2007 – 2010 Grand Strand Beach Nourishment Study

Final Report

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

*Individual beach profile figures and time-series photography are provided in the supplemental CD.

INTRODUCTION

The Grand Strand region of South Carolina is an arcuate shaped coastline, approximately 60 miles in length, located in the northeast corner of the state (Figure 1). Its location on a passive continental margin, lack of significant riverine sediment supply, and sea level rise, in combination with extensive shoreline development, has limited the region's ability to maintain healthy beaches and protect people and property from storms. This is significant locally and at the state level as the Grand Strand is South Carolina's most popular destination with nearly 13 million visitors annually (MBREDC, 2007). In order to maintain beach width and safe public use of this resource, effective beachfront management is required.

The state adopted the S.C. Coastal Zone Management Act in 1977 which gave the state limited beachfront jurisdiction. Jurisdiction was limited to the area seaward of the "critical line" (landward toe of primary dune) and hard stabilization structures were routinely permitted. In 1987, a Blue Ribbon Committee was developed to address unregulated development, beachfront armoring, and their future impacts on the coastal economy. The following year, the Beachfront Management Act was passed, which established two lines of jurisdiction (baseline and setback line), long-term erosion rates, and did not permit construction of new hard stabilization structures. As a result, beach nourishment projects have since become the primary method to combat beach erosion in the Grand Strand and throughout coastal South Carolina.

Two major nourishment projects have been conducted over the past 15 years in the Grand Strand. Locating and transporting beach compatible sand for beach nourishment in the region is challenging because there is no riverine source of sediment and hardbottoms account for approximately 50% of the Grand Strand's nearshore seafloor (Denny et al., 2005). Grand Strand-wide nourishment projects were conducted from 1996 to 1998 and most recently from 2007 to 2009.

The 2007 – 2009 Grand Strand Nourishment Project began November 2007 and was completed in January 2009. The project was divided into three reaches, Reach 1: North Myrtle Beach (NMB), Reach 2: Myrtle Beach (MB), and Reach 3: Garden City-Surfside (GC-SS) (Figure 1). An additional nourishment project was conducted at Arcadian Shores (AS) during this time (see CSE, 2008 for details). Approximate sand volumes placed on Grand Strand beaches were 750,000 yd^3 in Reach 1 and Reach 3, and 1.5 million yd^3 in Reach 2. Nourishment began Nov 2007 in Reach 3 and was completed in Mar 2008. Nourishment in Reach 1 was conducted from Aug to Oct 2008, and Reach 2 was nourished from Oct 2008 to Jan 2009 (Table 1).

The CMWS has developed partnerships with local, state, and federal resource management agencies to conduct applied beach and nearshore research and monitoring projects with the goal of providing sound, scientific information to decision makers. Information presented in this report represents data collected by the BERM program and CMWS staff at CCU from 2007 to present funded by the City of North Myrtle Beach, Horry County, the United States Army Corps of Engineers (USACE), and South Carolina Department of Health and Environmental Control-Ocean and Coastal Resource Management (SCDHEC-OCRM). Data includes beach and nearshore monitoring (beach profiles, shoreline surveys), mapping of borrow sites (bathymetry, side scan sonar), and photography (aerial photos, beach cameras). The objectives of this report are to:

1. Document and quantify physical changes throughout the beach and nearshore regions of the Grand Strand associated with beach nourishment,
2. Document and quantify physical changes at the three borrow sites associated with nourishment, and
3. Document impacts to nearshore index reefs associated with beach nourishment.

METHODS

Monitoring of the beach and nearshore system were conducted by the following methods: (1) beach and nearshore profile surveys, (2) Mean High Water (MHW) contour and upper beachface surveys, (3) aerial photography, (4) video monitoring, and (5) sidescan sonar. The following sections describe data collection and processing procedures.

Beach and Nearshore Profile Surveys

Approximately 150 shore normal (shore perpendicular) beach profiles initially developed by SCDHEC-OCRM (roughly 1000 ft spacing) were collected in the Grand Strand region on an annual to bi-annual basis from 2007 – present (Table 1). Approximately 42 profiles were monitored in Reach 1, 50 profiles in Reach 2, 30 profiles in Reach 3, and 19 profiles in Arcadian Shores (Figure 2, Figure 3, Figure 4, Figure 5). Profiles originate landward of the primary dune at benchmarks installed by the SCDHEC-OCRM and extend approximately 3000 ft offshore. Dates of beach profile surveys are generally indicated by year and Julian day (e.g. 2009.001 = Jan 1, 2009).

Surveys were conducted with an Ashtech Real-Time Kinematic Global Positioning System (RTK-GPS). Briefly, a base station was set-up on an established benchmark which broadcasted a real-time GPS correction via Airlink cellular modems to a roving RTK-GPS unit mounted to a back pack and/or boat, allowing the surveyor to view accurate X,Y, Z data in real-time. Horizontal and vertical accuracy of the subaerial beach of < 0.2 ft were determined by comparison of established benchmark values versus collected data. Subaerial surveys were conducted using a back pack GPS unit and marine surveys were conducted aboard an 18 ft rigid hull inflatable boat (Figure 6) or 20 ft Carolina Skiff. The survey boats were outfitted with Knudsen Mini-Sounders, TSS motion reference units, and dual frequency GPS antennas. Raw depth and positional data were merged, heave/pitch/roll and tide corrections were applied, and data was processed to produce a corrected, RTK-positioned depth with HYPACK software (Figure 7). Initial outlier points were removed using the HYPACK Single Beam editor and exported as a text file. Data were then run through a MATLAB script for final filtering and smoothing. Processed profiles were analyzed in a GIS database (PMAS) developed by M. Scott Harris (Harris et al., 2007) and are available on-line at gis.coastal.edu. Profile volumes were determined after inputting the appropriate X-on value (distance along profile) and contour (see Appendix 1 for X-on values).

MHW and Dune Line Surveys

MHW and dune line surveys were conducted monthly in Reach 1, Arcadian Shores, and Reach 3 and were conducted quarterly in Reach 2 from Oct 2007 – Feb 2010 (Table 2). Data was collected with an Ashtech RTK-GPS system as previously described; however, the dual frequency GPS antenna was mounted to an ATV, rather than a back pack or boat, and data was collected using HYPACK software and/or Carlson SurvCE software. Shoreline data were contoured with Surfer 8 software and maps were developed by the kriging method. The MHW contour was extracted, saved as a shapefile, and uploaded to ArcMap 9.3.1. Analysis of the MHW contour relative to the OCRM baseline was conducted with the Digital Shoreline Analysis System (DSAS) 4.1 software, developed by the United States Geological Survey (USGS) (Thieler et al., 2009). Transects were cast every 100 m. Data output includes end point rate (distance between oldest and most recent shoreline locations divided by time) and shoreline change envelope (distance between baseline and closest and farthest shorelines throughout the entire dataset at each transect) calculations. Negative values indicate landward movement of contour.

The MHW elevation is 2.05 ft NAVD88 for the epoch 1983-2001 based on the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service Springmaid Pier station MROS1-8661070 located at the southern end of Myrtle Beach. **All elevation data in this report is in NAD83/NAVD88**. MHW and other tidal elevations in this report are based on data from station MROS1-8661070.

Aerial Photography

Aerial photographs were collected on a quarterly basis from Nov 2007 to Nov 2009 to produce a qualitative time series representation of the nourishment project. Photographs were taken aboard a small plane at 1500–3000 ft above land surface with a Sony R-1 10.3 Megapixel camera. Individual images are merged with ArcSoft Panorama Maker software and orthorectified with ArcMap 9.3.1. Aerial photography is found in Appendix 4, 7, and 10.

Beach Cameras

Three digital video systems (Sony Block Camera in environmental camera housing and mount connected to a PC configured for FTP upload) by Erdman Video Systems were installed in North Myrtle Beach (R1), Myrtle Beach (R2), and Surfside Beach (R3) prior to beach nourishment (Figure 8). Camera 1 (NMB) was installed in August 2008, Camera 2 (MB) in May 2008, and Camera 3 (SS) was installed in Oct 2007. Additional video systems have been installed at Singleton Swash (Winter 2009) and White Point Swash (Spring 2010). Each video system is programmed to capture still photographs during daylight hours. Beach camera imagery is available in the supplemental CD.

Borrow Sites (Single Beam and Sidescan Sonar)

Three borrow sites, one per reach, were used as sediment sources for the nourishment project. Sites were Little River, Cane South, and Surfside, corresponding to Reaches 1, 2, and 3; respectively (Figure 1, Figure 9). The borrow site used for the Arcadian Shores nourishment project is labeled as Arcadian Shores borrow site. Track lines for single beam bathymetric surveys were 246 ft (75m) x 492 ft (150m). After data processing, single beam point data was imported into Fledermaus Dmagic to interpolate 100 ft digital elevation model (DEM) grids. The 100 ft grids were exported as ArcInfo ASCII rater files (.asc) which were converted into 100 ft bathymetry ArcInfo grids inArcGIS. The Spatial Analyst Surface Analysis tool (Cut/Fill) was used to calculate time-series volume change. Survey dates for pre, post, and post + 1 year-dredge bathymetric and sidescan sonar surveys conducted at all borrow sites are listed in Table 3.

Index Reefs

Sidescan sonar acquisition

A series of sidescan sonar surveys across a 2 km x 8 km section of seafloor, offshore of southern Myrtle Beach and northern Surfside Beach, were completed in three phases related to the Grand Strand Beach Nourishment Project: pre-nourishment (Mar 2008), post-nourishment (Jan 2009) and one year post-nourishment (Mar 2010). The survey was designed to provide complete coverage of the index reef sites proposed for physical habitat monitoring, as well as the suite of invertebrate recruitment tiles emplaced by SC Department of Natural Resources (DNR) as part of this study, and surrounding areas, extending as close to the shoreline as possible.

All sidescan sonar data were recorded on the 24 ft vessel Privateer. A Garmin 498 was used to obtain WAAS-enabled GPS navigation. The X, Y data was input into a laptop computer via a NMEA-0183 data format. The vessel then used HYPACK software for survey navigation. A TEI Isis laptop with software v6.4 was used for acquisition and storage of sidescan data in .xtf format (Extended Triton Format). The sidescan sonar system used for all surveys was a Klein

3000 dual-frequency system provided by CCU CMWS. The system is capable of collecting continuous backscatter data of the seafloor at frequencies of 100 kHz and 455 kHz. A swath of 100 m in the athwart ship direction is ensonified with each pulse of the system's transducers. By mosaicking the sidescan data along all shiptracks over the site, complete coverage was achieved, with significant data overlap (as much as 100%) between lines.

Sidescan sonar data processing

Raw sidescan sonar data were processed following the protocols in Danforth (1997). Each line was demultiplexed, applied a running window filter for stripe removal, corrected for slant range and beam pattern, and linearly stretched to distribute the digital values over a Gaussian scale of gray values. The navigation was checked for bad fixes. Once processed in this manner, individual lines collected were pieced together to produce a sidescan sonar 'mosaic', which is equivalent to a map-view image of the seafloor showing surface roughness. The mosaic was sampled at a 0.5 by 0.5 meter pixel size. The digital file format of this mosaic was TIFF, which was registered to UTM coordinates by means of an associated world file (.tfw) and displayed as georeferenced image in a GIS with ESRI software (e.g., ArcMap).

Textural analysis mapping of habitat

A methodology for thematic mapping of seafloor habitats based on sidescan sonar mosaics was implemented by the CMWS during the study of the nearshore index reef sites adjacent to the first phase of Grand Strand Nourishment Project (Ojeda et al., 2001). A complete discussion of this methodology can be found in Ojeda et al. (2003). The method is based on a combination of textural analysis of images and a neural network classifier. A series of parameters representing diverse relationships between neighboring pixels within a small (i.e. 5 x 5 pixel area) window are first calculated for areas where ground control information exists. These parameters are then used as a training set and fed to a neural network classifier, which learns the parameters that represent each of the input classes. Once trained, a network is capable of deciding what class best resembles the input features calculated over portions of the image where ground control data do not exist. This technique has worked well in previous studies of nearshore habitats and presents one among few alternatives for the problem of generating spatially comprehensive, thematic maps of the seafloor (Ojeda, et al., 2001; Gayes, et al., 2002; Ojeda, et al., 2003).

For this study, the algorithm implemented for the first phase of the Grand Strand Nourishment study (Ojeda, et al., 2001) was utilized. This algorithm produces only two possible outcomes from a given sidescan sonar image or image window: sand and hard bottom. Future developments of this technique will revisit the spectrum of sonar and video data available at CMWS for training of a new algorithm.

Preparation of Change Maps

Interpretive raster maps obtained with the textural analysis routine are useful to evaluate the distribution of bottom change by allowing comparisons to be made on a pixel by pixel basis between two different survey years. The values of these maps depend on four possible combinations, depending on whether a pixel (1) remained as sand, (2) remained as hard bottom, (3) changed from hard bottom to sand, and (4) changed from sand to hard bottom. The extent of a change map is limited to the overlapping area of the two input maps and thus contains values only on areas where both input maps hold data. To ensure a consistent comparison of habitat classification between the 1999 and 2008 sidescan sonar studies and reduce the effects of acoustic noise, all sonar mosaics were resampled to a 2 m pixel size prior to running through the textural analysis algorithm. The resulting 10 m pixel habitat classification maps were then used for comparison of the surveys.

Monitoring Reef-Associated Fish Communities

Short (seasonal) and longer-term (2 year) changes in benthic fish communities was to be monitored by deploying blackfish traps within the index reef sites. Traps were baited with clupeids and deployed for 2-4 hours with at least 12 traps deployed over a period of two days. Fish were not caught during the initial deployments (pre-nourishment) and additional sampling was not conducted.

RESULTS

Reach 1

Approximately 42 beach profiles (5650-5895) were collected in Reach 1 six times between Jan 2007 and Dec 2009 (Table 1). All profiles were located within the nourished section of Reach 1. USACE design plans indicate approximately 15 $yd^3 ft^{-1}$ of sediment was to be placed at profiles 5700-5715, 5735-5825, and 5860-5895 and 25 $yd^3 ft^{-1}$ at profiles 5720-5730 and 5830-5855 (USACE, 2007).

Profile analysis indicates an addition of 11.3 ± 9.8 $yd^3 ft^{-1}$ (average ± standard deviation) of sediment was present above the MLW contour at Reach 1 profiles following beach nourishment (Table 4). Profile 5845 illustrates increased volume above the MLW contour following nourishment (Figure 10; see Figure 2 for location). Pre and post-nourishment surveys indicate 10-35 $yd^3 ft^{-1}$ were measured above the MLW contour throughout the southern and central sections of Reach 1 while the northern section ranged from -35 to +10 $yd^3 ft^{-1}$ (Figure 11). Variability of sediment volumes are a function of design plans, inlet dynamics, and timing of beach nourishment. Generally, 15-25 $yd^3 ft^{-1}$ of sediment was placed throughout Reach 1 with approximately 15 $yd^3 ft^{-1}$ placed north of profile 5860. Nourishment proceeded from north to south in this section, allowing additional time (1-2 months) for sediment mobilization and transport in the northern section of Reach 1 relative to the southern and central sections. Significant transport of sediment offshore was observed between the MLW and -10 ft contours between pre and post-nourishment surveys (Figure 12). Inlet processes associated with the movement of the Hog Inlet channel and ebb tidal delta influenced sediment volumes and beach widths in the adjacent areas.

Interestingly, profile volume increased consistently from Jan 2007 to Dec 2009 for a total additional increase of 17.0 ± 4.6 $yd^3 ft^{-1}$ above the MLW contour and 27.4 ± 7.4 $yd^3 ft^{-1}$ above the -10 ft contour (Table 4). Relative to pre-nourishment volumes, total volume of Reach 1 profiles increased by 34.5, 16.3, and 7.5% at the MHW, MLW, and -10 ft contours, respectively (Table 5). One year after nourishment, sediment volume above the MLW contour ranged from -10 to +15 $yd^3 ft^{-1}$ with the southern and central sections remaining relatively stable (most profiles -5 to +5 $yd^3 ft^{-1}$) and the northern section was generally accretional (-5 to +15 $yd^3 ft^{-1}$) (Figure 13). Overall, an addition of 10-25 $yd^3 ft^{-1}$ of sediment above the MLW contour was measured at most Reach 1 profiles from Jan 2007 to Dec 2009 (Figure 14). For additional Reach 1 profile data, see Appendices 1, 2, and 3.

Monthly MHW surveys of Reach 1 indicate the MHW contour migrated seaward from Jan 2007 until beach nourishment with significant landward migration at the northern and southern boundaries of Reach 1 (Figure 15). The highest retreat values at northern and southern boundaries were upwards of 40 ft yr^{-1} while shoreline change rates for the larger central section of Reach 1 ranged from -10 to +40 ft yr^{-1}. Following nourishment through May 2010, the MHW contour throughout most of Reach 1 moved landward 6-40 ft yr^{-1} (Figure 16). The northern section of Reach 1 was highly variable as a result of inlet dynamics and a one mile area of central Reach 1 remained more stable with shoreline movement rates of -4 to +20 ft yr^{-1}.

Overall, the MHW contour moved seaward 6-20 ft yr^{-1}on average throughout Reach 1 from Jan 2007 to May 2010 with significant retreat observed near Hog Inlet (Figure 17). Figure 18 illustrates seaward movement of the MHW contour based on Jan 2007 and May 2010 surveys near Cherry Grove pier, a common erosional hotspot. The shoreline change envelope for Reach 1, Jan 2007-May 2010, ranged from 40 to 200 ft with most transects within the 50-150 ft range (Figure 19).

Reach 2

Approximately 50 beach profiles (5250-5505) were collected in Reach 2 six times between Feb 2007 and Feb 2010 (Table 1). Profiles 5300-5480 were located within the nourished section of Reach 2. Nourishment plans called for approximately 35 yd^3 ft^{-1} to be placed from profile 5300-5320 and 5460-5480, 15 yd^3 ft^{-1} from profiles 5330-5350 and 5430-5455, and 45 yd^3 ft^{-1} from profiles 5400-5425 (USACE, 2007). Profile analysis indicates an addition of 17.2 ± 10.4 yd^3 ft^{-1} and 23.3 ± 12.0 yd^3 ft^{-1} of sediment was present above the MLW and -10 ft contours, respectively, following Reach 2 beach nourishment (Table 6; Figure 20).

Pre and post-nourishment surveys indicate an addition of 0-35 yd^3 ft^{-1} of sediment was measured above the MLW contour throughout the nourished sections of Reach 2 (Figure 21). Over the same time period, non-nourished profiles located on the southern and northern boundaries (5260-5280, 5500-5505) lost 0-10 yd^3 ft^{-1}. Volume change analysis above the -10 ft contour indicates an addition of 35.0-45.0 yd^3 ft^{-1} between profiles 5400-5425 and generally confirm estimated sand volume placement along Reach 2 (Figure 22). Profile volume increased 29.5 and 14.5% above the MLW and -10 ft contours, respectively, as a result of beach nourishment (Table 7). Variability associated with fill volume plans versus measured volumes is likely a result of the pre-nourishment survey occurring three months before beach nourishment (Table 1).

One year following beach nourishment in Reach 2, profile volume change above the MLW contour ranged from -20 to +10 yd^3 ft^{-1} in the nourished section, with most profiles losing upwards of 10 yd^3 ft^{-1} (Figure 23). Profiles immediately north and south of nourished profiles gained 5-10 yd^3 ft^{-1} over the same period indicating sediment transport to adjacent profiles. Relative to pre-nourishment conditions, an additional 21.3 and 12.8% of sediment was present above the MLW and -10 ft. contours, respectively (Table 7). Over the three year period (Feb 2007-Feb 2010), sediment volumes increased 15.1 ± 9.9 and 20.8 ± 13.1 yd^3 ft^{-1} above the MLW and -10 ft contours, respectively, over the nourished area of Reach 2 (Table 6) with the greatest increases located in central Reach 2 (Figure 24). For additional profile data, see Appendices 5, 6, and supplemental CD.

Based on quarterly MHW surveys prior to nourishment in Reach 2 (Oct 2007-May 2008), the MHW contour moved landward throughout most of Reach 2 at a rate of 20-40 ft yr^{-1} (Figure 25). Following nourishment, MHW change rates were also high (-90 to +40 ft yr^{-1}) with most areas experiencing retreat rates of 10-90 ft yr^{-1} (Figure 26). Over the entire MHW monitoring period (Oct 2007-Feb 2010), the MHW contour moved seaward 4 to 40 ft yr^{-1} throughout most of the nourished area while non-nourished areas along the northern and southern boundaries were variable (Figure 27). The MHW contour near Withers Swash (Figure 28, red box in Figure 27) moved seaward 20-40 ft yr^{-1} above the 2nd Ave Pier while rates south of the pier were more variable with shoreline change rates of -4.0 to +40.0 ft yr^{-1} (Figure 28A). Quarterly post-nourishment MHW shoreline locations south of the pier indicate general landward retreat while north of the pier shows retreat through Aug 2009 and then seaward movement (Figure 28B). MHW locations north and south of the pier are representative of the MHW contour dataset throughout the Grand Strand with significant movement both landward and seaward on monthly/quarterly time scales. Sediment is very active within the surf zone and while the MHW contour often migrates landward, the sediment is generally retained within the active system. The shoreline change envelope indicates high variability (30-150 ft) throughout the nourished areas of Reach 2 while the northern and southern boundaries were much less variable (Figure 29).

Reach 3

Approximately 30 beach profiles (4920-5240) were collected in Reach 3 five times between Jan 2007 and Jun 2009 (Table 1). Profiles 4950-5240 were located within the nourished section and plans called for 12 $yd^3\ ft^{-1}$ at profiles 4950 and 5240, 17 $yd^3\ ft^{-1}$ at 4955-5000 and 5210-5230, 23 $yd^3\ ft^{-1}$ at 5025-5200, and 25 $yd^3\ ft^{-1}$ at 5005-5020 (USACE, 2007). Based on pre and post-nourishment surveys, an addition of 6.7 ± 3.2 $yd^3\ ft^{-1}$ and 14.1 ± 4.8 $yd^3\ ft^{-1}$ of sediment was measured above the MLW and -10 ft contours, respectively (Table 8; Figure 30). Spatially, sediment volume at profiles 5000-5130 increased 10-15 $yd^3\ ft^{-1}$, volumes increased 0-10 $yd^3\ ft^{-1}$ at profiles 4950-4999, while profile volumes south of the nourished area decreased 0-10 $yd^3\ ft^{-1}$ (Figure 31). Spatial trends of sediment volume change were also consistent at the -10 ft contour with an addition of 10-30 $yd^3\ ft^{-1}$ at profiles 5000-5130, 5-15 $yd^3\ ft^{-1}$ at profiles 4950-4999, and sediment loss south of the nourished area (Figure 32). Overall, profile volume increased 14 and 9.2% at the MLW and -10 ft contour in the nourished area following nourishment (Table 9).

Post + 1 year surveys indicate volume change above the MLW contour ranged from -10 to +6 $yd^3\ ft^{-1}$ within the nourished area with minor sediment loss at most profiles (Figure 33). Sediment volume above the MHW contour increased from 24% immediately following nourishment to 39% over a year later (Jun 2009) while sediment volumes decreased slightly above the MLW and -10 ft contours (Table 9). Sediment volume change over the entire study period (Jan 2007-Jun 2009) indicates an addition of 7.5 ± 2.1, 7.3 ± 3.7, and 13.0 ± 4.3 $yd^3 ft^{-1}$ of sediment at the MHW, MLW, and -10 ft contours, respectively, throughout the nourished area (Table 8). Spatially, an addition of 6-15 $yd^3 ft^{-1}$ was documented at profiles 4999-5180 and 2-6 $yd^3 ft^{-1}$ was documented at profiles 4955-4980 while profiles at the southern boundary of the nourishment and farther south lost 0-10 $yd^3 ft^{-1}$ (Figure 34). For additional profile data, see Appendices 8, 9, and supplemental CD.

Pre-nourishment monthly MHW surveys indicate landward movement of the MHW contour throughout nearly all of Garden City/Surfside with minor seaward movement at the northern and southern boundaries and over approximately 1 mile in central Garden City (Figure 35). Following nourishment, movement of the MHW contour was variable, ranging from -40 to +20 ft yr^{-1} with most areas remaining stable or moving slightly landward (Figure 36). Since Jan 2007, the MHW contour at Garden City/Surfside has generally moved seaward 0-20 ft per year (Figure 37, Figure 38). The shoreline change envelope over the same period was 80-150 ft throughout most of Garden City/Surfside with an upward range of 200 ft at the northern-most stretch (Figure 39).

Arcadian Shores

Approximately 19 beach profiles were collected in the Arcadian Shores region six times between Feb 2007 and Jan 2010 (Table 1). Profiles 5510-5518 were nourished in Mar 2008 while all other profiles did not receive nourishment. Profile data indicated an increase of 24.3 ±

1.3, 44.7 ± 2.1, and 59.7 ± 3.8 yd^3 ft^{-1} at the MHW, MLW, and -10 ft contours, respectively, in the nourished area relative to pre-nourishment conditions (Table 10). Beach profiles within the nourished section showed dramatic change above MLW following nourishment (Figure 40). Volume change at profiles located north of the nourished area ranged from -10 to +5 yd^3 ft^{-1} over the same time period (Figure 41). Comparison of surveys conducted immediately before and after nourishment may vary as pre and post-nourishment surveys conducted by the BERM program were in Oct 2007 and May 2008, respectively (Table 1).

Following nourishment, 15-25 yd^3 ft^{-1} of sediment was lost above the MLW contour across the nourished area while profiles 5520-5528 gained 20-30 yd^3 ft^{-1} as a result of sediment transport to the north (Figure 42). Profiles 5530-5580 gained 0-10 yd^3 ft^{-1} over the same time period, likely influenced by adjacent nourishment at Arcadian Shores and Reach 1. From 2007 to present, an addition of 24.7 ± 1.4 and 40.4 ± 1.9 yd^3 ft^{-1} of sediment was measured above the MLW and -10 ft contours, respectively, in the nourished area (Table 10), increasing profile volumes 39.8 and 22.4%, respectively (Table 11). Profile volume of non-nourished sections of Arcadian Shores increased 0-20 yd^3 ft^{-1}, increasing from north to south (Figure 43). For additional profile data, see Appendices 11, 12, and supplemental CD.

MHW surveys conducted pre-nourishment suggest high variability (-40 to +40 ft yr^{-1}) with the MHW contour moving seaward in the northern half of the area while the southern half moved landward or remained stable (Figure 44). Following nourishment, the MHW contour in the nourished area moved landward 10-40 ft yr^{-1} while the MHW contour moved seaward throughout the non-nourished area with greatest seaward movement occurring immediately adjacent to the nourished area (Figure 45). Since Jan 2007, the MHW contour moved seaward 10-40 ft yr^{-1} along the southern half of Arcadian Shores and the northern half was relatively stable with a range of -6 to +10 ft yr^{-1} (Figure 46, Figure 47). The shoreline change envelope since 2007 was 150-200 ft along the southern third of Arcadian Shores and 100-150 ft along the northern two-thirds (Figure 48).

Index Reefs Studies

Physical Habitat Characterization and Monitoring

A time series of sidescan sonar and bottom video characterizations of 13 known nearshore hardbottom areas was completed in 2001 to assess potential change in critical reef habitat associated with any potential influx of sand from the initial Grand Strand Beach Nourishment Project (Figure 49; Ojeda et al. 2001). In that study, sites were partitioned with respect to proximity to location of beach fill emplacement both along the beach and in an on-offshore direction. Most areas exhibited only modest change in habitat and that was largely balanced with amount of characterized habitat loss being roughly equivalent to habitat gain (Table 12). Two areas (Sites 3 and 4), both located proximal to beach nourishment locations, were interpreted to have exhibited modest change in habitat with a small net loss of hardbottom habitat. These results indicate that there is some potential for adverse impacts to the nearshore reef communities in areas immediately adjacent to the nourishment project in this region.

Table 12 shows the Net Change Analysis for these sites associated with the 1997-2001 study of the initial Grand Strand Nourishment Project (Ojeda et al., 2001). Areas 3 and 4 exhibited modest change with small net habitat loss in the initial study. Areas 1, 2, 11 and 13 exhibited modest change with no net habitat loss in the initial study and site. Areas 5 and 9 exhibited modest change with a small net gain in hardbottom habitat during the initial study.

Based on these results, monitoring of the second phase of the Grand Strand Nourishment Project (2007-2009) focused on the nearshore locations located proximal to the stretch of beach where the greatest impact was seen during the first nourishment. This includes Areas 1, 2, 3 and 4, which are located inshore and proximal to the Myrtle Beach section of the project. In addition, two sites (Areas 9 and 11) offshore of the Myrtle Beach, as well as two sites (one inshore-Area 6 and one offshore-Area 13) adjacent to the Surfside-Garden City, were selected to assist with assessment of natural variability in these critical inner shelf habitats and potentially document change in an area of extensive hardbottom exposures off Surfside Beach.

The area offshore of Myrtle Beach is comprised of a series of small-scale, shore-perpendicular, low relief sediment ridges, with areas of hardbottom seafloor interspersed among the sediment lobes (Figure 50). In addition, there appears to be extensive, but thin and discontinuous sediment cover along the edges of these ridges, in the form of sand ribbons. In many cases, small (~10 cm) wave-orbital ripples are observed within the moderately high backscatter sand ribbons. A series of shore-parallel ledges in 4-6 m water depth directly offshore of the 3rd Avenue pier in Myrtle Beach are another prominent feature in the sidescan sonar data (Figure 50). Based on their morphology and location, these ledges may play an important role in funneling sediment out of the nearshore zone along this portion of the beach. In contrast to the slightly more sediment rich region to the north, the seafloor offshore of Surfside Beach exhibits extensive relatively consistently high-backscatter hardbottom, with a sinuous pattern of low relief ledges suggestive of bedrock layers outcropping at the seafloor (Figure 50). There is some evidence of sediment ripples across this region as well, although the sediment cover here is far more limited and patchy than the southern Myrtle Beach area.

Comparison of the sidescan sonar mosaics from 1999 (Figure 51) and 2008 (Figure 50) is useful for determining the baseline conditions of sediment distribution for the region (Figure 52). In general, many of the major seafloor features (sediment ridges offshore of Myrtle Beach and extensive hardbottom offshore of Surfside Beach) appear persistent with relatively little change in the past decade. Similar to the findings of Ojeda et al. (2001) following the first phase of the Grand Strand Nourishment Project, change analyses of the habitat classifications for the two surveys suggests there has been almost no net change in hardbottom area in the past decade; however, several trends are apparent.

Based on geomorphic features and sediment grain size analyses, Denny et al. (2001) inferred a general southward sediment transport, reflected in the morphology of the sediment ridges offshore of Myrtle Beach. A southward migration of these sediment lobes is apparent in the habitat classification change analysis (Figure 52). There often appears to be a change from sand to hardbottom on the northern side of a sediment lobe, and change from hardbottom to sand on the southern side of the lobe, indicating sediment within the lobe has moved southward. In some cases, a change from hardbottom to sand is observed on either side of the sediment lobe, suggesting the sediment feature may have relaxed (flattened) or expanded slightly.

The 2008 sidescan sonar mosaic also shows evidence of small sediment fingers extending shore perpendicular in the nearshore zone just offshore of Surfside Beach that were not apparent in the 1999 mosaic (Figure 52). These small sediment lobes were observed in 5-8 m water depth and appear to be 25-50 m across. Given that the 2008 survey was completed several months after nourishment of Reach 3 (although prior to nourishment of Reach 2), these features likely represent offshore movement of newly placed sand. These small sediment lobes persist in the 2009 (Figure 53) and 2010 (Figure 54) surveys and may be significant conduits for across shelf sediment transport in this region (Figure 55; Figure 56). The 2009 post-nourishment survey also indicates a continued build up of sediment along the nearshore shore-parallel ledges in the northern region, inshore of Areas 1 and 2 (Figure 53). The nearshore appears mixed in the central portion of the survey area immediately post-nourishment, with a decrease in sediment cover along the southern end of Myrtle Beach, but an increase in sediment across the lower shoreface in front of Myrtle Beach State Park (Figure 53). In the post + 1 year nourishment survey, the entire central portion of the study area shows an increase in nearshore sediment cover (Figure 56). In particular, there appears to be an increase in sediment on the upper shoreface offshore of Myrtle Beach State Park, which is notable given that this stretch of beach was not nourished. Across the inner shelf there are several relatively stable hardbottom areas separated by shore perpendicular sediment ridges that do display much change during the observation period. As expected, mixed areas of hardbottom seafloor with thin, patchy sediment cover display the most variation within the surveys, as the sediment appears to be relatively mobile across these regions. In general there is not a large net change in distribution of hardbottom vs. sediment following the beach nourishment (Table 13); however the post + 1 year survey displays the most notable increase in sediment across the nearshore and inner shelf.

While much of the hardbottom seafloor appears to have remained relatively stable over observation period, several of the original index reef study sites varying degrees of sediment cover. The most stable regions (Areas 2, 3, 6 and 13) exhibit prominent hardbottom platforms with little to no sediment cover in all the sidescan sonar surveys. In contrast, the most unstable regions (Areas 1, 4 and 11) are located in close proximity to large sediment lobes and appear to have thin, discontinuous sediment cover across much of these study sites. Area 9 encompasses a mixed region of sediment and hardbottom that exhibits modest variation, but little net change. Descriptions of each site monitored in this study are presented below.

Index Reef Study Sites

Area 1 is located 800 meters east of SC OCRM Benchmark 5405 (Figure 49; see Appendix 13). The area is made up of two separate sub-areas elongated in the NE-SW direction: a narrow and long eastern sub-area, and a wider and shorter western sub-area. The northern sub-area exhibits a slightly mottled high backscatter character that reflects mostly hardbottom in the habitat classification algorithm. In contrast, the southern sub-area appears to be almost entirely sand covered and may not be an important hardbottom habitat region.

Over the past decade, this nearshore area has become increasingly sand covered, with ~68% of the area exhibiting change from hardbottom to sand in the period from November 1999 to March 2010 (Table 14). While some of this change may be due to slight changes in survey method and instrumentation, most of the change likely reflects the ongoing erosion of hardbottom substrate and continued mobilization of a thin veneer of sediment across the region. In March 2008, prior to the beach nourishment, the area was composed of roughly equal amounts of hardbottom and sand. The area showed significant decreases in the amount of hardbottom seafloor immediately following the beach nourishment (January 2010), with further declines in the year after (March 2010).

Area 2 is located 1200 meters east of SC OCRM Benchmark 5335 (Figure 49; see Appendix 13). While there appears to be a minor encroachment of sand along the southern edge of the area, most of the hardbottom appears to be relatively stable, with very little change in composition during the period of observation (Table 15). The seafloor habitat classification algorithm indicates a slight increase in potential seafloor habitat since 1999 that shows no evidence of encroachment from the beach nourishment.

Area 3 is located 980 meters east of SC OCRM Benchmarks 5270 and 5280 (Figure 49; see Appendix 13). Influx of sediment since the 1999 sonar survey appears to have bifurcated the area, creating two distinct zones of high backscatter. These two zones appear to represent hardbottom that has been relatively stable during the past decade; however, they are surrounded by sediment ribbons with small-scale rippled bedforms that are evident in high-resolution sampling of the sonar mosaic (10 cm pixels). The northeastern edge (and ‘panhandle’) of the area also appears to be covered by a large sediment lobe that was first observed in 1998. During the most recent beach nourishment observation period, the area showed very little net change in seafloor habitat (Table 16). The post-nourishment survey in January 2009 indicates very little sand cover, with a return to slightly sandier than pre-nourishment conditions in the one-year post-nourishment survey (March 2010).

Area 4 is located 620 meters east of SC OCRM Benchmark 5260, and is the most inshore study area (Figure 49; see Appendix 13). This site is comprised of six small, irregular sub-areas aligned in the NE-SW direction. Area 4 appears to be a relatively active area, in terms of sediment migration. Both the northern and southern sub-areas appear largely sand covered, while the central area is the only sub-area that appears to have significant hardbottom. The region exhibited a significant loss of hardbottom habitat in the decade prior to the 2008 renourishment; however there appears to have been a slight increase in hardbottom seafloor during the 2008-2010 observations (Table 17). This area has some of the highest variability across the region, most likely as a result of the inshore location and the patchiness of the reef area. Most notably, while there was an initial decrease in hardbottom seafloor area in the survey post-nourishment (January 2009), there appears to be a significant increase in hardbottom seafloor area in the one-year post-nourishment survey (March 2010).

Area 6 is located approximately 740 meters east of SC OCRM Benchmark 5230 (Figure 49; see Appendix 13). This area has a swath of apparently stable hardbottom in the central portion, with sediment encroaching on either side. While not apparent at the resolution of the habitat classification algorithm, much of the southwestern portion of the area appears to have a thin sediment cover of sand ribbons, as numerous sand ripple fields are observed in the sonar mosaic sampled at a higher resolution of 10 cm pixels. The slight decrease in hardbottom seafloor area in the both the post-nourishment surveys (January 2009, March 2010) reflects the encroachment of sediment on the relatively stable central hardbottom platform from the more mobile sediment lobes on either side (Table 18).

Area 9 is located 3710 meters east of SC OCRM Benchmark 5310 (Figure 49; see Appendix 13). This area appears to be largely sediment covered with only small, isolated patches of hardbottom. Numerous sediment ribbons with ripples are observed across the area in sonar mosaics sampled at a higher resolution of 10 cm pixels. The largest and most stable swath of hardbottom is observed in the southern portion of this area. Sediment cover across the northern section appears to be thin and patchy, with much of the area alternating between hardbottom and sediment cover between surveys. Overall, there was a slight net increase in hardbottom area immediately following the beach nourishment, which was maintained in the survey one year later (Table 19).

Area 11 is located 2890 meters east of SC OCRM Benchmark 5260 (Figure 49; see Appendix 13). Most of this area appears to be covered with a thin veneer of sediment. The easternmost section of the area appears to represent the most stable hardbottom. Encroachment of the sand lobe on the northeastern side of the area, along with hardbottom exposure on the southern side, is consistent with a general trend of southward sediment transport observed by Denny et al. (2005). There also appears to be a southward shifting of smaller sediment fingers within the area in the long-term. The area showed no net change in hardbottom area in the survey immediately following the beach nourishment; however, there appears to be a significant net decrease (-15%) in hardbottom seafloor area in the survey one year after nourishment (March 2010) (Table 20). It is unclear whether this increase in sediment cover is directly related to an influx of sediment associated with the beach nourishment, but most likely represents the continued mobility of shifting sand sheets offshore.

Area 13 is located 2730 meters east of SC OCRM Benchmark 5180 (Figure 49; see Appendix 13). A sinuous pattern of ledges is evident over most of Area 13, suggesting exposure of stratified rocks at the seafloor. The area appears to be comprised of relatively stable hardbottom, and exhibits little change during the most recent nourishment observation period. Habitat classification change analyses indicate a decrease in sediment cover over the last decade; however, evidence of small-scale (~10 cm) sediment ripples in the sidescan sonar data suggests there may be strands of thin, discontinuous sediment cover across the region (Table 21).

Borrow Sites

Pre, post, and post + 1 year bathymetric and side scan sonar surveys were conducted at Little River, Cane South, and Surfside borrow sites from Oct 2007-Mar 2010 (Table 3).

Little River

The Little River borrow site is 1.3 mi^2 (~24,000 ft x 1,600 ft) with a pre-nourishment depth range of -33.7 to -37.8 ft (average = -36.3 ± 0.8 ft) increasing in depth from north to south (Table 22, Figure 59). The site is generally featureless and comprised of low backscatter, suggestive of a relatively homogeneous sand body (Figure 60). The edges of several sediment lobes are observed in the southern central portion of the survey, outside of the borrow area designated zones. Given the proximity to the large tourist destination of North Myrtle Beach and the time of year, there was a great deal of boat traffic during the survey. Boat wakes can cause anomalous high backscatter returns in the sidescan sonar data, which are noted in the figure.

Post-dredge survey depths ranged from -34.0 to -38.3 ft (average = -36.6 ± 0.9 ft) with increased depths as a result of dredging (Figure 61). An estimated 1,069,390 yd^3 of sediment was removed from the borrow site based on pre and post-dredge survey volume change (Table 23). Approximately 21% of the borrow site was impacted by removal of sediment to depths >1.0 ft while 82% of the site was impacted by removal of sediment to depths >0.5ft. Dredging activity removed sediment from zones 1, 2, 3, and 4 (Figure 62). Pre to post-dredge elevation change ranged from 0.83 to -1.69 ft for an average of -0.31 ± 0.36 ft across the entire borrow site. Zones 2 and 3 show the most seafloor disturbance in the post-dredging sidescan survey (Figure 63), and all dredged zones (1-4) exhibit high backscatter indicative of seafloor irregularity in the one-year post-dredging survey (Figure 64).

The post + 1 year-dredge survey indicates sediment has been deposited across the entire borrow site for an average elevation change of +0.46 ± 0.1 ft (range = -0.21 to +1.31 ft) (Figure 65). Estimated sedimentation across the borrow site was +696,640 yd^3 with 50% of the site experiencing an elevation change of >0.5 ft and no areas experienced elevation changes > 1 ft (Table 23). Final elevations based on the post + 1 year survey ranged from -33.7 ft to -37.7 ft with an average depth of -36.1 ± 0.8 ft across the entire borrow site. Depth in the borrow site continued to increase from north to south with greatest depths located in zones 2, 3, and 4 (Figure 66).

Cane South

The Cane South borrow site is 0.85 mi^2 (~6,200 ft x 3,900 ft) with an east-west oriented bathymetric high running across the center of the borrow site (Figure 67). Pre-dredge elevations ranged from -32.3 ft to -37.7 ft with an average depth across the entire borrow site of -34.9 ± 1.0 ft (Table 22). High backscatter from two prominent sediment lobes on the inner shelf extends into the borrow site on the northwestern side; otherwise the area is comprised on relatively homogeneous low backscatter sediment cover (Figure 68).

Post-dredge depths ranged from -32.3 ft to -39.0 ft (average = -35.7 ± 2.0 ft) with the largest elevation changes located in the central section of the borrow site (Figure 69). An estimated 1,580,740 yd^3 was removed from the borrow site, accounting for > 0.5 ft of sediment removed across 98% of the borrow site and > 1 ft of sediment was removed over 88% of the borrow site (Table 23). Sediment was removed from all zones with an elevation change range of -3.0 to +1.0 ft and an average of -0.76 ± 0.93 ft across the borrow site (Figure 70). In the post-dredging sidescan survey, all zones in this borrow site exhibit high backscatter lineations with sharp boundaries, indicating the removal of material during dredging (Figure 71). These features appear slightly less pronounced in the one-year post-dredging survey (Figure 72), suggesting a smoother seafloor.

One year after dredging, minor infilling in the north-northeastern half of the borrow site was documented (Figure 73). Comparison of post and post + 1 year surveys indicate an addition of 111,450 yd^3 across the borrow site with only 16% of the borrow site filling in > 0.5 ft (Table 23). Calculated post vs. post + 1 year elevation change ranged from 1.4 to -2 ft (Figure 73). Post

+ 1 year dredge elevations ranged from -32.8 ft to -39.0 ft with an average depth of -35.7 ± 1.3 ft (Table 22) with greatest depths located in immediately north and south of the east-west oriented bathymetric high (Figure 74).

Surfside

The Surfside borrow site is 0.64 mi^2 (~8,000 ft x 2,400 ft), increasing in depth from east to west (Figure 75). The borrow site is located on the southern edge of a southward migrating field of sediment lobes. Average pre-dredge elevation at the borrow site was -32.2 ± 3.5 ft with a range of -24.3 ft to -38.0 ft (Table 22). Average post-dredge elevation was -32.6 ± 3.9 ft with a range of -24.6 ft to -42.1 ft and the greatest elevation changes were located in zone 1 (northern most zone) (Figure 76). Pre vs. post-dredge survey data indicates approximately 838,350 yd^3 of sediment was removed from the borrow site, removing sediment to depths > 0.5 ft over 49% of the borrow site and > 1 ft over 41% of the borrow site (Table 23). Comparison of pre and post-dredge elevations indicate all sediment was removed from zone 1 (Figure 77) with elevation change ranging from -6.2 to 2.5 ft and average elevation change across the entire borrow site of -0.4 ± 1.3 ft (Table 22). Zone 1 is characterized by very high backscatter in both the post-dredging surveys while zones 2 and 3 are comprised of low backscatter sediment and appear to not have been impacted by dredging (Figure 78).

Comparison of post and post + 1 year dredging surveys indicate infilling across the entire borrow site (Figure 79). Volume change analysis based on post-dredge and post + 1 year-dredge surveys indicate an addition of 452,660 yd^3 of sediment, adding > 0.5 ft of sediment across 79%

of the borrow site and > 1.0 ft over 17% of the borrow site (Table 23). Elevation change ranged from -3.9 to 3.6 ft for an average elevation change of 0.6 ± 0.4 ft (Table 22). Final post + 1 year elevation at the Surfside borrow site was -32.0 ± 3.8 ft with a range of -24 ft to -42 ft and greatest depths were located in the eastern half of zone 1 (Figure 80). Both post-dredging surveys of zones 2 and 3 are remarkably similar, indicating little change along this portion of the seafloor (Figure 81).

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TABLES

Table 1. Beach Profile Data Collection Dates.

Location	Profiles	Survey Month*
Reach 1: North Myrtle Beach	5650-5895	Jan 2007
		May 2008
		Aug 2008
		Beach Nourishment#
		Nov 2008
		Jul 2009
		Nov 2009
Arcadian Shores	5510-5590	Feb 2007
		Oct 2007
		Beach Nourishment#
		May 2008
		July 2008
		Nov 2008
		May 2009
		Jan 2010
Reach 2: Myrtle Beach	5300-5505	Feb 2007
		Nov 2007
		Feb 2008
		Jul 2008
		Beach Nourishment#
		Jan 2009
		May 2009
		Feb 2010
Reach 3: Garden City/Surfside	4915-5280	Jan 2007
		Oct 2007
		Beach Nourishment#
		Mar 2008
		Sep 2008
		Jun 2009
		Feb 2010

*Due to the length of each reach, large number of profiles at each beach, and sea/weather conditions, some surveys for specific beaches may include additional survey days in previous or proceeding months.

#Beach nourishment dates are: Aug 2008 – Oct 2008 (Reach 1), Mar 2008 (Arcadian Shores), Oct 2008 – Jan 2009 (Reach 2), and Nov 2007 – Mar 2008 (Reach 3).

Table 2. MHW Shoreline Survey Data Collection Dates.

Date	North Myrtle Beach (R1) (day of month)	Myrtle Beach (R2) (day of month)	Garden City/Surfside (R3) (day of month)	Arcadian Shores (day of month)
Jan-07	24		5	30
Feb-07	28		15	19
M ar-07	27		8	15
Apr-07	27		12	26
May-07	10		9	14
Jun-07	21		13	25
Jul-07	18		16	19
Aug-07	15		13	17
Sep-07	19		12	17
Oct-07	12	23	/2	5
Nov-07				
Dec-07	13	11	12	27
Jan-08	18		4	
Feb-08	15	6	14	5
Mar-08			17	27
Apr-08	29		10	9
May-08	8	12	2	16
Jun-08	11		2	10
Jul-08	22		9	15
Aug-08	9	25	28	12
Sep-08	3		1	22
Oct-08	24		8	1
Nov-08	7	26	11	12
Dec-08	31		12	31
Jan-09	11		13	22
Feb-09	27	26	11	13
Mar-09	11		12	24
Apr-09	10		3	7
May-09	29	4	7	6
Jun-09	11		4	17
Jul-09	29		23	28
Aug-09	28	27	6	20
Sep-09	28		9	30
Oct-09	29		28	26
Nov-09	17	16	13	4
Dec-09	3		17	15

Date	North Myrtle Beach (R1)	Myrtle Beach (R2)	Garden City/Surfside (R3)	Arcadian Shores
Jan-10	12		26	11
Feb-10	3	16	4	1
Mar-10	17		16	3
Apr-10	30		8	27
May-10	12		7	19

Table 3. Pre, post, and post + 1 year bathymetric and side scan sonar survey dates at borrow sites.

Borrow Site	Survey	Pre-dredge	Post-dredge	Post + 1 Year-dredge
Little River	Bathymetry	Jun/Jul 2008	Dec 2008	Jan 2009
Little River	Side Scan Sonar	Aug 2008	Dec 2008	Oct 2009
Cane South	Bathymetry	Feb/Mar 2008	Apr 2009	Mar 2010
Cane South	Side Scan Sonar	Sep 2008	Apr 2009	Jan 2010
Surfside	Bathymetry	Oct/Nov 2007	May 2008	Jun/Jul 2009
Surfside	Side Scan Sonar		Sep 2008	Aug 2009

Table 4. Average volume change (yd^3 ft^{-1}) in nourished areas of Reach 1 (5650-5895), 2007-2010.

Contour	Pre-nourishment 2007.030-2008.224	Nourishment 2008.224-2008.315	Post-nourishment 2008.315-2009.335	Total 2007.030-2009.335
MHW	+3.2 ± 2.7	+9.8 ± 4.2	+0.6 ± 2.7	+13.6 ± 3.5
MLW	+3.6 ± 7.2	+11.3 ± 9.8	+2.1 ± 4.6	+17.0 ±4.6
-10	+4.8 ± 6.4	+7.8 ± 9.2	+14.7 ± 10.3	+27.4 ± 7.4

Table 5. Average volume change (%) of nourished Reach 1 profiles (5650-5895) relative to pre-nourishment conditions*.

	Volume Change (%)	
Contour	Post-nourishment	Final
MHW	+32.5	+34.5
MLW	+14.0	+16.3
-10 ft	+1.7	+7.5

*Data relative to 2008.224 pre-nourishment survey. Post-nourishment survey: 2008.315, final survey: 2009.335.

Table 6. Average profile volume change (yd ft^{-1}) in nourished areas of Reach 2 (5300–5480), 2007-2010.

Contour	Pre-nourishment 2007.053–2008.199	Nourishment 2008.199-2009.030	Post-nourishment 2009.030-2010.042	Total 2007.053-2010.042
MHW	+3.9 ± 2.9	+8.2 ± 5.0	-3.5 ± 2.7	+8.6 ± 5.1
MLW	+3.1 ± 5.3	+17.2 ± 10.4	-5.1 ± 4.8	+15.1 ± 9.9
-10 ft	+0.4 ± 6.7	+23.3 ± 12.0	-2.8 ± 6.2	+20.8 ± 13.1

Table 7. Average volume change (%) of nourished Reach 2 profiles (5300–5480) relative to pre-nourishment volumes*.

	Volume Change (%)	
Contour	Post-nourishment	Final
MHW	37.1	21.6
MLW	29.5	21.3
-10 ft	14.5	12.8

*Data relative to 2008.1999 pre-nourishment survey. Post-nourishment survey: 2009.030, final survey: 2010.042.

Table 8. Average profile volume change ($yd^3\ ft^{-1}$) in nourished areas of Reach 3 (4950–5240), 2007–2009.

Contour	Pre-nourishment 2007.006-2007.254	Nourishment 2007.254-2008.071	Post-nourishment 2008.071-2009.154	Total 2007.006-2009.154
MHW	1.3 ± 0.7	3.7 ± 1.4	2.5 ± 1.9	7.5 ± 2.1
MLW	1.4 ± 1.9	6.7 ± 3.2	-0.8 ± 2.8	7.3 ± 3.7
-10 ft	1.8 ± 2.6	14.1 ± 4.8	-3.0 ± 3.2	13.0 ±4.3

Table 9. Average volume change (%) of nourished Reach 3 profiles (4950-5240) relative to pre-nourishment volumes*.

	Volume Change (%)	
Contour	Post-nourishment	Final
MHW	+24.6	+39.1
MLW	+14	+12.2
-10	+9.2	+7.5

*Data relative to 2007.254 pre-nourishment survey. Post-nourishment survey: 2008.071, final survey: 2009.154.

Table 10. Average profile volume change ($yd^3\ ft^{-1}$) in nourished areas of Arcadian Shores (5510-5590), 2007–2010.

Contour	Nourishment 2007.053-2008.136	Post-nourishment 2008.136-2010.027	Total 2007.053-2010.027
MHW	+24.3 ± 1.3	-7.7 ± 1.4	+16.2 ± 0.2
MLW	+44.7 ± 2.1	-20.0 ± 0.9	+24.7 ± 1.4
-10 ft	+59.7 ± 3.8	-19.3 ± 3.2	+40.4 ± 1.9

Table 11. Average volume change (%) of nourished Arcadian Shores profiles (5510-5590) relative to pre-nourishment volumes*.

	Volume Change (%)	
Contour	Post-nourishment	Final
MHW	+113.3	+77.6
MLW	+72.1	+39.8
-10 ft	+33.1	+22.4

*Data relative to 2007.053 pre-nourishment survey. Post-nourishment survey: 2008.136, final survey: 2010.027.

Table 12. Results of Change Analysis from 1997 to 2001 (Ojeda et al., 2001).

Proximity to Phase II	Area	Sand to Sand	Hardbottom to Hardbottom	**Sum of no change**	Hardbottom to Sand	Sand to Hardbottom
Nearshore Proximal	1	32%	40%	**72%**	14%	14%
	2	0%	91%	**91%**	4%	5%
	3	5%	68%	**73%**	21%	6%
	4	5%	46%	**51%**	31%	18%
Offshore Proximal	9	9%	59%	**68%**	7%	25%
	10	8%	58%	**66%**	18%	16%
	11	18%	47%	**65%**	17%	18%
	12	9%	65%	**74%**	10%	16%
Nearshore Distal	5	5%	38%	**43%**	23%	34%
	6	1%	86%	**87%**	7%	6%
	7	7%	58%	**65%**	20%	15%
	8	2%	80%	**82%**	10%	8%
Offshore Distal	13	2%	74%	**76%**	16%	8%

Table 13. Index Reef Survey Area Seafloor Characterization**.**

	Seafloor Habitat Classification			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	58.8%	41.2%	
Post	January 2009	59.2%	40.8%	
Post + 1 yr	March 2010	58.4%	41.6%	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	9 %	5.6 %	85.4 %
Post	Mar 2008 – Jan 2009	3 %	3.3 %	93.7 %
1 yr / Post	Jan 2009 – Mar 2010	3.1 %	3.6 %	93.4 %
1 yr / Pre	Mar 2008 – Mar 2010	3.2%	3.4%	93.4%
Long Term	Nov 1999 – Mar 2010	9.2%	6.4%	84.5%

Table 14. Index Reef Area 1 Seafloor Characterization.

Area 1	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	50.3 %	49.7 %	
Post	January 2009	19.0 %	81.0 %	
Post + 1 yr	March 2010	11.3 %	88.7 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	5.6 %	33.8 %	60.5 %
Post	Mar 2008 – Jan 2009	2.1 %	33.3 %	64.6 %
1 yr / Post	Jan 2009 – Mar 2010	3.1 %	10.8 %	86.2 %
1 yr / Pre	Mar 2008 – Mar 2010	2.1 %	41.0 %	56.9 %
Long Term	Nov 1999 – Mar 2010	1.0 %	68.2 %	30.8 %

Table 15. Index Reef Area 2 Seafloor Characterization.

Area 2	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	99.5 %	0.5 %	
Post	January 2009	99.6 %	0.4 %	
Post + 1 yr	March 2010	98.9 %	1.1 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	3.3 %	0.4 %	96.3
Post	Mar 2008 – Jan 2009	0.4 %	0.3 %	99.3
1 yr / Post	Jan 2009 – Mar 2010	0.1 %	0.8 %	99.1
1 yr / Pre	Mar 2008 – Mar 2010	0.3 %	0.8 %	98.9
Long Term	Nov 1999 – Mar 2010	3.2 %	0.9 %	95.9

Table 16. Index Reef Area 3 Seafloor Characterization**.**

Area 3	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	83.8 %	16.2 %	
Post	January 2009	99.6 %	0.4 %	
Post + 1 yr	March 2010	79.0 %	21.0 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	12.6 %	4.7 %	82.6 %
Post	Mar 2008 – Jan 2009	3.8 %	7.8 %	88.4 %
1 yr / Post	Jan 2009 – Mar 2010	5.9 %	6.7 %	87.4 %
1 yr / Pre	Mar 2008 – Mar 2010	3.4 %	8.2 %	88.4 %
Long Term	Nov 1999 – Mar 2010	11.3 %	8.3 %	80.4 %

Table 17. Index Reef Area 4 Seafloor Characterization.

Area 4	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	48.4 %	51.6 %	
Post	January 2009	38.7 %	61.3 %	
Post + 1 yr	March 2010	61.3 %	38.7 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	7.5 %	46.2 %	46.2 %
Post	Mar 2008 – Jan 2009	4.3 %	14.0 %	81.7 %
1 yr / Post	Jan 2009 – Mar 2010	30.1 %	7.5 %	62.4 %
1 yr / Pre	Mar 2008 – Mar 2010	29.0 %	16.1 %	54.8 %
Long Term	Nov 1999 – Mar 2010	6.5 %	33.3 %	60.2 %

Table 18. Index Reef Area 6 Seafloor Characterization**.**

Area 6	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	94.2 %	5.8 %	
Post	January 2009	92.3 %	7.7 %	
Post + 1 yr	March 2010	90.8 %	9.2 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	12.5 %	3.9 %	83.5 %
Post	Mar 2008 – Jan 2009	3.8 %	5.7 %	90.4 %
1 yr / Post	Jan 2009 – Mar 2010	4.5 %	5.9 %	89.7 %
1 yr / Pre	Mar 2008 – Mar 2010	3.9 %	7.3 %	88.8 %
Long Term	Nov 1999 – Mar 2010	10.9 %	5.7 %	83.4 %

Table 19. Index Reef Area 9 Seafloor Characterization.

Area 9	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	72.1 %	27.9 %	
Post	January 2009	77.9 %	22.1 %	
Post + 1 yr	March 2010	77.5 %	22.5 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	25.3 %	15.9 %	58.8 %
Post	Mar 2008 – Jan 2009	18.8 %	13.0 %	68.2 %
1 yr / Post	Jan 2009 – Mar 2010	12.0 %	12.4 %	75.7 %
1 yr / Pre	Mar 2008 – Mar 2010	16.8 %	11.5 %	71.7 %
Long Term	Nov 1999 – Mar 2010	26.4 %	11.7 %	61.9 %

Table 20. Index Reef Area 11 Seafloor Characterization.

Area 11	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	80.8 %	19.2 %	
Post	January 2009	80.9 %	19.1 %	
Post + 1 yr	March 2010	65.5 %	34.5 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	21.2 %	10.8 %	68.0 %
Post	Mar 2008 – Jan 2009	10.8 %	10.7 %	78.5 %
1 yr / Post	Jan 2009 – Mar 2010	7.7 %	22.4 %	69.9 %
1 yr / Pre	Mar 2008 – Mar 2010	8.7 %	22.6 %	68.7 %
Long Term	Nov 1999 – Mar 2010	16.1 %	21.4 %	62.6 %

Table 21. Index Reef Area 13 Seafloor Characterization

Area 13	***Seafloor Habitat Classification***			
	Time Frame	**Hardbottom**	**Sand**	
Pre	March 2008	92.8 %	7.2 %	
Post	January 2009	95.4 %	4.6 %	
Post + 1 yr	March 2010	92.1 %	7.9 %	
	Change in Seafloor Habitat			
	Time Frame	**Sand to Hardbottom**	**Hardbottom to Sand**	**No Change**
Pre	Nov 1999 – Mar 2008	23.1 %	4.3 %	72.6 %
Post	Mar 2008 – Jan 2009	5.9 %	3.4 %	90.7 %
1 yr / Post	Jan 2009 – Mar 2010	3.4 %	6.7 %	89.9 %
1 yr / Pre	Mar 2008 – Mar 2010	5.1 %	5.9 %	88.9 %
Long Term	Nov 1999 – Mar 2010	22.7 %	4.8 %	72.5 %

Table 22. Minimum, maximum, and average depths at borrow sites for pre, post, and post + 1 year bathymetric surveys.

Borrow Site	Survey	Min. depth (ft)	Max. depth (ft)	Avg. depth (ft)
Little River	Pre	-33.7	-37.8	-36.3 ± 0.8
Little River	Post	-34.0	-38.3	-36.6 ± 0.9
Little River	Post + 1 year	-33.7	-37.7	-36.1 ± 0.8
Cane South	Pre	-32.3	-37.4	-34.9 ± 1.0
Cane South	Post	-32.3	-39.0	-35.7 ± 2.0
Cane South	Post + 1 year	-32.8	-39.0	-35.7 ± 1.3
Surfside	Pre	-24.3	-38.0	-32.2 ± 3.5
Surfside	Post	-24.6	-42.1	-32.6 ± 3.9
Surfside	Post + 1 year	-24.0	-42.0	-32.0 ± 3.8

Table 23. Areas of borrow sites with depth changes > 0.5 ft and 1.0 ft based on comparison of pre, post, and post + 1 year nourishment bathymetric surveys.

Borrow site	Pre vs. post nourishment			Post vs. post+1 year nourishment		
	Vol. Change (yd^3)*$	< -0.5 ft mi^2 (%)#	< -1.0 ft mi^2 (%)#	Vol. Change (yd^3)*	> +0.5 ft mi^2 (%)#	> +1.0 ft mi^2 (%)#
Little River	-1,069,390	1.06 (82)	0.27 (21)	+696,640	0.65 (50)	0.00 (0)
Cane South	-1,580,740	0.83 (98)	0.75 (88)	+111,450	0.14 (16)	0.00 (0)
Surfside	-838,350	0.31 (49)	0.26 (41)	+452,660	0.51 (79)	0.11 (17)

*Volume change based on modeled estimates.

$Sand volumes placed on the beach were: 902,725 yd^3 (Reach 1), 1,497,975 yd^3 (Reach 2), and 857,633 yd^3 (Reach 3).

#% area was determined by dividing areas of depth change > 0.5 ft or 1.0 ft by total borrow site area. Borrow site areas were 1.30, 0.85, and 0.64 mi^2 for Little River, Cane South, and Surfside borrow sites, respectively.

FIGURES

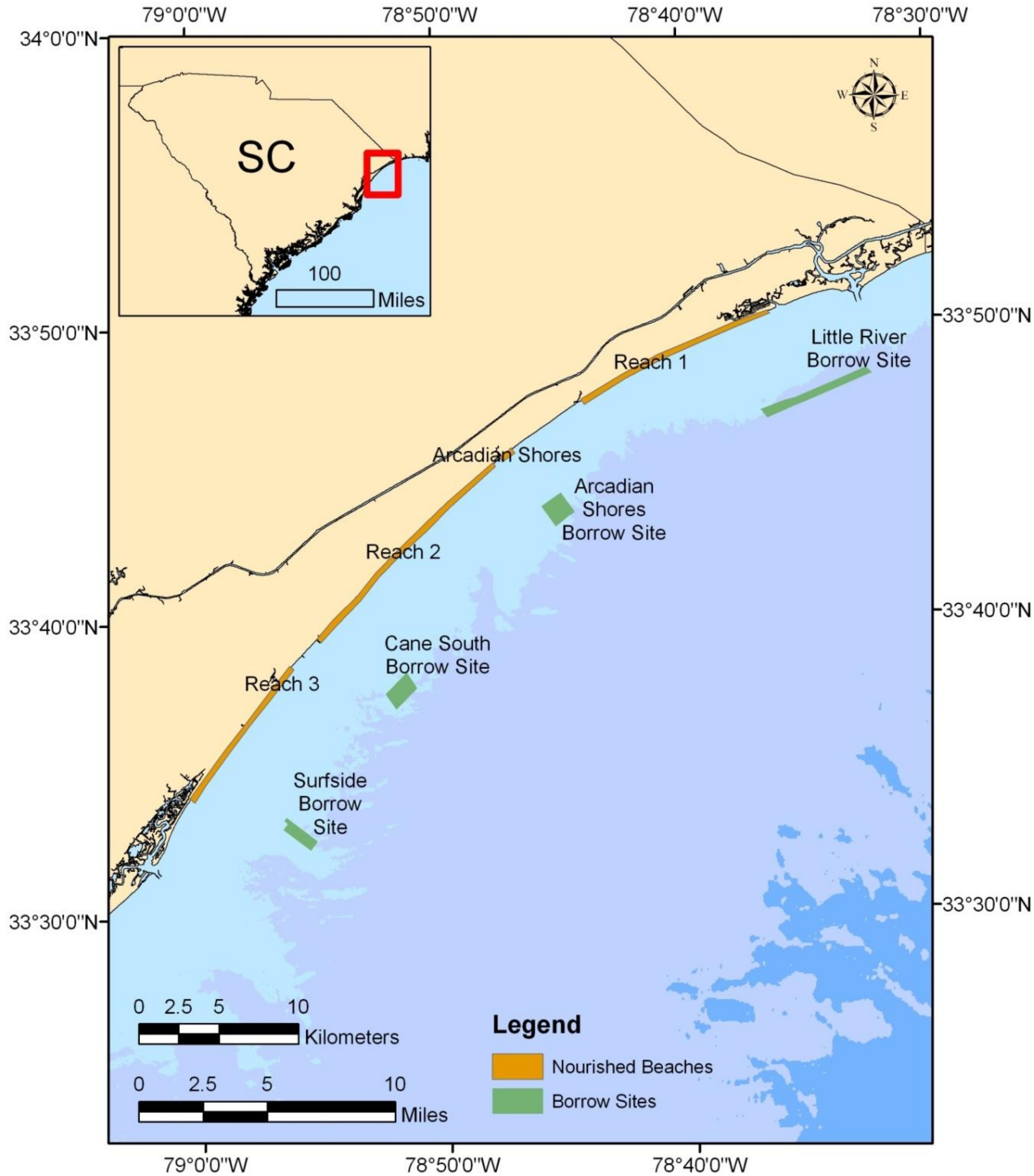


Figure 1. Map of the Grand Strand region indicating beaches nourished from 2007-2009 and borrow site locations. Reach 1: North Myrtle Beach, Reach 2: Myrtle Beach, Reach 3: Garden City/Surfside.

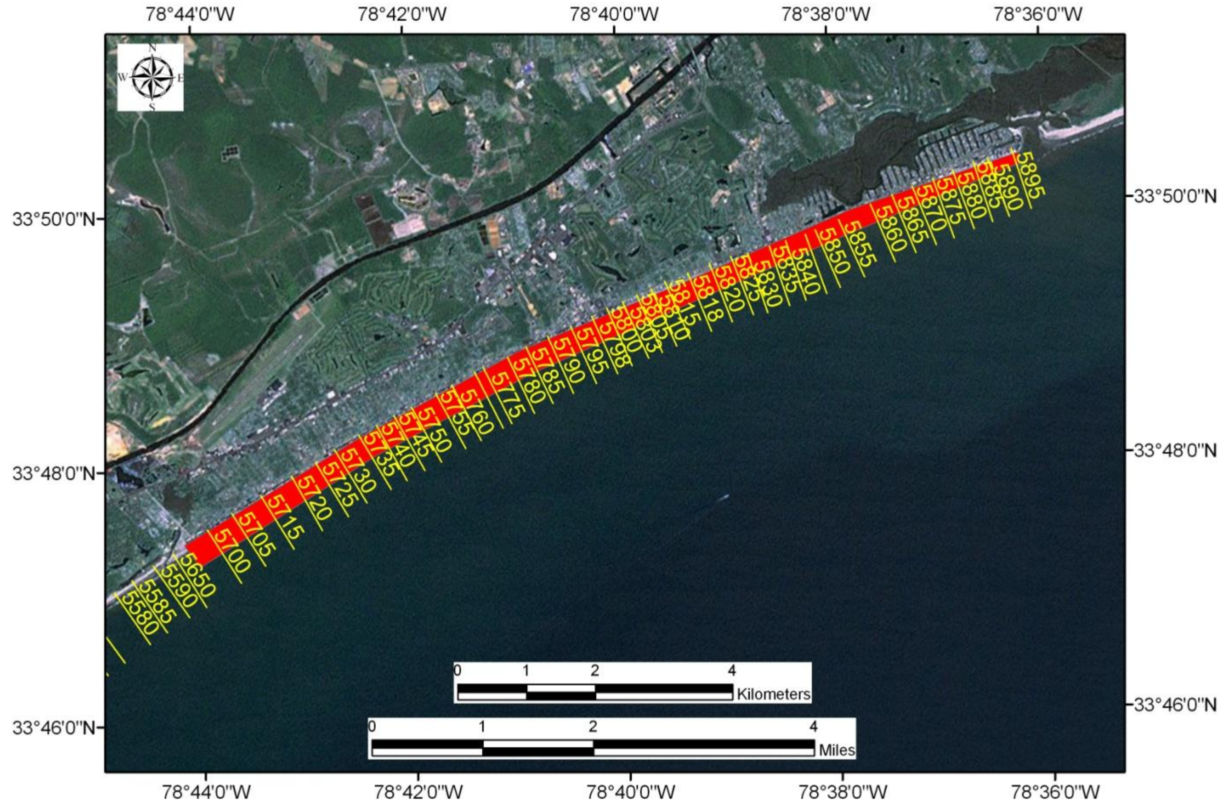


Figure 2. Beach profile locations for Reach 1 (NMB). Red highlighted region indicates extent of beach nourishment (profiles 5700 – 5895).

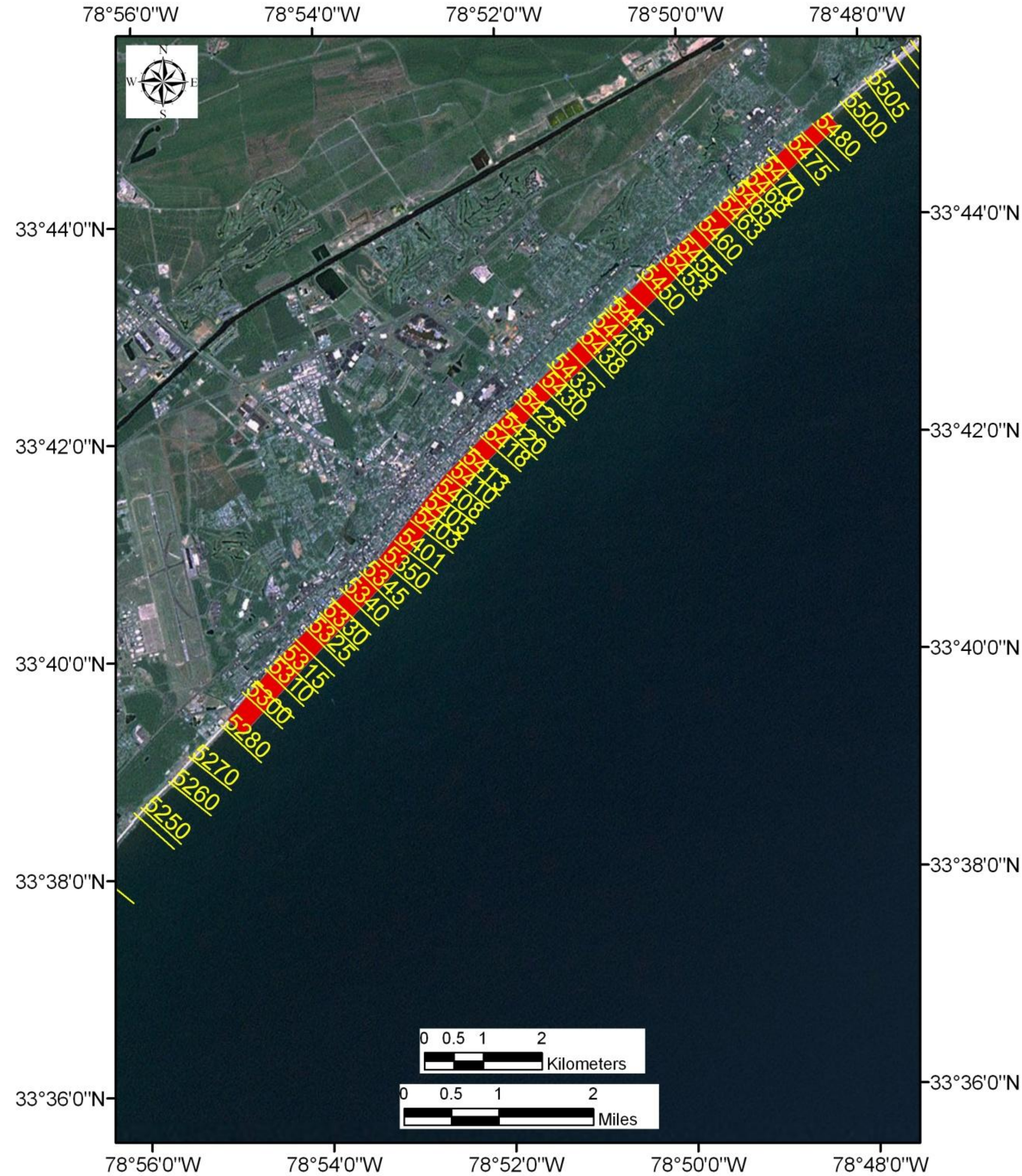


Figure 3. Beach profile locations for Reach 2 (MB). Red highlighted region indicates extent of beach nourishment (profiles 5300 – 5480).

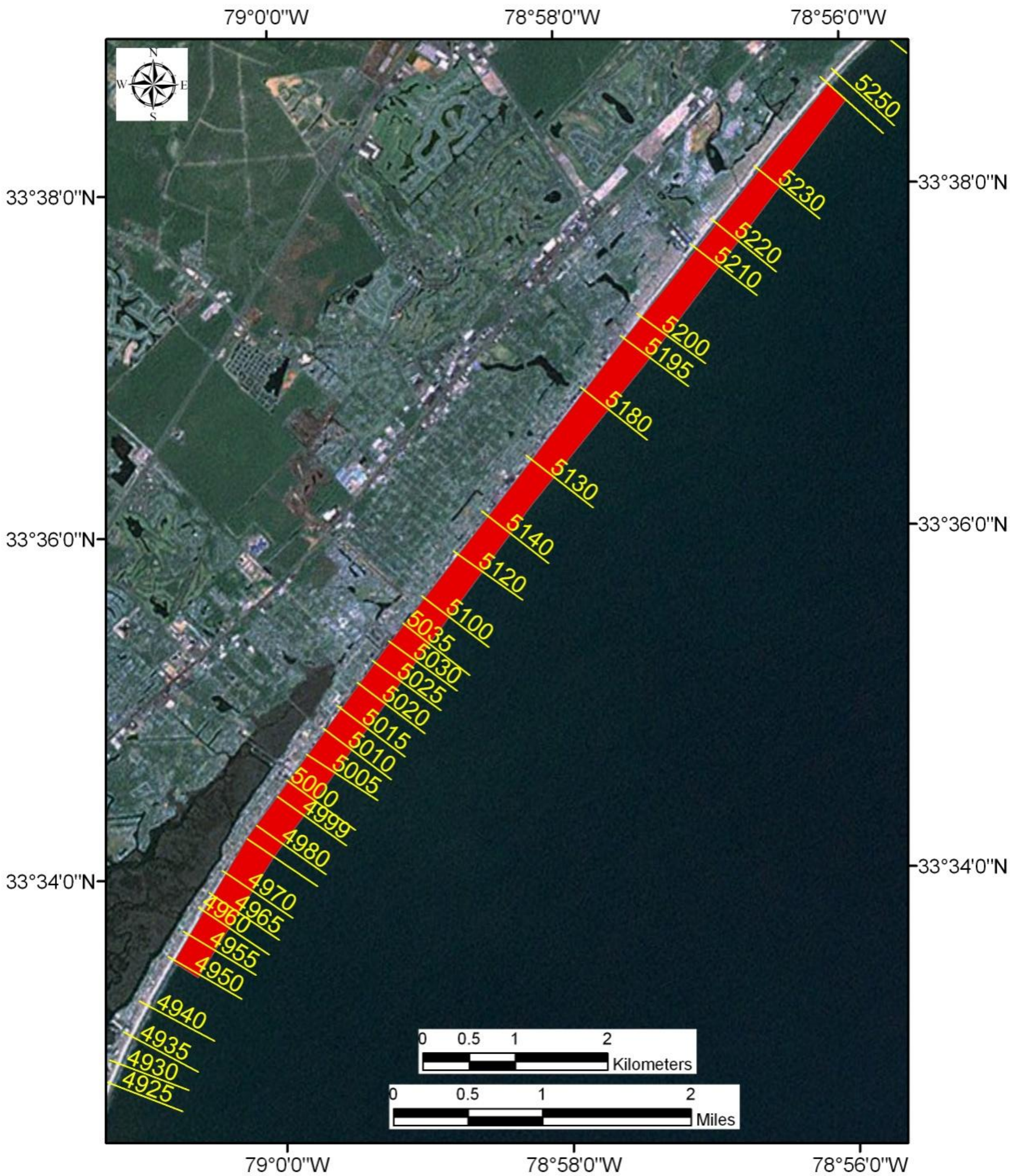


Figure 4. Beach profile locations for Reach 3 (SS-GC). Red highlighted region indicates extent of beach nourishment (profiles 4950 – 5240).

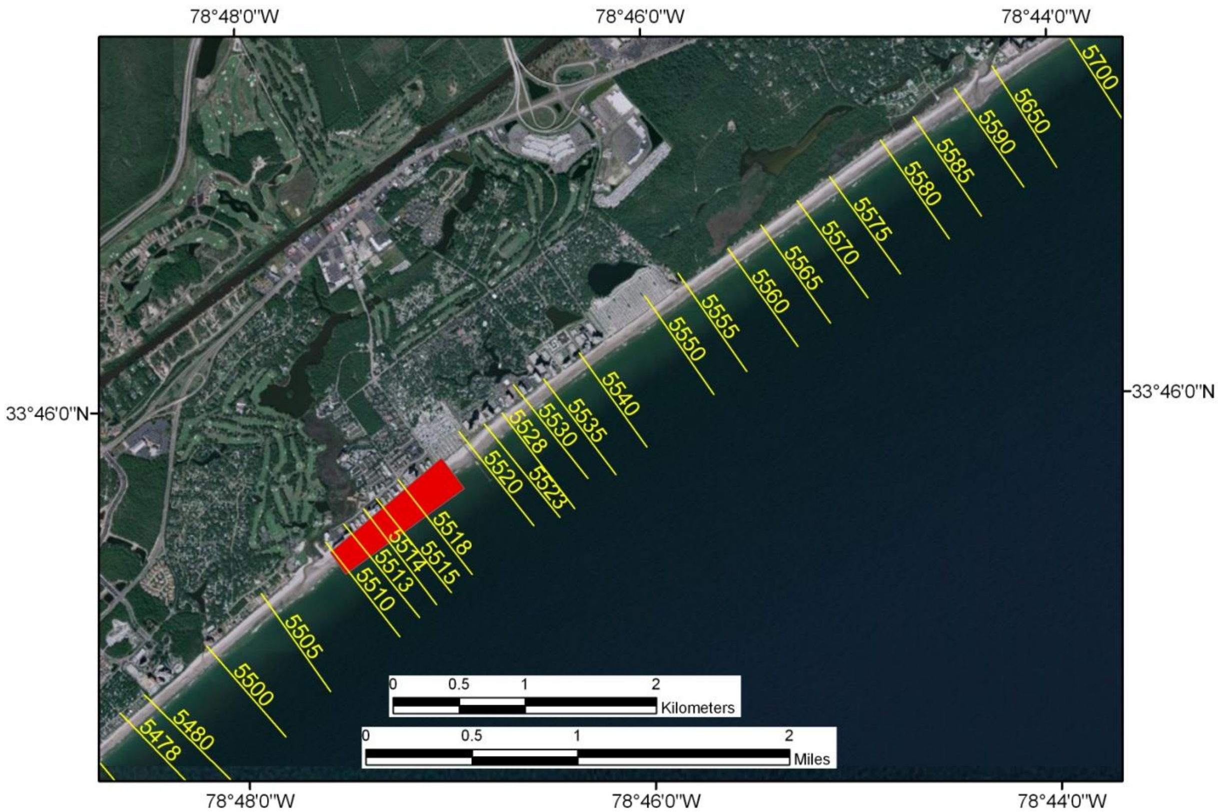


Figure 5. Beach profile locations for Arcadian Shores (AS). Red highlighted region indicates extent of beach nourishment (profiles 5510 – 5518).

Figure 6. Single-beam survey boat (a), and back pack GPS data acquisition (b).

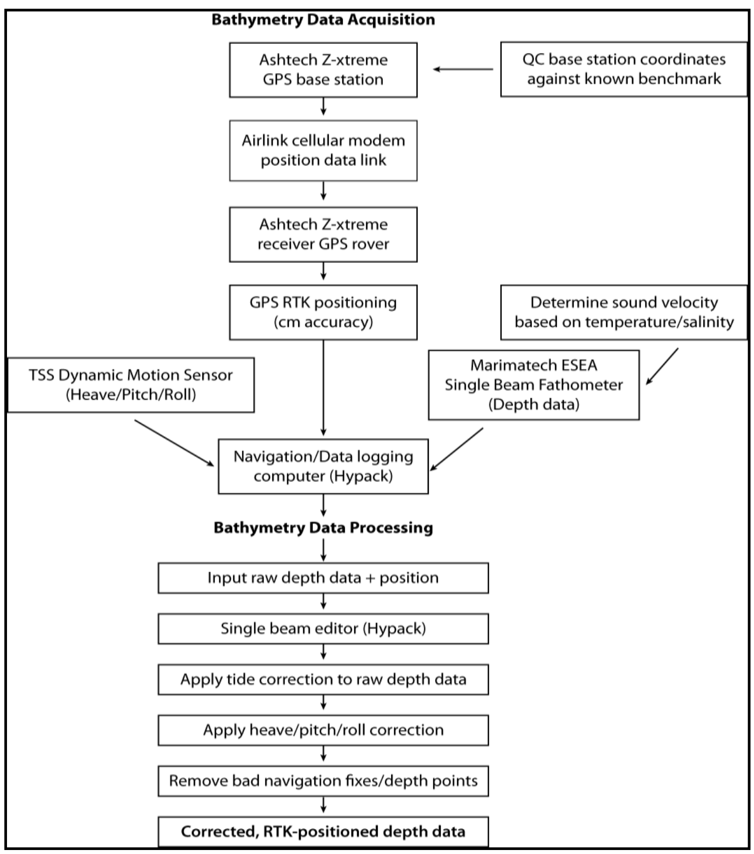


Figure 7. Bathymetric data collection workflow.

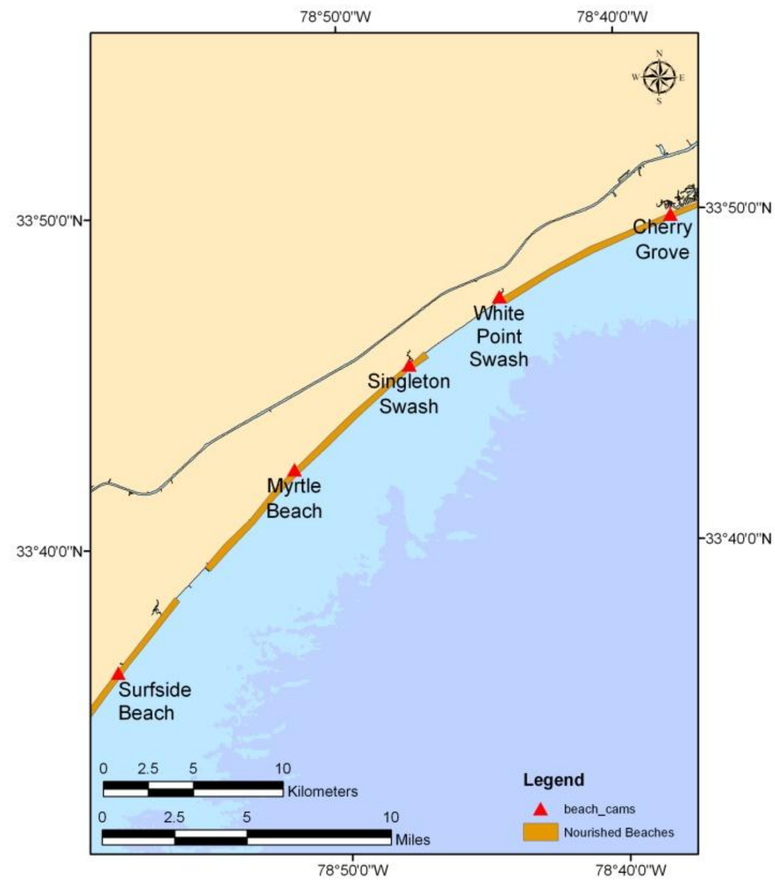
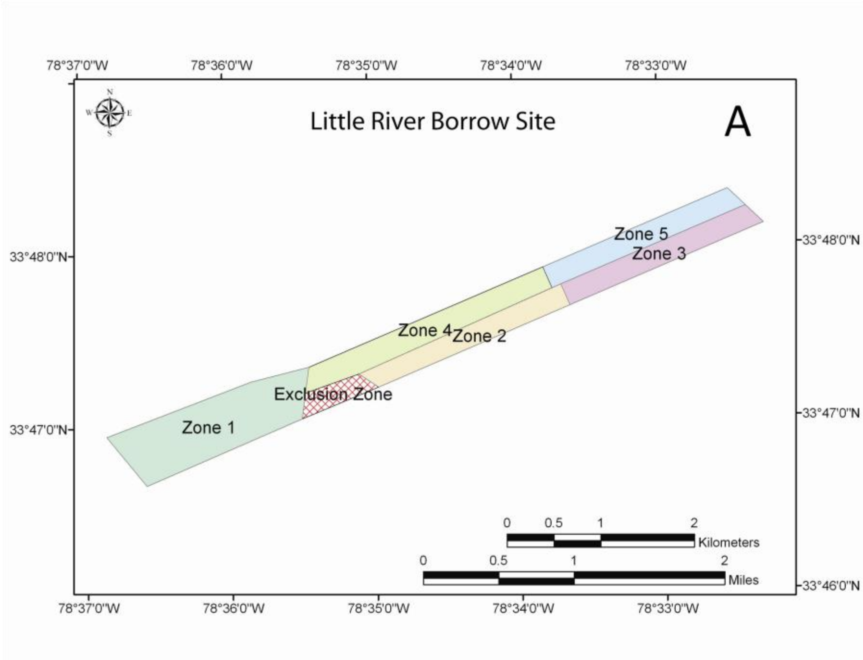
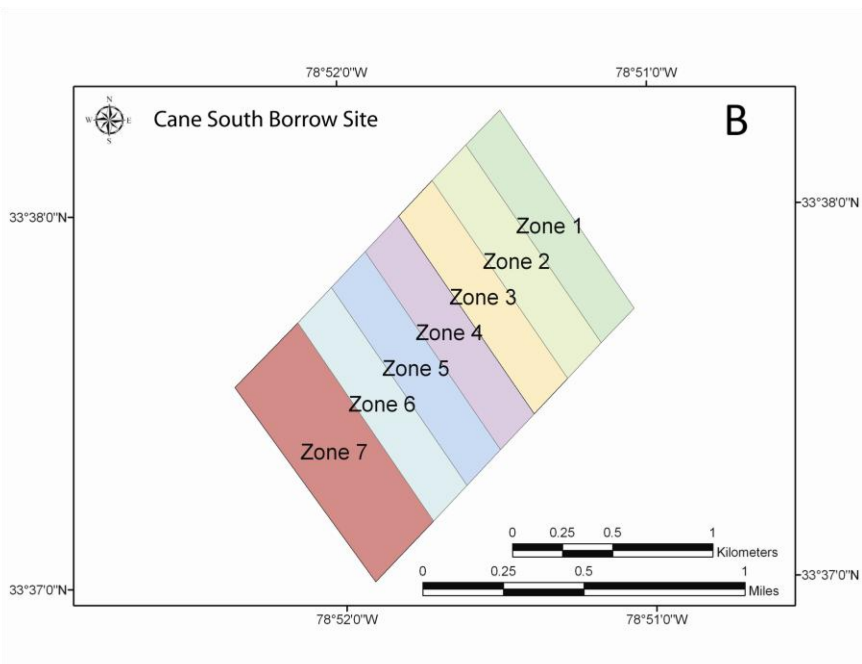


Figure 8. Map of beach camera locations along the Grand Strand.



Little River Borrow Site
A
Zone 5
Zone 3
Zone 4
Zone 2
Exclusion Zone
Zone 1
78°37'0"W
78°36'0"W
78°35'0"W
78°34'0"W
78°33'0"W
33°48'0"N
33°47'0"N
33°46'0"N
0 0.5 1 2
Kilometers
0 0.5 1 2
Miles



Cane South Borrow Site
B
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Zone 6
Zone 7
78°52'0"W
78°51'0"W
33°38'0"N
33°37'0"N
0 0.25 0.5 1
Kilometers
0 0.25 0.5 1
Miles

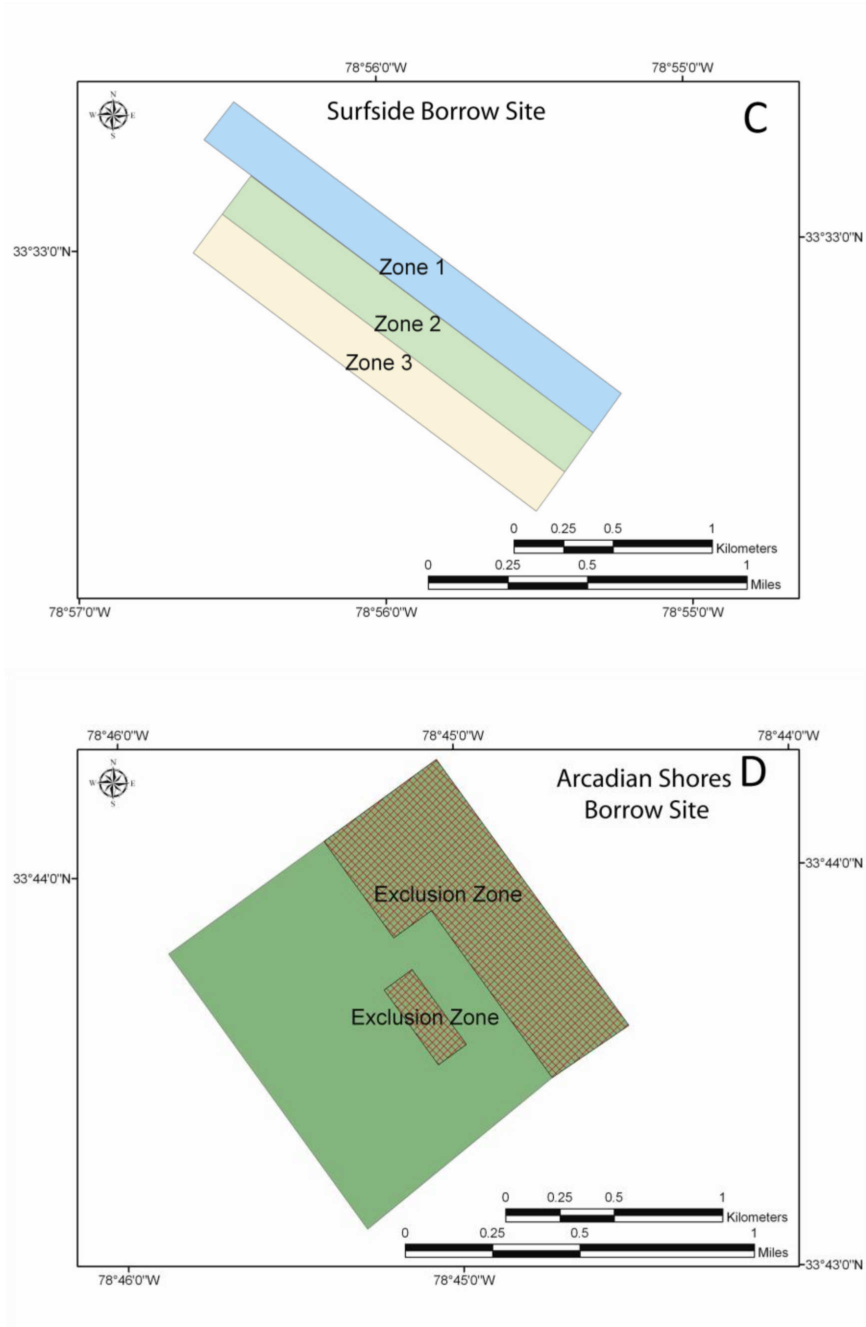


Figure 9. Map view of borrow site lay-out for Reach 1 (A), Reach 2 (B), Reach 3 (C), and Arcadian Shores (D).

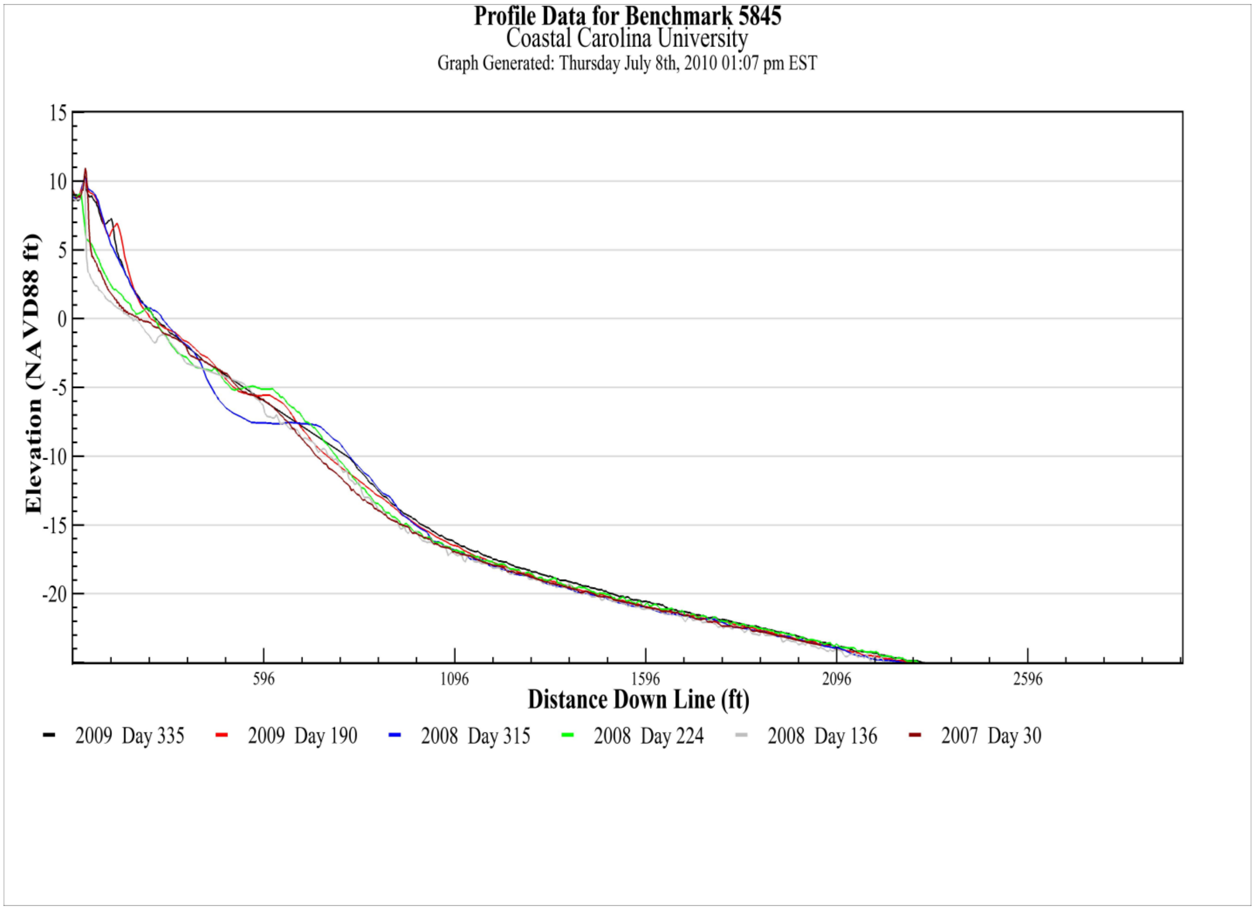


Figure 10. Beach profile data from benchmark 5845 (2007-2009).

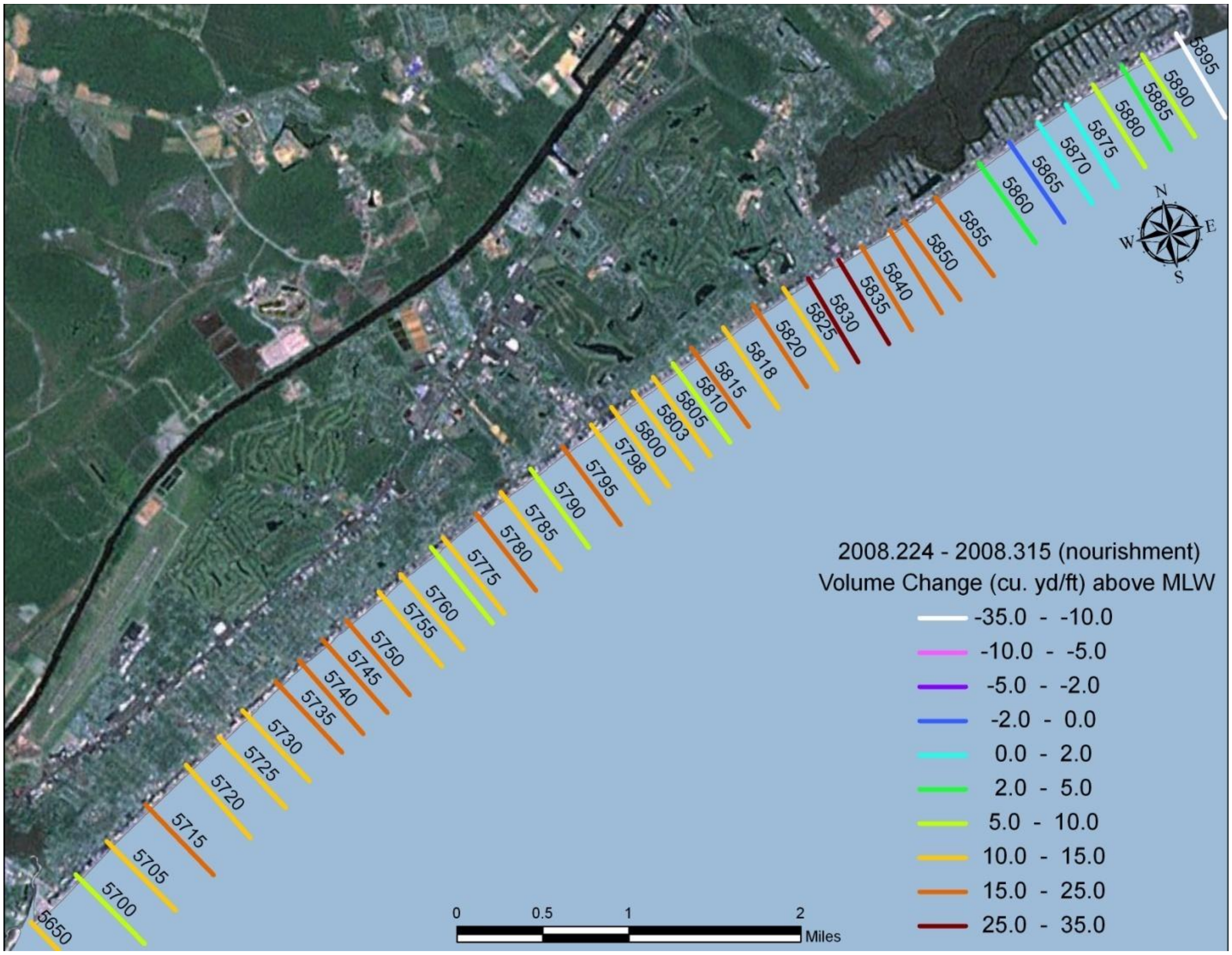


Figure 11. Volume change (yd^3 ft^{-1}) above MLW contour at Reach 1 profiles based on pre-nourishment (2008.224) and post-nourishment (2008.315) surveys. Beach nourishment spanned profiles 5700 – 5895.

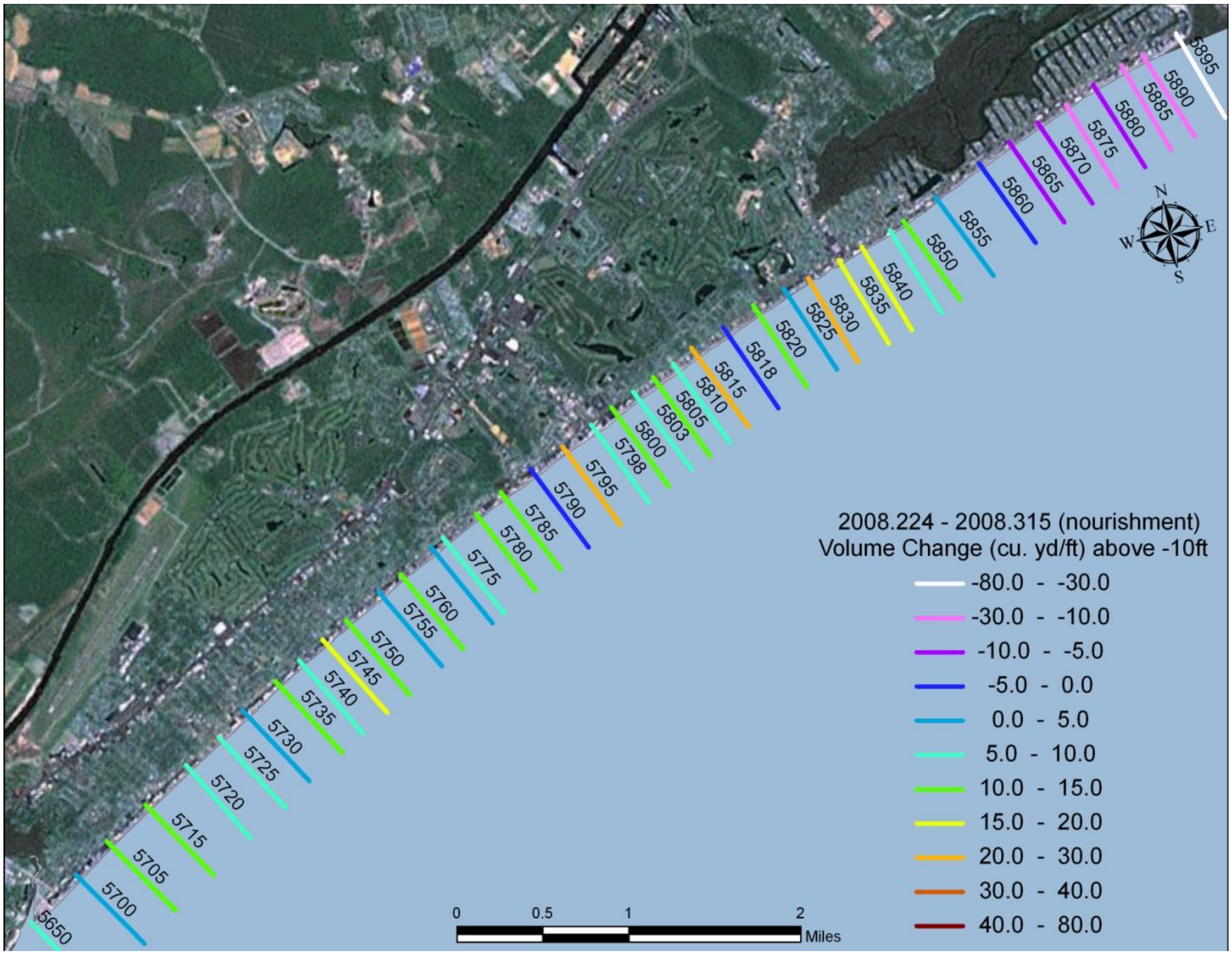


Figure 12. Volume change ($yd^3\ ft^{-1}$) above the -10 ft contour at Reach 1 profiles based on pre-nourishment (2008.224) and post-nourishment (2008.315) surveys. Beach nourishment spanned profiles 5700 – 5895.

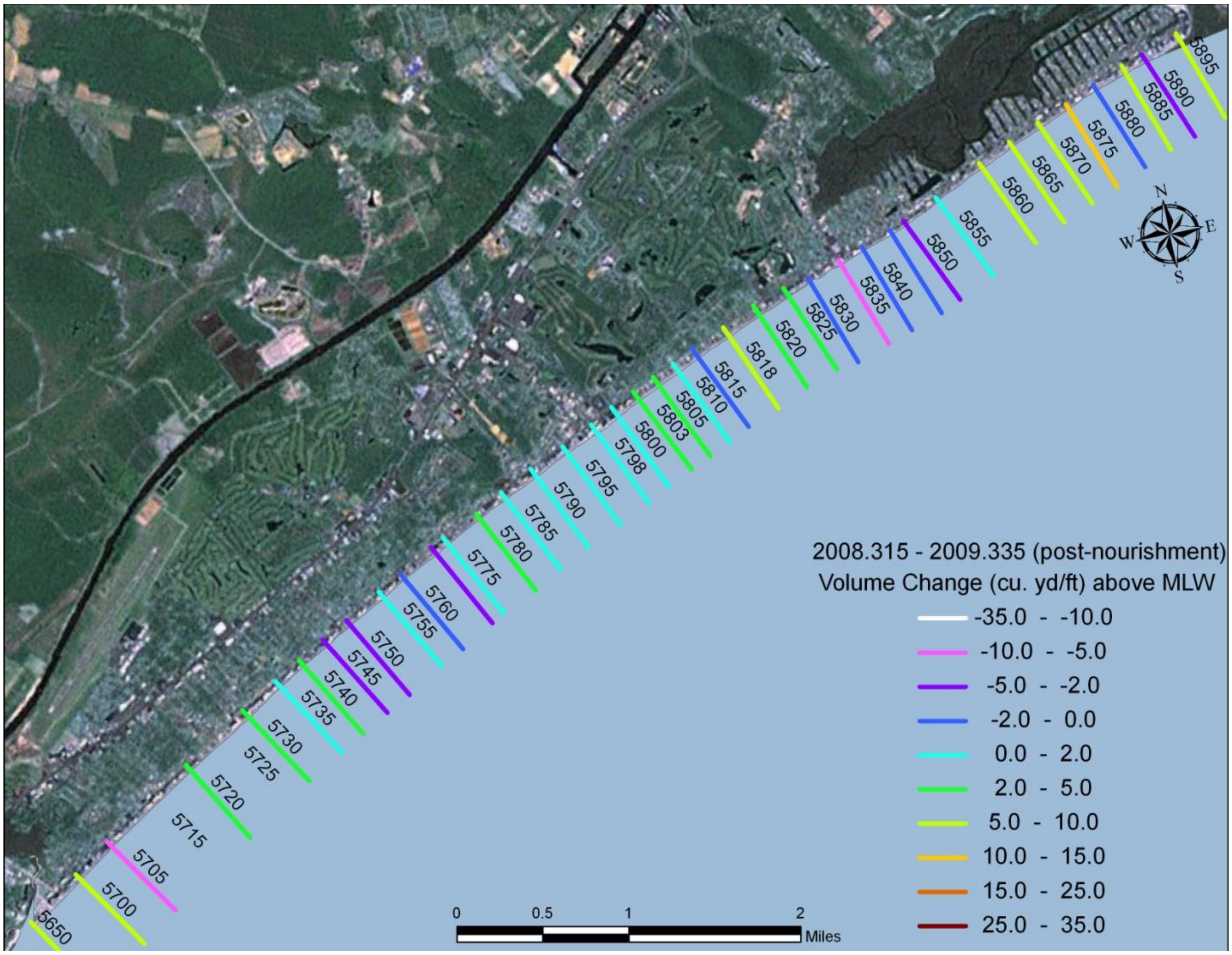


Figure 13. Volume change (yd^3 ft^{-1}) above MLW contour at Reach 1 profiles based on closest post-nourishment (2008.315) and most recent (2009.335) surveys. Beach nourishment spanned profiles 5700 – 5895.

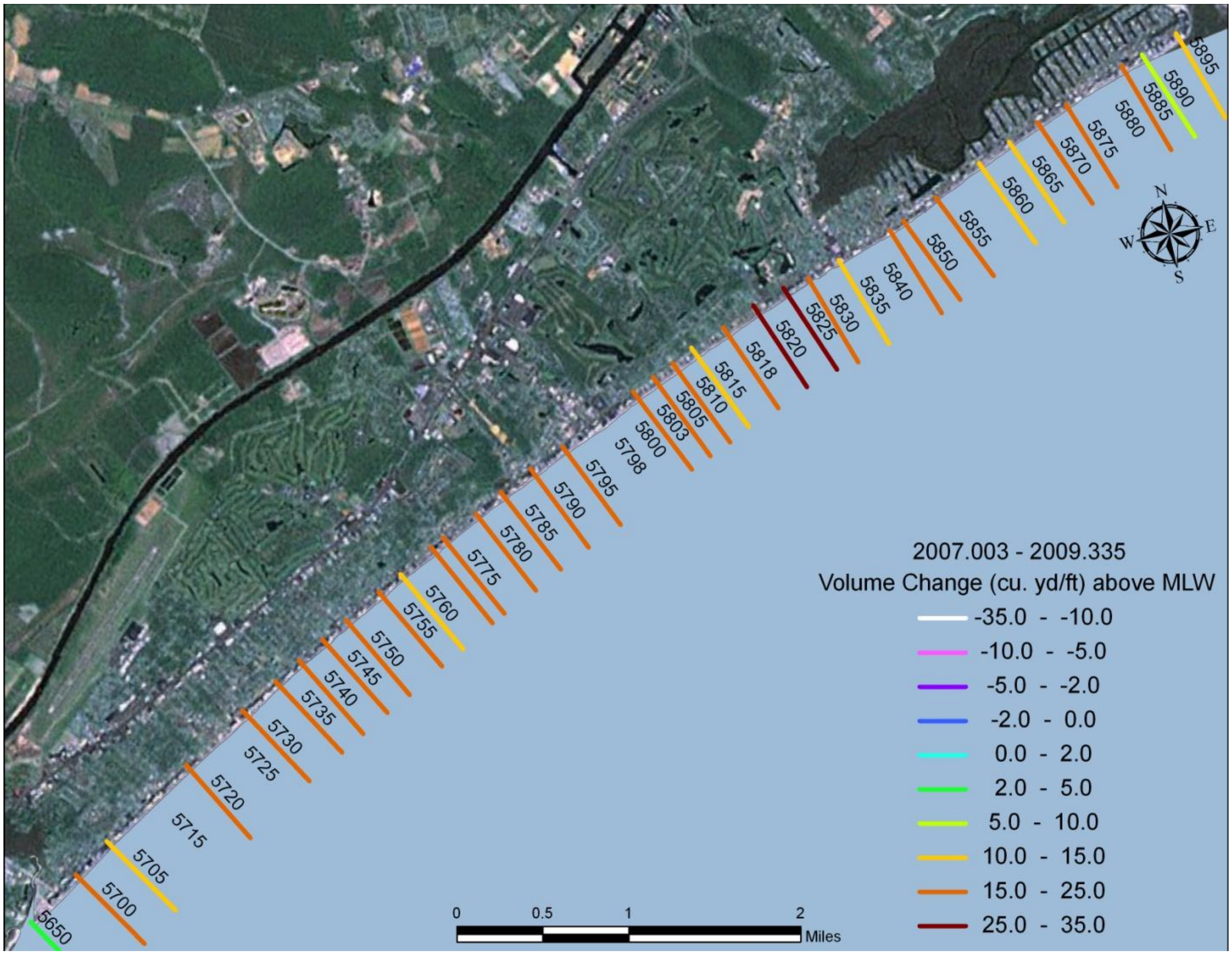


Figure 14. 2007–2009 volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 1 profiles based on Jan 2007 (2007.003) and Dec 2010 (2009.335) surveys. Beach nourishment spanned profiles 5700 – 5895.

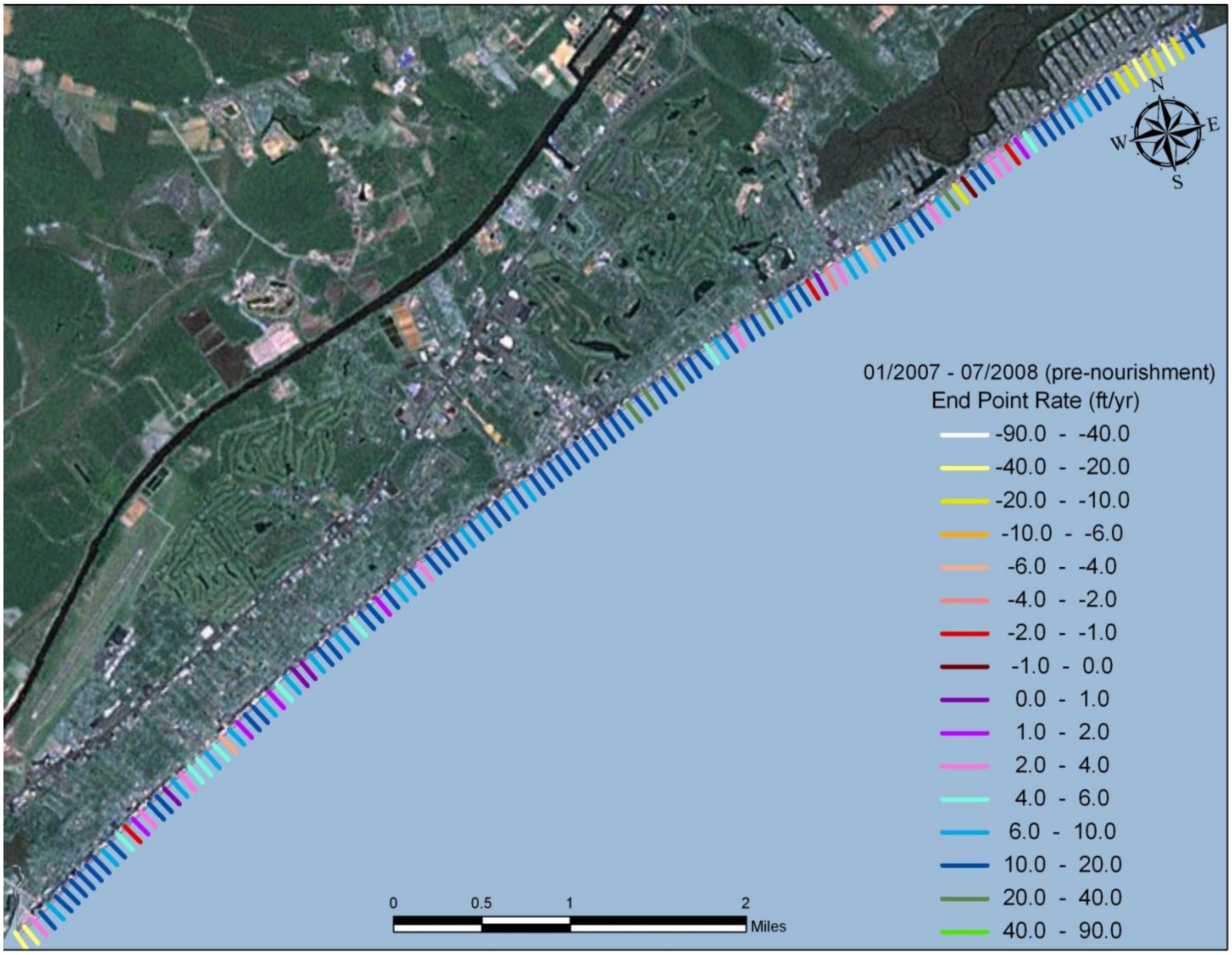


Figure 15. Pre-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 1, Jan 2007–Jul 2008.

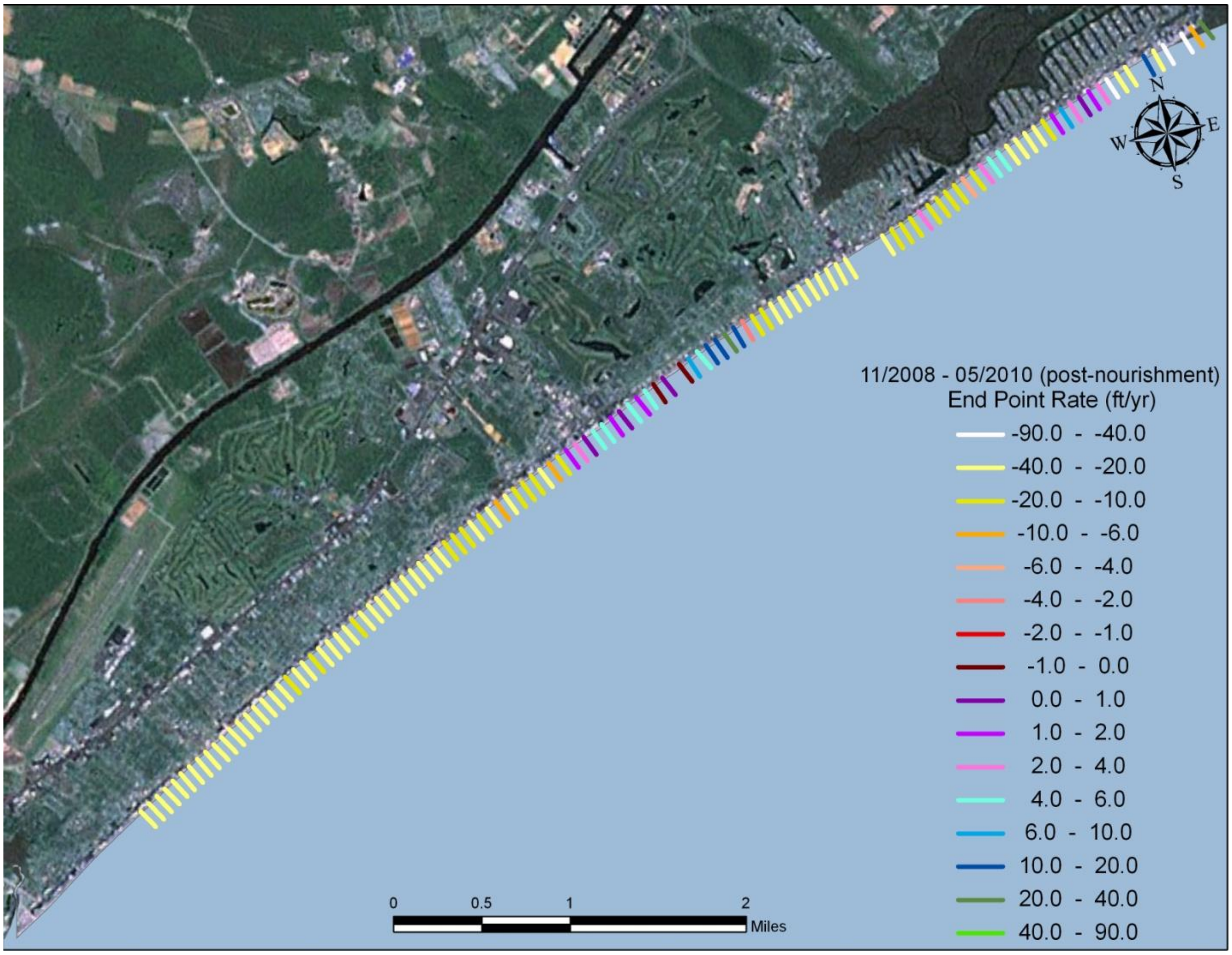


Figure 16. Post-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 1, Nov 2008–May 2010.

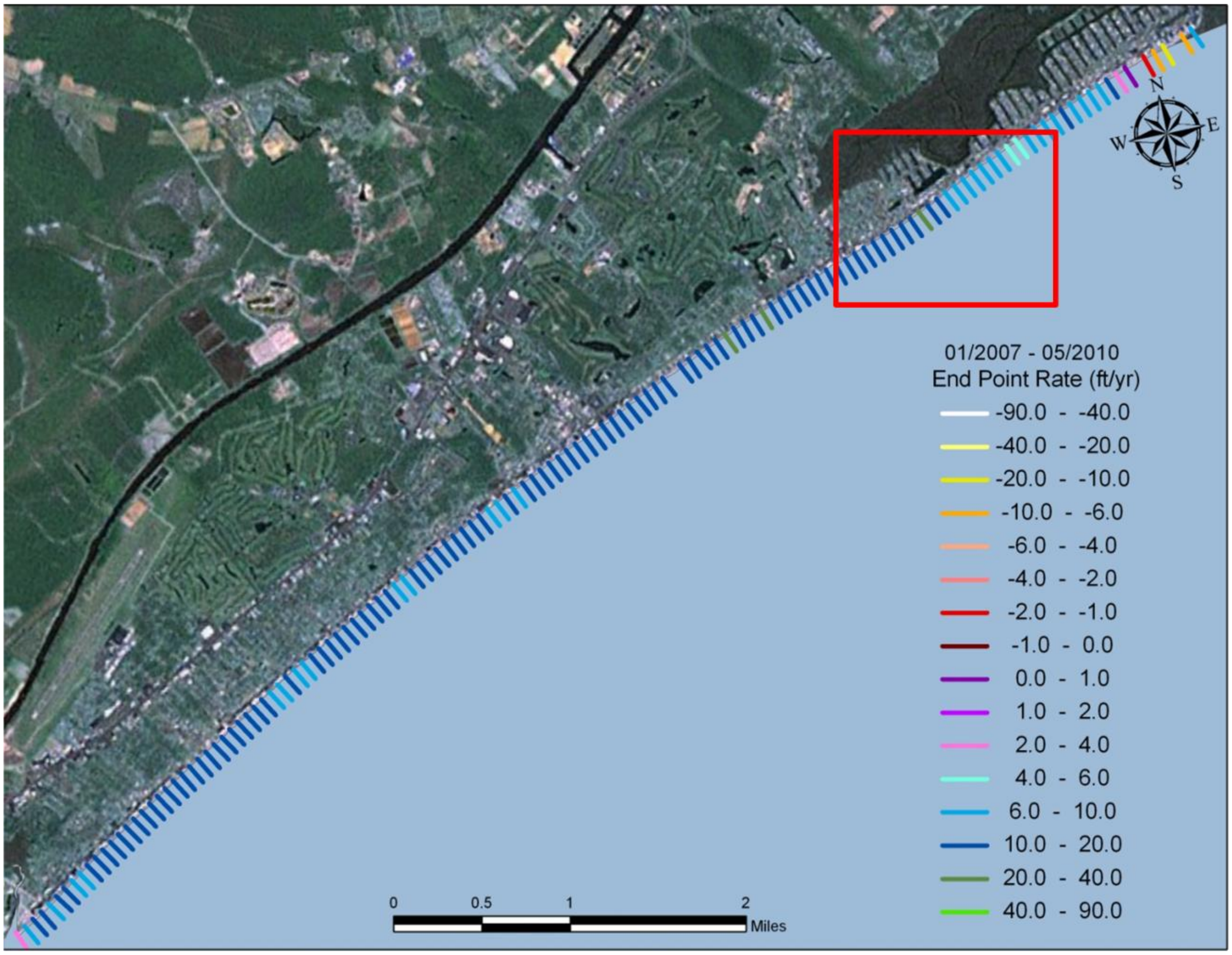


Figure 17. 2007-2010 end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 1, Jan 2007–May 2010. Red outlined region is illustrated in Figure 15.

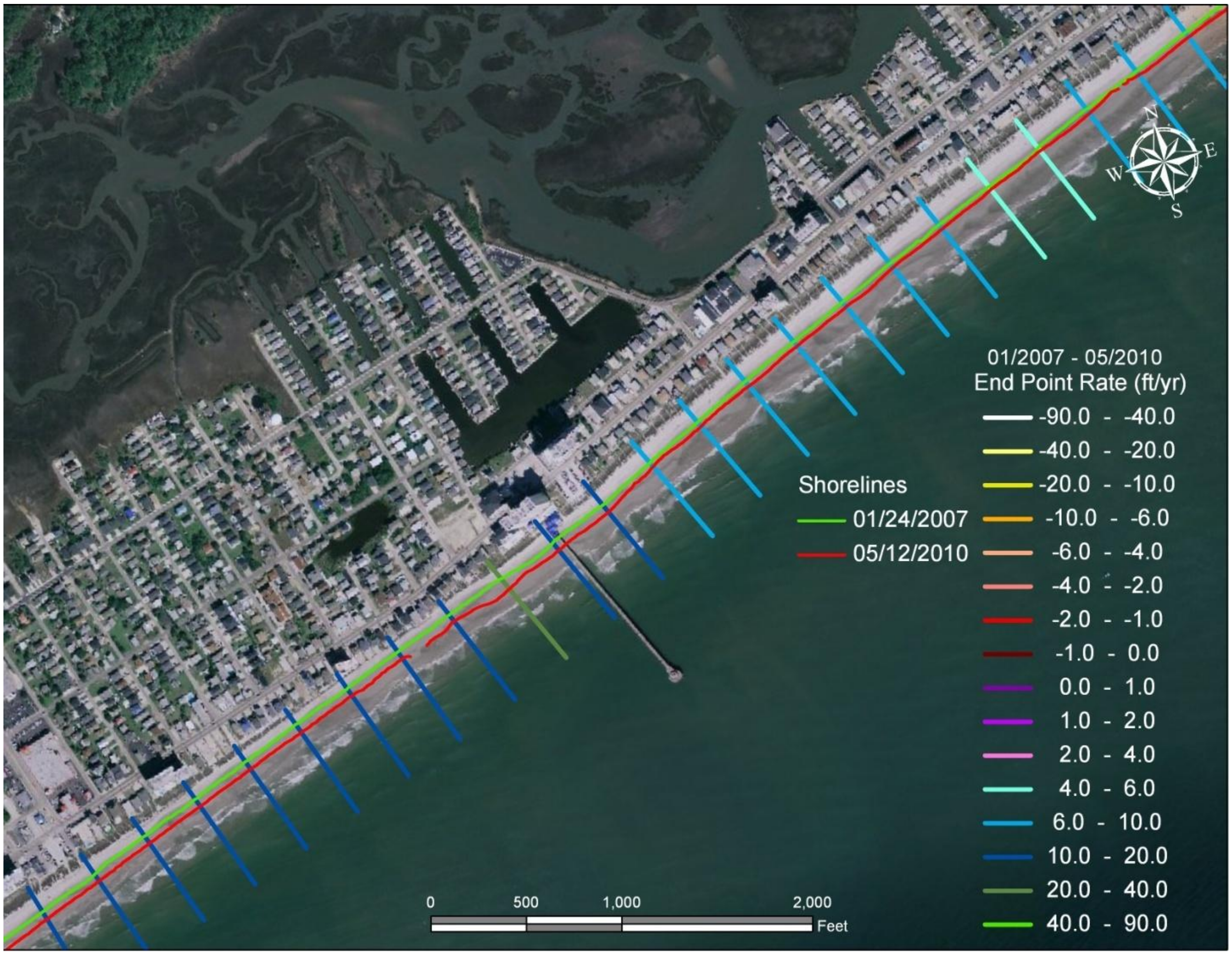


Figure 18. Highlighted region of Reach 1 (see Figure 14 for location) documenting Jan 2007 and May 2010 MHW contours and calculated end point rates.

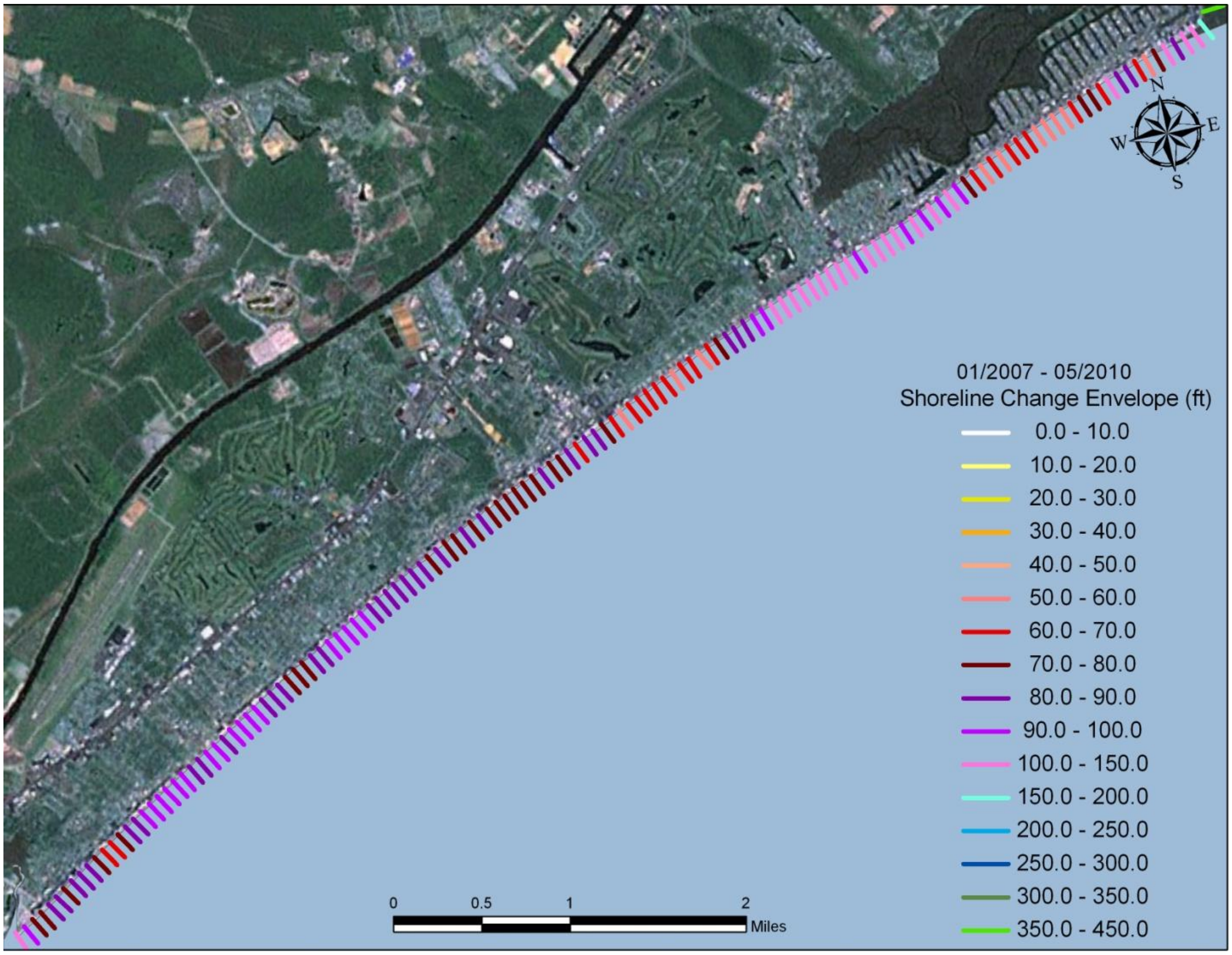


Figure 19. Shoreline change envelope (ft) for Reach 1 based on monthly MHW surveys, Jan 2007–May 2010.

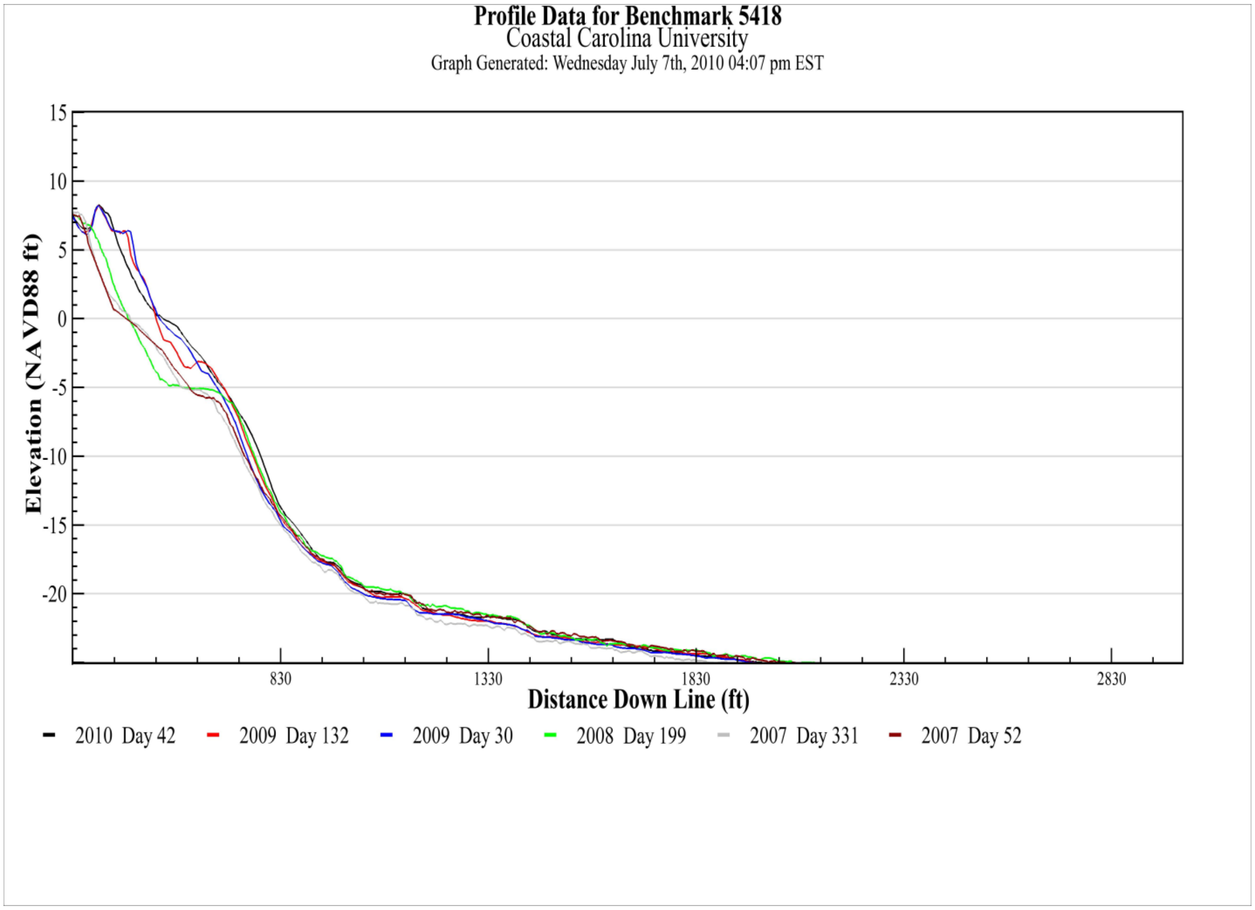


Figure 20. Beach profile data from benchmark 5418 (2007-2010).

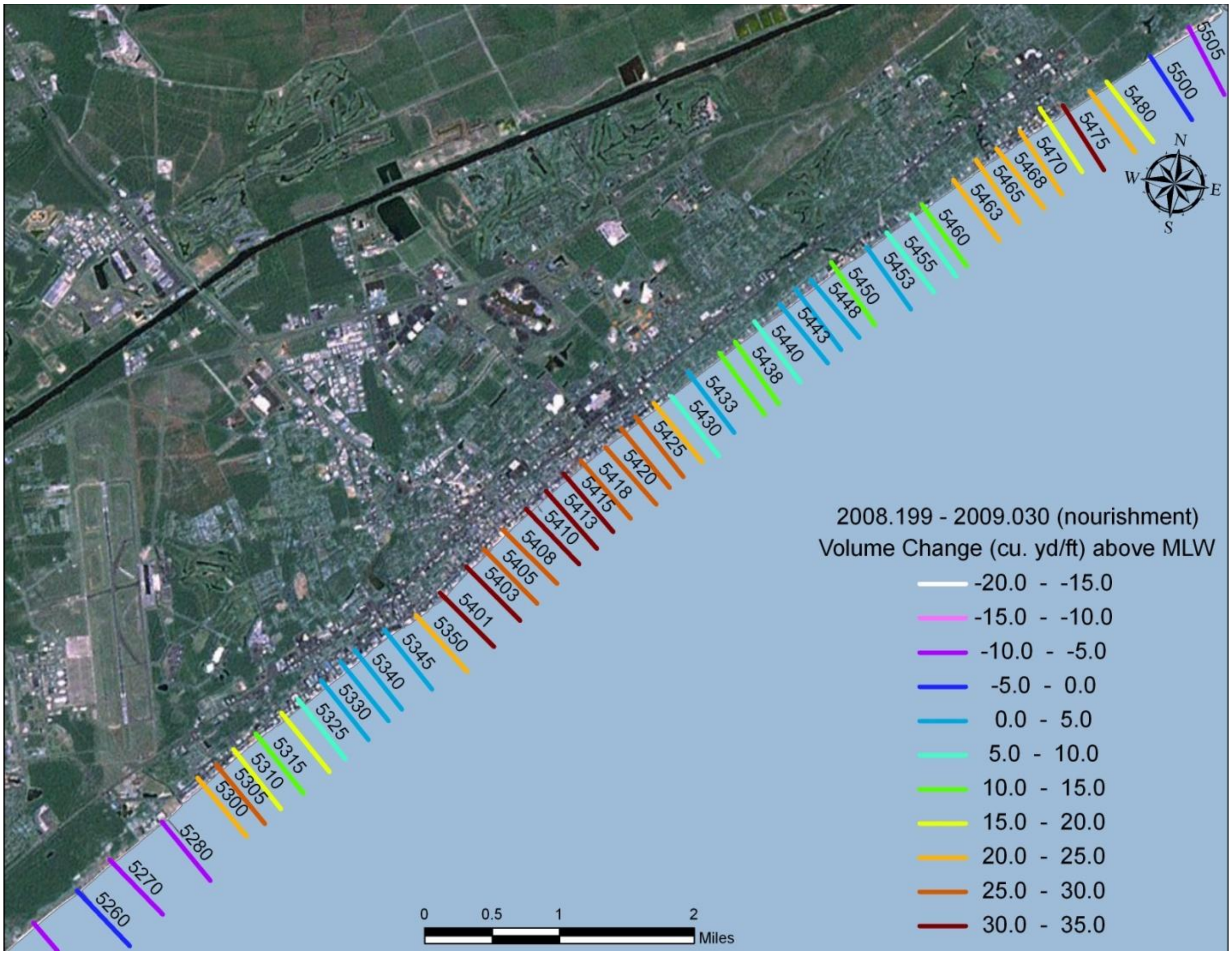


Figure 21. Volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 2 profiles based on pre-nourishment (2008.199) and post-nourishment (2009.030) surveys. Beach nourishment spanned profiles 5300 – 5480.

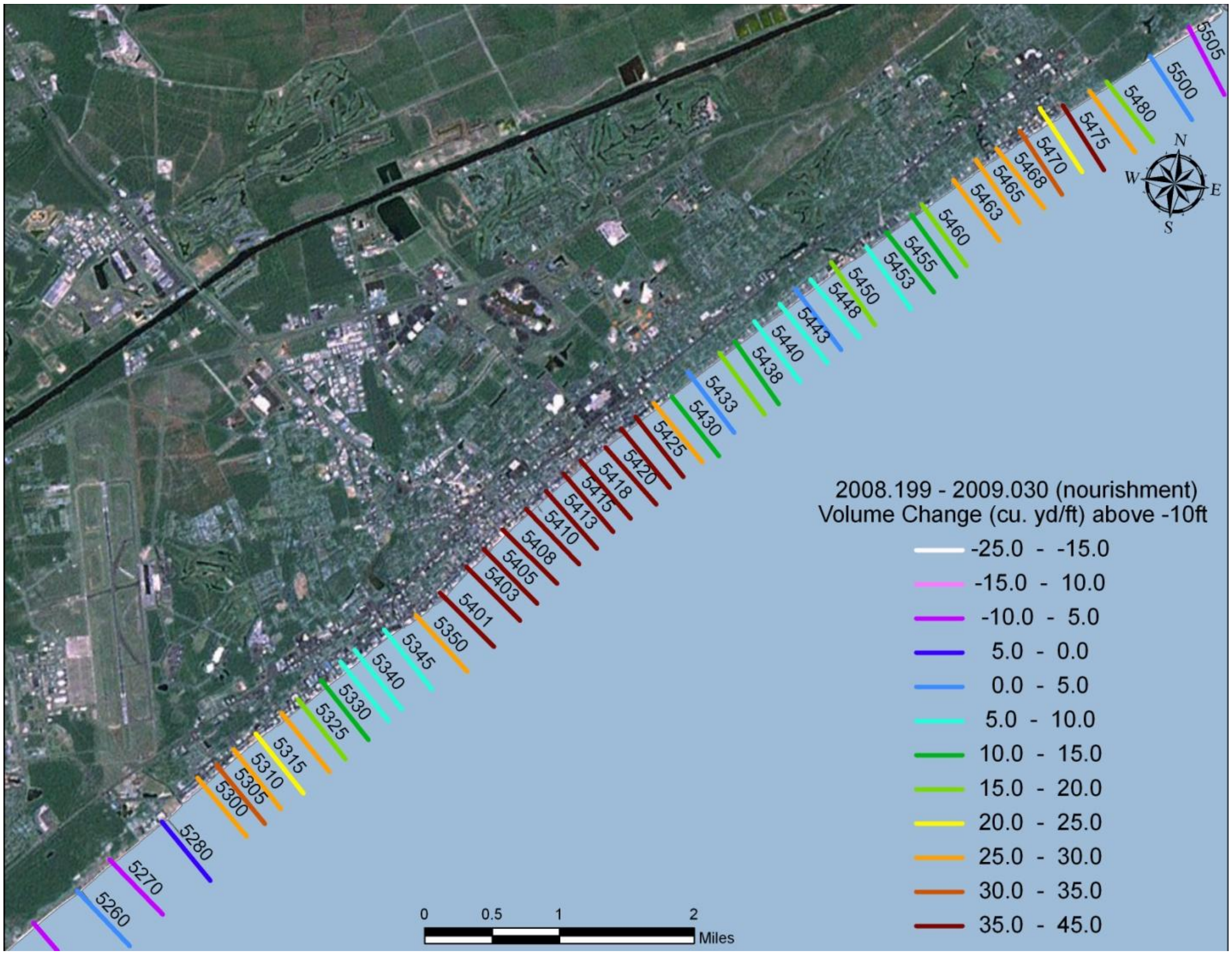


Figure 22. Volume change (yd^3 ft^{-1}) above -10 ft contour at Reach 2 profiles based on pre-nourishment (2008.199) and post-nourishment (2009.030) surveys. Beach nourishment spanned profiles 5300 – 5480.

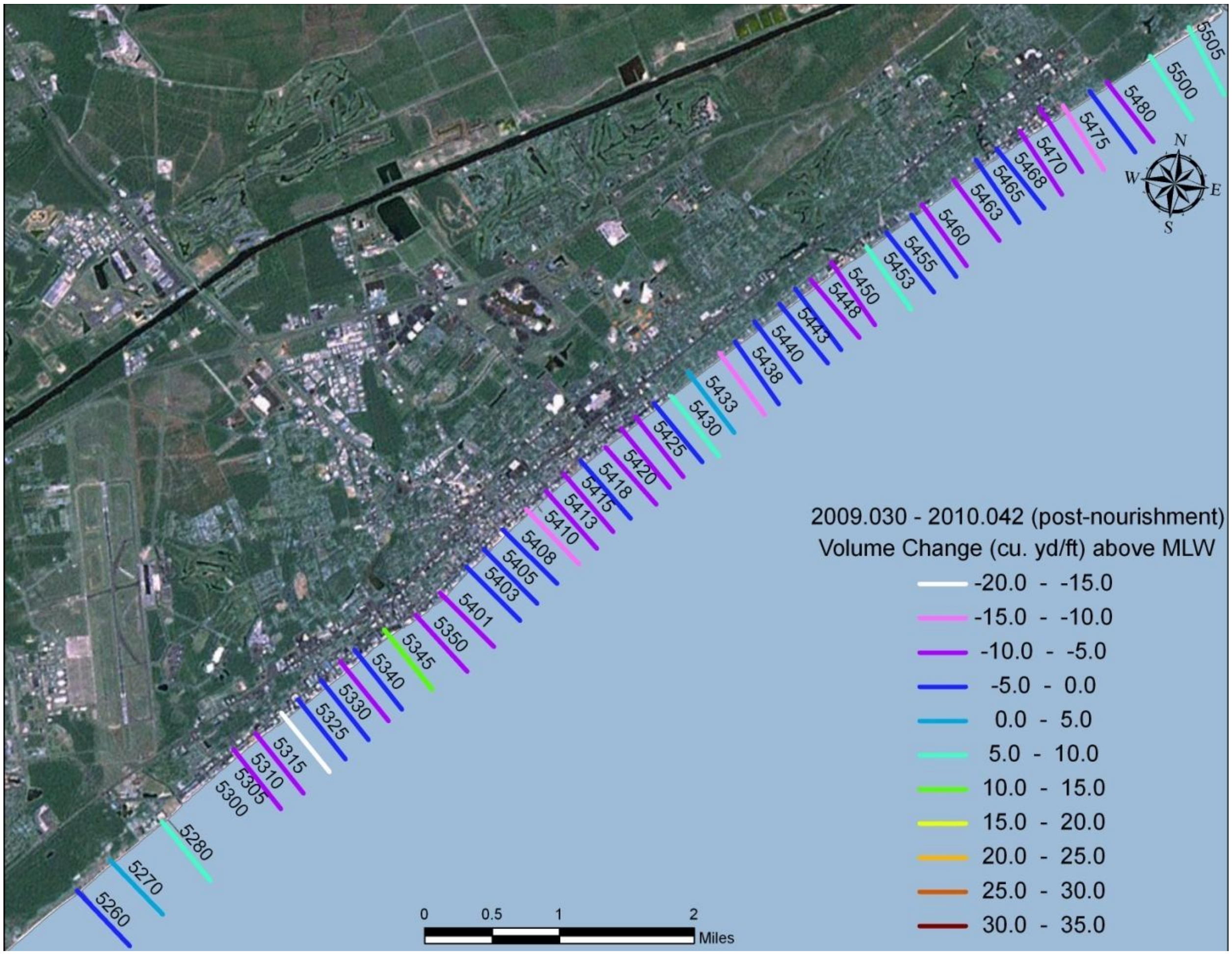


Figure 23. Volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 2 profiles based on closest post-nourishment (2009.030) and most recent (2010.042) surveys. Beach nourishment spanned profiles 5300 – 5480.

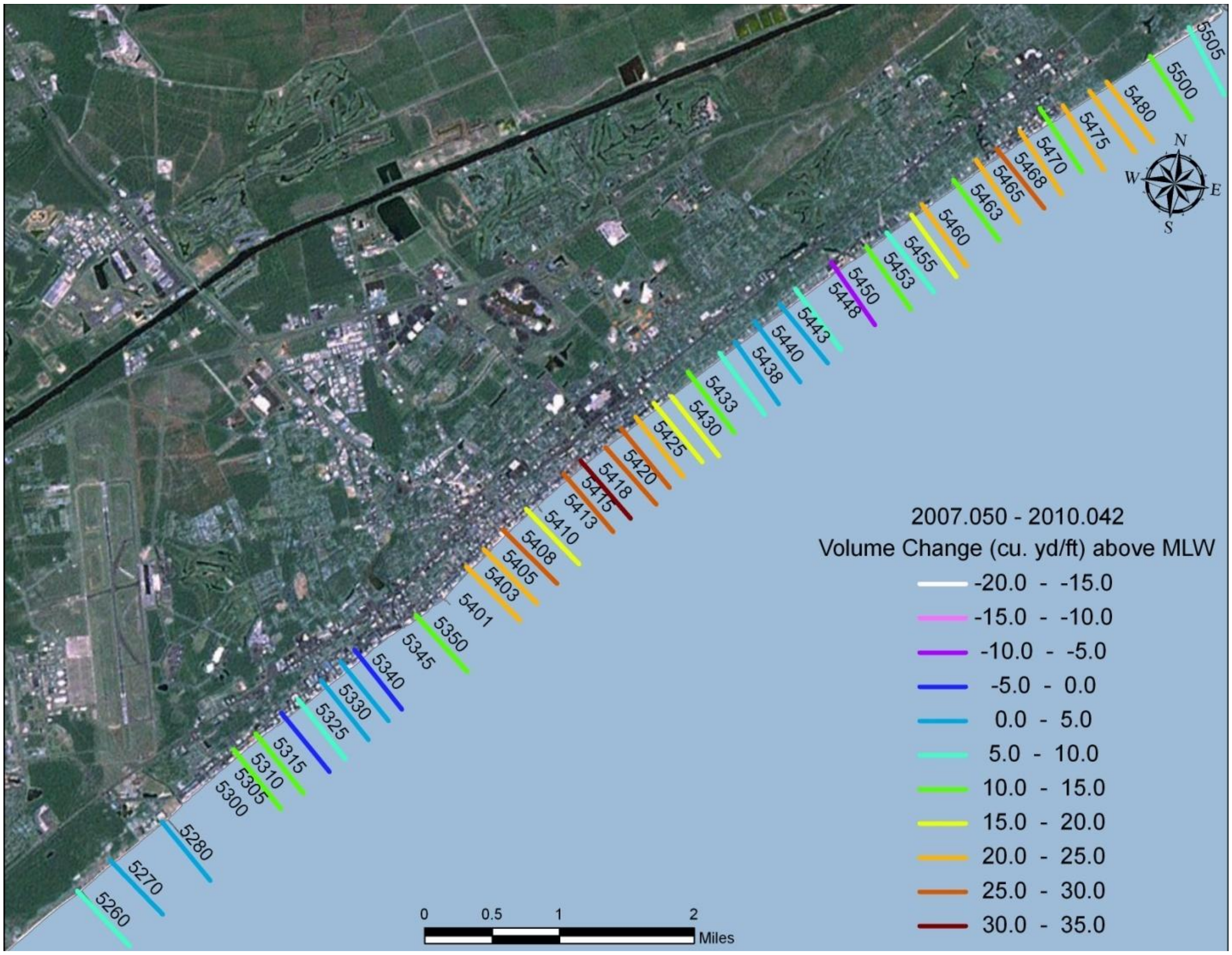


Figure 24. 2007–2010 volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 2 profiles based on Feb 2007 (2007.050) and Feb 2010 (2010.042) surveys. Beach nourishment spanned profiles 5300 – 5480.

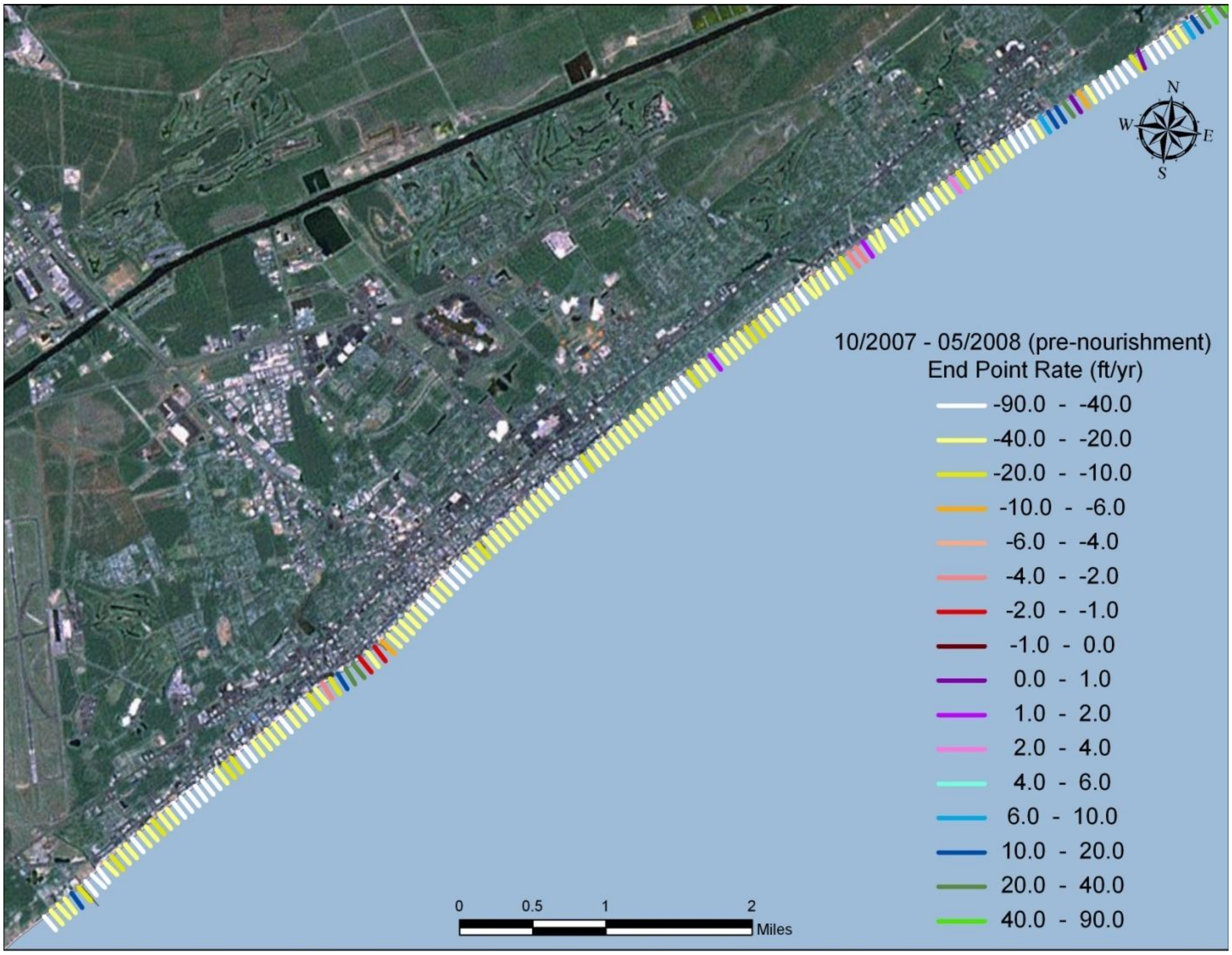


Figure 25. Pre-nourishment end point rate (ft yr^{-1}) of MHW contour based on quarterly MHW surveys of Reach 2, Oct 2007–May 2008.

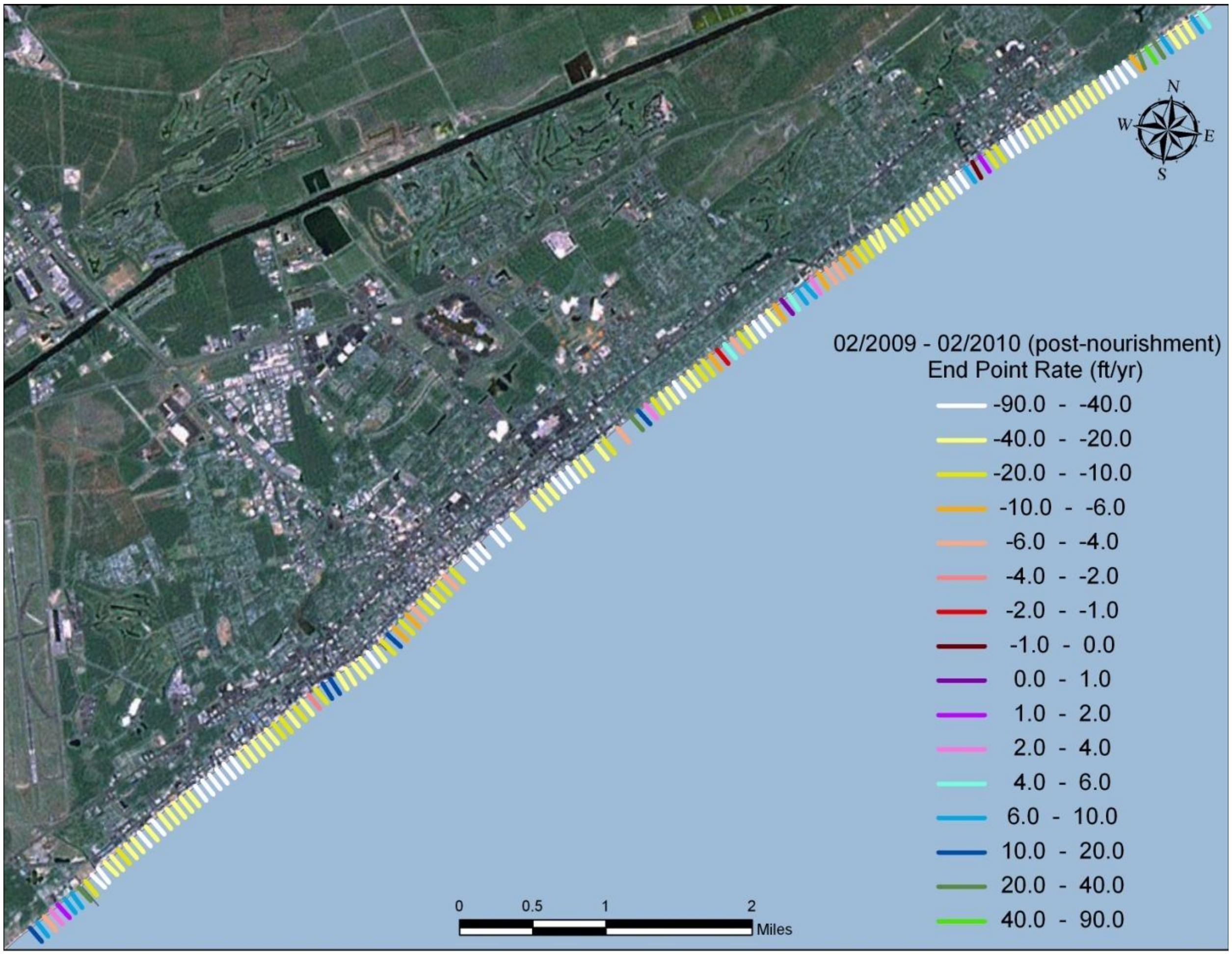


Figure 26. Post-nourishment end point rate (ft yr^{-1}) of MHW contour based on quarterly MHW surveys of Reach 2, Feb 2009–Feb 2010.

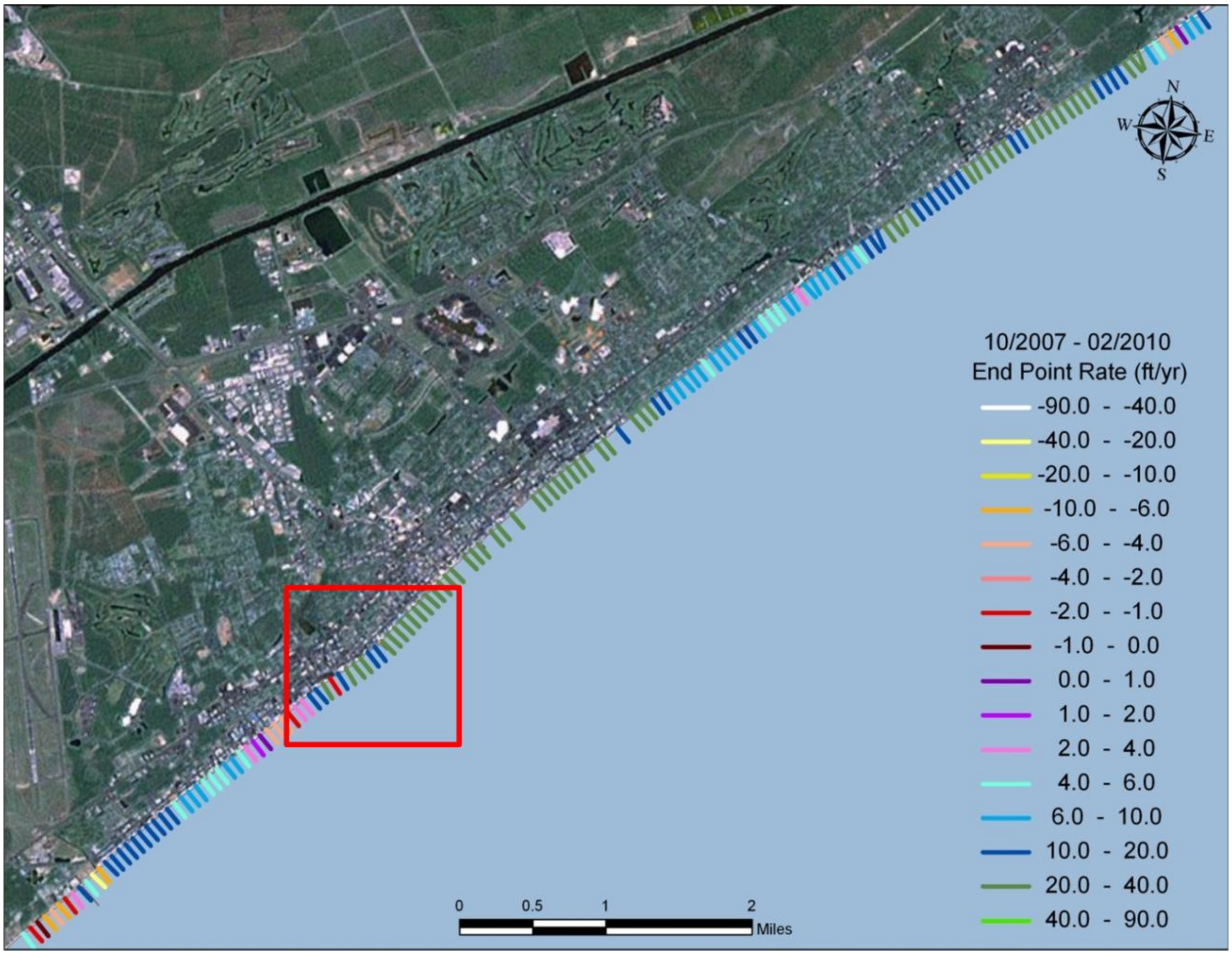


Figure 27. 2007–2010 end point rate (ft yr^{-1}) of MHW contour based on quarterly MHW surveys of Reach 2, Oct 2007–Feb 2010.

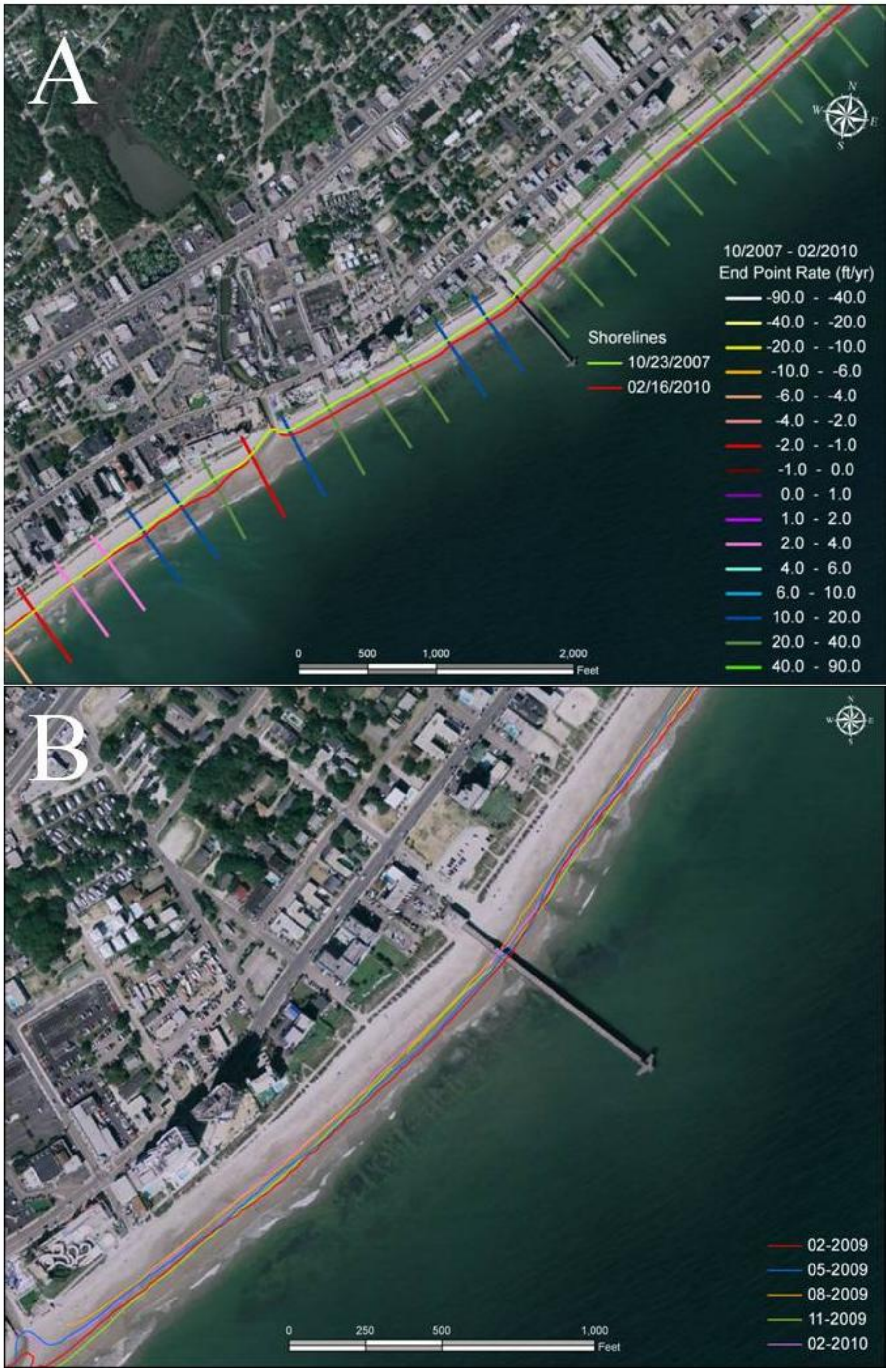


Figure 28. (A) Highlighted region of Reach 2 (see Figure 27 for location) documenting Oct 2007 and Feb 2010 MHW contours and calculated end point rates, and (B) quarterly post-nourishment MHW shoreline locations documenting initial landward migration and representative variability.

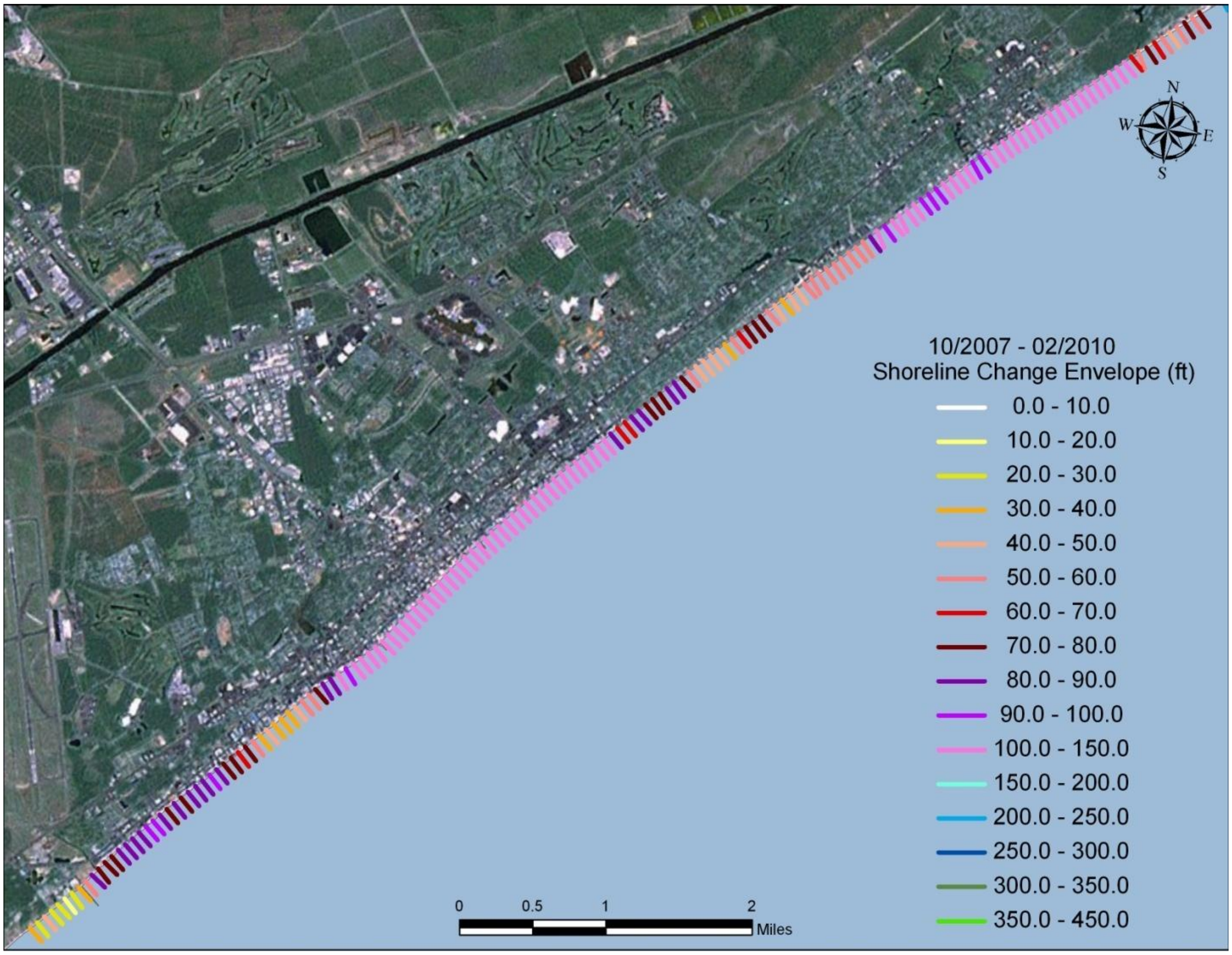


Figure 29. Shoreline change envelope (ft) for Reach 2 based on quarterly MHW surveys, Oct 2007–Feb 2010.

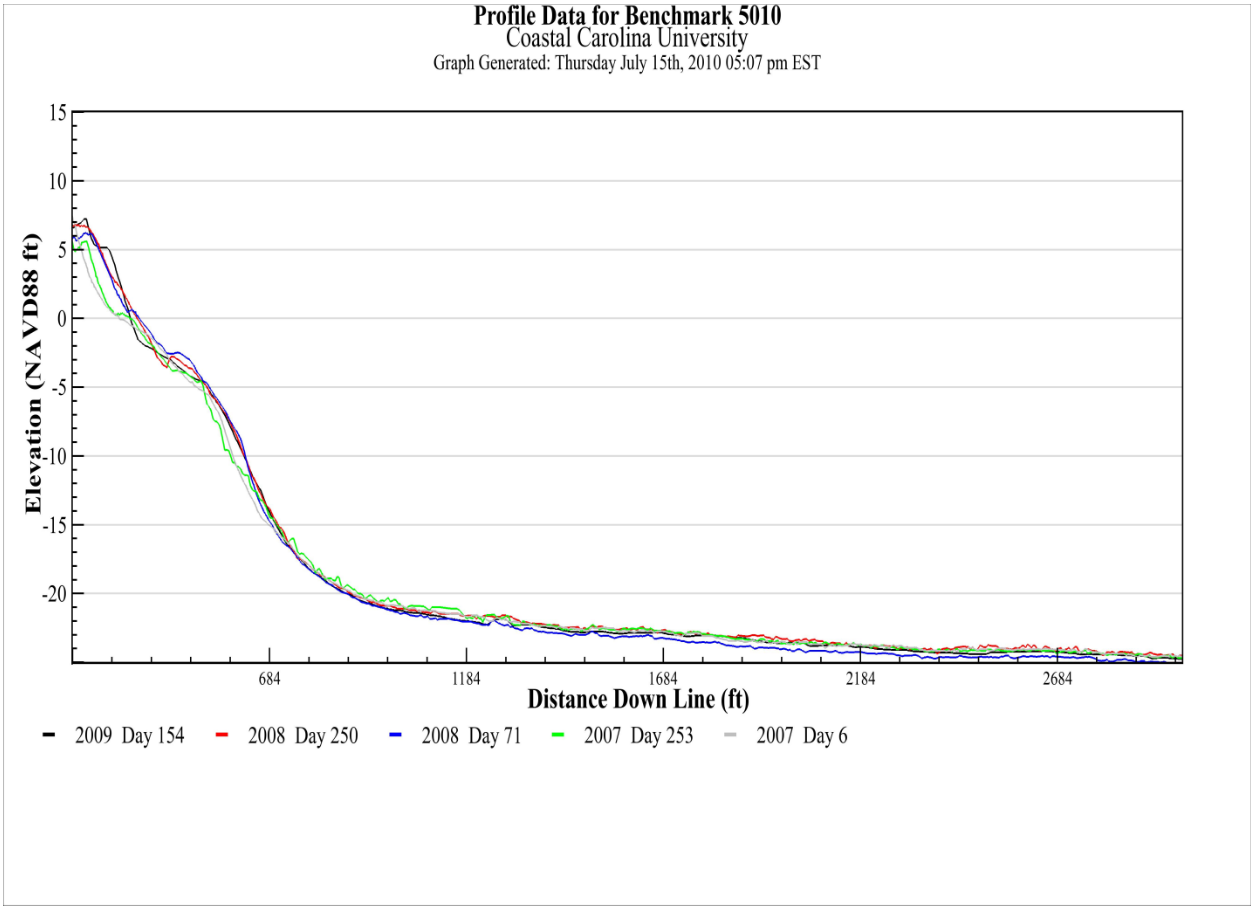


Figure 30. Beach profile data from benchmark 5010 (2007-2009).

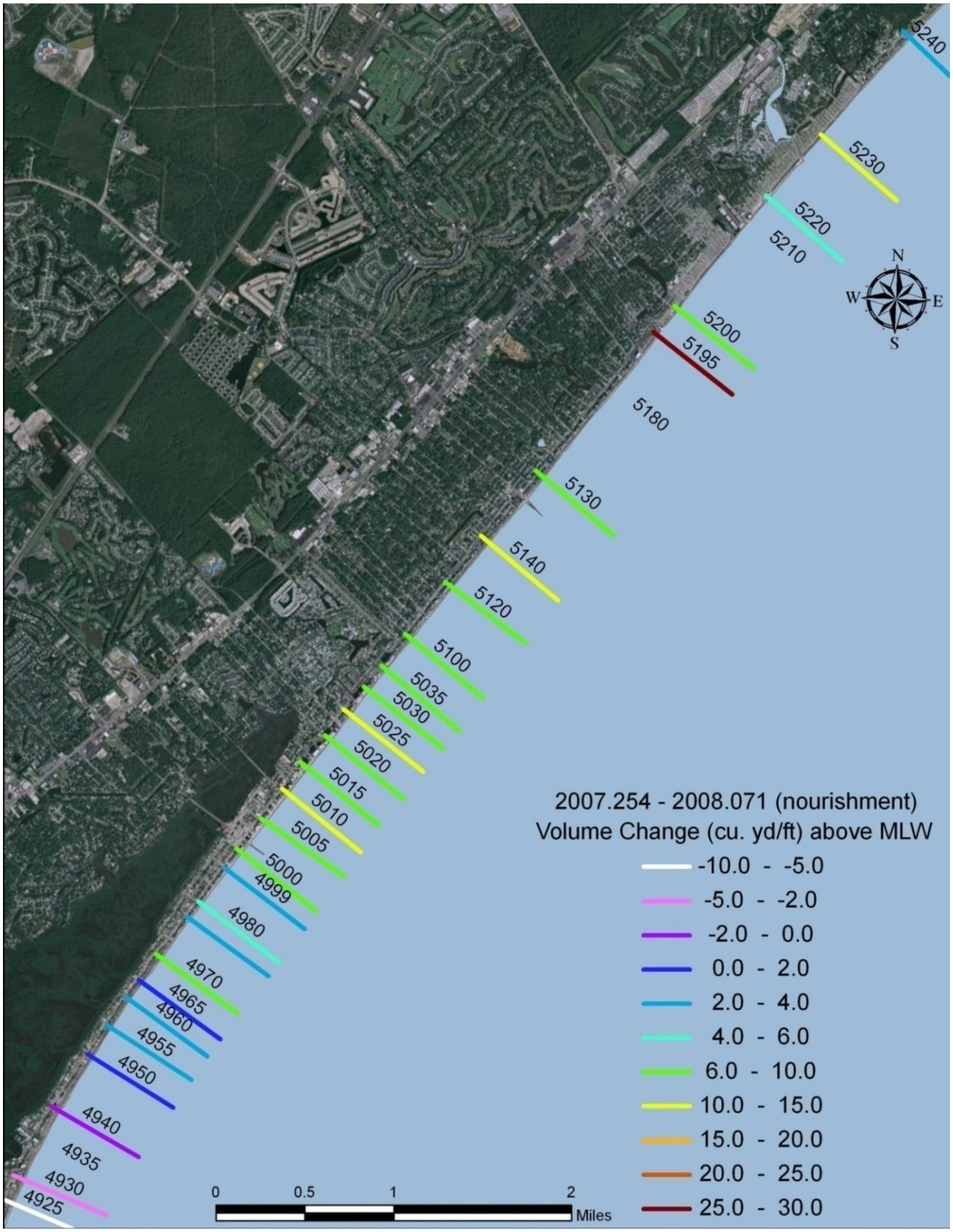


Figure 31. Volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 3 profiles based on pre-nourishment (2007.254) and post-nourishment (2008.071) surveys. Beach nourishment spanned profiles 4950 – 5240.

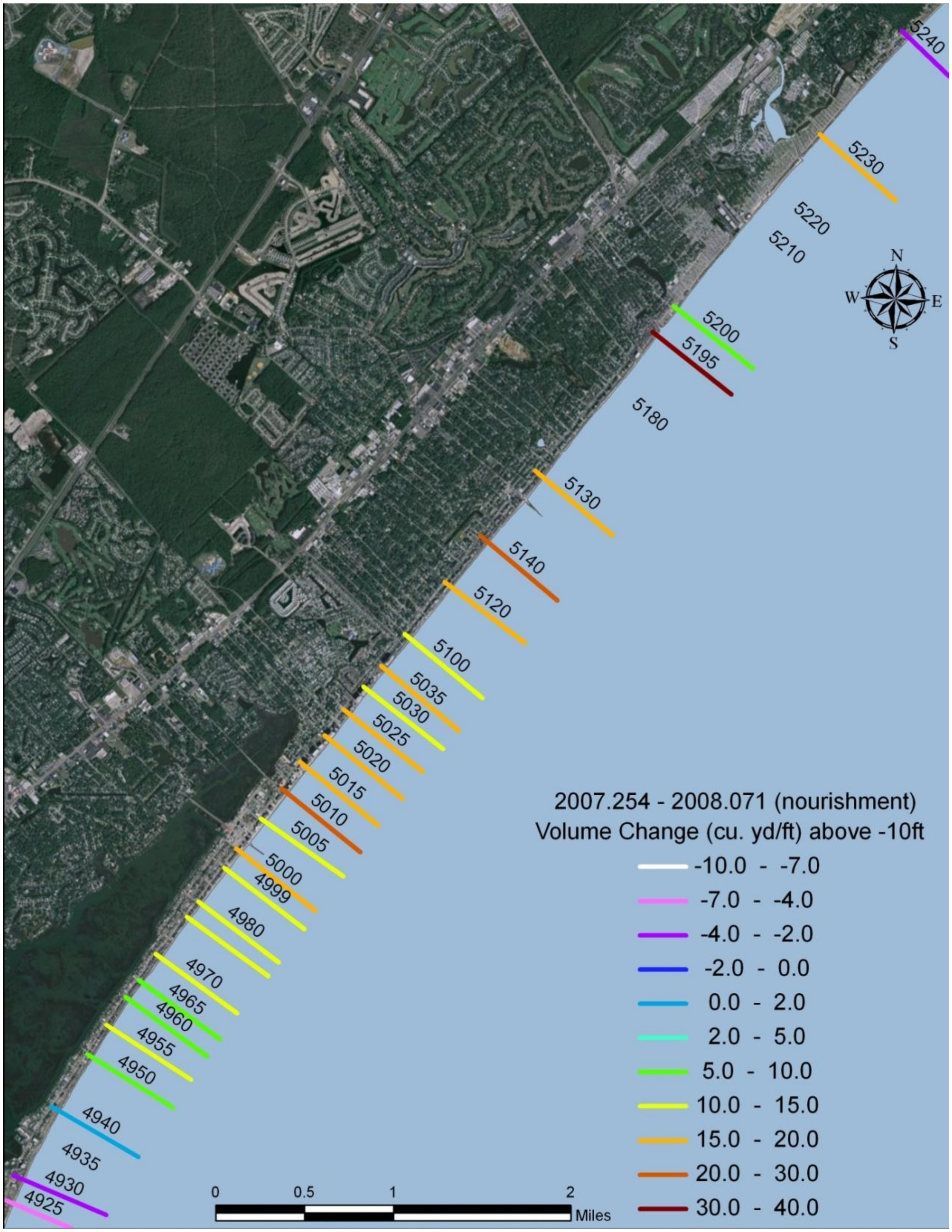


Figure 32. Volume change ($yd^3 ft^{-1}$) above the -10 ft contour at Reach 3 profiles based on pre-nourishment (2007.254) and post-nourishment (2008.071) surveys. Beach nourishment spanned profiles 4950 – 5240.

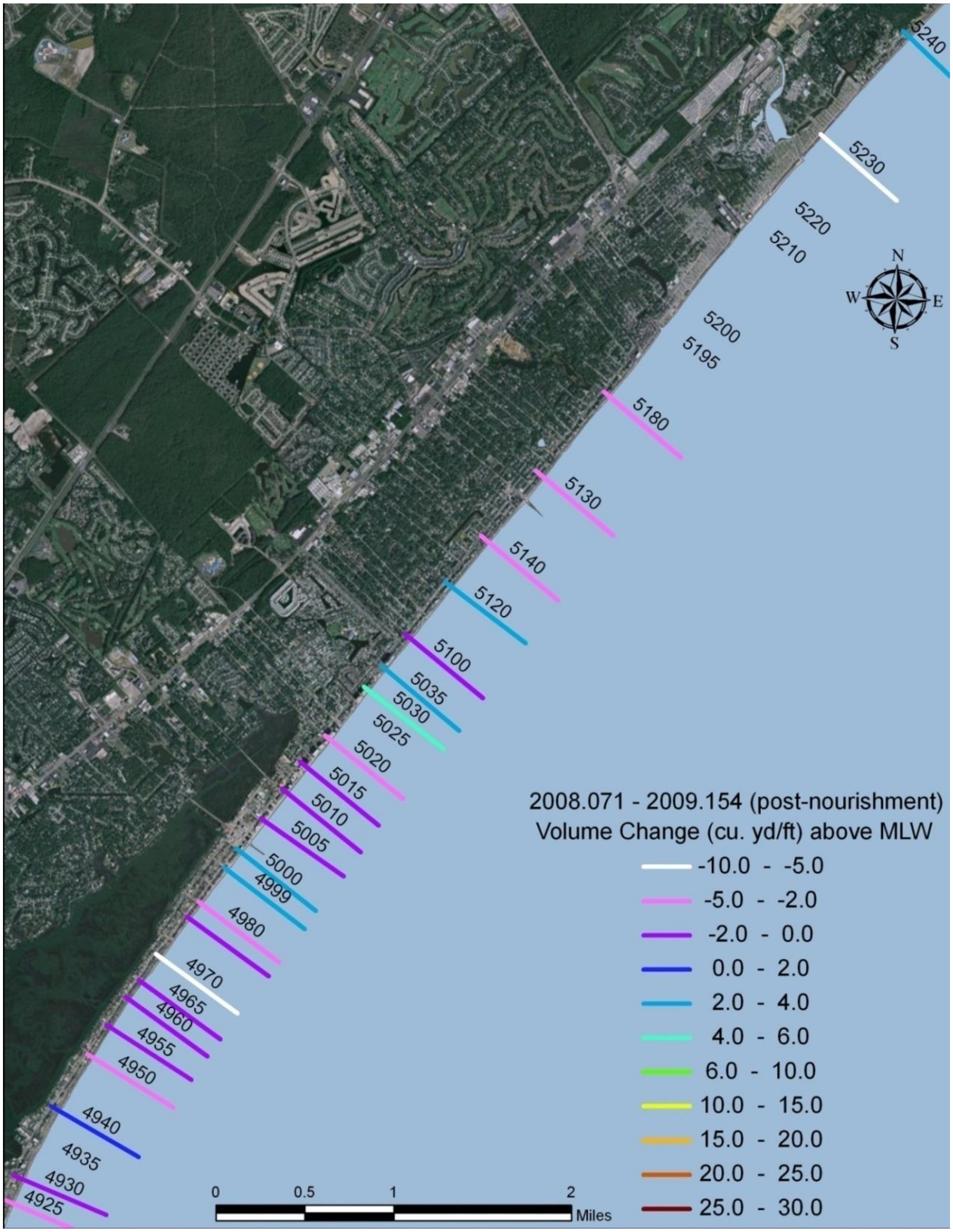


Figure 33. Volume change (yd^3 ft^{-1}) above MLW contour at Reach 3 profiles based on closest post-nourishment (2008.071) and most recent (2009.154) surveys. Beach nourishment spanned profiles 4950 – 5240.

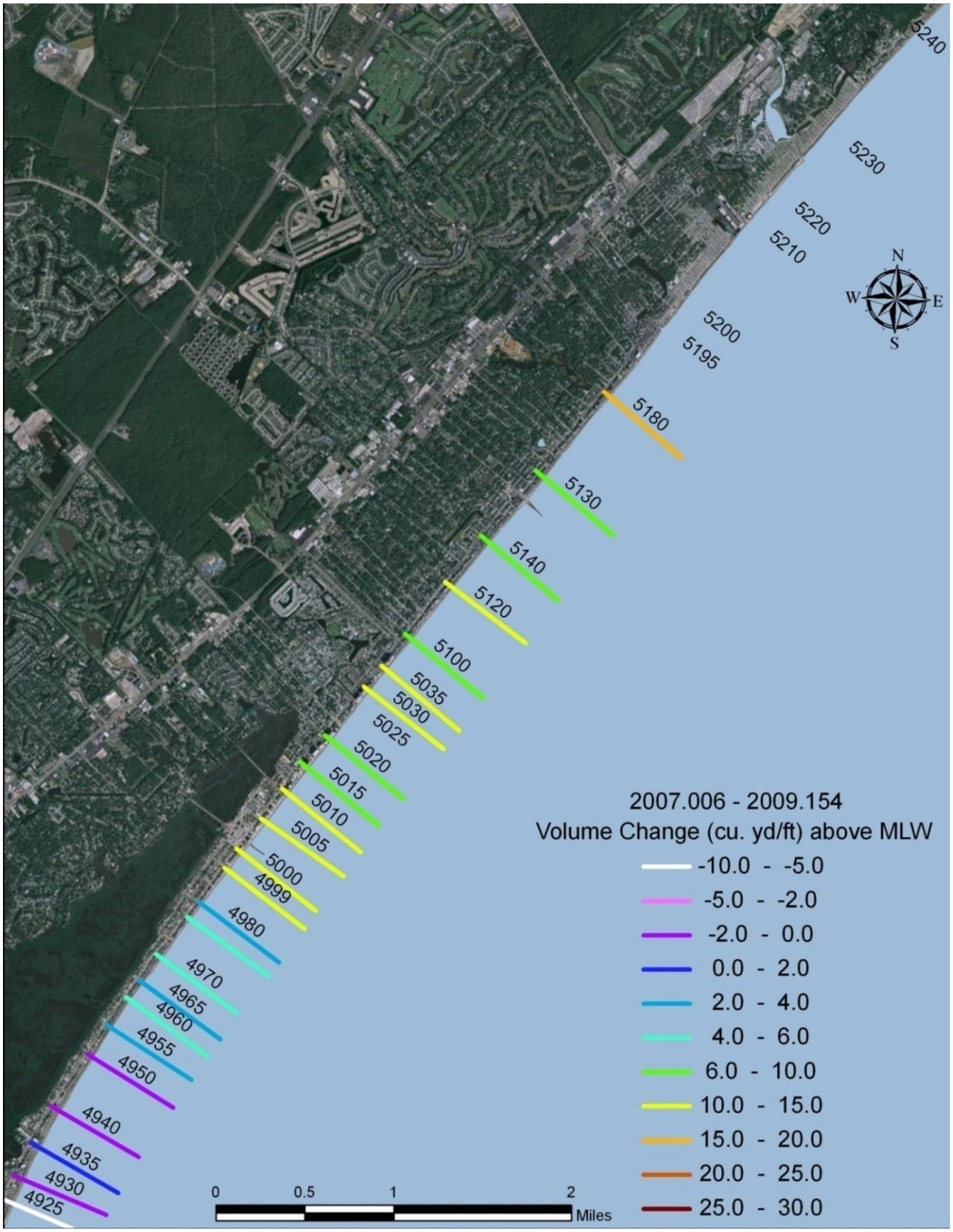


Figure 34. 2007-2009 volume change ($yd^3\ ft^{-1}$) above MLW contour at Reach 3 profiles based on Jan 2007 (2007.006) and Jun 2009 (2009.154) surveys. Beach nourishment spanned profiles 4950 – 5240.

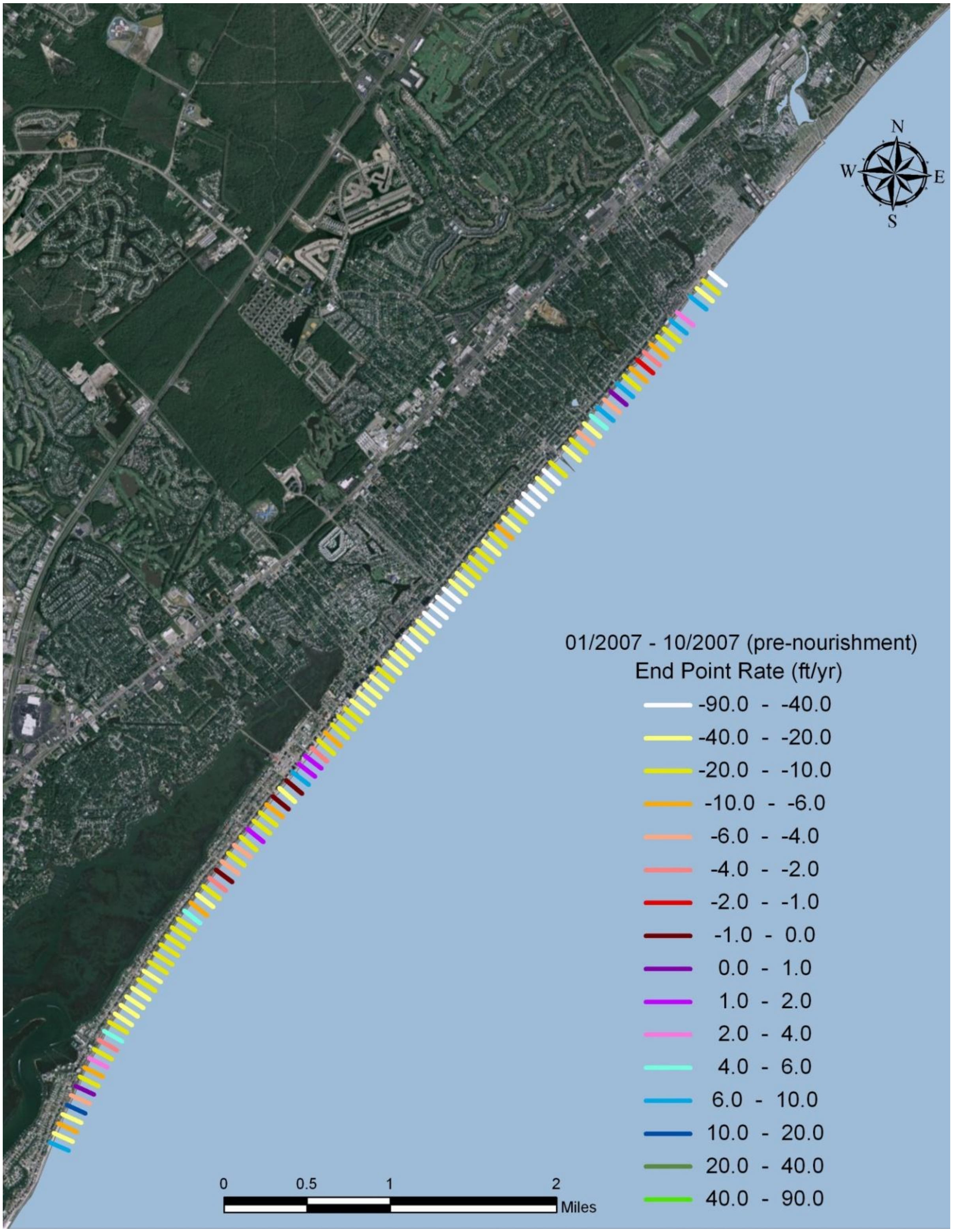


Figure 35. Pre-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 3, Jan 2007-Oct 2007.

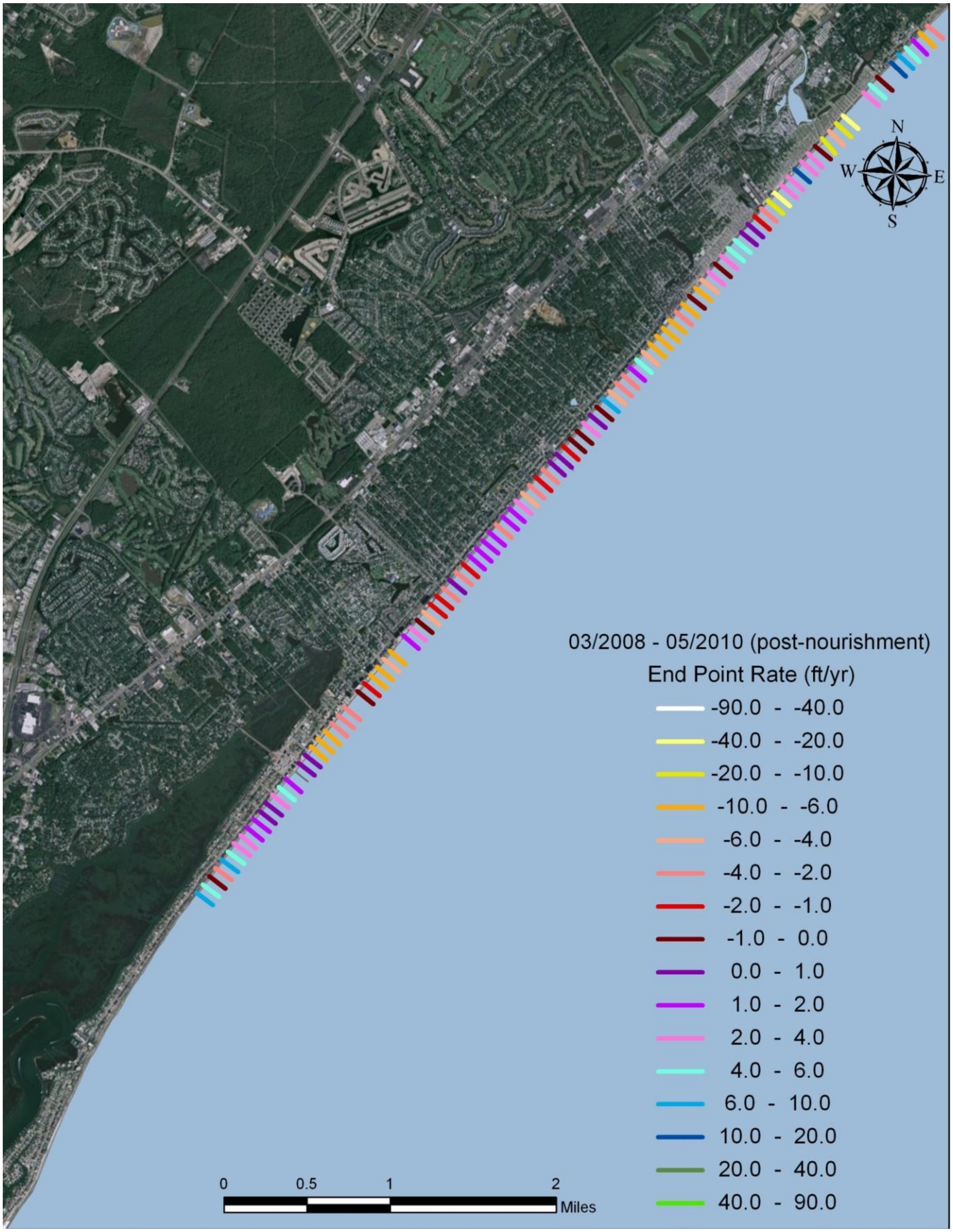


Figure 36. Post-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 3, Mar 2008-May 2010.

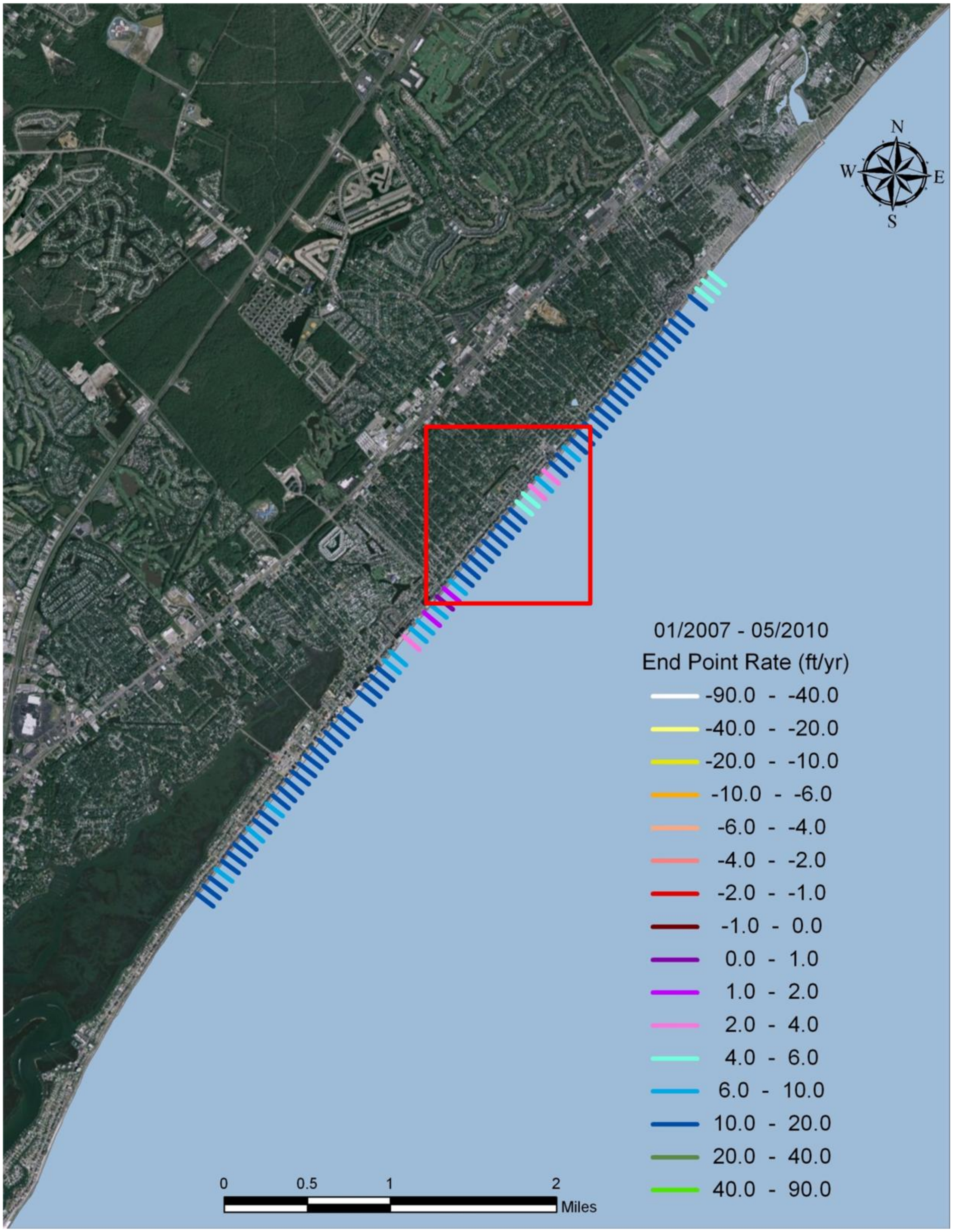


Figure 37. 2007-2010 end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Reach 3, Jan 2007-May 2010.

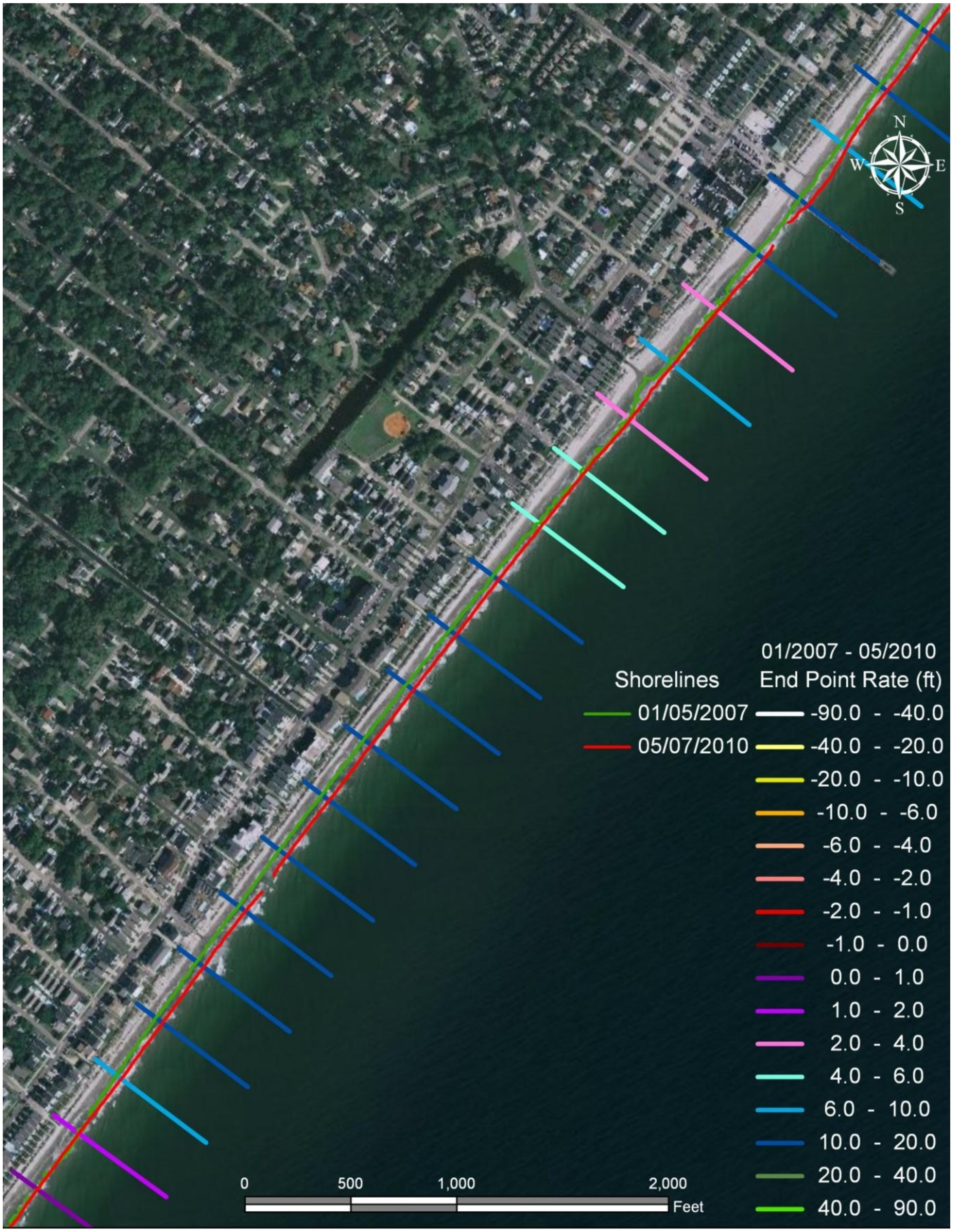


Figure 38. Highlighted region of Reach 3 (see Figure 37 for location) documenting Jan 2007 and May 2010 MHW contours and calculated end point rates.

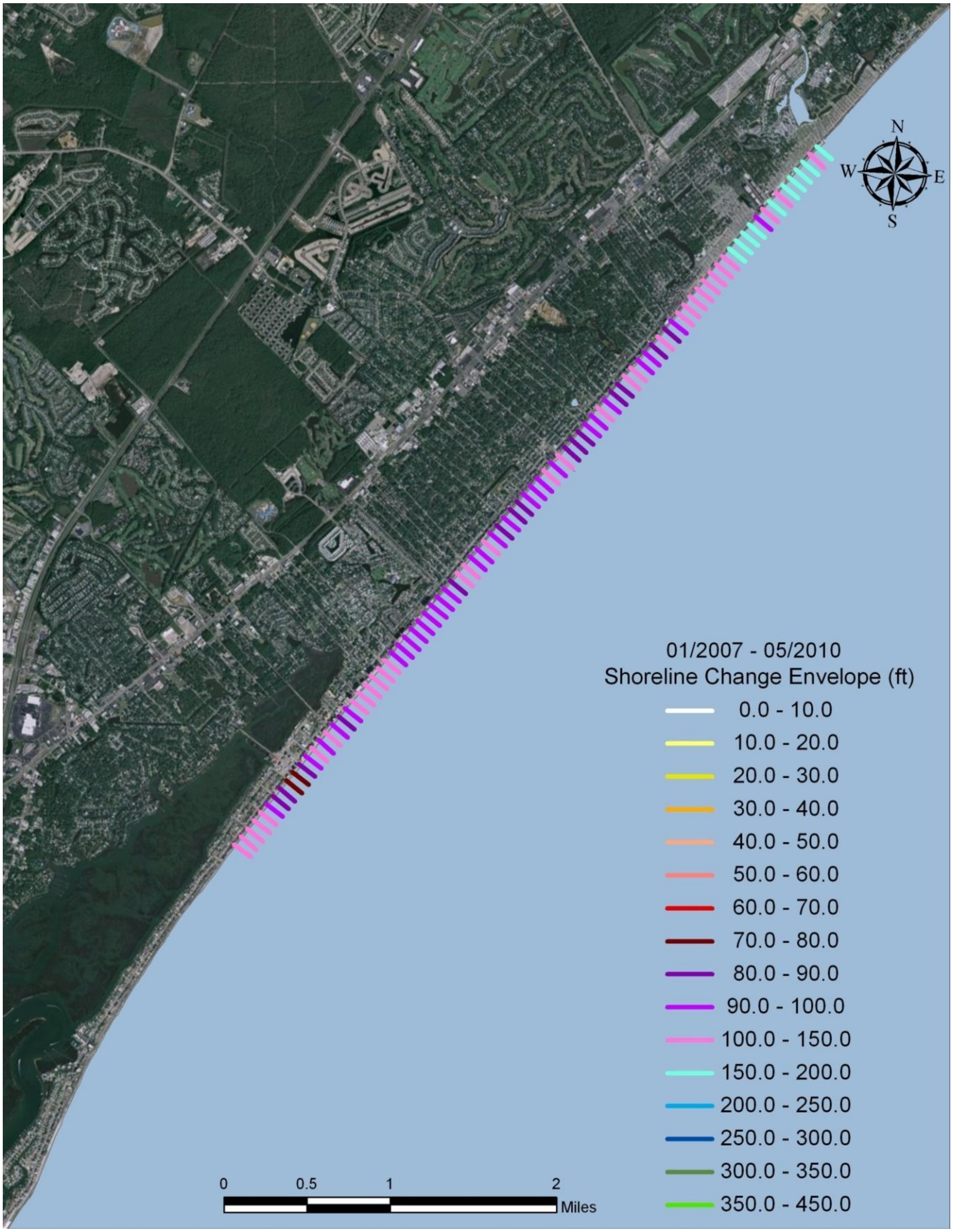


Figure 39. Shoreline change envelope (ft) for Reach 3 based on monthly MHW surveys, Jan 2007-May 2010.

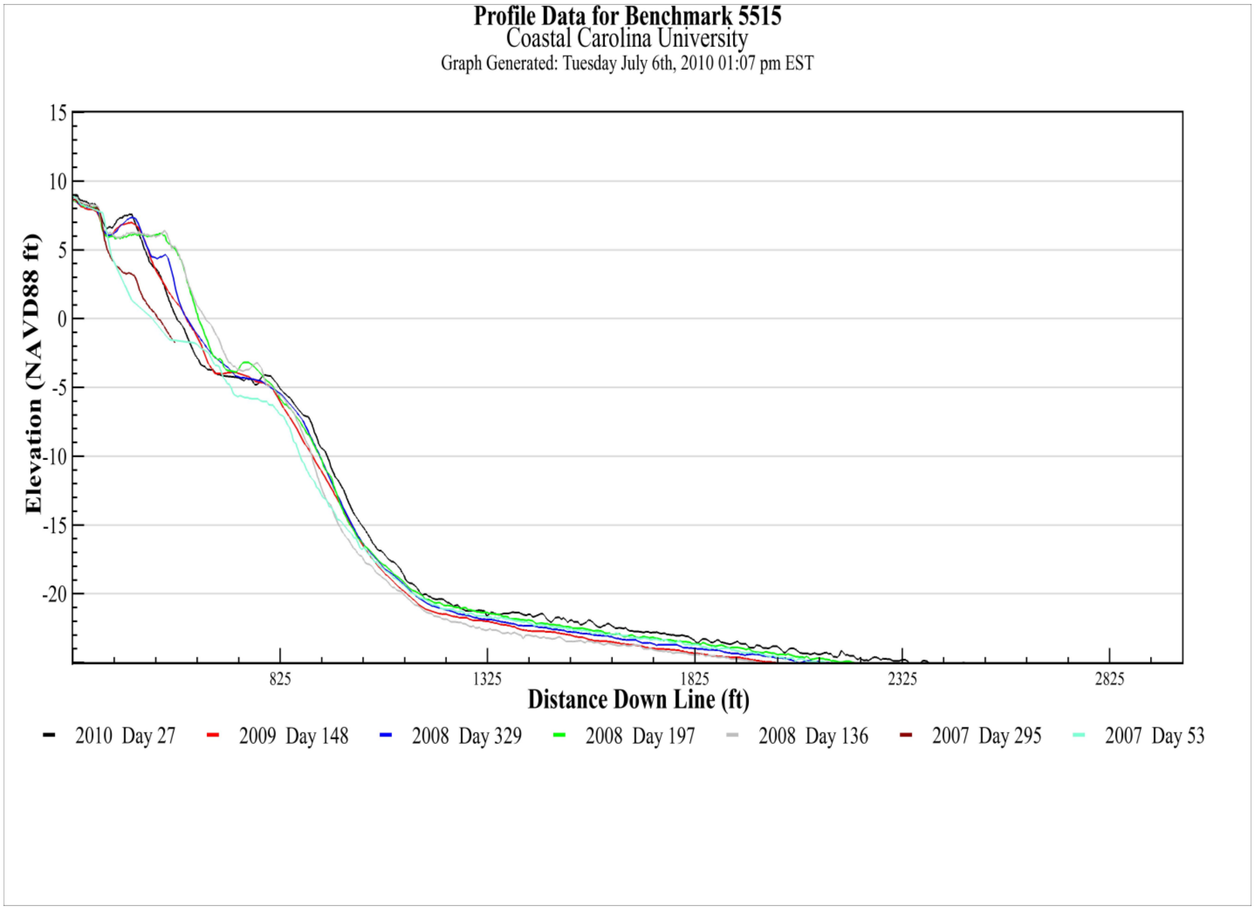


Figure 40. Beach profile data from benchmark 5515 (2007-2010) located in the nourished section of Arcadian Shores.

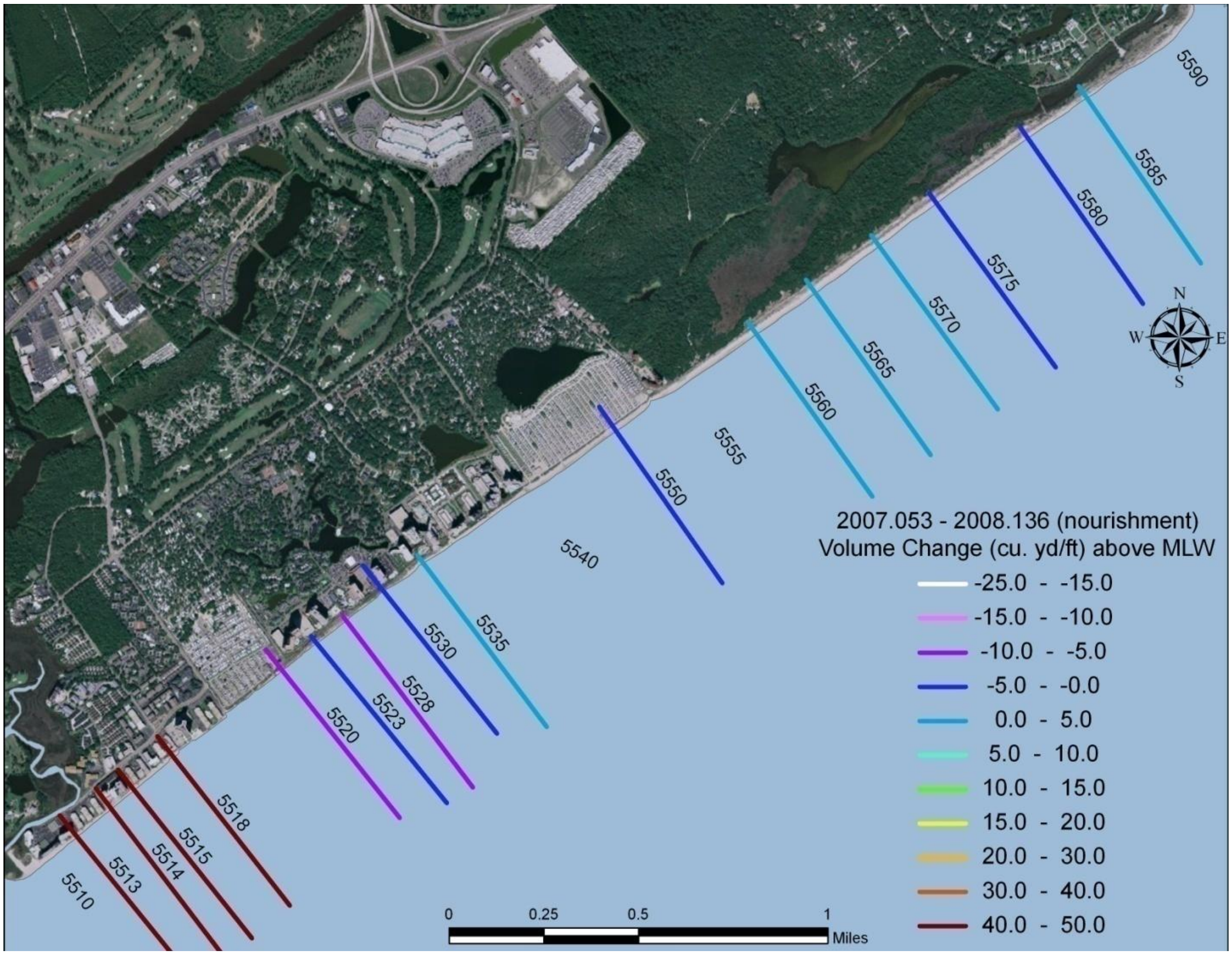


Figure 41. Volume change ($yd^3\ ft^{-1}$) above MLW contour at Arcadian Shores profiles based on pre-nourishment (2007.053) and post-nourishment (2008.136) surveys. Beach nourishment spanned profiles 5510 – 5518.

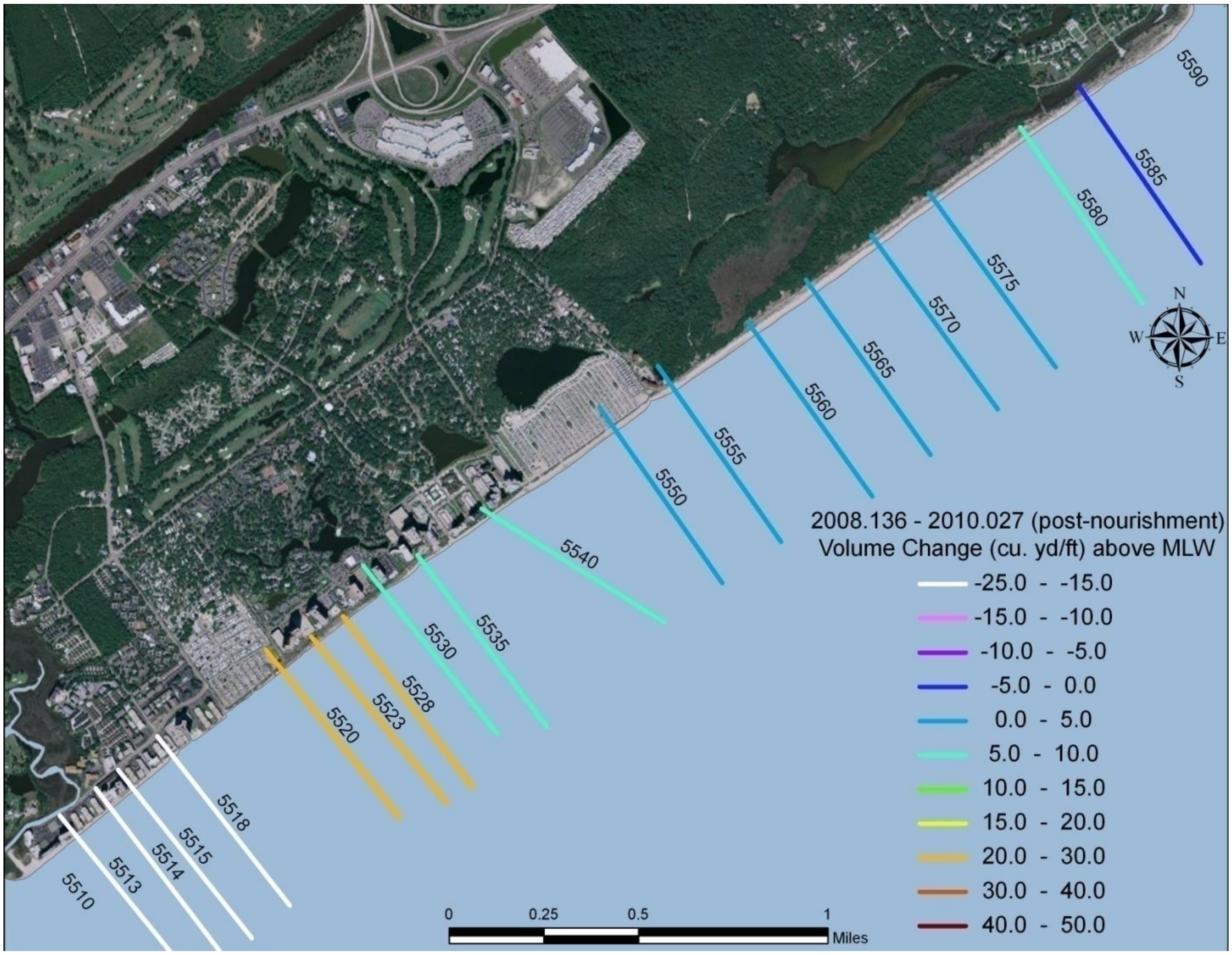


Figure 42. Volume change ($yd^3\ ft^{-1}$) above MLW contour at Arcadian Shores profiles based on closest post-nourishment (2008.136) and most recent (2010.027) surveys. Beach nourishment spanned profiles 5510 – 5518.

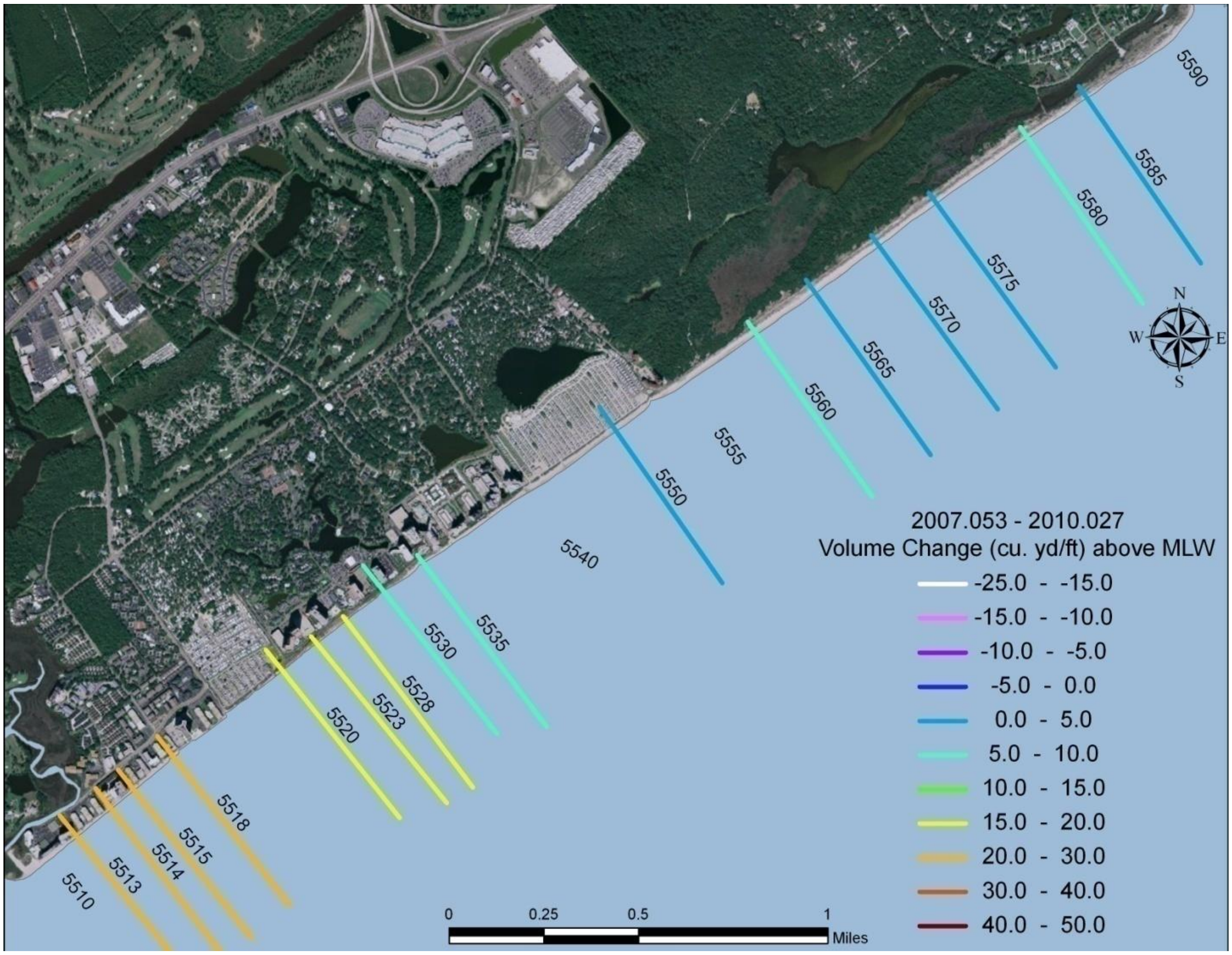


Figure 43. 2007-2010 volume change (yd^3 ft^{-1}) above MLW contour at Arcadian Shores profiles based on Feb 2007 (2007.054) and Jan 2010 (2010.027) surveys. Beach nourishment spanned profiles 5510 – 5518.

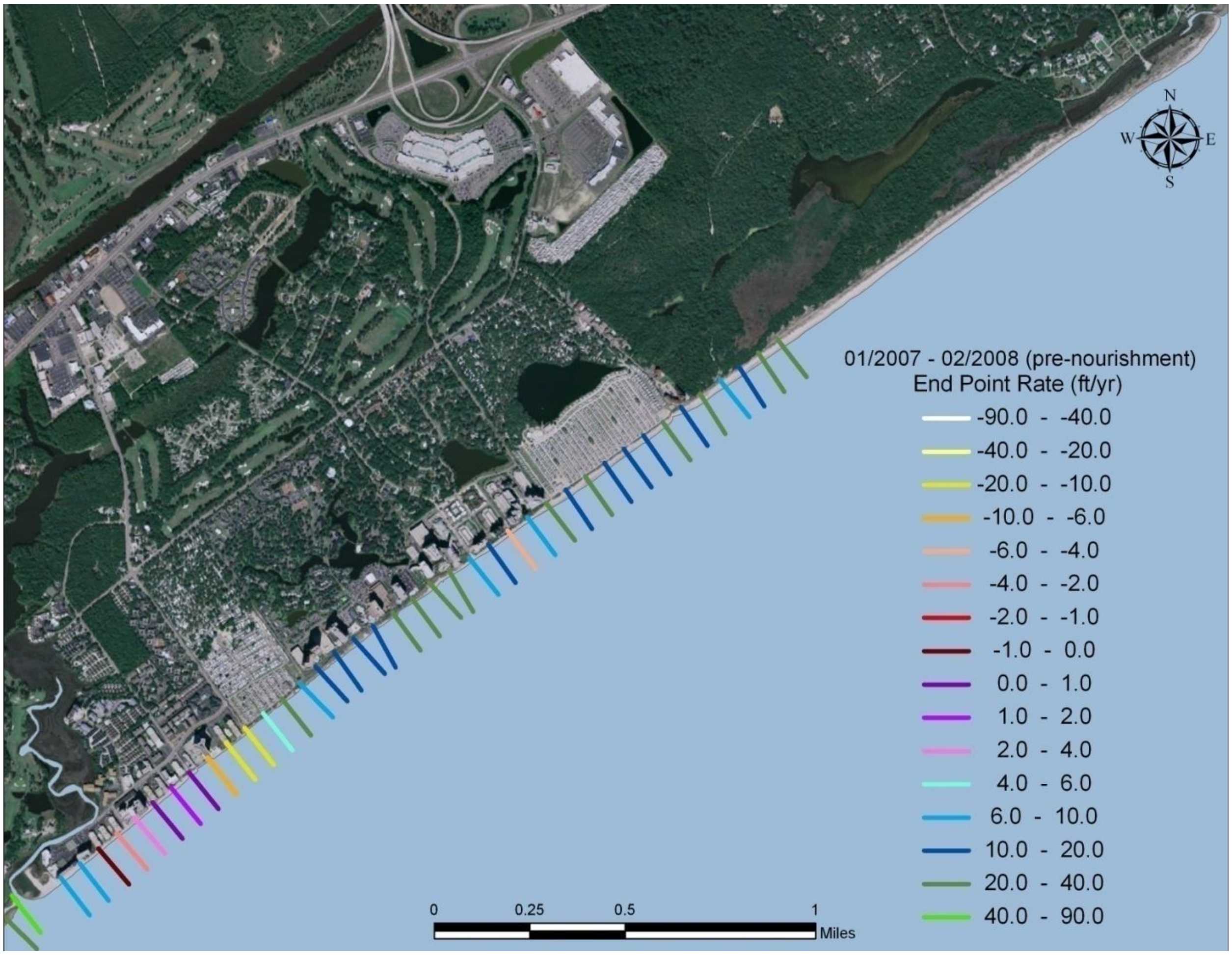


Figure 44. Pre-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Arcadian Shores, Jan 2007-Feb 2008.

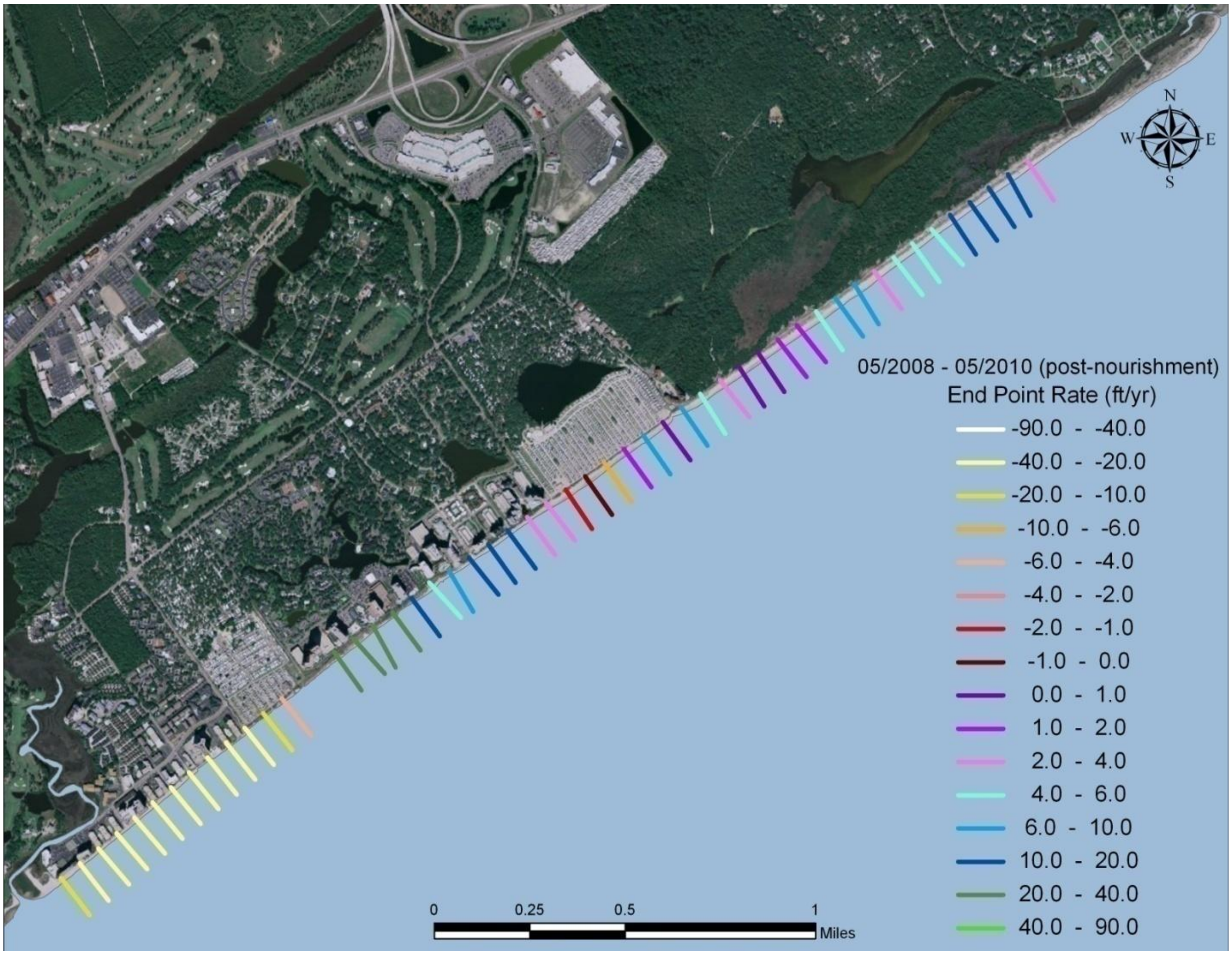


Figure 45. Post-nourishment end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Arcadian Shores, May 2008-May 2010.

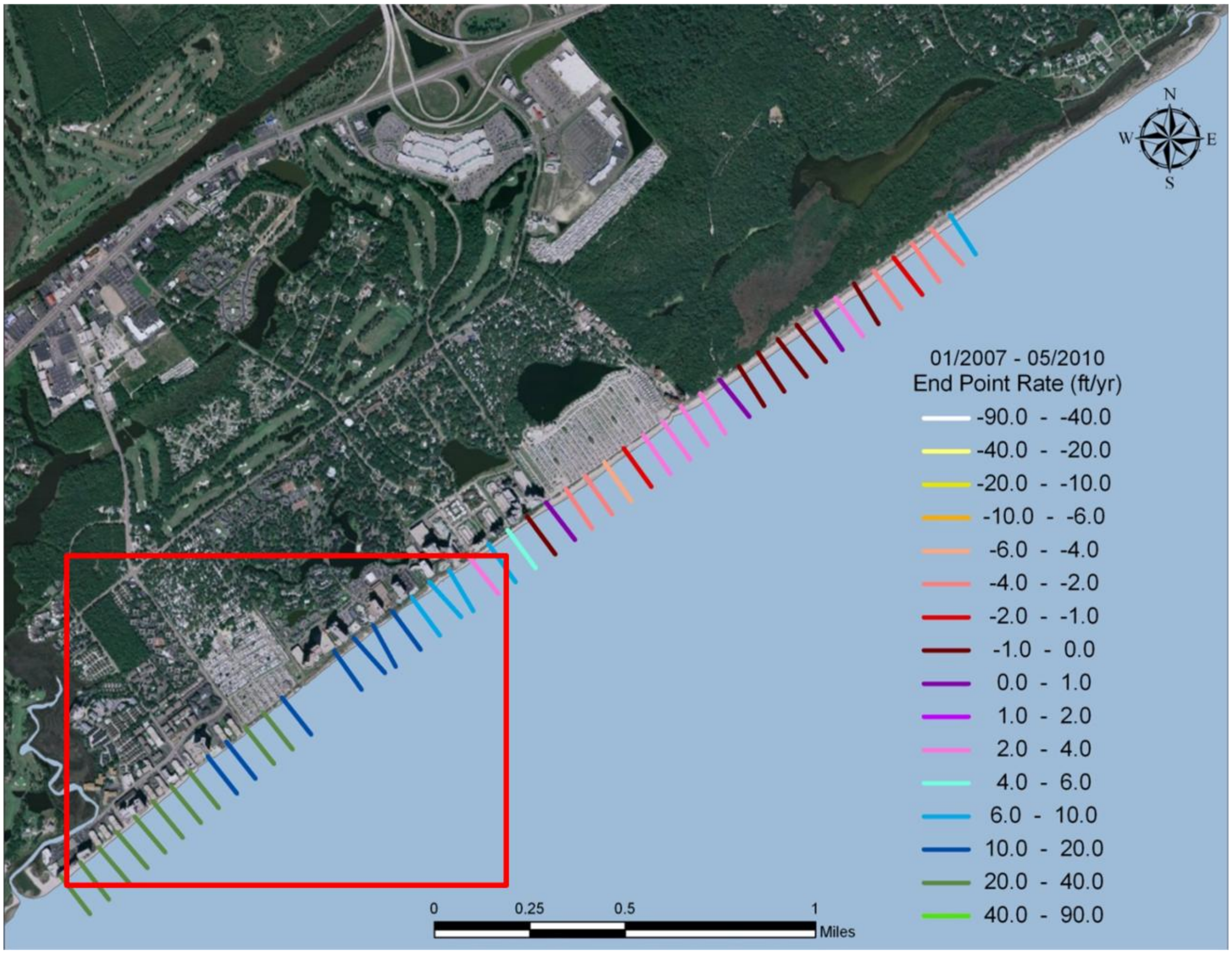


Figure 46. 2007-2010 end point rate (ft yr^{-1}) of MHW contour based on monthly MHW surveys of Arcadian Shores, Jan 2007-May 2010.

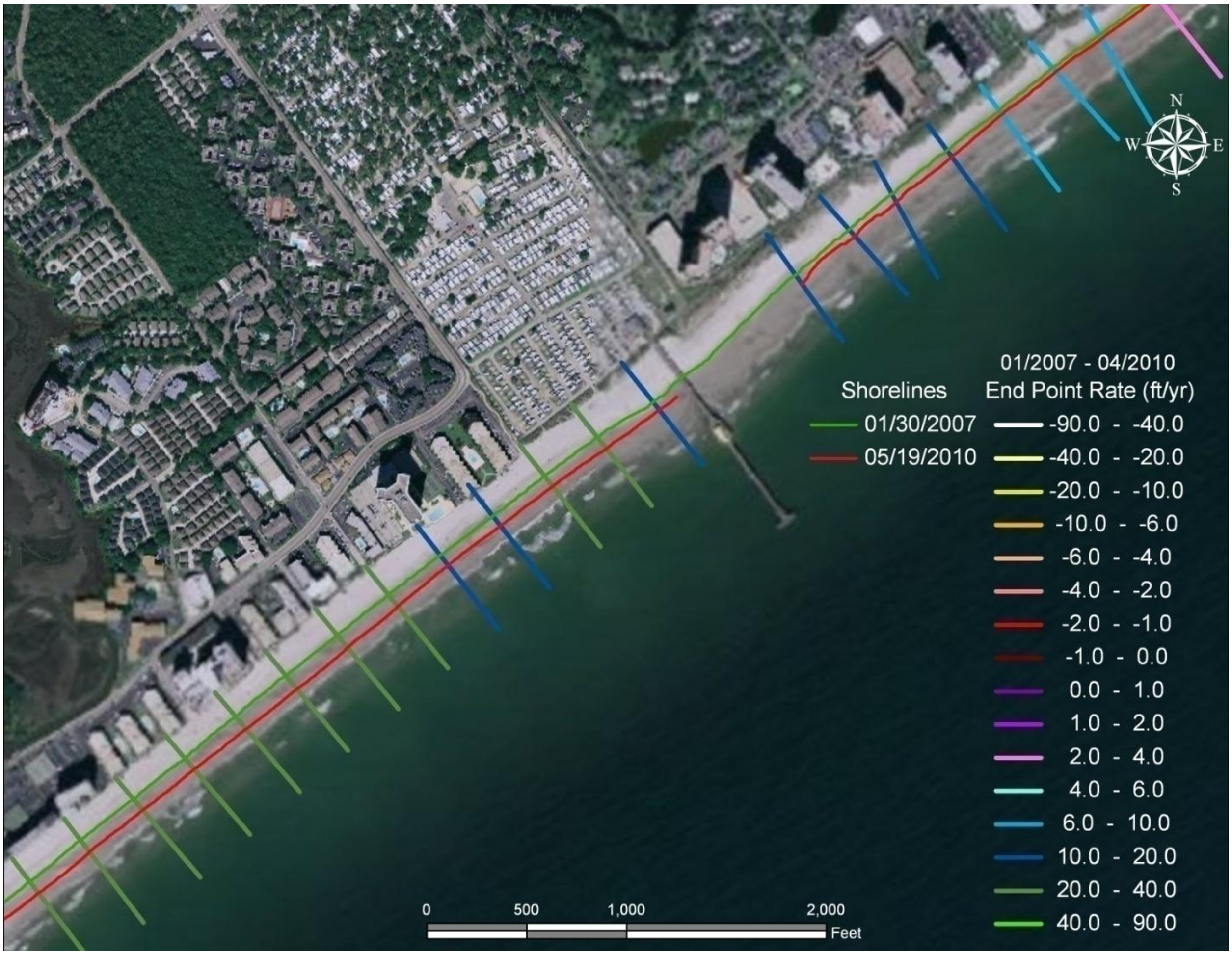


Figure 47. Highlighted region of Arcadian Shores (see Figure 47 for location) documenting Jan 2007 and Apr 2010 MHW contours and calculated end point rates.

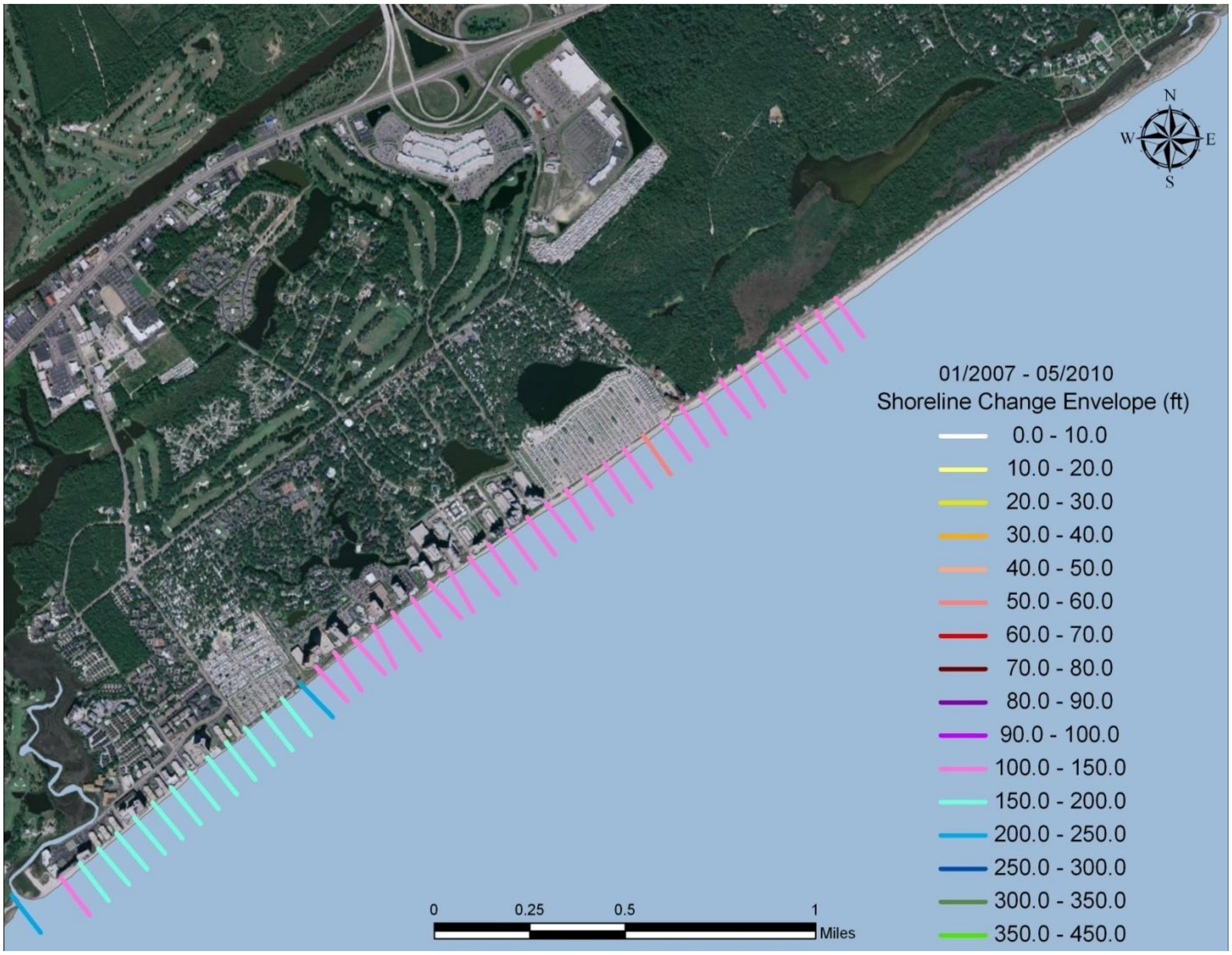


Figure 48. Shoreline change envelope (ft) for Arcadian Shores based on monthly MHW surveys, Jan 2007-May 2010.

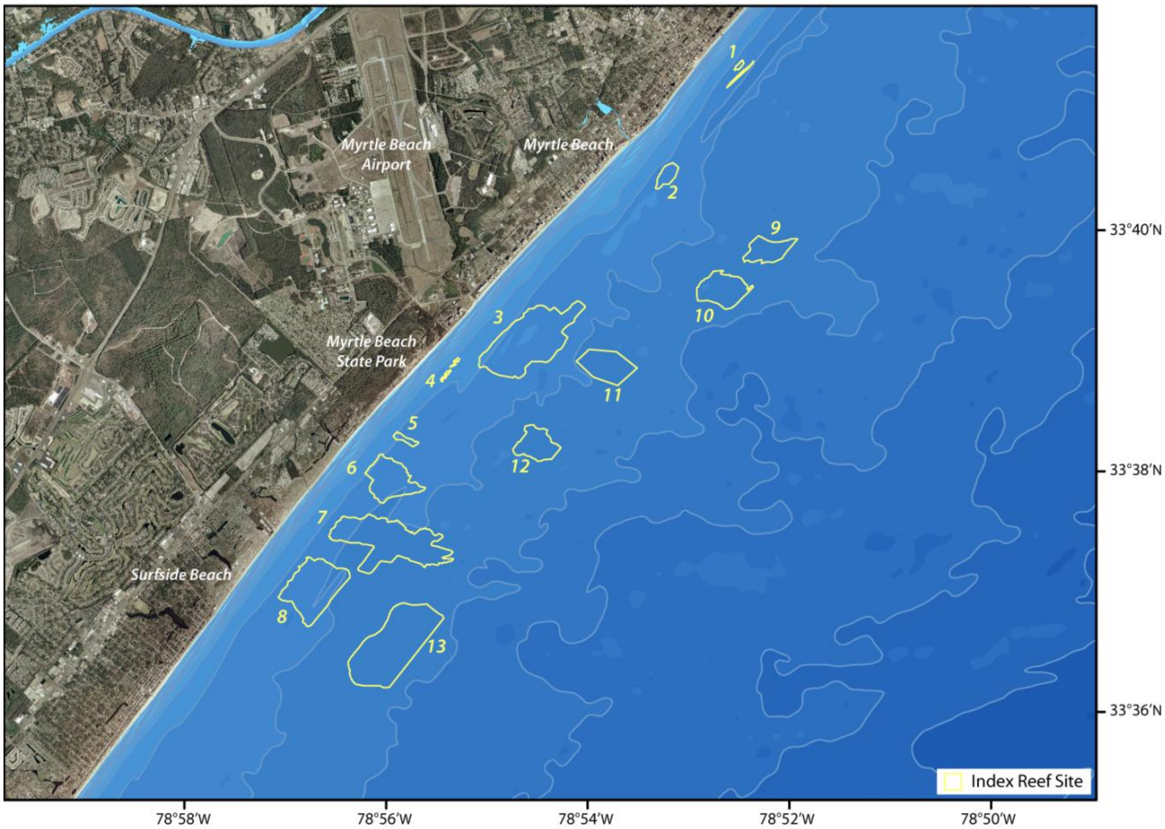


Figure 49. Location of 13 index reef sites, offshore of Myrtle Beach and northern Surfside Beach, monitored during the initial Grand Strand Nourishment Project (1997-2001).

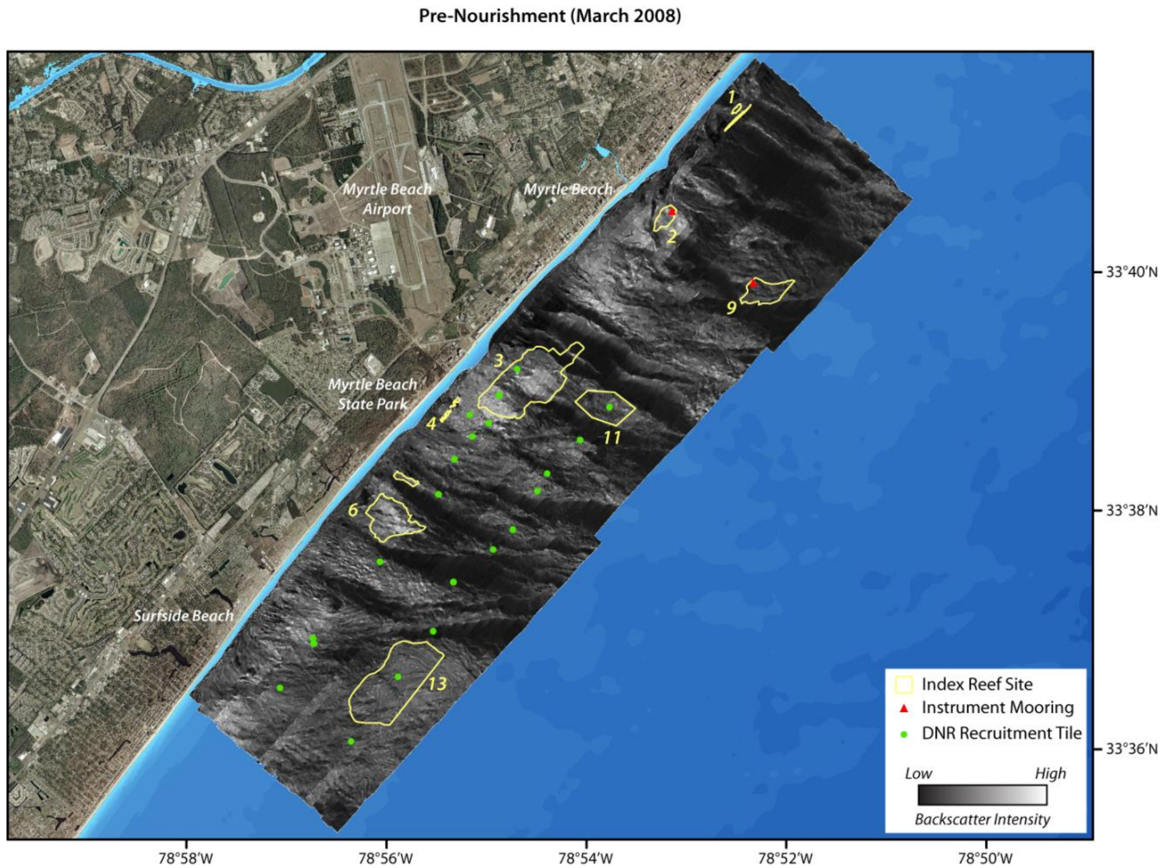


Figure 50. Sidescan sonar mosaic for the survey completed in March 2008, prior to the beach nourishment.

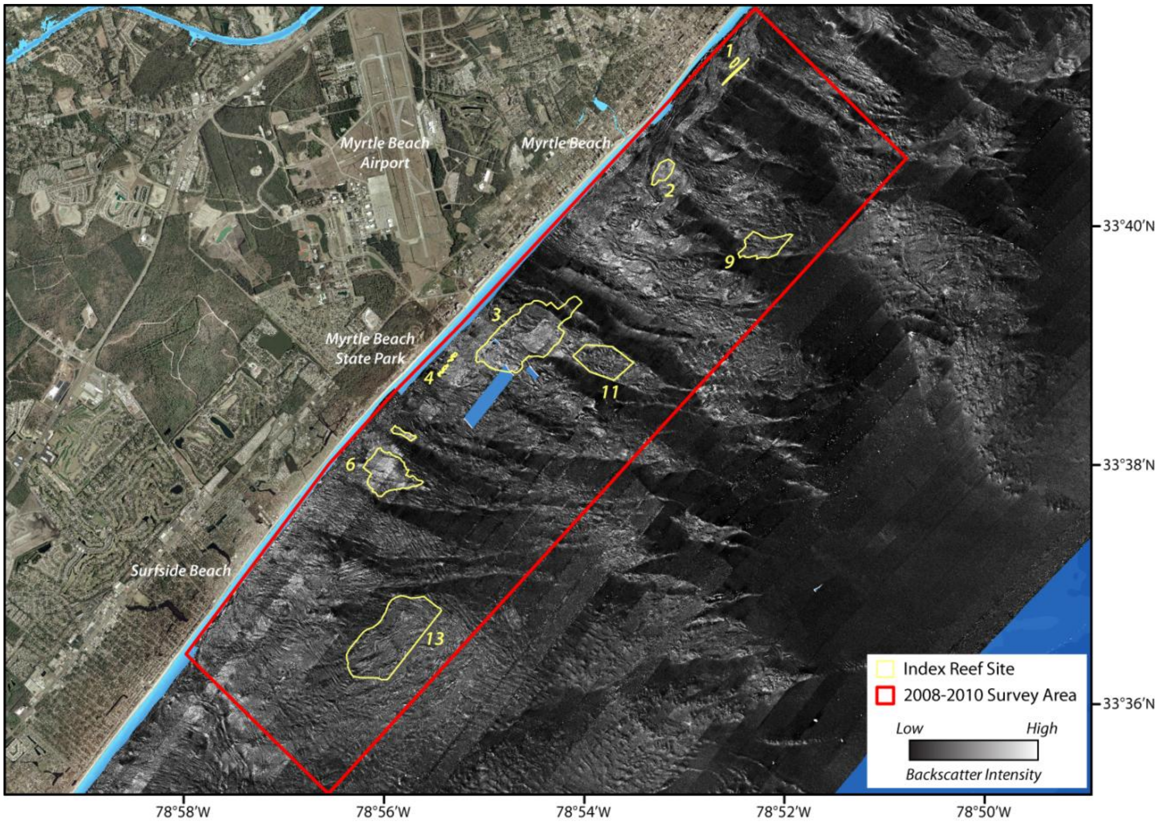


Figure 51. Sidescan sonar mosaic from survey completed in 1999 as part of the USGS South Carolina Coastal Erosion Study. The red box indicates the area that was surveyed in 2008-2010.

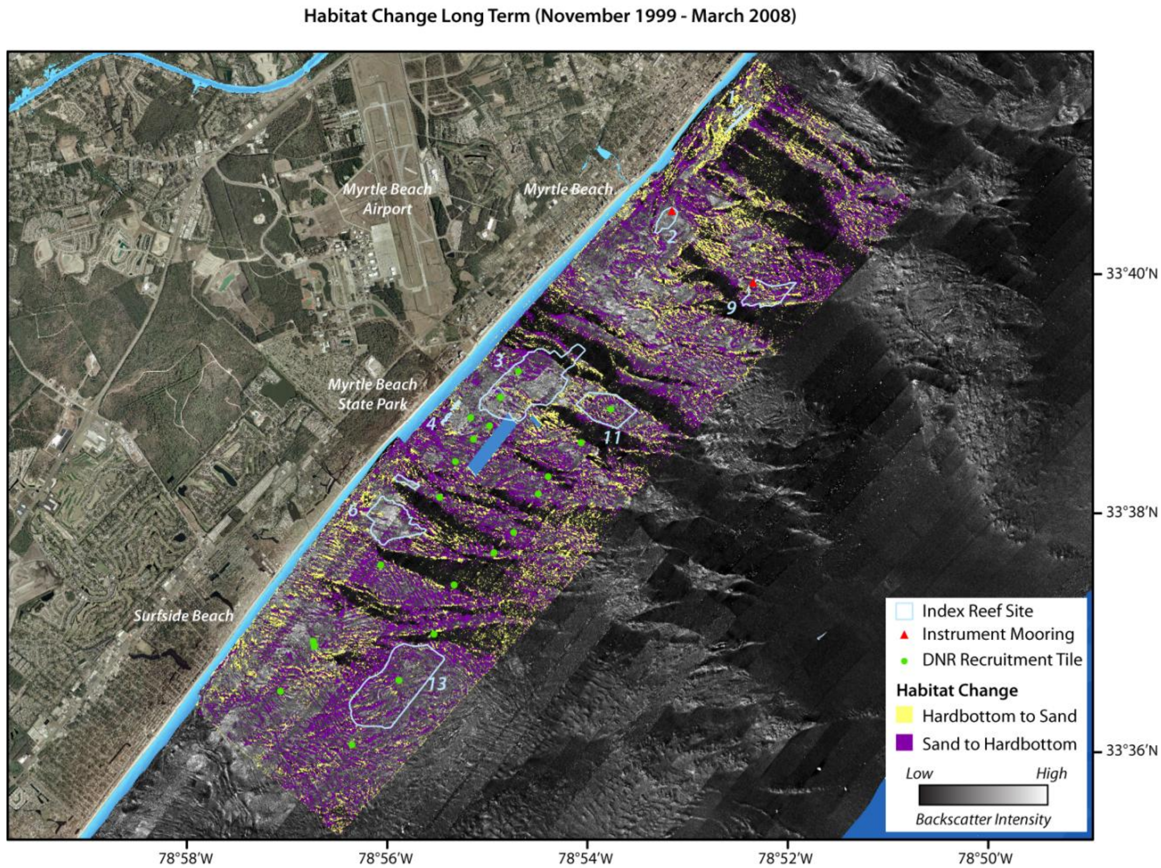


Figure 52. Change in seafloor habitat classification from November 1999 to March 2008.

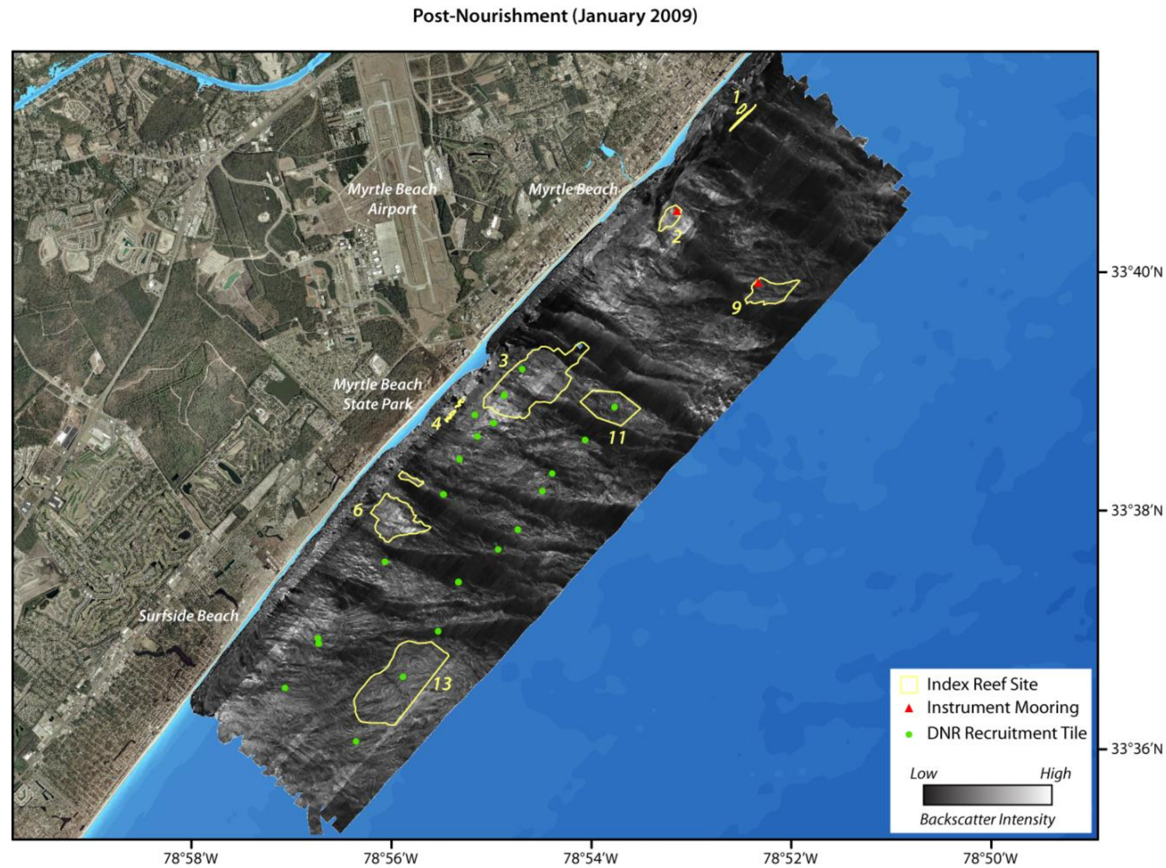


Figure 53. Sidescan sonar mosaic for the survey completed in January 2009, following beach nourishment of Reach 2 and 3.

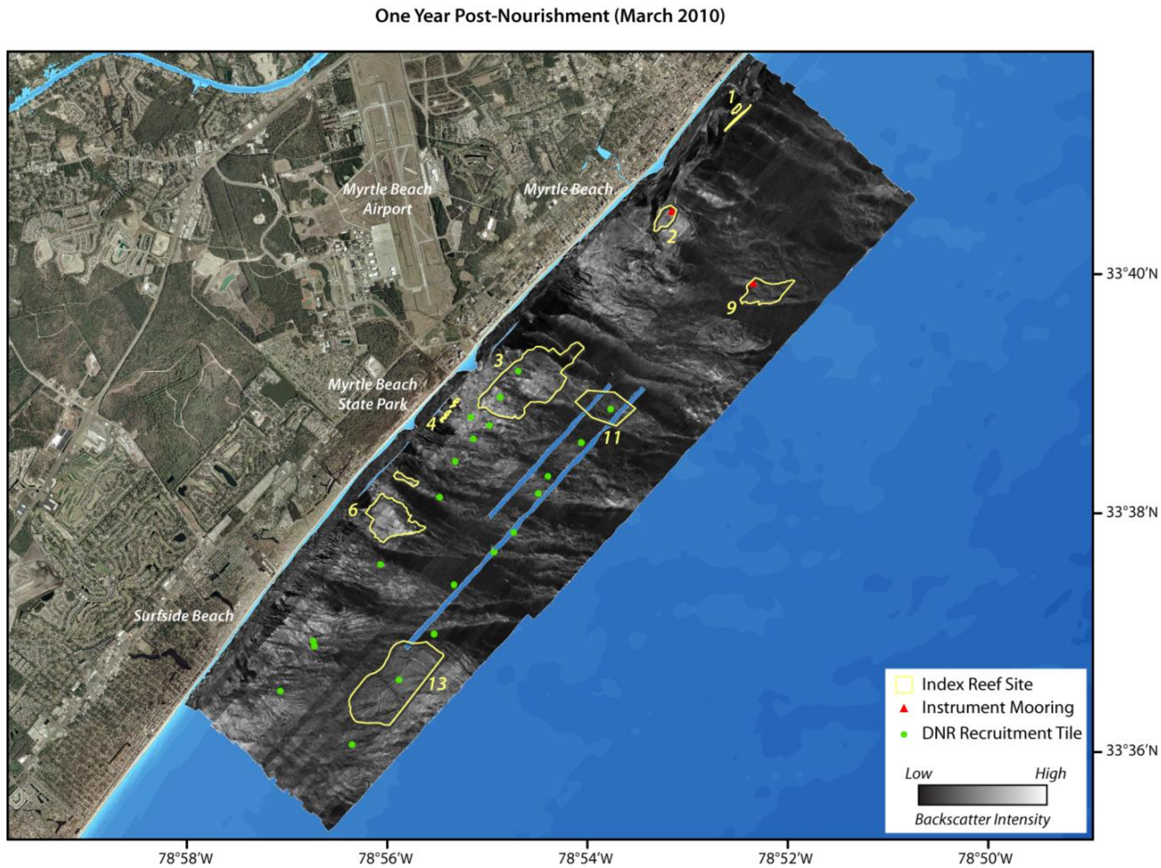


Figure 54. Sidescan sonar mosaic for the survey completed in March 2010, one year after beach nourishment.

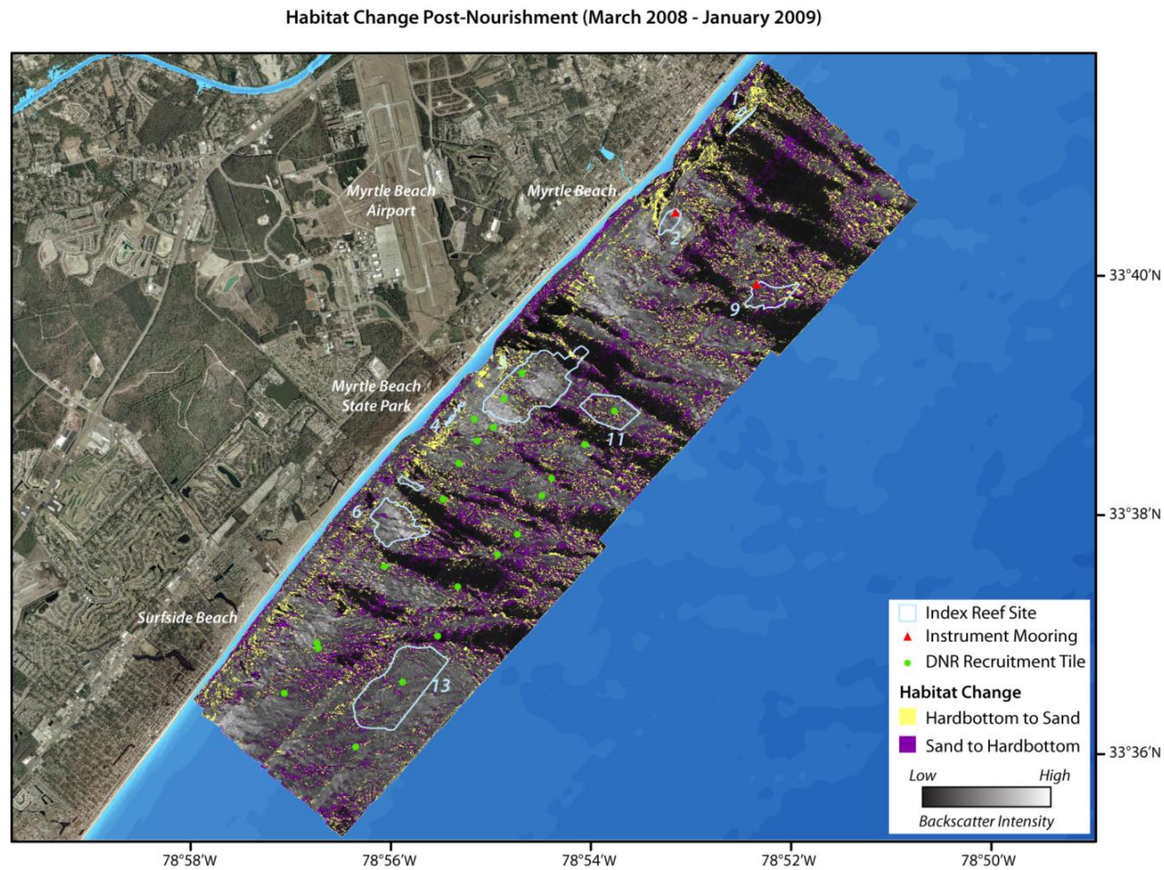


Figure 55. Change in seafloor habitat classification from March 2008 (pre-nourishment) to January 2009 (post-nourishment).

Habitat Change One Year Post-Nourishment (January 2009 - March 2010)

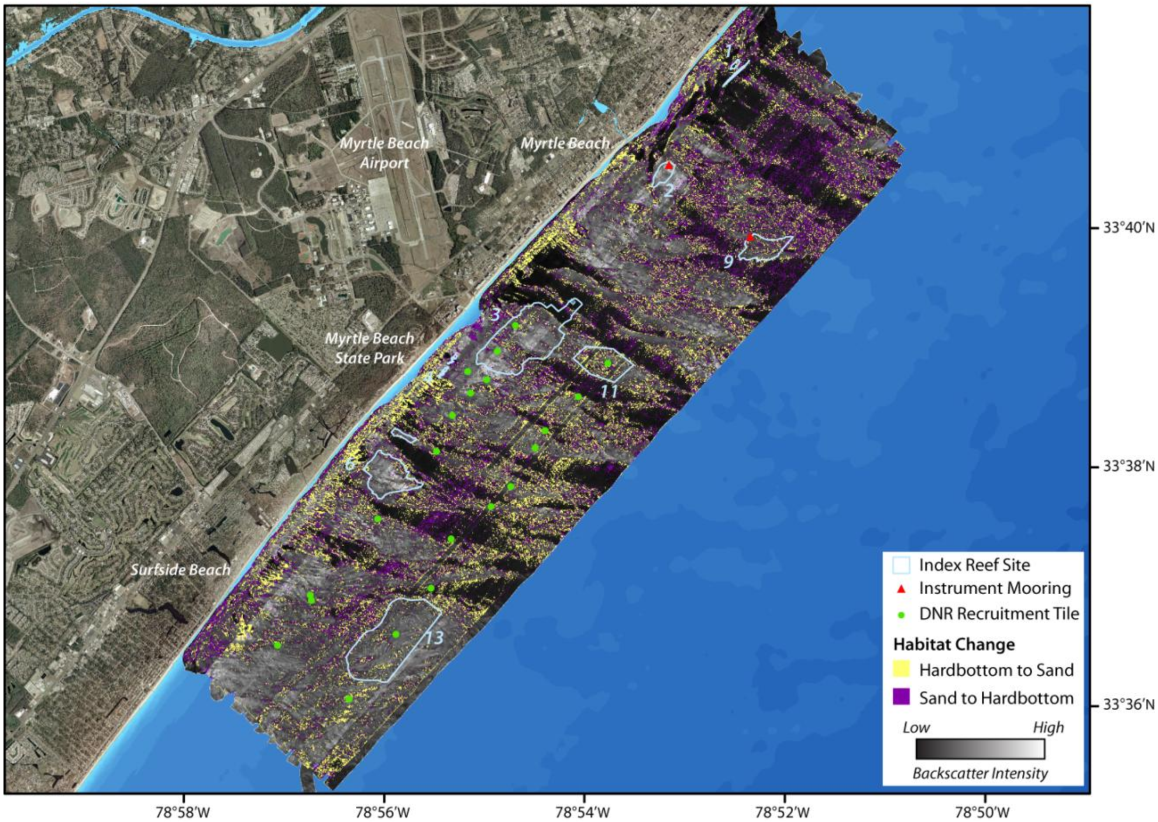


Figure 56. Change in seafloor habitat classification from January 2009 (post-nourishment) to March 2010, (one year post-nourishment).

Post-Nourishment (January 2009)

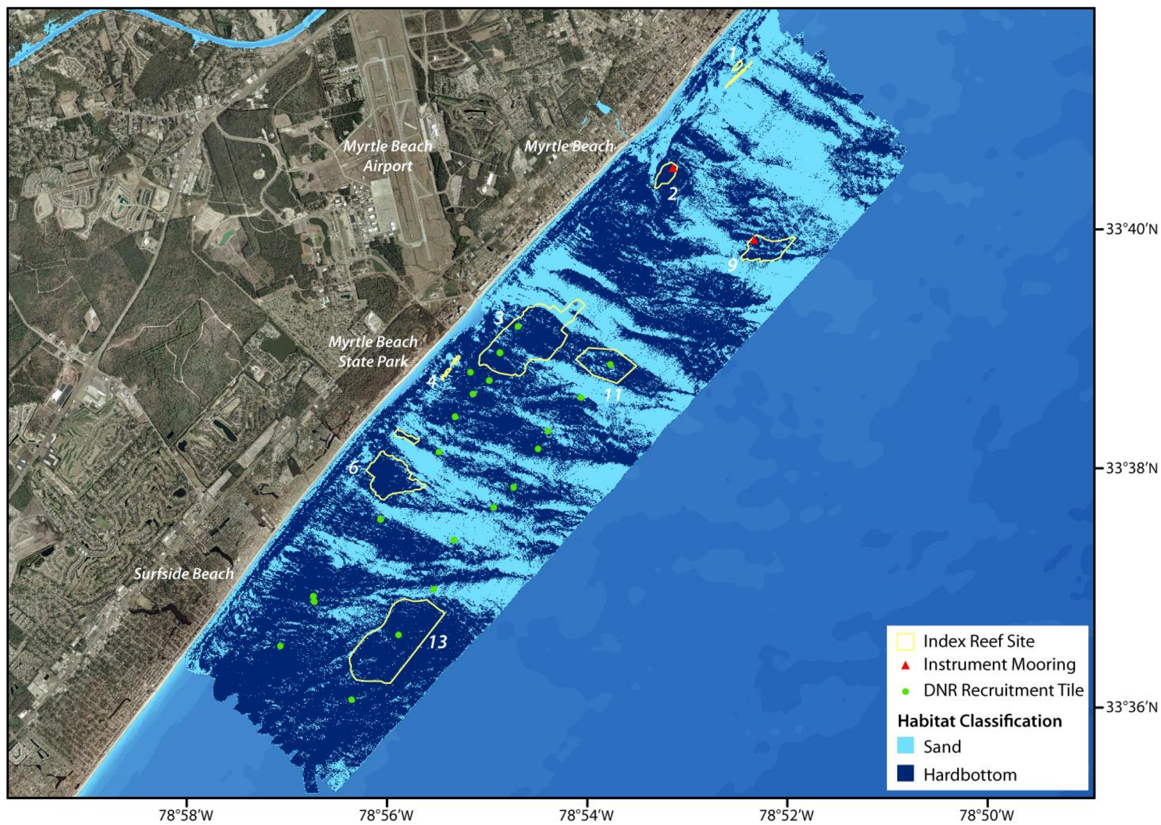


Figure 57. Seafloor habitat classification derived from textural analysis of the sidescan sonar survey completed in January 2009, following the beach nourishment.

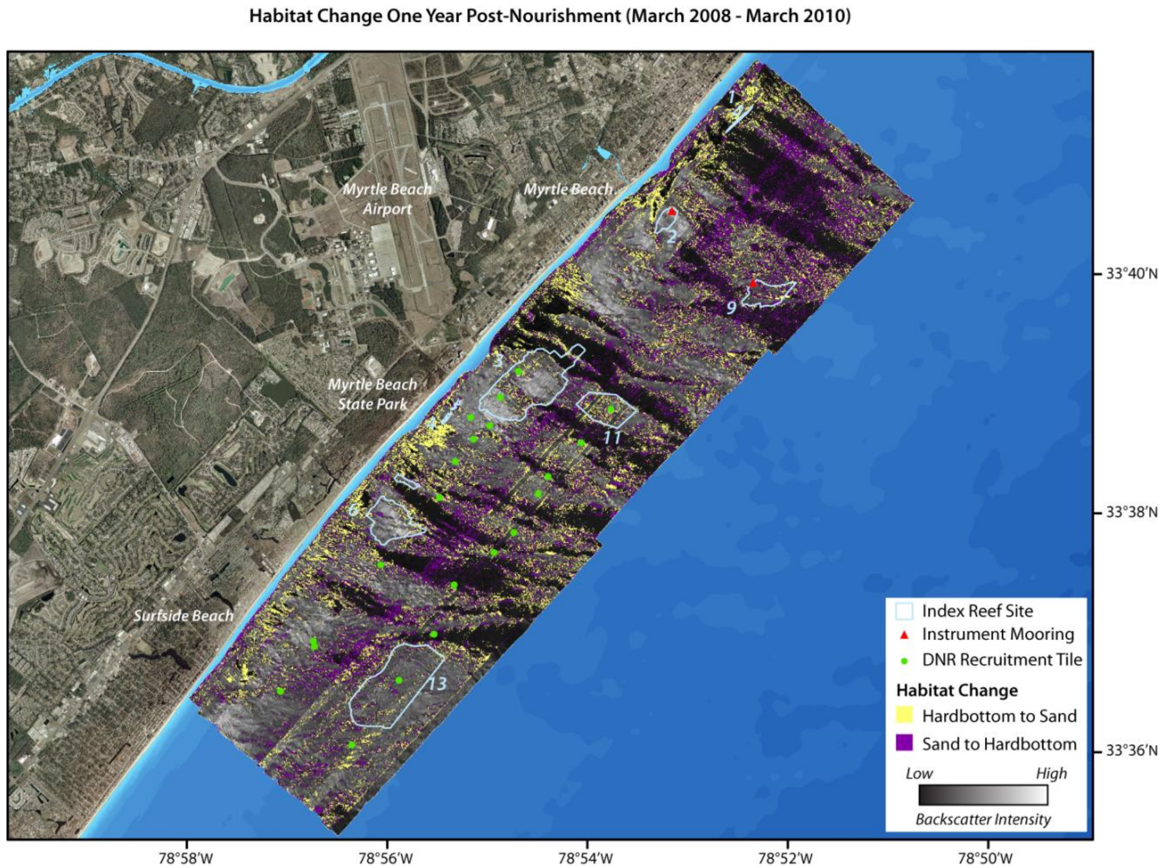


Figure 58. Change in seafloor habitat classification from March 2008 (pre-nourishment) to March 2010 (one year post-nourishment).

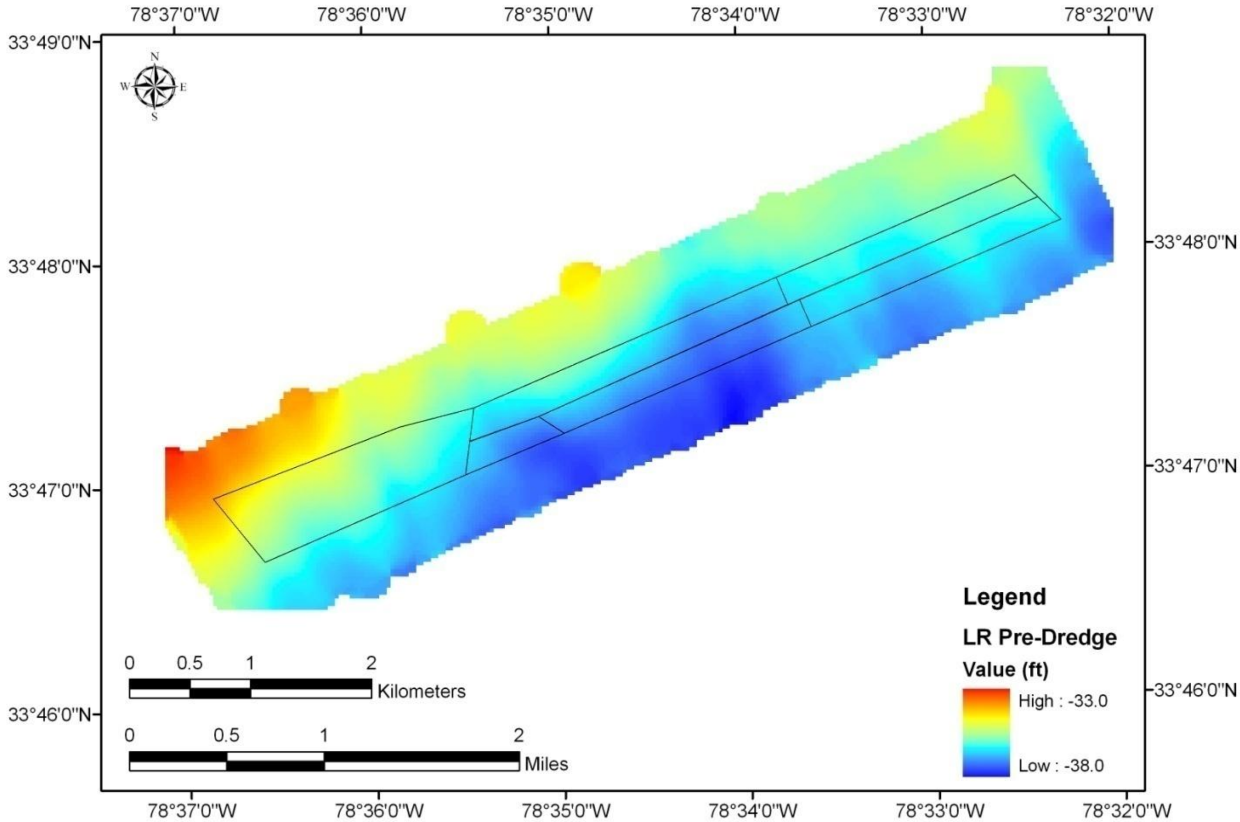


Figure 59. Little River Borrow Site Pre-Dredge Bathymetry.

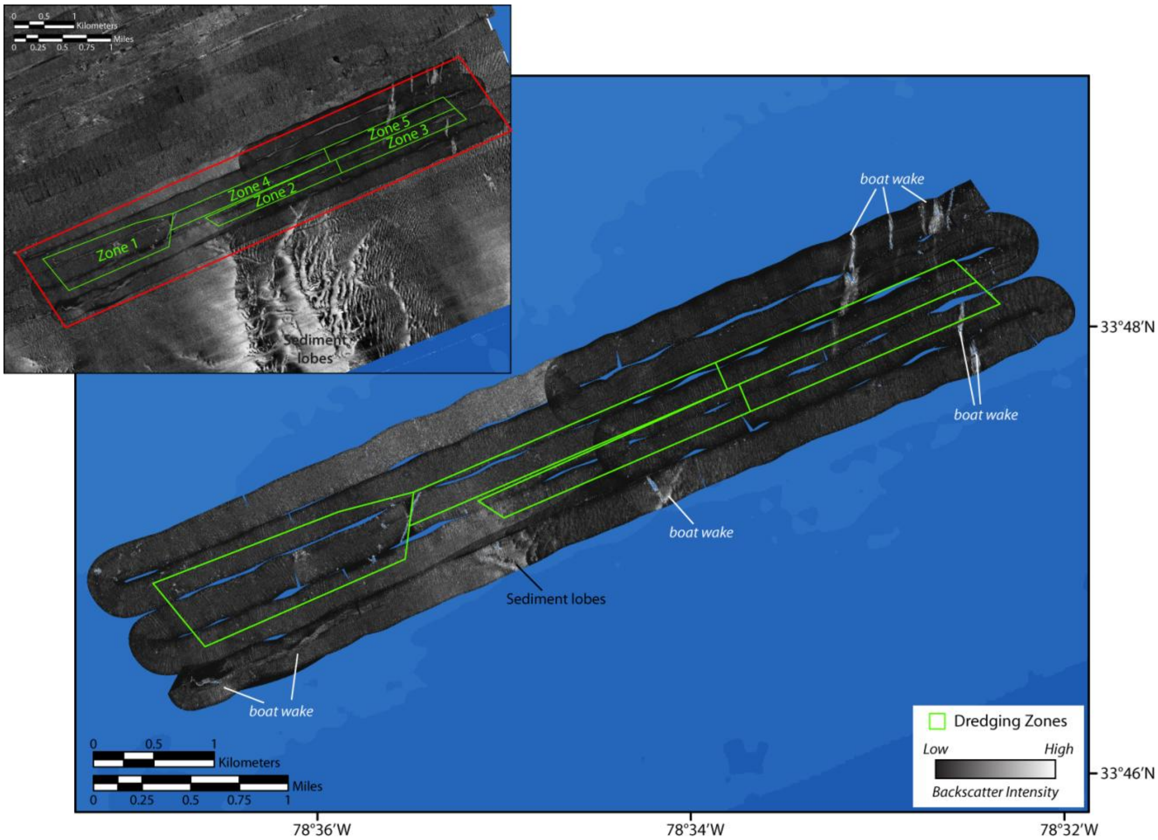


Figure 60. Sidescan mosaic of the Little River Borrow Site prior to dredging (Aug 2008). Inset: 2008 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

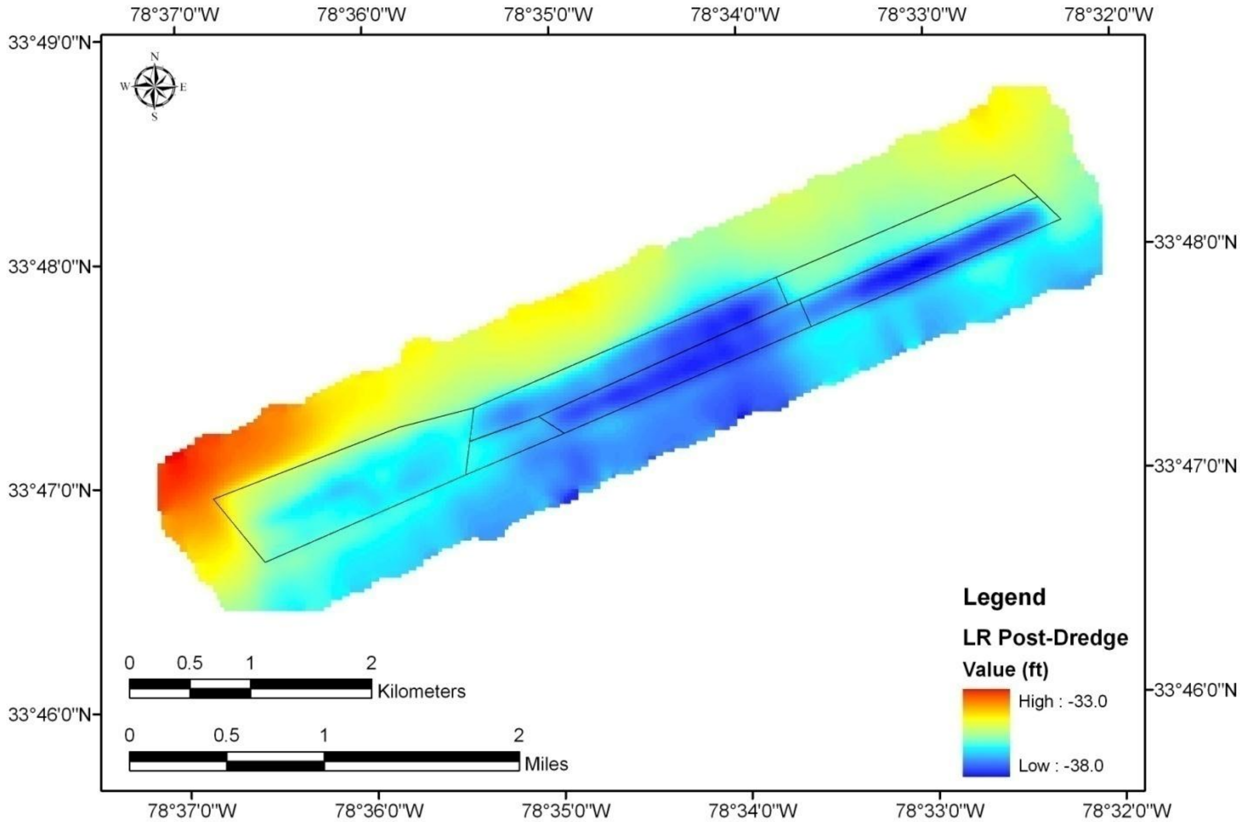


Figure 61. Little River Borrow Site Post-Dredge Bathymetry.

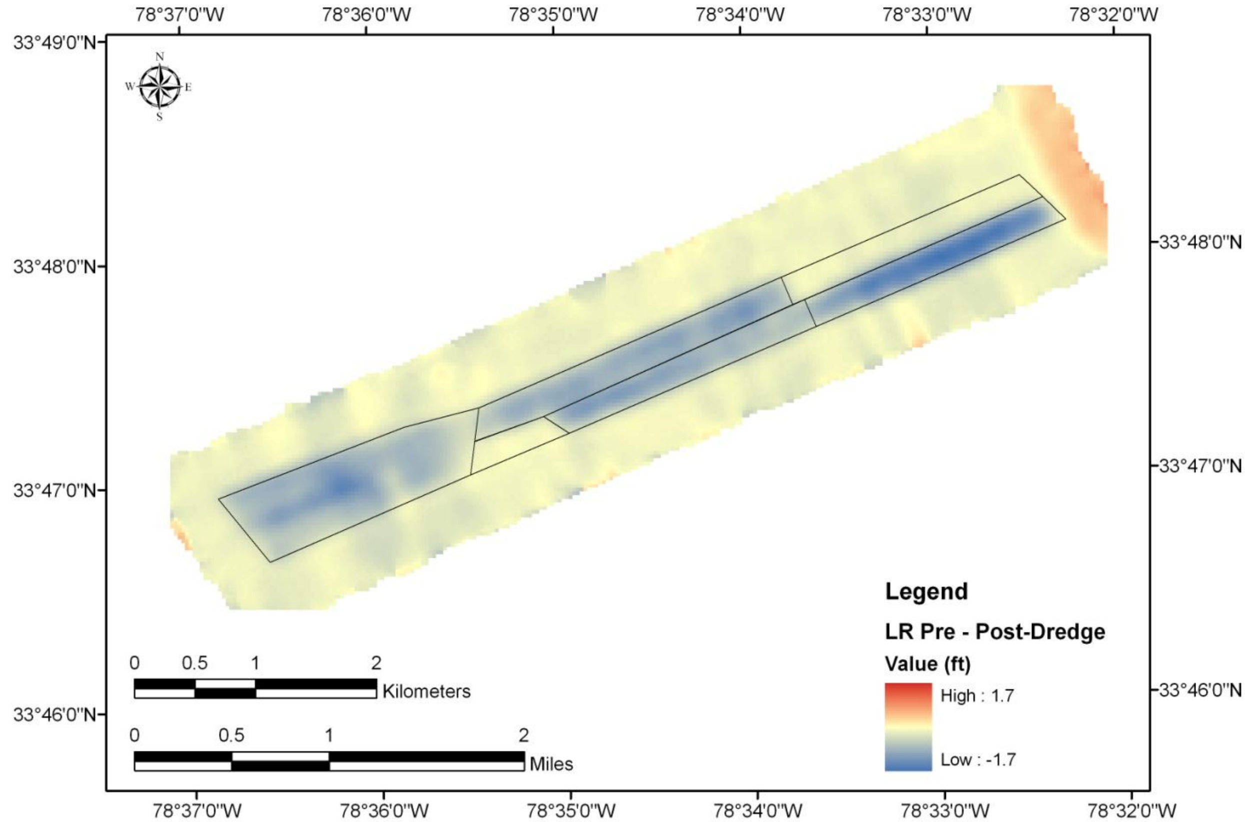


Figure 62. Little River Borrow Site Pre-Dredge – Post-Dredge Change Map.

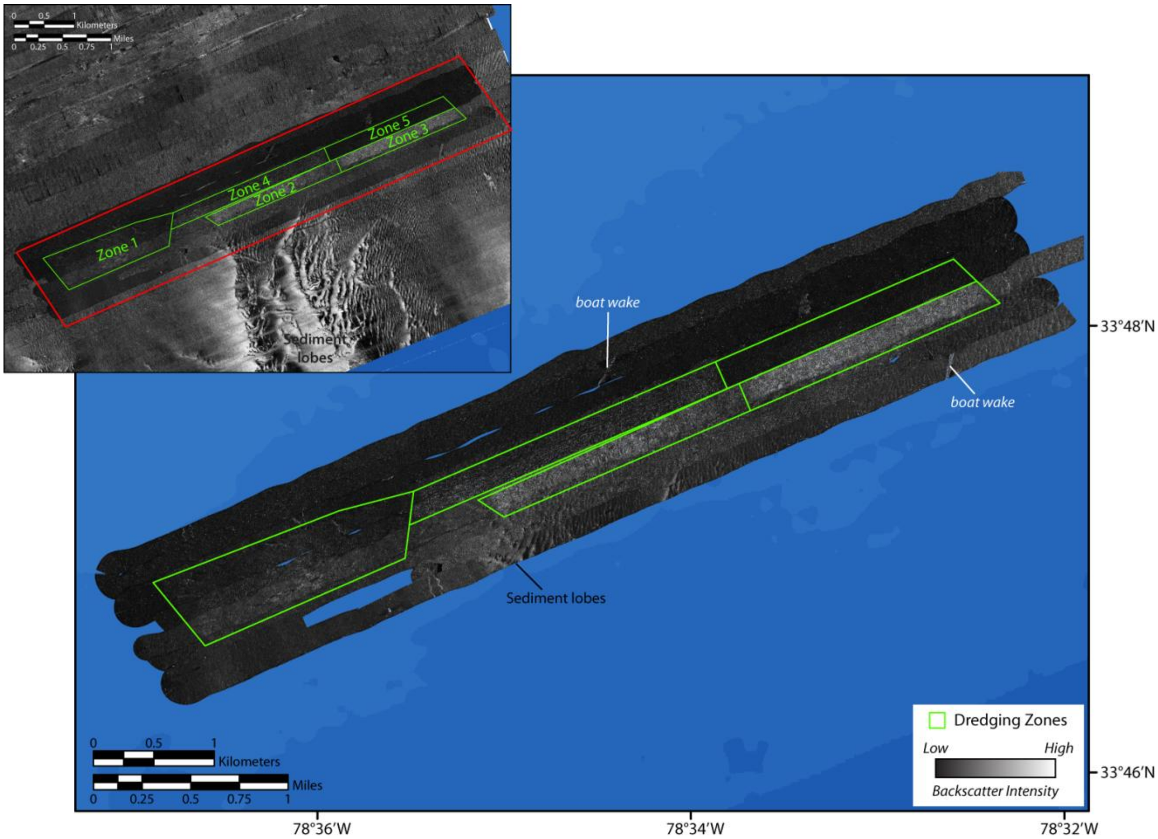


Figure 63. Sidescan mosaic of the Little River Borrow Site after dredging (Dec 2008). Inset: 2008 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

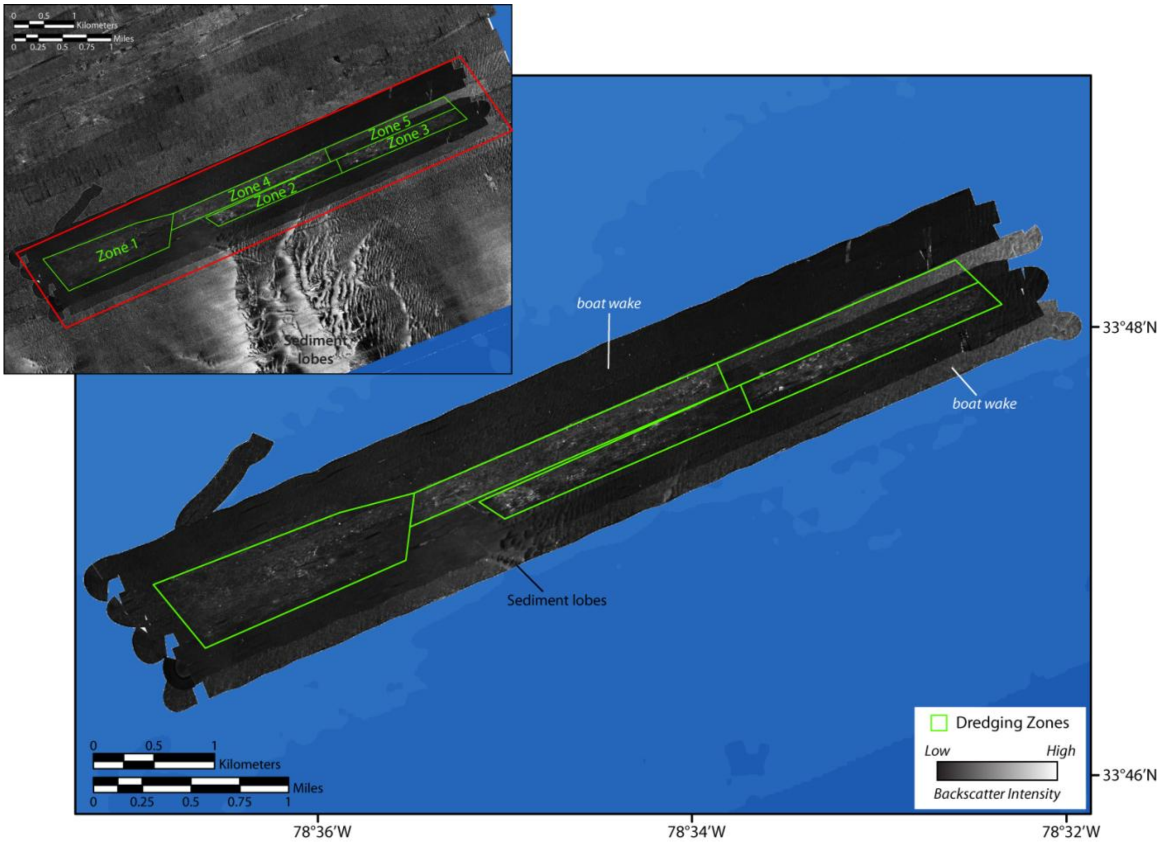


Figure 64. Sidescan mosaic of the Little River Borrow Site one year after dredging (Jan 2009).

Inset: 2009 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

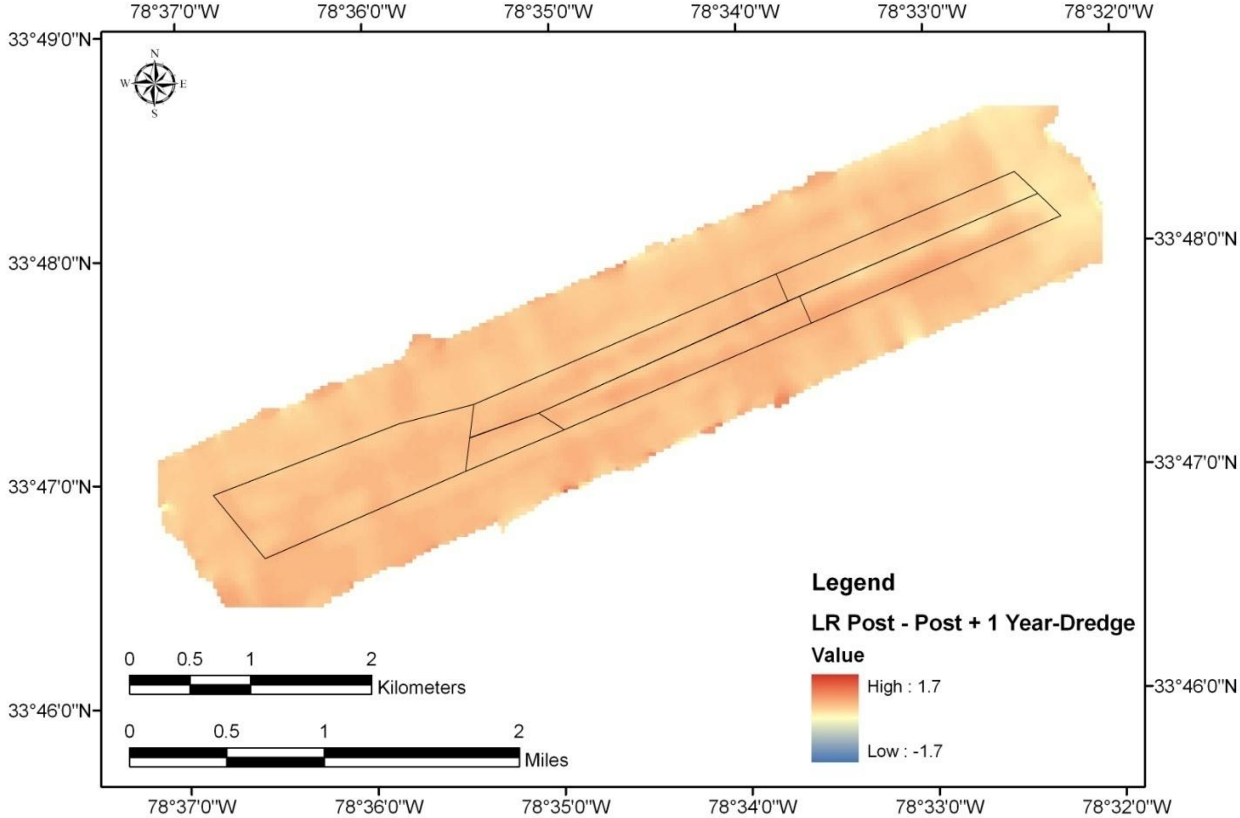


Figure 65. Little River Borrow Site Post-Dredge – Post + 1 Year-Dredge Change Map.

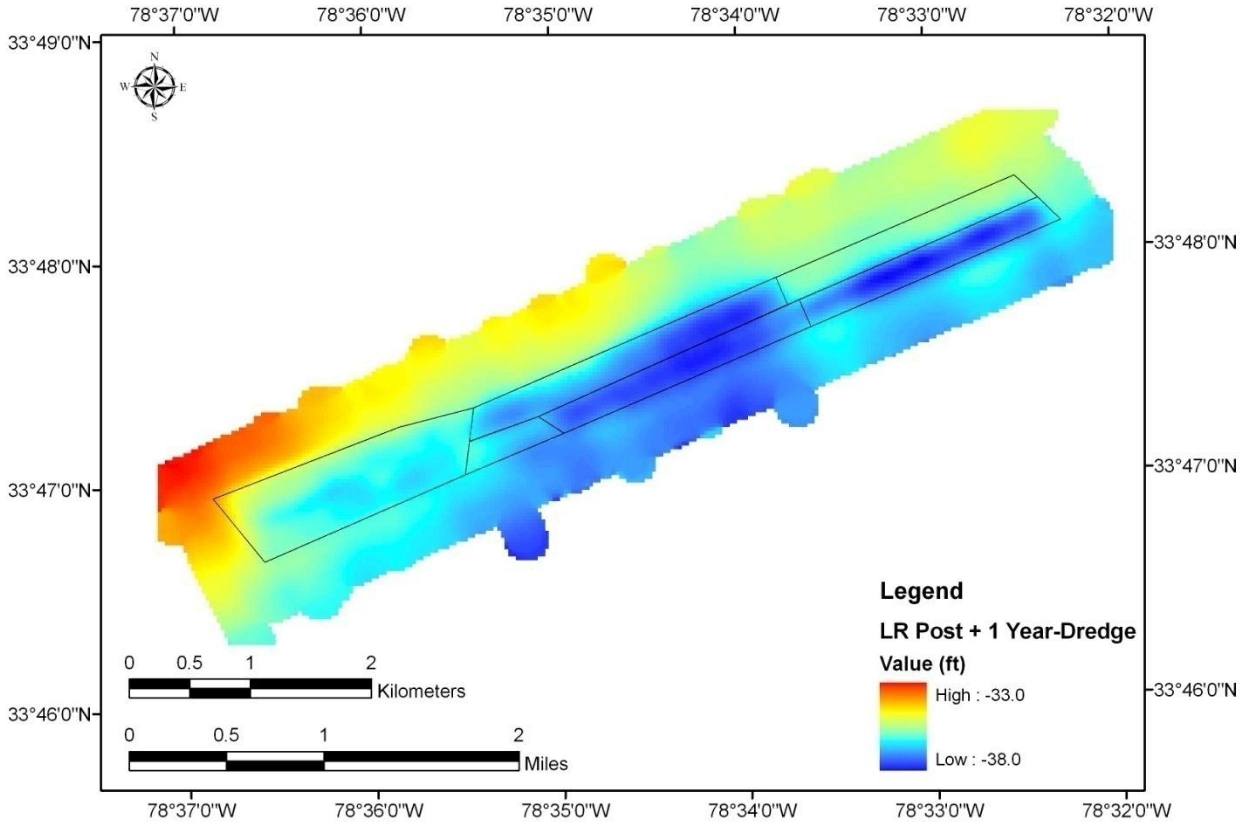


Figure 66. Little River Borrow Site Post + 1 Year-Dredge Bathymetry.

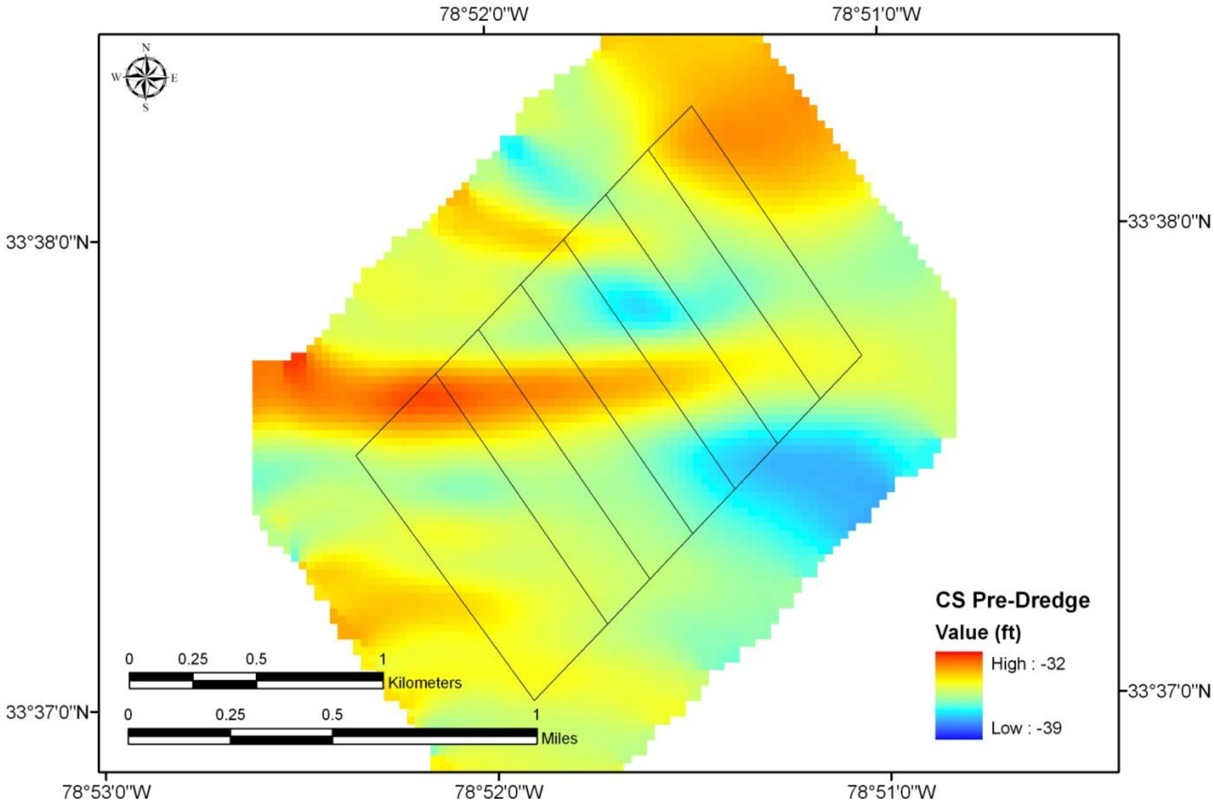


Figure 67. Cane South Borrow Site Pre-Dredge Bathymetry.

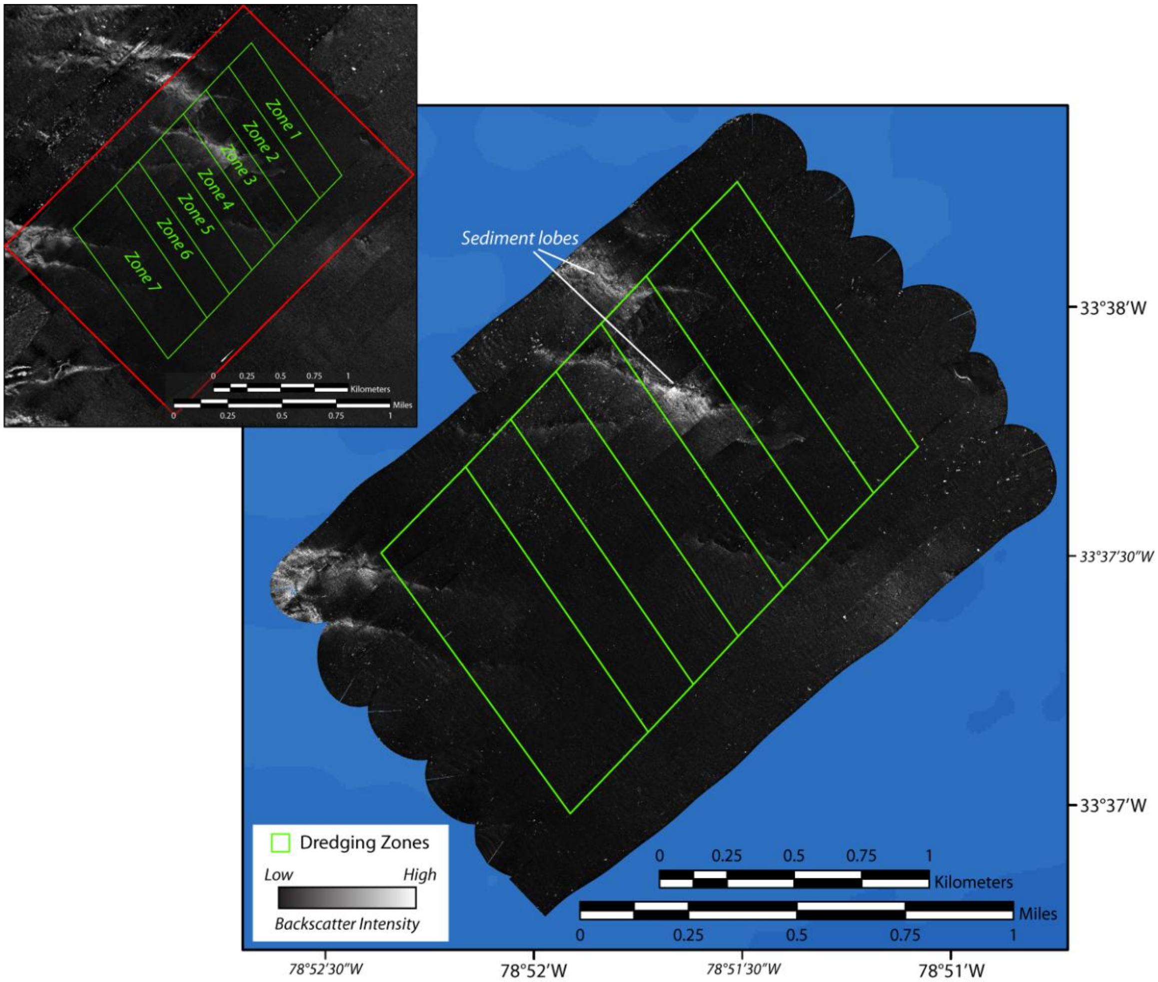


Figure 68. Sidescan mosaic of the Cane South Borrow Site prior to dredging (Sep 2008). Inset: 2008 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

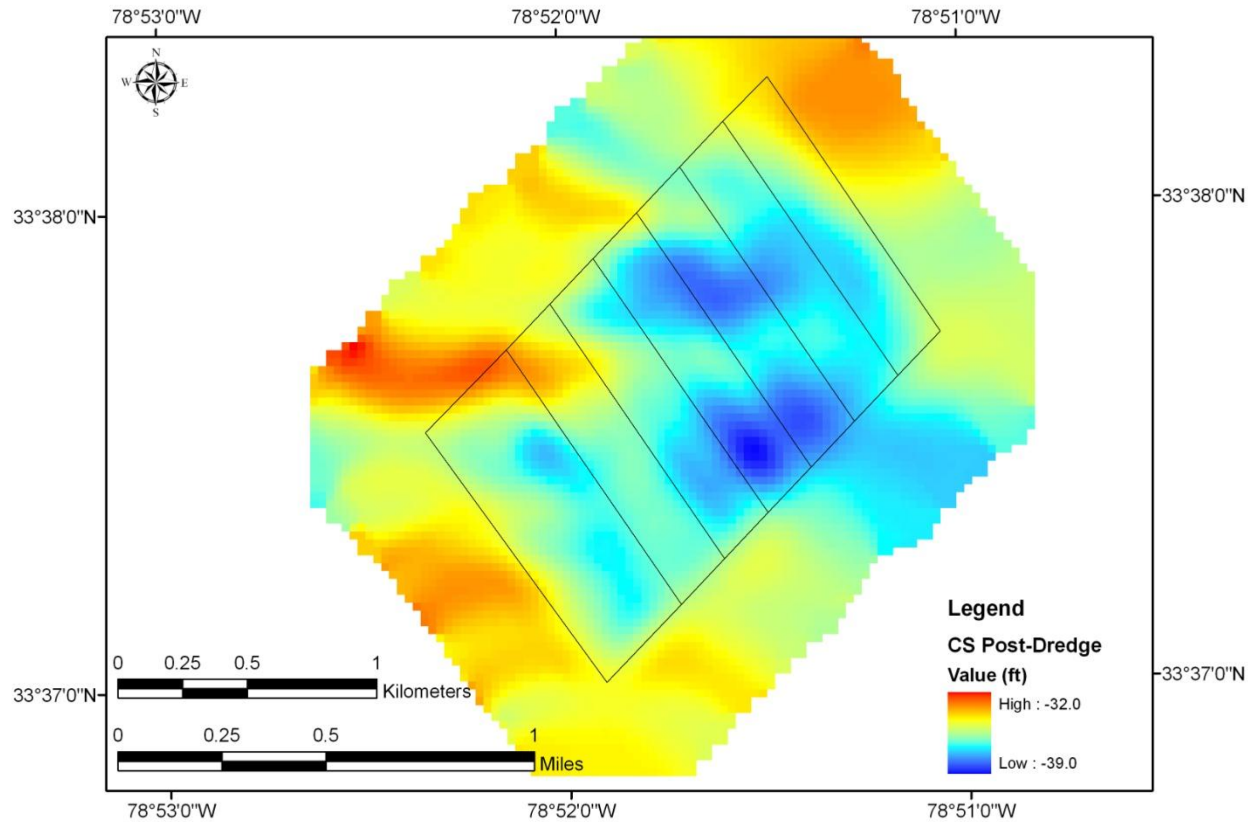


Figure 69. Cane South Borrow Site Post-Dredge Bathymetry.

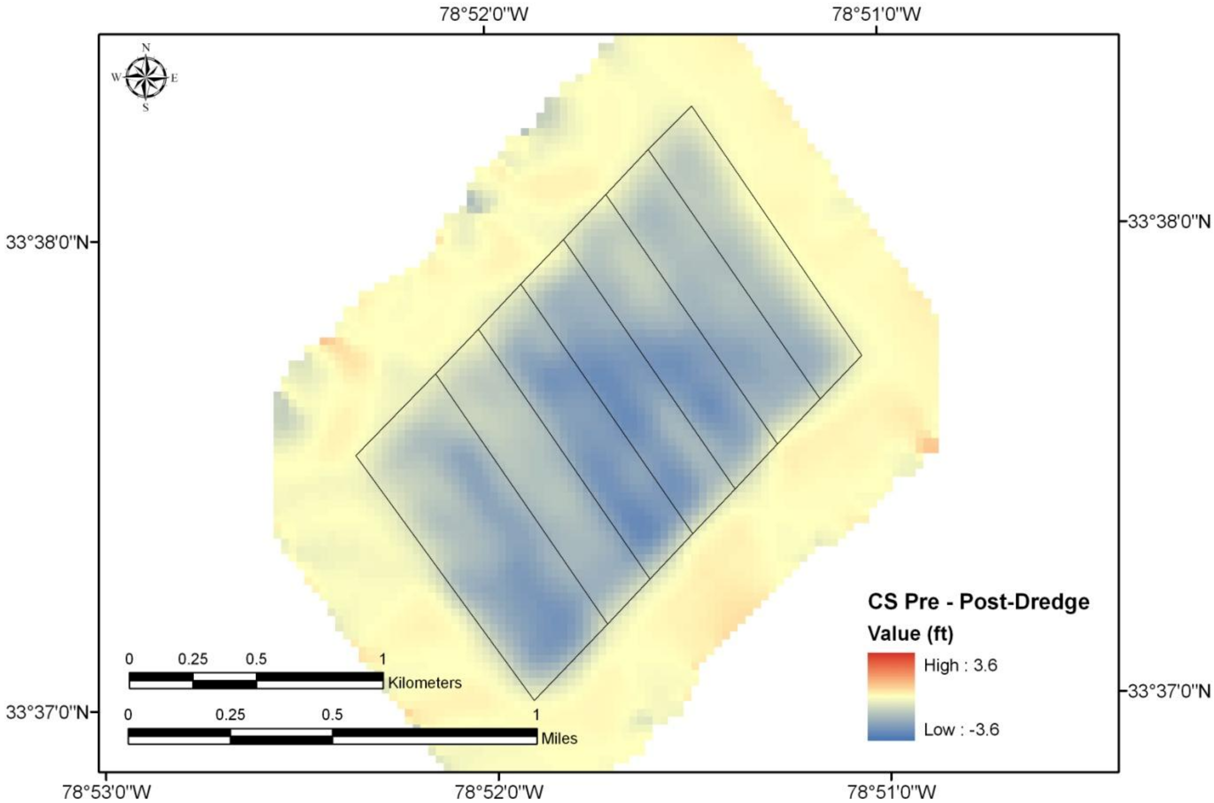


Figure 70. Cane South Borrow Site Pre-Dredge – Post-Dredge Change Map.

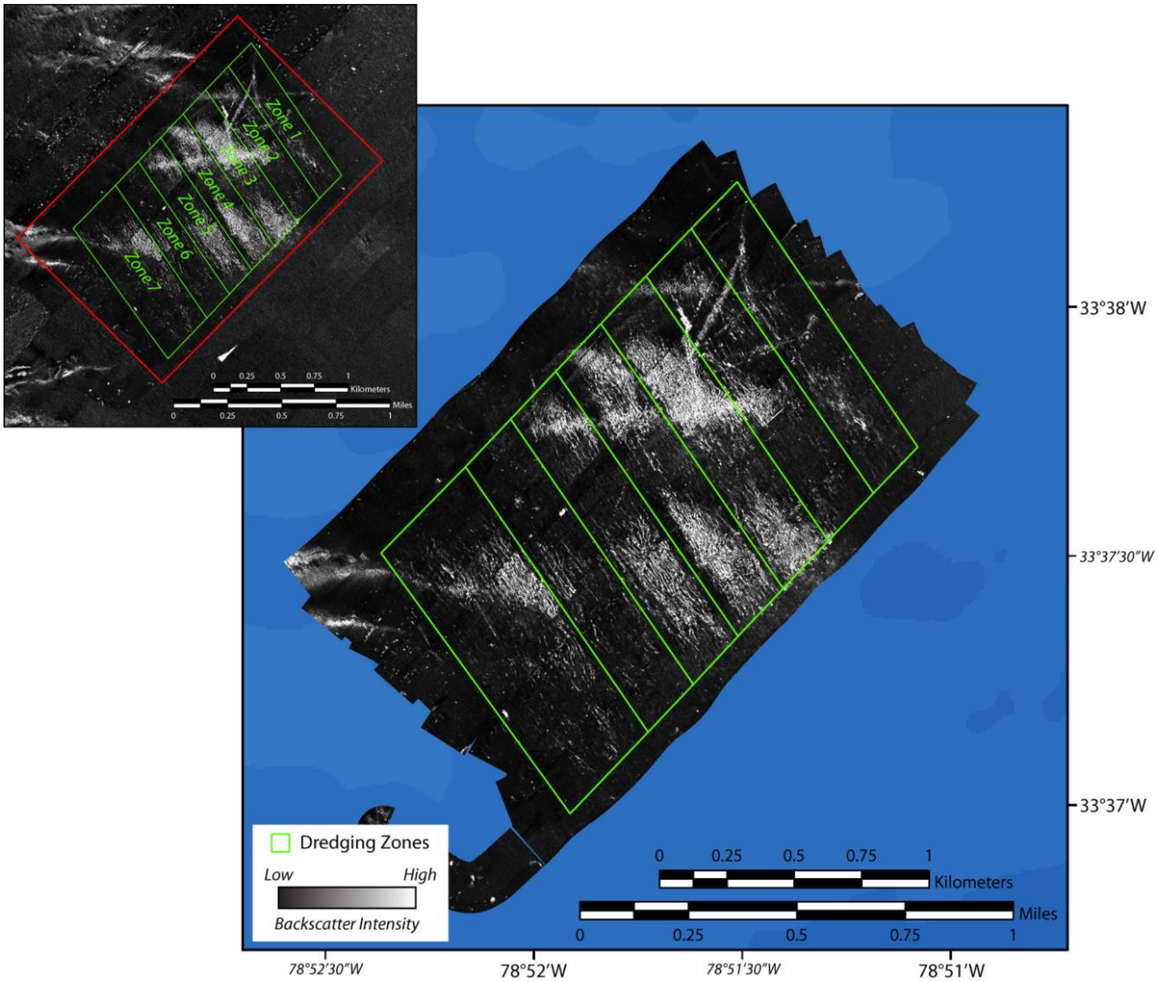


Figure 71. Sidescan mosaic of the Cane South Borrow Site after dredging (Apr 2009). Inset: 2009 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

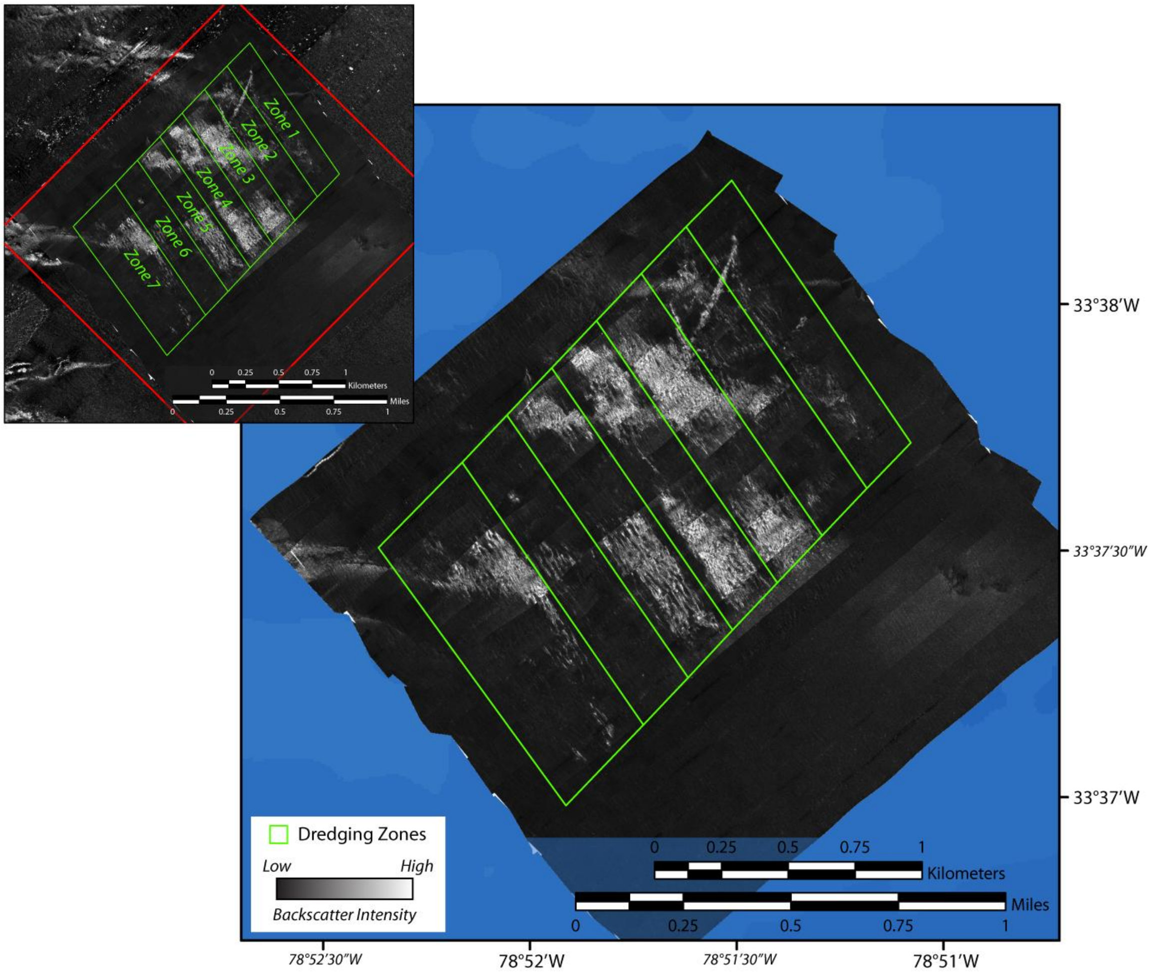


Figure 72. Sidescan mosaic of the Cane South Borrow Site one year after dredging (Jan 2010).

Inset: 2010 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

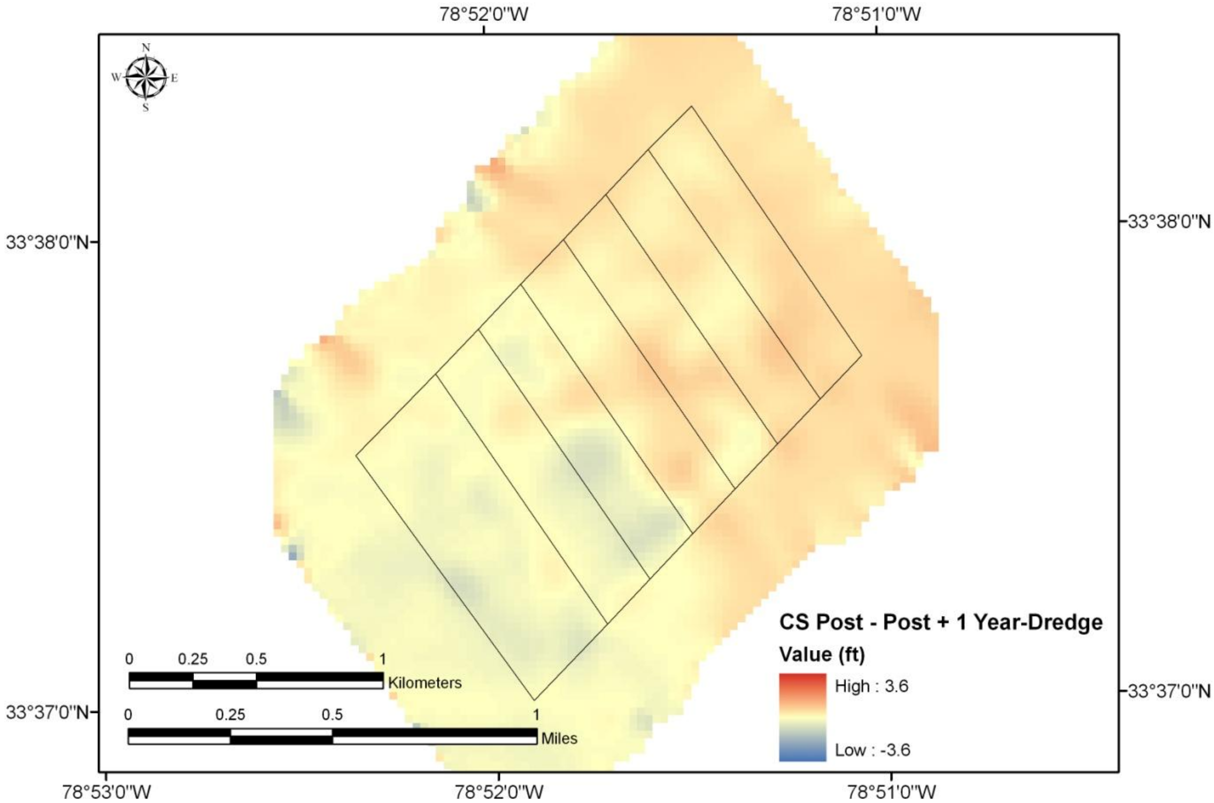


Figure 73. Cane South Borrow Site Post-Dredge – Post + 1 Year-Dredge Change Map.

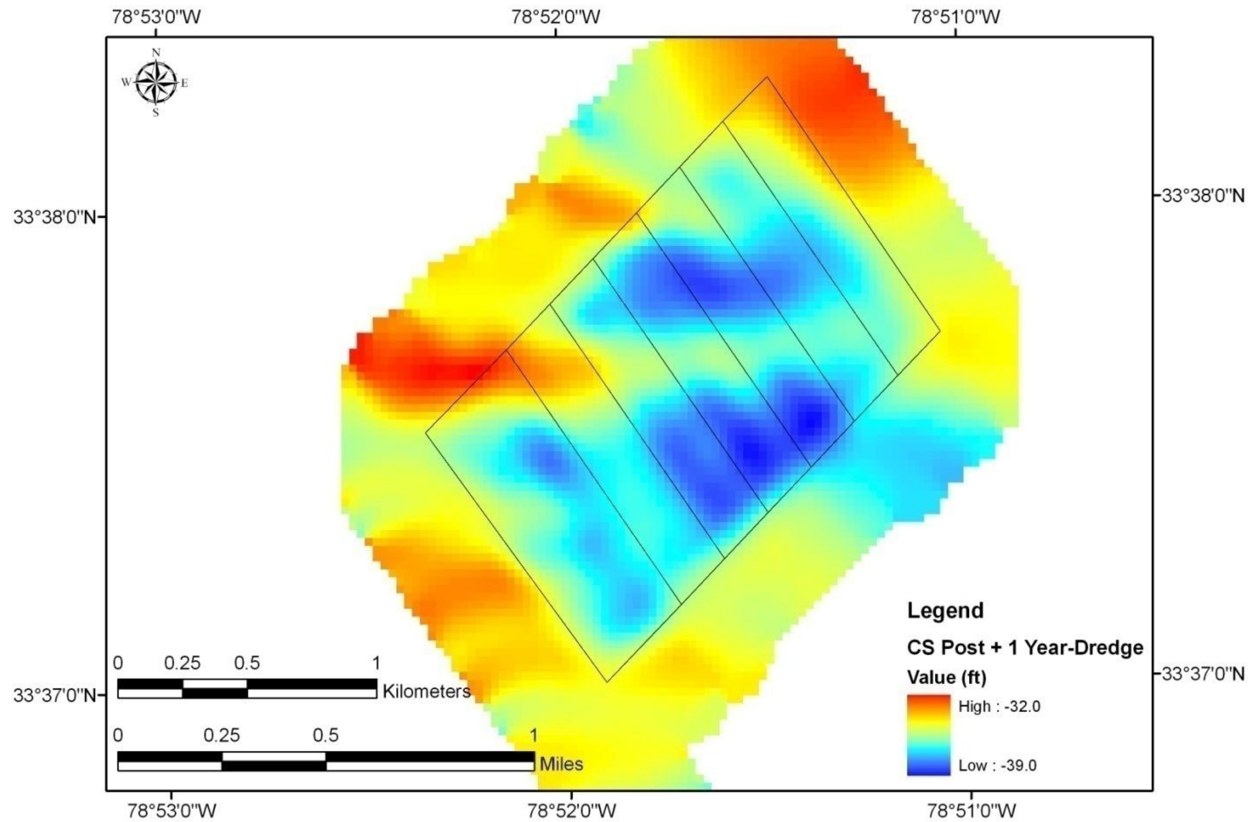


Figure 74. Cane South Borrow Site Post + 1 Year-Dredge Bathymetry.

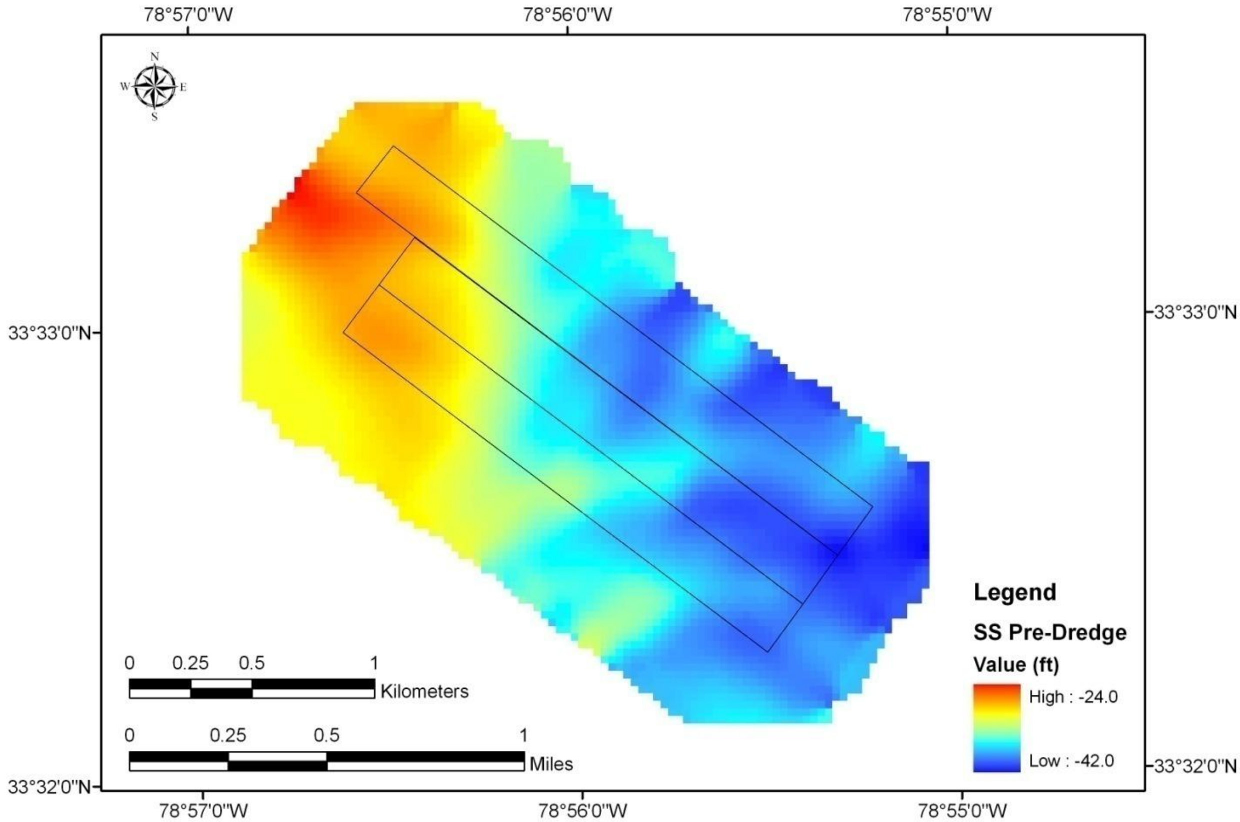


Figure 75. Surfside Borrow Site Pre-Dredge Bathymetry.

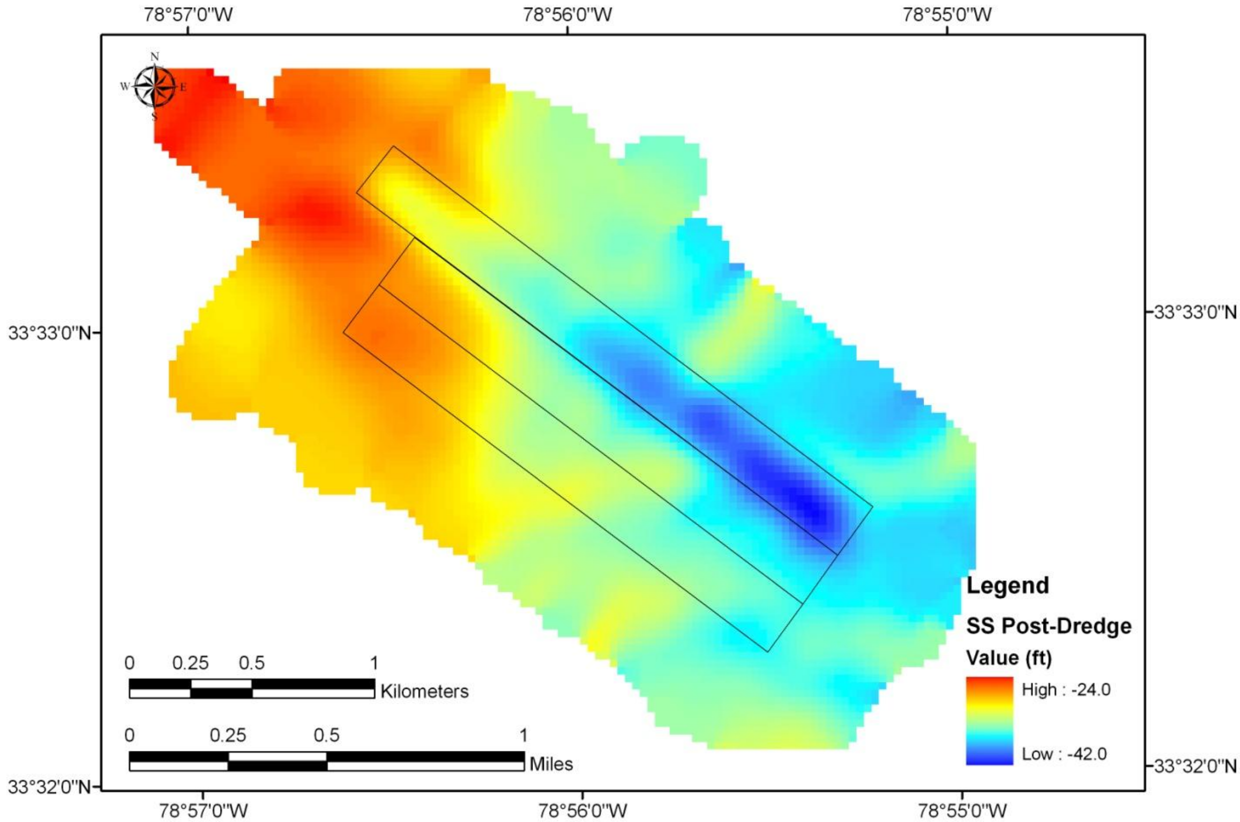


Figure 76. Surfside Borrow Site Post-Dredge Bathymetry.

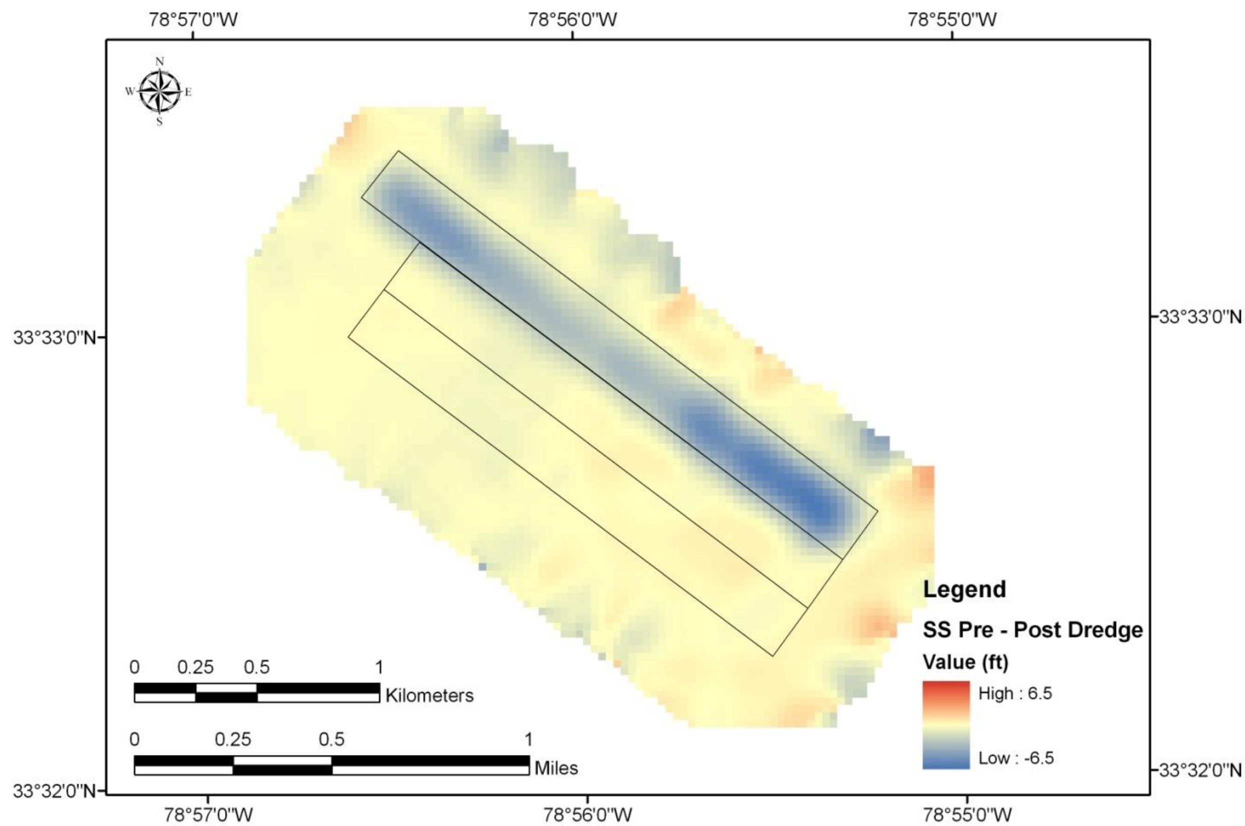


Figure 77. Surfside Borrow Site Pre-Dredge – Post-Dredge Change Map.

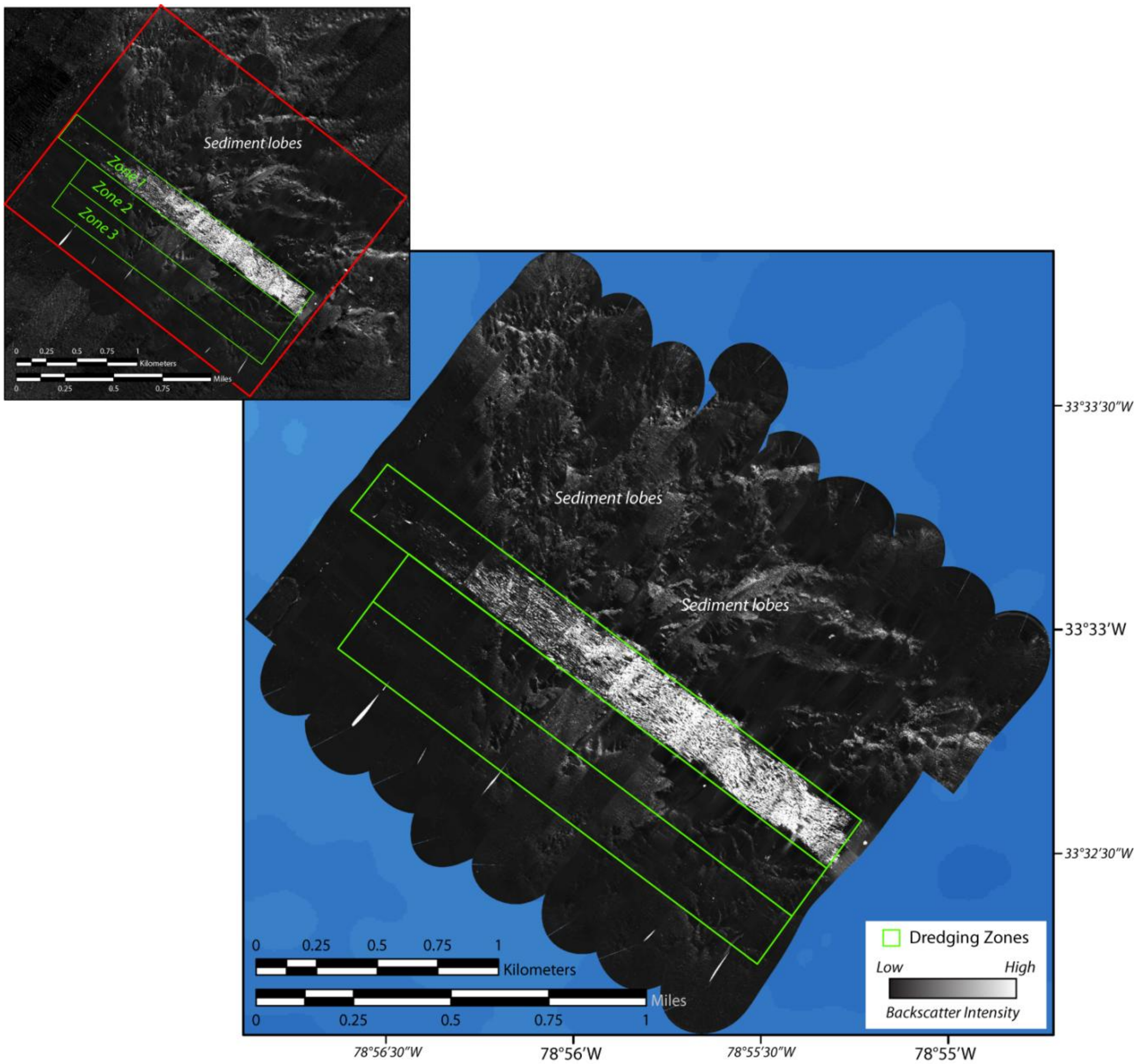


Figure 78. Sidescan mosaic of the Surfside Borrow Site after dredging (Sep 2008). Inset: 2008 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

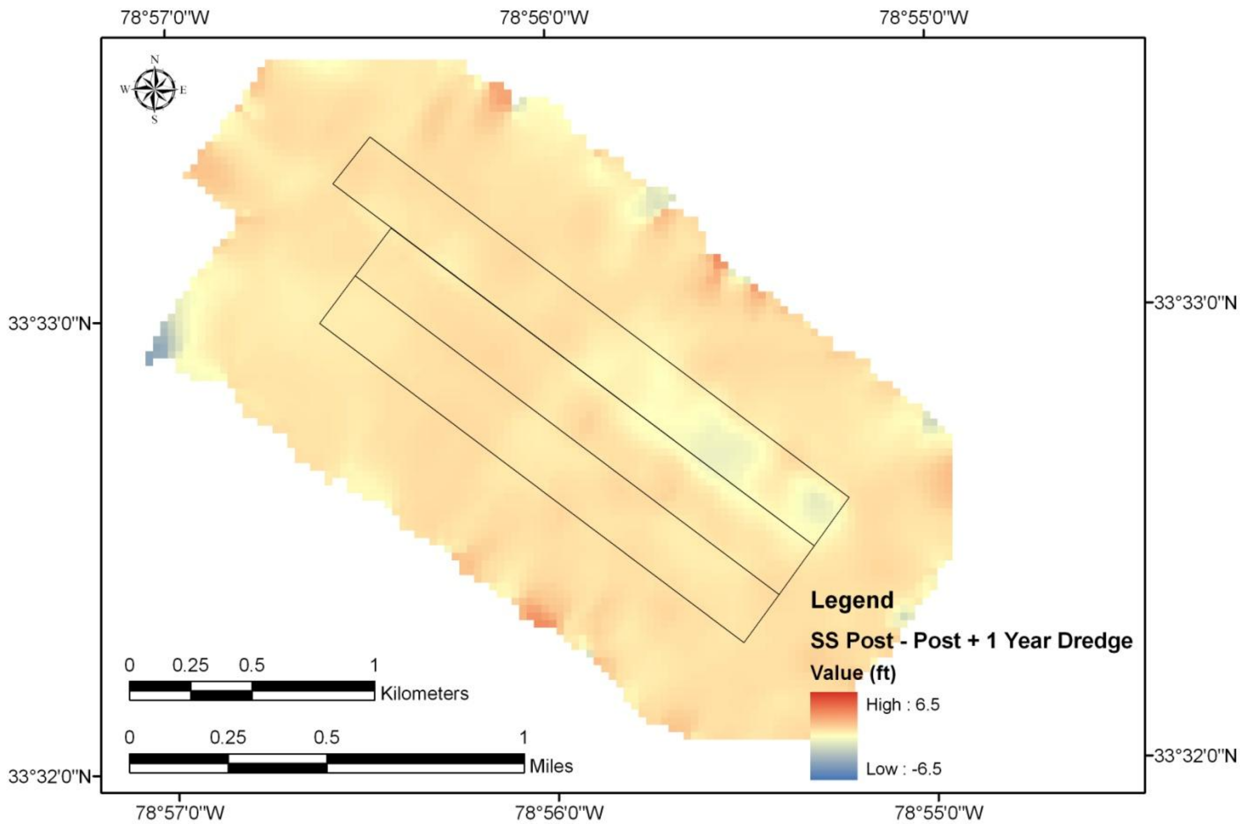


Figure 79. Surfside Borrow Site Post-Dredge – Post + 1Year-Dredge Change Map.

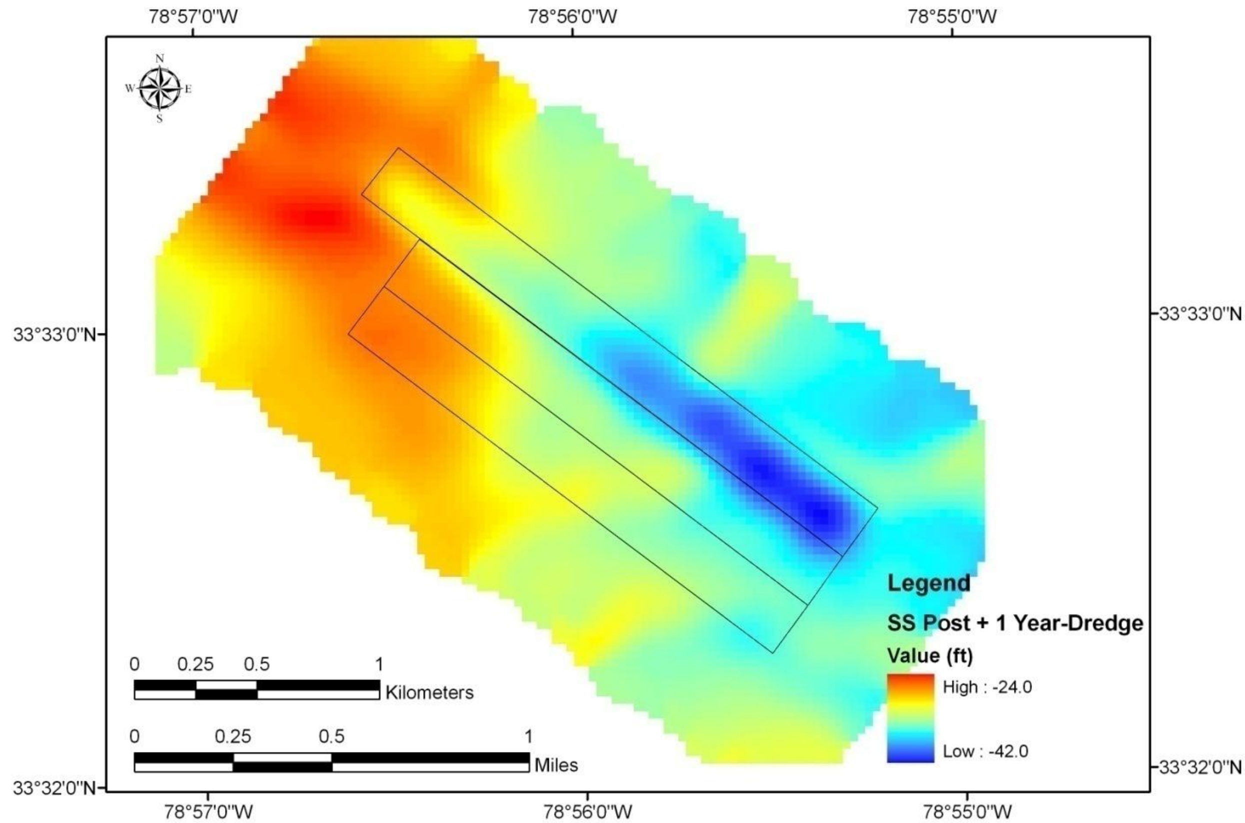


Figure 80. Surfside Borrow Site Post + 1 Year –Dredge Bathymetry.

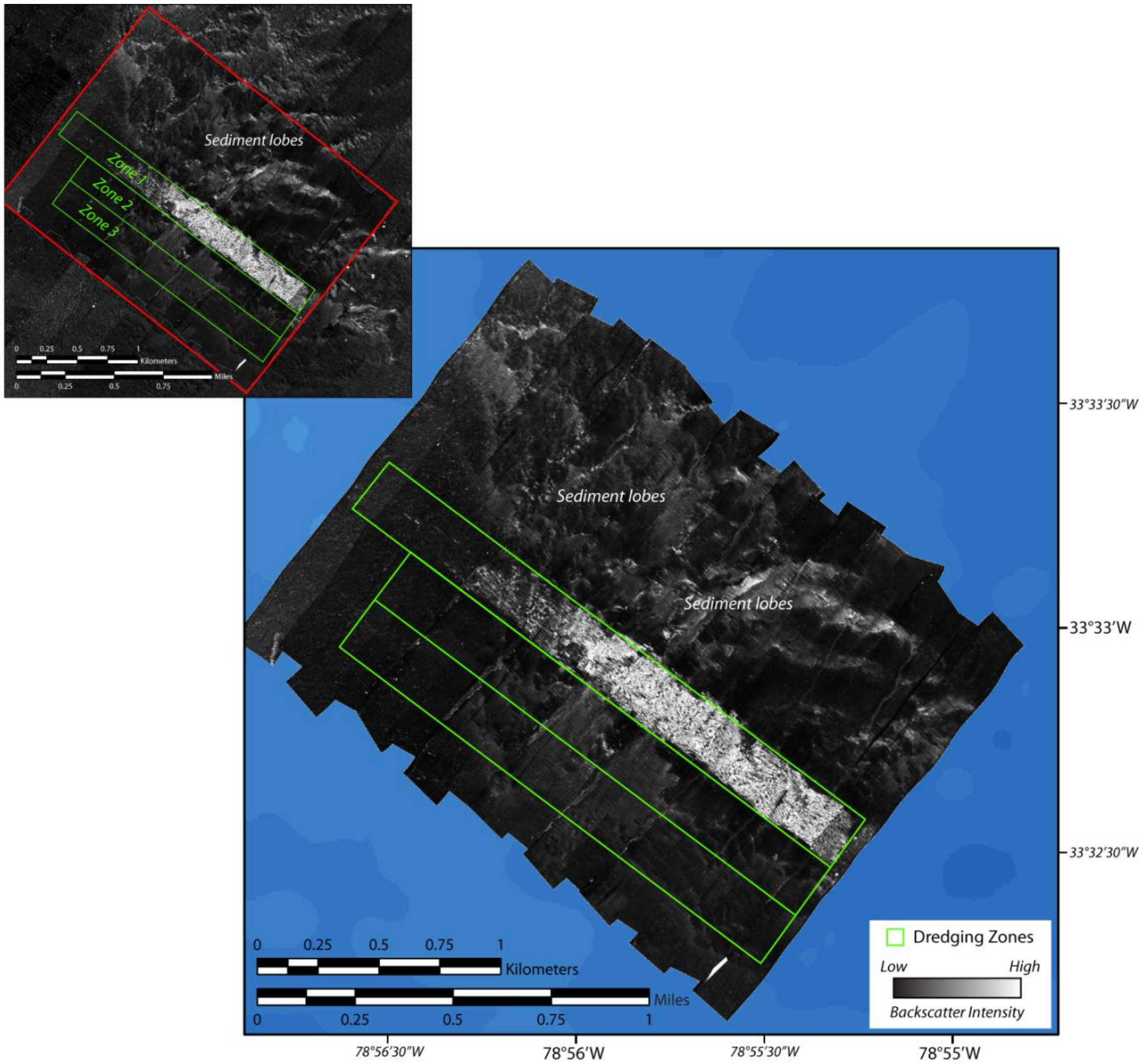


Figure 81. Sidescan mosaic of the Surfside Borrow Site one year after dredging (Aug 2009).

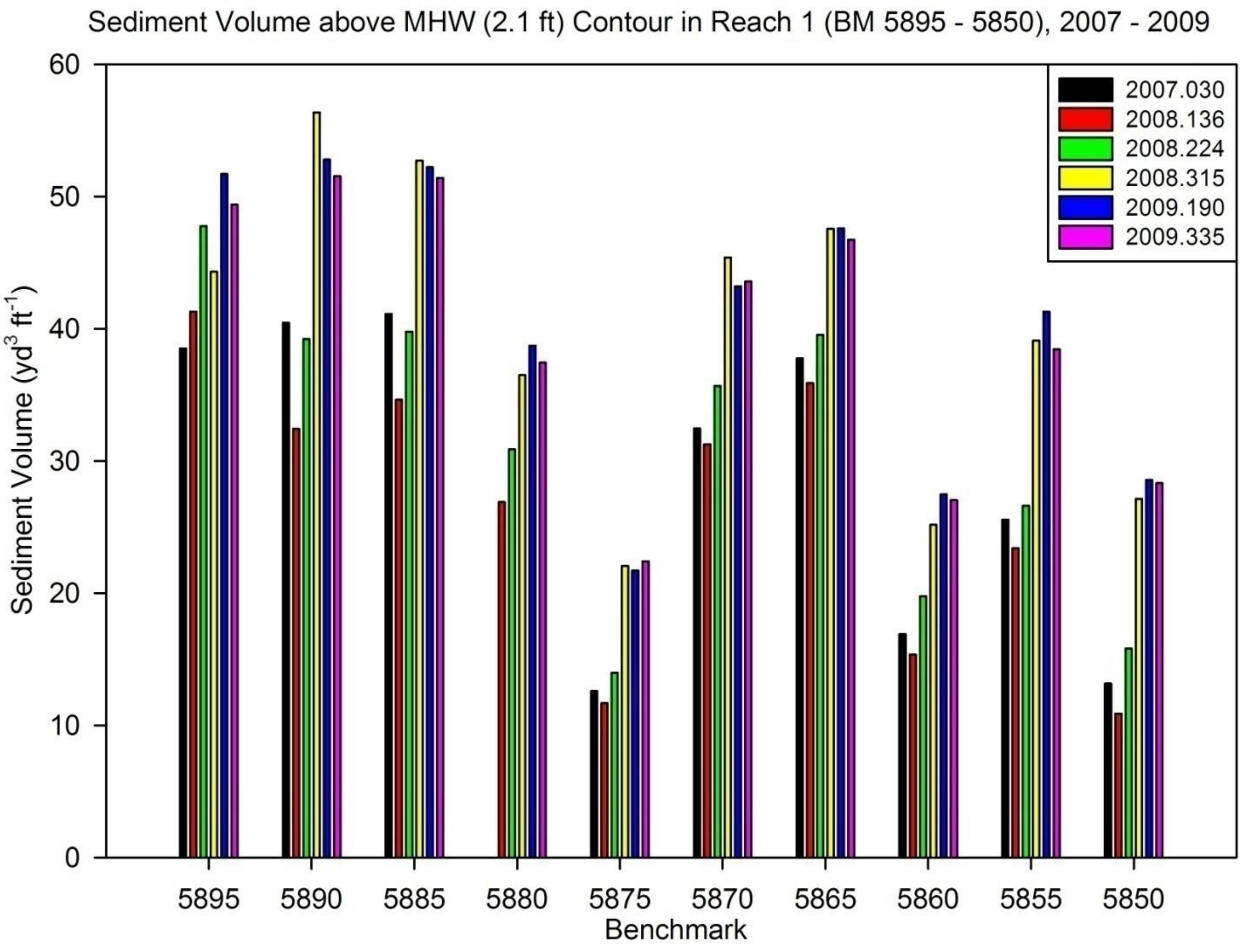
Inset: 2008 Sidescan sonar mosaic overlain on the 1999 mosaic for reference.

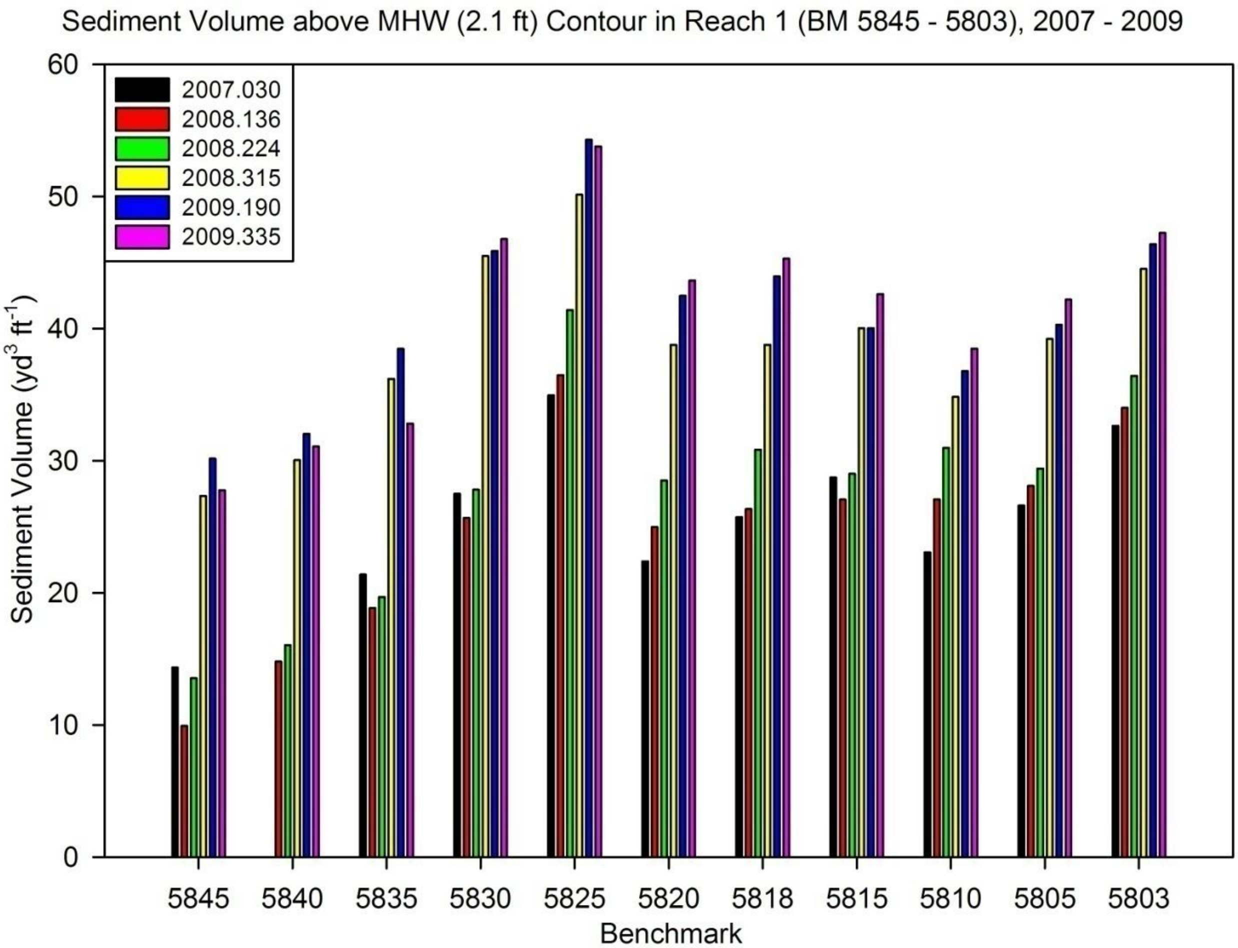
APPENDICES

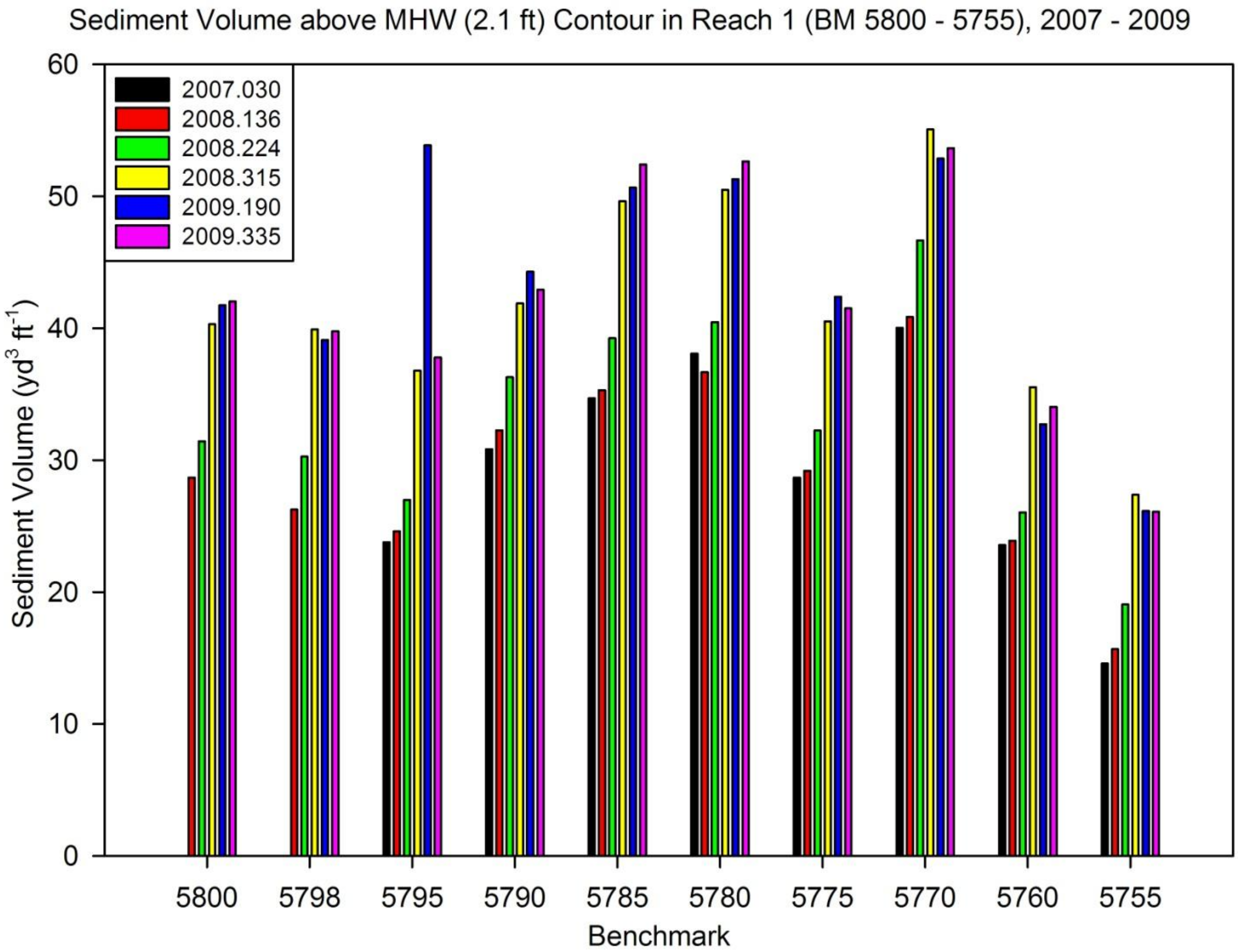
Appendix 1: X-on Values for Beach Profiles

Reach 1		Reach 2		Reach 3		Arcadian Shores	
Profile	X-on (ft)	Profile	X-on (ft)	Profile	X-on (ft)	Profile	X-on (ft)
5895	198.5	5505	221.0	5280	52.0	5590	105.0
5890	235.0	5500	95.7	5270	186.8	5585	140.0
5885	200.0	5480	176.0	5260	56.0	5580	80.2
5880	171.1	5478	238.0	5250	108.8	5575	100.0
5875	170.0	5475	313.9	5240	256.7	5570	65.0
5870	116.0	5473	716.0	5230	20.5	5565	100.0
5865	123.8	5470	421.0	5220	90.0	5560	92.3
5860	180.0	5468	300.0	5210	120.0	5555	294.2
5855	115.0	5465	385.2	5200	104.4	5550	335.0
5850	130.7	5463	290.0	5195	133.2	5540	104.1
5845	95.6	5460	224.5	5180	200.0	5535	73.4
5840	134.4	5458	160.0	5140	269.4	5530	425.0
5835	160.6	5455	160.0	5130	300.0	5528	53.5
5830	175.0	5453	115.3	5120	223.0	5523	60.0
5825	293.0	5450	470.0	5100	195.0	5520	330.5
5820	390.0	5448	365.0	5035	136.8	5518	310.0
5818	350.0	5445	397.0	5030	185.0	5515	325.0
5815	395.0	5443	330.0	5025	188.6	5514	360.0
5810	345.0	5440	390.0	5020	250.0	5513	348.0
5805	340.0	5438	210.0	5015	240.0	5510	254.1
5803	318.0	5435	225.0	5010	183.6		
5800	318.8	5433	365.0	5005	89.1		
5798	261.3	5430	40.0	5000	143.0		
5795	237.4	5428	250.0	4999	51.8		
5790	285.0	5425	297.0	4980	70.4		
5785	258.0	5423	265.0	4975	70.0		
5780	183.0	5420	75.0	4970	156.9		
5775	239.0	5418	330.0	4965	111.9		
5770	218.0	5415	315.0	4960	150.0		
5760	210.0	5413	250.0	4955	180.0		
5755	252.0	5410	257.0	4950	200.0		
5750	254.0	5408	266.0	4940	260.0		
5745	245.0	5405	260.0	4935	325.0		
5740	248.0	5403	250.0	4930	273.0		
5735	250.0	5401	250.0	4925	250.0		
5730	300.0	5350	179.0	4920	150.0		
5725	176.8	5345	360.0				
5720	225.0	5340	480.0				
5715	170.0	5335	490.0				
5705	211.5	5330	400.0				
5700	190.0	5325	257.5				
5650	45.0	5320	300.0				
		5315	300.0				
		5310	370.0				
		5305	335.0				
		5300	425.0				

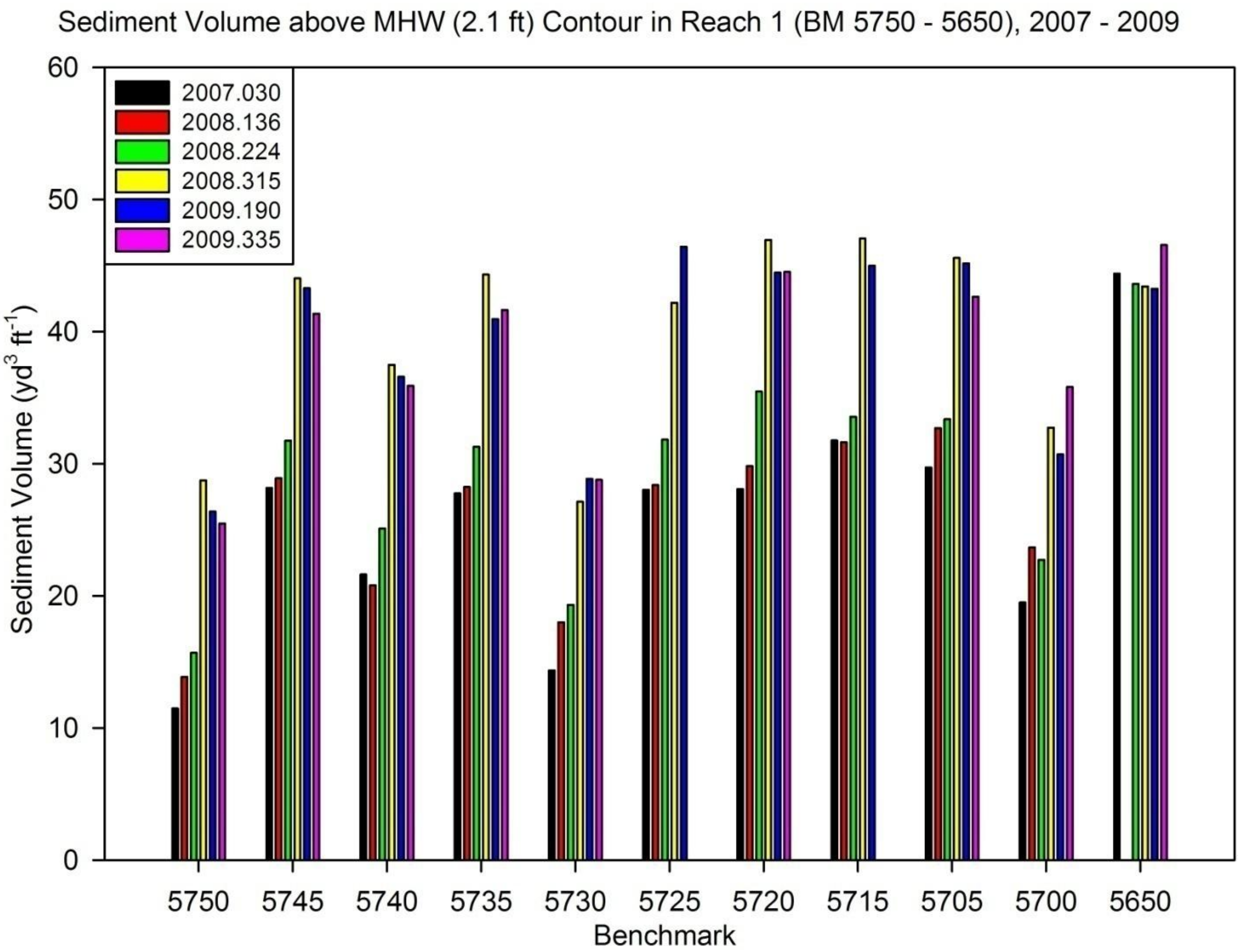
Appendix 2: Reach 1 Beach Profile Volume Bar Graphs

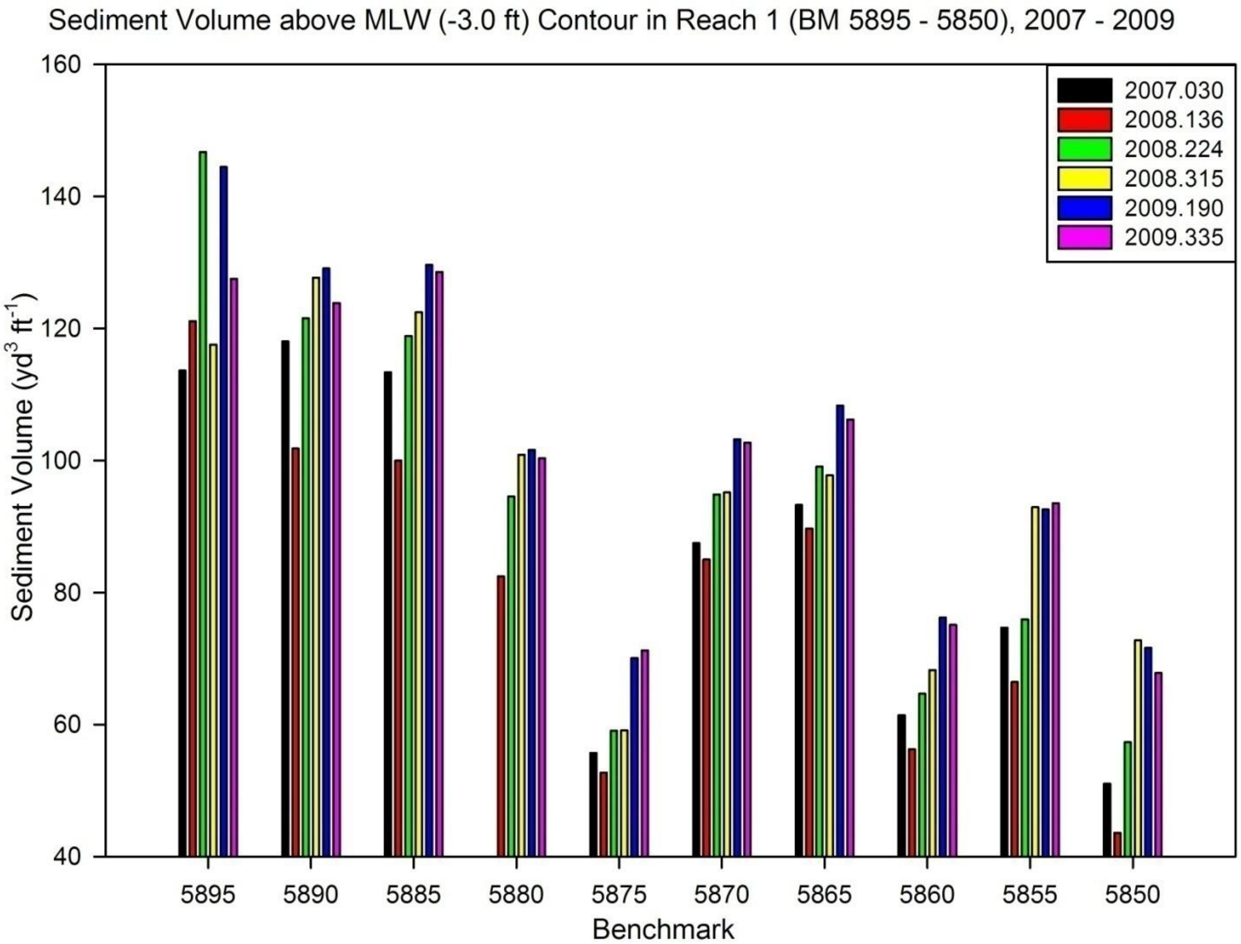

Sediment Volume above MHW (2.1 ft) Contour in Reach 1 (BM 5895 - 5850), 2007 - 2009
Sediment Volume (yd3 ft-1)
Benchmark
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
0
10
20
30
40
50
60
5895
5890
5885
5880
5875
5870
5865
5860
5855
5850

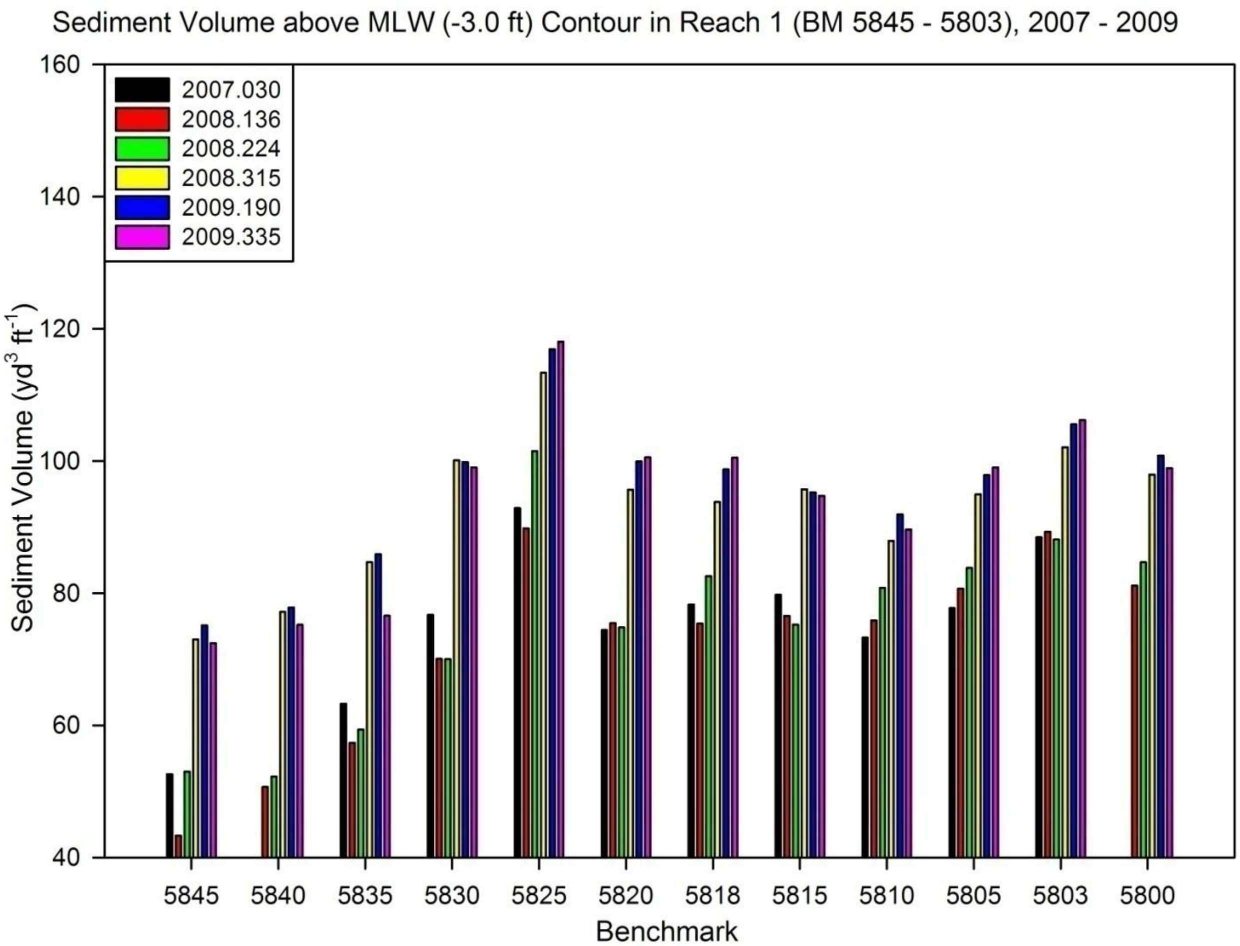

Sediment Volume above MHW (2.1 ft) Contour in Reach 1 (BM 5845 - 5803), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
60
5845
5840
5835
5830
5825
5820
5818
5815
5810
5805
5803
Benchmark

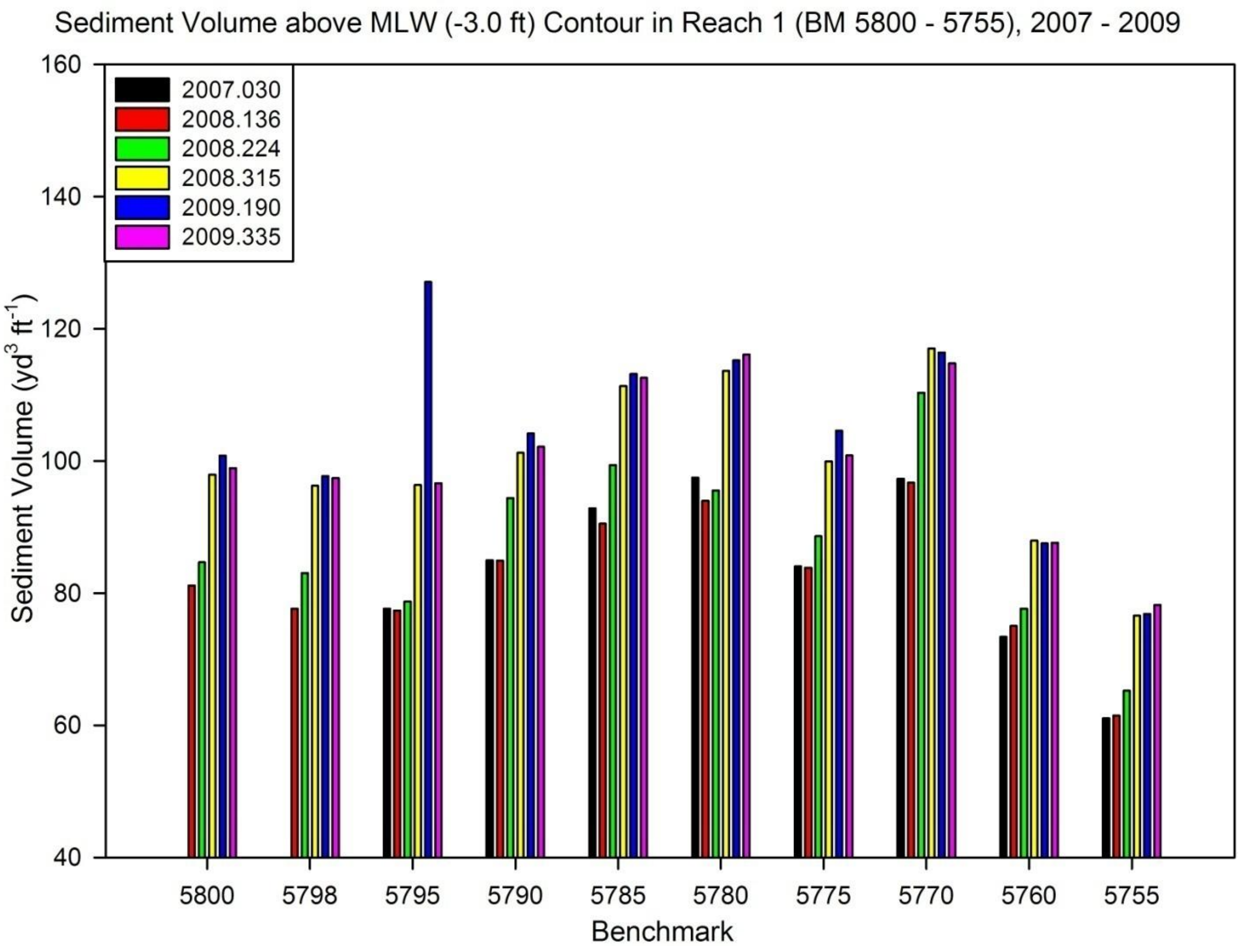


Sediment Volume above MHW (2.1 ft) Contour in Reach 1 (BM 5800 - 5755), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
60
5800
5798
5795
5790
5785
5780
5775
5770
5760
5755
Benchmark

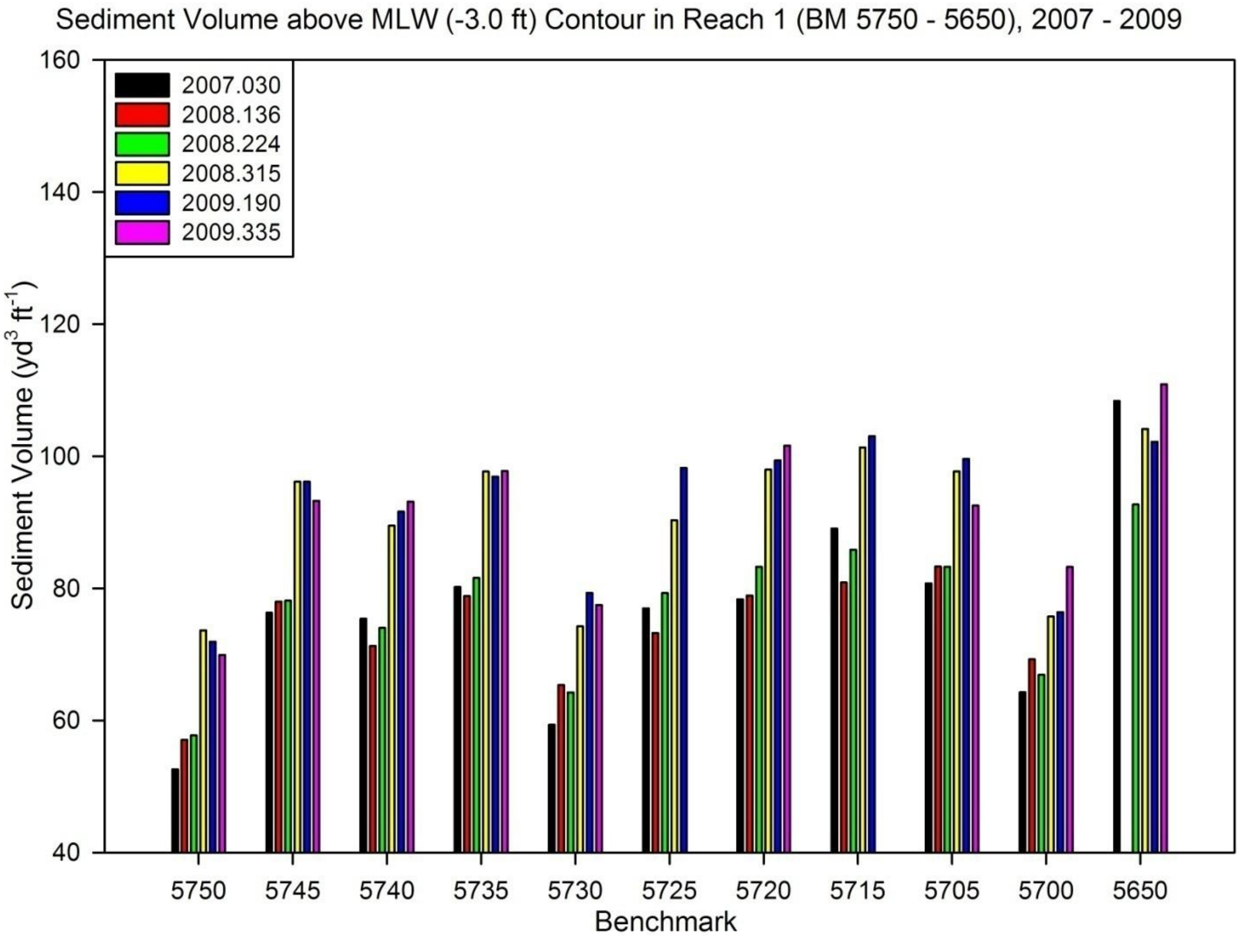

Sediment Volume above MHW (2.1 ft) Contour in Reach 1 (BM 5750 - 5650), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
60
5750
5745
5740
5735
5730
5725
5720
5715
5705
5700
5650
Benchmark

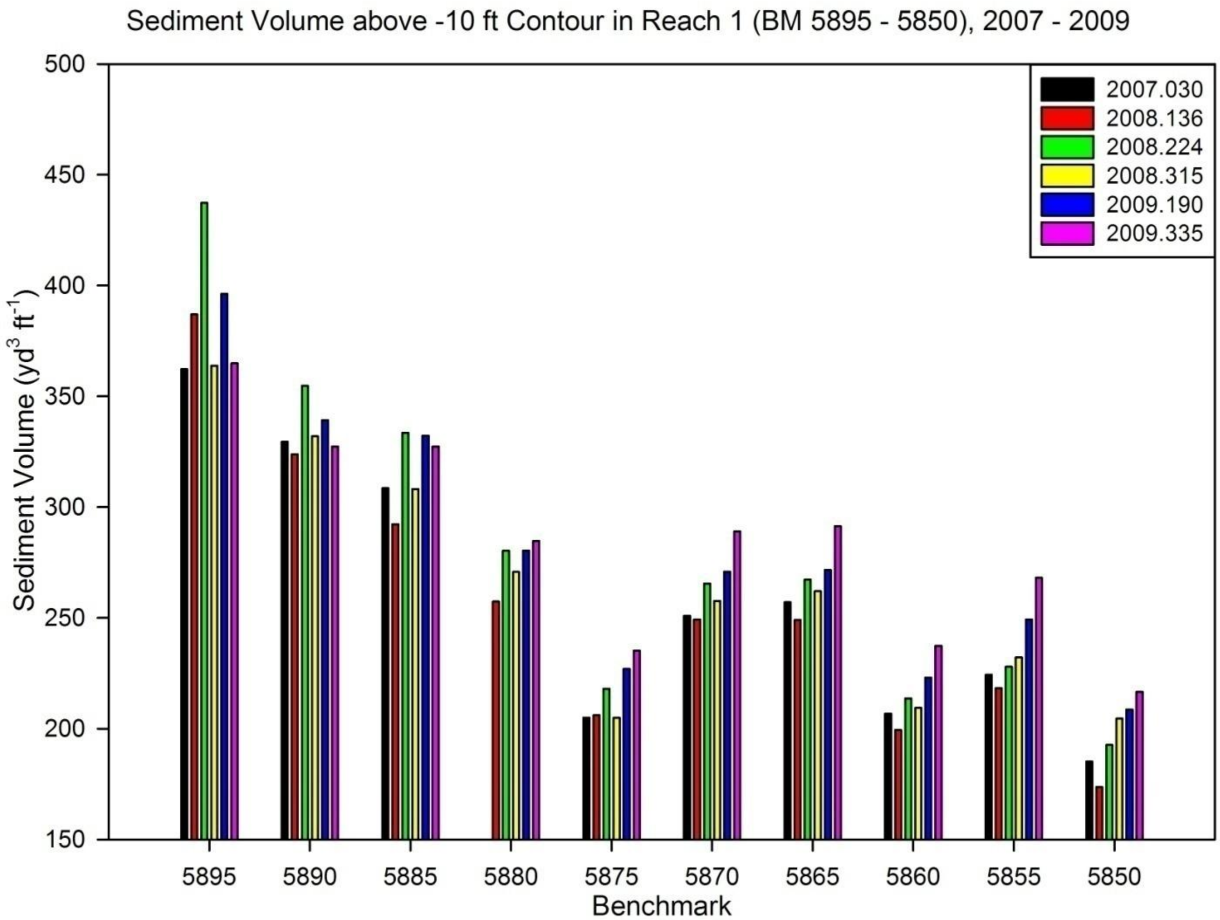

Sediment Volume above MLW (-3.0 ft) Contour in Reach 1 (BM 5895 - 5850), 2007 - 2009
Sediment Volume ($yd^3 ft^{-1}$)
160
140
120
100
80
60
40
5895
5890
5885
5880
5875
5870
5865
5860
5855
5850
Benchmark
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335


Sediment Volume above MLW (-3.0 ft) Contour in Reach 1 (BM 5845 - 5803), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd^3 ft^{-1})
160
140
120
100
80
60
40
5845
5840
5835
5830
5825
5820
5818
5815
5810
5805
5803
5800
Benchmark

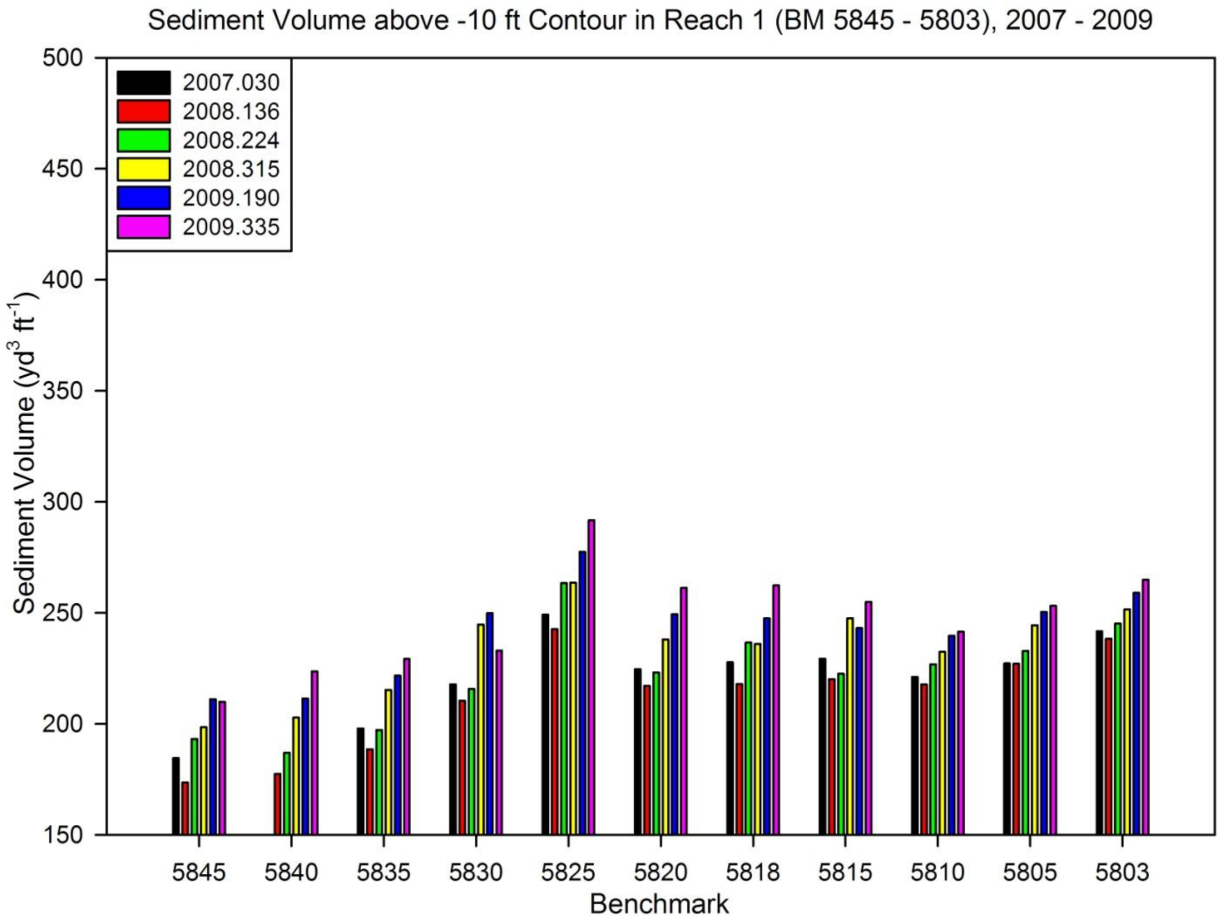


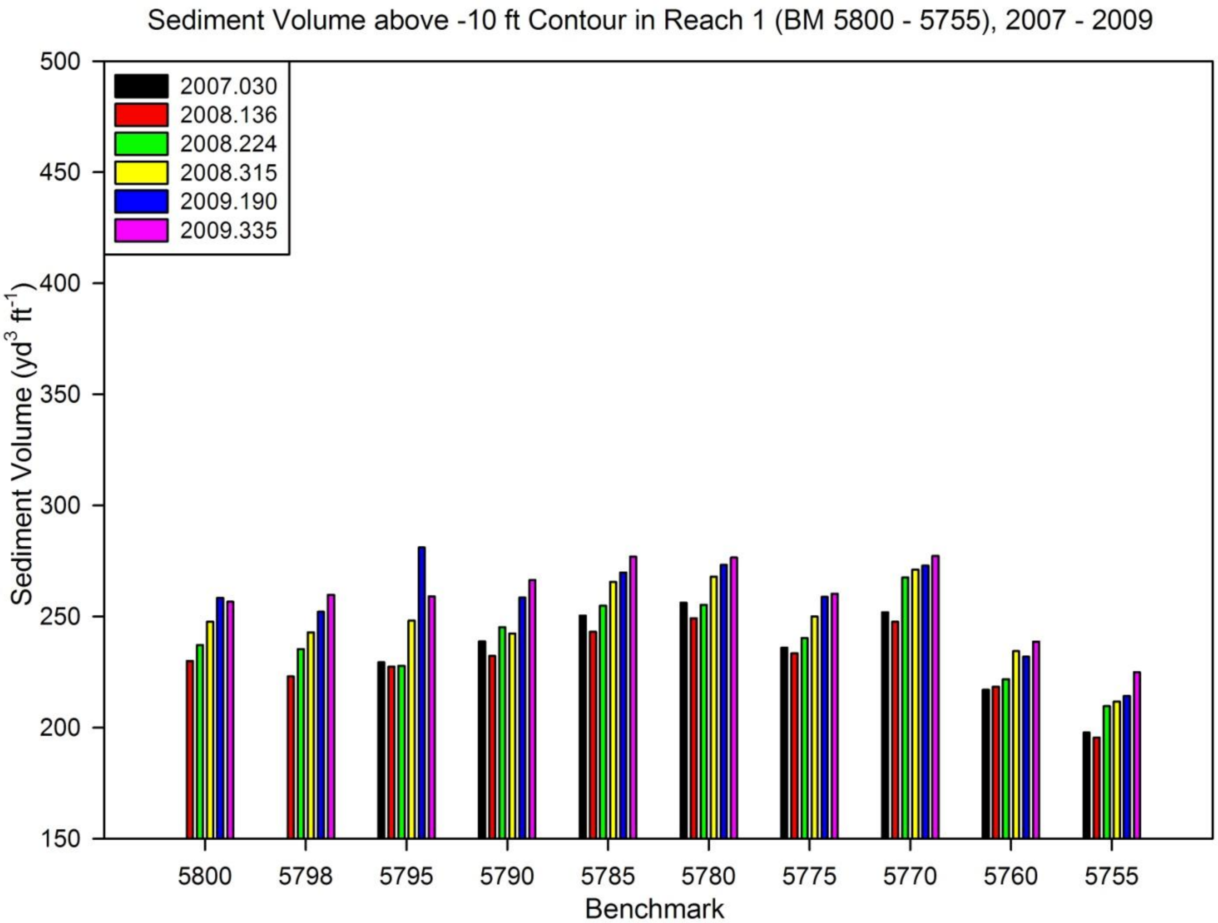
Sediment Volume above MLW (-3.0 ft) Contour in Reach 1 (BM 5800 - 5755), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd3 ft-1)
Benchmark
160
140
120
100
80
60
40
5800
5798
5795
5790
5785
5780
5775
5770
5760
5755


Sediment Volume above MLW (-3.0 ft) Contour in Reach 1 (BM 5750 - 5650), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd^3 ft^{-1})
160
140
120
100
80
60
40
5750
5745
5740
5735
5730
5725
5720
5715
5705
5700
5650
Benchmark

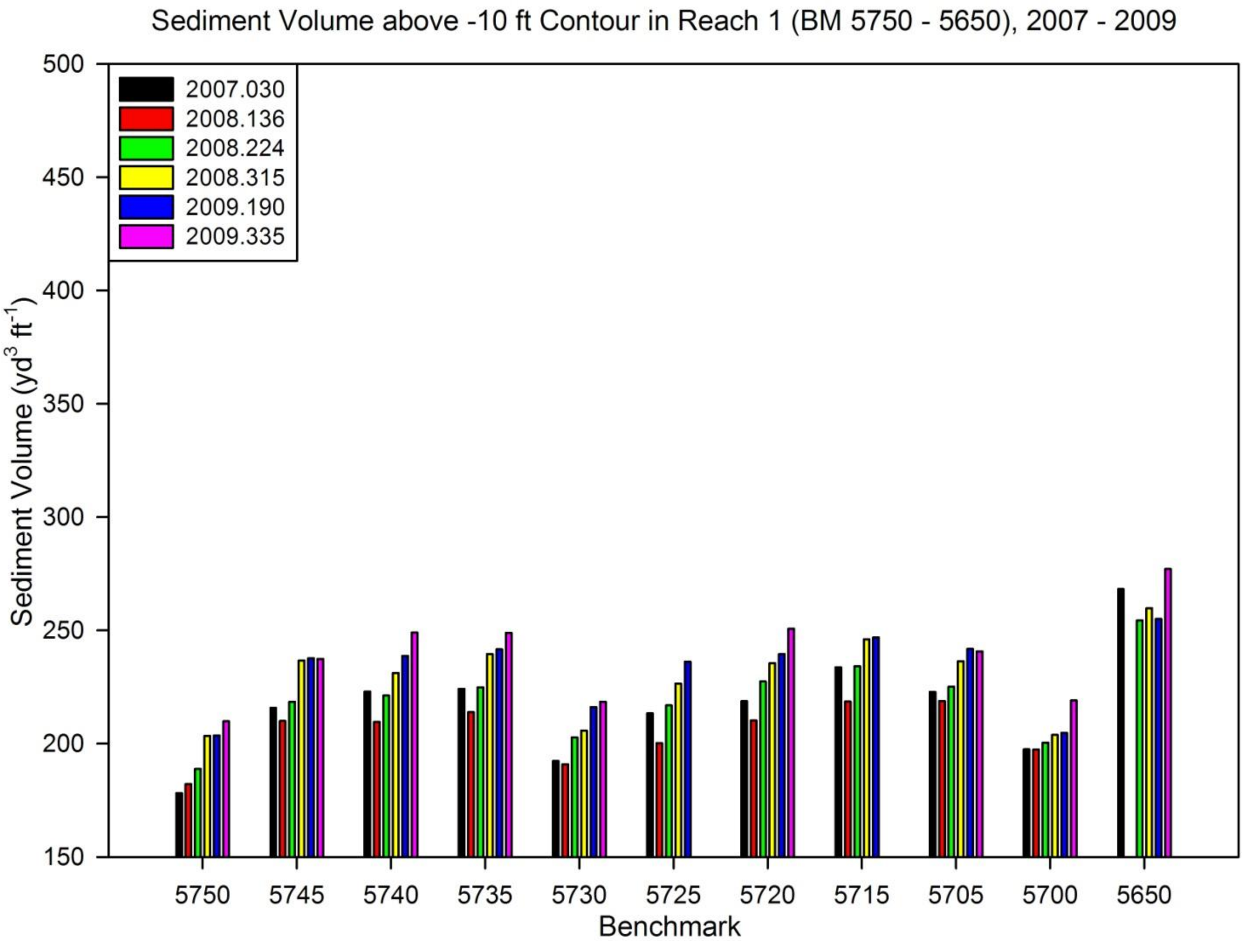


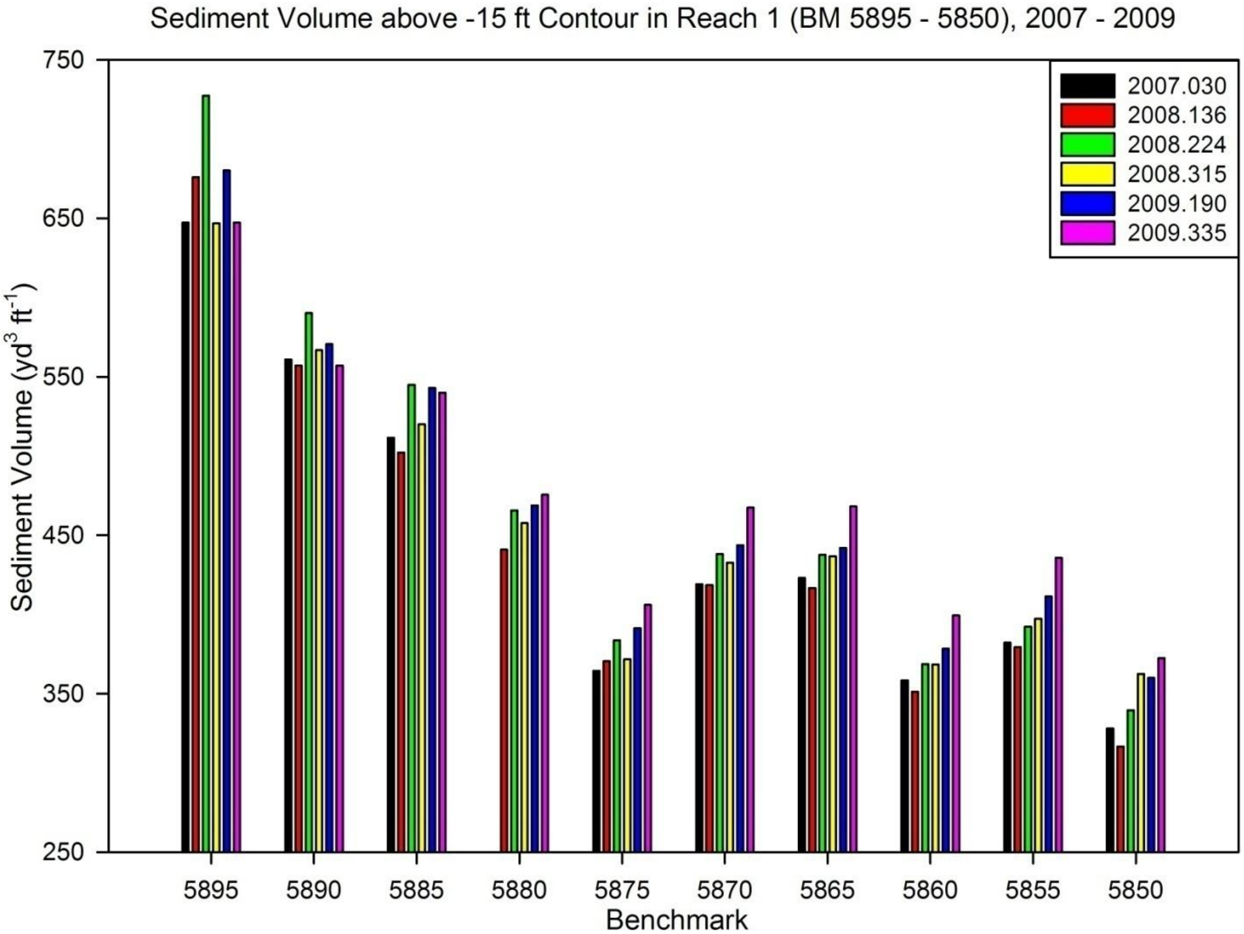
Sediment Volume above -10 ft Contour in Reach 1 (BM 5895 - 5850), 2007 - 2009
500
450
400
350
300
250
200
150
Sediment Volume (yd3 ft-1)
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
5895
5890
5885
5880
5875
5870
5865
5860
5855
5850
Benchmark


Sediment Volume above -10 ft Contour in Reach 1 (BM 5845 - 5803), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume ($yd^3\ ft^{-1}$)
500
450
400
350
300
250
200
150
5845
5840
5835
5830
5825
5820
5818
5815
5810
5805
5803
Benchmark

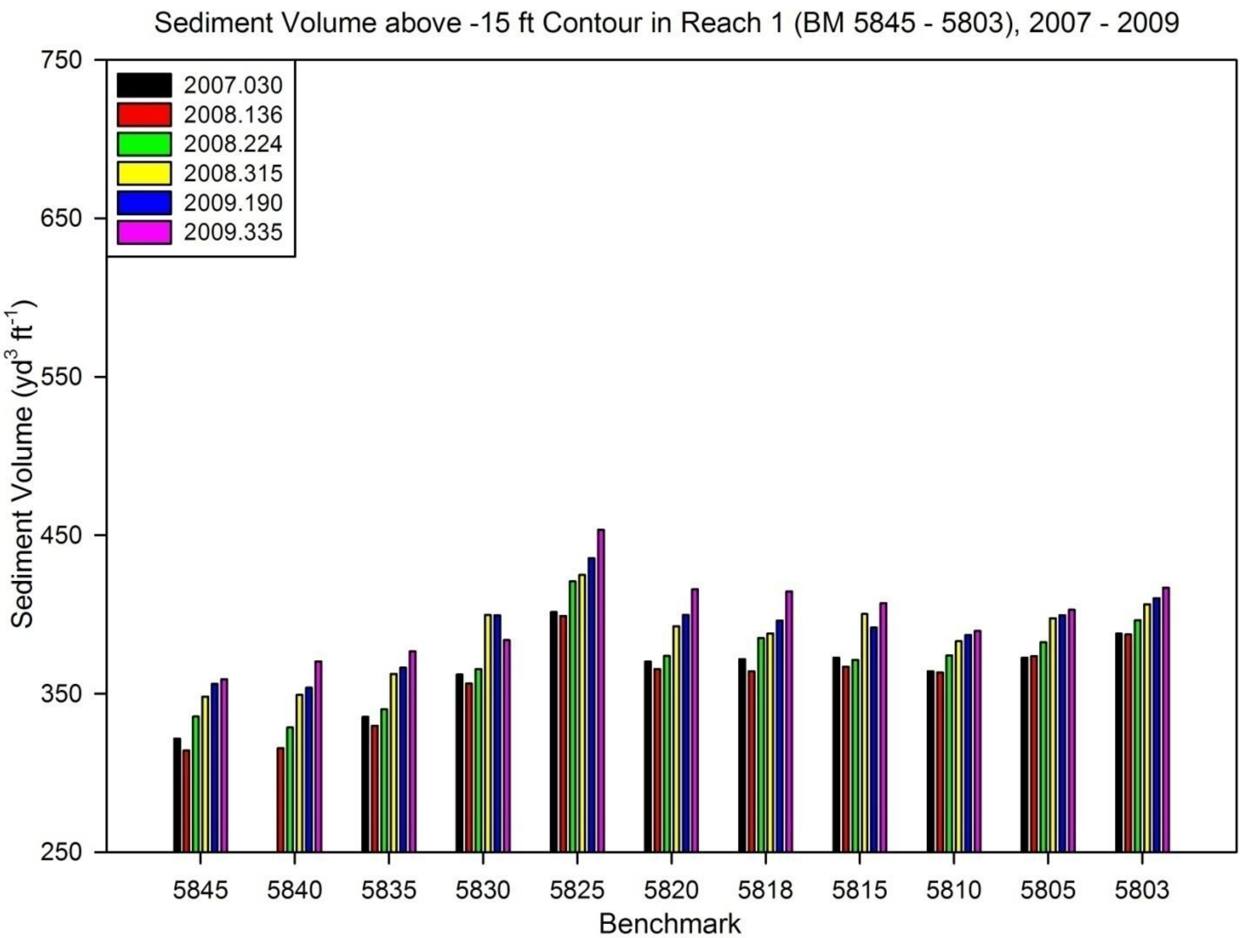


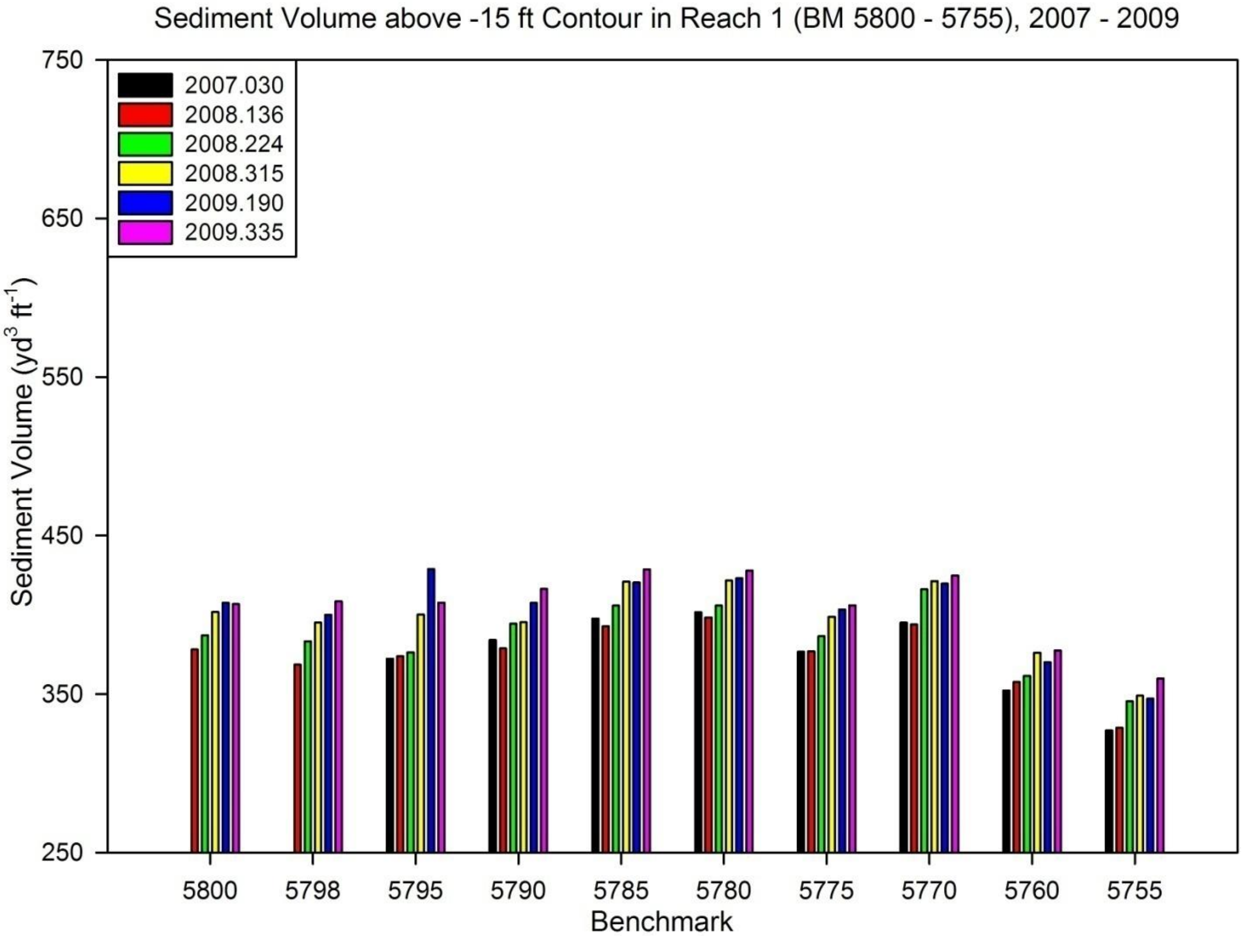
Sediment Volume above -10 ft Contour in Reach 1 (BM 5800 - 5755), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd^3 ft^{-1})
500
450
400
350
300
250
200
150
5800
5798
5795
5790
5785
5780
5775
5770
5760
5755
Benchmark

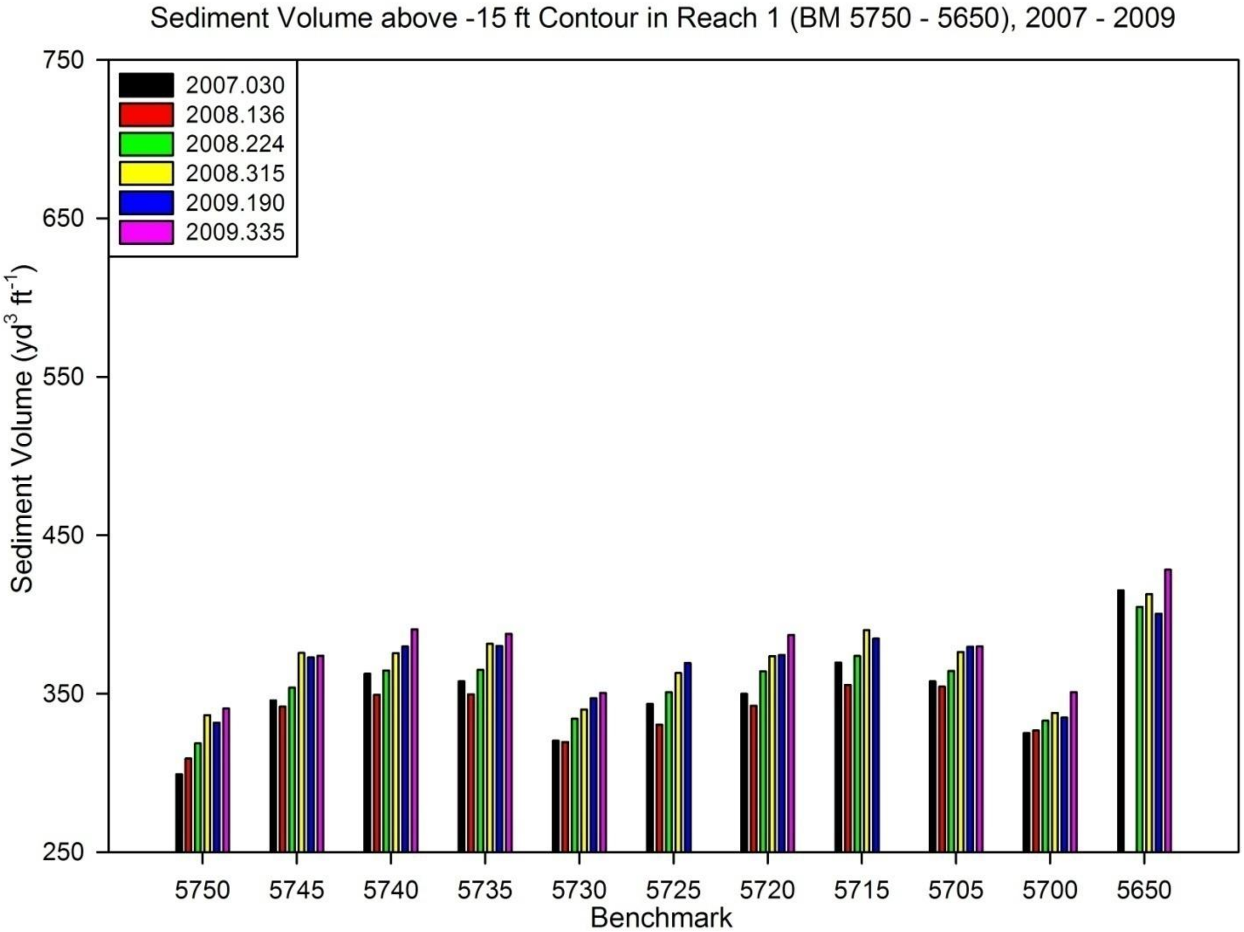

Sediment Volume above -10 ft Contour in Reach 1 (BM 5750 - 5650), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd3 ft-1)
500
450
400
350
300
250
200
150
5750
5745
5740
5735
5730
5725
5720
5715
5705
5700
5650
Benchmark



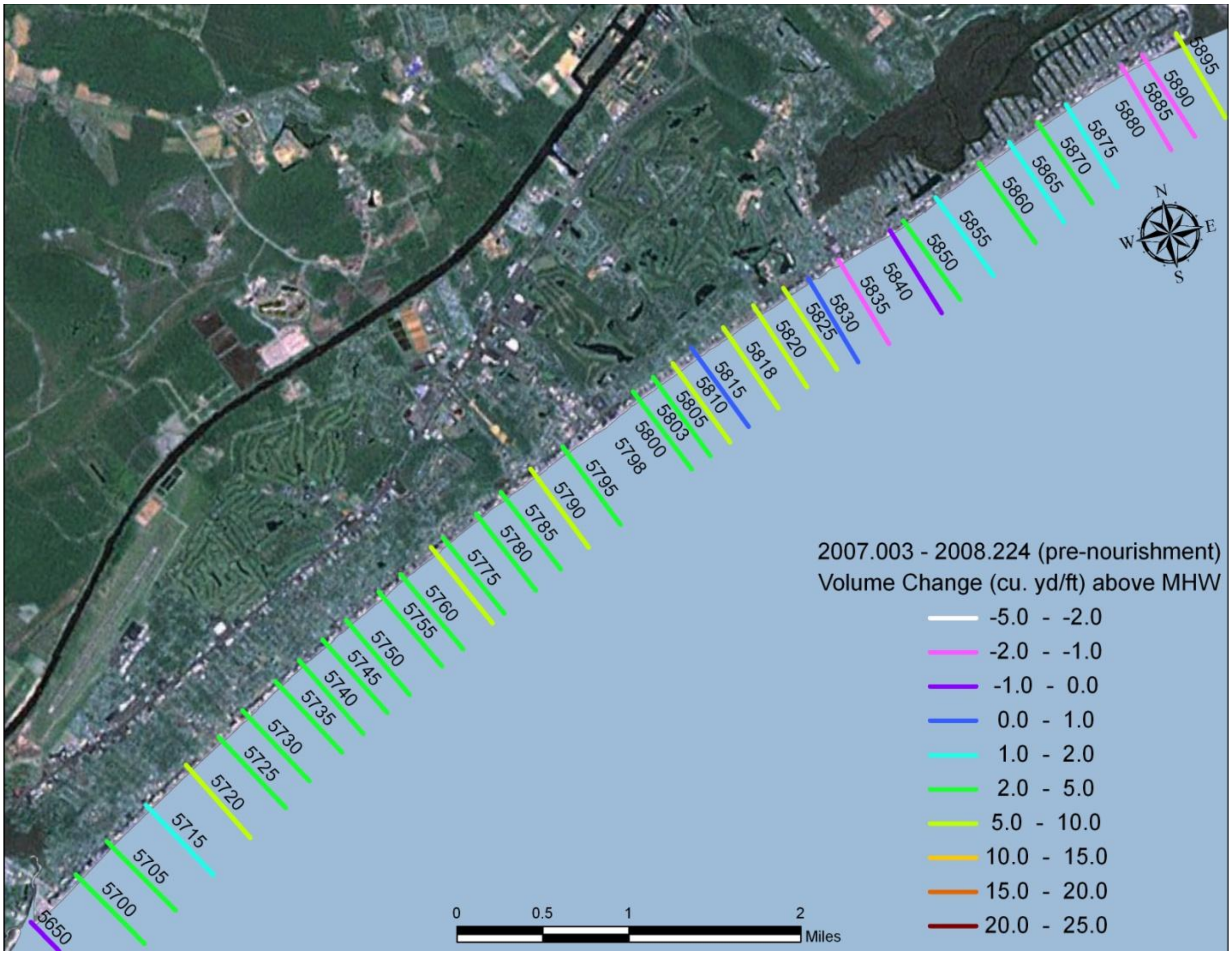
Sediment Volume above -15 ft Contour in Reach 1 (BM 5895 - 5850), 2007 - 2009
Sediment Volume (yd^3 ft^{-1})
750
650
550
450
350
250
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
5895
5890
5885
5880
5875
5870
5865
5860
5855
5850
Benchmark

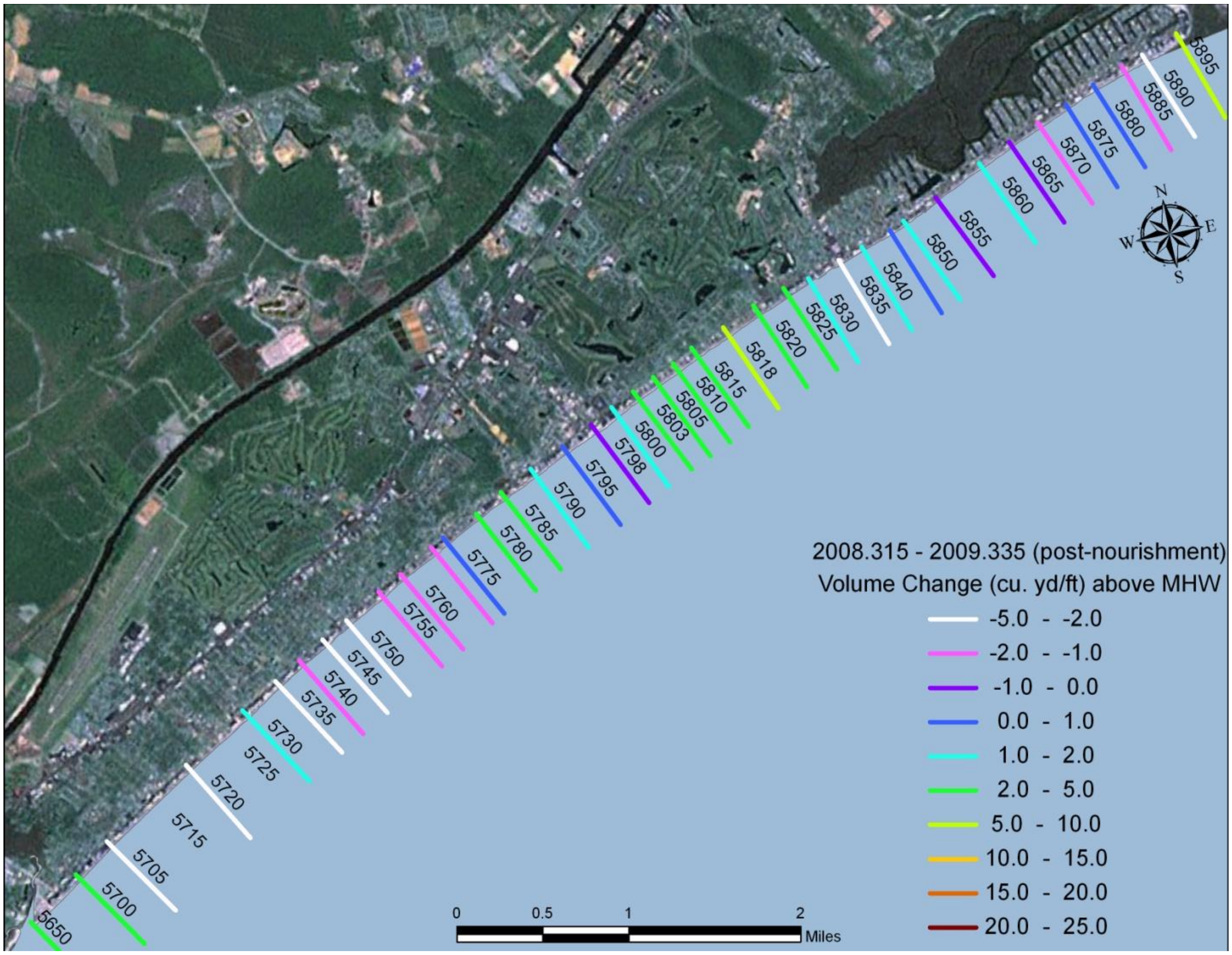

Sediment Volume above -15 ft Contour in Reach 1 (BM 5845 - 5803), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
750
650
550
450
350
250
Sediment Volume (yd3 ft-1)
5845
5840
5835
5830
5825
5820
5818
5815
5810
5805
5803
Benchmark


Sediment Volume above -15 ft Contour in Reach 1 (BM 5800 - 5755), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd^3 ft^{-1})
750
650
550
450
350
250
5800
5798
5795
5790
5785
5780
5775
5770
5760
5755
Benchmark

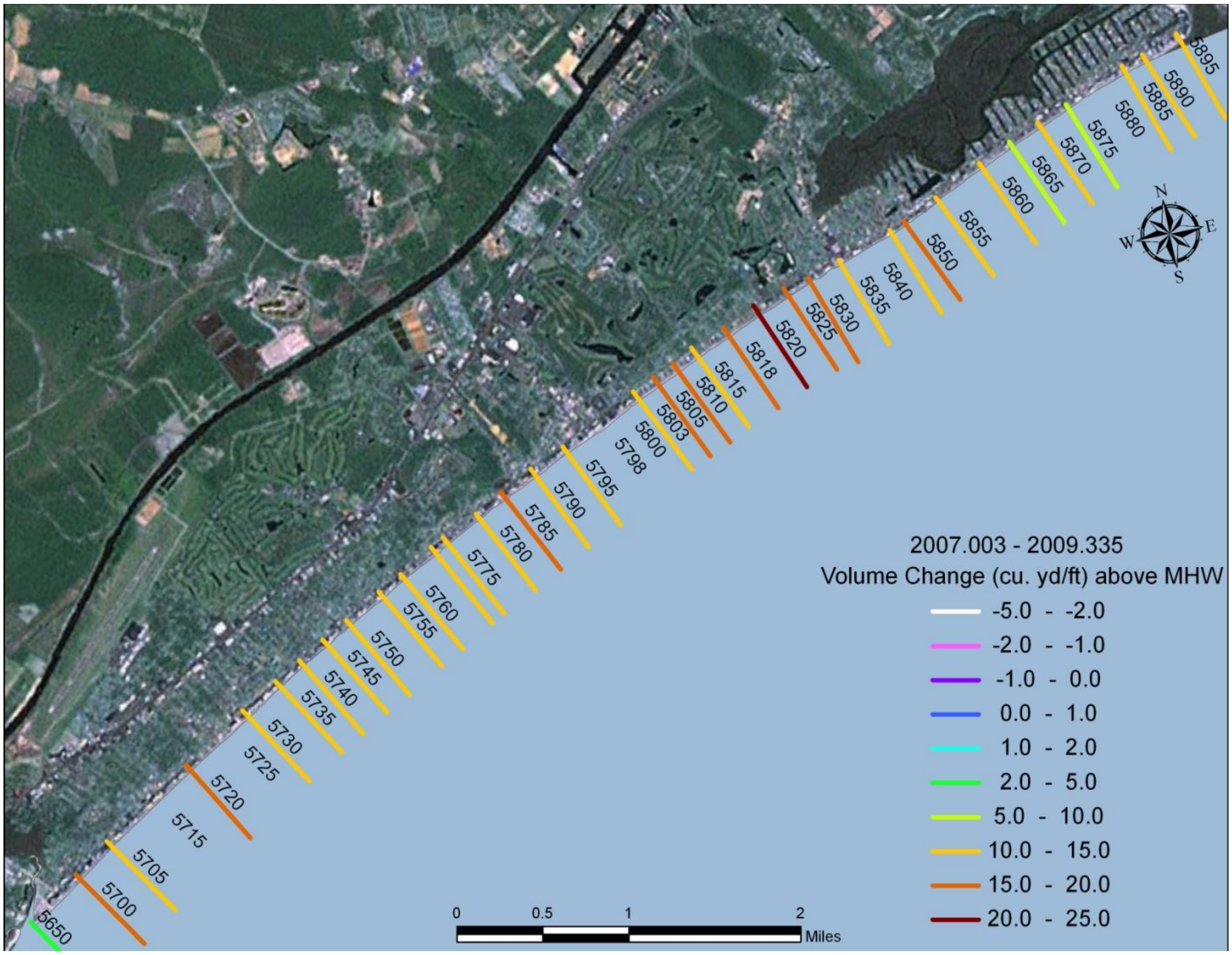

Sediment Volume above -15 ft Contour in Reach 1 (BM 5750 - 5650), 2007 - 2009
2007.030
2008.136
2008.224
2008.315
2009.190
2009.335
Sediment Volume (yd^3 ft^{-1})
750
650
550
450
350
250
5750
5745
5740
5735
5730
5725
5720
5715
5705
5700
5650
Benchmark

Appendix 3: Reach 1 Beach Profile Volume Change Map View

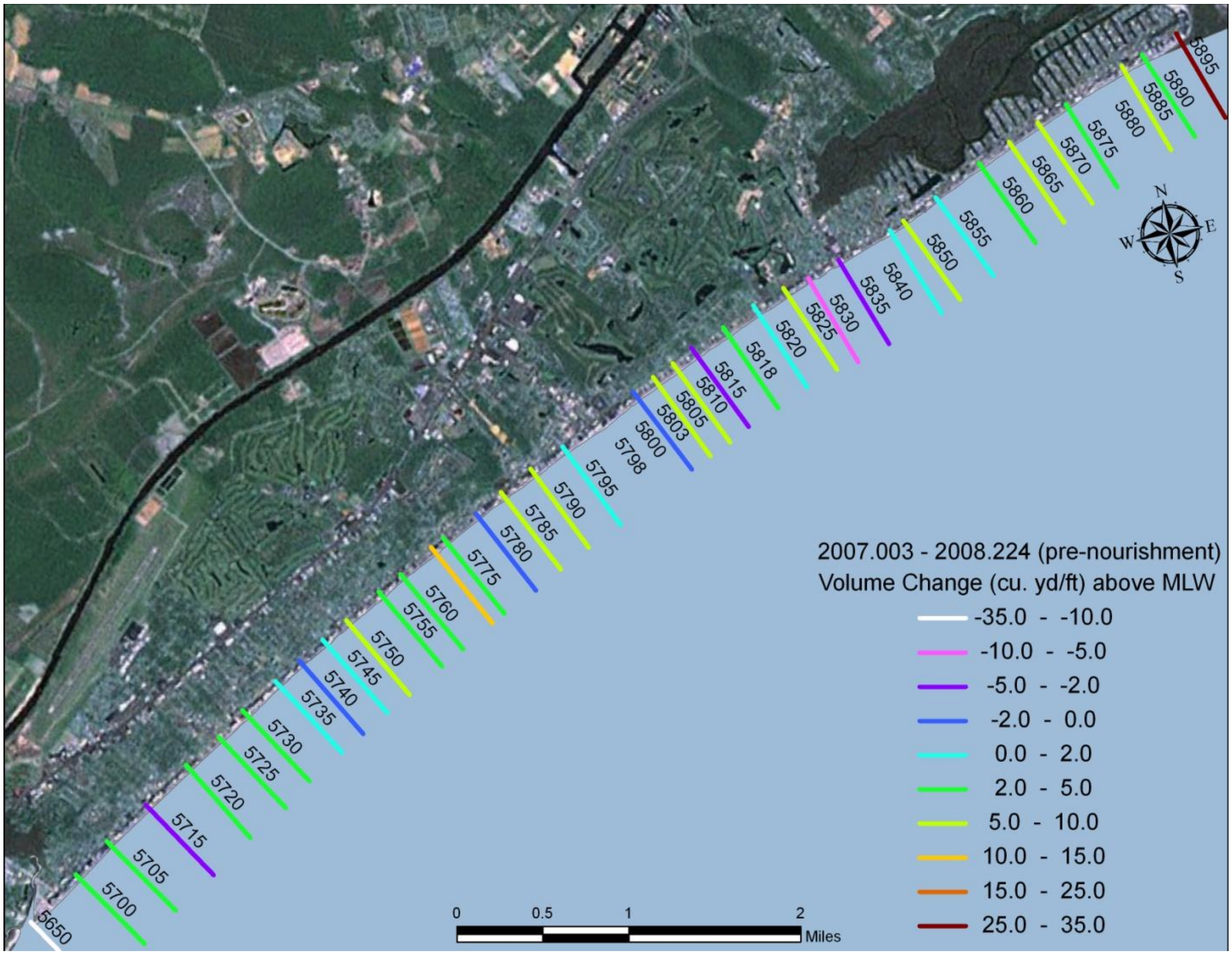

2007.003 - 2008.224 (pre-nourishment)
Volume Change (cu. yd/ft) above MHW
-5.0 - -2.0
-2.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
0 0.5 1 2 Miles
N E S W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895

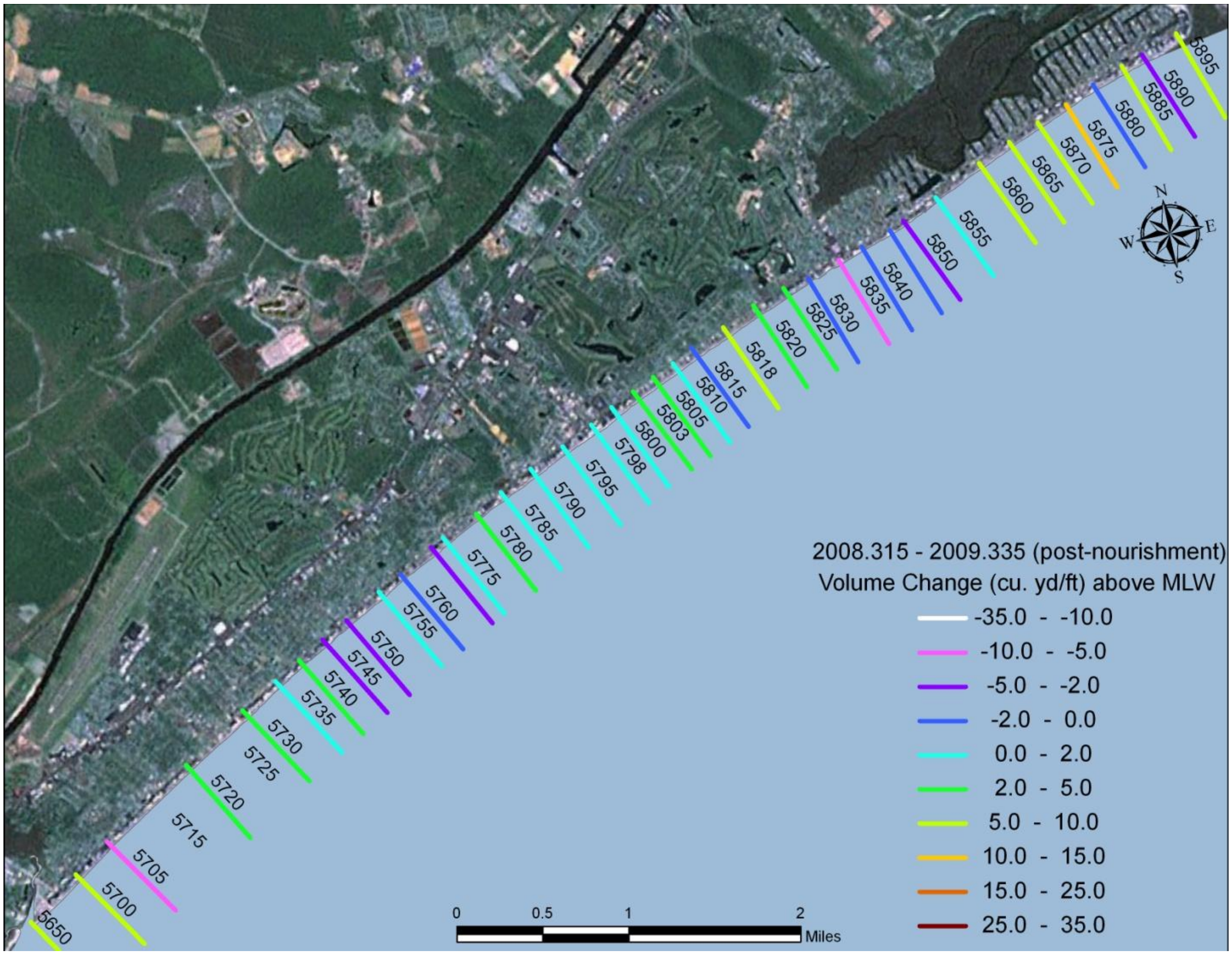


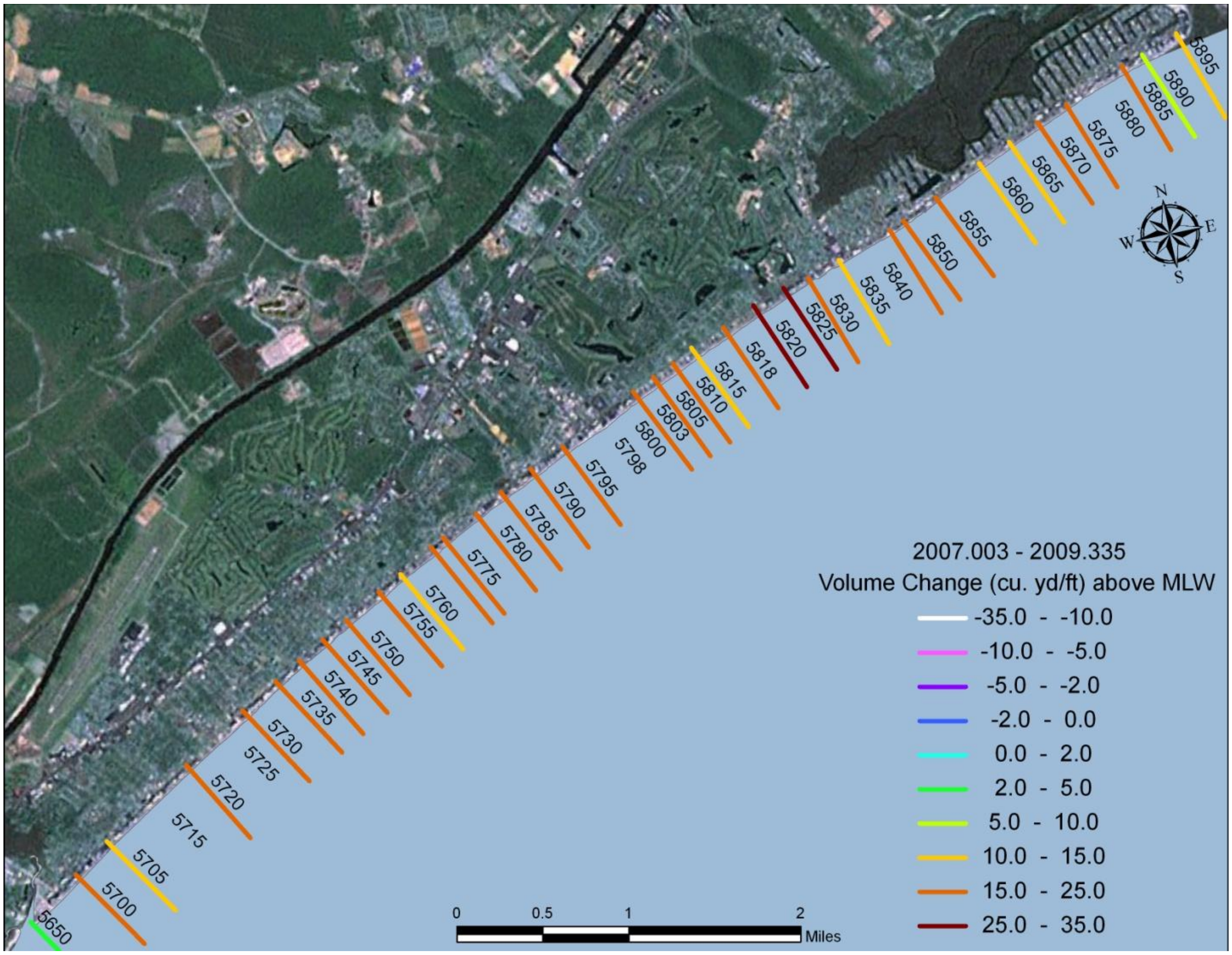
2008.315 - 2009.335 (post-nourishment)
Volume Change (cu. yd/ft) above MHW
-5.0 - -2.0
-2.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895

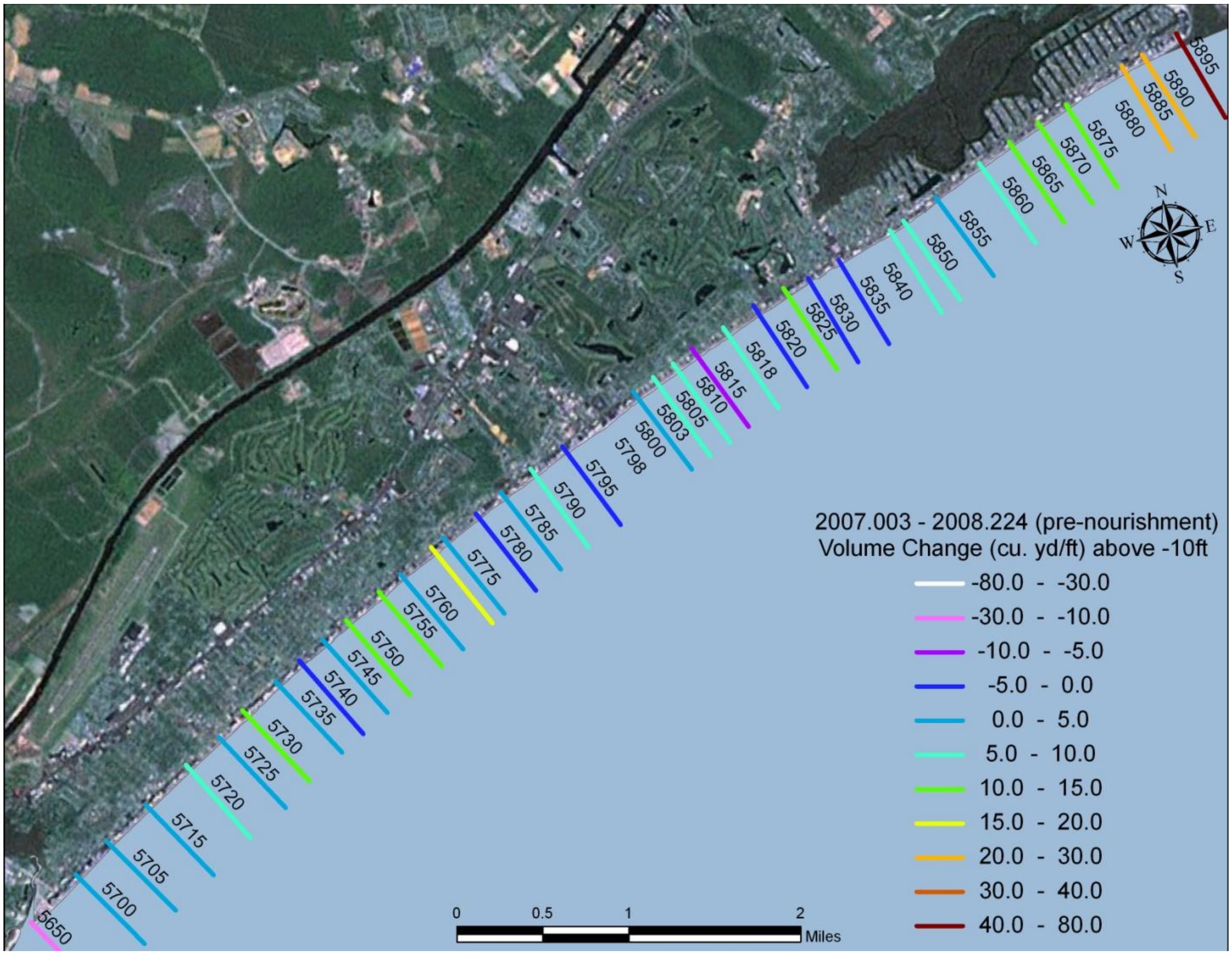


2007.003 - 2009.335
Volume Change (cu. yd/ft) above MHW
-5.0 - -2.0
-2.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895


2007.003 - 2008.224 (pre-nourishment)
Volume Change (cu. yd/ft) above MLW
-35.0 - -10.0
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 25.0
25.0 - 35.0
0
0.5
1
2
Miles
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895
N
E
S
W


2008.315 - 2009.335 (post-nourishment)
Volume Change (cu. yd/ft) above MLW
-35.0 - -10.0
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 25.0
25.0 - 35.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895


2007.003 - 2009.335
Volume Change (cu. yd/ft) above MLW
-35.0 - -10.0
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 25.0
25.0 - 35.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895



2007.003 - 2008.224 (pre-nourishment)
Volume Change (cu. yd/ft) above -10ft
-80.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 80.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
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5825
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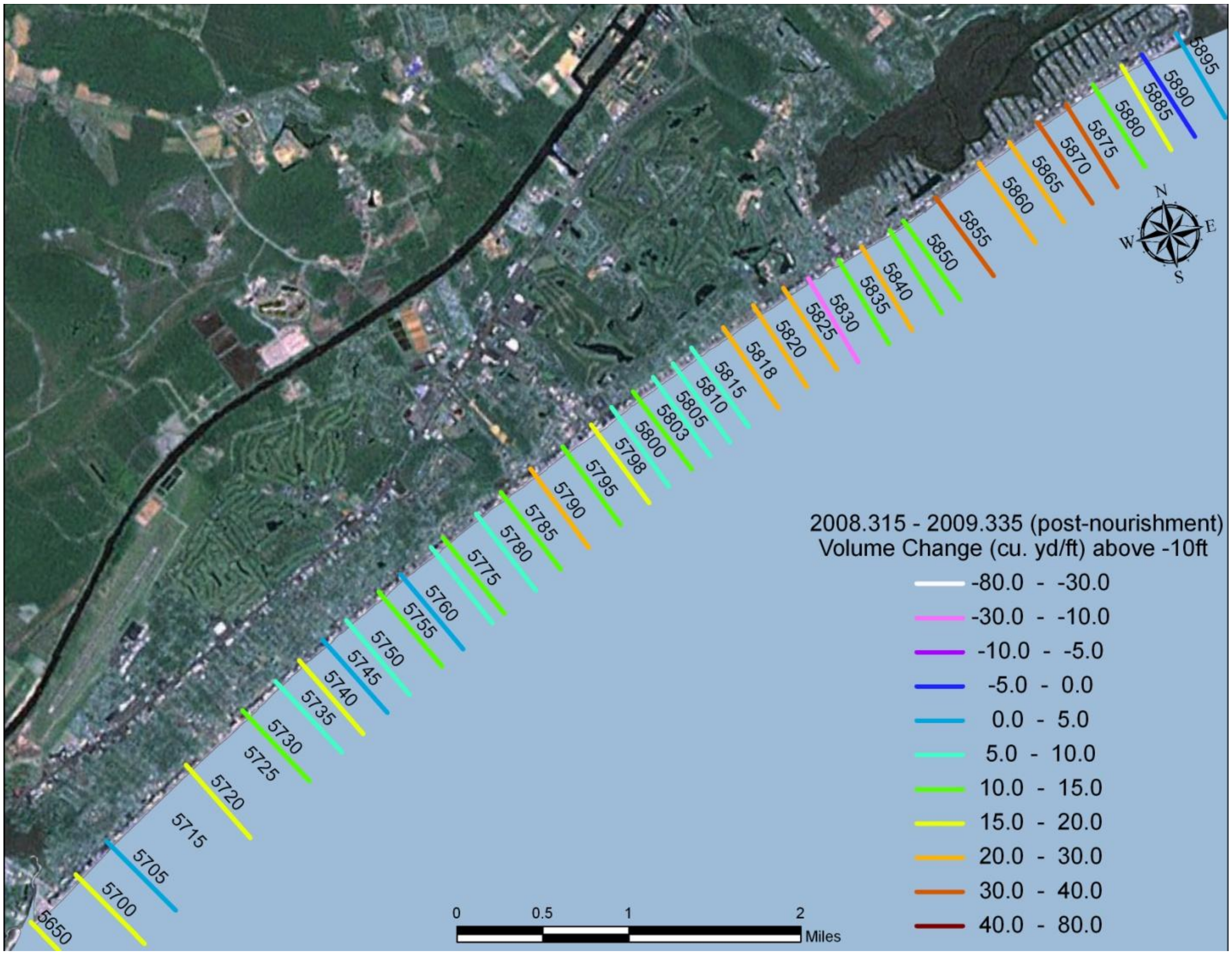
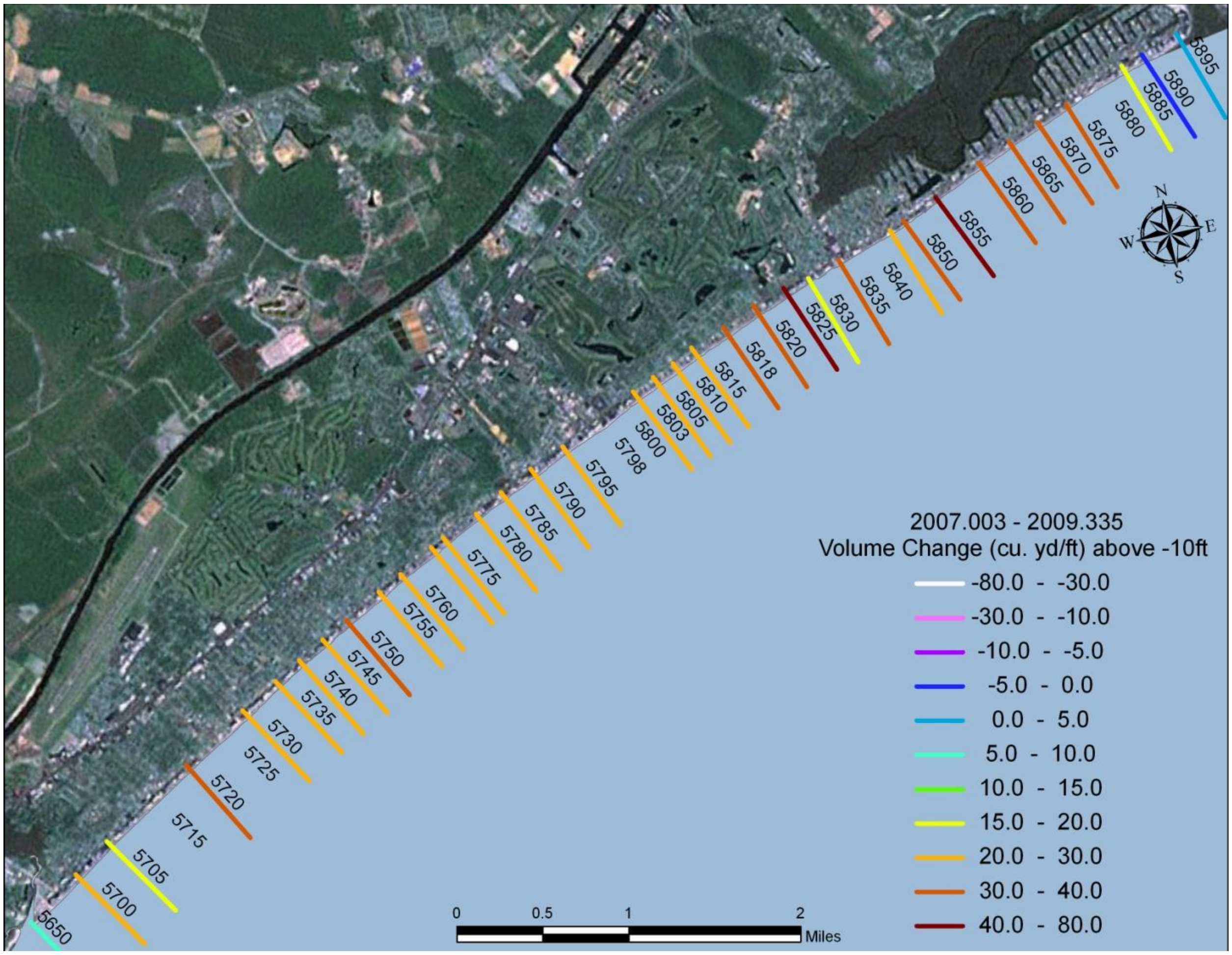
5880
5885
5890
5895



2008.315 - 2009.335 (post-nourishment)
Volume Change (cu. yd/ft) above -10ft
-80.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 80.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895


2007.003 - 2009.335
Volume Change (cu. yd/ft) above -10ft
-80.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 80.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
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5855
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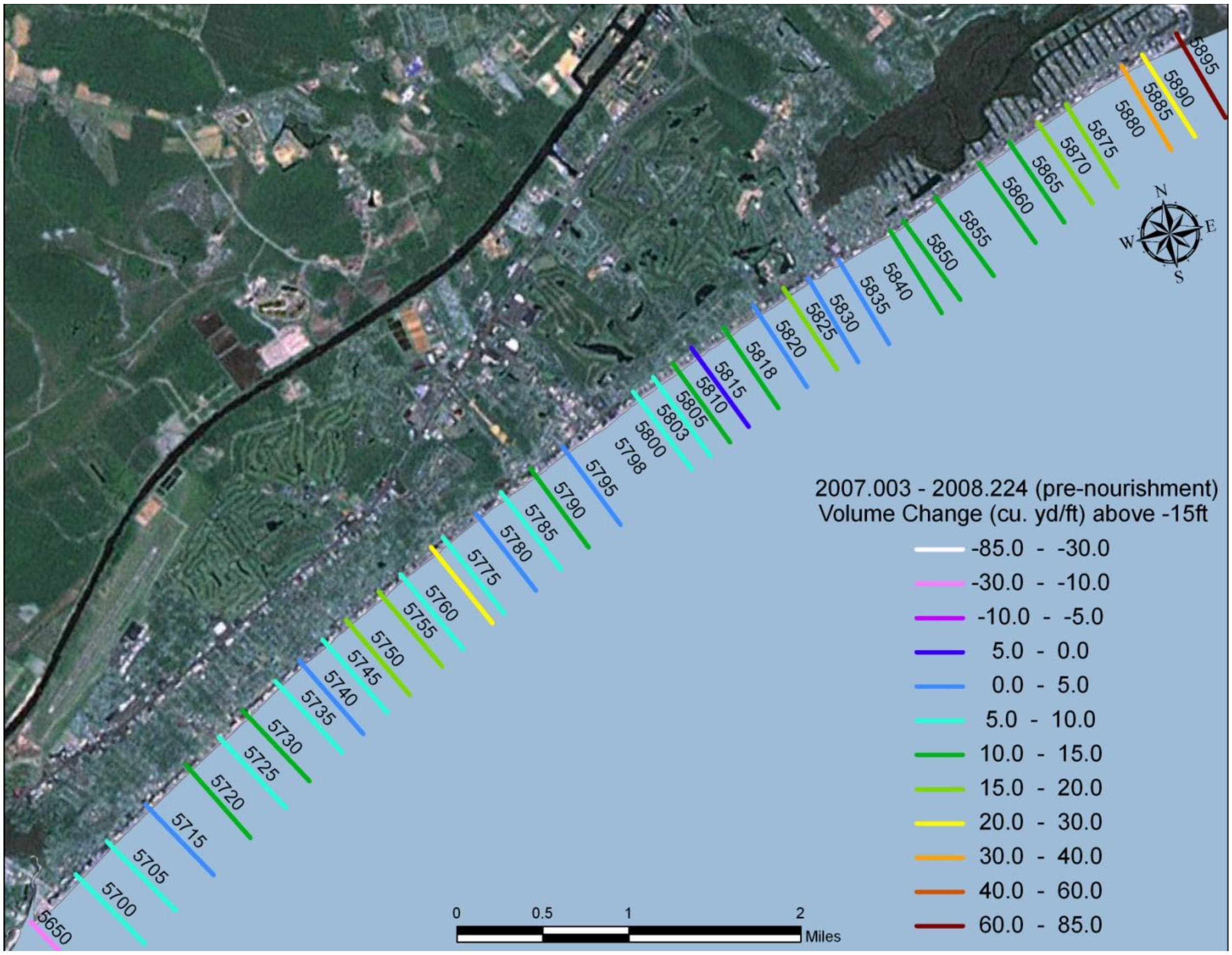
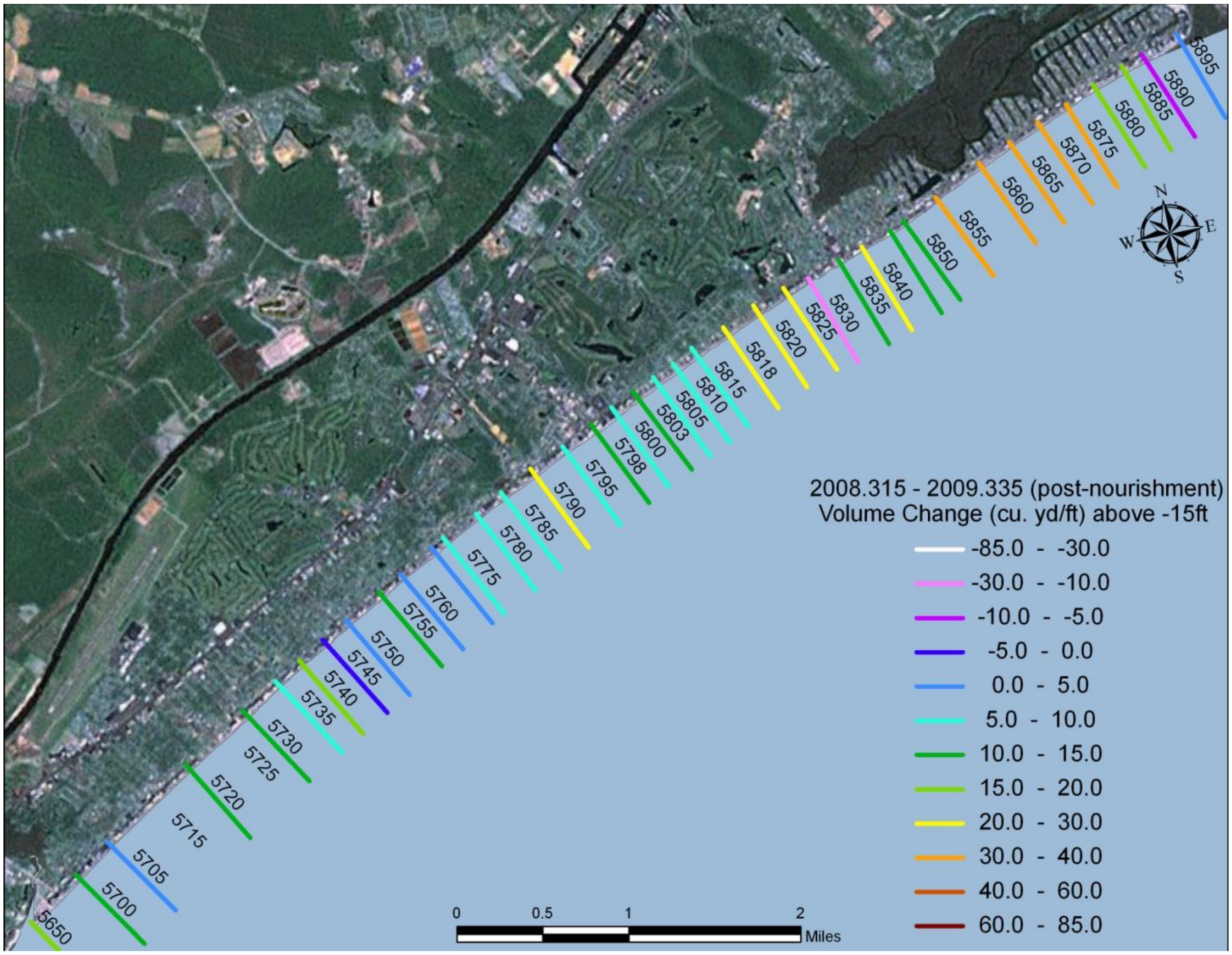
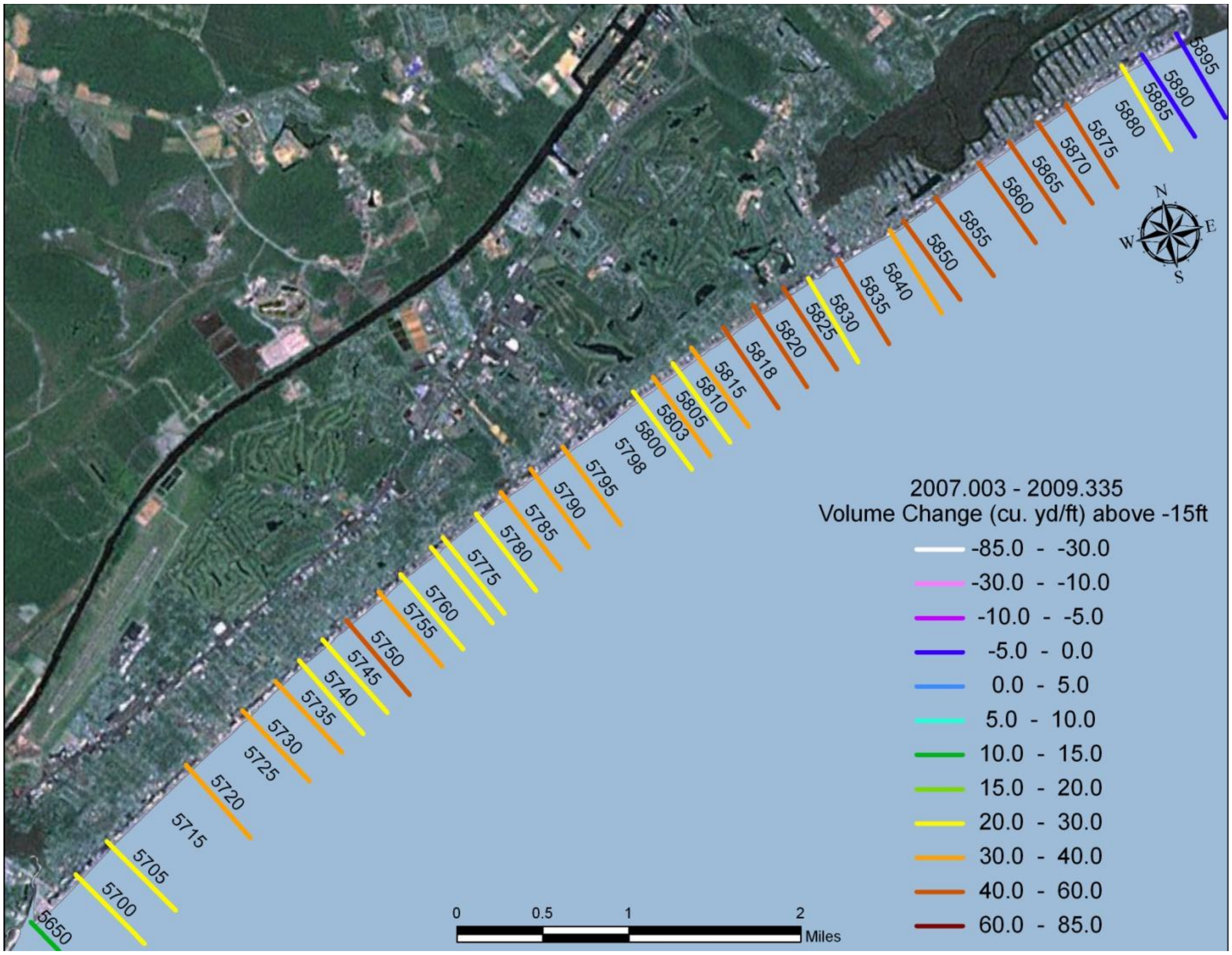
5880
5885
5890
5895


2007.003 - 2008.224 (pre-nourishment)
Volume Change (cu. yd/ft) above -15ft
-85.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 60.0
60.0 - 85.0
0 0.5 1 2 Miles
N E S W
5650 5700 5705 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5775 5780 5785 5790 5795 5798 5800 5803 5805 5810 5815 5818 5820 5825 5830 5835 5840 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895


2008.315 - 2009.335 (post-nourishment)
Volume Change (cu. yd/ft) above -15ft
-85.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 60.0
60.0 - 85.0
0
0.5
1
2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
5790
5795
5798
5800
5803
5805
5810
5815
5818
5820
5825
5830
5835
5840
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895


2007.003 - 2009.335
Volume Change (cu. yd/ft) above -15ft
-85.0 - -30.0
-30.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 60.0
60.0 - 85.0
0 0.5 1 2
Miles
N
E
S
W
5650
5700
5705
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5775
5780
5785
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5798
5800
5803
5805
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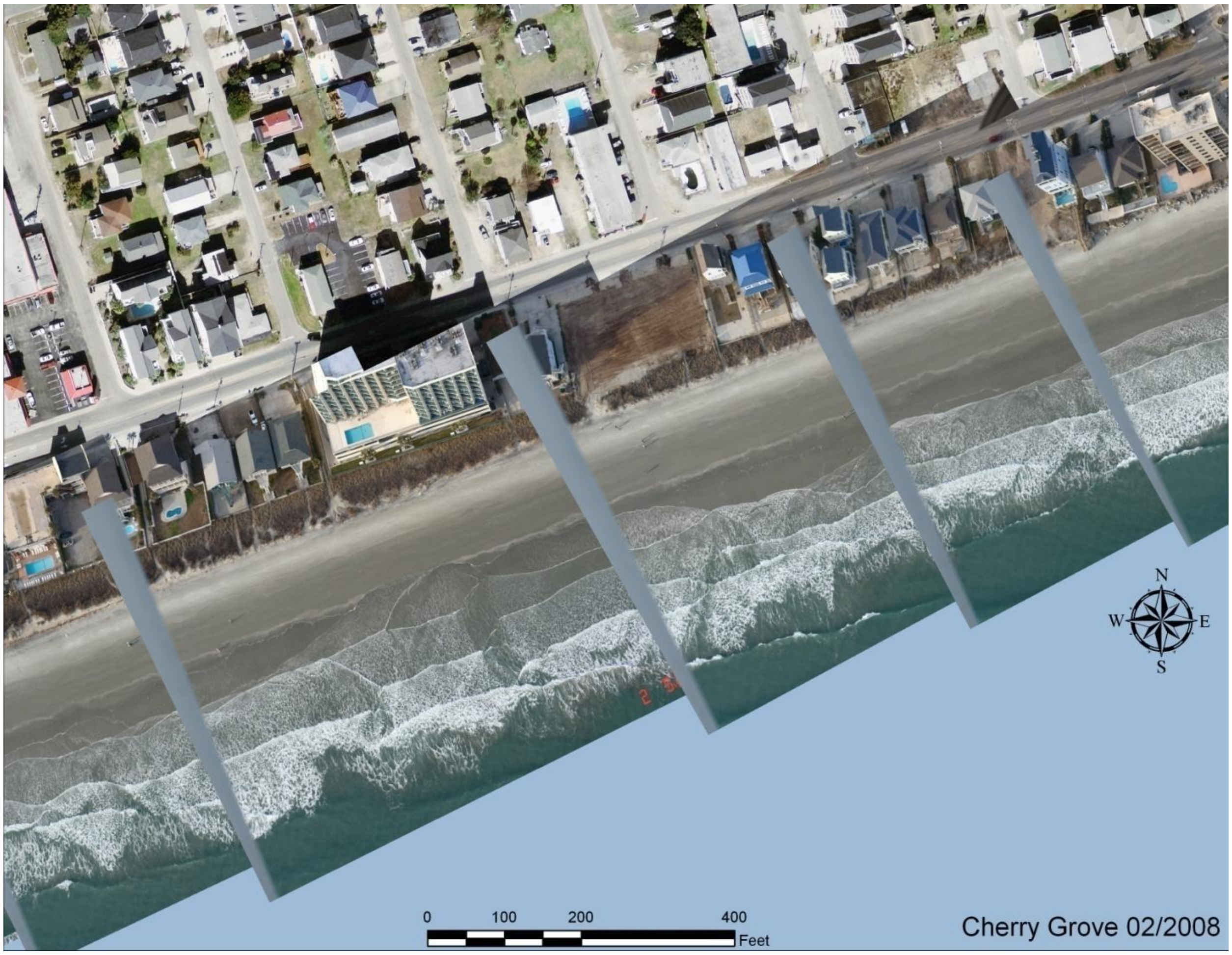
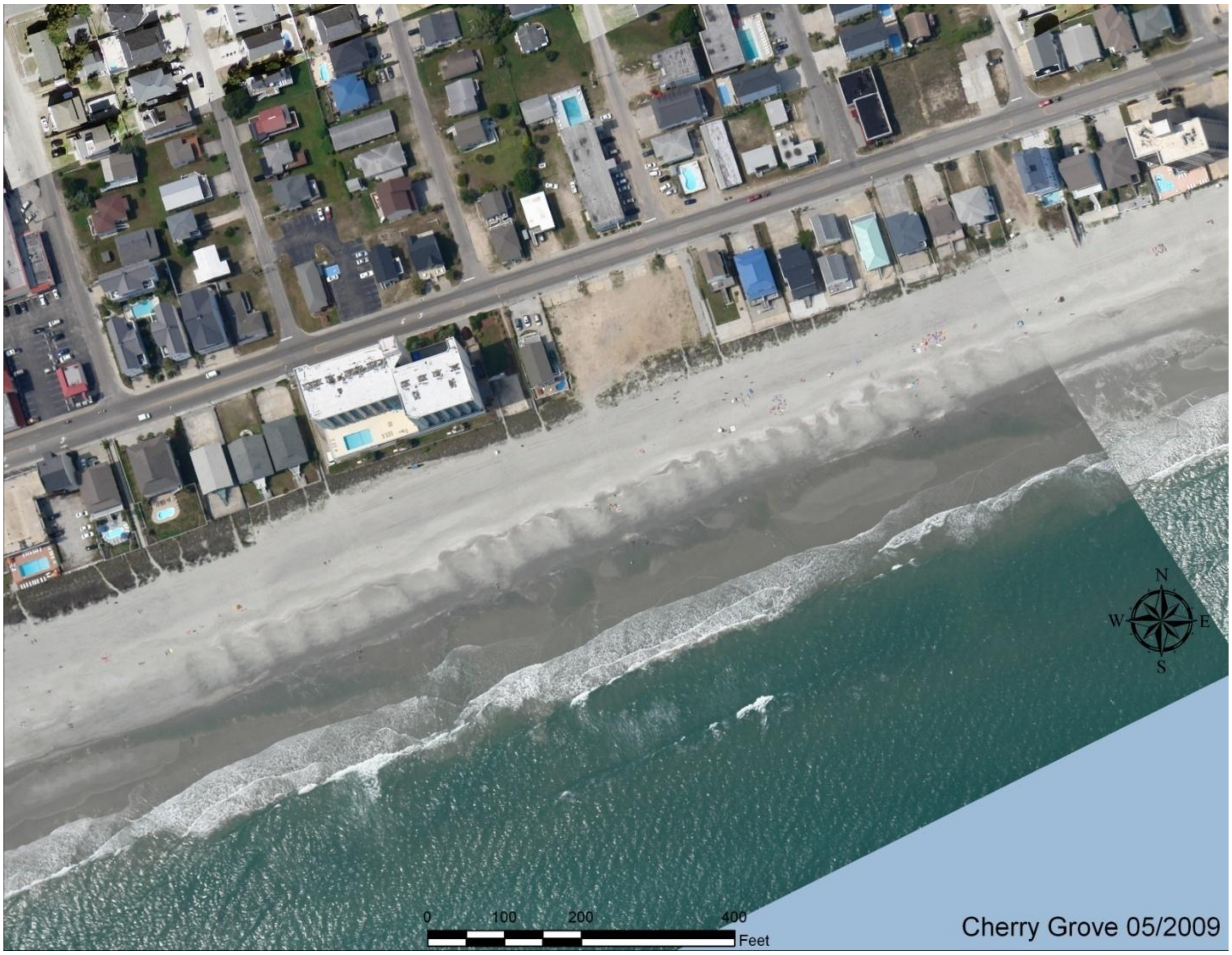
5855
5860
5865
5870
5875
5880
5885
5890
5895

Appendix 4: Reach 1 Time-Series Aerial Photography


N
W
E
S
0
100
200
400
Feet
Cherry Grove 02/2008


N
W
E
S
0
100
200
400
Feet
Cherry Grove 11/2008

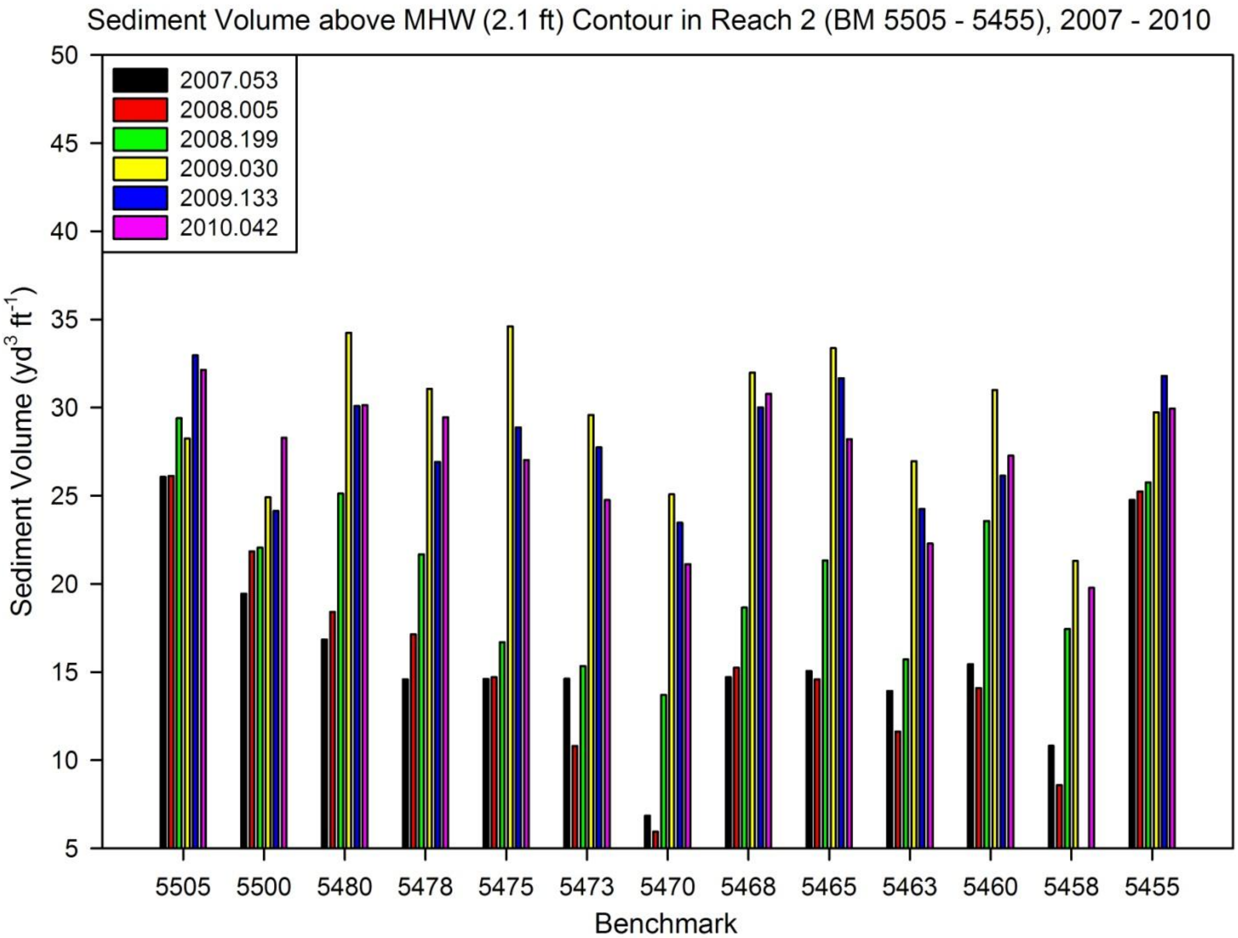

N
W
E
S
0
100
200
400
Feet
Cherry Grove 02/2009

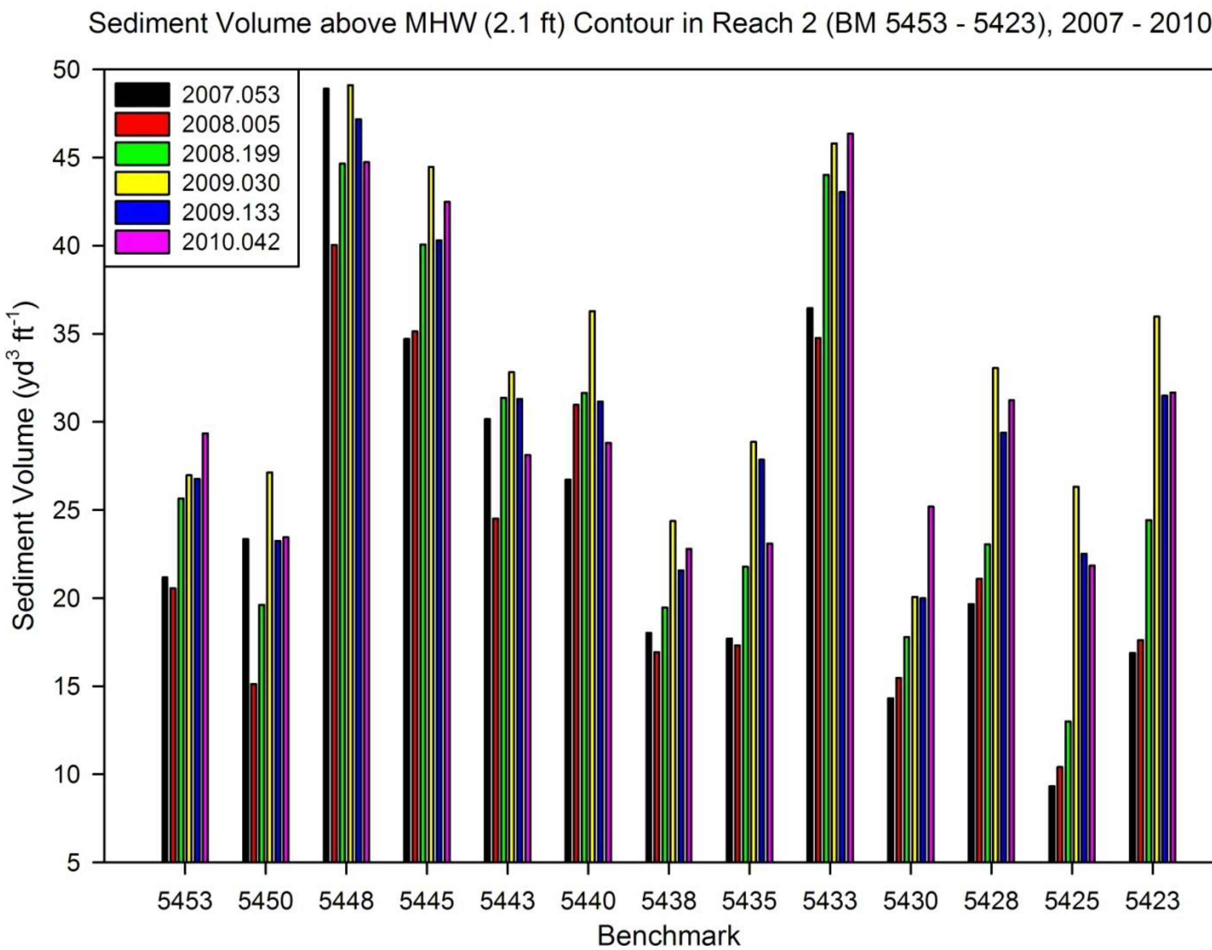


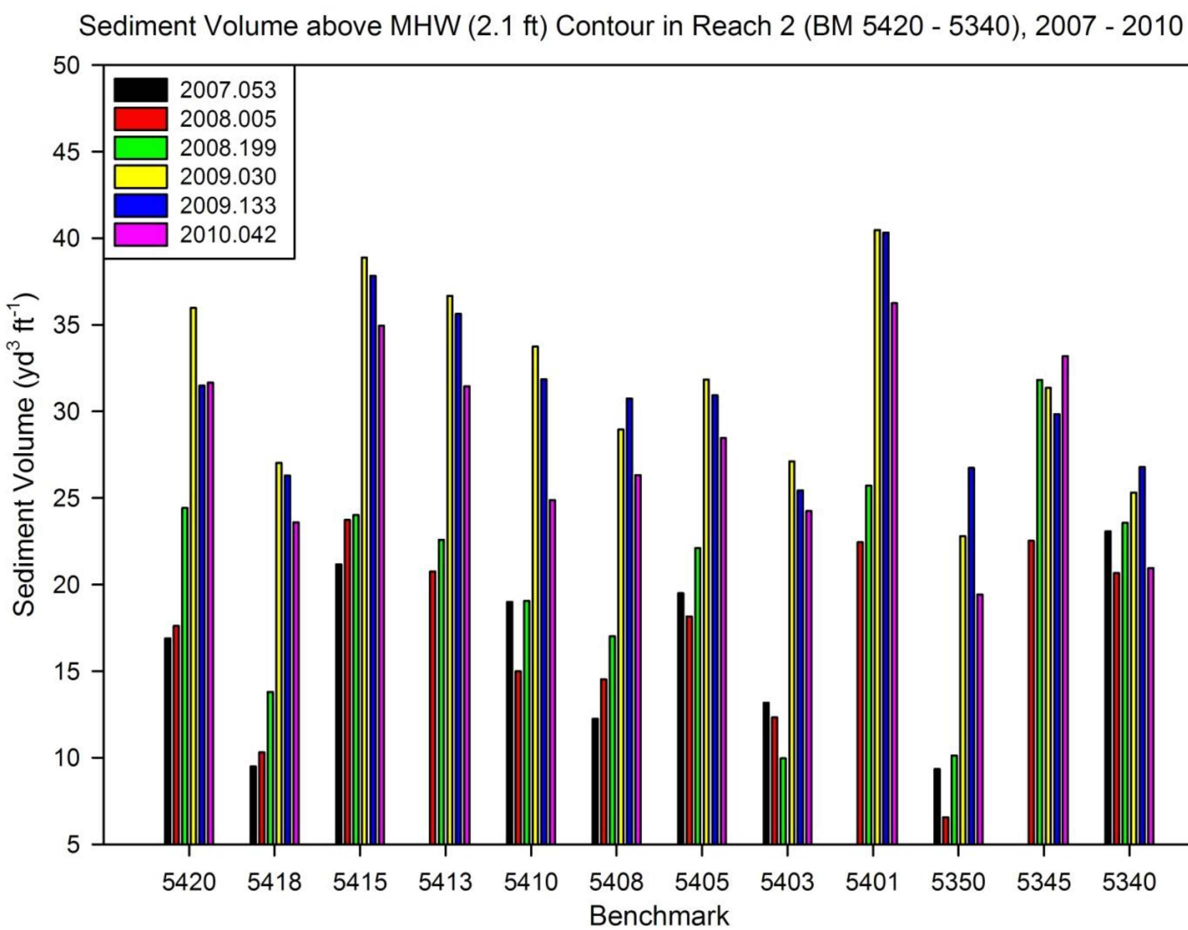
N
W
E
S
0
100
200
400
Feet
Cherry Grove 05/2009

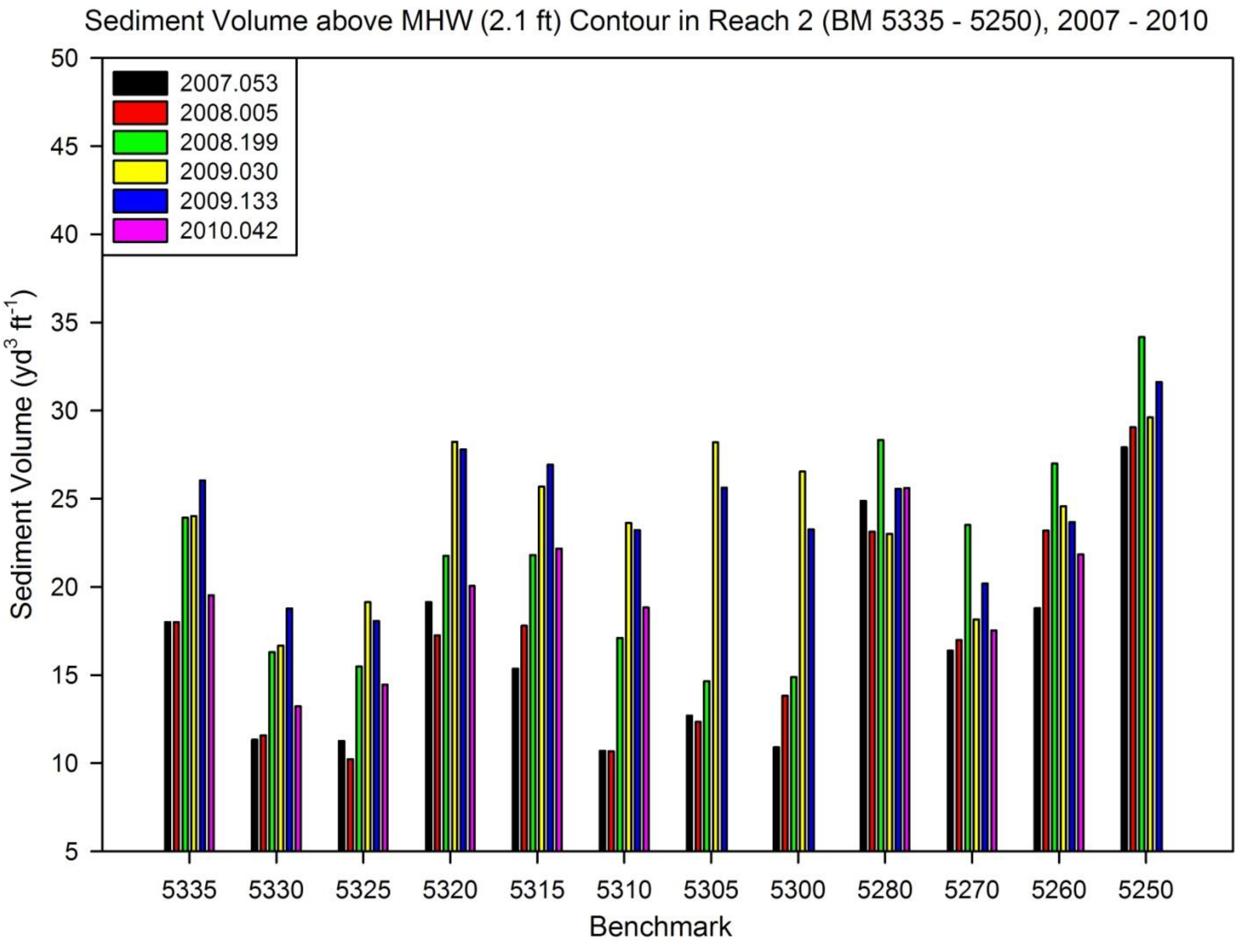

N
W
E
S
0
100
200
400
Feet
Cherry Grove 08/2009

Appendix 5: Reach 2 Beach Profile Volume Bar Graphs

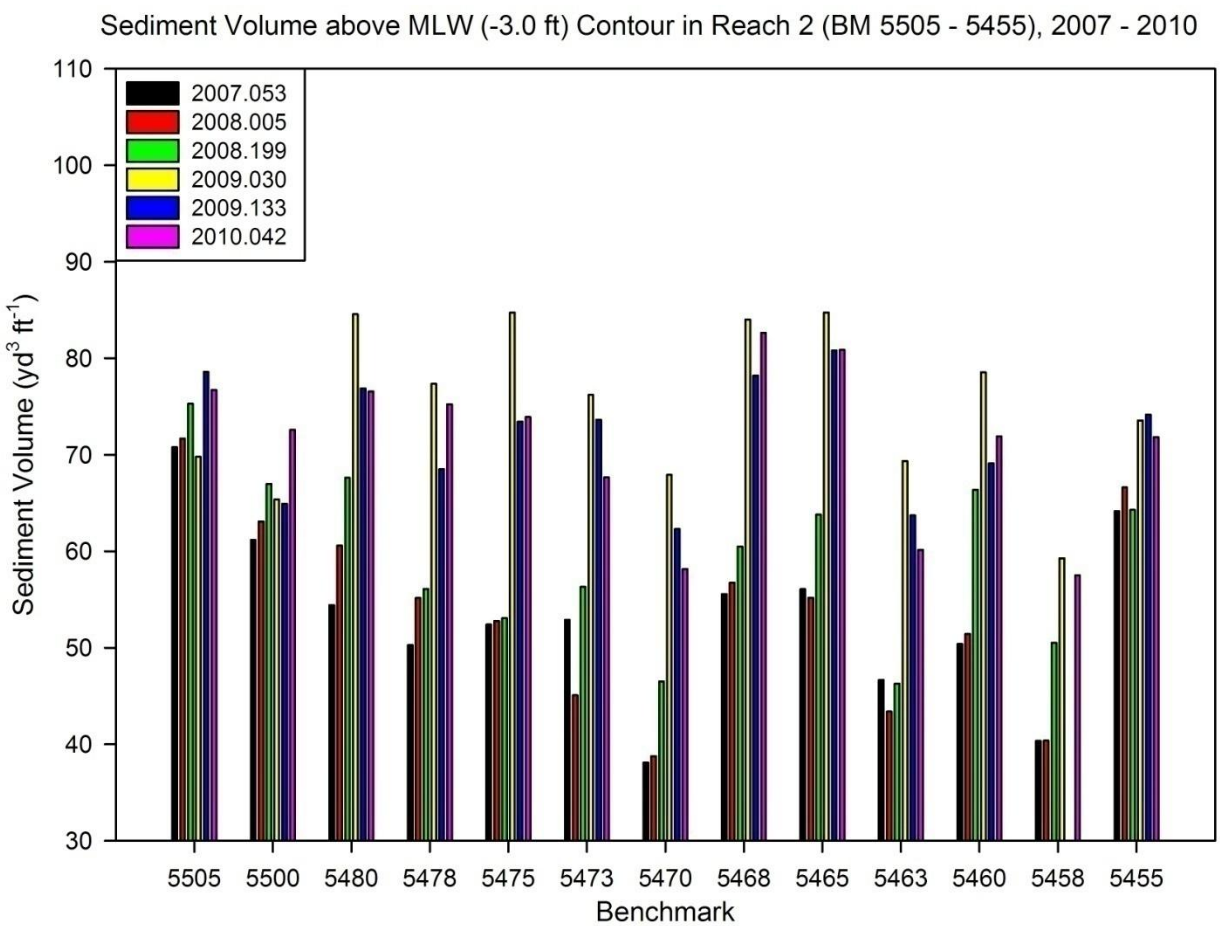

Sediment Volume above MHW (2.1 ft) Contour in Reach 2 (BM 5505 - 5455), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd^3 ft^{-1})
50
45
40
35
30
25
20
15
10
5
5505
5500
5480
5478
5475
5473
5470
5468
5465
5463
5460
5458
5455
Benchmark

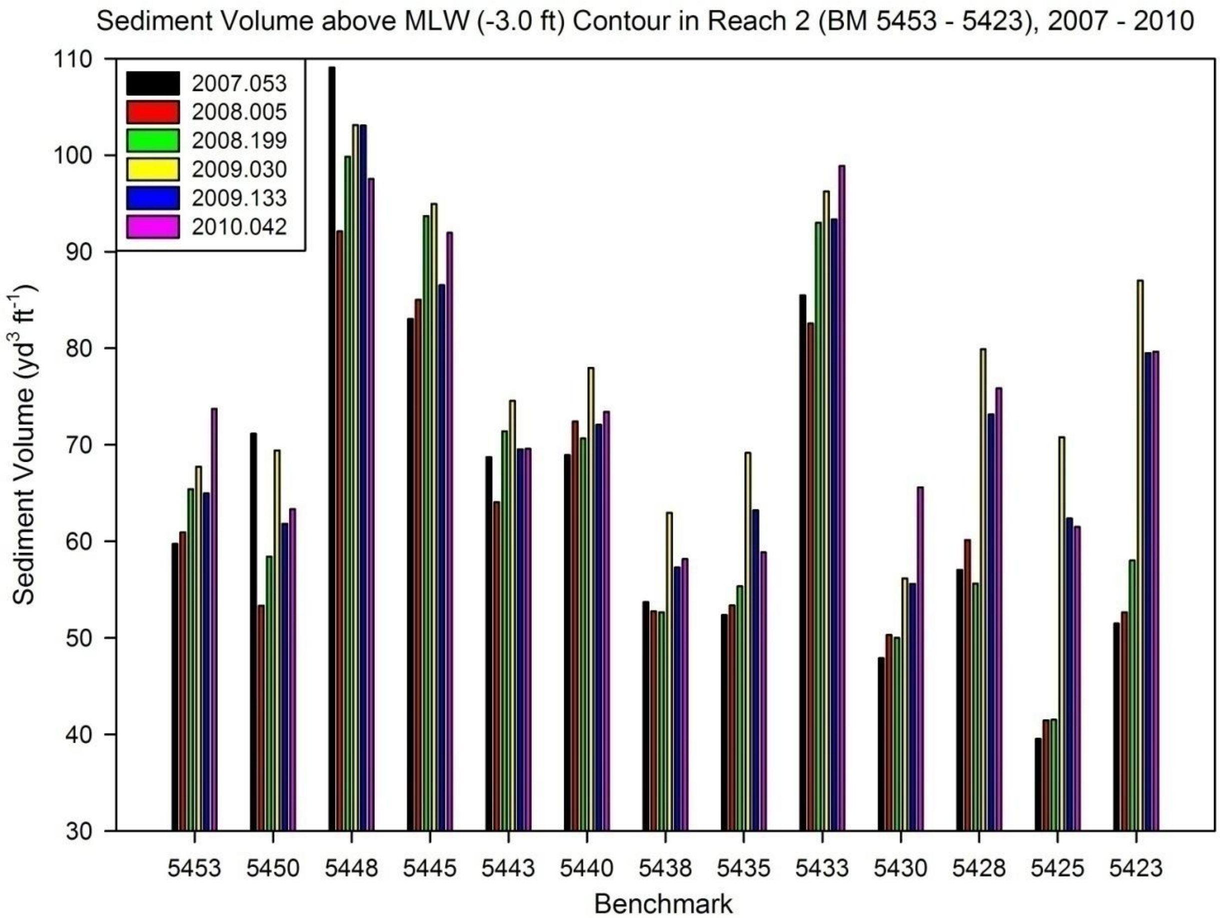

Sediment Volume above MHW (2.1 ft) Contour in Reach 2 (BM 5453 - 5423), 2007 - 2010
Sediment Volume (yd3 ft-1)
Benchmark
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
5453
5450
5448
5445
5443
5440
5438
5435
5433
5430
5428
5425
5423
50
45
40
35
30
25
20
15
10
5

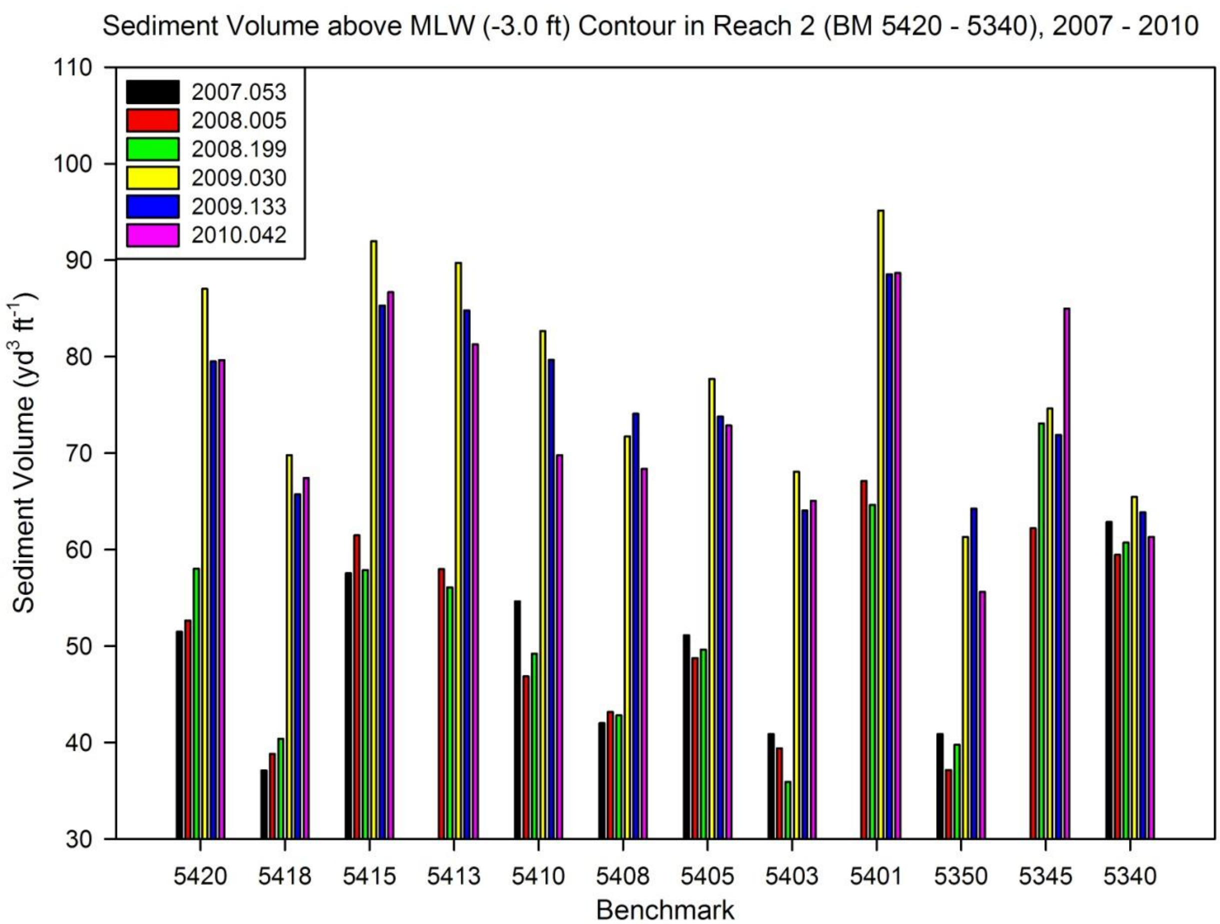

Sediment Volume above MHW (2.1 ft) Contour in Reach 2 (BM 5420 - 5340), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
50
45
40
35
30
25
20
15
10
5
5420
5418
5415
5413
5410
5408
5405
5403
5401
5350
5345
5340
Benchmark

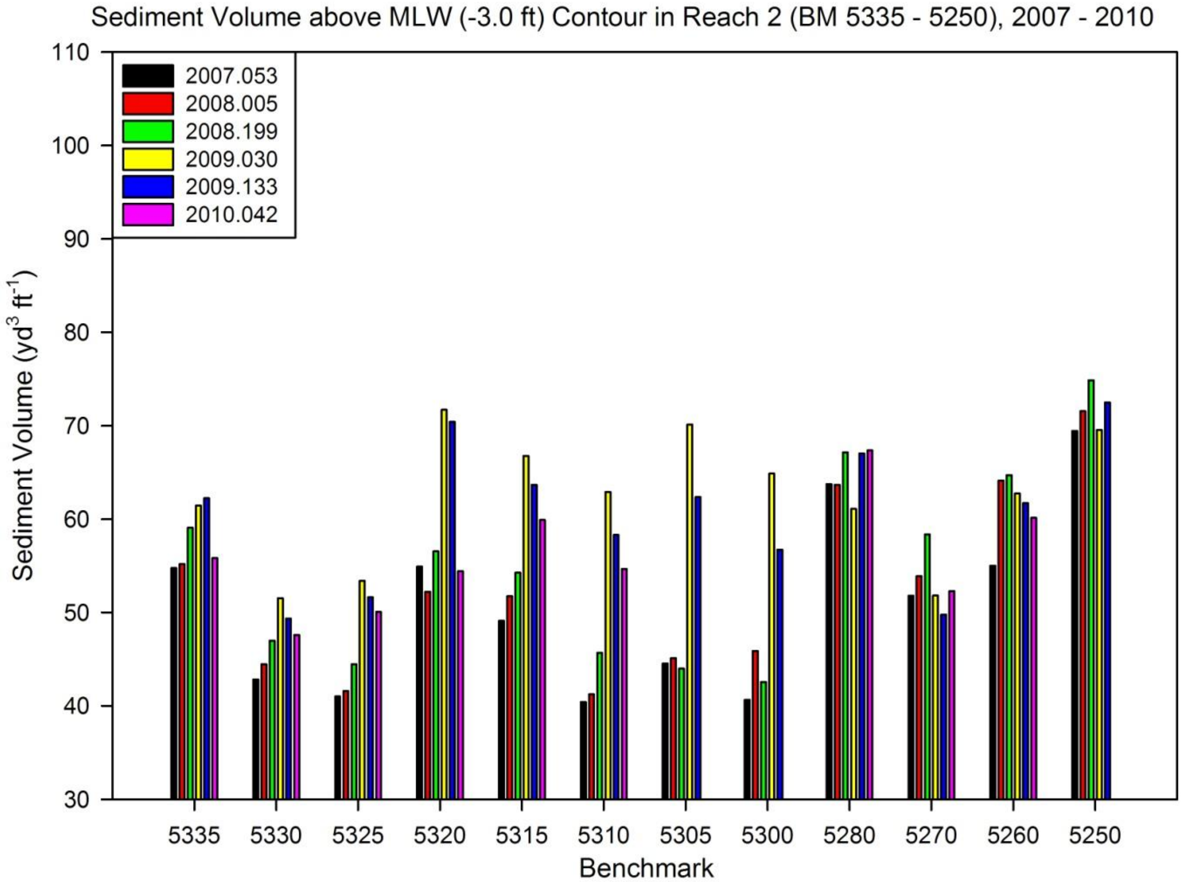


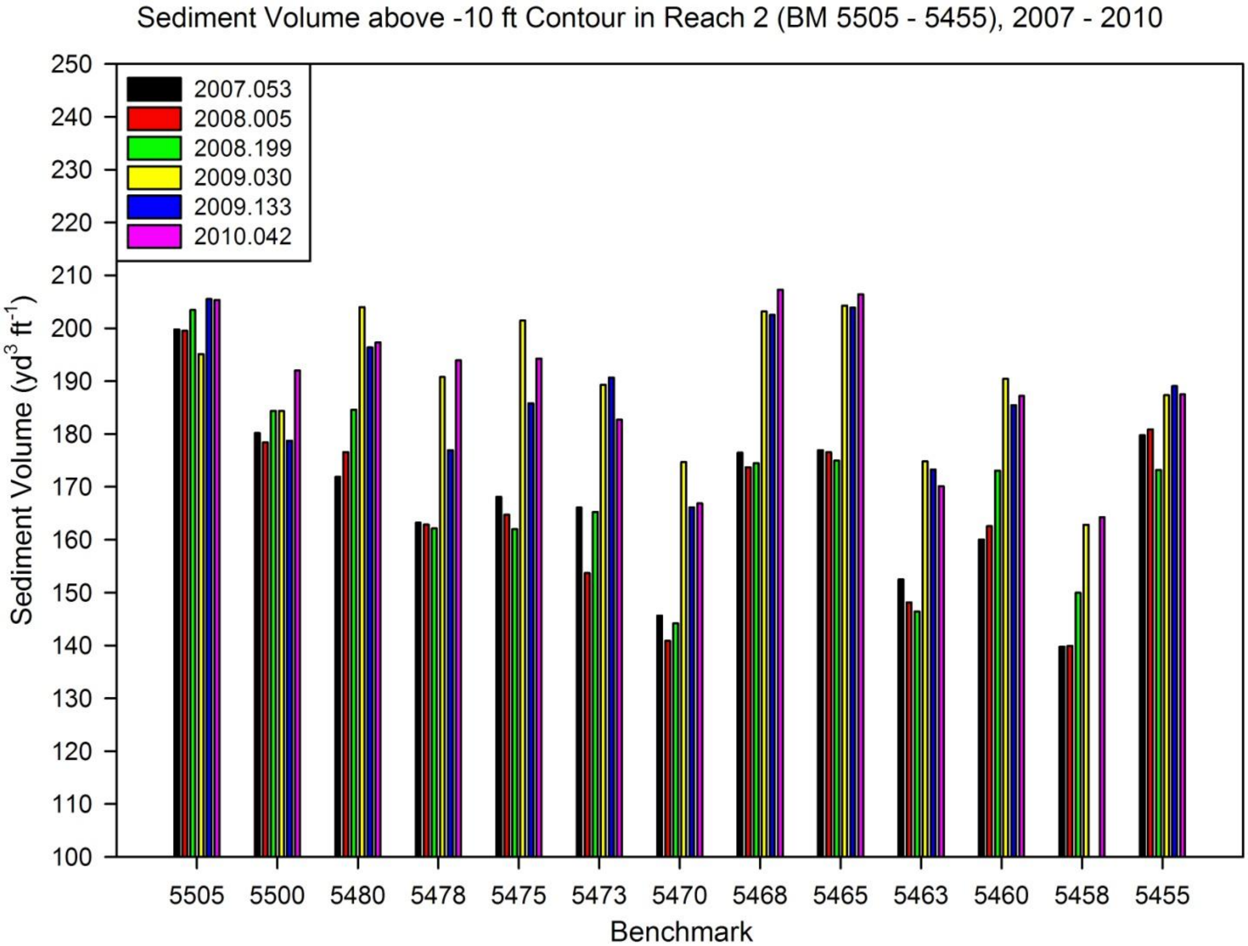
Sediment Volume above MHW (2.1 ft) Contour in Reach 2 (BM 5335 - 5250), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume ($yd^3 ft^{-1}$)
50
45
40
35
30
25
20
15
10
5
5335
5330
5325
5320
5315
5310
5305
5300
5280
5270
5260
5250
Benchmark

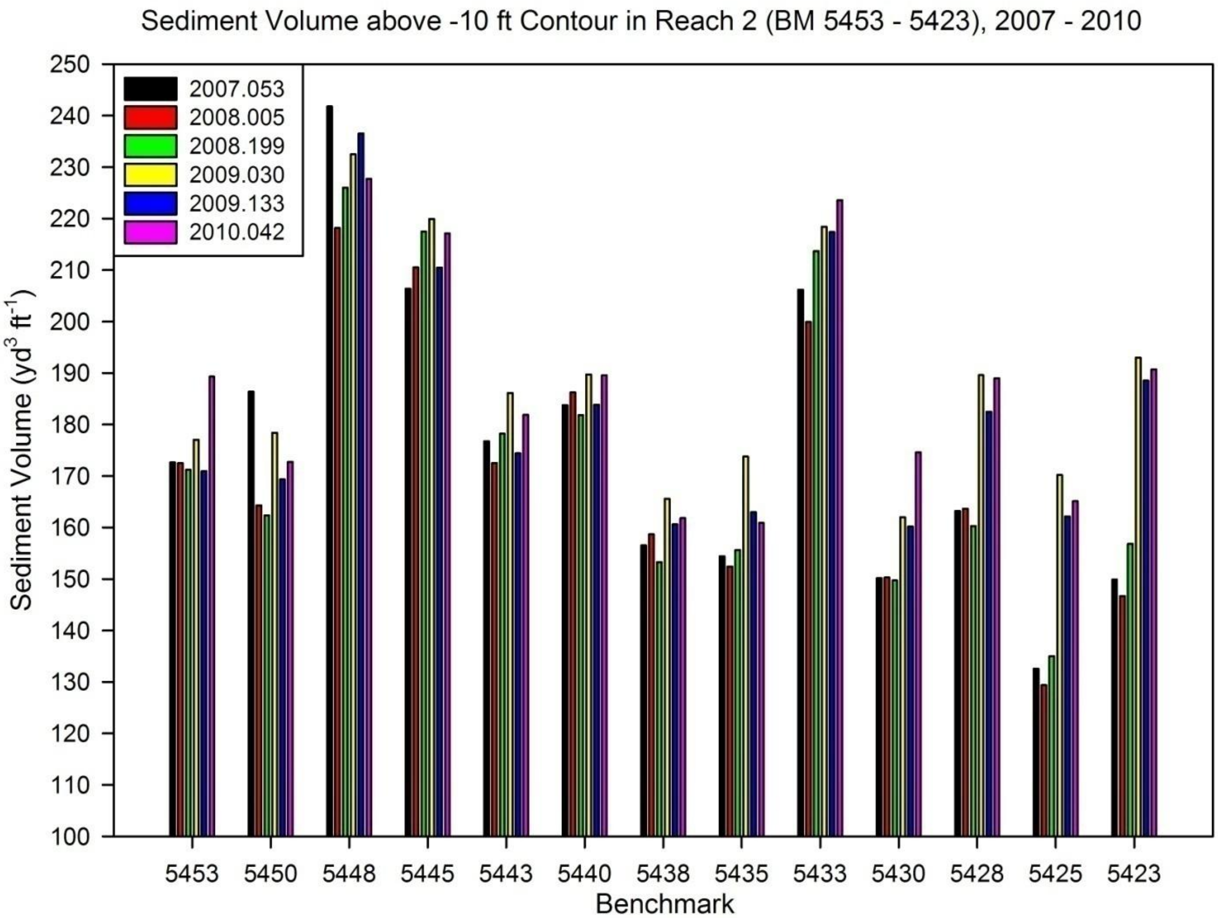

Sediment Volume above MLW (-3.0 ft) Contour in Reach 2 (BM 5505 - 5455), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd^3 ft^{-1})
110
100
90
80
70
60
50
40
30
5505
5500
5480
5478
5475
5473
5470
5468
5465
5463
5460
5458
5455
Benchmark

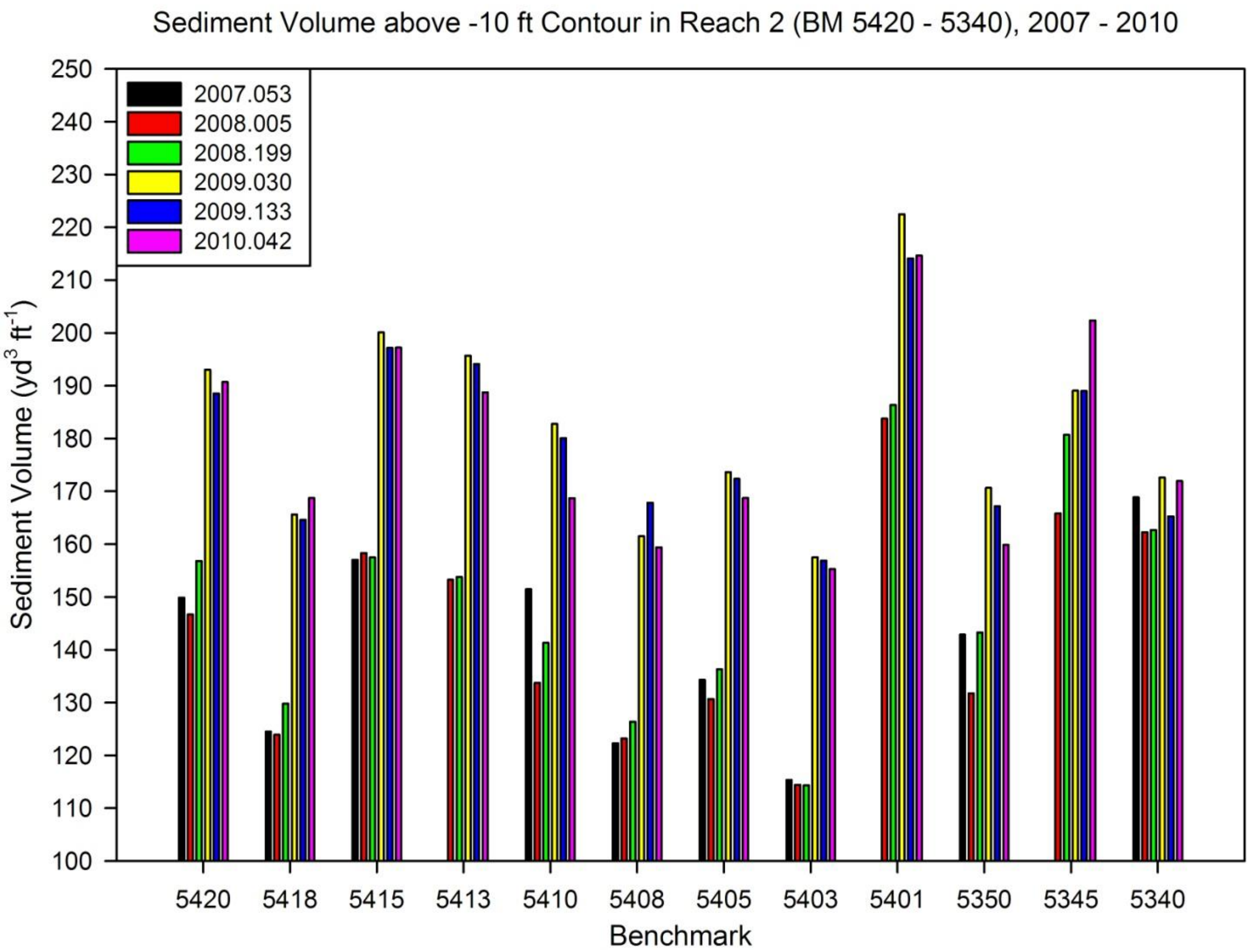

Sediment Volume above MLW (-3.0 ft) Contour in Reach 2 (BM 5453 - 5423), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
Benchmark
110
100
90
80
70
60
50
40
30
5453
5450
5448
5445
5443
5440
5438
5435
5433
5430
5428
5425
5423


Sediment Volume above MLW (-3.0 ft) Contour in Reach 2 (BM 5420 - 5340), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
110
100
90
80
70
60
50
40
30
5420
5418
5415
5413
5410
5408
5405
5403
5401
5350
5345
5340
Benchmark

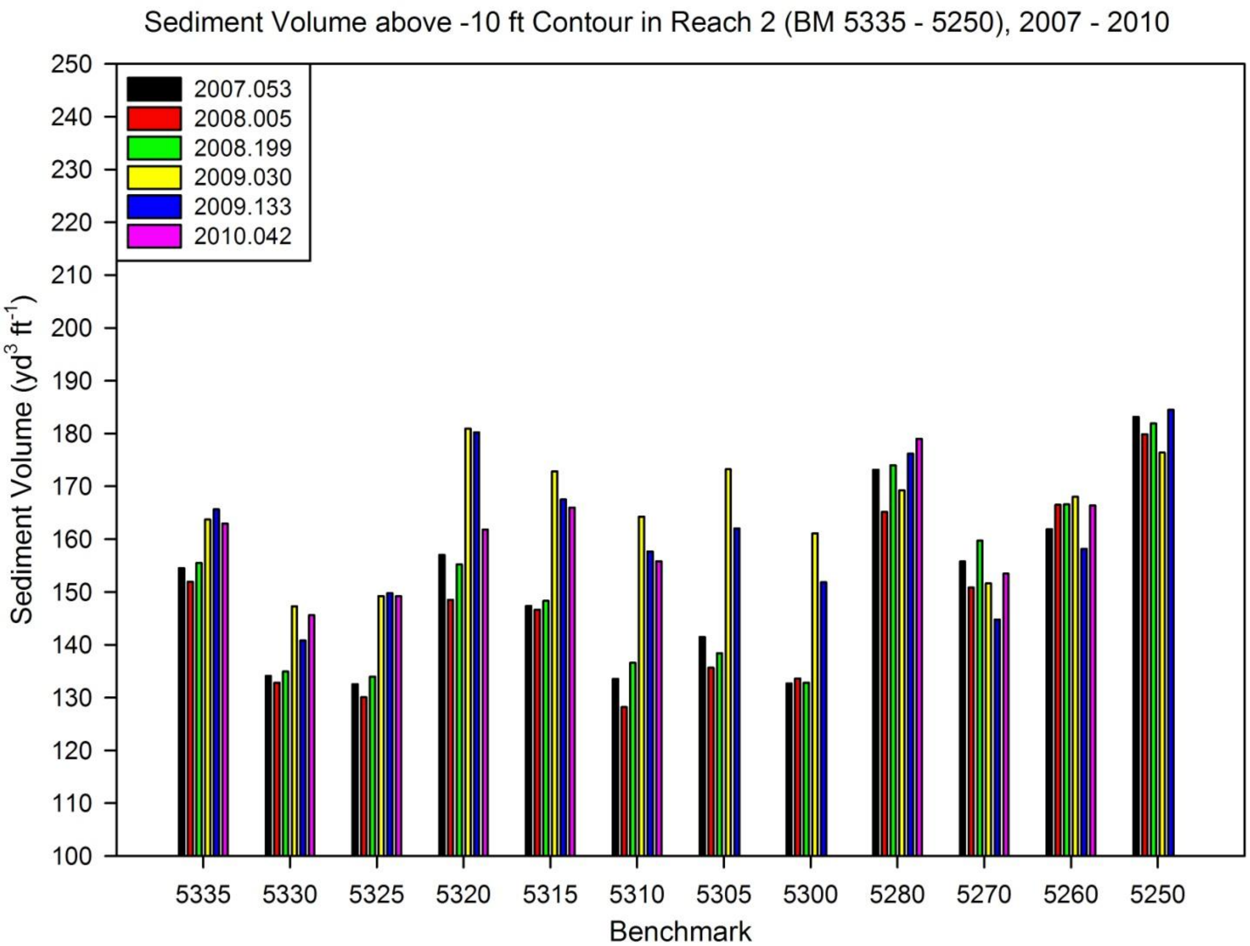

Sediment Volume above MLW (-3.0 ft) Contour in Reach 2 (BM 5335 - 5250), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
Benchmark
5335
5330
5325
5320
5315
5310
5305
5300
5280
5270
5260
5250
30
40
50
60
70
80
90
100
110

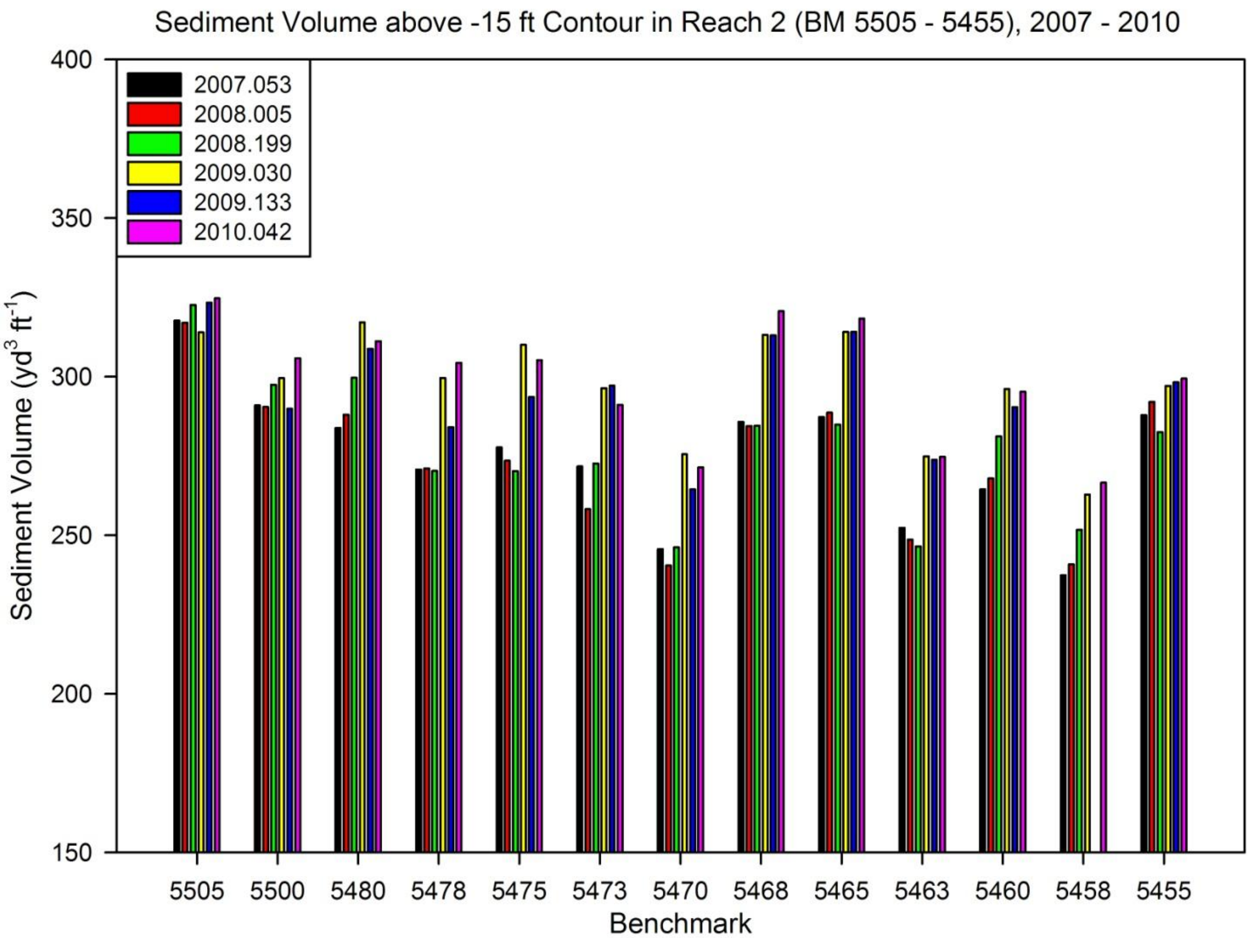

Sediment Volume above -10 ft Contour in Reach 2 (BM 5505 - 5455), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
5505
5500
5480
5478
5475
5473
5470
5468
5465
5463
5460
5458
5455
Benchmark

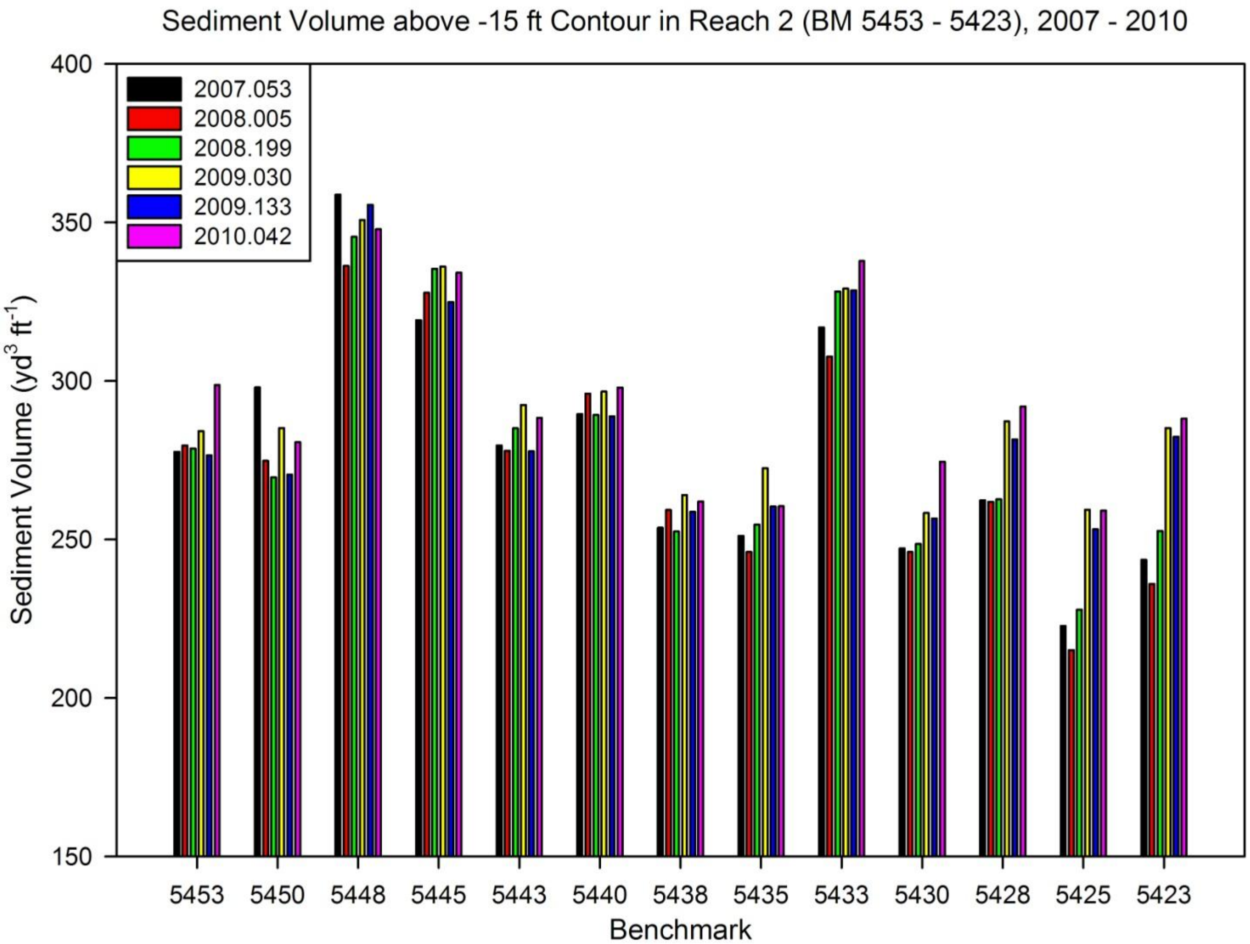

Sediment Volume above -10 ft Contour in Reach 2 (BM 5453 - 5423), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd^3 ft^{-1})
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
5453
5450
5448
5445
5443
5440
5438
5435
5433
5430
5428
5425
5423
Benchmark

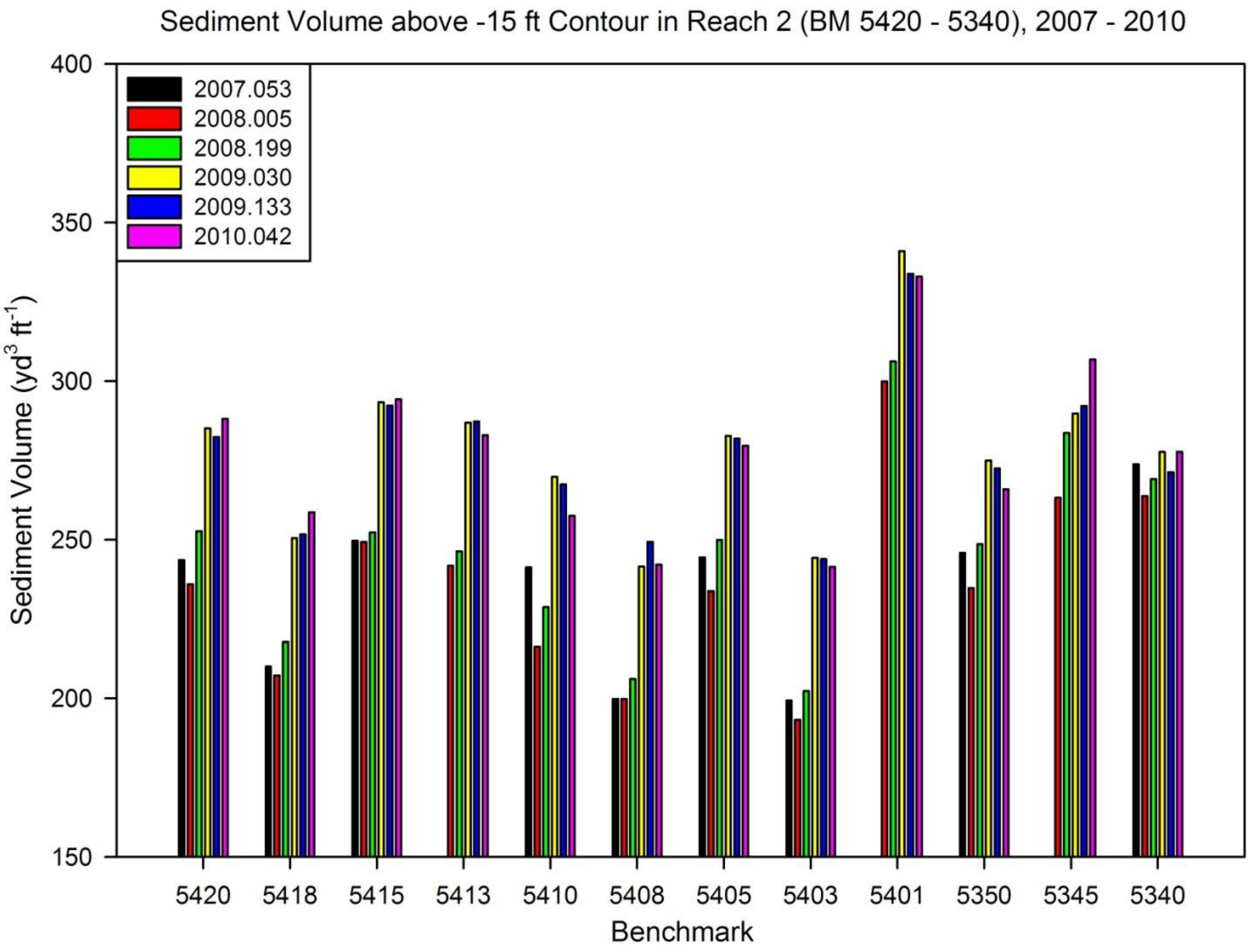


Sediment Volume above -10 ft Contour in Reach 2 (BM 5420 - 5340), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd^3 ft^{-1})
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
5420
5418
5415
5413
5410
5408
5405
5403
5401
5350
5345
5340
Benchmark

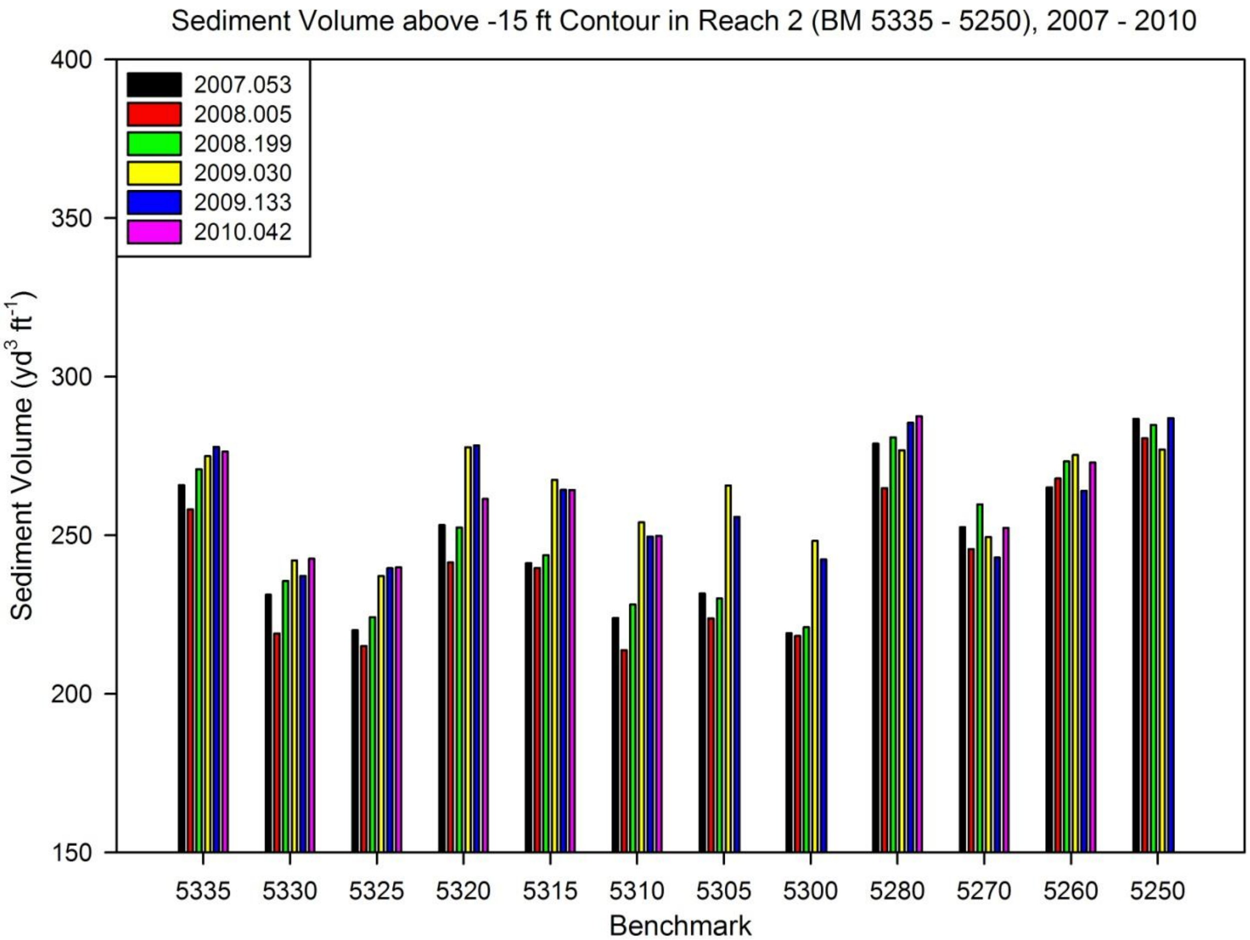

Sediment Volume above -10 ft Contour in Reach 2 (BM 5335 - 5250), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
5335
5330
5325
5320
5315
5310
5305
5300
5280
5270
5260
5250
Benchmark


Sediment Volume above -15 ft Contour in Reach 2 (BM 5505 - 5455), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
400
350
300
250
200
150
5505
5500
5480
5478
5475
5473
5470
5468
5465
5463
5460
5458
5455
Benchmark

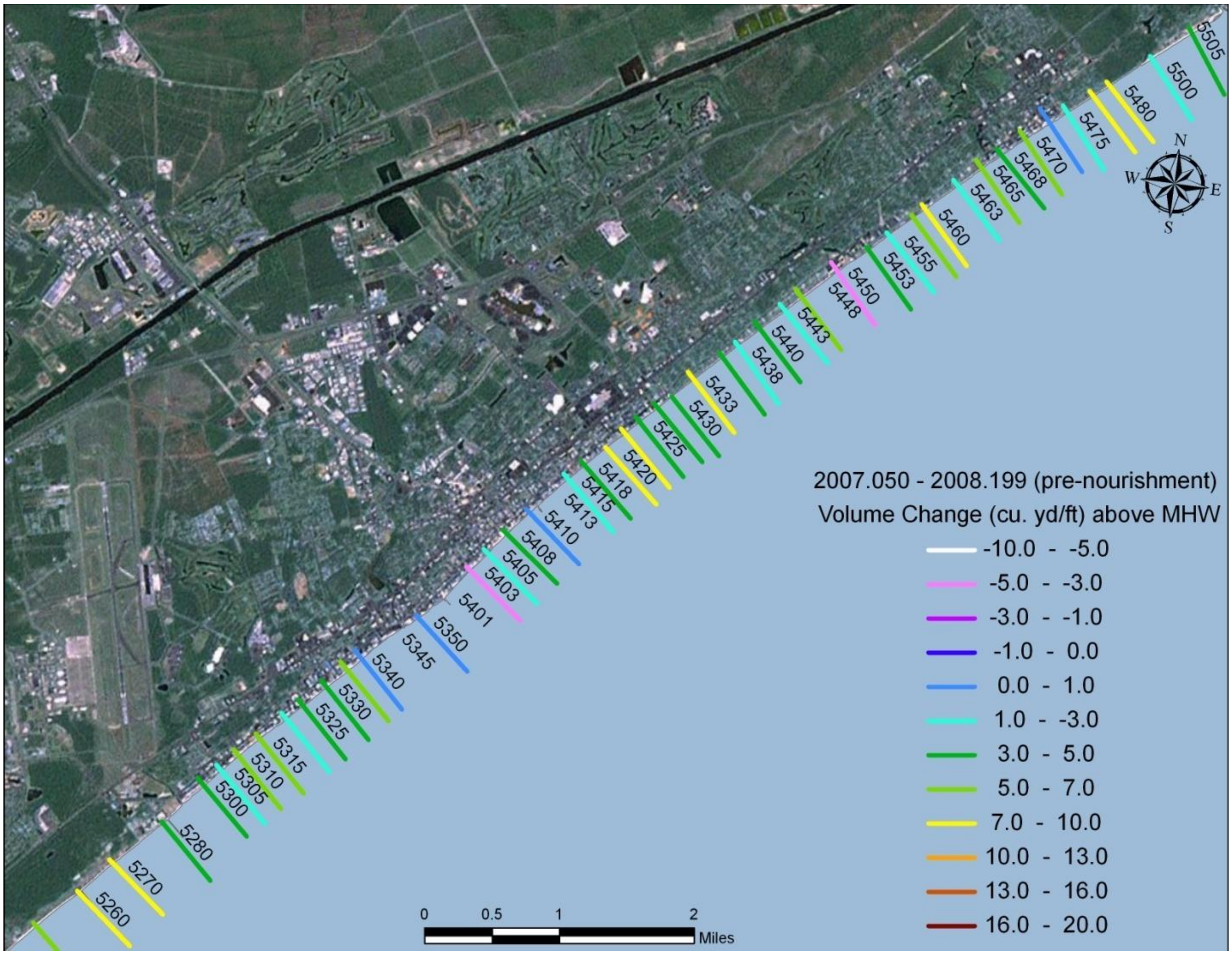

Sediment Volume above -15 ft Contour in Reach 2 (BM 5453 - 5423), 2007 - 2010
Sediment Volume (yd3 ft-1)
400
350
300
250
200
150
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
5453
5450
5448
5445
5443
5440
5438
5435
5433
5430
5428
5425
5423
Benchmark

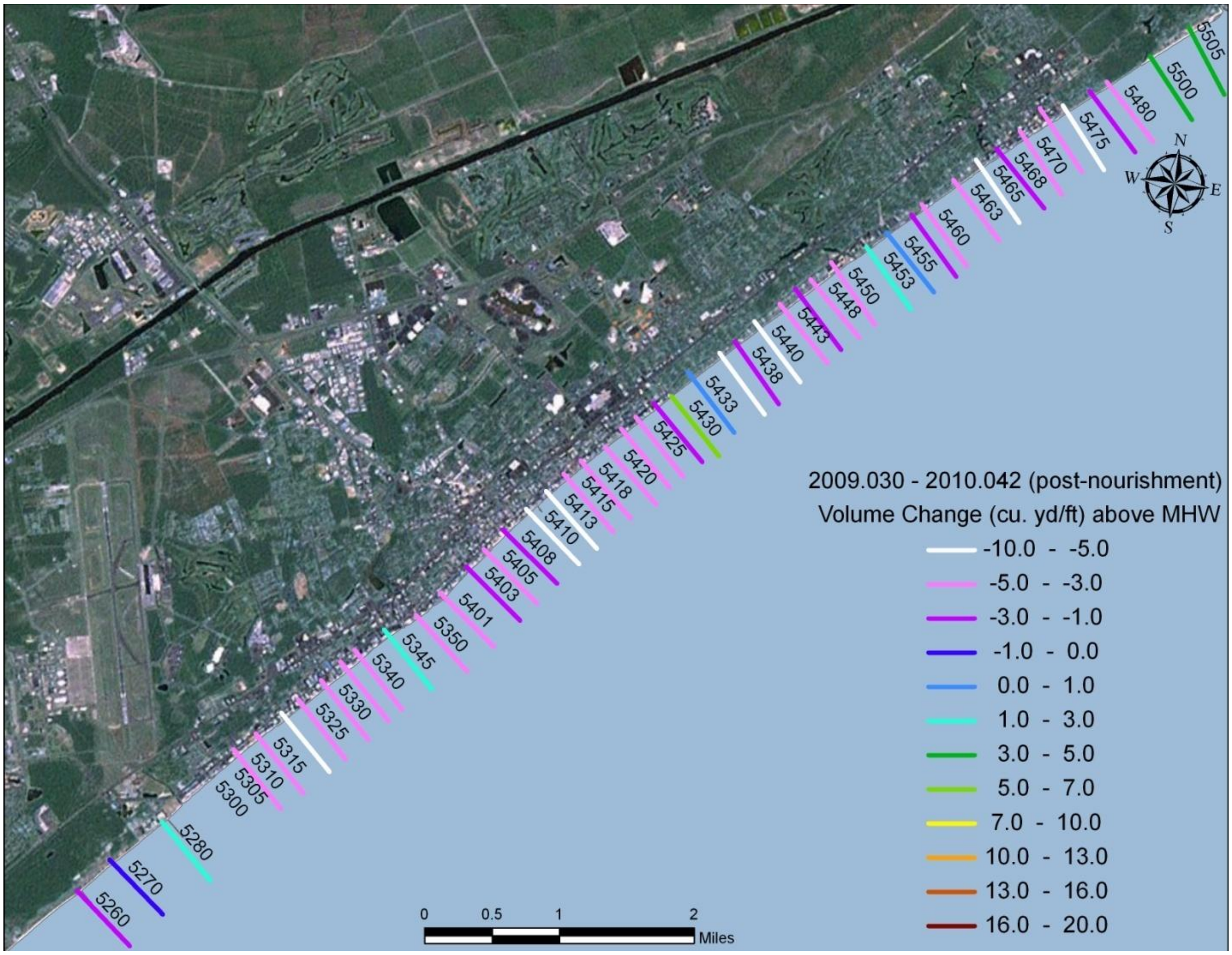


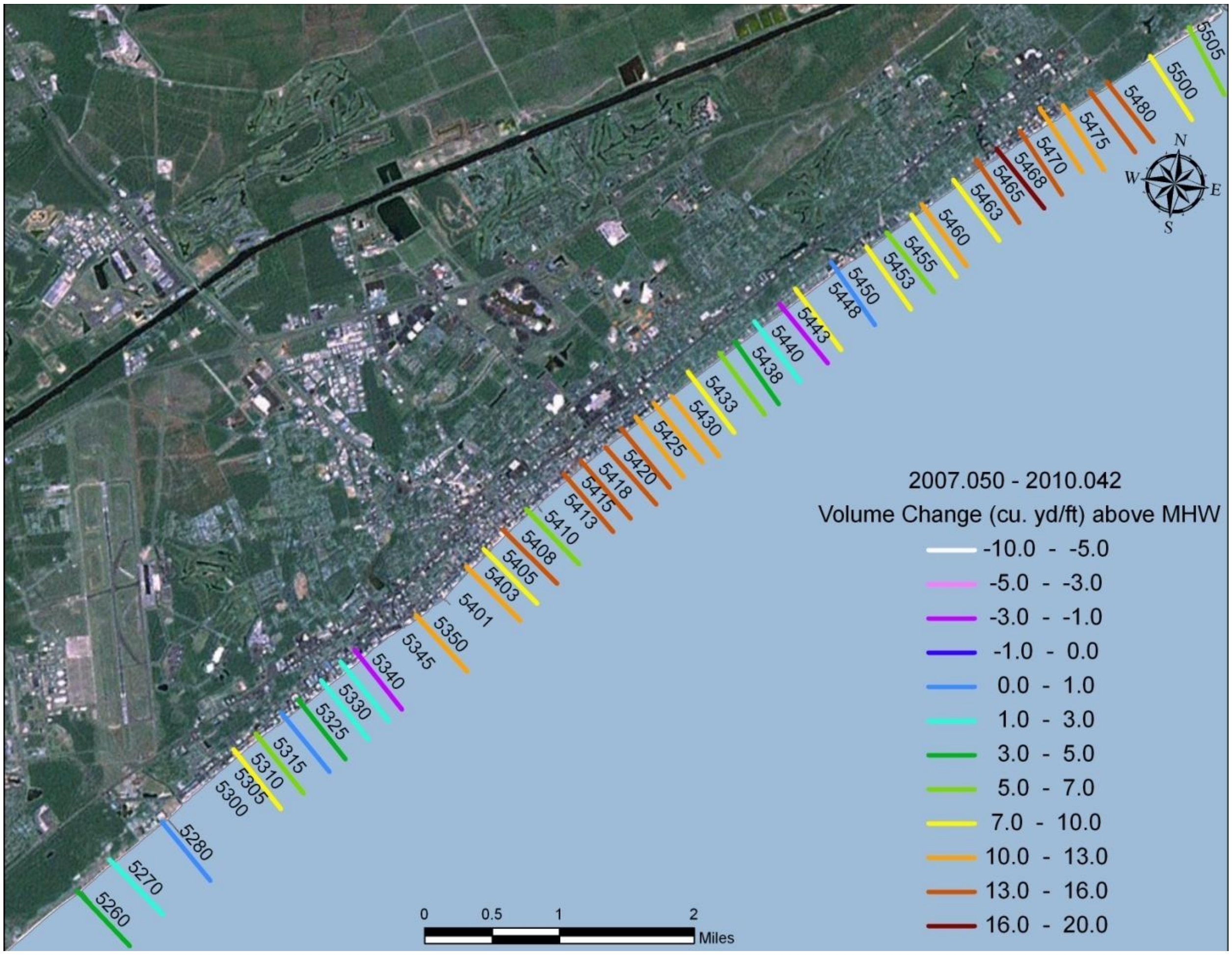
Sediment Volume above -15 ft Contour in Reach 2 (BM 5420 - 5340), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd3 ft-1)
400
350
300
250
200
150
5420
5418
5415
5413
5410
5408
5405
5403
5401
5350
5345
5340
Benchmark


Sediment Volume above -15 ft Contour in Reach 2 (BM 5335 - 5250), 2007 - 2010
2007.053
2008.005
2008.199
2009.030
2009.133
2010.042
Sediment Volume (yd^3 ft^{-1})
400
350
300
250
200
150
5335
5330
5325
5320
5315
5310
5305
5300
5280
5270
5260
5250
Benchmark

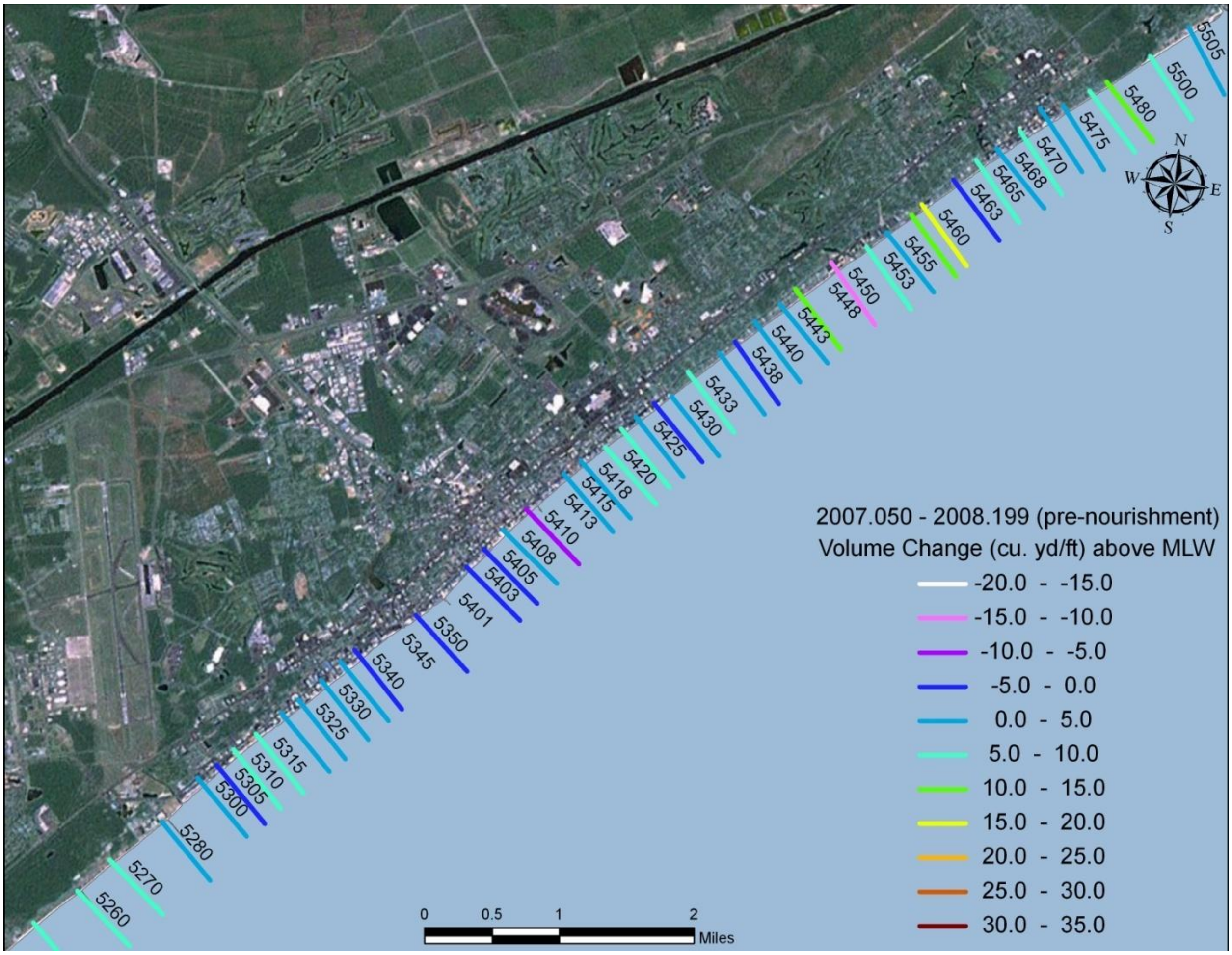
Appendix 6: Reach 2 Beach Profile Volume Change Map View

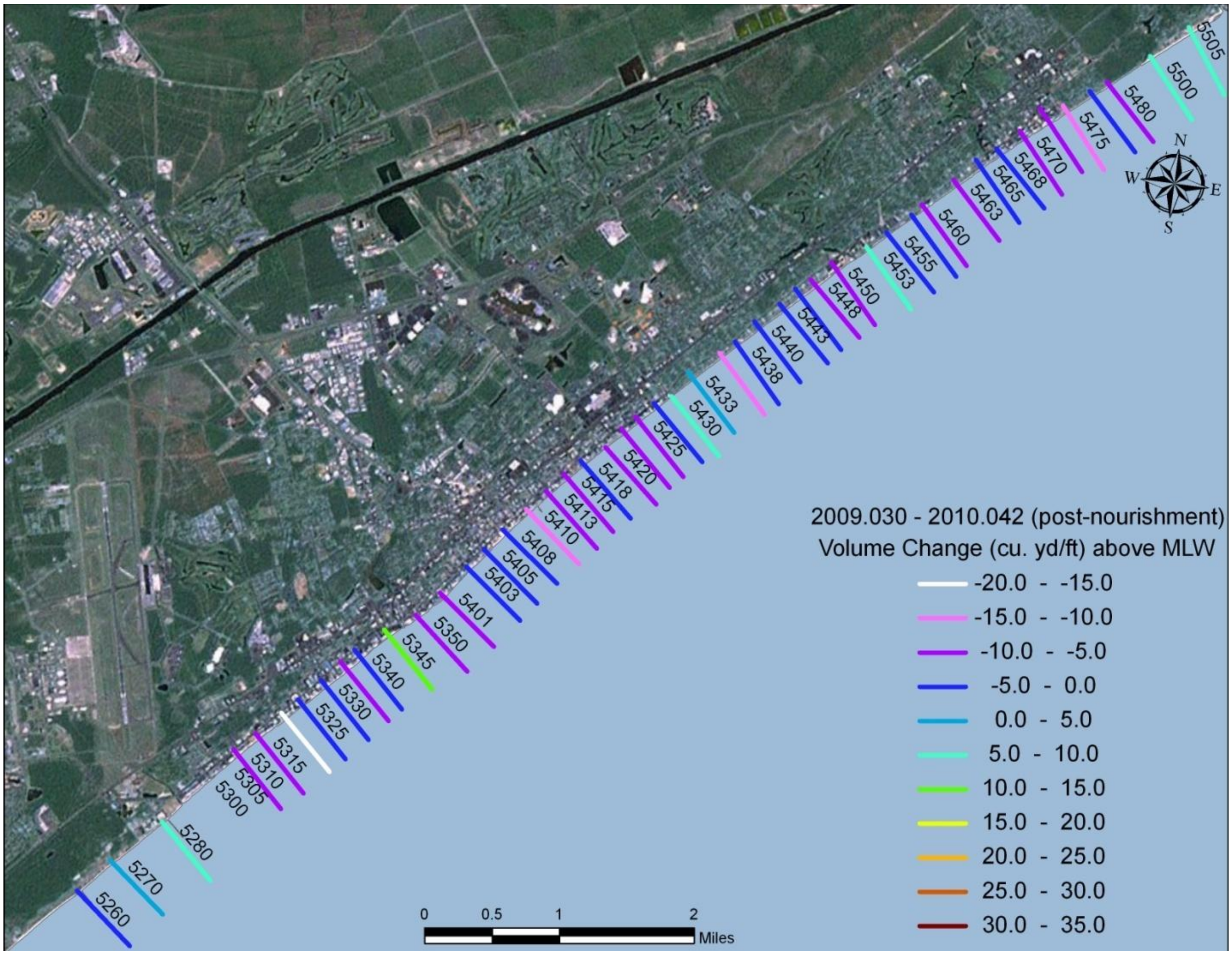

2007.050 - 2008.199 (pre-nourishment)
Volume Change (cu. yd/ft) above MHW
-10.0 - -5.0
-5.0 - -3.0
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - -3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 10.0
10.0 - 13.0
13.0 - 16.0
16.0 - 20.0
0 0.5 1 2 Miles
N S E W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505


2009.030 - 2010.042 (post-nourishment)
Volume Change (cu. yd/ft) above MHW
-10.0 - -5.0
-5.0 - -3.0
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 10.0
10.0 - 13.0
13.0 - 16.0
16.0 - 20.0
0 0.5 1 2 Miles
N S E W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

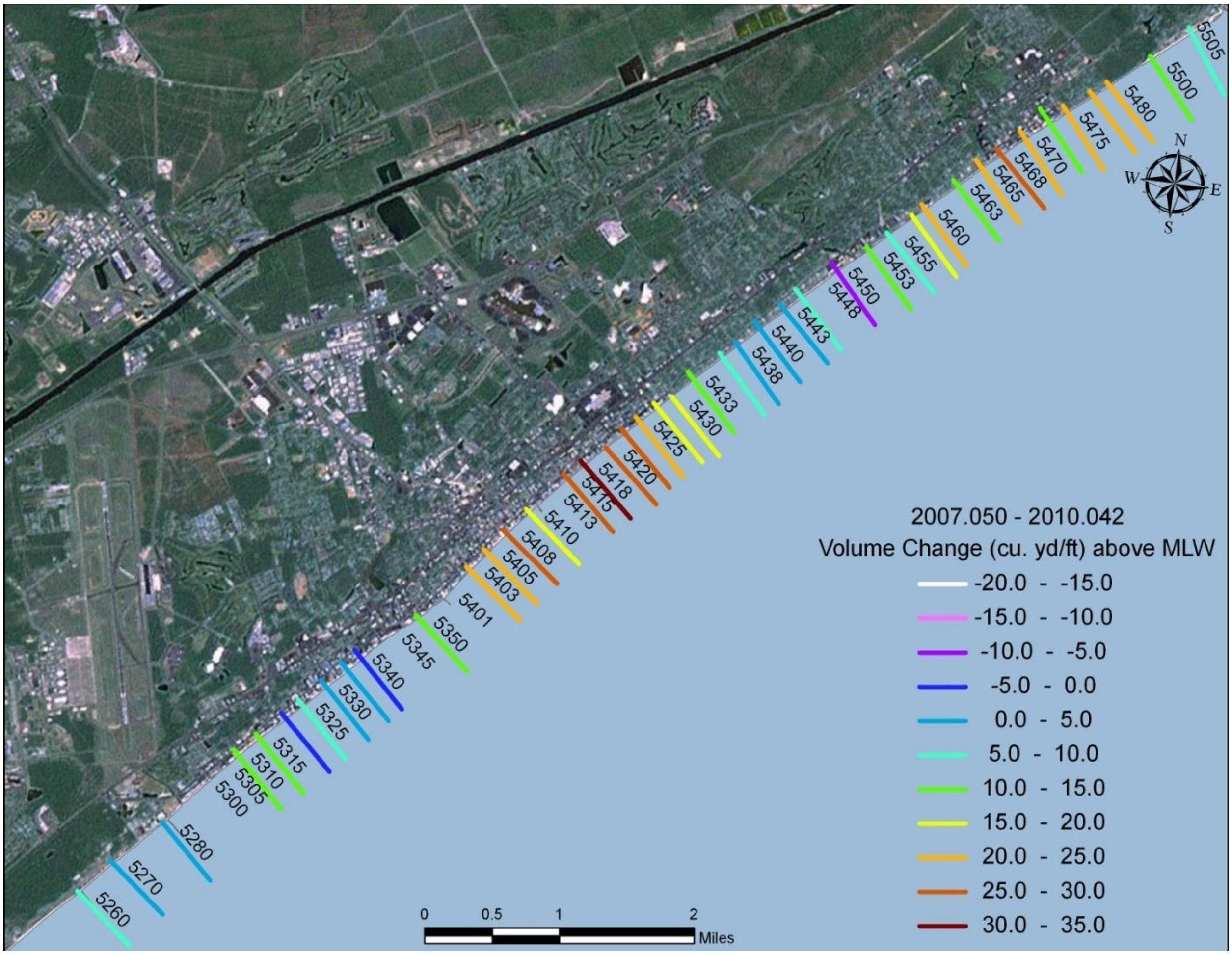


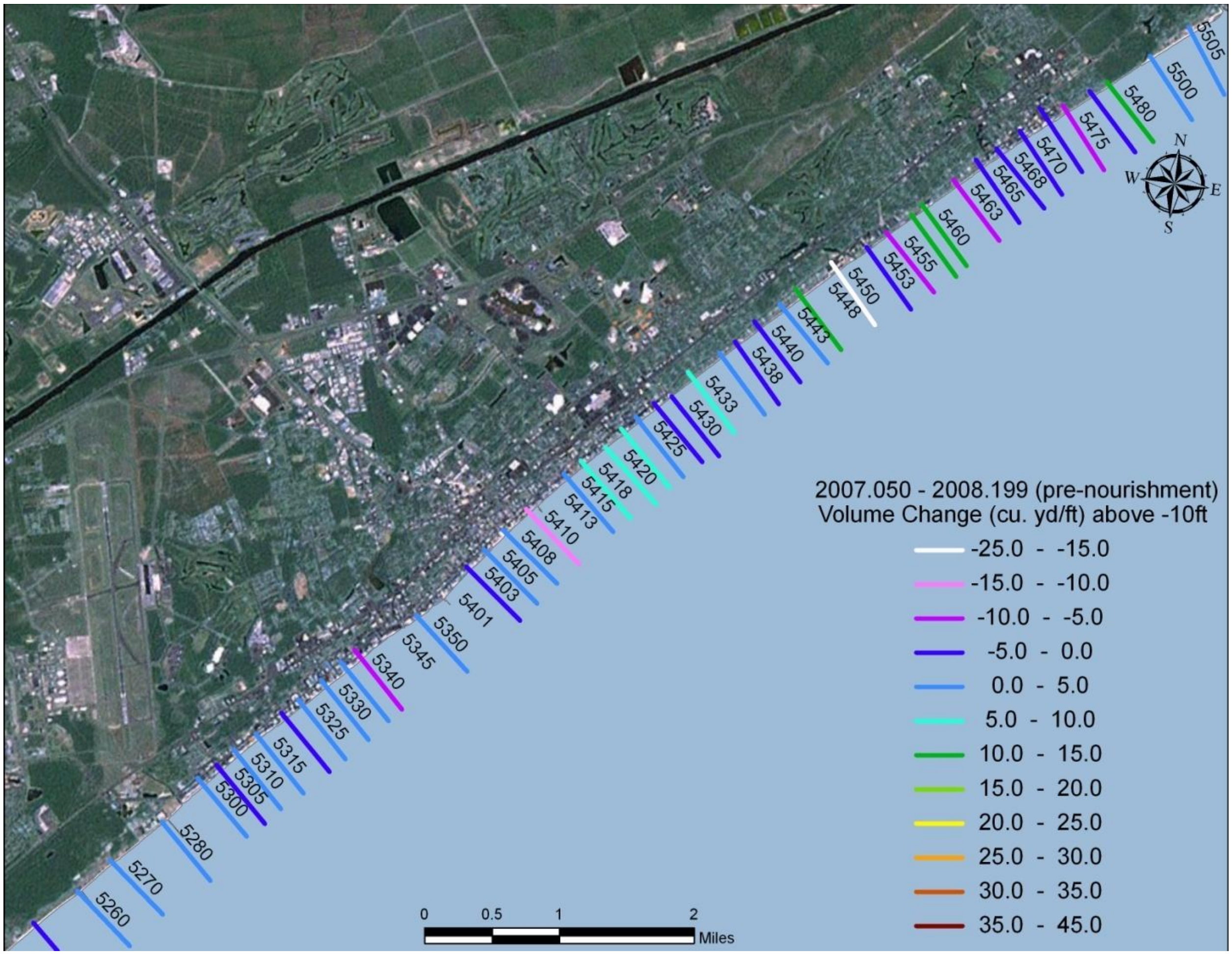
2007.050 - 2010.042
Volume Change (cu. yd/ft) above MHW
-10.0 - -5.0
-5.0 - -3.0
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 10.0
10.0 - 13.0
13.0 - 16.0
16.0 - 20.0
0
0.5
1
2
Miles
N
S
E
W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

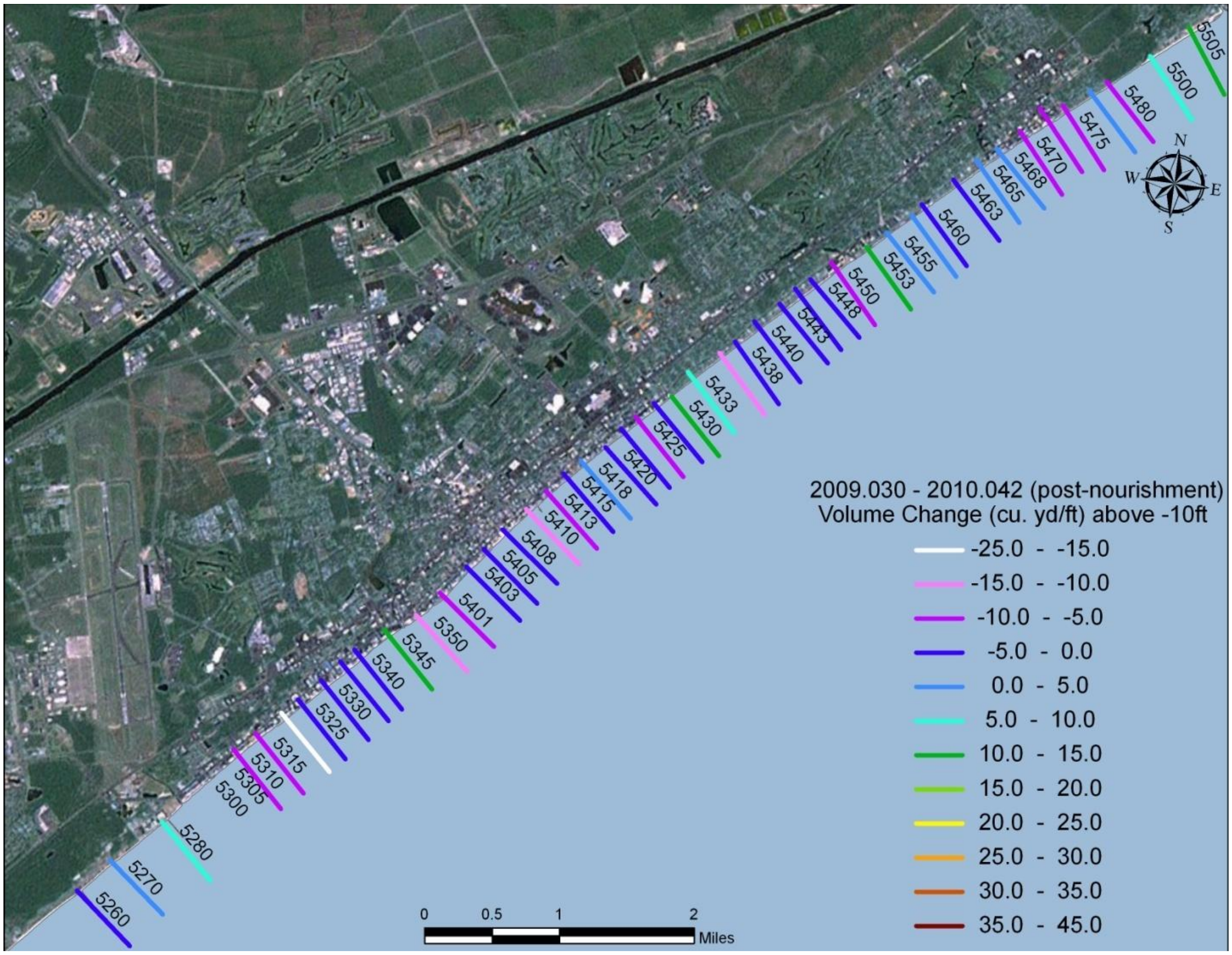

2007.050 - 2008.199 (pre-nourishment)
Volume Change (cu. yd/ft) above MLW
-20.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
0 0.5 1 2 Miles
N
S
E
W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

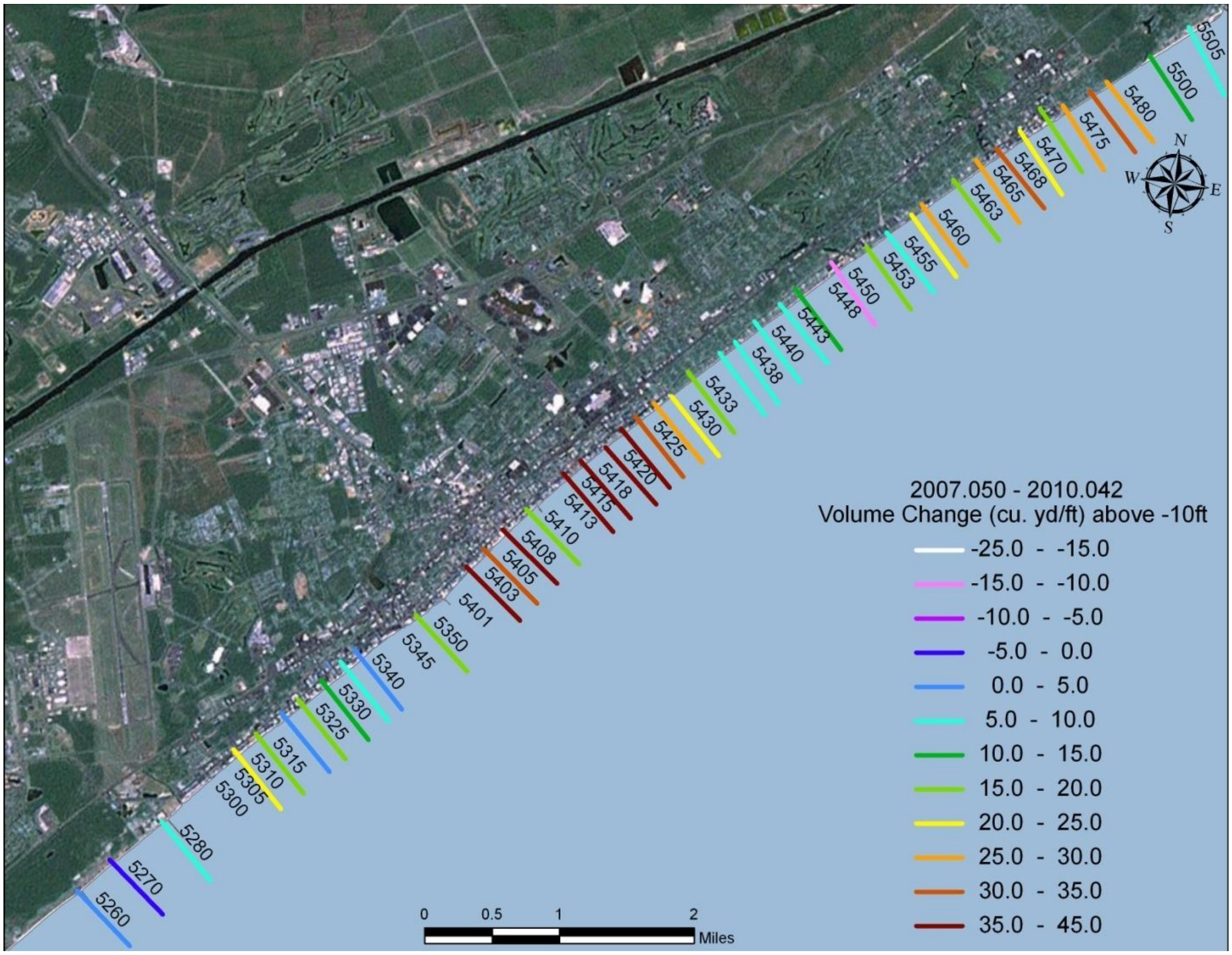


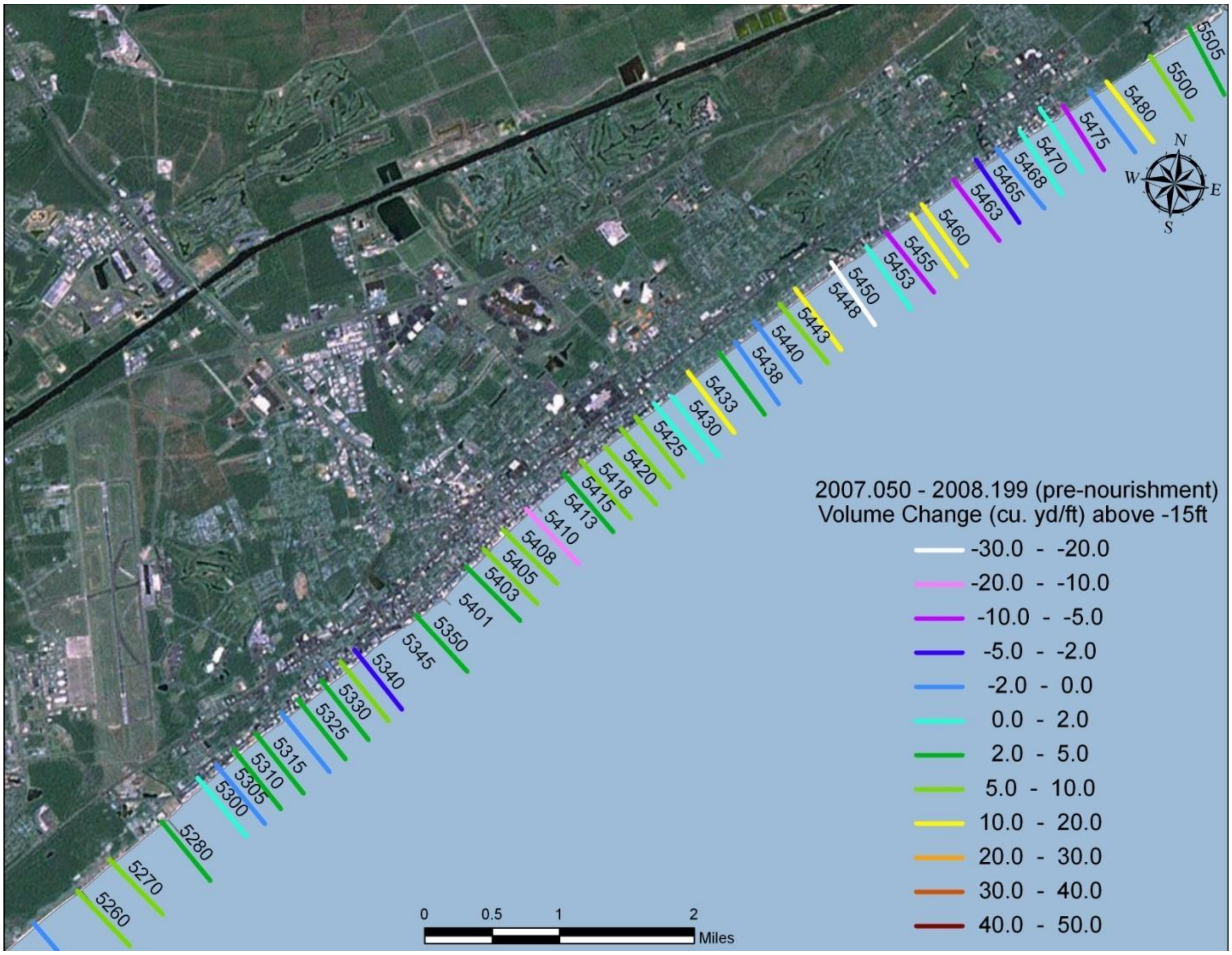
2009.030 - 2010.042 (post-nourishment)
Volume Change (cu. yd/ft) above MLW
-20.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
0 0.5 1 2 Miles
N E S W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

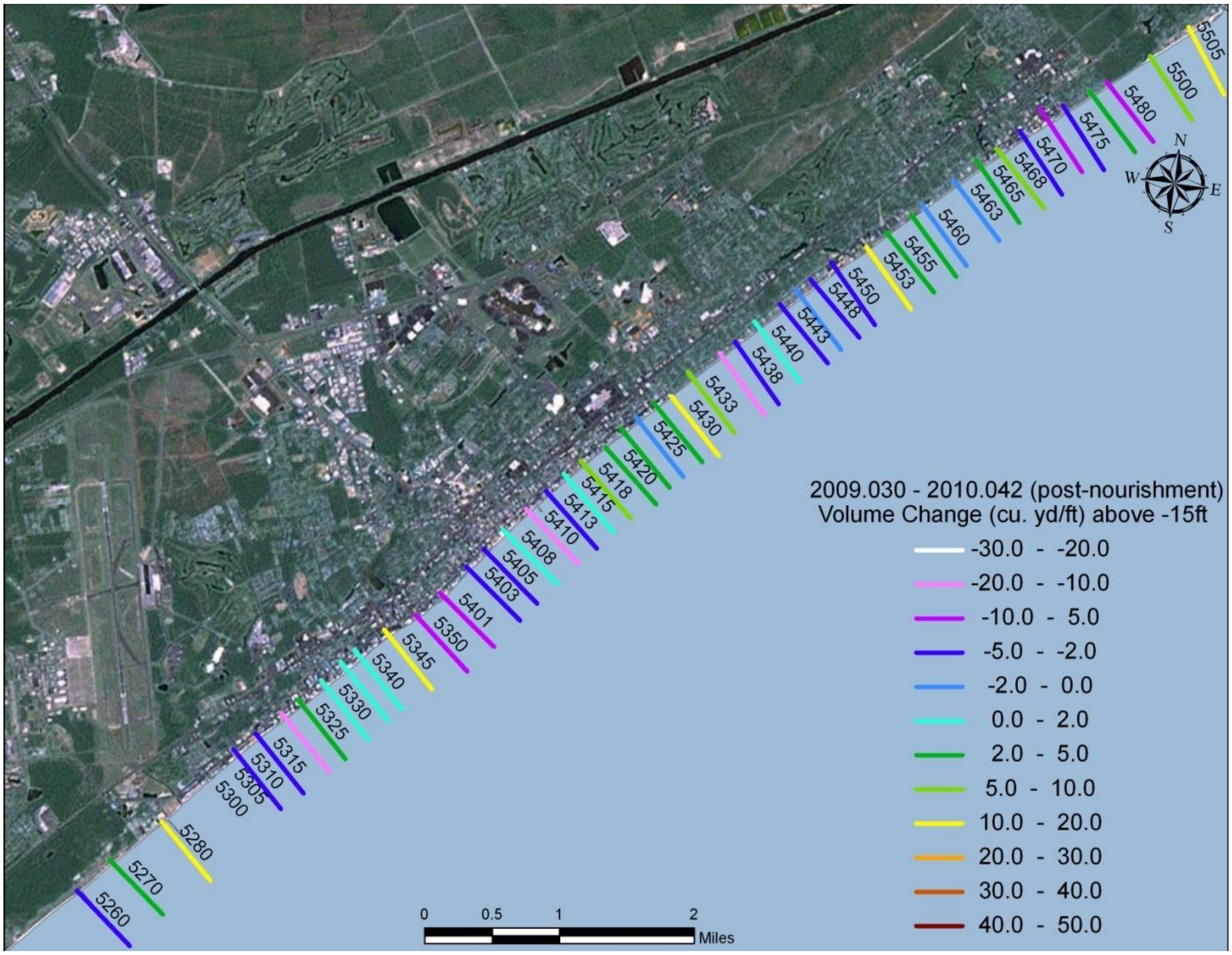

2007.050 - 2010.042
Volume Change (cu. yd/ft) above MLW
-20.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
0 0.5 1 2 Miles
N S E W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

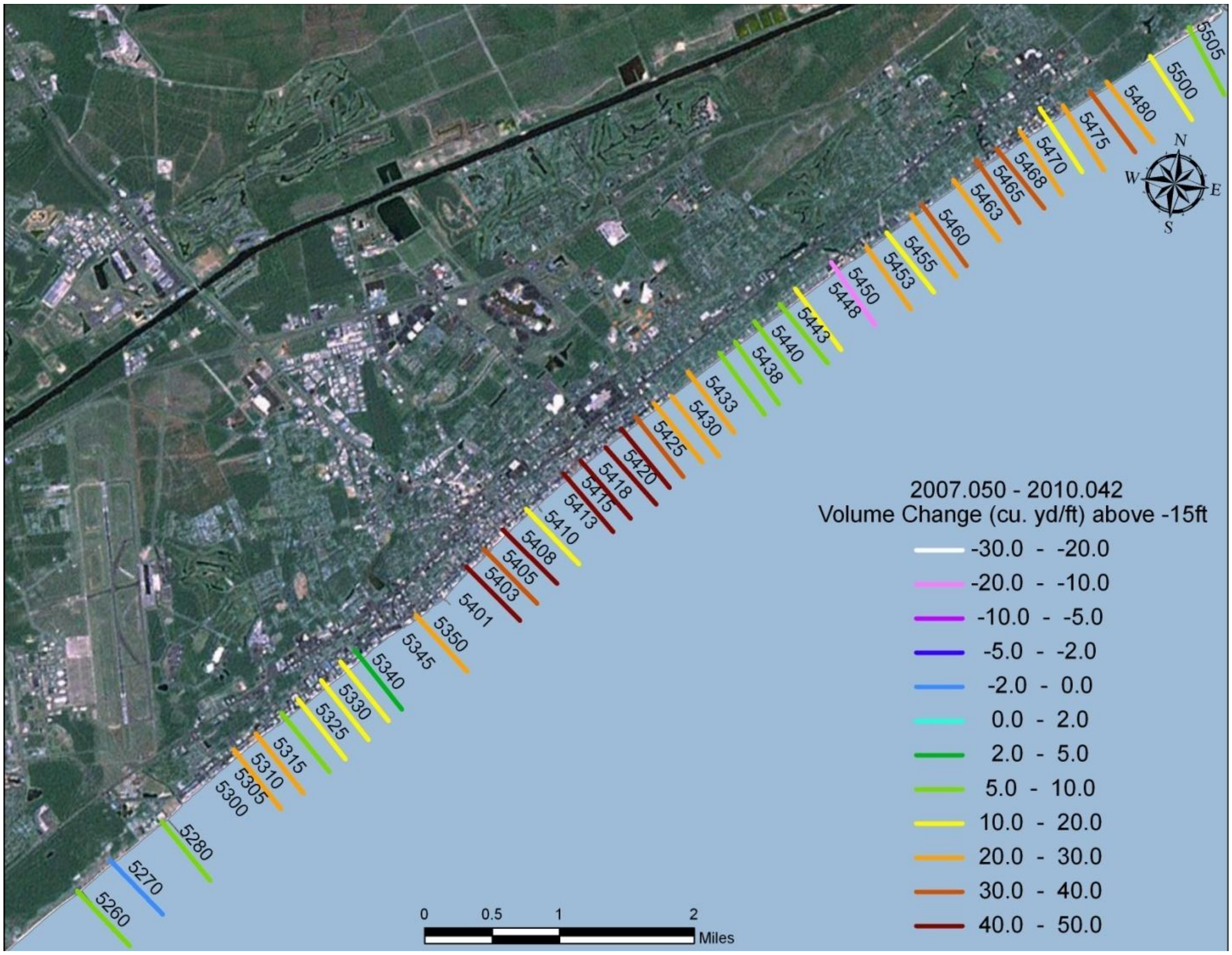

2007.050 - 2008.199 (pre-nourishment)
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
35.0 - 45.0
0 0.5 1 2 Miles
N E S W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505


2009.030 - 2010.042 (post-nourishment)
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
35.0 - 45.0
0 0.5 1 2 Miles


2007.050 - 2010.042
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
35.0 - 45.0
0 0.5 1 2 Miles


2007.050 - 2008.199 (pre-nourishment)
Volume Change (cu. yd/ft) above -15ft
-30.0 - -20.0
-20.0 - -10.0
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
0 0.5 1 2
Miles
N
S
E
W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505


2009.030 - 2010.042 (post-nourishment)
Volume Change (cu. yd/ft) above -15ft
-30.0 - -20.0
-20.0 - -10.0
-10.0 - 5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
0 0.5 1 2
Miles
N
S
E
W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505


2007.050 - 2010.042
Volume Change (cu. yd/ft) above -15ft
-30.0 - -20.0
-20.0 - -10.0
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
0 0.5 1 2
Miles
N
E
S
W
5260
5270
5280
5300
5305
5310
5315
5325
5330
5340
5345
5350
5401
5403
5405
5408
5410
5413
5415
5418
5420
5425
5430
5433
5438
5440
5443
5448
5450
5453
5455
5460
5463
5465
5468
5470
5475
5480
5500
5505

Appendix 7: Reach 2 Time-Series Aerial Photography


N
W
E
S
0
100
200
400
Feet
Myrtle Beach 02/2008


N
S
E
W
0
100
200
400
Feet
Myrtle Beach 04/2008

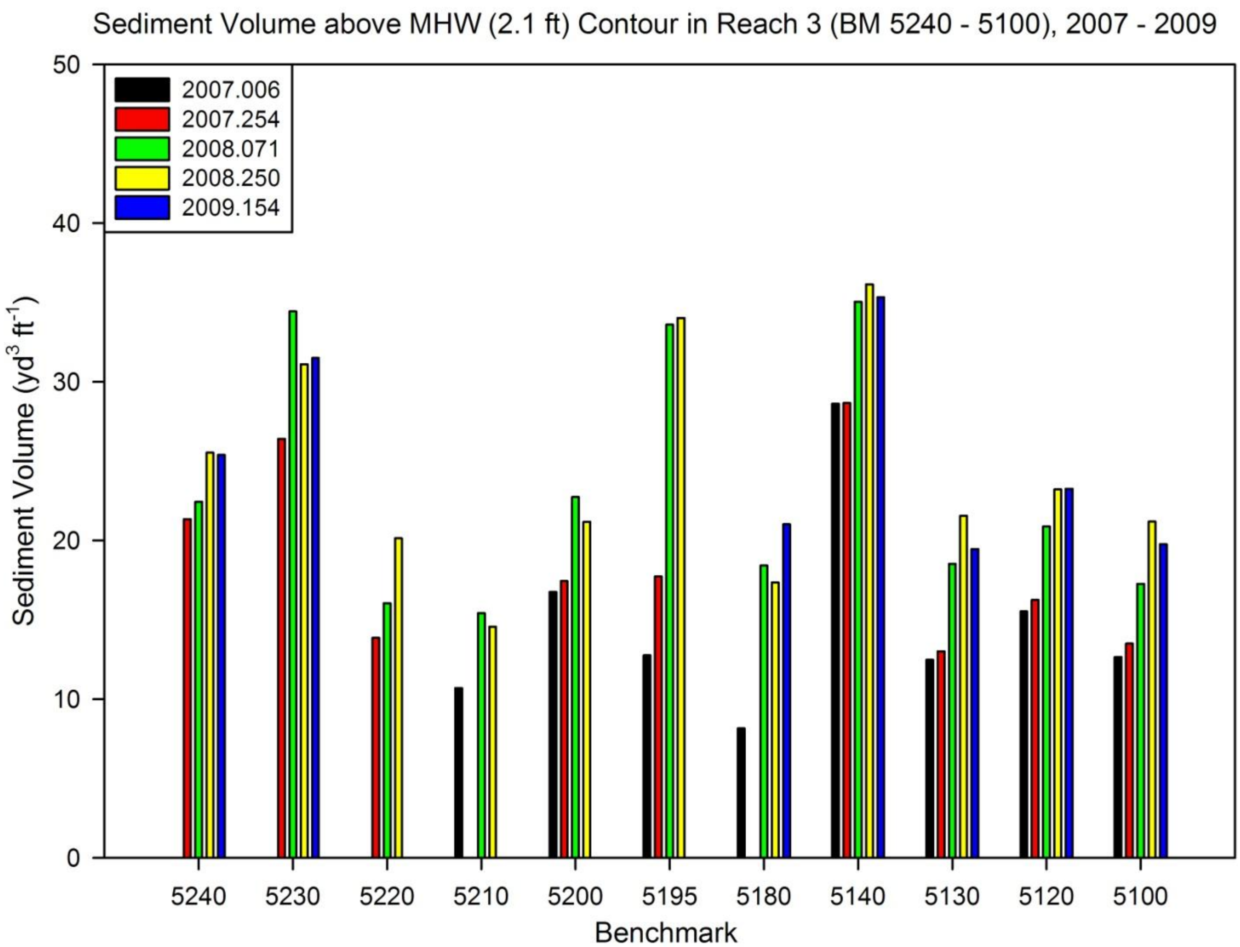

N
W
E
S
0
100
200
400
Feet
Myrtle Beach 08/2008

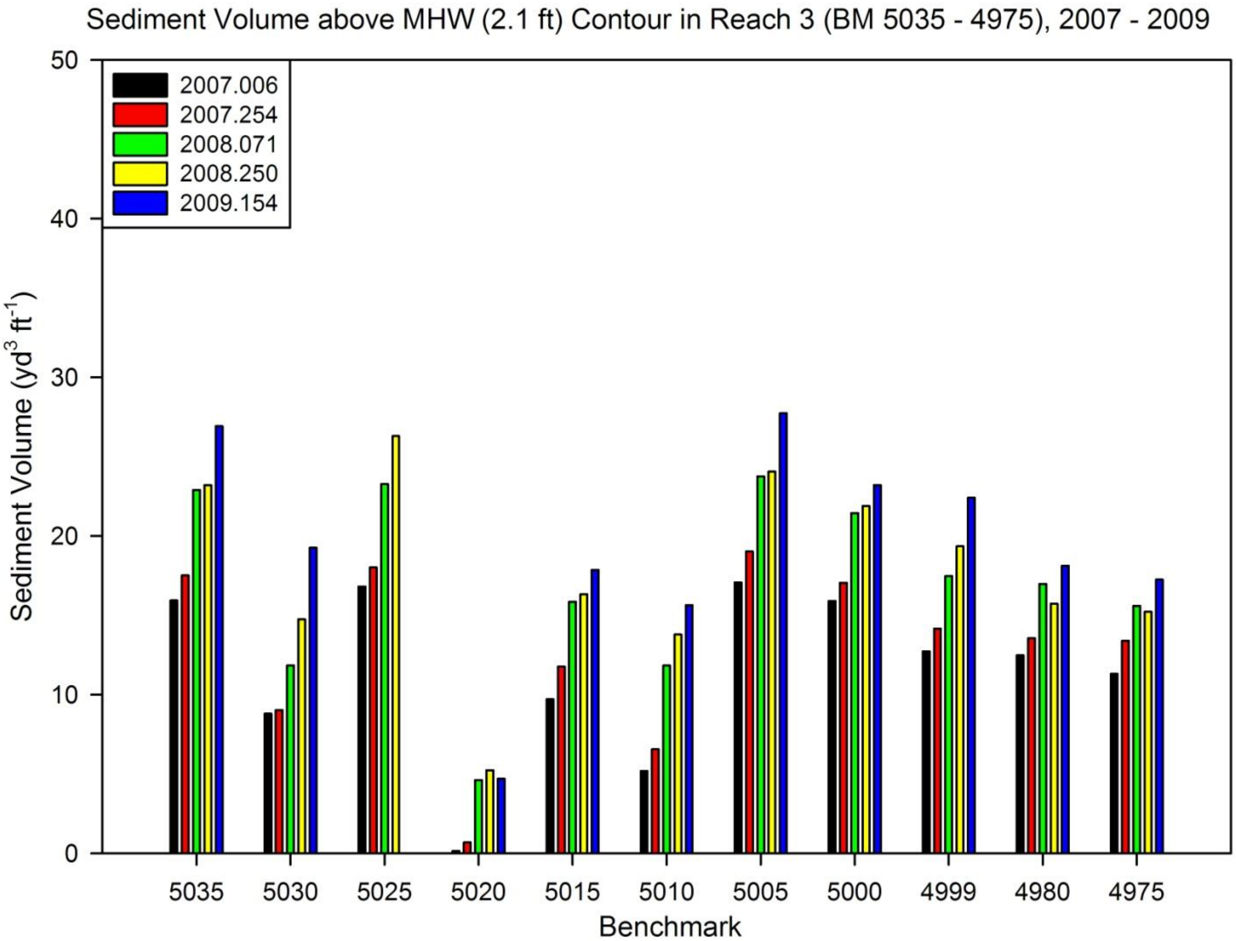

N
W
E
S
0
100
200
400
Feet
Myrtle Beach 11/2008


N
W
E
S
0
100
200
400
Feet
Myrtle Beach 02/2009

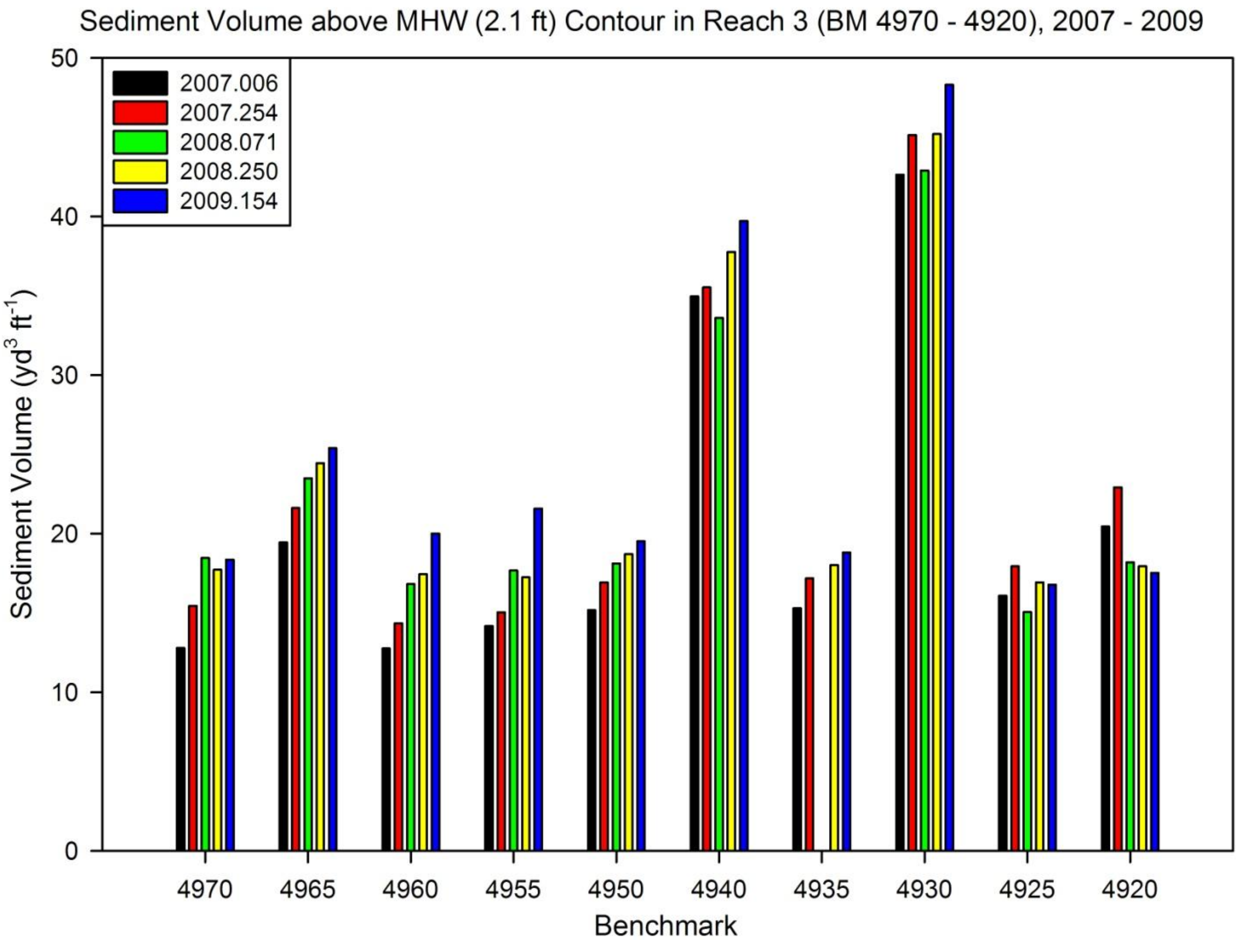

N
W
E
S
0
100
200
400
Feet
Myrtle Beach 05/2009

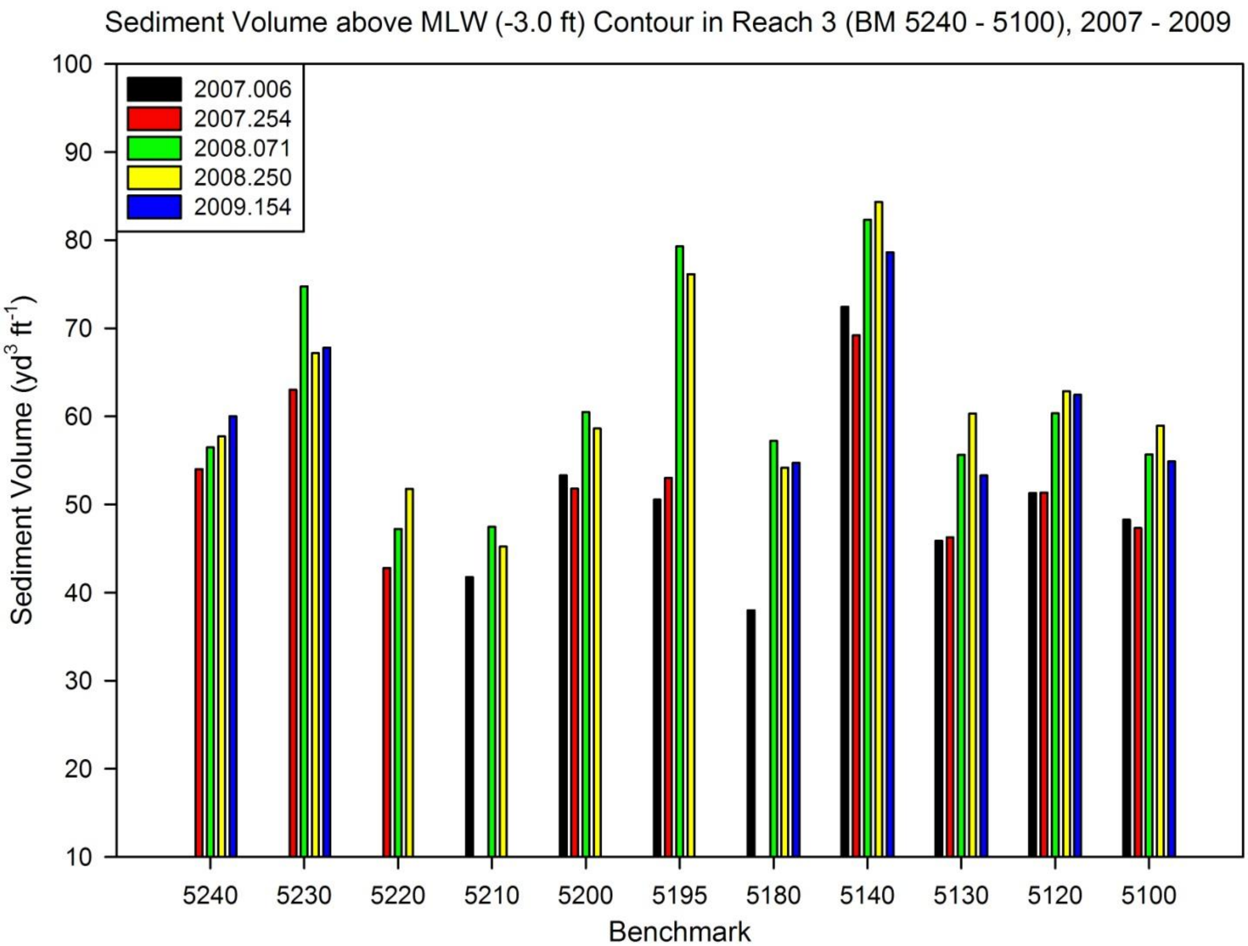
Appendix 8: Reach 3 Beach Profile Volume Bar Graphs


Sediment Volume above MHW (2.1 ft) Contour in Reach 3 (BM 5240 - 5100), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
5240
5230
5220
5210
5200
5195
5180
5140
5130
5120
5100
Benchmark

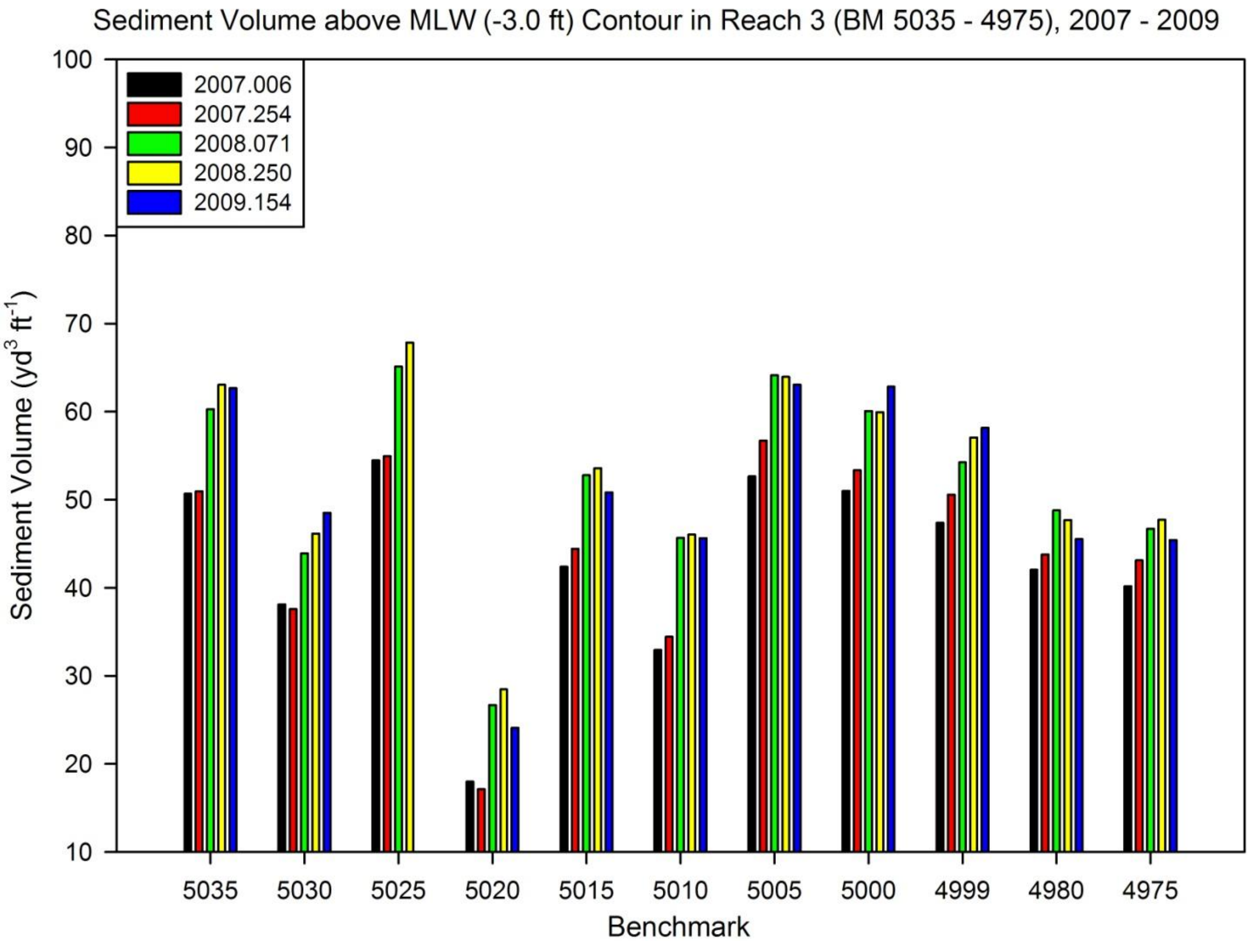


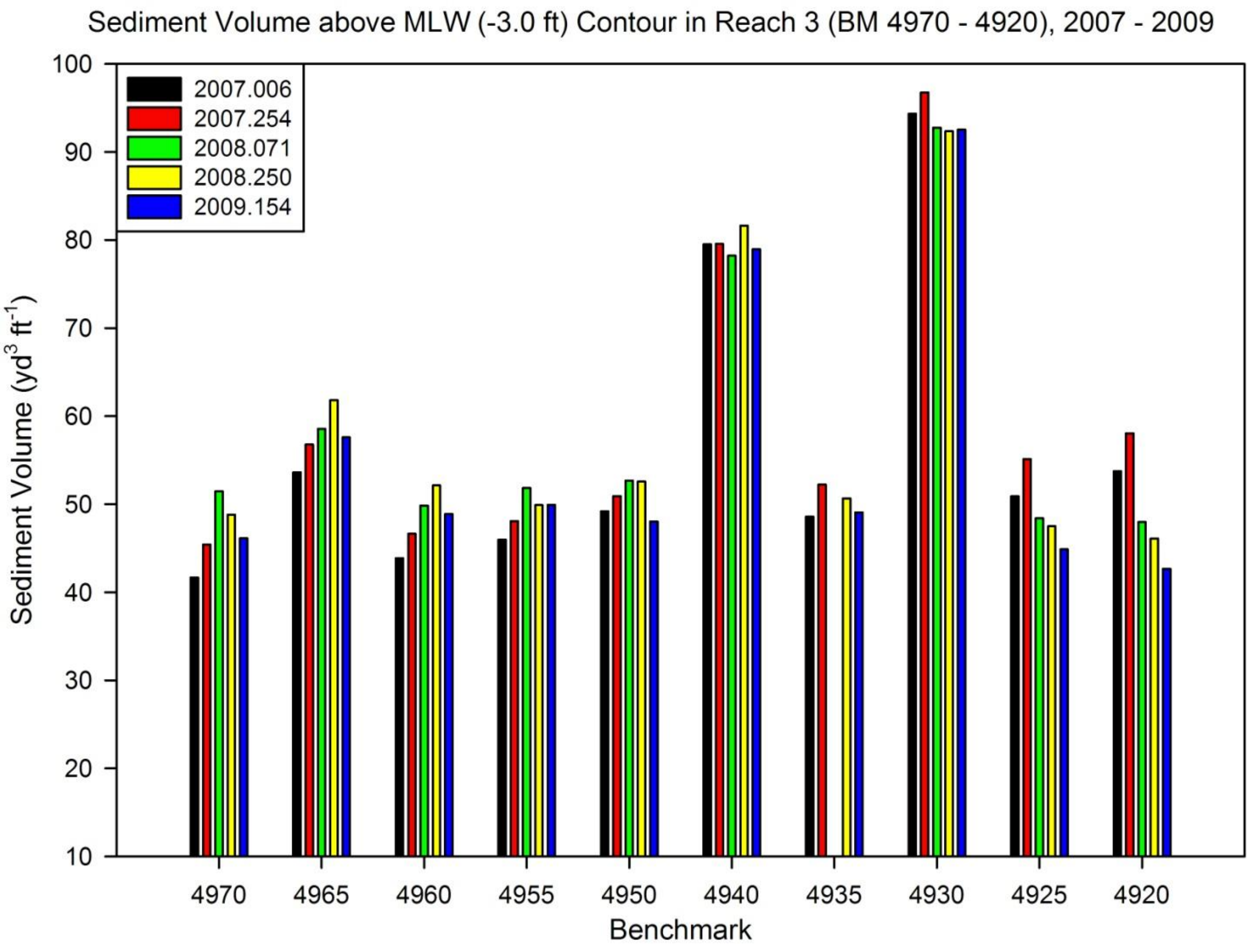
Sediment Volume above MHW (2.1 ft) Contour in Reach 3 (BM 5035 - 4975), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4975
Benchmark

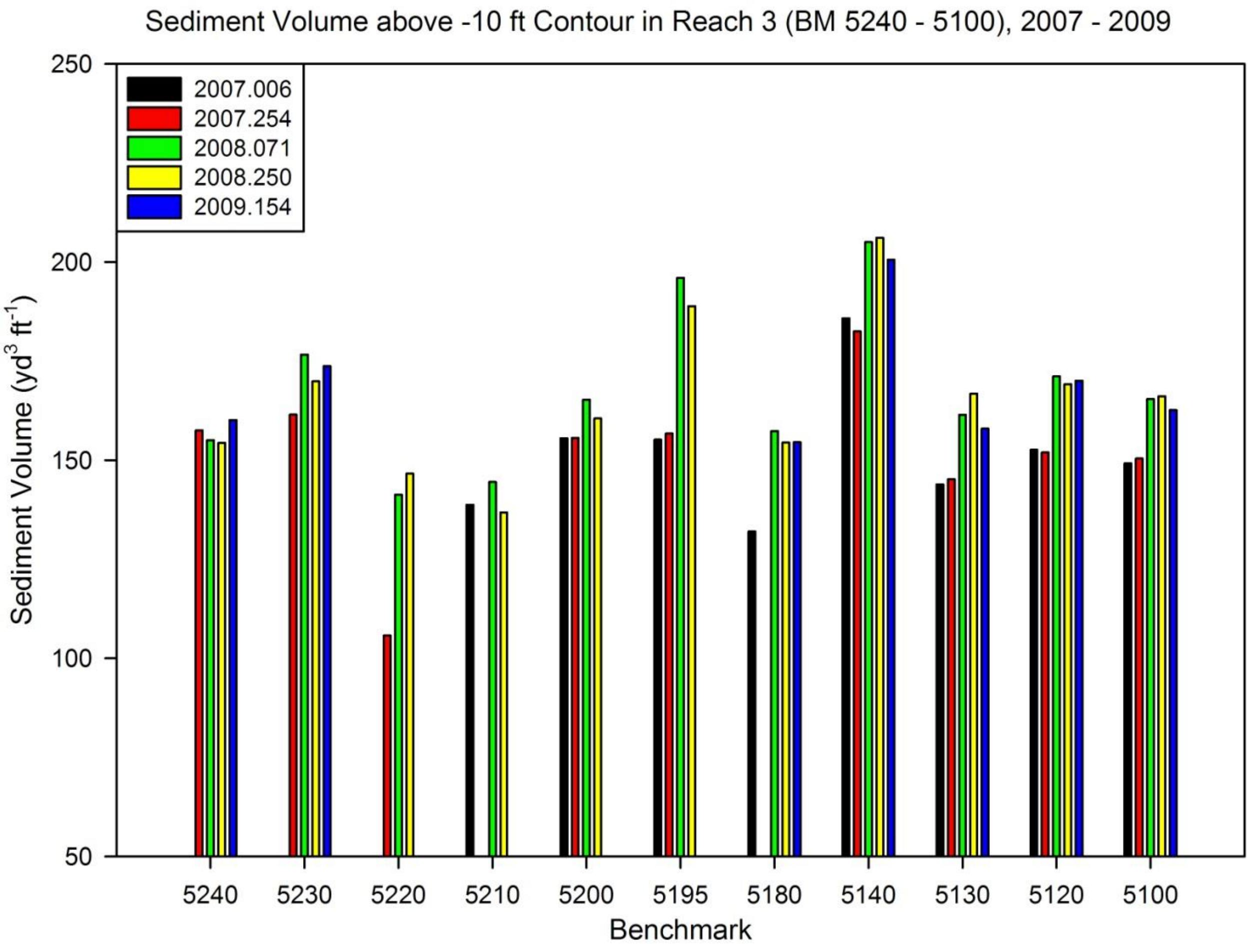

Sediment Volume above MHW (2.1 ft) Contour in Reach 3 (BM 4970 - 4920), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
0
10
20
30
40
50
4970
4965
4960
4955
4950
4940
4935
4930
4925
4920
Benchmark

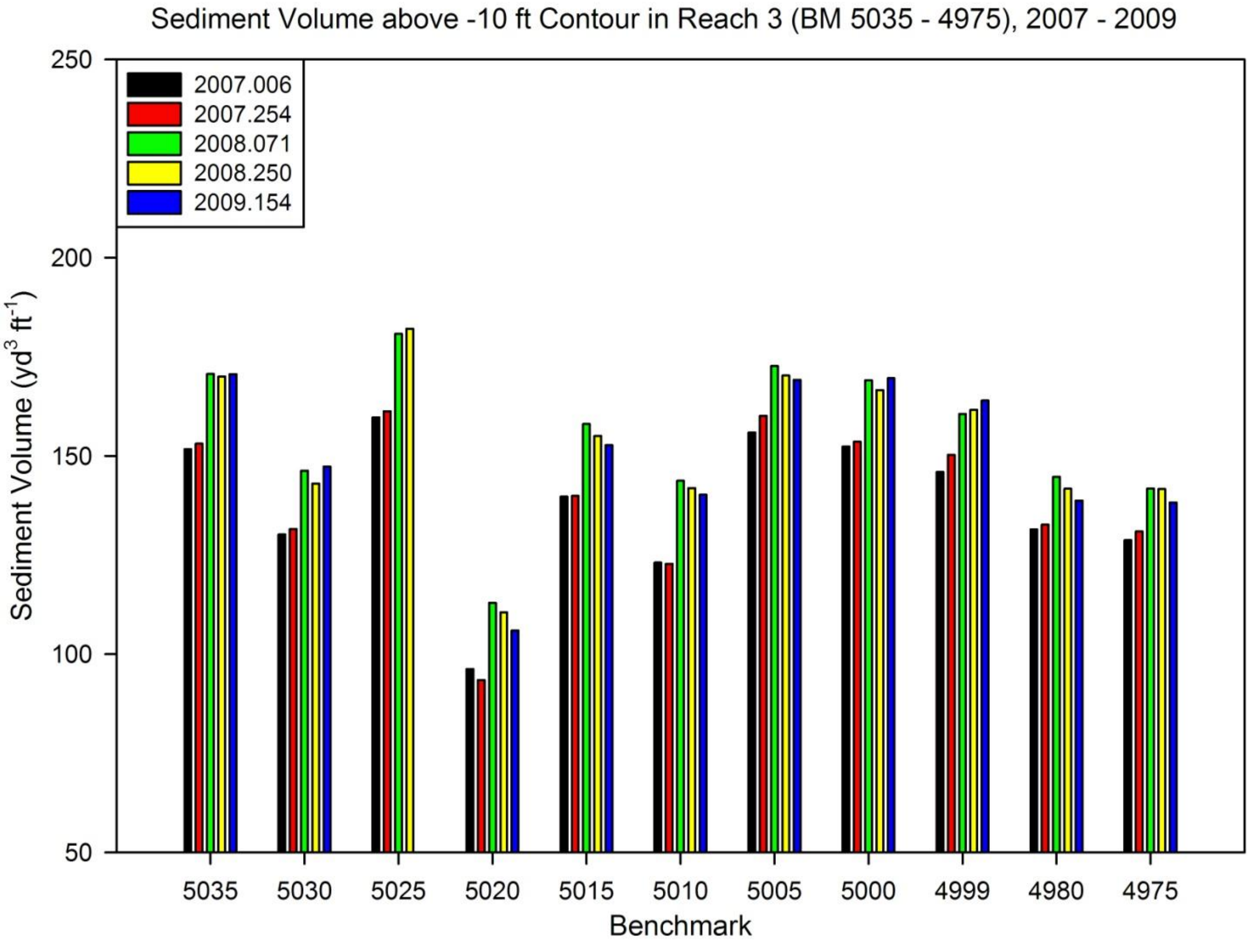


Sediment Volume above MLW (-3.0 ft) Contour in Reach 3 (BM 5240 - 5100), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
100
90
80
70
60
50
40
30
20
10
5240
5230
5220
5210
5200
5195
5180
5140
5130
5120
5100
Benchmark

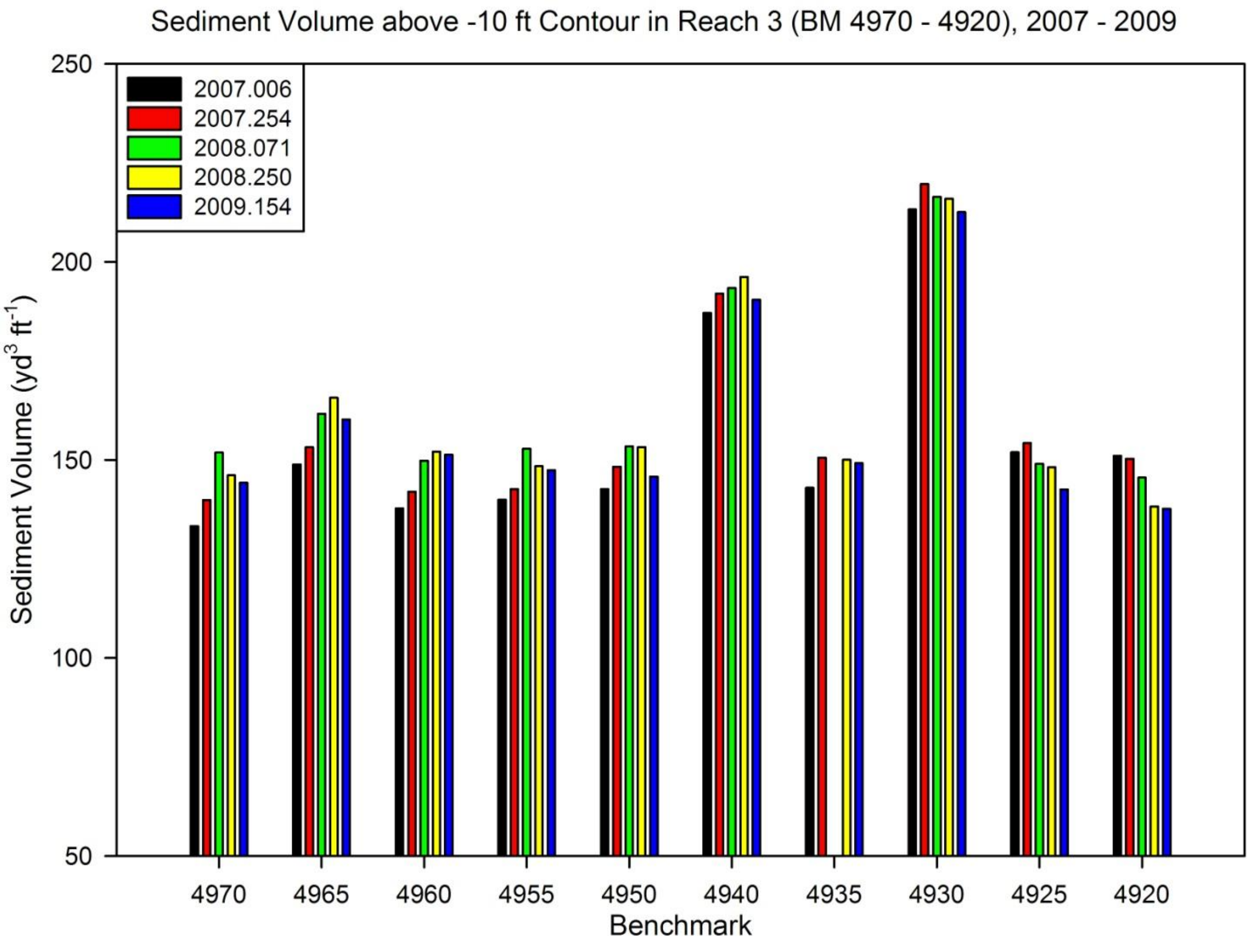

Sediment Volume above MLW (-3.0 ft) Contour in Reach 3 (BM 5035 - 4975), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
100
90
80
70
60
50
40
30
20
10
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4975
Benchmark


Sediment Volume above MLW (-3.0 ft) Contour in Reach 3 (BM 4970 - 4920), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd3 ft-1)
Benchmark
4970
4965
4960
4955
4950
4940
4935
4930
4925
4920
10
20
30
40
50
60
70
80
90
100

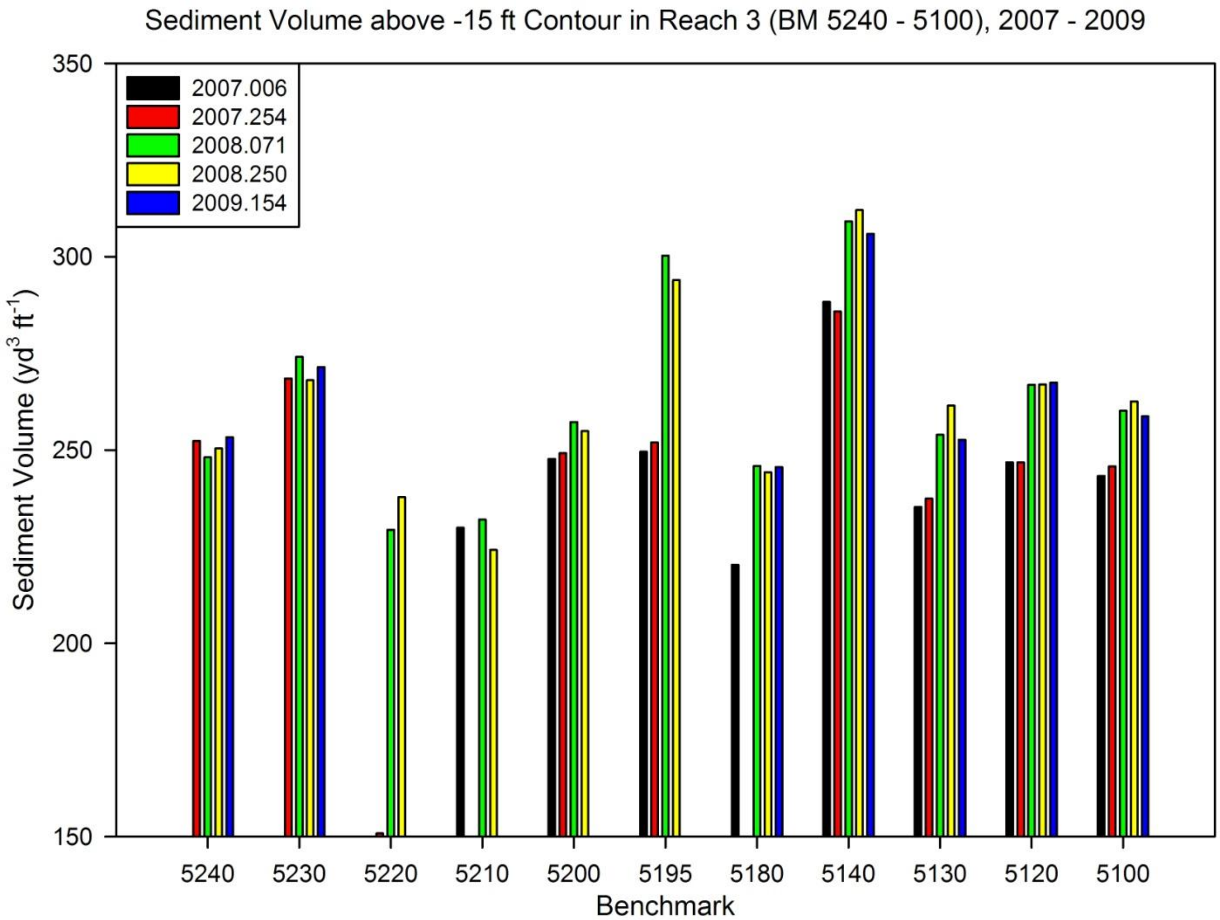

Sediment Volume above -10 ft Contour in Reach 3 (BM 5240 - 5100), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
250
200
150
100
50
5240
5230
5220
5210
5200
5195
5180
5140
5130
5120
5100
Benchmark

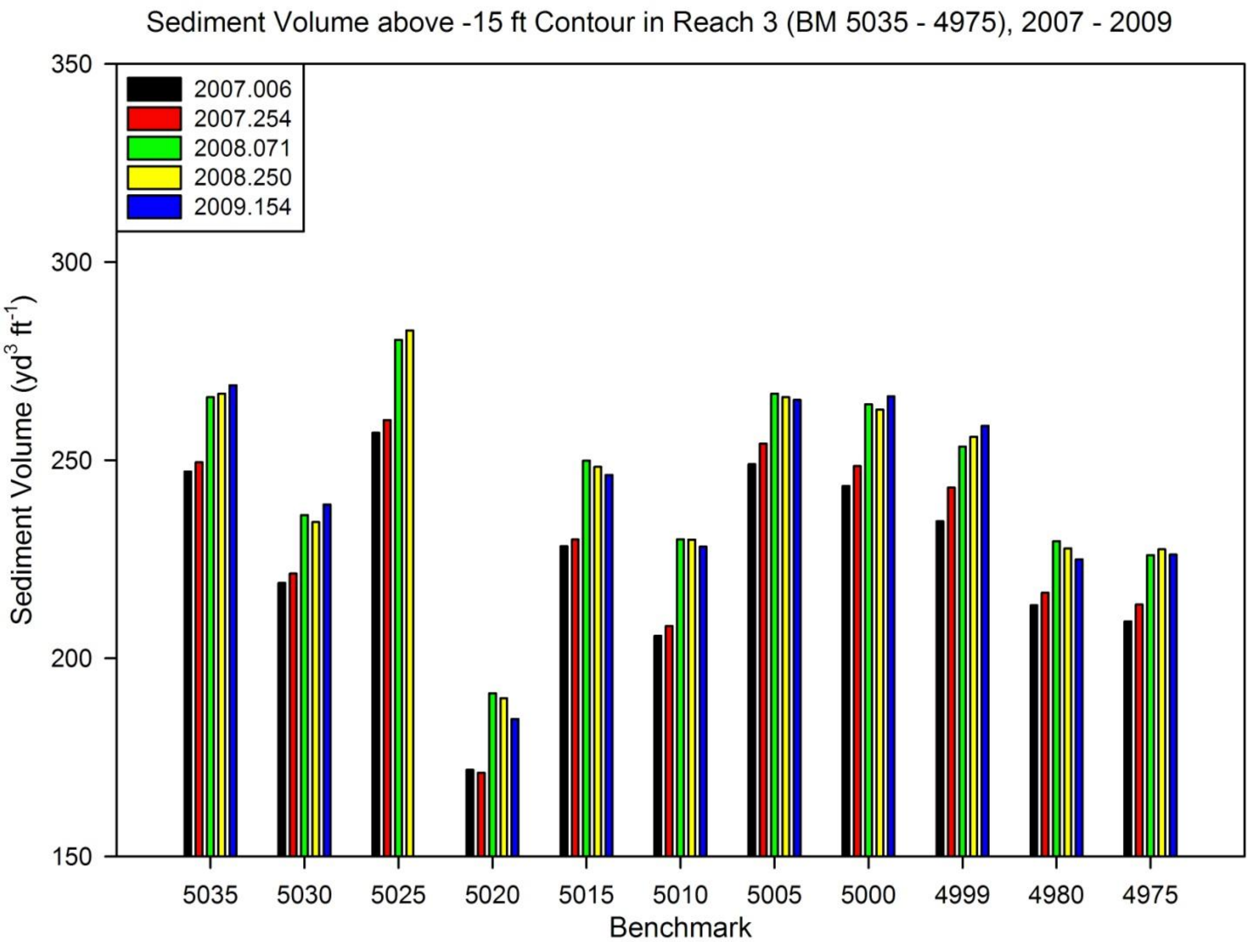


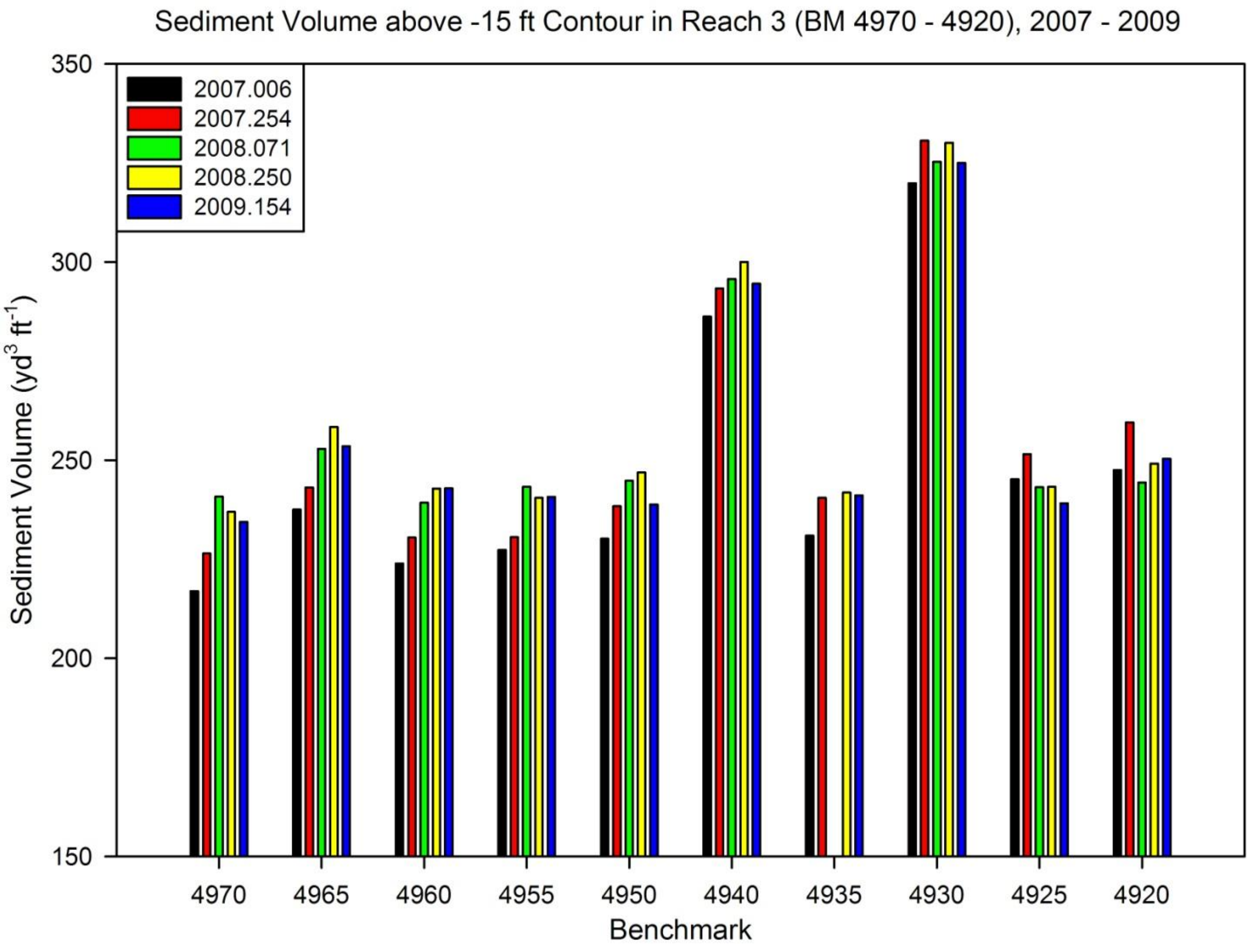
Sediment Volume above -10 ft Contour in Reach 3 (BM 5035 - 4975), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
250
200
150
100
50
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4975
Benchmark



Sediment Volume above -10 ft Contour in Reach 3 (BM 4970 - 4920), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
250
200
150
100
50
4970
4965
4960
4955
4950
4940
4935
4930
4925
4920
Benchmark

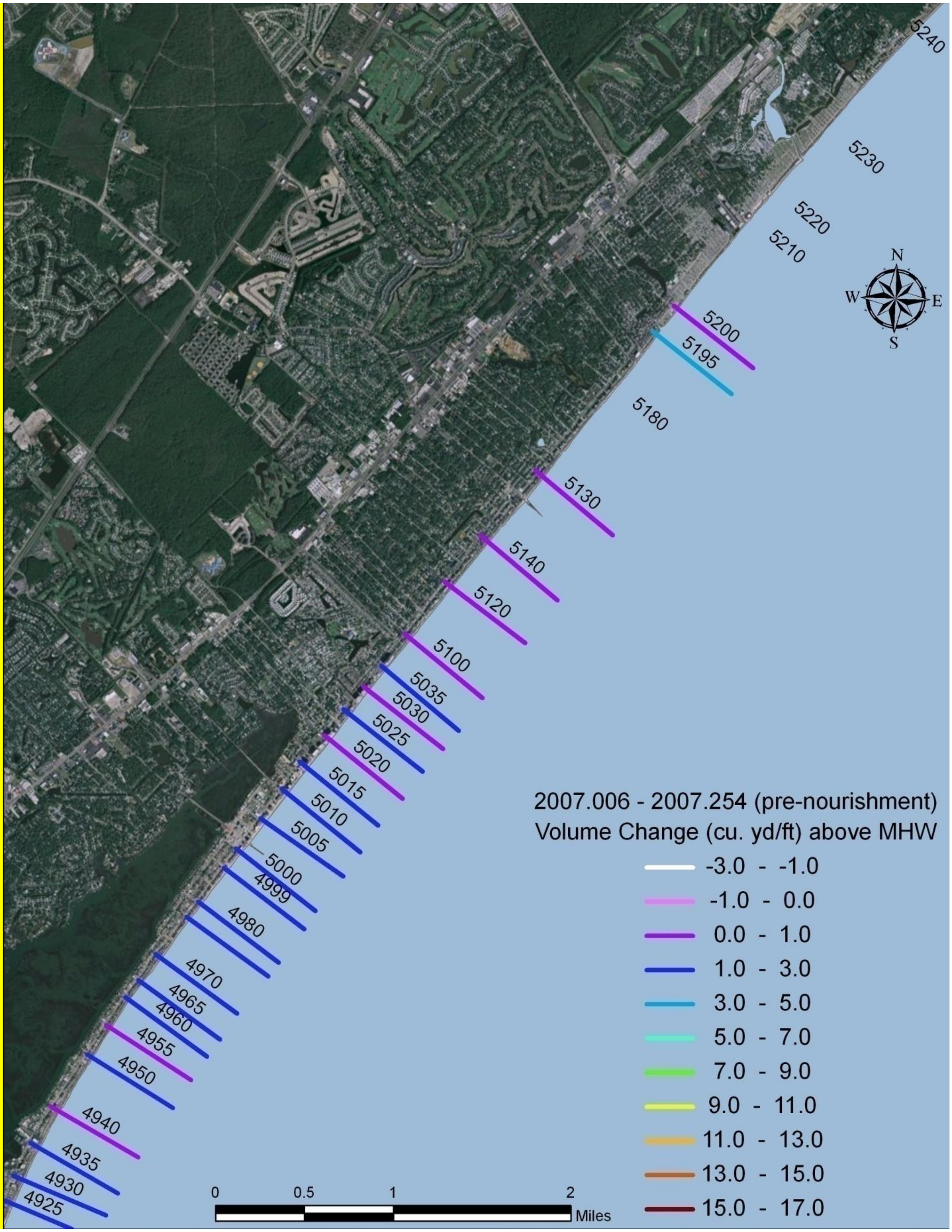

Sediment Volume above -15 ft Contour in Reach 3 (BM 5240 - 5100), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
350
300
250
200
150
5240
5230
5220
5210
5200
5195
5180
5140
5130
5120
5100
Benchmark


Sediment Volume above -15 ft Contour in Reach 3 (BM 5035 - 4975), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd^3 ft^{-1})
350
300
250
200
150
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4975
Benchmark

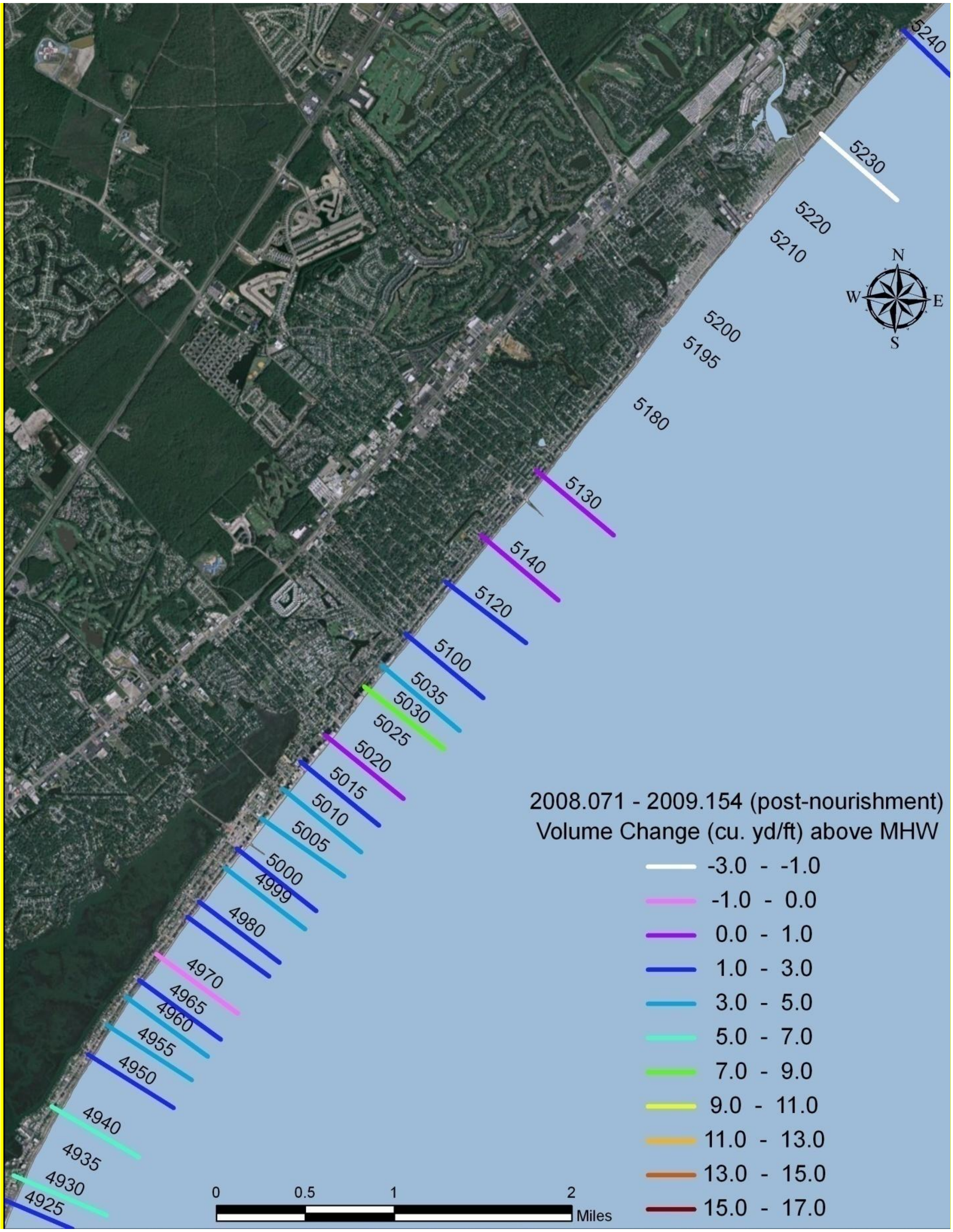


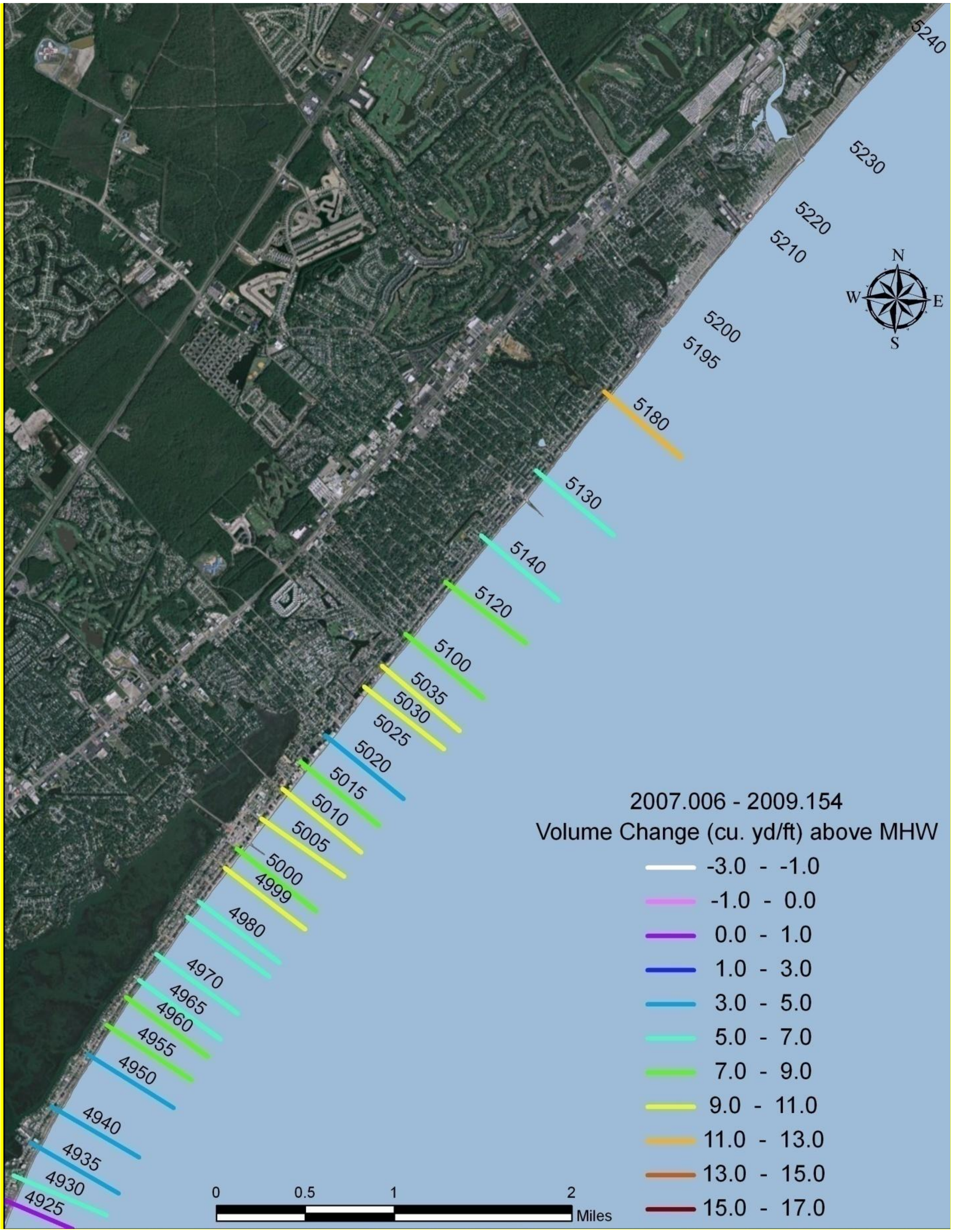
Sediment Volume above -15 ft Contour in Reach 3 (BM 4970 - 4920), 2007 - 2009
2007.006
2007.254
2008.071
2008.250
2009.154
Sediment Volume (yd³ ft⁻¹)
350
300
250
200
150
4970
4965
4960
4955
4950
4940
4935
4930
4925
4920
Benchmark

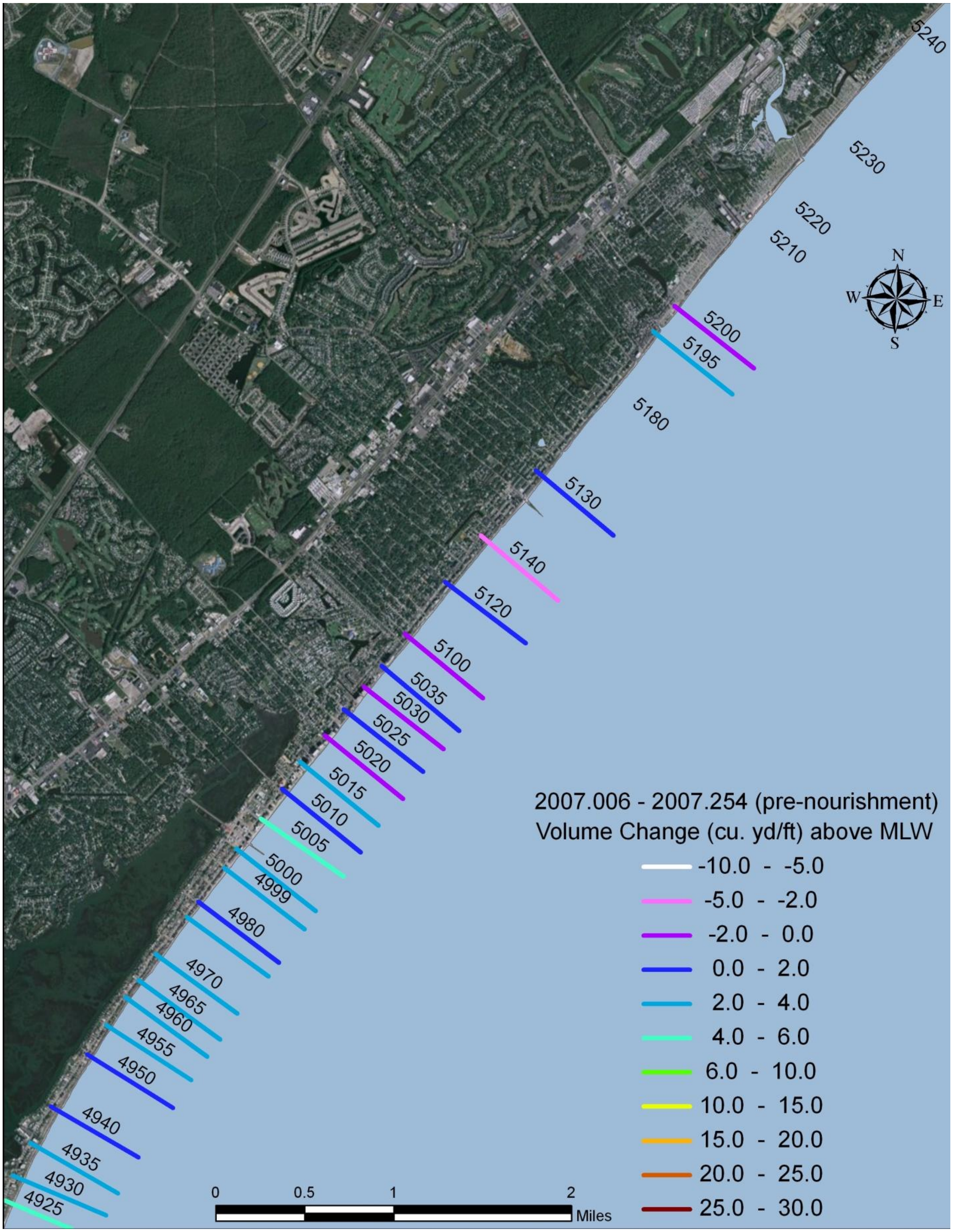
Appendix 9: Reach 3 Beach Profile Volume Change Map View

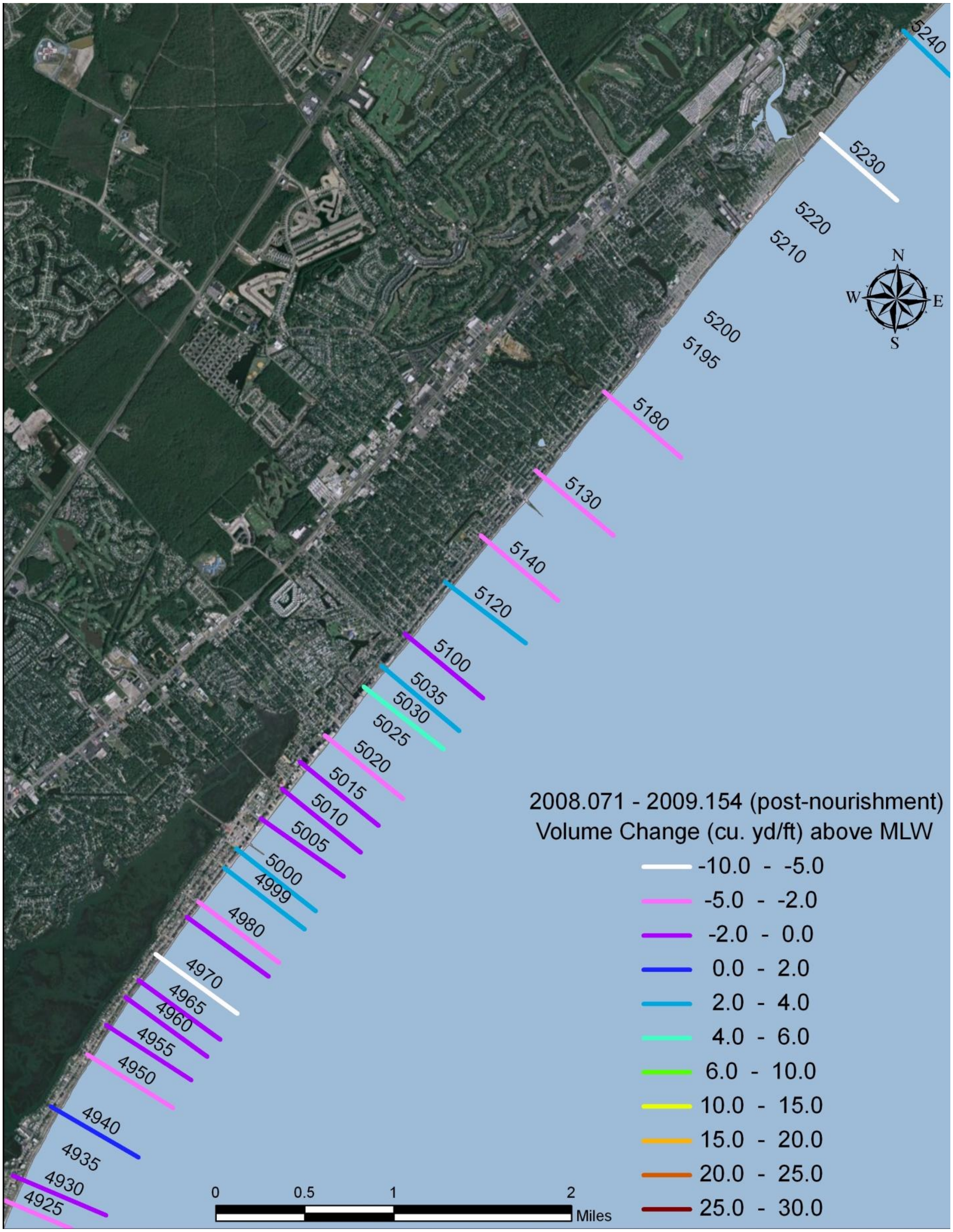


5240
5230
5220
5210
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2007.006 - 2007.254 (pre-nourishment)
Volume Change (cu. yd/ft) above MHW
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 9.0
9.0 - 11.0
11.0 - 13.0
13.0 - 15.0
15.0 - 17.0


5240
5230
5220
5210
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2008.071 - 2009.154 (post-nourishment)
Volume Change (cu. yd/ft) above MHW
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 9.0
9.0 - 11.0
11.0 - 13.0
13.0 - 15.0
15.0 - 17.0


5240
5230
5220
5210
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2007.006 - 2009.154
Volume Change (cu. yd/ft) above MHW
-3.0 - -1.0
-1.0 - 0.0
0.0 - 1.0
1.0 - 3.0
3.0 - 5.0
5.0 - 7.0
7.0 - 9.0
9.0 - 11.0
11.0 - 13.0
13.0 - 15.0
15.0 - 17.0


5240
5230
5220
5210
N
W
E
S
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
0
0.5
1
2
Miles
2007.006 - 2007.254 (pre-nourishment)
Volume Change (cu. yd/ft) above MLW
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0



5240
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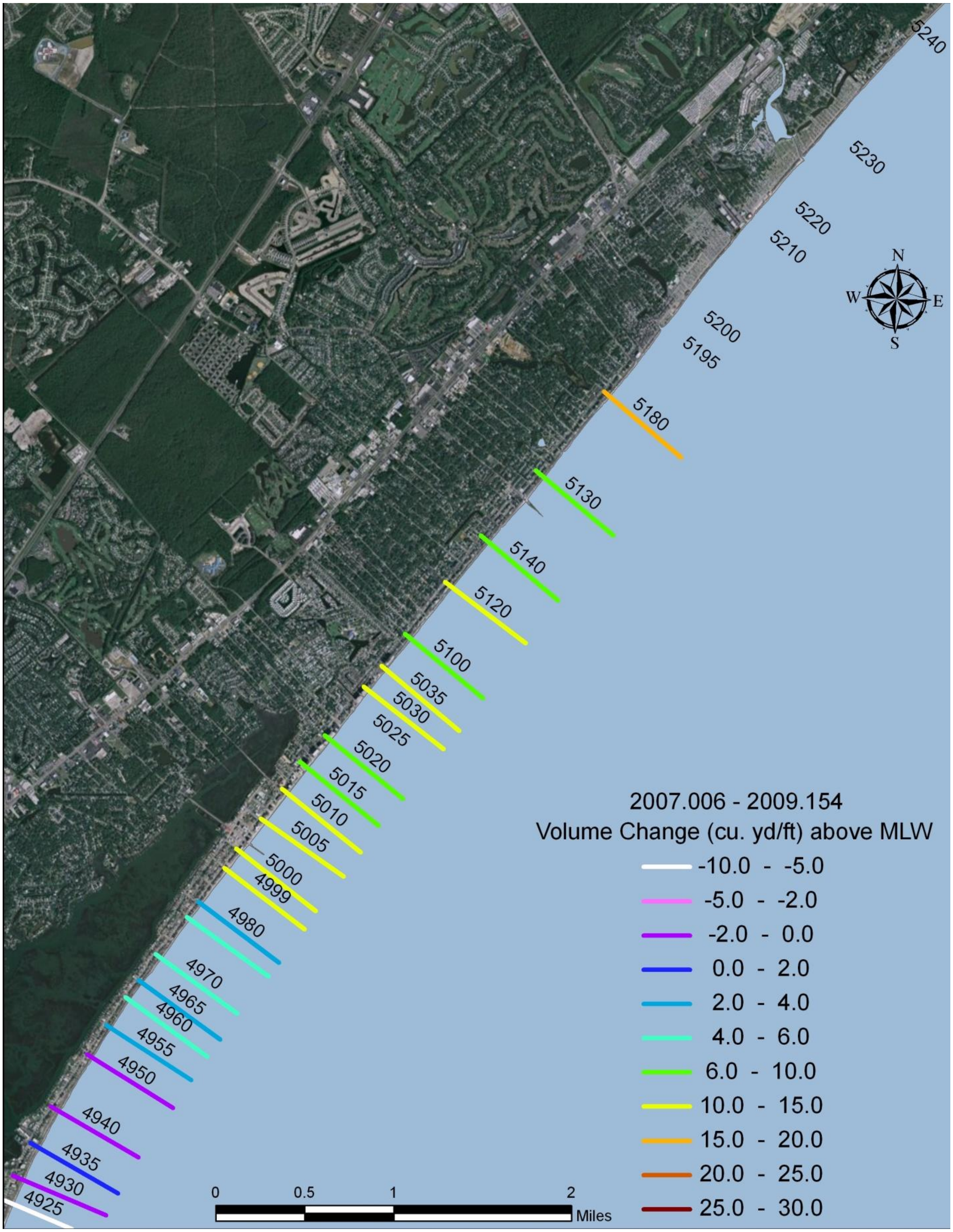
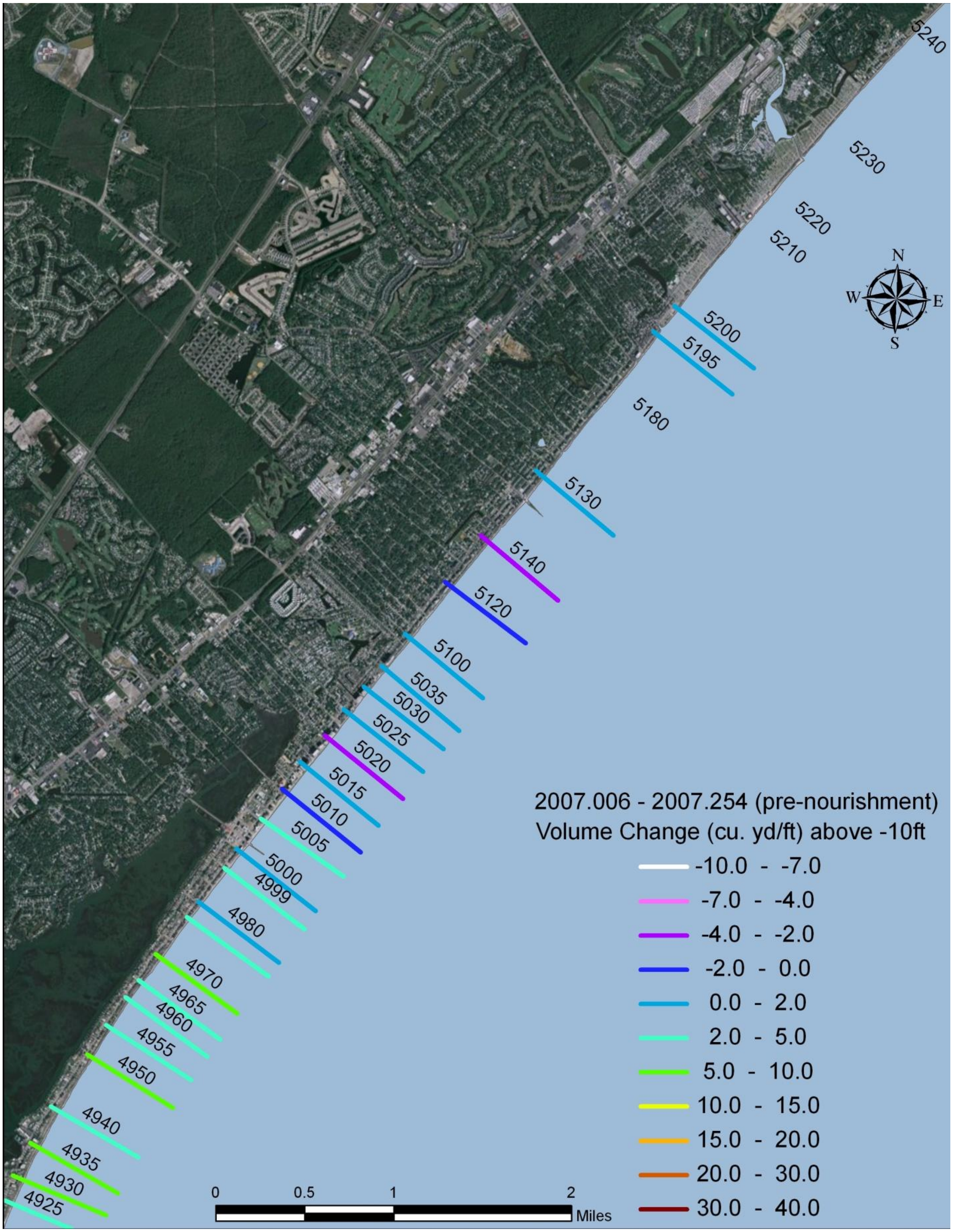
5220
5210
N
W
E
S
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
2008.071 - 2009.154 (post-nourishment)
Volume Change (cu. yd/ft) above MLW
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
0
0.5
1
2
Miles



5240
5230
5220
5210
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2007.006 - 2009.154
Volume Change (cu. yd/ft) above MLW
-10.0 - -5.0
-5.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 6.0
6.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0



5240
5230
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5120
5100
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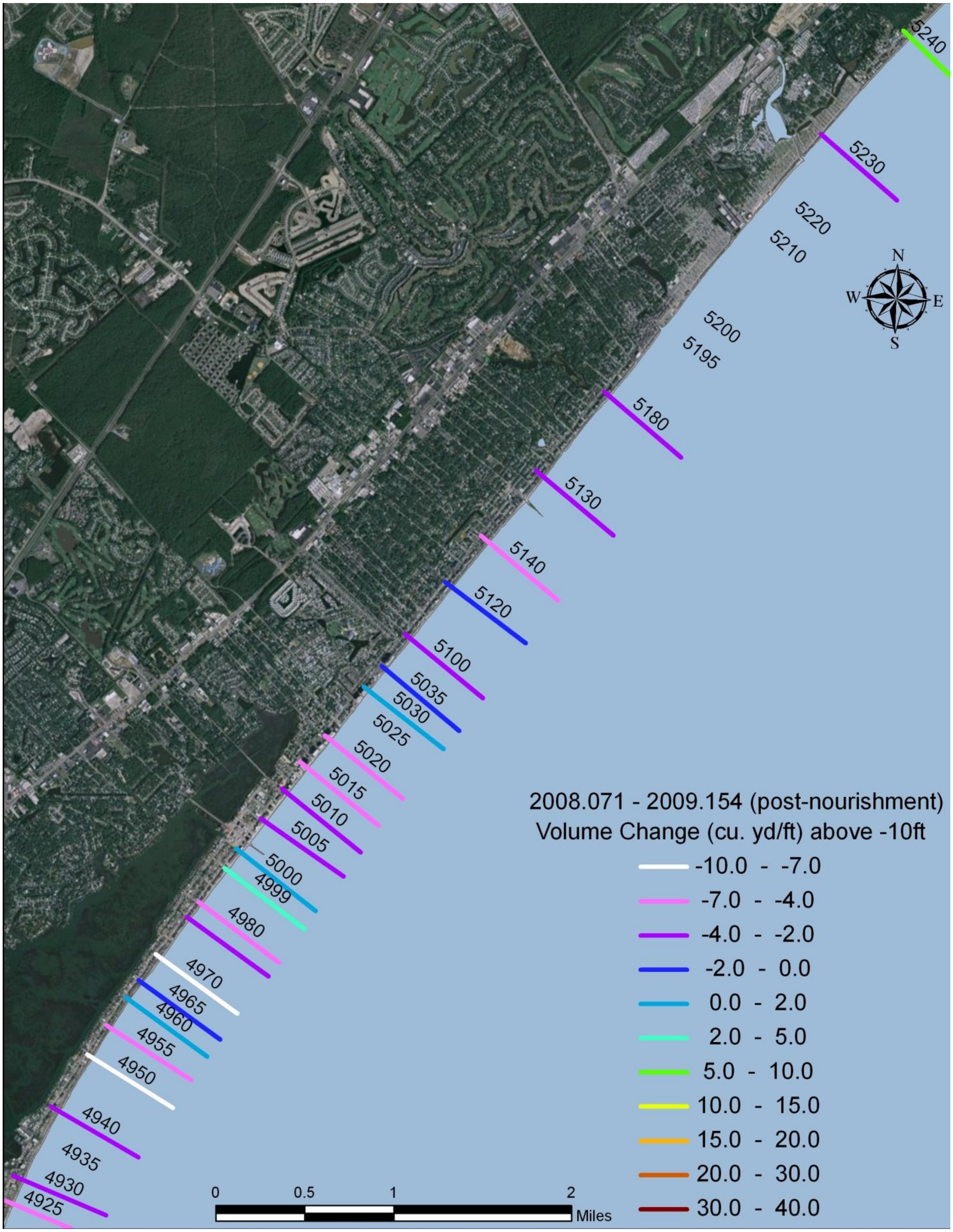
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
0
0.5
1
2
Miles
2007.006 - 2007.254 (pre-nourishment)
Volume Change (cu. yd/ft) above -10ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0



5240
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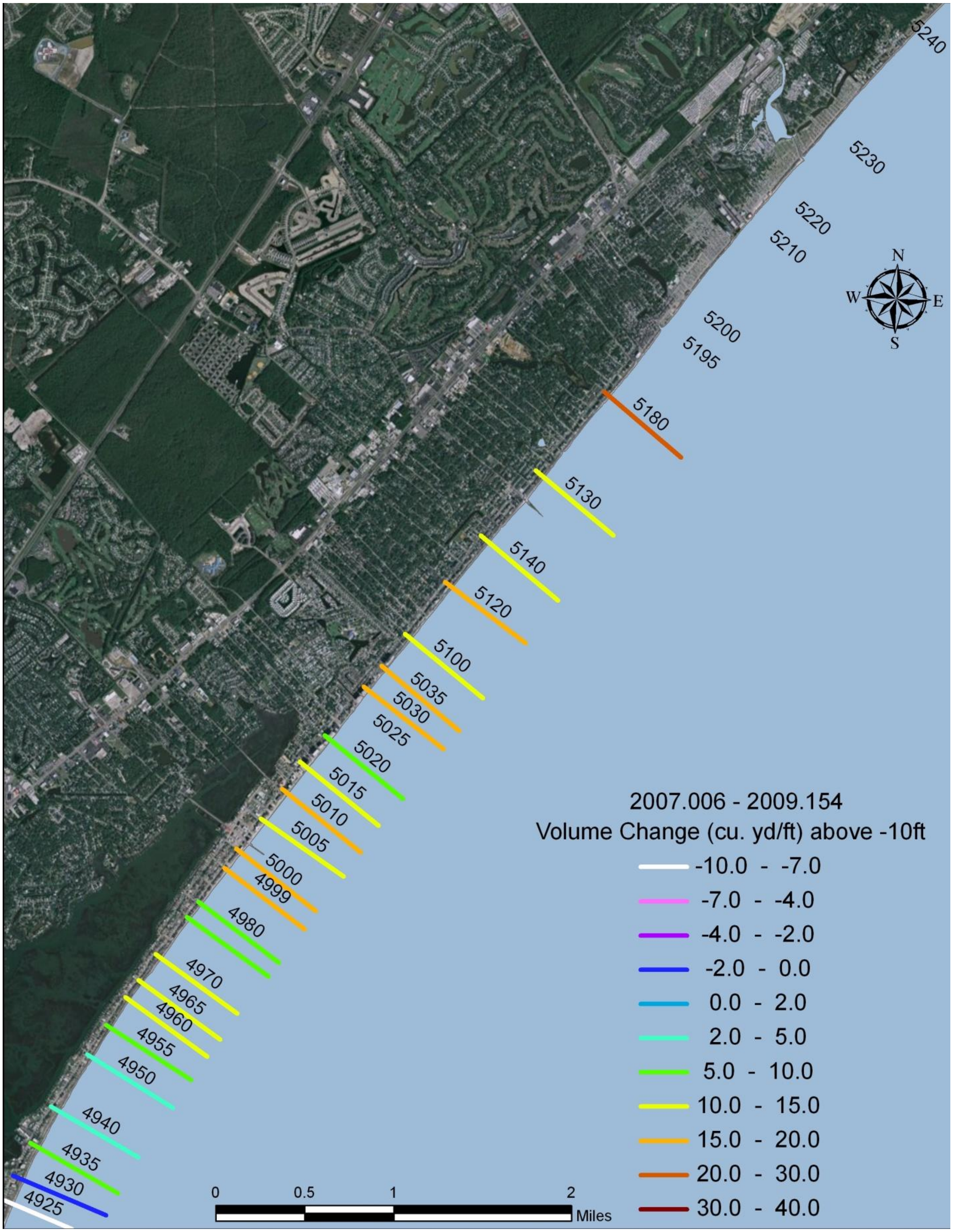
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
2008.071 - 2009.154 (post-nourishment)
Volume Change (cu. yd/ft) above -10ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
0
0.5
1
2
Miles



5240
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5210
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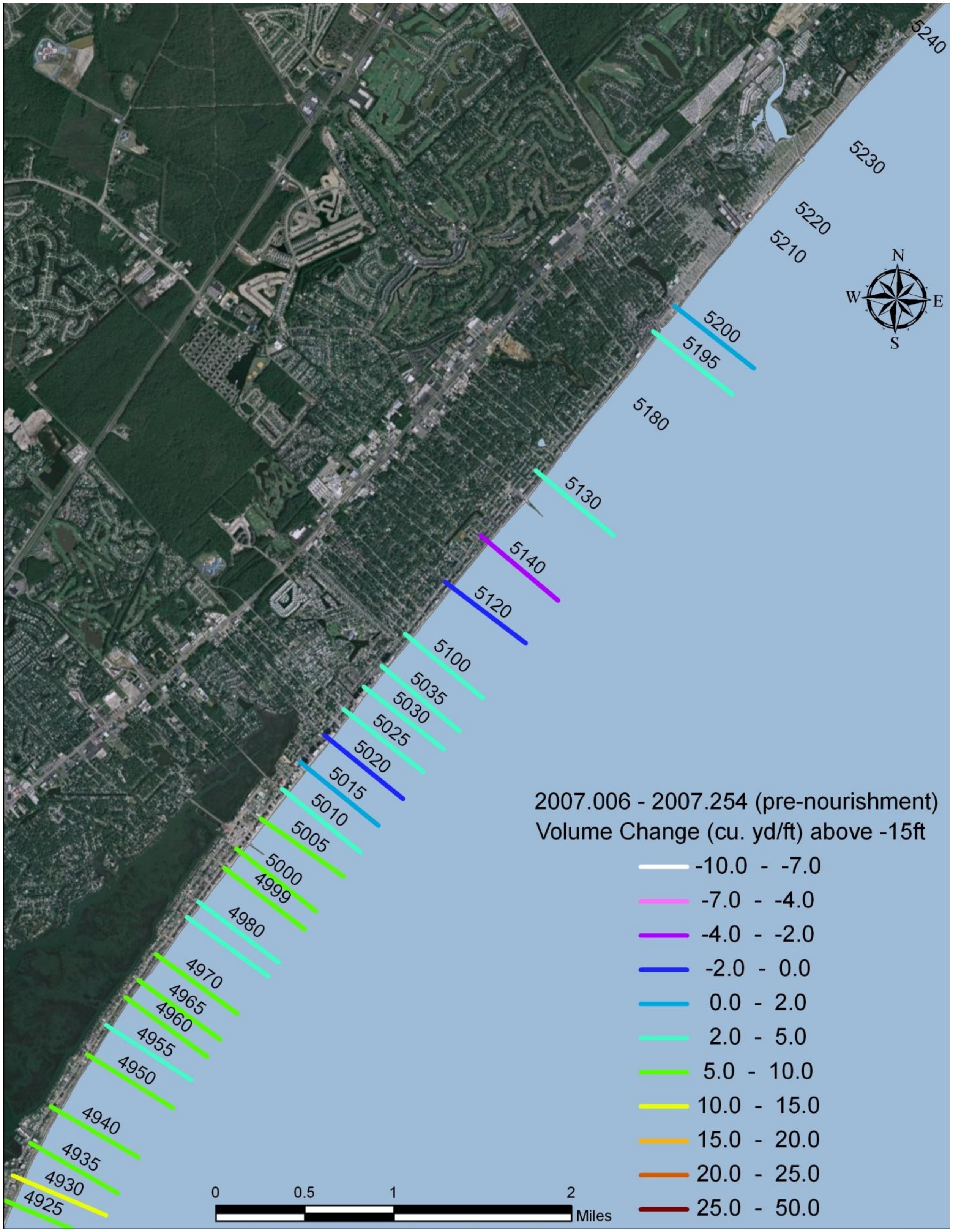
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2007.006 - 2009.154
Volume Change (cu. yd/ft) above -10ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0


5240
5230
5220
5210
N
W
E
S
5200
5195
5180
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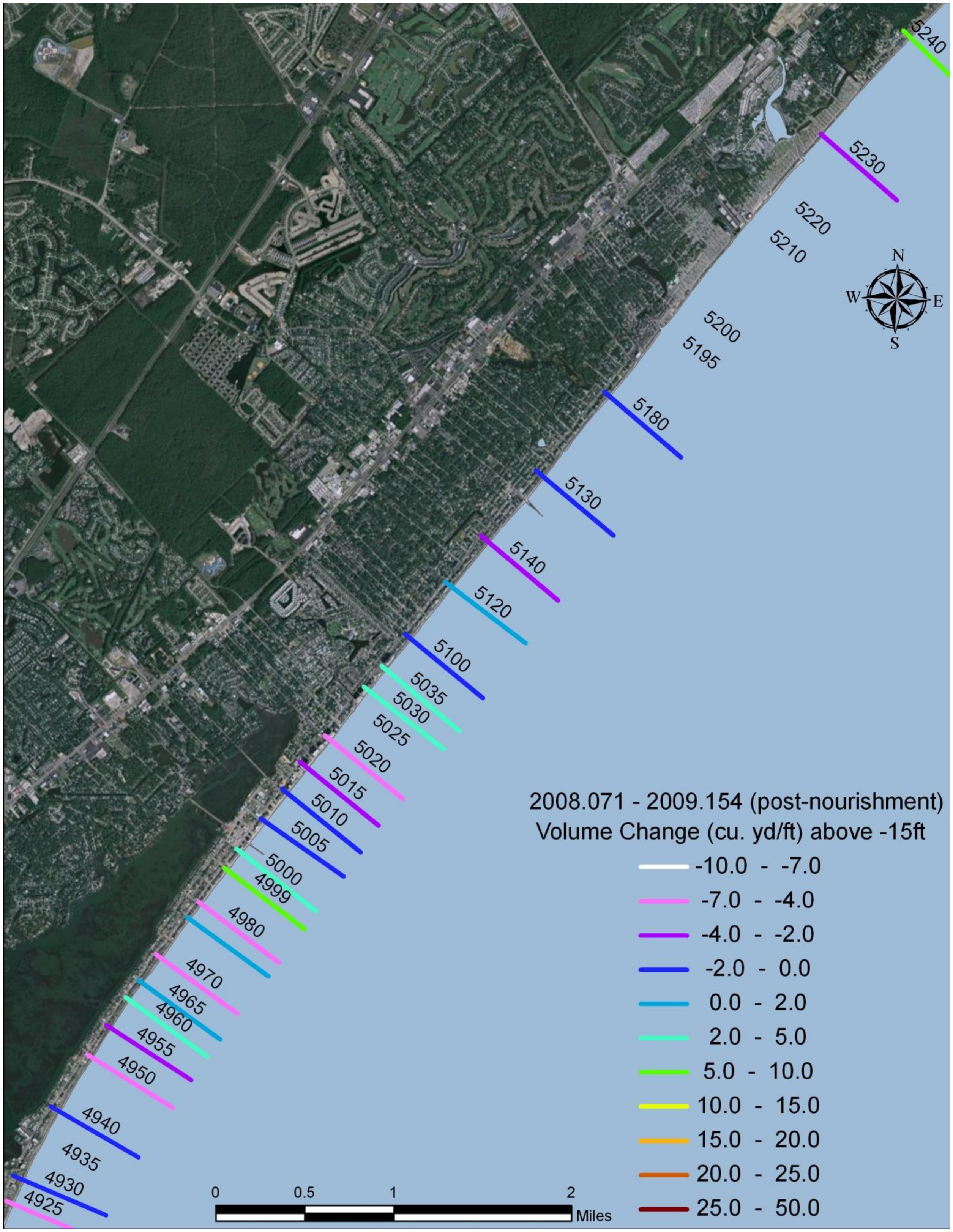
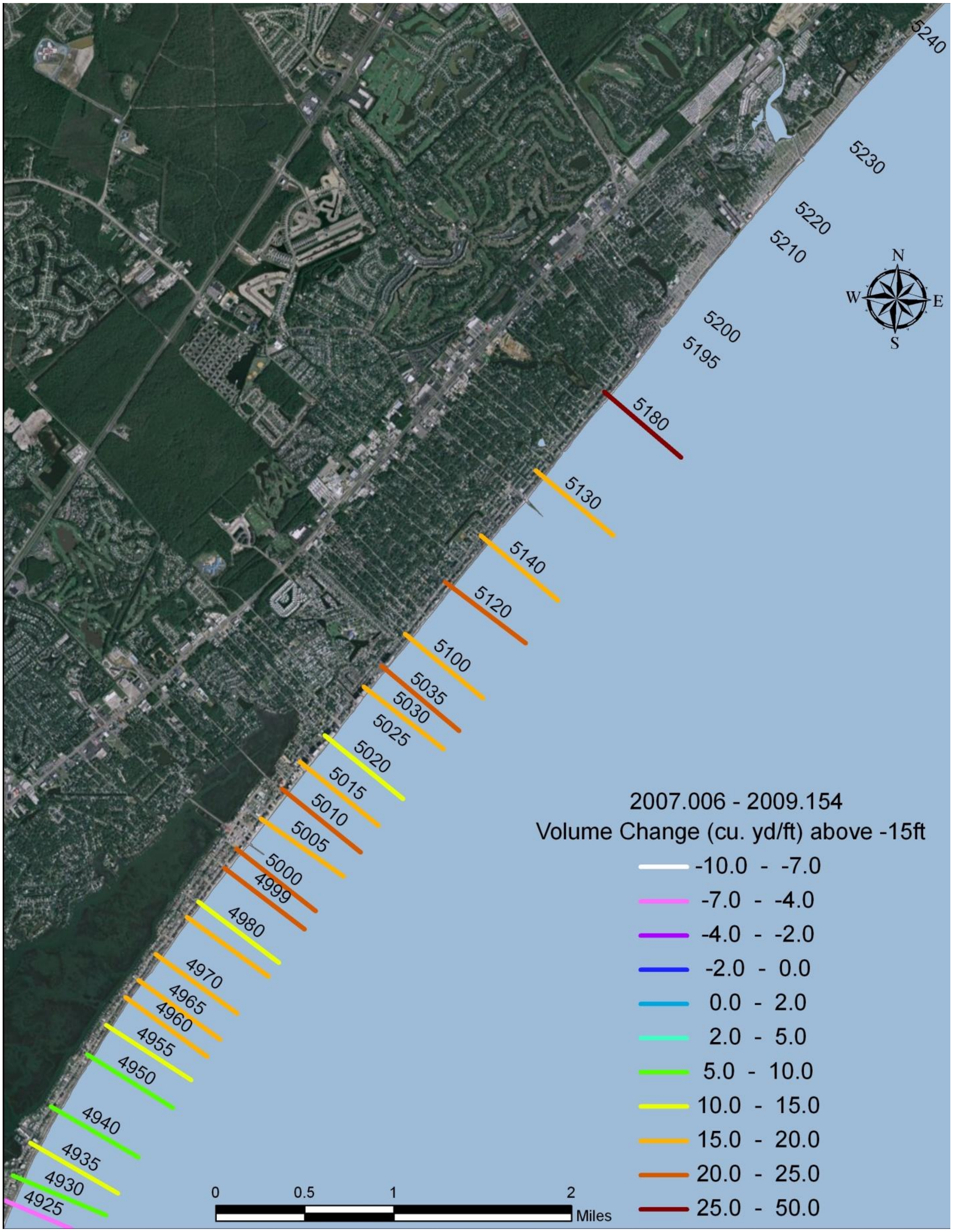
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
0
0.5
1
2
Miles
2007.006 - 2007.254 (pre-nourishment)
Volume Change (cu. yd/ft) above -15ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 50.0


5240
5230
5220
5210
N
W
E
S
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
2008.071 - 2009.154 (post-nourishment)
Volume Change (cu. yd/ft) above -15ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 50.0
0
0.5
1
2
Miles



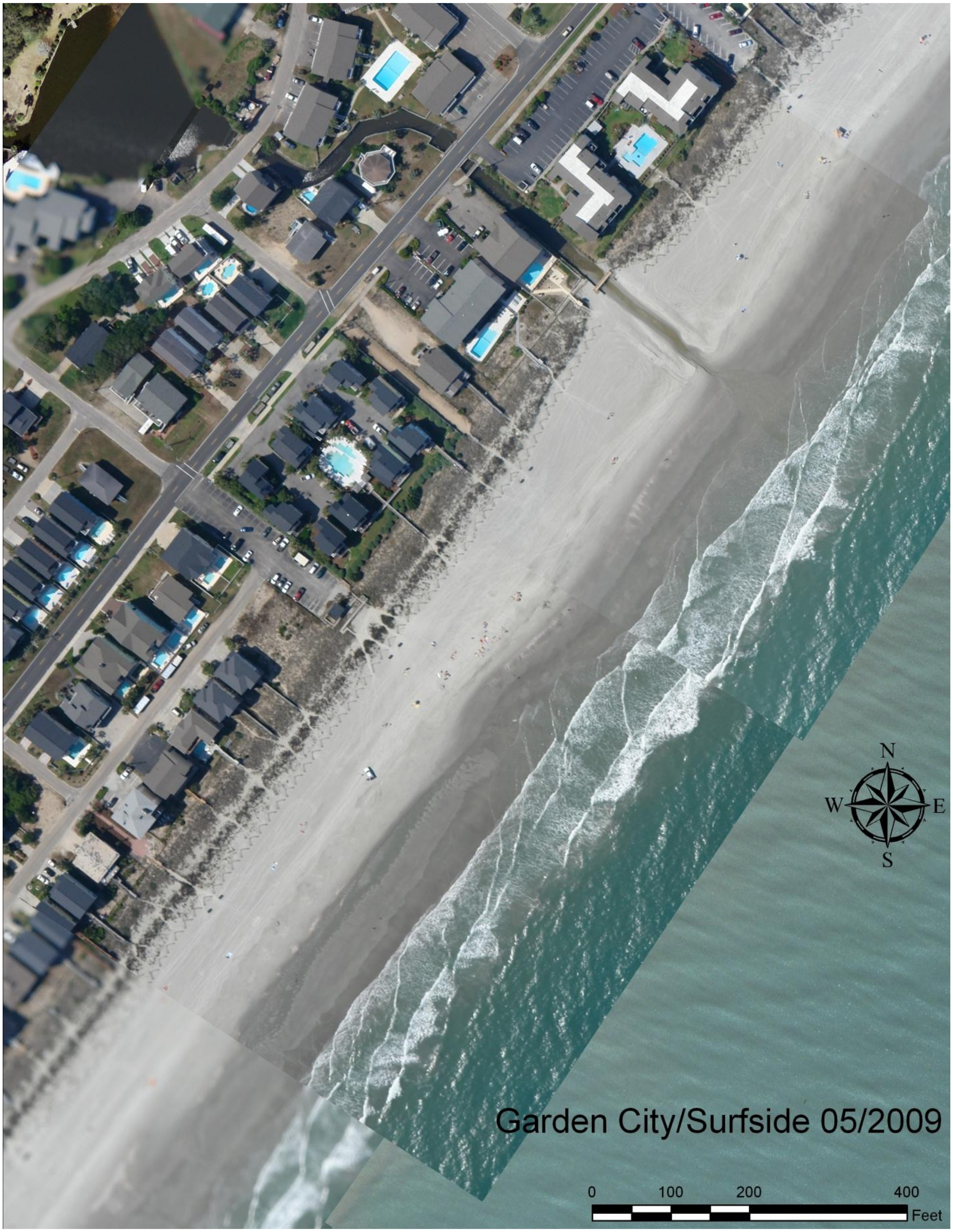
5240
5230
5220
5210
5200
5195
5180
5130
5140
5120
5100
5035
5030
5025
5020
5015
5010
5005
5000
4999
4980
4970
4965
4960
4955
4950
4940
4935
4930
4925
N
W
E
S
0
0.5
1
2
Miles
2007.006 - 2009.154
Volume Change (cu. yd/ft) above -15ft
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 50.0

Appendix 10: Reach 3 Time-Series Aerial Photography

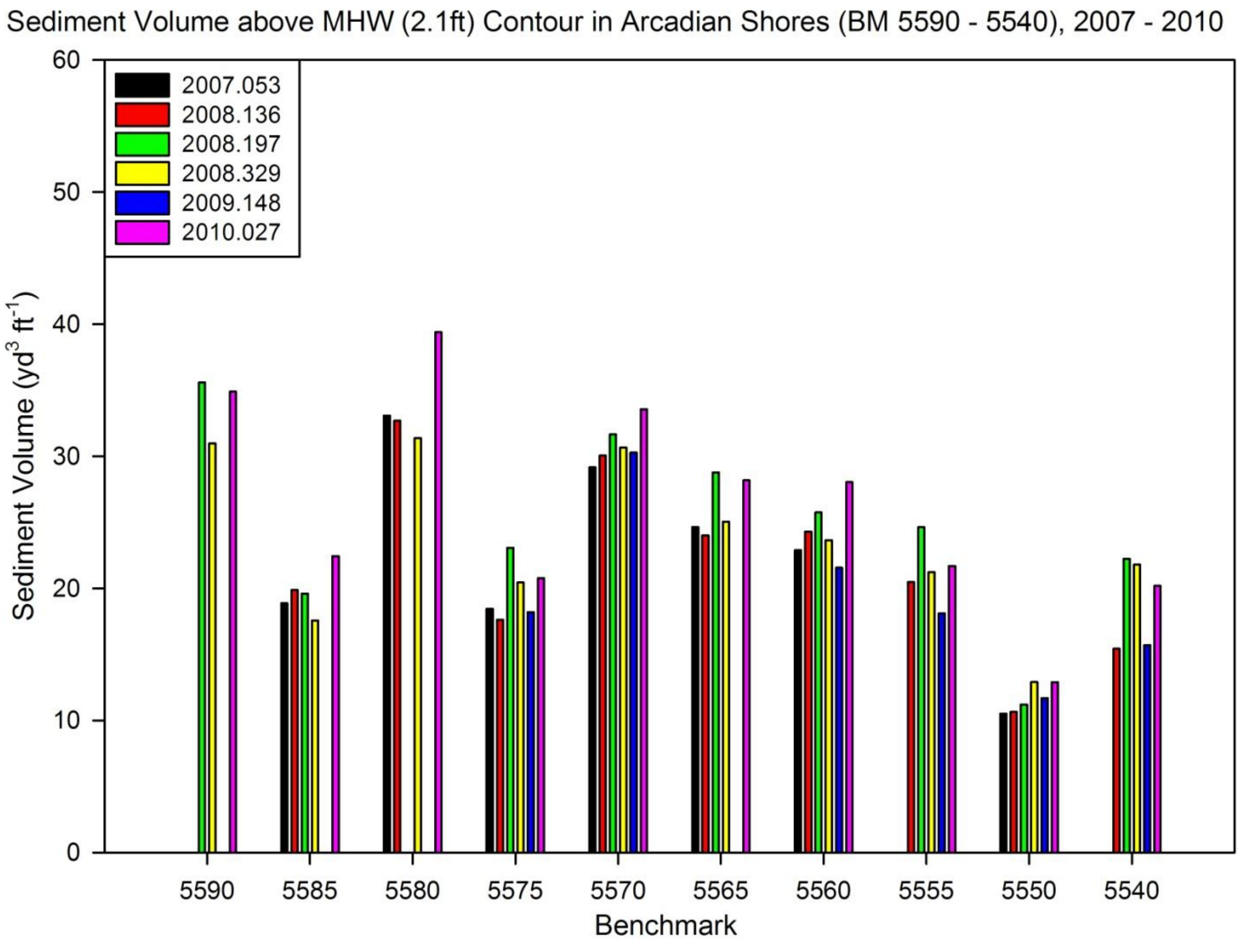

N
W
E
S
Garden City/Surfside 02/2008
0
100
200
400
Feet

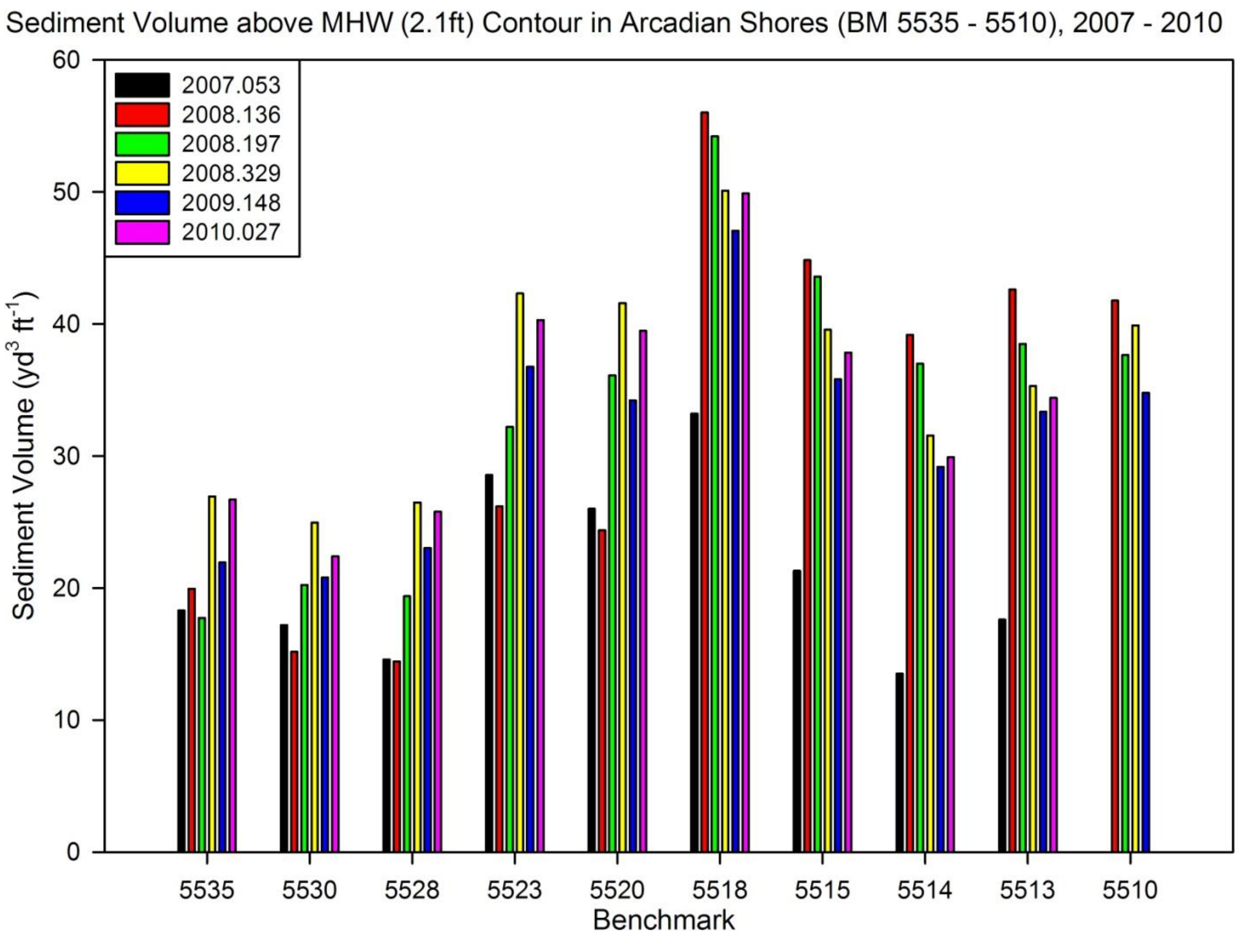

N
W
E
S
Garden City/Surfside 04/2008
0
100
200
400
Feet

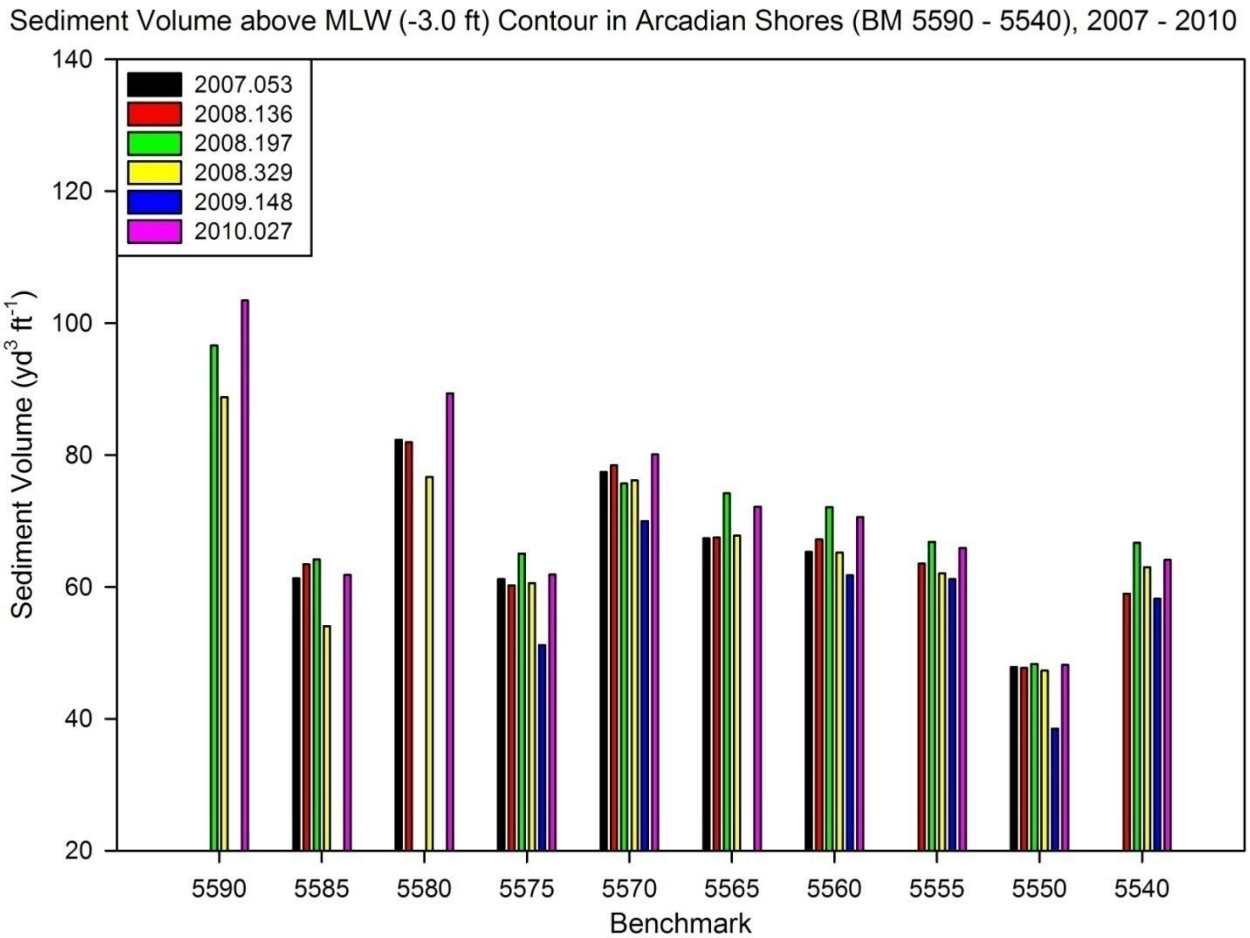

N
W
E
S
Garden City/Surfside 11/2008
0
100
200
400
Feet


N
W
E
S
Garden City/Surfside 05/2009
0
100
200
400
Feet

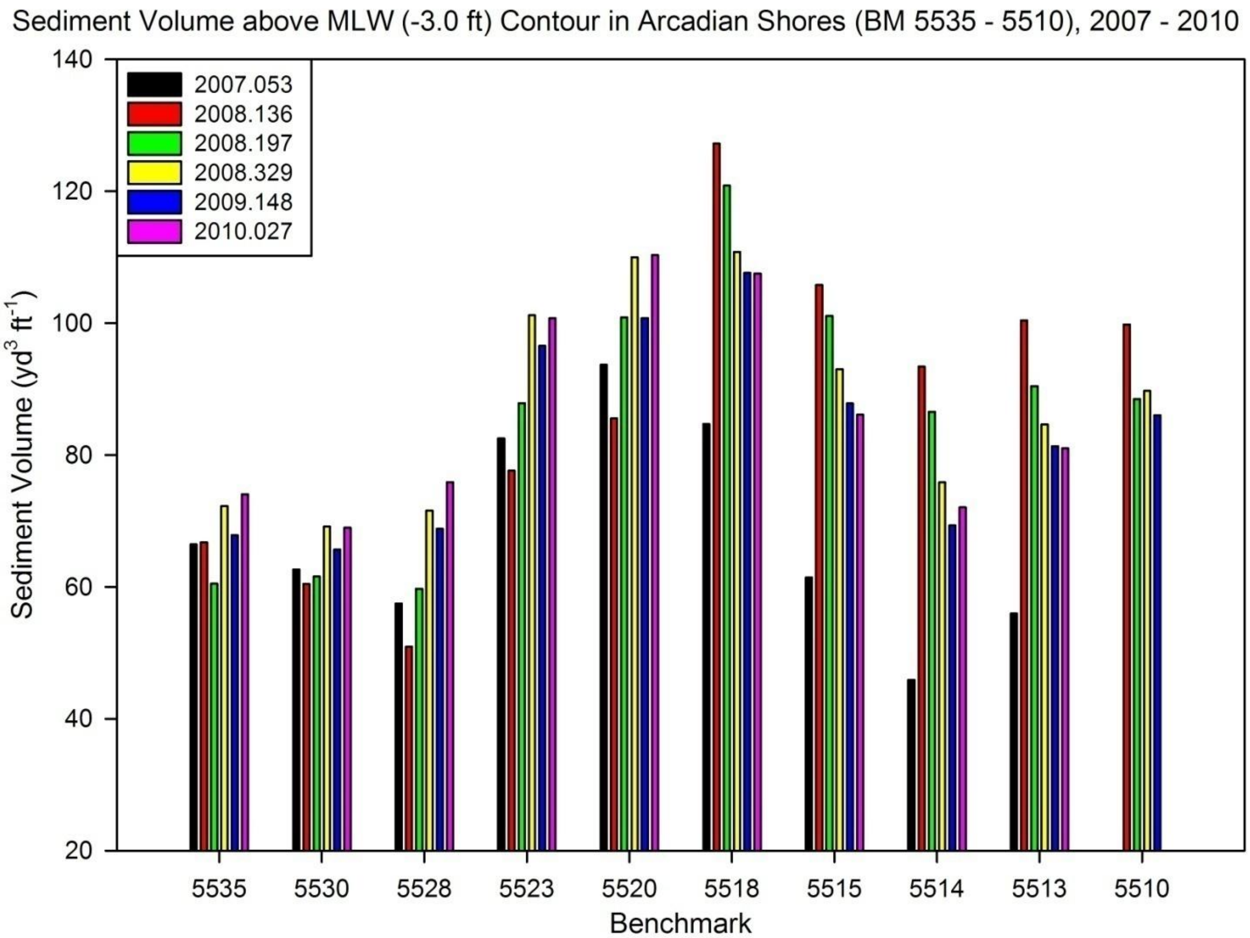
Appendix 11: Arcadian Shore Beach Profile Volume Bar Graphs

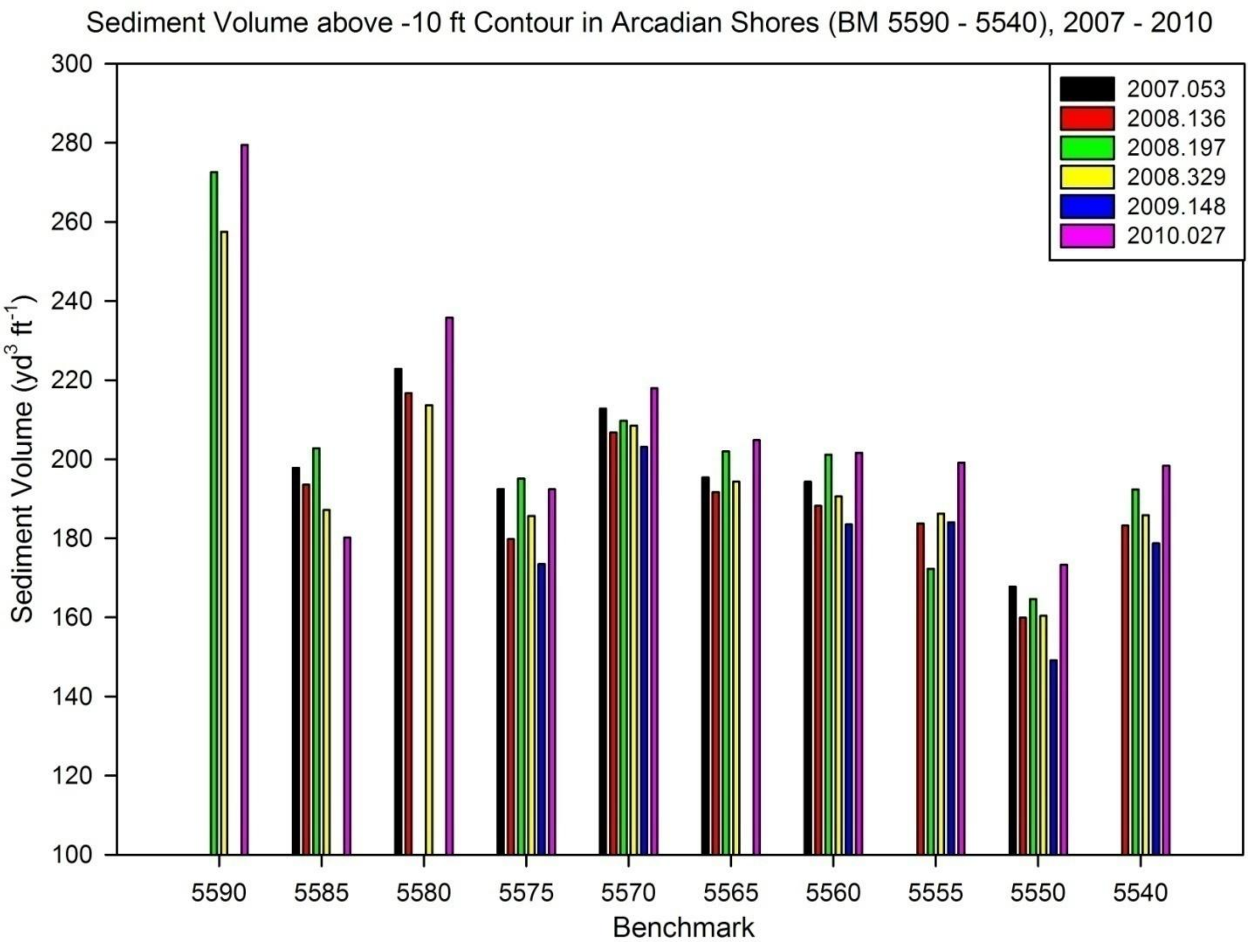

Sediment Volume above MHW (2.1ft) Contour in Arcadian Shores (BM 5590 - 5540), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
60
5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
Benchmark

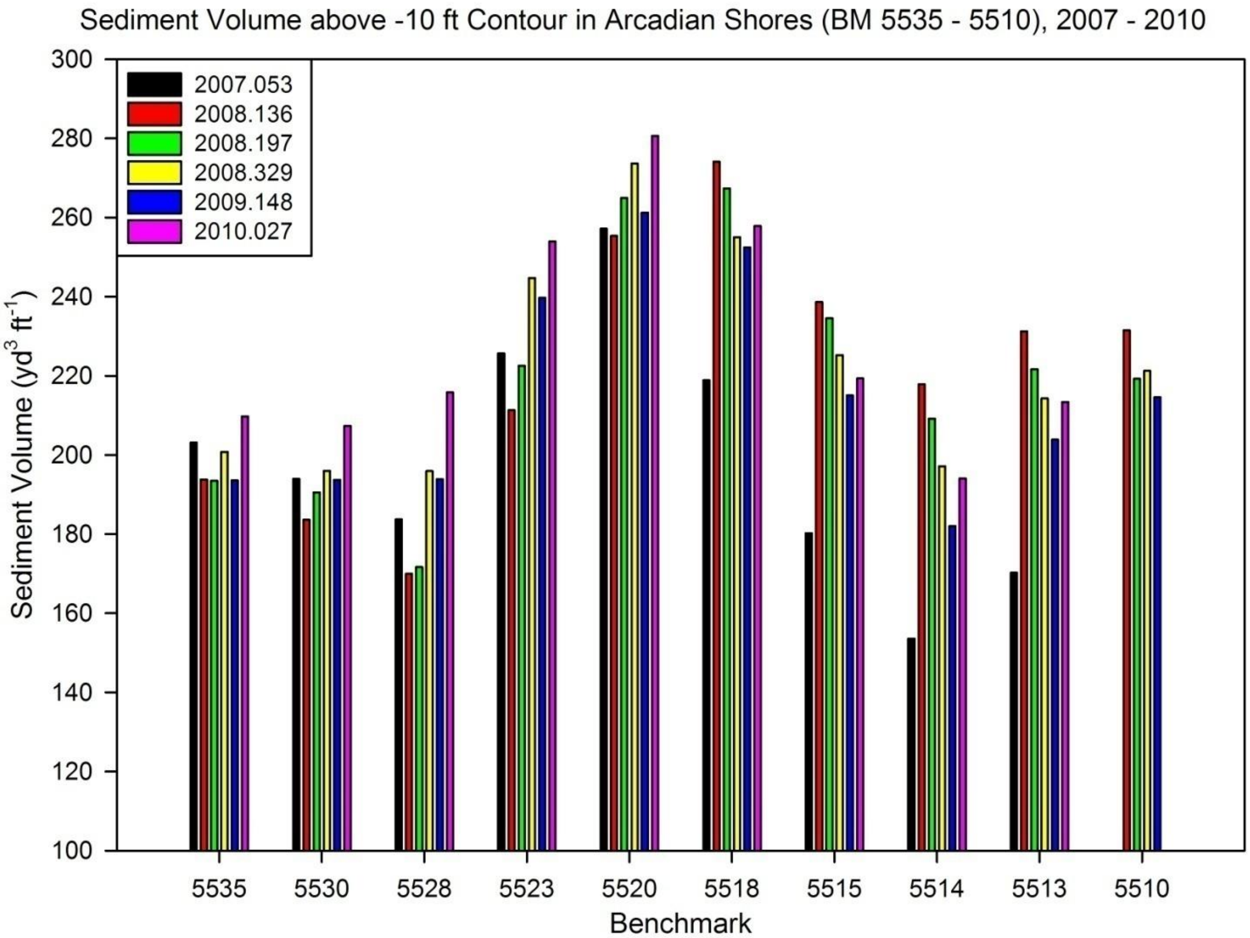

Sediment Volume above MHW (2.1ft) Contour in Arcadian Shores (BM 5535 - 5510), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd3 ft-1)
0
10
20
30
40
50
60
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
Benchmark

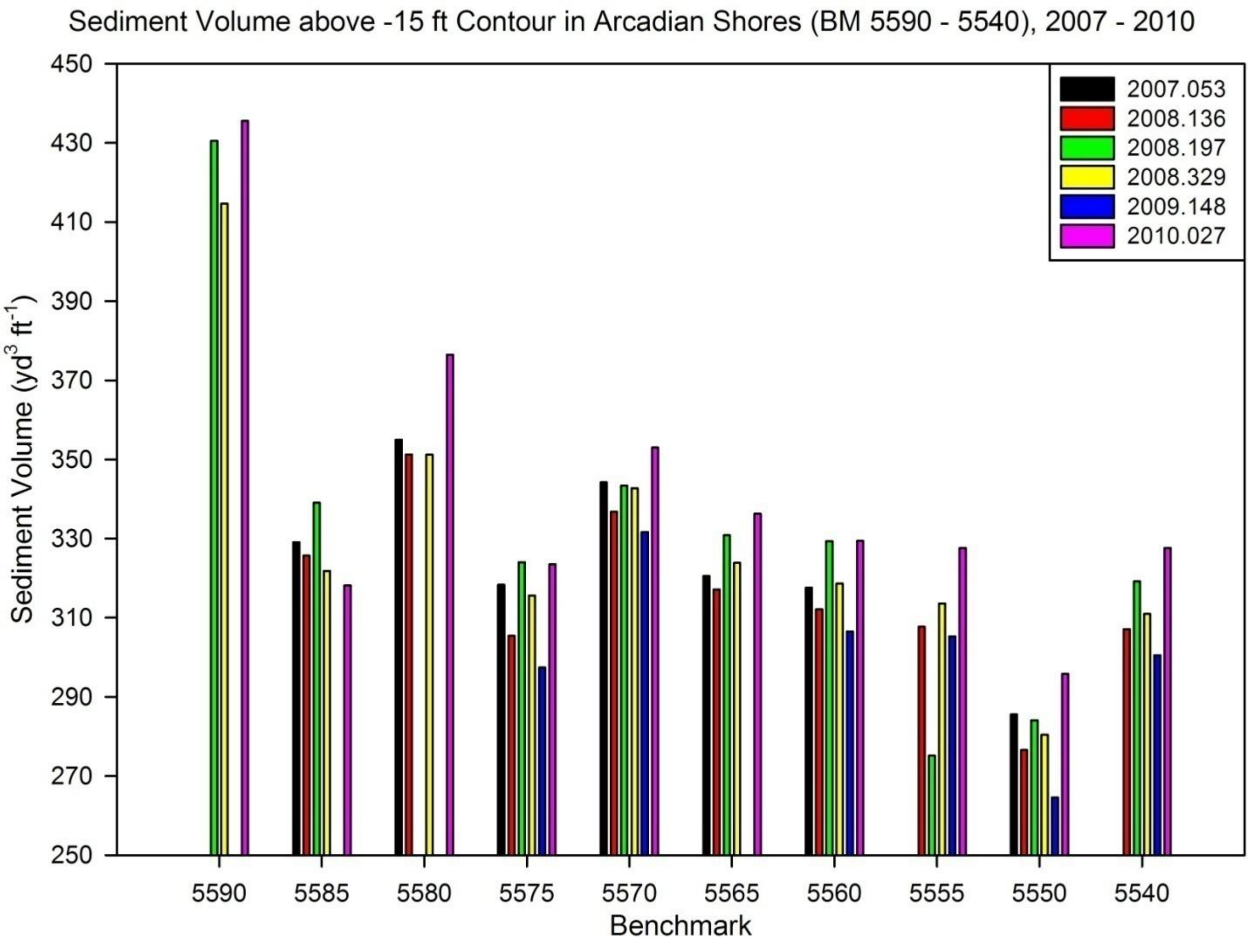


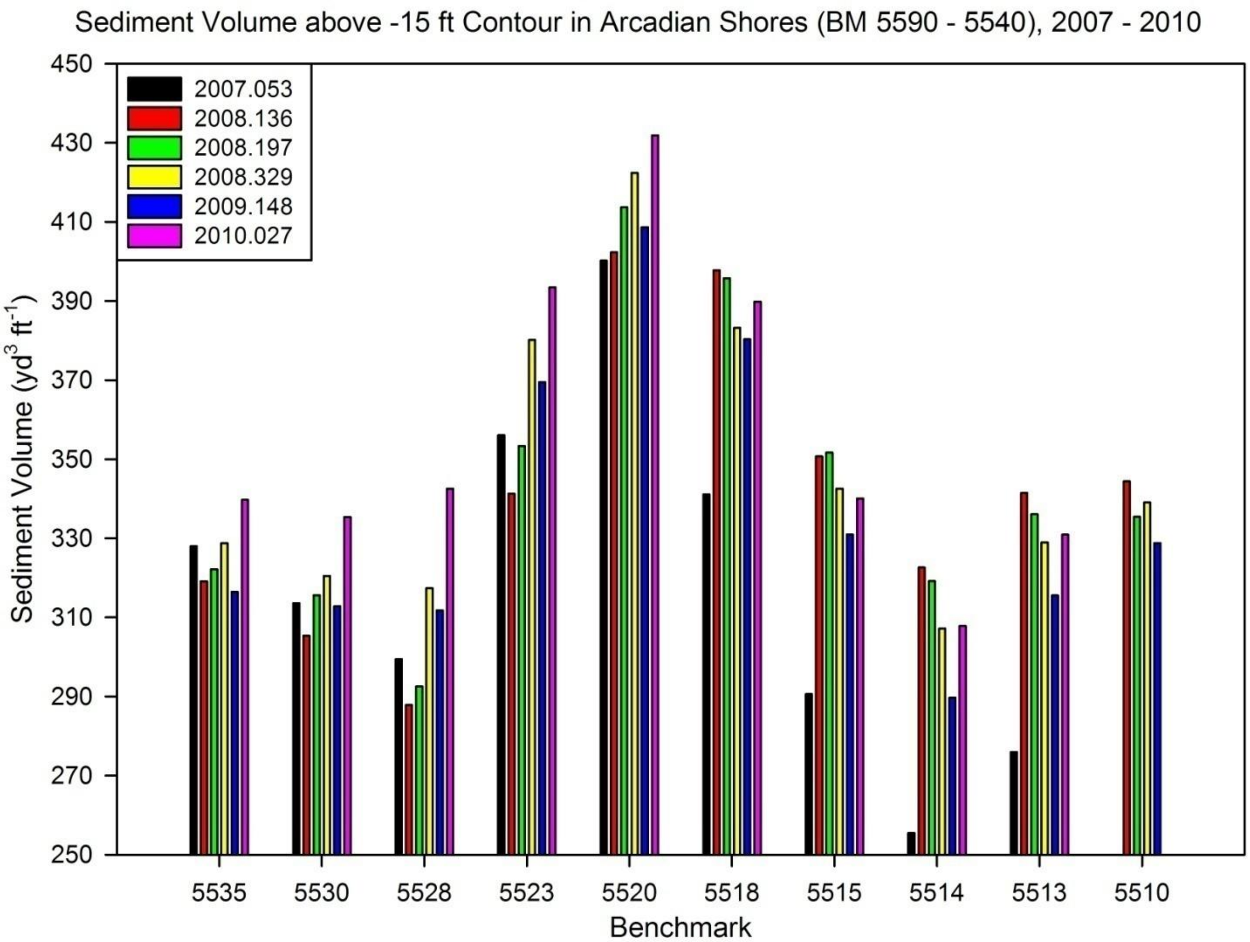
Sediment Volume above MLW (-3.0 ft) Contour in Arcadian Shores (BM 5590 - 5540), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd3 ft-1)
140
120
100
80
60
40
20
5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
Benchmark


Sediment Volume above MLW (-3.0 ft) Contour in Arcadian Shores (BM 5535 - 5510), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd^3 ft^{-1})
20
40
60
80
100
120
140
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
Benchmark


Sediment Volume above -10 ft Contour in Arcadian Shores (BM 5590 - 5540), 2007 - 2010
Sediment Volume (yd3 ft-1)
300
280
260
240
220
200
180
160
140
120
100
5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
Benchmark
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027

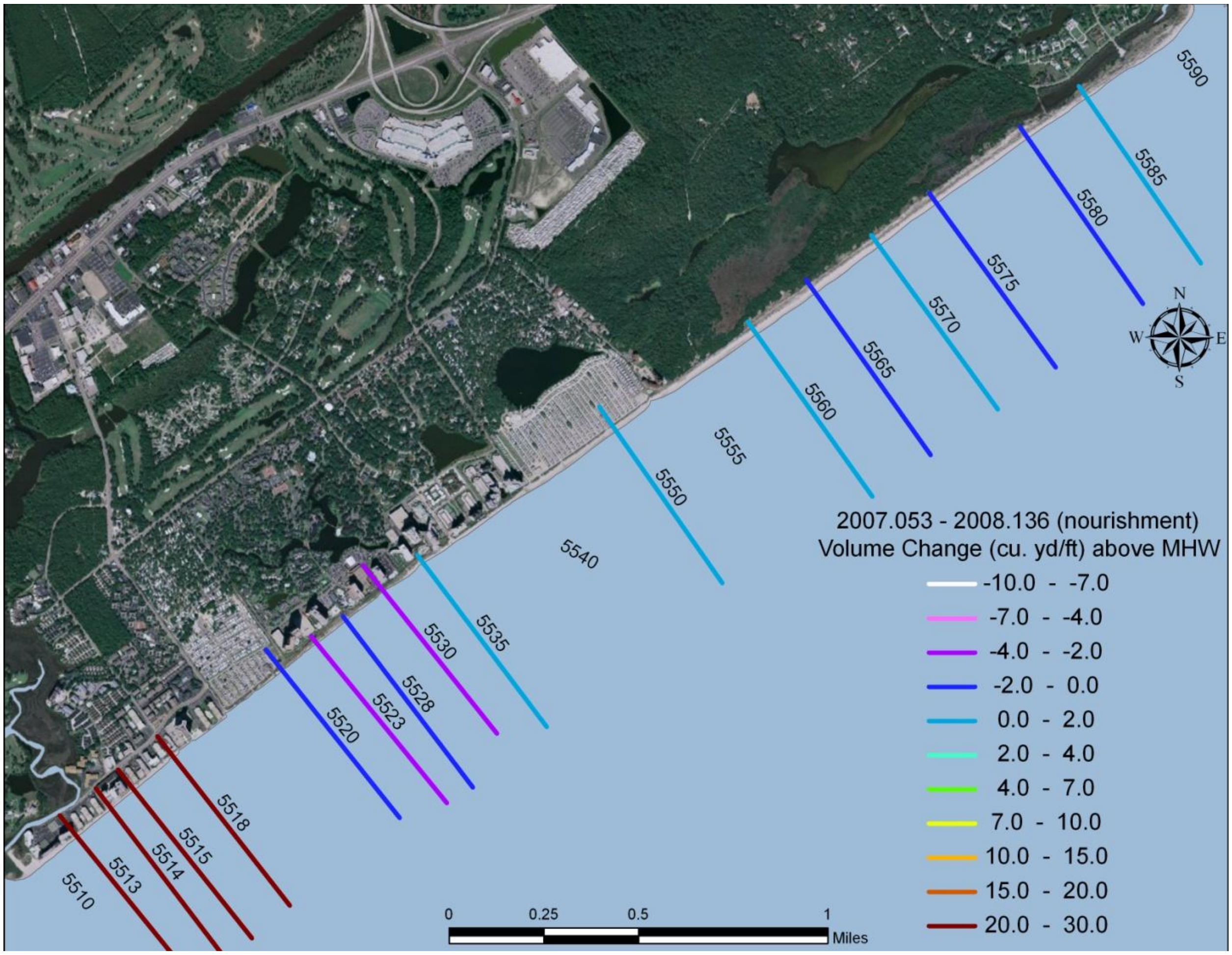

Sediment Volume above -10 ft Contour in Arcadian Shores (BM 5535 - 5510), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd^3 ft^{-1})
300
280
260
240
220
200
180
160
140
120
100
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
Benchmark

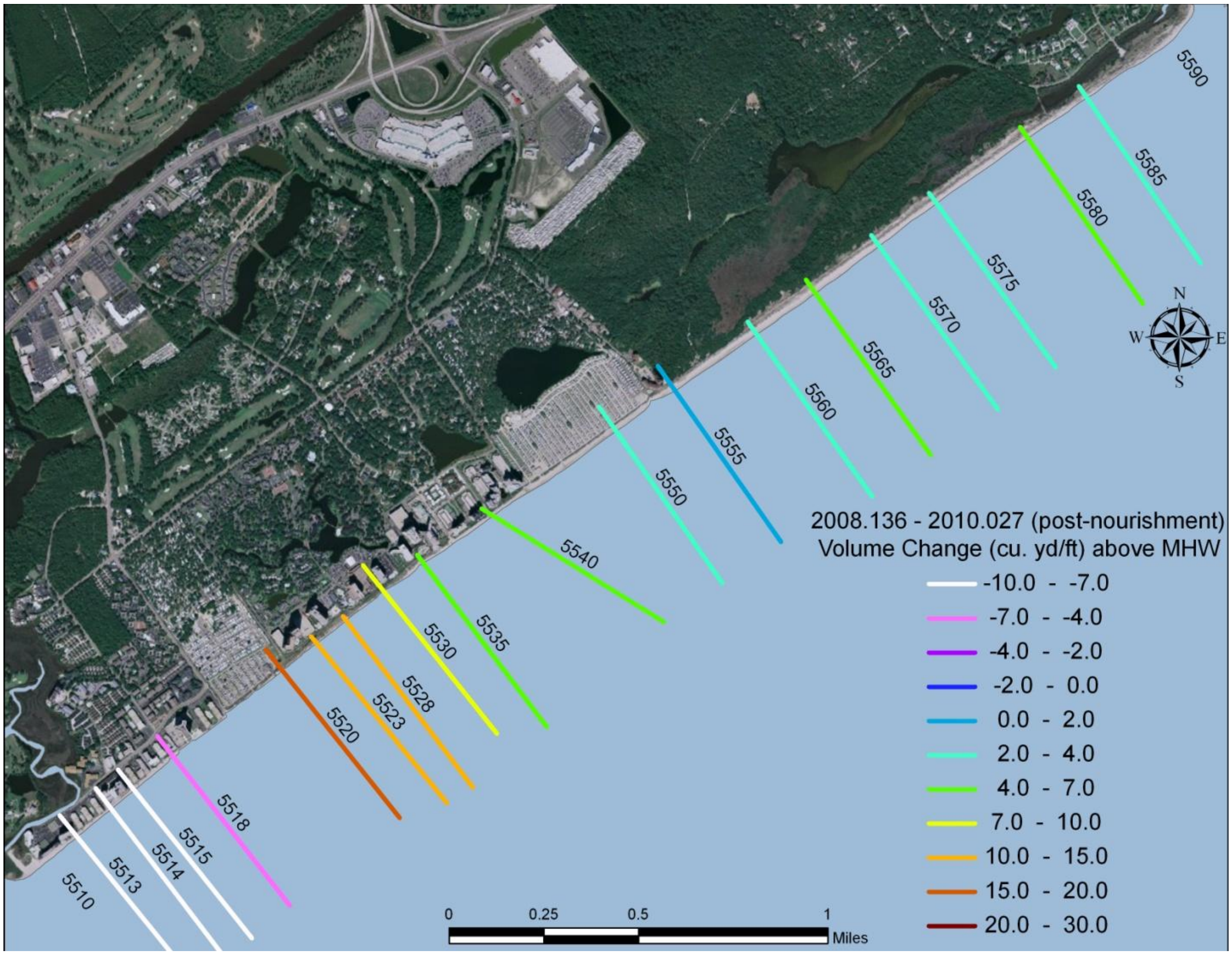

Sediment Volume above -15 ft Contour in Arcadian Shores (BM 5590 - 5540), 2007 - 2010
Sediment Volume (yd^3 ft^{-1})
Benchmark
450
430
410
390
370
350
330
310
290
270
250
5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027



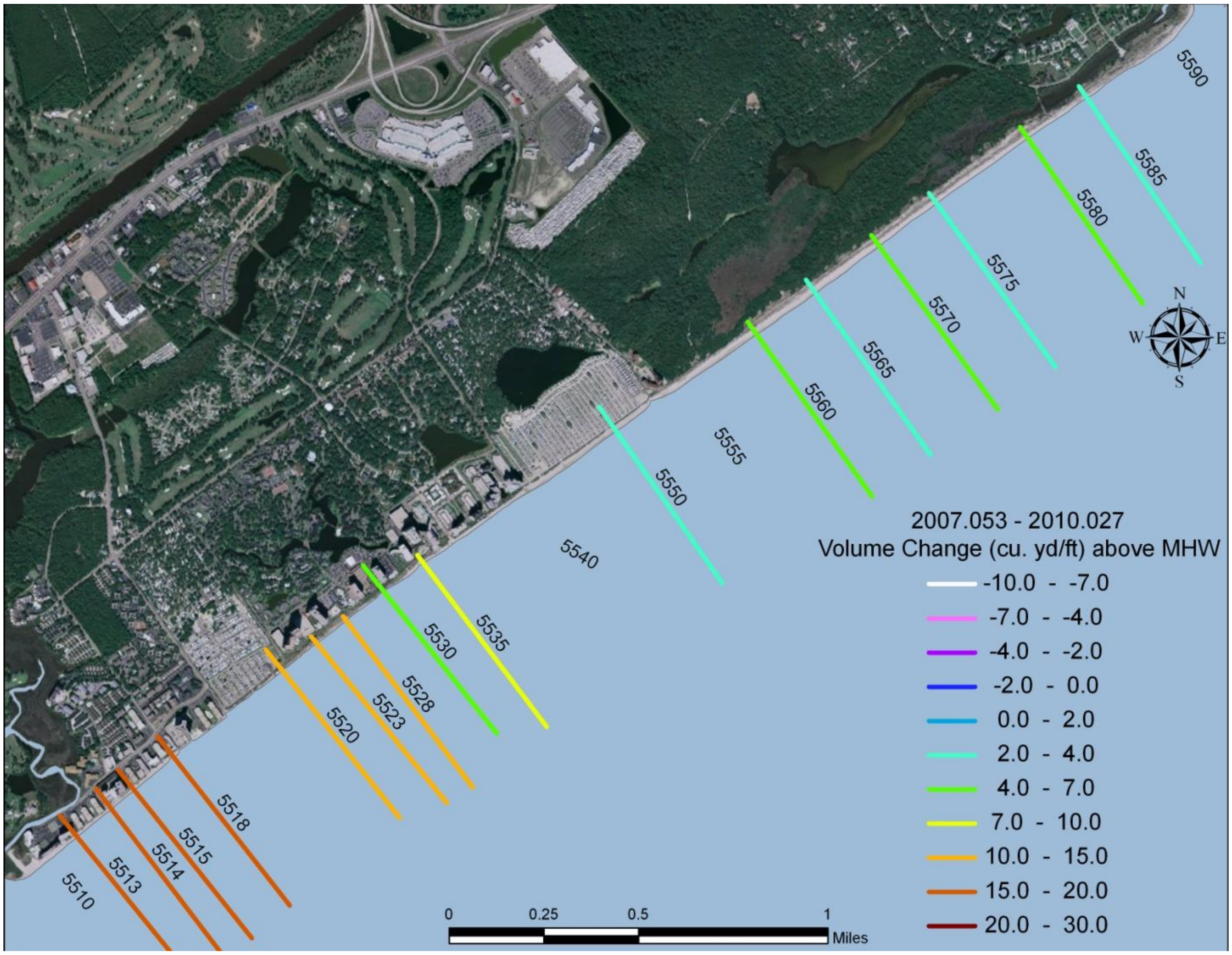
Sediment Volume above -15 ft Contour in Arcadian Shores (BM 5590 - 5540), 2007 - 2010
2007.053
2008.136
2008.197
2008.329
2009.148
2010.027
Sediment Volume (yd3 ft-1)
450
430
410
390
370
350
330
310
290
270
250
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
Benchmark

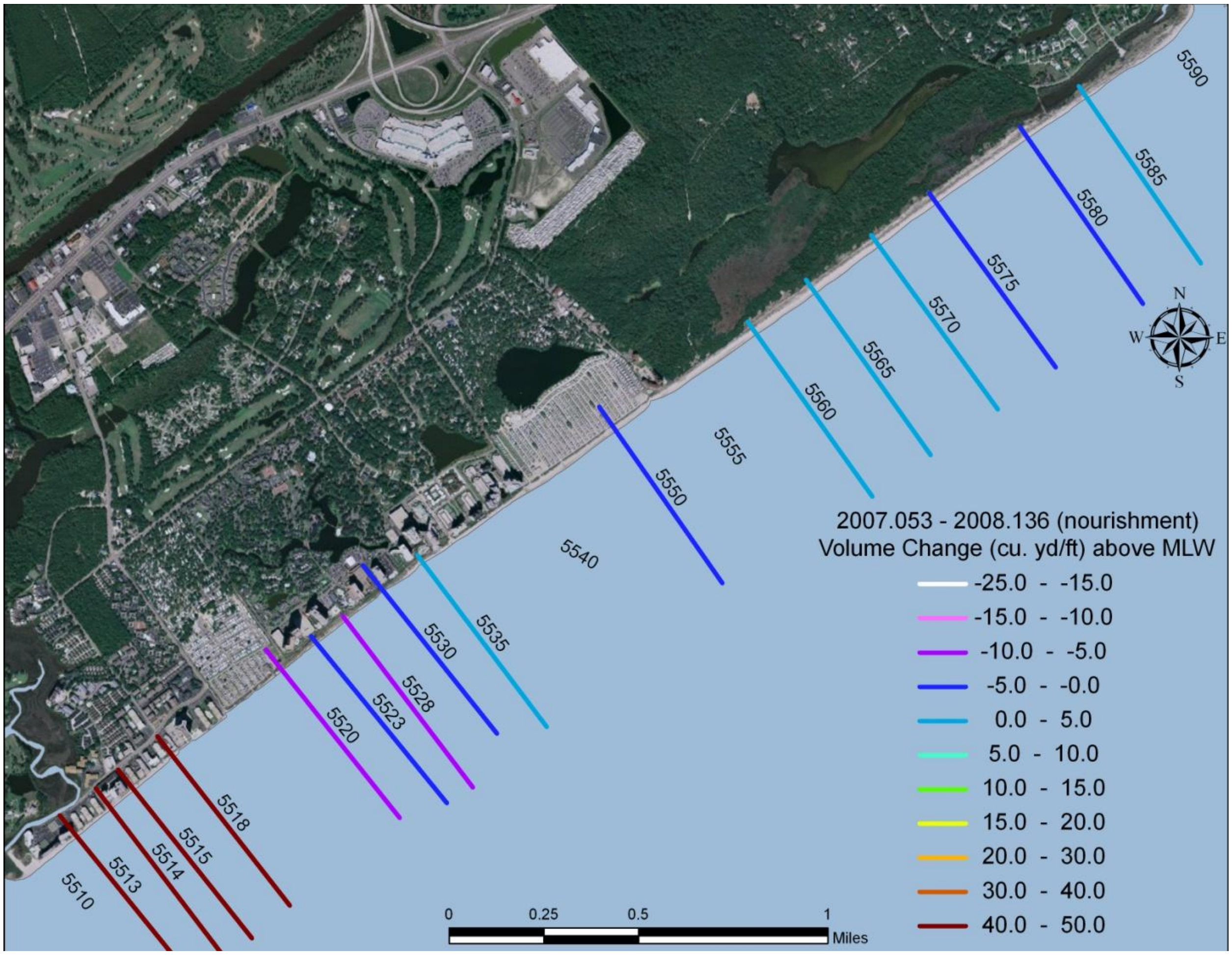
Appendix 12: Arcadian Shores Beach Profile Volume Change Map View

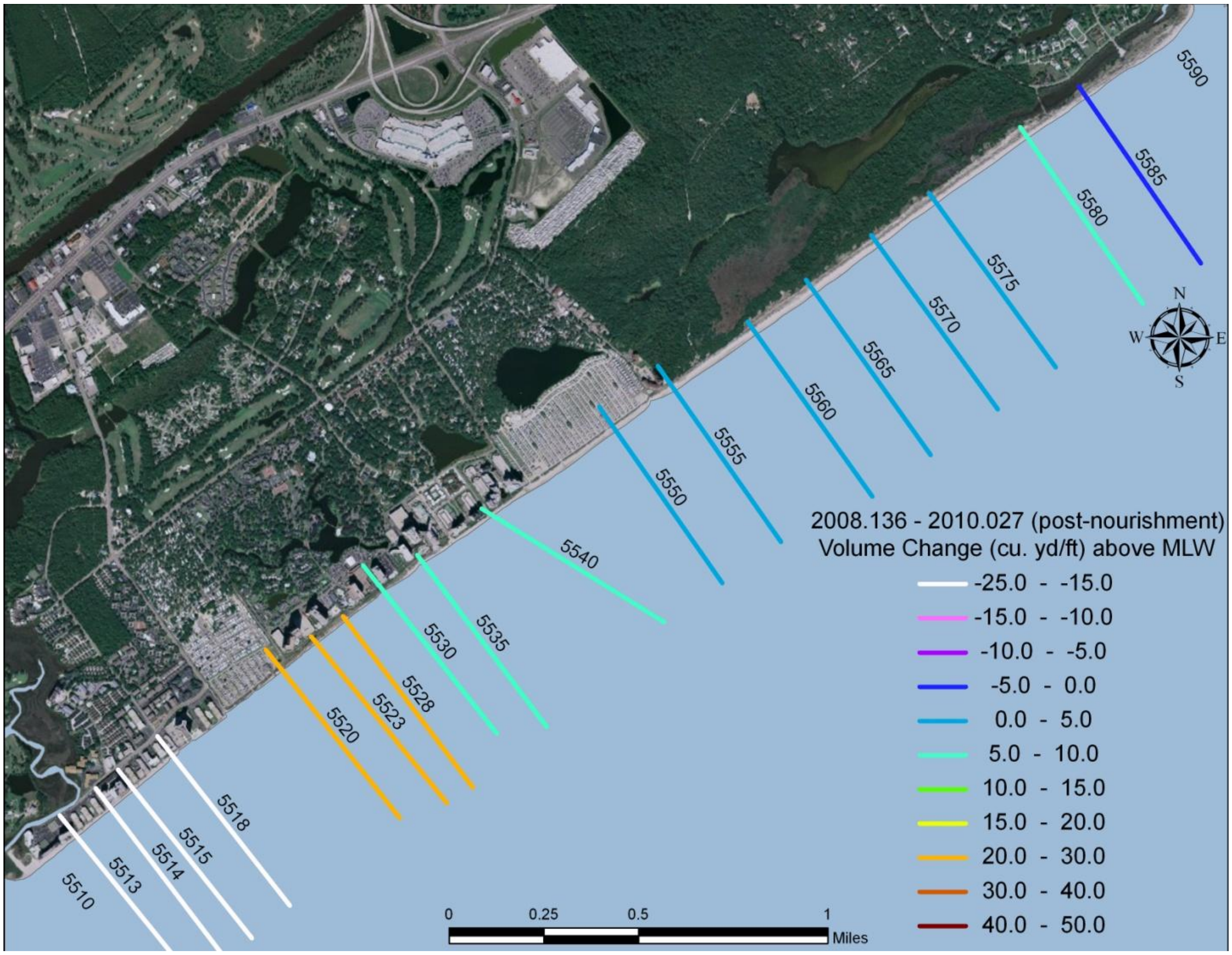

2007.053 - 2008.136 (nourishment)
Volume Change (cu. yd/ft) above MHW
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 7.0
7.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
0
0.25
0.5
1
Miles
N
S
E
W
5510
5513
5514
5515
5518
5520
5523
5528
5530
5535
5540
5550
5555
5560
5565
5570
5575
5580
5585
5590



5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2008.136 - 2010.027 (post-nourishment)
Volume Change (cu. yd/ft) above MHW
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 7.0
7.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
0
0.25
0.5
1
Miles


5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2007.053 - 2010.027
Volume Change (cu. yd/ft) above MHW
-10.0 - -7.0
-7.0 - -4.0
-4.0 - -2.0
-2.0 - 0.0
0.0 - 2.0
2.0 - 4.0
4.0 - 7.0
7.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
0
0.25
0.5
1
Miles


2007.053 - 2008.136 (nourishment)
Volume Change (cu. yd/ft) above MLW
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - -0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
5510
5513
5514
5515
5518
5520
5523
5528
5530
5535
5540
5550
5555
5560
5565
5570
5575
5580
5585
5590
N
S
E
W
0
0.25
0.5
1
Miles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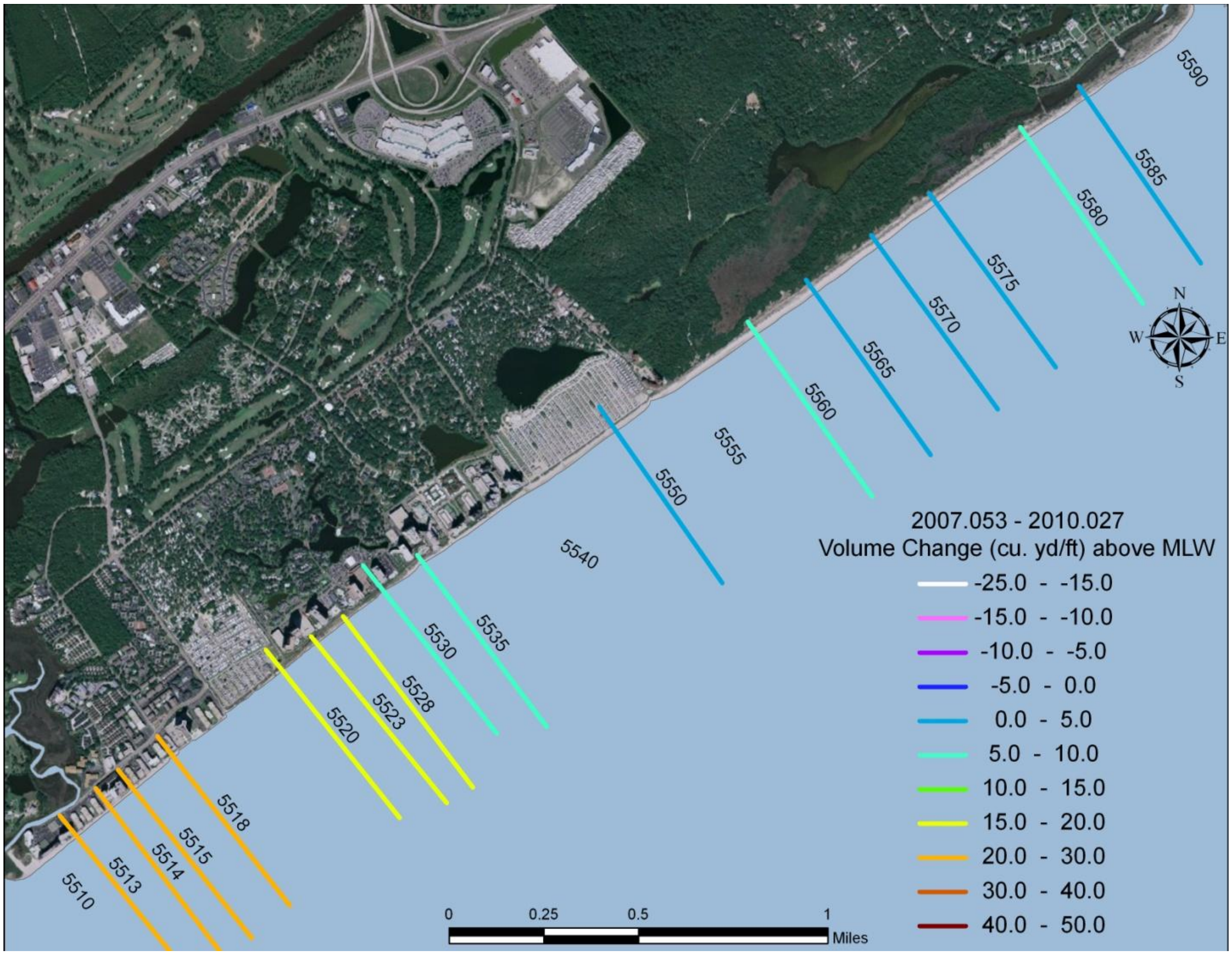
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2008.136 - 2010.027 (post-nourishment)
Volume Change (cu. yd/ft) above MLW
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
0
0.25
0.5
1
Miles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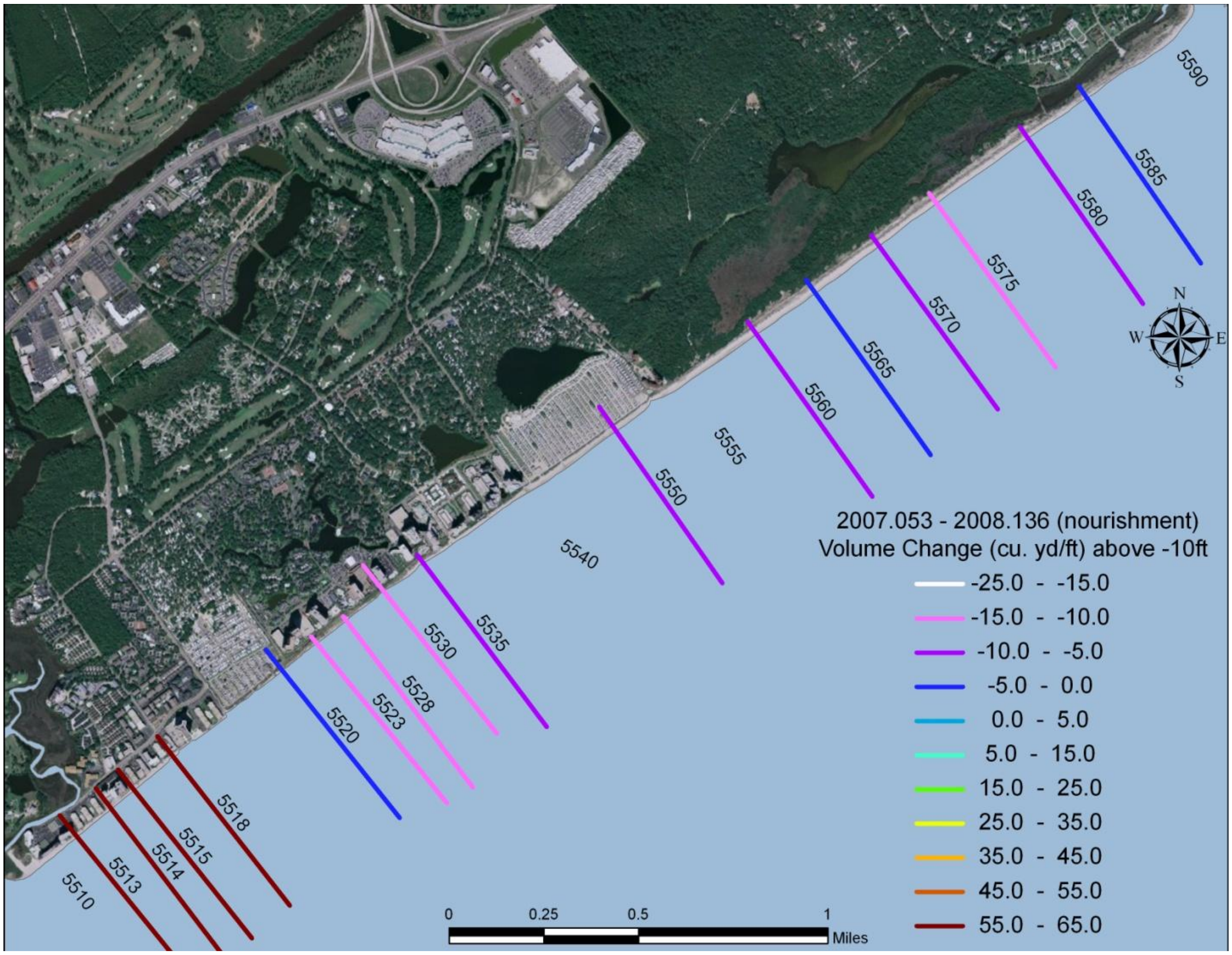
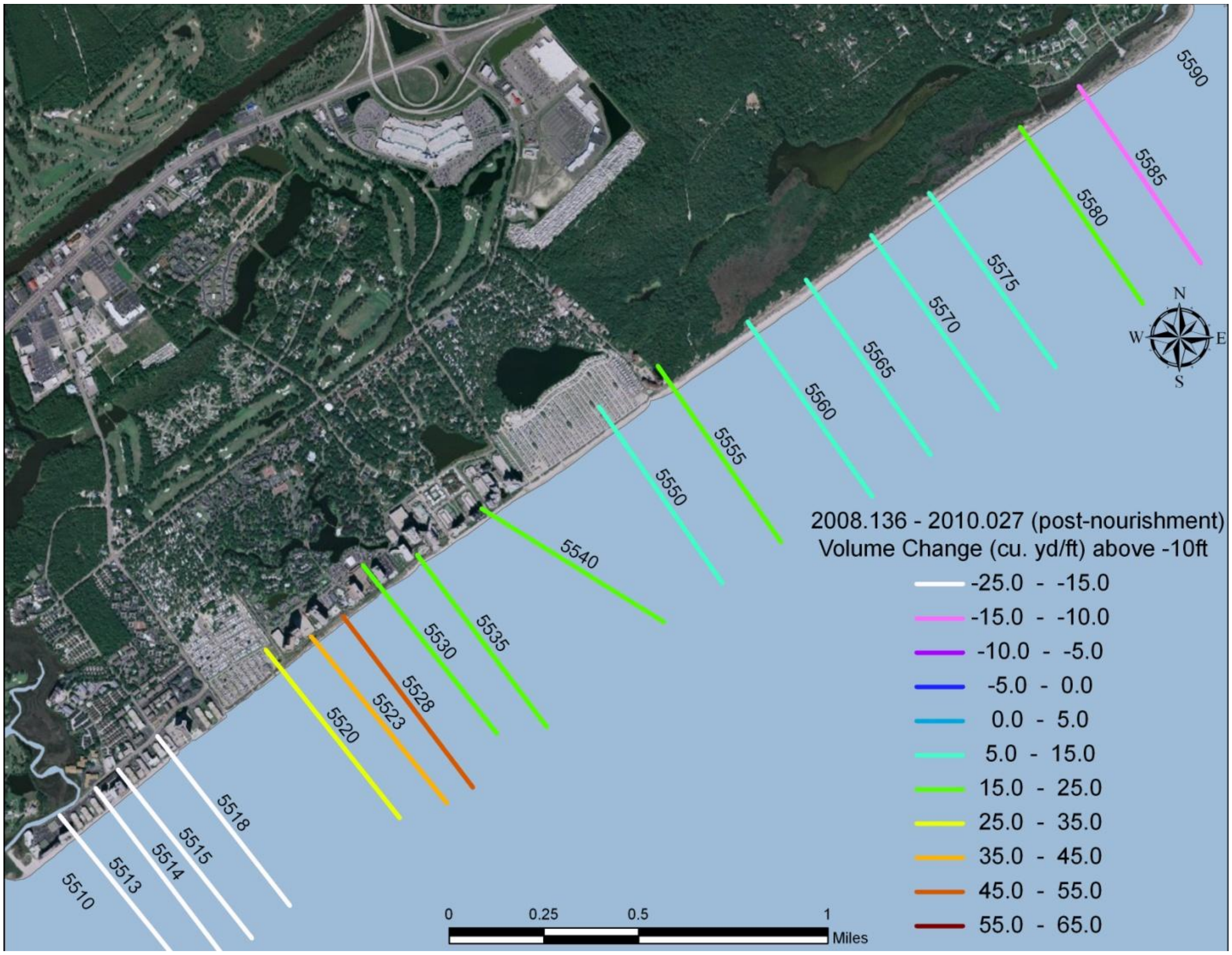
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2007.053 - 2010.027
Volume Change (cu. yd/ft) above MLW
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
0
0.25
0.5
1
Miles



5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2007.053 - 2008.136 (nourishment)
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 15.0
15.0 - 25.0
25.0 - 35.0
35.0 - 45.0
45.0 - 55.0
55.0 - 65.0
0
0.25
0.5
1
Miles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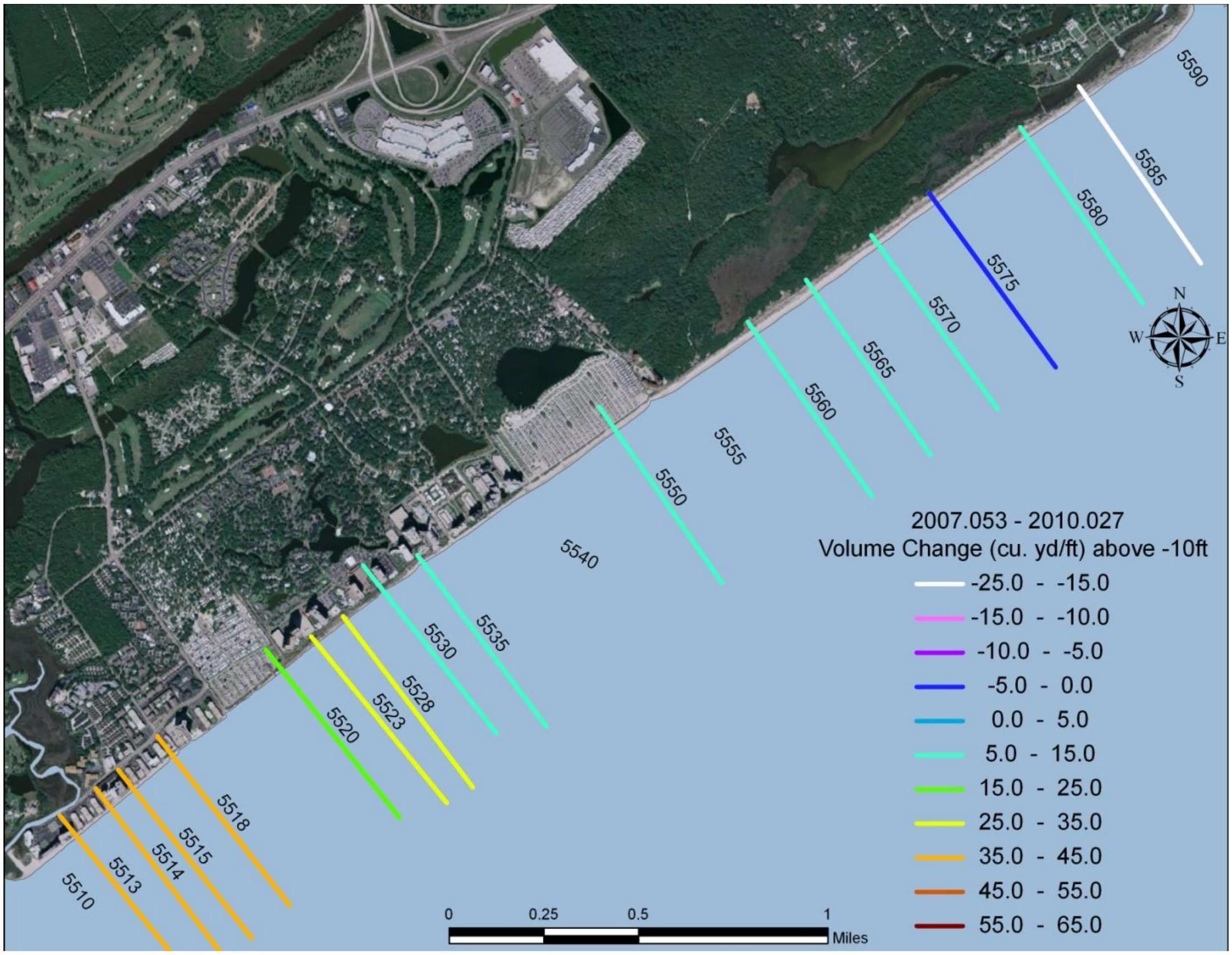
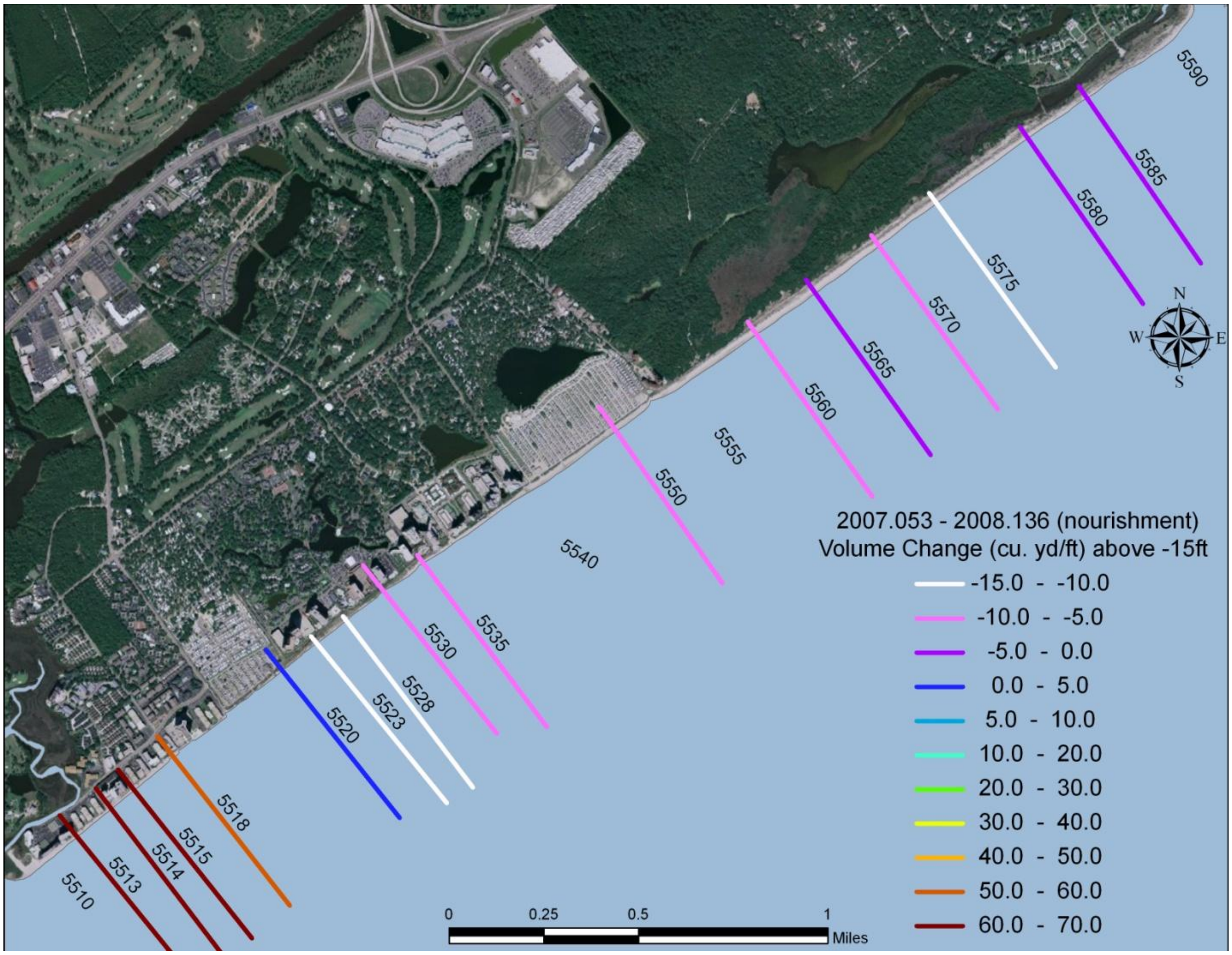
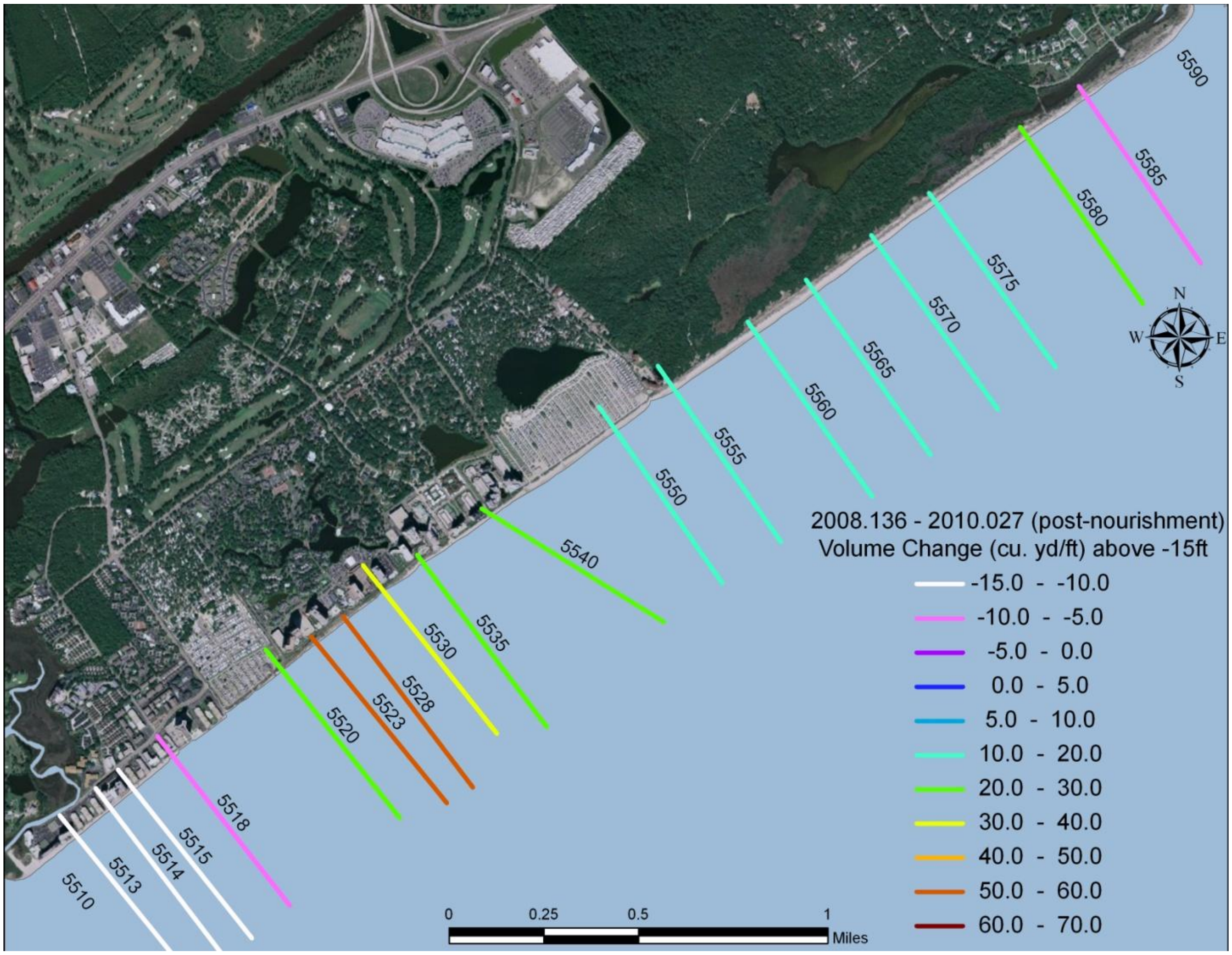
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2008.136 - 2010.027 (post-nourishment)
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 15.0
15.0 - 25.0
25.0 - 35.0
35.0 - 45.0
45.0 - 55.0
55.0 - 65.0
0
0.25
0.5
1
Miles



5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2007.053 - 2010.027
Volume Change (cu. yd/ft) above -10ft
-25.0 - -15.0
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 15.0
15.0 - 25.0
25.0 - 35.0
35.0 - 45.0
45.0 - 55.0
55.0 - 65.0
0
0.25
0.5
1
Miles

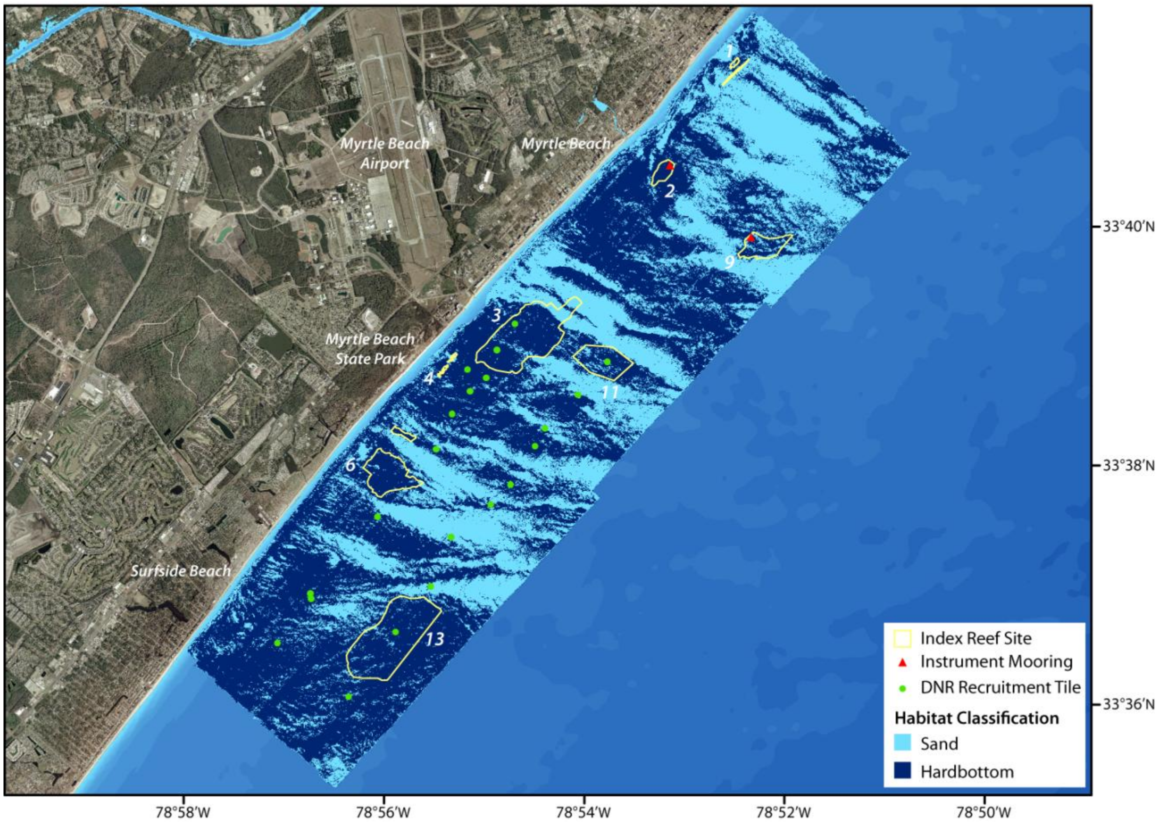


5590
5585
5580
5575
5570
5565
5560
5555
5550
5540
5535
5530
5528
5523
5520
5518
5515
5514
5513
5510
N
W
E
S
2007.053 - 2008.136 (nourishment)
Volume Change (cu. yd/ft) above -15ft
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
50.0 - 60.0
60.0 - 70.0
0
0.25
0.5
1
Miles

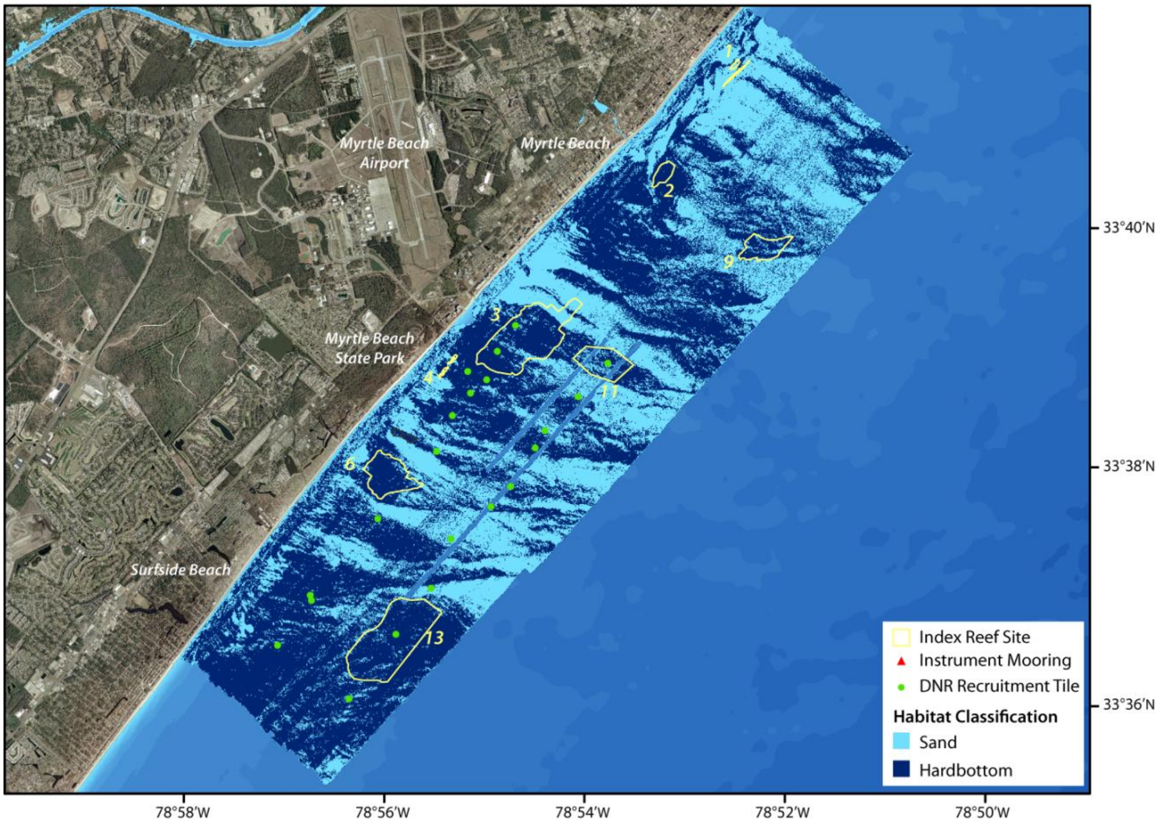

2008.136 - 2010.027 (post-nourishment)
Volume Change (cu. yd/ft) above -15ft
-15.0 - -10.0
-10.0 - -5.0
-5.0 - 0.0
0.0 - 5.0
5.0 - 10.0
10.0 - 20.0
20.0 - 30.0
30.0 - 40.0
40.0 - 50.0
50.0 - 60.0
60.0 - 70.0
0
0.25
0.5
1
Miles
N
S
E
W
5510
5513
5514
5515
5518
5520
5523
5528
5530
5535
5540
5550
5555
5560
5565
5570
5575
5580
5585
5590

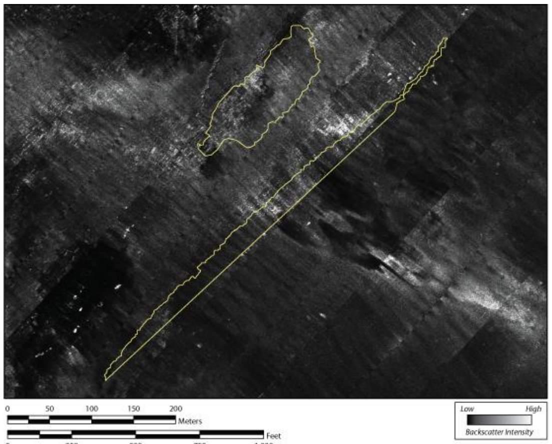
Appendix 13: Index Reefs Habitat Maps

Pre-Nourishment (March 2008)

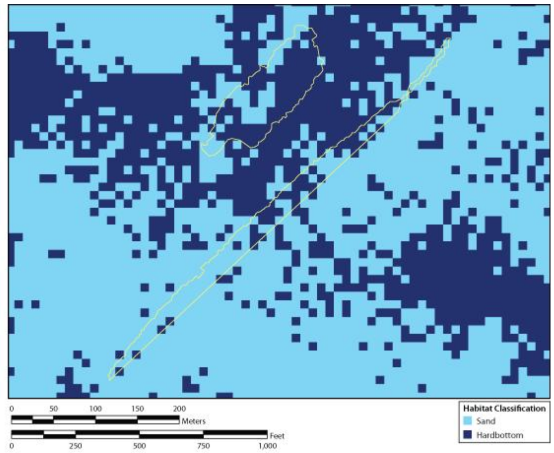


One Year Post-Nourishment (March 2010)

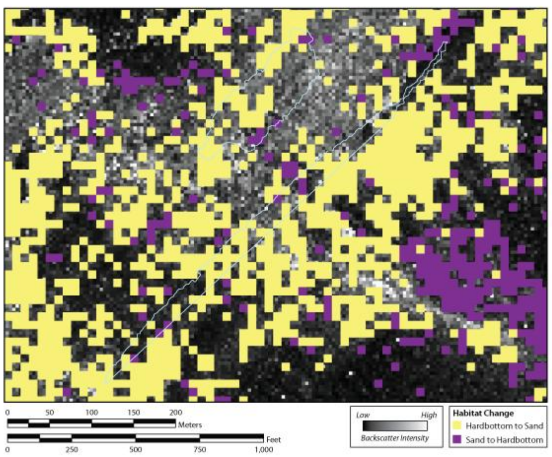




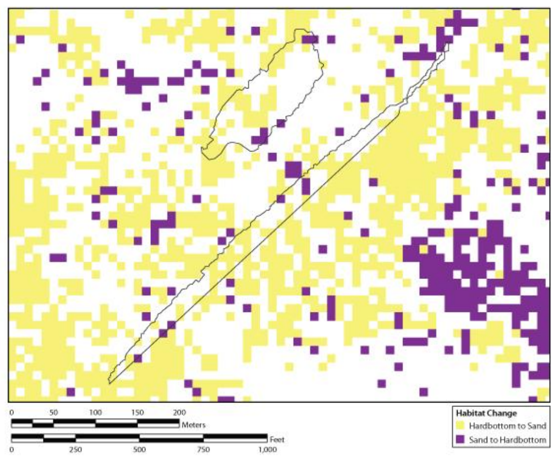
A. Area 1: Sidescan Sonar Pre-Nourishment
(*March 2008*)



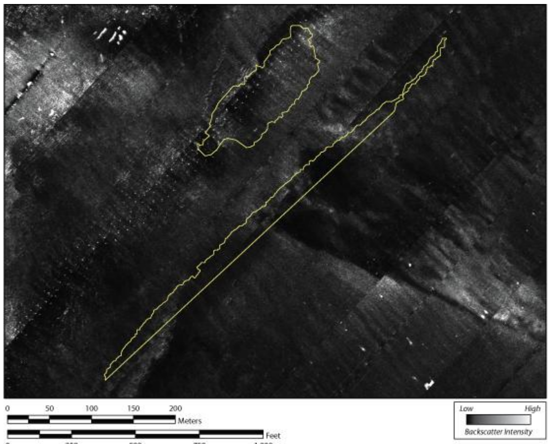
B. Area 1: Habitat Classification Pre-Nourishment
(*March 2008*)



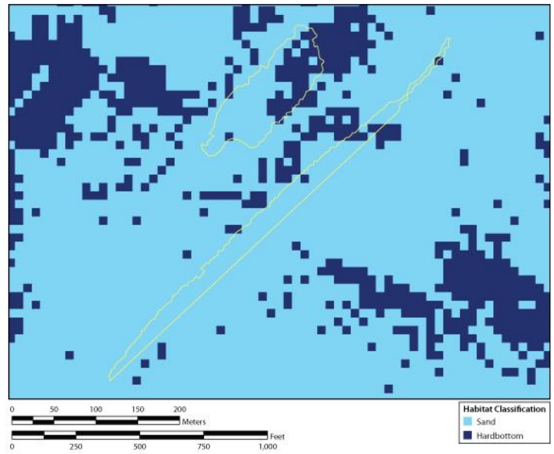
C. Area 1: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



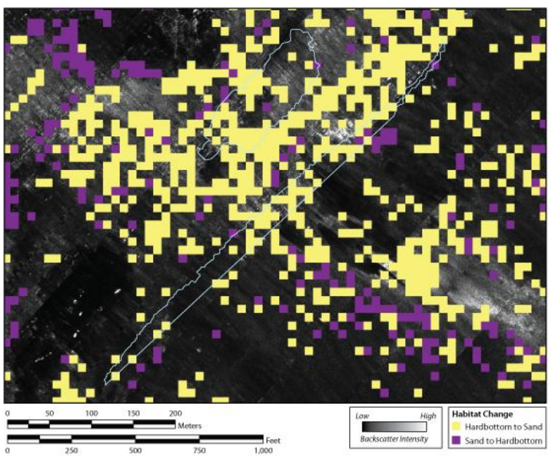
D. Area 1: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



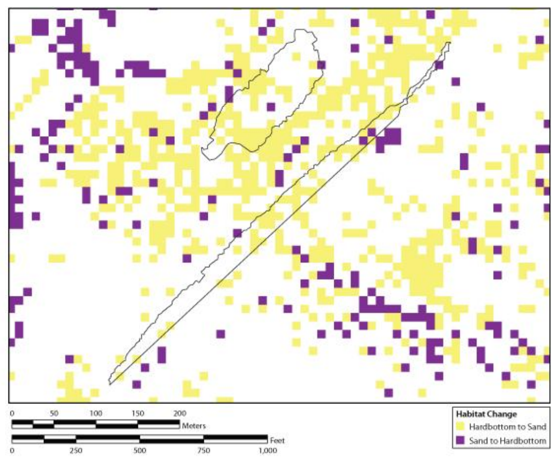
A. Area 1: Sidescan Sonar Post-Nourishment
(*January 2009*)



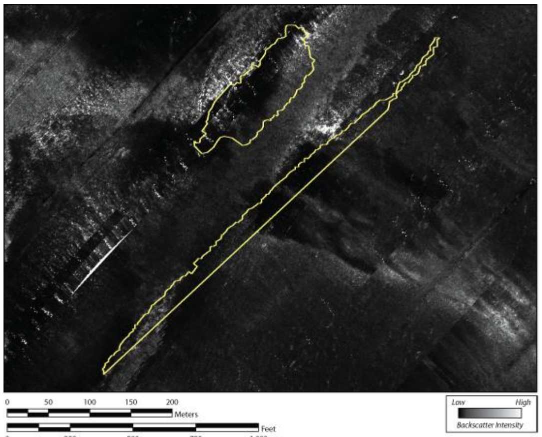
B. Area 1: Habitat Classification Post-Nourishment
(*January 2009*)



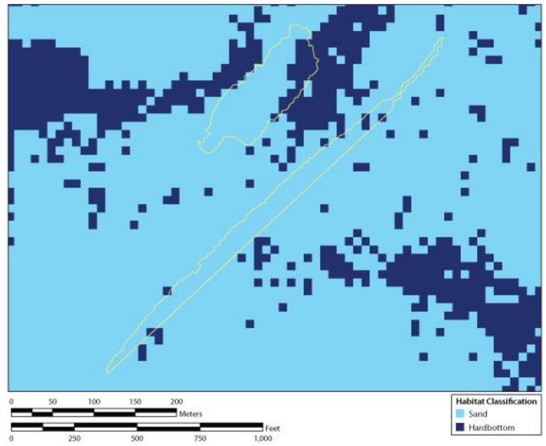
C. Area 1: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



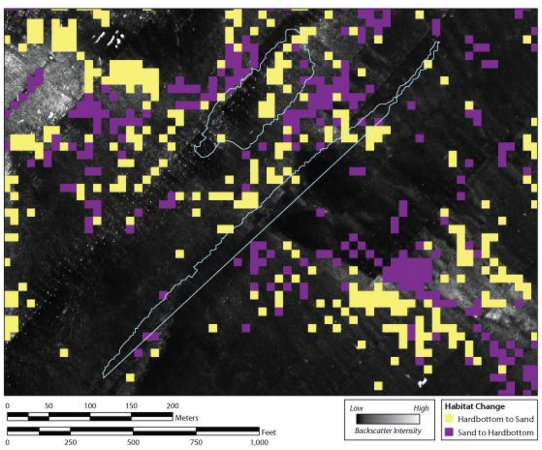
D. Area 1: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



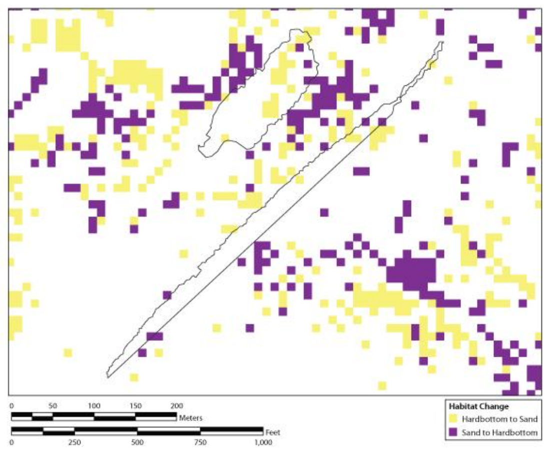
A. Area 1: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



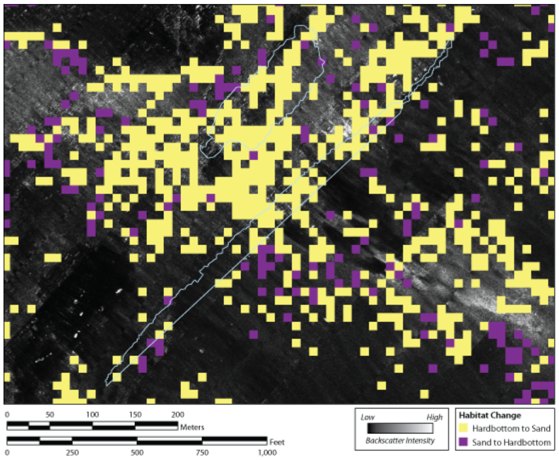
B. Area 1: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



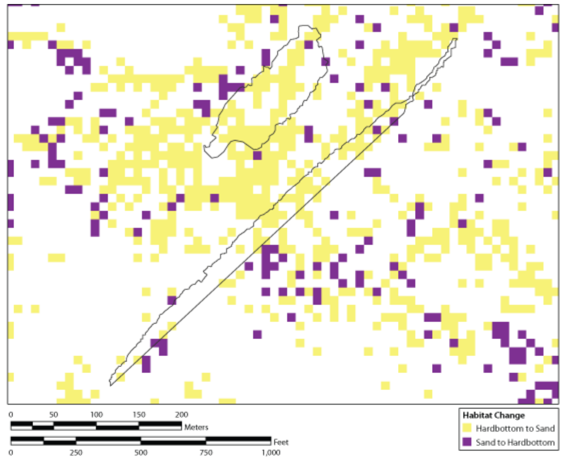
C. Area 1: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



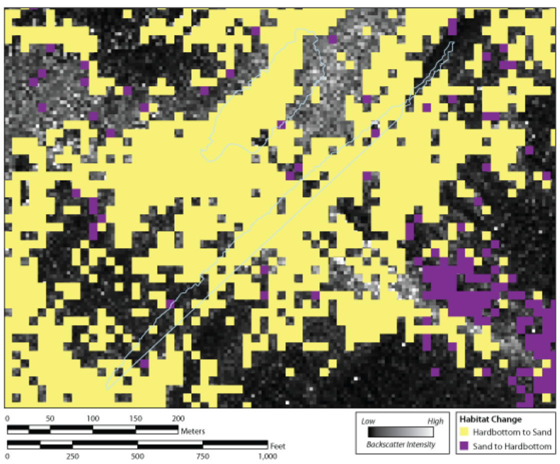
D. Area 1: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



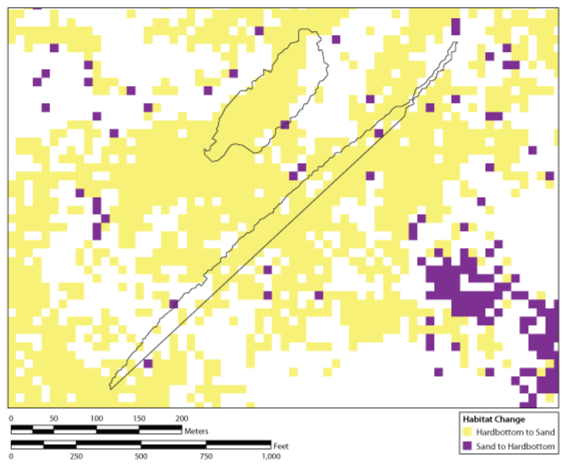
A. Area 1: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



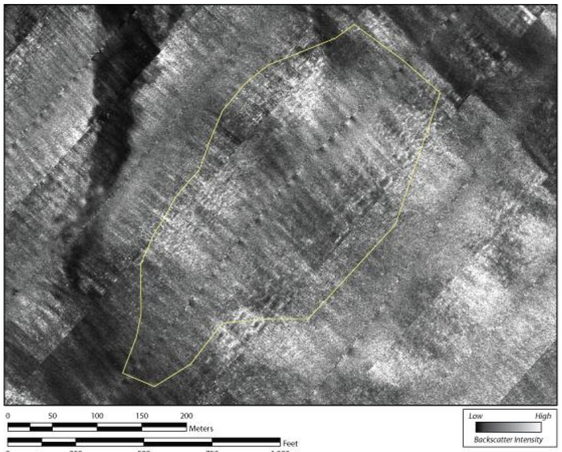
B. Area 1: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



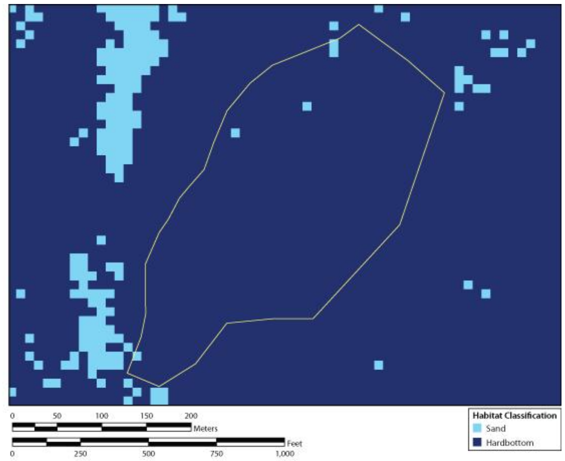
C. Area 1: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



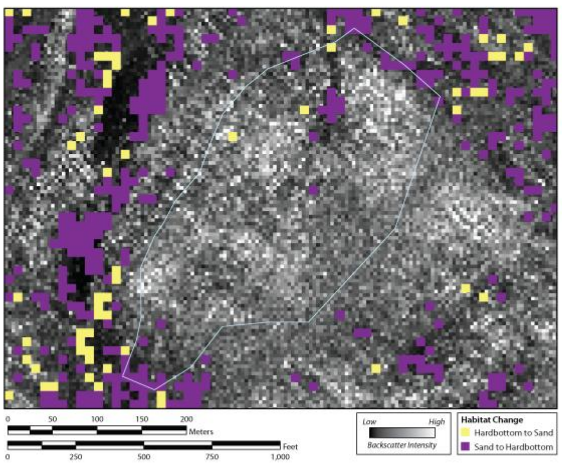
D. Area 1: Habitat Change Long Term
(*November 1999 - March 2010*)



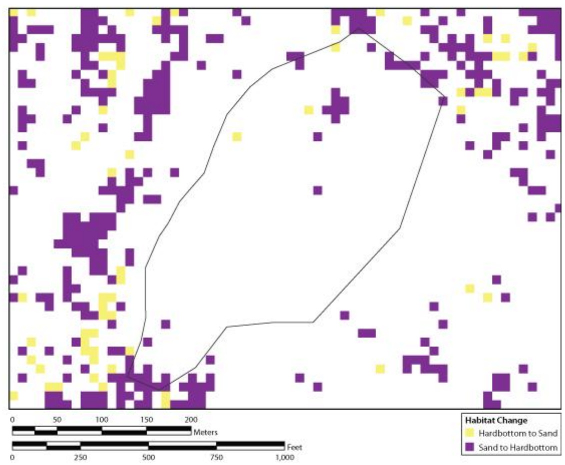
A. Area 2: Sidescan Sonar Pre-Nourishment
(*March 2008*)



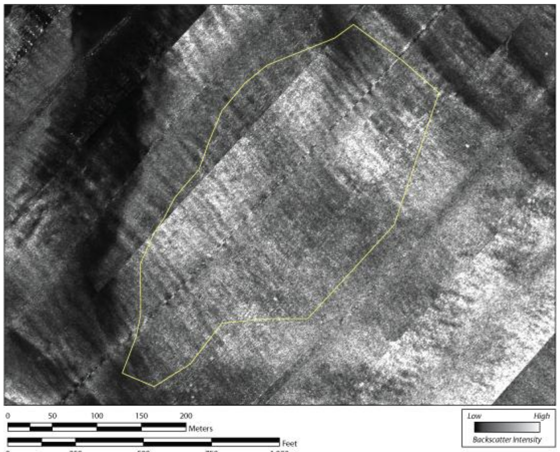
B. Area 2: Habitat Classification Pre-Nourishment
(*March 2008*)



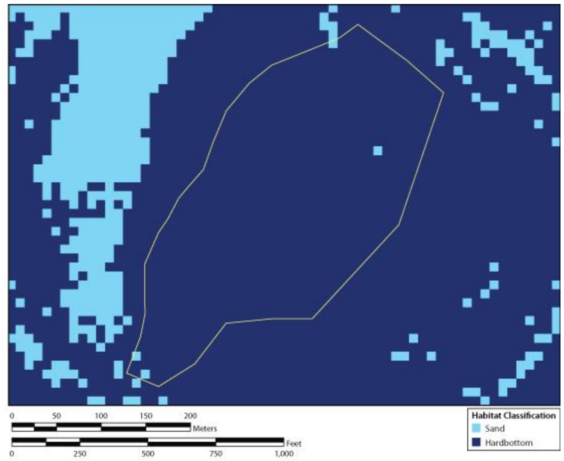
C. Area 2: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



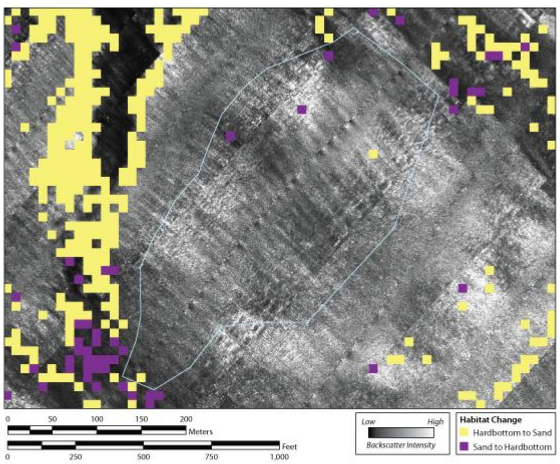
D. Area 2: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



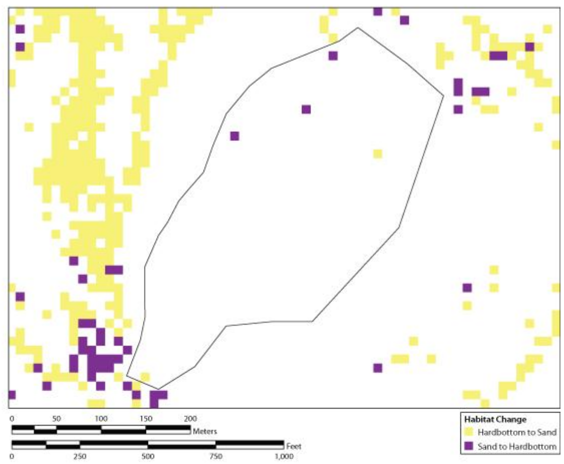
A. Area 2: Sidescan Sonar Post-Nourishment
(*January 2009*)



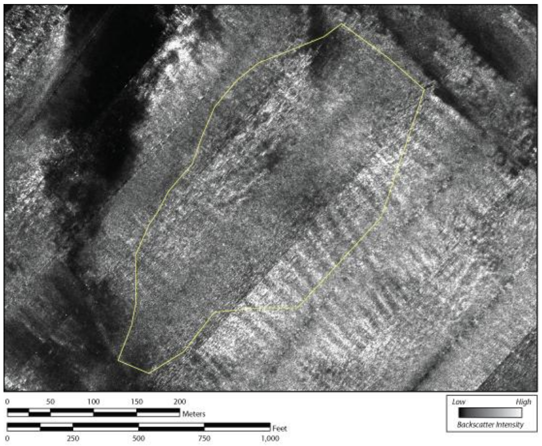
B. Area 2: Habitat Classification Post-Nourishment
(*January 2009*)



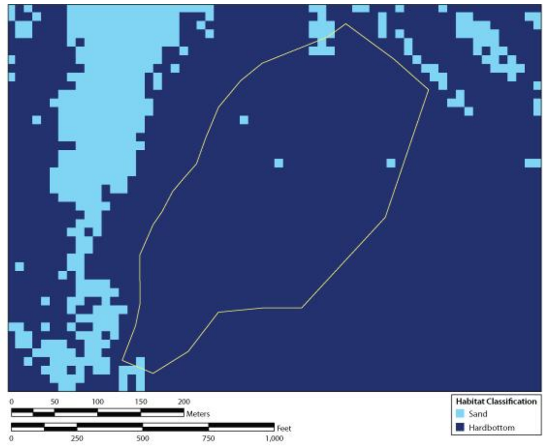
C. Area 2: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



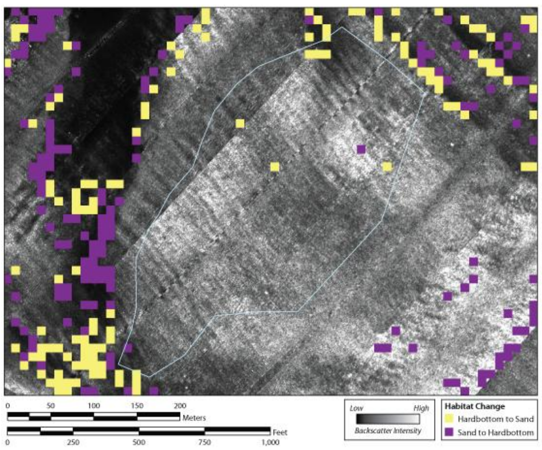
D. Area 2: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



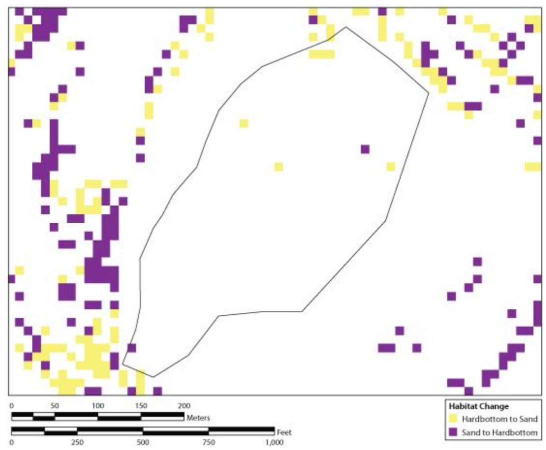
A. Area 2: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



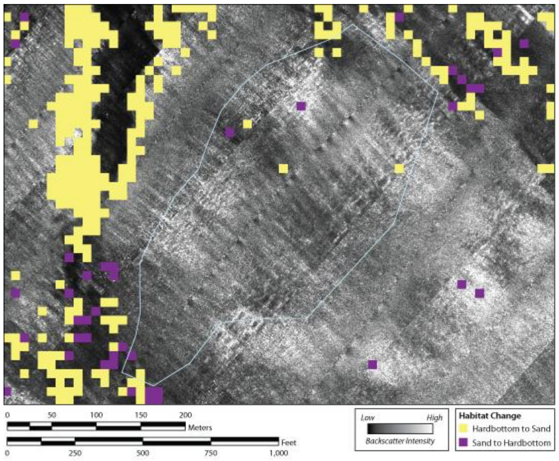
B. Area 2: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



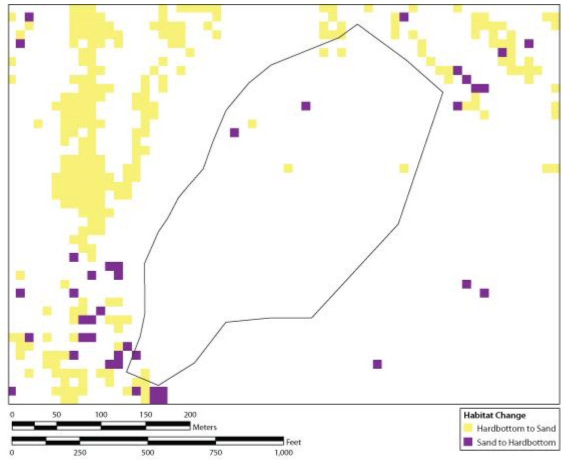
C. Area 2: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



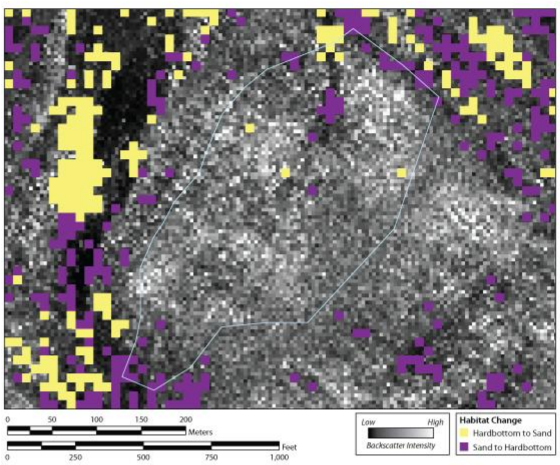
D. Area 2: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



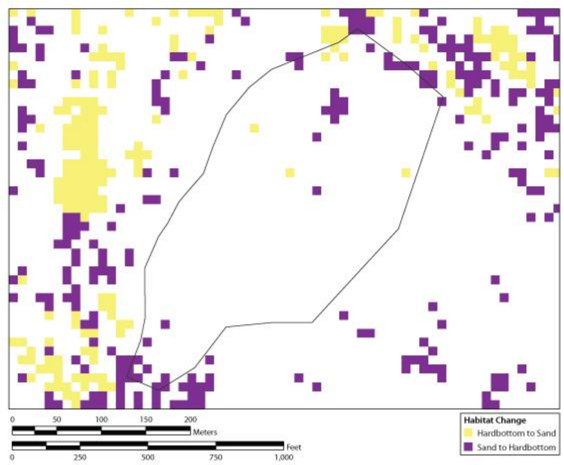
A. Area 2: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



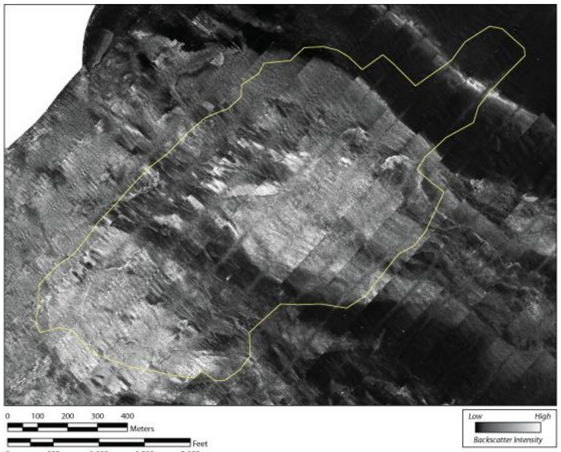
B. Area 2: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



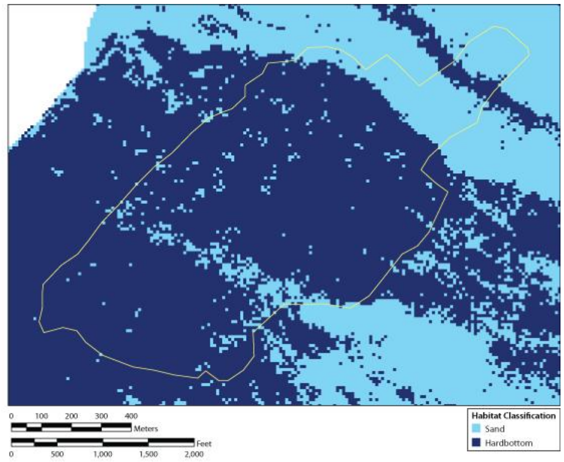
C. Area 2: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



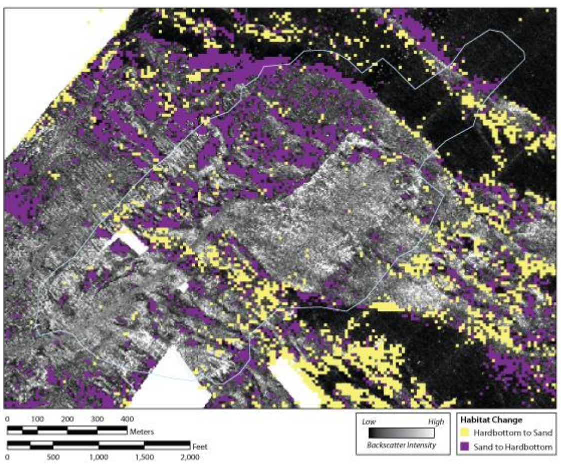
D. Area 2: Habitat Change Long Term
(*November 1999 - March 2010*)



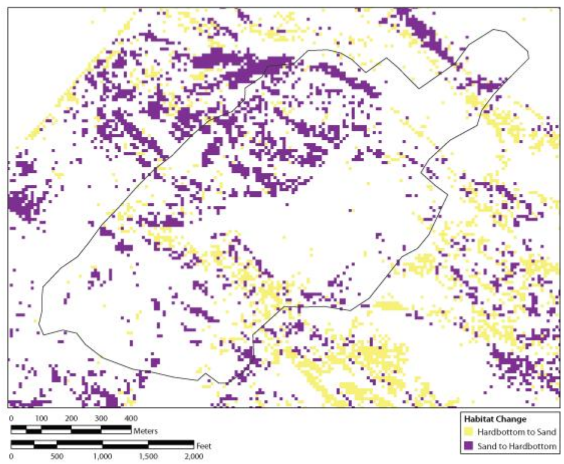
A. Area 3: Sidescan Sonar Pre-Nourishment
(*March 2008*)



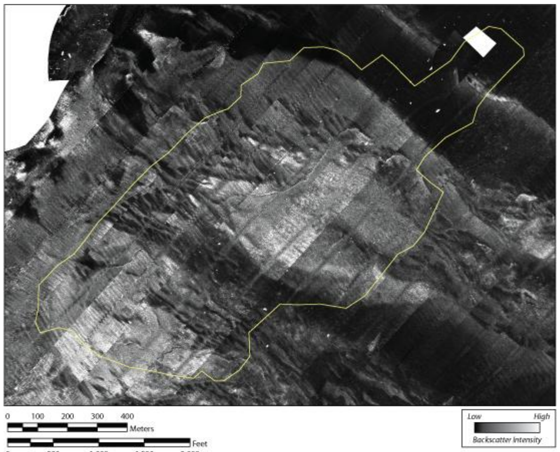
B. Area 3: Habitat Classification Pre-Nourishment
(*March 2008*)



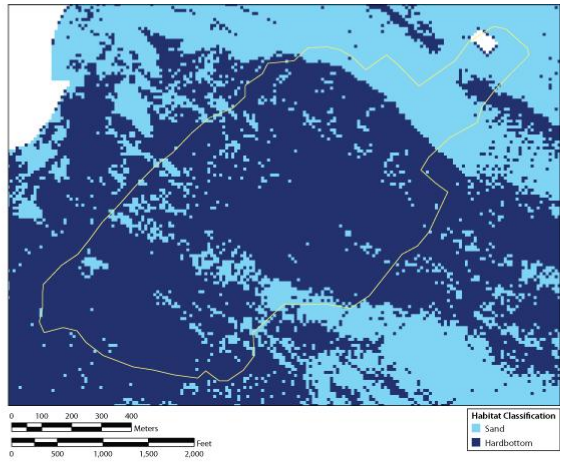
C. Area 3: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



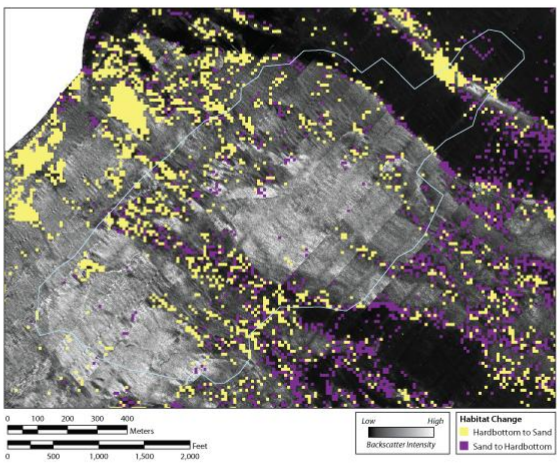
D. Area 3: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



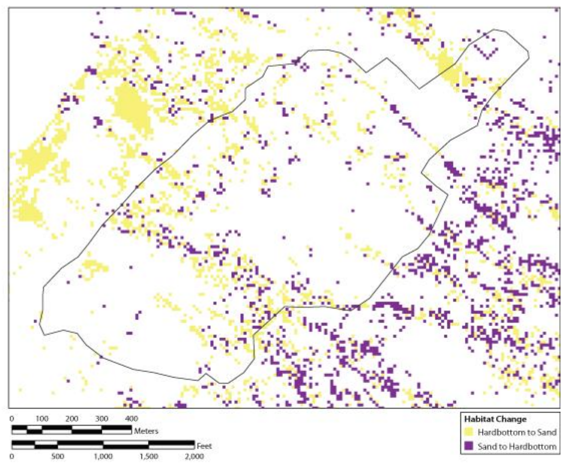
A. Area 3: Sidescan Sonar Post-Nourishment
(*January 2009*)



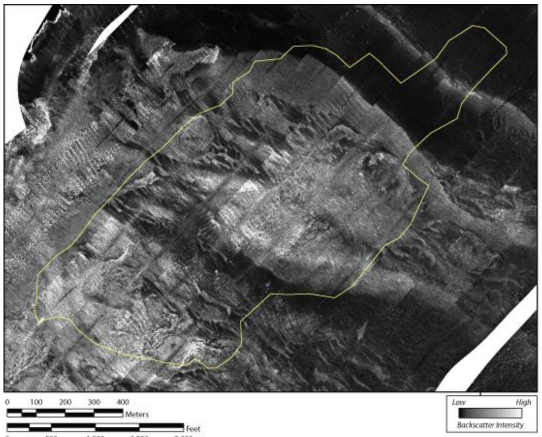
B. Area 3: Habitat Classification Post-Nourishment
(*January 2009*)



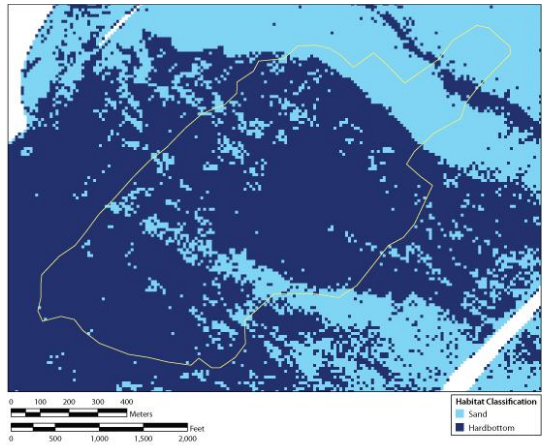
C. Area 3: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



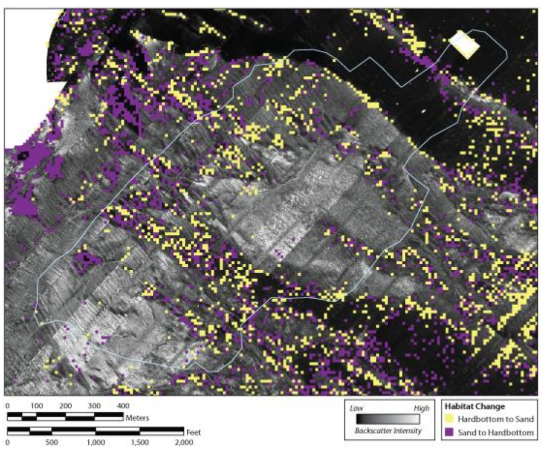
D. Area 3: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



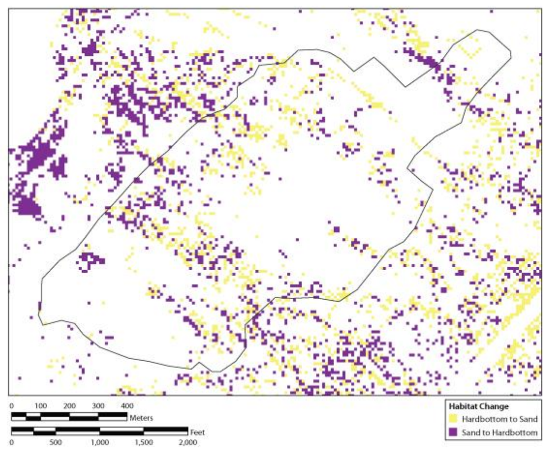
A. Area 3: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



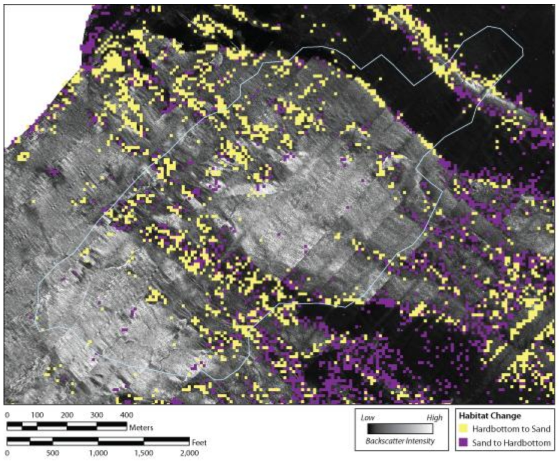
B. Area 3: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



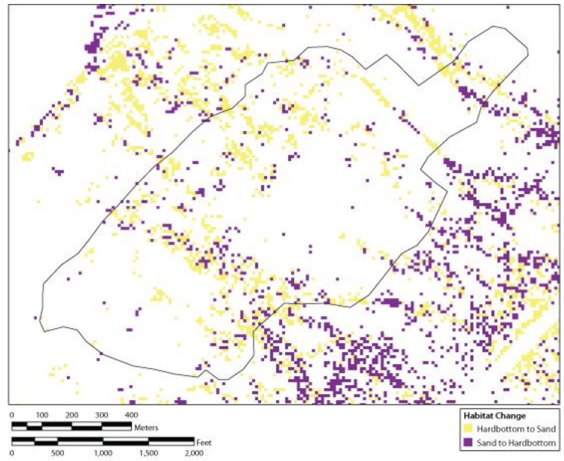
C. Area 3: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



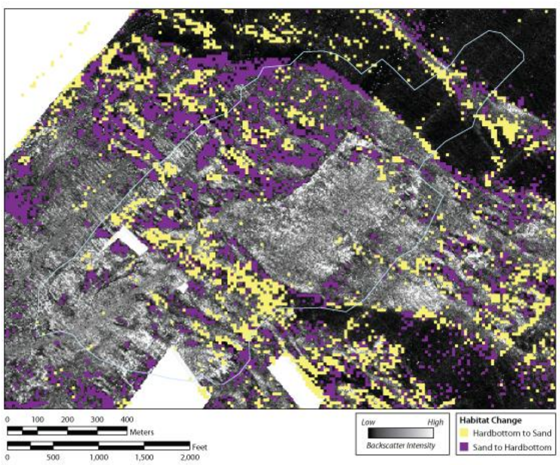
D. Area 3: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



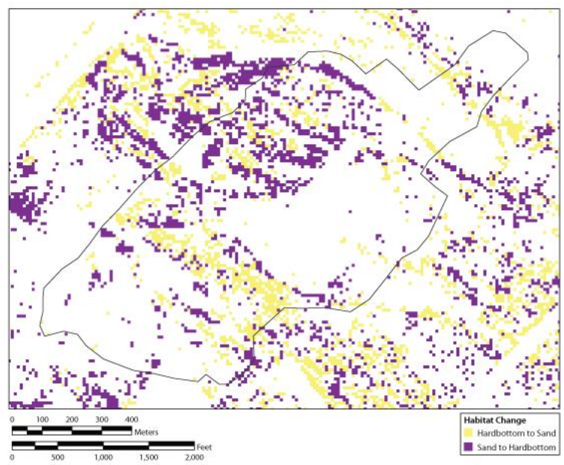
A. Area 3: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



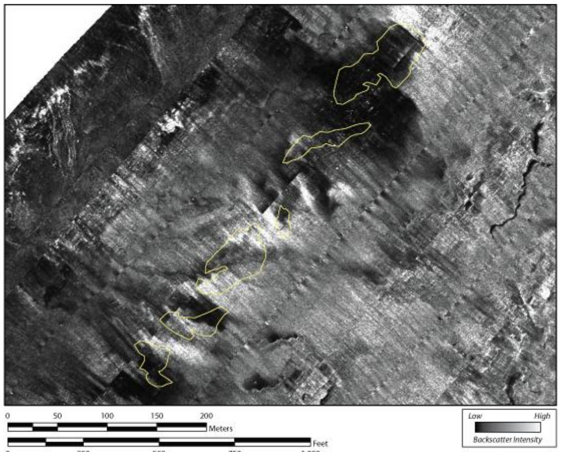
B. Area 3: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



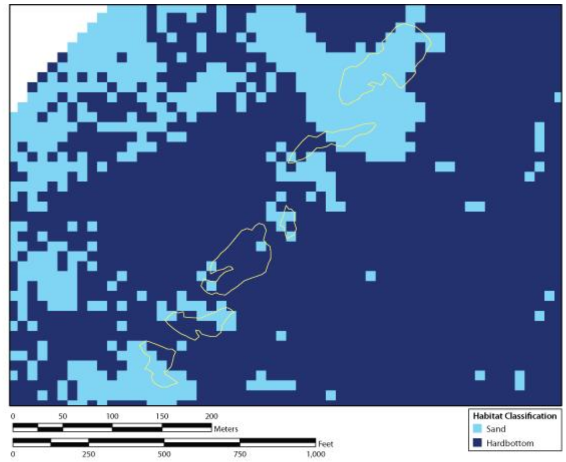
C. Area 3: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



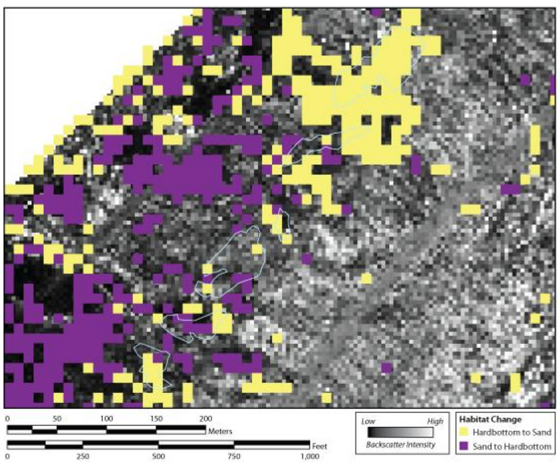
D. Area 3: Habitat Change Long Term
(*November 1999 - March 2010*)



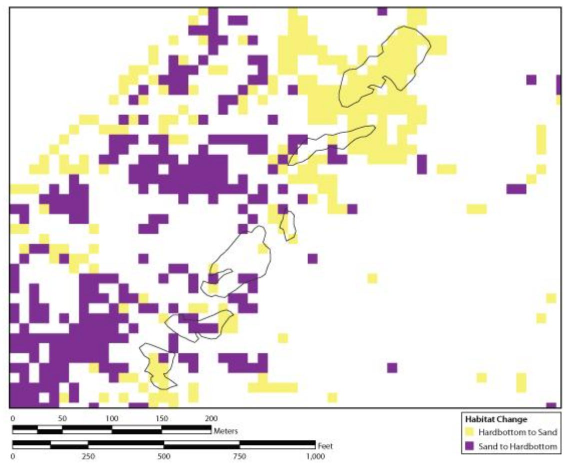
A. Area 4: Sidescan Sonar Pre-Nourishment
(*March 2008*)



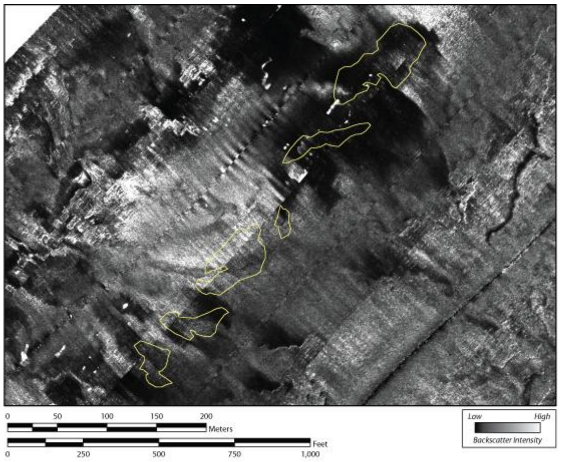
B. Area 4: Habitat Classification Pre-Nourishment
(*March 2008*)



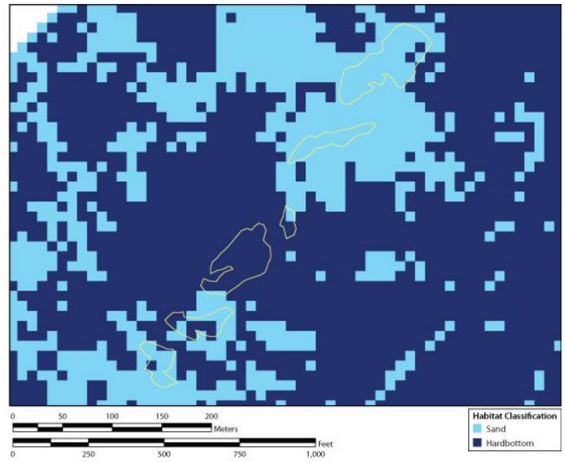
C. Area 4: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



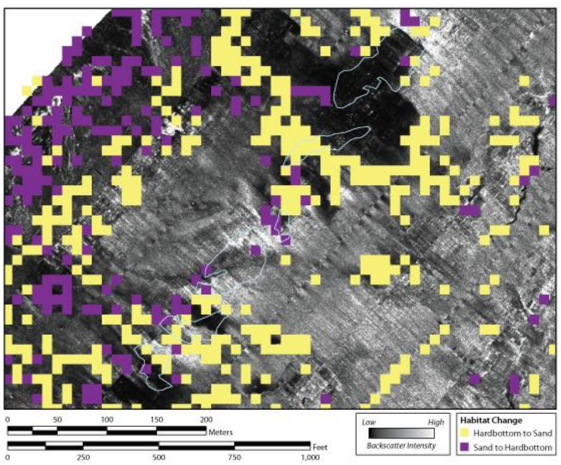
D. Area 4: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



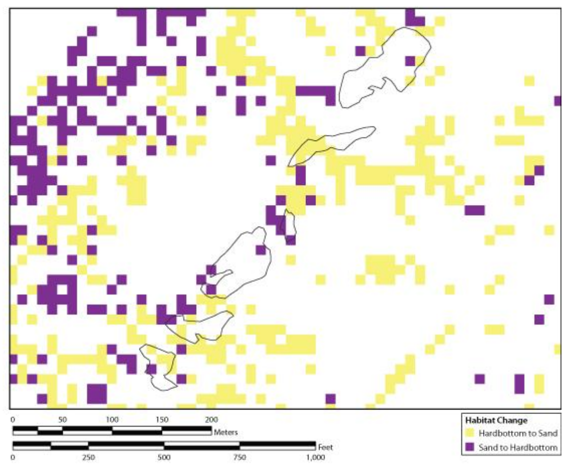
A. Area 4: Sidescan Sonar Post-Nourishment
(*January 2009*)



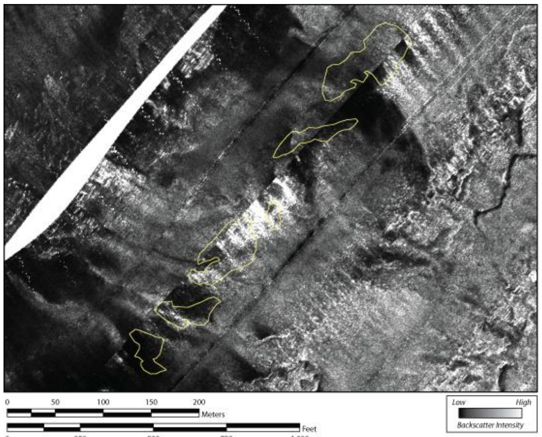
B. Area 4: Habitat Classification Post-Nourishment
(*January 2009*)



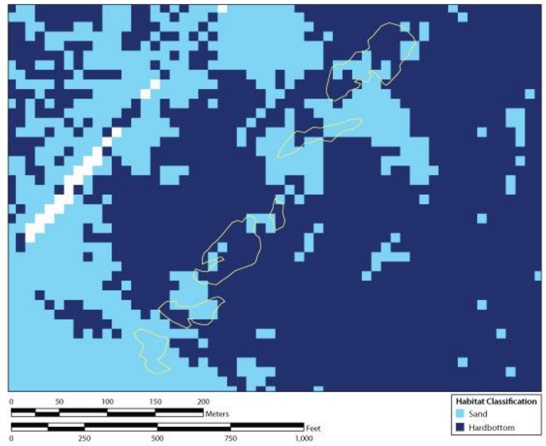
C. Area 4: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



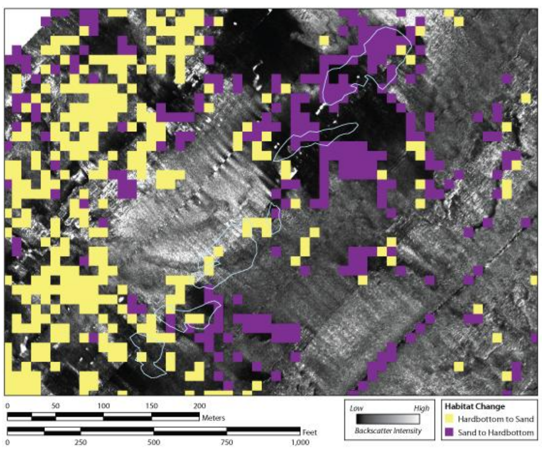
D. Area 4: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



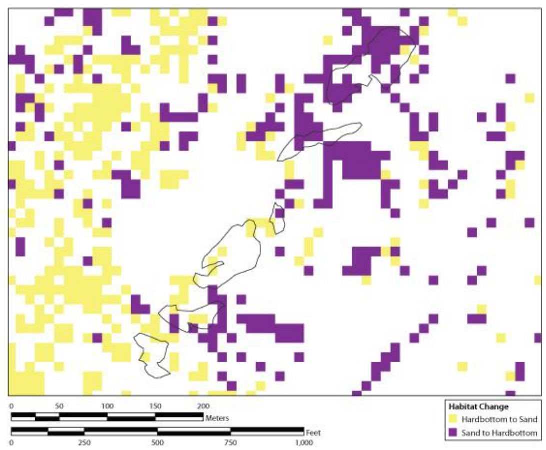
A. Area 4: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



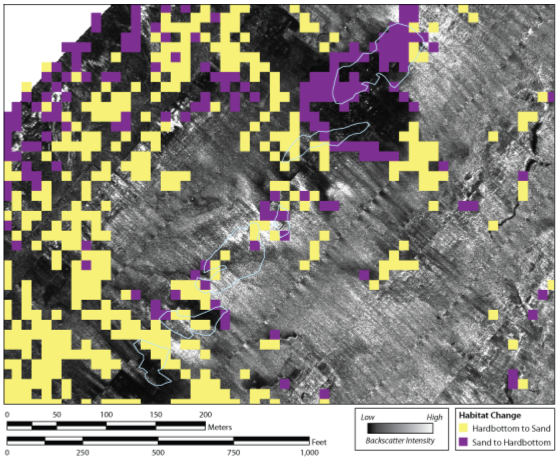
B. Area 4: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



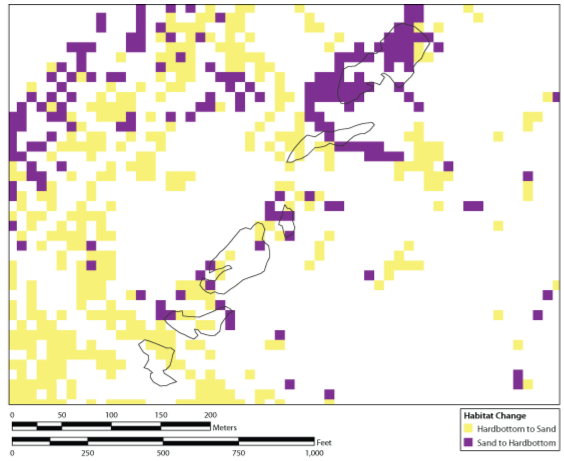
C. Area 4: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



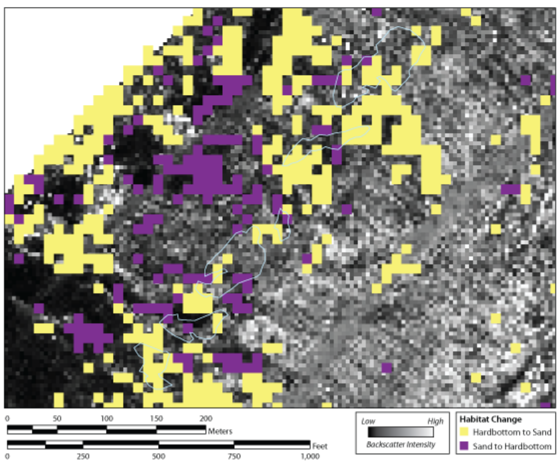
D. Area 4: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



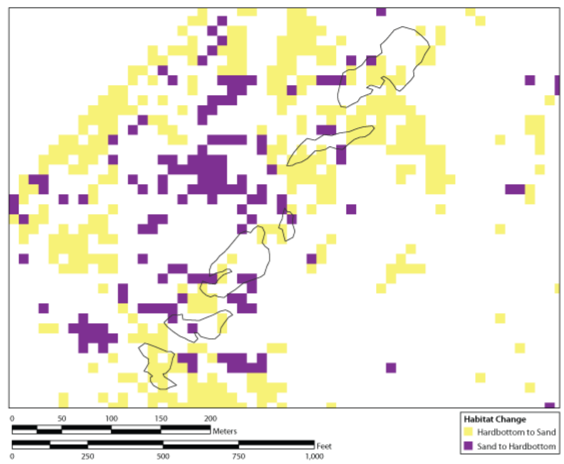
A. Area 4: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



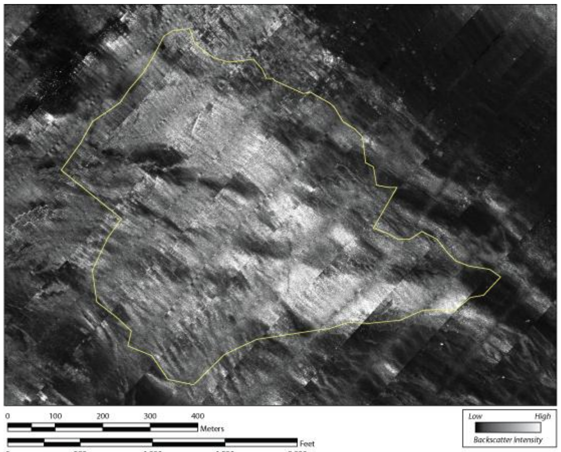
B. Area 4: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



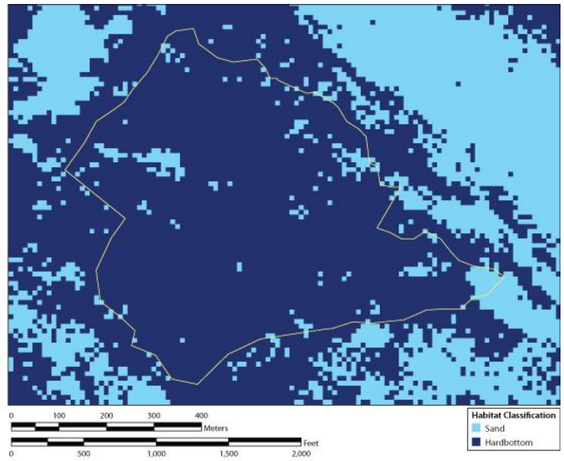
C. Area 4: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



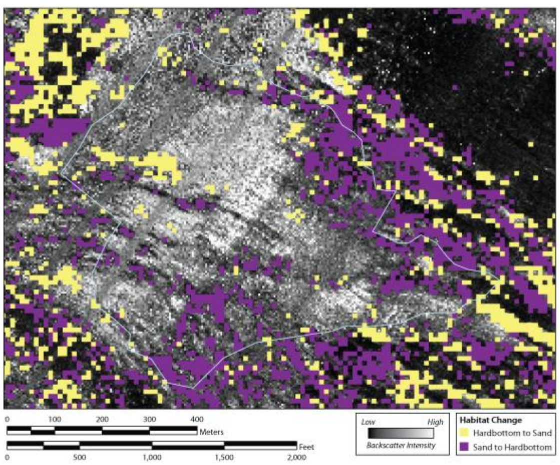
D. Area 4: Habitat Change Long Term
(*November 1999 - March 2010*)



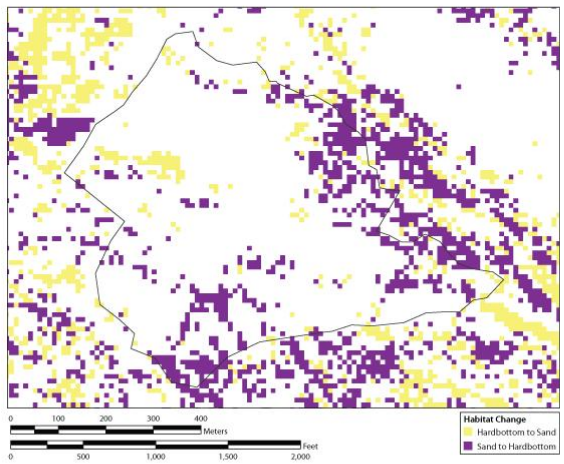
A. Area 6: Sidescan Sonar Pre-Nourishment
(*March 2008*)



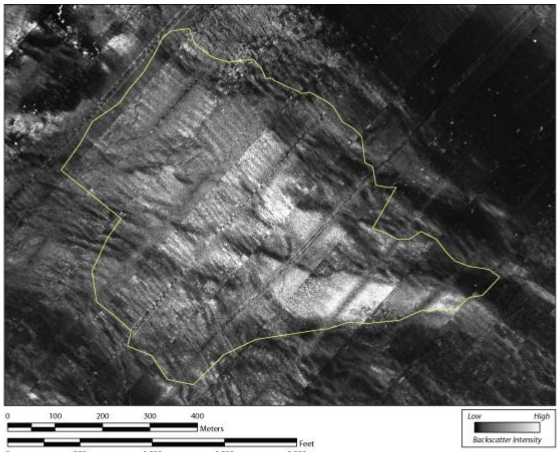
B. Area 6: Habitat Classification Pre-Nourishment
(*March 2008*)



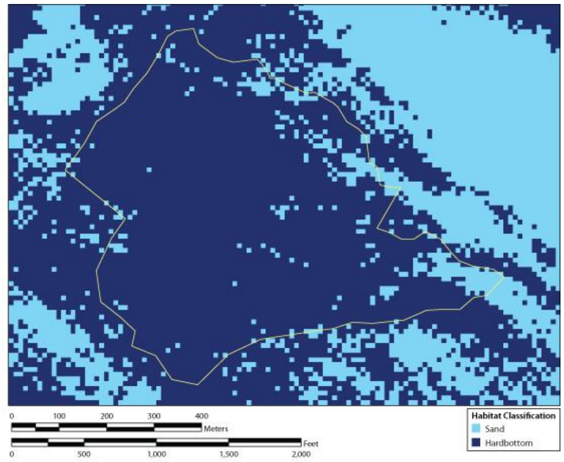
C. Area 6: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



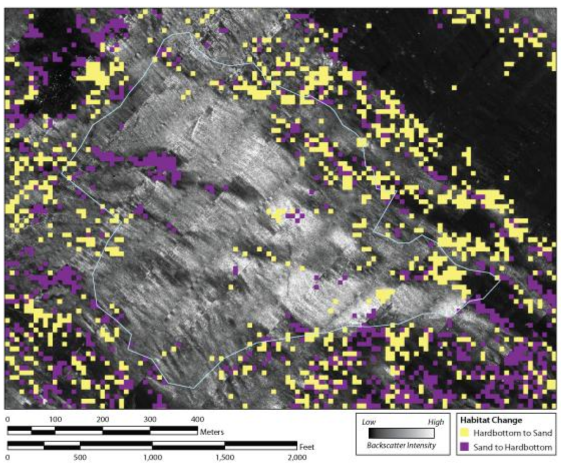
D. Area 6: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



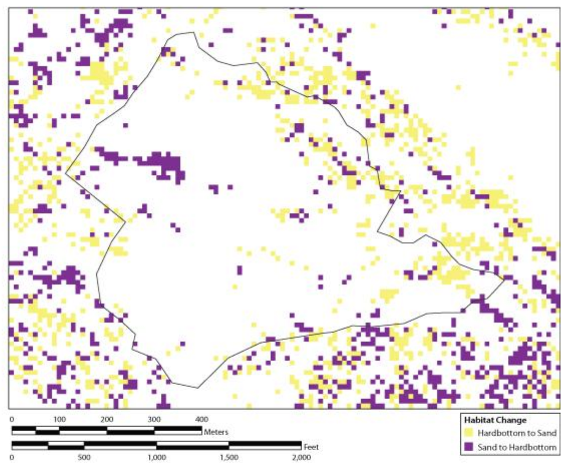
A. Area 6: Sidescan Sonar Post-Nourishment
(*January 2009*)



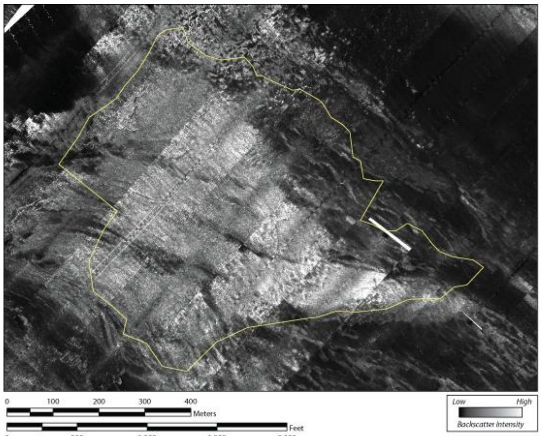
B. Area 6: Habitat Classification Post-Nourishment
(*January 2009*)



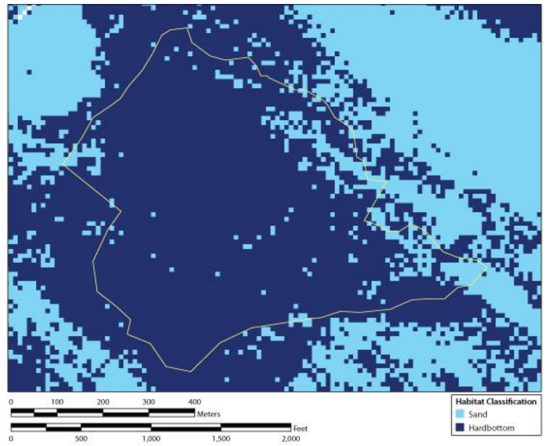
C. Area 6: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



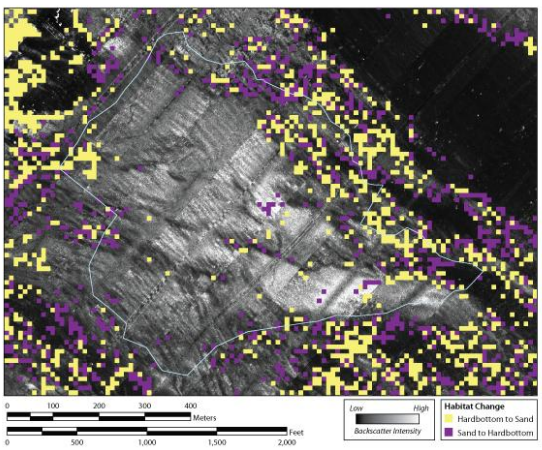
D. Area 6: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



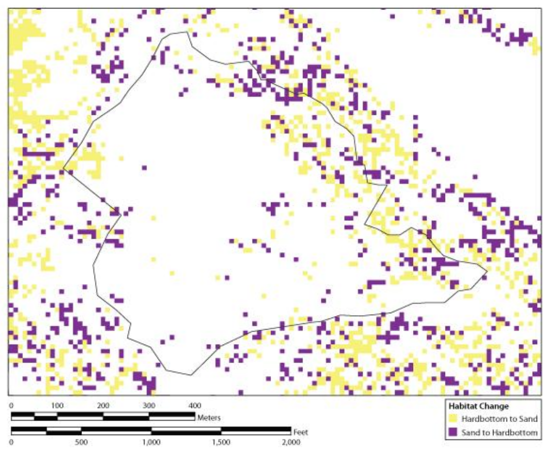
A. Area 6: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



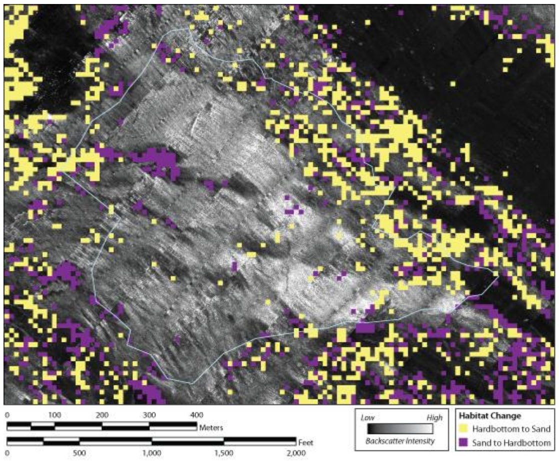
B. Area 6: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



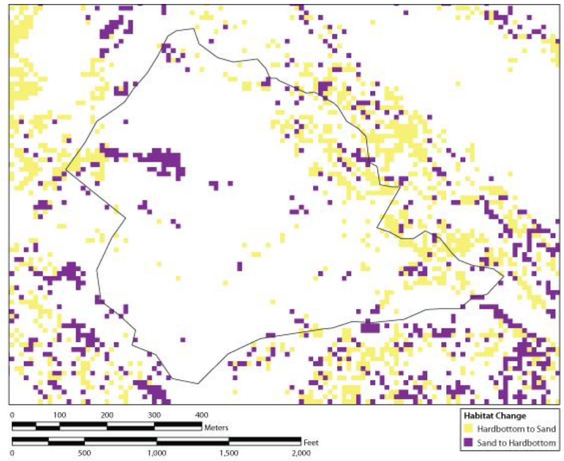
C. Area 6: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



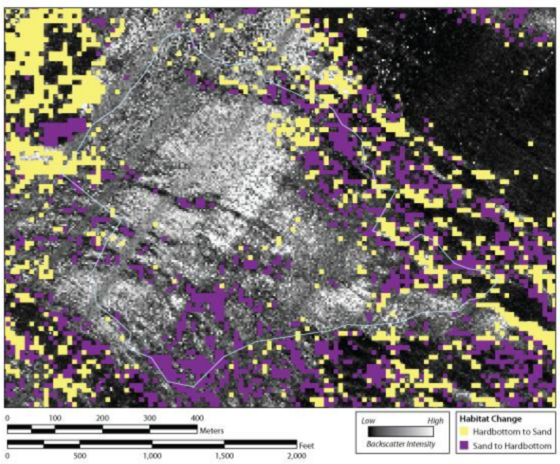
D. Area 6: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



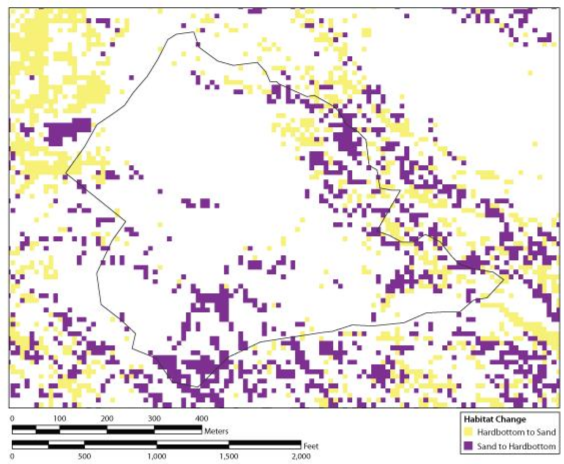
A. Area 6: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



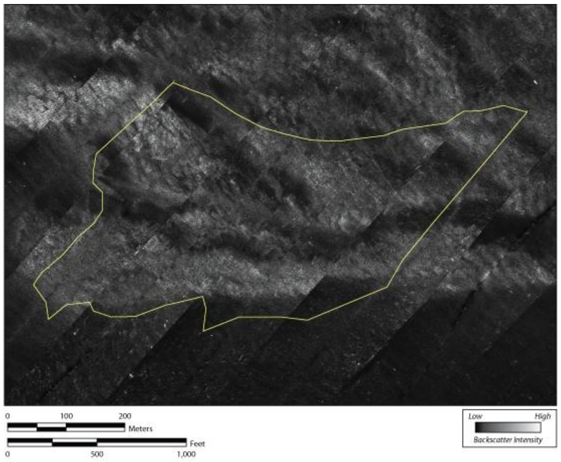
B. Area 6: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



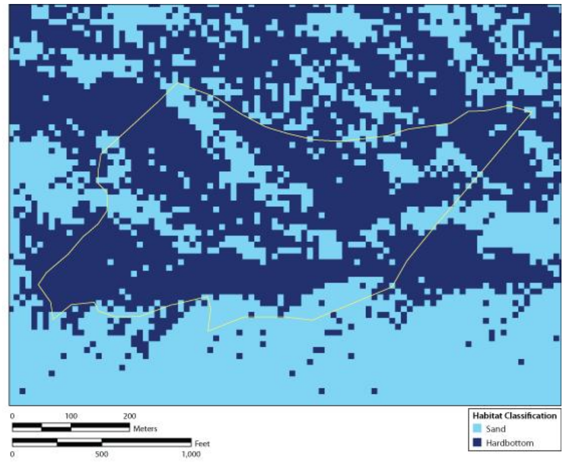
C. Area 6: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



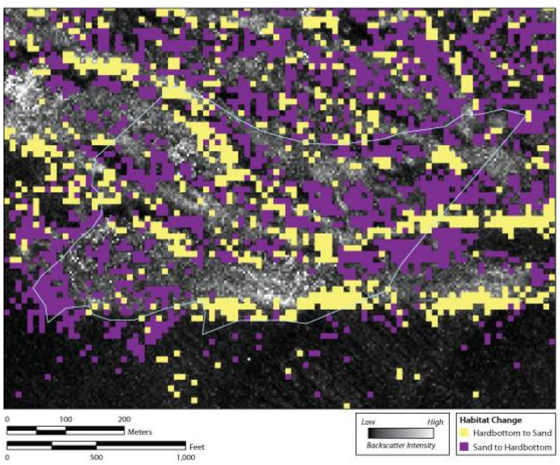
D. Area 6: Habitat Change Long Term
(*November 1999 - March 2010*)



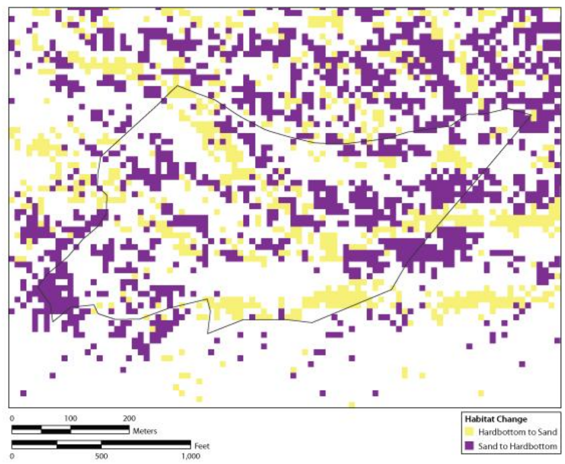
A. Area 9: Sidescan Sonar Pre-Nourishment
(*March 2008*)



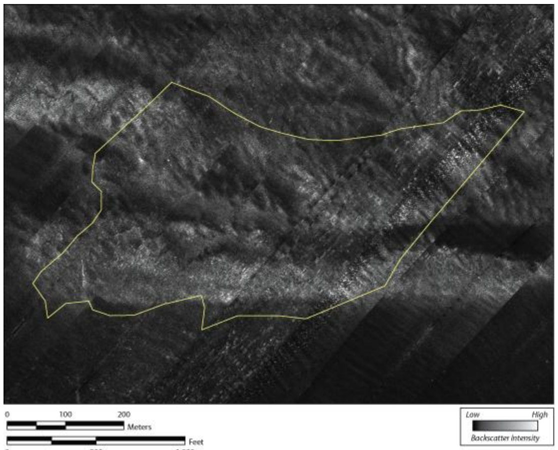
B. Area 9: Habitat Classification Pre-Nourishment
(*March 2008*)



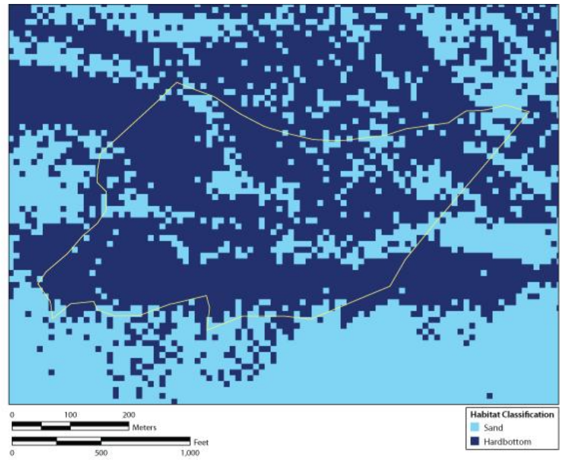
C. Area 9: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



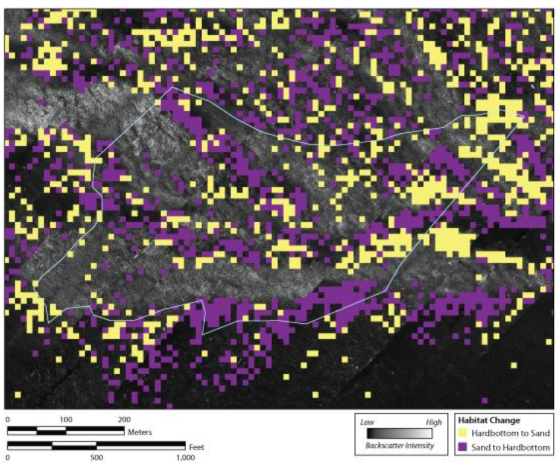
D. Area 9: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



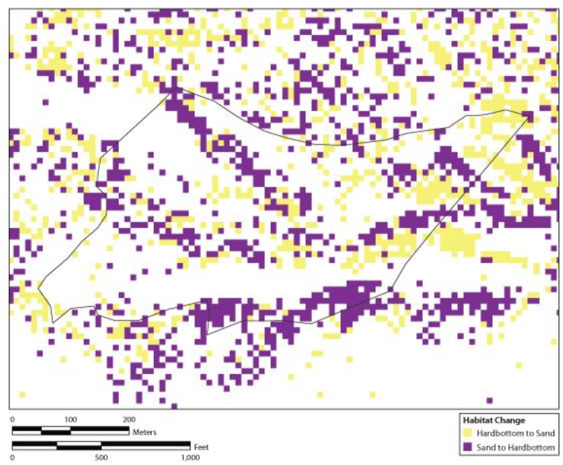
A. Area 9: Sidescan Sonar Post-Nourishment
(*January 2009*)



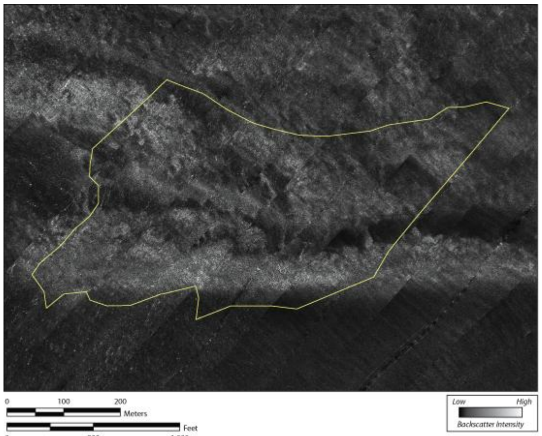
B. Area 9: Habitat Classification Post-Nourishment
(*January 2009*)



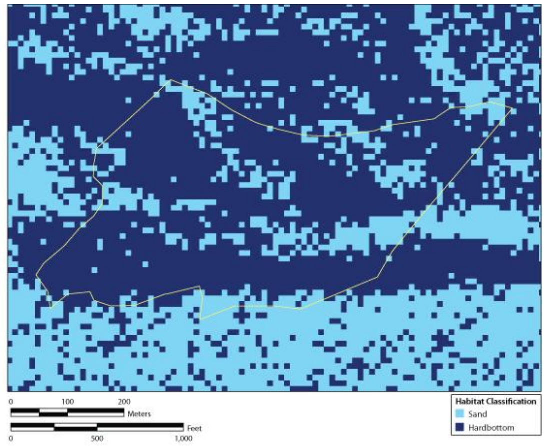
C. Area 9: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



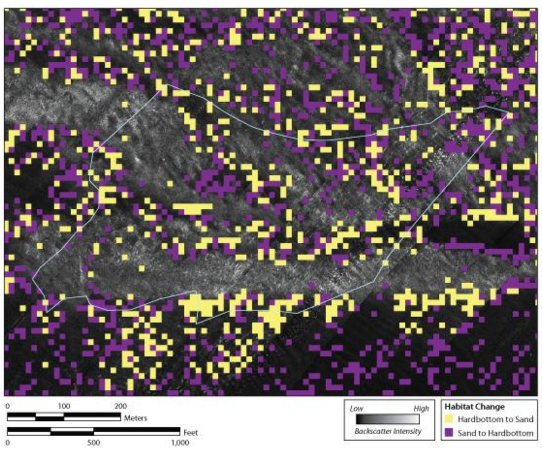
D. Area 9: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



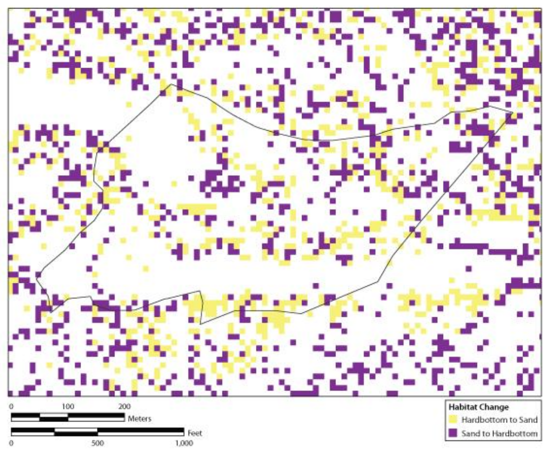
A. Area 9: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



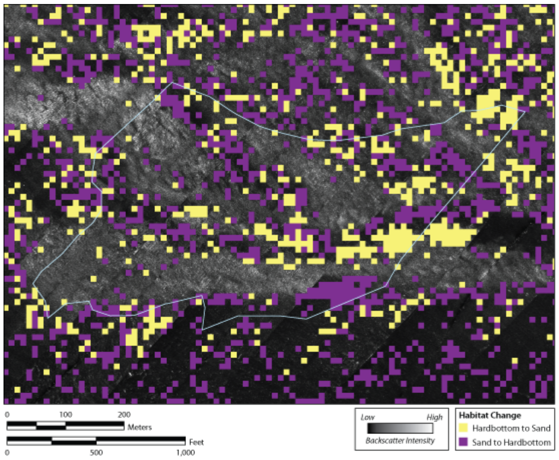
B. Area 9: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



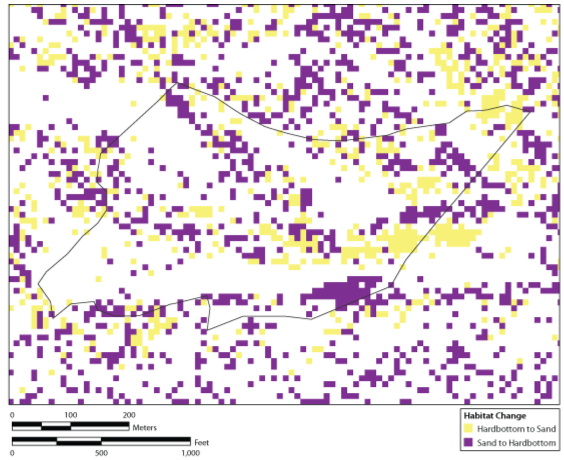
C. Area 9: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



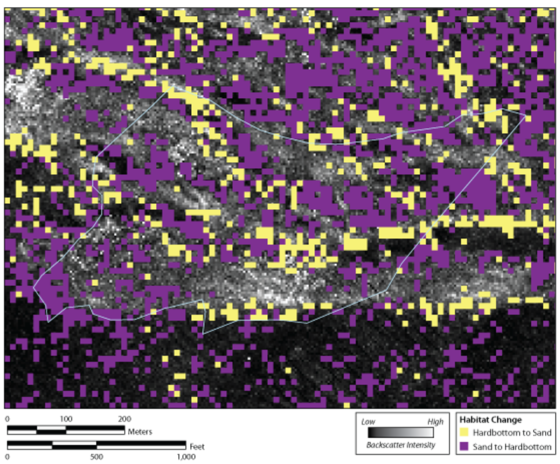
D. Area 9: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



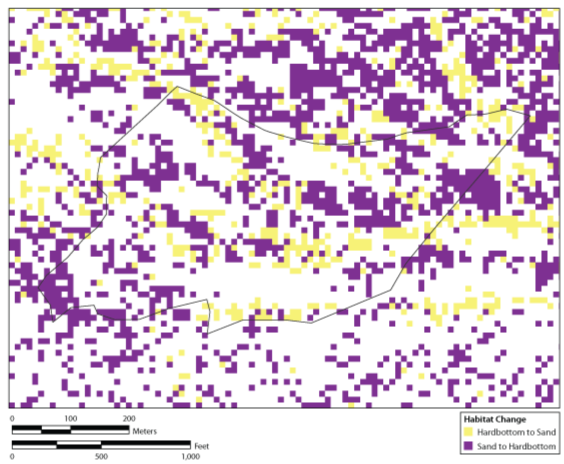
A. Area 9: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



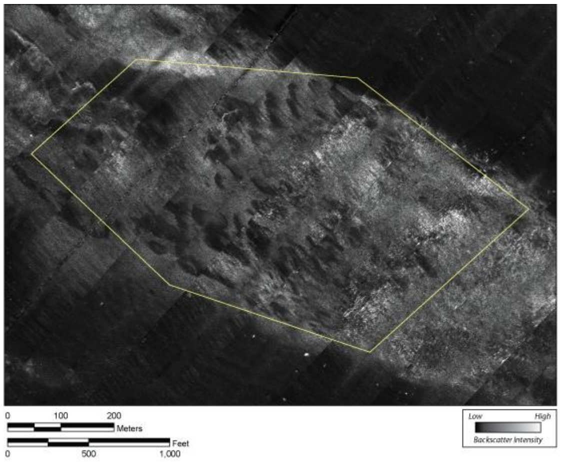
B. Area 9: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



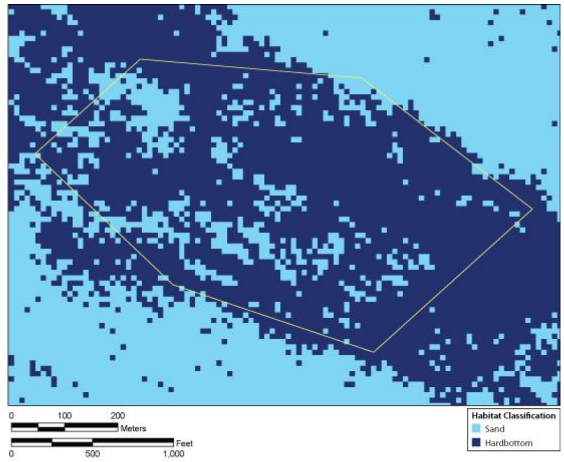
C. Area 9: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



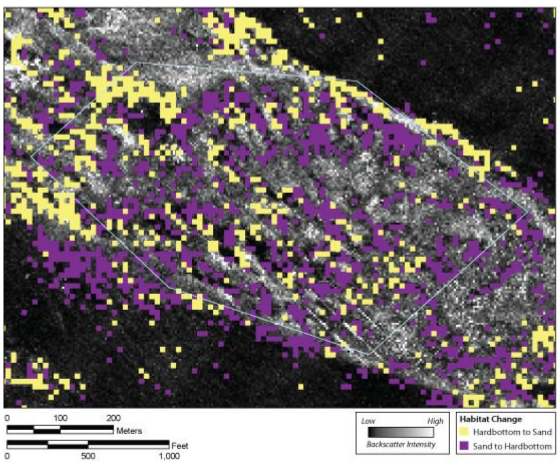
D. Area 9: Habitat Change Long Term
(*November 1999 - March 2010*)



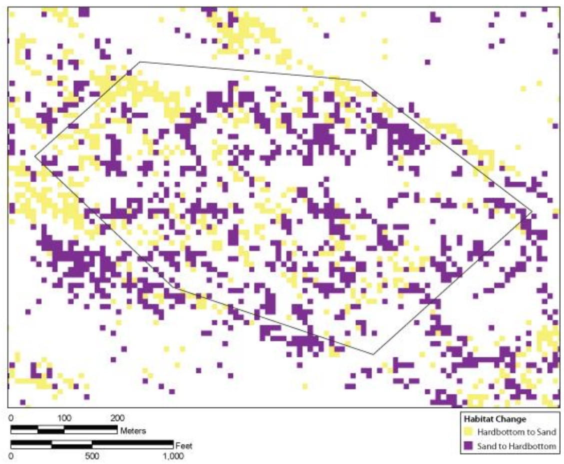
A. Area 11: Sidescan Sonar Pre-Nourishment
(*March 2008*)



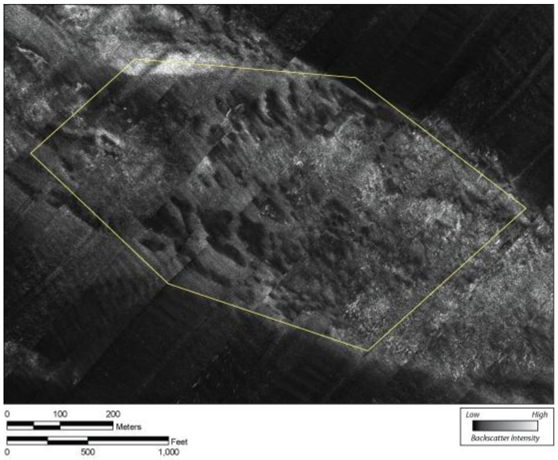
B. Area 11: Habitat Classification Pre-Nourishment
(*March 2008*)



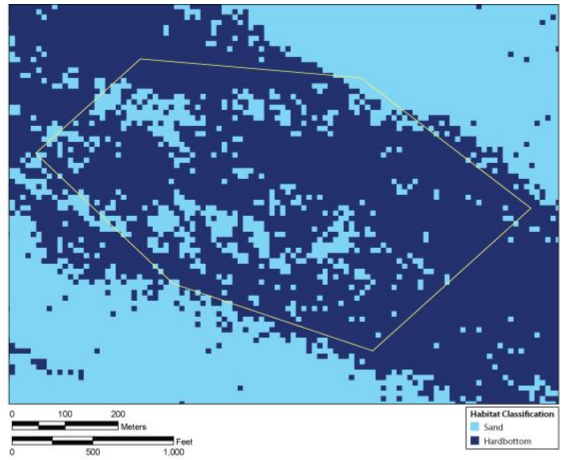
C. Area 11: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



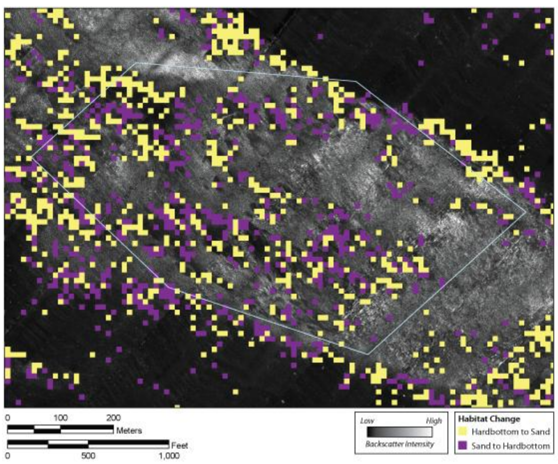
D. Area 11: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



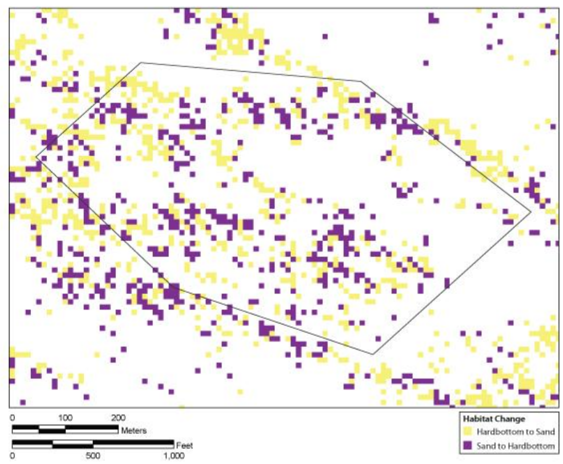
A. Area 11: Sidescan Sonar Post-Nourishment (*January 2009*)



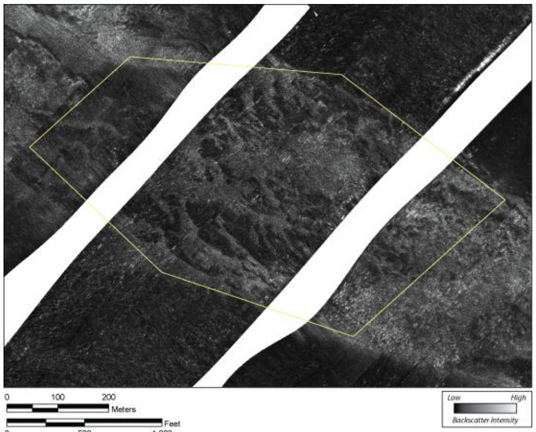
B. Area 11: Habitat Classification Post-Nourishment (*January 2009*)



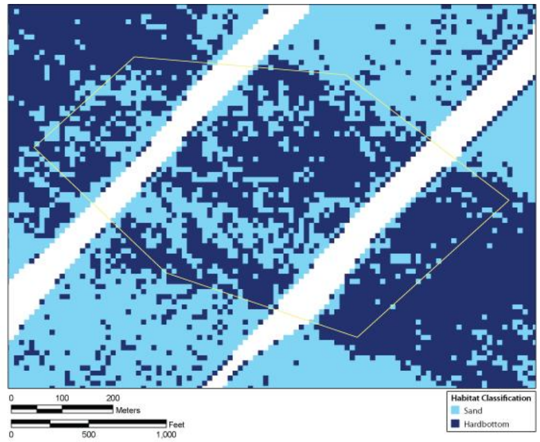
C. Area 11: Habitat Change Post-Nourishment (*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



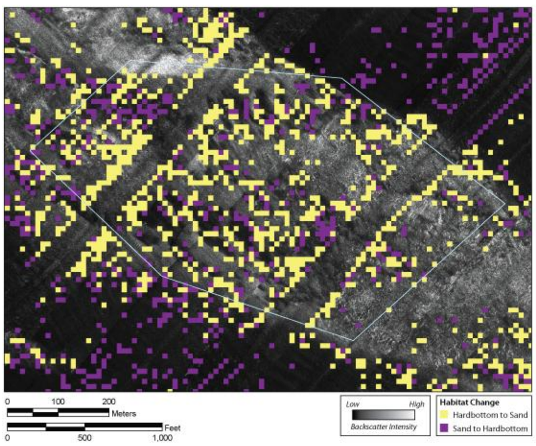
D. Area 11: Habitat Change Post-Nourishment (*March 2008 - January 2009*)



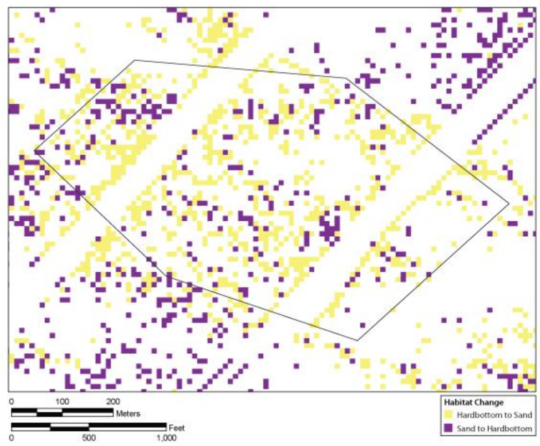
A. Area 11: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



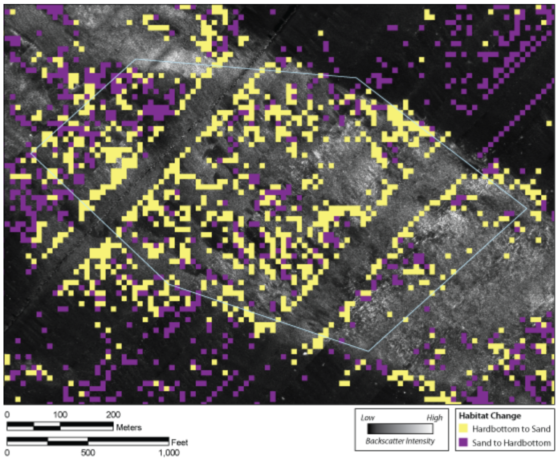
B. Area 11: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



C. Area 11: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009

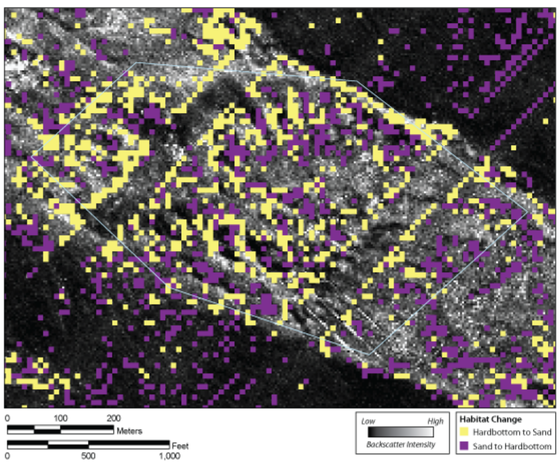


D. Area 11: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



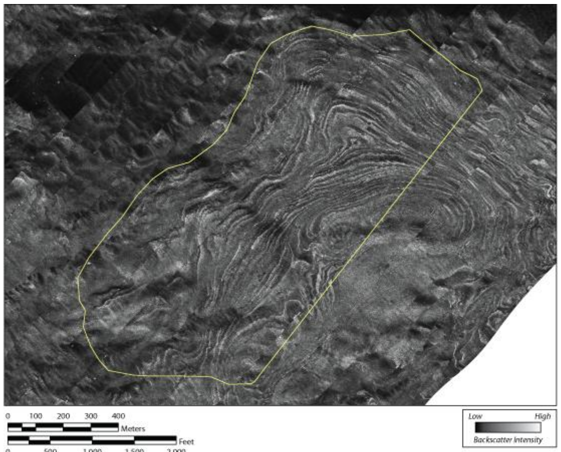
A. Area 11: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008

B. Area 11: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)

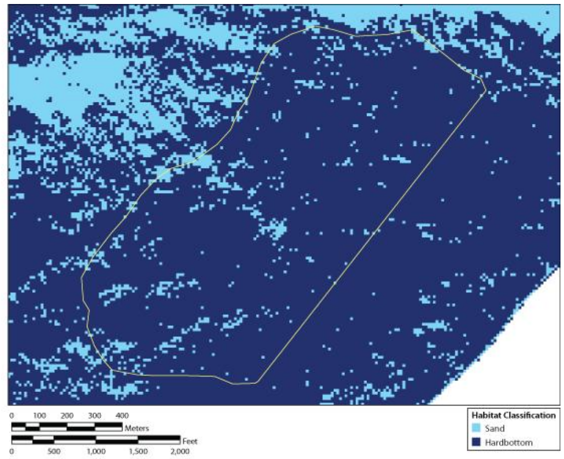


C. Area 11: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999

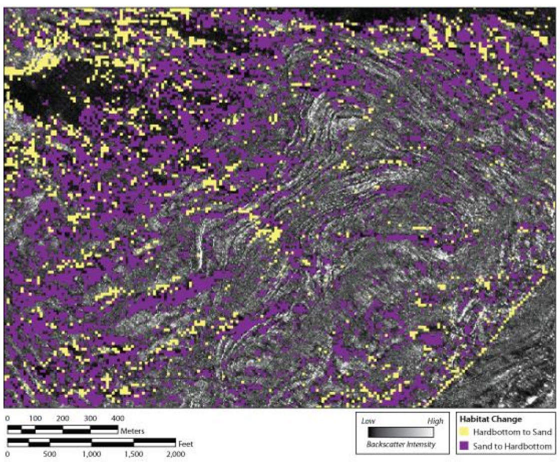
D. Area 11: Habitat Change Long Term
(*November 1999 - March 2010*)



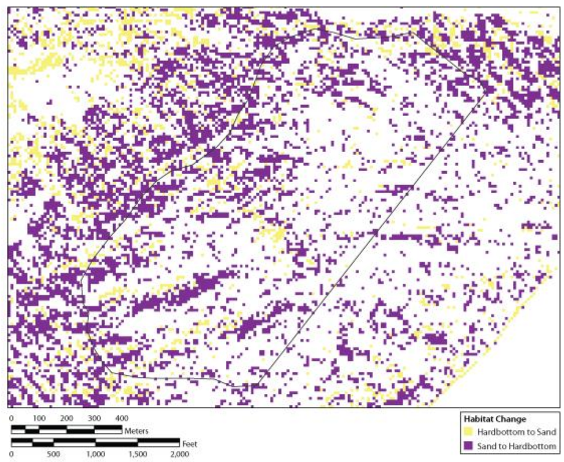
A. Area 13: Sidescan Sonar Pre-Nourishment
(*March 2008*)



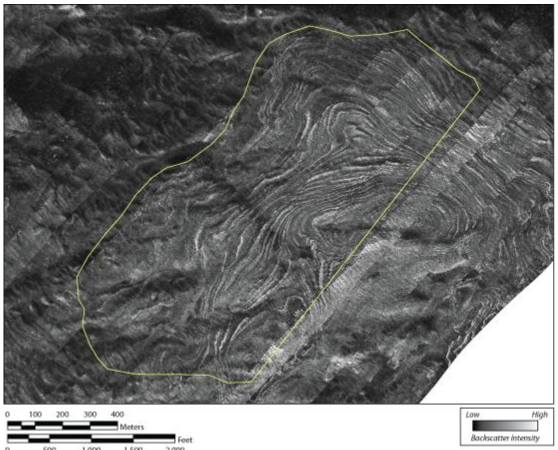
B. Area 13: Habitat Classification Pre-Nourishment
(*March 2008*)



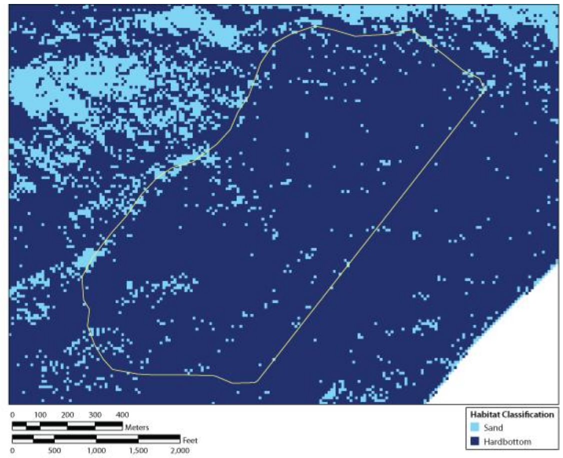
C. Area 13: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)
Background sidescan sonar imagery is from 1999



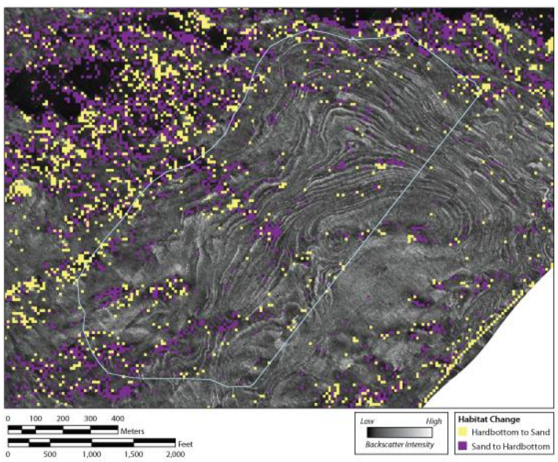
D. Area 13: Habitat Change Pre-Nourishment
(*November 1999 - March 2008*)



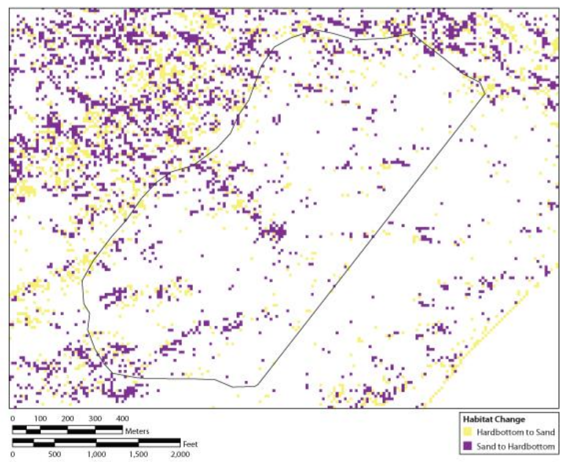
A. Area 13: Sidescan Sonar Post-Nourishment
(*January 2009*)



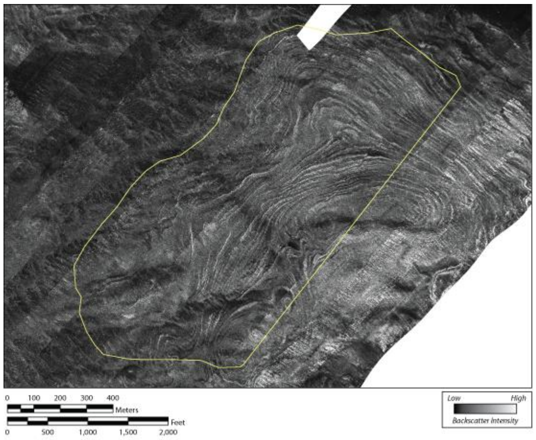
B. Area 13: Habitat Classification Post-Nourishment
(*January 2009*)



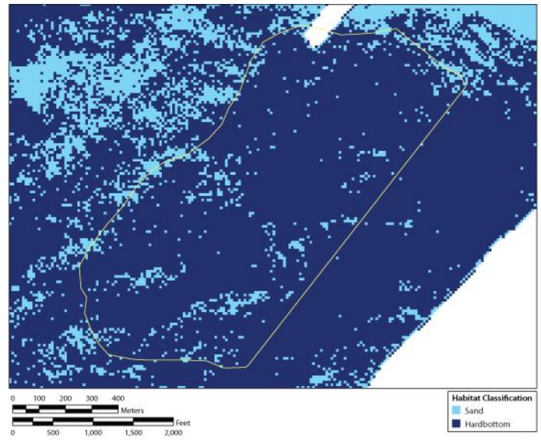
C. Area 13: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)
Background sidescan sonar imagery is from March 2008



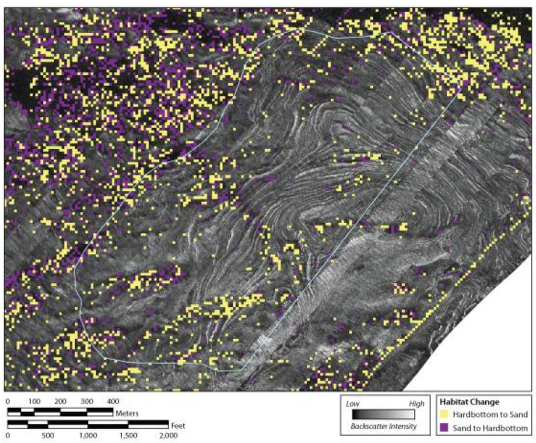
D. Area 13: Habitat Change Post-Nourishment
(*March 2008 - January 2009*)



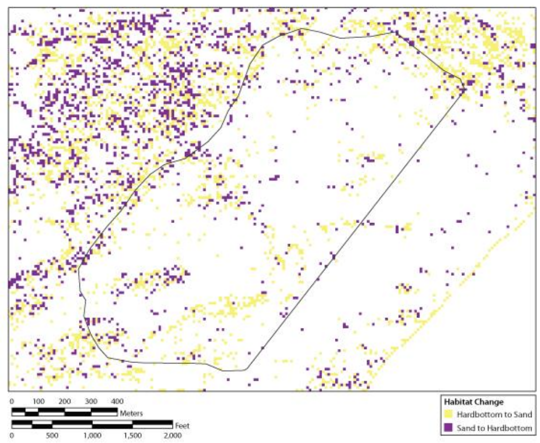
A. Area 13: Sidescan Sonar 1 Year Post-Nourishment (*March 2010*)



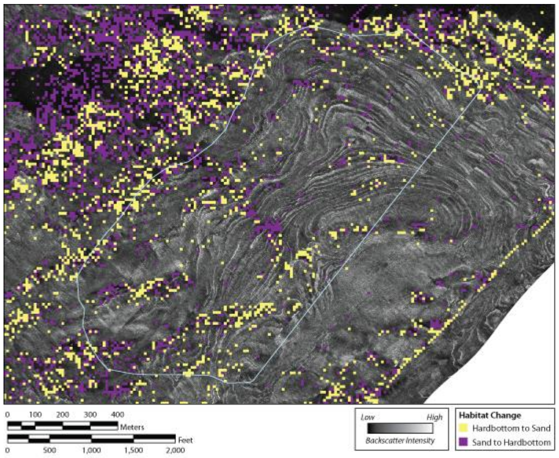
B. Area 13: Habitat Classification 1 Year Post-Nourishment (*March 2010*)



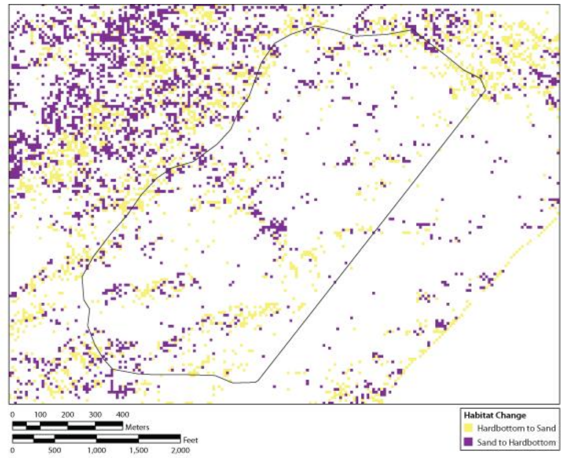
C. Area 13: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)
Background sidescan sonar imagery is from January 2009



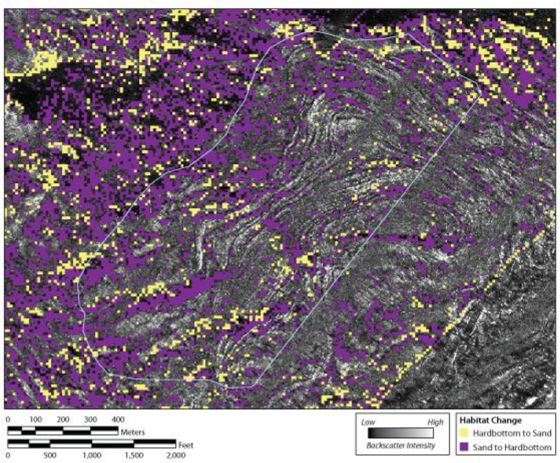
D. Area 13: Habitat Change 1 Year Post-Nourishment (*January 2009 - March 2010*)



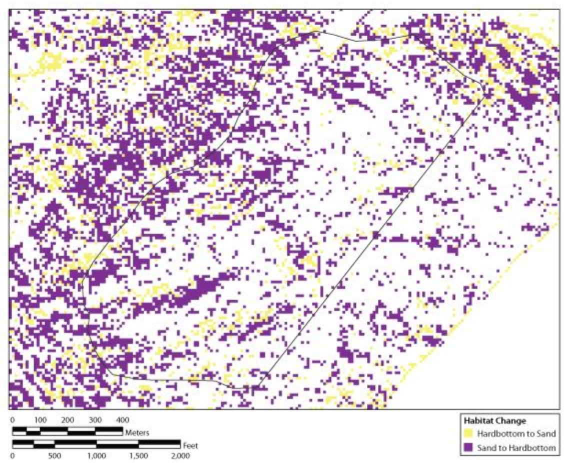
A. Area 13: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)
Background sidescan sonar imagery is from March 2008



B. Area 13: Habitat Change 1 Year Post-Nourishment
(*March 2008 - March 2010*)



C. Area 13: Habitat Change Long Term
(*November 1999 - March 2010*)
Background sidescan sonar imagery is from November 1999



D. Area 13: Habitat Change Long Term
(*November 1999 - March 2010*)