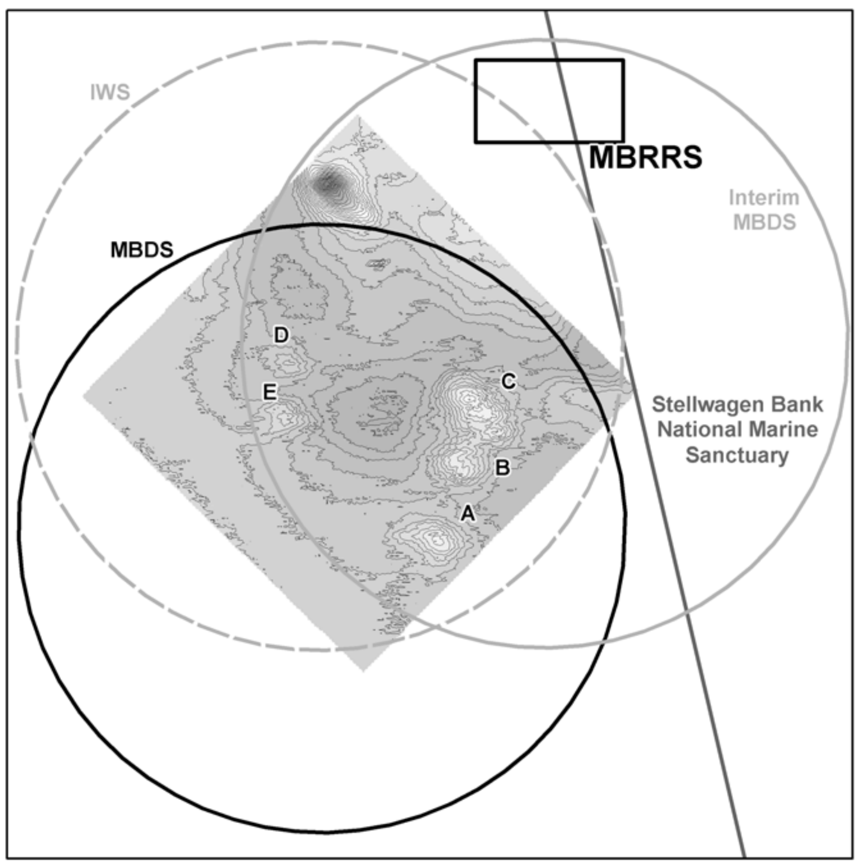
Monitoring Survey at the Massachusetts Bay Rock Reef Site Summer 2002

Disposal Area Monitoring System DAMOS



D A M O S

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Science Applications International Corporation
221 Third Street
Newport, RI 02840

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13. ABSTRACT

Blasted rock emanating from the Third Harbor Tunnel Project in Boston and an additional dredging project in Weymouth Fore River was deposited at the Massachusetts Bay Rock Reef Site (MBRRS) between 1992 and 1993. The intention of placing rock within an area of homogenous silty sand substrate was to promote habitat diversity and serve as a beneficial use of dredged material. Occurring approximately ten years postdisposal, a survey conducted in the summer of 2002 was the first monitoring effort performed under the DAMOS program to determine the spatial limits of the rock, evaluate seafloor topography, and assess benthic recolonization within MBRRS. Other objectives of the survey included documentation of the presence and relative abundance of rock colonizing sessile organisms, numbers of motile fish and invertebrates, and presence of fishing gear at the reef.

Bathymetry and side scan sonar results indicated that the rock material placed within MBRRS appeared to be concentrated near the center of the site and consisted of numerous elongated and overlapping deposits adjacent to areas of sandy, coarse-grained sediment. The majority of the reef structure offered approximately 2 to 3 m of vertical relief over the ambient bottom with a maximum height of 5 m near the center of the feature. Approximately ten years following disposal activities, the benthic recolonization over the surface of the deposit appeared to be progressing slowly. Various types of sponges, bryozoans, and tunicates composed the sessile community encrusting the rocky substrate, while mud anemones were established in the softer sediments surrounding the rock deposits. The density of encrusting organisms ranged from 5 to 25 percent cover in the cobble areas and 1 to 5 percent in the boulder areas. Geo-tactile fish and invertebrates such as lobsters, crabs, bivalves, and sea stars appeared to inhabit the reef. In addition, active and abandoned fixed fish harvesting gear (lobster pots) were present, suggesting the reef site may represent a relatively productive fishing area.

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U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742-2751

Submitted by:
Science Applications International Corporation
Admiral's Gate
221 Third Street
Newport, RI 02840
(401) 847-4210

US Army Corps
of Engineers ®
New England District

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EXECUTIVE SUMMARY

In support of the Disposal Area Monitoring System (DAMOS), Science Applications International Corporation (SAIC) conducted a series of environmental monitoring surveys at the Massachusetts Bay Rock Reef Site (MBRRS). The reef site is located approximately 1 km northeast of the current Massachusetts Bay Disposal Site (MBDS) boundary, within the confines of the historic dredged material disposal site known as Interim MBDS, or Foul Area Disposal Site (FADS). The summer 2002 field effort consisted of collecting precision bathymetric, side scan sonar, and drop video data over areas of seafloor along the western margin of Stellwagen Bank subjected to the deposition of excavated rock between 1992 and 1993. The objectives of the survey were to document the presence and relative abundance of rock colonizing sessile organisms, numbers of motile fish and invertebrates, and presence of fishing gear at the reef.

Blasted rock emanating from the Third Harbor Tunnel Project in Boston and an additional dredging project in Weymouth Fore River was deposited at the MBRRS between 1992 and 1993. The intention of placing rock within an area of homogenous silty sand substrate was to promote habitat diversity and serve as a beneficial use of dredged material. Prior to the summer 2002 survey, limited monitoring consisting of a laser line scan survey was performed at MBRRS in April 1993. Occurring approximately ten years postdisposal, the summer 2002 survey was the first monitoring effort performed under the DAMOS program to determine the spatial limits of the rock, evaluate seafloor topography, and assess benthic recolonization within MBRRS.

Bathymetry and side scan sonar results indicated that the rock material placed within MBRRS appeared to be concentrated near the center of the site and consisted of numerous elongated and overlapping deposits adjacent to areas of sandy, coarse-grained sediment. Depth difference comparisons based upon bathymetric data collected over the Interim MBDS in November 1988 indicated the majority of the reef structure offered approximately 2 to 3 m of vertical relief over the ambient bottom with a maximum height of 5 m near the center of the feature. Drop video data agreed well with the bathymetric and side scan sonar results and indicated the seafloor within the MBRRS consisted primarily of sandy, coarse-grained sediment overlain by cobbles, boulders, and gravel. The seafloor within the area of concentrated rock placement (center of MBRRS) consisted of hard substrate dominated by cobble and boulders.

Approximately ten years following disposal activities, the benthic recolonization over the surface of the deposit appeared to be progressing slowly. Various types of sponges, bryozoans, and tunicates composed the sessile community encrusting the rocky substrate, while mud anemones were established in the softer sediments surrounding the rock deposits.

Footage from the drop video survey indicated the density of encrusting organisms ranged from 5 to 25 percent cover in the cobble areas and 1 to 5 percent in the boulder areas. These densities are considered low relative to other areas of hard substrate at equivalent water depths along the coast of New England. The recolonization process may be progressing more slowly than anticipated due to the presence of a sediment drape on many of the rock surfaces that accumulates between ocean storm events and may have been acting to smother thin encrusting forms or interfering with settlement cues of invertebrate larvae.

Geo-tactile fish and invertebrates such as lobsters, crabs, bivalves, and sea stars appeared to inhabit the reef. In addition, active and abandoned fixed fish harvesting gear (lobster pots) were present. These findings suggest this area of seafloor has likely developed into a relatively productive fishing area over the past ten years.

1.0 INTRODUCTION

1.1 Background

In 1977, the New England District (NAE) of the U.S. Army Corps of Engineers established the Disposal Area Monitoring System (DAMOS) to monitor the environmental impacts associated with the subaqueous disposal of sediments dredged from harbors, inlets, and bays in the New England region. The DAMOS Program conducts detailed monitoring studies to detect and minimize any physical, chemical, and biological impacts of dredging and dredged material disposal activities. DAMOS monitoring helps to ensure that any effects of sediment deposition on the marine environment are confined to designated seafloor areas and are of limited duration. A flexible, tiered, monitoring protocol (Germano et al. 1994) is applied in the long-term management of dredged material disposal at open-water sites along the coast of New England.

The Massachusetts Bay Disposal Site (MBDS) is one of three regional dredged material disposal sites located off the Massachusetts coast. The current MBDS boundary is configured as a circle, centered at 42° 25.106´ N, 70° 34.969´ W (NAD 83), and covers a 10.75 km^2 (3.14 nmi^2) area of seafloor in Massachusetts Bay. It is located approximately 22.2 km (12 nmi) southeast of Gales Point, Manchester, Massachusetts (Figure 1-1). Sediments deposited at MBDS have originated from dredging projects in Boston, Gloucester, and Salem Harbors, as well as various small ports and coastal communities. MBDS in its current configuration was officially designated as an ocean dredged material disposal site by the U.S. Environmental Protection Agency (EPA) in 1993 (EPA 1992; DeAngelo and Murray 1997).

Prior to formal EPA designation of the current MBDS, the Interim Massachusetts Bay Disposal Site was used for the placement of sediments dredged from the harbors of northeastern Massachusetts from 1977 through 1993. During this period, in 1992 and 1993, the Third Harbor Tunnel Project in Boston was a major contributor of dredged material to the Interim MBDS. Large volumes of Boston Blue Clay and rock removed as part of the project were transported to MBDS for disposal. The clay was placed at a DAMOS disposal buoy, which resulted in the formation of a dredged material disposal mound (MBDS-A) that lies within the boundary of the reconfigured, formally designated MBDS boundary.

The blasted rock was directed to the Massachusetts Bay Rock Reef Site (MBRRS), located in the northern portion of the Interim MBDS and northeast of the current MBDS (Figure 1-2). The center of MBRRS is located at 42° 26.504´ N, 70° 33.973´ W

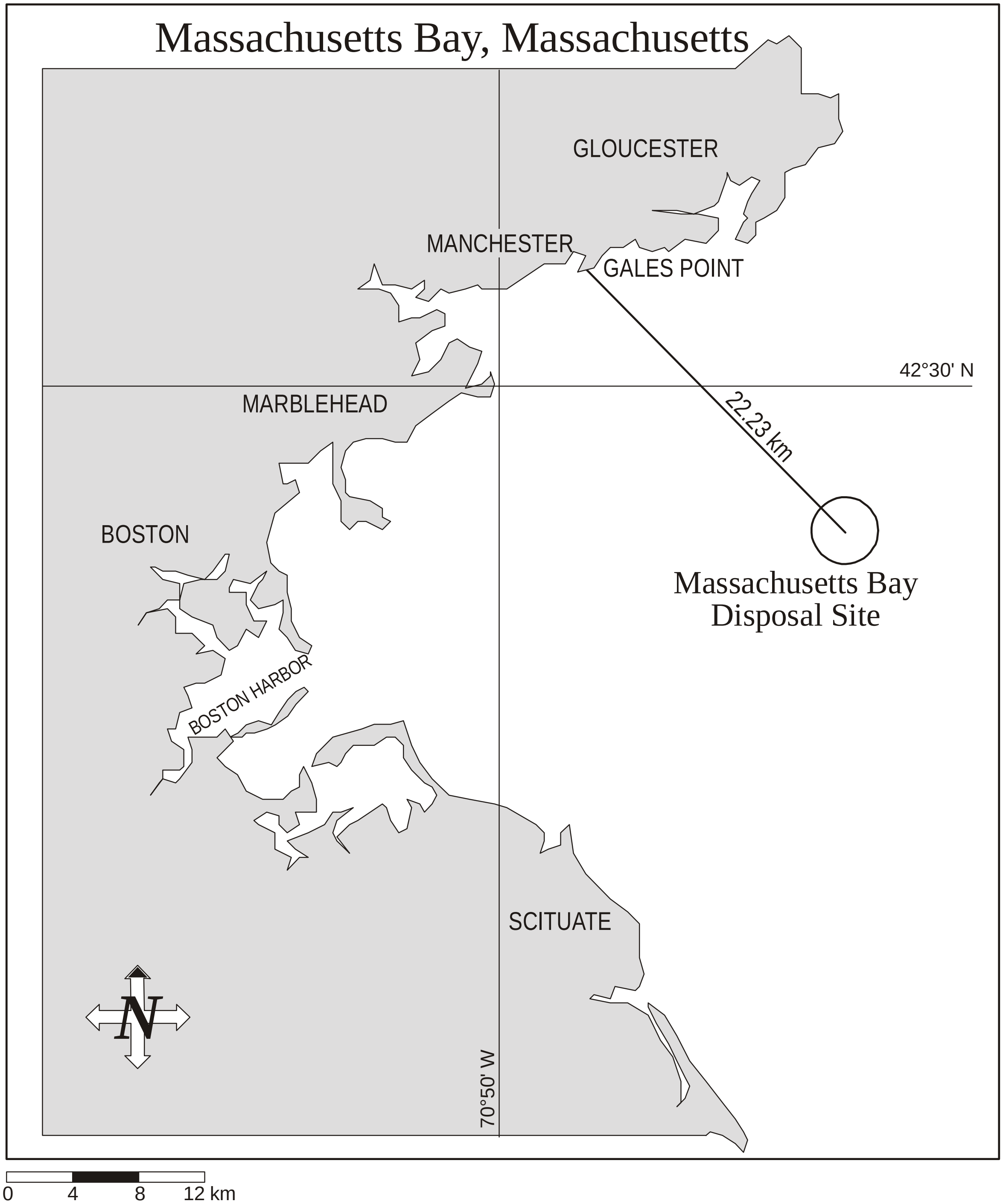


Figure 1-1. Location of the Massachusetts Bay Disposal Site relative to the Massachusetts shoreline

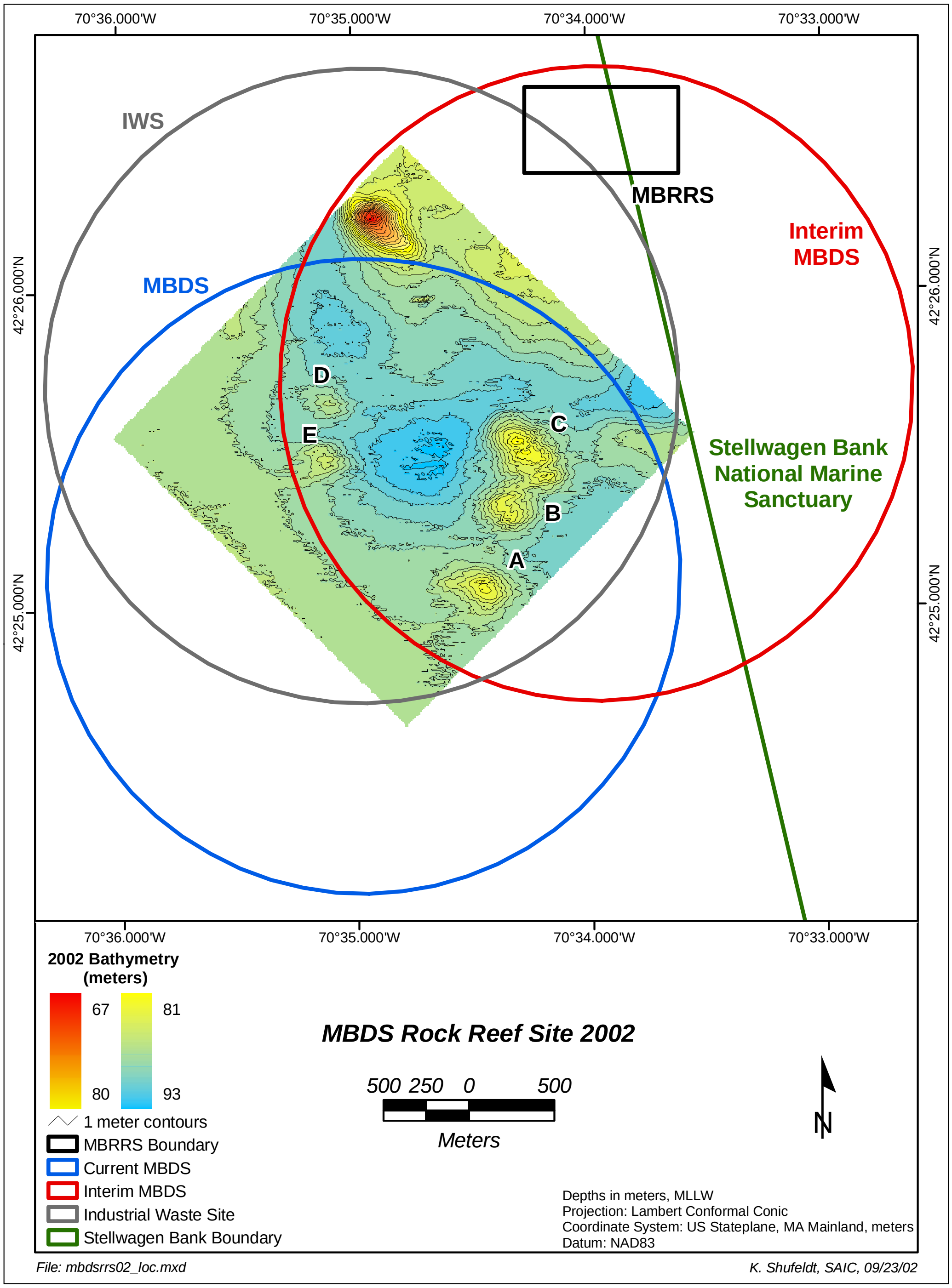


Figure 1-2. Location of MBRRS relative to the boundaries of the current MBDS (blue), Interim MBDS (red), Industrial Waste Site (IWS; gray), and Stellwagen Bank National Marine Sanctuary (green) in Massachusetts Bay

(NAD 83), approximately 1 km northeast of the current MBDS boundary (Figure 1-2). The placement of rock on the seafloor was seen as a beneficial use of this dredged material by providing habitat diversity over a homogenous silty sand substrate at the western edge of Stellwagen Bank.

An additional volume of rock excavated during a dredging project in Weymouth Fore River was added to this site during the same period of time. Based on disposal log information, nearly 546,000 m^3 of rock was placed at MBRRS between June 1992 and October 1993 (Table 1-1). The reported positions for the 1992 disposal events indicate the initial placements were within a 250 m radius of the center point, while the 1993 placements were concentrated within a 100 m radius of the center of the reef site (Figure 1-3).

Limited monitoring has been completed at MBRRS since the deposition of rock began in 1992. A laser line scan survey was performed over this site in April 1993 during an assessment of conditions within the former Industrial Waste Site (IWS), an area of seafloor partially overlapping MBDS that was subjected to disposal of sediments and various forms of waste products (chemical, low-level radiological, etc.) between 1946 and 1977. The U.S. Geological Survey obtained bottom photographs of the site as part of survey activities conducted in the vicinity of the MBDS in 1999 (Valentine et al., 1999). The summer 2002 survey marks the first monitoring effort performed under the DAMOS program to determine the spatial limits of the rock deposits, evaluate seafloor topography and assess benthic recolonization within the MBRRS approximately ten years postdisposal.

Table 1-1.

Summary of Reported Disposal Volumes of Rock Placed within MBRRS between June 1992 and October 1993

Year	Project	Volume (m³)
1992	Third Harbor Tunnel Weymouth Fore River	280,685 1,530
	1992 Total	282,215
1993	Third Harbor Tunnel Weymouth Fore River	242,860 20,644
	1993 Total	263,504
Total Estimated Barge Volume of Rock Placed at MBRRS		545,719

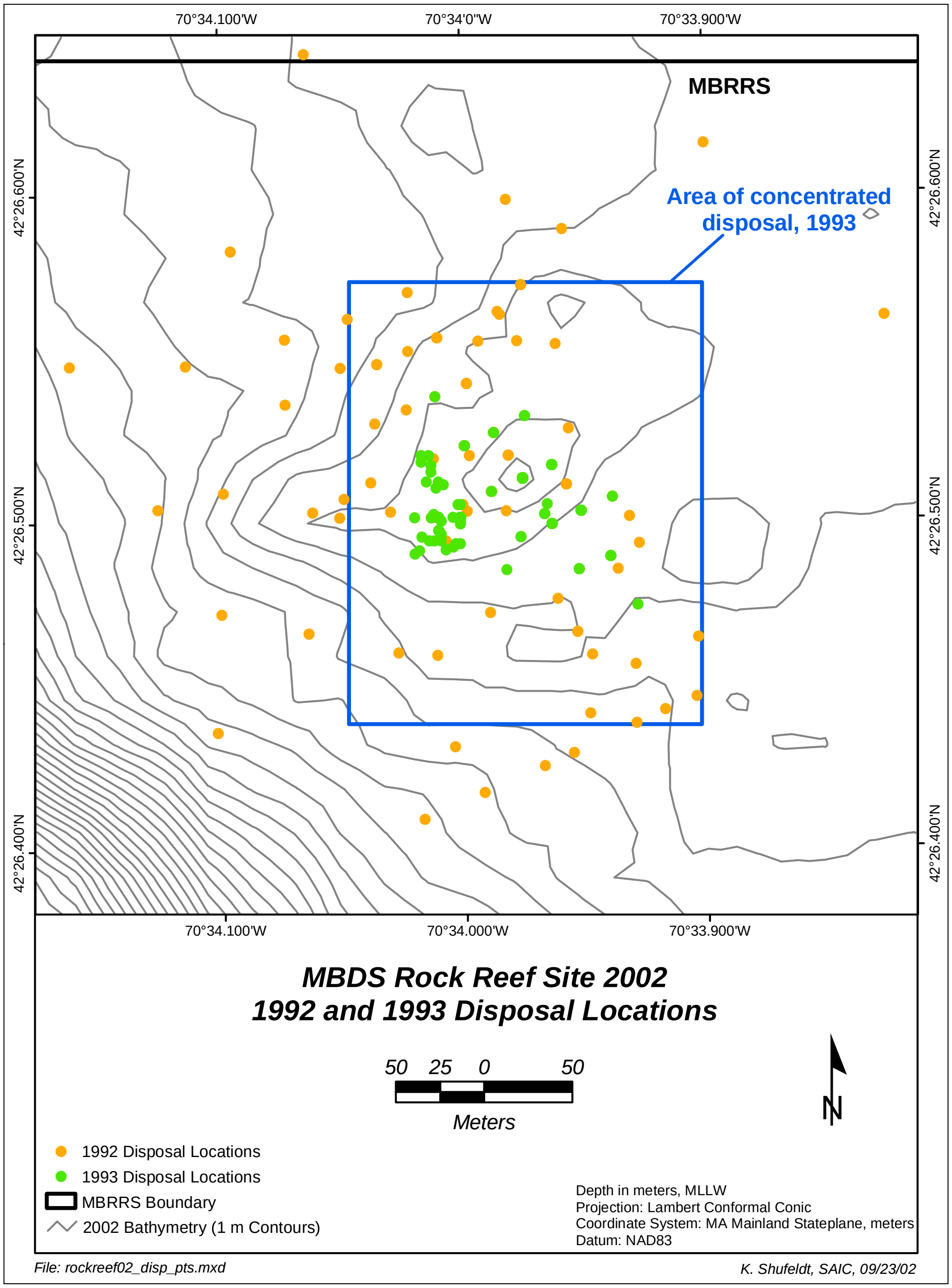


Figure 1-3. Reported positions of the rock placement events at MBRRS between June 1992 and October 1993 as recorded in barge disposal logs. The blue box represents the area of concentrated rock disposal for 1993.

1.2 Survey Objectives and Predictions

The objectives of the summer 2002 monitoring survey at MBRRS were to:

1) document the presence and relative abundance of rock-colonizing sessile organisms;

2) document the presence and relative abundance of motile fish and invertebrates at the reef; and

3) document the presence and relative abundance of fishing gear at the reef.

The summer 2002 field effort tested the following predictions:

1) The rock surfaces on the rock reef are expected to be highly colonized by various sessile or encrusting species such as sponges, hydroids, anemones, and bryozoa.

2) Habitat usage of the reef structure by geo-tactile fish and invertebrate species, such as lobsters, crabs, bivalves and sea stars is expected to be common.

3) Fixed fish harvesting gear such as lobster, crab, or fish pots is expected to be present at low to moderate densities

2.0 METHODS

Field operations were conducted aboard the *M/V Beavertail* on 27 June and 10 July 2002. Field operations on 27 June consisted of side-scan sonar and single-beam bathymetry. The site was re-visited on 10 July for the completion of a drop video survey.

2.1 Survey Areas

Although no defined boundaries have been established for MBRRS, the reported disposal points from 1992 and 1993 were used to define the likely limit of rock deposits on the seafloor. This assumed limit was then factored into the development of a relatively broad survey area encompassing 0.88 km^2 (1100 × 800 m) of seafloor to ensure that all rock disposal areas would be included. The area was first surveyed using side-scan sonar to determine the actual spatial extent of the rock deposits. The results of the side-scan sonar survey were then used to define the boundaries of a more refined 900 × 500 m survey area for the completion of precision bathymetry and drop video surveys. For the purposes of the 2002 monitoring report, this smaller, 0.45 km^2 survey area was used to represent the boundary of the rock reef site.

The initial side-scan sonar survey consisted of 11 survey lanes that were 500 m in length, oriented north/south, and spaced at 100 m intervals to ensure adequate sonar coverage of the seafloor within MBRRS. In addition, two supplemental lanes oriented east/west and spaced at approximately 100 m intervals were completed to the north of the main survey area in an effort to locate the northern extent of the rock deposits.

Based on the side-scan sonar survey observations, a 900 × 500 m detailed bathymetric survey centered at coordinates 42° 26.504´ N, 70° 33.973´ W was completed over MBRRS to examine seafloor topography and assess the distribution of rock deposits placed within the site (Figure 2-1). The survey consisted of 37 lanes oriented north-south and spaced at 25 m intervals.

The drop video survey was completed on 10 July, approximately two weeks after the geophysical survey. Placement of video transect survey lines was determined from the results of the June field effort, which determined the density and spatial extent of the rock reef structures. A total of nine transects were occupied over MBRRS, with emphasis on assessing conditions within a 0.05 km^2 area of concentrated disposal near the center of the site (Figure 2-2). Bathymetric survey lanes near the center of MBRRS served as targets for the long drifts completed over the reef site. A northerly wind enabled the completion

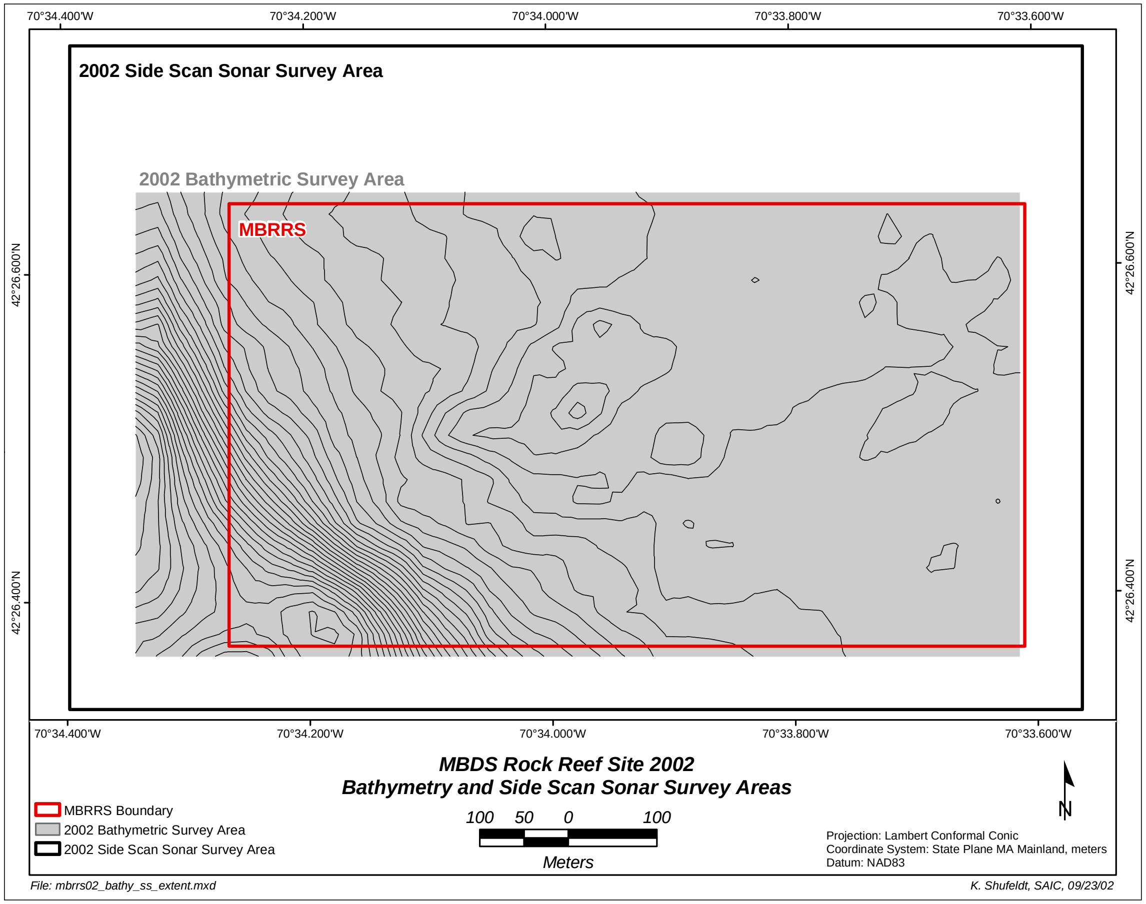


Figure 2-1. Bathymetric and side-scan sonar survey areas occupied as part of the summer 2002 monitoring survey over MBRRS

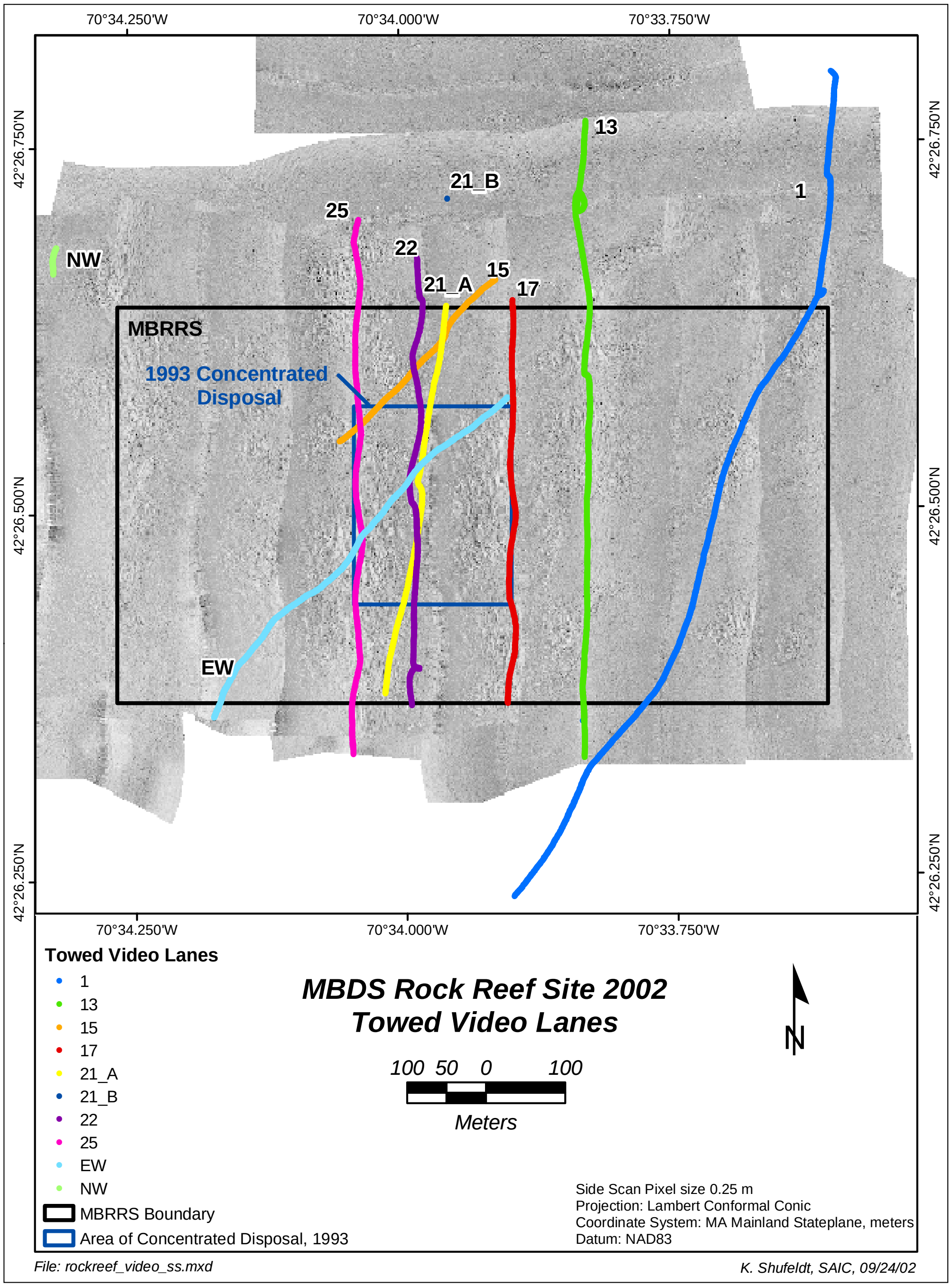


Figure 2-2. Color-coded track lines occupied over MBRRS as part of the July 2002 drop video survey. The track lines are overlaid on the side-scan sonar mosaic from Figure 3-5.

of Lanes 21, 17, 25, 22, 13, and NW, before the wind slacked and vessel drift turned southwest. Survey lanes with a southwest drift included Lanes 1, 15, and EW.

2.2 Navigation

During the field operations, differentially-corrected Global Positioning System (DGPS) data in conjunction with Coastal Oceanographic's HYPACK® navigation and survey software were used to provide real-time positioning of the survey vessel to an accuracy of ± 3 m. A Trimble DSMPro GPS receiver was used to obtain raw satellite data and provide vessel position information in the horizontal control of North American Datum of 1983 (NAD 83). The GPS receiver has an integrated differential beacon receiver to improve the overall accuracy of the satellite data to the necessary tolerances. The U.S. Coast Guard differential beacon broadcasting from Portsmouth, NH (288 kHz) was utilized for real-time satellite corrections due to its geographic position relative to MBRRS.

The DGPS data were ported to Coastal Oceanographic's HYPACK® data acquisition software for position logging and helm display. Side-scan sonar and bathymetric survey lanes were determined from historic disposal points before the commencement of the field operations and stored in a project database. During the field operations, individual lanes were selected and displayed by the navigation system in order to position the survey vessel over the correct geographic coordinates. During the bathymetric survey, the presence of fishing gear buoys were noted in the logbook, and the position of the vessel was logged with a time stamp in Universal Time Coordinated (UTC) and a text identifier to facilitate Quality Control (QC) and rapid input into a Geographic Information System (GIS) database.

2.3 Bathymetric Data Acquisition and Analysis

2.3.1 Bathymetric Data Acquisition

During the bathymetric survey, HYPACK® was interfaced with an Odom Hydrotrac® survey echosounder, as well as the Trimble DGPS. The Hydrotrac® uses a narrow-beam (3°), 208-kHz transducer to make discrete depth measurements and produce a continuous analog record of the seafloor. The Hydrotrac® transmitted approximately 10 digital depth values per second (depending on water depth) to the data acquisition system. Within HYPACK®, the time-tagged position and depth data were merged to create continuous depth records along the actual survey track. These records were viewed in near real time to ensure adequate coverage of the survey area.

2.3.2 Bathymetric Data Processing

The bathymetric data were fully edited and processed using the HYPACK® data processing modules. Raw position and sounding data were edited as necessary to remove or correct questionable values, apply sound velocity and draft corrections, and reduce the depth soundings to the vertical datum of Mean Lower Low Water (MLLW) using observed tides obtained from the National Oceanic and Atmospheric Administration (NOAA).

During bathymetric survey data acquisition, an assumed and constant water column sound velocity was entered into the Odom echosounder. To account for the variable speed of sound through the water column, a Seabird Instruments, Inc. SEACAT SBE 19-01 conductivity, temperature, and depth (CTD) probe was used to obtain sound velocity profiles at the start and end of each field survey day. An average sound velocity was calculated for each day from the water column profile data, and then entered into a HYPACK® sound velocity correction table. Using the assumed sound velocity entered into the echosounder and the computed sound velocity from the CTD casts, HYPACK® then computed and applied the required sound velocity corrections to all of the sounding records.

Observed tide data were obtained from the NOAA tide station in Boston Harbor, MA (Station 8443970) through the National Water Level Observation Network. The NOAA six-minute tide data were downloaded in the MLLW datum and the published time and height corrections based on Gloucester Harbor, MA were applied to correct for tidal offsets.

2.3.3 Bathymetric Data Analysis

The purpose of the bathymetric analysis was to characterize the seafloor topography and identify any unique features resulting from historic rock disposal. Because single-beam bathymetric survey data typically cover only a small percentage of the total seafloor area (approximately 5%), the analysis relies on interpolating between the discrete survey data points to generate a three-dimensional seafloor surface model.

After the bathymetric data were fully edited and reduced to MLLW, cross-check comparisons on overlapping data were performed in order to verify the proper application of the correctors and to evaluate the consistency of the data set. Once the data were verified, they were then processed through the HYPACK® Sort routine in order to thin the survey data and reduce the overall size of the dataset. Because of the rapid rate at which a survey echosounder can generate data (approximately ten depths per second), the along-track data density for a single-beam survey tends to be very high (multiple soundings per meter). In most cases, these data sets contain many redundant data points that can be eliminated without any effect on the overall quality of the data. The Sort routine examines the full dataset along each survey line and then extracts only the representative soundings based on a user-specified distance interval or search radius. The output from the Sort routine is a merged ASCII-xyz file that may contain anywhere from 2 to 10% of the original data set. These greatly reduced, but still representative, data sets are far more efficient to use in the subsequent modeling and analysis routines. The 2002 MBRRS bathymetric survey data were gridded through the ArcGIS® ArcInfo software module to generate a depth model for the entire survey area, using a grid cell size of 25 × 25 m.

2.4 Side-Scan Sonar Data Acquisition and Analysis

Side-scan sonar systems provide an acoustic image of the seafloor by detecting the strength of the backscatter returns from signals emitted from a towed side-scan sonar transducer array. The transducers emit and receive sound waves at specific frequencies typically ranging from 100 to 500 kHz. The transmittal angles of the transducers can be adjusted so that a specific swath of area is covered, such as 75 or 100 m range scale on both sides of the towfish. Side-scan sonar data can reveal general seafloor surface characteristics and also provide the size and location of distinct objects. Dense objects (e.g., metal, rocks, hard sand seafloor areas) will reflect strongly and appear as darker areas in the records presented in this report. Conversely, areas characterized by soft features (e.g., silt or mud sediments), which absorb sonar energy, appear as lighter areas in the sonar records.

2.4.1 Side-Scan Sonar Data Acquisition

Side-scan sonar imagery data were acquired with an EdgeTech DF1000 side-scan sonar towfish, interfaced with a PC-based Triton-Elics ISIS® sonar acquisition system. The DF1000 operates at frequencies of 100 and 500 kHz, and the range scale was set to 100 m throughout the survey. The DF1000 side-scan fish was towed behind the survey vessel with a double-armored coaxial tow cable. The ISIS® system recorded acoustic data from the towfish and position information from the navigation system, and displayed real-time imagery on a PC monitor. With the lanes spaced at 100 m intervals and side-scan range scale set to 100 m, over 200% bottom coverage was obtained during the side-scan operations. The position of the towfish was calculated in real time by HYPACK® navigation package, based on cable scope (layback) and speed of the survey vessel. This information was embedded within the digital side-scan sonar data to allow for the geo-referencing of each acoustic return.

2.4.2 Side-Scan Sonar Data Processing

Individual survey lines were played back in ISIS® and converted to a format for use in the Delph Map mosaicing program. Upon playback of the side-scan records, adjustments were made to the time-varying-gain (TVG) of the return signal, and the portion of the signal corresponding to the water column was removed. As each line was completed in ISIS®, it was imported into Delph Map to check for processing accuracy and development of a digital mosaic. After the mosaic was completed, it was saved and exported out of Delph Map as a geo-referenced Tiff file to be used in a Geographic Information System (GIS) environment in order to use the imagery as a basis of comparison with other data from the area.

2.5 Drop Video Data Acquisition and Analysis

2.5.1 Drop Video Data Acquisition

An Outland USW-6010 Integrated Color Video System was used to document the benthic conditions and habitat at the site, as well as to map the extent of the rock deposits on the MBRRS seafloor (Figure 2-3). Real-time video was fed to a console on the surface for in-situ monitoring and recorded on a S-VHS recording system. Video data from the camera was fed to the surface via a video cable that was connected to the operating and data collection console. The video was monitored in real time via the monitor, and focus and light intensity were adjusted accordingly based on the environmental conditions of the survey. The video data were also routed directly to the VCR, where they were recorded for later analysis. Real-time audio was overlaid onto the video noting time "markers" using the HYPACK® navigation clock, significant events, and any additional information that was relevant to the video data collection. During data collection, HYPACK® was used to log time and vessel position along the video track lines to give positional data to video footage.

2.5.2 Drop Video Data Processing

The videotapes generated during the July video survey were sent to Hecker Environmental of Falmouth, MA for analysis. The video footage was analyzed to characterize benthic habitat and identify resident species and relative density of colonizing organisms on the reef site. The audio time stamps on the video footage were correlated with the HYPACK® survey times and used to calculate positional data for the video. HYPACK® survey track lines were overlaid on the side-scan sonar mosaic to correlate the habitat and features seen in the video footage with geophysical data. A detailed list of organisms, habitat type, and other relevant observations was prepared from the video data, as well as an overview of general conditions and habitat within the site.

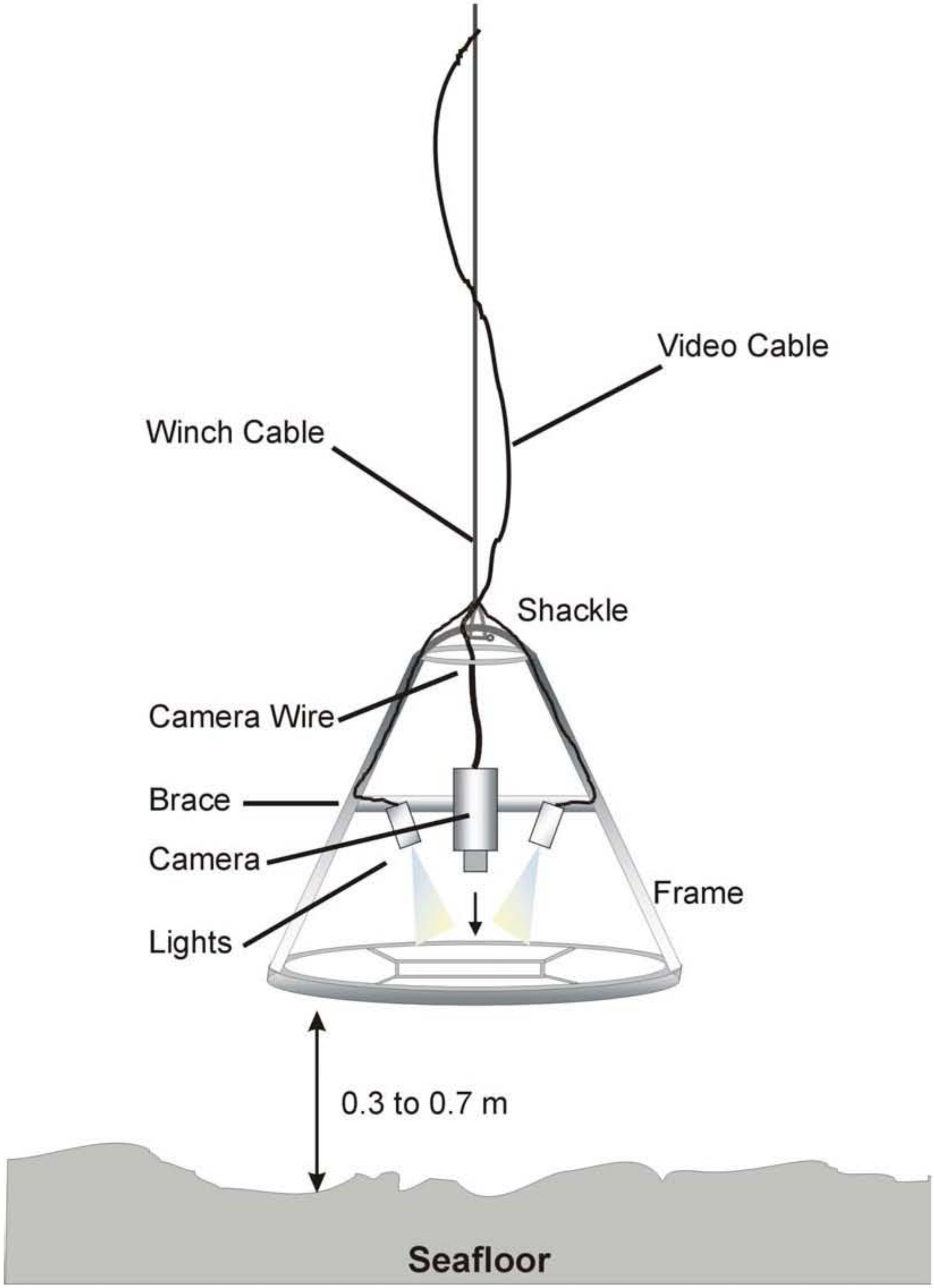


Figure 2-3. Schematic diagram of the Outland drop video system used to evaluate benthic conditions over the rock deposits within MBRRS

3.0 RESULTS

3.1 Bathymetry

The natural seafloor within the survey area was relatively flat to the north and east, with steep slopes associated with the western margin of Stellwagen Bank present to the south and west (Figure 3-1). A minimum depth of 48 m was detected in the northeast corner of the site, while a maximum depth of 86 m was documented along the western survey boundary (Figure 3-1). A maximum depth of 79 m was detected within the MBRRS boundaries, located at the base of a distinct bottom slope in the southwest corner of the site.

One large and several small topographic features associated with the placement of rock were discernible in the bathymetric data (Figure 3-1). The largest bottom feature within the rock reef site is located within the area of concentrated disposal. Water depths within this 0.05 km^2 area ranged from 46 m over the apex of the feature to approximately 52 m in the southwest corner (Figure 3-2). Comparisons made between the June 2002 survey over MBRRS and bathymetric data collected over the Interim MBDS (Foul Area Disposal Site) in November 1988 (i.e., pre-disposal) provided some insight into changes in seafloor topography resulting from the placement of nearly 546,000 m^3 of rock. (Figure 3-3).

Depth difference comparisons between the June 2002 and November 1988 surveys indicated the formation of a bottom feature approximately 600 m wide along the southwest-northeast axis, with a maximum relief of 5 m above the ambient seafloor (Figure 3-4). However, the southwestern portion of the rock reef feature detected through depth difference comparisons corresponded to an area of significant slope (edge of Stellwagen Bank). Although a rocky substrate may have been present southwest of the area of concentrated disposal, the morphology of the feature as documented by depth difference comparisons may be exaggerated somewhat by survey artifacts (false indications of depth change) resulting from the slope. The smaller seafloor features located to the north and east were generally 0.25 to 1 m high and were likely valid representations of depth change resulting from individual disposal events.

During the bathymetric survey, the presence of fishing gear surface buoys was also recorded. Only four surface buoys were encountered in the site boundary at the time of survey, in lane quadrants 5A, 5C, 33C, and 37B (Figure 3-5). Given the fishing practices in the Massachusetts Bay region, these four buoys likely represent only two trawls of lobster traps at the site. Drop video operations gave visual confirmation that both actively fished and abandoned lobster fishing gear were present on the seafloor.

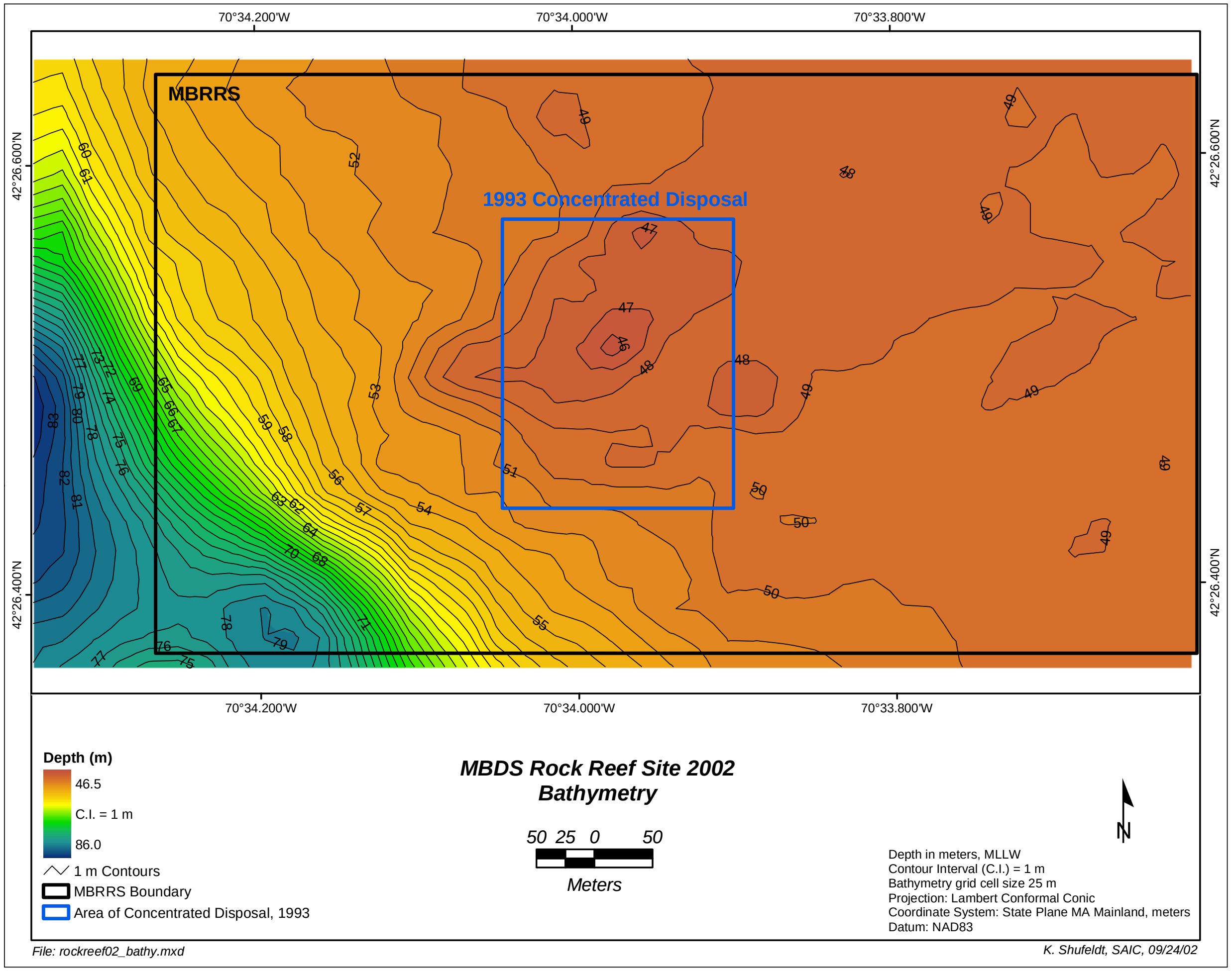


Figure 3-1. Bathymetric chart showing the range of water depths detected over MBRRS and the surrounding area during the 2002 monitoring survey, 1.0 m contour interval

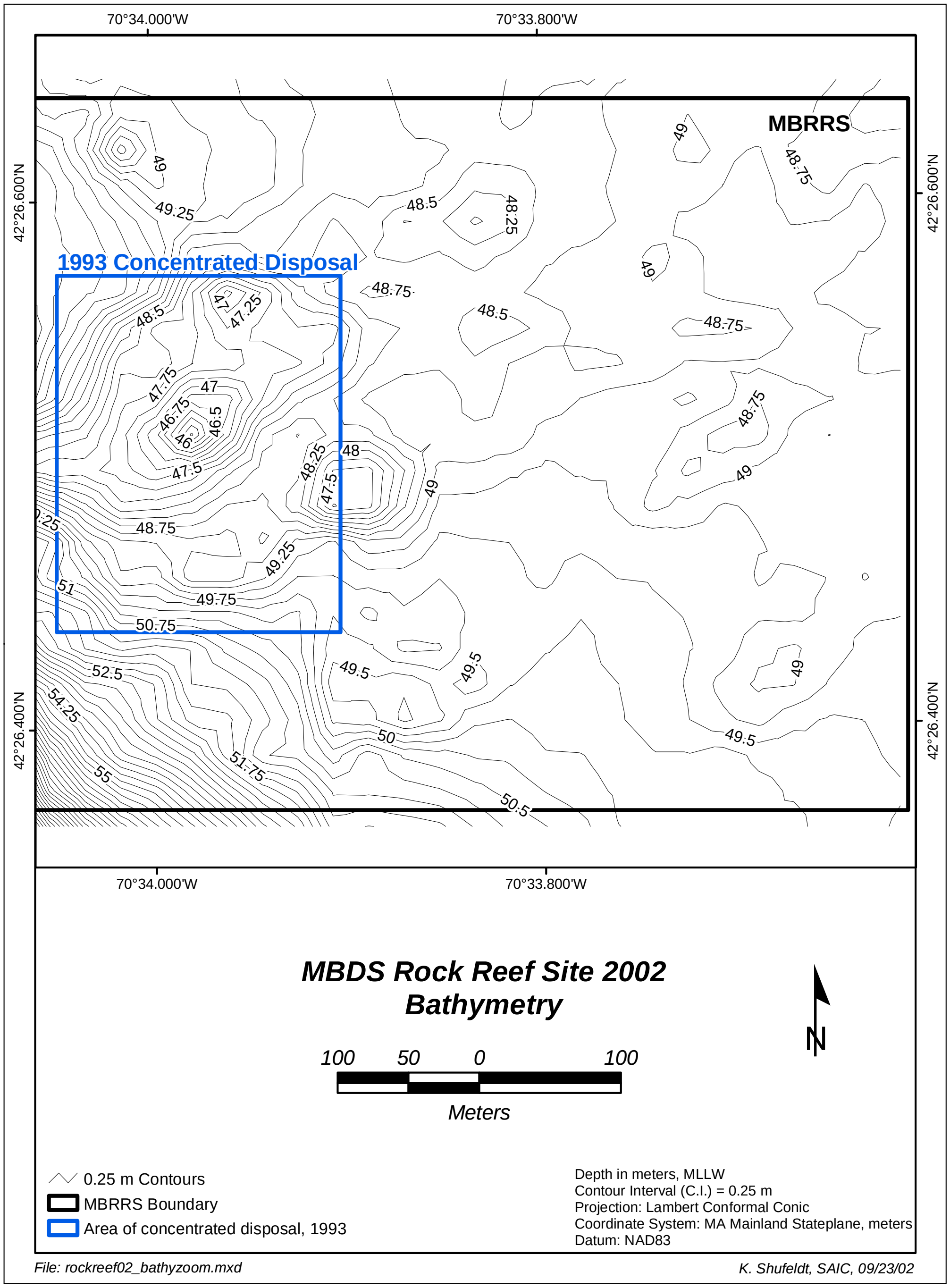


Figure 3-2. Bathymetric chart focusing on the center and eastern portions of MBRRS showing bottom features on the Massachusetts Bay seafloor formed by the deposition of rock, 0.25 m contour interval

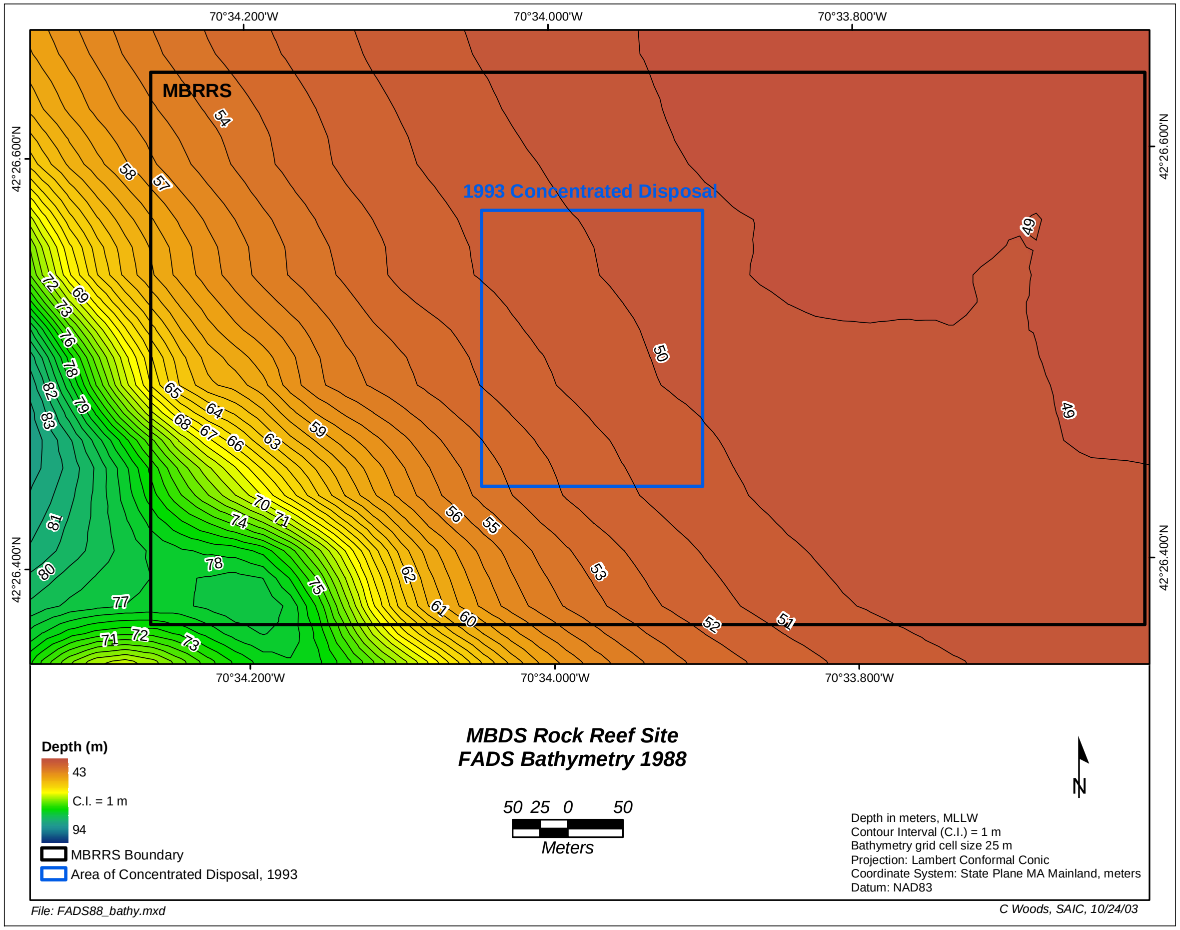


Figure 3-3. Bathymetric chart of the area surrounding MBRRS displaying seafloor topography as detected during the November 1988 master bathymetric survey of the Foul Area Disposal Site (FADS) prior to the placement of rock material, 1.0 m contour interval

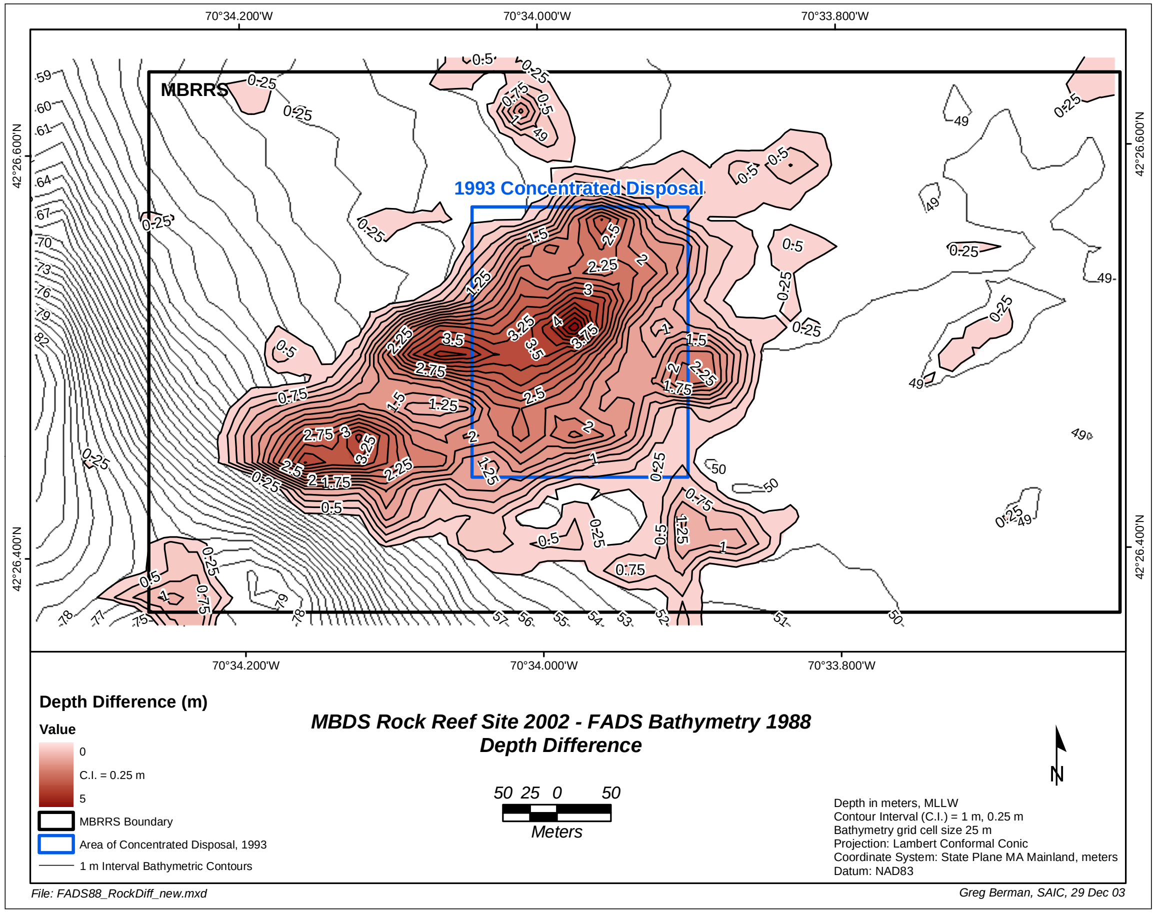


Figure 3-4. Depth difference comparison between the June 2002 and November 1998 bathymetric surveys displaying the morphology of the rock reef structure constructed on Stellwagen Bank in 1992 and 1993, 0.25 m contour interval

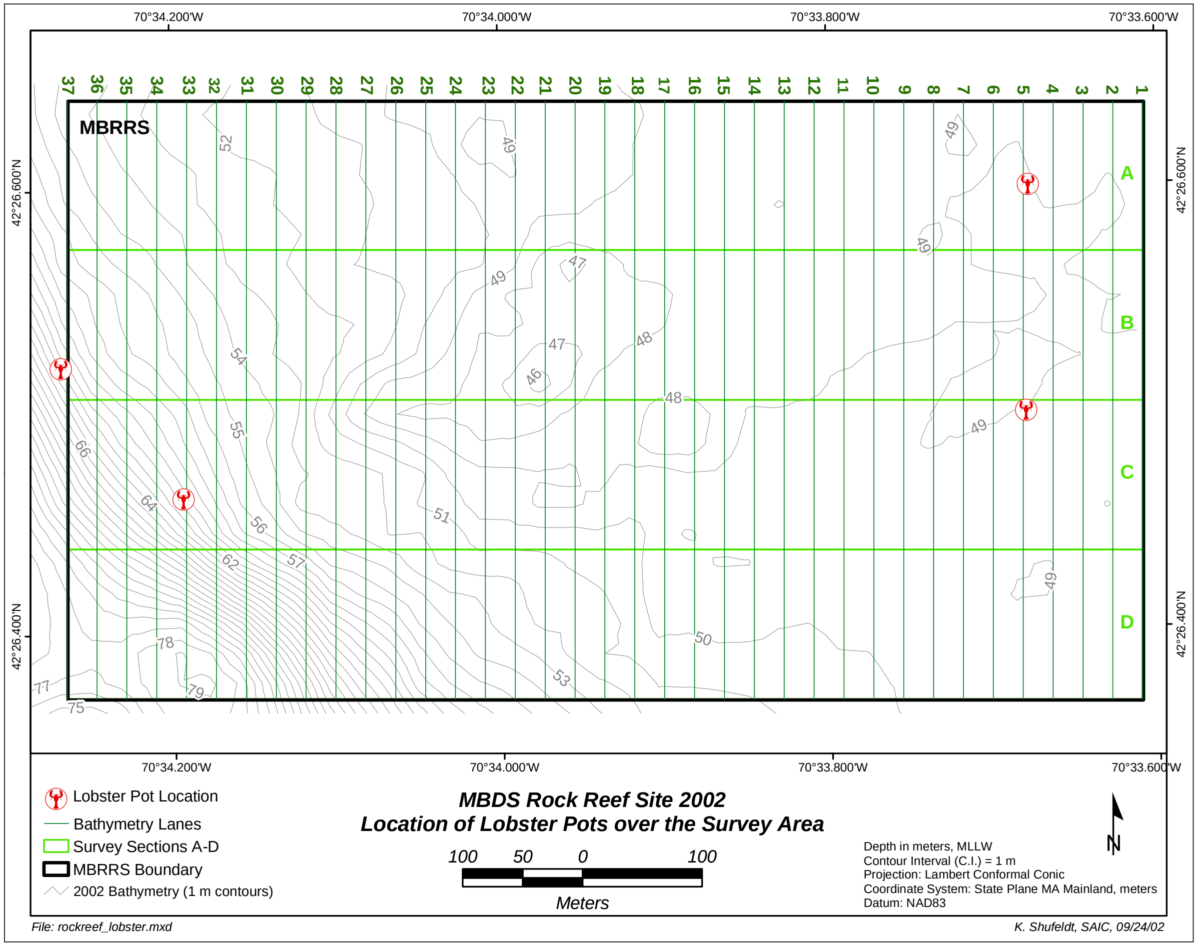


Figure 3-5. Plot of surface buoy locations designating lobster trap trawls deployed within the area relative to the bathymetric survey lanes and large-scale bottom features within MBRRS

3.2 Side-Scan Sonar

A complete 100 kHz image mosaic, representing 200% side-scan bottom coverage, was created for the entire MBRRS survey area (Figure 3-6). In the mosaic, darker areas represent stronger acoustic returns (higher reflectance) and indicate harder seafloor surface materials (i.e., rock deposits). The lighter areas of the mosaic represent weaker acoustic returns (lower reflectance) and indicate relatively softer seafloor surface material such as silt and sand. Although some resolution was lost when creating the small-scale mosaic over a large area, it provided a useful overview and enabled a broad seafloor characterization of the entire survey area.

Based on the full area mosaic, about half the survey area is characterized by higher reflectance, stronger acoustic returns that are indicative of high density rock and cobble deposits that are surrounded by finer-grained sediments comprised of silt and sand (Figure 3-6). Rather than a single dense reef at the site of the historic disposal, there are numerous elongated and overlapping deposits of rock with cobble at the periphery, ranging from 50 to 150 m in length. The spatial extent of the rock deposits extends slightly to the north and west of the MBRRS boundary, although it appears the swath coverage of the side-scan sonar imaged the majority of the rock placed at the site (Figure 3-6). A significant percentage of the rock appears to be concentrated near the center of MBRRS, as surface texture appears quite rough and irregular within the mosaic in that area (Figure 3-7A). In addition, isolated rock deposits located within the eastern portion of the survey area provide a strong contrast to the sands and silts of the smooth ambient seafloor (Figure 3-7B). Sand waves were present in sonar images obtained over the northernmost side-scan survey lanes (Figure 3-7C). These features are likely the product of sediment transport forced by the passage of storm-generated waves over this area of Stellwagen Bank. In the southwest corner of the site, lower reflectance returns indicate fewer rock deposits and a predominance of softer sediment (Figure 3-6). This area lies west of Stellwagen Bank within the deeper basin of Massachusetts Bay, which offers deeper water depths and ambient sediments composed of silty clay (SAIC 2002).

To correlate the acoustically visible rock deposits with the bathymetric features, the colorized bathymetry data were overlaid on the side-scan sonar mosaic (Figure 3-8). The rock deposit apex seen in the bathymetry (Figures 3-1 and 3-4) appears around the center of the feature seen in the mosaic, but many of the other deposits seen in the side–scan data do not have sufficient relief to appear in the 1 m color gradient of the bathymetric data overlay. At a smaller scale and color gradient, the isolated rock deposits on the eastern edge of the site begin to show some relief from the surrounding seafloor (Figure 3-9). At this scale, the rock deposit at the center of the site begins to more closely resemble the

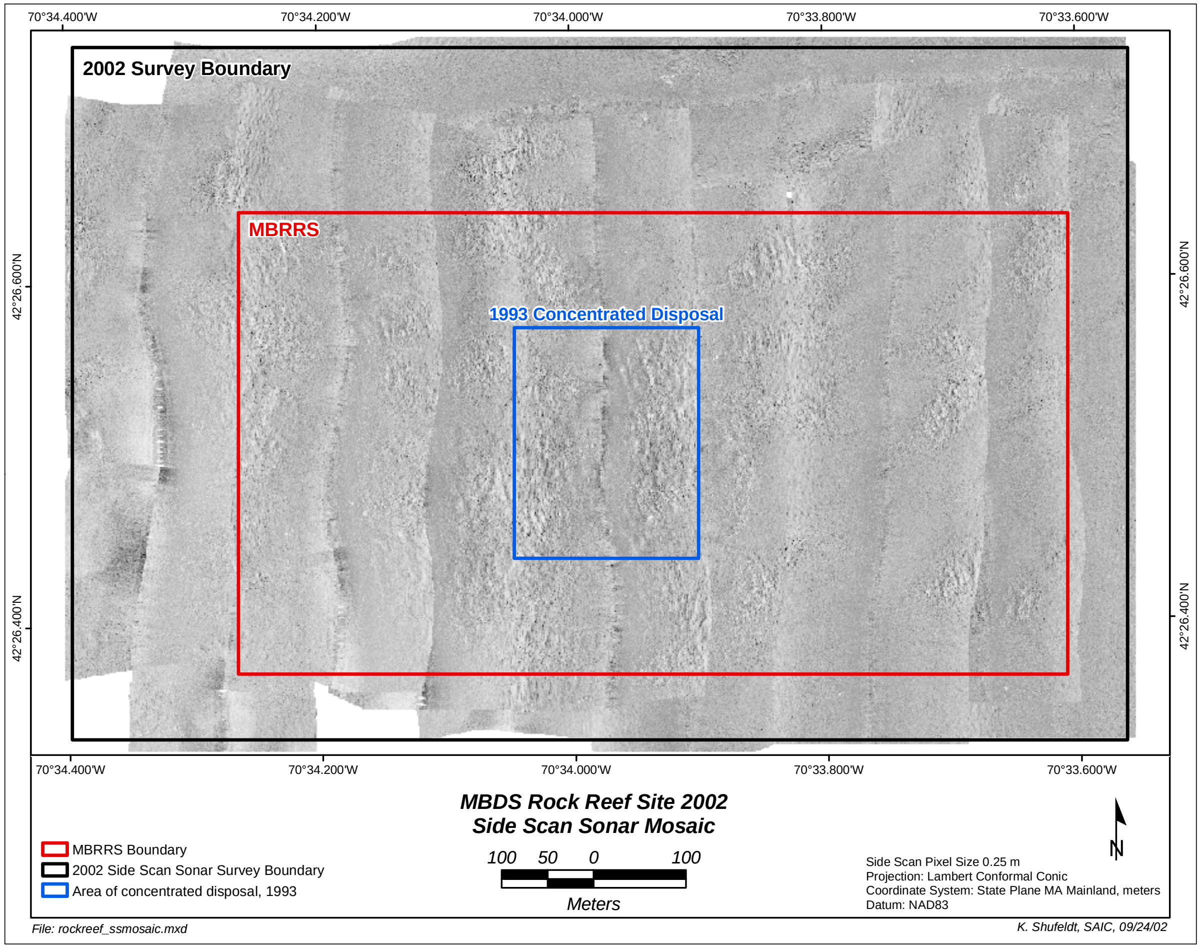


Figure 3-6. Side-scan sonar mosaic developed for MBRRS showing differences in surface texture and strength of acoustic return due to the presence of rock deposits on the seafloor

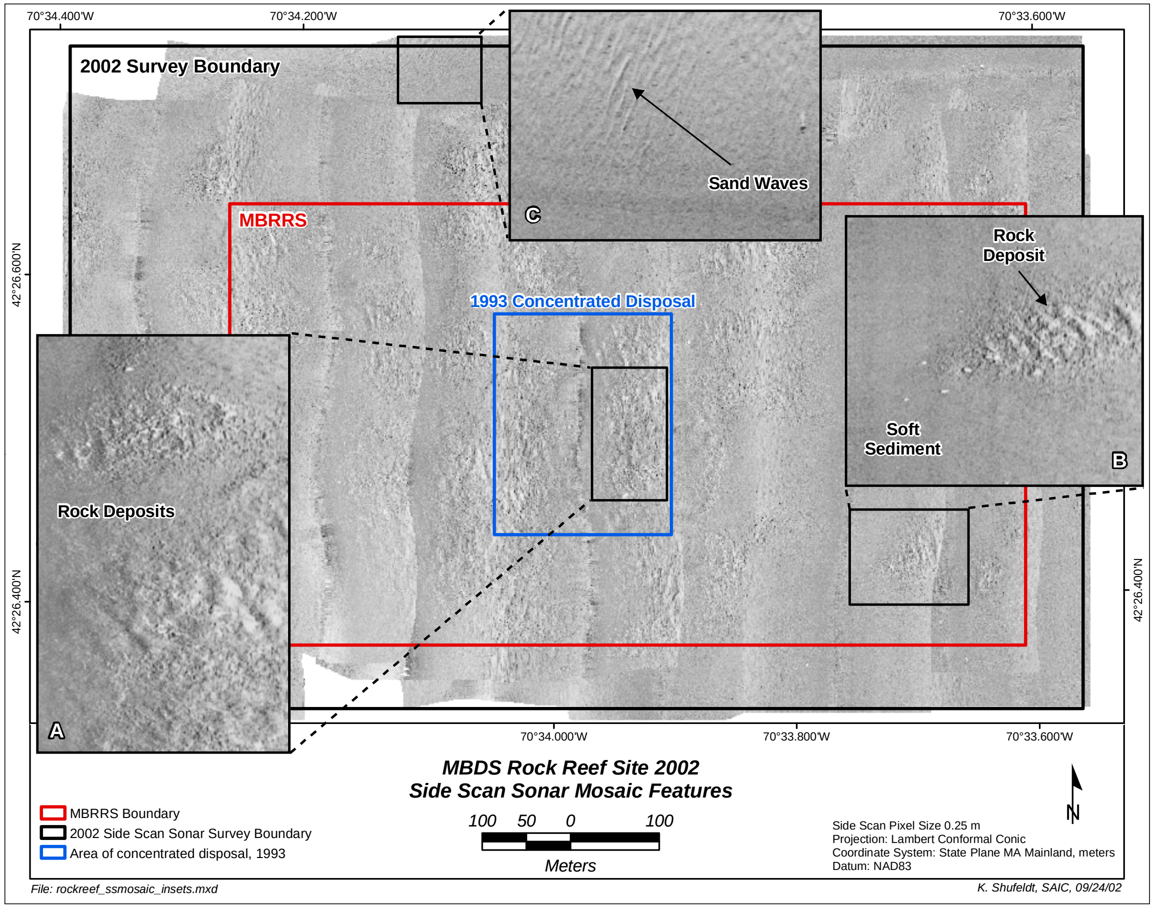


Figure 3-7. Results of side-scan sonar imagery collected over MBRRS showing seafloor composition over the area of concentrated disposal (A), contrast in acoustic signature between soft ambient sediments and a single rock deposit (B), and the presence of sand waves along the northern margin of the survey area (C)

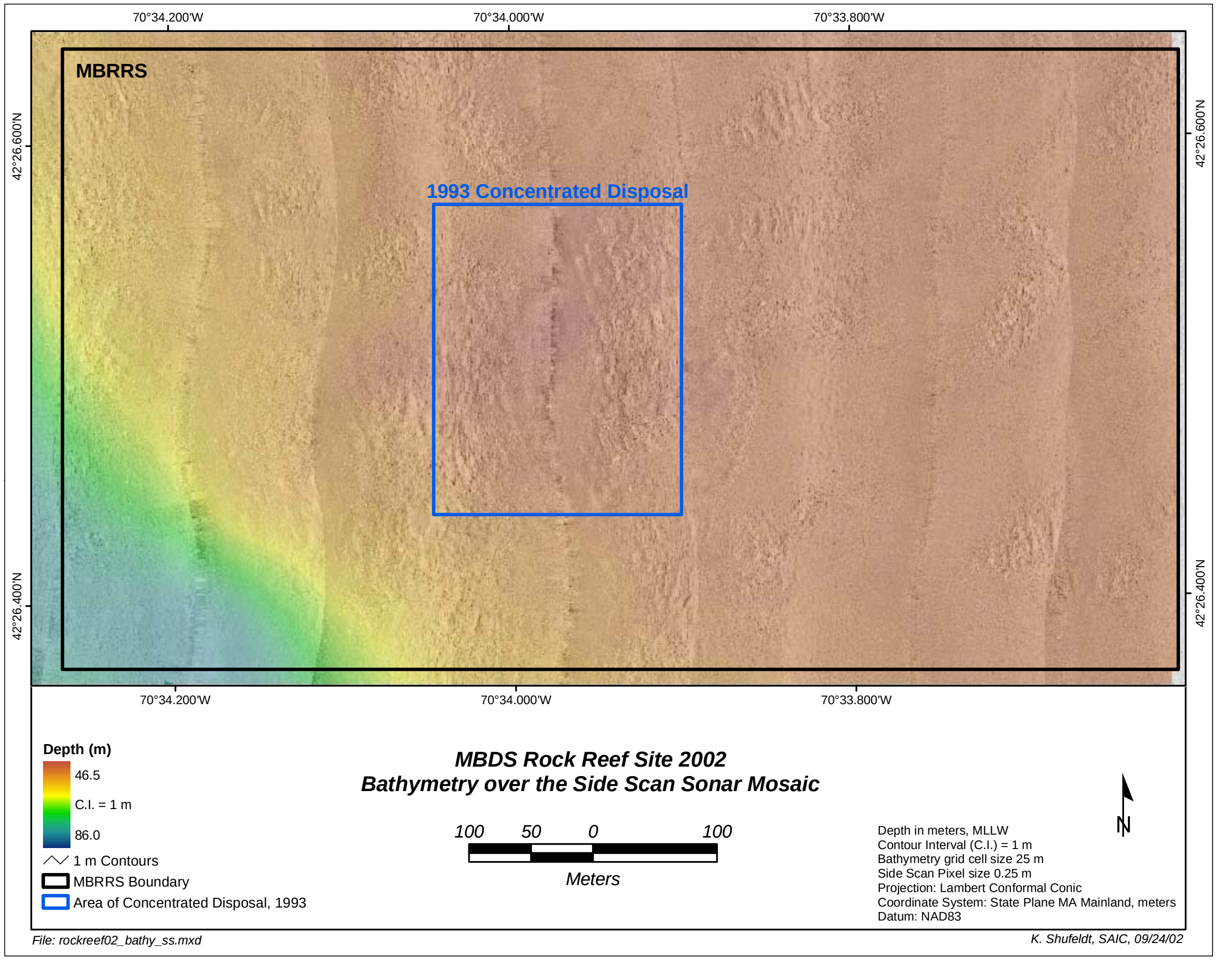


Figure 3-8. Composite graphic displaying the side-scan sonar mosaic overlain by bathymetry data to examine the relationship between seafloor topography and seafloor composition, 1 m color gradient

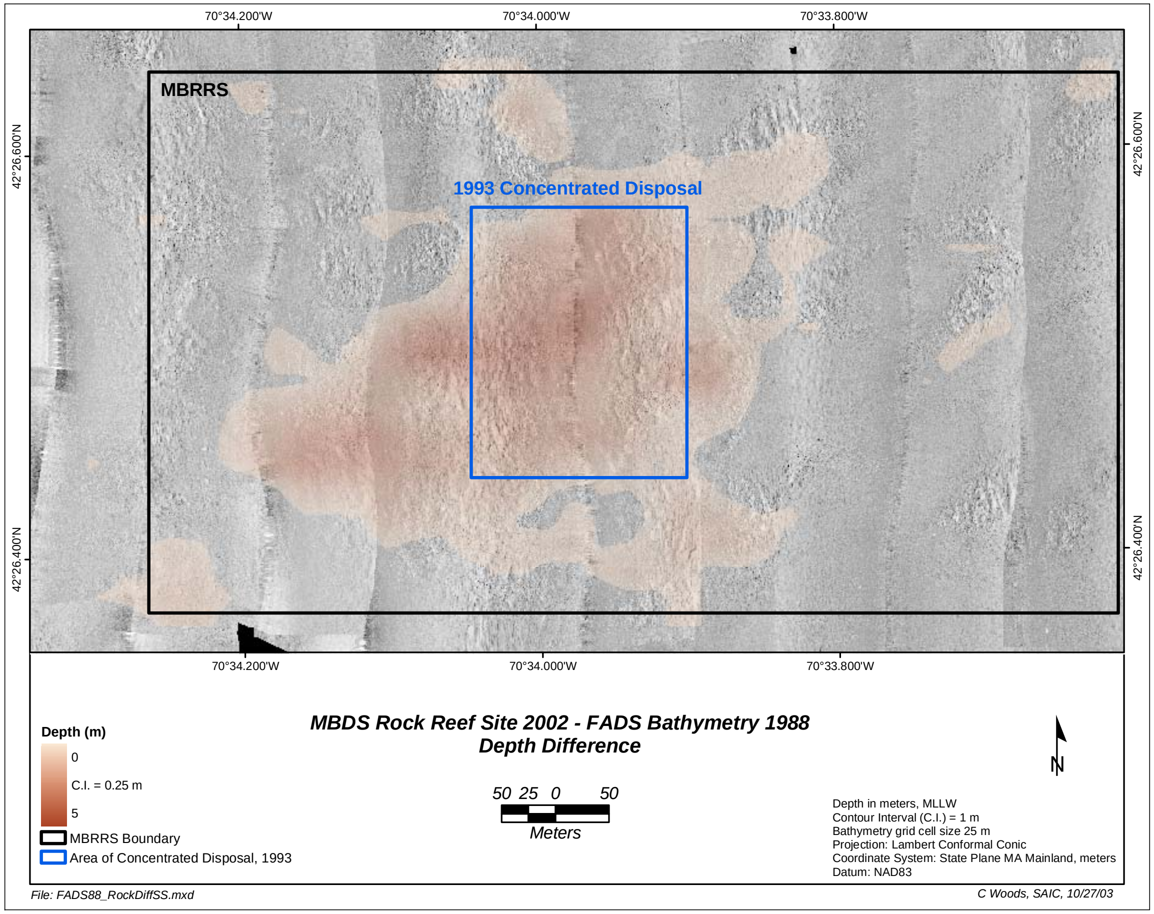


Figure 3-9. Composite graphic displaying the side-scan sonar mosaic overlain by bathymetric depth difference results showing the relationship between the morphology of the rock deposits and seafloor composition, 0.25 m color gradient

bathymetric data, with a center area of high relief with two smaller areas of relief to the north and east along the initial survey boundary.

3.3 Drop Video

The video data collected during the 10 July field operation indicated that the seafloor in the vicinity of MBRRS primarily consists of sandy, coarse-grained sediment overlain to varying degrees by cobbles, boulders, and gravel (Figure 3-10A). The seafloor in the regions immediately surrounding the rock deposits frequently consisted of greater than 50 percent sediment interrupted by patches of gravel and cobbles (Figure 3-10B). The seafloor within the area of concentrated rock placement usually consisted of hard substrate with cobble and boulders dominating (Figures 3-10C and D). The distribution of substrates tended to be patchy, with some smaller patches of sediment being interspersed with larger areas of hard substrate. A thin to moderate layer of fine-grained sediment and flocculent material covered many of the rock surfaces.

The sediment areas were usually inhabited by numerous *Cerianthus borealis* (burrowing cerianthid or mud anemone) and occasional *Myxicola infundibulum* (slime or fan worm; Table 3-1; Figure 3-11A). Cobbles were frequently heavily encrusted with an unidentified palmate white sponge (possibly belonging to the genus *Isodictya*) in areas that consisted of a mixture of cobbles and sediment (frequently at the periphery of the reef). This sponge appeared to exhibit growth forms ranging from a spreading knobby encrusting form to an upward form with flattened fingerlike branches. Boulders in the reef area were commonly colonized by *Haliclona oculata* (finger sponge) and *Suberites ficus* (fig sponge) on the tops of boulders, and *Terebratulina septentrionalis* (northern lamp shell, a brachiopod) and *Halocynthia pyriformis* (sea peach tunicate) on the sides of boulders (Table 3-1; Figure 3-11B). The shells of the brachiopods were frequently colonized by an encrusting white sponge. Larger boulders were also frequently colonized by *Urticina felina* (northern red anemone), *Boltenia ovifera* (stalked tunicate), unidentified yellowish encrusting sponges (possibly *Cliona* spp.—boring sponge), some larger encrusting sponges (possibly *Haliclona* spp. and *Halochondria* spp.), and unidentified beige (possibly bryozoans) and whitish (possibly bryozoans and/or colonial tunicates) encrusting organisms. Several frilled anemones (*Metridium senile*) were also observed.

Area coverage of encrusting organisms ranged from 5 to 25 percent cover in the cobble areas dominated by the palmate sponge to 1 to 5 percent cover in the boulder areas. Generally, encrusting organisms accounted for less than 5 percent cover. Part of the reason why these small percentages of encrusting organisms were observed may be related to the moderate layer of soft sediment and flocculent material seen on many of the rock

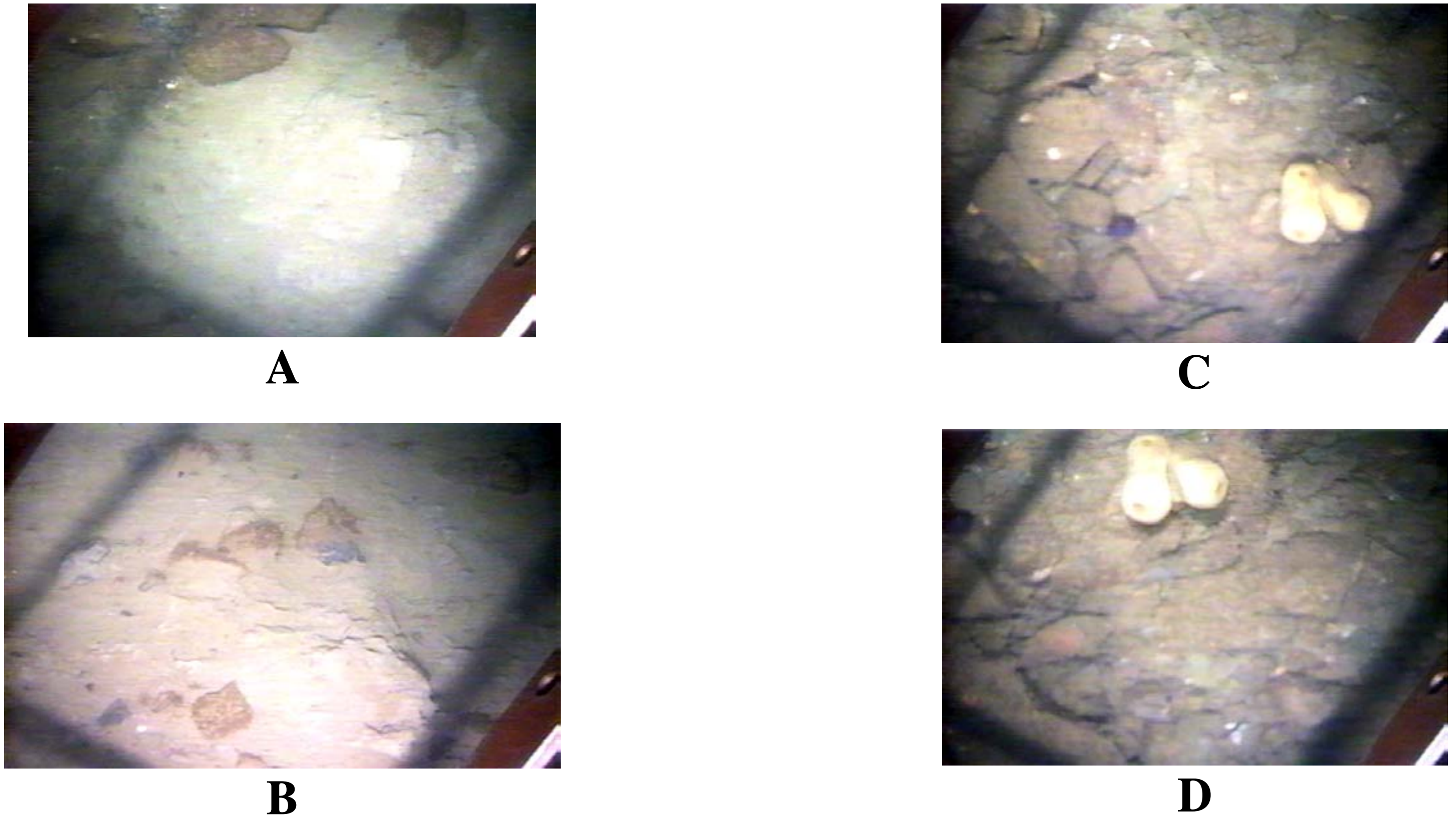


Figure 3-10. Example images obtained from the drop video footage collected over MBRRS showing the various sediment types encountered during the 2002 monitoring survey. The images above depict the following: Sandy, coarse-grained sediment overlain to varying degrees by cobbles, boulders, and gravel (A); greater than 50 percent sediment interrupted by patches of gravel and cobbles (B); and hard substrate with cobble and boulders dominating (C and D).

A

B

Figure 3-11. Example images obtained from the towed video footage showing a mud anemone (*Cerianthus borealis*; A) and a finger sponge (*Haliclona oculata*; B) detected on the seafloor within MBRRS

Table 3-1. List of Organisms Encountered in the Drop Video Survey Performed over MBRRS

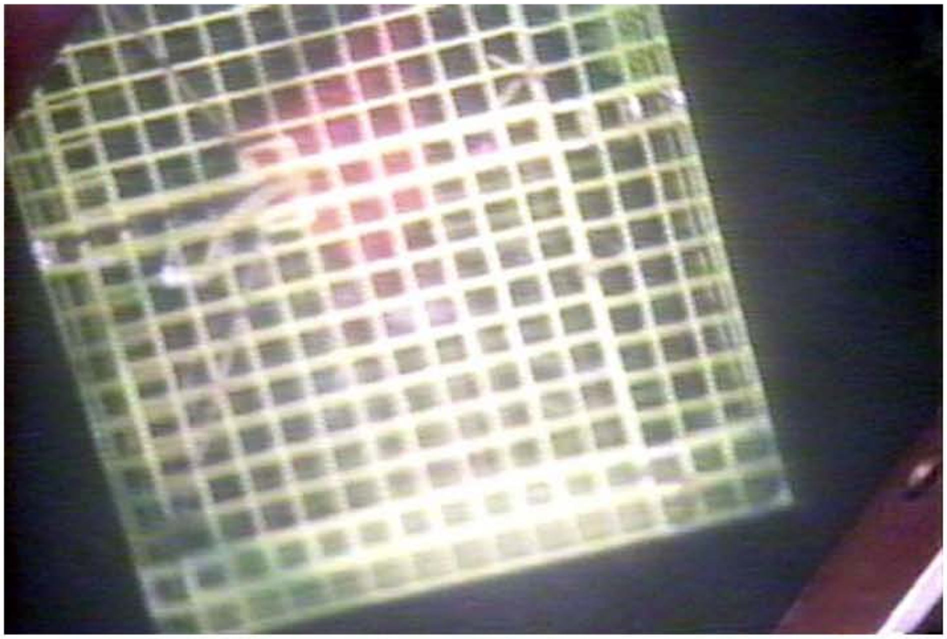
Taxa	**Common name**	**Abundance**	**KEY**	**Habitat**
Isodictya spp.?	white knobby sponge (palmate)	abundant	Rare:	cobbles
Cliona spp.?	boring sponge	few	1-5 individuals	boulders
Halchondria spp.?	crumb of bread sponge	rare		boulders
Haliclona oculata	finger sponge	very common	Few:	boulders
Haliclona spp.?	encrusting sponge	rare	>15 individuals	boulders
Suberites ficus	fig sponge	common		boulders
Corymorpha pendula	stalked solitary hydroid	rare	Common:	sediment
Urticina felina	northern red anemone	few	approximately	cobbles and boulders
Metridium senile	frilled anemone	rare	100 individuals	boulders
Cerianthus borealis	burrowing mud anemone	very common		sediment
Myxicola infundibulum	slime or fan worm	common	Very Common:	sediment
Neptunea decemcostata	ten-ridged whelk	rare	approximately	
Porania insignis	badge star	rare	200 individuals	boulders
Hippasteria phrygiana	horse star	rare		boulders
Asterias vulgaris	northern sea star	few-common	Abundant:	cobbles
Henricia sanguinolenta	blood sea star	few-common	>1000 individuals	boulders
Crossaster papposus	spiny sunstar	few-common		cobbles and boulders
Solaster endeca	smooth sunstar	rare		boulders
Homarus americanus	northern lobster	rare		boulders
Boltenia ovifera	stalked tunicate	few		boulders
Halocynthia pyriformis	sea peach tunicate	common		boulders
Terebratulina septentrionalis	northern lamp shell – brachiopod	common		boulders
	beige encrusting	few		boulders
	whitish encrusting (bryozoan?)	few		boulders
Tautogolabrus adspersus	cunner	few-common		boulders
Myxocephalus spp.	sculpin	rare		sediment
Gadus morhua	cod	rare		boulders
Hemitripterus americanus?	sea raven	rare		cobbles and boulders
Macrozoarces americanus	ocean pout	rare		cobbles and boulders
	flounder	rare		sediment
	skate	rare		sediment
	hake	rare		cobbles

surfaces. The sediment drape likely accumulates on the rock surface between ocean storm events and could contribute to smothering of thin encrusting forms and interfere with settlement cues of larvae.

Apart from sessile organisms, the video data suggests the reef structure offers suitable habitat for various higher forms of marine invertebrates and geo-tactile finfish. Several species of asteroids were seen in and around the reef (Table 3-1). The most common sea stars encountered were the northern sea star, *Asterias vulgaris*, which was most common in sediment and cobble areas, and the blood sea star, *Henricia sanguinolenta*, which was most common in boulder areas. Numerous unidentified small white sea stars were also commonly seen in the boulder areas. Two species of sunstars also occurred throughout the reef area, including numerous spiny sunstars, *Crossaster papposus*, and occasional smooth sunstars, *Solaster endeca*. Two other species of asteroids were also seen, *Porania insignis* (the badge star) and *Hippasteria phrygiana* (the horse star).

Several other species of invertebrates, *Corymorpha pendula* (a stalked solitary hydroid), *Neptunea decemcostat* (the ten-ridged whelk), and *Homarus americanus* (the northern lobster) were only seen once during the survey (Table 3-1). Although abundance of lobster was low based on the drop video data, several sets of lobster fishing gear were documented on site (Figure 3-5). The video imagery revealed the presence of both actively fished and abandoned lobster gear, suggesting this area may have developed into a relatively productive lobster fishing area over the past ten years (Figure 3-12).

The most common finfish observed was the cunner, *Tautogolabrus adspersus*, which was only seen in the vicinity of boulders (Figure 3-13). The second most common fish seen were sculpin (*Myxocephalus* spp.), which were usually seen in areas of sediment and cobbles. Other fish seen included several flounder, several ocean pout (*Macrozoarces americanus*), two cod (*Gadus morhua*), two hake, a skate, one possible sea raven (*Hemitripterus americanus*), and eight other unidentified fish.



A

B

Figure 3-12. Example images obtained from the towed video footage showing actively fished (A) and abandoned (B) lobster traps within MBRRS

Figure 3-13. Example image obtained from the towed video footage showing small cunner (*Tautogolabrus adspersus*) in the upper left quadrant of the image inhabiting the rock reef structure

4.0 DISCUSSION

4.1 Biological Status

The placement of 546,000 m³ of rock north of the current MBDS a decade ago was seen as a beneficial use of this dredged material by providing habitat diversity over a homogenous silty sand substrate at the western edge of Stellwagen Bank. The data collected over MBRRS during the 2002 survey indicate that the placement of rock has resulted in a substantial change in the physical properties of the substrate within an area approximately 0.16 km² in size. Although the change in substrate has promoted increased species diversity within the area, the findings of the summer 2002 study suggest the overall abundance of epifaunal organisms (encrusting growth) is low relative to similar deep-water, rocky habitats in New England waters.

The types of benthic fauna observed colonizing MBRRS are characteristic of those inhabiting other deep water sites of Stellwagen Bank, Massachusetts Bay, and the Gulf of Maine, in general. However, the density of organisms inhabiting the boulder habitats within MBRRS was lower than that found at a number of rocky offshore sites. This difference in population density may be indicative of physical differences between the MBRRS and some of the more studied offshore Gulf of Maine sites, in terms of availability of suitable substrates, settlement of fine-grained sediments, and food supply.

Cerianthid anemones were the most common organisms seen in the sediment areas of the MBRRS. These burrowing anemones are one of the most commonly found organisms in deep-water gravelly to sandy substrates in Massachusetts Bay (Blake et al, 1998; Valentine et al., 1999), the Gulf of Maine (Watling, 1998), and along the northeastern coast of the United States (Hecker et al., 1979,1980, 1983; Hecker, 1990, 1994). All of the cerianthids seen during this survey were adults and were likely inhabiting the soft sediments between the individual rocks (interstitial spaces) rather than being attached to the rock substrate itself. Since this species is believed to be quite long lived (>50 years), it is likely that many of the individuals seen during the drop video survey represent animals that survived the initial placement events rather than animals that colonized afterward. The other species seen on the softer sediments at the MBRRS are also characteristic of sediment habitats in western Massachusetts Bay (Blake et al., 1998; Kropp et al., 2000).

The dominant organism seen in the cobble areas was an unidentified white sponge that had a variable growth form, ranging from a short knobby club to a flattened palmate branching type. In its palmate form it resembled members of the genus *Isodictya*. Similar unidentified sponges have commonly been seen in the Stellwagen Bank region (NOAA

Stellwagen Bank website; http://www.santuaries.nos.noaa.gov) and during a 1996 survey of MBDS (Valentine et al., 1999). Similar sponges were seen in a deep-water cobble habitat located in the western part of Massachusetts Bay (Hecker, unpublished data). The other common inhabitant of the cobble areas was the sea star *Asterias vulgaris*, which is another common species in western Massachusetts Bay (Blake et al., 1998, Kropp et al., 2000).

The fauna inhabiting the boulders at the MBRRS were all species that are common throughout Massachusetts Bay and the Gulf of Maine region. The species and faunal densities observed during the present survey are similar to those seen in previous photographs taken at this site (Valentine et al., 1999) and in the western Massachusetts Bay (Blake et al, 1998; Kropp et al, 200; Hecker, unpublished data). The species densities were similar to those observed in the vicinity of the MBDS by Valentine et al. (1999). Although strict comparisons of faunal density cannot be made between the two surveys due to differences in sampling techniques, it appeared that the unidentified white sponge found on cobbles might have been more abundant during the present survey (2002) than it was in 1996.

Despite the dissimilarity to others surveys (Witman and Sebens, 1990; Witman, 1998), a qualitative comparison of the summer 2002 data shows that the densities noted at MBRRS are considerably lower than those shown in photographs obtained at many of the more exposed offshore ledges that exist in the Gulf of Maine. The rock surfaces at these ledge sites tend to be heavily colonized by sponges, tunicates, brachiopods, and anemones. However, the rock surfaces at these sites frequently consist of sheer walls that remain relatively free of sediment drape. In contrast, as indicated in the drop video results section above, much of the rocky substrate at MBRRS was covered by fine-grained sediment and flocculent material. The presence or absence of sediment drape has been found to be a major determinant of benthic community structure at rocky habitats in western Massachusetts Bay (Blake et al., 1998; Kropp et al, 2000). The configuration of the rock surfaces at MBRRS, generally consisting of boulders in widely distributed piles with a relatively low slope, establish conditions where deposition could occur given a source of material and lack of sufficient current velocities to subsequently erode it. The observations of a thin sediment drape at MBRRS indicate that the site is located in a sedimentary regime that is apparently prone to moderate dusting with sediment and flocculent particles.

The sediment drape on the rocks has likely delayed and/or prevented colonization of much of the substrate within MBRRS by sessile organisms; possible mechanisms include interference with settlement cues required by larvae, and sediment loading causing smothering of existing encrusting forms. Additionally, the lack of sediment drape at some of the ledge sites in the Gulf of Maine suggests the presence of higher current velocities relative to MBRRS, which would prevent the long-term formation of sediment cover. A more energetic system (i.e., greater current velocities) could also provide increased food resources and well-oxygenated waters to support higher densities of suspension feeders (Leichter and Witman, 1997; Atlantic and Gulf States Marine Fisheries Commissions, 1998). In addition, the higher current velocities increase the productivity of these reef features by preventing the formation of a sediment drape, which can prevent settlement and/or smother settling forms of larvae (Atlantic and Gulf States Marine Fisheries Commissions, December 1998).

Mobile organisms inhabiting the reef were also relatively sparse during the summer 2002 survey, but this may partially be an artifact of the survey technique. Many of the tactile fish and crustaceans attracted to "reef" habitats respond to the structural complexity afforded by the reef because it provides them with suitable places to hide from potential predators. Thus, a drop video system with a small field of view (downward looking) and a slow speed (drift) substantially underestimates the density of such highly mobile individuals (Hecker, unpublished data). Future surveys of this site should be conducted with a more continuous visualization technique and higher quality images, such as those associated with vehicles that are separated from the surface motion of the ship. Additionally, visualization of some of the more mobile organisms, including commercially important crustaceans and finfish, would be greatly enhanced by utilizing a system that has the ability to look forward, as well as under and behind rocks. An ideal appraoch for accomplishing this would be to conduct a survey with a remotely operated vehicle (ROV) at specified locations within the reef site.

4.2 Recommendations for Increasing Productivity

Marine resource and regulatory agencies along the eastern seaboard have recognized the potential biological and economic benefits of constructing artificial reefs along the coast in areas of moderate and deep water depth. Many members of the marine science community view the distinct changes in substrate and seafloor topography provided by artificial reef systems as beneficial to marine organisms by providing habitat diversity. The construction of an artificial reef in an otherwise homogeneous environment increases the surface area of hard substrate, promoting the settlement of larval forms of encrusting invertebrates, as well as providing tactile fish with increased forage and protection from larger pelagic predators. But since many of these reefs were established less than 15 years ago, data confirming the long-term benefits of these man-made features remain relatively sparse.

Studies of rock ledge and seamount habitats indicate areas of seafloor offering abrupt changes in vertical relief tend to support high densities of suspension feeders and encrusting organisms. Areas of strong seafloor relief often display higher current speeds over the hard substrate relative to low profile areas of seafloor since the water mass driven by tidal currents must move horizontally or vertically to bypass the obstruction. Furthermore, these sheer ledge and reef features often rise to a significant height above the seafloor and interact with water column currents that tend to be stronger than those along the bottom.

The information obtained from the summer 2002 survey at MBRRS indicates that ambient hydrodynamic conditions are not sufficient to prevent accumulations of fine-grained sediment and organic flocculent material. The most recent study over MBRRS suggests species abundance has improved with respect to the pre-reef conditions, indicating that the reef has provided some increased habitat diversity in the area. Additionally, low-profile reefs may provide more suitable habitat areas for demersal species than pelagic species (Atlantic and Gulf States Marine Fisheries Commissions, 1998), and the survey methods used to date were not very successful at documenting motile macrofauna at the site. Potential reef enhancements to try to foster a hard-bottom community comparable to other natural rocky/reef settings in Massachusetts Bay would require additional evaluation and planning. More detailed information on the current regime throughout the water column, and comparison to the currents and topography that exist at more successfully colonized, natural reef sites, would be helpful in doing this.

Although the morphology of the rock reef differs somewhat from other artificial reef structures along the east coast, it is possible that the productivity and overall habitat value of this rock reef at MBRRS could be enhanced through the strategic placement of additional volumes of rock at one or more well-defined locations. The key elements to this effort would be to tightly control rock placement to a few (one to four) well-defined locations, with the goal of constructing rock deposits with a height above the seafloor that permits interaction with water column currents at speeds regularly exceeding 20 $cm \bullet sec^{-1}$, to prevent the settlement of fine-grained material. The ideal height of these individual bottom features would be dependent upon the water column current regime. As a result, future monitoring of MBRRS should include an assessment of water column current velocities in order to better characterize the depositional/erosional attributes of the site in relation to the natural mechanisms for sediment transport.

In the event that large volumes of rock become available as part of future dredging projects, this material could be directed to MBRRS and strategically placed over the existing reef. By focusing rock deposition to one or more specific locations, the vertical relief and surface area of the bottom features would rapidly increase with relatively small amounts of material. The highest point on the existing rock reef (5 m of relief, 46 m depth) is located at 42° 26.500´ N, 70° 33.960´ W. The placement of another significant volume of rock at this location would drastically increase seafloor relief to levels that could promote interaction with stronger water column currents. These currents would need to be of sufficient velocity to prevent the formation of a sediment drape and contain enough planktonic biomass to provide a robust food source for suspension feeders likely to colonize the reef.

5.0 CONCLUSIONS

- The excavated rock material placed within the MBRRS consists of numerous elongated and overlapping deposits of rock within a 0.45 km^2 area. The rock deposits range in length from 50 to 150 m and generally correlate with the positions reported in disposal barge logs. The seafloor adjacent to the individual rock deposits consists of sandy, coarse-grained sediment overlain to varying degrees by cobbles, boulders, and gravel.

- Although rock deposits were observed throughout the survey area, a significant percentage of the rock appeared to have accumulated in a 0.05 km^2 area near the center of MBRRS. This feature is the product of concentrated placement of rock during 1993 disposal operations. This area of seafloor now consists of a hard substrate with cobble and boulders found in abundance intermixed with patches of natural sediments consisting of sand and gravel. Bathymetry data indicate this central reef structure is approximately 5 m high at the apex and 600 m in diameter, with most of the reef structure having somewhat lower vertical relief (2 – 3 m). The morphology of the reef feature may be exaggerated somewhat by survey artifacts in the southwest region, where the topography is steeper due to the pre-existing relief associated with Stellwagen Bank.

- Drop video footage indicates various types of sponges, bryozoans, and tunicates compose the sessile community encrusting the rocky substrate, while mud anemones were established in the softer sediments surrounding the rock deposits.

- The density of encrusting organisms ranged from 5 to 25 percent cover in the cobble areas and 1 to 5 percent cover in the boulder areas ten years after placement. The reef provides increased species diversity and habitat structure compared to pre-reef conditions. However, the density of encrusting growth appears low when compared to other areas of hard substrate at equivalent water depths along the coast of New England. The presence of a thin to moderate layer of sediment on many of the rock surfaces may be inhibiting more successful colonization of the harder substrate as this flocculent material may contribute to smothering of thin encrusting organisms and interfere with settlement cues of larvae.

- Motile organisms inhabiting the reef include larger invertebrates (gastropods, sea stars, and lobster) and finfish. Relatively low numbers of commercially important species were detected during the drop video survey; however, the presence of actively fished and abandoned lobster gear suggests this area of seafloor may have developed into a relatively productive lobster fishing area over the past ten years.

Due to the limitations associated with a downward-looking video system, a different approach to data collection (i.e., ROV survey) is recommended if a detailed assessment of motile macrofaunal use of the rock reef is conducted in the future.

- The controlled placement of additional volumes of rock material from future dredging projects could be used to change the morphology of the existing reef. However, an assessment of the current structure throughout the water column, as well as a comparison to current regimes at other natural reef sites would be required prior to additional placement to determine if reef conditions could be improved. Provided the current regime indicates higher current velocities are common above the current reef top, the focused disposal of rock at one to four locations on the existing rock reef would increase the vertical relief of the bottom feature and permit interaction with strong water column currents. This may help prevent the formation of a sediment drape on the rock surface and provide a more robust food supply for sessile, suspension feeders, promoting increased population densities and productivity.

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APPENDIX A

Appendix A, Disposal Logs

Year: 1992 **Disposal Site: MBDS** **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	6/2/92	6/3/92	6/3/92	42.44166667	-70.5655		3000
NA	6/3/92	6/3/92	6/4/92	42.44166667	-70.5675		4000
NA	6/8/92	6/9/92	6/9/92	42.44284809	-70.5662338		4000
NA	6/9/92	6/9/92	6/9/92	42.44096479	-70.5668338		3000
NA	6/10/92	6/10/92	6/10/92	42.44171477	-70.5687505		4000
NA	6/11/92	6/11/92	6/11/92	42.44244809	-70.5693506		3000
NA	6/12/92	6/12/92	6/12/92	42.44258142	-70.5678672		4000
NA	6/12/92	6/13/92	6/13/92	42.44356476	-70.5649671	150' se	3000
NA	6/14/92	6/14/92	6/14/92	42.44168144	-70.5660838		1500
NA	6/15/92	6/15/92	6/15/92	42.44198143	-70.5666005		2000
NA	6/15/92	6/16/92	6/16/92	42.44313142	-70.5659505	ON COORD	4000
NA	6/16/92	6/16/92	6/16/92	42.44169811	-70.5671505	ON COORD	3000
NA	6/17/92	6/17/92	6/17/92	42.44284809	-70.5662338	ON COORD	4000
NA	6/17/92	6/17/92	6/17/92	42.44328142	-70.5663338	ON COORD	3000
NA	6/18/92	6/18/92	6/18/92	42.44256477	-70.5662671	ON COORD	4000
NA	6/18/92	6/18/92	6/18/92	42.44169811	-70.5666171	ON COORD	3000
NA	6/19/92	6/19/92	6/19/92	42.44269809	-70.5663838	ON COORD	4000
NA	6/19/92	6/19/92	6/20/92	42.4440314	-70.5677172	ON COORD	3000
NA	6/20/92	6/20/92	6/20/92	42.44256477	-70.5665338	ON COORD	4000
NA	6/21/92	6/21/92	6/21/92	42.44244809	-70.5685505	ON COORD	3000
NA	6/22/92	6/22/92	6/22/92	42.44183144	-70.5659338	ON COORD	4000
NA	6/23/92	6/23/92	6/23/92	42.44198144	-70.5663338	ON COORD	3000
NA	6/23/92	6/24/92	6/24/92	42.4425481	-70.5660005	ON COORD	4000
NA	6/24/92	6/25/92	6/25/92	42.44211478	-70.5659171	ON COORD	3000
NA	6/25/92	6/25/92	6/25/92	42.44124812	-70.5660005	ON COORD	4000
NA	6/25/92	6/25/92	6/26/92	42.44183144	-70.5659338	ON COORD	3000
NA	6/26/92	6/26/92	6/26/92	42.44096479	-70.5657671	ON TARGET	4000
NA	6/27/92	6/27/92	6/27/92	42.44168144	-70.5660838	ON COORD	3000
NA	6/29/92	6/29/92	6/29/92	42.44183144	-70.5659338	ON COORD	4000
NA	6/29/92	6/29/92	6/30/92	42.44154811	-70.5667671	ON COORD	3000
NA	6/30/92	6/30/92	7/1/92	42.4406648	-70.5657838	ON TARGET	3500
NA	7/1/92	7/1/92	7/1/92	42.44139812	-70.5655838	ON TARGET	3800
NA	7/2/92	7/2/92	7/2/92	42.44169811	-70.5663505	ON TARGET	3600
NA	7/3/92	7/3/92	7/3/92	42.44198144	-70.5663338	ON COORD	3000
NA	7/20/92	7/21/92	7/21/92	42.44243142	-70.5674838	50.0 SOU	3600
NA	7/21/92	7/21/92	7/21/92	42.4418481	-70.5672838	50.0 SOU	3800
NA	7/22/92	7/22/92	7/23/92	42.44039813	-70.5661004	50.0 SOU	4000
NA	7/23/92	7/23/92	7/23/92	42.44303141	-70.5682339	50.0 SOU	3000
NA	7/23/92	7/23/92	7/23/92	42.44108145	-70.5658671	50.0 SOU	4000
NA	7/24/92	7/24/92	7/24/92	42.44203143	-70.5666338	20.0 NOR	3000
NA	7/24/92	7/24/92	7/25/92	42.44108145	-70.5658671	60.0 SOU	4000
NA	7/25/92	7/25/92	7/25/92	42.44153145	-70.5654338	50.0 SOU	3000

Year: 1992 **Disposal Site: MBDS** **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	7/26/92	7/26/92	7/26/92	42.4423481	-70.5666171	20.0 NOR	4000
NA	7/26/92	7/26/92	7/27/92	42.44281476	-70.5670172	50.0 NOR	3000
NA	7/27/92	7/27/92	7/27/92	42.4423481	-70.5666171	50.0 SOU	4000
NA	7/27/92	7/27/92	7/28/92	42.4409148	-70.5654671	100.0 SOU	3000
NA	7/27/92	7/28/92	7/28/92	42.44013146	-70.5669338	50.0 SOU	5000
NA	7/28/92	7/28/92	7/28/92	42.4402648	-70.5665171	50.0 SOU	4000
NA	7/28/92	7/29/92	7/29/92	42.44108144	-70.5677172	50.0 SOU	4000
NA	7/30/92	7/30/92	7/30/92	42.44074813	-70.5650504	ON COORD	3000
NA	7/31/92	7/31/92	7/31/92	42.44258142	-70.5668172	ON COORD	3000
NA	7/31/92	7/31/92	7/31/92	42.44179811	-70.5664505	ON COORD	4000
NA	8/1/92	8/1/92	8/2/92	42.44166478	-70.5668671	ON COORD	4000
NA	8/2/92	8/2/92	8/2/92	42.44203143	-70.5666338	50.0 SOU	3000
NA	8/3/92	8/3/92	8/3/92	42.44258142	-70.5668172	ON COORD	4000
NA	8/3/92	8/3/92	8/3/92	42.44163144	-70.5660338	50.0 SOU	3000
NA	8/4/92	8/4/92	8/5/92	42.44221477	-70.5670338	50.0 SOU	4000
NA	8/5/92	8/5/92	8/5/92	42.44118145	-70.5664671	30.0 SOU	3500
NA	8/5/92	8/6/92	8/6/92	42.44186478	-70.5662338		3800
NA	8/6/92	8/6/92	8/6/92	42.44186478	-70.5662338	ON COORD	3000
NA	8/7/92	8/7/92	8/7/92	42.44203143	-70.5666338	ON COORD	4000
NA	8/7/92	8/7/92	8/8/92	42.4420981	-70.5664338	ON COORD	3000
NA	8/8/92	8/8/92	8/8/92	42.44179811	-70.5664505	50.0 S-E	4000
NA	8/9/92	8/9/92	8/9/92	42.44179811	-70.5664505	50.0 S-E	3000
NA	8/10/92	8/10/92	8/10/92	42.44186478	-70.5662338	50.0 S-E	4000
NA	8/10/92	8/11/92	8/11/92	42.44104812	-70.5650338	ON TARGET	3000
NA	8/10/92	8/11/92	8/11/92	42.44203143	-70.5666338	75.0 S-E	3000
NA	8/10/92	8/11/92	8/11/92	42.44203143	-70.5666338	75.00 S-E	3000
NA	8/11/92	8/12/92	8/12/92	42.44268143	-70.5637337	ON TARGET	3000
NA	8/13/92	8/14/92	8/14/92	42.44196477	-70.5668505		3000
NA	8/14/92	8/14/92	8/14/92	42.44166478	-70.5668671	ON TARGET	4000
NA	8/16/92	8/16/92	8/16/92	42.44196477	-70.5668505	75.00 S-E	4000
NA	8/17/92	8/17/92	8/17/92	42.44271476	-70.5664005	100.00 N	3000
NA	8/19/92	8/19/92	8/19/92	42.44163144	-70.5660338	50.00	3650
NA	8/20/92	8/20/92	8/20/92	42.44058145	-70.5683505	100.00	3000
NA	8/23/92	8/23/92	8/23/92	42.44049813	-70.5667171	120.00	3500
NA	8/24/92	8/24/92	8/24/92	42.4417981	-70.5683005	25.00	2900
NA	8/25/92	8/25/92	8/25/92	42.44118144	-70.5683172	35.00	3400
NA	8/26/92	8/26/92	8/26/92	42.44169811	-70.5658338	25.00	2000
NA	8/28/92	8/28/92	8/28/92	42.44139812	-70.5658505	40.00	1650
NA	8/29/92	8/29/92	8/30/92	42.44186478	-70.5662338	50.00	2100
NA	8/30/92	8/30/92	8/30/92	42.44169811	-70.5658338	40.00	3500
NA	8/31/92	8/31/92	8/31/92	42.44203143	-70.5666338	55.00	2500
NA	9/1/92	9/1/92	9/1/92	42.44179811	-70.5664505	45.00	3000
NA	9/2/92	9/2/92	9/2/92	42.4422481	-70.5678672	75.00	2000
NA	9/4/92	9/4/92	9/4/92	42.44179811	-70.5664505	40.00	3000

Year: 1992 **Disposal Site:** MBDS **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	9/5/92	9/5/92	9/5/92	42.44173144	-70.5666505	75.00	2000
NA	9/6/92	9/6/92	9/6/92	42.44203143	-70.5666338	35.00	3000
NA	9/6/92	9/6/92	9/6/92	42.44186478	-70.5662338	10.00	2000
NA	9/7/92	9/7/92	9/7/92	42.4420981	-70.5664338	30.00 SOU	4000
NA	9/8/92	9/9/92	9/9/92	42.4404648	-70.5659004	ON TARGET	2600
NA	9/9/92	9/9/92	9/9/92	42.44176478	-70.5656171	ON TARGET	4000
NA	9/10/92	9/10/92	9/10/92	42.4406148	-70.5654671	ON TARGET	2800
NA	9/11/92	9/11/92	9/11/92	42.44228143	-70.5668338	100.00 SOU	4000
NA	9/12/92	9/12/92	9/12/92	42.4423481	-70.5666171	30.00 SOU	3000
NA	9/15/92	9/15/92	9/15/92	42.44203143	-70.5666338	65.00	3200
NA	9/16/92	9/16/92	9/16/92	42.44251476	-70.5670172	175.00 SOU	2100
NA	9/16/92	9/17/92	9/17/92	42.44186478	-70.5662338	NO BOUY	3000
NA	9/18/92	9/18/92	9/18/92	42.44098145	-70.5671005	75.00 SOU	2000
NA	9/19/92	9/19/92	9/19/92	42.44176477	-70.5674672	70.00 SOU	3000
NA	9/19/92	9/19/92	9/19/92	42.44169811	-70.5676838	50.00 SOU	2000
NA	9/20/92	9/20/92	9/20/92	42.4421481	-70.5672505	75.00 SOU	3000
NA	9/22/92	9/22/92	9/22/92	42.4424481	-70.5672338	95.00 SOU	2000
NA	9/22/92	9/23/92	9/23/92	42.44186478	-70.5662338	BOUY OFF S	2000
NA	9/23/92	9/23/92	9/23/92	42.44268142	-70.5674338	100.00 SOU	3200
NA	9/23/92	9/24/92	9/24/92	42.44186478	-70.5662338	NO BOUY	2500
NA	9/25/92	9/25/92	9/25/92	42.44203143	-70.5666338	NO BOUY	1800
NA	9/26/92	9/26/92	9/26/92	42.4424481	-70.5672338	NO BOUY	2600
NA	9/27/92	9/27/92	9/27/92	42.44186478	-70.5662338	40.00 SOU	2000
NA	9/28/92	9/28/92	9/28/92	42.44258142	-70.5668172	5.00 SOU	3000
NA	9/29/92	9/29/92	9/29/92	42.44179811	-70.5664505	25.00 SOU	2000
NA	12/6/92	12/6/92	12/6/92	42.44068146	-70.5652671	200.00 SOU	2800
NA	12/8/92	12/8/92	12/8/92	42.44186478	-70.5662338	25.00 NOR	3000
NA	12/15/92	12/15/92	12/15/92	42.44169811	-70.5658338	50.00	3200
NA	12/15/92	12/15/92	12/15/92	42.44179811	-70.5664505	40.00	2000
					Project Total Volume:	**280,685 CM**	**367,100 CY**

Project: WEYMOUTH FORE RIVER

Permit Number: 199102068 **Permittee:** CITGO PETROLEUM

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	12/30/92	12/30/92	12/30/92	42.44186478	-70.5662338		2000
					Project Total Volume:	**1,529 CM**	**2,000 CY**
					Yearly Total Volume:	**282,214 CM**	**369,100 CY**

Appendix A, Disposal Logs

Year: 1993 **Disposal Site:** MBDS **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	3/8/93	3/9/93	3/9/93	42.44166667	-70.5666667	ROCKSITE NO	1800
NA	3/10/93	3/11/93	3/11/93	42.44166667	-70.5666667	ROCKSITE NO	2000
NA	3/11/93	3/11/93	3/11/93	42.44166667	-70.5666667	ROCKSITE NO	3200
NA	3/11/93	3/12/93	3/12/93	42.44166667	-70.5666667	ROCKSITE NO	1000
NA	3/15/93	3/15/93	3/15/93	42.44166667	-70.5666667	ROCKSITE NO	2000
NA	3/20/93	3/20/93	3/20/93	42.44166667	-70.5666667	ROCKSITE NO	2000
NA	3/22/93	3/22/93	3/23/93	42.44166667	-70.5666667	ROCKSITE NO	2000
NA	3/25/93	3/25/93	3/26/93	42.44166667	-70.5666667	ROCKSITE NO	2000
NA	3/28/93	3/28/93	3/28/93	42.44186478	-70.5662338	ROCKSITE NO	2000
NA	3/29/93	3/29/93	3/29/93	42.44186478	-70.5662338	ROCKSITE NO	1800
NA	3/29/93	3/29/93	3/29/93	42.44186478	-70.5662338	ROCKSITE NO	1900
NA	3/31/93	3/31/93	4/1/93	42.44186478	-70.5662338	ROCKSITE NO	2000
NA	4/2/93	4/2/93	4/2/93	42.44163144	-70.5660338	ROCKSITE NO	1800
NA	4/3/93	4/3/93	4/3/93	42.4420981	-70.5664338	ROCKSITE NO	1500
NA	4/4/93	4/4/93	4/4/93	42.44169811	-70.5658338	ROCKSITE NO	2000
NA	4/4/93	4/4/93	4/4/93	42.44218143	-70.5662171	ROCKSITE NO	800
NA	4/5/93	4/5/93	4/5/93	42.44228143	-70.5668338	ROCKSITE NO	2000
NA	4/6/93	4/6/93	4/6/93	42.44169811	-70.5658338	ROCKSITE NO	3000
NA	4/8/93	4/8/93	4/8/93	42.44186478	-70.5662338	ROCKSITE NO	3200
NA	4/8/93	4/8/93	4/8/93	42.44203143	-70.5666338	ROCKSITE NO	2000
NA	4/9/93	4/10/93	4/10/93	42.44193144	-70.5660338	ROCKSITE NO	3100
NA	4/14/93	4/15/93	4/15/93	42.44186478	-70.5662338	ROCKSITE NO	1200
NA	4/15/93	4/15/93	4/15/93	42.44169811	-70.5658338	ROCKSITE NO	2000
NA	4/18/93	4/18/93	4/18/93	42.44146479	-70.5656338	ROCKSITE NO	2000
NA	4/20/93	4/21/93	4/21/93	42.44186478	-70.5662338	ROCKSITE NO	2000
NA	4/22/93	4/22/93	4/23/93	42.44218143	-70.5662171	ROCKSITE NO	500
NA	5/10/93	5/11/93	5/11/93	42.44186478	-70.5662338	ROCKSITE NO	3000
NA	5/13/93	5/13/93	5/13/93	42.44186478	-70.5662338	ROCKSITE NO	3000
NA	5/15/93	5/15/93	5/15/93	42.44186478	-70.5662338	ROCKSITE NO	3000
NA	5/16/93	5/16/93	5/16/93	42.44186478	-70.5662338	ROCKSITE NO	2000
NA	5/19/93	5/19/93	5/19/93	42.44163144	-70.5660338	ROCKSITE NO	3200
NA	5/22/93	5/22/93	5/22/93	42.44186478	-70.5662338	ROCKSITE NO	2500
NA	5/23/93	5/23/93	5/23/93	42.44186478	-70.5662338	ROCKSITE NO	3500
NA	5/24/93	5/24/93	5/24/93	42.44193144	-70.5660338	ROCKSITE NO	2300
NA	5/26/93	5/26/93	5/26/93	42.44156478	-70.5662505	ROCKSITE NO	3500
NA	5/26/93	5/26/93	5/26/93	42.4420981	-70.5664338	ROCKSITE NO	2300
NA	5/27/93	5/27/93	5/27/93	42.44186478	-70.5662338	ROCKSITE NO	3500
NA	5/28/93	5/28/93	5/28/93	42.44146479	-70.5656338	ROCKSITE NO	2600
NA	5/29/93	5/29/93	5/29/93	42.44169811	-70.5658338	ROCKSITE NO	3600
NA	5/30/93	5/30/93	5/30/93	42.44186478	-70.5662338	ROCKSITE NO	2500
NA	5/30/93	5/31/93	5/31/93	42.44146479	-70.5656338	ROCKSITE NO	3500
NA	6/2/93	6/2/93	6/2/93	42.44163144	-70.5660338	ROCKSITE NO	2600

Year: 1993 **Disposal Site: MBDS** **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	6/5/93	6/5/93	6/5/93	42.44186478	-70.5662338	ROCKSITE NO	3200
NA	6/8/93	6/8/93	6/8/93	42.44156478	-70.5662505	ROCKSITE NO	2300
NA	6/9/93	6/9/93	6/9/93	42.44163144	-70.5660338	ROCKSITE NO	2500
NA	6/11/93	6/11/93	6/11/93	42.44193144	-70.5660338	ROCKSITE NO	2000
NA	6/15/93	6/15/93	6/15/93	42.44139812	-70.5658505	ROCKSITE NO	1000
NA	6/15/93	6/15/93	6/15/93	42.44186478	-70.5662338	ROCKSITE NO	1000
NA	6/15/93	6/15/93	6/16/93	42.44193144	-70.5660338	ROCKSITE NO	1200
NA	6/17/93	6/17/93	6/17/93	42.44163144	-70.5660338		2200
NA	6/18/93	6/18/93	6/18/93	42.44179811	-70.5664505	ROCKSITE NO	1800
NA	6/19/93	6/19/93	6/19/93	42.44163144	-70.5660338	ROCKSITE NO	1200
NA	6/20/93	6/20/93	6/20/93	42.44186478	-70.5662338	ROCKSITE NO	1300
NA	6/20/93	6/20/93	6/20/93	42.44169811	-70.5658338	ROCKSITE NO	1350
NA	6/22/93	6/22/93	6/23/93	42.44186478	-70.5662338	ROCKSITE NO	1300
NA	6/23/93	6/23/93	6/23/93	42.44193144	-70.5660338	ROCKSITE NO	3500
NA	6/25/93	6/25/93	6/25/93	42.44166667	-70.5666667	ROCKSITE NO	3500
NA	6/25/93	6/25/93	6/25/93	42.44169811	-70.5658338	ROCKSITE NO	1150
NA	6/27/93	6/27/93	6/28/93	42.44165	-70.5666667	ROCKSITE NO	3000
NA	6/29/93	6/29/93	6/30/93	42.44163333	-70.5666667	ROCKSITE NO	1400
NA	7/2/93	7/2/93	7/3/93	42.44193144	-70.5660338	ROCKSITE NO	3000
NA	7/3/93	7/3/93	7/3/93	42.44179811	-70.5664505	ROCKSITE NO	2100
NA	7/7/93	7/7/93	7/8/93	42.44166667	-70.5666667	ROCKSITE NO	3000
NA	7/9/93	7/9/93	7/10/93	42.44166667	-70.5666667	ROCKSITE NO	1800
NA	7/15/93	7/15/93	7/15/93	42.44166667	-70.5666667		2800
NA	7/15/93	7/15/93	7/15/93	42.44166667	-70.5666667	NO BOUY ROC	2800
NA	7/18/93	7/18/93	7/18/93	42.44166667	-70.5666667		2800
NA	7/18/93	7/18/93	7/18/93	42.44166667	-70.5668333	ROCKSITE NO	2800
NA	7/18/93	7/18/93	7/18/93	42.44166667	-70.5666667		1550
NA	7/18/93	7/18/93	7/18/93	42.44166667	-70.5666667	ROCKSITE NO	1550
NA	7/19/93	7/19/93	7/19/93	42.44166667	-70.5666667		3500
NA	7/20/93	7/20/93	7/20/93	42.44166667	-70.5666667		2800
NA	7/21/93	7/21/93	7/21/93	42.44166667	-70.5666667		3300
NA	7/23/93	7/23/93	7/23/93	42.44176478	-70.5656171		3000
NA	7/23/93	7/23/93	7/23/93	42.44166667	-70.5666667		1750
NA	7/24/93	7/24/93	7/24/93	42.44166667	-70.5666667		2200
NA	7/24/93	7/24/93	7/25/93	42.44186478	-70.5662338		1500
NA	7/25/93	7/25/93	7/25/93	42.44186478	-70.5662338		3100
NA	7/25/93	7/25/93	7/25/93	42.44186478	-70.5662338		1550
NA	7/26/93	7/26/93	7/26/93	42.44186478	-70.5662338		1500
NA	7/26/93	7/26/93	7/26/93	42.44186478	-70.5662338		2500
NA	7/27/93	7/27/93	7/27/93	42.44186478	-70.5662338		3200
NA	7/30/93	7/30/93	7/30/93	42.44186478	-70.5662338		2300
NA	7/31/93	7/31/93	8/1/93	42.44186478	-70.5662338		1900
NA	8/1/93	8/1/93	8/1/93	42.44186478	-70.5662338		2100
NA	8/2/93	8/2/93	8/2/93	42.44186478	-70.5662338		1400

Year: 1993 **Disposal Site: MBDS** **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	8/2/93	8/2/93	8/2/93	42.44186478	-70.5662338		3500
NA	8/3/93	8/3/93	8/4/93	42.44186478	-70.5662338		2800
NA	8/4/93	8/4/93	8/4/93	42.44186478	-70.5662338		1350
NA	8/6/93	8/6/93	8/6/93	42.44186478	-70.5662338		3000
NA	8/6/93	8/6/93	8/6/93	42.44186478	-70.5662338		1700
NA	8/10/93	8/10/93	8/10/93	42.44163144	-70.5660338	NO	2500
NA	8/15/93	8/15/93	8/15/93	42.44186478	-70.5662338	NA NA	2200
NA	8/16/93	8/16/93	8/17/93	42.44186478	-70.5662338	NA NA	3500
NA	8/17/93	8/17/93	8/17/93	42.44163144	-70.5660338		2700
NA	8/18/93	8/18/93	8/19/93	42.44163144	-70.5660338		3000
NA	8/19/93	8/19/93	8/19/93	42.44163144	-70.5660338		2000
NA	8/20/93	8/20/93	8/21/93	42.44169811	-70.5658338		2000
NA	8/21/93	8/21/93	8/21/93	42.44169811	-70.5658338		2100
NA	8/23/93	8/23/93	8/23/93	42.44163144	-70.5660338		2900
NA	8/24/93	8/24/93	8/24/93	42.44186478	-70.5662338		1850
NA	8/26/93	8/26/93	8/26/93	42.44193144	-70.5660338		2000
NA	8/26/93	8/26/93	8/27/93	42.44166478	-70.5668671		2500
NA	8/27/93	8/27/93	8/27/93	42.44203143	-70.5666338		1300
NA	8/31/93	8/31/93	8/31/93	42.44146479	-70.5656338		1800
NA	8/31/93	8/31/93	8/31/93	42.44121479	-70.5654504		1600
NA	9/3/93	9/3/93	9/3/93	42.44186478	-70.5662338		2100
NA	9/4/93	9/4/93	9/4/93	42.44139812	-70.5658505		2250
NA	9/5/93	9/5/93	9/5/93	42.44186478	-70.5662338		2000
NA	9/5/93	9/5/93	9/5/93	42.44186478	-70.5662338		2200
NA	9/21/93	9/21/93	9/21/93	42.44148333	-70.5669833	NO BUOY	900
NA	9/21/93	9/21/93	9/22/93	42.44173144	-70.5660671	NO BUOY	1800
NA	9/22/93	9/22/93	9/22/93	42.44139811	-70.5663505	NO BUOY	2000
NA	9/22/93	9/22/93	9/22/93	42.44166667	-70.5666667	NO BUOY	800
NA	9/23/93	9/23/93	9/23/93	42.44195	-70.5669333	NO BUOY	2000
NA	9/23/93	9/23/93	9/24/93	42.44183333	-70.5668167	NO BUOY	3400
NA	9/24/93	9/24/93	9/24/93	42.44166667	-70.56685	NO BUOY	1100
NA	9/24/93	9/24/93	9/25/93	42.44185	-70.5669	NO BUOY	2500
NA	9/25/93	9/25/93	9/26/93	42.44198333	-70.5669333	NO BUOY	1950
NA	9/26/93	9/26/93	9/26/93	42.44183333	-70.5667833	NO BUOY	2000
NA	9/27/93	9/27/93	9/28/93	42.44155	-70.5668833	NO BUOY	2650
NA	9/28/93	9/28/93	9/28/93	42.44158333	-70.5668	NO BUOY	2600
NA	9/29/93	9/29/93	9/29/93	42.4419	-70.5668667	NO BUOY	1900
NA	10/2/93	10/3/93	10/3/93	42.44198333	-70.5668833	NO BUOY	1850
NA	10/3/93	10/4/93	10/4/93	42.44181667	-70.5668333	NO BUOY	2000
NA	10/4/93	10/4/93	10/4/93	42.44166667	-70.5666667	NO BUOY	230
NA	10/4/93	10/5/93	10/5/93	42.4415	-70.5667667	NO BUOY	2100
NA	10/5/93	10/6/93	10/6/93	42.44193333	-70.5668667	NO BUOY	1900
NA	10/7/93	10/7/93	10/7/93	42.44166667	-70.5666667	NO BUOY	2200
NA	10/7/93	10/7/93	10/8/93	42.4416	-70.5668167	NO BUOY	2000

Year: 1993 **Disposal Site: MBDS** **Rock Reef**

Project: THIRD HARBOR TUNNEL

Permit Number: 199101378 **Permittee:** MA HIGHWAY DEPT.

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	10/7/93	10/8/93	10/8/93	42.44173333	-70.5666833	NO BUOY	1800
NA	10/9/93	10/9/93	10/9/93	42.44166667	-70.5669833	NO BUOY	3000
NA	10/9/93	10/9/93	10/9/93	42.44155	-70.5668	NO BUOY	2100
NA	10/10/93	10/10/93	10/10/93	42.44155	-70.56685	NO BUOY	1750
NA	10/10/93	10/10/93	10/10/93	42.44165	-70.5668	NO BUOY	2800
NA	10/10/93	10/11/93	10/11/93	42.44168333	-70.56685	NO BUOY	1600
NA	10/11/93	10/11/93	10/11/93	42.44153333	-70.5667	NO BUOY	1150
NA	10/12/93	10/12/93	10/12/93	42.44156667	-70.5669333	NO BUOY	1800
NA	10/13/93	10/13/93	10/13/93	42.44173333	-70.5666667	NO BUOY	1800
NA	10/13/93	10/13/93	10/13/93	42.4415	-70.56695	NO BUOY	1800
NA	10/14/93	10/14/93	10/14/93	42.44153333	-70.5666667	NO BUOY	1900
NA	10/14/93	10/14/93	10/15/93	42.4416	-70.5668167	NO BUOY	1650
NA	10/15/93	10/15/93	10/15/93	42.44151667	-70.5667167	NO BUOY	1850
NA	10/15/93	10/16/93	10/16/93	42.44166667	-70.5667167	NO BUOY	1000
NA	10/16/93	10/17/93	10/17/93	42.44185	-70.5668167	NO BUOY	2100
NA	10/20/93	10/20/93	10/20/93	42.4416	-70.5668167	NO BUOY	1800
NA	10/24/93	10/24/93	10/24/93	42.44166667	-70.5668167	NO BUOY	900
				Project Total Volume:		**242,860 CM**	**317,630 CY**

Project: WEYMOUTH FORE RIVER

Permit Number: 199102068 **Permittee:** CITGO PETROLEUM

Buoy	Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
NA	1/1/93	1/1/93	1/2/93	42.44186478	-70.5662338		2200
NA	1/6/93	1/6/93	1/7/93	42.44186478	-70.5662338		1500
NA	1/12/93	1/12/93	1/13/93	42.44168144	-70.5660838		2100
NA	1/19/93	1/19/93	1/20/93	42.44186478	-70.5662338		2000
NA	1/19/93	1/20/93	1/20/93	42.44186478	-70.5662338		1200
NA	1/30/93	1/30/93	1/30/93	42.44168144	-70.5660838		400
NA	2/3/93	2/3/93	2/3/93	42.44186478	-70.5662338		2100
NA	2/3/93	2/4/93	2/4/93	42.44186478	-70.5662338	NO BOUY	1400
NA	2/5/93	2/5/93	2/6/93	42.44186478	-70.5662338	NO BOUY	1000
NA	2/8/93	2/9/93	2/9/93	42.44186478	-70.5662338	NO BOUY	1700
NA	2/11/93	2/11/93	2/12/93	42.44186478	-70.5662338	NO BOUY	1400
NA	2/14/93	2/15/93	2/15/93	42.44186478	-70.5662338	NO BOUY	1400
NA	2/18/93	2/18/93	2/18/93	42.44186478	-70.5662338	NO BOUY	2200
NA	2/20/93	2/20/93	2/20/93	42.44186478	-70.5662338	NO BOUY	2000
NA	2/22/93	2/23/93	2/23/93	42.44186478	-70.5662338	NO BOUY	1800
NA	2/24/93	2/25/93	2/25/93	42.44186478	-70.5662338	NO BOUY	2200
NA	2/26/93	2/27/93	2/27/93	42.44186478	-70.5662338	NO BOUY	400
				Project Total Volume:		**20,644 CM**	**27,000 CY**
				Yearly Total Volume:		**263,504 CM**	**344,630 CY**

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