RESEARCH & DEVELOPMENT

Research to support design and siting of deposition areas for dredged material from the Rodanthe Emergency Channel

Nancy White, PI

D. Reide Corbett Robert McClendon, John McCord, Adam Parker, Michael Piehler, Nathan Richards, J.P. Walsh

UNC Coastal Studies Institute

East Carolina University

NCDOT Project 14-0790

FHWA/NC/20YY-NN

June 2017

Research to support the design and siting of deposition areas for dredged material from the Rodanthe Emergency Ferry Channel (REFC)

Final Report : NCDOT Project 14-0790

Nancy White, PI

D. Reide Corbett, Robert McClendon, John McCord, Adam Parker, Michael Piehler, Nathan Richards, J.P. Walsh

UNC Coastal Studies Institute

East Carolina University

Technical Report Documentation Page

1. Report No. *FHWA/NC/20??????*	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Research to support design and siting of deposition areas for dredged material from the Rodanthe Emergency Channel		5. Report Date June 30, 2017 6. Performing Organization Code … …
7. Author(s) Nancy White, D. Reide Corbett Robert McClendon, John McCord, Adam Parker, Michael Piehler, Nathan Richards, J.P. Walsh		8. Performing Organization Report No. … …
9. Performing Organization Name and Address UNC Coastal Studies Institute East Carolina University 850 NC-345, Wanchese, NC 27981		10. Work Unit No. (TRAIS) … … 11. Contract or Grant No. … …
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Development Unit 104 Fayetteville Street Raleigh, North Carolina 27601		13. Type of Report and Period Covered Final Report *1/1/2015 – 6/30/2016* 14. Sponsoring Agency Code *14-0790*
Supplementary Notes: … …		

16. Abstract

The Rodanthe Emergency Ferry Channel (REFC) is essential for transporting emergency personnel, equipment, and supplies to Hatteras Island communities following any event that renders the Herbert C. Bonner Bridge and/or North Carolina Highway 12 impassable. The N. C. Ferry Division runs ferries during these emergency situations from Stumpy Point to Rodanthe. Maintaining this channel is a public safety issue and addressing any associated logistical challenges is a NC DOT priority. The REFC is currently too shallow to allow safe passage of the ferries. There is only one landward dredge material deposition site available, but it is not large enough to accommodate the amount of material generated by dredging the channel to necessary depths/ widths. There are limited locations available on land due to dense residential and business development in the area, as well as U. S. Fish and Wildlife property.

This project was developed to provide the needed site characterization to assist the NC DoT Ferry Division with assessing the use of dredge material and minimizing negative impacts of dredge material deposition. The data presented provides an improved understanding of the geological, ecological, and anthropological factors affecting siting of dredge material deposition sites. The decision framework developed is based on best available data from the study area and information from similar sites in the literature.

17. Key Words *Ferry terminal; dredged material; Decision support system; Channels (waterways); Sedimentation; Habitat; Ecology*	18. Distribution Statement … …		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages *…fill in…*	22. Price … …

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

DISCLAIMER

ACKNOWLEDGMENTS

Many people have helped with data collection and processing. Linda D'Anna, Corey Adams, Lindsay Dubbs, Jason Wilkinson, and Maggie Fuentes for field, lab, and synthesis support in the ecology and decision making sub-groups. Data collection and processing related to the sedimentary environment sections was greatly aided by the help of CJ Cornette, Kieth Garmire, Émeric Bourineau, David Hawkins, Ian Conery, Luke Stevens, Nick Kelly, Ryan Gibbons and Brian Querry. Ryan Bradley was integral to the outreach programing. Many individuals provided information and/or time to develop the Maritime Archaeology and History section, including individuals from the North Carolina Underwater Archaeology Branch (John Morris III, Nathan Henry, Greg Stratton), East Carolina University (Jim Kinsella, Adam Parker, C.J. Cornette, Scott Rose, Mark Keusenkothen, Mike Baker, Eric Diaddorio), UNC-CSI (Dr. Lindsay Dubbs, Ryan Bradley, Marie Magee, and Corey Adams), Outer Banks History Center (KaeLi Schurr, Tama Creef, and Stuart Parks), North Carolina Department of Transportation (John Kirby, Pablo Hernandez (Manteo Resident Engineer), Matt T. Wilkerson (NCDOT archaeologist), Gretchen Byrum, and Demetria F. Walker (NCDOT maintenance yard)), Roanoke Island Dive Center (Pam Landrum and Matt Landrum), as well as Dawson V. Carr, Edwin Hooper, Priscilla Delano, Mel Covey. Financial support was provided by the North Carolina Department of Transportation.

EXECUTIVE SUMMARY

The Rodanthe Emergency Ferry Channel (REFC) is essential for transporting emergency personnel, equipment, and supplies to Hatteras Island communities following any event that renders the Herbert C. Bonner Bridge and/or North Carolina Highway 12 impassable. The N. C. Ferry Division runs ferries during these emergency situations from Stumpy Point to Rodanthe. Maintaining this channel is a public safety issue and addressing any associated logistical challenges is a NC DOT priority. The REFC is currently too shallow to allow safe passage of the ferries. There is only one landward dredge material deposition site available, but it is not large enough to accommodate the amount of material generated by dredging the channel to necessary depths/ widths. There are limited locations available on land due to dense residential and business development in the area, as well as U. S. Fish and Wildlife property.

In coastal regions sediment is now regarded as a critical commodity that allows stabilizing natural habitats such as marshes and submerged aquatic vegetation (SAV) to maintain themselves in the face of long and short-term changes in water levels. However, sediment can also have detrimental impacts on these same habitats if it is not applied appropriately. Selection of deposition sites that minimize environmental damage and maximize environmental benefits is necessarily an interdisciplinary venture. This project provides an improved understanding of the geological, ecological and cultural factors affecting siting of dredge material deposition sites in shallow coastal waters. Specifically, we provide perspective on disposal options in the REFC area and decision matrices to make and defend decisions regarding dredge material deposition sites for the REFC. The decision making framework we present should be applicable across multiple NC DOT sites. More specifically, we explored the feasibility of sediment deposition approaches including multi-habitat island development, reef creation, shoreline/marsh reconstruction, marsh accretion through thin-layer disposal, and local usage. Each of these have benefits and challenges, and this project sheds light on the value and feasibility of the options.

Following are key findings from the disciplinary investigations and from the integrated decision making assessments.

Sediment dynamics

Shoreline erosion was the dominant shoreline change process across the study area and areas of high erosion rates showed increased anthropogenic modification. As marsh shorelines erode and are replaced with sediment banks, shoreline erosion is expected to continue and possibly increase until bulkheads and rip-rap exceed natural shoreline presence or shoreline hardening occurs. Sediment flux from the shoreline does not appear to be a significant sediment source in the offshore back-barrier.

Resuspension events remobilize sediments by current or wave processes, and these events likely maintain largely mud-free sands along the back-barrier by removing supplied muds and organic matter. Shear stress exceeded τ_{cr} during stronger winds of the instrument deployments, suggesting that waves and currents episodically resuspend sediments during moderate wind conditions (>10 m s^{-1}). Times of moderate waves indicate that forces associated with currents exceed τ_{cr}. Paired with the low LOI and mud percent, resuspension events provide a mechanism for the local transport of sands. Channel bathymetry data suggest large local sediment deposition events occur associated with storms, requiring dredging operations to maintain navigable waters for ferry access to the island. In the future, the option of placing dredged sediment in the system should be considered, potentially as nourishment for eroding shorelines.

The optimal depth of SAV habitats at Rodanthe is 0.5-2.2 m due to wind-influenced water levels and light limitation. Persistent SAV habitat was mapped throughout the back-barrier shoal system where low mud percentages and organic matter are observed. Wind tides affect water level along with astronomical tides and likely influence SAV distribution due to subaerial exposure of nearshore shallow habitat. The large area of SAV recurrence across a decadal period suggests habitat stability with regards to wave and current resuspension, as well as sediment properties (low mud, low organic matter).

Ecology

Denitrification occurred in all habitats in the study, but rates were on the lower end of those in the literature. There was evidence that habitat restoration could ameliorate any loss of denitrification potential due to habitat loss.

Assessments at similar restored sites with saltmarsh and oyster reefs showed that both rates of denitrification and biomass of benthic microalgae were significant after 1 year and that they remained substantial through 20 years. This finding provides evidence to support projection of significant value from future function in restored habitats.

Maritime Archeology

Except for the wreckage of a twentieth-century shipwreck (PAS0001), we identified only isolated sound-floor marine debris, such as relict pilings, lost crab pots, buried vegetation, and other detritus picked up during side scan sonar and magnetometer survey that is of no historical significance. There is little to no risk of adversely impacting heritage sites in the area through sediment removal or deposition, or from construction activities

Decision framework and recommendations

We evaluated a range of sediment deposition options in the context of the geology, ecology, and maritime archeology of the study area. They included:

1) *Existing Disposal Area (Confined; Upland)*
2) *Pamlico Sound Island (Openwater, Confined or Beneficial Use)*
3) *Back-barrier Reef (Openwater, Confined, or Beneficial Use)*
4) *Shoreline Nourishment and Reconstruction (Confined or Beneficial Use)*
5) *Marsh Accretion (Confined or Beneficial Use)*
6) *New Local Area (Confined or Beneficial Use)*
7) *Distal Area (Beneficial Use)*

Decision matrices are provided to assess individual alternative. Weighing all of the factors involved in a deposition siting decision, we recommend a hybrid approach that includes two or more disposal alternatives. A back-barrier reef and estuarine shoreline reconstruction (3 and 4 above) are particularly desirable to target the clearly defined issue with estuarine shoreline loss in the area. In addition, a large volume of the material can be deposited on land to dewater and then (or directly) be used for upland needs, e.g., elevating property or potentially building dunes.

TABLE OF CONTENTS

INTRODUCTION

The Rodanthe Emergency Ferry Channel (REFC) is essential for transporting emergency personnel, equipment, and supplies to Hatteras Island communities following any event that renders the Herbert C. Bonner Bridge and/or North Carolina Highway 12 impassable. The N. C. Ferry Division runs ferries during these emergency situations from Stumpy Point to Rodanthe. This situation occurred in September 2011 following Hurricane Irene. In November of 2013, the ferries were called into service again following the closure of the Bonner Bridge due to safety concerns. This emergency route is also used by all NCDOT personnel/contractors associated with reconstruction or recovery efforts post-storm. Maintaining this channel is a public safety issue and addressing any associated logistical challenges is a NCDOT priority. The REFC is often too shallow to allow safe passage of the ferries. There is only one landward dredge material deposition site available, but it is not large enough to accommodate the amount of material generated by dredging the channel to necessary depths/widths. There are no available locations on land due to dense residential and business development in the area, as well as U. S. Fish and Wildlife property.

In the broader context, NCDOT and the Army Corps of Engineers are committed to assessing the beneficial use of dredged material and minimizing negative impacts of dredge material deposition. In many coastal systems, sediment is a critical commodity that allows habitats to maintain themselves in the face of long and short-term changes in water levels. In areas with high value habitats such as submerged aquatic vegetation, finding low impact sites to deposit sediments is a challenge. Design of deposition sites that minimize environmental damage and maximize environmental benefits is necessarily an interdisciplinary venture. As such, this project brought together an interdisciplinary team to address the full suite of factors that must be considered in evaluating the amount of sediment that may be generated and selecting a compatible deposition site.

BACKGROUND

Coastal sediment supply has been a focal point for decision makers for several decades. Issues related to sediment deficiencies are the result of the compounding of factors such as the loss of natural rock and oyster reefs (Rothschild et al., 1994), destabilization and elimination of littoral zones, hardening of shorelines (Squires, 1992; Yozzo et al., 2004), and the background stress of storms. Maintenance dredging is an ongoing activity and integral part of the sediment budget in many of these systems (Stickney and Perlmutter, 1975; Wildish, 1985). Over the past several decades, dredged material has been suggested as a potential solution for restoring ecosystem function in many of these areas (Milrath et al., 2001; Weinstein and Weishar, 2002; Yozzo et al., 2004). Depending on the properties of the dredged material, it has the potential to be used in the restoration of beaches, wetlands, and wildlife habitats or the creation of structures such as artificial islands and reefs and berm break waters (Landin, 1997; USEPA/USACE, 2007a,b).

In many areas that dredging occurs, the re-use of dredged material is already underway. New Jersey, California, Maryland, Massachusetts, and North Carolina all have artificial reef systems in place, created by using rocks from dredged material (Yozzo et al., 2004; Rousseau, 2008). These reefs mitigate the impact of habitat loss for reef-dwelling organisms and result in overall water quality improvement due to their ability to support fast growing filter feeder communities (Bortone et al., 2011; D’Anna et al., 1994; Rosseau, 2008).

In Maryland dredged materials from the Baltimore Harbor have been used to restore several islands within the Chesapeake Bay over the past four decades (Coch, 1996; Dalal et al., 1999). Dredged materials have not only restored degraded habitats on the islands, but created new environments that have been designated as wildlife preserves (Coch, 1996). Similarly, dredged materials from the creation of the Tennsssee-Tombigbee Waterway were used to create additional recreational areas, such as parks and reserves, along the Tennessee and Tombigbee Rivers (McClure, 1988). Beach nourishment projects are the most common use of dredged materials and have been implemented along all three US coastlines (Kelley et al., 2004; Parson and Swafford, 2012). Nourishment projects consist of both the deposition of dredged materials directly onto shorelines and through the creation of both shallow and deep water berms (Langan, 1988; Bradley and Hands, 1989; Allison and Pollock, 1993; Yozzo et al., 2004). Dredged material has been important in protecting and stabilizing shorelines particularly in the face of extreme weather events, such as Hurricane Sandy in 2012 (Hurricane Sandy Rebuilding Task Force, 2013). Feeder berms, located in shallow waters, act as a source of sand to eroding beaches, while stable berms, which are located in deeper water, reduce the energy in large storm waves (Yozzo et al., 2004). Though not their primary purpose, berms have also been observed to positively impact fisheries, acting as form of stabilization and refuge (Clark et al., 1988).

The REFC is essential for transporting emergency personnel, equipment, and supplies to Hatteras Island communities following any event that renders the Herbert C. Bonner Bridge and/or North Carolina Highway 12 impassable. The N. C. Ferry Division runs ferries during these emergency situations from Stumpy Point to Rodanthe. This situation occurred in September 2011 following Hurricane Irene. In November of 2013 the ferries were called into service again following the closure of the Bonner Bridge due to safety concerns. This emergency route is also used by all NCDOT personnel/contractors associated with reconstruction or recovery efforts post storm. Maintaining this channel is a public safety issue and addressing any associated logistical challenges is a NC DOT priority. The REFC is currently too shallow to allow safe passage of the ferries. There is only one landward dredge material deposition site available, but it is not large enough to accommodate the amount of material generated by dredging the channel to necessary depths/ widths. There are limited locations available on land due to dense residential and business development in the area, as well as U. S. Fish and Wildlife property.

As described above, sediment is a critical commodity that allows habitats to maintain themselves in the face of long and short-term changes in water levels. In areas with high value habitats such as submerged aquatic vegetation, finding low impact sites to deposit sediments is a challenge. Selection of deposition sites that minimize environmental damage and maximize environmental benefits is necessarily an interdisciplinary venture. This project provides an improved understanding of the geological, ecological and cultural factors affecting siting of dredge material deposition sites in shallow coastal waters. Specifically, we provide perspective on disposal options in the REFC area and decision matrices to make and defend decisions regarding dredge material deposition sites for the REFC. Though this project focused on one site, the framework developed should be applicable across multiple NC DOT sites. More specifically, we explored the feasibility of sediment deposition approaches including multi-habitat island development, reef creation, shoreline/marsh reconstruction, marsh accretion through thin-layer disposal, and local usage. Each of these have benefits and challenges, and this project sheds light on the value and feasibility of the options.

SUMMARY OF DATA COLLECTION

Maritime Archaeology and History

Maritime archaeological and historical research focused on recording potential maritime heritage assets (tangible and intangible cultural resources) in an area adjacent to the present-day REFC, and the evaluation as to whether there are significant (tangible) cultural resources in the same area. Once collected, described, and analyzed, this information along with reports from other project co-investigators had the potential to assist in fulfilling research objectives. All research occurred under permit 16PAS652 as granted by the North Carolina Office of State Archaeology.

Rather than focus on one category of maritime archaeological site type (e.g. shipwrecks), the maritime archaeologists chose to undertake a very broad consideration of the many ways that humans may have left indelible signatures of their activities in the landscape (i.e. their impacts over time). Following research, these came to be defined as, 1) impacts from dredging, 2) impacts from commerce, 3) impacts from conflict, and 4) impacts from marine accidents. This way researchers hoped to capture a picture of more intangible zones of human interaction within the study area, and understand how a broad array of changing water and shoreline use adjacent to Rodanthe may have culminated in the deposition of artifacts and the creation of archaeological sites within it. This approach allowed the researchers to understand the activities as reported in local history before archaeological research was undertaken so that ephemeral archaeological sites and isolated sound floor finds could be contextualized in association with documented human use of the area. Furthermore, such information could provide researchers with rich information that would illuminate the history of an area of Pamlico Sound and Hatteras Island that has not been the subject of extensive study. The location of Rodanthe, and the study areas are displayed in Figure 1.

Archaeologists employed multiple stages, techniques, and tools to assess the potential for the presence of archaeological sites in the area adjacent to the Rodanthe-Stumpy Point Emergency Ferry Channel. The first step consisted of extensive historical research and the review of reports from previous archaeological investigations. The primary sources of historical data came from the North Carolina Underwater Archaeology Branch's (NCUAB, Kure Beach) maritime archaeological site reports and shipwreck histories, microfilm records of the United States Life-Saving Service from the Outer Banks Historical Center in Manteo, and the National Oceanographic and Atmospheric Administration's (NOAA) online database of historic maps. Additionally, newspapers from East Carolina University's historical online databases and secondary sources were also used. The goal of these phases of data collection was to, 1) assess whether shipwrecks may have been wrecked in, or adjacent to the study area, 2) to consider whether other commercial, industrial, or recreational activities undertaken by humans may have culminated in other archaeological sites or deposits in the area, and 3) whether changing use of the area could be reflected in the cartographic record.

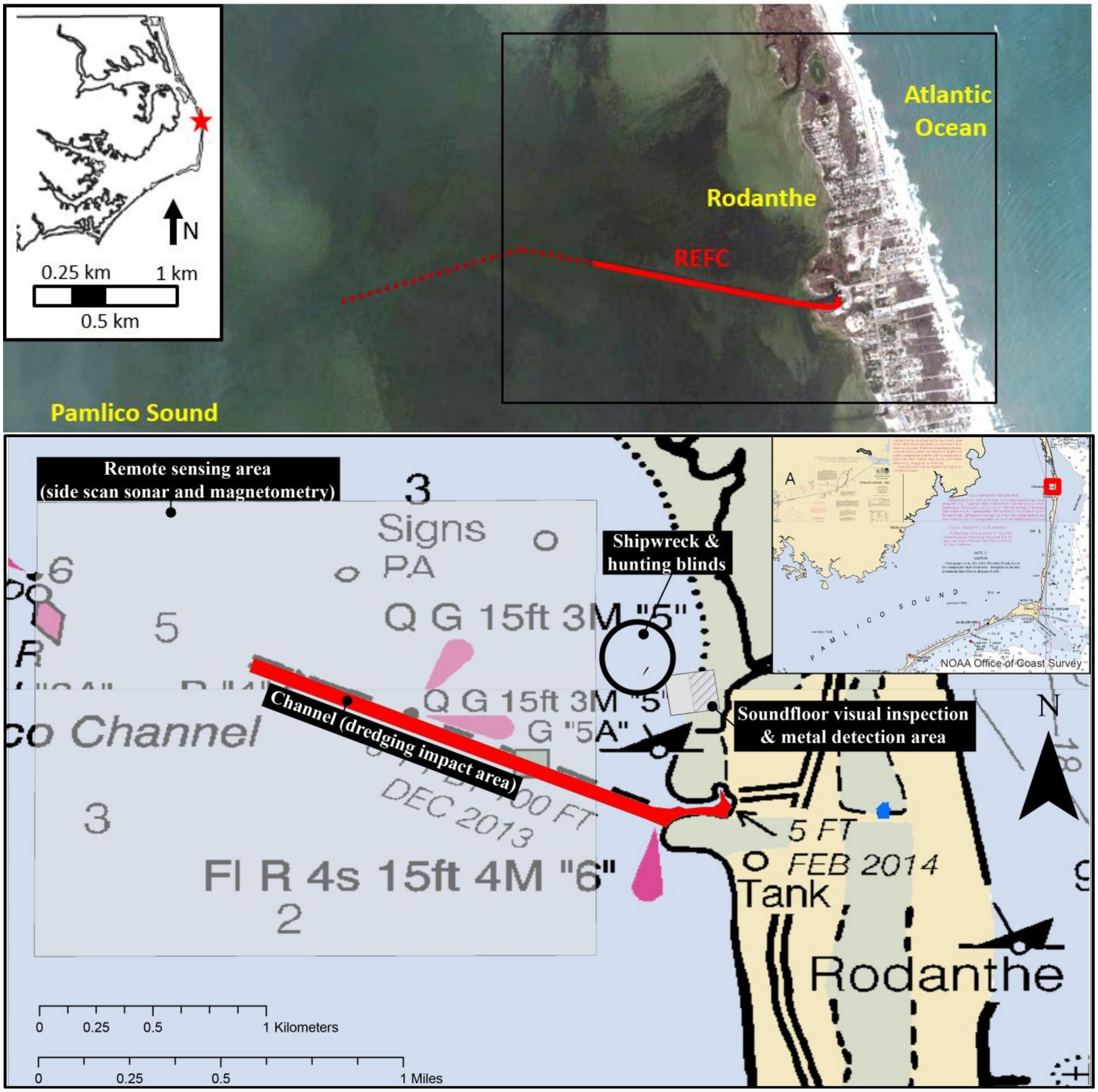


Figure 1. Overview of survey area, showing channel area (dredging impacts), area investigated during remote sensing, area of sound floor inspection and metal detection (sampled area), and discrete archaeological sites (shipwreck and hunting blinds) (Image by Nathan Richards).

The second step in the project's methodology was to compile a Geographic Information Systems (GIS) model of the study area. This allowed researchers to collate all historical research into a layered geospatial format allowing for activity areas to be displayed and to examine how the Rodanthe shoreline may have changed over time. This was also an important phase in identifying potential shipwreck locations. The final step was to conduct field work per the research contained within the GIS. For this, a side scan sonar and magnetometer survey (Figure 2) was conducted along with a shoreline transect survey in areas close to shore that were too shallow for boat access.

The study area and sites outlined over the course of research represent a zone of human interaction with marine resources that can only be described in terms of intangible heritage. From a reading of historical records researchers have gleaned general interpretations of broad marine-based activities that occurred in the area in the nineteenth and twentieth century and imagined how these may have left impressions on the sound floor and coastline of this stretch of Pamlico Sound and Hatteras Island beach. Another way to conceptualize the area is as a prominent point of intersection for larger networks of trade, communication, and conflict. However, apart from a chance that a prominent Civil War event occurred in the vicinity (unsubstantiated, and currently a matter of debate), the activities occurring in the area were a part of day-to-day marine-based transportation, industry, resource extraction, and associated activities (such as life-saving and rescue actions). Where catastrophic events did happen, they were mostly resolved in a manner that suggests a low chance that archaeological signatures would remain from them today. Cartographic and aerial photo evidence support this claim with no evidence of significant marine infrastructure having been placed in any permanent fashion in the area. Indeed, the erection and disappearance of features like hunting blinds during the survey tell a story of temporary and evolving uses of the area. Hence, the area's history is one of interwoven representative histories – but not the story of a place where incredible, catastrophic, or remarkably significant events occurred.

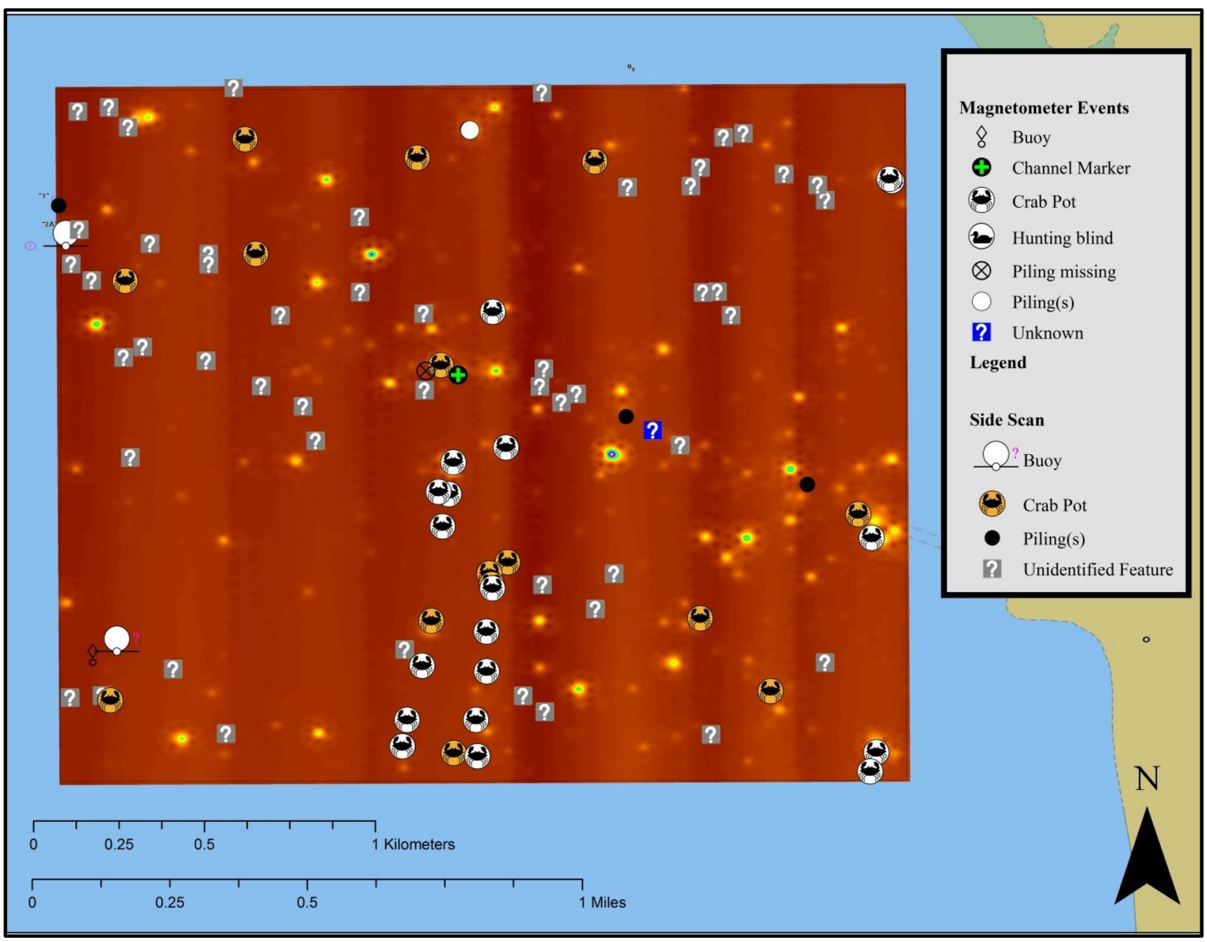


Figure 2. Depiction of interpolated magnetism and sonar targets, with the addition of "surface events" noted during remote sensing survey).

Except for the wreckage of a twentieth-century shipwreck (PAS0001), the study area examined during research appears to only contain isolated sound-floor marine debris, such as relict pilings, lost crab pots, buried vegetation, and other detritus picked up during side scan sonar and magnetometer survey, that is of no historical significance. While this supports assertions about the area's significance outlined above, it is also important to note because any removal of sediment from the area will likely extract such debris (with potentially damaging effects to machinery), or will bury it if sediment is deposited in the area. Nevertheless, there is little to no risk of adversely impacting heritage sites in the area through sediment removal or deposition, or from construction activities.

While the wreckage of PAS0001 was not within the remote sensing survey area, research undertaken during this project suggests there is a high likelihood that the wreckage does not represent the gravel barge it is most commonly identified as by the local community, and may in fact be a late-nineteenth or early-twentieth century vessel of some significance (or at least, presently unknown significance). Hence, it is recommended that dredging and sediment deposition activities occur away from site PAS0001 until the vessel's identity is further investigated and a better determination of its significance is obtained. In September 2016, Panamerican Consultants, Ltd. released a report on their fieldwork in the area. This included an assessment of PAS0001. During their work, they were in contact with one of the archaeologists (Richards), and their research cites the 2010 ECU/CSI research and the nature of the 2014-2016 CSI research. They cite the vessel as a late-nineteenth or early-twentieth century iron-hulled seagoing vessel (Panamerican Consultants, Ltd. 2016:i). Critically, Panamerican archaeologists undertook successful side-scan, magnetometer, and sub-bottom profiler surveys of the area – including the area at and around PAS0001. This verification supports the need for further archaeological examination of the hull remains.

Analysis of the Sedimentary Environment

Geoscience research in this project focused on understanding the existing sedimentary conditions, habitats, historical changes and dynamics of potential placement areas around the REFC. A wide variety of data were collected, including shoreline, seabed, and island information. A brief review of relevant material is provided here in three sub-sections: 1) Estuarine Shoreline Properties and Changes, 2) Subaqueous Back-Barrier Environment and 3) Characterization of Sediment Dynamics, and more detail can be found in Appendix 2. Additionally, these data and associated insights were used to inform the disposal options presented below.

Estuarine Shoreline Properties and Changes

The coast in the immediate vicinity of the REFC is managed by private, local (Dare County), state (NCDOT) and federal (USFWS/NPS) entities (Fig. 3), and the shoreline parcels specifically are largely privately owned except for the immediate ferry terminal area (Dare County) and Pea Island National Wildlife Refuge to the north. Along the immediate shoreline is largely eroding marsh (Fig. 3). To the south, bulkheading is more common.

Long-term shoreline change was measured using the offset of the 1949 and 2015 aerial photos. Mean shoreline change using all transects was -27.9 ± 2.1 m with a mean change rate of -0.41 ±

0.03 m y^{-1} (Fig. 4). The highest accretion areas were sediment banks with <0.50 m y^{-1}. The highest erosion rates (~2.0 m y^{-1}) were found in southern marsh regions of Pea Island National Wildlife Refuge and a separate area in Rodanthe made up of sediment banks that were anthropogenically modified in 2015. Marshes in the central portion of the study and areas far to the north and south yielded the lowest shoreline change rates.

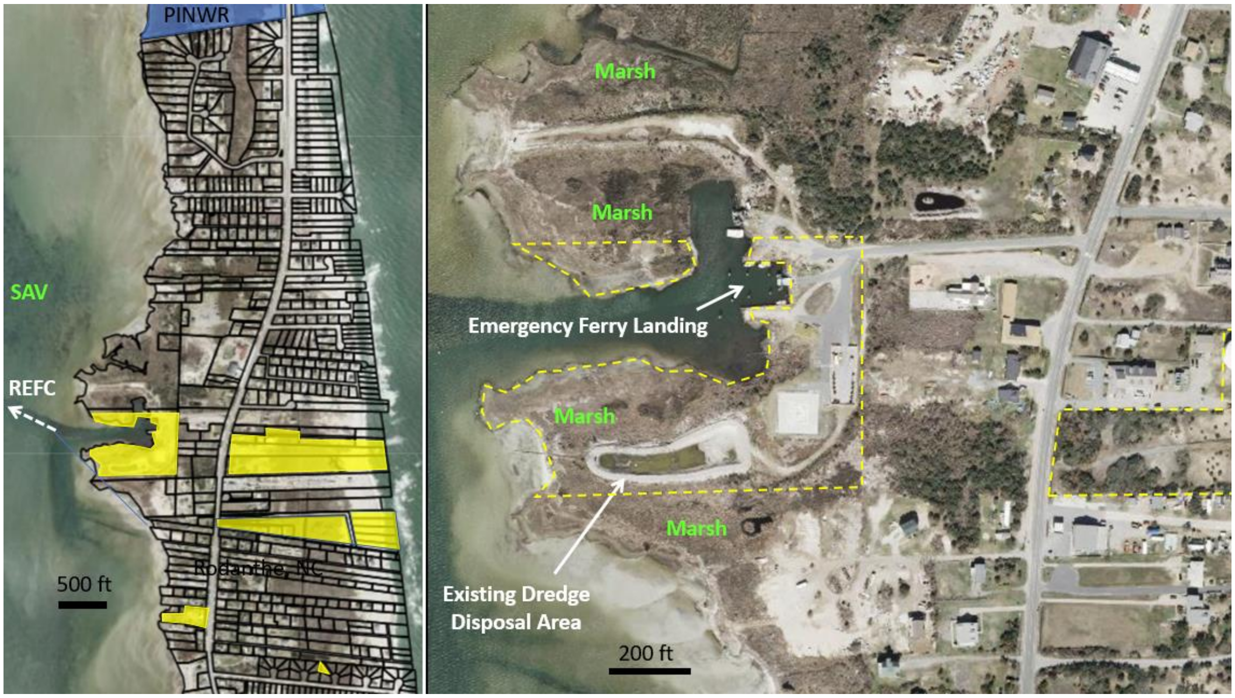


Figure 3: Parcel map (left) and zoomed aerial photograph of the area around the Rodanthe (NC) emergency ferry landing. Parcels owned by Dare County are shaded yellow on left and outlined with dashed lines on right. The Pea Island National Wildlife Refuge (PINWR) is shaded blue. The REFC, the ferry landing and existing dredge disposal area are noted in white. Important habitats are labelled in green. Imagery was from the Dare County GIS (http://gis.darecountync.gov). Positions and distances are approximate.

Shoreline change rates measured in this study agree with previous studies along the Outer Banks estuarine shoreline (Eulie et al., 2013; Conery, 2014; Smith et al., 2008; Dolan et al., 1993). Areas of moderate to high erosion rates have been attributed to limited back-barrier sediment supply and high wave energy in large fetch areas (Eulie et al., 2014; Riggs et al., 2009; Riggs and Ames, 2003). Shoreline change rates for each time step show widespread erosion throughout the study area (Fig. 4). The limited amount of erosion during the 2007-2012 time step is surprising as Hurricane Irene impacted the region with high winds and storm surge (data not shown). The areas of accretion between 2007 and 2012 were associated with bulkheads and revetments. The shoreline modification and lateral, basinward movement of the shoreline testifies to the anthropogenic response associated with hurricane recovery.

Estuarine marsh has been shown to have significantly lower rates of shoreline erosion compared to sediment banks (e.g., Cowart et al., 2010, 2011), so a loss of marsh and transition to sediment bank ultimately increases susceptibility of high rates of erosion (Gittman et al., 2014; Pinsky et al., 2013; Shepard et al., 2011). Shoreline regions with persistent marsh presence (Regions 1, 3, 5) had lower historic change rates than regions with marsh loss (2, 4) (Fig. 4, 1949-2015). This observation highlights a problem: with marsh removal, the back-barrier area will likely see an increased rate of erosion. In response to more erosion, an increase in shoreline modification is anticipated as has been observed in the more recent shoreline data (Fig. 4).

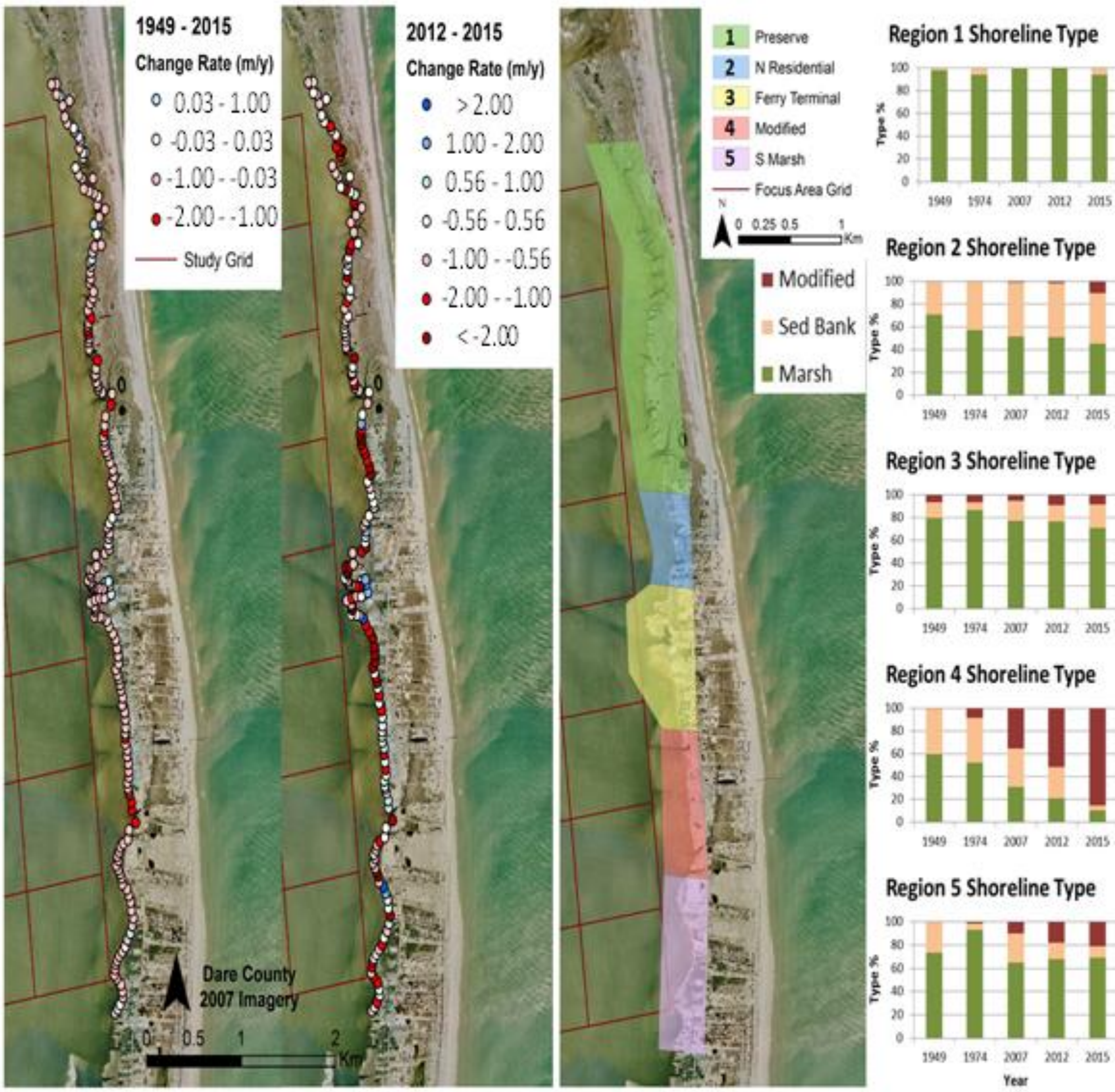


Figure 4. Shoreline change rates for 1949-2015 (left) and 2012-2015 (middle). Note the widespread erosion. Shoreline type change for each region for all time steps (right).

Subaqueous Back-Barrier Environment

Single-beam bathymetric surveys mapped the broad (>3 km wide), shallow (<1.5 m depth) shoal region, i.e., the "Hatteras Flats", along the back-barrier shore (Fig. 5a). Two, especially shallow (<0.5 m), shore-parallel areas are noticeable near the western edge of the Flats. Two channel-like depressions penetrate at least 2 km into the back-barrier shoal system. The northern channel or "slough" connects Pamlico Sound to the western end of the REFC which was authorized for navigational purposes by the United States Army Corps of Engineers (USACE) (see Appendix 1 and USACE Reports: 01 Nov 2012; 26 Nov 2012; 15 Jul 2013).

Previous research identified the Hatteras Flats region of the Outer Banks as a sandy, subtidal flat of reworked and coalesced flood tidal deltas (Peek et al., 2013; Mallinson et al., 2011; Riggs et al., 2011; Mallinson et al., 2010; Culver et al., 2006). Bottom sediment grab samples were collected throughout the study area on three different occasions. Data indicate a dominance of sand throughout the area, with sample mean grain sizes ranging from 122 to 284 μm. Values for d_{10} always were in the fine to very find sand range, ranging from 67 to 160 μm, and d_{50} values ranged from 101 to 259 μm (very fine to medium sand) (Fig. 5b). The maximum d_{90} value was 431 μm, and the lowest was 172 μm. With only one sample having >5% mud (found at the deepest depth sampled, 4.1 m), this shallow subtidal area is dominated by fine to medium sandy surface sediments (Fig. 5b,c). Nevertheless, grain-size distributions vary spatially across the study area. Finer samples were generally found in deeper waters, especially in the north and northwest sector of the grid. Larger grain sizes were seen closer to shore due to shoaling and an increased impact of waves as they transition to shallow water (Mason, 2010). There was very little change (< 0.4 phi change between samples) in the grain-size distributions between the first collection (June) and the second (December) suggesting little variation in new, seasonal inputs. Both marsh and SAV habitats across the back-barrier are capable of producing organic matter and can induce organic-rich sediments (Fourqurean and Serrano, 2012; Mcleod et al., 2011). However, with extremely low loss on ignition values (<1%; Fig. 5d), it appears the study area does not store a large amount of organic sediment despite the potential (Swerida, 2013; D'Andrea et al., 2002). Eroding marshes undoubtedly provide a source of organic matter to estuarine sediments (Canuel and Hardison, 2016). A few samples that were taken directly from marsh scarps showed high LOI (6-25%). The lack of LOI in the back-shore sediments compared to the marsh samples suggests eroded organic materialisdispersed beyond the area, consumed or moved onto the barrier.

Mapping of SAV using historical aerial photography showed widespread coverage in the study area. SAV was most prominent in the back-barrier shoal (i.e., the "Flats") portion of the study area. No SAV was noted in the western area, i.e., the deeper Pamlico Sound. Extent of SAV varied little with time (Fig. 6). Area of coverage varied from 25 to 31 km^2. The greatest variation occured along the western (deepest) boundary where SAV was more difficult to discern due to depth. A visible habitat break occurs in all time steps at the shallow shoal areas ~4 km west of the shoreline. Also, a sharp edge in SAV habitat was commonly seen nearshore. Several areas of ephemeral SAV habitats were mapped in the north. Based on the frequency of cover mapping (Fig. 6), SAV covered 45% of the study area during at least one time step, and 29% of the area was covered during all five time steps. Analysis of bathymetry and SAV occurrence along a grid of points across the area showed SAV was distributed in a discrete depth band (Fig. 6). SAV occurrence ranged from 0.4 to 2.7 m depth. SAV occurrence for all five observations (i.e., persistent coverage) was limited to a depth range of 0.5 to 2.2 m. The mode for the occurrence of SAV (both >0 and all observations) was 1.3 to 1.4 m.

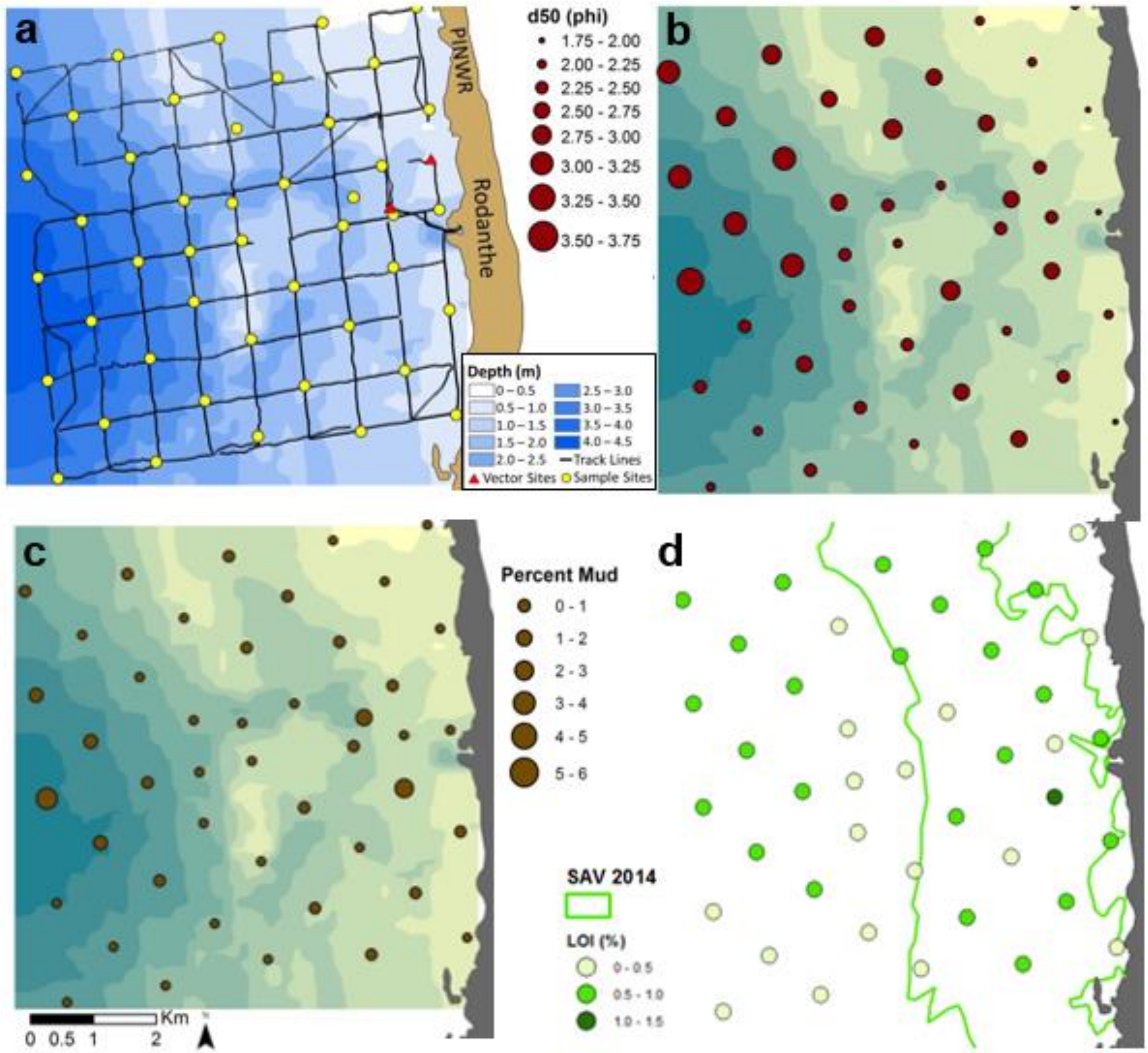


Figure 5. a) Bathymetric map showing sites of sediment samples (yellow) and transport measurements (red). (b) Median grain size (d_{50}) of sediment samples in phi units, (c) Percent mud in samples, and (d) Loss on ignition as a proxy for organic content.

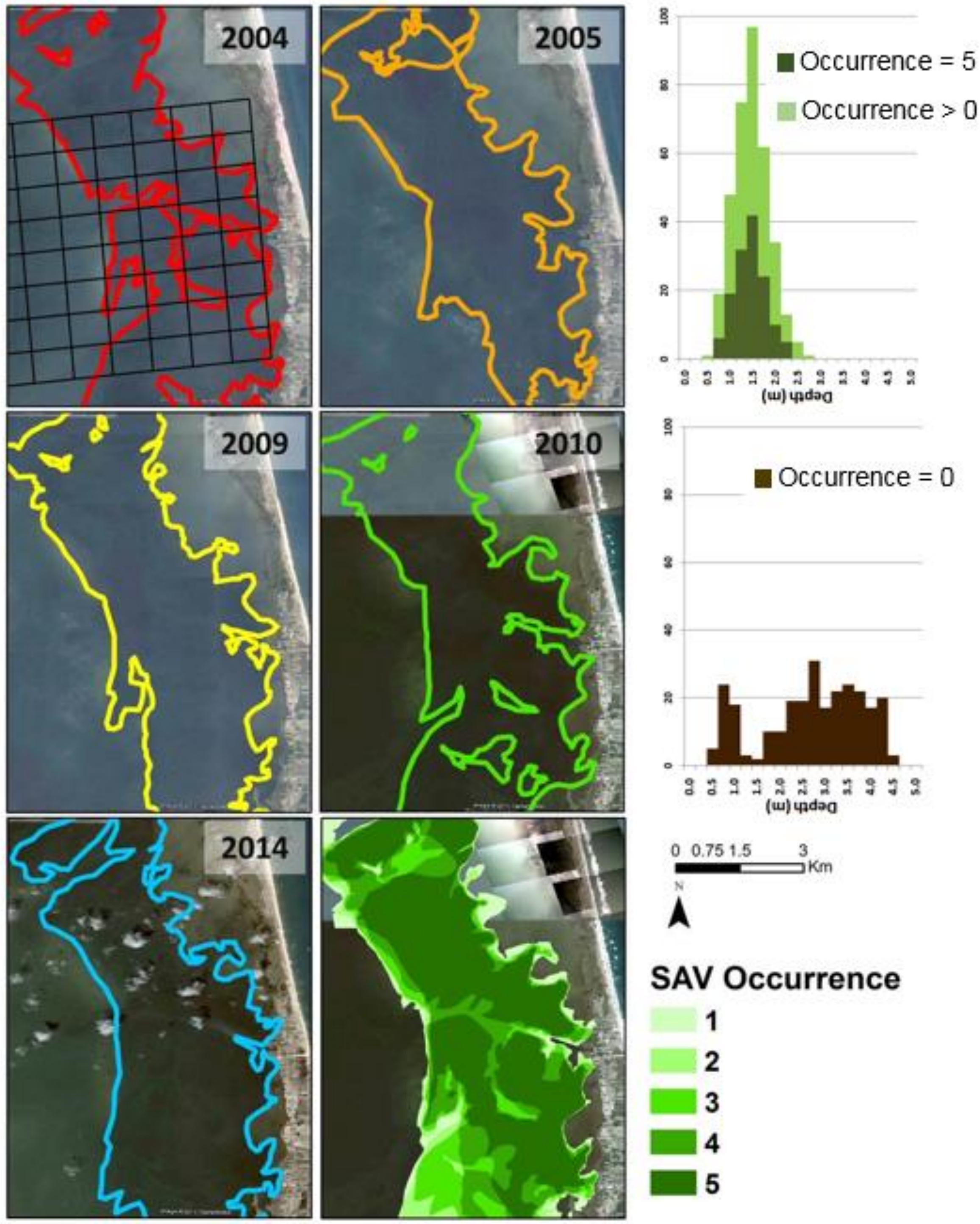


Figure 6. Heads-up mapped SAV boundaries for all time steps. Study area grid is shown in the 2004 data. The occurrence of SAV between all-time steps is summarized in the bottom right map. Occurrence = 1 means SAV was only present during 1 year mapped. Occurrence = 5 means SAV was present at all years mapped. Data show persistent coverage of SAV with moderate variability between years. SAV frequency with depth (top right) and depth without SAV present (bottom) provide data on region SAV growth is expected. Occurrence of 5 shows SAV persistent across all maps. Occurrence >0 shows SAV presence during at least one map. The depth range of persistent SAV was 0.5-2.2 m, and all SAV was 0.4-2.7 m.

The persistent depth zone of SAV in this study (0.5-2.2 m) is somewhat different than reported elsewhere (Angradi et al., 2013; Orth et al., 2010). Depth ranges for SAV vary greatly across the eastern U.S. as a result of varying water quality conditions. Previous studies suggest SAV habitats are largely controlled by depth due to light dependence (Findlay et al., 2014; Angradi et al., 2013; Koch et al., 2001; Hall et al., 1999). Other studies found that SAV habitats were generally shallower than 1 m below mean low water level (Findlay et al., 2014; Angradi et al., 2013). An SAV habitat depth range of 0.3 – 1.3 m would be expected in the study area if water level was controlled by tide alone. Water level data from the instrument deployment in Rodanthe shows a region affected by astronomical as well as wind tides. Wind-influenced water level changes may prevent shallower habitat growth (> -0.5) in study area shoals by increased subaerial exposure during strong NE wind events (Angradi et al., 2013; Palinkas and Koch, 2012), and the deeper depth (>1.3 m) is likely due to relatively clear water in the area.

Low organic content in the sediment samples contradicts past research; higher carbon sequestration is common in SAV beds. With 30-45% of the study area covered by SAV, both allochthonous and autochthonous organic carbon is expected to be present (Fourqurean et al., 2012; Mcleod et al., 2011; Kennedy et al., 2010). Other studies hypothesize persistent SAV habitats are characterized by low organic matter (Palinkas and Koch, 2012; Wicks et al., 2009). The near-zero organic matter content in the study area suggests there is not high carbon storage in the sediments surrounding SAV. The low (<1.5%) LOI in all sediment samples within Rodanthe SAV habitat is attributable to either low productivity, or more likely, frequent sediment flushing.

Characterization of Sediment Dynamics

In situ hydrodynamic and sediment data (i.e., waves, currents, turbidity) were collected during multiple time periods over the course of the study. These data show bed shear stress exceeded τ_{cr} (e.g., capable of resuspending bottom sediments) during periods of moderate or stronger winds. The theoretical critical bed stress ($\tau_{critical}$, the force per area needed to initial sediment motion) of fine sands across the basin is estimated to be 0.18 N/m^2 based on the basin sediment mean grain size (see above and http://pubs.usgs.gov/sir/2008/5093). For example, a resuspension event on 13 September 2015 was brief, with wave heights quickly reaching ~0.5 m. During a second event (Sep. 24, 2015), smaller waves (H_s <0.1 m) were measured, but the bed stress exceeded the threshold for motion for an extended period of time. The sustained wind direction was notably different between the events. The wave event (i.e. Fig. 7, blue box) showed sustained SW winds and the current event (i.e. Fig. 7, green box) showed sustained N-NE winds.

Sediment transport in the Albemarle-Pamlico estuarine system has been reported to be dominated by wind-driven resuspension and weak wind-driving circulation due to the low tidal range (generally <30 cm in the system) (Dillard, 2008; Benninger and Wells, 1993; Wells and Kim, 1989). Observations made in this study support the idea that sediments in the back-barrier are likely remobilized during strong wind events by both waves and currents, and the largest amount of transport occurs during storm events, especially hurricanes like Isabel, Ophelia and Irene. Wave and current data from the August-September 2015 deployment showed bed shear stresses exceeding the critical shear stress for motion of fine sands. Note, each exceedance event occurred during sustained winds along a SW-NE trend (i.e., SW for wave event; NE for current event), which is the greatest fetch extent for wave generation in the Pamlico Sound. Sediment transport during such events will be in the direction of the dominant currents, resulting in transport onshore during SW winds and offshore during NE winds. With strong SW winds following storm events, sediments may be transported onshore after storm departure. In both cases, sediment is likely to be transported into the REFC where will accumulate. In this way, these processes are responsible for channel filling.

Bathymetric surveys of the REFC suggest that variations in depth are associated with major storms and dredging events (Figure 8). Shoaling appears to be associated with hurricanes Isabel (2003), Ophelia (2005) and Irene (2011). The high energy wind (>20 m s^{-1}) and wave processes in these hurricanes are likely dramatic for sediment redistribution in the back-barrier because the bedload transport rate scales non-linearly with the near-bed velocity. For example, substantial back-barrier flooding (and thus currents) and wave activity resulted during Hurricane Irene (Mulligan et al., 2016), and these dynamics likely were responsible, at least in part, for the required post-storm dredging of 49,820 cubic yards of sediment from the REFC (USACE Report, 2011).

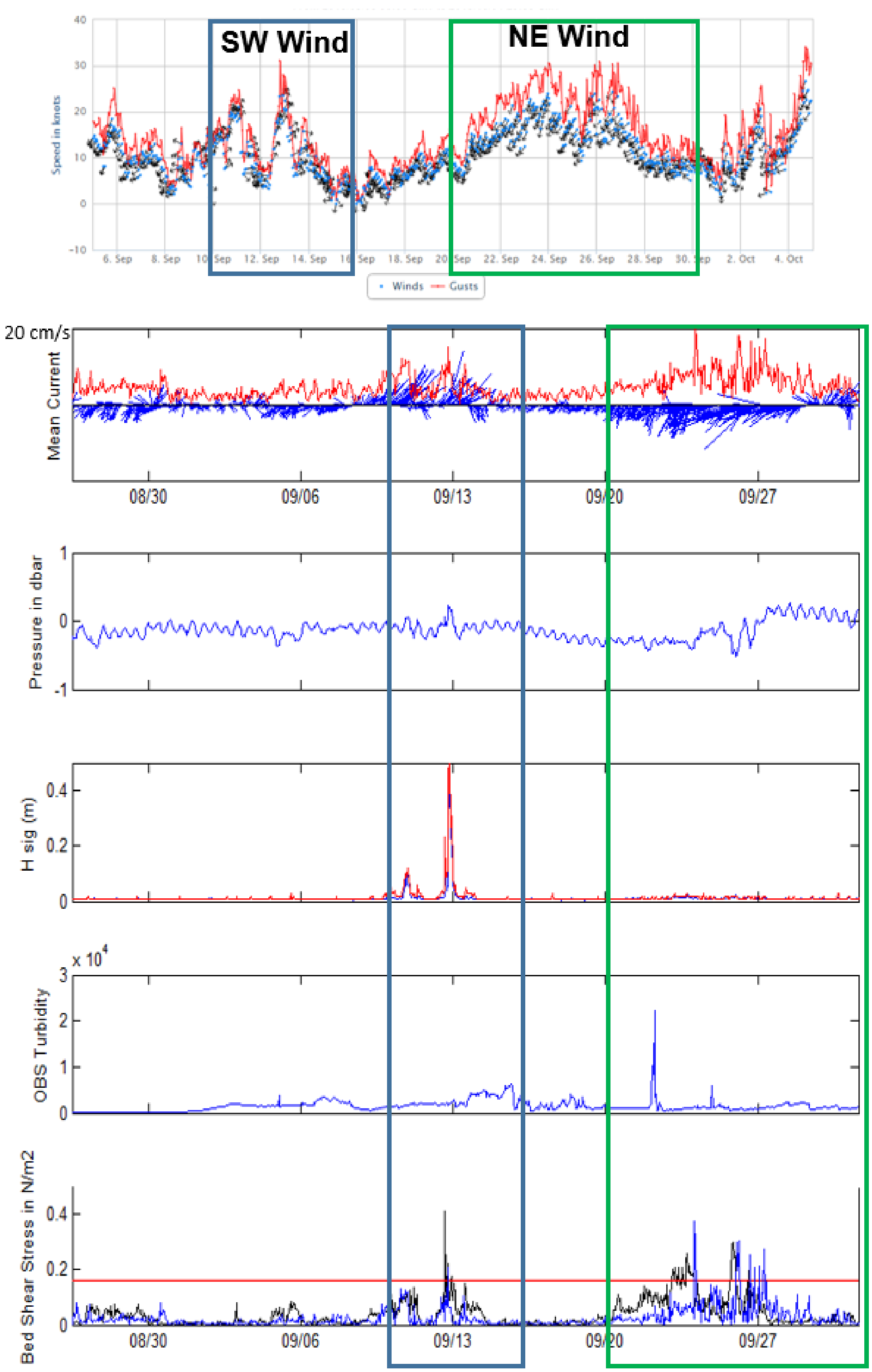


Figure 7: Wind data (top panel) from NOAA shows to "events", a SW and NE wind event. In situ observations and calculated bed stresses are shown in bottom five panels. Blue box indicates the "wave" event, while the green box was the "current" event. Currents are typically <10 cm/s, but during wind events currents can be >15 cm/s. Waves exceeded 0.4 m during the SW wind event. Bed shear stress can exceed the threshold for motion (red line, bottom panel) during SW (on back-shore) and NE off-back-shore wind events.

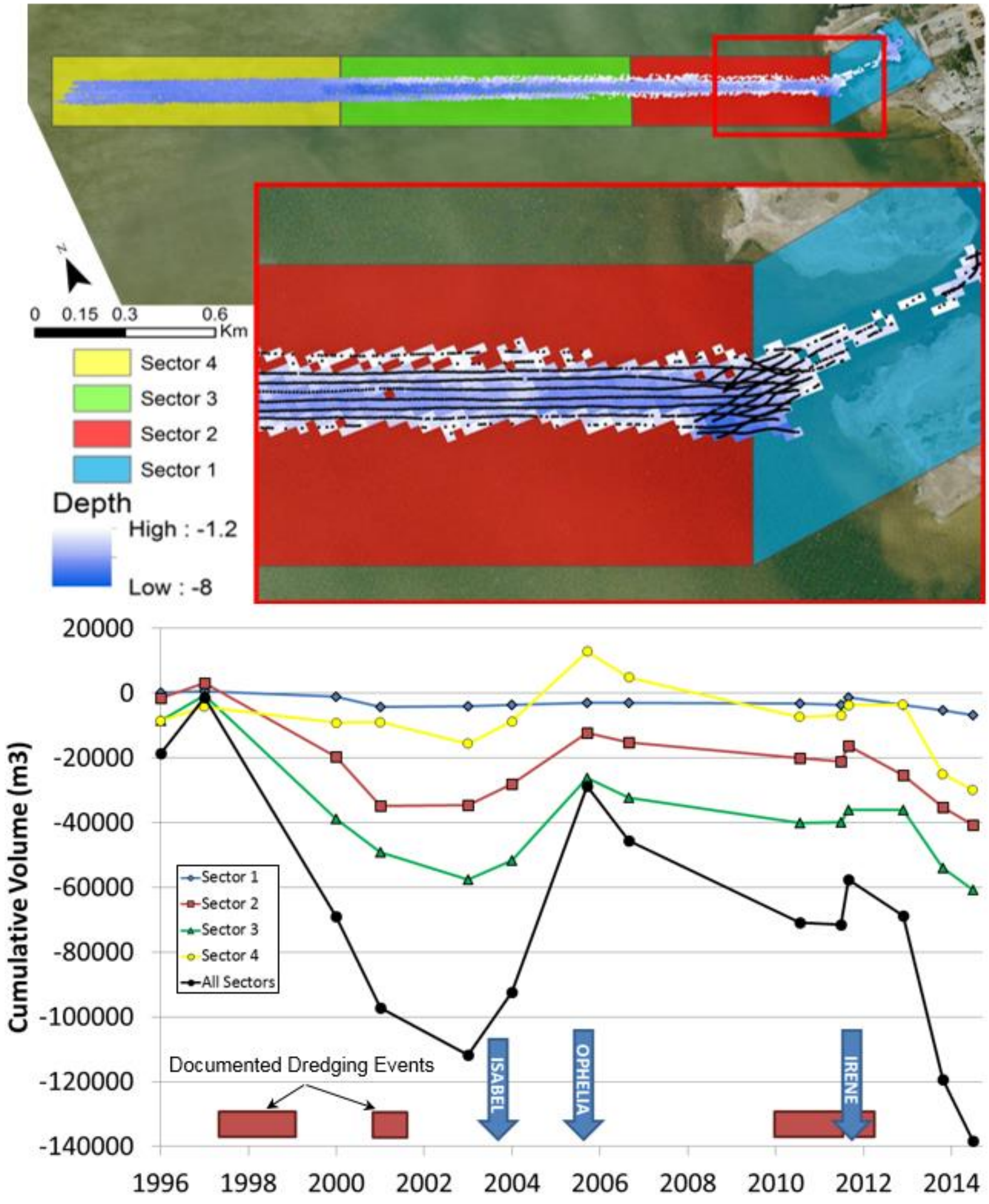


Figure 8. The emergency ferry channel was divided into 4 sectors to evaluate sediment volume changes with time (e.g., differencing bathymetric datasets). Cumulative volume change (bottom) for the channel by sector and for all sectors combined show significant changes with time. Note the large volumetric increases in 2003-2005 and 2011 associated with named tropical systems and the known dredging events that reduced sediment volume.

Ecological connections to sediment supplies

Excessive sediment delivery has long been regarded as a pollutant in aquatic ecosystems, however maintaining and enhancing sediment supply to some coastal habitats such as marshes is recent management priority. Additionally, as the quantity of undeveloped shoreline decreases, using dredged material to create new, or restore degraded shoreline areas is a desirable alternative in many settings. We assessed critical features of ecosystem function in reference deposition sites and in sites being considered for additional deposition sites. Measurements focused on components of ecosystem function that have been found to contribute most to the overall values of ecosystem services and allowed assessment of expected changes in ecosystem function, and the concomitant changes in the values of ecosystem services.

Nitrogen cycling is an important component of shallow estuarine ecosystem function because nitrogen generally limits primary production in coastal ecosystems (Smith 1984, Vitousek et al 1997). Nitrogen supplied in excess can also be considered an important coastal pollutant (Nixon 1995, Howarth and Paerl, 2008, Conley et al 2009, Paerl 2009). Negative impacts linked to excessive nitrogen delivery to coastal regions include, but are not limited to, harmful algal blooms (Paerl 1997), shifts in primary producer communities (Hauxwell et al 2001) and increased hypoxia (Rabalais et al 2002). In areas where nitrogen loading to estuaries is excessive, any processes that remove nitrogen from the system become increasingly important (Brush, 2009). Denitrification is the microbially-mediated process by which nitrate (NO3-, biologically active) is converted to nitrogen gas (N2, biologically inactive). Results of recent studies show that denitrification can account for significant nitrate removal from estuaries (Piehler and Smyth, 2011; Bartkow and Udy, 2004; Mulholland et al., 2008).

Seasonal rates of denitrification were measure at the REFC site in habitats likely to be either affected by deposition of dredged material or created as a part of a material deposition plan (Figure 9). Denitrifications was analyzed with a membrane inlet mass spectrometer (MIMS). Rates were generally low and there was variability in habitat specific patterns. In summer, denitrification rates were highest in the fringing marsh and zero in the seagrass beds. Fall denitrification rates were all positive, but were also all below 20um m-2 h-1. The highest rates of denitrification were measured in the spring, and seagrass had the highest among the habitats. These data provide site specific information on the rates of nitrogen removal that can be expected from habitats in the study area as well as being estimates of what could be expected from habitats that may be restored as a part of dredged material deposition plans.

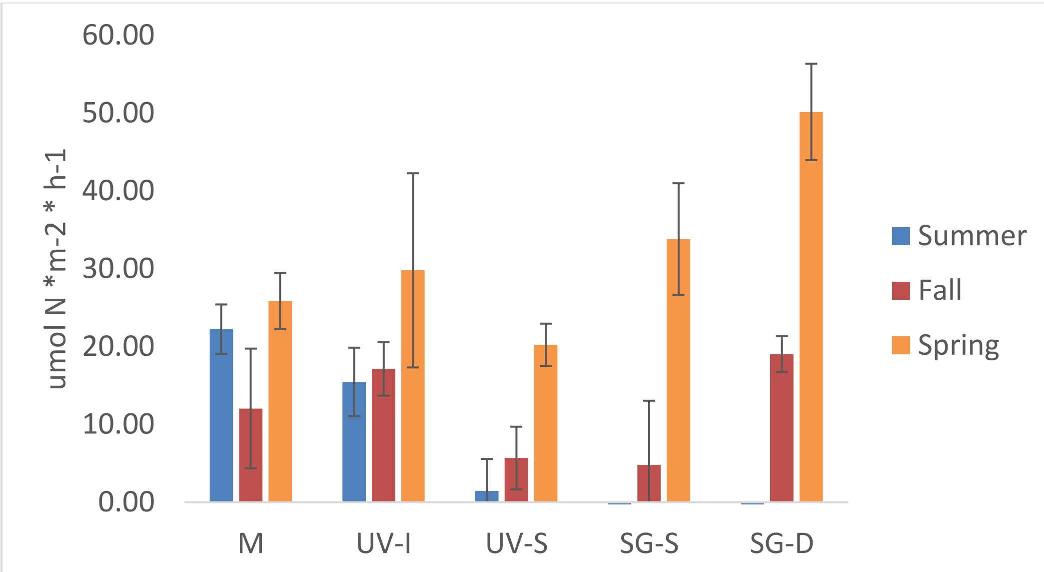


Figure 9. Sedimentary nitrogen flux from sediments in the major habitat types in the REFC (M-Marsh, UV-I – unvegentated intertidal, UV-S – unvegetateed subtidal, SG-S – sparse seagrass, SG-D – dense seagrass).

To inform estimations of impacts of habitat creation using dredged materials future ecosystem function and thus ecosystem services, we conducted similar nitrogen flux experiments in habitats restored in the past. Salt marshes and oyster reefs are often restored on shorelines to prevent coastal erosion and provide ecosystem functions, including denitrification. We used a chronosequence space-for-time replacement design spanning 0 to 20 years to evaluate N cycling following restoration. Sediment cores were collected seasonally. Nitrogen fluxes in the overlying water were analyzed using MIMS. Denitrification always increased from the 0- to 7-year-old sites; changes in rates between the 7- and 20-year-old sites were not consistent across seasons (Figure 10). Sediment oxygen demand (SOD) was significantly correlated with annual denitrification and may be a viable proxy. These data show that restored salt marshes and oyster reefs can augment denitrification and that the increased N removal should be sustained through time.

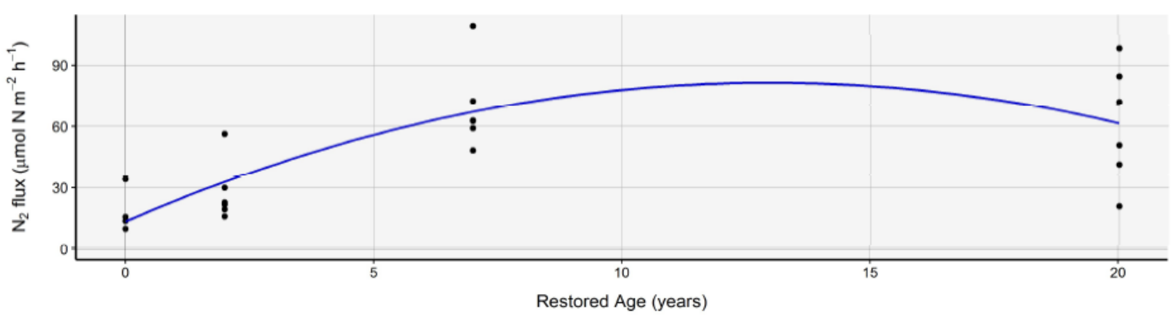


Figure 10. Nirogen flux (denitrification) from saltmarshes and oyster reefs restored at different times in areas similar to the REFC. All habitats have sustained and generally increasing denitrification through time, indicating that restoration of these habitats will provide significant nitrogen removal.

Benthic microalgal communities are composed of diverse assemblages that may include benthic diatoms, cyanobacteria and green algae (Whitney and Darley 1983). These communities are an important source of primary production (Admiraal 1984, Pinckney & Zingmark 1993a, MacIntyre & Cullen 1996) and may provide as much as one third of the total primary productivity in estuarine systems (Sullivan and Moncreiff 1988, Pinckney and Zingmark 1993a). They may also be important contributors to the stabilization of bottom sediments (Paterson 1988, Sutherland et al. 1998), may serve as a food source for grazers (Pinckney & Zingmark 1993a,b, Miller et al. 1996) and have been demonstrated to reduce fluxes of nitrogen from the sediment to the water in estuaries (Anderson et al 2014) and it these roles they also provide ecosystem services.

Benthic microalgal biomass was quantified in all habitats throughout this study (Figure 11). Average annual biomass was higher in the marsh than any other habitats. Seagrass beds also had elevated biomass, with the lowest benthic microalgal biomass in the unstructured habitats (intertidal flat and subtidal flat). Though the economic values of ecosystem services provided by benthic microalgae have not been quantified to the level of detail for organisms like oysters (Grabowksi et al 2012) or processes like denitrification (Piehler and Smyth 2011), there are significant environmental benefits that result from their presence. Sediment deposition plans will have to consider the potential values of benthic microalgae, particularly marsh restoration as it will result in significant increases in their biomass.

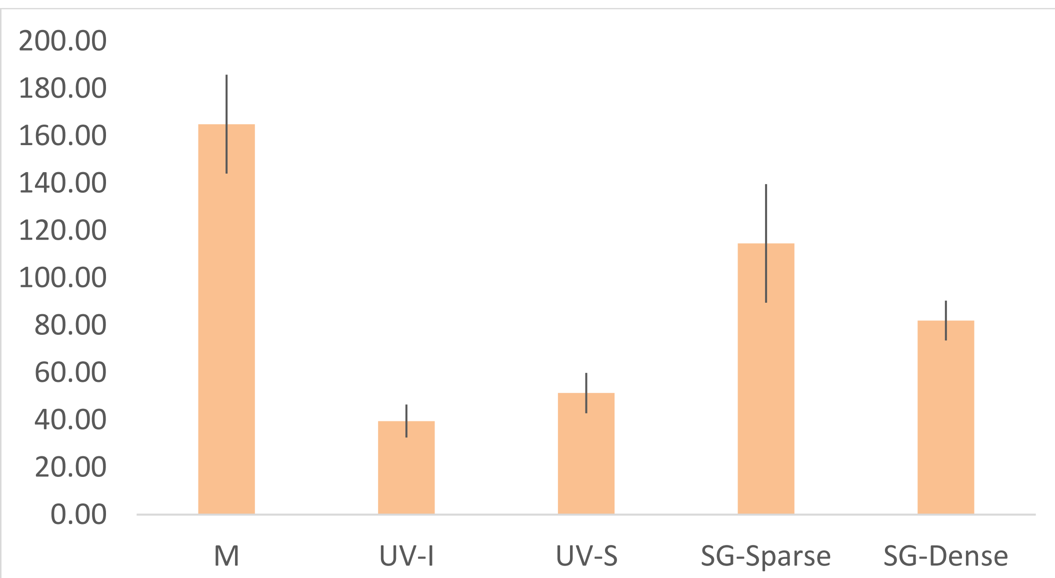


Figure 11. Biomass of benthic microalgae (g m-2) in the major habitat areas in the REFC.

Assessments of current conditions in the area proximate to the REFC revealed that structured habitats had generally higher rates of denitrification and higher biomass of benthic microalgae. These findings corroborate related findings in the literature and are in line with studies assessing the importance of habitats for fish habitat (ref). These data can be extrapolated to the entire study area using the seagrass and shoreline maps presented in the Sediment Dynamics chapter. Using results from this work we are able to populate the decision matrices to provide guidance for the best and simplest sites for sediment deposition. In addition to using the matrices to select sites for sediment deposition, these results can be used to quantify immediate and future ecosystem function changes that will result from ecosystem restoration that accompanies sediment deposition activities.

EVALUATION OF DISPOSAL OPTIONS

Because of anticipated future need and possible expansion of the REFC, the NCDOT is interested in understanding potential sediment disposal options for dredged material. Fundamental to this evaluation is determining the proximity, size and shape of possible placement areas. Additional factors that must be considered include, the potential post-depositional mobility of sediment, ecological impacts (positive or negative) as well as the practicality (e.g., permitting and cost). This research was not intended to provide a design-ready plan but rather give perspective on the possibilities, including non-traditional and potentially innovative options with environmental or societal benefits. The USEPA/USACE (2004) provides a detailed review of the various possibilities and aspects to consider for dredged material disposal. The guiding document describes three management alternatives for dredged material: 1) openwater disposal, 2) confined (diked) disposal, and 3) beneficial use. Also, it highlights that the policy of the USACE is "…to fully consider all aspects of the dredging and disposal operations with a view toward maximizing public benefits." For confined disposal, three possibilities are outlined: Upland, Nearshore or Island. (Fig. 12). Also, the formal process for evaluating alternatives is outlined in Section 3 of the USEPA/USACE Framework (2004). This project has considered seven possible options for material disposal, and these fall into three different alternative categories:

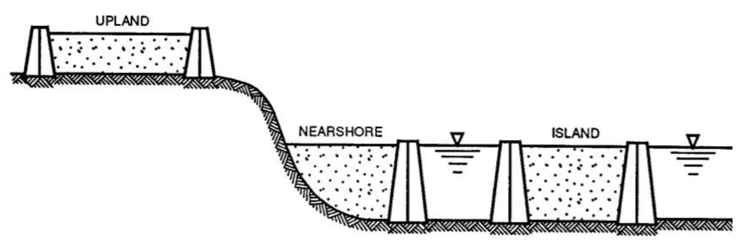


Figure 12. The three types of Confined Disposal Facilities (USEPA/USACE, 2004, Fig. 2-3)

1) *Existing Disposal Area (Confined; Upland)*
2) *Pamlico Sound Island (Openwater, Confined or Beneficial Use)*
3) *Back-barrier Reef (Openwater, Confined, or Beneficial Use)*
4) *Shoreline Nourishment and Reconstruction (Confined or Beneficial Use)*
5) *Marsh Accretion (Confined or Beneficial Use)*
6) *New Local Area (Confined or Beneficial Use)*
7) *Distal Area (Beneficial Use)*

After a discussion of the potential disposal volume, each of these disposal possibilities is presented below along with some explanation on the rational and potential value for each.

The Beneficial Use Planning Manual (USEPA/USACE, 2007) explains how there are seven ways which sediment can be beneficially used: 1) habitat restoration and development (using dredged material to build and restore wildlife habitat, especially wetlands or other water-based habitat), 2) beach nourishment, 3) parks and recreation, 4) agriculture, forestry, horticulture, and aquaculture, 5) strip-mine reclamation and solid waste management, 6) construction/industrial development, and 7) multiple-purpose activities. It is hypothesized that there is an excellent opportunity for beneficial use of dredge material from the REFC because of the nature of the study area (i.e., a back-barrier channel far from any substantial industrial activity). So, sediment is likely suitable for many uses, and the area is generally sediment-limited. The first step in confirming if the material is suitable for beneficial use is by testing and assessment according to procedures outlined Clean Water Act Section 404(b). Surficial sediment evaluation indicates that sediment is dominately sand, with little mud and organic matter (see ***Subaqueous Back-Barrier Environment*** section above), suggesting it may be appropriate for many uses.

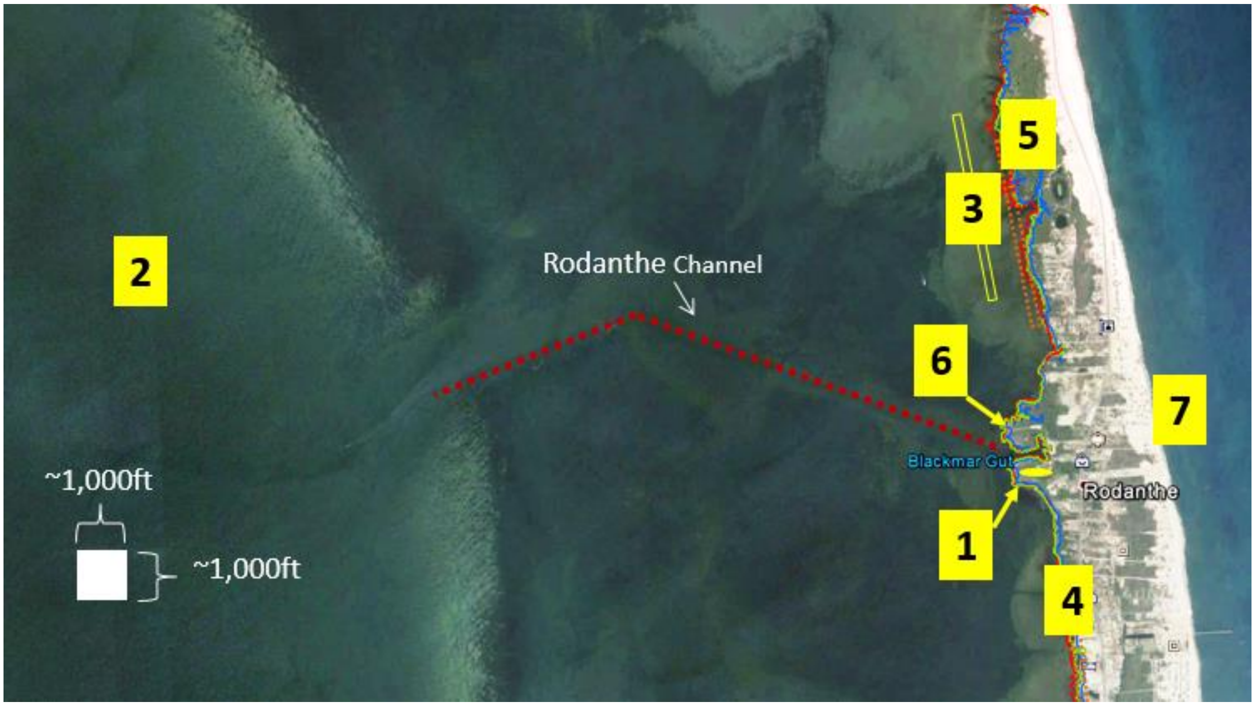


Figure 13. Disposal options considered in this study: 1) *Existing Disposal Area, 2) Pamilico Sound Island, 3) Back-barrier Shoal, 4) Shoreline Nourishment and Reconstruction, 5) Marsh Accretion 6) New Local Area and 7) Distal Area.*

Rodanthe Channel and Dredge Spoil Disposal Needs

The REFC, often referred to as the "Channel from Pamlico Sound to Rodanthe, N.C." in USACE documentation, is located ~25 miles north of Cape Hatteras, NC and west of Rodanthe, N.C. (See Coast and Geodetic Survey Chart 1231). The current project was authorized by River and Harbor Act of 1945 (H.D. 234, 76th Cong., 1st sess.) (see USACE, 1948). A detailed review of the channel history is given in Appendix 1. The channel created by the USACE was designed to connect a naturally deeper slough crossing the back-barrier bar (i.e., "Pugh's Channel") to a channel and harbor dredged by the USCG in 1936-1937 (USACE, 1948). According to recent USACE reports, the REFC is currently maintained to "…6 feet deep, 100 ft wide, and 1.25 miles long from Pamlico Sound to a basin at the shore end near Rodanthe of the same depth, 80 to 100 feet wide and total length of 1,200 ft." Since its initial dredging, the channel has required numerous maintenance and clearing efforts (Appendix 1). Reported excavation volumes have ranged from about 50 to 120 thousand cubic yards. It is difficult to determine the total volume excavated over time as volumes were not reported in several maintenance efforts.

Because sedimentation is related to storm activity, existing and future dredging need is difficult to assess. Since numerous storms have transpired since the last known dredging, maintenance on the order of 50 thousand cubic yards is estimated, similar to that reportedly removed in 2012 after Hurricane Irene (which impacted NC August 26-27, 2011). With continued storm activity, it is likely that one or two similarly sized dredging volumes may be needed in the next decade to maintain the existing channel. Although it is worth reiterating that dredging need is highly dependent on the storm frequency, strength, and path.

Based on conversations with the NCDOT, channel widening and deepening is desired for the anticipated usage of the REFC in the future. Dredge volumes for two possible improvement designs were considered. Details for the "Moderate" (i.e., 8 ft deep; 150 ft wide) and "Preferred" (i.e., 10 ft deep; 200 ft wide) improvements are presented in Table 1. To evaluate possible disposal volumes, the cross-sectional area and excavation volume was determined for each design assuming a starting depth similar to the surrounding area (Fig. 14; 4.6 ft east and 7.5 ft west of Marker 2) and a 1:3 slope on the channel sidewalls (Fig. 15). Based on seabed sampling, surficial channel sediments are dominantly sand, and as a result, it is assumed that the dry volume (for disposal) is comparable to the excavated wet volume (i.e., no effort was made to adjust the volume for sediment bulk density).

Table 1: Estimates of channel properties and disposal volume needs. Note, a 20% error was assumed as dredging depth, bathymetry and exact channel location are variable.

Channel	Length (ft)	Channel Bottom Width (ft)	Depth (ft)	Estimated Average Excavation Depth (ft)	Cross-sectional Excavation Area (ft^2)	Estimated Disposal Volume Required (thousands yd^3)
Existing	7800*	100	6	1.4	146	**50 ± 10**%
Moderate Improvement	7800*	150	8	3.4	545	158
	4000#	150	8	0.5#	76	11
					Total:	**169 ± 34**$
Preferred Improvement	7800*	200	10	5.4	1167	338
	4000#	200	10	2.5#	101	77
					Total:	**415 ± 83**$

*Denotes the measured distance from the Rodanthe boat basin to Marker "2", where depths generally exceed 7 ft (Fig. X). %denotes amount dredge volume estimated from past maintenance efforts. #For channel improvements, dredging west of Marker "2" would also be required, therefore this length indicates the estimated value for the channel portion west of Marker "2" that would also require dredging to reach designated depth. $Indicates total estimated dredge volume considering portions east and west of Marker "2".

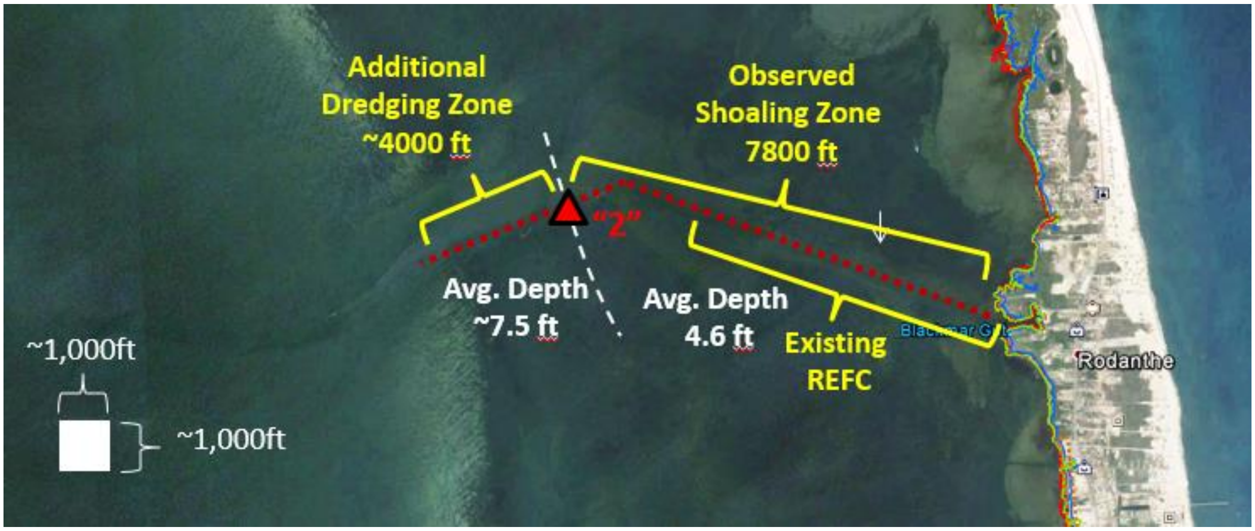


Figure 14. Channel lengths and average seabed depths used for calculations in Table 1.

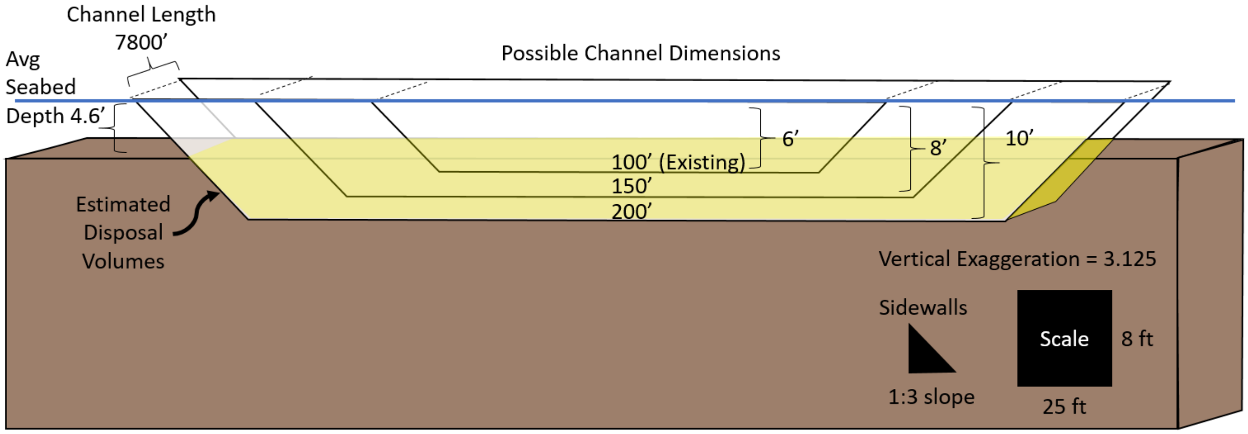


Figure 15. Schematic illustrating the Existing, Moderate (150 ft wide channel) and Preferred (200 ft wide channel) options for the existing REFC. Note, Table X provides estimated disposal volumes, and these were calculated using the channel dimensions shown. The calculated average depth of the surrounding seabed (4.6 ft east of Marker 2; 7.5 ft west of Marker 2; Fig. 3X) is needed to estimate the disposal volume and was determined by an ArcGIS analysis the 1996 USACE bathymetry, which covered a larger area beyond the navigation channel.

In the next several sections, various dredge material disposal options are presented. To be conservative regarding the disposal volume and recognize that maintenance dredging will be needed in the future, the equivalent of a large maintenance dredging (50 thousand cubic yards) is added to the three dredge volume estimates in Table 1. Thus, the volumes used for the Existing+, Moderate+, and Preferred+ scenarios are 100, 219 and 465 thousand cubic yards, respectively.

Option 1: Existing Disposal Area

The existing disposal area is located on land, immediately south of the Rodanthe boat basin at the eastern end of the REFC (Figs. 3 and 16). This area is located on Dare County property and was created in 1996 to accommodate dredge spoil from the channel (Fig. 3). Recent (2014) LIDAR data reveals the disposal area is ~400 ft long and 50-100 ft wide and largely unfilled. If it is assumed that this area can be overfilled to ~10 ft, a total volume of ~300,000 ft^3 or 11,111 yd^3 is available. Note, this volume is significantly less than disposal needs outlined (Existing+, Moderate+, and Preferred+ scenarios of 100, 219 and 465 thousand cubic yards, respectively).

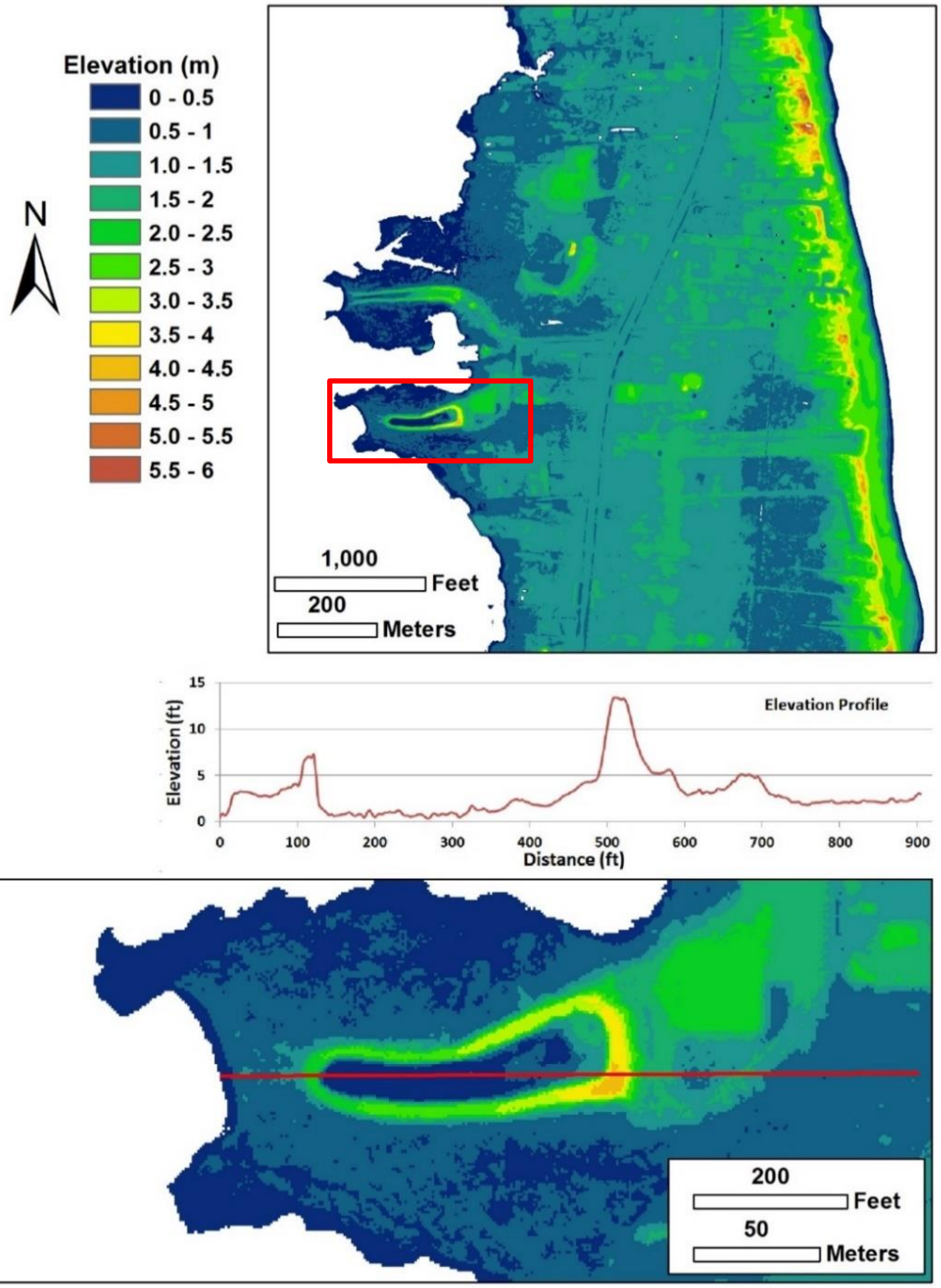


Figure 16: Map (top), profile (middle), zoomed map (bottom) of digital elevation data for the existing dredge disposal area in Rodanthe, NC. See Figure 3 for location. Elevation grid is derived from LIDAR, and data show a well-defined oval-shaped receiving basin. LIDAR was obtained from NOAA (2014, Post-Sandy), and plots were generated using ArcGIS.

Option 2: Pamlico Sound Island

Disposal of sediment in Pamlico Sound could take the form of a submerged mound or an island. Existing examples of such disposal are found around the world, including some not far from the study site. For example, Big Foot Island near Ocracoke proved to be an important area for nesting birds during Hurricane Arthur (Vankevich, 2015). The shapes and sizes of spoil islands vary widely. An oft-used example is Poplar Island in Blackwater, VA (USEPA/USACE, 2007a; 2007b). This collaborative project involving the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service and the Maryland Port Administration seeks to rebuild an island which was much larger in the mid-19th century. Here, 1,140 acres of wildlife habitat (half wetland and half upland) will be created by the deposition of 40 million cubic yards of dredged material. The dyked disposal area is a 3-mile-long by 0.7-mile-wide crescent-shaped island (Fig. 17).

Construction of such an island would likely occur west of the shallow back-barrier area (Fig. 17). Measurements of waves and currents at the tripod sites (see Fig. 5 for location) showed that conditions are episodically conducive to sediment transport in the shallow back-barrier area (i.e., between the shoals and the back-barrier shoreline; Fig. 7 and Appendix 2). Because wave heights would be elevated in the deeper potions of Pamlico Sound (e.g., Mulligan et al., 2016), a similar reworking concern exists for an open-sound disposal site. Thus, armoring would likely be required to minimize dispersal, and this could dramatically increase costs. If planning for the longer term (3-5 decades), the cost may be more easily justified.

Assuming an island thickness of 15 ft (e.g., the island just breaches sea level seaward of the shoal areas), the diameter of such an island could be 500 (0.1 miles) to over 1500 ft (0.3 miles), depending on the desired longevity and estimated dredging reoccurrence volumes (Table 2). Note, this would be considerably smaller than Poplar Island shown in Fig. 17. Such a construction can have multiple benefits. Subtidal and intertidal areas provide habitat for fish and shellfish, and bird populations can use upland and wetlands for nesting and foraging (Yozzo et al., 2004; McKinney et al., 2010).

Figure 17. Potential size and approximate location of island (top left), oblique (top right) and annotated (lower) aerial example of a dredge spoil island (Poplar Island, MD). Image in top right from USEPA/USACE (2007b). Annotated image from Stinchcomb and Sharrett (2015). Of course, the location should not obstruct ferry traffic.

Table 2. Calculations for different disposal options based on estimated disposal volumes.

Improvement	Assumed Disposal Volume (thousand cubic yd)	Option 2: Island Diameter (ft)	Option 3: Small Reef Length (mi)	Option 3: Large Reef Length (mi)	Option 4: Shoreline Width (ft)	Option 4: Erosion Time Equivalent (y)	Option 5: Marsh Required (acres)	Option 7: Dump Truck Trips
Existing+	100	479	11	3	82	61	151	8333
Moderate Improvement+	219	708	25	6	181	134	331	18250
Preferred Improvement+	465	1032	53	13	384	284	703	38750

Option 3: Back-barrier Reef

The creation of reefs has become more common along the NC coast with the goal of mitigating shoreline erosion and simultaneously providing habitat for marine life. Many examples of such structures can be found nearby, such as reefs along the coast of Jockey's Ridge State Park, Nags Head Woods and the Alligator River National Wildlife Refuge. These are typically constructed to extend from the seabed upward near mean sea level to induce wave breaking and reduce the wave energy expenditure on the coastline. They have been constructed from oyster shell bags, limestone, concrete and concrete-coated wire frame (e.g., crab pots). A rigid structure would help maintain the reef shape, especially considering the episodically energetic waves (Mulligan et al., 2016), although such construction could costly and require maintenance with time. The height of such structures typically scales with the water depth, while their horizontal and lateral dimensions have varied. Dredged sediment would be deposited within the surrounding hard barrier, e.g., oyster shell bag, rock (Fig. 18).

To estimate the reef length needed to accommodate the dredge spoil, two reef dimensions were assumed. The "Small Reef" assumed a height of 1.5 ft and width of 30 ft, and the "Large Reef" considered dimensions of 3 ft height and width of 60 ft. The exact size would need to be designed for the best placement zones. Estimated lengths needed for the disposal volumes ranged from 11-53 and 3-13 miles, respectively for the Small and Large Reef options (Table 2). An example placement location and design is shown in Fig. 18. It should be noted that a SAV-free area is evident along much of the estuarine shoreline in this area, and could make permitting more feasible. However, with the estimated disposal volumes, the structure sizes would probably be prohibitively long, and it is noted that these estimates do not include reef gaps, which would likely be required for construction. Consequently, the practicality of this disposal option is low unless combined with another approach.

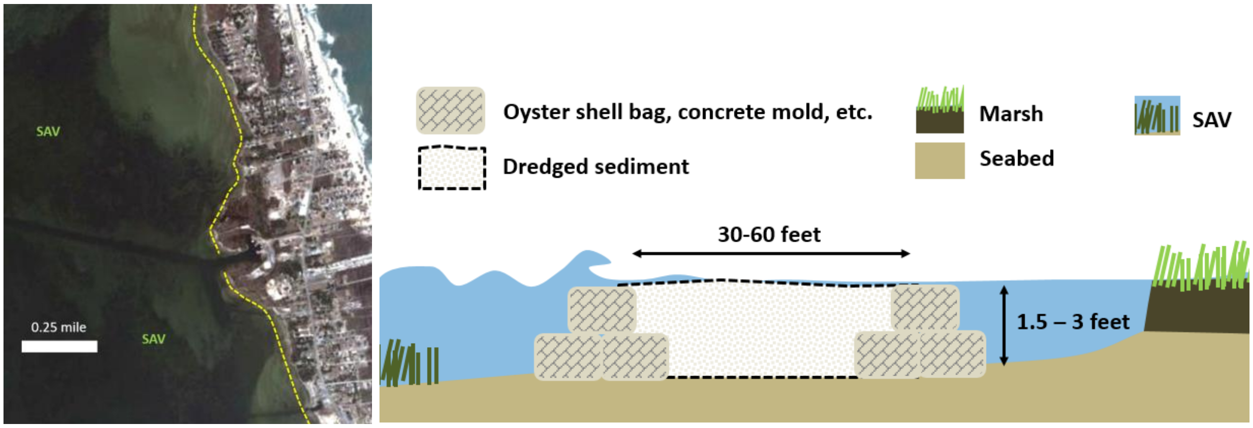


Fig. 18: Example installation location of ~1.5 mile-long "Large Reef" (left) and a design schematic (right). Note, this example reef could hold approximately 25,000 cubic yards (Table 1).

Option 4: Estuarine Shoreline Nourishment and Reconstruction

Our study revealed that the estuarine shoreline in this area is largely eroding (Fig. 4). Rates have varied with time and spatially, but the average long-term erosion rate was 1.3 ft/y (0.41 m/y). It is expected that a portion of the sediment infilling the REFC is sourced from estuarine shoreline erosion. To mitigate against ongoing erosion, dredged sediment could be used to resupply (i.e., nourish) the estuarine shoreline with sediment directly and/or backfill or frontfill a newly constructed or existing living shoreline or bulkhead. Examples of various types of shoreline reconstruction zone are shown in Fig. 19. In fact, a significant portion of the estuarine shoreline to the south of the REFC is already bulkheaded (i.e., see Region 4, Fig. 4), The ecological benefits of bulkheading have been shown to be reduced relative to a living shorelines (Arkema et al., 2013, Gittman et al., 2014). Thus, it is recommended that if this option is pursued, a living shoreline installation should be considered.

Assuming an average fill thickness of 1.5 ft and an average shoreline length of 3.1 miles, the lateral extension of the shoreline would need to range from 80-380 ft for the disposal volume estimates (Table 2). For comparison, these distances represent erosion over 60-280 years at the long-term erosion rate (Table 2). Given the limited shoreline outside of USFWS and NPS (i.e., 3.1 miles) and the extensive lateral extension required (80-380ft), the practicality of this disposal option alone is also low. Moreover, much of the shoreline is private property, which could represent another challenge (Fig. 3). However, it is worth noting that the USACE recently made the permitting for these structures easier (Talton, 2017)

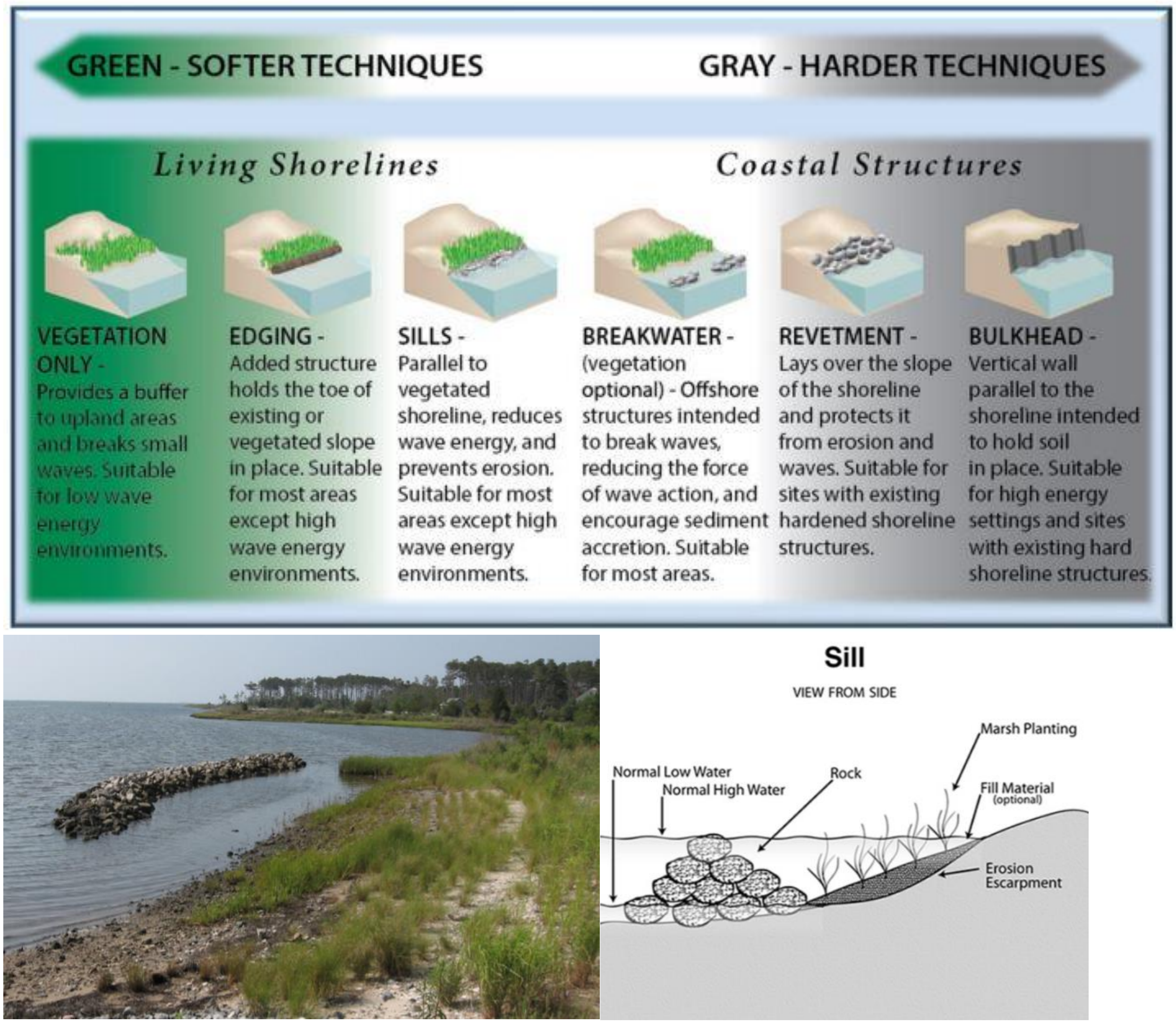


Figure 19: Various possibilities of shoreline reconstructions. The dredged material would be used to add volume to shoreline (i.e., nourish), building an extensive marsh or backfilling with upland and/or marsh. Top from NOAA in Talton (2017). Bottom images from NC Division of Coastal Management (2009).

Option 5: Thin-Layer Deposition on Marsh

With sea-level rising and potentially at faster rates in the future (Kemp et al., 2009; NC Sea-Level Rise Report, 2010; 2015) many coastal scientists and managers are concerned about the viability of marshes, specifically in their ability to accrete sediment fast enough to keep up with the rising water level (Fitzgerald et al., 2008; Fig. 20). Outer Banks marshes are additionally challenged by the limited availability of fine sediment to enhance sedimentation. Over the last couple decades, several projects have used dredged material to enhance marsh accretion. This can benefit the marsh by adding elevation and reducing inundation time. For example, a thin-layer placement study of a microtidal, back-barrier marsh on Masonboro Island near Wilmington documented that sediment accretion had positive benefits (e.g., increased stem density) for degraded marshes without detrimental impacts (Croft et al., 2006). This was a small-scale study but the results were positive, and the setting was similar to that of the REFC. Information for many other studies (large and small) can be found at the Engineer Research & Development Center Thin-Layer Placement website (2017, https://tlp.el.erdc.dren.mil/case-studies/). Assuming deposition of a 12.5 cm layer of material on the marsh (based on previous work Fig. 20, right panel), a marsh area of 151-703 acres would be needed (Table 2). However, marsh in the immediate vicinity is approximately 18 acres, and much of it is located on private property (Fig. 3). More marsh is located to the north in the Pea Island National Wildlife Refuge, but it is unknown if the U.S. Fish and Wildlife Service would be interested. However, the area to the north was heavily eroded by the island breach during Hurricane Irene and marshes are a critical bird habitat, so it is possible there may be interest.

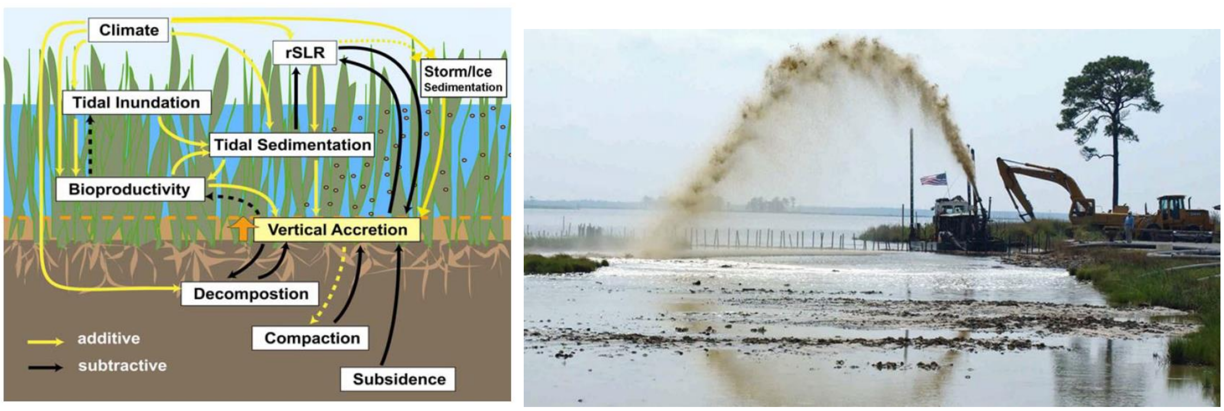


Figure 20. A conceptual model (left panel) of the major processes influencing marsh elevation, including storm sedimentation, tidal sedimentation, and bioproductivity and example of thin-layer placement from ERDC (2017)(right panel). Layer placement thicknesses have varied; 10-15 cm was assumed here.

Option 6: New Local Area on Land

The creation of an additional dredge spoil disposal area is another possibility, but available land is limited in the area. Consultation of the Dare County GIS (i.e., parcel map) indicated that the parcel immediately to the north of the Rodanthe boat basin is owned privately. The most likely possibility for additional local storage would be on a combination of Dare County parcels to the east (Fig. 3). Creating a new disposal area or a temporary holding area to allow time for sediment to dewater is a possibility. It is noteworthy that according to the River and Harbor Act of March 2, 1945, local interests must furnish free (to the United States) suitable spoil-disposal areas for new work and for subsequent maintenance as required. According to the USACE (2012), Dare County has indicated its willingness to do so as needed. On a related note, Dare County and its residents may be interested in seeing this sediment used to shore up dunes along this coastal region; recent elevation data suggest dunes are fairly discontinuous (Fig. 16, top).

Option 7: Distal Deposition on Land

While moving the dredged sediment further from the site will have associated costs, it can provide benefits as sediment is in relatively short supply along Hatteras Island. Other potential beneficial uses of this material include beach nourishment, dune development, lot elevation or road construction. To make this possible, sediment can be dewatered in the existing disposal area and/or a new adjacent disposal area (see Option 6) and moved (nearly simultaneously) to an offsite location. In order for the material to be considered for beach application, the compatibility of the sediment must be assessed. While the gravel content is unlikely to be a problem, the fine fraction may preclude beach nourishment. For this option, the cost and practicality of moving the sediment must be carefully considered. For example, a standard dump truck can hold 10-14 cubic yards, thus for a 50,000 cubic yard maintenance project, over 4,000 truck trips would be needed to distribute the material, and many more are anticipated for the long-term (Table 2). Another option is pipe transport. The Town of Topsail recently installed a cross-island pipe to enable the pumping of Intercoastal Waterway channel fill to the oceanfront for beach nourishment (personal communication, Chris Gibson, TI Coastal); a similar approach could be explored.

A hybrid sediment deposition plan

Finally, it is possible a combination of approaches (e.g., reef and shoreline) could be used and research could be conducted to test their efficacy and economic and ecological value. Examples of such partnerships can be found at ERDC (2017). For example, the reef, shoreline and marsh options all can potentially provide longer-term sustainability to the dynamic and dwindling barrier-island system. Ultimately, some of these approaches may be a solution to estuarine erosion problems in other areas in the region (e.g., Buxton). Examples of innovative and hybrid efforts as well as the partnerships (e.g., in Mobile, Alabama) that enabled their success can be found at ERDC (2017).

DECISION MATRICES

In many coastal systems, sediment is a critical commodity that allows habitats to maintain their position in the face of long and short-term changes, related to sea-level rise or erosion. In areas with high value habitats such as submerged aquatic vegetation, identifying sites to deposit sediments without damage to the environment is the primary challenge. However, significant opportunities exist to use dredged material to create benefits for both the environment and for people. Selection and design of deposition sites that minimize environmental damage and maximize environmental benefits requires a multidisciplinary approach. Information presented here has improved the understanding of the geological, ecological and cultural factors affecting siting of dredge material deposition sites in shallow coastal waters. We have assembled a decision framework to make and explain decisions regarding dredge material deposition sites for the REFC.

The first matrix (Table 3) synthesizes the data from the geological, ecological and cultural research in this project. We broke out the segments of ecosystem function that had the most

Table 3. Decision matrix for sediment deposition in the RFEC area. Areas and processes that will benefit from sediment deposition are in green, yellow indicates neutral impacts and red indicates negative impacts. NA indicates information is not available because potential areas of action represent adjacent locations not researched or surveyed during historical research and archaeological inspection, and therefore would require separate assessment.

	Sediment stabilization	Biota	Nitrogen removal	Cultural resources
Upland				NA
Intertidal - unvegetated				
Marsh				
Subtidal - unvegetated				
Seagrass - sparse				
Seagrass - dense				
Offshore				NA

significant and direct connections to human uses. The included sediment stabilization, enhancement of biota, nitrogen removal, and the presence of important cultural resources. These categories were then assessed in the context of the potential disposal sites identified. Green shading indicates dredged material deposition in this area can be undertaken without concern for the factor identified (e.g. placing dredged material in unvegetated intertidal areas is not a concern in the context of the service of sediment stabilization). This matrix can be used to compare ecosystem concerns across sites or select an ecosystem function and compare its response to sediment deposition in multiple sites.

Table 4 includes a more general decision matrix that coalesces data from the disciplines into the categories of environmental, cultural, and added a column for permitting complexity. This matrix permits high level assessment of the likely ease of permitting and development of a science-based argument to support sediment deposition plans and site selection.

As noted above, the anticipated uncontaminated nature of the dredge material means that it can likely be used for a variety of beneficial uses, and this is priority for the USACE (USEPA/USEPA, 2004; 2007). One potential challenge is the volume of material generated, depending on the improvement option pursued and funding available. Nevertheless, this project represents an excellent opportunity to generate environmental and societal value, including critical habitat expansion (e.g., SAV and marsh) or erosion protection by dunes, reefs or marshes. Consequently, it is recommended that options beyond confined disposal be explored.

Table 4. Consolidated decision matrix for sediment deposition in the RFEC area. Disposal options and factors of concern (permitting, environmental, cultural) for which sediment deposition is not an issue are in green, yellow indicates neutral impacts and red indicates area and factor of concern. The cultural category assumes project will avoid the potential wreck site. NA indicates information is not available because potential areas of action represent adjacent locations not researched or surveyed during historical research and archaeological inspection, and therefore would require separate assessment.

	Permitting Complexity	Environmental	Cultural
Option 1: Existing Disposal Area			NA
Option 2: Pamlico Sound Island			
Option 3: Back-barrier Reef			
Option 4: Estuarine Shoreline Nourishment and Reconstruction			
Option 5: Thin-Layer Deposition on Marsh			
Option 6: New Local Area on Land			NA
Option 7: Distal Deposition on Land			NA

The Beneficial Use Planning Manual suggest to accomplish these projects can require a variety of partners with different perspectives which can become challenging, but ultimately, important benefits can be realized by involving partners early and working closely through time (USEPA/USEPA, 2007). Potential partners could include the U.S. Fish and Wildlife Service (that manages Pea Island National Wildlife Refuge), Dare County, and private property owners, as each could obtain significant benefits from sediment-dependent projects.

PUBLIC EDUCATION AND OUTREACH OVERVIEW

Public education and outreach efforts on the project have been focused on interpreting the work performed by the project scientists in three main research area areas including ecology, geology, and maritime archaeology. Educational products have targeted the general public, K-12 students and teachers and stakeholders related to the proposed ferry channel dredging. The education and outreach programming created for the project includes the following:

Project Website
A comprehensive website was created to communicate the research goals, work performed and importance of the project.

A project overview page can be found here:
http://www.coastalstudiesinstitute.org/research/multi-disciplinary-projects/ncdot-ferry-channel-project/

Individual project research areas were broken into three research pages that highlighted the ecological, geological and archaeological research related to the project.

An estuarine ecology research page can be found here:
http://www.coastalstudiesinstitute.org/research/multi-disciplinary-projects/ncdot-ferry-channel-project/estuarine-ecology/

A coastal processes research page can be found here:
http://www.coastalstudiesinstitute.org/research/multi-disciplinary-projects/ncdot-ferry-channel-project/the-role-coastal-processes/

A maritime archaeology research page can be found here:
http://www.coastalstudiesinstitute.org/research/multi-disciplinary-projects/ncdot-ferry-channel-project/estuarine-ecology/

K-12 Programming and Lesson Plan Development
In addition to website content, programming for K-12 audiences and teachers was developed. This programming highlights the natural and cultural resources of the estuarine system found within the research area, the processes that affect these systems and the research topics covered in the project. Programming content was included into existing K-12 courses offered at UNC CSI. These courses based on North Carolina Department of Public Instruction (NCDPI) essential standards, complement existing school curriculums and reach over 3500 students annually through onsite programming from visiting schools to the UNC CSI campus site in Wanchese, NC. Content related to the project was included in the following courses offered for 5-12 grade students: "*Exploring Estuaries – An Ecosystem of Its Own", "Who Left This Ship Here?",* and "*Sustainable Coastal Communities".* A complete list of K-12 course offerings can be found here: http://www.coastalstudiesinstitute.org/education/k-12-programs/k-12-programming-available-on-campus/

Lesson plans and educational resources for teachers were also developed, highlighting the research of the project and the science behind the work. The lesson plans are available free for teachers on the project website, and can be found here:
http://www.coastalstudiesinstitute.org/research/multi-disciplinary-projects/ncdot-ferry-channel-project/education-resources/

Media Development

Digital video content was created for the project, focusing on the research of the project and the project importance to the community. An overview video on the project can be found here: https://youtu.be/8Uzg-4junVA

In addition, UNC CSI staff worked closely with UNC-TV producers to create a video segment for its popular "North Carolina Now" television program. The video can be viewed here: http://science.unctv.org/content/sittin-bottom-bay

Public Presentation

A public presentation on the project is being planned with guidance from NCDOT. The program is part of the UNC Coastal Studies institute's "Science on the Sound" lecture series. This series, held monthly, highlights information on coastal topics and issues in northeast North Carolina. The presentation will be done in a panel discussion format, with a short presentation given by scientists in each of the three research areas covered in the project including estuarine ecology, geology, and maritime archaeology. Following the presentations, the audience will be able to ask questions and engage the scientists in discussion of the project and the scientific methods used. The program will be open to the public and will also be streamed live on UNC CSI's website at the following web address: http://www.coastalstudiesinstitute.org/outreach/live-streaming/

The presentation will be recorded and become part of the ongoing list of "Science on the Sound" lectures available for watching on the UNC CSI YouTube page. A playlist of current "Science on the Sound" lectures can be found here:
https://www.youtube.com/playlist?list=PLX09KgwgnTc7wIirstw3l_kN9yYh3UogG

NCDOT
Research Digest

Research Project Title:
Research to support the design and siting of deposition areas for dredged material from the Rodanthe Emergency Ferry Channel

Researcher's Name, affiliation, and contact information:
Nancy White (PI), D. Reide Corbett Robert McClendon, John McCord, Adam Parker, Michael Piehler, Nathan Richards, J.P. Walsh

UNC Coastal Studies Institute
850 NC-345, Wanchese, NC 27981
252-475-5400

Picture *(related to the project)*:

Background: (Circumstances that led to research initiation – specific opportunities, challenges, problems, etc.)

Specific Research Objective:

This project will result in an improved understanding of the geological, ecological and anthropological factors affecting siting of dredge material deposition sites in shallow coastal waters. Specifically we will provide a decision framework to make and defend decisions regarding dredge material deposition sites for the Rodanthe Emergency Channel. Though this project will focus on one site, the framework developed should be applicable across multiple NC DOT sites. Additionally, we will explore the geological and ecological feasibility of novel sediment deposition approaches including linear marshes, multi-habitat islands and thin layer disposal.

What research work was done?

Implementable Research Product:

How will the research product be used:
An environmental and anthropological framework has been developed to better inform NC DoT on the implications of modifying the REFC. Multiple sediment disposal options have been outlined. Based on eth data collected, information on the possible impacts associated with these options have been outlined.

Who within NCDOT will use the research product:

How the use of the research product will benefit the Department:

Estimated dollar value of research product (if it can be readily estimated):

Any other comment:

Literature cited

Admiraal, W. (1984). The ecology of estuarine sediment-inhabiting diatoms. Progress in phycological research, 269-322.

Allison, M.C., Pollock, C.B., 1993. Nearshore berms: an evaluation of prototype designs. in: Coastal Zone'93, Proceedings of the Eighth Symposium on Coastal and Ocean Management.

Anderson, IC MJ Brush, MF Piehler, CA Currin, JW Stanhope, AR Smyth, JD Maxey and ML Whitehead. 2014. Impacts of climate related drivers on the benthic nutrient filter in a shallow photic estuary. Estuaries and Coasts, 37:46-62.

Angradi, T. R., Pearson, M. S., Bolgrien, D. W., Bellinger, B. J., Starry, M. A., Reschke, C., 2013. Predicting submerged aquatic vegetation cover and occurrence in a Lake Superior estuary. Journal of Great Lakes Research 39:536-546.

Arkema, K.K., G. Guannel, G. Verutes, S.A. Wood, A. Guerry, M. Ruckelshaus, P. Kareiva, M. Lacayo, and J.M. Silver, 2013. Coastal habitats shield people and property from sea-level rise and storms. Nature Climate Change, 3, 913–918.

Benninger, L. K., Wells, J. T., 1993. Sources of sediment to the Neuse River estuary, North Carolina. Marine Chemistry 43:137-156.

Bortone, S. A., Brandini, F. P., Fabi, G., & Otake, S. (Eds.). (2011). Artificial reefs in fisheries management. CRC Press.

Bradley, K.P., Hands, E., 1989. Dredged material underwater berms. in: Coastal Zone'89, Proceedings of the Sixth Symposium on Coastal and Ocean Management, Charleston, SC, July 11–14, 1989, pp. 2947– 2954.

Brush, G. S. 2009. Historical land use, nitrogen, and coastal eutrophication: A paleoecological perspective. Estuaries and Coasts 32:18–28.

Canuel, E. A., Hardison, A. K., 2016. Sources, ages, and alteration of organic matter in estuaries. The Annual Review of Marine Science. Doi: 10.1146/annurev-marine-122414-034058.

Clarke, D., Fredette, T.J., Imsand, D., 1988. Creation of offshore topographic features with dredged material. Environmental Effects of Dredging, Information Exchange Bulletin. US Army Engineer Waterways Experiment Station, Vicksburg, MS

Coch, C. A. (1996). Containment islands: A solution for ports and the environment. Journal of Urban Technology, 3(2), 39-63.

Conery, I., 2014. Decadal-scale evolution of a barrier island: Insights from storm overwash and shoreline change on Ocracoke Island, NC. MS Thesis, East Carolina University.

Conley, D. J., H. W. Paerl, R. W. Howarth, D. F. Boesch, S. P. Seitzinger, K. E. Havens, C. Lancelot, and G. E. Likens. 2009. Controlling eutrophication: Nitrogen and phosphorus. Science 323:1014–1015.

Cowart, L., Walsh, J. P., Corbett, D. R., 2010. Analyzing estuarine shoreline change: a case study of Cedar Island, North Carolina. Journal of Coastal Research, 26:817-830.

Cowart, L., D.R. Corbett, J.P. Walsh, 2011. Shoreline Change along Sheltered Coastlines: Insights from the Neuse River Estuary, NC. Remote Sensing, 3, 1516-1534.

Croft, A.L.; Leonard, L.A.; Alphin, T.D.; Cahoon, L.B.; Posey, M.B. 2006. The Effects of Thin Layer Sand Renourishment on Tidal Marsh Processes: Masonboro Island, North Carolina. Estuaries and Coasts. 29 (5): 737-750.

Culver, S.J., Ames, D., Corbett, D.R., Mallinson, D.J., Riggs, S.R., Christopher, S., Vance, D., 2006. Foraminiferal and Sedimentary Record of Late Holocene Barrier Island Evolution, Pea Island, North Carolina: The Role of Storm Overwash, Inlet Processes, and Anthropogenic Modification. Journal of Coastal Research 22, 836-846.

Croft, A.L.; Leonard, L.A.; Alphin, T.D.; Cahoon, L.B.; Posey, M.B. 2006. The Effects of Thin Layer Sand Renourishment on Tidal Marsh Processes: Masonboro Island, North Carolina. Estuaries and Coasts. 29 (5): 737-750.

Dalal, V. P., Baker, J. E., & Mason, R. P. (1999). Environmental assessment of Poplar Island dredged material placement site, Talbot County, Maryland. Estuaries and Coasts, 22(3), 770-784.

D’Andrea, A. F., Aller, R. C., Lopex, G. R., 2002. Organic matter flux and reactivity on a South Carolina sandflat: The impacts of porewater advection and macrobiological structures. Limnological Oceanography, 47 (4):1056-1070.

D'Anna, C., Badalamenti, F., Gristina, M., & Pipitone, C. (1994). Influence of artificial reefs on coastal nekton assemblages of the Gulf of Castellammare (Northwest Sicily). Bulletin of Marine Science, 55(2-3), 418-433.

Dillard, S. C., 2008. Resuspension events and seabed dynamics in the Neuse River Estuary, NC. MS Thesis, East Carolina University.

Dolan, R., Fenster, M. S., 1993. Historical shoreline trends along the Outer Banks, North Carolina: Processes and Responses. Journal of Coastal Research 9:172-188.

Engineer Research & Development Center. 2017. Thin-Layer Placement website. https://tlp.el.erdc.dren.mil/case-studies/.

Eulie, D. O., Walsh, J. P., Corbett, D. R., 2013. High-resolution analysis of shoreline change and application of balloon-based aerial photography, Albemarle-Pamlico Estuarine System, North Carolina, USA. Limnology and Oceanography: Methods. 11, 151-160.

Eulie, D. O., 2014. Examination of estuarine sediment dynamics: Insights from the large, shallow, Albemarle-Pamlico Estuarine System, NC, USA. Dissertation. East Carolina University, Coastal Resources Management.

Findlay, S. E. G., Strayer, D. L., Smith, S. D., Curri, N., 2014. Magnitude and patterns of change in submerged aquatic vegetation of the tidal freshwater Hudson River. Estuaries and Coasts 37:1233-1242.

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., & Serrano, O., 2012. Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience, 5(7):505-509.

Gittman, R.K., A.M. Popowich, J.F. Bruno, and C.H. Peterson, 2014. Marshes with and without sill protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane. Ocean & Coastal Management 102: 94-102.

Grabowski, J.H., R.D. Brumbaugh, R. Conrad, A.G. Keeler, J. Opaluch, C.H. Peterson, M.F. Piehler, S.P. Powers, A.R. Smyth. 2012. Economic valuation of ecosystem services provided by oyster reefs. Bioscience 62: 900-909.

Hauxwell, J., J. Cebrian, C. Furlong, and I. Valiela. 2001. Macroalgal canopies contribute to eelgrass Zostera marina decline in temperate estuarine ecosystems. Ecology 82:1007–1022.

Hochard, S., C. Pinazo, C. Grenz, and J. L. B. Evans. 2010. Impact of microphytobenthos on the sediment biogeochemical cycles: A modeling approach. Ecological Modeling 221:1687–1701.

Howarth, R. W., and H. W. Paerl. 2008. Coastal marine eutrophication: Control of both nitrogen and phosphorus is necessary. Proceedings of the National Academy of Sciences of the United States 105:E103–E103.

Howarth, R. W., G. Billen, D. Swaney, A. Townsend, N. Jaworski, K. Lajtha, J. Downing, R. Elmgren, N. Caraco, T. Jordan, F. Berendse, J. Freney, V. Kudeyarov, P. Murdoch, and Z. Zhao-Liang. 1996. Regional nitrogen budgets and riverine N & P fluxes for the drainages to the North Atlantic Ocean: Natural and human influences. Biogeochemistry 35:75–139.

Hurricane Sandy Rebuilding Task Force, 2013. Hurricane Sandy Rebuilding Strategy. US Department of Housing and Urban Development, Washington, DC pp. 1–205.

Kelley, S. W., Ramsey, J. S., & Byrnes, M. R. (2004). Evaluating shoreline response to offshore sand mining for beach nourishment. Journal of Coastal Research, 89-100.

Kennedy, H., Beggins, J., Duarte, C. M., Fourqurean, J. W., Holmer, M., Marba, N., Middelburg, J. J., 2010. Seagrass sediments as a global carbon sink: Isotopic constraints. Global Biogeochemical Cycles 24.

Landin, M.C., 1997. The history, practice, and studies of construction, nourishment, protection, monitoring, and management of more than 2000 dredged material islands in US waterways. In: Landin, M., (Ed.), Proceedings, International Workshop on Dredged Material Beneficial Uses, Baltimore, MD, July 28–August, 1997, pp. 82–85.

Langan, J.P., 1988. Benefits of underwater berms. In: Landin, M.C., (Ed.), Beneficial Uses of Dredged Material: Proceedings of the North Atlantic Conference. 12–14 May 1987, Baltimore, MD. US Army Engineer Waterways Experiment Station, Vicksburg, MS, pp. 183–187

Larry E. Parson and Russell Swafford (2012) Beneficial Use of Sediments from Dredging Activities in the Gulf of Mexico. Journal of Coastal Research: Special Issue 60: pp. 45 – 50.

MacIntyre, H. L., & Cullen, J. J. (1995). Fine-scale vertical resolution of chlorophyll and photosynthetic parameters in shallow-water benthos. Marine Ecology Progress Series, 227-237.

Mallinson, D. J., Smith, C. W., Culver, S. J., Riggs, S. R., Ames, D., 2010. Geological characteristics and spatial distribution of paleo-inlet channels beneath the outer banks barrier islands, North Carolina, USA. Estuarine, Coastal and Shelf Science 88:175-189.

Mallinson, D.J., Smith, C.W., Mahan, S., Culver, S.J., McDowell, K., 2011. Barrier island response to late Holocene climate events, North Carolina, USA. Quaternary Research 76:46–57. doi:10.1016/j yqres.2011.05.001

Mcleod, E., Chmura, G. L, Bouillon, S., Salm, R., Bjork, M., Duarte, C. M., Lovelock, C. E., Schlesinger, W. H., Silliman, B. R., 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Frontiers in Ecology and the Environment 9(10):552-560.

McKinney, R.A., Raposa, K.B., Kutcher, T.E., 2010. Use of urban marine habitats by foraging wading birds. Urban Ecosyst. 13, 191–208.

Miller, D. C., Geider, R. J., & MacIntyre, H. L. (1996). Microphytobenthos: the ecological role of the “secret garden” of unvegetated, shallow-water marine habitats. II. Role in sediment stability and shallow-water food webs. Estuaries and Coasts, 19(2), 202-212.

Millrath, K., Kozlova, S., Shimanovich, S., & Meyer, C. (2001). Beneficial use of dredged material 2. Progress report prepared for Echo Environmental, Inc., Columbia University, New York, NY.

Mulligan, R. P., Walsh, J. P., Wadman, H. M., 2014. Storm surge and surface waves in a shallow lagoonal estuary during the crossing of a hurricane. American Society of Civil Engineers.

NC Division of Coastal Management. 2009. https://deq.nc.gov/about/divisions/coastal-management/coastal-management-estuarine-shorelines/stabilization/how-stabilize-your-estuarine-shoreline

NC Sea Level Rise Report, 2010. http://deq.nc.gov/about/divisions/coastal-management/coastal-management-hot-topics/sea-level-rise.

NC Sea Level Rise Report, 2015. https://deq.nc.gov/about/divisions/coastal-management/coastal-resources-commission/sea-level-rise-study-update.

Orth, R. J., Wilcox, D. J., Whiting, J. R., Kenne, A. K., Nagey, L., Smith, E. R., 2014. 2014 Distribution of submerged aquatic vegetation in Chesapeake Bay and coastal bays. Special Scientific Report #158. Virginia Institute of Marine Science.

Palinkas, C.; Koch, E., 2012. Sediment Accumulation Rates and Submersed Aquatic Vegetation (SAV) Distributions in the Mesohaline Chesapeake Bay, USA. Estuaries and Coasts 35:1416-1431.

Panamerican Consultants, Ltd., 2016. Underwater Archaeological Survey and Diver Assessment/Evaluation for Future Extension Concept/2014B Revised Bridge on New Location, Bonner Bridge Project, Dare County, North Carolina. Report prepared for North Carolina Department of Transportation.

Peek, K.M., Mallinson, D.J., Culver, S.J., Mahan, S.A., 2013. Holocene Geologic Development of the Cape Hatteras Region, Outer Banks, North Carolina, USA. Journal of Coastal Research 30:41–58.

Piehler, M.F. and A.R. Smyth. 2011. Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. Ecosphere 2(1):art12.

Pinckney, J., & Zingmark, R. G. (1993a). Biomass and production of benthic microalgal communities in estuarine habitats. Estuaries and Coasts, 16(4), 887-897.

Pinckney, J., & Zingmark, R. G. (1993b). Photophysiological responses of intertidal benthic microalgal communities to in situ light environments: methodological considerations. Limnology and Oceanography, 38(7), 1373-1383.

Pinsky, M. L., G. Guannel, and K. K. Arkema. 2013. Quantifying wave attenuation to inform coastal habitat conservation. Ecosphere 4(8):95. http://dx.doi.org/10.1890/ES13-00080.1

Rabalais, N., R. Turner, and W. Wiseman. 2002. Gulf of Mexico hypoxia, aka ‘‘The dead zone’’. Annual Review of Ecology and Systematics 33:235–263.

Riggs, S.R., Ames, D.V., Culver, S.J., Mallinson, D.J., 2011. The battle for North Carolina’s coast: Evolutionary history, present crisis, and vision for the future. The University of North Carolina Press. Chapel Hill, NC, 160 pp.

Riggs, S.R., Ames, D.V., Culver, S.J., Mallinson, D.J., Corbett, D.R., and Walsh, J.P., 2009, Eye of a human hurricane: Pea Island, Oregon Inlet, and Bodie Island, northern Outer Banks, North Carolina, in Kelley, J.T., Pilkey, O.H., and Cooper, J.A.G., eds., America’s Most Vulnerable

Coastal Communities: Geological Society of America Special Paper 460, p. 43–71, doi: 10.1130/2009.2460(04).

Riggs, S. R., Ames, D. V., 2003. Book: Drowning NC Coast.

Rothschild, B. J., J. S. Ault, P. Goulietquer & M. He´ral. 1994. Decline of the Chesapeake Bay oyster population: A century of habitat destruction and overfishing. Mar. Ecol. Prog. Ser. 111:29–39.

Rousseau, M.A., (2008), Massachusetts Marine Artificial Reef Plan, Massachusetts Division of Marine Fisheries, Fisheries Policy Report FP-3.

Shepard, C. C., Crain, C. M., Beck, M. W., 2011. The protective role of coastal marshes: a systematic review and meta-analysis. Plos One 6, 11: e27374. doi:10.1371/journal.pone.0027374

Smith, C. G. S.J. Culver, S.R. Riggs, D. Ames, D.R. Corbett, and D. Mallinson, 2008. Geospatial Analysis of Barrier Island Width of Two Segments of the Outer Banks, North Carolina, USA: anthropogenic curtailment of natural self-sustaining processes. Journal of Coastal Research. 24, 70-83.

Squires, D. F. (1992). Quantifying anthropogenic shoreline modification of the Hudson River and estuary from European contact to modern time. Coastal Management, 20(4), 343-354.

Stickney, R. R., & Perlmutter, D. (1975). Impact of intracoastal waterway maintenance dredging on a mud bottom benthos community. Biological Conservation, 7(3), 211-225.

Stinchcomb, C. and R. Sharrett. 2015. Poplar Island Reaching Capacity; Expansion Authorized by WRRDA 2014. International Dredging Review. January-February 2015. http://www.dredgemag.com/January-February-2015/P-oplar-Island-Reaching-Capacity-Expansion-Authorized-by-WRRDA-2014/

Swerida, R.M., 2013. Water flow and sediment grain size as co-varying SAV habitat requirements (M.S.). University of Maryland, College Park, Ann Arbor.

Talton, T. 2017. Corps Eases Living Shoreline Permit Process. Coastal Review Online. https://www.coastalreview.org/2017/01/corps-eases-living-shoreline-permit-process/

USEPA/USACE. 2004. "Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework," EPA842-B-92-008, U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Washington, D.C. https://www.epa.gov/sites/production/files/2015-09/documents/2004_08_20_oceans_regulatory_dumpdredged_framework_techframework.pdf

USEPA/USACE. 2007a. "Identifying, Planning, and Financing Beneficial Use Projects Using Dredged Material- Beneficial Use Planning Manual." EPA842-B-07-001, U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Washington, D.C.

https://www.epa.gov/sites/production/files/2015-08/documents/identifying_planning_and_financing_beneficial_use_projects.pdf

USEPA/USACE. 2007b. "Case Study: Beneficial Uses of Dredged Material Poplar Island, Chesapeake Bay." EPA842-F-07-001C. U.S. Environmental Protection Agency/U.S. Army Corps of Engineers, Washington, DC.

Vankevich, P. 2015. "Maritime birds find sanctuary on dredge spoil island". Ocracoke Observer, September 24, 2015. https://ocracokeobserver.com/2015/09/24/maritime-birds-find-sanctuary-on-dredge-spoil-island/

Weinstein, M. P., & Weishar, L. L. (2002). Beneficial use of dredged material to enhance the restoration trajectories of formerly diked lands. Ecological Engineering, 19(3), 187-201.

Wells, J., Kim, S.-Y., 1989. Sedimentation in the Albemarle-Pamlico Lagoonal System: Synthesis and Hypothesis. Marine Geology 88:263–284.

Whitney, D. E., and W. M. Darley. Effect of light intensity upon salt marsh benthic microalgal photosynthesis. Marine Biology 75.2 (1983): 249-252.

Wicks, E. C., Koch, E. W., O'Neil, J. M., Elliston, K., 2009. Effects of sediment organic content and the hydrodynamic conditions on the growth and distribution of Zostera marina. Marine Ecology Progress Series 378:71-80.

Wildish, D. J., & Thomas, M. L. H. (1985). Effects of dredging and dumping on benthos of Saint John Harbour, Canada. Marine Environmental Research, 15(1), 45-57.

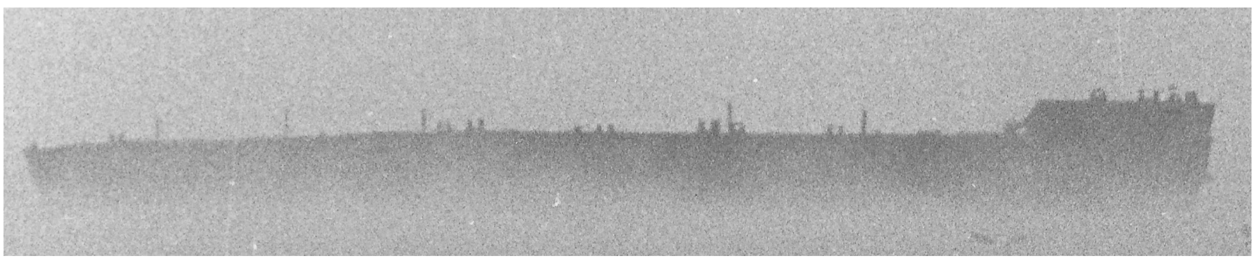
Yozzo, D. J., Wilber, P., & Will, R. J. (2004). Beneficial use of dredged material for habitat creation, enhancement, and restoration in New York–New Jersey Harbor. Journal of Environmental Management, 73(1), 39-52.

APPENDICES

Rodanthe-Stumpy Point Ferry Channel
Marine Debris/Cultural Resources Assessment

Nathan Richards, PhD, RPA
Adam Parker, MA, RPA

UNC-Coastal Studies Institute, Maritime Heritage Program &
East Carolina University, Program in Maritime Studies



Report submitted to:

North Carolina Department of Transportation (partial fulfilment of project ID: 2015-20)

&

North Carolina Underwater Archaeology Branch (fulfilment of permit #16PAS652)

March 2017

ACKNOWLEDGEMENTS

Thanks are owed to Greg Stratton for sharing archival research advice before the commencement of research and to Jim Kinsella for assist with historical research in the spring of 2015 (especially initial record collection at the NCUAB). The authors also want to extend our appreciation to Jim Kinsella and Scott Rose for assistance with remote sensing and shoreline transect fieldwork during the summer of 2015 and C.J. Cornette for providing access to historical dredging documents.

The staff of the NC Underwater Archaeology Branch at Kure Beach, NC (John Morris, III and Nathan Henry) are owed our appreciation for providing access to archaeology and maritime history site archives and for providing scans of files used in the preliminary phases of research. Similarly, Mark Keusenkothen, Mike Baker, and Eric Diaddorio (East Carolina University's Diving and Water Safety Office) are thanked for assisting with boat operations. Thanks must also be extended to all of our CSI colleagues responsible for leading the ecological and geological components of this project – Dr. Mike Piehler, Dr. Lindsay Dubbs, Dr. Reide Corbett, Dr. J.P. Walsh, and Dr. Nancy White. Particular thanks are extended to colleagues and CSI employees John McCord, Robert McClendon, Ryan Bradley, Marie Magee, and Corey Adams, who either assisted in field work or helped with critical aspects of grant management.

The staff of the Outer Banks History Center, KaeLi Schurr, Tama Creef, and Stuart Parks, helped immensely during the process of researching local history. Many individuals at the North Carolina Department of Transportation (NCDOT) assisted throughout the project – thanks in particular to John Kirby.

Work on site PAS0001 is now continuing because of this report. We are indebted to Mel Covey (Waves, NC) for allowing us to use photographs of the "Pappy's Lane Wreck" and for providing us copies of his research reports. Toward the end of the project, as clues regarding the Pappy's Lane Wreck were followed, parts of NCDOT aided with important historical research leads. Thanks to Pablo Hernandez (Manteo Resident Engineer), Matt T. Wilkerson (NCDOT archaeologist), Gretchen Byrum**,** and Demetria F. Walker (NCDOT maintenance yard). We appreciate the assistance of Dawson V. Carr, Edwin Hooper, and Pam Landrum for their ongoing assistance regarding this wreck. Last, but not least, our heartfelt appreciation is for Priscilla Delano, who helped with edits (all remaining errors are our own).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This report outlines an assessment of potential cultural resources and marine debris lying in an area subject to study under a North Carolina Department of Transportation (NCDOT) grant awarded to the UNC-Coastal Studies Institute entitled, "Research to support design and siting of deposition areas for dredged material from the Rodanthe Emergency Channel" (Project ID: 2015-20). The executive summary of the original grant proposal outlines the project's overall intentions in the areas of geological, ecological, and archaeological research, as well as in the area of education and outreach:

> This proposal from the UNC Coastal Studies Institute, administered by East Carolina University is to assist the NC DOT Ferry Division with assessing the use of dredged material and minimizing negative impacts of dredge material deposition. In many coastal systems, sediment is a critical commodity that allows habitats to maintain themselves in the face of long and short-term changes in water levels. In areas with high value habitats, finding low impact sites to deposit sediments, either on land or water based, is a challenge. Design of deposition sites that minimize environmental damage and maximize environmental benefits is necessarily an interdisciplinary venture.
>
> We have assembled a team to address the full suite of factors that must be considered in selecting a spill deposition site.
>
> Objectives and tasks
>
> 1. Map ecological, geological, physical and maritime heritage attributes of the area inland of the Rodanthe Channel,
> 2. Design material deposition site plans including location, size, morphology, ecological restoration and recreational attributes,
> 3. Evaluate the net impacts of potential material deposition site plans, including but not limited to negative and positive ecological, geological and anthropological impacts,
> 4. Design and execute an education campaign to inform the local and regional constituents about the rationale and costs and benefits of dredging and depositing the material from the Rodanthe Emergency Ferry Channel, and
> 5. Develop a material deposition site selection matrix that favors reducing negative ecological, geological and anthropological impacts.
>
> This project will result in an improved understanding of the geological, ecological and anthropological factors affecting siting of dredge material deposition sites in shallow coastal waters. Specifically we will provide a decision framework to support decisions – making with regards to dredge material deposition sites for the Rodanthe Emergency Channel (White et al. 2014:2).

This report predominantly concerns the objectives outlined in points 1 and 3, specifically the mapping of maritime heritage (tangible and intangible cultural resources) in an area adjacent to the present-day ferry channel at Rodanthe, and the evaluation as to whether there are significant (tangible) cultural resources in the same area. Once collected, described, and analyzed, this information along with reports from other project co-investigators may assist in fulfilling objectives outlined in points 2, 4, and 5. All research occurred under permit 16PAS652 as granted by the North Carolina Office of State Archaeology.

Rather than focus on one category of maritime archaeological site type (e.g. shipwrecks), the authors of this report chose to undertake a very broad consideration of the many ways that humans may have left indelible signatures of their activities in the landscape (i.e. their impacts over time). Following research, these came to be defined as, 1) impacts from dredging, 2) impacts from commerce, 3) impacts from conflict, and 4) impacts from marine accidents. This way researchers hoped to capture a picture of more intangible zones of human interaction within the study area, and understand how a broad array of changing water and shoreline use adjacent to Rodanthe may have culminated in the deposition of artifacts and the creation of archaeological sites within it. This approach allowed the researchers to understand the activities as reported in local history before archaeological research was undertaken so that ephemeral archaeological sites and isolated sound floor finds could be contextualized in association with documented human use of the area. Furthermore, such information could provide researchers with rich information that would illuminate the history of an area of Pamlico Sound and Hatteras Island that has not been the subject of extensive study. The location of Rodanthe, and the study areas are displayed in Figure 1.

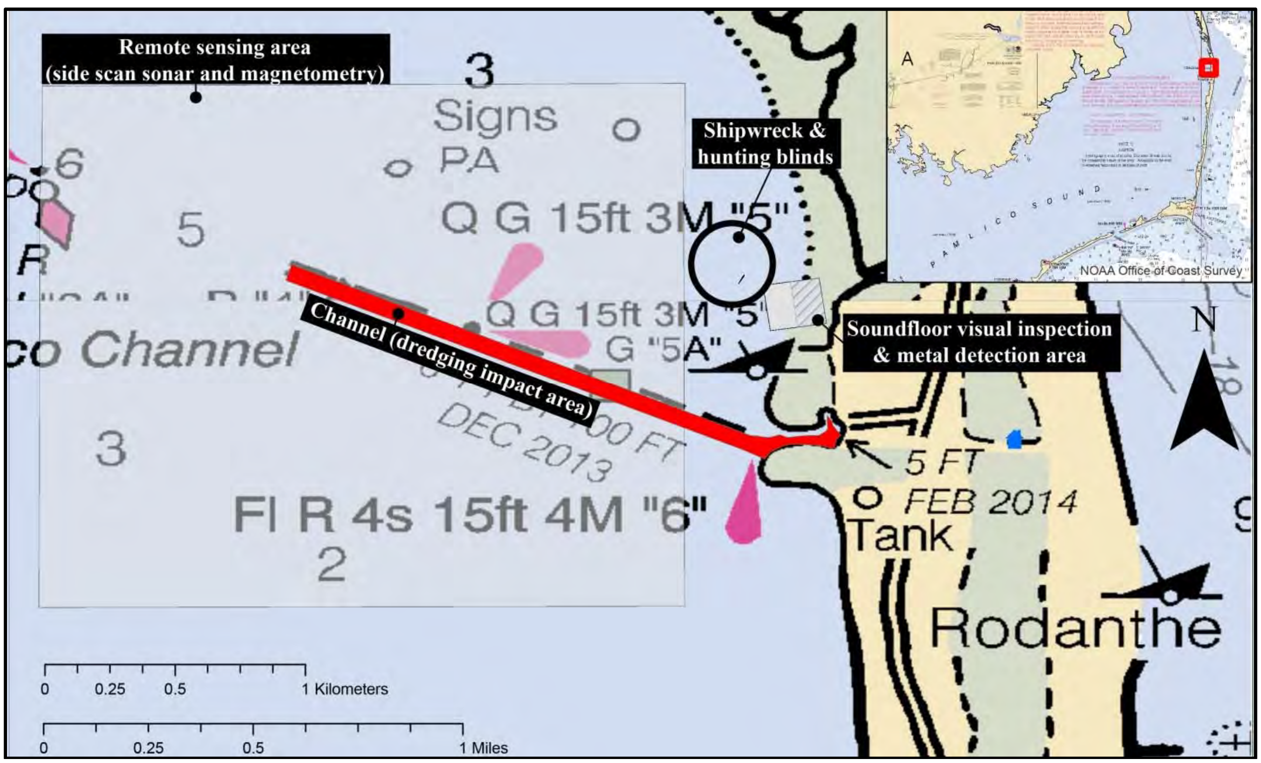


Figure 1. Overview of survey area, showing channel area (dredging impacts), area investigated during remote sensing, area of sound floor inspection and metal detection (sampled area), and discrete archaeological sites (shipwreck and hunting blinds) (Image by Nathan Richards).

The study area sits in a section of Pamlico Sound, adjacent to the village of Rodanthe. Today, Rodanthe is located toward the northern extent of Hatteras Island. It is the northernmost village of several settlements in the area – located 1.9 miles N of Waves, 3.8 miles N of Salvo, 17.3 miles N of Avon, and 23.5 miles N of Buxton. Rodanthe and two close villages (Salvo and Avon) for much of history were known by other names – Chicamacomico, Little Kinnakeet (13.2 miles S), and Big Kinnakeet (17.5 miles S), respectively, and associated most closely with U.S. Life-Saving Stations once situated there. This is the simplest way to tell the story of an area that has undergone numerous coastal and toponymic alterations over the last few centuries. As Powell and Hill explain, the name "Chicamacomico" refers to, "three communities on n part of Outer Banks, e Dare County, s of Pea Island: formerly North Rodanthe, South Rodanthe, and Clarks, now known as Rodanthe, Waves, and Salvo" (Powell and Hill 2010:111). To complicate matters further, this area is often referred to as the "Chicamacomico Banks," defined as "the name commonly given to Pea Island in e Dare County" (Powell and Hill 2010:111).

This name for this area, reputedly "derived from an Algonquian word for 'sinking-down sand'" (Wechter 1974:6; Powell and Hill 2010:11), has been labelled many ways, including "Chickinnaccamoc" and "Chichinock-cominock" over centuries (Stick 1958:284-285). These names first feature of John Lawson's map of 1709 – showing a feature sitting in the water well to the E of Cape Hatteras (Figure 2). The same name features on Herman Moll's 1729 map in a similar way (Figure 3).

The string of islands nestled between the Atlantic and the present-day Pamlico Sound as depicted in these maps has changed considerably since the eighteenth-century. Pamlico Sound (alternate spellings "Pamplico," "Pamtico," and "Pamticoe") is defined as

> ne and n North Carolina, is separated from the Atlantic Ocean by a part of the Outer Banks. Approx. 80 mi. long and 15 to 30 mi. wide. Shallow in the n; max. depth 21 ft. in the s. Sea level, freshwater, not affected by the tide. Waters from Albemarle Sound and Pamlico and Neuse Rivers enter the Sound, and it drains to the Atlantic Ocean through Hatteras and Ocracoke Inlets. Named for the Pamlico Indians who lived along its shores. Shown but not named on early maps; appears simply as The Sound on the Ogilby map, 1671, but as Pamticoe Sound on the Moseley map, 1733. The White map, 1590, labels the central part of the sound as Mentso, *which see*, and the n part as Nausegoc, *which see*. The largest sound on the e coast of the United States (Powell and Hill 2010:395).

Mentso, was defined as:

> … marked as the central part of Pamlico Sound, present-day Hyde County, on the White map, 1590, but apparently a place on the shore, as the name comes from an Indian word meaning "he cooks for the first time." The word could be the name given for a stopping place for eating on travels, perhaps the end of a day's journey in the direction of Roanoke Island (Powell and Hill 2010:342).

Powell and Hill also describe that this region was referred to as *Paquiac* by early European explorers:

Figure 2. John Lawson's map of The Western Ocean showing the location of North Carolina and the location of "Chickinnaccamoc" in red circle (Lawson 1709:60)

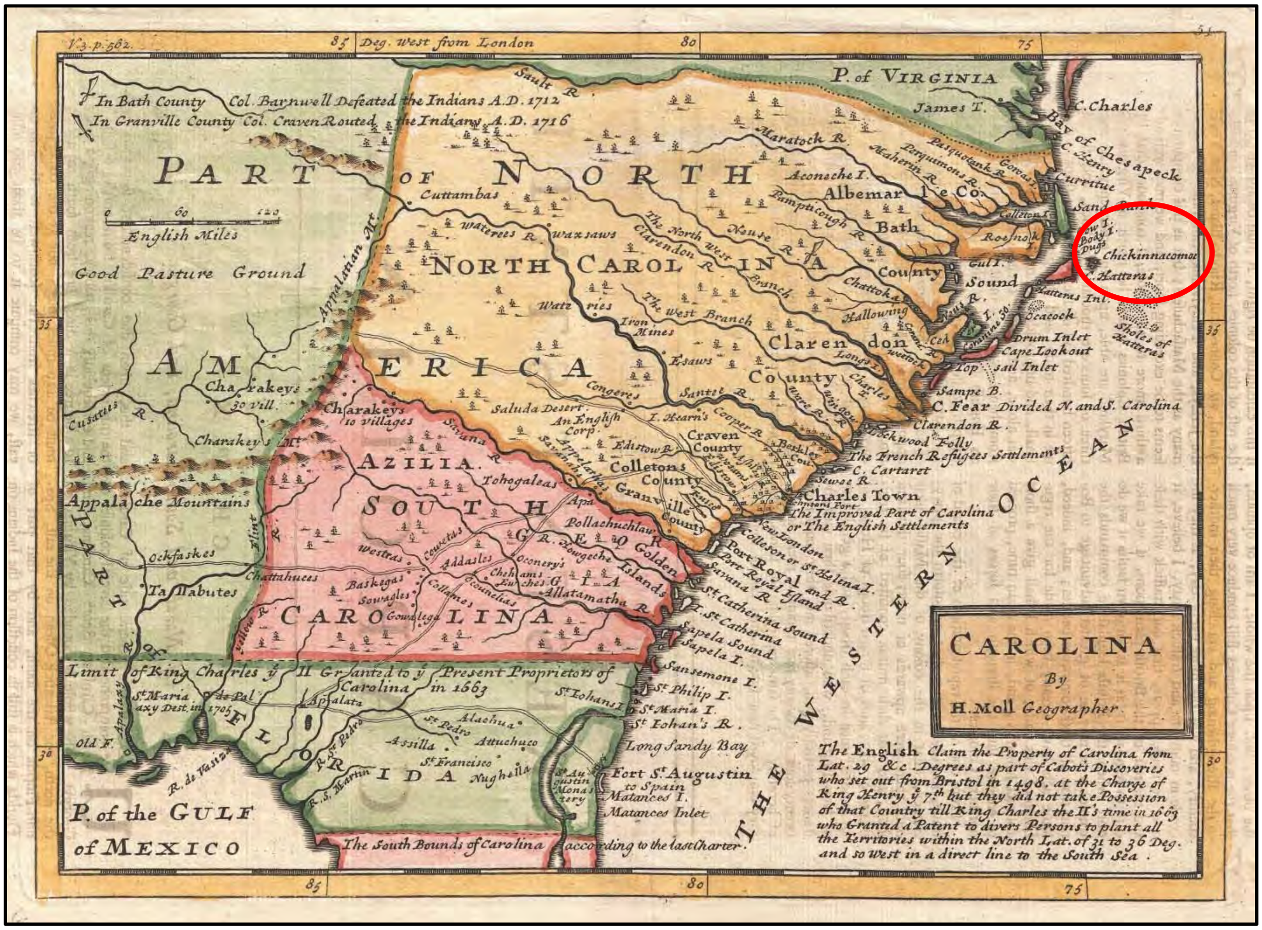


Figure 3. Herman Moll's map of Carolina, 1729. Red circle denotes location of "Chickinnacomoc" (Lefler and Powell 1973:63).

> … name given by John White on his maps of 1585 and 1590 to the section of Hatteras Island s of Cape Kenrick and extending almost to modern Cape Hatteras, se Dare County. The section lay between present Chicamacomico Banks and Kinnakeet Banks. The name Paquiac is an Algonquian Indian term for "it is too shallow," describing the adjacent Pamlico Sound (Powell and Hill 2010:396)

This leads one to the changing definition of "Chicamacomico Banks" and its variation "Chicamacomico." Rodney Barfield notes:

> **Chicamacomico Banks.** Chicamacomico once referred to the northern portion of what is today called Hatteras Island. In the colonial period, Chicamacomico ran from present-day Oregon Inlet to what was designated Kinnakeet Banks. The area was called Hatorask by the Raleigh colonists and on John White's map. Of Indian derivation, this name has been through a dozen different spellings (Barfield 1995:7, original emphasis)

David Stick (1958:284-285) gives a better overview of the nuances and importance of understanding the place name "Chicamacomico":

> This is a designation applied in the early days of settlement to what is now the entire northern section of Hatteras Island, as well as an inlet which was then located in the vicinity of Pea Island and to the shoal formation now referred to as Wimble Shoals.
>
> Undoubtedly it derives from an Indian name, and the early settlers seem to have had a difficult time deciding just how to spell it, for at least fourteen different spellings have been found on maps and in written records between 1730 and 1799. Among the earliest were "Chickony-Commock," "Chichinnacomoc," "Chickinocommock," and "Chickinocommuck." Later it appeared as "Chick," "Chickamacoomick," and "Chickamicomico" before becoming Chicamacomico in more recent times.
>
> All this confusion could have been averted if the first permanent settlers had retained the same name the Raleigh colonists used, for they called this area Hatorask—a designation which was applied later to the section farther south.
>
> A number of people had settled on Chicamacomico Banks well before the outbreak of the Revolutionary War. In 1744, when commissioners set out to survey the line which separated the so-called Granville Grant from the rest of North Carolina, they began at "a cedar stake set upon the sea side … being six miles and half to the southward of Chickmacomack inlet," and then they ran to the southward of the house wherein Thomas Wallis Liveth" before striking Pamlico Sound. In 1764 a commodity inspection port was located "At Chiconocomick, at Thomas Paine's Landing."

Politically, the area around present-day Rodanthe would have been located at the approximate southern boundary of the area defined as the Granville district (surveyed 1743-74) (Merrens 1964:8).

Various historical sources maintain several names for these villages bordering both the Atlantic Ocean and Pamlico Sound. While there are some variations in the story that is told regarding the place names of the region (see Table 1), many historical sources agree that the grouping of villages in the northern portion of Hatteras Island has also been known at various times as "Chicamacomico," "Chicamacomico Banks," or "old Chicamacomico" (Powell and Hill 2010:111; Babits et al. 2015:5). Elvin Hooper contends that today, locals call the area "the tri-village" and that people born in Rodanthe are called "Rodanthers" (Hooper 2004:xi, 2016:xi). Much of the uncertainty about place names is cleared up in the later part of the nineteenth century. In the 1870s, a series of Post Offices were established across the Outer Banks and the U.S. Postal Service, deciding that "Chicamacomico" was too difficult to pronounce, renamed the village "Rodanthe," though the Life-saving station also established there in 1874 (and later a U.S. Coast Guard base) retained the old name (Stick 1970:36-37; Wechter 1974:6; Barfield 1995:7-8; Kidder 2005:56; MacNeill 2008[1958]:52). This occurrence is discussed in MacNeill's 1958 semi-fictional work *The Hatterasman*, with irreverence:

> But now there were post offices and postmasters and a contract carrier of the mail. For reasons that continue to be obscure the Department, when it established post offices, changed the names of the communities. Chicamacomico became Rodanthe for no reason that I have been able to discover. Salvo became Salvo by

> virtue of having been the target for a badly aimed litter of cannonballs. The two Kinnakeets were lumped together and became just as obscurely, Avon. Cape became Buxton, Trent became Frisco, and only Hatteras retained its original name. Ocracoke, of course, had its own post office (MacNeill 2008[1958]:198-199).

Table 1. Various names for the "villages" of northern Hatteras Island (Sources Stick 1958:154, 285, 174, 1970:34; Barfield 1995:7-8; Hooper 2004:xi; Impact Assessment 2005a: 72, 108, 132, 2005b:488-489; Kidder 2005:56, 57; Powell and Hill 2010:452, 464, 552; Babits et al. 2015:5).

Place	Stick 1958, 1970	Barfield 1995	Hooper 2004	Kidder 2005	Powell and Hill 2010	Babits et al. 2015	Impact Assessment 2005a
Rodanthe	Chicamacomico/ North Rodanthe	Chicama-comico	Northard Woods	Chicama-comico	North Rodanthe	Chicamacomico	Chicamacomico
Waves	Chicamacomico/ South Rodanthe		Southard Woods	-	South Rodanthe	Chicamacomico/ South Chicamacomico/ South Rodanthe	Chicamacomico/ South Chicamacomico/ South Rodanthe
Salvo	Clarks/ Clarksville/ Cape Kenrick		Clarks	Chicama-comico/ Clarks	Clarks/ Clarksville	-	Clarks/ Clarksville

These toponymic variations are important because they are clues to the long human occupation of the region, as well as the complexities of undertaking research in the area. Researching human occupation and activities at "Rodanthe" is not just a scenario of researching this place name. In this case, the label had changed several ways over time. However, an additional hurdle is that amongst historians of the area, there is some disagreement regarding place names. The place names ostensibly connect one with the activities that occurred at the place, which in turn assist the researcher with ascertaining what archaeological material may lie within the study area.

The area around present-day Rodanthe could be considered a *peripheral location* which, while connected with the earliest days of European exploration and settlement attempt is not often explicitly listed in written histories of the state. Hence, toponymical variations can be important to researchers of this area due to a lack of mention in state historical records. As Lefler and Powell (1973:xv) write in their study of North Carolina's colonial history, "In the classic national histories, events in North Carolina often went unreported." If this is the case for the entire state, it is even more difficult for an isolated portion of its coastline which may not have featured prominently. This is a significant challenge when researching the area around Rodanthe. Indeed, the area of North Hatteras Island does not feature in published histories of the state until the nineteenth-century, and from a state-wide perspective cannot be considered an economically important place until the twentieth-century following the development of tourism in the region. In effect, it barely features in histories of North Carolina (e.g. Merrens 1964; Lefler and Powell 1973; Powell 1989).

There is an additional hurdle for researching the Rodanthe area. Any person researching a long period of history concerning any location on Hatteras Island soon realizes that place names have drifted as often and as far as its moving sands. Indeed, the area around present-day Rodanthe represents a place where that continues to go through changes. Think about the consequences for the people in the area as inlets opened and closed. An image published by Barfield (1995:viii) shows that various inlets known as "New Inlet" opened and closed at various times in the past 300 years, being open between 1708-1922 and 1932-1945 (see also Stick 1958:9). A more scientifically-based image created by Mallinson (et al. 2008:6) illustrates a dynamic pattern of multiple inlet openings and closings with a range of named inlets opening and closing at various times since 1657 and for different periods of time (Figure 4). Each opening or closing would have dramatically transformed the lives of the people in the area by having effects (some negative, some positive) on transportation to and from their homes, and the nature of trade occurring there, as well as influencing the rate and nature of development. Adverse weather has played a role as well – as hurricanes and nor'easters have had a long history of significant social and economic impacts on the people of Northern Hatteras Island, some of which is potentially decipherable within the archaeological record in the form of lost boats and nets or the washing of building materials into adjacent waters (see for example, Stick 1987:xi; Downing 2014:78).

With the knowledge that the people living in this study area have lived on a periodically inundated and shifting sand bar with constantly changing physical, political, economic, and social boundaries, the authors of this report resolved to gather as much information from the historical record regarding human activities adjacent to the study area before carrying out a multi-stage schedule of fieldwork to inspect a portion of the Pamlico Sound's shorelines and sound floor. The remaining sections of this report outline the methodology of the project (Chapter 2), an assessment of cultural impacts described in the historical record (Chapter 3), and a communication of the results of archaeological research (Chapter 4), before final conclusions and recommendations are presented (Chapter 5).

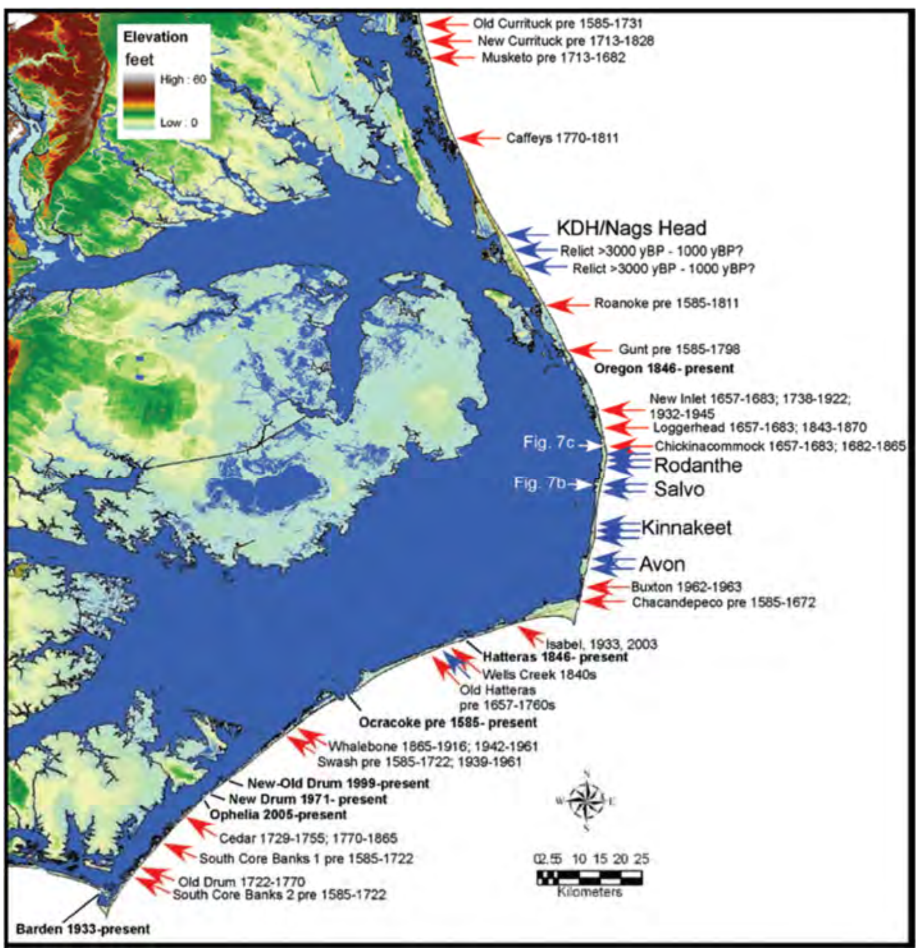


Figure 4. Map illustrating the approximate locations and dates of existence of documented historic inlets (red arrows) and modern-day place names (blue arrows) (from Mallinson et al. 2008:6).

2

METHODOLOGY

Archaeologists employed multiple stages, techniques, and tools to assess the potential for the presence of archaeological sites in the area adjacent to the Rodanthe-Stumpy Point Emergency Ferry Channel. The first step consisted of extensive historical research and the review of reports from previous archaeological investigations. The primary sources of historical data came from the North Carolina Underwater Archaeology Branch's (NCUAB, Kure Beach) maritime archaeological site reports and shipwreck histories, microfilm records of the United States Life-Saving Service from the Outer Banks Historical Center in Manteo, and the National Oceanographic and Atmospheric Administration's (NOAA) online database of historic maps. Additionally, newspapers from East Carolina University's historical online databases and secondary sources were also used. The goal of these phases of data collection was to, 1) assess whether shipwrecks may have been wrecked in, or adjacent to the study area, 2) to consider whether other commercial, industrial, or recreational activities undertaken by humans may have culminated in other archaeological sites or deposits in the area, and 3) whether changing use of the area could be reflected in the cartographic record.

The second step in the project's methodology was to compile a Geographic Information Systems (GIS) model of the study area. This allowed researchers to collate all historical research into a layered geospatial format allowing for activity areas to be displayed and to examine how the Rodanthe shoreline may have changed over time. This was also an important phase in identifying potential shipwreck locations. The final step was to conduct field work according to the research contained within the GIS. For this, a side scan sonar and magnetometer survey was conducted along with a shoreline transect survey in areas close to shore that were too shallow for boat access.

Historical Research

Historical research commenced with a survey of some of the most general overviews of the region including Gary S. Dunbar's *Historical Geography of the North Carolina Outer Banks* (1958), David Stick's *The Outer Banks of North* Carolina (1958) and *An Outer Banks Reader* (1998), Charles T. Williams, II's *The Kinnakeeter* (1975, 2nd edition 2016), Rodney Barfield's *Seasoned by Salt* (1995), John Hairr's *Images of America: Outer* Banks (1999), Chris Kidder's *The Outer Banks in Vintage Postcards* (2005), specific articles in Powell's *Encyclopedia of North Carolina* (2006), Sarah Downing's *Hidden History of the Outer Banks* (2013) and *On this Day in Outer Banks History* (2014), and Hoyt et al.'s *"Graveyard of the Atlantic": An Overview of North Carolina's Maritime Cultural Landscape* (2014) in order to assess the role of the area in general Outer Banks history.

Other thematic reading was also undertaken. The early and colonial history of the area was gleaned through Merren's *Colonial North Carolina in the Eighteenth Century: A Study in Historical Geography* (1964), Lefler and Powell's *Colonial North Carolina: A History* (1973), Cumming's *Mapping the North Carolina Coast: Sixteenth-Century Cartography and the Roanoke Voyages* (1988), and sections of Powell's *North Carolina: Through Four Centuries* (1989). County and regional histories examined include Stick's *Dare County: A Brief History* (1970) and *The Ash Wednesday Storm* (1987), Mansfield's *Song of an Unsung Place: Living Traditions by the Pamlico Sound* (2001), Simpson and Taylor's *The Coasts of Carolina: Seaside* *and Sound Country* (2010), and Wise's *History of Stumpy Point: Village in the Wilderness* (2014). Some nineteenth and twentieth century reminiscences and travelogues were also found, including Nathaniel Bishop's *Voyage of the Paper Canoe: A Geographical Journey of 2500 miles from Quebec to the Gulf of Mexico, During the Years 1874-5* (1878), and Henry Plummer's *The Boy, Me and the Cat: Life Aboard the Small Boat from Massachusetts to Florida and Back in 1912* (1914). These provided context to social and economic conditions in the area and also described many of the factors influencing travel through the area (including extant landmarks and utilization of Pamlico Sound).

Research on historical themes, such as the Civil War, involved examining many of the seminal sources on the subject such as Trotter's *Ironclads and Columbiads: The Civil War in North Carolina (The Coast)* (1989), Marcinko's "Federal Operations at Hatteras Inlet, North Carolina, 1861" (2000), Carbone's *The Civil War in Coastal North* Carolina (2001), and Zatarga's *The Battle of Roanoke Island: Burnside and the Fight for North Carolina* (2015), and also included recent terrestrial archaeological surveys of the area (Babits et al. 2015; Covey 2016). While some of these sources were not primarily concerned with the study area, they outlined histories of events peripheral to it, or that involved combatants and actors who would be involved in events of importance. In this regard, the source of most relevance to Civil War history of the study area was Lee Oxford's *The Civil War on Hatteras: The Chicamacomico Affair and the Capture of the U.S. Gunboat Fanny* (2013).

Finally, no study of this area would be complete without a review of the role of the United States Life-Saving Service. Literature reviewed included Joe Mobley's *Ship Ashore! The U.S. Lifesavers of Coastal North Carolina* (1994), Wright and Zoby's *Fire on the Beach: Recovering the Lost Story of Richard Etheridge and the Pea Island Lifesavers* (2000), Shanks and York's *The U.S. Life-Saving Service: Heroes, Rescues and Architecture of the Early Coast Guard* (2009), and Joshua Marano's MA thesis "Ship Ashore! The Role of Risk in the Development of the United States Life-Saving Service and Its Effects on Wrecking Patterns Along the North Carolina Coast" (2012). By reading a broad array of sources, the research team was able to piece together a picture of the region's changing economic and social conditions translated to activities that occurred in the study area (and may have culminated in the creation of archaeological sites within it). Reading these sources also gave insight into potential demographic changes.

This research allowed for general themes regarding the survey area and surrounding landscape to be collated and understood. It also provided insight into the population and trade connections between the study area and other areas, in addition to shedding light on any commercial, industrial, and recreational activities that occurred near Rodanthe and may have left behind physical remnants of such activity. As such, this research to identify the *tangible resources* that may be within the study area's boundaries, but also ascertain some of the area's *intangible significance*.

Historical research regarding shipwrecks came in three distinct forms: analysis of the NCUAB's shipwreck report and histories databases, analysis of Life-Saving Station records, specifically those from the Chicamacomico Station, and examination of historic maps for later embedding in the GIS model. These phases of research built upon each other and helped researchers determine the possibility of finding any new cultural resources in the search area by pinpointing which ships had wrecked in the area.

The NCUAB's archives are split into two groups. The first consists of shipwreck reports of maritime archaeological sites already found and examined and researched. If a vessel was identified, the history of the wrecking event was included in these files. These files also include the site's state archaeological code designation. For example, there are two shipwrecks that have been inspected in Pamlico Sound and identified in the archive – with site designations PAS0001 and PAS0002 denoting that they are the first and second verified wrecks (or wreck debris) reported to the NCUAB. In this case, PAS0001 lies within the study area, and is known as the "Pappy's Lane Wreck" (Figure 5). The wreck was recorded in 2010 by students from East Carolina University under the instruction of Dr. Nathan Richards. At the time of the project, local lore contended that the wreck is that of an unidentified ferrous-hulled barge, used to carry gravel to Rodanthe. While it had an archaeological site file, it had no corresponding historical site file -- it is a relatively modern wreck with very little historical information pertaining to it, and no definitive historical identity.

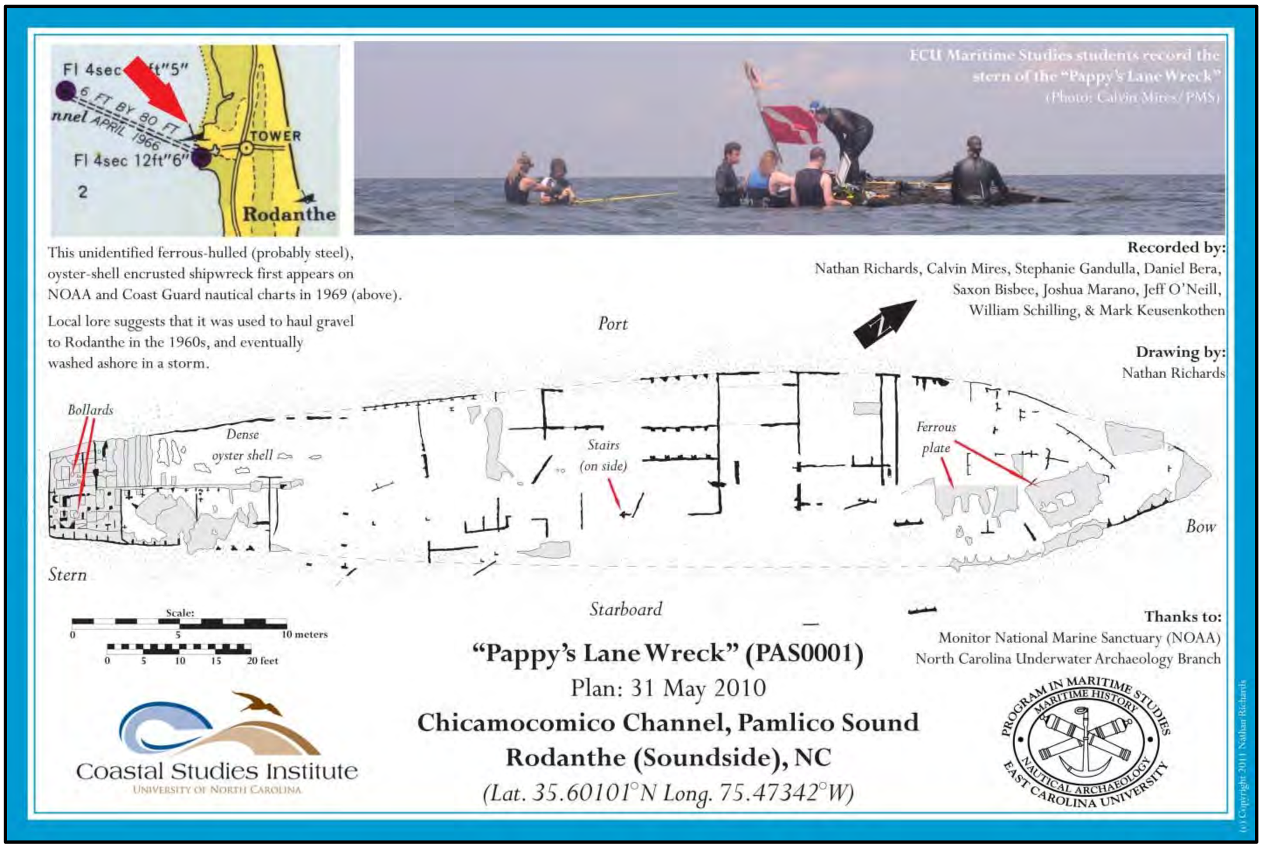


Figure 5. Poster showing site plan and interpretation of "Pappy's Lane Wreck" (PAS0001) from 31 May 2010 survey undertaken by East Carolina University and the UNC-Coastal Studies Institute (Image by Nathan Richards, 2010).

The second group of NCUAB archival material includes those ships that have potentially been wrecked (i.e. have been involved in maritime incidents and accidents), but may or may not have a corresponding file representing archaeological evidence of the wrecking event. All available records from both groups were photocopied with permission from the UAB and later analyzed for those wrecking events that occurred near Chicamacomico.

The project team cast a wide net when beginning research, assessing all the records listed under the "PAS," "NHB," and "SHB" designations (Pamlico Sound, North Hatteras Beach, and South Hatteras Beach, respectively) in the NCUAB record in case any sites were misclassified. Records of over 800 *disaster incidents* (i.e. not necessarily confirmed *shipwrecks*) from the areas were copied and examined (as Pamlico Sound is very large – stretching from the southern tip of Roanoke Island to the mouth of the Neuse River). NHB- and SHB-classified wrecks were also included because shipwrecks may be periodically misclassified into the wrong adjacent region (e.g. one example of a shipwreck in the Pea Island Beach area has been determined to lie within Pamlico Sound area, and potentially within the study area). Following conformation that NHB and SHB classifications were correct, attention was placed on the PAS files (310 candidates). Following their assessment, wrecks were placed into "outside study area" classification (and excluded from further research), and either "unknown" (17 candidates) or "confirmed" (7 apparently unambiguous candidates) status. "Unknown status" was assigned to vessels whose incident location needed to be determined to ascertain their proximity to the study area. Only records of ships that had been involved in a disaster on Pamlico Sound were taken, as any that had occurred on the Atlantic Ocean were outside the project's scope and objectives. At this stage, additional research was required.

First, to determine locations of potential wrecking locations, researchers examined place names in *The North Carolina Gazeteer* (Powell and Hill 2010), and collated historic maps and charts of the Rodanthe area. Some additional secondary sources were also consulted -- for example, a 2012 MA thesis by Joshua Marano which studied wrecking incidents adjacent to Oregon Inlet from 1876 to 1915. Marano's research lists ten incidents or wrecks in the approximate study area and is mostly congruent with the NCUAB dataset.

These lists of ships were subjected to historical research to find out if the maritime incidents they represented occurred within or close to the study area. Research began by examining U.S. Life-Saving Station wreck reports located at the Outer Banks History Center in Manteo. References to the ships in newspapers and published government reports (U.S. Life-Saving Service, U.S. Coast Guard, U.S. Army Corps of Engineers, U.S. Department of Commerce, and U.S. Department of Treasury) were sought out. At this stage, thirteen vessels were observed to have been involved in a disaster near the study area (Table 2). It should be noted that due to a preponderance of very detailed and accessible records pertaining to the periods following the establishment of the U.S. Life-Saving Station (and later the U.S. Coast Guard) on the Outer Banks, there is a bias present for the period 1874 to 1954. Only one shipwreck is listed before this period, and its extant records are not considerable.

Most the thirteen candidates in the list above are mentioned in marine incident reports made by a life-saving station keeper within the area. This explicit mention also listed an estimated distance and location. As these approximations were made in the nineteenth century or early twentieth century during a time before very accurate position fixing, a tolerance of many miles was added to projected spatial locations to account for possible errors made by the station keeper. This was a conservative approach for any later consideration that a ship may be laying in the study area.

The historical researchers also engaged in other careful archival research. Even if a notation to the "loss" of a ship was noted in the wrecking report, they opted to continue research regarding the ship post-wrecking. In cases where an official number for the ship was included this was very easy, as marine insurance registers and U.S. government reports such as the *Annual List of Merchant Vessels of the United States* (U.S. Bureau of Marine Inspection and Navigation) utilized these numbers as an equivalent of a Vehicle Identification Number (VIN), enabling the tracking of each ship's vital statistics (such as length, beam, depth of hold, tonnage, port of registry, port of construction, and at times crew size) through time. With these data, service life biographies of each vessel were written. Some secondary sources were also used, which at times mentioned individual ships by name if they were involved in significant events.

Table 2. List of final marine accident and incident candidates.

#	Final candidates (ordered by year of incident)	UAB	Marano	Note
1	*Captain's Boat* – 1821	Y		
2	*Lydia Ann* – 1886	Y	Y	Year of incident misclassified
3	*Extra* – 1887	Y	Y	
4	*Lou Willis* – 1895	Y	Y	
5	*Haze – 1895*	Y		
6	*Rosa B. Cora* – 1895	Y	Y	
7	*Anna Laura* – 1896	Y		
8	*Lula Tillet* – 1898	Y	Y	
9	Unknown Boat – 1899	Y	Y	Marano classifies as "Fishboat"
10	*Two Sisters* – 1902 & 1914		Y	
11	*Lonie Buren* – 1903	Y	Y	
12	*Mabel E. Horton* – 1906	Y	Y	
13	*R.C. Beaman* - 1910	Y	Y	Misclassified under "PEB" – Pea Island Beach

As a result, researchers were able to determine that many of the vessels had multiple wrecking events associated with them, and that in almost all cases, the ships were eventually refloated (many having long successful commercial lives elsewhere). It also allowed the researchers to consider if the wrecking event, while not culminating in a wrecked hull may have left behind some sort of material culture – in the form of hull debris or lost cargo. The compilation of these ship biographies also allowed for additional contextual information regarding the historical significance of the ship to be determined and assisted in building a picture of the activities occurring within the study area.

Researchers too an additional precaution by checking many of the volumes outlining lists of shipwrecks in North Carolina. These included Stick's *Graveyard of the Atlantic* (1952); Lonsdale and Kaplan's *A Guide to Sunken Ships in American Waters* (1964), Berman's *Encyclopedia of American Shipwrecks* (1972), Gentile's *Shipwrecks of North Carolina from Diamond Shoals North* (1993), Freitag's *Shipwrecks Unforgotten from New Jersey to the Gulf of Florida*: *A Reference Guide* (1998), Charles' *North Carolina Shipwreck Accounts: 1709 to 1950 including over 1100 named wrecks* (2004), and Duffus' *Shipwrecks of the Outer Banks: An Illustrated Guide* (2007).

As a penultimate step, the final list of ship names was correlated to photographic collections, such as the photographic collections of the Library of Congress, the National Archives, UNC-Chapel Hill, East Carolina University, the Outer Banks History Center, and the Mariner's Museum Library. No historical photographs of any of the ships were found.

As a final step of historical research, researchers used the compiled dossier on each of the thirteen ships to reconstruct an approximate relative position of the wrecking event within the study area – allowing the GIS model to be collated and used for planning the remote sensing methodology.

Cartographic Sources and Geographical Information System

Researchers paid close attention to cartographic sources of the area due to the extremely dynamic and ever-changing environment of North Carolina's Outer Banks islands. Ocean and sound side shorelines are constantly eroding or being built up by sand deposition due to the influence of the Atlantic Ocean (Riggs and Ames 2003:13). Given the shorelines' ever-changing nature, maps throughout the history of the Outer Banks' settlements must be considered in any study of the area to determine which hazards the coastal traders may have encountered during their day.

The second reason behind using historical maps is to examine how the shoreline has changed from the past to its present form and how the shoreline changes may have affected any cultural material that may be present in the study area. Additionally, it would show where certain inlets such as Loggerhead or New Inlets, were located and when they were closed by shoaling. All cartographic sources were collected from the National Oceanic and Atmospheric Administration's (NOAA) Historic Maps Collection.

To begin the process of creating a GIS model, a modern NOAA basemap (chart) was imported into ESRI *ArcGIS* 10.1 software. The GIS software was then used to geo-rectify the cartographic images to the modern base-maps and to examine changes in the areas shoreline throughout history. The collation of these cartographic depictions also allowed researchers to examine changing cartographic symbols within the area (a clue to wrecking events or changing landscape use). A collection of 180 separate charts adjacent to Rodanthe are available for download from the NOAA historical charts website (http://historicalcharts.noaa.gov/, see Appendix 1).

While the NOAA basemaps contain geospatial information such as the latitude and longitude confinements of the chart's survey area and projection, this information was not present in the map images. The historic maps were images scanned by NOAA and thus had to be rectified to line up to the geospatially accurate base-maps. Using this method purposefully distorts the map images by taking a certain point on the image and lining that point up to a corresponding point on the modern basemap. In order for the most accurate geo-rectification, this process was repeated with several points on each map image. As each map displayed different information from a distinct period in time, each was georeferenced separately to the basemaps.

The choice of which reference points to select was a complicated matter. The best options for points are buildings or landscape features that typically remain static and unchanging for several years, such as lighthouses or mountains. For the Outer Banks, this proves difficult, as there was little development throughout the islands until modern times (Dolan and Lins 2000:20-25). Thus, with appropriate stable and long-term landscape features absent on many of the maps, natural landscape features present between the map image and modern basemaps were used. Due to the issues associated with the dynamic nature of the Outer Banks' shorelines (Riggs and Ames 2003:13), there is a certain degree of error in using the natural landscape features as points to rectify the images. This is noted to ensure transparency in the methodology of the GIS model creation. While the points used for the rectification of each map was determined as each was imported (due to the differences in content each map displayed), there are several points that were used on a large majority of the maps. These points included: Stumpy Point, Pains Point, Gull Island, Duck Island, Cape Hatteras and nearby Durant and Brooke Points. Three separate points were used on Roanoke Island: Northwest Point, Ballast Point, and the S end of the island's marsh shoreline. Despite the degree of error involved in the geo-rectification from using natural landscape features, every map was referenced with an average of 15-17 points. Using this many points offset the degree of error. The result was a fairly accurate geo-rectification for each map image.

Following geo-rectification, estimations regarding areas of human activities, or the location of potential shipwreck sites associated with the survey area could be plotted onto the

GIS. Here it should be noted that, for example, the wreck reports made by life-saving station keepers give details about the position of the wrecked ship in relation to the life-saving station. None of these locations can be taken as completely accurate – rather, they are general estimates of unknowable accuracy. Nevertheless, they are the best estimations available for plotting wreck or disaster locations. Therefore, using the Chicamacomico Station as the starting point, a line was measured in the general direction of the wreck from the station. Each location was then recorded as a point feature in the model. To offset the degree of error from the station keeper's estimation, the point was then buffered to have a radius of one-half mile that represented where evidence of the wreck may be present. From this point, the buffers of all wrecking events were turned on and examined for relationships to the proposed survey area.

Side Scan Sonar and Magnetometer Survey

Field work to collect data within the survey area (Figure 1) was conducted from 20 July to 19 August 2015. The proposed methodology for the remote sensing portion of the survey included using a Klein 3000H dual frequency (445/900 kHz) model side scan sonar, a Geometrics G882 Cesium magnetometer (Figure 6), and a Trimble AgGPS542 differential global positioning system (GPS). The sonar and GPS belonged to University of North Carolina's Coastal Studies Institute (CSI) while the magnetometer was on loan from East Carolina University's Program in Maritime Studies. Additionally, the vessel chosen was R/V *Viper*, rented from East Carolina University's Diving and Water Safety Office.

Figure 6. Jim Kinsella and Scott Rose retrieve Geometrics G882 magnetometer (Nathan Richards/CSI).

Since historical research had indicated there was no specific wreck to be discovered during remote sensing, a standard lane spacing for remote sensing based on a sonar range of 25 meters (50 meters swath) was decided upon. This would allow for 200% coverage of the survey area (each square meter of seabed would be insonified from two perspectives). The magnetometer was to be towed behind the research vessel while the sonar would be attached to a hull mount system to keep it stable and at the same depth at all times. The data would be acquired through *Hypack* 2015 software. The area subjected to remote sensing represented an area of sound floor about 2.5 kms by 2.5 kms – in line with instructions provided before the commencement of fieldwork (i.e. that the search area should lie within 1 mile of the existing channel). *Hypack* also served as the software through which "surface events" were geospatially and temporally logged. This included times when the magnetometer passed by or had to avoid buoys (invariably associated with crab pots), or where structures emerging from the water were noticed (such as hunting blinds, navigation buoys, and channel markers) as these structures would affect magnetometer readings.

Following reconnaissance at the site several aspects of this methodology had to be changed due to site characteristics. The sonar mounting bracket allows for shallow water insonification of the sound-floor requires a vessel with a thick, reinforced gunwhale. The survey boat optimized for remote sensing with the shallowest draft vessel was East Carolina's R/V *Viper*. Upon inspection of the launching area adjacent to Blackmar Gut, it was determined that the launching of *Viper* at the study area would be impractical due to the degraded status or poor maintenance of the boat ramp and the configuration (v-hull) and draft (three feet) of the vessel's hull. Additionally, kayak-based reconnaissance had determined that the survey area was very shallow, and a large section potentially contained underwater hazards associated with shipwreck PAS0001 and other structures seen in the water (such as hunting blinds). Researchers decided to test launching *Viper* from Wanchese for deeper water (i.e. the westernmost) portions of the survey area, and utilizing a research vessel with a shallower draft (i.e. skiff) for the easterly (shoreward) areas. A test of *Viper* leaving from the UNC-Coastal Studies Institute, however, indicated that such a journey from Wanchese with the pole-mounted system required near-optimal wind and weather conditions and would culminate in a two- to three-hour round trip that would cut down significantly on survey time. Moreover, during a test of the system researchers found that at the western-most extent of the survey area, the pole-mounted Klein 3000H sonar was in danger of hitting the bottom of the sound (at places around two feet depth) and would become fouled in sub-aquatic vegetation within a short period, reducing the quality of the sonar imagery. To avoid damage to sonar equipment and boat hull, and to maximize survey time, researchers determined that neither R/V *Viper* nor the hull mounted Klein sonar were suitable.

After considering the other fleet options available to the team at East Carolina University and the Coastal Studies Institute, a viable solution was found. Researchers employed a pontoon boat with an alternative sonar system -- a Tritech Starfish 450F which was mounted by a stainless-steel pole off the bow. Due to the configuration of the boat hull, researchers could deploy at a shallower depth than the Klein sonar. While the Tritech sonar offered a lower resolution than the Klein (50% reduction) it still produced the standard resolution for sonar projects – and would be sufficient for the discovery of cultural anomalies. If significant sonar targets equating to a substantial inundated archaeological site were discovered, researchers planned to return with the Klein 3000H for a confined area survey adjacent to the target was possible (given the lack of shipwreck candidates discovered during historical research, this was highly unlikely). Thus, the final remote sensing configuration was to mount the Tritech sonar on the bow of the pontoon boat (Figure 7) while the magnetometer was towed behind it. This change of boat and sonar device configuration did not precipitate any change to the lane spacing for the survey (25 meters).

Figure 7. Adam Parker retrieves pole-mounted Tritech Starfish 650F sonar (Nathan Richards/CSI).

After the reconfiguration of the remote sensing equipment, all data were still acquired with *Hypack* 2015 software. During data processing, the side scan sonar and magnetometer datasets were separated. The magnetometer raw files were processed in *Hypack* 2015 software. This process consisted of first editing errors from that data (which may have been caused by magnetometer or GPS dropout, power spikes, or currents and bottom-strike causing pitching or rolling in the magnetometer towfish). The edited files were then sorted with a radius of 25 meters (equal to the lane spacing). The sorted files were then imported into *ArcGIS* and interpolated (using the inverse distance weighting method) and subsequently contoured.

The side scan sonar dataset was processed in Chesapeake Technologies' *SonarWiz 5* software. The first step in the process was to manually bottom track the side scan files. In this way, the team edited the location of the seabed so that the sonar's "blind spot," directly below the sonar, was eliminated from the mosaic. Each image file was visually inspected for anomalies and targets multiple times to ensure that no targets were missed, and a contact report was collated.

Shoreline Transect Survey and Metal Detection

In addition to the remote sensing survey, a shoreline transect survey was also conducted in areas close to shore and too shallow for work on the research vessel. Even after switching to the pontoon boat, this was deemed necessary due to increasingly shallow depths near the shore and because of the potential for submerged hazards adjacent to the remains of PAS0001 and nearby structures (such as hunting blinds). The area was not designed to be a comprehensive survey of the entire zone from the waterline to the edge of the remote sensing area – but rather a sample. The survey grid was established as a 600 by 600-foot section defined using handheld GPS units (Garmin Rino 655t WAAS-compatible units) which would be visually inspected, with all features and finds recorded. First, a 600-foot baseline was established parallel to shore (Figure 8) – with intervals along the line divided into sections 40 feet wide by 300 feet long (determined by 300-foot-long fiberglass measuring tapes).

The baseline for the survey area was set off the immediate shore in roughly ankle-deep water. The baseline was laid with a 300-foot-long measuring tape and staked off at both ends and every 40 feet. These stakes were then buoyed to serve as visual identifiers after the team moved further out in the search grid and to warn recreational kite surfers and kayakers in the area of the danger. From the 0 end, the baseline was the run directly north at 0 degrees (magnetic) until the end of the first 300-foot section. From here, stakes were taken out due W at 270 degrees from the baseline, set in, and buoyed at 300 feet and 600 feet. GPS positions were then taken of every stake (Figure 9).

Figure 8. Image of baseline and datums for seabed inspection and close-plot metal detection survey (Nathan Richards/CSI).

Team members then visually inspected the seabed for any cultural anomalies. If too much sediment was kicked up causing a reduction in visibility, team members resorted to searching by touch. In the deeper sections of the survey grid, masks and snorkels were sometimes needed to get a good visual inspection of any target of interest. Not only were cultural anomalies mapped in per the baselines, all sea bed vegetation was also mapped in to ensure as full coverage as possible. In addition, after each grid section was mapped out, one team member conducted a metal detector test of the grid section, to determine if any anomalies were buried and not visible in the original mapping. While each member of the shoreline transect team surveyed, another team member carried out a metal detector survey with a Minelab CTX3030 metal detector. This waterproof detector allows for spatial locations (known as "findpoints") to be logged with an integrated GPS.

Logged findpoints also record an estimated depth of an anomaly, as well the object's conductive (CO, on a scale of 1 to 50, per increasing conductivity) and ferrous (FE, on a scale of 1 to 35, per increasing iron content) properties (Minelab 2015). No excavation was undertaken, though the location of each findpoint was later integrated into the GIS for analysis, with FE and CO values symbolically depicted.

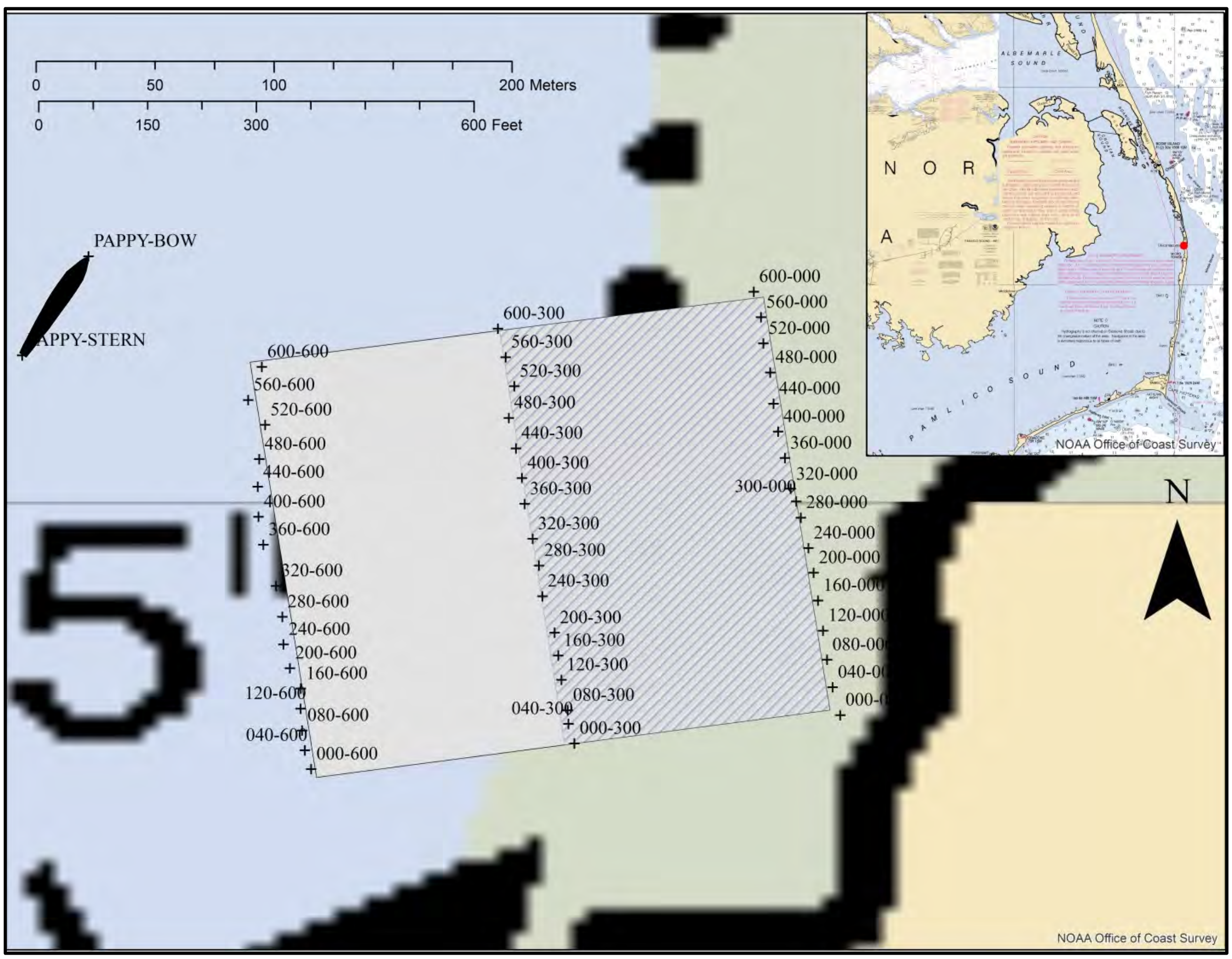


Figure 9. Depiction of sound floor inspection area. Crosses depict GPS positions of stakes used in establishing transects and GPS positions of the bow and stern of PAS0001 (the "Pappy's Lane Wreck"). The grey box indicates the area mapped, with the striped portion representing the area where additional metal detection sweeps were conducted (Image by Nathan Richards).

Photogrammetry

Late in the project, and as a last stage of fieldwork, the authors decided to add a photogrammetric recording assessment. This was done due to the complexities of working on the complex ferrous structure of PAS0001 and a desire to assess if other sites or features could be detected on the fringes of the study area. The photogrammetry data would be used for three purposes, 1) creating a three-dimensional view of the entire landscape, 2) imaging the above-water structure of PAS0001, and 3) recording the hunting blind within the study area.

A drone (a DJI Inspire 1 Pro, Figure 10) with an X5 Camera was piloted by John McCord (Figure 11). The DJI Inspire 1 Pro used micro 4:3 sensor camera with a 15-mm lens from a height of 101 meters. The camera stills obtained were 16 MP (JPG and DNG raw formats).

Figure 10. DJI Inspire Pro 1 drone (Source: DGI).

Figure 11. John McCord pilots the DJI Inspire Pro 1 drone to attempt aerial capture and photogrammetry within study area (Photo: Ryan Bradley, 15 November 2016).

The drone survey was first attempted on 15 November 2016 (Figure 12) and culminated in a high resolution ortho-photo of the shoreline as well as a three-dimensional rendition of the area. Due to high water, only an aerial ortho-photo of PAS0001 was possible (no three-dimensional data could be extracted due to most of the structure being underwater). On this day, it was determined that one of the recent tropical weather systems (Tropical depression 8, August 28-September 1; Hurricane Hermine, August 26-September 3; Hurricane Matthew, September 28-October 9) had destroyed the extant hunting blind, leaving only floating debris.

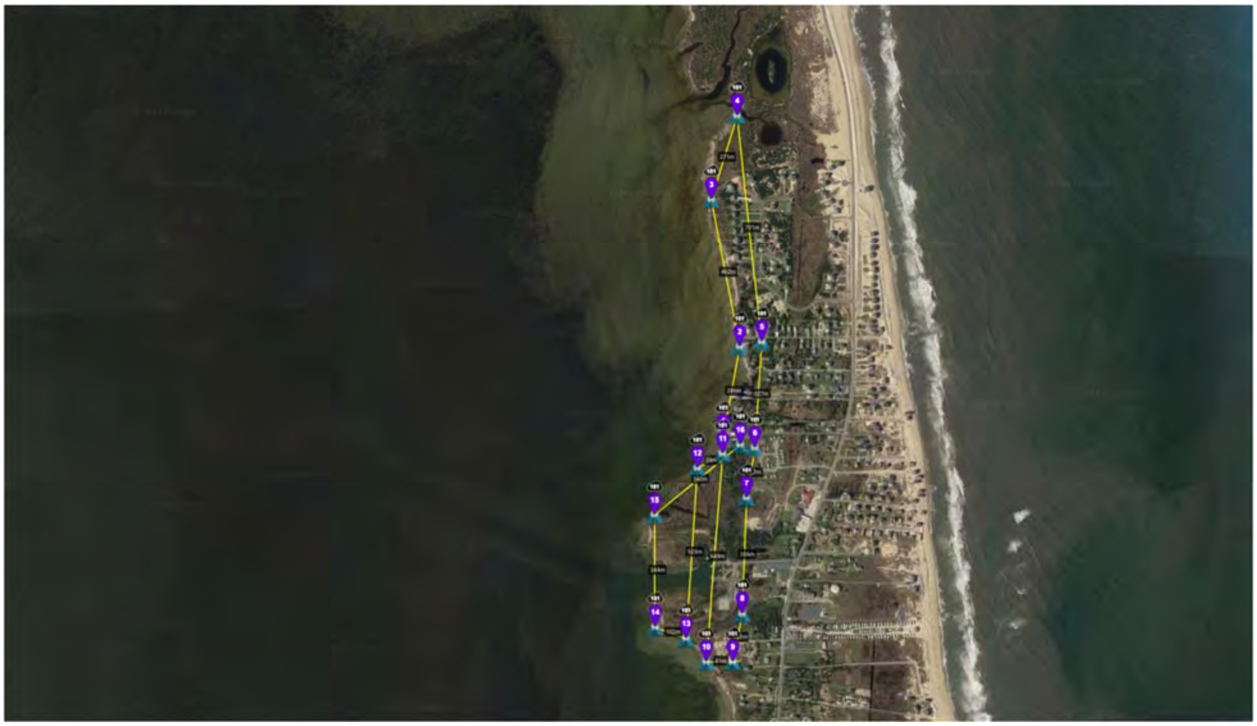


Figure 12. Flight plan for aerial capture of land adjacent to study area, 15 November 2016 (Image by John McCord, 15 November 2016).

On 10 February 2017, an additional photogrammetric assessment was undertaken with the same equipment. With a successful single-image orthophoto of PAS0001, and a multi-image photogrammetric model and orthophoto of the area adjacent to the study area, researchers decided to take advantage of lower water levels and low wind to attempt a high-resolution multi-image photogrammetric model and orthophoto of PAS0001 to assess condition, determine if much debris surrounded the wreckage, and hopefully identify the hull at a future date. A tight series of transects were designed to be flown at a height of 10-20 meters (33-66 feet) across each dimension of the vessel (see flight plan in Figures 13-14). During this recording, it was also noted that since November 2016, two new hunting blinds had been erected in the area near PAS0001, perhaps suggesting that the loss and re-erection of such blinds happens periodically (and the hunting blinds are unlikely to have any historical significance).

Figure 13. Flight plan for aerial capture of PAS0001, 10 February 2017 (Image by John McCord, 10 February 2017).

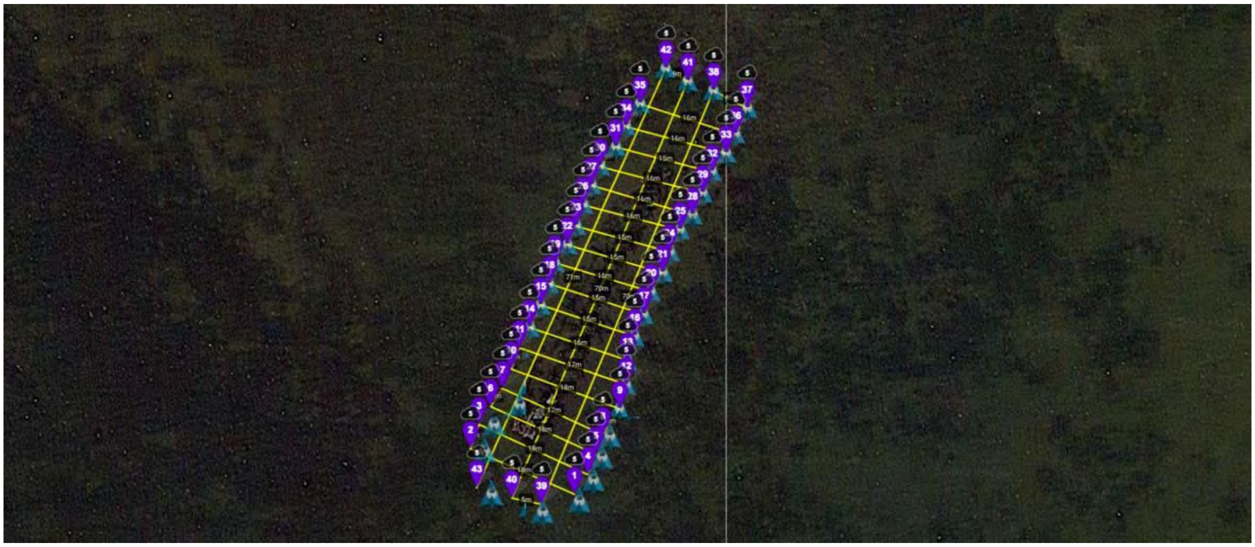


Figure 14. Detail of flight plan for aerial capture of PAS0001, 10 February 2017 (Image by John McCord, 10 February 2017).

In total, 404 high-resolution GPS-tagged TIFF files were recorded from the drone, and 171 of the files were used in the creation of a photogrammetric model. To create the final products, photographs were first imported into Agisoft *Photoscan Professional* software (Figure 15).

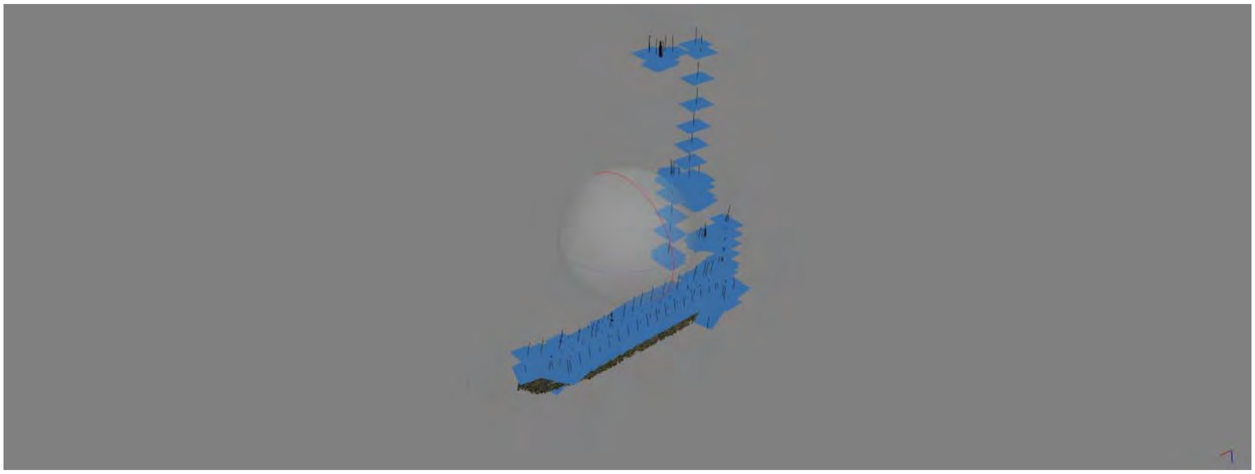


Figure 15. Screen shot from *Photoscan* showing camera locations used to create three dimensional models and high-resolution orthophotos of PAS0001 (Image by Nathan Richards)

Following a process of alignment, a high-quality sparse point cloud was created (Figure 16), which was then used to create a dense point cloud (Figure 17), a rendering of dense point cloud classes (Figure 18), meshed models (shaded, Figure 19; solid Figure 20; wireframe, Figure 21), and finally a high-resolution multi-image photogrammetric model with high-resolution photo-textures embedded (Figure 22). The phototextured model was exported as a very high resolution geo-rectified orthophoto (XY perspective) from which researchers made interpretations of the in situ remains (extant hull structure and surrounding debris). Due to good weather conditions on the day of the aerial survey it was possible to produce a model with a greater than normal amount of debris sticking above the water and with some degree of water penetration, allowing for the modeling of submerged hull materials, despite murky waters (Figure 23).

Figure 16. Sparse point cloud created from PAS0001 photographs (Image by Nathan Richards).

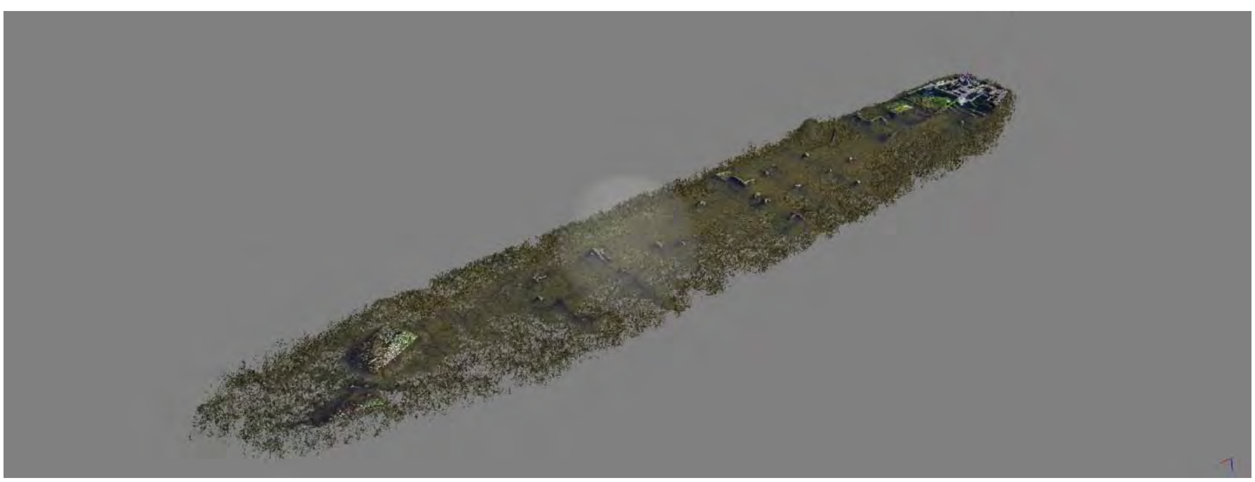


Figure 17. Dense point cloud created from PAS0001 photographs (Image by Nathan Richards).

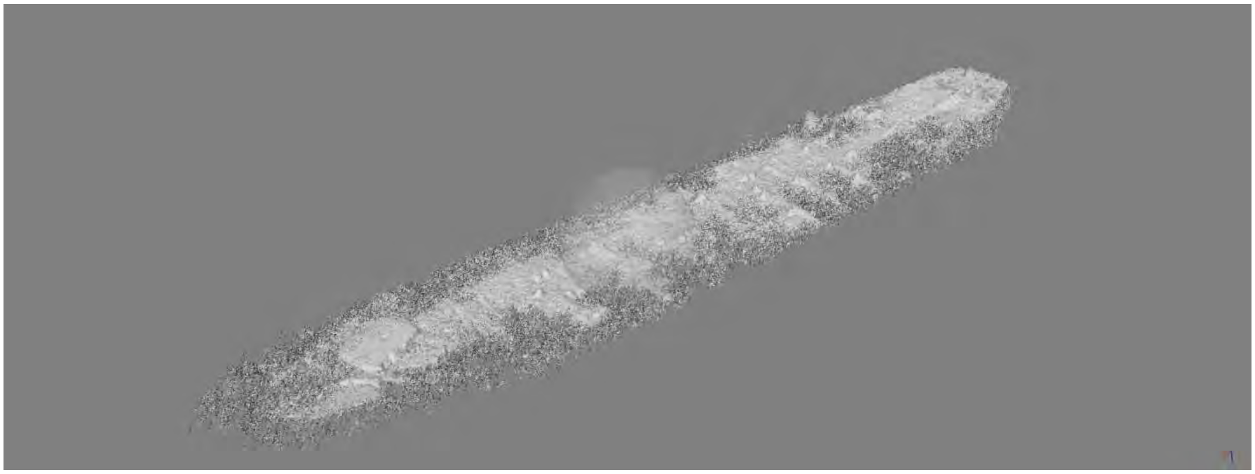


Figure 18. Sparse point cloud classses created from PAS0001 photographs (Image by Nathan Richards).

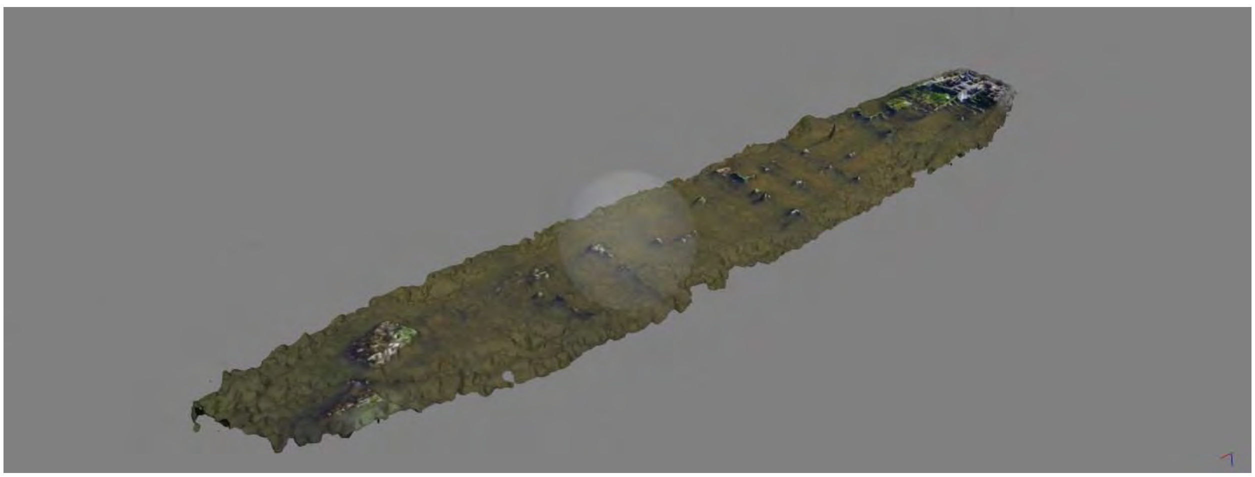


Figure 19. Shaded mesh created from PAS0001 photographs (Image by Nathan Richards).

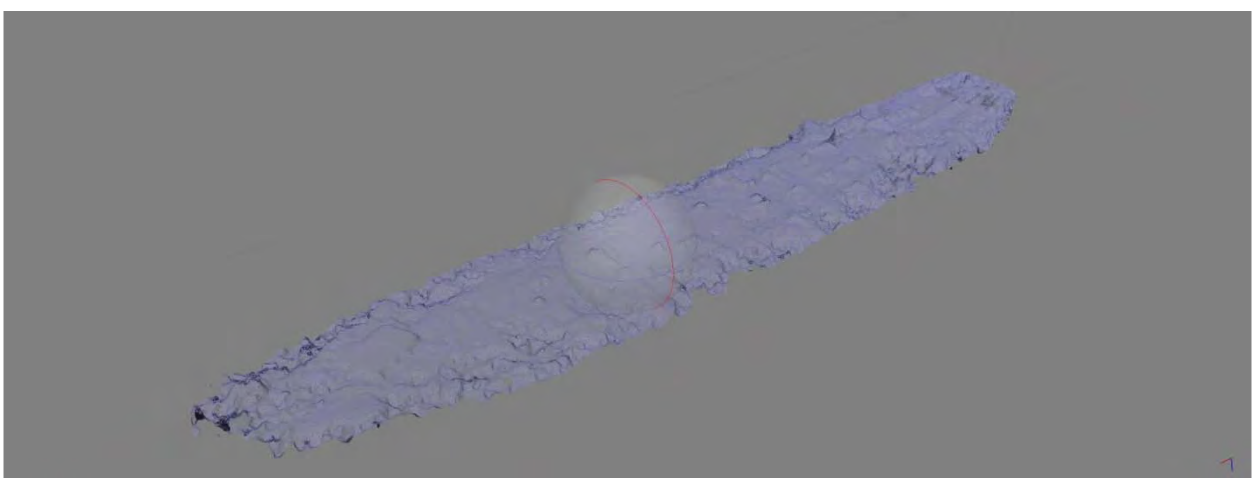


Figure 20. Solid mesh created from PAS0001 photographs (Image by Nathan Richards).

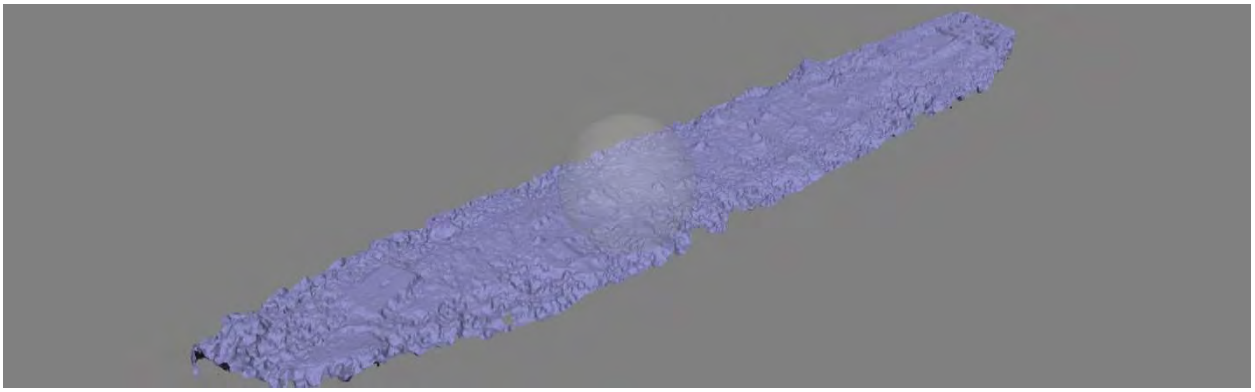


Figure 21. Wireframe mesh created from PAS0001 photographs (Image by Nathan Richards).

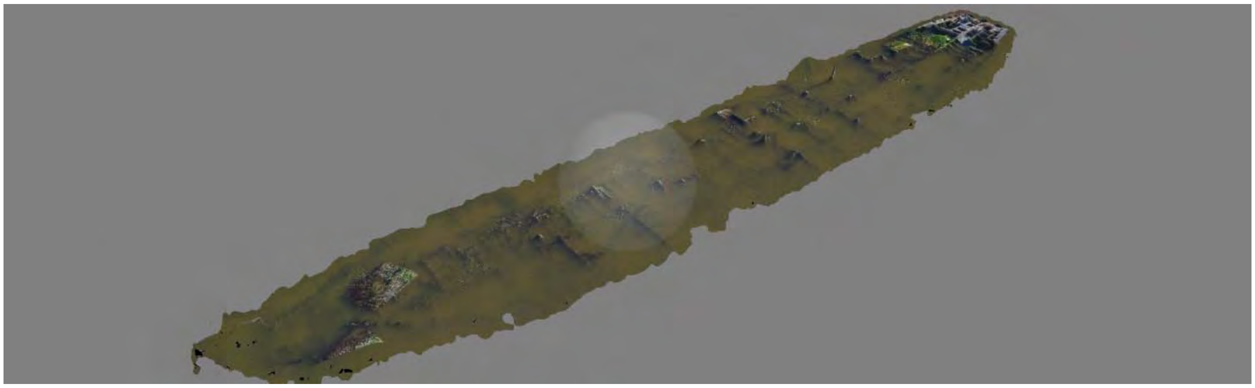


Figure 22. Photo-textured three-dimensional model created from PAS0001 photographs (Image by Nathan Richards).

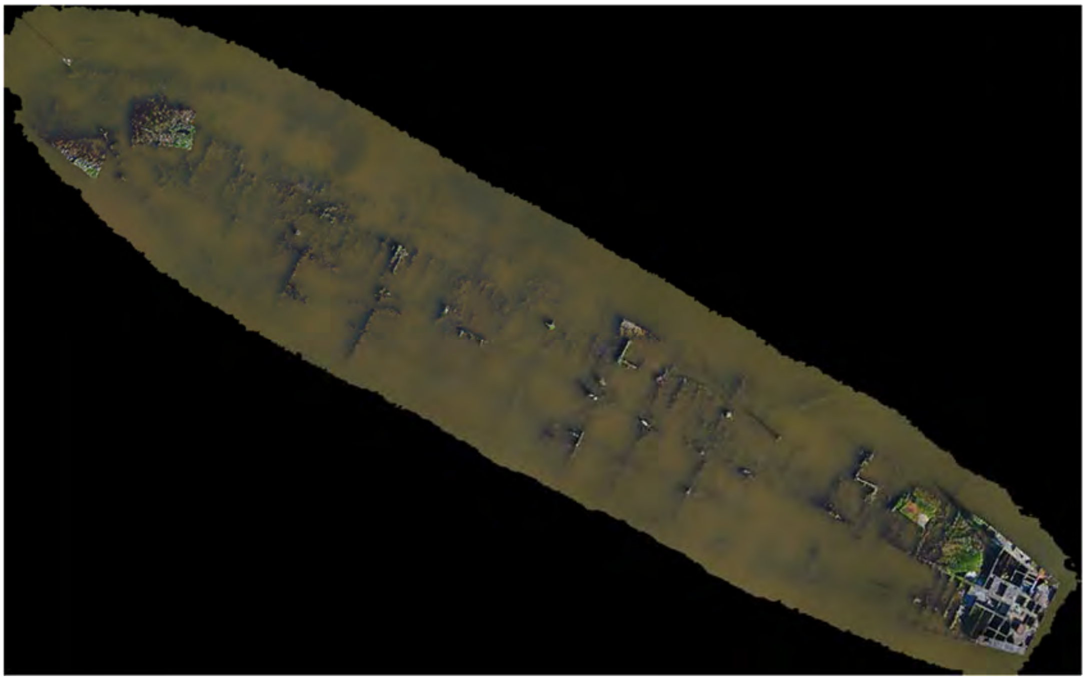


Figure 23. High resolution, scaled orthophoto exported from three-dimensional *Photoscan* model (Image by Nathan Richards).

3

AN ASSESSMENT OF CULTURAL IMPACTS

While major parts of Hatteras Island may appear to be a natural landscape (especially the sections of today's Cape Hatteras National Seashore), this is far from the case. It is a landscape significantly altered by human agency (see Binkley 2007:54). This section outlines an assessment of cultural impacts to the study area as extracted from the historical record. The following sections cover a range of themes -- impacts from commerce, impacts from dredging, impacts from conflict, and impacts from specific marine accidents and incidents. A final section outlines how these (or other) historical events have (or have not) appeared in cartographic sources. This information sets a baseline for understanding the history of human activities within and around present-day Rodanthe, assists in the subsequent design of archaeological methodologies, and aids in the classification or identification of sites or objects found within the study area.

Impacts from Commerce

The area of present-day Rodanthe may not have featured very prominently in the economic development of North Carolina. According to David Stick, in the early decades of the 1700s, there was a plan to establish a port on Roanoke Island. By 1723, local demographics caused this plan to be reconsidered. As he notes:

> This failure to establish a port down on Roanoke Island was influenced by two developments then taking place. The first was that the settlement of the interior was spreading out below Albemarle Sound, while more habitations were appearing on Chicamacomico Banks, Kinnakeet Banks, and Hatteras Banks, so that Roanoke Inlet was no longer centrally located (Stick 1958:25-26).

While this quote does not give any substantive impression of the number or extent of people living in the area during the early part of the eighteenth century, other references give us some impression of the establishment of settlements in the area. Per David Stick (1970:25) people were living at "Kinekeet" (Kinakeet) in 1774, though Chris Kidder (2005:56) contends the area around the northern end of Hatteras Island was "settled as early as 1744." Other researchers have noted an even earlier settlement of the area,

> The Outer Banks are an area whose isolation and access to the riches of the sea brought the first non-native settlers to this part of Colonial America. The first Colonial settlers appear to have come to Kinnakeet (now Avon) in or around 1711 when the first grant of land was made. Living on the narrow barrier islands of the Outer Banks was a way of life reserved for a hearty lot. The coastal winds were harnessed, for example, to grind corn as early as 1723 with mainland-introduced windmills rising at Kinnakeet. Now gone, those windmills were a prominent feature of the maritime cultural landscape of the Outer Banks (Hoyt et al. 2014:15).

The presence of these windmills (Figure 24), veritable beacons of economic activity on the coast, is probably the most noted component of the Outer Bank's commercial infrastructure of the eighteenth and nineteenth centuries (Dunbar 1958:143-144; Stick 1958:34; Littleton 1980; Barfield 1995:78; Downing 2013:30-32). Indeed, a map of the approximately 155 windmills in operation prior to 1900 produced by Littleton (1980:9) could arguably be considered a map of the important trading maritime centers of coastal North Carolina, including the villages from present-day Rodanthe to Avon (Figure 25). Other scholars have noted that this area around "Kinnakeet" was an important, central place, while the isolated farmsteads around present-day Rodanthe, Waves, Salvo, and Frisco eventually grew into bone fide settlements (Hoyt et al. 2015:19).

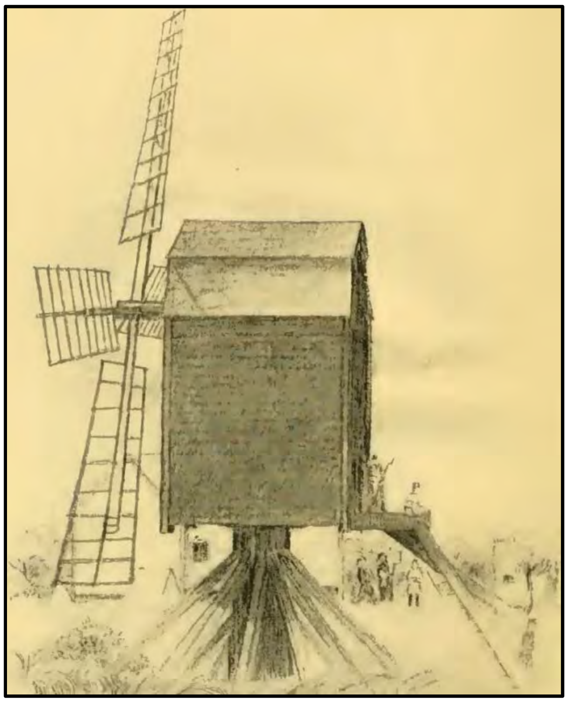


Figure 24. "The Windmill Picket at Hatteras" (Johnson 1911: plate XIII)

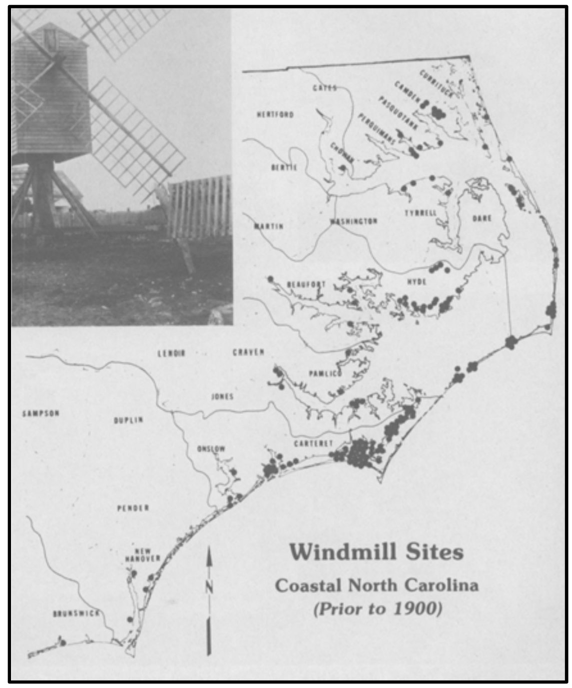


Figure 25. Windmill sites: Coastal North Carolina (Prior to 1900) (Littleton 1980:9, see also Dunbar 1958:33).

One windmill, an unnamed post mill reported to have been located at Green's Point, and believed by some researchers to have been in Rodanthe by the 1850s, is an important landmark for events occurring on Hatteras Island during the American Civil War (Johnson 1911:53-54, 76, and see Babits et al. 2013:8-12 for an extended discussion). Moreover, this mill is documented as lying at this location as late as 1874 (Bishop 1878:172-178). By the middle of the nineteenth-century there are some indications of many people living in the area. The ethnohistorical description undertaken by Impact Assessment (2005a:72) cites the 1850 census, which contends that there were 206 people and 37 families living on Chicamacomico Banks at the time. David Stick estimates that by 1861 there were around 1,200 people living on Hatteras Island (including 100 enslaved individuals) (Stick 1958:154). Babits et al. (2015:6), referencing the 1861 correspondence of William Lyons Brown, are more specific, suggesting that "50 families" were living "within a distance of three miles" of the settlement at Chicamacomico.

Another notable economic activity focused on northern Hatteras Island was a relatively short-lived timber industry. As one scholar suggests, "Beginning about 1820 large quantities of live oak and cedar were cut on Kinnakeet and Chicamacomico Banks, and the timbers used in many of the famous clipper ships were said to have come from there" (Stick 1958:286), and by the 1880s and 1890s the area had been extensively deforested (Spears 1890; Stick 1958:4; Williams 2016[1975]:21-22). Such deforestation would have had significant and lasting social and economic consequence for the area.

The other commercial activities that likely dominated the lives of local people were invariably connected to the water. An important commercial activity and source of subsistence was waterfowl hunting, with hunting blinds and camps still located in the area (see Dunbar 1958:35; Hooper 2016:20-43, 61-86; Williams 2016[1975]:27-30). Activities noted within the folk life of what is today Hyde County, include engaging in agriculture, raising livestock, securing lumber, hunting, trapping, decoy-making, tanning, boatbuilding, crabbing, and constructing fishing nets – and are good approximations of the trades of the wider area (see Mansfield 2001). This is repeated in Hatteras Island and Dare County, with the addition of clamming, a small amount of wool gathering and a seaweed harvesting industry (Impact Assessment 2005a:118; Hooper 2016:2, 18-20, 43; Williams 2016[1975]:23-26). Wright and Zoby, in describing the freed African-American soldiers returning to Roanoke Island after the Civil War, reinforce this when they note, "They described themselves as fishermen, hunters of fowl, and "proggers," not farmers" (Wright and Zoby 2000:124). The term "progging," defined by Wright and Zoby (2000:123) as a "local term for foraging for goods and supplies, such as lumber, that washed ashore" is here referring to activities occurring in the late nineteenth century – but is something that was likely an important activity prevalent along the Outer Banks since colonization (and well into the twentieth century). David Stick also reports that gleaning activities were an important part of subsisting on the Outer Banks, writing that inhabitants of the area made their living "by fishing gathering oysters, wrecking and piloting" (Stick 1958:155 see also Williams 2016[1975]:23-24,67-78). In the twentieth century, the prevalence of fish traps in the northern extents of Pamlico Sound is something commented on by people such as travelogue writer Henry Plummer, who insinuated their presence as a navigation hazard in the area (especially around Stumpy Point) when traveling through the area in his Cape Cod catboat *Mascot* in 1912 (Plummer 1914:28,109). As Dawson Carr states, by 1925 Dare County's oyster beds had been ruined through overuse, commercial fishing had declined, and grasses had been depleted by livestock (Carr 2016:19). Commercial fishing became more important at Rodanthe in the early 1900s, and fishing vessels were moored in Pamlico Sound (Impact Assessment 2005:88-89). Along with the boats came the infrastructure to support them. This included fish houses which dotted the shoreline – locations where fish were delivered to be packed in ice for eventual shipping via boat, or truck (after the opening of the Bonner Bridge). For example, a report by Impact Assessment notes that the area along the southern shore adjacent to the study area once held fish houses owned and operated by Joseph Midgett, Herbert Midgett, Ed Lyman, and Etheridge Seafood before the 1950s (Impact Assessment 2005:78,89).The importance and prevalence of these extractive actions must be taken into account when considering what material may have become a part of the archaeological record within Pamlico Sound – both in the water, and along the shoreline.

While there is this evidence or interpretation of commercial life in the area, there is often a paucity of easily accessible historical records of trade (commercial statistics) to illuminate the economic life of the area in the eighteenth century. This is because the area around Chicamacomico was near the borders of influence of two prominent North Carolinian ports of the time– Port Roanoke and Port Bath Town, and the statistics of their production was likely reported within the statistics of those ports (Merrens 1964:87; Combs 2003:3-4). An additional factor is that the economic statistics for Port Roanoke often merged with those of Port Currituck. One can surmise that the area around Rodanthe was part of a decentralized economic frontier during the eighteenth century (Merrens 1964:95,144). It was likely dominated by subsistence industries attached to the activities mentioned above, with the economy boosted by drift whales and wrecked ships up until the time the Life-Saving Station came along, and especially until the time that the Outer Banks was developed for tourism and other recreational activities.

However, in the context of Pamlico trade and commerce, it must be kept in mind that an extensive *trade network* and ferry system existed in the area that changed in concert with many technological, economic, social and political factors influencing the area. One of the critical factors in this development was the growth of adjacent centers of commerce that cemented important bonds between people across water. One of the strongest links in this regard were the links to ports to the north – particularly in Manteo, which became an important social and economic hub after it became the seat of newly-formed Dare County in 1870 (Wechter 1975:xxi; Khoury 1999:61,63-64). As Angel Khoury notes,

> It was not until two centuries later, that Roanoke Island became anything approaching a "Chiefe towne," when in 1870, the small Roanoke Island settlement of Manteo became the county seat. After that, commercial activity began to grow apace with government, so that when it came to buying, selling, or bartering, Manteo was at the crossroads of commerce in Dare County. In this case, the crossroads were on water, not land, for in 1899, when the town was formed, travel to and from the island was only by boat. Boats streamed in from Roanoke Island, into Shallowbag Bay, and finally into Dough's Creek, or from the mainland, across Croatan Sound to the west shore of the island, bringing people into the town for court or county business (Khoury 1999:61).

Such connections continued into the twentieth century because of ferry connections, personal travel via small watercraft, deliveries made via barges, and eventually the bridge that would connect Pea Island and Bodie Island (Carr 2016:17; Hooper 2016:104-105). Another important connection forming in the twentieth century were the connections between Rodanthe and Wanchese via commercial fishing (Impact Assessment 2005a:72). David Stick also outlines how taxation in newly-formed Dare County was organized after 1870, illustrating additional bureaucratic connections between Manteo and surrounding settlements:

> For taxing purposes the new county was divided into five townships. Two of these, Hatteras and Kinnekeet, were located on the south banks of Hatteras Island and two more, Croatan and East Lake, were located on the mainland. The fifth township, Nags Head, consisted of all of Roanoke Island as well as the north banks from Oregon Inlet to the south edge of the community of Kitty Hawk (Stick 1970:31).

The connections between Rodanthe and Manteo are reinforced with various references to Manteo in U.S. Life-Saving Station reports (to be mentioned in a later section). In another example of the relative closeness between the two locations, one of the prominent businesses that would serve Manteo (M.L. Daniels' general merchandise store, "Moncies") was actually floated into the town from Rodanthe (Khoury 1999:63-64). In another demonstration of connection:

> On occasion, it is hurricanes that are the dreaded curse of late summer and fall. While Roanoke Island was spared the worst of three hurricanes of August and September 1899, those storms changed the face of Manteo when Kinnakeeters from Hatteras Island floated their houses up the sound to make a new life away from the barrier island (Khoury 1999:147).

Other connections existed too. While Stumpy Point and Rodanthe are connected today via the DoT Emergency Ferry channel, this connection has also been present since 1876 when a post office opened at Stumpy Point, "A mail carrier, under contract to the government, took the outgoing mail to Rodanthe by boat once a week and returned with any incoming mail" (Wise 2014:25). Businesses like the "Wanchese Line," which delivered ice to locations within Albemarle, Pamlico, and Currituck Sounds from the late-nineteenth to mid-twentieth century and provided critical services for a nascent fishing industry (operating out of various ports on Roanoke Island at Skyco, Manteo, and Wanchese) also included Rodanthe as a port of call (Ward and Gray 2013).

Another very prominent part of commerce in the region was the influence of the Postal Service. As noted by Crumbley (2006:900-901) there were only four post offices in North Carolina in 1789 (Edenton, New Bern, Washington, and Wilmington) and 285 by 1851. This expansion was disrupted by the Civil War, and many Post Offices did not open on the Outer Banks until the 1870s. For example, a Post Office opened in Manteo in 1873 (Khoury 1999:61). David Stick (1970:36-37) says the following about the role of Post Offices on Hatteras Island, explaining that the villages on the island, like elsewhere often changed their names to that of the Post Office:

> Kinnakeet Post Office was established the same year [1873], and it too was changed to Avon, in 1883. Rodanthe was established at Chicamacomico in 1874, and Frisco at the community of Trent in 1898. Apparently the post office department refused to accept the name Chicamacomico because it was so hard to spell and pronounce, and it rejected Trent as a name because of a possible confusion with the existing town of Trenton in Jones County. The other Hatteras Island post offices were Salvo, established at South Rodanthe in 1901, and Waves, which began operations in the old community of Clarks in 1939.

As Harold Wise illustrates, the connection between Stumpy Point and Rodanthe was also represented in a mail route

> During the late reconstruction period, the Federal government opened a series of post offices all over Dare County. The Stumpy Point post office opened in 1876 and, for the first time, the villagers had an official regular link to the outside world. A mail carrier, under contract to the government, took the outgoing mail to Rodanthe by boat once a week and returned with any incoming mail (Wise 2014:25).

These connections were major social links. Indeed, Charles T. Williams titles one of his chapters in *The Kinnakeeter*, “Contact with the Outside World” and begins his discussion of local connections with a description of the links created by the Postal Service (Williams 2016[1975]:79]. Probably most extensive, is the network of connections outlined by MacNeill:

> And here is a divergence that for a long time drew the two Islands apart. Ocracoke’s post office was served then, as now, by a mailboat that sailed from the little mainland village of Atlantic, or from New Bern directly. The Hatteras Island villages were connected, by mail as well as by telegraph, with communities to the north. A steamship line between Elizabeth City and Manteo on Roanoke Island carried mail, and there was direct contact with Norfolk, also by boat. The mail came three times a week to Roanoke Island.
>
> Thence sailboats came down the Sound, stopping first at Rodanthe, which continues, by most Islanders, to be called simply “Chicky,” and from that point, south and west, the mail was taken aboard a horse, in saddlebags, and fetched down the island. The mail-rider left Rodanthe upon the arrival of the mail boat, which depended on the wind. He rode down the Island, fetching letters, sometimes as many as a dozen, and an occasional newspaper. It required the whole of a day to make the return trip. He carried also messages, verbally entrusted and verbally delivered. He also dealt in leisurely intelligence of a more general nature.
>
> There exists nowhere, in so far as my searching discloses, any official record of these operations, and it is not possible to determine who had the job of mail carrier in any specific year. It is tolerably certain that Bannister Midgett carried the mail from his native Chicamacomico-Rodanthe for a while, despite the fact that he was unable, as he maintained, to read and write. There are some who maintain that he was admirably equipped for the duty because he never tarried along the way while reading post cards (MacNeill 2008[1958]:198-199).

As will be illustrated in the section of this report regarding marine casualties, quite a few of the vessels which came to grief in the study area did so while carrying mail to or from the Post Office at Rodanthe.

Finally, it must be noted that the Life-Saving Service (later, the U.S. Coast Guard) was a central part of commercial activity in the region. Like the Postal Service, this developed in the 1870s, with the first life-saving station at Chicamacomico built at Rodanthe in 1874. The original structure would become a boathouse when a new station was constructed at the same site in 1911 (Mobley 1994:27, 104, 110; Barfield 1995:708; Hairr 1999:55-56). It is no surprise that the Chicamacomico Life-Saving Station, lying adjacent to the study area, is the epicenter of human-maritime activity for much of history. This station, along with the stations immediately north (the New Inlet Station) and immediately S (the Gull Shoal Station) would be the first responders to any marine disaster that occurred in or near the area inspected during this project (Shanks and York 2009:143).

The Chicamacomico Station, most famous for the *Mirlo* rescue of 1918, was operated under the auspices of the U.S. Life-Saving Service from 1874 until the service became a part of the United States Coast Guard in 1915. From 1915 until its closing in 1954, the station remained part of the U.S. Coast Guard. The station was then decommissioned and ultimately abandoned, passing through private hands until 1993 when the Chicamacomico Historical Association became its custodian (Stick 1953:204, 1958:284-285; Carter 2006:673; Stick and Carter 2006:752; Downing 2014:23, 246).

Of course, the most prominent interaction between life-saving crews and Pamlico Sound is the rescues that have occurred in the area (those described later in this report), but there were likely other interactions pertaining to training that likely existed. For example, Nell Wise Wechter's *The Mighty Midgetts of Chicamacomico* (1974), a text that focuses on three of the keepers of the Chicamacomico Station (Captain Ban Midgett, Captain John Allen Midgett, and Captain Levene Midgett), outlines activities like experimentation with new technologies (such as naphtha engines) that occurred in the shallow, sheltered waters of the Pamlico Sound (Wechter 1974:14-16, see also Impact Assessment 2005a:102-103). Semi-fictional accounts, such as MacNeill's awardwinning *The Hatterasman* (1958) have also used keepers of the Chicamacomico Life-Saving Station (Bannister Midgett, in particular) as central characters in their narratives (MacNeill 2008[1958]:214-216,229-232).

It also must be acknowledged that other major initiatives have had impacts on the island's landscape. In 1935 and 1936, camps for the Civilian Conservation Corps (CCC) were established along the Outer Banks – including one at Rodanthe (Binkley 2007:26). With the entire initiative in the area overseen by Clark Stratton, this camp, located in the Black Mar Gut area was a major enterprise:

> Besides aircraft and thousands of transient and CCC workers, the operation was equipped with a radio-system and at one point Stratton oversaw a fleet of up to twenty-seven barges and nine tugboats used to ferry supplies (Binkley 2007:28).

The main task of the CCC project on the Outer Banks was the construction of dunes from Ocracoke to the Virginia border, in addition to some primitive road building. The camp at Rodanthe, administered by the National Park Service included the use of two barges which were made into bunkhouses and moored at Black Mar Gut (Impact Assessment 2005a:104, 2005b:343,481). The eventual formation of the Cape Hatteras National Seashore (authorized by Congress in 1937 and established in January 1957) also had an impact on the area – but this is mainly responsible for the preservation of large tracts of land where little development occurred (north of Rodanthe) (Binkley 2007:1; Whisnant and Whisnant 2015:210). Added to this are the industries that came to the Outer Banks but never left a significant impression – such as the oil companies Standard Oil and Sinclair Oil, who arrived in the area in the mid-1940s, but did not find oil extraction to be a commercially viable enterprise (Impact Assessment 2005a:234; Binkley 2007:69).

Impacts from Dredging

As indicated, the landscape of today's Rodanthe likely does not resemble its past. This is also the case for sections of nearby Pamlico Sound floor, which has seen its own impacts due to the transformation in the importance of this part of northern Hatteras Island in the twentieth century. Indeed, investment in dredging a channel into present-day Rodanthe, is in many ways a clear sign as to the current economic importance of Hatteras Island. Other than road construction and housing development, likely no human activity has left more of an indelible impression on the landscape and seabed than dredging.

David Stick reports that, "In 1936 and 1937 the Coast Guard built a channel and harbor on the sound side at Rodanthe. A camp for CCC boys engaged in erosion control work was located there at the time” (Stick 1958:285). The T-shaped harbor was built (the only one in the area not constructed by the U.S. Army Corps of Engineers) in an area called “Blackmar Gut” – with “gut” being synonymous with “creek” in the area. The construction of the harbor also assisted local commercial fisherfolk who no longer had to lighter their fish to buyboats waiting in the sound, and the area also eventually became an emergency ferry landing channel in 1990 after the emergency closure of Bonner Bridge due to damage (Dunbar 1958:52-53; Wechter 1975:155-156; Impact Assessment 2005a:76-77,89, 2005b:355).

Inspection of U.S. Army Corps of Engineer’s annual reports between the years 1866 and 1938 indicate that no dredging occurred in this portion of Pamlico Sound until dredging work in the area from “Pamlico Sound to Rodanthe” and “Pamlico Sound to Stumpy Point” was authorized in two separate efforts under the River and Harbors Act on August 26, and January 27, 1937, respectively (U.S. Congress 1938:1978). The “Rodanthe-Stumpy Point Channel” was authorized under the River and Harbor Act of March 2, 1945.

In 1945, the USACE’s “existing project” at Rodanthe called for a “channel 6 feet deep, 100 feet wide from the contour in Pamlico Sound to the shore end” noting that $5,000 was allocated to the project in 1938 and $2,000 for maintenance in 1945. Neither amount was spent because a mean low water depth of 4.5 feet was available in the channel and basin (USACE 1945:599; Dunbar 1958:52-53; Impact Assessment 2005a:76). No dredging activity occurred in the area over 1946 or 1947– though $10,000 was expected to be spent in 1948 for 10,000 cubic yards of maintenance dredging (USACE 1946:650-651, 1947:640-641). By 1950 an estimate of cost for this work had risen to $45,000, though efforts were again delayed until 1952 (USACE 1948:708-709, 1949:624-625, 1950:624-625). By 1964, costs had risen to $80,000, with preconstruction plans for dredging commencing that year (USACE 1964:352-353).

The channel was excavated in 1965 with 75,408 cubic yards of sediment removed between February 28 and March 11 (Figure 26). Two upland disposal areas, located close to Rodanthe Harbor were the intended location for any subsequent maintenance dredging of the channel, but by 1996 had not been utilized (USACE 1965:339-340, 1996:1-2) (Figure 27). No subsequent maintenance dredging appears to have occurred until February 1997 (USACE 1975:6-6, 1997:6-6).

In 1996 shoaling at three sites on the Outer Banks (Rodanthe, Avon, and Rollinson channels) precipitated the need for maintenance dredging at all three locations (USAC 1996:1). In the case of the Rodanthe channel:

> Dredged material from Rollinson and Avon channels, which is suitable for beach disposal (sandy) would be placed in designated disposal sites on nearby beaches. The sandy material that would be dredged from the Rodanthe project would be placed in the designated beach disposal site at Rodanthe or in an upland disposal site that is 1.5 miles north of the Rodanthe harbor, on the east side of Highway 12. For the 1997 maintenance dredging of the Rodanthe channel, all beach quality sand would be placed in the site on the east side of the Highway 12 … Dredged material from Rodanthe and Rollinson Harbors that is not suitable for beach disposal (muddy/silty) would be placed in upland diked disposal sites (USAC 1996:1).

The intended use for these dredged materials was for the deposition of “coarse-grained material … in an upland area on the east side of Highway 12” and for “[f]ine-grained, muddy material … within the designated upland diked disposal sites (USACE 1996:2-3).

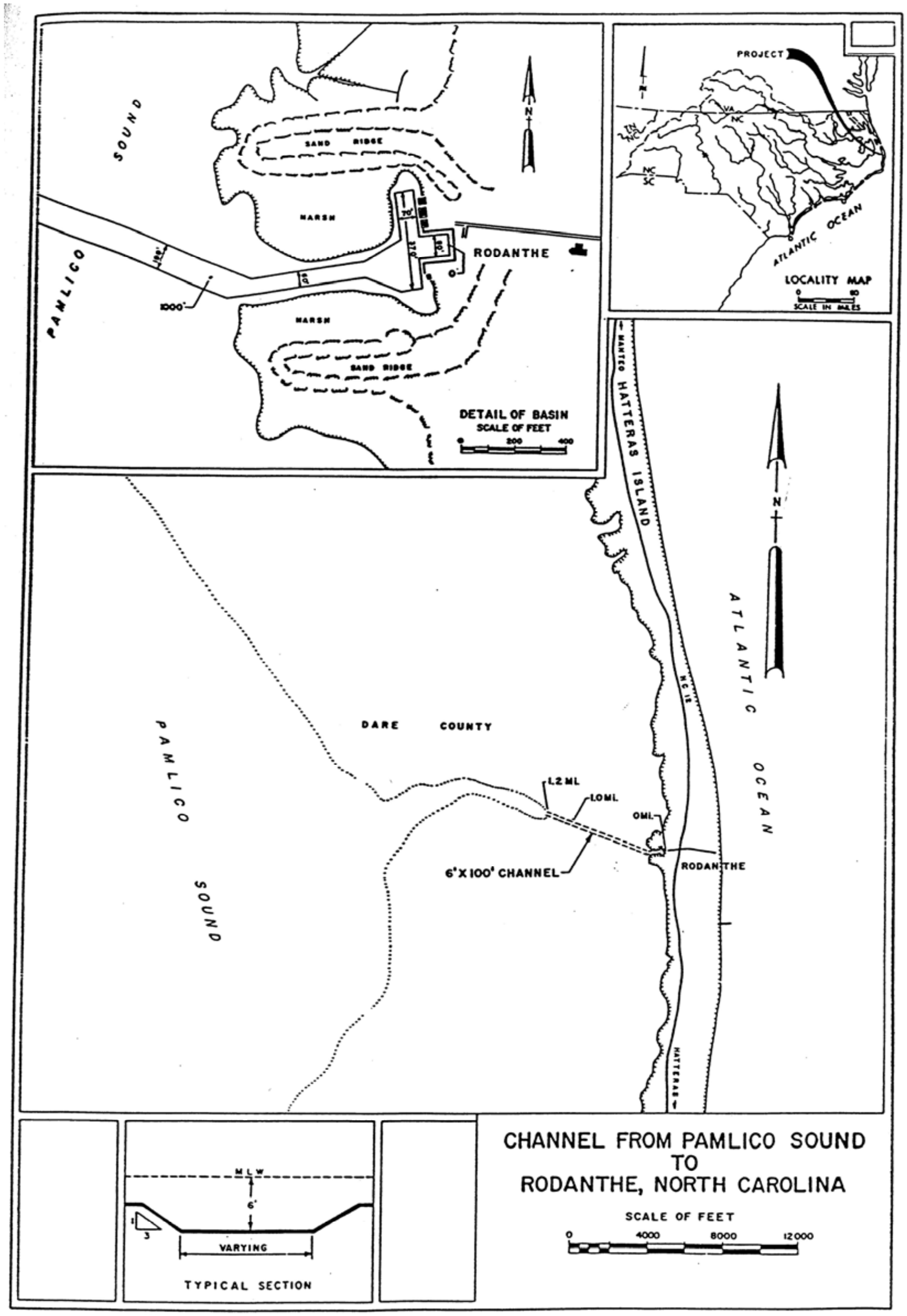


Figure 26. Channel from Pamlico Sound to Rodanthe, North Carolina (USAC 1996:23).

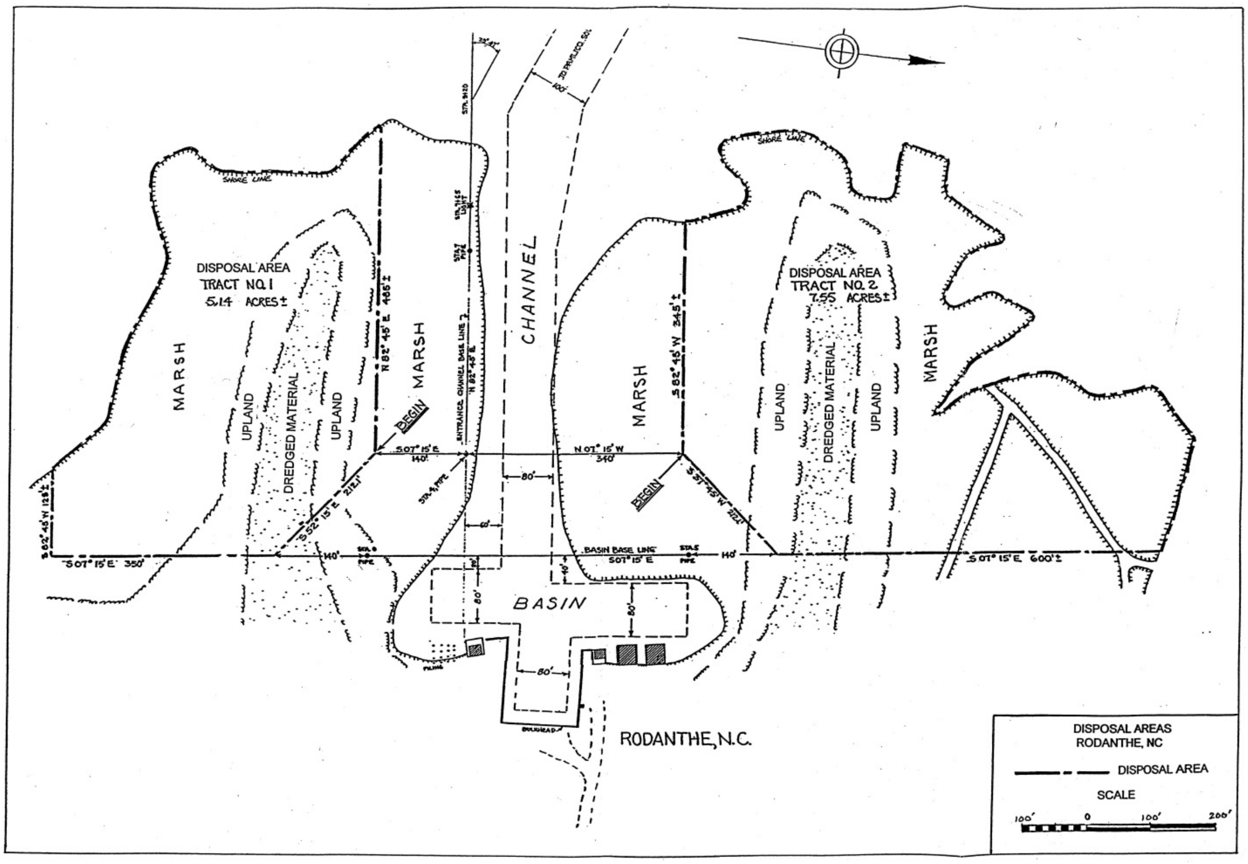


Figure 27. Disposal areas, Rodanthe, NC (USAC 1996:43).

The estimated amount of dredged material of the intended 1997 maintenance dredging activities was 118,000 cubic yards (USACE 1996:4). At the time of this recommendation, contact was made with the North Carolina Department of Cultural Resources regarding the status of cultural resources in the affected areas, and the following information was presented:

> No archaeological or historical resources would be affected by the proposed maintenance dredging or the disposal of the dredged material in the upland diked disposal sites or in the Highway 12 site. The area to be dredged is a previously dredged channel and the upland disposal areas have been previously utilized for dredged material disposal. The proposed control-of-effluent site is located in the area where Highway 12 previously existed (before it was relocated in 1995) and is, therefore, highly disturbed. Should unanticipated archaeological or historical remains be encountered during the proposed maintenance dredging operation, or within any of the disposal areas, they will be evaluated pursuant to Federal agency responsibilities under the National Historic Preservation Act (USACE 1996:15)

The only potential impacts listed at the time were the impacts from dumping dredged material at designated beach sites (mainly from heavy vehicle use on the beach). At the time twenty-five historic shipwrecks were listed in the NCUAB files as lying close to the areas on North Hatteras Beach where Rodanthe sediments would be dumped. One shipwreck located at Avon was to be monitored for impacts (USACE 1996:15-16). No wrecks in the dredge area, or adjacent locations in Pamlico Sound, or other submerged archaeological sites were listed for potential impacts. By 1996, in preparation for dredging the next year, the channel was defined as:

> … a channel 5,336 feet long and 100 feet wide to a depth of 6 feet at mean low water (mlw) from the mouth of Blackmar Gut westward into Pamlico Sound. Through the gut the channel was authorized to a depth of 6 feet at mlw for a width of 60 feet and a length of 1,000 feet into an 80- to 100-foot wide turning basin … (USACE 1996:1).

In 1997's annual report, the U.S. Army Corps of Engineers, include the following note:

> Between February 21 and March 12, 1997, the contract dredge *Richmond* dredged 89,662 cubic yards from shoals in the channel at a cost of $737,223. Diking work in connection with contract dredging was accomplished at a contributed funds cost of $104,005 (USACE 1997:6-6).

By 1998, the channel had a new definition of the channel, extended some 200 feet:

> A channel 6 feet deep, 100 feet wide, and 1.25 miles long from Pamlicao [sic] Sound to a basin at the shore end near Rodanthe of same depth, 80 to 100 feet wide, and total length of about 1,200 feet (USACE 1998:6-5).

Some dredging was also reported in minutes from the Outer Banks Task Force (OBTF) in 2001 (OBTF 2001:1). Other than this report, maintenance dredging and snag removal occurred yearly over 2010-2012, and probably thereafter:

> During intermittent periods, the U.S. debris boat *Snell* conducted clearing and snagging and dredging operations at a cost of $193,120. Project condition surveys were conducted at a cost of $8,540 and environmental coordination at a cost of $10,029 in Operation and Maintenance funds (USACE 2010:6-5)

> During intermittent periods, the U.S. debris boat *Snell* conducted dredging operations at a cost of $208,000 and project condition surveys were conducted at a cost of $5,500 using Emergency Supplemental funds. Hurricane Irene eliminated road access to Hatteras and Ocracoke Island in North Carolina. The storm also resulted in shoaling within the channel which inhibited safe ferry access. Emergency supplemental funds were reprogrammed to the project and the U.S. sidecasting dredge *Merritt* restored access to the islands by removing 49,820 cubic yards of material at a cost of $130,000 and related project condition surveys were conducted at a cost of $11,000 (USACE 2011:6-5).

> During intermittent periods, the U.S. debris boat *Snell* conducted clearing and snagging, and dredging operations at a cost of $319,206, and project coordination at a cost of $6,114 in Operations and Maintenance funds (USACE 2012:6-4).

By 2015, the channel area had been extensively dredged (an unknown total amount between 1938 and 2012, but at least 214,890 cubic yards) and had undergone periodic obstruction clearing and snagging. This information is important because the channel had a role in supporting trade and driving the dynamics of movement, but also because it communicates that archaeological sites within the area (and especially within the channel) may have already been adversely impacted by dredging.

Impacts from Conflict

History books dealing with the Civil War in Dare County tend to emphasize actions on Roanoke Island or focused at Hatteras Inlet (see Stick 1970:20-26; Belton and Branch 2006:238, 239; Zatarga 2015). This is partially because primary source historical records sometimes indicate that the sound-side waters of the area adjacent to present-day Rodanthe were bypassed, and hence avoided any impacts from the Civil War (see Figure 28). However, isolated incidents of importance did occur in the area – the capture of the USS *Fanny*, and the ensuing "Chicamacomico Races," which have been outlined by many authors of fictional and non-fictional works (Duyckinck 1861; Johnson 1911:54-55; Dunbar 1958:40; Stick 1958:106; Wechter 1974:14-16, 1975:152; Trotter 1989:43-49; Barfield 1995:7, 92-104; Marcinko 2000:43, 45, 52, 74; Carbone 2001:18-21; MacNeill 2008[1958]:161-164; Babits et al. 2013:13-17).

Fanny had been a U.S. army steam tug, used for transporting men and munitions. On 1 October 1861, Acting Master Morrison brought *Fanny* up from Hatteras Inlet to Loggerhead Inlet to bring supplies of clothing, ammunition, and provisions to the Federal forces located at a field camp at Chicamacomico known as *Live Oak Camp*. A navy steamer, USS *General Putnam*, was supposed to keep watch and protect *Fanny*, but instead left its position. After anchoring in eight feet of water at 1 PM, Morrison waited two hours for a flatboat to take the supplies ashore. About 4 PM, CSS *Curlew* had appeared and cut off their escape route--shortly reinforced by CSS *Raleigh* and another steamer, possibly CSS *Junalaska*. At that time, *Curlew* began closing in and firing on *Fanny* (Figure 29). Captain Hart of the 20th Indiana Regiment was aboard with some of his soldiers. He immediately proposed surrendering the vessel. The mate and some soldiers threw overboard 30 cases of ammunition and would have tossed the cannon as well had Captain Hart let them. In the end, the crew slipped the anchor and ran *Fanny* aground to be taken by *Curlew* while the crew of *Fanny*

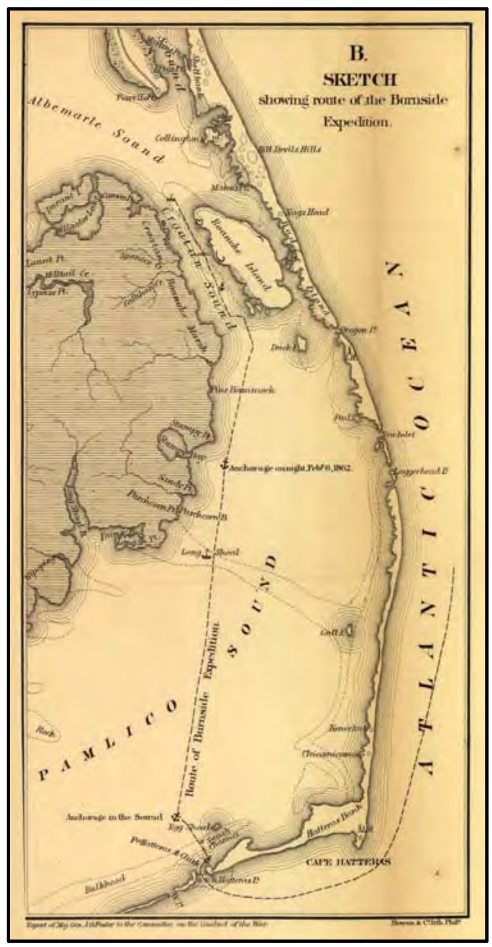


Figure 28. Map showing the Burnside Expedition (Government Printing Office, 1866, see also Hairr 1999:84, for an 1862 version)

got away in a one of the ship's boats (Rowan 1861:275; Morrison 1861:276). David Stick has the following to say about the event:

> In the sound off Chicamacomico they encountered the *Fanny*, armed with two rifled guns, and a "brisk fire was opened which was promptly responded to." The battle lasted for approximately fifteen minutes, at which time "one shell exploded on the deck of the *Fanny*" (Confederate version) or "The *Fanny* go aground" (Federal version), and she was captured, together with forty-three solders and her crew, plus the valuable cargo listed as being worth approximately $150,000.
>
> Historians have since determined that this was "the first capture of an armed vessel during the war," and insofar as the great bulk of the Confederates were concerned "it dispelled the gloom of recent disasters." But the Confederate commanders on Roanoke Island interrogated the prisoners they had taken on the *Fanny* and learned that a large Federal force already was encamped at Chicamacamico, some of the old gloom returned (Stick 1958:132).

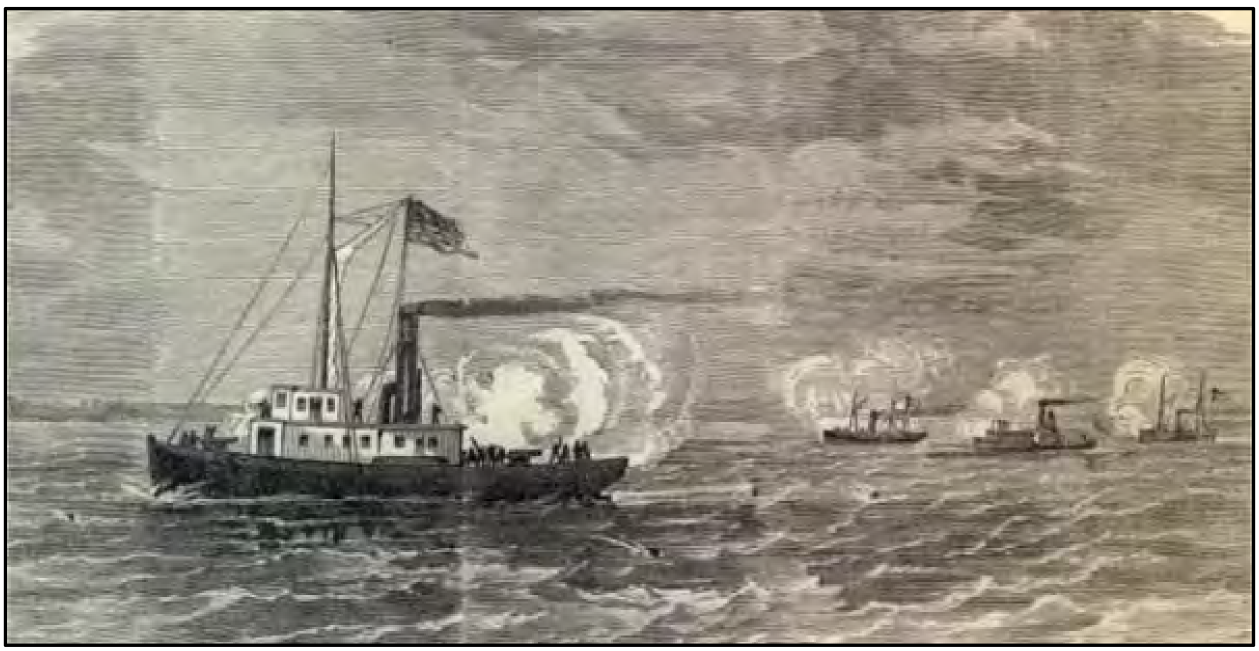


Figure 29. Capture of USS *Fanny* (*Frank Leslie's Illustrated Newspaper* 1861).

When asked why he had abandoned *Fanny*, Captain Hotchkiss of *General Putnam* claimed that he needed coal despite having the ability to procure some from *Fanny* (Rowan 1861:275; Morrison 1861:276; Stick 1958:131). Historians write that *Fanny* was so full of goods that it took many days to unload its hull while at Roanoke Island. Then,

> At one o'clock on the morning of the 5th of October," Colonel Snead reported, the two regiments "were embarked on the steamers *Curlew*, *Raleigh*, *Junaluska*, *Fanny*, *Empire*, and *Cotton Plant.* Passing through Croatan Sound into and down Pamlico Sound, the little fleet arrived off Chicamacomico, and about three miles therefrom, just after sunrise. All the vessels were of too deep a draft to get nearer

this point of the island, except the *Cotton Plant*, which was enabled to advance a mile further on (Stick 1958:133).

In this way, the capture of *Fanny* precipitated further actions, and served as prelude of sorts to the subsequent “Chicamacomico Races” (alternatively known as the “Chicamacomico Affair), as outlined by Stick (1958:284-285):

> Soon after Federal troops captured Hatteras Inlet in 1861 a regiment was dispatched to Chicamacomico, where an outpost called “Live Oak Camp” was established. Even before the camp was completed, the Confederates attacked this position, chasing the Federal troops southward to Cape Hatteras, while most of the residents of Chicamacomico, having cast their lot with the Federals, fled ahead of the attacking force. The next day, however, Federal reinforcements arrived and the Confederates fled back up the Banks again, embarking on boats at Chicamacomico for their base at Roanoke Island. This engagement was referred to as “The Chicamacomico Races.”

These events were captured by a member of the 20th Indiana Regiment (Dr. Everts) and reproduced in *Frank Leslie’s Illustrated Newspaper* (Figure 30).

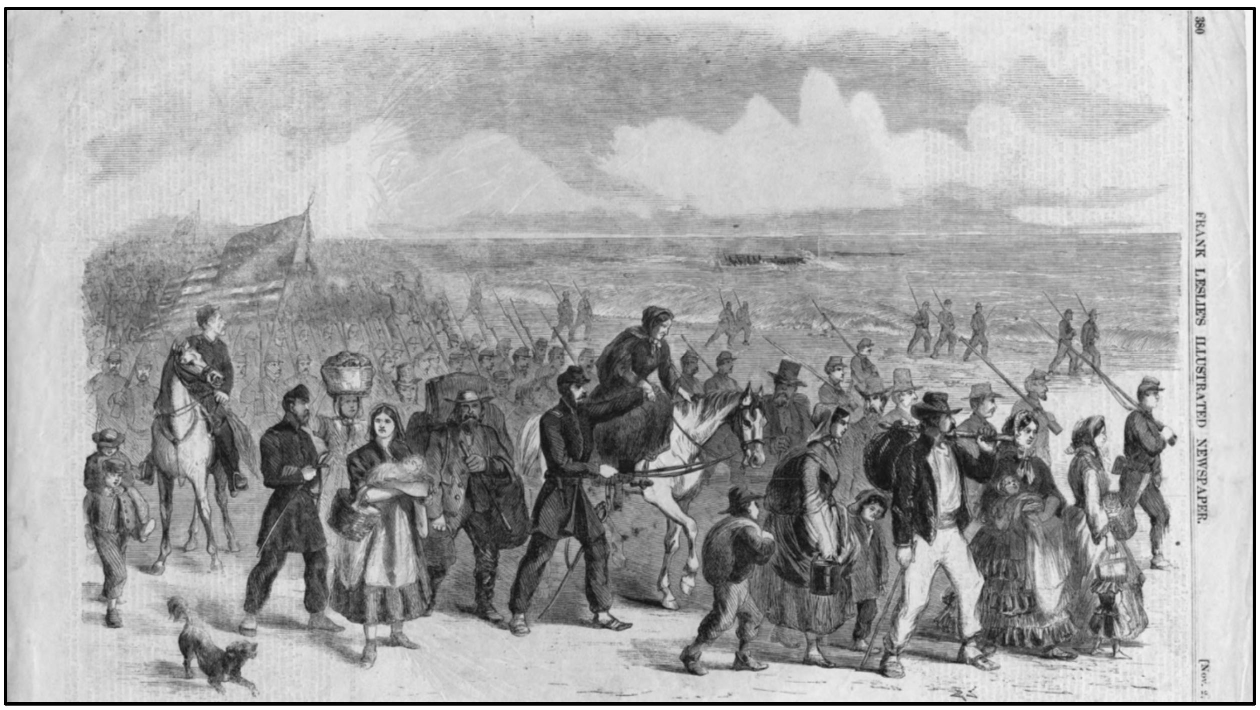
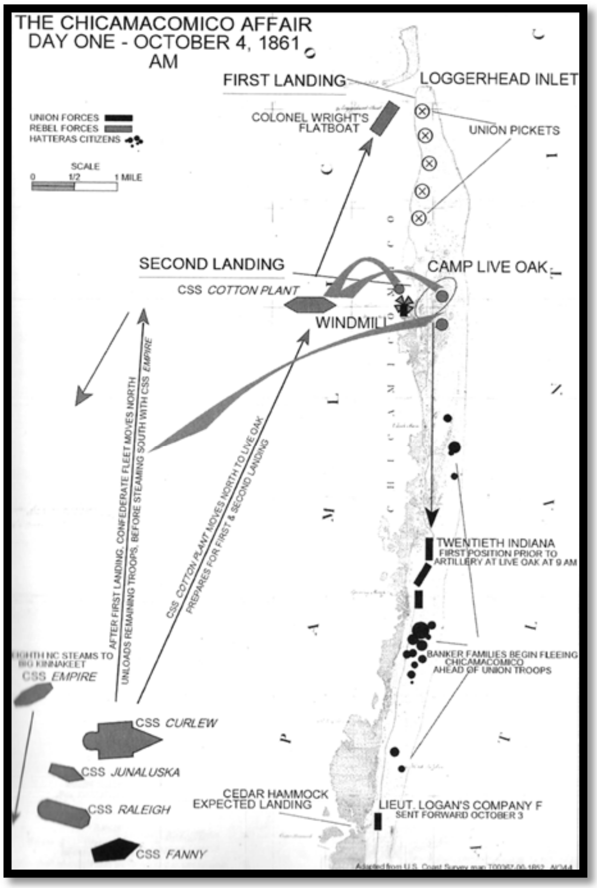


Figure 30. “The Loyal inhabitants of Hatteras Island expelled from their homes by the rebel troops, overtaken by the 20th Indiana Regiment, while retreated to Fort Hatteras for protection, October 4 [1861], From a Sketch by Dr. Everts, of the 20th Indiana Regiment” (*Frank Leslie’s Illustrated Newspaper,* 2 November 1861:380).

The most extensive examination of the incident with *Fanny* and the subsequent “races” is the work of Lee Oxford (2013, see especially pages 63-117), whose in-depth examination also includes a series of maps which provide an interpretation of the positions of Federal and Confederate combatants along Hatteras Island and a consideration of where landings and bombardments occurred. Critically, these maps suggest that some of the events described above occurred within the study area (see Figures 31 and 32).



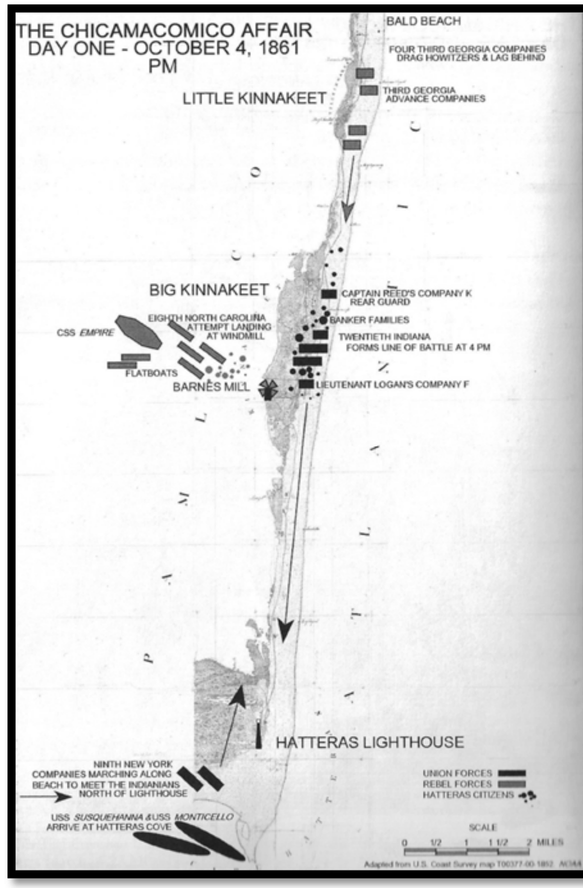


Figure 31. Lee Oxford's depiction of "The Chicamacomico Affair, Day One -- October 4, 1861, AM" (Oxford 2013:149).

Figure 32. Lee Oxford's depiction of "The Chicamacomico Affair, Day One -- October 4, 1861, PM" (Oxford 2013:150).

Prompted by an alternative hypothesis by a present-day Waves resident (Mr. Mel Covey) regarding the location of *Live Oak Camp*, a terrestrial archaeological survey was undertaken by a group of archaeologists in 2015 (see Babits et al. 2015) to test if the said encampment might have instead been located at Waves, NC (underwritten via funds obtained by Mr. Covey). Following their assessment of a site on private property at Waves and review of historical records, the archaeologists concluded that there was no Civil War encampment at Waves, and the Chicamacomico location for Live Oak Camp was the most likely. The Babits et al. work was subsequently rebutted by Mr. Covey in the form of an extensive report which contends that the tests were incomplete or flawed (Covey 2016). This is of relevance to this report because the authors of this report have incorporated the "Oxford" and "Babits" hypotheses which support the location of the capture of USS *Fanny* and other actions during the Chicamacomico Affair within proximity to the study area. This would suggest that there is some chance that material from these encounters could still lie within the survey area in the form of small arms and expended naval artillery ammunition. However, should Mr. Covey's hypothesis prove correct, the location of the USS *Fanny* capture would be moved some distance S (around 2.4 miles/3.87 km), placing it well outside of the study area. Determining the accuracy of the Oxford/Babits or Covey arguments is outside of the scope of this study, but taken into consideration when planning remote sensing operations and reading data from it.

Impacts from Marine Incidents and Accidents

Pamlico Sound, particularly the part of the sound that borders the western shores of Hatteras Island, is notoriously shallow. Emblematic of the importance of the area's shallowness is the following reminiscence by Henry Plummer dated to 2 December 1912:

> Gunners returning to Stumpy Point from Hatteras told us that the gale of Thanksgiving day blew all the water out of the sound and left a big 60 ft. motor yacht high and dry off the beach. Then when wind hauled N.W. all the water blew back with such a rush that she was afloat in 40 minutes but lost her nice bower launch, anchor and 15 fathoms chain, but was able to get shelter under power herself (Plummer 2003[1914]:30).

This quote represents what is more or less a repeating historical pattern. Ships continuously run aground in the sound along Hatteras Island's shoreline. While they may lose parts of their hull, cargo, or equipment, they tend to be refloated – with or without human help.

Hence, of the list of potential shipwrecks lost in Pamlico Sound, historical records mention 13 as having been involved in *incidents* within proximity to the study area – but the clear majority do not represent *bona fide* shipwrecks (i.e. where the hulls of the ship lie *in situ* in the present day), nevertheless, the locations of these incidents can be estimated (Figure 33).

When examining Figure 33, it must be considered that the spatial locations depicted are approximations interpreted by the authors from reading reports written during a time before technology for very accurate position fixing was available. Due to this, the authors have exhibited caution in selecting candidates within miles of the study area (of which only three could have arguably occurred within, or close to the surveyed area, see Figure 34). Given the proximity of the Chicamacomico Life-Saving Station to the study area, this gives us a very good idea of the potential wrecking events occurring adjacent to the present-day ferry channel over the period of the Life-Saving Station's operations (1874-1915) and as a Coast Guard station from 1915 to 1954. Additionally, oral histories tell of accidents and incidents in the post-1954 era (specifically the early 1960s), which may have seen four additional watercraft aground in the area, one of which still lies in situ today (PAS0001, or the "Pappy's Lane Wreck).

The text below outlines the maritime incidents currently known to have occurred within the vicinity of the study area. First, incident circumstances regarding historically documented *named vessels* over the period 1822 to 1914 are discussed. Of these events, only *Captain's Boat* is listed in historical records as being lost in such a manner where uncertainty exists whether it could still lie on the sound floor. Of the remaining 12 vessels, all had a definitive statement regarding their loss or their salvation. Regardless of the vessel's reported fate, the authors did additional historical research to examine the potential historical significance of the ships interacting with the study area and to determine if this fate changed.

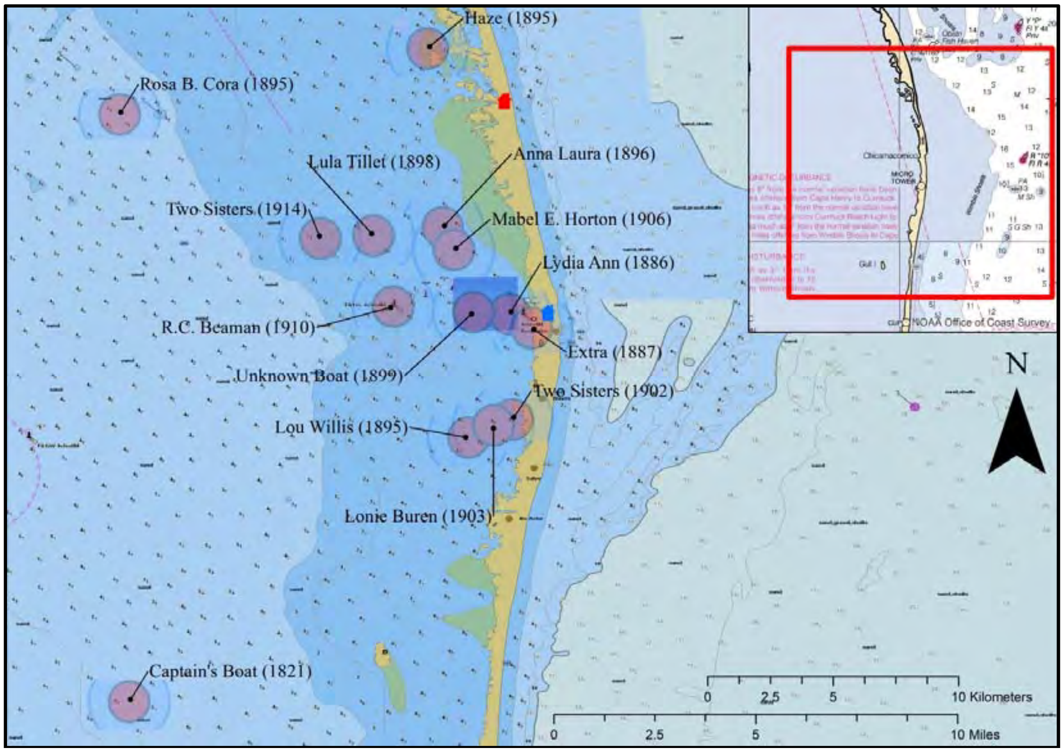


Figure 33. Image of thirteen "maritime incidents" locating within proximity to the study area. Red and blue bubbles indicate 1-mile and 2-mile diameter confidence zones, respectively. Blue and red house symbols denote location of Chicamacomico and Gull Shoal Life-Saving Stations, respectively (Image by Nathan Richards).

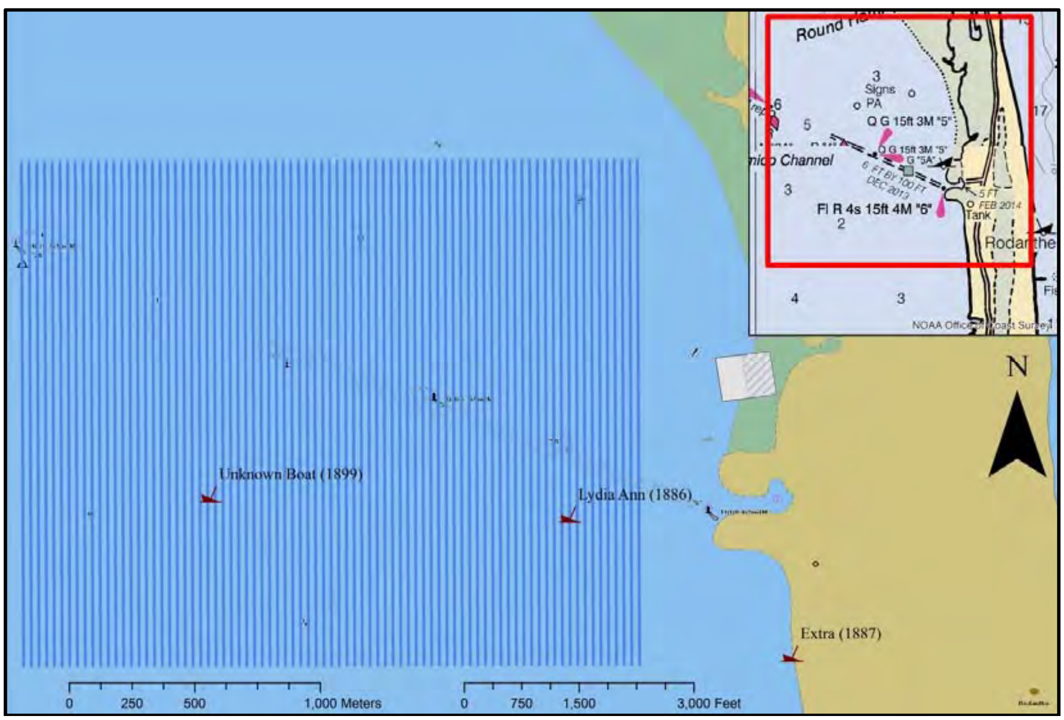


Figure 34. Detail of 2015 survey areas showing the estimated incidents of the three marine incidents believed to have occurred in closest proximity to the studied areas of seabed – areas in the water represent incidences concerning *Lydia Ann* (1886) and Unknown Boat (1899). An incident concerning *Extra* likely lies along the present-day shoreline, or beneath developed areas (Image by Nathan Richards).

In one case this proved fruitful, as one vessel, *Lonie Buren*, listed as “lost” in a life-saving report was actually found to have been refloated sometime later. Because of this only one out of thirteen vessels (*Captain’s Boat*) likely represented an actual total loss (i.e. potentially wrecked and remaining in place), and the remaining twelve were considered “partial losses” (i.e. there was damage to hull, cargo, crew, or a combination of the three and material from the event potentially became a part of the archaeological record) at most. Details of the 1821 loss *Captain’s Boat* are very few, and the area of this loss is very uncertain and likely far removed from the remote sensing area. This means that there is a high likelihood that there are no extant ship remains in the study area, although there is some chance that debris from these events may lay *in situ*. It would be very difficult to detect such material, and even more difficult to connect it to specific watercraft.

An interesting corollary related to collating these wrecking events adjacent to the Chicamacomico Life-Saving Station is independent verification of an observation noted by Wright and Zoby (2000:266) in regards to the proximal Pea Island station that,

> Vigilant service and good fortune had helped keep ships off the shoals at Pea Island for the better part of the 1880s. With the new decade, Richard Etheridge and his crew suddenly found themselves confronted with disaster after disaster. The ten months between Christmas, 1895, and November 1896 were particularly nasty at Pea Island. Ships came ashore like never before, their hapless crews leaving their fate in the hands of lifesavers.

Four out of thirteen of the ships (almost 31%) mentioned below as coming to grief within Pamlico Sound do so within this time. The biographies of these watercraft are listed below, chronologically by date of incident.

Events in the 1960s concerning PAS0001 and perhaps other watercraft are less well documented in historical records, though information was obtained from knowledgeable Hatteras Islanders, and are therefore included following the 1822-1914 ship biographies.

Captain’s Boat (unknown-1821): 9 November 1821 wrecking

NCUAB file #5089 mentions the foundering and subsequent loss (via scuttling) of the schooner *Captain’s Boat* during a squall in Pamlico Sound on 9 December 1821, while carrying cargo and passengers (with all lives lost). This is corroborated in a newspaper article in the *Edenton Gazette* (later repeated in the *Baltimore Patriot* on 26 December 1821, with minor spelling disagreements and capitalization differences) and is all that has currently been found regarding the wrecking event (actually one month earlier, on 9 November 1821):

> SHIPWRECK -- On Friday the 9th of November last, the schr *Captain's-Boat*, Capt. Greaves, of Currituck, from Charleston, bound to this port, upset in a squall, in Pamplico Sound, about 25 miles below the Marshes, and all on board perished. Among the persons on board, we learn was *Mr. ---- Fisher* of Powell's Point, and *Mr. Paulus Emelus Niel* of this town, who was returning in the vessel with the proceeds of the outward cargo. Two of the men drifted on shore at Chicknacomico Banks, and were buried; one of whom, from his dress, was supposed to be the unfortunate *Niel*. The sch’r has since been boarded by friends

> of the deceased; but she appeared to have been scuttled, and robbed of everything on board (*Edenton Gazette* 1821).

This vessel has proved to be difficult to research. No vessel by this name has been found in any extant marine insurance record, shipping register, or government report (it should be noted that this event pre-dates the establishment of the USLSS in North Carolina by over half a century). However, the solitary citation represents the only suggestion of an actual shipwreck potentially lying within close (but undeterminable) proximity to the study area. Nevertheless, no reference to a vessel of this name can be found in any of the sources regarding North Carolina shipwrecks (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007).

Lydia Ann (c.1875-unknown): 9 January 1886 incident

NCUAB files (File ID#2609) outline the loss of the sloop *Lydia Ann* three quarters of a mile W of the Chicamacomico Life-Saving Station on 31 December 1895. However, this appears to be an error, as life-saving station wreck reports indicate this incident actually happened off Bodies Island in the vicinity of Roanoke Island and that the vessel was saved, according to J.S. Etheridge's wreck report (Etheridge 1896).

On 9 January 1896, the sloop *Lydia Ann,* under master and owner John Coumbs, rode high on shore due to a parted painter. It was en route from Currituck to Roanoke Island without cargo and foundered 3 ½ miles NW of the Bodie Island Station roughly ½ a mile from shore. It was noted to have wrecked at Cow Island Flats during the night due to weather. The wreck was discovered by S.L. Midgett at 11:00 as a SW gale was blowing. However, Captain Coumbs did not immediately request for help by the station crew, thinking he would wait for high tide to refloat the sloop. Therefore, the station crew did not immediately render assistance. After a few days when the tides did not refloat the vessel, Captain Coumbs left to retrieve lumber to get the sloop off the shore. On 13 January 1896, he requested help from the station crew and they spent two days refloating *Lydia Ann*. Presumably, the sloop continued on its way, as it was reported to have been saved as opposed to lost and sustained no reported damage (Etheridge 1896).

The information is duplicated in the 1897 edition of the Annual Report of the U.S. Life-Saving Service which notes that the vessel "parted line and stranded" three and a half miles NW of the Bodie Island station on 31 December 1895– that the vessel was valued at $100, and that it, along with its two passengers, were saved (USTD 1897:318-319). The same edition of the 1897 Annual Report (USTD 1897:132) quotes,

> Jan. 13. Am. sl. Lydia Ann.. Bodie Island, North Carolina. This vessel had stranded, 3 miles from the station, on December 31, 1895, coming ashore high and dry without sustaining any damage. On January 13, 1896, her owner applied at the station for aid in getting her afloat. For two dates the life-saving drew assisted him, moving his boat about 300 yards, until she was in a position where the master was satisfied she would float at high water.

The error, as it turns out, is that the wrong station and date have been combined in the NCUAB files, and the incident at Chicamacomico is an earlier event that occurred on January 9, 1886 at Chicamacomico (which was not discovered at the time this report was written). The entry in USLSS Annual Report for 1887 reads, "1886. Jan 9. Pamlico Sound, three-fourths of a mile W of station. Chicamicomico. Sl. Lydia Ann, Elizabeth City, NC." The master and tonnage of the vessel is unlisted. The report outlines that the vessel was headed to Rodanthe from Colington Island without cargo (one crew member) at the time of the incident. It also notes that it was valued at $200 and sustained $50 of damage (USTD 1887:328-329).

Research has not yet turned up any additional instances of *Lydia Ann* being involved in other incidences in the region after 1895, no other reference to this vessel has been found in government reports or ship registers from this time, and no vessel by this name is listed as "totally lost" in other publications (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007). The activities and fate of *Lydia Ann* after 1897 are currently unknown.

Extra (1853?–unknown): 22 March 1887 incident

The 1887 Annual Report of the U.S. Life-Saving Service (USTD 1887:310-311) outlines the loss of a schooner named *Extra* on 22 March 1887 approximately ½ mile SW of Chicamacomico station. The vessel's home port is listed as Elizabeth City, and it was on a voyage from Collington, NC to Chicamacomico, NC. The estimated value of the vessel was $2,500, of which $2,470 was saved. Two people were on board – both were saved. Cargo, Master, and tonnage are unspecified in the file (see also NCUAB File #3166). The listing of a $30 loss indicates that the vessel was almost certainly refloated. The full details of the wrecking incident, as outlined in the Chicamacomico wreck report (22 March 1887), have not been relocated.

The *Record of American and Foreign Shipping* does list a vessel named *Extra* (Official Number 8054) over the years 1861-1870, 1872, and 1882-1886. The single-decked, 58 ton (listed as 78 tons between 1861 and 1865) wooden schooner (variously described as constructed of oak or oak and pine with iron fasteners), built in Dorcester County, Maryland (no specified builder) in 1853, was 73.2 feet long, 21.3 feet wide, and 6.1 feet deep. From 1861 to 1872, *Extra* was classed grade 2½ (a 3rd class rating, falling under the description implying a lack of "confidence for the conveyance of cargoes in their nature subject to sea damage") and owned by "Ridgeway" of Baltimore, Maryland (inspected at Baltimore in October 1860 and at Philadelphia in March 1864 and March 1866). Between 1861 and 1870 the captain is listed as "Wilson." In 1872 the vessel is listed as being captained by "Taylor." A column of remarks notes the vessel had CB (a centerboard) and HP (a half poop deck) (American Lloyds [AL] 1861:399, 1862:420, 1863:429, 1864:474, 1865:468, 1866:494, 1867:74, 1868:513, 1869:76, 1870:73, 1872:64). Over the years 1881-1886 the hailing port is listed as Crisfield, Maryland (owned by R.P. Darby, Thomas H. Murphy, master) (AL 1881:420, 1882:407, 1883:408, 1884:410, 1885:411, 1886:377). These details are also repeated in the 1885 and 1886 volumes of the *Annual List of Merchant Vessels of the United States* (AL 1885:132, 1886:128). Nothing else is known about this vessel.

This vessel is not listed in insurance registers after 1886, creating the slim potential that it may have been transferred to Elizabeth City in 1886 or early 1887. However, there is currently no definitive connection between *Extra* reported in the *Record of American and Foreign Shipping* and *Extra* reported as having being partially damaged at Chicamacomico in 1887.

None of the seminal published texts regarding North Carolina shipwrecks (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007) include a shipwreck named *Extra*, suggesting it was not permanently lost in the state.

Lou Willis (1876-c.1912): 27 January 1895 incident

Lou Willis is listed in the NCUAB files (#3117) as having been stranded 3.5 miles S by W of Chicamacomico Life-Saving Station on 27 January 1895 – and subsequently totally recovered. *Lou Willis* (official number 140160) was a schooner built in Smyrna, North Carolina in 1876. It had a length of 42.9 feet and a beam measuring 13.8 feet while its hold was 4.2 feet deep. It had a gross and net tonnage of 15.33 and 14.57 tons respectively (United States Bureau of Navigation 1897:120). Beginning in 1902, the required number of crew needed to sail it was two sailors (United States Bureau of Navigation 1902:116).

Before the schooner's first encounter off the Chicamicomico Station, it had already befallen misfortune once in its service life. On 21 July 1886, *The News and Observer* (1886:2) reported that the schooner had been found capsized by the revenue cutter, *Stevens*. It had foundered in Roanoke Sound, between Nags Head and Manteo. Several of the fourteen passengers aboard were already being rescued in a canoe that *Willis* had in tow by the time the cutter's boat reached the scene. It was ascertained that a young woman from Hertford had already drowned while a child and elderly woman were still trapped in the cabin. With *Willis* lying on its beams in heavy seas, Lieutenant Hand of *Stevens* ordered his crew to begin smashing through the hull and the cabin walls. After four hours of work, they succeeded and Lieutenant Hand delivered the survivors to Manteo. The capsizing event occurred due to the crew's drunkenness during a storm (*The News and Observer* 1886:2). Sometime after the incident, *Lou Willis* was refloated and repaired to continue in trade on the sounds.

On 27 December 1895, the schooner had its first encounter with the Life-Saving Station at Chicamicomico. Under Master L.R. O'Neal, *Lou Willis*' anchor fouled and allowed the schooner to drag in heavy seas around 2:00 AM. It was carrying no cargo except passengers -- a woman from Stumpy Point, North Carolina and three children from Elizabeth City, NC (Midgett Jr. 1895). It was en route from Stumpy Point to docks at Chicamicomico.

At sunrise, roughly 8:45 AM, Keeper L.B. Midgett Jr. spotted the vessel a mile from shore and three-and-a-half miles S by W from the station. The station lookout then informed him that a distress signal had been made from the schooner, and the crew set out for the stranded vessel. Midgett Jr. made note that by the time the life-saving crew had reached the wreck, the water was calm but that the tide was very high. Despite this, the schooner had become stranded, leaving the vessel "dry". Thus, the life-saving crew could do nothing until Master O'Neal had retrieved skids to re-launch the schooner (Midgett Jr. 1895).

On 23 January 1895, these skids were retrieved and the life-saving station crew succeeded in getting the schooner afloat again. From this point, Master O'Neal and owners A.S. and A.W. Hoopers took charge of the schooner and continued on the way (Midgett Jr. 1895). The report is interesting because at the time of the wreck, *Lou Willis* is listed as having Elizabeth City, North Carolina as its homeport and being 17 years old. In the *Annual List of Merchant Vessels of the United States* for 1895, the schooner is registered in Edenton, NC (United States Bureau of Navigation 1895:125). As the wrecking event is so early in the year 1895, it may be that the vessel was registered in Elizabeth City in the year 1894 before being re-registered in 1895 in Edenton. This may also imply that the schooner was sold to different owners soon after the wrecking event. However, the actual age of the vessel at the time of the wrecking event was not 17 years; instead it was 19 years old (United States Bureau of Navigation 1895:125).

Over the next several years, *Lou Willis* was registered in several different ports. As noted above, in 1895, it was registered in Edenton (United States Bureau of Navigation 1895:125). The following year, it was registered in New Bern (United States Bureau of Navigation 1896:123).

Here it remained registered until 1898. The records show that it was registered in Edenton once again in 1899 (United States Bureau of Navigation 1899:117). For three years, it remained registered in that port. In 1903, the schooner was registered once more in Elizabeth City (United States Bureau of Navigation 1903:111). It remained registered in Elizabeth City until the end of its service career in 1912 (United States Bureau of Navigation 1912:63).

In the year 1902, *Lou Willis* provided passage for two men who were destined to change the world: Wilbur and Orville Wright, inventors of the first successful self-propelled crewed aircraft. On 26 August 1902, the Wright Brothers arrived in Elizabeth City with intentions to travel once again to Kitty Hawk in the Outer Banks to test their new glider design. They arrived at 5:45 PM, with the intention of finding suitable transportation to the barrier islands the next day. Instead, they immediately spotted *Lou Willis* tied up to the city docks. They quickly discovered that the schooner was departing for Kitty Hawk in the morning and hurried to retrieve their baggage and freight before the train depot closed at 6:00 PM (Wright 1902:70; Kirk 1995:109).

At this time, the schooner was being captained by Franklin Midgett, a member of the same Midgett family who had been in long service to the Life-Saving Stations of the Outer Banks. He had recently left the life-saving service to start a boat line. On this trip, the schooner was carrying a cargo of lumber as well as another passenger (Kirk 1995:110). At 4:00 AM, Captain Midgett cast off and proceeded down the Pasquotank River. There was little wind - so little in fact that the schooner had to be poled out from the wharves. The passage was particularly slow due to adverse wind conditions, and in 12 hours, the schooner had only gone 15 miles. At this point, Captain Midgett decided to cast anchor and wait until the next day for better winds (Wright 1902:70-71). At 4:30 AM, the morning of 28 August, *Lou Willis* weighed anchor and reached Kitty Hawk without further interruptions at 4:00 PM the same day (Kirk 1995:110). A few weeks later, the schooner brought their 1902 glider to Kitty Hawk from Elizabeth City after they had established their camp and did the same in 1903 (Howard 1998:91,114).

Lou Willis again met the Life-Saving Service on 10 March 1906. The schooner was sailing in ballast from Martin's Point, NC, to Kitty Hawk under Master J.E. Midgett and another crew member. They were near the Paul Gamiels Hill Station. A missing staysail caused the schooner to become stranded on a sand shoal, 300 yards from shore and two miles SW of the station. Two days later, with help from the keeper and surfmen from the Kitty Hawk Station, station keeper Harris and five of his crew rowed out to the schooner at 9:00 AM. At 2:00 PM, they returned to duty as they had saved the schooner and moved it once more into deeper water (Harris 1906). Per newspaper accounts, the Kitty Hawk Station was called for help because the Paul Gamiels station did not have an experienced diver (*The Daily Economist* 1906a:2).

In 1908, after the Wright Brothers settled several lawsuits against their patents, *Lou Willis* again ferried them and supplies to the Outer Banks. At this point, it was being captained by Franklin Midgett's son, Spencer. Franklin Midgett was piloting a gasoline launch. Upon learning that their old camp was in ruins, Wilbur Wright traveled to Kitty Hawk in the launch while *Lou Willis* followed carrying as much lumber as possible (Howard 1998:239-240). Difficulties with the schooner such as sails being lost on return trips for more lumber or winds leaving it stranded on sand bars resulted in 1908 being the last year *Lou Willis* provided service for the Wright Brothers (Howard 1998:240-241).

While it no longer serviced the Wright Brothers, *Lou Willis* appears to have done similar duties throughout the rest of its career until 1912. It seems to have been well-known in Outer Banks communities, probably due to its association with the Midgett family and their connections. In 1906, it is not listed for services among the packet service vessels or in the canal trade in the *Daily Economist*. Instead, its arrival in Elizabeth City is mentioned on the same page in the personal mentions (The Daily Economist 1906b:3). This suggests that it served the rest of its career making private runs out to the Outer Banks for the Life-Saving Service stations and private residents receiving supplies from Elizabeth City.

Lou Willis does not appear in any of the seminal historical sources concerning shipwrecks in North Carolina waters (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007). Its fate after 1912 remains unknown.

Haze (1890-c.1907): 10 March 1895 incident

The schooner (also described as a "schooner yacht") *Haze* (official number 96071) was built in 1890 at East River, Connecticut. Its length is recorded as 44.4 feet, its breadth at 12.5 feet, and its depth of hold was 2.7 feet. Its gross tonnage was noted to be 10.53 tons, and its net tonnage was 10.01 tons. In the year 1895, it was registered in Edenton, NC (United States Bureau of Navigation 1895:86). By 1902, it was reported to only require one crew member (United States Bureau of Navigation 1902:80).

Haze only had a single encounter with the Life-Saving Station. The station involved with the life-saving service in this case was the New Inlet Station. On 10 March 1895, the schooner was sailing from Elizabeth City, NC to New Inlet, NC under Master G. Heath. The schooner had no cargo, but was providing passage for two passengers. Master Heath was assisted on the voyage by a cook, A. Fearing. Both crewmembers resided in Elizabeth City. The passengers, J. Derby and E. Richards, were both traveling from Sandy Hill, New York (Wescott 1895).

During the early morning hours of 10 March, the schooner became stranded one mile from shore and two miles NW of the station on Jack Shoal. The cause of the stranding was determined to be miscalculation by Master Heath. At 7:00 AM, lookout A. Etheridge spotted the wreck flying a distress signal. Keeper Wescott gathered his crew in a sailing fishing boat and sailed out to the schooner, the fishing boat being the fastest way to reach the stranded vessel. They reached the wreck at 8:00 AM and were soon joined by the keeper and crew from the Pea Island Life-Saving Station (Wescott 1895).

Wescott discovered the schooner to be high on the shoal. The crew agreed to run out *Haze*'s anchors and wait until hide tide before trying to float it once more. The first attempt to re-float the schooner failed and the crews agreed to meet in the morning to try again. The next morning at high tide, the crews met again and positioned the schooner where it would be easiest to get it floating once more and this second attempt proved successful. From here, *Haze* continued on its voyage (Wescott 1895).

Little more is known of the schooner *Haze*. It continued working from its homeport of Edenton until 1903. In this year, a possible change in ownership saw it registered in Elizabeth City (USBMIN 1903:77). It only continued service from Elizabeth City until 1905. In 1906 it was recorded as registered in New Bern, North Carolina (USBMIN 1906:70). It continued working from New Bern until the next year or until early 1908, as it is not recorded in the *Annual List of Merchant Vessels of the United States* past the 1907 registry year (USBMIN 1907:64). No other anecdotal evidence of the schooner can be found, and no sources list a wreck named *Haze* as occurring in North Carolina waters (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007).

Rosa B. Cora (1892-c.1914): 7 August 1895 incident
NCUAB File #3073 lists an incident occurring 10 miles NW by W of Chicamacomico on 7 August 1895 which culminated in the partial recovery of a schooner out of Elizabeth City (bound for Rodanthe) named *Rosa B. Cora*.

Rosa B. Cora (Official Number 111006, no signal letters) was a sailing vessel of dimensions 41 feet length, 13 feet width, 4 feet depth (17.06 gross tons/16.18 net tons burden), built at Elizabeth City in 1892. The vessel operated with a single crewmember out of three North Carolina ports during its life – Edenton (1892-1895, 1899-1901), New Bern (1896-1898, 1904-1914), and Elizabeth City (1902-1903) (USBMIN 1894: 227, 1895:173, 1896:169, 1897:166, 1898:168, 1899:162, 1900:164, 1901:164, 1902:160, 1903:154, 1904:149, 1905:148, 1905:148, 1906:139, 1907:129, 1908:119, 1909:113, 1910:103, 1911:95, 1912:87, 1913:75, 1914:75). It is unknown what happened to *Rosa B. Cora* after 1914 – the vessel is not listed in any subsequent reports for vessels (of any type) in the 1915 report and is not listed in the list of vessels lost – it simply disappears from the historical record. It is not mentioned in any publications dedicated to North Carolina shipwrecks (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007).

The incident concerning *Rosa B. Cora* is found in an entry in Sarah Downing's *On This Day in Outer Banks History*, titled, August 7, 1895—Hatteras Crews Right Edenton Vessel:

> The two-masted schooner *Rosa B. Cora*, of Edenton, North Carolina, capsized in the Pamlico Sound during an early morning squall. The ship, en route to Rodanthe from Elizabeth City, carried a load of ice, flour, corn and salt. The captain of the vessel, William R. Balance, requested assistance from the Chicamacomico Life-Saving Station and he was taken to Rodanthe in a shad boat that the *Rosa B. Cora* had in tow. The Chicamacomico crew, assisted by crew from the New Inlet and Pea Island Stations, was unable to raise the schooner for two days due to rough conditions in the sound but was successful on the third day when the water calmed. The ship was righted, bailed out and towed to a safe harbor, when the owner thanked the crew for its assistance" (Downing 2014:232).

Likewise, Wright and Zoby (2000:266) discuss the event in *Fire on the Beach: Recovering the Lost Story of Richard Etheridge and the Pea Island Lifesaver:*

> In August 1895, Richard Etheridge and his men were summoned to the wreck of the *Rosa Cora*, which had capsized in the Pamlico Sound. The combined Chicamacomico, New Inlet, and Pea Island crews raised and righted her and sent her on her way. But more dangerous weather and the resultant disasters were still to come.

The information used by both Downing and Wright and Zoby comes from L.B. Midgett's 12 August 1895 wreck report (Midgett 1895) which outlines additional details of the capsizing event, rescue, and eventual recovery of *Rosa B. Cora*. The wreck report is presented as a synopsis in two locations within the Annual Report of the U.S. Life-Saving Service of 1896, first outlining that the Women's National Relief Association provided assistance to "the crew of the schooner *Rosa B. Cora*, at the Chicamacomico Station, coast of North Carolina, August 7, 1895" (USTD 1896:52), and the actual wreck details:

> 1895, Aug. 7. Am. sc. Rosa B. Cora. Chicamacomico, North Carolina. Capsized by a squall 10 miles from station in the nighttime. Crew rescued by boatman in tow at the time of accident. Captain came to station for assistance. Station crew went to vessel in company with crews of Pea Island and New Inlet stations, but being unable to raise her, took her crew of two persons to station, gave them clothing and succor. Worked on the vessel the two succeeding days, finally getting her afloat. Towed to a good harbor (USTD 1896:70).

Anna Laura (c.1892-unknown): 15 December 1896 incident

The North Carolina Underwater Archaeology Branch files (file #3040) list the sailboat *Anna Laura* as capsizing in Pamlico Sound off Loggerhead Shoals on 15 December 1896. The Roanoke Island-owned vessel (valued at $150) was bound for Chicamacomico at the time of the event. The two people on board survived (and were boarded at the Chicamacomico station for four days), with the vessel and cargo sustaining $5 damage (USTD 1897:318-319).

Life-saving station keeper L.B. Midgett, Sr's wreck report (Chicamacomico Life-Saving Station, 18 December 1896) provides more information (Midgett 1896). According to the wreck report, *Anna Laura* was an unregistered sprit-sailed shad boat, built around 1892 that operated between Rodanthe and Roanoke Island as a mail boat (captained by William M. Beasley and owned by William St. Clara Pugh). The boat, with its crew of two people (W.M. Beasley and W.W. Spenser of Roanoke Island and Hatteras, respectively), capsized in a gale while carrying mail and was subsequently rescued with the help of four men from the Chicamacomico station (no vessels or other rescue apparatus were needed).

The *Merchant Sailing Vessels of the United States* (USBMIN 1895:14, 1897:13, 1898:13) lists only one *Anna Laura* (official number 105165) – a schooner of 19.17 gross tons (18.21 net tons) and dimensions 45.6 feet length, 15.9 feet breadth, and 5.0 feet draft built in Crisfield, Maryland in 1872 and operating out of Onancock, Virginia (and later Cape Charles, VA). The discrepancy in build date and home port suggests these vessels are not the same *Anna Laura* – and tells us that the Roanoke Island-based *Anna Laura* was a different, much smaller boat (reinforced by the lack of official number noted in the wreck report).

A short notation in the USLSS's Annual Report of 1898 (USTD 1898:58) lists the rescue, but differs in one detail – that only three men were rescued from the capsized sailboat. The authors are currently unaware of *Anna Laura's* history before or after this 1896 event. None of the seminal published texts regarding North Carolina shipwrecks (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007) suggest it became a shipwreck in the state. From the description outlined in the wreck report, little to no archaeological evidence from this incident would be expected to remain in the area.

Lula Tillett (c.1887-unknown): 31 January 1898 incident

The vessel *Lula Tillett* is listed in NCUAB files (file #3004) as being involved in a marine incident 4 miles NW by W of the Chicamacomico Life-Saving Station.

All the information currently available about *Lula Tillett* is contained within L.B. Midgett, Jr's 1898 wreck report (Midgett 1898) and the corresponding entry in the Life-Saving Service's 1899 Annual Report (USTD 1899:278-279).

The 1899 report contends that the incident (a capsizing) involving the Manteo-based "sailboat" *Lula Tillett* occurred on January 29, 1898 at a location four miles NW by W of the

Chicamacomico station. The boat was carrying no cargo at the time it capsized. The vessel itself was valued at $125 (totally recovered). Two people were listed as being on board (both saved). Other details, such as the master, tonnage of vessel, and the people housed and fed at the station following their rescue are not noted (USTD 1899:278-279). Midgett's original wreck report, however gives us much more detail, outlining the circumstances leading up to the vessel's capsizing, the rescue of the two crew, and the nature of the damage to the vessel (loss of two oars, four thwarts, and a tiller) and the loss of some of its cargo (10 sand bags).

As *Lula Tillett* was listed as a pleasure vessel and was likely less than 5 tons burthen, it is not listed in publications such as the *Annual List of Merchant Vessels of the United States*, and therefore its life is difficult to track –almost nothing of its life or its fate following recovery is currently known. No vessel with this name is listed as being wrecked in the state (no entries for *Lula Tillett* exist in Stick 1952, Lonsdale and Kaplan 1964, Berman 1972, Freitag 1998, Charles 2004, or Duffus 2007). The name "Lula Tillett" however is easily found in the NE part of North Carolina and was likely the name of a prominent local woman. This particular combination of first and surname can easily be found – for example a Lula Tillett was born in Elizabeth City around 1904 (deceased 1997), another is listed as living in Edenton in 2002 (Obituaries *Greensboro News and Record* 24 February 2002:B5) and multiple Lula Tilletts have lived (and live) in Manteo (see *Outer Banks Sentinel*, 6 March 2013:A7; *Charlotte Observer* 23 August 1988:1B).

Unknown Boat (Fishboat)/Dory/No name (unknown-unknown): 26 March 1899 incident
On 26 March 1899, a shad boat with no reported name was spotted by Chicamacomico station lookout B.W. O'Neal in the early afternoon W of the station at about 1 ½ miles distant. The boat had no cargo and was under command of Engean Seaman of Manteo with another crew member. O'Neal account describes how he continued watching the boat as is made its way from Chicamicomico for Manteo as the wind began to pick up. The N to NE wind shifted into a gale, causing the shad boat to capsize. O'Neal quickly alerted station keeper L.B. Midgett who sent two of his crew with a neighbor's (Mr. Meekins), shad boat. Additionally, another station keeper, Captain Pugh, spotted the boat in distress and sent some of his men in another shad boat to assist. Three civilians also rendered assistance. By 1:00 PM both Master Seaman and his crew member were brought ashore and taken to the station's boarding house while the shad boat was brought back into the harbor and saved (Midgett 1899).

Additional files in the NC Underwater Archaeology Branch list an incident concerning an "Unknown Boat" 1.5 miles from Chicamacomico Life-Saving Station on 26 March 1899. The file (UAB file #3040) lists the boat as a fishing boat lost on a journey from Chicamacomico, NC to Manteo, NC. The boat was a total recovery. The *Annual Report of the Operations of the United States Life-Saving Service* in 1900 (USTD 1900:169) confirm this loss (listed as "Fish boat; no name"), and describe the nature of the casualty and service rendered:

> Capsized in a squall 1 ½ miles W of station. Surfmen from Chicamacomico and Gull Shoal stations and several citizens pulled out in shad boats, rescuing the two men who had been in the boat and bringing the boat to the harbor where they put it in trim. The rescued men went to their boarding house, close by (USTD 1900:169).

It is unlikely that the event culminated in the creation of any kind of archaeological signature and no such named vessel is mentioned in North Carolina shipwreck sources (Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; Duffus 2007)

Two Sisters (unknown build and loss dates): 5 December 1902 and 19 April 1914 incidents
There are five wrecking events in the Pamlico Sound attributed to multiple vessels named *Two Sisters* between the years 1902 and 1922 (1902 and 1914 at Chicamacomico Station; 1911 at Pea Island Station; two incidents in 1922 at Little Kinnakeet Station). Close to the study area two occurred – and it is currently unknown whether these can be attributed to a single *Two Sisters* involved in two incidents or two different vessels. Complicating research, there are multiple vessels with this name that had comparable service careers -- and scant evidence regarding the vessels involved in the incidents makes differentiation and identification difficult. First, none of the wreck reports offer an official number for the vessel (so it is difficult to determine if one *Two Sisters* was involved in multiple events, or if multiple vessels with the same name were reported). Nor do any of the wreck reports, save one, give the age of the schooner. A wreck report from 5 December 1902 does list the age of a vessel named *Two Sisters* -- however, when the record was transferred to microfilm, a crease in the page makes reading the age impossible (perhaps reading "5 years"). Finally, none of the reports state the schooner's tonnage.

Specifically, there are at least two vessels *registered* under the name of *Two Sisters* that can be identified as working the North Carolina coastal trade. One was a sloop built in 1893 with official number 145657, and the other was a schooner built in 1899 with the official number 145827.

The first, the 1893 sloop was built at North River, NC. Its length was 39.0 feet and in beam it was 11.1 feet with a depth of hold of 3.1 feet. The gross and net tonnage of the sloop are listed as 7.62 tons. In 1895, the sloop was registered in Beaufort, NC (United States Bureau of Navigation 1895:195). It continued its service career out of Beaufort until 1903, when it was then registered in New Bern, NC. It was noted to only require a crew of one sailor (USBMIN 1903:174). The sloop remained in service until 1914 or early 1915.

The second *Two Sisters* was the schooner built in 1899, although it was not registered until the 1900 *Annual List*. Its length was 43.2 feet, its breath was 12.7 feet, and its depth of hold was 2.7 feet. In the 1900 Annual List, it is listed as having been built in Mount Pleasant, NC. However, the next year, its port of construction is changed to Lake Landing, NC (USBMIN 1900:185, 1901:185). From this year forward, Lake Landing is always given as its build location. This schooner stands out from all the vessels discussed above because it is the only one whose homeport never changed. Throughout its service career, it is always registered in New Bern, NC. This schooner also had the shortest service career, from 1900 to 1914 or early 1915. This fact may point to it being the *Two Sisters* that was reported sunk in *Charlotte Daily Observer*. Even if it was raised and repaired, such a damaging event may have cut the service life of the schooner short.

Additionally, there is the prospect of an *unregistered* vessel (or vessels) named *Two Sisters*. For example, there is also mention of a two-masted schooner sinking on Pamlico Sound in 1908. On 10 July of that year, while off Maul's Point (10 to 15 miles from Washington, NC), the schooner struck a submerged buoy under owner and Master T.M. Credle. This *Two Sisters* had been a regular Pamlico River trader and the day before, had taken on a valuable cargo of general merchandise. After striking the buoy, the vessel sank in a few minutes, resulting in a complete loss of cargo and personal items of the crew. The schooner sank in a shallow part of the river, and the crew clung to the rigging before being saved by a passing vessel. However, the report does state that efforts to raise the schooner were going to be attempted (*Charlotte Daily Observer* 1908:2). The news article's only description of the schooner is that it was two-masted, an attribute it shares with the schooner in the Life-Saving Station reports. However, it is not known if the schooner from the wreck reports was regularly engaged in the Pamlico River trade or if the schooner from the *Charlotte Daily Observer* report was ultimately raised and repaired.

There remains one last problem in the *Annual Lists*. Both the 1893 sloop and 1899 schooner disappear from service in the year 1914. Two reports from 1922 list *Two Sisters* as the schooner in distress (Gray 1922a, 1922b). There are no schooners by the name *Two Sisters* registered in North Carolina waters in 1921, 1922, or 1923 in any section of the *Annual Lists*. As no evidence of this vessel could be found, outside of the wreck reports, these reports cannot be accounted for. Thus, discussion of *Two Sisters* will focus on both the potential candidates for which evidence can be obtained: the 1893 sloop and 1899 schooner. A description of the events of the known wreck reports will first be examined followed by a discussion on the service career of both vessels.

All the life-saving reports state that *Two Sisters* was a schooner, registered first in Rodanthe (Midgett 1902) and then in Avon (Midgett 1914), which would seemingly eliminate the sloop from consideration. There is a discrepancy in the annual reports where the sloop is listed as a schooner for four years, 1897-1900 (USBMIN 1897:187, 1898:184, 1899:182, 1900:185). With this in mind, the sloop must be considered a potential candidate. A final note on both the 1893 sloop and 1899 schooner is that both are registered in New Bern during the wrecking events. No other candidate vessel was registered in either Rodanthe or Avon during this period. With the uncertainty regarding the specific vessel in consideration, all that is left to consider are the nature and consequences of the incidents concerning vessels named *Two Sisters* adjacent to the study area. In both wrecking events, the *Two Sisters* in question were saved, and no subsequent mention of a vessel of this name wrecking in North Carolina can be located (see Stick 1952; Lonsdale and Kaplan 1964; Freitag 1998; Charles 2004; Duffus 2007). A reference to the loss of a sloop *Two Sisters* is noted in Berman (1972:148) as occurring off Hampton Roads – but the loss date (12 March 1888) demonstrates no connection to the incidents in Pamlico Sound.

There are two marine incidents reported by Chicamacomico Station concerning a vessel named *Two Sisters* for which reports exist. They occur on 5 December 1902 and 19 April 1914. These wrecking events will be discussed in chronological order.

On 5 December 1902, the schooner *Two Sisters* was making a run from Elizabeth City, North Carolina to Rodanthe, North Carolina with a crew made up of Master L.B. Midgett Jr. and the schooner's owner John Payne. They were shipping a cargo of general merchandise that had an estimated value of 1,000 dollars. At 5:00 AM, the schooner's chain parted leading to it becoming stranded about 300 yards from shore two-and-three-quarters miles S by W from the Chicamicomico Station. As Master Midgett Jr. was the son of the Station Keeper, he immediately put up a distress signal that was spotted by lookout B. O'Neal (Midgett 1902).

The schooner was left where it stranded until 8 December. At 8:00 AM on that day, Midgett and six of the life-saving station crew, along with four from other nearby crews, met on shore at the wreck site. They hitched the schooner to the old boat wagon and re-floated the schooner by 4:00 PM. In addition to the old boat wagon, they also used skids to re-launch the schooner (Midgett 1902).

On 19 April 1914, the schooner *Two Sisters* was sailing from Elizabeth City to Avon, North Carolina. Once again, the schooner was carrying a cargo of general merchandise with an estimated value of 1,000 dollars. The schooner's master was B. Pierce who had a crew of one sailor and two passengers aboard. At about 1:00 PM, *Two Sisters* sent up a distress signal to which Keeper Midgett sent two of his crew in the station supply boat to investigate. The schooner was anchored on the backside of Pugh's Reef about five miles W by NW from the Chicamicomico Station, and five miles out from shore (Midgett 1914).

The two crew members arrived at the wreck around 1:45 PM and discovered that the schooner had lost its foremast. The life-saving crew assisted in rigging the schooner's jib stay to the main mast. They also escorted the schooner into harbor. The last of the assistance they rendered was to bring the two passengers ashore to stay the night at the Life-Saving Station at about 3:30 PM. Keeper Midgett remarked that another Station Keeper, Captain Styron, had offered to tow *Two Sisters* the rest of the journey to Avon with his power boat the next day. Although the schooner suffered about $10 worth of damage, the cargo was not lost and was in good condition when *Two Sisters* was brought into harbor (Midgett 1914).

Lonie Buren (1902-c.1981): 15 September 1903 incident

The records of the North Carolina Underwater Archaeology Branch include a file (NCUAB File #2911) on the loss of *Lonie Buren* at a location three miles SSW of the Chicamacomico Life-Saving Station on 15 September 1903. This information is repeated in the Annual Report of the Operations of the United States Life-Saving Service (USTD 1905:284), which outlines that on 15 September 1903, the 9-ton schooner *Lonie Buren,* out of Elizabeth City and under the command of "O'Neal," was a casualty three miles SSW of Chicamacomico Station and was responded to by the Chicamacomico and Gull Shoal Life-Saving Stations. Midgett elaborates on these details in his 11 October 1903 wreck report (Midgett 1903). While the NCUAB files list *Lonie Buren* as a total loss (as implied by Midgett's report), further research suggests that the vessel was actually later recovered (the vessel is not mentioned in sources such as Stick 1952; Lonsdale and Kaplan 1964, Berman 1972, Freitag 1998, Charles 2004, and Duffus 2007). A more complete picture of activities in Pamlico Sound concerning *Lonie Buren* are listed elsewhere in the US Life-Saving Station report for 1905 (USTD 1905:95):

> At 11 a.m. on the 16th instant, the lookout reported this vessel in Pamplico Sound, about 3 miles S. of the station, flying a signal of distress. The keeper and four surfmen proceeded to her in supply boat, and found that in the gale of the previous night she had dragged her anchors and was driven ashore on the marsh. She was high and dry, and, as nothing could be done until the master procured materials for launching her, the life-savers returned to the station. On the 28th instance, the life-saving crew, with the assistance of the crews of the Gull Shoal and New Inlet stations, placed skids under the vessel, and, working on her for four days, moved her across the marsh, dug a canal through a reef, and, on October 1 launched her into deep water.

Indeed, the *Annual List of Merchant Vessels* informs us that *Lonie Buren* would have an exceptionally long commercial life and a highly varied career. Charles T. Williams, II mentioned the building of *Lonie Buren* in his 1975 book, *The Kinnakeeter,* wherein he writes, "Zion B. Scarborough built the schooner *Lonie Buren*, the most beautiful, graceful, and prideful ship that ever sailed the inland waters of North Carolina" (Williams 2016[1975]:130). Preceding this quote is an implication that *Lonie Buren* represents the pinnacle of Kinnakeet shipbuilding (c.1890-1905).

First appearing in the 1903 register (USBMIN 1903:110), *Lonie Buren* (official number 141820, no signal letters) is listed as a schooner built at "Kinnekeet" in 1902 of 9 gross tons (8 net tons), dimensions of 46.4 feet length, 15.6 feet width, and 3.1 feet draft, and a crew of one person operating out of Elizabeth City, NC. The details remain the same until 1909 when the vessel's homeport became Tappahannock, Virginia (USBMIN 1904:107, 1905:106, 1906:100, 1907:91, 1908:85, 1909:81, 1910:74). Sometime around 1911, the vessel's entry is moved to the section on steam vessels (actually a motor vessel, as listed as gas screw). All other details remain the same (the horsepower of its engines are unlisted), although it is now operating as an oyster boat (USBMIN 1911:233). The boat would serve the oyster industry in Tappahannock until around 1914 when its homeport moved to Reedville, Virginia (USBMIN 1912:230, 1913:228, 1914:227; 1915:271). *Lonie Buren* called Reedville home for the next half-century.

Over this time, however, *Lonie Buren* underwent some changes. The vessel was involved in oystering out of Reedville in the above configuration until around 1921 (USBMIN 1916:265, 1918:267, 1919:273, 1920:275, 1921:279). From 1922 until 1927, the boat was employed in fishing, with the 1924 *Annual List* giving the horsepower of its engine as 4ihp, and the 1925 register adding the name (W.S. Lankford) and address (Byrdton, VA) of the owner (USBMIN 1922:275, 1923:224, 1924:219, 1925:404-405, 1926:406-407, 1927:390-391).

Lonie Buren underwent major modifications in 1928, with significant structural changes indicated by new dimensions (60 feet long, 16.4 feet wide, 4.4 feet draft), new tonnage (26 gross, 18 net), a new engine (horsepower of 40hp), and a new purpose – that of a freighter (USBMIN 1928:400-401). The vessel remained a freighter until sometime in late 1936 or early 1937, after which Lankford spent ten more years using it to fish (USBMIN 1929:404-405, 1930:398-399, 1931:394-395, 1932:408-409, 1933:412-413, 1934:422-423, 1935:428-429, 1936:424-425; 1937:215; 1938:205, 1939:203, 1941:198, 1942:196, 1943:202, 1944:218, 1945:234, 1946:281, 1947:290). Around 1948 a new owner, James R. Atkins, also of Reedville, took over the vessel – and it continued to fish (with an additional crewmember) for over 13 years (USBMIN 1948:296, 1949:312; 1950:314, 1951:318, 1952:321, 1955:300, 1956: 303, 1957:307, 1958:314, 1959:320, 160:326, 1961:338). In 1962, Atkins installed a new 165hp oil engine in the old hull and re-converted the vessel back to a freighter (around this time the boat was also be given the radio call letters of WI4442) but sold it two years later (USBMIN 1962:353, 1963:365, 1964:378). From 1965-1971 a new owner (John P. Copper) would operate *Lonie Buren* out of Cambridge, MD. From 1971-1977, Paul Joseh Cianferano took over its operation and continued to work out of Cambridge (USBMIN 1965:378, 1968:458, 1969:481, 1970:507, 1971:532, 1972:555, 1973:582. 1974:621, 1975:666. 1976:706, 1977:746). Starting in 1977 a new owner, Bronzie Douglas White took over *Lonie Buren*, operating the vessel out of Cape Charles, VA until at least 1981 (USBIN 1978:791, 1979:837, 1981:996). In 1979, the White family, and *Lonie Buren*, were featured in a *Washington Post Magazine* article examining the Maine Street Fish Market in Washington, DC. It includes the following tract:

> Captain White's boat, the *Lonie Buren*, at the very end of the dock on the 12th Street side of the wharf, has a public address system, and the man at the mike hawks his fish like a county fair barker:
> "Over 30 varieties of seafood!

> "Come right on down -- our prices cannot be beat!
> "The lowest prices to pay, you better come down today.
> "I'm telling you, we got the lowest prices around,
> "You better shop around,
> "Captain White he give you sweet as honey,
> "He give you cash money ..."
> "When I'm finished here," says Billy White, heir to the captain, taking in his outfit with a rhetorical sweep of the arm, "I'm gonna be pulling' 'em off the bridge." He is remodeling his three-ship fleet, installing giant freezers and streamlining his logistics. This fall, there will be a grand re-opening of White's by its Young Turks. Says Billy White, with a visionary gleam: "Our business will be renamed Seafood City (Downs 1979:27).

While the Maine Street Fish Market, and "Captain White Seafood City," is still around today, the fate of *Lonie Buren* after 1981 is currently unknown.

Mabel E. Horton (1905-1926): 11 December 1906 incident
NCUAB files (File #2899) list an incident concerning the "gas launch" *Mabel E. Horton* on 11 December 1906 at a location three miles W by N of Chicamacomico Life-Saving Station that culminated in its rescue and recovery.

Mabel E. Horton (official number 202730), crewed by two people, was an 8-gross ton (six net ton) gas launch freight vessel (20ihp engine, until 1922 after which a 35 ihp engine was installed) built in Manteo, North Carolina in 1905. The vessel had dimensions of 40.2 feet length, 10.2 feet breadth, and 2.2 feet depth. Th*e Annual List of Merchant Vessels of the United States* includes a listing of the vessel from 1906 to 1914. The vessel had a home port of Elizabeth City from 1905 to 1907, with Manteo becoming its home port from 1908 to 1915, before a final move to Philadelphia, PA from 1916 until 1926. Around 1911, *Mabel E. Horton* became a passenger vessel with a single crew member (two crew from 1924), and become a towing vessel in the last two years of its life while owned by Ralph N. Cavileer, a resident of Atlantic City, NJ (USBIN 1906:261, 1907:249, 1908:245, 1909:247, 1910:240, 1911:237, 1912:235, 1913:233, 1914:232, 1915:275, 1916:269, 1918:271, 1919:277, 1920:278, 1921:282, 1922:279, 1923:228, 1925:410-411). In 1926, the Annual List of Merchant Vessels lists *Mabel E. Horton* in a list of vessels "Abandoned, Reduced, or Removed" (USBIN 1926:861).

The details of the 1906 incident are outlined in the Annual Report of the US Life-Saving Service for 1908 (USTD 1908:127), which lists,

> December 11, 1906. Chicamacomico, North Carolina. Gas.sc. Mabel Horton. Mail boat grounded 3 miles west of station. Life-savers went out and took off mail and passengers. Later delivered mail and passengers to her.

L.B. Midgett's 1907 report provided much more detail, outlining how the vessel (owned by W.J. Griffon and company), laden with mail (valued at $300), a crew of two (Henry Ward, master, and an engineer), and five additional passengers (Waston Gray of Avon, Albert Neal and John Balince of Hatteras, N.C., Debenport of Manteo, and Jesse E. Midgett of Rodanthe), stranded on the SW point of Pugh reef during "thick weather." The vessel was later refloated, as evidenced by later historical references of the vessel operating in the region (and its subsequent working life out of state).

Little is known about *Mabel E. Horton's* commercial life in North Carolina, though one reference to its use is found in a two-part series of articles by Colonel Fred A. Olds in the *Charlotte Observer*, titled "A Trip Over the Route of the Proposed Inland Waterway." The second part of the article mentions *Mabel E. Horton's* use by the Manteo Chamber of Commerce in support of a congressional survey of the inter-coastal canal system of North Carolina (Olds 1909a:10, 1909b:10).

R.C. Beaman (1901-c.1917): 4 January 1910 incident

R.C. Beaman is represented by file #2887 at the NCUAB archive. While it is erroneously classified as lying off Pea Island Beach (i.e. an ocean-side location), the file lists a marine incident three miles W of Chicamacomico Station – placing it within the Pamlico Sound, and likely within the study area.

R.C. Beaman (official number 111387) was a two-masted schooner built in 1901 at Hatteras, North Carolina; however, its construction must have been completed towards the end of the year as it is not listed in the 1901 *Annual List of Merchant Vessels of the United States* (USBMIN 1901:158). It measured at 44.3 feet long, 15.9 feet in beam, and had a depth of hold of 2.6 feet. Its gross tonnage was 12 tons, while its net tonnage was 9 tons, it was registered in Edenton, North Carolina in 1902, and later in Elizabeth City (United States Bureau of Navigation 1902:154, 1903:148, 1904:143, 1905:142, 1906:134, 1907:122, 1908:114, 1909:109). The schooner's possible namesake was an influential minister, the Reverend Dr. R.C. Beaman, a prominent Temperance Movement activist in North Carolina (*Charlotte Daily Observer* 1906:3). The Reverend Dr. Beaman was noted to have lived in New Bern, and presided over the Centenary Methodist Episcopal Church. He is reported to have had a period of long prosperity at the church, which was the largest in New Bern and one of the most influential in the state (*Charlotte Daily Observer* 1909:1). It is not a stretch of the imagination to consider that a prominent local leader could become the namesake for a locally built schooner.

R.C. Beaman was involved with the U.S. Life-Saving Service at least two times in its life. On July 7, 1906, *R.C. Beaman* stranded at Durants, North Carolina:

> This vessel, lumber laden and with 2 men on board, stranded on Oyster Point, 3 miles N. of the station. She having filled with water the keeper, with assistance, bailed and pumped her out, then hauled her afloat, and took her into Durants Bay to a safe anchorage (USTD 1908:75).

Its second encounter was at the Life-Saving Station at Chicamicomico. On 4 January 1910, the schooner was en route from Powell's Point, North Carolina to Rodanthe, North Carolina under Master Harrison Midgett. The crew consisted of Master Midgett and his mate, Joseph Midgett. It had a cargo consisting of two cords of split pinewood estimated at a value of $6. It was also providing passage for 10 people. At 3:30 in the afternoon, the schooner became stranded on the NE point of Frank Reef, while coming into Rodanthe, three miles from shore and due W of the station. The schooner grounded due to a low tide and a damaged jib sail (Midgett 1910).

Lookout A. O'Neal immediately informed Keeper L.B. Midgett of the stranded vessel. The keeper sent three of his crew to the distressed schooner in surfman J. Meekins' sailing skiff.

The tide was too low for the station's supply boat. The crew met the vessel at 5:30 PM and found that the schooner was not in immediate danger. They took all 10 passengers ashore: two men, two women, and six children. Master Midgett and his mate stayed aboard the vessel, and it was brought into the harbor the next morning at 9:00 AM with the cargo and schooner both in good condition (Midgett 1910; see also USTD 1911:97).

A third and perhaps fourth incident is reported in two government reports of the US Department of Commerce concerning the "Freighter R.C. Beaman" indicating the vessel may have run aground and stranded twice near the North Landing River Light Station (Virginia) in 1917 and required assistance from the light house service (USDC 1918a:56, 1918b:191)

Beginning in 1903, *R.C. Beaman* was registered out of Elizabeth City, North Carolina. It remained registered there for the rest of its service career until 1917 (USBMIN 1903:148, 1910: 99, 1911:92 , 1912:84, 1914:275, 1916:294). There is evidence that *R.C. Beaman* underwent a conversion during its service career, with the addition of a gasoline engine. In 1913, it was no longer listed under the merchant sailing vessel section of the *Annual List of Merchant Vessels of the United States*. That year, it was moved to the section covering merchant steam vessels. Here it is listed as a freighter operating with a screw propeller powered by gas (USBMIN 1913:275). This year for the registry did not include a separate section for vessels power by a gasoline motor and placed *R.C. Beaman* in the steam category accordingly. This was remedied in 1915, when a motor craft section was added to the registry and the schooner was moved again to this section (USBMIN 1915:300). *R.C. Beaman* disappears from American vessel registries in 1916 (USBMIN 1916:294), and other than the rescue it was involved with in 1917 its fate is unknown (it is not listed in Stick 1952; Lonsdale and Kaplan 1964; Berman 1972; Freitag 1998; Charles 2004; or Duffus 2007 as wrecking in North Carolina).

PAS0001 (Pappy's Lane Wreck) and Associated Marine Incidents

The existence of the Pappy's Lane Wreck (PAS0001) has been known to local people since it was first deposited in its current location. The first archaeologists to note the existence of the wreck were from Panamerican Consultants, Inc in 2003 (Krivor 2004). At that time the wreck was identified based on information from local informants as a

> … 160-foot long … barge used to move gravel to Rodanthe for the development of roads in the 1960s, which led archaeologists to prematurely identify the wreck as non-significant, as the archaeologists assumed to be a modern steel barge without assessing the actual vessel time and construction detail, or addressing NRHP [National Register of Historic Places] eligibility criteria (Panamerican Consultants, Inc. 2016:31).

On 31 May 2010, during a teaching exercise for a field school run by East Carolina University's Program in Maritime Studies, one of the authors of this report (Richards) carried out an inspection of the oyster-shell encrusted *Pappy's Lane Wreck*. Upon conclusion of the survey, the site was reported to the North Carolina Underwater Archaeology Branch and given a state designation of PAS0001. At this time two things were communicated to Richards about the wreckage by Hatteras Island residents – local knowledge contended that the vessel had been used to haul gravel to Rodanthe during the 1960s, and it eventually washed ashore in a storm. The unidentified ferrous-hulled (likely steel) wreckage first appears on NOAA and US Coast Guard nautical charts c.1970, suggesting that at the earliest, it had been there since at least the year before. Since the 2010 ECU survey Richards has periodically researched the identity of the vessel.

With the commencement of this Rodanthe project, a reexamination of the site's history, with some basic recording of it, was included. In late summer 2016, local Waves resident, Mr. Mel Covey, came to the UNC-Coastal Studies Institute to donate copies of two reports regarding recent terrestrial archaeological research carried out in Waves on a suspected Civil War-era archaeological site (see Babits et al. 2015; Covey 2016). In examining Appendix U1 (Figure 35) and U2 (Figure 36) of Mr. Covey's report, it was noticed that he had included two images of PAS0001 from Greens Point, adjacent to the location Mr. Covey calls "Camp No Live Oak" (his name for the area near Chicamacomico), dating to 1977 and 1982 (see Covey 2016:185). The images were included by Mr. Covey to support his argument regarding the area's extreme shallowness and the presence of a shoal.

Figure 35. PAS0001, c.1977 from Mr. Mel Covey's collection and included as "Appendix U1" (Covey 2016:185).

Figure 36. PAS0001 c.1982 from Mr. Mel Covey's collection and included as "Appendix U2" (from Covey 2016:185). Inspection of original print indicates the film was developed in April 1980.

The captions Mr. Covey includes are further evidence about the nature of the waters in the area. The caption for Appendix U1 reads:

> Pamlico Soundside at Camp Live Oak. This is an area which is historically documented to be a broad extensive shoal that extends southward to **Greens Point.** The abandoned barge lies over a quarter of a mile offshore in about 3 feet of water. The shallowness of these waters is confirmed by the flock of sea gulls standing on the left on a barely submerged shoal: 1977 (Covey 2016:185, original emphasis).

The caption for Appendix U2 reads:

> The same area seen from a vantage point in front of the Baarslag cottage five years later, and just to the north of the photograph above. The old creosote pole on the left is positioned on the shoals' shallower parts [.] The sand shoal is normally exposed, except during high tides, and the pole was installed to assist with the barge's salvage operations.

Upon seeing the images Richards contacted Mr. Covey to gain permission to use the photographs. Mr. Covey informed Richards that he had additional photographs and details of the site. Per local knowledge, Mr. Covey outlined that in the early- to mid-1960s there were several wooden barges owned by the National Park Service moored on the edge of the Black Mar Gut (a mispronunciation of "Back Mire Gut") area for use as barracks. Additionally, there were two ferrous barges employed for transporting limestone marl for road construction. During a storm, all the vessels ran aground. The NPS barges and one of the ferrous barges were refloated. One barge was unloaded but could not be refloated – this being the present day remains of PAS0001, which was subsequently salvaged (the evidence cited in his image captions of creosote poles being used to assist in salvage activities). Mr. Covey also provided information about other Hatteras Islanders with knowledge of these events (Mel Covey, pers. comm. 2016).

Mr. Covey on 27 October 2016 provided additional black and white and color print images of the site from film developed in February and April 1980. At this point in time, Mr. Covey provided permission to utilize the images of the site for this report, and indicated that he had verified much of the information that he had communicated. His testimony suggesting that PAS0001 may have at one point resided two wooden barges is circumstantially substantiated in NPS records from the WPA/CCC era – but no evidence of an additional ferrous barge has so far been located.

Following some questions asked of local people, more information has since been found. Additional images of PAS0001 were found in the collections of negatives held by the Outer Banks History Center and in the newspaper, the *Virginian-Pilot* thanks to the photographs taken by journalist Drew Wilson between the 1980s and 2005 (Figures 37-40). These photographic leads, in addition to information from a range of local informants on Hatteras Island, now suggest that while PAS0001 may have at one time served as a gravel barge, the vessel may actually be a significant shipwreck that was misreported. This discovery has prompted a series of additional investigations on vessel types and specific watercraft to better ascertain the identity and significance of the wreckage at Pappy's Lane, including a full analysis of the vessel's construction. As this research is currently ongoing and extensive (and outside of the scope of the original brief for this project) a research design on a separate site-specific investigation is being written by Richards with the intention of holding a field school at the site in the fall of 2017.

Figure 37. "Shipwreck of Rodanthe, Pamlico Sound, 10 November 1988," by Drew Wilson (Source, Drew Wilson Collection, Box 21, Outer Banks History Center, Manteo).

Figure 38. "Shipwreck of Rodanthe, Pamlico Sound, 10 November 1988," by Drew Wilson (Source, Drew Wilson Collection, Box 21, Outer Banks History Center, Manteo).

Figure 39. "Shipwreck of Rodanthe, Pamlico Sound, 10 November 1988," by Drew Wilson (Source, Drew Wilson Collection, Box 21, Outer Banks History Center, Manteo).

Figure 40. "A Sight to Sea" Color photo Drew C. Wilson/The Virginian-Pilot. A pair of kayakers float Monday near the dilapidated hulk of an old wooden vessel sunk in Pamlico Sound west of Rodanthe. The vessel, about 150 feet long, is only one-quarter of a mile from shore and has become a popular destination for paddlers (*The Virginian-Pilot* (Norfolk, VA) - July 23, 2004, page Y1)

Historical Events Depicted in Cartography and Aerial Photos

The intention of engaging in an examination of geo-rectified charts of the study area was to gauge how the shorelines and landscapes of the area have changed. To commence the process of assessment, the most current geo-rectified nautical chart was obtained. In modern times, all the North Carolina Outer Banks are not included on the same map. They are separated into north and south sections with Wimble Shoals representing the connection point. Thus, two base-maps were downloaded from NOAA's online navigation chart database. The first of these maps, 12204_1, represented the northern half of the Outer Banks, Currituck Beach to Wimble Shoals (NOAA 2012). The second, 11555_1, represented the southern half of the Outer Banks, Cape Hatteras: Wimble Shoals to Ocracoke Inlet (NOAA 2015). Both are depicted at 1:80,000 Mercator projections according to the North American Datum of 1983 (NOAA 2012, 2015). The extract of these charts with remote sensing and sound floor inspection areas superimposed is depicted in Figure 41.

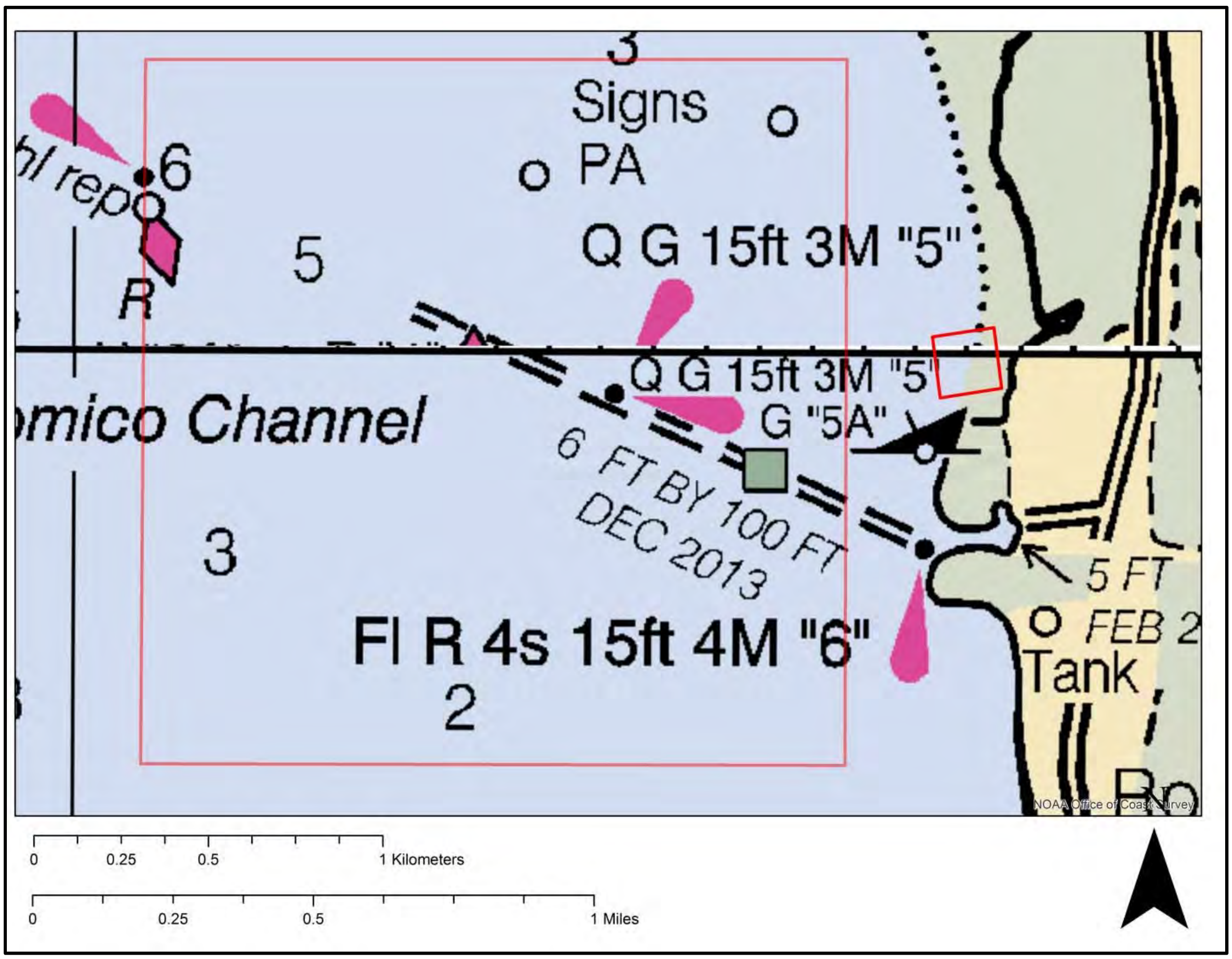


Figure 41. 2015 NOAA Nautical chart (NOAA 2015); Study areas are represented by red boxes.

As stated above, the area surrounding Rodanthe is found on both maps as Wimble Shoals makes up the separation point between the maps. Wimble Shoals can be found almost due E of Rodanthe. As such, the study area could have extended through one map and onto the other. Therefore, both maps were used to create the base of the GIS model. This created the most accurate representation of points along the proposed study area. From this point, older maps were geo-rectified onto the 2015 chart. Starting with the earliest found chart, an assessment follows.

1852 Eastern Coast of North Carolina, North Carolina, Sheet No. 14
This map displayed a close-up view of the area immediately north and south of the Chicamicomico Life-Saving Station at 1:20,000 projection scale. The map shows the location of the station, and its relation to the Pea Island Life-Saving Station. Furthermore, although the map does not depict any sounding data for water depth on either ocean or sound sides, it does show in detail the makeup of the natural landscape circa 1852. Marshes, dry land and intermediate zones are clearly defined. Areas of vegetation on dry land are also illustrated. Thus, it shows the shoreline in more geographic detail than other maps used in the project. This chart is also important because of the indication of a windmill within proximity to the study area – likely the aforementioned Green's Point windmill (Figure 42).

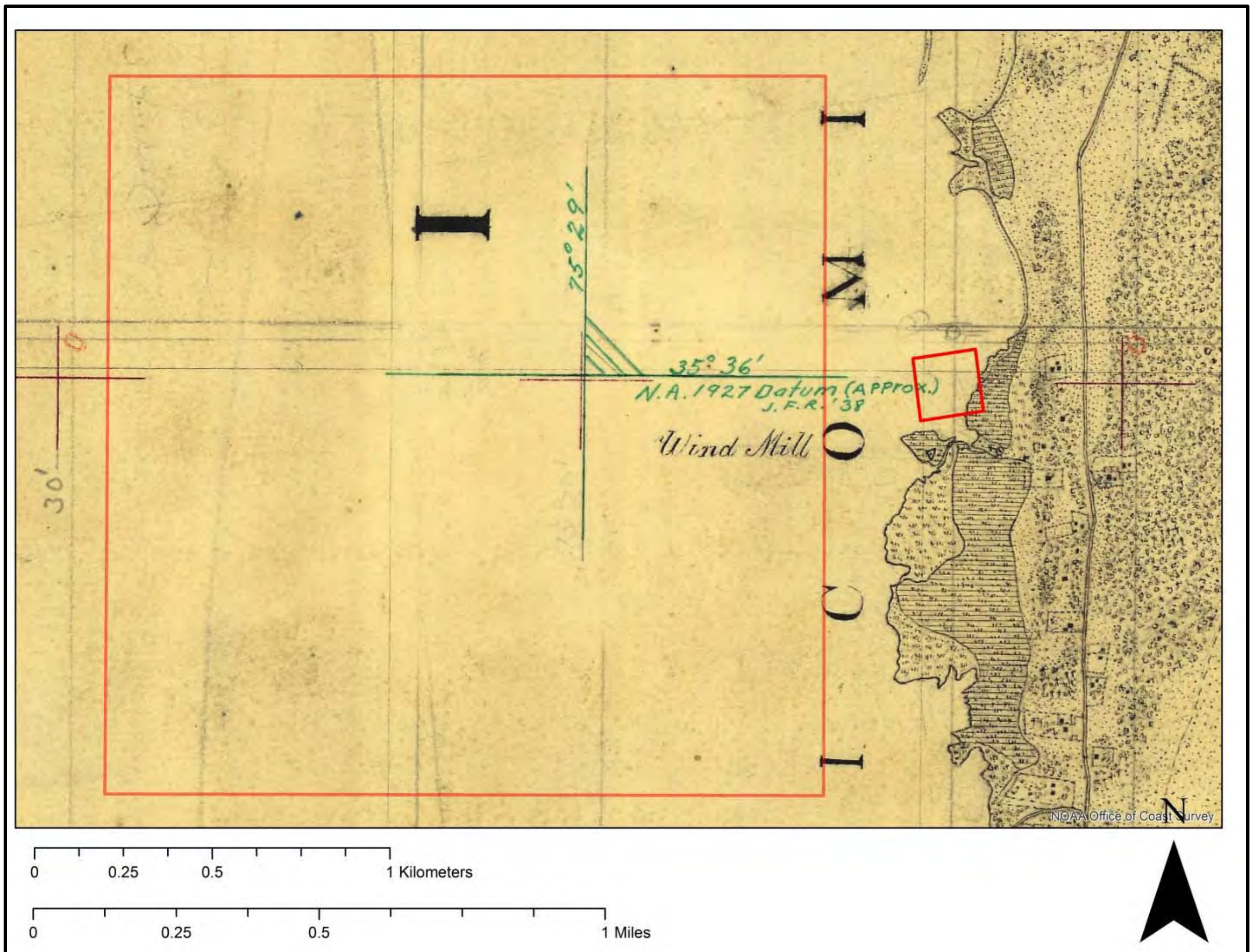


Figure 42. 1852 Eastern Coast of North Carolina, North Carolina, Sheet No. 14 (United States Coast Survey 1852); Red boxes represent extents of study areas.

1855 Map of the Albemarle and Chesapeake Canal
This map was produced to show the navigation routes used by the A&C Canal Company. As such, the entirety of Albemarle and Pamlico Sounds are shown. The shore of Chicamicomico is

included, although not in detail (Figure 43). Instead, the value of this map comes from its depiction of the company's navigation route through the sound, which may have also been used by local trading ships. A second value of the map is that it displays early soundings taken in Pamlico Sound. Though not as detailed as later soundings that will be examined, this map does offer a look at the early soundings and shoals within the sound that masters and sailors encountered.

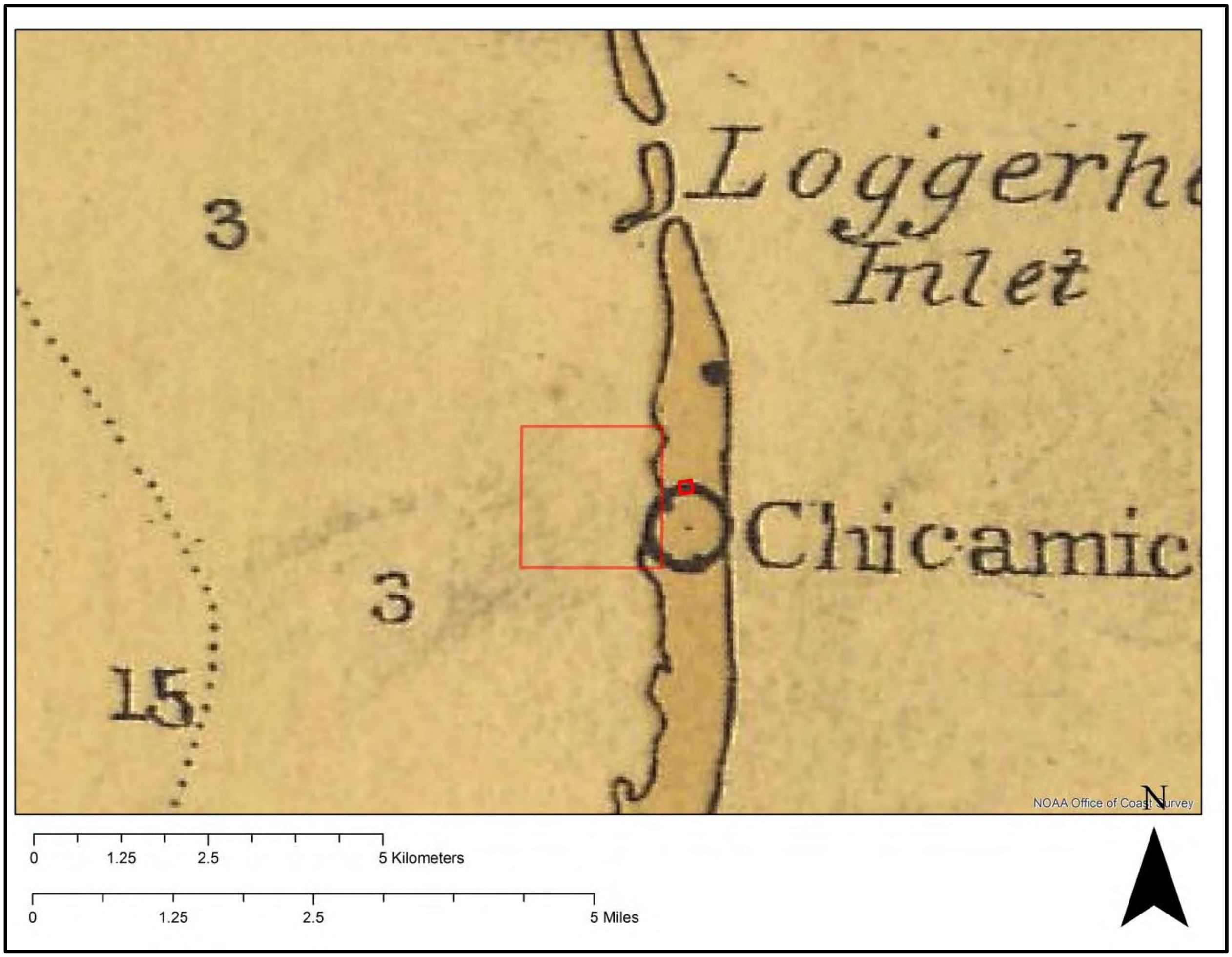


Figure 43. 1855 Map of the Albemarle and Chesapeake Canal (Albemarle and Chesapeake Canal Company 1855); Study areas shown in red box.

1862 Coast of North Carolina and Virginia

This map, at 1:200,000 scale, depicts a simple outline of the shore surrounding the study area. The lack of depictions of inland vegetation in the northern extent of Hatteras Island is of interest to researchers. Beginning in the Chicamacomico area, the differences between marshes, dry land, and vegetation are illustrated (Figure 44).

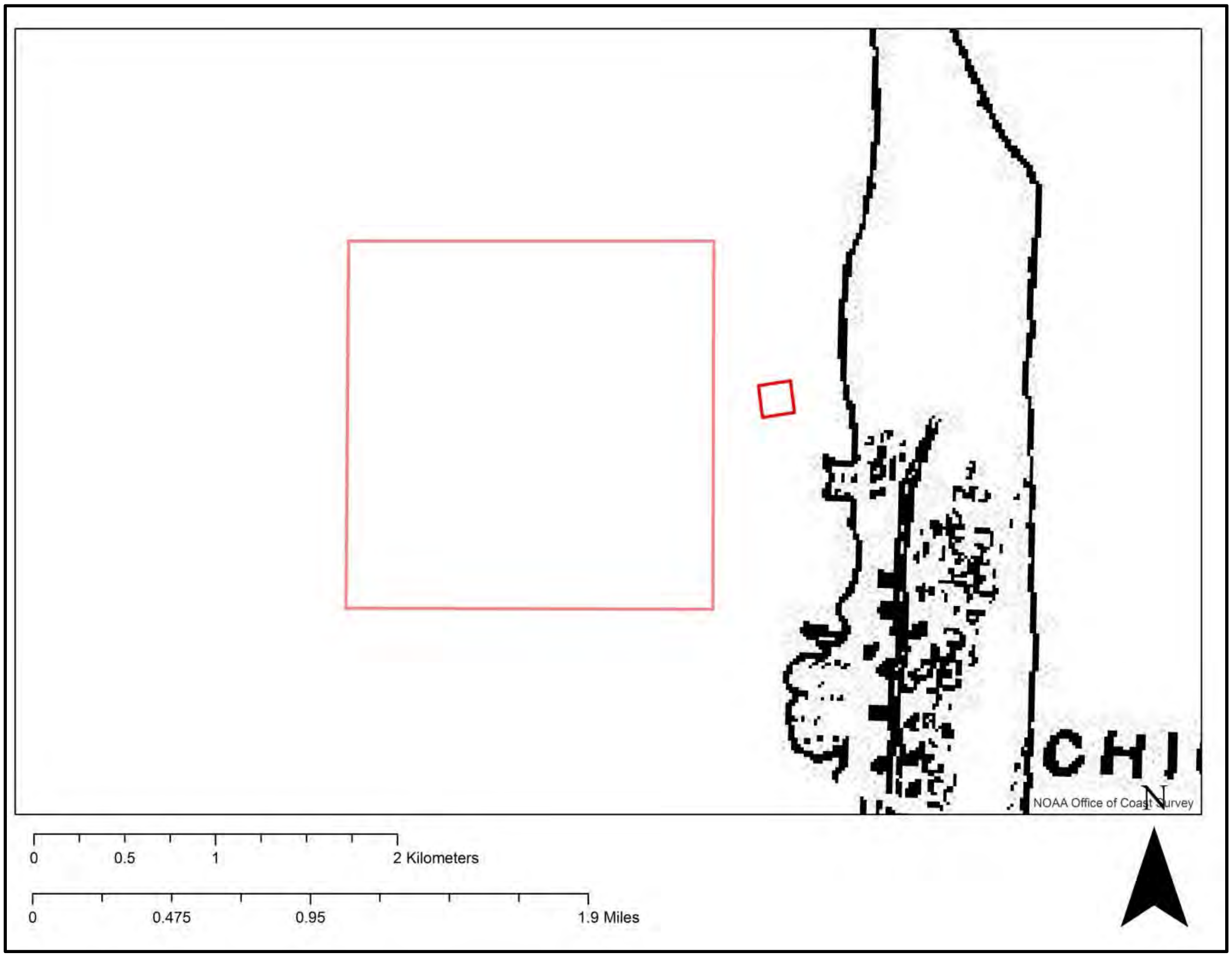


Figure 44. 1862 Coast of North Carolina and Virginia (United States Coast Survey 1862); Study areas shows within red boxes.

1865 Civil War Atlantic Coast (United States Coast Survey 1865)

This map includes a simple outline of the shoreline, at the unusual projection scale of 1:633,600. This map proved beneficial because even though it does not show actual sounding data, it does include lines of the same sounding value. In this sense, the downward slope of the sea and sound bed can be examined (Figure 45). This emphasizes areas where vessels could find themselves stranded and needing rescue by the life-saving crews.

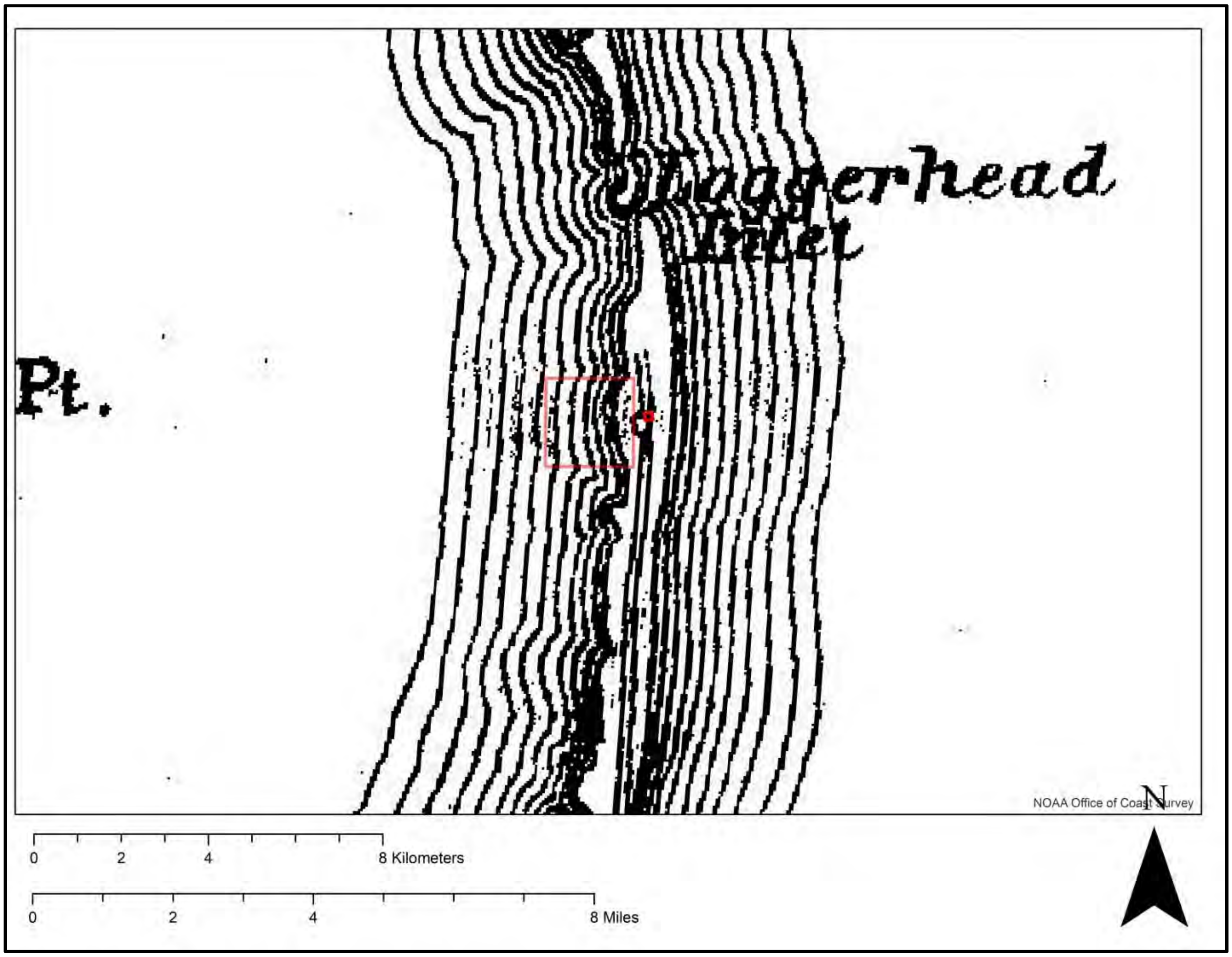


Figure 45. 1865 Civil War Atlantic Coast (United States Coast Survey 1865); Study areas shows within red boxes.

Assorted Years Pamlico Sound, Eastern Sheet

These charts are the most useful for the creation of the GIS model for the pre-World War II period. They show the entire Outer Banks' shore from Oregon Inlet to Cape Hatteras. The sound-side shorelines are shown in detail, along with the makeup of marshes, dry land, and vegetation. They all show Loggerhead Inlet but also label it as closed. Additionally, these maps show the roadways present on the Outer Banks island chain. All of the Life-Saving Stations in the area are also shown and labeled.

One of the most notable values these charts have is their detailed soundings on both the ocean and Pamlico Sound. In the sound, soundings were taken an average one-half mile apart. This proximity indicates the increase attention to navigation concerns in Pamlico Sound. Shoals are illustrated with stippling with two layers, lighter meaning deeper shoals and the darker stippling depicting shallower shoals. Finally, these maps are all part of the period during which the schooners discussed earlier in the report were actively trading in coastal North Carolina (Figure 46).

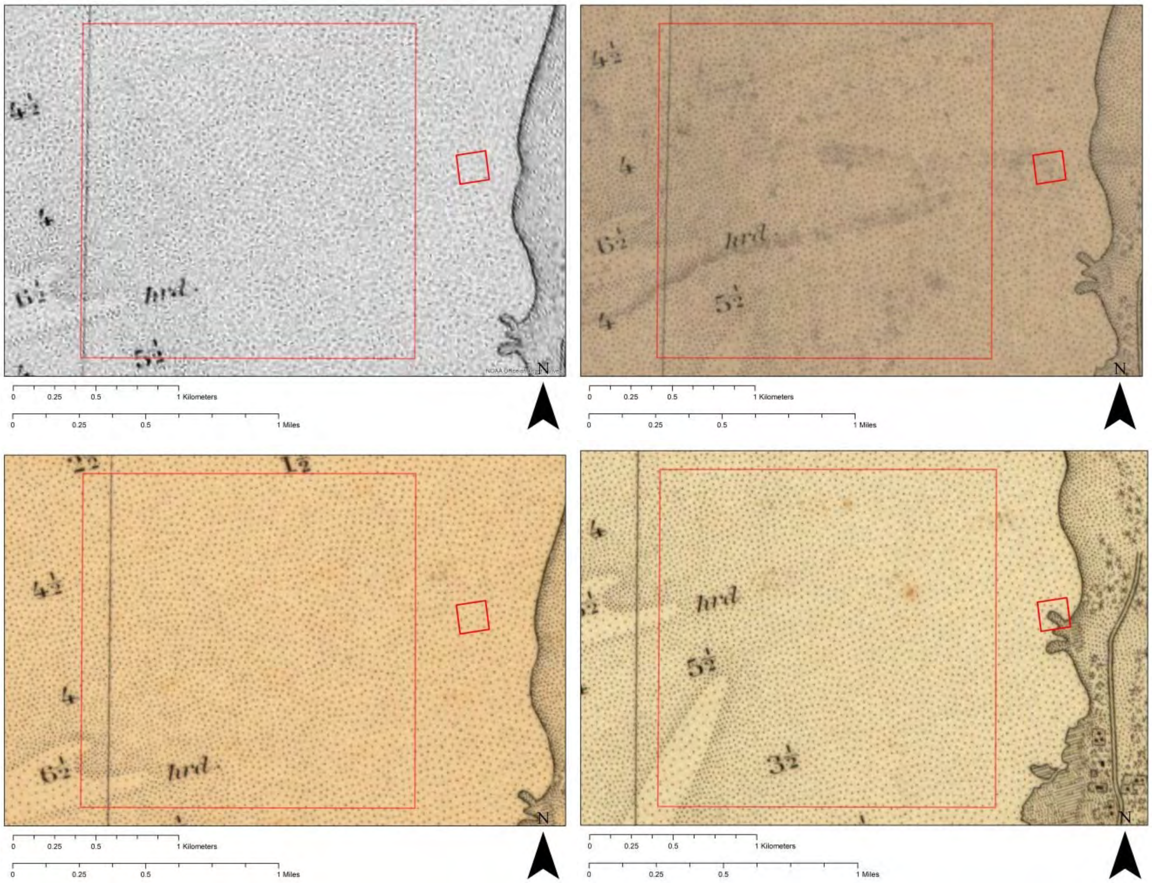


Figure 46. Pamlico Sound, Eastern Sheet showing comparison of 1883 (top left), 1888 (top right), 1899 (bottom left), and 1911 (bottom right) (US Coast and Geodetic Survey 1883, 1888, 1899, 1911); Study areas shows within red boxes.

Assorted Years Currituck Beach Light to Wimble Shoals

These maps depict the northern half of the Outer Banks. They represent the predominantly post-World War II efforts to accurately map Pamlico Sound. They show the shoreline of the islands as well as basic illustrations of marshland. These maps also show the locations of some known wrecks along the shore. Road systems throughout the islands and emerging artificial landscape features such as buildings begin to be labeled. The sounding data is present for both the ocean and Pamlico Sound. There are a larger number of charts from the mid-20th century available to researchers, so in an effort discern changes in the landscape only maps depicting relative five year intervals (i.e., 1960 to 1965 to 1970) are shown here (until the mid-1970s). In this way, minute changes in sounding data could be eliminated and more significant changes over large spans of time could be noted. Finally, these maps also show the emergency ferry terminal channel in Rodanthe on the 1942 map and later.

The 1970 chart first depicts the appearance of PAS0001, the Pappy's Lane wreck. The 1975 chart depicts the appearance of signs (Figure 47).

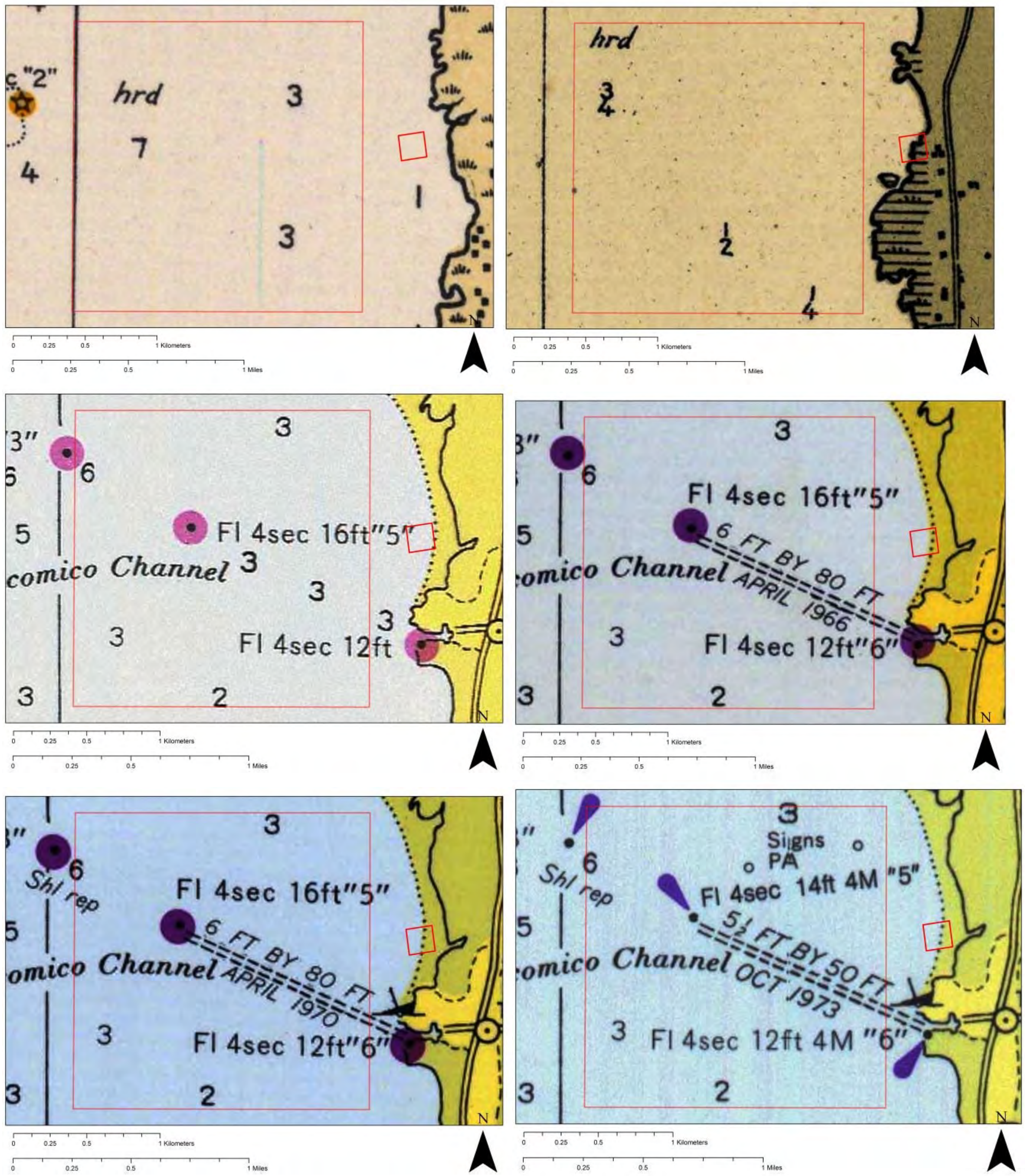


Figure 47. Cape Hatteras: Wimble Shoals to Ocracoke Inlet sheets showing comparisons of 1936 (top left) 1942 (top right), 1961 (middle left) 1964 (middle right), 1970 (bottom left) and 1975 (bottom right) (United States Coast and Geodetic Survey 1936, 1964; NOAA 1970, 1975); Study areas marked by red boxes.

Following the 1975 chart, all subsequent NOAA charts only depict minor alteration to dredge depths, names of channel markers (when present), and some details like the orientation or disposition (degree of inundation) of the Pappy's Lane Wreck. These charts indicate a simple shoreline demarcation and indicate no development other than adjacent roads. They show the persistence of features like the NFWS signs since 1975. The Pappy's Lane wreck first appears in chart 1229 from December 1970, and is not present in other 1970 (or earlier maps) (Figure 48). It is important to note that these charts indicate a major discrepancy between the location of PAS0001 (at location 35.600753 N -75.473544 W) and the location of its wreck symbol on nautical charts (35.598 N -75.473 W) of over 330 meters (1,083 feet).

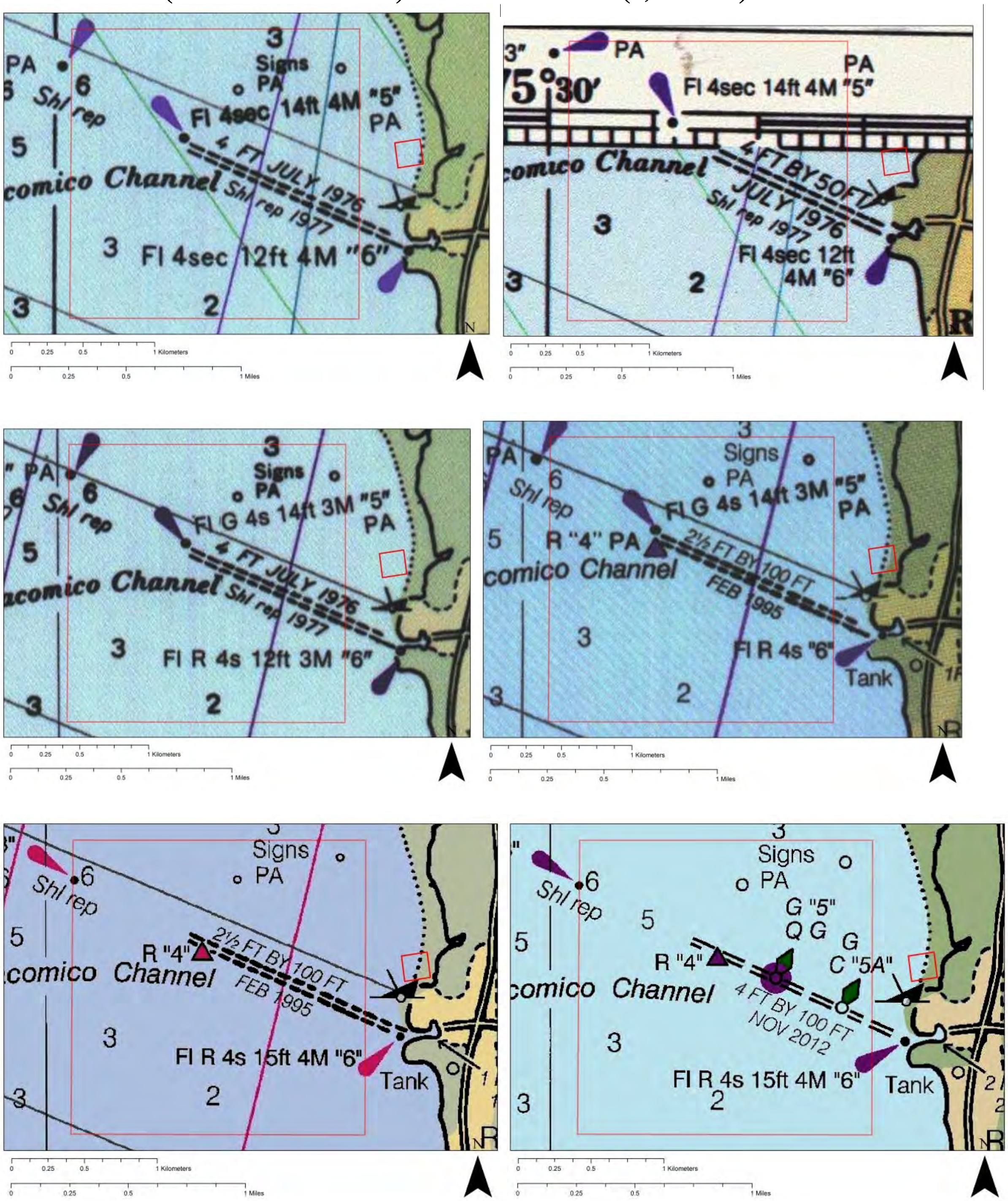


Figure 48. Cape Hatteras: Wimble Shoals to Ocracoke Inlet sheets showing comparisons of 1980 (top left), 1984 (top right), 1990 (middle left), 1996 (middle right), 2004 (bottom left), and 2012 (bottom right) (NOAA 1980, 1984, 1990, 1996, 2004, 2012).

These maps were selected per the same criteria as the assorted maps from Currituck Beach Light to Wimble Shoals shown in Figure 47. The difference is that these maps represent the southern half of the Outer Banks to Ocracoke Inlet. Just as before, the closest maps to a five-year interval were used to track the sounding data changes through a large span of time and eliminate small changes over a short period.

An additional step of cross-referencing a sequence of maps to aerial photos was attempted to ascertain if there were industries adjacent to the area, and to examine the placement of PAS0001 in more detail. All extant USGS aerial photographs currently residing in USGS *Earth Explorer*, a repository of high-resolution aerial and satellite-based photographs were downloaded and examined. This examination corroborated the cartographic sources regarding the lack of development in the area. One series of aerial photographs were useful for better determining a chronology of events concerning site PAS0001 (USGS aerial photogrammetry, 5 March 1956 to 22 December 1982, see Table 3). From these records the authors determined that the wreckage appeared in its current location sometime between 10 April 1964 to 24 September 1970.

Table 3. List of USGS single frame aerial photos examined (5 March 1956 to 22 December 1982).

Aerial Photo (single frame)	**Acquisition Date**	**Scale**	**PAS0001 Present?**	**Note**
ARA550540010010	5-Mar-56	1:60000	NO	
ARB640120203094	10-Apr-64	1:50000	NO	PAS0001 missing
AR6144003000063	24-Sep-70	1:65254	YES	PAS0001 first appearance
ARD012001020091	19-Apr-72	1:20000	YES	
ARD015501020049	9-Aug-72	1:10000	YES	Best resolution
ARD015501020361	9-Aug-74	1:20000	YES	
ARD038303020084	12-Aug-76	1:20000	YES	
ARD040701010145	9-Dec-77	1:21000	YES	
ARL820510505046	22-Dec-82	1:23922	YES	PAS0001 appears broken up

First, ARB640120203094 (10 April 1964, Figure 49) shows that there is no wreckage in the area adjacent to Blackmar Gut. The next available USGS aerial photo, AR6144003000063 (24 September 1970, Figure 50) shows the wreck for the first time. In this image, the wreck's outline from bow to stern can be seen. The outline conforms approximately to the present-day shape of the wreckage with its pointed bow, rounded stern and squared midship. Unfortunately, the scale of the photograph (listed as 1:65,254) does not allow for a clear extraction of any other additional details from the wreck. The best resolution of the entire dataset over this period (at 1:10,000) is found in aerial photo ARD015501020049 (9 August 1972, Figure 51) which provides a very clear outline of the wreck, gives details regarding the configuration of bow, midship section, and stern (note that the stern is less rounded than it appears in 1970), and also provides some details of the deck for interpretation. Notably, the aerial photograph suggests that instead of the characteristic "open" form of a barge or scow's deck plan, the vessel appears to be mostly decked in 1972– with extensive decking at the stern, an open or damaged area near the bow and what may be five or six open areas across the rest of the deck. These areas may represent hatches, areas where superstructure has been removed, or damaged areas (or a combination of the three). Critically, suggest that the vessel was not a bottom-dump (i.e. hopper) barge of any sort. A final aerial photo worth examining is ARL820510505046 (22 December 1982, Figure 52), taken at a lower resolution (at 1:23922 scale), but which suggests that by this date, extensive salvage or deterioration of the hull has occurred – but that the stern section and port-side bow remain the most intact areas.

Finally, UNC-CSI staff returned to the site to conduct an aerial survey via drone in 2016. The images obtained show that the site has a lot of structure intact at the stern and the bow that rise above the water level, but that areas along the port and starboard sides have undergone additional deterioration since 1982. Still, the aerial photograph closely resembles the 2010 site survey data, and hence it has not changed much in the last six years (differences between drawing and photo may be attributed by drafting errors, or photographic barrel distortion).

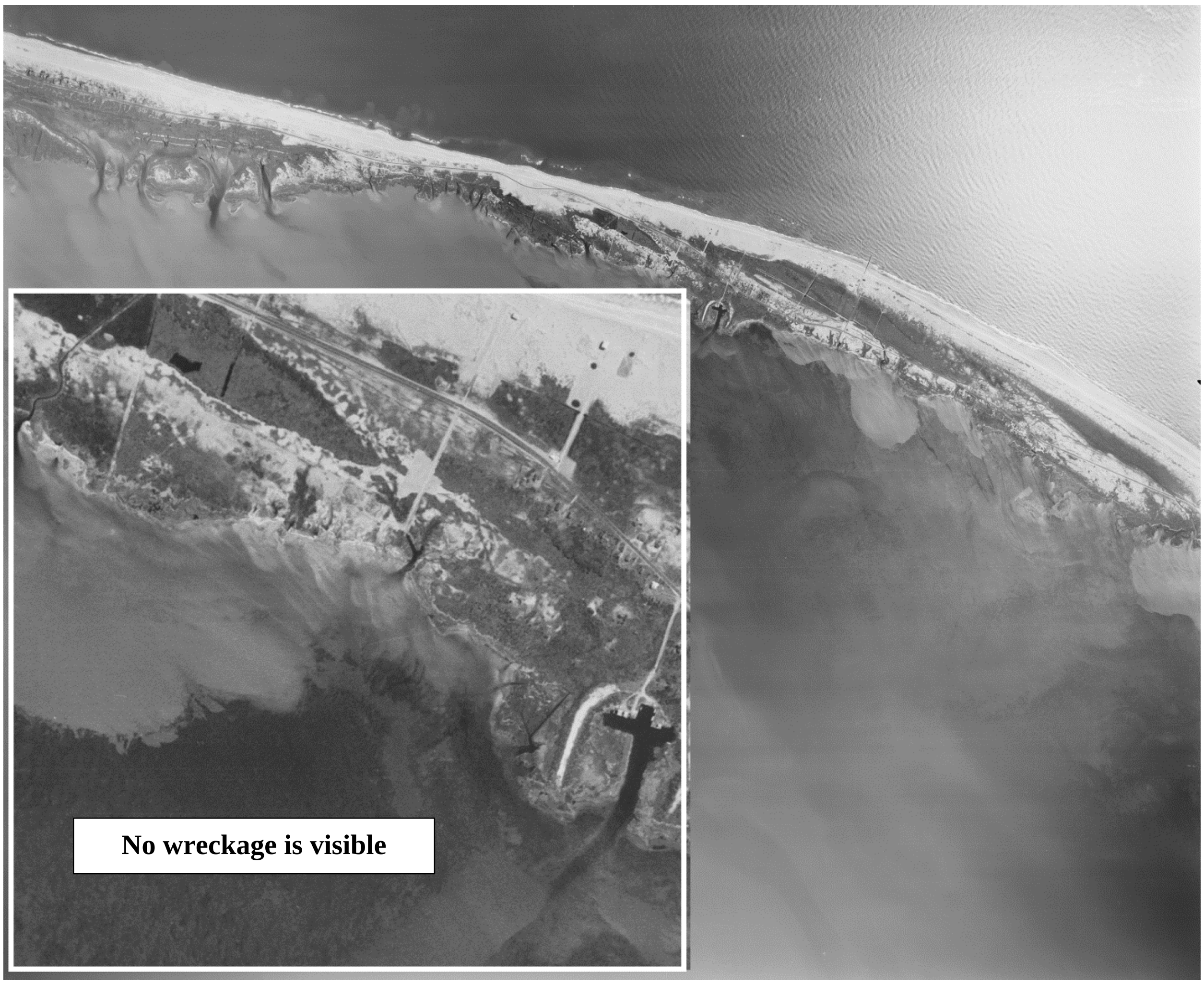


Figure 49. Two views of USGS aerial photo 10 April 1964 showing absence of PAS0001 (USGS single frame aerial photo ARB640120203094).

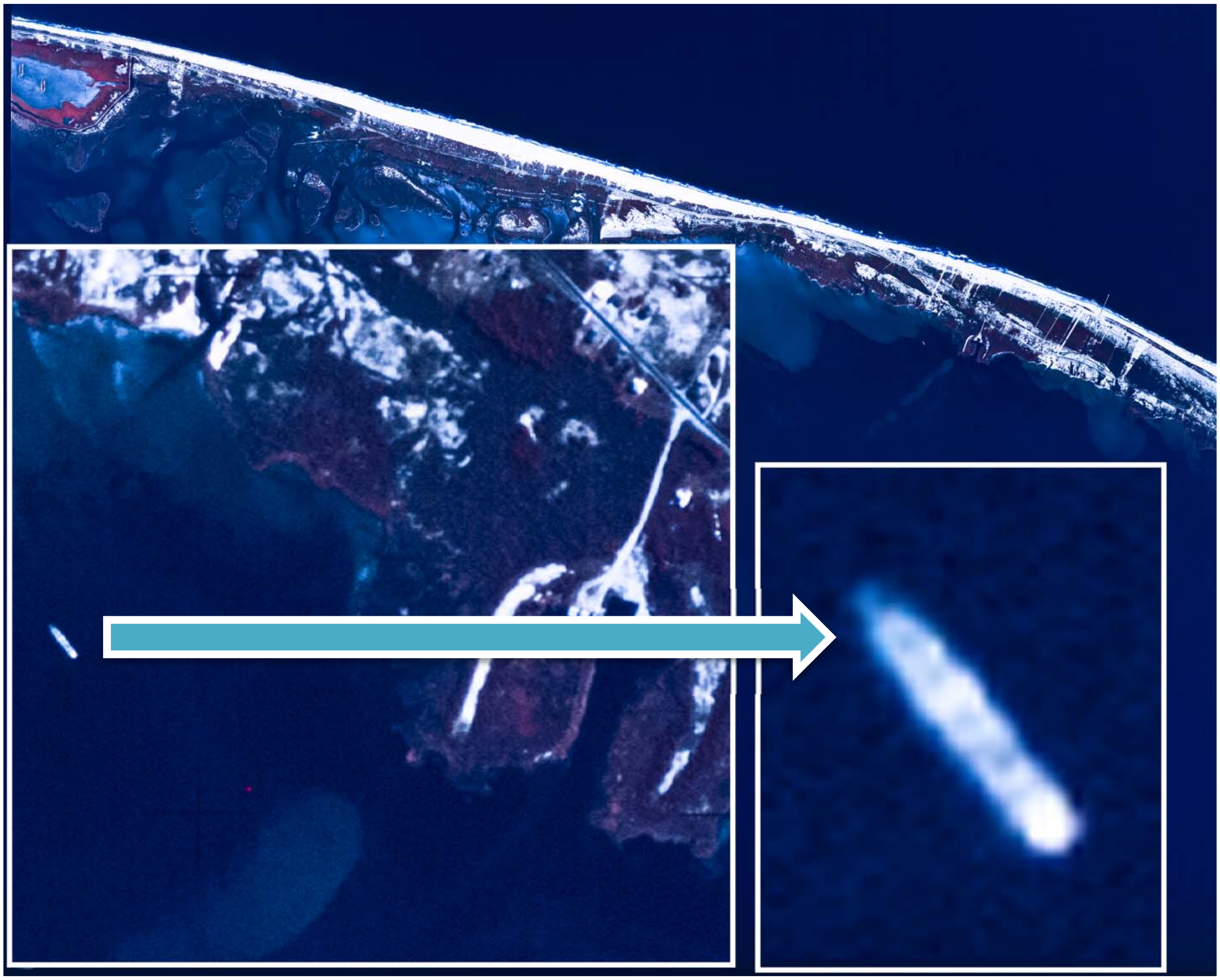


Figure 50. Three views of USGS aerial photo 24 September 1970 showing location and state of preservation of PAS0001 (USGS single frame aerial photo AR6144003000063).

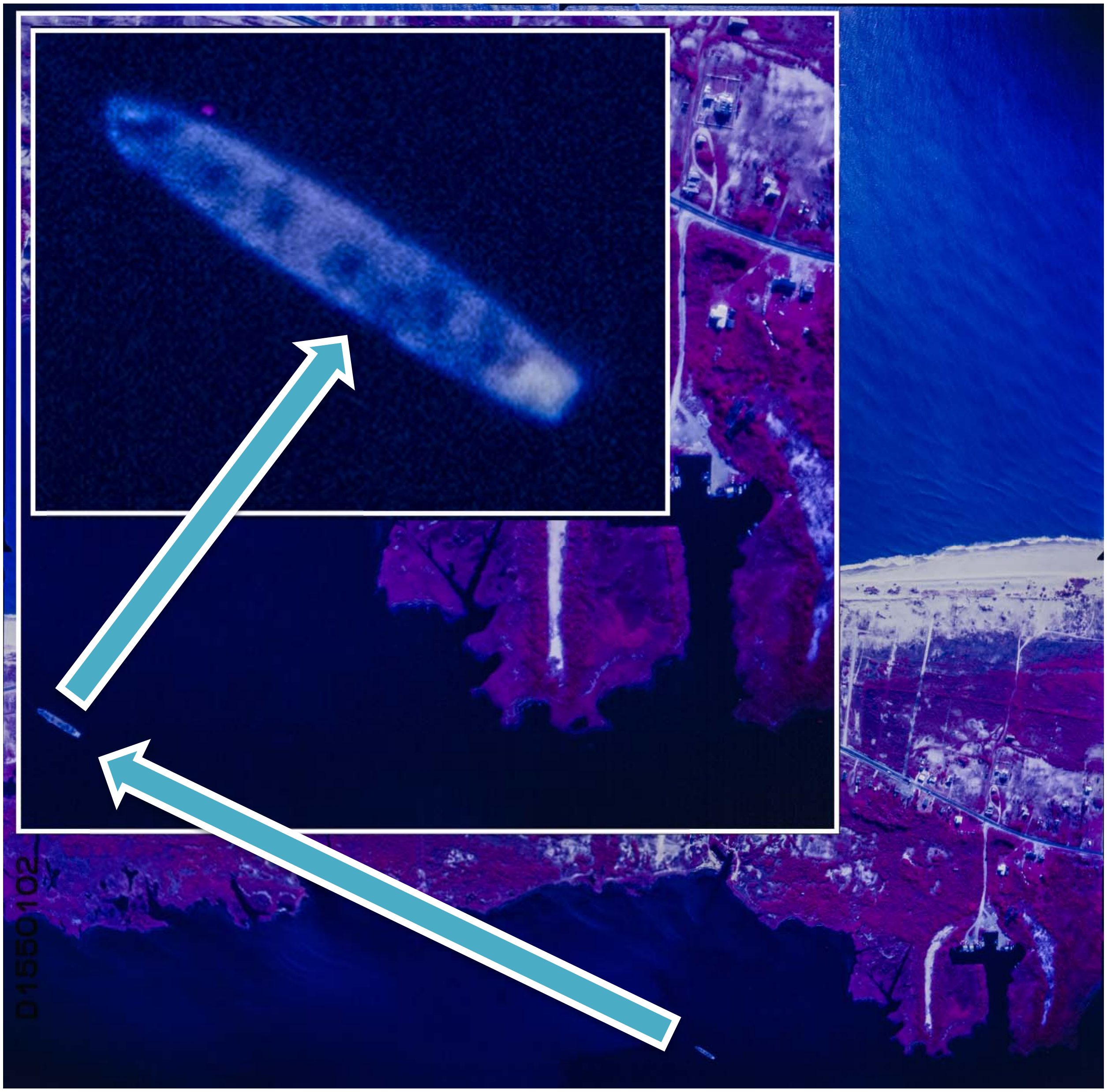


Figure 51. Three views of USGS aerial photo 9 August 1972 showing location and state of preservation of PAS0001 (USGS single frame aerial photo ARD015501020049).

Figure 52. Three views of USGS aerial photo 22 December 1982 showing location and state of preservation of PAS0001 (USGS single frame aerial photo ARL820510505046).

RESULTS OF ARCHAEOLOGICAL FIELDWORK

Archaeological fieldwork entailed a three-phase approach. First, during the summer of 2016, following kayak-based reconnaissance, a boat-based side-scan sonar and magnetometer survey was completed in the area. Immediately following this, visual inspection of nearshore areas was carried out, in addition to a visual inspection of a sample area of the sound-floor. Fifty percent of areas visually inspected were also subjected to metal detection survey. Finally, a drone-based photogrammetry mission captured high resolution orthophotos and three-dimensional models of the shorelines adjacent to the study area and the remains of the one confirmed shipwreck in the study area (the wreckage of PAS0001). Each set of results is communicated below.

Side Scan Sonar

The area covered during sonar survey is depicted in Figure 53. Additionally, the percentage of coverage (100%, 200%, or >300%) can be depicted graphically (Figure 54). Numerically, a total of 4,195,717 square meters (approx. 4.2 km^2) was surveyed with 100% coverage; of this 3,832,485 square meters (3.8km^2) was surveyed at 200% coverage (i.e. insonified from two perspectives), and 242,106 square meters (0.24km^2) was surveyed at 300% coverage (three perspectives). This allowed for any potential sonar target to be detected and classified from two perspectives and ensured that the sound floor within the area was thoroughly inspected.

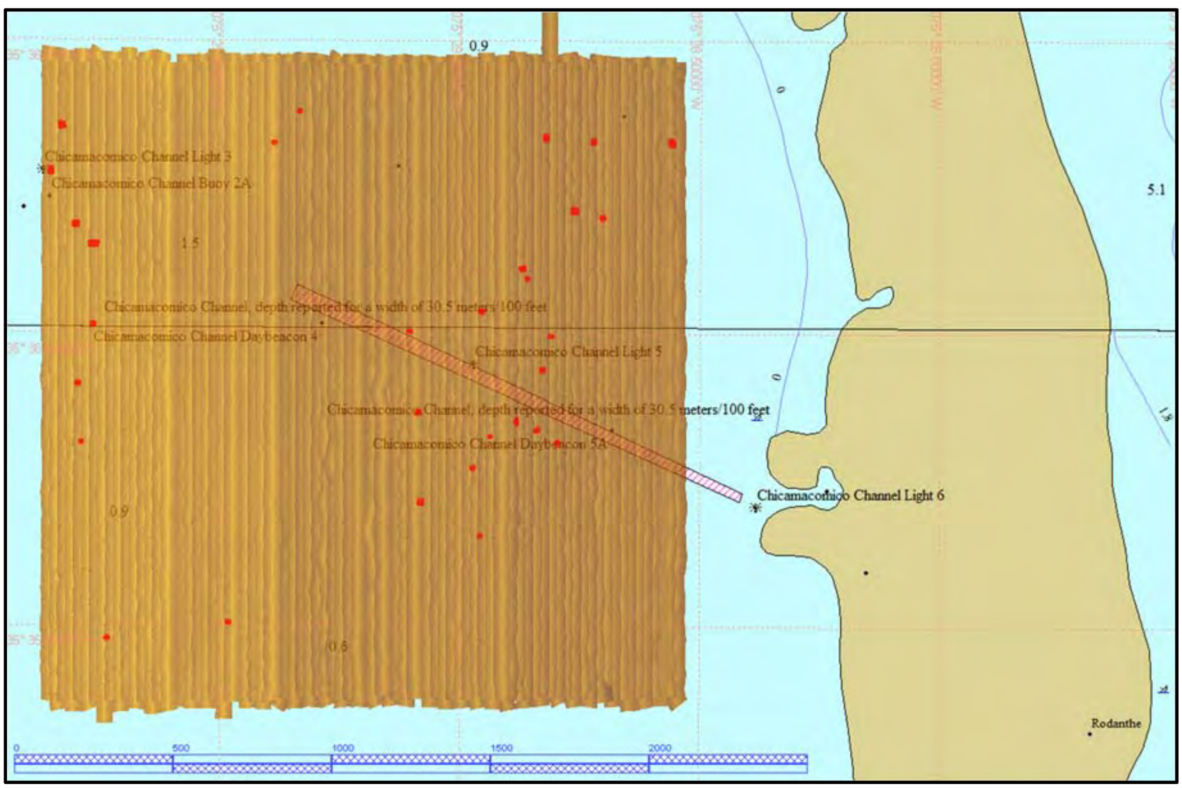


Figure 53. Survey coverage (Image by Nathan Richards).

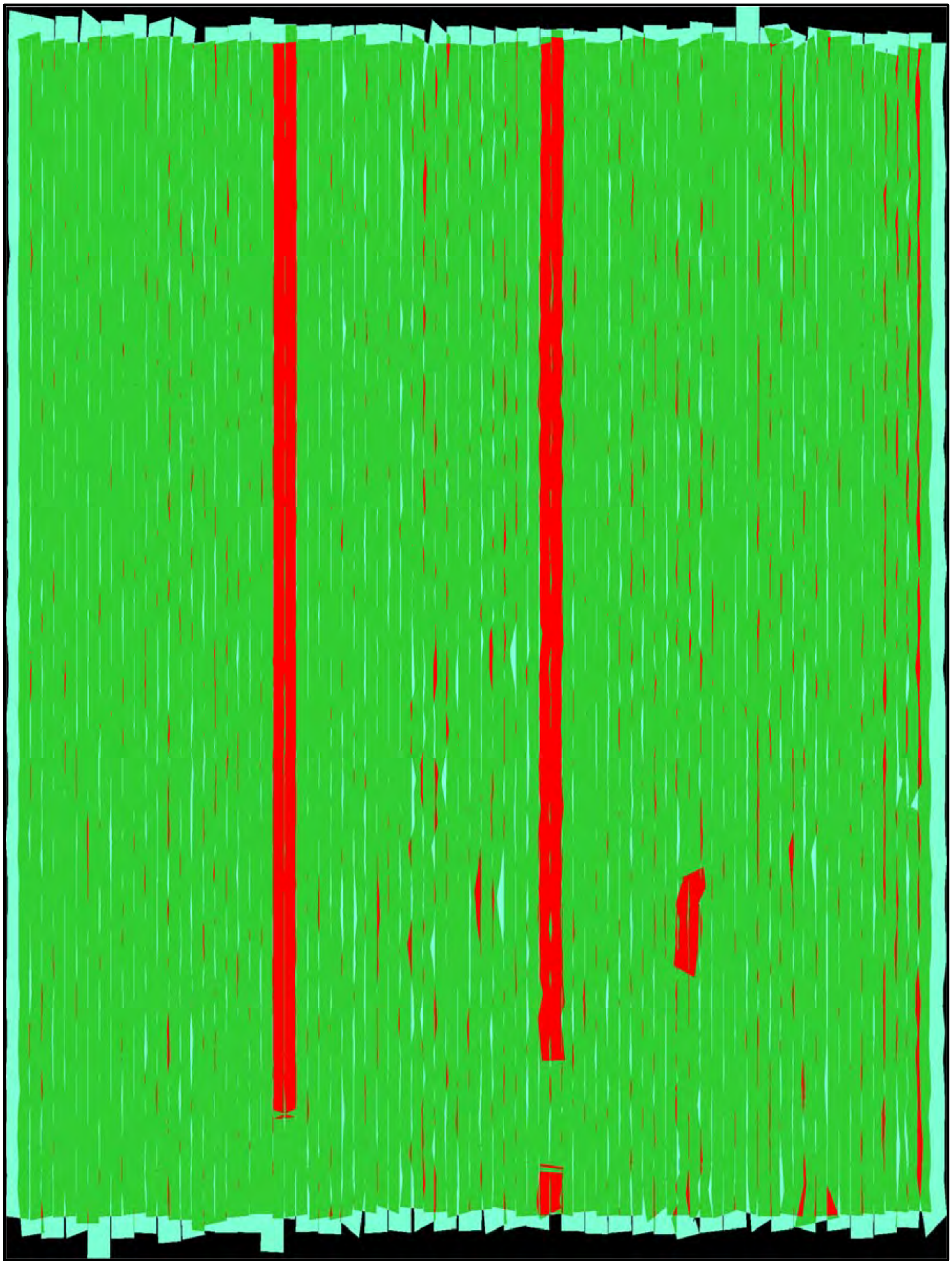


Figure 54. Detail of survey coverage showing areas of 0% coverage (black), 100% coverage (cyan), 200% coverage (green), and 300% coverage (red) (Image by Nathan Richards).

From this insonified area, 89 targets were classified and described. Following deletion of duplicates, 75 targets remained. All the sonar targets fell into four categories – pilings (extant and remnant), crab pots, a channel buoy, and unidentified features (Figure 55). Seventeen targets were later found to have magnetic signatures.

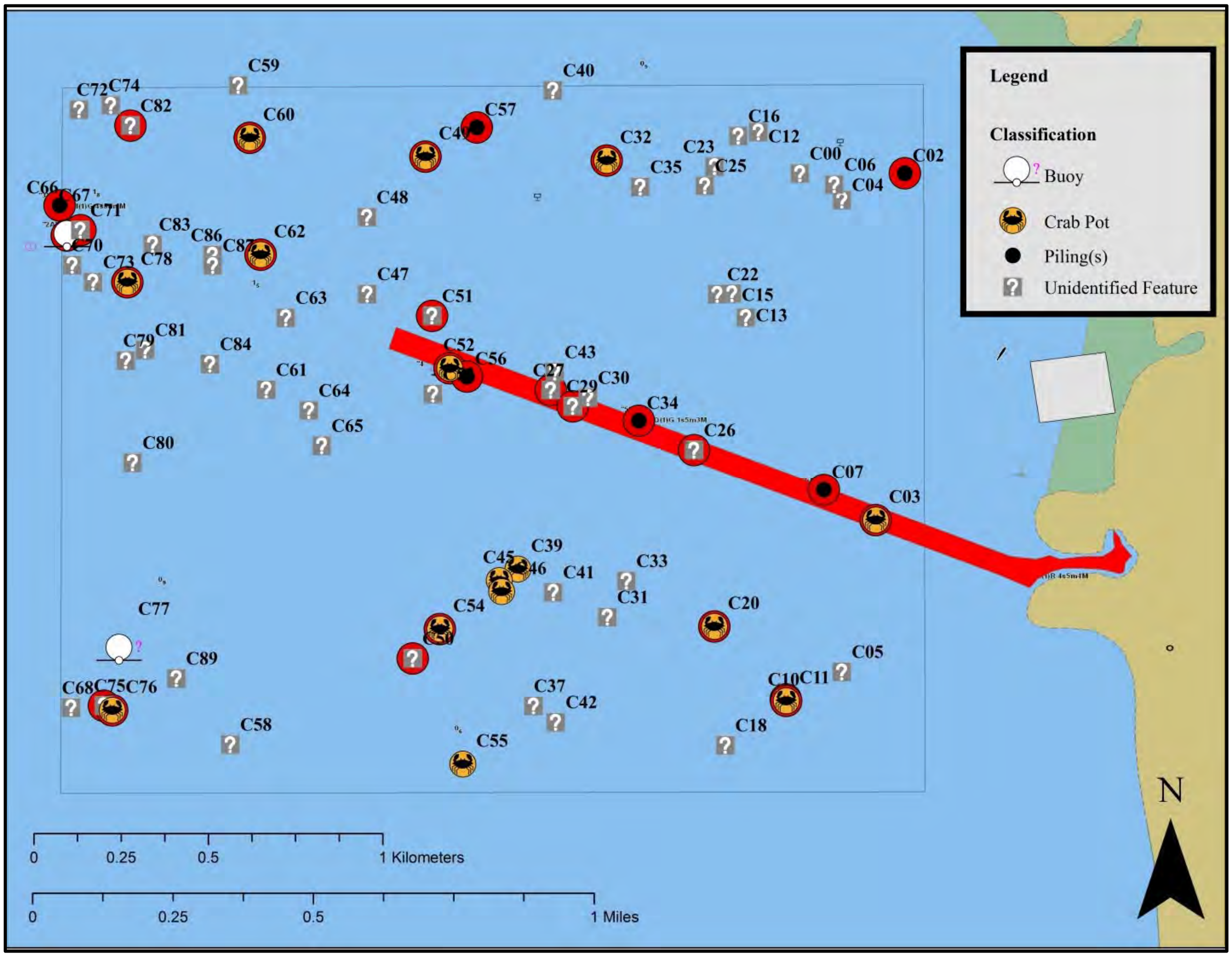


Figure 55. Classified targets from side scan operations within survey area; Red polygon represents the area of the present-day channel (Image by Nathan Richards).

There are three site types associated with pilings in the area. Contact 02 (Figure 56) represents pilings associated with an extant hunting blind (present at the time of remote sensing, but destroyed by the November 2016 photogrammetry fieldwork). Contact 57 (Figure 57) belongs to a piling noting the entry into the adjacent National Fish and Wildlife Service (NFWS) conservation area. Contacts 07, 34, 56, and 67 note channel markers (Figure 58). In most cases, these correspond with present day channel beacons and channel lights noted on present day navigation charts (C07=day beacon 5A; C34=light 5; C56=day beacon 4; C67=light 3). The one exception is C56, which although associated with day beacon 4 demonstrates that the day beacon is over 300 feet from the position marked on the chart. This follows with other ATONs, such as C67's association with channel buoy 2A, although C77 seems to represent a red "can" navigation buoy that has moved off site.

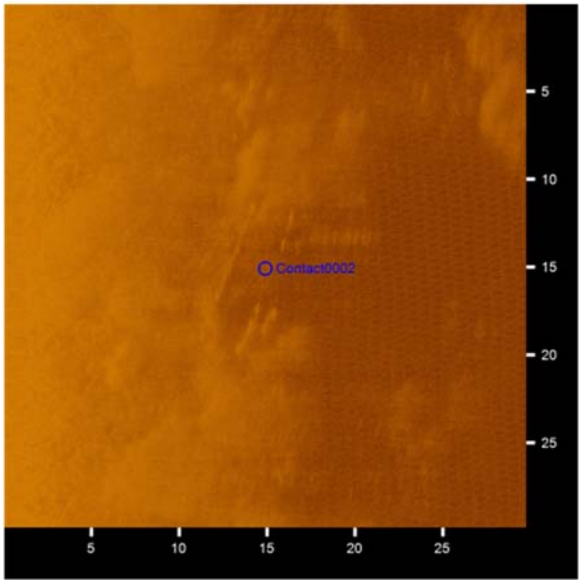


Figure 56. Contact 02, showing pilings associated with hunting blind.

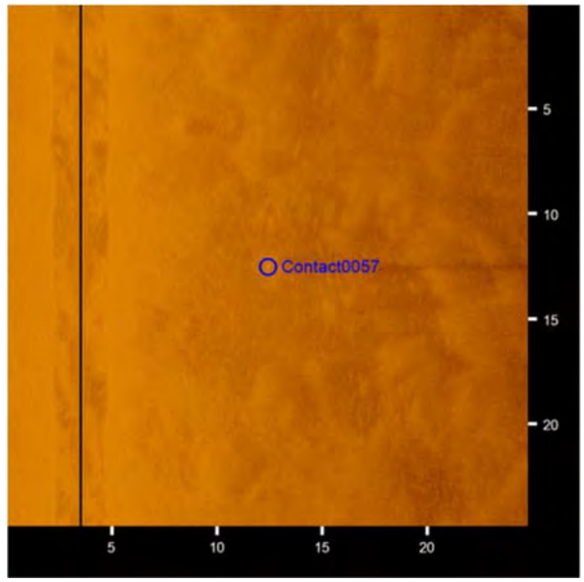


Figure 57. Contact 57, showing piling adjacent to the NFWS conservation area.

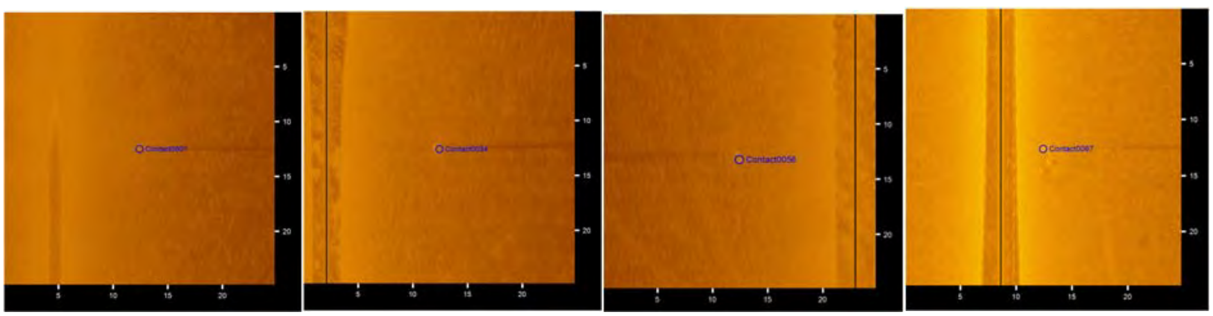


Figure 58. Contacts 07 (top left), 34 (top right), 56 (bottom left) and 67 (bottom right) show pilings associated with present-day beacons and channel lights.

Numerous crab pots litter the area. In some cases, these represent pots that were no longer attached to buoys but readily distinguishable and recorded on sonar (Figure 59). In other cases, buoys were still attached (becoming impediments to survey). At least 15 crab pots were easily distinguishable during sonar – though many more likely lie in the area and it appears many did not show up on sonar but were detected with the magnetometer (indicating burial).

Indeed, pots disassociated from their buoys may make up a major portion of the largest percentage of classified targets – unidentified targets. Most contacts represent unidentified features (Figure 60). All the unidentified targets represent small isolated features randomly distributed across the search area. In no instance was a sonar target identified that looks like a large structure (such as a shipwreck) with any convincing degree of sound floor distribution or articulation. It is highly likely that most unidentified contacts represent natural features (such as tree limbs) and other marine debris such as buried or obscured remnant crab pots (Figure 61).

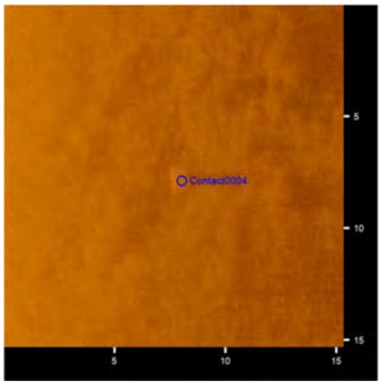


Figure 59. Contact 04, example sonogram of crabpot without attached buoy.

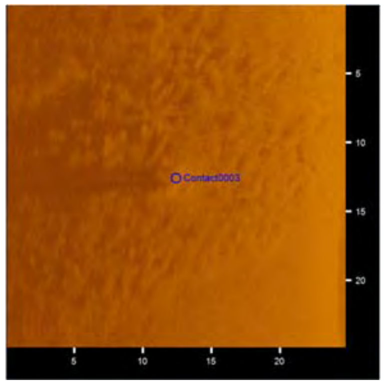


Figure 60. Contact 03, example of an isolated, unidentified object on the sound floor.

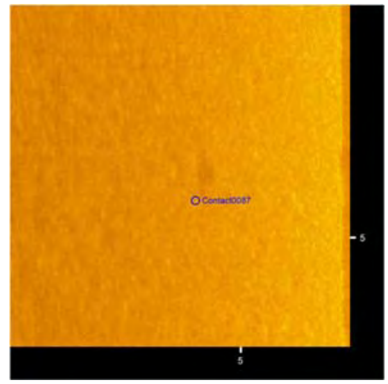


Figure 61. Contact 87, showing an impression in the sound floor -- likely created by a buried object such as a tree limb.

Magnetometry

The magnetometer results depicted in Figure 62 show the interpolated and contoured magnetic data from all days of survey (geo-rectified in *ArcGIS*). Across the survey area, magnetic range varied 1,254.6 gammas/nanoteslas (nT) from 48,125.6 nT to 49,380.2 nT. The addition of sonar targets (Figure 63) demonstrates the degree of correlation between objects recorded as sitting upon the seabed (or within the water column) and corresponding magnetism. During survey, events were marked as features within the search area (e.g. when passing channel markers or crab pots). Adding these points to the catalog of targets (Figure 64) accounts for many more magnetic anomalies and demonstrates that in some cases, magnetic objects at the end of buoy lines were either too small to be insonified (such as weights), were not seen during side scan processing, or represented crab pots that may be obscured or buried in sediment. The remaining magnetic signatures are all small, isolated magnetic spikes, and likely represent similar buried objects such as crab pots or ferrous line weights. As with the side scan sonar data, all unclassified magnetic targets appear to represent small isolated features randomly distributed across the search area. In no areas do magnetic anomalies suggest the existence of a large structure such as a shipwreck.

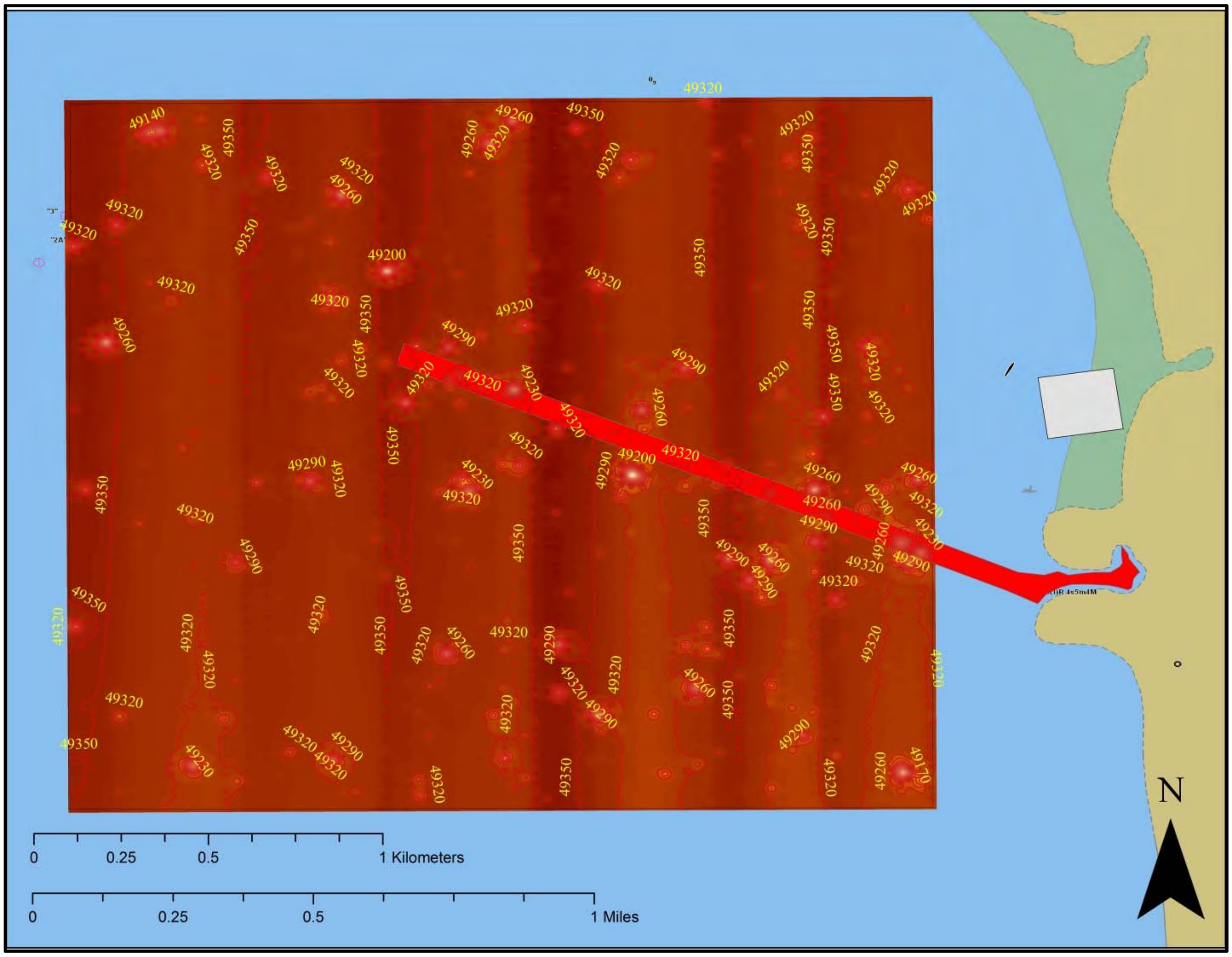


Figure 62. Depiction of georectified, interpolated, and contoured magnetism of survey area; Grey box depicts shoreline survey area (Image by Nathan Richards).

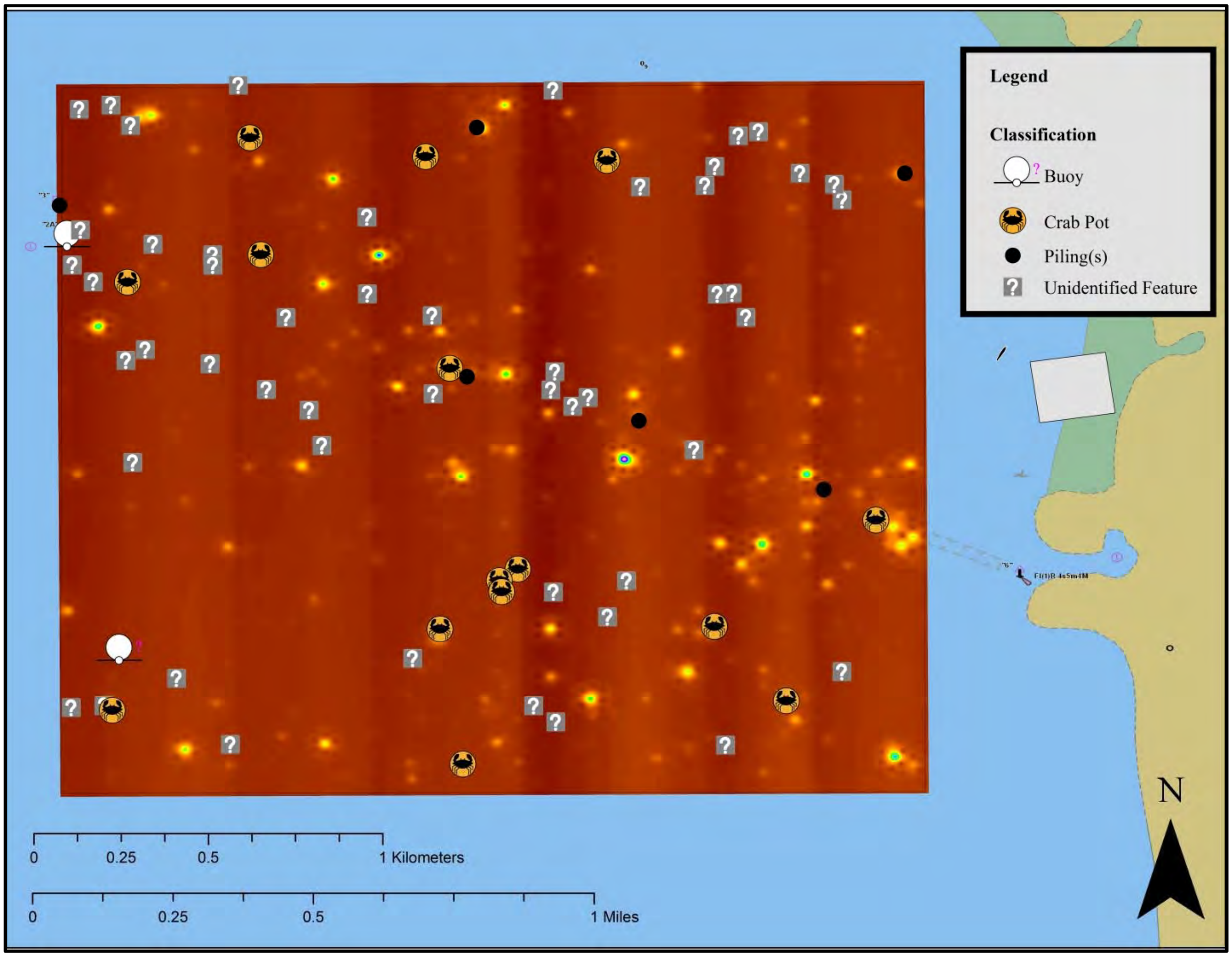


Figure 63. Depiction of interpolated magnetism across the survey area, with the addition of sonar targets; Grey box represents shoreline survey area (Image by Nathan Richards).

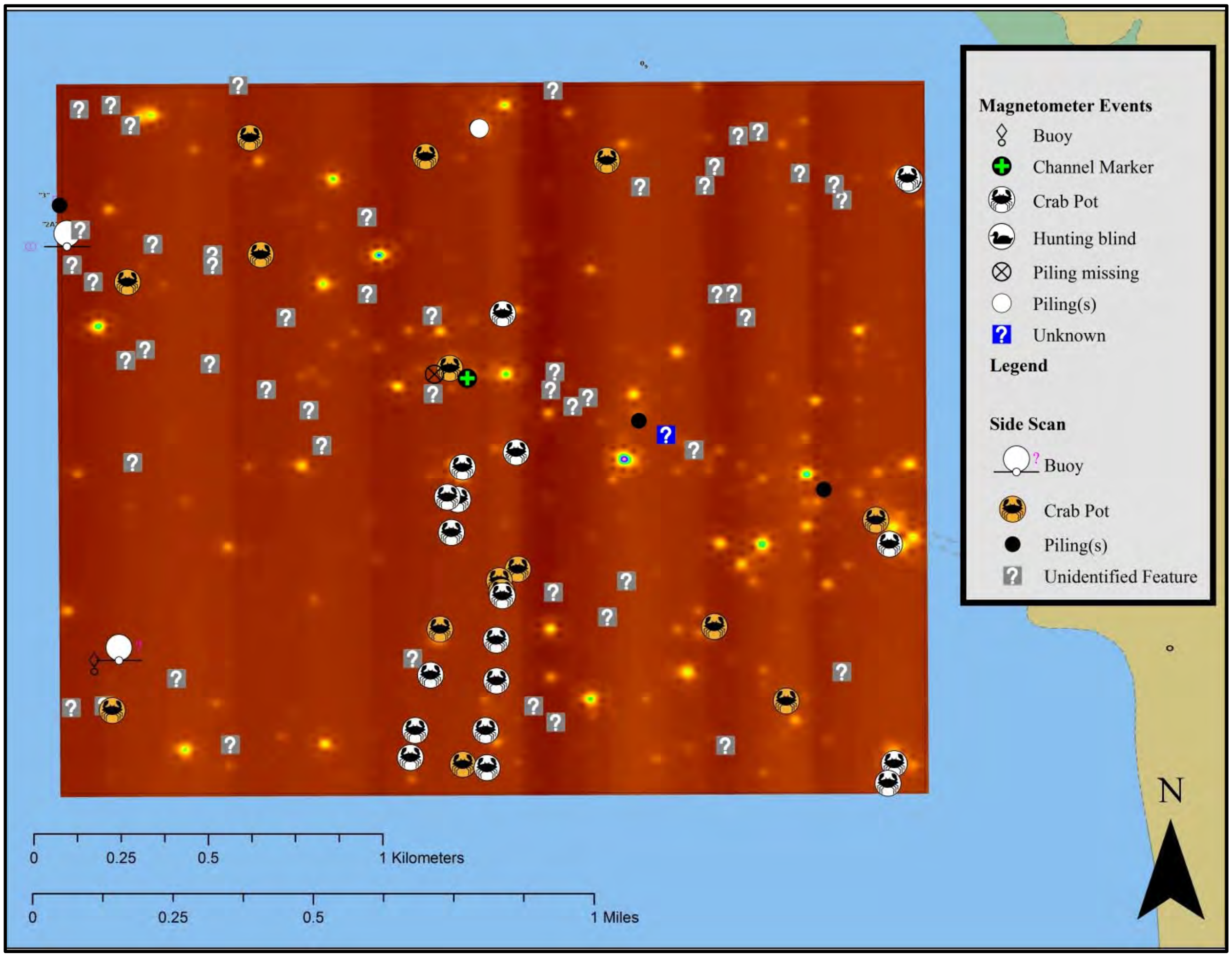


Figure 64. Depiction of interpolated magnetism and sonar targets, with the addition of "surface events" noted during remote sensing survey).

Shoreline Transect Survey and Metal Detection

The shoreline transect survey of a sample shallow zone area close to shore indicated that the area is composed of a sandy bottom with a significant coverage of subaquatic vegetation (Figure 65). Only isolated modern intrusive artifacts (a crab pot, a cinder block, and a modern timber), in addition to naturally occurring surface features (branches), were found spread out across the search area.

One half of the search area was systematically searched using a Minelab CTX3030 metal detector. This metal detector allows for the logging of the spatial location (latitude and longitude), conductivity (CO, on a scale of 1 to 50 in increasing conductivity) and ferrous content (FE, on a scale of 1 to 35 in increasing ferrous content) as well as object depth to be logged into the detector. This information can later be exported from the instrument for analysis (Table 4). Thirty metal anomalies were detected during metal detection activities. The finds discovered ranged from 2-19 cm below the sediment. Twenty-two anomalies were detected spread out across the area. Additionally, following the detection of some metallic objects within the search area, some sweeps of the area between the search grid and the nearest points of access was carried out. During these sweeps eight additional anomalies were detected. No ground-truthing (excavation) of these anomalies occurred.

Table 4. CTX3030 metal detection data showing Findpoint Name, ferrous reading (FE, 1-35), conductivity reading (CO, 1-50), and depth.

Findpoint	Ferrous reading	Conductivity reading	Depth (m)
FP001	9	34	0.18
FP002	11	34	0.08
FP003	10	45	0.06
FP004	35	43	0.12
FP005	29	41	0.07
FP006	11	38	0.18
FP007	18	38	0.19
FP008	23	40	0.19
FP009	35	44	0.1
FP010	12	37	0.19
FP011	29	45	0.12
FP012	2	44	0.19
FP013	6	41	0.16
FP014	5	11	0.1
FP015	32	45	0.11
FP016	35	42	0.16
FP017	30	40	0.12
FP018	30	41	0.09
FP019	23	47	0.17
FP020	30	42	0.07
FP021	33	46	0.05
FP022	6	35	0.17
FP023	11	38	0.02
FP024	21	42	0.11
FP025	8	41	0.05
FP026	35	45	0.11
FP027	34	42	0.17
FP028	35	42	0.17
FP029	24	41	0.17
FP030	13	44	0.18

When the location of the finds are spatially displayed (Figure 66) they are found to be distributed randomly across the area but potentially leading toward the shore. Due to the proximity of the area to nearby beaches used extensively for recreational purposes (kayaking, stand-up-paddle-boarding and kite surfing) one interpretation may be that these anomalies represent personal or recreational objects dropped or lost from these activities.

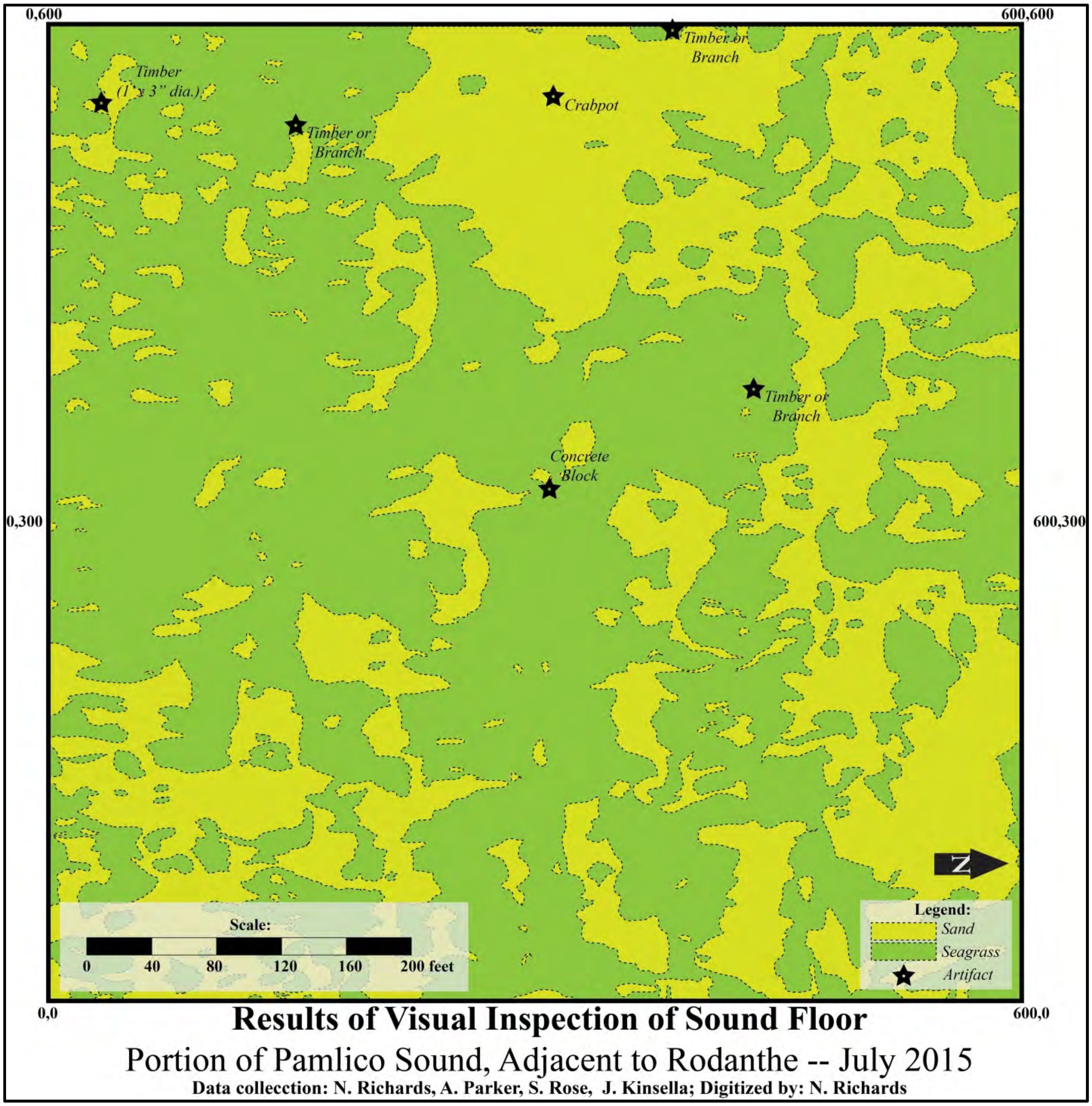


Figure 65. Results of visual inspection of sound floor (Image by Nathan Richards).

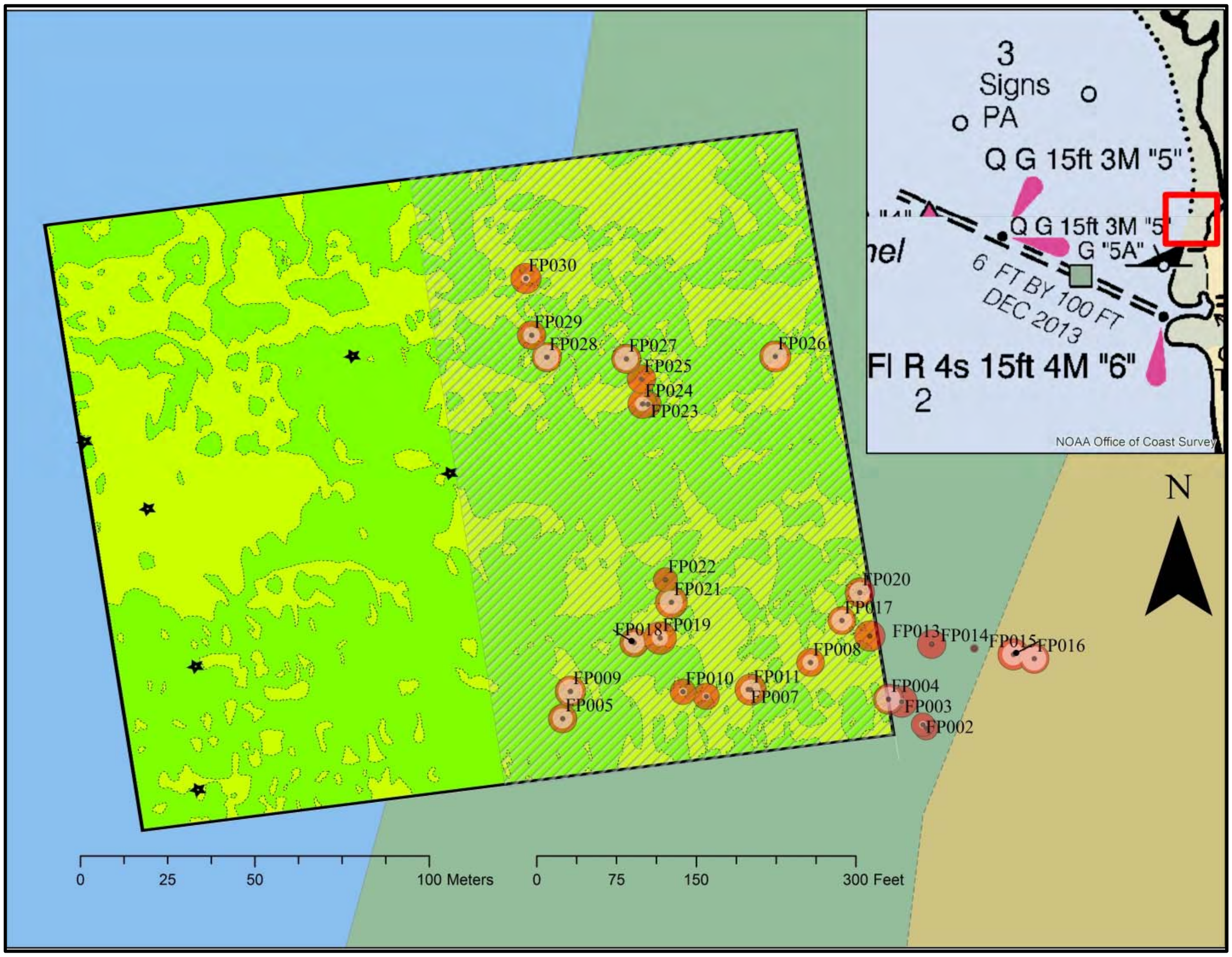


Figure 66. Results of metal detection survey, superimposed on georectified depiction of visually inspected area of sound floor (Image by Nathan Richards).

Photogrammetry

As mentioned in the methodology section, drone-based photogrammetry data collection was successful on two occasions. On 15 November 2016, researchers successfully captured a high resolution orthographic photo and three-dimensional model of the shorelines adjacent to the study area, including the entirety of Black Mar Gut (Figure 67). Examination of the three-dimensional mesh produced by the modeling process in addition to inspection of details in the photographic representation suggest no additional extant structures protruding from the water or occupying the coastal fringes the surround the study area.

An attempt to do the same for the remains of PAS0001 were only partially successful at the time due to high-water and brisk winds. Consequently, only a single-frame aerial photograph of the wreckage could be obtained (Figure 68). The photograph shows the extent of the wreckage, and demonstrates that the vessel has not undergone significant scrambling or deterioration since it was first seen by UNC-CSI and ECU personnel in 2010. The photograph also suggests that the 2010 site plan was still a good representation of the current site preservation, and that areas around the hull may contain other wreckage and debris.

Figure 67. High resolution three-dimensional photograph of survey area (Image by John McCord/CSI).

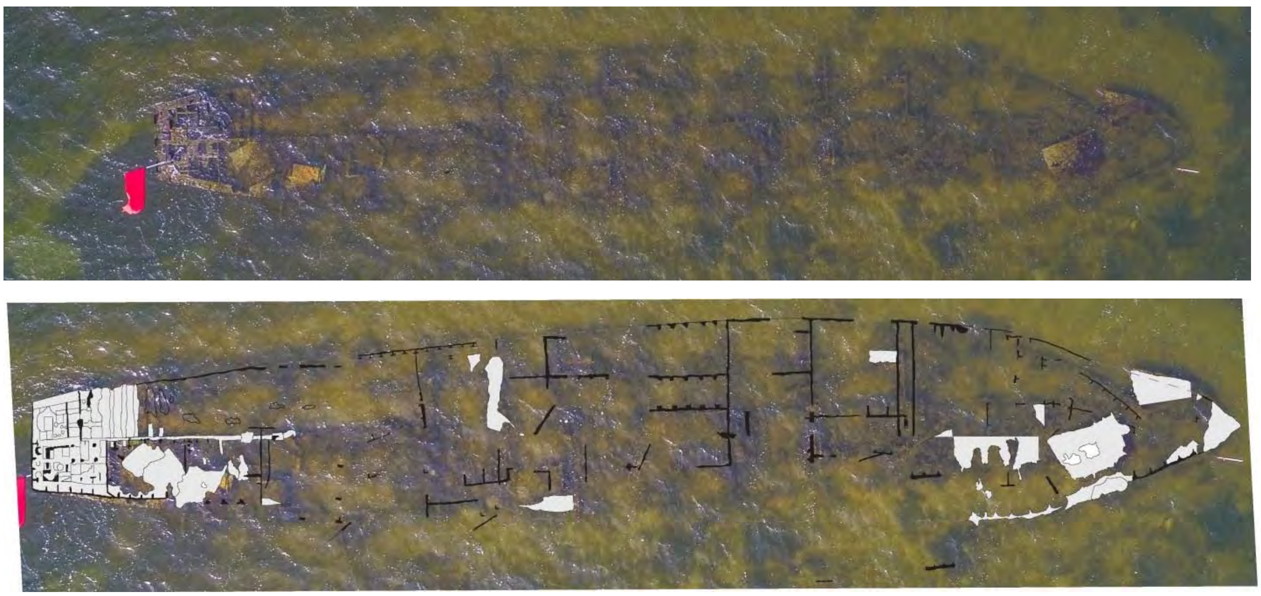


Figure 68. (L) Aerial image of PAS0001 (John McCord) (R) Aerial image with PAS0001 site plan superimposed.

Personnel returned in 10 February 2017 when water levels were low and wind was weak and successfully created both a three-dimensional model and a very high-resolution multi-image ortho-photograph of PAS0001 (see Figure 69). The results indicate a degree of penetration of some of the water across the surface of the wreck, and indicate that areas around the wreckage – particularly areas on the starboard side (right hand side of image) may have buried hull plates and other vessel components. Using these results, it is now possible to investigate further leads to potentially identify the hull by focusing on diagnostic elements of the vessel. For example, the 2010 site plan implies that the location of the extreme end of the bow is known – but the multi-image orthophoto suggests this may not be discerned properly and that the hull could be shorter or longer than once thought (i.e. disarticulated debris must be differentiated from articulated hull in more detail).

By capturing some elevation data in the three-dimensional model, it may also be possible to compare the present-day wreckage with the photographs from the 1970s, 1980s and early 2000s already presented and infer the loss of material from the hull in such a way as to predict potential future hull material deterioration.

The orthophoto and 3D model will also allow for future archaeological work to occur on the site. This may range from correlation between hull features and builder's plans that may be discovered in the future. It also shows that there is likely a zone around the wreckage which does not represent articulated hull structure, but may be hull plating which has fallen away from the hull and is now buried an unknown distance from the present-day intact structure. Due to poor water clarity, only re-survey of PAS0001 will be able to determine the actual outline and dimensions of the wreckage and the extent (and burial depth) of associated debris. Some of these questions may only be answered through additional remote sensing of the site, and some invasive archaeological activities (i.e. excavation of silt within and adjacent to the site).

Figure 69. High resolution multi-image orthophoto of PAS0001 (Image by Nathan Richards).

5

CONCLUSIONS AND RECOMMENDATIONS

The study area and sites outlined in this report represent a zone of human interaction with marine resources that can only be described in terms of intangible heritage. From a reading of historical records researchers have gleaned general interpretations of broad marine-based activities that occurred in the area in the nineteenth and twentieth century and imagined how these may have left impressions on the sound floor and coastline of this stretch of Pamlico Sound and Hatteras Island beach. Another way to conceptualize the area is as a prominent point of intersection for larger networks of trade, communication, and conflict. However, apart from a chance that a prominent Civil War event occurred in the vicinity (unsubstantiated, and currently a matter of debate), the activities occurring in the area were a part of day-to-day marine-based transportation, industry, resource extraction, and associated activities (such as life-saving and rescue actions). Where catastrophic events did happen, they were mostly resolved in a manner that suggests **a low chance that archaeological signatures would remain from them today**. Cartographic and aerial photo evidence support this claim with **no evidence of significant marine infrastructure having been placed in any permanent fashion in the area**. Indeed, the erection and disappearance of features like hunting blinds during the survey tell a story of temporary and evolving uses of the area. Hence, the area's history is one of interwoven representative histories – but not the story of a place where incredible, catastrophic, or remarkably significant events occurred.

Except for the wreckage of PAS0001, the study area defined in this report appears to only contain isolated sound-floor marine debris, such as relict pilings, lost crab pots, buried vegetation, and other detritus picked up via side scan sonar and magnetometer survey, that is of no historical significance. While this supports assertions about the area's significance outlined above, it is also important to note because any removal of sediment from the area will likely extract such debris (with potentially damaging effects to machinery), or will bury it if sediment is deposited in the area. Nevertheless, there is **little to no risk of adversely impacting heritage sites in the area through sediment removal or deposition, or from construction activities**.

While the wreckage of PAS0001 was not within the remote sensing survey area, research undertaken during this project suggests there is a high likelihood that the wreckage does not represent the gravel barge it is most commonly identified as by the local community, and may in fact be a late-nineteenth or early-twentieth century vessel of some significance (or at least, presently unknown significance). Hence, **it is recommended that dredging and sediment deposition activities occur away from site PAS0001 until the vessel's identity is further investigated and a better determination of its significance is obtained**. In September 2016, Panamerican Consultants, Ltd. released a report on their fieldwork in the area. This included an assessment of PAS0001. During their work, they were in contact with Richards, and their research cites the 2010 ECU/CSI research and the nature of the 2014-2016 CSI research. They cite the vessel as a late-nineteenth or early-twentieth century iron-hulled seagoing vessel (Panamerican Consultants, Ltd. 2016:i). Critically, Panamerican archaeologists undertook successful side-scan, magnetometer, and sub-bottom profiler surveys of the area – including the area at and around PAS0001. This verification supports **the need for further archaeological examination of the hull remains**.

6

REFERENCES

American Lloyds Register of American and Foreign Shipping (AL)

1861 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1862 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1863 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1864 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1865 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1866 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1867 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1868 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1869 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1870 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1872 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1881 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1882 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1883 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1884 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1885 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

1886 *Record of American and Foreign Shipping*. American Bureau of Shipping. New York, NY.

Babits, Lawrence E., Gregory Stratton, C.J. Idol, Calvin Mires, and Charles Ewen

2015 Final Report: Archaeological Test Investigations (Fortification and Camp Live Oak, Waves, Dare County, North Carolina). Report prepared for Mr. Mel Covey, Rodanthe, NC.

Baltimore Patriot
1821 Edenton,N.C.: Shipwreck. 26 December, p. 1. Baltimore, MD.

Barfield, Rodney
1995 *Seasoned by Salt: A Historical Album of the Outer Banks.* The University of Chapel Hill Press, NC.

Belton, Tom, and Paul Branch
2006 Civil War, in pps. 235-239 *Encyclopedia of North Carolina,* William S. Powell (editor). University of North Carolina Press: Raleigh.

Berman, Bruce D.
1972 *Encyclopedia of American Shipwrecks.* The Mariners Press: Boston, MA.

Binkley, Cameron
2007 *The Creation and Establishment of Cape Hatteras National Seashore: The Great Depression through Mission 66.* Report prepared for National Park Service, U.S. Department of Interior. Atlanta, GA.

Bishop, Nathaniel H.
1878 *Voyage of the Paper Canoe: A Geographical Journey of 2500 miles from Quebec to the Gulf of Mexico, During the Years 1874-5.* David Douglas: Edinburgh, United Kingdom.

Carbone, John S.
2001 *The Civil War in Coastal North Carolina*. North Carolina Office of Archives and History: Raleigh, NC.

Carr, Dawson
2016 *NC 12: Gateway to the Outer Banks*. The University of North Carolina Press: Chapel Hill.

Carter, Kathy
2006 Lifesaving Service, U.S. in pps. 673 *Encyclopedia of North Carolina,* William S. Powell (editor). University of North Carolina Press: Raleigh.

Charles, Joan
2004 *North Carolina Shipwreck Accounts: 1709 to 1950 including over 1100 named wrecks.* Published by the author: Hampton, VA.

Charlotte Daily Observer
1906 Debate on Dispensary. Col. J. A. Long and Rev. R. C. Beaman Discuss Absorbing Topic before Large Audience in Alamance Court House. *Charlotte Daily Observer* 29 March:3. Charlotte, NC.
1908 Two-Masted Schooner Sunk. Submerged Buoy Caused a Leak and Cargo is Lost, Crew Escaping by Clinging to Rigging. *Charlotte Daily Observer* 11 July:2. Charlotte, NC.
1909 Minister's Wife Skips. *Charlotte Daily Observer* 22 June:1. Charlotte, NC.

Combs, Edwin L., III.
2003 Trading in Lubberland: Maritime Commerce in Colonial North Carolina, in *The North Carolina Historical Review*, Vol. 80(1):1-27.

Covey, Mel
2016 A Continuing Conflict for Chicamacomico's Camp Live Oak: Unbeknownst to Babits – A Critical Analysis of the Babits, et al [sic] Final Report. Report by the author, Waves, North Carolina.

Crumbley, Tony L.
2006 Postal Service. in pps. 900-901, *Encyclopedia of North Carolina,* William S. Powell (editor). University of North Carolina Press: Raleigh.

Cumming, William P.
1988 *Mapping the North Carolina Coast: Sixteenth-Century Cartography and the Roanoke Voyages*. Division of Archives and History, North Carolina Department of Cultural Resources: Raleigh, NC.

Dolan, Robert, and Harry Lins
2000 The Outer Banks of North Carolina. *US Geological Survey Professional Paper*, 1177-B. Washington, DC.

Downs, Terrence
1979 Remember the Maine Fish Market!: Down among the porgies, chowder clams, sea bass and oysters—this stubborn enclave is still the way it used to be. *The Washington Post Magazine,* 23 September 1979: 24-27.

Downing, Sarah
2013 *Hidden History of the Outer Banks.* The History Press: Charleston, SC.
2014 *On this Day in Outer Banks History*. The History Press: Charleston, SC.

Duffus, Kevin P.
2007 *Shipwrecks of the Outer Banks: An Illustrated Guide*. Looking Glass Productions, Inc.: Raleigh, NC.

Dunbar, Gary S.
1958 *Historical Geography of the North Carolina Outer Banks.* Louisiana State University Press: Baton Rouge, LA.

Duyckinck, Evert A.
1861 The Chicamacomico Races, in David Stick, editor, *An Outer Banks Reader*, pps.132-135. The University of North Carolina Press: Chapel Hill, NC.

Edenton Gazette
1821 Shipwreck. 10 December, p. 3 col. 3, Edenton, NC.

Etheridge, J.S.
1896 Form 1806, United States Life-Saving Service, Wreck Report: *Lydia Ann*, March 20, 1896, Bodies Island Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center. Outer Banks History Center, Box 1, Folder 4.

Freitag, Norbert
1998 *Shipwrecks Unforgotten from New Jersey to the Gulf of Florida*: *A Reference Guide*. Finley-Greene Publications, Inc.: Island Park, NY.

Gentile, Gary
1993 *Shipwrecks of North Carolina from Diamond Shoals North.* Gary Gentile Productions: Philadelphia, PA.

Gray, L.B.
1922a Form 2625, U.S. Coast Guard Report of Assistance Rendered: *Two Sisters*, February 8, 1922, Coast Guard Station No. 181 (Little Kinnakeet). U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 18, Folder 125.
1922a Form 2625, U.S. Coast Guard Report of Assistance Rendered: *Two Sisters*, June 13, 1922, Coast Guard Station No. 181 (Little Kinnakeet). U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 18, Folder 129.

Hairr, John
1999 *Images of America: Outer Banks*. Arcadia Publishing: Charleston, SC.

Harris, Thomas
1895 Form 1806, United States Life-Saving Service, Wreck Report: *Lou Willis*, March 21, 1906, Paul Gamiels Hill Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 4, Folder 4.

Hooper, Elvin
2004 *Chicamacomico: How it was back then.* Chapel Hill Press, Inc., NC.
2016 *Gull Island and Other Stories*. Chapel Hill Press, Inc., NC.

Howard, Fred
1998 *Wilbur and Orville: A Biography of the Wright Brothers*. Dover Publications, Mineola, NY.

Hoyt, Joseph, James P Delgado, Bradley Barr, Bruce Terrell, and Valerie Grussing
2014 *"Graveyard of the Atlantic": An Overview of North Carolina's Maritime Cultural Landscape.* NOAA research report No. 4.

Impact Assessment, Inc.
2005a *Final Technical report – Volume One: Ethnohistorical Description of the Eight Villages adjoining Cape Hatteras National Seashore and Interpretive Themes of History and Heritage.* Report prepared for the Cape Hatteras National Seashore, Manteo, NC.

2005b *Final Technical report – Volume Two: Ethnohistorical Description of the Eight Villages adjoining Cape Hatteras National Seashore and Interpretive Themes of History and Heritage.* Report prepared for the Cape Hatteras National Seashore, Manteo, NC.

Johnson, Charles F.
1911 *The Long Roll: Being a Journal of the Civil War, as set down during the years 1861-1865 by Charles F. Johnson, sometime of Hawkins Zoaves*. The Roycrofters: East Aurora, NY.

Khoury, Angel Ellis
1999 *Manteo: A Roanoke Island Town.* The Donning Company/Publishers: Virginia Beach, VA.

Kidder, Chris
2005 *The Outer Banks in Vintage Postcards*. Arcadia Publishing: Charleston, SC.

Kirk, Stephen
1995 *First in Flight: The Wright Brothers in North Carolina*. John F. Blair Publishers: Winston-Salem, NC.

Krivor, Michael C.
2004 Bonner Bridge Cultural Resources Survey and Diver Assessment of Submerged Targets, Dare County, North Carolina. Conducted for the North Carolina Department of Transportation under contract to Parson, Brinkerhoff, Quade and Douglas, Inc., by Panamerican Consultants, Inc., Memphis, Tennessee.

Lawson, John
1709 *A New Voyage to Carolina; Containing the Exact Description and Natural History of That Country: Together with the Present State Thereof. And A Journal of a Thousand Miles, Travel'd Thro' Several Nations of Indians. Giving a Particular Account of Their Customs, Manners, &c.* London

Lefler, Hugh T., and William S. Powell
1973 *Colonial North Carolina: A History*. Charles Scribner's Sons: New York, NY.

Littleton, Tucker R.
1980 "When Windmills Whirled on the Tar Heel Coast," in *The State*, June 1980, Vol. 48(1): 8-12.

Lonsdale, Adrian L., and H.R. Kaplan
1964 *A Guide to Sunken Ships in American Waters.* Compass Publications, Inc.: Arlington, VA.

MacNeill, Ben Dixon
1998[1958] Cap'n Ban and the Infernal Engine, in David Stick, editor, 1998, *An Outer Banks Reader,* pps.191-193. The University of North Carolina Press: Chapel Hill, NC.
2008[1958] *The Hatterasman.* The Publishing Laboratory: Wilmington, NC.

Mallinson, David J., Stephen J. Culver, Stanley R. Riggs, J.P. Walsh, Dorothea Ames, and Curtis W. Smith

2008 *Past, Present and Future Inlets of the Outer Banks Barrier Islands, North Carolina.* A White Paper projected by Member of the North Carolina Coastal Geology Cooperative Research Program, East Carolina University.

Mansfield, Bill

2001 *Song of an Unsung Place: Living Traditions by the Pamlico Sound*. Coastal Carolina Press: Wilmington, NC.

Marano, Joshua

2012 Ship Ashore! The Role of Risk in the Development of the United States Life-Saving Service and Its Effects on Wrecking Patterns Along the North Carolina Coast. Unpublished MA thesis, Program in Maritime Studies, East Carolina University: Greenville, NC.

Marcinko, Thomas J.

2000 Federal Operations at Hatteras Inlet, North Carolina, 1861. Unpublished MA thesis, Department of History, East Carolina University: Greenville, NC.

Merrens, Harry Roy

1964 *Colonial North Carolina in the Eighteenth Century: A Study in Historical Geography*. University of North Carolina Press: Chapel Hill, NC

Midgett, L.B, Sr.

1895 Form 1806, United States Life-Saving Service, Wreck Report: *Lou Willis*, January 23, 1895, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 3, Folder 23.

1895 Form 1806, United States Life-Saving Service, Wreck Report: *Rosa B. Cora*, August 12, 1895, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 1, Folder 4.

1896 Form 1806, United States Life-Saving Service, Wreck Report: *Anna Laura*, December 15, 1896, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 3, Folder 25.

1898 Form 1806, United States Life-Saving Service, Wreck Report: *Lula Tillett* January 31, 1898, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 4, Folder 41.

1899 Form 1806, United States Life-Saving Service, Wreck Report: *No Name Shad Boat* March 26, 1899, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 4, Folder 41.

1902 Form 1806, United States Life-Saving Service, Wreck Report: *Two Sisters*, December 9, 1902, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 2, Folder 63.

1903 Form 1806, United States Life-Saving Service, Wreck Report: *Lonia Buren*, September 15, 1903, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 4, Folder 41.
1907 Form 1806, United States Life-Saving Service, Wreck Report: *Mable* [sic] *E. Horton*, May 25, 1907, Chicamacomico Station. Outer Banks History Center, Box 4, Folder 45.
1910 Form 1806, United States Life-Saving Service, Wreck Report: *R.C. Beaman*, January 4, 1910, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 6, Folder 58.
1914 Form 1806, United States Life-Saving Service, Wreck Report: *Two Sisters*, April 19, 1914, Chicamacomico Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 8, Folder 73.

Minelab, Pty. Ltd.
2015 CTX3030 Instruction Manual. Minelab, Australia.

Mobley, Joe A.
1994 *Ship Ashore! The U.S. Lifesavers of Coastal North Carolina*. North Carolina Department of Cultural Resources: Raleigh, NC.

Morrison, J.H.
1861 Statement of the Master of the *Fanny*. In *Official Records of the Union and Confederate Navies in the War of Rebellion Series 1 Volume 6*, C.C. Marsh, editor, pp. 276. Department of the Navy, Washington, D.C.

National Oceanic and Atmospheric Administration
2012 Nautical Charts Collection. Office of Coast Survey <http://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml>. Accessed 10 January 2015.
2012 Historical Map & Chart Collection. United States Office of Coast Survey <http://historicalcharts.noaa.gov/>. Accessed 10 January 2015.

North Carolina Underwater Archaeology Branch (NCUAB)
2015 File #2609 (Lydia Ann). Kure Beach, NC. Accessed 22 January 2015.
2015 File #2887 (R.C. Beaman). Kure Beach, NC. Accessed 22 January 2015.
2015 File #2899 (Mabel E. Horton). Kure Beach, NC. Accessed 22 January 2015.
2015 File #2911 (Lonie Buren). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3004 (Lula Tillett). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3040 (Unknown Boat). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3070 (Anna Laura). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3073 (Rosa B. Cora). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3117 (Lou Willis). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3166 (Extra). Kure Beach, NC. Accessed 22 January 2015.
2015 File #3208 (Haze). Kure Beach, NC. Accessed 22 January 2015.
2015 File #5089 (Captain's Boat). Kure Beach, NC. Accessed 22 January 2015.

Olds, Fred A.

1909a “A Trip Over the Route of the Proposed Inland Waterway, Part I,” in *Charlotte Observer*, 12 January 1909:10.
1909b “A Trip Over the Route of the Proposed Inland Waterway, Part II,” in *Charlotte Observer,* 17 January 1909:10.

Outer Banks Task Force (OBTF)
2001 Outer Banks Task Force Meeting Minutes, 22 May 2001, College of the Albemarle, Edenton, NC. Copy held at UNC-Coastal Studies Institute, 2016.

Oxford, Lee Thomas,
2013 *The Civil War on Hatteras: The Chicamacomico Affair and the Capture of the U.S. Gunboat Fanny*. The History Press: Charleston, SC.

Panamerican Consultants, Ltd.
2016 Underwater Archaeological Survey and Diver Assessment/Evaluation for Future Extension Concept/2014B Revised Bridge on New Location, Bonner Bridge Project, Dare County, North Carolina. Report prepared for North Carolina Department of Transportation.

Plummer, Henry
2003[1914] *The Boy, Me, and the Cat: Life Aboard the Small Boat from Massachusetts to Florida and Back in 1912*. The Narrative Press: Santa Barbara, CA.

Powell, William S.
1989 *North Carolina: Through Four Centuries.* University of North Carolina Press: Raleigh.

Powell, William S. (editor)
2006 *Encyclopedia of North Carolina*. University of North Carolina Press: Raleigh.

Powell, William S., and Michael Hill
2010 *The North Carolina Gazetteer*, 2nd Edition. The University of North Carolina Press: Raleigh, NC.

Rowan, Stephen C.
1861 Report of Commander Rowan, US Navy, Commanding USS Pawnee. In Official Records of the Union and Confederate Navies in the War of Rebellion Series 1 Volume 6, C.C. Marsh, editor, pp. 275-276. Department of the Navy, Washington, D.C.

Riggs, Stanley R. and Dorothea V. Ames
2003 *Drowning the North Carolina Coast: Sea Level Rise and Estuarine Dynamics*. North Carolina Sea Grant, Raleigh, NC.

Shanks, Ralph, and Wick York
2009 *The U.S. Life-Saving Service: Heroes, Rescues and Architecture of the Early Coast Guard.* Costano Books: Novato, CA.

Spears, John
1890 The Sand Wave, in David Stick, editor, *An Outer Banks Reader*, pps.52-55. The University of North Carolina Press: Chapel Hill, NC.

Simonds, Lucas
2014 A Determination Worthy of a Better Cause: Naval Action at the Battle of Roanoke Island 7 February 1862. Master's Thesis. Department of History, East Carolina University, Greenville, NC.

Simpson, Bland and Scott Taylor
2010 *The Coasts of Carolina: Seaside and Sound Country*. The University of North Carolina Press: Chapel Hill

Stick, David
1953 *Graveyard of the Atlantic: Shipwrecks of the North Carolina Coast.* The University of North Carolina Press: Chapel Hill, NC.
1958 *The Outer Banks of North Carolina.* The University of North Carolina Press: Chapel Hill, NC.
1970 *Dare County: A Brief History*. North Carolina Department of Cultural Resources: Raleigh, NC.
1987 *The Ash Wednesday Storm*. Gresham Publications: Kill Devil Hills, NC.

Stick, David (editor)
1998 *An Outer Banks Reader*. The University of North Carolina Press: Chapel Hill, NC.

Stick, David and Kathy Carter
2006 *Mirlo* Rescue. in pps. 752, *Encyclopedia of North Carolina,* William S. Powell (editor). University of North Carolina Press: Raleigh.

The Daily Economist
1906a Kitty Hawk News. *The Daily Economist* 15 March:2. Elizabeth City, NC.

1906b Personals. *The Daily Economist* 8 August:3. Elizabeth City, NC.

Tillet, Avery B.L.
1906 Form 1806, United States Life-Saving Service, Wreck Report: *Lou Willis,* March 20, 1906, Kitty Hawk Station. U.S. Life-Saving Service Reports, 1823-1929 Collection (33 MSS-8), Outer Banks History Center, Box 4, Folder 41.

Trotter, William R.
1989 *Ironclads and Columbiads: The Civil War in North Carolina (The Coast).* John F. Blair: Winston-Salem, NC.

U.S. Army Corps of Engineers (USACE)
1945 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1944 to 30 June 1945*. U.S. Army Corps of Engineers, Washington, DC.

1946 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1945 to 30 June 1946*. U.S. Army Corps of Engineers, Washington, DC.
1947 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1946 to 30 June 1947*. U.S. Army Corps of Engineers, , NY., Washington, DC.
1948 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1947 to 30 June 1948*. U.S. Army Corps of Engineers, , Washington, DC.
1949 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1948 to 30 June 1949*. U.S. Army Corps of Engineers, , Washington, DC.
1950 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1949 to 30 June 1950*. U.S. Army Corps of Engineers, Washington, DC.
1964 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1963 to 30 June 1964*. U.S. Army Corps of Engineers, Washington, DC.
1965 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1964 to 30 June 1965*. U.S. Army Corps of Engineers, Washington, DC.
1975 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1974 to 30 June 1975*. U.S. Army Corps of Engineers, Washington, DC.
1996 Environmental Assessment for Maintenance Dredging of Rodanthe, Avon, and Rollinson Channels, Dare County, North Carolina (December 1996). Unpublished Report, US Army Corps of Engineers, Wilmington District, Wilmington, NC.
1997 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1996 to 30 June 1997*. U.S. Army Corps of Engineers, Washington, DC.
1998 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 1997 to 30 June 1998*. U.S. Army Corps of Engineers, Washington, DC.
2010 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 2009 to 30 June 2010*. U.S. Army Corps of Engineers, Washington, DC.
2011 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 2010 to 30 June 2011*. U.S. Army Corps of Engineers, Washington, DC.
2012 *Annual Report of the Secretary of the Army on Civil Works Activities, For Fiscal Year 1 July 2011 to 30 June 2012*. U.S. Army Corps of Engineers, Washington, DC.

U.S. Congress
1938 List of all outstanding investigations called for by the River and Harbor Acts, Flood Control Acts, and requested by resolutions of committees of Congress. Report of the Chief of Engineers, US Army, pp. 1957-1988. 76th Congress, 1st Session, House Document 6 part 1, volume 2 (Serial Set 10363). Washington, DC.

U.S. Bureau of Marine Inspection and Navigation (USBMIN)
1886 *Eighteenth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1895 *Twenty-seventh Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1895 *Twenty-eighth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1897 *Twenty-ninth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1898 *Thirtieth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1899 *Thirty-first Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1900 *Thirty-second Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1901 *Thirty-third Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation Washington, DC.
1902 *Thirty-Fourth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1903 *Thirty-fifth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1904 *Thirty-sixth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1905 *Thirty-seventh Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1906 *Thirty-eighth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1907 *Thirty-ninth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1908 *Fortieth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1909 *Forty-first Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1910 *Forty-second Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1911 *Forty-third Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1912 *Forty-fourth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1913 *Forty-fifth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1914 *Forty-sixth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1915 *Forty-seventh Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1916 *Forty-eighth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1917 *Forty-ninth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1918 *Fiftieth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1919 *Fifty-first Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1920 *Fifty-first Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1921 *Fifty-second Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1922 *Fifty-third Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1923 *Fifty-fifth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1924 *Fifty-sixth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1925 *Fifty-seventh Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1926 *Fifty-eighth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1927 *Fifty-ninth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1928 *Sixtieth Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1929 *Sixty-first Annual List of Merchant Vessels of the United States.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1930 *Merchant Vessels of the United States, Year ended June 30, 1930.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1931 *Merchant Vessels of the United States, Year ended June 30, 1931.* U.S. Bureau of Marine Inspection and Navigation , Washington, DC.

1932 *Merchant Vessels of the United States, Year ended June 30, 1932.* U.S. Bureau of Marine Inspection and Navigation Washington, DC.

1933 *Merchant Vessels of the United States, Year ended June 30, 1933.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1934 *Merchant Vessels of the United States, Year ended June 30, 1934.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1935 *Merchant Vessels of the United States, Year ended June 30, 1935.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1936 *Merchant Vessels of the United States, Year ended June 30, 1936.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1937 *Merchant Vessels of the United States, Year ended June 30, 1937.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1938 *Merchant Vessels of the United States, Year ended June 30, 1938.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1939 *Merchant Vessels of the United States, Year ended June 30, 1939.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1941 *Merchant Vessels of the United States, Year ended June 30, 1941.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1942 *Merchant Vessels of the United States, Year ended June 30, 1942.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1943 *Merchant Vessels of the United States, Year ended June 30, 1943.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1944 *Merchant Vessels of the United States, Year ended June 30, 1944.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1945 *Merchant Vessels of the United States, Year ended June 30, 1945.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1946 *Merchant Vessels of the United States, Year ended June 30, 1946.* U.S. Bureau of Marine Inspection and Navigation Washington, DC.
1947 *Merchant Vessels of the United States, Year ended June 30, 1947.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1948 *Merchant Vessels of the United States, Year ended June 30, 1948.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1949 *Merchant Vessels of the United States, Year ended June 30, 1949.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1950 *Merchant Vessels of the United States, Year ended June 30, 1950.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1951 *Merchant Vessels of the United States, Year ended June 30, 1951.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1952 *Merchant Vessels of the United States, Year ended June 30, 1952.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1955 *Merchant Vessels of the United States, Year ended June 30, 1955.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1956 *Merchant Vessels of the United States, Year ended June 30, 1956.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1957 *Merchant Vessels of the United States, Year ended June 30, 1957.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1958 *Merchant Vessels of the United States, Year ended June 30, 1958.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1959 *Merchant Vessels of the United States, Year ended June 30, 1959.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1960 *Merchant Vessels of the United States, Year ended June 30, 1960.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1961 *Merchant Vessels of the United States, Year ended June 30, 1961.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1962 *Merchant Vessels of the United States, Year ended June 30, 1962.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1963 *Merchant Vessels of the United States, Year ended June 30, 1963.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1964 *Merchant Vessels of the United States, Year ended June 30, 1964.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1965 *Merchant Vessels of the United States, Year ended June 30, 1965.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1968 *Merchant Vessels of the United States, Year ended June 30, 1968.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1969 *Merchant Vessels of the United States, Year ended June 30, 1969.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1970 *Merchant Vessels of the United States, Year ended June 30, 1970.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1971 *Merchant Vessels of the United States, Year ended June 30, 1971.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

1972 *Merchant Vessels of the United States, Year ended June 30, 1972.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1973 *Merchant Vessels of the United States, Year ended June 30, 1973.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1974 *Merchant Vessels of the United States, Year ended June 30, 1974.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1975 *Merchant Vessels of the United States, Year ended June 30, 1975.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1976 *Merchant Vessels of the United States, Year ended June 30, 1976.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1977 *Merchant Vessels of the United States, Year ended June 30, 1977.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1978 *Merchant Vessels of the United States, Year ended June 30, 1978.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1979 *Merchant Vessels of the United States, Year ended June 30, 1979.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.
1981 *Merchant Vessels of the United States, Year ended June 30, 1981.* U.S. Bureau of Marine Inspection and Navigation, Washington, DC.

U.S. Department of Commerce (USDC)
1918 *Annual Report of the Commissioner of Lighthouses to the Secretary of Commerce for the Fiscal Year Ended June 30, 1917.* U.S. Department of Commerce , Washington, DC.
1918 *Reports of the Department of Commerce, 1917.* U.S. Department of Commerce , Washington, DC.

U.S. Treasury Department (USTD)
1887 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1886.* U.S. Treasury Department, Washington, DC.
1896 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1895.* U.S. Treasury Department, Washington, DC.
1897 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1896.* U.S. Treasury Department Washington, DC.
1898 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1897.* U.S. Treasury Department, Washington, DC.
1899 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1898.* U.S. Treasury Department, Washington, DC.
1900 *Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year Ending June 30, 1900.* U.S. Treasury Department, Washington, DC.
1905 *Annual Report of United States Life-Saving Service for the Fiscal Year Ending June 30, 1904.* U.S. Treasury Department, Washington, DC.
1908 *Annual Report of United States Life-Saving Service for the Fiscal Year Ending June 30, 1907.* U.S. Treasury Department, Washington, DC.
1911 *Annual Report of United States Life-Saving Service for the Fiscal Year Ending June 30, 1910.* U.S. Treasury Department, Washington, DC.

Ward, Alvah H., and R. Wayne Gray

2013 *When Ice Came to the Outer Banks: A Local History of Ice and its Impact on The Development of the Coastal Region*. 8 dot graphics: Raleigh, NC.

Wechter, Nell Wise
1974 *The Mighty Midgetts of Chicamacomico.* Times Printing Company, Inc.: Manteo, NC.
1975 *Some Whisper of Our Name …* Times Printing Company, Inc.: Manteo, NC.

Westcott, J.H.
1895 Form 1806, United States Life-Saving Service, Wreck Report: *Haze*, May 16, 1895, New Inlet Station. Outer Banks History Center, Box 1, Folder 3.

Whisnant, David E., and Anne Mitchell Whisnant
2015 *Gateway to the Atlantic World: Cape Lookout National Seashore Historic Resource Study*. Report prepared for Organization of American Historians under cooperative agreement with Southeast Region, National Park Service, U.S. Department of Interior. Atlanta, GA.

White, Nancy, Mike Piehler, Nathan Richards, Reide Corbett, J.P. Walsh, and John McCord
2014 Grant Proposal, Design and Siting of Deposition Locations for Dredged Material from the Rodanthe Emergency Ferry Channel. Proposal submitted to NC Department of Transportation, 22 May 2014.

Williams II, Charles T.
2016[1975] *The Kinnakeeter*, 2nd edition. Chapel Hill Press, North Carolina.

Wise, Harold,
2014 *History of Stumpy Point: Village in the Wilderness.* Stumpy Point Civic Club: Stumpy Point, NC.

Wright, Wilbur
1902 Letter from Wilbur Wright to his Father. In *Miracle at Kitty Hawk: The Letters of Wilbur and Orville Wright*, Fred C. Kelley, editor, pp. 70-71. De Capo Press, New York, NY.

Wright, David and David Zoby
2000 *Fire on the Beach: Recovering the Lost Story of Richard Etheridge and the Pea Island Lifesavers*. Oxford University Press: New York, NY.

Zatarga, Michael P.
2015 *The Battle of Roanoke Island: Burnside and the Fight for North Carolina*. The History Press: Charleston, SC.

APPENDIX 1: AVAILABLE MAPS AND CHARTS AVAILABLE FOR DOWNLOAD FROM THE NOAA HISTORICAL CHARTS WEBSITE

#	Map Title	NOAA Database Number	Year	Scale	Publisher
1	Eastern Coast of North Carolina, North Carolina	T00367-00-1852	1852	1/20000	U.S. Coast Survey
2	Oregon Inlet to Cape Hatteras	OICH	1880	1/80000	US Coast and Geodetic Survey
3	MANTEO	NI18-2	1980	1/250000	NOAA
4	Sketch of the Coast of North Carolina from Oregon Inlet to Ocracoke Inlet	NC_Ocracoke-00-1861	1861	1/200000	U.S. Coast Survey
5	Navigation Chart of the Coast from Cape Henry to Cape Lookout	CP1839C	NA	1/400000	U.S. Coast Survey
6	Sketch Showing the Arrangement of General Coast Charts and Preliminary Charts in Progress of Publication	AR64-00-1857	1857	1/15000000	U.S. Coast Survey
7	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1857	AR25-00-1857	1857	1/400000	U.S. Coast Survey
8	Wimble Shoals, Coast of North Carolina	AR22-00-1854	1854	1/80000	U.S. Coast Survey
9	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1862	AR21-00-1862	1862	1/400000	U.S. Coast Survey
10	Wimble Shoals, Coast of North Carolina	AR18-00-1869	1870	1/80000	U.S. Coast Survey
11	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1859	AR15-00-1859	1859	1/400000	U.S. Coast Survey
12	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1868	AR14-00-1868	1868	1/400000	U.S. Coast Survey
13	General Chart of the Coast #5 from Cape Henry to Cape Lookout	AR14-00-1866	1867	1/400000	U.S. Coast Survey
14	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1855	AR14-00-1855	1855	1/400000	U.S. Coast Survey
15	Sketch D Showing the Progress of the Survey in Section Number 4 from 1850 to 1866	AR13-00-1866	1866	1/400000	U.S. Coast Survey
16	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1856	AR13-00-1856	1856	1/400000	U.S. Coast Survey
17	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1861	AR11-00-1861	1861	1/400000	U.S. Coast Survey
18	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1860	AR10-00-1860	1860	1/400000	U.S. Coast Survey
19	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1858	AR10-00-1858	1858	1/400000	U.S. Coast Survey
20	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1881	AR09-06-1881	1881	1/400000	US Coast and Geodetic Survey
21	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1881	AR09-06-1880	1881	1/400000	US Coast and Geodetic Survey

22	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1879	AR09-00-1879	1879	1/400000	US Coast and Geodetic Survey
23	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1867	AR08-00-1867	1867	1/400000	US Coast Survey
24	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1879	AR07-00-1878	1879	1/400000	US Coast and Geodetic Survey
25	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1877	AR07-00-1877	1877	1/400000	U.S. Coast Survey
26	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1875	AR07-00-1875	1875	1/400000	U.S. Coast Survey
27	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1873	AR07-00-1873	1873	1/400000	U.S. Coast Survey
28	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1878	AR07-00-1872	1873	1/400000	U.S. Coast Survey
29	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1868	AR07-00-1869	1869	1/400000	U.S. Coast Survey
30	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1871	AR06-00-1871	1871	1/400000	U.S. Coast Survey
31	Sketch D Showing the Progress of the Survey in Section Number 4 from 1845 to 1870	AR06-00-1870	1870	1/400000	U.S. Coast Survey
32	Sketch Showing the Progress of the Survey in Section #4	AR05-06-1884	1884	1/400000	US Coast and Geodetic Survey
33	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1883	AR05-06-1883	1883	1/400000	US Coast and Geodetic Survey
34	Sketch Showing the Progress of the Survey in Section #4 from 1845 to 1882	AR05-06-1882	1882	1/400000	US Coast and Geodetic Survey
35	Currituck Beach Light to Wimble Shoals	12204-12-2012	2012	1/80000	NOAA-NOS
36	CURRITUCK BEACH LIGHT TO WIMBLE SHOALS	12204-12-1978	1978	1/80000	NOAA-NOS
37	Currituck Beach Light to Wimble Shoals	12204-11-2004	2004	1/80000	NOAA
38	CURRITUCK BEACH LIGHT TO WIMBLE SHOALS	12204-10-1991	1991	1/80000	NOAA-NOS
39	Currituck Beach Light to Wimble Shoals	12202-10-1988	1988	1/80000	NOAA-NOS
40	Currituck Beach Light to Wimble Shoals	12204-09-2007	2007	1/80000	NOAA
41	Currituck Beach Light to Wimble Shoals	12204-6-1996	1996	1/80000	NOAA-NOS
42	Currituck Beach Light to Wimble Shoals	12204-6-1990	1990	1/80000	NOAA-NOS
43	Currituck Beach Light to Wimble Shoals	12204-04-2001	2001	1/80000	NOAA
44	Currituck Beach Light to Wimble Shoals	12204-4-1994	1994	1/80000	NOAA-NOS
45	Currituck Beach Light to Wimble Shoals	12204-3-1976	1976	1/80000	NOAA-NOS
46	Currituck Beach Light to Wimble Shoals	12204-3-1975	1975	1/80000	NOAA-NOS
47	Currituck Beach Light to Wimble Shoals	12204-2-1982	1982	1/80000	NOAA-NOS
48	Currituck Beach Light to Wimble Shoals	12204-2-1980	1980	1/80000	NOAA-NOS
49	Currituck Beach Light to Wimble Shoals	12204-2-1978	1978	1/80000	NOAA-NOS
50	Currituck Beach Light to Wimble Shoals	12204-2-1977	1977	1/80000	NOAA-NOS
51	Currituck Beach Light to Wimble Shoals	12204-01-2003	2003	1/80000	NOAA
52	Cape Hatteras	11555-12-1980	1980	1/80000	NOAA-NOS
53	Cape Hatteras	11555-11-1992	1992	1/80000	NOAA-NOS
54	Cape Hatteras	11555-11-1982	1982	1/80000	NOAA-NOS

55	Cape Hatteras	11555-11-1979	1979	1/80000	NOAA-NOS
56	Cape Hatteras	11555-11-1978	1978	1/80000	NOAA-NOS
57	Cape Hatteras	11555-11-1977	1977	1/80000	NOAA-NOS
58	Cape Hatteras	11555-9-1991	1991	1/80000	NOAA-NOS
59	Cape Hatteras	11555-9-1975	1975	1/80000	NOAA-NOS
60	Cape Hatteras-Wimble Shoals to Ocracoke Inlet	11555-08-2001	2001	1/80000	NOAA
61	Cape Hatteras	11555-8-1974	1974	1/80000	NOAA-NOS
62	Cape Hatteras-Wimble Shoals to Ocracoke Inlet	11555-06-2002	2002	1/80000	NOAA
63	Cape Hatteras	11555-5-1990	1990	1/80000	NOAA-NOS
64	Cape Hatteras-Wimble Shoals to Ocracoke Inlet	11555-04-2006	2006	1/80000	NOAA
65	Cape Hatteras-Wimble Shoals to Ocracoke Inlet	11555-03-2012	2012	1/80000	NOAA-NOS
66	Cape Hatteras	11555-3-1994	1994	1/80000	NOAA-NOS
67	Cape Hatteras-Wimble Shoals to Ocracoke Inlet	11555-02-2004	2004	1/80000	NOAA
68	Cape Hatteras	11555-1-1997	1997	1/80000	NOAA-NOS
69	Cape Hatteras	11555-1-1984	1984	1/80000	NOAA-NOS
70	Cape Hatteras	11555-1-1982	1982	1/80000	NOAA-NOS
71	Cape Hatteras	11555-1-1977	1977	1/80000	NOAA-NOS
72	Cape Hatteras	1232-12-1973	1973	1/80000	NOAA-NOS
73	Cape Hatteras	1232-12-1933	1933	1/80000	US Coast and Geodetic Survey
74	Cape Hatteras	1232-11-1971	1971	1/80000	NOAA-NOS
75	Cape Hatteras	1232-11-1970	1970	1/80000	NOAA-NOS
76	Cape Hatteras	1232-8-1966	1966	1/80000	US Coast and Geodetic Survey
77	Cape Hatteras	1232-6-1967	1967	1/80000	US Coast and Geodetic Survey
78	Cape Hatteras	1232-6-1955	1955	1/80000	US Coast and Geodetic Survey
79	Cape Hatteras	1232-5-1968	1968	1/80000	US Coast and Geodetic Survey
80	Cape Hatteras	1232-3-1969	1969	1/80000	US Coast and Geodetic Survey
81	Cape Hatteras	1232-2-1964	1964	1/80000	US Coast and Geodetic Survey
82	Cape Hatteras	1232-1-1973	1973	1/80000	NOAA-NOS
83	Cape Hatteras	1232-1-1970	1970	1/80000	NOAA-NOS
84	Currituck Beach to Wimble Shoals	1229-12-1970	1970	1/80000	NOAA-NOS
85	Currituck Beach to Wimble Shoals	1229-12-1969	1969	1/80000	US Coast and Geodetic Survey
86	Currituck Beach to Wimble Shoals	1229-12-1942	1942	1/80000	US Coast and Geodetic Survey
87	Currituck Beach to Wimble Shoals	1229-11-1967	1967	1/80000	US Coast and Geodetic Survey
88	Currituck Beach to Wimble Shoals	1229-11-1966	1966	1/80000	US Coast and Geodetic Survey
89	Currituck Beach to Wimble Shoals	1229-8-1961	1961	1/80000	US Coast and Geodetic Survey
90	Currituck Beach to Wimble Shoals	1229-8-1936	1936	1/80000	US Coast and Geodetic Survey
91	Currituck Beach to Wimble Shoals	1229-7-1933	1933	1/80000	US Coast and Geodetic Survey
92	Currituck Beach to New Inlet	1229-6-1913	1913	1/80000	US Coast and Geodetic

					Survey
93	Currituck Beach to Wimble Shoals	1229-4-1932	1932	1/80000	US Coast and Geodetic Survey
94	Currituck Beach to Wimble Shoals	1229-3-1974	1974	1/80000	NOAA-NOS
95	Currituck Beach to Wimble Shoals	1229-2-1973	1973	1/80000	NOAA-NOS
96	Currituck Beach to Wimble Shoals	1229-1-1972	1972	1/80000	NOAA-NOS
97	Currituck Beach to Wimble Shoals	1229-1-1969	1969	1/80000	US Coast and Geodetic Survey
98	Pamlico Sound, NC, Eastern Sheet	LC00142_09_1899	1899	1/80000	US Coast and Geodetic Survey
99	Pamlico Sound, NC, Eastern Sheet	LC00142_08_1911	1911	1/80000	US Coast and Geodetic Survey
100	Pamlico Sound, NC, Eastern Sheet	LC00142_06_1883	1883	1/80000	US Coast and Geodetic Survey
101	Pamlico Sound, NC	LC00142_03_1888	1888	1/80000	US Coast and Geodetic Survey
102	Pamlico Sound East	142-00-1883	1883	1/80000	US Coast and Geodetic Survey
103	From Oregon Inlet to Cape Hatteras, NC	LC00139_10_1913	1913	1/80000	US Coast and Geodetic Survey
104	From Oregon Inlet to Cape Hatteras, NC	LC00139_05_1894	1894	1/80000	US Coast and Geodetic Survey
105	From Oregon Inlet to Cape Hatteras, NC	LC00139_03_1902	1902	1/80000	US Coast and Geodetic Survey
106	ATLANTIC COAST OF THE UNITED STATES SHEET TWO NANTUCKET TO CAPE HATTERAS	P-976-00-1863	1863	1/1200000	US Coast Survey
107	Civil War Atlantic Coast	cwvanc4	1865	1/633600	US Coast Survey
108	Coast of NC and VA- 1862	cwvanc1	1862	1/1200000	US Coast Survey
109	Nautical Chart of Cape May to Cape Hatteras	CP3619C	1913	1/415000	US Coast and Geodetic Survey
110	Navigation Chart for the Atlantic Coast from Chesapeake Bay to Jupiter Inlet	CP2538C	1898	1/1200000	US Coast and Geodetic Survey
111	Navigation Chart of the Chesapeake Bay to Jupiter inlet	CP2300C	1893	1/1200000	US Coast and Geodetic Survey
112	Cape May to Cape Hatteras	12200-12-1998	1998	1/419706	NOAA-NOS
113	Cape May to Cape Hatteras	12200-11-2000	2000	1/419706	NOAA-NOS
114	Cape May to Cape Hatteras	12200-11-1979	1979	1/416944	NOAA-NOS
115	Cape May to Cape Hatteras	12200-10-1986	1986	1/416944	NOAA-NOS
116	Cape May to Cape Hatteras	12200-10-1980	1980	1/416944	NOAA-NOS
117	Cape May to Cape Hatteras	12200-9-1994	1994	1/419706	NOAA-NOS
118	Cape May to Cape Hatteras	12200-08-2002	2002	1/419706	NOAA
119	Cape May to Cape Hatteras	12200-8-1997	1997	1/419706	NOAA-NOS
120	Cape May to Cape Hatteras	12200-8-1996	1996	1/419706	NOAA-NOS
121	Cape May to Cape Hatteras	12200-07-2011	2011	1/419706	NOAA
122	Cape May to Cape Hatteras	12200-06-2014	2014	1/419706	NOAA-NOS
123	Cape May to Cape Hatteras	12200-06-2007	2007	1/419706	NOAA
124	Cape May to Cape Hatteras	12200-06-2004	2004	1/419706	NOAA
125	Cape May to Cape Hatteras	12200-5-1993	1993	1/416944	NOAA-NOS
126	Cape May to Cape Hatteras	12200-5-1992	1992	1/416944	NOAA-NOS
127	Cape May to Cape Hatteras	12200-4-1977	1977	1/416944	NOAA-NOS
128	Cape May to Cape Hatteras	12200-4-1976	1976	1/416944	NOAA-NOS
129	Cape May to Cape Hatteras	12200-4-1975	1975	1/416944	NOAA-NOS
130	Cape May to Cape Hatteras	12200-3-1978	1978	1/416944	NOAA-NOS

131	Cape May to Cape Hatteras	12200-2-1984	1984	1/416944	NOAA-NOS
132	Cape May to Cape Hatteras	12200-1-1991	1991	1/416944	NOAA-NOS
133	Cape May to Cape Hatteras	12200-1-1990	1990	1/416944	NOAA-NOS
134	Cape May to Cape Hatteras	12200-1-1983	1983	1/416944	NOAA-NOS
135	Cape May to Cape Hatteras	12200-1-1982	1982	1/416944	NOAA-NOS
136	Cape May to Cape Hatteras	12200-1-1979	1979	1/416944	NOAA-NOS
137	Cape May to Cape Hatteras	1109-A-00-0000	1916	1/415000	NOAA-NOS
138	Cape May to Cape Hatteras	1109-12-1934	1934	1/415000	US Coast and Geodetic Survey
139	Cape May to Cape Hatteras	1109-11-1968	1968	1/415000	US Coast and Geodetic Survey
140	Cape May to Cape Hatteras	1109-11-1933	1933	1/415000	US Coast and Geodetic Survey
141	Cape May to Cape Hatteras	1109-10-1945	1945	1/415000	US Coast and Geodetic Survey
142	Cape May to Cape Hatteras	1109-09-1947	1947	1/415000	NOAA-NOS
143	Cape May to Cape Hatteras	1109-09-1942	1942	1/415000	US Coast and Geodetic Survey
144	Cape May to Cape Hatteras	1109-08-1967	1967	1/415000	US Coast and Geodetic Survey
145	Cape May to Cape Hatteras	1109-08-1966	1966	1/415000	US Coast and Geodetic Survey
146	Cape May to Cape Hatteras	1109-8-1936	1936	1/415000	US Coast and Geodetic Survey
147	Cape May to Cape Hatteras (Loran-A)	1109-6-1974	1974	1/415000	NOAA-NOS
148	Cape May to Cape Hatteras	1109-6-1969	1969	1/415000	US Coast and Geodetic Survey
149	Cape May to Cape Hatteras	1109-6-1944	1944	1/415000	US Coast and Geodetic Survey
150	Cape May to Cape Hatteras	1109-5-1937	1937	1/415000	US Coast and Geodetic Survey
151	Cape May to Cape Hatteras	1109-5-1922	1922	1/415000	US Coast and Geodetic Survey
152	Cape May to Cape Hatteras	1109-4-1973	1973	1/415000	NOAA-NOS
153	Cape May to Cape Hatteras	1109-4-1972	1972	1/415000	NOAA-NOS
154	Cape May to Cape Hatteras	1109-4-1970	1970	1/415000	NOAA-NOS
155	Cap May to Cape Hatteras	1109-3-1951	1951	1/415000	US Coast and Geodetic Survey
156	Cape May to Cape Hatteras	1109-3-1938	1938	1/415000	US Coast and Geodetic Survey
157	Cape May to Cape Hatteras	1109-3-1930	1930	1/415000	US Coast and Geodetic Survey
158	Cape May to Cape Hatteras	1109-2-1971	1971	1/415000	NOAA-NOS
159	Cape May to Cape Hatteras	1109-00-0000	1911	1/415000	NOAA-NOS
160	Map of the Albemarle and Chesapeake Canal Connecting Chesapeake Bay with Currituck Albemarle and Pamlico Sounds and their Tributary Streams	181ns-00-1855	1855	1/506880	A&C Canal Co.
161	ATLANTIC COAST FROM CAPE HENRY TO CAPE LOOKOUT, VIRGINIA AND NORTH CAROLINA	LC00010-11-1905	1905	1/400000	US Coast and Geodetic Survey
162	GENERAL CHART OF THE COAST NO. X. FROM CAPE HENRY TO CAPE LOOKOUT	LC00010_09_1887	1887	1/400000	US Coast and Geodetic Survey
163	GENERAL CHART OF THE COAST NO. X. FROM CAPE HENRY TO CAPE LOOKOUT	LC00010_04_1895	1895	1/400000	US Coast and Geodetic Survey

164	GENERAL CHART OF THE COAST NO. X. FROM CAPE HENRY TO CAPE LOOKOUT	LC00010_03_1888	1888	1/400000	US Coast and Geodetic Survey
165	GENERAL CHART OF THE COAST NO. X. FROM CAPE HENRY TO CAPE LOOKOUT	LC00010_02_1893	1893	1/400000	US Coast and Geodetic Survey
166	ATLANTIC COAST FROM CAPE HENRY TO CAPE LOOKOUT, VIRGINIA AND NORTH CAROLINA	LC00010_01_1911	1911	1/400000	US Coast and Geodetic Survey
167	MAGNETIC DECLINATION IN THE UNITED STATES EPOCH 1980	I-1283-A-00-1980	1980	1/5000000	US Geological Survey
168	GRID VARIATION 1945	GV2-7-1944	1944	1/5000000	US Coast and Geodetic Survey
169	Map Showing the Distribution of the Slave Population of the Southern States of the United States - 1860	CWSLAVE	1860	1/2842889	E. Hergesheimer
170	Historical Sketch of the Civil War and Index - 1863	CWPL01	1961	1/5940000	US Coast Survey
171	Historical Sketch of the Rebellion - 1860	cweast	NA	1/5830675	US Coast Survey
172	Index Map No. 2, from NY to NC	cp1938c	NA	1/1261138	US Coast and Geodetic Survey
173	Nautical Chart of Gay Head to Cape Lookout	CP1894C	1890	1/1215148	US Coast and Geodetic Survey
174	Condition of Field Operations	AR53-00-1917	1917	1/3493489	Automobile Club of Southern California
175	Isogonic Chart for 1885-0 Eastern Sheet	AR38-12-1882	1882	1/4946167	US Coast and Geodetic Survey
176	Condition of Field Operations	AR31-00-1916	1916	1/3497220	US Coast and Geodetic Survey
177	Lighthouse Districts and Principal Lights Depots and District Offices	14216-07-1918	1918	1/14183495	US Coast and Geodetic Survey
178	Lighthouse Districts and Principal Lights Depots and District Offices	14216-03-1912	1912	1/6984192	US Coast and Geodetic Survey
179	Lloyd's Map of the Southern States Showing all the Railroads Their Stations and Distances also the Counties Towns Villages Harbors Rivers and Forts	1319-00-1861	1861	1/2032476	J.T. Lloyd
180	Geologic Map of North America	14037-00-1911p4	1911	1/5000000	US Geological Survey

APPENDIX 2: TRANSCRIPTS OF WRECK REPORTS

Form 1806, United States Life-Saving Service, Wreck Report: Lydia Ann, March 20, 1896, Bodies Island Station. Outer Banks History Center, Box 1, Folder 4.

#	Item	Description
1	Name of vessel.	Lydia Ann
2	Rig and tonnage.	Sloop [illegible]
3	Hailing port and nationality.	Elizabeth City, NC
4	Age.	20 years
5	Official number.	Non [None]
6	Name of master.	John Coumbs
7	Name of owners.	John Coumbs
8	Where from.	Currituck, NC
9	Where bound.	Roanoke Island
10	Number of crew, including captain.	Two
11	Number of passengers.	Non [None]
12	Nature of cargo.	Non [None]
13	Estimated value of vessel.	100 dollars
14	Estimated value of cargo.	Non [None]
15	Exact spot where wrecked.	On Cow Island Flats
16	Direction and distance from station.	NW 3 ½ miles
17	Supposed cause of wreck (specifying particularly).	Painter parted
18	Nature of disaster, whether stranded, sunk, collision, etc.	Weather [?] came a shore [?] all night
19	Distance of vessel from shore at time of accident.	1/2 mile
20	Time of day or night.	Night
21	State of wind and weather.	SW wind gail [sic]
22	State of tide and sea.	high tide
23	Time of discovery of wreck.	11:00 AM
24	By whom discovered.	S.J. Midgett
25	Time of arrival of station-crew at wreck.	Did not gow [sic] untill [sic] requested by sloop captain
26	Time of return of station-crew from wreck.	Rendered assistance Jan 13
27	Were there any of the station-crew absent? If so, who?	Non [None]
28	Was life-boat used?	Non [None]
29	Number of trips with life-boat.	Non [None]
30	Number of persons brought ashore in life-boat.	Non [None]
31	Was surf-boat used?	No
32	Number of trips with surf-boat.	Non [None]
33	Number of persons brought ashore in surf-boat.	Non [None]
34	Was small boat used?	No
35	Number of trips with small boat.	No
36	Number of persons brought ashore with small boat.	Non [None]
37	Time of launching of boat	No boat used
38	Was mortar, Lyle gun, or rocket used (which, if either)?	Non [None]
39	Charge of shot-line used.	Non [None]
40	Size of shot-line used.	Non [None]
41	Distance of wreck from shore when shot was fired.	No shot used
42	Number of shots fired.	Non [None]
43	If any shots were unsuccessful, state cause	Non [None]

	of failure in each case.	
44	Was whip-line sent on board double or single?	Non [None]
45	If anything occurred to interfere with favorable operations, state fully nature and cause	Non [None]
46	Was heaving-stick used?	No
47	Was life-car used?	No
48	Number of trips of life-car.	Non [None]
49	Number of persons brought ashore in life-car.	Non [None]
50	Was breeches-buoy used?	No
51	Number of trips of breeches-buoy.	Non [None]
52	Number of persons brought ashore with breeches-buoy.	Non [None]
53	Was life-saving dress used, and how?	Non [None]
54	Number of lives saved, with names and residence.	John Coumbs master Hill Land, Currituck NC
55	Number of lives lost, with names and residence.	Non [None]
56	State fully the circumstances of the loss of each life.	Non lost
57	State damage, if any, to boat or apparatus.	Non used
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	Non [None]
60	Estimated value of cargo saved, and its condition.	Non [None]
61	Estimated value of cargo lost.	Non [None]
62	Amount of insurance on vessel.	Non [None]
63	Amount of insurance on cargo.	Non [None]
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Non [None]
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non [None]
66	Number of persons found after death and cared for.	Non [None]
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	Sloop went high on the shour [sic] Capt. Did not want any help as the tides fill so quick got out AM [illegible] home and came back with lumber to git [sic] his boat off and then ask for help which was granted for two days.

Form 1806, United States Life-Saving Service, Wreck Report: Lou Willis, January 23, 1895, Chicamacomico Station. Outer Banks History Center, Box 3, Folder 23.

#	Item	Description
1	Name of vessel.	Lou Willis

2	Rig and tonnage.	Schooner rig 14 51/100 tons
3	Hailing port and nationality.	Elizabeth City, NC, USA
4	Age.	Seventeen years
5	Official number.	140160
6	Name of master.	L.R. Oneal
7	Name of owners.	A.S. and A.W. Hoopers
8	Where from.	Stumpy Point, NC
9	Where bound.	Chicamacomico NC
10	Number of crew, including captain.	Two
11	Number of passengers.	Five
12	Nature of cargo.	None
13	Estimated value of vessel.	One thousand dollars
14	Estimated value of cargo.	none
15	Exact spot where wrecked.	3 1/2 miles S by W from station
16	Direction and distance from station.	3 1/2 miles S by W from station
16	Supposed cause of wreck (specifying particularly).	Anchors fouled and heavy sail
18	Nature of disaster, whether stranged, sunk, collision, etc.	Drug up on marsh
19	Distance of vessel from shore at time of accident.	about one mile
20	Time of day or night.	about 2 am
21	State of wind and weather.	W … cloudy
22	State of tide and sea.	Not much sea but very high tide
23	Time of discovery of wreck.	about sunrise
24	By whom discovered.	Keeper
25	Time of arrival of station-crew at wreck.	at 130 PM
26	Time of return of station-crew from wreck.	none
27	Were there any of the station-crew absent? If so, who?	no
28	Was life-boat used?	none
29	Number of trips with life-boat.	no
30	Number of persons brought ashore in life-boat.	none
31	Was surf-boat used?	no
32	Number of trips with surf-boat.	none
33	Number of persons brought ashore in surf-boat.	none
34	Was small boat used?	no
35	Number of trips with small boat.	none
36	Number of persons brought ashore with small boat.	none
37	Time of launching of boat	none used
38	Was mortar, Lyle gun, or rocket used (which, if either)?	no
39	Charge of shot-line used.	none
40	Size of shot-line used.	none
41	Distance of wreck from shore when shot was fired.	none
42	Number of shots fired.	none
43	If any shots were unsuccessful, state cause of failure in each case.	none
44	Was whip-line sent on board double or single?	none
45	If anything occurred to interfere with favorable operations, state fully nature and cause	nothing
46	Was heaving-stick used?	no
47	Was life-car used?	no

48	Number of trips of life-car.	none
49	Number of persons brought ashore in life-car.	none
50	Was breeches-buoy used?	no
51	Number of trips of breeches-buoy.	none
52	Number of persons brought ashore with breeches-buoy.	none
53	Was life-saving dress used, and how?	no
54	Number of lives saved, with names and residence.	All save them selves - L.R. Oneal Capt Rodanthe NC [...] Payne Stumpy pooint NC one lady and three children from E City NC one lady from Stumpy Point NC
55	Number of lives lost, with names and residence.	none
56	State fully the circumstances of the loss of each life.	none
57	State damage, if any, to boat or apparatus.	none
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	none
60	Estimated value of cargo saved, and its condition.	none
61	Estimated value of cargo lost.	none
62	Amount of insurance on vessel.	none
63	Amount of insurance on cargo.	none
64	Number of persons sheltered at station, how long, and total number of meals furnished.	none
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	none
66	Number of persons found after death and cared for.	none
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	About sunrise of this date the keeper discovered from … top the schooner Lou Willis ashore a few minutes later the lookout man saw a signal on the schooner. Keeper and crew started at onced and assisted by Capt Pugh and crew when we arrived at the wreck we found the tide had ... off and left her dry. Se we could not do any think untill [sic] the captain of sch got skids. After captain got skids and launching gear he set signal for my assistance so on January 23rd 1895 we succeed in launching her afloat where captain and owners took charge of her and returned many thanks unto us for our noble work. We was assisted all the way through by Captain ... Pugh and crew also some of Captain Wescotts crew one day. I would have said that the crew all landed them selves. Two or three day before she drug ashore. January 23, 1895, L.B. Midgett, Jr.

Form 1806, United States Life-Saving Service, Wreck Report: Haze, May 16, 1895, New Inlet Station. Outer Banks History Center, Box 1, Folder 3.

Item	**Description**
Name of vessel.	*Haze*
Rig and tonnage.	Schooner 10 tons
Hailing port and nationality.	E. City NC American
Age.	5 years
Official number.	96071
Name of master.	G. Heath
Name of owners.	J.B. Brocket
Where from.	E. City NC
Where bound.	New Inlet NC
Number of crew, including captain.	Two

Number of passengers.	Two
Nature of cargo.	None
Estimated value of vessel.	$600.00
Estimated value of cargo.	-
Exact spot where wrecked.	Jack Shoal Pamlico Sound
Direction and distance from station.	NW two miles
Supposed cause of wreck (specifying particularly).	miscalculation
Nature of disaster, whether stranged, sunk, collision, etc.	Stranded
Distance of vessel from shore at time of accident.	One mile
Time of day or night.	7 a.m.
State of wind and weather.	S.W. light clear
State of tide and sea.	High water
Time of discovery of wreck.	7 a.m.
By whom discovered.	A.S. Etheridge
Time of arrival of station-crew at wreck.	8 a.m.
Time of return of station-crew from wreck.	12 noon
Were there any of the station-crew absent? If so, who?	None
Was life-boat used?	-
Number of trips with life-boat.	-
Number of persons brought ashore in life-boat.	-
Was surf-boat used?	Fish boat. Yes
Number of trips with surf-boat.	Two
Number of persons brought ashore in surf-boat.	-
Was small boat used?	-
Number of trips with small boat.	-
Number of persons brought ashore with small boat.	-
Time of launching of boat	-
Was mortar, Lyle gun, or rocket used (which, if either)?	-
Charge of shot-line used.	-
Size of shot-line used.	-
Distance of wreck from shore when shot was fired.	-
Number of shots fired.	-
If any shots were unsuccessful, state cause of failure in each case.	-
Was whip-line sent on board double or single?	-
If anything occurred to interfere with favorable operations, state fully nature and cause	-
Was heaving-stick used?	-
Was life-car used?	-
Number of trips of life-car.	-
Number of persons brought ashore in life-car.	-
Was breeches-buoy used?	-
Number of trips of breeches-buoy.	-
Number of persons brought ashore with breeches-buoy.	-
Was life-saving dress used, and how?	-
Number of lives saved, with names and residence.	G. Heath E. City NC. R. Fearing Cook E. City J.S. Derby and E. Richards pasengers [sic] both from Sandy Hill, NY
Number of lives lost, with names and residence.	-
State fully the circumstances of the loss of each life.	-
State damage, if any, to boat or apparatus.	-
Was vessel saved or lost?	Saved
Amount of damage, if saved.	None
Estimated value of cargo saved, and its condition.	-
Estimated value of cargo lost.	-
Amount of insurance on vessel.	None

Amount of insurance on cargo.	-
Number of persons sheltered at station, how long, and total number of meals furnished.	None
Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	-
Number of persons found after death and cared for.	-
Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employe at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	At 7 a.m. of date given the look out many discovered a signal on the Sch yacht Haze which had stranded on Jack Shoal I took my crew and boarded her in a sail boat being the quickest way to reach her. When I got to her I was joined by the keeper and crew of the Pea Island Station I found the yacht high on shoal we run her anchors and wated [sic] until high water and then failed to float her we agreed to meet the next morning at High water which we did we placed her where they could easly [sic] get her off when the tide made. Date of Report: May 16, 1895. J.S. Wescott, keeper.

Form 1806, United States Life-Saving Service, Wreck Report: Rosa B. Cora, August 12, 1895, Chicamacomico Station. Outer Banks History Center, Box 1, Folder 4.

#	Item	Description
1	Name of vessel.	*Rosa B. Cora*
2	Rig and tonnage.	2 mast sch. 16 18/100 tons
3	Hailing port and nationality.	Edenton NC USA
4	Age.	Three years
5	Official number.	111006
6	Name of master.	William R. Balance
7	Name of owners.	Thomas P. Midgett
8	Where from.	Elizabeth City NC
9	Where bound.	Rodanthe NC
10	Number of crew, including captain.	Two
11	Number of passengers.	none
12	Nature of cargo.	ice flour corn and salt
13	Estimated value of vessel.	sixteen hundred dollars
14	Estimated value of cargo.	one hundred dollars
15	Exact spot where wrecked.	off stumpy point bay
16	Direction and distance from station.	NW by W about 10 miles
17	Supposed cause of wreck (specifying particularly).	Capsized in a squall
18	Nature of disaster, whether stranded, sunk, collision, etc.	Capsized
19	Distance of vessel from shore at time of accident.	five miles from Old Point
20	Time of day or night.	About 4 am
21	State of wind and weather.	About WSW squally
22	State of tide and sea.	heavy sea running in sound
23	Time of discovery of wreck.	capt reported to sta[tion] at 8 a.m.
24	By whom discovered.	by no one until capt reported
25	Time of arrival of station-crew at wreck.	about 11am
26	Time of return of station-crew from wreck.	at 630 pm
27	Were there any of the station-crew absent? If so, who?	E.S. Midgett on days privlege
28	Was life-boat used?	no
29	Number of trips with life-boat.	none
30	Number of persons brought ashore in life-boat.	none
31	Was surf-boat used?	no shadding boat in stead
32	Number of trips with surf-boat.	none

33	Number of persons brought ashore in surf-boat.	none
34	Was small boat used?	no
35	Number of trips with small boat.	none
36	Number of persons brought ashore with small boat.	none
37	Time of launching of boat	boat ready launched keepers sail boat
38	Was mortar, Lyle gun, or rocket used (which, if either)?	none
39	Charge of shot-line used.	none
40	Size of shot-line used.	none
41	Distance of wreck from shore when shot was fired.	none
42	Number of shots fired.	none
43	If any shots were unsuccessful, state cause of failure in each case.	none
44	Was whip-line sent on board double or single?	none
45	If anything occurred to interfere with favorable operations, state fully nature and cause	none
46	Was heaving-stick used?	none
47	Was life-car used?	none
48	Number of trips of life-car.	none
49	Number of persons brought ashore in life-car.	none
50	Was breeches-buoy used?	none
51	Number of trips of breeches-buoy.	none
52	Number of persons brought ashore with breeches-buoy.	none
53	Was life-saving dress used, and how?	none
54	Number of lives saved, with names and residence.	Two Capt W.R. Balance E City NC and seaman Dunbar Pierce[?] E City NC
55	Number of lives lost, with names and residence.	none
56	State fully the circumstances of the loss of each life.	none
57	State damage, if any, to boat or apparatus.	none
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	one hundred dollars
60	Estimated value of cargo saved, and its condition.	25 dollars condition bad
61	Estimated value of cargo lost.	75 dollars
62	Amount of insurance on vessel.	none
63	Amount of insurance on cargo.	none
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Two -- one night -- two meals
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	none
66	Number of persons found after death and cared for.	none
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons	About 8 a.m. this morning I was called on by Captain William R. Balance to take my crew and go off in the sound and help to get up the sch Rosa B Cora up which turned over about 4 am in a squall and I took four of my crew and went but we were unable to get her up as it was so rough in the sound. Further details of the wreck appears on the other days we worked. We brought the Capt and seaman ashore when we came in the evening and dried. There with clothes from the WNRA association they stayed all night

	who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	and next morning. Shipped them off and returned them again. Second day we were unable to get her up as the water was so deep and rough. So we returned back and in the next day we went off and hat it smooth and we soon got her righted up and bailed her water up and towed her ashore into harbor. When we received many thanks from owner for the assist and we were also assisted by Captain ... and crew and Capt. Richard Etheridge and crew. Each day that we worked Capt. W.R. Ballance and seaman was takened [sic] of the wreck by J.K. Meekins who they had towed from E City NC in a small shadding boat as it was out of sight of the life savers and was in the night. See on transcript of 7th 8th and 9th 1895. Date of report August 12th 1895 L.B. Midgett, Sr.

Transcription of 18 December, 1896 wreck report (Midgett 1896)

#	Item	Description
1	Name of vessel.	*Anna Laura*
2	Rig and tonnage.	*Spreet [Sprit] Sail Shadding Boat*
3	Hailing port and nationality.	*Roanoke Island, NC, USA*
4	Age.	*Four years*
5	Official number.	*None*
6	Name of master.	*William M. Beasley*
7	Name of owners.	*William St. Clara Pugh*
8	Where from.	*Rodanthe P.O., N.C.*
9	Where bound.	*Roanoke Island, N.C. with mail*
10	Number of crew, including captain.	*Two*
11	Number of passengers.	*none*
12	Nature of cargo.	*U.S. mail only*
13	Estimated value of vessel.	*one hundred dollars*
14	Estimated value of cargo.	*Unknown as it was mail*
15	Exact spot where wrecked.	*N.W. Point Loggerhead shoals*
16	Direction and distance from station.	*NW three miles*
16	Supposed cause of wreck (specifying particularly).	*Skudding [Shadding?] before heavy gail [sic] stretch a shoal and rolled over*
18	Nature of disaster, whether stranded, sunk, collision, etc.	*Capsized in a gale*
19	Distance of vessel from shore at time of accident.	*About a mile*
20	Time of day or night.	*6 p.m.*
21	State of wind and weather.	*N.N.W. heavy gale. Thick rain*
22	State of tide and sea.	*tide medium full on shore*
23	Time of discovery of wreck.	*About daylight*
24	By whom discovered.	*Keeper of Station from lookout*
25	Time of arrival of station-crew at wreck.	*About 12 noon*
26	Time of return of station-crew from wreck.	*About 4 p.m.*
27	Were there any of the station-crew absent? If so, who?	*N.W. Daily on day Priviledge [sic]*
28	Was life-boat used?	*no*
29	Number of trips with life-boat.	*none*
30	Number of persons brought ashore in life-boat.	*none*
31	Was surf-boat used?	*no*
32	Number of trips with surf-boat.	*none*
33	Number of persons brought ashore in surf-boat.	*none*
34	Was small boat used?	*no*
35	Number of trips with small boat.	*none*
36	Number of persons brought ashore with small boat.	*none*

37	Time of launching of boat	*none used*
38	Was mortar, Lyle gun, or rocket used (which, if either)?	*no*
39	Charge of shot-line used.	*no*
40	Size of shot-line used.	*none used*
41	Distance of wreck from shore when shot was fired.	*none shot fire [sic]*
42	Number of shots fired.	-
43	If any shots were unsuccessful, state cause of failure in each case.	-
44	Was whip-line sent on board double or single?	-
45	If anything occurred to interfere with favorable operations, state fully nature and cause	-
46	Was heaving-stick used?	-
47	Was life-car used?	-
48	Number of trips of life-car.	-
49	Number of persons brought ashore in life-car.	-
50	Was breeches-buoy used?	-
51	Number of trips of breeches-buoy.	-
52	Number of persons brought ashore with breeches-buoy.	-
53	Was life-saving dress used, and how?	-
54	Number of lives saved, with names and residence.	*W.M. Beasley, Roanoke Island, NC. W.W. Spencer, Hatteras, NC.*
55	Number of lives lost, with names and residence.	*none*
56	State fully the circumstances of the loss of each life.	*none*
57	State damage, if any, to boat or apparatus.	*none used*
58	Was vessel saved or lost?	*Saved*
59	Amount of damage, if saved.	*5,0 0 five dollars*
60	Estimated value of cargo saved, and its condition.	*- unknown mail was saved*
61	Estimated value of cargo lost.	*none*
62	Amount of insurance on vessel.	*none*
63	Amount of insurance on cargo.	*none as it was mail*
64	Number of persons sheltered at station, how long, and total number of meals furnished.	*Two, Two days*
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	*none*
66	Number of persons found after death and cared for.	*none*
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employee at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the	*About day light this morning I discovered two men from the lookout as I allways [sic] take a look. Soon wading ashore from a boat leaned [?] over. It proved to be a shadding boat with the mail. I took four of my men and went and got the boat up. The men we stripped of their wet clothes and furnished them with dry clothes from the W.N.R.A. (?) but until theirs got dry mules [sic] being at New Inlet to work we had to use our own team. We put the boat in a harbor and gathered all of their effects we could.* *The two men that were capsized on the 15th and came to the station the 16th left this morning with their mail for their homes. They were furnished with food and a place to sleep for two days and nights. We received many thanks from them for our kindness.*

	person from who the team was hired.	

Form 1806, United States Life-Saving Service, Wreck Report: Lula Tillett January 31, 1898, Chicamacomico Station. Outer Banks History Center, Box 4, Folder 41.

#	Item	Description
1	Name of vessel.	Lula Tillett
2	Rig and tonnage.	Spreet [Sprit] sail shad boat
3	Hailing port and nationality.	Manteo, NC USA
4	Age.	Eleven years.
5	Official number.	None.
6	Name of master.	R. F. Gaskins
7	Name of owners.	G.J. Wescott
8	Where from.	Manteo N.C.
9	Where bound.	Hatteras N.C.
10	Number of crew, including captain.	Two
11	Number of passengers.	None
12	Nature of cargo.	Sand ballast
13	Estimated value of vessel.	One hundred twenty five dollars
14	Estimated value of cargo.	None
15	Exact spot where wrecked.	West side Pugh Reef
16	Direction and distance from station.	N.W. by W. about four miles
16	Supposed cause of wreck (specifying particularly).	Capsized by whirl wind
18	Nature of disaster, whether stranged, sunk, collision, etc.	Capsized
19	Distance of vessel from shore at time of accident.	About 3 ½ miles
20	Time of day or night.	About 5.30 P.M.
21	State of wind and weather.	N.N.W. Fresh Clear
22	State of tide and sea.	Tide full. Sea rough.
23	Time of discovery of wreck.	About 10 a.m.
24	By whom discovered.	Surfman N.W. Daily after report by keeper New Inlet L.S.S.
25	Time of arrival of station-crew at wreck.	Met boat with men about 11.30 am Jan 30
26	Time of return of station-crew from wreck.	About 4.45 PM
27	Were there any of the station-crew absent? If so, who?	Keeper absent family sick for short time
28	Was life-boat used?	No
29	Number of trips with life-boat.	None
30	Number of persons brought ashore in life-boat.	None
31	Was surf-boat used?	No. Used J.T. Paynes [sic] Shad Boat.
32	Number of trips with surf-boat.	None. One with shad boat
33	Number of persons brought ashore in surf-boat.	None. met other boat in shad boat
34	Was small boat used?	No
35	Number of trips with small boat.	None
36	Number of persons brought ashore with small boat.	None
37	Time of launching of boat	Boarded shad boat at 10.10 am
38	Was mortar, Lyle gun, or rocket used (which, if either)?	None
39	Charge of shot-line used.	None
40	Size of shot-line used.	None
41	Distance of wreck from shore when shot was fired.	None
42	Number of shots fired.	None
43	If any shots were unsuccessful, state cause of failure in each case.	None

44	Was whip-line sent on board double or single?	None
45	If anything occurred to interfere with favorable operations, state fully nature and cause	None
46	Was heaving-stick used?	None
47	Was life-car used?	None
48	Number of trips of life-car.	None
49	Number of persons brought ashore in life-car.	None
50	Was breeches-buoy used?	None
51	Number of trips of breeches-buoy.	None
52	Number of persons brought ashore with breeches-buoy.	None
53	Was life-saving dress used, and how?	None
54	Number of lives saved, with names and residence.	Two. R.F. Gaskins. Master Hatteras. L.A. Midgett, Seaman, Hatteras N.C.
55	Number of lives lost, with names and residence.	None
56	State fully the circumstances of the loss of each life.	None
57	State damage, if any, to boat or apparatus.	None
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	None. Only lost 2 oars, 4 thwarts, 10 sand bags, 1 tiller.
60	Estimated value of cargo saved, and its condition.	No cargo
61	Estimated value of cargo lost.	None
62	Amount of insurance on vessel.	None
63	Amount of insurance on cargo.	None
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Two sheltered at surfman D.O. Midgett one night two meals
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	None
66	Number of persons found after death and cared for.	None
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	At about 10 a.m. Captain Wescott Called up station by telephone ask if that wasn't a boat capsized off back of reef in Sound. Surfman N. W. Daly who answered as the telephone went on top and spied could only see a very small lump about N.W. by N. about four miles from station I being about went home to see my family for short time who was sick. I left at 9 a.m. So surfman No. 1. Took too [sic] Surfmen with him and started as soon as the discovery was made. On his way to the object he met with men in shad boat who had started to Manteo N.C. and they had come acrost [sic] this capsized boat and took the men off. So he returned with them to shore and there took them in chard finding that they were very much weather beaten he took them to the Residence of Surfman D.O. Midgett. They were too bad off to cast over to the station in their condition after stripping them and putting on dry clothing leaving the two surfmen to rub and attend them hee [sic] made his way for the station for the medicine chest. Also telephoned to Gullshoal for keeper. I arrived there at 12 noon and found all had been done by Surfman No 1. could be done. He had given them brandy and hot water also put mustard plasters to the needed places put them to bed wrapped them in blankets put bottles of hot water to feet stomach and arm pits. On my arrival there I took charge of the men and sent Surfman No 1 with three other surfmen to wright [sic] the boat which they did and brought her into creek for harbor. There was missing from her 2 oars. 4

		short thwarts ten sand bags and tiller. boat apparently in good condition men still too bad off to bring over to station. So I and four of the surfmen returned to station at 4.45 P.M. leaving Surfman D.O. Midgett to attend to the two men. And I put G. H. Barret a good substitute in his plance until tomorrow morning – expended 3 mustard plasters, 1 bandage, and fill of brandy. Jan 31st surfman No. 1 visited the two shipwrecked men early this morning. They are in good condition. They proceeded to their homes with their boat at 10 a.m. Meals provided and furnished them at the residence of D.O. Midgett Surfmen. Date of Report: January 31st 1898 L.B. Midgett, Sr.

Form 1806, United States Life-Saving Service, Wreck Report: No Name Shad Boat, March 26, 1899, Chicamacomico Station. Outer Banks History Center, Box 1, Folder 9.

#	Item	Description
1	Name of vessel.	No name shad boat
2	Rig and tonnage.	Spreat [sic] sail
3	Hailing port and nationality.	Manteo NC
4	Age.	5 years oald [sic]
5	Official number.	Non
6	Name of master.	Engean Seaman
7	Name of owners.	Engean Seaman
8	Where from.	Chicamacomico neighborhood
9	Where bound.	Manteo NC
10	Number of crew, including captain.	Two 2
11	Number of passengers.	None
12	Nature of cargo.	None
13	Estimated value of vessel.	One hundred dollars
14	Estimated value of cargo.	Non
15	Exact spot where wrecked.	1 1/2 from station in Pamplico Sound
16	Direction and distance from station.	W one and a half miles
17	Supposed cause of wreck (specifying particularly).	Shipfting of wind to a gale
18	Nature of disaster, whether stranged, sunk, collision, etc.	Capsized
19	Distance of vessel from shore at time of accident.	One and a half miles
20	Time of day or night.	11:30AM
21	State of wind and weather.	NNE fresh gale clean
22	State of tide and sea.	tide turning and sea high
23	Time of discovery of wreck.	11:30 AM was watching him
24	By whom discovered.	B.W. O'Neal lookout man
25	Time of arrival of station-crew at wreck.	About 12 noon
26	Time of return of station-crew from wreck.	At one PM
27	Were there any of the station-crew absent? If so, who?	E.S. Midgett and D.O. Midgett
28	Was life-boat used?	No
29	Number of trips with life-boat.	Non
30	Number of persons brought ashore in life-boat.	Non
31	Was surf-boat used?	No used shad boat
32	Number of trips with surf-boat.	One trip in shad boat

33	Number of persons brought ashore in surf-boat.	2 two
34	Was small boat used?	Non
35	Number of trips with small boat.	Non
36	Number of persons brought ashore with small boat.	Non
37	Time of launching of boat	11.45AM
38	Was mortar, Lyle gun, or rocket used (which, if either)?	Non
39	Charge of shot-line used.	Non
40	Size of shot-line used.	Non
41	Distance of wreck from shore when shot was fired.	No shot fired
42	Number of shots fired.	Non
43	If any shots were unsuccessful, state cause of failure in each case.	Non fired
44	Was whip-line sent on board double or single?	Not used
45	If anything occurred to interfere with favorable operations, state fully nature and cause	Non
46	Was heaving-stick used?	No
47	Was life-car used?	No
48	Number of trips of life-car.	Non
49	Number of persons brought ashore in life-car.	Non
50	Was breeches-buoy used?	No
51	Number of trips of breeches-buoy.	Non
52	Number of persons brought ashore with breeches-buoy.	Non
53	Was life-saving dress used, and how?	No
54	Number of lives saved, with names and residence.	Capt. Engean Seaman, Manteo Dare County NC
55	Number of lives lost, with names and residence.	Non
56	State fully the circumstances of the loss of each life.	Non lost
57	State damage, if any, to boat or apparatus.	Non
58	Was vessel saved or lost?	Shad boat saved
59	Amount of damage, if saved.	None
60	Estimated value of cargo saved, and its condition.	None
61	Estimated value of cargo lost.	None
62	Amount of insurance on vessel.	None
63	Amount of insurance on cargo.	No cargo on board light
64	Number of persons sheltered at station, how long, and total number of meals furnished.	None
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	None

66	Number of persons found after death and cared for.	None
67	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employe at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	At 11:30 AM my lookout man B.W. O'Neal was looking at the boat when she capsized I was all so looking at him the lookout man to his table and I ran [?] on the lookout top [?] with the glasses when the lookout man holload [hollered?] out me and so he report to me calling my attention to the boat so we both was looking at the boat when she capsized and I immeditelay [sic] started to him assistance [?] going over to the sound those one and my men we got a shad boat of one of the neighbors [?] Mr. L.W. Meekings and went to the rescue and Capt. Pugh all so saw the baot capsize and he went all so assistance me 2 of my my [sic] men and one of his went off with him in another shad boat -- and also 3 of the citizens [?] was thair [sic] about the same time in another shad boat and they all so assisted [illegible] and my crew returned back to station at 1 PM the 2 men rescued went to their boarding house where they was staying after being safely landed [illegible] those and their boat being put in harbor. March 26, 1899. L.B. Midgett.

Form 1806, United States Life-Saving Service, Wreck Report: Two Sisters, December 9, 1902, Chicamacomico Station. Outer Banks History Center, Box 2, Folder 63.

#	Item	Description
1	Name of vessel.	Two Sisters
2	Rig and tonnage.	Schr two masts
3	Hailing port and nationality.	Rodantha [sic], NC
4	Age.	5 years [?]
5	Official number.	Non
6	Name of master.	L.B. Midgett Jr.
7	Name of owners.	John F. Payne
8	Where from.	Elizabeth City NC
9	Where bound.	Rodantha [sic], NC
10	Number of crew, including captain.	Two Sisters
11	Number of passengers.	Non
12	Nature of cargo.	merchandise
13	Estimated value of vessel.	Four hundred and seventy five $475
14	Estimated value of cargo.	one thousan [sic] $1000
15	Exact spot where wrecked.	2 3/4 miles south on Pamplico Sound
16	Direction and distance from station.	2 3/4 miles S by W
16	Supposed cause of wreck (specifying particularly).	parted his chain
18	Nature of disaster, whether stranged, sunk, collision, etc.	Stranded
19	Distance of vessel from shore at time of accident.	About 3 hundered [sic] yds
20	Time of day or night.	5 a.m.
21	State of wind and weather.	SW blowing a gail [sic]
22	State of tide and sea.	high tide rough sea
23	Time of discovery of wreck.	7:00 AM
24	By whom discovered.	B.W. Oneal Dec 5
25	Time of arrival of station-crew at wreck.	Dec 8 at 8 am
26	Time of return of station-crew from wreck.	Dec 8 at 4.30 pm
27	Were there any of the station-crew absent? If so, who?	B.W. Oneal on 24 hours
28	Was life-boat used?	Non
29	Number of trips with life-boat.	Non
30	Number of persons brought ashore in life-boat.	Non
31	Was surf-boat used?	Non
32	Number of trips with surf-boat.	Non

33	Number of persons brought ashore in surf-boat.	Non
34	Was small boat used?	Non
35	Number of trips with small boat.	Non
36	Number of persons brought ashore with small boat.	Non
37	Time of launching of boat	Non launched
38	Was mortar, Lyle gun, or rocket used (which, if either)?	Non
39	Charge of shot-line used.	Non
40	Size of shot-line used.	Non
41	Distance of wreck from shore when shot was fired.	Non
42	Number of shots fired.	Non
43	If any shots were unsuccessful, state cause of failure in each case.	Non
44	Was whip-line sent on board double or single?	Non
45	If anything occurred to interfere with favorable operations, state fully nature and cause	Non
46	Was heaving-stick used?	Non
47	Was life-car used?	Non
48	Number of trips of life-car.	Non
49	Number of persons brought ashore in life-car.	Non
50	Was breeches-buoy used?	Non
51	Number of trips of breeches-buoy.	Non
52	Number of persons brought ashore with breeches-buoy.	Non
53	Was life-saving dress used, and how?	Non
54	Number of lives saved, with names and residence.	Nobody on bord [sic] at time of […] Capt L.B. Midgett, Jr. and […] A. Midgett Jr at home Rodantha [sic], NC.
55	Number of lives lost, with names and residence.	Non
56	State fully the circumstances of the loss of each life.	Non
57	State damage, if any, to boat or apparatus.	Non
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	Non
60	Estimated value of cargo saved, and its condition.	$1000 dol. Saved condition good
61	Estimated value of cargo lost.	Non
62	Amount of insurance on vessel.	Non
63	Amount of insurance on cargo.	Non
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Non
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non
66	Number of persons found after death and cared for.	Non
67	Were any other persons than members of the life-saving crew employed by the keeper to assist? If so, who?	Non
68	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employe at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	On December 8 1902 I was cauld [sic] on by Capt L.B. Midgett Jr of schr Two Sisters and John F. Payne owner to … and launch his schooner whitch [sic] parted her chain and went a shore 2 3/4 miles sound of this station on Dec 5 on Pamplico Sound. I tuck [sic] my team hitched to old boat wagon and six of my men on Dec 8 the day cauld [sic] on by Capt L.B. Midgett Jr of schr Two Sisters I left one man at the station. ... ... B.W. Oneal place and cauld [sic] on Capt Pugh and crew of Gull Shoal Station and Capt Wesctott of New Inlet Station who sent me 4 men we all arrived at schr at 8 am and went to work to launch ... Succeded in launching her at 4 p.m. we launch his on skids about 65 yds it was all so assisted by some of the neighborhoods people who willingly hope me. I returned back to station at 430 p.m. with my team and men. Date of report: December 9, 1902. L. Bannister Midgett, Keeper.

Form 1806, United States Life-Saving Service, Wreck Report: Two Sisters, April 19, 1914, Chicamacomico Station. Outer Banks History Center, Box 8, Folder 73.

#	Item	Description
1	Rig and name of vessel.	*2 mst schr. Two Sisters*
2	Tonnage and official number.	No tonnage
3	Hailing port and nationality.	Avon NC
4	Age.	Not known
5	Name of master.	B.B. Pierce
6	Names of owners.	B.B. Pierce
7	Where from.	Elizabeth City NC
8	Where bound.	Avon NC
9	Number of crew, including captain.	2
10	Number of passengers.	2
11	Nature of cargo.	Merchandise
12	Estimated value of vessel.	250
13	Estimated value of cargo.	1000
14	Exact spot where wrecked.	Back of Pughs Reef Pamplico Sound
15	Direction and distance from station.	about 5 miles WNW of station
16	Supposed cause of wreck (specifying particularly).	carried away foremast
17	Nature of disaster, whether stranged, sunk, collision, etc.	carried away foremast
18	Distance of vessel from shore at time of accident.	about 5 miles
19	Time of day or night.	day about 1 PM
20	State of wind, weather, and temperature.	SW … cloudy
21	State of tide and sea.	Moderate
22	Time of discovery of wreck.	About 1 PM
23	By whom discovered.	J.T. Payne
24	Time of starting to scene of disaster.	About 1 PM
25	Time of arrival on scene of disaster.	145 PM
26	Time of return from scene of disaster.	330 PM
27	Amount of damage to vessel (if totally lost, so state).	About ten dollars
28	Estimated value of cargo saved, and its condition.	1000 condition good
29	Amount of insurance on vessel.	non
30	Amount of insurance on cargo.	None
31	Number of lives saved, with names and residence.	H. Capt. B.B. Pierce Avon NC. D.F. Meekins Avon NC Chancy Meekins Avon NC Selby Pierce Avon NC
32	Number of lives lost, with names and residence.	Non
33	Number of persons sheltered at station, how long, and total number of meals furnished.	2 spent the night meals 2
34	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non
35	Number and names of persons found after death and cared for.	Non
36	State what assistance, if any, was afforded the station crew by outside parties.	Non
37	Who, if any, of station crew did not participate in rescue or relief work?	2 men only went to rescue J.A. Meekins No. 2 and A.V. Midgett No. 3. Boat and apparatus used: suply [sic] boat spreat [sic] sail; Trips made by boat: 1; Persons landed or taken to place of safecy by boat: non; Trips made by breeches buoy: non; Persons landed in breeches buoy: non.
38	Time of launching boat.	1:00 PM
39	Was Lyle gun, Hunt gun, or rocket used (which, if either)?	No
40	Charge of powder used.	None
41	Size of shot line used.	None
42	Distance of wreck from shore when shot was fired.	No shot fired
43	Number of shots fired.	None
44	If any shots were unsuccessful, state cause of	None

	faiure in each case.	
45	Was whip line sent on board double or single?	Not sent
46	If anything occurred to interfere with operations, state fully nature and cause.	None
47	What heaving stick used?	No
48	State damage, if any, to boat or apparatus.	None
49	Remarks. Here should be set forth in detail the circumstances of the disaster and the measures taken to afford assistance or effect a rescue. Full information regarding each loss of life should in all cases be given. The names of all persons who volunteer, or are called upon, to assist the life-saving crew in the performance of wreck or relief work should be stated. If it is necessary to hire draft animals or vehicles to transport boats or apparatus to facilitate life-saving operations that fact should be noted, and the name of the person from whom team or vehicle is hired should be mentioned.	Station watch sighted schr flying signal about 11am I sent 2 of my men to the scene it was the Two Sisters from E. City NC bound to Avon NC. Looked with merchandise she had carried a way foremast and was anchored on the back of Pughs Reef in Pamplico Sound about 5 miles WNW from station they assisted the capt in rigging jib stay to mainmast and bought her into harbor left at 1 pm arrived at scene at 145 pm returned to station at 330 pm later on Mr Meekins and boy came a shore in skiff from schr and spend the night at station I phoned capt Styron of Durants Station to come and tow him to Avon NC in his power boat he said he would come tomorrow if the weather permitted. L. Bannister Midgett, Keeper. 27 April 1914

Form 1806, United States Life-Saving Service, Wreck Report: Lonia Buren, September 15, 1903, Chicamacomico Station. Outer Banks History Center, Box 4, Folder 41. (Midgett 1903)

#	Item	Description
1	Name of vessel.	Lonia [sic] Buren
2	Rig and tonnage.	2 mast schr 9 tons gross
3	Hailing port and nationality.	Elizabeth City, NC.
4	Age.	One years
5	Official number.	14820 [should be 141820]
6	Name of master.	Warren D. O'Neal
7	Name of owners.	*ion B. Scarborough
8	Where from.	Big Kinekeet [sic] N.C.
9	Where bound.	Chicamacomico N.C.
10	Number of crew, including captain.	Two 2
11	Number of passengers.	Non
12	Nature of cargo.	Fine wood
13	Estimated value of vessel.	1500 fifteen hundred dollars
14	Estimated value of cargo.	thirty two dollars
15	Exact spot where wrecked.	On the back of grate island
16	Direction and distance from station.	Sswest three miles
16	Supposed cause of wreck (specifying particularly).	Draged [sic] a shore [sic] in a gale of wind
18	Nature of disaster, whether stranged, sunk, collision, etc.	Stranded
19	Distance of vessel from shore at time of accident.	half mile from main land
20	Time of day or night.	6 p.m.
21	State of wind and weather.	Thick and rane [sic] heavy gails [sic]
22	State of tide and sea.	high tide heavy sea
23	Time of discovery of wreck.	11 am on the 16
24	By whom discovered.	Benjamin Oneal
25	Time of arrival of station-crew at wreck.	11.20 am
26	Time of return of station-crew from wreck.	2 pm
27	Were there any of the station-crew absent? If so, who?	No
28	Was life-boat used?	Non
29	Number of trips with life-boat.	Non
30	Number of persons brought ashore in life-boat.	Non
31	Was surf-boat used?	No Sound supply boat

32	Number of trips with surf-boat.	One with supply boat
33	Number of persons brought ashore in surf-boat.	Non
34	Was small boat used?	Non
35	Number of trips with small boat.	Non
36	Number of persons brought ashore with small boat.	Non
37	Time of launching of boat	I left landing in supply boat 11** am
38	Was mortar, Lyle gun, or rocket used (which, if either)?	None
39	Charge of shot-line used.	Non
40	Size of shot-line used.	Non
41	Distance of wreck from shore when shot was fired.	Non fired
42	Number of shots fired.	Non used
43	If any shots were unsuccessful, state cause of failure in each case.	Non
44	Was whip-line sent on board double or single?	Non used
45	If anything occurred to interfere with favorable operations, state fully nature and cause	No
46	Was heaving-stick used?	No
47	Was life-car used?	Non
48	Number of trips of life-car.	Non
49	Number of persons brought ashore in life-car.	Non
50	Was breeches-buoy used?	Non
51	Number of trips of breeches-buoy.	Non
52	Number of persons brought ashore with breeches-buoy.	Non
53	Was life-saving dress used, and how?	Non
54	Number of lives saved, with names and residence.	Captain Warren D. O'Neal Master Avon, NC, Wispions [?] G. O'Neal, Avon, NC
55	Number of lives lost, with names and residence.	Non
56	State fully the circumstances of the loss of each life.	Non
57	State damage, if any, to boat or apparatus.	Non
58	Was vessel saved or lost?	Lost
59	Amount of damage, if saved.	Non
60	Estimated value of cargo saved, and its condition.	32 dolers [sic] condition good
61	Estimated value of cargo lost.	Non
62	Amount of insurance on vessel.	Non
63	Amount of insurance on cargo.	Non
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Non
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non
66	Number of persons found after death and cared for.	Non
67	Were any other persons than members of the life-saving crew employed by the keeper to assist? If so, who?	Non
68	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if	This morning at 11am lookout man BW Oneal reported signal fling[?] on a Schr about 3 miles south of this station on Pamplico Sound with luck[?] 4 of my crew and suply [sic] boat and event at sea what the trouble was it proved to be the Schr Lonia [sic] Buren.

	the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	From Big Kinekeet [sic] N B for Rodanthe NC with wood the storm of last night drove her on the marsh about 20 yars and cauld [sic] keeper and crew from Gull Shoal Station to assist by we could do nothing untill [sic] the capt of Schr gets material to gather to launch her schr in no danger my self and crew returned back to station at 2 PM and will try to launch the Schr as soon as Capt gits [sic] material together On Sept. 28 and tuck [took?] 5 of my men and left the station at 7 am to go and launch Schr Lonia [sic] Buren. I cauld [called?] on Capt DM Pugh and his crew and Capt Wescott sent 5 of his crew we all arrived at the Schr at about 8 am and went to work we pride [pried] her up got skids under her and moved her about her ... 14 feet arrived bat to station at 4 PM on Sept 29 and tuck 5 of my men and wend down to the schr Lonia [sic] Buren was assisted by Capt Pugh and his crew of 4 men from New Inlet we got her off in the sound where she will float when the tide comes in we arrived at the Schr at 8 am and returned to the station at 4 PM we will float Schr when the tide rises on Sept 30 Tuck [sic] 5 of my men and went down to the Schr Lonia Buren but could do nothing til the tide comes in all so Capt Pugh and 5 of his men come and 3 from New Inlet byt I could do nothing we arrived at the Schr at 8am and returned back at station at 3pm. On October 1 and took 5 of my crew and cauld [sic] on Capt Pugh of Gull Shoal Station and went down to the Schr Lonia Buren we left the station at 8 am and arrives at the stranded Schr at 830 am and went to work diggin [sic] her out over a way Capt Pugh arrived with 5 of his crew we suceeded [sic] in launchin [sic] her at 6pm and arrived back to station at 7 PM 3 of my crow other 2 sent back to Station at 5 PM to take patrole [sic] it was a hard days work. Very respectfully L. Banister Midgett, Keeper.

Form 1806, United States Life-Saving Service, Wreck Report: Mabel E. Horton, March 10, 1906, Paul Gamiels Hill Station. Outer Banks History Center, Box 4, Folder 4.

#	Item	Description
1	Name of vessel.	*Lou Willis*
2	Rig and tonnage.	Schooner, 14 tons
3	Hailing port and nationality.	Elizabeth City NC US
4	Age.	30 years
5	Official number.	140160
6	Name of master.	J.E. Midgett
7	Name of owners.	F.N. Midgett
8	Where from.	Martin's Point NC
9	Where bound.	Kitty Hawk Bay, NC
10	Number of crew, including captain.	Two
11	Number of passengers.	None
12	Nature of cargo.	None
13	Estimated value of vessel.	$700
14	Estimated value of cargo.	None
15	Exact spot where wrecked.	On shole [sic] in Currituck Sound
16	Direction and distance from station.	SW about 2 miles
17	Supposed cause of wreck (specifying particularly).	Missed staye [?]
18	Nature of disaster, whether stranged, sunk, collision, etc.	Stranded
19	Distance of vessel from shore at time of accident.	300 yards
20	Time of day or night.	About 2 PM
21	State of wind and weather.	W fresh clear
22	State of tide and sea.	-
23	Time of discovery of wreck.	-

24	By whom discovered.	-
25	Time of arrival of station-crew at wreck.	9:00 AM
26	Time of return of station-crew from wreck.	2:00 PM
27	Were there any of the station-crew absent? If so, who?	Keeper and 5 surfmen went to wreck
28	Was life-boat used?	None
29	Number of trips with life-boat.	None
30	Number of persons brought ashore in life-boat.	None
31	Was surf-boat used?	No
32	Number of trips with surf-boat.	None
33	Number of persons brought ashore in surf-boat.	None
34	Was small boat used?	No
35	Number of trips with small boat.	None
36	Number of persons brought ashore with small boat.	None
37	Time of launching of boat	-
38	Was mortar, Lyle gun, or rocket used (which, if either)?	No
39	Charge of shot-line used.	None
40	Size of shot-line used.	None
41	Distance of wreck from shore when shot was fired.	-
42	Number of shots fired.	-
43	If any shots were unsuccessful, state cause of failure in each case.	-
44	Was whip-line sent on board double or single?	No
45	If anything occurred to interfere with favorable operations, state fully nature and cause	-
46	Was heaving-stick used?	No
47	Was life-car used?	No
48	Number of trips of life-car.	None
49	Number of persons brought ashore in life-car.	None
50	Was breeches-buoy used?	No
51	Number of trips of breeches-buoy.	None
52	Number of persons brought ashore with breeches-buoy.	None
53	Was life-saving dress used, and how?	No
54	Number of lives saved, with names and residence.	None
55	Number of lives lost, with names and residence.	None
56	State fully the circumstances of the loss of each life.	None
57	State damage, if any, to boat or apparatus.	None
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	None
60	Estimated value of cargo saved, and its condition.	No cargo
61	Estimated value of cargo lost.	None
62	Amount of insurance on vessel.	None
63	Amount of insurance on cargo.	None
64	Number of persons sheltered at station, how long, and total number of meals furnished.	None
65	Number and names of persons resuscitated from apparent death by drowning or	None

	exposure to cold.	
66	Number of persons found after death and cared for.	None
67	Were any other persons than members of the life-saving crew employed by the keeper to assist? If so, who?	None
68	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employe at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	The schooner Lou Willis went ashore on a sand shole [sic] in Currituck Sound 10th the owner ask for assistance to get his vessel off the shole [sic] Monday March 12th the keeper and 5 surfmen went to help him and with keeper and surfmen went to help him from Kitty Hawk Station succeeded in getting her afloat and in deep water. March 21st, 1906. Thomas Harris, Keeper.

Form 1806, United States Life-Saving Service, Wreck Report: Mabel E. Horton, May 25, 1907, Chicamacomico Station. Outer Banks History Center, Box 4, Folder 45.

#	Item	Description
1	Name of vessel.	*Mable* [sic] *E. Horton*
2	Rig and tonnage.	Gasoline Launch: 8 tons gross, 6 net
3	Hailing port and nationality.	American: Elizabeth City, N.C.
4	Age.	2 years
5	Official number.	202730
6	Name of master.	Henry Ward, Master
7	Name of owners.	W.J. Griffon and Co.
8	Where from.	Manteo, N.C.
9	Where bound.	N.S. Mail for Hatteras N.C.
10	Number of crew, including captain.	2, captain and engineer
11	Number of passengers.	5[?] on board
12	Nature of cargo.	N.S. Mail and Merchandise
13	Estimated value of vessel.	3000. thousan dolers [sic]
14	Estimated value of cargo.	300 dolers [sic]
15	Exact spot where wrecked.	on S.W. Point Pugh Reef in N.E.[?] Pamplico [sic] Sound
16	Direction and distance from station.	3 miles W by N
17	Supposed cause of wreck (specifying particularly).	low tide, thick weather
18	Nature of disaster, whether stranDed, sunk, collision, etc.	Stranded
19	Distance of vessel from shore at time of accident.	3 miles
20	Time of day or night.	9:15 AM
21	State of wind and weather.	NNE fresh and thick
22	State of tide and sea.	Heavy sea, low tide
23	Time of discovery of wreck.	9:15 AM
24	By whom discovered.	J.T. Payne
25	Time of arrival of station-crew at wreck.	2:00 PM
26	Time of return of station-crew from wreck.	At sunset
27	Were there any of the station-crew absent? If so, who?	E.S. Midgett, J.S. Midgett and J.T. Payne
28	Was life-boat used?	Non
29	Number of trips with life-boat.	Non

30	Number of persons brought ashore in life-boat.	Non
31	Was surf-boat used?	Non
32	Number of trips with surf-boat.	Non
33	Number of persons brought ashore in surf-boat.	Non
34	Was small boat used?	Non
35	Number of trips with small boat.	[missing from page]
36	Number of persons brought ashore with small boat.	[missing from page]
37	Time of launching of boat	Supply boat, sprit[?] sail: 1:20 PM had to launch boat [rest of note is cut off]
38	Was mortar, Lyle gun, or rocket used (which, if either)?	Non
39	Charge of shot-line used.	Non
40	Size of shot-line used.	Non
41	Distance of wreck from shore when shot was fired.	Non
42	Number of shots fired.	Non
43	If any shots were unsuccessful, state cause of failure in each case.	Non
44	Was whip-line sent on board double or single?	Non
45	If anything occurred to interfere with favorable operations, state fully nature and cause	Tide being very low and hard winds. Had to launch boat out of creek over the flats about 300 yards consuming from 9:20 AM to 1:20 PM to git [sic] her to deep water.
46	Was heaving-stick used?	Non
47	Was life-car used?	Non
48	Number of trips of life-car.	Non
49	Number of persons brought ashore in life-car.	Non
50	Was breeches-buoy used?	Non
51	Number of trips of breeches-buoy.	Non
52	Number of persons brought ashore with breeches-buoy.	Non
53	Was life-saving dress used, and how?	Non
54	Number of lives saved, with names and residence.	5. Waston Gray, Avon, N.C. Albert Neal, Hatteras, N.C. John Balince[?] Hatteras, N.C. Debenport Manteo, N.C. Jesse E. Midgett Rodanthe, N.C
55	Number of lives lost, with names and residence.	non
56	State fully the circumstances of the loss of each life.	non
57	State damage, if any, to boat or apparatus.	[missing from page]
58	Was vessel saved or lost?	[missing from page]
59	Amount of damage, if saved.	non
60	Estimated value of cargo saved, and its condition.	All saved
61	Estimated value of cargo lost.	non
62	Amount of insurance on vessel.	unknown
63	Amount of insurance on cargo.	not known
64	Number of persons sheltered at station, how long, and total number of meals furnished.	2 sheltered at the Sta. [sic] for one night
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non
66	Number of persons found after death and cared for.	Non
67	Were any other persons than members of the life-saving crew employed by the keeper to assist? If so, who?	Non

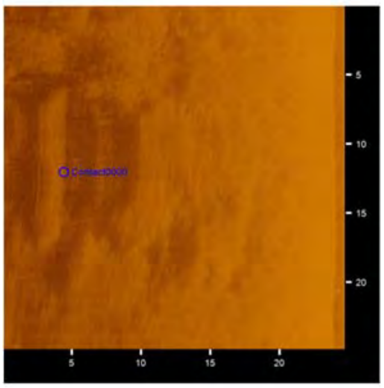
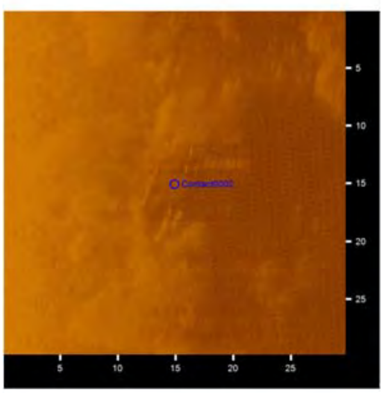
68	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employed at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	N.S. mail boat stoped [sic] on Pugh Reaf [sic] 3 miles west by N from station. Set Flag of distress at 9:15 AM. I took 4 of my men and went to him. Took mail out for Rodanthe and Salvo, N.C. and 5 passengers on shore. Boat in good shape and will be all right [sic] when tide comes in. I give [sic] him right corses [sic] to git [sic] out when tide comes in. The man J.A. Makins that was home on days privilage [sic] I took him along. I left the station at 9:20 AM, tide being very low and had to launch supply boat 300 yards. It was 2 PM when I got out to the mail boat. I have 2 passengers at the station and delivered the mail bags. One to Salvo, N.C. and one to Rodanthe, N.C. I returned to [the] station at sunset with my crew. Date of Report: May 25, 1907 L. Banister Midgett

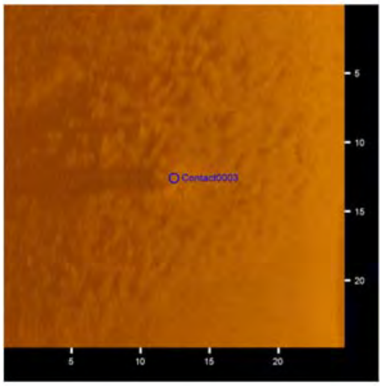
Form 1806, United States Life-Saving Service, Wreck Report: R.C. Beaman, January 4, 1910, Chicamacomico Station. Outer Banks History Center, Box 6, Folder 58.

#	Item	Description
1	Name of vessel.	*R.C. Beaman. Schr*
2	Rig and tonnage.	Two mast schr. 12 tons gross
3	Hailing port and nationality.	Elizabeth City NC U.S.A.
4	Age.	9 years old
5	Official number.	111387
6	Name of master.	Harison Midgett. Master
7	Name of owners.	A.B. Midgett
8	Where from.	Powells Point N.C.
9	Where bound.	Rodanthe N.C.
10	Number of crew, including captain.	Capt and mate 2
11	Number of passengers.	10 passengers
12	Nature of cargo.	split pine wood 2 cord
13	Estimated value of vessel.	$300.00 three hundred
14	Estimated value of cargo.	$6.00 six dolers [sic]
15	Exact spot where wrecked.	N.E. point Franke Reef
16	Direction and distance from station.	West course dist 3 miles
17	Supposed cause of wreck (specifying particularly).	low tide bused jib
18	Nature of disaster, whether stranded, sunk, collision, etc.	stranded
19	Distance of vessel from shore at time of accident.	3 miles
20	Time of day or night.	3.30 PM
21	State of wind and weather.	N.N.E. fresh cloudy
22	State of tide and sea.	low tide. Surf rough
23	Time of discovery of wreck.	3.30 PM
24	By whom discovered.	A. Oneal sta watch
25	Time of arrival of station-crew at wreck.	5.30 PM
26	Time of return of station-crew from wreck.	7:00 PM
27	Were there any of the station-crew absent? If so, who?	No.1 + No. 2 + No. 6 was all that went on board rest of crew at station
28	Was life-boat used?	No
29	Number of trips with life-boat.	Non
30	Number of persons brought ashore in life-boat.	Non
31	Was surf-boat used?	No
32	Number of trips with surf-boat.	Non
33	Number of persons brought ashore in surf-boat.	Non
34	Was small boat used?	No

35	Number of trips with small boat.	No
36	Number of persons brought ashore with small boat.	No
37	Time of launching of boat	4.40 PM
38	Was mortar, Lyle gun, or rocket used (which, if either)?	Non
39	Charge of shot-line used.	Non
40	Size of shot-line used.	No
41	Distance of wreck from shore when shot was fired.	Non
42	Number of shots fired.	Non
43	If any shots were unsuccessful, state cause of failure in each case.	Non
44	Was whip-line sent on board double or single?	No
45	If anything occurred to interfere with favorable operations, state fully nature and cause	Low tide we had to launch skiff about 200 yards which consumed some time
46	Was heaving-stick used?	No
47	Was life-car used?	No
48	Number of trips of life-car.	No
49	Number of persons brought ashore in life-car.	No
50	Was breeches-buoy used?	No
51	Number of trips of breeches-buoy.	Non
52	Number of persons brought ashore with breeches-buoy.	Non
53	Was life-saving dress used, and how?	Non
54	Number of lives saved, with names and residence.	Capt Harrison Midgett Powells Point NC Joseph Midgett mate Powells Point NC Passengers E. Payne & wife & child of Powells Point NC Mr WM Walesfield and Wive and 4 children of Powells Point NC and Miss Bunie Midgett of Powells Point NC
55	Number of lives lost, with names and residence.	Non
56	State fully the circumstances of the loss of each life.	Non
57	State damage, if any, to boat or apparatus.	None
58	Was vessel saved or lost?	Saved
59	Amount of damage, if saved.	None
60	Estimated value of cargo saved, and its condition.	600 wood
61	Estimated value of cargo lost.	Non
62	Amount of insurance on vessel.	Non
63	Amount of insurance on cargo.	Non
64	Number of persons sheltered at station, how long, and total number of meals furnished.	Non all went to visit these people
65	Number and names of persons resuscitated from apparent death by drowning or exposure to cold.	Non
66	Number of persons found after death and cared for.	Non
67	Were any other persons than members of the life-saving crew employed by the keeper to assist? If so, who?	Non
68	Remarks.--All particulars not included in the above list will be here stated, giving specially the nature of the assistance rendered by the Life-Saving Service; and if the wreck occurred at the same time when the crew was not employe at the station, give the names of those persons who rendered assistance, using additional sheets of paper if necessary. Whenever the circumstances make it necessary to hire horses to transport the boat or apparatus to or from the scene of the disaster, that fact should be noted, giving the name of the person from who the team was hired.	This evening about 3.00 PM Schr R.C. Beaman Capt Midgett was coming on chanel [sic] and he busted his job and before he could get more sail on she struck on leward side of chanel [sic] and he had to anchor … signal of distress and sent 3 of my crew to his assistance they fond [sic] schr laying all right and they brought ashore 10 passengers 2 men 2 women and 5 children Capt and mate stade [sic] on board of schr as there was no damage crew arrives at station at 7 P.M. we brought them ashore in surfman J.A. Meekins sail skiff tie was so low we could no git [sic] on suply [sic] boat a float as the tide was very low this morning January 5 about 9 o'clock Capt of Schr R.C. Beaman bought her into harbor all right.

APPENDIX 3: SONAR TARGET CATALOG

Target Image	Target Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 7/29/2015 10:06:03 AM • Click Position 35.6054623858 -75.4787290814 (WGS84) 35.6052823675 -75.4791257957 (NAD27LL) 35.6054623858 -75.4787290814 (LocalLL) (X) 456639.24 (Y) 3940295.37 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\069 1001.XTF • Ping Number: 78449 • Range to target: 20.35 • Fish Height: 0.00 • Heading: 0.000 Degrees • Event Number: 45 • Line Name: 069_1001 • Water Depth: 0.00 • Positioning System to Sensor: 0.4379	**Dimensions and attributes** • Target Width: 2.88 • Target Height: 0.00 • Target Length: 12.32 • Target Shadow: 1.59 • Mag Anomaly: No • Avoidance Area: • Classification1: Unknown Feature • Classification2: • Area: • Block: • Description: Unknown feature
	**Contact0002** • Sonar Time at Target: 7/28/2015 9:48:59 AM • Click Position 35.6054678281 -75.4760266607 (WGS84) 35.6052877986 -75.4764234976 (NAD27LL) 35.6054678281 -75.4760266607 (LocalLL) (X) 456884.01 (Y) 3940294.79 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\080 0944.XTF • Ping Number: 21197 • Range to target: 14.15 • Fish Height: 1.44 • Heading: 0.000 Degrees • Event Number: 23 • Line Name: 080_0944 • Water Depth: 0.00 • Positioning System to Sensor: 0.4395	**Dimensions and attributes** • Target Width: 0.00 • Target Height: 0.00 • Target Length: 0.00 • Target Shadow: 0.00 • Mag Anomaly: Yes • Avoidance Area: • Classification1: Pilings • Classification2: Hunting Blind • Area: • Block: • Description: Hunting blind

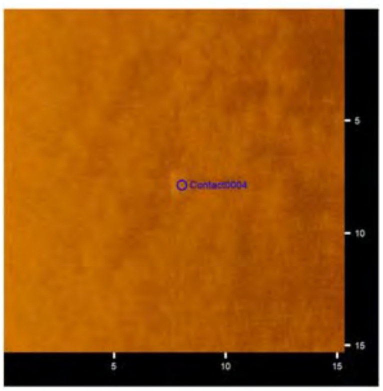


Contact0003

- Sonar Time at Target: 7/28/2015 12:06:54 PM
- Click Position
  35.5965227318 -75.4767784911 (WGS84)
  35.5963427138 -75.4771755170 (NAD27LL)
  35.5965227318 -75.4767784911 (LocalLL)
  (X) 456811.11 (Y) 3939303.03 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\076 1150.XTF
- Ping Number: 228562
- Range to target: 12.38
- Fish Height: 1.57
- Heading: 0.000 Degrees
- Event Number: 31
- Line Name: 076_1150
- Water Depth: 0.00
- Positioning System to Sensor: 0.0184

Dimensions and attributes

- Target Width: 1.40
- Target Height: 0.73
- Target Length: 2.07
- Target Shadow: 11.03
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description: Potential crabpot

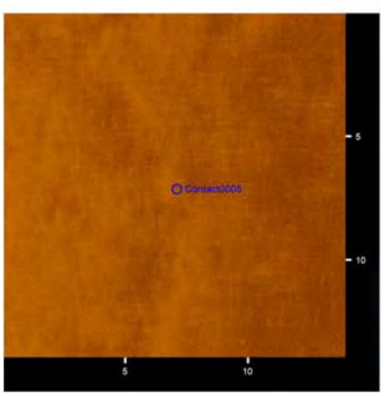


Contact0004

- Sonar Time at Target: 7/28/2015 12:56:27 PM
- Click Position
  35.6047766001 -75.4776404128 (WGS84)
  35.6045965780 -75.4780371936 (NAD27LL)
  35.6047766001 -75.4776404128 (LocalLL)
  (X) 456737.47 (Y) 3940218.83 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\074 1251.XTF
- Ping Number: 305277
- Range to target: 10.39
- Fish Height: 0.92
- Heading: 0.000 Degrees
- Event Number: 35
- Line Name: 074_1251
- Water Depth: 0.00
- Positioning System to Sensor: 1.0590

Dimensions and attributes

- Target Width: 0.73
- Target Height: 0.23
- Target Length: 1.15
- Target Shadow: 3.60
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description: Possible Crab Pot

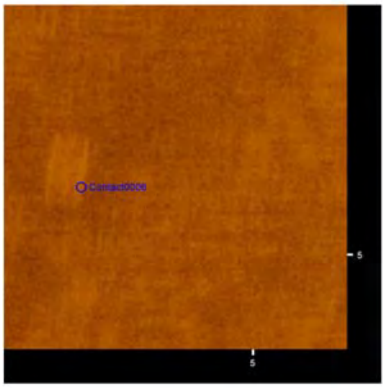


Contact0005

- Sonar Time at Target: 7/28/2015 1:16:07 PM
- Click Position
  35.5926191910 -75.4776468456 (WGS84)
  35.5924391805 -75.4780439294 (NAD27LL)
  35.5926191910 -75.4776468456 (LocalLL)
  (X) 456730.35 (Y) 3938870.48 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\074 1251.XTF
- Ping Number: 335722
- Range to target: 16.53
- Fish Height: 0.86
- Heading: 0.000 Degrees
- Event Number: 35
- Line Name: 074_1251
- Water Depth: 0.00
- Positioning System to Sensor: 0.7869

Dimensions and attributes

- Target Width: 1.11
- Target Height: 0.14
- Target Length: 1.24
- Target Shadow: 3.27
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description: Possible crab pot

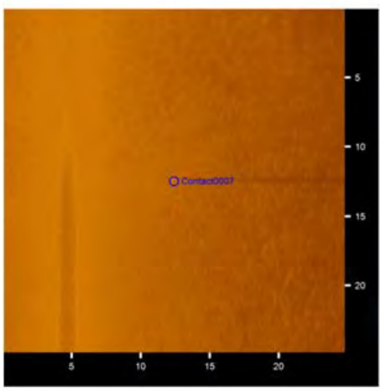


Contact0006

- Sonar Time at Target: 7/28/2015 1:58:42 PM
- Click Position
  35.6051801189 -75.4778428938 (WGS84)
  35.6050000972 -75.4782396553 (NAD27LL)
  35.6051801189 -75.4778428938 (LocalLL)
  (X) 456719.35 (Y) 3940263.67 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\072 1354.XTF
- Ping Number: 401674
- Range to target: 20.64
- Fish Height: 0.79
- Heading: 0.000 Degrees
- Event Number: 39
- Line Name: 072_1354
- Water Depth: 0.00
- Positioning System to Sensor: 0.4817

Dimensions and attributes

- Target Width: 0.73
- Target Height: 0.00
- Target Length: 1.46
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

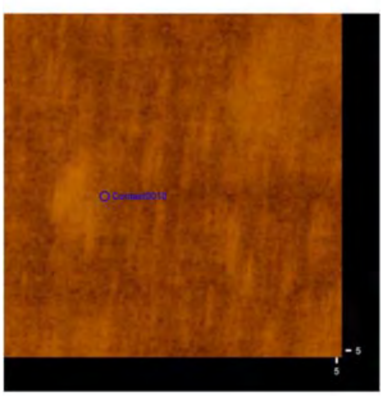


Contact0007

- Sonar Time at Target: 7/28/2015 2:11:48 PM
- Click Position
  35.5973073544 -75.4781115037 (WGS84)
  35.5971273415 -75.4785084494 (NAD27LL)
  35.5973073544 -75.4781115037 (LocalLL)
  (X) 456690.78 (Y) 3939390.64 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\072 1354.XTF
- Ping Number: 421950
- Range to target: 7.69
- Fish Height: 1.06
- Heading: 0.000 Degrees
- Event Number: 39
- Line Name: 072_1354
- Water Depth: 0.00
- Positioning System to Sensor: 0.1818

Dimensions and attributes

- Target Width: 0.29
- Target Height: 0.64
- Target Length: 0.57
- Target Shadow: 12.04
- Mag Anomaly:
- Avoidance Area:
- Classification1: Piling
- Classification2: Channel Marker
- Area:
- Block:
- Description:

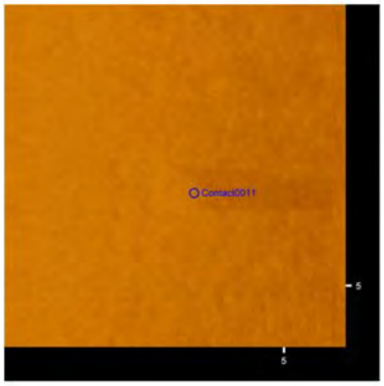


Contact0010

- Sonar Time at Target: 7/29/2015 10:30:22 AM
- Click Position
  35.5919103579 -75.4790946115 (WGS84)
  35.5917303545 -75.4794916472 (NAD27LL)
  35.5919103579 -75.4790946115 (LocalLL)
  (X) 456598.81 (Y) 3938792.50 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\069 1001.XTF
- Ping Number: 116103
- Range to target: 21.12
- Fish Height: 1.28
- Heading: 0.000 Degrees
- Event Number: 45
- Line Name: 069_1001
- Water Depth: 0.00
- Positioning System to Sensor: 0.6248

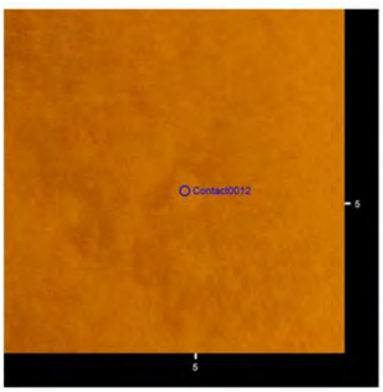
Dimensions and attributes

- Target Width: 0.72
- Target Height: 0.16
- Target Length: 1.26
- Target Shadow: 3.21
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature



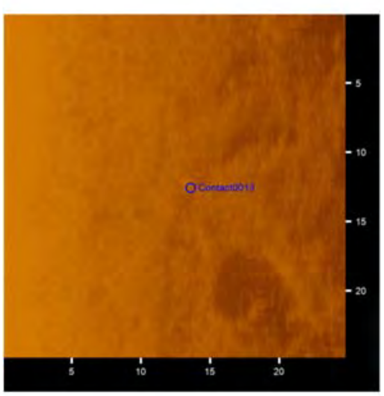
Contact0011
- Sonar Time at Target: 7/29/2015 11:07:41 AM
- Click Position
  35.5918691645 -75.4790846028 (WGS84)
  35.5916891611 -75.4794816399 (NAD27LL)
  35.5918691645 -75.4790846028 (LocalLL)
  (X) 456599.70 (Y) 3938787.92 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\068 1104.XTF
- Ping Number: 12463
- Range to target: 3.43
- Fish Height: 1.40
- Heading: 0.000 Degrees
- Event Number: 47
- Line Name: 068_1104
- Water Depth: 0.00
- Positioning System to Sensor: 0.1370

Dimensions and attributes
- Target Width: 0.58
- Target Height: 0.49
- Target Length: 0.72
- Target Shadow: 2.05
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description: Possible crab pot



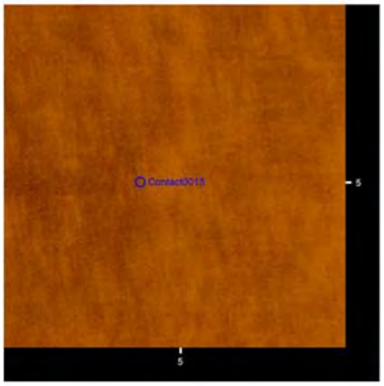
Contact0012
- Sonar Time at Target: 7/29/2015 12:39:26 PM
- Click Position
  35.6065367493 -75.4797964286 (WGS84)
  35.6063567344 -75.4801930676 (NAD27LL)
  35.6065367493 -75.4797964286 (LocalLL)
  (X) 456543.14 (Y) 3940415.00 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\066 1212.XTF
- Ping Number: 154530
- Range to target: 5.99
- Fish Height: 0.93
- Heading: 0.000 Degrees
- Event Number: 53
- Line Name: 066_1212
- Water Depth: 0.00
- Positioning System to Sensor: 0.5596

Dimensions and attributes
- Target Width: 0.78
- Target Height: 0.06
- Target Length: 1.13
- Target Shadow: 0.44
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature



Contact0013
- Sonar Time at Target: 7/29/2015 12:53:18 PM
- Click Position
  35.6017512046 -75.4801225898 (WGS84)
  35.6015711958 -75.4805193333 (NAD27LL)
  35.6017512046 -75.4801225898 (LocalLL)
  (X) 456511.01 (Y) 3939884.38 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\065 1243.XTF
- Ping Number: 176013
- Range to target: 13.54
- Fish Height: 0.87
- Heading: 0.000 Degrees
- Event Number: 55
- Line Name: 065_1243
- Water Depth: 0.00
- Positioning System to Sensor: 0.0267

Dimensions and attributes
- Target Width: 0.96
- Target Height: 0.01
- Target Length: 1.29
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature

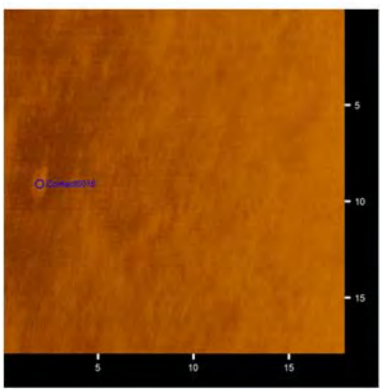


Contact0015

- Sonar Time at Target: 7/29/2015 1:36:20 PM
- Click Position
  35.6023709952 -75.4804799730 (WGS84)
  35.6021909873 -75.4808766848 (NAD27LL)
  35.6023709952 -75.4804799730 (LocalLL)
  (X) 456478.97 (Y) 3939953.28 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\064 1315.XTF
- Ping Number: 242628
- Range to target: 20.21
- Fish Height: 0.73
- Heading: 0.000 Degrees
- Event Number: 57
- Line Name: 064_1315
- Water Depth: 0.00
- Positioning System to Sensor: 0.4952

Dimensions and attributes

- Target Width: 1.30
- Target Height: 0.11
- Target Length: 1.52
- Target Shadow: 3.90
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature

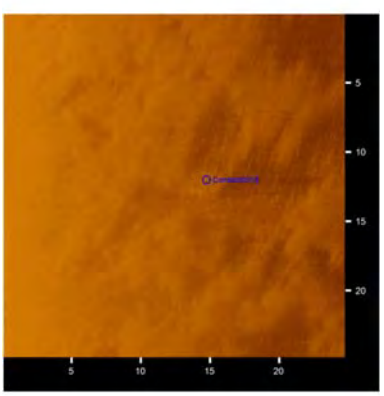


Contact0016

- Sonar Time at Target: 7/29/2015 2:00:41 PM
- Click Position
  35.6064320737 -75.4803153209 (WGS84)
  35.6062520610 -75.4807119389 (NAD27LL)
  35.6064320737 -75.4803153209 (LocalLL)
  (X) 456496.09 (Y) 3940403.62 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\063 1358.XTF
- Ping Number: 280343
- Range to target: 22.82
- Fish Height: 0.87
- Heading: 0.000 Degrees
- Event Number: 59
- Line Name: 063_1358
- Water Depth: 0.00
- Positioning System to Sensor: 0.9339

Dimensions and attributes

- Target Width: 0.77
- Target Height: 0.00
- Target Length: 1.63
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature

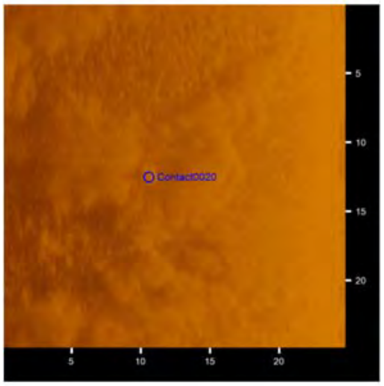


Contact0018

- Sonar Time at Target: 7/29/2015 2:30:30 PM
- Click Position
  35.5907285651 -75.4806509289 (WGS84)
  35.5905485698 -75.4810479232 (NAD27LL)
  35.5907285651 -75.4806509289 (LocalLL)
  (X) 456457.18 (Y) 3938662.11 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\063 1358.XTF
- Ping Number: 326498
- Range to target: 14.70
- Fish Height: 1.14
- Heading: 0.000 Degrees
- Event Number: 59
- Line Name: 063_1358
- Water Depth: 0.00
- Positioning System to Sensor: 0.4775

Dimensions and attributes

- Target Width: 1.91
- Target Height: 0.32
- Target Length: 1.30
- Target Shadow: 5.75
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Unknown feature

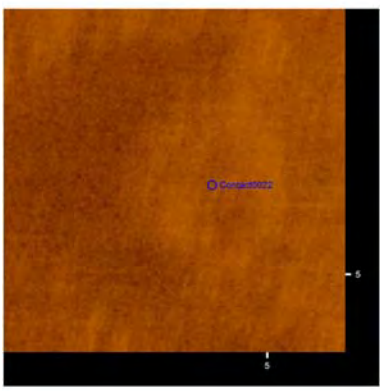


Contact0020

- Sonar Time at Target: 7/29/2015 2:43:18 PM
- Click Position
  35.5937850399 -75.4809341580 (WGS84)
  35.5936050427 -75.4813310633 (NAD27LL)
  35.5937850399 -75.4809341580 (LocalLL)
  (X) 456433.18 (Y) 3939001.23 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\062 1436.XTF
- Ping Number: 346338
- Range to target: 14.21
- Fish Height: 1.02
- Heading: 0.000 Degrees
- Event Number: 61
- Line Name: 062_1436
- Water Depth: 0.00
- Positioning System to Sensor: 0.4759

Dimensions and attributes

- Target Width: 0.90
- Target Height: 0.42
- Target Length: 1.26
- Target Shadow: 10.25
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description: Potential crabpot

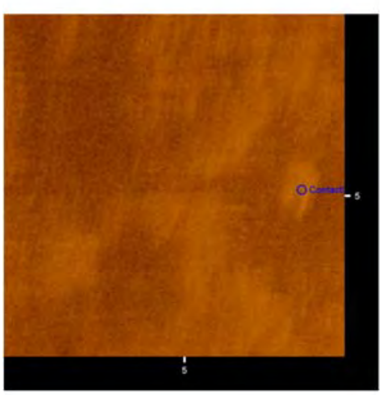


Contact0022

- Sonar Time at Target: 7/29/2015 3:19:12 PM
- Click Position
  35.6023505850 -75.4808600596 (WGS84)
  35.6021705787 -75.4812567547 (NAD27LL)
  35.6023505850 -75.4808600596 (LocalLL)
  (X) 456444.54 (Y) 3939951.19 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\061 1509.XTF
- Ping Number: 401908
- Range to target: 20.79
- Fish Height: 0.99
- Heading: 0.000 Degrees
- Event Number: 63
- Line Name: 061_1509
- Water Depth: 0.00
- Positioning System to Sensor: 0.8864

Dimensions and attributes

- Target Width: 2.89
- Target Height: 0.09
- Target Length: 3.00
- Target Shadow: 2.24
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

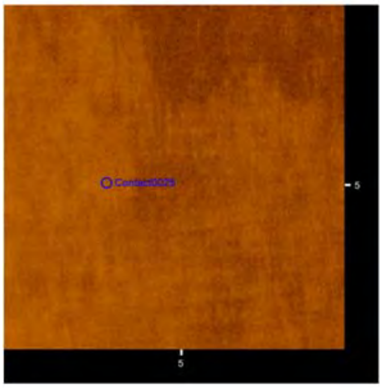
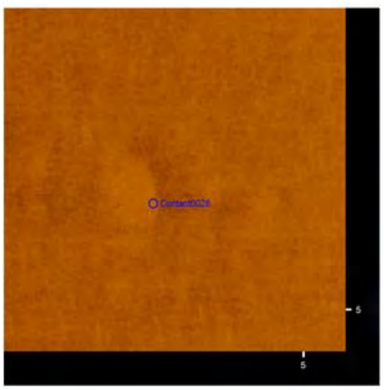
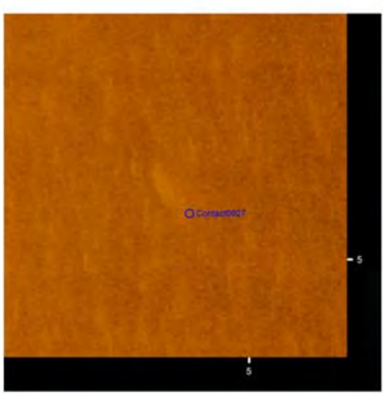


Contact0023

- Sonar Time at Target: 7/29/2015 3:13:30 PM
- Click Position
  35.6056387163 -75.4809257031 (WGS84)
  35.6054587069 -75.4813223132 (NAD27LL)
  35.6056387163 -75.4809257031 (LocalLL)
  (X) 456440.37 (Y) 3940315.90 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\061 1509.XTF
- Ping Number: 393097
- Range to target: 16.53
- Fish Height: 0.99
- Heading: 0.000 Degrees
- Event Number: 63
- Line Name: 061_1509
- Water Depth: 0.00
- Positioning System to Sensor: 0.3881

Dimensions and attributes

- Target Width: 0.92
- Target Height: 0.31
- Target Length: 1.31
- Target Shadow: 7.63
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

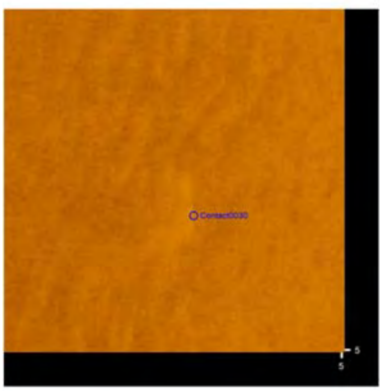
	**Contact0025** • Sonar Time at Target: 7/30/2015 9:10:12 AM • Click Position 35.6051486175 -75.4811777548 (WGS84) 35.6049686097 -75.4815743656 (NAD27LL) 35.6051486175 -75.4811777548 (LocalLL) (X) 456417.28 (Y) 3940261.65 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\060_0846.XTF • Ping Number: 48932 • Range to target: 18.08 • Fish Height: 0.91 • Heading: 0.000 Degrees • Event Number: 65 • Line Name: 060_0846 • Water Depth: 0.00 • Positioning System to Sensor: 1.0658	**Dimensions and attributes** • Target Width: 1.20 • Target Height: 0.08 • Target Length: 0.86 • Target Shadow: 1.77 • Mag Anomaly: • Avoidance Area: • Classification1: • Classification2: • Area: • Block: • Description:
	**Contact0026** • Sonar Time at Target: 7/30/2015 9:35:36 AM • Click Position 35.5983365707 -75.4814585341 (WGS84) 35.5981565711 -75.4818553021 (NAD27LL) 35.5983365707 -75.4814585341 (LocalLL) (X) 456388.15 (Y) 3939506.26 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\059_0917.XTF • Ping Number: 88261 • Range to target: 13.10 • Fish Height: 2.07 • Heading: 0.000 Degrees • Event Number: 67 • Line Name: 059_0917 • Water Depth: 0.00 • Positioning System to Sensor: 0.9385	**Dimensions and attributes** • Target Width: 0.77 • Target Height: 0.18 • Target Length: 1.15 • Target Shadow: 1.29 • Mag Anomaly: • Avoidance Area: • Classification1: • Classification2: • Area: • Block: • Description:
	**Contact0027** • Sonar Time at Target: 8/5/2015 2:42:38 PM • Click Position 35.5998801282 -75.4851516679 (WGS84) 35.5997001427 -75.4855482295 (NAD27LL) 35.5998801282 -75.4851516679 (LocalLL) (X) 456054.46 (Y) 3939679.10 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\047_1427.XTF • Ping Number: 564505 • Range to target: 19.29 • Fish Height: 1.27 • Heading: 0.000 Degrees • Event Number: 95 • Line Name: 047_1427 • Water Depth: 0.00 • Positioning System to Sensor: 0.1047	**Dimensions and attributes** • Target Width: 0.35 • Target Height: 0.07 • Target Length: 1.25 • Target Shadow: 1.23 • Mag Anomaly: • Avoidance Area: • Classification1: Unknown Feature • Classification2: • Area: • Block: • Description:

Contact0029

- Sonar Time at Target: 8/5/2015 2:13:41 PM
- Click Position
  35.5994623950 -75.4845866611 (WGS84)
  35.5992824076 -75.4849832588 (NAD27LL)
  35.5994623950 -75.4845866611 (LocalLL)
  (X) 456105.41 (Y) 3939632.52 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\048 1400.XTF
- Ping Number: 519698
- Range to target: 5.17
- Fish Height: 2.12
- Heading: 0.000 Degrees
- Event Number: 93
- Line Name: 048_1400
- Water Depth: 0.00
- Positioning System to Sensor: 1.2863

Dimensions and attributes

- Target Width: 0.71
- Target Height: 0.00
- Target Length: 0.77
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

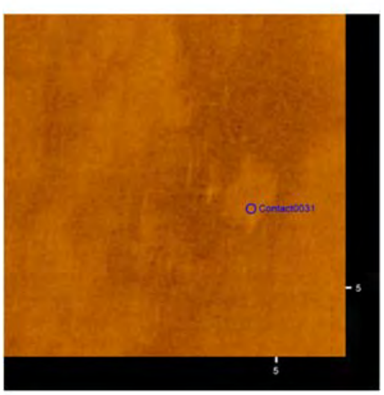


Contact0030

- Sonar Time at Target: 8/5/2015 1:19:25 PM
- Click Position
  35.5996855318 -75.4841900341 (WGS84)
  35.5995055425 -75.4845866442 (NAD27LL)
  35.5996855318 -75.4841900341 (LocalLL)
  (X) 456141.46 (Y) 3939657.09 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\050 1305.XTF
- Ping Number: 435674
- Range to target: 7.15
- Fish Height: 1.54
- Heading: 0.000 Degrees
- Event Number: 89
- Line Name: 050_1305
- Water Depth: 0.00
- Positioning System to Sensor: 0.3294

Dimensions and attributes

- Target Width: 0.55
- Target Height: 0.24
- Target Length: 1.06
- Target Shadow: 1.38
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:



Contact0031

- Sonar Time at Target: 8/5/2015 12:10:40 PM
- Click Position
  35.5940284259 -75.4836926405 (WGS84)
  35.5938484405 -75.4840894143 (NAD27LL)
  35.5940284259 -75.4836926405 (LocalLL)
  (X) 456183.43 (Y) 3939029.45 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\052 1203.XTF
- Ping Number: 329202
- Range to target: 14.26
- Fish Height: 1.11
- Heading: 0.000 Degrees
- Event Number: 85
- Line Name: 052_1203
- Water Depth: 0.00
- Positioning System to Sensor: 0.8919

Dimensions and attributes

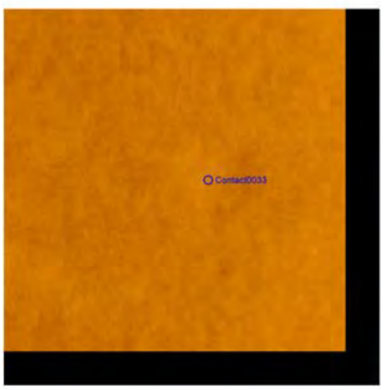
- Target Width: 0.77
- Target Height: 0.00
- Target Length: 1.10
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description: Possible crab pot

Contact0032

- Sonar Time at Target: 8/5/2015 12:29:22 PM
- Click Position
  35.6057981770 -75.4837121791 (WGS84)
  35.6056181789 -75.4841086586 (NAD27LL)
  35.6057981770 -75.4837121791 (LocalLL)
  (X) 456188.07 (Y) 3940334.82 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\052 1203.XTF
- Ping Number: 358171
- Range to target: 10.68
- Fish Height: 1.22
- Heading: 0.000 Degrees
- Event Number: 85
- Line Name: 052_1203
- Water Depth: 0.00
- Positioning System to Sensor: 0.2770

Dimensions and attributes

- Target Width: 0.51
- Target Height: 0.12
- Target Length: 1.10
- Target Shadow: 1.22
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:

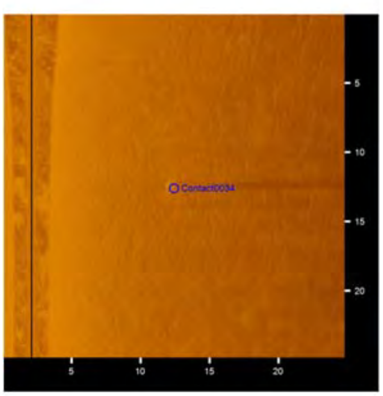


Contact0033

- Sonar Time at Target: 8/5/2015 11:51:34 AM
- Click Position
  35.5949531260 -75.4832007405 (WGS84)
  35.5947731376 -75.4835975136 (NAD27LL)
  35.5949531260 -75.4832007405 (LocalLL)
  (X) 456228.49 (Y) 3939131.78 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\053 1129.XTF
- Ping Number: 299641
- Range to target: 4.59
- Fish Height: 1.36
- Heading: 0.000 Degrees
- Event Number: 83
- Line Name: 053_1129
- Water Depth: 0.00
- Positioning System to Sensor: 0.3009

Dimensions and attributes

- Target Width: 0.66
- Target Height: 0.00
- Target Length: 0.84
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

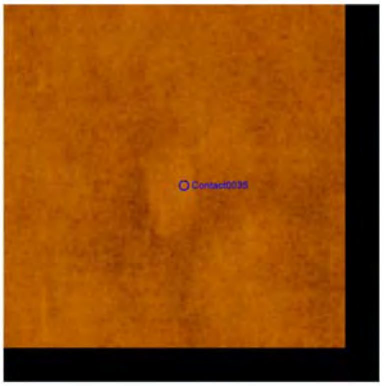


Contact0034

- Sonar Time at Target: 8/5/2015 11:12:42 AM
- Click Position
  35.5990910732 -75.4828810300 (WGS84)
  35.5989110789 -75.4832777144 (NAD27LL)
  35.5990910732 -75.4828810300 (LocalLL)
  (X) 456259.70 (Y) 3939590.58 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\054 1056.XTF
- Ping Number: 239445
- Range to target: 10.30
- Fish Height: 1.66
- Heading: 0.000 Degrees
- Event Number: 81
- Line Name: 054_1056
- Water Depth: 0.00
- Positioning System to Sensor: 0.5781

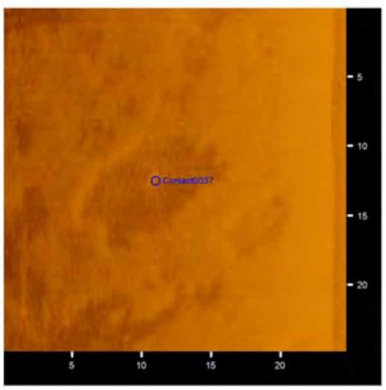
Dimensions and attributes

- Target Width: 0.51
- Target Height: 0.89
- Target Length: 0.51
- Target Shadow: 12.03
- Mag Anomaly:
- Avoidance Area:
- Classification1: Piling
- Classification2: Channel Marker
- Area:
- Block:
- Description:



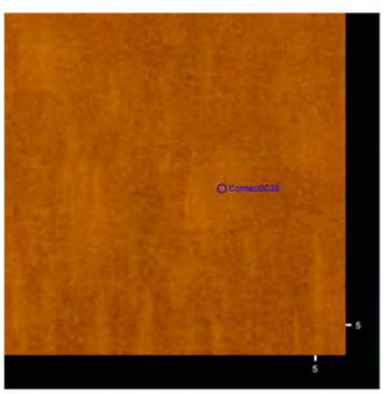
Contact0035
- Sonar Time at Target: 8/5/2015 11:22:41 AM
- Click Position
  35.6051147792 -75.4828422098 (WGS84)
  35.6049347783 -75.4832387458 (NAD27LL)
  35.6051147792 -75.4828422098 (LocalLL)
  (X) 456266.50 (Y) 3940258.64 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\054 1056.XTF
- Ping Number: 254909
- Range to target: 17.84
- Fish Height: 1.17
- Heading: 0.000 Degrees
- Event Number: 81
- Line Name: 054_1056
- Water Depth: 0.00
- Positioning System to Sensor: 1.0508

Dimensions and attributes
- Target Width: 0.74
- Target Height: 0.00
- Target Length: 1.18
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description: Possible Crab Pot



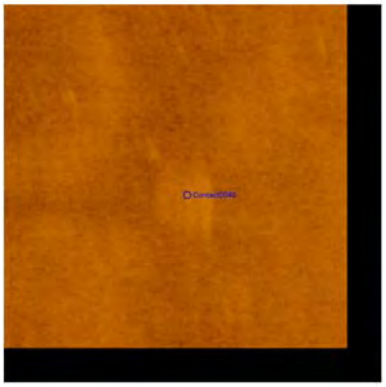
Contact0037
- Sonar Time at Target: 8/5/2015 5:22:17 PM
- Click Position
  35.5917410323 -75.4855934062 (WGS84)
  35.5915610579 -75.4859901506 (NAD27LL)
  35.5917410323 -75.4855934062 (LocalLL)
  (X) 456009.99 (Y) 3938776.60 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\044 1654.XTF
- Ping Number: 191920
- Range to target: 13.78
- Fish Height: 1.32
- Heading: 0.000 Degrees
- Event Number: 103
- Line Name: 044_1654
- Water Depth: 0.00
- Positioning System to Sensor: 0.7785

Dimensions and attributes
- Target Width: 0.53
- Target Height: 0.00
- Target Length: 1.30
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:



Contact0039
- Sonar Time at Target: 8/5/2015 5:16:08 PM
- Click Position
  35.5952601725 -75.4860033915 (WGS84)
  35.5950801959 -75.4864000296 (NAD27LL)
  35.5952601725 -75.4860033915 (LocalLL)
  (X) 455974.77 (Y) 3939167.09 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\044 1654.XTF
- Ping Number: 182413
- Range to target: 21.90
- Fish Height: 1.43
- Heading: 0.000 Degrees
- Event Number: 103
- Line Name: 044_1654
- Water Depth: 0.00
- Positioning System to Sensor: 0.1285

Dimensions and attributes
- Target Width: 0.98
- Target Height: 0.09
- Target Length: 1.08
- Target Shadow: 1.52
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crabpot
- Classification2:
- Area:
- Block:
- Description:

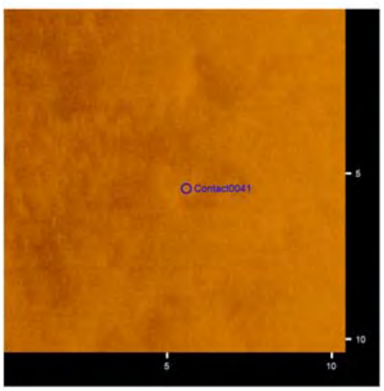


Contact0040

- Sonar Time at Target: 8/5/2015 3:56:04 PM
- Click Position
  35.6076035815 -75.4850935368 (WGS84)
  35.6074235871 -75.4854899086 (NAD27LL)
  35.6076035815 -75.4850935368 (LocalLL)
  (X) 456063.94 (Y) 3940535.67 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\046 1555.XTF
- Ping Number: 58429
- Range to target: 14.16
- Fish Height: 1.35
- Heading: 0.000 Degrees
- Event Number: 99
- Line Name: 046_1555
- Water Depth: 0.00
- Positioning System to Sensor: 0.1345

Dimensions and attributes

- Target Width: 0.78
- Target Height: 0.38
- Target Length: 0.93
- Target Shadow: 5.74
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

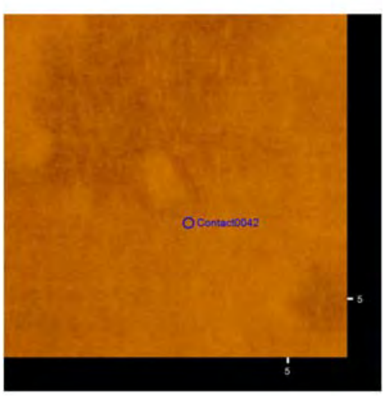


Contact0041

- Sonar Time at Target: 8/5/2015 4:16:38 PM
- Click Position
  35.5946673396 -75.4850876839 (WGS84)
  35.5944873597 -75.4854843783 (NAD27LL)
  35.5946673396 -75.4850876839 (LocalLL)
  (X) 456057.40 (Y) 3939100.93 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\046 1555.XTF
- Ping Number: 90277
- Range to target: 9.52
- Fish Height: 1.46
- Heading: 0.000 Degrees
- Event Number: 99
- Line Name: 046_1555
- Water Depth: 0.00
- Positioning System to Sensor: 0.3321

Dimensions and attributes

- Target Width: 0.82
- Target Height: 0.20
- Target Length: 1.07
- Target Shadow: 1.57
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

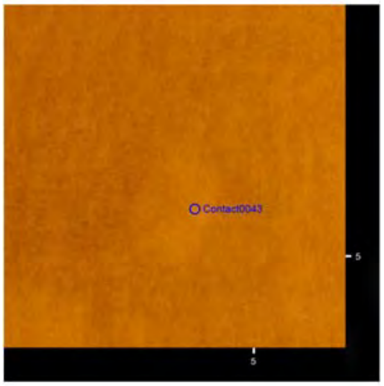
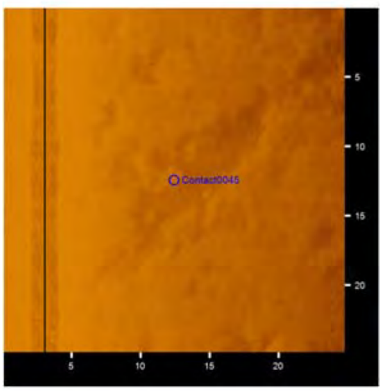
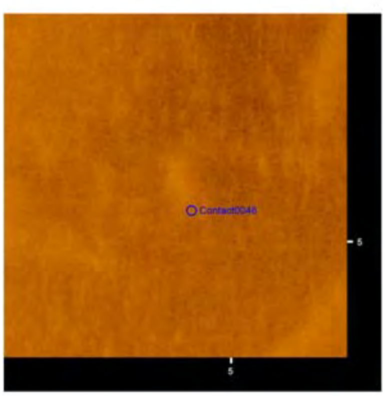


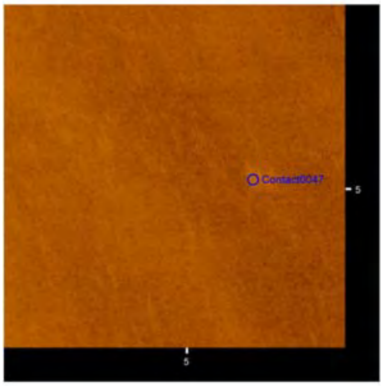
Contact0042

- Sonar Time at Target: 8/5/2015 4:21:50 PM
- Click Position
  35.5913216733 -75.4850236840 (WGS84)
  35.5911416969 -75.4854204647 (NAD27LL)
  35.5913216733 -75.4850236840 (LocalLL)
  (X) 456061.37 (Y) 3938729.84 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\046 1555.XTF
- Ping Number: 98321
- Range to target: 11.94
- Fish Height: 1.39
- Heading: 0.000 Degrees
- Event Number: 99
- Line Name: 046_1555
- Water Depth: 0.00
- Positioning System to Sensor: 0.1422

Dimensions and attributes

- Target Width: 0.53
- Target Height: 0.00
- Target Length: 0.96
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2: Crab Pot
- Area:
- Block:
- Description:

	**Contact0043** • Sonar Time at Target: 8/5/2015 3:40:07 PM • Click Position 35.6003470531 -75.4850501852 (WGS84) 35.6001670667 -75.4854467398 (NAD27LL) 35.6003470531 -75.4850501852 (LocalLL) (X) 456063.90 (Y) 3939730.84 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\047 1523.XTF • Ping Number: 33726 • Range to target: 9.33 • Fish Height: 1.44 • Heading: 0.000 Degrees • Event Number: 97 • Line Name: 047_1523 • Water Depth: 0.00 • Positioning System to Sensor: 0.9856	**Dimensions and attributes** • Target Width: 1.55 • Target Height: 0.27 • Target Length: 2.04 • Target Shadow: 2.24 • Mag Anomaly: • Avoidance Area: • Classification1: Unknown Feature • Classification2: • Area: • Block: • Description: Possible natural feature
	**Contact0045** • Sonar Time at Target: 8/6/2015 9:57:57 AM • Click Position 35.5949625404 -75.4864843576 (WGS84) 35.5947825662 -75.4868809812 (NAD27LL) 35.5949625404 -75.4864843576 (LocalLL) (X) 455931.04 (Y) 3939134.29 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\041 0950.XTF • Ping Number: 126276 • Range to target: 9.33 • Fish Height: 1.34 • Heading: 0.000 Degrees • Event Number: 109 • Line Name: 041_0950 • Water Depth: 0.00 • Positioning System to Sensor: 0.2036	**Dimensions and attributes** • Target Width: 1.13 • Target Height: 0.00 • Target Length: 1.07 • Target Shadow: 0.00 • Mag Anomaly: • Avoidance Area: • Classification1: Crab pot • Classification2: • Area: • Block: • Description:
	**Contact0046** • Sonar Time at Target: 8/6/2015 9:57:31 AM • Click Position 35.5946810875 -75.4864256077 (WGS84) 35.5945011134 -75.4868222410 (NAD27LL) 35.5946810875 -75.4864256077 (LocalLL) (X) 455936.21 (Y) 3939103.05 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\041 0950.XTF • Ping Number: 125603 • Range to target: 12.42 • Fish Height: 1.33 • Heading: 0.000 Degrees • Event Number: 109 • Line Name: 041_0950 • Water Depth: 0.00 • Positioning System to Sensor: 0.1236	**Dimensions and attributes** • Target Width: 0.90 • Target Height: 0.00 • Target Length: 1.39 • Target Shadow: 0.00 • Mag Anomaly: • Avoidance Area: • Classification1: Crab Pot • Classification2: • Area: • Block: • Description: crab pot seen on surface

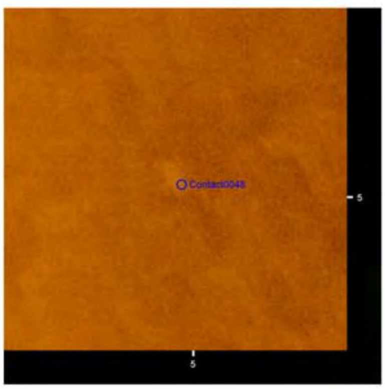


Contact0047

- Sonar Time at Target: 8/6/2015 3:15:55 PM
- Click Position
  35.6023565607 -75.4898825995 (WGS84)
  35.6021765923 -75.4902788844 (NAD27LL)
  35.6023565607 -75.4898825995 (LocalLL)
  (X) 455627.29 (Y) 3939955.88 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\030 1507.XTF
- Ping Number: 618621
- Range to target: 22.24
- Fish Height: 1.89
- Heading: 0.000 Degrees
- Event Number: 131
- Line Name: 030_1507
- Water Depth: 0.00
- Positioning System to Sensor: 0.5225

Dimensions and attributes

- Target Width: 0.79
- Target Height: 0.00
- Target Length: 0.67
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

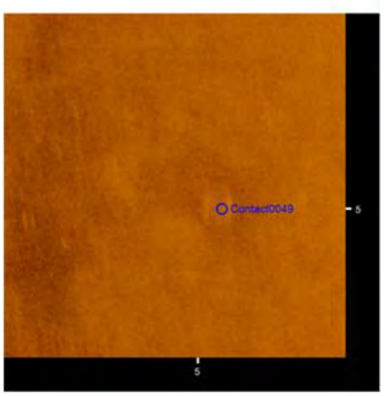


Contact0048

- Sonar Time at Target: 8/6/2015 3:12:42 PM
- Click Position
  35.6043370887 -75.4898943625 (WGS84)
  35.6041571178 -75.4902905976 (NAD27LL)
  35.6043370887 -75.4898943625 (LocalLL)
  (X) 455627.31 (Y) 3940175.54 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\030 1507.XTF
- Ping Number: 613636
- Range to target: 17.60
- Fish Height: 1.76
- Heading: 0.000 Degrees
- Event Number: 131
- Line Name: 030_1507
- Water Depth: 0.00
- Positioning System to Sensor: 0.1498

Dimensions and attributes

- Target Width: 0.46
- Target Height: 0.00
- Target Length: 0.89
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1:
- Classification2:
- Area:
- Block:
- Description:

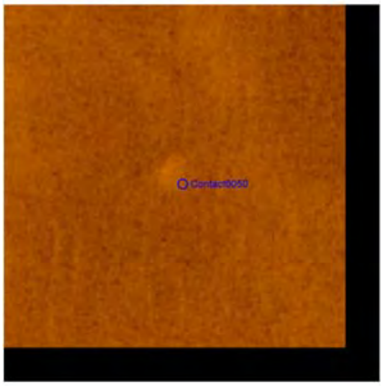


Contact0049

- Sonar Time at Target: 8/6/2015 1:16:37 PM
- Click Position
  35.6058951512 -75.4883825656 (WGS84)
  35.6057151722 -75.4887788305 (NAD27LL)
  35.6058951512 -75.4883825656 (LocalLL)
  (X) 455765.11 (Y) 3940347.66 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\034 1313.XTF
- Ping Number: 433887
- Range to target: 15.47
- Fish Height: 1.72
- Heading: 0.000 Degrees
- Event Number: 123
- Line Name: 034_1313
- Water Depth: 0.00
- Positioning System to Sensor: 0.7893

Dimensions and attributes

- Target Width: 0.75
- Target Height: 0.08
- Target Length: 0.57
- Target Shadow: 0.77
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

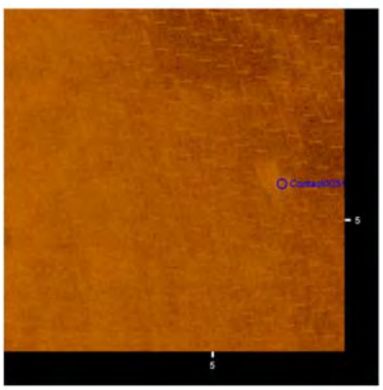


Contact0050

- Sonar Time at Target: 8/6/2015 1:35:35 PM
- Click Position
  35.5929633726 -75.4887147160 (WGS84)
  35.5927834106 -75.4891112881 (NAD27LL)
  35.5929633726 -75.4887147160 (LocalLL)
  (X) 455727.90 (Y) 3938913.57 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\034 1313.XTF
- Ping Number: 463251
- Range to target: 19.38
- Fish Height: 1.37
- Heading: 0.000 Degrees
- Event Number: 123
- Line Name: 034_1313
- Water Depth: 0.00
- Positioning System to Sensor: 0.4722

Dimensions and attributes

- Target Width: 0.41
- Target Height: 0.02
- Target Length: 0.55
- Target Shadow: 0.36
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:

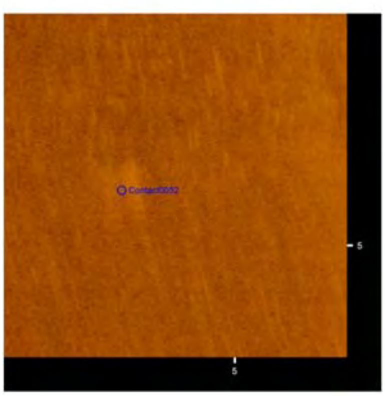


Contact0051

- Sonar Time at Target: 8/6/2015 12:23:09 PM
- Click Position
  35.6017953366 -75.4882134175 (WGS84)
  35.6016153619 -75.4886097923 (NAD27LL)
  35.6017953366 -75.4882134175 (LocalLL)
  (X) 455778.17 (Y) 3939892.88 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\036 1213.XTF
- Ping Number: 351116
- Range to target: 23.25
- Fish Height: 1.62
- Heading: 0.000 Degrees
- Event Number: 119
- Line Name: 036_1213
- Water Depth: 0.00
- Positioning System to Sensor: 0.1596

Dimensions and attributes

- Target Width: 0.81
- Target Height: 0.08
- Target Length: 0.94
- Target Shadow: 1.23
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:

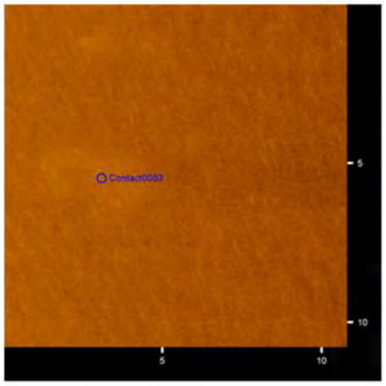


Contact0052

- Sonar Time at Target: 8/6/2015 12:25:34 PM
- Click Position
  35.6004417263 -75.4877592833 (WGS84)
  35.6002617512 -75.4881557124 (NAD27LL)
  35.6004417263 -75.4877592833 (LocalLL)
  (X) 455818.56 (Y) 3939742.55 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\036 1213.XTF
- Ping Number: 354852
- Range to target: 22.19
- Fish Height: 2.13
- Heading: 0.000 Degrees
- Event Number: 119
- Line Name: 036_1213
- Water Depth: 0.00
- Positioning System to Sensor: 0.8976

Dimensions and attributes

- Target Width: 0.78
- Target Height: 0.18
- Target Length: 1.03
- Target Shadow: 2.14
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

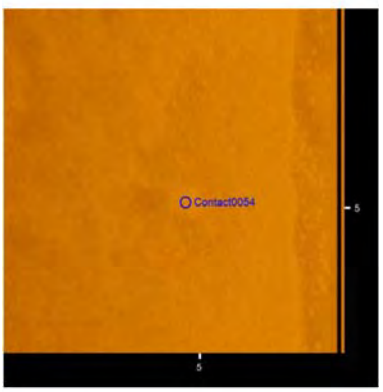


Contact0053

- Sonar Time at Target: 8/6/2015 12:26:48 PM
- Click Position
  35.5997794205 -75.4881873889 (WGS84)
  35.5995994481 -75.4885838150 (NAD27LL)
  35.5997794205 -75.4881873889 (LocalLL)
  (X) 455779.42 (Y) 3939669.29 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\036 1213.XTF
- Ping Number: 356764
- Range to target: 17.02
- Fish Height: 1.91
- Heading: 0.000 Degrees
- Event Number: 119
- Line Name: 036_1213
- Water Depth: 0.00
- Positioning System to Sensor: 0.0200

Dimensions and attributes

- Target Width: 3.41
- Target Height: 0.52
- Target Length: 1.41
- Target Shadow: 6.43
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:

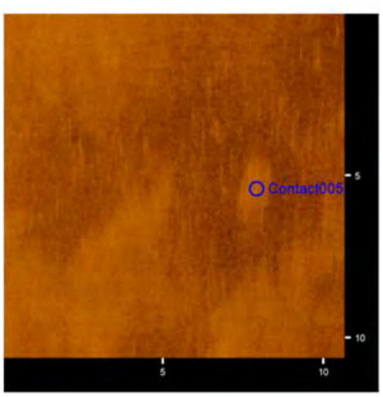


Contact0054

- Sonar Time at Target: 8/6/2015 12:36:59 PM
- Click Position
  35.5937166372 -75.4880142817 (WGS84)
  35.5935366712 -75.4884108668 (NAD27LL)
  35.5937166372 -75.4880142817 (LocalLL)
  (X) 455791.77 (Y) 3938996.80 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\036 1213.XTF
- Ping Number: 372537
- Range to target: 3.87
- Fish Height: 1.36
- Heading: 0.000 Degrees
- Event Number: 119
- Line Name: 036_1213
- Water Depth: 0.00
- Positioning System to Sensor: 0.1624

Dimensions and attributes

- Target Width: 0.54
- Target Height: 0.26
- Target Length: 0.56
- Target Shadow: 0.97
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

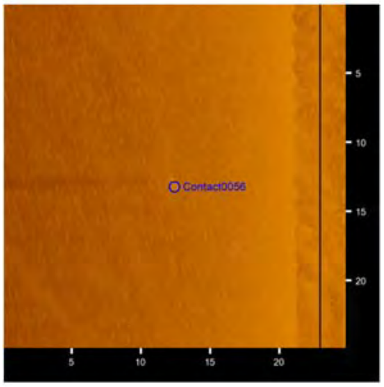
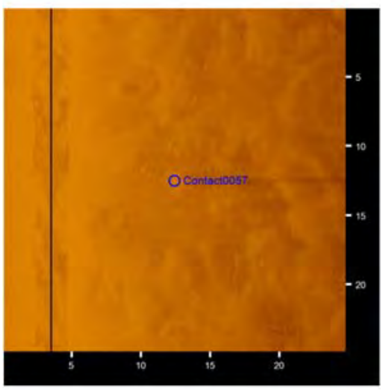
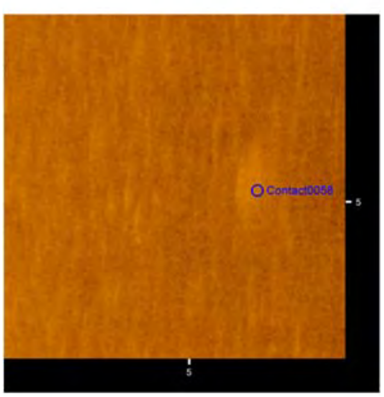


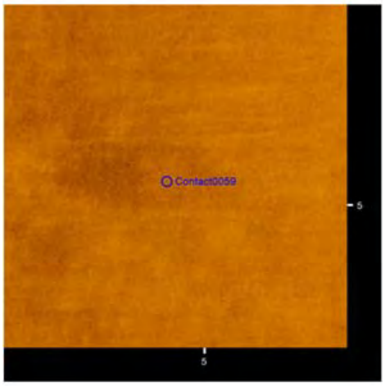
Contact0055

- Sonar Time at Target: 8/6/2015 11:44:12 AM
- Click Position
  35.5902441691 -75.4874207964 (WGS84)
  35.5900642046 -75.4878174950 (NAD27LL)
  35.5902441691 -75.4874207964 (LocalLL)
  (X) 455843.62 (Y) 3938611.41 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\037 1143.XTF
- Ping Number: 290812
- Range to target: 21.99
- Fish Height: 1.18
- Heading: 0.000 Degrees
- Event Number: 117
- Line Name: 037_1143
- Water Depth: 0.00
- Positioning System to Sensor: 0.3055

Dimensions and attributes

- Target Width: 0.00
- Target Height: 0.07
- Target Length: 1.39
- Target Shadow: 1.59
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab pot
- Classification2:
- Area:
- Block:
- Description:

<table>
<tr>
<td>
</td>
<td>Contact0056
• Sonar Time at Target: 8/6/2015 11:27:46 AM
• Click Position
35.6002303078 -75.4873115399 (WGS84)
35.6000503311 -75.4877079946 (NAD27LL)
35.6002303078 -75.4873115399 (LocalLL)
(X) 455859.00 (Y) 3939718.90 (Projected Coordinates)
• Map Projection: UTM84-18N
• Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\038 1117.XTF
• Ping Number: 265367
• Range to target: 10.54
• Fish Height: 2.09
• Heading: 0.000 Degrees
• Event Number: 115
• Line Name: 038_1117
• Water Depth: 0.00
• Positioning System to Sensor: 0.9712</td>
<td>Dimensions and attributes
• Target Width: 0.65
• Target Height: 1.08
• Target Length: 1.02
• Target Shadow: 11.68
• Mag Anomaly:
• Avoidance Area:
• Classification1: Unidentified Feature
• Classification2:
• Area:
• Block:
• Description:</td>
</tr>
<tr>
<td>
</td>
<td>Contact0057
• Sonar Time at Target: 8/6/2015 11:13:37 AM
• Click Position
35.6066498774 -75.4870629164 (WGS84)
35.6064698921 -75.4874592224 (NAD27LL)
35.6066498774 -75.4870629164 (LocalLL)
(X) 455885.05 (Y) 3940430.78 (Projected Coordinates)
• Map Projection: UTM84-18N
• Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\039 1049.XTF
• Ping Number: 243436
• Range to target: 8.89
• Fish Height: 1.44
• Heading: 0.000 Degrees
• Event Number: 113
• Line Name: 039_1049
• Water Depth: 0.00
• Positioning System to Sensor: 0.4828</td>
<td>Dimensions and attributes
• Target Width: 0.26
• Target Height: 0.81
• Target Length: 0.26
• Target Shadow: 11.76
• Mag Anomaly:
• Avoidance Area:
• Classification1: Unidentified Feature
• Classification2:
• Area:
• Block:
• Description:</td>
</tr>
<tr>
<td>
</td>
<td>Contact0058
• Sonar Time at Target: 8/10/2015 3:16:33 PM
• Click Position
35.5907493035 -75.4934145618 (WGS84)
35.5905693651 -75.4938109753 (NAD27LL)
35.5907493035 -75.4934145618 (LocalLL)
(X) 455300.91 (Y) 3938670.13 (Projected Coordinates)
• Map Projection: UTM84-18N
• Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\017 1453.XTF
• Ping Number: 360651
• Range to target: 22.38
• Fish Height: 1.69
• Heading: 0.000 Degrees
• Event Number: 158
• Line Name: 017_1453
• Water Depth: 0.00
• Positioning System to Sensor: 0.8064</td>
<td>Dimensions and attributes
• Target Width: 1.06
• Target Height: 0.12
• Target Length: 1.40
• Target Shadow: 1.75
• Mag Anomaly:
• Avoidance Area:
• Classification1: Possible Crab Pot
• Classification2:
• Area:
• Block:
• Description:</td>
</tr>
</table>

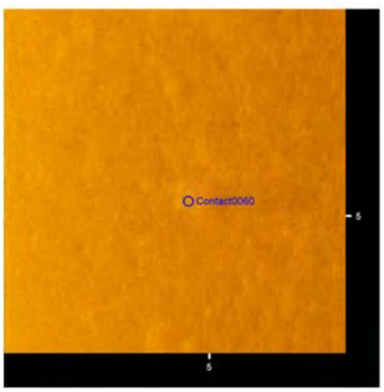


Contact0059

- Sonar Time at Target: 8/10/2015 2:35:27 PM
- Click Position
  35.6077361083 -75.4932122347 (WGS84)
  35.6075561469 -75.4936082344 (NAD27LL)
  35.6077361083 -75.4932122347 (LocalLL)
  (X) 455328.68 (Y) 3940554.02 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\018 1406.XTF
- Ping Number: 297026
- Range to target: 20.69
- Fish Height: 1.45
- Heading: 0.000 Degrees
- Event Number: 156
- Line Name: 018_1406
- Water Depth: 0.00
- Positioning System to Sensor: 0.0475

Dimensions and attributes

- Target Width: 1.20
- Target Height: 0.13
- Target Length: 0.98
- Target Shadow: 2.21
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:

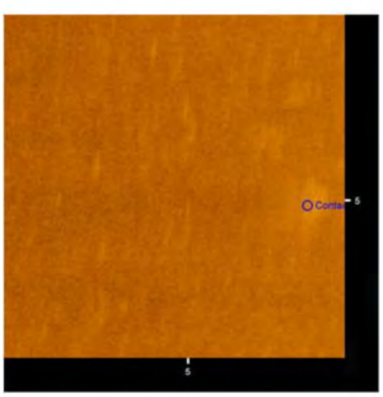


Contact0060

- Sonar Time at Target: 8/10/2015 2:33:27 PM
- Click Position
  35.6063825768 -75.4929143772 (WGS84)
  35.6062026158 -75.4933104241 (NAD27LL)
  35.6063825768 -75.4929143772 (LocalLL)
  (X) 455354.91 (Y) 3940403.77 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\018 1406.XTF
- Ping Number: 293927
- Range to target: 6.09
- Fish Height: 1.78
- Heading: 0.000 Degrees
- Event Number: 156
- Line Name: 018_1406
- Water Depth: 0.00
- Positioning System to Sensor: 1.1226

Dimensions and attributes

- Target Width: 0.69
- Target Height: 0.54
- Target Length: 0.51
- Target Shadow: 2.83
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

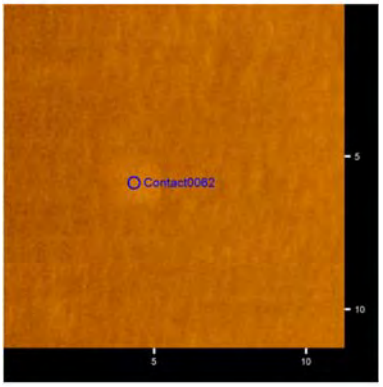
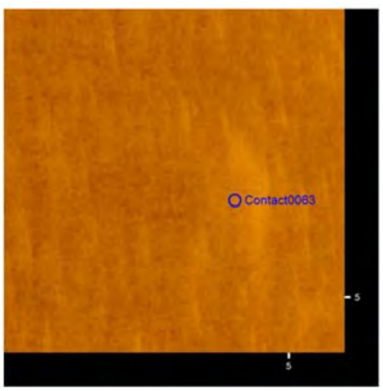
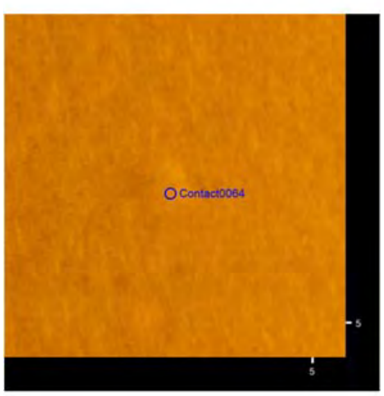


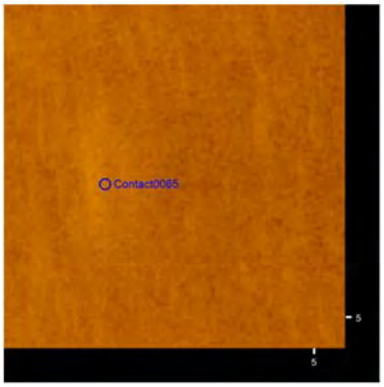
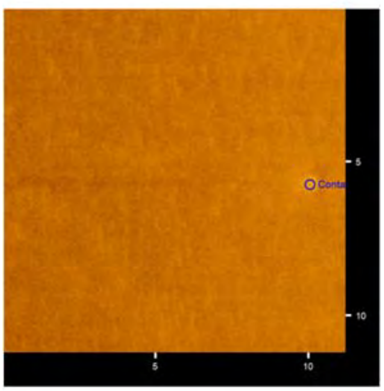
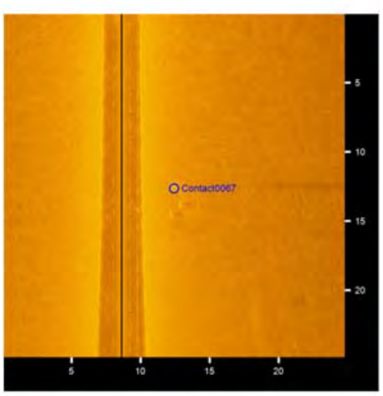
Contact0061

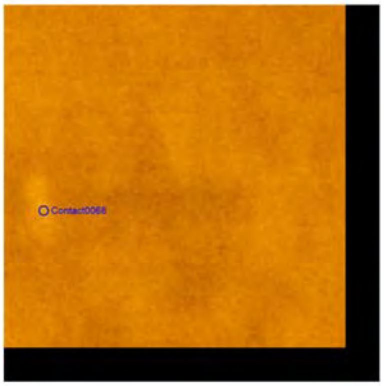
- Sonar Time at Target: 8/10/2015 1:47:50 PM
- Click Position
  35.5998896040 -75.4924878576 (WGS84)
  35.5997096497 -75.4928840856 (NAD27LL)
  35.5998896040 -75.4924878576 (LocalLL)
  (X) 455389.94 (Y) 3939683.45 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\019 1335.XTF
- Ping Number: 223296
- Range to target: 16.53
- Fish Height: 1.93
- Heading: 0.000 Degrees
- Event Number: 154
- Line Name: 019_1335
- Water Depth: 0.00
- Positioning System to Sensor: 0.9913

Dimensions and attributes

- Target Width: 0.80
- Target Height: 0.62
- Target Length: 0.91
- Target Shadow: 7.84
- Mag Anomaly:
- Avoidance Area:
- Classification1: Possible Crab Pot
- Classification2:
- Area:
- Block:
- Description:

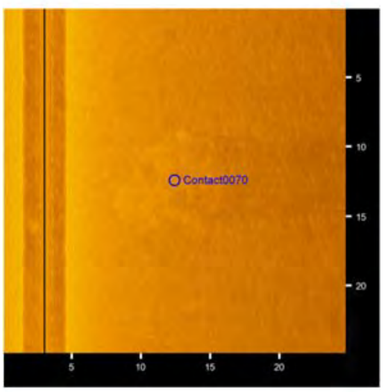
	**Contact0062** • Sonar Time at Target: 8/10/2015 1:27:41 PM • Click Position 35.6033690168 -75.4926359408 (WGS84) 35.6031890586 -75.4930320754 (NAD27LL) 35.6033690168 -75.4926359408 (LocalLL) (X) 455378.45 (Y) 3940069.41 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\020 1310.XTF • Ping Number: 192084 • Range to target: 20.40 • Fish Height: 1.94 • Heading: 0.000 Degrees • Event Number: 152 • Line Name: 020_1310 • Water Depth: 0.00 • Positioning System to Sensor: 0.4017	**Dimensions and attributes** • Target Width: 1.19 • Target Height: 0.00 • Target Length: 1.13 • Target Shadow: 0.00 • Mag Anomaly: • Avoidance Area: • Classification1: Possible Crab Pot • Classification2: • Area: • Block: • Description:
	**Contact0063** • Sonar Time at Target: 8/10/2015 12:52:56 PM • Click Position 35.6017453033 -75.4919836701 (WGS84) 35.6015653444 -75.4923798748 (NAD27LL) 35.6017453033 -75.4919836701 (LocalLL) (X) 455436.63 (Y) 3939889.04 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\021 1245.XTF • Ping Number: 138284 • Range to target: 14.36 • Fish Height: 2.02 • Heading: 0.000 Degrees • Event Number: 150 • Line Name: 021_1245 • Water Depth: 0.00 • Positioning System to Sensor: 0.7686	**Dimensions and attributes** • Target Width: 0.99 • Target Height: 0.24 • Target Length: 0.98 • Target Shadow: 2.03 • Mag Anomaly: • Avoidance Area: • Classification1: Possible Crab Pot • Classification2: • Area: • Block: • Description:
	**Contact0064** • Sonar Time at Target: 8/10/2015 11:40:15 AM • Click Position 35.5993599764 -75.4913890217 (WGS84) 35.5991800180 -75.4917853128 (NAD27LL) 35.5993599764 -75.4913890217 (LocalLL) (X) 455489.18 (Y) 3939624.21 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\024 1126.XTF • Ping Number: 25746 • Range to target: 9.23 • Fish Height: 1.95 • Heading: 0.000 Degrees • Event Number: 144 • Line Name: 024_1126 • Water Depth: 0.00 • Positioning System to Sensor: 0.6610	**Dimensions and attributes** • Target Width: 0.65 • Target Height: 0.21 • Target Length: 0.57 • Target Shadow: 1.17 • Mag Anomaly: • Avoidance Area: • Classification1: Unidentified Feature • Classification2: • Area: • Block: • Description:

	**Contact0065** • Sonar Time at Target: 8/10/2015 11:38:59 AM • Click Position 35.5984495204 -75.4910556033 (WGS84) 35.5982695618 -75.4914519323 (NAD27LL) 35.5984495204 -75.4910556033 (LocalLL) (X) 455518.88 (Y) 3939523.09 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\024_1126.XTF • Ping Number: 23773 • Range to target: 20.88 • Fish Height: 1.84 • Heading: 0.000 Degrees • Event Number: 144 • Line Name: 024_1126 • Water Depth: 0.00 • Positioning System to Sensor: 0.0676	**Dimensions and attributes** • Target Width: 0.77 • Target Height: 0.26 • Target Length: 1.38 • Target Shadow: 3.45 • Mag Anomaly: • Avoidance Area: • Classification1: Possible Crab Pot • Classification2: • Area: • Block: • Description:
	**Contact0066** • Sonar Time at Target: 8/13/2015 4:22:08 PM • Click Position 35.6046418479 -75.4978183748 (WGS84) 35.6044619096 -75.4982142423 (NAD27LL) 35.6046418479 -75.4978183748 (LocalLL) (X) 454909.75 (Y) 3940212.94 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\001_1557.XTF • Ping Number: 714061 • Range to target: 14.70 • Fish Height: 1.79 • Heading: 0.000 Degrees • Event Number: 190 • Line Name: 001_1557 • Water Depth: 0.00 • Positioning System to Sensor: 0.1235	**Dimensions and attributes** • Target Width: 0.37 • Target Height: 0.69 • Target Length: 0.51 • Target Shadow: 9.30 • Mag Anomaly: • Avoidance Area: • Classification1: Unknown Feature • Classification2: • Area: • Block: • Description: Possible chanel marker
	**Contact0067** • Sonar Time at Target: 8/13/2015 4:20:53 PM • Click Position 35.6038629371 -75.4976315015 (WGS84) 35.6036829991 -75.4980273968 (NAD27LL) 35.6038629371 -75.4976315015 (LocalLL) (X) 454926.24 (Y) 3940126.47 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\001_1557.XTF • Ping Number: 712103 • Range to target: 3.77 • Fish Height: 1.40 • Heading: 0.000 Degrees • Event Number: 190 • Line Name: 001_1557 • Water Depth: 0.00 • Positioning System to Sensor: 0.2451	**Dimensions and attributes** • Target Width: 0.67 • Target Height: 1.04 • Target Length: 0.68 • Target Shadow: 11.87 • Mag Anomaly: • Avoidance Area: • Classification1: buoy • Classification2: • Area: • Block: • Description: Possible Chanel Marker



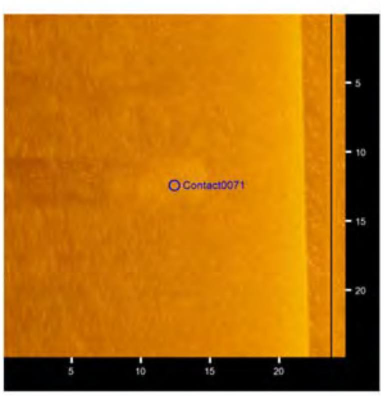
Contact0068
- Sonar Time at Target: 8/13/2015 4:01:23 PM
- Click Position
  35.5916932851 -75.4975191271 (WGS84)
  35.5915133637 -75.4979153306 (NAD27LL)
  35.5916932851 -75.4975191271 (LocalLL)
  (X) 454929.60 (Y) 3938776.70 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\001 1557.XTF
- Ping Number: 681931
- Range to target: 9.91
- Fish Height: 1.17
- Heading: 0.000 Degrees
- Event Number: 190
- Line Name: 001_1557
- Water Depth: 0.00
- Positioning System to Sensor: 0.0384

Dimensions and attributes
- Target Width: 0.33
- Target Height: 0.26
- Target Length: 0.59
- Target Shadow: 2.89
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:



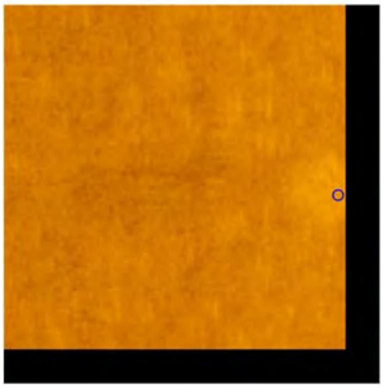
Contact0070
- Sonar Time at Target: 8/13/2015 3:35:34 PM
- Click Position
  35.6031000585 -75.4974874454 (WGS84)
  35.6029201210 -75.4978833663 (NAD27LL)
  35.6031000585 -75.4974874454 (LocalLL)
  (X) 454938.86 (Y) 3940041.80 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\002 1528.XTF
- Ping Number: 641954
- Range to target: 9.38
- Fish Height: 1.61
- Heading: 0.000 Degrees
- Event Number: 188
- Line Name: 002_1528
- Water Depth: 0.00
- Positioning System to Sensor: 1.0909

Dimensions and attributes
- Target Width: 8.03
- Target Height: 0.76
- Target Length: 7.11
- Target Shadow: 8.67
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:



Contact0071
- Sonar Time at Target: 8/13/2015 3:34:15 PM
- Click Position
  35.6040050603 -75.4972789553 (WGS84)
  35.6038251206 -75.4976748631 (NAD27LL)
  35.6040050603 -75.4972789553 (LocalLL)
  (X) 454958.26 (Y) 3940142.07 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\002 1528.XTF
- Ping Number: 639907
- Range to target: 11.36
- Fish Height: 2.15
- Heading: 0.000 Degrees
- Event Number: 188
- Line Name: 002_1528
- Water Depth: 0.00
- Positioning System to Sensor: 0.6823

Dimensions and attributes
- Target Width: 4.93
- Target Height: 0.97
- Target Length: 3.16
- Target Shadow: 9.60
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:

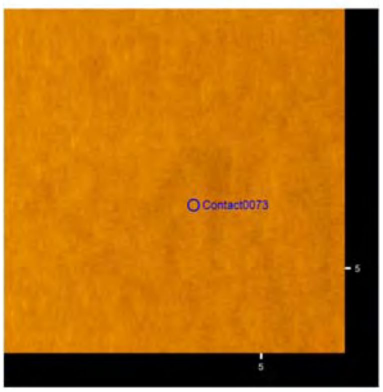


Contact0072

- Sonar Time at Target: 8/13/2015 3:29:50 PM
- Click Position
  35.6071127908 -75.4973115905 (WGS84)
  35.6069328469 -75.4977074194 (NAD27LL)
  35.6071127908 -75.4973115905 (LocalLL)
  (X) 454957.04 (Y) 3940486.76 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\002 1528.XTF
- Ping Number: 633057
- Range to target: 7.88
- Fish Height: 1.70
- Heading: 0.000 Degrees
- Event Number: 188
- Line Name: 002_1528
- Water Depth: 0.00
- Positioning System to Sensor: 0.1981

Dimensions and attributes

- Target Width: 0.97
- Target Height: 0.41
- Target Length: 0.99
- Target Shadow: 2.59
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

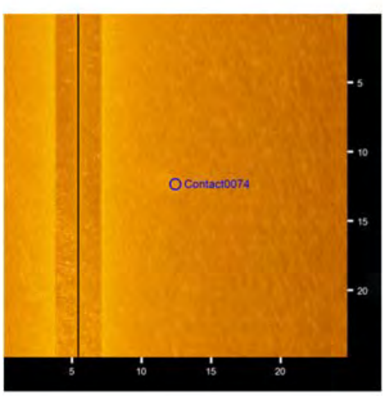


Contact0073

- Sonar Time at Target: 8/13/2015 2:34:07 PM
- Click Position
  35.6026650297 -75.4969492367 (WGS84)
  35.6024850905 -75.4973451929 (NAD27LL)
  35.6026650297 -75.4969492367 (LocalLL)
  (X) 454987.37 (Y) 3939993.30 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\004 1427.XTF
- Ping Number: 546786
- Range to target: 11.36
- Fish Height: 1.74
- Heading: 0.000 Degrees
- Event Number: 184
- Line Name: 004_1427
- Water Depth: 0.00
- Positioning System to Sensor: 1.2850

Dimensions and attributes

- Target Width: 0.81
- Target Height: 0.05
- Target Length: 0.83
- Target Shadow: 0.39
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:

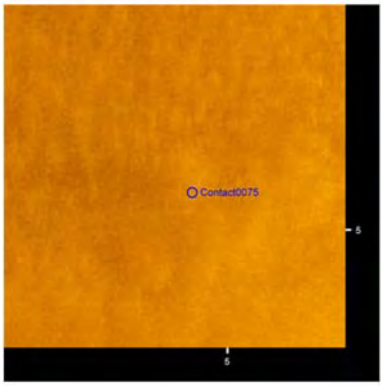


Contact0074

- Sonar Time at Target: 8/13/2015 2:24:52 PM
- Click Position
  35.6072208029 -75.4964954224 (WGS84)
  35.6070408555 -75.4968912858 (NAD27LL)
  35.6072208029 -75.4964954224 (LocalLL)
  (X) 455031.03 (Y) 3940498.37 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\005 1400.XTF
- Ping Number: 532472
- Range to target: 6.96
- Fish Height: 1.76
- Heading: 0.000 Degrees
- Event Number: 182
- Line Name: 005_1400
- Water Depth: 0.00
- Positioning System to Sensor: 0.3224

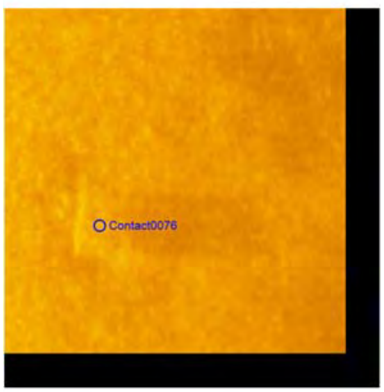
Dimensions and attributes

- Target Width: 1.27
- Target Height: 0.00
- Target Length: 1.40
- Target Shadow: 0.00
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description:



Contact0075
- Sonar Time at Target: 8/13/2015 2:49:23 PM
- Click Position
  35.5917472970 -75.4966772652 (WGS84)
  35.5915673718 -75.4970735055 (NAD27LL)
  35.5917472970 -75.4966772652 (LocalLL)
  (X) 455005.90 (Y) 3938782.31 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\004 1427.XTF
- Ping Number: 570439
- Range to target: 9.86
- Fish Height: 1.25
- Heading: 0.000 Degrees
- Event Number: 184
- Line Name: 004_1427
- Water Depth: 0.00
- Positioning System to Sensor: 0.5888

Dimensions and attributes
- Target Width: 0.81
- Target Height: 0.29
- Target Length: 1.13
- Target Shadow: 3.03
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unknown Feature
- Classification2:
- Area:
- Block:
- Description: Possible Natural Feature

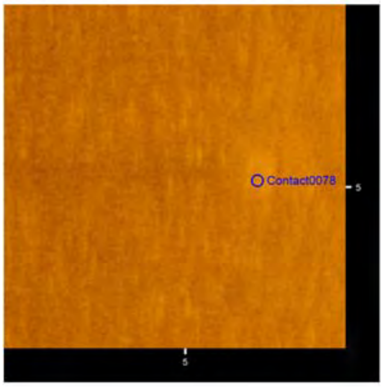
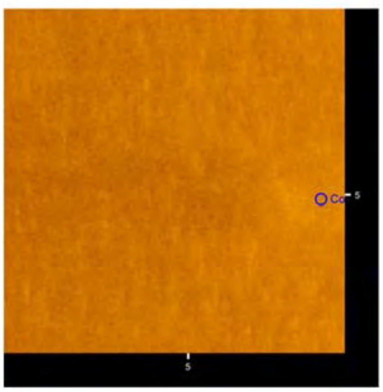
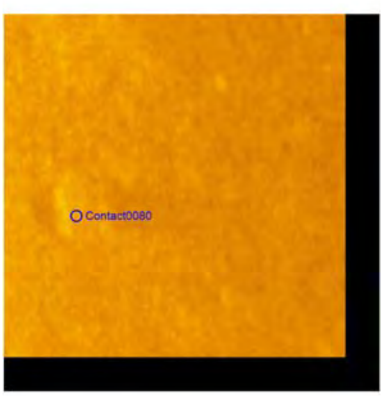


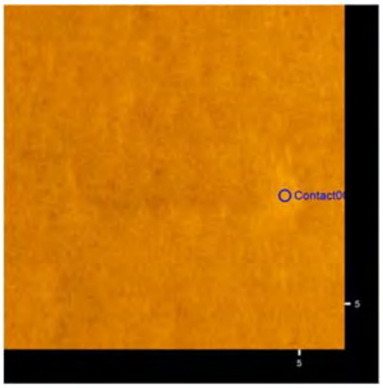
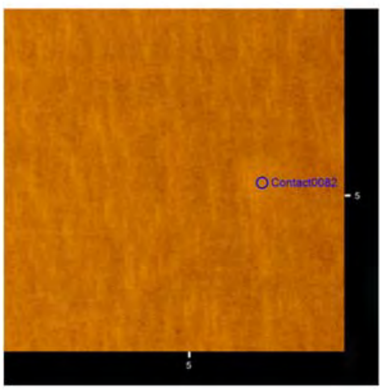
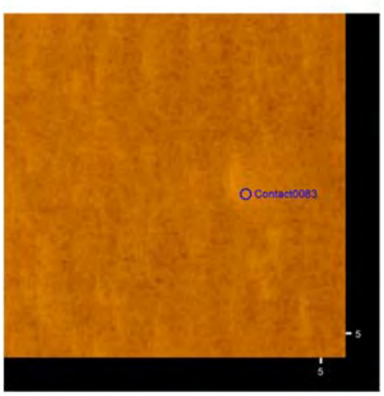
Contact0076
- Sonar Time at Target: 8/13/2015 2:03:09 PM
- Click Position
  35.5916300956 -75.4964627072 (WGS84)
  35.5914501696 -75.4968589602 (NAD27LL)
  35.5916300956 -75.4964627072 (LocalLL)
  (X) 455025.27 (Y) 3938769.21 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\005 1400.XTF
- Ping Number: 498842
- Range to target: 3.34
- Fish Height: 1.27
- Heading: 0.000 Degrees
- Event Number: 182
- Line Name: 005_1400
- Water Depth: 0.00
- Positioning System to Sensor: 0.0314

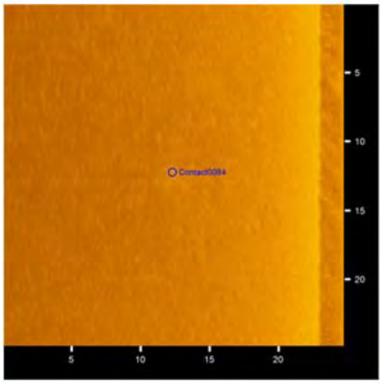
Dimensions and attributes
- Target Width: 0.46
- Target Height: 0.36
- Target Length: 0.63
- Target Shadow: 1.46
- Mag Anomaly:
- Avoidance Area:
- Classification1: Crab Pot
- Classification2:
- Area:
- Block:
- Description:

Contact0077
- Sonar Time at Target: 8/13/2015 1:53:17 PM
- Click Position
  35.5931972919 -75.4962913597 (WGS84)
  35.5930173630 -75.4966875814 (NAD27LL)
  35.5931972919 -75.4962913597 (LocalLL)
  (X) 455041.67 (Y) 3938942.95 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\006 1334.XTF
- Ping Number: 483563
- Range to target: 5.17
- Fish Height: 1.35
- Heading: 0.000 Degrees
- Event Number: 180
- Line Name: 006_1334
- Water Depth: 0.00
- Positioning System to Sensor: 1.3092

Dimensions and attributes
- Target Width: 2.50
- Target Height: 0.40
- Target Length: 2.37
- Target Shadow: 2.34
- Mag Anomaly:
- Avoidance Area:
- Classification1: Buoy
- Classification2:
- Area:
- Block:
- Description:

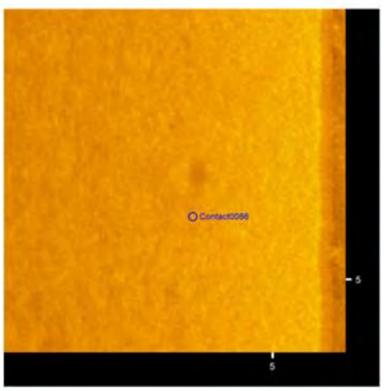
	**Contact0078** • Sonar Time at Target: 8/13/2015 1:40:43 PM • Click Position 35.6026604521 -75.4960691901 (WGS84) 35.6024805092 -75.4964651863 (NAD27LL) 35.6026604521 -75.4960691901 (LocalLL) (X) 455067.08 (Y) 3939992.39 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\006 1334.XTF • Ping Number: 464104 • Range to target: 17.79 • Fish Height: 1.84 • Heading: 0.000 Degrees • Event Number: 180 • Line Name: 006_1334 • Water Depth: 0.00 • Positioning System to Sensor: 1.3217	**Dimensions and attributes** • Target Width: 0.79 • Target Height: 0.48 • Target Length: 1.21 • Target Shadow: 6.35 • Mag Anomaly: • Avoidance Area: • Classification1: • Classification2: • Area: • Block: • Description:
	**Contact0079** • Sonar Time at Target: 8/13/2015 1:23:06 PM • Click Position 35.6006450756 -75.4961070374 (WGS84) 35.6004651357 -75.4965030821 (NAD27LL) 35.6006450756 -75.4961070374 (LocalLL) (X) 455062.53 (Y) 3939768.89 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\007 1307.XTF • Ping Number: 436827 • Range to target: 10.88 • Fish Height: 1.56 • Heading: 0.000 Degrees • Event Number: 178 • Line Name: 007_1307 • Water Depth: 0.00 • Positioning System to Sensor: 1.1130	**Dimensions and attributes** • Target Width: 2.21 • Target Height: 0.56 • Target Length: 2.16 • Target Shadow: 6.19 • Mag Anomaly: • Avoidance Area: • Classification1: Unknown Feature • Classification2: • Area: • Block: • Description:
	**Contact0080** • Sonar Time at Target: 8/13/2015 1:19:36 PM • Click Position 35.5980093213 -75.4959310988 (WGS84) 35.5978293842 -75.4963272171 (NAD27LL) 35.5980093213 -75.4959310988 (LocalLL) (X) 455076.99 (Y) 3939476.48 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\007 1307.XTF • Ping Number: 431410 • Range to target: 4.06 • Fish Height: 1.31 • Heading: 0.000 Degrees • Event Number: 178 • Line Name: 007_1307 • Water Depth: 0.00 • Positioning System to Sensor: 1.1983	**Dimensions and attributes** • Target Width: 0.53 • Target Height: 0.18 • Target Length: 0.76 • Target Shadow: 0.71 • Mag Anomaly: • Avoidance Area: • Classification1: Crab Pot • Classification2: • Area: • Block: • Description: Possible crab pot

 	**Contact0081** • Sonar Time at Target: 8/13/2015 12:49:25 PM • Click Position 35.6009208835 -75.4956105036 (WGS84) 35.6007409411 -75.4960065641 (NAD27LL) 35.6009208835 -75.4956105036 (LocalLL) (X) 455107.66 (Y) 3939799.25 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\008 1240.XTF • Ping Number: 384681 • Range to target: 8.80 • Fish Height: 1.71 • Heading: 0.000 Degrees • Event Number: 176 • Line Name: 008_1240 • Water Depth: 0.00 • Positioning System to Sensor: 0.1433	**Dimensions and attributes** • Target Width: 0.57 • Target Height: 0.41 • Target Length: 0.76 • Target Shadow: 2.85 • Mag Anomaly: • Avoidance Area: • Classification1: Crab Pot • Classification2: • Area: • Block: • Description: Possible crab pot
 	**Contact0082** • Sonar Time at Target: 8/13/2015 12:41:45 PM • Click Position 35.6066984647 -75.4959895904 (WGS84) 35.6065185160 -75.4963854898 (NAD27LL) 35.6066984647 -75.4959895904 (LocalLL) (X) 455076.55 (Y) 3940440.21 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\008 1240.XTF • Ping Number: 372805 • Range to target: 22.53 • Fish Height: 1.86 • Heading: 0.000 Degrees • Event Number: 176 • Line Name: 008_1240 • Water Depth: 0.00 • Positioning System to Sensor: 1.2095	**Dimensions and attributes** • Target Width: 0.81 • Target Height: 0.10 • Target Length: 0.84 • Target Shadow: 1.29 • Mag Anomaly: • Avoidance Area: • Classification1: Unidentified Feature • Classification2: • Area: • Block: • Description:
 	**Contact0083** • Sonar Time at Target: 8/13/2015 11:47:51 AM • Click Position 35.6036386335 -75.4954123859 (WGS84) 35.6034586865 -75.4958083876 (NAD27LL) 35.6036386335 -75.4954123859 (LocalLL) (X) 455127.12 (Y) 3940100.58 (Projected Coordinates) • Map Projection: UTM84-18N • Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\010 1142.XTF • Ping Number: 289346 • Range to target: 21.46 • Fish Height: 1.93 • Heading: 0.000 Degrees • Event Number: 172 • Line Name: 010_1142 • Water Depth: 0.00 • Positioning System to Sensor: 0.9843	**Dimensions and attributes** • Target Width: 0.32 • Target Height: 0.11 • Target Length: 0.37 • Target Shadow: 1.39 • Mag Anomaly: • Avoidance Area: • Classification1: Unidentified Feature • Classification2: • Area: • Block: • Description:



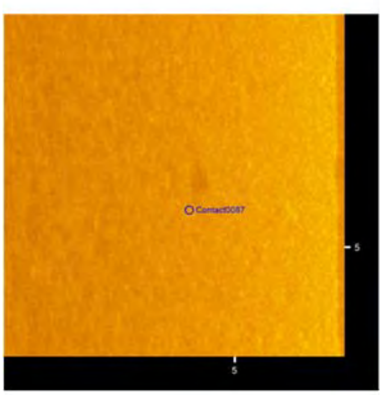
Contact0084
- Sonar Time at Target: 8/13/2015 9:30:04 AM
- Click Position
  35.6005525883 -75.4939383094 (WGS84)
  35.6003726393 -75.4943344550 (NAD27LL)
  35.6005525883 -75.4939383094 (LocalLL)
  (X) 455258.92 (Y) 3939757.64 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\015_0908.XTF
- Ping Number: 76009
- Range to target: 12.47
- Fish Height: 1.93
- Heading: 0.000 Degrees
- Event Number: 162
- Line Name: 015_0908
- Water Depth: 0.00
- Positioning System to Sensor: 0.6072

Dimensions and attributes
- Target Width: 0.41
- Target Height: 0.90
- Target Length: 0.36
- Target Shadow: 11.31
- Mag Anomaly:
- Avoidance Area:
- Classification1: Possible Crab Pot
- Classification2:
- Area:
- Block:
- Description:



Contact0086
- Sonar Time at Target: 8/13/2015 9:35:36 AM
- Click Position
  35.6033588261 -75.4938726650 (WGS84)
  35.6031788731 -75.4942687436 (NAD27LL)
  35.6033588261 -75.4938726650 (LocalLL)
  (X) 455266.43 (Y) 3940068.85 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\015_0908.XTF
- Ping Number: 84587
- Range to target: 4.11
- Fish Height: 2.06
- Heading: 0.000 Degrees
- Event Number: 162
- Line Name: 015_0908
- Water Depth: 0.00
- Positioning System to Sensor: 0.0094

Dimensions and attributes
- Target Width: 0.39
- Target Height: 0.09
- Target Length: 0.49
- Target Shadow: 0.23
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:



Contact0087
- Sonar Time at Target: 8/13/2015 9:35:07 AM
- Click Position
  35.6030936453 -75.4938671086 (WGS84)
  35.6029136927 -75.4942631941 (NAD27LL)
  35.6030936453 -75.4938671086 (LocalLL)
  (X) 455266.78 (Y) 3940039.43 (Projected Coordinates)
- Map Projection: UTM84-18N
- Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\015_0908.XTF
- Ping Number: 83846
- Range to target: 5.08
- Fish Height: 2.11
- Heading: 0.000 Degrees
- Event Number: 162
- Line Name: 015_0908
- Water Depth: 0.00
- Positioning System to Sensor: 0.3226

Dimensions and attributes
- Target Width: 0.25
- Target Height: 0.11
- Target Length: 0.74
- Target Shadow: 0.31
- Mag Anomaly:
- Avoidance Area:
- Classification1: Unidentified Feature
- Classification2:
- Area:
- Block:
- Description:

	Contact0089 ● Sonar Time at Target: 8/13/2015 11:15:36 AM ● Click Position 35.5924477001 -75.4948065217 (WGS84) 35.5922677657 -75.4952028296 (NAD27LL) 35.5924477001 -75.4948065217 (LocalLL) (X) 455175.76 (Y) 3938859.13 (Projected Coordinates) ● Map Projection: UTM84-18N ● Acoustic Source File: C:\HYPACK 2013\Projects\Rodanthe2015\Raw\011_1110.XTF ● Ping Number: 239422 ● Range to target: 3.87 ● Fish Height: 1.34 ● Heading: 0.000 Degrees ● Event Number: 170 ● Line Name: 011_1110 ● Water Depth: 0.00 ● Positioning System to Sensor: 0.1194	**Dimensions and attributes** ● Target Width: 0.96 ● Target Height: 0.00 ● Target Length: 0.89 ● Target Shadow: 0.00 ● Mag Anomaly: ● Avoidance Area: ● Classification1: Unidentified Feature ● Classification2: ● Area: ● Block: ● Description:

Back-Barrier Sediment and Hydrodynamic Processes: Insights from Rodanthe, NC

by

Christopher J. Cornette

APPROVED BY:
D. Reide Corbett, PhD
J.P. Walsh, PhD
David Mallinson, PhD
Michael Piehler, PhD
Stephen Culver, PhD
Paul Gemperline, PhD

1.0 INTRODUCTION

Barrier islands are found around the world, and they are important ecologically and economically (Stutz and Pilkey, 2001; Feagin et al., 2010). Their natural geomorphic evolution is related to ocean and estuarine processes including sediment mobilization and shoreline evolution on both the ocean and estuarine side of the land (Riggs et al., 1995; Timmons et al., 2010; Riggs et al., 2011). Change occurs related to many short-term (days) events (e.g., hurricanes, nor'easters) and longer-term evolution over years to decades as geomorphic responses. In modern barrier environments, anthropogenic impacts add another facet to barrier evolution (Riggs et al., 2009; Timmons et al., 2010). Further understanding of the complex interplay of modern processes and anthropogenic forcings in the back-barrier environment is necessary for predicting barrier island evolution.

This research occurs along the Outer Banks (OBX) of North Carolina, which is a series of dynamic barrier landforms, and its evolution has been influenced by both natural and artificial processes (Culver et al., 2006; Riggs et al., 2009; Currin and Deaton, 2010). Landward of the OBX is the Albemarle Pamlico Sound Estuarine System, the second largest estuary in the U.S. Back-barrier environments in the system are extensive with over 1500 km of estuarine shoreline in Dare County (McVerry, 2012). The town of Rodanthe, NC is a small unincorporated town on Hatteras Island that is bound to the north by Pea Island National Wildlife Refuge and to the south by the towns of Waves and Salvo. This study aims to better understand the interface of the back-barrier and sound in and near the town of Rodanthe, NC.

Like other barriers, the OBX is made up of a patchwork of habitats that make up the coastal landforms of barrier islands (Fig. 1), and these areas may show rapid change in response to winds, waves and currents. In addition, tides drive water flow through inlets and influence flooding of the beach and back-barrier habitats. The underlying geology is the platform upon which this system operates, and it may influence the dynamics such as inducing erosional hot spots (Riggs et al., 1995; McNinch, 2004; Miselis and McNinch, 2006). Human influence on barrier islands (e.g. shoreline hardening, nourishment, navigational channels) further complicates barrier dynamics and influences long-term barrier evolution (Culver et al., 2006; Riggs et al., 2009). Barrier islands are diverse in their processes and interactions between these processes and the natural and man-made environments are complicated.

This study aims to improve our understanding of the natural and human processes acting on the modern back-barrier system of Hatteras Island. Through observations and measurements of shoreline change, waves, currents, and sediment characteristics, the relationships between physical processes, anthropogenic activities and the changing shallow-water habitat were evaluated. Specific objectives of this project were to: 1) measure spatial and temporal patterns of shoreline change using aerial imagery and RTK-GPS and quantify shoreline erosion as a potential source of sediment into the study region; 2) characterize the sediments and evaluate their relation to physical forces (e.g., waves, currents) that act to move and deposit material in and beyond the study area; and 3) evaluate bathymetric dynamics and the spatial extent and persistence of SAV in the study region as both are important for management characteristics.

2.0 BACKGROUND

2.1 Geologic History

The morphology and stratigraphy of the modern OBX barrier system has an important relation to the Last Glacial Maximum, ~18,000 years BP (Mallinson et al., 2005; Clark et al., 2009). Since that time, paleo-river valleys of Pamlico Creek and the Tar and Neuse rivers were flooded as sea level rose leading to the unique estuarine morphology of today (Mallinson et al., 2010). Pamlico Creek (modern Pamlico Sound) was a body of water separated from the eastern barrier islands and the ocean by a high-elevation peninsular region known as the Hatteras Flats Interstream Divide. However, at approximately 5,000 years BP the interstream divide was inundated by rising seas forming what is the present day Pamlico Sound (Riggs and Ames, 2003; Mallinson et al., 2005; Culver et al., 2007; Zarimba et al., in press).

Exchange between the Pamlico Sound and the Atlantic occurs at several inlets through the islands. Historically, inlets have opened and closed at various locations throughout the region with major inlets existing for several centuries (Fig. 2) (Riggs, 1995; Mallinson et al., 2010; Riggs, 2009). New Inlet is the closest inlet to the study area in modern history. Based on historical accounts, it opened in the 1700s and separated Bodie Island and Hatteras Island, but began to shoal after the opening of Oregon Inlet in 1846. New Inlet closed completely in 1922 (Stick, 1958; Fisher, 1967; Riggs et al., 2009). It briefly reopened in 1933 to 1945, and in 2011 Hurricane Irene breached the island forming “New” New Inlet (aka Irene Inlet) (Clinch et al., 2012; Mulligan et al., 2014). The two modern inlets that bound Hatteras Island are Oregon Inlet to the north of the study area and Hatteras Inlet to the southwest. Hatteras inlet opened with Oregon Inlet in 1846 due to a strong hurricane (Mallinson et al., 2010).

Ground penetrating radar surveys, coring and optically stimulated luminescence dating were used by Mallinson et al. (2010) to detail the great extent of paleo-inlet channels across the Outer Banks. It has been demonstrated that portions of Hatteras Flats are composed of relict flood tidal deltas that were deposited during a period of high storm frequency and active open marine exchange between the Pamlico Sound and Atlantic Ocean approximately 1000 calendar years BP, during the Medieval Climate Anomaly (Fig. 3) (Culver et al., 2006; Mallinson et al., 2011; Peek et al., 2013). Peake et al. (2013) address the origin of sand bars that establish bathymetric relief on the subtidal back-barrier platform. The platform of Hatteras Flats provides a stage for modern processes.

2.2 Pea Island and Rodanthe Back-Barrier

The area around Rodanthe has a diversity of back-barrier environments adjacent to Pamlico Sound with shoreline types that include marshes, sediment banks, and human modified areas. The boundaries of this study extended slightly north and south of Rodanthe to encompass a broader perspective on processes (Fig. 4). To the north of Rodanthe is the Pea Island National Wildlife Refuge, a federally protected and managed area with expansive back-barrier marshes and channels with little development. To the south lie the towns of Waves, Salvo, Avon and eventually Buxton near Cape Hatteras. In the center of Rodanthe is an emergency ferry terminal that serves as a means of transportation when the road (i.e., Hwy 12) is impassable due to island overwash or other closures. The area adjacent to the ferry terminal is marsh that extends further soundward than the nearby back-barrier shoreline. Hatteras Flats is a subtidal shoal that extends ~4 km landward (into the sound) of the back-barrier shoreline (Riggs et al., 2009; Riggs et al., 1995). The Flats are continuous from Pea Island through Ocracoke Island but have variable sound-ward extent (Riggs et al., 2009).

2.3 Hydrodynamics

The astronomical tidal range is low in the APES due to its shallow nature and restricted inlet flow (Reed et al., 2008; Luettich et al., 2000; Benninger and Wells, 1993). Predicted tides for Rodanthe have a range of ~30 cm (NOAA Station 8653215, Rodanthe, NC). Currents related to the tides are minimal; currents in the APES are enhanced by wind-forced conditions (Dillard, 2008; Luettich et al., 2000).

The large Pamlico Sound fetch, wind strength, and duration dictate the magnitude of waves and wind currents (Wells and Kim, 1989; Luettich et al., 2002; Dillard, 2008; Mulligan et al., 2014). Drag forces due to surface friction between wind and water creates waves, which form orbital motion that propagates downward in the water column. When orbital velocities are strong enough and the water column is shallow enough, waves can create a stress on the sediment bed (τ_w). Using measured values of significant wave height (H_s, the mean of the highest one third of measured waves) and peak wave period (T_p, the wave period with the highest energy), τ_w (calculated) can exceed the threshold of sediment motion (Whitehouse et al., 2001; Dillard, 2008). Winds are seasonal in the Pamlico Sound and predominantly S-SW in summer and N-NE in winter (Whipple, Luettich, and Seim, 2006; Reynolds-Flemming and Leuttich, 2004; Leuttich, 2002; Benninger and Wells, 1993), aligning with the length of greatest fetch. Sustained winds and storm winds are capable of inundating the back-barrier which can remobilize or deposit new sediments beyond the shoreline (e.g. Hurricane Irene, 2011; Mulligan et al., 2014; Clinch et al., 2012; Hardin et al, 2012).

Erosion of marine sediments occurs when either τ_w (wave shear stress) or τ_c (current shear stress), or a combination of the two, exceed τ_{cr} (critical bed shear stress), considering sediment type and cohesiveness (Whitehouse et al., 2001; Ziervogul, 2003; Grabowski et al., 2011). Critical bed shear stress is governed by a variety of factors and varies substantially with sediment type, organic content, etc. The inclusion of >5% mud-size grains increases cohesion, increasing τ_{cr} significantly (Grabowski et al., 2011; Ziervogul, 2003). Sediment bed properties (such as τ_{cr}) can be calculated theoretically in regions with low fine-grained percentages due to the expected lesser influence of cohesion (Ziervogul, 2003). Past studies have shown that winds are a significant driver of sediment resuspension in the Pamlico Sound, and the associated waves and/or wind can be measured to predict sediment resuspension frequency (Dillard, 2008; Booth, 2000).

2.4 Shoreline Processes

Back-barrier shoreline change is a process that controls barrier island width as well as the geologic evolution of the island (Smith et al., 2008; Timmons et al., 2010; Conery, 2014). Net change of the estuarine shoreline is dictated by natural sediment supply processes such as ocean overwash and inlet formation, as well as back-barrier attributes including sediment composition and elevation (Smith et al., 2008; Cowart et al., 2010). Storm events are also a significant process in back-barrier shoreline change due to resuspension and redistribution of sediments (Phillips, 1999; Gittman et al., 2014). Some research has shown that marshes can act as a natural barrier against erosion and potentially work better than human-emplaced hard structures (Gittman et al., 2014).

Estuarine shoreline change has been measured and calculated using several methods. A common method employs heads-up digitization of georectified aerial photography or satellite images (Fig. 5) (Eulie et al., 2014; Jackson et al., 2012). Eulie et al. (2014) measured short-term (sub-annual) shoreline change using balloon aerial photography. With several years of shoreline change, transect based approaches can be used to calculate point-value shoreline change rates (SCR) across a region (Jackson et al., 2012). Changes in back-barrier shoreline type influences SCRs, which in turn may impact back-barrier sediment processes (Gittman et al., 2014; Cowart et al., 2010; Jackson et al., 2002).

2.5 Submerged Aquatic Vegetation

Research has shown that SAV has a significant impact on local sediment deposition through wave and current attenuation (Chen et al., 2007; Koch, 2001). However, surface sediment grain size readily dictates SAV colonization (Swerida, 2013; Koch et al., 2001). Several models have been used to qualitatively evaluate SAV shoot attenuation of currents and waves (Peterson et al., 2004; Chen et al., 2007; Zeller et al., 2014). However, research by Luhar et al. (2010) concluded that wave orbital velocity within SAV beds is only marginally attenuated when compared with the more dramatic attenuation of unidirectional flow (i.e., currents).

Recent work by Palinkas and Koch (2012) assessed sediment trends (e.g. accumulation, grain size, sediment supply) across several SAV habitats in the Chesapeake Bay and their results yielded conceptual models of SAV based on sediment processes and properties (Fig. 6). Sandy sediments, low organic content and moderate (3-9 mm y^{-1}) sediment accretion rates characterized persistent SAV beds (Palinkas and Koch, 2012). They hypothesize sediment sources may have significant impact on SAV habitat stability, where fine-grained sediments prevent colonization and sands are easily colonized. Based on their conceptual model a change in shoreline type may negatively affect SAV habitats due to an alteration of sediment supply (Adair et al., 1994; Palinkas and Koch, 2012).

Studies have shown that SAV attenuates waves and currents enough to possibly increase fine-grained mud and organic matter deposition, which leads to a build-up of carbon in SAV sediments (Greiner et al., 2013; Fourqurean et al., 2012; Kennedy et al., 2010). Sustained SAV presence and environmental influence in this way can act to enhance carbon burial (Greiner et al., 2013). However, other research has hypothesized the increase of organic content in sediments promotes SAV populations with a high leaf to stem length ratio, making these areas more susceptible to erosion (Wicks et al., 2009). Regardless, the broad scope of past research suggests a complex relationship between SAV and sediment processes that will vary on different spatial scales coincident with depositional regimes.

3.0 METHODS

3.1 Shoreline Data Collection and Analysis

In this study shoreline change rates were evaluated over several time scales (e.g., seasonal, decadal) to help evaluate processes influencing change (e.g., Cowart et al., 2010; Jackson, 2010; Geis and Bendell, 2010). Shoreline data was obtained for 1949 (from Outer Banks History Center), 1974 (from National Park Service, Manteo, NC), 2007 (NC DCM, 2007), and 2012 (NC DCM, 2012). Also, a 2015 shoreline was mapped for the study area using a combination of RTK-GPS and aerial imagery. The RTK-GPS survey was conducted by walking the shoreline along the wet-dry line for sediment bank shore type and on the scarp for marsh shorelines (Strand, 2015; Eulie, 2014; Eulie et al., 2013). Hard structures were measured by walking on (seawall) or basinward (rip-rap) and then later checked based on aerial images for georeference. Areas inaccessible by foot within the Pea Island National Wildlife Refuge shoreline were defined by fish-eye-corrected Go Pro aerial imagery (Fig. 5), collected in October 2015. The 2015 images were georectified by second-order polynomial with greater than 10 control points (Cowart et al., 2010). The shoreline was digitized in a heads-up fashion (on a computer screen) using the vegetation boundary or wet-dry line in sediment banks (Cowart et al., 2010; Geis and Bendell, 2010). Wind-induced water level changes at the time of photography may add error due to shoreline location appearance.

Shoreline change rates (SCR) were evaluated with the Analyzing Moving Boundaries Using R (AMBUR) package that measures boundary change across a series of transects (Jackson et al, 2010, 2012; Eulie et al, 2014). Baselines were created with the buffer tool in ArcMap at a distance of 100 m from the nearest shoreline before casting transects. Transect spacing distance was set at 50 m using the AMBUR package. Transects were filtered by AMBUR and manually to reduce error by excess shoreline capture and to ensure shore normality. Long-term (1949 – 2015) and short-term (i.e., 1949-1974, 1974-2007, 2007-2012, 2012 – 2015) SCRs were calculated.

Aerial images were used to classify shoreline polylines into one of three shoreline types: marsh, sediment bank, or modified (e.g., seawall, rip-rap) following methods outlined by Geis and Bendell, 2010. Length and percentage of each shoreline type was calculated from the shoreline polylines using ArcGIS (Version 10.2). To help synthesize the data, shoreline data are reported for four discrete sub-regions. The sub-regions were classified by the modern shoreline type with the highest presence (e.g. marsh, modified, sediment bank).

3.2 Volumetric Change Analysis

Volumetric change rates (VCR) of shorelines show a sediment flux from shoreline erosion that is delivered to the adjacent basin (Davies-Vollum and West, 2015; Hawkins, 2015; Zhou et al., 2014; Biribo and Woodroffe, 2013). This study used three methods for VCR calculations to provide a range of shoreline volume change. Method 1 calculated the VCR by multiplying a scarp height, SCR and shoreline length. Scarp heights were determined for each shoreline region using RTK-measured elevations taken at the top and bottom of scarps. Relief data from at least five scarps were averaged to calculate the mean scarp height for each region. Method 2 calculated shoreline length relative to an ArcGIS-defined baseline in an effort to account for potential loss in tortuosity of the shoreline. Method 3 used the mean scarp height and a polygon of lost shorezone area change between two time steps (i.e., 1949 and 2015) to calculate estimate volume loss. Error from Method 3 was based on the shoreline mapping error and scarp height error.

3.3 Bathymetry

Bathymetry was measured in the study area with a Sonarmite Echo Sounder synced with a Trimble TSC5 (handheld) and RTK-GPS SPS882 (receiver). The echosounder was mounted on the gunnel of a small vessel, and data was collected along track lines across the study region (Fig. 4). Echosounder data were obtained during days with low winds to reduce error associated with boat heave, pitch and roll. Depth values were determined relative to the NAD83 datum. All data were combined in ArcGIS and the Kriging tool was used to interpolate between data points to create a seamless bathymetry.

Bathymetric (XYZ) data for the emergency ferry channel also was obtained from the NC DOT for various surveys during the 1995-2014 time period. Data were imported into ArcMap and krigged to produce a raster surface (Fig. 7). Raster surfaces from older bathymetric surveys were subtracted from newer surveys using the Raster Calculator tool in ArcGIS to estimate depth change between time steps. Areas of non-overlap were not analyzed. Volume change between data years was calculated by summing the product of the cell area and vertical change for all analyzed cells (calculated in ArcMap).

3.4 Sediment Characterization and SAV Coverage

To understand sediment and SAV coverage, samples and observations were made on a grid across the study region (Fig. 4). The first collection retrieved 45 samples (Fig. 4). Subsequent sampling retrieved a smaller subset of the original samples, at 14 sites across the study area. A bulk sample of surface sediment (100 to 300 g) was collected using a grab at each site. It was placed in a whirl-pack bag and stored until processed.

Because of very limited mud in the area, all samples were analyzed for grain size using a dry sieve method. Sediments were homogenized, and a 50 to 100 g subsample was dried at 105 °C for 24 hrs. Subsamples were then dry-sieved via Ro-Tap with sieves ranging from 4 to -2 ϕ (1/2 ϕ increments) to measure mud to very fine gravel (Open File Report 00-358, http://pubs.usgs.gov/of/2000/of00358/text/chapter1.htm,http://woodshole.er.usgs.gov/openfile/of 2005-1001/htmldocs/videos/dry_sieve/dry_sieve.htm). Grain-size statistics were calculated using the GRADISTAT-2008 program (Blott and Pye, 2001).

Loss on ignition (LOI) was measured on all samples; it is often used to calculate percent organic content (Heiri et al., 2001; Dean, 1974). When organic matter is heated past 500 °C, it is oxidized to ash and carbon dioxide. The percent change in mass of a dry sample pre and post-ignition at 500 °C is a measurable removal of organic matter (Heiri et al., 2001). A 5 to 10 g subsample was initially dried at 105 °C for 24 hours. Then, the mass loss was measured after combustion at 550 °C for 8 hours (Strand, 2015; Heiri, 2001; Dean, 1974).

SAV coverage data was assessed visually in the field during the first sediment sample collection. Presence (i.e., present or absent) and qualitative density (i.e., no SAV, patchy, moderate or extensive) was evaluated at all sites. Also, SAV coverage was mapped using imagery from Google Earth Pro. Images from 2004, 2005, 2009, 2010, and 2014 were saved, clipped and georeferenced in ArcGIS. All images used were from the July-October when SAV coverage was likely to be well developed. SAV boundaries were heads-up digitized to evaluate distribution across the study area. These data were later converted into polygons to measure recurrence (Orth et al, 2014). An error depth (2.5 m) was defined where increased water depth prevented identification of the SAV-sediment boundary in the 2014 image. A 22 x 22 grid of points was used to extract depth and SAV data across the study area. The values at each point were plotted to evaluate the relationship between SAV and depth.

3.5 Wave and Current Measurements

Several hydrodynamic instruments were used to measure waves and currents. A Nortek Vector current meter and an OBS-3+ turbidity sensor were mounted on a constructed deployment platform. Both instruments were set to measure 25 cm above bed at 8 Hz for 2048 samples (~4 minutes) at one hour intervals. The instrument platform was deployed just outside of the Rodanthe emergency ferry channel (Fig. 4). The platform was deployed for ~1 month.

Data from the deployments were processed with QuickWave software to determine wave height and period (Dillard, 2008). The law of the wall equation was used to calculate bed shear stress from the current velocity data (Ziervogul, 2003; Soulsby and Humphery, 1990; Soulsby, 1983):

$$u(z) = \frac{u_*}{K} \cdot \ln\left(\frac{z}{z_0}\right) \qquad \text{Eq. 1}$$

where z is a measured height above bed (i.e., 25 cm in the deployment); u_* is the shear velocity which is related to the bed stress; K is the Von Karman constant equal to 0.41 (unitless), and z_0 is the roughness length, the height above bed in which velocity becomes zero (Ziervogul, 2003; Soulsby, 1983). Roughness length was assumed to be 0.006 m based on data from Soulsby (1983) and presence of ripples (observed on instrument deployment) on sandy bottom. Solving equation 1 for u_* for any measured velocity 25 cm above bed with a rippled sandy bottom gives:

$$u_* = u(25\ cm) \cdot 0.097 \qquad \text{Eq. 2}$$

where u and u_* are defined above. Measured currents were also processed using the turbulent kinetic energy method to estimate the bed shear stress (Pope et al., 2006; Kim et al., 2000).

4.0 RESULTS

4.1 Shoreline Change

With 50-m spacing, SCR was measured along 181 transects for each time step. Change values showed prominent erosion across the region, with only a few areas showing accretion. The accretion zones were in areas of modified shoreline (i.e. bulkhead, rip rap) that extended basinward of historic shoreline. The mean SCR for each time step was negative except for 2007-2012 (0.01 ± 0.32 m y^{-1}), which was within the error of no measurable change (Table 1).

The "Modern" shoreline change was determined by comparing the RTK-GPS mapped shoreline in 2015 with the 2012 digitized shoreline (Fig. 9). SCR ranged from -10 to +5 m y^{-1}. Thirty-two of the 181 transects displayed accretion. Of those accretion points, only 12 exceeded the measurement error (±0.56 m y^{-1}). The accretion spots were associated with areas of sediment banks or modified shoreline where new hard structures (e.g., rip rap, bulkhead) had been emplaced.

Long-term shoreline change was measured using the offset of the 1949 and 2015 aerial photos. Mean shoreline change using all transects was -27.9 ± 2.1 m with a mean change rate of -0.41 ± 0.03 m y^{-1} (Fig. 9). The highest accretion areas were sediment banks with <0.50 m y^{-1}. The highest erosion rates (~2.0 m y^{-1}) were found in southern marsh regions of Pea Island National Wildlife Refuge and a separate area in Rodanthe made up of sediment banks that were anthropogenically modified by 2015. Marshes in the central portion of the study and areas far to the north and south yielded the lowest shoreline change rates.

Shoreline type varied significantly across the study area. Data were analyzed by discrete subregion to help synthesize the shoreline attributes (Fig. 10; note R# indicates the region number). Region 1 (R1) had marsh as the major shoreline type (>90%) across all time steps. Variation in shore type was greater than R1 in Region 2 (R2) with a decrease in marsh and increase in sediment bank through time with the exception of the 2012 shoreline. In 2015, one portion of the shoreline in R2 was classified as modified because of a new revetment. Marsh shoreline represented less than 50% during all observation periods. Region 3 (R3) exceeded 70% marsh through all time steps. A minor increase in the modified and sediment bank shore types was noted in 2007 through 2015. Region 4 (R4) experienced a significant change from being dominated by marsh and sediment bank in 2007 to almost 85% modified in 2015. Region 5 (R5) maintained >60% marsh since 1949, but has lost sediment bank shoreline to modification in recent years.

4.1.1 Volumetric Change Rates

To evaluate volume change, scarp measurements were made at several areas in each region, and data were averaged to provide a representative value for the region. The greatest mean scarp was in R3 (i.e., the ferry terminal marsh) at 0.55 m. Mean scarp values for R1, R2 and R5 were 0.23, 0.45 and 0.47 m, respectively. No scarps were measured in R4 due to high amount of shoreline modification.

Volume change rates calculated for each region varied greatly by method, but all indicated a significant release of sediments to the sound. Using Method 1, i.e., the SCR-based method, calculated subregion values ranged from -240 to -800 m^3/y. For the Method 2, estimates were between -150 and -240 m^3/y, and Method 3 gave values that ranged from -160 to -320 m^3/y. Regions 2 and 3 had the highest volume loss regardless of the method. Total volume change rates across the study area also varied by method and were -1900 m^3/y, -760 m^3/y, -970 m^3/y respectively.

4.2 Bathymetry

The single beam bathymetry surveys confirmed the presence of a broad (>3 km wide), shallow (<1.5 m depth) shoal region, i.e., the “Flats”, along the back-barrier shore (Fig. 4). Two, especially shallow, shore-parallel areas (<0.5 m) are also noticeable near the western edge of the Flats. Two channel-like depressions penetrate at least 2 km into the back-barrier shoal system. The northern channel connects to the soundward (western) extent of the emergency ferry channel and has apparently been dredged in the past for navigational purposes by the United States Army Corps of Engineers (USACE) (Army Corps of Engineers, Reports: 01 Nov 2012; 26 Nov 2012; 15 Jul 2013). There is no record of USACE dredging in the southern channel.

Changes in bathymetry through time for the emergency ferry channel show periods of large losses (dredging) and gains of material (i.e., deposition events). Volumetric change calculated between the measurement time intervals was variable (Fig. 11). Periods of loss appear to correlate with dredging operations preceding measurements in the years 1998, 2001, and 2011-2012 (Department of the Army/Corps of Engineers, 2012, 2011, 2010, 1998, 1997). Three periods of channel shoaling, or bathymetric gain, occurred prior to the mapping in 2004, 2005 and 2011. Change preceding the 2005 step is an increase of 53,000 m^3. Losses (negative changes) in channel sediment volumes range from -5,000 to -50,000 m^3; the highest loss volume was estimated between the 2012 and 2013 channel mappings.

4.3 Meteorological Data and Hydrodynamics

Meteorological data retrieved for three hurricanes (i.e., Isabel, September 18, 2003, Ophelia, September 14, 2005 and Irene, August 27, 2011) reveal high sustained winds and gusts of tropical storms (Fig. 12). Maximum recorded sustained winds for Isabel were southerly and exceeded 20 m s^{-1} before station outages (Fig. 12). Sustained winds during Ophelia and Irene exceeded 25 m s^{-1}at nearby sites (Diamond Shoals data buoy and Oregon Inlet Marina, respectively), with gusts exceeding 35 m s^{-1} (Fig. 12). Winds were generally from east during Ophelia and Irene and then shifted to the southwest after the systems passed. Each of these storms impacted the study region just days prior to bathymetric surveys of the emergency ferry channel (USACE, Reports: Sep. 18, 2005; Aug. 31, 2011).

Vector and OBS data from an August-September deployment measured waves and currents, and calculations show bed shear stresses exceeded τ_{cr} during two periods of high winds (Fig. 13). Theoretical τ_{crit} of fine sands across the basin is estimated to be 0.18 N/m^2 (http://pubs.usgs.gov/sir/2008/5093) based on the basin sediment mean grain size (see below). The first resuspension event (Sep. 13, 2015) was brief with wave heights reaching ~0.5 m, while the second event (Sep. 24, 2015) had smaller waves (H_s <0.1 m) but the bed stress exceeded the threshold for motion for an extended period of time. The sustained wind direction was largely different between events. The wave event (i.e. Fig. 13, blue box) showed sustained SW winds and the current event (i.e. Fig. 13, green box) showed sustained N-NE winds.

4.4 Sediment Character

A total of 46 surface samples were collected in June, 2015 (Fig. 4), and data show a dominance of sand in the area. Mud content was always <6% (Fig. 14), and mean grain sizes were from 122 to 284 µm. For all samples, an average mean grain size of 199 µm (fine sand) was determined. Values for d_{50}, varied from very fine sand (>64 µm) to medium sand (<450 µm). Values for d_{10} always were in the fine to very find sand range, ranging from 67 to 160 µm, and d_{50} values ranged from 101 to 259 µm (very fine to medium sand) (Fig. 14). The maximum d_{90} value was 431 µm, and the lowest was 172 µm. Based on the average mean grain size (199 µm, a fine sand), the theoretical critical bed shear stress is ~0.18 N/m^2 (USGS, 2008-5093).

A total of 16 sediment samples were collected in December, 2015, and 14 of those were from sites previously sampled. Average mean grain size was 208 µm (fine sand) for these samples. Values for December d50 deviated from June samples slightly (decrease of >-10 and increase of <42 µm) (Fig. 14). A comparison using two-tailed t-test of the June and December resampled subset showed no statistical difference.

Sediment samples collected in both June and December had very low LOI. Only one sample exceeded 1% LOI (Fig. 14). December sediments appeared to have slightly higher values for LOI (Table 2), although none exceeded 1%. Scarp samples taken within the study area displayed much higher LOI, between 5 and 26%.

4.5 Submerged Aquatic Vegetation

Mapping of SAV using historical aerial photography showed widespread coverage in the study area (Fig. 8). SAV was most prominent in the eastern portion of the study area. No SAV was noted in the western (deeper) parts of the study area. Extent of SAV varied little with time (Fig. 15). Area of coverage varied from 25 to 31 km^2 (Table 3). The greatest variation occurs at along the seaward (deepest) boundary where SAV was more difficult to discern due to depth. A visible habitat break occurs in all time steps at the shallow areas ~4 km west of the shoreline. Also, a sharp edge in SAV habitat was commonly seen nearshore. Several areas of ephemeral SAV habitats were mapped in the north. Based on the frequency of cover mapping (Fig. 15, lower right), SAV covered 45% of the study area during at least one time step, and 29% of the area was covered during all five time steps.

Analysis of bathymetry and SAV occurrence along a grid of points across the area showed SAV was distributed in a discrete depth band (Fig. 16). SAV occurrence ranged from 0.4 to 2.7 m depth. SAV occurrence for all five observations (i.e., persistent coverage) was limited to a depth range of 0.5 to 2.2 m. The mode for the occurrence of SAV (both >0 and all observations) was 1.3 to 1.4 m.

5.0 DISCUSSION

5.1 Shoreline Loss and Transformation

Shoreline change rates measured in this study agree with previous studies along the Outer Banks estuarine shoreline (Eulie et al., 2013; Conery, 2014; Smith et al., 2008; Dolan et al., 1993). Areas of moderate to high erosion rates have been attributed to limited back-barrier sediment supply and high wave energy in large fetch areas (Eulie et al., 2014; Riggs et al., 2009; Riggs and Ames, 2003). SCRs for each time step show widespread erosion throughout the study area, except during the 2007-2012 period (Fig. 9; Table 1). The limited amount of erosion during the 2007-2012 time step is surprising as Hurricane Irene impacted the region with high winds and storm surge (Fig. 12) (Mulligan et al., 2014). Other research on storms has shown their predominantly erosive effects on back-barrier and estuarine shorelines (McNinch et al., 2012; Timmons et al., 2010; Riggs et al., 2009; Eulie et al., 2013). The areas of accretion between 2007 and 2012 were in areas of increased bulkheads and revetments. The shoreline modification (and lateral, basinward accretion) shows the impact of anthropogenic response to hurricane erosion recovery.

Estuarine marsh has been shown to have significantly lower rates of shoreline erosion compared to sediment banks, so a loss of marsh and transition to sediment bank ultimately increases susceptibility of high rates of erosion (Gittman et al., 2014; Pinsky et al., 2013; Shepard et al., 2011; Cowart et al., 2011). Shoreline regions with persistent marsh presence (Regions 1, 3, 5) showed lower historic change rates than regions with marsh loss (2, 4) (Fig. 9, 1949-2015). This observation highlights a problem: with marsh removal, the back-barrier area will likely see an increased rate of erosion. In response to more erosion, an increase in shoreline modifications are anticipated as has been noted (Fig. 10).

A logical follow-up question is, how can shoreline erosion be mitigated? Based on historical photograph analysis, bulkhead creation in response to shoreline erosion is common in the Rodanthe back-barrier. Work by Currin and others (2010) noted no reduction in permitting for bulkheads in North Carolina. Yet research has shown that bulkheads, in fact, are often related to increased erosion and more loss of marsh (National Research Council, 2007; Douglass and Pickel, 1999). This results because bulkheads increase wave reflection and eventually scour which has been shown to reduce the width of the nearshore environment and cause the destruction of nearshore tidal zones (National Research Council, 2007; Riggs, 2001; Douglass and Pickel, 1999). Bulkheads also are known to inhibit landward migration of marsh vegetation, thereby leading to net marsh loss (National Research Council, 2007). For this reason, although the use of bulkheads in the study area may minimize short-term erosion, the long-term sedimentological (increased nearshore erosion) and ecological impacts (loss of marsh) suggest the need for a more sustainable alternative.

The living shoreline approach to shoreline stabilization employs artificial methods (e.g. sills, vegetation planting) to increase stability of natural shoreline habitats and may mitigate marsh loss in the study area (Fig. 17) (Bilkovic and Mitchell, 2013; Currin et al., 2010). Living shoreline methods can sustain and rehabilitate present shorelines; this provides an alternative to common hardening methods (e.g. bulkheads) (Currin et al., 2010). Maintaining marsh shoreline instead of bulkheads also sustains necessary estuarine nutrient cycling such as denitrification (O/Meara et al., 2015). Back-barrier shorelines in Rodanthe would benefit from marsh sills that mitigate modern marsh loss and vegetation planting which encourages new marsh growth. Each of these shoreline stabilization methods are recommended by the NC Department of Environmental Quality for shorelines with moderate to large fetch in the Pamlico Sound (NCDEQ, 2013).

Additional options could be construction of oyster or oyster cultch reefs, as these offer natural alternatives to rock sills (Currin et al., 2010). Oyster reefs were historically present in Pamlico Sound and constructed intertidal reefs with native eastern oyster have proven successful restoration efforts (Powers et al., 2009). Reefs also operate as breakwaters and may have the same effect as sills when mitigating storm impacts on shoreline (Scyphers et al., 2011; Gittman et al., 2014). Work by Meyer and others (1997) on marshes with adjacent oyster cultch suggests positive impacts. There was significantly higher accretion in cultch-protected marsh than unprotected marsh. The use of oyster reefs would provide a natural method of reducing wave impact on the Rodanthe shoreline while restoring significant oyster habitats.

5.1.1 Sediment Fluxes and Storage

Utilizing the scarp and shoreline data, the three methods estimated a significant volume of sediment generated by erosion and likely supplied to the study area (760 to 1,900 m^3 y^{-1}) However, it is worth noting that the annual volume estimates were substantially less than the calculated sedimentation in the emergency ferry channel for Hurricane Irene (14,000 m^3). This highlights the magnitude of storm remobilized sediments. The predominance of deposition within sectors 1 and 2 (near shore sectors) of the ferry channel, suggests remobilized storm sediments are locally transported and deposited. With such a high volume of sediments resuspended during large wind events (e.g., hurricanes), fine-grained sediments eroded from the shoreline may be transported beyond the study area.

Moreover, the VCR from method 3 (-970 m^3 y^{-1}) when distributed across the study area (32 km^2) yielded a layer of only <30 µm y^{-1} (~97,000 m^3 total shoreline erosion over 66 years). Based on this calculation, sediment eroding from the shoreline may not be sufficient to cause much, if any, accretion. With a low annual shoreline sediment supply to the region, sediment deposition in the ferry channel may be due from local sediment remobilization during storms (e.g., Irene). The deposition from Irene (14,000 m^3) taken from the study area would amount to

400 µm of vertical sediment loss. Thus, dredging of the channel following storms and emplacement of this material on land may represent an important net loss of sediment in the back-barrier study area. Perhaps, a Regional Sediment Management (http://rsm.usace.army.mil/) perspective should be taken and some or all of this material should remain (i.e., be replaced) in the back-barrier system.

5.2 Sediment Character and Remobilization

Previous research identified the Hatteras Flats region of the Outer Banks as a sandy, subtidal flat of reworked and coalesced flood tidal deltas (Peek et al., 2013; Mallinson et al., 2011; Riggs et al., 2011; Mallinson et al., 2010; Culver et al., 2006). Data from this study support this idea. With only one sample with >5% mud (found at the deepest depth sampled, 4.1 m), this shallow subtidal area is dominated by fine to medium sandy surface sediments (Fig. 11). Nevertheless, grain size varies spatially in the study area. Finer samples are generally found in deeper waters, especially in the north and northwest sector of the grid. Larger grain sizes were seen closer to shore due to shoaling and an increased impact of waves as they transition to shallow water (Mason, 2010). Change in the grain sizes between the first collection (June) and the second (December) showed very little change (< 0.4 phi change between samples) suggesting little short-term (sub-annual) change.

Both marsh and SAV habitats across the back-barrier are capable of producing organic matter and can induce organic-rich sediments (Fourqurean and Serrano, 2012; Mcleod et al., 2011). However, with extremely low loss on ignition values (<1%), it appears the study area does not store high organic sediment (Swerida, 2013; D'Andrea et al., 2002). Eroding marshes undoubtedly provide a source of organic matter to estuarine sediments (Canuel and Hardison, 2016). A few samples that were taken directly from marsh scarps showed high LOI (6-25%). The lack of LOI in the back-shore sediments compared to the marsh samples suggests eroded organic material must be dispersed beyond the area, consumed or moved onto the barrier.

Sediment transport in the APES has been reported to be dominated by wind-driven resuspension and weak wind-driving circulation due to the low tidal range (generally <30 cm in the system) (Dillard, 2008; Benninger and Wells, 1993; Wells and Kim, 1989). Observations indicate that sediments in the back-barrier are likely remobilized during strong wind events by both waves and currents, with large sediment transport occurring during storm events (e.g., Fig. 11, 12), especially hurricanes like Isabel, Ophelia and Irene. Wave and current data from the August-September 2015 deployment showed bed shear stresses exceeding the critical shear stress for motion of fine sands (Fig. 13). Note, each exceedance event occurred during sustained winds along a SW-NE trend (i.e., SW for wave event; NE for current event), which is the greatest fetch extent for wave generation in the Pamlico Sound. Sediment transport in these events will follow the currents and indicate transport onshore during SW winds and offshore during NE winds (Fig. 13). With strong SW winds following storm events, sediments may be transported onshore after storm departure (Fig. 12). Although the period of instrument deployment did not include a major storm, it suggests some episodic sediment resuspension and redistribution during non-storm weather conditions as well.

Bathymetric surveys of the emergency ferry channel suggest the importance of major storms. Several survey periods show large bathymetry change. These shoaling changes occur across survey periods with hurricanes (i.e. Isabel, Ophelia, Irene). The high energy wind (>20 m s^{-1}) and wave processes in these hurricanes were likely ideal for sediment redistribution in the back-barrier (Fig. 12).

5.3 SAV Habitat Properties

The persistent depth zone of SAV in this study (0.5-2.2 m) is somewhat different than reported elsewhere (Angradi et al., 2013; Orth et al., 2010; Short et al., 2002). Depth ranges for SAV vary greatly across the eastern U.S. as a result of varying water quality conditions (Short et al., 2002). Previous studies suggest SAV habitats are largely controlled by depth due to light dependence (Findlay et al., 2014; Angradi et al., 2013; Short et al., 2002; Koch et al., 2001; Hall et al., 1999). Other studies found that SAV habitats were generally shallower than 1 m below mean low water level (Findlay et al., 2014; Angradi et al., 2013). An SAV habitat depth range of 0.3 – 1.3 m would be expected in the study area if water level was controlled by tide alone. Water level data from the instrument deployment in Rodanthe shows a region affected by tides and influenced by wind (Fig. 13). Wind-influenced water level changes may prevent shallower habitat growth (>-0.5) in study area shoals by increased subaerial exposure during strong NE wind events (Angradi et al., 2013; Palinkas and Koch, 2012; Short et al., 2002), and the deeper depth is likely because of the relatively clearly water in the area.

Low organic content in the sediment samples contradicts past research; higher carbon sequestration is common in SAV beds. With 30-45% of the study area covered by SAV, both allochthonous and autochthonous organic carbon is expected to be present (Fourqurean and Serrano, 2012; Mcleod et al., 2011; Kennedy et al., 2010). Other studies hypothesize persistent SAV habitats are characterized by low organic matter (Fig. 6) (Palinkas and Koch, 2012; Wicks et al., 2009). The near-zero organic matter content in the study area suggests there is not high carbon storage in the sediments surrounding SAV. The low (<1.5%) LOI in all sediment samples within Rodanthe SAV habitat is attributable to either low productivity or frequent sediment flushing and may contribute to SAV extent stability. This study did not address in situ organic matter production or destruction, but wave and current data suggest remobilization events are episodic and may remove organic matter from SAV habitat.

6.0 CONCLUSION

Through analysis and comparison of shoreline dynamics, sediment properties, bathymetry, and submerged aquatic vegetation mapping this study yielded three conclusions regarding the Rodanthe back-barrier:

(1) Shoreline erosion was the dominant shoreline change process across the study area and areas of high erosion rates showed increased anthropogenic modification. As marsh shorelines erode and are replaced with sediment banks, shoreline erosion is expected to continue and possibly increase until bulkheads and rip-rap exceed natural shoreline presence or shoreline hardening occurs. Living shoreline methods (nourishment, sills and vegetation planting) may prove a better alternative to bulkheads for reducing back-barrier erosion. Sediment flux from the shoreline would have produced less than 30 μm y^{-1} of accretion across the basin, which does not appear to be a significant sediment source in the offshore back-barrier.

(2) Resuspension events remobilize sediments by current or wave processes, and these events likely maintain largely mud-free sands along the back-barrier by removing supplied muds and organic matter. Shear stress exceeded τ_{cr} during stronger winds of the instrument deployments, suggesting that waves and currents episodically resuspend sediments during moderate wind conditions (>10 m s^{-1}). Times of moderate waves indicate that forces associated with currents exceed τ_{cr}. Paired with the low LOI and mud percent, resuspension events provide a mechanism for the local transport of sands. Channel bathymetry data suggest large local sediment deposition events occur associated with storms, requiring dredging operations to maintain navigable waters for ferry access to the island. In the future, the option of placing dredged sediment in the system should be considered, potentially as nourishment for eroding shorelines.

(3) The optimal depth of SAV habitats at Rodanthe is 0.5-2.2 m due to wind-influenced water levels and light limitation. Persistent SAV habitat was mapped throughout the back-barrier shoal system where low mud percentages and organic matter are observed. Wind tides affect water level along with astronomical tides and likely influence SAV distribution due to subaerial exposure of nearshore shallow habitat. The large area of SAV recurrence across a decadal period suggests habitat stability with regards to wave and current resuspension, as well as sediment properties (e.g., low mud, low organic matter). The lack of organic matter in an area of persistent SAV may indicate low carbon storage potential for the Rodanthe SAV habitat.

The study area represents an active back-barrier environment characterized by shoreline erosion and episodic remobilization of sediments. Understanding sediment dynamics is necessary to maintain a healthy back-barrier from shoreline to SAV habitat.

Table 1: Shoreline Change Rates

Year	Mean Change (m)	Mean Change Rate (m y^{-1})
1949-1974	-9.28 ± 3.46	-0.38 ± 0.14
1974-2007	-15.42 ± 1.63	-0.47 ± 0.14
2007-2012	-0.61 ± 1.62	-0.10 ± 0.32
2012-2015	-3.50 ± 1.68	-0.98 ± 0.56
1949-2015	-27.9 ± 2.10	-0.41 ± 0.03

Table 2: Change of Loss on Ignition (%) of Resampled Sites in 2015.

Station ID	June	Dec	% ΔLOI
1	0.24	0.56	133
7	0.28	0.53	89
13	0.17	0.46	171
33	0.19	0.46	142
39	0.33	0.62	88
41	0.20	0.37	85
43	0.24	0.56	133
45	0.58	0.79	36
55	0.21	0.34	62
59	0.16	0.33	106
61	0.20	0.37	85
63	0.41	0.75	83
75	0.19	0.35	84
79	0.22	0.59	168

Table 3: SAV Coverage Area

Year	Coverage (km^2)
2004	30.8
2005	24.8
2009	28.7
2010	29.8
2014	29.5

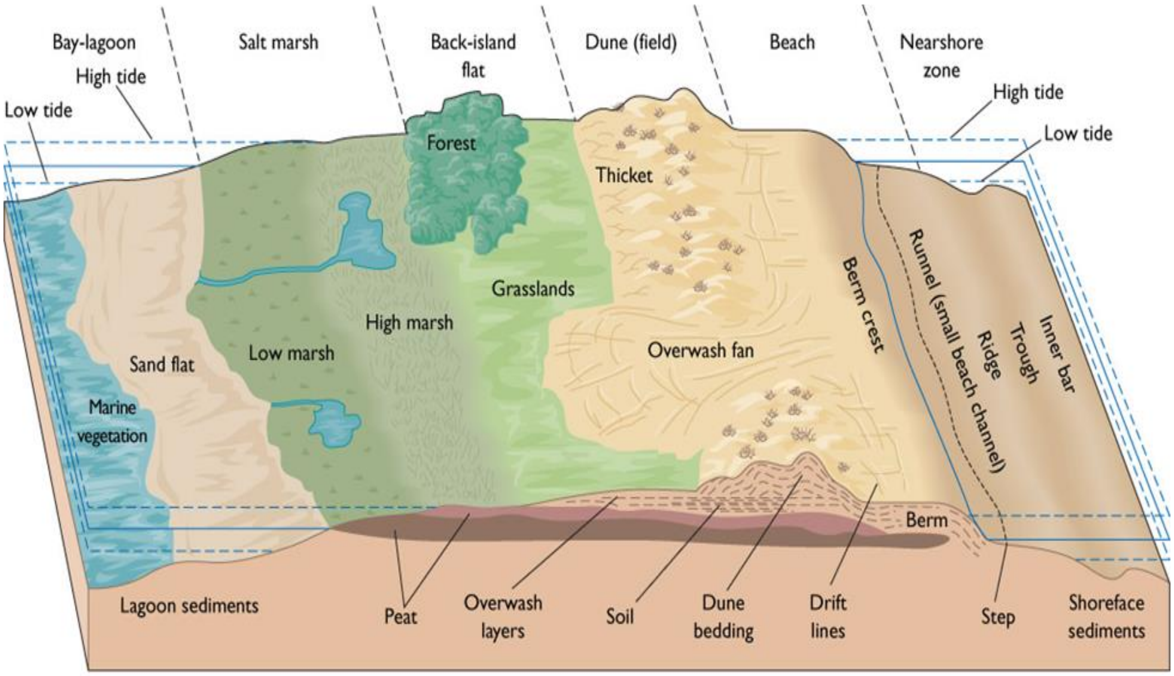


Figure 1: A cross section of an idealized barrier island. The focus of this project is the back-barrier region extends from the lagoon (or bay or sound) to the back-island flat. (http://www.geo.arizona.edu/geo4xx/geos412/OcSci07.Coastal.pdf)

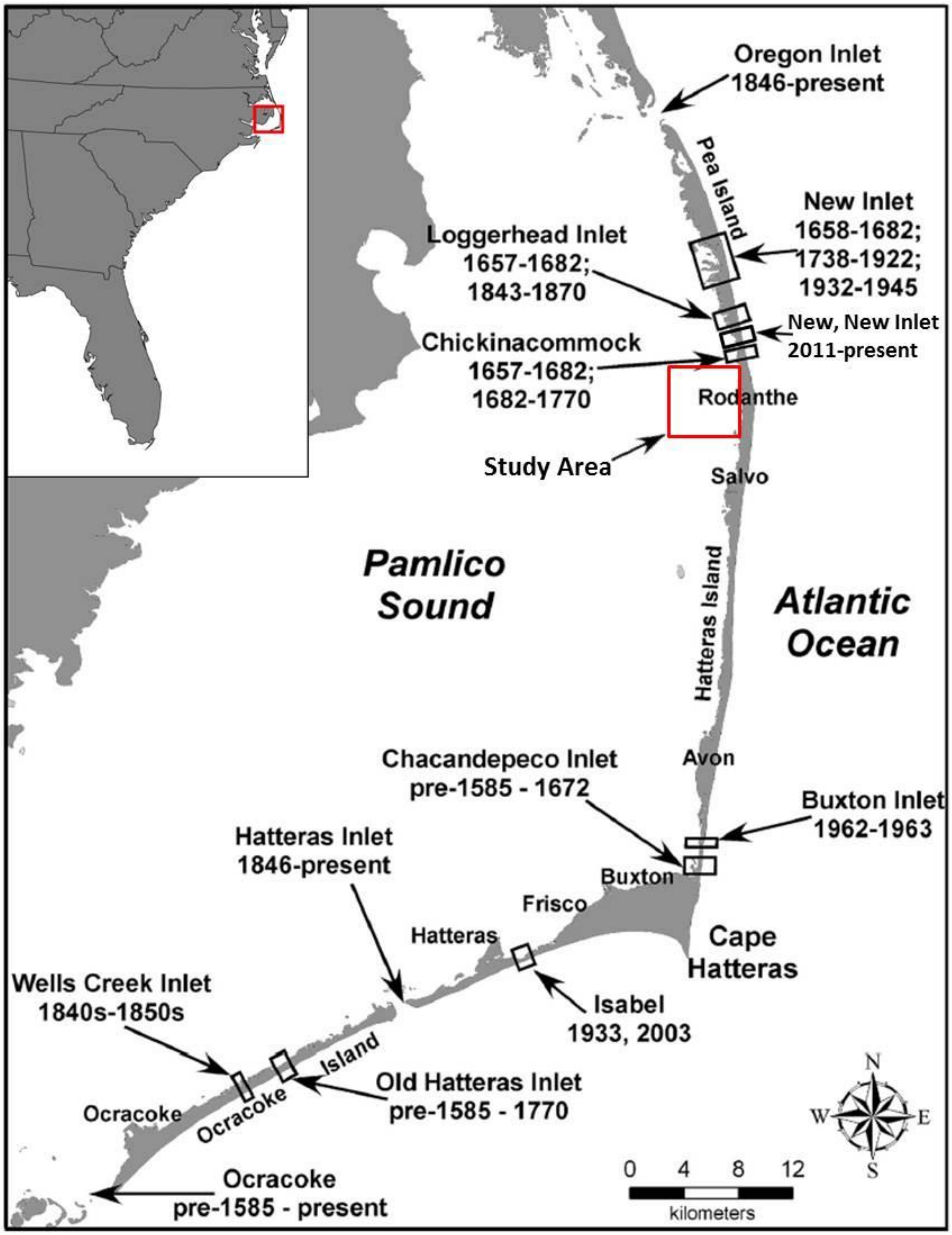


Figure 2: Historic and present inlets in the Outer Banks. Modified from Mallinson et al., 2010. Note the location of the study area.

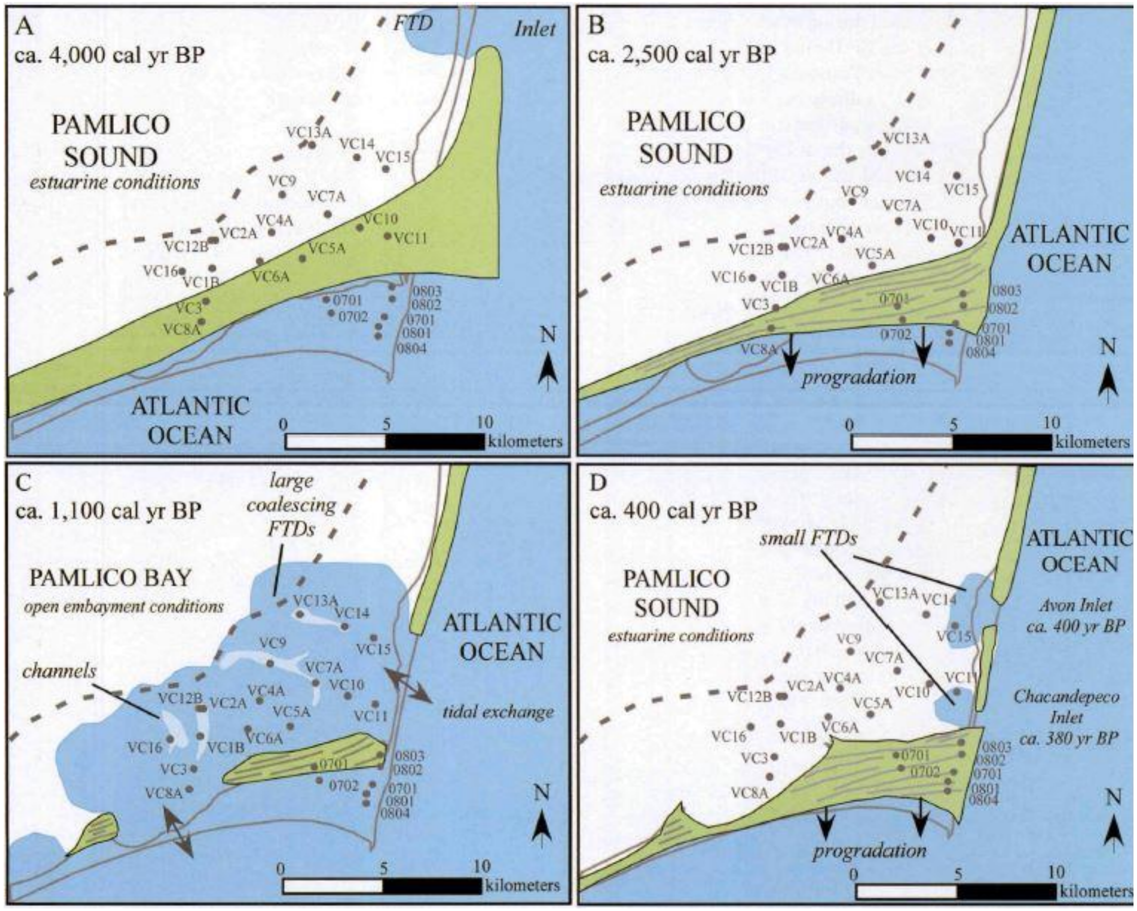


Figure 3: Holocene evolution of the southern Hatteras Flats during open marine exchange between Pamlico Sound and the Atlantic Ocean (Peek et al., 2013). This shows the development of the coalesced flood tidal deltas (FTD) that create bathymetric topography on the flats south of the study area.

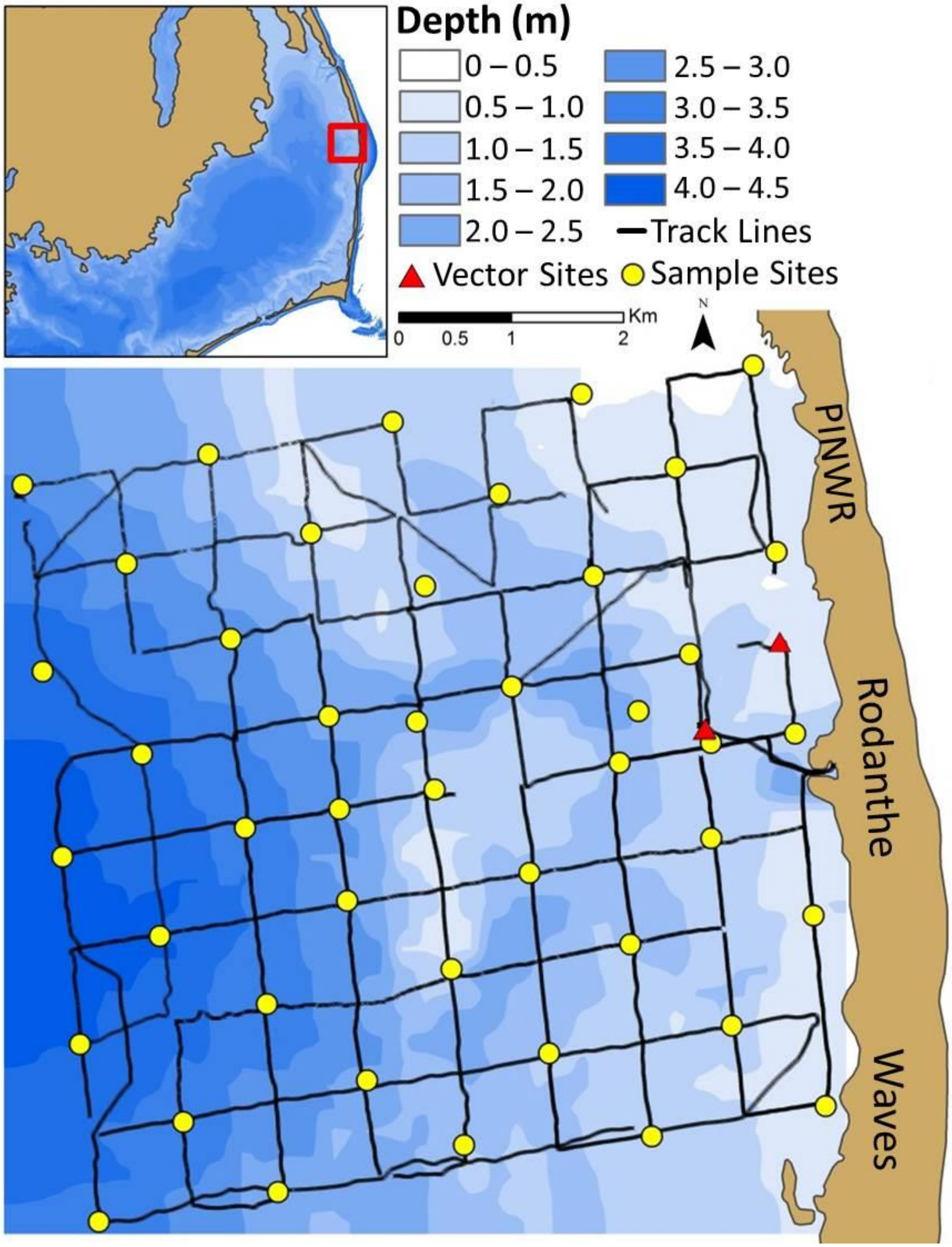


Figure 4: The back-barrier study area near Rodanthe, NC. Bathymetry was mapped using a single-beam echosounder (track lines shown as solid black line). Sites where currents and waves were measured with a Nortek Vector are noted by red triangles. Sediment sample sites are shown with yellow circles.

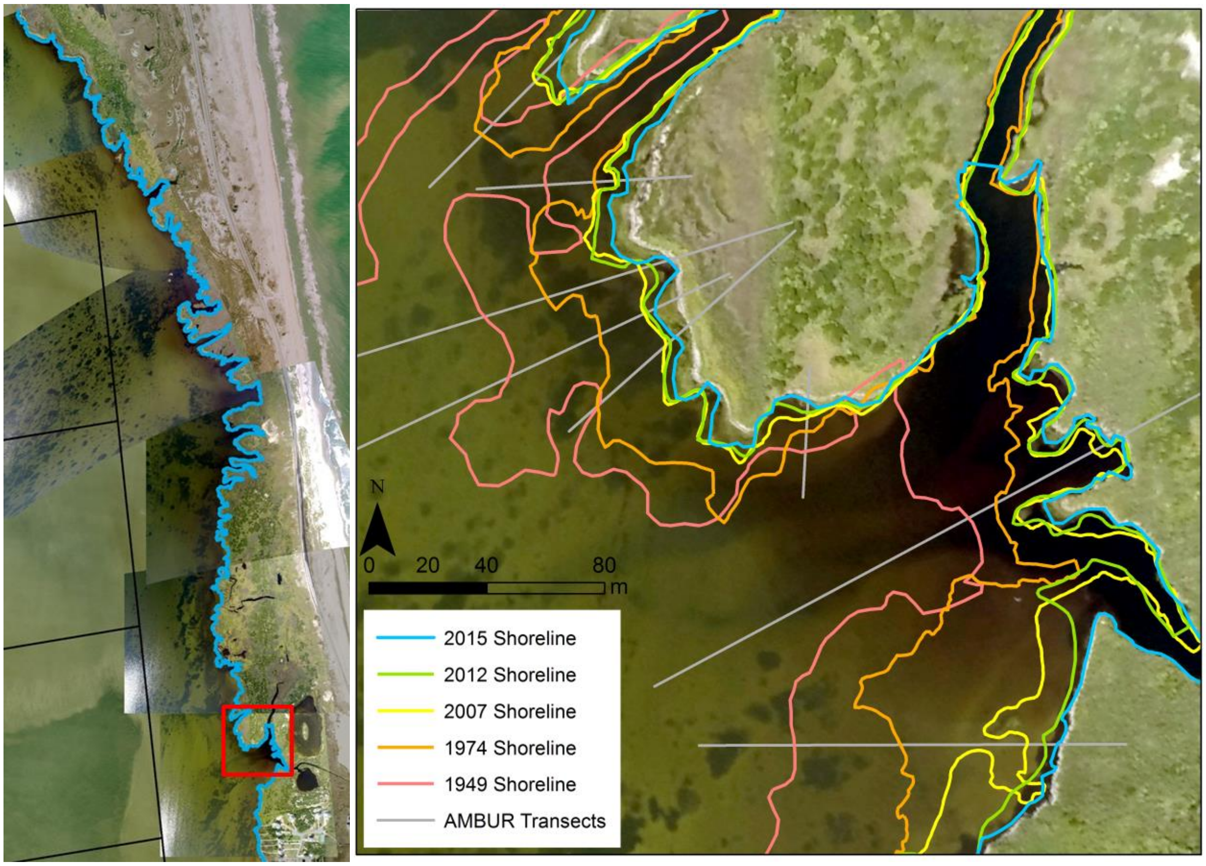


Figure 5: Mapping of the 2015 shoreline with aerial photography (left) and example of shoreline change over time for area highlighted in the red box (right).

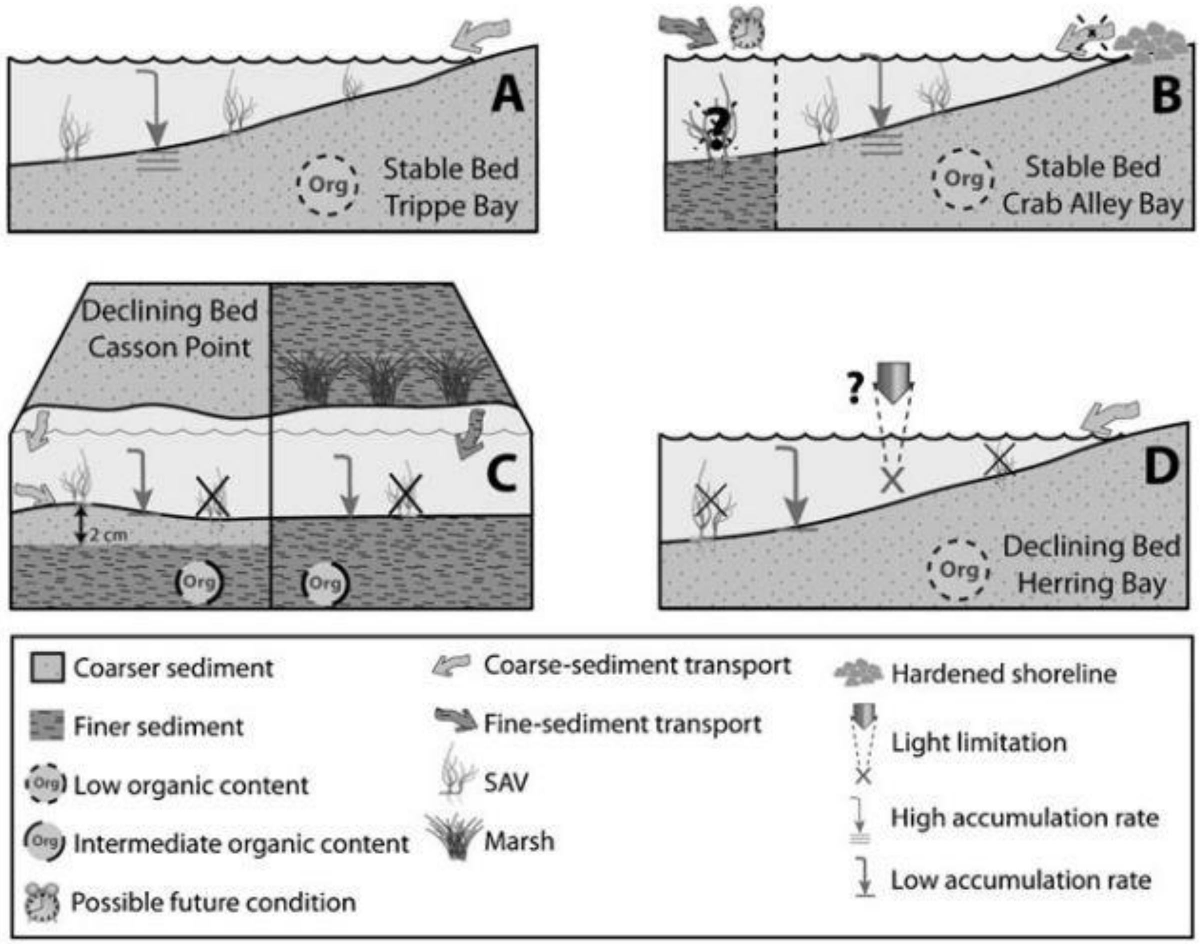


Figure 6: Conceptual models for persistent (top) and ephemeral (bottom) SAV beds (Palinkas and Koch, 2012). These models suggest the importance of sand presence in SAV beds to facilitate frequent water exchange around SAV roots. They also show removal of SAV when organic content is too great and enables SAV uprooting during high wave and current conditions.

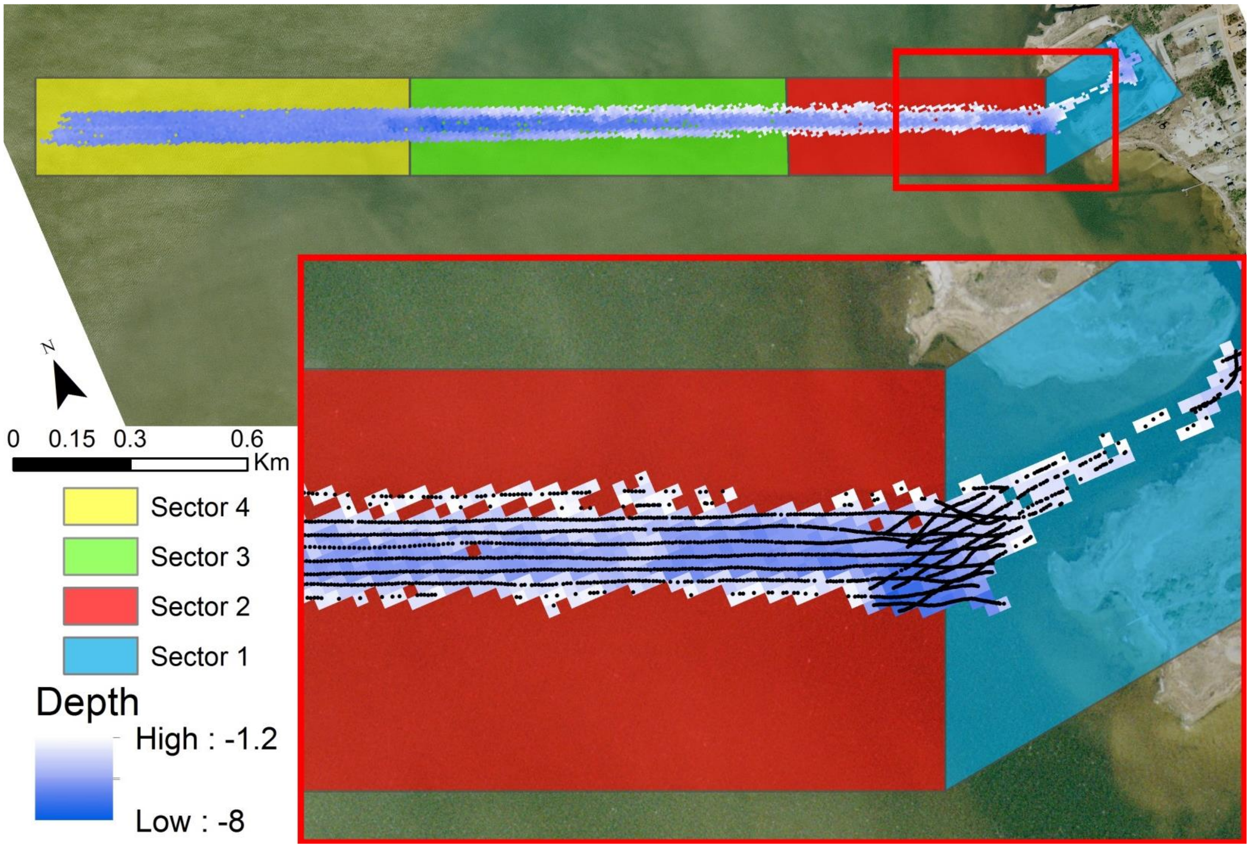


Figure 7: Example measured bathymetry for 2000 in the emergency ferry channel approaching Rodanthe. Data shown is derived from a Kriged bathymetry survey (black point data). Sectors were defined to evaluate spatial change in the channel. These maps were created for several years between 1995 and 2014.

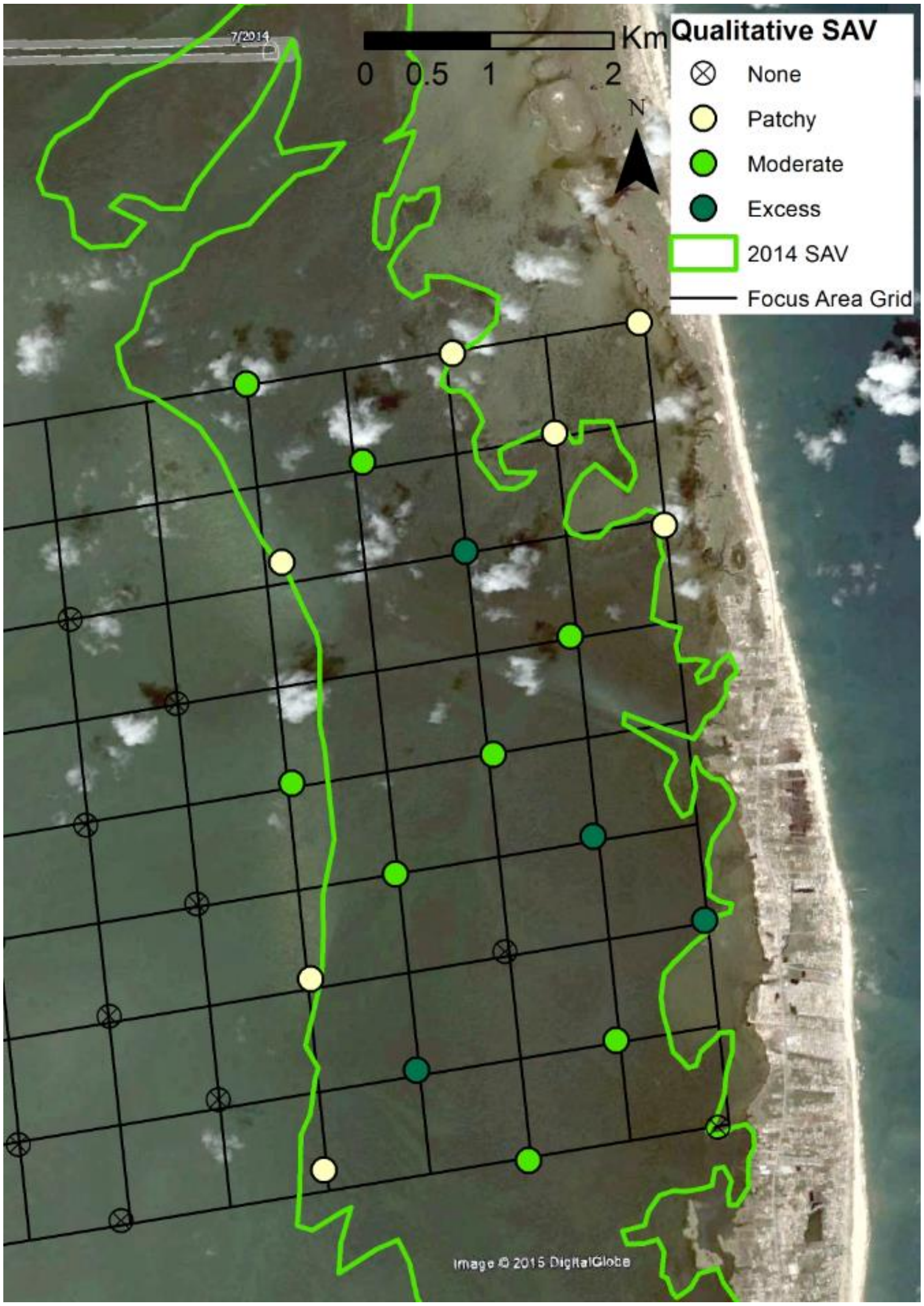


Figure 8: Example of SAV area mapped by heads-up digitization and 2014 qualitative SAV survey. Note the dark shades indicating the SAV in shallow water. The qualitative survey agreed with SAV boundary digitization.

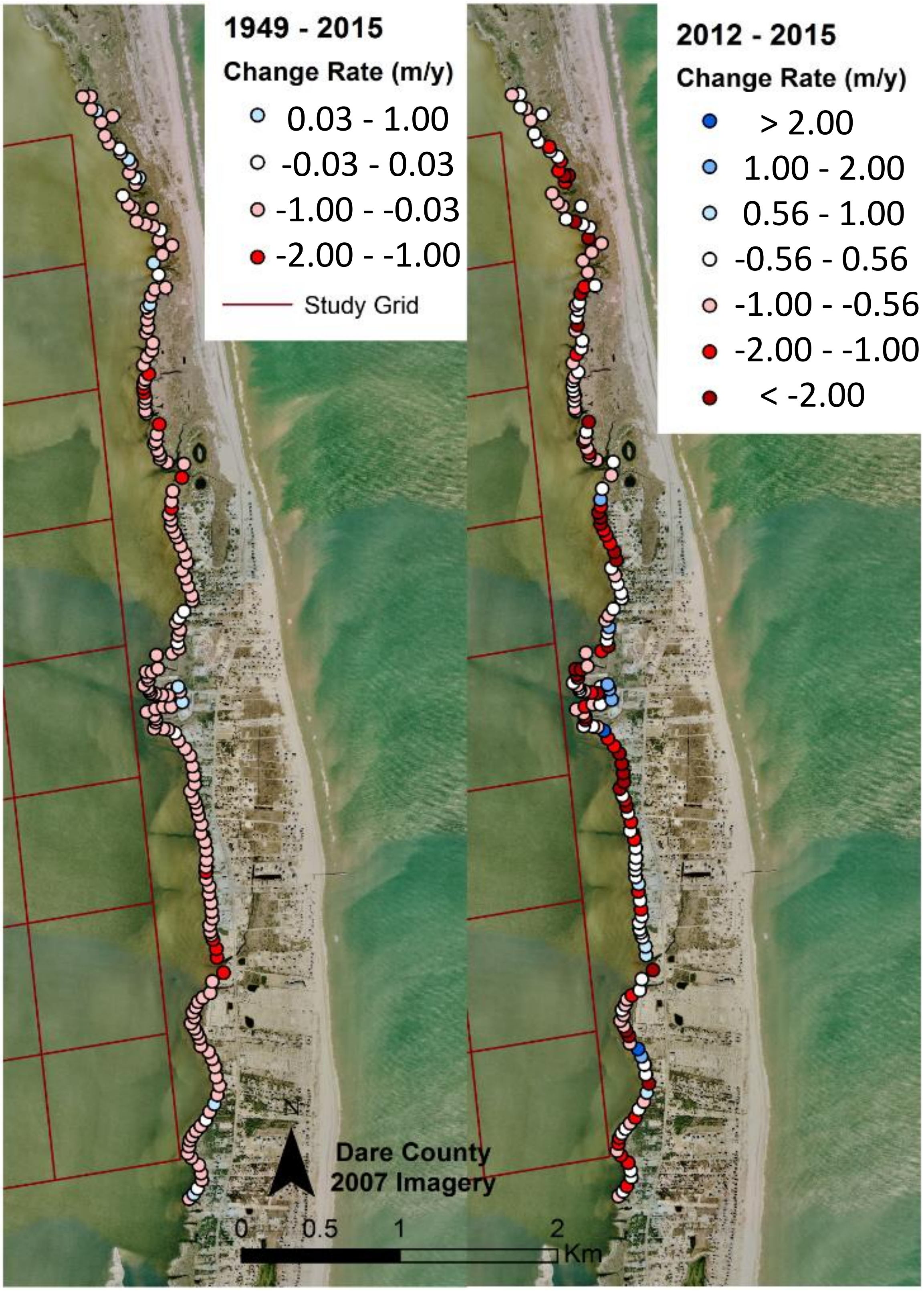


Figure 9: Shoreline change rates for 1949-2015 (left) and 2012-2015 (right). Note the widespread erosion.

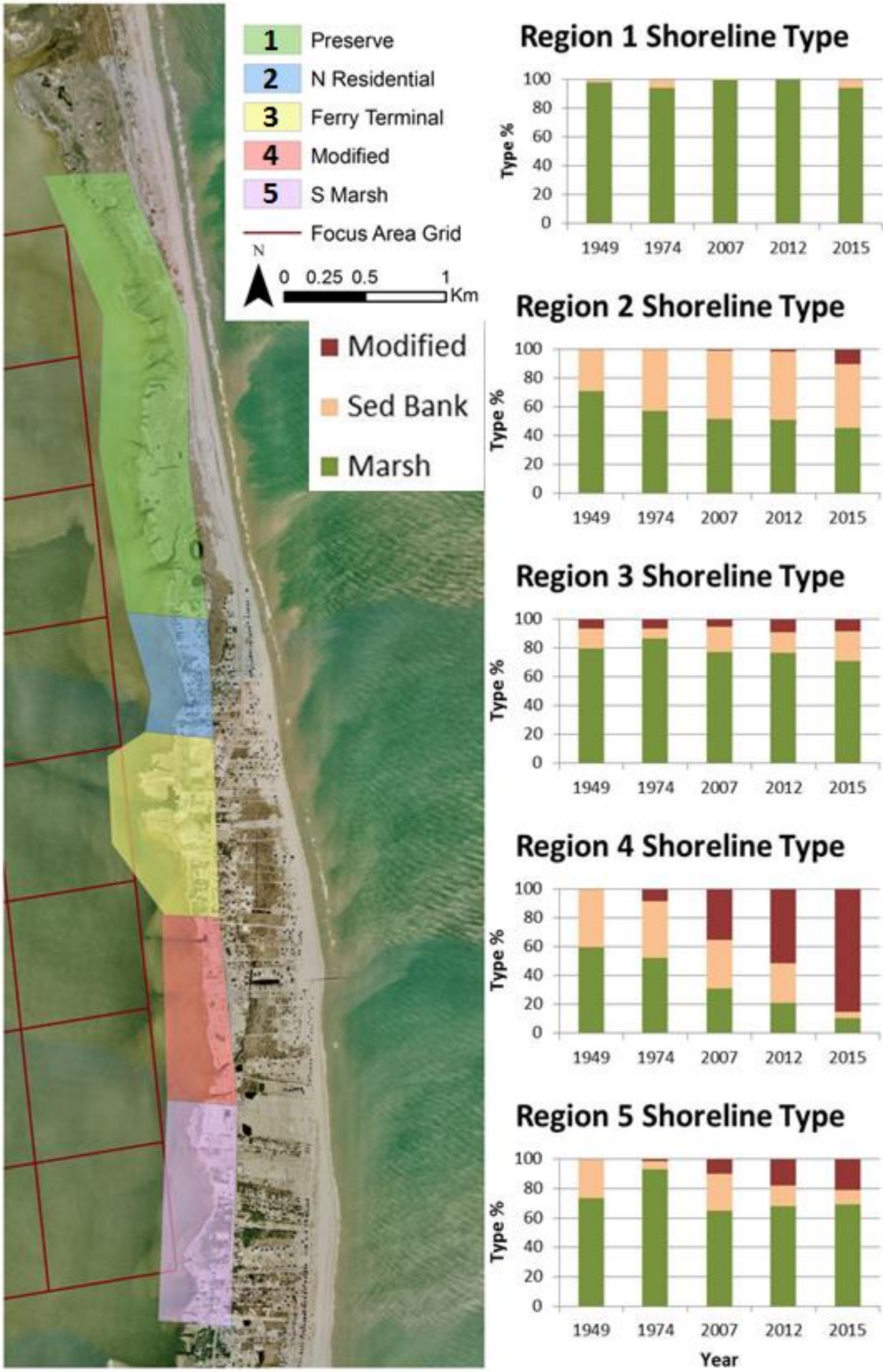


Figure 10: Shoreline type change for each region for all time steps.

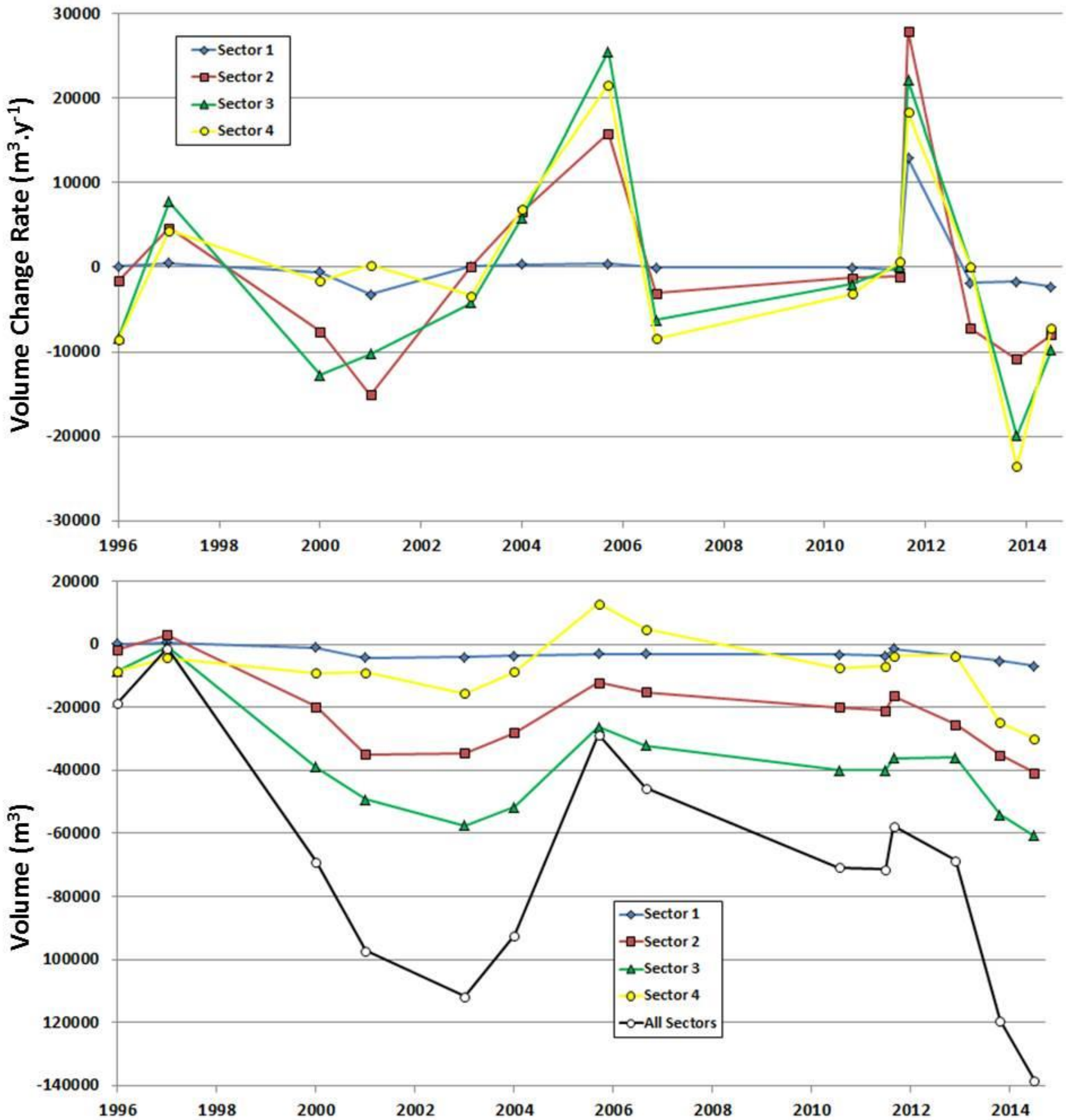


Figure 11: Channel volume change between time steps (top, m^3/y), adjusted for the length of time between each step. Cumulative volume change (bottom) for the channel by sector and for all sectors combined. Note the large increases in 2003-2005 and 2011.

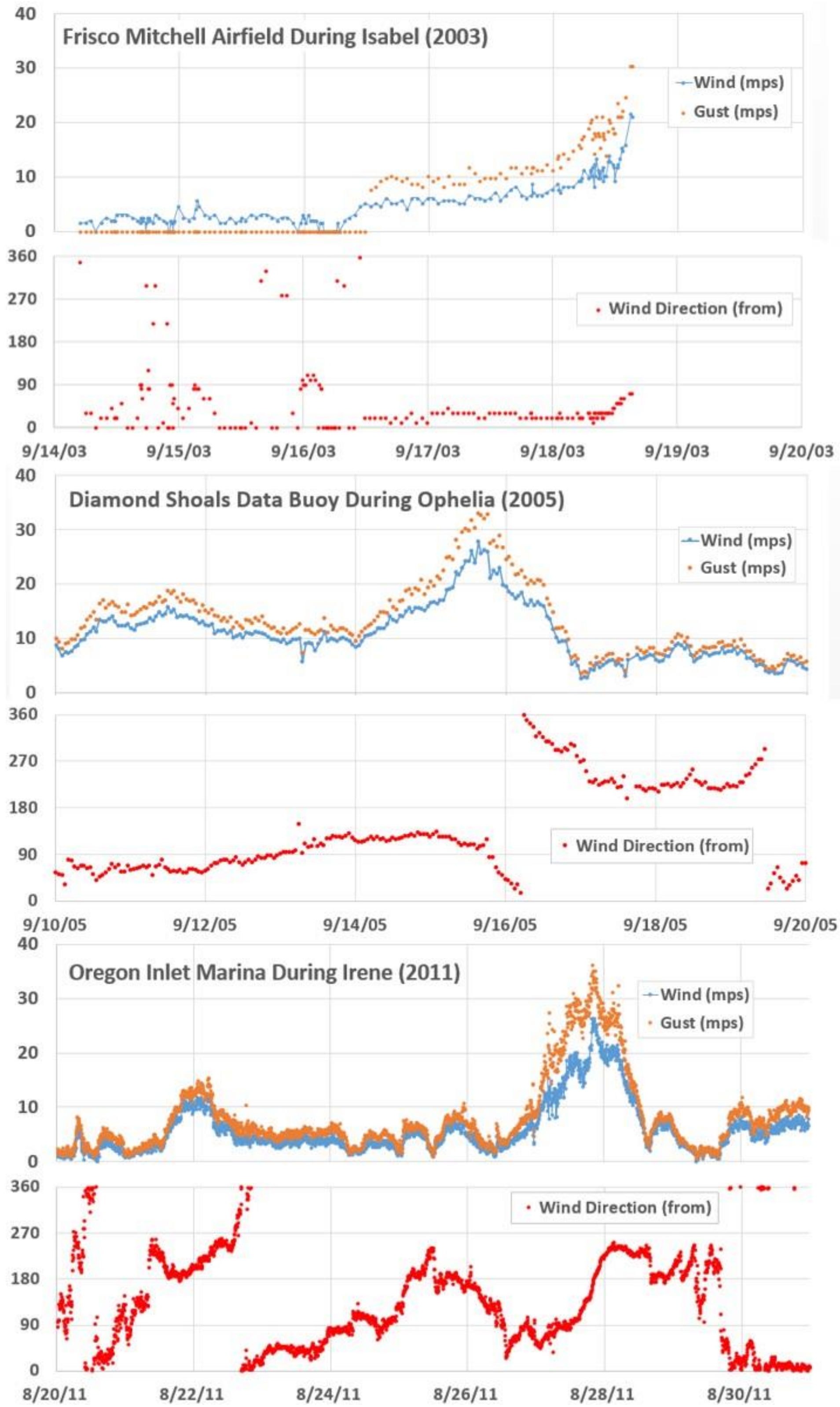


Figure 12: Meteorological data for Ophelia (top), Isabel (middle), and Irene (bottom). Each show winds and gusts exceed 20 m/s (or m s^{-1}) within storm onset and SW winds following storm departure. Data sources are varied due to station outages during storms.

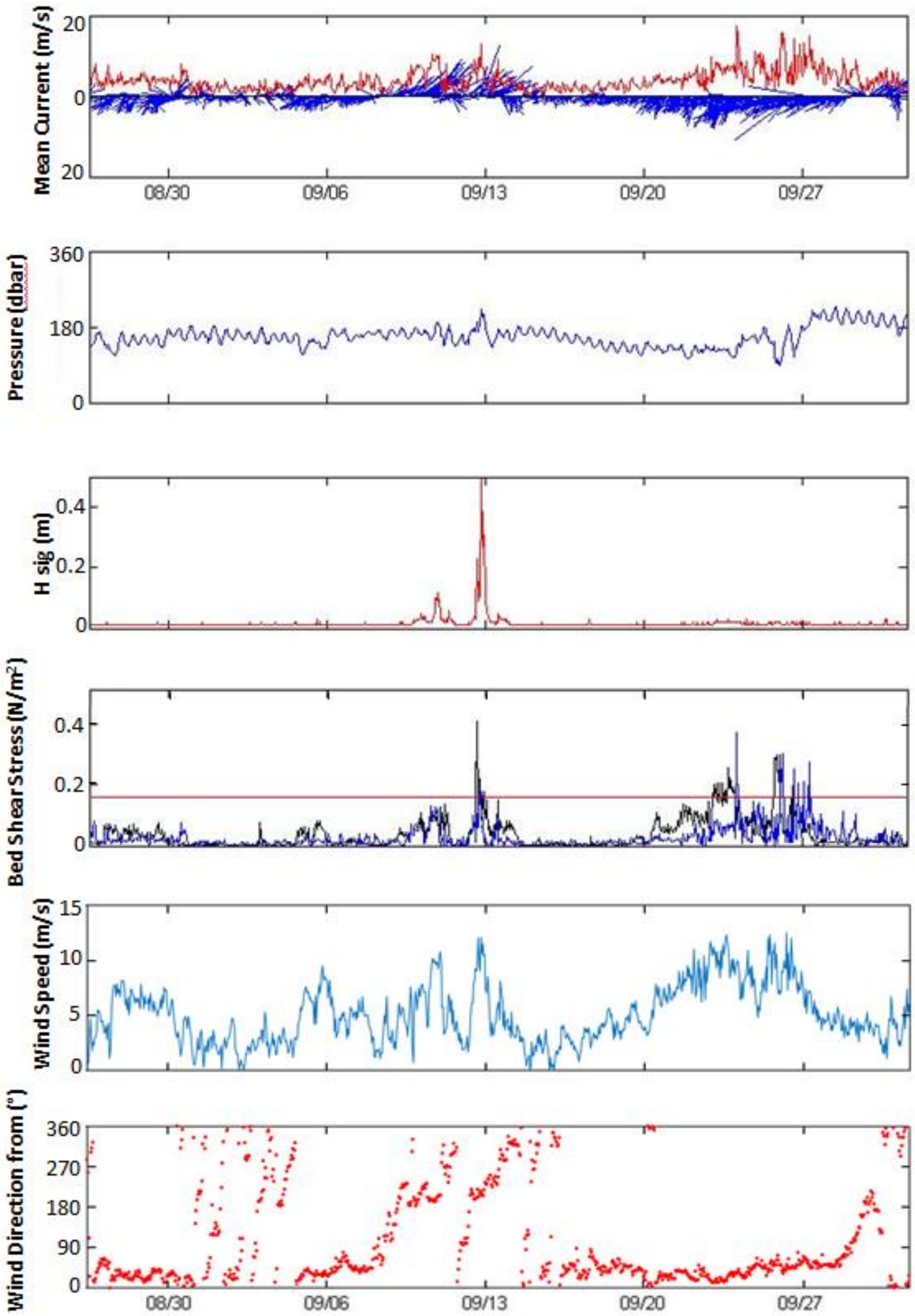


Figure 13: Measured hydrodynamic data from the vector deployment. Mean currents are shown as magnitude (red) and direction (blue). Pressure shows changes in water level. Bed shear stresses exceeded τ_{crit} (0.18 N/m^2, red line) for two wind events. The first event showed high H_s where the latter event showed very low H_s and high currents. Each period of high shear stress was during winds >10 m s^{-1}. Sediment transport direction is onshore in the first event (SW wind) and offshore in the second event (NE wind).

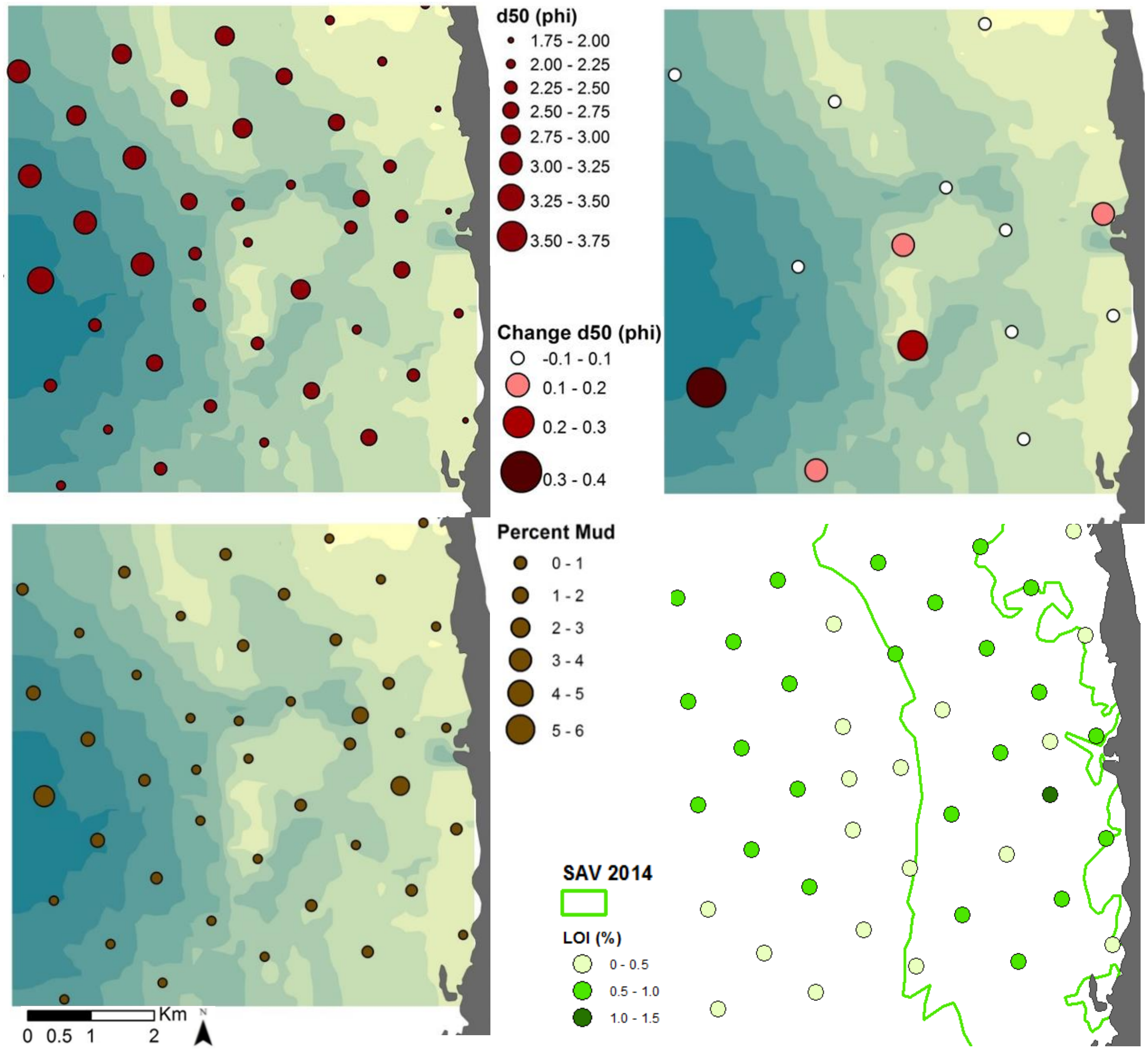


Figure 14: d50 of sediment samples (top left). Change of d50 (top right). Percent mud in samples (bottom left). Loss on ignition as a proxy for organic content (bottom right). Sediments were fine to medium sands with low mud and organic content. Samples showed little change between sampling periods.

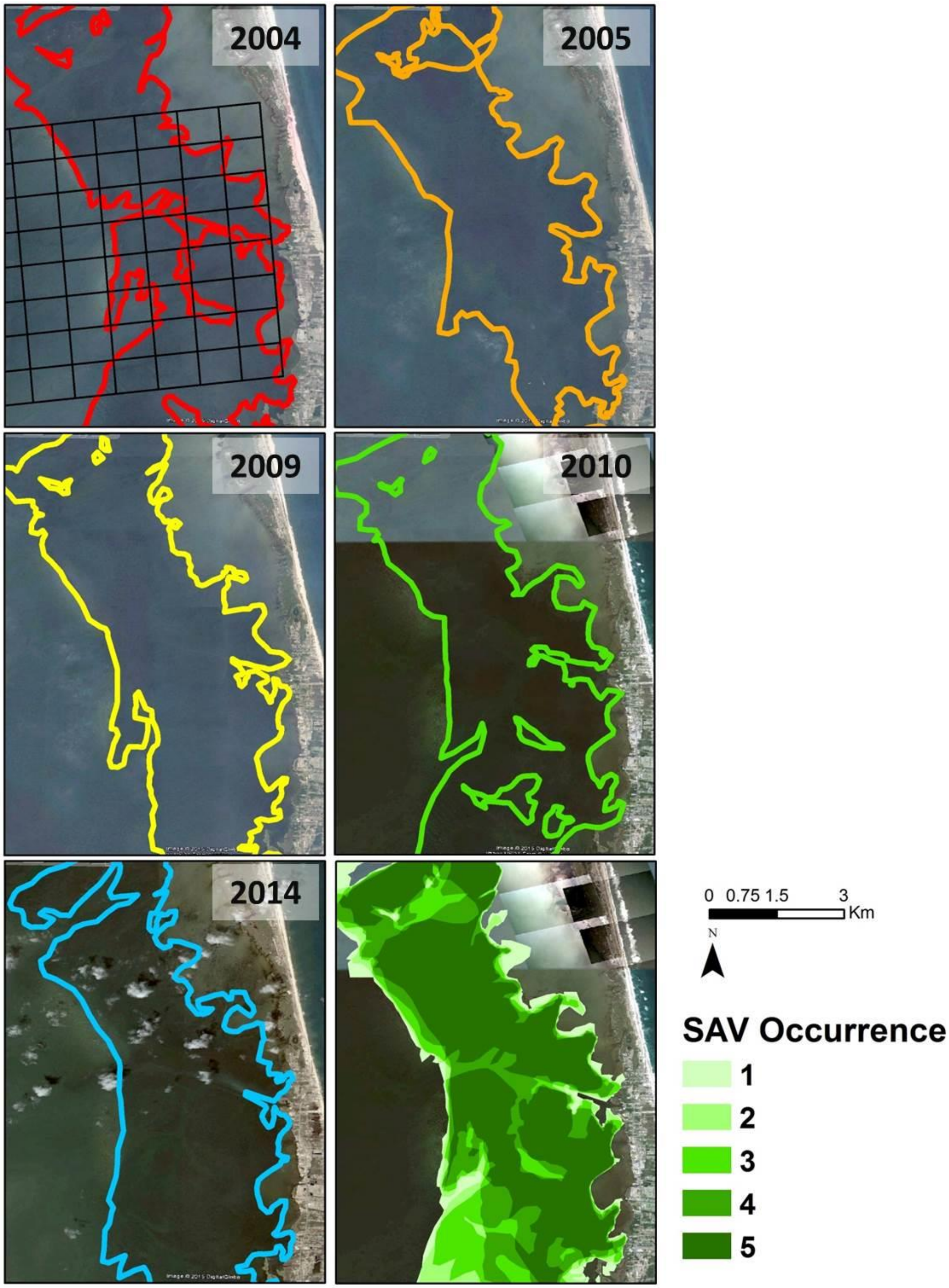


Figure 15: Heads-up mapped SAV boundaries for all time steps. Study area grid is shown in the 2004 data. (Bottom right) Occurrence of SAV between all time steps. Occurrence = 1 means SAV was only present during 1 year mapped. Occurrence = 5 means SAV was present at all years mapped. Data show persistent coverage of SAV with moderate variability between years.

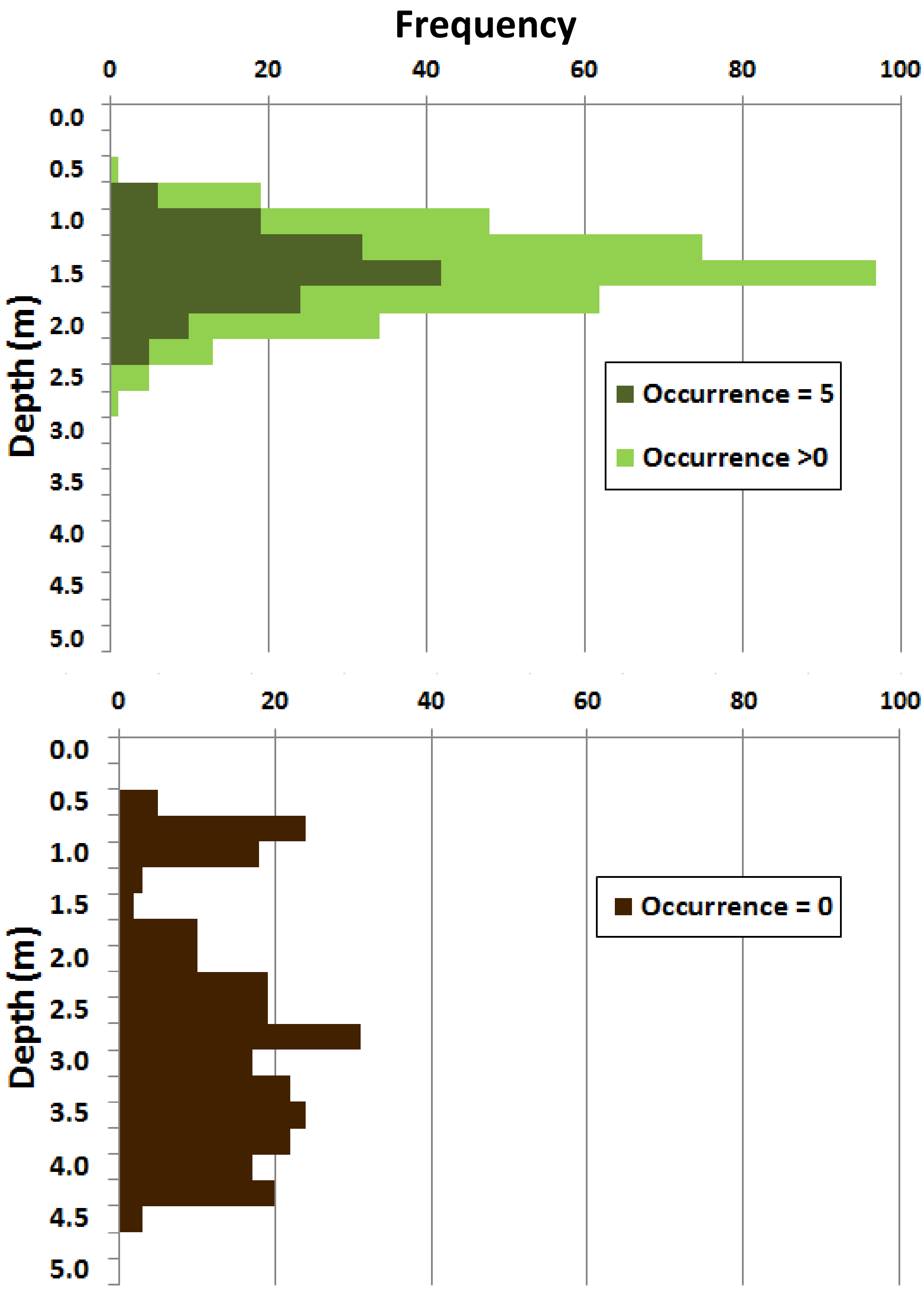


Figure 16: SAV frequency with depth (top) and depth values without SAV (bottom). Occurrence of 5 shows SAV persistent across all maps. Occurrence > 0 shows SAV presence during at least one map. The depth range of persistent SAV was 0.5-2.2 m, and all SAV was 0.4-2.7 m.

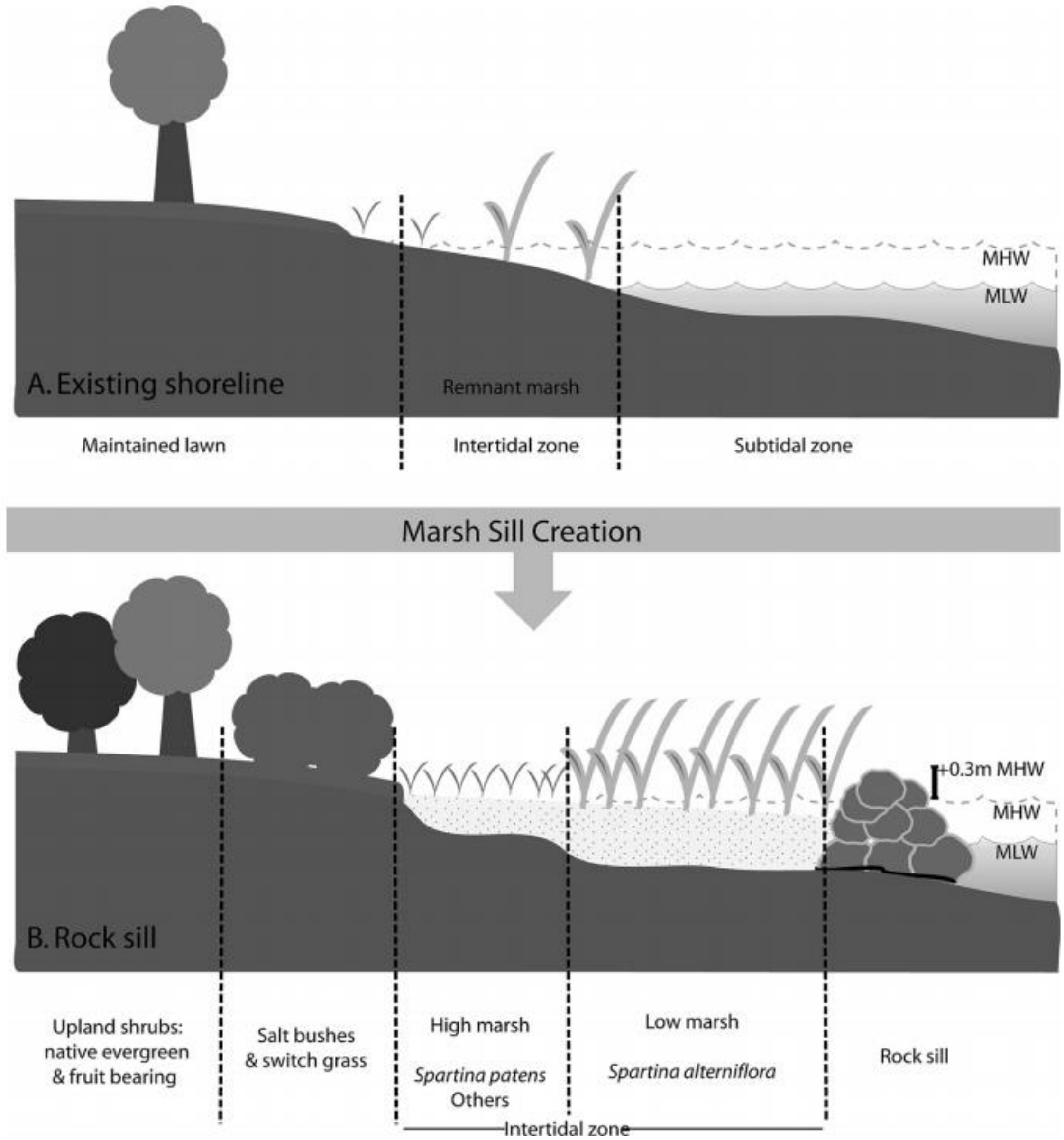


Figure 17: Example marsh-sill living shoreline stabilization method (Bilkovic and Mitchell, 2013). This method places a sill to protect current marsh and promote natural vegetation stabilization.

Literature Cited:

Adair, S. E., Moore, J. L., & Onuf, C. P., 1994. Distribution and status of submerged vegetation in estuaries of the upper Texas coast. Wetlands, 14(2):110-121.

Angradi, T. R., Pearson, M. S., Bolgrien, D. W., Bellinger, B. J., Starry, M. A., Reschke, C., 2013. Predicting submerged aquatic vegetation cover and occurrence in a Lake Superior estuary. Journal of Great Lakes Research 39:536-546.

Austin, M. J., Masselink, G., 2008. The effect of bedform dynamics on computing suspended sediment fluxes using optical backscatter sensors and current meters. Coastal Engineering 55:251-260.

Bartholdy, J., Aagaard, T., 2001. Storm surge effects on a back-barrier tidal flat of the Danish Wadden Sea. Geo-Marine Letters 20:133–141. doi:10.1007/s003670000048

Bell, S. S., Robbins, B. D., Jensen, S. L., 1999. Gap Dynamics in a Seagrass Landscape. Ecosystems 2:493-504.

Benninger, L. K., Wells, J. T., 1993. Sources of sediment to the Neuse River estuary, North Carolina. Marine Chemistry 43:137-156.

Bilkovic, D. M., Mitchell, M. M., 2013. Ecological tradeoffs of stabilized salt marshes as a shoreline protection strategy: Effects of artificial structures on macrobenthic assemblages. Ecological Engineering 61:469-481.

Biribo, N., Woodroffe, C. D., 2013. Historical area and shoreline change of reef islands around Tarawa Atoll, Kiribati. Sustainability Science 8:345-362.

Blott, S. J., Pye, K., 2001. GRADISTAT: A grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surface Processes and Landforms 26:1237-1248.

Blunt, J. A.C., Larcombe, P., Jago, C. F., 1999. Quantifying the response of optical backscatter devices and transmissometers to variations in suspended particulate matter. Continental Shelf Research 19:1199-1220.

Booth, J.G., Miller, R.L., McKee, B.A., Leathers, R.A., 2000. Wind-induced bottom sediment resuspension in a microtidal coastal environment.pdf. Continental Shelf Research 20:785–806.

Canuel, E. A., Hardison, A. K., 2016. Sources, ages, and alteration of organic matter in estuaries. The Annual Review of Marine Science. Doi: 10.1146/annurev-marine-122414-034058.

Chanson, H., Reungoat, D., Simon, B., Lubin, P., 2011. High-frequency turbulence and suspended sediment concentration measurements in the Garonne River Tidal Bore. Estuarine Coastal and Shelf Science 95:298-306.

Chen, S.-N., Sanford, L.P., Koch, E.W., Shi, F., North, E.W., 2007. A nearshore model to investigate the effects of seagrass bed geometry on wave attenuation and suspended sediment transport. Estuaries and Coasts 30:296–310.

Clinch, A. S., Russ, E. R., Oliver, R. C., Mitasova, H., Overton, M. F., 2012. Hurricane Irene and the Pea Island Breach: Pre-storm site characterization and storm surge estimation using geospatial technologies. Shore and Beach Vol. 80, No. 2.

Condition Survey Rodanthe Harbor, July 15, 2013. 1:3,600. Mapped by: DJM. Surveyed by: BRJ, DCH. U.S.Army Engineer District Corps of Engineers, Wilmington, NC.

Condition Survey Rodanthe Harbor, November 01, 2012. 1:3,600. Mapped by: MSA. Surveyed by: BRJ, DCH. U.S.Army Engineer District Corps of Engineers, Wilmington, NC.

Condition Survey Rodanthe Harbor, November 26, 2012. 1:3,600. Mapped by: DJM. Surveyed by: BRJ, DCH. U.S.Army Engineer District Corps of Engineers, Wilmington, NC.
Conery, I., 2014. Decadal-scale evolution of a barrier island: Insights from storm overwash and shoreline change on Ocracoke Island, NC. MS Thesis, East Carolina University.
Cowart, L., Walsh, J. P., Corbett, D. R., 2010. Analyzing estuarine shoreline change: a case study of Cedar Island, North Carolina. Journal of Coastal Research, 26:817-830.
Cowart, L., D.R. Corbett, J.P. Walsh, 2011. Shoreline Change along Sheltered Coastlines: Insights from the Neuse River Estuary, NC. Remote Sensing, 3, 1516-1534.
Culver, S.J., Ames, D., Corbett, D.R., Mallinson, D.J., Riggs, S.R., Christopher, S., Vance, D., 2006. Foraminiferal and Sedimentary Record of Late Holocene Barrier Island Evolution, Pea Island, North Carolina: The Role of Storm Overwash, Inlet Processes, and Anthropogenic Modification. Journal of Coastal Research 22, 836-846.
Currin, C. A., Chappell, W. S., Deaton, A., 2010. Developing alternative shoreline armoring strategies: The living shoreline approach in North Carolina. Proceedings of a State of the Science Workshop.
D'Andrea, A. F., Aller, R. C., Lopex, G. R., 2002. Organic matter flux and reactivity on a South Carolina sandflat: The impacts of porewater advection and macrobiological structures. Limnological Oceanography, 47 (4):1056-1070.
Davies-Vollum, K. S., West, M., 2015. Shoreline change and sea level rise at the Muni-Pomadze coastal wetland (Ramsar site), Ghana. Journal of Coastal Conservation 19:515-525.
De Swart, H.E., Zimmerman, J.T.F., 2009. Morphodynamics of Tidal Inlet Systems. Annual Review of Fluid Mechanics 41:203–229. doi:10.1146/annurev.fluid.010908.165159
Dean, W. E., 1974. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. Journal of Sedimentary Petrology 44:242-248.
Department of the Army/Corps of Engineers, Fiscal Years: 2012, 2011, 2010, 1998, 1997. Annual Reports of the Secretary of the Army on Civil Works Activities. Extract reports of the Wilmington, N.C., District.
Dillard, S. C., 2008. Resuspension events and seabed dynamics in the Neuse River Estuary, NC. MS Thesis, East Carolina University.
Dolan, R., Fenster, M. S., 1993. Historical shoreline trends along the Outer Banks, North Carolina: Processes and Responses. Journal of Coastal Research 9:172-188.
Douglass, S. L., Pickel, B. H., 1999. The tide doesn't go out anymore- The effect of bulkheads on urban bay shorelines. Shore and Beach 67:19-25.
Eulie, D. O., 2014. Examination of estuarine sediment dynamics: Insights from the large, shallow, Albemarle-Pamlico Estuarine System, NC, USA. Dissertation. East Carolina University, Coastal Resources Management.
Eulie, D. O., Walsh, J. P., Corbett, D. R., 2013. High-resolution analysis of shoreline change and application of balloon-based aerial photography, Albemarle-Pamlico Estuarine System, North Carolina, USA.
Feagin, R.A., Smith, W.K., Psuty, N.P., Young, D.R., Martínez, M.L., Carter, G.A., Lucas, K.L., Gibeaut, J.C., Gemma, J.N. and Koske, R.E., 2010. Barrier islands: coupling anthropogenic stability with ecological sustainability. *Journal of Coastal Research*, *26*(6), pp.987-992.

Findlay, S. E. G., Strayer, D. L., Smith, S. D., Curri, N., 2014. Magnitude and patterns of change in submerged aquatic vegetation of the tidal freshwater Hudson River. Estuaries and Coasts 37:1233-1242.

Fisher, John J. "Barrier island formation: discussion." Geological Society of America Bulletin 79.10 (1968)

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., & Serrano, O., 2012. Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience, 5(7):505-509.

Friedrichs, C. T., 2011. "3.06-Tidal Flat Morphodynamics: A Synthesis." Treatise on Estuarine and Coastal Science, edited by E. Wolanski and D. McLusky: 137-170.

Fugate, D. C., Friedrichs, C. T., 2002. Determining concentration and fall velocity of estuarine particle populations using ADV, OBS, and LISST. Continental Shelf Research, 22:1867-1886.

Gartner, J. W., 2004. Estimating suspended solids concentrations from backscatter intensity measured by acoustic Doppler current profiler in San Francisco Bay, California. Marine Geology 211:169-187.

Geis, S., Bendell, B., 2010. Charting the estuarine environment: A methodology spatially delineating a contiguous, estuarine shoreline of North Carolina. North Carolina Department of the Environment and Natural Resources, Division of Coastal Management.

Gittman, R.K., Popowich, A.M., Bruno, J.F., Peterson, C.H., 2014. Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane. Ocean & Coastal Management 102:94–102. doi:10.1016/j.ocecoaman.2014.09.016

Grabowski, R. C., Droppo, I. G., Wharton, G., 2011. Erodibility of cohesive sediment: The importance of sediment properties. Earth-Science Reviews 105:101-120.

Greiner, J. T., McGlathery, K. J., Gunnell, J., McKee, B. A., 2013. Seagrass restoration enhances "blue carbon" sequestration in coastal waters. PLoS ONE 8(8): e72469. doi:10.1371/journal.pone.0072469

GSAA, 1949 and 1974 Dare County Shoreline. Governors' South Atlantic Alliance. Unpublished data.

Hale, R. P., Ogston, A. S., Walsh, J. P., Orpin, A. R., 2014. Sediment transport and event deposition on the Waipaoa River Shelf, New Zealand. Continental Shelf Research 86:52-65.

Hall, M. O., Durako, M. J., Fourqurean, J. W., Zieman, J. C., 1999. Decadal changes in seagrass distribution and abundance in Florida Bay. Estuaries 22:445-459.

Hardin, E., Mitasova, H., Overton, M., 2012. GIS-Based analysis of storm vulnerability change at Pea Island, NC. Coastal Engineering, 2012.

Hawkins, D. W., 2015. Modern sedimentation and estuarine shoreline change around Roanoke Island, North Carolina. MS Thesis, East Carolina University.

Heiri, O., Lotter, A. F., Lemcke, G., 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. Journal of Paleolimnology 25:101-110.

Huettel, M., Rusch, A., 2000. Transport and degradation of phytoplankton in permeable sediment. Limnological Oceanography 45 (3):534-549.

Jackson, C. W., Alexander, C. R., Bush, D. M., 2012. Application of the AMBUR R package for spatio-temporal analysis of shoreline change: Jekyll Island, Georgia, USA. Computers & Geosciences 41:199-207.
Jackson, C. W., Alexander, C. R., Bush, D. M., 2012. Application of the AMBUR R package for spatio-temporal analysis of shoreline change: Jekyll Island, Georgia, USA. Computers & Geosciences 41:199-207.
Jackson, C.W., Jr., 2010. Basic User Guide for the AMBUR package for R, version 1.0a. Unpublished.

Jackson, N. L., Nordstrom, K. F., Eliot, I., Masselink, G., 2002. 'Low energy' sandy beaches in marine and estuarine environments: a review. Geomorphology 48:147-162.

Kelley, J. T., Pilkey, O. H., Cooper, J. A. G., 2009. America's most vulnerable coastal communities. Geological Survey of America Special Paper 460, 2009.

Kennedy, H., Beggins, J., Duarte, C. M., Fourqurean, J. W., Holmer, M., Marba, N., Middelburg, J. J., 2010. Seagrass sediments as a global carbon sink: Isotopic constraints. Global Biogeochemical Cycles 24.

Koch, E., 2001. Beyond light: Physical, geological, and geochemical parameters as possible submersed aquatic vegetation habitat requirements. Estuaries 24:1–17. doi:10.2307/1352808

Liu, J.T., Stauble, D.K., Giese, G.S., Aubrey, D.G., 1993. Morphodynamic Evolution of a Newly Formed Tidal Inlet, in: Formation and Evolution of Multiple Tidal Inlets. American Geophysical Union, pp. 62–94.

Luettich, R. A., Carr, S. D., Reynolds-Fleming, J. V., Fulcher, C. W., McNinch, J. E., 2002. Semi-diurnal seiching in a shallow, micro-tidal lagoonal estuary. Continental Shelf Research 22:1668-1681.

Mallinson, D. J., Smith, C. W., Culver, S. J., Riggs, S. R., Ames, D., 2010. Geological characteristics and spatial distribution of paleo-inlet channels beneath the outer banks barrier islands, North Carolina, USA. Estuarine, Coastal and Shelf Science 88:175-189.

Mallinson, D.J., Smith, C.W., Mahan, S., Culver, S.J., McDowell, K., 2011. Barrier island response to late Holocene climate events, North Carolina, USA. Quaternary Research 76:46–57. doi:10.1016/j yqres.2011.05.001

Mason, M. A., 2010. The transformation of waves in shallow water. Coastal Engineering Proceedings 1.1, 3.

Matias, A., Ferreira, Ó., Vila-Concejo, A., Garcia, T., Dias, J.A., 2008. Classification of washover dynamics in barrier islands. Geomorphology 97:655–674. doi:10.1016/j.geomorph.2007.09.010

Mcleod, E., Chmura, G. L, Bouillon, S., Salm, R., Bjork, M., Duarte, C. M., Lovelock, C. E., Schlesinger, W. H., Silliman, B. R., 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. Frontiers in Ecology and the Environment 9(10):552-560.

McNinch, J., et al. (2012). "Observations of wave run-up, shoreline hotspot erosion, and sound-side seiching during Hurricane Irene at the Field Research Facility." Shore Beach, 80(2):19–37

Meyer, D. L., Townsend, E. D., Thayer, G. W., 1997. Stabilization and erosion control value of oyster cultch for intertidal marsh. Restoration Ecology 5:93-99.

Mulligan, R. P., Walsh, J. P., Wadman, H. M., 2014. Storm surge and surface waves in a shallow lagoonal estuary during the crossing of a hurricane. American Society of Civil Engineers.

National Hurricane Center, 2015. Hurricane Tracks at 2015. http://www.nhc.noaa.gov/data/tracks/tracks-at-2015.png
National Research Council, 2007. Mitigating Shore Erosion along Sheltered Coasts. Washington, US: National Academies Press. ProQuest ebrary. Web.
NC DCM, 2007 (Data). North Carolina's 2007 Estuarine Shoreline. Estuarine Shoreline Mapping Project. http://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/spatial-data-maps
NC DCM, 2012 (Data). North Carolina's 2012 Estuarine Shoreline. Estuarine Shoreline Mapping Project.
NCDEQ, 2013. Weighing your options. How to protect your property from shoreline erosion: A handbook for estuarine property owners in North Carolina. Updated by the NC Division of Coastal Management – North Carolina Coastal Reserve & National Estuarine Research Reserve (NCNERR). http://portal.ncdenr.org/c/document_library/get_file?uuid=3ea68378-6f3f-4eb8-bd9d-04f6995f1d24&groupId=61572
O'Meara, T., Thompson, S. P., Piehler, M. F., 2015. Effects of shoreline hardening on nitrogen processing in estuarine marshes of the U.S. mid-Atlantic coast. Wetlands Ecology and Management 23:385-394.
Orth, R. J., Wilcox, D. J., Whiting, J. R., Kenne, A. K., Nagey, L., Smith, E. R., 2014. 2014 Distribution of submerged aquatic vegetation in Chesapeake Bay and coastal bays. Special Scientific Report #158. Virginia Institute of Marine Science.
Palinkas, C.; Koch, E., 2012. Sediment Accumulation Rates and Submersed Aquatic Vegetation (SAV) Distributions in the Mesohaline Chesapeake Bay, USA. Estuaries and Coasts 35:1416-1431.
Paphitas, D., Collins, M. B., 2005. Sediment resuspension events within the (microtidal) coastal waters of Thermaikos Gulf, northern Greece. Continental Shelf Research 25:2350-2365.
Peek, K.M., Mallinson, D.J., Culver, S.J., Mahan, S.A., 2013. Holocene Geologic Development of the Cape Hatteras Region, Outer Banks, North Carolina, USA. Journal of Coastal Research 30:41–58.
Peterson, C.H., Luettich, R.A., Micheli, F., Skilleter, G.A., 2004. Attenuation of water flow inside seagrass canopies of differing structure. Marine Ecology Progress Series 268.
Phillips, J.D., 1999. Event timing and sequence in coastal shoreline erosion: Hurricanes Bertha and Fran and the Neuse estuary. Journal of coastal research 616–623.
Pinsky, M. L., G. Guannel, and K. K. Arkema. 2013. Quantifying wave attenuation to inform coastal habitat conservation. Ecosphere 4(8):95. http://dx.doi.org/10.1890/ES13-00080.1
Pope, N. D., Widdows, J., Brinsley, M. D., 2006. Estimation of bed shear stress using the turbulent kinetic energy approach- A comparison of annular flume and field data. Continental Shelf Research 26:959-970.
Powell, M.A., Thieke, R.J., Mehta, A.J., 2006. Morphodynamic relationships for ebb and flood delta volumes at Florida's tidal entrances. Ocean Dynamics 56:295–307. doi:10.1007/s10236-006-0064-3
Powers, S. P., Peterson, C. H., Grabowski, J. H., Lenihan, H. S., 2009. Success of constructed oyster reefs in no-harvest sanctuaries: implications for restoration. Marine Ecology Progress Series 389:159-170.
Reed, D.J., D.A. Bishara, D.R. Cahoon, J. Donnelly, M. Kearney, A.S. Kolker, L.L. Leonard, R.A. Orson, and J.C. Stevenson. 2008. Site-Specific Scenarios for Wetlands Accretion as

Sea Level Rises in the Mid-Atlantic Region. Section 2.1 in: Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.
Reynolds-Fleming, J. V., Luettich, R. A., 2004. Wind-driven lateral variability in a partially mixed estuary. Estuarine, Coastal and Shelf Science 60:395-407.
Reynolds-Fleming, J. V., Luettich, R. A., Fleming, J. G., 2013. Comparative hydrodynamics during events along a barrier island: explanation for overwash. Estuaries and Coasts 36:334-346.
Riggs, S. R., 2001. Shoreline erosion in North Carolina estuaries. 1-11 Vol. Raleigh, NC: North Carolina Sea Grant, NC State University.
Riggs, S. R., Ames, D. V., 2003. Book: Drowning NC Coast.
Riggs, S. R., Ames, D. V., Culver, S. J., Mallinson, D. J., Corbett, D. R., Walsh, J. P., 2009. Eye of a human hurricane: Pea Island, Oregon Inlet and Bodie Island, northern Outer Banks, North Carolina.
Riggs, S. R., Cleary, W. J., Snyder, S. W., 1995. Influence of inherited geologic framework on barrier shoreface morphology and dynamics. Marine Geology 126:213-234.
Riggs, S.R., Ames, D.V., Culver, S.J., Mallinson, D.J., 2011. The battle for North Carolina's coast: Evolutionary history, present crisis, and vision for the future. The University of North Carolina Press. Chapel Hill, NC, 160 pp.
Rusus, E., Soares, C. G., 2010. Validation of two wave and nearshore current models. Journal of Waterway Port Coastal and Engineering, January, 2010.
Scyphers, S. B., Powers, S. P., Heck, K. L., Byron, D., 2011. Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries. PLoS ONE 6, Iss. 8.
Shepard, C. C., Crain, C. M., Beck, M. W., 2011. The protective role of coastal marshes: a systematic review and meta-analysis. Plos One 6, 11: e27374. doi:10.1371/journal.pone.0027374
Smith, Christopher G., Stephen J. Culver, Stanley R. Riggs, Dorothea Ames, D. Reide Corbett, David J. Mallinson, 2008. Geospatial analysis of barrier island width of two segments of the Outer Banks, NC, USA, anthropogenic curtailment of natural selfsustaining processes. Journal of Coastal Research 24, 70 pp.
Smith, K., North, E. W., Shi, F. Y., Koch, E. W., 2009. Modeling the effects of oyster reefs and breakwaters on seagrass growth. Estuaries and Coasts 32:748-757.
Soulsby, R. L., Humphery, J. D., 1990. Field observations of wave-current interaction at the sea bed. Book: Water Wave Kinematics, 413-428. Kluwer Academic Publishers.
Soulsby, R.L., 1983. The bottom boundary layer of shelf seas. *Elsevier oceanography series 35*:189-266.
Stick, David. The Outer Banks of North Carolina, 1584-1958. The University of North Carolina Press, 1958.
Stone, G.W., Liu, B., Pepper, D.A., Wang, P., 2004. The importance of extratropical and tropical cyclones on the short-term evolution of barrier islands along the northern Gulf of Mexico, USA. Marine Geology 210:63–78. doi:10.1016/j.margeo.2004.05.021
Strand, J., 2015. Examining coastal marsh sedimentation in the northeastern North Carolina. MS Thesis, East Carolina University.
Stutz, M. L., Pilkey, O. H., 2001. A review of global barrier island distribution. Journal of Coastal Research 34:15-22.

Swerida, R.M., 2013. Water flow and sediment grain size as co-varying SAV habitat requirements (M.S.). University of Maryland, College Park, Ann Arbor.
Timmons, E.A., Rodriguez, A.B., Mattheus, C.R., DeWitt, R., 2010. Transition of a regressive to a transgressive barrier island due to back-barrier erosion, increased storminess, and low sediment supply: Bogue Banks, North Carolina, USA. Marine Geology 278:100–114. doi:10.1016/j.margeo.2010.09.006
Tully, L. C., 2004. Evaluation of sediment dynamics using geochemical tracers in the Pamlico Sound Estuarine System, North Carolina. MS Thesis, East Carolina University.
U.S. Geological Survey, 2008. Critical shear stresses by particle-size classification for determining approximate condition for sediment mobility at 20 degrees Celsius. Scientific Investigations Report 2008-5093. http://pubs.usgs.gov/sir/2008/5093/table7.html
Wells, J., Kim, S.-Y., 1989. Sedimentation in the Albemarle-Pamlico Lagoonal System: Synthesis and Hypothesis. Marine Geology 88:263–284.
Whipple, A. C., Luettich, R. A., Seim, H. E., 2006. Measurements of Reynolds stress in a wind-driven lagoonal estuary. Ocean Dynamics 56:169-185.
Wicks, E. C., Koch, E. W., O'Neil, J. M., Elliston, K., 2009. Effects of sediment organic content and the hydrodynamic conditions on the growth and distribution of Zostera marina. Marine Ecology Progress Series 378:71-80.
Woodshole, 2005. U. S. Geological Survey Open-File Report 2005-1001. http://woodshole.er.usgs.gov/openfile/of2005-1001/htmldocs/videos/dry_sieve/dry_sieve.htm
Wren, D. G., Barkdoll, B. D., Kuhnle, R. A., Derrow, R. W., 2000. Field techniques for suspended-sediment measurement. Journal of Hydaulic Engineering 126:97-104.
Wright, L. D., Prior, D. B., Hobbs, C. H., Byrne, R. J., Boon, J. D., Schaffner, L. C., Green, M. O., 1987. Estuarine, Coastal and Shelf Science 24:765-784.
Zaremba, N., Mallinson, D. J., Leorri, E., Culver, S., Riggs, S., Mulligan, R., Horsman, E., Mitra, S., 2016. Controls on the stratigraphic framework and paleoenvironmental change within a Holocene estuarine system: Pamlico Sound, North Carolina, USA, Marine Geology, Volume 379, 1 September 2016, Pages 109-123, ISSN 0025-3227, http://dx.doi.org/10.1016/j.margeo.2016.04.012.
Zeller, R.B., Weitzman, J.S., Abbett, M.E., Zarama, F.J., Fringer, O.B., Koseff, J.R., 2014. Improved parameterization of seagrass blade dynamics and wave attenuation based on numerical and laboratory experiments. Limnology and Oceanography 59:251–266. doi:10.4319/lo.2014.59.1.0251
Zhou, L., Liu, J., Saito, Y., Zhang, Z., Chu, H., Hu, G., 2014. Coastal erosion as a major sediment supplier to continental shelves: example from the abandoned Old Huanghe delta. Continental Shelf Research 82:43-59.

Appendix A: Region Shoreline Change Rates

Region	Year	Mean Change (m)	Mean Change Rate ($m\ y^{-1}$)
1	1949-1974	-11.9 ± 3.46	-0.45 ± 0.14
	1974-2007	-11.2 ± 1.63	-0.34 ± 0.14
	2007-2012	-0.3 ± 1.62	-0.06 ± 0.32
	2012-2015	-3.3 ± 1.68	-0.92 ± 0.56
2	1949-1974	-11.5 ± 3.46	-0.46 ± 0.14
	1974-2007	-17.9 ± 1.63	-0.54 ± 0.14
	2007-2012	1.7 ± 1.62	0.35 ± 0.32
	2012-2015	-4.0 ± 1.68	-1.11 ± 0.56
3	1949-1974	3.0 ± 3.46	0.12 ± 0.14
	1974-2007	-19.4 ± 1.63	-0.59 ± 0.14
	2007-2012	-1.0 ± 1.62	-0.21 ± 0.32
	2012-2015	-5.1 ± 1.68	-1.35 ± 0.56
4	1949-1974	-26.5 ± 3.46	-1.06 ± 0.14
	1974-2007	-29.7 ± 1.63	-0.90 ± 0.14
	2007-2012	0.3 ± 1.62	0.07 ± 0.32
	2012-2015	-1.2 ± 1.68	-0.33 ± 0.56
5	1949-1974	-4.7 ± 3.46	-0.19 ± 0.14
	1974-2007	-7.2 ± 1.63	-0.22 ± 0.14
	2007-2012	0.2 ± 1.62	0.04 ± 0.32
	2012-2015	-3.0 ± 1.68	-0.84 ± 0.56

Appendix B: Percent Shoreline Type

Region	Shore Type	1949	1974	2007	2012	2015
1	Marsh	97.7	93.9	99.6	100.0	94.3
	Sed Bank	2.3	6.1	0.4	0.0	5.7
	Modified	0.0	0.0	0.0	0.0	0.0
2	Marsh	70.8	57.2	52.0	82.9	45.7
	Sed Bank	29.2	42.8	47.0	15.6	44.2
	Modified	0.0	0.0	1.0	1.5	10.1
3	Marsh	80.0	86.4	77.0	76.9	71.1
	Sed Bank	13.7	7.3	18.0	14.4	20.6
	Modified	6.4	6.4	5.0	8.7	8.3
4	Marsh	60.0	52.1	31.0	21.0	10.5
	Sed Bank	40.0	39.6	34.0	27.6	4.5
	Modified	0.0	8.3	35.0	51.5	85.0
5	Marsh	73.7	93.4	65.0	67.7	69.4
	Sed Bank	26.3	5.3	25.0	14.5	9.7
	Modified	0.0	1.3	10.0	17.8	20.9
All	Marsh	76.4	76.6	64.9	69.7	58.2
	Sed Bank	22.3	20.2	24.9	14.4	16.9
	Modified	1.3	3.2	10.2	15.9	24.9

Appendix C: Shoreline Volumetric Change Rates, 1949 - 2015

Region	Mean SCR ($m\ y^{-1}$)	Mean Scarp (m)	Shoreline (m)	VCR (m^3/y)		Baseline (m)	VCR (m^3/y)		ACR (m^2/y)	VCR (m3/y)
1	-0.38 ± 0.03	0.23 ± 0.02	9406	-800 ± 67		2867	-240 ± 67		-1400 ± 21	-320 ± 22
2	-0.48 ± 0.03	0.45 ± 0.02	1261	-270 ± 52		742	-160 ± 52		-371 ± 21	-170 ± 11
3	-0.34 ± 0.03	0.55 ± 0.02	3199	-600 ± 72		1113	-210 ± 72		-587 ± 21	-320 ± 9
5	-0.22 ± 0.03	0.47 ± 0.02	2320	-240 ± 110		1375	-150 ± 110		-345 ± 21	-160 ± 10
			Total	**-1910 ± 156**			**-760 ± 1560**			**-970 ± 28**

Appendix D: Scarp Measurements

Scarp Heights (m)

Region	Mean Scarp	Scarp 1	Scarp 2	Scarp 3	Scarp 4	Scarp 5	Scarp 6	Scarp 7
1	0.23	0.14	0.29	0.18	0.21	0.26	0.41	0.10
2	0.45	0.47	0.55	0.40	0.47	0.35		
3	0.55	0.51	0.58	0.59	0.63	0.46	0.87	
5	0.47	0.43	0.41	0.34	0.58	0.65	0.60	0.30

Scarp Sample LOI

Date	Region	Pre-ignition (g)	Post-ignition (g)	% LOI
22-Jun	1	2.2481	1.675	25.5
22-Jun	2	3.0534	2.7306	10.6
22-Jun	3	4.3569	4.0748	6.5
22-Jun	5	1.7312	1.3806	20.3

Appendix E: Sediment Sample Results (µm)

Date	Sample ID	Mean	Sorting	Skewness	Kurtosis	d10	d50	d90
22-Jun	1	147	105	9.9	194	83	124	217
22-Jun	3	154	90	10.7	257	92	138	228
22-Jun	5	170	136	9.3	124	94	148	236
22-Jun	7	246	109	3.6	34	138	224	347
22-Jun	9	259	144	3.4	22	137	222	394
22-Jun	11	145	97	12.2	246	92	131	179
22-Jun	13	164	51	4.6	50	118	154	221
22-Jun	15	182	106	9.4	172	102	163	254
22-Jun	17	260	120	2.5	16	139	235	382
22-Jun	19	132	128	11.2	183	71	108	178
22-Jun	21	130	67	18.1	549	91	118	172
22-Jun	23	151	103	12.5	224	92	140	195
22-Jun	25	179	94	3.1	26	92	158	285
22-Jun	27	279	122	2.6	16	160	256	409
22-Jun	29	125	76	6.5	74	75	109	173
22-Jun	31	177	88	6.9	189	95	159	270
22-Jun	33	243	118	2.6	17	123	220	352
22-Jun	35	204	127	8.7	120	129	178	295
22-Jun	37	122	119	10.3	160	67	101	173
22-Jun	39	152	104	3.7	26	77	116	261
22-Jun	40	205	94	3.3	26	110	192	305
22-Jun	41	226	67	2.9	29	147	215	312
22-Jun	43	221	94	1.9	16	115	208	330
22-Jun	44	221	93	4.2	44	132	206	318
22-Jun	45	281	156	3.5	25	142	251	431
22-Jun	47	205	128	3.5	31	80	184	329
22-Jun	49	206	131	8.7	117	113	190	291
22-Jun	51	142	107	12.5	217	83	128	181
22-Jun	53	175	153	7.9	89	81	150	261

22-Jun	55	231	118	3.2	24	127	207	343
22-Jun	57	195	137	7.7	97	97	172	292
22-Jun	59	195	60	3.6	41	129	190	247
22-Jun	61	223	91	2.4	20	122	210	325
22-Jun	63	229	118	3.9	38	119	210	339
22-Jun	65	250	117	3.7	31	136	229	346
22-Jun	67	204	97	6.4	140	113	187	306
22-Jun	69	179	111	10.2	165	101	161	244
22-Jun	71	203	99	5.3	71	106	192	306
22-Jun	73	231	104	4.1	34	138	211	324
22-Jun	75	231	136	4.6	37	130	200	335
22-Jun	77	226	101	9.1	173	135	213	318
22-Jun	79	187	100	6.4	83	96	176	274
22-Jun	81	284	139	3.6	26	158	259	403
22-Jun	C2	178	115	7.5	118	82	157	289
22-Jun	C3	227	110	3.6	33	117	209	333
16-Dec	1	157	99	6.4	71	93	133	234
16-Dec	7	243	112	3.5	29	136	221	347
16-Dec	13	160	62	8.3	114	110	150	209
16-Dec	26	265	110	3.2	27	158	240	374
16-Dec	33	242	125	3.6	31	125	218	352
16-Dec	39	156	127	8.5	169	73	117	273
16-Dec	41	213	128	9.4	129	128	199	293
16-Dec	43	219	96	3.0	26	120	205	324
16-Dec	45	262	184	6.2	71	127	226	402
16-Dec	50	197	66	5.5	71	132	188	249
16-Dec	55	181	93	4.3	42	93	165	264
16-Dec	59	178	73	7.6	103	126	163	237
16-Dec	61	236	108	3.2	28	123	218	341
16-Dec	63	225	118	3.8	37	109	206	339
16-Dec	75	205	108	5.2	51	119	185	301
16-Dec	79	196	93	6.0	80	109	186	282

Appendix F: Loss on Ignition Results

Date	ID	Pre-ignition (g)	Post-ignition (g)	% LOI
22-Jun	1	5.7512	5.7189	0.56
22-Jun	3	7.1539	7.1109	0.60
22-Jun	5	6.1972	6.1378	0.96
22-Jun	7	8.5017	8.4563	0.53
22-Jun	9	8.9945	8.9523	0.47
22-Jun	11	9.7693	9.7129	0.58
22-Jun	13	8.4944	8.4550	0.46
22-Jun	15	7.1562	7.0998	0.79
22-Jun	17	7.8147	7.7753	0.50
22-Jun	19	7.9006	7.8468	0.68
22-Jun	21	9.5521	9.4938	0.61
22-Jun	23	8.7615	8.6852	0.87
22-Jun	25	10.183	10.1113	0.70
22-Jun	27	9.5344	9.4978	0.38
22-Jun	29	11.3475	11.2653	0.72
22-Jun	31	10.9043	10.8532	0.47
22-Jun	33	8.2096	8.1716	0.46
22-Jun	35	7.378	7.3222	0.76
22-Jun	37	9.8299	9.7342	0.97
22-Jun	39	8.016	7.9666	0.62
22-Jun	40	9.9869	9.9476	0.39
22-Jun	41	10.181	10.1438	0.37
22-Jun	43	8.8923	8.8421	0.56
22-Jun	44	9.2939	9.2516	0.46
22-Jun	45	8.7943	8.7251	0.79
22-Jun	47	11.83	11.7661	0.54
22-Jun	49	8.2532	8.2130	0.49
22-Jun	51	8.4577	8.4026	0.65
22-Jun	53	9.6815	9.5473	1.39
22-Jun	55	10.5006	10.4650	0.34

22-Jun	57	7.4722	7.4289	0.58
22-Jun	59	6.4032	6.3819	0.33
22-Jun	61	8.058	8.0285	0.37
22-Jun	63	7.9594	7.8995	0.75
22-Jun	65	7.9303	7.9056	0.31
22-Jun	67	7.5928	7.5643	0.38
22-Jun	69	6.9582	6.9110	0.68
22-Jun	71	7.2933	7.2502	0.59
22-Jun	73	7.3197	7.2960	0.32
22-Jun	75	7.2668	7.2411	0.35
22-Jun	77	7.4832	7.4638	0.26
22-Jun	79	7.1148	7.0730	0.59
22-Jun	81	8.4949	8.4686	0.31
16-Dec	1	22.7905	22.7369	0.24
16-Dec	7	21.7169	21.6552	0.28
16-Dec	13	21.6057	21.5693	0.17
16-Dec	26	25.1887	25.1523	0.14
16-Dec	33	22.9151	22.8714	0.19
16-Dec	39	22.5183	22.4448	0.33
16-Dec	41	23.104	23.0583	0.20
16-Dec	43	26.6402	26.5774	0.24
16-Dec	45	22.0408	21.9124	0.58
16-Dec	50	23.1413	23.1050	0.16
16-Dec	55	21.106	21.0610	0.21
16-Dec	59	21.3704	21.3365	0.16
16-Dec	61	23.7266	23.6786	0.20
16-Dec	63	21.1713	21.0845	0.41
16-Dec	75	23.0216	22.9785	0.19
16-Dec	79	26.6142	26.5555	0.22