US Feet
- Fish Height: 4.82 US Feet
- Event Number: 0
- Line Name: MV_062210_423_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_423-02





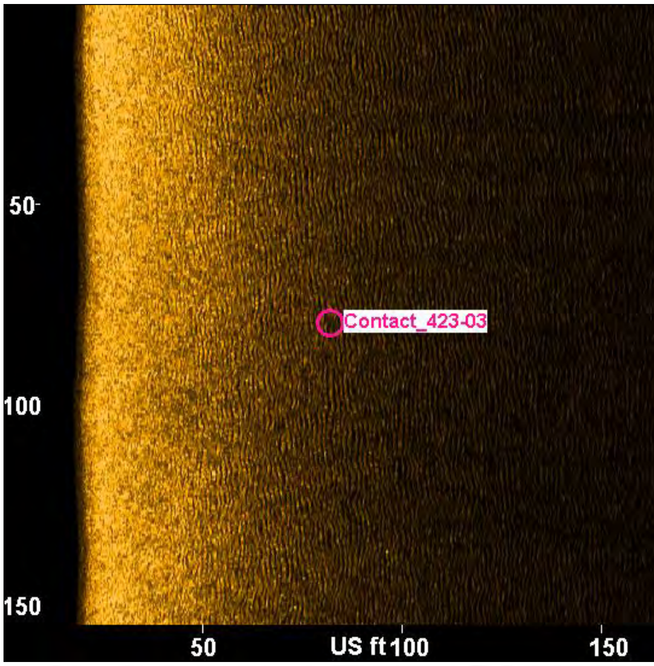
Contact Info: Contact_423-02

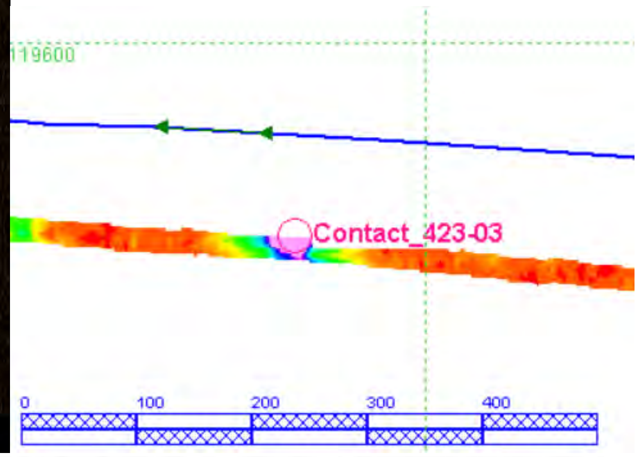
- Sonar Time at Target: 05/23/2010 18:24:49
- Click Position (Lat/Lon Coordinates)
  41.3273468018 -70.5059127808 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1638791.63 (Y) 119273.21
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_423_SS.000.jsf
- Ping Number: 155195
- Range to Target: 17.47 US Feet
- Fish Height: 4.73 US Feet
- Event Number: 0
- Line Name: MV_062210_423_SS.000

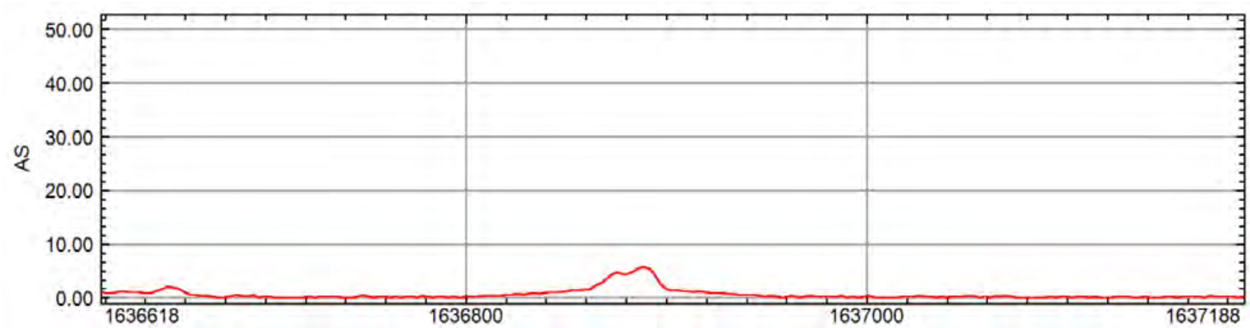
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_423-03







Contact Info: Contact_423-03

- Sonar Time at Target: 05/23/2010 18:28:36
- Click Position (Lat/Lon Coordinates)
  41.3277854919 -70.5128479004 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636888.00 (Y) 119433.63
- Map Proj:
- Acoustic Source File:

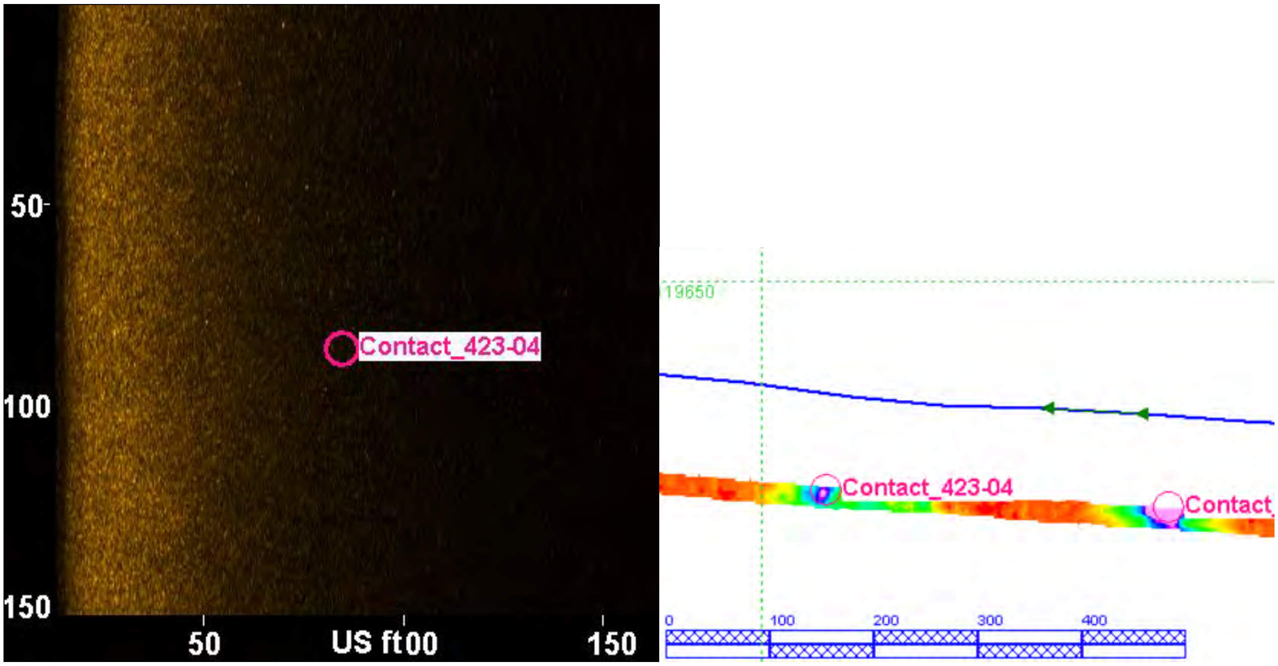
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_423_SS.000.jsf

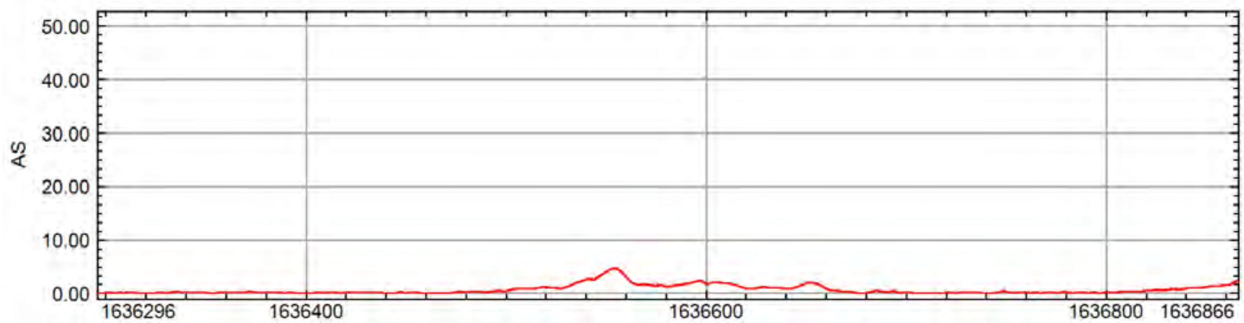
- Ping Number: 158214
- Range to Target: 23.61 US Feet
- Fish Height: 4.30 US Feet
- Event Number: 0
- Line Name: MV_062210_423_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_423-04





Contact Info: Contact_423-04

- Sonar Time at Target: 05/23/2010 18:29:16
- Click Position (Lat/Lon Coordinates)
  41.3278312683 -70.5140380859 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636561.13 (Y) 119450.06
- Map Proj:
- Acoustic Source File:

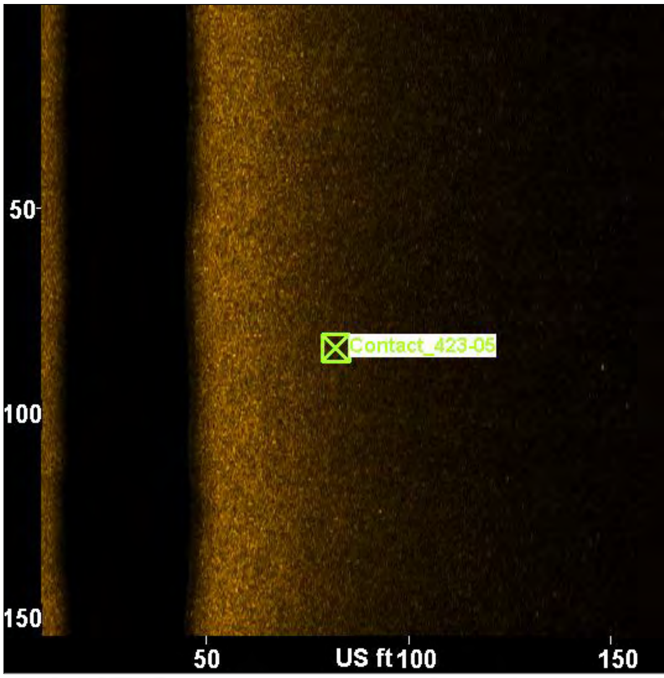
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_423_SS.000.jsf

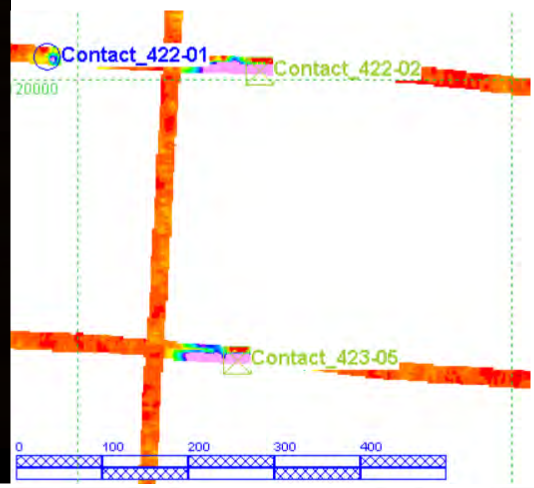
- Ping Number: 158751
- Range to Target: 22.15 US Feet
- Fish Height: 4.25 US Feet
- Event Number: 0
- Line Name: MV_062210_423_SS.000

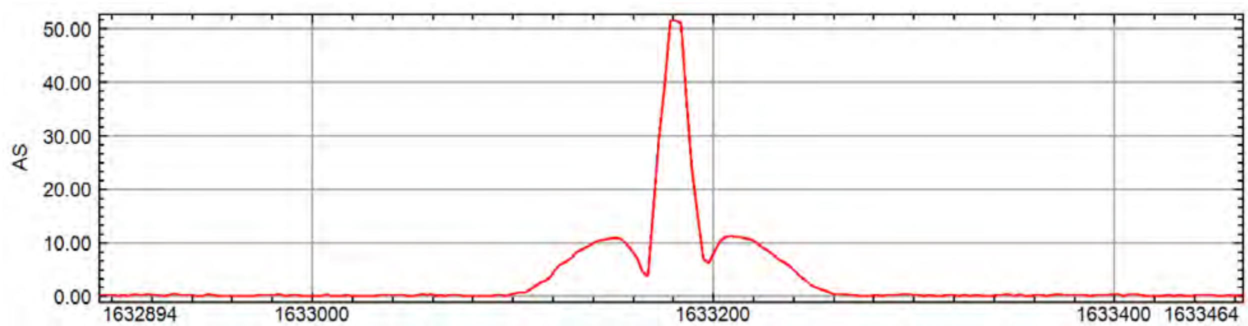
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_423-05







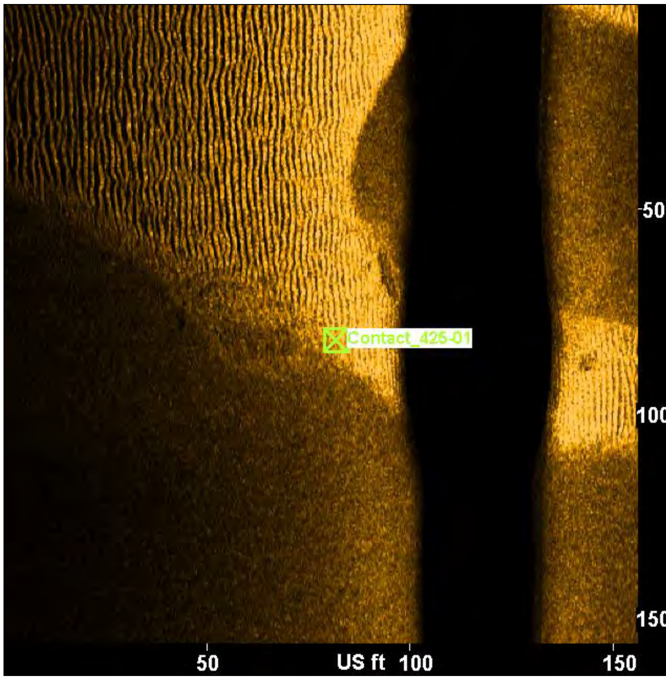
Contact Info: Contact_423-05

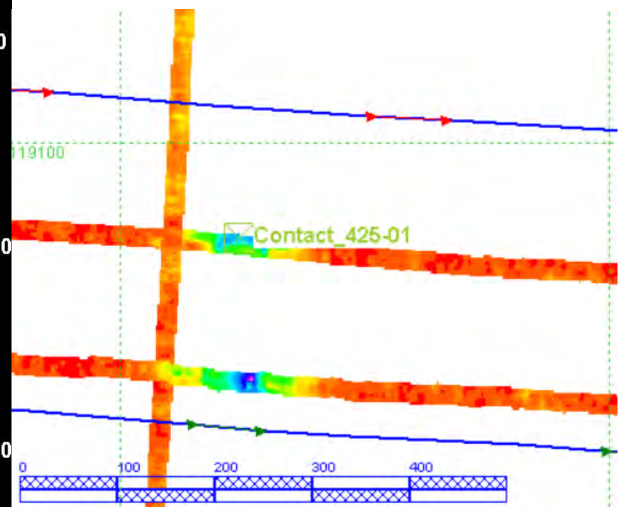
- Sonar Time at Target: 05/23/2010 18:35:58
- Click Position (Lat/Lon Coordinates)
  41.3284568787 -70.5263366699 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633183.63 (Y) 119678.13
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_423_SS.000.jsf
- Ping Number: 164099
- Range to Target: 15.61 US Feet
- Fish Height: 4.63 US Feet
- Event Number: 0
- Line Name: MV_062210_423_SS.000

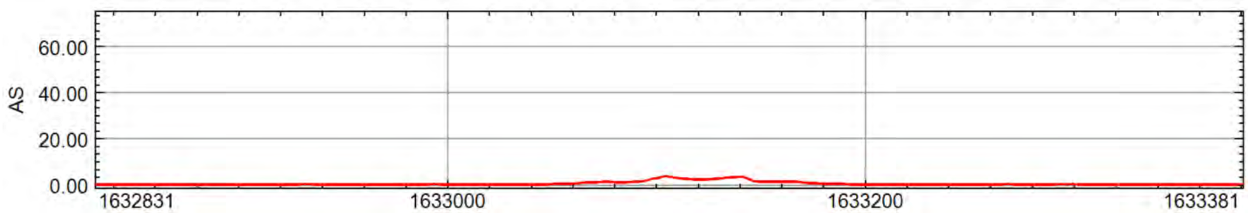
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-01







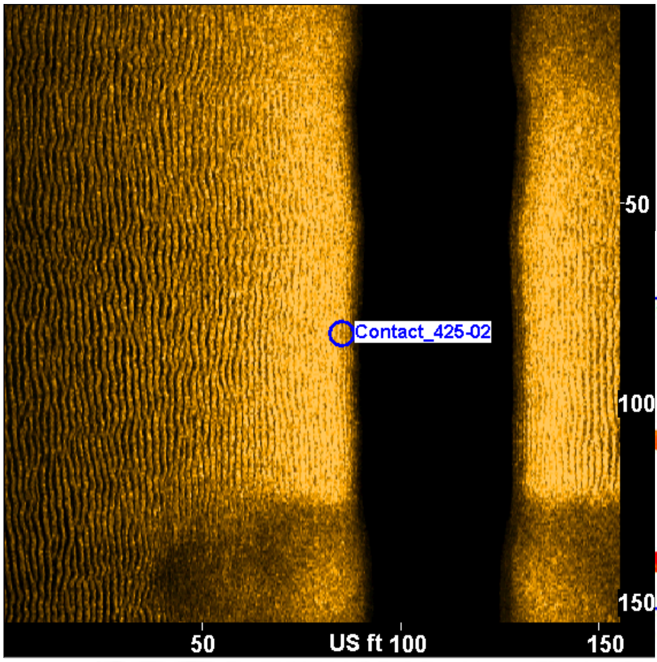
Contact Info: Contact_425-01

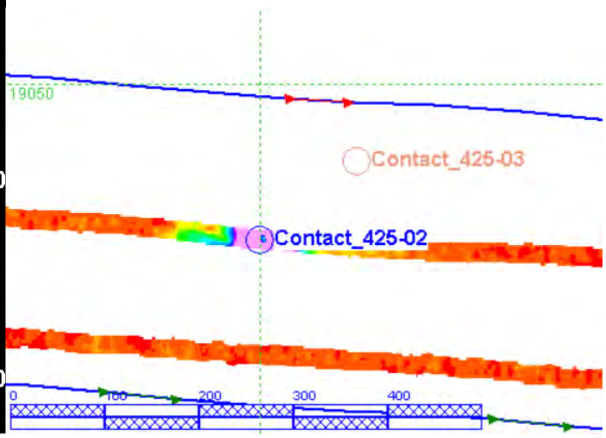
- Sonar Time at Target: 05/23/2010 17:51:06
- Click Position (Lat/Lon Coordinates)
  41.3266029358 -70.5265655518 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1633121.00 (Y) 119002.92
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 128245
- Range to Target: 10.73 US Feet
- Fish Height: 5.66 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

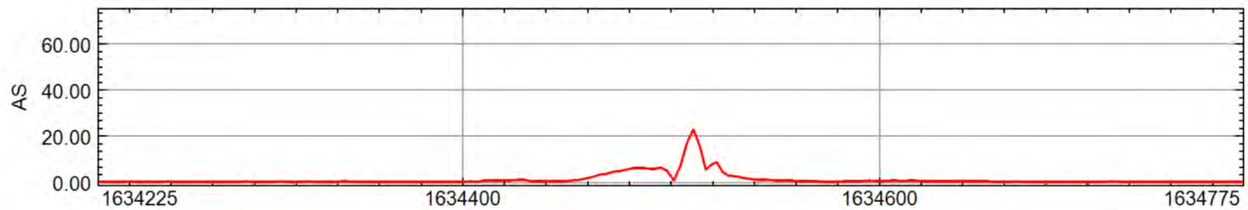
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-02







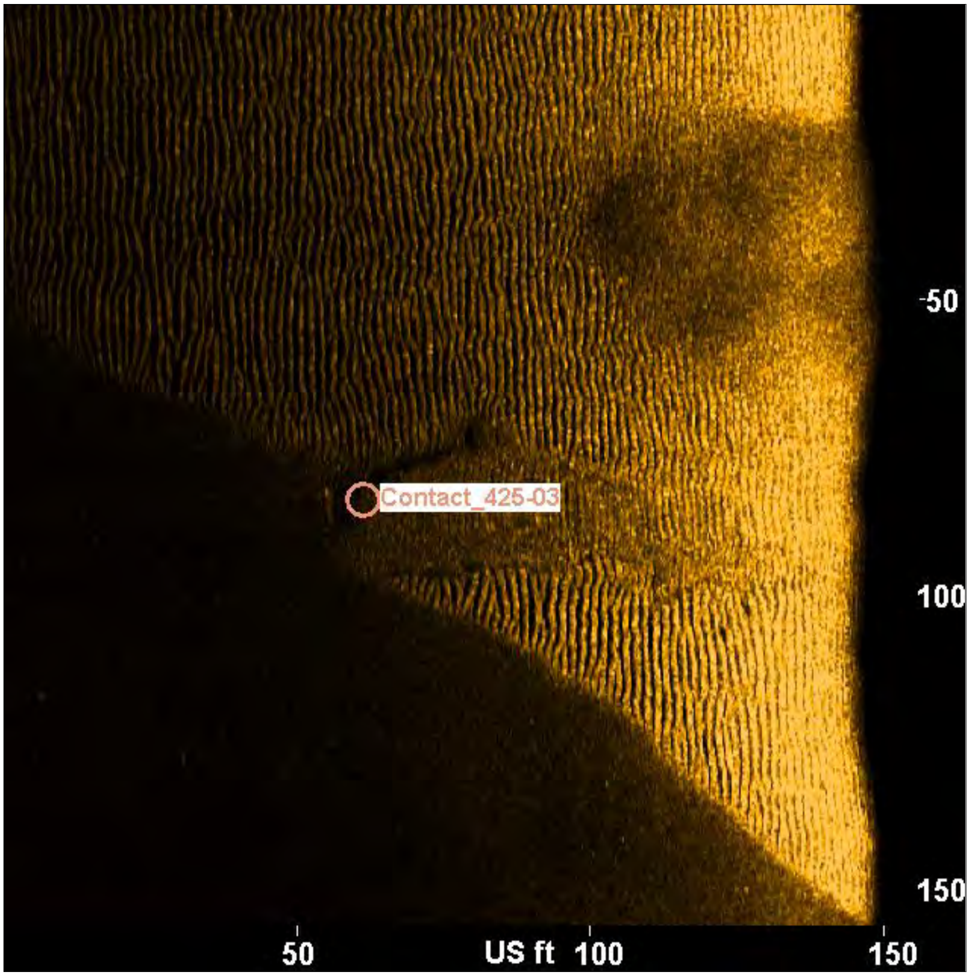
Contact Info: Contact_425-02

- Sonar Time at Target: 05/23/2010 17:54:18
- Click Position (Lat/Lon Coordinates)
  41.3262786865 -70.5215377808 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1634500.88 (Y) 118884.61
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 130804
- Range to Target: 6.64 US Feet
- Fish Height: 5.52 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-03



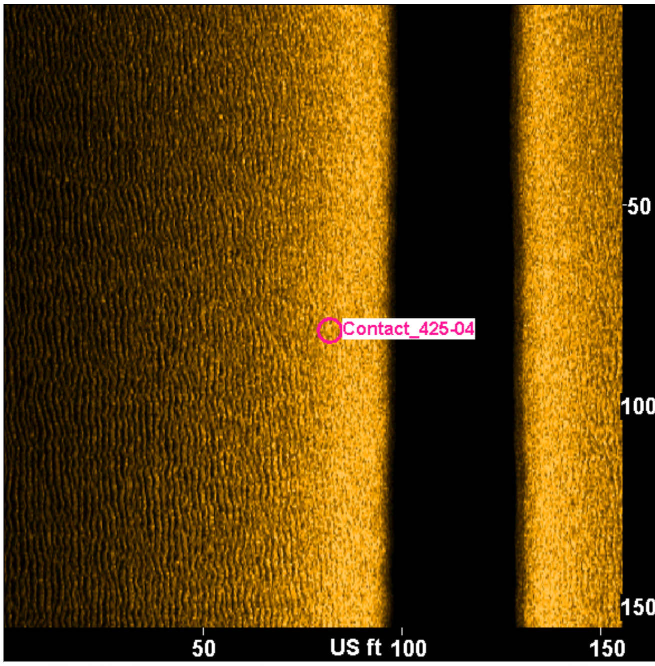
Contact Info: Contact_425-03

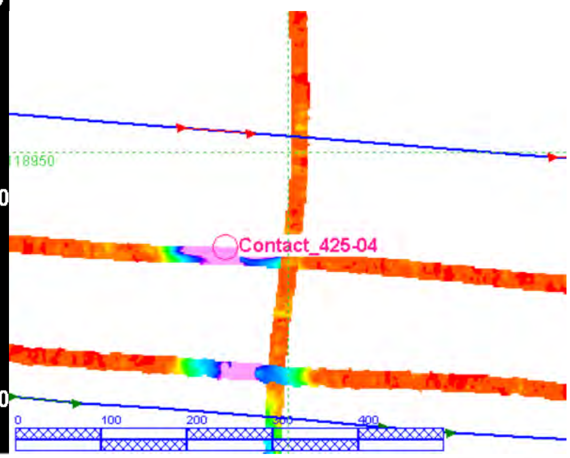
- Sonar Time at Target: 05/23/2010 17:54:33
- Click Position (Lat/Lon Coordinates)
  41.3265075684 -70.5211639404 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1634603.50 (Y) 118967.89
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 131002
- Range to Target: 31.32 US Feet
- Fish Height: 5.46 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

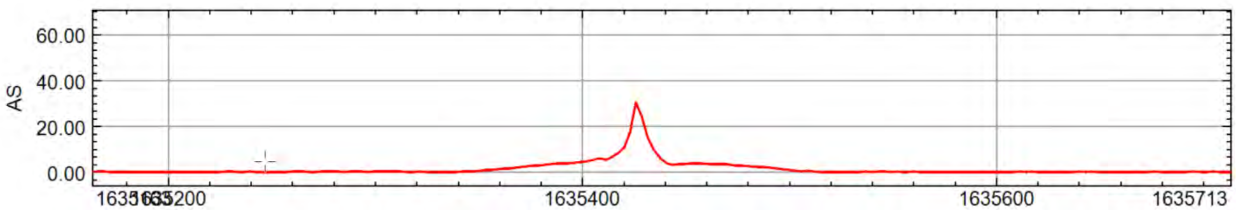
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: Anomalous SS texture outside of MGA swath

Contact_425-04







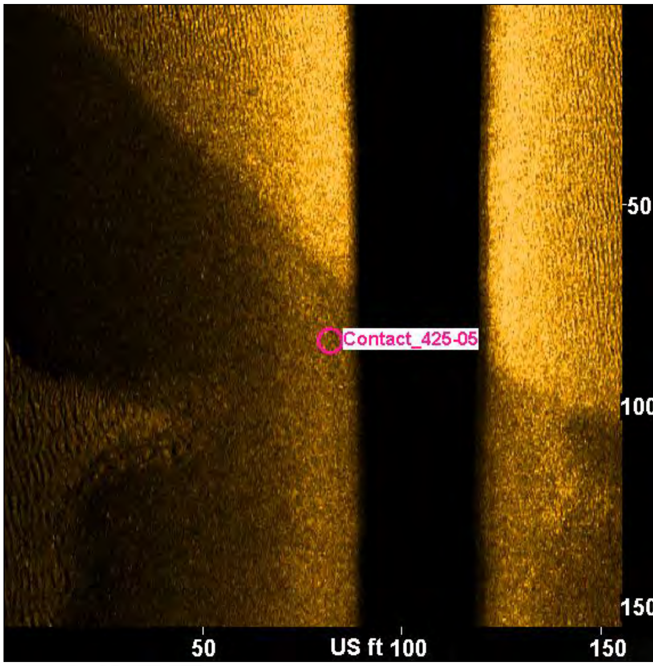
Contact Info: Contact_425-04

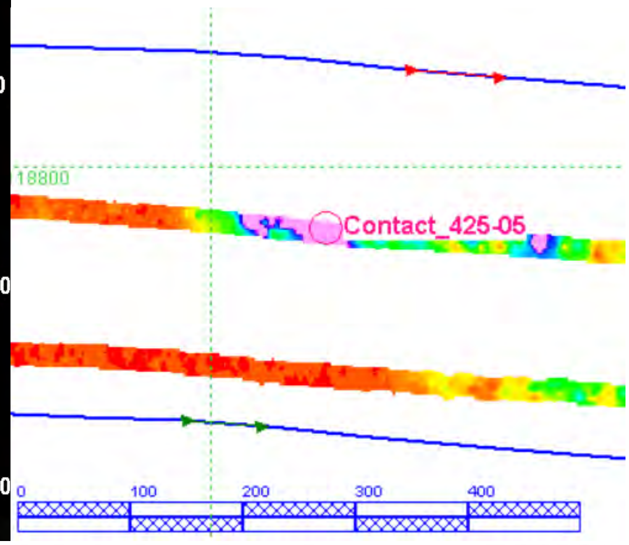
- Sonar Time at Target: 05/23/2010 17:56:26
- Click Position (Lat/Lon Coordinates)
  41.3261528015 -70.5181655884 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1635427.88 (Y) 118838.55
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 132512
- Range to Target: 9.56 US Feet
- Fish Height: 4.63 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

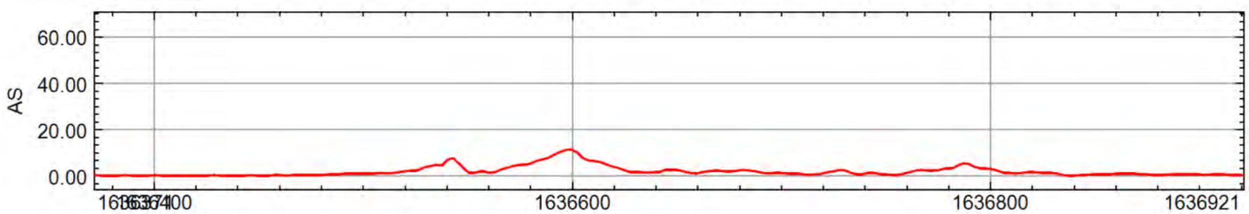
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-05







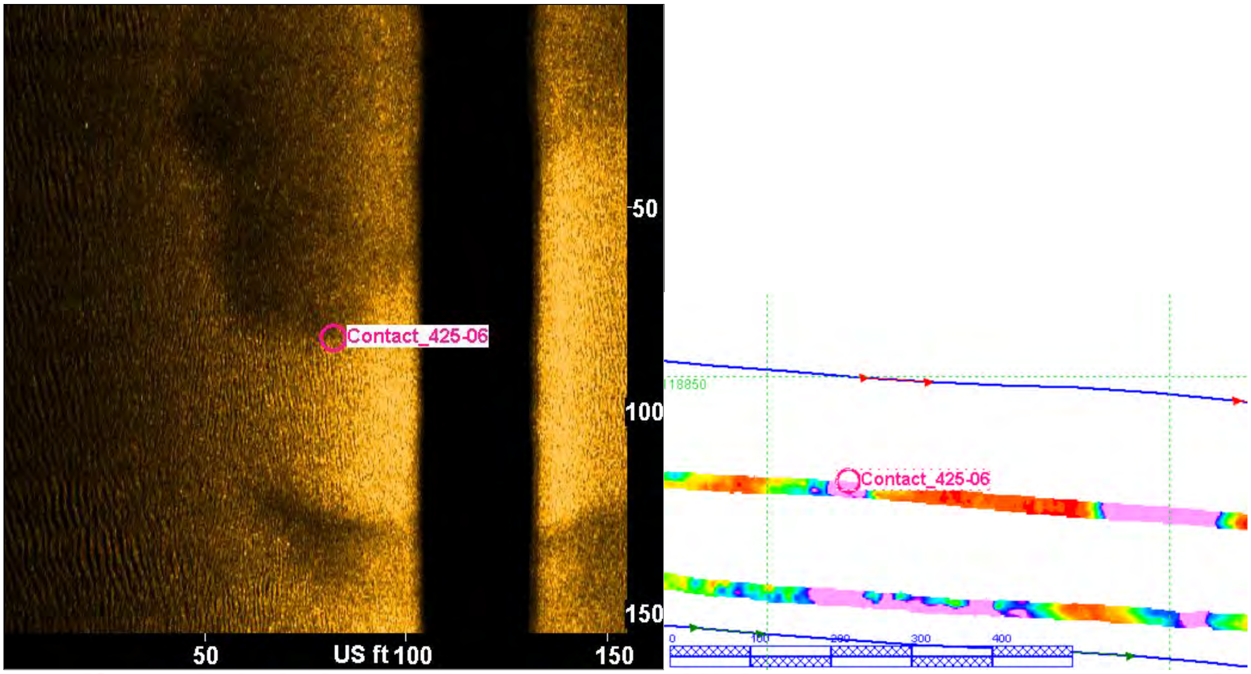
Contact Info: Contact_425-05

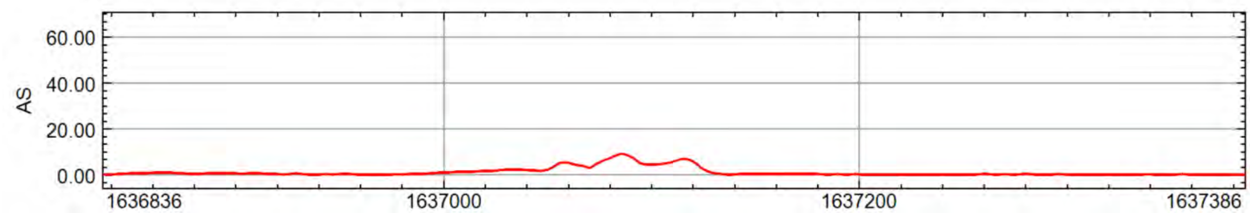
- Sonar Time at Target: 05/23/2010 17:59:06
- Click Position (Lat/Lon Coordinates)
  41.3258972168 -70.5138854980 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1636602.50 (Y) 118745.39
- Map Proj:
- Acoustic Source File:
  Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 134645
- Range to Target: 6.83 US Feet
- Fish Height: 4.64 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-06





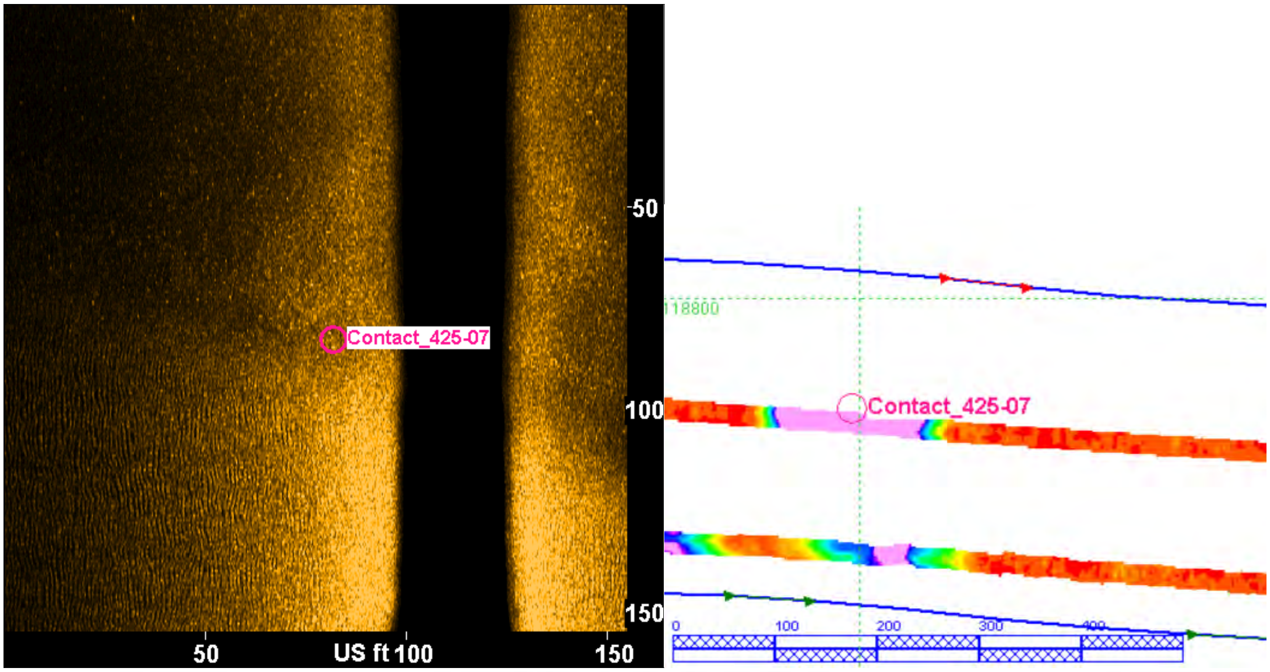
Contact Info: Contact_425-06

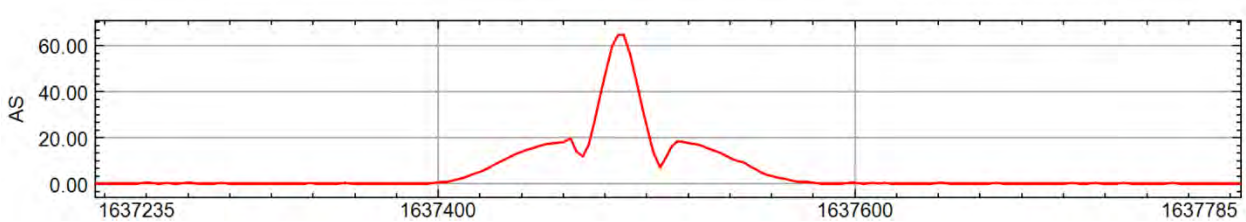
- Sonar Time at Target: 05/23/2010 18:00:12
- Click Position (Lat/Lon Coordinates)
  41.3258285522 -70.5120697021 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1637101.63 (Y) 118719.85
- Map Proj:
- Acoustic Source File:
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf
- Ping Number: 135518
- Range to Target: 10.93 US Feet
- Fish Height: 4.12 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-07





Contact Info: Contact_425-07

- Sonar Time at Target: 05/23/2010 18:01:02
- Click Position (Lat/Lon Coordinates)
  41.3257522583 -70.5106506348 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1637492.13 (Y) 118692.13
- Map Proj:
- Acoustic Source File:

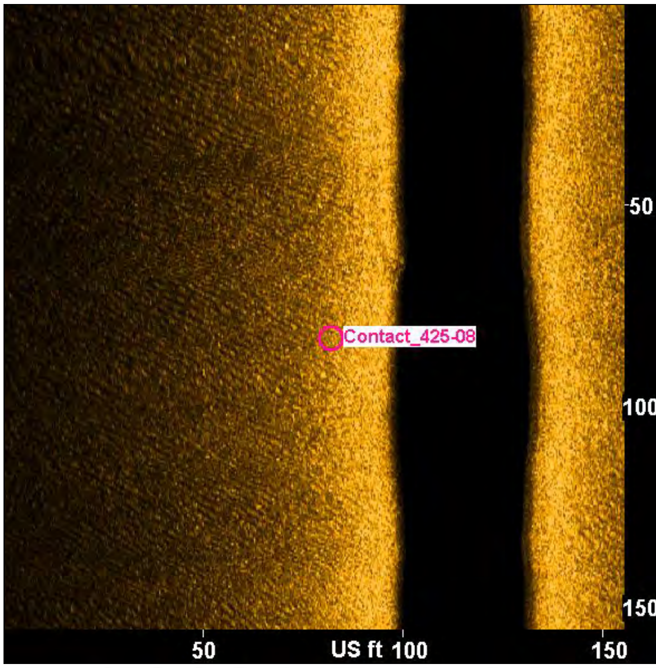
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf

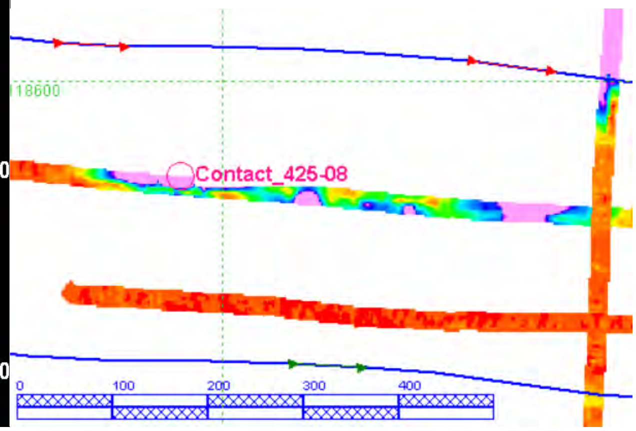
- Ping Number: 136186
- Range to Target: 9.17 US Feet
- Fish Height: 3.75 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

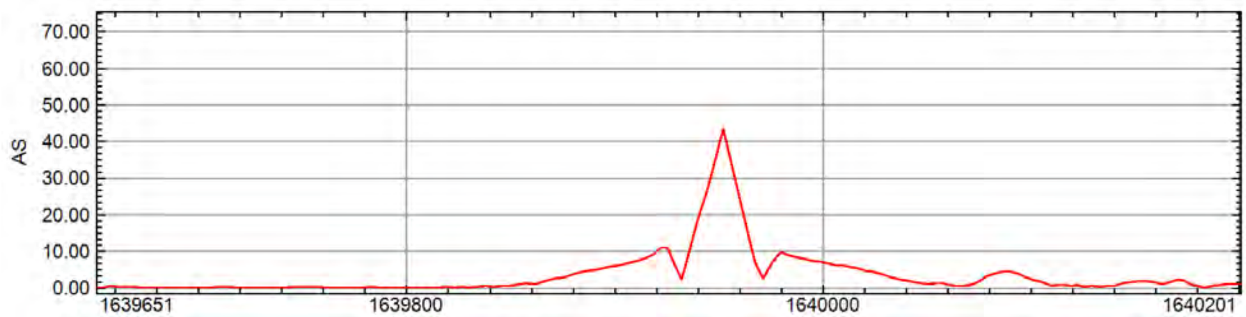
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-08







Contact Info: Contact_425-08

- Sonar Time at Target: 05/23/2010 18:06:24
- Click Position (Lat/Lon Coordinates)
  41.3252334595 -70.5016708374 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1639957.13 (Y) 118502.15
- Map Proj:
- Acoustic Source File:

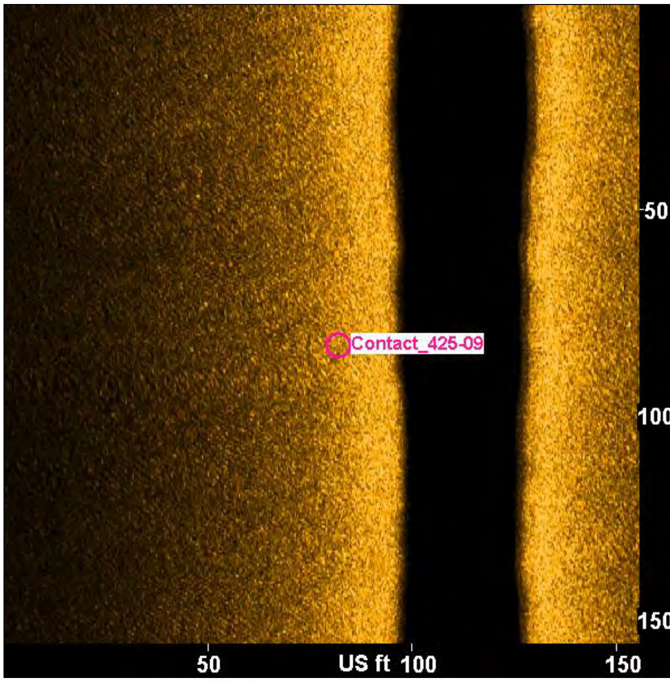
Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf

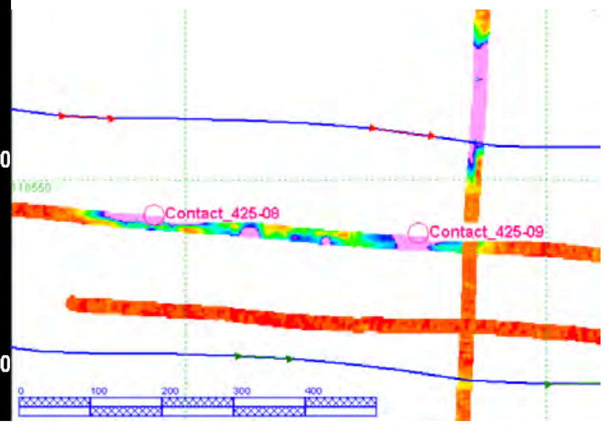
- Ping Number: 140477
- Range to Target: 10.15 US Feet
- Fish Height: 5.01 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

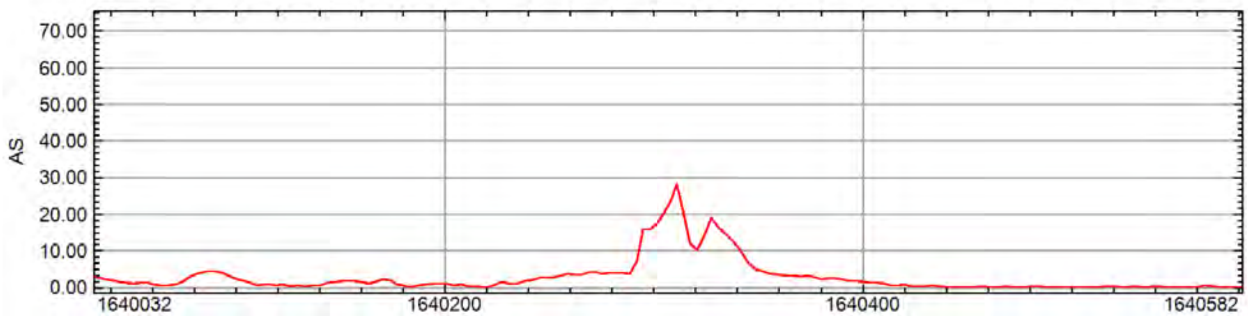
User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Contact_425-09







Contact Info: Contact_425-09

- Sonar Time at Target: 05/23/2010 18:07:15
- Click Position (Lat/Lon Coordinates)
  41.3251609802 -70.5003433228 (WGS84)
- Click Position (Projected Coordinates)
  (X) 1640323.38 (Y) 118476.05
- Map Proj:
- Acoustic Source File:

Z:\Marthas_Vineyard_June_2010\Sidescan\MV_062210\MV_062210_425_SS.000.jsf

- Ping Number: 141152
- Range to Target: 9.27 US Feet
- Fish Height: 4.53 US Feet
- Event Number: 0
- Line Name: MV_062210_425_SS.000

User Entered Info

Target Height >= 0.0 US Feet
Target Length0.0 US Feet
Target Shadow:0.0 US Feet
Target Width:0.0 US Feet
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description: