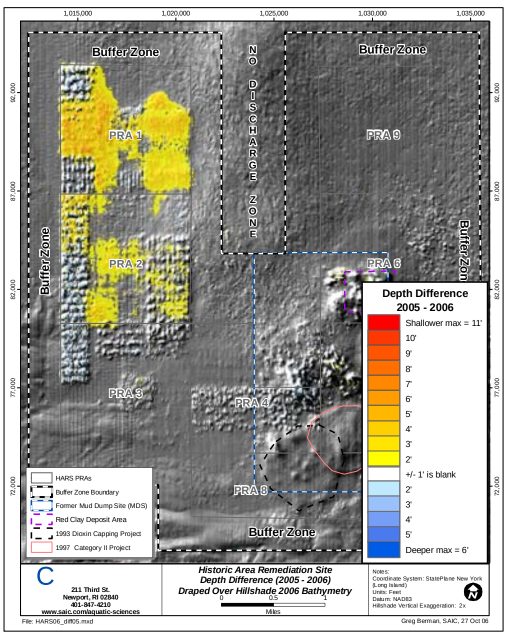
RESULTS OF THE SUMMER 2006 MULTIBEAM BATHYMETRIC AND BACKSCATTER SURVEYS AT THE HISTORIC AREA REMEDIATION SITE, SHARK RIVER REEF, AXEL CARLSON REEF, AND SANDY HOOK REEF

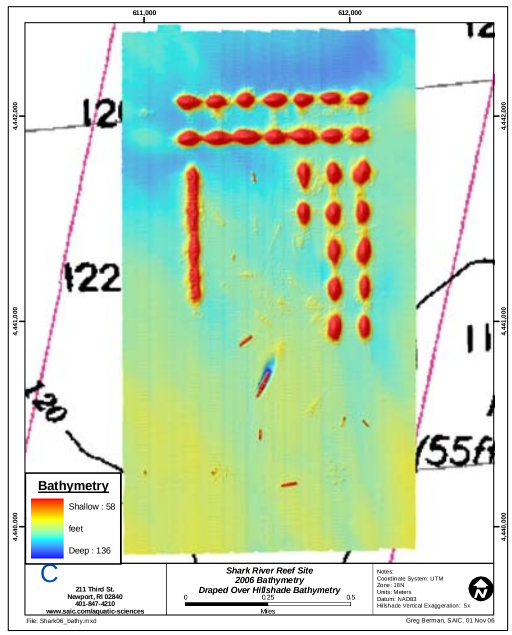
FINAL REPORT

December 2006

Contract No.
SAIC Project No. 01-0236-04-5000-300

SAIC Report No. 716





Prepared for:
U.S. Army Corps of Engineers
New York District, Operations Division
26 Federal Plaza
New York, NY 10278-0090

Prepared by:
Science Applications International Corporation
Admiral's Gate
221 Third Street
Newport, RI 02840

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LIST OF ACRONYMS

CMG	Course Made Good
CTD	Conductivity, Temperature, Depth profiler
DAPR	Data Acquisition and Processing Report
DAT	Digital Audio Tape
DGPS	Differential Global Positioning System
DPC	Data Processing Center
DR	Descriptive Report
DTC	Data Transaction Center
EPA	Environmental Protection Agency
FAT	Factory Acceptance Test
GGA	NMEA-183 Global Positioning System Fix Data String
GPS	Global Positioning System
GSF	Generic Sensor Format
HARS	Historic Area Remediation Site
HDOP	Horizontal Dilution Of Precision
HDU	Helm Display Unit
IMU	Inertial Measurement Unit
ISO	International Organization for Standardization
ISS-2000	Integrated Survey Software 2000
ISSC	Integrated Survey System Computer
JD	Julian Day
MLLW	Mean Lower Low Water
MSU	Mass Storage Unit
MVE	Multi-View Editor
MVP	Moving Vessel Profiler
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NYD	New York District
PFM	Pure File Magic
POS/MV	Position Orientation System/Marine Vessels
PRA	Priority Remediation Area
SABER	Survey Analysis and area Based EditoR
SAIC	Science Applications International Corporation
SAT	Sea Acceptance Tests, or Swath Alignment Tool
SDF	Sonar Data Format
SMMP	Site Management and Monitoring Plan
SVP	Sound Velocity Profile
TPU	Transceiver Processing Unit
UPS	Uninterruptible Power Supply
USACE	U.S. Army Corps of Engineers
XTF	eXtended Triton Format

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1.0 INTRODUCTION

1.1 Background

Sediments dredged from New York/New Jersey Harbor Estuary 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 Site Management and Monitoring Plan (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 2006 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 2006 to provide an updated broad-scale physical characterization of the entire area. In addition, the 2006 monitoring effort also entailed sediment-profile imaging and sub-bottom profiling surveys that are addressed in a separate companion report (SAIC 2006).

In addition to the work conducted at the HARS, this report will also address the similar multibeam survey operations that were conducted at the Shark River Reef and Sandy Hook Reef during the same time period, as well as Axel Carlson Reef that had been covered during previous NOAA-related charting operations in May 2006 (Figure 1.1-1). Each of these reef sites are administered by the State of New Jersey and have been used for the placement of dredged rock material from New York Harbor over the last few years. The 2006 survey results will be compared to the prior bathymetric surveys at these sites over the last few years to document the progress of the on-going placement operations and also to evaluate the potential future capacity still remaining at these sites.

1.2 Survey Objectives

The primary objective for this portion of the 2006 monitoring effort was to obtain an updated broad-scale physical characterization of the entire HARS (including the buffer areas and the no-discharge zone), as well as Axel Carlson, Shark River, and Sandy Hook Reefs. The multibeam bathymetry acquired during this effort provided updated high-resolution datasets that will be used to monitor and plan future placement activity at all of these sites. In addition, the broad-scale characterization also provided multibeam backscatter imagery data that were used to help characterize the composition of the surface sediments in these areas.

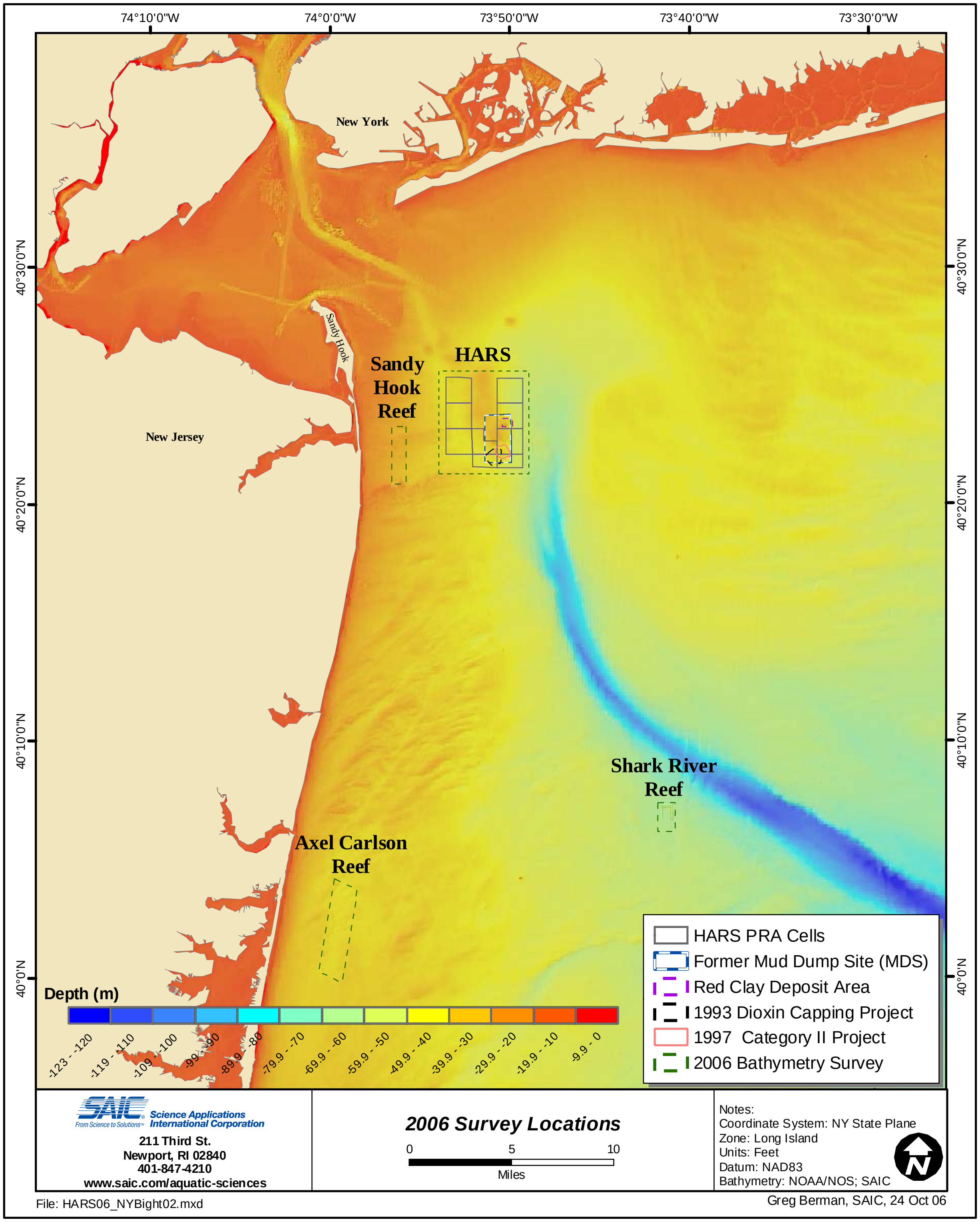


Figure 1.1-1. Location of the Historic Area Remediation Site, Axel Carlson Reef, Shark River Reef, and Sandy Hook Reef in the New York Bight

2.0 METHODS

This portion of the 2006 monitoring effort entailed a complete multibeam bathymetric survey over the entire HARS (including the buffer areas and the no-discharge zone), Shark River Reef, a portion of Sandy Hook Reef, and Axel Carlson Reef. Concurrently with the multibeam data acquisition, multibeam backscatter imagery was also acquired over each of the sites. 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 at the HARS, Shark River Reef, and Sandy Hook Reef were conducted continuously on a 24-hour basis over two main time periods from 27 August through 15 September 2006 (Table 2.0-1). The multibeam operations were suspended during the middle part of this period due to two periods of poor sea conditions and coordination with the NOAA charting project. Multibeam data over the Axel Carlson Reef had been acquired in May 2006 in conjunction with NOAA nautical chart surveys being conducted along that portion of the New Jersey coast.

2.1 Data Acquisition

All of the multibeam 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 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.

Three 20-foot ISO containers were secured on the aft deck. One was used as the real-time, survey data collection office, one as a data processing office, and the third for maintenance and repairs as well as spares storage. All data were shipped to the Data Processing Center (DPC) in the SAIC Newport, RI office for final data processing. The Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) was mounted below the main deck of the vessel, 0.34 m port of centerline and 0.12 m forward and 1.64 m above the RESON 8101 transducer. The multibeam sounder transducer was mounted on the hull 0.46 meters port of the keel. A Brook Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted to the starboard stern quarter.

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. 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 2006 survey operations at the HARS and Shark River Reef

Date	Daily Activity Type	Daily Operations Overview
8/27/2006	Mob / Transit	Mobilize survey personnel aboard the *Atlantic Surveyor* and transit to Shark River Reef
8/28/2006	MB Survey	Complete MB survey at Shark River Reef, transit to HARS, and begin MB survey at the HARS (cross-lines and mainscheme)
8/29/2006	MB Survey	Continue 24-hour multibeam operations at the HARS
8/30/2006	MB Survey	Continue 24-hour multibeam operations at the HARS
8/31/2006	MB Survey	Continue 24-hour multibeam operations at the HARS; operations are suspended late in the day due to poor sea conditions
9/1/2006 - 9/4/2006	NOAA Inport (Weather)	Due to poor extended forecast associated with the passage of Tropical Storm Ernesto, the *Atlantic Surveyor* returned to homeport in Point Pleasant, NJ and all personnel and equipment were taken off of the project
9/5/2006 - 9/8/2006	NOAA MB Survey	*Atlantic Surveyor* resumes its NOAA work to fill-in exisitng data gaps from their previous surveys
9/9/2006 - 9/11/2006	NOAA Inport (Weather)	*Atlantic Surveyor* suspends NOAA work due to poor weather conditions and returns to Point Pleasant for a NOAA inport
9/12/2006	Mob / Transit	Personnel are remobilized aboard the *Atlantic Surveyor* and it transits back to the HARS
9/13/2006	MB Survey	Continue 24-hour multibeam operations at the HARS
9/14/2006	MB Survey	Complete multibeam operations at the HARS and begin multibeam operations at Sandy Hook Reef
9/15/2006	MB Survey / Transit	Complete multibeam operations at Sandy Hook Reef and transit back to Point Pleasant, NJ
9/16/2006	Demob	Demobilize equipment and personnel from the *M/V Atlantic Surveyor*

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 these surveys included the following primary components:

- 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 m 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 each of the required survey areas by running a series of 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, several east-west lanes were also established in each area to provide the required cross-check comparisons with the main-scheme bathymetric data.

2.1.2 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 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).

2.1.3 Tidal (or Water-Level) Corrections

During prior bathymetric surveys at the HARS, a pressure tide gauge has sometimes been deployed near the site to acquire tidal height data in close proximity to the survey area. The

Table 2.1-1.
Summary of sound velocity profiles (SVPs) taken aboard the M/V *Atlantic Surveyor* during the summer 2006 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)			
240	ASSVP06240.D01	13:37:10	2.11	40.10233333	074.042000	USED FOR LEADLINE	240/13:39:59	N/A
240	ASSVP06240.D02	17:24:26	35.72	40.0971666	073.698667	APPLIED	240/17:35:22	240/18:57:50
240	AS_240_1730.CNV	17:35:00	36.32	40.1000395	073.696410	USED FOR COMPARISON	240/17:35:10	N/A
240	ASSVP06240.D04	18:57:29	37.92	40.128000	073.693167	APPLIED	240/18:57:50	240/21:53:39
240	ASSVP06240.D05	21:53:03	34.81	40.095500	073.690833	APPLIED	240/21:53:39	240/23:34:03
240	ASSVP06240.D06	23:33:47	36.87	40.1281666	073.683000	APPLIED	240/23:34:03	241/00:19:36
240	AS_240_1730.CNV	17:35:00	36.32	40.100040	073.696410	USED FOR COMPARISON	240/17:35:10	N/A
241	ASSVP06241.D02	02:08:58	37.30	40.345500	073.811500	APPLIED	241/02:09:31	241/02:49:09
241	ASSVP06241.D03	02:48:52	29.08	40.431500	073.814333	APPLIED	241/02:49:09	241/03:15:16
241	ASSVP06241.D04	03:14:51	30.23	40.3883333	073.818000	APPLIED	241/03:15:16	241/04:17:03
241	ASSVP06241.D05	04:15:32	28.00	40.433000	073.818833	APPLIED	241/04:17:03	241/04:58:58
241	ASSVP06241.D06	04:57:38	35.06	40.349500	073.815333	APPLIED	241/04:58:58	241/05:46:30
241	ASSVP06241.D07	05:45:10	30.05	40.4243333	073.810167	APPLIED	241/05:46:30	241/06:04:28
241	ASSVP06241.D08	06:03:07	21.11	40.4226666	073.845833	APPLIED	241/06:04:28	241/06:48:15
241	ASSVP06241.D08	06:03:07	21.11	40.4226666	073.845833	APPLIED	241/07:09:12	241/07:38:13
241	ASSVP06241.D09	06:43:13	17.99	40.413000	073.908833	APPLIED	241/06:48:15	241/07:09:12
241	ASSVP06241.D10	07:36:40	27.87	40.4318333	073.816667	APPLIED	241/07:38:13	241/08:18:54
241	ASSVP06241.D11	08:17:02	31.29	40.3491666	073.819333	APPLIED	241/08:18:54	241/09:38:25
241	ASSVP06241.D12	09:36:32	31.81	40.3491666	073.818500	APPLIED	241/09:38:25	241/10:23:44
241	ASSVP06241.D13	10:21:54	27.27	40.4323333	073.819000	APPLIED	241/10:23:44	241/11:38:50
241	ASSVP06241.D14	11:38:38	26.84	40.4321666	073.823833	APPLIED	241/11:38:50	241/12:17:58
241	ASSVP06241.D14	11:38:38	26.84	40.4321666	073.823833	APPLIED	241/12:18:39	241/12:18:56
241	ASSVP06241.D15	12:17:42	30.91	40.349500	073.821167	APPLIED	241/12:17:58	241/12:18:39
241	ASSVP06241.D15	12:17:42	30.91	40.349500	073.821167	APPLIED	241/12:18:56	241/13:32:52
241	ASSVP06241.D16	13:32:30	29.56	40.350000	073.825500	APPLIED	241/13:32:52	241/14:18:35
241	ASSVP06241.D17	14:18:17	27.82	40.432500	073.821167	APPLIED	241/14:18:35	241/15:34:59
241	ASSVP06241.D18	15:34:28	26.78	40.4331666	073.825833	APPLIED	241/15:34:59	241/16:36:08
241	ASSVP06241.D19	16:35:10	28.41	40.398500	073.829333	APPLIED	241/16:36:08	241/17:45:16
241	ASSVP06241.D20	17:44:58	27.10	40.383500	073.828500	APPLIED	241/17:45:16	241/19:22:53
241	ASSVP06241.D21	19:20:11	25.94	40.426500	073.829333	APPLIED	241/19:22:53	241/19:57:21
241	ASSVP06241.D22	19:56:48	25.44	40.3521666	073.831000	APPLIED	241/19:57:21	241/21:23:17
241	ASSVP06241.D23	21:20:43	22.00	40.3698333	073.835500	APPLIED	241/21:23:17	241/22:33:30
241	ASSVP06241.D24	22:33:13	24.29	40.3668333	073.834167	APPLIED	241/22:33:30	242/02:22:55
242	AS_242_0219.CNV	02:19:20	22.07	40.399951	073.845472	APPLIED	242/02:22:55	242/11:02:35
242	AS_242_1054.CNV	10:53:00	23.03	40.3985733	073.842961	APPLIED	242/11:02:35	242/16:17:04
242	AS_242_1613.CNV	16:13:11	23.63	40.3667875	073.849832	APPLIED	242/16:17:04	242/22:03:52
242	AS_242_2200.CNV	21:59:22	16.72	40.4062376	073.855984	APPLIED	242/22:03:52	243/03:34:20
243	AS_243_0331.CNV	03:31:42	25.89	40.3693253	073.867684	APPLIED	243/03:34:20	243/16:29:57
243	AS_243_1627.CNV	16:27:23	24.27	40.3927866	073.882053	APPLIED	243/16:29:57	243/17:58:00
243	AS_243_1804.CNV	18:03:28	33.51	40.373736	073.812212	BOUNDING CAST	243/18:04:57	N/A
243	AS_243_1819.CNV	18:19:21	36.11	40.37173317	073.816014	USED FOR COMPARISON	243/18:24:34	N/A
244	ASSVP06244.D01	13:14:13	1.5	40.10235217	074.041978	USED FOR LEADLINE	244/13:26:26	N/A
249	ASSVP06249.D01	21:23:20	2.0	40.102330	074.041923	USED FOR LEADLINE	249/21:45:37	N/A
250	AS_250_0034.CNV	00:34:38	22.63	40.061854	074.009040	USED FOR COMPARISON	250/00:39:25	N/A
250	AS_250_0045.CNV	00:45:44	20.58	40.061240	074.007755	USED FOR COMPARISON	250/00:49:43	N/A
256	AS_256_0306.CNV	03:06:25	21.84	40.3490175	073.876505	APPLIED	256/03:11:51	256/04:02:00
256	AS_256_0306.CNV	03:06:25	21.84	40.3490175	073.876505	APPLIED	256/04:42:44	256/05:02:46
256	AS_256_0354.CNV	03:54:53	21.29	40.4321323	073.877832	APPLIED	256/04:02:00	256/04:42:44
256	AS_256_0354.CNV	03:54:53	21.29	40.4321323	073.877832	APPLIED	256/05:02:46	256/06:04:45
256	AS_256_0354.CNV	03:54:53	21.29	40.4321323	073.877832	APPLIED	256/06:42:58	256/07:19:49
256	AS_256_0354.CNV	03:54:53	21.29	40.4321323	073.877832	APPLIED	256/07:51:40	256/08:39:38
256	AS_256_0557.CNV	05:57:36	20.89	40.0351048	073.881409	APPLIED	256/06:04:45	256/06:42:58
256	AS_256_0557.CNV	05:57:36	20.89	40.0351048	073.881409	APPLIED	256/07:19:49	256/07:51:40
256	AS_256_0838.CNV	08:38:14	23.70	40.3831106	073.884066	APPLIED	256/08:39:38	256/10:17:02
256	AS_256_1015.CNV	10:15:42	22.89	40.363566	073.886509	APPLIED	256/10:17:02	256/12:59:00
256	AS_256_1256.CNV	12:56:52	20.57	40.3502455	073.889525	APPLIED	256/12:59:00	256/15:00:58
256	AS_256_1500.CNV	15:00:09	21.22	40.4331658	073.892898	APPLIED	256/15:00:58	256/17:24:35
256	AS_256_1723.CNV	17:23:38	21.24	40.387353	073.897461	APPLIED	256/17:24:35	256/19:21:02
256	AS_256_1920.CNV	19:20:09	19.93	40.4360778	073.894820	APPLIED	256/19:21:02	256/21:59:33
256	AS_256_2152.CNV	21:52:45	0.00	40.4315456	073.897572	APPLIED	256/21:59:33	257/02:00:26
257	AS_257_0157.CNV	01:57:24	21.65	40.4127481	073.883733	APPLIED, TAKEN WITH CTD 648	257/02:00:26	257/06:41:44
257	AS_257_0633.CNV	06:33:54	0.00	40.3914865	073.862042	APPLIED	257/06:41:44	257/09:23:28
257	AS_257_0922.CNV	09:21:42	19.78	40.4326023	073.856918	APPLIED	257/09:23:28	257/13:12:27
257	AS_257_1311.CNV	13:11:03	14.96	40.387067	073.847806	APPLIED	257/13:12:27	257/17:00:24
257	AS_257_1659.CNV	16:59:19	36.64	40.3885455	073.806219	APPLIED	257/17:00:24	257/17:49:07
257	AS_257_1659.CNV	16:59:19	36.64	40.3885455	073.806219	APPLIED	257/20:08:19	257/20:15:39
257	AS_257_1747.CNV	17:47:47	24.86	40.3863625	073.878582	APPLIED	257/17:49:07	257/19:44:51
257	AS_257_1943.CNV	19:43:40	20.58	40.3592626	073.905257	APPLIED	257/19:44:51	257/20:08:19
257	AS_257_2022.CNV	20:22:55	37.71	040.359000	073.811987	USED FOR BOUNDING CAST	257/20:24:12	N/A
258	AS_258_1730	17:31:14	36.32	40.10233333	074.042000	USED FOR LEADLINE	258/17:31:00	N/A
259	AS_259_1538	15:38:00	3.45	40.10233333	074.042000	USED FOR COMPARISON	N/A	N/A

primary purpose of the previous HARS tide gauge installations was to assess any observed differences in tidal range and phase between the HARS and the primary NOAA reference tide station located at the Sandy Hook Coast Guard Station (Station 8531680). Because the HARS gauges were deployed at an offshore location, they were not referenced to any tidal benchmarks or vertical datum (as is typically the case with shore-based tidal stations). However, by normalizing the HARS pressure gauge data about the mean tide level (MTL), it was possible to make direct comparisons between the non-referenced HARS tidal data and Sandy Hook tidal data referenced to MLLW. Because the HARS pressure gauge data was not referenced to a true datum, tidal correctors for the HARS bathymetric data have typically been based on verified Sandy Hook observations with applicable phase and range offsets applied.

Well after the completion of the 2005 data analysis and reporting effort, we conducted a more thorough analysis of the HARS pressure tide gauge data from both 2005 and 2002. By accounting for the changes in atmospheric pressure that were observed during the course of the previous HARS pressure gauge deployments, the overall agreement between the HARS and the Sandy Hook tide data was improved considerably. Based on the strong and consistent agreement observed during these past surveys, the Sandy Hook tide data could be relied on to accurately and consistently reflect the tidal level at the HARS. As a result of this detailed analysis, slightly revised phase and range offset corrections were generated for the HARS. A more thorough discussion of the results of this tidal analysis is provided in Section 3.1.2.

2.1.4 Side-Scan Sonar Systems and Operations

The towed side-scan sonar system used for the Axel Carlson 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. 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.

2.1.5 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 4-mm 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 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.

The observed, verified water-level data from the NOAA Sandy Hook station (Station 8531680), modified with appropriate phase and range offsets, were used to reduce the HARS, Sandy Hook Reef, and Shark River Reef bathymetric data to MLLW. As discussed in Section 2.1.1.2, somewhat revised offset correctors were developed for the HARS based on the additional analyses conducted on HARS pressure tide gauge data from previous years. The observed, verified water-level data from the NOAA Atlantic City station (Station 8534720), modified with appropriate phase and range offsets, were used to reduce the Axel Carlson Reef bathymetric data to MLLW. The range and phase offsets applied for the Axel Carlson Reef data were based on tidal zoning correctors that were provided by NOAA within their project instructions for the nautical chart surveying project. 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). For each of the four main survey areas, the following phase and range offsets were applied to the verified NOAA tide station data:

- HARS (on Sandy Hook) phase: minus 30 minutes, range ratio: 0.94
- Sandy Hook Reef (on Sandy Hook) phase: minus 30 minutes, range ratio: 0.94
- Shark River Reef (on Sandy Hook) phase: minus 30 minutes, range ratio: 0.80
- Axel Carlson Reef (on Atlantic City) phase: minus 6 minutes, range ratio: 1.07

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 Axel Carlson 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 the three Reef sites) grid cell size by selecting the sounding closest to the center of each cell. These thinned datasets were then imported into ArcGIS 9.1 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-ft 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-ft grid cell size and was comprised of 1,111 rows and 971 columns. For the Shark River Reef dataset, a 75-ft 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-ft grid cell size and was comprised of 1,669 rows and 947 columns. For the Axel Carlson Reef dataset, a 75-ft fixed search radius along with a power rating of two provided the best results. The resulting gridded dataset was based on a 5-ft grid cell size and was comprised of 4,065 rows and 1478 columns. For the Sandy Hook Reef dataset, a 75-ft fixed search radius along with a power rating of two provided the best results. The resulting gridded dataset was based on a 5-ft grid cell size and was comprised of 1,101 rows and 574 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 against both 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 2005. For the Shark River Reef, the baseline survey was from 2002 and the most recent prior survey was from 2005. For the Axel Carlson Reef, the baseline, as well as the most recent prior survey, was from 2003. The Sandy Hook Reef dataset was compared only to the prior survey that was conducted in 2001. Within ArcGIS 9.1, a bathymetric difference grid was generated between the 2006 and prior datasets to 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 four-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 survey operations.

3.1.2 Tidal Data Analysis

As discussed in Section 2.1.3, additional analyses were conducted on pressure tide gauge data that were acquired at the HARS during prior surveys in 2005 and 2003. The primary purpose of the previous HARS tide gauges was to assess any observed differences in tidal range and phase between the HARS and the primary NOAA reference tide station located at the Sandy Hook Coast Guard Station. Because the HARS gauges were deployed at an offshore location, they were not referenced to any tidal benchmarks or vertical datum (as is typically the case with shore-based tidal stations). However, by normalizing the HARS pressure gauge data about the mean tide level (MTL), it was possible to make direct comparisons between the non-referenced HARS tidal data and Sandy Hook tidal data referenced to MLLW.

As observed during the 2005 project at the HARS, the agreement between the HARS tide gauge data and the offset Sandy Hook data was generally consistent throughout the period

(SAIC 2005). 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 the 2005 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 (Figure 3.1-1). 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 bathymetric data from the 2005 survey were reduced to MLLW based only on the verified Sandy Hook tide data adjusted by appropriate offsets for the HARS. Consistent with past surveys, a minus 45 minute phase shift (water level at Sandy Hook lags that at HARS) and 0.95 range multiplier (the range is higher at Sandy Hook than at HARS) were applied to the Sandy Hook data.

Well after the completion of the 2005 data analysis and reporting effort, a more thorough analysis of past HARS pressure tide gauge data was conducted to better evaluate the tidal relationship between the HARS and Sandy Hook. The following discussion presents the results from the 2005 survey, though similar analyses were also conducted for three separate tidal datasets that were acquired during the 2002 survey operations. Principal analyzed data consisted of NOAA verified water level observations at Sandy Hook and pressure measurements from the HARS tide gauge. Initially, all of the water level time series datasets were screened for statistical outliers and then, in accordance with the NOAA recommendations for tidal data analysis, smoothed to suppress noisy fluctuations with periods of less than one hour. This data smoothing was accomplished with an 8-th order infinite impulse response Chebyshev filter.

Next, the time series of recorded atmospheric pressure were used to improve the conversion of the HARS pressure gauge measurements to depth units (Figure 3.1-2). This was necessary because the tide gauge recorded pressure exerted on the instrument by both the water column and the atmosphere. The time series of recorded atmospheric pressure was subtracted from the tide gauge pressure data to produce a time series of pressure exerted only by the water column on the gauge. To convert this pressure to water height, we used the hydrostatic relationship:

$$h = \frac{p}{g\rho}.$$

Where, p is the measured pressure of the water column (after subtracting the atmospheric pressure), g is the gravity acceleration, and ρ is the average water density. The average water density, ρ = 1022.0 kg/m^3, was selected based on the results of the CTD casts taken in the area during the survey operations. Application of the recorded atmospheric pressure data to the HARS pressure gauge data greatly improved the overall agreement between the observed Sandy Hook and HARS tidal results (Table 3.1-1). The noticeable range and phase differences were eliminated, and the observed tidal patterns were very consistent between the two stations. The computed standard error between the stations was reduced from 0.072 m to 0.020 m, and the maximum observed error was reduced from 0.205 m to 0.071 m.

The computed MLLW at the HARS pressure tide gauge location for the period of observation was 23.13 m. For the same period, the observed MLLW at the Sandy Hook station was 0.37 m

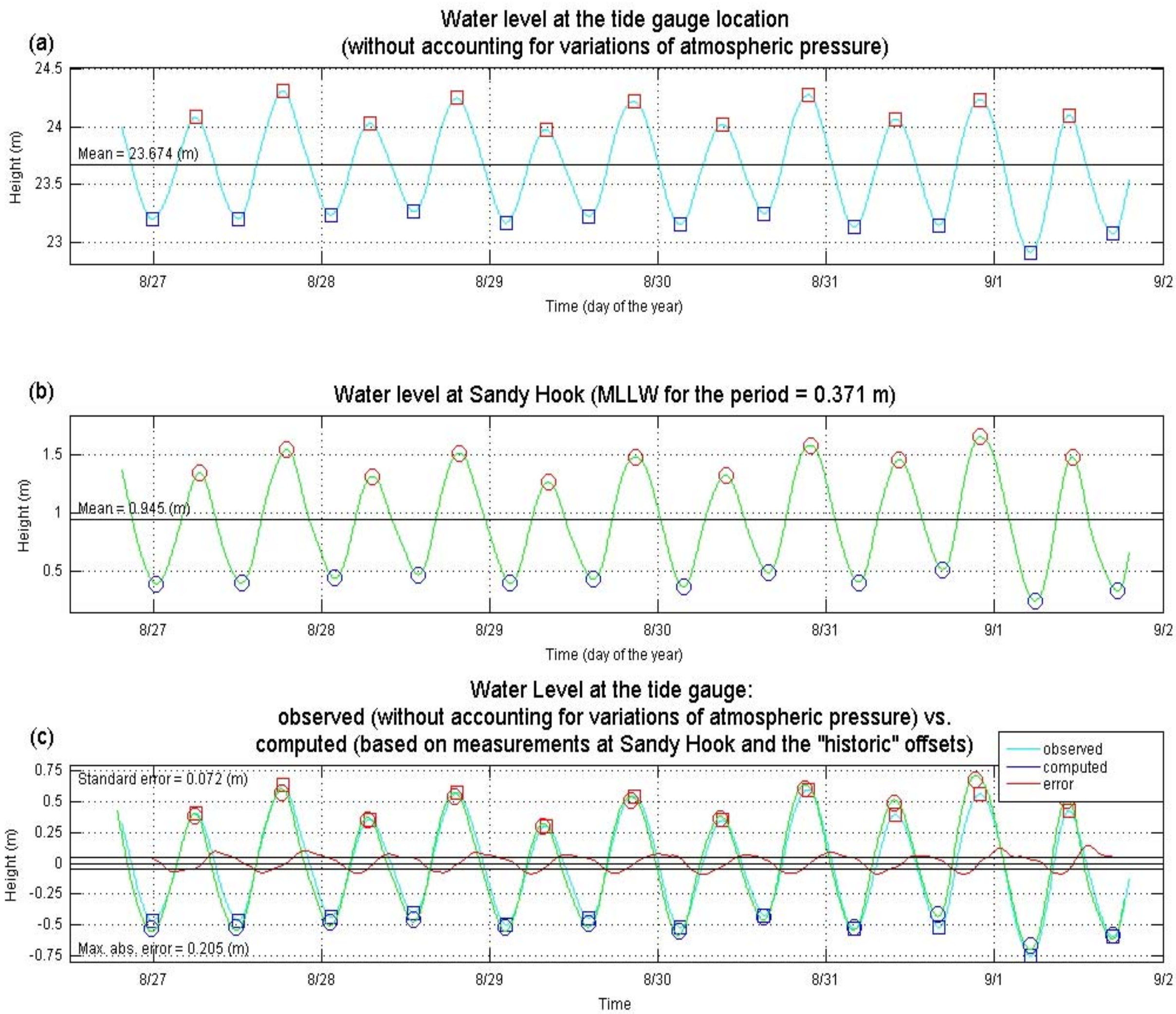


Figure 3.1-1. Panel (a) provides a time series of the observed water level at the HARS pressure tide gauge during a seven day measurement period in 2005; Panel (b) provides the verified MLLW tidal heights from the NOAA Sandy Hook tide gauge during the same time period; Panel (c) provides a time series of the observed differences between the HARS tide gauge data (normalized about the MTL) and the Sandy Hook tide gauge data (with historical range and phase offset correctors applied for the HARS). The observed standard error was 0.072 m and the maximum observed error was 0.205 m.

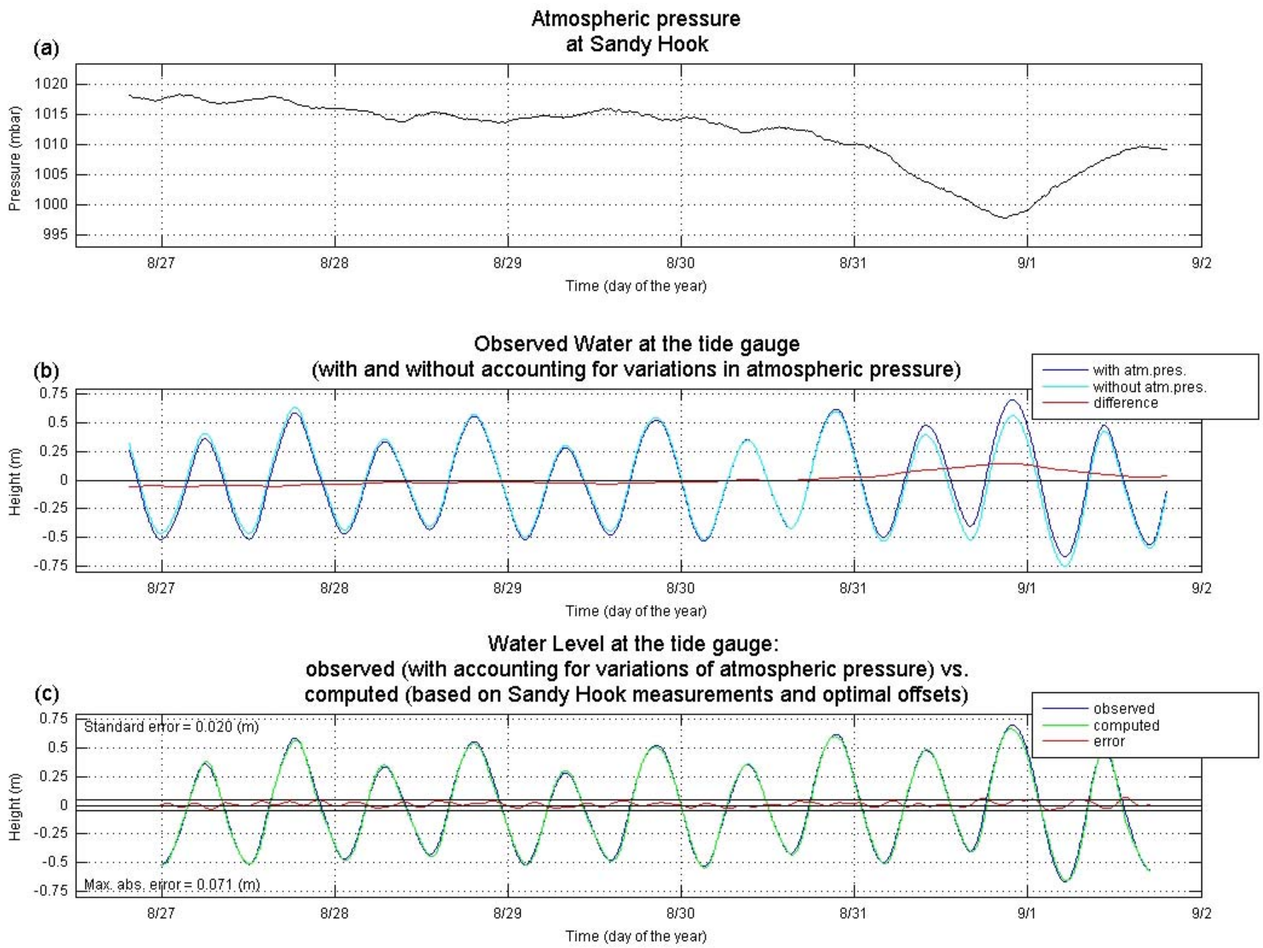


Figure 3.1-2. Panel (a) provides the times series of the observed atmospheric pressure as measured at the Sandy Hook tide station during the HARS pressure gauge deployment period in 2005; Panel (b) shows the times series of the observed HARS pressure gauge tide data with and without the atmospheric pressure correction, as well as the measured difference between these two measurements; Panel (c) provides a time series of the observed differences between the HARS tide gauge data (with the atmospheric pressure correction and normalized about the MTL) and the Sandy Hook tide gauge data (with historical range and phase offset correctors applied for the HARS). The observed standard error was 0.020 m and the maximum observed error was 0.071 m.

Table 3.1-1.
Summary of optimal phase (time shift) and range offsets computed for different HARS tide gauge deployments. Positive time shift indicates that water level at Sandy Hook lags that at HARS

Deployment	Year	Duration (days)	Computed Optimal Offsets		Standard Error (cm)
			Range Multiplier (ratio)	Phase Shift (min)	
1	2005	6	0.94	24	0.02
2	2002	7	0.92	24	0.02
3	2002	17	0.94	30	0.03
4	2002	4	0.95	30	0.03

relative to the verified MLLW datum. Therefore, the corrected MLLW datum at the location of the HARS tide gauge was:

MLLW(corrected) = 23.13 – 0.37 = 22.76 m (Figure 3.1-1).

The range offset (multiplier) is meant to be applied to deviations of the observed water level from the mean tidal level. According to this, the equation for transferring Sandy Hook tidal observations to HARS by using phase and range offsets is:

$$WL(time)_{MLLW}^{HARS} - MTL_{MLLW}^{HARS} = \alpha[WL(time + \Delta time)_{MLLW}^{SandyHook} - MTL_{MLLW}^{SandyHook}].$$

Here, *WL* stands for water level, *MTL* is the mean tidal level (the average of the observed highs and lows) for the period of observations, α is the range multiplier, and $\Delta time$ is the phase (or time) shift. For the analyzed data, the MTL was computed for the period 27 August to 31 August 2005; a portion of data for 31 August were not used in this particular calculation because data coverage did not include the second high during the day. The two calculated MTLs were subtracted from the corresponding time series and the resulting deviations were used to find optimal values for α and $\Delta time$ using a least squares procedure. This procedure was employed to compute optimal values for α and $\Delta time$ for three separate 2002 deployments, as well as the 2005 case discussed above (Figure 3.1-1). These results showed that the optimal offsets fell within a tight parameter space in all four cases – α ranged from 0.92 to 0.95 while $\Delta time$ ranged from 24 to 30 min – with all combinations resulting in low 0.02 to 0.03 cm standard error. Because the second deployment in 2002 was significantly longer (e.g., 17 days) than the other three observation periods, the results from this period have been used to establish the updated offset tidal correctors for the HARS. For the 2006 bathymetric survey, the HARS tidal offsets applied to the verified Sandy Hook tidal data used to generate the final tidal correctors were minus 30 minutes, range ratio: 0.94.

3.1.3 Cross-Check Comparisons

<u>Junction Analysis</u>

The following discussion on cross-check comparisons and data quality will focus primarily on the HARS and Shark River Reef datasets. Because the Axel Carlson Reef data were extracted from a much larger NOAA-related dataset, the discussion of cross check comparisons for these data has been addressed in previous NOAA technical deliverables. During post processing, two overlapping grids were built for each of the main survey areas - 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 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. 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 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

(0-5 cm, 5-10 cm, 10-15 cm, etc.) and the percent of the total observations encompassed by each depth difference range (Table 3.1-2). This comparison of the cross lane soundings and main scheme soundings showed that 95.8% of the depth differences were less than 25 cm and that 99.3% 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 3.1-3 and 3.1-4). The comparison between all of the cross lane soundings and main scheme soundings showed that 90.5% 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) showed that 98.6% of the depth differences were less than 25 cm.

Crossings Analysis

Beam by beam comparisons 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. 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 3.1-3 through 3.1-6). 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.

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

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0->5cm	4621	37.61%	1894	37.05%	2148	32.56%	579	100%
5->10cm	3641	67.24%	1528	66.94%	2113	64.59%	0	100%
10->15cm	2339	86.27%	983	86.17%	1356	85.14%	0	100%
15->20cm	745	92.33%	300	92.04%	445	91.89%	0	100%
20->25cm	428	95.82%	164	95.25%	264	95.89%	0	100%
25->30cm	229	97.68%	96	97.12%	133	97.91%	0	100%
30->35cm	91	98.42%	43	97.97%	48	98.64%	0	100%
35->40cm	39	98.74%	18	98.32%	21	98.95%	0	100%
40->45cm	37	99.04%	18	98.67%	19	99.24%	0	100%
45->50cm	26	99.25%	10	98.87%	16	99.48%	0	100%
50->60cm	37	99.55%	21	99.28%	16	99.73%	0	100%
60->70cm	13	99.66%	7	99.41%	6	99.82%	0	100%
70->80cm	8	99.72%	4	99.49%	4	99.88%	0	100%
80->90cm	11	99.81%	7	99.63%	4	99.94%	0	100%
90->100cm	4	99.85%	4	99.71%	0	99.94%	0	100%
100->110cm	3	99.87%	2	99.75%	1	99.95%	0	100%
110->120cm	3	99.89%	1	99.77%	2	99.98%	0	100%
120->130cm	2	99.91%	2	99.8%	0	99.98%	0	100%
130->140cm	3	99.93%	2	99.84%	1	100%	0	100%
140->150cm	1	99.94%	1	99.86%	0	100%	0	100%
150->160cm	0	99.94%	0	99.86%	0	100%	0	100%
160->170cm	0	99.94%	0	99.86%	0	100%	0	100%
170->180cm	0	99.94%	0	99.86%	0	100%	0	100%
180->190cm	1	99.95%	1	99.88%	0	100%	0	100%
190->200cm	1	99.96%	1	99.9%	0	100%	0	100%
200->220cm	0	99.96%	0	99.9%	0	100%	0	100%
220->240cm	2	99.98%	2	99.94%	0	100%	0	100%
240->260cm	2	99.99%	2	99.98%	0	100%	0	100%
260cm->	1	100%	1	100%	0	100%	0	100%
Total	12288	100%	5112	100%	6597	100%	579	100%

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

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	Cumulative Percent	Count	Cumulative Percent	Count	Cumulative Percent	Count	Cumulative Percent
0->5cm	387	23.44%	139	33.1%	201	16.98%	47	100%
5->10cm	372	45.97%	98	56.43%	274	40.12%	0	100%
10->15cm	356	67.53%	54	69.29%	302	65.62%	0	100%
15->20cm	134	75.65%	27	75.71%	107	74.66%	0	100%
20->25cm	102	81.83%	20	80.48%	82	81.59%	0	100%
25->30cm	62	85.58%	16	84.29%	46	85.47%	0	100%
30->35cm	27	87.22%	8	86.19%	19	87.08%	0	100%
35->40cm	27	88.86%	14	89.52%	13	88.18%	0	100%
40->45cm	27	90.49%	8	91.43%	19	89.78%	0	100%
45->50cm	10	91.1%	2	91.9%	8	90.46%	0	100%
50->60cm	44	93.76%	11	94.52%	33	93.24%	0	100%
60->70cm	30	95.58%	3	95.24%	27	95.52%	0	100%
70->80cm	9	96.12%	3	95.95%	6	96.03%	0	100%
80->90cm	13	96.91%	5	97.14%	8	96.71%	0	100%
90->100cm	5	97.21%	0	97.14%	5	97.13%	0	100%
100->110cm	9	97.76%	2	97.62%	7	97.72%	0	100%
110->120cm	5	98.06%	0	97.62%	5	98.14%	0	100%
120->130cm	6	98.43%	3	98.33%	3	98.4%	0	100%
130->140cm	7	98.85%	3	99.05%	4	98.73%	0	100%
140->150cm	2	98.97%	0	99.05%	2	98.9%	0	100%
150->160cm	2	99.09%	0	99.05%	2	99.07%	0	100%
160->170cm	6	99.45%	1	99.29%	5	99.49%	0	100%
170->180cm	1	99.52%	0	99.29%	1	99.58%	0	100%
180->190cm	0	99.52%	0	99.29%	0	99.58%	0	100%
190->200cm	2	99.64%	1	99.52%	1	99.66%	0	100%
200->220cm	0	99.64%	0	99.52%	0	99.66%	0	100%
220->240cm	2	99.76%	1	99.76%	1	99.75%	0	100%
240->260cm	0	99.76%	0	99.76%	0	99.75%	0	100%
260->280cm	3	99.94%	1	100%	2	99.92%	0	100%
>280cm	1	100%	0	100%	1	100%	0	100%
Total	1651	100%	420	100%	1184	100%	47	100%

Table 3.1-4.
Summary of Junction Analysis Results for crossings over the flat areas during the Shark River Reef Survey

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**	**Count**	**Cumulative Percent**
0->5cm	81	21.49%	30	47.62%	40	13.2%	11	100%
5->10cm	112	51.19%	25	87.3%	87	41.91%	0	100%
10->15cm	107	79.58%	7	98.41%	100	74.92%	0	100%
15->20cm	41	90.45%	1	100%	40	88.12%	0	100%
20->25cm	**24**	**96.82%**	0	100%	24	96.04%	0	100%
25cm->	12	100%	0	100%	12	100%	0	100%
Total	377	100%	63	100%	303	100%	11	100%

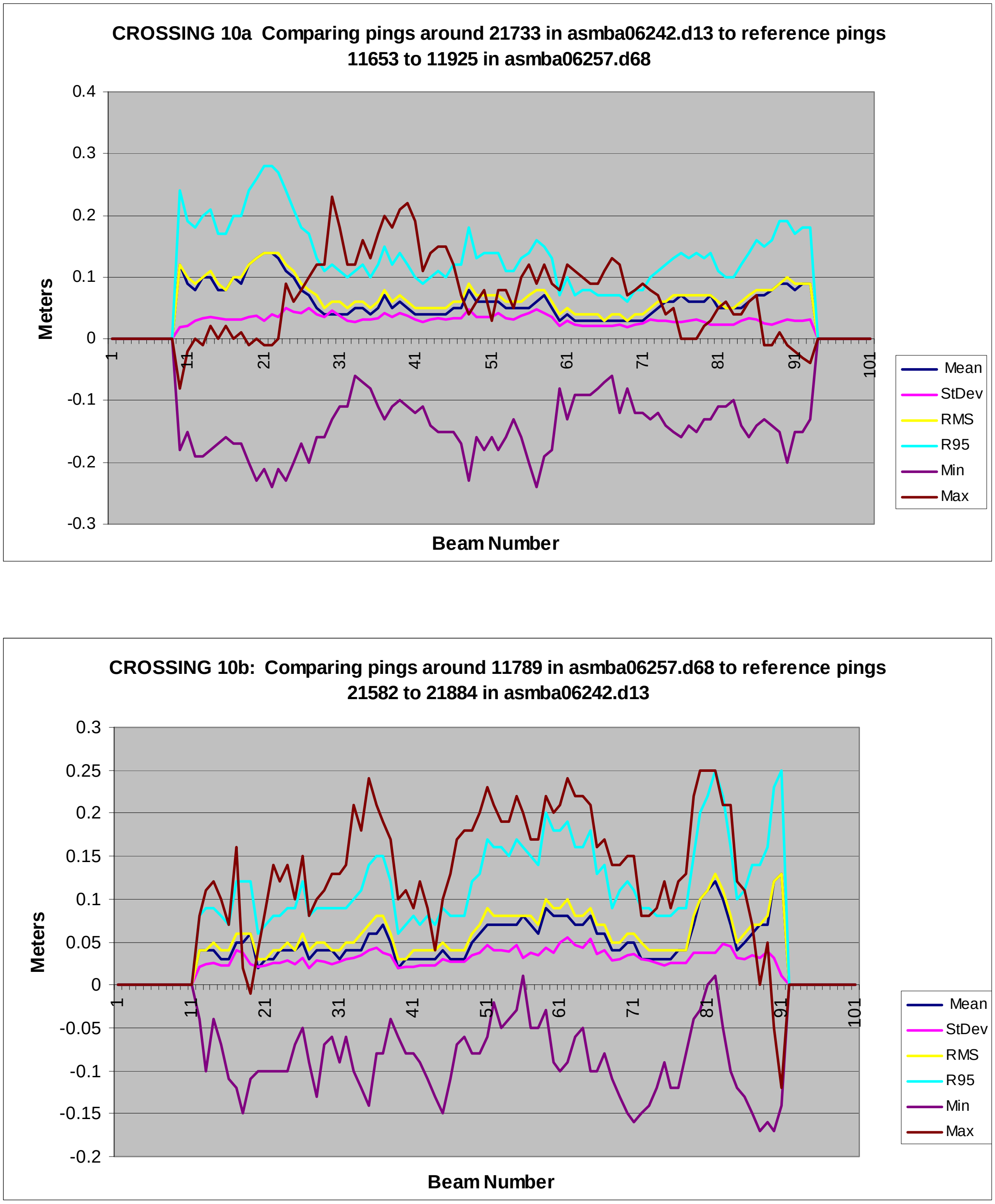
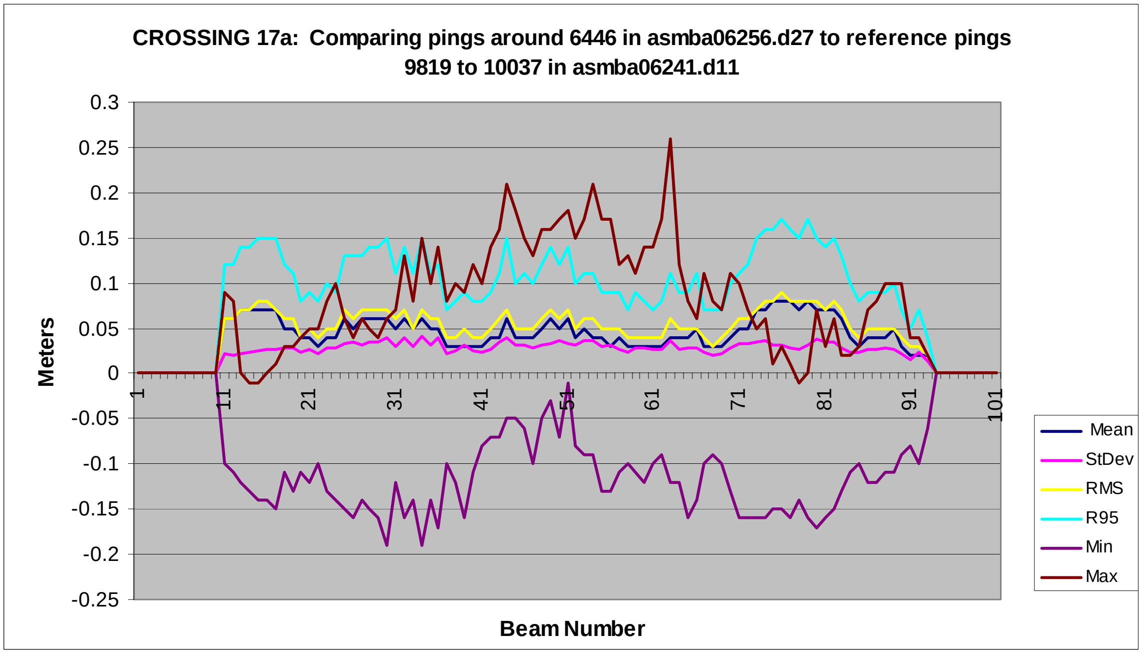


Figure 3.1-3. HARS Crossing 10 a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



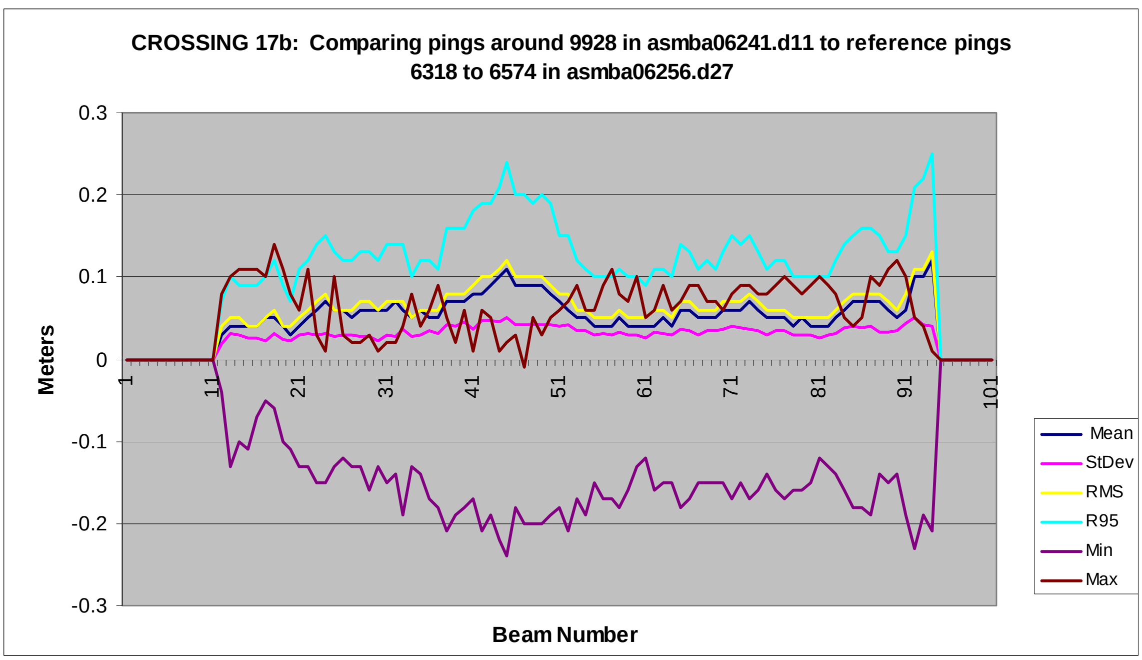
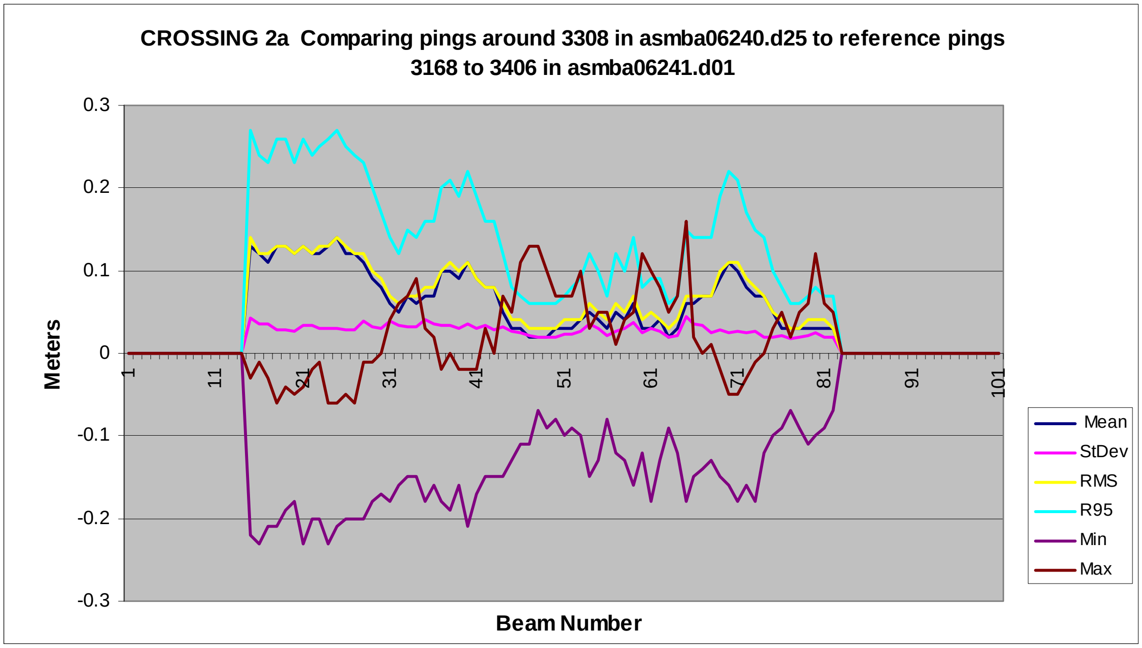


Figure 3.1-4. HARS Crossing 17a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



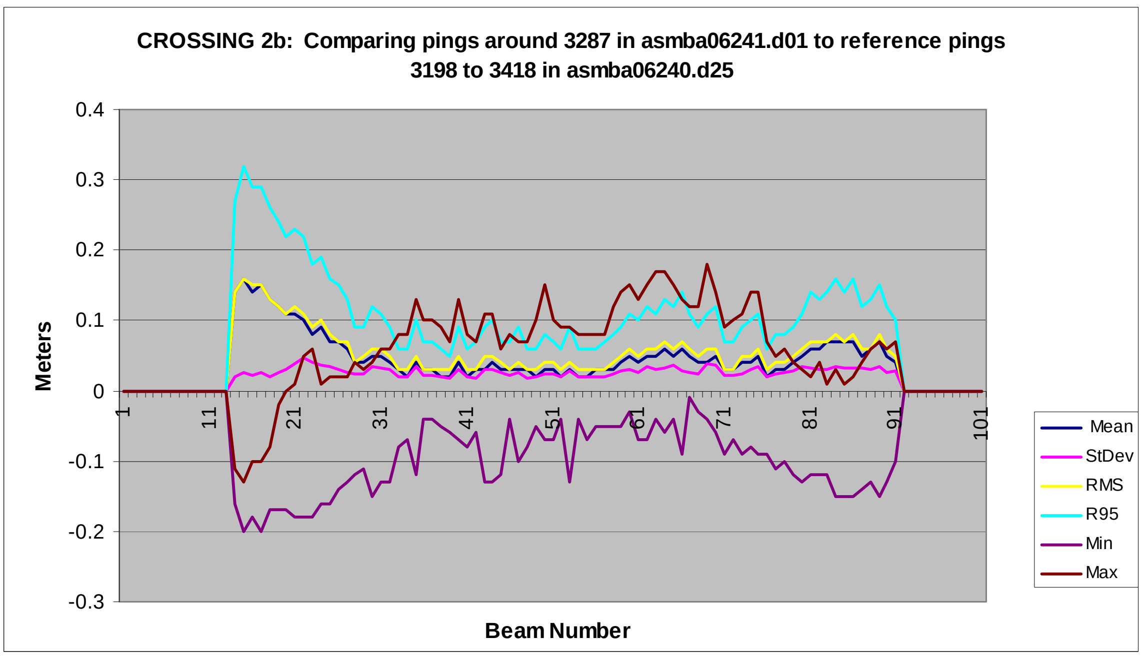


Figure 3.1-5. Shark River Reef Crossing 2a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.

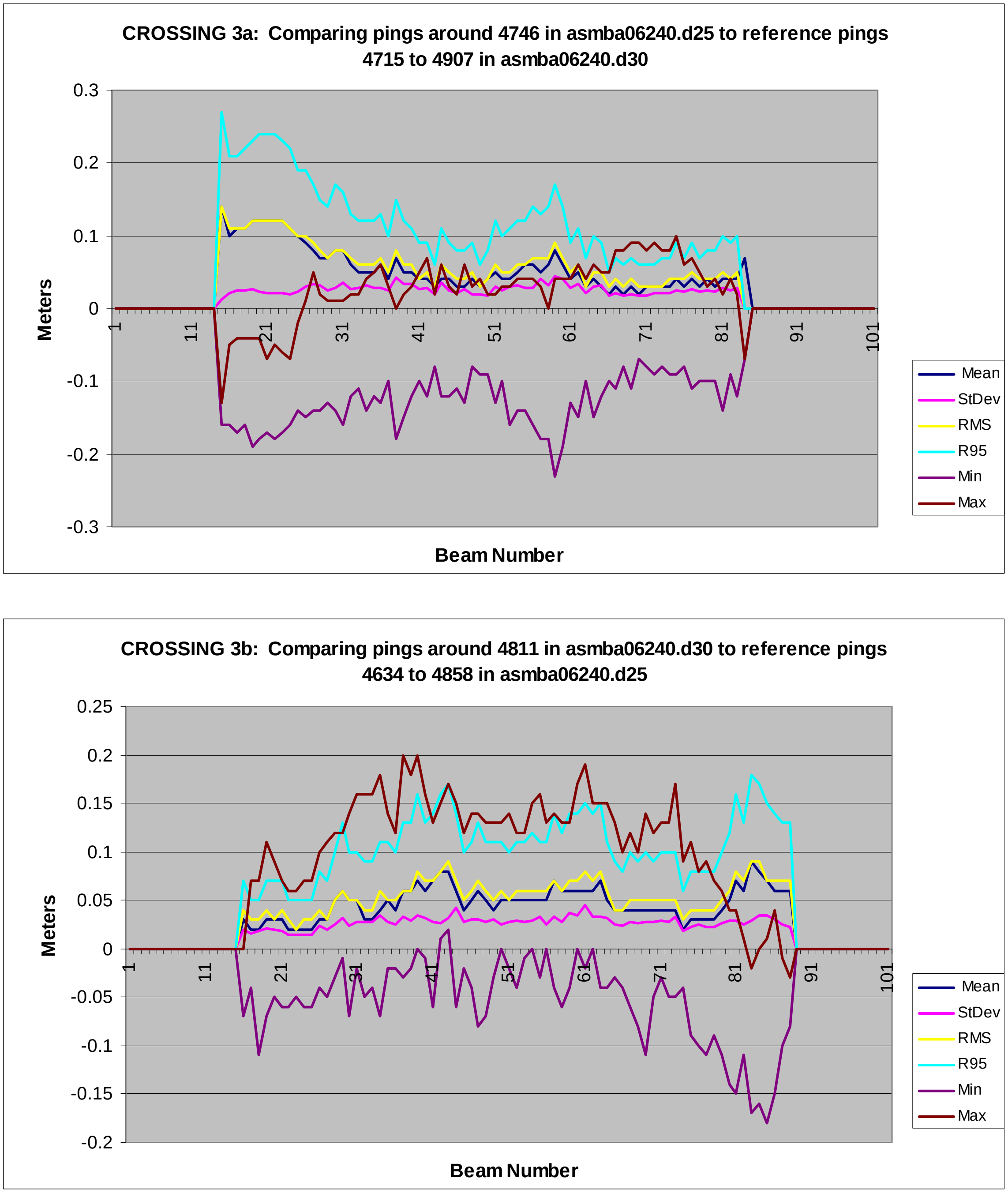


Figure 3.1-6. Shark River Reef Crossing 3a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.

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 shows 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.

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 2006 survey was compared to a 1998 single-beam survey and a 2005 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 2006 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).

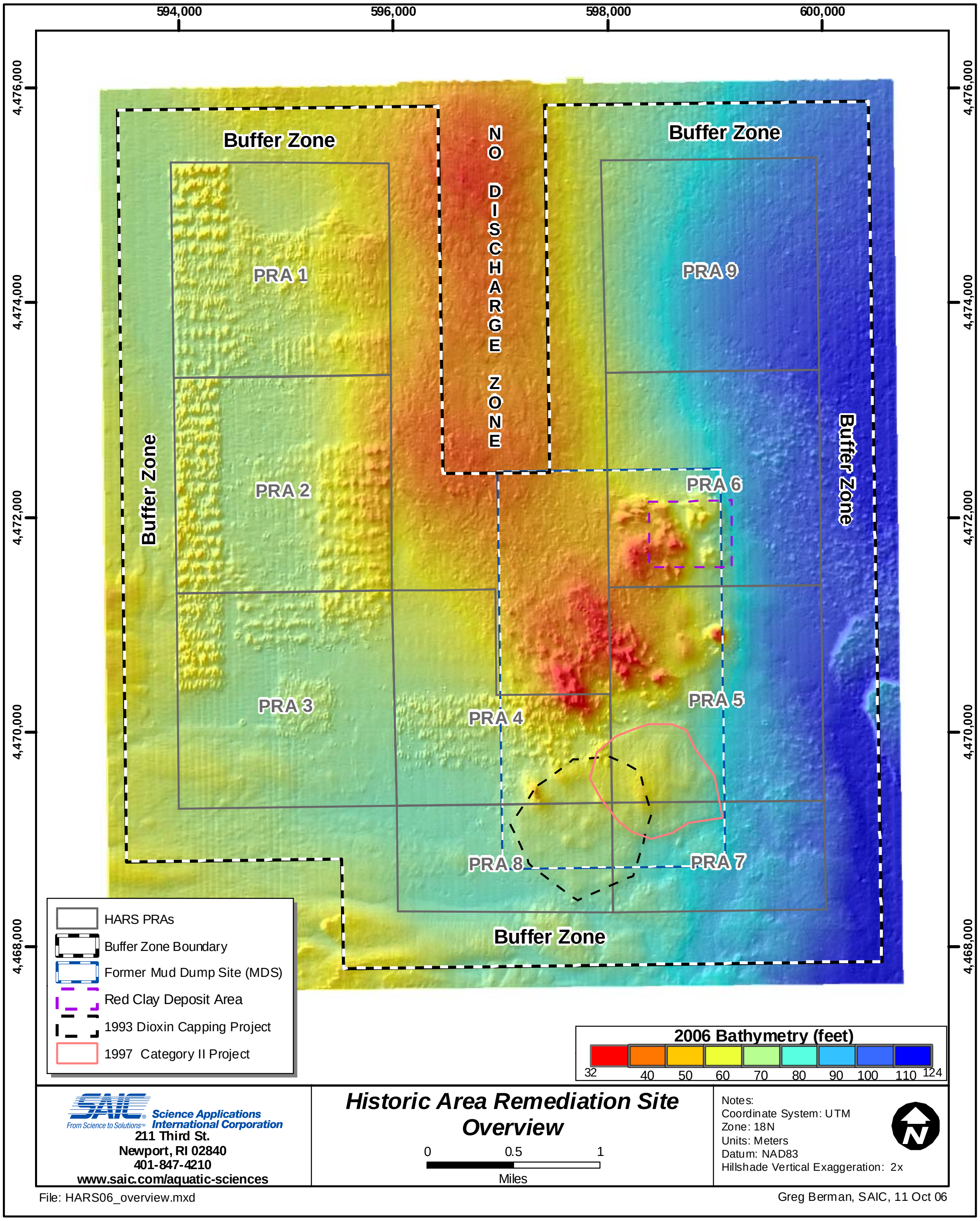


Figure 3.2-1. Hill-shaded relief model based on the 2006 multibeam bathymetric survey at the HARS

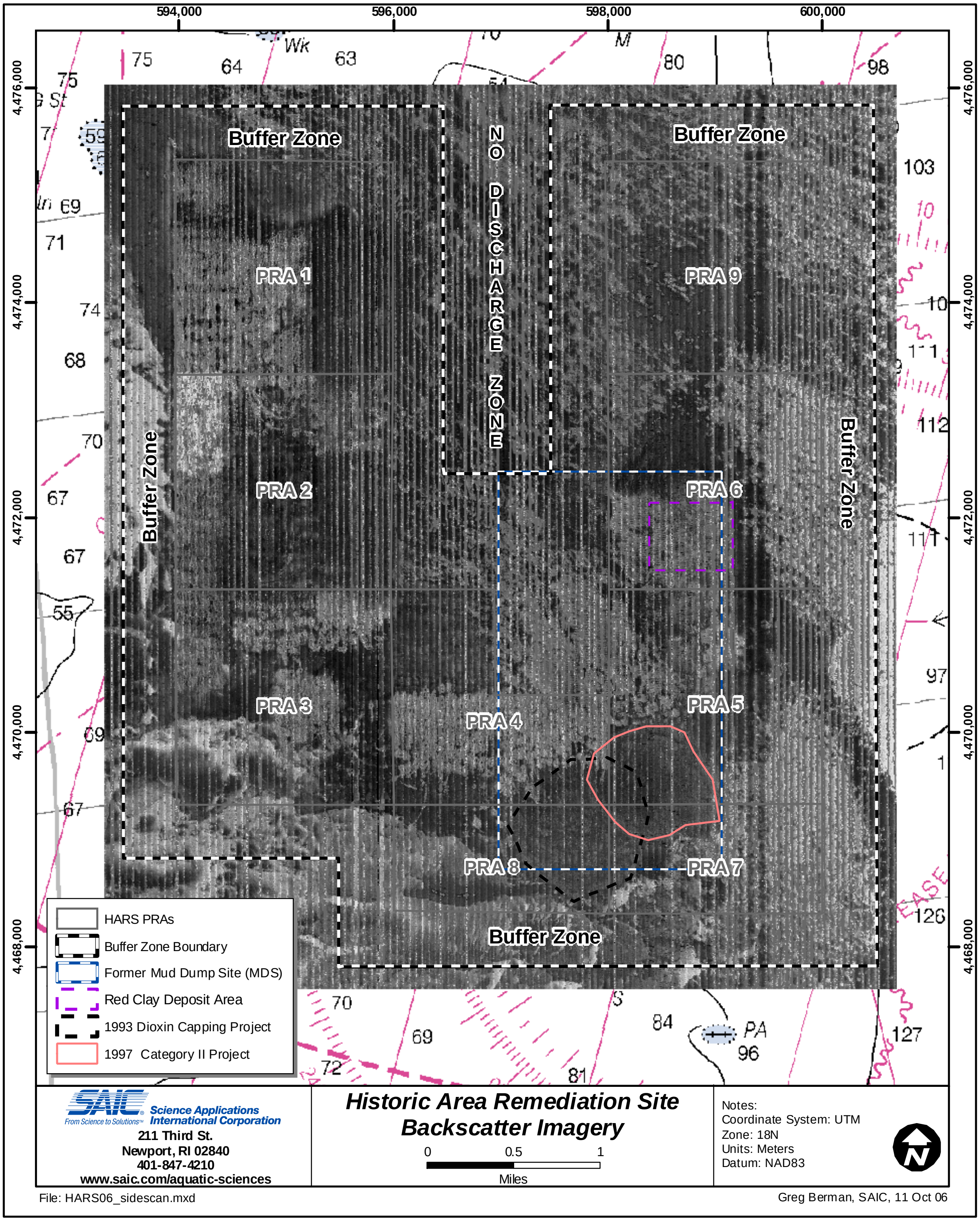


Figure 3.2-2. Multibeam backscatter imagery mosaic based on the 2006 bathymetric survey at the HARS

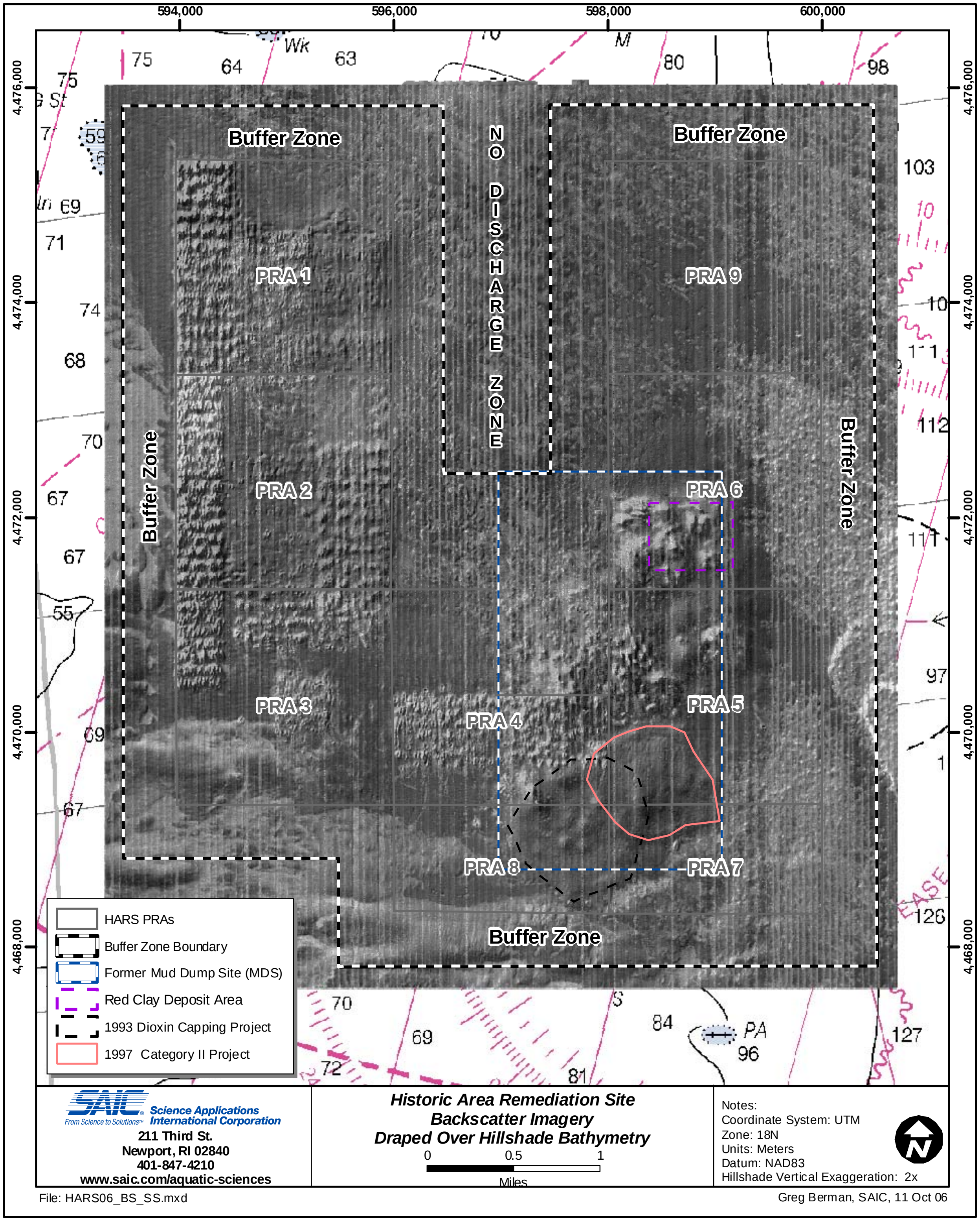


Figure 3.2-3. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2006 HARS dataset

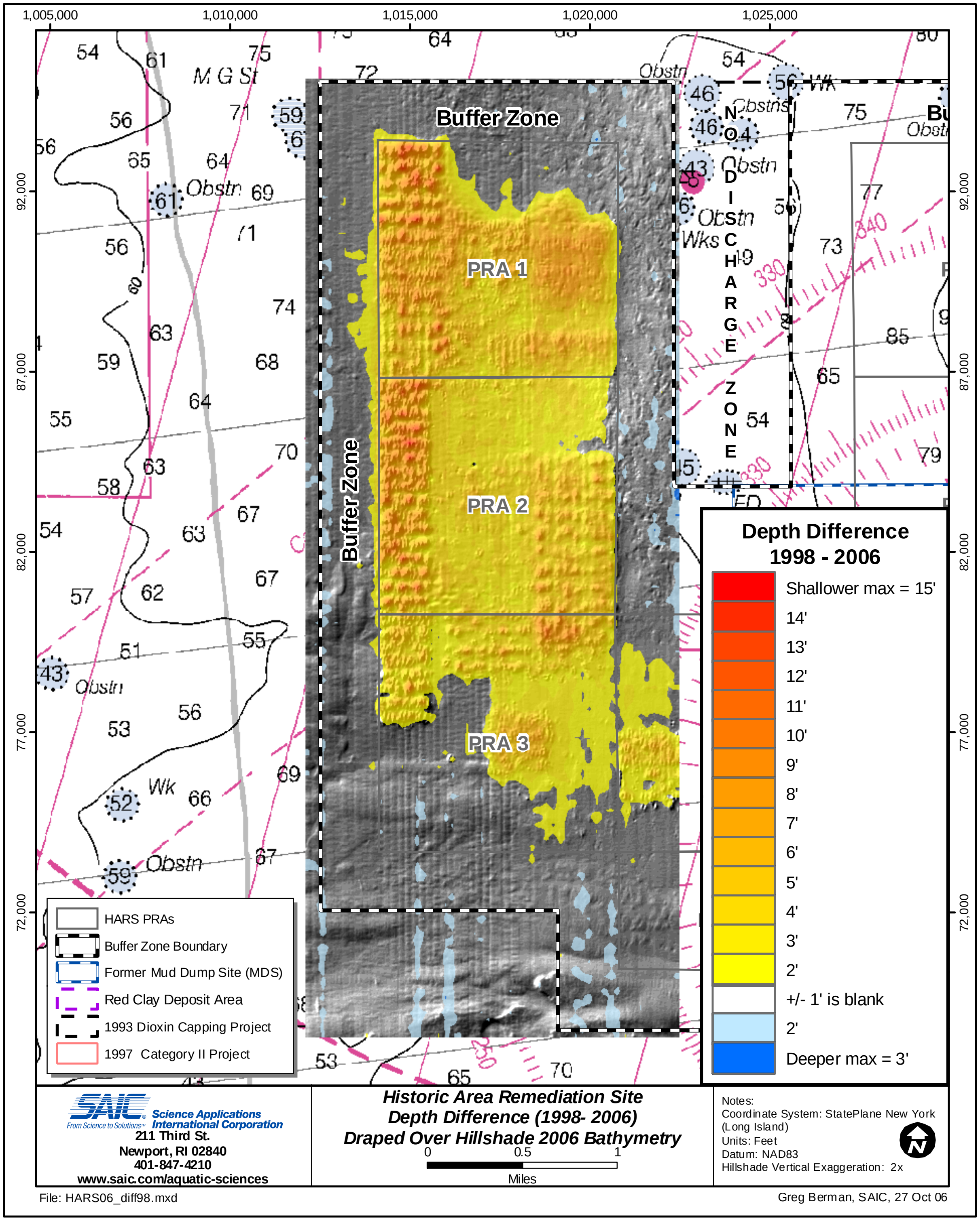


Figure 3.2-4. Bathymetric depth difference between the 2006 multibeam survey and the 1998 survey over PRAs 1, 2, and 3

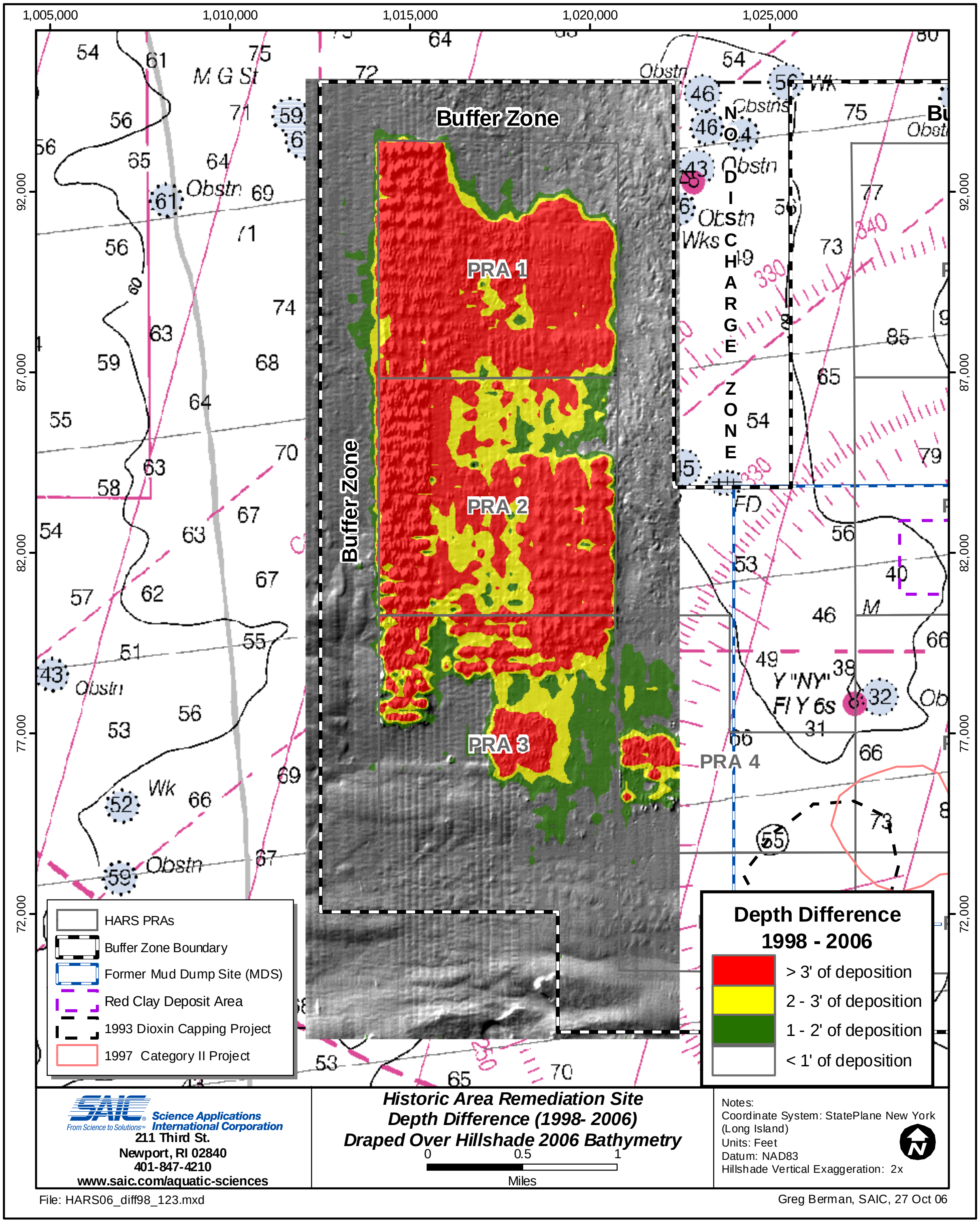


Figure 3.2-5. Bathymetric depth difference between the 2006 multibeam survey and the 1998 survey over PRAs 1, 2, and 3

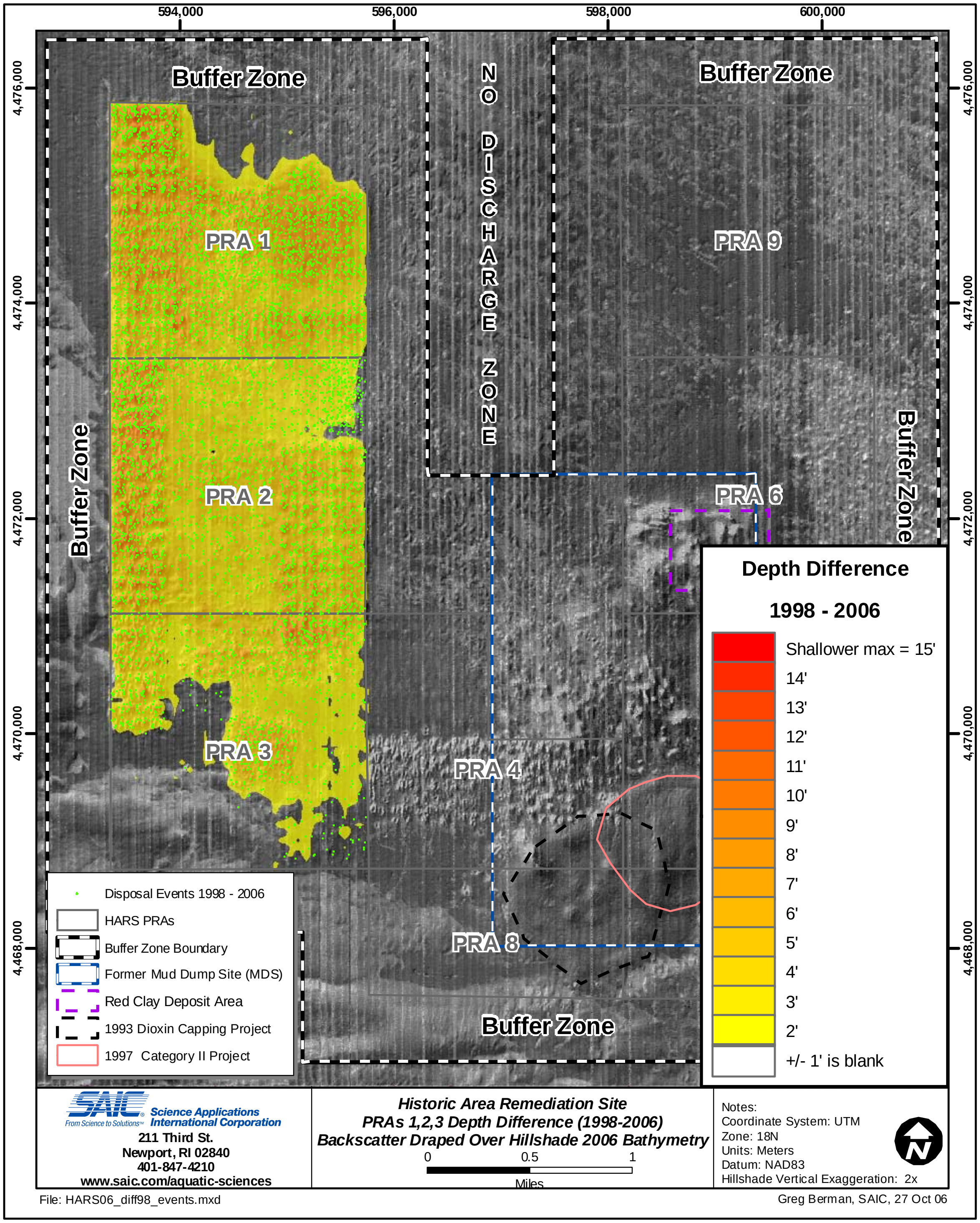


Figure 3.2-6. Disposal point data from the HARS from 1998 through 2006 depicted over the depth difference grid computed between a 1998 single-beam baseline survey of PRAs 1, 2, and 3 and a 2006 multibeam survey of the entire HARS; the 2006 multibeam hillshade bathymetry and backscatter is included as the backdrop.

Prior to the 2006 survey, the most recent bathymetric dataset from the HARS originated from a multibeam survey conducted in September 2005. In order to evaluate recent deposition trends, a depth difference grid was also generated between the 2005 and 2006 datasets. The bathymetric depth difference grid generated between the 2006 and 2005 surveys clearly showed dredged material accumulation (deposition) across different areas of PRAs 1 and 2 (Figure 3.2-7). The most significant accumulation occurred in the middle western portion of PRA 1, where one area of recent deposition measured almost 10 ft thick. The areas of accumulation noted in the depth difference comparison agreed well with the ADISS-recorded disposal point information from the period between these two surveys (Figure 3.2-8). The few areas of minor deepening noted between these surveys in the northwest portion of PRA 1 and the southwest portion of PRA 2 were likely due to consolidation of the sediments that had been placed in these areas prior to the 2005 survey.

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 shows 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. To assist with the site visualization, it was also useful to view the multibeam backscatter imagery draped over the multibeam hillshade view (Figure 3.3-2). The primary features of interest noted on the backscatter 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.

3.3.1 Comparison with Prior Surveys and Disposal Information

Because the placement of rocky dredged 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 2006 survey was compared to the 2002 single-beam survey and the 2005 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 2006 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 3.3-3). 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 four years. The

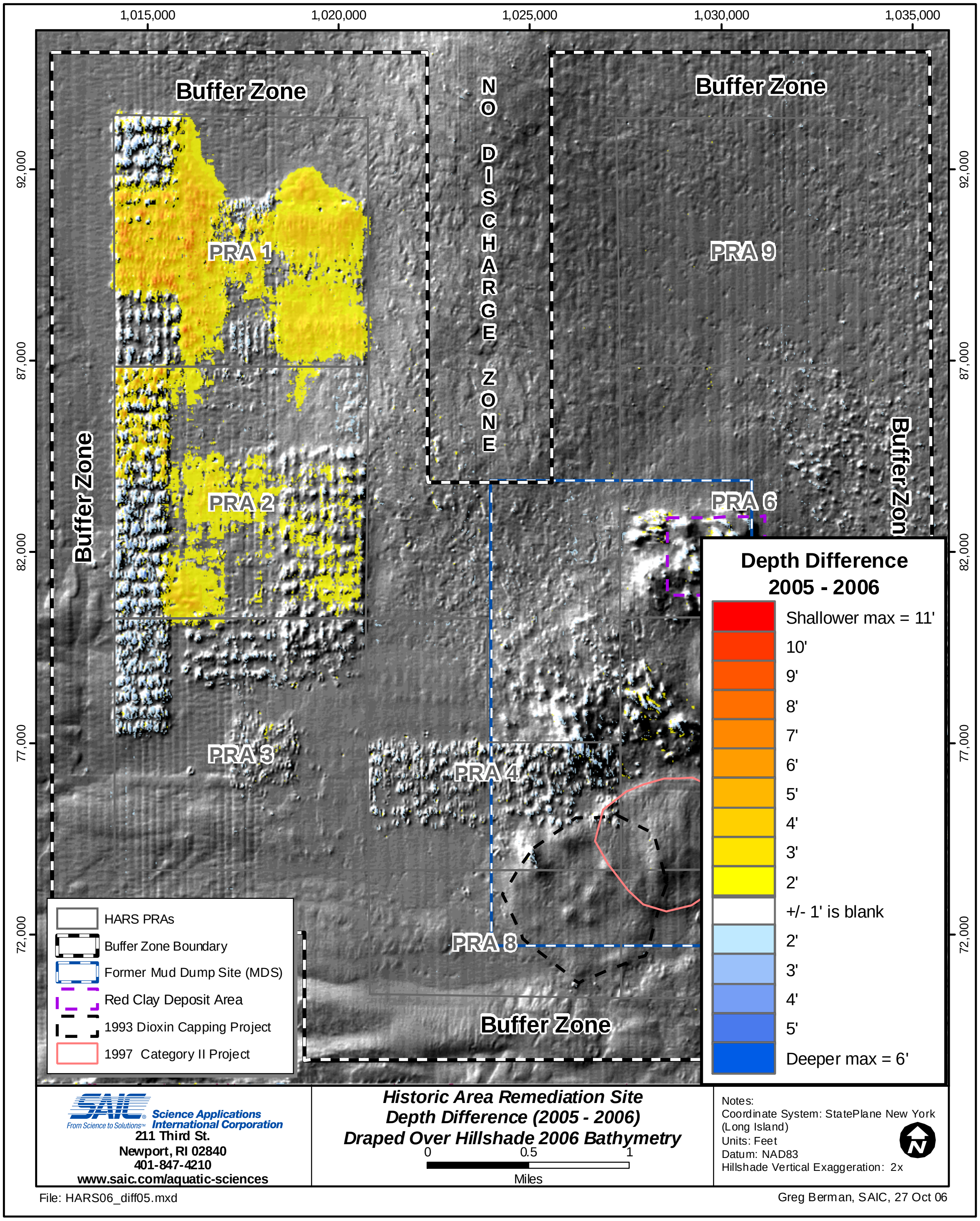


Figure 3.2-7. Bathymetric depth difference between the 2005 multibeam survey and the 2006 multibeam survey over the entire HARS

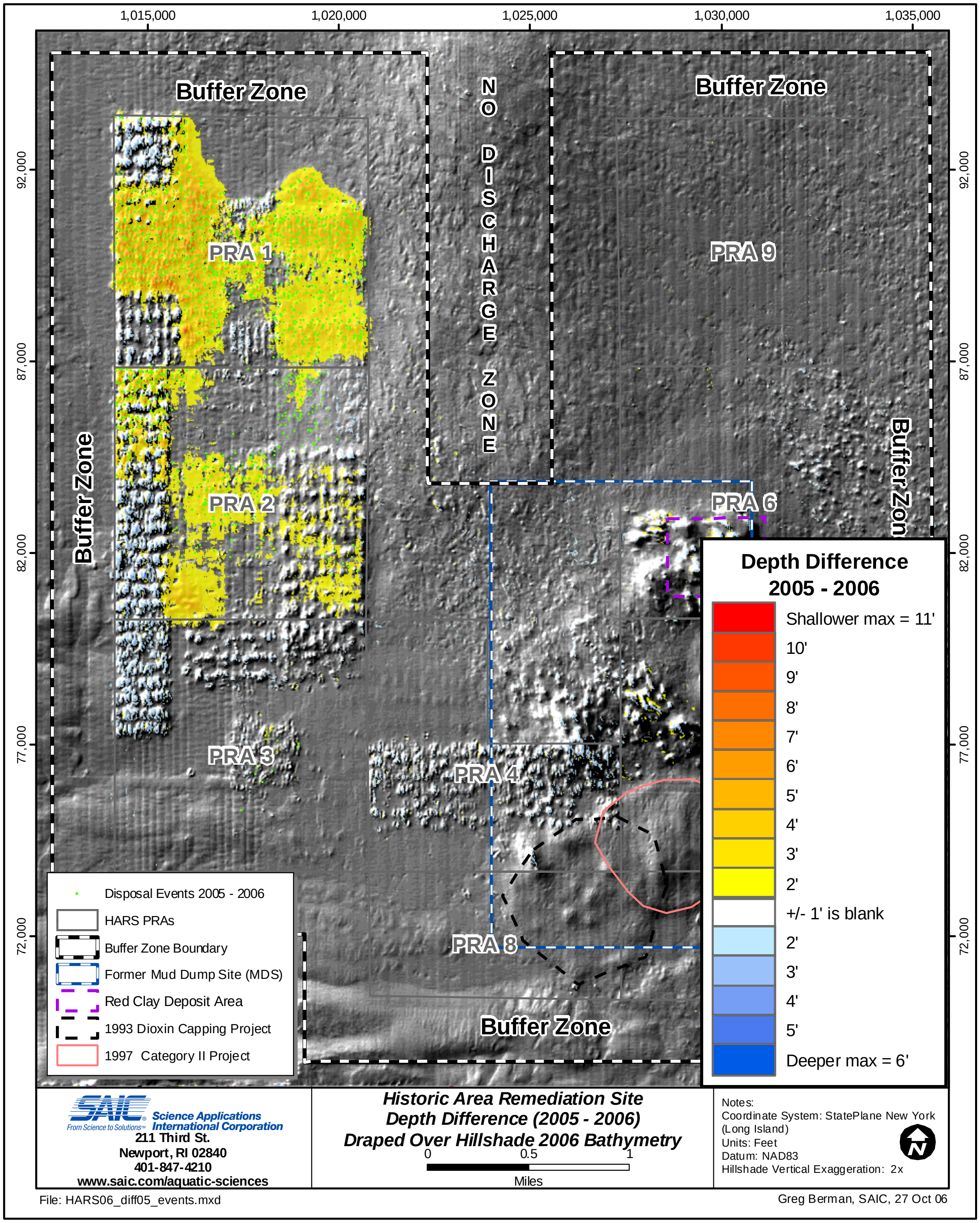


Figure 3.2-8. Disposal point data from the HARS from 2005 and 2006 depicted over the depth difference grid computed between multibeam surveys conducted in 2005 and 2006; the 2006 multibeam hillshade bathymetry and backscatter is included as the backdrop.

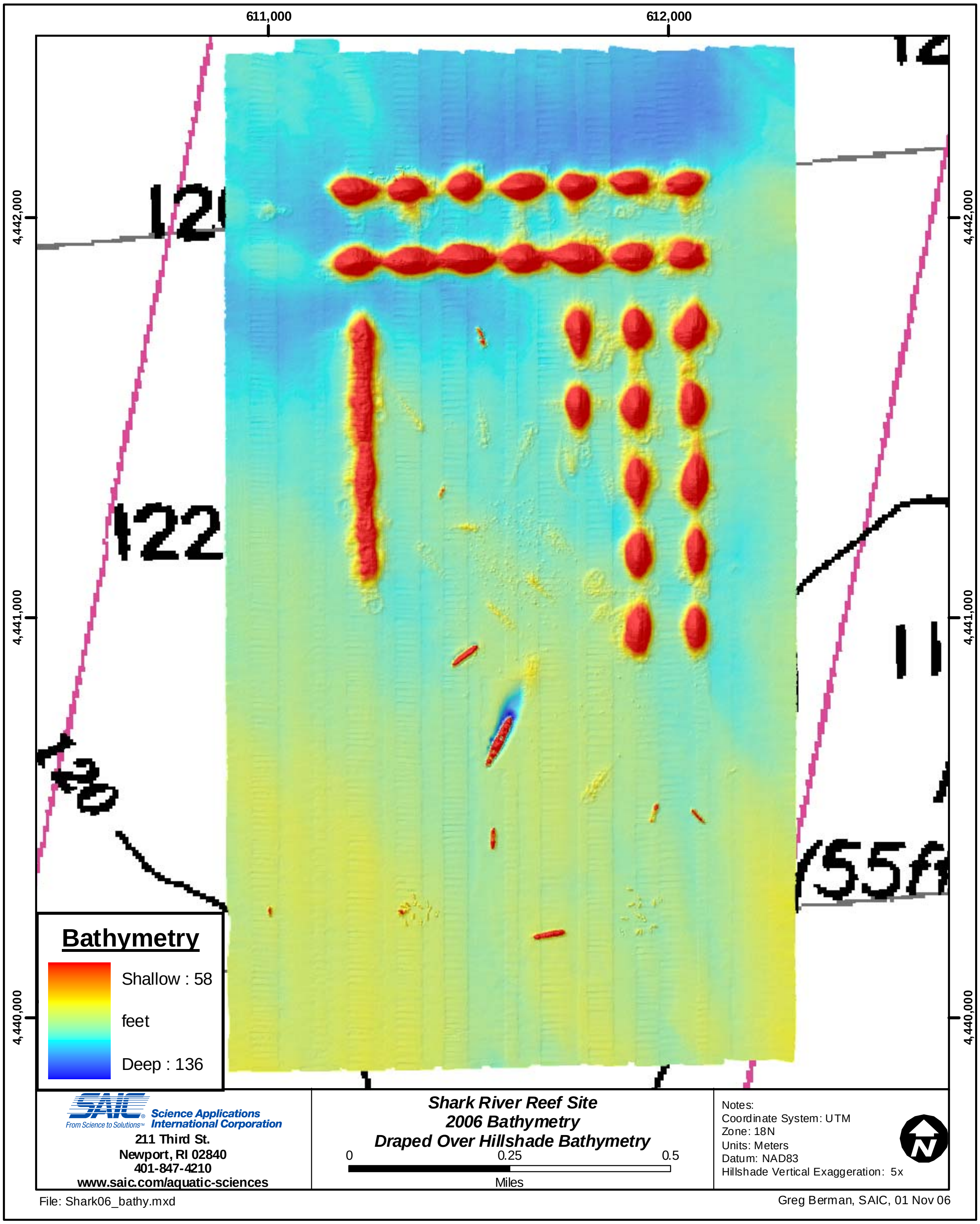


Figure 3.3-1. Hill-shaded gridded relief model based on the August 2006 multibeam bathymetric survey at the Shark River Reef

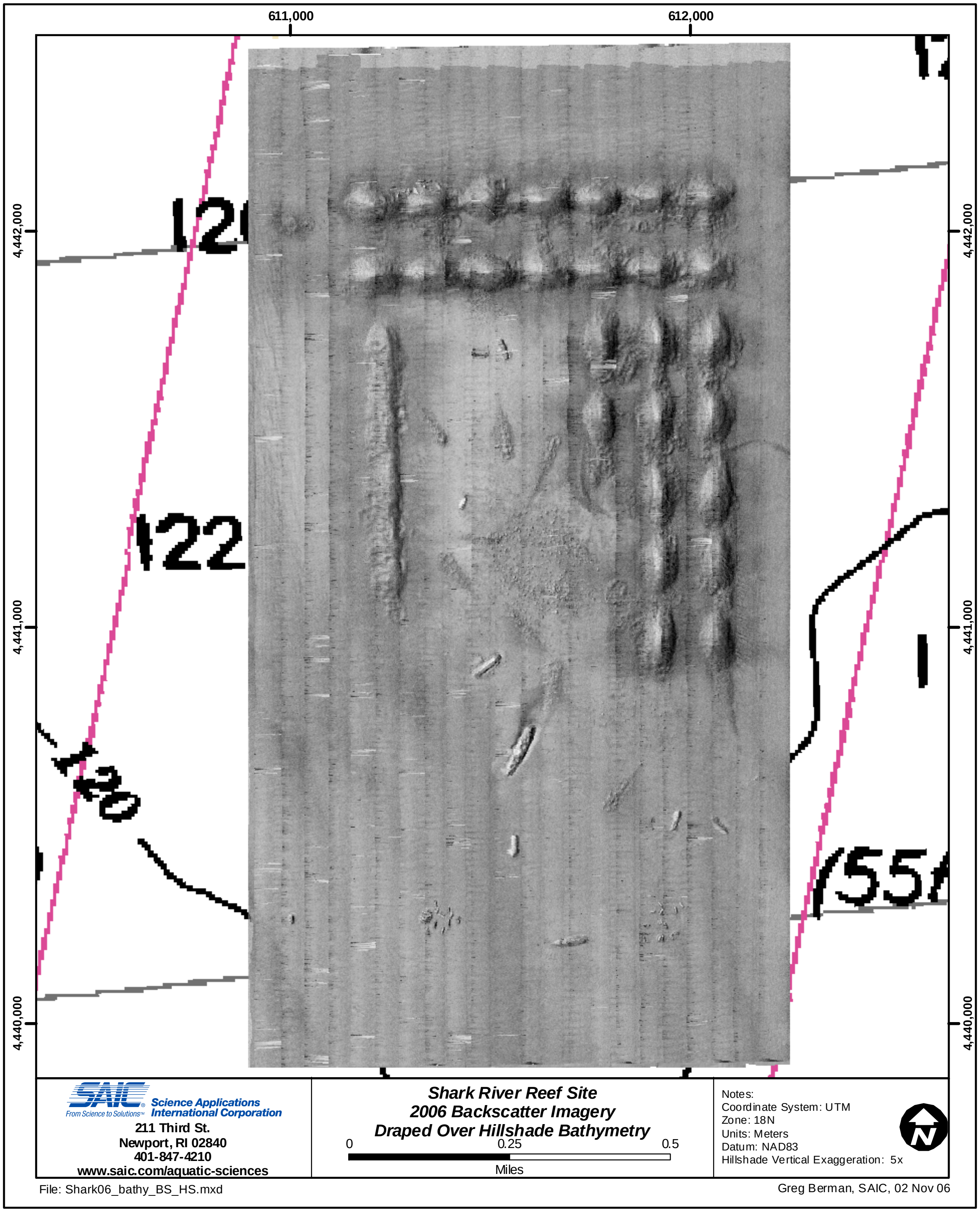


Figure 3.3-2. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2006 Shark River Reef dataset

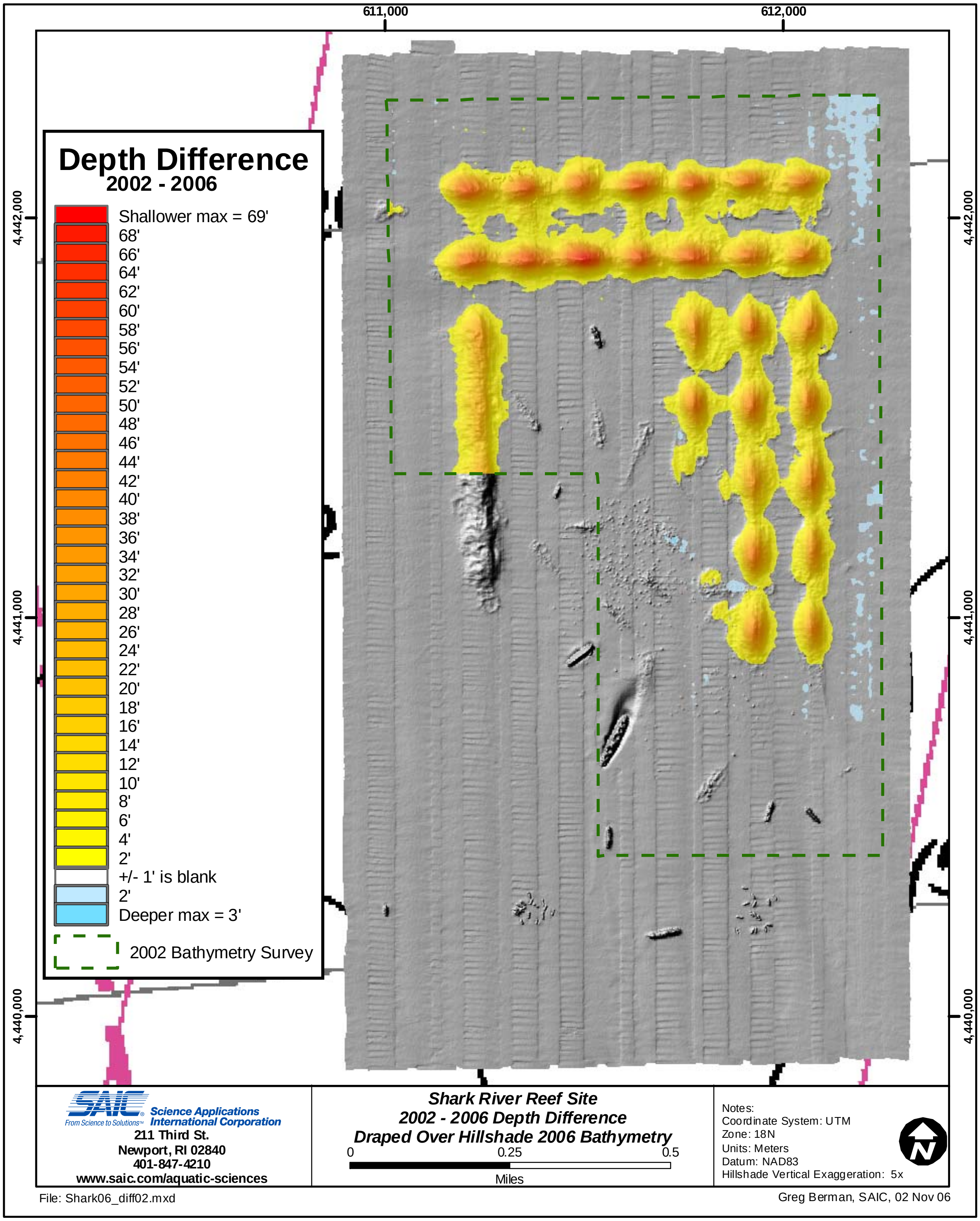


Figure 3.3-3. Bathymetric depth difference between the August 2006 multibeam survey and the January 2002 survey over the Shark River Reef

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 3.3-4).

Prior to the 2006 survey, the most recent bathymetric dataset from the Shark River Reef originated from a multibeam survey conducted in August 2005. The bathymetric depth difference grid generated between the 2006 and 2005 surveys showed dredged material accumulation (deposition) limited only to the north-south trending feature along the western edge of the site (Figure 3.3-5). This is consistent with the limited disposal activity at the site – only 22 individual placement events – since the time of the 2005 survey (Figure 3.3-6). There also appears to have been some minor deepening over some portions of most of the recently created rock mounds within the site. This is likely the result of consolidation and settling of the dredged rock that were placed over the last few years. Though the more recently created mounds along the eastern side of the site show primarily deepening, some of the older mounds along the northern edge also show some areas that are shallower than last year. These shallower areas occur along the flanks of the mounds, and may be associated with settling or slope adjustments of rocky material from the tops of the mounds.

3.4 Physical Characterization of the Axel Carlson Reef

As discussed in the Introduction, the Axel Carlson Reef area was covered as part of a much larger NOAA-sponsored survey effort focused along the New Jersey near coastal areas. No significant data problems were encountered during processing or analysis of the multibeam bathymetric data, and the entire Axel Carlson Reef was well characterized based on these data. The color-coded gridded hill-shade model view shows that the natural topography around Axel Carlson Reef is characterized by variable depths throughout, with generally deeper areas in the middle of the site and numerous large sand ridges that trend across the site but are more prominent along the eastern and western edges (Figure 3.4-1). In addition, there are also numerous man-made and irregular bottom features (e.g., wrecks, tanks, rubble mounds, etc.) scattered throughout the site that are associated with past reef-making activities. The minimum depth observed during this survey was 45.9 ft MLLW over one of the previously placed wrecks in the northeast portion of the area. In addition, three other features with depths shallower than 50 ft MLLW were also observed within the site (Figure 3.4-1). The maximum depth of around 83.0 ft MLLW occurred in the deeper pocket near the northern edge of the survey area.

A complete 100 kHz image mosaic, representing 100% side-scan sonar coverage, was also created for the entire survey area. To assist with the site visualization, it was useful to view the side-scan sonar imagery draped over the multibeam hillshade view (Figure 3.4-2). 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 rock mounds that were created over the last few years of dredged material placement at the site. In

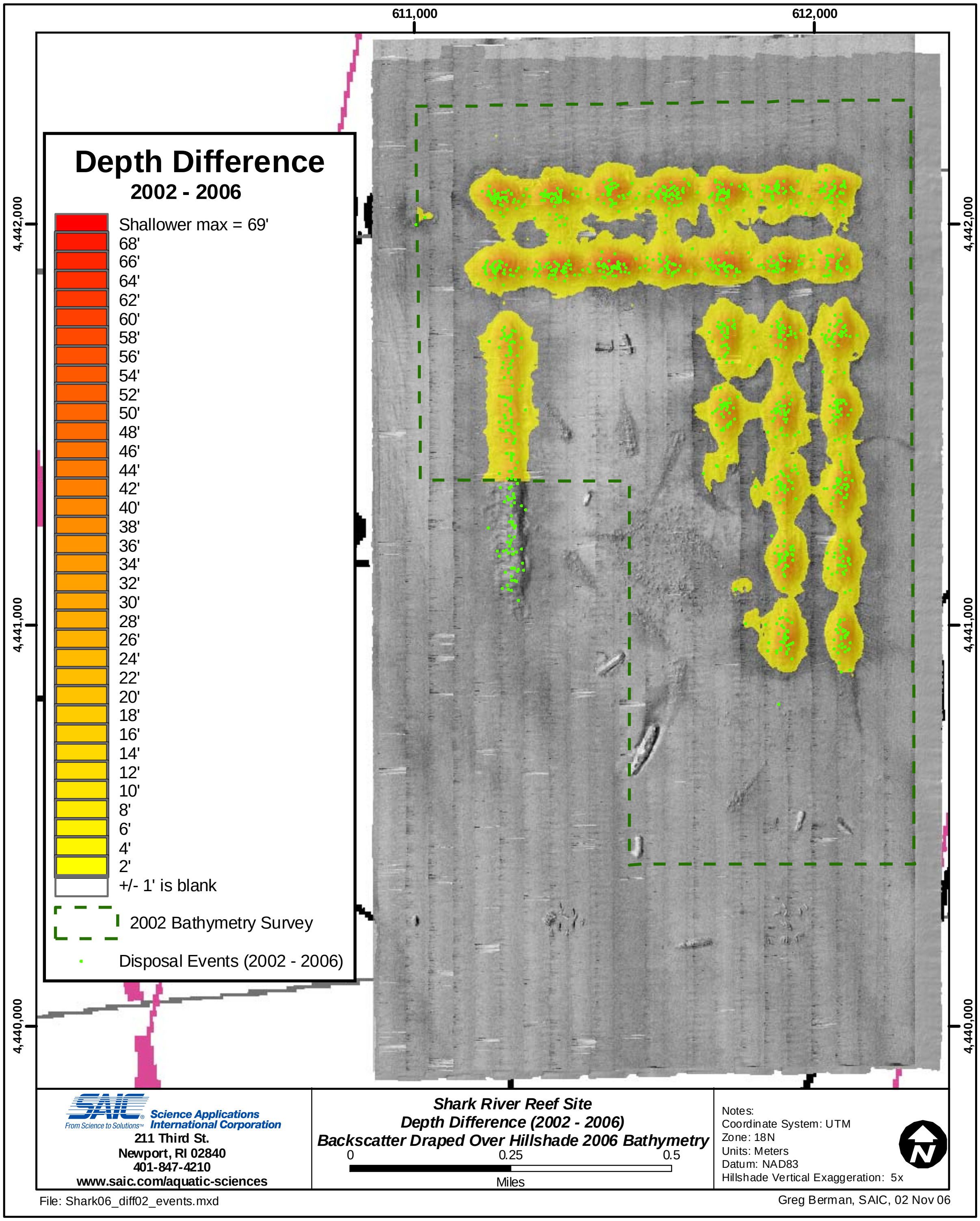


Figure 3.3-4. Disposal point data from the Shark River Reef from 2002 through 2006 depicted over the depth difference grid computed between the 2002 baseline survey and the 2006 multibeam surveys; the 2006 backscatter mosaic is included as the backdrop.

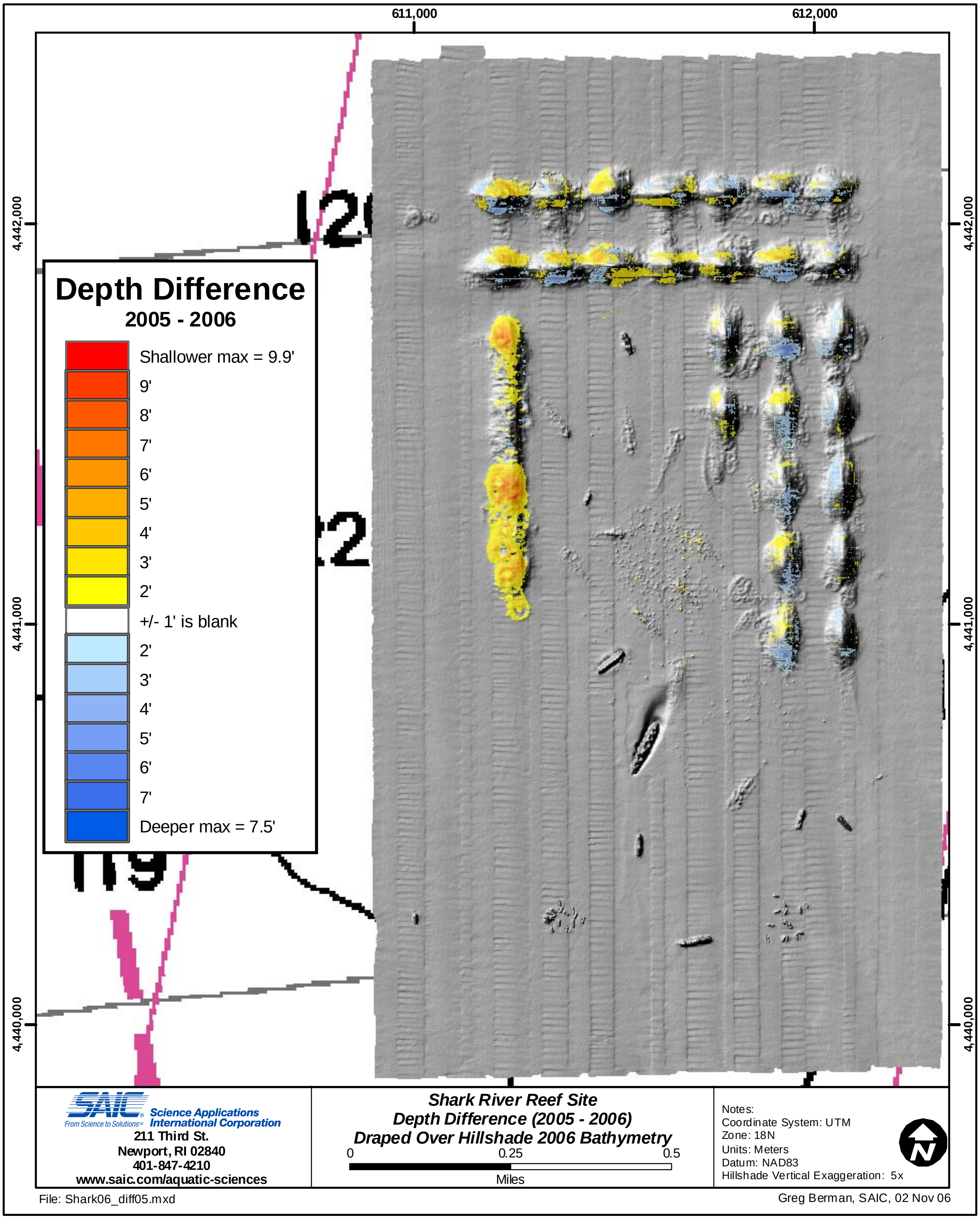


Figure 3.3-5. Bathymetric depth difference between the August 2006 survey and the August 2005 multibeam survey at the Shark River Reef

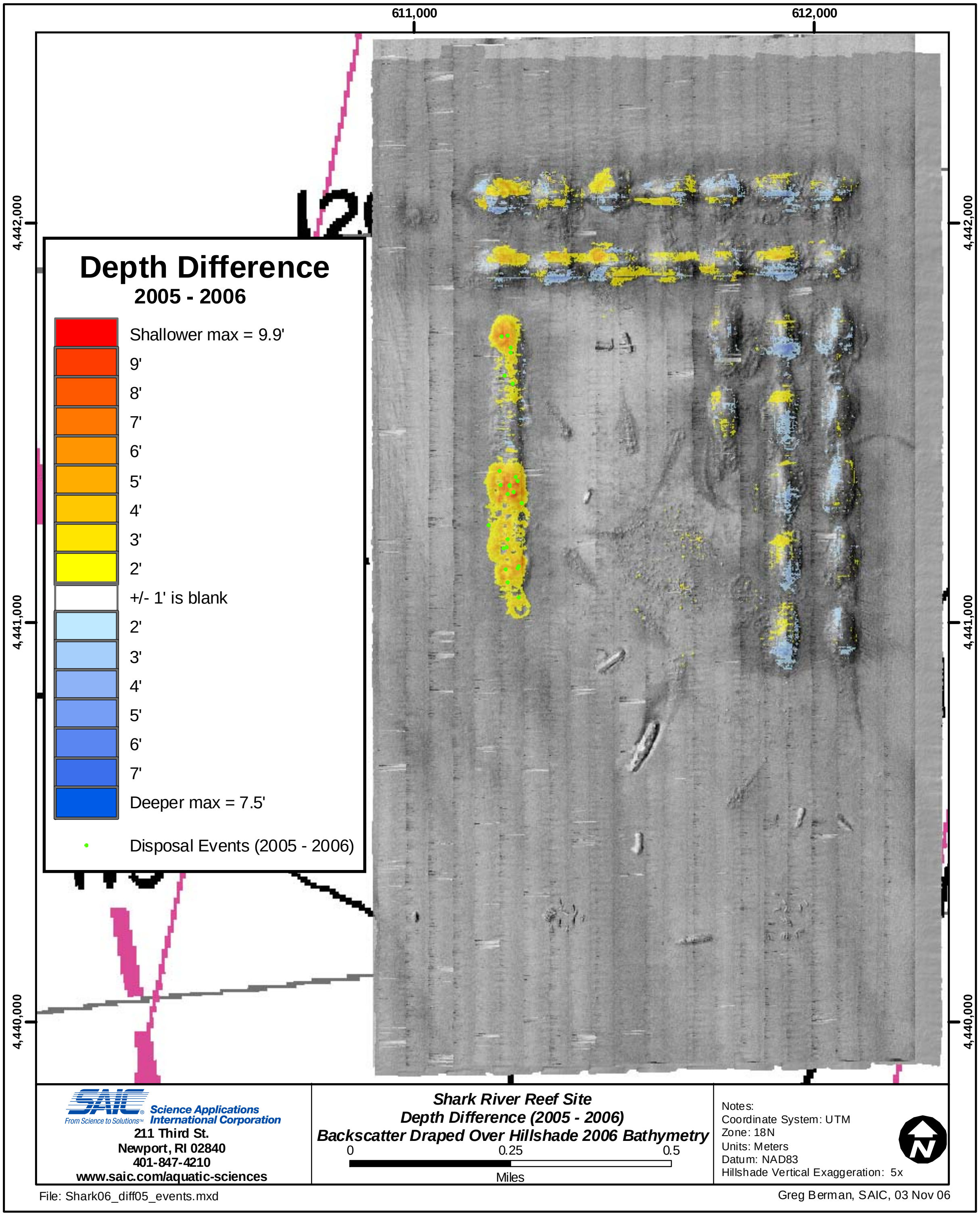


Figure 3.3-6. Disposal point data from the Shark River Reef from 2005 through 2006 depicted over the depth difference grid computed between the 2005 and 2006 multibeam surveys; the 2006 backscatter mosaic is included as the backdrop.

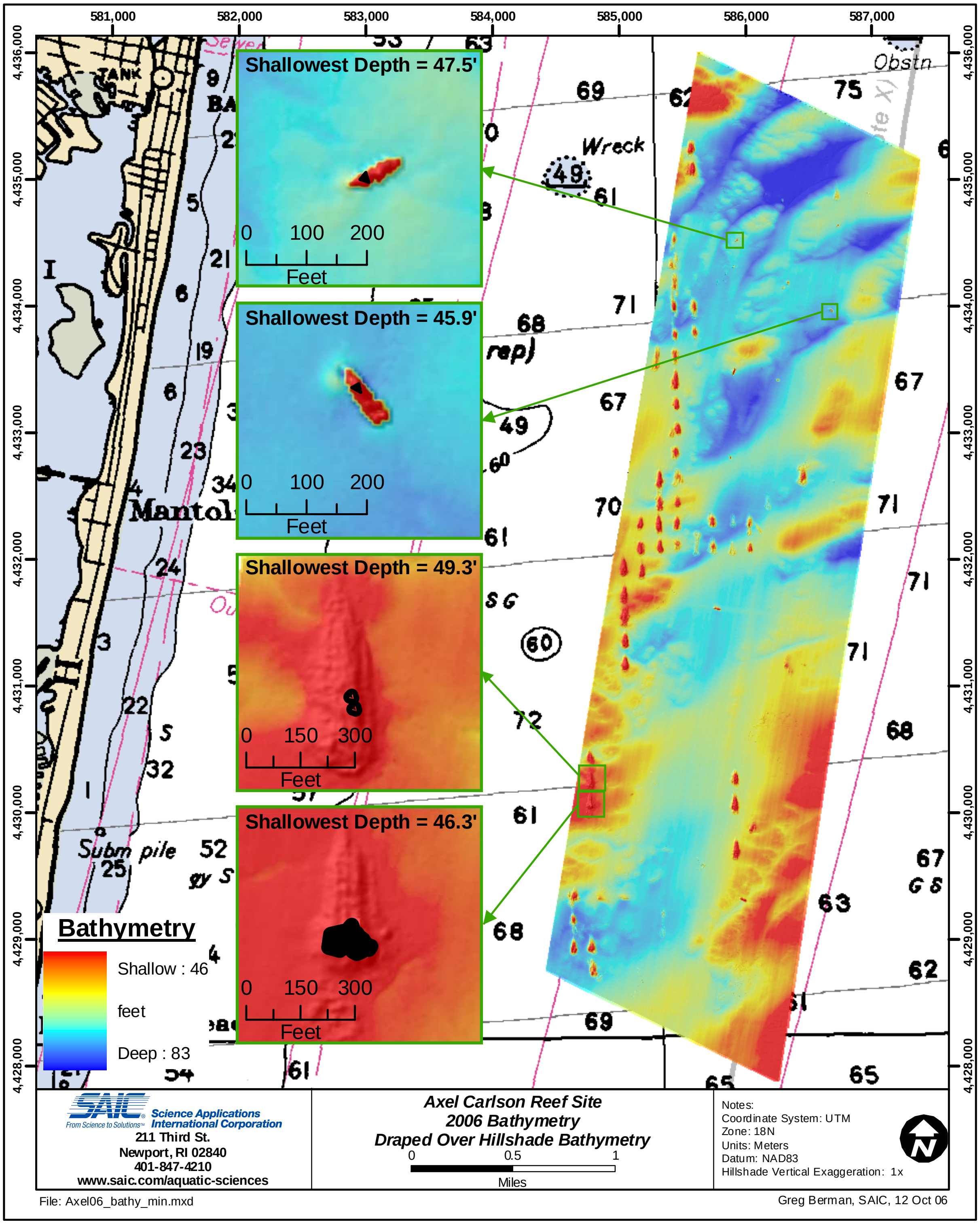


Figure 3.4-1. Hill-shaded gridded relief model based on the April 2006 bathymetric survey at the Axel Carlson Reef. Areas with depths shallower than 50 ft MLLW are identified in this figure.

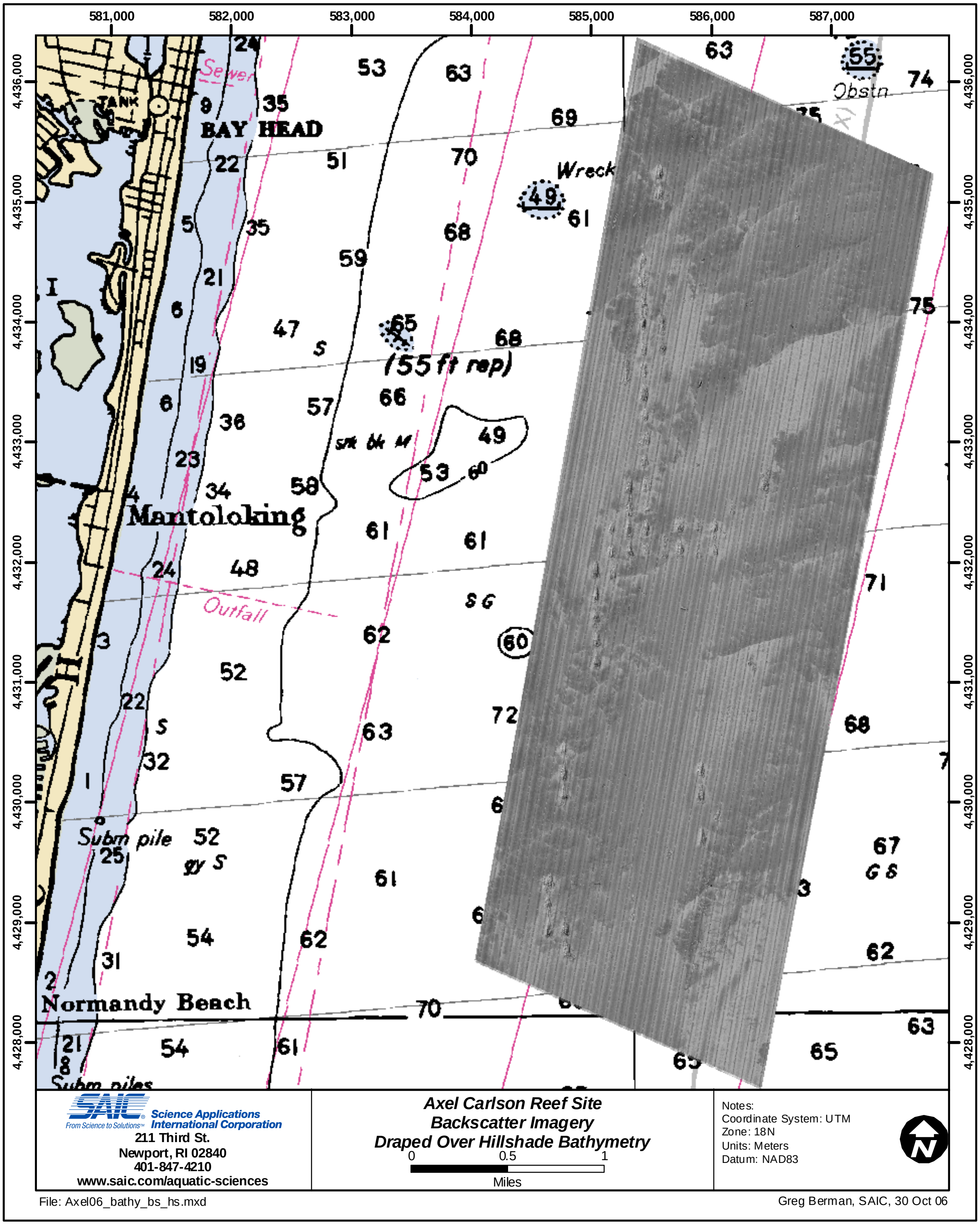


Figure 3.4-2. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2006 Axel Carlson Reef dataset

addition, the differing pockets of finer and coarser grained sediments could also be seen in the imagery data.

3.4.1 Comparison with Prior Surveys and Disposal Information

For this effort, the recent 2006 survey was compared to a single-beam survey conducted in the summer 2003 prior to the use of the site for dredged material placement operations; this 2003 dataset is considered the baseline survey for tracking recent placement operations at Axel Carlson Reef. The bathymetric depth difference grid generated between the 2006 and 2003 surveys clearly showed dredged material accumulation (deposition) focused in numerous small circular mound features scattered throughout the site, though mostly concentrated along the western edge (Figures 3.4-3). 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 15 ft above the surrounding seafloor. In addition to the numerous mound features associated with dredged material placement, there were also a few areas of minor shoaling and deepening scattered across the site that were likely associated with natural migration of the large sand ridges. 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 3.4-4).

3.5 Physical Characterization of the Sandy Hook Reef

The southeastern portion of the Sandy Hook Reef was surveyed at the end of the 2006 field effort to help evaluate its future use as a potential placement site for dredged materials from New York Harbor. No significant data problems were encountered during processing or analysis of the multibeam bathymetric data, and the southeastern portion of Sandy Hook Reef was well characterized based on these data. The color-coded gridded hill-shade model view shows that the northern portion of this area is characterized by numerous irregular features created by past disposal or reef-making operations, while the southern portion features a prominent, naturally-occurring shoal area (Figure 3.5-1). The deeper areas are focused along the eastern half of the site. The minimum depth observed during this survey was 31.1 ft MLLW over the shoal area at the southern edge of the survey area. The maximum depth of around 63.5 ft MLLW occurred in the lower southeast corner of the survey area (Figure 3.5-1). To assist with the site visualization, it was also useful to view the multibeam backscatter imagery draped over the multibeam hillshade view (Figure 3.5-2). The primary areas of interest noted on the backscatter mosaic were the numerous man-made reef features (e.g., primarily rubble and other debris) that had been placed at the site, as well as the pockets of finer-grained sediments among the more widespread coarser sediments.

3.5.1 Comparison with Prior Surveys and Disposal Information

Prior to the 2006 multibeam survey effort, the most recent survey of the entire Sandy Hook Reef was conducted in 2001 (Figure 3.5-3). The bathymetric depth difference grid generated between the 2006 and 2001 surveys over their common areas clearly shows dredged material accumulation (deposition) focused in a broad area in the northeastern portion of the site (Figure 3.5-4). Based on the known placement history at the site, this area of deposition was

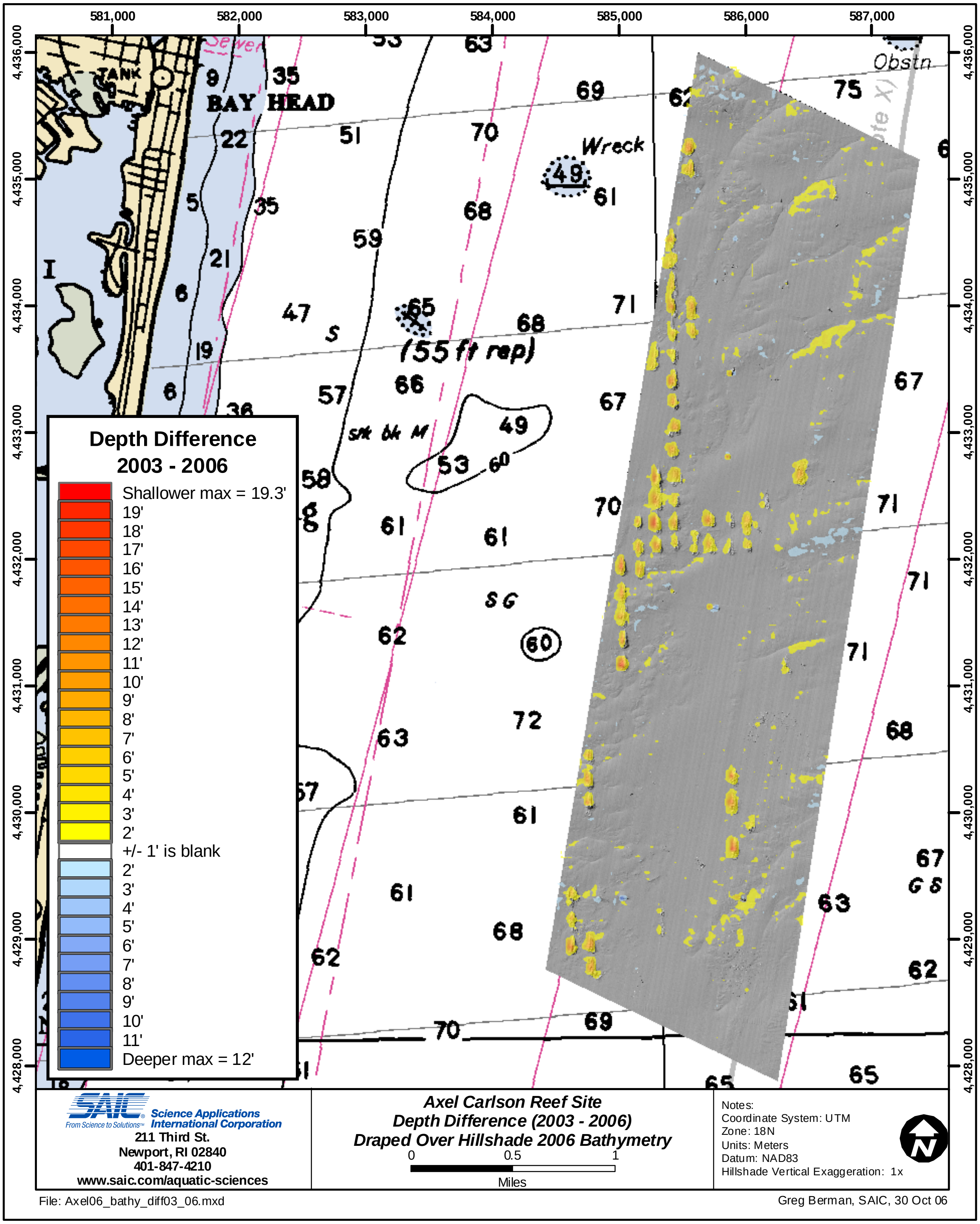


Figure 3.4-3. Bathymetric depth difference between the April 2006 multibeam survey and the August 2003 baseline single-beam survey over the Axel Carlson Reef

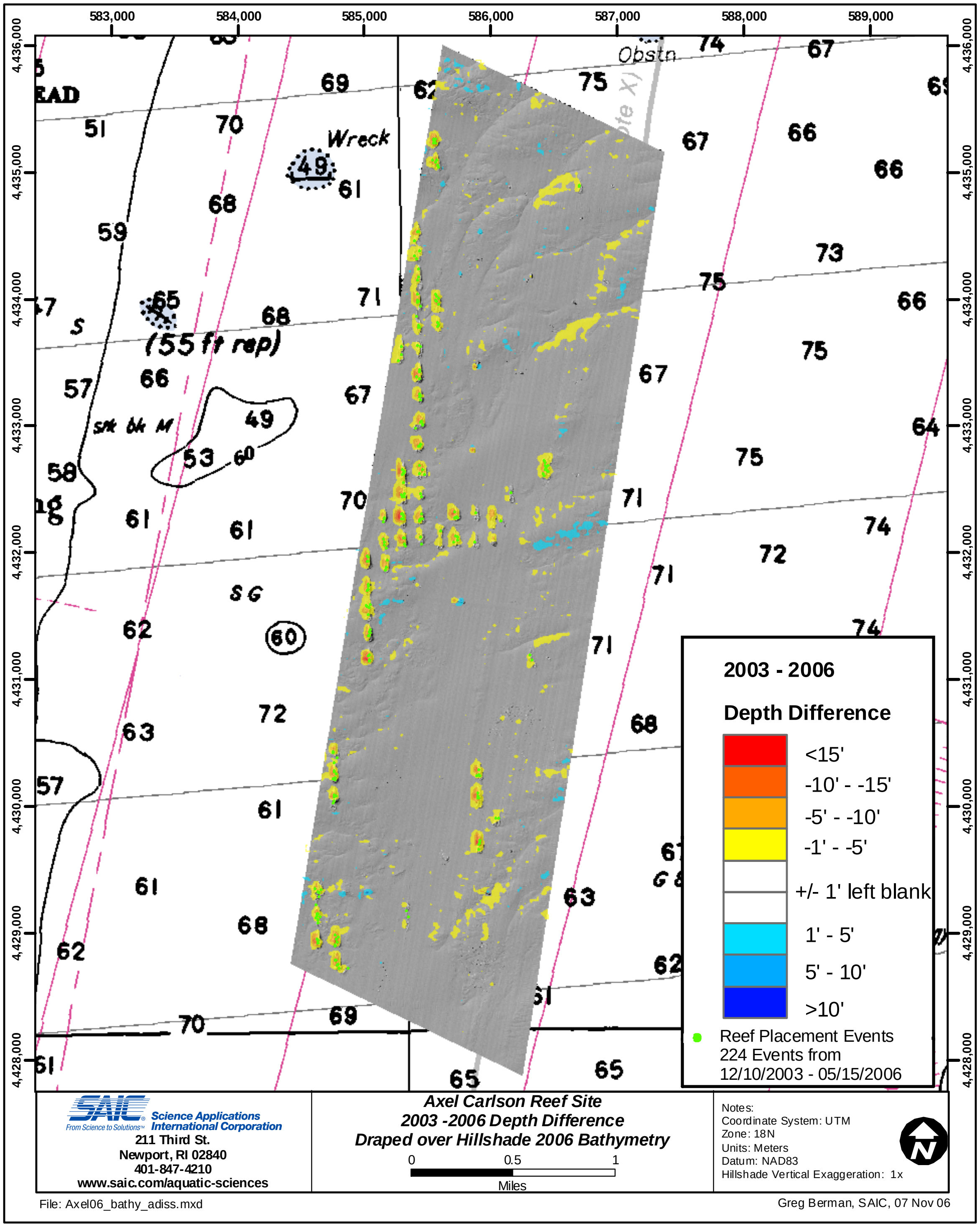


Figure 3.4-4. Disposal point data from the Axel Carlson Reef from 2003 through early 2006 depicted over the depth difference grid computed between the 2003 single-beam baseline survey and the 2006 multibeam survey; the 2006 backscatter mosaic is included as the backdrop.

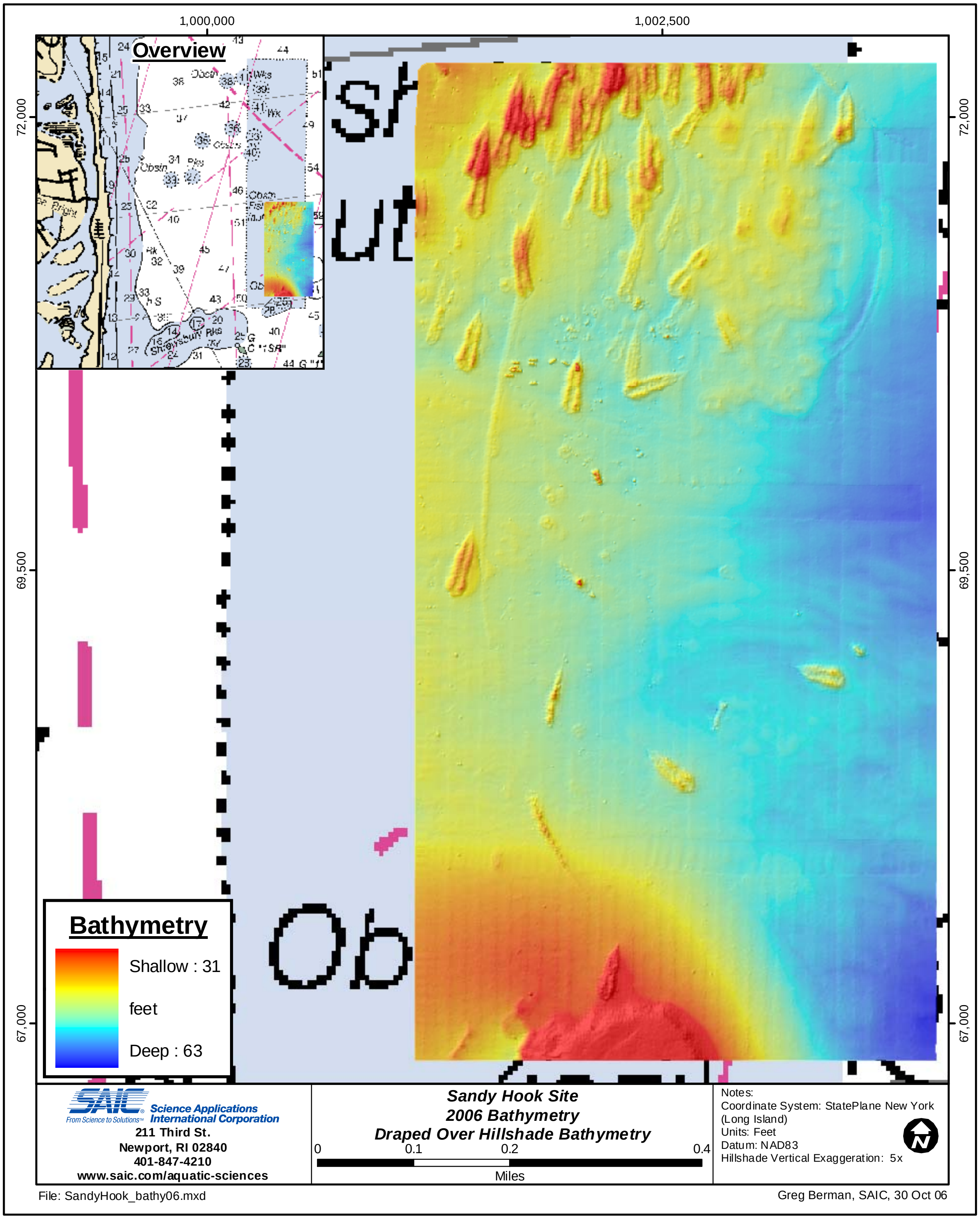


Figure 3.5-1. Hill-shaded gridded relief model based on a September 2006 multibeam bathymetric survey of the southwest portion of Sandy Hook Reef

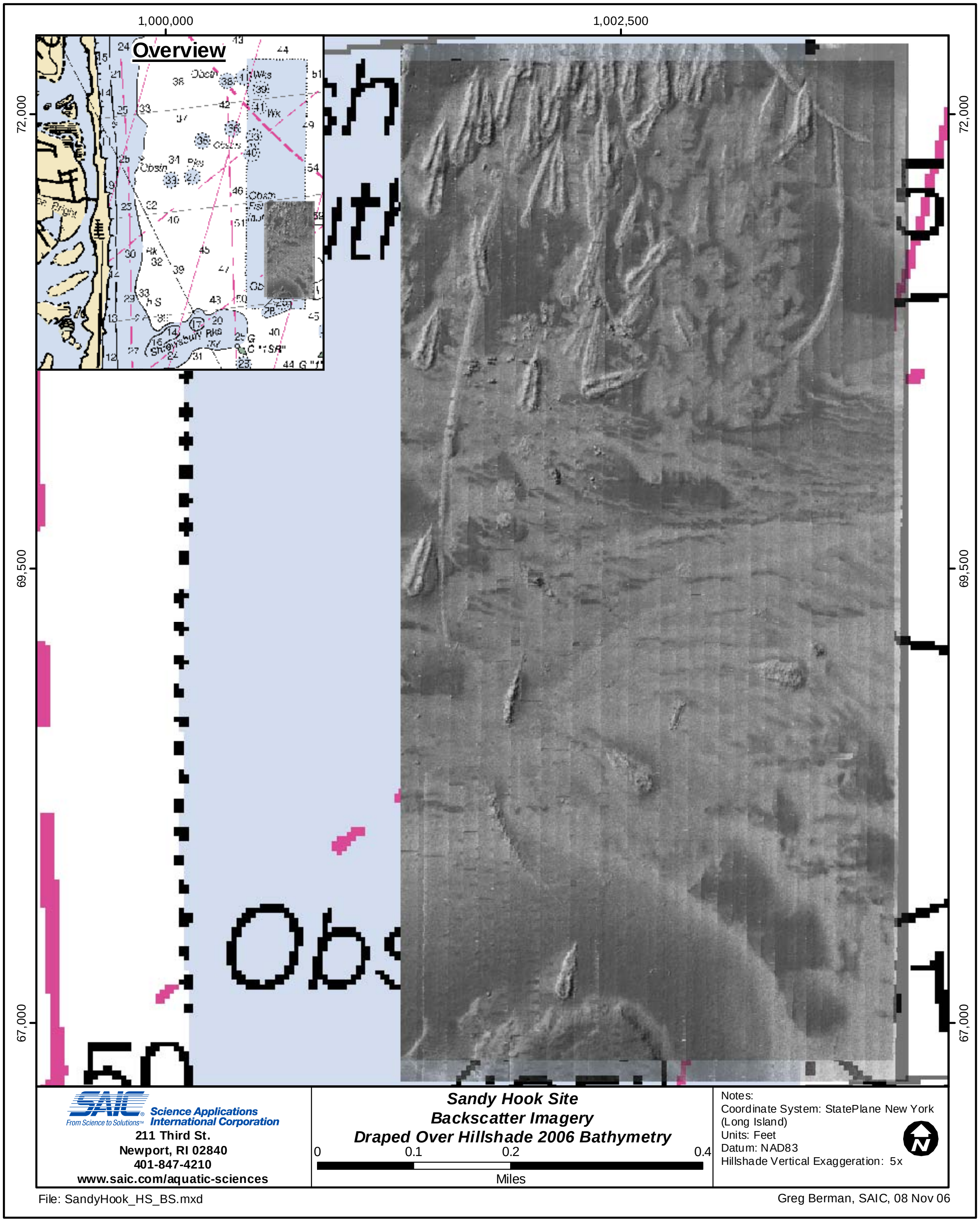


Figure 3.5-2. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2006 dataset for the southeastern portion of Sandy Hook Reef

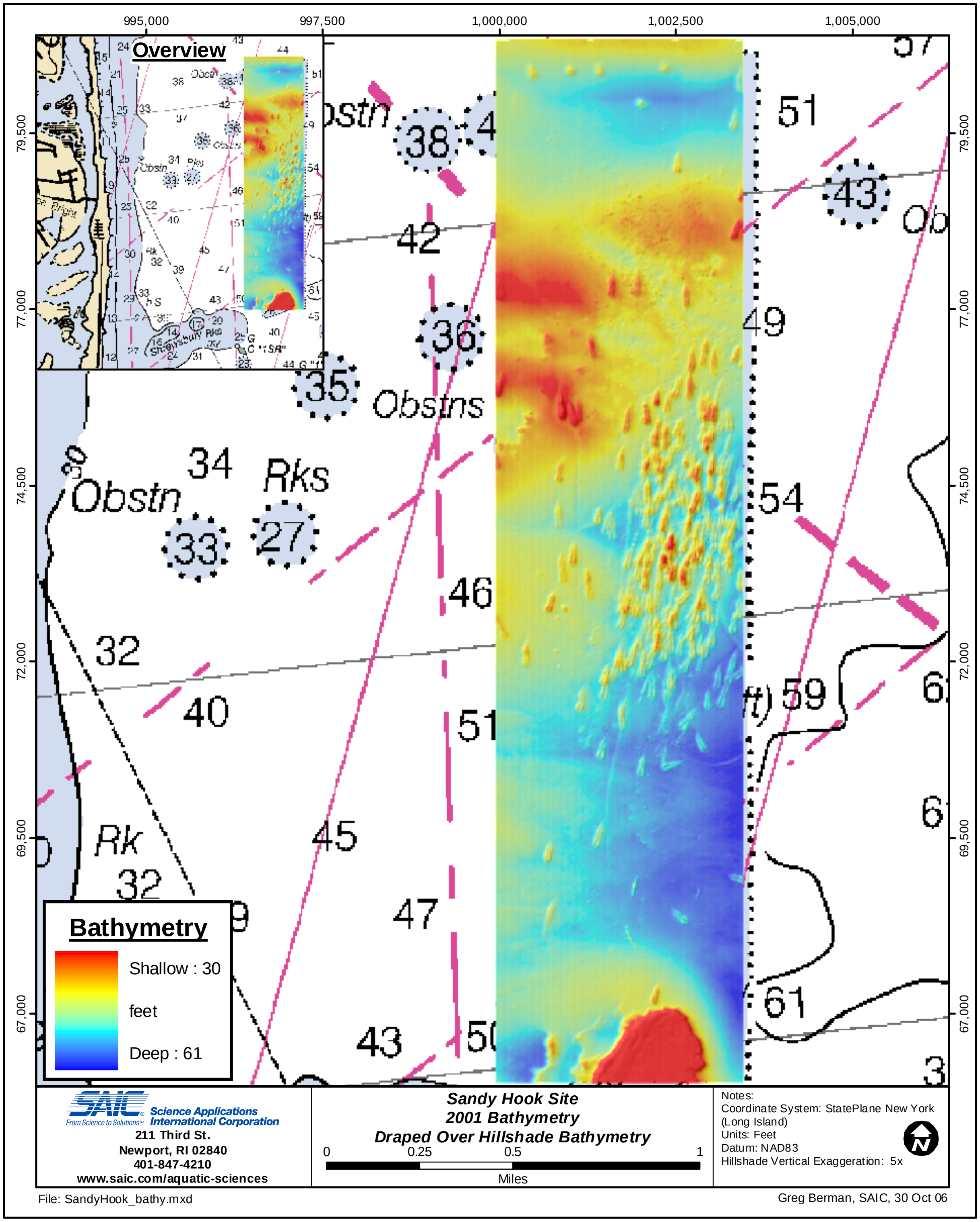


Figure 3.5-3. Hill-shaded gridded relief model based on a 2001 bathymetric survey at the Sandy Hook Reef

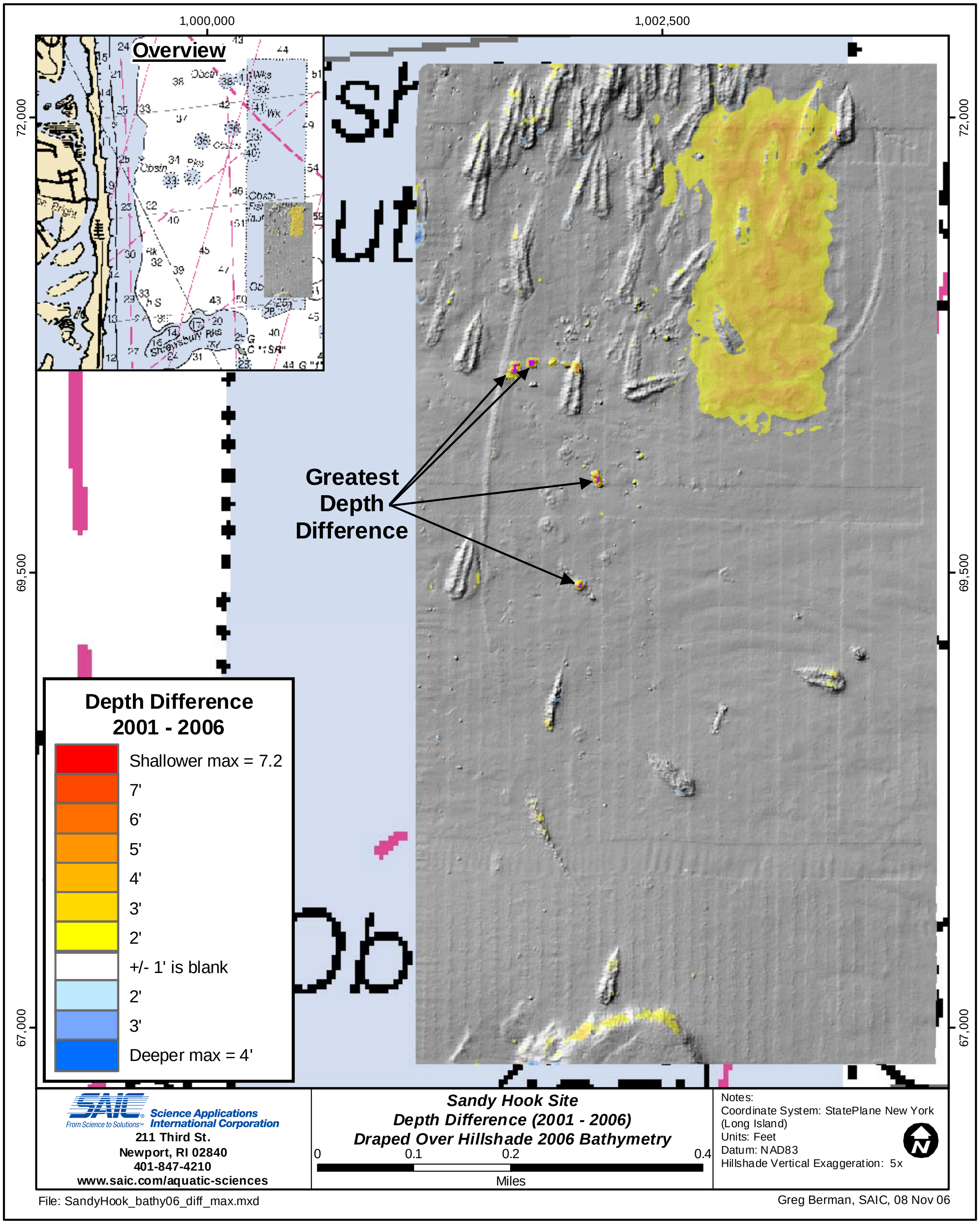


Figure 3.5-4. Bathymetric depth difference between the September 2006 multibeam survey and the 2001 bathymetric survey over the southwest portion of Sandy Hook Reef

created by the placement of material that was excavated during the dredging of the Ambrose Shoal area in 2001. In addition, there were also four small, but relatively prominent, depth difference features identified in the central western portions of the site that rose about 7 ft above the surrounding bottom. These features did not coincide with any ADISS-monitored disposal operations, so they may have been associated with reef-making operations over the last several years. With the exception of these four features, 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 3.5-5).

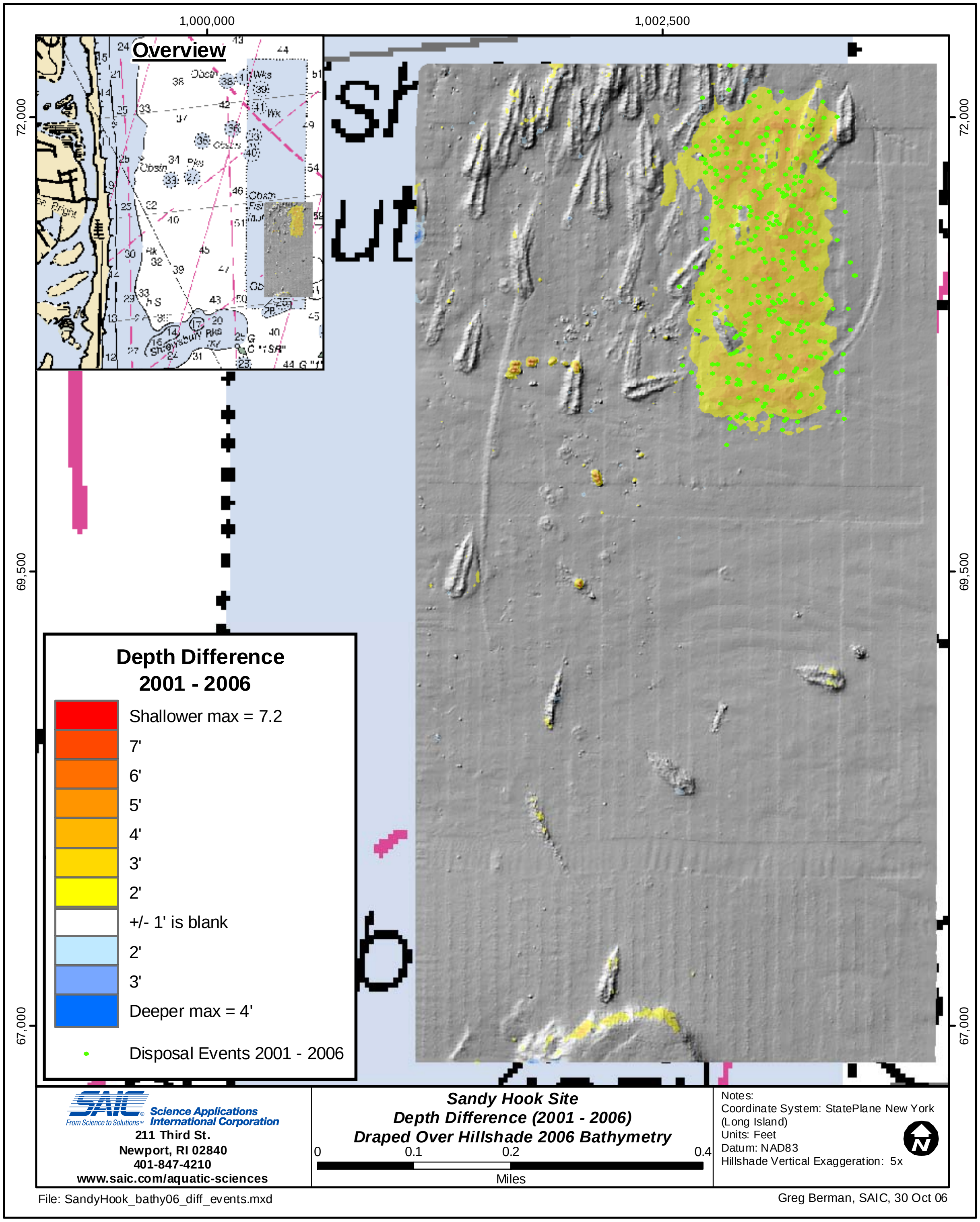


Figure 3.5-5. Disposal point data from the Sandy Hook Reef from 2001 through 2006 depicted over the depth difference grid computed between the 2001 survey and the 2006 multibeam survey; the 2006 hillshade is included as the backdrop.

4.0 REFERENCES

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