RESULTS OF THE SUMMER 2005 MULTIBEAM BATHYMETRIC AND BACKSCATTER SURVEYS AT THE HISTORIC AREA REMEDIATION SITE AND THE SHARK RIVER REEF

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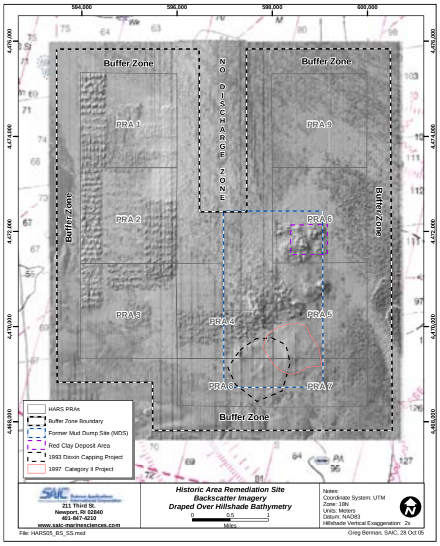

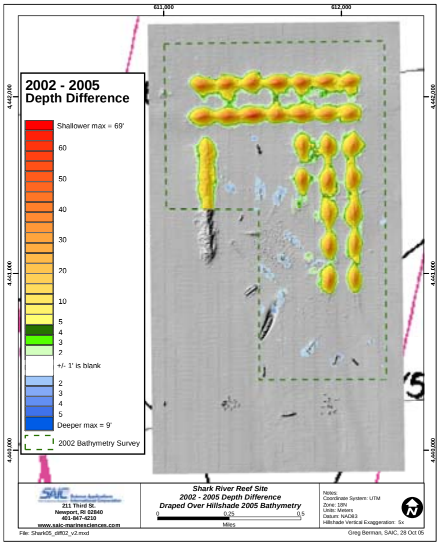

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LIST OF ACRONYMS

CMG	**C**ourse **M**ade **G**ood
CTD	**C**onductivity, **T**emperature, **D**epth profiler
DAPR	**D**ata **A**cquisition and **P**rocessing **R**eport
DAT	**D**igital **A**udio **T**ape
DGPS	**D**ifferential **G**lobal **P**ositioning **S**ystem
DPC	**D**ata **P**rocessing **C**enter
DR	**D**escriptive **R**eport
DTC	**D**ata **T**ransaction **C**enter
EPA	**E**nvironmental **P**rotection **A**gency
FAT	**F**actory **A**cceptance **T**est
GGA	NMEA-183 Global Positioning System Fix Data String
GPS	**G**lobal **P**ositioning **S**ystem
GSF	**G**eneric **S**ensor **F**ormat
HARS	**H**istoric **A**rea **R**emediation **S**ite
HDOP	**H**orizontal **D**ilution **O**f **P**recision
HDU	**H**elm **D**isplay **U**nit
IMU	**I**nertial **M**easurement **U**nit
ISO	**I**nternational **O**rganization for **S**tandardization
ISS-2000	**I**ntegrated **S**urvey **S**oftware 2000
ISSC	**I**ntegrated **S**urvey **S**ystem **C**omputer
JD	**J**ulian **D**ay
MLLW	**M**ean **L**ower **L**ow **W**ater
MSU	**M**ass **S**torage **U**nit
MVE	**M**ulti-**V**iew **E**ditor
MVP	**M**oving **V**essel **P**rofiler
NMEA	**N**ational **M**arine **E**lectronics **A**ssociation
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
NYD	**N**ew **Y**ork **D**istrict
PFM	**P**ure **F**ile **M**agic
POS/MV	**P**osition **O**rientation **S**ystem/**M**arine **V**essels
PRA	**P**riority **R**emediation **A**rea
SABER	**S**urvey **A**nalysis and area **B**ased **E**dito**R**
SAIC	**S**cience **A**pplications **I**nternational **C**orporation
SAT	**S**ea **A**cceptance **T**ests, or **S**wath **A**lignment **T**ool
SDF	**S**onar **D**ata **F**ormat
SMMP	**S**ite **M**anagement and **M**onitoring **P**lan
SVP	**S**ound **V**elocity **P**rofile
TPU	**T**ransceiver **P**rocessing **U**nit
UPS	**U**ninterruptible **P**ower **S**upply
USACE	**U.S**. **A**rmy **C**orps of **E**ngineers
XTF	e**X**tended **T**riton **F**ormat

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1.0 INTRODUCTION

1.1 Background

Sediments dredged from New York Harbor were deposited at the Mud Dump Site (MDS), located in the New York Bight about six nautical miles east of Sandy Hook, New Jersey, until September 1997. Based on an agreement among the Environmental Protection Agency (EPA), the Department of the Army, and the Department of Transportation, the MDS and some surrounding historical dredged material disposal areas were re-designated as the Historic Area Remediation Site (HARS; Figure 1.1-1) beginning in September 1997.

The HARS SMMP serves as a guideline document for the monitoring of the PRAs during the course of remediation efforts. The recommended routine monitoring tools in the SMMP include high-resolution bathymetry, sediment-profile imaging (SPI), sediment coring, sediment chemistry and toxicity testing, tissue chemistry testing, benthic community analyses, and fish/shellfish surveys. Over the last several years, periodic monitoring surveys have been conducted following the guidelines of the SMMP to document the overall environmental conditions within the HARS. The 2005 field monitoring surveys were a continuation of periodic physical characterization surveys that have been conducted annually over all or parts of the HARS since 2002. The primary focus of this report is on the multibeam bathymetric and backscatter imagery survey that was conducted over the HARS in late summer 2005 to provide an updated broad-scale physical characterization of the entire area. In addition, the 2005 monitoring effort also entailed sediment toxicity and sediment-profile image surveys that are addressed in a separate companion report (SAIC 2005a).

In addition to the work conducted at the HARS, this report will also address the similar multibeam and side-scan sonar survey operations that were conducted at the Shark River Reef during the same time period (Figure 1.1-1). The Shark River Reef is an offshore reef site administered by the State of New Jersey that has been used for the placement of dredged rock material from New York Harbor over the last few years. The 2005 survey results will be compared to the prior bathymetric and side-scan sonar surveys at the Shark River Reef over the last few years to document the progress of the on-going rock placement operations at the Site.

1.2 Survey Objectives

The primary objective for this portion of the 2005 monitoring effort was to obtain an updated broad-scale physical characterization of the entire HARS (including the buffer areas and the no-discharge zone) and the Shark River Reef. The multibeam bathymetry acquired during this effort provided updated high-resolution datasets that will be used to monitor and plan future placement activity at the HARS and the Shark River Reef. In addition, the broad-scale characterization also provided multibeam backscatter or side-scan sonar imagery that were used to help characterize the composition of the surface sediments in both areas.

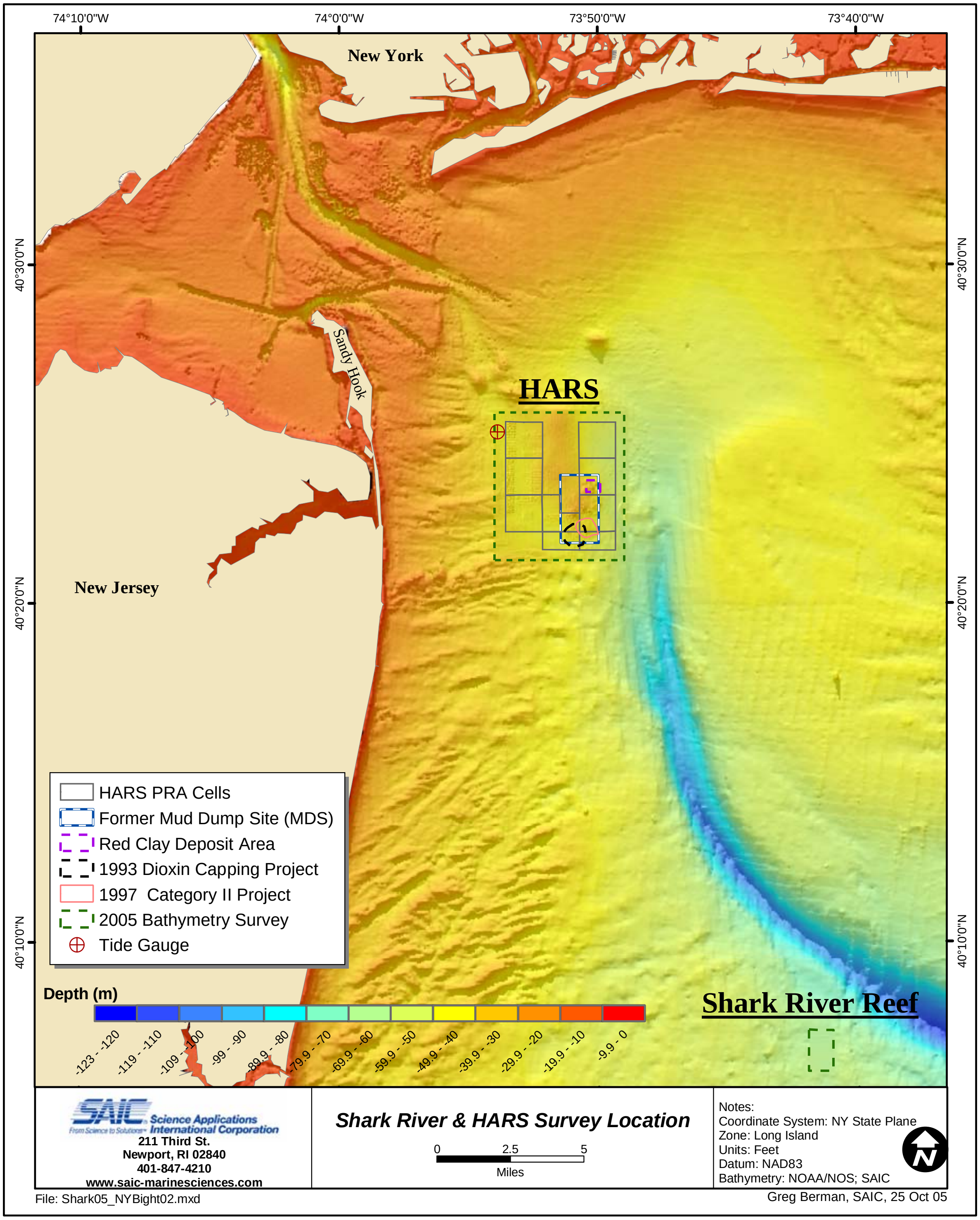

Figure 1.1-1. Location of the Historic Area Remediation Site and the Shark River Reef in the New York Bight

2.0 METHODS

This portion of the 2005 monitoring effort entailed a complete multibeam bathymetric survey over the entire HARS (including the buffer areas and the no-discharge zone) and the Shark River Reef. Concurrently with the multibeam data acquisition, multibeam backscatter imagery was also acquired over the HARS and side-scan sonar imagery was acquired over the Shark River Reef. A detailed description of the field data acquisition and processing techniques for each of the main survey elements is presented in the sections below. Survey operations were conducted continuously on a 24-hour basis from 25 August through 31 August 2005 throughout the program with no significant weather or equipment-related downtime (Table 2.0-1).

2.1 Data Acquisition

All of the survey operations were conducted aboard the M/V *Atlantic Surveyor* that was based out of Point Pleasant, New Jersey for the duration of these operations (Figure 2.1-1). In addition to the primary survey components installed by SAIC and identified in the figure (also discussed in further detail below), the vessel was also equipped with an autopilot, echo sounder, Differential Global Positioning System (DGPS), radars, and two 40 KW diesel generators. Accommodations for up to twelve survey support personnel were available within three cabins.

Two 20-foot International Organization for Standardization (ISO) containers were secured on the aft deck. One was used as the real-time, survey data acquisition space and the other as the data processing space. A Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) was mounted below the main deck on the vessel's centerline just forward and above the Reson 8101 multibeam transducer, which was affixed to the hull just to port of the keel. An A-frame at the stern of the vessel allowed for towing the side-scan sonar towfish. A Brook Ocean Technologies Moving Vessel Profiler (MVP-30), used to measure sound velocity profiles, was deployed from the starboard stern of the vessel.

Central to SAIC's onboard survey data acquisition system was the Integrated Survey System Computer (ISSC). The ISSC consists of a high-end dual processor computer with the Windows 2000 operating system, which runs SAIC's ISS-2000 software. This software provided survey planning and control in addition to data acquisition and logging for multibeam and navigation data. Klein 3000 side-scan sonar data were acquired using Klein's SonarPro sonar software running on a high-end dual processor computer with the Windows 2000 operating system. Data acquisition was carried out using the SAIC ISS-2000 software on a Windows 2000 operating system to control real-time navigation, data time tagging, and data logging. Position data were recorded from both the POS/MV system and the Trimble 7400. Data from the POS/MV was merged with multibeam data and was the primary navigation and positioning sensor. Vessel-positioning confidence checks were performed daily by comparing position data from the POS/MV to position data from the Trimble DGPS.

Table 2.0-1.
Summary of field operations aboard the M/V *Atlantic Surveyor* during the summer 2005 survey operations at the HARS and Shark River Reef

Date	Daily Activity Type	Daily Operations Overview
8/25/2005	Transit / Survey	Transit to the Shark River Reef Site and conduct the multibeam and side-scan sonar survey; reterminate side-scan sonar cable due to interference from fishing gear; transit back to Pt Pleasant, NJ.
8/26/2005	Transit / Survey	Offload survey personnel in Pt Pleasant and transit to the HARS; deploy pressure tide gauge along the western edge of HARS; begin HARS multibeam survey with N/S lanes spaced at 60-m intervals
8/27/2005	Survey	Continue HARS multibeam survey - 24-hour ops
8/28/2005	Survey	Continue HARS multibeam survey - 24-hour ops
8/29/2005	Survey	Continue HARS multibeam survey - 24-hour ops
8/30/2005	Survey	Continue HARS multibeam survey - 24-hour ops
8/31/2005	Survey / Transit	Continue / complete HARS multibeam survey; transit back to Pt Pleasant for crew and equipment demob

Vessel Name	LOA	Beam	Draft	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
M/V *Atlantic Surveyor*	110’	26’	9’	14 knots	Displacement 68 net tons	900	D582365

Primary On-Board Survey Systems by Manufacturer

	Manufacturer / Model Number	Subsystem
Multibeam Sonar	RESON SeaBat 8101	Transducer 8101 Processor
Side Scan Sonar	Klein 3000 Towfish	K-Wing Depressor, Transceiver/Processing Unit
Vessel Attitude System	TSS POS/MV Inertial Navigation System	
Positioning System	TSS POS/MV	
	Trimble 7400 GPS Receiver	
	Trimble Probeacon Differential Beacon Receiver	
	Leica MX41R Differential Beacon Receiver	
Sound Velocity System	Brooke Ocean Technology Ltd., Moving Vessel Profiler-30	Applied Microsystems Ltd. Smart SV and Pressure Sensor
	Sea-Bird Electronics, Inc. CTD Profiler	

Figure 2.1-1. Specifications for the M/V *Atlantic Surveyor* and an overview of the primary survey systems installed on the vessel

2.1.1 Multibeam Systems and Operations

The real-time multibeam acquisition system used for the HARS and Shark River Reef surveys included each of the following unless further specified:

- Windows 2000 workstation (ISSC) for data acquisition, system control, survey planning, survey operations, and real-time quality control
- Reson 8101 multibeam transducer
- Reson 81P sonar processor
- POS M/V 320 Position and Orientation System with a Trimble Probeacon Differential Receiver
- Trimble 4000 GPS Receiver with a Leica MX-40 Differential Receiver
- MVP 30 Moving Vessel Profiler with four interchangeable Applied Microsystem Smart Sound Velocity and Pressure Sensors and a Notebook computer to interface with the ISSC and the deck control unit
- Notebook computer for maintaining daily navigation and operation logs
- Two Seabird Model SBE-19-01 Conductivity, Temperature, Depth (CTD) profilers
- Uninterrupted power supplies (UPS) for protection of the entire system

The user selectable range scale on the Reson 8101 was adjusted appropriately depending upon the survey depth. Vessel speed was also adjusted to ensure that no less than three ping footprints occurred within 1.0 meter in the along-track direction. Confidence checks of the multibeam echo sounder were made using leadline comparisons during port calls.

Multibeam bathymetric data, meeting the USACE Class I survey standards (USACE 2002), were acquired over the entire HARS by running a series of 183 north-south main-scheme survey lanes that were spaced at either 30- or 60-m intervals, depending on the survey depth (and resultant swath coverage). In addition, five east-west lanes were also established to provide the required cross-check comparisons with the main-scheme bathymetric data (Figure 2.1-2). At the Shark River Reef, 21 north-south main-scheme survey lanes spaced at 60-m intervals were used to obtain the required coverage. In addition, three east-west lanes were also occupied to provide the required cross-check comparison data (Figure 2.1-3).

2.1.1.1 Sound Velocity Profiles

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with Applied Microsystems Smart Sound Velocity and Pressure sensors was used to collect sound velocity profile (SVP) data. SVP data were obtained at intervals frequent enough to reduce sound velocity errors and generally spaced at not more than two-hour intervals throughout the survey day. The frequency of the casts was based on observed sound velocity changes from previously collected profiles and time elapsed since the last cast. Multiple casts were also taken along a survey lane to identify the rate and location of sound velocity changes. Subsequent casts were made based on the observed trend of sound velocity changes. As the sound velocity profiles changed, cast frequency and

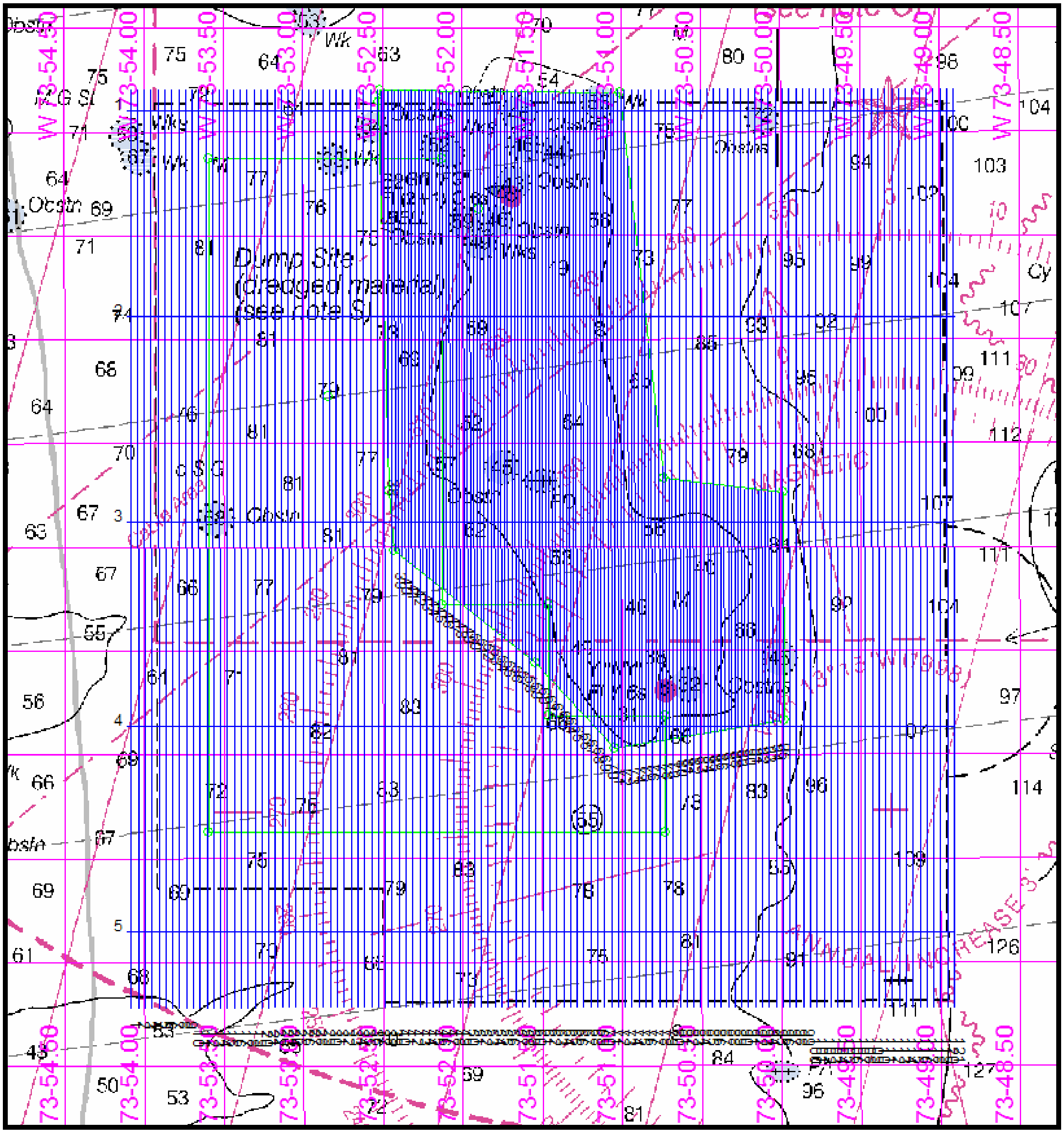

Figure 2.1-2. Depiction of north-south main scheme lanes (spaced at 60 and 30 m intervals) and east-west cross lanes that were occupied during the Summer 2005 multibeam survey operations conducted at the HARS.

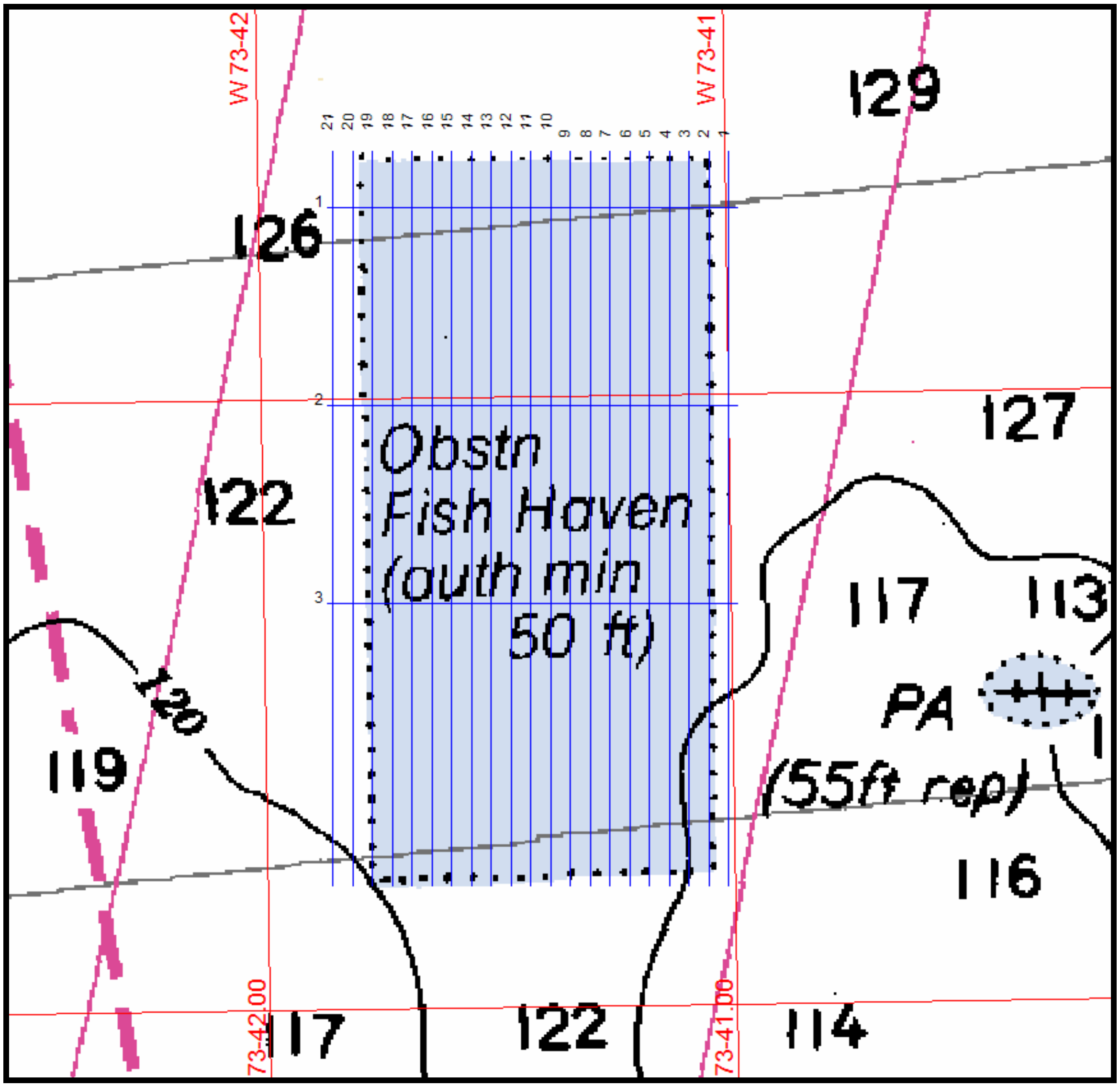

Figure 2.1-3. Depiction of north-south main scheme lanes (spaced at 60 and 30 m intervals) and east-west cross lanes that were occupied during the Summer 2005 multibeam survey operations conducted at Shark River Reef.

location were modified accordingly. Confidence checks of the sound velocity profile casts were conducted at the beginning and at the end of the survey by comparing two consecutive casts taken with different sound velocity and pressure sensors. Over the course of these survey operations, a total of 68 SVP casts were acquired (Table 2.1-1).

2.1.1.2 Tidal (or Water-Level) Observations

To monitor tidal and other water-level impacts during this survey, a bottom-mounted tide gauge was deployed along the western buffer zone of the HARS (Figure 1.1-1). The tide gauge consisted of a Seabird SBE-26 wave and tide gauge mounted on a weighted bottom tripod outfitted with an acoustic release for recovery. The tide gauge was deployed just prior to the start of survey operations and successfully recovered the day after the completion of the survey (Table 2.0-1). The calibrated pressure sensor and an internal data logger recorded the water height above the sensor at six-minute intervals throughout the survey. The data from this gauge were used to make comparisons with the preliminary data from the primary National Oceanic and Atmospheric Administration (NOAA) tide gauge at Sandy Hook (Station No. 8531680) and to help document non-tidal water-level differences between the HARS and Sandy Hook Bay. During the multibeam survey operations, predicted tide correctors were used within ISS-2000 to provide an initial Mean Lower Low Water (MLLW) adjustment to the sounding data. During post-processing, these predicted tidal correctors were replaced with verified observed tides from the Sandy Hook station that were modified by accepted phase and range offsets to the different survey areas.

2.1.2 Side-Scan Sonar Systems and Operations

The towed side-scan sonar system used for the Shark River Reef survey included the following:

- Klein 3000 digital side-scan sonar towfish with a Klein K2 k-wing depressor
- Klein 3000 Windows 2000 computer for data collection and logging of 3000 sonar data with Klein **SonarPro** software
- Klein 3000 Transceiver Processing Unit (TPU)
- McArtney sheave with cable payout indicator
- Sea Mac winch with remote controller
- Uninterrupted power supplies (UPS) for protection of the entire system

The backup side-scan system maintained aboard included:

- Klein 3000 digital side-scan sonar towfish with a Klein K1 k-wing depressor
- Klein 3000 Transceiver Processing Unit (TPU)
- Triton-Elics Windows 2000 computer for data collection and logging of Klein 3000 sonar data using Klein SonarPro software

Table 2.1-1.
Summary of sound velocity profiles (SVPs) taken aboard the M/V *Atlantic Surveyor* during the summer 2005 survey operations at the HARS and Shark River Reef

Julian Day	Cast File Number	Cast Time (UTC)	Depth (m)	Position (NAD83)		Notes	Application Start Time (UTC)	Application End Time (UTC)
				Latitude (N)	Longitude (W)			
232	ASSVP05232.D15	12:53:56	3.68	40.102333	074.042167	APPLIED FOR LEADLINE	232/12:54:08	N/A
237	ASSVP05237.D01	02:32:32	35.85	40.104500	073.677500	APPLIED FOR COMPARISON CAST	237/02:32:43	237/02:39:13
237	ASSVP05237.D02	02:39:06	36.97	40.103833	073.678667	APPLIED FOR COMPARISON CAST	237/02:39:13	237/03:35:22
237	ASSVP05237.D03	03:35:11	36.42	40.127000	073.697833	APPLIED	237/03:35:22	237/05:25:36
237	ASSVP05237.D04	05:25:27	34.14	40.104167	073.694000	APPLIED	237/05:25:36	237/07:07:39
237	ASSVP05237.D05	07:07:33	34.51	40.108167	073.689000	APPLIED	237/07:07:39	237/08:28:08
237	ASSVP05237.D06	08:27:36	34.57	40.102167	073.686333	APPLIED	237/08:28:08	237/09:56:29
237	ASSVP05237.D07	09:55:56	31.64	40.105667	073.687000	APPLIED	237/09:56:29	237/17:03:44
237	ASSVP05237.D08	17:03:38	2.85	40.102333	074.042000	APPLIED FOR LEADLINE	237/17:03:44	N/A
238	ASSVP05238.D01	19:19:14	23.54	40.420167	073.899667	APPLIED	238/19:19:29	238/20:04:53
238	ASSVP05238.D02	20:04:38	32.19	40.419000	073.810500	APPLIED	238/20:04:53	238/20:57:05
238	ASSVP05238.D03	20:55:01	21.18	40.391667	073.897667	APPLIED	238/20:57:05	238/23:20:57
238	ASSVP05238.D04	23:20:44	32.40	40.401000	073.814333	APPLIED	238/23:20:57	239/01:38:34
239	ASSVP05239.D01	01:38:08	35.96	40.350833	073.813833	APPLIED	239/01:38:34	239/03:40:22
239	ASSVP05239.D02	03:40:09	29.20	40.434167	073.816167	APPLIED	239/03:40:22	239/05:44:44
239	ASSVP05239.D03	05:44:23	32.08	40.350000	073.823333	APPLIED	239/05:44:44	239/07:44:05
239	ASSVP05239.D04	07:43:36	24.60	40.432833	073.822833	APPLIED	239/07:44:05	239/11:24:25
239	ASSVP05239.D05	11:24:17	30.55	40.350167	073.824500	APPLIED	239/11:24:25	239/11:46:19
239	ASSVP05239.D06	11:45:18	25.43	40.433333	073.829833	APPLIED	239/11:46:19	239/13:54:17
239	ASSVP05239.D07	13:53:51	26.32	40.350333	073.831333	APPLIED	239/13:54:17	239/16:10:46
239	ASSVP05239.D08	16:10:20	19.59	40.433333	073.871500	APPLIED	239/16:10:46	239/18:22:37
239	ASSVP05239.D09	18:22:24	20.33	40.351333	073.870500	APPLIED	239/18:22:37	239/20:44:12
239	ASSVP05239.D10	20:44:01	24.38	40.433000	073.835000	APPLIED	239/20:44:12	239/22:52:08
239	ASSVP05239.D11	22:51:55	26.40	40.349833	073.834000	APPLIED	239/22:52:08	239/23:47:26
239	ASSVP05239.D12	23:46:45	19.52	40.432333	073.871500	APPLIED	239/23:47:26	240/01:53:43
240	ASSVP05240.D01	01:53:10	19.15	40.350167	073.872667	APPLIED	240/01:53:43	240/03:52:58
240	ASSVP05240.D02	03:52:10	18.39	40.432333	073.876500	APPLIED	240/03:52:58	240/06:04:09
240	ASSVP05240.D03	06:03:43	18.93	40.350500	073.878833	APPLIED	240/06:04:09	240/06:59:39
240	ASSVP05240.D04	06:59:31	24.26	40.433500	073.837500	APPLIED	240/06:59:39	240/09:06:35
240	ASSVP05240.D05	09:06:12	25.52	40.350333	073.836833	APPLIED	240/09:06:35	240/11:06:19
240	ASSVP05240.D06	11:06:02	23.28	40.432000	073.841833	APPLIED	240/11:06:19	240/13:23:03
240	ASSVP05240.D07	13:22:51	20.09	40.349833	073.864667	APPLIED	240/13:23:03	240/15:26:04
240	ASSVP05240.D08	15:25:44	20.24	40.434500	073.868333	APPLIED	240/15:26:04	240/16:53:40
240	ASSVP05240.D09	16:53:17	18.22	40.432667	073.882000	APPLIED	240/16:53:40	240/19:18:28
240	ASSVP05240.D10	19:18:05	24.89	40.349667	073.838333	APPLIED	240/19:18:28	240/21:21:42
240	ASSVP05240.D11	21:21:33	23.07	40.432333	073.845000	APPLIED	240/21:21:42	240/23:31:00
240	ASSVP05240.D12	23:29:42	22.71	40.349333	073.857500	APPLIED	240/23:31:00	241/01:00:18
241	ASSVP05241.D01	01:00:04	25.88	40.346000	073.850167	APPLIED	241/01:00:18	241/03:00:41
241	ASSVP05241.D02	03:00:27	19.36	40.432667	073.855667	APPLIED	241/03:00:41	241/05:06:57
241	ASSVP05241.D03	05:06:11	22.16	40.351000	073.851833	APPLIED	241/05:06:57	241/07:02:57
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241	ASSVP05241.D06	11:05:36	22.15	40.433833	073.845833	APPLIED	241/11:05:47	241/13:22:28
241	ASSVP05241.D07	13:14:14	22.87	40.349667	073.843167	APPLIED	241/13:22:28	241/14:41:08
241	ASSVP05241.D08	14:40:57	21.73	40.350667	073.862000	APPLIED	241/14:41:08	241/16:50:24
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242	ASSVP05242.D06	11:35:24	16.37	40.351000	073.898500	APPLIED	242/11:36:02	242/13:12:54
242	ASSVP05242.D07	13:12:27	19.95	40.370667	073.849667	APPLIED	242/13:12:54	242/15:43:56
242	ASSVP05242.D08	15:43:03	19.65	40.431667	073.853500	APPLIED	242/15:43:56	242/17:09:51
242	ASSVP05242.D09	17:09:38	18.63	40.382833	073.859333	APPLIED	242/17:09:51	242/19:05:13
242	ASSVP05242.D10	19:05:01	19.51	40.373333	073.850000	APPLIED	242/19:05:13	242/20:25:16
242	ASSVP05242.D11	20:25:07	18.97	40.400333	073.847500	APPLIED	242/20:25:16	242/22:24:33
242	ASSVP05242.D12	22:24:16	24.22	40.376667	073.835333	APPLIED	242/22:24:33	242/23:54:12
242	ASSVP05242.D13	23:53:51	21.30	40.373833	073.842333	APPLIED	242/23:54:12	243/01:42:47
243	ASSVP05243.D01	01:42:29	19.09	40.432167	073.860667	APPLIED	243/01:42:47	243/04:28:45
243	ASSVP05243.D02	04:28:23	18.92	40.387167	073.865333	APPLIED	243/04:28:45	243/06:00:24
243	ASSVP05243.D03	05:59:43	19.61	40.389000	073.868333	APPLIED	243/06:00:24	243/07:37:10
243	ASSVP05243.D04	07:36:48	18.18	40.423167	073.870500	APPLIED FOR COMPARISON CAST	243/07:37:10	N/A
243	ASSVP05243.D05	07:42:56	18.29	40.426833	073.869167	APPLIED FOR COMPARISON CAST	243/07:43:02	N/A
243	ASSVP05243.D06	22:07:38	1.66	40.102333	074.042000	APPLIED FOR LEADLINE	243/22:08:00	N/A

The Klein 3000 is a conventional dual frequency side-scan sonar system with a single beam per side. At a range scale of 50 m, a ping rate of 15 pings/second is set by the transceiver, which allowed for a maximum survey speed of 9 knots. Changing the Klein 3000 range scale to 75 m, a ping rate of 11.25 pings/second is set by the transceiver, which allowed for a maximum survey speed of 6 knots. These maximum survey speeds, based on Klein 3000 range scale, ensured an average of three pings per meter in the along-track distance. During the side-scan sonar survey operations at the Shark River Reef, a range scale of 75 m was used.

During survey operations, digital data from the Klein 3000 TPU were sent directly to the Klein 3000 computer for display and logging by Klein SonarPro software. Raw digital side-scan data from the Klein 3000 were collected in Klein's proprietary Sonar Data Format (SDF). These files were periodically archived to the data processing computer for initial processing and quality control review. The SDF format files were converted to eXtended Triton Format (XTF) prior to processing and review. The raw SDF and XTF side-scan data files were backed up on 4-mm Digital Audio Tapes (DAT), which were shipped to the Data Processing Center in Newport, RI once the survey vessel reached port.

Towfish positioning was provided by ISS-2000 through a module that used the Payout and Angle method to compute towfish position. The Payout and Angle method computed the position of the tow point using the offsets of the tow point from the POS/MV IMU and the vessel heading. The towfish position was calculated from the position of the tow point using the cable-out value provided by the cable payout meter, an operator-entered tow angle (determined for each side-scan configuration), and the Course Made Good (CMG) of the vessel. The ship's north and east velocity vectors were filtered to calculate the ship's CMG; the CMG was then used to determine the azimuth from the tow block to the side-scan towfish. The position for the side-scan towfish was computed based on the vessel's heading, the reference position (POS/MV IMU), the measured offsets to the tow point, the tow angle, Course Made Good, and the amount of cable out. This calculated towfish position was sent to the sonar data collection system where it was merged with the SDF data file.

Cable adjustments were made using a remote winch controller inside the real-time survey van in order to maintain acceptable towfish altitudes and sonar record quality. Changes to the amount of cable out were automatically saved to the ISS-2000 message file and a payout file. Towfish altitude was variable and determined by the topography and/or the presence of large manmade bottom features (e.g., shipwrecks). For equipment and personnel safety, data were sometimes acquired at a towfish altitude well above 20% of the range in areas where large disposal mounds, obstructions, and wrecks required higher towfish altitudes. Periodic confidence checks on linear features (e.g., trawl scars) or geological features (e.g., sand waves or sediment boundaries) were made to verify the quality of the sonar data.

2.1.3 Quality Control

A systematic approach to tracking data has been developed to maintain data quality and integrity throughout the data acquisition and editing process. Several forms and checklists were used to identify and track the flow of data as it was collected and processed. During data collection, the watch-standers continuously monitored the systems, checking for errors and alarms. Thresholds set in the ISS-2000 system alerted the watch-stander by displaying alarm messages when error thresholds or tolerances were exceeded. These alarms, displayed as they occurred, were reviewed and acknowledged on a case-by-case basis. Alarm conditions that compromised survey data quality were corrected and then noted in both the navigation log and the message files. Warning messages such as the temporary loss of differential GPS, excessive cross-track error, or vessel speed approaching the maximum allowable survey speed were addressed by the watch-stander and automatically recorded into a message file. Approximately every 1-2 hours, the real-time watch-standers completed checklists to ensure critical system settings and data collection were valid. Following data collection, initial processing began on the vessel. This included the first level of quality control:

- Initial swath editing of multibeam data flagging invalid pings and beams
- Second review and editing of multibeam data
- Turning unacceptable data “offline”
- Turning additional data “online”
- Track plots
- Cross-line checks

During port calls a complete backup of all raw and processed multibeam data and side-scan data was sent to the Newport Data Processing Center. Analysis of the data at the Newport facility included the following steps:

- Generation of multibeam and side-scan track lanes
- Swath editing and review of multibeam data (if not performed on the vessel)
- Calculation and application of verified tide correctors to multibeam data
- Bottom tracking of both the Klein side-scan and the multibeam side-scan files
- Coverage plots of multibeam data
- Cross-lane checks of multibeam data
- Quality control reviews of side-scan data
- Final Coverage mosaic plots of Klein side-scan sonar data
- Final Coverage mosaic plots of multibeam side-scan data
- Final quality control of all delivered data products

The post-processing and quality control procedures for multibeam and side-scan data acquisition are described in detail in the following section.

2.2 Data Processing

2.2.1 Multibeam Data Processing

The multibeam data was initially edited on-board the vessel using SAIC’s Multi-View Editor (MVE) program – an area-based editor that can project each beam in its true geographic position and depth in both plan and profile views. At the end of each survey lane, all data files were closed and new files opened for data logging. The closed files were then auto-archived to the processing computer where track lanes were generated and the multibeam data files were reviewed (twice) to flag erroneous data such as noise, flyers, fish, etc. At the end of each survey day, both the raw and processed data were backed up onto 4mm tapes. These tapes were shipped to the Data Processing Center in Newport, RI at each port call. Once the data were in Newport, and extracted to local processing computers in the Data Processing Center (DPC), the initial step in processing was to create track lanes from the multibeam data. Once created, the tracks were reviewed to confirm that no navigational errors existed and that the tracks extended to the outermost boundaries of the survey area. Upon the completion of multibeam data reviews, verified tides were applied.

Prior to generating the final Mean Lower Low Water (MLLW) tidal correctors, the NOAA Sandy Hook tidal data were compared to the HARS pressure tide gauge data that had been normalized to an approximate MLLW reference datum (based upon simultaneous mean tide-level comparisons). Ultimately, the observed, verified water-level data from the NOAA Sandy Hook station (modified with appropriate phase and range offsets) were used to reduce both the HARS and Shark River Reef bathymetric data to MLLW. Preliminary and verified tide data for this station were downloaded from the NOAA CO-OPS web page (http://www.co-ops.nos.noaa.gov/hydro.html). Consistent with the conventions followed during past surveys at both areas, the following phase and range offsets were applied to verified Sandy Hook tide data.

1) **HARS**: phase - minus 45 minutes, range ratio - 0.95
2) **Shark River Reef**: phase - minus 30 minutes, range ratio - 0.80

Final water-level files for each area were created from downloaded verified tide data using the SABER Create Water Level Files tool. Water-level files contained water-level heights that were algebraically subtracted from depths to correct the sounding for tides and water levels. These water-level files were applied to the multibeam data using the SABER Apply Tides program. When it was necessary to apply updated tide correctors such as verified tides to the GSF files, the program removed the previous tide corrector and applied the new corrector. Each time a routine was run on the GSF multibeam data file, a history record was appended to the end of the GSF file. For quality assurance, the Check Tides program was run on all GSF files to confirm that the appropriate water-level corrector had been applied to the GSF file. After confirmation that verified tides were applied to all multibeam data, grids were created and analyzed using various color-change intervals. The color intervals provided a means to check for significant, unnatural changes in depth across zone boundaries due to water-level correction errors, unusual currents, storm surges, etc. had they existed.

Following the application of verified tides, multibeam closest-to-cell-center depth grids were generated and reviewed for consistency. If any anomalies were detected, the edited multibeam files were re-examined and re-edited. When all of the multibeam files were determined to be satisfactory, the data were gridded to the required 5-m cell size (as well as 2-m for Shark River Reef), populating the cell with sounding closest to the cell's center. The following three grids were created:

- Main scheme and gaps (+/- 60° from nadir)
- Cross lanes using only near nadir (+/- 5° from nadir)
- All Survey lanes (main, cross, gaps)

The main scheme grid and cross-lane grid were used for subsequent cross-check analysis. The all grid was used to export the final ASCII XYZ file.

2.2.2 Multibeam Backscatter Data Processing

Digital side-scan data were recorded in eXtended Triton Format (XTF), in real time, from the Reson 8101. At the end of each survey leg the files were backed up to 4-mm tapes for transfer to the Newport, RI data processing facility. The raw backscatter XTF data were then processed to generate a 5-m backscatter mosaic for the HARS and a 1-m backscatter mosaic for the Shark River Reef. Initially, the backscatter XTF data were reviewed and bottom-tracked using Triton-Elics ISIS image processing tools. A time-window file was then created to indicate imagery-range coverage for each of the sonar lanes. In addition, all sonar track lanes were viewed to evaluate navigation quality. Using SABER mosaic tools, a 5-m preliminary mosaic was created to verify swath coverage, bottom tracking, and gain changes by lane. After additional edits were made to the bottom tracking, time windows, and gain settings, the final 5- and 1-m mosaics were generated, evaluated, and then exported as a georeferenced TIFF (geoTIFF) file.

2.2.3 Side-Scan Sonar Data Processing

For the Shark River Reef side-scan sonar survey, the Klein 3000 digital side-scan data were recorded in SDF format on the hard disk of the Klein's SonarPro acquisition system. At 0000 (UTC) of each survey day, the files for the previous day were auto-archived to the on-board processing computer. All original side-scan data files were backed up onto 4-mm tapes for transfer to the Newport, RI Data Processing Center. Once in Newport, initial processing included converting the Klein 3000 SDF data into XTF files. The Klein XTF data were then re-navigated to apply more accurate towfish positions using the SABER Navup routine. This routine replaced the towfish position recorded in the original side-scan data with the towfish position recorded in the real-time catenary data file recorded by ISS-2000. It also computed a unique position and heading for each ping record. Using Triton-Elics ISIS, each sonar lane was reviewed for completeness and quality, and the bottom-tracking was edited as necessary.

Within SABER, a time-window file was then created to indicate side-scan sonar imagery range coverage for each of the sonar lanes. In addition, all sonar-track lanes were viewed to evaluate navigation quality. Using SABER mosaic tools, a 5-m preliminary mosaic was created to verify swath coverage, bottom tracking, and gain changes by lane. After additional edits were made to improve the bottom tracking, time windows, and gain settings, the final 5- and 1-m side-scan sonar mosaics were generated, evaluated, and then exported as a georeferenced TIFF (geoTIFF) file.

2.3 Data Analysis and Presentation

The primary intent of this analysis was to evaluate the seafloor surface defined by the bathymetric data in an attempt to identify any unique features and to account for any observed differences with prior surveys. Because this multibeam bathymetric survey data covered the total seafloor area (approximately 100%), these analysis tools relied on a minimal amounts of interpolation between the discrete survey data points in order to generate the subsequent three-dimensional seafloor surface model. This is in contrast to past single-beam surveys conducted over these same areas that often relied on a high-degree of interpolation to create the final surface models.

The fully edited multibeam datasets were initially gridded to a 5-m (for the HARS) and 2-m (for Shark River Reef) grid cell size by selecting the sounding closest to the center of each cell. These thinned datasets were then imported into ArcGIS 8.3 for gridding to a continuous raster surface. The Spatial Analyst extension for ArcGIS was used to explore the variance of the bathymetric track-lane data and determine the optimal gridding parameters. Several gridding routines were investigated before final interpolation using Inverse-Distance Weight. The IDW method estimates grid cell values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. For the HARS dataset, a 150-foot fixed search radius along with a power rating of two appeared to provide the best results. The resulting gridded dataset was based on a 25-foot grid cell size and was comprised of 1,104 rows and 971 columns. For the Shark River Reef dataset, a 75-foot fixed search radius along with a power rating of two appeared to provide the best results. The resulting gridded dataset was based on a 5-foot grid cell size and was comprised of 1,669 rows and 933 columns. These final gridded datasets were used for all subsequent analysis and graphics production.

The primary analysis done on the final bathymetric gridded datasets were depth-difference comparisons with the baseline and most recent prior bathymetric dataset. For the HARS, the baseline survey was from 1998 and the most recent prior survey was from 2004. For the Shark River Reef, the baseline survey was from 2002 and the most recent prior survey was from 2004. Because most of the placement at the HARS since its designation in 1998 has been focused in PRAs 1, 2, and 3, the depth-difference comparison was focused in this area. Within ArcGIS 8.3, a bathymetric difference grid was then generated that helped illustrate the magnitude of change within this area since these previous surveys and also to evaluate the consistency of the prior survey results.

3.0 RESULTS

3.1 Bathymetric Data Quality Review

This section presents the results of the various analyses that were conducted to improve and/or assess the quality and consistency of the bathymetric survey data. The first two subsections below provide a thorough review and analysis of the sound velocity and tidal data that were acquired during the course of this survey. The third subsection presents the results of the cross-check analysis and addresses the overall consistency of the complete dataset. The variability associated with both the water column sound velocity and tidal heights represented the two most significant vertical corrections that were applied to produce the final post-processed bathymetric data. Accurate measurement of sound velocity and tidal heights throughout the survey operations and proper application of the resulting correctors were essential to produce consistent survey results.

3.1.1 Sound Velocity Analysis

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure sensor was used to collect frequent sound velocity profile (SVP) data throughout the survey. SVP data were obtained at intervals frequent enough to reduce sound velocity errors and generally spaced at not more than two-hour intervals throughout the survey day. The frequency of the casts was based on observed sound velocity changes from previously collected profiles and time elapsed since the last cast. Multiple casts were also taken along a survey lane to identify the rate and location of sound velocity changes. Subsequent casts were made based on the observed trend of sound velocity changes. As the sound velocity profiles changed, cast frequency and location were modified accordingly. Confidence checks of the sound velocity profile casts were conducted at the beginning and at the end of the survey by comparing two consecutive casts taken with different Sound Velocity and Pressure sensors. Over the course of these survey operations, a total of 68 SVP casts were acquired (Table 2.1-1). A detailed review of the SVPs showed that the profiles were generally consistent throughout the survey period with no significant changes noted at anytime during the course of the week-long survey operations.

3.1.2 Tidal Data Analysis

The HARS pressure tide gauge was operational throughout the survey at the HARS, and all data were recovered as required. The tide gauge was deployed at an offshore location near the HARS and was not referenced to any tidal benchmarks or vertical datum as is typically the case with shore-based tidal stations. In order to develop an approximate MLLW tidal datum at this station, a measure of the mean tide level (MTL) was computed by averaging all of the six-minute tidal heights that were recorded at this station during the entire deployment period. The difference between the non-referenced MTL at the HARS and the MLLW-referenced MTL at Sandy Hook was used to establish an approximate MLLW water surface elevation for the HARS data. The HARS pressure data was then normalized by subtracting this MLLW reference water surface elevation from all of these data. These adjusted HARS tide data were then used to make direct comparisons with the offset Sandy Hook tide data. As discussed in section 2.1.2, consistent with past surveys at the HARS, a phase offset of – 45 minutes and a range offset of 0.95 were applied to transfer the observed Sandy Hook tide data out to the HARS.

The agreement between the HARS tide gauge data and the offset Sandy Hook data was generally consistent throughout the period. A time-series view of the offset between the HARS tide gauge and the raw and corrected Sandy Hook data revealed a general diurnal trend that tended to mirror the change in the tide (Figure 3.1-1). During the data review portion of this study, these tidal comparison results were used to highlight specific days where the tidal differences may have had an impact on the processed data results. The largest observed differences (approximately 0.2 m) generally occurred during the mid-cycle phase of the tide when there was a noticeable (though slight) phase offset between the HARS tide gauge and the corrected Sandy Hook data. Because the magnitude of the tide changes rapidly during the mid-cycle, even small time offsets could lead to fairly large differences between observed tides, though these impacts were generally limited to a fairly narrow time window. In addition, the sign of these differences varied depending on whether the tide was rising or falling.

Ultimately, because the magnitude of the observed differences between the corrected Sandy Hook tide data and the HARS tide data were relatively minor and not consistent, no further tidal adjustments were made and all of the edited survey data were reduced to MLLW based only on the corrected Sandy Hook tide data. Based on the review of the HARS tide gauge data there may be reason to consider making revisions to the standard range and phase offsets that have been applied to the Sandy Hook data when transferring tides out to the HARS. However, based on the review of these data, it appeared that the phase and range relationship between Sandy Hook and the HARS was not consistent. Though the offset Sandy Hook data provided somewhat better agreement with the HARS pressure gauge data than the uncorrected Sandy Hook data, the differences were not that great. Based on these data, it seemed likely that any HARS datum reduction based solely on Sandy Hook tidal data would introduce some vertical error into the final sounding data. Of the various vertical offsets that may have impacted the accuracy of the final sounding data, the measurement and application of the proper tidal correction for each sounding was probably the most difficult to address.

3.1.3 Cross-Check Comparisons

<u>Junction Analysis</u>
During post processing, two overlapping grids were built for each of the two survey areas (HARS and Shark River Reef), one of main scheme-lane multibeam data and one of cross-lane multibeam data. The main scheme grid was built from multibeam data having the cut-off angle

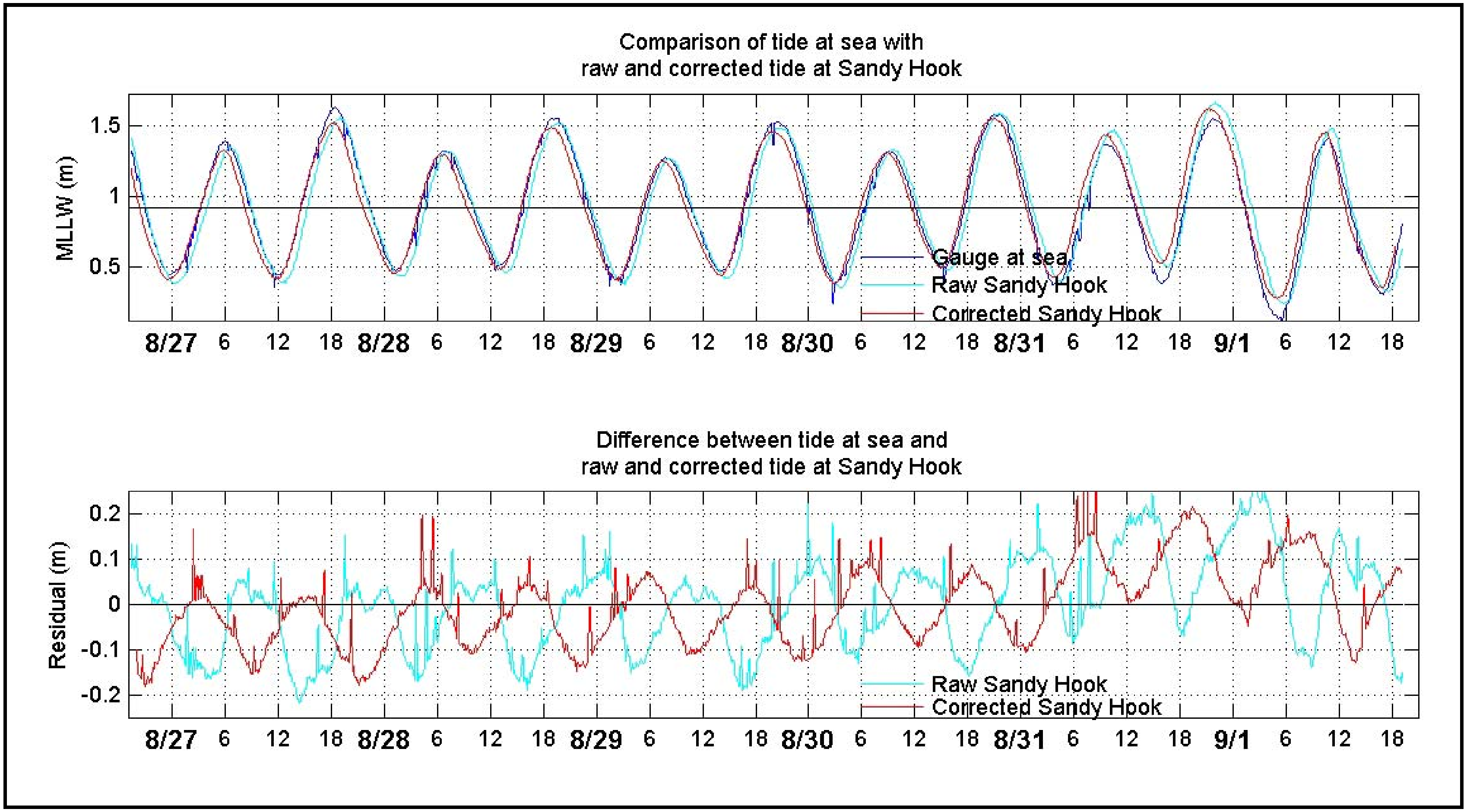


Figure 3.1-1. Time series comparison of the observed tidal heights from the NOAA Sandy Hook tide gauge (with and without offset correctors applied) and the HARS pressure tide gauge. Top panel provides time-series tidal heights relative to MLLW and the bottom panel provides the differences between the HARS pressure gauge and both the direct and offset Sandy Hook tidal values.

set to 60˚, while the cross lane grid was built from multibeam data having the cut-off angle set to 5˚ (or only the beams closest to nadir). The two grids were used to create a third depth difference grid for each area that was used as the basis to perform the junction analysis routine. The cells of the depth difference grid contained the depth difference between overlapping cells from the cross lane grid and the main scheme grid.

The SABER Junction Analysis tool was used to perform the statistical analysis on all of the HARS overlapping gridded data. The result was an ASCII text file listing the total number of observations (count), the number of positive and negative differences for various depth ranges (0-5cm, 5-10cm, 10-15cm, etc.) and the percent of the total observations encompassed by each depth difference range (Table 3.1-1). This comparison of the cross lane soundings and main scheme soundings showed that 97.98% of the depth differences were less than 30 cm and that 99.76% of the differences were less than 50 cm. The comparisons larger than 50 cm were accounted for by normal small DGPS position scatter over the irregular bottom areas of debris and disposal mounds found across extensive areas of the HARS.

The Shark River Reef survey area had numerous large disposal mounds, piles of debris, and large wrecks. During the survey, each of the three cross lanes overlapped a significant portion of the high mounds and debris. Because of the large amount of irregular seafloor relief, there were two junction analyses performed on this area. The first analysis included comparisons of all data between the main and cross lane grid differences and the second analysis included only the relatively flat overlapping areas (Table 3.1-2 and 3.1-3). The comparison between all of the cross lane soundings and main scheme soundings showed that 95% of the depth differences were less than 45 cm. The comparisons larger than 50 cm were accounted for by normal small DGPS position scatter over the large disposal mounds, debris fields, and large wrecks found in the Shark River Reef survey area. The comparison between the cross lane soundings and main scheme soundings over the areas of relatively flat bottom (excluding disposal mounds, debris fields, and wrecks) reported that 96.94% of the depth differences were less than 20 cm and that 99.07% of the differences were less than 30 cm.

<u>Crossings Analysis</u>

Beam by beam comparison of cross lane data to main scheme data was performed on two of the crossings for both the HARS and the Shark River Reef survey areas. This two-step process began by finding all beam-to-beam crossings that occurred between the main-scheme lanes and cross lanes within a given area. This was accomplished by running SABER's Find Crossings utility on two file lists, one containing main scheme files and one containing cross lane files. The resulting ASCII file contained positional data for all crossings between the two file lists that were displayed in SABER. The second step of the process was to compare the near nadir beams of one file to the associated full swath beams of another file for each crossing. Using SABER's Analyze Crossings utility, a subset consisting of two identified crossings was analyzed. The subset of crossings was established by selecting crossings that were located in relatively flat areas of the seafloor.

Table 3.1-1.
Summary of Junction Analysis Results for all crossings during the HARS Survey

	All		Positive		Negative		Zero	
Category	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**
0-> 5cm	3552	29.78%	1342	44.78%	1770	20.84%	440	100.00%
5-> 10cm	3126	55.98%	1030	79.15%	2096	45.53%	0	100.00%
10-> 15cm	2541	77.28%	429	93.46%	2112	70.40%	0	100.00%
15-> 20cm	1204	87.38%	89	96.43%	1115	83.53%	0	100.00%
20-> 25cm	859	94.58%	45	97.93%	814	93.11%	0	100.00%
25-> 30cm	**406**	**97.98%**	28	98.87%	378	97.56%	0	100.00%
30-> 35cm	131	99.08%	12	99.27%	119	98.96%	0	100.00%
35-> 40cm	36	99.38%	7	99.50%	29	99.31%	0	100.00%
40-> 45cm	22	99.56%	5	99.67%	17	99.51%	0	100.00%
45-> 50cm	23	99.76%	3	99.77%	20	99.74%	0	100.00%
50-> 60cm	13	99.87%	1	99.80%	12	99.88%	0	100.00%
60-> 70cm	9	99.94%	2	99.87%	7	99.96%	0	100.00%
70-> 80cm	1	99.95%	1	99.90%	0	99.96%	0	100.00%
80-> 90cm	3	99.97%	2	99.97%	1	99.98%	0	100.00%
90-> 100cm	3	100.00%	1	100.00%	2	100.00%	0	100.00%
Total	11929	100.00%	2997	100.00%	8492	100.00%	440	100.00%

Table 3.1-2.
Summary of Junction Analysis Results for all crossings during the Shark River Reef Survey

	All		Positive		Negative		Zero	
Category	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**
0-> 5cm	2403	36.35%	953	36.61%	1158	31.17%	292	100.00%
5-> 10cm	1848	64.31%	707	63.77%	1141	61.88%	0	100.00%
10-> 15cm	1049	80.18%	396	78.99%	653	79.46%	0	100.00%
15-> 20cm	301	84.74%	125	83.79%	176	84.20%	0	100.00%
20-> 25cm	242	88.40%	125	88.59%	117	87.35%	0	100.00%
25-> 30cm	199	91.41%	95	92.24%	104	90.15%	0	100.00%
30-> 35cm	123	93.27%	61	94.58%	62	91.82%	0	100.00%
35-> 40cm	65	94.25%	29	95.70%	36	92.79%	0	100.00%
40-> 45cm	**82**	**95.49%**	33	96.97%	49	94.10%	0	100.00%
45-> 50cm	48	96.22%	23	97.85%	25	94.78%	0	100.00%
50-> 60cm	92	97.61%	30	99.00%	62	96.45%	0	100.00%
60-> 70cm	37	98.17%	10	99.39%	27	97.17%	0	100.00%
70-> 80cm	30	98.62%	3	99.50%	27	97.90%	0	100.00%
80-> 90cm	13	98.82%	1	99.54%	12	98.22%	0	100.00%
90-> 100cm	19	99.11%	3	99.65%	16	98.65%	0	100.00%
100->110cm	16	99.35%	3	99.77%	13	99.00%	0	100.00%
110- 120cm	16	99.59%	1	99.81%	15	99.41%	0	100.00%
120- 130cm	6	99.68%	0	99.81%	6	99.57%	0	100.00%
>130cm	21	100.00%	5	100.00%	16	100.00%	0	100.00%
Total	6610	100.00%	2603	100.00%	3715	100.00%	292	100.00%

Table 3.1-3.
Summary of Junction Analysis Results for crossings over the flat areas during the Shark River Reef Survey

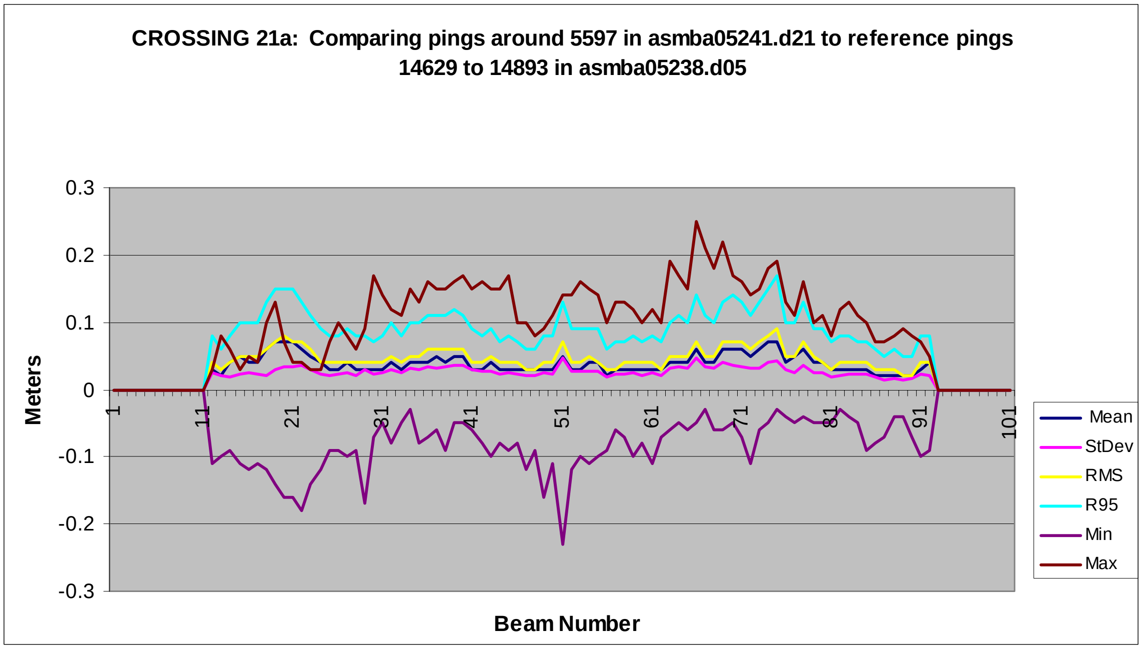
	All		**Positive**		**Negative**		**Zero**	
Category	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**
Category	Count	Cumulative Percent	Count	Cumulative Percent	Count	Cumulative Percent	Count	Cumulative Percent
0-> 5cm	1684	47.69%	666	48.83%	810	41.35%	208	100.00%
5-> 10cm	1152	80.32%	468	83.14%	684	76.26%	0	100.00%
10-> 15cm	495	94.34%	156	94.57%	339	93.57%	0	100.00%
15-> 20cm	**92**	**96.94%**	22	96.19%	70	97.14%	0	100.00%
20-> 25cm	50	98.36%	29	98.31%	21	98.21%	0	100.00%
25-> 30cm	25	99.07%	10	99.05%	15	98.98%	0	100.00%
30-> 35cm	8	99.29%	6	99.49%	2	99.08%	0	100.00%
35-> 40cm	7	99.49%	1	99.56%	6	99.39%	0	100.00%
40-> 45cm	5	99.63%	1	99.63%	4	99.59%	0	100.00%
45-> 50cm	4	99.75%	3	99.85%	1	99.64%	0	100.00%
50-> 60cm	5	99.89%	2	100.00%	3	99.80%	0	100.00%
60-> 70cm	1	99.92%	0	100.00%	1	99.85%	0	100.00%
70-> 80cm	1	99.94%	0	100.00%	1	99.90%	0	100.00%
80-> 90cm	0	99.94%	0	100.00%	0	99.90%	0	100.00%
90-> 100cm	0	99.94%	0	100.00%	0	99.90%	0	100.00%
100->110cm	2	100.00%	0	100.00%	2	100.00%	0	100.00%
Total	3531	100.00%	1364	100.00%	1959	100.00%	208	100.00%

The ASCII file generated from SABER's Analyze Crossings utility tabulated the number of comparisons, number and percentage of comparisons that met an operator specified criteria for acceptable depth difference, maximum difference, minimum difference, and statistics that included mean, standard deviation, and R95, for each beam-to-beam comparison. Each crossing generated two analysis reports. One report was for near nadir beams of the main scheme lane as compared to the full swath beams of the cross lane, and the second was for the near nadir beams of the cross lane as compared to the full swath beams of the main scheme lane (Figures 3.1-1 through 3.1-4). This beam-to-beam comparison of depths at the intersections of cross lane and main scheme lanes can help to highlight potential problems with sound velocity correctors, sensor offsets, draft, or water level correctors. Based on the observed crossing results from both survey areas, there were no apparent offset problems introduced during acquisition or processing of the multibeam data.

3.2 Physical Characterization of the HARS

As discussed in the preceding section, no significant data problems were encountered during processing or analysis of the multibeam bathymetric data, and the entire HARS was well characterized based on these data. The color-coded gridded hill-shade model view showed that the HARS lies on a gradually sloping portion of the seafloor that has been greatly altered by the placement of large volumes of dredged material (and other products) over many years (Figure 3.2-1). The bottom topography within the HARS was quite variable and many irregular bottom features were evident throughout the site. The minimum depth observed during this survey was 32.0 ft MLLW and occurred near the center of the former Mud Dump Site about 1300 ft southwest of the existing "NY" buoy. The maximum depth of around 124.5 ft MLLW occurred in the lower southeast corner of the survey area.

A 100 kHz image mosaic, representing 100% multibeam backscatter coverage, was also created for the entire survey area (Figure 3.2-2). Because the seafloor within this survey area was comprised of a wide range of bottom materials, the imagery mosaic was useful for providing a relative indication of the bottom type. In these mosaics, darker areas represented stronger acoustic returns (higher reflectance) and usually indicated harder seafloor surface materials such as well-consolidated sand and larger rocks or cobble. Within the PRAs they may have also indicated recent, well-consolidated, but finer-grained, dredged material deposits. The lighter areas of the mosaic represented weaker acoustic returns (lower reflectance) and indicated slightly softer seafloor surface material such as unconsolidated fine sand, silt, or clay. To assist with the site visualization, it was also useful to view the backscatter imagery draped over the multibeam hillshade view (Figure 3.2-3). Although it is outside the scope of this basic reporting effort, the recently collected sediment profile imaging dataset (approximately 120 high-resolution images scattered around the HARS) would be a useful tool to help ground truth the interpretation of the acoustic backscatter data. These bottom type characterizations could then be entered into a GIS and used to create maps differentiating between varying bottom types found within the HARS.



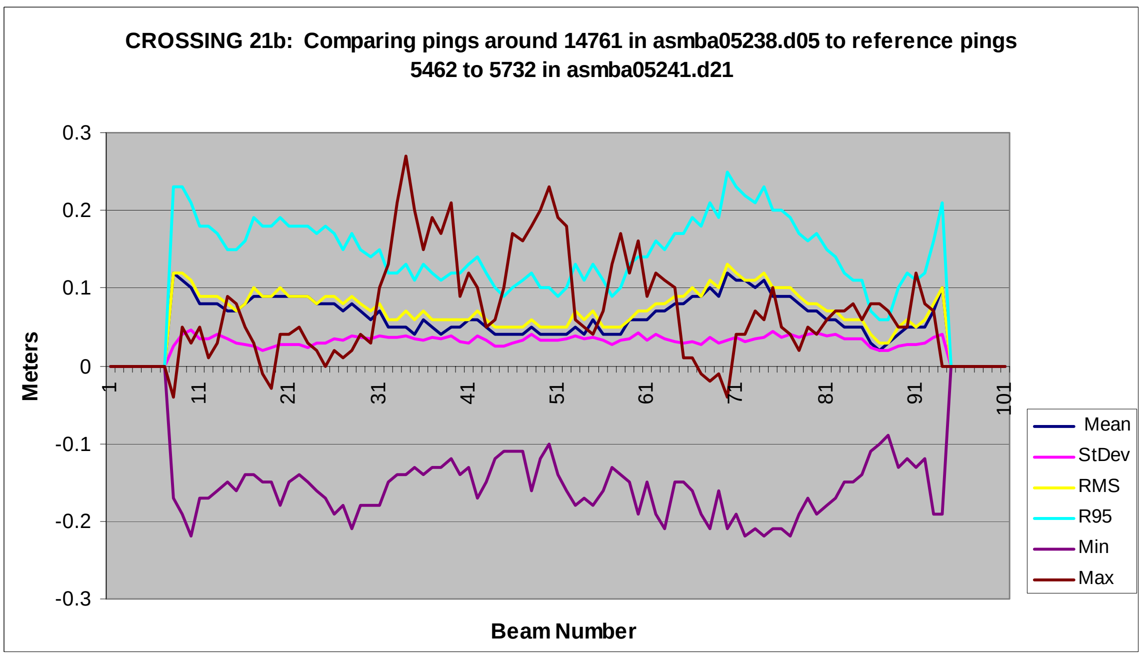
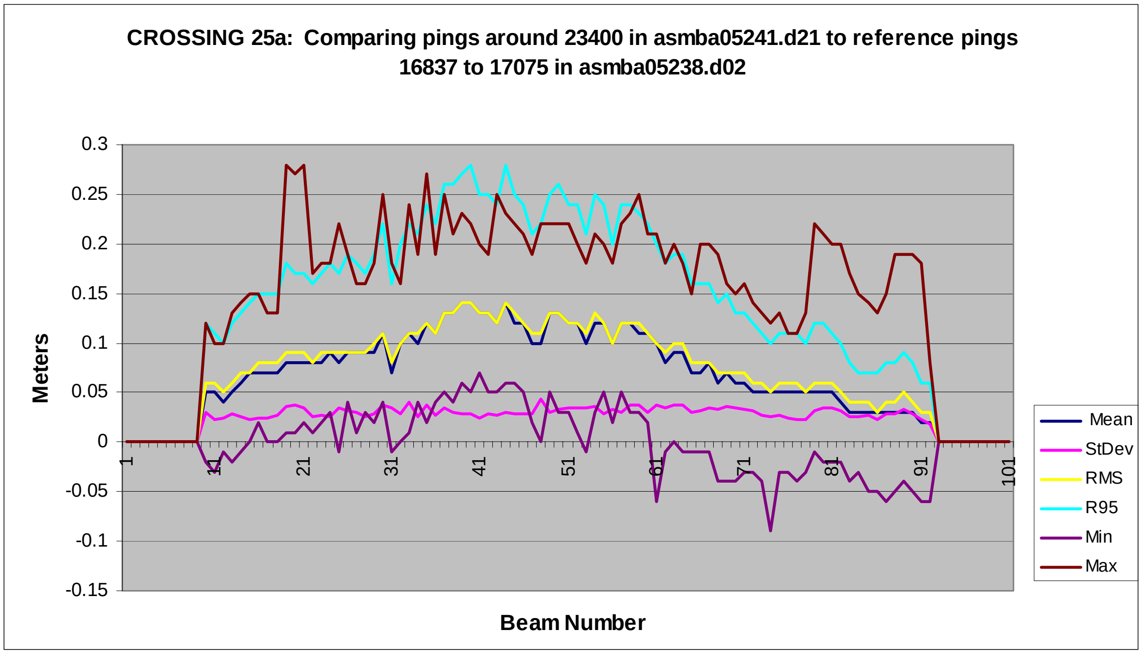


Figure 3.1-2. HARS Crossing 21a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



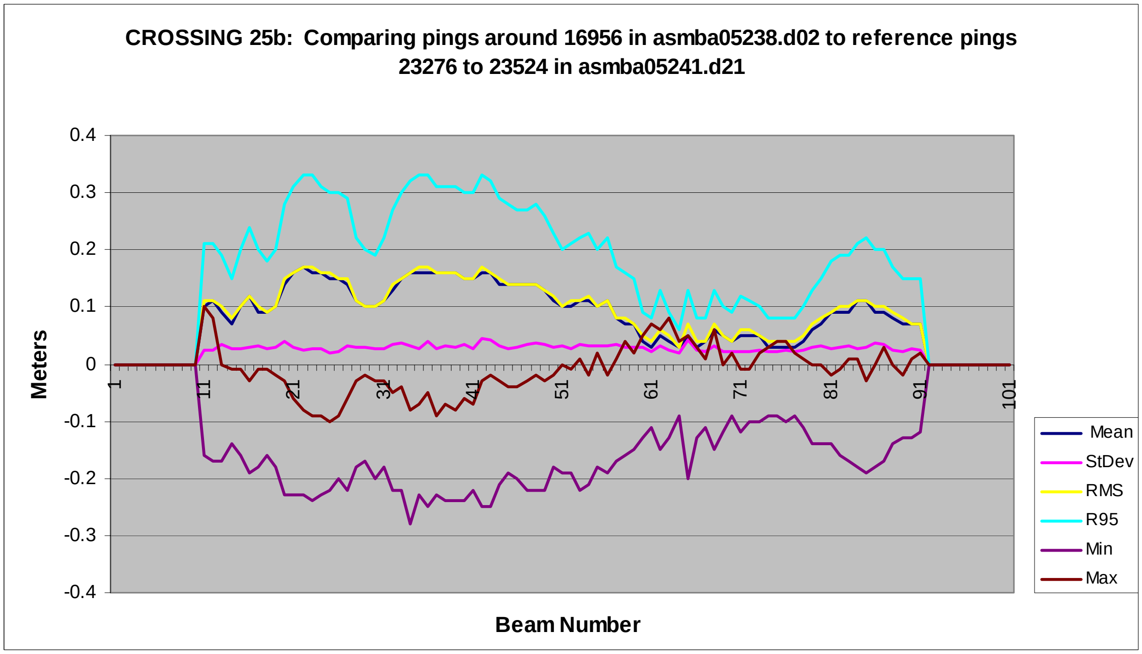
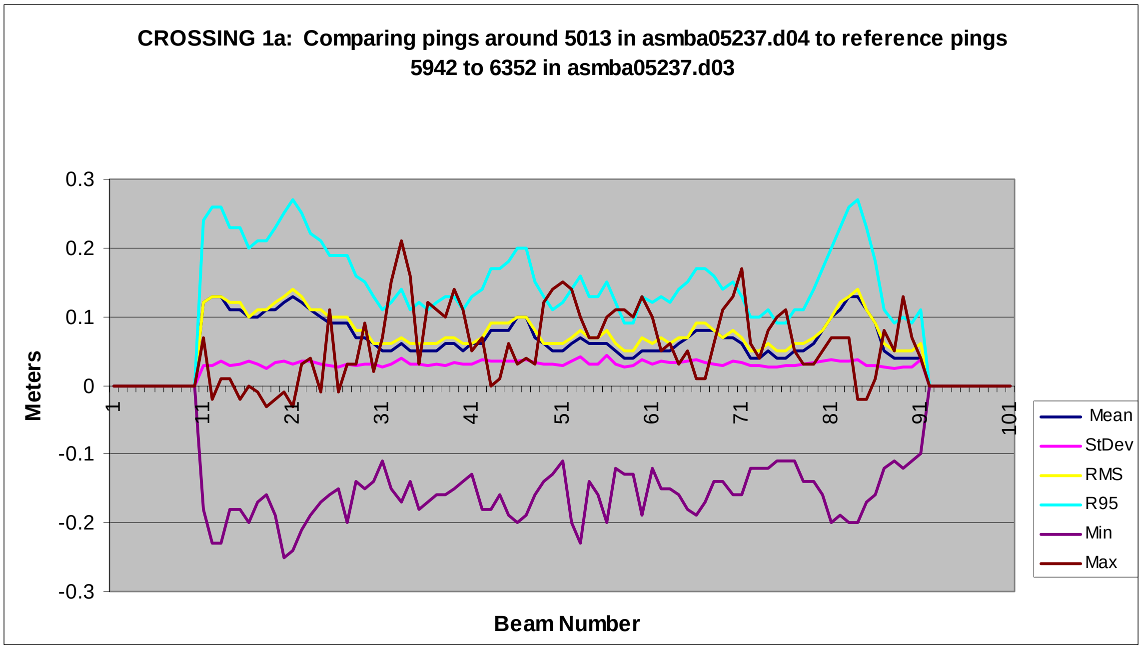


Figure 3.1-3. HARS Crossing 25a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



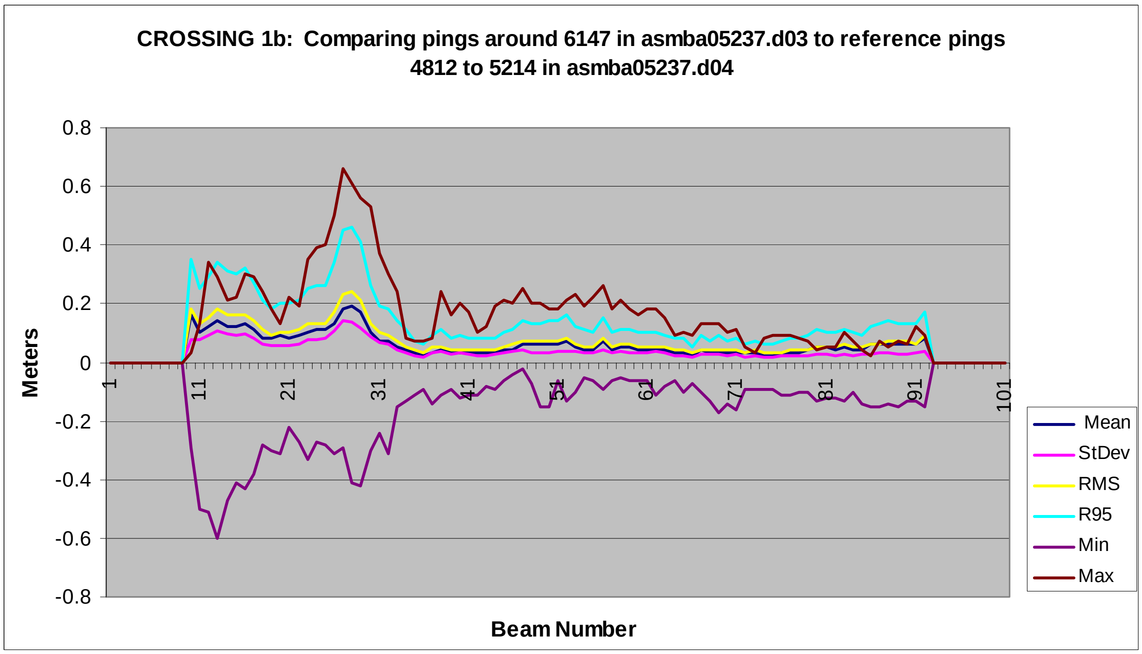
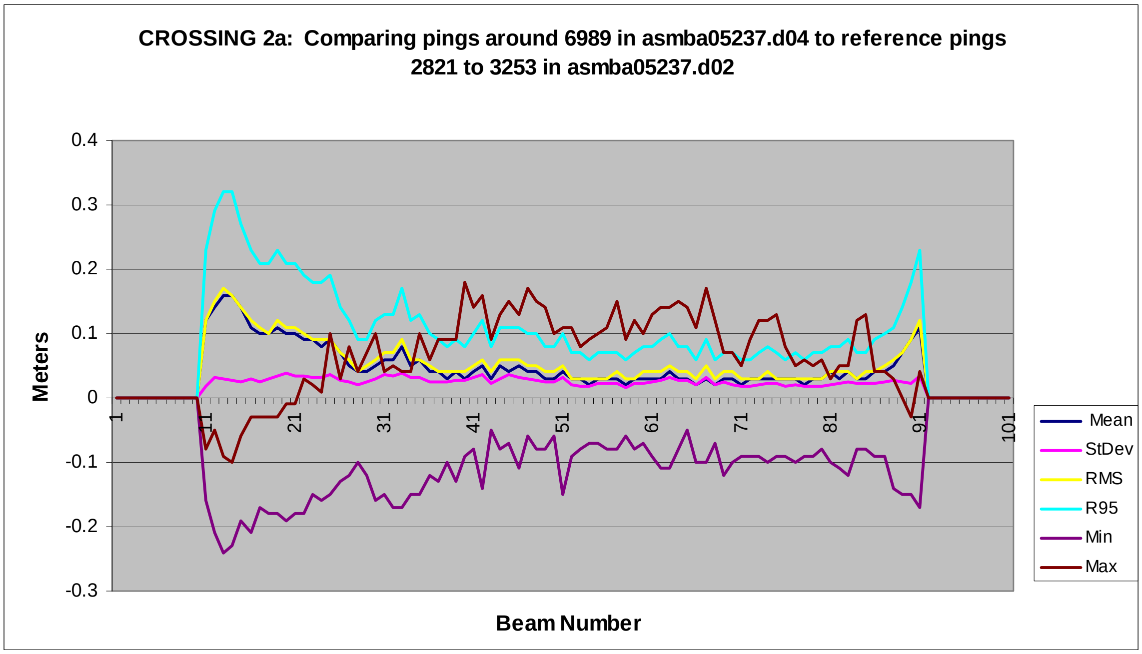


Figure 3.1-4. Shark River Reef Crossing 1a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



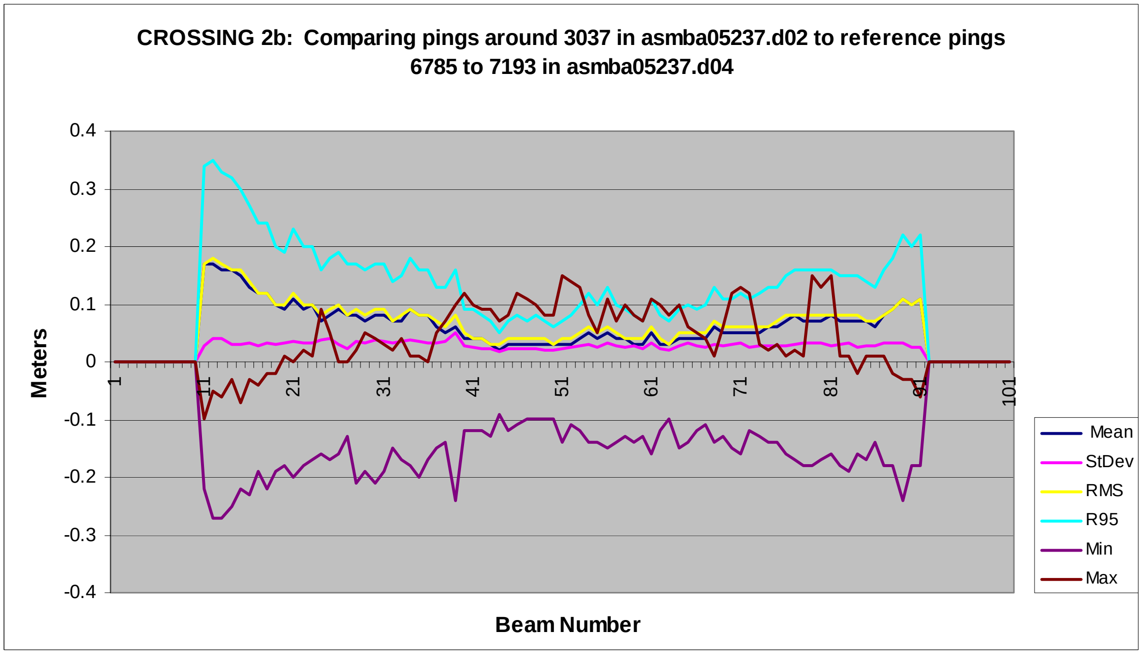


Figure 3.1-5. Shark River Reef Crossing 2a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.

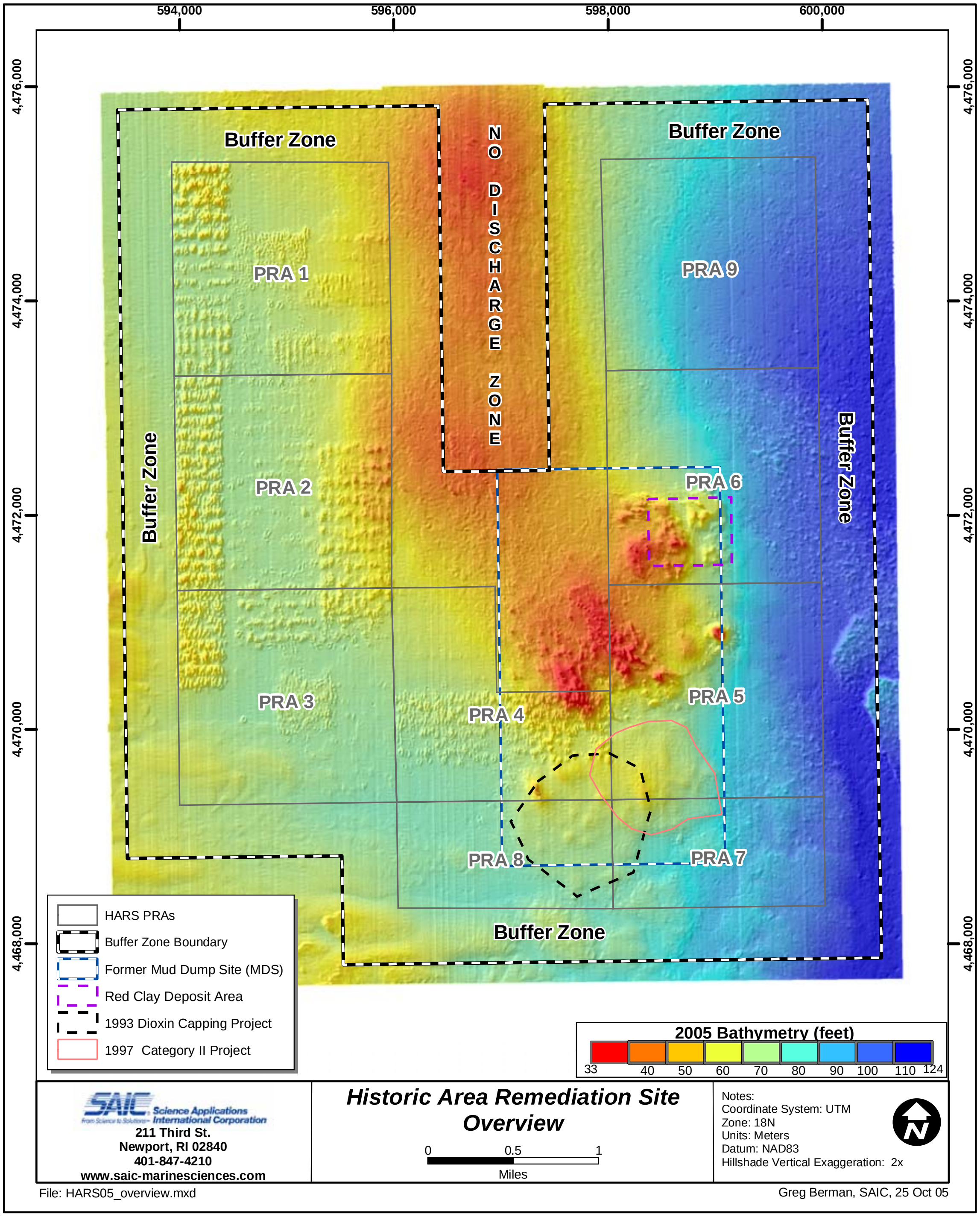


Figure 3.2-1. Hill-shaded relief model based on the August 2005 bathymetric survey at the HARS

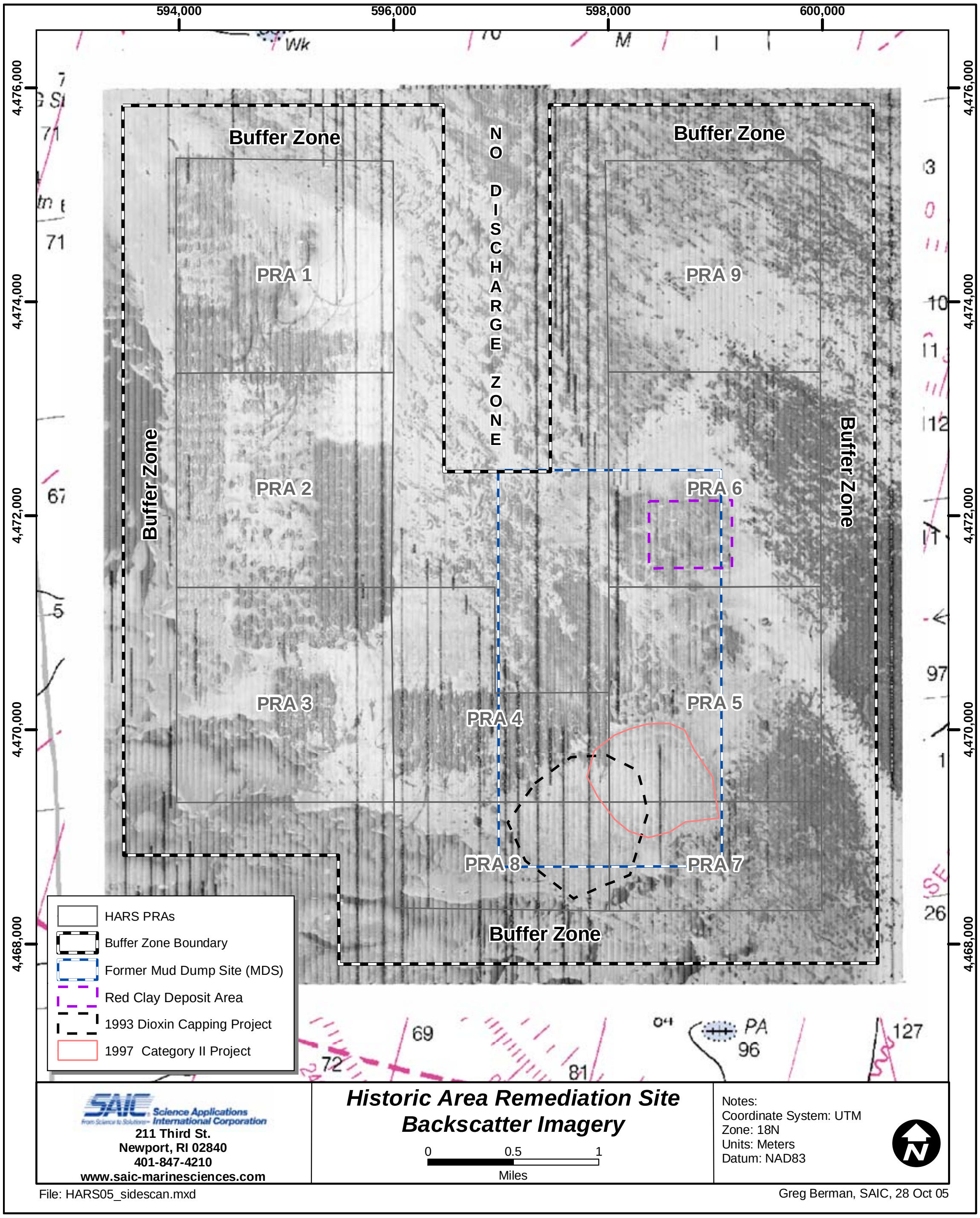


Figure 3.2-2. Multibeam backscatter imagery mosaic based on the August 2005 bathymetric survey at the HARS

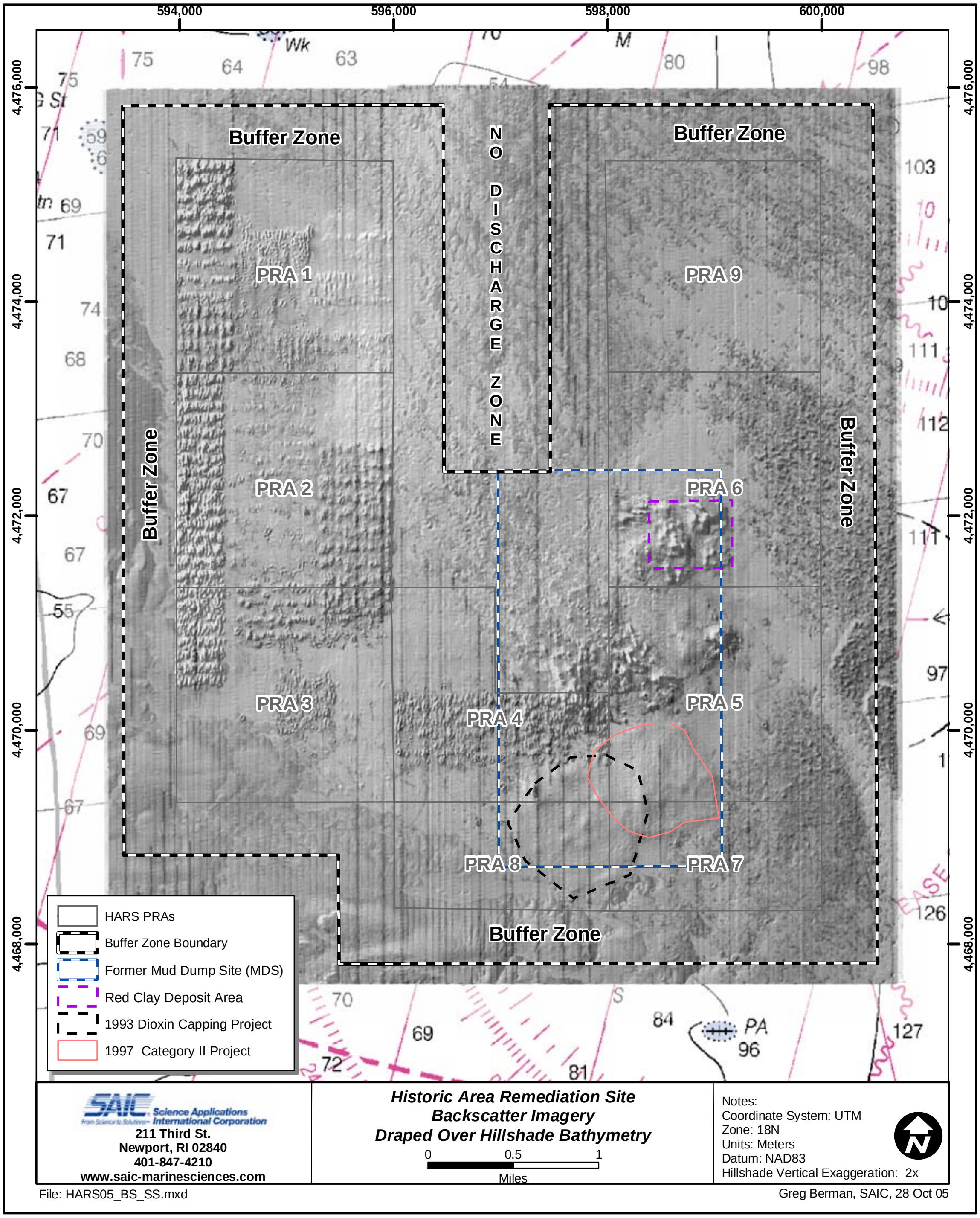


Figure 3.2-3. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2005 HARS dataset.

3.2.1 Comparisons with Prior Surveys and Disposal Information

Because placement of remediation material at the HARS has been concentrated in PRAs 1, 2, 3 and 4 since 1998, this section is focused on evaluating the extent of that deposition based on comparisons between the recent and past surveys. For this effort, the recent 2005 survey was compared to a 1998 single-beam survey and a 2004 multibeam survey. The September 1998 dataset originated from a series of north-south single-beam survey lanes that were spaced at 25-meter intervals over just PRAs 1, 2, and 3; this survey is considered the baseline survey for placement operations at the HARS. The bathymetric depth difference grid generated between the 2005 and 1998 surveys clearly showed dredged material accumulation (deposition) throughout many areas of PRAs 1, 2, and 3 (Figure 3.2-4 and 3.2-5). Based on the depth difference grid, it appeared that most of PRA 2, about three-fourths of PRA 1, and about half of PRA 3 were covered with more than 3 ft of remediation material. The greatest deposits occurred in the western half of PRA 1 and in the eastern half of PRA 2, where deposits measured up to almost 19 ft thick. A view of the ADISS-recorded disposal point information from the period between these two surveys generally coincided well with the areas of accumulation indicated by the depth difference plot (Figure 3.2-6).

Prior to the 2005 survey, the most recent bathymetric dataset from the HARS originated from a multibeam survey conducted in October 2004. In order to evaluate recent deposition trends, a depth difference grid was also generated between the 2004 and 2005 datasets. The bathymetric depth difference grid generated between the 2005 and 2004 surveys clearly showed dredged material accumulation (deposition) across different areas of PRA 1 (Figure 3.2-7). The most significant accumulation occurred in the northwestern portion of PRA 1, where one area of recent deposition measured almost 10 ft thick. In addition to the areas of accumulation, the depth difference grid also showed many areas of unnatural vertical striping that were indicative of apparent deepening of more than one foot between the two surveys. While areas of deepening in a depth difference grid can sometimes be attributed to consolidation of recently deposited dredged material, in this instance most of this apparent deepening is undoubtedly due to a small offset or bias between the 2004 and 2005 surveys. This bias would most likely be associated with a tidal or sound velocity offset, or perhaps a difference in the vertical datum used as a reference for these surveys. In general, it appears that the 2004 survey depths were somewhat shallower than they should have been which has probably led to a somewhat diminished view of the areas of accumulation in the depth difference grid. This may help to explain the lack of the deposition noted in the northeast portion of PRA 2 where we would have expected greater accumulation would have been expected, based on the ADISS-recorded disposal point information from the period between these two surveys (Figure 3.2-8).

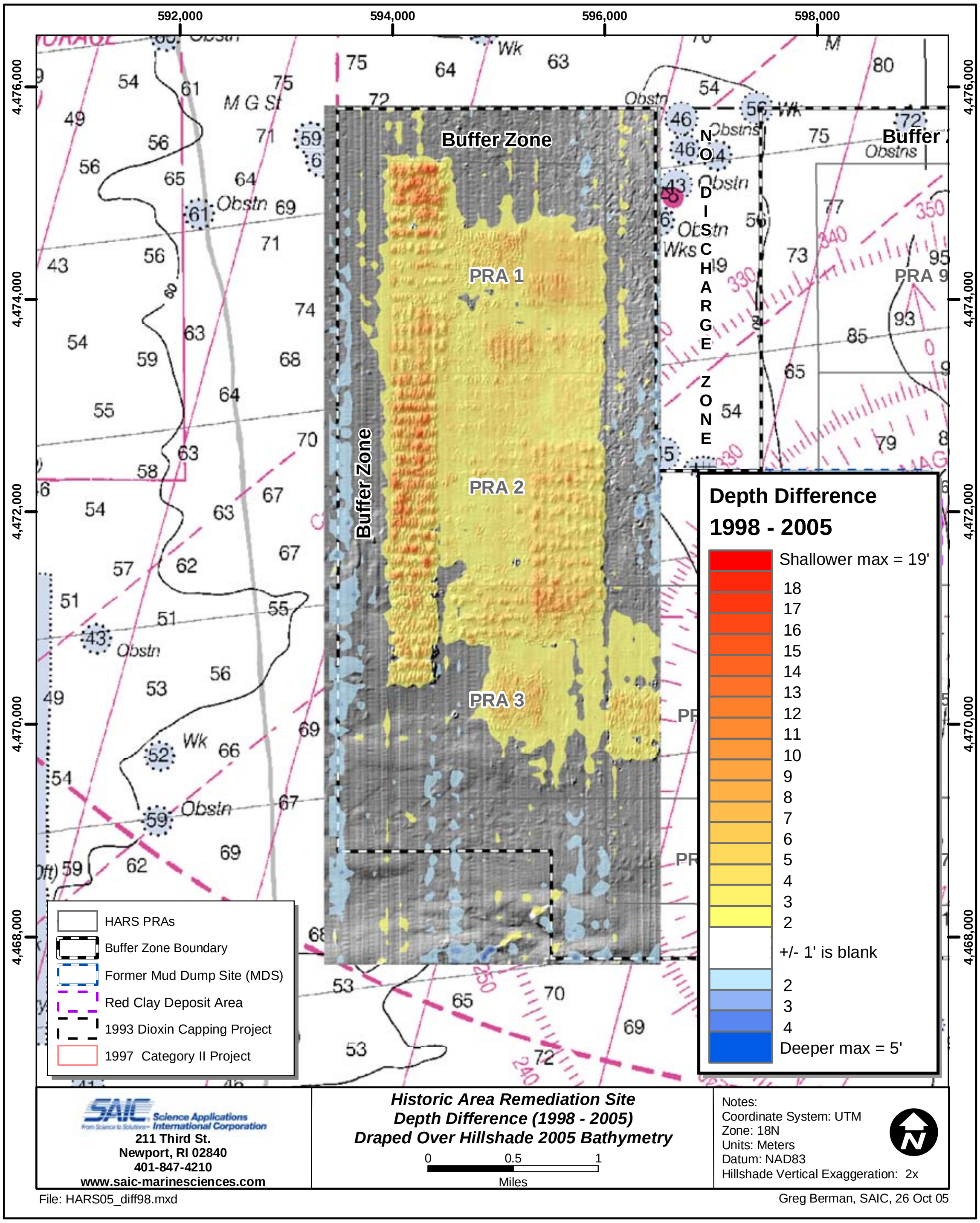


Figure 3.2-4. Bathymetric depth difference between the August 2005 multibeam survey and the September 1998 survey over PRAs 1, 2 and 3

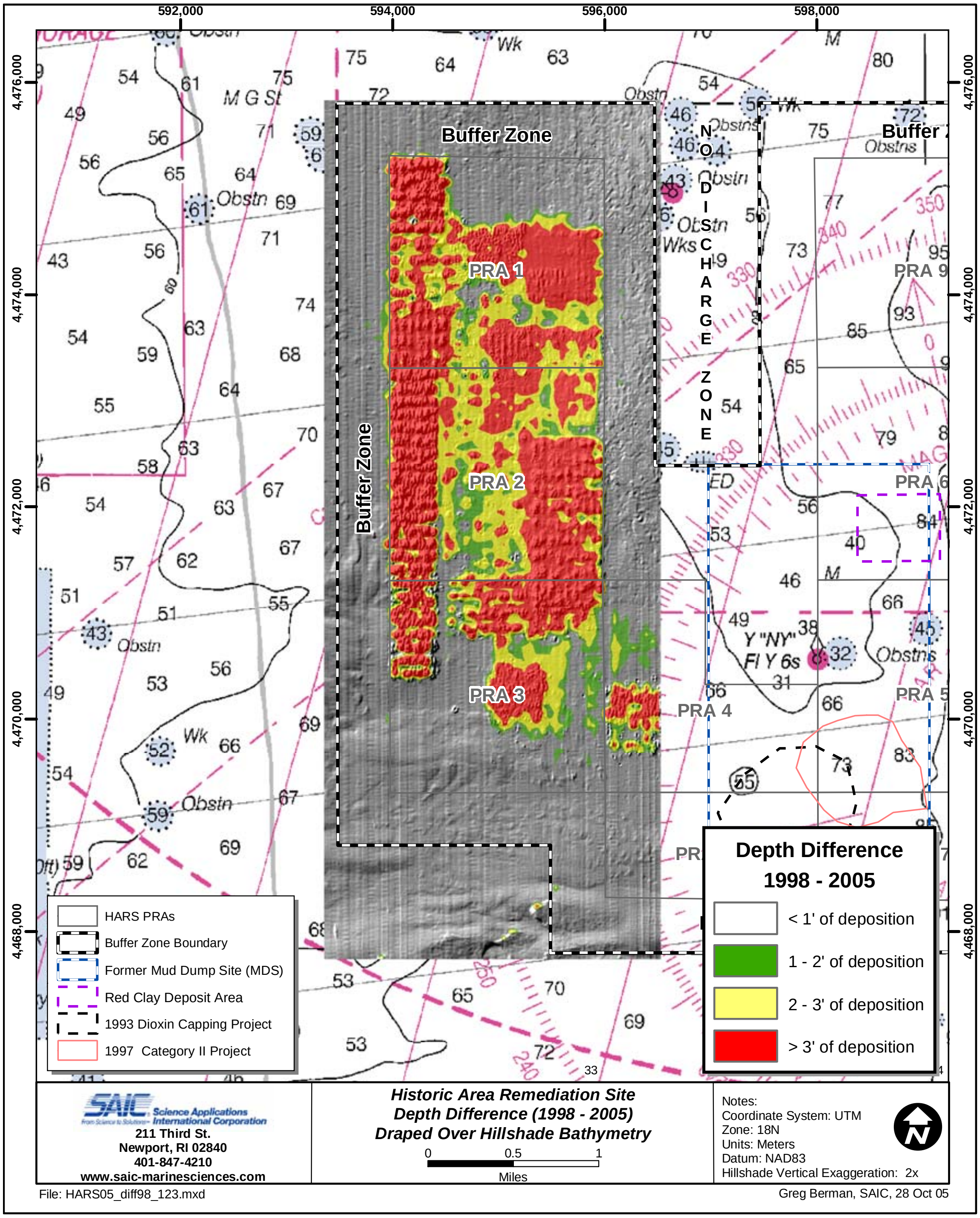


Figure 3.2-5. Bathymetric depth difference between the August 2005 multibeam survey and the September 1998 survey over PRAs 1, 2 and 3

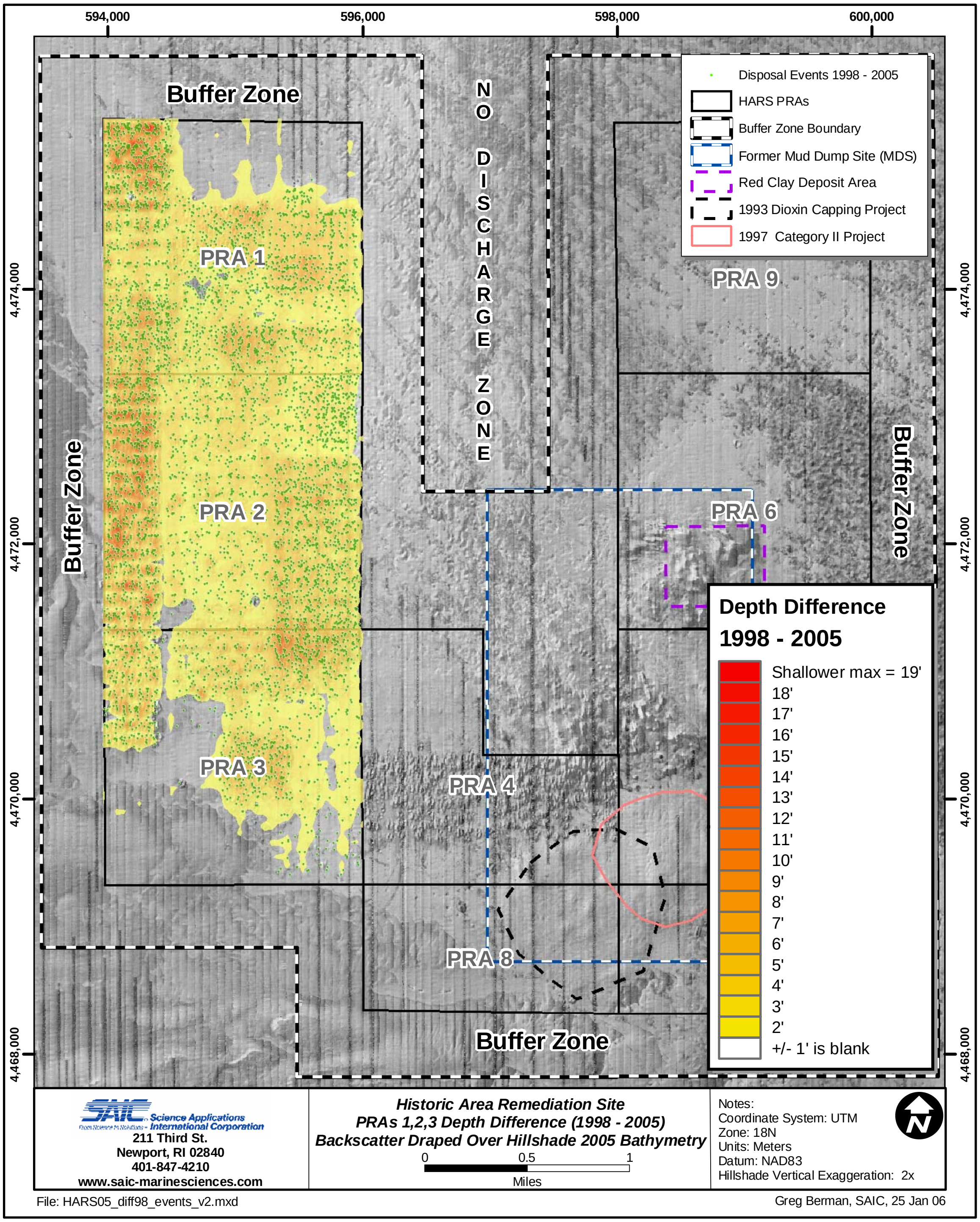


Figure 3.2-6. Disposal point data from the HARS from 1998 through 2005 depicted over the depth difference grid computed between a 1998 single-beam baseline survey of PRAs 1,2, and 3 and a 2005 multibeam survey of the entire HARS; the 2005 multibeam hillshade bathymetry and backscatter is included as the backdrop.

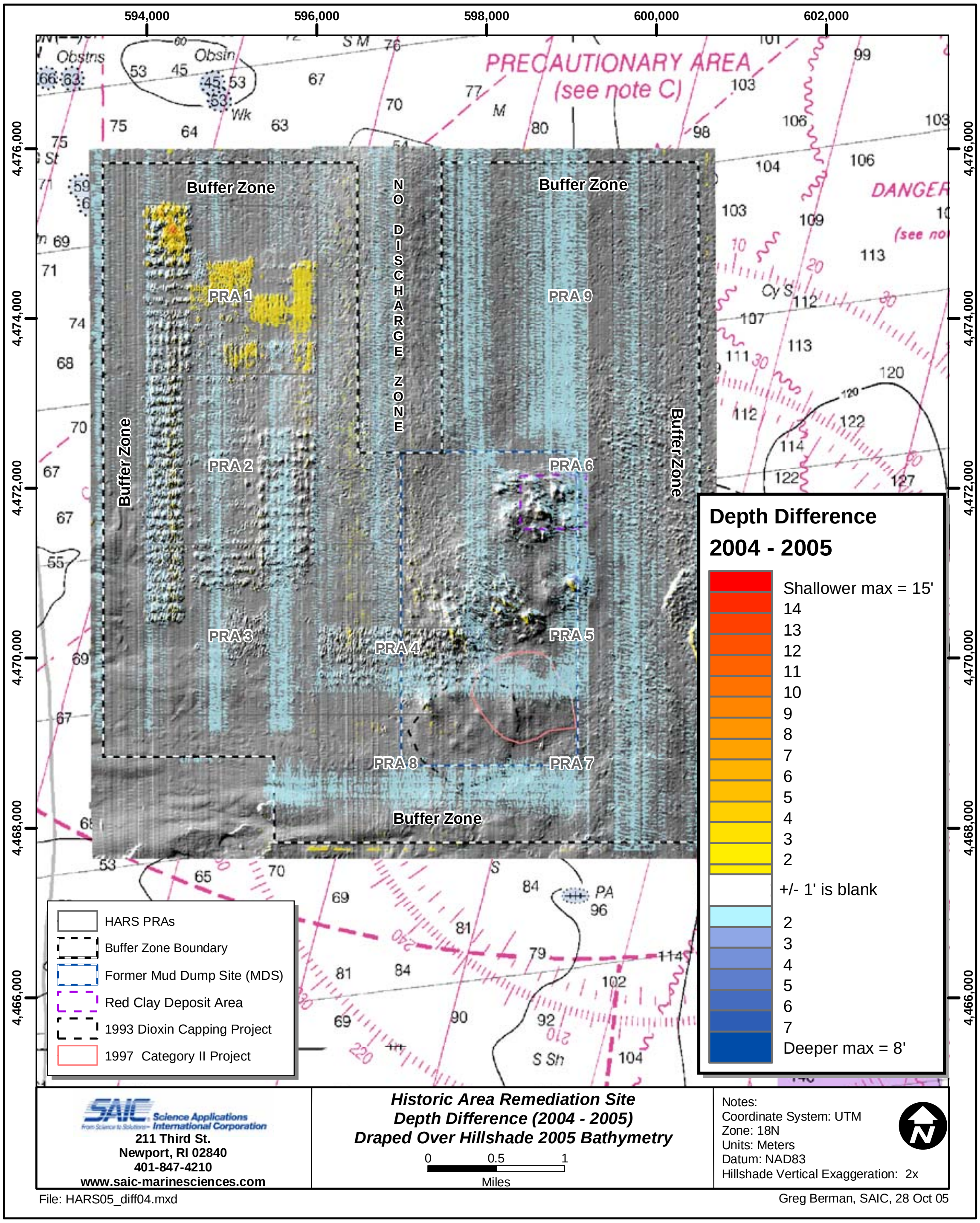


Figure 3.2-7. Bathymetric depth difference between the August 2005 survey and the 2004 multibeam survey

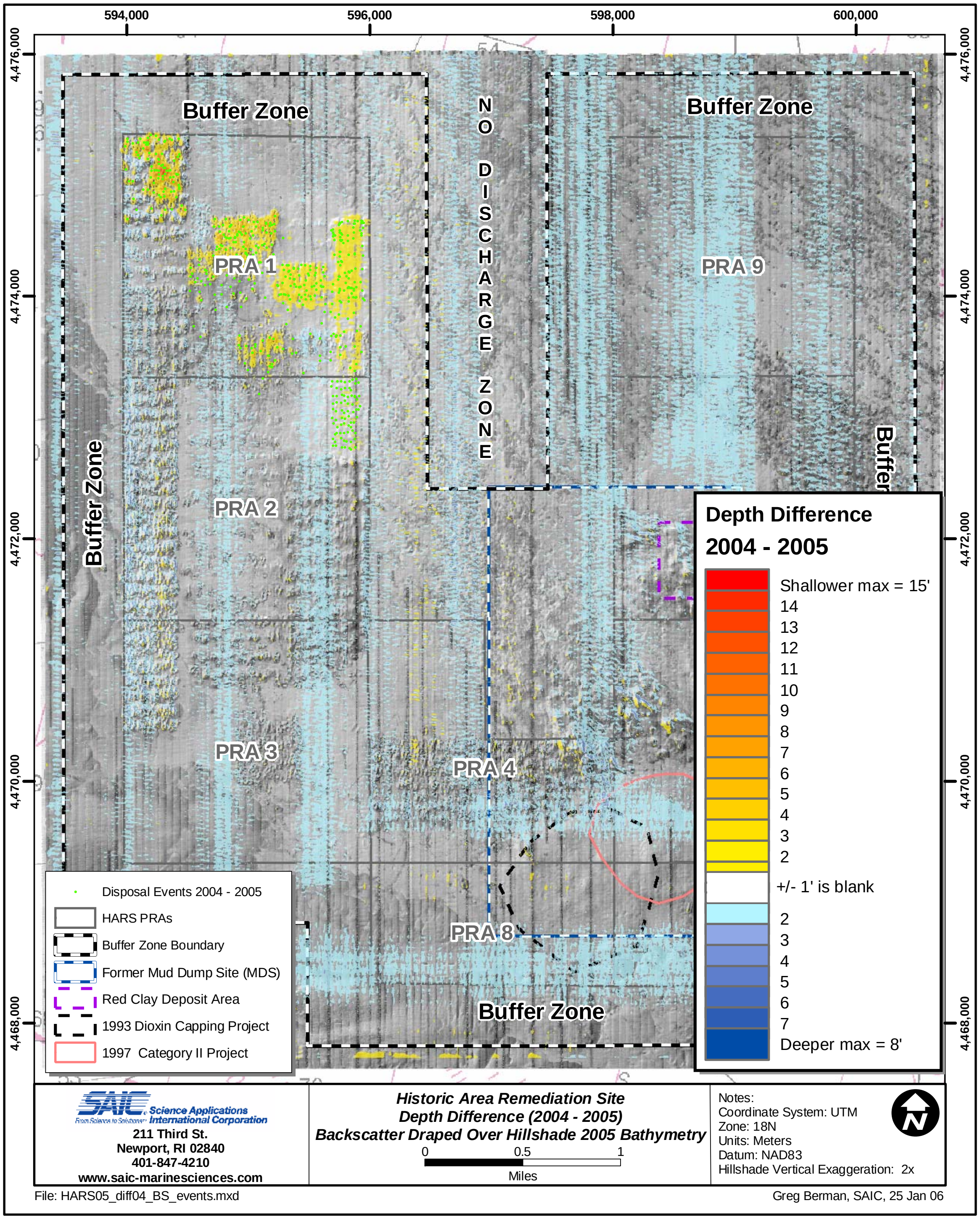


Figure 3.2-8. Disposal point data from the HARS from 2004 and 2005 depicted over the depth difference grid computed between multibeam surveys conducted in October 2004 and August 2005; the 2005 multibeam hillshade bathymetry and backscatter is included as the backdrop.

3.3 Physical Characterization of the Shark River Reef

As discussed in the preceding section, no significant data problems were encountered during processing or analysis of the multibeam bathymetric data, and the entire Shark River Reef was well characterized based on these data. The color-coded gridded hill-shade model view showed that the Shark River Reef lies on a generally flat portion of the seafloor that has been greatly altered by the placement of large volumes of dredged material and other man-made reef materials over many years (Figure 3.3-1). The bottom topography within the Shark River Reef was quite variable and many irregular bottom features were evident throughout the site. The minimum depth observed during this survey was 56.8 ft MLLW over one of the recently created rock mounds. The maximum depth of around 139.0 ft MLLW occurred in the lower southeast corner of the survey area.

A complete 100 kHz image mosaic, representing 100% side-scan sonar coverage, was also created for the entire survey area (Figure 3.3-2). The primary features of interest noted on the side-scan mosaic were the numerous man-made reef objects (e.g., wrecks, rubble, other debris) that had been placed at the site, as well as the numerous large rock mounds that were created over the last few years of dredged material placement at the site. To assist with the site visualization, it was also useful to view the backscatter imagery draped over the multibeam hillshade view (Figure 3.3-3)

3.3.1 Comparison with Prior Surveys and Disposal Information

Because placement of remediation material at the Shark River Reef has been concentrated in the northern half of the area since 2002, this section is focused on evaluating the extent of that deposition based on comparisons between the recent and past surveys. For this effort, the recent 2005 survey was compared to the 2002 single-beam survey and the 2004 multibeam survey. The 2002 dataset is considered the baseline survey for placement operations at the Shark River Reef. The bathymetric depth difference grid generated between the 2005 and 2002 surveys clearly showed dredged material accumulation (deposition) focused in circular mound features along the northern and eastern portions of the survey area, as well as a linear mound trending north-south in the western portion of the survey area (Figures 3.3-4 and 3.3-5). The depth difference grid did not reflect the full extent of the recent deposition along the western side of the sight because the 2002 baseline survey did not extend into this region. Based on the known placement history at the site, these mound features were created by the placement of rock material dredged from New York Harbor over the last three years. The greatest depth difference values occurred over the northern areas, where the tops of some of the mounds measured up to 70 ft above the surrounding seafloor. The few areas that the depth difference grid indicated as having deepened over time tended to be near wrecks that were previously placed at the site. This apparent deepening may be due to natural scour around these prominent bottom features or it may be associated with averaging artifacts associated with the prior single-beam survey. A view of the ADISS-recorded disposal point information from the period between these two surveys coincides very well with the areas of accumulation indicated by the depth difference plot (Figure 3.3-6).

Prior to the 2005 survey, the most recent bathymetric dataset from the Shark River Reef originated from a multibeam survey conducted in May 2004. In order to evaluate recent deposition trends, a depth difference grid was also generated between the 2004 and 2005 datasets. The bathymetric depth difference grid generated between the 2005 and 2004 surveys showed dredged material accumulation (deposition) throughout all of the previously identified mounds (Figure 3.3-7). Besides the areas of obvious accumulation due to dredged material placement, this difference grid was mostly characterized by extensive areas of unnatural vertical striping that were indicative of varying amounts of material accumulation throughout the survey area. Though the amount of this apparent accumulation varied, in many instances it was greater than five ft (even in areas with known placement activity). Because of the strong agreement between the 2002 and 2005 surveys (discussed in the preceding paragraph), the significant differences seen in the comparison between the 2004 and 2005 surveys were likely due to a bias in the 2004 dataset. Based on both the time and depth varying nature of these differences, this bias may be associated with both a tidal and sound velocity offset. In general, it appeared that the 2004 survey depths were noticeably deeper than they should have been, which has overstated the extent of the areas of accumulation in the depth difference grid.

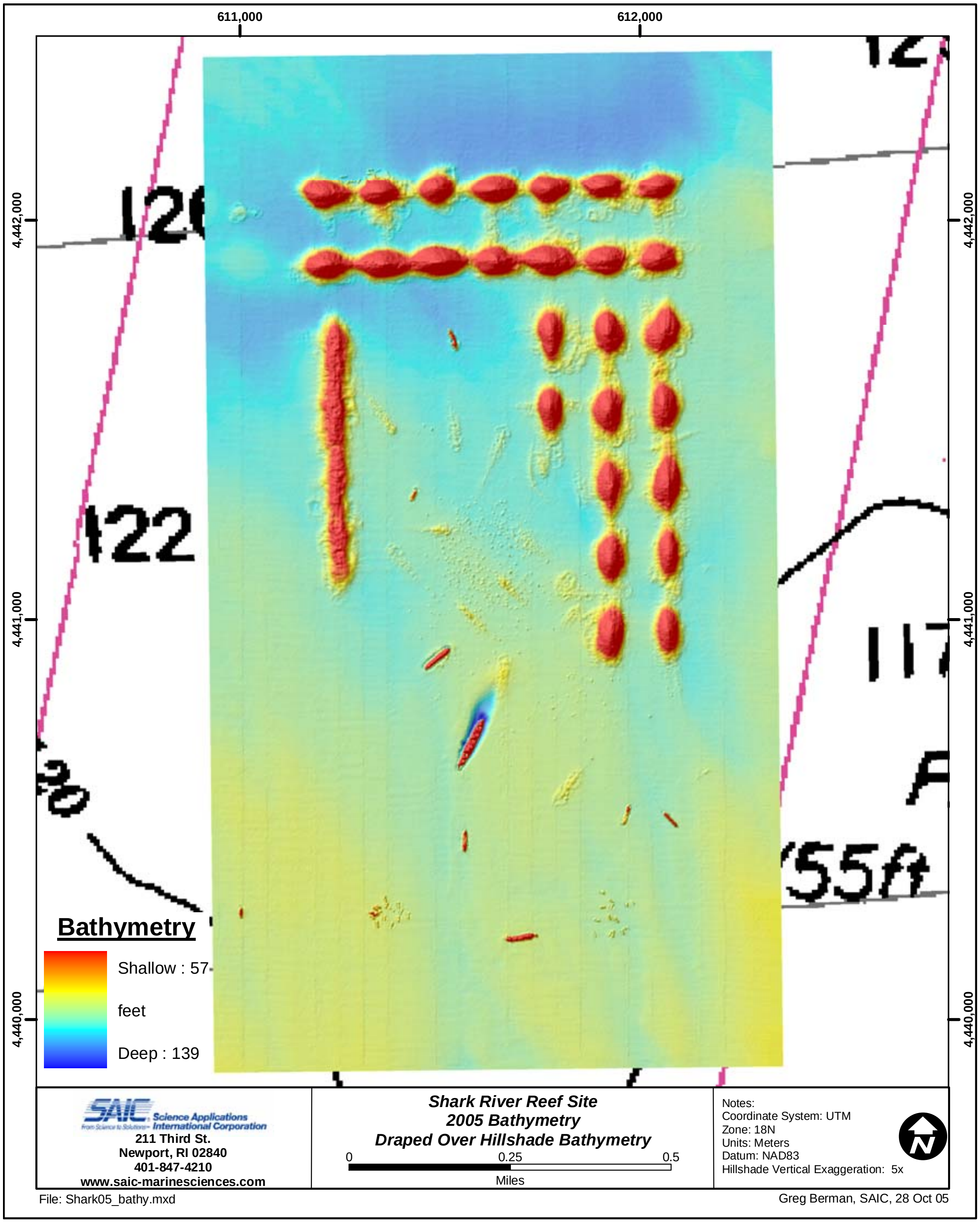


Figure 3.3-1. Hill-shaded gridded relief model based on the August 2005 bathymetric survey at the Shark River Reef

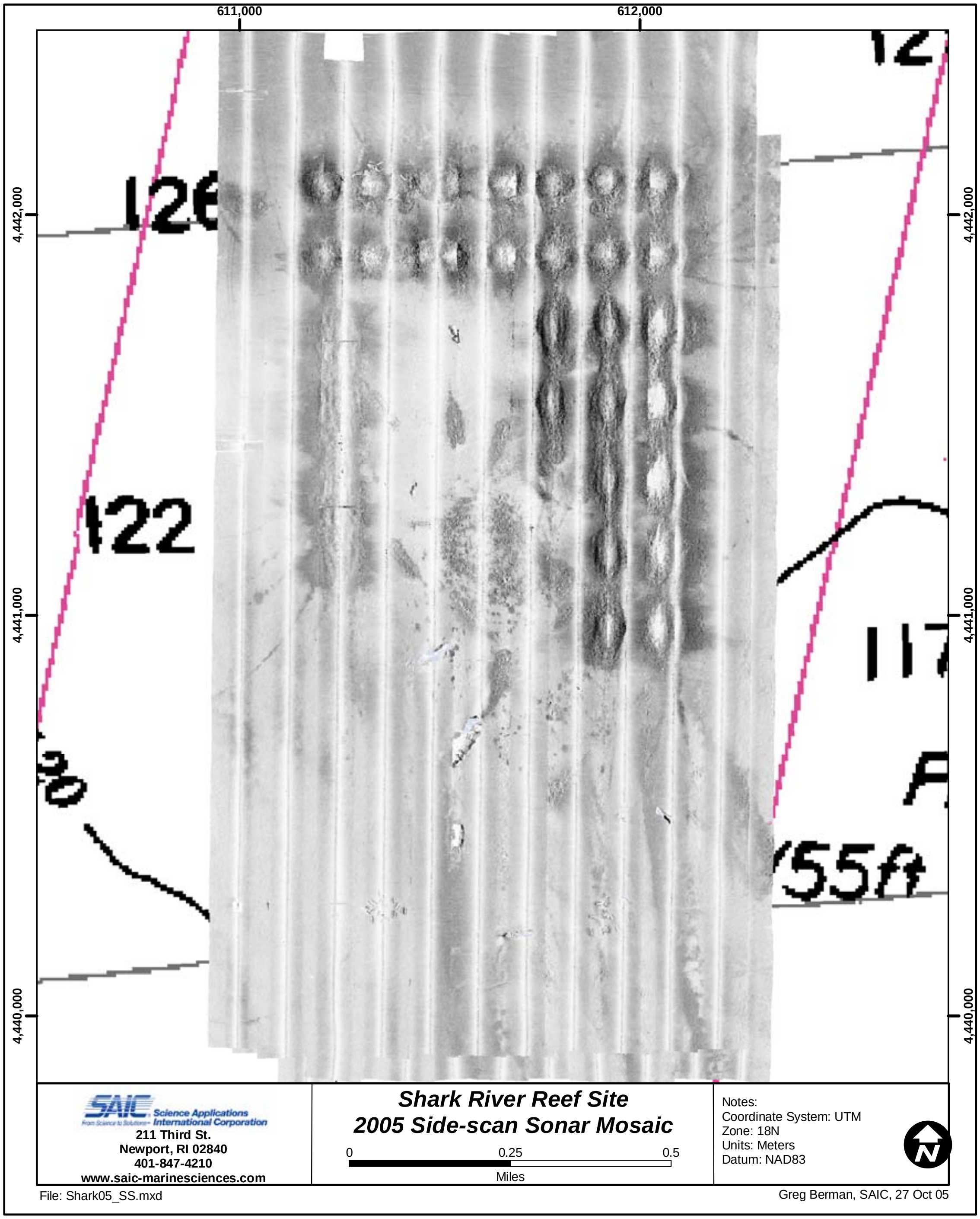


Figure 3.3-2. Side-scan sonar imagery mosaic based on the August 2005 bathymetric survey at the Shark River Reef

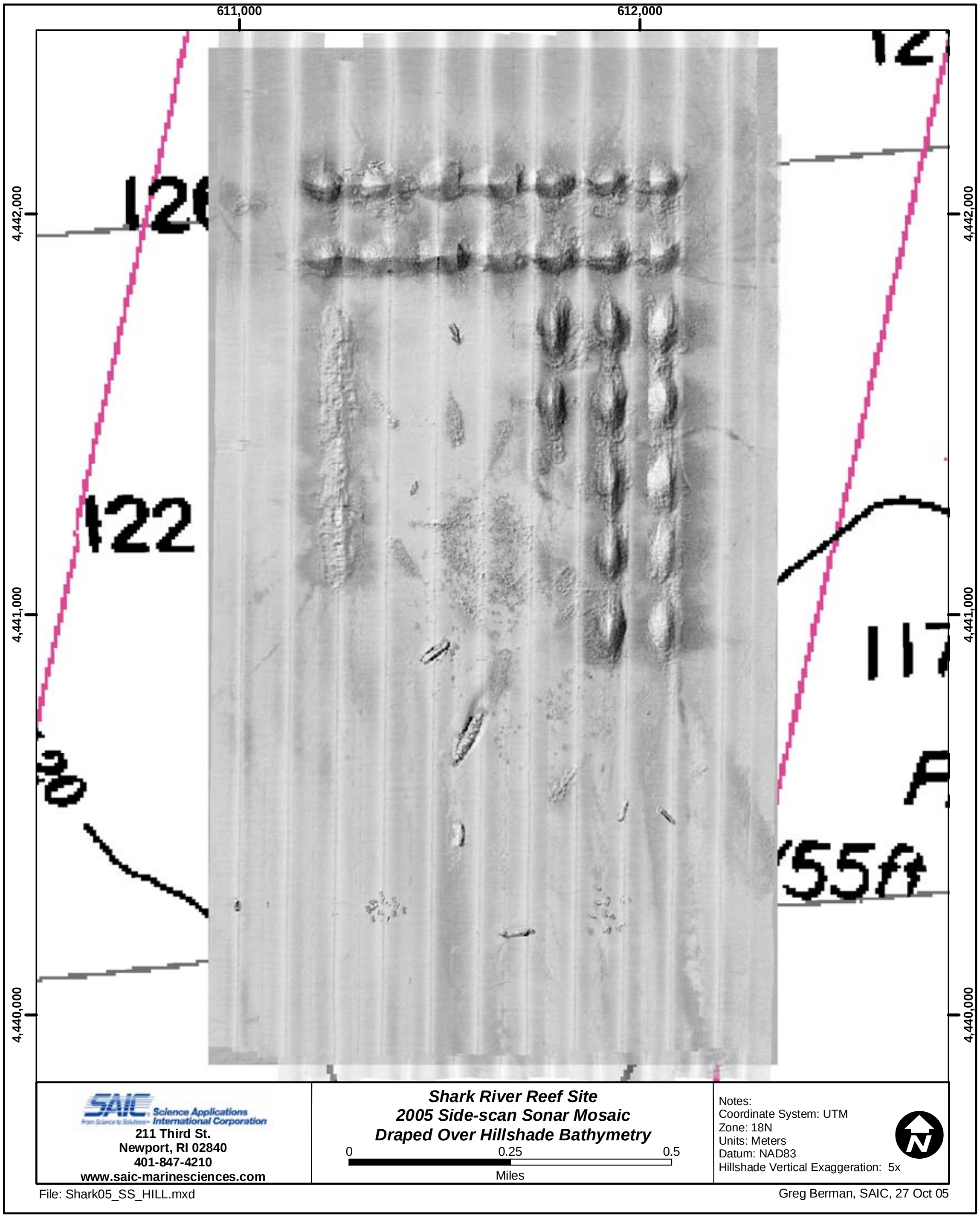


Figure 3.3-3. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2005 Shark River Reef dataset.

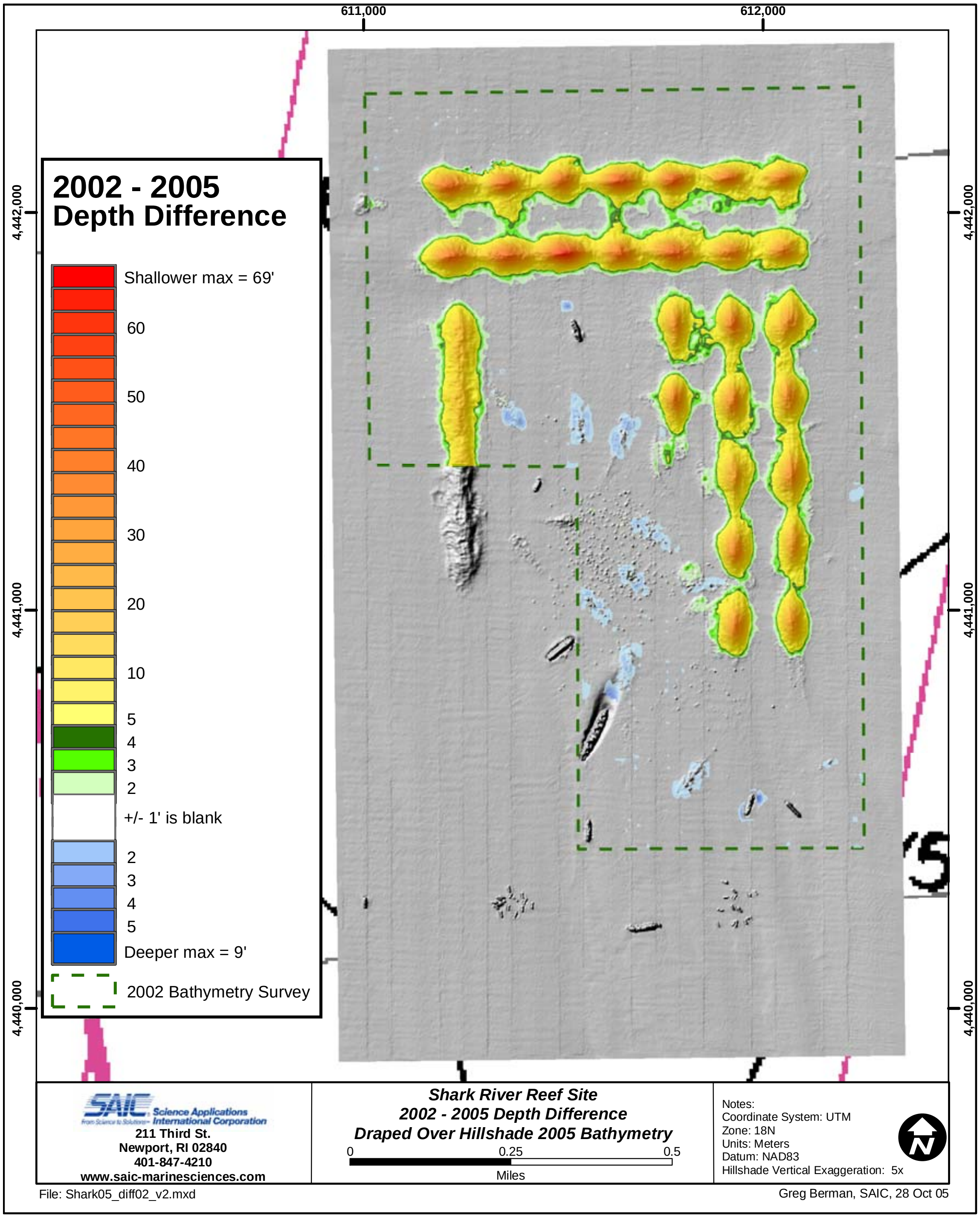


Figure 3.3-4. Bathymetric depth difference between the August 2005 multibeam survey and the January 2002 survey over the Shark River Reef

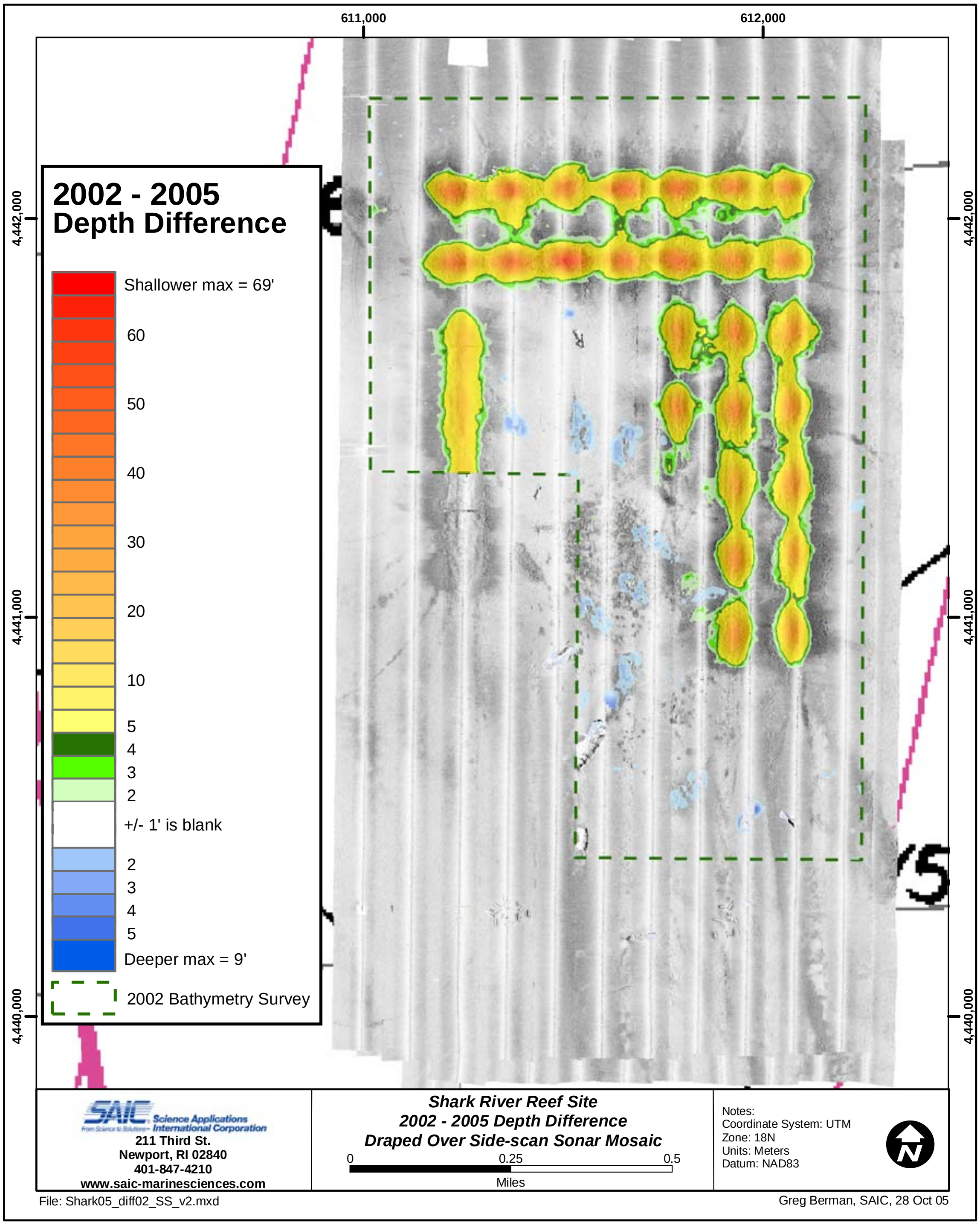


Figure 3.3-5. Bathymetric depth difference between the August 2005 multibeam survey and the January 2002 survey over the Shark River Reef

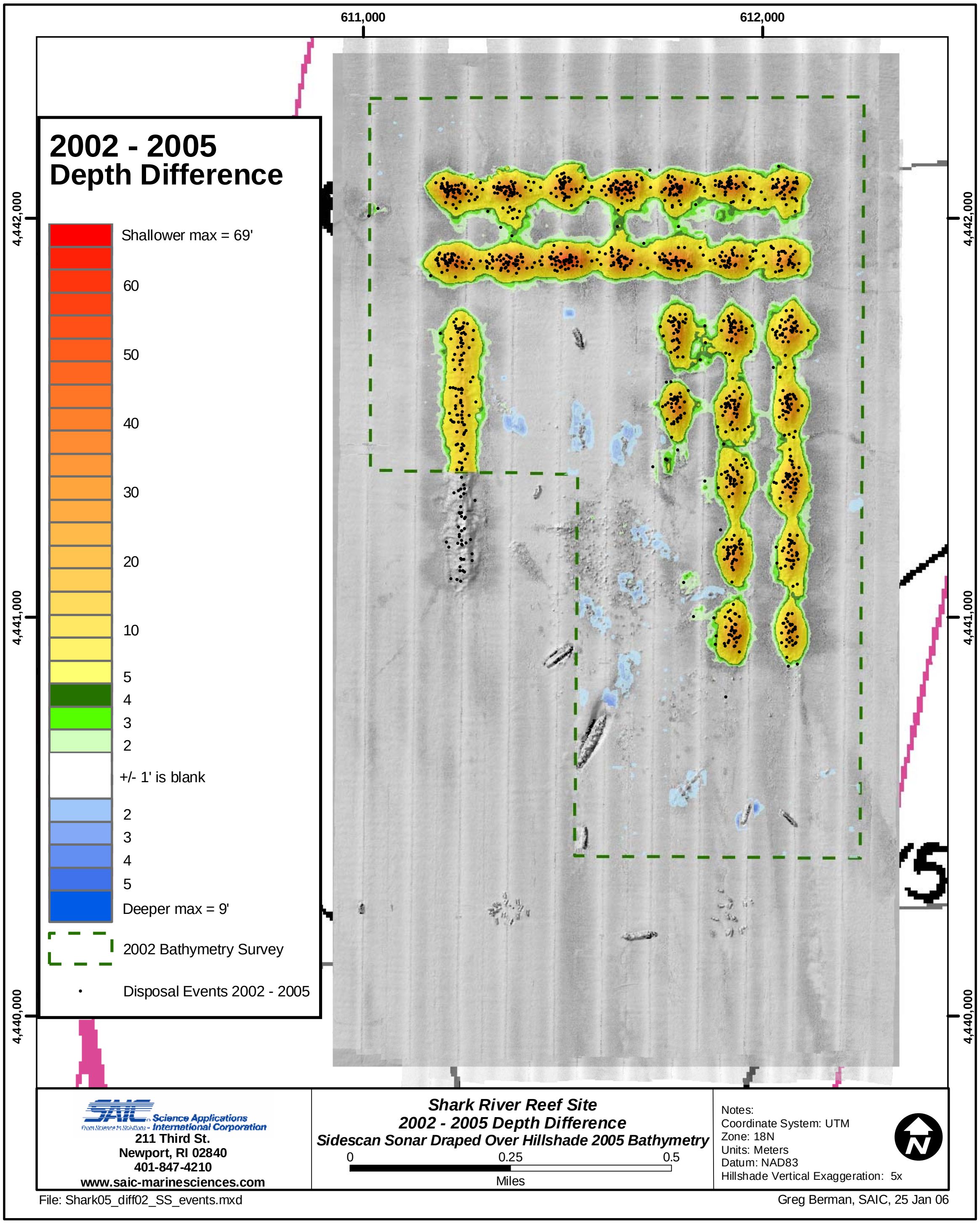


Figure 3.3-6. Disposal point data from the Shark River Reef from 2002 through 2005 depicted over the depth difference grid computed between the 2002 single-beam baseline survey and the 2005 multibeam survey; the 2005 side-scan sonar mosaic is included as the backdrop.

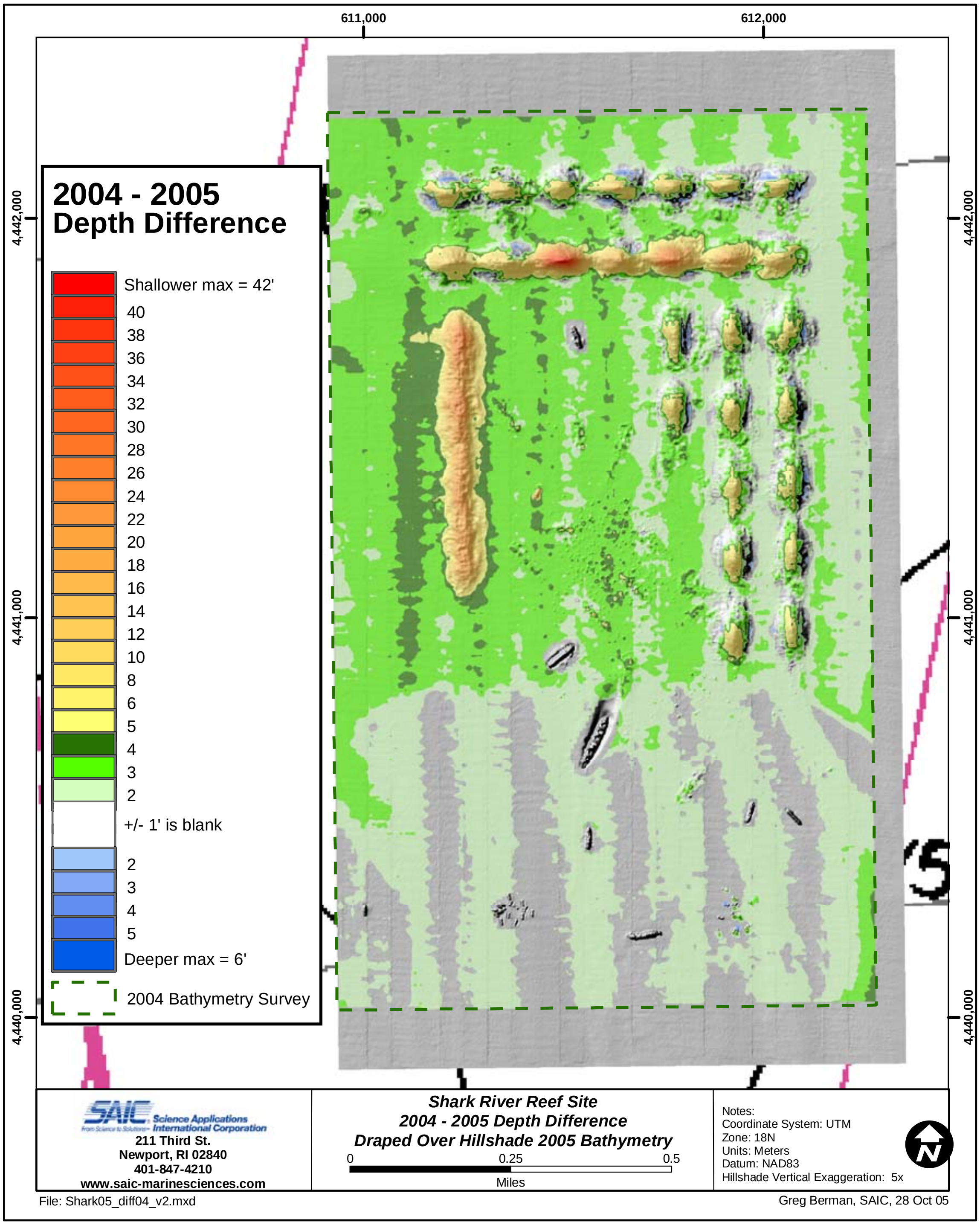


Figure 3.3-7. Bathymetric depth difference between the August 2005 survey and the May 2004 multibeam survey at the Shark River Reef

4.0 REFERENCES

SAIC. 2005a. Results of the Summer 2005 Sediment Toxicity and Sediment Profile Imaging Survey at the Historic Area Remediation Site. SAIC Report No. 622. November 2005.

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