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October 2009

Disposal Area Monitoring System DAMOS

DAMOS
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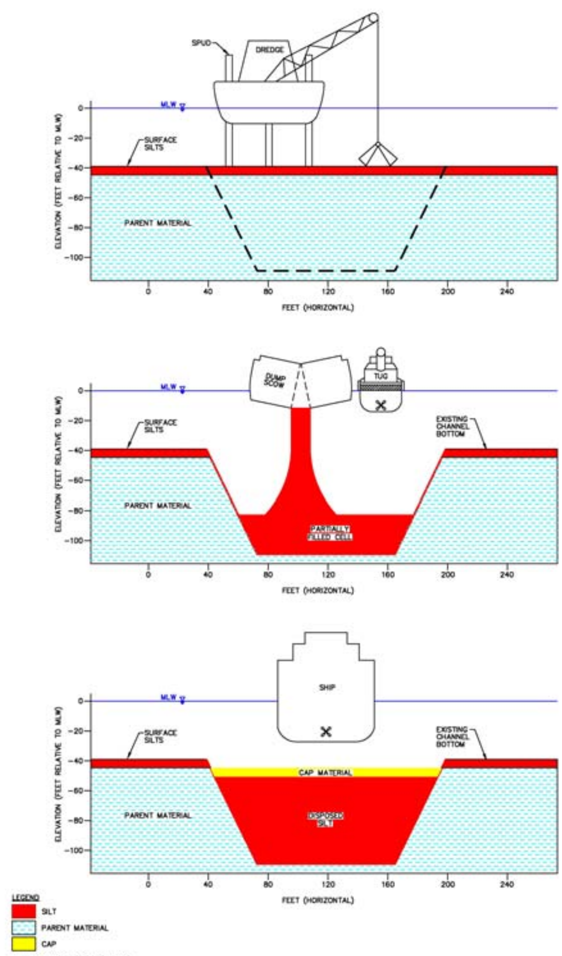

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13. ABSTRACT
CAD cells have been used in multiple locations within New England as the preferred alternative for disposal of UDM. A monitoring survey was conducted at CAD cells located in four New England harbors in October 2009 as part of the DAMOS Program. The 2009 CAD cell investigation was conducted as a baseline for longer term study of the performance of CAD cells, including physical stability and biological recovery, under the range of environmental conditions present in four New England Harbors, including Norwalk and New London, Connecticut; Providence, Rhode Island; and Hyannis, Massachusetts.

The specific objectives of the investigation were to conduct bathymetric surveys of the CAD cells in each of the four harbors to document depths in and around the CAD cells, characterize cell morphology, and assess changes in morphology relative to available previous surveys; to assess the benthic recolonization status of the CAD cells, relative to representative references areas within each harbor, using SPI and plan-view video; and to complete a towed underwater video survey of select CAD cells to further assess the general physical condition of the cells and further document the presence and abundance of marine organisms within the CAD cells compared to representative reference areas within each harbor.

The 2009 bathymetric surveys revealed the CAD cells as identifiable features on the harbor bottom in all four harbors. A comparison of the 2009 bathymetric data with available previous bathymetric data for each cell showed distinct changes that were dependent on specific harbor conditions as well as the construction, disposal, and capping strategies for each cell or set of cells. SPI and underwater video analysis of each harbor found distinct assemblages of benthic infauna and epifauna, which reflected the environmental conditions of each area and showed no evidence of detrimental impact from CAD cell construction. In general, the CAD cells at all four harbors exhibited benthic communities that were comparable to local reference (ambient) conditions.

The results of the 2009 survey, coupled with previous monitoring conducted within each of the four harbors, further supported the use of CAD cells as an effective tool for managing UDM in near-shore sites. While all the CAD cells surveyed in 2009 remained as identifiable features on the bottom, the diverse range of environmental settings coupled with distinct construction, disposal, and capping strategies had significantly influenced the current status of each of the CAD cells and the understanding of how to construct and manage CAD cells for the disposal of UDM in near-shore sites.

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TABLE OF CONTENTS

Page

LIST OF TABLES ... iii

LIST OF FIGURES ... iv

EXECUTIVE SUMMARY ... ix

1.0 INTRODUCTION ... 1
1.1 Overview of the DAMOS Program ... 1
1.2 Introduction to CAD Cells ... 2
1.3 A Chronological History of CAD Cell Use in New England ... 4
1.4 Description of Four New England Harbor CAD Cells ... 6
1.4.1 Norwalk CAD Cells ... 7
1.4.2 New London CAD Cell ... 8
1.4.3 Providence CAD Cells ... 9
1.4.4 Hyannis CAD Cell ... 12
1.5 Survey Objectives ... 13

2.0 METHODS ... 29
2.1 Navigation ... 29
2.2 Bathymetry ... 29
2.2.1 Bathymetric Data Collection ... 30
2.2.2 Bathymetric Data Processing ... 31
2.2.3 Bathymetric Data Analysis ... 31
2.3 SPI and Plan-View Video ... 31
2.3.1 SPI and Plan-View Video Collection ... 32
2.3.2 SPI and Plan-View Video Analysis ... 32
2.4 Underwater Video Transects ... 33
2.4.1 Video Collection ... 34
2.4.2 Video Analysis ... 34

3.0 RESULTS ... 46
3.1 Norwalk ... 46
3.1.1 Bathymetry ... 46
3.1.2 SPI and Plan-View Video ... 47
3.1.3 Underwater Video ... 49
3.2 New London ... 50
3.2.1 Bathymetry ... 50

3.2.2 SPI and Plan-View Video 50
3.2.3 Underwater Video 53
3.3 Providence 54
3.3.1 Bathymetry 54
3.3.2 SPI and Plan-View Video 54
3.3.3 Underwater Video 57
3.4 Hyannis 58
3.4.1 Bathymetry 58
3.4.2 SPI and Plan-View Video 58
3.4.3 Underwater Video 60
3.5 Summary 61
3.5.1 Physical Characteristics 61
3.5.2 Biological Conditions 62

4.0 DISCUSSION 119
4.1 Norwalk 120
4.2 New London 122
4.3 Providence 123
4.4 Hyannis 125
4.5 Comparison of Four Harbor Study Results 126

5.0 CONCLUSIONS AND RECOMMENDATIONS 131

6.0 REFERENCES 133

INDEX

APPENDICES

A SEDIMENT-PROFILE IMAGE RESULTS: NEW ENGLAND CAD CELLS, OCTOBER 2009

B PLAN-VIEW VIDEO RESULTS: NEW ENGLAND CAD CELLS, OCTOBER 2009

C UNDERWATER VIDEO ANNOTATION AND MAPS: NEW ENGLAND CAD CELLS, OCTOBER 2009

LIST OF TABLES

Page

Table 1-1. CAD Cell Construction, Disposal, and Capping Histories 15

Table 1-2. Summary of Previous Investigations at CAD Cell Locations 16

Table 2-1. Summary of Field Activities, October 2009 35

Table 2-2. Project Grid and Water Level Data Source for Each Survey, October 2009 36

Table 2-3. Norwalk CAD Cell SPI and Plan-View Video Target Locations 37

Table 2-4. New London CAD Cell SPI and Plan-View Video Target Locations 38

Table 2-5. Providence CAD Cell SPI and Plan-View Video Target Locations 39

Table 2-6. Hyannis CAD Cell SPI and Plan-View Image Target Locations 40

Table 3-1. Summary of Norwalk Harbor CAD Cell and Reference Station SPI Results 63

Table 3-2. Summary of New London CAD Cell and Reference Station SPI Results.... 65

Table 3-3. Summary of Providence Harbor CAD Cell and Reference Station SPI Results 67

Table 3-4. Summary of Hyannis Harbor CAD Cell and Reference Station SPI Results 69

Table 3-5. Summary of 2009 Survey Results 71

Table 4-1. Overview of CAD Cell Setting, Operational History, and Survey Results 128

LIST OF FIGURES

Page

Figure 1-1. Cross section of CAD cell construction 17

Figure 1-2. CAD cell locations in New England 18

Figure 1-4. Timeline of CAD cell construction/usage in New England.. 19

Figure 1-5. New Bedford Harbor CAD cells 20

Figure 1-6. Boston Harbor CAD cell locations 21

Figure 1-7. Hyannis CAD cell location 22

Figure 1-8. Providence CAD cell locations 23

Figure 1-9. Norwalk CAD cell location.. 24

Figure 1-10. New London CAD cell location.. 25

Figure 1-11. Timeline of CAD cell events 26

Figure 1-12. Excavated depth of CAD cells relative to surrounding channel bottom ... 27

Figure 1-12. New London CAD cell in Thames River....................................... 28

Figure 2-1. Norwalk, New London, Providence, and Hyannis bathymetric survey boundaries and tracklines 41

Figure 2-2. Target SPI stations and actual video transects for Norwalk 42

Figure 2-3. Target SPI stations and actual video transects for New London 43

Figure 2-4. Target SPI stations and actual video transects for Providence 44

Figure 2-5. Target SPI stations and actual video transects for Hyannis.................... 45

Figure 3-1. Bathymetric contour map over hillshaded bathymetry of the Norwalk Harbor CAD cells, October 2009 73

Figure 3-2. Depth difference contour map of the Norwalk Harbor CAD cells, December 2007 and October 2009, overlaying 2009 hillshaded bathymetry 74

Figure 3-3. Spatial distribution of grain size major mode (phi) for Norwalk Harbor 75

Figure 3-4. Spatial distribution of station-averaged camera prism penetration depth (cm) for Norwalk Harbor.. 76

Figure 3-5. Mean penetration results for all four CAD cell study areas.................... 77

Figure 3-6. Spatial distribution of station-averaged surface boundary roughness (cm) for Norwalk Harbor. 78

Figure 3-7. Mean surface boundary roughness results from all CAD cell study areas... 79

Figure 3-8. Examples of biogenic process features observed in SPI from Norwalk Harbor. 80

Figure 3-9. Spatial distribution of methane presence in Norwalk Harbor 81

Figure 3-10. Spatial distribution of station-averaged aRPD depths (cm) for Norwalk Harbor 82

Figure 3-11. Mean aRPD depth for all CAD cell study areas.. 83

Figure 3-12. Spatial distribution of infaunal successional stages for Norwalk Harbor ... 84

Figure 3-13. Example of mobile epibenthic community observed in SPI images from Norwalk Harbor. 85

Figure 3-14. Underwater video transect and representative clips for Norwalk Harbor .. 86

Figure 3-15. Bathymetric contour map over hillshaded bathymetry of the New London CAD cell, October 2009 87

Figure 3-16. Depth difference contour map of the New London CAD cell, November 2006 and October 2009, overlaying 2009 hillshaded bathymetry 88

Figure 3-17. Spatial distribution of grain size major mode (phi) for New London....... 89

Figure 3-18. Spatial distribution of station-averaged camera prism penetration depth (cm) for New London 90

Figure 3-19. Spatial distribution of station-averaged mean boundary roughness (cm) for New London........ 91

Figure 3-20. Evidence of physical and biogenic processes observed in SPI from New London CAD cell and surrounding reference areas. 92

Figure 3-21. Spatial distribution of station-averaged aRPD depths (cm) for New London 93

Figure 3-22. Sediment layers observed within the New London CAD cell and surrounding reference area 94

Figure 3-23. Spatial distribution of infaunal successional stages for New London. 95

Figure 3-24. Underwater video for New London 96

Figure 3-25. Bathymetric contour map over hillshaded bathymetry of the Providence CAD cells, October 2009........ 97

Figure 3-26. Depth difference contour map of the Providence CAD cells, May 2005 and October 2009, overlaying 2009 hillshaded bathymetry 98

Figure 3-27. Spatial distribution of grain size major mode (phi) for Providence Harbor........ 99

Figure 3-28. Spatial distribution of station-averaged camera prism penetration depth (cm) for Providence Harbor 100

Figure 3-29. Spatial distribution of station-averaged mean boundary roughness (cm) for Providence Harbor 101

Figure 3-30. Boundary roughness and bacterial mats in Providence Harbor........ 102

Figure 3-31. Presence of amphipod tubes at Providence Harbor reference station 103

Figure 3-32. Spatial distribution of methane presence for Providence Harbor 104

Figure 3-33. Spatial distribution of station-averaged aRPD depths (cm) for Providence Harbor 105

Figure 3-34. Spatial distribution of *Beggiatoa* sp. in Providence Harbor 106

Figure 3-35. Spatial distribution of infaunal successional stages for Providence Harbor........ 107

Figure 3-36. Underwater video transects and representative clips for Providence Harbor 108

Figure 3-37. Bathymetric contour map over hillshaded bathymetry of the Hyannis CAD cell, October 2009 109

Figure 3-38. Post-capping bathymetric contour map of the Hyannis CAD cell, April 1999........ 110

Figure 3-39. Depth difference contour map of the Hyannis CAD cell, April 1999 and October 2009, overlaying the 2009 hillshaded bathymetry........ 111

Figure 3-40. Spatial distribution of grain size major mode (phi) for Hyannis Harbor 112

Figure 3-41. Spatial distribution of station-averaged camera prism penetration depth (cm) for Hyannis Harbor 113

Figure 3-42. Spatial distribution of station-averaged mean boundary roughness (cm) for Hyannis Harbor 114

Figure 3-43. Examples of biological and physical features observed in SPI images from Hyannis Harbor 115

Figure 3-44. Spatial distribution of station-averaged aRPD depths (cm) for Hyannis Harbor 116

Figure 3-45. Spatial distribution of infaunal successional stages for Hyannis Harbor........ 117

Figure 3-46. Underwater video transects and representative clips for Hyannis Harbor 118

Figure 4-1. Suspended sediment from vessel traffic in the Thames River............... 130

Confined aquatic disposal (CAD) cells have been used in multiple locations within New England as the preferred alternative for the disposal of dredged material deemed unsuitable (UDM) for unconfined open water disposal. The technique involves placing UDM within existing depressions or cells cut into the seafloor for containment and optionally placing a layer of suitable cap material to further sequester the UDM. A monitoring survey was conducted at CAD cells located in four New England harbors in October 2009 as part of the U.S. Army Corps of Engineers New England District Disposal Area Monitoring System (DAMOS) Program. The 2009 CAD cell investigation was conducted as a baseline for longer term study of the performance of CAD cells, including physical stability and biological recovery, under the range of environmental conditions present in four New England harbors, including Norwalk and New London, Connecticut; Providence, Rhode Island; and Hyannis, Massachusetts.

The specific objectives of the investigation were to conduct bathymetric surveys of the CAD cells in each of the four harbors to document depths in and around the CAD cells, characterize cell morphology, and assess changes in morphology relative to available previous surveys; to assess the benthic recolonization status of the CAD cells, relative to representative references areas within each harbor, using sediment-profile imaging (SPI) and plan-view video; and to complete a towed underwater video survey of select CAD cells to further assess the general physical condition of the cells and further document the presence and abundance of marine organisms within the CAD cells compared to representative reference areas within each harbor.

The 2009 bathymetric surveys revealed the CAD cells as identifiable features on the harbor bottom in all four harbors. A comparison of the 2009 bathymetric data with available previous bathymetric data for each cell showed distinct changes that were dependent on specific harbor conditions as well as the construction, disposal, and capping strategies for each cell or set of cells. The two Norwalk River CAD cells remained as stable, prominent features on the harbor bottom nearly four years following construction and capping. No significant changes in depth were observed since the previous survey conducted in 2007, well after cap placement. The New London CAD cell also remained a prominent feature on the river bottom three years following construction and capping, with only limited consolidation since the previous survey conducted in 2007.

The Providence CAD cells remained uncapped at the time of the 2009 survey, and the surfaces of each of the six cells remained well-depressed below the surrounding seafloor. Since the previous bathymetry survey conducted in 2005, additional non-Federal project material had been placed into one cell, and there had been some consolidation of the largest, most recently filled cell, but relatively little change over the remaining inactive cells. The Hyannis CAD cell was also still identifiable on the harbor bottom more than 10 years since construction, but was not as prominent a feature as the CAD cells in the other harbors. Comparison of the 2009 bathymetric data with the 1999 post cap bathymetric data indicated a decrease in depth, attributed to cell infilling along the steep-sloped southern boundary of the cell, and redistribution of sediments in the flatter interior areas of the cell, highlighting the physical processes at work on a CAD cell placed in a more dynamic coastal environment.

SPI and underwater video analyses found distinct assemblages of benthic infauna and epifauna over the range of environmental conditions, from stressed to healthy, present in the four harbor settings. Advanced Stage 3 succession was apparent across the Norwalk and New London cells and the adjacent references areas; however, the Norwalk cells were higher in organic content and had a lower apparent redox potential depth than the New London cell. The benthic community across the Providence CAD cells had not yet recovered to the condition at the adjacent reference area; however, both methane gas and extensive *Beggiatoa* sp. bacterial mats were observed across the CAD cell and reference area, indicative of overall stressed conditions throughout the harbor. The biological condition of the Hyannis CAD cell was similar to the adjacent reference area, and the community present within both areas was more characteristic of a mobile community. While biological assemblages differed from harbor to harbor, they reflected the environmental conditions of each area and showed no evidence of detrimental impact from CAD cell construction.

The results of the 2009 survey, coupled with previous monitoring conducted within each of the four harbors, further supported the use of CAD cells as an effective tool for managing UDM in near-shore sites. While all the CAD cells surveyed in 2009 remained as identifiable features on the bottom, the diverse range of environmental settings coupled with distinct construction, disposal, and capping strategies had significantly influenced the current status of each of the CAD cells and the understanding of how to construct and manage CAD cells for the disposal of UDM in near-shore sites.

1.0 INTRODUCTION

A monitoring survey was conducted at confined aquatic disposal (CAD) cells located in four New England harbors in October 2009 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns associated with the use of aquatic disposal sites throughout the New England region. An introduction to the DAMOS Program and the use of CAD cells in New England, including a brief description of previous dredged material disposal activities and previous monitoring surveys, is provided below.

1.1 Overview of the DAMOS Program

For over 30 years, the DAMOS Program has conducted monitoring surveys at aquatic disposal sites throughout New England and evaluated the patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity. The DAMOS Program features a tiered disposal site management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Fredette and French 2004; Germano et al. 1994).

DAMOS monitoring surveys fall into two general categories. Confirmatory studies are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established, active disposal sites. The data collected and evaluated during these studies provide input to help effectively manage the use of aquatic dredged material disposal sites. Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive/historic disposal sites and contribute to the research and development of dredged material placement and capping techniques. The CAD cell investigation reported in this contribution included elements of both types of studies, surveying cells still receiving active disposal as well as cells inactive for 10+ years.

Two primary goals of DAMOS confirmatory monitoring surveys are to document the physical location and stability of dredged material placed into the aquatic environment and to evaluate the biological recovery of the sites following cessation of disposal activities. Sequential bathymetric measurements are performed to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites as well as the accumulation/consolidation of dredged material into CAD cells. Sediment-profile imaging (SPI) surveys are performed to support evaluation of seafloor (benthic) habitat conditions and recovery over time as well as to provide additional data on the physical characteristics of surficial sediments. Each type of data collection activity is conducted periodically at disposal sites, and data are evaluated to determine the next step in the disposal site management process. The conditions found after a defined period of disposal activity are compared with the long-term data set at a specific site (Germano et al. 1994). Focused and confirmatory DAMOS monitoring surveys may also feature additional types of data collection activities such as side-scan sonar, towed video, sediment coring, or grab sampling, as deemed appropriate to achieve specific survey objectives.

1.2 Introduction to CAD Cells

Materials dredged during maintenance and improvement of navigation channels have limited disposal options when contaminant levels in the materials preclude unconfined open water disposal. Options considered for disposal of dredged material deemed unsuitable for unconfined open water disposal (Unsuitable Dredged Material [UDM]; Fredette and French 2004) typically include upland placement, creation of shoreline/coastal confined disposal facilities, and aquatic (in water) placement followed by capping.

Upland placement can be a very costly option with not-insignificant potential impacts associated with shoreside transfer/staging, upland transportation (e.g., increased traffic and air emissions from numerous truck trips), and material handling and placement at the final disposal site. This option presents multiple potential contaminant transfer pathways, including dermal contact, dust and volatile emissions, and groundwater pathways (Fredette 2006). The feasibility of upland disposal is also dependent on distance to placement sites and disposal site capacity. Treatment of sediment to remove, degrade, or stabilize contaminants can allow for reuse of material at upland sites (e.g. construction, roadbed) or allow for easier placement at disposal facilities, but treatment is generally not feasible for large volume navigation projects because of the logistics and costs associated with the additional handling and processing required.

Confined disposal facilities (CDF) involve the construction of an upland, shoreline or in-water dike system to contain dredged material that is typically hydraulically dredged and pumped into the CDF. For in-water CDFs this ultimately creates a new upland area as an extension of the shoreline or an island. Following dewatering and capping, the

CDF may be available for some light use (depending of the geotechnical properties of the consolidated dredged material) or for upland habitat creation. Given the extent of development of much of the existing New England coastline and concerns about losing existing aquatic habitat, CDF creation has had limited applicability in the region.

Level-bottom capping is also a viable option for aquatic disposal of UDM. This practice entails placing UDM directly on the seafloor and then covering it with a layer of material that is suitable for open water disposal, resulting in sequestration of the unsuitable material. This option has the environmental advantage of not requiring land staging and transportation and is generally less costly than upland or CDF disposal. However, level-bottom capping in harbors generally is not feasible because of the need to maintain navigational depth requirements. Level-bottom capping in ocean waters can also face significant challenges in obtaining regulatory approval.

CAD cells are being selected as the disposal option of choice for a growing number of navigational dredging and sediment remediation projects throughout the world (USACE MPA 1995; Whiteside et al. 1996; Shaw et al. 1998; USEPA 2000; USACE 2001, 2002; Alfageme et al. 2002; Moore et al. 2002; MPCA 2004). The technique involves placing the UDM within existing depressions or cells cut into the seafloor for containment and optionally placing a layer of suitable cap material to further sequester the UDM (Figure 1-1).

CAD cells have been used in New England since the 1980's as a practical alternative for the disposal of UDM. Factors that favor CAD cells over other options include regulatory considerations, public perception, relative ecological and human health risk, and cost (Driscoll et al. 2002, Fredette 2006, USACE 2001). Because CAD cells typically are located in the vicinity of the origin of the UDM, no new areas are impacted by their creation, and transportation and handling of material are minimized. CAD cells also can reduce the potential for human health and ecological risk presented by UDM by confining the material to a smaller footprint, removing the UDM farther from the physical processes that can result in transport and exposure, and sequestering the UDM more deeply beneath the sediment-water interface (Fredette 2006). These factors can minimize cost (compared to upland disposal) and risk, and therefore contribute to regulatory appeal and more favorable public acceptance of this option (Fredette 2006). For instance, an analysis by Driscoll et al. (2002) of disposal options for dredged sediment from New York/New Jersey Harbor determined that CAD cells presented one of the lowest ecological and human health risk options compared to other typical disposal alternatives (confined disposal facilities, landfill, treatment, and no action).

1.3 A Chronological History of CAD Cell Use in New England

Within New England, CAD cells have been used at multiple locations, including Boston Harbor, New Bedford Harbor, and Hyannis Harbor in Massachusetts; Norwalk Harbor/River and Thames River (New London) in Connecticut; and Providence River in Rhode Island (Figure 1-2). A timeline of CAD cell use in New England is presented in Figure 1-3.

The first New England CAD cell was constructed in Norwalk Harbor, Connecticut in 1981. Approximately 2,500 m^3 of sediment contaminated by a spill was removed from an area near the I-95 Bridge and placed in a cell constructed nearby beneath the navigational channel. In 1989 a shallow CAD cell was constructed in New Bedford Harbor, Massachusetts as part of a pilot study for the New Bedford Harbor Superfund project (Figure 1-4). The CAD cell, located in Pierce Mill Cove, was constructed to contain contaminated sediment dredged from the surrounding area and to evaluate in-water disposal methods. The CAD cell was subsequently capped with clean parent material (ENSR 2005).

The most extensively studied CAD cells in New England are the Boston Harbor CAD (BHCAD) cells (Figure 1-5). The first CAD cells in Boston Harbor, Massachusetts were constructed as part of the Boston Harbor Navigation Improvement Project (BHNIP) from 1997-2000. Approximately 800,000 m^3 of silty material from maintenance and improvement dredging in channels and berths within Boston Harbor was disposed into CAD cells created within the dredging project footprint beneath the Federal navigation channels (USACE and Massport 1995). Nine cells were constructed during the project, located in the channel area of the Mystic and Chelsea Rivers and the Inner Confluence at the junction of the two rivers (Figure 1-5). Cells were constructed, filled, and capped with increasing consolidation time prior to capping and refinements to the capping technique of successive groups to increase capping performance.

Also in Massachusetts, a CAD cell was created outside of Hyannis Harbor in September 1998. The Hyannis CAD cell is located beneath the former harbor entrance channel that is aligned east-west in the outer anchorage area southwest of the Lewis Bay inlet (Figure 1-6). The suitable material removed during cell construction was placed on the beaches at Great Island and within the dikes built the previous year on Dunbar Point behind Kalmus Beach. Approximately 57,600 m^3 of silty material from the inner harbor basin was disposed in the CAD cell from December 1998 to March 1999. The cell was capped with clean sand from the Lewis Bay channel deepening project in March 1999.

In Rhode Island, a series of CAD cells were constructed beneath the upper portion of the Providence Harbor channel as part of the Providence River and Harbor Maintenance Dredging Project (PRHMDP) between May 2003 and January 2004 (Figure 1-7). Approximately 920,000 m^3 of maintenance material dredged from the channel was placed into six constructed CAD cells. One cell was specifically designated for use with smaller private projects, with management provided by the State of Rhode Island. The State of Rhode Island has also taken over tracking consolidation of the other cells and will direct capping of the cells with suitable dredged material when all remaining capacity has been utilized.

An additional three CAD cells were used in New Bedford Harbor, Massachusetts beginning in 2005, associated with improvements to the harbor requiring removal of UDM that was outside of the area being remediated as part of the Superfund project (Figure 1-4). The first cell used was a historic borrow pit created from past sand mining activities. Once that borrow pit site was filled, approximately 65,000 m^3 of sand was dredged from an area north of Popes Island in constructing the two additional CAD cells. Some of the suitable material from CAD cell construction was used in a pilot capping demonstration project over a portion of the Superfund site just outside the mouth of the harbor. The construction and management of these cells has been provided by the New Bedford Harbor Development Commission. As some of the existing cells continue to be used and additional CAD cells are planned, the New Bedford Harbor cells were not included in this investigation.

A second set of CAD cells was constructed in Norwalk Harbor, Connecticut in 2006. Two CAD cells were constructed beneath the channel of the Norwalk River, approximately 2.7 km upriver from Norwalk Harbor (Figure 1-8). The cells were constructed in January 2006, in conjunction with routine maintenance dredging of the channel. Approximately 38,000 m^3 of material was excavated to create the two CAD cells. Approximately 26,700 m^3 of unsuitable fine-grained silt and clay from the channel and berth areas was placed in the cells in January and February 2006. The cells were capped in late February 2006 with approximately 3,800 m^3 of silty material from near the mouth of the harbor within the East Norwalk navigation channel.

Also in Connecticut, there are currently two CAD cells located in the Federal Navigation Channel of the Thames River, immediately south of the Naval Submarine Base, in New London (Figure 1-9). The first cell, termed the "Pier 6" cell, was constructed in October 2006. In November 2006, approximately 117,400 m^3 of dredged material, primarily fine silty clay with some sand, was placed into the cell. Directly following UDM disposal, the cell was capped with 13,300 m^3 of fine silty clay material that was originally excavated to create the CAD cell. A second CAD cell, termed the "maintenance dredged material" cell, was constructed in the winter of 2009-2010. This cell, located immediately south of the initial CAD cell, remains partially filled and was not included in this investigation.

Two additional CAD cells were created as part of a separate maintenance dredging project in Boston Harbor in 2008 (Mystic CAD cell and Main Ship Channel CAD cell, Figure 1-5). Approximately 537,000 m^3 of material was placed into the two most recent CAD cells. Eleven of the 12 Boston Harbor CAD cells have been capped with sand; only the Chelsea cell remains uncapped. The most recent survey of the BHCAD cells was conducted in November 2009 and is presented in a separate report (USACE in prep).

Although previous surveys have been performed at the CAD cells described above, most have focused on measurement of bathymetry during construction and immediately following filling/capping. In an effort to provide a baseline of data for longer term study of the performance of CAD cells, more comprehensive surveys were performed at select CAD cells in four harbors, and background information on these cells and harbor settings is provided in Section 1.4.

1.4 Description of Four New England Harbor CAD Cells

The October 2009 New England CAD cell survey included the CAD cells located in Norwalk, Connecticut; New London, Connecticut; Providence, Rhode Island; and Hyannis, Massachusetts. The four sites studied in this survey represent four distinct harbor/river conditions found along the New England coast. Land uses range from the highly industrial and developed port of Providence to the recreational setting of Hyannis Harbor. Environmental conditions also vary considerably from the upriver location in the Norwalk River to the exposed, wave-dominated site in Hyannis. Data collected during this effort, combined with future monitoring, will allow for evaluation of the long-term effectiveness of CAD cells at these sites as well as aid general future management decisions concerning the disposal of unsuitable dredged material in near-shore sites.

CAD cell construction, disposal, and capping history as well as the environmental setting of each CAD cell and previous investigations are described below (Tables 1-1 and 1-2, Figures 1-10 and 1-11).

1.4.1 Norwalk CAD Cells

The Norwalk CAD cells are located in the Norwalk River, beneath the 3-m deep MLLW channel, near Norwalk, Connecticut (Figure 1-8). The cells are located approximately 2.7 km upriver from Norwalk Harbor. The Norwalk River watershed (from the Route 1 Bridge in Norwalk upstream to Ridgefield) consists primarily of forested lands (53%) and urban, developed areas (37%). The remaining land area consists of open space, wetland areas, and agricultural lands (CTDEP 2005). The lower reach of the Norwalk River forms Norwalk Harbor, which houses five commercial port facilities and 15 marinas, with more than 1,800 berths and 500 moorings available to recreational vessels (NHMC 2010). The mean tidal range in Norwalk Harbor is 2.16 m with a spring range of 2.50 m and a mean tide level of 1.16 m, as measured near the Washington Street Bridge approximately 1.2 km downstream of the CAD cells (NOAA 2010). Average current speeds in the Norwalk River at Gregory Point, approximately 2.8 km downstream of the CAD cells, range from 0.26 m/s at ebb tide to 0.31 m/s at flood tide (NOAA 2010). The average daily discharge for the Norwalk River at Wilton, Connecticut, approximately 5.5 km upstream of the CAD cells, ranges from 0.28 m^3/s in September to 4.8 m^3/s in March (USGS 2011).

The Norwalk CAD cells were constructed in January 2006, in conjunction with routine maintenance dredging of the channel. The CAD cells were irregularly shaped and had areas of 0.44 hectares (north cell [Cell 2]) and 0.49 hectares (south cell [Cell 1]) (Figure 1-8). Approximately 38,000 m^3 of material was excavated to create the CAD cells. The excavated material was deemed suitable for offshore disposal and was placed at the Central Long Island Sound Disposal Site (CLDS). CAD Cell 1 was dredged to 10.7 m mean lower low water (MLLW) (approximately 7.6 m below the surrounding river bottom), while CAD Cell 2, located to the north of Cell 1, was dredged to 15.2 m MLLW (approximately 12.2 m below the surrounding river bottom) (Table 1-1).

Approximately 25,200 m^3 of unsuitable fine-grained silt and clay from the area around the I-95 Bridge was placed in the cells in January and February 2006. An additional 1,500 m^3 of sediment from the Travel Lift pits at Norwest and Total Marine and from areas adjacent to the South Norwalk Boat Club were also deposited in the cells resulting in a total thickness of material placed of 4.6 m in Cell 1 and 9.2 m in Cell 2. The cells were capped in late February 2006 with approximately 3,800 m^3 of silty material from within the East Norwalk navigation channel, near the mouth of the harbor. The cap averaged 1 m in thickness and brought the cells up to 2 m below the ambient channel bottom (Table 1-1, Figure 1-11).

Previous surveys of the Norwalk CAD cells have included post-construction, post-disposal, and post-capping bathymetric surveys (Table 1-2). A bathymetric survey of the Norwalk River and Harbor was also conducted in December 2007, approximately 22 months following cap placement.

1.4.2 New London CAD Cell

There are currently two CAD cells located in the Federal Navigation Channel of the Thames River, immediately south of the Naval Submarine Base, in New London, Connecticut (Figures 1-9 and 1-12). The Thames River is a tidal river formed by the confluence of the Shetucket River and Yantic River, after which it enters New London Harbor and flows into Long Island Sound. The cells are located approximately 7.5 km upstream of where the river enters Long Island Sound. The Federal channel is authorized to 7.6 m MLLW, but the Navy maintains it to 11.6 m MLLW. The channel area surrounding the cells was last dredged in 1995 to 11.6 m. A small shoal, approximately 2.5 m in depth, exists to the west of the CAD cells, outside of the navigational channel (Figure 1-12).

Land use in the Thames River Basin is 68% forest, 12% agriculture, and 9% urban; the remaining land use (approximately 11%) consists of wetlands (Trench 2005). The mean tidal range in the Thames River, near the I-95 Bridge, is 0.79 m with a spring tidal range of 0.94 m; the mean tide level is 0.46 m (NOAA 2010). Average current speed in the Thames River, just upstream of the CAD cell, ranges from 0.26 m/s at ebb tide to 0.36 m/s at flood tide (NOAA 2010). Under certain conditions, a saltwater wedge may extend from the mouth of the river upstream for the entire extent of the river (Trench 2005). In addition to the Navy base, there is some larger commercial vessel traffic that moves upriver of the cells. River discharge data are not available for the Thames River in the vicinity of the CAD cells, but discharge data are available for the Yantic River at Yantic, Connecticut and the Shetucket River at Willimantic, Connecticut. The average daily discharge for the Yantic River at Yantic, approximately 20 km upstream of the CAD cells, ranges from 0.82 m^3/s in September to 14 m^3/s in March. The average daily discharge for the Shetucket River at Willimantic, approximately 38 km upstream of the CAD cells, ranges from 5.0 m^3/s in March to 49 m^3/s in September (USGS 2011).

The first cell, termed the "Pier 6" cell, was constructed in October 2006. Approximately 167,800 m^3 of material was excavated via clamshell dredge to create a CAD cell approximately 2.4 hectare in area and 26.6 m MLLW deep (13.7 m below the surrounding river bottom). In November 2006, approximately 117,400 m^3 of dredged material was removed from the vicinity of several local piers. Approximately 11.2 m of fine-grained silt and clay was placed into the CAD cell (Figure 1-11). Immediately after disposal the cell was capped with 13,300 m^3 of fine silty clay that was originally excavated to create the CAD cell (Table 1-1). The cap thickness was 1 m. The final cap elevation was 14 m MLLW, approximately 1.5 m below the surrounding river bottom. The remaining material that was excavated to create the CAD cell, approximately 154,500 m^3, was placed at the New London Disposal Site (NLDS). Table 1-1 summarizes the site construction, disposal, and capping history for this initial New London CAD cell.

A second CAD cell, termed the "maintenance dredged material" cell, was constructed in the winter of 2009-2010 following the October 2009 survey reported here. This cell, located immediately south of the initial CAD cell, was partially filled at the time of this report. Only results from the first CAD cell are discussed in this report.

Previous surveys of the New London CAD cell have included post-construction, post-disposal, and post-capping bathymetric surveys (Table 1-2). A bathymetric and sediment sampling survey of the first cell was also conducted one year following cap placement (TEC 2008). This survey included sampling of the upper 10 cm, 30.5 cm, and 61 cm layers of the CAD cell. Samples were analyzed for physical and chemical parameters including copper, lead, and zinc. The one-year post capping survey showed consolidation of 2.7 to 3.0 m, resulting in a surface approximately 4.6 m below the ambient river bottom. Results from the sediment analysis also suggested possible mixing of the UDM and cap material (TEC 2008) which was likely a function of the minimal consolidation time prior to capping required under the State water quality permit.

1.4.3 Providence CAD Cells

The Providence CAD cells are located in Providence Harbor, just south of Fox Point and the confluence of the Providence River and Seekonk River, in Providence, Rhode Island (Figure 1-7). The cells are located approximately 10 km from the mouth of Providence Harbor where it enters Narragansett Bay. A series of CAD cells were constructed below the Providence Harbor channel in order to sequester UDM generated from the Providence River and Harbor Maintenance Dredging Project (PRHMDP; ENSR 2008). Providence River and Harbor together constitute the principal commercial waterway in Rhode Island. The deep-draft traffic in Providence River and Harbor consists mainly of tankers, barges, and general cargo vessels. There are 27 water terminal facilities serving the Port of Providence; four facilities are owned by the City of Providence and two by the State of Rhode Island. There are also 10 wharves with major oil-handling capabilities on the main channel (ENSR 2008).

The mean tidal range in Providence Harbor is 1.34 m, the spring range is 1.71 m, and the mean tide level is 0.73 m (NOAA 2010). Average current speeds at Fox Point, located just upstream of the CAD cells, are relatively weak, ranging from 0.05 m/s at ebb tide to 0.1 m/s at flood tide (NOAA 2010). Depth-averaged current velocities measured during CAD cell construction in Fox Point Reach were relatively slow, at less than 0.12 m/s during most of the tidal cycle. Current velocities measured downstream of the CAD cells, at Bullock Point and Sabin Point, were similar in magnitude, ranging from 0.08 to 0.2 m/s (Reine et al., *in prep*). Although depth-averaged current speeds have not been reported to exceed 0.2 m/s, surface currents in the vicinity of the Providence CAD cells have been observed during previous monitoring events to be significantly higher, on the order of 0.5 m/s, particularly on the ebb tide.

Several watersheds drain into the Providence River, including the Woonasquatucket River, Moshassuck River, and Blackstone River basins. The Seekonk River also joins the Providence River where it enters Providence Harbor, just upstream of the CAD cells. River discharge data are not available for the Providence River or the Seekonk River in the vicinity of the CAD cells but discharge data are available upstream of the CAD cells for the Woonasquatucket River, Moshassuck River, and Blackstone River. The average daily discharge for the Woonasquatucket River at Centerdale, Rhode Island, approximately 7.3 km upstream of the CAD cells, ranges from 0.65 m^3/s in September to 5.0 m^3/s in March. The average daily discharge for the Moshassuck River at Providence, approximately 2.7 km upstream of the CAD cells, ranges from 0.37 m^3/s in August/September to 2.9 m^3/s in March. The average daily discharge for the Blackstone River at Pawtucket, approximately 7.5 km upstream of the CAD cells, ranges from 60 m^3/s in September to 93 m^3/s in April (USGS 2011).

In the Woonasquatucket River and Moshassuck River basins, land use is primarily forest (36% and 24%, respectively) and residential (28% and 37%, respectively) (Nimiroski and Wild 2005). Land in the Blackstone River basin is primarily forested (>50%) with 21% residential land use (Barbaro and Zarriello 2007). While the inland portions of the contributing watersheds are largely forested and residential, the area immediately around Providence Harbor is heavily developed. Land use within the Providence and Seekonk subbasin is predominately residential (49%) and commercial/industrial/urban (27%). Less than 15% of the area is undeveloped

(Nimiroski and Wild 2005). The city of Providence also has an impervious surface area (ISA) of 37%, one of the highest ISA's in the state (Zhou and Wang 2007).

Prior to 2003, significant shoaling of the Providence River shipping channel affected navigation safety, restricting access for large vessels enroute to the Port of Providence. The PRHMDP was initiated to restore the depth and width of the Federal Navigation Channel, a 27 km long channel that runs from Providence Harbor south along the Providence River to deeper waters near Prudence Island. The channel has an authorized depth of 12.2 m and width of 183 m; to restore the channel to its authorized dimensions, an estimated 3.3 million m^3 of material needed to be removed (USACE 2001). Approximately 920,000 m^3 of material dredged from the channel was considered unsuitable for unconfined open water disposal. Based on the findings of the PRHMDP Final Environmental Impact Statement (USACE 2001), this material was placed into a series of CAD cells.

The Providence CAD cells were constructed between May 2003 and January 2004. Similar to Boston, cell sizes were staged to accommodate uncovering successively larger cells and additional PRHMDP material. One cell was specifically designated for longer-term use by smaller private projects, with management provided by the State of Rhode Island. A total of six cells were constructed as square or rectangular pits (or slightly trapezoidal in the case of Cell 3AR) with dimensions at the sediment-water interface ranging from approximately 91 x 91 m to 340 x 347 m, and areas ranging from approximately 0.90 hectares to 10.1 hectares. The cells were dug to depths of 20.7 to 30.2 m MLLW, or 8.5 to 18.0 m below the authorized channel bottom (Figure 1-11), with side slopes generally ranging from slightly steeper than 2:1 (horizontal: vertical) to slightly flatter than 3:1. The cells were constructed shallower than originally planned because the initial clearing of the CAD cell area revealed less unsuitable surficial material than anticipated; thus, less overall CAD cell capacity was needed.

As the surficial material removed during initial clearing of the CAD cells was unsuitable for unconfined open water disposal, it was temporarily stored in barges during construction of the smaller first cell, and placed into the initial starter cells during uncovering of the larger cells. Approximately 2.0 million m^3 of parent material (suitable for unconfined open water disposal) was removed during construction of the six cells (ENSR 2008). The parent material was composed of a mixture of gravel, sand, and clay (glacial till) and was transported primarily to the Rhode Island Sound Disposal Site (RISDS) for disposal. A small portion of the total was used beneficially as fill in an upland construction project.

Disposal into the CAD cells occurred via split-hull disposal barges throughout the dredging project. The smaller CAD cells were filled with surficial material generated from the construction of the larger CAD cells. Cell 3AR, the largest CAD cell, was used primarily for disposal of unsuitable maintenance material from Fox Point Reach (outside of the CAD cell footprint). The second largest cell, Cell 6/7R, was reserved for disposal of unsuitable material from State and private dredging projects (e.g., marinas and berths) in the vicinity of Providence Harbor. As of the completion of the PRHMDP in July 2005, approximately 198,800 m^3 of dredged material from private projects had been disposed in Cell 6/7R. This cell continues to be used for the disposal of dredged material from private projects and through 2010, an additional 117,000 m^3 of material had been disposed into Cell 6/7R (Table 1-1). The thickness of material deposited in the Providence CAD cells ranged from approximately 7 to 12.6 m.

The original plan was for the CAD cells to be capped at the conclusion of the PRHMDP with material from upper Fuller Rock Reach, which was determined to be suitable for unconfined open water disposal (USACE 2001). However, following completion of the PRHMDP in 2005, bathymetric survey results showed that the surface of each of the six cells remained well-depressed below the surrounding seafloor, with substantial additional capacity remaining in Cells 5R and 6/7R. The State of Rhode Island assumed management responsibility for all the CAD cells to make full use of this remaining cell capacity for other, non-federal projects. The State will ultimately cap all the cells with suitable dredged material. Table 1-1 summarizes the site construction and disposal history.

1.4.4 Hyannis CAD Cell

The Hyannis CAD cell is located in Hyannis Harbor, off the south coast of Hyannis, Massachusetts (Figure 1-6). Hyannis Harbor receives runoff from the Lewis Bay watershed, which consists primarily of land designated as public service/government (42%) including the Hyannis Airport and protected water supply areas (Howes et al. 2007). Residential use accounts for 35% and commercial use accounts for 12% of the area (Howes et al. 2007). The mean tidal range in Hyannis Harbor is 0.94 m, the spring range is 1.13 m, and the mean tide level is 0.49 m (NOAA 2010).

Hyannis Harbor is open to Nantucket Sound to the south. Lewis Bay, located northeast of Hyannis Harbor, generally has finer sediments than those in Nantucket Sound, indicating that Lewis Bay is a depositional area with low sediment transport (MMS 2009). Because Hyannis Harbor is in a more exposed location, relative to Lewis

Bay, sediments in the harbor are coarser, with a higher sand content. Currents in the Sound are driven by strong, semidiurnal tidal flows; wind driven currents are moderated by sheltering land masses surrounding the Sound (Nantucket and Martha's Vineyard) (MMS 2009). Average current speeds range from 0.46 m/s at flood tide to 0.67 m/s at ebb tide (NOAA 2010). Modeled wave heights for the sound near Horseshoe Shoals (approximately 12.9 km from the CAD cell) indicate wind-generated waves ranging from <0.30 m to nearly 1.22 m with spectral peak wave periods from 2 to 4 seconds (MMS 2009). The largest wind driven waves in the sound can result in significant sediment transport (MMS 2009).

The Hyannis CAD cell is located beneath the former harbor entrance channel that is aligned east-west in the outer anchorage area southwest of the Lewis Bay inlet (Figure 1-6). The approximately 2.6 hectare CAD cell was constructed as a rectangle, 480 m in length (east-west) and 55 m in width (north-south). The cell was dredged with a hydraulic pipeline dredge from September to December 1998 and required the removal of about 107,800 m^3 of sand. The depth of the cell was variable, ranging from 7.6 to 9.1 m MLLW with a few areas as shallow as 5 m MLLW (Table 1-1 and Figure 1-11). The excavated material was placed on the beaches at Great Island and within the dikes built the previous year on Dunbar Point behind Kalmus Beach (Figure 1-6).

Approximately 57,600 m^3 of silty material from the inner harbor basin was disposed in the cell from December 1998 to March 1999 (Table 1-1). The deposited silty material created a layer approximately 3 m thick (Figure 1-11). The cell was capped with 0.9 to 1.5 m of clean sand (approximately 28,300 m^3) from the Lewis Bay channel deepening project in March 1999. At the conclusion of capping, the cell surface was approximately 1 m below the surrounding bottom, ranging from level with or just above the surrounding seafloor to 2.5 m below the surrounding seafloor (Figure 1-11).

1.5 Survey Objectives

The October 2009 CAD cell investigation was conducted as a baseline for longer term study of the performance of CAD cells, including physical stability and biological recovery, under the range of environmental conditions present in four New England Harbors.

The specific objectives of the investigation were as follows:

- Conduct bathymetric surveys of the CAD cells in each of the four harbors to document depths in and around the CAD cells, characterize cell morphology, and assess changes in morphology relative to available previous surveys;
- Assess the benthic recolonization status of the CAD cells, relative to representative references areas within each harbor, using SPI and plan-view video; and
- Complete a towed underwater video survey of select CAD cells using a bottom sled to further assess the general physical condition of the cells and further document the presence and abundance of marine organisms within the CAD cells compared to representative reference areas within each harbor.

Data collected during this effort, combined with future monitoring, will provide information necessary to assess the stability of these sites as well as aid general future management decisions concerning the confined placement of unsuitable dredged material at near-shore sites.

Table 1-1.
CAD Cell Construction, Disposal, and Capping Histories

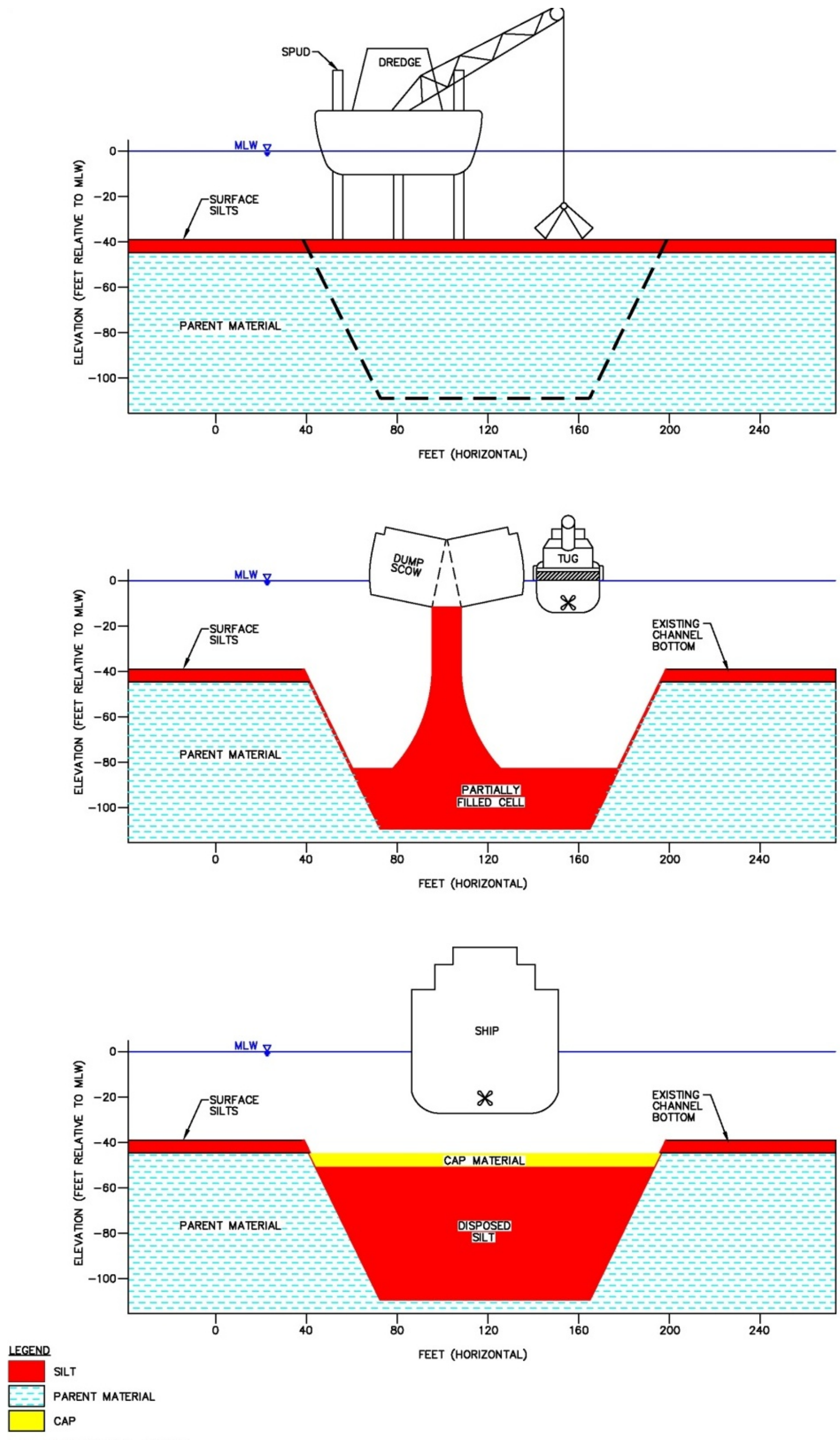
Harbor	Surrounding Channel Depth[1] (m)	CAD Cell	Cell Dimensions[2] (m)	Total Excavated Depth[3] (m)	Volume Removed in Construction (m^3)	UDM Characteristics	UDM Fill Volume (m^3)	Initial UDM Fill Thickness (m)	Cap Material Type	Cap Volume (m^3)	Cap Thickness (m)	Notes
Norwalk	3.0	Cell 1	126 x 69 (irregular[2])	7.6 (10.7)	38,000	fine silt and clay	26,700	4.6	silty material	3,800	1.0	Cells capped ~1 month following UDM placement with material from nearby project
		Cell 2	91 x 91 (irregular)	12.2 (15.2)				9.2			1.0	
New London	11.6	1 Cell	122 x 189 (irregular)	13.7 (26.6)	167,800	fine silty clay and sand	117,400	11.2	fine silty clay	13,300	1.0	Cells capped immediately after UDM placement with material removed from the CAD cell; Consolidation and mixing apparent one year post capping
Providence	12.2	Cell 1R	91 x 91	10.1 (22.3)	2.0 million	silty material	55,000	9.1	not yet capped[4]	not yet capped[4]	0[4]	Cell sizes were staged to accommodate uncovering successively larger cells. One cell (6/7R) was specifically designated for small project use. Cells remained uncapped at the end of the project to allow for additional consolidation and material placement prior to capping
		Cell 3R	122 x 91	11.0 (23.2)			55,000	8.0				
		Cell 3AR	340 x 347 (irregular)	14.6 (26.8)			873,000	12.6				
		Cell 4R	152 x 91	8.5 (20.7)			88,000	7.5				
		Cell 5R	259 x 91	10.1 (22.3)			113,000	7.1				
		Cell 6/7R	396 x 165 (irregular)	18.0 (30.2)			315,800 (thru 2010)	11.0				
Hyannis	3.5	1 Cell	480 x 55	5.1 (8.6)	107,800	silty material	57,600	3.0	sand	28,300	0.9-1.5	Cell was capped immediately after UDM placement

[1]Surrounding channel depth relative to MLLW
[2]Cell dimensions are measurements at longest and widest points (non-rectangular cells are noted as "irregular")
[3]Excavated depth of CAD cell below channel bottom. Depth relative to MLLW in parentheses ( ) and considered approximate given the cell bottoms were often uneven.
[4]All cells will be capped when capacities are reached
Source: Norwalk: ACOE, unpublished; New London: TEC 2008; Providence: ENSR 2008; Hyannis: ACOE, unpublished.

Table 1-2.
Summary of Previous Investigations at CAD Cell Locations

Site	Date	Study Type	Source
Norwalk	2005 (pre-construction)	Sediment borings	USACE unpublished data (Jack Karalius, personal communication)
	January 2006 (post-construction)	Bathymetric survey	
	February 2006 (post-disposal)	Bathymetric survey	
	December 2006 (post-cap [Cell 1])	Bathymetric survey	
	*December 2007 (Norwalk River and Harbor)	Bathymetric survey	
New London	October 2006 (post-construction)	Bathymetric survey	TEC 2008
	November 2006 (post-disposal)	Bathymetric survey	
	*November 2006 (post-capping)	Bathymetric survey	
	December 2007 (one year post-construction)	Bathymetric survey	
Providence	September 2003 (cell construction)	Plume monitoring	Reine and Clarke, in prep
	May–September 2003 (cell disposal)	Plume and water quality monitoring	USACE submittals to Rhode Island Department of Environmental Management
	2003–2005 (post-construction; cell disposal)	Bathymetric surveys	ENSR 2008
	*May 2005 (post-disposal)	Bathymetric survey	ENSR 2008
Hyannis	During Feasibility Study	Bathymetric survey	USACE unpublished (Steve Wolf, Mark Habel, personal communication)
	During preparation of Plans and Specifications	Bathymetric survey	
	March 1999 (post-disposal)	Bathymetric survey	
	*April 1999 (post-cap)	Bathymetric survey	
	March 2000 (one year post-construction)	Bathymetric survey	

Note: Asterisk (*) indicates dataset used in comparison to 2009 dataset



Initial removal of surficial material overlying planned CAD cell

Placement of material into an excavated CAD cell using a split-hulled scow

Completed CAD cell with cap, typically remaining slightly depressed below the ambient seafloor

Figure 1-1. Cross section of CAD cell construction

Figure 1-2. CAD cell locations in New England

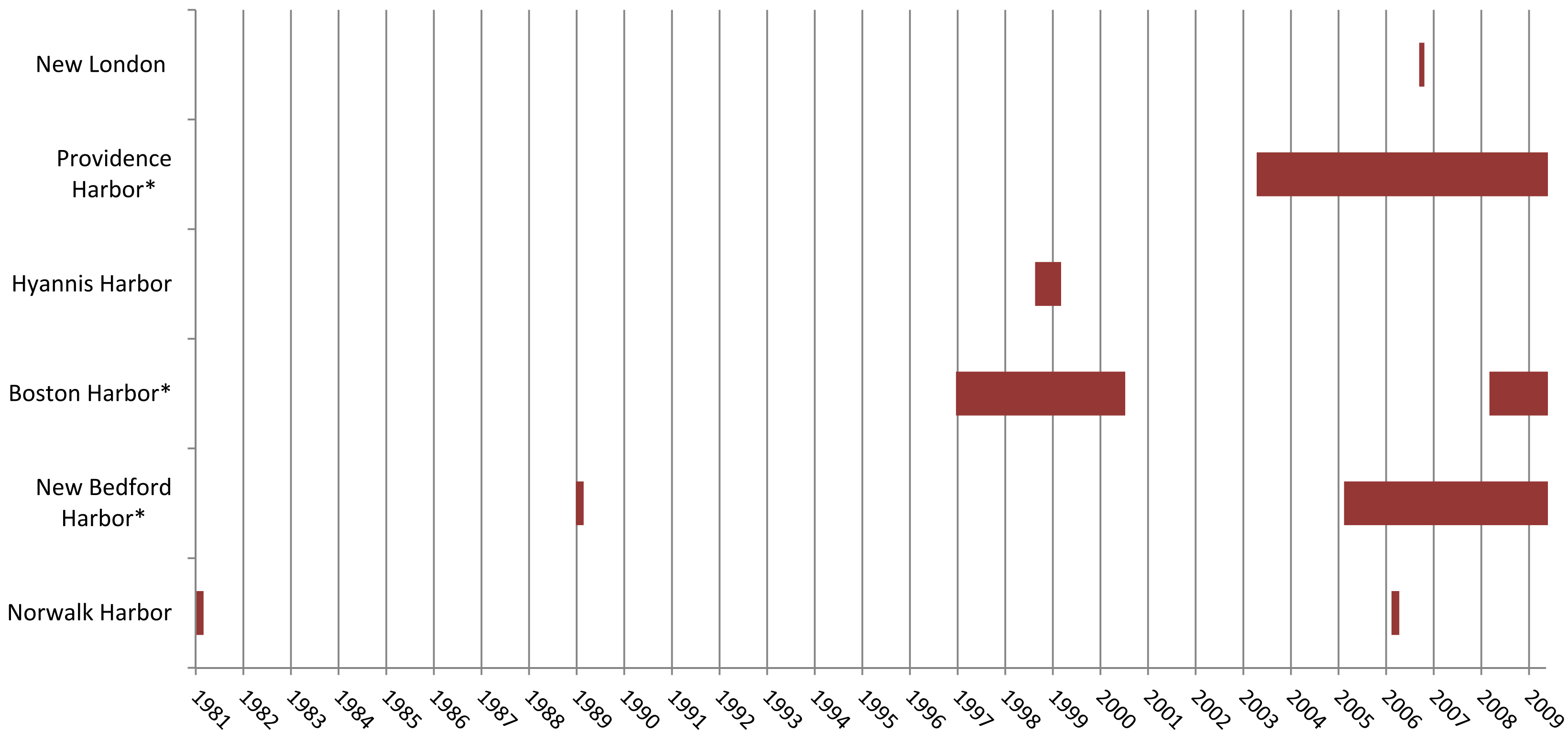


Figure 1-3. Timeline of CAD cell construction/usage in New England. Asterisk (*) indicates sites with uncapped CAD cells.

Figure 1-4. New Bedford Harbor CAD cells

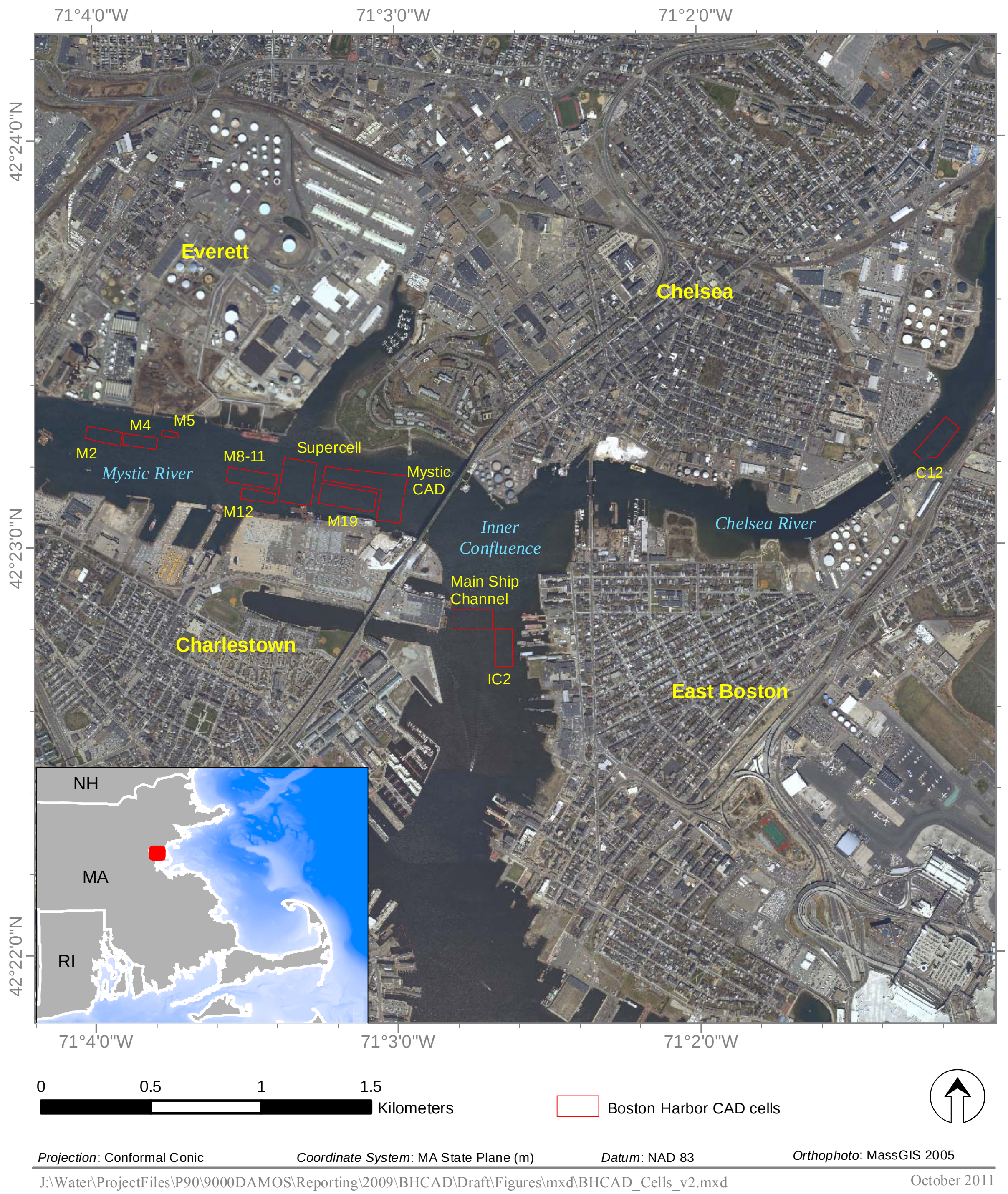


Figure 1-5. Boston Harbor CAD cell locations

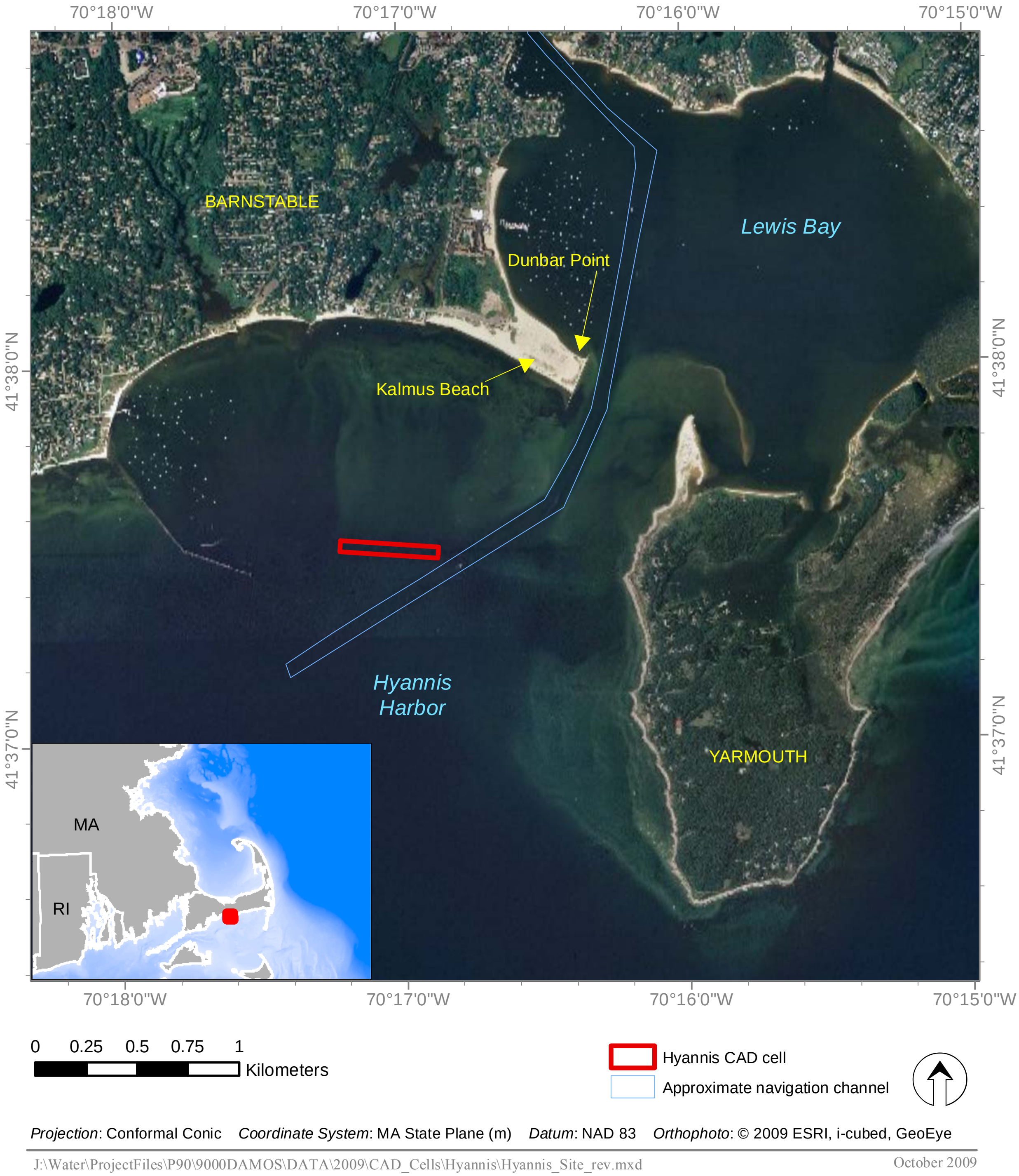


Figure 1-6. Hyannis CAD cell location

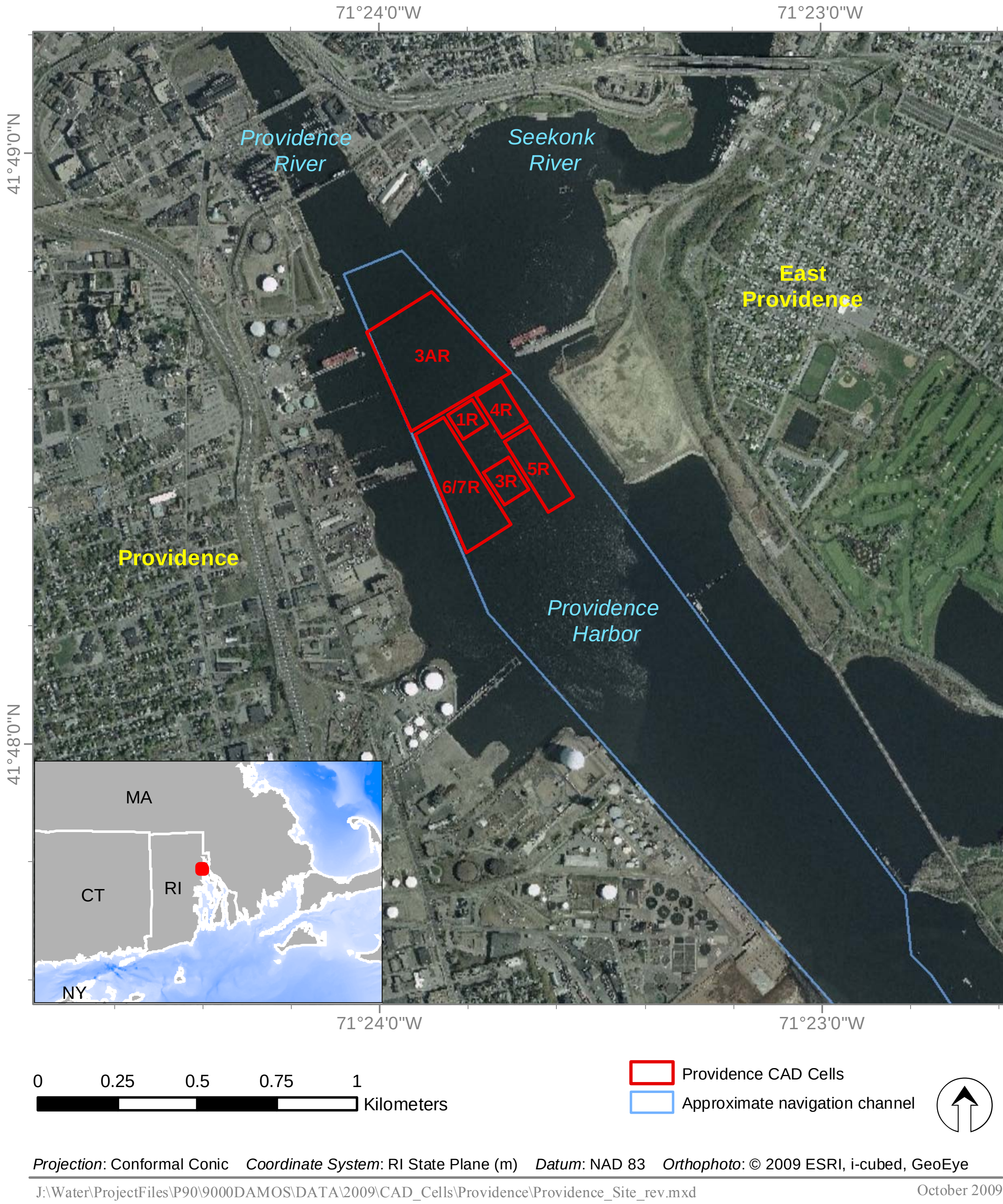


Figure 1-7. Providence CAD cell locations

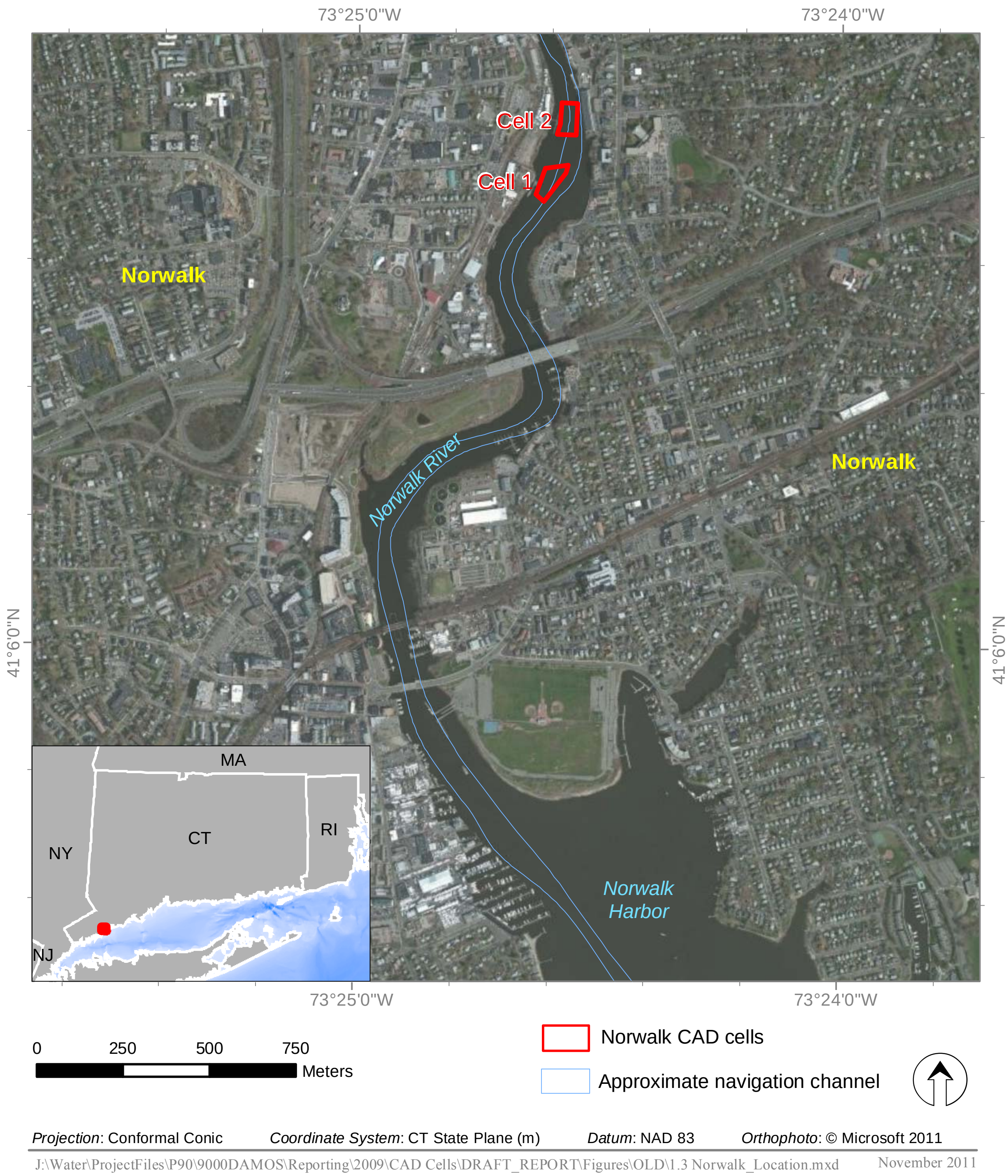


Figure 1-8. Norwalk CAD cell location

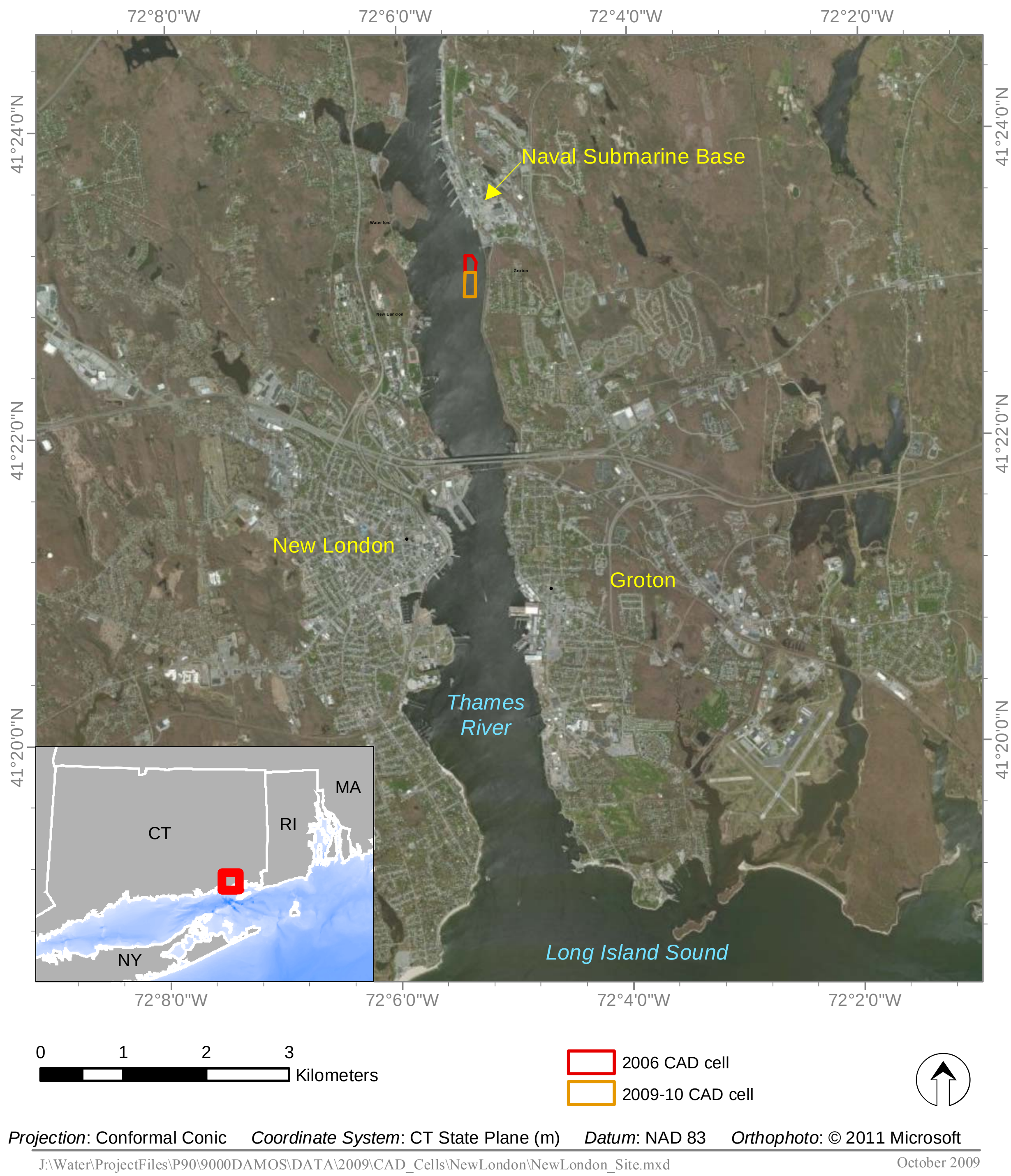


Figure 1-9. New London CAD cell location

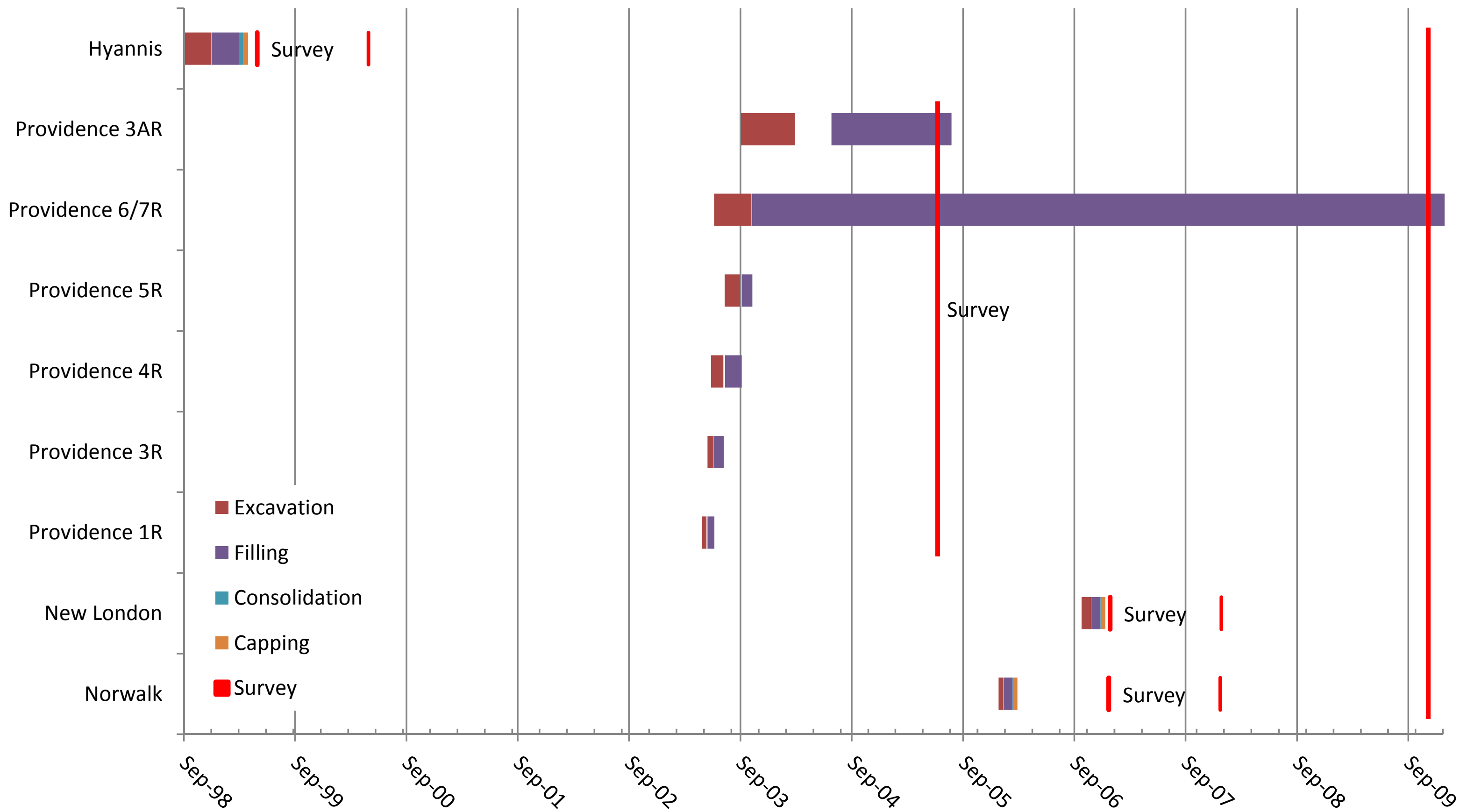


Figure 1-10. Timeline of CAD cell events

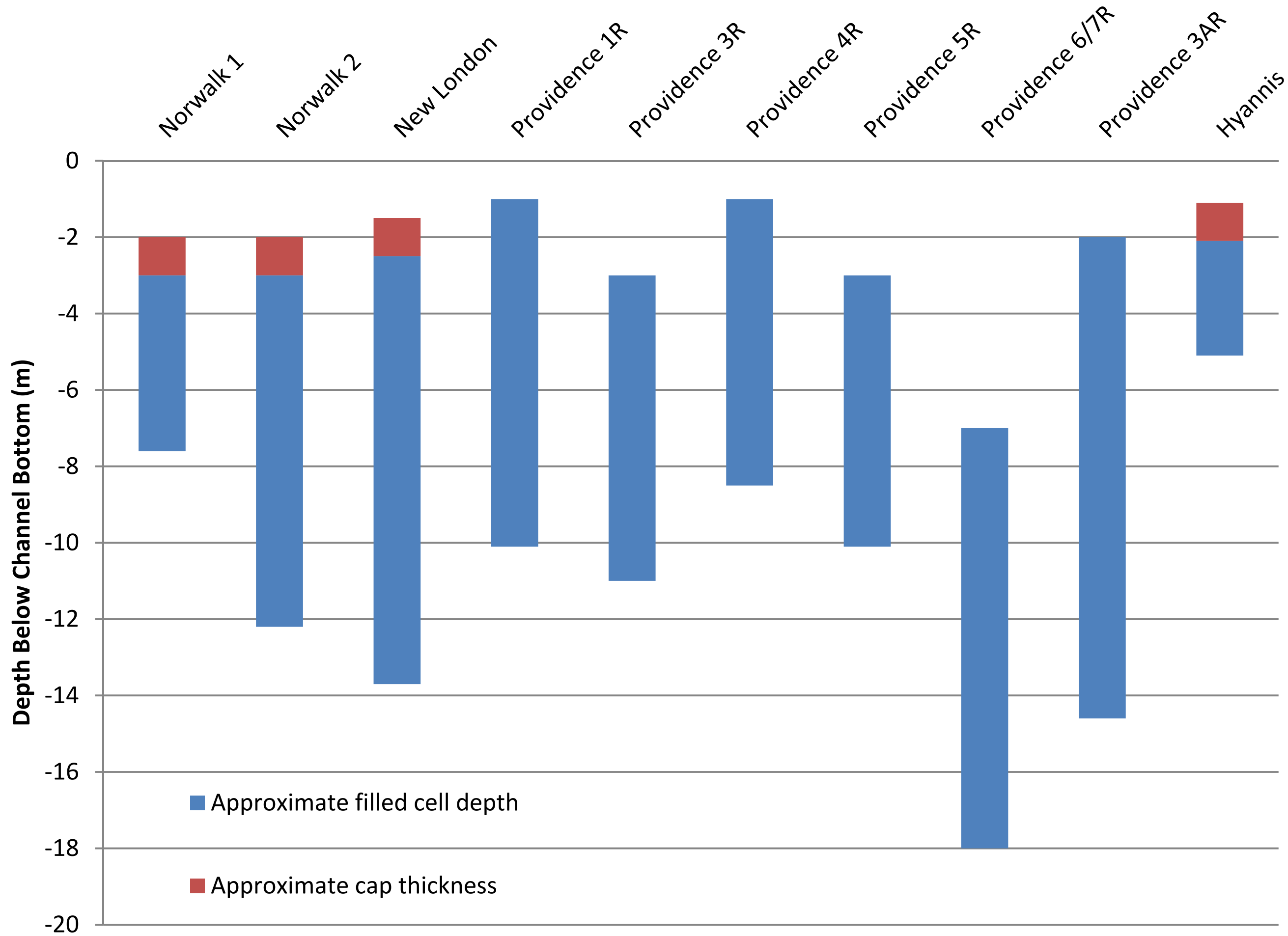


Figure 1-11. Excavated depth of CAD cells relative to surrounding channel bottom

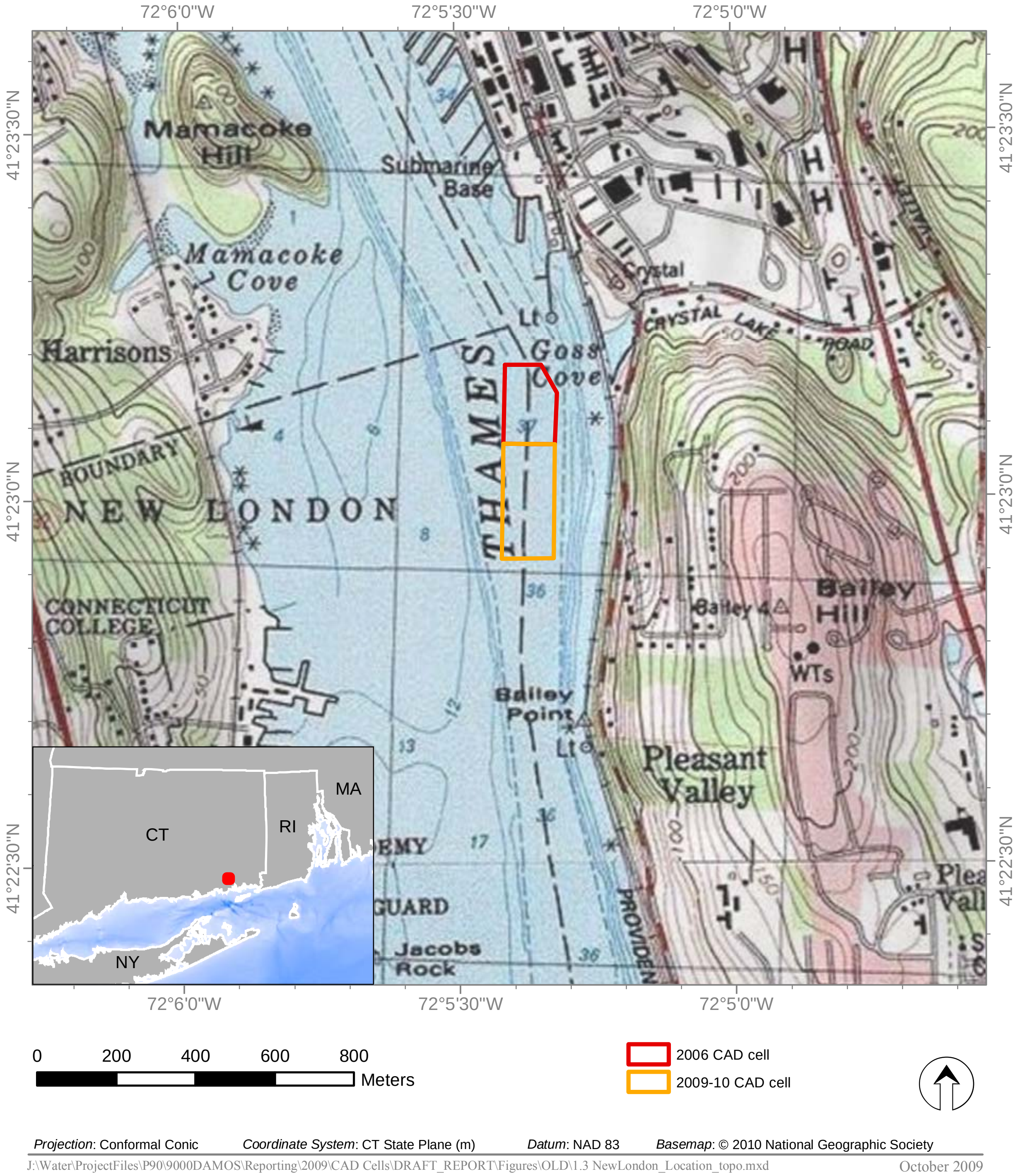


Figure 1-12. New London CAD cell in Thames River

2.0 METHODS

The October 2009 surveys conducted at the Norwalk, New London, Providence, and Hyannis CAD cells were performed by AECOM; Diaz & Daughters; Ocean Surveys; Inc. (OSI); and CR Environmental, Inc. The bathymetric surveys were conducted 15–22 October 2009 to document depths in and around each CAD cell location. Sediment-profile imaging (SPI) and underwater video surveys were conducted 19–24 October 2009 to assess benthic recolonization and presence and abundance of marine organisms within the CAD cells compared to reference areas.

Field activities are summarized in Table 2-1, and an overview of the methods used to collect, process, and analyze the survey data is provided below.

2.1 Navigation

Navigation and horizontal positioning were obtained using a Trimble AG-132 Differential Global Positional System (DGPS) unit integrated with HYPACK®, a hydrographic survey package, which provided a real-time display of vessel position on an electronic nautical chart. Correctors broadcast from the U.S. Coast Guard differential beacon transmitters at Moriches, New York, and Acushnet, Massachusetts, were applied to the POS MV raw GPS solution resulting in accurate and repeatable positioning. The accuracy of the system was validated at the beginning of each survey day by comparing the observed DGPS position to that of an established reference point with known coordinates. HYPACK® provided guidance to accurately maintain the position of the vessel along pre-established survey transects and targets and managed data acquisition and storage of geographical information during the survey.

2.2 Bathymetry

Bathymetric surveys provide measurements of water depth that, when processed, can be used to map the seafloor topography. The processed data can also be compared with data from previous surveys to track changes in the size and location of seafloor features.

The 2009 multibeam bathymetric survey of the four CAD cell locations was conducted 14-22 October 2009 aboard the R/V *Able*. Multibeam bathymetric data as well as acoustic backscatter data were collected at each site. Site-specific data are detailed below.

2.2.1 Bathymetric Data Collection

The bathymetric and acoustic backscatter data were collected using a Reson 8125 Ultra High Resolution Echo Sounder outfitted with a 0.5°, 455-kHz transducer. An Applanix POS-MV Position and Orientation System was combined with the DGPS to provide accurate heading and measurement of heave, pitch, and roll. A Seabird SBE-37 Sound Velocity Sensor was installed to measure sound velocity at the transducer face; the system was calibrated for local water mass speed of sound by performing conductivity-temperature-depth (CTD) casts at frequent intervals throughout the day with a Seabird SBE-19 Seacat CTD profiler.

Water depths over the survey area were recorded in meters and referenced to mean lower low water (MLLW) based on water levels recorded at each location (Table 2-2). HYPACK® managed data acquisition and storage of data from the echosounder and the navigation system. HYPACK® also recorded depth, vessel heave, heading, position, and time along each survey transect line.

The Norwalk bathymetric survey was conducted 14 October 2009 and covered a 122 x 306 m area, covering both the existing and proposed CAD cells. A total of 52 survey lines was collected, with variable spacing between each line based on the varying water depths. Lines were oriented in an upstream–downstream direction over the entirety of the cells (Figure 2-1). Additional lines were run perpendicular to the main survey lines to assess data quality.

The New London bathymetric survey was conducted 15 October 2009. The survey covered a 305 x 610 m area and consisted of a total of 26 lines, with approximately 18 m spacing between each line. Lines were oriented in a north-south direction over the entirety of the CAD cell (Figure 2-1). Additional lines were run perpendicular to the main survey lines to assess data quality.

The Providence bathymetric survey was conducted 19 October 2009 and covered a 457 x 914 m area. A total of 49 lines was collected, with variable spacing between each line based on the varying water depths. Lines were oriented in a north-south direction over the entirety of the CAD cells (Figure 2-1). Additional lines were run perpendicular to the main survey lines to assess data quality.

The Hyannis bathymetric survey was conducted 21-22 October 2009 and covered a 305 x 701 m area. A total of 92 lines was collected, with variable spacing between each line based on varying water depth. Lines were oriented in an east-west direction over the entirety of the CAD cell (Figure 2-1). Additional lines were run perpendicular to the main survey lines to assess data quality.

2.2.2 Bathymetric Data Processing

The bathymetric data were processed using the HYPACK® software program and included corrections for tidal conditions, local speed of sound, and spurious data points. Tidal correction consisted of transforming the raw measurements of depth below the transducer to seafloor elevation measurements relative to MLLW using the locally collected tidal elevation data. Heave data supplied by the Applanix POS-MV Position and Orientation System was incorporated into the raw data to minimize the effects of vessel motion. The bathymetric data were also reviewed for spurious data points (clearly unrealistic measurements resulting from signal interference), and these points were removed. (Note, however, that some outliers can indicate gas ebullition from sediments). The final data set was averaged into 1.0-m^2 square bins. All soundings located within a given bin were averaged, and the average value was assigned to the coordinates at the center of the bin.

2.2.3 Bathymetric Data Analysis

Bathymetric data were analyzed to document depths in and around the CAD cells and to evaluate changes in morphology relative to previous surveys. The corrected bathymetric data were processed for display using a combination of the contouring and surface plotting software program Surfer® 8.0 and the GIS-based software package ArcMap® 9.3. The processed bathymetric data were converted into grids using Surfer®, and bathymetric contour lines were generated and displayed using ArcMap®.

Surfer® was also used to generate depth difference grids based on available previous bathymetric data sets. The depth difference grids were calculated by subtracting the previous interpolated depth estimates from the 2009 survey depth estimates at each point throughout the grid. The resulting depth differences were contoured and displayed using ArcMap®.

2.3 SPI and Plan-View Video

SPI and plan-view video are monitoring techniques used to provide data on the physical characteristics of the seafloor as well as the status of the benthic biological community. The sediment profile camera system consisted of a 15-megapixel digital camera enclosed in a pressure-resistant housing, a 45° prism, and a mirror that reflected an image of the sediment through the camera lens. A strobe mounted inside the prism was used to illuminate the sediment. The digital camera was also equipped with a video feed that was used to send images to the surface via cable so that prism penetration was monitored in real time. The camera/prism system was mounted in a cradle that was secured to a larger frame, which ensured that the prism penetrated the sediment at a 90° angle. Stop collars, located on the camera frame, were adjusted to limit the penetration of the camera. Weights may also be added to the frame to increase penetration when hard sediments are encountered. Weight amounts and frame stop collar position were recorded. For this study, the stop collar setting and number of weights were kept constant for each harbor.

2.3.1 SPI and Plan-View Video Collection

The 2009 imaging survey design included the collection of SPI and plan-view video at each of the four CAD cell study sites. The SPI technique produces a cross-sectional image of the upper 15 to 20 cm of the sediment column while the plan-view video technique produces video of the seafloor surface. These surveys were performed on 20 October 2009 in Norwalk, 21 October 2009 in New London, 22 October 2009 in Providence, and 23 October 2009 in Hyannis, all aboard the F/V *Shanna Rose*. At each site 15 stations were located within the CAD cells, and 10 stations were located outside of the CAD cell footprint to serve as reference (Tables 2-3 through 2-6 and Figures 2-2 through Figure 2-5). Images were collected from a total of 100 stations over the four harbors.

At each SPI station, the vessel was positioned at the target coordinates using the onboard GPS system, and the camera frame was deployed within a station tolerance of 10 m. Three replicate sediment-profile images and plan-view video were collected at each of the 100 stations. All sediment-profile images were reviewed after collection and labeled with station and replicate number with reference to the image time stamp, navigation log, and field notes. All image data were stored in digital format for subsequent image analysis.

2.3.2 SPI and Plan-View Video Analysis

Computer-aided analysis of images provided a set of standard measurements that enabled comparison between different locations and different surveys. Image-Pro Plus Version 7.0 was used to measure minimum, maximum, and mean penetration depths; apparent redox potential discontinuity (aRPD) depths; and the depths of any observed voids, burrows, or sedimentary layers in the SPI. Penetration depth is the depth to which the camera penetrated into the seafloor. When the stop collar setting and number of weights are kept constant, the camera penetration depth can be used as a proxy for weight-bearing strength of the sediments. Sediment grain size (major mode) was determined by directly comparing images against photographs of different sediment phi classes. Apparent RPD provides a measure of the integrated time history of the balance between near surface oxygen conditions and biological reworking of sediments. Sediment particles exposed to oxygenated waters oxidize and lighten in color to brown or light grey. As the particles are moved downwards by biological activity or buried, they are exposed to reduced oxygen concentrations in subsurface pore waters and their oxic coating slowly reduces, changing color to dark grey or black.

Additional calculated and observed parameters included boundary roughness, successional stage of the infauna, presence/absence of methane bubbles, and evidence of anoxia. Surface boundary roughness is a measure of the vertical relief of features at the sediment-water interface. The boundary roughness may be related to physical structures (e.g., ripples, rip-up structures, mud clasts) or biogenic features (e.g., burrow openings, fecal mounds, foraging depressions). The infaunal successional stage is a measure of the biological community inhabiting the seafloor. Current theory holds that organism-sediment interactions in fine-grained sediments follow a predictable sequence of development (Pearson and Rosenberg 1978) after a major disturbance (such as dredged material disposal), and this sequence has been divided subjectively into three stages (Rhoads and Germano 1982, 1986). Successional stage was assigned by assessing which types of species or organism-related activities were apparent in the images.

Three replicate images from each of the 100 stations (300 images) were analyzed using Image-Pro Plus, and the results were loaded into a Microsoft Access database. The data for each image were compiled on individual sheets for quality control purposes. After review, a data table was exported to Microsoft Excel and then formatted for clarity.

The video signal (from the plan-view camera mounted on the frame) showing the surface of the seafloor was recorded on mini-DVD digital videotape. The plan-view video was initially examined in the field and preliminary observations were recorded in the logbook. Sediment type and observed epifauna and biogenic features were recorded into a preformatted, standardized spreadsheet that was then loaded into a Microsoft Access database.

2.4 Underwater Video Transects

The underwater video survey provided real-time video output that was used to characterize the physical and biological properties of the seafloor within each CAD cell and the surrounding area. The underwater video was used to create representative video clips and representative screen captures throughout the survey area.

2.4.1 Video Collection

An Outland Technologies' high resolution video camera mounted to a lightweight aluminum sled with two 250 watt lights was towed behind the F/V *Shanna Rose* along predetermined transects. The lights were turned on prior to deployment of the sled and remained on at a constant intensity until the sled was retrieved. The frame was lowered and dragged at or near the bottom along the length of the survey transect at a speed of approximately 0.26 m/s. The video output was monitored topside on two high-resolution flat screen monitors for image clarity and bottom coverage. The camera setup was equipped with scale lasers that were used as a range finder, to maintain a target distance off the bottom. The cable length was adjusted throughout the survey, with the assistance of the scale lasers, to maintain a sled height of 0–10 cm off the bottom and obtain a viewing area of approximately one meter. The sled did, on occasion, contact the seafloor, causing sediment to obscure the image with some limited "black outs" when towing in fine sediments. However, the occasional observance of disturbed material aided in the confirmation of sediment type. The system also used an Outland Technologies' navigation overlay system that permitted the display and recording of latitude and longitude along with the video image, although the video's navigation system was not operational for one of the Norwalk transects. Data were recorded in digital format on a computer hard drive and DVD recorder.

2.4.2 Video Analysis

Positional data were imported into ArcMap® 9.3 GIS software for plotting of track lines. These data were not corrected for layback but the shallow water depths and slow vessel speed resulted in minimal tow cable lengths (layback was estimated at <5 m from the recorded position). The underwater video footage was reviewed using VLC Viewer® software and cataloged with a Microsoft Excel spreadsheet. Debris with known dimensions (i.e. soda cans) were used to estimate the sizes of organisms and substratum features. Representative sequences illustrating some of the most interesting features were selected for creation of short clips or screen captures. In addition, the entire video footage was reviewed and annotated, with references to sediment characteristics, observed fauna, and debris.

Table 2-1.
Summary of Field Activities, October 2009

Survey Location	Date	Summary
Norwalk	14 October 2009	Bathymetry Area: 122 x 305 m Lines: 52 Spacing: Variable
	20 October 2009	Imaging Stations: 25 CADs: 15 Reference: 10 Video Transects: 3
New London	15 October 2009	Bathymetry Area: 305 x 610 m Lines: 26 Spacing: approx. 18 m
	21 October 2009	Imaging Stations: 25 CAD: 15 Reference: 10 Video Transects: 2
Providence	19 October 2009	Bathymetry Area: 457 x 914 m Lines: 49 Spacing: Variable
	22 October 2009	Imaging Stations: 25 CADs: 15 Reference: 10 Video Transects: 4
Hyannis	21–22 October 2009	Bathymetry Area: 305 x 701 m Lines: 92 Spacing: Variable
	23 October 2009	Imaging Stations: 25 CAD: 15 Reference: 10 Video Transects: 2

Table 2-2.
Project Grid and Water Level Data Source for Each Survey, October 2009

Survey Location	Project Horizontal Grid System (NAD 83 meters)	Water Level Source
Norwalk	Connecticut State Plane	Project tide gauge leveled to USACE benchmark "TBM 95 South (2007)"
New London	Connecticut State Plane	New London NOS gauge
Providence	Rhode Island State Plane	Providence NOS gauge
Hyannis	Massachusetts State Plane (Mainland)	Project tide gauge leveled to a NOS benchmark "NO 11 1934"

NOS - National Ocean Service

Table 2-3.
Norwalk CAD Cell SPI and Plan-View Video Target Locations

Station	Latitude(N)	Longitude(W)	Station	Latitude(N)	Longitude(W)
CAD Cell			Reference		
1C	41° 06.846'	73° 24.575'	1R	41° 06.878'	73° 24.581'
2C	41° 06.828'	73° 24.572'	2R	41° 06.878'	73° 24.566'
3C	41° 06.815'	73° 24.572'	3R	41° 06.888'	73° 24.577'
4C	41° 06.809'	73° 24.556'	4R	41° 06.773'	73° 24.574'
5C	41° 06.823'	73° 24.561'	5R	41° 06.779'	73° 24.587'
6C	41° 06.802'	73° 24.583'	6R	41° 06.765'	73° 24.587'
7C	41° 06.804'	73° 24.566'	7R	41° 06.675'	73° 24.649'
8C	41° 06.738'	73° 24.600'	8R	41° 06.662'	73° 24.653'
9C	41° 06.728'	73° 24.614'	9R	41° 06.658'	73° 24.669'
10C	41° 06.714'	73° 24.620'	10R	41° 06.646'	73° 24.669'
11C	41° 06.744'	73° 24.604'			
12C	41° 06.718'	73° 24.601'			
13C	41° 06.738'	73° 24.583'			
14C	41° 06.708'	73° 24.615'			
15C	41° 06.841'	73° 24.559'			

Notes: Coordinate system NAD83

Table 2-4.
New London CAD Cell SPI and Plan-View Video Target Locations

Station	Latitude(N)	Longitude(W)	Station	Latitude(N)	Longitude(W)
CAD Cell			Reference		
1C	41° 23.108'	72° 05.386'	1R	41° 22.868'	72° 05.333'
2C	41° 23.150'	72° 05.387'	2R	41° 22.892'	72° 05.386'
3C	41° 23.083'	72° 05.399'	3R	41° 22.891'	72° 05.346'
4C	41° 23.099'	72° 05.361'	4R*	41° 22.847'	72° 05.390'
5C	41° 23.173'	72° 05.396'	5R	41° 22.869'	72° 05.373'
6C	41° 23.132'	72° 05.398'	6R	41° 23.123'	72° 05.479'
7C	41° 23.139'	72° 05.323'	7R	41° 23.195'	72° 05.477'
8C	41° 23.173'	72° 05.362'	8R	41° 23.163'	72° 05.478'
9C	41° 23.160'	72° 05.362'	9R	41° 23.143'	72° 05.457'
10C	41° 23.087'	72° 05.342'	10R	41° 23.178'	72° 05.453'
11C	41° 23.158'	72° 05.342'			
12C	41° 23.132'	72° 05.341'			
13C	41° 23.084'	72° 05.378'			
14C	41° 23.117'	72° 05.347'			
15C	41° 23.136'	72° 05.372'			

*4R relocated, too close to channel navigational buoy, coordinates represent relocated position

Notes: Coordinate system NAD83

Table 2-5.
Providence CAD Cell SPI and Plan-View Video Target Locations

Station	Latitude(N)	Longitude(W)	Station	Latitude(N)	Longitude(W)
CAD Cell			Reference		
1C	41° 48.584'	71° 23.753'	1R	41° 48.184'	71° 23.662'
2C	41° 48.536'	71° 23.718'	2R	41° 48.216'	71° 23.609'
3C	41° 48.556'	71° 23.700'	3R	41° 48.217'	71° 23.542'
4C	41° 48.556'	71° 23.735'	4R	41° 48.256'	71° 23.491'
5C	41° 48.597'	71° 23.727'	5R	41° 48.258'	71° 23.422'
6C	41° 48.490'	71° 23.681'	6R	41° 48.732'	71° 24.008'
7C	41° 48.509'	71° 23.667'	7R	41° 48.775'	71° 23.911'
8C	41° 48.428'	71° 23.628'	8R	41° 48.757'	71° 23.948'
9C	41° 48.452'	71° 23.610'	9R	41° 48.755'	71° 23.985'
10C	41° 48.477'	71° 23.651'	10R	41° 48.736'	71° 24.040'
11C	41° 48.586'	71° 23.854'			
12C	41° 48.604'	71° 23.926'			
13C	41° 48.668'	71° 23.797'			
14C	41° 48.720'	71° 23.880'			
15C	41° 48.661'	71° 23.937'			

Notes: Coordinate system NAD83

Table 2-6.
Hyannis CAD Cell SPI and Plan-View Image Target Locations

Station	Latitude(N)	Longitude(W)	Station	Latitude(N)	Longitude(W)
CAD Cell			Reference		
1C	41° 37.525'	70° 17.191'	1R	41° 37.510'	70° 16.836'
2C	41° 37.525'	70° 17.075'	2R	41° 37.500'	70° 16.820'
3C	41° 37.505'	70° 16.931'	3R	41° 37.507'	70° 16.801'
4C	41° 37.512'	70° 16.968'	4R	41° 37.499'	70° 16.781'
5C	41° 37.508'	70° 17.033'	5R	41° 37.505'	70° 16.761'
6C	41° 37.510'	70° 17.159'	6R	41° 37.342'	70° 17.108'
7C	41° 37.512'	70° 16.888'	7R	41° 37.349'	70° 17.068'
8C	41° 37.499'	70° 16.991'	8R	41° 37.369'	70° 17.028'
9C	41° 37.504'	70° 17.081'	9R	41° 37.386'	70° 17.015'
10C	41° 37.498'	70° 16.911'	10R	41° 37.369'	70° 17.054'
11C	41° 37.516'	70° 17.046'			
12C	41° 37.527'	70° 17.116'			
13C	41° 37.514'	70° 17.131'			
14C	41° 37.521'	70° 17.002'			
15C	41° 37.531'	70° 17.169'			

Notes: Coordinate system NAD83

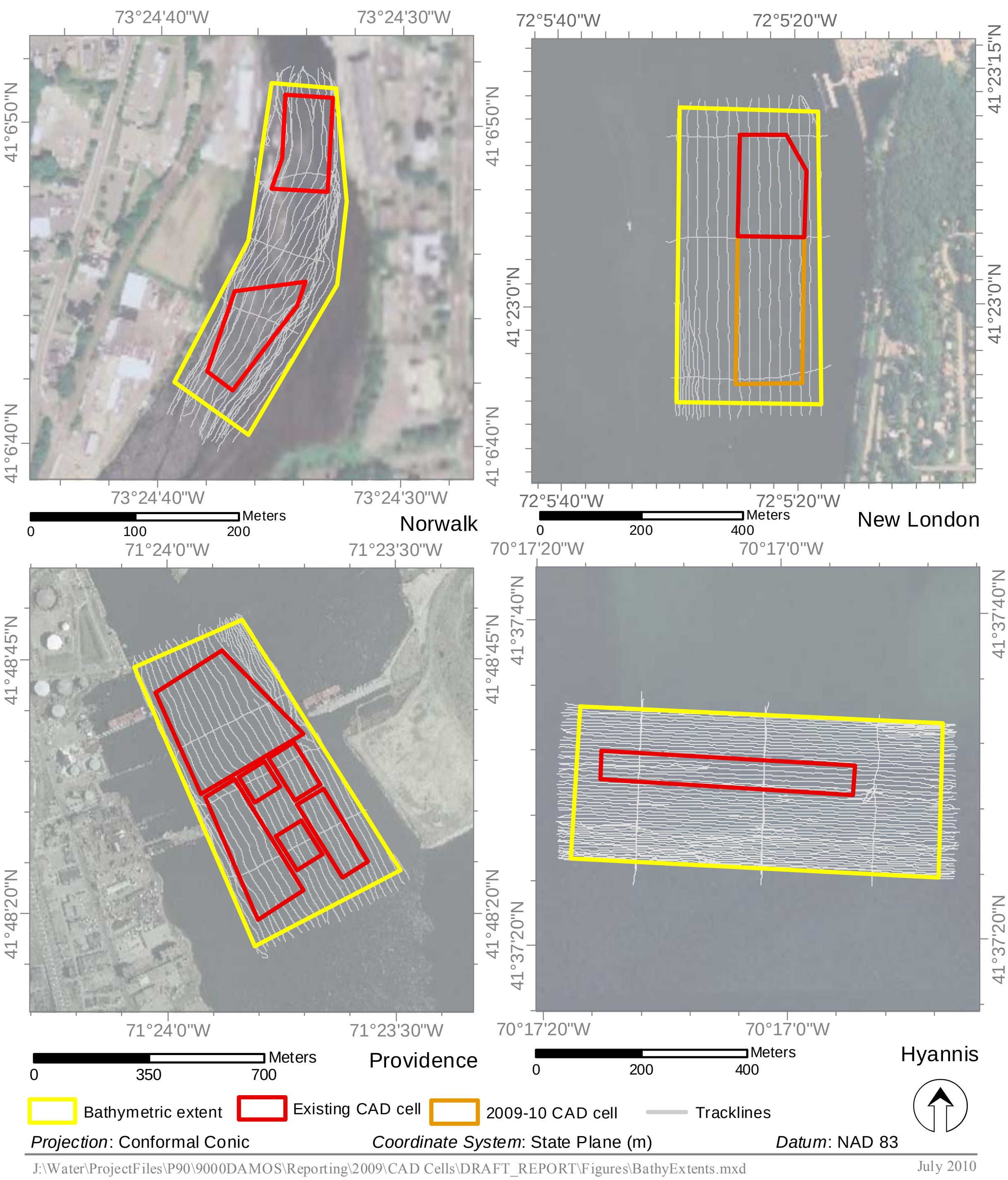


Figure 2-1. Norwalk, New London, Providence, and Hyannis bathymetric survey boundaries and tracklines

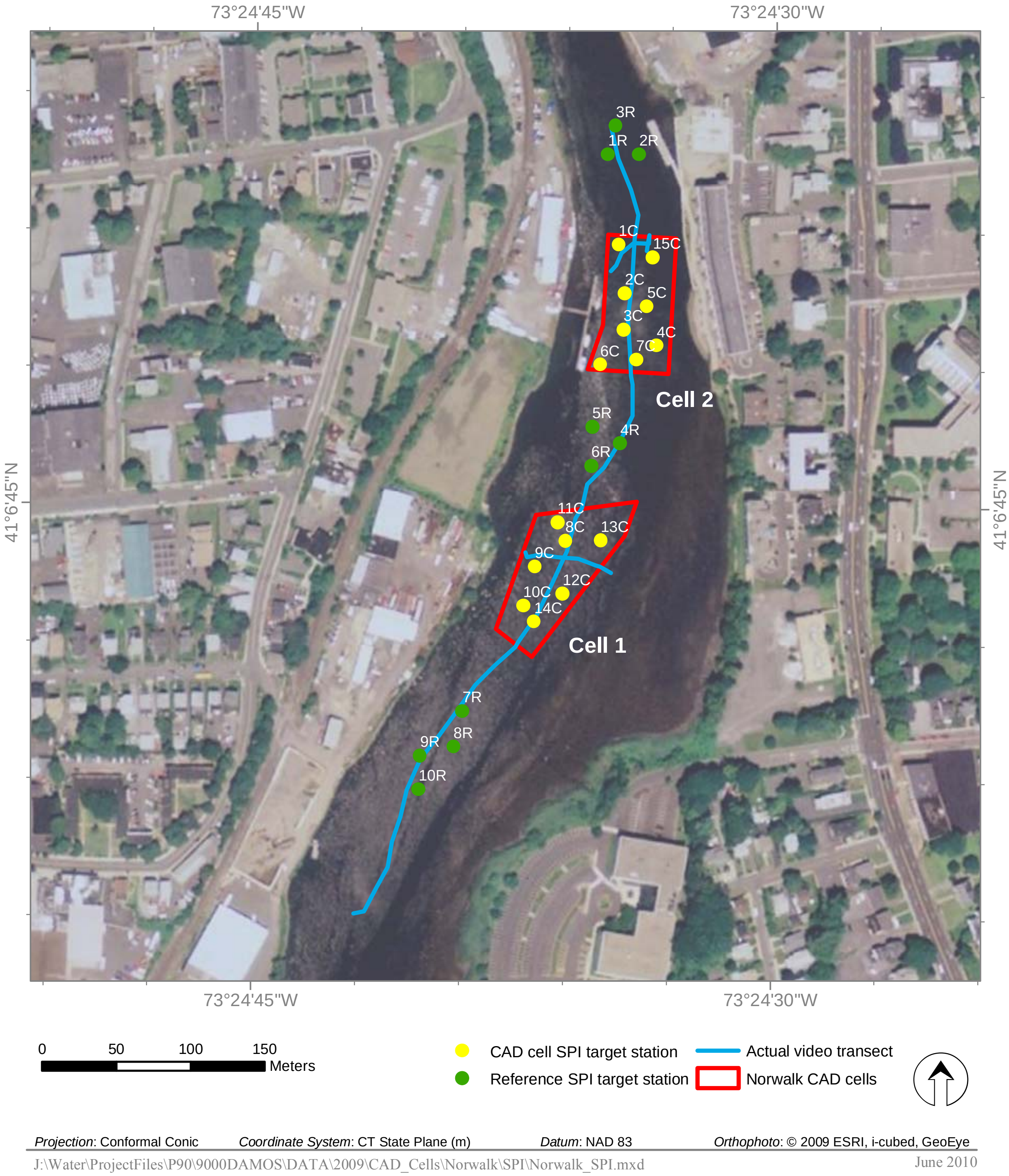


Figure 2-2. Target SPI stations and actual video transects for Norwalk

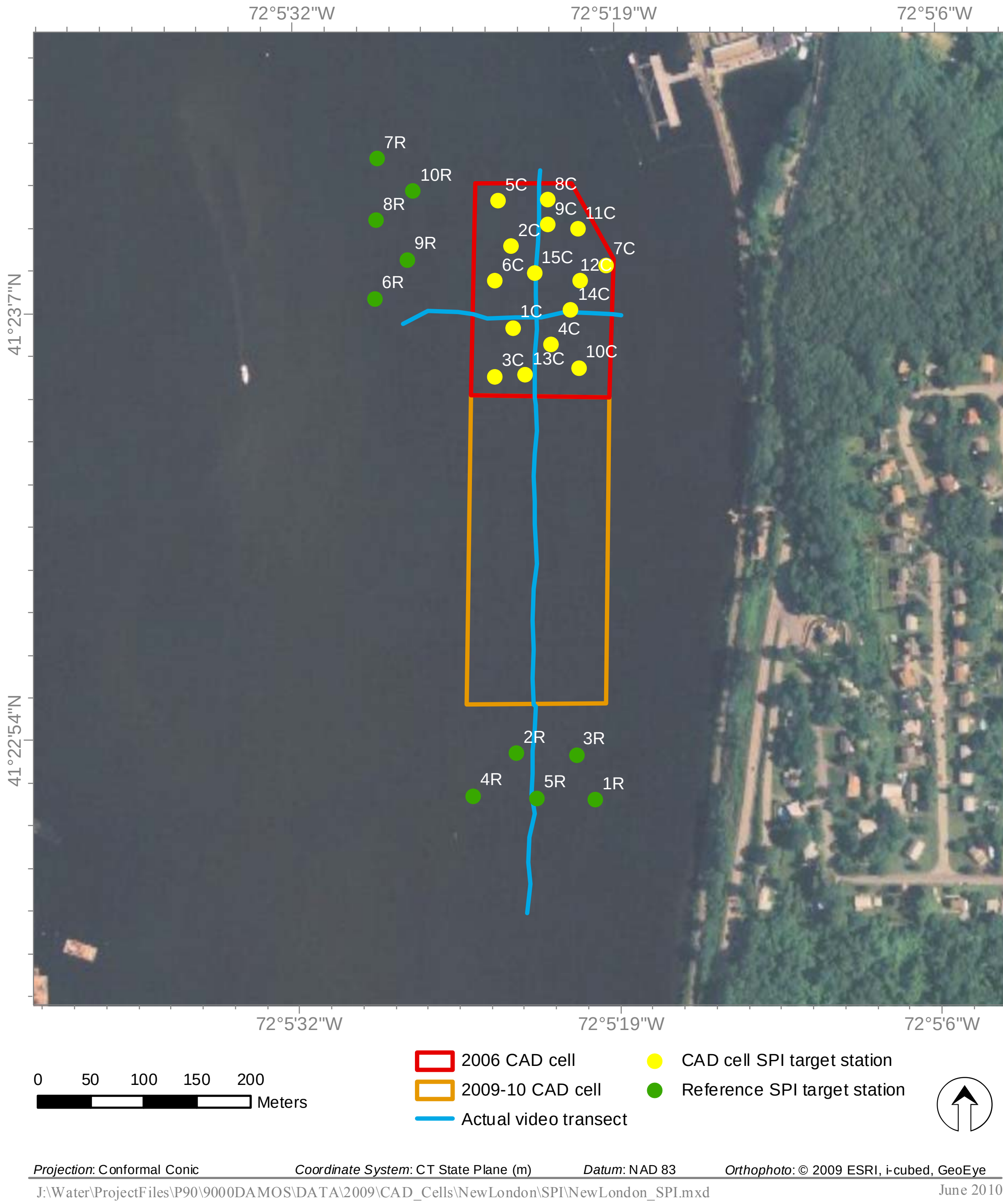


Figure 2-3. Target SPI stations and actual video transects for New London

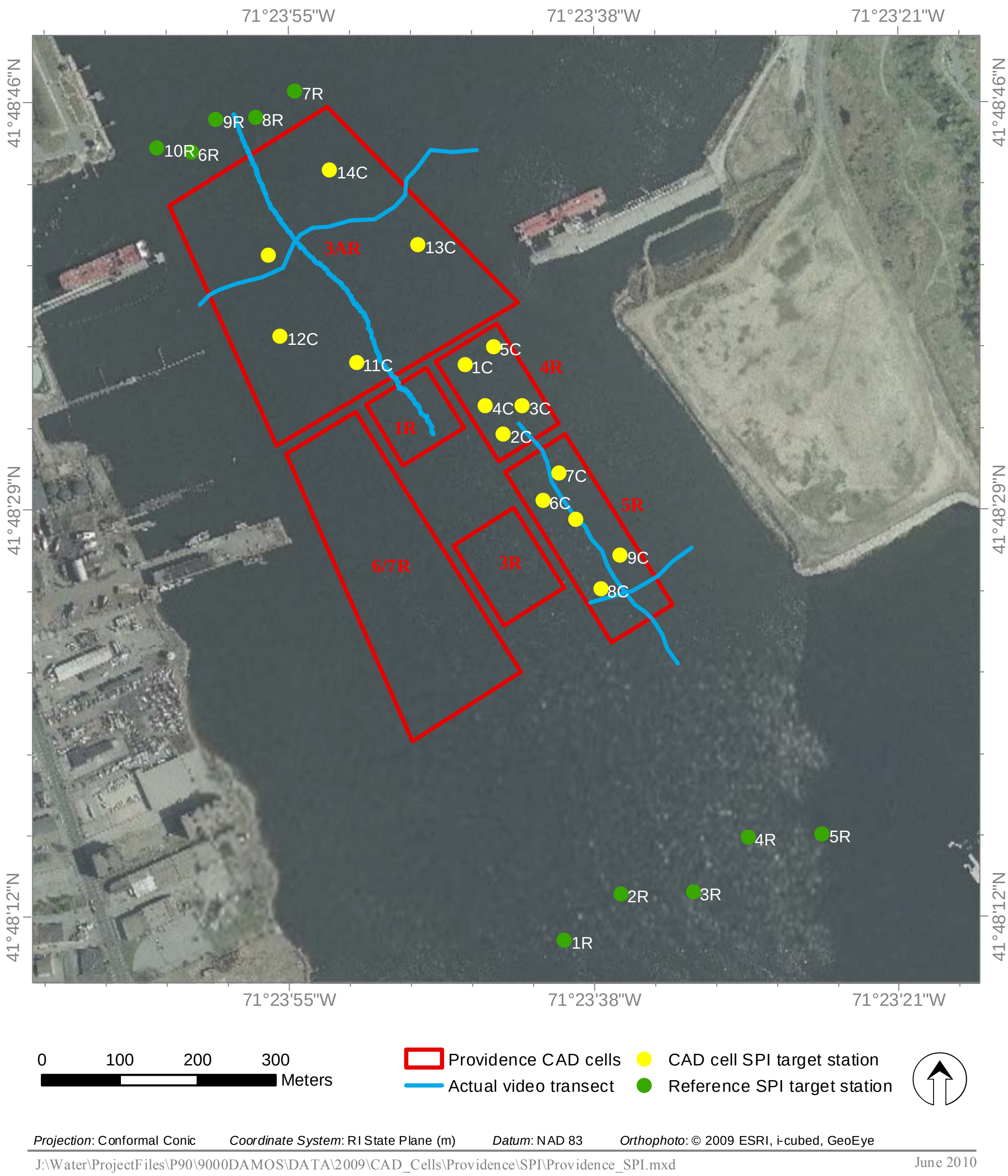


Figure 2-4. Target SPI stations and actual video transects for Providence

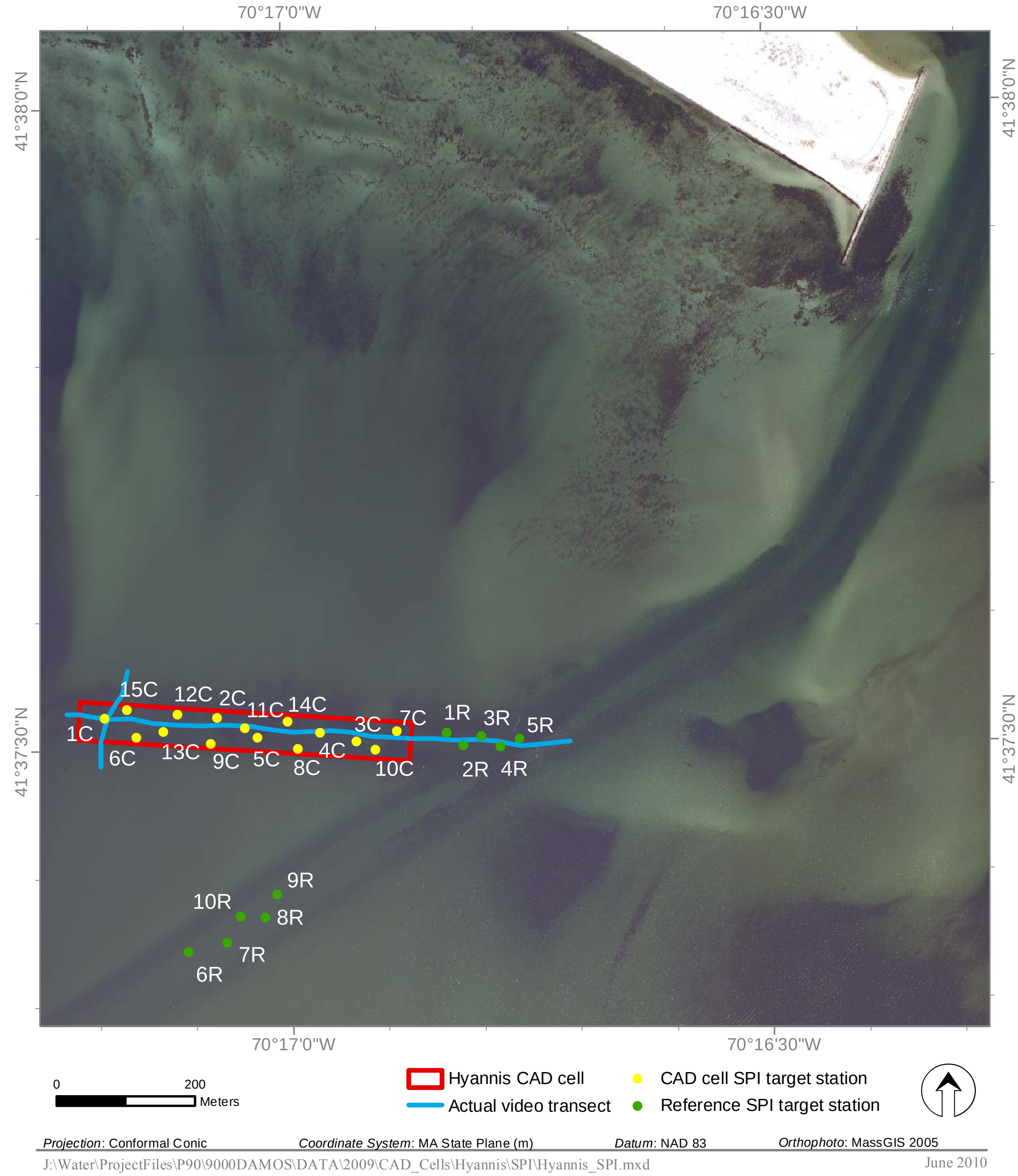


Figure 2-5. Target SPI stations and actual video transects for Hyannis

3.0 RESULTS

Bathymetric surveys were performed as described in Section 2 at each of the four New England CAD cell study sites to document the seafloor topography in and around the cells. Results for each area, including a bathymetric contour map and depth difference figure, are presented below.

A SPI and plan-view video survey was performed in conjunction with an underwater towed video survey at each of the four CAD cell study locations to aid in the physical and biological characterization of the CAD cells and surrounding areas. A summary of results that includes representative SPI and video clips from each harbor, along with station and transect locations, is presented below. The complete set of SPI results, plan-view video results, and an annotated log of each video clip are provided in Appendices A, B, and C, respectively.

3.1 Norwalk

3.1.1 Bathymetry

The October 2009 multibeam bathymetric survey of the CAD cells in the Norwalk River extended approximately 60 m south of CAD cell 1 and 30 m north of CAD cell 2. The survey covered the entire width of the channel and surrounding river bed with the exception of the shallow coves along both banks (Figure 3-1).

The footprints of both CAD cells were apparent as depressions in the river bottom when compared to the surrounding navigation channel depth of 3 m MLLW. CAD cell 1 had an approximate 10:1 slope (horizontal: vertical), and the depth of the cap surface was approximately 4.5 m MLLW. The CAD cell 1 cap surface appeared fairly uniform with the exception of a cluster of small (0.2 m diameter) pits in the center of the cell. CAD cell 2 also had a 10:1 slope or less on three sides but had a steeper 5:1 slope along the eastern edge. The surface of the cap was also slightly deeper than CAD cell 1 with a maximum depth of 5.25 m MLLW (Figure 3-1). CAD cell 1 was approximately 1.5 m below the surrounding channel bottom while CAD cell 2 was approximately 2 m below the surrounding channel bottom.

A depth difference map was generated using the 2009 bathymetric dataset and the 2007 dataset, which was collected 22 months after placement of the cap. The depth difference map indicated that there had been little change in the bathymetry of the CAD cells or the surrounding channel (Figure 3-2). Bathymetric data were not available from the 2006 post-cap bathymetry survey with which to assess short-term consolidation. A small area with an approximate 1.25 m decrease in depth (i.e. accumulation) was apparent at the northern end of CAD cell 2 extending into the ambient river bed. Small areas of limited increased or decreased depth (< 0.5 m) were also apparent, mainly along the perimeter of the cells and the edge of the navigation channel. These small areas should be interpreted with caution, as measurement and processing artifacts can accentuate differences along relatively steep bathymetric gradients.

3.1.2 SPI and Plan-View Video

Sediments within the two CAD cells were compared to in-channel areas located to the north, to the south, and between the two CAD cells in the Norwalk River using SPI and plan-view video. These in-channel areas were considered typical of baseline harbor conditions and served as reference stations for comparison of physical and biological conditions apparent in the SPI and plan-view images. A standard set of measurements were collected that enabled comparison between the CAD cells and reference areas. These measurements included grain size; penetration depth; aRPD; boundary roughness; successional stage; presence/absence of methane bubbles; evidence of anoxia; and the depth of any observed voids, burrows, or sedimentary layers (Table 3-1, Appendix A).

Physical Parameters

Grain size composition for sediments observed within the CAD cells and the reference areas (as identified with SPI) was consistent for all stations with a major mode of >4 phi (silt-clay) (Table 3-1 and Figure 3-3). The formation of mineral aggregates of clay particles resulted in a maximum replicate grain size measurement of 3–2 phi for a limited number of reference (e.g. 1R-1, 1R-2, 2R-1) and CAD cell stations (e.g. 1C-1, 1C-2, 2C-1) (Appendix A). The plan-view video at Norwalk agreed with the SPI as all stations appeared to be soft silt-clay.

The stop collar setting and number of weights were kept constant; as a result, SPI camera prism penetration depths were determined to be a reasonable proxy for the weight-bearing strength of the sediments. Mean camera prism penetration depth ranged from 11.7 to 19.5 cm for reference stations, with an overall average of 15.2 cm (Table 3-1 and Figure 3-4). The mean camera prism penetration depth for CAD cell stations ranged from 12.6 to 19.9 cm, with an overall average of 17.0 cm (Table 3-1 and Figure 3-4). Although the ranges for these two sets of measurements overlapped, the means were distinct (Figure 3-5), with deeper penetration in the CAD cell stations. Hence, despite the observed similar major modal grain size at reference and CAD cell stations, penetration results suggested that CAD cell stations had somewhat softer, less consolidated surficial sediment than the reference locations.

Mean boundary roughness at reference stations ranged from 0.8 to 2.4 cm, with an overall average value of 1.4 cm, and CAD cell stations had a mean boundary roughness that ranged from 0.6 to 2.6 cm, with an overall average of 1.3 cm (Table 3-1, Figure 3-6). Although the mean boundary roughness values were similar (Figure 3-7), individual station roughness appeared to trend higher at the northern stations (Figure 3-6). All small-scale surface roughness elements were biogenic in origin, caused by infaunal fecal mounds, burrows, openings, and/or feeding pits (Figure 3-8).

Biological processes also dominated the structure of surface sediments visible in the plan-view video. At several stations, biogenic structures such as pits and mounds were observed and layers of detritus (leaves) covered the sediment surface at Stations 1R, 3R, 8C, 8R, and 13C. Tubes of various sizes were observed at many stations (e.g., 6C and 8R) with tube densities varying from only a few to over 50 per field-of-view.

Methane was present within the sediment at five of the 10 reference locations and within 11 of the 15 CAD cell locations (Table 3-1 and Figure 3-9). Methane is produced by bacteria that utilize carbon within anaerobic systems, and its presence is an indication of organic-rich/oxygen-depleted sediment. The depth distribution of methane bubbles was measured and provided in Appendix A.

Biological Conditions and Recolonization Status

Apparent redox potential discontinuity (aRPD) was measured within the Norwalk CAD cell and reference locations using SPI. Sediment at all locations appeared to have high organic content, consistent with the presence of methane, as noted above. All stations within the cells and at the reference locations had aRPD values below 2.0 cm, with 20 of the 25 stations having aRPD values below 1.0 cm. Reference locations had aRPD values that ranged from 0.0 to 1.5 cm, with an overall average of 0.7 cm. CAD cell aRPDs were similar to that of the reference locations, with values ranging from 0.3 to 1.7 cm, and an overall average of 0.8 cm (Table 3-1 and Figures 3-10 and 3-11).

Sediment layers with distinct color variations were observed in SPI at both reference and CAD cell locations. Distinct layers were observed at all CAD cell stations and at seven of 10 reference stations. Sediment layers of note were those that had darker, low reflectance layers overlying lighter, high reflectance layers. This specific sequence of layers is consistent with relict surfaces that were previously oxidized and occupied by a benthic infaunal community or possibly the placement of material that was lighter in color. The presence and depth of these layers were measured and are provided within Appendix A.

A developed benthic community was apparent at both reference and CAD cell locations in the Norwalk River based on evidence of Stage 3 succession in the SPI. Evidence of Stage 3 succession was apparent in the majority of collected images, and only one location (reference station 1R) displayed evidence of only Stage 1 succession (Table 3-1 and Figure 3-12).

Amphipod tubes (*Ampelisca* sp.) were observed in images from Stations 6R, 1C, 10C, and 14C, but not at high densities. Mud snails (*Ilyanassa obsoleta*) were also commonly observed on the surface at both reference and CAD cell locations (Figure 3-13). Stations 1R, 2R, 4R, 7R, 9R, 5C, 2C, and 1C showed cross sections through burrows most likely created by crustaceans, possibly lobsters (*Homarus americanus*) (Figure 3-8).

3.1.3 Underwater Video

Three video transects were performed within the Norwalk River channel: an along-channel (longitudinal) transect that ran south to north and covered both cells and the three areas with reference stations; a west-to-east transect across cell 1 (cross CAD cell 1); and a southwest-to-northeast transect across the northern portion of cell 2 (cross CAD cell 2) (Figure 3-14). Select images from the video transects are presented in Figure 3-14, and a detailed log of physical and biological observations is presented in Appendix C.

The CAD cell boundaries could not be visually distinguished on the video as the substratum remained fairly uniform throughout the transect tracks. A moderate topographic change was seen on the northern edge of CAD cell 2 as the camera exited the apparent cell footprint and entered the ambient channel.

Biological activity in the CAD cells and the surrounding ambient channel was also not visually distinct. Throughout the transect tracks, occasional small fish (individuals and schools) darted into the field of view while numerous snails and snail trails were visible on the substratum (e.g. approximately 14:00 on Figure 3-14). Fields of large (approximately 9 cm in diameter) burrow holes were noted frequently in the reference area and within the CAD cells and are assumed to be created by burrowing crustaceans, possibly juvenile lobsters (approximately 8:00 and 19:00 on Figure 3-14). The substratum was littered with leafy debris (approximately 25:00 on Figure 3-14) and trash at times. The leafy debris was more apparent in the northern (upriver) portion of the longitudinal transect and the cross CAD cell 2 transect (Figure 3-14). Sediment suspended by the sled's progress over the bottom was occasionally apparent in the field of view, revealing a soft, silty substratum within the CAD cells and in the ambient channel.

3.2 New London

3.2.1 Bathymetry

The 2009 bathymetric survey of the New London CAD cell covered the entire footprint of the cell and extended approximately 125 m west into the navigation channel and 350 m south of the cell to cover the area of a proposed second CAD cell in the Thames River (Figure 3-15). (Note: This second cell was constructed in late 2009/early 2010.)

Depths in the surrounding navigation channel ranged from 12 to 13.5 m MLLW. The footprint of the existing CAD cell was well defined with a fairly uniform 4:1 slope along all sides. The cap surface was relatively uniform with an average depth of about 17.5 m MLLW, approximately 4 m below the surrounding channel. Surrounding the existing cell were a series of small depressions, ranging in size from approximately 2–5 m in diameter. The depressions were not evident within the CAD cell and are likely caused by the spuds of the dredge during construction (Figures 3-15 and 3-16).

Comparison of the surface of the CAD cell between the 2006 (less than one month post capping) and 2009 bathymetric surveys showed a considerable increase in depth over the footprint of the cell (Figure 3-16). The sloped boundaries of the cell showed an increase in depth of about 1 m along the perimeter to 2.5 m at the bottom of the slope. The surface of the cap showed even more substantial change with most of the surface exhibiting 3–4 m of depth increase since the 2006 survey. Given the timing of the 2006 survey (immediately following filling/capping of the cell), the identified depth increase is attributed to consolidation of the cell contents.

3.2.2 SPI and Plan-View Video

Sediments within the New London CAD cell were compared to in-channel areas located to the west and south of the existing CAD cell in the Thames River using SPI and plan-view video. These in-channel areas were considered typical of channel conditions and served as reference stations for comparison of physical and biological conditions apparent in the SPI and plan-view images. A standard set of measurements were collected that enabled comparison between the CAD cells and reference areas. These measurements included grain size; penetration depth; aRPD; boundary roughness; successional stage; presence/absence of methane bubbles; evidence of anoxia; and the depth of any observed voids, burrows, or sedimentary layers (Table 3-2, Appendix A).

Physical Characteristics

The grain size composition of sediments from within the CAD cell and from reference locations was consistent for all stations with a major mode of >4 phi (silt-clay) (Table 3-2 and Figure 3-17). The formation of mineral aggregates of clay particles and possibly some very fine sand (3-2 phi) was observed in individual replicates for both reference (e.g. 2R-1, 2R-2, and 3R-1) and CAD cell stations (e.g. 1C-1, 1C-2, and 2C-1) (Appendix A). Plan-view video analysis also indicated that all stations consisted of a mix of fine sand, silt, and clay.

For the New London SPI survey, the stop collar setting and number of weights were kept constant among CAD cell and reference stations; as a result, penetration depths were determined to be a reasonable proxy for the weight-bearing strength of the sediments. Average camera prism penetration depth for reference stations ranged from 6.1 to 18.0 cm, with an overall average of 12.6 cm. The average camera prism penetration depth ranged from 12.4 to 20.2 cm for CAD cell stations, with an overall average penetration of 16.1 (Table 3-2 and Figure 3-18). Although the penetration results indicate a difference in the average penetration between reference and CAD cell stations, a distinct difference in penetration depths also exists between the two reference areas surveyed. The mean camera penetration at the western reference stations ranged from 13.9 to 17.7 cm with an overall average of 15.5 cm. The mean camera penetration at the southern reference stations ranged from 6.1 to 18.0 cm with an overall average of 9.8 cm. Comparison of the camera penetration results from all three areas suggest that the sediments from the two reference areas differ and that sediments within the CAD cell are more similar to those in the western reference area than those in the southern reference area (Table 3-2).

Average small-scale boundary roughness was similar between the New London CAD cell and the two reference areas as measured with SPI. Boundary roughness at reference stations ranged from 0.5 to 2.7 cm, with an overall average value of 1.3 cm. CAD cell stations had a boundary roughness that ranged from 0.7 to 2.4 cm, with an overall average of 1.3 cm (Table 3-2 and Figures 3-19 and 3-7). Boundary roughness at the western reference stations and CAD cell stations was biogenic in origin, caused by infaunal fecal mounds, burrows, openings, and/or feeding pits (Figure 3-20). Boundary roughness at the southern reference stations was the result of both physical (shell hash) and biogenic factors including tubes, burrows, and feeding pits (Figure 3-20).

The plan-view video at New London also indicated that biological processes dominated the structure of surface sediments; biogenic structures such as pits and mounds were observed at most of the CAD cell stations. Physical processes were also evident at several stations; shell beds (1R, 2R, and 4R) and shell hash (5R and 13C) dominated the sediment surface at both CAD cell and reference station locations.

Methane was not observed in SPI from reference locations and was only observed at one of the 15 New London CAD cell locations (Station 10C) (Table 3-2). Absence of methane is often indicative of lower organic carbon content and/or higher porewater salinity at depth, but may also result from greater flushing capacity. Depth of the methane bubbles at Station 10C was measured and is reported in Appendix A.

Biological Conditions and Recolonization Status

Apparent RPD was measured within the New London CAD cell and reference locations using SPI. Reference locations had aRPD values that ranged from 0.9 to 2.3 cm, with an overall average of 1.6 cm. The CAD cell aRPD values ranged from 0.6 to 2.9 cm, with an overall average of 1.7 cm (Table 3-2 and Figure 3-21). Although the average aRPD results indicate an overlap in aRPD between the reference areas and CAD cell, a distinct difference in aRPD exists within the two reference areas surveyed. The western reference area average aRPD was 1.9 cm and the southern area average was 1.3 cm, evidence that the CAD cell aRPD results were more similar to the western reference results. The low aRPD measurements, coupled with the shallow penetration depths apparent in the southern reference area, are attributed to the presence of shell hash that was not observed within the western reference locations and was only present at two CAD cell stations (15C and 12C).

Sediment layering was observed with SPI at both reference and CAD cell locations (Table 3-2, Figure 3-22). Layering was observed at nine of the 15 CAD cell stations and six of the 10 reference area stations. Within the reference areas, the layering was more common at stations within the western reference area. Sediment layers of note are those that have darker, low reflectance layers overlying lighter, high reflectance layers. This specific sequence of layers is consistent with relict surfaces that were previously oxidized and occupied by a benthic infaunal community or possibly the placement of material that was lighter in color. The presence and depth of these layers were measured and are provided within Appendix A.

A developed benthic community was present at both reference and CAD cell locations within the Thames River at New London. Evidence of Stage 1 on 3 succession, consisting of small polychaete tubes at the sediment surface and deeper burrows and/or feeding voids at depth, was observed at all 15 CAD cell locations (Table 3-2 and Figure 3-23). One replicate at Station 15C had no evidence of Stage 3 succession. Stage 1 on 3 succession was also observed at all 10 sampled reference locations (Figure 3-23). Only one replicate at the most southernmost location, Station 4R, consisted of only Stage 1 succession.

3.2.3 Underwater Video

Two video transects were performed within the Thames River at New London (Figure 3-24). The longitudinal transect ran south to north, beginning south of the CAD cell in the ambient channel of the Thames River, traveling over the area of the proposed CAD cell into the existing CAD cell, and terminating in the ambient channel north of the existing cell. The second transect was run west to east across the center of the existing CAD cell (cross cell transect). Select images from the video transects are presented in Figure 3-24, and a detailed log of physical and biological observations is presented in Appendix C.

Although soft, silty sediment was apparent throughout the area, each transect revealed varying benthic conditions. The ambient channel to the south of the CAD cell was characterized by high densities of empty snail shells and shell hash. Some cobble was also apparent at the surface. Moving north along the longitudinal transect, the shells and cobble began to thin out prior to entering the CAD cell. The edge of the cell was apparent as a defined slope break. The substrate within the cell was consistent with reduced shell/cobble. Large debris was apparent also within the cell including, timber, pilings, and larger rocks. In the west-to-east transect across the channel and CAD cell, the substrate was similar with fewer shells and rocks compared to the longitudinal transect. The slope break into the cell was also apparent on this transect, and debris within the cell was similar to that identified in the longitudinal transect.

Evidence of extensive biological activity was present both within the CAD cell and the surrounding channel. Large (6.0–10.0 cm) (13:30 min on Figure 3-24) and small burrow holes (0.5–2.0 cm) (17:30 min on Figure 3-24) were visible at various locations across the video transect. The smaller holes were likely associated with clam beds while the larger burrows were assumed to be created by burrowing crustaceans, possibly lobsters. Whelks, moonsnails, and a burrowing lobster (8:30 min on Figure 3-24) were noted in the area of the proposed CAD cell. Cancer, hermit, and spider crabs (25:00 min on Figure 3-24) were also observed numerous times throughout the CAD cell and ambient channel. Bottom fish, likely flounder, occasionally emerged from the substratum creating turbidity plumes, and other fish occasionally swam within view of the camera.

3.3 Providence

3.3.1 Bathymetry

The October 2009 bathymetric survey of Providence Harbor covered the footprint of all six CAD cells (Figure 3-25). The survey also extended 100 m north and 100 m south of the cells and as far east–west as allowed by channel depth and navigation obstructions.

The surfaces of cells 1R and 4R were generally less than 0.5 m below the channel depth of 13 m MLLW; the deepest points of each cell were approximately 14.5 m MLLW. The surface of cell 3R was more depressed than the other two small cells (1R and 4R) at 15 m MLLW, approximately 2 m below the channel. Cells 3AR and 5R had irregular surfaces with depths that ranged from the channel depth of 13 m to almost 18 m MLLW. The surface of cell 6/7R was uneven with some small areas as deep as 18.5 m MLLW and other areas near the ambient channel depth of 13 m MLLW. Unlike the other CAD cells, cell 6/7R has been actively receiving dredged material.

The 2009 bathymetric data were compared to the May 2005 bathymetric data, which was collected at the conclusion of the PRHMDP (Figure 3-26). Based on this comparison, there has been very little change in the depth of cells 1R, 3R, 4R, or 5R since the 2005 survey (Figure 3-26). Cell 3AR, which was one of the last cells to be filled, and also contains the thickest deposit of dredged sediment of all the cells surveyed (Table 1-1, Figure 1-20), displayed a broad area of depth increase of 0.5–2.5 m between 2005 and 2009. In contrast, cell 6/7R, which continued to receive dredged material over that period, showed a significant depth decrease over almost the entire cell with some areas as much as 6 m above the 2005 elevation. All six cells remain well-depressed below the surrounding seafloor, with significant additional capacity remaining in cells 3AR, 5R and 6/7R.

3.3.2 SPI and Plan-View Video

Sediments within select Providence River CAD cells (cells 3AR, 4R, and 5R) were compared to in-channel areas located to the north and south of the existing CAD cells within the Providence River using SPI and plan-view video. These in-channel areas were considered typical of channel conditions and served as reference stations for comparison of physical and biological conditions apparent in the SPI and plan-view video. A standard set of measurements were collected that enabled comparison between the CAD cells and reference areas. These measurements included grain size; penetration depth; aRPD; boundary roughness; successional stage; presence/absence of methane bubbles, evidence of anoxia; and the depth of any observed voids, burrows, or sedimentary layers (Table 3-3).

Physical Characteristics

Grain size composition of sediments observed within the CAD cells and from reference locations (as identified with SPI), was consistent for all stations with a major mode of >4 phi (silt-clay) (Table 3-3 and Figure 3-27). Soft silt-clay sediments were also observed in the plan-view video at all stations.

For the SPI survey at Providence, the stop collar setting and number of weights were kept constant among CAD cell and reference stations; as a result, penetration depths were determined to be a reasonable proxy for the weight-bearing strength of the sediments. Average camera prism penetration depth ranged from 11.9 to 18.6 cm for reference stations, with an overall average of 14.9 cm. The average camera prism penetration depth for CAD cell stations ranged from 13.3 to 21.1 cm, with an overall average of 17.4 cm (Table 3-3 and Figure 3-28). Despite the observation of similar major modal grain size at reference and CAD cell stations, penetration results suggested that sediments within the Providence CAD cells were slightly softer and less consolidated than sediments observed at reference locations (Figure 3-28).

There was some overlap in the range of small-scale boundary roughness between the reference stations and the CAD cell stations, but the average small-scale boundary roughness was slightly deeper at the reference stations. Small-scale boundary roughness at Providence reference stations ranged from 0.7 to 3.0 cm, with an overall average value of 1.3 cm. CAD cell stations had an average boundary roughness that ranged from 0.4 to 2.1 cm, with an overall average of 0.9 cm. The highest boundary roughness values were observed at the northern reference area at station 6R and within cell 4R at station 1C (Table 3-3 and Figure 3-29). Small-scale boundary roughness elements were biogenic in origin, caused by bacterial mats (in most instances), infaunal burrows, openings, and/or feeding pits (Figure 3-30). Physical factors were not an observed component of small-scale boundary roughness within the Providence River.

In the plan-view video, biogenic structures such as pits and mounds were observed at only a few of the stations within the CAD cells and in the reference areas (e.g. Stations 9R and 11C). Infaunal tubes, consisting mainly of dense amphipod tube mats and polychaete tubes, dominated the surface at two stations, 6R and 9R, at densities of about 50 per field-of-view (Figure 3-31).

Methane was observed within images from both reference and CAD cell locations (Table 3-3 and Figure 3-32). Methane bubbles were observed at three of the five stations in the northern reference area and four of the five stations in the southern reference area. Within the three CAD cells surveyed, 10 of the 15 stations contained methane. The presence and the depth of observed methane bubbles within the sediment are provided in Appendix A.

Biological Conditions and Benthic Recolonization

Apparent RPD was measured within Providence CAD cells and reference locations. The average aRPD values at reference stations ranged from 0.1 to 0.6 cm, with an overall average of 0.4 cm. Average aRPD values ranged from 0.0 to 0.3 cm, with an overall average of 0.1 cm at the CAD cell stations (Table 3-3 and Figures 3-11 and 3-33). Although aRPD values at both CAD cell and reference stations were less than 1.0 cm, indicative of low biological activity, the overall average aRPDs was slightly deeper at the reference stations (Figure 3-11).

Beggiatoa sp. bacterial mats were observed at many CAD cell and reference locations. All sampled CAD cell locations contained *Beggiatoa* sp. mats while six of the 10 reference stations contained *Beggiatoa* sp. mats (Figure 3-34). These mats are typically found in sediments with high sulfide levels and significant organic enrichment.

Evidence of Stage 3 succession was observed at six of the 10 reference stations and five of the 15 CAD cell stations based on the presence of feeding voids and polychaete tubes (Table 3-3). Azoic conditions were observed in at least one replicate image at four CAD cell stations and one reference station. The successional stage was classified as indeterminate in one or more images at six of the CAD cell stations because bacterial mats covered the entire surface, and infauna was not identifiable (Figure 3-35).

Sediment layers with distinct colors were observed within images at both reference and CAD cell locations (Table 3-3, Figure 3-30). Distinct layers were present at 13 of the 15 CAD cell stations and all of the reference area stations. Sediment layers of note are those that have darker, low reflectance layers overlying lighter, high reflectance layers. This specific sequence of layers is consistent with relict surfaces that were previously oxidized and occupied by a benthic infaunal community or possibly the placement of material that was lighter in color. The presence and depth of these layers were measured and are provided within Appendix A.

3.3.3 Underwater Video

Four video transects were conducted in Providence Harbor, traversing four of the CAD cells as well as areas located outside of the CAD cells (Figure 3-36). Two longitudinal (along channel) transects were performed through cells 1R and 3AR and cells 5R and a small portion of 4R. Two cross channel transects were performed through cells 3AR and 5R. All four transects included portions outside of the CAD cells for comparison, and the end portion of the longitudinal transect through cells 1R and 3AR included the northern reference area (Figure 3-36). Select images from the video transects are presented in Figure 3-36, and a detailed log of physical and biological observations is presented in Appendix C.

Uniformly soft silt with light brown and white marbled patches was observed over the majority of the ambient channel and CAD cells of Providence Harbor. The marbled patches located on the surface were assumed to be *Beggiatoa* sp. mats (1:00 min and 7:00 min in CAD cell 5R on Figure 3-36). Moving north along the longitudinal transect through CAD cell 1R, a large patch of coarse sand was observed but quickly transitioned back into soft silt. Furrows were visible on the substratum within cell 1R, possibly from the dragging of an anchor, towing, or fishing activity (1:00 min in CAD cell 1R on Figure 3-36). A more consistent silt substratum was observed along the second longitudinal transect through cells 5R and 4R. In the east to west transect across the channel and cell 3AR, the substratum within the CAD cell was soft silt, but the substratum within the channel was characterized by large patches of shell hash.

Burrow holes (0.5-2.0 cm), shell hash, woody debris, leaf litter, and green and brown algae were occasionally seen on the substratum. The burrow holes were assumed to have been created by mollusk siphons or small burrowing shrimp and were more common in cells 3AR and 5R than the other cells. Large patches of algae were also commonly seen in cells 3AR and 5R. A significant amount of woody debris was observed in the video along all four transects, particularly on the eastern end of the cross transects that approached the shoreline. Sea robins and other small fish frequently swam in front of the camera during the video survey (19:00 min in CAD cell 3AR on Figure 3-36). Trash and debris, including lines and plastics, were also noted in all four of the surveyed CAD cells.

3.4 Hyannis

3.4.1 Bathymetry

The bathymetric survey of Hyannis Harbor covered approximately 300 x 700 m including the entire CAD cell, a portion of the adjacent entrance channel to Lewis Bay, and the surrounding harbor floor (Figure 3-37). The ambient seafloor in the area of the Hyannis Harbor survey ranged from 2.5 to 4 m depth (MLLW). The entrance channel to Lewis Bay had an average depth of about 3.5 m. A narrow trough, approximately 5.5 m deep, separated the current entrance channel from the former harbor entrance channel, where the CAD cell was located.

The eastern half of the CAD cell was clearly distinguished from the former channel and surrounding seafloor by several irregular depressions over 6 m (MLLW) deep. However, the western half of the cell was not clearly visible as depths within the footprint were similar to the surrounding seafloor and the gradual slope into the former harbor entrance channel (Figure 3-37).

The 2009 bathymetric dataset was compared to the April 1999 dataset (Figure 3-38), which was collected immediately after cap placement and was limited to the area of the CAD cell. In the 10 years since cap placement, small areas of minor change in depth were observed (Figure 3-39). Although no net change was observed over the majority of the cell, a depth decrease of 0.5-2.0 m was noted along the steeply sloped southern boundary and in the deep pocket located in the southeast corner of the cell. Small areas of depth increase, less than 1.0 m, were also noted in the interior of the cell in areas where the cell surface was near level with the surrounding seafloor after cap placement (Figure 3-39).

3.4.2 SPI and Plan-View Video

Sediments within the Hyannis Harbor CAD cell were compared to in-channel areas located to the east and south of the existing CAD cell within Hyannis Harbor using SPI and plan-view video. These in-channel areas were considered typical of harbor conditions and served as reference stations for comparison of physical and biological conditions apparent in the SPI and plan-view video. A standard set of measurements were collected that enabled comparison between the CAD cells and reference areas. These measurements included grain size; penetration depth; aRPD; boundary roughness; successional stage; presence/absence of methane bubbles; evidence of anoxia; and the depth of any observed voids, burrows, or sedimentary layers (Table 3-4, Appendix A).

Physical Characteristics

The major modal grain size of sediments at both CAD cell and reference stations was sand, ranging from very fine sand (4 to 3 phi) to medium sand (2 to 1 phi) (Table 3-4). Fine sand was observed at the majority of CAD cell stations, two eastern reference stations, and all five stations in the southern reference area (Table 3-4). Medium sand (2 to 1 phi) was observed at two of the CAD cell stations and three of the five stations in the eastern reference area, near the junction of the former channel, and the current channel.

In the plan-view video the Hyannis CAD cell and reference sites appeared comprised of fine to medium sand with no indication of finer sediments (silts and clays) on the surface. At several stations, shell beds (7C and 14C) and shell hash (3R, 4R, and 5R) dominated the sediment surface.

For the SPI survey at Hyannis, the stop collar setting and number of weights were kept constant among CAD cell and reference stations; as a result, penetration depths were determined to be a reasonable proxy for the weight-bearing strength of the sediments. Average camera prism penetration depth for reference stations ranged from 2.5 to 8.4 cm, with an overall average of 6.1 cm. The average camera prism penetration depth for CAD cell stations ranged from 3.4 to 9.5 cm, with an overall average of 6.1 cm (Table 3-4 and Figure 3-41). Penetration was relatively consistent among stations, and results suggested that there was no difference in camera penetration between the CAD cell stations and selected reference locations (Figure 3-5).

Small-scale boundary roughness values at reference stations ranged from 1.2 to 5.7 cm, with an overall average value of 2.6 cm while CAD cell station locations had a boundary roughness that ranged from 1.1 to 5.5 cm, with an overall average of 3.0 cm (Table 3-4). Boundary roughness values were similar between the Hyannis CAD cell and reference locations with overlapping ranges and standard errors around the means (Figures 3-42 and 3-7). Small-scale boundary roughness at the CAD cell and within the reference areas was dominated by physical factors, as indicated by the observation of sand ripples, shell hash, and poorly sorted sediments in the SPI and plan-view video. Algal holdfasts, invertebrate burrows, and mats of *Codium fragile* were also observed in some images, indicating that biological factors may also be contributing to the boundary roughness, but to a lesser extent (Figure 3-43).

Hyannis CAD cell and reference stations were dominated by sands and appeared to have low organic content. Most stations were characterized by hard, compact, sand ripples with either well sorted (e.g. 2R, 4C, 9C and 9R) or poorly sorted (e.g. 1R, 3R, and 14C) sediment. No methane was observed at any of the Hyannis Harbor CAD cell or reference locations.

Biological Conditions and Benthic Recolonization

Apparent RPD was measured within the Hyannis CAD cell and reference locations using SPI. Reference locations had aRPD values that ranged from 2.9 to 8.3 cm, with an overall average of 5.6 cm, while CAD cell aRPD values ranged from 0.7 to 7.9 cm, with an overall average of 4.4 cm (Table 3-4). Apparent RPD values at the reference stations were, on average, higher than aRPD values within the CAD cell (Figure 3-11), but aRPD values exceeded 3.0 cm at 12 of the 15 CAD cell stations and nine of the 10 reference stations, indicating a well oxygenated environment (Table 3-4). The lowest aRPD values were measured at the edges of the CAD cell (Figure 3-44). Sediment layers, such as those observed in the other three harbors were not observed at CAD cell or reference locations in Hyannis.

Codium fragile, as well as benthic brown and red algae, were found both alive and decaying at CAD cell and reference locations in Hyannis Harbor. *Codium fragile* was commonly found intertwined with brown and red filamentous algae creating dense algal mats (1R, 3R, 4R, 7C, 8C, and 12C) (Figure 3-43).

Evidence of Stage 3 succession was observed at all 15 CAD cell stations and eight of the 10 reference stations (Figure 3-45). Stage 1 only was observed at two stations in the reference area (05R and 06R). Stage 1 succession was also commonly observed at the surface of stations where Stage 3 organisms were evident (Table 3-4).

3.4.3 Underwater Video

Two video transects were performed within Hyannis Harbor (Figure 3-46). The first transect was a longitudinal transect that ran east to west; starting in the current harbor channel, through the former channel and into the CAD cell. The second transect ran across the western end of the CAD cell; starting north of the CAD cell in the ambient harbor, through the western end of the CAD cell and terminating south of the CAD cell in the ambient harbor. Select images from the video transects are presented in Figure 3-46, and a detailed log of physical and biological observations is presented in Appendix C.

The substratum in and around the Hyannis CAD cell appeared as coarse sand, shell hash (6:00 min on Figure 3-46), and mixed gravel with large patches of the green algae, *Codium fragile* (approximately 9:00 min and 17:00 min on Figure 3-46). The ambient seafloor topography featured sand ripples while the topography within the CAD cell boundaries had less relief.

The biological community observed over the CAD cell and adjacent reference areas was more characteristic of a motile community. Dense patches of *Codium fragile* were present both inside and outside of the CAD cell providing habitat for numerous crabs and small fish. Numerous scallops, whelks, hermit crabs, cancer crabs, and spider crabs, not associated with *Codium fragile,* were also noted inside and outside of the CAD cell. Snail trails and small (0.5 cm) burrow holes were visible within the CAD cell on the substratum (21:30 min on Figure 3-46), as well as outside of the CAD cell. Outside the western edge of the CAD cell multiple crab carapaces and moon snail shells covered an area comprised of sand and *Codium fragile* (22:30 min on Figure 3-46). Features of note included two horseshoe crabs (*Limulus polyphemus*) observed outside the of the CAD cell (3:00 min on Figure 3-46) and a whelk egg case inside the western portion of the CAD cell.

3.5 Summary

A summary of the physical characteristics and biological condition of each of the CAD cells sites from the October 2009 survey is described below and presented in Table 3-5.

3.5.1 Physical Characteristics

The CAD cells at all four sites remained as identifiable features on the seafloor and the cell surface remained below the surrounding channel, at varying depths, for all sites. The surface of the Norwalk CAD cells remained 1.5-2 m below the channel bottom. Many small areas of limited (< 0.5 m) increase or decrease in depth were noted along the perimeter of the cells and the edge of the navigation channel, and a small area of 1.25 m depth decrease was noted in the northern portion of Cell 2 since 2007. The New London cell remained 4 m below the surrounding channel, and a substantial increase in depth of 3-4 m was apparent since cap placement in 2006. The surfaces of the Providence CAD cells remained approximately 0.5-5.5 m below the harbor bottom, and little change in depth was noted over the inactive cells. A small increase in depth (0.5-2.5 m) was noted at cell 3AR, both the most recently filled cell and the one with the thickest deposit of placed sediment; and a significant decrease in depth (up to 6 m) was noted in cell 6/7R, which was still being used for disposal of UDM. The irregular surface of the Hyannis CAD cell ranged in depth from even with the surrounding channel bottom to 6 m below the channel bottom. In the 10 years since cap placement, minor changes in depth were observed; a depth decrease (0.5 – 2.0 m) was noted along the steeply sloped southern boundary and within the deep pocket located in the southeast corner of the cell, and small areas of depth increase (< 1.0 m) were noted in interior areas of the cell that were near level with the surrounding seafloor after cap placement.

3.5.2 Biological Conditions

The biological condition of the CAD cells at all four sites was at or nearing the conditions of the surrounding reference areas. Although advanced Stage 3 succession was apparent across the Norwalk and New London cells and the adjacent references areas, the Norwalk cells were higher in organic content and had a lower aRPD than the New London cell. The benthic community across the Providence CAD cells had not yet recovered to the condition at the adjacent reference area; however, both methane and extensive *Beggiatoa* sp. bacterial mats were observed across the CAD cell and reference area, indicative of a stressed environment. The biological condition of the Hyannis CAD cell was similar to the adjacent reference area; however the community, in general was more characteristic of a motile community.

Table 3-1.
Summary of Norwalk Harbor CAD Cell and Reference Station SPI Results

Station-CAD Cell	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01C	15.2	0.4	2.6	Yes	> 4	Yes	2 on 3 (1), 1 on 3 (2)
02C	15.2	0.6	1.1	Yes	> 4	Yes	1 on 3 (3)
03C	17.1	0.4	0.9	Yes	> 4	Yes	1 on 3 (3)
04C	12.6	0.8	1.0	Yes	> 4	Yes	1 on 3 (2)
05C	17.2	0.3	2.4	Yes	> 4	Yes	Azoic (1), 1 on 3 (2)
06C	19.9	0.7	0.8	Yes	> 4	Yes	1 on 3 (3)
07C	18.1	0.4	1.6	Yes	> 4	Yes	1 on 3 (3)
08C	17.6	1.2	0.6	Yes	> 4	Yes	1 on 3 (3)
09C	19.8	0.8	1.0	No	> 4	Yes	1 on 3 (3)
10C	19.0	0.9	0.6	No	> 4	Yes	1 on 3 (3)
11C	18.4	0.7	0.9	Yes	> 4	Yes	1 on 3 (3)
12C	19.6	0.6	2.4	Yes	> 4	Yes	1 (1), 1 on 3 (2)
13C	15.6	1.7	0.6	Yes	> 4	Yes	1 on 3 (3)
14C	13.9	1.3	1.3	No	> 4	Yes	1-2 (1), 2 on 3 (2)
15C	16.6	0.7	1.4	No	> 4	Yes	1 on 3 (2), 2 on 3 (1)
Overall Average	17.0	0.8	1.3				
Standard Deviation	2.2	0.36	0.68				
Standard Error	0.57	0.09	0.17				

Table 3-1 cont.

Summary of Norwalk Harbor CAD Cell and Reference Station SPI Results

Station-Reference	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01R	11.7	0.0	2.4	No	> 4	No	1 (3)
02R	15.0	0.8	2.4	Yes	> 4	Yes	1 on 3 (3)
03R	15.2	0.2	2.1	No	> 4	Yes	1 (1), 1 on 3 (1)
04R	16.2	0.6	1.9	Yes	> 4	Yes	1 on 3 (3)
05R	12.3	1.5	1.0	No	> 4	No	1 on 3 (3)
06R	15.6	0.7	0.8	No	> 4	Yes	2 on 3 (3)
07R	15.4	0.7	1.1	No	> 4	Yes	1 on 3 (3)
08R	13.7	0.7	1.2	Yes	> 4	Yes	1 on 3 (3)
09R	19.5	0.7	2.0	Yes	> 4	No	1 on 3 (3)
10R	17.7	1.1	0.9	Yes	> 4	Yes	1 on 3 (3)
Overall Average	15.2	0.7	1.4				
Standard Deviation	2.4	0.40	0.63				
Standard Error	0.75	0.13	0.20				

Table 3-2.
Summary of New London CAD Cell and Reference Station SPI Results

Station-CAD Cell	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01C	15.2	2.3	1.3	No	>4	Yes	1 on 3 (3)
02C	17.0	2.5	2.2	No	>4	Yes	1 on 3 (3)
03C	12.6	1.2	2.1	No	>4	No	1 on 3 (3)
04C	14.1	1.8	1.0	No	>4	No	1 on 3 (3)
05C	14.1	2.0	1.0	No	>4	Yes	1 on 3 (3)
06C	16.3	1.7	1.0	No	>4	Yes	1 on 3 (3)
07C	16.7	1.9	0.7	No	>4	No	1 on 3 (3)
08C	15.2	1.9	1.1	No	>4	No	1 on 3 (3)
09C	20.0	2.8	1.4	No	>4	Yes	1 on 3 (3)
10C	18.0	1.2	1.0	Yes	>4	No	1 on 3 (3)
11C	20.2	2.9	1.3	No	>4	Yes	1 on 3 (3)
12C	17.8	1.5	1.0	No	>4	Yes	1 on 3 (3)
13C	12.4	0.7	1.3	No	>4	Yes	1 on 3 (3)
14C	18.3	0.8	1.4	No	>4	Yes	1 on 3 (3)
15C	13.1	0.6	2.4	No	>4	No	1 (1), 1 on 3 (2)
Overall Average	16.1	1.7	1.3				
Standard Deviation	2.5	0.72	0.50				
Standard Error	0.65	0.19	0.13				

Table 3-2 cont.

Summary of New London CAD Cell and Reference Station SPI Results

Reference Area	Station-Reference	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
South	01R	6.7	1.0	1.5	No	>4	No	1 on 3 (3)
South	02R	18.0	1.9	0.9	No	>4	Yes	1 on 3 (3)
South	03R	8.9	1.2	2.7	No	>4	No	1 on 3 (3)
South	04R	6.1	0.9	1.5	No	>4	No	1 (1), 1 on 3 (2)
South	05R	9.2	1.3	2.1	No	>4	Yes	1 on 3 (3)
South	06R	17.7	2.3	1.2	No	>4	Yes	1 on 3 (3)
West	07R	15.8	2.2	0.8	No	>4	Yes	1 on 3 (3)
West	08R	15.3	2.0	0.5	No	>4	Yes	1 on 3 (3)
West	09R	14.9	1.1	1.0	No	>4	Yes	2 on 3 (1), 1 on 3 (1)
West	10R	13.9	1.9	0.7	No	>4	No	1 on 3 (3)
Overall Average		12.6	1.6	1.3				
Standard Deviation		4.5	0.53	0.69				
Standard Error		1.4	0.17	0.22				

Table 3-3.
Summary of Providence Harbor CAD Cell and Reference Station SPI Results

Station-CAD Cell	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01C	14.3	0.0	2.1	No	>4	Yes	1 (2), Ind (1)
02C	17.4	0.2	1.2	No	>4	Yes	1 (2), 1 on 3 (1)
03C	20.7	0.0	0.5	Yes	>4	Yes	1 (1), Ind (1)
04C	19.0	0.1	1.2	Yes	>4	Yes	Azoic (1), 1 (2)
05C	20.0	0.1	0.4	Yes	>4	Yes	Azoic (1), 1 (1), Ind (1)
06C	21.1	0.1	0.4	Yes	>4	No	1 on 3 (1), Ind (2)
07C	19.6	0.2	0.4	Yes	>4	Yes	1 on 3 (1), Ind (1)
08C	16.9	0.3	1.0	Yes	>4	Yes	1 (3)
09C	18.9	0.1	0.8	No	>4	No	1 (3)
10C	19.3	0.0	1.2	No	>4	Yes	1 (2), Ind (1)
11C	13.8	0.2	0.9	Yes	>4	Yes	1 (2), 1 on 3 (1)
12C	15.1	0.2	1.1	No	>4	Yes	1 (2), Azoic
13C	13.3	0.1	1.3	Yes	>4	Yes	1 (1), 1 on 3 (2)
14C	15.8	0.2	0.5	Yes	>4	Yes	1 (2)
15C	15.8	0.0	1.0	Yes	>4	Yes	Azoic (2), 1 (1)
Overall Average	17.4	0.1	0.9				
Standard Deviation	2.6	0.09	0.45				
Standard Error	0.67	0.02	0.12				

Notes: Ind - Indeterminate

Table 3-3 cont.

Summary of Providence Harbor CAD Cell and Reference Station SPI Results

Station-Reference	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01R	13.9	0.6	1.4	Yes	>4	Yes	1 (2), 1 on 3 (1)
02R	18.6	0.4	0.8	Yes	>4	Yes	1 (1), 1 on 3 (2)
03R	11.9	0.5	0.8	No	>4	Yes	1 (1), 1 on 3 (2)
04R	14.4	0.4	0.7	Yes	>4	Yes	1 (3), 1 on 3 (2), Azoic (1)
05R	15.5	0.2	0.8	Yes	>4	Yes	1 on 3 (3)
06R	15.9	0.1	3.0	Yes	>4	Yes	1(1), 1-2 (2)
07R	15.7	0.3	1.2	Yes	>4	Yes	1 (3)
08R	14.6	0.4	0.9	Yes	>4	Yes	1-2 (3)
09R	14.0	0.6	1.4	No	>4	Yes	1-2 (1), 1 on 3 (2)
10R	14.4	0.4	1.6	No	>4	Yes	1 (2), 1-2 (1)
Overall Average	14.9	0.4	1.3				
Standard Deviation	1.7	0.16	0.69				
Standard Error	0.55	0.05	0.22				

Table 3-4.
Summary of Hyannis Harbor CAD Cell and Reference Station SPI Results

Station-CAD Cell	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01C	6.4	5.2	1.8	No	3 to 2	No	1 on 3 (3)
02C	5.3	4.4	3.6	No	2 to 1	No	3 (2), 1 on 3 (1)
03C	6.4	3.3	2.6	No	2 to 1	No	1 (1), 1 on 3 (2)
04C	5.3	4.1	1.9	No	3 to 2	No	1 (1), 1 on 3 (2)
05C	4.3	6.6	4.2	No	3 to 2	No	1 (1), 1 on 3 (2)
06C	9.5	6.2	4.2	No	3 to 2	No	1 (1), 1 on 3 (2)
07C	8.8	0.7	2.8	No	4 to 3	No	1 on 3 (2), Ind (1)
08C	4.2	1.3	3.1	No	3 to 2	No	1 (2), 1 on 3 (1)
09C	4.3	1.1	2.3	No	3 to 2	No	1 (2), 1 on 3 (1)
10C	8.2	4.8	1.9	No	3 to 2	No	1 (1), 1 on 3 (2)
11C	5.1	7.9	5.5	No	3 to 2	No	1 (2), 1 on 3 (1)
12C	6.4	4.5	1.1	No	3 to 2	No	1 (1), 1 on 3 (20
13C	5.5	3.9	2.4	No	3 to 2	No	1 on 3 (3)
14C	3.4	5.8	4.6	No	3 to 2	No	1 (2), 1 on 3 (1)
15C	8.3	6.3	3.4	No	3 to 2	No	1 on 3 (3)
Overall Average	6.1	4.4	3.0				
Standard Deviation	1.9	2.1	1.2				
Standard Error	0.48	0.55	0.31				

Note: Ind - Indeterminate

Table 3-4 cont.
Summary of Hyannis Harbor CAD Cell and Reference Station SPI Results

Station-Reference	Mean Penetration (cm)	Mean aRPD (cm)	Boundary Roughness (cm)	Methane	Major Mode Grain Size (phi)	Distinct Layering	Successional Stage
01R	2.5	2.9	1.2	No	3 to 2	No	1 (2), 1 on 3 (1)
02R	7.3	4.9	2.2	No	3 to 2	No	1 on 3 (3)
03R	6.0	4.9	1.8	No	2 to 1	No	1 (1), 1 on 3 (2)
04R	3.8	4.7	2.0	No	2 to 1	No	1 (1), 3 (1), Ind (1)
05R	6.2	7.1	1.8	No	2 to 1	No	1 (3)
06R	4.3	4.9	1.5	No	3 to 2	No	1 (3)
07R	8.4	8.3	4.5	No	3 to 2	No	1 (2), 1 on 3 (1)
08R	7.5	3.4	2.5	No	3 to 2	No	1 (2), 1 on 3 (1)
09R	8.2	6.9	5.7	No	3 to 2	No	1 on 3 (3)
10R	6.8	7.7	2.4	No	3 to 2	No	1 (2), 1 on 3 (1)
Overall Average	6.1	5.6	2.6				
Standard Deviation	2.0	1.8	1.4				
Standard Error	0.62	0.57	0.45				

Note: Ind - Indeterminate

Table 3-5.
Summary of 2009 Survey Results

CAD Cell Site	Bathymetry	Change in Bathymetry (2009 survey compared to earlier post-fill/cap survey)	aRPD (cm)[1]	Organic Content	Recolonization Status[2]
Norwalk (2 cells)	Uniform topography Cell surface 1.5-2 m below channel bottom	Small area with 1.25 m decrease in depth (Previous bathymetry 22 months post cap)	Cell - 0.8 Ref – 0.7	Cell - Methane present (66% stations) Ref – Methane present (50% stations) Leaf litter present throughout area	Cell - Stage 3 (100% stations) Ref – Stage 3 (90% stations)
New London (1 cell)	Uniform topography Cell surface 4 m below channel bottom	Increase in depth (3-4 m) (Previous bathymetry immediately post cap)	Cell – 1.7 Ref – 1.6	Cell - Methane present (7% stations) Ref - No methane	Cell - Stage 3 (100% stations) Ref – Stage 3 (100% stations)
Providence (6 cells)	Cells 1R and 4R relatively uniform topography; 0.5-1.5 m below channel bottom Cell 3R uniform topography; 2-3 m below channel bottom Cells 3AR and 5R irregular topography; 0-5 m below channel bottom Cell 6/7R irregular topography; 0 -5.5 m below channel bottom	Little change in depth of inactive cells (cells 1R, 3R, 4R, and 5R). Increase in depth (0.5-2.5 m) at cell 3AR. Decrease in depth (up to 6 m) at cell 6/7R (active disposal in this cell)	Cell – 0.1 Ref – 0.4	Cell - Methane present (67% stations) *Beggiatoa* sp. present (100% stations) Ref – Methane present (70% stations) *Beggiatoa* sp. present (60% stations) Wood debris present throughout area	Cell - Stage 3 (33% stations) Ref – Stage 3 (60% stations)

Table 3-5 cont.
Summary of 2009 Survey Results

CAD Cell Site	Bathymetry	Change in Bathymetry (2009 survey compared to earlier post-fill/cap survey)	aRPD (cm)[1]	Organic Content	Recolonization Status[2]
Hyannis (1 cell)	Irregular cell surface; 0-3 m below channel bottom	Depth decrease of 0.5-2.0 m along southern border and in southeast corner. Small areas of depth increase (<1.0 m)	Cell – 4.4 Ref –5.6	No methane at cell or ref stations	Cell – Stage 3 (100% stations) Ref – Stage 3 (80% stations)

Ref – Reference location selected within the surrounding harbor area
[1]aRPD – apparent redox potential discontinuity (overall average)
[2]Recolonization status – highest successional stage observed at station

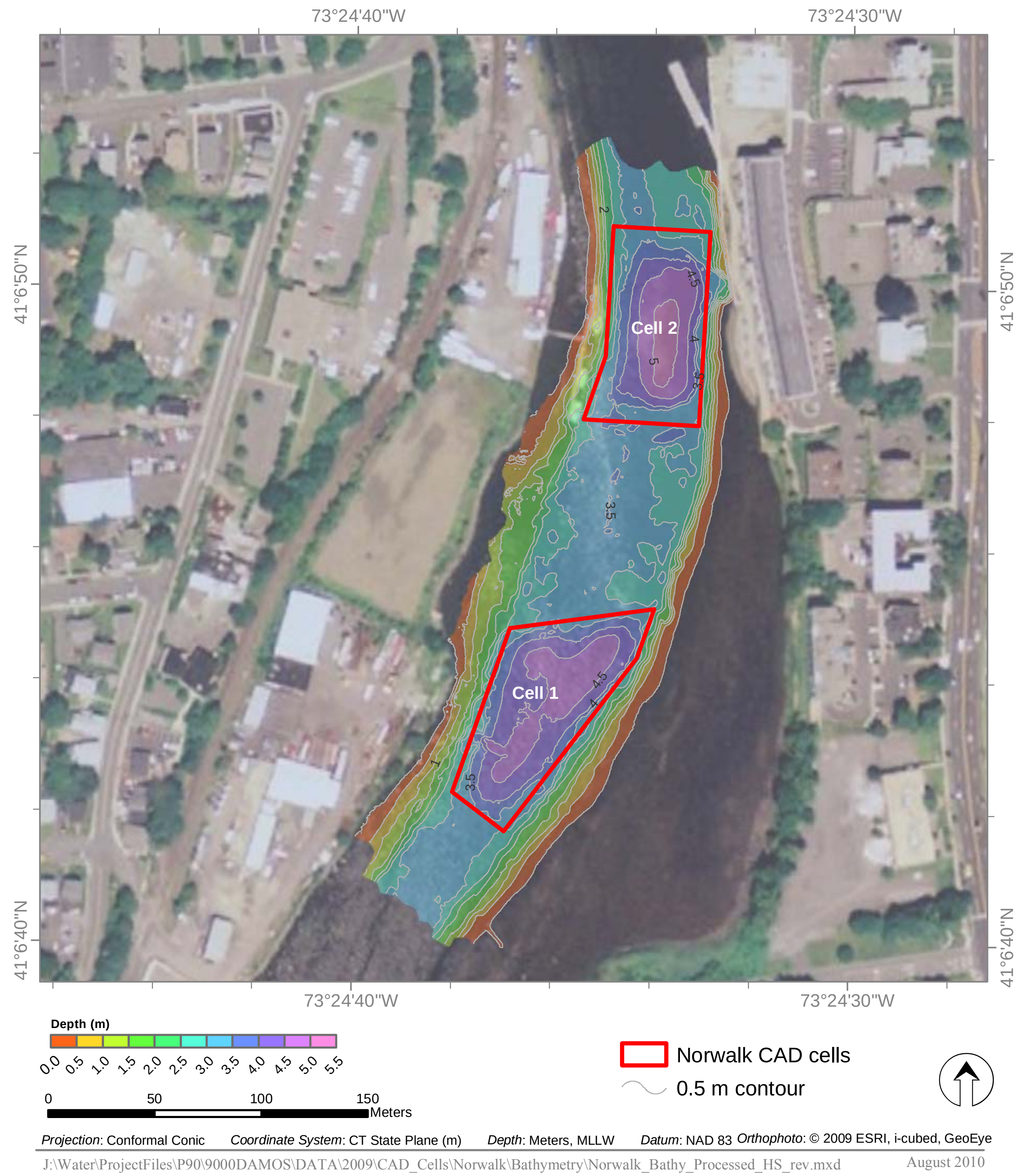


Figure 3-1. Bathymetric contour map over hillshaded bathymetry of the Norwalk Harbor CAD cells, October 2009

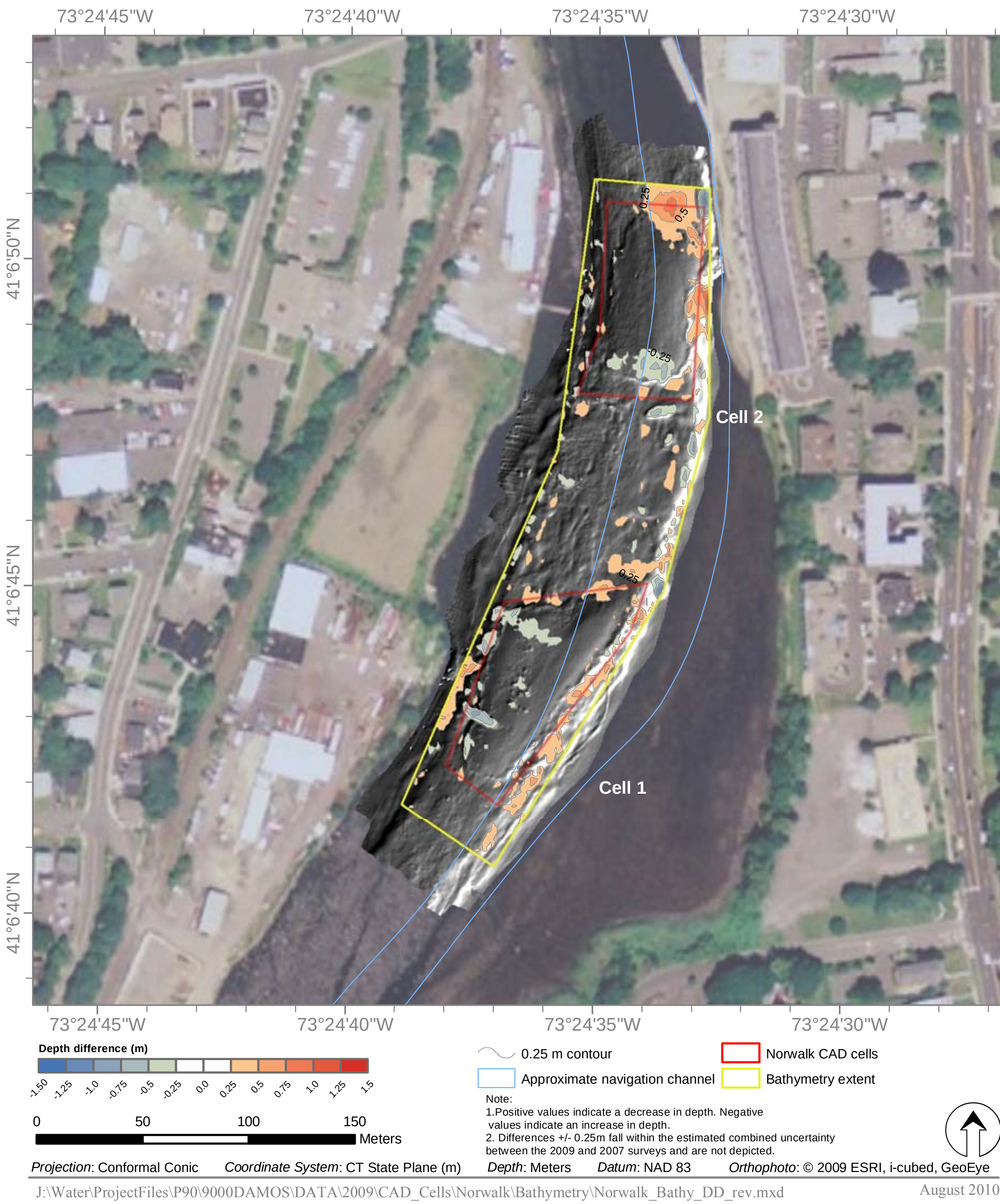


Figure 3-2. Depth difference contour map of the Norwalk Harbor CAD cells, December 2007 and October 2009, overlaying 2009 hillshaded bathymetry

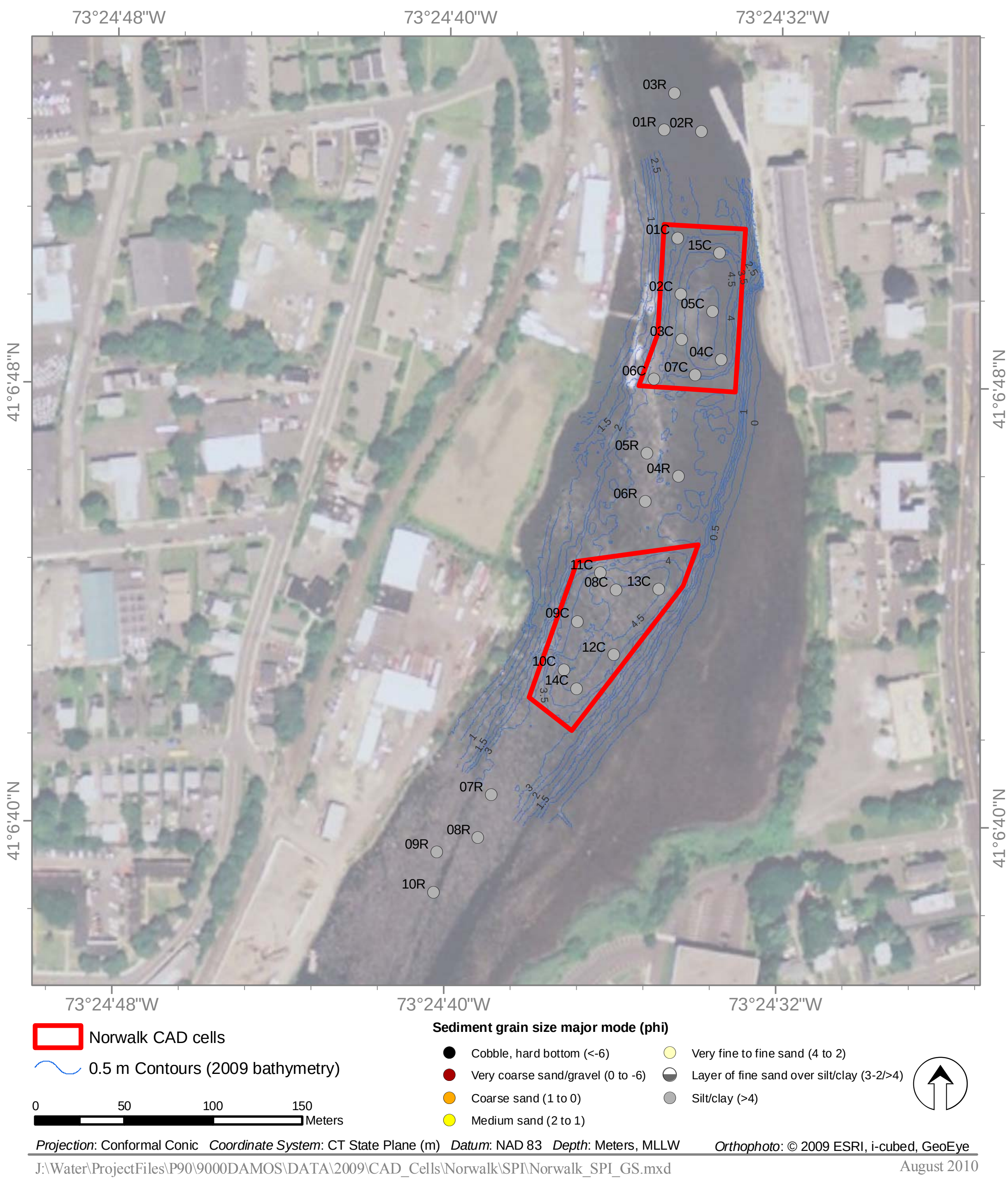


Figure 3-3. Spatial distribution of grain size major mode (phi) for Norwalk Harbor

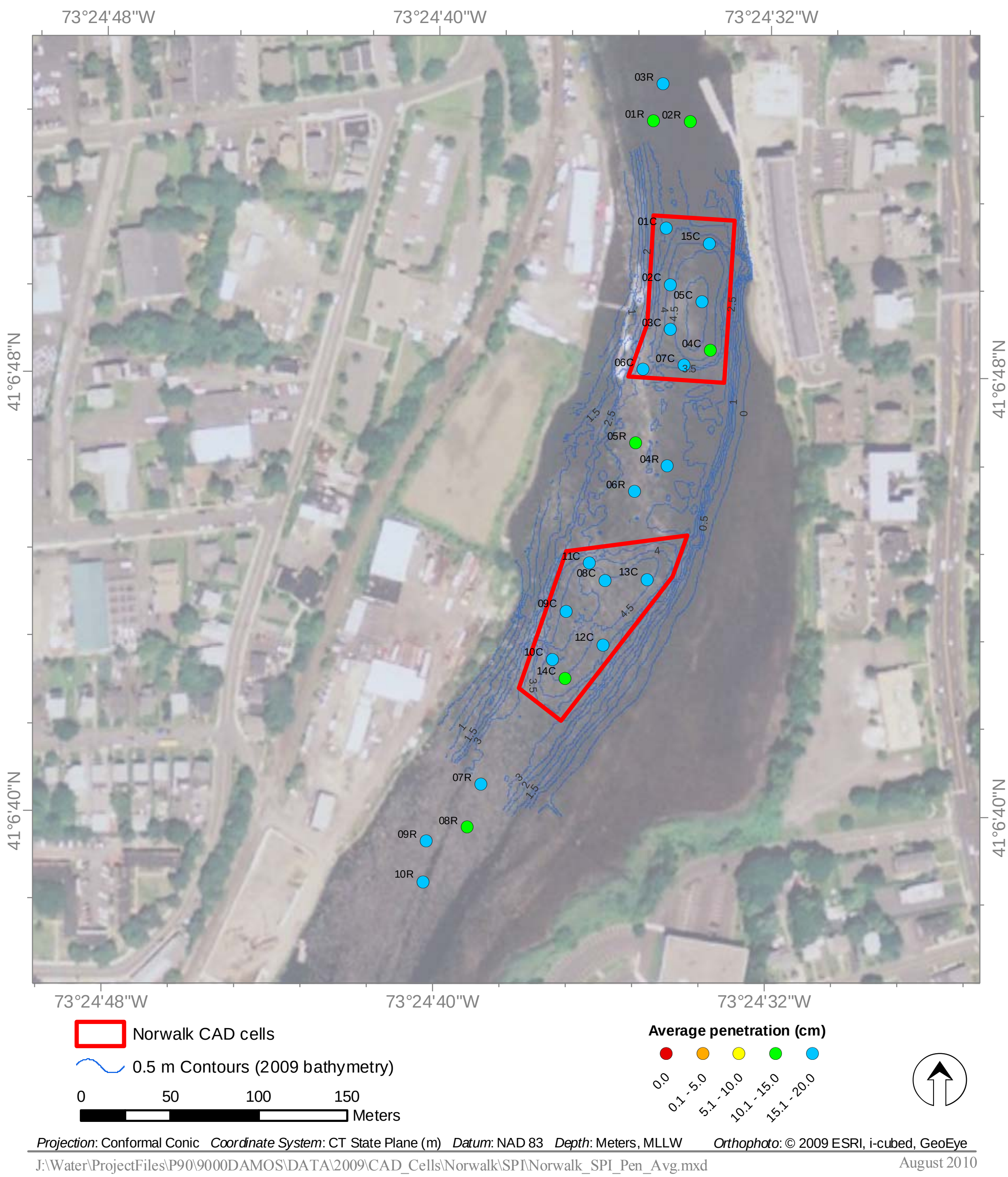


Figure 3-4. Spatial distribution of station-averaged camera prism penetration depth (cm) for Norwalk Harbor

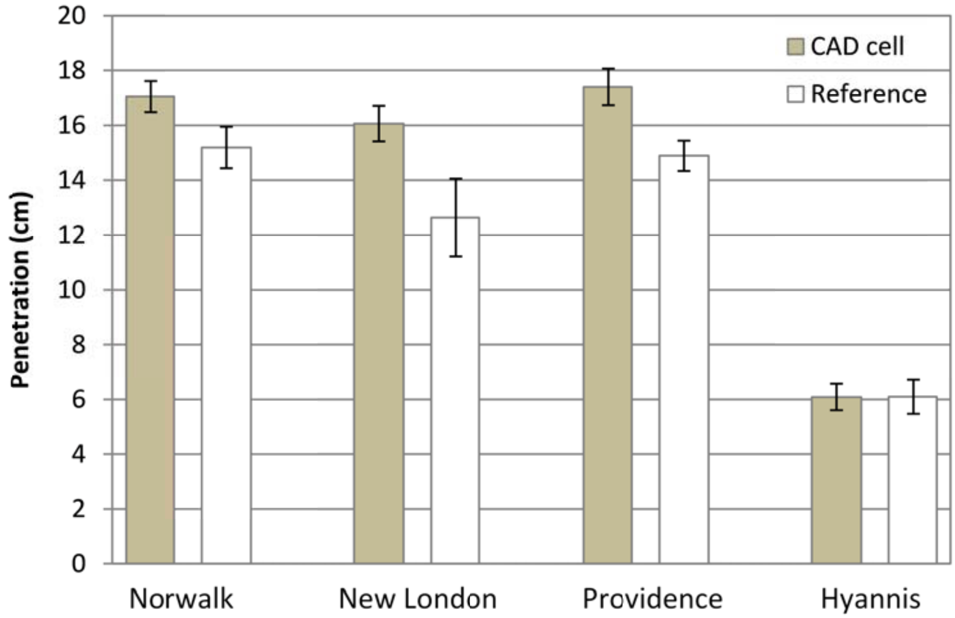


Figure 3-5. Mean penetration results for all four CAD cell study areas. Bars represent standard error (SE).

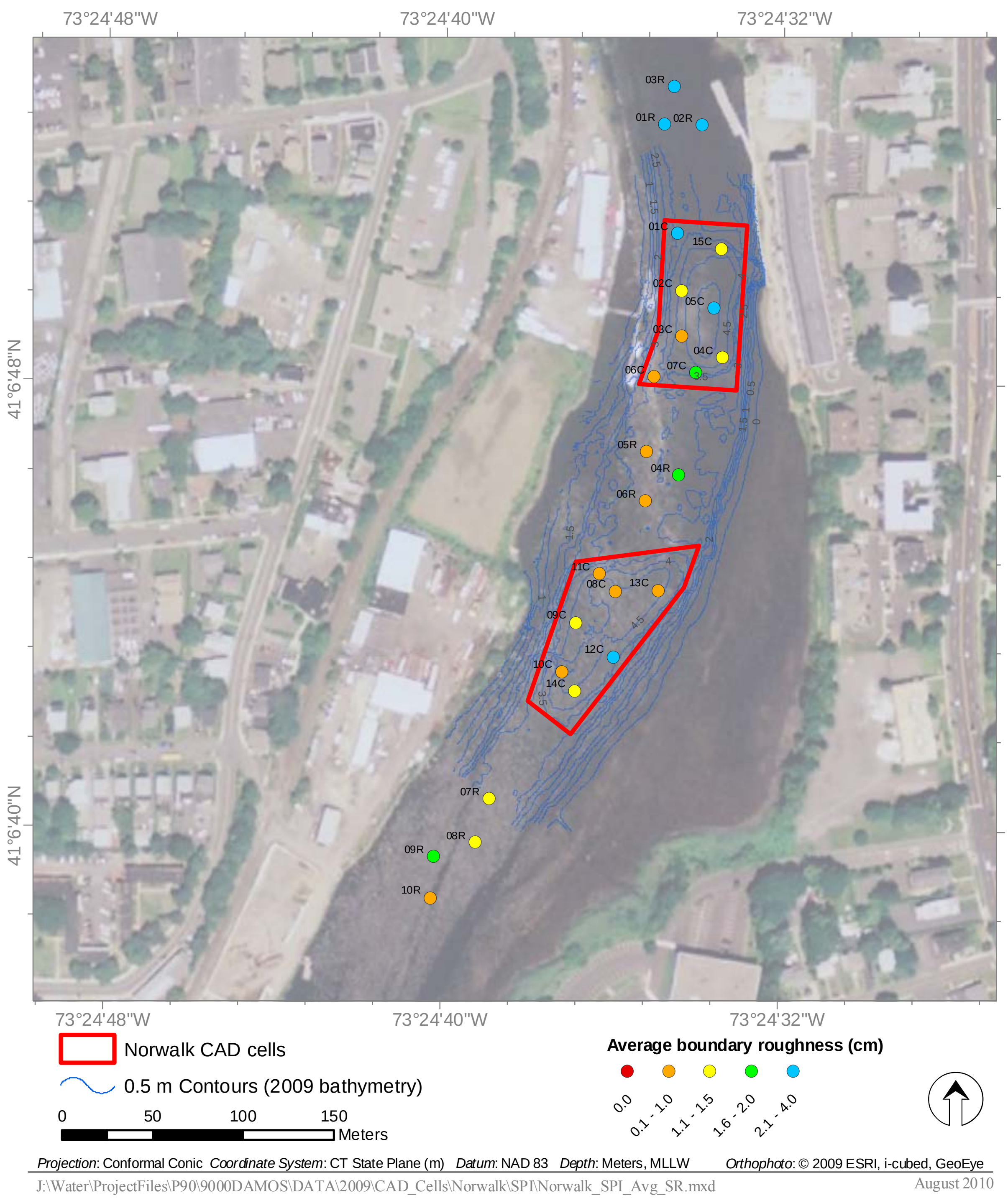


Figure 3-6. Spatial distribution of station-averaged surface boundary roughness (cm) for Norwalk Harbor

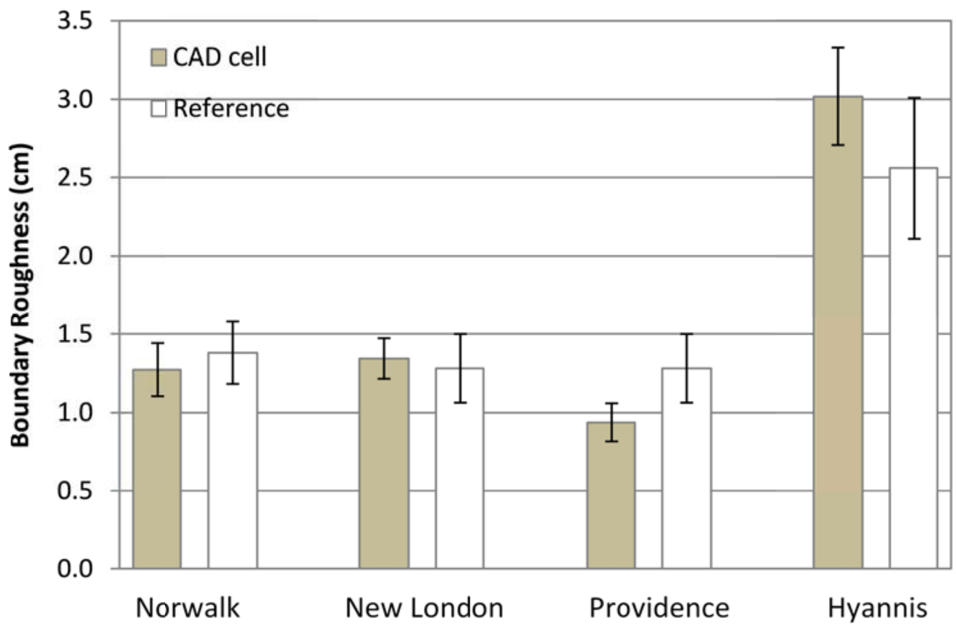


Figure 3-7. Mean surface boundary roughness results from all CAD cell study areas. Bars represent standard error (SE).

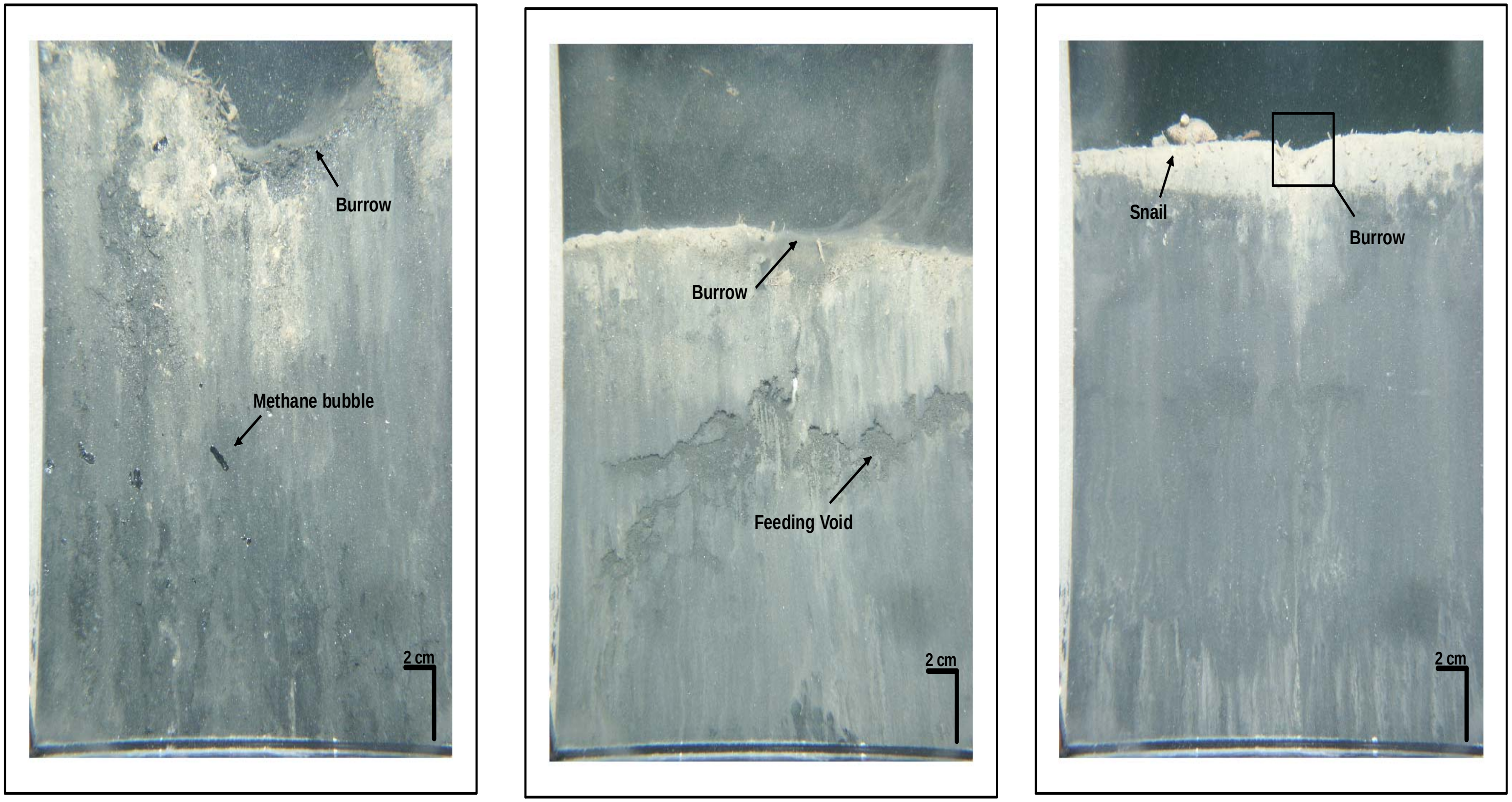


Figure 3-8. Examples of biogenic process features observed in SPI from Norwalk Harbor. Burrow and methane bubble at Station 2R (left), burrow and feeding void at Station 7R (center), and burrow and mud snail (*Ilyanassa obsoleta*) at Station 11C (right).

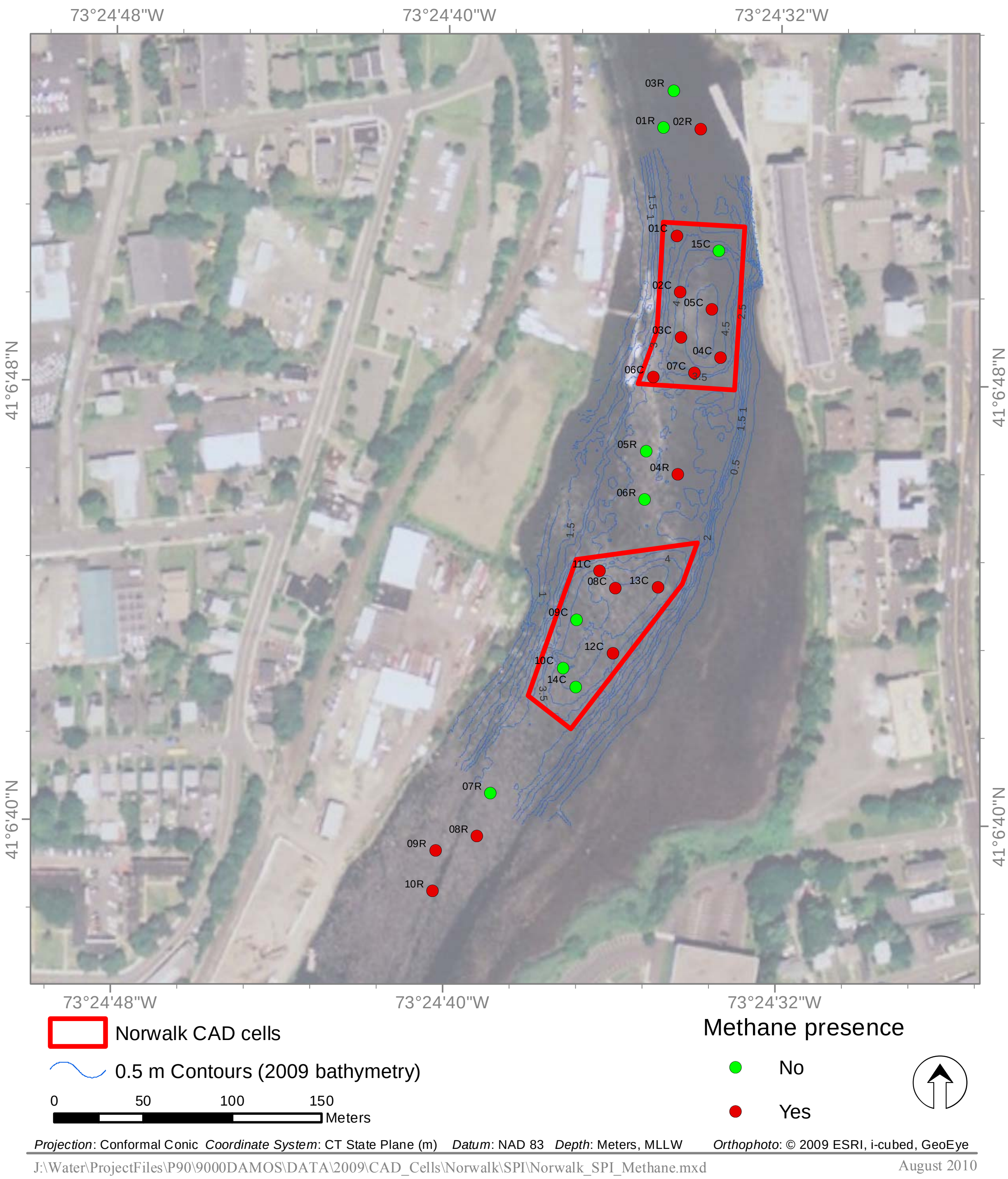


Figure 3-9. Spatial distribution of methane presence in Norwalk Harbor

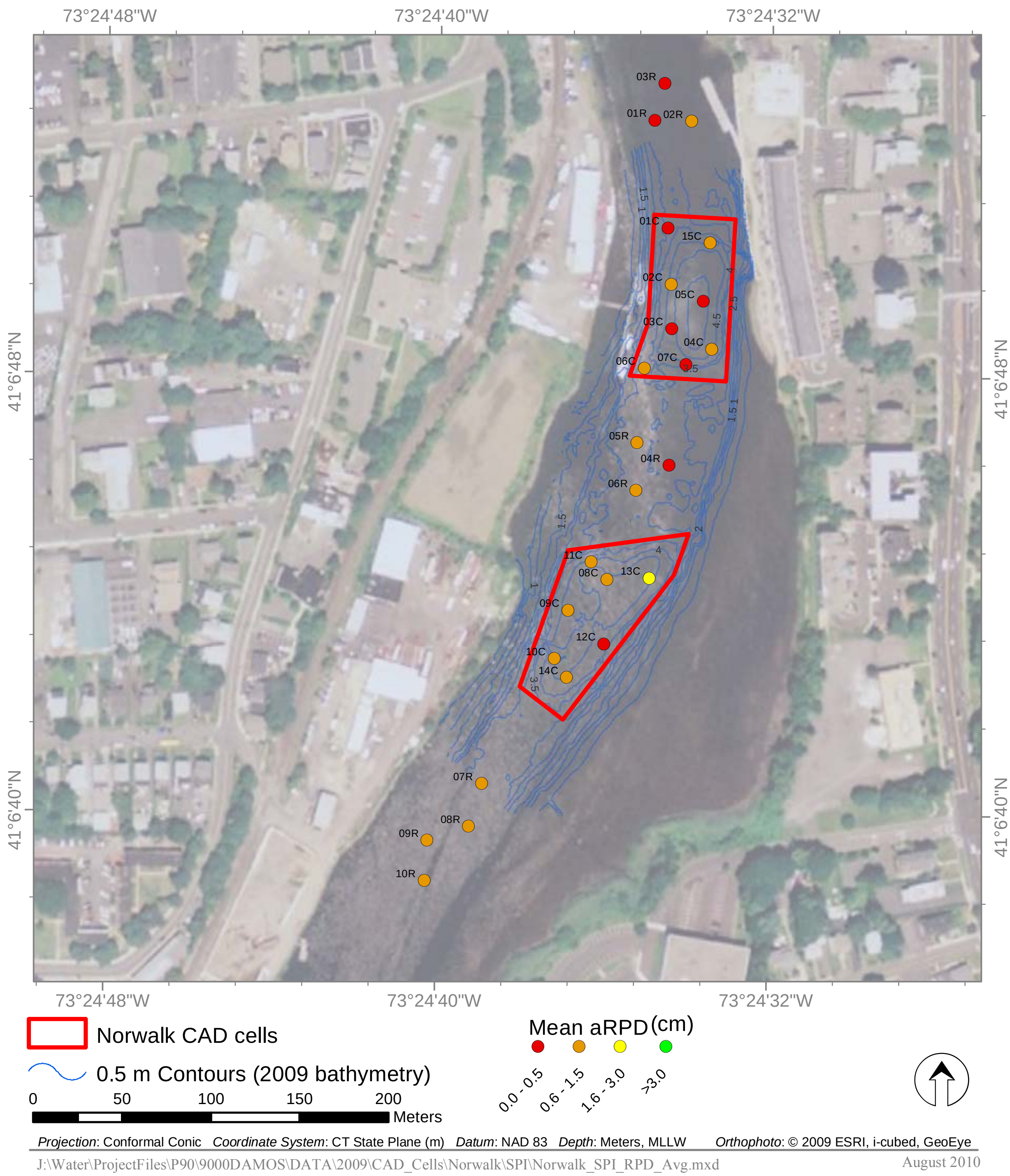


Figure 3-10. Spatial distribution of station-averaged aRPD depths (cm) for Norwalk Harbor

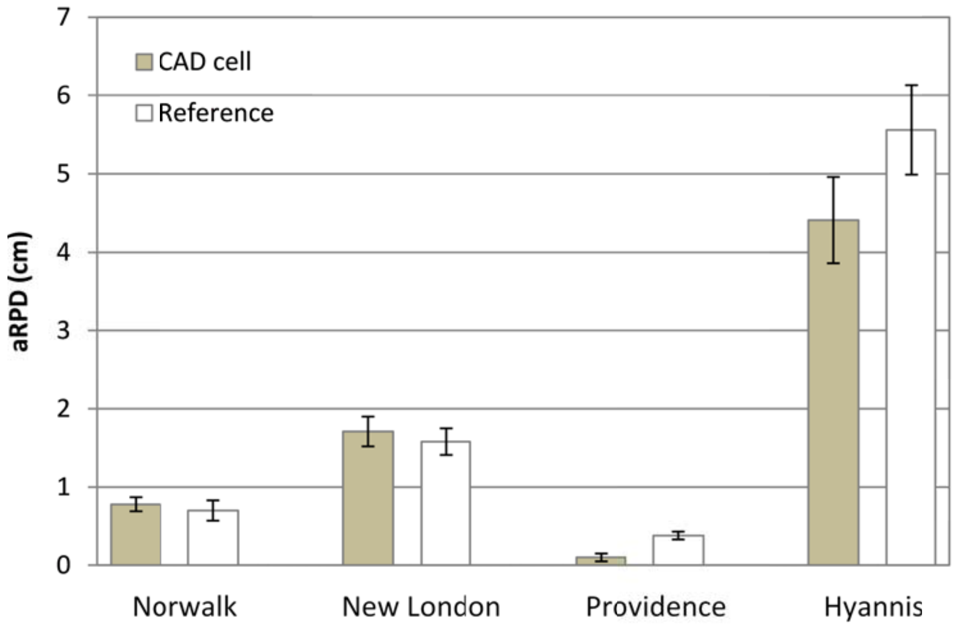


Figure 3-11. Mean aRPD depth for all CAD cell study areas. Bars represent standard error (SE).

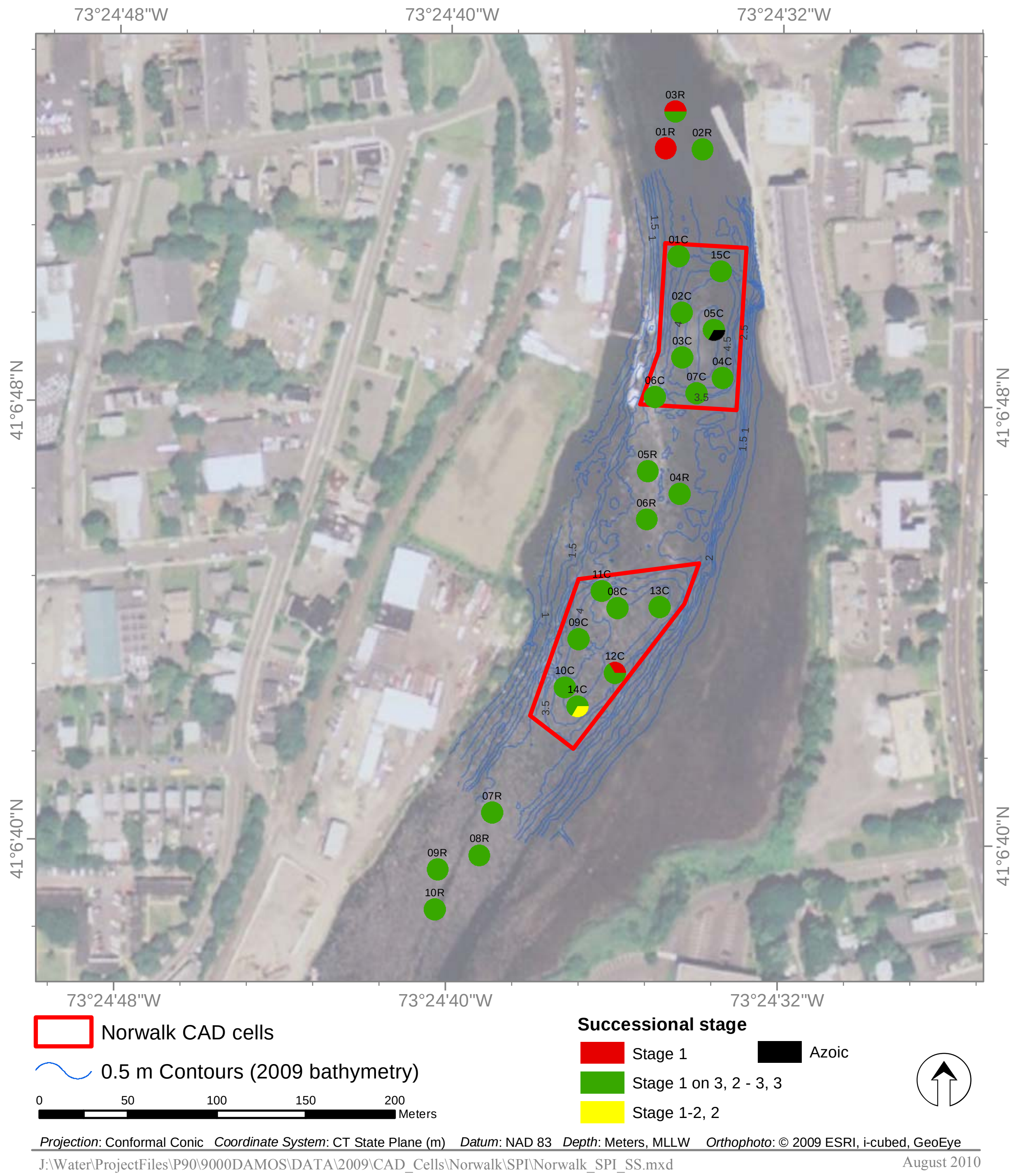


Figure 3-12. Spatial distribution of infaunal successional stages for Norwalk Harbor. Each station is represented by a circle, the number of SPI replicates for each station is represented as a pie wedge of the circle.

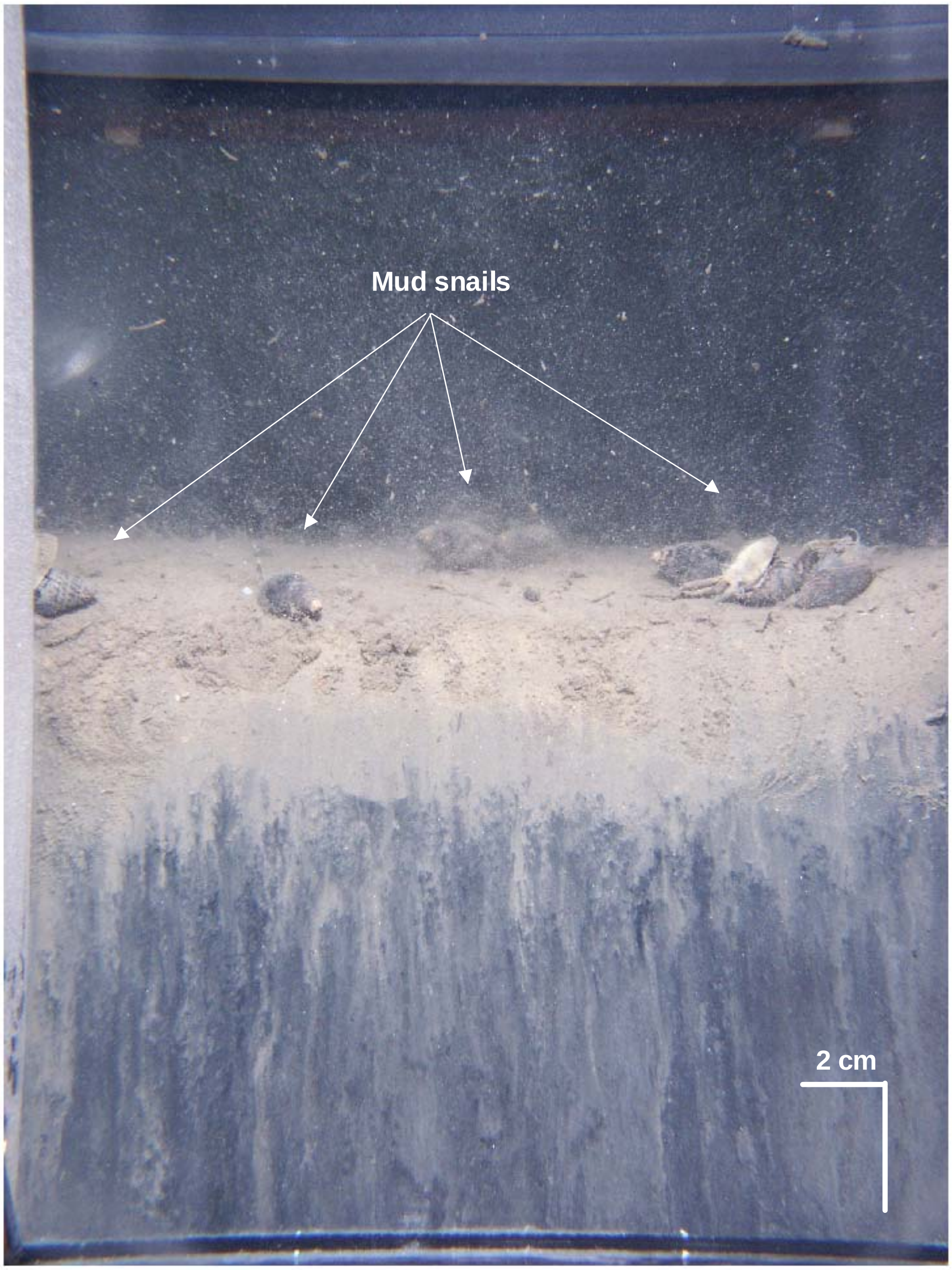


Figure 3-13. Example of mobile epibenthic community observed in SPI images from Norwalk Harbor: mud snails (*Ilyanassa obsoleta*) at Station 5R outside Norwalk CAD cell.

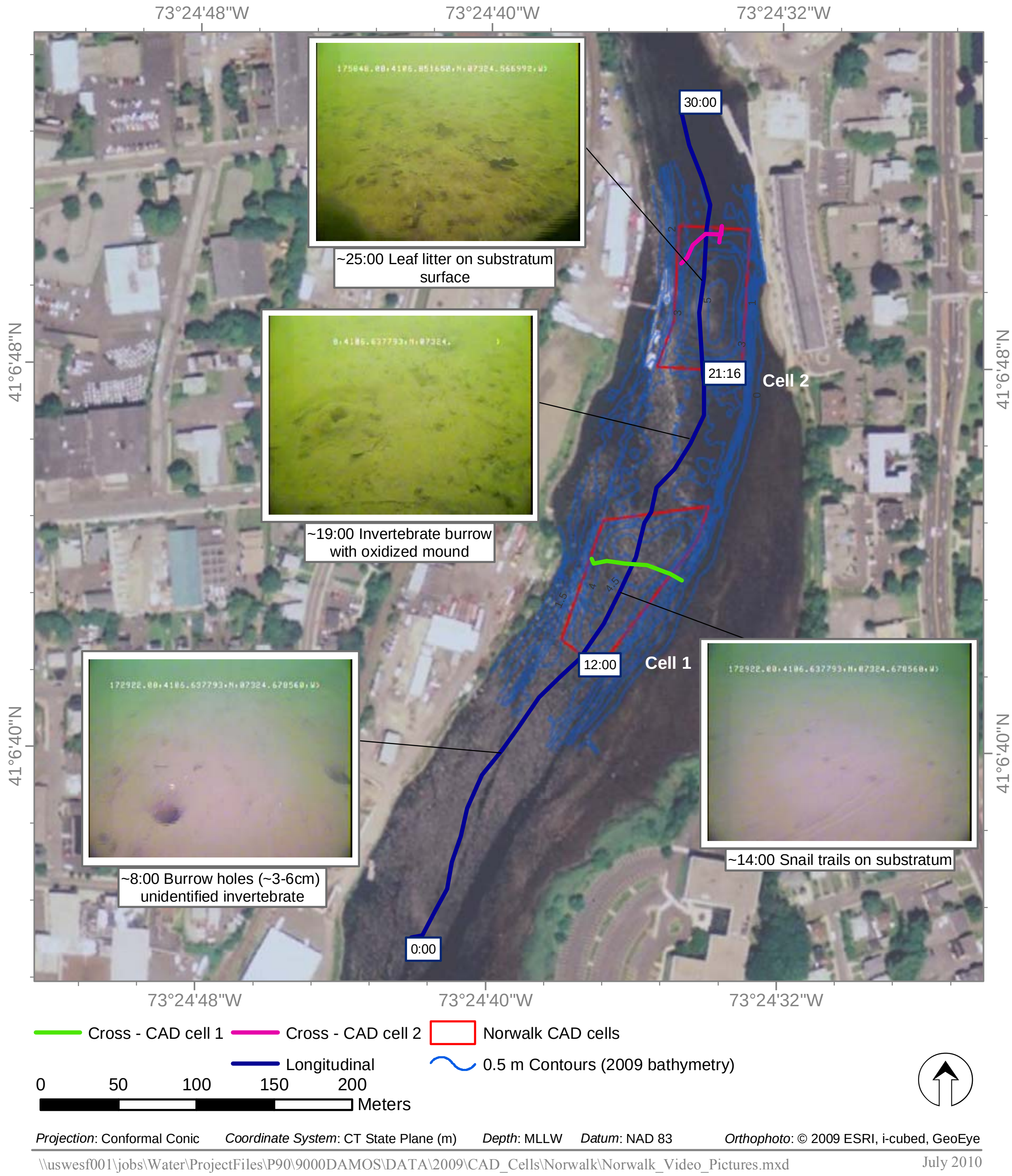


Figure 3-14. Underwater video transect and representative clips for Norwalk Harbor

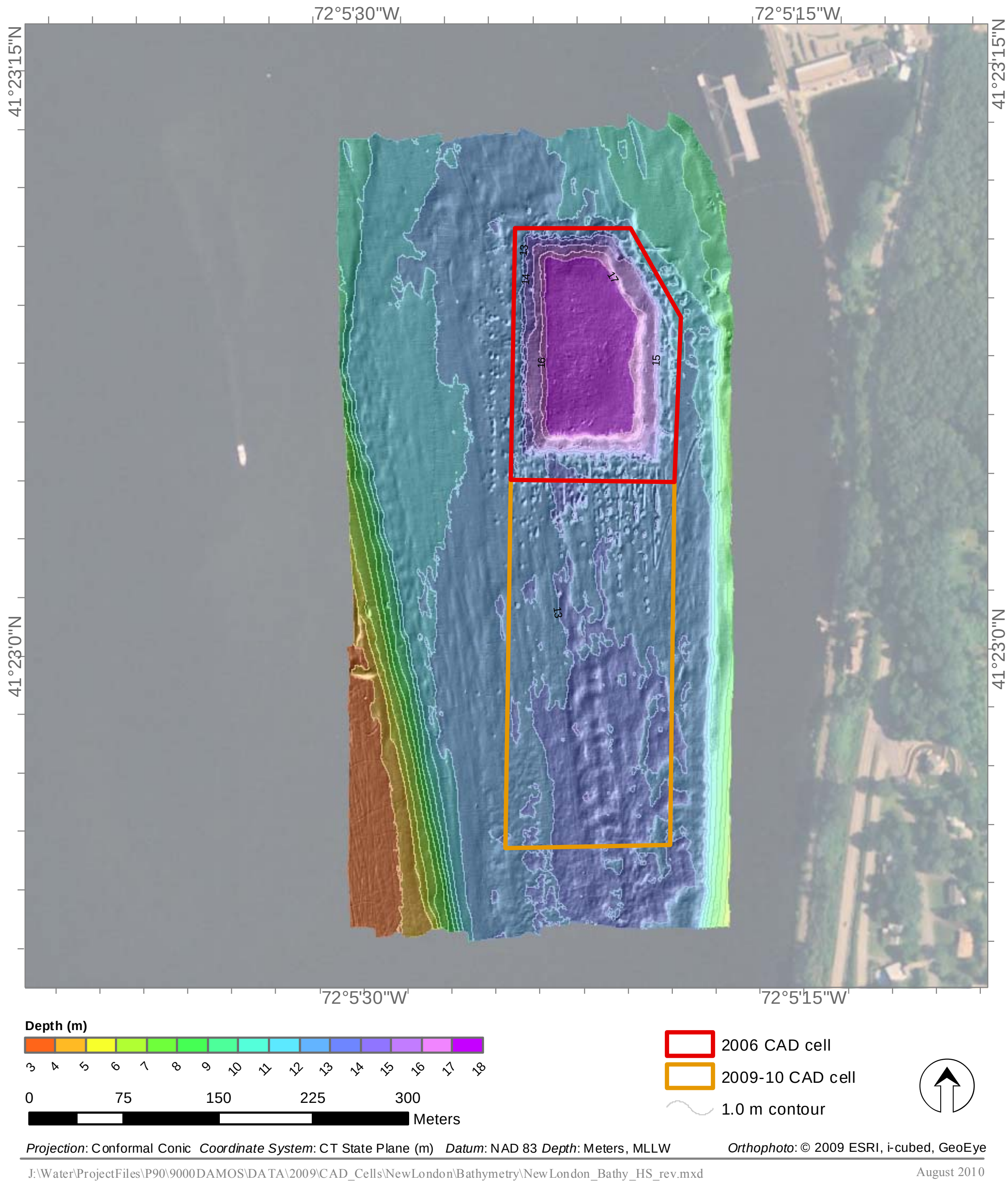


Figure 3-15. Bathymetric contour map over hillshaded bathymetry of the New London CAD cell, October 2009

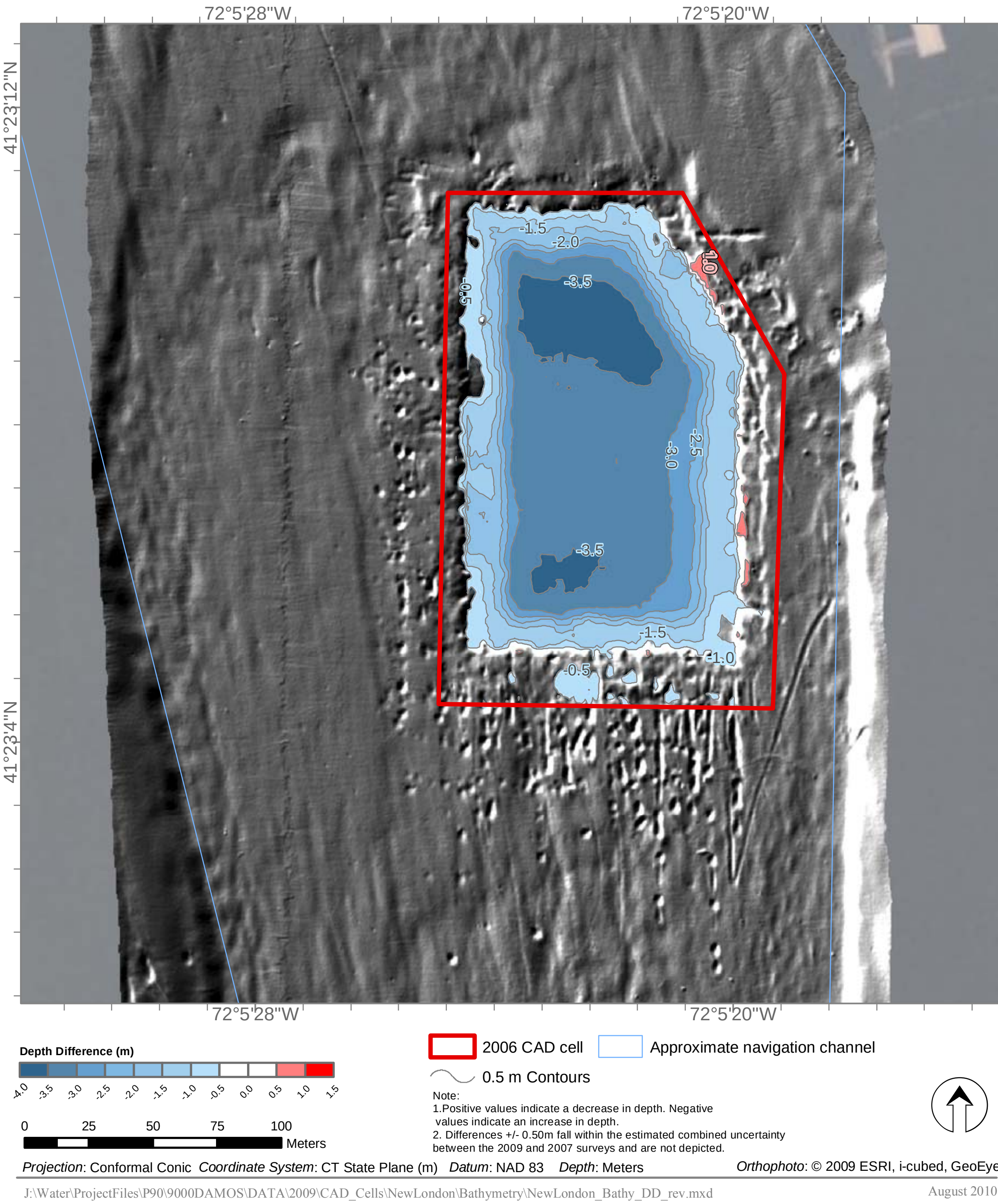


Figure 3-16. Depth difference contour map of the New London CAD cell, November 2006 and October 2009, overlaying 2009 hillshaded bathymetry

Figure 3-17. Spatial distribution of grain size major mode (phi) for New London

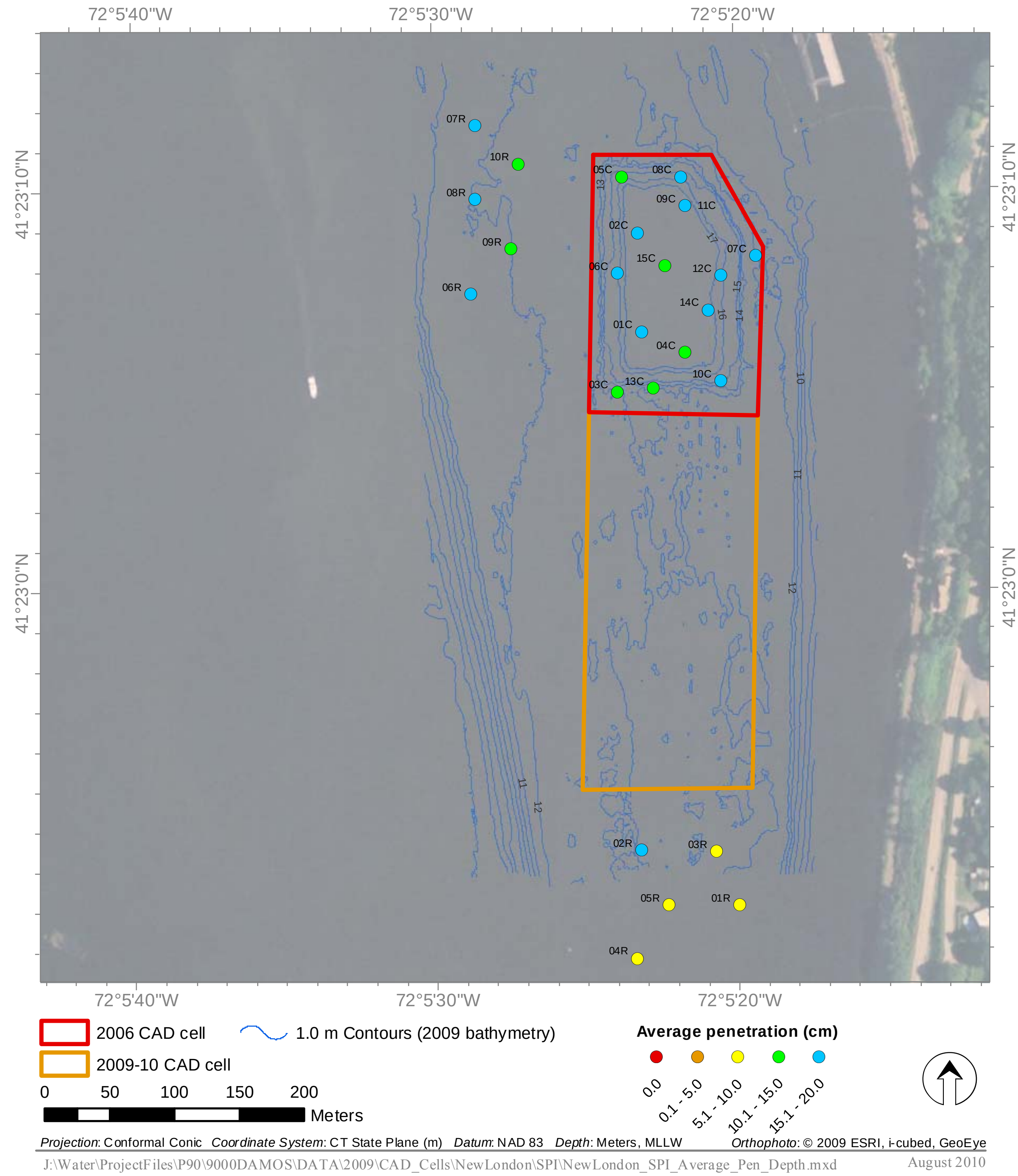


Figure 3-18. Spatial distribution of station-averaged camera prism penetration depth (cm) for New London

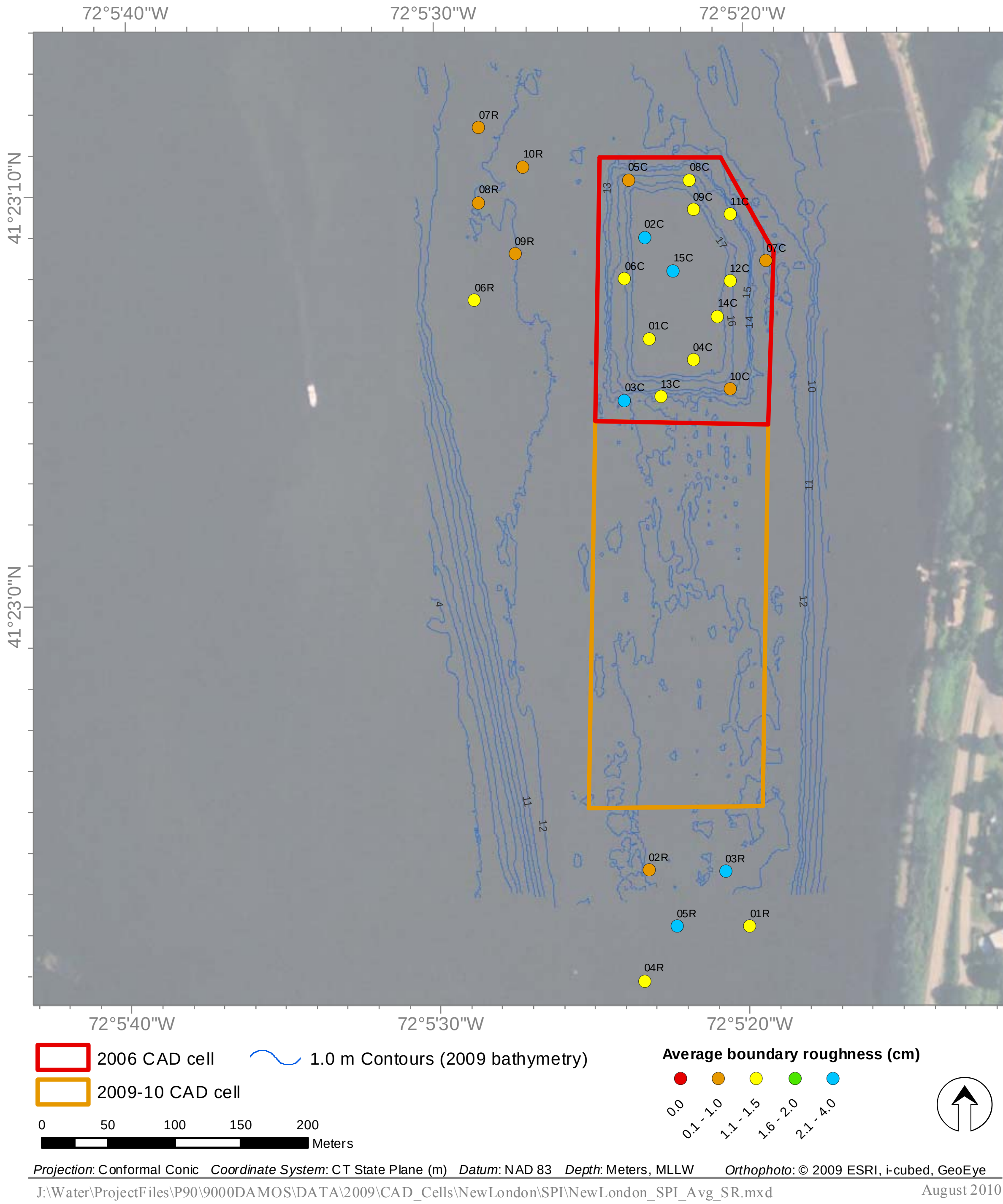


Figure 3-19. Spatial distribution of station-averaged mean boundary roughness (cm) for New London

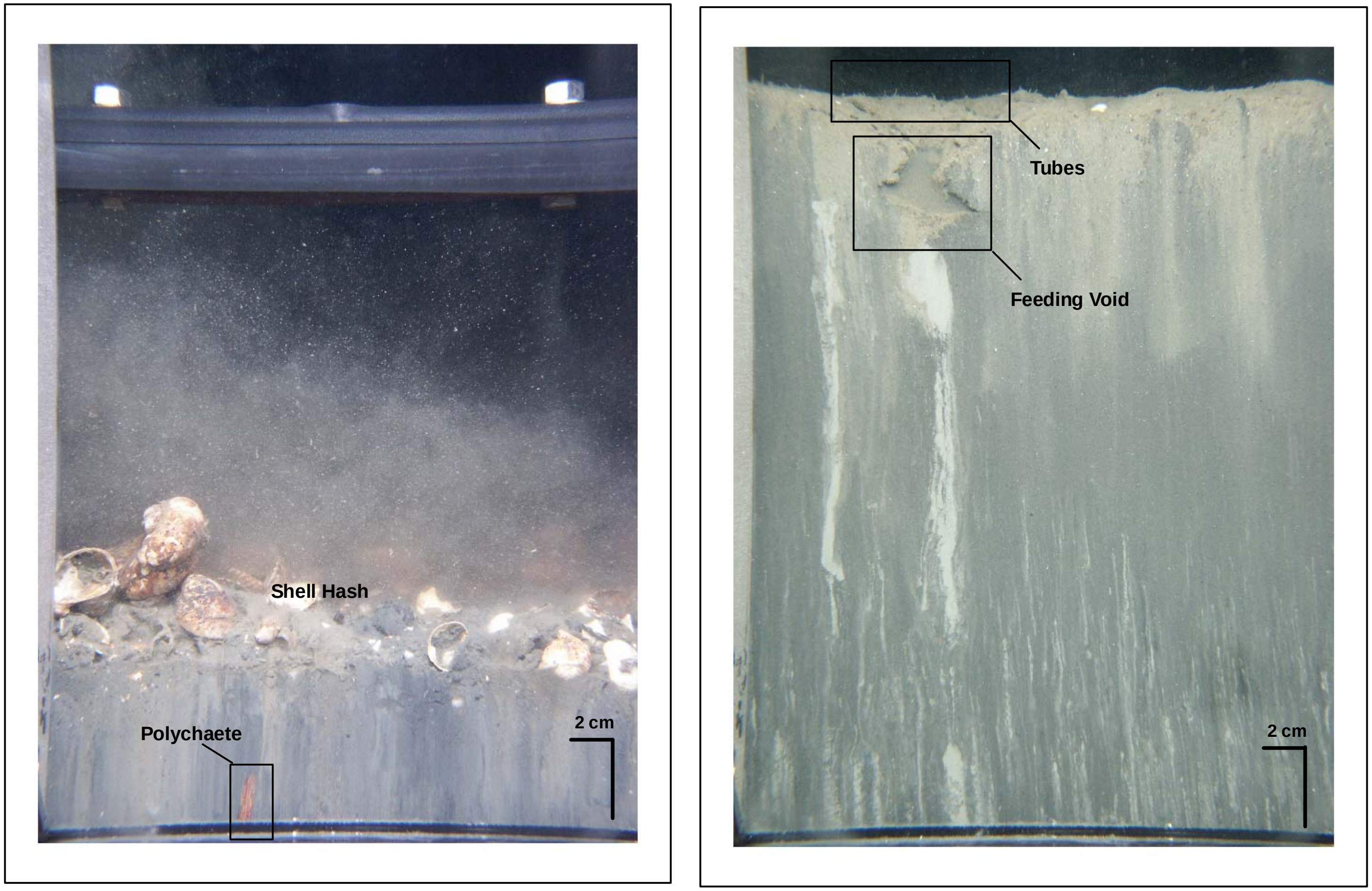


Figure 3-20. Evidence of physical and biogenic processes observed in SPI from New London CAD cell and surrounding reference areas: shell hash in southern reference area at Station 1R (left) and burrow and tubes in CAD cell at Station 10C (right).

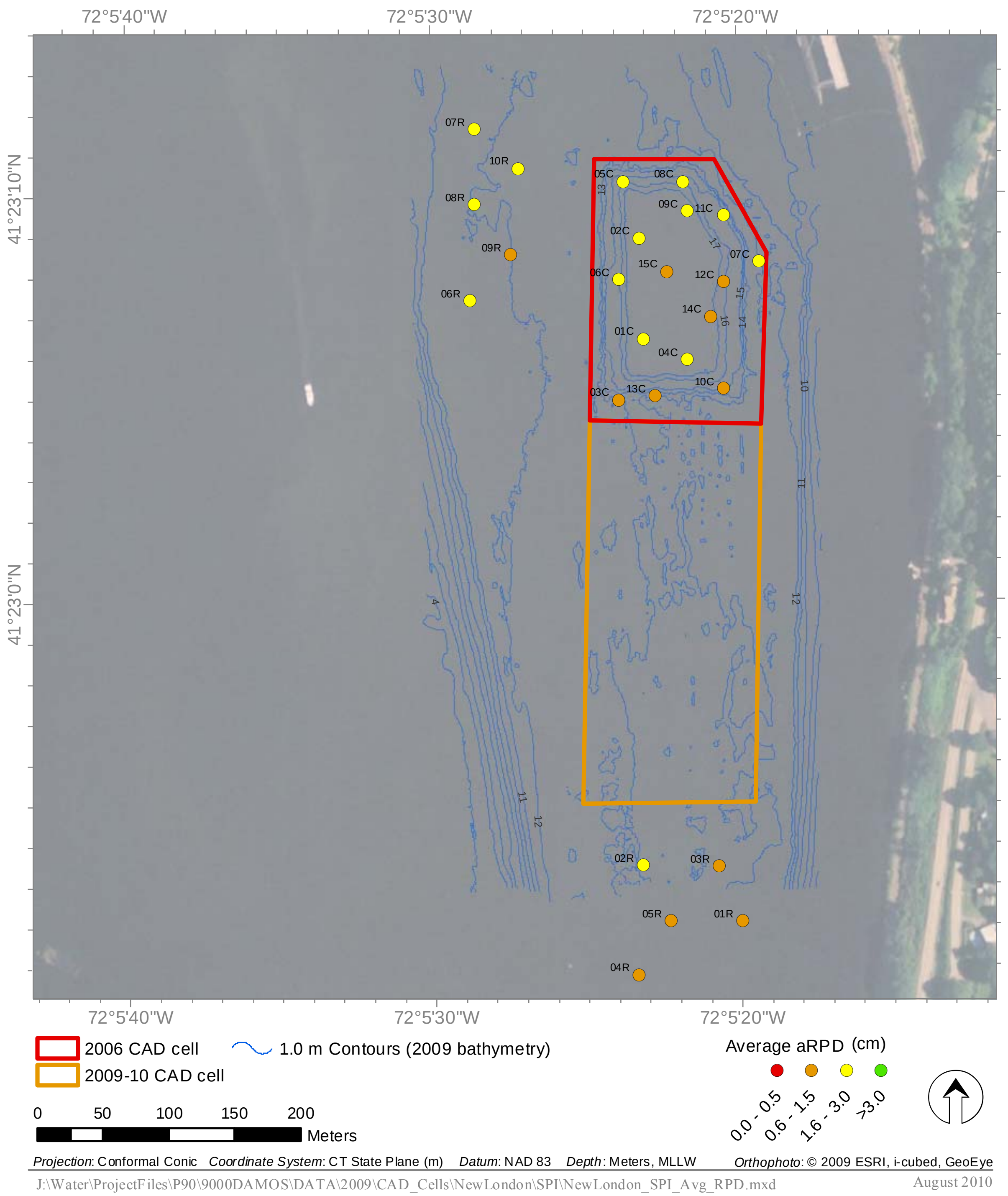


Figure 3-21. Spatial distribution of station-averaged aRPD depths (cm) for New London

Figure 3-22. Sediment layers observed within the New London CAD cell (Station 6C, right) and surrounding reference area (Station 8R, left).

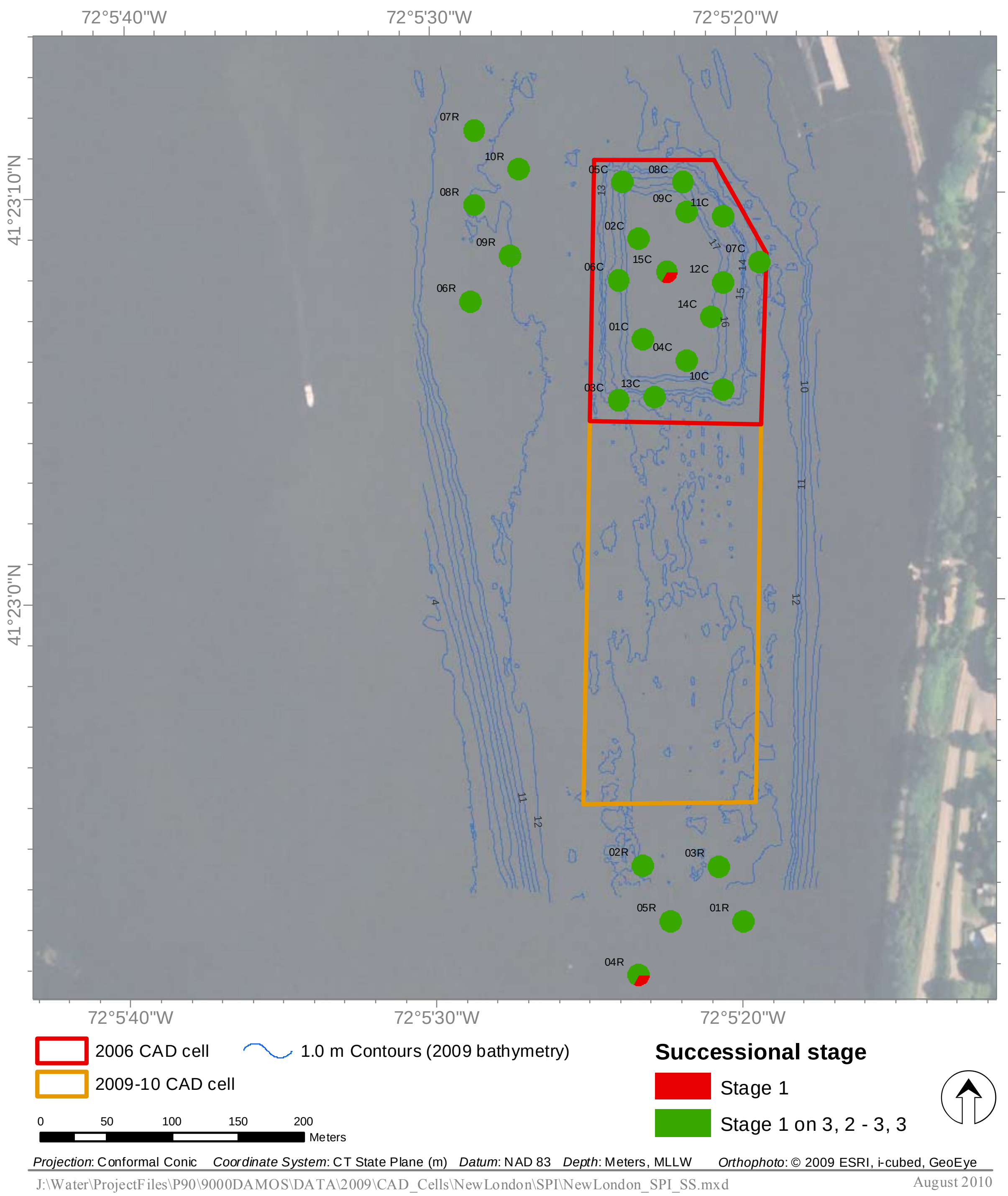


Figure 3-23. Spatial distribution of infaunal successional stages for New London. Each station is represented by a circle, the number of SPI replicates for each station is represented as a pie wedge of the circle.

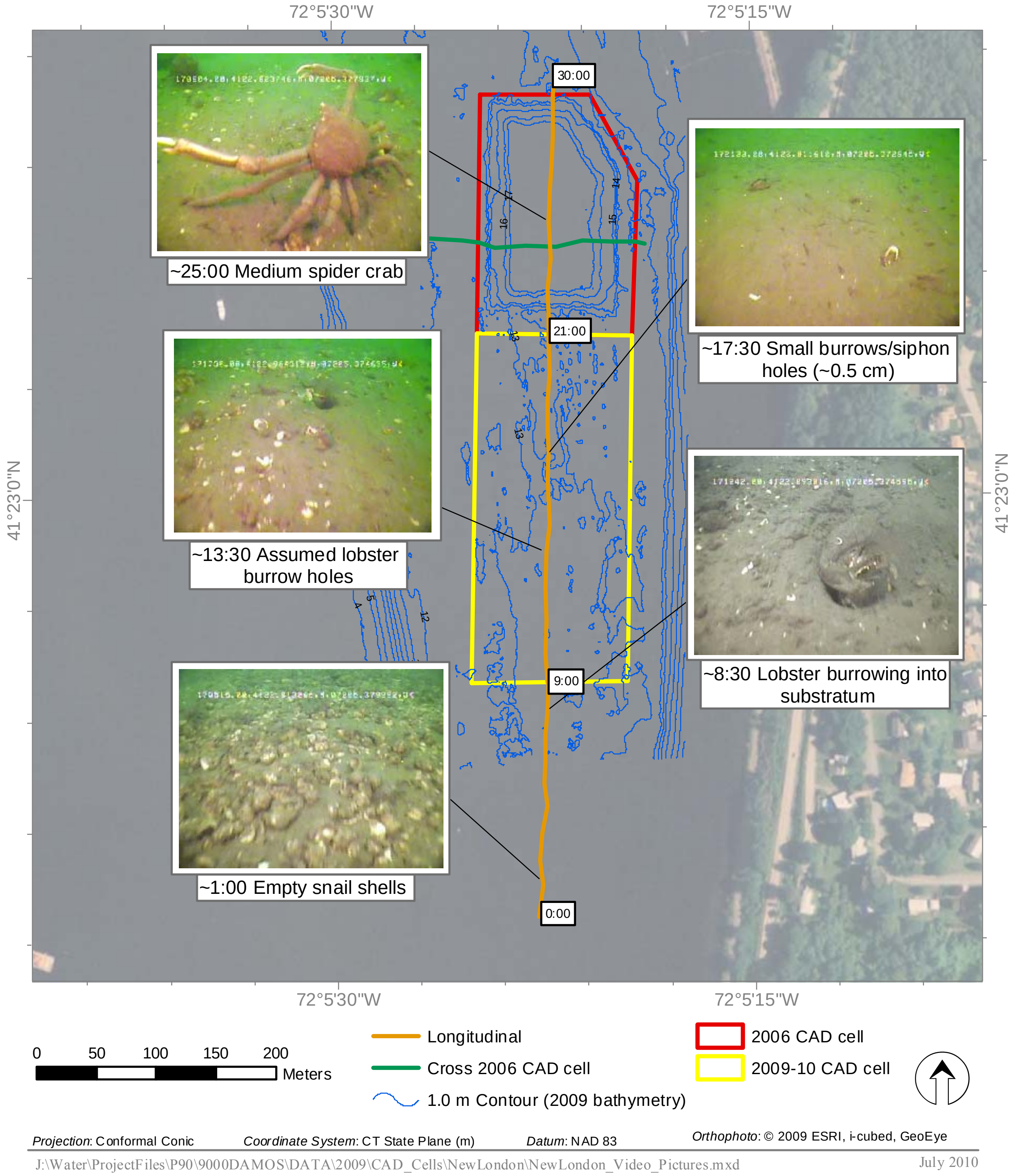


Figure 3-24. Underwater video for New London

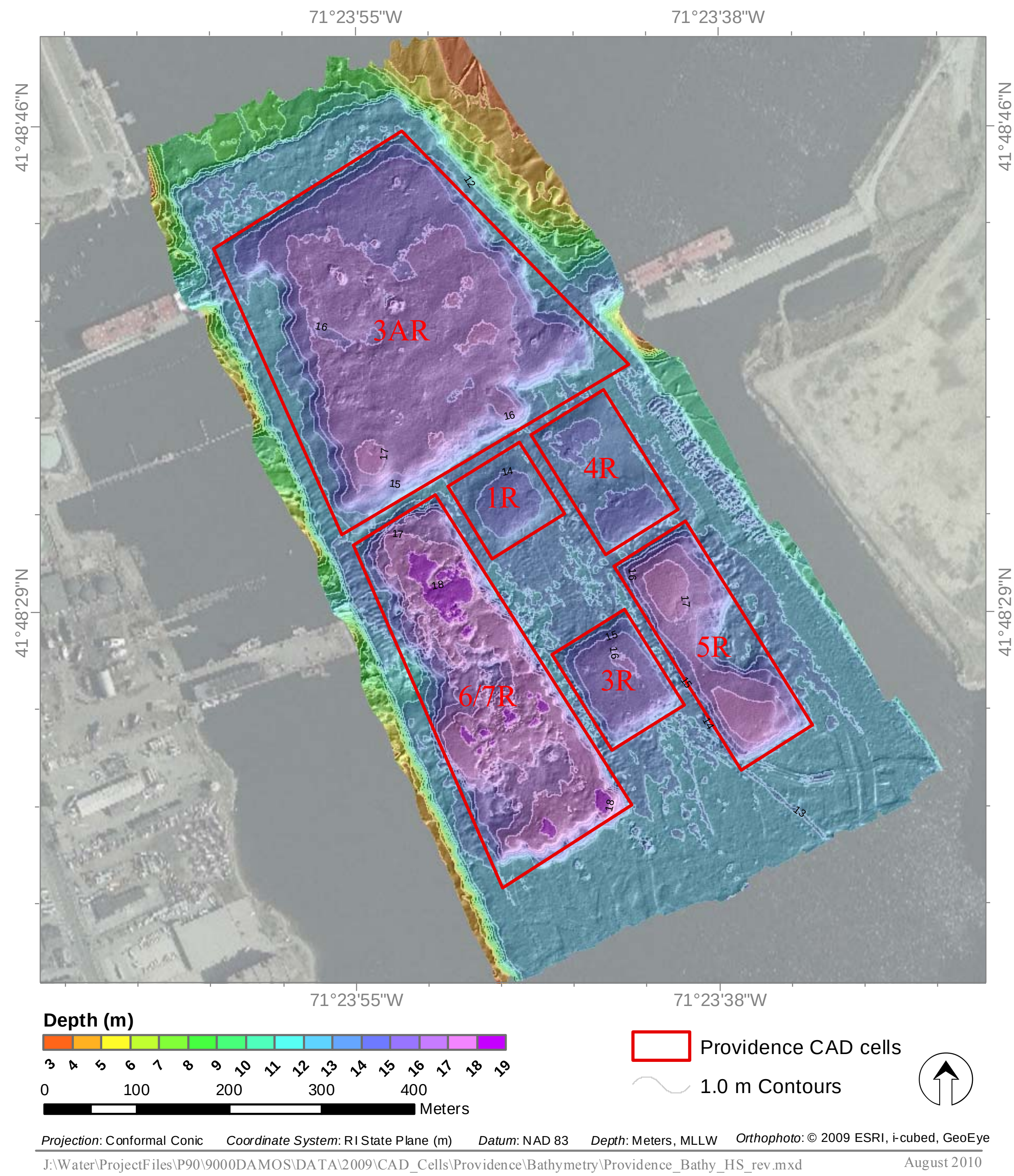


Figure 3-25. Bathymetric contour map over hillshaded bathymetry of the Providence CAD cells, October 2009

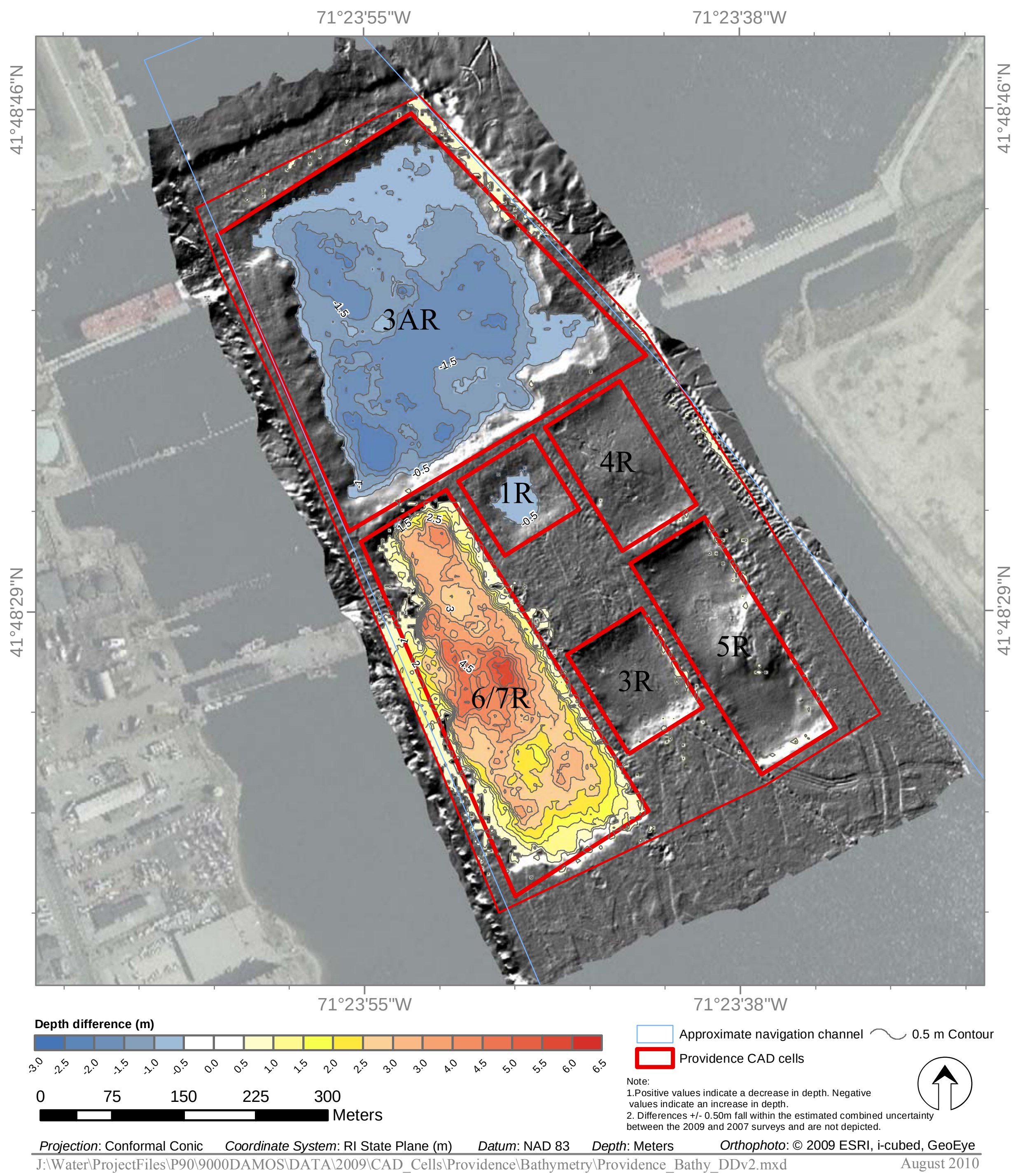


Figure 3-26. Depth difference contour map of the Providence CAD cells, May 2005 and October 2009, overlaying 2009 hillshaded bathymetry

Figure 3-27. Spatial distribution of grain size major mode (phi) for Providence Harbor

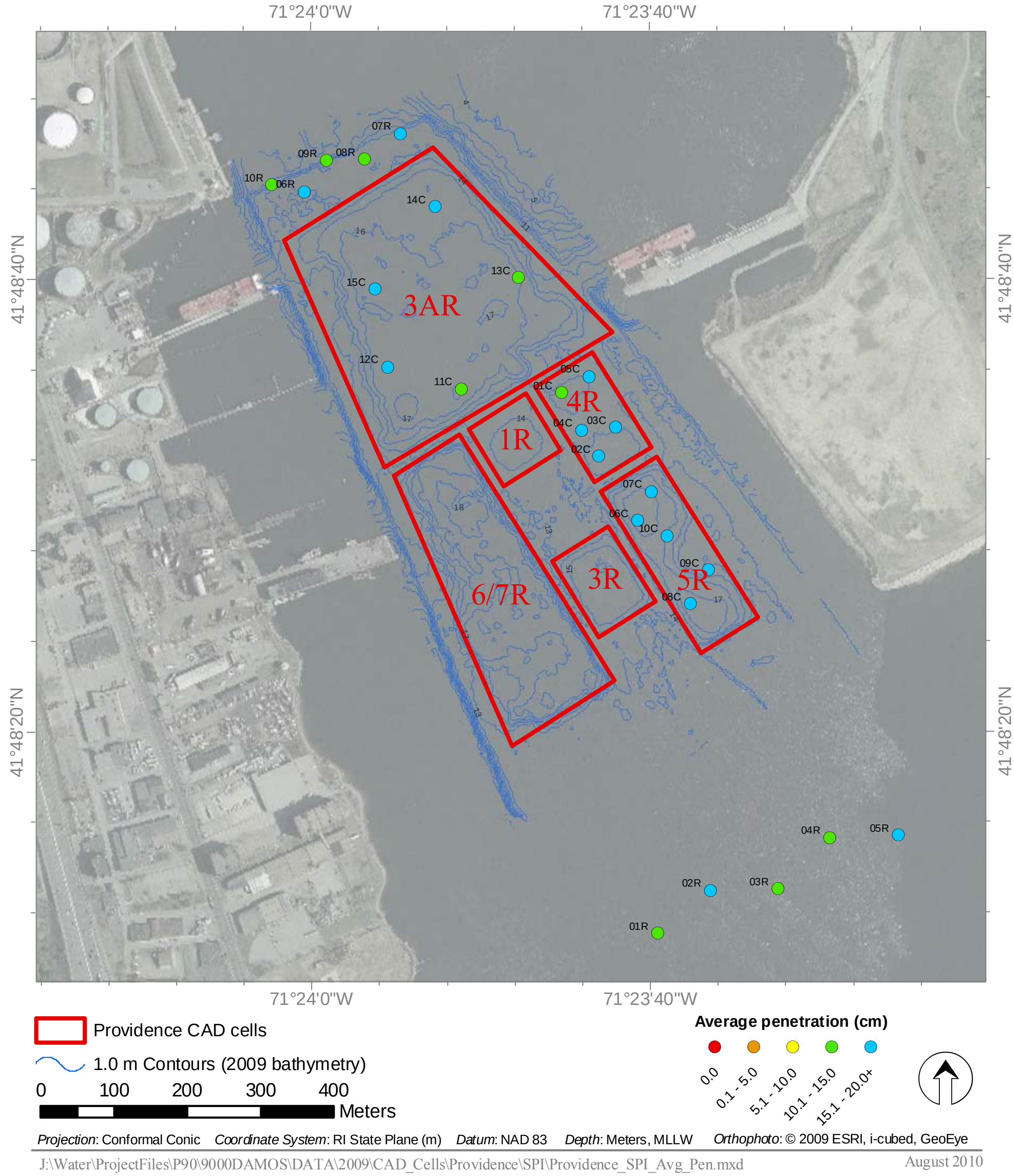


Figure 3-28. Spatial distribution of station-averaged camera prism penetration depth (cm) for Providence Harbor

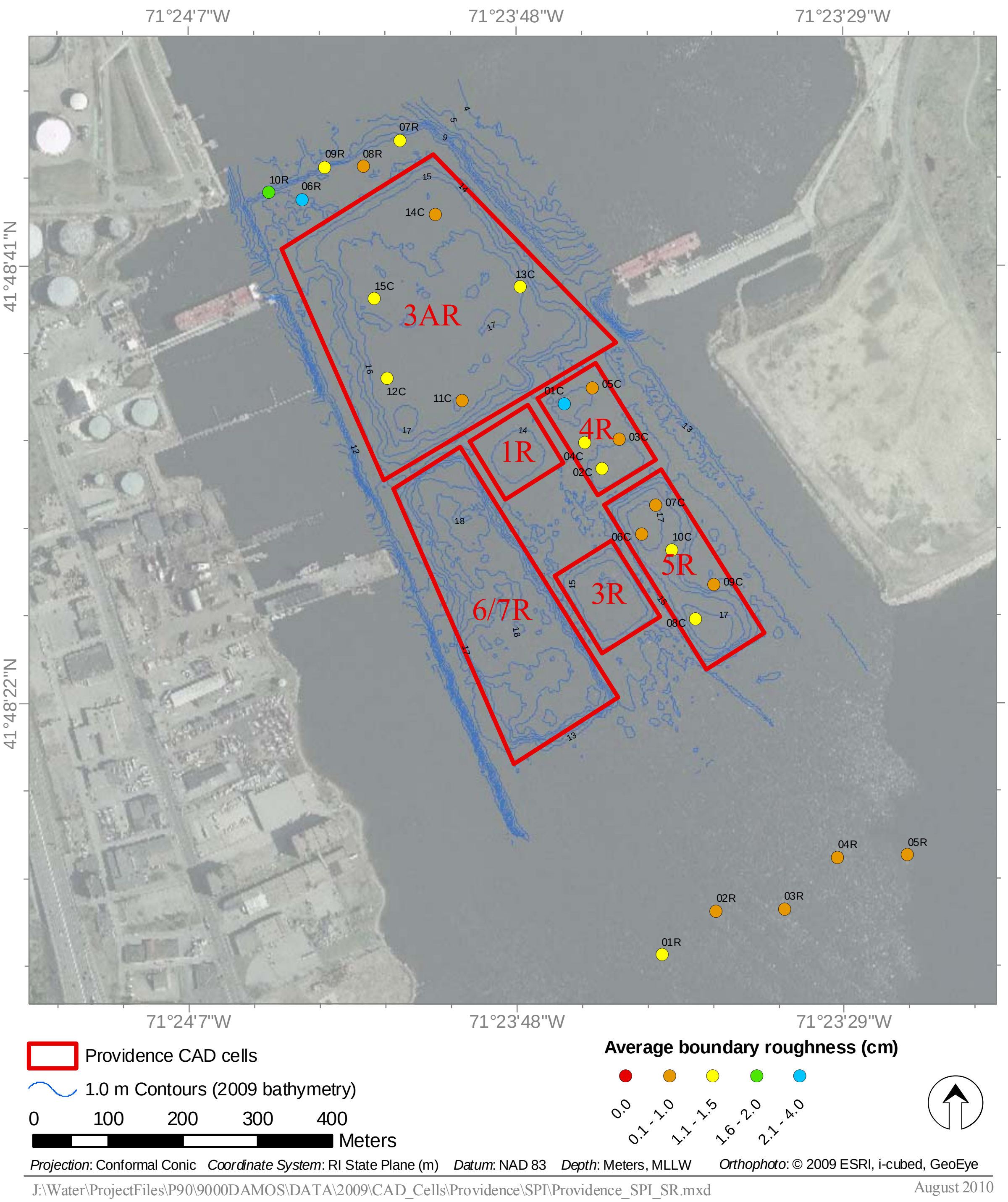


Figure 3-29. Spatial distribution of station-averaged mean boundary roughness (cm) for Providence Harbor

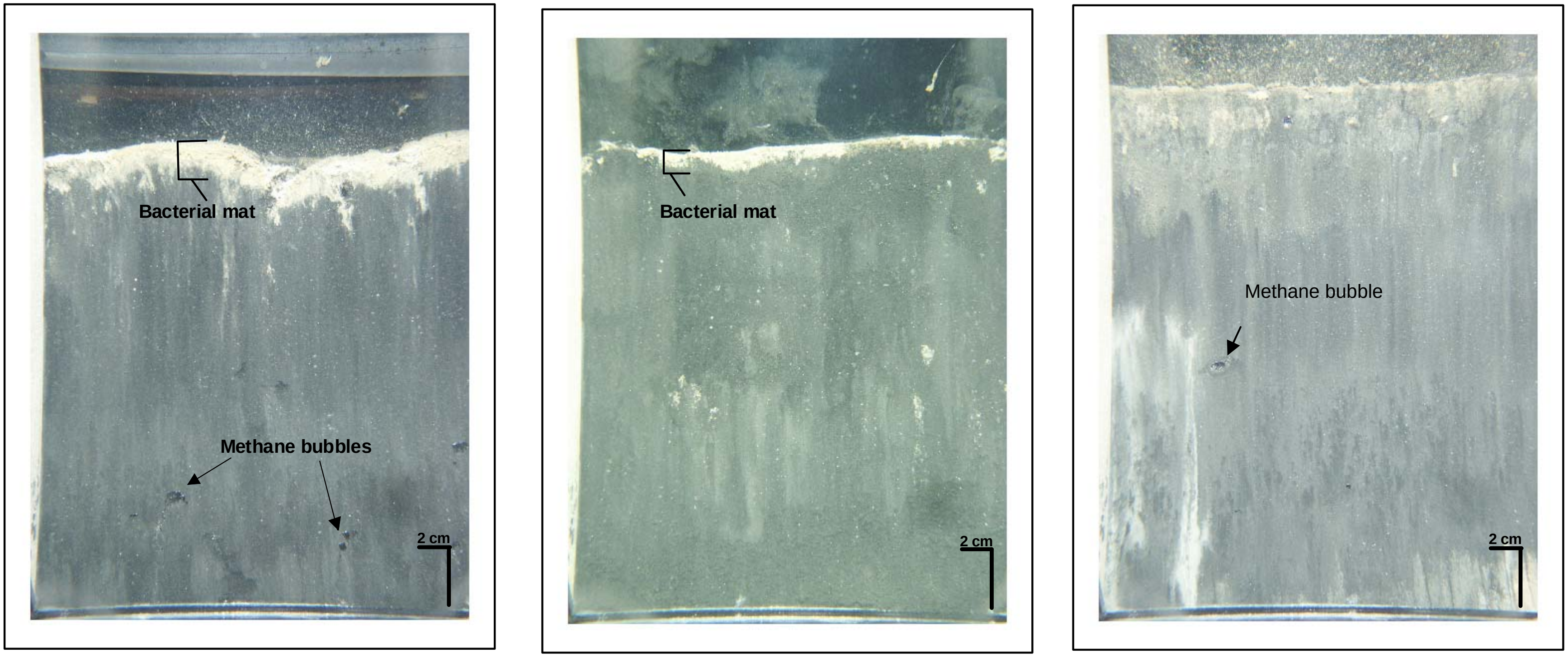


Figure 3-30. Boundary roughness and bacterial mats in Providence Harbor at Stations 1R (left), 8C (middle), and 14C (right). Methane bubbles are also visible at Stations 1R and 14C.

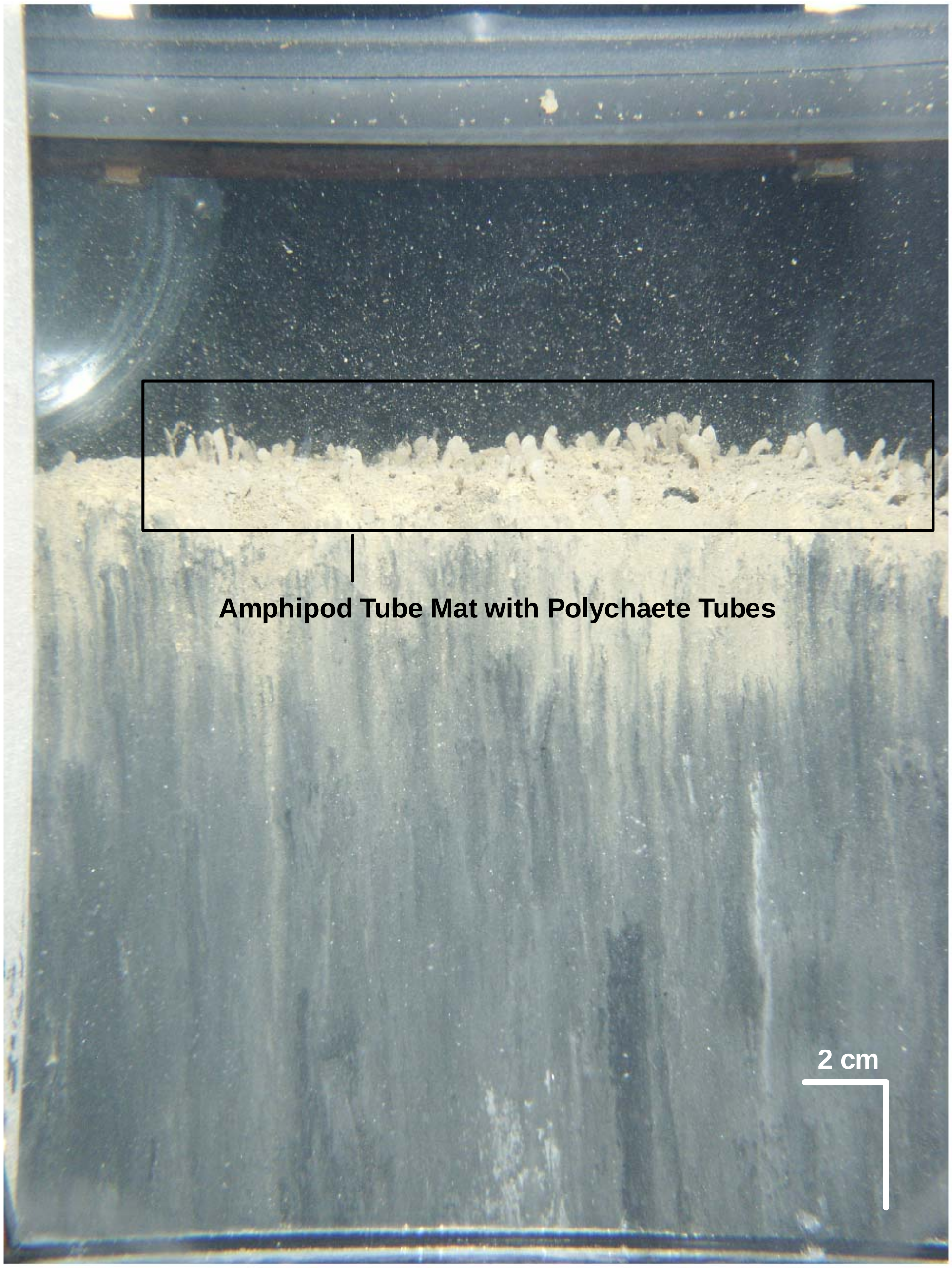


Figure 3-31. Presence of amphipod tubes at Providence Harbor reference station 9R

Figure 3-32. Spatial distribution of methane presence for Providence Harbor

Figure 3-33. Spatial distribution of station-averaged aRPD depths (cm) for Providence Harbor

Figure 3-34. Spatial distribution of *Beggiatoa* sp. in Providence Harbor

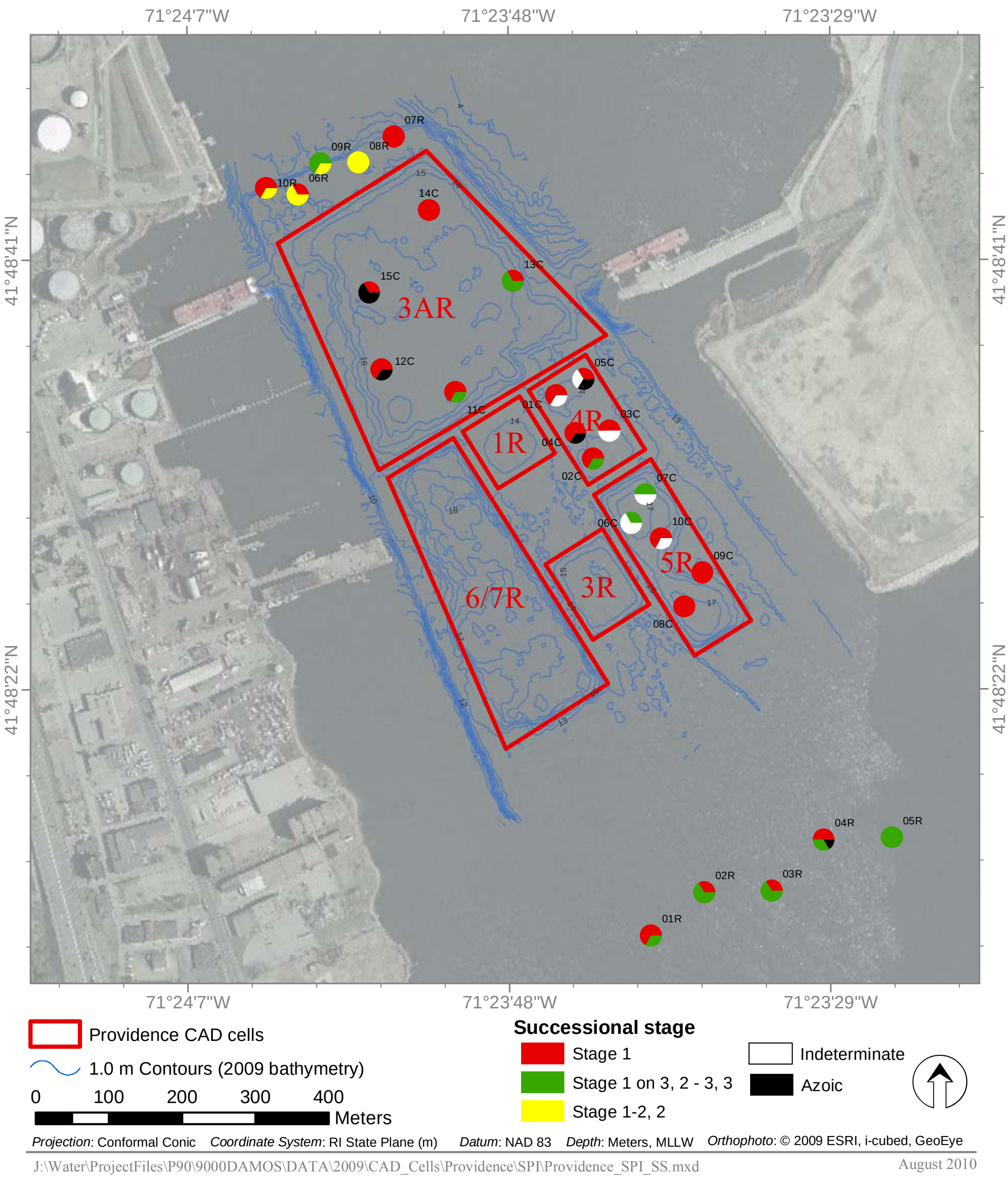


Figure 3-35. Spatial distribution of infaunal successional stages for Providence Harbor. Each station is represented by a circle; the number of SPI replicates for each station is represented as a pie wedge of the circle.

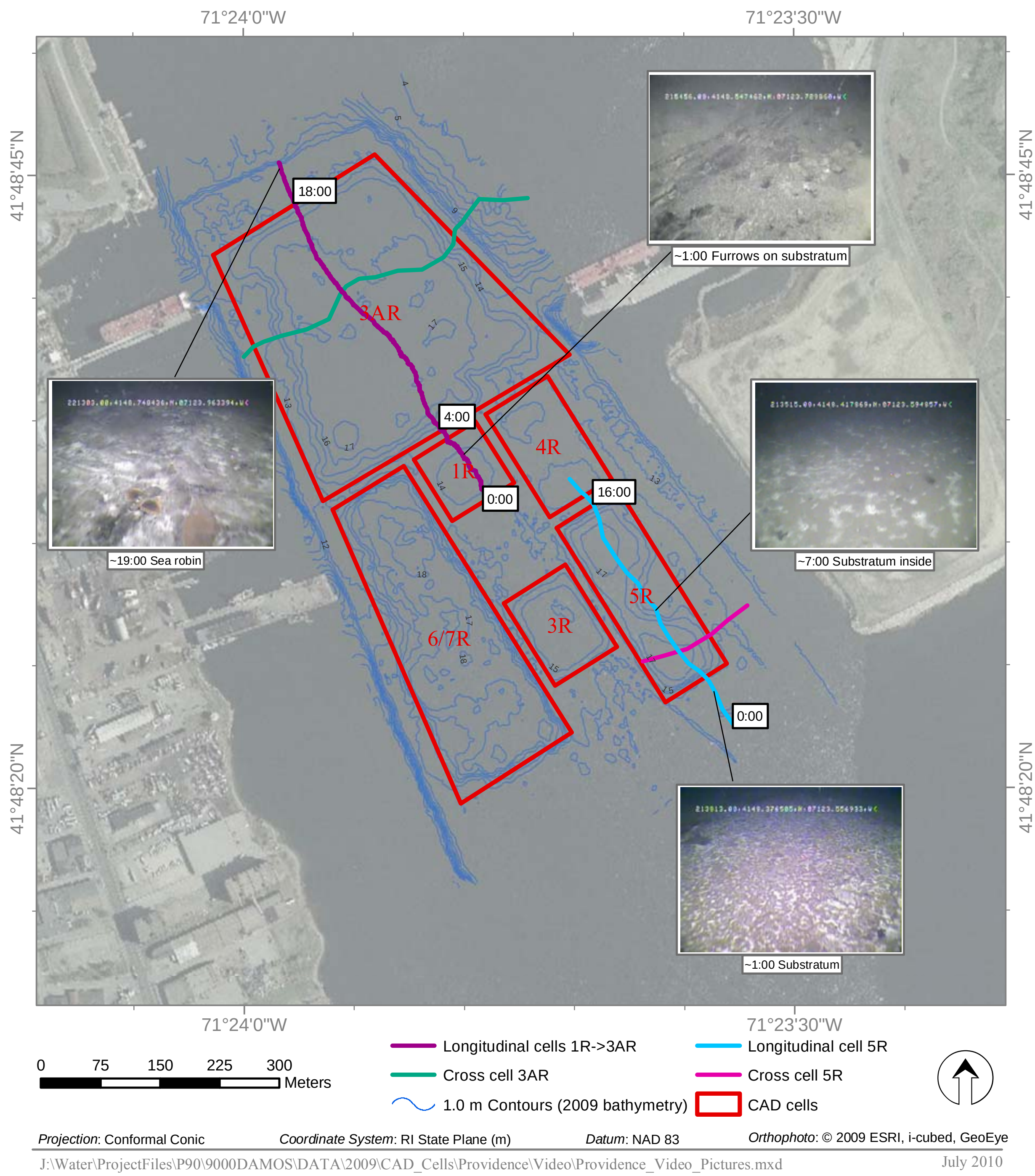


Figure 3-36. Underwater video transects and representative clips for Providence Harbor

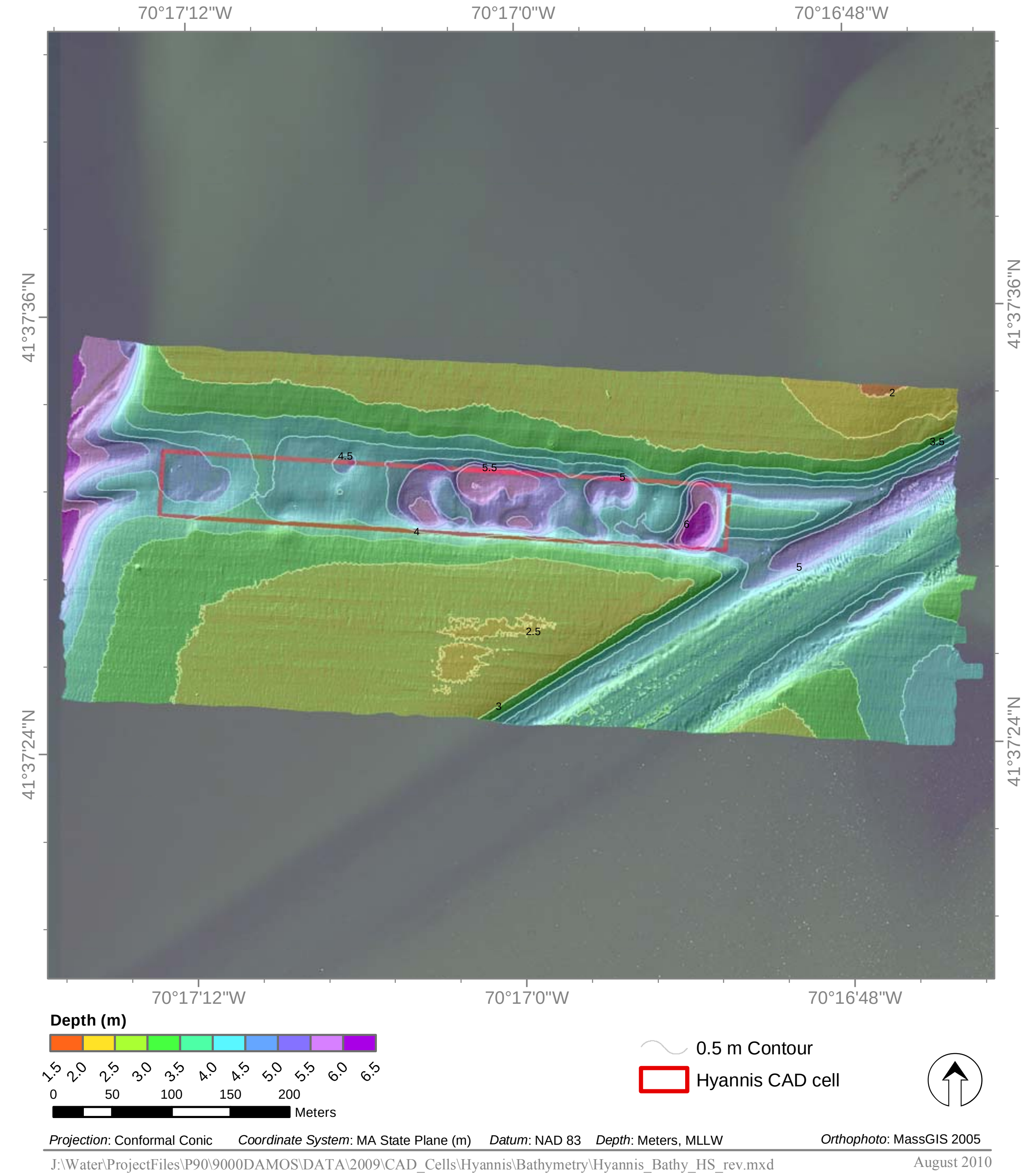


Figure 3-37. Bathymetric contour map over hillshaded bathymetry of the Hyannis CAD cell, October 2009

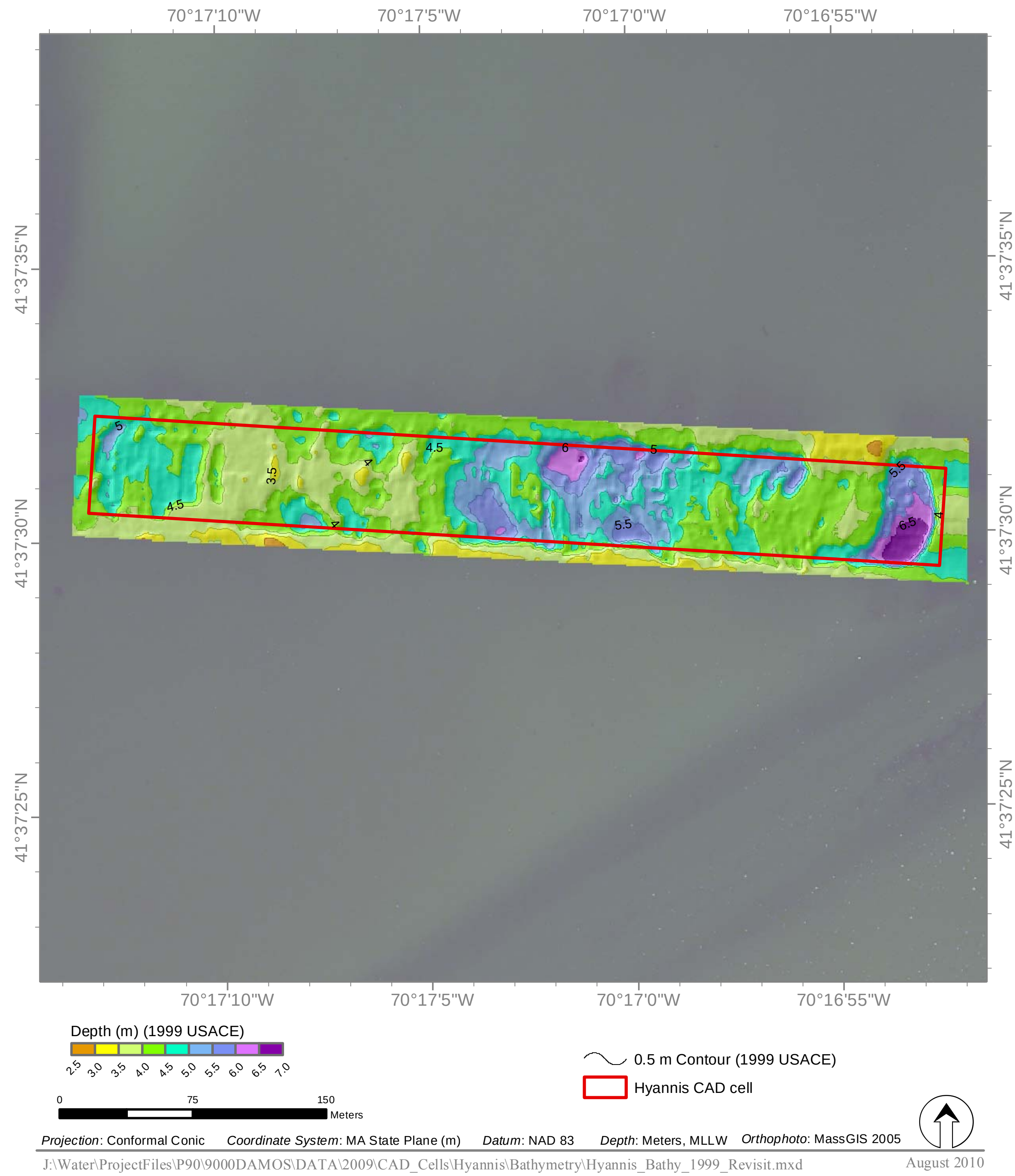


Figure 3-38. Post-capping bathymetric contour map of the Hyannis CAD cell, April 1999

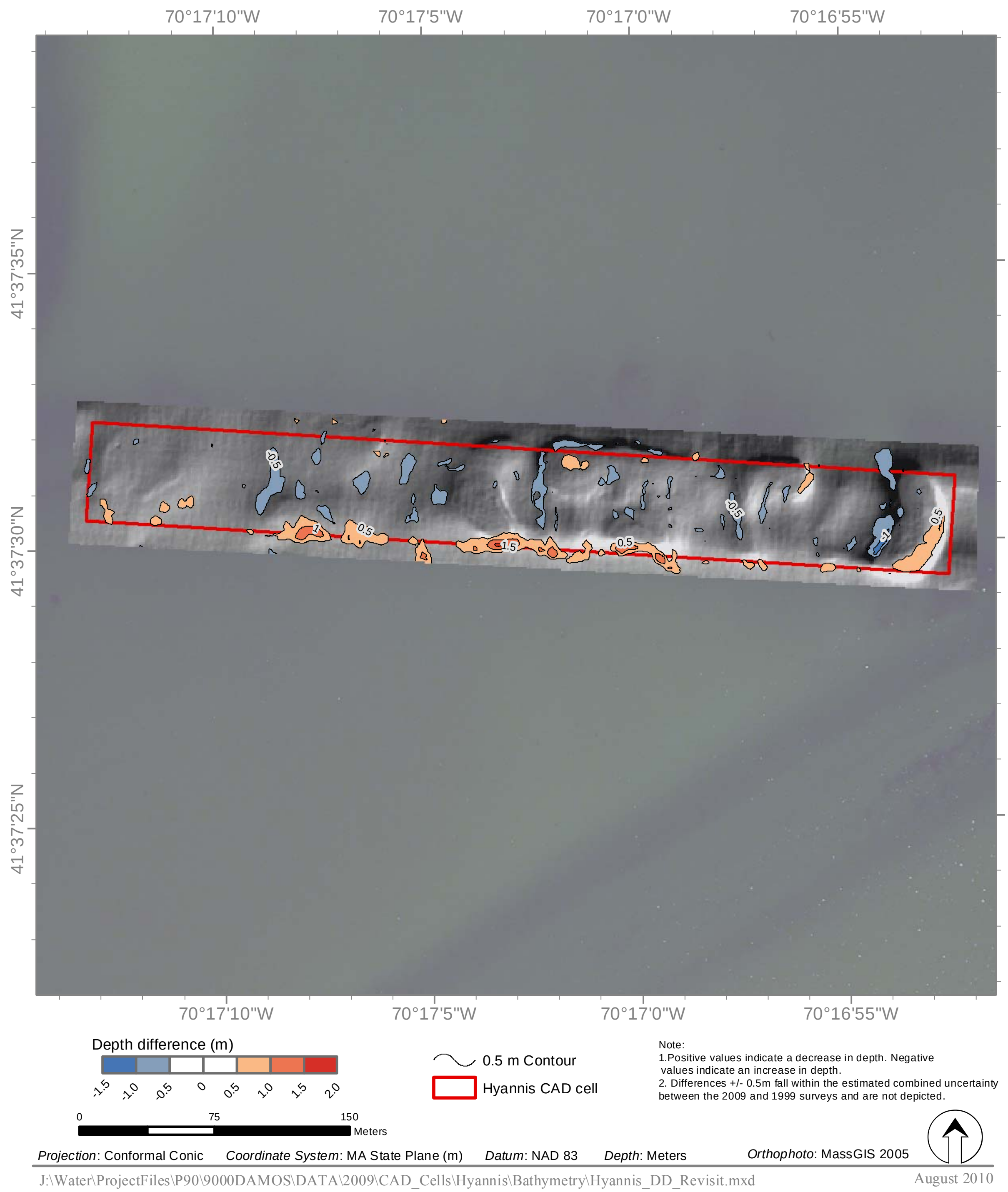


Figure 3-39. Depth difference contour map of the Hyannis CAD cell, April 1999 and October 2009, overlaying the 2009 hillshaded bathymetry.

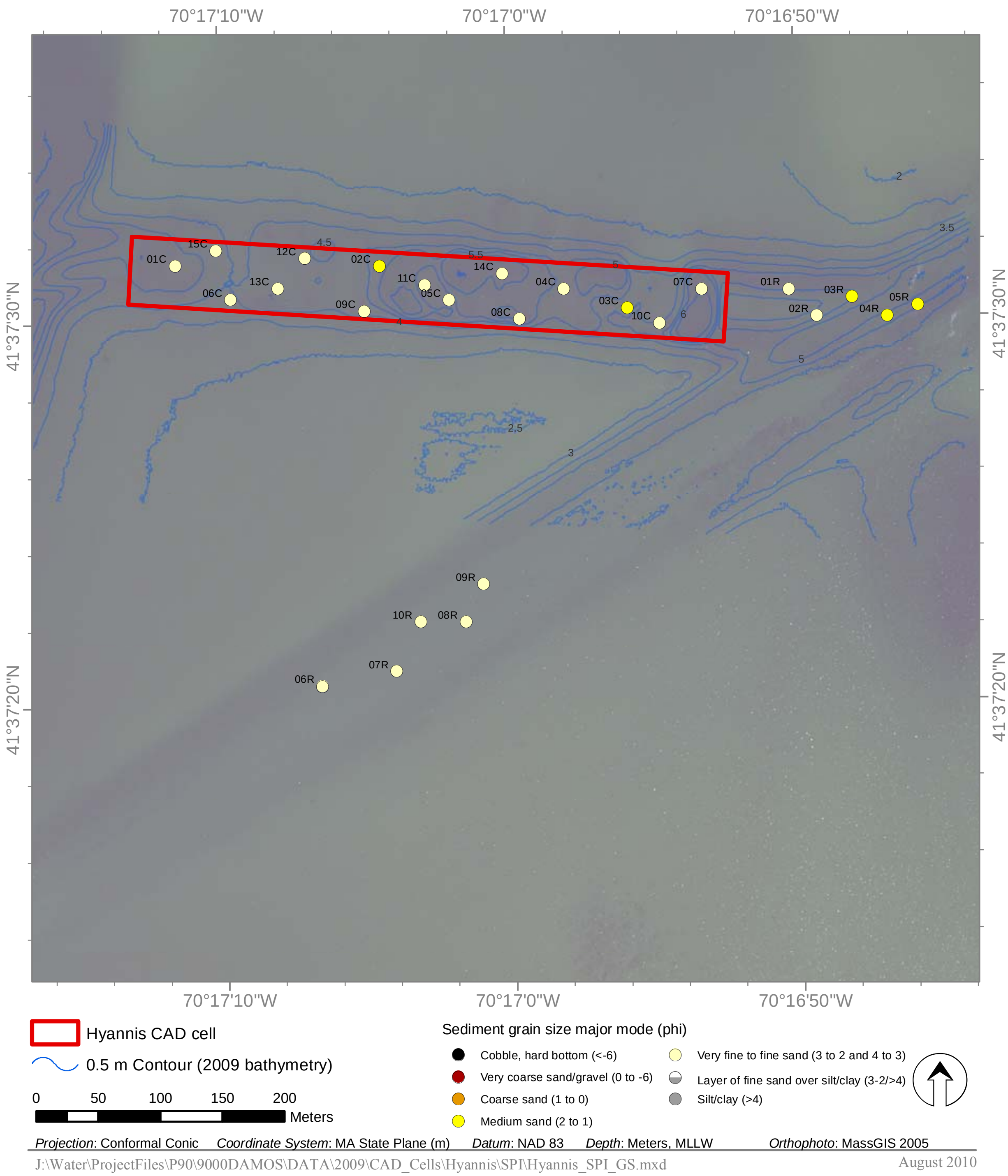


Figure 3-40. Spatial distribution of grain size major mode (phi) for Hyannis Harbor

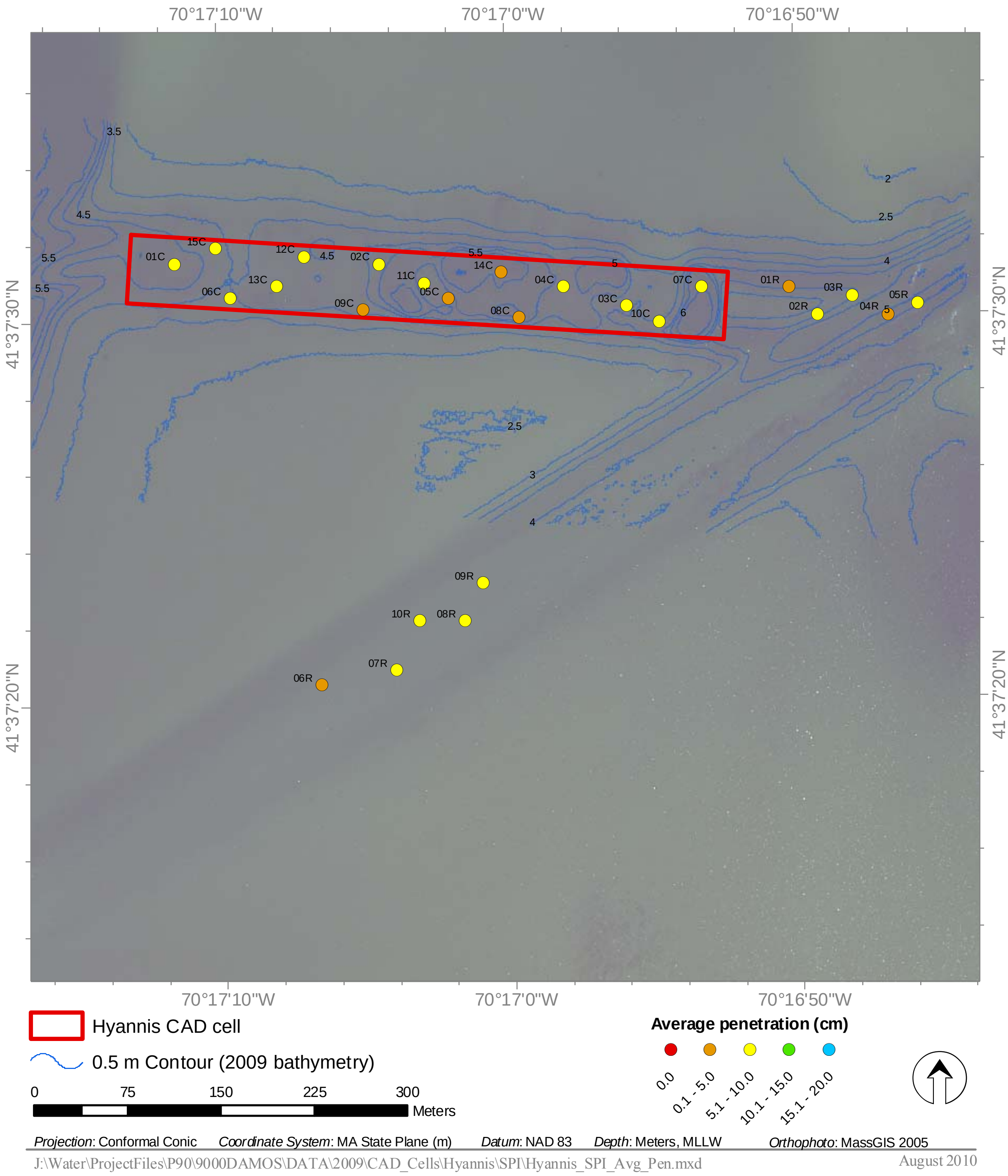


Figure 3-41. Spatial distribution of station-averaged camera prism penetration depth (cm) for Hyannis Harbor

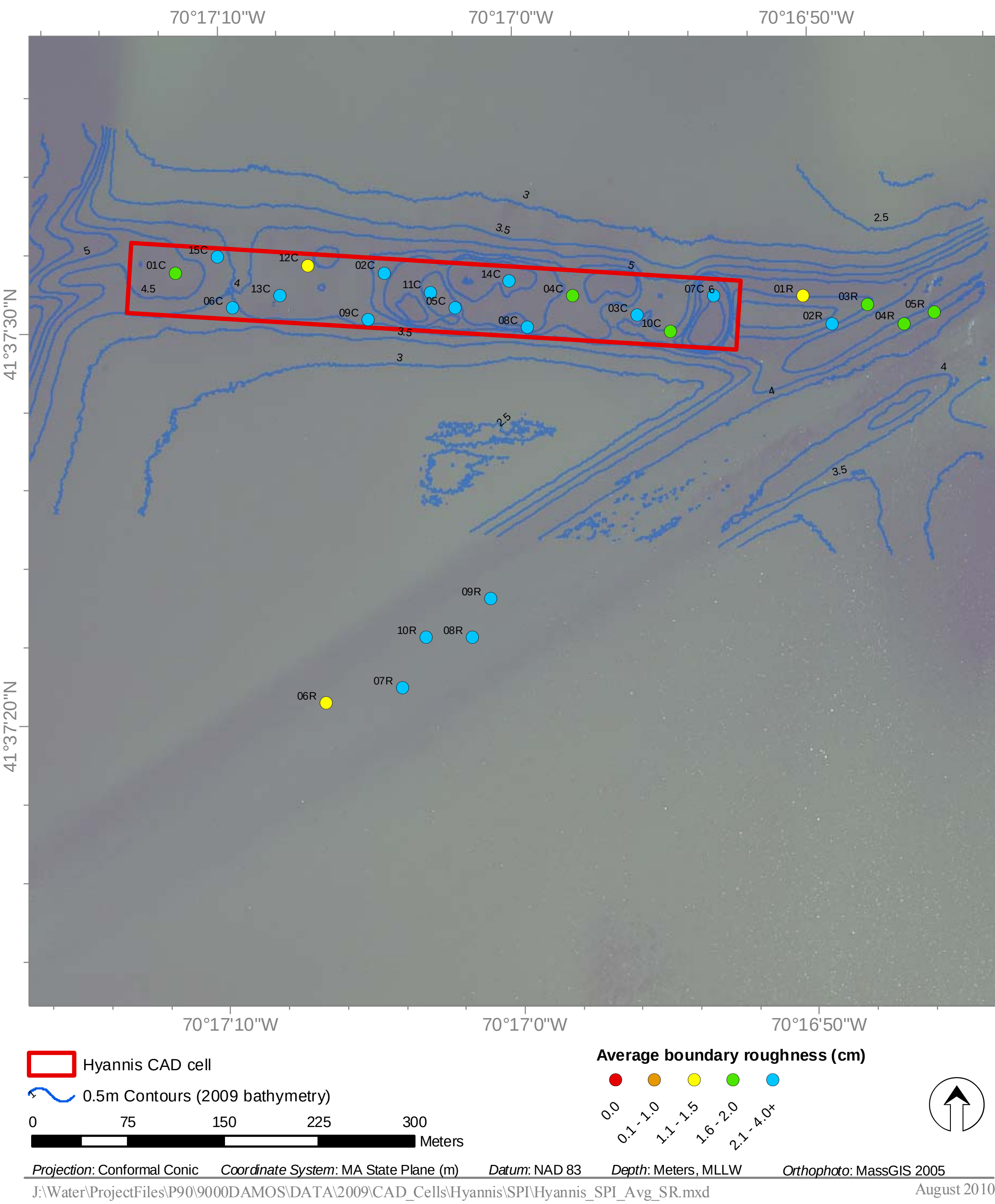


Figure 3-42. Spatial distribution of station-averaged mean boundary roughness (cm) for Hyannis Harbor

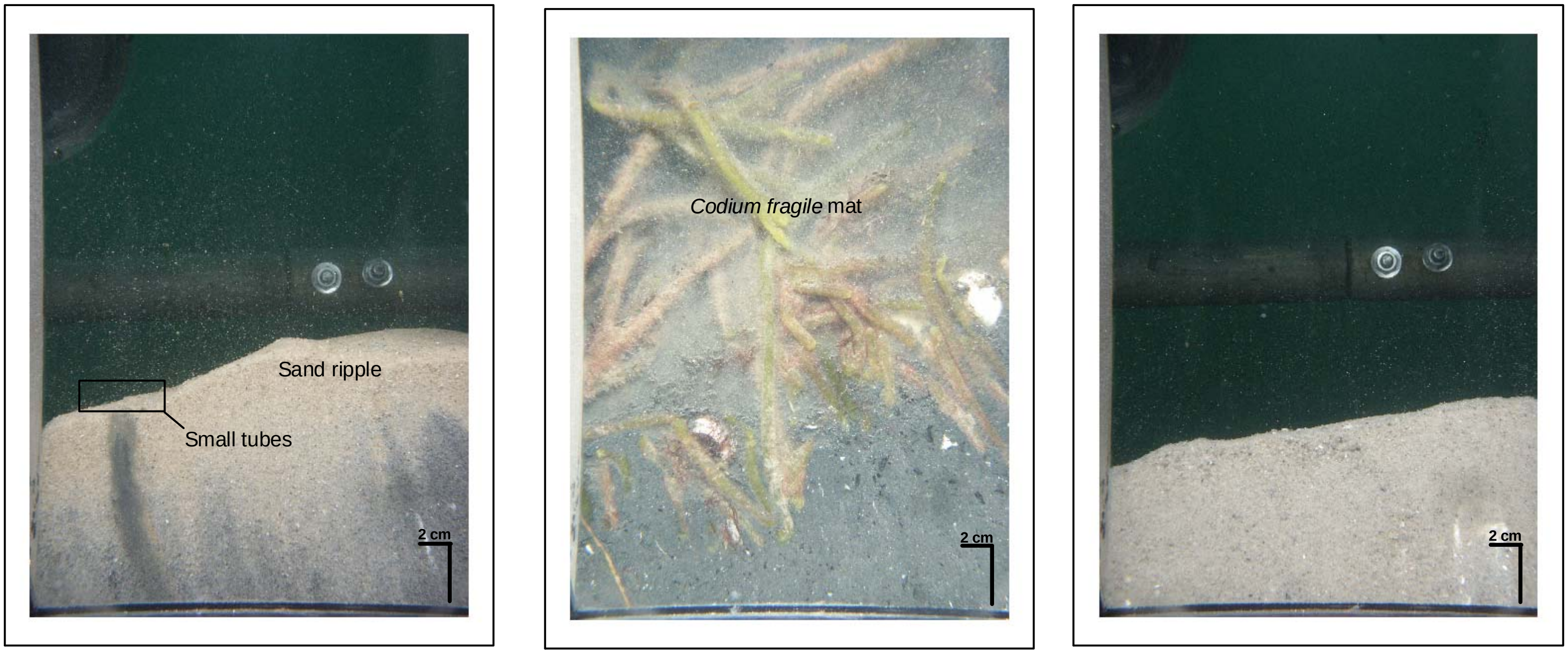


Figure 3-43. Examples of biological and physical features observed in SPI images from Hyannis Harbor: boundary roughness within CAD cell at Station 1C (left), *Codium fragile* at Station 7C (center), and fine sand at Station 6R, outside of CAD cell (right)

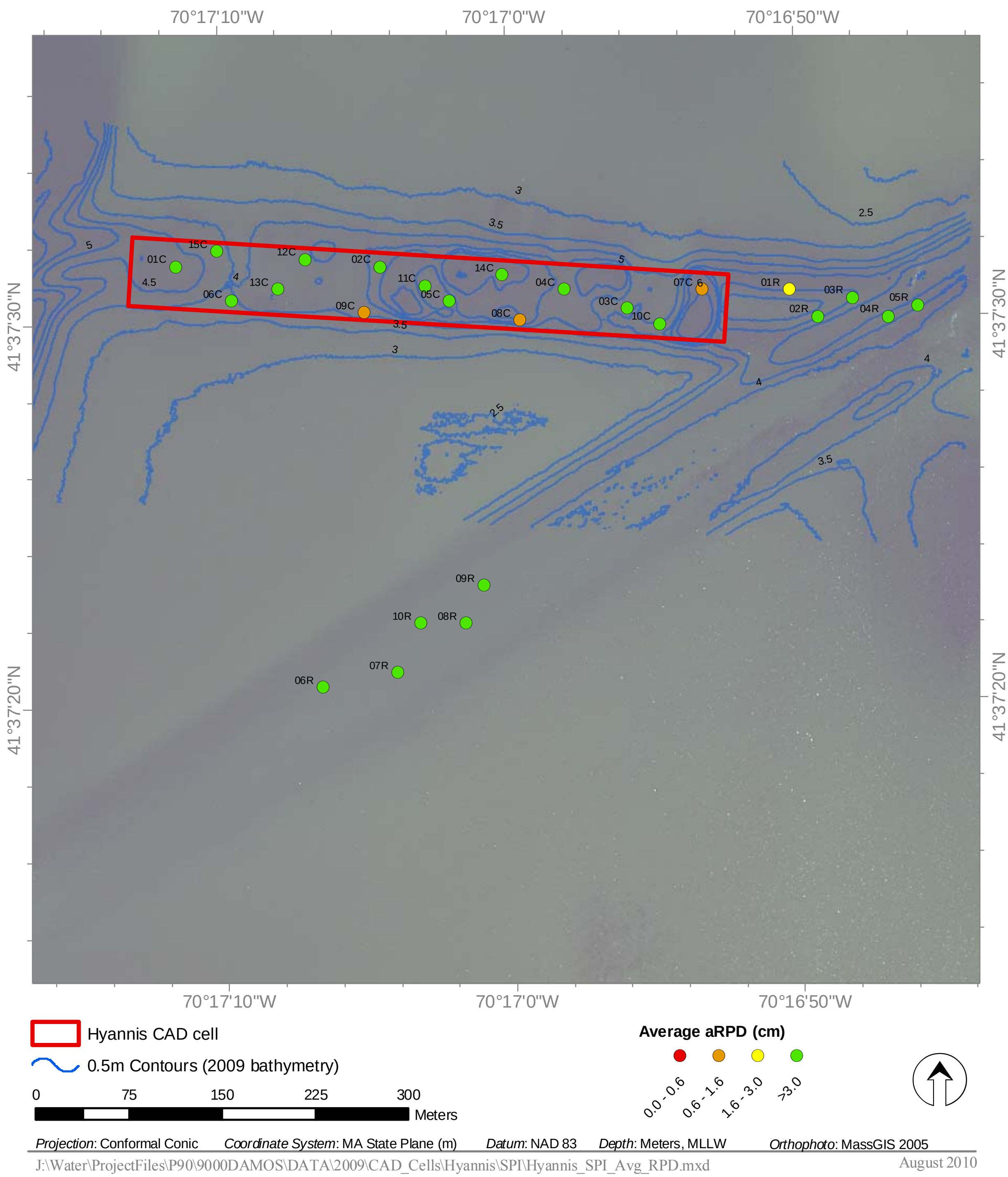


Figure 3-44. Spatial distribution of station-averaged aRPD depths (cm) for Hyannis Harbor

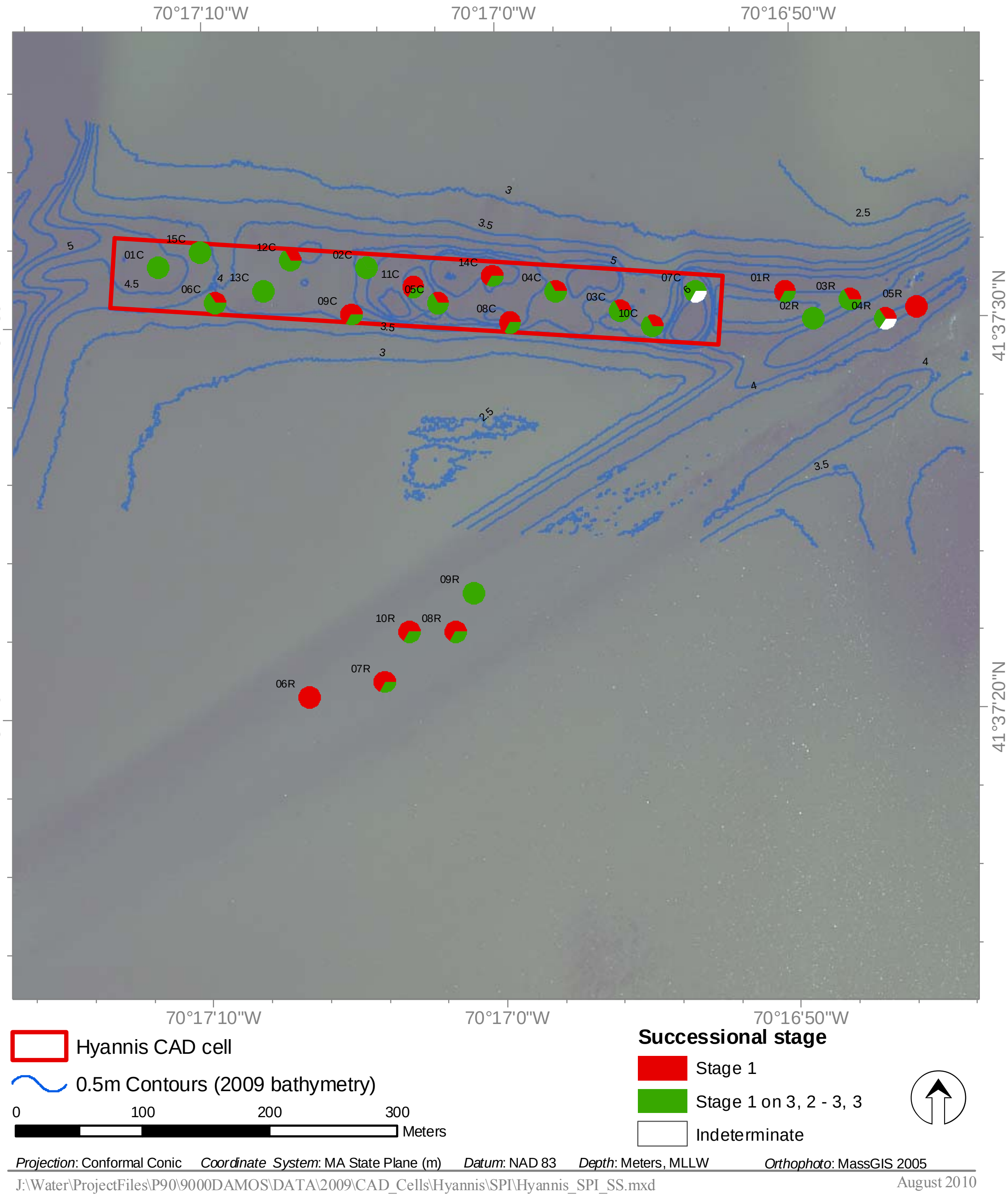


Figure 3-45. Spatial distribution of infaunal successional stages for Hyannis Harbor. Each station is represented by a circle, the number of SPI replicates for each station is represented as a pie wedge of the circle.

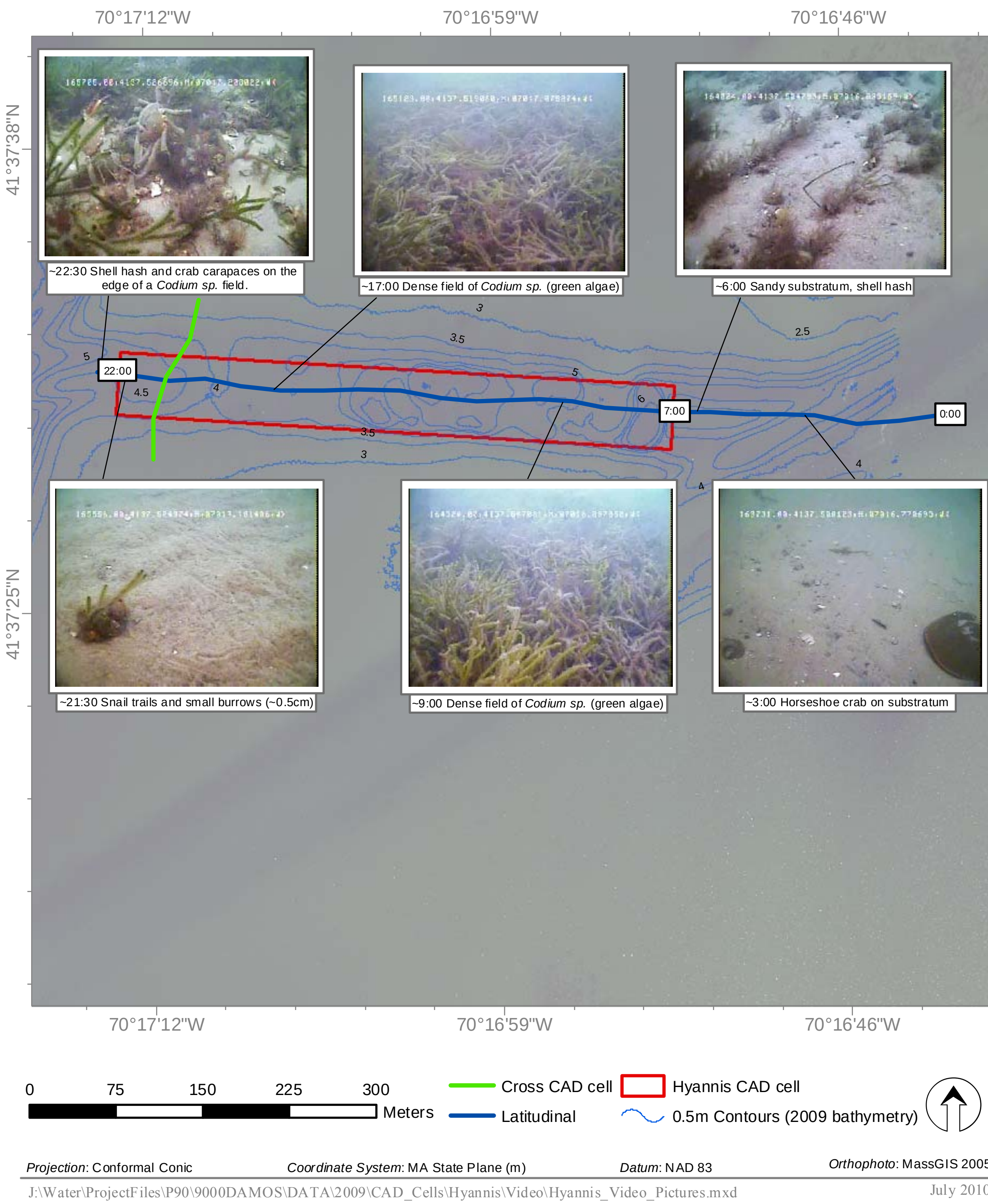


Figure 3-46. Underwater video transects and representative clips for Hyannis Harbor

4.0 DISCUSSION

Confined aquatic disposal (CAD) cells provide an alternative placement strategy for dredged material deemed unsuitable for unconfined open-water placement (termed unsuitable dredged material or UDM). The technique involves sequestering the UDM within existing natural depressions or excavated cells in the seafloor and optionally placing a layer of cap material to further isolate the UDM. CAD can offer environmental as well as cost advantages over other alternatives such as upland placement (e.g. landfill), construction of and placement into a shoreline or island confined disposal facility, or treatment and reuse. Although typically more costly than level-bottom capping (placement of UDM at a level-bottom, open-water site followed by capping), CAD can again offer environmental advantages as well as being a more implementable alternative politically (Fredette 2006). As such, CAD cells have become and continue to be considered the disposal option of choice for a growing number of navigational dredging and sediment remediation projects within the United States and internationally (USACE MPA 1995; Whiteside et al. 1996; Shaw et al. 1998; USEPA 2000; USACE 2001, 2002; Alfageme et al. 2002; Moore et al. 2002; MPCA 2004).

In New England, CAD cells have been successfully implemented in six harbors, with the oldest cell constructed over 30 years ago in Norwalk, Connecticut. The largest CAD project was located in Boston Harbor, with 11 cells constructed dating back to 1997. As this was the first major CAD cell project in the United States with cells constructed beneath the footprint of the navigable channel, the construction, filling, capping, and subsequent benthic recovery of the cells have been well-studied and documented (Fredette et al., 2000; ENSR 2002, 2007; USACE in prep). Other CAD cell sites, particularly those in the smaller harbors, have been the subject of limited monitoring and offer the opportunity to evaluate CAD cell performance in a range of physical, environmental, and operational settings.

The October 2009 investigation described in this report was conducted as a baseline survey for longer term study of the performance of CAD cells in four New England rivers/harbors: Norwalk River, Connecticut; Thames River (New London), Connecticut; Providence Harbor, Rhode Island; and Hyannis Harbor, Massachusetts. The investigation included both physical and biological evaluations with the following specific operational objectives:

- Conduct bathymetric surveys of the CAD cells in each of the four rivers/harbors to document depths in and around the CAD cells, characterize cell morphology, and assess changes in morphology relative to available previous surveys;

- Assess the benthic recolonization status of the CAD cells, relative to representative references areas within each harbor, using SPI and plan-view video; and

- Complete a towed underwater video survey of select CAD cells using a bottom sled to further assess the general physical condition of the cells and further document the presence and abundance of marine organisms within the CAD cells compared to representative reference areas within each harbor.

The results of the 2009 survey are discussed individually for the CAD cells in each of the four harbors in Sections 4.1-4.4 and collectively in Section 4.5. An overview of the CAD cell setting, operation history, and 2009 survey results for each harbor is provided in Table 4-1 for reference.

4.1 Norwalk

The Norwalk CAD cells are located in the Norwalk River, approximately 2.7 km upriver from Norwalk Harbor (Figure 1-8). The two cells are located beneath the 3-m deep MLLW channel and were constructed in January 2006 in conjunction with routine maintenance dredging of the channel. Each CAD cell was approximately 0.5 hectares in area, and both were constructed and filled from January-February 2006. Cell 1 was excavated to a depth of approximately 7.6 m below the surrounding river bottom, and Cell 2 was excavated deeper, to a depth of approximately 12.2 m below the river bottom. Silty clay UDM was placed in both cells, filling to approximately 3 m below the cell lip for each. Both cells were capped less than a month later with approximately 1 m of silty material suitable for open water placement. The cap brought the surface of both cells up to a level approximately 2 m below the surrounding channel bottom.

Nearly four years following construction and capping, the Norwalk River CAD cells remained as distinct, stable features on the harbor bottom in 2009 with very little change in bathymetry since the previous survey in 2007. Limited consolidation of cell contents was expected over this period as the 2007 bathymetric survey was completed almost two years following filling and capping of the cells, and the majority of consolidation of cell contents was expected to have already occurred by that time (Fredette et al. 2000, Silva et al. 1994). However, SPI camera penetration differences between CAD cell stations and reference stations suggested that while grain size was similar (silt-clay) across the entire site, the sediment over the CAD cells remained less consolidated than the surrounding channel bottom. Hence, some further long-term consolidation of the CAD cell surface may occur as the CAD cell material progresses towards ambient conditions, but it will likely be limited in extent and offset by natural deposition into the cells within the tidal river setting and, hence, not measureable with bathymetry.

The surface of both cells was fairly uniform with the exception of a cluster of small (0.2 m diameter) pits near the center of Cell 1 attributed to biological (burrowing) and/or physical (ebullition) origin. Fields of large burrow holes were frequently observed within and adjacent to the CAD cells in the towed video. Although the organisms that created these burrows were not observed in any SPI images, one burrowing lobster was observed with the underwater video, and lobster have been reported in western LIS near the Norwalk River through late fall before moving offshore to deeper waters (Gottschall 2000).

The release of gas bubbles, such as methane, from sediments (termed ebullition) is a common mechanism for the discharge of biogenic and geogenic gases into the water column and can result in pits on the surface of the sediment. This process has been observed in many organic rich locations throughout the world (EPA 2010, SAIC 2000, Brothers et al. 2011). In the Norwalk River, methane was observed in surficial sediments in the majority of SPI images both within and outside of the cells, and organic debris (primarily leaf litter) was observed in both the SPI and towed video. Ebullition pits observed at other sites have been described as linear chains or fields of pits ranging from a few millimeters in size (Ostrovsky et al. 2008) to hundreds of meters in diameter with depths up to 50 m (Rogers et al. 2006). Consolidated caps have been found to minimize the release of gas bubbles into the water column (Rockne et al. 2010); however, the Norwalk cell was capped with unconsolidated silty material that likely would not prevent the release of gas into the water column.

The presence of distinct sediment layers (some up to 16 cm thick) observed in SPI collected from the Norwalk CAD cells and reference areas suggests some periodic deposition has occurred over the area. Sediment particles exposed to oxygenated waters are in an oxidized condition and typically brown or light grey in color. Moving downward in the sediment, particles are exposed to reduced oxygen concentrations in subsurface pore waters, and their oxic coating reduces, changing color to dark grey or black. As this process is relatively slow, the visually distinct layer can be observed deeper in the sediment following a deposition event. In the presence of active Stage 3 burrowing organisms, shallow relict layering would be mixed and difficult to detect after one or two summer seasons. The presence of distinct layers of low reflectance, sulfidic sediments in the Norwalk River may be an indication of recent redeposition of harbor materials resuspended in a storm, from passage of vessels, or other nearby activity that resuspends sediment. Based on data recorded at the USGS gage in South Wilton, Connecticut there was a major flow event in the Norwalk River on 16 April 2007. The daily discharge of 64.3 m^3/sec was more than double any recorded discharge in the last 20 years of record and could have caused resuspension and deposition of material within the river.

While the sediments appeared to be organically enriched across the entire survey area, possibly due to discharge from the nearby wastewater treatment plant (located less than 1.6 km down river of the sampling area) or from the mats of decaying leaf litter seen throughout the underwater video transects, the enrichment did not seem to be at sufficient levels to inhibit benthic infaunal community succession. A stable, biologically active benthic habitat, as indicated in the SPI, plan-view video, and towed underwater video was present throughout the area, and Stage 3 infaunal assemblages were present at most SPI stations in the reference areas as well as all of the CAD cell stations (Figure 3-12).

4.2 New London

At the time of the 2009 survey there was one CAD cell located in the Federal Navigation Channel of the Thames River, immediately south of the Naval Submarine Base, in New London (a second cell was constructed in 2009-10 just south of the original cell) (Figure 1-9). The first cell was constructed in October 2006 using a mechanical dredge and covered an area of approximately 2.4 hectare. The cell was dug approximately 13.7 m below the surrounding channel depth of 11.6 m MLLW. Silty clay UDM was placed into the cell in November 2006, filling to within 2.5 m of the cell lip. The cell was capped immediately following UDM placement with an approximately 1 m layer of silty clay parent material that was originally excavated as part of cell construction. The cap brought the surface of the cell up to a level approximately 1.5 to 1.8 m below the surrounding channel bottom.

Given that the cell was constructed relatively deep (nearly 14 m) and was filled and capped within a relatively short time period (2 months), the significant consolidation reported just over a year later (2.7 to 3.0 m) in a December 2007 survey (TEC 2008) was not unexpected. Between the 2007 and 2009 surveys, the depth over the cell increased approximately 0.5 to 0.8 m. Given the relatively uniform surface of the cell and that the surface now resides approximately 4 m below the surrounding channel bottom (buffering it from any erosive forces), this depth increase is attributed to additional consolidation rather than loss of material from the cell. Some additional consolidation is still likely, but this may be balanced by deposition, and the cell is expected to remain a distinct and stable feature on the channel bottom.

Similar to Norwalk Harbor, distinct sediment layers up to 11 cm in thickness were apparent in the SPI images from both the CAD cell and reference stations and could be attributed to deposition related to storm events, vessel passage, or other in-water construction activities. Input from vessel passage is likely given the expected volume of vessel traffic in this harbor and the shoal area directly to the west of the CAD cell (see Figure 4-1 where the 2009 orthophoto captured a vessel transiting over the shoal and creating a large suspended solids plume).

A developed benthic community was present at both reference and CAD cell locations within the Thames River at New London. Evidence of Stage 1 on 3 succession, consisting of small polychaete tubes at the sediment surface and deeper burrows and/or feeding voids at depth, was observed at almost all stations. Although the CAD cell has apparently continued to experience consolidation, the SPI and underwater video analysis revealed advanced successional stages, a deep aRPD, and observations of macro epifauna indicative of a healthy benthic community similar to the surrounding area.

4.3 Providence

The Providence CAD cells are located beneath the Federal Navigation Channel in Providence Harbor, just south of Fox Point and the confluence of the Providence and Seekonk Rivers (Figure 1-7). Six cells were constructed as part of the Providence River and Harbor Maintenance Dredging Project (PRHMDP) between May 2003 and January 2004. The cells were constructed as square, rectangular, or slightly trapezoidal pits, and cell size varied, ranging from 0.90 to 10.1 hectares. Cell depth also varied, ranging from 8.5 to 18 m below the authorized channel depth of 12.2 m MLLW.

As part of the PRHMDP, fine-grained UDM was placed sequentially into five of the six cells from May 2003 through July 2005. The sixth cell was reserved for use by non-federal projects and managed by the State of Rhode Island. The original plan was for the CAD cells to be capped with suitable dredged material at the conclusion of the PRHMDP. However, as additional capacity remained in some of the cells at the end of the project, the State assumed management responsibility for all the CAD cells to make full use of the remaining cell capacity with other, non-federal projects and will ultimately cap all the cells with suitable dredged material.

At the time of the 2009 survey, cell disposal histories ranged from six-years after last disposal for cell 1R to four-years after last disposal for cell 3AR to ongoing active disposal for cell 6/7R. The 2009 bathymetric survey revealed that all cells remained as distinct features on the harbor bottom. The 2009 bathymetric data was compared with data from the May 2005 survey performed at the end of the PRHMDP. Four of the cells showed very little change in bathymetry over the 2005 to 2009 period (1R, 3R, 4R, and 5R in Figure 3-26). This was expected given that these cells had undergone nearly two years of consolidation at the time of the 2005 survey. Cell 3AR showed a significant increase in depth over much of its area between 2005 and 2009. This depth increase was attributed to consolidation given that cell 3AR contained the thickest layer of placed UDM and that placement into the cell had continued until just prior to the 2005 survey. Cell 6/7R showed a significant decrease in depth over much of its area since 2005, attributed to the continued placement of material into the cell over that period.

The presence of distinct sediment layers, up to 18 cm thick, identified in the SPI from the CAD cells as well as the reference areas suggests periodic sediment deposition over the harbor area. The relatively shallow aRPD measured within Providence CAD cells and reference locations, coupled with the extensive presence of *Beggiatoa* sp. bacterial mats and lack of Stage 3 succession suggests that relatively little biological mixing of surficial sediment was occurring, making it possible for relict layers to remain unmixed and detectable within the SPI images. The presence of these distinct layers of low reflectance, sulfidic sediments may be an indication of periodic deposition of material introduced in storm runoff from this urban area or from redeposition of harbor materials resuspended from passage of vessels or nearby in-water activities. Providence River and Harbor together constitute the principal commercial waterway in Rhode Island, and are subject to deep-draft vessel traffic which could cause the occasional resuspension of and subsequent deposition of material. Cell 6/7R was also still actively receiving dredged material in 2009 from non-federal projects; the limited spread of material from disposal activity could also have contributed to the layering observed in the SPI data in the surrounding area. This layering is able to persist in low energy, depositional areas with both shallow biological mixing as well as limited physical disturbance, such as the Providence River.

At the time of the 2009 survey, the benthic community in the Providence CAD cells and reference locations appeared affected by anoxia, and bacterial mats were widespread on the seafloor. Although the CAD cell sediment appeared to be less consolidated, softer, and more organically enriched than ambient locations, the entire ecosystem within the Providence River was representative of a stressed, urban marine environment. Visible mats of *Beggiatoa* in shallow water have previously been regarded as an indicator of organic enrichment and low oxygen in the overlying waters (Fenchel & Bernard 1995, Jørgensen 1977). They have been specifically cited as indicators of organic input from pulp mills (Pearson 1975). While low dissolved oxygen is often a problem in this area during the late summer/early fall as water temperatures peak, 2009 was observed to be a particularly bad year. Severe hypoxia (low dissolved oxygen) conditions were observed throughout much of the Upper and Mid-Narragansett Bay including the Providence River in late summer 2009 (Baykeeper 2009). The severity of these conditions may have been due in part to record-breaking rainfall in July 2009 (Baykeeper 2009), which likely resulted in accelerated eutrophication due to excessive runoff.

In summary, the 2009 survey identified that the Providence CAD cells remain as physically stable features on the harbor bottom. Biologically, the 2009 survey revealed that the benthic community within the entire Upper Harbor was indicative of a stressed urban marine environment that was independent of the CAD cells.

4.4 Hyannis

The Hyannis CAD cell is located beneath the former harbor entrance channel in Hyannis Harbor (Figure 1-6). The cell was constructed as a long, narrow rectangle covering approximately 2.6 hectare and cut to a depth of approximately 5 m below the surrounding water depth of 3.5 m MLLW. An approximately 3 m layer of silty UDM dredged from the inner harbor basin was placed into the cell from December 1998 to March 1999. Directly after filling, the cell was capped with a 0.9 to 1.5 layer of sand. The resulting surface was irregular, ranging in depth from level with the surrounding seafloor to depressed over 3 m below the surrounding seafloor (Figure 3-38).

In 2009, the cell was no longer a distinct feature on the seafloor, but was still apparent in the 2009 bathymetry, particularly in the western portion of the cell (Figure 3-37). In the 10 years since cap placement, minor changes in depth were observed within the Hyannis CAD cell. A decrease in depth, due to cell infilling, was noted along the steep sloped southern boundary of the cell and within the deep pocket in the southeast corner of the cell. Small areas of depth increase were also found in the interior areas of the cell due to reworking of sediments. The Hyannis CAD cell provides an illustration of the result of the physical processes at work for a cell placed in a dynamic environment. Hyannis Harbor is exposed to the south, with sufficient wave and current energy such that the ambient sediment is predominantly coarse grained. The infilling of the southern boundary and deep pocket in the southeast corner, and redistribution of sediments in the shallow areas in the interior of the Hyannis CAD cell, supports the prediction that CAD cells depressed below the surrounding area will act as receptors for sediment mobilized as scouring forces act on the surrounding, shallower area (or areas within the cell that are level with the surrounding bottom, as is the case for Hyannis) (Fredette 2006).

The physical forces present in Hyannis Harbor have also affected the apparent biological colonization of the CAD cell and reference areas. Although the successional dynamics of invertebrate communities, as defined by the Pearson-Rosenberg successional model for fine-grained sediments, are not as well known for coarse sediments, some assessment of the animal-sediment structures and apparent biological mixing depth can be made. The aRPD measurements from the CAD cell and reference area stations suggest a well-mixed and oxidized environment, with aRPDs exceeding 2.9 cm at all stations. Although Stage 3 succession was identified in nearly all stations throughout the reference area and CAD cell stations, the percentage of replicates indicating Stage 3 succession was relatively low overall and lower in the reference area compared to the CAD cell stations. Because the seafloor of the entire harbor area is exposed to physical forces that periodically result in mobilization and transport, benthic colonization by Stage 3 organisms may be limited. The resultant sand ripples, shell hash, and poorly sorted coarse sediments of the harbor may provide poor habitat for establishment and maintenance of a “typical” Stage 3 successional community. It is also possible that the environmental conditions present in Hyannis Harbor support a sequence of development and colonization that departs from the Pearson-Rosenberg successional model. In this case, the advanced successional stage may be represented by a more motile benthic community comprised of crabs, scallops, whelks, and snails. Overall, the data indicate that the CAD cell benthic community is fully recovered compared to the community in the reference areas.

4.5 Comparison of Four Harbor Study Results

The CAD cells surveyed in four New England harbors in 2009 represent a range of physical and environmental settings as well as varied operational approaches. All the cells are located beneath active navigation channels, with the exception of Hyannis, which is located within a former harbor entrance channel. The channel depths at Norwalk and Hyannis are comparatively shallow, approximately 3-3.5 m, while the channel depth in New London is 11.6 m and the channel depth in Providence is 12.8 m (all depths MLLW). The physical settings for the cells range from the relatively narrow tidal Norwalk River, to the much wider urban/industrial Providence Harbor, to the more open and exposed Hyannis Harbor. Tidal ranges vary from less than 1 m in Hyannis Harbor to over 2 m in Providence Harbor. Reported currents range from relatively low in Providence Harbor to nearly 0.7 m/s within Hyannis Harbor. The ambient sediment type at three of the four locations is silt/clay, while fine to medium sand is found in the higher energy environment of Hyannis Harbor.

The primary land use in the surrounding and upriver watershed of the Norwalk and New London cells is forest, coupled with urban in Norwalk and agriculture in New London. The land use in the surrounding watershed of Providence consists mainly of urban/industrial and residential, while the land use surrounding Hyannis is primarily residential, municipal open space (airport, public water supply), and some commercial. Usage of the waterway over the cells also varies, ranging from primarily recreational and fishing vessels in Norwalk and Hyannis Harbor to deep draft commercial vessels in Providence Harbor and Navy traffic in New London.

Construction and operation techniques varied, with the Hyannis cell constructed using hydraulic dredging (filled and capped mechanically) while cells in the other three harbors were constructed using mechanical dredging and filled and capped using split-hulled scows. Cell size, constructed depth, and thickness of the UDM layer placed into the cells varied across the four sites, ranging from a 3-m thick UDM layer in the Hyannis cell to an over 12-m thick layer in one of the Providence cell. The cell construction-fill-cap sequence was quite short for Norwalk (two months) and New London (three months) and extended over a six-month period for Hyannis. For Providence, the cells have remained uncapped for four to six years at the time of the 2009 survey as the State of Rhode Island plans to make use of capacity for additional UDM placement prior to capping.

In general, it is understood that regardless of the setting, CAD cells will be depressed below the surrounding harbor area at the time of completion because of safety factors built into the design to allow for uncertainty in the amount of UDM that requires placement (estimated at the time of project start but not precisely known), to allow for potential bulking of the UDM as it is placed into the cell, and to limit potential material loss from the cell as it nears capacity. Once completed, it is understood that the material within the cell will consolidate somewhat over time. The 2009 monitoring was designed to expand upon this understanding of CAD cell performance. Despite all of the variations in setting and operational approach noted above, the 2009 monitoring provided a consistent picture of longer term CAD cell performance across the four harbor settings; the cells were identifiable, stable (or infilling) features with no evidence of material loss outside the cells over time periods ranging up to 10 years, and the benthic communities within the cells had recovered to a level similar to the surrounding harbor area. Monitoring of the Boston Harbor CAD (BHCAD) cells has revealed similar results regarding physical stability and benthic recovery (USACE in prep). The most recent survey of the BHCAD cells also identified an accelerated deposition rate over the cells, suggesting that the need for and specifics of capping CAD cells should be evaluated further based on the physical setting of the cell and the characteristics of the UDM placed into the cell.

Table 4-1.
Overview of CAD Cell Setting, Operational History, and Survey Results

Site	Setting	Ambient Channel Characteristics	Harbor Conditions	Cell History	Cell Characteristics	Overview of Results
Norwalk (2 cells)	Norwalk River, approx. 2.7 km upstream from Norwalk Harbor, within navigation channel footprint	Sediment type – Silt/clay Channel depth – 3 m	Vessel traffic - Recreational, some commercial Tidal range (m) - 2.16 (1.2 km downstream of cells) Current regime (m/s) – 0.26 – 0.31(mouth of harbor) Land use of surrounding/upriver watershed – Forest/Urban	2006 January – Construction 2006 January – February – Disposal 2006 February – Cap 2006 December – Post-cap bathymetry survey (Cell 1 only; data not available) 2007 December – Norwalk River and Harbor bathymetry survey	UDM material/origin - Fine silt and clay from around I-95 bridge in Norwalk River and Norwalk Harbor Cap material /origin – Silt from East Norwalk navigation channel	• Cells are stable, distinct features with uniform topography, approximately 1.5-2 m below channel bottom • Only minor depth change from December 2007 bathymetry survey • Well-developed biological community at cells similar to surrounding reference area, although entire area shows signs of organic enrichment
New London (1 cell)	Thames River, approx. 7.5 km upstream of Long Island Sound, within Federal navigation channel footprint	Sediment type – Silt/clay Channel depth – 11.6 m	Vessel traffic – Navy and commercial traffic Tidal range (m) – 0.79 Current regime (m/s) – 0.26 – 0.36 Land use of surrounding/upriver watershed – Forest/agriculture	2006 October - Construction 2006 November - Disposal 2006 November - Cap 2006 November – Post-cap bathymetry survey 2007 December – Bathymetry survey (data not available)	UDM material/origin - Fine silty clay and sand from local vicinity Cap material /origin – Fine silty clay from CAD cell construction	• Cell is stable, distinct feature with uniform topography, approximately 4 m below channel bottom • Substantial depth increase (3-4 m) due to consolidation of the cell contents since November 2006 post-cap bathymetry survey • Well-developed biological community at cells similar to surrounding reference area.
Providence (6 cells)	Providence River /Harbor, approx. 10 km from opening to Narragansett Bay, within Federal navigation channel footprint	Sediment type – Silt/clay Channel depth – 12.8 m	Vessel traffic – Heavy commercial traffic Tidal range (m) – 1.34 Current regime (m/s) – 0.05 – 0.20 Land use of surrounding/upriver watershed – Industrial/Forest/Residential	1R 2003 May – Construction 2003 May – June - Disposal	1R UDM material/origin – Silt from construction of cells 3R, 4R, and 6R (no cap)	Inactive cells (cells 1R, 3R, 4R, and 5R) • Uniform topography, approximately 0.5-2.5 m below the channel bottom. • Minor depth change since May 2005 bathymetry survey • Biological community of cells 4R and 5R has not recovered to condition similar to the reference area, although entire area indicates signs of organic enrichment and hypoxia
				3R 2003 May – June – Construction 2003 June – July - Disposal	3R UDM material/origin – Silt from construction of cells 6R, 4R, 7R and 5R (no cap)	
				4R 2003 June – July – Construction 2003 July - September - Disposal	4R UDM material/origin – Silt from construction of cells 5R, 7R, and 3AR (no cap)	
				5R 2003 July –September – Construction 2003 September – October - Disposal	5R UDM material/origin – Silt from construction of cells 3AR and 1R (no cap)	
				6/7R 2003 June – October – Construction 2003 – present - Disposal	6/7 UDM material/origin – Silty material from multiple private dredging projects in Providence Harbor (still active)	Active cell (cell 6/7R) • Irregular topography approximately 0-5.5 m below channel bottom • Decrease in depth of up to 6 m due to ongoing disposal into the cell

Table 4-1 cont.

Overview of CAD Cell Survey Results

Site	Setting	Ambient Channel Characteristics	Harbor Conditions	Cell History	Cell Characteristics	Overview of Results
Providence (continued)				3AR 2003 September – 2004 February - Construction 2004 June – 2005 July – Disposal 2004 February – Post-construction bathymetry survey of all Providence cells (data not available) 2005 May – Post-PRHDMP bathymetry survey of all Providence cells	3AR UDM material/origin - Silty material from Fox Point and Fuller Rock (no cap)	Recently filled cell (3AR) • Irregular topography approximately 0-5 m below the channel bottom • Increase in depth 0.5-2.5 m due to apparent consolidation since disposal activity ceased • Biological community has not recovered to condition similar to the reference area, although entire area indicates signs of organic enrichment and hypoxia
Hyannis (1 cell)	Hyannis Harbor adjacent to Nantucket Sound, within former harbor entrance channel	Sediment type – fine to medium sand Channel depth – 3.5 m	Vessel traffic – Recreational, some commercial Tidal range (m) – 0.94 Current regime (m/s) 0.46 – 0.67 Land use of surrounding/upriver watershed – Municipal, Residential, Commercial	1998 September - December - Construction 1998 December – 1999 March – Disposal 1999 March – Cap 1999 April – Post-cap bathymetry survey 2000 March – One year post-construction bathymetry survey	UDM material/origin – Silt from inner harbor basin Cap material /origin – Sand from Lewis Bay channel	• Cell is stable feature, with irregular topography, approximately 0-3 m below channel bottom • Decrease in depth of 0.5-2 m along southern boundary and in southeast corner since the April 1999 survey due to apparent accumulation/infilling • Increase in depth of less than 1.0 m in interior of cell due to apparent redistribution of sediments in areas level with the surrounding seafloor. • Biological community has recovered to condition similar to the reference area; community characteristic of a motile community

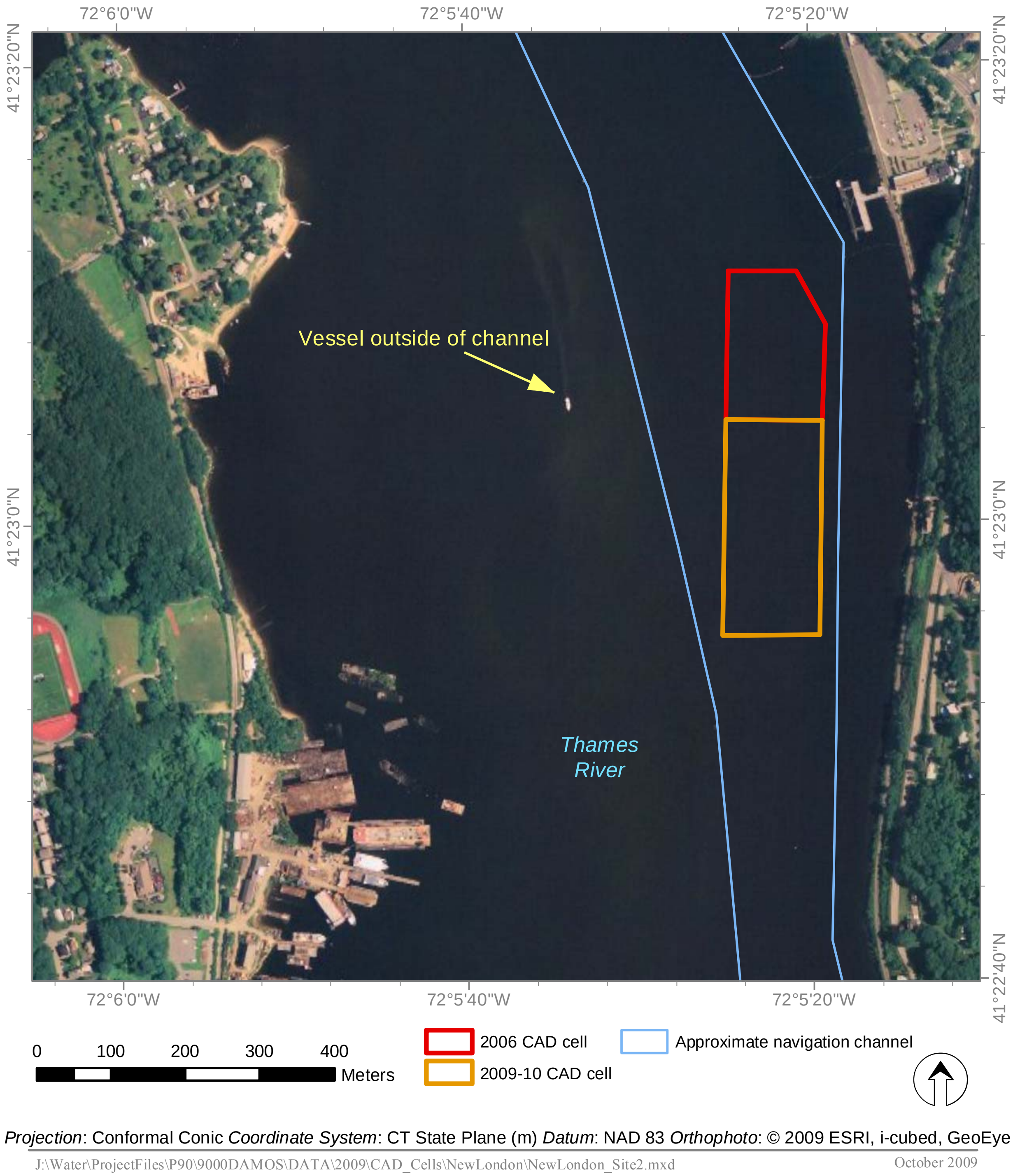


Figure 4-1. Suspended sediment from vessel traffic in the Thames River

5.0 CONCLUSIONS AND RECOMMENDATIONS

The CAD cells surveyed in four New England harbors in 2009 represent a range of physical and environmental settings, from the relatively narrow tidal river setting up the Norwalk River to the more exposed, higher energy of outer Hyannis Harbor. The cells also represent varied operational approaches, ranging from the single cell constructed, filled, and capped within a two-month period in New London Harbor to multiple cells constructed, filled, and remaining uncapped over a period of years in Providence Harbor. The physical monitoring conducted in 2009 revealed the CAD cells to be stable structures over time periods of more than 10 years, with no evidence of material loss from any of the cells. Biological monitoring indicated that, while the sites varied greatly in general environmental setting and biological community structure, benthic biota had recolonized all cells similar to the surrounding harbor system. Overall, the monitoring further supports CAD cells as an effective tool for managing UDM.

Providence and New London CAD Cells

The CAD cells in both Providence and New London are still considered active. For Providence, placement of material continues, and capping is planned once the cells are filled to capacity. For New London, a second cell was constructed, filled, and capped subsequent to the 2009 survey. Specific recommendations for continued monitoring at these two harbors include:

- Confirmatory surveys in the next two to four years incorporating physical and biological monitoring to track material placement and benthic recovery.

Norwalk and Hyannis CAD Cells

As no additional placement or capping activity is anticipated at the CAD cells in Norwalk and Hyannis, the following monitoring is recommended:

- Longer term (five to 10 year) monitoring focusing on the physical stability of the cells should be performed. Monitoring could be triggered by environmental conditions such as storms with major river discharge (Norwalk) or storms with major southerly wind component (Hyannis).

General Monitoring for Future Implementation of CAD Cells

To aid in interpreting long term monitoring data sets such as those collected for this report, the following studies are recommended as part of general CAD cell construction and operation:

- “As built” bathymetry of the constructed cell prior to filling providing a record of side slope and bottom topography;

- Clear record of the filling and capping history noting the timing and location of placement, the estimated volume, and material description (including photographs where possible); and

- Periodic bathymetric surveys to document the operational history including; following completion of UDM placement, just prior to cap placement (if a consolidation period was included), and post-capping.

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INDEX

anoxia/hypoxia, 45, 64, 68, 72, 76, 154, 158, 160, 166
aRPD, v, vi, vii, viii, x, 44, 64, 65, 68, 69, 72, 73, 76, 78, 80, 81, 82, 83, 85, 86, 87, 88, 89, 90, 91, 92, 105, 106, 117, 132, 144, 152, 153, 155
bacterial mats, vii, x, 73, 74, 75, 80, 91, 129, 133, 153, 154, 166
baseline, ix, 16, 24, 64, 148
bathymetry, i, ii, v, vi, vii, viii, x, 16, 41, 48, 63, 67, 71, 75, 90, 91, 93, 94, 111, 112, 122, 124, 137, 139, 149, 153, 155, 158, 160, 163
boundary roughness, v, vi, vii, viii, 45, 64, 65, 68, 69, 72, 73, 76, 77, 81, 82, 83, 85, 86, 87, 88, 89, 99, 100, 115, 128, 129, 142, 143
burrow, 45, 67, 71, 75, 79, 101, 116, 150
CAD, ix, 11, 148, 165, 167
CAD cell
  Hyannis, i, iii, iv, vii, viii, x, 15, 23, 24, 34, 41, 54, 77, 78, 79, 80, 137, 138, 139, 154, 155, 162
  New London, i, iii, iv, vi, ix, 18, 19, 20, 37, 40, 52, 67, 68, 69, 83, 85, 111, 112, 116, 118, 162
  Norwalk, i, iii, iv, 17, 18, 36, 51, 65, 79, 109, 149, 150
  Providence, i, iii, iv, vi, vii, x, 20, 22, 23, 35, 53, 73, 79, 80, 122, 124, 152, 153, 154
capping, iii, vii, ix, x, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 24, 26, 28, 67, 138, 148, 149, 156, 157, 162, 163, 168
CDF, 12, 13, 14, 148
consolidation, ix, x, 12, 14, 15, 20, 26, 64, 67, 149, 151, 152, 153, 158, 160, 163
current, x, 17, 19, 20, 23, 45, 76, 77, 78, 155, 158, 160, 165
deposition, 150, 152, 153, 157
dissolved oxygen (DO), 154, 164
epifauna, x, 45, 152
feeding void, 70, 74, 101, 152
grain size, v, vi, vii, viii, 45, 64, 65, 68, 72, 73, 76, 81, 82, 83, 85, 86, 87, 88, 89, 95, 113, 125, 140, 150
habitat, 12, 13, 79, 151, 155
infauna, v, vi, vii, viii, x, 45, 65, 66, 69, 70, 73, 74, 107, 119, 134, 145, 151
methane, v, vii, x, 45, 64, 65, 68, 69, 72, 73, 76, 77, 80, 81, 82, 83, 85, 86, 87, 88, 89, 90, 91, 92, 101, 103, 129, 131, 150, 166
morphology, ix, 24, 43, 148
penetration depth, v, vi, vii, viii, 44, 45, 64, 68, 69, 72, 76, 77, 97, 114, 127, 141
recolonization, ix, 25, 41, 65, 69, 73, 78, 90, 91, 149
recovery, ix, 11, 24, 148, 157, 162
sediment
  clay, 16, 18, 19, 22, 26, 64, 68, 72, 77, 149, 150, 151, 156, 158
  mud, 45, 101, 109, 167, 169
  sand, 15, 16, 22, 23, 24, 26, 68, 75, 76, 77, 78, 79, 143, 154, 155, 156, 158, 160
  silt, 16, 18, 19, 26, 64, 68, 72, 75, 150, 156, 158, 160
Sediment-profile image (SPI), i, ii, iii, iv, v, vi, viii, ix, x, 12, 25, 41, 43,

44, 51, 52, 53, 54, 57, 58, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72, 76, 77, 78, 81, 82, 83, 85, 86, 87, 88, 89, 101, 108, 109, 116, 120, 135, 143, 146, 149, 150, 151, 152, 153
stability, ix, 11, 24, 25, 157, 162
succession, v, vi, vii, viii, 45, 64, 68, 72, 74, 76, 81, 82, 83, 85, 86, 87, 88, 89, 92, 107, 119, 134, 145, 152, 155
successional stage
Indeterminate, 86, 88, 89
Stage 1, 66, 70, 78, 152
Stage 1 on 3, 70, 152
Stage 3, x, 66, 70, 74, 78, 80, 90, 91, 92, 151, 153, 155
suspension, 151, 153
topography, 41, 63, 78, 90, 91, 158, 159, 160, 163
UDM, ix, x, 12, 13, 15, 16, 17, 20, 25, 26, 79, 148, 149, 151, 153, 154, 156, 157, 158, 159, 160, 162, 163

Appendix A

Sediment-Profile Image Results for New England CAD cells
October 2009

APPENDIX A
Sediment-Profile Image Results for New England CAD Cells
October 2009

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**01C-1**	10/20/2009 11:44	15.0	14.5	15.5	0.4	0.1	1.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage II on III	Y	N	N	Y	2	8.3	color change @ 8.28 cm; many worm tubes, few amphipod tubes; worm in burrow; microvoids near surface, voids @ 7.77 & 12.45 cm, possible weathered CDM, layering caused by CDM placement or natural events?
Norwalk 2009	**01C-2**	10/20/2009 11:45	15.6	14.2	16.5	0.3	0.0	0.8	N	3 to 2	>4	>4	N	Y	1	Biological	2.3	Stage I on III	Y	N	N	N	--	--	no color change; many of worm tubes; methane @ 7.78 cm; large burrow in center; microvoids near surface, voids @ 1.03 & 3.57 cm
Norwalk 2009	**01C-3**	10/20/2009 11:45	14.9	13.2	17.8	0.6	0.0	1.7	N	3 to 2	>4	>4	Y	Y	0	Physical	4.6	Stage I on III	Y	N	N	N	--	--	very recent RPD, no color change; few worm tubes at new surface; burrow @ 8.45 cm, burrow hole filling in; microvoids near surface, void @ 3.78 cm, excavation
Norwalk 2009	**01R-1**	10/20/2009 12:01	10.4	9.7	10.9	0.0	0.0	0.0	N	3 to 2	>4	>4	N	Y	0	Physical	1.3	Stage I	Y	N	N	N	--	--	no color change; few worm tubes; few burrows; few microvoids near surface, abundant leaf litter from possible storm event
Norwalk 2009	**01R-2**	10/20/2009 12:02	12.1	10.5	14.7	0.0	0.0	0.0	N	3 to 2	>4	>4	N	Y	0	Physical	4.2	Stage I	Y	N	N	N	--	--	no color change; few worm tubes; few microvoids near surface, abundant leaf litter from possible storm event?
Norwalk 2009	**01R-3**	10/20/2009 12:03	11.7	10.6	12.3	0.0	0.0	0.0	N	3 to 2	>4	>4	Y	Y	0	Physical	1.7	Stage I	Y	N	N	N	--	--	no color change, very disturbed; few worm tubes; few burrows; abundant leaf litter
Norwalk 2009	**02C-1**	10/20/2009 11:34	16.5	16.0	17.1	0.9	0.2	1.8	Y	3 to 2	>4	>4	N	Y	5	Biological	1.1	Stage I on III	Y	N	N	N	--	--	no color change; Ilyanassa obsoleta; worm tubes; methane @ 8.00, 10.64, 12.15, 13.66, & 16.45 cm ; microvoids near surface, void @ 2.27 cm, well worked surface over black anoxic mud, possible CDM or ambient sediment
Norwalk 2009	**02C-2**	10/20/2009 11:35	13.2	12.4	13.5	0.5	0.0	1.3	Y	3 to 2	>4	>4	N	Y	0	Biological	1.1	Stage I on III	Y	Y	N	Y	3	7.0	color change @ 7.04 & 11.76 cm; Ilyanassa obsoleta; worm tubes; worm in burrow anoxic, may be from camera frame; microvoids near surface, voids @ 1.65 & 1.01 cm, well worked sediment, layering possible from storm event or CDM placement?
Norwalk 2009	**02C-4**	10/20/2009 11:36	16.0	15.3	16.2	0.5	0.0	1.2	N	3 to 2	>4	>4	N	Y	3	Biological	0.9	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes; methane @ 8.29, 6.95, & 7.92 cm; worm in burrow, maybe snail anoxic; microvoids near surface, voids @ 14.95 & 14.53 cm
Norwalk 2009	**02R-1**	10/20/2009 12:07	7.7	6.9	8.5	0.9	0.0	1.7	N	3 to 2	>4	>4	N	Y	0	Both	1.6	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; biological/physical; microvoids near surface, voids @ 3.47 & 4.76 cm, abundant leaf litter possible from storm event
Norwalk 2009	**02R-2**	10/20/2009 12:07	17.1	16.4	17.8	0.9	0.0	2.8	Y	3 to 2	>4	>4	N	Y	2	Physical	1.4	Stage I on III	Y	N	N	Y	2	6.1	color change @ 6.08 cm; possible living snail; many of worm tubes; methane @ 8.95 & 9.94 cm; microvoids near surface, void @ 12.98 cm, little bit of leaf litter, patches of black sulfidic mud at depth, evidence of leaf litter suggestive of natural wash from storm event
Norwalk 2009	**02R-3**	10/20/2009 12:08	20.1	17.7	21.8	0.6	0.0	4.3	N	3 to 2	>4	>4	N	Y	11	Both	4.1	Stage I on III	Y	N	N	Y	2	13.3	color change @ 13.26 cm; many of worm tubes; methane @ 2.27, 3.01, 8.76, 12.20, 10.18, 18.78, 16.12, 15.99, 13.88, 12.86, 13.35 cm; biological/physical; large excavation, maybe lobster, excavation filling in; microvoids near surface, black sulfidic mud below excavation
Norwalk 2009	**03C-1**	10/20/2009 11:20	16.7	16.3	17.1	0.6	0.0	1.3	Y	3 to 2	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	Y	N	Y	2	5.9	color change @ 5.90 cm; Ilyanassa obsoleta; many worm tubes; several burrows clasts may be from camera frame?; several microvoids near surface, void @ 5.73 cm in center, possible CDM or resuspended sediment from storm events
Norwalk 2009	**03C-2**	10/20/2009 11:21	20.0	19.6	20.3	0.7	0.2	1.4	N	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	Y	N	Y	2	7.1	color change @ 7.06 cm; several worm tubes; several burrows 1 small clast at surface may be from camera several microvoids near surface, voids at 5.86 (R), 7.24 (R), 5.22 (L), & 9.96 cm (R)

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**03C-3**	10/20/2009 11:23	14.7	14.2	15.4	0.2	0.0	0.4	N	3 to 2	>4	>4	N	Y	2	Both	1.2	Stage I on III	Y	Y	N	Y	4	0.9	color change @ 0.85, 8.77, & 11.35 cm; surface only; many worm tubes; methane @ 12.50 & 12.51 cm; biological/ physical; recent clasts at surface several microvoids near surface, void @ 3.06 cm (L), layering possible from CDM placement or storm events? Not well worked at surface
Norwalk 2009	**03R-1**	10/20/2009 11:55	18.1	17.5	19.0	0.0	0.0	0.0	N	4 to 3	>4	>4	Y	Y	0	Physical	1.5	Stage I	Y	N	N	N	--	--	no color change, recent RPD at surface <1 cm; few worm tubes; few burrows; microvoids near surface
Norwalk 2009	**03R-2**	10/20/2009 11:56	12.2	10.9	13.6	0.5	0.0	1.8	N	3 to 2	>4	>4	N	Y	0	Physical	2.8	Stage I on III	Y	N	N	Y	2	6.1	color change @ 6.07 cm; few worm tubes; numerous microvoids near surface, voids @ 1.80, 1.33, & 5.62 cm, leaf imprint in sediment, decaying leaves present, color change due to anoxic sediment created by leaf litter decaying?
Norwalk 2009	**04C-1**	10/20/2009 11:16	6.7	6.0	7.5	0.4	0.0	1.0	N	4 to 3	>4	>4	N	Y	0	Biological	1.5	Stage I on III	Y	Y	N	N	--	--	underpenetrated; no color change; worm tubes; several burrows near surface may be from camera? few microvoids near surface, voids @ 1.82, 1.44, & 2.85 cm, big void at 2.41 cm
Norwalk 2009	**04C-3**	10/20/2009 11:18	18.5	18.2	18.8	1.3	0.6	2.6	Y	3 to 2	>4	>4	N	Y	5	Biological	0.6	Stage I on III	Y	N	N	Y	2	14.2	color change @ 14.15 cm; Ilyanassa obsoleta; worm tubes; methane @ 9.59, 12.15, 14.76, 15.17, 8.52 cm; big burrow in center; few microvoids near surface, void @ 6.24 cm
Norwalk 2009	**04R-1**	10/20/2009 12:16	14.3	12.8	15.8	0.7	0.0	3.5	Y	3 to 2	>4	>4	N	Y	0	Biological	3.0	Stage I on III	Y	Y	N	N	--	--	no color change; Ilyanassa obsoleta; many worm tubes; several anoxic clasts (may be from camera?); microvoids near surface, voids @ 10.79 & 13.72 cm, former excavation (lobster)?, well worked sediment
Norwalk 2009	**04R-2**	10/20/2009 12:16	20.3	19.9	20.5	0.7	0.0	1.3	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	Y	4	6.7	color change @ 6.70, 12.95, 16.19 cm; worm tubes, worm @ 0.46 cm; microvoids near surface, voids @ 2.53 & 6.98 cm, patches of black sulfidic mud
Norwalk 2009	**04R-3**	10/20/2009 12:18	14.0	12.8	15.0	0.3	0.0	0.4	N	4 to 3	>4	>4	Y	Y	4	Both	2.3	Stage I on III	Y	N	N	Y	2	5.9	color change @ 5.91 cm; worm tubes; lots of methane bubbles; methane @ 9.74, 11.22, 9.40, 8.43 cm; biological/physical; microvoids near surface, voids @ 6.54 & 0.96 cm, patches of black sulfidic mud
Norwalk 2009	**05C-1**	10/20/2009 11:26	15.0	12.0	17.4	0.0	0.0	0.0	N	4 to 3	>4	>4	Y	Y	1	Biological	5.4	Azoic	Y	N	N	N	--	--	no color change; few tiny tubes; methane @ 13.31 cm; burrow hole?, 1 big burrow - Callianassa?; no microvoids, excavation, black sulfidic mud
Norwalk 2009	**05C-5**	10/20/2009 11:29	16.9	16.4	17.3	<1	0.0	1.0	N	4 to 3	>4	>4	Y	Y	0	Physical	0.9	Stage I on III	Y	N	N	Y	5	1.0	recent RPD at surface, color change @ 0.96, 4.98, 9.95, & 12.89 cm; worm tubes; microvoids near surface, void @ 2.34 cm, Beggiatoa present, possible CDM layering or from storm events?
Norwalk 2009	**05C-6**	10/20/2009 11:30	19.6	19.2	20.1	0.0	0.0	0.0	N	4 to 3	>4	>4	Y	Y	7	Biological	0.8	Stage I on III	Y	Y	N	N	--	--	no color change; few worm tubes & burrows; methane @ 13.17, 14.15, 14.46, 16.36, 16.61, 17.37, & 18.90 cm; worms in burrows; small clast at surface; no microvoids, layering possible CDM placement or storm events?
Norwalk 2009	**05R-1**	10/20/2009 12:11	14.6	13.9	15.3	0.8	0.2	1.8	N	4 to 3	>4	>4	N	Y	0	Biological	1.4	Stage I on III	Y	N	N	N	--	--	no color change; many of worm tubes; several burrows; microvoids near surface, great feeding voids at depth @ 15.02, 13.65, 12.78, 13.25, 10.87, 12.43 cm, well worked sediment
Norwalk 2009	**05R-2**	10/20/2009 12:12	10.1	9.8	10.4	2.2	1.1	3.7	Y	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	N	--	--	no color change; Ilyanassa obsoleta; many worm tubes; microvoids near surface, voids @ 2.63 & 6.37 cm, well worked sediment over black sulfidic mud
Norwalk 2009	**06C-1**	10/20/2009 11:07	18.3	18.1	18.4	0.6	0.2	2.0	Y	3 to 2	>4	>4	N	Y	0	Biological	0.3	Stage I on III	Y	N	N	N	--	--	no color change; possible snail; well mixed; many worm tubes & worms in burrows; numerous burrows; numerous microvoids near surface, relict voids at depth, voids @ 2.41, 1.53, 2.43, 4.31cm

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**06C-2**	10/20/2009 11:07	20.2	19.4	21.0	0.7	0.0	1.8	N	3 to 2	>4	>4	N	Y	5	Biological	1.6	Stage I on III	Y	Y	N	N	--	--	no color change, shell hash, mottled sediment; many worm tubes; methane @ 8.57, 9.54, 11.84, 11.17, 12.30 cm; several burrows several clasts; many microvoids near surface, voids @ 3.84 & 0.77 cm, well worked sediment, possible CDM, mottled
Norwalk 2009	**06C-3**	10/20/2009 11:08	21.2	20.9	21.4	0.9	0.0	1.8	N	3 to 2	>4	>4	N	Y	7	Biological	0.5	Stage I on III	Y	Y	N	Y	2	11.9	color change @ 11.89 cm; many worm tubes, worm @ 10.33 cm on left; methane @ 8.06, 9.54, 9.94, 11.67, 10.77, 11.89, 12.65 cm; several burrows; many microvoids near surface, voids @ 2.83 & 10.75 cm, layering possible from CDM placement or storm events?
Norwalk 2009	**06R-1**	10/20/2009 12:20	14.7	14.3	15.1	0.8	0.1	1.4	Y	4 to 3	>4	>4	N	Y	0	Biological	0.7	Stage II on III	Y	N	N	Y	2	7.3	color change @ 7.29 cm; dead mussel shells; worm & amphipod tubes; microvoids near surface, voids @ 14.05, 7.51, & 7.97 cm, well worked sediment
Norwalk 2009	**06R-2**	10/20/2009 12:21	13.6	12.9	14.0	0.9	0.4	1.5	Y	4 to 3	>4	>4	N	Y	0	Biological	1.1	Stage II on III	Y	N	N	N	--	--	no color change; Ilyanassa obsoleta; worm & amphipod tubes, worm @ 7.07 cm; microvoids near surface, voids @ 0.72 & 0.55 cm
Norwalk 2009	**06R-3**	10/20/2009 12:21	18.6	18.2	18.9	0.5	0.0	1.2	Y	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage II on III	Y	N	N	Y	3	5.3	color change @ 5.32 & 7.91 cm; may be caprellid amphipod?; worm & amphipod tubes; microvoids near surface, voids @ 2.33, 2.44, & 7.93 cm, layering possible from resuspension or storm events?
Norwalk 2009	**07C-1**	10/20/2009 11:10	19.0	18.1	20.0	1.1	0.2	2.3	Y	3 to 2	>4	>4	Y	Y	0	Biological	1.9	Stage I on III	Y	Y	N	Y	2	10.6	color change @ 10.63 cm; snail foot left of center; shell bits many worm tubes; many burrows 1 with lots of tubes & black smear from camera several microvoids near surface, voids @ 1.06 & 3.21 cm, surface well worked, sediment below black sulfidic, layering possible from CDM placement or storm events?
Norwalk 2009	**07C-3**	10/20/2009 11:12	13.3	12.7	13.7	0.2	0.0	0.3	N	4 to 3	>4	>4	N	Y	2	Biological	0.9	Stage I on III	Y	N	N	N	--	--	no color change; few worms & tubes, deep burrowing worms @ 5.65 cm & 13.23 cm; methane @ 9.30 & 11.94 cm; surface highly bioturbated, loose few microvoids near surface, void @ 1.15 cm, sediment surface not well worked, sulfidic sediment with layering from possible CDM or storm events
Norwalk 2009	**07C-4**	10/20/2009 11:13	20.1	19.5	21.2	0.2	0.0	0.9	N	4 to 3	>4	>4	N	Y	8	Biological	1.7	Stage I on III	Y	N	N	Y	3	8.3	color change @ 8.27 & 10.66 cm; worm tubes, worm @ 4.01 cm; methane @ 12.29, 11.28, 15.68, 16.38, 18.12, 16.69, 13.20, 16.24 cm; big burrow on right; few microvoids near surface, voids @ 1.55, 1.82, 2.64 cm, sediment not well worked, slight oxidized surface, layering possible from CDM placement or storm events
Norwalk 2009	**07R-1**	10/20/2009 12:26	15.7	15.0	16.0	0.6	0.0	1.3	N	4 to 3	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; large excavation & burrow near surface; microvoids near surface, void @ 6.87 cm, large excavation @ 6.87 cm, possible crustacen, well worked sediment
Norwalk 2009	**07R-2**	10/20/2009 12:27	11.7	10.6	12.1	0.8	0.0	1.6	Y	4 to 3	>4	>4	N	Y	0	Biological	1.6	Stage I on III	Y	N	N	N	2	4.5	no color change; Ilyanassa obsoleta; many worm tubes; many burrows; microvoids near surface, void @ 5.24 cm, well worked sediment good oxidized layer
Norwalk 2009	**07R-3**	10/20/2009 12:29	18.9	18.4	19.2	0.6	0.0	1.9	Y	4 to 3	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	N	N	Y	2	6.2	color change @ 6.22 cm; Ilyanassa obsoleta; many worm tubes; many burrows; microvoids near surface, voids @ 0.22, 0.65, 4.50 cm, possible resuspesion of sediment evidenced as layering?
Norwalk 2009	**08C-1**	10/20/2009 10:52	21.2	21.0	21.6	0.7	0.2	1.4	Y	3 to 2	>4	>4	N	Y	4	Biological	0.6	Stage I on III	Y	Y	N	N	--	--	no color change; Ilyanassa obsoleta; worm tubes, worm at depth 15.66 cm; methane @ 15.08,12.47,12.04,12.35 cm; worm in burrow one clast @ surface some pellets at surface microvoids near surface, voids @ 1.71 & 2.88 cm, possible CDM layering worked surface over black sulfidic mud

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**08C-2**	10/20/2009 10:53	14.9	14.3	15.0	2.1	0.1	4.9	N	3 to 2	>4	>4	N	Y	0	Biological	0.7	Stage I on III	Y	N	N	Y	3	6.0	color change @ 6.00 & 14.00 cm; dead mussel shells worm tubes, small clam on left; microvoids near surface, voids @ 0.90 cm (C) & 4.52 cm (C)
Norwalk 2009	**08C-3**	10/20/2009 10:54	16.7	16.4	16.9	0.8	0.2	1.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	Y	N	N	--	--	no color change; many worm tubes; several one at surface in background microvoids near surface, void at end of burrow @ 1.81 cm
Norwalk 2009	**08R-1**	10/20/2009 12:32	12.8	12.6	13.2	0.5	0.1	1.1	N	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	Y	2	4.3	color change @ 4.34 cm; worm tubes, worm @ 1.75 cm; large burrow in center ; microvoids near surface, void @ 11.51 cm, patches of black sulfidic mud, mottled, possible resuspension due to storm events?
Norwalk 2009	**08R-2**	10/21/2009 12:33	11.6	10.9	12.2	0.5	0.1	1.8	N	4 to 3	>4	>4	N	Y	0	Biological	1.3	Stage I on III	Y	Y	N	Y	3	3.8	color change @ 3.80 & 8.53 cm; many worm tubes; 4 small clasts, oxidized @ surface; microvoids near surface, voids @ 2.07 & 2.50 cm, layering possible due to resuspension events?
Norwalk 2009	**08R-3**	10/20/2009 12:35	16.6	15.8	17.4	1.2	0.3	3.7	N	4 to 3	>4	>4	N	Y	4	Biological	1.6	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, worm in burrow 1.49 cm; methane @ 13.24, 13.08, 9.81, 6.97 cm; many burrows; microvoids near surface, void @ 1.60 cm, patches of black sulfidic mud
Norwalk 2009	**09C-1**	10/20/2009 10:01	17.1	16.6	17.8	0.8	0.0	1.7	NA	3 to 2	>4	>4	N	NA	0	Biological	1.1	Stage I on III	NA	NA	NA	N	--	--	no color change, sediment from camera frame pushed to depth because of u-shaped burrow; sandier than previous stations, pink color to surface sediment lots of pink worms (burrows?); many u-shaped, y-shaped burrows, big u-shaped burrow on right; small microvoids near surface, voids? @ 1.76 cm (R) & 2.5 cm (L), consolidated patchy oxidized sediment at depth, possible drag down from camera or previous CDM with black sulfidic sediment above and oxidized surface layer.
Norwalk 2009	**09C-2**	10/20/2009 10:02	21.3	21.0	21.5	0.7	0.2	1.8	Y	4 to 3	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	Y	3	6.7	color change @ 6.70 & 16.68 cm; Ilyanassa obsoleta; worm tubes, worm @ 17.89 cm, poss. tiny clam; lots of burrows; microvoids near surface, poss. active void @ 3.47 cm in center, layering possible from CDM placement or storm events?
Norwalk 2009	**09C-3**	10/20/2009 10:03	21.0	20.6	22.0	0.9	0.1	1.5	Y	3 to 2	>4	>4	N	Y	0	Biological	1.5	Stage I on III	Y	Y	N	Y	3	6.6	overpenetrated on right side; color changes @ 6.64 & 16.75 cm; ? Ilyanassa; worm tubes; may be from camera frame 2 voids? @ 13.51 &14.26 cm on right, microvoids near surface, layering possible from CDM placement or storm events?
Norwalk 2009	**09R-1**	10/20/2009 12:38	19.5	18.6	20.1	0.6	0.0	1.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.5	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 7.97 & 6.88 cm
Norwalk 2009	**09R-2**	10/20/2009 12:39	19.6	19.1	19.8	1.2	0.1	2.4	N	4 to 3	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	Y	N	N	--	--	no color change; many worm tubes; many burrows 1 clast at surface; microvoids near surface, voids @ 10.24 & 1.18 cm
Norwalk 2009	**09R-3**	10/20/2009 12:40	19.5	17.5	21.1	0.4	0.0	2.1	N	4 to 3	>4	>4	N	Y	2	Biological	3.6	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; methane @ 18.30 & 17.00 cm; microvoids near surface, void @ 9.68 cm, large excavation at surface
Norwalk 2009	**10C-1**	10/20/2009 09:36	19.0	18.8	19.2	0.9	0.4	2.0	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage II on III	Y	N	N	N	2	5.7	color change @ 5.71 & 7.49 cm; trash at surface; worm tubes, few amphipod tubes, worm @ 2.5 cm on right; microvoids near surface, voids at 0.94, 2.96, & 3.42 cm on left, relict void @ 6.82 cm in center, possible color change from CDM placement or storm events
Norwalk 2009	**10C-2**	10/20/2009 09:37	18.4	17.9	18.9	0.7	0.0	1.7	N	3 to 2	>4	>4	N	Y	0	Biological	0.9	Stage I on III	Y	Y	N	Y	2	13.2	color change @ 13.16 cm; many worm tubes, few worms @ 0.91cm (R) & 1.05 cm (c); clasts possibly from camera frame? microvoids near surface; voids at 1.29 (R), 1.49 (R), 2.25 (L), 1.51 (L), & 2.16 cm (L), oxidized surface over black sediment, layering possible from CDM placement or storm events

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**10C-3**	10/20/2009 09:37	19.5	19.2	19.7	0.9	0.1	1.9	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	Y	N	Y	3	5.0	color change @ 5.00 & 10.00 cm, RPD disturbed by clasts; sediment shaggy near surface many worm tubes, no amphipod tubes; very tiny physical due to SPI camera clasts; several burrows near surface, may be 1 at depth from, camera frame; small microvoids near surface & deeper, Relict voids @ 11.08 & 13.44 cm, active voids @ 8.47, 4.57, 2.73 cm, layering of CDM or storm events possible, oxidized surface over black sediment
Norwalk 2009	**10R-1**	10/20/2009 12:42	18.9	18.6	19.2	1.4	0.0	4.2	N	4 to 3	>4	>4	N	Y	8	Biological	0.6	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; methane @ 10.46, 11.53, 12.34, 10.61, 9.00, 10.19, 9.12, 16.14 cm; microvoids near surface, voids @ 0.61 cm (L) & 1.35 cm (L), patches of black sulfidic mud
Norwalk 2009	**10R-2**	10/20/2009 12:42	20.0	19.3	20.9	0.7	0.2	1.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.6	Stage I on III	Y	N	N	Y	3	5.0	color change @ 4.95 & 10.14 cm; worm tubes; microvoids near surface, voids @ 3.90 cm (L), 2.94 cm (L), & 1.89 cm , patches of black sulfidic mud
Norwalk 2009	**10R-3**	10/20/2009 12:43	14.1	13.8	14.4	1.1	0.4	1.6	N	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	Y	3	5.0	color change @ 4.98 & 8.77 cm; many worm tubes; many burrows; many microvoids near surface, voids @ 2.93 cm (L) & 2.11 cm , patches of black sulfidic mud
Norwalk 2009	**11C-1**	10/20/2009 10:59	20.0	19.7	20.3	0.7	0.2	2.3	Y	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	Y	N	Y	2	16.0	color change @ 15.97; Ilyanassa obsoleta w/ juvenlies?; many worm tubes; many burrows, big burrow in center small clast near snail microvoids near surface, voids @ 2.53 & 2.73 cm, layering possible from CDM placement or storm events? Surface oxidized over black sulfidic mud
Norwalk 2009	**11C-2**	10/20/2009 11:00	16.2	15.8	16.4	0.8	0.2	1.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	Y	N	Y	2	5.4	color change @ 5.37 cm; many worm tubes; several 1 clast possibly from camera; many microvoids near surface, voids @ 1.32 & 2.18 cm, well worked surface over black sulfidic mud
Norwalk 2009	**11C-4**	10/20/2009 11:03	19.0	18.3	19.6	0.6	0.2	1.6	Y	3 to 2	>4	>4	N	Y	4	Biological	1.3	Stage II on III	Y	Y	N	Y	2	8.4	color change @ 8.44 cm; small Ilyanassa obsoleta at right ?; many worm tubes; methane @ 7.48, 11.76, 12.59, 12.79 cm; several burrows, 1 large burrow in center 1 small anoxic clast, may be from camera; many microvoids near surface, void @ 1.63 cm (C) & 0.56 cm (R), reworked surface over black sulfidic mud
Norwalk 2009	**12C-1**	10/20/2009 09:42	20.2	20.0	20.5	0.6	0.2	1.5	Y	4 to 3	>4	>4	N	Y	13	Biological	0.5	Stage I on III	Y	N	N	Y	3	5.0	color change @ 5.00 & 9.00 cm; Ilyanassa obsoleta; worm tubes, worm @ 6.04 cm; methane near surface & at 15.78, 16.38, 15.37 ,12.63 ,12.87, 13.51, 16.46, 6.70, & 3.15 cm; poss. void near methane bubble, microvoids near surface, no large active feeding voids, layering from CDM placement or storm events possible, well oxidized surface over black sulfidic mud
Norwalk 2009	**12C-2**	10/20/2009 09:45	17.8	15.8	21.0	IND	0.0	0.0	N	4 to 3	>4	>4	N	Y	0	Indeter-minate	5.2	Stage I on III	N	Y	N	Y	2	9.0	disturbed from camera; color change about 9 cm; worm tubes; small microvoids near surface; small voids @ 9.88, 9.89, & 7.82 cm in center, well worked sediment with large burrow
Norwalk 2009	**12C-4**	10/20/2009 09:54	20.7	20.1	21.7	0.6	0.3	1.3	N	3 to 2	>4	>4	N	Y	10	Biological	1.6	Stage I	Y	N	N	Y	2	11.0	color change @ 11 cm; many worm tubes (capitellids?), no amphipods; methane @ 8.17, 9.38, 13.72, 12.42, 13.38, 14.76, 15.08, 16.41, 17.20, 14.57 cm; clasts could be camera artifact; few microvoids near surface, same as rep 1.
Norwalk 2009	**13C-1**	10/20/2009 10:07	16.3	15.9	16.6	0.5	0.1	1.2	Y	3 to 2	>4	>4	N	Y	7	Biological	0.7	Stage I on III	Y	Y	N	Y	3	6.1	color change @ 6.09 & 13.40 cm; Ilyanassa obsoleta; many worm tubes; mehane @ 11.40,12.03,14.67,13.24,14.07,15.32,14.83 cm; 3 clasts at surface; microvoids near surface, possible active void near surface @ 1.11 cm on right

APPENDIX A
Sediment-Profile Image Results for New England CAD Cells
October 2009

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Norwalk 2009	**13C-2**	10/20/2009 10:07	21.5	21.2	21.9	0.8	0.3	2.6	N	3 to 2	>4	>4	N	Y	0	Biological	0.7	Stage I on III	Y	Y	N	y	2	13.5	over penetrated & disturbed; worm tubes; microvoids near surface, relic voids @ 8.29 & 16.04 cm, voids @ 0.67, 1.20, 10.53 cm, big fecal mound in center, oxidized surface over black sulfidic sediment with dark black layer at depth, possible CDM or evidence of storm event
Norwalk 2009	**13C-3**	10/20/2009 10:08	9.1	8.9	9.3	0.4	0.1	1.3	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	Y	N	Y	2	4.5	under-penetrated; color change @ 4.47 cm ; worm tubes, poss. small clam @ surface; several clasts possibly from camera frame; many microvoids near surface, voids @ 0.69 & 0.75
Norwalk 2009	**14C-1**	10/20/2009 09:03	16.6	16.1	17.1	0.6	0.2	1.3	Y	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage I - II	Y	N	N	Y	2	5.3	color change 5.28 cm; dead mussel shell; few amphipod tubes, few polychaete tubes, leaf bit; worm in burrow; microvoids near surface, possible relict void at depth, voids @ 0.98 & 1.64 cm
Norwalk 2009	**14C-2**	10/20/2009 09:29	16.5	16.0	17.0	2.5	1.4	5.6	N	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage II on III	Y	N	N	Y	2	12.0	color change @ 11.99 cm; worm tubes, amphipod tubes, worm @ 3.25 cm; many thin burrows near surface; microvoids near surface, poss. relict void @ 7.12cm, poss. void or burrow @ 3.78, poss. oxic void @ 3.37 cm
Norwalk 2009	**14C-4**	10/20/2009 09:33	8.6	7.4	9.1	0.8	0.5	2.3	N	3 to 2	>4	>4	N	Y	0	Biological	1.7	Stage II on III	Y	N	N	N	--	--	no color change, no relict voids; few tubes; few microvoids near surface
Norwalk 2009	**15C-1**	10/20/2009 11:48	15.6	14.8	16.4	< 1	0.0	1.0	N	3 to 2	>4	>4	Y	Y	0	Biological	1.6	Stage I on III	Y	N	N	Y	3	8.8	color change @ 8.77 & 12.28 cm; few worm tubes, microvoids near surface, voids @ 0.63 & 0.87 cm, possible evidence of CDM layering? Sediment black and not well oxidized
Norwalk 2009	**15C-4**	10/20/2009 11:50	19.1	18.6	19.9	0.6	0.0	1.5	N	4 to 3	>4	>4	N	Y	0	Biological	1.3	Stage II on III	Y	N	N	N	--	--	no color change; many worm tubes; microvoids near surface, voids @ 0.95 & 1.31 cm, large unknown void @ 13.86 cm, possible Beggiatoa, black patches of sulfidic mud
Norwalk 2009	**15C-5**	10/20/2009 11:51	15.2	14.7	16.0	0.5	0.0	2.6	N	3 to 2	>4	>4	N	Y	0	Physical	1.3	Stage I on III	Y	N	N	N	--	--	recent RPD layer on surface, no color change; few worm tubes, worm @ 2.19 cm (r); microvoids near surface, void at 4.74 cm, large void at 6.61 cm, abundant leaf litter, black sulfidic mud possibly reworked with leaf litter contributing to organic content

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
New London 2009	**01C-1**	10/21/2009 14:33	15.8	15.1	16.2	2.4	0.7	4.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.1	Stage I on III	Y	Y	N	Y	2	8.4	color change @ 8.43 cm; worm tubes; many burrows; 2 very small anoxic clasts at surface; microvoids near surface, voids @ 1.34, 10.06, & 8.31 cm, sandier ambient sediment over possible weathered CDM for reps 1-3, bottom layer with patcy black sulfidic areas
New London 2009	**01C-2**	10/21/2009 14:33	11.4	10.2	12.1	1.9	0.1	4.3	Y	3 to 2	>4	>4	N	Y	0	Biological	2.0	Stage I on III	Y	Y	N	N	--	--	no color change; hermit crab in excavation; worm tubes, worm @ 2. 89 cm; 2 clasts at surface; microvoids near surface, voids @ 10.34 & 7.92 cm
New London 2009	**01C-3**	10/21/2009 14:34	18.4	18.1	18.9	2.6	1.1	4.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.7	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 1.58, 0.83, & 1.80 cm
New London 2009	**01R-1**	10/21/2009 16:29	6.3	5.4	6.9	1.3	0.1	5.2	N	4 to 3	>4	>4	N	Y	0	Both	1.5	Stage I on III	Y	N	N	N	--	--	no color change; shell hash worm tubes, worm @ 2.93 cm; biological/physical big burrow in center; microvoids near surface, void @ 0.54 cm
New London 2009	**01R-2**	10/21/2009 16:29	8.2	7.3	9.0	1.3	0.2	3.7	N	4 to 3	>4	>4	N	Y	0	Both	1.7	Stage I on III	Y	N	N	N	--	--	no color change; abundant shell hash; worm tubes; biological/physical; large burrow in center; microvoids near surface, void @ 5.55 cm
New London 2009	**01R-3**	10/21/2009 16:30	5.8	5.1	6.3	0.4	0.0	1.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	Y	N	N	--	--	no color change; little shell hash worm tubes, worms @ 0.94 & 0.75 cm; small oxic & anoxic clasts at surface; microvoids near surface, void @ 0.67 cm
New London 2009	**02C-1**	10/21/2009 15:09	17.5	14.2	19.1	2.9	1.0	9.0	N	3 to 2	>4	>4	N	Y	0	Biological	4.9	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, large excavation; microvoids near surface, void @ 13.59 cm, ambient sediment, recent deposition over black sulfidic mud that may be CDM for reps 1-3, rep 1 well worked
New London 2009	**02C-2**	10/21/2009 15:11	16.9	16.7	17.1	2.1	0.7	3.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.4	Stage I on III	Y	N	N	Y	2	7.3	color change @ 7.30 cm?; worm tubes; microvoids near surface, voids @ 5.25 & 11.33 cm
New London 2009	**02C-3**	10/21/2009 15:11	16.7	15.7	17.1	2.4	1.4	2.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.3	Stage I on III	Y	N	N	Y	2	3.3	possible recent sediment deposition or pull away; possible color change @ 3.27 cm; worm tubes; microvoids near surface, voids @ 11.31, 6.56, & 7.30 cm
New London 2009	**02R-1**	10/21/2009 16:19	17.1	16.7	17.3	2.2	0.9	3.5	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	Y	3	5.1	color change @ 5.06 & 9.22 cm; worm tubes, worm @ 2.74 cm on left; microvoids near surface, void @ 1.11 cm on left, distinct layers possible from storm events or resuspension of sediment, well worked surface for reps.
New London 2009	**02R-2**	10/21/2009 16:20	18.9	18.0	19.2	1.7	0.6	3.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	Y	N	Y	3	6.6	color change @ 6.59 & 9.96 cm; worm tubes; small oxic voids @ surface microvoids near surface, void @ 0.73 cm
New London 2009	**03C-1**	10/21/2009 14:17	12.4	11.7	15.0	1.7	0.0	4.4	N	4 to 3	>4	>4	N	Y	0	Both	3.3	Stage I on III	Y	Y	N	N	--	--	no color change; very clayey; worm tubes; biological/physical, many small & large burrows many clasts @ surface; microvoids near surface, voids @ 3.51, 2.51, & 6.48 cm, excavation near surface, clayey, possible CDM with sulfidic patches, ambient sediment at surface sandier, reps 1-3
New London 2009	**03C-2**	10/21/2009 14:19	12.1	11.4	12.4	1.2	0.1	3.8	Y	4 to 3	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	N	N	N	--	--	no color change; Asterias vulgaris; clayey few worm tubes; microvoids near surface, voids @ 0.75 & 3.73 cm
New London 2009	**03C-3**	10/21/2009 14:20	13.5	12.3	14.3	0.7	0.0	2.4	Y	4 to 3	>4	>4	N	Y	0	Both	2.0	Stage I on III	Y	Y	N	N	--	--	no color change; Ilyanassa obsoleta; clayey, dead Mulinia lateralis shells; worm tubes; biological/physical; several burrows several clasts @ surface; microvoids near surface, voids @ 2.70 & 2.46 cm
New London 2009	**03R-1**	10/21/2009 16:24	10.6	8.0	12.2	1.1	0.0	4.0	N	3 to 2	>4	>4	N	Y	0	Both	4.2	Stage I on III	Y	Y	N	N	--	--	no color change; abundant shell hash; worm tubes, worm @ 4.80 cm on left & 3.13 cm on right; biological/physical; large & small oxic clast @ surface; microvoids near surface, many voids, voids @ 1.23 cm (L), 1.06 cm (L), & 1.20 cm (R)
New London 2009	**03R-2**	10/21/2009 16:24	6.7	6.0	7.5	1.3	0.0	6.0	N	4 to 3	>4	>4	N	Y	0	Both	1.5	Stage I on III	Y	N	N	N	--	--	no color change; shell hash; worm tubes, worm @ 2.52 & 3.41 cm; biological/physical; large burrow in center; microvoids near surface, void @ 5.18 cm

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New London 2009	**03R-3**	10/21/2009 16:25	9.5	8.to depth	10.7	1.2	0.3	2.8	N	4 to 3	>4	>4	N	Y	0	Both	2.5	Stage I on III	Y	N	N	N	--	--	no color change; abundant shell hash; worm tubes, worm @ 1.01 cm on left; biological/physical; many burrows; microvoids near surface, voids @ 3.23 cm (L) & 1.65 cm (C)
New London 2009	**04C-2**	10/21/2009 14:26	11.9	11.5	12.3	1.3	0.4	2.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.9	Stage I on III	Y	Y	N	N	--	--	no color change; sandier at surface than @ previous stations with less clay (03C, 13C, 10C); worm tubes ; small oxic clasts at surface; microvoids near surface, void @ 2.66 cm, black sulfidic patches, possibe CDM with ambient sediment at surface reps 2, 4, and 5
New London 2009	**04C-4**	10/21/2009 14:28	20.4	19.7	21.4	1.9	0.0	5.0	N	3 to 2	>4	>4	N	Y	0	Biological	1.7	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes, worm @ 1.20 & 6.89 cm; few oxidized clasts @ surface; microvoids near surface, voids @ 4.52, 6.88, & 3.60 cm
New London 2009	**04C-5**	10/21/2009 14:28	9.8	9.5	10.0	2.4	0.9	4.2	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	N	--	--	no color change; several worm tubes; microvoids near surface, void @ 1.35 cm center
New London 2009	**04R-1**	10/21/2009 16:39	5.5	5.0	5.8	0.3	0.0	1.4	N	1 to 0	>4	>4	N	Y	0	Both	0.9	Stage I	Y	Y	N	N	--	--	no color change; few worm tubes; biological/physical; few small oxic clasts; few microvoids near surface
New London 2009	**04R-2**	10/21/2009 16:40	8.1	7.2	8.5	1.1	0.3	7.4	N	<-1	>4	>4	N	Y	0	Both	1.3	Stage I on III	Y	N	N	N	--	--	no color change; abundant shell hash, compact; few worm tubes; biological/physical; few microvoids near surface, voids @ 3.17, 1.22, & 4.79 cm, mottled well worked, clayey sediment
New London 2009	**04R-3**	10/21/2009 16:41	4.7	3.3	5.4	1.3	0.9	4.7	N	<-1	>4	>4	N	Y	0	Both	2.3	Stage I on III	Y	Y	N	N	--	--	no color change; abundant Crepidula shell hash; few worm tubes, worm @ 4.12 cm; biological/physical; few small clasts, oxic & anoxic; very few microvoids near surface, void @ 2.08 cm, large excavation (R)
New London 2009	**05C-1**	10/21/2009 15:47	12.8	12.1	13.4	1.8	0.3	3.2	N	4 to 3	>4	>4	N	Y	0	Biological	1.3	Stage I on III	Y	N	N	Y	2	7.7	color change @ 7.65 cm; few worm tubes; few microvoids near surface, voids @ 2.44, 5.34, & 5.36 cm all on left, worked surface with black sulfidic sediment over grey clayey sediment, possible CDM or ambient sediment layers or both
New London 2009	**05C-2**	10/21/2009 15:47	13.6	12.9	14.1	1.6	1.2	1.9	N	4 to 3	>4	>4	N	Y	0	Biological	1.1	Stage I on III	Y	N	N	Y	3	4.7	slight pull away; color change @ 4.67 & 6.15 cm; worm tubes; few microvoids near surface, voids @ 1.29 cm (C), 0.77 cm (R), & 0.33 cm, possible ambient sediment recent surface well worked, with layers of CDM or ambient sediment with black sulfidic layer, possible storm events causing recent layering
New London 2009	**05C-3**	10/21/2009 15:48	15.9	15.7	16.2	2.7	0.4	5.7	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 0.94 & 0.67 cm on left, well worked, possible ambient material over CDM?, ambient material sandier?
New London 2009	**05R-1**	10/21/2009 16:32	5.6	4.9	6.4	1.0	0.0	2.6	N	4 to 3	>4	>4	N	Y	0	Both	1.5	Stage I on III	Y	Y	N	N	--	--	no color change; shell hash worm tubes; biological/physical; large burrow in center small oxic & anoxic clasts @ surface; few microvoids near surface, voids @ 3.43 cm (C) & 5.60 cm (L)
New London 2009	**05R-2**	10/21/2009 16:33	6.3	5.7	7.2	2.1	0.5	5.4	N	4 to 3	>4	>4	N	Y	0	Both	1.5	Stage I on III	Y	Y	N	N	--	--	no color change; abundant shell hash; few worm tubes, worm @ 5.46 cm (R) & 2.21 cm; biological/physical; large burrow across image small oxic & anoxic clasts @ surface; very few microvoids near surface, void @ 4.30 cm
New London 2009	**05R-3**	10/21/2009 16:33	15.7	13.4	16.7	0.9	0.0	2.5	N	4 to 3	>4	>4	N	Y	0	Both	3.3	Stage I on III	Y	Y	N	Y	2	10.8	color change @ 10.76 cm; abundant shell hash; worm tubes, crustacean in burrow (little crab or lobster); biological/physical; burrow on right side small & large oxic & anoxic clasts; few microvoids near surface, voids @ 13.44 cm (C) & 5.95 cm (R) - lobster?, very recent deposition @ 2.85 cm, sediment layering possibly from storm events

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New London 2009	**06C-2**	10/21/2009 15:03	20.1	19.5	20.9	2.0	0.6	4.1	N	3 to 2	>4	>4	N	Y	0	Biological	1.4	Stage I on III	Y	Y	N	Y	2	11.4	color change @ 11.44 cm; worm tubes, worm @ 5.58 & 6.37 cm; few small oxic clasts; few microvoids near surface, voids @ 17.44 & 14.85 cm, well worked sediment at surface, over black sulfidic sediment all three reps.
New London 2009	**06C-3**	10/21/2009 15:04	17.4	16.7	17.9	1.2	0.0	4.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.1	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; few microvoids near surface, voids @ 9.59, 8.59, & 8.95 cm
New London 2009	**06C-5**	10/21/2009 15:06	11.3	11.1	11.7	1.9	0.4	3.4	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, large worm @ surface; few microvoids near surface, void @ 5.05 cm
New London 2009	**06R-1**	10/21/2009 06:12	16.1	15.9	16.7	1.9	0.8	5.8	N	3 to 2	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes, worm @ 0.86 cm on left; small oxic clast @ surface; microvoids near surface, voids @ 0.79 cm (R) & 0.62 cm, well worked sediment over black sulfidic sediment, sandier at surface, similar to sediment in cell for all three reps.
New London 2009	**06R-2**	10/21/2009 16:14	17.3	16.7	18.0	2.2	1.2	3.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.3	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes, clam @ 1.67 cm on right; small clam @ right? small oxic clast @ surface; microvoids near surface, void @ 11.38 cm
New London 2009	**06R-3**	10/21/2009 16:15	19.7	19.0	20.5	2.6	1.6	4.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.5	Stage I on III	Y	Y	N	Y	4	6.4	color change @ 6.42, 12.21, & 14.51 cm; worm tubes, worm @ 2.61 cm in center; small oxic clasts @ surface; microvoids near surface, void @ 3.04 cm on left. Shallow layering and mixing from possible result of storm events
New London 2009	**07C-2**	10/21/2009 14:42	18.7	18.3	19.1	1.6	0.2	3.5	N	2 to 1	>4	>4	N	Y	0	Biological	0.9	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; many burrows near surface; microvoids near surface, voids @ 9.08, 8.48, & 8.21 cm, patch of grey clay at depth, could be CDM or wash-in from abmient clayey area after storm event
New London 2009	**07C-5**	10/21/2009 14:46	16.1	16.0	16.3	1.8	0.8	3.6	N	2 to 1	>4	>4	N	Y	0	Biological	0.3	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, small isopod at surface?; microvoids near surface, voids @ 0.88 & 3.34 cm well worked surface over black sulfidic sediment
New London 2009	**07C-6**	10/21/2009 14:47	15.3	14.9	15.7	2.2	0.6	4.9	N	2 to 1	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	N	N	N	3	4.9	color change @ 4.94 & 9.52 cm; worm tubes, live Mulinia; microvoids near surface, voids @ 14.03, 14.59, & 14.19 cm well worked sediment, black sulfidic layer between two lighter grey layers, possible layering from CDM or storm events
New London 2009	**07R-2**	10/21/2009 15:53	15.7	15.0	16.2	2.7	0.4	4.8	N	3 to 2	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, worm @ 3.04 cm on left; microvoids near surface, void @ 8.72 cm
New London 2009	**07R-3**	10/21/2009 15:54	16.5	16.3	16.9	2.4	0.1	4.7	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	Y	N	Y	2	8.9	color change @ 8.85 cm; worm tubes, worm @ 2.02 cm (C) & 1.54 cm (R); few small oxic clasts near surface; microvoids near surface, voids @ 0.22 cm (R) & 8.42 cm (L)
New London 2009	**07R-4**	10/21/2009 15:55	15.2	15.0	15.5	1.6	0.3	3.7	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	Y	N	Y	3	4.1	color change @ 4.09 & 8.04 cm; few worm tubes, worm @ 4.28 cm; small oxic clast at surface; few microvoids near surface, void @ 12.68 cm, black band of sulfidic sediment below surface layer, possibly from storm events?, well worked surface all three reps.
New London 2009	**08C-2**	10/21/2009 15:43	18.5	18.0	19.0	2.8	1.0	3.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 1.47 cm (L) & 3.84 cm (R)
New London 2009	**08C-3**	10/21/2009 15:43	11.9	11.2	12.3	1.1	0.2	2.9	N	4 to 3	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; soft fluffy layer few microvoids near surface, void @ 1.85 cm
New London 2009	**08R-1**	10/21/2009 16:03	14.8	14.5	15.0	2.2	1.0	4.2	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	N	--	--	no color change; few worm tubes; microvoids near surface, voids @ 0.71 & 2.32 cm
New London 2009	**08R-2**	10/21/2009 16:03	15.7	15.5	16.0	1.9	0.1	4.1	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	Y	N	Y	3	5.0	color change @ 4.96 & 10.79 cm; Mulinia @ surface, worm tubes, worm @ 0.47 cm; small oxic clasts @ surface; microvoids near surface, void @ 2.99 cm, well worked sediment surface both reps, black sulfidic band rep 2, possible storm event
New London 2009	**09C-2**	10/21/2009 15:19	18.9	18.7	19.2	2.5	1.2	4.1	N	3 to 2	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	Y	3	6.4	color change @ 6.44 & 11.87 cm; worm tubes; microvoids near surface, voids @ 3.26, 2.28, & 5.13 cm

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New London 2009	**09C-3**	10/21/2009 15:20	21.0	19.4	21.7	3.0	0.6	5.1	N	3 to 2	>4	>4	N	Y	0	Biological	2.3	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 0.75 & 1.33 cm
New London 2009	**09R-1**	10/21/2009 16:08	12.4	11.6	12.7	0.2	0.0	2.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.1	Stage II on III	Y	N	N	Y	2	6.9	color change @ 6.91; Several of Mulinia at surface; few microvoids near surface, void @ 6.97 cm, worked surface over possible weathered sediment with black band of sulfidic sediment in middle, layering could be CDM or from storm event
New London 2009	**09R-2**	10/21/2009 16:09	16.2	15.7	16.6	1.6	0.1	3.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes; few small oxic clasts at surface; microvoids near surface, void @ 2.74 cm, shallow RPD over black mottled sulfidic sediment
New London 2009	**10C-2**	10/21/2009 14:06	13.1	13.5	14.4	1.3	0.0	5.5	Y	2 to 1	>4	>4	N	Y	0	Biological	0.9	Stage I on III	Y	N	N	N	--	--	no color change; possible Ilyanassa; several worm tubes; many burrows; microvoids near surface, voids @ 5.06, 3.91, & 13.13 cm, mottled black sulfidic sediment with deeper RPD compared to rep 1, streaky grey clay in each rep, possibly from storm events from ambient areas, reworked surface over black sulfidic sediment
New London 2009	**10C-4**	10/21/2009 14:08	20.0	19.5	20.5	1.1	0.1	3.6	N	3 to 2	>4	>4	N	Y	1	Biological	1.0	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; methane @ 11.33 cm; large burrow at surface with void; microvoids near surface, void @ 2.31 cm
New London 2009	**10C-5**	10/21/2009 14:09	20.8	20.5	21.5	1.2	0.3	2.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	Y	N	N	--	--	no color change; worm tubes; 1 clast at surface; microvoids near surface, voids @ 8.09, 4.27, & 11.00 cm
New London 2009	**10R-1**	10/21/2009 15:58	14.0	13.6	14.2	1.9	0.6	3.6	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes, possible Mulinia in sediment near surface; microvoids near surface, voids @ 4.00 & 6.10 cm, well worked surface over black sulfidic mud with streaky patches near or at depth all three reps
New London 2009	**10R-2**	10/21/2009 15:58	14.2	13.8	14.5	1.5	0.0	2.9	N	3 to 2	>4	>4	N	Y	0	Biological	0.7	Stage I on III	Y	Y	N	N	--	--	color change @ 4.07 cm; worm tubes, clam, Mulinia on left; great "u"shaped burrow few oxic clasts @ surface; few microvoids near surface, void @ 1.04 cm
New London 2009	**10R-3**	10/21/2009 15:59	13.5	13.1	13.9	2.4	1.1	4.4	N	3 to 2	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	Y	N	N	--	--	color change @ 5.89 cm; few worm tubes; few small oxic clasts @ surface; microvoids near surface, voids @ 1.77 & 0.82 cm
New London 2009	**11C-2**	10/21/2009 15:19	19.0	18.7	19.3	3.1	1.4	4.9	N	3 to 2	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	Y	3	6.2	color change @ 6.23 & 11.79 cm; worm tubes; microvoids near surface, voids @ 3.15 & 1.61 cm on left, well worked surface with band of streaky black sulfidic mud all three reps, band possible CDM or from storm event?
New London 2009	**11C-3**	10/21/2009 15:20	20.9	19.5	21.6	3.0	1.5	4.4	N	3 to 2	>4	>4	N	Y	0	Biological	2.2	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, voids @ 2.35 cm (R), 0.79 cm (L), & 0.58 cm (C)
New London 2009	**11C-4**	10/21/2009 15:20	20.6	19.8	21.0	2.5	0.9	5.0	N	3 to 2	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	Y	N	Y	3	6.8	color change @ 6.82 & 13.34 cm; many worm tubes; 2 small oxidized clasts at surface; few microvoids near surface, voids @ 0.35 cm (L), 0.52 cm (C), & 1.86 cm (R)
New London 2009	**12C-2**	10/21/2009 14:52	19.8	19.3	20.2	0.5	0.0	2.5	N	4 to 3	>4	>4	N	Y	0	Both	0.8	Stage I on III	Y	Y	N	Y	3	6.3	color change @ 6.28 & 11.06 cm; worm tubes; biological/physical; large clast @ surface; microvoids near surface, voids @ 10.50 & 12.55 cm, well worked surficial sediment, patchy areas of black sulfidic mud, layering possibly from storm events or CDM all three reps
New London 2009	**12C-3**	10/21/2009 14:53	18.8	17.6	19.4	2.5	0.0	4.4	N	3 to 2	>4	>4	N	Y	0	Biological	1.8	Stage I on III	Y	Y	N	Y	2	7.7	color change @ 7.74 cm; worm tubes; 1 clast in background; microvoids near surface, voids @ 9.85 & 13.07 cm, small excavation @ surface
New London 2009	**12C-4**	10/21/2009 14:54	14.8	14.6	15.0	1.3	0.4	2.8	N	4 to 3	>4	>4	N	Y	0	Biological	0.4	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; microvoids near surface, relict void @ 11.44 cm
New London 2009	**13C-1**	10/21/2009 14:13	13.1	12.6	13.8	1.2	0.0	10.4	N	4 to 3	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	N	N	N	--	--	no color change; sediment clayey, dead snail & Crepidula shell worm tubes; large oxic burrow; microvoids near surface, voids @ 1.50 & 0.44 cm, clayey sediment with layering of sulfidic sediment, streaky and similar to ambient locations all three reps

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
New London 2009	**13C-2**	10/21/2009 14:14	10.6	10.0	11.2	0.5	0.0	2.6	N	4 to 3	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	Y	N	Y	3	4.9	color change @ 4.91 & 7.61 cm; worm tubes; microvoids near surface, voids @ 4.46, 10.18, 2.03 cm
New London 2009	**13C-3**	10/21/2009 14:15	13.7	12.3	13.9	0.3	0.0	1.4	N	4 to 3	>4	>4	N	Y	0	Biological	1.7	Stage I on III	Y	Y	N	Y	2	6.3	color change @ 6.28 cm; clayey worm tubes, worm @ 10.22 cm on left; several burrows clasts @ surface; microvoids near surface, voids @ 1.89 & 0.94 cm, small excavation @ surface
New London 2009	**14C-1**	10/21/2009 14:37	19.4	18.9	19.9	0.3	0.0	1.5	N	4 to 3	>4	>4	N	Y	0	Physical	1.0	Stage I on III	Y	Y	N	Y	3	6.8	recent RPD layer at surface, color change @ 6.78 & 9.78 cm; few worm tubes; few burrows small oxic clast @ surface; few microvoids near surface, void @ 5.09 cm on left, patchy shallow RPD, possibly overturned or disturbed sediment over black sulfidic layers both reps.
New London 2009	**14C-3**	10/21/2009 14:38	17.2	16.1	17.8	1.4	0.1	2.9	N	3 to 2	>4	>4	N	Y	0	Biological	1.7	Stage I on III	Y	Y	N	Y	2	5.1	color change @ 5.05 cm; worm tubes, live Mulinia?; small oxic & anoxic clasts; microvoids near surface, voids @ 1.97 cm (L) & 0.81 cm (R)
New London 2009	**15C-1**	10/21/2009 14:58	4.4	3.0	6.2	0.3	0.0	2.2	N	4 to 3	>4	>4	N	Y	0	Both	3.2	Stage I on III	Y	N	N	N	NA	NA	shallow penetration, obstructed by brick; no color change; worm tubes; biological/physical; few microvoids near surface, void @ 2.07 cm, large brick on surface, rep 1 and 3 shallow RPD over black sulfidic mud
New London 2009	**15C-2**	10/21/2009 14:59	18.5	18.0	18.8	1.3	0.3	2.6	N	3 to 2	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	N	N	N	--	--	no color change; worm tubes; many burrows; microvoids near surface, voids @ 4.11 & 2.39 cm, relict void @ 10.55 cm, deeper RPD than rep 1 and 3, over black sulfidic mud
New London 2009	**15C-3**	10/21/2009 15:00	16.5	15.3	18.5	0.3	0.0	2.2	N	4 to 3	>4	>4	N	Y	0	Biological	3.3	Stage I	Y	N	N	N	--	--	no color change, no relict voids; few tubes; few microvoids near surface

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes: Providence cells uncapped and receiving UDM layering likely from placement of dredge material or natural filling of ambient sediment into CAD cells. Sediment inside and outside CAD cells black and anoxic with very shallow RPDs when present
Providence 2009	**01C-1**	10/22/2009 16:00	12.1	10.9	13.1	0.0	0.0	0.0	N	>4	>4	>4	N	Y	0	Biological	2.2	Stage I	N	Y	N	Y	3	5.9	color change @ 5.90 & 10.41 cm; very few tiny worm tubes; small anoxic clast; Beggiatoa sp. mat
Providence 2009	**01C-2**	10/22/2009 16:04	16.3	14.7	17.9	0.0	0.0	0.0	N	>4	>4	>4	Y	N	0	Biological	3.2	Indeter-minate	N	N	N	Y	2	14.2	color change @ 14.19 cm; relict voids @ 6.27 & 7.15 cm
Providence 2009	**01C-3**	10/22/2009 16:01	14.6	14.3	15.0	0.0	0.0	0.0	N	>4	>4	>4	Y	Y	0	Biological	0.8	Stage I	N	N	N	Y	2	8.3	color change @ 8.32 cm; very few tiny worm tubes , black sulfidic mud, bacterial mat at surface, layer from possible UDM placement in rep 1 and 2
Providence 2009	**01R-10**	10/22/2009 13:49	21.1	20.9	21.5	0.7	0.0	0.8	N	4 to 3	>4	>4	N	Y	4	Biological	0.6	Stage I	Y	N	N	Y	4	5.4	color change @ 5.36, 7, 10.55 cm; few worm tubes, Beggiatoa? Methan @1.33, 10.91, 15.79, & 16.82 cm; few burrows; few microvoids near surface
Providence 2009	**01R-5**	10/22/2009 13:43	0.8	7.1	9.1	0.8	0.1	1.8	N	4 to 3	>4	>4	N	Y	0	Biological	2.0	Stage I on III	Y	Y	N	N	--	--	no color change; few worm tubes; small oxic clast at surface; few microvoids near surface, void @ 2.80 cm
Providence 2009	**01R-9**	10/22/2009 13:47	19.7	18.9	20.6	0.2	0.0	1.0	N	4 to 3	>4	>4	N	Y	0	Biological	1.7	Stage I	Y	N	N	Y	3	2.2	color change @ 2.20 & 19.76 cm; few worm tubes; few burrows; few microvoids near surface, relict void @ 14.60 cm
Providence 2009	**02C-1**	10/22/2009 15:43	17.3	16.4	17.6	0.2	0.0	0.6	N	>4	>4	>4	N	Y	0	Biological	1.2	Stage I	Y	Y	N	Y	3	14.0	color change @ 13.98 & 15.92 cm; very few tiny worm tubes; very few burrows; large clast on left, patchy oxic; relict void @ 14.58 cm
Providence 2009	**02C-3**	10/22/2009 15:46	17.0	16.5	17.6	0.0	0.0	0.0	N	>4	>4	>4	Y	Y	0	Biological	1.1	Stage I	Y	N	N	Y	2	15.0	color change @ 14.69 cm; very few tiny worm tubes; one small burrow; Beggiatoa sp. @ surface
Providence 2009	**02C-4**	10/22/2009 15:47	18.0	17.6	18.7	0.3	0.0	0.8	Y	>4	>4	>4	N	Y	0	Biological	1.2	Stage I on III	Y	N	N	Y	4	14.3	color change @ 4.64, 16.63, & 14.31 cm; Crangon septimspinosa @ surface; few tiny worm tubes; few burrows; very few microvoids near surface, voids @ 6.51 cm left & 4.50 cm right, Beggiatoa sp. @ surface
Providence 2009	**02R-1**	10/22/2009 13:53	21.0	20.6	21.5	0.5	0.0	1.6	N	4 to 3	>4	>4	N	Y	2	Biological	0.8	Stage I on III	Y	Y	N	Y	4	1.1	color change @ 17.76, 5.07, & 1.07 cm; small worm tubes 15.02 & 20.23 cm; few small oxic clasts @ surface; few microvoids near surface, void @ 3.97 cm
Providence 2009	**02R-2**	10/22/2009 13:54	20.7	20.3	21.4	0.4	0.0	1.2	N	4 to 3	>4	>4	N	Y	0	Biological	1.1	Stage I	Y	N	N	N	--	--	no color change; small worm tubes; few microvoids near surface
Providence 2009	**02R-3**	10/22/2009 13:55	14.0	13.8	14.4	0.4	0.1	0.8	N	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	N	--	--	no color change; small worm tubes; few microvoids near surface, void @ 5.42 cm in center
Providence 2009	**03C-1**	10/22/2009 15:49	19.4	18.9	19.8	0.0	0.0	0.0	N	>4	>4	>4	N	Y	0	Biological	0.9	Stage I	Y	N	N	Y	3	16.3	color change @ 16.26 & 17.95 cm; very few tiny worm tubes; few burrows; very few tiny microvoids
Providence 2009	**03C-2**	10/22/2009 15:50	22.0	22.0	22.0	0.0	0.0	0.0	NA	>4	>4	>4	N	NA	2	Indeter-minate	0.0	Indeter-minate	Y	NA	N	Y	3	15.0	overpenetrated; color change @ 14.95 7 16.17 cm; methane @21.10 & 21.20 cm; 1 small burrow; Beggiatoa sp. @ surface
Providence 2009	**03R-1**	10/22/2009 13:58	14.1	13.4	14.7	0.6	0.0	1.8	N	4 to 3	>4	>4	N	Y	0	Biological	1.3	Stage I on III	Y	N	N	Y	2	13.5	color change @ 13.54; few small worm tubes; few microvoids near surface, void @ 2.95 cm in center
Providence 2009	**03R-2**	10/22/2009 13:59	12.4	12.2	12.7	0.6	0.3	1.0	N	4 to 3	>4	>4	N	Y	0	Biological	0.5	Stage I on III	Y	N	N	Y	3	3.2	color change @ 3.16 & 4.58 cm; few worm tubes; few microvoids near surface, voids @ 1.66 & 1.15 cm, Beggiatoa sp.
Providence 2009	**03R-3**	10/22/2009 13:59	9.3	9.0	9.8	0.3	0.0	1.1	N	4 to 3	>4	>4	N	Y	0	Biological	0.8	Stage I	Y	N	N	Y	2	3.0	color change @ 2.99 cm (recent) & 5.13 cm; few worm tubes; few burrows; few microvoids near surface, Beggiatoa sp.
Providence 2009	**04C-1**	10/22/2009 15:54	19.6	19.5	19.7	0.1	0.0	0.3	N	>4	>4	>4	N	Y	1	Biological	0.2	Stage I	Y	N	N	Y	3	5.1	color change @ 15.03& 5.07 cm; very few tiny worm tubes 9.65 cm; very few burrows; Beggiatoa sp. @ surface
Providence 2009	**04C-2**	10/22/2009 15:55	19.2	18.9	19.4	0.2	0.0	0.6	N	>4	>4	>4	N	Y	0	Biological	0.5	Stage I	Y	N	N	Y	4	2.3	color change @ 2.25, 3.93, & 16.45 cm; very few tiny worm tubes; very few burrows; very few microvoids near surface, relict void @ 7.73 cm, some Beggiatoa sp. @ surface
Providence 2009	**04C-3**	10/22/2009 15:55	18.3	17.1	20.0	0.0	0.0	0.0	N	>4	>4	>4	Y	N	3	Biological	2.8	Azoic	N	Y	N		Ind	Ind	methane @8.04, 14.55, & 15.32 cm; bacteria mat; medium size anoxic clast; Beggiatoa sp. mat
Providence 2009	**04R-1**	10/22/2009 17:12	14.7	14.5	14.8	0.1	0.0	0.3	N	>4	>4	>4	N	Y	0	Biological	0.4	Stage I	N	N	N	Y	3	6.2	color change @ 10.08 & 6.20 cm; few tiny worm tubes; Beggiatoa sp. mat, relict void @ 11.48 cm

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes: Providence cells uncapped and receiving UDM layering likely from placement of dredge material or natural filling of ambient sediment into CAD cells. Sediment inside and outside CAD cells black and anoxic with very shallow RPDs when present
Providence 2009	**04R-10**	10/22/2009 14:25	19.8	19.4	20.4	0.4	0.1	0.9	N	4 to 3	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	N	N	N	--	--	no color change; few worm tubes; few burrows; very few microvoids near surface, void @ 12.11 cm, Beggiatoa sp.
Providence 2009	**04R-2**	10/22/2009 17:13	15.2	14.8	15.6	0.2	0.0	0.5	N	>4	>4	>4	N	N	1	Biological	0.7	Azoic	N	N	N	Y	3	4.4	color change @ 4.38 & 6.03 cm; 6.44 cm in center; Beggiatoa sp. mat
Providence 2009	**04R-3**	10/22/2009 17:13	15.2	14.8	15.7	0.1	0.0	0.4	N	>4	>4	>4	N	Y	0	Biological	0.9	Stage I	Y	N	N	Y	3	4.3	color change @ 4.30 & 6.38 cm; few tiny worm tubes; few burrows; Beggiatoa sp. patches at surface
Providence 2009	**04R-6**	10/22/2009 14:16	9.9	9.6	10.2	0.4	0.0	0.9	N	4 to 3	>4	>4	N	Y	0	Biological	0.6	Stage I on III	Y	N	N	Y	2	2.8	color change @ 2.75 cm; few tiny worm tubes; few burrows; few microvoids near surface, void @ 9.05 cm, Beggiatoa sp.
Providence 2009	**04R-9**	10/22/2009 14:23	11.3	11.0	11.7	0.9	0.3	2.0	N	4 to 3	>4	>4	N	Y	0	Biological	0.7	Stage I	Y	N	N	Y	3	3.6	color change @ 3.55 & 6.00 cm; few small worm tubes; few burrows; few microvoids near surface, Beggiatoa sp.
Providence 2009	**05C-2**	10/22/2009 16:00	22.0	22.0	22.0	0.0	0.0	0.0	N	>4	>4	>4	Y	N	0	Biological	0.0	Indeter-minate	N	N	N	Y	2	14.9	overpenetrated; color change @ 14.94 cm; Beggiatoa sp. mat
Providence 2009	**05C-3**	10/22/2009 06:05	19.7	19.5	20.0	0.0	0.0	0.0	N	>4	>4	>4	Y	N	1	Biological	0.5	Azoic	N	N	N	Y	2	18.1	color change @ 18.06; methane 3.12 cm on right; Beggiatoa sp. mat
Providence 2009	**05C-4**	10/22/2009 16:06	17.8	17.5	18.2	0.2	0.0	0.6	N	>4	>4	>4	N	Y	0	Biological	0.8	Stage I	N	N	N	Y	2	14.0	color change @ 14.02 cm; very few tiny worm tubes; Beggiatoa sp. mat
Providence 2009	**05R-1**	10/22/2009 17:08	17.4	16.9	17.8	0.2	0.0	0.8	N	>4	>4	>4	N	Y	1	Biological	0.9	Stage I on III	Y	N	N	Y	2	7.1	color change @ 7.14 cm; few worm tubes 12.66 cm; Beggiatoa sp. @ surface, relict voids @ 5.54 & 12.66 cm
Providence 2009	**05R-2**	10/22/2009 17:09	15.0	14.4	15.5	0.2	0.0	0.8	N	>4	>4	>4	N	Y	1	Biological	1.2	Stage I on III	N	N	N	Y	2	6.3	color change @ 6.29 cm; very few worm tubes 10.13 cm; relict voids @ 12.12, 10.13, & 8.82 cm, Beggiatoa sp. @ surface
Providence 2009	**05R-3**	10/22/2009 17:09	14.2	14.0	14.4	0.0	0.0	0.0	N	>4	>4	>4	N	N	0	Biological	0.4	Stage I on III	N	N	N	Y	2	4.6	color change @ 4.55 cm; Beggiatoa sp. mat, possible dewatering pipe
Providence 2009	**06C-1**	10/22/2009 15:24	22.0	22.0	22.0	0.0	0.0	0.0	NA	>4	>4	>4	N	NA	5	Indeterminat e	0.0	Indeter-minate	NA	NA	NA	N	--	--	overpenetrated; no color change; methane @ 14.61, 16.05, 14.84, 16.91, & 17.25 cm
Providence 2009	**06C-2**	10/22/2009 15:26	19.3	18.7	20.0	0.2	0.0	0.5	N	>4	>4	>4	N	Y	1	Biological	1.3	Stage I on III	N	Y	N	N	--	--	no color change; very few tiny worm tubes; methane @ 14.75 cm; few small oxic & anoxic clasts @ surface; very few tiny microvoids near surface, void @ 4.19 cm, Beggiatoa sp.
Providence 2009	**06C-3**	10/22/2009 15:27	22.0	22.0	22.0	0.0	0.0	0.0	NA	>4	>4	>4	N	NA	0	Indeter-minate	0.0	Indeter-minate	NA	NA	NA	N	--	--	overpenetrated; no color change; Beggiatoa sp.
Providence 2009	**06R-1**	10/22/2009 16:56	16.8	16.3	17.2	0.1	0.0	0.4	N	>4	>4	>4	N	Y	1	Biological	0.9	Stage I-II	Y	Y	N	Y	2	12.0	color change @ 12.0 cm; few worm tubes & 2 amphipod tubes; methane @ 16.27 cm; few small anoxic clasts @ surface; small amount of Beggiatoa sp. on surface
Providence 2009	**06R-2**	10/22/2009 16:56	16.4	12.4	19.9	0.0	0.0	0.0	N	>4	>4	>4	Y	Y	7	Biological	7.5	Stage I	Y	N	N	Y	2	10.8	sloped, may be edge of cell? color change @ 10.84 cm; few worm tubes; methane @ 17.17, 12.10, 9.77, 16.39, 15.03, 5.86, & 11.98 cm; 1 possible burrow
Providence 2009	**06R-3**	10/22/2009 16:57	14.6	14.4	15.0	0.3	0.1	0.6	N	>4	>4	>4	N	Y	0	Biological	0.6	Stage I-II	Y	N	N	Y	2	12.2	color change @ 12.16; worm tubes & a few amphipod tubes; small amount of Beggiatoa sp. @ surface
Providence 2009	**07C-1**	10/22/2009 15:38	22.0	22.0	22.0	0.0	0.0	0.0	NA	>4	>4	>4	N	NA	9	Biological	0.0	Indeter-minate	NA	NA	NA	N	--	--	overpenetrated; no color change; methane @ 14.85, 14.75, 12.73, 13.27, 15.16, 16.10, 17.98, 17.86, & 18.22 cm; Beggiatoa sp.
Providence 2009	**07C-3**	10/22/2009 15:40	17.2	16.7	17.5	0.3	0.0	0.5	N	>4	>4	>4	N	Y	0	Biological	0.9	Stage I on III	Y	N	N	Y	2	11.3	color change @ 11.25 cm; very few tiny worm tubes; very few burrows; void @ 1.46 cm, Beggiatoa sp. @ surface
Providence 2009	**07R-1**	10/22/2009 16:37	16.1	15.2	16.7	0.1	0.0	0.5	N	>4	>4	>4	N	Y	6	Biological	1.6	Stage I	N	Y	N	N	--	--	no color change; very few tiny worm tubes; methane @ 11.76, 12.22, 14.73, 13.48, 15.85, & 10.57 cm; small anoxic clasts at surface; Beggiatoa sp. @ surface
Providence 2009	**07R-3**	10/22/2009 16:37	15.8	15.4	16.1	0.5	0.0	1.1	N	>4	>4	>4	N	Y	9	Biological	0.8	Stage I	Y	N	N	N	--	--	no color change; several tiny worm tubes; methane @ 15.26, 13.77, 13.14, 14.15, 13.39, 13.07, 12.69, 9.49, & 10.08 cm; 2 burrows in center; few microvoids near surface
Providence 2009	**07R-4**	10/22/2009 16:40	15.3	14.4	15.8	0.2	0.0	0.4	N	>4	>4	>4	N	Y	0	Biological	1.4	Stage I	Y	N	N	Y	3	10.3	color change @ 10.33 & 13.09 cm; few small worm tubes; burrows center @ right ; very few microvoids near surface

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Change	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes: Providence cells uncapped and receiving UDM layering likely from placement of dredge material or natural filling of ambient sediment into CAD cells. Sediment inside and outside CAD cells black and anoxic with very shallow RPDs when present
Providence 2009	**08C-1**	10/22/2009 14:42	20.3	20.0	20.6	0.2	0.0	0.6	Y	>4	>4	>4	N	Y	1	Biological	0.6	Stage I	N	N	N	N	--	--	no color change; Crangon septimspinosa @ surface; very few worm tubes 10.51 cm
Providence 2009	**08C-2**	10/22/2009 14:45	12.3	11.4	13.3	0.4	0.0	0.9	Y	>4	>4	>4	N	Y	0	Biological	1.8	Stage I	Y	N	N	Y	2	6.6	color change @ 6.60 cm; mysid; few small worm tubes; very few burrows; few microvoids near surface, relict void @ 11.19 cm, Beggiatoa sp.
Providence 2009	**08C-5**	10/22/2009 14:50	18.0	17.7	18.3	0.3	0.0	0.7	Y	>4	>4	>4	N	Y	0	Biological	0.6	Stage I	Y	N	N	N	--	--	no color change; Crangon septimspinosa @ surface; few small worm tubes; very few small burrows; very few tiny microvoids near surface, possible dewatering pipe
Providence 2009	**08R-1**	10/22/2009 16:45	15.0	14.6	15.5	0.3	0.0	0.7	N	>4	>4	>4	N	Y	8	Biological	0.9	Stage I-II	Y	N	N	Y	2	10.6	color change @ 10.64 cm; few tiny worm tubes, possibly 2 small amphipod tubes; methane @ 13.88, 12.80, 15.88, 9.32, 9.76, 14.29, 10.37, & 11.65 cm; few burrows ; few microvoids near surface, Beggiatoa sp. at surface
Providence 2009	**08R-2**	10/22/2009 16:46	15.6	15.0	16.2	0.4	0.1	0.8	N	>4	>4	>4	N	Y	5	Biological	1.2	Stage I-II	Y	N	N	N	--	--	no color change; several worm tubes & possibly 1 amphipod tube; methane @ 12.05, 12.22, 10.10, 11.13, & 9.88 cm; few burrows near surface
Providence 2009	**08R-3**	10/22/2009 16:47	13.2	12.9	13.4	0.5	0.2	0.8	N	>4	>4	>4	N	Y	4	Biological	0.5	Stage I-II	Y	N	N	Y	2	8.6	color change @ 8.61cm; few worm & amphipod tubes; methane @ 12.79, 10.45, 11.99, & 9.97 cm; few burrows near surface; few microvoids near surface
Providence 2009	**09C-2**	10/22/2009 15:14	19.6	19.3	20.0	0.3	0.0	0.7	N	>4	>4	>4	N	Y	0	Biological	0.7	Stage I	Y	N	N	N	--	--	disturbed, some surface intact, pull-away; no color change; few small worm tubes; very few burrows; Beggiatoa sp.
Providence 2009	**09C-3**	10/22/2009 15:15	15.1	14.2	16.0	0.0	0.0	0.0	N	>4	>4	>4	N	Y	0	Both	1.8	Stage I	N	Y	N	N	--	--	no color change; few small worm tubes; biological/physical; small anoxic & oxic clasts @ surface
Providence 2009	**09C-4**	10/22/2009 15:16	22.0	22.0	22.0	0.0	0.0	0.0	NA	>4	>4	>4	N	Y	0	Indeter-minate	0.0	Stage I	N	NA	N		Ind	Ind	overpenetrated; very few tiny worm tubes
Providence 2009	**09R-1**	10/22/2009 16:50	13.0	12.4	13.4	0.9	0.3	1.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.0	Stage I-II	Y	N	N	N	--	--	no color change; worm & amphipod tubes; few microvoids near surface
Providence 2009	**09R-3**	10/22/2009 19:51	15.5	14.6	16.8	0.4	0.0	1.0	N	4 to 3	>4	>4	N	Y	0	Biological	2.2	Stage I on III	Y	N	N	Y	2	11.4	color change @ 11.35 cm; worm & amphipod tubes; few microvoids near surface, voids @ 8.13 & 6.50 cm
Providence 2009	**09R-4**	10/22/2009 16:52	13.4	12.7	13.7	0.6	0.2	0.9	N	4 to 3	>4	>4	N	Y	0	Biological	1.0	Stage I on III	Y	Y	N	Y	2	10.1	color change @ 10.08 cm; worm & amphipod tubes; large anoxic clast at surface on right; few microvoids near surface, void @ 5.79 cm
Providence 2009	**10C-1**	10/22/2009 15:20	18.1	17.4	19.0	0.0	0.0	0.0	N	>4	>4	>4	Y	N	0	Biological	1.6	Indeter-minate	N	N	N	Y	3	5.0	color change @ 4.99 & 13.46 cm; Beggiatoa mat
Providence 2009	**10C-2**	10/22/2009 15:21	18.9	18.7	19.6	0.0	0.0	0.0	N	>4	>4	>4	Y	Y	0	Biological	0.9	Stage I	N	N	N	Y	3	15.2	color change @ 15.16 & 17.83 cm; 8 tiny worm tubes; Beggiatoa sp. mat
Providence 2009	**10C-3**	10/22/2009 15:22	20.8	20.5	21.6	0.0	0.0	0.0	N	>4	>4	>4	Y	Y	0	Biological	1.1	Stage I	N	N	N	N	--	--	no color change; 3 tiny worm tubes at surface; Beggiatoa sp. mat
Providence 2009	**10R-1**	10/22/2009 17:00	13.3	12.7	13.5	0.5	0.0	1.4	N	>4	>4	>4	N	Y	0	Biological	0.8	Stage I	Y	N	N	N	--	--	no color change; few worm tubes
Providence 2009	**10R-2**	10/22/2009 17:01	13.1	11.4	14.0	0.3	0.0	0.7	N	4 to 3	>4	>4	N	Y	0	Biological	2.6	Stage I-II	Y	N	N	N	--	--	no color change; few worm & amphipod tubes; few microvoids near surface
Providence 2009	**10R-3**	10/22/2009 17:02	16.8	16.2	17.5	0.3	0.0	0.7	N	4 to 3	>4	>4	N	Y	0	Biological	1.3	Stage I	Y	N	N	Y	2	7.6	color change @ 7.64 cm; worm tubes; small patch Beggiatoa sp.
Providence 2009	**11C-1**	10/22/2009 16:10	13.2	12.7	13.4	0.3	0.0	0.7	Y	>4	>4	>4	N	Y	0	Biological	0.8	Stage I on III	Y	Y	N	Y	2	11.4	color change @ 11.36 cm; two Crangon septimspinosa in water column; few small worm tubes; few burrows; large oxic clast on right; few microvoids near surface, void @ 10.57 cm, Beggiatoa sp.
Providence 2009	**11C-2**	10/22/2009 16:11	13.8	13.5	14.5	0.1	0.0	0.3	N	>4	>4	>4	N	Y	0	Biological	1.0	Stage I	N	N	N	Y	2	10.0	color change @ 9.98 cm; very few tiny worm tubes; Beggiatoa sp.
Providence 2009	**11C-3**	10/22/2009 16:11	14.5	14.0	14.9	0.1	0.0	0.6	N	>4	>4	>4	N	Y	3	Biological	0.9	Stage I	N	Y	N	Y	2	11.1	color change @ 11.05 cm; very few tiny worm tubes; methane @ 12.75, 7.24, & 8.24 cm; large anoxic clast in middle; Beggiatoa sp.
Providence 2009	**12C-1**	10/22/2009 16:15	14.9	14.6	15.1	0.3	0.0	0.6	N	>4	>4	>4	N	Y	0	Biological	0.5	Stage I	N	N	N	Y	2	11.6	color change @ 11.58; very few tiny worm tubes; relict void @ 13.21 cm, Beggiatoa sp.

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Providence 2009	**12C-2**	10/22/2009 16:16	15.0	14.2	15.6	0.0	0.0	0.0	N	>4	>4	>4	Y	N	0	Biological	1.4	Azoic	N	Y	N	Y	2	10.9	color change @ 10.92; large anoxic clast on left ; Beggiatoa sp. mat
Providence 2009	**12C-3**	10/22/2009 16:16	15.3	14.2	15.7	0.2	0.0	0.6	N	>4	>4	>4	N	Y	0	Biological	1.5	Stage I	N	N	N	Y	2	9.8	color change @ 9.82 cm; very few tiny tubes; Beggiatoa sp.
Providence 2009	**13C-1**	10/22/2009 16:21	11.8	11.5	12.3	0.1	0.0	0.7	N	>4	>4	>4	N	Y	1	Biological	0.8	Stage I on III	Y	Y	N	N	--	--	no color change; few tiny worm tubes 5.72 cm; burrow in center clast in center; void @ 7.28 cm
Providence 2009	**13C-2**	10/22/2009 16:22	14.1	12.8	14.9	0.2	0.0	0.7	N	>4	>4	>4	N	Y	0	Biological	2.1	Stage I on III	Y	N	N	N	--	--	no color change, no relict voids; few tubes; few microvoids near surface
Providence 2009	**13C-3**	10/22/2009 16:23	14.0	13.5	14.5	0.1	0.0	0.4	Y	>4	>4	>4	N	Y	0	Biological	1.0	Stage I	Y	Y	N	Y	2	9.9	color change @ 9.85 cm; Crangon septimspinosa; very few tiny worm tubes; burrow in center; small oxic clast on surface; relict void @ 9.85 cm, Beggiatoa sp. at surface
Providence 2009	**14C-1**	10/22/2009 16:32	17.0	16.3	17.7	0.1	0.0	0.6	Y	>4	>4	>4	N	Y	6	Biological	1.4	Stage I	Y	N	N	Y	3	15.2	color change @ 16.34 & 15.21 cm; 1 Crangon septimspinosa @ surface; few worm tubes; methane @ 15.55, 14.42, 13.3, 11.85, 8.27, & 8.49 cm; burrow in center; relict void @ 16.34 cm, Beggiatoa sp. on surface
Providence 2009	**14C-3**	10/22/2009 16:33	15.2	15.1	15.1	0.2	0.0	0.5	Y	>4	>4	>4	N	Y	3	Biological	0.0	Stage I	Y	N	N	Y	2	10.9	color change @ 10.86 cm; tube on surface, worm?; pink worm on right; methane @ 11.52, 15.01, & 14.46 cm; burrow on right; Beggiatoa sp. on surface
Providence 2009	**15C-1**	10/22/2009 16:27	16.7	15.4	16.2	0.0	0.0	0.0	N	>4	>4	>4	N	N	2	Biological	0.8	Azoic	Y	N	N	N	--	--	no color change; methane @ 15.91 & 17.15 cm; burrow in center, may be excavation?; Beggiatoa sp. at surface
Providence 2009	**15C-2**	10/22/2009 16:27	15.9	15.0	16.4	0.0	0.0	0.0	N	>4	>4	>4	N	N	6	Biological	1.4	Azoic	N	N	N	Y	2	11.9	color change @ 11.92 cm; methane @ 13.17, 14.32, 12.51, 11.84, 12.10, & 12.25 cm; Beggiatoa sp. mat
Providence 2009	**15C-3**	10/22/2009 16:28	14.8	14.2	15.1	0.1	0.0	0.3	N	>4	>4	>4	N	Y	5	Biological	0.9	Stage I	N	Y	N	Y	2	8.6	color change @ 8.56 cm; very few tiny worm tubes; methane @ 13.04, 10.59, 11.16, 12.50, & 8.29 cm; small anoxic clast at surface; Beggiatoa sp. at surface

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Hyannis 2009	**01C-1**	10/23/2009 16:40	8.7	6.7	9.7	4.1	0.0	7.2	N	1 to 0	>4	3 to 2	N	Y	0	Physical	3.0	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard compact sand ripples; void @ 1.10 cm on right, no algae
Hyannis 2009	**01C-2**	10/23/2009 16:40	3.0	2.7	3.5	>3.51	0.3	>pen	N	1 to 0	>4	3 to 2	N	Y	0	Physical	0.8	Stage I on III	Y	N	N	N	--	--	no color change ; well sorted; very few tiny worm tubes; hard, compact sand ripples; void @ 0.65 cm, shell & small patch of benthic brown algae
Hyannis 2009	**01C-3**	10/23/2009 16:41	7.4	6.5	8.1	>8.14	4.4	>pen	N	1 to 0	>4	3 to 2	N	Y	0	Physical	1.6	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripple; small patch benthic brown algae on shell, void @ 1.32 cm
Hyannis 2009	**01R-1**	10/23/2009 15:10	1.8	0.1	2.7	>2.67	>pen	>pen	N	<-1	4 to 3	3 to 2	N	Y	0	Both	2.6	Stage I	N	N	N	N	--	--	no color change; very poorly sorted, abundant shell hash; very few tiny worm tubes; biological/physical; Codium, red filamentous algae
Hyannis 2009	**01R-2**	10/23/2009 15:11	2.8	2.5	3.5	2.4	0.2	3.6	N	<-1	4 to 3	2 to 1	N	Y	0	Both	0.0	Stage I on III	Y	N	N	N	--	--	no color change; well sorted compact sand; possible worm in tube (maldanid tube?), tiny worm tubes, benthic brown algae; biological/physical, sand ripples, little shell hash; large void on right @ 1.76 cm
Hyannis 2009	**01R-3**	10/23/2009 15:12	3.1	2.7	3.7	>3.72	>pen	>pen	N	<-1	3 to 2	3 to 2	N	Y	0	Both	1.1	Stage I	Y	N	N	N	--	--	no color change; moderately sorted compact sand; very few tiny worm tubes; biological/physical, sand ripples; benthic brown algae mat w/ red filamentous algae
Hyannis 2009	**02C-1**	10/23/2009 16:08	5.6	2.4	8.0	>7.97	0.9	>pen	N	<-1	>4	3 to 2	N	Y	0	Physical	5.5	Stage I on III	Y	N	N	N	--	--	no color change; well sorted, little shell hash; very few tiny worm tubes in center; sand ripples, hard compact sand; voids @ 0.93, 4.53, & 3.43 cm, small patch benthic brown algae
Hyannis 2009	**02C-2**	10/23/2009 16:09	4.9	3.8	6.2	2.7	0.3	4.8	N	0 to -1	>4	2 to 1	N	N	0	Physical	2.3	Stage III	Y	N	N	N	--	--	no color change; well sorted, hard compact; no tiny tubes, 1 small void; sand ripple; void @ 1.87 cm, small patch benthic brown algae
Hyannis 2009	**02C-3**	10/23/2009 16:10	5.5	4.2	7.0	2.6	0.0	4.5	Y	<-1	>4	2 to 1	N	N	0	Physical	2.8	Stage III	Y	N	N	N	--	--	no color change; possible moon snail?; well sorted; hard compact, sand ripple; few burrows; tiny void @ 3.10 cm on left, tiny patch brown algae
Hyannis 2009	**02R-1**	10/23/2009 15:03	7.4	7.0	8.0	3.7	0.4	6.9	N	<-1	>4	3 to 2	N	Y	0	Both	1.0	Stage I on III	Y	N	N	N	--	--	no color change; well sorted w/ few pebbles & shell hash @ surface; few worm tubes at surface, worm @ 2.74 cm in center; biological/physical, sand ripples; voids @ 4.04 & 3.94 cm, abundant of benthic brown algae
Hyannis 2009	**02R-2**	10/23/2009 15:04	7.2	5.6	8.6	5.9	4.5	7.2	N	0 to -1	>4	3 to 2	N	Y	0	Both	3.0	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; small worm tubes; biological/physical, sand ripples; voids @ 6.18 (R), 0.59 (R), & 0.92 cm (C), benthic brown algae
Hyannis 2009	**02R-3**	10/23/2009 15:04	7.4	6.0	8.6	5.0	2.1	8.6	N	<-1	>4	3 to 2	N	Y	0	Both	2.6	Stage I on III	N	N	N	N	--	--	no color change; moderately sorted @ surface over well sorted; very few small worm tubes@ surface; biological/physical, sand ripples; void @ 1.65 cm, little bit of benthic brown algae
Hyannis 2009	**03C-1**	10/23/2009 15:43	6.0	3.7	6.7	3.8	1.9	5.2	Y	0 to -1	>4	2 to 1	N	Y	0	Both	3.0	Stage I	N	N	N	N	--	--	no color change; mysid in center; well sorted; few very small worm tubes @ surface; biological/physical, sand ripples
Hyannis 2009	**03C-2**	10/23/2009 15:44	6.0	5.2	6.9	3.5	0.9	6.3	N	0 to -1	>4	2 to 1	N	Y	0	Physical	1.7	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; few tiny worms at surface; sand ripples; no algae, void @ 0.78 cm
Hyannis 2009	**03C-3**	10/23/2009 15:45	7.2	5.8	8.8	2.5	0.3	4.3	N	<-1	>4	3 to 2	N	Y	0	Physical	3.0	Stage I on III	Y	N	N	N	--	--	no color change; moderately sorted, sloped, compact sand; Pectinaria, small worms @ surface; sand ripple; voids @ 5.61 & 2.32 cm
Hyannis 2009	**03R-1**	10/23/2009 15:00	3.3	2.5	3.9	>3.88	>pen	>pen	N	<-1	4 to 3	0 to -1	N	Y	0	Both	1.4	Stage I	N	N	N	N	--	--	no color change; poorly sorted, little shell hash; very few tiny worm tubes; biological/physical, sand ripples; abundant of brown algae @ surface, Grassilaria, dead eelgrass blade
Hyannis 2009	**03R-2**	10/23/2009 15:00	6.2	5.6	6.9	5.1	2.9	6.9	N	<-1	4 to 3	2 to 1	N	Y	0	Both	1.3	Stage I on III	N	N	N	N	--	--	no color change; poorly sorted over well sorted, little shell hash; spirorbids & very few tiny worm tubes; biological/physical, sand ripples; voids @ 3.33 & 2.40 cm on right, brown benthic algae & dead eelgrass blade

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Hyannis 2009	**03R-3**	10/23/2009 15:01	8.4	6.8	9.4	5.6	2.2	9.0	N	<-1	>4	2 to 1	N	Y	0	Both	2.6	Stage I on III	N	N	N	N	--	--	no color change; moderately sorted over well sorted; tiny worm tubes on pebble surfaces; biological/physical, sand ripple; void @ 3.30 cm, abundant of benthic brown algae, little Codium
Hyannis 2009	**04C-1**	10/23/2009 15:47	3.0	2.7	3.4	>3.38	0.9	>pen	N	<-1	>4	2 to 1	N	Y	0	Physical	0.7	Stage I	Y	N	N	N	--	--	no color change; well sorted, hard, compact; very few tiny worm tubes; sand ripple; burrow near surface; no algae
Hyannis 2009	**04C-2**	10/23/2009 15:48	8.0	6.1	9.3	3.2	0.0	6.9	N	2 to 1	>4	3 to 2	N	Y	0	Physical	3.1	Stage I on III	Y	N	N	N	--	--	no color change; very well sorted; Pectinaria gouldii, very few tiny worm tubes @ surface; hard, compact sand ripple; burrow near surface; voids @ 4.81 cm (R) & 1.23 cm (L), no algae
Hyannis 2009	**04C-3**	10/23/2009 15:48	4.8	4.0	5.8	>5.82	2.8	>pen	N	2 to 1	>4	3 to 2	N	Y	0	Physical	1.8	Stage I on III	Y	N	N	N	--	--	no color change; very well sorted, hard compact; few worm tubes; sand ripples; void @ 1.81 cm, buried eelgrass blade, little bit of benthic brown algae
Hyannis 2009	**04R-1**	10/23/2009 15:07	3.4	3.0	4.1	>4.05	>pen	>pen	N	<-1	4 to 3	2 to 1	N	N	0	Physical	1.1	Stage III	N	N	N	N	--	--	moderate to well sorted; no visible worm tubes; sand ripples; possible active void @ 2.08 cm
Hyannis 2009	**04R-2**	10/23/2009 15:07	5.8	3.8	6.8	>6.83	>pen	>pen	N	<-1	3 to 2	2 to 1	N	N	0	Both	3.1	Indeter-minate	N	N	N	N	--	--	no color change; Medium sand; biological/physical, sand ripples; Codium & benthic brown algae
Hyannis 2009	**04R-3**	10/23/2009 15:08	2.2	1.5	3.3	>3.30	>pen	>pen	N	<-1	3 to 2	3 to 2	N	Y	0	Both	1.8	Stage I	N	N	N	N	--	--	no color change; well sorted, some pebbles at surface, hard compact sand; very few tiny worm tubes; biological/physical, sand ripples; dead & live Codium, benthic brown algae, red filamentous algae?
Hyannis 2009	**05C-1**	10/23/2009 16:01	1.8	0.0	4.5	>4.51	0.5	>pen	N	3 to 2	>4	3 to 2	N	Y	0	Physical	4.5	Stage I	N	N	N	N	--	--	no color change; hard compact, Crepidula shell hash; tiny worm tubes @ surface; no algae
Hyannis 2009	**05C-2**	10/23/2009 16:01	5.4	3.3	8.2	>8.19	2.7	>pen	N	3 to 2	>4	3 to 2	N	Y	0	Both	4.9	Stage I on III	N	N	N	N	--	--	no color change; well sorted, little shell hash; few tiny worm tubes @ surface; biological/physical, sand ripple; void @ 4.28 cm, benthic brown algal mat, little Codium
Hyannis 2009	**05C-3**	10/23/2009 16:02	5.7	4.0	7.2	>7.19	2.5	>pen	N	<-1	>4	2 to 1	N	Y	0	Physical	3.2	Stage I on III	N	Y	N	N	--	--	no color change; moderately sorted, large pebble @ surface, compact, hard; few tiny worm tubes @ surface; sand ripple; anoxic clast on left void @ 2.23 cm, no algae
Hyannis 2009	**05R-2**	10/23/2009 14:56	7.3	6.7	8.2	>8.19	>pen	>pen	N	<-1	3 to 2	2 to 1	N	Y	0	Physical	1.5	Stage I	N	N	N	N	--	--	no color change; poorly sorted over well sorted medium to coarse sand; very few tiny worm tubes; sand ripples
Hyannis 2009	**05R-3**	10/23/2009 14:56	6.5	4.8	7.6	>7.61	>pen	>pen	N	<-1	3 to 2	1 to 0	N	Y	0	Physical	2.8	Stage I	N	N	N	N	--	--	no color change; moderately sorted; very few tiny worm tubes; sand ripple
Hyannis 2009	**05R-4**	10/23/2009 14:57	4.7	4.2	5.4	>5.36	>pen	>pen	N	<-1	4 to 3	2 to 1	N	Y	0	Physical	1.1	Stage I	N	N	N	N	--	--	no color change; moderately sorted; very few tiny worm tubes; sand ripple; Codium on surface, dead eelgrass frond
Hyannis 2009	**06C-1**	10/23/2009 16:33	9.2	6.3	11.9	3.7	1.8	6.5	N	1 to 0	>4	3 to 2	N	Y	0	Physical	5.6	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripples `
Hyannis 2009	**06C-2**	10/23/2009 16:34	10.6	8.0	12.4	5.1	4.1	7.2	N	<-1	>4	3 to 2	N	Y	0	Physical	4.4	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes & burrows near surface; hard, compact sand ripples; snail feces @ surface, no algae
Hyannis 2009	**06C-3**	10/23/2009 16:35	8.6	7.1	9.7	>9.68	2.7	>pen	N	0 to -1	>4	3 to 2	N	Y	0	Physical	2.6	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; several tiny worm tubes at surface; hard, compact, sand ripple; voids @ 1.97 & 1.19 cm on left, no algae
Hyannis 2009	**06R-1**	10/23/2009 16:45	3.4	2.9	4.0	>3.99	>pen	>pen	N	1 to 0	3 to 2	3 to 2	N	Y	0	Physical	1.1	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripple; no algae
Hyannis 2009	**06R-2**	10/23/2009 16:46	2.7	2.5	3.1	>3.07	1.1	>pen	N	0 to -1	>4	3 to 2	N	Y	0	Physical	0.5	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripples; no algae
Hyannis 2009	**06R-3**	10/23/2009 16:47	6.6	5.0	7.8	>7.78	>pen	>pen	N	<-1	4 to 3	3 to 2	N	Y	0	Physical	2.8	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripple; no algae
Hyannis 2009	**07C-2**	10/23/2009 15:20	8.0	6.4	9.0	IND	0.2	5.1	N	3 to 2	>4	4 to 3	N	Y	0	Both	2.6	Stage I on III	Y	N	N	N	--	--	no color change; moderately sorted below layer of shell hash at surface; very few tiny worm tubes; biological/physical, abundant shell hash, sand ripple; several burrows; microvoids near surface, voids @ 5.34 (R), 2.76 (C), & 5.50 cm (L), red filamentous, benthic brown, Codium

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Changes	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Hyannis 2009	**07C-3**	10/23/2009 15:21	8.5	7.2	11.2	IND	IND	IND	N	3 to 2	>4	4 to 3	N	N	0	Both	4.0	Indeter-minate	N	N	N	N	--	--	moderately sorted below; Codium at surface; biological/physical, little shell hash, bits of rotting Codium in sediment ; Codium mat, little red filamentous
Hyannis 2009	**07C-4**	10/23/2009 15:22	10.0	8.9	10.8	IND,	IND	IND	N	3 to 2	>4	4 to 3	N	Y	0	Both	1.8	Stage I on III	Y	N	N	N	--	--	no color change; poorly sorted, dead and live Codium at surface with shell hash; very few tiny worm tubes; biological/physical, abundant shell hash, bits of rotting Codium in sediment; void @ 9.55 cm, Codium mat, little red filamentous
Hyannis 2009	**07R-1**	10/23/2009 16:48	8.3	4.9	10.4	>10.44	2.7	>pen	N	0 to -1	>4	3 to 2	N	Y	0	Physical	5.5	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripple; one branch Codium
Hyannis 2009	**07R-2**	10/23/2009 16:49	9.9	6.6	11.4	>11.36	5.7	>pen	N	<-1	>4	0 to -1	N	Y	0	Physical	4.8	Stage I on III	Y	N	N	N	--	--	no color change; poorly sorted, shell hash, dead scallop shell; few tiny worm tubes @ surface, crab claw @ surface, possible isopod @ 7.51 cm?; hard, compact sand; voids @ 3.46 cm (R) & 8.72 cm (L)
Hyannis 2009	**07R-3**	10/23/2009 16:50	7.1	5.0	8.4	3.0	1.4	4.8	N	2 to 1	>4	3 to 2	N	Y	0	Physical	3.4	Stage I	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard, compact sand ripple
Hyannis 2009	**08C-1**	10/23/2009 15:50	7.4	5.5	9.0	3.2	1.6	5.2	N	2 to 1	>4	3 to 2	N	Y	0	Physical	3.4	Stage I on III	Y	N	N	N	--	--	no color change; very well sorted, hard compact sand; very few small worm tubes @ surface; sand ripples; void @ 0.55 cm in center, small patch benthic brown algae
Hyannis 2009	**08C-2**	10/23/2009 15:51	3.0	2.1	5.2	IND	IND	IND	N	3 to 2	>4	3 to 2	N	Y	0	Both	3.1	Stage I	N	N	N	N	--	--	moderately sorted, little shell hash, hard compact; small worms near surface @1.37 & 1.88 cm in center; biological/physical, sand ripple; whelk eggs, Codium mat, decayed Codium in sediment
Hyannis 2009	**08C-3**	10/23/2009 15:52	2.2	1.2	3.9	0.7	0.0	1.5	N	1 to 0	>4	3 to 2	N	Y	0	Both	2.7	Stage I	N	N	N	N	--	--	no color change; poorly sorted, hard; small reddish worms near surface; biological/physical, sand ripple; Codium mat, Crepidula, decayed Codium in sediment, benthic brown algae
Hyannis 2009	**08R-1**	10/23/2009 16:55	9.3	7.4	10.7	3.6	2.5	4.5	N	0 to -1	>4	3 to 2	N	Y	0	Physical	3.3	Stage I on III	Y	N	N	N	--	--	no color change; moderately sorted, shell hash; very few tiny worm tubes; hard compact sand ripples; voids @ 6.87 & 5.50 cm on right, no algae
Hyannis 2009	**08R-2**	10/23/2009 16:56	6.3	4.2	7.6	3.9	3.0	5.7	Y	<-1	>4	3 to 2	N	Y	0	Physical	3.4	Stage I	Y	N	N	N	--	--	no color change; possible whelk in background; moderately sorted; very few tiny worm tubes; hard compact sand ripple; no algae
Hyannis 2009	**08R-3**	10/23/2009 16:56	6.9	6.2	7.1	2.7	1.3	4.4	N	0 to -1	>4	3 to 2	N	Y	0	Physical	1.0	Stage I	Y	N	N	N	--	--	no color change; dead scallop, shell hash, moderately sorted; very few tiny worm tubes, worm @ 3.55; hard compact sand ripple; voids @ 4.71 cm (L), 5.58 cm (C), & 4.85 cm (R), small patch Codium
Hyannis 2009	**09C-1**	10/23/2009 16:23	5.3	4.6	6.8	0.5	0.0	1.1	N	2 to 1	>4	3 to 2	N	Y	0	Physical	2.2	Stage I	Y	N	N	N	--	--	no color change; well sorted; few worm tubes; hard, compact, sand ripple; no algae
Hyannis 2009	**09C-2**	10/23/2009 16:24	4.2	3.1	4.7	1.3	0.5	3.2	N	2 to 1	>4	3 to 2	N	Y	0	Physical	1.6	Stage I	Y	N	N	N	--	--	no color change; well sorted; few worm tubes; hard, compact, sand ripples; no algae
Hyannis 2009	**09C-3**	10/23/2009 16:25	3.4	0.8	3.9	1.5	0.1	3.7	N	2 to 1	>4	3 to 2	N	Y	0	Both	3.1	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; biological/physical, hard, compact, sand ripple; burrow in center ; voids @ 0.73 cm (L) & 1.50 cm (R), large patch benthic brown algae
Hyannis 2009	**09R-1**	10/23/2009 16:58	8.3	4.4	11.0	6.4	4.3	8.0	N	0 to -1	>4	3 to 2	N	Y	0	Physical	6.6	Stage I on III	Y	N	N	N	--	--	no color change; well sorted, compact sand; very few tiny worm tubes; hard compact sand ripple; voids @ 2.17 cm (L) & 0.80 cm (R), no algae
Hyannis 2009	**09R-2**	10/23/2009 16:58	6.4	2.7	9.2	3.2	1.7	4.3	N	<-1	>4	3 to 2	N	Y	0	Physical	6.5	Stage I on III	Y	N	N	N	--	--	no color change; well sorted, compact sand; very few tiny worm tubes; hard compact sand ripple; voids @ 1.21 cm (L) & 2.05 cm (R), no algae
Hyannis 2009	**09R-3**	10/23/2009 16:59	9.8	7.2	11.1	>11.13	7.2	>pen	N	0 to -1	>4	3 to 2	N	Y	0	Physical	4.0	Stage I on III	Y	N	N	N	--	--	no color change ; well sorted, compact sand; very few tiny worm tubes on surface; hard compact sand ripples; void @ 1.78 cm

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Changes	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Hyannis 2009	**10C-1**	10/23/2009 15:24	8.0	5.9	9.7	2.4	0.0	5.9	N	2 to 1	>4	3 to 2	N	Y	0	Physical	3.9	Stage I on III	Y	N	N	N	--	--	no color change; well sorted compact sand; very few small worm tubes; sloped, sand ripple, no algae; void @ 8.75 cm
Hyannis 2009	**10C-2**	10/23/2009 15:25	6.5	6.3	6.8	5.2	2.7	6.6	N	2 to 1	>4	3 to 2	N	Y	0	Physical	0.5	Stage I	Y	N	N	N	--	--	no color change; very well sorted compact sand; very few tiny worm tubes; sand ripples, no algae
Hyannis 2009	**10C-3**	10/23/2009 15:26	10.2	9.6	11.0	6.8	3.8	9.3	N	2 to 1	>4	3 to 2	N	Y	0	Physical	1.5	Stage I on III	Y	N	N	N	--	--	no color change; very well sorted, hard compact sand; very few tiny worm tubes @ surface; sand ripples, no algae; void @ 2.45 cm
Hyannis 2009	**10R-1**	10/23/2009 16:52	6.9	5.7	7.3	>7.27	>pen	>pen	N	2 to 1	3 to 2	3 to 2	N	Y	0	Physical	1.5	Stage I	Y	N	N	N	--	--	no color change; very well sorted, broken shell @ surface; very few tiny worm tubes @ surface; hard, compact sand ripple
Hyannis 2009	**10R-2**	10/23/2009 16:52	5.0	5.0	5.0	>4.99	>pen	>pen	N	1 to 0	3 to 2	3 to 2	N	Y	0	Physical	0.0	Stage I	Y	N	N	N	--	--	no color change; very well sorted; very few tiny worm tubes @ surface; hard, compact sand ripple
Hyannis 2009	**10R-3**	10/23/2009 16:53	8.6	5.2	10.8	>10.82	4.6	>pen	N	1 to 0	>4	3 to 2	N	Y	0	Physical	5.7	Stage I on III	Y	N	N		--	--	no color change; very well sorted; very few tiny worm tubes; hard, compact sand ripple; void @ 0.51 cm on right, no algae
Hyannis 2009	**11C-1**	10/23/2009 16:05	3.0	0.0	6.7	>6.68	>pen	>pen	N	3 to 2	>4	3 to 2	N	Y	0	Both	6.7	Stage I	N	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes @ surface; biological/physical, hard compact, sand ripples; benthic brown algal mat
Hyannis 2009	**11C-2**	10/23/2009 16:05	7.3	5.5	8.9	>8.93	2.2	>pen	N	<-1	>4	3 to 2	N	Y	0	Both	3.5	Stage I on III	Y	N	N	N	--	--	no color change; hard, compact, well sorted; Diopatra? few tiny worm tubes @ surface, worm in burrow @ 5.60 cm; biological/physical, sand ripples; voids @ 4.24 (L), 2.93 (R), & 1.91 cm (L), benthic brown algal mat, eelgrass blade buried
Hyannis 2009	**11C-3**	10/23/2009 16:06	4.9	1.9	8.2	>8.18	3.8	>pen	N	1 to 0	>4	2 to 1	N	Y	0	Physical	6.2	Stage I	Y	N	N	N	--	--	no color change; very well sorted; possible few tiny tubes; hard compact, sand ripple; tiny burrows at surface; no algae
Hyannis 2009	**12C-1**	10/23/2009 16:27	2.6	2.3	2.9	>2.88	2.0	>pen	N	2 to 1	>4	3 to 2	N	N	0	Physical	0.6	Stage I	Y	N	N	N	--	--	no color change; little shell hash, very well sorted; hard, compact, sand ripple; small burrows near surface; tiny bit of benthic brown algae
Hyannis 2009	**12C-2**	10/23/2009 16:27	6.2	5.6	6.5	>6.46	2.6	>pen	N	0 to -1	>4	3 to 2	N	Y	0	Physical	0.8	Stage I on III	Y	N	N	N	--	--	no color change; moderately sorted, little shell hash; small burrows; hard, compact, sand ripple; voids @ 1.09 & 0.82 cm on left, no algae
Hyannis 2009	**12C-3**	10/23/2009 16:28	10.4	8.9	10.9	4.3	2.2	6.3	N	1 to 0	>4	3 to 2	N	Y	0	Physical	2.0	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; few tiny worm tubes; hard, compact, sand ripples; voids @ 2.59 & 6.91 cm, encrusted rock with Codium & brown algae
Hyannis 2009	**13C-1**	10/23/2009 16:30	6.7	6.0	7.5	4.6	1.6	7.2	N	<-1	>4	2 to 1	N	Y	0	Physical	1.5	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes, Diopatra @ surface?; hard compact sand ripple; void @ 2.12 cm on right, no algae
Hyannis 2009	**13C-2**	10/23/2009 16:30	4.0	3.8	4.3	>4.32	3.6	>pen	N	<-1	>4	3 to 2	N	Y	0	Both	0.6	Stage I on III	Y	N	N	N	--	--	no color change; moderately sorted, shell hash; few tiny worm tubes, possible Diopatra?; biological/physical, hard compact sand ripples; large burrow on right; voids @ 2.26 cm (L), 2.34 cm (R), & 1.20 cm (R), patch of red algae, dead Codium @ surface
Hyannis 2009	**13C-3**	10/23/2009 16:31	5.8	0.6	5.6	2.8	0.6	5.6	Y	<-1	>4	3 to 2	N	Y	0	Both	5.0	Stage I on III	Y	N	N	N	--	--	no color change, no relict voids; few tubes; few microvoids near surface
Hyannis 2009	**14C-1**	10/23/2009 15:55	3.2	0.9	5.8	>5.76	0.0	>pen	N	<-1	>4	4 to 3	N	Y	0	Physical	4.8	Stage I	N	N	N	N	--	--	no color change; poorly sorted at surface, well sorted at depth, compact sand, scallop & Crepidula shell hash, large pebble; very tiny worm tubes @ surface; sand ripple; dead eelgrass blades, small patch benthic brown algae
Hyannis 2009	**14C-2**	10/23/2009 15:55	3.1	1.5	5.4	>5.39	0.0	>pen	N	1 to 0	>4	3 to 2	N	Y	0	Physical	3.9	Stage I	N	N	N	N	--	--	no color change; poorly sorted, Crepidula shell hash; few small worm tubes @ surface; hard compact sand; no algae
Hyannis 2009	**14C-3**	10/23/2009 15:56	4.0	1.1	6.3	>6.28	0.7	>pen	N	<-1	>4	well	N	Y	0	Physical	5.2	Stage I on III	N	N	N	N	--	--	no color change; shell hash, poorly sorted; few tiny worm tubes @ surface; sand ripples, hard compact; void @ 4.74 cm, no algae

Harbor ID	Stat ID	Image Date Time	Pen Mean (cm)	Pen Min (cm)	Pen Max (cm)	RPD Mean (cm)	RPD Min (cm)	RPD Max (cm)	Epi-fauna	GrnSz Max (phi)	GrnSz Min (phi)	GrnSz Mode (phi)	Anoxia	In-fauna	Meth Count	Surface Roughness	Surface Roughness (cm)	Succ Stage	Burrow	Clast	Pell Lyr	Color Changes	Number of Distinct Layers	Upper Layer Thickness (cm)	Notes
Hyannis 2009	**15C-1**	10/23/2009 16:37	9.2	6.8	10.8	3.4	1.0	7.1	N	0 to -1	>4	3 to 2	N	Y	0	Physical	4.1	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes & 1 amphipod tube; hard, compact sand ripple; void @ 8.74 cm (R) & 3.87 cm (L)
Hyannis 2009	**15C-2**	10/23/2009 16:38	9.4	7.4	11.0	>11.04	2.4	>pen	N	1 to 0	>4	3 to 2	N	Y	0	Physical	3.6	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; very few tiny worm tubes; hard compact sand ripples; voids @ 2.80 cm (C), 2.64 cm (R), & 1.03 cm (R), no algae
Hyannis 2009	**15C-3**	10/23/2009 16:38	6.5	5.3	7.8	4.4	2.3	6.3	N	0 to -1	>4	3 to 2	N	Y	0	Physical	2.5	Stage I on III	Y	N	N	N	--	--	no color change; well sorted; few tiny worm tubes; hard, compact sand ripple; voids @ 0.50 & 1.21 cm in center, no algae

Appendix B

Plan-View Video Results for New England CAD Cells
October 2009

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Norwalk	1R-1	SOFT	-	DETRITUS
Norwalk	1R-2	SOFT	-	DETRITUS
Norwalk	1R-3	SOFT	-	DETRITUS
Norwalk	2C-1	SOFT	-	PITS
Norwalk	2C-2	SOFT	-	DETRITUS
Norwalk	2C-3	SOFT	-	DETRITUS
Norwalk	2R-1	SOFT	SNAILS	DETRITUS
Norwalk	2R-2	SOFT	SNAILS	DETRITUS
Norwalk	2R-3	SOFT	-	DETRITUS
Norwalk	3C-1	SOFT	-	PITS
Norwalk	3C-2	SOFT	-	PITS
Norwalk	3C-3	SOFT	-	PITS
Norwalk	3R-1	SOFT	SNAILS	DETRITUS
Norwalk	3R-2	SOFT	-	DETRITUS
Norwalk	3R-3	SOFT	-	DETRITUS
Norwalk	4C-1	SOFT	-	-
Norwalk	4C-2	SOFT	-	-
Norwalk	4C-3	SOFT	-	-
Norwalk	4R-1	SOFT	SNAILS	-
Norwalk	4R-2	SOFT	SNAILS	-
Norwalk	4R-3	SOFT	SNAILS	-
Norwalk	5C-1	SOFT	-	-
Norwalk	5C-2	SOFT	-	-
Norwalk	5C-3	SOFT	-	-
Norwalk	5R-1	SOFT	SNAILS	-
Norwalk	5R-2	SOFT	SNAILS	TUBES
Norwalk	5R-3	SOFT	-	-
Norwalk	6C-1	SOFT	SNAILS	TUBES
Norwalk	6C-2	SOFT	SNAILS	TUBES
Norwalk	6C-3	SOFT	SNAILS	TUBES
Norwalk	6R-1	SOFT	SNAILS	TUBES
Norwalk	6R-2	SOFT	SNAILS	TUBES
Norwalk	6R-3	SOFT	SNAILS	TUBES
Norwalk	7C-1	SOFT	SNAILS	PITS
Norwalk	7C-2	SOFT	SNAILS	-
Norwalk	7C-3	SOFT	SNAILS	-
Norwalk	7R-1	SOFT	SNAILS	TUBES
Norwalk	7R-2	SOFT	SNAILS	TUBES
Norwalk	7R-3	SOFT	SNAILS	TUBES
Norwalk	8C-1	SOFT	SNAILS	DETRITUS. PITS
Norwalk	8C-2	SOFT	-	-

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Norwalk	8C-3	SOFT	SNAILS	-
Norwalk	8R-1	SOFT	-	ALGAE, DETRITUS
Norwalk	8R-2	SOFT	-	TUBES
Norwalk	8R-3	SOFT	SNAILS	TUBES
Norwalk	9C-1	SOFT	SNAILS	DETRITUS
Norwalk	9C-2	SOFT	-	-
Norwalk	9C-3	SOFT	-	-
Norwalk	9R-1	SOFT	-	TUBES
Norwalk	9R-2	SOFT	SNAILS	-
Norwalk	9R-3	SOFT	-	TUBES
Norwalk	10R-1	SOFT	SNAILS	TUBES
Norwalk	10R-2	SOFT	-	-
Norwalk	10R-3	SOFT	-	-
Norwalk	11C-1	SOFT	SNAILS	TUBES
Norwalk	11C-2	SOFT	-	-
Norwalk	11C-3	SOFT	-	-
Norwalk	13C-1	SOFT	SNAILS	PITS
Norwalk	13C-2	SOFT	SNAILS	-
Norwalk	13C-3	SOFT	SNAILS	DETRITUS. PITS
Norwalk	15C-1	SOFT	-	DETRITUS
Norwalk	15C-2	SOFT	-	-
Norwalk	15C-3	SOFT	SNAILS	PITS

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
New London	1C-1	SOFT-PEBBLE	-	-
New London	1C-2	SOFT	-	-
New London	1C-3	SOFT	-	-
New London	1R-1	SOFT/SHELL	-	-
New London	1R-2	SOFT/SHELL	-	-
New London	1R-3	SOFT/SHELL	-	-
New London	2C-1	SOFT	-	PITS
New London	2C-2	SOFT	-	PITS
New London	2C-3	SOFT	-	PITS
New London	2R-1	SOFT/SHELL	-	-
New London	2R-2	SOFT/SHELL	-	-
New London	2R-3	SOFT/SHELL	-	-
New London	3C-1	SOFT/SHELL	-	-
New London	3C-2	SOFT/SHELL	-	PITS
New London	3C-3	SOFT/SHELL	-	-
New London	4C-1	SOFT	-	PITS
New London	4C-2	SOFT	-	PITS
New London	4C-3	SOFT	-	-
New London	4R-1	SOFT/SHELL	-	-
New London	4R-2	SOFT/SHELL	-	-
New London	4R-3	SOFT/SHELL	-	-
New London	5C-1	SOFT	-	PITS
New London	5C-2	SOFT	-	PITS
New London	5C-3	SOFT	-	PITS
New London	5R-1	SOFT/SHELL	-	-
New London	5R-2	SOFT/SHELL	-	-
New London	5R-3	SOFT/SHELL	-	-
New London	6R-1	SOFT	-	-
New London	6R-2	SOFT	-	-
New London	6R-3	SOFT	-	-
New London	7C-1	SOFT	-	PITS
New London	7C-2	SOFT	-	PITS
New London	7C-3	SOFT	-	PITS
New London	7R-1	SOFT	-	PITS
New London	7R-2	SOFT	-	PITS
New London	7R-3	SOFT	-	PITS
New London	8C-1	SOFT	-	PITS
New London	8C-2	SOFT	-	PITS
New London	8C-3	SOFT	-	PITS
New London	8R-1	SOFT	-	-
New London	8R-2	SOFT	-	-

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
New London	8R-3	SOFT	-	PITS
New London	9C-1	SOFT	-	PITS
New London	9C-2	SOFT	-	PITS
New London	9C-3	SOFT	-	PITS
New London	9R-1	SOFT	-	PITS
New London	9R-2	SOFT	-	-
New London	9R-3	SOFT	-	PITS
New London	10C-1	SOFT	-	PITS
New London	10C-2	SOFT	-	PITS
New London	10C-3	SOFT	-	PITS
New London	10R-1	SOFT	-	-
New London	10R-2	SOFT	-	-
New London	10R-3	SOFT	-	-
New London	11C-1	SOFT	-	-
New London	11C-2	SOFT	-	-
New London	11C-3	SOFT	-	PITS
New London	12C-1	SOFT	-	PITS
New London	12C-2	SOFT	-	-
New London	12C 3	SOFT	-	-
New London	13C-1	SOFT/SHELL	-	-
New London	13C-2	SOFT/SHELL	-	-
New London	13C-3	SOFT/SHELL	-	-
New London	4C -1	SOFT	-	PITS
New London	14C-2	SOFT	-	PITS
New London	14C-3	SOFT	-	PITS
New London	15C-1	SOFT/SHELL	-	-
New London	15C-2	SOFT	-	-
New London	15C-3	SOFT	-	PITS

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Providence	1C-1	SOFT	-	-
Providence	1C-2	SOFT	-	-
Providence	1C-3	SOFT	-	-
Providence	1R-1	SOFT	-	-
Providence	1R-2	SOFT	-	-
Providence	1R-3	SOFT	-	-
Providence	2C-1	SOFT	BACTERIA MAT?	-
Providence	2C-2	SOFT	BACTERIA MAT?	-
Providence	2C-3	SOFT	BACTERIA MAT?	DETRITUS
Providence	2R-1	SOFT	-	-
Providence	2R-2	SOFT	-	-
Providence	2R-3	SOFT	-	-
Providence	3R-1	SOFT	-	-
Providence	3R-2	SOFT	-	-
Providence	3R-3	SOFT	-	-
Providence	4C-1	SOFT	-	-
Providence	4C-2	SOFT	-	-
Providence	4C-3	SOFT	-	-
Providence	4R-1	SOFT	BACTERIA MAT?	-
Providence	4R-2	SOFT	-	-
Providence	4R-3	SOFT	BACTERIA MAT?	-
Providence	5C-1	SOFT	BACTERIA MAT?	-
Providence	5C-2	SOFT	-	-
Providence	5C-3	SOFT	-	-
Providence	5R-1	SOFT	BACTERIA MAT?	-
Providence	5R-2	SOFT	BACTERIA MAT?	-
Providence	5R-3	SOFT	BACTERIA MAT?	-
Providence	6C-1	SOFT	-	-
Providence	6C-2	SOFT	BACTERIA MAT?	-
Providence	6C-3	SOFT	BACTERIA MAT?	-
Providence	6R-1	SOFT	BACTERIA MAT?	-
Providence	6R-2	SOFT	-	-
Providence	6R-3	SOFT	-	TUBES
Providence	7C-1	SOFT	-	-
Providence	7C-2	SOFT	-	ALGAE
Providence	7C-3	SOFT	-	-
Providence	7R-1	SOFT	-	DETRITUS
Providence	7R-2	SOFT	-	-
Providence	7R-3	SOFT	-	-
Providence	8C-1	SOFT	BACTERIA MAT?	-
Providence	8C-2	SOFT	BACTERIA MAT?	-

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Providence	8C-3	SOFT	BACTERIA MAT?	-
Providence	8R-1	SOFT	-	-
Providence	8R-2	SOFT	-	DETRITUS
Providence	8R-3	SOFT	-	-
Providence	9C-1	SOFT	-	-
Providence	9C-2	SOFT	-	-
Providence	9C-3	SOFT	-	-
Providence	9R-1	SOFT	-	-
Providence	9R-2	SOFT	-	TUBES
Providence	9R-3	SOFT	-	TUBES
Providence	10C-1	SOFT	BACTERIA MAT?	-
Providence	10C-2	SOFT	-	-
Providence	10R-1	SOFT	-	-
Providence	10R-2	SOFT	-	-
Providence	10R-3	SOFT	-	-
Providence	11C-1	SOFT	-	-
Providence	11C-2	SOFT	-	-
Providence	11C-3	SOFT	-	-
Providence	12C-1	SOFT	-	-
Providence	12C-2	SOFT	-	-
Providence	12C-3	SOFT	-	-
Providence	13C-1	SOFT	MICROALGAL MAT?	-
Providence	13C-2	SOFT	MICROALGAL MAT?	-
Providence	13C-3	SOFT	-	DETRITUS
Providence	14C-1	SOFT	-	-
Providence	14C-2	SOFT	-	-
Providence	14C-3	SOFT	-	-
Providence	15C-1	SOFT	BACTERIA MAT?	-
Providence	15C-2	SOFT	-	-
Providence	15C-3	SOFT	-	-

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Hyannis	1C-1	SAND	-	-
Hyannis	1C-2	SAND	ALGAE	-
Hyannis	1C-3	SAND	-	-
Hyannis	1R-1	SAND/SHELL	ALGAE	-
Hyannis	1R-2	SAND/SHELL	ALGAE	-
Hyannis	1R-3	SAND/SHELL	ALGAE	-
Hyannis	2C-1	SAND/SHELL	ALGAE	-
Hyannis	2C-2	SAND/SHELL	-	-
Hyannis	2C-3	SAND/SHELL	-	-
Hyannis	2R-1	SAND/SHELL	ALGAE	-
Hyannis	2R-2	SAND/SHELL	ALGAE	-
Hyannis	2R-3	SAND/SHELL	ALGAE	-
Hyannis	3C-1	SAND	ALGAE	-
Hyannis	3C-2	SAND	-	-
Hyannis	3C-3	SAND/SHELL	-	-
Hyannis	3R-1	SAND-PEBBLE/SHELL	ALGAE	-
Hyannis	3R-2	SAND-PEBBLE/SHELL	ALGAE	-
Hyannis	3R-3	SAND-PEBBLE/SHELL	ALGAE	-
Hyannis	4C-1	SAND	-	-
Hyannis	4C-2	SAND	-	-
Hyannis	4C-3	SAND	ALGAE	-
Hyannis	4R-1	SAND/SHELL	-	-
Hyannis	4R-2	SAND/SHELL	ALGAE	-
Hyannis	4R-3	SAND/SHELL	ALGAE	-
Hyannis	5C-1	SAND/SHELL	ALGAE	-
Hyannis	5C-2	SAND/SHELL	ALGAE	-
Hyannis	5C-3	SAND/SHELL	ALGAE	-
Hyannis	5R-1	SAND-PEBBLE/SHELL?	ALGAE	-
Hyannis	5R-2	SAND-PEBBLE/SHELL	ALGAE	-
Hyannis	5R-3	SAND-PEBBLE/SHELL	ALGAE	-
Hyannis	5R-4	SAND/SHELL	ALGAE	-
Hyannis	6C-1	SAND	-	-
Hyannis	6C-2	SAND	-	-
Hyannis	6C-3	SAND	-	-
Hyannis	6R-1	SAND	-	-
Hyannis	6R-2	SAND	-	-
Hyannis	6R-3	SAND/SHELL	-	-
Hyannis	7C-1	SAND/SHELL	ALGAE	-
Hyannis	7C-2	SAND/SHELL	ALGAE	-
Hyannis	7C-3	SAND/SHELL	ALGAE	-
Hyannis	7R-1	SAND	ALGAE	-

APPENDIX B
Plan-View Video Results for New England CAD Cells
October 2009

SITE	STATION	SEDIMENT	EPIFAUNA	BIOGENIC
Hyannis	7R-2	SAND/SHELL	ALGAE	-
Hyannis	7R-3	SAND	-	-
Hyannis	8C-1	SAND/SHELL	ALGAE	-
Hyannis	8C-2	SAND/SHELL	ALGAE	-
Hyannis	8C-3	SAND/SHELL	ALGAE	-
Hyannis	8R-1	SAND/SHELL	-	-
Hyannis	8R-2	SAND/SHELL	-	-
Hyannis	8R-3	SAND/SHELL	ALGAE	-
Hyannis	9C-1	SAND	-	-
Hyannis	9C-2	SAND	-	-
Hyannis	9C-3	SAND	ALGAE	-
Hyannis	9R-1	SAND	-	-
Hyannis	9R-2	SAND/SHELL	-	-
Hyannis	10C-1	SAND	-	-
Hyannis	10C-2	SAND	-	-
Hyannis	10C-3	SAND	-	-
Hyannis	10R-1	SAND	-	-
Hyannis	10R-2	SAND	-	-
Hyannis	10R-3	SAND	-	-
Hyannis	11C-1	SAND/SHELL	ALGAE	-
Hyannis	11C-2	SAND	ALGAE	-
Hyannis	11C-3	SAND/SHELL	ALGAE	-
Hyannis	12C-1	SAND/SHELL	ALGAE	-
Hyannis	12C-2	SAND/SHELL	ALGAE	-
Hyannis	12C-3	SAND/SHELL	ALGAE	-
Hyannis	13C-1	SAND/SHELL	ALGAE	-
Hyannis	13C-2	SAND/SHELL	ALGAE	-
Hyannis	13C-3	SAND/SHELL	ALGAE	-
Hyannis	14C-1	SAND/SHELL	-	-
Hyannis	14C-2	SAND/SHELL	ALGAE	-
Hyannis	14C-3	SAND/SHELL	-	-
Hyannis	15C-1	SAND	-	-
Hyannis	15C-2	SAND	-	-
Hyannis	15C-3	SAND	-	-

Appendix C

Underwater Video Transect Logs for New England CAD Cells
October 2009

Norwalk South-North Transect (VTS_02_0)

Total Time: 30:42

The transect begins to the southwest of the CAD cells, proceeds northeast and enters CAD cell 1 in the center of the southern border, exiting in the center of the northern border. It continues north, entering CAD cell 2 in the center of the southern border and exiting just west of center of the northern border.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:51		Camera travels through water column; bottom not visible
0:52		Bottom visible
0:55		Sled makes contact with bottom, creating turbidity plume
0:55-1:10	Polychaete and possibly amphipod tubes; occasional macroalgae; abundant large burrow holes	Level bottom with soft sediment and occasional pebbles and shells/shell hash. Abundant leaf litter. Sled periodically makes contact with bottom, creating turbidity plumes
1:10	Polychaete and possibly amphipod tubes; snails and snail trails	
1:12		Debris
2:42		Debris
2:53		Plastic debris
2:59		Plastic debris
3:11		Woody debris
3:44		Debris
3:46		Aluminum can
3:47	Small fish	
4:15		Large plastic debris (bag?) becomes entangled on sled, creating occasional turbidity plumes
4:20	Small fish	
4:43-4:45	Snail trails	
5:10	Small fish	
5:18		Plastic debris
5:21-6:00	Small fish	
5:30		Plastic bag
6:21		Plastic bag
6:22-7:15	Small fish	
7:40-8:20	Occasional small fish	
8:06		Woody debris
8:14	Crab carcass	
8:18	Crab	
8:10	Snail trails	
8:31		Possible aluminum can
8:35	Small fish	
8:40		Encrusted debris
8:54-9:00	Small fish	
9:01-9:22		Camera becomes entangled in encrusted line; bottom no longer visible
9:23		Bottom visible
9:25		Plastic bag
9:28-10:40	Small fish, abundant at times	
9:33-9:40		Possible encrusted lines
9:49		Woody debris
10:03-10:13		Camera possibly directed upward; bottom not visible
10:20		Plastic debris
10:21-10:40	Macroalgae	Woody debris, mussel shell, shell hash
10:41-11:14		Camera becomes entangled in barnacle-encrusted plastic bag; bottom not visible

Norwalk South-North Transect (VTS_02_0)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
11:15		Camera enters southern end of CAD cell 1 footprint and makes contact with seabed; brief turbidity plume; no visible change in substrate
11:15-14:03	Small fish, abundant at times; occasional macroalgae; large burrow holes	Bottom is similar to ambient channel bottom: soft sediment with leaf litter, woody debris, trash, shell hash
12:12		Debris (metal?)
12:37-12:39	Small fish	
13:20		Woody debris with entangled plastic
13:43		Aluminum can or plastic cup
14:04-14:11	Numerous small fish	Bottom no longer visible
14:12-16:09	Occasional small fish	Bottom visible, but with poor visibility. Bottom similar to previous but with less leaf litter, woody debris, trash, and shell hash. Visibility continues to decline throughout survey as camera lens is fouled
14:51	Crab	
14:56	Snail trails	
15:04-15:40	Snail trails	
16:10	Snail trails	
16:10-16:20		Softer sediment
16:20-16:36		Sled creates turbidity, bottom not visible
16:37		Bottom briefly visible
16:38-16:59		Bottom not visible due to turbidity and then camera ascending through water column. Camera exits northern end of CAD cell 1 footprint; no visible change in substrate
16:47-16:54		Camera cable visible
17:00-17:33		Camera is just below water surface, camera cable visible
17:34		Camera breaks surface and is pulled up on deck
18:03		Camera is deployed again and descends through water column
18:13		Camera makes contact with seabed, generating turbidity
18:17-18:42		Bottom not visible due to turbidity and then camera ascending through water column
18:43-18:58	Numerous large burrow holes	Bottom visible
18:59-19:11		Bottom not visible due to turbidity plume
19:12		Bottom visible. Very soft sediment
19:14		Plastic bag
19:15-19:19		Bottom not visible due to turbidity plume
19:20-21:34	Large burrow holes	Bottom visible. Very soft sediment with occasional leaf litter
19:55	Rockweed	Rockweed caught on camera
20:30	Snail trails	
20:38	Numerous fish trails	
20:50-20:56	Abundant encrusting algae	
21:12-21:24	Numerous fish trails	
21:35-23:06	Snail trails	Camera enters southern end of CAD cell 2 footprint; no visible change in substrate
23:06-23:12	Polychaete and possibly amphipod tubes	
23:17-23:23		Bottom not visible. Camera appears to be descending
23:24	Occasional fish trails, large burrow holes	Camera makes contact with seabed, generating turbidity. Bottom is similar to ambient channel bottom: soft sediment with leaf litter, some macroalgae. Topography is slightly more irregular than ambient seafloor
23:52		Aluminum can
24:20		Plastic debris
24:37		Plastic debris

Norwalk South-North Transect (VTS_02_0)		(continued)
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
24:40-24:45		Turbidity plume
25:13		Sled catches on linear (woody?) debris
25:53		Aluminum can
26:02-26:12		Turbidity obscures view. Camera exits northern end of CAD cell 2 footprint (not visible in video)
26:13-30:42		Seabed is soft sediment with leaf litter; sled generates turbidity intermittently as it makes contact with bottom
26:37	Beggiatoa sp. bacterial mats	
26:41		Plastic debris
27:33	Crab carcass	
28:03-28:07		Leaf over camera lens partially obscures view
29:20		Large timber
29:25-29:36		Abundant leaf litter
29:37-30:08		Somewhat irregular topography
30:09-30:42		Abundant leaf litter

*Indicates area is within the approximate CAD cell footprint.

Norwalk West-East Transect (VTS_03_0) Total Time: 2:36 The transect begins in the Northwest corner of CAD cell 2 (northern most cell) and proceeds northeast along the northern edge of the cell.		
Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:10		Camera enters CAD cell and travels through water column, bottom not visible.
0:11		Bottom visible
0:12		Sled makes contact with bottom and creates a turbidity plume
0:12-0:26		Sled ascends, bottom not visible
0:26-0:30		Sled makes contact with the bottom and creates a plume
0:30-0:43		Sled ascends, bottom not visible
0:43-0:50		Soft sediment, leaf litter, sticks, and debris on bottom; small pock marks in sediment, possibly borrows
0:50-0:53	2 small crabs	
0:53-1:04		Soft sediment with intermittent gravel, leaf litter, woody debris, and other debris
1:04-1:11		Bottom not visible
1:12		Sled hits bottom and creates a silty plume
1:12-1:14		Camera is in plume, no visibility
1:14		Stick caught on right side of camera Lens
1:14-1:22		Camera is too high in water column to see the bottom
1:22		Sled bounces off the bottom and creates a plume
1:22-1:38		Turbidity plume, bottom not visible
1:38-1:55		Sled is dragged across the bottom, stirring up sediment and leaf litter and impairing visibility
1:54		Camera briefly exits and re-enters CAD cell, no visible change in substrate, substantial turbidity
1:55-2:25		Sled continues to bounce off the bottom and stir up sediment, bottom is not visible
2:25		Plastic bag
2:25-2:28		Plastic bad tangled in woody debris
2:28-2:35	Barnacles attached to woody debris	Woody debris
2:36	Macroalgae	

*Indicates area is within the approximate CAD cell footprint.

Norwalk West-East Transect (VTS_04_0) Total Time: 3:16 The transect begins in the Northwest corner of CAD cell 1 (southern CAD Cell) and proceeds northeast through the middle of the cell.		
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
0:00-0:13		Camera enters the CAD cell and travels through water column, bottom not visible
0:13		Bottom visible
0:15		Sled makes contact with bottom and creates a turbidity plume
0:15-0:25	Snails, snail trails, and burrow holes	Soft, silty sediment
0:26		Dark sediment patch
0:26-0:42		Soft sediment with leaf litter; camera slowly ascends, or the CAD cell is deepening
0:42-0:47		Sled makes contact with the bottom and creates a plume
0:47-1:03	Snails, snail trails, and burrow holes	Soft, silty sediment with intermittent gravel
1:04-1:05		Sled makes contact with the bottom and creates a turbidity plume
1:05-1:20	Snails, snail trails, and burrow holes	Soft sediment with intermittent gravel, leaf litter
1:20	Macroalgae	Debris pile
1:21		Plastic bag
1:22-1:26		Cluster of woody debris caught on camera Lens
1:26		Trash, plastic cup
1:26-1:33		Cluster of woody debris caught on camera lens
1:33-1:35		Bottom is not visible, camera is too high in the water column
1:35		Sled makes contact with bottom and creates a turbidity plume
1:36		Plastic bag
1:36-1:43		Soft sediment with intermittent gravel and leaf litter
1:43	Snail trails	
1:43-1:45		Sled makes contact with the bottom and creates a turbidity plume
1:45-1:49		Soft sediment with intermittent gravel and leaf litter
1:49		Plastic bag
1:49-1:53		Soft sediment with intermittent gravel and leaf litter
1:55-2:29	Snails and snail trails	Soft sediment with intermittent gravel and leaf litter
2:24		Camera exits the CAD cell, substrate remains uniform
2:29-2:31		Sled makes contact with the bottom and creates a turbidity plume
2:31-2:37	Snails and snail trails	Soft sediment with intermittent gravel and leaf litter
2:37-2:40		Sled drags across the bottom
2:40-2:42		Turbidity obscures visibility
2:42-2:45		Sled drags across the bottom
2:45-2:50		Turbidity obscures visibility
2:50-2:56	Snails and snail trails	Soft, silty sediment with intermittent gravel and leafy debris
2:56-2:58		Sled digs into the sediment
2:58-3:09		Turbidity obscures visibility
3:09-3:15	Snails and snail trails	Low visibility, soft bottom with intermittent gravel
3:16		Camera begins ascent through the water column

*Indicates area is within the approximate CAD cell footprint.

New London North-South Transect (VTS_01_1)
Total Time: 31:37
The transect begins south of the proposed CAD cell and travels north through the proposed CAD cell and into the existing CAD cell.

Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
0:00-0:17		Video camera is resting on the bottom; silty substrate, shell hash, large empty whelk shells, and various other shells
0:17	Hermit crab begins emerging from its shell just before camera lifts off of substrate	
0:17-0:34		Camera high in the water column, bottom not visible
0:34		Camera makes contact with substrate, creates turbidity plume
0:35-0:52	Numerous moon snails, alive and dead	Silty substrate, shell hash, mixed cobbles
0:52-1:40		Dense shells and shell hash patch, silty substrate
1:08	Large spider crab	
1:15	Large spider crab	
1:40-1:44		Silty substrate, less dense shells and shell hash, mixed cobbles
1:44-1:50		Dense shells and shell hash patch, silty substrate
1:50-2:06		Silty substrate, less dense shell hash, mixed cobbles
1:54	Atlantic rock crab runs across screen, creates a turbidity plume	
2:02-2:08	Large spider crab stuck on the bottom of the camera	Silty substrate, dense shells and shell hash
2:08-5:04		Silty substrate, dense shells and shell hash
2:56-2:57	Large rock crab emerges from substrate and creates a turbidity plume	
2:59	Small fish darts away (middle-left of screen)	
3:20	Large whelk, trail visible in video	
3:40-3:41	Medium hermit crab	
3:57	Medium spider crab	
4:11	Hermit crab	
4:13	Medium spider crab	
5:04-5:09		Silty substrate, scattered cobble, sparse shell hash
5:09-6:15		Silty substrate, moderate shells and shell hash, scattered cobble
5:45	Small spider crab	
5:56	Small spider crab	
5:57	Possibly small shrimp	
6:15-6:18		Camera runs into a large log; silty substrate, moderate shells and shell hash
6:18-6:55		Silty substrate, moderate shells and shell hash
6:21	Medium spider crab	
6:50	Hermit crab	
6:55		Medium sized log
6:55-7:07		Silty substrate, moderate shells and shell hash, scattered cobble
7:07-7:58		Silty substrate, dense shells and shell hash, scattered cobble
7:43	Hermit crab	
7:51	Medium spider crab	
7:58-8:01		Silty substrate, moderate shells and shell hash, scattered cobble
8:01-8:17		Silty substrate, dense shells and shell hash, scattered cobble
8:06	Large spider crab	
8:17-8:30		Silty substrate, moderate shells and shell hash, scattered cobble
8:30-8:39		Silty substrate, moderate cobble, sparse shell hash
8:38	Lobster in burrow hole	

New London North-South Transect (VTS_01_1)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
8:39-8:46		Silty substrate, moderate shells and shell hash, scattered cobble
8:46-9:24		Silty substrate, moderate shells and shell hash, more dense cobble
8:53	Small fish darts across screen	
9:24-9:35		Silty substrate, dense shells and shell hash, scattered cobble
9:35-9:39		Silty substrate, sparse shell hash
9:39-9:41		Large boulder covered in algae, dense shell hash
9:39	Tunicates attached to rock	
9:41-10:01		Silty substrate, moderate shells and shell hash, scattered cobble
10:01-10:04		Silty substrate, dense shells and shell hash, scattered cobble
10:04	Rope/line with green (maybe brown) algae attached	Entrance into proposed CAD Cell
10:04-10:29		Silty substrate, dense shells and shell hash, scattered cobble
10:20	Large moon snail, snail trail visible	
10:29-10:36		Silty substrate, moderate cobble, sparse shell hash
10:36-10:50		Silty substrate, moderate shells and shell hash, scattered cobble
10:50-10:59		Silty substrate, dense shells and shell hash
10:59-11:14		Silty substrate, dense cobble, sparse shells and shell hash
11:14-11:39		Silty substrate, moderate shells and shell hash, scattered cobble
11:39-11:46		Silty substrate, sparse shells and shell hash
11:46-11:54		Silty substrate, moderate shells and shell hash, scattered cobble
11:54		Pile of small woody debris
11:54-12:29		Silty substrate, dense shells and shell hash, scattered cobble
12:22	Medium spider crab	
12:29-12:42		Silty substrate, sparse shells and shell hash
12:42-12:55		Silty substrate, dense shells and shell hash
12:46	Small (pencil sized) burrow holes (~10 holes), possibly from small shrimp	
12:55-13:03		Silty substrate, sparse shells and shell hash
13:03-13:16		Silty substrate, moderate shells and shell hash
13:16-13:29		Silty substrate, sparse shells and shell hash, scattered cobble
13:29-13:30		Large turbidity plume
13:30-13:44		Silty substrate, sparse shells and shell hash
13:44-13:49		Silty substrate, sparse shells and shell hash, scattered pebbles and cobble
13:49-15:04		Silty substrate, sparse shells and shell hash
14:02-14:54	Small (pencil sized) burrow holes, possibly from small shrimp	
15:04-15:16		Silty substrate, moderate shells and shell hash
15:16-15:28		Silty substrate, sparse shells and shell hash, scattered pebbles
15:28-15:38		Silty substrate, moderate shells and shell hash
15:38-15:53		Silty substrate, sparse shells and shell hash
15:48	Small (pencil sized) burrow holes, possibly from small shrimp	
15:53-16:10		Silty substrate, sparse shells and shell hash, scattered pebbles
16:10-16:29		
16:12	Medium sized flounder swims in front of camera	

New London North-South Transect (VTS_01_1)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
16:15	Small fish, possibly flounder, darts along seafloor, creating turbidity plume	Silty substrate, sparse shells and shell hash
16:26	Small (pencil sized) burrow holes, possibly from small shrimp	Silty substrate, sparse shells and shell hash
16:29-17:09		Silty substrate, piles of moderate shells, and shell hash
16:52	Small (pencil sized) burrow holes, possibly from small shrimp	
17:09-17:34		Silty substrate, sparse shells and shell hash
17:16	Hermit crab	
17:29	Small gashes on substrate	
17:34-18:01		Silty substrate, moderate shells and shell hash
18:01		Branch on silty substrate
18:01-18:59		Silty substrate, moderate shells and shell hash, scattered pebbles
18:17	Small fish darts off and stirs up sediment	
18:28	Small gashes on substrate	
18:30-18:33	Small (pencil sized) burrow holes, possibly from small shrimp	
18:37-18:39	Atlantic rock crab emerges from substrate, creates a turbidity plume	
18:46	Moon snail and snail trail	
18:49	Snail trail	
18:59-19:50		Silty substrate, sparse shells and shell hash
19:18	Small (pencil sized) burrow holes, possibly from small shrimp	
19:21	Clump of green algae	
19:43	Organism creates a turbidity plume while burrowing into substrate (left side of screen)	
19:47-19:51	Crab swims off leaving turbidity trail behind	
19:51-21:36		Silty substrate, sparse shells and shell hash, occasional leaf litter, occasional burrow holes
20:13	Green algae	
20:24	Small gashes on substrate	
20:52	Snail trail	
21:33	Small (pencil sized) burrow holes, possibly from small shrimp	
21:36-21:37		Large chunk of debris covered in silty sand
21:37-23:18		Silty substrate, sparse shells and shell hash, occasional leaf litter, occasional burrow holes
21:52	Small (pencil sized) burrow holes, possibly from small shrimp	
21:57	Small (pencil sized) burrow holes, possibly from small shrimp	
22:18	Small (pencil sized) burrow holes, possibly from small shrimp	Entrance into existing CAD cell, no noticable change in substrate
22:37	Medium burrow hole	Silty substrate, sparse shells and shell hash, occasional leaf litter, occasional burrow holes
22:41	Small gashes on substrate	
22:43	Small gashes on substrate	
22:44	Fish darts from substrate, creating a turbidity plume	
22:57-23:02	Numerous pencil sized burrow holes, possibly from small shrimp	
23:12-23:16	Numerous pencil sized burrow holes, possibly from small shrimp	
23:18-24:02		Silty substrate, sparse/moderate shells and shell hash
24:02-24:05		Silty/silty substrate, uneven terrain, sloping cliff
24:05-24:17		Camera too high in the water column, no visibility

New London North-South Transect (VTS_01_1)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
24:17		Camera makes contact with substrate, creates turbidity plume
24:18-24:26		Camera too high in the water column, no visibility
24:26-24:29		Silty/silty substrate, very sparse shell hash, visibility is poor
24:28	Medium fish, unknown species	
24:29-24:36		Camera too high in the water column, no visibility
24:36-24:37	Green algae	Camera makes contact with object, possibly large rock, bounces off and lands on substrate
24:37-24:48		Camera too high in the water column, no visibility
24:48	Green algae	Camera makes contact with substrate, creates turbidity plume
24:58	Green algae	
24:48-25:20		Silty/silty substrate, very sparse shell hash, visibility is poor
25:10	Medium spider crab	
25:15	Green algae	
25:20	Green algae	
25:20-25:49		Silty/silty substrate, very sparse shell hash, visibility is poor
25:23	Green algae	
25:27	Green algae	
25:38	Small fish, unknown species	
25:44	Small burrow hole	
25:49-25:51		Camera makes contact with large log, creates a turbidity plume
25:51-26:41		Silty/silty substrate, very sparse shell hash, visibility is poor
26:30	Burrow hole	
26:35	small gashes on substrate	
26:41	Green algae	Camera makes contact with large rock
26:41-27:06		Silty/silty substrate, very sparse shell hash, visibility is poor
26:50	Medium sculpin on bottom, swims off and creates turbidity plume	
27:06-27:08	Patch of green, red, and brown algae	
27:08-27:10		Camera makes contact with large rock/large log
27:10-27:15		Silty/silty substrate, very sparse shell hash, visibility is poor
27:15		Debris
27:15-27:26		Silty/silty substrate, very sparse shell hash, visibility is poor
27:22	Patch of burrow holes, pencil sized	
27:26		Camera makes contact with large rock/large log
27:26-27:33		Camera is too high in the water column, no visibility
27:33-27:56		Silty/silty substrate, very sparse shell hash, visibility is poor
27:37	Medium burrow hole	
27:56-28:00	Green algae	Silty/silty substrate, patch of green algae
28:00-30:36		Silty/silty substrate, very sparse shell hash, visibility is poor
28:10	Medium burrow hole	
28:14-28:16	Flounder creates turbidity plume	
28:21	Green algae	
28:22	Patch of burrow holes, pencil sized	
28:29	Green algae	
28:39	Green algae	
28:42	Patch of burrow holes, pencil sized	
28:46	Medium burrow hole	
28:57	2 medium borrow holes	
29:01	Medium burrow hole	
29:19	Green algae	
29:36	Medium burrow hole	
29:52	Medium fish	
30:21		Camera exits CAD cell, no noticable change in substrate

New London North-South Transect (VTS_01_1)		(continued)
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
30:36-30:39	Green algae	Camera runs into a debris pile covered with green algae
30:38		Aluminum can
30:39-30:59		Silty/silty substrate, very sparse shell hash, visibility is poor
30:59-31:02		Camera runs into clump of silt covering the screen, no visibility
31:02-31:21		Silty/silty substrate, very sparse shell hash, visibility is poor
31:14	Crab claw	
31:21		Camera runs into large rock covered in debris
31:21-31:37		Silty/silty substrate, very sparse shell hash, visibility is poor

*Small pencil sized burrows, most likely clam beds

*Indicates area is within approximate existing CAD cell footprint

New London North-South Transect (VTS_02_0)
Total Time: 8:30

The transect begins to the west of the CAD cell and travels eastward, approximately bisecting the cell and exiting on the cell's eastern border.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:06		Camera descends to the seafloor
0:07-0:29		Camera appears to bounce off the soft seafloor several times, each time creating a turbidity plume as it makes contact with the bottom and then ascending, during which the bottom is no longer visible
0:29-3:32	Numerous small fish; small burrow holes	Bottom is flat and featureless with fine-grained sediment; occasional leaf litter; visibility is fair to poor
1:04	Green algae	
1:02	Medium burrow hole	
1:06	Green algae covering object	
1:13	Green algae	
1:37		Camera makes contact with soft seafloor, creating turbidity plume
2:01	Possible partially buried flounder	
2:23		Possible fishing line
2:26	Medium burrow hole	
2:50		Camera makes contact with soft seafloor, creating turbidity plume
3:06		Possible fishing line
3:12		Possible fishing line
3:21	Possible flounder	
3:32-3:38		Descent into CAD cell; bottom not visible
3:39-8:01	Small burrow holes	CAD cell bottom is similar to surrounding channel bottom; level, featureless, fine-grained substrate with, sparse shell hash, and occasional leaf litter; visibility is fair to poor
3:41-3:48		Descent; bottom not visible
3:43	Green algae	
3:49		Bottom is visible; log
3:51	Several unidentified fish	
3:55	Green algae and possible flounder	
4:02		Camera makes contact with soft seafloor, creating turbidity plume
4:12-4:16		Bottom not visible
4:17		Bottom is momentarily visible
4:18-4:22		Camera makes contact with soft seafloor, creating turbidity plume; bottom not visible
4:23	Green algae covering object	
4:24-4:27		Bottom barely visible
4:28		Camera makes contact with seafloor
4:29	Medium burrow hole	
4:33		Large encrusted object, possibly clay clast or rock
4:39		Aluminum can
4:44	Large burrow hole	
4:50	Green algae	
4:50-4:54	Green and red algae covering 2 logs	
4:55-5:02		Camera ascends after contact with logs; bottom not visible

New London North-South Transect (VTS_02_0)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
5:03		Bottom visible
5:07	Green algae	
5:08		Camera makes contact with soft seafloor, creating brief turbidity plume
5:21	Green algae	
5:26	Several patches of green algae	
5:29	Medium burrow hole	
5:53		Possible fishing line
5:55		Possible fishing line
5:56	Green algae	
6:00	Large burrow hole	
6:02		Possible fishing line
6:17	Large burrow hole	
6:19	Large burrow hole	
6:32	Large burrow hole	
6:40	Green algae	
6:54	Medium burrow hole	
6:59	Medium burrow hole	
7:01	Green algae	
7:09	Partially buried sculpin swim off as camera approaches	
7:10	Medium burrow hole	
7:12	Medium burrow hole	
7:20	Green algae	
7:26	Green algae encrusting object (rock or log?)	
7:29	Medium burrow hole	
7:31	Flounder resting on surface swims away as camera approaches; medium burrow hole	
7:42	Flounder resting on surface swims away as camera approaches	
7:47	2 medium burrow holes	
7:52	Medium burrow hole	Camera begins exiting CAD Cell
7:59	Green algae	
8:02-8:12		Camera appears to climb up steep cell wall; substrate is uneven with small clay clasts and shell
8:04	Green algae caught on camera	
8:13-8:30		Seafloor is smooth and flat, with sparse shell hash

*Indicates area is within approximate existing CAD cell footprint

Providence East-West Transect Through CAD Cell 3AR (E_W_1)
Total Time: 18:55

The transect begins to the east of CAD cell 3AR and travels west-southwest through the middle of the cell, exiting in the middle of the western boundary of the cell.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:07		Camera sits on seafloor; substrate is silty with dark patches
0:08		Camera starts to move
0:08-6:04		Substrate is silty with occasional dark patches and sparse shell hash; visibility is poor
0:10		Camera passes through turbidity plume
0:13	Crab (likely Atlantic rock crab) swims away from camera	
0:27		More abundant shell hash
0:29	Medium burrow hole	
0:32		More abundant shell hash
0:36		Woody debris
0:39		More abundant shell hash
0:48		Possible clay clast
0:52	Crab (likely Atlantic rock crab) swims away from camera	
1:02		More abundant shell hash
1:04		Debris
1:15	Large burrow hole	
1:20	Organism swims away from camera	
1:23	Unidentified fish swims in front of camera, creating turbidity plume	
1:40-1:45		More abundant shell hash
1:45	Crab (likely Atlantic rock crab) swims away from camera	
2:06-2:09		Camera drags on seafloor, creating turbidity plume
2:38	Organism (same as above) swims away from camera	
3:19	Medium burrow hole	
3:31	Medium burrow hole	
3:38	Medium burrow hole	
4:12	Apparent snail with snail trail	
4:20	Small holes	
4:20-6:00		Camera bounces off seafloor numerous times (possibly as it descends into CAD cell); view of bottom is obscured by turbidity plumes and elevated camera height
5:39-6:07	Several small fish	
5:56	Sea robin swims away	
6:04-8:40	Occasional green algae and small siphon or burrow holes	Camera strikes seafloor several times (possibly indicating uneven seafloor), creating turbidity plume and then ascending; poor to no visibility; seafloor is similar to ambient channel bottom but more marbled; occasional dark patches and leaf litter
6:31	Small fish	
6:46-6:55		Rope/mooring line; camera catches on line
8:39	Sea robin swims away	
8:40-12:26	Occasional green algae and small siphon or burrow holes	Silty bottom with dark and white patches and occasional leaf litter; poor visibility

Providence East-West Transect Through CAD Cell 3AR (E_W_1)		(continued)
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
8:54		Aluminum can, plastic bag, and apparent fern fronds
10:10	Sea robin swims in front of camera	
10:34		Plastic bottle
10:45	Medium burrow hole	
10:46-11:00		Camera hits bottom, creating turbidity plume; no visibility
10:56		Rope/mooring line
10:58	Sea robin swims away	
11:07	Possibly red algae	
11:11-11:18		Rope/mooring line
11:20-11:25		Camera hits bottom, creating turbidity plume; no visibility
11:52	Small fish	
12:02-12:06		Rope/mooring line
12:13	Unidentified medium-sized fish	
12:21	Possibly red algae	
12:27-12:40	Small siphon or burrow holes and occasional green algae	Seafloor has marbled appearance
12:34		Unusual shaped debris
12:40-15:10		Camera strikes bottom numerous times (possibly indicating uneven seafloor), creating turbidity plume and then ascending; visibility is poor
12:55	Sea robin swims away	
13:36		Debris - plastic bag?
14:50-15:15	Occasional green algae	Silty bottom with occasional dark patches
15:15	Large clump of several types of algae	Algae becomes entangled on camera; no visibility
15:26		Algae breaks free of camera
15:26-16:26	Siphon or burrow holes and occasional green algae	Substrate is silty with white patches and occasional dark patches
15:41		Rope/mooring line
16:21	Medium fish, possibly flounder	
16:27-18:55	Occasional large clumps of algae; siphon or burrow holes and occasional green algae	Seafloor has marbled appearance, with dark and white patches
16:30-16:45		Camera strikes seafloor several times, creating turbidity plume and then ascending; poor to no visibility
16:50-17:15	Occasional red algae	
16:57		Rope/mooring line
17:03		Debris - plastic bag?
17:04	Large clump of several types of algae	
17:08	Sea robin swims above substrate	
17:09-18:10		Camera strikes seafloor several times (possibly as camera ascends CAD cell wall), creating turbidity plume and then ascending; poor visibility
18:03	Small fish darts in front of camera	
18:25		Ambient channel bottom is undistinguishable from CAD cell bottom
18:33	Unidentified fish	

*Indicates area is within approximate CAD cell footprint.

Providence West-East Transect Through CAD Cell 5R (E_W_2)
Total Time: 5:03 [verify]

The transect begins on the southwest border of CAD cell 5R and travels east-northeast through the southern portion of the cell, ending east of the cell.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00	Beggiatoa sp. bacterial mats covering substrate	Flat substrate with marbled appearance; ocassaional leaf litter
0:09	Green algae	
0:18		Possible fishing line
0:45-0:52		Camera bounces off seafloor; bottom not visible
1:20	Green algae; possible fish	
1:23	Green algae	
1:25-2:00		Striations on substrate, darker marbled appearance dissipates
1:43	Green algae	
1:50		Debris
1:52	Green algae	
1:57	Green algae	
1:59	Green algae	
2:01	Green algae	
2:04	Dark patch	
2:12-2:25	Abundant green algae; ocassional dark patches	Leaf litter, ocassional shell hash
2:30		Camera exits cell 5R; no change in substrate
2:35	Unidentified fish	
2:38		Woody debris is pushed forward by camera
2:49		Possible encrusted line/rope
2:55		Substrate becomes more marbled
3:02	Unidentified fish	
3:12	Unidentified fish	
3:41		Woody debris
3:45	Small, frequent patches of Beggiatoa	
3:57	Unidentified fish	
4:05-5:03	Occasional dark patches - unidentified algae	

*Indicates area is within approximate CAD cell footprint.

Providence South-North Transect Through CAD Cells 1R and 3AR (N_S_2)
Total Time: 19:54

The transect begins in CAD cell 1R and travels north into and through CAD cell 3AR terminating north of CAD cell 3AR.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:34		Silty substrate
0:34-0:40		Camera is high in water column; bottom not visible
0:40-0:42		Sled makes contact with bottom and creates a turbidity plume
0:42-0:59		Silty substrate, large gashes on substrate
0:59-1:16		Camera is high in water column; bottom not visible
1:16-1:18		Large area of coarse sand
1:18		Two track lines in substrate
1:18-2:35		Silty substrate, darker spots, light tan layer on top of substrate
2:35		Plastic bottle
2:35-3:36		Silty substrate, darker spots, light tan layer on top of substrate
3:36	Small fish	
3:36-4:52	Small siphon or burrow holes, occasional small fish	Silty substrate, darker spots, light tan layer on top of substrate
4:06		Camera exits CAD cell 1R, substrate becomes less uniform
4:51		Camera enters CAD cell 3AR, no visible change in substrate
4:52-5:00		Camera digs into substrate; turbidity obscures visibility
5:00-5:04		Camera is high in water column; bottom not visible
5:04-5:43	Small siphon or burrow holes	Silty substrate, occasional dark spots
5:43-5:49		Camera is high in water column; bottom not visible
5:49		Camera bounces off the bottom, creates a turbidity plume
5:49-6:00		Camera is high in water column; bottom not visible
6:00-6:03		Camera bounces off the bottom, creates a turbidity plume
6:03-6:17		Camera is high in water column; bottom not visible
6:17-6:59	Small siphon or burrow holes	Silty substrate, occasional dark spots
6:59		Dark patch
6:59-7:43		Silty substrate, occasional dark spots, substrate uneven and less uniform that previously observed
7:43-7:45		Camera digs into substrate; turbidity obscures visibility
7:45-9:09	Small siphon or burrow holes	Silty substrate, occasional dark spots
9:09		Large gash in substrate, possibly from an anchor dragging
9:09-10:49	Small siphon or burrow holes	Silty substrate, occasional dark spots
10:01	Medium sized fish darts toward camera	
10:02	Same medium sized fish swims in front of camera	
10:49		Mooring pillar
10:49-10:54		Camera too high in water column
10:54-10:59		Camera bounces off the bottom, creates a turbidity plume
10:59-12:39	Small siphon or burrow holes	Silty substrate, occasional dark spots
11:35		Plastic debris
12:26		Plastic debris
12:27		Camera bounces off the bottom, creates a turbidity plume
12:36-12:40		Camera bounces off the bottom, creates a turbidity plume, screen briefly goes black
12:40-13:56	Small siphon or burrow holes	Silty substrate, occasional dark spots
12:56	Sea robin darts in front of camera	
13:08		Large gash in substrate
13:13	Two large burrow holes	

Providence South-North Transect Through CAD Cells 1R and 3AR (N_S_2) (continued)		
Running Time (m:s)	Biological Characteristics	Physical Characteristics
13:30	Small burrow hole	
13:32	Small burrow hole	
13:56-13:57		Camera bounces off the bottom, creates a turbidity plume
14:06	Small fish darts close to substrate	
13:57-14:21		Silty substrate
14:21-14:24		Camera bounces off the bottom, creates a turbidity plume
14:24-16:51		Silty substrate, occasional black patches
15:18	Small fish darts close to substrate	
15:20	Small fish darts close to substrate	
15:23-15:25	Sea robin darts across screen	
15:26	Small fish darts close to substrate	
15:50		Plastic debris
16:15	Patch of brown and green algae	
16:24	Large flounder swims from sediment	
16:31	Small fish darts across screen	
16:32-16:34	Medium sized sea robin swims in front of camera	
16:34	Medium sized sea robin swims in front of camera	
16:38	Medium sized sea robin swims in front of camera	
16:41		Plastic tub debris
16:41-16:45	Patch of algae	
16:45-16:52		Camera bounces off the bottom, creates a turbidity plume
16:52-17:08	Small sea robin swims in front of camera	Silty substrate, occasional black patches
17:08-17:09		Camera bounces off the bottom, creates a turbidity plume
17:13	Small sea robin swims in front of camera	
17:09-17:35		Silty substrate, occasional black patches
17:35-17:38		Camera bounces off the bottom, creates a turbidity plume
17:38		Debris
17:39-17:46		Silty substrate
17:46-17:48		Camera bounces off the bottom, creates a turbidity plume
17:48-17:56		Silty substrate
17:51		Camera exits CAD cell 3AR; no visible change in substrate
17:56-18:00		Camera bounces off the bottom, creates a turbidity plume
18:00-18:29	Small siphon or burrow holes	Silty substrate, occasional black patches
18:17	Medium sized fish darts across screen	
18:29-18:36		Camera bounces off the bottom, creates a turbidity plume
18:36-19:54	Small siphon or burrow holes	Silty substrate, occasional black patches
19:20-19:24	Medium sized sea robin continually swims in front of camera	

*Indicates area is within approximate CAD cell footprint.

Providence North-South Transect Through CAD Cell 5R (VTS_01_1)
Total Time: 18:58

The transect begins south of CAD cell 5R and travels north through CAD cell 5R terminating in CAD cell 4R .

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:27	Beggiatoa sp. mats covering substrate	Silty substrate
0:27		Debris
0:27-0:36		Debris caught on camera
0:36-0:43		Camera is too high in water column, limited visibility
0:43-2:50	Beggiatoa sp. mats covering substrate	Silty substrate
1:45	Fish darts along bottom, generating turbidity	
2:50	2 small swimming fish (upper portion of the screen)	
2:50-4:07	Beggiatoa sp. mats covering substrate	Silty substrate
2:59	Red algae clump	
3:29		Camera enters CAD cell 5R; no visible change in substrate
4:07-4:30	Beggiatoa sp. mats covering substrate	Silty substrate
4:30		Sled makes contact with substrate and creates a turbidity plume
4:30-4:37		Camera is high in water column; limited visibility
4:37-4:41		Silty substrate
4:41-4:44		Camera is high in water column; limited visibility
4:44-4:49		Silty substrate
4:49	Large burrow hole	
4:49-5:12		Sled makes contact with soft substrate and creates a turbidity plume
5:12-6:12	Beggiatoa sp. mats covering substrate	Silty substrate
6:12-6:15		Dark spot on substrate, detritus
6:15	Camera hits bottom, air bubble emerges from possible small organism burrow	
6:15-7:03	Occasional red, brown, and green algae; leaf litter; small bivalve siphon holes	Silty substrate
7:03-7:07		Camera becomes entangled in algae patch
7:07-7:11	Small bivalve siphon holes	Silty substrate
7:11-7:14		Sled skids along substrate, creating a turbidity plume
7:14-7:20	Small bivalve siphon holes	Silty substrate
7:20-7:27		Sled skids along substrate, creating a turbidity plume; camera is high in water column; no visibility
7:27-7:42	Small bivalve siphon holes	Silty substrate
7:42-7:43		Sled makes contact with soft substrate and creates a turbidity plume
7:43-8:00	Small bivalve siphon holes	Silty substrate
8:00		Aluminum can
8:00-8:21	Small bivalve siphon holes	Silty substrate
8:21	Algae patch	Large metal mesh debris
8:21-8:56	Small bivalve siphon holes	Silty substrate; camera continually bounces off substrate
8:41	Small fish darts in front of camera	
8:56-9:08		Sled continually makes contact with substrate, generating turbidity; limited visibility
9:08-10:40	Small bivalve siphon holes	Silty substrate, slad continually bounces off substrate
10:40		Trash bag caught on camera lens
10:40-11:07	Small bivalve siphon holes	Silty substrate
11:07-11:19		Camera high in the water column; limited visibility
11:19-11:53	Small bivalve siphon holes	Silty substrate
11:53-11:55		Sled makes contact with soft substrate, generating turbidity

Providence North-South Transect Through CAD Cell 5R (VTS_01_1)		(continued)
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
11:55-12:38	Small bivalve siphon holes	Silty substrate; sled continually bounces off substrate
12:38-12:41		Camera high in the water column; limited visibility
12:41-12:48		Silty substrate, soft pillows of something unknown
12:48-12:56		Silty substrate
12:55-12:59		Camera high in the water column; limited visibility
12:59-13:03		Silty substrate
13:03-13:13		Camera high in the water column; limited visibility
13:13-14:45	Small bivalve siphon holes	Silty substrate
14:31	Medium sized sea robin	
14:45-14:46		Sled makes contact with soft substrate, generating turbidity
14:46-15:00	Small bivalve siphon holes	Silty substrate
14:55		Plastic debris
14:57	Green, brown, and red algae	
15:00-15:04		Silty substrate
15:04-15:05	Algae patch covering substrate	
15:05-15:12		Silty substrate
15:12-15:13		Sled makes contact with soft substrate, generating turbidity
15:13-16:28	Small bivalve siphon holes, small fish (maybe shrimp)	Silty substrate
16:03		Camera exits CAD cell 5R; no visible change in substrate
16:28-16:31		Camera high in the water column; limited visibility
16:31-17:23	Small shrimp/amphipods dart in front of camera	Silty substrate
16:48		Camera enters CAD cell 4R; no visible change in substrate
17:23-17:25		Sled makes contact with substrate
17:25-17:39		Silty substrate
17:39-17:41		Sled makes contact with substrate
17:41-17:45		Silty substrate
17:45-17:47		Sled makes contact with substrate
17:47-17:55		Silty substrate
17:55-17:58		Sled makes contact with substrate
17:58-18:25	Small siphon holes	Silty substrate
18:25-18:27		Sled makes contact with substrate
18:27-18:58	Small siphon holes	Silty substrate, occasional leaf litter

*Indicates area is within the approximate CAD cell footprint.

Hyannis East-West Transect (VTS_01_0)
Total Time: 24:06
The transect begins outside of the CAD cell to the east. The video survey is run in an east to west direction, terminating outside of the western edge of the CAD cell.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-0:04		Camera descends to the substrate
0:04-0:45		Rolling hills consisting of sandy substrate and shell hash
0:05	Live crab	
0:10	Live crab	
0:21	Live crab	
0:31	Crab Shell	
0:37	Crab, possibly alive	
0:43	5+ crabs	
0:45-2:10		Sandy substrate with shell hash; bottom becomes level
0:46	Crab, possibly alive	
1:47	Crab, possibly alive	
2:10-2:45		Sandy substrate, shell hash (numerous scallop and snail shells), gravel
2:15	Crab buried in sand	
2:39	Horseshoe crab on substrate surface	
2:45-2:46		Pile of shell hash
2:46-2:49		Sandy substrate, shell hash, and gravel
2:49-2:55		Sandy substrate with piles of coarse shell hash
2:55-3:12		Sandy substrate, shell hash, and gravel
3:12-3:36		Mostly sandy substrate, some shell hash and gravel
3:13	Horseshoe crab on substrate surface	
3:15	Horseshoe crab on substrate surface, trail in sand, evidence of movement	
3:26	Crab, alive	
3:36-3:40	Green algae patch	
3:37	Crab on algae, alive; green algae patch	
3:40-3:48	Camera screen covered in green algae	
3:48-4:55		Sandy substrate patches with shell hash and cobble
3:58	Crab, alive; green algae	
4:17	Scallops (3+), green algae	
4:30	Partially buried scallop	
4:55-5:31	intermittent green and red algae	Sandy substrate, shell hash, and gravel
5:19	Whelk, intermittent green and red algae	
5:31-7:42	intermittent green and red algae	Sandy substrate, shell hash, and gravel
5:38	Moon jellyfish	
5:53	Horseshoe crab buried in sand	
6:40	Swimming crab	
7:27	Crab, alive	
7:42	Intermittent green and red algae	Entrance into CAD cell, substrate remains uniform - sandy substrate, shell hash, and gravel
7:42-7:55	Intermittent green and red algae	Sandy substrate, shell hash, and gravel
7:55		Pile of shell hash
7:55-8:23	Intermittent green and red algae	Sandy substrate, shell hash, and gravel
8:20	Scallop	
8:22	Scallop	
8:23-8:27	Camera runs along the edge of a field of green algae	Sandy substrate and shell hash
8:27-8:28	Intermittent green and red algae	Sandy substrate, shell hash, and gravel
8:28-8:30		CAD cell deepens and camera lifts off the bottom into the water column
8:30-8:46	Field of green algae on sandy substrate	Camera still high in water column
8:46	Camera drops down into algae bed	

Hyannis East-West Transect (VTS_01_0)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
8:46-9:10	Field of green algae	Sandy substrate
9:10-9:20	End of algae field, patches of green and red algae	Sandy patches with shell hash
9:15	Scallop	
9:20-11:53	intermittent green and red algae	Sandy substrate with shell hash
9:33	Scallop buried in sand	
9:52	Burrowing crab	
10:26	2 fish	
11:53-12:07	Green algae field	Sandy substrate
11:59	Crab	
12:07-12:51	End of algae field, patches of green and red algae	
12:30	Fish movement generates turbidity	Sandy patches with shell hash
12:51-13:03	Dense patches of green algae	Sandy substrate
13:03	Fish	
13:03-13:36	Sparse green algae patches	Sandy substrate
13:36-13:53	Dense green algae	Sand and shell hash
13:45	Crab	
13:53-14:14	Sparse green algae patches	Sandy substrate, shell hash
14:14-14:28	Dense green algae	Sand and shell hash
14:28-14:44	Sparse green algae patches	Sandy substrate, shell hash
14:30	Crab - possibly hermit crab	
14:38	Scallop partially buried in sand	
14:44-14:55	Dense patch of green algae	Sandy substrate
14:55-14:58	Moderate green algae	Sandy substrate
14:58	Crab	
14:58-15:38	Dense green algae, sparse red algae	Sandy substrate
15:02	Hermit crab	
15:29	Jellyfish	
15:38-16:02		Sandy substrate, shell hash with moderate green and red algae patches
16:02-16:28	Green algae patches	Sandy substrate, shell hash
16:28-16:48	Dense green algae field sparse red algae,	Sandy substrate
16:48-16:50	Camera becomes entangled in green algae, no visibility	
16:50-17:03	Dense green algae field sparse red algae	Sandy substrate
16:59	2 small fish	
17:03-17:11	Dense patches of green and red algae	Sandy substrate
17:11-17:13	Camera becomes entangled in green algae, no visibility	
17:13-17:50	Sparse green and red algae	Sandy substrate, shell hash
17:50-18:05	Moderate to sparse green and red algae	Sandy substrate, shell hash
18:05-18:17	Sparse green and red algae	Sandy substrate, shell hash
18:10	Large moon snail	
18:17-18:23		Sandy substrate, shell hash
18:23-18:34	Sparse green and red algae	Sandy substrate, shell hash
18:34-18:52	Moderate green and red algae	Sandy substrate, shell hash
18:52-19:10	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash
19:10-19:31		Coarse sand substrate with mixed gravel and shell hash
19:19	Large dead crab	
19:31-19:39	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash
19:35	Jellyfish	
19:39-19:54		Coarse sand substrate with mixed gravel and shell hash
19:54-20:13	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash

Hyannis East-West Transect (VTS_01_0)		(continued)
Running Time (m:s)	Biological Characteristics	Physical Characteristics
20:09	Large dead crab	Coarse sand substrate with mixed gravel and shell hash
20:10	Large rock crab	
20:12	Scallop	
20:13-21:41		Coarse sand substrate with mixed gravel and shell hash, evidence of wave action
20:28	Whelk egg casing	
20:51	Large Dead crab	
20:54	Whelk egg casing	
21:41-21:56	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash
21:44	Large Moon snail	
21:51	Fish	
21:56-22:11		Coarse sand substrate with mixed gravel and shell hash
22:02	Large empty whelk shell	
22:11-22:28	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash
22:16	Dead rock crab	
22:20-22:34	Numerous moon snails, deal and alive	
22:28-22:34	Moderate green and red algae	
22:39	Atlantic rock crab and spider crab eating moon snails and other unidentified mollusks	Coarse sand substrate with mixed gravel and shell hash
22:34-22:48	Moderate green and red algae	
22:35	Dead rock crab	
22:36	Rock crab	Coarse sand substrate with mixed gravel and numerous medium sized empty snail shells
22:37	Rock crab	
22:48-23:00	Moderate green and red algae	Coarse sand substrate with mixed gravel shell hash and empty snail and clam shells
22:50		Exit from CAD cell; substrate remains uniform, no distinct change
22:59	Dead crab	
23:00-23:05	Dense green algae field, sparse red algae, sandy substrate	
23:02	Numerous dead crabs	
23:06	Numerous dead crabs and mollusks	
23:05-23:12	Numerous dead crabs and mollusks, dense green algae field, sparse red algae, sandy substrate, empty snail shells and clam shells	
23:09	Crab	
23:12-23:25	Moderate green and red algae	Coarse sand substrate with mixed gravel shell hash and empty snail and clam shells
23:13	Medium sized moon snail	
23:15	Rock crab burrowing in sand	
23:22	Horseshoe crab partially buried in sand	
23:25-24:06	Sparse green and red algae	Coarse sand substrate with mixed gravel and shell hash
23:32	Crab attached to bottom of camera	
23:47	Hermit crab	
23:58	Hermit crab	

*Indicates area is within approximate CAD cell footprint

Hyannis North-South Transect (VTS_02_0)
Total Time: 4:33

The transect begins outside of the CAD cell to the north. The video survey is run in a north to south direction on the western end of the CAD cell, terminating to the south of the cell.

Running Time (m:s)	Biological Characteristics	Physical Characteristics
0:00-1:37	Intermittent uprooted brown algae with sparse red algae	Sandy bottom with regular sand ripples, sparse shell hash
0:41-0:44	4 snail clusters	
0:50	Large moon snail	
0:56	2 moon snails	
1:04	Comb jelly	
1:04-1:07	Several snail clusters	
1:20-1:21	Several snail clusters	
1:23		Camera enters CAD cell; descent not detectable; bottom remains uniform
1:38-2:04	Dense field of brown algae; intermittent red algae; numerous moon snails and other mollusks	Sandy bottom with abundant shells
1:38	3+ crabs (likely Atlantic rock crabs) eating moon snails and other unidentified mollusks	
1:40	Dead crab	
1:47	Crab, possibly alive	
1:48	Crab, possibly alive	
1:49	Crab, possibly alive	
1:54	Eelgrass frond	
1:58-2:00	Scallop shells	
2:01	Crab (likely Atlantic rock crab)	
2:02	Comb jelly	
2:04-2:05	Several eelgrass fronds	
2:05-2:53	Sparse to moderate brown and red algae, occasional snail clusters	Sandy bottom with regular sand ripples, sparse shell hash
2:11	Crab (likely Atlantic rock crab), possibly alive	
2:46	Dead crab	
2:54-3:36	Dense brown algae, intermittent red algae, abundant moon snails or other mollusks	Sandy bottom
3:00		Camera exits CAD cell; ascent not detectable; bottom remains uniform
3:02	Whelk shell	
3:02-3:18	Numerous (20+) crabs (likely Atlantic rock crabs and spider crabs), dead and alive	
3:10	Scallop shell	
3:29	Ulva fragment	
3:37-4:33	Sparse to moderate brown and red algae	Sandy bottom with regular sand ripples, sparse shell hash
3:40	Crab (likely Atlantic rock crab), possibly alive	
3:47	Scallop shell	
3:51	Hermit crabs	
3:55	Scallop shell	
3:59	Scallop shell	
4:08	Scallop shell	
4:09	Large moon snail	
4:10	Scallop shell, possible Molpadia sea cucumber	
4:11	Whelk egg case	

Hyannis North-South Transect (VTS_02_0)		(continued)
Running Time (m:s)	**Biological Characteristics**	**Physical Characteristics**
4:16	Whelk egg case	
4:17		Possible fishing gear or other linear debris
4:25	Crab (likely Atlantic rock crab), possibly alive	
4:27	Partially buried crab or crab shell	
4:30	Unidentified fish	

*Indicates area is within approximate CAD cell footprint