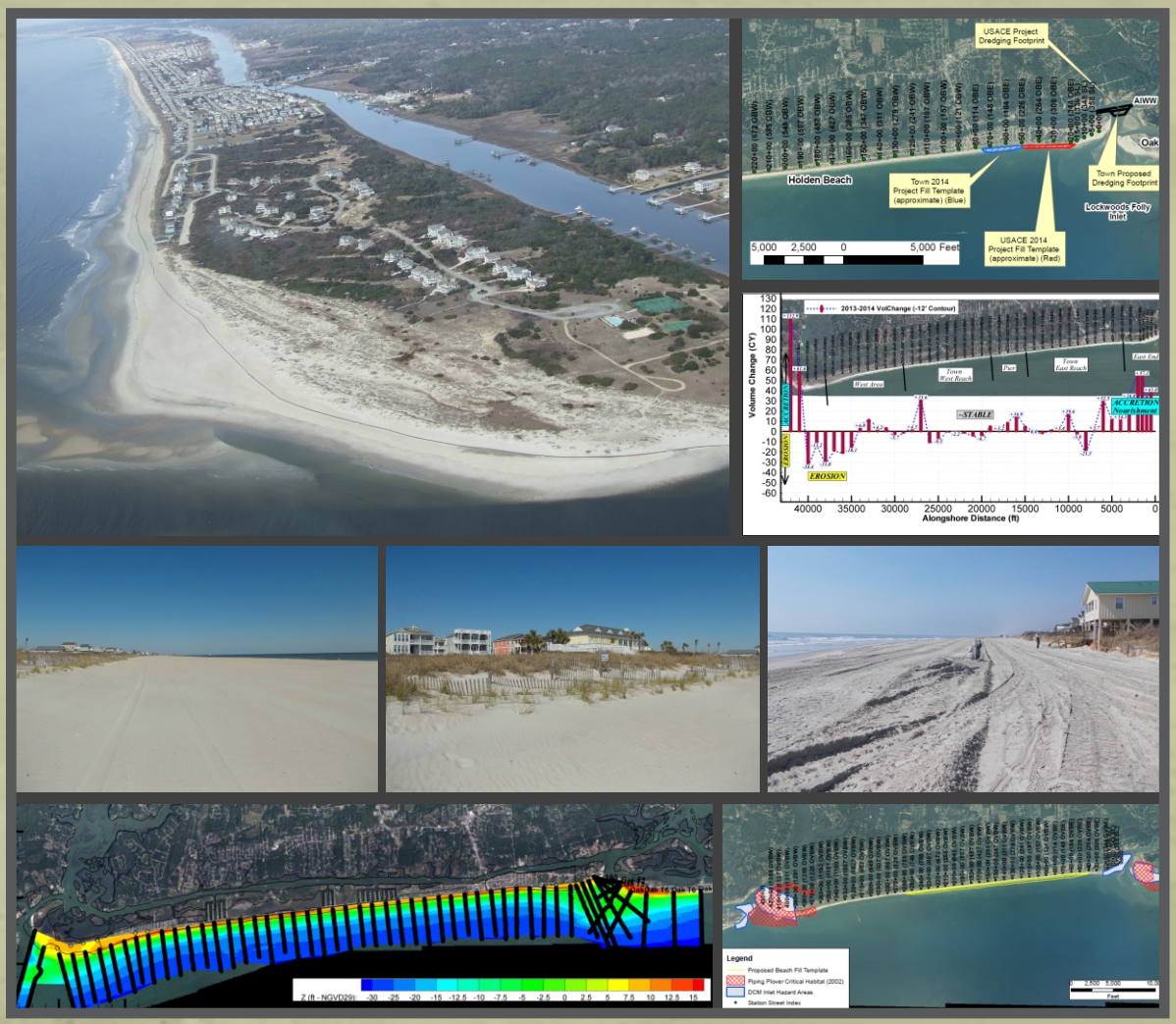
# Holden Beach

## Annual Beach Monitoring Report

Prepared For:
Town of Holden Beach, North Carolina




September 2014

APPLIED TECHNOLOGY & MANAGEMENT

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# 1.0 INTRODUCTION

Holden Beach is a 9-mile-long barrier island located in Brunswick County, North Carolina (see Figure 1-1), where long-term and episodic storm erosion continually threatens the coastal habitats, recreational beach, tourism, and upland developments on the island. Consequently, the Town of Holden Beach, referred to herein as the "Town," has undertaken a comprehensive beach management and maintenance program to protect and enhance its beach system. All nourishment and dune enhancement activities resulting from this program have proven valuable in providing a healthy beach system as well as a storm buffer to reduce losses to homeowners and to Town, State and Federal infrastructure.

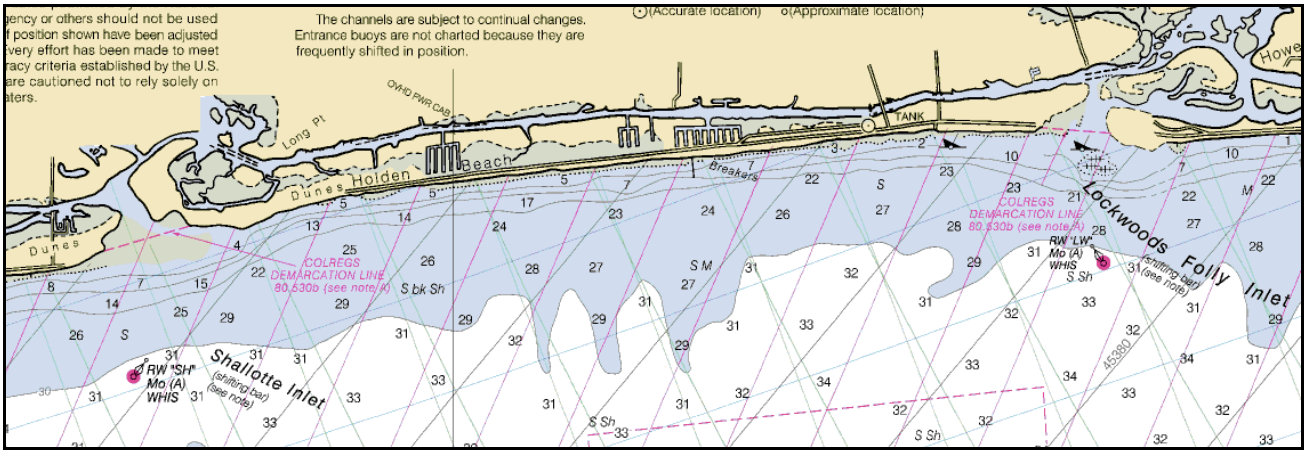


*Figure 1-1. Project Location Map of Holden Beach, NC (NOAA Chart 11536)*

The Town has been documenting nourishment and dune project performance and environmental effects through annual field surveys, analyses, and monitoring reports according to regulatory agency permit conditions, as well as to remain eligible for Federal Emergency Management Agency (FEMA) mitigation funding related to "engineered" beaches. Another objective is to identify erosional areas of shoreline that warrant future nourishment consideration.

This report summarizes the 2013 to 2014 beach management activities, as well as comparing the most recent survey (April 2014) with beach profile surveys collected from 2000 through 2013. Beach profile data is used to assess the status of the beach through an evaluation of volume and contour change and to establish rates of change with respect to nourishment projects and historical background erosion rates.

## 2.0 RECENT AND FUTURE PROJECTS

This section provides a brief project history, beginning with the 2001/2002 U.S. Army Corps of Engineers (USACE) Wilmington Harbor Deepening nourishment project. Prior to this event, Town and USACE beach management efforts were sporadic and on a smaller scale, with the first documented nourishment occurring in 1971. Beach scraping and dune repairs have been documented as far back as 1954, mitigating Hurricane Hazel impacts. Significant erosion and the loss of more than 30 houses on the eastern end of Holden Beach in the 1990s were major factors in establishing current beach management activities. Table 2-1 and Figure 2-1 present a summary of nourishment activities and locations.

Table 2.1. Summary of Holden Beach Nourishment Projects since 2001

| Date | Completed By | Beach Stations Nourished | Approx. Volume of Material Placed (cubic yards) | Nourishment Material Source |
|---|---|---|---|---|
| 12/8/01 – 2/20/02 | USACE | 87+00 – 192+00 | 525,000 | Wilmington Harbor Deepening Project |
| 3/7/02 – 4/30/02 | Town of Holden Beach Phase I | 66+00 - 90+00, 175+00 – 217+00 | 141,700 | Oyster Harbor upland site |
| 3/02-4/02 | USACE | 20+00 – 30+00[1)] | 32,000 | Lockwood Folly Inlet crossing of AIWW |
| Winter 2002-2003 | Town of Holden Beach | 90+00 – 175+00 | 30,000 | Boyd Street Disposal Area |
| 9/16/04 – 11/2/04 | USACE | 15+00 – 40+00 | 113,230 | Lockwood Folly Inlet crossing of AIWW |
| 12/03 – 4/04 | Town of Holden Beach | 46+00 – 68+00 and 215+00 – 238+00 | 123,000 | Smith borrow site |
| 5/5/06 – 5/24/06 | USACE | 15+00 – 40+00 | 62,853 | Lockwood Folly Inlet crossing of AIWW |
| Early 2006 | Town of Holden Beach | Eastern Reach | 42,000 | Smith borrow site |
| Early 2006 | Town of Holden Beach | Western Reach | 3,200 | Smith borrow site |
| 1/24/08 – 3/28/08 | Town of Holden Beach | 60+00 – 95+00 and 245+00 – 270+00 | 201,000 | Smith borrow site |
| 2008/2009 | USACE | 20+00 – 40+00 | 100,000 | Lockwood Folly Inlet crossing of AIWW |
| 03/24/09 – 4/30/09 | Town of Holden Beach | 55+00 – 110+00 and 210+00 – 255+00 | 190,000 | Smith borrow site |
| Spring 2010 | USACE | 20+00 – 55+00 | 140,000 | Lockwood Folly Inlet crossing of AIWW |
| February 2011 | USACE | 20+00 – 40+00 | 32,000 | Lockwood Folly Inlet crossing of AIWW |
| January 2012 | USACE | 20+00 – 30+00 | 25,000 | Lockwood Folly Inlet crossing of AIWW |
| 2/10/14-2/27/14 | USACE | 18+00 – 50+00 | 93,000 | Lockwood Folly Inlet crossing of AIWW |
| 2/27/14-3/15/14 | Town of Holden Beach | 50+00 – 73+00 | 95,000 | Lockwood Folly Inlet crossing of AIWW |
| | | Approximate Total Volume since 2001 | **1,948,983** | |

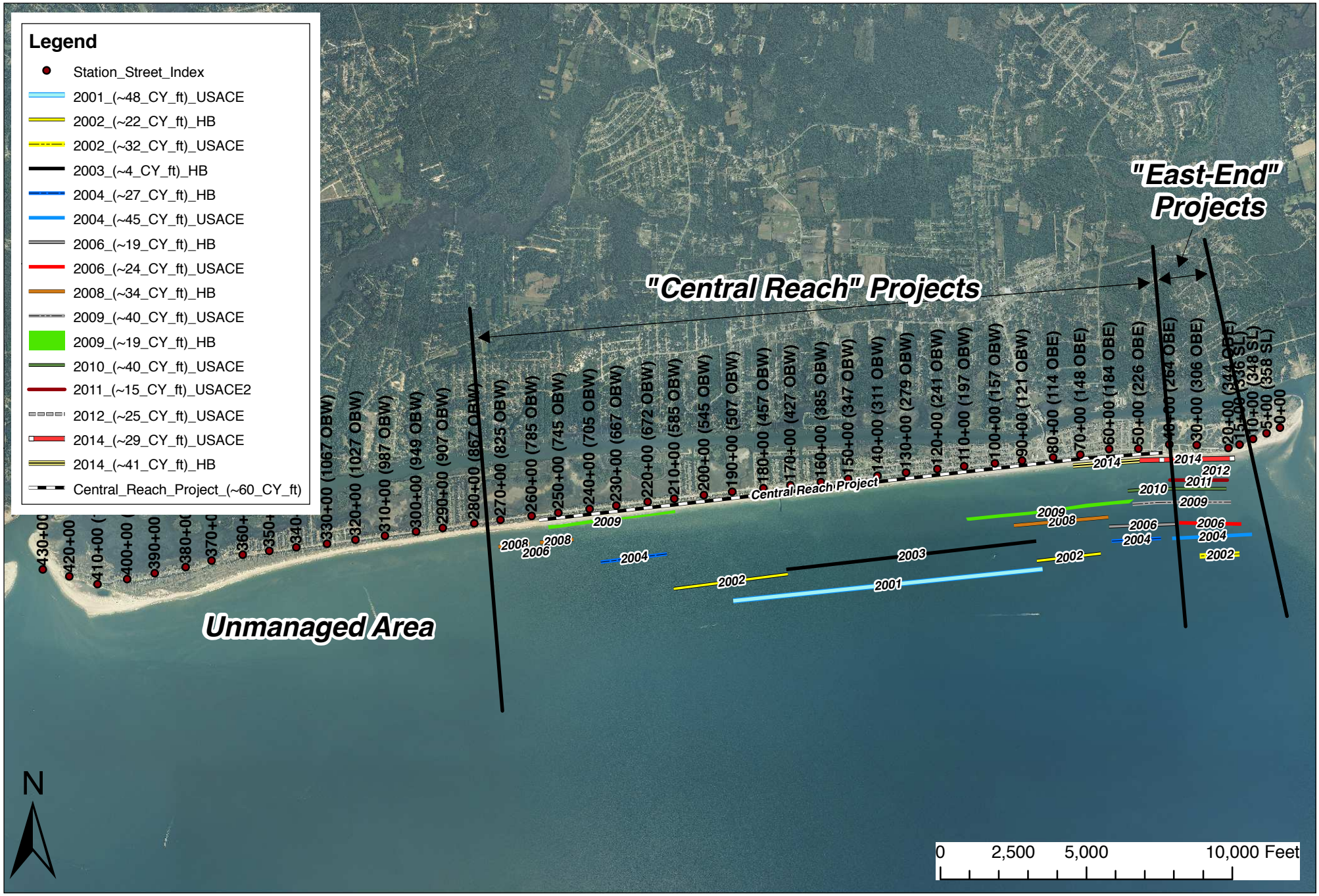


Figure 2-1
Holden Beach Historic Nourishment Activity (2001-2014)
HB= Holden Beach, USACE= U.S. Army Corps of Engineers

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Following the spring 2002 completion of the USACE Wilmington Harbor Deepening nourishment project, the Town conducted six beach nourishment projects using upland borrow sources. The Town placed 190,000 cubic yards (cy) of upland fill along approximately 10,000 linear feet (LF) of shoreline in spring 2009. In addition to upland fill beach nourishments, the Town recently placed 95,000 cy from the Lockwood Folly (LWF) Inlet AIWW Crossing (LWFIX) along approximately 2,300 LF of shoreline

## 2.1 2009 TOWN UPLAND FILL PROJECT

The most recent major beach fill construction utilizing an upland borrow source by the Town occurred between March 24 and April 30, 2009. Approximately 115,000 cy was placed between Stations 55+00 and 110+00 (21 cy/LF average) along the Eastern Reach and 75,000 cy between Stations 210+00 and 255+00 (16.5 cy/LF average) along the Western Reach. Figure 2-2 illustrates the placed-fill footprint and the permitted footprint. Sand was obtained from the Smith upland borrow site.


*Figure 2-2. 2009 Constructed Project Reaches and Permitted Sand Placement (the existing permit was modified and expanded in 2009)*

## 2.2 2014 USACE AND TOWN LWFIX PROJECT

Beginning in early February 2014 (approximately February 10), the USACE dredged the LWFIX, including a 50-foot (ft) bend widener, and placed approximately 93,000 cy of beach-compatible dredged material along approximately 3,200 ft of Holden Beach shoreline, approximately between baseline stations 18+00 and 50+00 (29 cy/LF average). The USACE project was completed on February 27.

The USACE typically performs this project every 2 years, depending on shoaling and funding. The primary goal of this annual/bi-annual project is navigation, while a secondary and important benefit is placement of this compatible material on the beach.

In 2010, the USACE used a 400-ft bend widener and placed approximately 150,000 cy of sand. The February 2011 and January 2012 USACE LWFIX projects only provided 32,000 cy and 25,000 cy of material placed. Since the USACE 2010 LWFIX project, which was supported with economic stimulus funding, the USACE has not had funds available to include the 400-ft bend widener, despite sufficient sand volume within the dredging template.

Consequently, the Town of Holden Beach recently performed an independent project that "piggybacked" the 2014 USACE LWFIX project and expanded the bend widener to 400 ft so more material could be placed on the beach. The 400-ft bend widener is still within the authorized Federal navigation project footprint, which simplified the permitting process.

The Town's piggybacking of the USACE project maximizes sand placement while minimizing costs by using of the dredge already onsite for the Federal project. The Town project placed approximately 95,000 cy of beach-compatible material along approximately 2,300 ft of Holden Beach shoreline, between baseline stations 50+00 and 73+00 (41 cy/LF average). The Town portion of the project spanned from February 27 to March 15 (about 17 days, including a few days of down time). Both the Town and USACE project footprints, as well as the respective LWFIX and bend widener borrow areas, are shown in Figure 2-3.

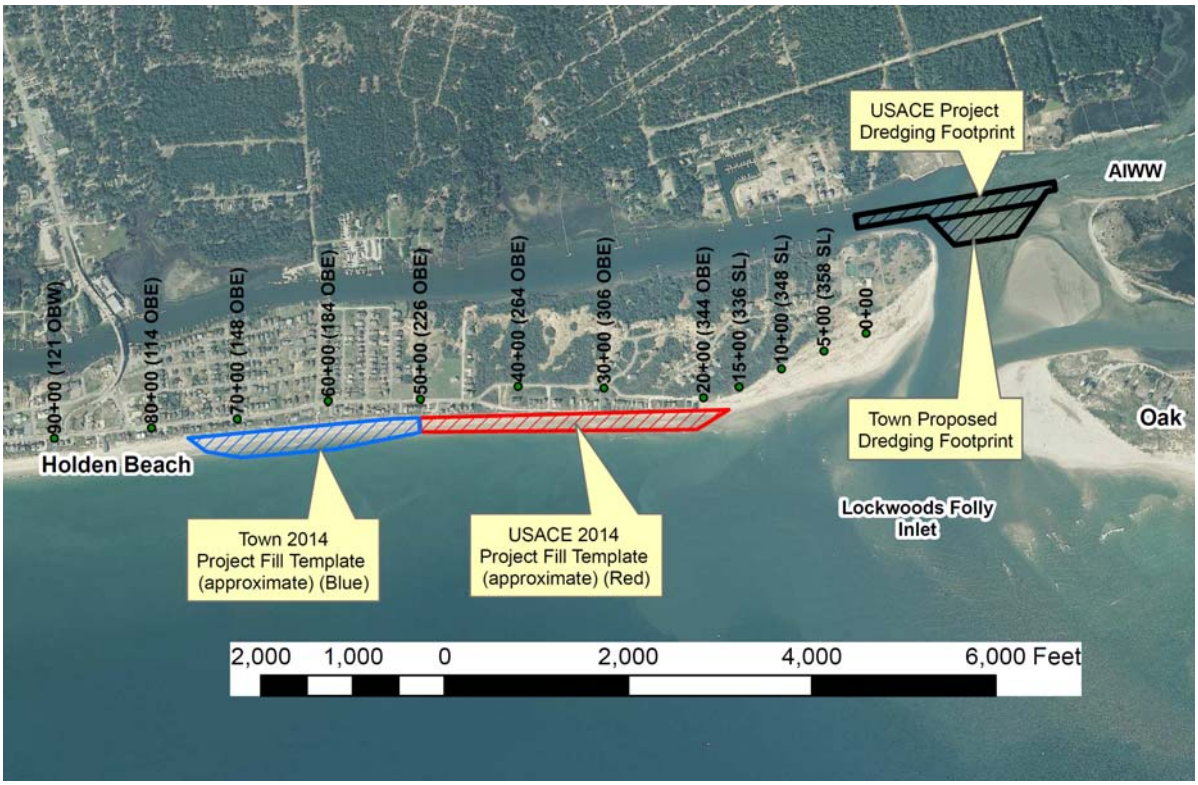



*Figure 2-3. USACE and Town LWFIX 2014 Project Dredging and Beach Placement*

The USACE project placed sand volume densities of approximately 29 cy/LF, whereas the Town project placed approximately 41 cy/LF. This was due to two primary factors: 1) the USACE portion of the project placed smaller unit volumes than expected due to shallower nearshore bathymetry and 2) the dredge contractor's limitation on pumping distance due to booster power required the dredger to "fatten up" the template along the Town project shoreline. The nourished shoreline reaches were both within the permitted footprints. Figure 2-4 through 2-8 show the nourishment progress.

*Figure 2-4. Aerial Photograph of Ongoing 2014 Nourishment (source: NCDNR CAMA)*


*Figure 2-5. Photograph Looking East toward Nourished Beach near Station 40+00 (ATM Photo)*


*Figure 2-6. Photograph Looking West toward As Yet Un-Nourished Beach near Station 40+00 (ATM Photo)*

*Figure 2-7. Photograph near the East End of Holden Beach, Post-Nourishment (Station ~20+00) (ATM Photo)*

*Figure 2-8. Photograph near Ferry Road Access (Station ~62+00) Approximately 2 Weeks Post-Nourishment (ATM Photo)*

The Town's LWFIX project was very successful. Approximately 95,000 cy of material was placed for about $8/cy, which is a very favorable rate. Nourishment dredging costs are typically much higher than this (depending on the borrow area and pumping distance) and can range from $10/cy to $25/cy. The North Carolina Department of Environment and Natural Resources (NCDENR) paid for half the project cost (via the Water Resources Development Project Grant Program), and Brunswick County also contributed to the funding of the project. Additionally, Town resources (staff, equipment, oversight) expended for this project were significantly less than those expended for upland fill projects.

As previously discussed, the 400-ft bend widener was first utilized by the USACE for the 2010 project largely because of the economic stimulus funds that were available to the USACE at the time. It is anticipated that the USACE will not have the funds available to perform the LWFIX project with the 400-ft widener in the near future. As a result, the Town and Applied Technology & Management, Inc. (ATM) will continue to work closely with the USACE, NCDENR and other agencies to ensure that the Town can piggyback the USACE LWFIX project from now on.

NCDENR has begun a Shallow Draft Inlet (SDI) program that includes five USACE-recognized shallow draft inlets in the state. The five inlets are Lockwood Folly, Bogue, Carolina Beach, New Topsail and Shallotte (New River Inlet also qualified but North Topsail Beach has other plans). More information on this topic is provided in Section 2.3.

## 2.3 SHALLOW DRAFT INLET PROGRAM

Six shallow draft (less than 12 ft deep) inlets in North Carolina are traditionally dredged by the USACE sidecaster *Merritt* and these include: Lockwood Folly, Shallotte, Bogue, Carolina Beach, New Topsail, and New River. In recent years, several concerns have arisen about the federal government's continued maintenance of these inlets. The USACE has only one sidecaster dredge (the *Merritt*) since the sidecaster dredge *Fry* was decommissioned in 2010 and sold at auction with the stipulation it could not be used as a dredge in United States waters (SDI Reconnaissance Study, 2013). The *Merritt* is approximately 50 years old and is reaching the end of its service life (SDI Reconnaissance Study, 2013).

The USACE shallow draft split-hull hopper dredges (i.e., the *Currituck* and *Murden*) can dredge LWF Inlet, however, federal funding for these projects has been significantly lacking over the last few years while demand and funding for the *Currituck* (see Figure 2-9) and *Murden* in other USACE districts and states from Maine to Texas remains strong.


*Figure 2-9. USACE Shallow Draft Split-Hull Hopper Dredge the Currituck Rarely Dredges the LWF Inlet*

The lack of funding for North Carolina shallow draft inlet maintenance can result and has resulted in the Coast Guard removing navigation buoys from inlets and making navigation dangerous. In an attempt to mitigate this issue, the State, in conjunction with local county and municipal governments, has:

1. Obtained a memorandum of agreement (MOA) with the USACE to fund shallow draft inlet dredging, and
2. Begun the process of obtaining permits to maintain the navigability of the State's shallow draft inlets independently of the USACE.

More information on both of these initiatives is provided in the next sections.

### 2.3.1 STATE AND USACE SHALLOW DRAFT MOA

In November 2013, the State signed an MOA that allows the State and local stakeholders to contribute funds to the USACE for shallow draft inlet maintenance dredging. The MOA contribution limit is $4 million/year. The North Carolina General Assembly established the Shallow Draft Navigation Channel and Lake Dredging Fund to provide State funding, which will be endowed by both an increase in boat registration fees and an excise on motor fuel, to the North Carolina Wildlife Resources Commission's boating account. The USACE and NCDENR have quarterly meetings regarding this implementation of the long-term MOA, with the most recent meeting on July 15, 2014. Town staff attended this meeting and it is recommended that Town and/or ATM attend these meetings on a regular basis.

At the July 15 meeting, the USACE reported that for FY 2014, the funded balance for LWF Inlet maintenance was $344,000. The USACE also projected a FY 2015 LWF Inlet maintenance cost of $665,600. Available FY 2015 funds for inlet maintenance will not be known until the FY 2015 USACE budget is finalized in Washington DC in the next month.

The USACE prefers to sidecast dredge LWF Inlet once per quarter if adequate funding is available. Each sidecast dredge maintenance event costs between $225,000 and $250,000, including the associated pre-dredging and post-dredging surveys (USACE navigation communication, 2013). In recent years, the USACE has reduced the dredging frequency to once every 6 months or even longer. Additional effort can be required if the intervals between dredging events are longer.

### 2.3.2 STATE SHALLOW DRAFT INLET PERMITTING

The State has taken the lead in the shallow draft inlet permitting and, in October 2013, released the SDI reconnaissance study that assessed the feasibility of transferring the Federal permit to the local governments. This effort was predicated on two major factors: 1) there is only one sidecast dredge remaining in the federal government fleet (the *Merritt*), which is 50 years old and could be decommissioned soon, and 2) Federal funding has been limited/absent and may never return.

In addition to the *Merritt*, the *Currituck* and *Murden* can work the LWF and Shallotte Inlets, however, they cannot safely navigate the other SDI inlets. In any case, there will be a significantly limited availability of USACE dredges that can maintain the SDI inlets even if adequate local/State funding is generated The results of the reconnaissance study estimated that it would cost $300,000 total to transfer the Federal permits to local governments.

Following the reconnaissance study, the State has begun gathering all the necessary materials (geotechnical data, biological reports, survey data, etc.) to apply for permits for locally held authorizations [North Carolina Division of Coastal Management (NCDCM) Major Permit/USACE General Permit 2878]. These authorizations would allow the Town an additional option for maintaining (at current USACE templates) the LWF Inlet AIWW (LWFIX) crossing, the inlet throat and through the currently authorized USACE inlet linear distance beyond the COLREGs line (refer to Section 2.3.3 for more on this topic). The authorizations would minimally include all currently approved dredge material management locations, including shoreline beneficial placement, nearshore placement and/or upland confined disposal placement. Town staff and ATM are assisting the State in the permit submittal process by providing comprehensive geotechnical, survey and biological data at LWF Inlet and for the area in general.

### 2.3.3 LOCKWOOD FOLLY INLET PROJECTS

Due to different USACE funding sources, there are two basic routine maintenance activities that occur at LWF Inlet:

1. Outer Bar side-cast dredging, and
2. LWF Inlet AIWW crossing (LWFIX) cutter-head dredging and beach fill placement

Figure 2-10 provides a representation of these two regions.

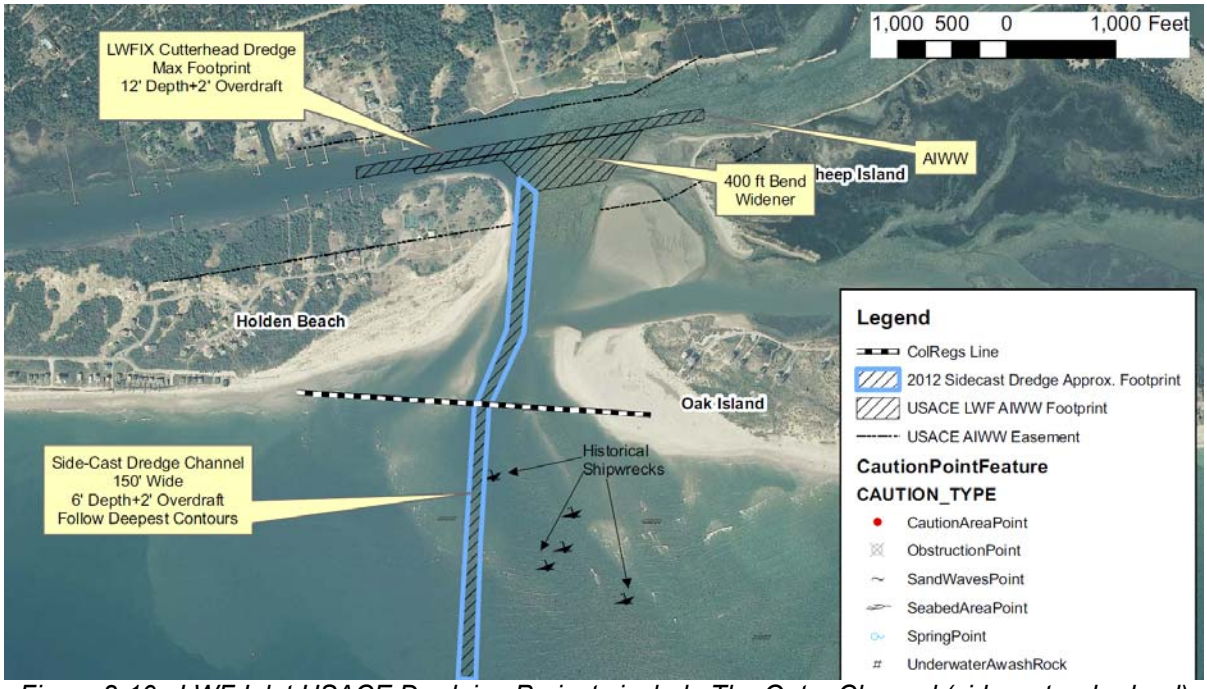



*Figure 2-10. LWF Inlet USACE Dredging Projects include The Outer Channel (sidecaster dredged) and the LWFIX (cutterhead dredged)*

The authorizations will allow the Town (with State, County and potentially Oak Island funding assistance) to maintain both these areas. The COLREGs line is the Coast Guard collision regulation demarcation that only allows "ocean-certified" dredges seaward of this delineation. Ocean-certified dredges are typically larger dredges that are much more expensive to mobilize/demobilize (typically between $2 to $4 million per event). The the USACE shallow draft dredges are specialized in that they are small enough to navigate these small inlets, while also being Coast Guard ocean-certified. As an example, the LWFIX dredge projects are predominantly awarded to smaller dredge companies whose dredges are not ocean-certified (e.g., Southwinds, Cottrell).

Another goal of the SDI is to coordinate with private industry dredgers to ascertain interest in the shallow draft inlet maintenance projects and to have several economically competitive options for these projects.

## 2.4 DUNE ENHANCEMENT

In addition to placement of sand, the Town has been proactively enhancing dune habitat on an annual basis. The dune-building program includes:

- Vegetation planting (sea oats, American beach grass, bitter panicum, etc.)
- Fertilization
- Sand fence maintenance and expansion
- Dune walkover maintenance

In the winter of 2013/2014, 100,000 sprigs of American beach grass were planted between Captain Jack's (approximately Station 85+00) and the East End of Holden Beach. The summer 2014 planting included 37,000 sprigs of sea oats and bitter panicum planted along approximately 8,000 ft of beachfront (from Greensboro St/500 Ocean Blvd W. – westward 8,000 ft to 800 Ocean Blvd W.). Fertilizer was applied island-wide three times over the last year (2 lb/1000 sq. ft). The forecasted plantings for the 2014/2015 winter are similar to the previous winters and the projected 2015 summer plantings are 60,000 sprigs of sea oats and bitter panicum.

Additionally, a fertilizer/microbe study is underway on the East End of Holden Beach. The study includes 3,000 sea oat sprigs and will investigate the effects of various fertilizer levels/types and mycorrhizae presence/absence on dune vegetation growth and overall health.

The continued diligence and effort of Holden Beach has resulted in a stable and healthy dune system along a majority of the island. Figures 2-11 and 2-12 illustrate some of the recent efforts and resulting dune system.

*Figure 2-11. Recent Dune Vegetation Plantings and Rope Barriers (not yet installed) along the Central Reach of Holden Beach (Station ~65+00) (ATM photo, taken 3-26-14)*

*Figure 2-12. Recent Dune Vegetation Plantings near Quinton Street (~Station 80+00) (ATM photo, taken 3-26-14)*

## 2.5 STORM ACTIVITY

The 2013 Atlantic hurricane season overall was relatively mild, especially when compared with the 2012 season, which was extremely active and tied with 1887, 1995, 2010, and 2011 for having the third-most named storms on record. While 2012 was an active hurricane season overall, it was relatively mild for Holden Beach and other regional beaches. A similar trend occurred for the 2013 season, where Holden Beach was only slightly affected by storms Andrea, Dorian, and Gabrielle (Figure 2-13).

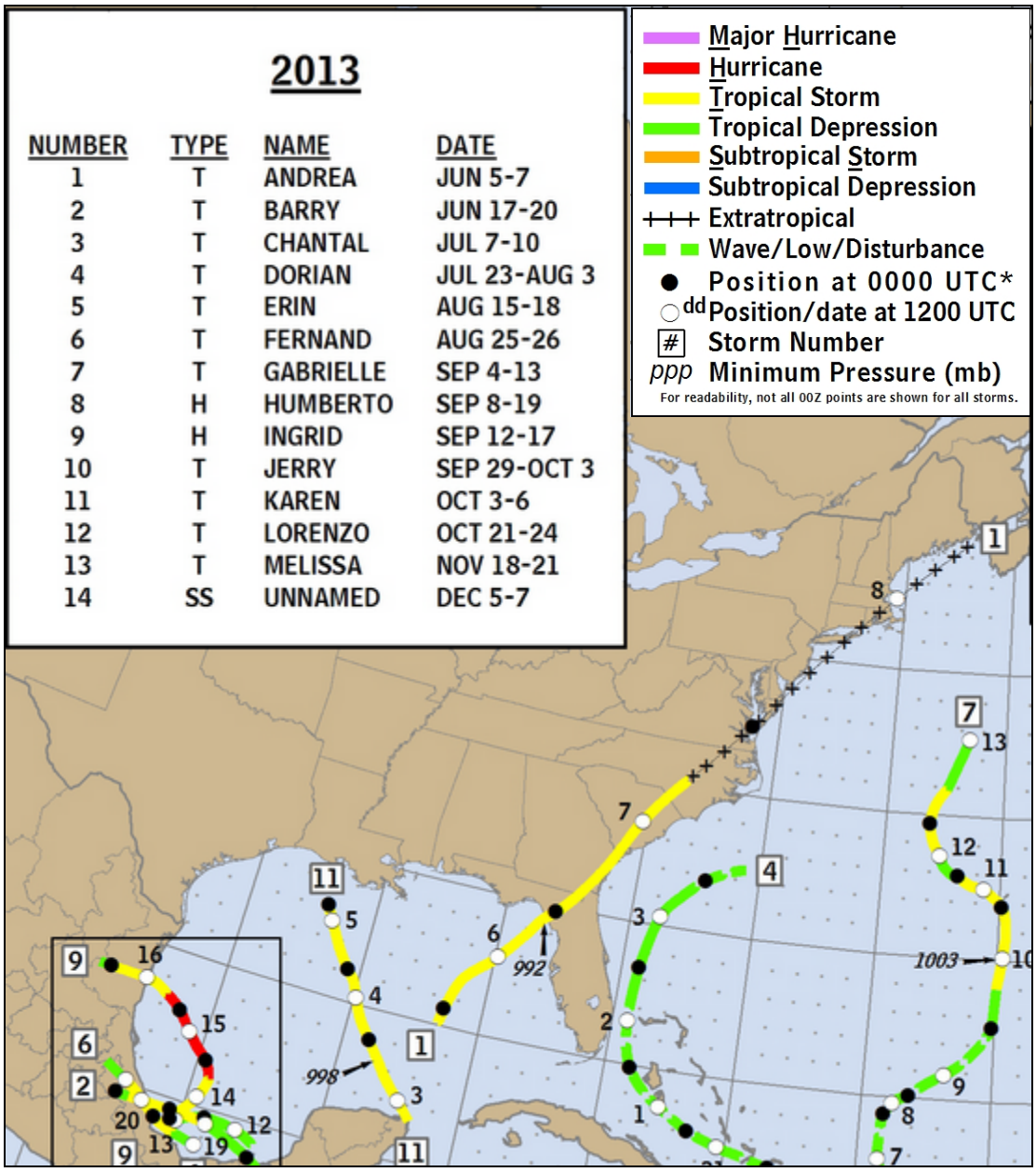



*Figure 2-13. 2013 Hurricane Summary for Holden Beach. Andrea (1), Dorian (4), and Gabrielle (7) had mild/moderate affects to Holden Beach*

Figure 2-13 presents a summary of 2013 Atlantic Hurricane tracks. Most of the 2013 tropical storms remained well offshore of Holden Beach (and generally east of Bermuda) and are not pictured in Figure 2-13.

Despite the lack of a hurricane passings nearby, the combination of storm surge and large swells can still create erosional conditions that directly impact the Holden Beach dune system. Nor-easters and periods of sustained southeast winds can create highly erosive conditions also.

## 2.6 TOWN CENTRAL REACH PROJECT

The Town's permitted Central Reach nourishment project represents the largest beach fill project to date on Holden Beach. The Central Reach project allows for placement of up to 1.31 million cubic yards (MCY) along 4.1 miles (22,000 ft) of shoreline [Ocean Boulevard East (OBE) 262 to Ocean Boulevard West (OBW) 781]. The Town has received the NCDCM, the North Carolina Division of Water Quality (NCDWQ) and the USACE permits needed for this effort. Figure 2-8 presents the beach fill project limits, and Figure 2-9 presents a typical fill cross-section. This project will utilize an offshore borrow area as its sand source.

This project is designed to last up to 10 years (based on historical erosion rates), and project construction timing will be dictated by annual monitoring results and/or major storm events. The project is conceptually planned to occur either in winter 2015/2016 or winter 2016/2017. The Town has some flexibility in scheduling this major event, which makes it very beneficial from a bidding perspective. For example, Superstorm Sandy created a very high demand for dredging contractors for the 2013/2014 season and, therefore, projects were significantly more costly (e.g., the Folly Beach SC 2014 nourishment cost about $21/cy) .

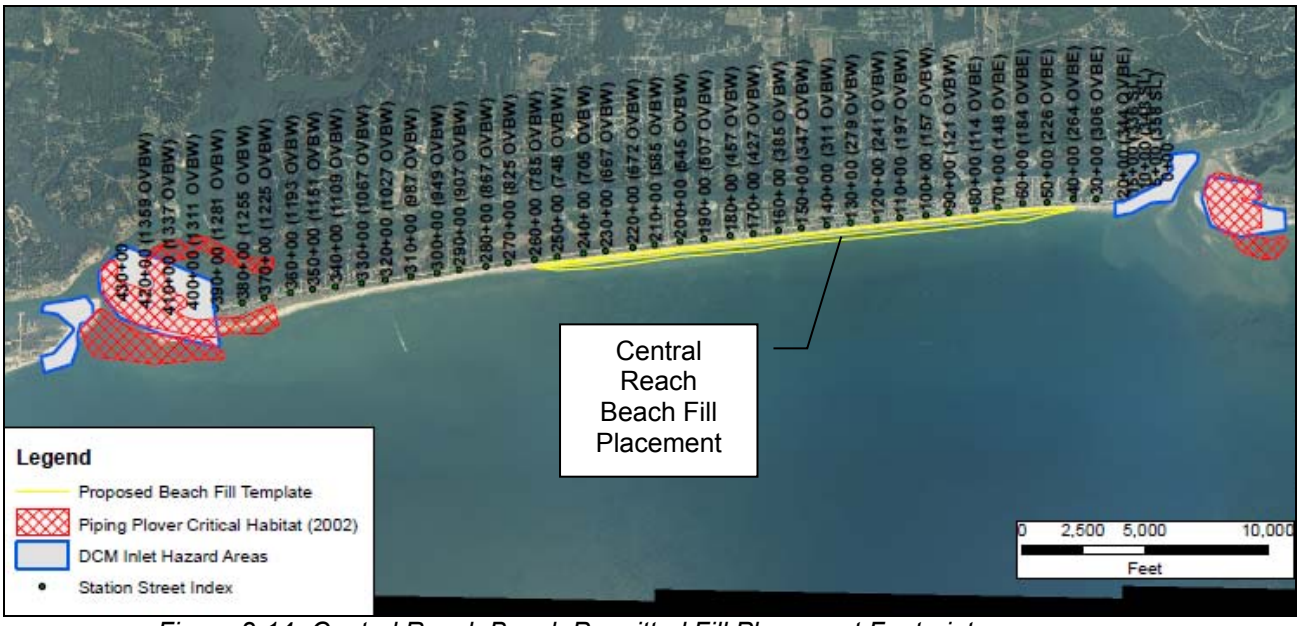



*Figure 2-14. Central Reach Beach Permitted Fill Placement Footprint*

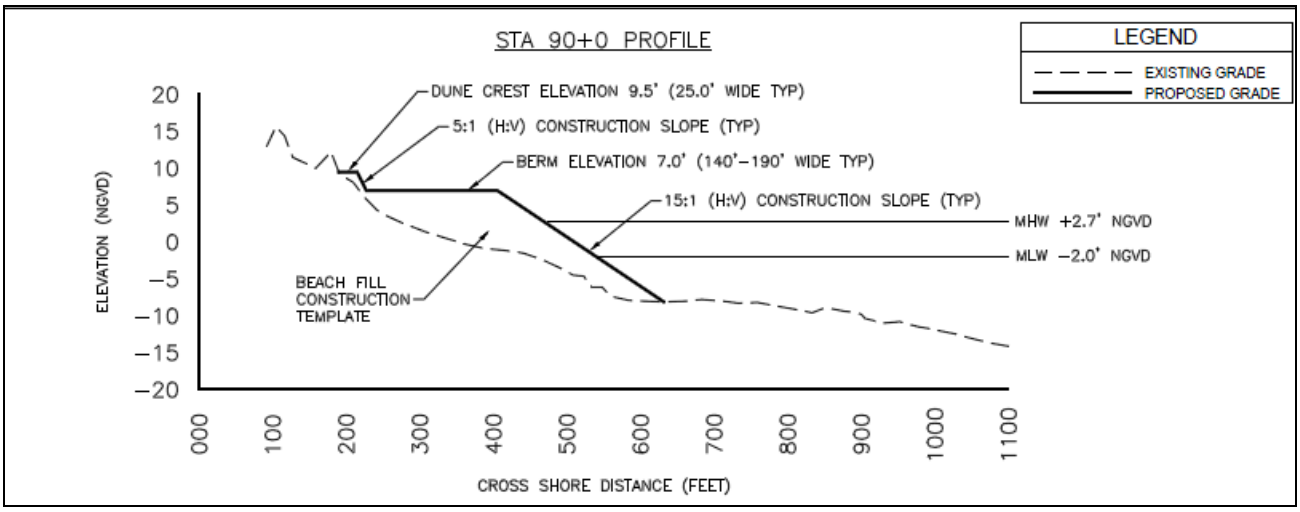



*Figure 2-15. Central Reach Nourishment Typical Cross-Section*

## 2.7 USACE BCB PROJECT

The USACE Brunswick County Beaches (BCB) project is ongoing, and the USACE has released several tomes of studies since the project's inception in about 1997. The project is several years behind schedule and is over budget. The USACE BCB project studies are 50/50 cost shared between the USACE and the participating communities (Holden Beach, Caswell Beach, Oak Island).

In October 2012, the USACE released the BCB Draft Integrated General Reevaluation Report (GRR) and Environmental Impact Statement (EIS) for Coastal Storm Damage

Reduction (CSDR), Pre-Alternative Formulation Briefing (AFB) Submittal for agency technical reviews (ATR). The GRR/EIS report states that the initial Holden Beach BCB nourishment is slated to occur in 2020 and 2021 (extending across two dredging seasons) and will place 4.5 MCY of sand over 24,000 ft of shoreline. This represents a *tremendous* volume (approximately 8 to 9 times greater than the USACE 2001/2002 Holden Beach project).

The USACE Headquarters (in Washington D.C.) review of the AFB/GRR/EIS documents was not favorable and according to April 2014 communications with the Town and the Wilmington USACE, additional studies and study updates are required. Additional funding is also required. Therefore, the documents remain in draft status and will not be issued to the public at the moment. Project implementation is still many years away.

According to the USACE studies, the 50-year project will initially nourish Holden Beach in 2020/2021, while the first BCB renourishment is slated to occur in 2025/2026 on Holden Beach (i.e., 5-year renourishment interval). However, according to the report, these timelines "could take longer" and are "subject to the availability in funds." Holden Beach BCB renourishment volumes are estimated at 1.7 MCY and will occur every 5 years. As always, the Town and ATM will continue to coordinate with the USACE to ensure ongoing Town beach management projects are complementary.

In general, ATM's opinion is that the BCB project as proposed is too large and too costly to receive funding, based on current and recent Federal funding for beach nourishment projects. A CSDR project more similar in scope to the Ocean Isle Beach CSDR project (and the Town's Central Reach Project) is much more likely to obtain funding. The Ocean Isle CSDR project placed approximately 1.8 MCY initially, and approximately 450,000 to 500,000 cy per renourishment project (Bill Dennis, USACE, personal communication).

## 2.8 EAST END TERMINAL GROIN PROJECT

The east end of Holden Beach (LWF Inlet to Station 40+00) experiences the highest erosion rates on the island. Storm damage and property loss are also correspondingly historically high on the east end. As a result, the Town and the USACE have focused significant beach nourishment resources on the east end. However, the area still remains vulnerable.

While a terminal groin and nourishment program has always been a feasible option for this area from a technical standpoint, State regulations have only recently allowed the permitting and construction of terminal groins. Note that groin exceptions due to bridge protection and historic structure preservation were previously allowed (e.g., Oregon Inlet terminal groin, Hatteras Lighthouse groins).

As such, the Town has begun the analysis and permitting required to construct a terminal groin and institute an associated beach nourishment program on the east end. This program will allow longer time intervals between nourishments and allow for a more stable upper beach and dune system; resulting in reduced long-term nourishment costs as well as reduced risk to coastal infrastructure.

On behalf of the Town, ATM completed the *East End Shoreline Protection Project Engineering and Modeling Report* as part of the draft EIS, being prepared by the third party consultant, Dial Cordy & Associates (DC&A), under direction of the USACE. The latest estimates from DC&A indicate the draft EIS will be publically released in November or December 2014.

## 2.9 BEACH MANAGEMENT PERMITS

The Town currently has Central Reach permits from the USACE, NCDCM, and NCDWQ. NCDCM chose to modify the beach nourishment permit initially obtained by the Town in 2002 (permit number 14-02). Several modifications have occurred to this permit since. These modifications include the 2008 and 2009 Town nourishments using the Smith borrow site. Following the Central Reach modification, the permit expiration date was December 31, 2015. NCDCM chose to issue another permit modification for the 2014 LWFIX project that placed 95,000 cy of material; however, the permit expiration date remains December 31, 2015.

The USACE typically creates new permits for each project (upland fill, LWFIX, Central Reach). The Central Reach project (permit number SAW-2012-00286) expires on December 31, 2017. The LWFIX project was issued under a General Permit (GP), which is simpler and faster than the typical Individual Permit (IP) Process. The LWFIX project (SAW-2013-02016 and General Permit No. 199602878) has been completed, although post-project compaction monitoring is required for 2 more years (performed in the spring prior to

turtle nesting season). No tilling has been required by the regulatory agencies as yet due to the compaction monitoring results.

The USACE permit for the upland borrow area nourishment project (SAW 2005-00935) was extended in 2009. This permit expires on December 31, 2014 and currently allows the placement of 64,000 cy of upland borrow material. *An extension to this permit is recommended.*

The NCDWQ permits are project specific and generally follow the lead of NCDCM. The USACE, NCDCM and NCDWQ generally coordinate to avoid any permit condition conflicts. If any future modifications are needed, it is anticipated that coordination will be needed with all of these agencies. Agencies have been amenable to permit modifications and extensions related to beach fill placement location and permitted borrow areas (Turkey Trap, Smith Site, Boyd Site, Central Reach) in the past.

On a similar note, the County's special exception permit to operate a mine in Brunswick County for the Turkey Trap Road borrow area has no expiration date. The Smith borrow site is a water feature for a residential development, therefore, a special exception permit is not needed (although this can be up to regulatory interpretation). Upland borrow areas also need a mining permit from the North Carolina Department of Environment and Natural Resources.

# 3.0 ANNUAL SURVEY RESULTS

## 3.1 SURVEY RESULTS

Beach surveys are performed annually as a part of the Town's Beach Management Plan and span from LWF Inlet to Shallotte Inlet. Figure 3-1 presents the stationing and azimuths established by the monitoring plan. Survey data were collected in April 2014 at 48 transects along Holden Beach. An additional seven transects were also included on western Oak Island. The monitoring of these additional transects began with the 2012 survey to more closely monitor inlet-related effects and establish more consistent baseline data. Similar to historical trends on the west end of Holden Beach, the west end of Oak Island is generally stable; however, long-term inlet dynamics have the potential to affect this area.

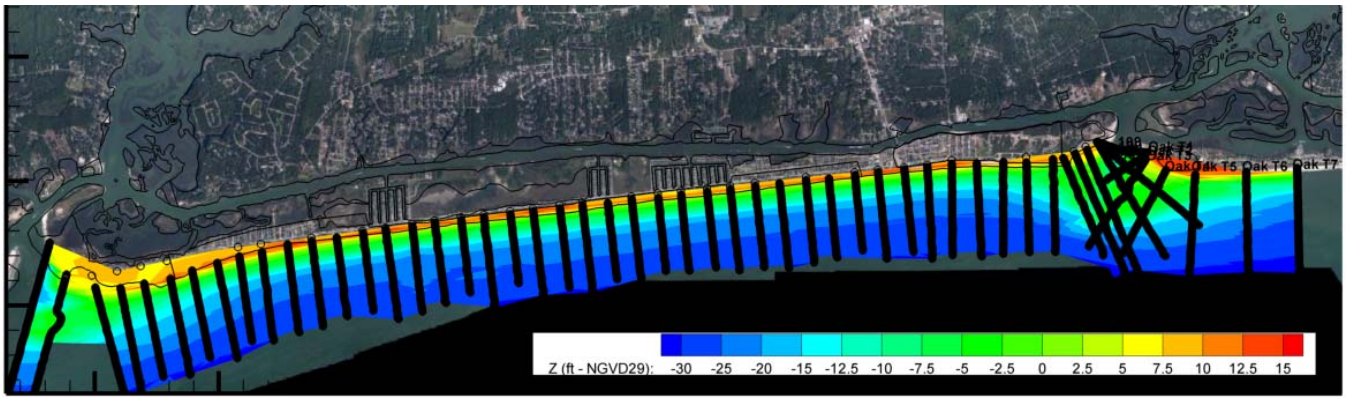



*Figure 3-1. Holden Beach Monitoring Survey Transects, 2014. An additional seven monitoring transects have also been added to western Oak Island beginning with the 2012 survey.*

Figures 3-2 and 3-3 present example transect surveys comparing 2013 and 2014 survey data. Figure 3-2 also shows a 2012 and 2013 survey comparison to illustrate changing sediment transport patterns (discussed further in subsequent sections). Note that some differences in profiles may be related to recent wave activity and are not necessarily indicative of long-term trends. Appendix A contains all transect data for the 2013 and 2014 surveys.

In general, comparison of the 2013 and 2014 surveys reveals a stable/mildly erosional beach along much of the island, especially within the Central Reach. Figure 3-3 also illustrates the effect of the recent east end nourishment. The east end typically displays more erosional conditions (consistent with historical trends), however, the recently completed 2014 USACE/Town LWFIX projects, which placed 188,000 cy of sand between

stations 18+00 and 73+00, provided a much needed replenishment to the east end sand supply. This sand will migrate to the west over time. The west end of the island is historically stable/accretional; however, it does exhibit some short-term and variably episodic erosional conditions. The Sections 3.2 and 3.3 present more information on volume and shoreline analysis, respectively.

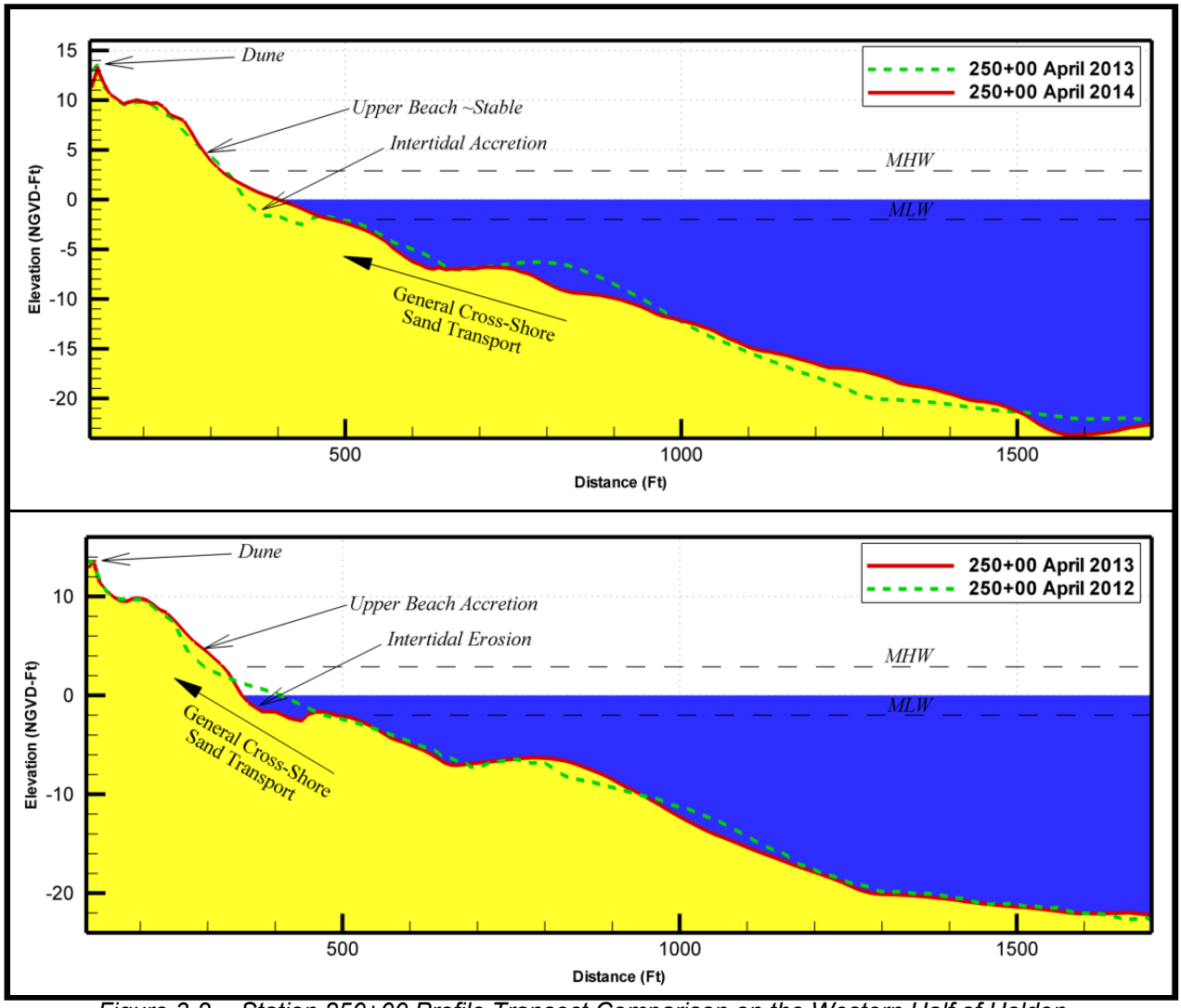



*Figure 3-2. Station 250+00 Profile Transect Comparison on the Western Half of Holden Beach. Upper panel shows 2013-2014 survey comparison. Lower panel shows 2012-2013 comparison and a cross-shore redistribution of sediment.*

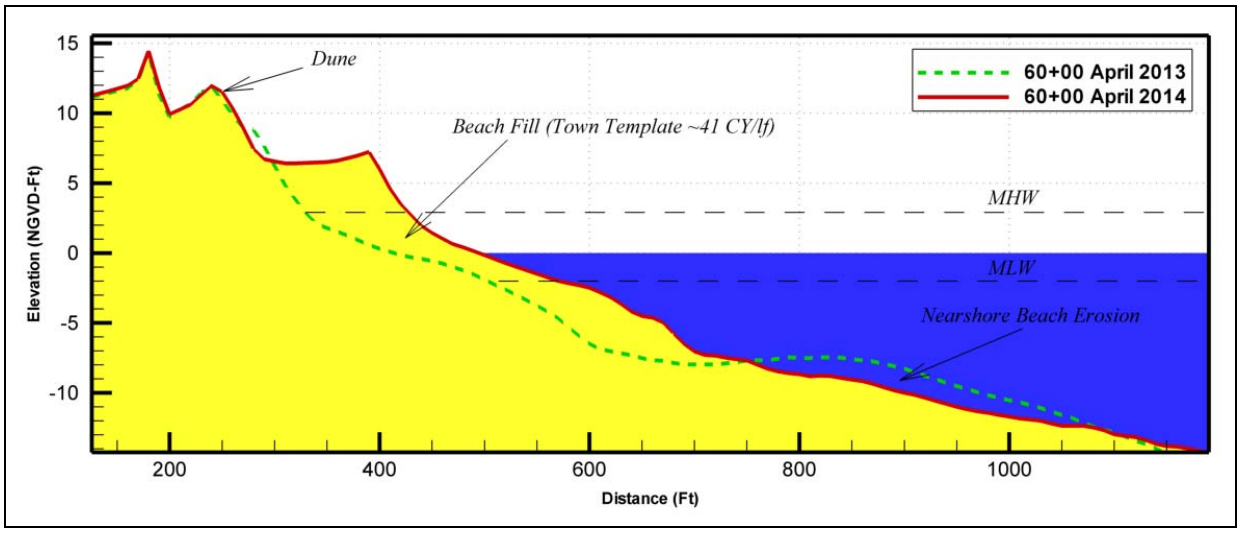



*Figure 3-3. Station 60+00 Profile Transect near the East End of Holden Beach. Note 2014 Town Beach Fill*

## 3.2 VOLUME ANALYSIS

Figure 3-4 presents changes in volumes from 2013 to 2014 along the entire beach. Volumes are quantified by comparing profile volumes from successive surveys. The USACE Beach Morphology Analysis Program (BMAP) was used to compute changes in profile volumes for each profile and for all surveys during the monitoring period.

Figure 3-4 shows a generally stable shoreline, with some variation from station to station. Some of this variation is due to survey precision as well as seasonal variation, shoal attachment, and recent wave activity. Additional variation may also be attributed to undulating patterns along the shoreline, which have been documented along nearby beaches[1]. The recent 2014 USACE and Town nourishment benefits are easily seen on the east end in Figure 3-4. The volumes calculated in Figure 3-4 are from the dune out to the -12 ft National Geodetic Vertical Datum (NGVD) contour, which represents a typical depth-of-closure limit. The vast majority of sand transport and profile change occurs in waters shallower than the depth-of-closure.

Comparing 2014 and 2013 changes in volume out to the depth-of-closure, the survey data indicates accretion and erosion has generally occurred in equal amounts over the last year within the middle of Holden Beach; indicative of a relatively stable shoreline. Slight erosion has been observed near the western end of the island over the past 2 years (reaching as far

[1] PARK, J.-Y.; GAYES, P.T., and WELLS, J.T., 2009. Monitoring beach renourishment along the sediment-starved shoreline of Grand Strand, South Carolina. *Journal of Coastal Research,* 25(2), 336–349. West Palm Beach (Florida), ISSN 0749-0208

east as Station 350+00). This erosion is likely due to inlet effects and is not of particular concern due to the large and wide dune system in the area.

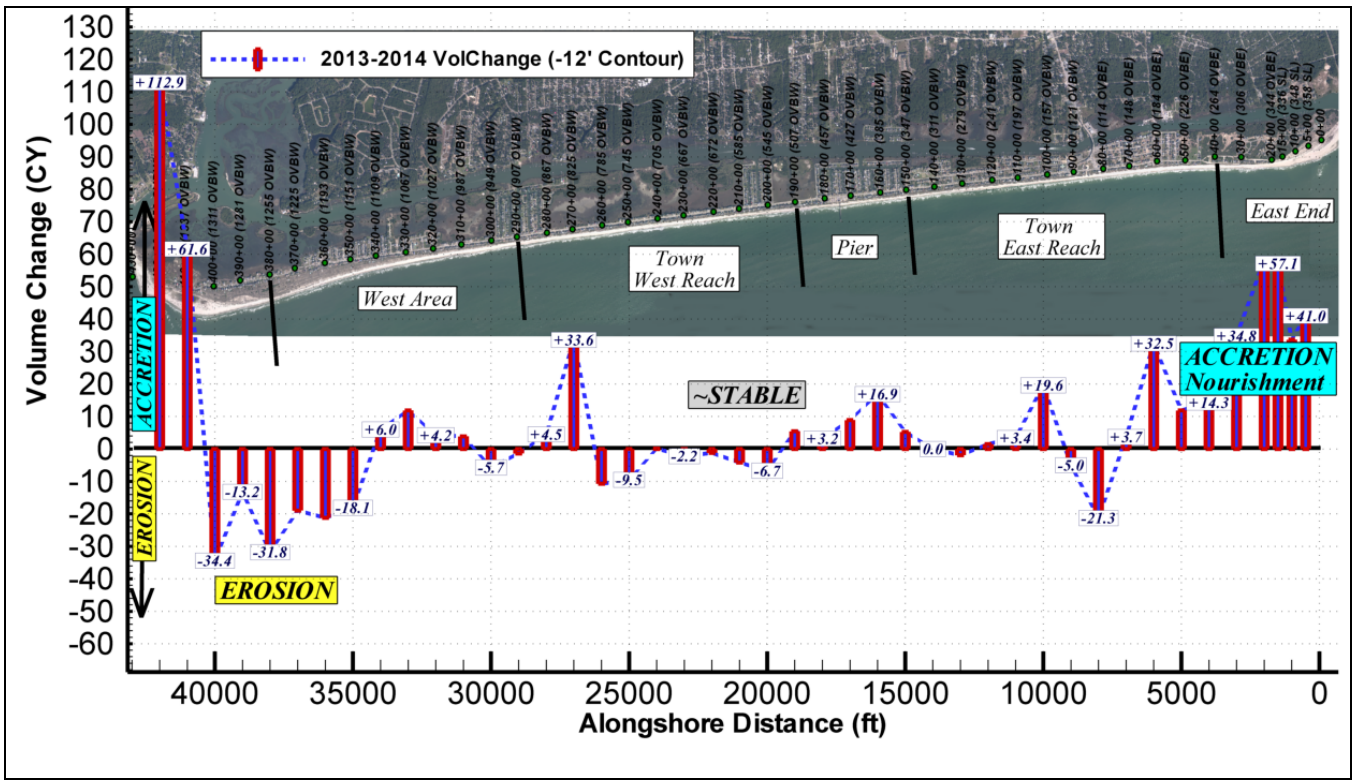



*Figure 3-4. Volume Change Using April 2013 and April 2014 Surveys. Positive values indicate accretion, negative values indicate erosion. Note accretion on extreme west and beach fill (accretion) on east end. Some erosion is seen along the west end.*

Volume calculations were also performed from the dune to the -5 ft NGVD contour, which represents the approximate typical surf-zone limit. Figure 3-5 presents the two different boundaries used for volume calculations.

Table 3-1 presents volume changes estimated by the reaches identified in Figure 3-4 (i.e., east end, Town East Reach, pier, etc.) from 2013 to 2014. In general, significantly more accretion (or less erosion) occurred within the dune to -5 ft NGVD region (i.e., dry beach/surf zone area) compared to the surf zone/depth-of-closure area. This is due, in part, to cross-shore transport of material from the nearshore/surf zone to the upper beach (Figure 3-2) as well as the recent East End nourishment (Figure 3-3) (especially the Town East Reach).

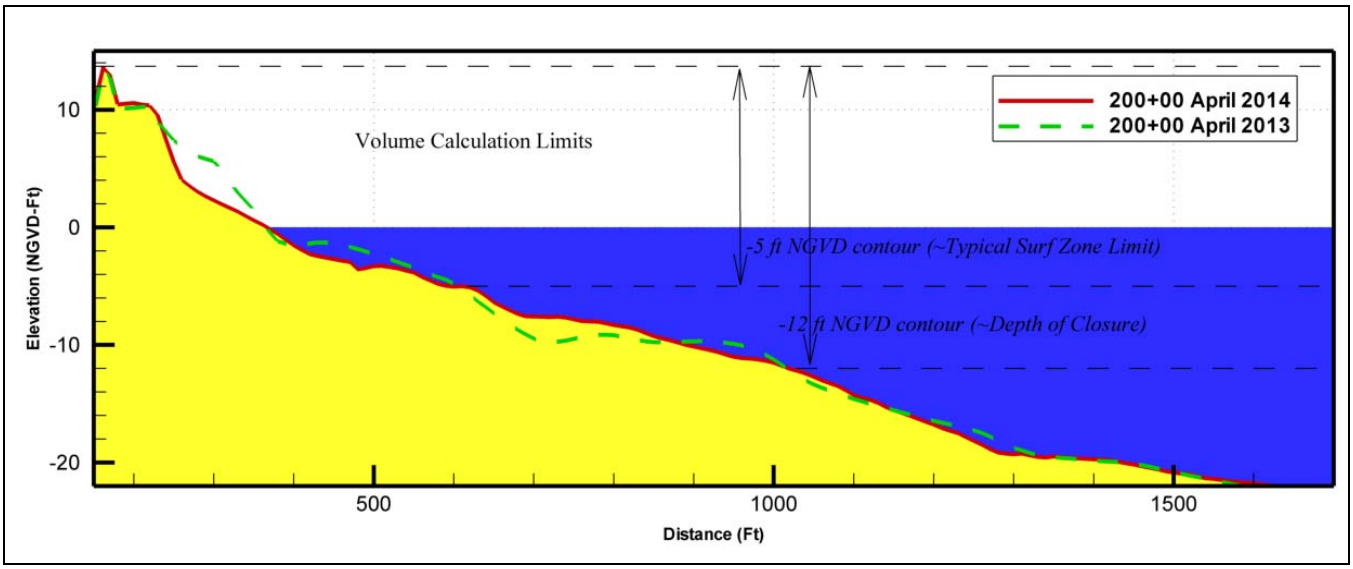



*Figure 3-5. Two different volume calculation limits were used for this analysis: 1) Dune to -12 ft NGVD and 2) Dune to –5 ft NGVD.*

Table 3-1. Volume Change by Shoreline Reach for 2013 and 2014 Surveys

| Reach Averages | Stations Included | Total Volume Change (CY) (Dune to -12 ft NGVD) | Dry Beach/Surf Zone Volume Change (CY) (Dune to -5 ft) | Surf Zone/Depth-of-Closure Volume Change (CY) (-5 ft to -12 ft NGVD)* |
|---|---|---|---|---|
| LWF Inlet | 5 to 15 | 41,000 | 29,000 | 12,000 |
| USACE East | 15 to 40 | 100,000 | 43,000 | 57,000 |
| Town East | 40 to 150 | 54,000 | 105,000 | -51,000 |
| Pier | 150 to 190 | 34,000 | 25,000 | 9,000 |
| Town West | 190 to 290 | 6,000 | 14,000 | -8,000 |
| West Area | 290 to 380 | -55,000 | 21,000 | -76,000 |
| Shallotte Inlet | 380 to 420 | 55,000 | 16,000 | 39,000 |
| | *TOTAL* | *235,000* | *253,000* | *-18,000* |
| Central Reach | 40 to 290 | 94,000 | 144,000 | -50,000 |

*Negative values indicate likely sediment movement from surf zone/depth-of-closure area to dry beach/surf zone area and/or nourishment effects.

As seen in Table 3-1, the beach has shown some background volumetric accretion over the last year. Even if the recent east end 188,000 cy nourishment is neglected, 47,000 cy of total accretion is still exhibited. A majority of the local erosion occurred in the surf zone/depth-of-closure area while accretion generally occurred within the dry beach/surf zone. Note that the survey area is not a closed system and that identifying sediment transport direction can only be inferred based on measured volume change and experience.

The east end area (Stations 5+00 to 40+00) is historically highly erosional. In general, monitoring stations east of Station 40+00 can exhibit highly variable changes based on inlet dynamics and annual USACE fill activities (timing, volume, placement, etc.). Side-casting and outer inlet maintenance (or lack thereof) also have an effect. Volume change calculations show the east end area exhibited accretion in the entire dune to the depth-of-closure zone. This, again, is due in large part to the recent nourishment.

A recent shoal attachment (documented in the 2013 Annual Report) also continues to contribute to localized dry-beach accretion, exhibited in the 2013 aerial photograph in Figure 3-6 (also shown in the 2014 aerial in Photograph 2-1) . The bump in the shoreline created by this shoal attachment will spread and smooth out over time. During this process, some localized erosion may occur to the shoreline immediately adjacent to the shoal attachment (note the hot-spot erosion feature in Figure 3-6). This shoal attachment is between Station 5+00 and Station 10+00, where the mean high water line accreted approximately 90 ft during the 2012-2013 survey period. Figure 3-7 presents a photograph from July 9, 2013 that shows this shoal attachment feature on the east end.

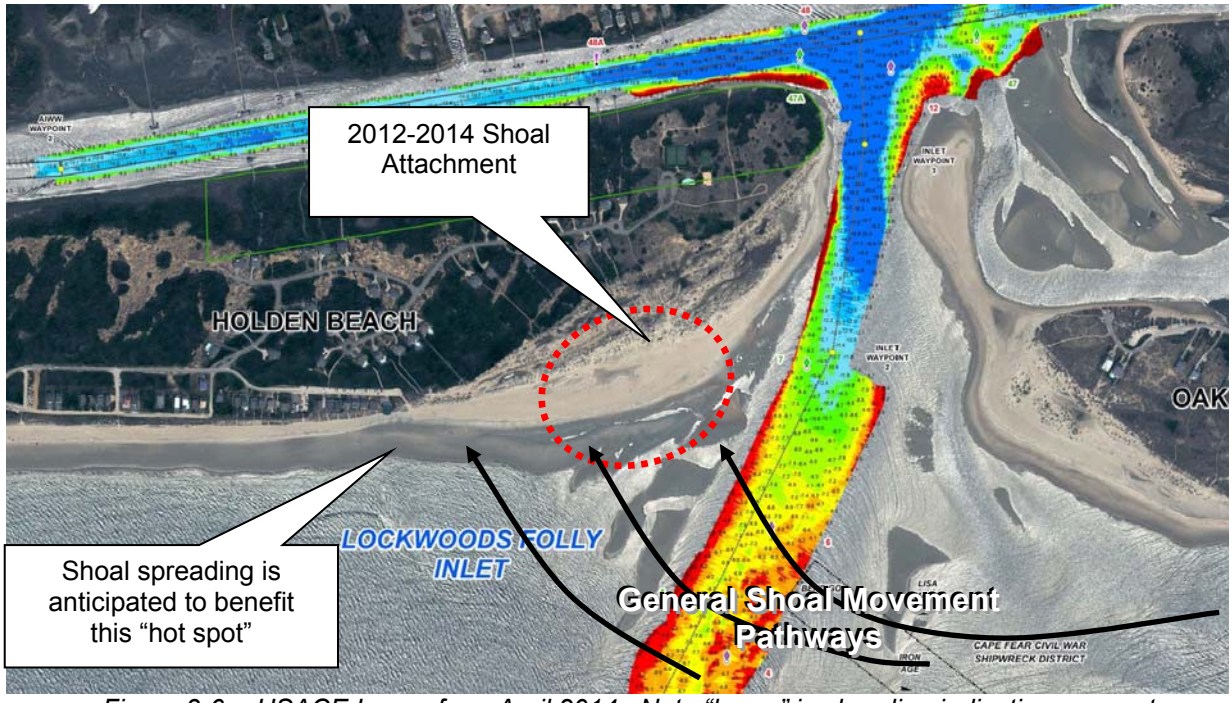



*Figure 3-6. USACE Image from April 2014. Note “bump” in shoreline indicating a recent shoal attachment (~Station 10+00) that has existed since 2012.*


*Figure 3-7. Ground-Level Photo from Approximately Shoal Attachment Site (~Station 10+00), Looking West (Photo date: 7-09-2013).*

The Central Reach segment of shoreline from Station 40+00 to 290+00 exhibited accretion (approximately +144,000 cy) in the dry beach/surf zone area (dune to -5 ft NGVD) and erosion (about -50,000 cy) in the surf zone/depth-of-closure area (-5 ft to -12 ft NGVD). This erosional/depositional pattern can generally be attributed to cross-shore sediment transport from the nearshore to the upper beach, in addition to the 2014 east end nourishment (extending to Station 73+00). This segment of shoreline continues to perform moderately well and allows some additional flexibility in performing the permitted Central Reach project.

The 2013-2014 cross-shore sediment transport pattern is similar to the results of the 2013 monitoring study, especially when accounting for the nourishment volumes. The 2013 study also found there was accretion (about +55,000 cy) in the dry beach/surf zone area (dune to -5 ft NGVD) and erosion (about -69,000 cy) in the surf zone/depth-of-closure area (-5 ft to -12ft NGVD). This is likely partially due to dune plantings and mild/moderate wave conditions (which help to build up the dry beach by moving sandbars onshore).

The West Area (Stations 290+00 to 380+00) is historically stable and has never been nourished. Fluctuations in volumes in this region can be attributed to net westerly sand transport, shoreline undulations, and inlet-related processes (including shoreline orientation/curvature and shoal formation). Dune system widths in the West Area can be up

to 600 ft (around Stations 370+00 to 390+00; see Figure 3-8a); therefore, large fluctuations in volume and/or shoreline position in this area are not as much of a concern.

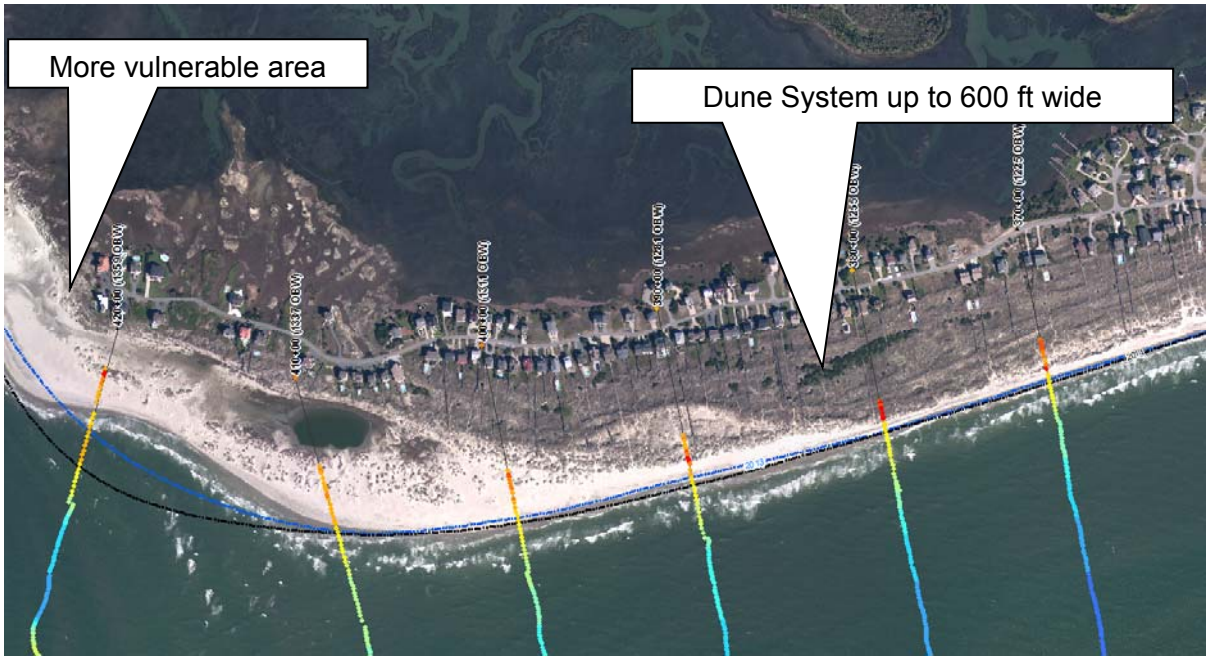



*Figure 3-8a. West End of Holden Beach Features a Very Large, Wide Dune Buffer (2012 aerial). 2013 (blue) and 2014 (black) smoothed mean high water (MHW) shorelines are also shown.*

Several homes on the extreme western end of the island near Station 420+00 (~1359 OBW) are close enough to Shallotte Inlet that close monitoring of inlet migration and USACE activities in Shallotte Inlet is warranted.

Some accretion of the mean high water (MHW) line is seen in Figure 3-8a and this is also shown in Figure 3-8b, which presents an aerial photograph taken at low-tide February 2014 of the west end where some buildup of the dry beach is exhibited. Note that the Ocean Isle nourishment project began in March 2014. The Ocean Isle nourishment uses Shallotte Inlet as a borrow area and shoreline monitoring will occur to assess any potential effects on the Holden Beach shoreline. Appendix B provides figures of the 2014 survey results for the entire island.

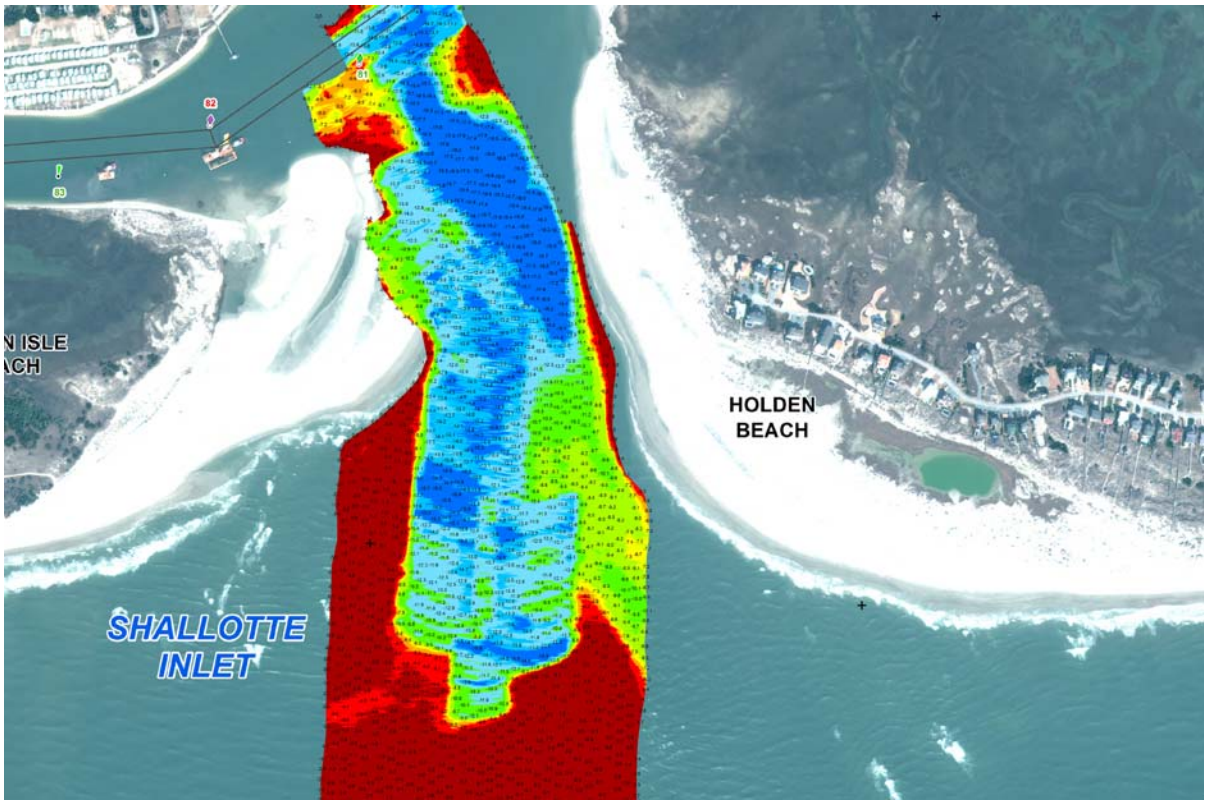



*Figure 3-8b. February 2014 USACE Aerial of the West End of Holden Beach*

## 3.3 SHORELINE ANALYSIS

In addition to a volumetric analysis, shoreline analyses were also performed as another useful metric in gauging beach health. Figures 3-9 and 3-10 were developed to view annual changes in the MHW and toe of dune (TOD) (+7 ft NGVD) shoreline contours along Holden Beach. These shorelines are landward on the upper beach, where moderate accretion was documented in the volumetric analysis.

Average MHW shoreline change by reach is presented in Table 3-2. Results show that the entire Holden Beach MHW shoreline accreted, with the exception of the Shallotte Inlet reach, where a very large dune buffer exists.

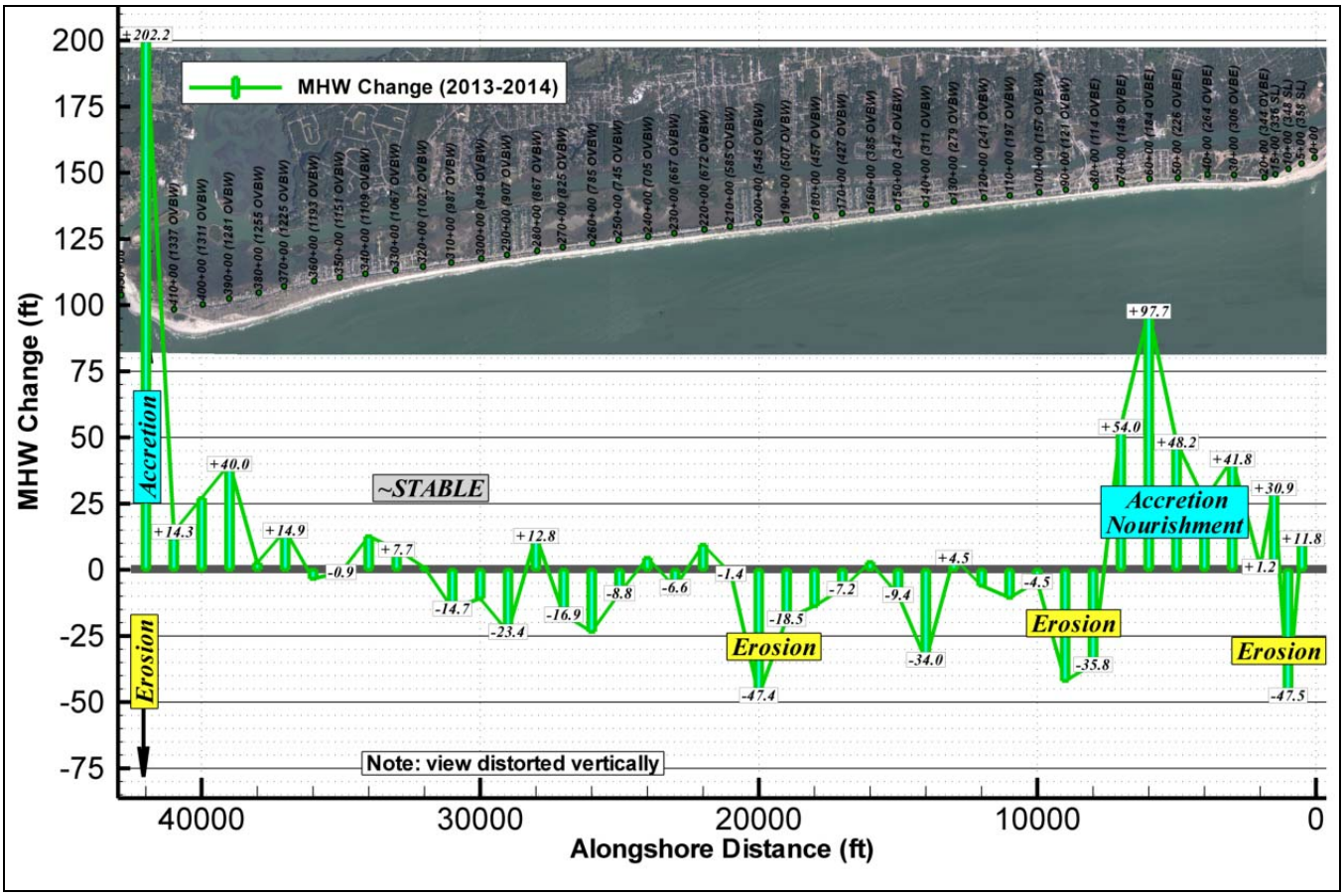



*Figure 3-9. MHW Shoreline Change from 2013 to 2014. Overall moderate accretion is exhibited with slight erosion within the central reach. High accretion rates on the eastern end are primarily due to 2014 USACE and Town fill activities and a recent shoal attachment (i.e., not representative of background erosion).*

Average MHW shoreline change by reach is presented in Table 3-2. On average (i.e., within the Central Reach), the MHW shoreline retreated by approximately 2 ft.

Table 3-2. MHW Shoreline Change by Reach for 2013 and 2014 Surveys

| Reach Averages | Stations Included | 2013 to 2014 MHW Change (ft) |
|---|---|---|
| LWF Inlet | 5 to 15 | -1.6 |
| USACE East | 15 to 40 | 23.1 |
| Town East | 40 to 150 | 7.4 |
| Pier | 150 to 190 | -9.2 |
| Town West | 190 to 290 | -10.9 |
| West Area | 290 to 380 | -1.5 |
| Shallotte Inlet | 380 to 420 | 21 |
| Central Reach | 40 to 290 | -1.9 |

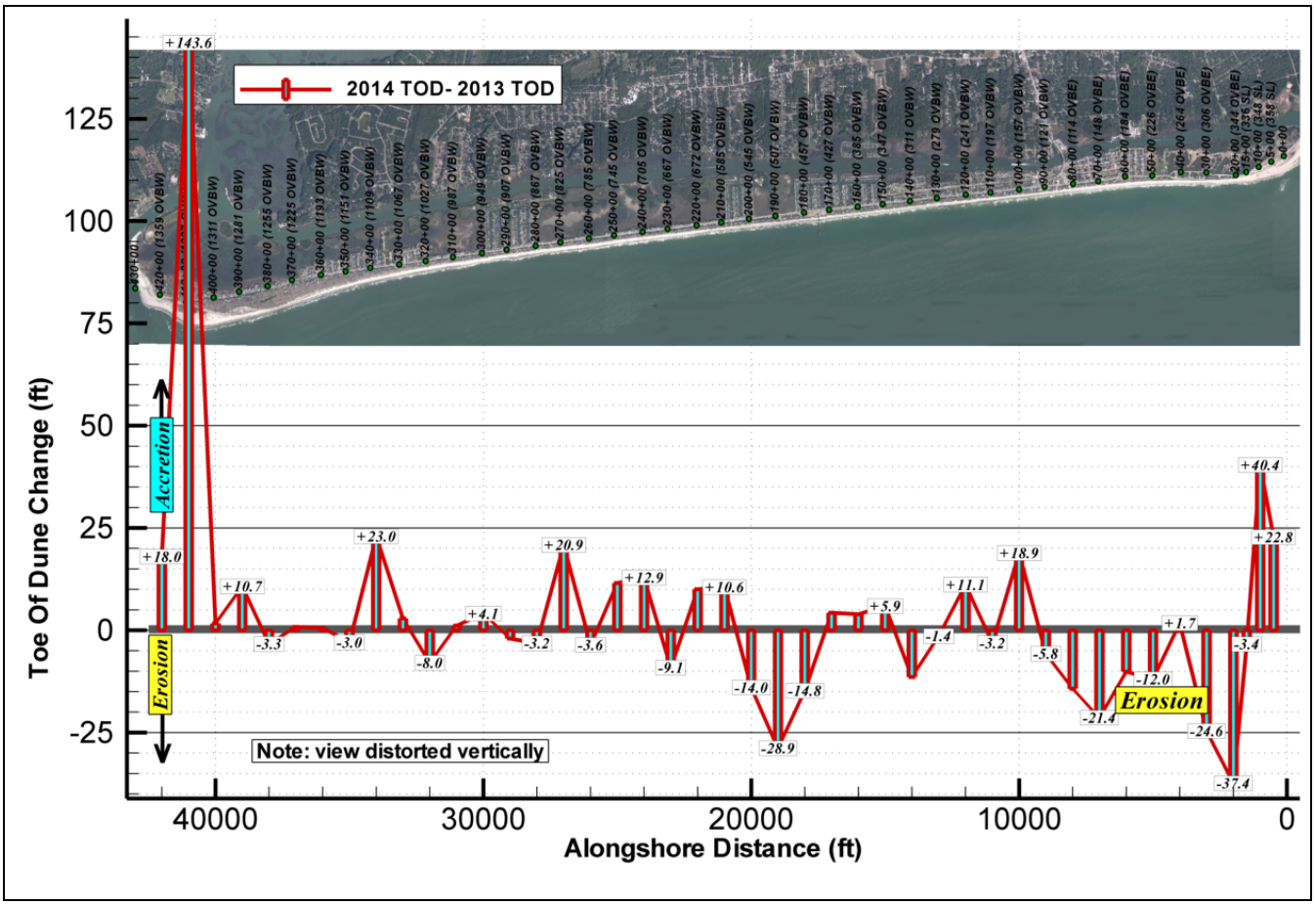



*Figure 3-10. Toe of Dune (TOD) (7 ft NGVD) Change from 2013 to 2014. Variable erosional/accretional trends are exhibited.*

Figure 3-10 shows the TOD shoreline (7 ft NGVD contour). Variable erosion and accretion of this shoreline have occurred since the 2013 survey. Proactive dune enhancements, discussed in Section 2.4, are an important activity related to maintaining a healthy dune line.

Figure 3-11 presents maximum dune heights for each Holden Beach station. Dune heights are generally healthy, although Stations 20+00, 400+00, and 410+00 show reduced dune heights and are more vulnerable to dune breaches during storms, especially under elevated water level conditions.

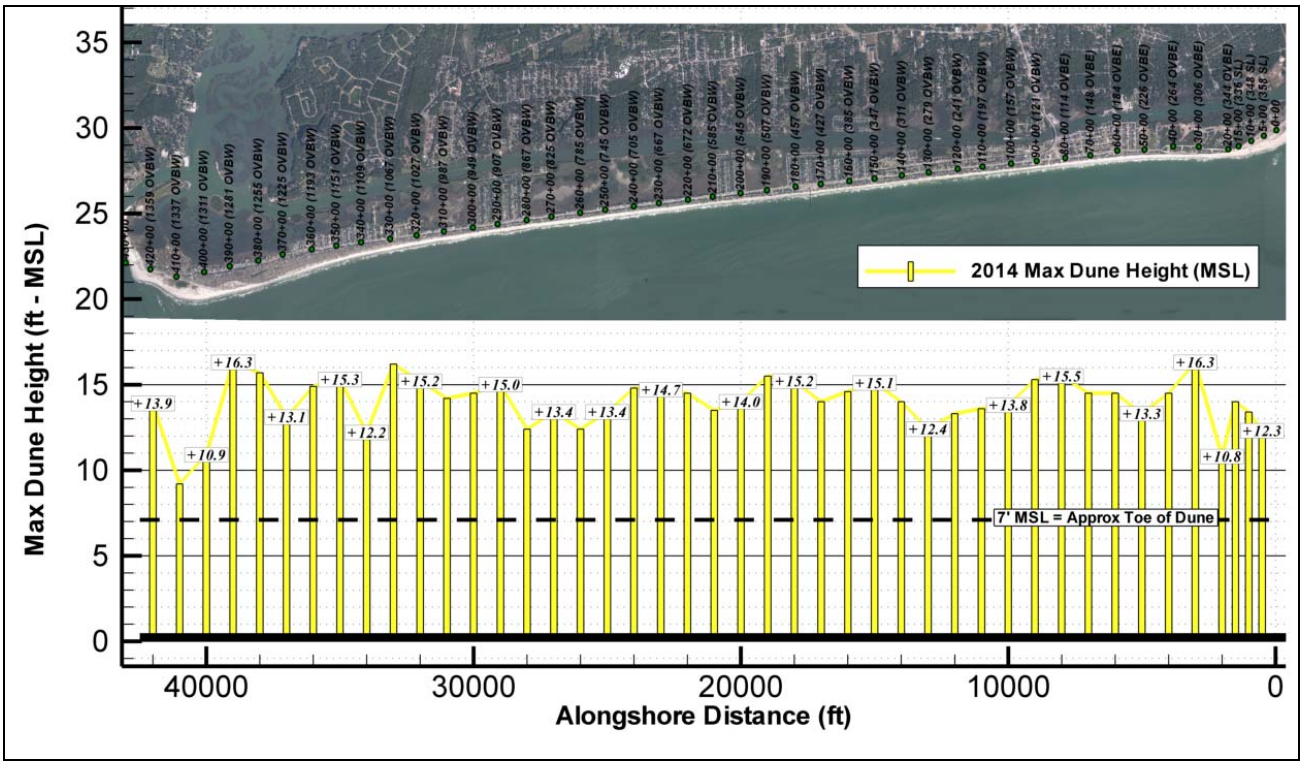



*Figure 3-11. Maximum 2014 Dune Height. Using 7 ft NGVD as the dune base, dunes are generally 5' to 8' high.*

## 3.4 HISTORICAL ANALYSIS

Figure 3-12 presents an approximately 14-year MHW shoreline comparison using 2000 and 2014 survey data. The 2000 survey represents a significantly erosional condition. A general accretional trend of 10 to 80 ft is exhibited for the MHW shoreline between 2000 and 2014 (not including the more variable inlet shorelines and recent east end nourishment).

The most recent North Carolina Division of Coastal Management (NCDCM) long-term background erosion rates from 2011 are included in Figure 3-12 for comparison purposes (note that NCDCM assigns a minimum long-term erosion of -2 ft/year). NCDCM 2011 erosion rates take into account recent fill activities and, therefore, reflect lower erosion rates. This is a benefit in terms of reduced setbacks for several areas of the island (when compared to the older 2004 NCDCM erosion rates).

The 2011 NCDCM erosion rate was converted to the same time span (January 2000 to April 2014) as the survey data in Figure 3-12. In comparison to NCDCM long-term erosion rates, the shoreline has generally gained between 40 and 110 ft since the January 2000 survey. Table 3-3 presents average MHW change by reach over the last 14 years.

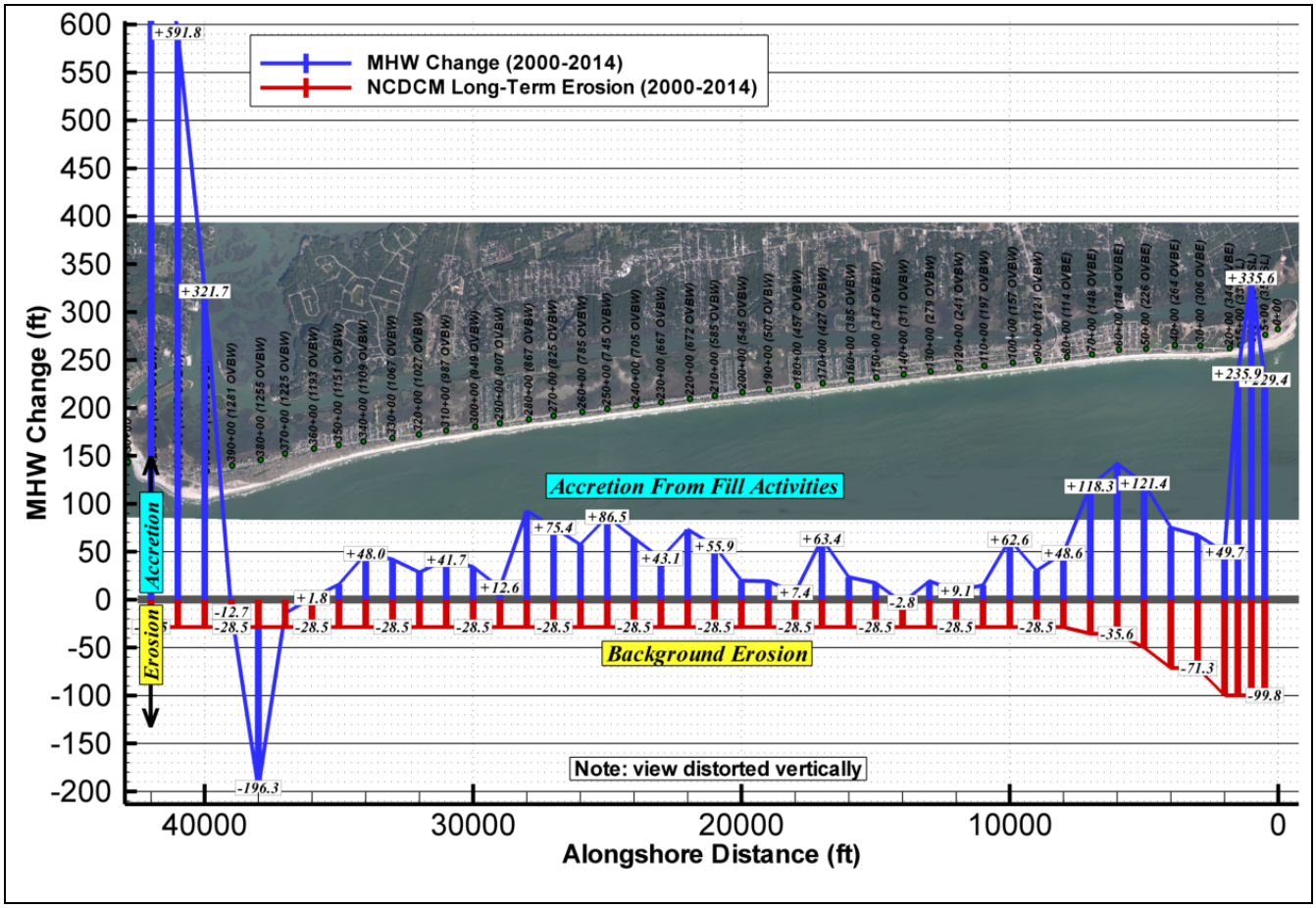



*Figure 3-12. MHW Change from 2000 to 2014 Compared to NCDCM Background Erosion for the Same Period*

Table 3-3. Historical MHW Shoreline Change by Reach (2000 to 2014)

| Reach Averages | Stations Included | Historical MHW Change (2000 to 2014) (ft) |
|---|---|---|
| LWF Inlet | 5 to 15 | 267 |
| USACE East | 15 to 40 | 64 |
| Town East | 40 to 150 | 54.7 |
| Pier | 150 to 190 | 26.2 |
| Town West | 190 to 290 | 54.6 |
| West Area | 290 to 380 | 1.4 |
| Shallotte Inlet | 380 to 420 | 176.1 |
| Central Reach | 40 to 290 | 52 |

Table 3-3 results show that Town and USACE fill and dune enhancement activities have been successful in combating erosion over the last 14 years. The inlet reaches exhibit the

largest increases in MHW change over the last 14 years, which also can be attributed to inlet dynamics and maintenance activities.

## 3.5 OAK ISLAND TRANSECTS

The Town of Holden Beach has been collecting additional survey data on the western end of Oak Island to establish baseline conditions of this area. Oak Island only performs annual surveys down the mean low water, which are not sufficient to completely capture sediment movement. Additionally, because regional sediment transport is from east to west in this area, any changes in this area have the potential to affect Holden Beach shorelines.

Oak Island monitoring transects are shown in Figure 3-13. As with the Holden Beach inlet transects, the Oak Island inlet transects 1 through 4 (i.e., not shoreline perpendicular) are excluded from some volume calculations.

The west end of Oak Island has more development closer to the active beach than the west end of Holden Beach and ,therefore, is more vulnerable to short-term erosional episodes (both west ends are stable/accretional in the long term). Figure 3-14 shows the west end of Holden Beach, where the dune system is up to 600 ft wide. Tables 3-4 and 3-5 present volume and MHW change for the Oak Island transects since the spring 2012 survey.


*Figure 3-13. Oak Island Transects with 2013 MHW (blue) and 2014 MHW (black) Lines shown on a 2012 Aerial. "Oak 2" and "Oak 3" transects begin at the same location as "Oak 1."*

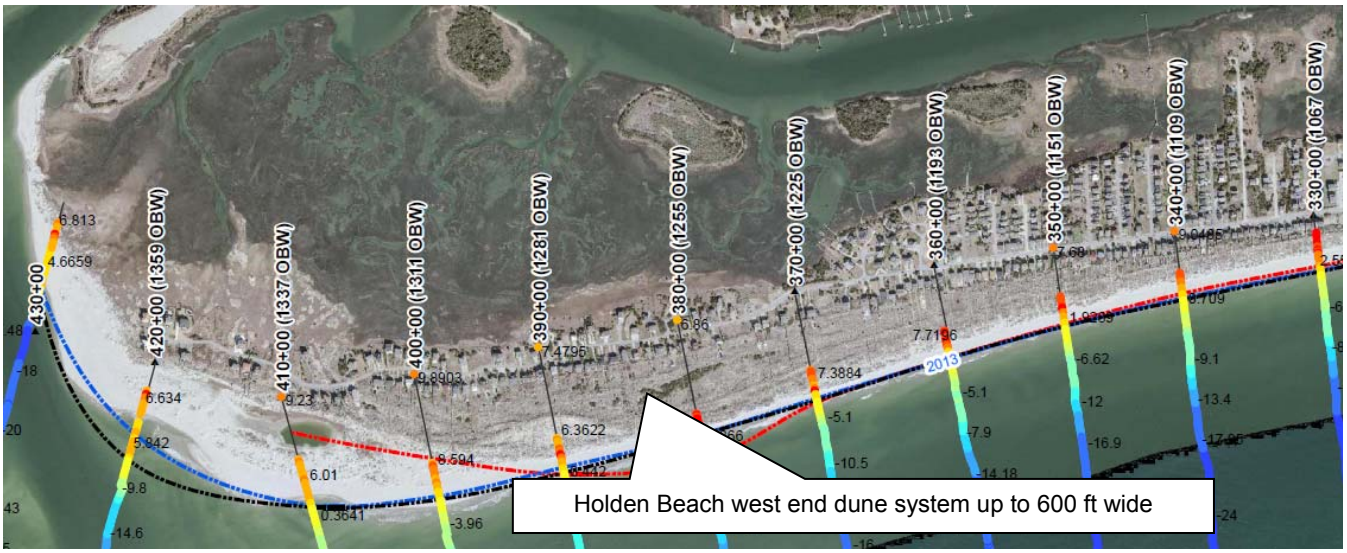



*Figure 3-14. Holden Beach West End has Significantly Larger Dune System Buffer than the West End of Oak Island*

Table 3-4. Oak Island Transect Volume Analysis from 2013 to 2014

| Station | Distance to Next Monument (ft) | Volume Change (cy/ft) (Dune to -12 ft*) | Volume Change (cy/ft) (Dune to -5 ft) | Notes |
|---|---|---|---|---|
| Oak 1 | 0 | -54.4 | -27.9 | LWF Inlet |
| Oak 2 | 0 | -7.1 | 35.2 | LWF Inlet |
| Oak 3 | 890 | 122.2 | 119.4 | LWF Inlet |
| Oak 4 | 1100 | -56.7 | -23.6 | LWF Inlet Shoulder |
| Oak 5 | 2000 | 4.4 | -26.9 | Oceanfront perpendicular |
| Oak 6 | 2000 | -21.0 | -11.2 | |
| Oak 7 | - | 5.4 | 12.2 | |

Table 3-5. Oak Island Transect MHW Change

| Transect | 2012-2013 MHW Change (ft) | 2013-2014 MHW Change (ft) | Notes |
|---|---|---|---|
| Oak1 | 65.4 | -51.9 | |
| Oak2 | -432.8 | 105.9 | Nearshore Shoals |
| Oak3 | -338.2 | 19.4 | Nearshore Shoals |
| Oak4 | -75.4 | -51.9 | |
| Oak5 | -91.7 | -12.6 | |
| Oak6 | -7.5 | -4.0 | |
| Oak7 | 13.7 | 14.0 | |

Similar to the inlet-influenced transects on the west end of Holden Beach, large variation is exhibited for Oak Transects 1 through 4. Oak Transect 5 is transitional, while Oak Transects 6 and 7 are largely removed from inlet effects and show less variability and are more stable (as expected). The Town of Oak Island has expressed interest in nourishing their west end for the last several years using sediment from the East Channel. Town staff and ATM will continue to follow this effort, as it has the potential to affect LWF Inlet and Holden Beach.

## 4.0 SUMMARY

The Holden Beach shoreline has historically exhibited moderate erosion rates (with the exception of the inlets). As a result, the Town has instituted a nourishment and beach management program to offset this erosion. Dating back to January 2000 (approximately 14 years), the Town and the USACE have placed an average of approximately 140,000 cy/year on the beach. This rate of sand placement has been effective at keeping pace with background erosion.

Over the last 4 years (2010 to present), annual placement rates have averaged approximately 100,000 cy/year [2010 (140,000 cy) and 2014 (188,000 cy) placements were significantly larger than 2011 (32,000 cy) and 2012 (25,000 cy)]. During this time, Hurricane Irene (2011) impacted the Holden Beach shoreline. Due to its "engineered beach" status and annual monitoring program, the Town is qualified to receive FEMA aid to mitigate erosion caused by the storm. Irene mitigation is for only 26,000 cy and only for a small section of beach west of the pier. The Town also received FEMA assistance for Hurricane Hanna erosion in 2008 and placed 190,000 cy of material, with FEMA reimbursing 75 percent of the total project cost.

The due date for the Hurricane Irene mitigation is August 2015. Ideally, dove-tailing this effort with another effort, such as the Central Reach project, would represent the most cost-efficient approach. However, mild erosion over the last year and the recent successful LWFIX project have most likely pushed the timing of the Central Reach project back another year. Town staff and ATM will continue to assess feasible options for placing this FEMA-qualified 26,000 cy west of the pier.

The most recent annual shoreline survey occurred in April 2014. In comparing this survey to the April 2013 survey, the entire island experienced a net gain of about 235,000 cy (or 47,000 cy, neglecting the 188,000 cy east end nourishment). Relatively extreme volumetric erosion was observed near the west end (about a 120,000 cy loss between STA 340+00 and 400+00). This loss was mainly observed in the nearshore (-5 ft to -12 ft NGVD) and the sediment likely moved onto the upper beach (above -5 ft NGVD) or toward Shallotte Inlet, accounting for increased MHW shoreline widths or portions of the accreted material farther west (STA 410+00 to 420+00).

Approximately 144,000 cy of material was gained on the upper beach within the Central Reach (i.e., STA 40+00 to 290+00) over the last survey period. A majority of this material can be taken into account in the recent USACE/Town nourishment (extending west to STA 73+00). The balance of material is most likely to have migrated from the nearshore (approximately -5 to -12 ft below mean sea level) or from neighboring reaches (east or west ends/inlets). In any case, this area represents the fill placement footprint for the permitted Central Reach project and accretional/stable results can afford the Town more flexibility in scheduling this large nourishment project.

Historical annual losses have been documented at about 100,000 cy/year for Holden Beach. Therefore, a total gain of approximately 94,000 cy (from dune to -12 ft) within the Central Reach over the last year represents a moderately accretional year from a volumetric perspective.

From a shoreline contour perspective, the center approximately 5 miles of island (Central Reach Station 40+00 to 290+00) exhibited an average MHW erosion of -2 ft between surveys. However, the recently nourished shorelines are influencing these observations (as expected). For example, beginning just west of the recent fill (STA 80+00) and moving about 4.5 miles west, along the center of the island (to STA 310+00), the average MHW erosion was -12.5 ft between surveys. The recently placed material on the east end should continue to positively influence MHW and volumetric changes within the Central Reach. The TOD line exhibited an average erosion of approximately 2 ft along the Central Reach, with more severe erosion along the east end and accretion adjacent to Shallotte Inlet.

In comparing the April 2014 survey with the January 2000 survey (14-year span), the MHW shoreline exhibits approximately 50 ft of accretion. Therefore, the shoreline is still in a generally healthy condition, while the Town holds all permits necessary for the Central Reach nourishment project. The Central Reach nourishment project proposes to place up to 1.31 MCY between Stations 40+00 and 260+00 (OBE 262 to OBW 781).

The Central Reach nourishment project represents the largest nourishment project on Holden Beach (approximately twice the size of the 2001-2002 USACE 933 project) and will advance the MHW shoreline approximately 60 to 80 ft. The purpose of the proposed project, which is a component of the Town's comprehensive beach management program, is to provide beach

restoration along eroding sections of shoreline sufficient to maintain the island's restored protective and recreational beachfront and natural dune system.

The Town's LWFIX piggyback nourishment project this spring placed about 95,000 cy of material on the east end. Combined with the USACE project of about 93,000 cy, almost 190,000 cy of material was placed on the east end. The majority of this material will migrate west and provide downdrift benefits to central and western reaches of Holden Beach shorelines. The Town's piggyback nourishment project placed material at about $8/cy, with the State assisting with 50 percent of the project cost and the County contributed funding also.

The Town's piggyback project was incredibly successful and is anticipated to reduce the immediate need for the larger and more costly Central Reach project. The piggyback project is recommended to continue in the future whenever the USACE plans a project that does not fully utilize the LWFIX borrow area (which is expected to happen most of the time due to USACE funding restrictions).

On a related topic, NCDENR has developed an SDI program that would provide the Town permits to dredge the inner and outer portions of LWF Inlet. These permits would essentially allow the Town, with potential help from the County and State, to perform the same inlet maintenance activities that the USACE currently performs (i.e., LWFIX dredging, outer channel sidecasting). The State has now established an annual funding source for these projects with the new State Shallow Draft Navigation Channel and Lake Dredging Fund, which will be endowed by both an increase in boat registration fees and an excise on motor fuel to the North Carolina Wildlife Resources Commission's boating account. The Town and ATM will continue to coordinate with NCDENR and its subcontractors as they are currently in the beginning stages of developing the necessary permit application materials.

In summary, the 2011 North Carolina Beaches and Inlets Management Plan (NC BIMP) report estimated the 2008 Beach Recreation *Annual* Total Impact Output for Holden Beach at $92.9 million, which accounted for 1,299 jobs. Additionally, the NC BIMP conducted a study of losses attributed to 50 percent beach width loss and found that, for Holden Beach, the 2008 estimated *annual loss* (including output/sales/business activity) would be $14.6 million. The Town's beach management and maintenance program strives to maintain and enhance this important economic and environmental benefit.

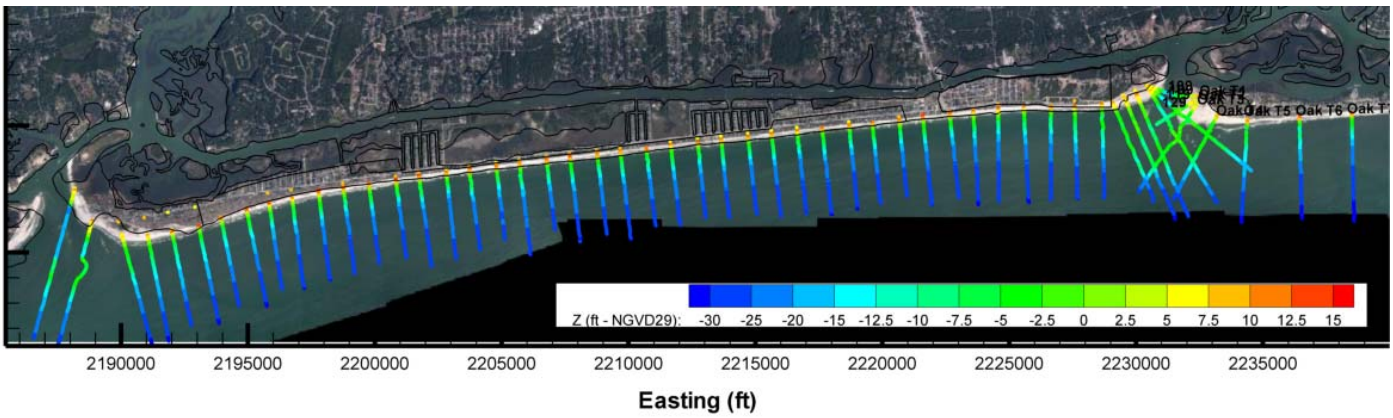
Recommendations for future and ongoing beach management activities include:

- Continue annual island-wide monitoring with beach profiles
- Continue with Central Reach nourishment planning
- Continue with terminal groin and beach nourishment permitting for the east end
- Continue with research towards conducting a pilot project with recycled glass as a sand source, which can likely be conducted under the existing upland fill permit
- Continue to coordinate with USACE on future outer LWF Inlet channel sidecast/hopper dredging and nearshore sand placement
- Continue with proactive dune enhancement activities (planting, fertilizing, fencing, etc.).
- Work closely with Congressional representatives to assure continued support of future USACE nourishment projects for Holden Beach
- Obtain an extension for the USACE upland borrow area permit
- Continue coordination and support of the State's SDI Program
- Regularly attend quarterly SDI MOA meetings held by the USACE and NCDENR

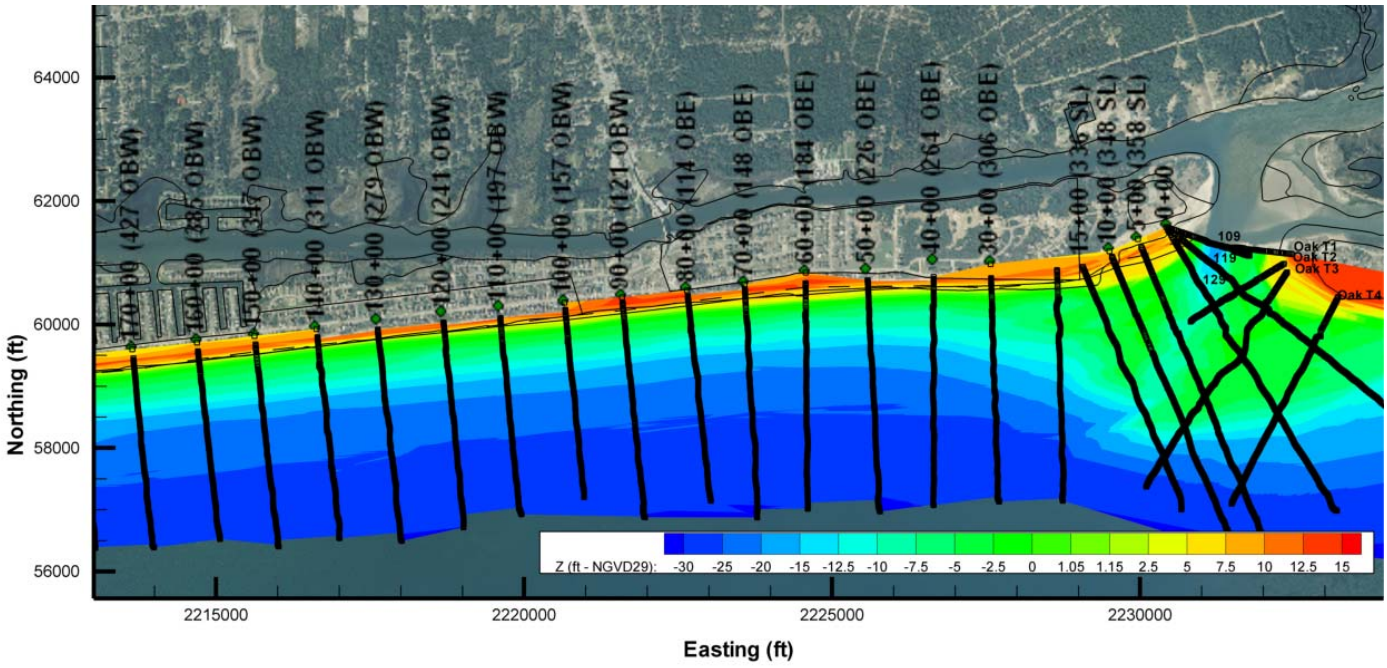
# Appendix A

# Station Profile Analysis

## APPENDIX A – ELEVATION PROFILE TRANSECTS




*Survey Stationing Figure. Plots below are from east (Lockwoods Folly Inlet) to west (Shallotte Inlet). Profile plots are zoomed in to nearshore area (typically from the dune to ~-20ft NGVD depth). Oak Island Transects are at the end of the section.*

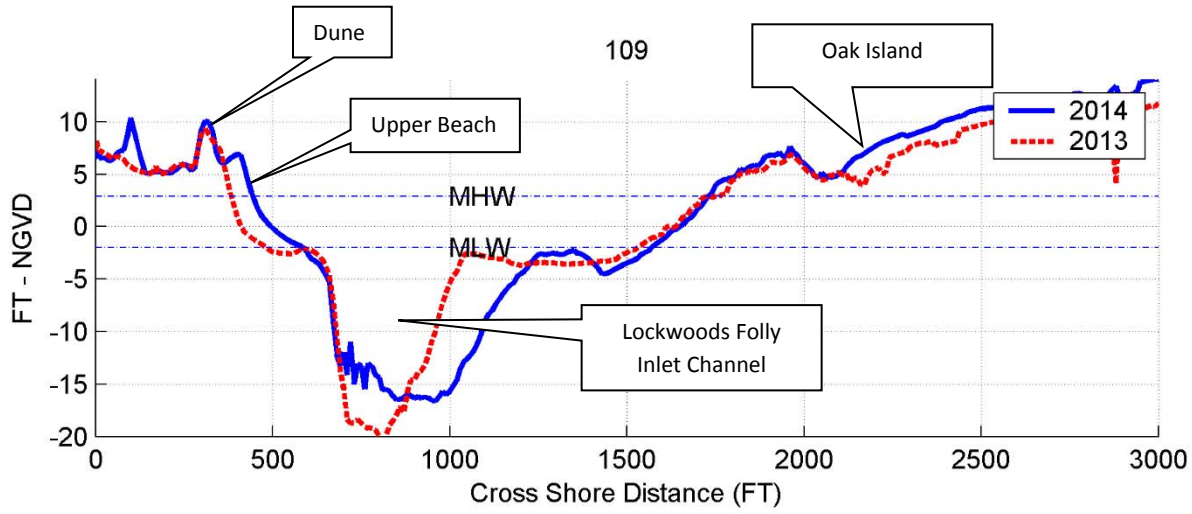



*Zoomed in to eastern half of island (station 170+00 is to the far left and just east of the pier).*

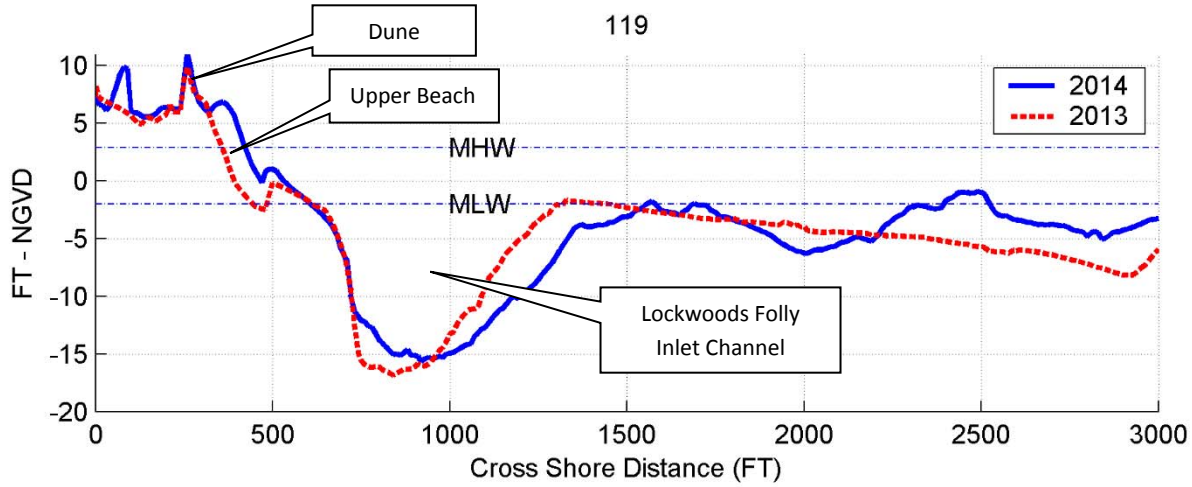
**Please Note:**

**In the following cross sections, the Station Number is shown at the center top of the figure.**

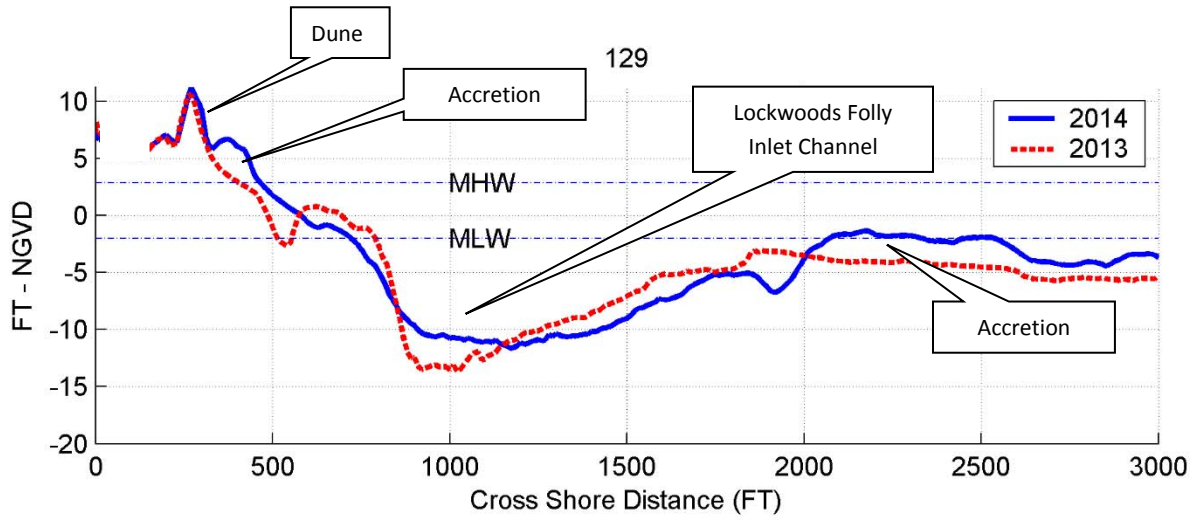
**Any notable features are described in "call-outs" or in blue below the figure.**



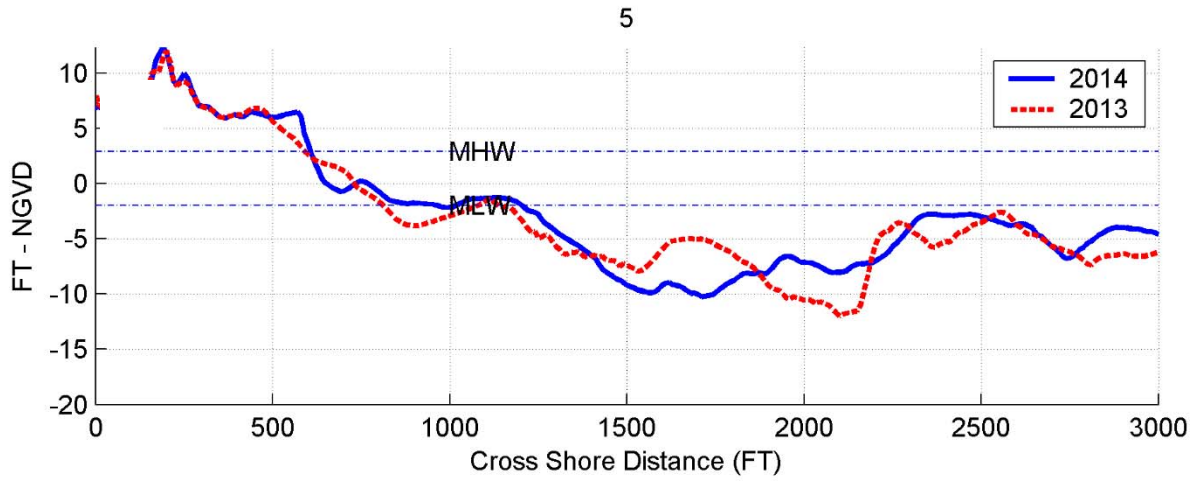

*Station 109+00 (far east). Plots typically show from dune (between ~7' and ~15' NGVD) out to ~-20' NGVD. MHW=Mean high water, MLW=mean low water. Note LWF Inlet Channel widening closer to Oak Island and upper beach accretion.*

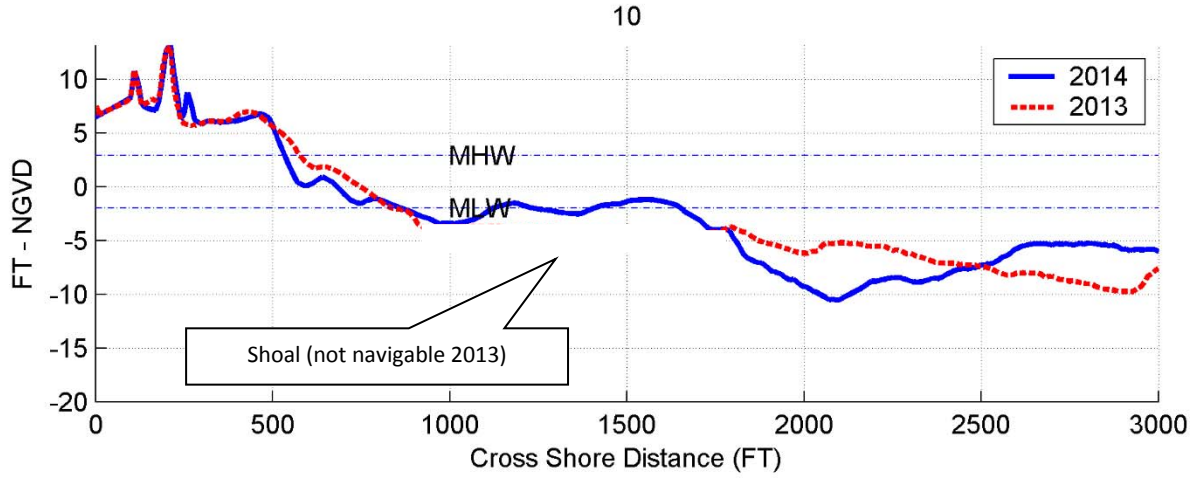



*Station 119+00. Inter-tidal beach showing some accretion since 2013 survey. Note LWF Inlet Channel widening closer to Oak Island and upper beach accretion.*

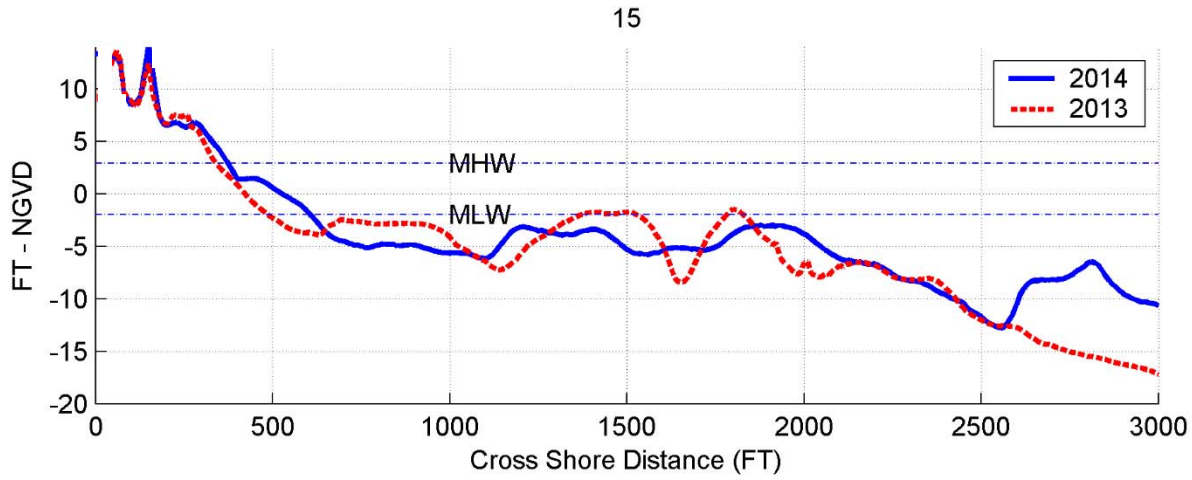


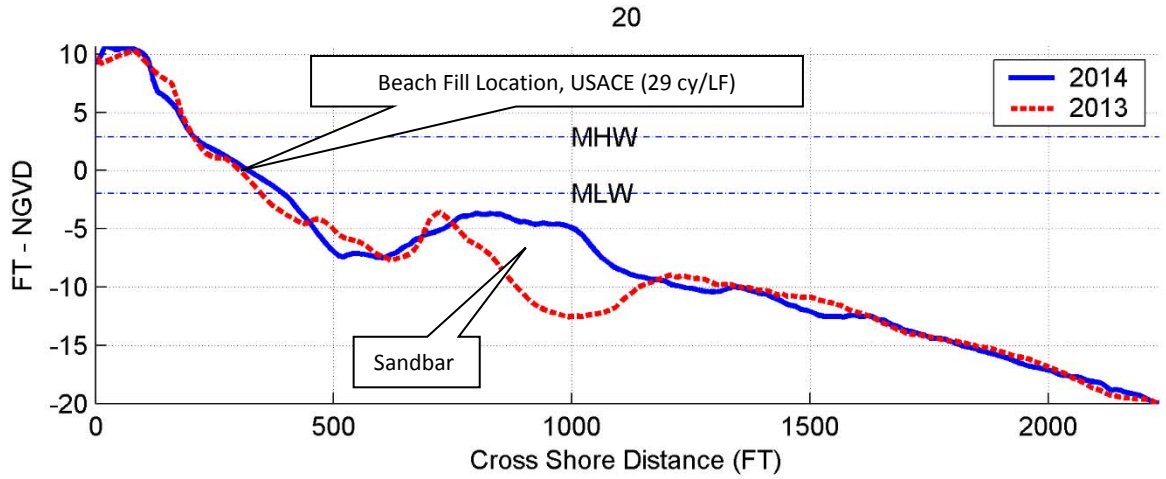

*Station 129+00. LWF Inlet Channel Approximately 900 ft from baseline. Some upper beach and below MHW accretion is seen.*



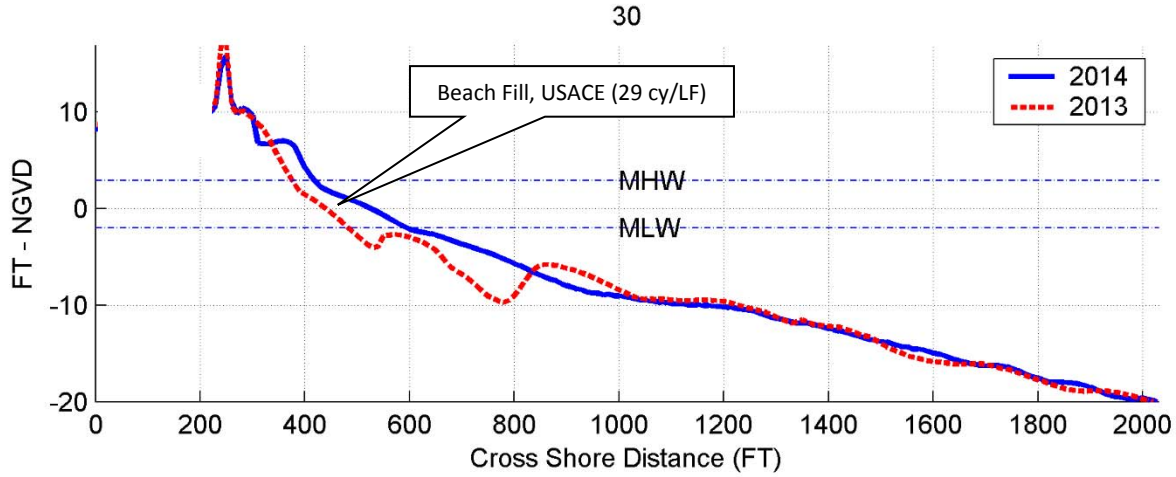



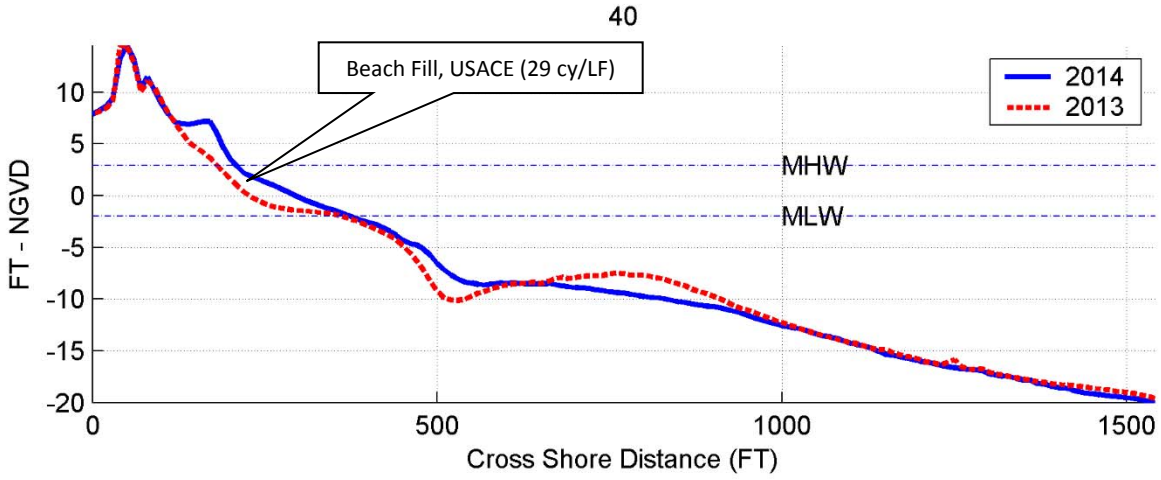

*Station 10+00. Some dry beach erosion; variable nearshore.*

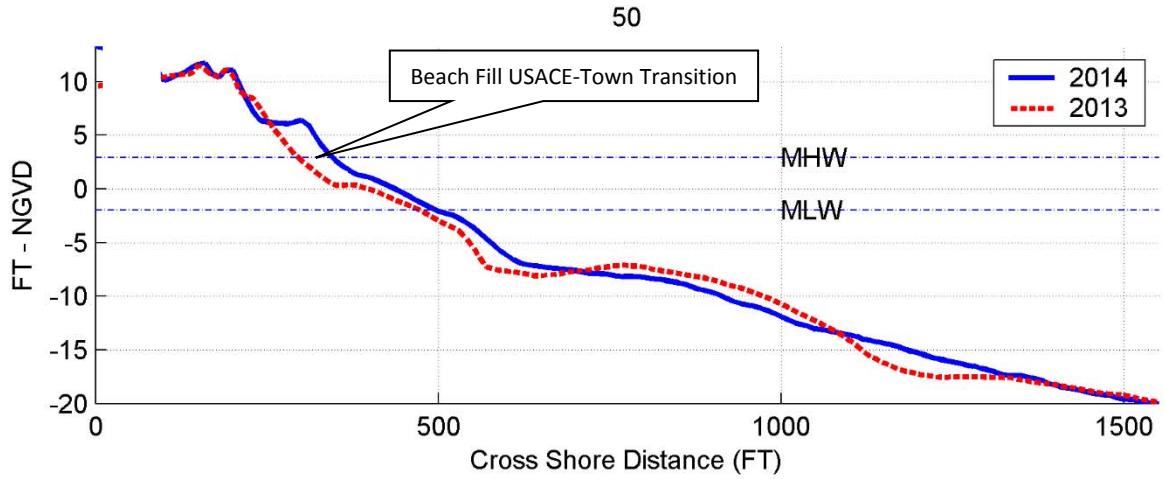


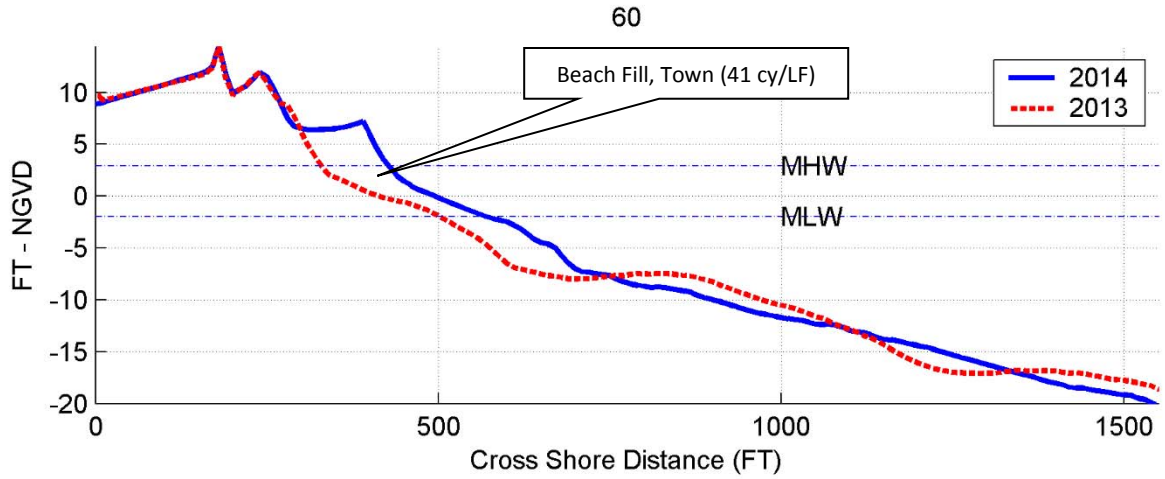

*Station 20+00. Note little net effect of 2014 beach fill vs 2013 survey.*

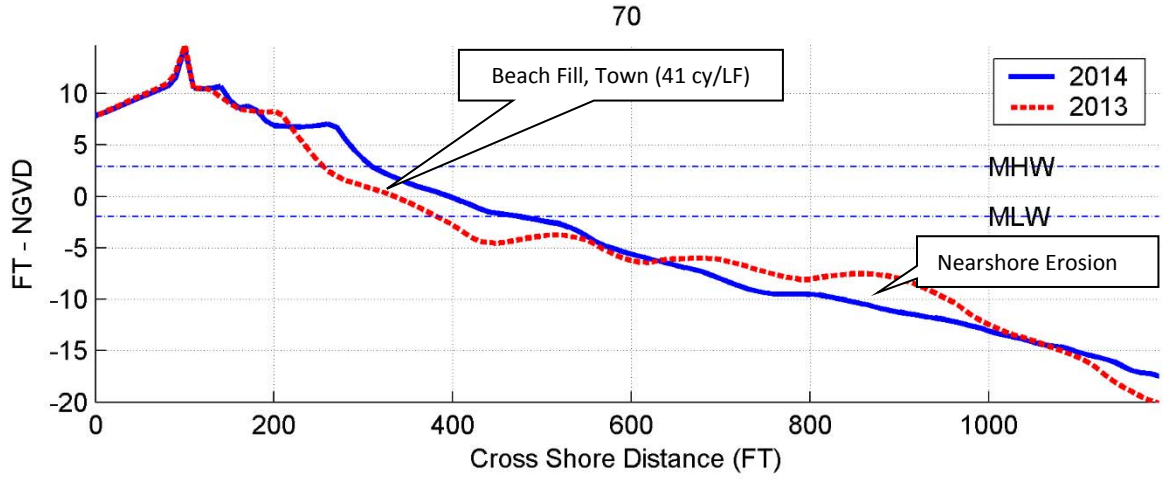


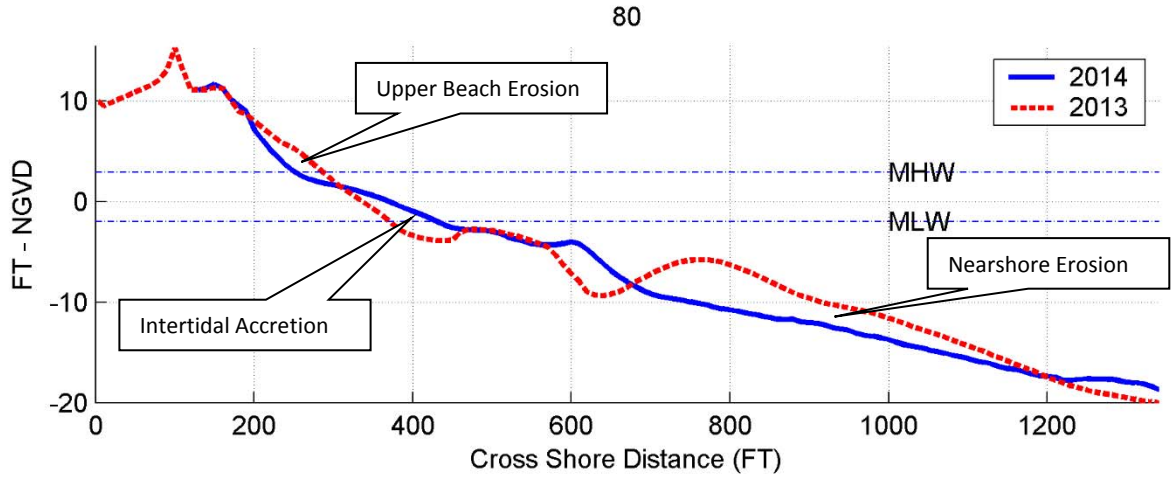


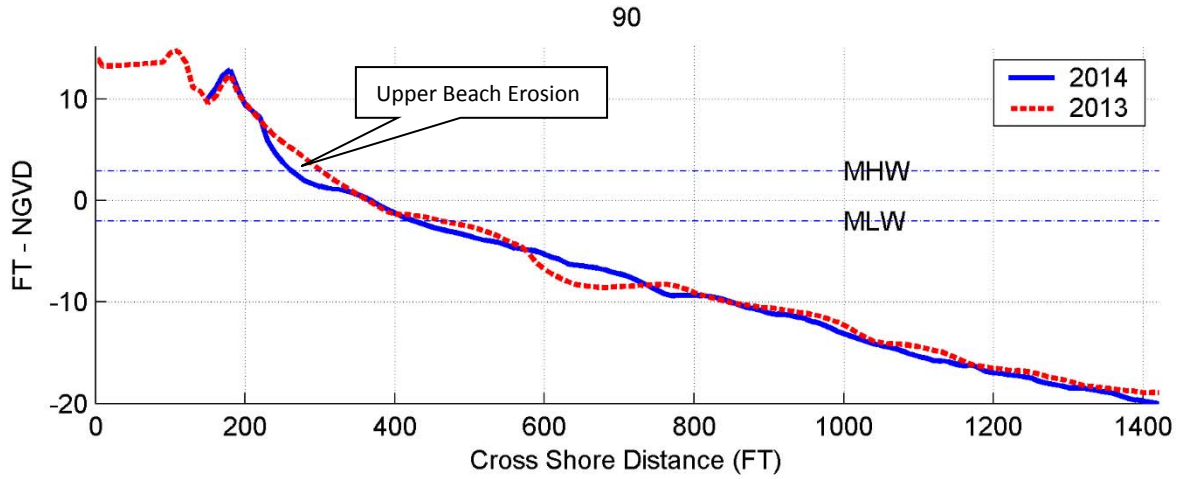

*Station 50+00. End of USACE template (29cy/LF) and beginning of Town template (41yc/LF)*

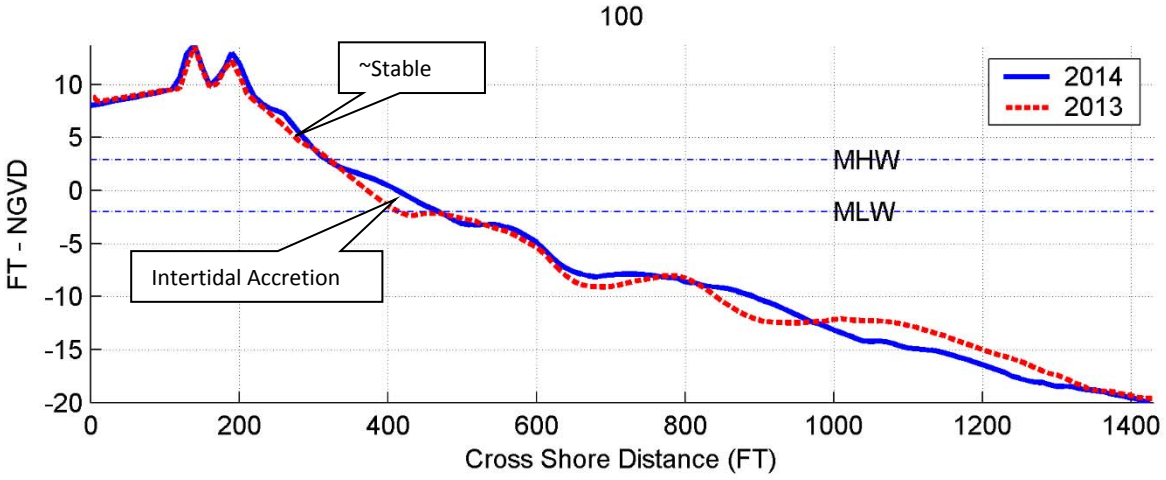


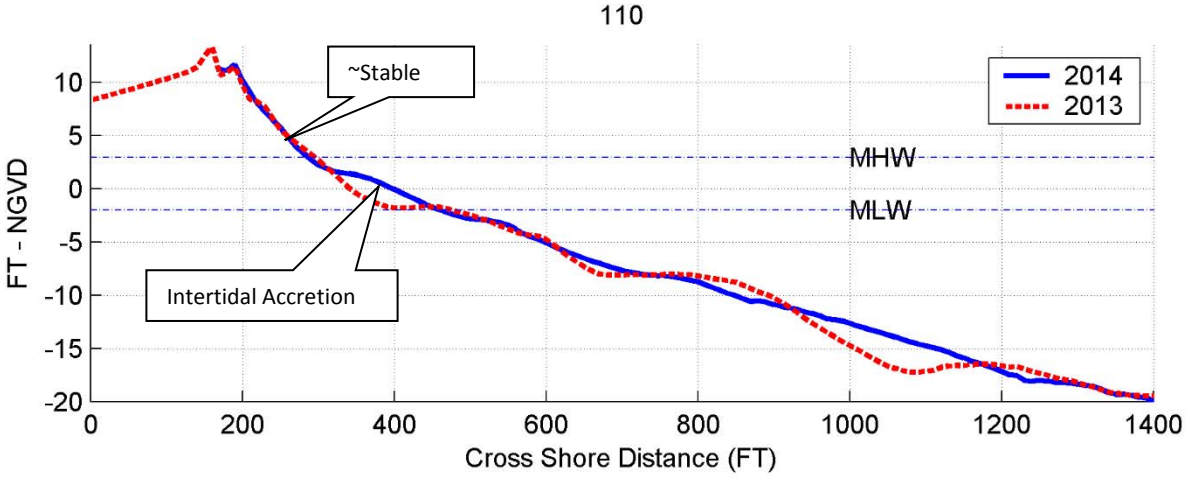


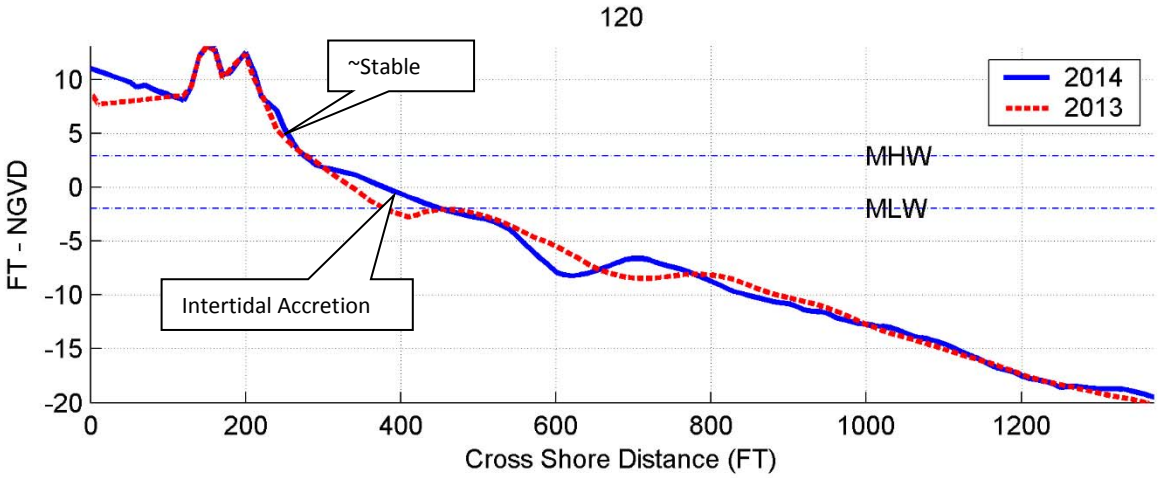



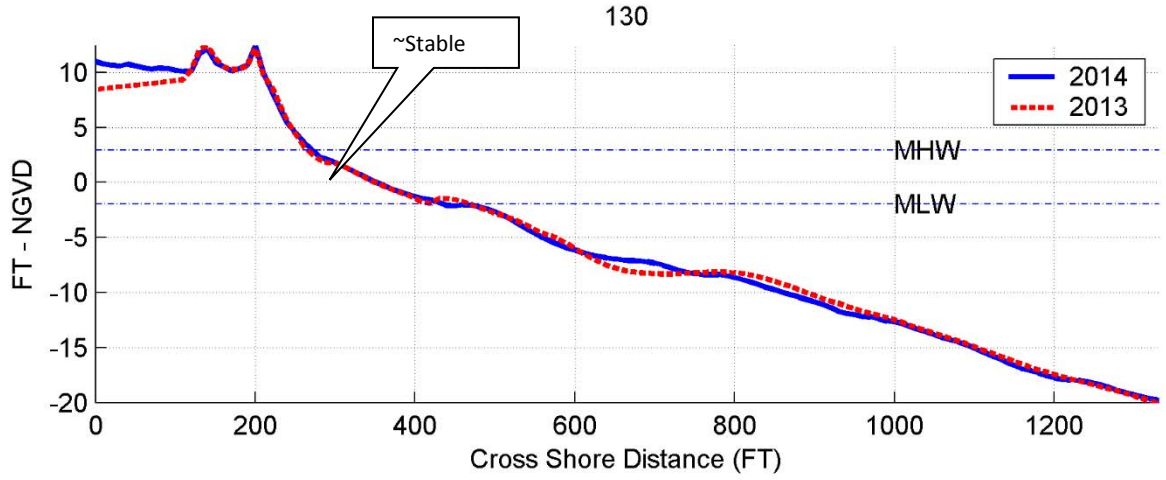

*Station 80+00. Note end of Town Nourishment at Station 73+00.*

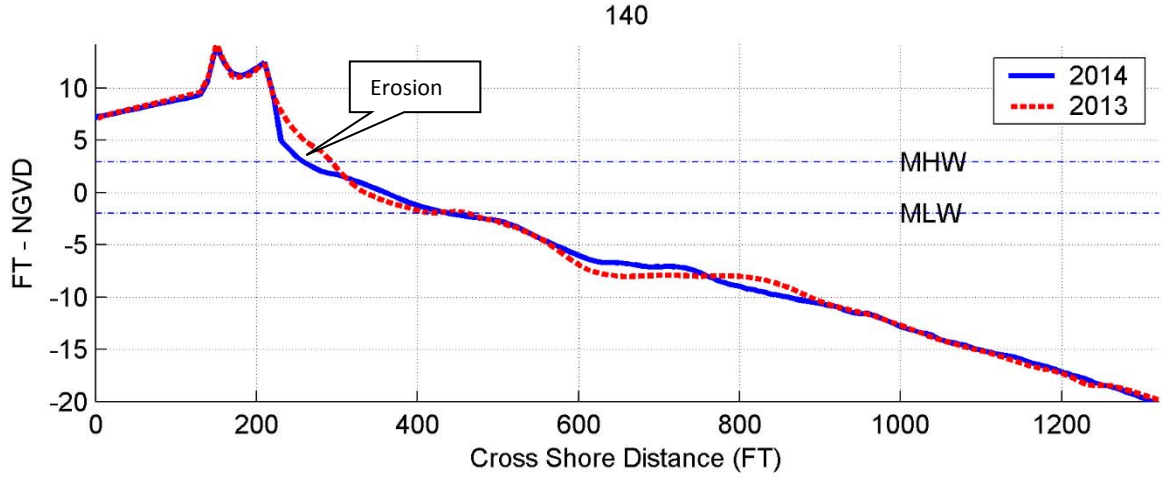


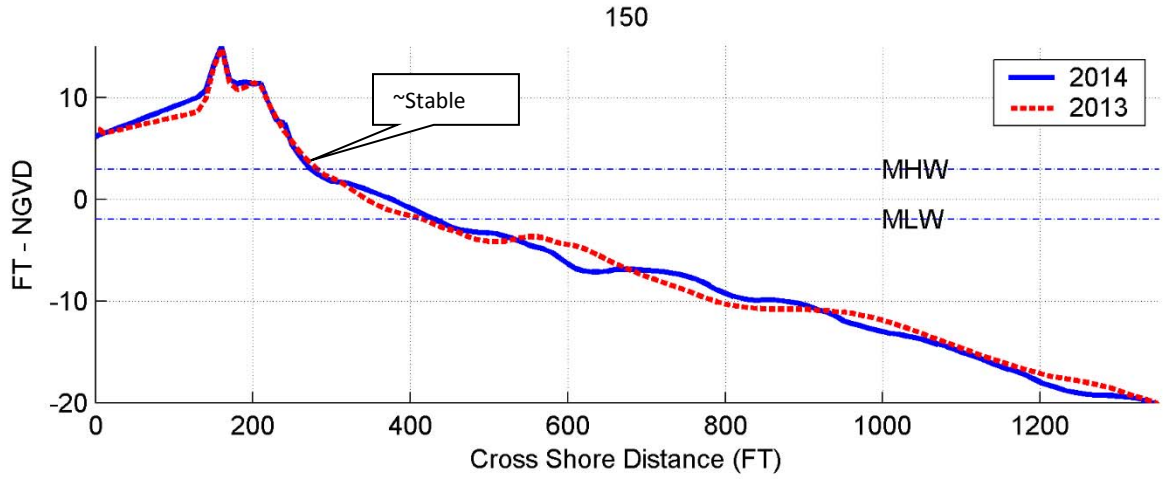

100
~Stable
Intertidal Accretion
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

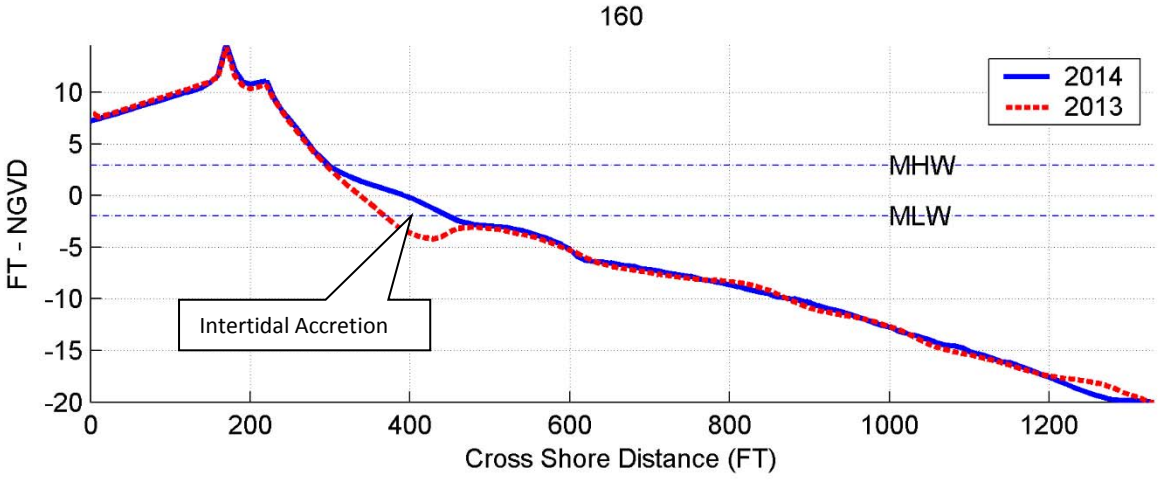

110
~Stable
Intertidal Accretion
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

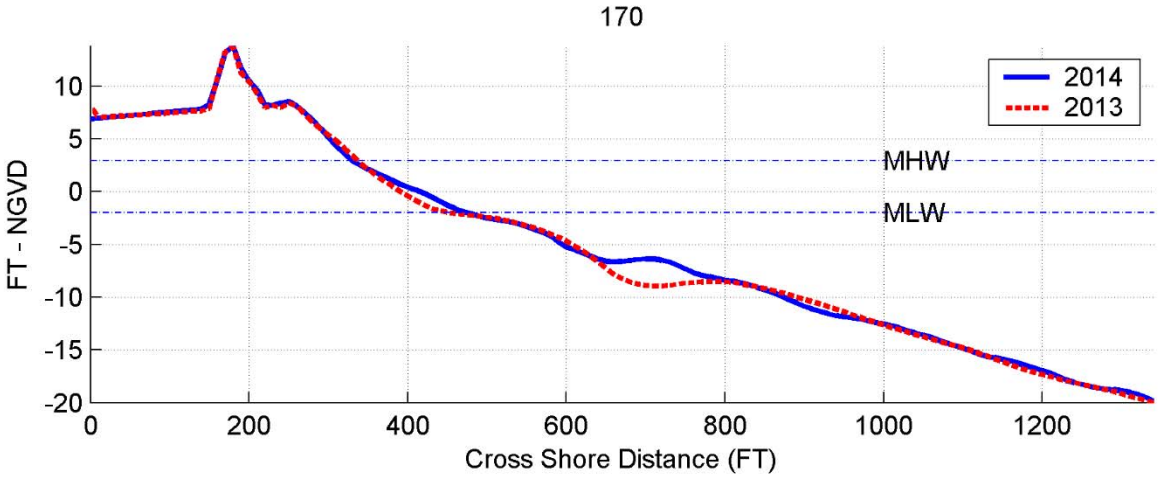

120
~Stable
Intertidal Accretion
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

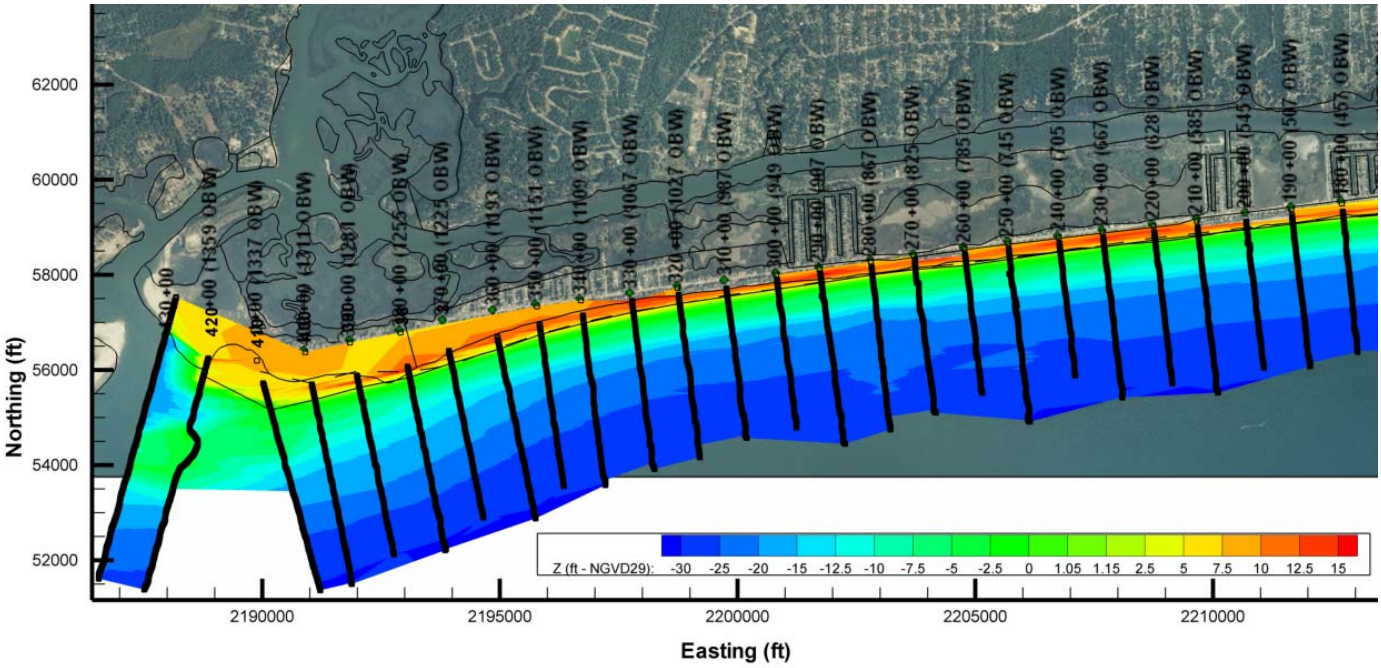

130
~Stable
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)


140
Erosion
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

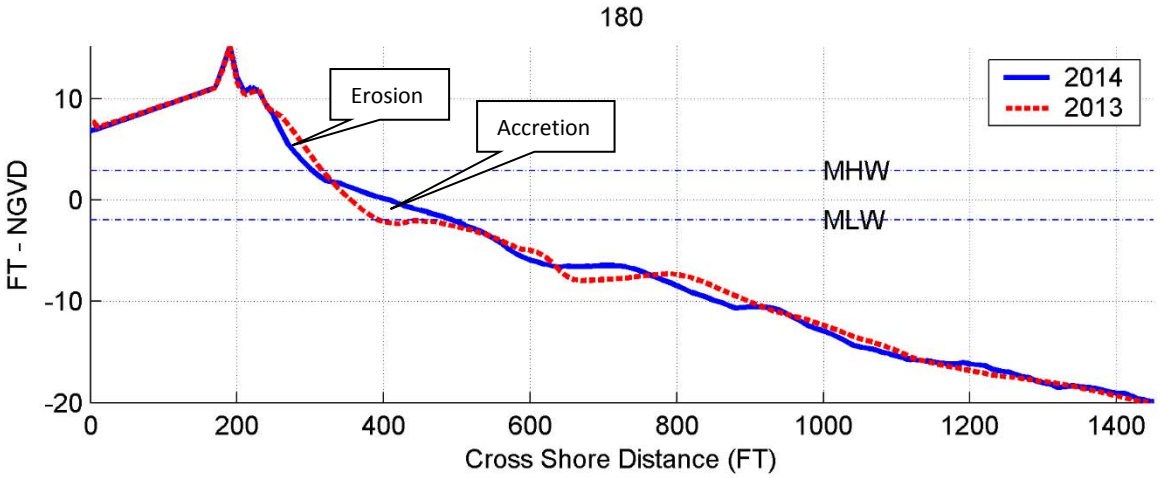

150
~Stable
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)


160
2014
2013
MHW
MLW
Intertidal Accretion
FT - NGVD
Cross Shore Distance (FT)

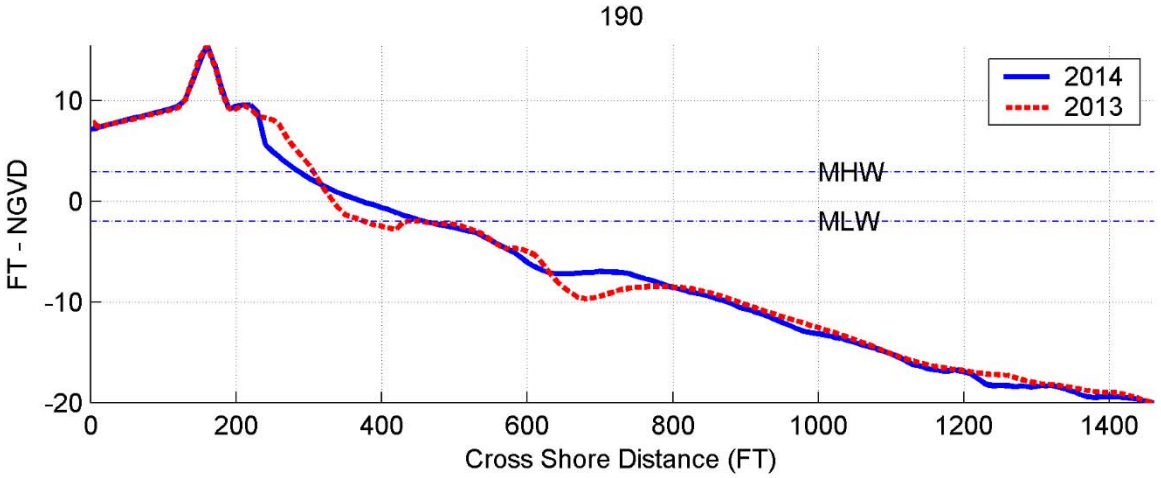

170
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)



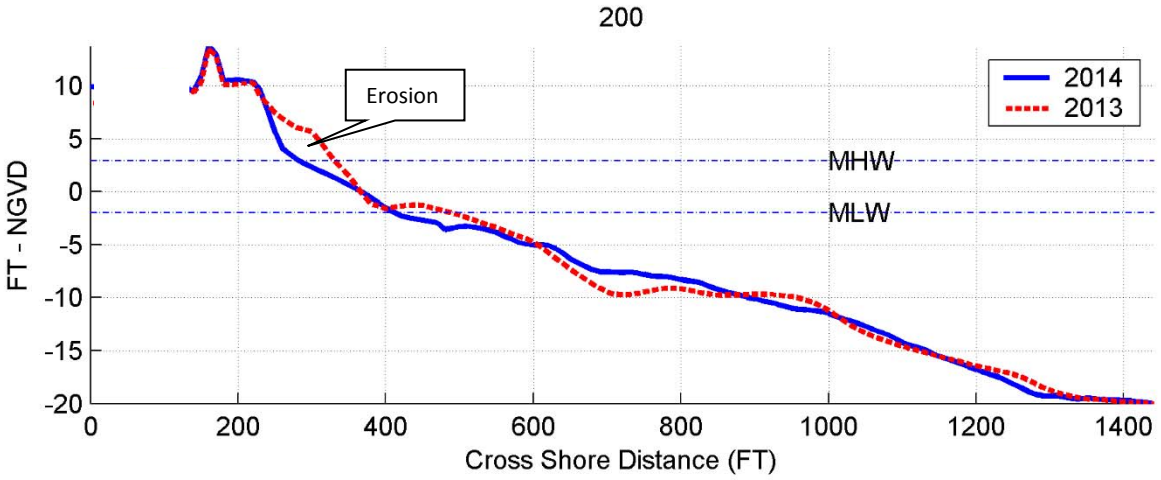

*Zoom in of western end (Station 180+00 near the pier to Station 430+00 at Shallotte Inlet)*

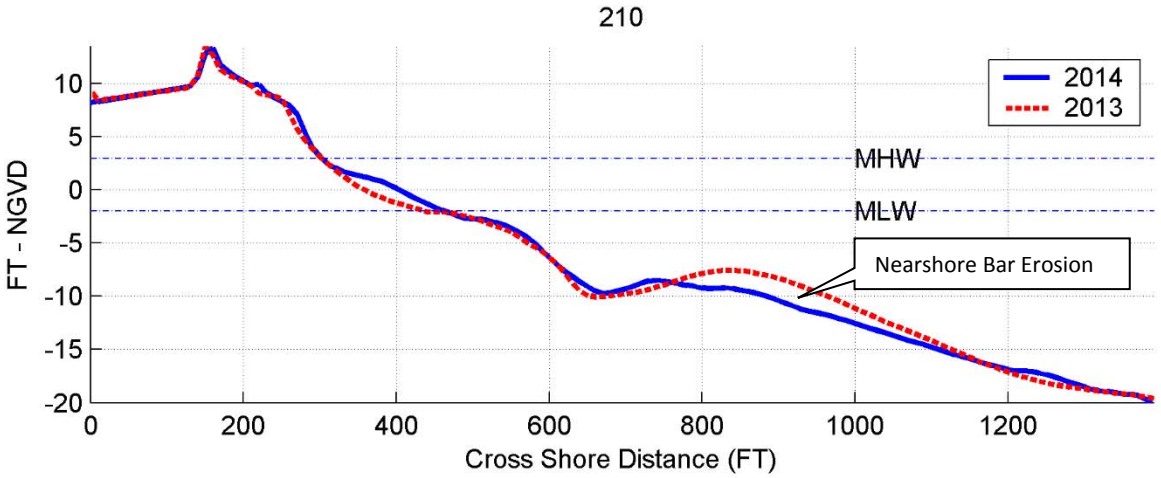



***Station 180+00. Cross shore transport from upper beach to intertidal zone.***

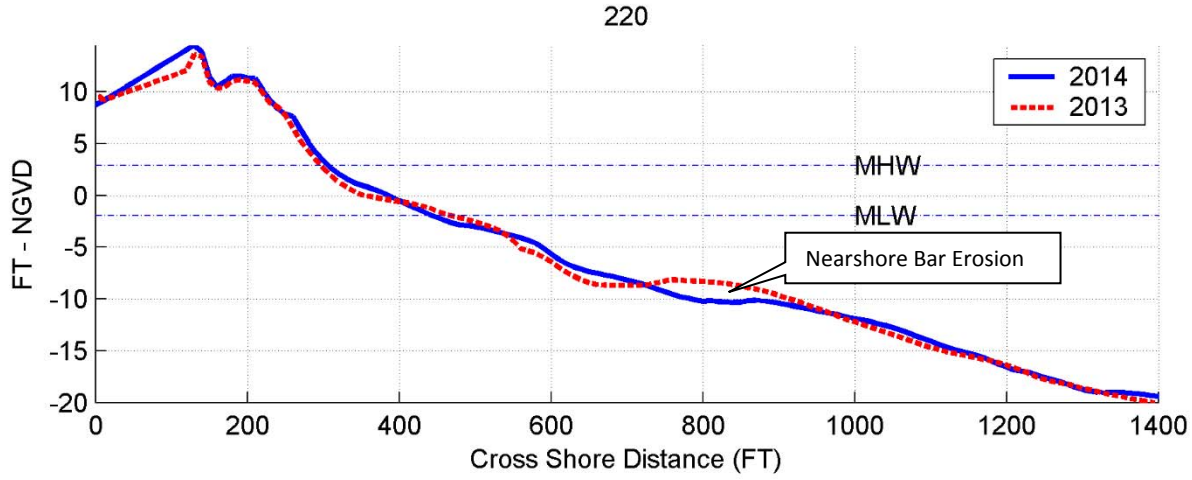


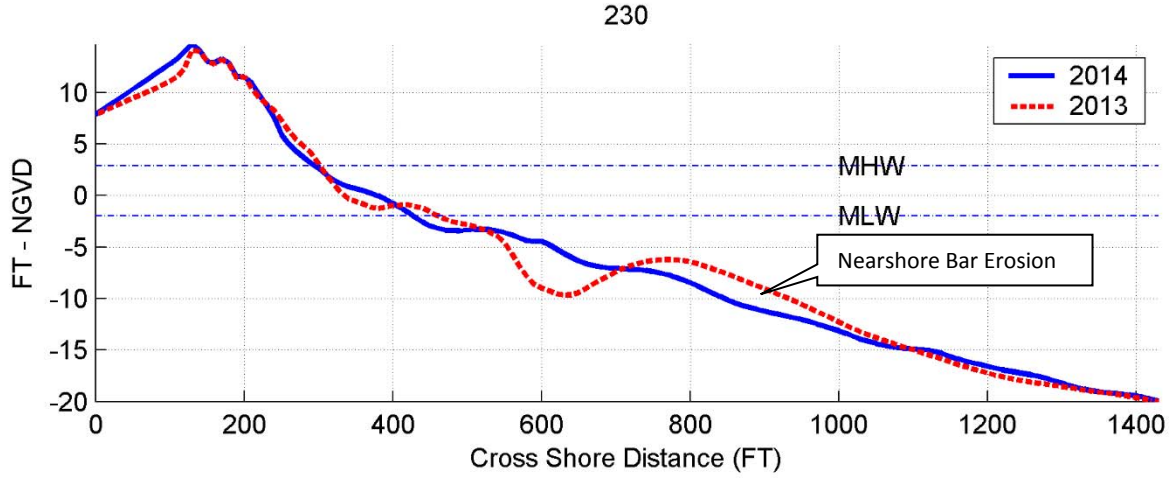

*Station 190+00. Cross shore transport from upper beach to intertidal zone.*

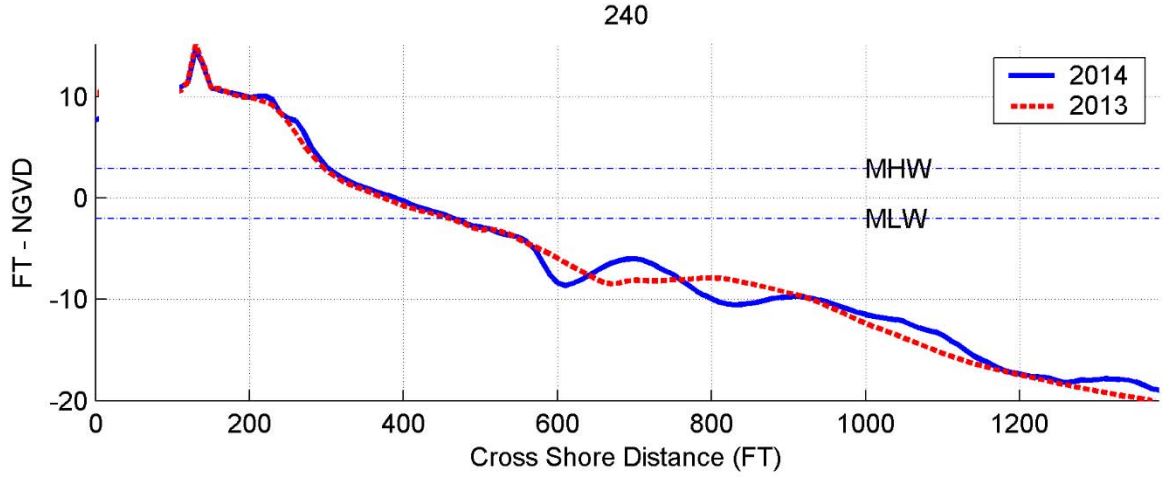


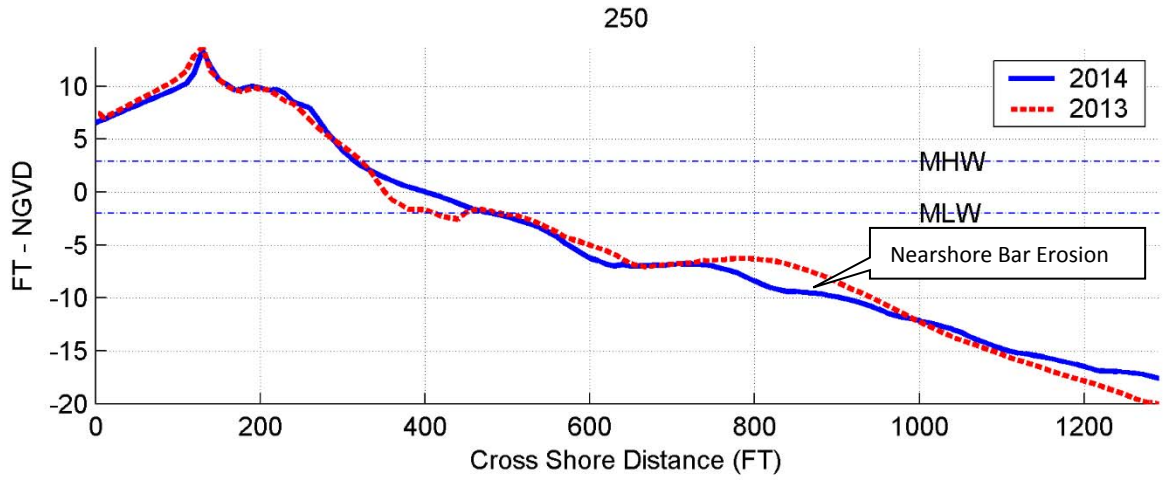



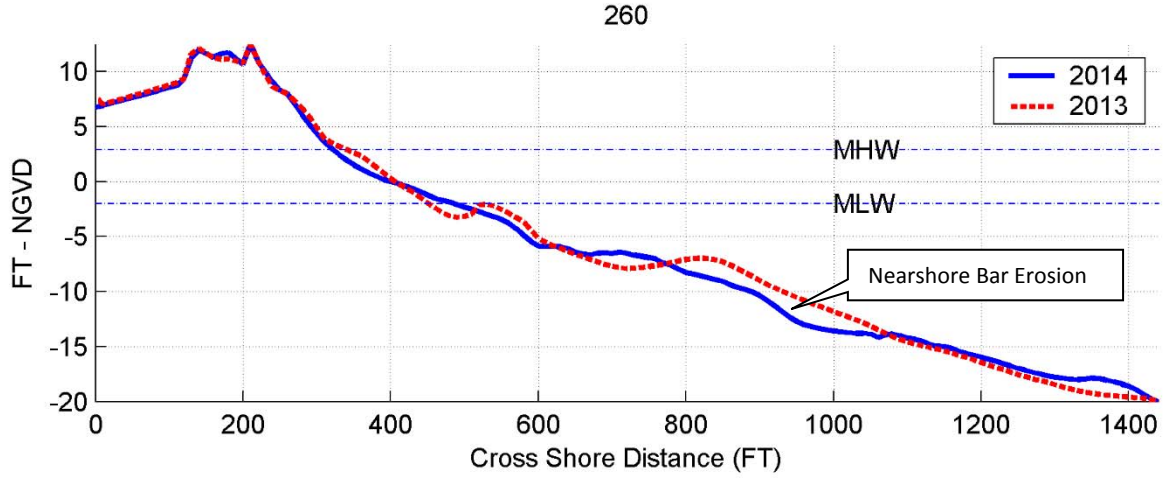

*Station 210+00. Nearshore bar erosion (continues to Station ~260-+00)*

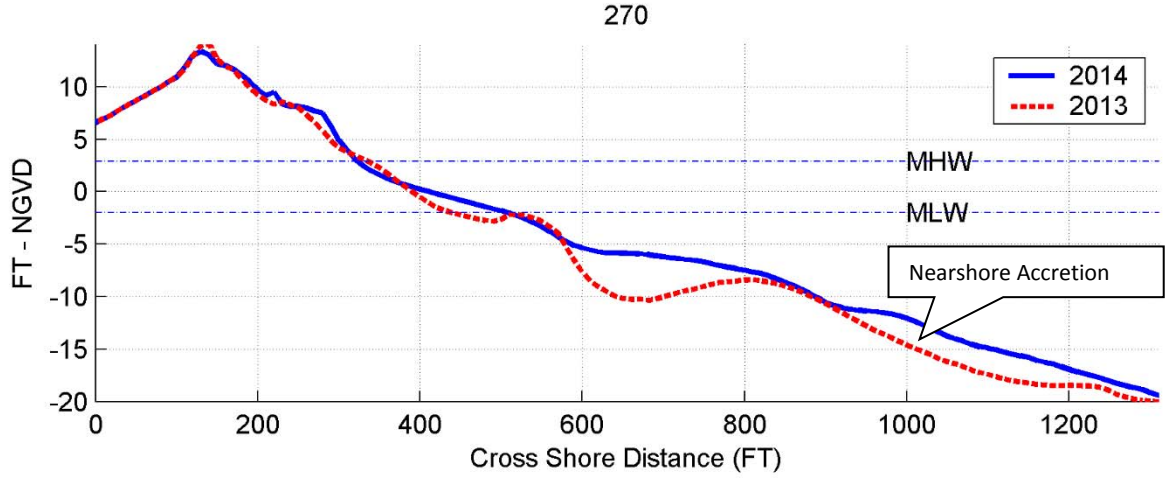

220
2014
2013
MHW
MLW
Nearshore Bar Erosion
FT - NGVD
Cross Shore Distance (FT)

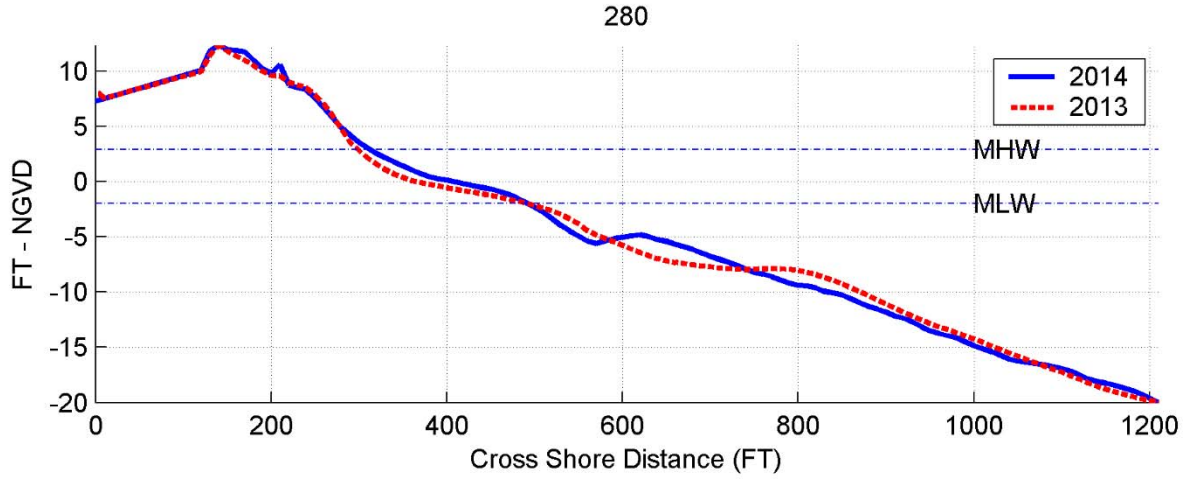

230
2014
2013
MHW
MLW
Nearshore Bar Erosion
FT - NGVD
Cross Shore Distance (FT)

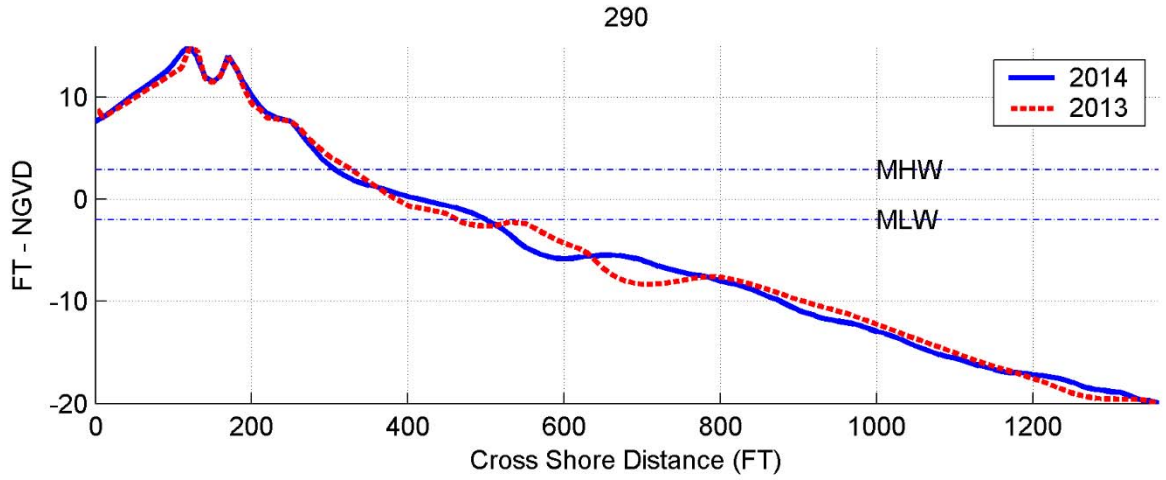

240
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

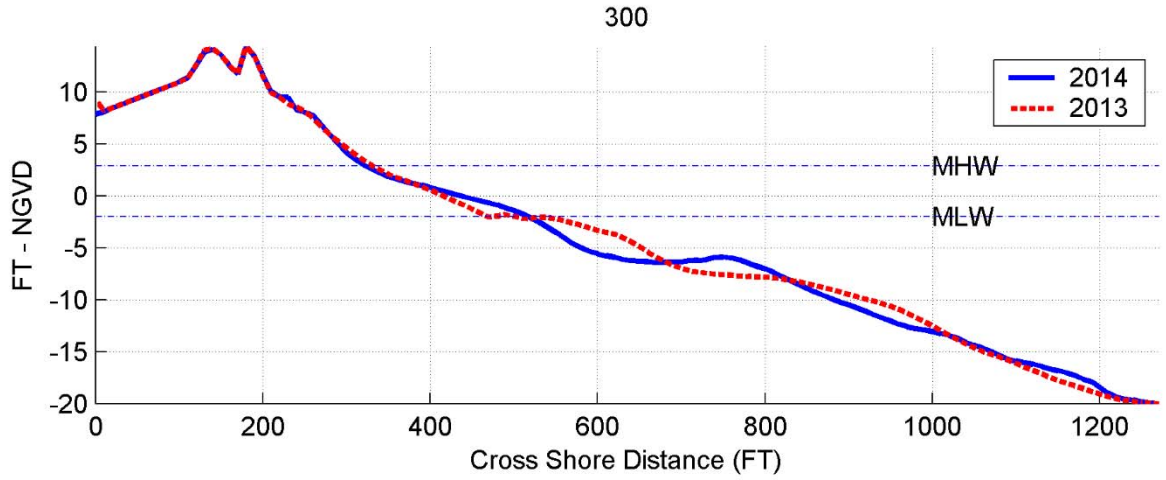

250
2014
2013
MHW
MLW
Nearshore Bar Erosion
FT - NGVD
Cross Shore Distance (FT)

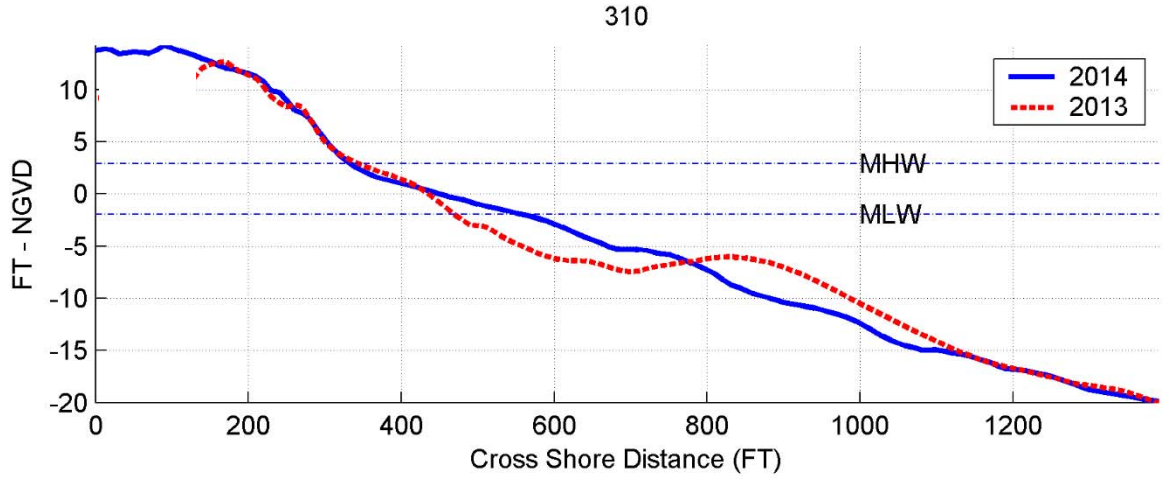

260
2014
2013
MHW
MLW
Nearshore Bar Erosion
FT - NGVD
Cross Shore Distance (FT)

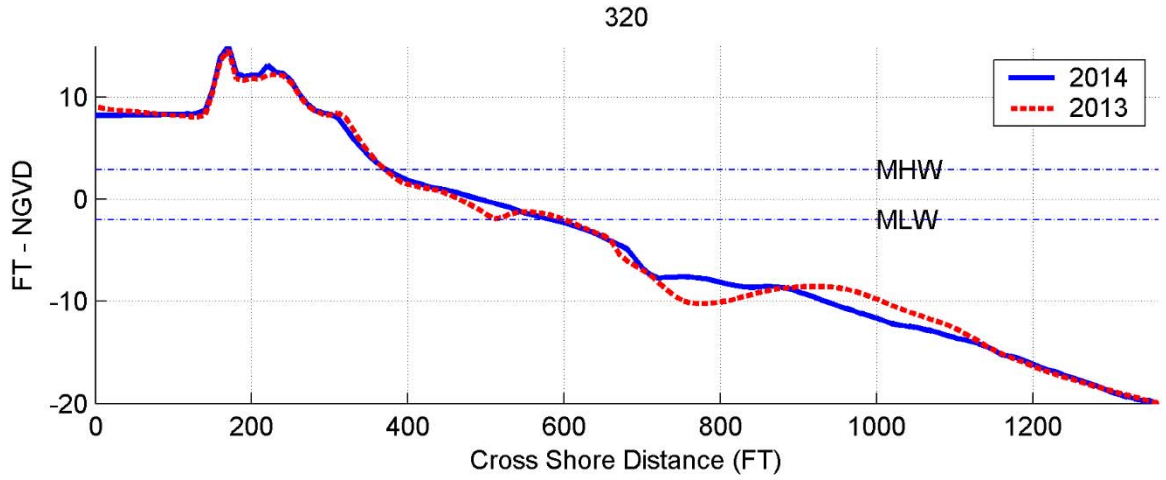

270
2014
2013
MHW
MLW
Nearshore Accretion
FT - NGVD
Cross Shore Distance (FT)

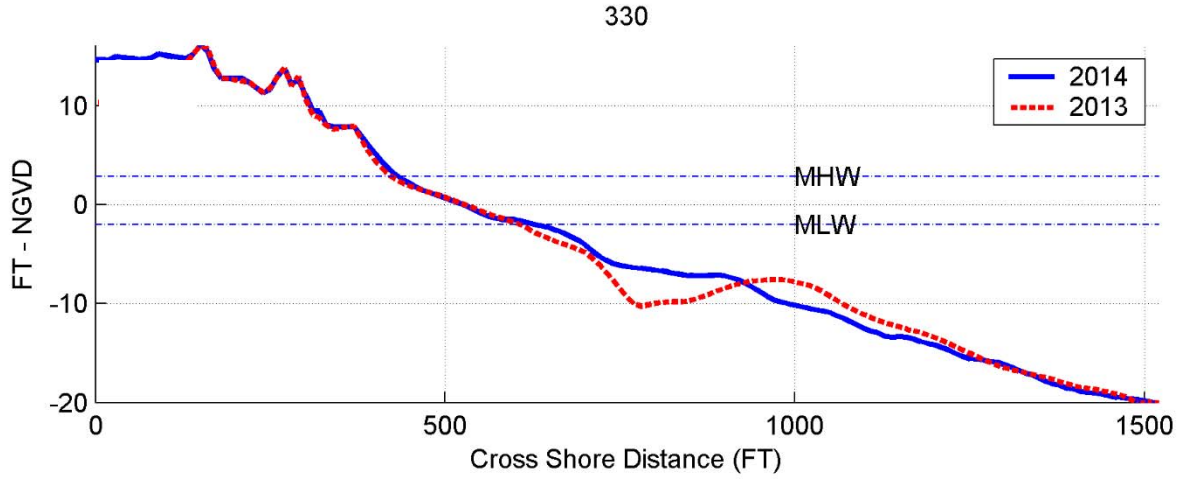

280
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

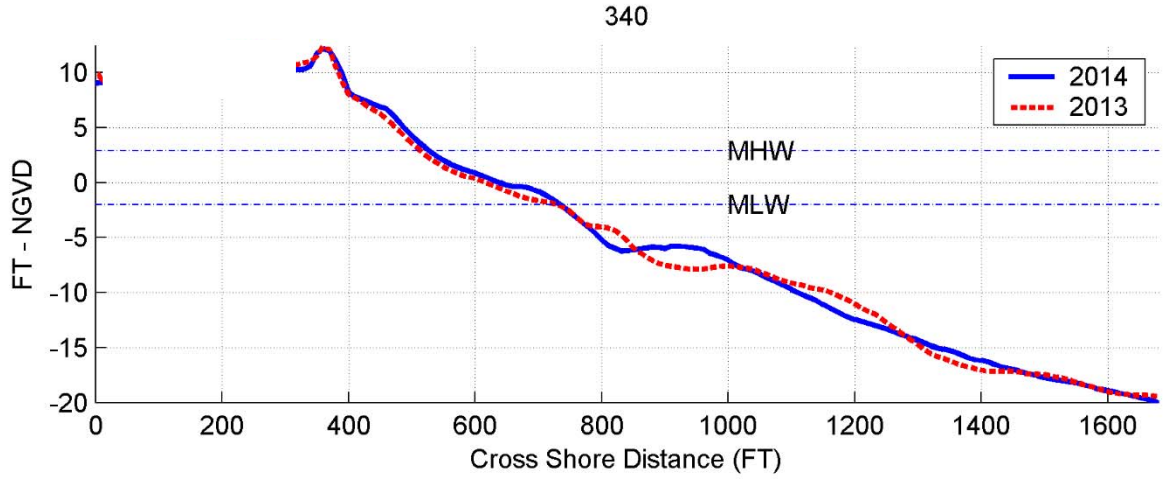

290
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

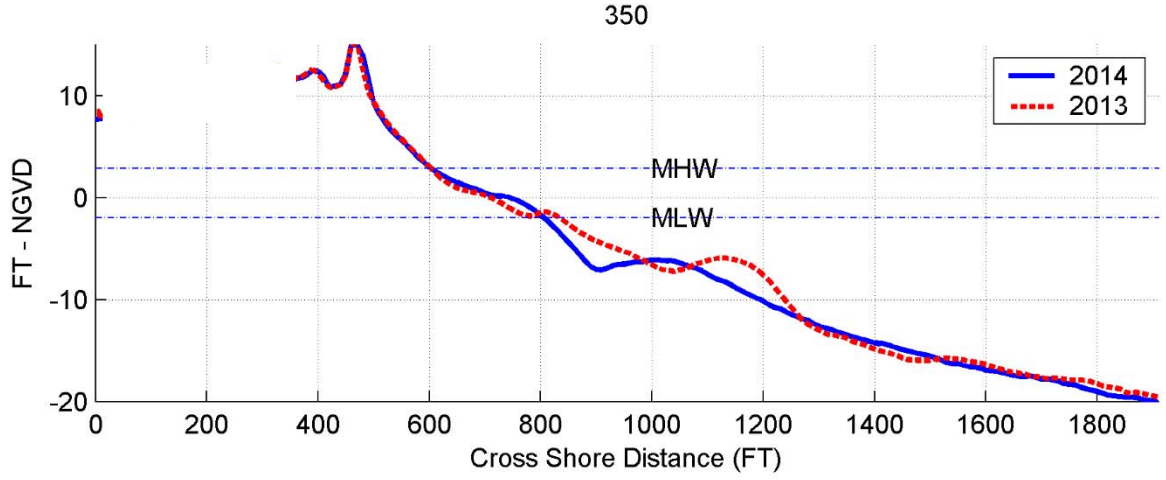

300
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

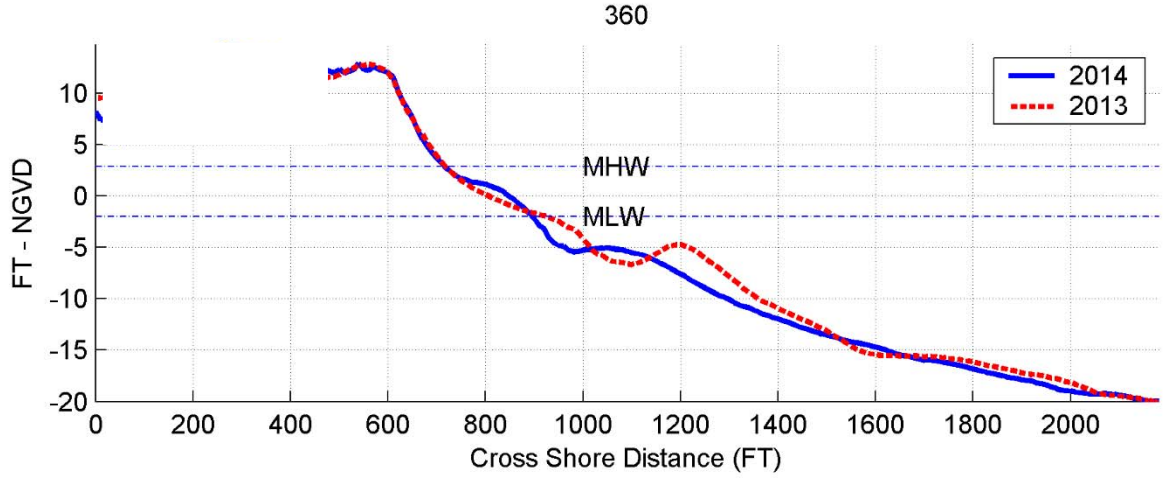

310
2014
2013
MHW
MLW
FT - NGVD
10
5
0
-5
-10
-15
-20
0
200
400
600
800
1000
1200
Cross Shore Distance (FT)

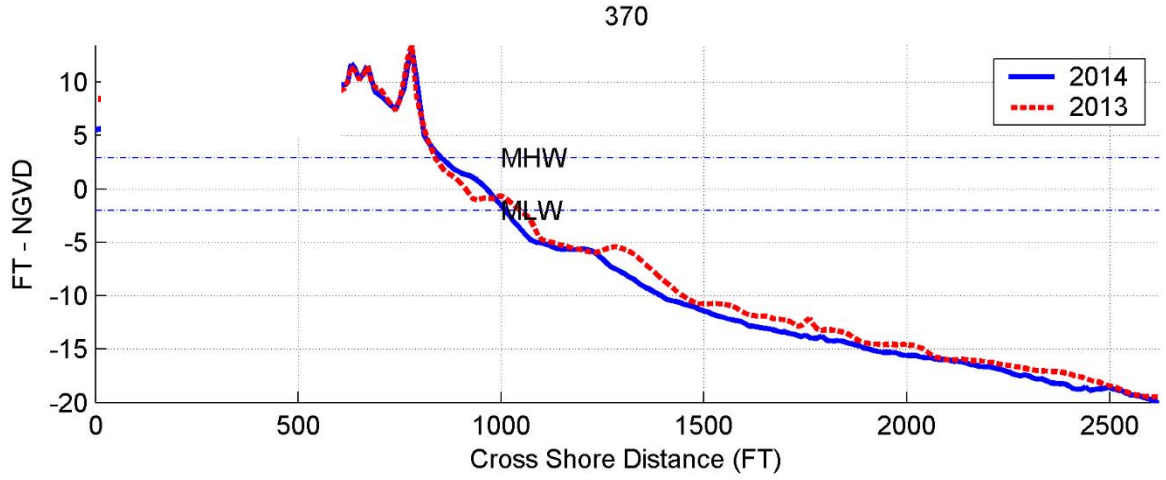

320
2014
2013
MHW
MLW
FT - NGVD
10
0
-10
-20
0
200
400
600
800
1000
1200
Cross Shore Distance (FT)

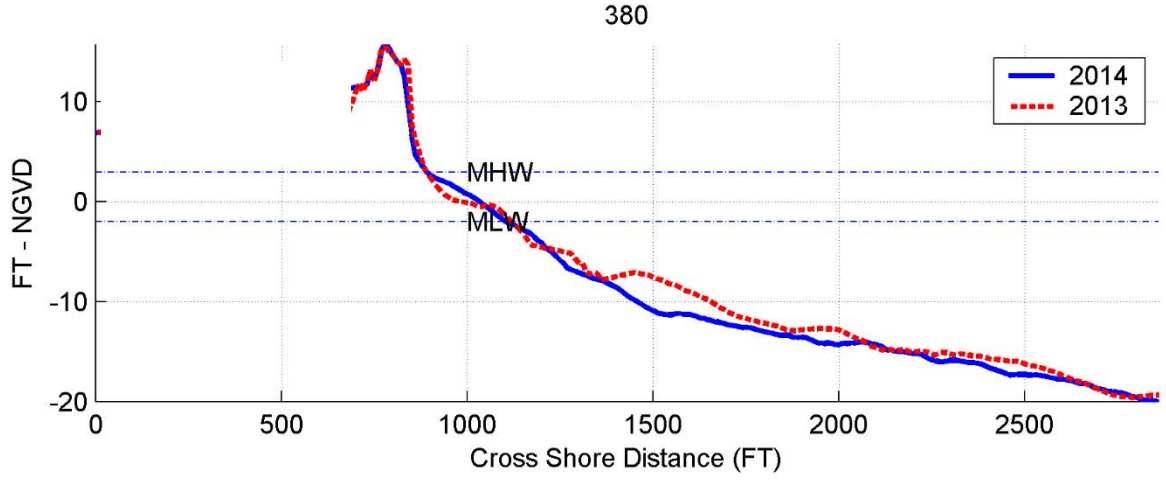

330
2014
2013
MHW
MLW
FT - NGVD
10
0
-10
-20
0
500
1000
1500
Cross Shore Distance (FT)

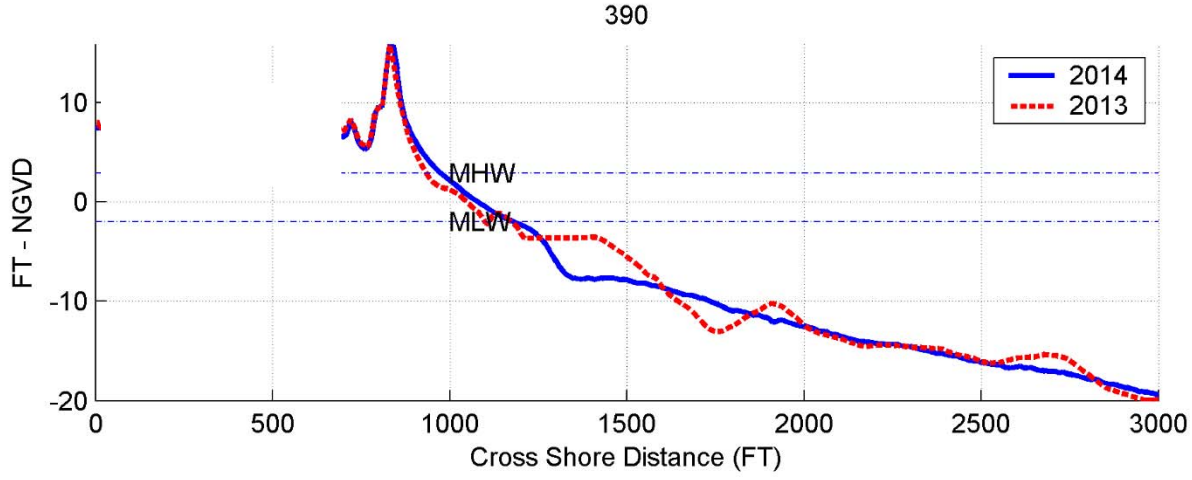

340
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

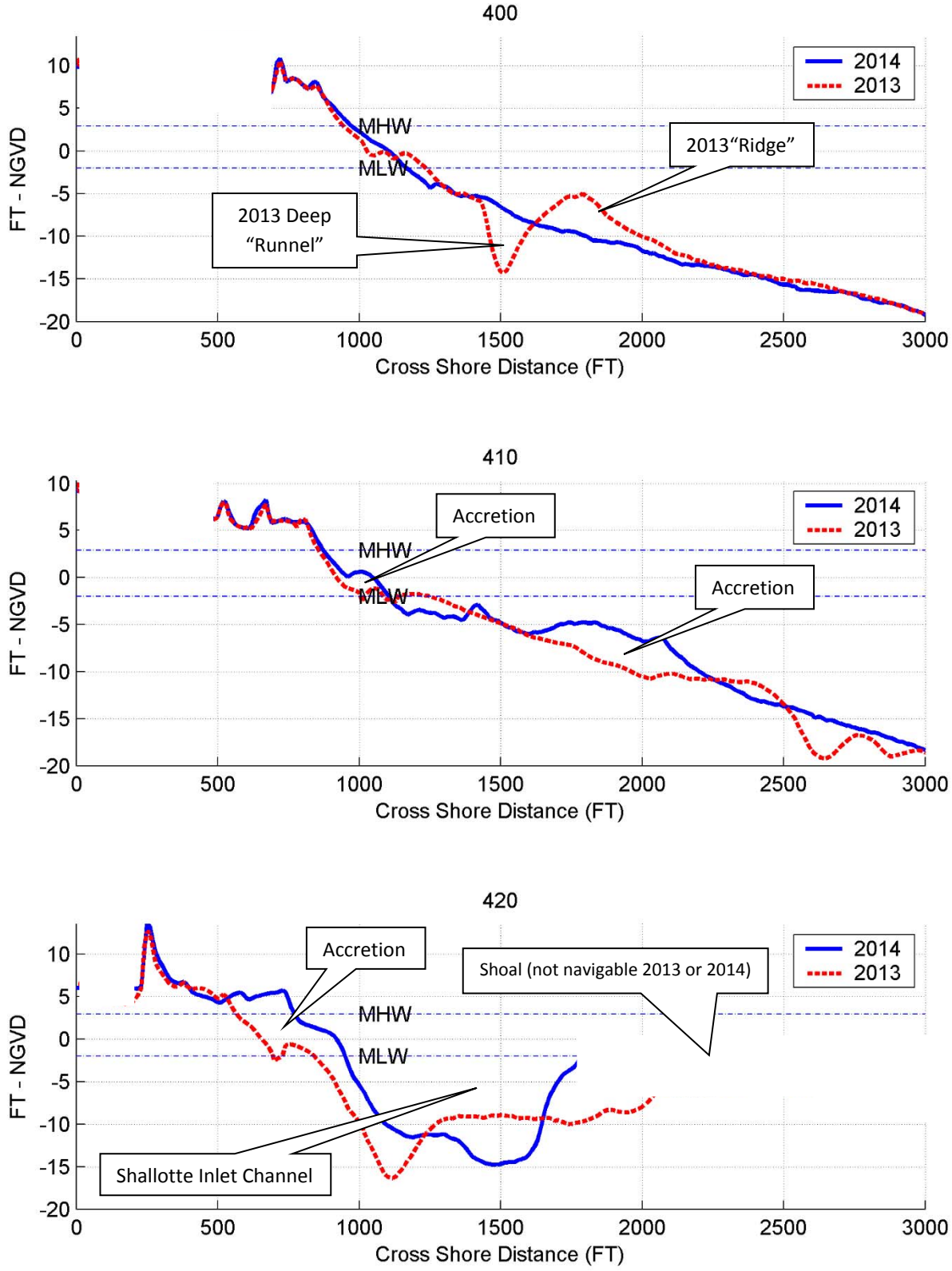

350
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)


360
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

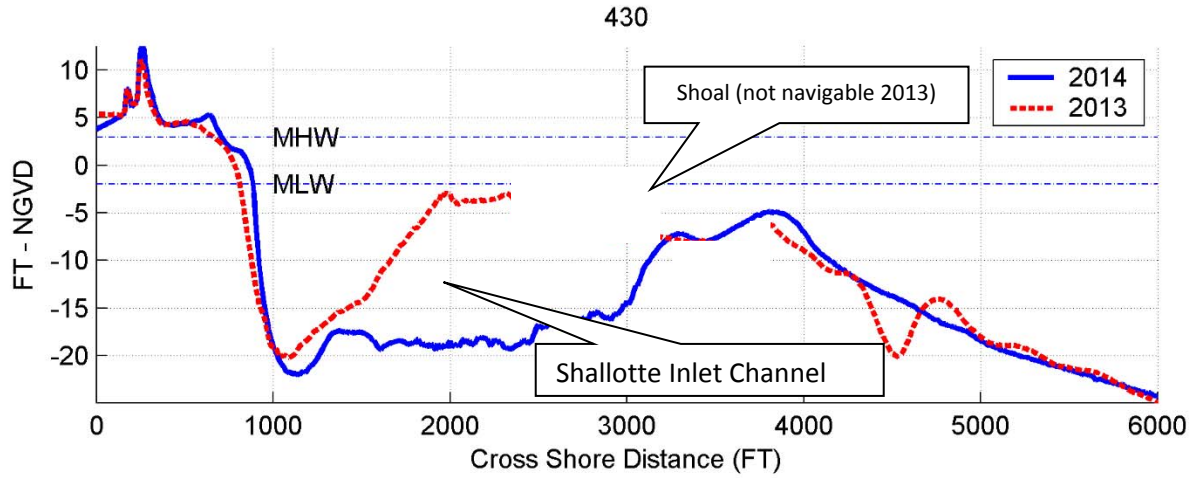

370
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)


380
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)

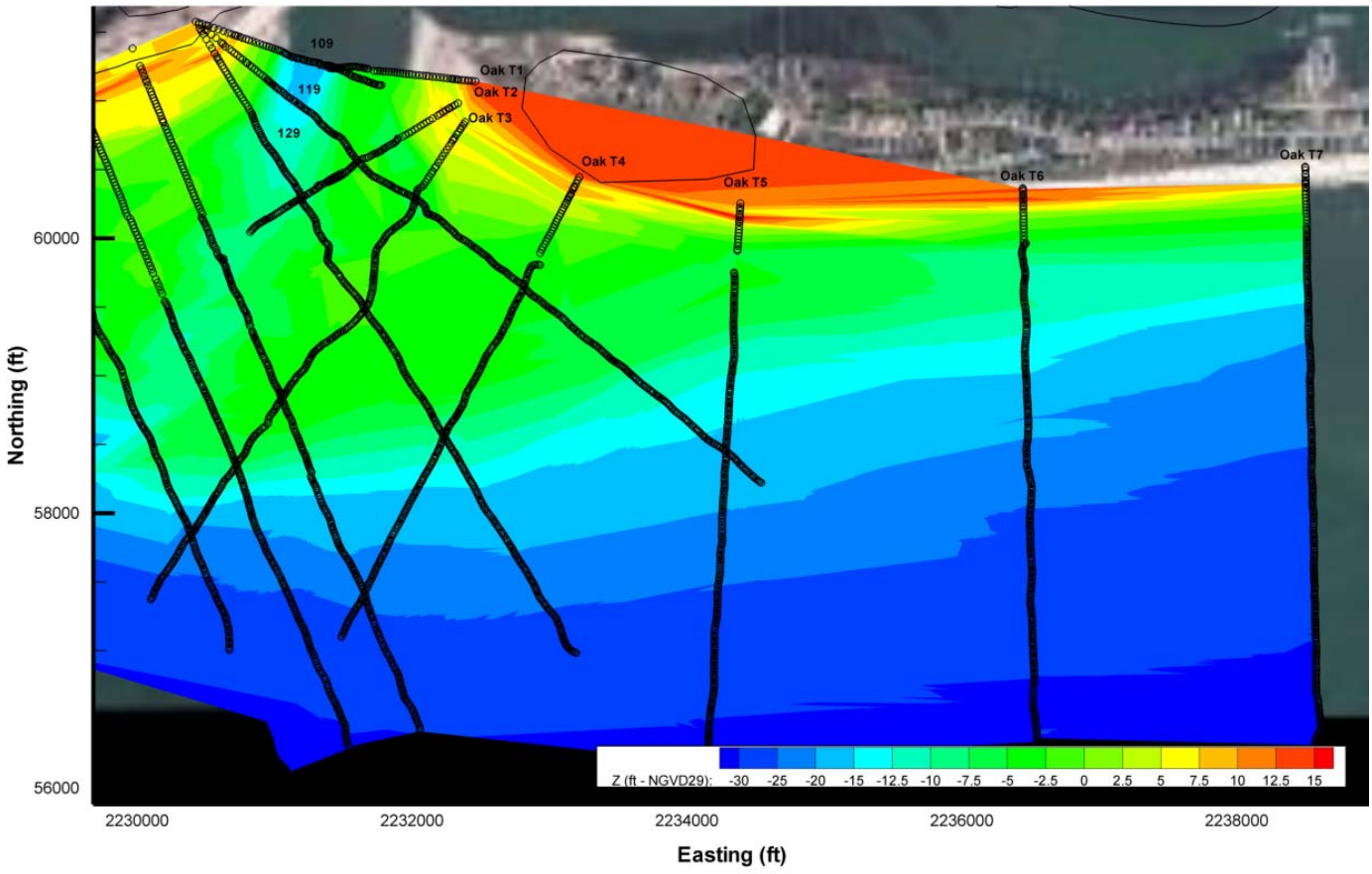

390
2014
2013
MHW
MLW
FT - NGVD
Cross Shore Distance (FT)



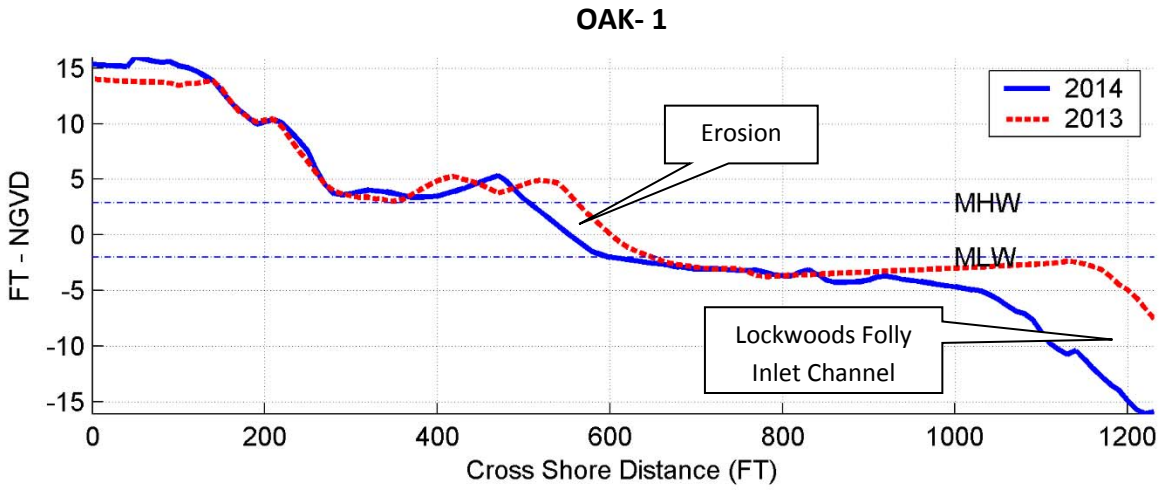

*Station 420+00. Shallotte Inlet Channel developing away from Holden Beach.*



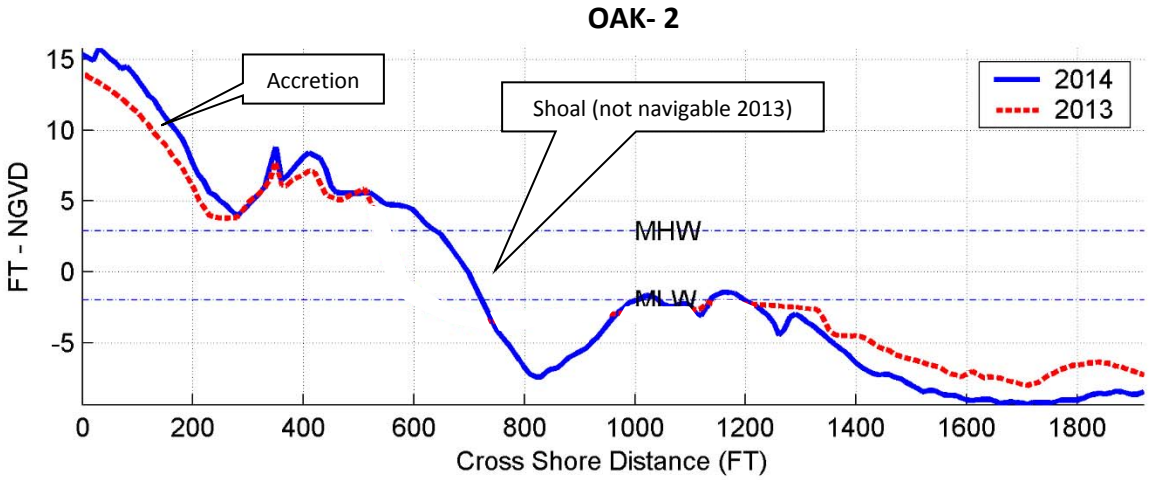

*Station 430+00. Shallotte Inlet Channel developing away from Holden Beach. Note erosion of 2013 shoal.*

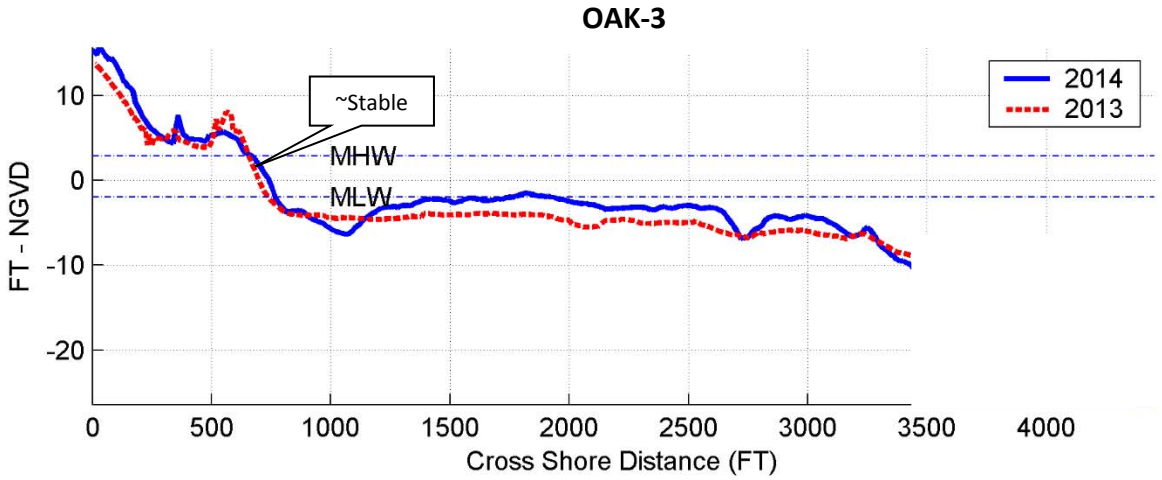



*Oak Island Transects (began surveying these transects in 2012)*

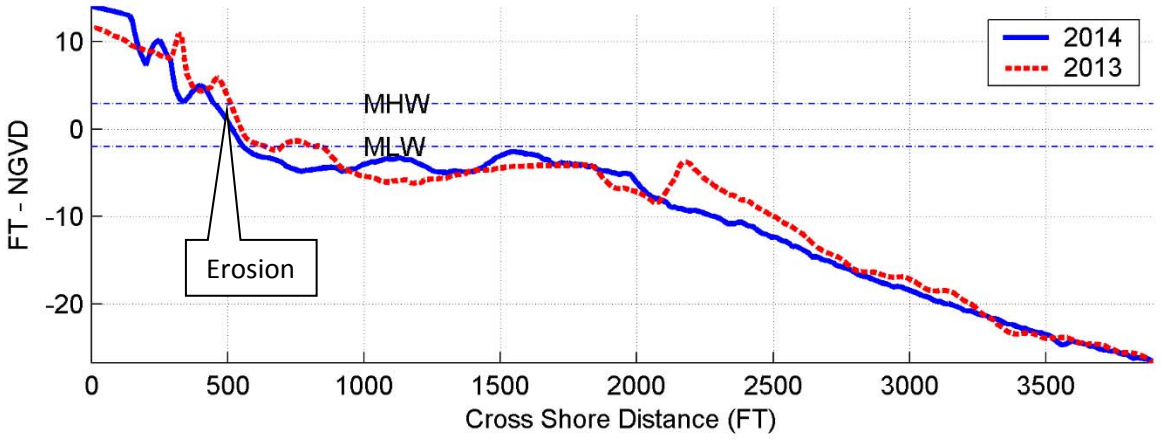



*Station OAK- 1. Note LWF Inlet Channel moving toward Oak Island.*

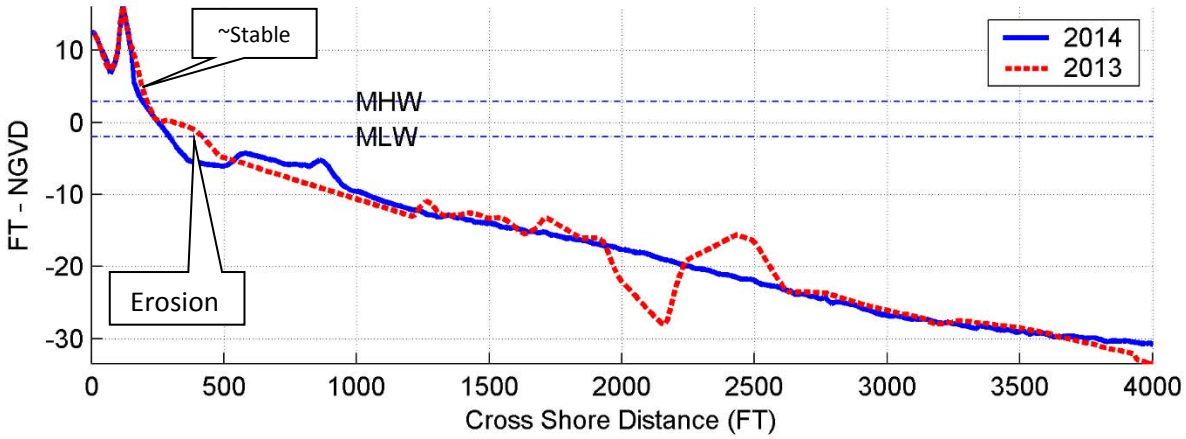


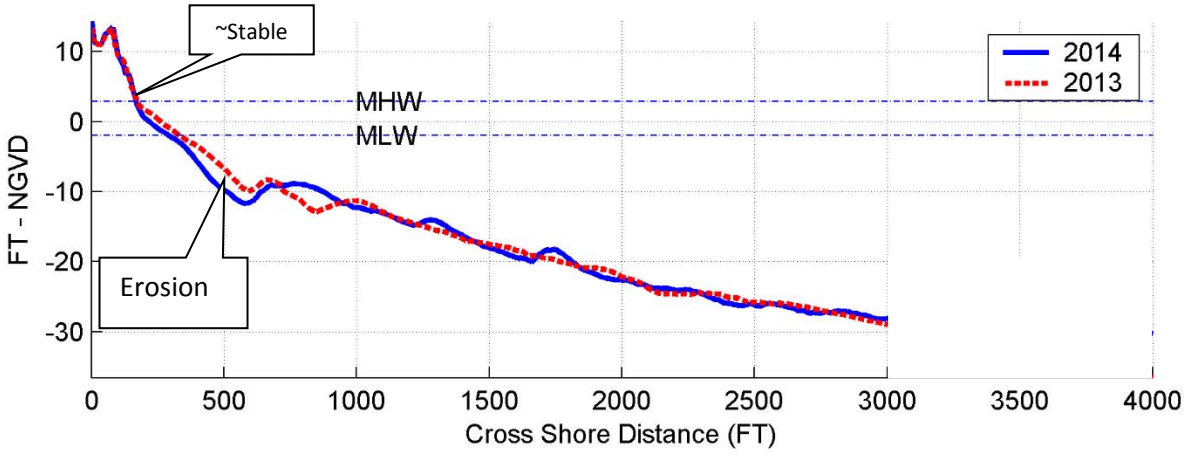
**OAK- 4**


2014
2013
MHW
MLW
Erosion
FT - NGVD
Cross Shore Distance (FT)
10
0
-10
-20
0
500
1000
1500
2000
2500
3000
3500

**OAK- 5**


~Stable
2014
2013
MHW
MLW
Erosion
FT - NGVD
Cross Shore Distance (FT)
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000
3500
4000

**OAK- 6**


~Stable
MHW
MLW
Erosion
2014
2013
FT - NGVD
Cross Shore Distance (FT)

**OAK- 7**

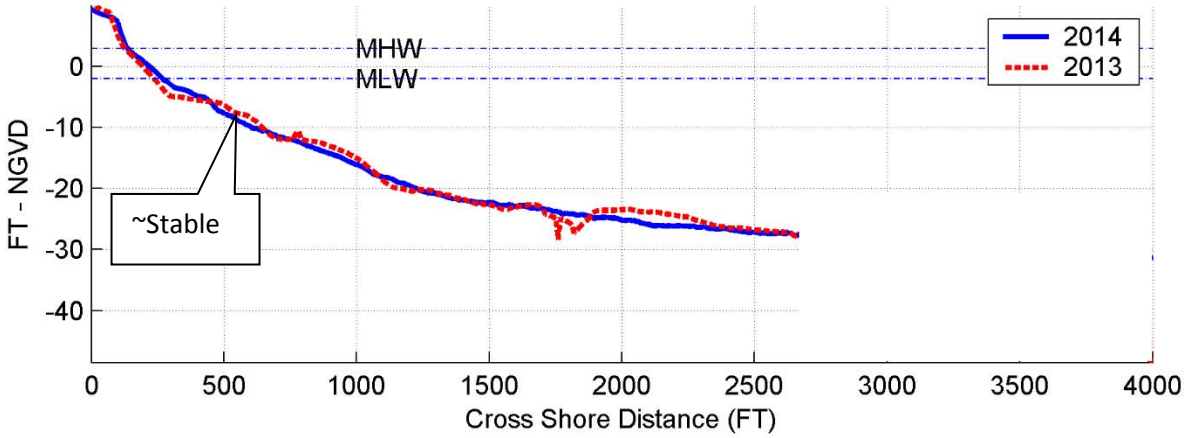

MHW
MLW
~Stable
2014
2013
FT - NGVD
Cross Shore Distance (FT)

**TABLE A-1: 2013 to 2014 Survey Transect Analysis**

General Note - Transects are primarily oceanfront perpendicular and parallel except for inlets and inlet shoulder transects

Unit Volume (cy/ft) changes at inlet and inlet shoulder transects cannot use "average end" method for calculating volumes

MHW change at inlet and inlet shoulder is not necessarily perpendicular to the shoreline due to variable orientation

*all elevations relative to NGVD29

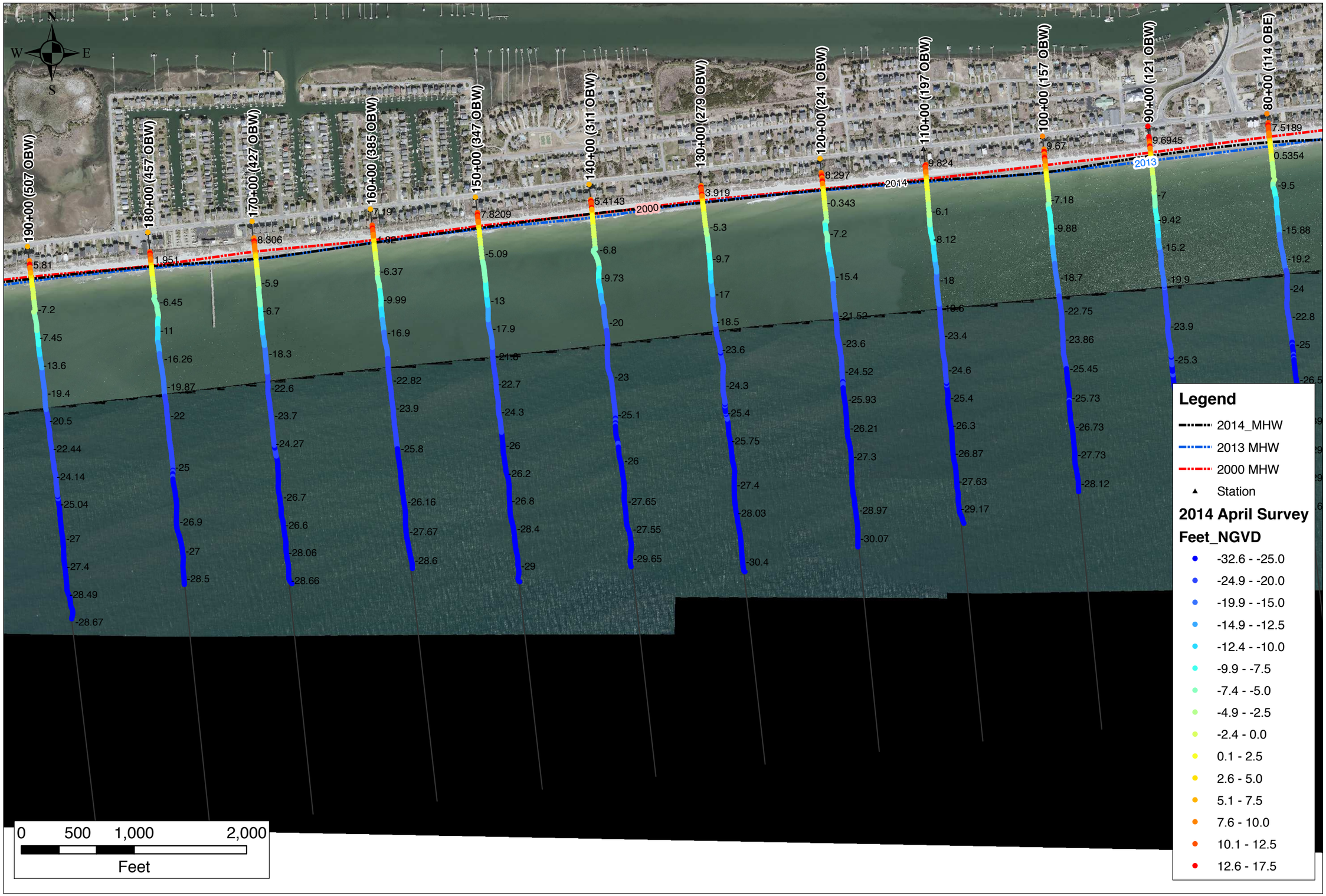
| 2013 to 2014 Survey Analysis | | | | | |
|---|---|---|---|---|---|
| **STATION** | **Distance to Next Monument (ft)** | **Volume Change (cy/ft) (Dune to -12 ft*)** | **Volume Change (cy/ft) (Dune to -5 ft)** | **MHW Change (ft)** | **Notes** |
| **109+00** | 0 | 20.5 | 21.8 | 61.4 | LWF Inlet |
| **119+00** | 0 | 25.0 | 24.6 | 63.6 | LWF Inlet |
| **129+00** | 500 | 18.5 | 10.8 | 54.6 | LWF Inlet |
| **5+00** | 500 | 41.0 | 39.1 | 11.8 | LWF Inlet Shoulder |
| **10+00** | 500 | 33.7 | 46.1 | -47.5 | LWF Inlet Shoulder |
| **15+00** | 440 | 57.1 | -15.3 | 30.9 | LWF Inlet Shoulder |
| **20+00** | 1000 | 58.1 | 10.0 | 1.2 | Oceanfront Perpendicular |
| **30+00** | 1000 | 34.8 | 30.5 | 41.8 | |
| **40+00** | 1000 | 14.3 | 16.7 | 26.3 | |
| **50+00** | 1000 | 11.9 | 17.7 | 48.2 | |
| **60+00** | 1000 | 32.5 | 37.1 | 97.7 | |
| **70+00** | 1000 | 3.7 | 28.5 | 54.0 | |
| **80+00** | 1000 | -21.3 | 3.9 | -35.8 | |
| **90+00** | 1000 | -5.0 | -9.8 | -42.0 | |
| **100+00** | 1000 | 19.6 | 9.4 | -4.5 | |
| **110+00** | 1000 | 3.4 | 5.4 | -10.6 | |
| **120+00** | 1000 | 1.5 | 6.7 | -6.0 | |
| **130+00** | 1000 | -1.9 | -0.2 | 4.5 | |
| **140+00** | 1000 | 0.0 | -3.1 | -34.0 | |
| **150+00** | 1000 | 5.3 | 3.2 | -9.4 | |
| **160+00** | 1000 | 16.9 | 15.9 | 2.9 | |
| **170+00** | 1000 | 8.9 | 2.6 | -7.2 | |
| **180+00** | 1000 | 3.2 | 5.1 | -13.8 | |
| **190+00** | 1000 | 5.5 | 0.2 | -18.5 | |
| **200+00** | 1000 | -6.7 | -14.9 | -47.4 | |
| **210+00** | 1000 | -4.2 | 7.6 | -1.4 | |
| **220+00** | 1000 | -1.2 | 3.9 | 9.4 | |
| **230+00** | 1000 | -2.2 | 0.4 | -6.6 | |

| | | | | | |
|---|---|---|---|---|---|
| **240+00** | 1000 | 0.1 | 4.1 | 4.5 | |
| **250+00** | 1000 | -9.5 | 6.5 | -8.8 | |
| **260+00** | 1000 | -10.7 | -3.0 | -23.4 | |
| **270+00** | 1000 | 33.6 | 6.4 | -16.9 | |
| **280+00** | 1000 | 4.5 | 4.5 | 12.8 | |
| **290+00** | 1000 | -1.4 | -2.4 | -23.4 | |
| **300+00** | 1000 | -5.7 | -3.3 | -10.9 | |
| **310+00** | 1000 | 3.9 | 14.5 | -14.7 | |
| **320+00** | 1000 | 4.2 | 3.6 | 0.9 | |
| **330+00** | 1000 | 11.9 | 5.2 | 7.7 | |
| **340+00** | 1000 | 6.0 | 5.4 | 12.7 | |
| **350+00** | 1000 | -18.1 | -0.8 | -0.9 | |
| **360+00** | 1000 | -21.2 | -3.7 | -3.5 | |
| **370+00** | 1000 | -19.0 | 0.2 | 14.9 | |
| **380+00** | 1000 | -31.8 | 1.4 | 2.6 | |
| **390+00** | 1000 | -13.2 | 4.1 | 40.0 | |
| **400+00** | 1000 | -34.4 | -14.0 | 27.1 | Oceanfront Perpendicular |
| **410+00** | 1000 | 61.6 | 5.0 | 14.3 | Shallotte Inlet Shoulder |
| **420+00** | 1000 | 112.9 | 41.3 | 202.2 | Shallotte Inlet |
| **430+00** | - | 43.2 | 30.8 | 47.3 | Shallotte Inlet |
| | **OAK ISLAND TRANSECTS** | | | | |
| **OAK 1** | 0 | -54.4 | -27.9 | -51.9 | LWF Inlet |
| **OAK 2** | 0 | -7.1 | 35.2 | 105.9 | LWF Inlet |
| **OAK 3** | 890 | 122.2 | 119.4 | 19.4 | LWF Inlet |
| **OAK 4** | 1100 | -56.7 | -23.6 | -51.9 | LWF Inlet Shoulder |
| **OAK 5** | 2000 | 4.4 | -26.9 | -12.6 | Oceanfront Perpendicular |
| **OAK 6** | 2000 | -21.0 | -11.2 | -4.0 | |
| **OAK 7** | - | 5.4 | 12.2 | 14.0 | |

# Appendix B

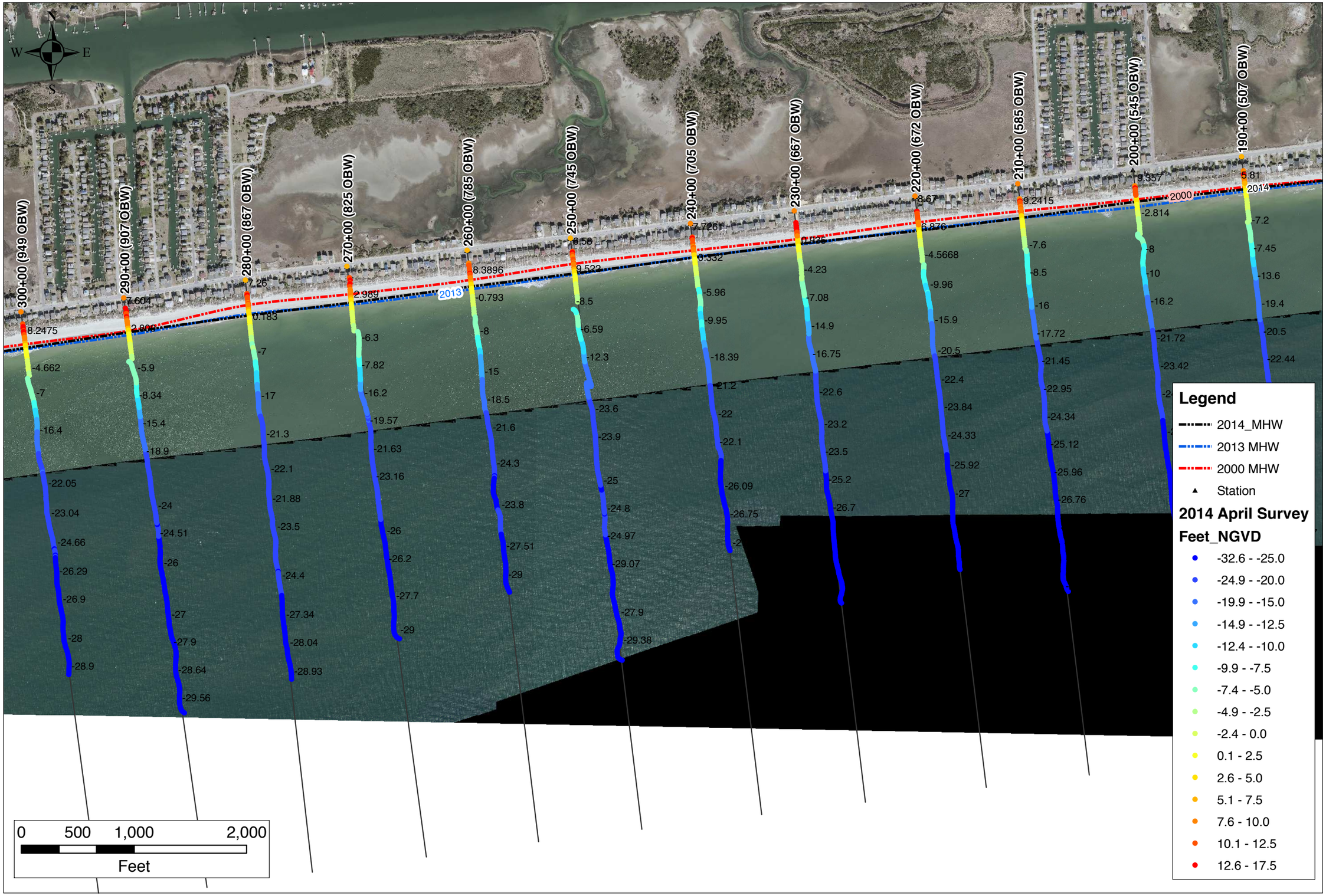
# 2014 Survey Plan View Figures


FIGURE B-1
April 2014 Survey Data. 2014 Mean High Water (MHW) Shoreline,
2013 MHW Shoreline and 2000 MHW Shoreline on 2012 Aerial.




APPLIED TECHNOLOGY & MANAGEMENT

FIGURE B-2
April 2014 Survey Data. 2014 Mean High Water (MHW) Shoreline, 2013 MHW Shoreline and 2000 MHW Shoreline on 2012 Aerial.




APPLIED TECHNOLOGY & MANAGEMENT

FIGURE B-3
April 2014 Survey Data. 2014 Mean High Water (MHW) Shoreline,
2013 MHW Shoreline and 2000 MHW Shoreline on 2012 Aerial.

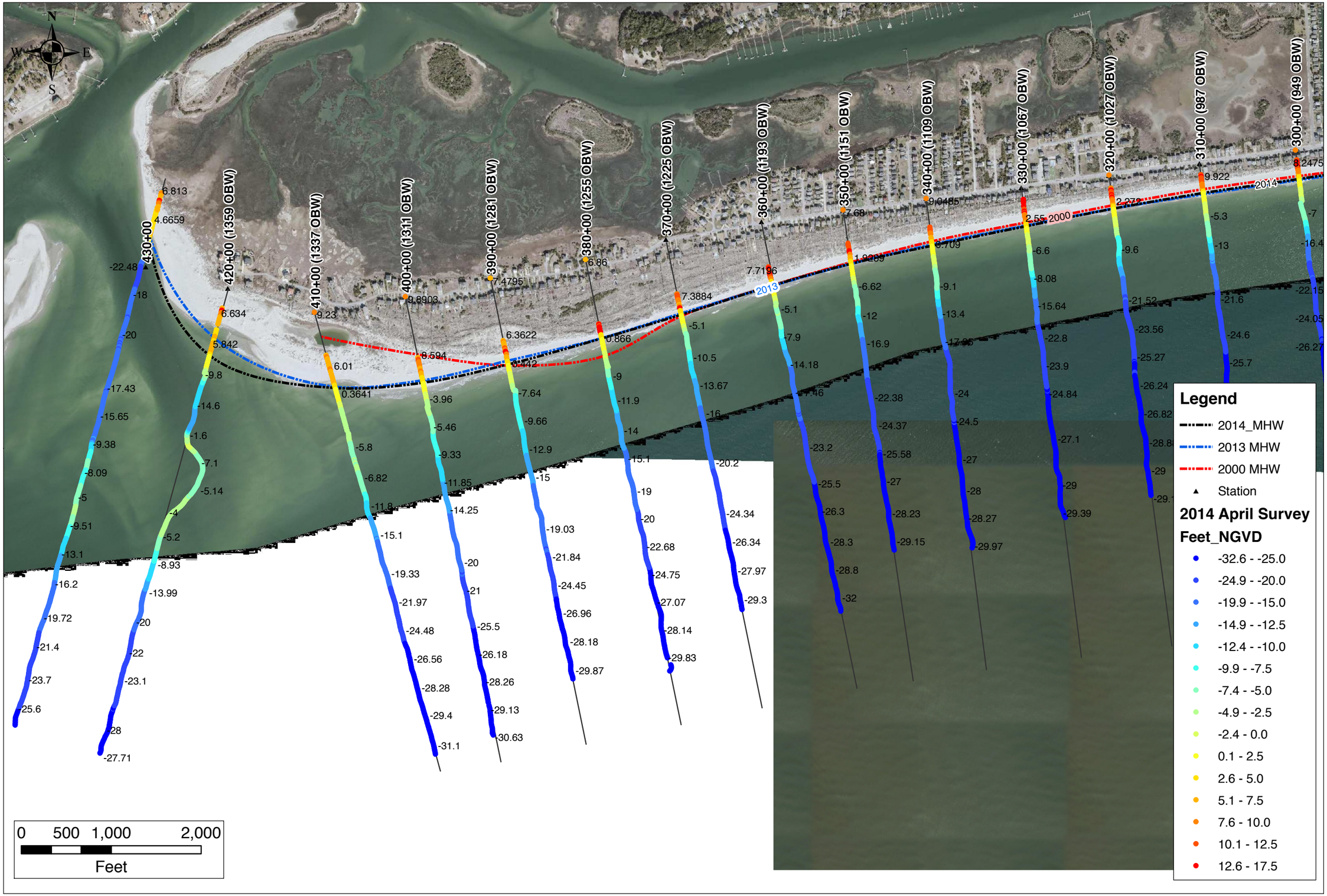



FIGURE B-4
April 2014 Survey Data. 2014 Mean High Water (MHW) Shoreline,
2013 MHW Shoreline and 2000 MHW Shoreline on 2012 Aerial.

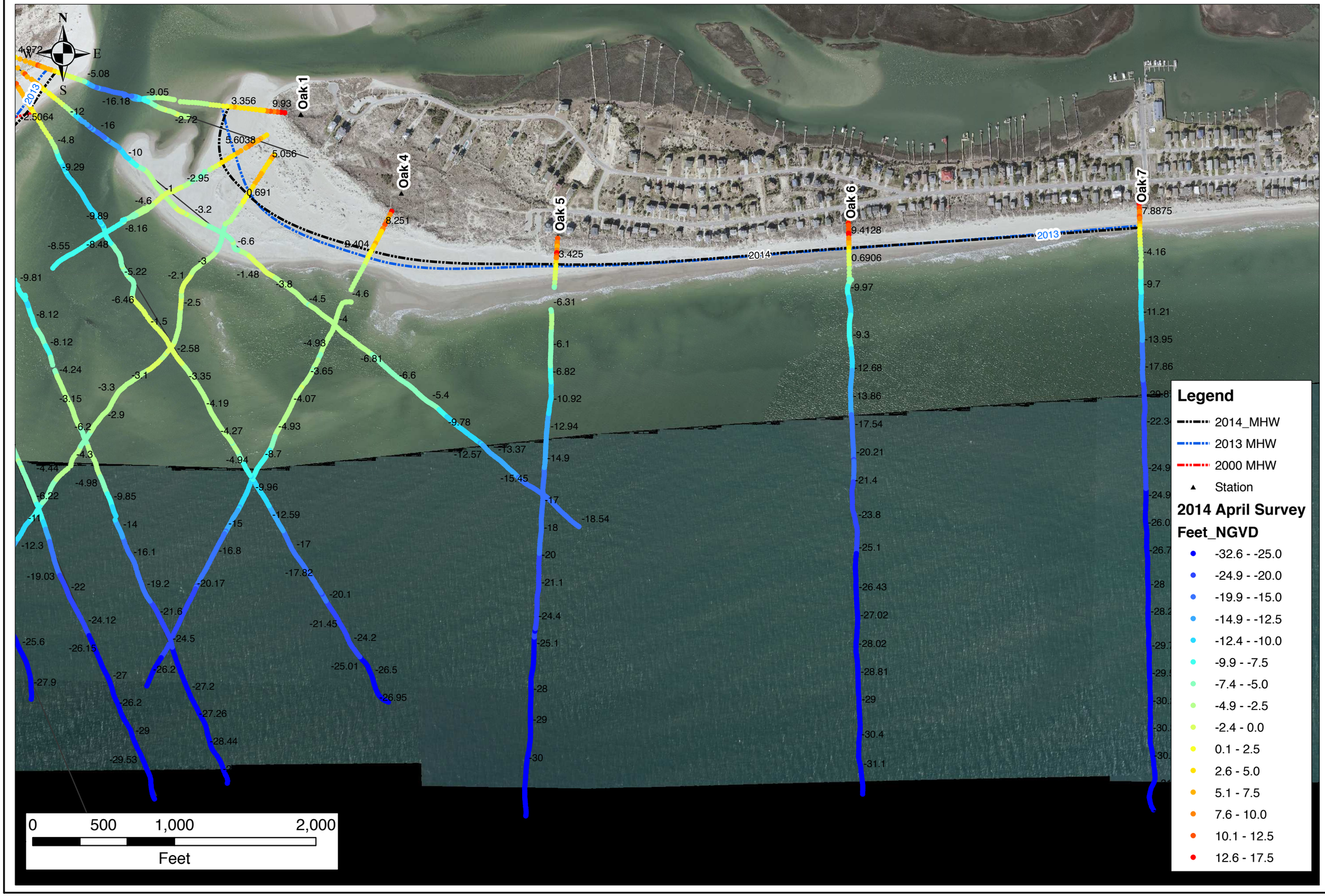



FIGURE B-5
April 2014 Survey Data. 2014 Mean High Water (MHW) Shoreline, 2013 MHW Shoreline and 2000 MHW Shoreline on 2012 Aerial.