SUBBOTTOM PROFILER DATA PROCESSING AND ANALYSIS

Post-processing of subbottom profiler data is done with SonarWiz.MAP, which in this case enables the user to view the subbottom data in a planar, trackline format. The user may view the data in a digitizer window as a waterfall format, allowing the digitizing of subbottom features of interest, linear extent, depth, and type. SonarWiz.MAP batch processes waterfall images to *.JPG formats in order to generate figures (Figure 27). Sidescan mosaics and the contact databases are exported to the GIS database as *.SHP files. Hyscan also allows the user to calculate the amount of sonar coverage and illuminate gaps to ensure full coverage of the project area.

For the presence of a wreck, expectation in the subbottom record would be high amplitude returns as wood components, in a constrained pattern, coincident with the magnetometer contours. Work in the United Kingdom with remote sensing of known wreck sites indicate that wooden wrecks may be imaged by a suitable subbottom profiler operating under appropriate survey conditions. They showed the buried wreck structure of *Invincible* as a high amplitude reflector (dark returns compared to the surrounding sediments) including structural angles in some passes (Quinn et al. 1997; 1998). They note that "owing to the nature of seismic data acquisition, the ability to image wooden artifacts is dependent not only upon the acoustic impedance contrast that exists between the artifact and the burial sediment, but also upon the size of the target."

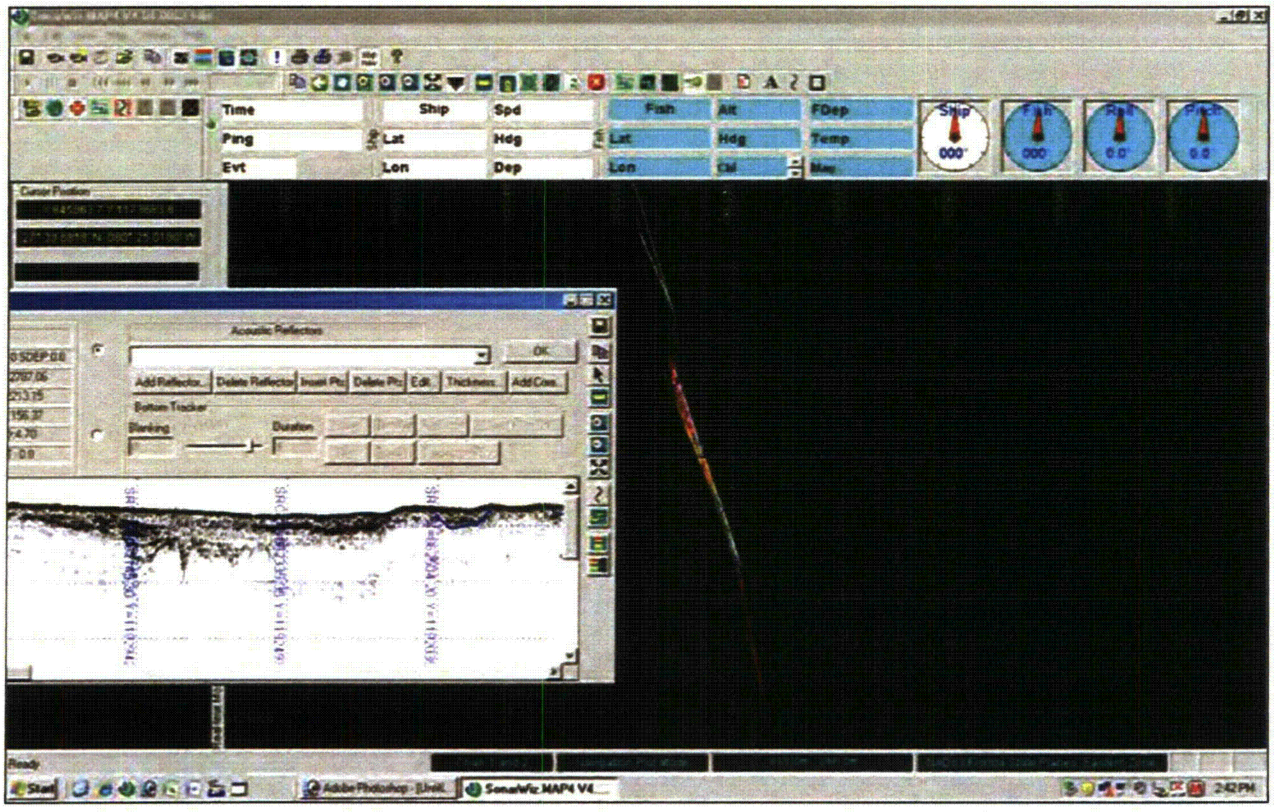

Figure 27. SonarWiz.MAP Subbottom waterfall example image showing the seismic profile-digitizing window.

Subbottom profilers generate low frequency acoustic waves that are capable of penetrating the seabed and then reflecting off boundaries or objects within the subsurface. These returns are received by hydrophone or hydrophone array operated in close proximity to the source. The data are then processed and reproduced as a cross section scaled in two-way travel time (the time taken for the pulse to travel from the source to the reflector and back to the receiver). This travel time can then be interpolated to depth in the sediment column by reference to the travel time of the sound down (averaging 1,500 meters-per-second) and forward (speed of the vessel).

These seismic cross sections can be studied visually and the shapes and extent of reflectors used to identify bottom and subbottom profile characteristics. In general, high and low amplitude reflectors (light and dark returns) distinguish between stratigraphic beds; parabolic returns indicate point-source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channels systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features).

Seismic stratigraphy is a form of stratigraphic correlation. The reflection characteristics (e.g., as amplitude, continuity, wipeout [erosion], and bedform geometry) of regional unconformities and strata surfaces are used to estimate rock or sediment properties, facies relationships and some stratigraphic details to infer structural evolution and paleo-environmental histories (Mitchum et al. 1977; Vail et al. 1977).

There are five types of spurious signals that may cause confusion in the two dimensional records: direct arrivals from the sound source, water surface reflection, side echoes, reflection multiples, and point source reflections. Judicious analysis is required to suspect them. This is particularly true when the bottom or subbottom being traversed has considerable deformation or point source anomalies.

Subbottom in the Identification of Shipwreck Sites

Previous research (Quinn et al. 1997, 1998) has shown that wooden wreckage can be recognized, dependent on the type of wood (hard woods better), size of the remains, and context (sand or silt, etc.). The strategy for identifying historic wrecks was to identify seismic features in the strata that might be coincident with magnetometer fluctuations, and thus indicate buried wreckage. In addition, the subbottom profiler record includes data on precise depth to bottom, and so can be used to reconstruct bathymetry.

This output record is a visual representation of density differences in the geologic bed and sound wave velocity of the device. In general, high and low amplitude reflectors (light and dark returns) distinguish between stratigraphic beds; parabolic and "spot" returns indicate point-source objects of sufficient size to be sensed by the wavelength and frequency of the power source. Erosional or non-depositional contacts can be identified by discontinuities in extent, slope angle, and shape of the reflector returns. This latter fact is important when identifying drowned channels systems and other relict and buried fluvial system features (e.g., estuarine, tidal, lowland, upland areas around drainage features), but not necessarily of value with respect to shipwreck remains.

Wooden objects of sufficient density and size can be sensed with CHIRP systems, but the image is dependent on "the orientation of the incident compression wave relative to the axis of the woods elastic symmetry cellular structure" (Quinn et al. 1997:27). In other words, the ability of the sensor to detect buried shipwreck remains is dependent on which angle the wood is approached with the sound waves, the character of the burial sediment, and the size of the remains (Quinn et al. 1997:33).

GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

A project GIS database is constructed using geo-referenced images and layers generated during the magnetometer, sidescan, and subbottom data analyses. Other layers can be added, such as orthophoto quads or navigation charts (Figure 28). Several important things are accomplished by GIS compilation. First, the collected data is compared to one another and evaluated for accuracy and consistency of the positioning information. Secondly, magnetic, sidescan, and other remote sensing targets are compared for relationship (proximity analysis). Employing the data in GIS, one can easily zoom in to further analyze spatial relationships as well as magnetic signature characteristics.

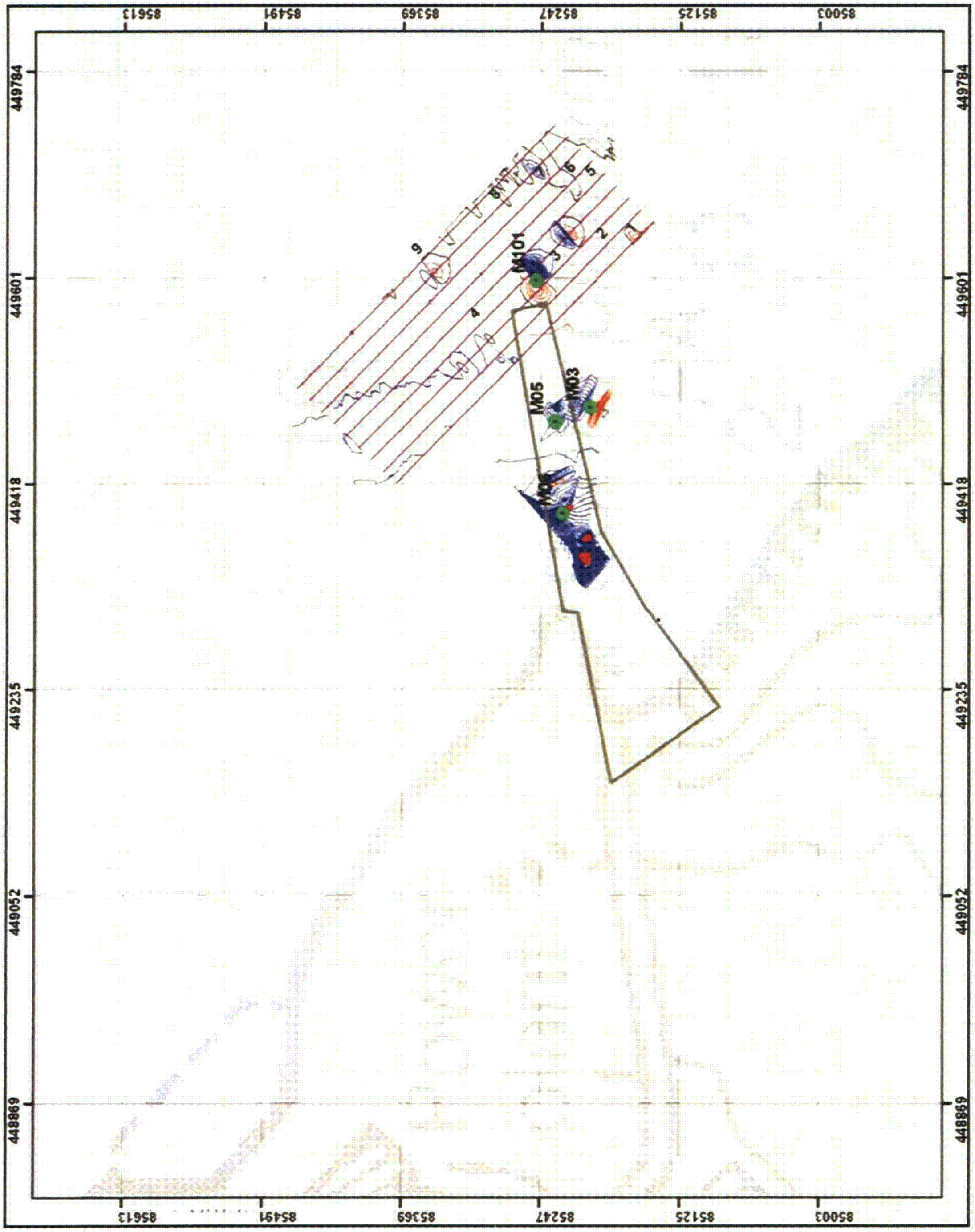

Figure 28. GIS database of the survey area showing magnetic anomalies, magnetic contour map, and NOAA RNC data layers. Grid squares are 122 meters (400 feet) as indicated. Data presented in Maryland State Plane, NAD83, meters.

DIVE INVESTIGATIONS

The second phase of the present project included an on-site diver investigation of the five selected anomalies that had the potential to represent significant submerged cultural resources eligible for listing on the NRHP, including four previously identified targets (Table 1, Figure 1) and one currently identified (Table 4). Prior to this second phase of the project, a Dive Operations Plan was submitted to the CCNPP prior to the diving operations. The Dive Operations Plan outlines procedures to (1) ensure the safety of project divers and (2) effectively and efficiently complete project goals and objectives. Diving operations for this project met all federal requirements for safe diving. All diving activities were in accordance with the strictest provisions of the U.S. Army Corps of Engineers, U.S. Navy, and Panamerican diving safety manuals and diving guidelines. During all diving operations, all persons diving and working under the auspices of Panamerican abided by this Dive Operations Plan.

Surface Supplied Air (SSA) was chosen as the most efficient and safe method of conducting investigations within the project area. Divers employed a Kirby-Morgan Superlite-17 dive helmet connected to a surface-supplied air source, radio communications cable, safety tether, and pneumo hose (Figure 29). On the surface, various individuals and pieces of equipment ensured safe diving operations. A dive tender was required to aid the diver in donning and doffing equipment and to tend the diver while submerged and moving about the sea floor. The radio communications operator kept in constant contact with the diver and relayed messages between the diver and the surface support team. A suited, standby diver was required on site in the event of an emergency situation that would require aid to the primary diver. Finally, a dive supervisor was present on site at all times to coordinate the activity of the diver and surface support team to achieve the project goals.

Air for SSA diving was provided by a cascade system of three 24-cubic-meter (80-cubic-foot) SCUBA bottles, opened to supply air one at a time. Pressure gauges and check valves were included in the air supply system. Two levels of redundant backup air supply were used, including an aluminum 24-cubic-meter (80-cubic-foot) SCUBA cylinder linked to the SSA cascade system and a 15-cubic-meter (50-cubic-foot) aluminum SCUBA cylinder worn by the diver and connected to the dive helmet. The dive supervisor acted as timekeeper, monitoring the air supply system during each dive to ensure that air pressure was correctly maintained and adequate reserve air was always available, as well as make notes of diver descriptions of the bottom type, excavation progress, stratigraphic details, when sampling subbottom (i.e., prehistoric) targets. A certificate of air quality was obtained from the air supplier and submitted to Mark Hunter, UniStar Safety Officer, for approval prior to commencement of diving activities.

Table 4. Previously identified magnetic anomalies.*

Anomaly	Line	X	Y	Sensor Height (m)	Amplitude (peak to peak [nT])	Duration (m)	Signature	Associated Anomalies	Identification	Avoidance (m)
M03	4	449493	85215	3	263	19	dipole	none	none	66
M05	5	449469	85220	3	155	31.5	dipole	none	none	66
M06	8	449392	85229	3	1042	62	dipole	none	none	66

*Data presented in Maryland State Plane, NAD83, meters.

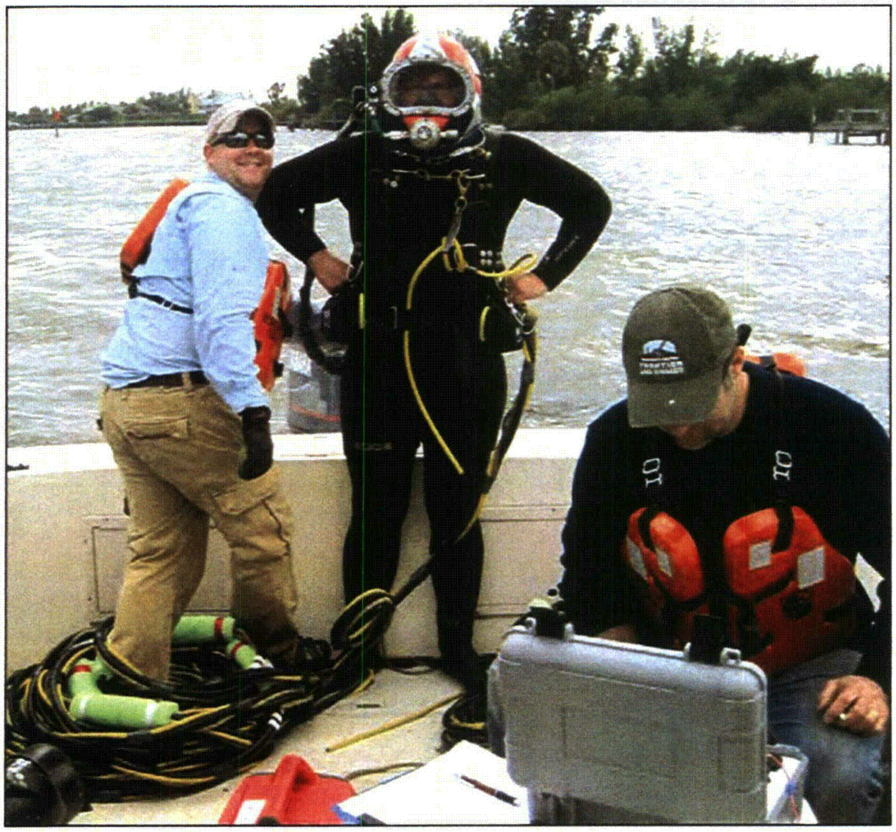

Figure 29. Surface supplied-equipped diver. Communications operator is in the foreground right with "com box". Note the yellow pneumo hose on the diver, which is employed for depth readings in low and zero visibility environments.

Prior to commencement of diving operations, a Pre-Dive Safety Meeting was held with all members of the dive team and vessel crew. All safety and diving procedures were discussed in detail. Diving commenced upon completion of the meeting.

The purpose of the diving phase of the project was to attempt to locate the source of the five selected anomalies or targets, either through visual or tactile methods. Each target was buoyed at its respective coordinate location. Prior to anchoring, the direction of the tidal current and wind direction relative to each target buoy had to be ascertained, so that when anchored, the distance from and the orientation of the survey vessel's stern to the buoy were optimal.

The standard operating procedure for the diver was to enter the water and be directed to the buoy location. He then conducted a visual and/or tactile inspection of the sea floor for the source of the sidescan target or anomaly, or began dredging excavations at a subbottom target. If a magnetic or side scan target was not immediately located, the diver was swung on arcs to cover all cardinal directions from the buoy. With respect to magnetic targets, the diver conducted the arcs with a metal detector or hydraulic probe. Once the target was located, the diver conducted an assessment of identity and significance through either tactile or visual methods, verbally passing target and environmental data to the communications operator on the surface. Measurements were taken of targets encountered.

Based on the refined remote sensing survey data, each target was buoyed at its respective refined coordinate location. Prior to anchoring, the direction of the tidal current and wind direction relative to each target buoy had to be ascertained, so that when anchored, the distance from and the orientation of the survey vessel's stern to the buoy were optimal. The standard operating procedure for the diver was to enter the water and be directed to the buoy location. Employing the buoy as the center point, he then conducted a visual inspection of the bottom. Performing a series of arcs by pivoting on his umbilical, which was let out in 10-foot increments from the stern of the vessel, the diver covered an area approximately 100-feet square surrounding the buoy. If nothing was encountered, a grid pattern of hydro-probes was conducted. Employing the 10-foot long hydroprobe, probes were conducted every 5 feet in the four cardinal directions to a distance of 20-foot from the refinement buoy.

Probing of anomalies or features is an effective means of determining the spatial extent and burial depth of a given target located beneath the sea floor. The hydro-probe apparatus consists of a water pump, lengths of garden hose, and the probe, which is 0.5-inch galvanized pipe. The hose was connected to the 0.5-inch diameter steel probe by a cam-lock. The hydro-probe used for this investigation was 10 feet in length and powered by a 5-hp Honda water pump. The basic function of the hydro-probe is to aid in determining the presence or absence of buried cultural material, and, if present, the spatial extent of the material, types of overburden (i.e., sand, mud, shell), the type of cultural material, and depth of overburden. This is accomplished by forcing water through the 10-foot pipe attached to the water pump's effluent hose. The force of the water ejected from the pipe end effectively allows the probe to be inserted through sediments of varying density (e.g., sands, silts, shell hash) and depth, thereby contacting the feature if present and/or sediment layers (Figure 30).

Figure 30. Probing was conducted at all magnetic targets, where objects were not located during diver sweeps, with a 10-foot-long hydro-probe.

Environmental conditions encountered during the diving phase were benign with the exception of water temperatures that were in the approximately 60°F range, mandating a wet suit be worn. Water depths, for the most part, were fairly shallow ranging 3.5–5 meters (12–16 feet) with no current. Visibility was generally 1 meter (3 feet) and the bottom type encountered was sand over bedrock with the shelf-like bedrock exposed in several locations.

NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

The purpose of a diver investigation is to gather enough information regarding each target to determine if it is historically significant, and if it is, to determine the character of that significance. This is done by applying four criteria of significance developed by the National Park Service as mandated by the Historic Preservation Act.

As stated in National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (National Park Service 2002), and Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places* (National Park Service 1985), "the quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association." To be considered significant and therefore eligible for nomination to the NRHP, the property must meet one or more of the four NRPH criteria:

> **A.** Be associated with events that have made a significant contribution to the broad patterns of our history; or
>
> **B.** Be associated with the lives of persons significant in our past; or
>
> **C.** Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> **D.** Yield, or likely to yield, information important in prehistory or history [National Park Service 1985:5-6].

Properties found potentially eligible, eligible, or listed on the NRHP must be considered within the framework of the proposed action. If adverse impact to such a property is possible, alternatives to the proposed action, i.e., avoidance, must be evaluated. If avoidance is not practical, additional activities relative to the evaluation of the resource may be required.

A vessel's significance, as stated in Bulletin 20, is based on a "representation of vessel type and (its) association with significant themes in American history and comparison with similar vessels" (National Park Service 1985:4). Of the five basic types of historic vessels that may be eligible for NRHP nomination as stated in National Register Bulletin 20, *Nominating Historic Vessels and Shipwrecks to the NRHP*, the remains located during this survey fall into the defined category of "shipwrecks." Bulletin 20 defines a shipwreck as "a submerged or buried vessel that has foundered, stranded, or wrecked. This includes vessels that exist as intact or scattered components on or in the seabed, lakebed, riverbed, mud flats, beaches, or other shorelines, excepting hulks" (National Park Service 1985:3). The significance of shipwrecks, as opposed to intact vessels (i.e., hulks), requires that the wreck display sufficient integrity to address architectural, technological, and other research concerns.

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IV. RESULTS

Extensive archival and records research was not requested as part of the Calvert Cliffs survey. Instead, Panamerican reviewed internal company reports dealing with the maritime history of Maryland and visited the Calvert Marine Museum in Solomons to inventory known shipwrecks in the area (there were none), and potentials for the same (considered low, as discussed in Chapter II). In addition, Panamerican had a conference call with local geoarchaeologist Darrin Lowery with regard to any known locations of submerged prehistoric sites (none are recorded) and the potentials for such (considered). In summary, potential for shipwreck remains within the project area is considered low, but potential for submerged prehistoric remains in the project area is considered possible to good, depending on the paleotopographic (sea level regressed) setting.

Sea conditions were slightly choppy to smooth, allowing for good to excellent sidescan and subbottom profiler imagery. The magnetometer towfish and data recording is not as affected by sea conditions as the acoustic data.

GEODETIC PARAMETERS

Geodetic parameters for the project are Maryland State Plane coordinates (MD-1900), 1983 North American Datum (NAD 83) in meters. All maps, tables, and data are presented in this projection and datum.

REMOTE SENSING SURVEY RESULTS

The additional area, as presented in Figures 1 and 2, was surveyed with magnetometer, sidescan sonar, and subbottom profiler.

MAGNETOMETER

Nine lines of magnetometry data were recorded and processed for contouring and analysis of anomalies. Figure 31 below shows magnetic strength contours at the Calvert Cliffs survey area. Contour intervals are at 10 nanoteslas; blue contours are below background (50,500 ±10) and red contours are above background. Details of the individual target characteristics are presented in Table 5.

All of the anomalies located during the survey fall outside the APE of the proposed dredging area as shown on Figure 31. Of the three anomalies listed in Table 5, only one (M101) occurs over two or more lines. All other targets appear to be isolated single-source items that are likely modern ferrous materials. One anomaly, M101, meets the criteria established in Chapter III for existence of potentially significant submerged cultural resources. M102 meets criteria for strength and duration, but is present on only one survey line, and so likely represents isolated ferrous debris. M103 does not meet any criteria. Anomaly M101 was selected for further investigation in the diving phase of the project, as detailed below. No further work was considered for either M102 or M103.

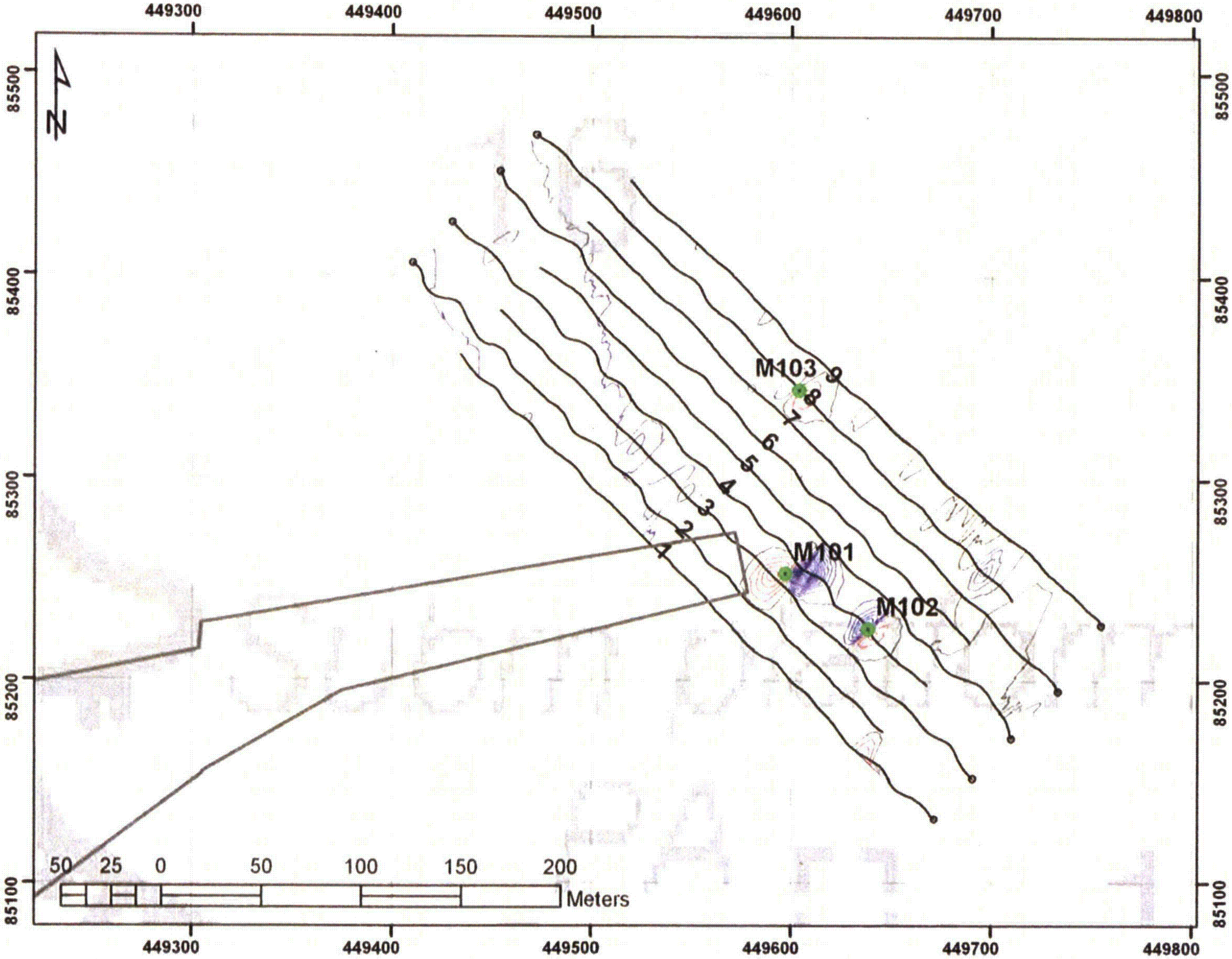

Figure 31. Tracklines, magnetic strength contours, and anomalies at Calvert Cliffs survey area. Proposed channel alignment in grey; contour intervals 10-nanotesla, blue contours below background, red contours above. As indicated on the map, gridlines are spaced every 100 meters (328 feet). Data presented in Maryland State Plane, NAD83, meters.

Table 5. Magnetic anomalies from the Calvert Cliffs remote sensing survey.*

Anomaly	Line	X	Y	Sensor Height (m)	Amplitude (peak to peak [nT])	Duration (m)	Signature	Associated Anomalies	Identification	Avoidance
M101	**3–4**	449608	85253	3	156	32	dipole	none	unknown	none†
M102	**4**	449638	85226	3	96	28	dipole	none	unknown	none‡
M103	**8**	449604	85344	3	33	20	dipole	none	unknown	none‡

*Data presented in Maryland State Plane, NAD83, meters.
†Avoidance not necessary, as target was investigated by divers.
‡ Avoidance not necessary, as target did not meet criteria.

SIDESCAN SONAR

No isolated objects indicative of potentially significant submerged cultural resources were identified in the sidescan record. The sidescan record also revealed the rocky nature of the bay bottom and that the layering of the cliffs nearby seems to continue below the waterline. Figure 32 (mosaic with magnetic contour overlay) illustrates the sidescan record.

The sidescan record reveals the layered nature of the bay bottom along Calvert Cliffs, which is that the facies sediment beds continue below the waterline showing different areas of rocky and less rocky appearance. These beds created high backscatter returns (bright areas with and without shadows) indicating rocky and sandy areas. Lower backscatter areas (dark areas) indicate silty or clayey sediments. Whether these are eroded, calved beds in secondary deposition, or exposed Miocene beds was not determined. Areas of high reflectivity representing rock outcrops in the sidescan data on the inner lines appear to be a continuation of exposed rock surfaces noted during the 2008 investigation (Faught 2009). They are interspersed in areas of lower reflectivity suggesting a rock layer continuing under sediment outward from the shore (Figure 33)

SUBBOTTOM PROFILER

The subbottom profiler was employed to penetrate the sediment beds, with the possibility that paleochannels, paleolandscape settings, or mounded midden features might be sensed. However, much of the Calvert Cliffs sediment beds are sand (or pebbly sand), silt, and clay beds that preclude deep penetration. The device was generally effective to a depth of more than 2 meters. Either these beds are the result of calved and collapsed beds of the cliff face, or they are exposed portions of similar—but earlier—beds below. Examination of the subbottom data revealed the presence of numerous rock outcrops and an area of high signal attenuation indicative of rock or sandstone in the vicinity of M101 (presented and discussed below). There were no paleochannels, buried paleosurfaces, or buried objects indicative of cultural resources present in the data. Figure 34 shows a typical subbottom profile for the additional survey area.

TARGET REFINEMENT

Prior to diver investigation of the three magnetic anomalies located in the previously surveyed area during the 2008 investigation, the target locations were refined using magnetometer and sidescan sonar. Ten lines of refinement were undertaken to relocate the targets, confirm they were still present, and better pinpoint their locations to enable easier location by divers. Magnetic refinement relocated all three previous targets (Figure 35, Table 6), indicating they were still *in situ*. In addition, objects were located by sidescan sonar in the vicinity of two magnetic anomalies (Table 7).

Table 6. Refined locations of 2008 magnetic anomalies.*

Anomaly	Line	X	Y	Sensor Height (m)	Amplitude (peak to peak [nT])	Duration (m)	Signature	Associated Anomalies	Identification	Avoidance
M03	4	449487	85204	3	209	42.5	dipole	C03	--	none
M05	5	449480	85235	3	116	29	dipole	C05	--	none
M06	8	449392	85229	3	2000	50	dipole	none	--	none

*Data presented in Maryland State Plane, NAD83, meters.

Table 7. Sidescan sonar contacts associated with refined anomaly locations.

Contact	Line	X	Y	Sensor Height (m)	Length (m)	Width (m)	Height (m)	Associated Anomalies	Identification	Avoidance
C03	4	449489	85202	3	7.2	0.5	0.1	M03	--	none
C05	5	449480	85229	3	7.3	3.8	1	M05	--	none

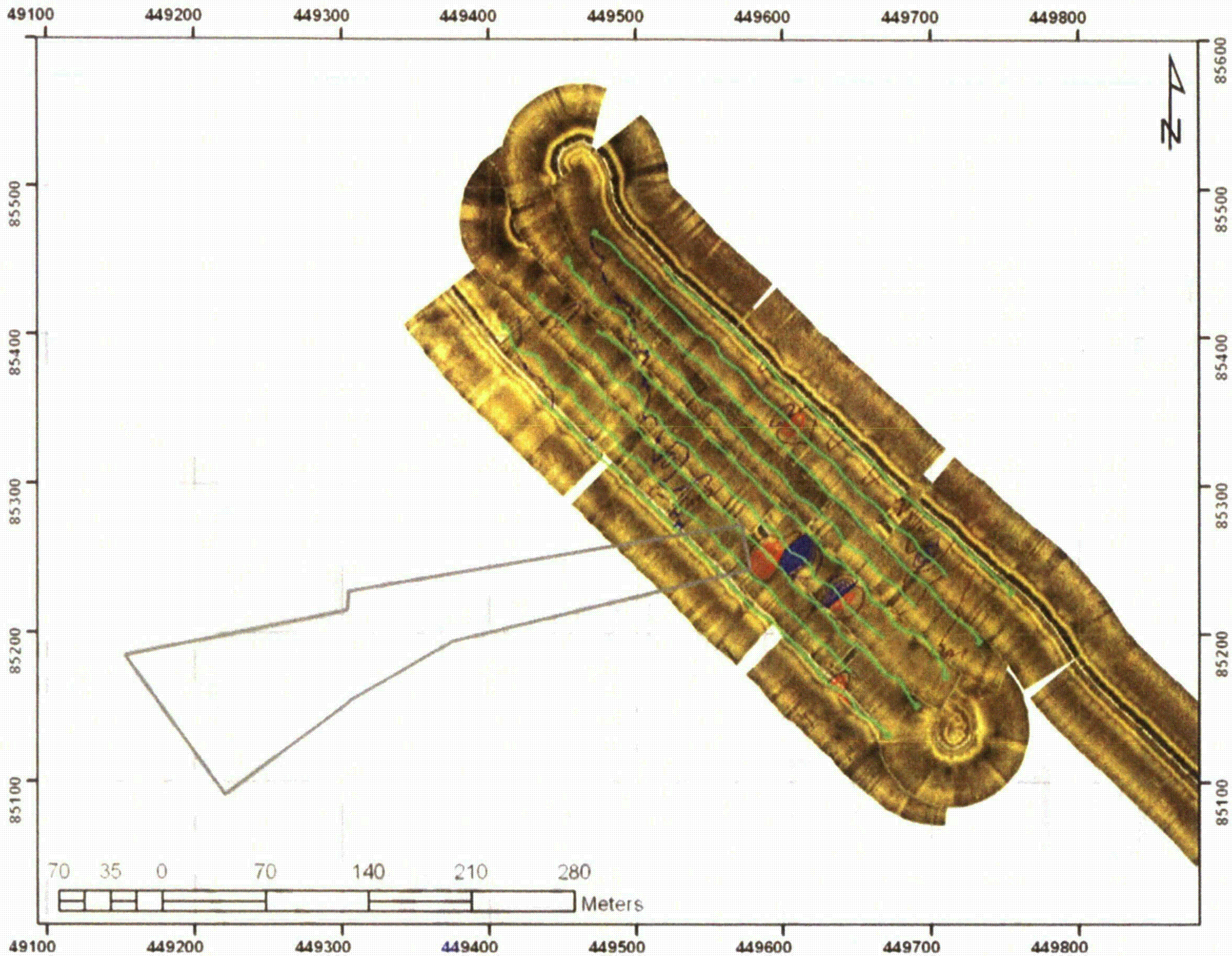

Figure 32. Mosaic of sidescan sonar data with magnetic contours. As indicated on the map, gridlines are spaced every 100 meters (328 feet). Data presented in Maryland State Plane, NAD83, meters.

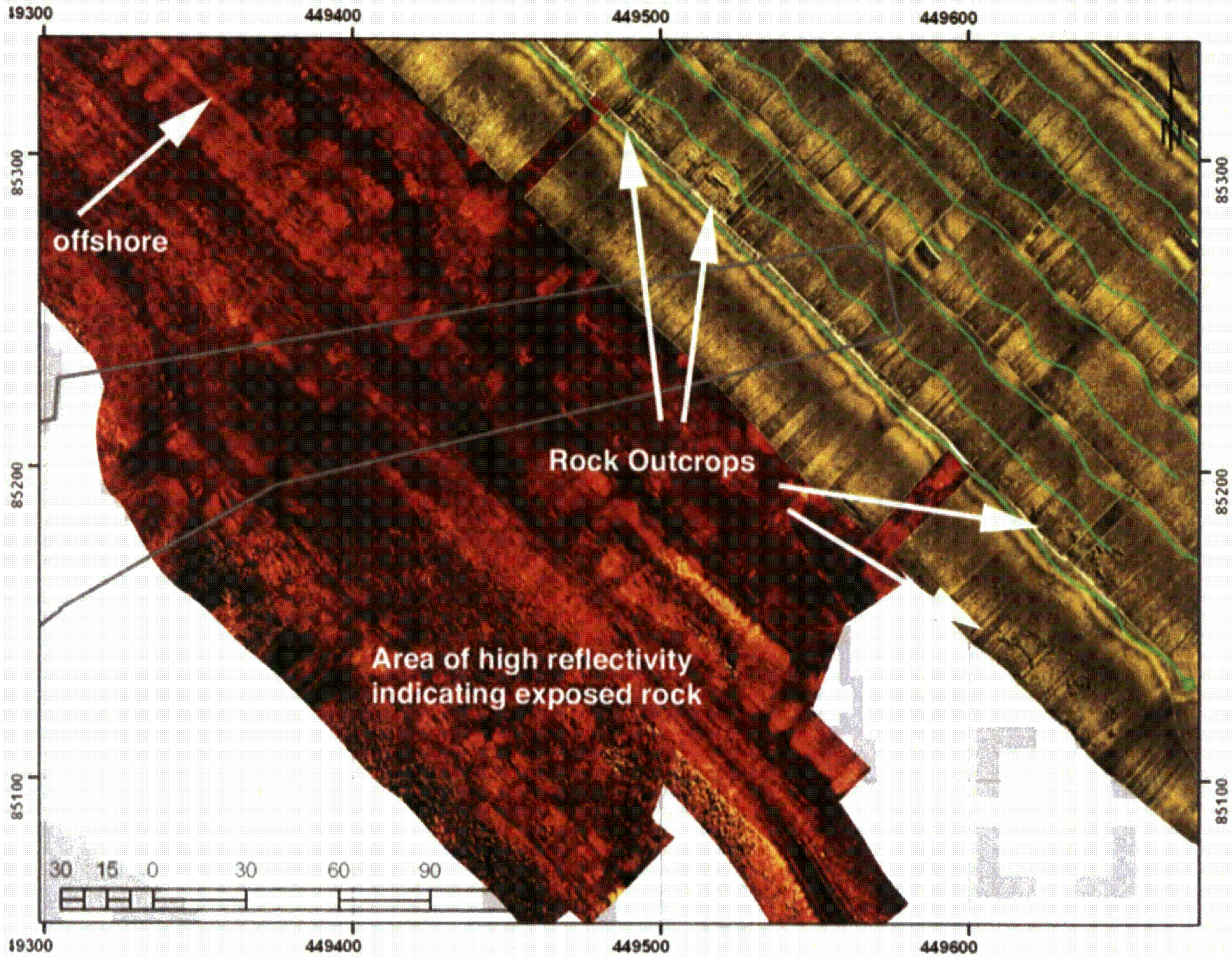

Figure 33. 2008 sidescan mosaic (red) showing location of exposed rock and 2011 sidescan mosaic (yellow) showing location of rock outcrops. Data presented in Maryland State Plane NAD83 meters.

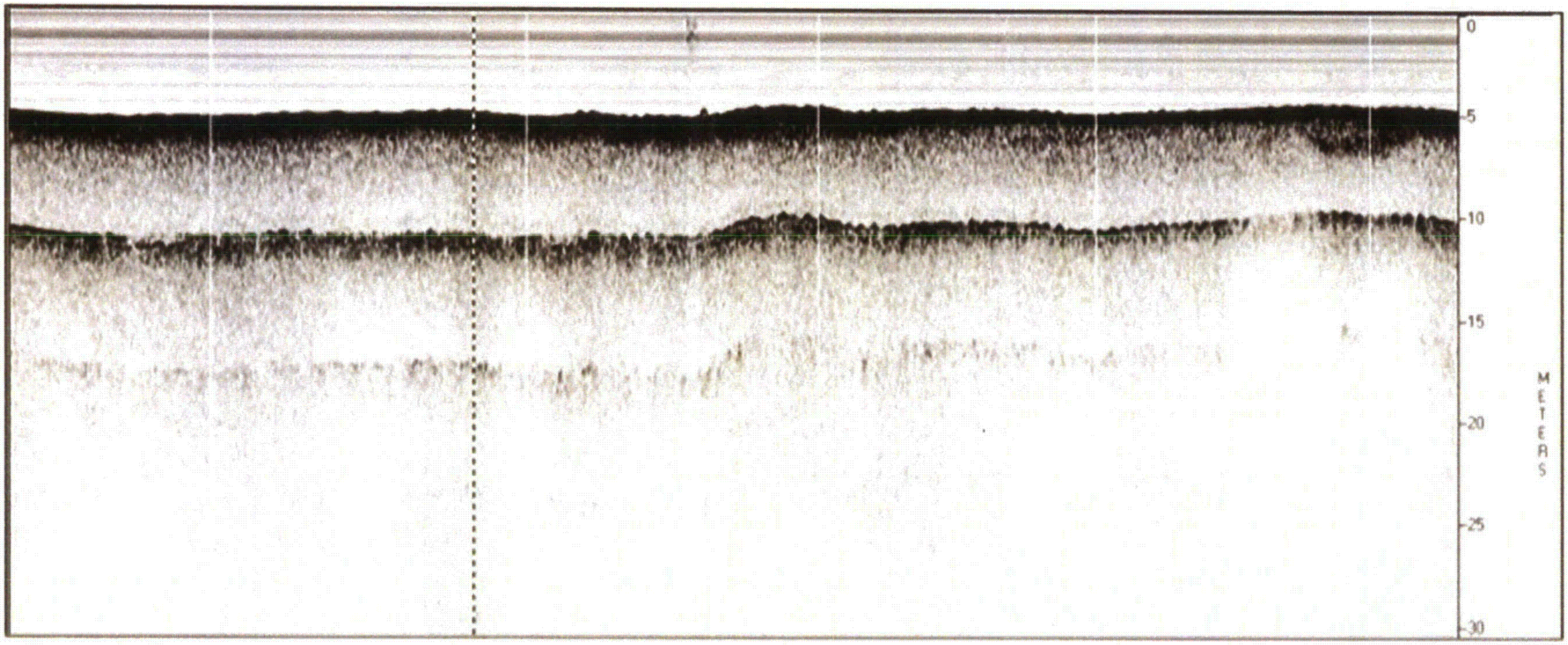

Figure 34. Subbottom profile Line 5. Vertical lines have 30-meter spacing, depth scale to the right in meters. Data presented in Maryland State Plane, NAD83, meters.

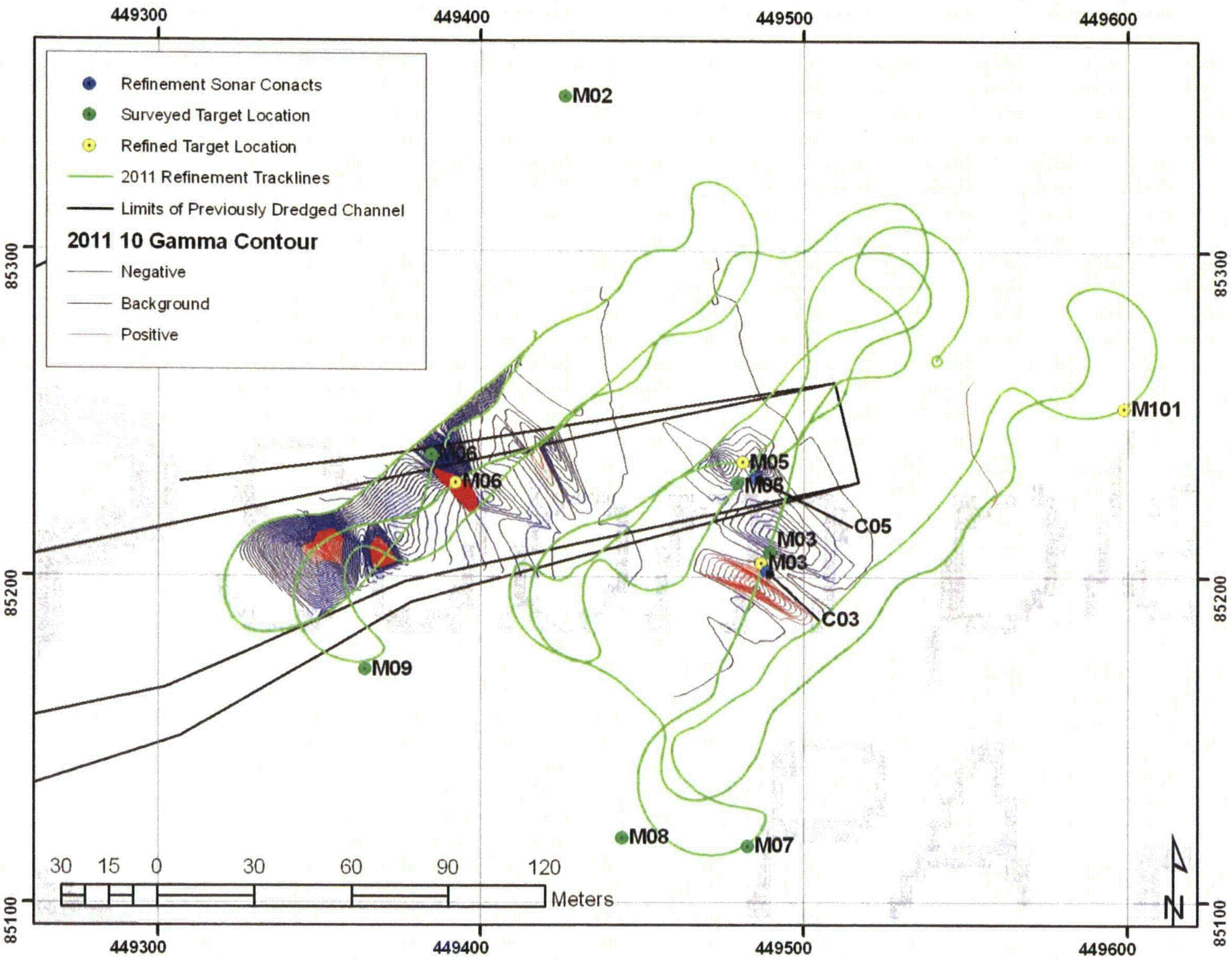

Figure 35. Magnetic refinement contour map of previously located targets indicating surveyed location, refined location, and dredged channel. Data presented in Maryland State Plane, NAD83, meters.

TARGET INVESTIGATIONS

Listed in Table 8, a total of four target locations were investigated as part of the diving phase of this project, including three previously identified anomalies (M03, M05, and M06; see Table 2 above) and one (M101) identified during the current survey (see Table 3 above). Investigations of each target consisted of a remote sensing refinement, and physical inspection of the target location by a diver, which included arc searches in 3-meter (10-foot) intervals and, in the event diver arcs failed to locate the source of the target, physical hydro-probing. Each target is discussed in turn in the following paragraphs and results are summarized in Table 8 (coordinates presented in Table 8 are the refined locations).

Table 8. Results of target investigations. *†

Anomaly	Line	X	Y	Sensor Height (m)	Amplitude (peak to peak [nT])	Duration (m)	Signature	Associated Anomalies	Identification	Avoidance
M101	**3-4**	449608	85253	3	156	32	dipole	none	assumed modern debris	none
M03	4	449487	85204	3	209	42.5	dipole	C03	3 meter pipe	none
M05	5	449480	85235	3	116	29	dipole	C05	prop and rudder from modern vessel	none
M06	8	449392	85229	3	2000	50	dipole	none	assumed modern debris	none

*Data presented in Maryland State Plane, NAD83, meters.
†Coordinates for anomalies located during previous investigation (M03, M05 and M06) represent refined locations.

M05

The magnetic refinement of M05 located a dipole magnetic anomaly with a total magnetic deviation of 116 nanoteslas and a total duration of 29 meters (95 feet) in the vicinity of the original anomaly (Table 6, Figures 35 and 36). The strength of the refined anomaly is slightly smaller than the original 155-nanotesla/31.5-meter (95 feet) dipole. This discrepancy can be explained via a difference in the proximity of the magnetometer sensor to the target between the survey and refinement.

Examination of the sidescan refinement data for M05 indicated the presence of a rectangular object approximately 2-x-3 meters (6.5-x-10 feet; Figures 36 and 37), the location of which coincides with both the refinement and survey magnetic data (Figures 38 and 39). Examination of the sidescan sonar data from the original 2008 survey indicates the presence of what appears to be a large rectangular object in the vicinity of M05 (Figures 39 and 40).

Diver examination of the target location indicated the presence of a propeller and rudder of modern origin. The propeller is 3 meters (10 feet) in diameter with four blades, located immediately adjacent to a 1.8-x-3-meter (6-x-10-foot) steel rudder. Discussions with Mark Hunter from the CCNPP indicated that a tugboat had lost its rudder and propeller near the barge dock in or around 2008 (Mark Hunter personal communication 2011). These objects are considered sufficient to account for both the survey and refinement anomalies.

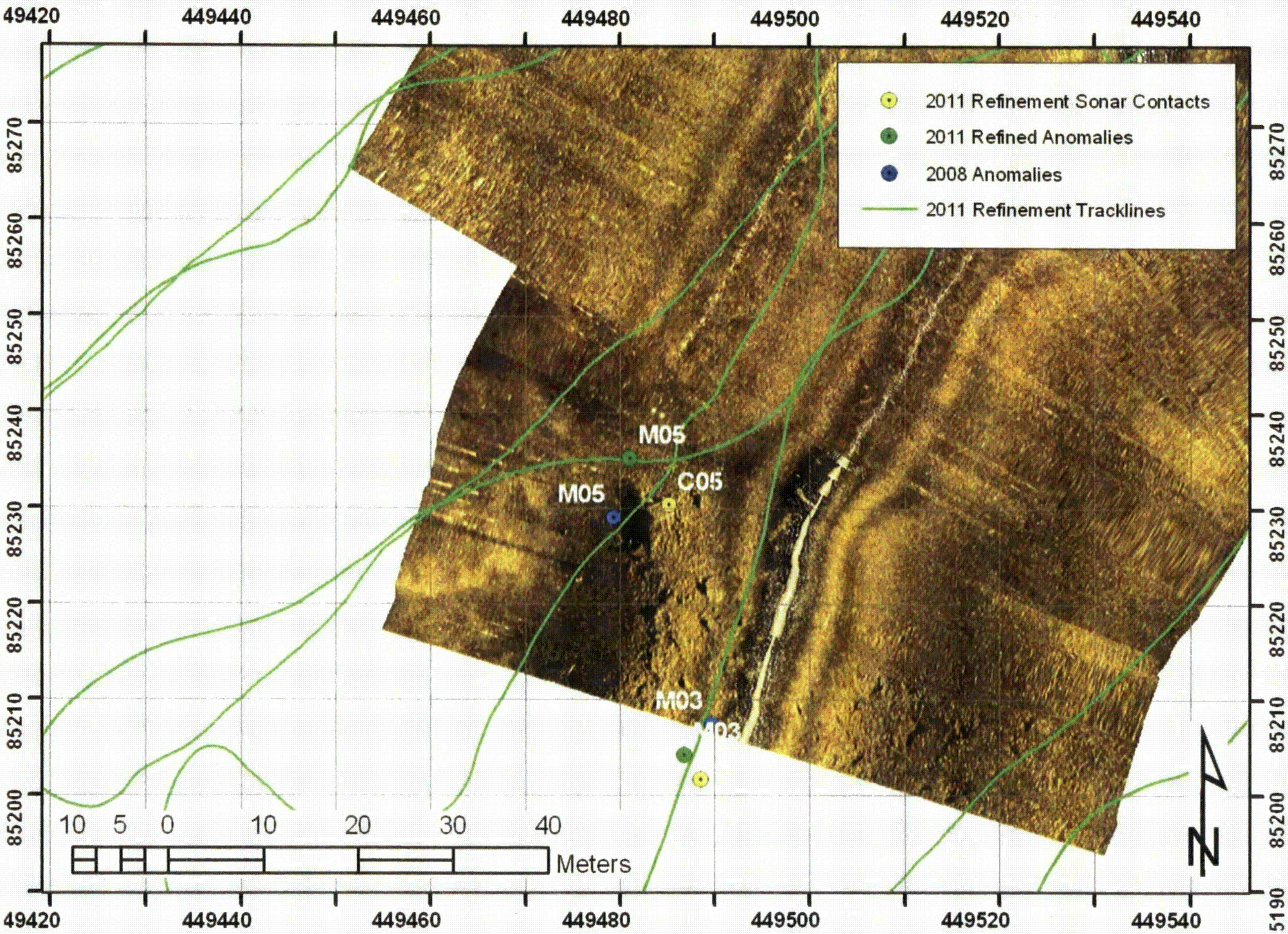

Figure 36. Refinement sonar image of anomaly M05, consisting of what appears to be a four-blade propeller 3 meters (10 feet) in diameter (center) and a large rectangular object approximately 3.5-x-2 meters (12-x-6 feet; center). Data presented in Maryland State Plane, NAD83, meters.

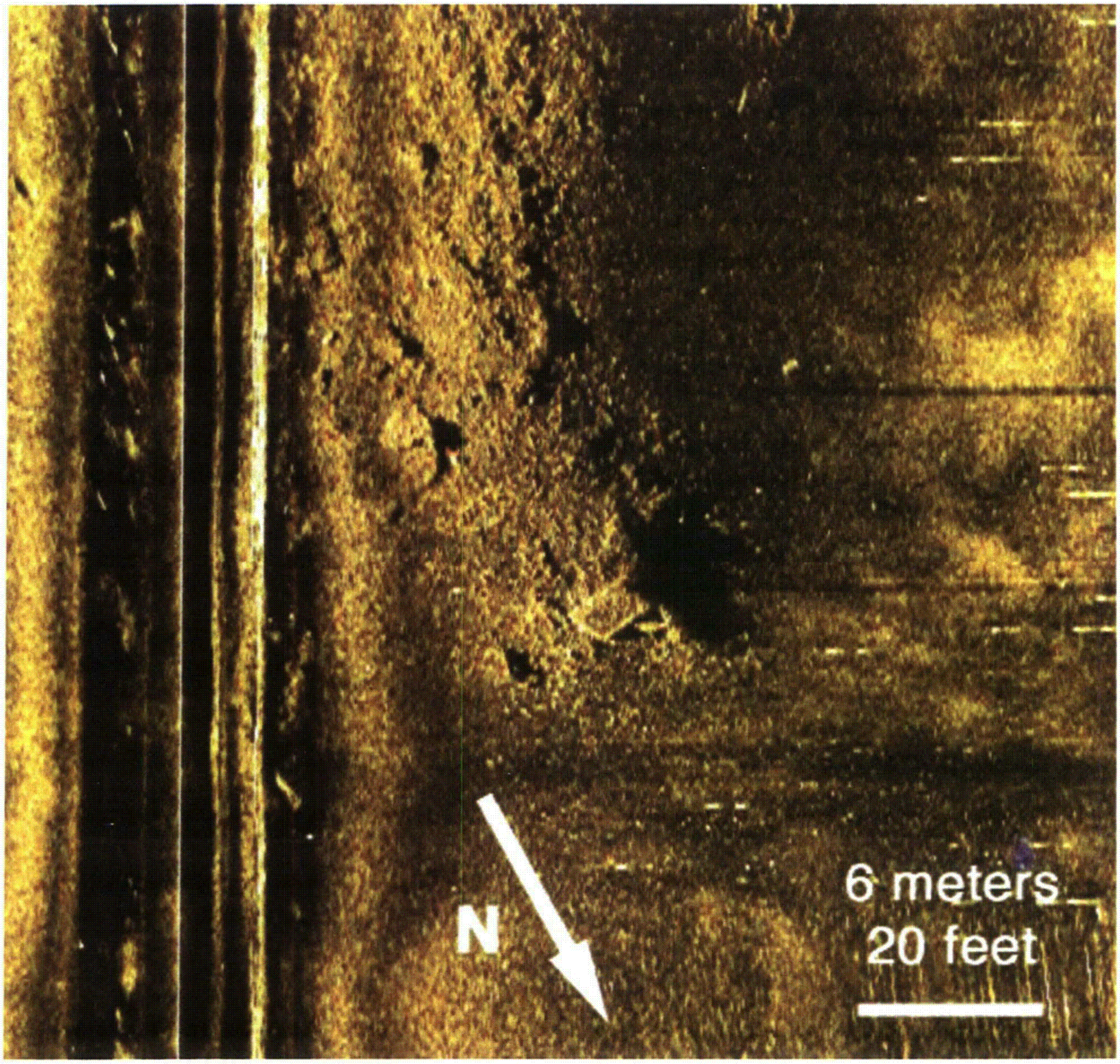

Figure 37. Raw sidescan sonar image of object associated with M05, collected during 2011 target refinement.

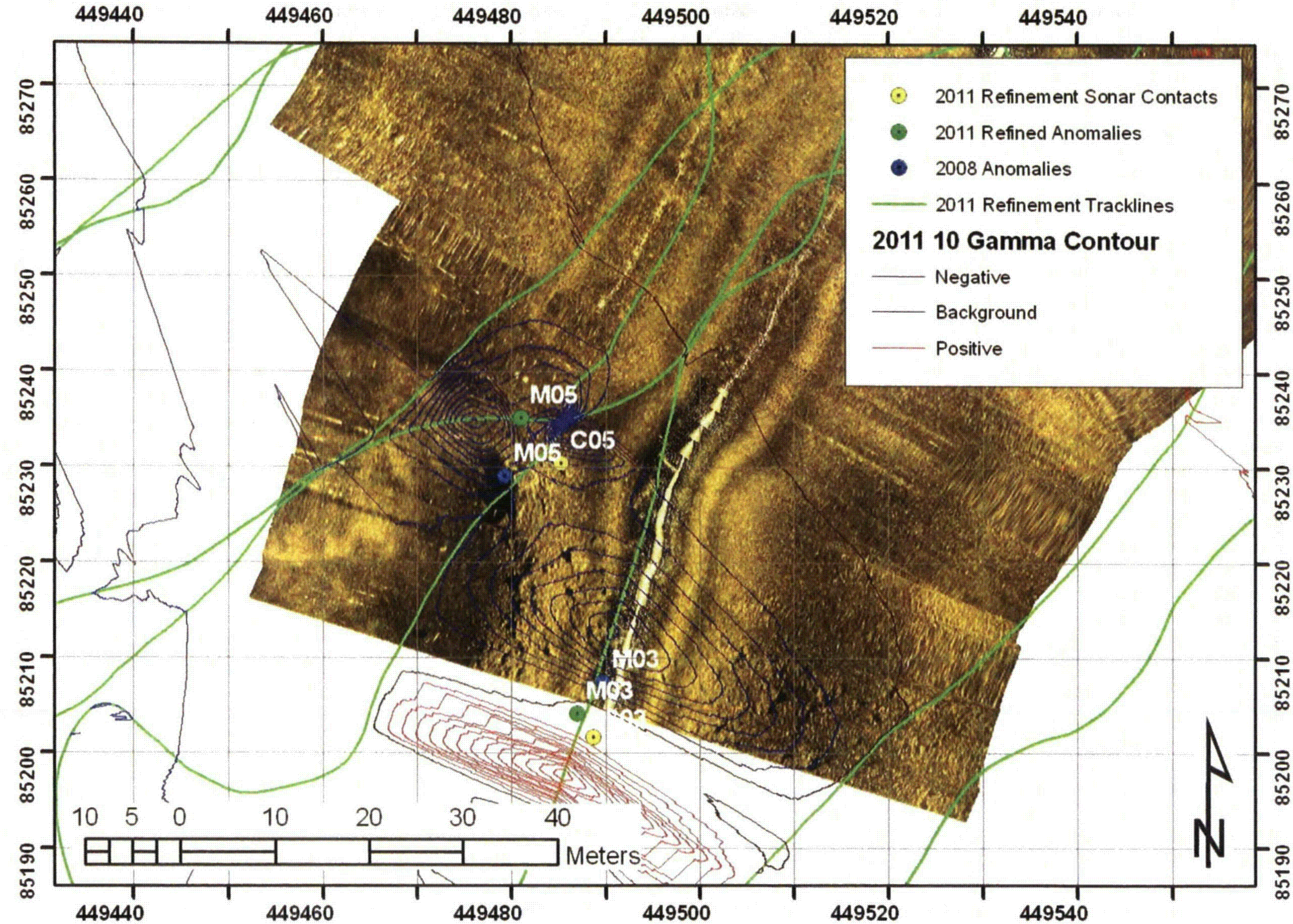

Figure 38. 2011 magnetic contour data overlaid on 2011 sidescan refinement data for target M05. Note presence of recognizable target in vicinity of 2011 refined target locations and absence of significant magnetic anomalies in the vicinity of 2008 anomaly M05. Data presented in Maryland State Plane, NAD83, meters.

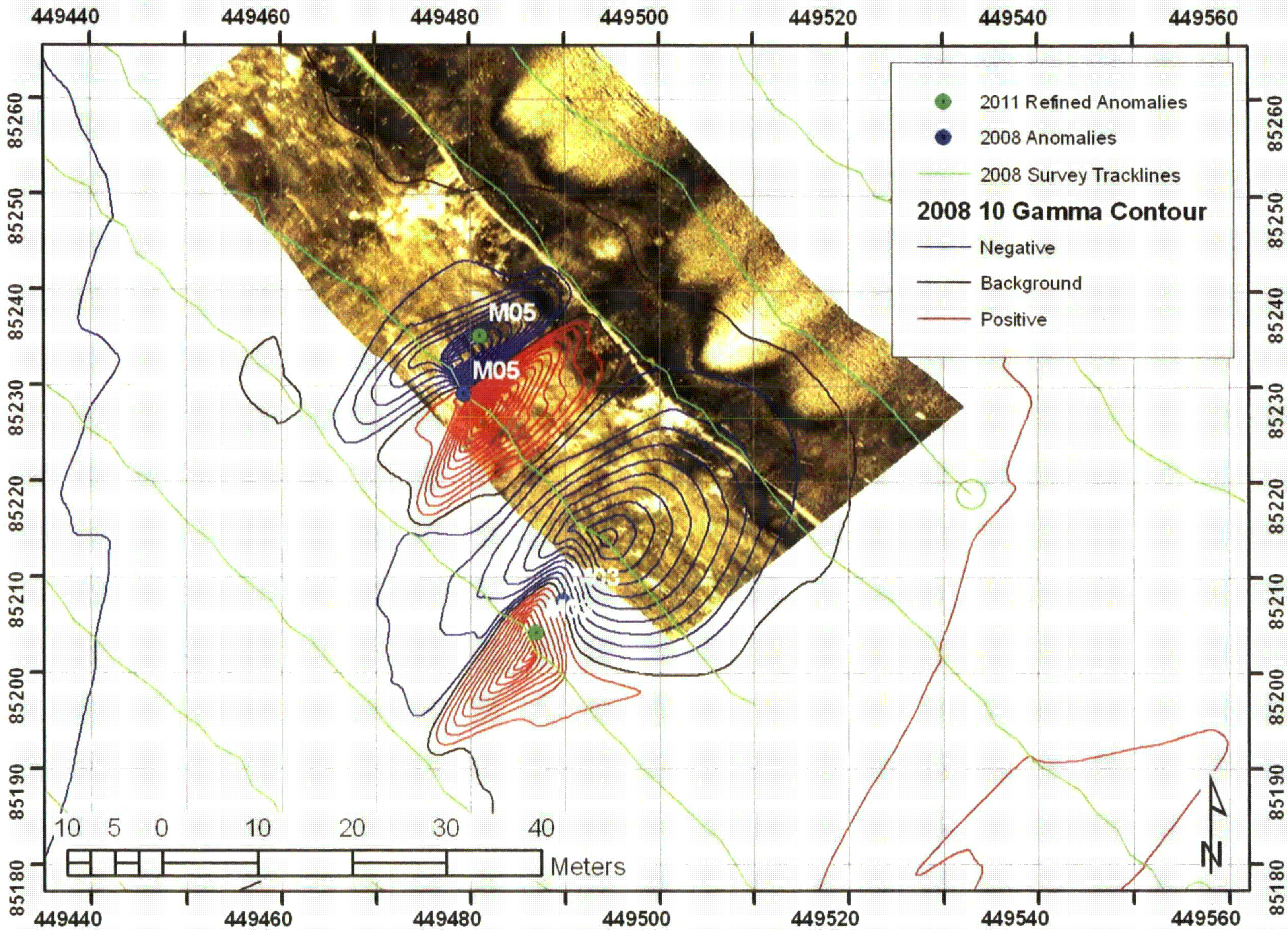

Figure 39. 2008 magnetic contour data overlaid on 2008 sidescan data showing the location of M05. Note absence of recognizable target in vicinity of 2011 refined target locations. Data presented in Maryland State Plane, NAD83, meters.

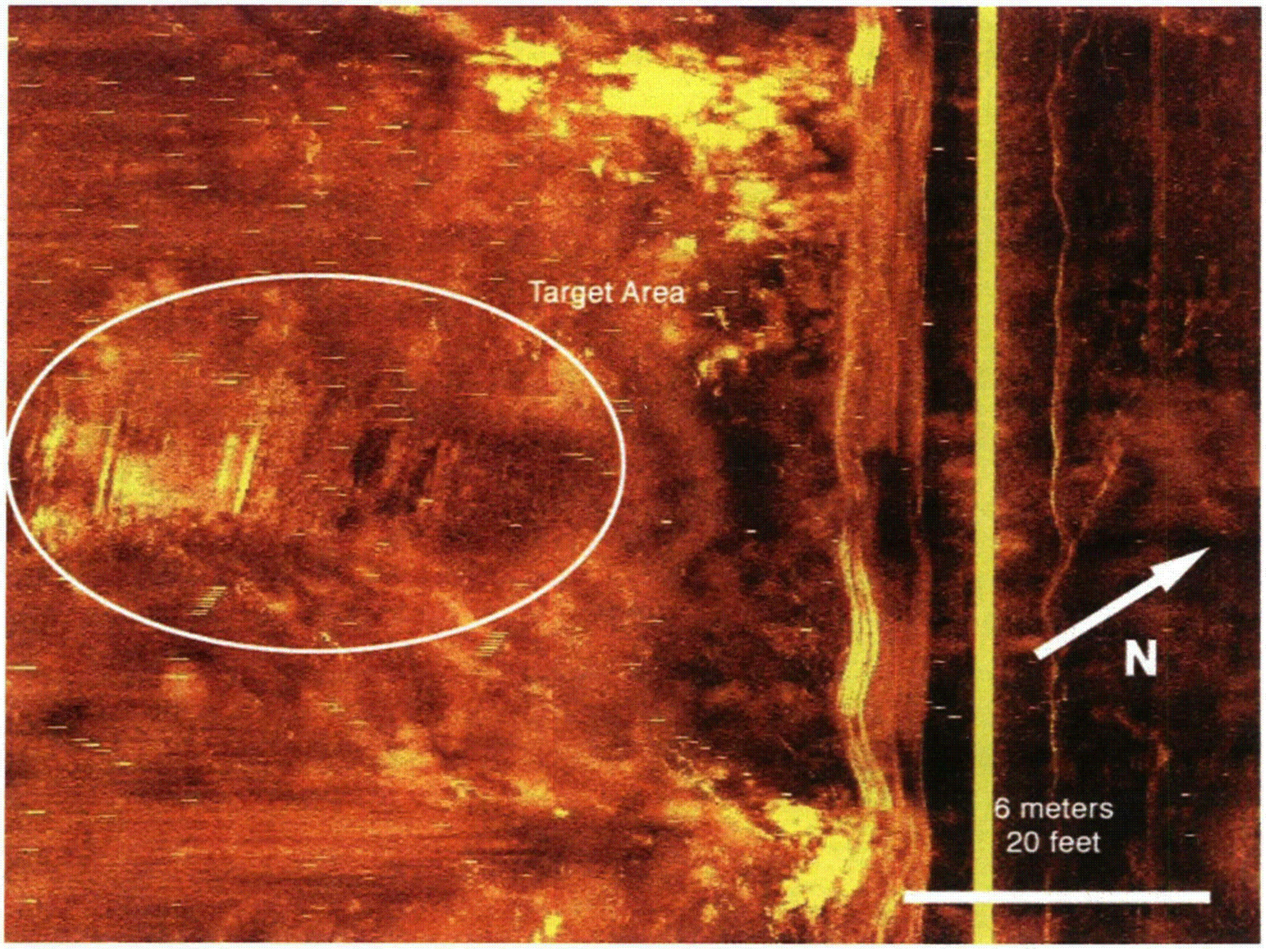

Figure 40. Raw sidescan sonar image of object associated with M05, collected during the 2008 remote sensing survey.

M03

The magnetic refinement of M03 indicated the presence of a 209-nanotesla dipole anomaly with a duration of 42.5 meters (140 feet; Table 6; Figure 35). This is smaller in intensity than the original 263-nanotesla anomaly, but also longer in duration. The discrepancy in strength can easily be accounted for by the difference in sensor distance from the target between the survey and the refinement, as in the case of M05 above. The discrepancy in duration can be accounted for by the difference in location of the refinement lines relative to the object associated with M03; the sensor passed directly over the object and through the longest dimension of its magnetic field during the refinement, resulting in a longer duration.

Review of the refinement sonar data indicated the presence of a linear object of approximately 5 meters (17 feet) in length at the refined location of M03 (Figures 41 and 42). This object coincides with the location of Object 1 from the 2008 survey (Figures 43 and 44). Diver investigation of the refined target location indicated the presence of a steel pipe 3 meters (10 feet) long and 0.5 meters (16-inches) in diameter.

The pipe is considered sufficient in size and location to account for both the survey anomaly (263 nanoteslas) and the refined anomaly (209 nanoteslas). This pipe is not considered historically significant and no further work is recommended.

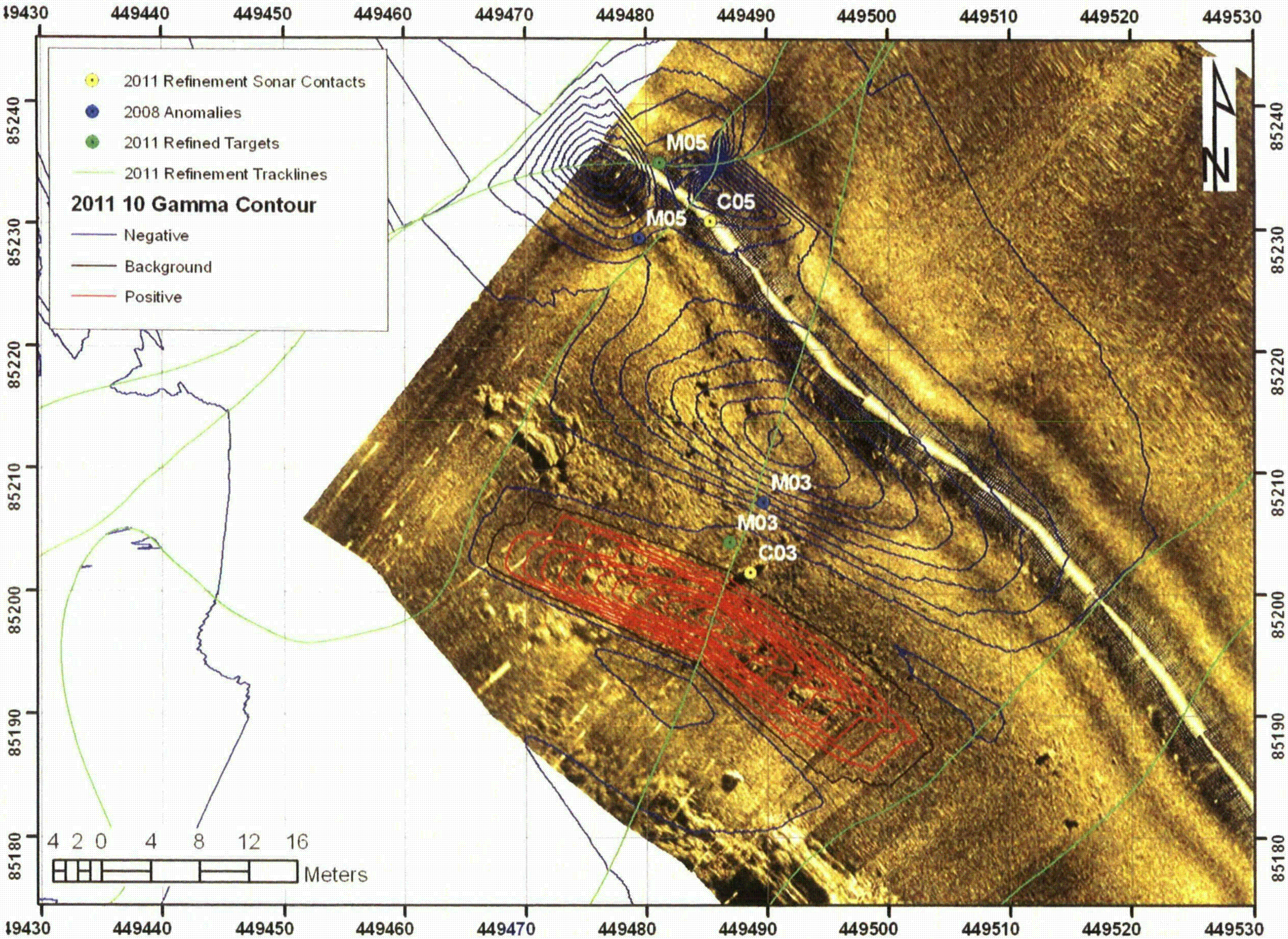

Figure 41. 2011 magnetic contour data overlaid on 2011 refinement survey sidescan sonar data, showing location of 2008 anomaly M03 and the 2011 refined location of M03. Data presented in Maryland State Plane, NAD83, meters.

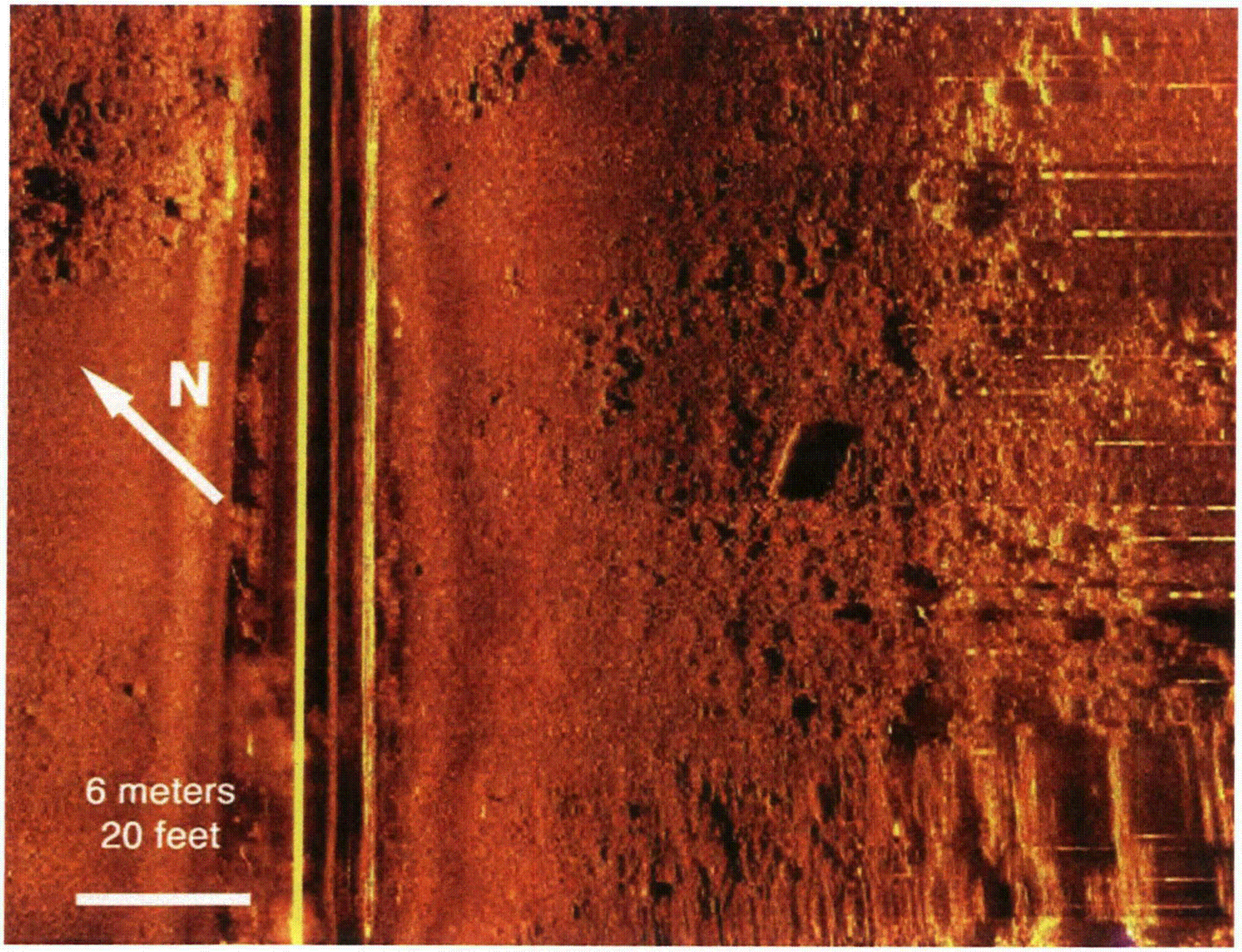

Figure 42. Raw sidescan sonar image of object associated with M03, collected during 2011 target refinement.

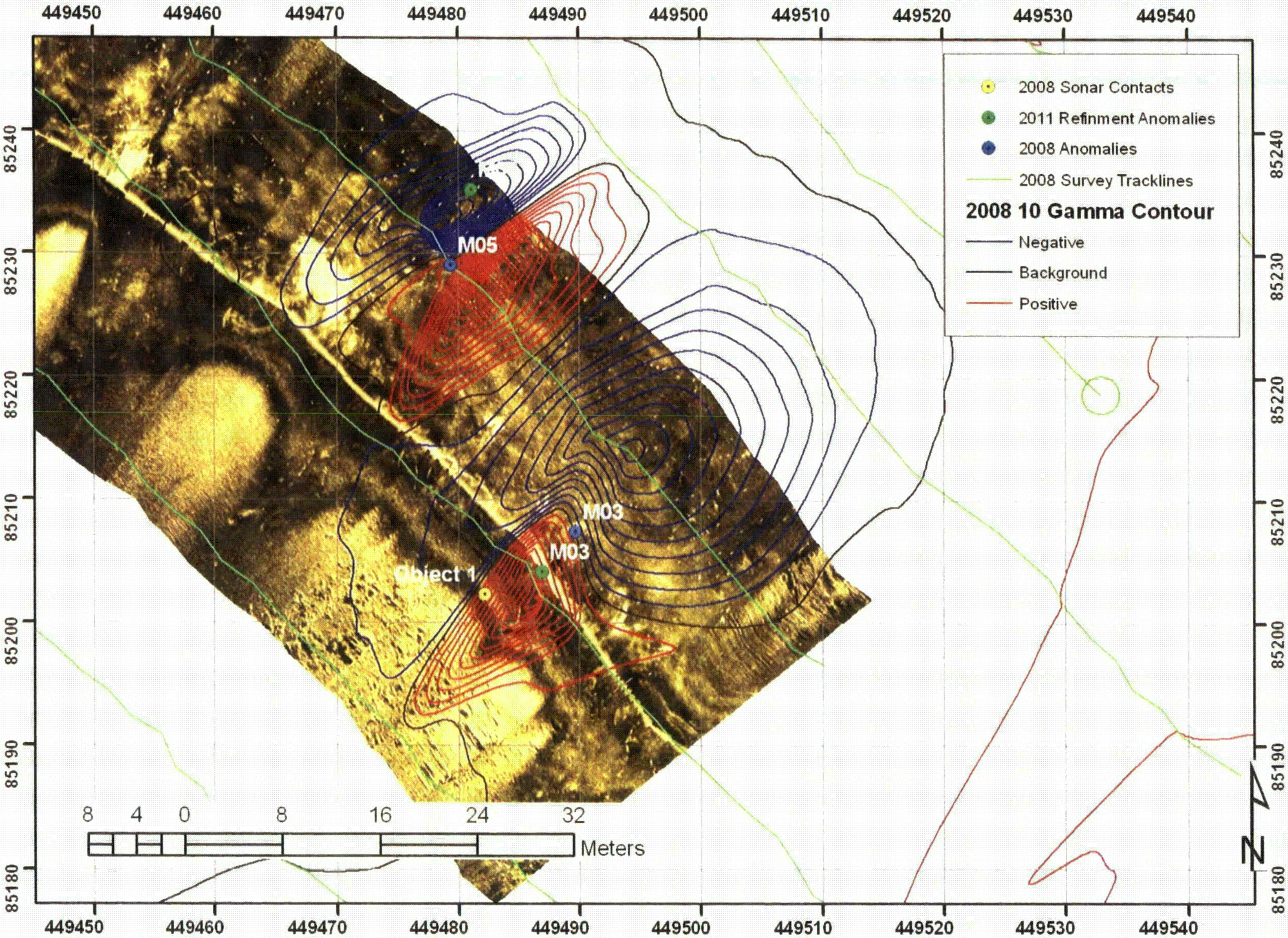

Figure 43. 2008 magnetic contour data overlaid on 2008 sidescan sonar data showing location of M03 and location of Object 1 (Faught 2009) and M03 as relocated during the 2011 refinement survey. Data presented in Maryland State Plane, NAD83, meters.

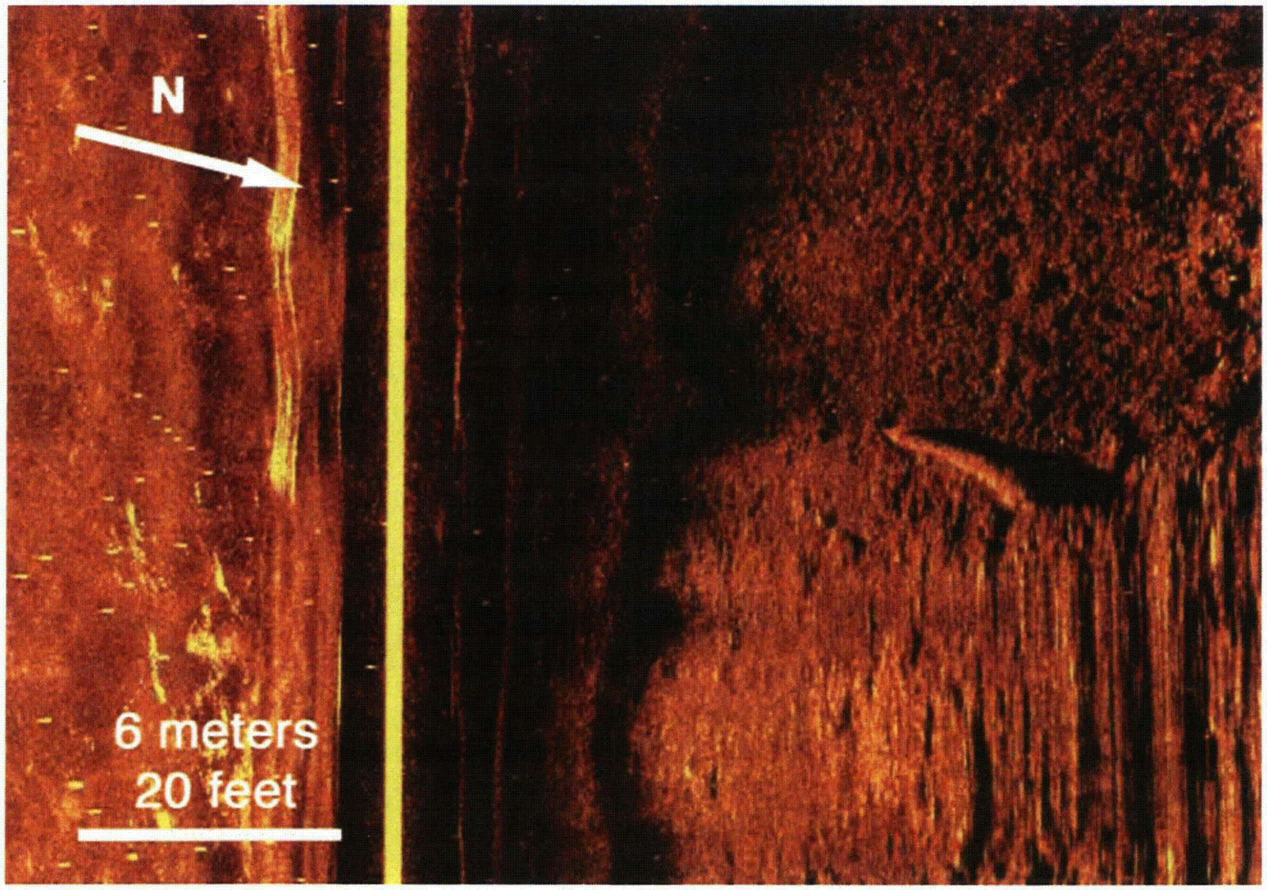

Figure 44. Raw sidescan sonar image of object associated with M03, collected during 2008 survey.

M06

The magnetic refinement of M06 indicated the presence of a 2,000-nanotesla dipole anomaly with a duration of 15 meters (50 feet; Table 6; Figure 45). The strength of the refined anomaly is significantly larger than the original 1,042-nanotesla dipole. This discrepancy can be explained via a difference in the proximity of the magnetometer sensor to the target between the survey and refinement. During the 2008 survey, the true target location likely fell between two survey lines, with the result being that the sensor did not pass very close to the target source. During the refinement, the sensor likely passed much closer to the target and was within 1 meter (≈ 3 feet) of the target source for several seconds, resulting in a much larger anomaly reading.

Examination of the sidescan refinement data does not indicate the presence of any object in the vicinity of either the refined or surveyed locations of M06 (Figures 45 and 46). Examination of the sidescan sonar data from the 2008 survey did not indicate the presence of any object in the vicinity of the magnetic anomaly (Figures 47 and 48).

A diver search of the bay bottom of a 30-meter (100-foot) radius in arcs with 3-meter (10-foot) intervals in the vicinity of the anomaly did not indicate the presence of any object or objects sufficient to account for the anomaly (Figure 45). A pattern of nine hydroprobes, spaced at 3-meter (10-foot) intervals in cardinal directions (out to 6 meters [20 feet] and to a depth of 2 meters [7 feet]), directly on the refined target location did not locate any objects sufficient to account for the anomaly (Figure 45). This failure to locate the object with a visual inspection and a pattern of subsurface probes indicates that the source object (or objects) consists of isolated marine debris (e.g., wire rope, rebar, fencing, railings, etc.) rather than a single large object, or is (are) located below the 2-meter (7-foot) probe depth. Given the location of the target, in a previously dredged working channel for a power plant and near a working dock (see Figure 35 above), it would be expected that the target would consist of marine debris lost or disposed of overboard during docking or cargo transfer operations. This target is not considered historically significant and no further work is recommended.

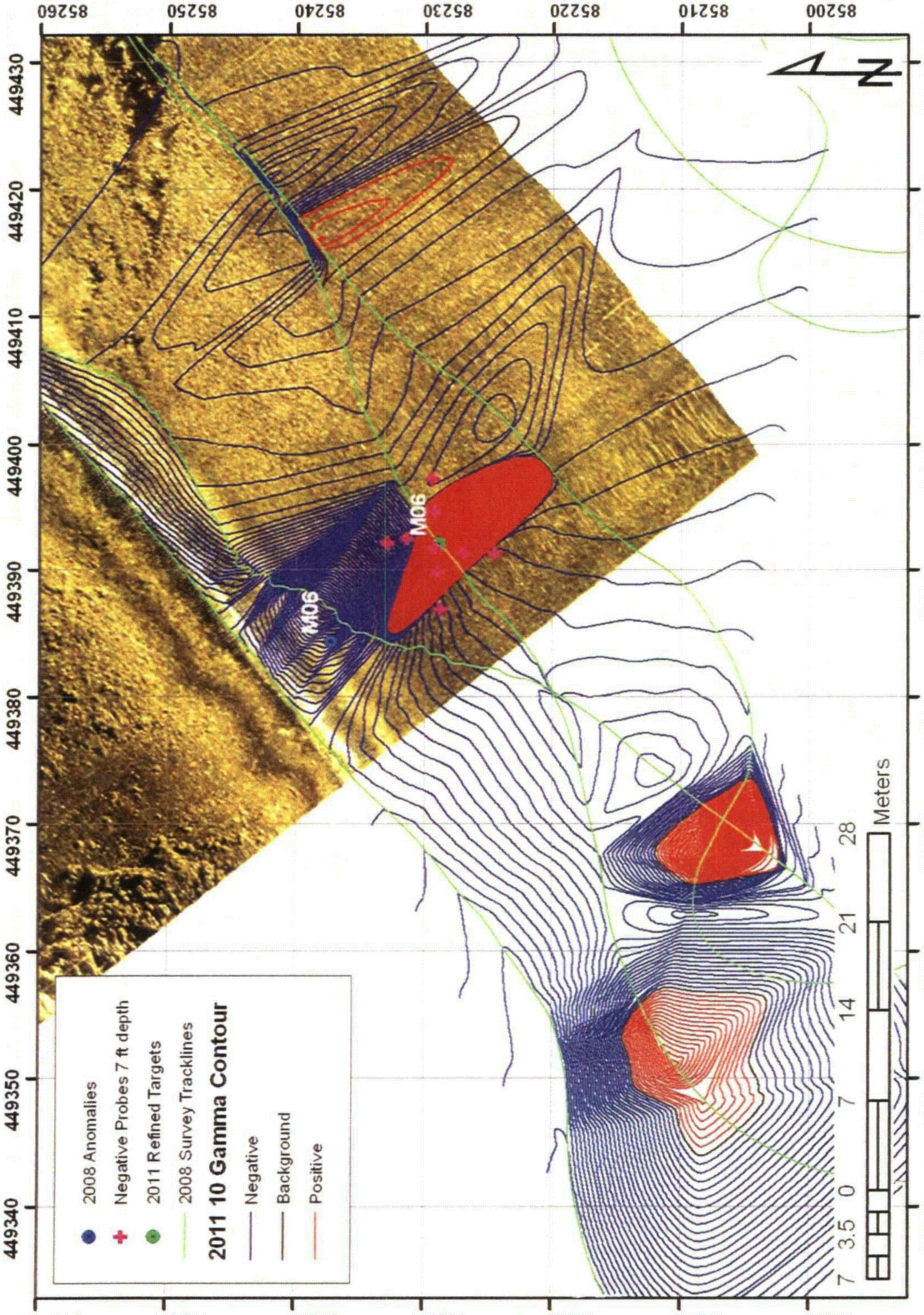

Figure 45. 2011 magnetic contour data overlaid on 2011 sidescan sonar data showing location of M06 and hydroprobe locations. Data presented in Maryland State Plane, NAD83, meters.

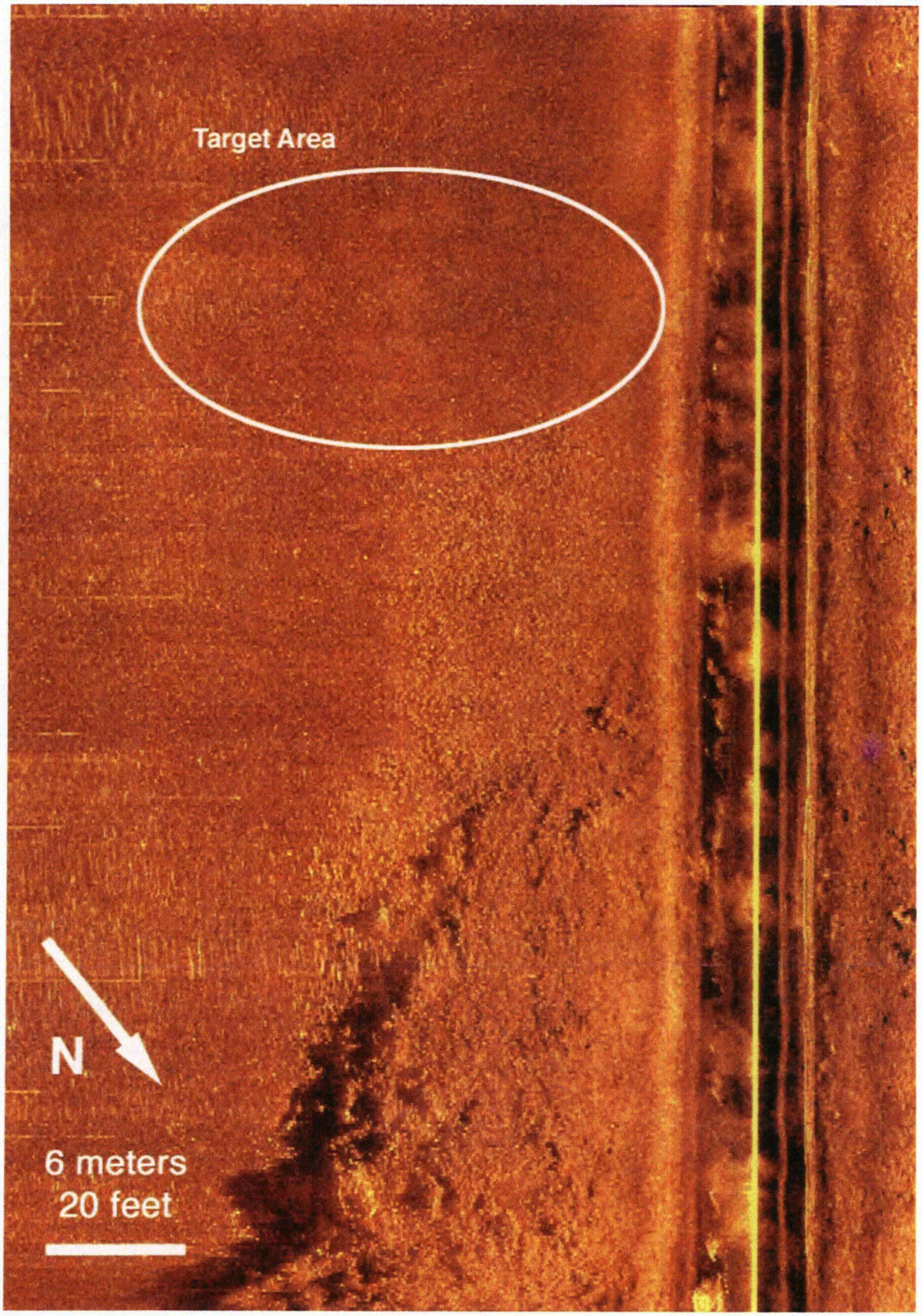

Figure 46. Raw sidescan sonar image of area surrounding M06, collected during 2011 refinement.

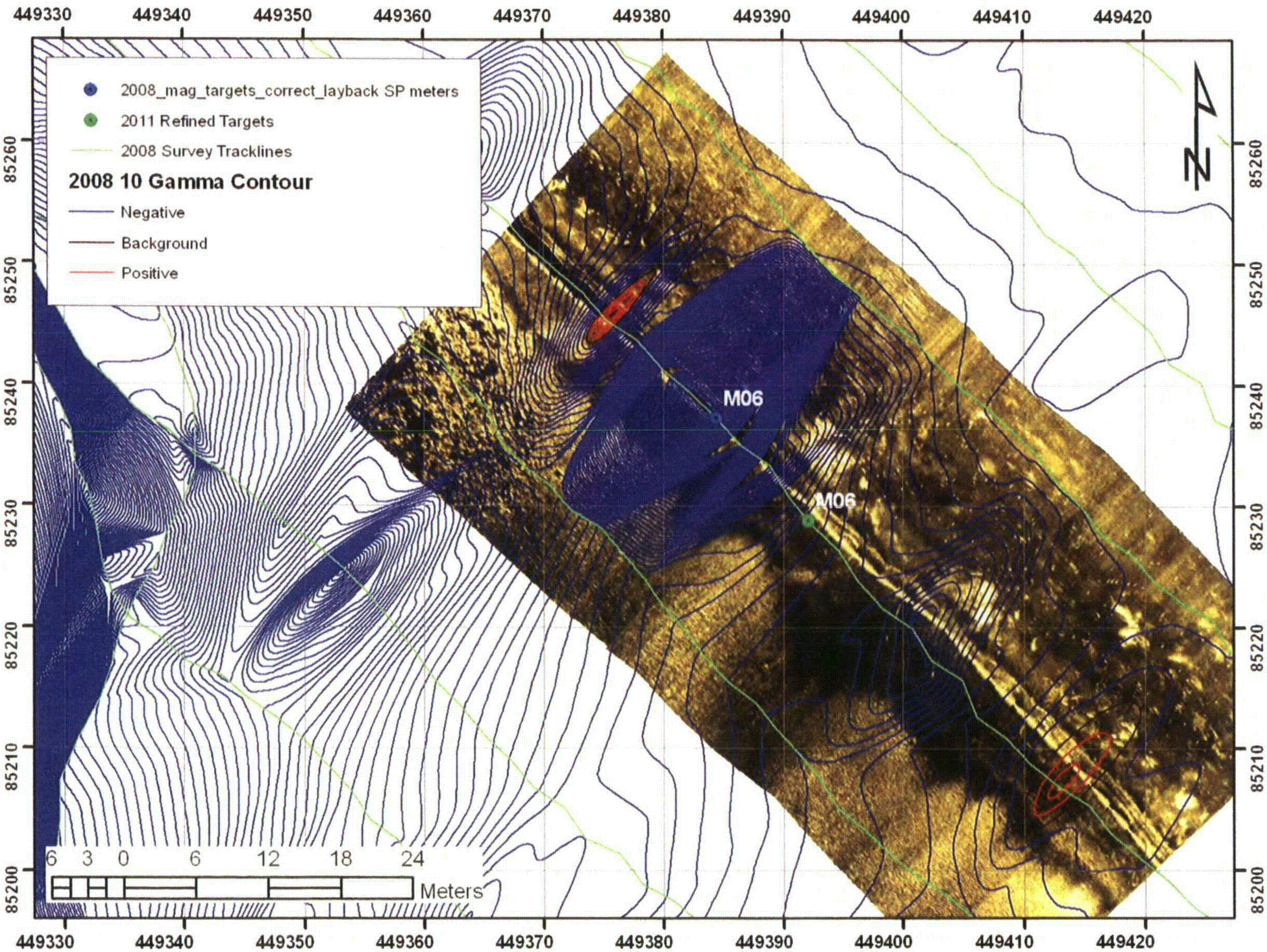

Figure 47. 2008 magnetic contour data overlaid on 2008 sidescan sonar data showing location of M06. Data presented in Maryland State Plane, NAD83, meters.

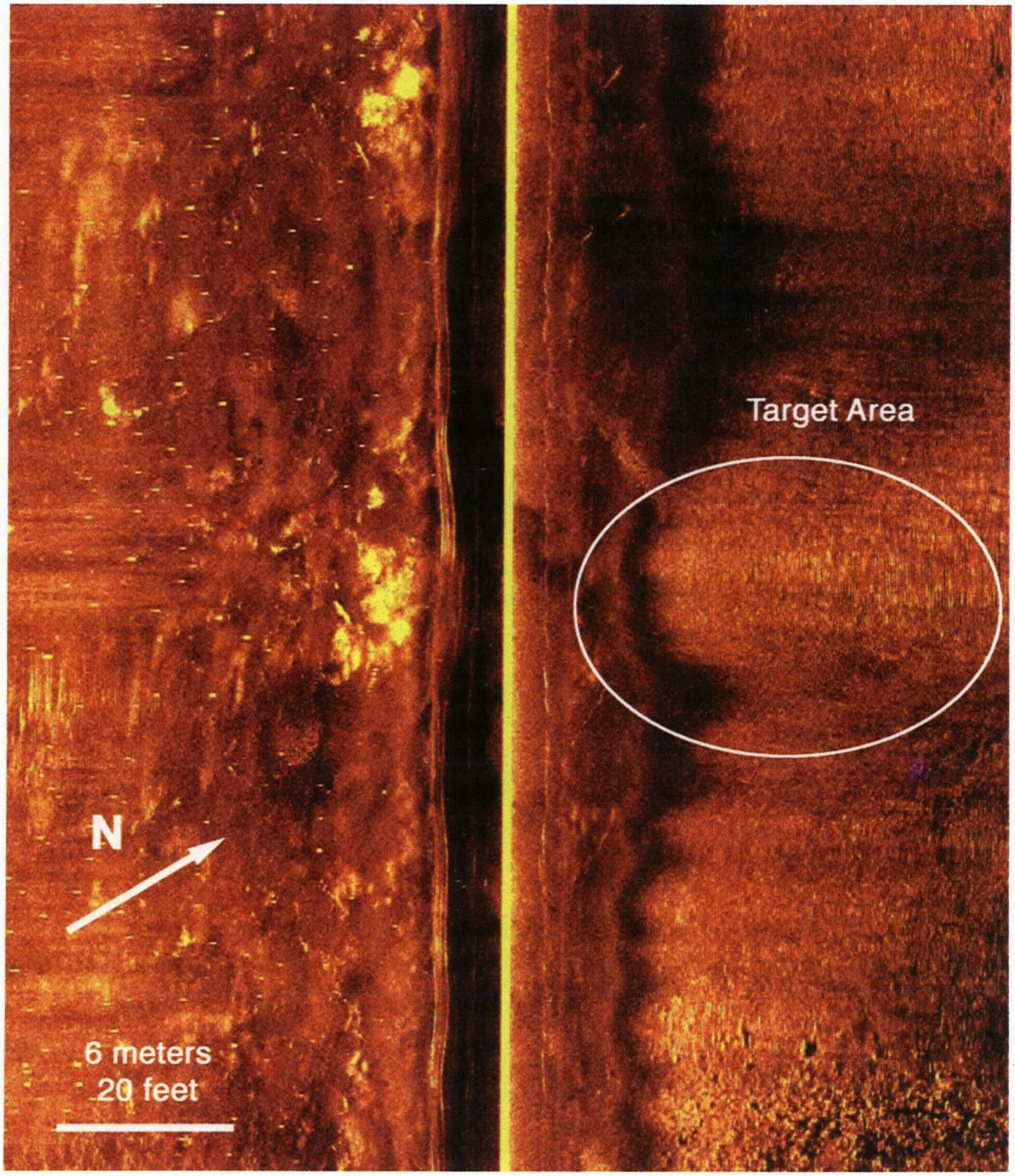

Figure 48. Raw sidescan sonar image of area surrounding M06, collected during 2008 survey.

M101

The survey data for M101 indicated the presence of a 156-nanotesla dipole anomaly with a duration of 32 meters (105 feet; Table 6; Figure 35). Examination of the sidescan sonar data indicated the presence of a possible linear object about 3 meters (10 feet) northwest of the anomaly location (Figures 49 and 50). However, a search of the bay bottom in the vicinity of the anomaly did not indicate the presence of any object (or objects) sufficient to account for the anomaly, indicating the object as seen in the sidescan data is likely the exposed rock located by the diver and discussed below. Following a search of an area of a 15-meter (50-foot) radius surrounding the target by the diver in arcs in a 3-meter (10-foot) interval with negative results, a pattern of nine hydroprobes, spaced at 3-meter (10-foot) intervals in cardinal directions (out to 6 meters [20 feet] in each direction and to a depth of 0.5 meters [2 feet]), did not locate any objects sufficient to account for the anomaly. The hydroprobes did indicate the presence of a hard layer at 0.5 meters (2 feet) below the bottom, which the probe was unable to penetrate.

Subbottom data for the survey indicated the presence of a layer of high-energy return with high signal attenuation below that return in the vicinity of the target (Figure 51). Such signal characteristics indicate a layer below the bottom surface that the subbottom profiler signal is unable to penetrate. This is represented by a dark layer indicating a high signal return, which in turn indicates a dense object or layer that is highly reflective to the frequency of signal being used. The most likely source of this high reflection is rock (Michael Faught personal communication 2011). Within 9 meters (30 feet) of the anomaly location, as reported by the diver, was exposed rock, indicating a fairly shallow accumulation of sediment in the vicinity of the anomaly location. Examination of the subbottom data from adjacent survey lines indicated the feature is 200–250 meters (650–800 feet) in width, extends over several lines, and likely represents not an area where rock extends upward, but rather where the sediment cover has been eroded. This can clearly be seen in Figure 51 as a depression, interpreted as reduced sediment cover, surrounding the target area. The spatial extent of the feature is illustrated in Figure 52 and it should be noted that it is located at the end of the dredged channel and the passage of vessels likely contributes to keeping the sediment cover light in the area.

Failure to locate the object with a visual inspection and a pattern of subsurface probes, coupled with a rock layer 2 feet below the bay bottom, indicates that the source object(s) consist(s) of isolated small marine debris such as wire rope or rebar, rather than a single large object such as a shipwreck. Given the shallow depth of sediment over solid material, any object greater than 2 feet in height would extend up through the sediment and be visible in the sidescan data and by divers. This target is not considered historically significant and no further work is recommended.

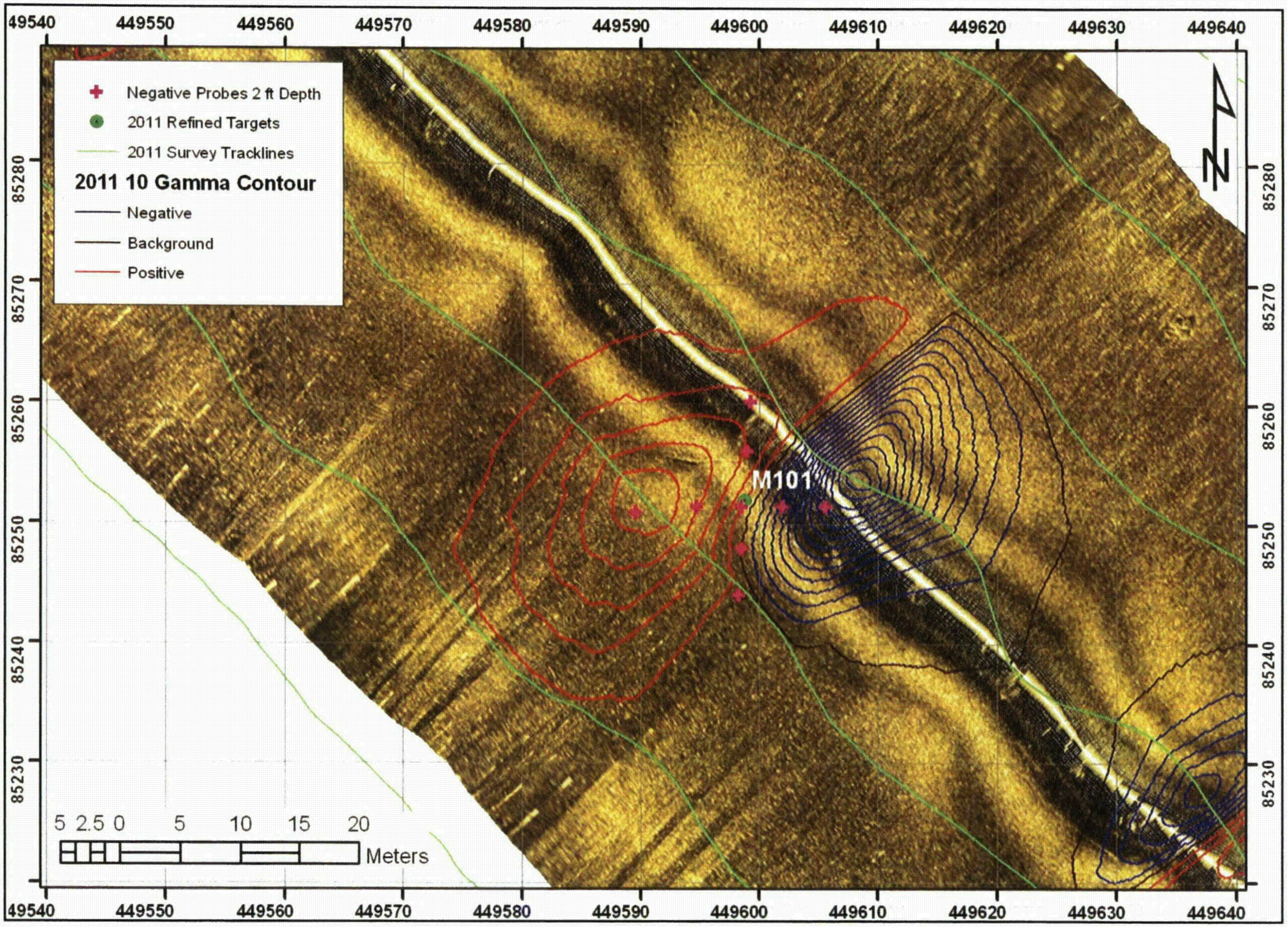

Figure 49. 2011 Magnetic contour map of M101 overlaid on sidescan sonar data, showing location of hydroprobes. Data presented in Maryland State Plane, NAD83, meters.

Figure 50. Raw sidescan sonar image of area surrounding M101 collected during 2011 survey. Note linear object, confirmed by diver inspection to be a rock outcrop.

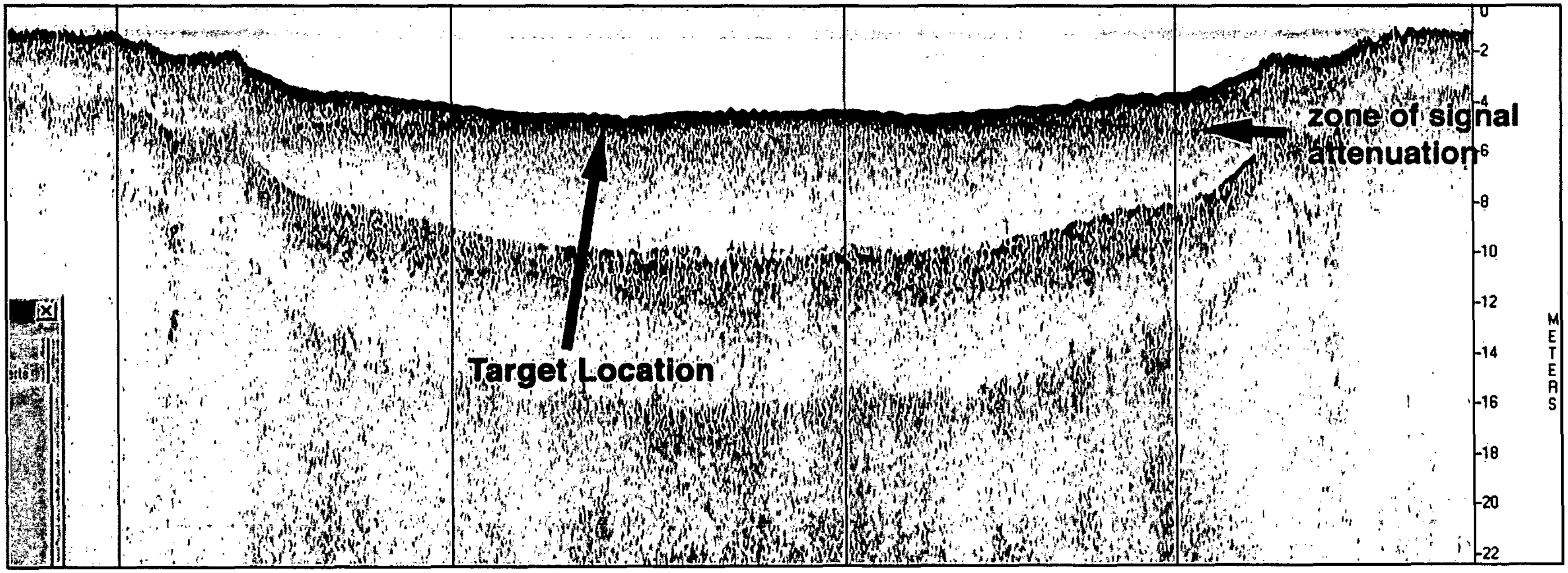

Figure 51. Subbottom data from survey Line 6, directly through M101, illustrating zone of signal attenuation below surface appearing as a dark horizontal region, representing an impenetrable rock layer. Vertical lines represent 100-meter intervals.

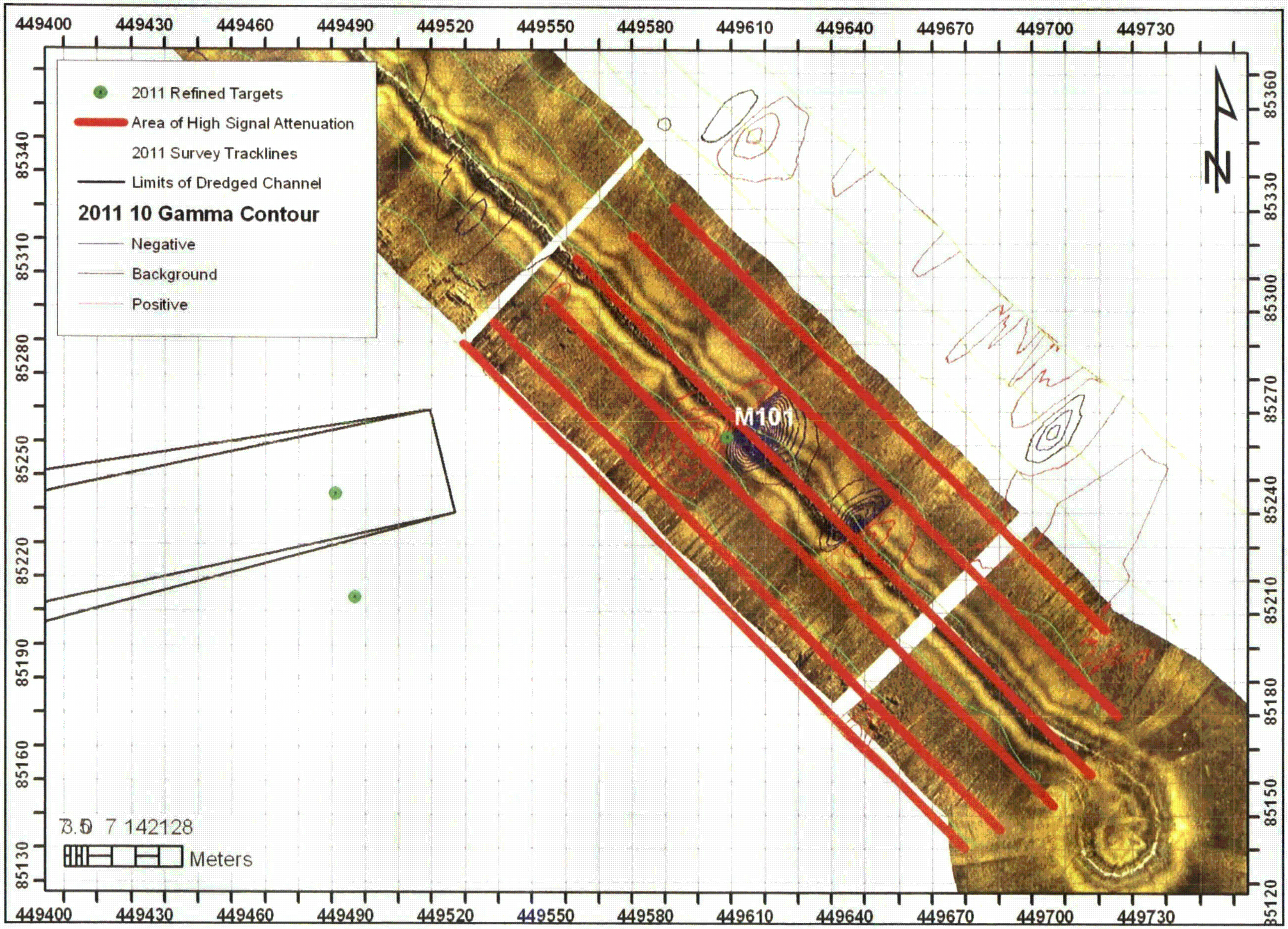

Figure 52. Spatial extent of subbottom feature interpreted as a rock layer within 0.50 meters (2 feet) of the surface. Data presented in Maryland State Plane NAD83 meters.

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V. CONCLUSIONS AND RECOMMENDATIONS

In 2008, archaeologists with Panamerican conducted an intensive submerged cultural resources remote sensing survey for UniStar of a proposed offshore construction impact area associated with construction of a new nuclear generation unit (CC3) at the CCNPP located in Calvert County, Maryland. Located north of both Solomons Point and the mouth of Patuxent River, the survey recorded four potentially significant magnetic anomalies within the offshore area (Faught 2009). Subsequent to completion of the archaeological investigation, UniStar identified modifications to the proposed offshore facilities, requiring additional archaeological investigations. Panamerican was tasked with conducting a comprehensive remote sensing survey of the new 91.5-x-213.5-meter (300-x-700-foot) construction/restoration area for a proposed barge dock/slip, as well as archaeological diving investigations to identify the sources of the four magnetic anomalies, M03, M04, M05, and M06, located during the 2008 survey, and any potentially significant anomalies located during the current survey.

Results of the current remote sensing survey identified a total of three magnetic anomalies and no sidescan sonar targets. One of the magnetic anomalies, M101, met established criteria and was considered potentially significant for the purposes of this investigation, and was further investigated as part of the diving phase.

A re-examination of the survey data collected during the 2008 project revealed a post-processing error in the magnetic data that had resulted in a significant error being introduced into the number and positions of the recommended magnetic anomalies. Reprocessing of the 2008 data led to the elimination of one target entirely (M04) and the adjustment of the positions of the remaining three.

Incorporating the reprocessed 2008 survey data, a total of four targets were investigated and assessed, including magnetic anomalies M03, M05 and M06, located during the 2008 survey and magnetic anomaly M101, located during the current survey. Target M05 was accounted for by the presence of a large rudder and propeller, M03 by the presence of a 10-foot length of 0.5-meter (16-inch) diameter steel pipe, and M06, probed via hydroprobe to a depth of 2 meters (7 feet), was determined to likely consist of a large amount of isolated marine related debris. M101 was probed to a depth of 0.5 meters (2 feet), to a depth where a large impenetrable rock layer was encountered. The source of M101 is considered to be isolated marine debris above this rock layer but covered by sediment. None of the targets are considered historically significant and no further work is recommended.

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