

Fall 12-15-2012

Potential Changes to the Cubitt Creek System After Dredging

Hillary Sparagna
Coastal Carolina University

Follow this and additional works at: <https://digitalcommons.coastal.edu/honors-theses>

 Part of the [Oceanography Commons](#)

Recommended Citation

Sparagna, Hillary, "Potential Changes to the Cubitt Creek System After Dredging" (2012). *Honors Theses*. 66.
<https://digitalcommons.coastal.edu/honors-theses/66>

This Thesis is brought to you for free and open access by the Honors College and Center for Interdisciplinary Studies at CCU Digital Commons. It has been accepted for inclusion in Honors Theses by an authorized administrator of CCU Digital Commons. For more information, please contact commons@coastal.edu.

Potential Changes to the Cubitt Creek System after Dredging

Hillary Sparagna

Marine Science 2012

Submitted in Partial Fulfillment of the
Requirements for the Degree of Bachelor of Science
In the Honors Program at
Coastal Carolina University

December 2012

Dredging is the process of removing sediments from beneath the water's surface to increase the depth of the area. Many times, dredging is used to deepen navigational channels for boats in inlets and bays, control river flow, and environmental remediation of contaminated sediments. Sustainable dredging is when the sediments that have been dredged are used to replenish beaches. This method saves money, minimizes ecological impact, saves capacity at deposit sites, and can be used for habitat restoration.

There is different equipment to be used based on the purpose and location of the dredging. There are three major types of dredgers: mechanical, hydraulic, and airlift. The mechanical dredgers are typically used in areas that are protected from the ocean such as docks and shallow channels. Hydraulic dredgers, also known as hopper dredges, use suction to suck up sediment and water from channel bottoms. The third, airlift dredges, uses air pressure to move sediments along the bottom and are typically used in deep areas (Sulaiman et al., 2011). Maintenance dredgers are a smaller type of mechanical dredge used to maintain the channel opening in between dredging events or if a location is not in need of major dredging activities.

Dredging is often utilized in inlets, which are complex marine environments. An inlet is a narrow passageway between land masses or sandbars which allows water to flow in and out. Cubitt Creek is a tide-dominated tributary of the Potomac River where the river meets the Chesapeake Bay. A tide dominated system is an area where flow in and out of the inlet is controlled by tides from the Potomac River and Chesapeake Bay. Ebb deltas are formed at the seaward mouth of an inlet where ebb-oriented tidal flows dissipated when unconstrained at the inlet throat. Flood tidal deltas similarly form on the landward side of inlets where flooding currents decrease as the jet within the inlet throat is free to expand. Most systems are dominated by stronger flooding or ebbing currents which results in an asymmetry of the delta system. This

tidal asymmetry is a function of tidal range and deformation of the tidal wave as it shoals in shallow water. The ebb delta is located on the bay-side of the mouth and the flood delta is located on the creek-side of the mouth. The sand which gets deposited on the bay side also undergoes longshore transport. This is the process of eroding sediments from the coast then moving the sediments back and forth along the shoreline by wave driven currents (longshore transport) where the directions of the waves is driven by the direction of the wind. In shallow systems such as these direct wind driven flows can also be important in augmenting longshore transport. The sediment that gets transported eventually gets deposited within inlet systems as long shore transport decreases to zero where there is no beach or boundary required for generation of that current. The deposition in inlets causes development of spits and shoals within the inlets, and similarly at mouths of the small creeks, which can result in the inlet or creek entrance to filled with sediment and close.. People then begin to dredge to remove the sediments from the mouth to re-open the river.

Cubitt Creek is located in Northumberland County, Virginia (approximately 37.949°N, 76.351°W). A 1973 USGS 7.5-minute topographic map of Burgess, Virginia documents this is a very low-lying area with limited vertical relief. (Figure 1). Large areas are inundated by the tides and support development of extensive salt marsh and creek systems. The study area is a creek whose water supply is provided by the Potomac River and is considered to be a part of the Lower Potomac Watershed. The creek system is a low energy system tide-dominated system, and contains both ebb and flood tidal deltas. The tidal range is approximately 1 foot and wave energy is modest but locally important. Estuarine and fluvial processes are also important particularly during flood or drought events. The area is also prone to episodic events of river flooding and hurricane surge inundation. The area is in a rural residential location adjacent to the

Potomac River. White Sand Harbor, the beach for the residents, is located to the southeast of the inlet. The inlet is under review by the Virginia Department of Environmental Quality and the White Sand Harbor Homeowners to be approved to be dredged to address water quality issues resulting from sedimentation reducing and modify circulation. The Cubitt Creek and Potomac River appear to be depositing sand in the inlet (Figure 2). A progression from April 1994 to January 2012 shows gradual sand deposition in the inlet (Figure 3). As of September 1, 2012, the maximum depth at the mouth of the channel was 8 inches with a minimum depth of 6 inches at mid-tide moving to high tide.



Figure 1: The USGS 1973 topographic map of Burgess, Virginia shows the elevation range of one to five feet and a mean sea level of three feet. The samples were taken along the red transect.

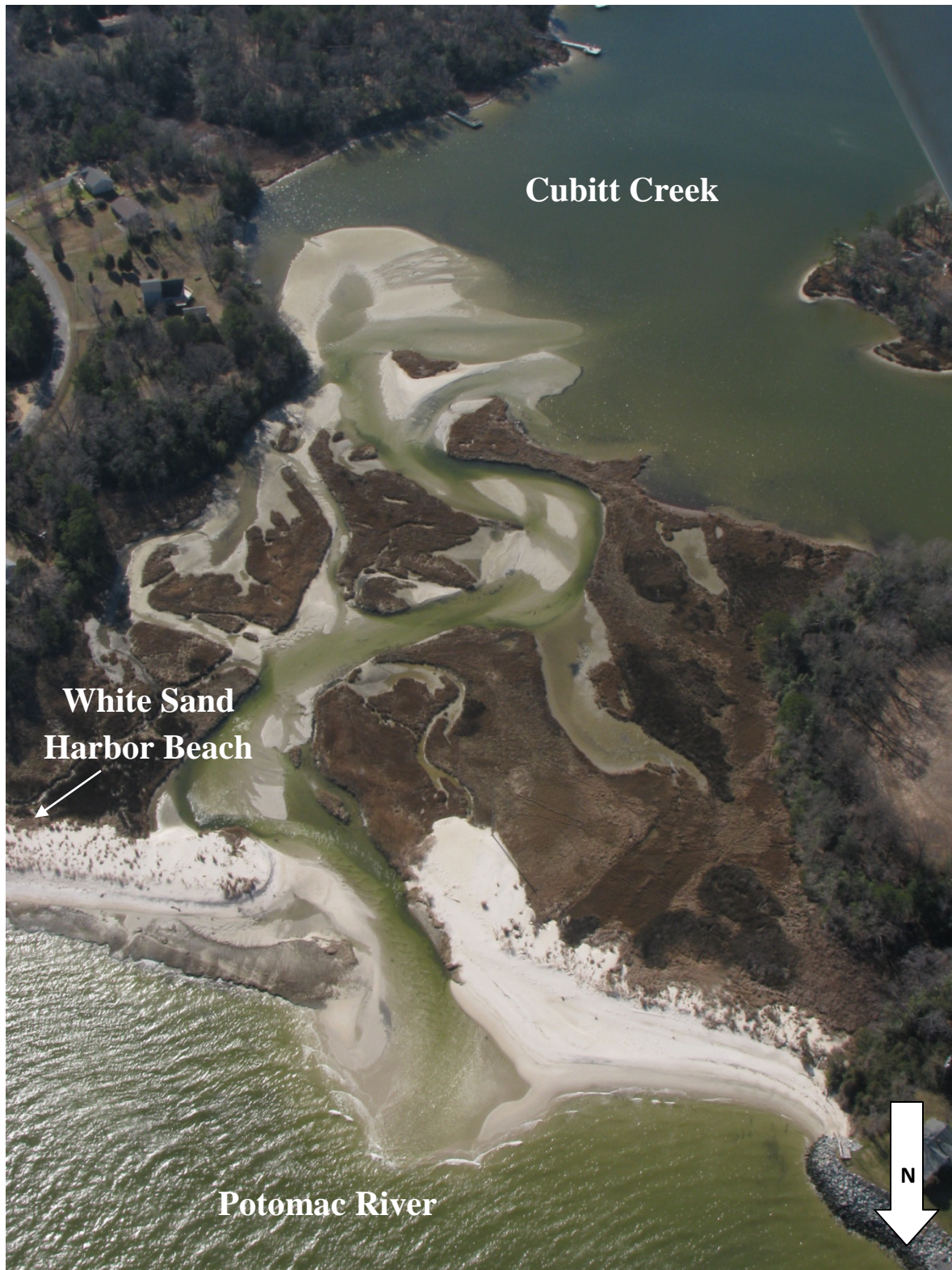


Figure 2: The view from an airplane of the inlet to Cubitt Creek taken by Steven J. Sparagna in January 2012.

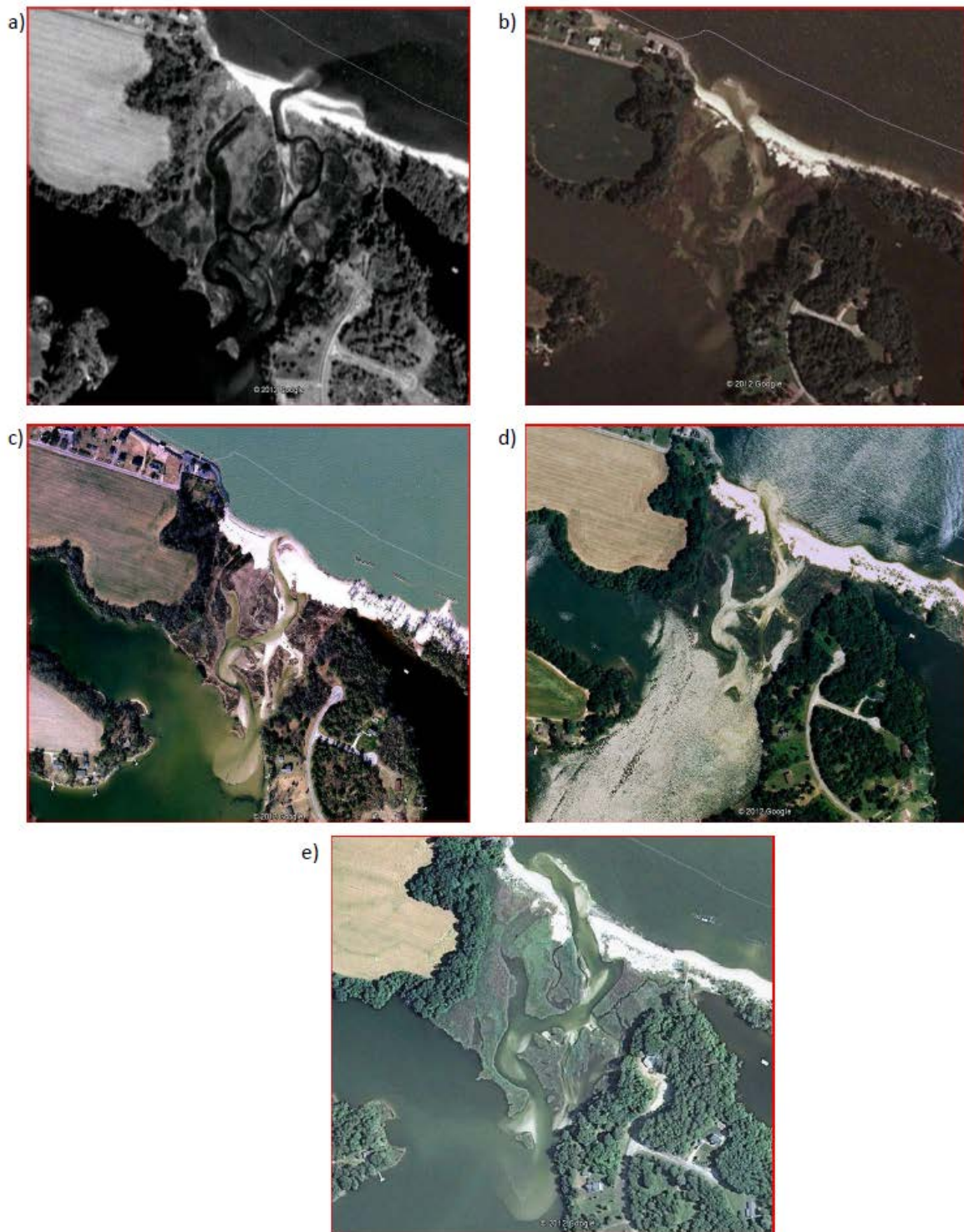


Figure 3: A progression of aerial photographs obtained from Google Earth for the following dates: a) April 4, 1994 b) September 22, 2005 c) April 29, 2007 d) October 30, 2008 e) September 27, 2011.

The history of the Cubitt Creek system is not well documented. However, it was found that the entire creek was listed as condemned on May 30, 1986 for the maximum extent for shellfish use based on the total maximum daily load (TDML). TDML is the total pollutant loading a water body can contain without being considered impaired. This not only suspended shellfishing, but also suspended recreational usage of the creek. In 2004, the creek was partially delisted due to the approval for recreational use, but still impaired for shellfishing (VDEQ 2009).

Another historical report related to Cubitt Creek was a 1975 Tidal Marsh Inventory was conducted by the Virginia Institute of Marine Science (VIMS) associated with the ecology of the marsh system. It was noted that Cubitt Creek had common saltmarsh plants such as, cordgrasses, saltmarsh bushes, cattails, and marsh hibiscus, but was dominated by Olney threesquare, a grassweed, in the upper section of the creek. Along with the vegetation, the area was found to be a nesting habitat for ospreys and blue herons and further development was not recommended (Silberhorn 1975). Today, the area is protected for the Northeastern Beach Tiger Beetle (*Cicindela dorsalis*) and the Bald Eagle (*Haliaeetus leucocephalus*). The dredging is not anticipated to affect *H. leucocephalus* because very few have been seen over the years at Cubitt Creek and nesting has not been observed. However, the habitat of *C. dorsalis* is sandy coasts. This species has restricted any land disturbance of the beach to occur between mid-January to mid-March. Further identification efforts and a study of other species have yet to be conducted.

White Sand Harbor and Cubitt Creek are currently in the process of obtaining permits to begin dredging. To start the permit process, several soil samples were taken by Steven J. Sparagna from a linear transect, shore-perpendicular, through the middle of the creek starting at the mouth on September 1, 2012 (Figure 1). A 4'6" sample taken at the mouth of the creek below the Mean Low Water (MLW) level showed sand which is identical in color, grain size, and

composition as the sand on White Sand Harbor Beach. Two additional samples were taken along the transect at increments of 500'. The samples had 3" of sand which is the same sand in the sample taken at the mouth. The remaining portion of the two samples was anaerobic clay. Testing by an independent laboratory determined there was a high bacterial composition in the samples but no contamination from hazardous substances (Figure 4). However, numerical values were not able to be obtained.

The research question this paper intends to examine is how dredging will impact the Cubitt Creek system. The proposed answer is there will be increased flushing and improvement of water quality within the system, less eutrophic, and little adverse impact from the dredging. Since the dredge material is compatible with local beaches, plan calls for adding the excavated material to the adjacent White Sand Harbor Beach, and contribute to the local sediment budget helping reduce erosion and associated habitat loss. The salt marsh area will be impacted the most by the dredging event. The flow in and out of the system will increase and water quality will improve. A detailed review of several scholarly articles associated with impacts of dredging from around the world and review of several reports conducted by agencies of a few sites along the East Coast of the United States will be utilized to provide evidence for this thesis.

An important part to study the impact of dredging is to know the system mechanics. Bridges et al. (2010) discusses the ways to apply the 4 R's of dredging a marine ecosystem to several studies around the world. The four R's are resuspension, release, residuals and risks. The dredging event can cause increased resuspension in the water column which leads to increased transport of particles in the water column. Fox River, Wisconsin was used as an example regarding the release of PCB-containing sediment into the water due to dredging. Residuals are considered to be the remaining contaminated sediment on the bedfloor. Benthos, pelagic, and

consumers of aquatic life have the highest risk factors when habitats are disturbed; however ecosystems are so dynamic that the impacts to the environment are unknown (Bridges et al. 2010). Risk control is an important factor to determining the effects of dredging on a site. To better understand an area, the study site needs to have a clear understanding of sediment characterization, topographic surveys, hydrodynamics of the site, location to deposit the dredged sediment and site use (Sulaiman et al. 2011). Both papers agree that particle suspension in the water column is an after effect of dredging which can affect the water quality and ecology of the ecosystem.

Along with this idea, the way to reduce the impact on the environment could be related to the type of dredge that was used. In a study in The Lakes, Australia, a channel needed to be cleared for boat traffic. Maintenance dredgers, suction-dredgers, and mechanical dredgers have been used since 1917. The dredger with the least impact to the system was the trailing suction hopper dredge (TSHD) which is a mechanical dredger (Wheeler et al 2010). Another way to reduce the impact from dredgers is to shorten the length of time between dredging events. Shorter periods between dredging and bypassing episodes caused the least impact on the erosion and drift of the beach at St. Augustine Inlet, Florida (Walton and Dean 2011). The Cubitt Creek system is a much smaller scale than these studies, and the dredging is proposed to occur each year as needed, which is a small length of time between dredging events resulting in a lessen impact by dredging.

The morphology of a system may or may not change depending on the ecosystem due to dredging. For example, Shinnecock Inlet, a boating area in New York, was dredged to increase boat traffic. It was found that the morphology changed the natural and artificial realignment due to erosion of an updrift sandbar, western bypass bar, and shore perpendicular bars. The updrift

resulted in eastward deflection and erosion of the shoal by waves and growth of the bypass bar caused westward deflection of the ebb bar due to wave activity to the east (Duonaiuto et al 2008). In contrast, the Baltic Sea underwent dredging and it was determined that the dredging event is undetectable over long periods of time. The only evidence of dredging was “scars.” A scar is a furrow that is created from the dredger (Manso et al 2008). However, this scar is an insignificant impact to the system.

However, anthropogenic causes must be taken into account at Shinnecock Inlet since it is a high boat traffic area. In Palm Beach County, Florida, inlets increased the shoreline fluctuations, and the sandy beaches experienced increases in advancing areas, but overall deposition rates increased on the east and west coasts. The greater was the west side, which reinforced the effectiveness of beach nourishment and sand bypassing projects (Absalonsen and Dean 2011). This area had increased sand deposition and renourishment of the beaches. The study in Palm Beach County differs from a study conducted among 16 of 19 inlets that are being managed by jetties and dredging along Florida’s coast. These inlets are also a popular destination for sea turtles to nest and tourism; a sand deficit could increase the number of seawalls and other wave-blocking structures to attempt to protect the coastline. It was determined that there is a major sand deficit which is lessening the beaches and impacting the nesting habitat for sea-turtles and storm-buffer for homeowners (Montague 2008). At a study done in the Quequen Grande River Estuary, Argentina, it was proven that humans do interfere with geomorphological changes. Anthropogenic causes significantly changed water circulation and wave velocities which created anoxic conditions for the estuary (Perillo et al 2004). A case study of the Tamar Estuary near England determined the decline of trout and salmon in the area was not a result of dredging activities, but rather a natural process (Widdows et al. 2007). Re-opening the inlet to

Cubitt Creek can stabilize the erosion problem at White Sand Harbor Beach in a sustainable and efficient way with as little anthropogenic impact as possible. The deepening of the channel will increase flow and change the wave mechanics of the creek. Since the Northeastern Beach Tiger Beetle is protected in the area, the increased sand area along the beach will provide additional habitat for the beetle, and dredging will be restricted to mid-January to mid-March to avoid mating season. There also is a diminished breakwater which is not anticipated to have any impact on the ecosystem. The Cubitt Creek dredging is limiting the effects on the habitat and organism population from anthropogenic manipulation.

The study of Schelde Estuary helped to determine the conflicting results. Dumping of sediment at or below the critical level will reduce the depth of the channel without closing the channel. The dredging threshold of 5-10 % will not likely change the morphology. In simple terms, the balance needs to be maintained. The threshold is likely to change when sediment is dumped into the flood channels. However, human and natural processes effect morphology changes which makes it harder to determine the transport capacity of the waters. The transport capacity is important to maintain the balance of the dredging and dumping activities (Jeuken and Wang 2010). The amount to be dredged at Cubitt Creek is undetermined at this time; however, based on the scale of the project, a large amount of sediment will not be removed.

Along with morphology, water quality is an important component when determining the potential impacts from dredging. Along the Atlantic Intracoastal Waterway, a sandbar built up due to boating traffic which stopped flow and the natural flushing of the creek. This area is known for shellfishing activities and was shut down due to hazardous contamination of fecal matter. Dredging was an option to reopen the shellfishing waters. Fecal coliform counts, temperature, dissolved oxygen, pH, salinity, and turbidity measurements were taken before and

after dredging. It was found that turbidity was not affected by dredging. Salinity increased and fecal concentrations decreased from pre-dredging to post-dredging measurements. (Mallin et al 2000). The Cubitt Creek system was also restricted from shellfishing like the Intracoastal Waterway. The dredging allowed fecal concentrations to decrease and allowed re-opening of the shellfishing. The waterway had a positive effect and is the anticipated results of the Cubitt Creek dredging.

Even though the Intracoastal Waterway produced promising results, immediate impairments were produced in Montalto di Castro (Tyrrhenian Sea, Italy); however, the ecosystem slowly returned to its normal conditions afterwards. A decrease in ecological abundance was noted in dredged areas, a stronger sediment suspension was generated by trailer dredge and the recolonization process was slow due to settlement of new planktonic larvae. After a few months after dredging, the ecosystem was rebounded to its original condition (La Porta et al 2009). Similar results were seen on the Coast of Cadiz. Salinity, pH, dissolved oxygen, temperature, and redox potential measurements showed no abnormal variations before or after dredging. No significant impacts on the environment were noted from sand removal (Roman-Sierra et al 2011). The Coorong Lagoon in Australia was studied to determine the changes in the morphology of the system after a dredging event. It was concluded that dredging needed to be continued to keep the mouth of the channel open so organisms and water quality were not majorly affected on the long term scale (Webster 2010). In another example, the Houston Ship Channel and upper Galveston Bay in Texas was studied to determine the affects of dredging on the dioxin concentration in the surface sediments. Dredging activities were hypothesized to reduce the total amount of dioxins in the Houston Ship Channel surface. However, the null

hypothesis for this study was supported; dredging does not significantly impact the dioxin concentration in surface sediments (Yeager et al 2010).

The previous studies analyzed did not mention the effects on the salt marsh environment surrounding the dredging event. Cubitt Creek has Lowes Pond southwest of the inlet as well as wetlands surrounding the inlet and behind the beach face. Marshes are built from sediments that are submerged in saltwater and contain organic material. When a marsh gets flooded, lagoons are created which is most likely how Lowes Pond was created. The southeast coast of North Carolina around New Top Sail inlet was analyzed to determine the impacts of dredging on saltmarsh loss. Dredging along with sea-level rise contribute to the decline in saltmarsh habitat. Dredging removes sediment which would build the marsh environment, and sea-level rise floods saltmarsh habitats and drowns the marsh (Hackney and Cleary 1987). The Westerschelde Estuary was examined to determine long-term changes in salt marsh area from a dredging event. After a dredging event, tidal range and flow velocities increase. This higher tide will increase the frequency and duration of submerging a salt marsh. This submergence does not allow soil aeration for vegetation growth and can potentially increase soil salinity and restrict growth. An increase in water level can allow direct wave action to reach the marsh and erode the sediment. This wave action can also be amplified by boat wakes. Along with a higher water level, velocity increases can potentially erode marsh sediment. However, salt marsh plants have a high salt tolerance and productivity may not be significantly affected by a higher tidal range. The ecosystem naturally undergoes retreat and accretion phases. Dredging increases erosion in a saltmarsh environment (Cox et al. 2003). The Tamar Estuary study contradicts the Westerschelde Estuary. The Tamar Estuary determined the marsh erosion was not a direct result of dredging, but a result of sea-level rise and isostatic adjustments. Surrounding the inlet to Cubitt Creek,

there is an abundance of marsh environments (Widdows et al. 2007). The proposed dredged channel to Cubitt Creek is not a straight inlet; the dredging will occur on the path of the natural flow of the creek, deepening the natural channel. However, this will still increase water flow and raise the tidal range of the creek, reducing the area of the marsh environment.

A larger-scale study was conducted in Charleston Harbor, South Carolina. Three rivers contribute to the discharge in the harbor: the Ashley, the Cooper, and the Wando. The majority of the discharge comes from the Cooper, but humans have altered the natural flow which changed the system drastically. Prior to 1895, the harbor was a tide-dominated, well-mixed estuary with a high salinity concentration (30.1 ppt). In 1895, the harbor was dredged and the entrance was maintained by dredging. The increased flow required dredging events to occur less often without impacting the environment. In 1917, the channel was dredged to a depth of 9m which had the same results as the 1895 dredging event. In the late 1930's the Santee-Cooper diversion was created to produce hydroelectric power. This diversion funneled approximately 90% of Santee River's flow into the Cooper, which eventually flowed into the Charleston Harbor. This increase in flow decreased salinity to 16.8 ppt, gravitational mixing became the dominating mixing process, and the salinity stratification changed from a vertically-well mixed to a partially mixed. With the increase in river discharge and physical changes in the harbor, shoaling increased. The harbor was deepened to an additional 1.5 m which increased deposition in the harbor. A rediversion was planned to reduce the shoaling and deposition in the harbor, however the rediversion was being examined concerning the changes in salinity of the creeks and rivers (Kjerfve 1989). The rediversion began in 1985 which began to reduce stratification in the water column and decrease sedimentation (USACE 2009). Since then dredging has been used to maintain the channel. The Army Corps of Engineers compared the impacts of a 1996 proposal to a 2009 proposal. The 1996 report stated the harbor would be deepened to 45 ft with 2 ft advance

maintenance and 2 ft of overdepth, as frequently as every six months in some areas. The dredge material would be placed in a location off the coast. In 2009, it was proposed to have the same standards, but increase depth in the creeks and basins in the surrounding the harbor due to higher shoaling rates (USACE 2009).

The 2009 Final Environmental Assessment examined the effects between the two proposals on various aspects of the ecosystem. The water quality was not considered to be impaired by the South Carolina Department of Health and Environmental Control (SCDHEC). The waters were open to aquatic life, recreational use, and crabbing and fishing for human consumption or market purposes. A major threat to the ecosystem from the diversion and dredging is the salinity concentrations. The salinity determines the marsh vegetation, aquatic species population, and dissolved oxygen concentrations. Salinity can vary due to river input, droughts, and increased precipitation. However, the USACE determined the water quality did not vary significantly during these events. Benthic organisms are however impacted by the dredging events. The mollusks, polychaetes, oligochaetes, nematodes, and amphipods are not stable or abundant in the channel compared to the wetlands and mudflats. These wetlands are dominated by common cordgrasses. Many fish are present in the harbor including sharks, skates, rays, anchovies, spot, Atlantic croaker, drum, trout, flounder, and catfish. These fish are for economic purposes as well as recreational purposes. Blue crab, white shrimp, and brown shrimp are also harvested commercially and recreationally in the estuary. Numerous endangered, threatened, and protected species live in the area. The area is also historically significant, and contributes greatly to the economic system through exporting goods. Other aspects which could be impacted by the dredging are noise, air quality, and toxic sediments (USACE 2009).

There are impacts associated with the dredging operations. The 1996 plan of action will have greater impacts than the 2009 plan because the 1996 plan has more frequent dredging operations.

The water quality will temporarily change due to turbidity. The 1996 plan is more frequent and will cause a greater disturbance in the water column. No major impacts to the salinity and dissolved oxygen concentrations between the two plans were anticipated. Benthic organisms will be removed when the sediment gets removed, however, the organisms will recolonize on the shoaling material. The organisms will not be diverse or abundant. The more frequent dredging associated with the 1996 plan will impact the benthic organisms more. The US Fish and Wildlife Service determined there will be no impact to resources affecting endangered, threatened, or protected species. However, fisheries are anticipated to be impacted because of habitat disturbance. The more frequent dredging with the 1996 proposal has a greater potential to impact fisheries and saltwater habitat. The terrestrial, freshwater, and wetland habitats are not anticipated to be impacted. An increase in exhaust emissions from the machinery is anticipated to temporarily affect the air quality, as well as an increase in noise from the machinery, but will be minimized in the 2009 plan. In conclusion, the dredging associated with the 2009 plan will not significantly impact the environment (USACE 2009).

The Charleston Harbor dredging prior to the diversion was a typical inlet. The dredging increased flow and required dredging to occur less often. This is similar to Cubitt Creek. The river input is not a part of the system, unlike the Charleston Harbor, to affect the salinity and potentially impact the water quality. The dredging will open the inlet and decrease the sediment deposition within the inlet. With the diversion and more frequent, more abundant dredging, the ecosystem was anticipated to have no significant impact. The Charleston Harbor is on a much larger scale and requires a significant amount of sediment to be removed since the harbor is a major port. Cubitt Creek's purpose to be dredged is to allow flow in and out, as well as, allow small recreation boats to pass through.

After a review of the studies and reports, it was determined the inlet system will be impacted by an increase in flow to increase water quality, and a larger beach area for recreational use with little impact to the habitat. The area which is anticipated to be impacted the most is the salt marsh environment. The increased flow, increased tidal range, and increased wave action along the marsh area will erode the sediment. This impact is anticipated to be minor though due to the small scale dredging operation at Cubitt Creek. Each study site differs from another. Some areas are impacted more than others. There is not a defining answer to how a creek or inlet system will be affected by a dredging event. It is very difficult to determine the impact of dredging on a study site because the study sites are a very complex and dynamic systems. This is a major limitation to the research. Also, several of the studies can be one-sided opinions, such as the Virginia Institute of Marine Science (VIMS), Virginia Department of Environmental Quality (VDEQ), and Army Corps of Engineers. These agencies are considered one-sided because they are biased to their research. This research will contribute greatly to the scientific community. Since it is very difficult to pre-determine what will actually happen to a site after dredging, this site will help provide another example of potential impacts of dredging. Also, the White Sand Harbor Homeowners Association will benefit the research by having an unbiased opinion about whether or not the community should dredge the inlet based on the potential impacts.



Figure 4: a) This image shows the mouth at the creek at mid-tide changing to high-tide b) This is the sample taken at the mouth of the creek c) This is the sample taken 500' from the mouth of the creek along the transect d) This is the sample taken 1000' from the mouth of the creek along the transect.

Acknowledgements

I would like to thank Ms. Keira Williams for editing the proposal and early drafts of this thesis. I would also like to thank Dr. Paul Gayes for his guidance with the thesis. Also I would like to thank Mr. Steven Sparagna for the data and pictures associated with Cubitt Creek.

Bibliography

- Absalonsen, L., and Dean, R. (2011). Characteristics of the Shoreline Change along Florida Sandy Beaches with an Example for Palm Beach County. *Journal of Coastal Research*. 16-26.
- Bridges et al. (2010). Dredging Processes and Remedy Effectiveness: Relationship to the 4 Rs of Environmental Dredging. *Integrated Environmental Assessment and Management*. 619-630.
- Cox R., Wadsworth R.A., Thomson A.G. (2003). Long-term changes in salt marsh extent affected by channel deepening in a modified estuary. *Continental Shelf Research*. Vol 23. 1833-1846.
- Duonaiuto, F. S. Jr., Bokuniewicz, H. J., FitzGerald, D. M. (2008). Principal Component Analysis of Morphology Change at a Tidal Inlet: Shinnecock Inlet New York. *Journal of Coastal Research*. 867-875.
- Hackney, C.T. and Clearey, W.J.(1987) Saltmarsh Loss in Southeastern North Carolina Lagoons: Importance of Sea Level Rise and Inlet Dredging. *Journal of Coastal Research*. Vol 3. 93-97.
- Jeuken M.C. J.L., Wang Z.B. (2010). Impact of dredging and dumping on the stability of ebb—flood channel systems. *Coastal Engineering*. 553-566.
- Kjerfve, B. (1989). Physical Processes in Charleston Harbor. In *Charleston Harbor: issues resources, status and management*. NOAA Estuary-of-the-month seminar series. 62.
- La Porta B., Taargusi M., Lattanzi L., La Valle P., Paganelli D., Nicoletti L. (2009). Relict sand dredging for beach nourishment in the central Tyrrhenian Sea (Italy): effects on benthic assemblages. *Marine Ecology*, 97-104.
- Mallin M.A., Cahoon L.B., Lowe R.P., Merritt J.F., Sizemore R.K. and Williams K.E. (2000). Restoration of Shellfishing Waters in a Tidal Creek Following Limited Dredging. *Journal of Coastal Research*. 40-47.
- Manso F., Radzevicius R., Blazaukas N., Ballay A., and Schwarzer K. (2008). Nearshore dredging in the Baltic Sea: Condition after cessation of activities and assessment of regeneration. *Journal of Coastal Research*. 187-194.
- Montague, Clay L. (2008). Recovering the Sand Deficit from a Century of Dredging and Jetties along Florida's Atlantic Coast: a Reevaluation of Beach Nourishment as an Essential Tool for Ecological Conservation. *Journal of Coastal Research*. 899-916.
- Perillo G.M.E., Perez D.E., Piccolo M. C., Palma E. D., and Cuadrado D. G. (2004). Geomorphologic and physical characteristics of a human impacted estuary: Quequen Grande River Estuary, Argentina. *Estuarine Coastal and Shelf Science (ELSEVIER)*. 301-312.
- Roman-Sierra J., Navarro, M., Muñoz-Perez, J.J., Gomez-Pina, G.(2011). Turbidity and Other Effects Resulting from Trafalgar Sandbank Dredging and Palmar Beach Nourishment. *Journal of waterway, port, coastal and ocean engineering*, 332-343.
- Sulaiman O.O., H. Saharuddina, W.B. Wan Nik, A.B. Saman. (2011). Environmental Risk and Reliability for Sustainable Dredging. *Journal of Marine Technology and Environment*, 137-158.

- Silberhorn, G.M.. (1975). Northumberland County Tidal Marsh Inventory. *Applied Marine Science and Ocean Engineering*. Virginia Institute of Marine Science (VIMS). <http://web.vims.edu/library/TidalMarsh/sramsoe058.pdf>. 68-70.
- United States Army Corps of Engineers (USACE). (2009). Final Environmental Assessment: Charleston Harbor Additional Advanced Maintenance Dredging. *Department of the Army Charleston District*.
- United States Army Corps of Engineers (USACE). (2009). Finding of No Significant Impact: Charleston Harbor Additional Advanced Maintenance Dredging. *Department of the Army Charleston District*.
- Virginia Department of Environmental Quality (VDEQ). (2009). Cod, Presley, Bridgeman, Hull, Rogers, Cubitt, and Hacks Creeks Total Maximum Daily Load (TDML) Report for shellfish Condemnation Areas Listed Due To Bacteria Pollution. *VDEQ*. http://epa.gov/waters/tmdldocs/38141_CodCreekReport.pdf
- Walton, T. L. Jr. and Dean, R. G. (2011). Addressing an Optimal Schedule for Inlet Bypassing. *Journal of Coastal Research*, 87-93.
- Webster, I. T. (2010). Dynamic Assessment of Oceanic Connectivity in a Coastal Lagoon- the Coorong, Australia. *Journal of Coastal Research* , 131-139.
- Wheeler P.J., Peterson J. A., Gordon-Brown L.N. (2010). Channel dredging Trials at Lakes Entrance, Australia: A GIS-Based Approach for Monitoring and Assessing Bathymetric Change. *Journal of Coastal Research* , 1085-1095.
- Widdows J., Bale A.J., Brinsley M.D., Somerfield P., Uncles R. J. (2007). An assessment of the potential impact of dredging activity on the Tamar Estuary over the last century: II. Ecological changes and potential drivers. *Hydrobiologia*. Vol 588. 97-108.