Leveraging Historical Cartography to Assess and Monitor the Geomorphologic Changes of the St. Augustine Inlet From 1589 – 2022

Presented by Thomas M. MacAvoy

My Work in St. Augustine and Relationship with the Study Area

- I work at the St. Augustine Lighthouse and Maritime Museum (SALMM) as the GIS technician and spatial analyst for the Lighthouse Archaeological Maritime Program (LAMP).

The St. Augustine Inlet from the top of the St. Augustine Lighthouse, 2022

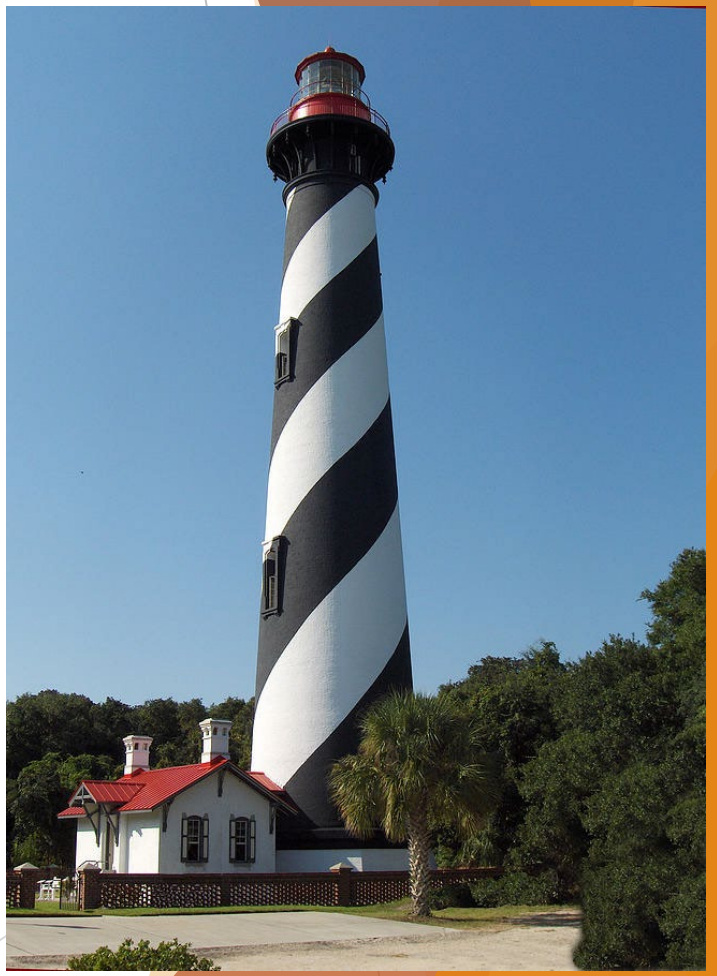


Image courtesy of Carol A Commins, uploaded on September 24th, 2011.

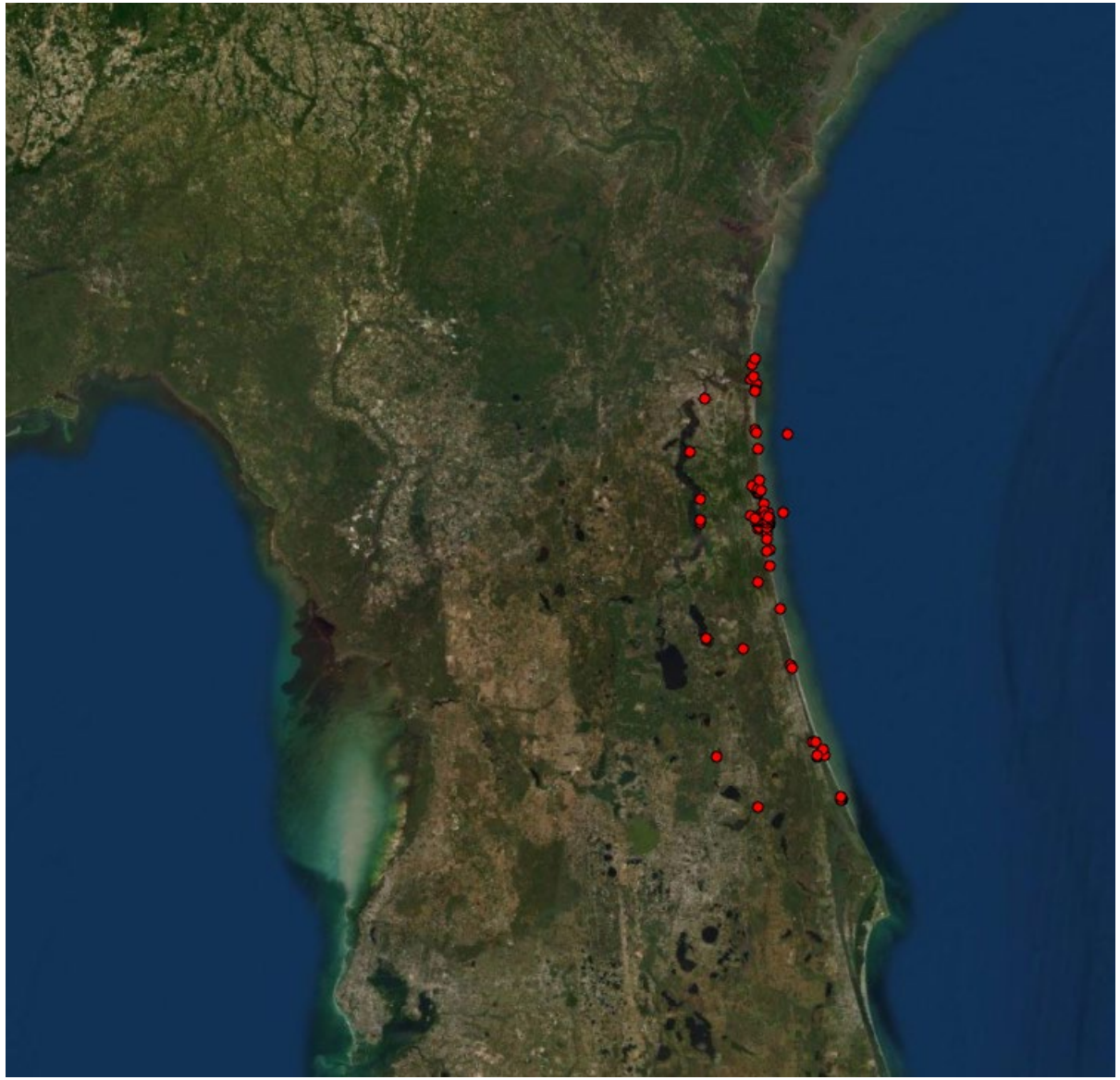
The Lighthouse Archaeological Maritime Program (LAMP)

- They are a team of archaeologists, conservators, and researchers whose mission is to discover, preserve, and protect historical artifacts of North Florida's Atlantic coast.
- Over 110 archaeological sites visited and thousands of individual artifacts discoveries.

LAMP. (2010, 2019, 2021). Field Photos [Photo]. St. Augustine Lighthouse and Maritime Museum, St. Augustine, FL. https://www.staugustinelighthouse.org/tag/lamp/

Archaeological and Historic Value of the Inlet

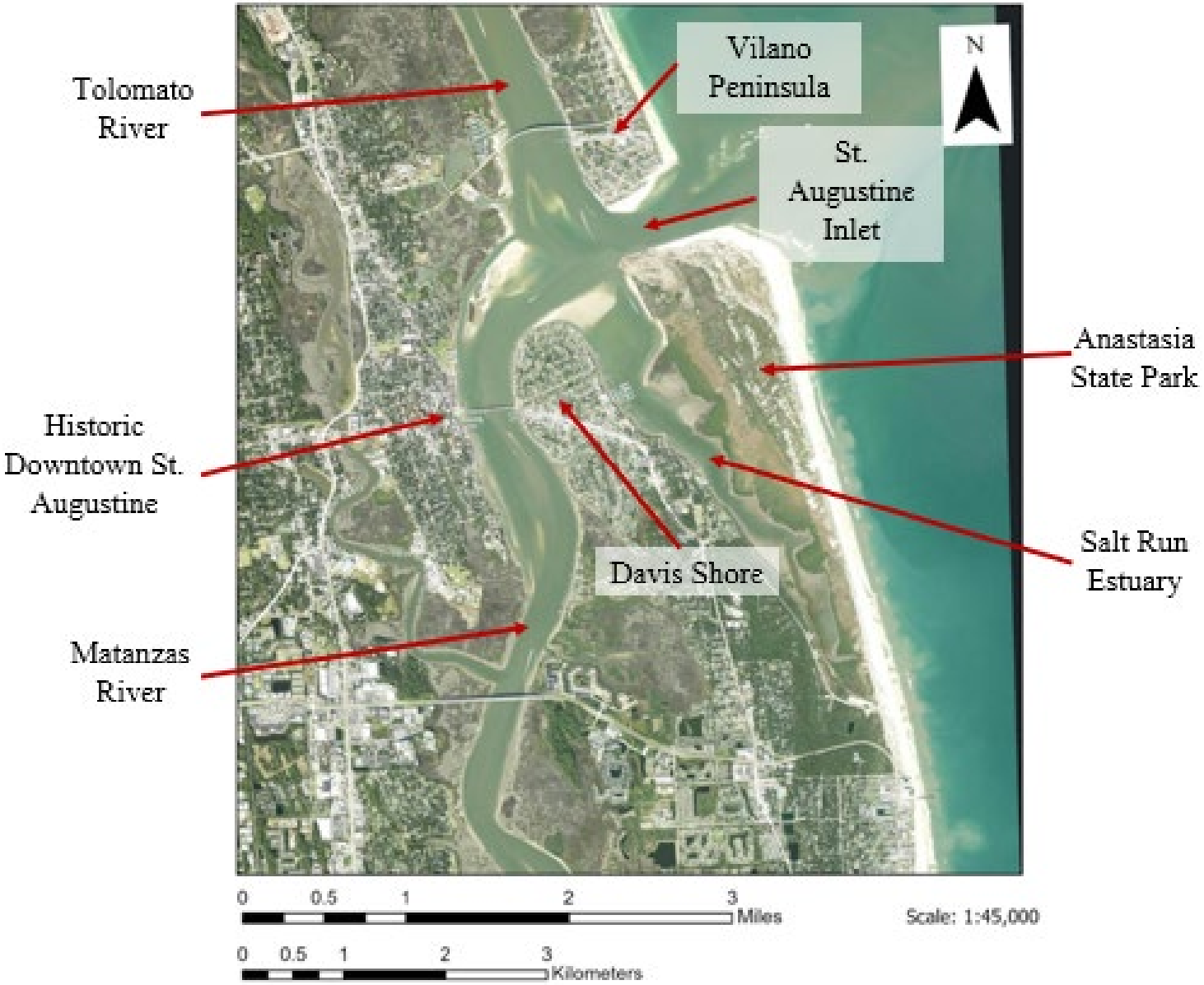
- The coastline around the inlet estimated to have over 500 individual shipwrecks.
- Most of these wrecks are within 1 mile of the coastline
- These wrecks are caused by:
  - Crazy banks and hidden shoals
  - Shifting sea-floor
  - Turbulent currents
  - Historically shallow point of entry



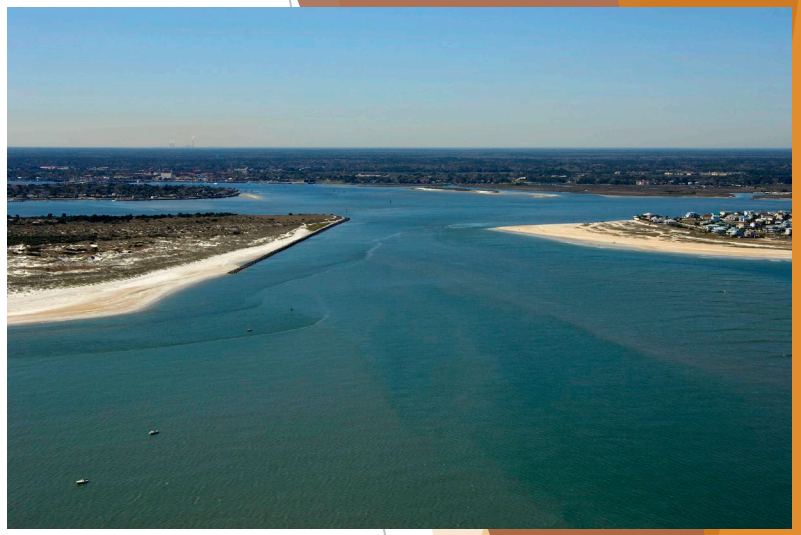
Shipwreck and archaeological sites worked on or discovered by the LAMP team as of 2022. Map: ESRI World Imagery, 2022, T. MacAvoy

Shipwreck and archaeological sites withing the study area. Map: NAIP, 2022, T. MacAvoy

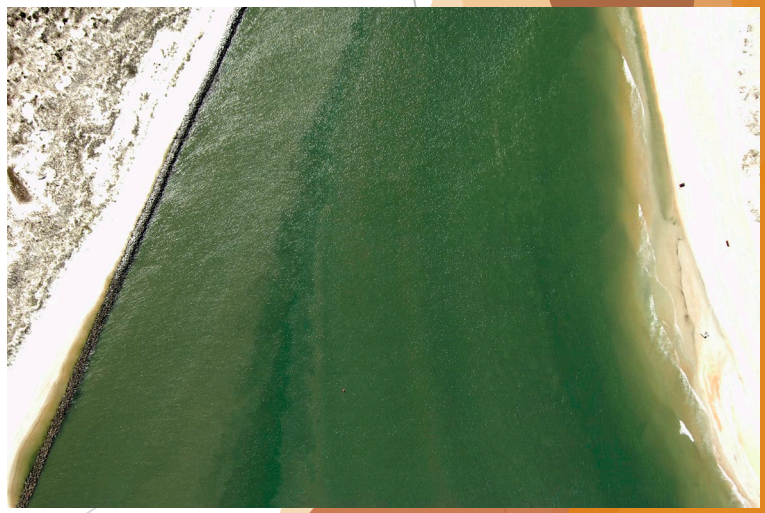
Shipwreck uncovered from the shoreline in Ponte Vedra, 2018. Photo courtesy of Chuck Miede, LAMP Director



The St. Augustine Inlet., NAIP (2021)



Approaching the inlet from the Atlantic, USCG (2020)

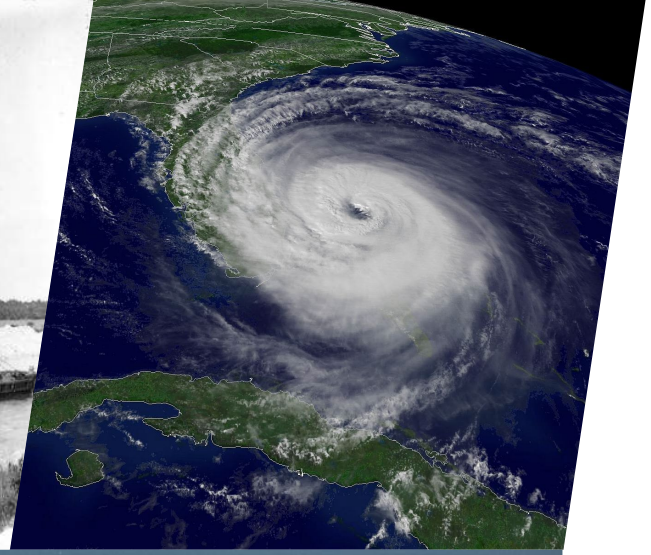


Birds-eye-view of the inlet. 90 USCG (2020)

Study Area Overview

- 25 square kilometers
- Consists of :
  - Littoral oceans
  - Lagoons
  - Sandy beaches
  - Saltmarshes
  - Developed urban areas
  - Maritime hammocks.

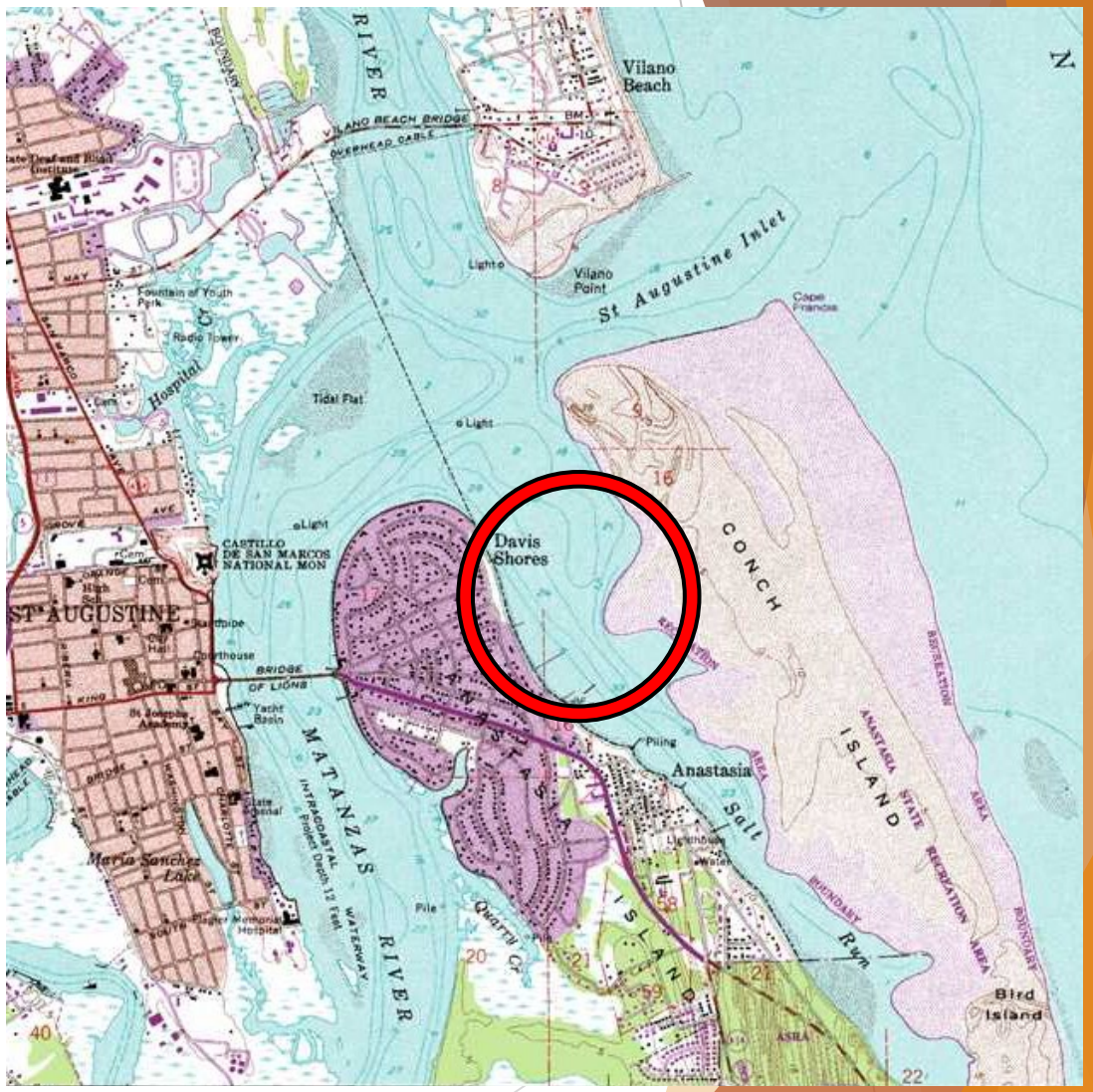
St. Augustine Inlet, 2022, T. MacAvoy



Factors Influencing the St. Augustine Inlet's Geomorphology

- Climatic: Hurricanes, Nor'easters, and other strong storms
- Hydrologic: Drainage of the Tolomato and Matanzas Rivers
- Anthropogenic: Dredging, development, and dune renourishment efforts

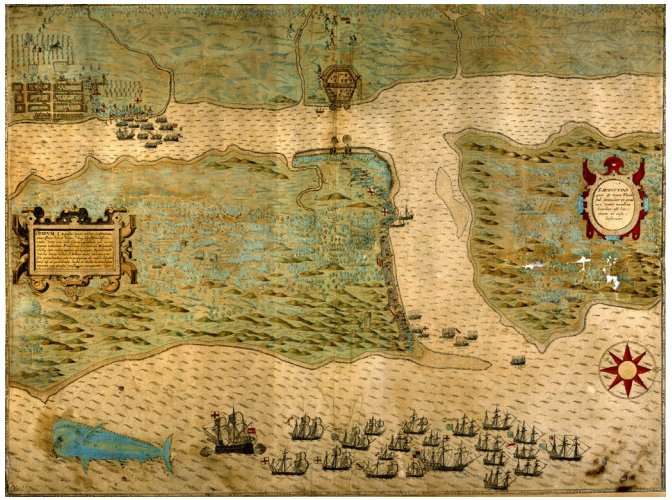
The Moving Inlet



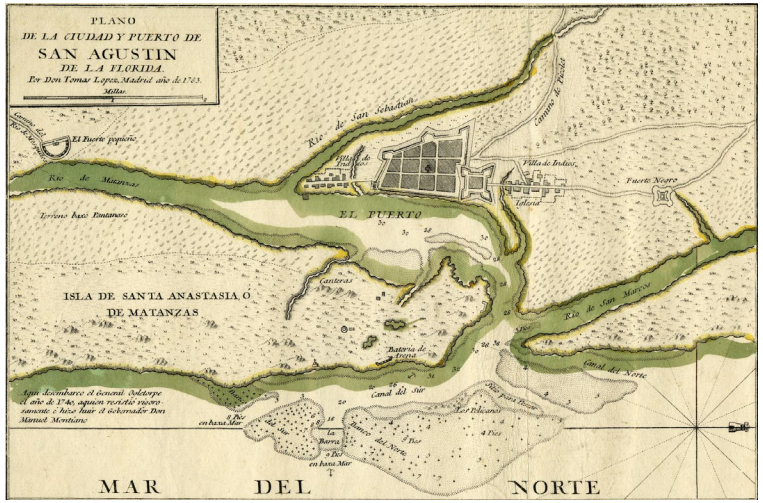
Left: St. Augustine Inlet, US Coastal Survey (1943) & Right: the present-day Inlet USGS (2020)

Problem Statement

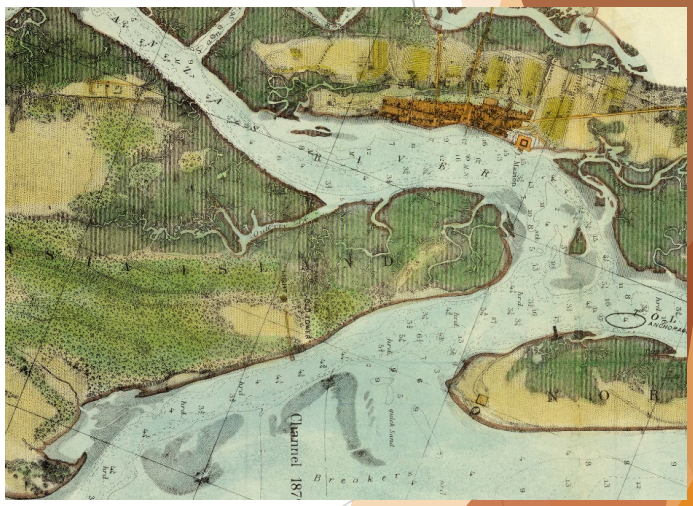
- Despite its long history, no concise historical understanding of the inlet's geomorphology exists, which has generated considerable frustration and debate among local historians and maritime archaeologists (Miede, 2013; Budsburg, 2022).



Courtesy of the Library of Congress. *Boazio, Sir Francis Drakes Raid of St. Augustine, 1585*



Courtesy of the Special Collections Department, University of South Florida. *Plano de la Ciudad y Puerto de San Agustin, Tomas Lopez, 1783*



Courtesy of the Offices of Coastal Survey. *St. Augustine Inlet to the Halifax river, B. Huger 1865*

This Study Will…

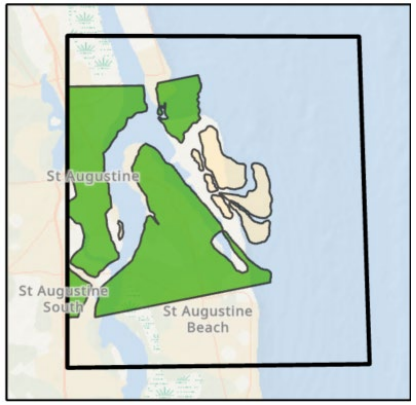
- Create a historical cartographic record for the St. Augustine inlet and its surrounding area from 1589 to 2022. The resulting sequence of georeferenced maps will aid local, state, and national organizations to anticipate the discovery of archaeological and cultural assets and to plan for mitigation efforts in the event of climate change induced sea-level rise and the resulting erosion.

Previous Work

- In 2020, I produced a series of georeferenced coastal datasets from 1741 to the present as part of a NOAA grant to monitor archaeologically sensitive sites in St. Augustine.

1741

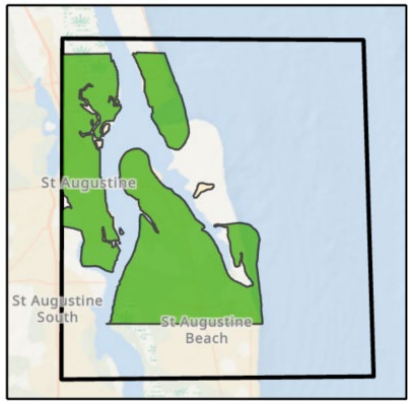
1765



1809

1865

1887

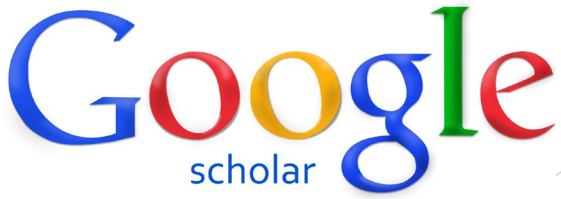


1941

2020

Literature Review:

- Several recurring themes were present in the literature reviewed:
  - Historical research and reviews into the study areas.
  - Factors considered when selecting historic maps.
  - Georeferencing methodologies for historic coastal maps.
  - Specific concerns when dealing with bathymetry studies and sources of errors.



Theme 1: Extent and Factors Considered in Historical Research into a Study Area

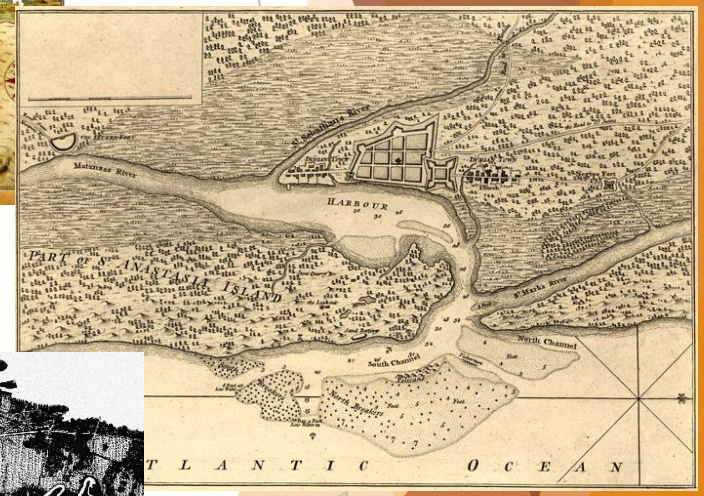
- Providing a history of the study area provides valuable context to geomorphological phenomena. More intricate or complex projects typically included a proportionally larger historical review section. (Orman, Morang, & Larson, 1998)
- Factors include :
  - The geologic and hydrological nature of the study area (Zhang & Yang, 2006)
  - Demographic trends and human impacts (Capiella et al., 1999, and Foxgrover et al., 2004)
  - Socio-economic considerations

Pan, E.(1950)

Theme 2: Selection of Historic Reference Maps

- Determining which maps to use in a geomorphological study involves:
  - Understanding a map's spatiotemporal relevance.
  - The availability to historical documents, (Fernández-Montblanc et al., 2007).
  - Factoring for scale between each map dataset (Rumsey & Williams, 2002).
  - The positional accuracy of one map in relation to the next in a sequence.
  - Age of a map especially if it is made prior to the 1800s (van der Wal & Pye, 2003).

Boazio, Sir Francis Drakes Raid of St. Augustine, 1585



Plan of the Town and Harbour of St. Augustine, 1762, William Roberts

US Coastal Survey, St. Augustine to Matanzas Inlet, 1861

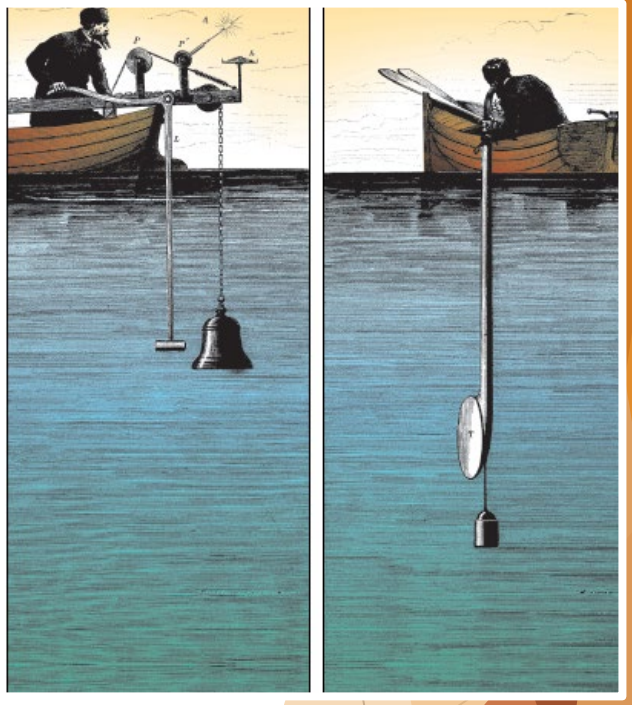
Example of georeferencing Sanborn Fire Insurance map from the 1910's of an urban setting. Photo courtesy of the University of Virginia Library

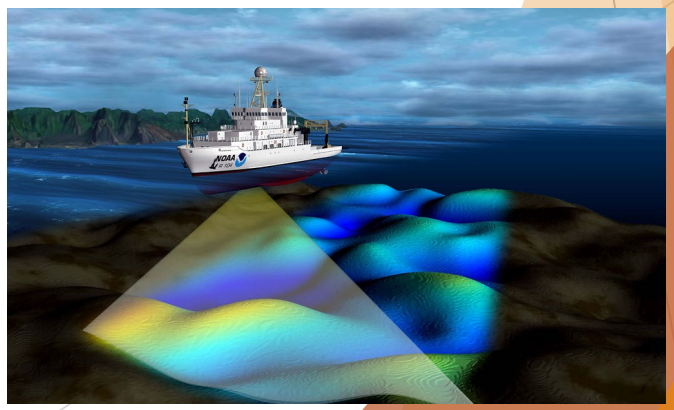
Theme 3: Methodologies Used to Georeference Historical Coastal Projects

- For long term sequential spaciotemporal change studies, it is ideal to have the following:
  - Several map samples of the study area
  - All maps be set to the same scale
  - Uniform coordinate system projection for local horizontal and vertical datums (Jakobbson et al., 2005)
  - That 3 to 10 control points are used for each time period
  - Regularly spaced intervals of time (i.e. every 20 years).

Theme 4: Specific Bathymetric Considerations and Sources of Errors.

- Van der Wal & Pry identify several key considerations when looking at historical bathymetric cartographic elements
  - Dubious accuracy before the advent of sound distancing technology (sonar) that became widely used in 1930-1940s. (Rayner, 1993)
  - Rectifying when soundings were taken during tidal phases for uniformity.
  - Correcting mean sea level rise (SLR) in the study area.
  - Identifying and confirming what is meant by the term “Coastline”.
  - Converting units of measurements to a uniform standard.
  - Ensuring uniform map projection and coordinate systems.





Examples of bathymetry recording devices. The earliest forms consisted of simplistic lead lines, it would not be until the 1890s that sonar would be invented, and it would take until 1930 before it was widely used. Today single and multi-beam sonars allow for more robust sea floor mapping.

Historical Review

- A brief history of the St. Augustine inlet and its cartographic record can be broken down in the following time periods:
  1. Pre-European Contact (40,000 B.C.E – 1513 C.E.)
  2. First Spanish Period (1513 C.E. – 1763 C.E.)
  3. British Period (1763 C.E – 1783 C.E.)
  4. Second Spanish Period (1784 C.E. – 1821 C.E.)
  5. American Statehood and Civil War Period (1821 C.E. – 1865 C.E.)
  6. Reconstruction and Resorts (1865 C.E. – 1920 C.E.)
  7. Modern Period (1920 C.E. – 1960 C.E.)
  8. Present Day (1960 C.E. – Present)

Pre-European Contact: (40,000 BCE – 1513 AD)

- Pre-Columbian maps and records do not exist that describe the St. Augustine Inlet.
- The earliest account of the area around St. Augustine comes from the journal entries of a Franciscan friar named Harrera, who was with Juan Ponce de Leon in his exploration of “La Florida” in 1513. (Turner, 2006)

Juan Ponce de Leon’s early map of the Atlantic coast of North America, De Leon, 1510

Modern replica of the Nina, a caravel used by Christopher Columbus. Photo Courtesy of: the Columbus Foundation.

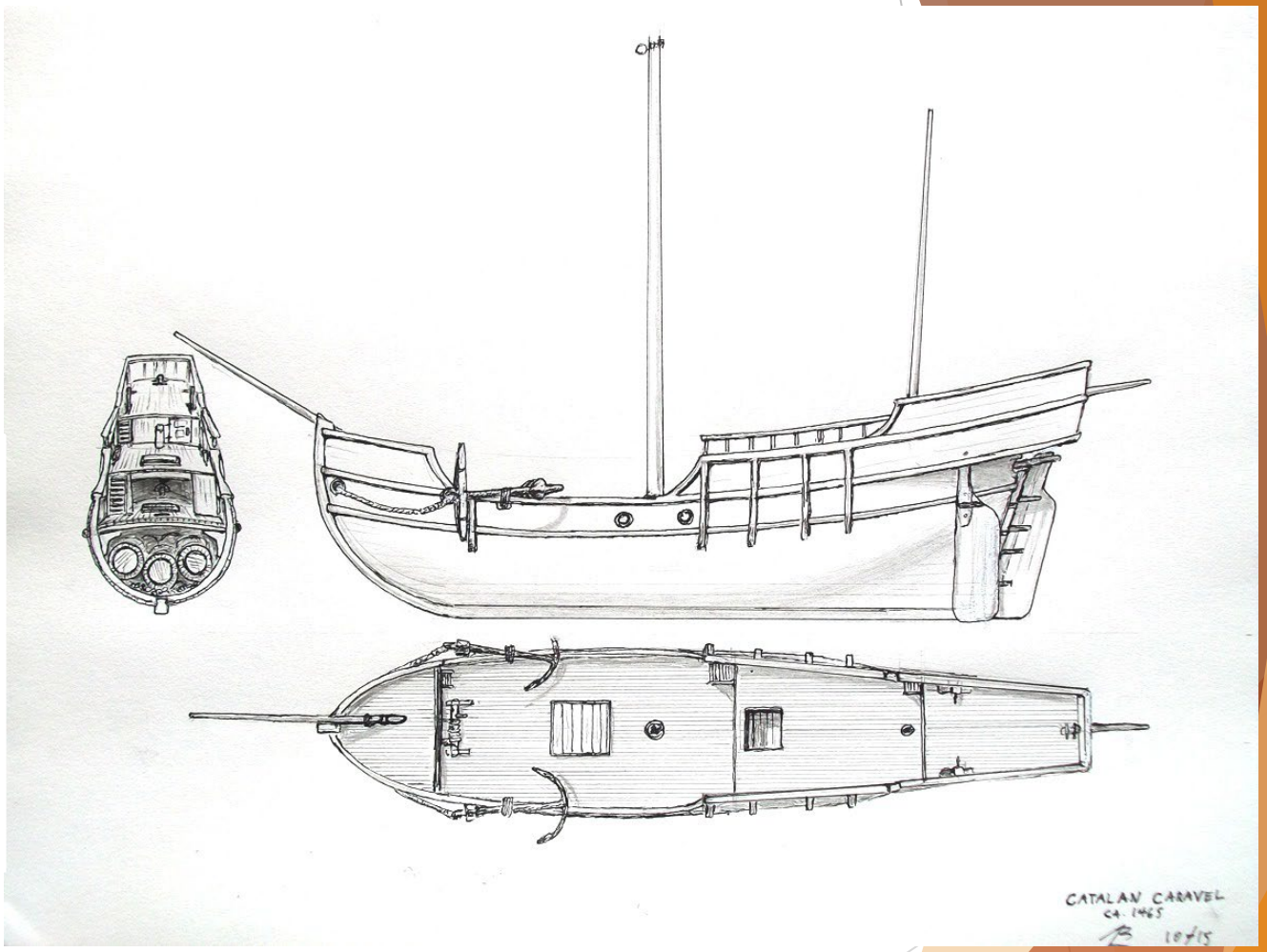
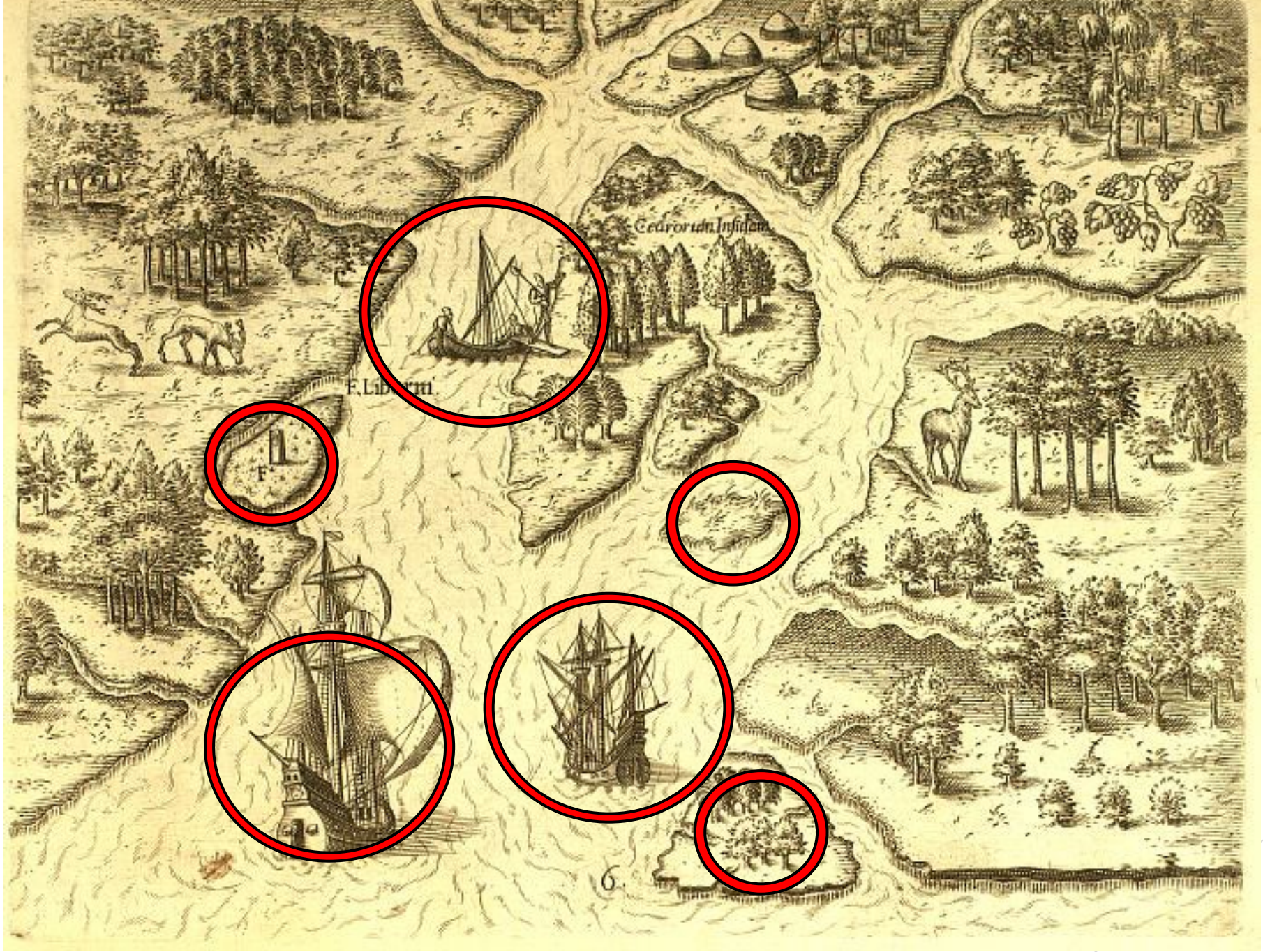
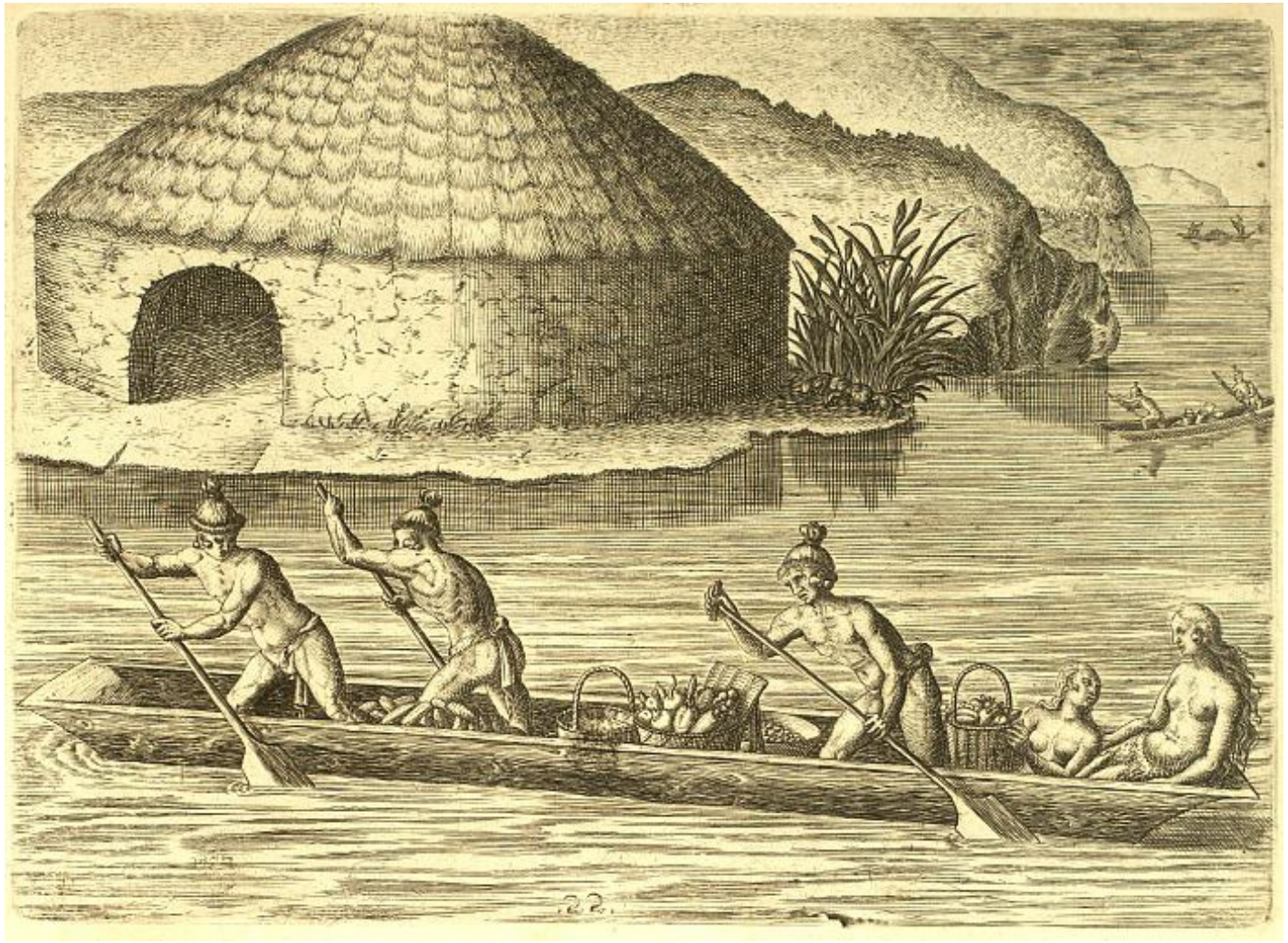


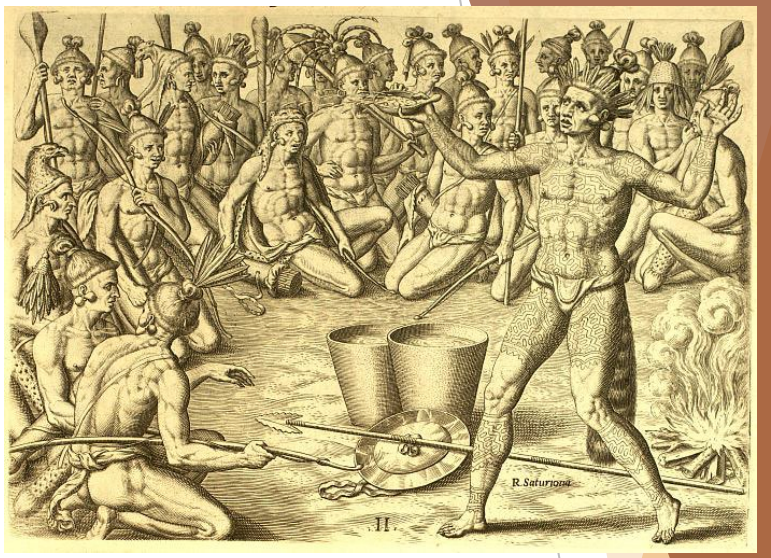
Photo Courtesy of: R.Little, July 2000, "Catalan Caravel"



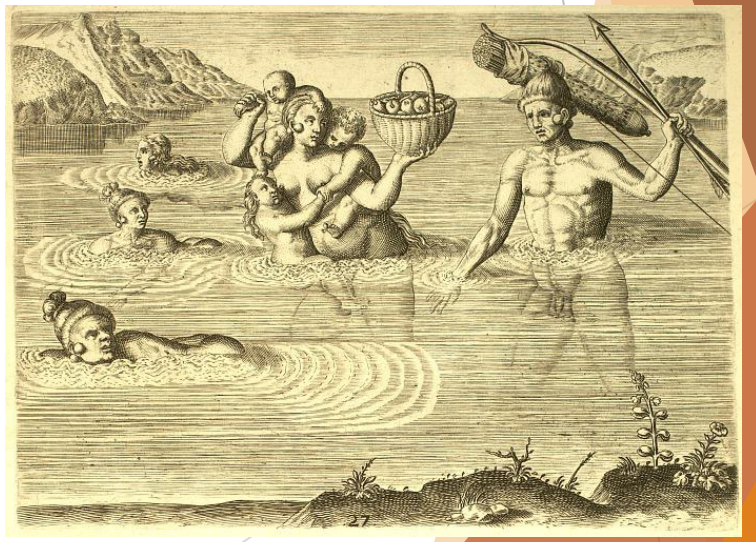
“la Florida”, Jaques La Moyne, Plate VI, Courtesy of the University of Southern Florida



Bringing crops to the public storehouse, la Moyne, Plate XXII. Photo credit: The Florida Center for Instructional Technology, University of South Florida



Chief Sarouriona prepares for battle, Photo credit: The Florida Center for Instructional Technology, University of South Florida

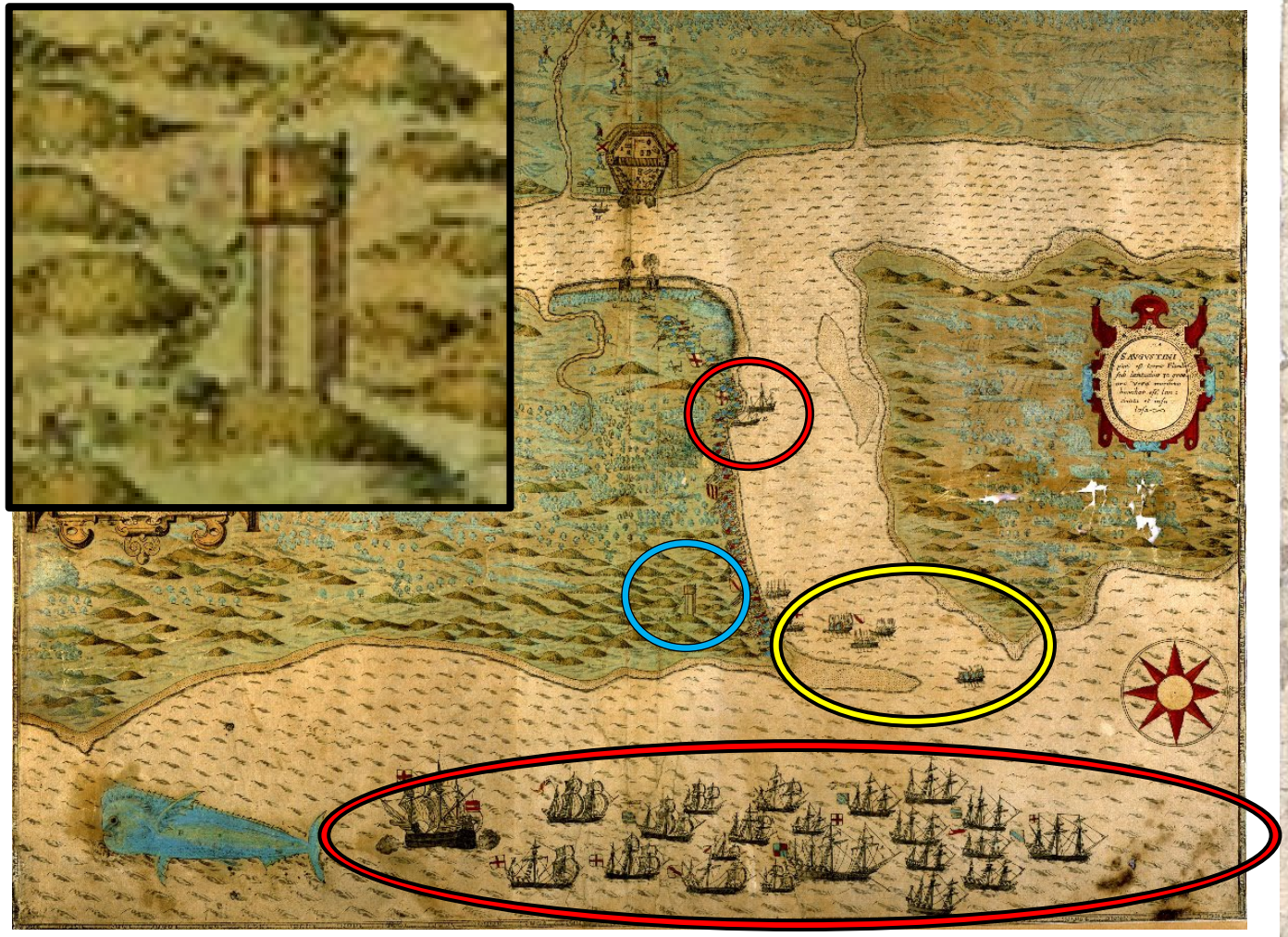


Chief Sarouriona prepares for battle, Photo credit: The Florida Center for Instructional Technology, University of South Florida

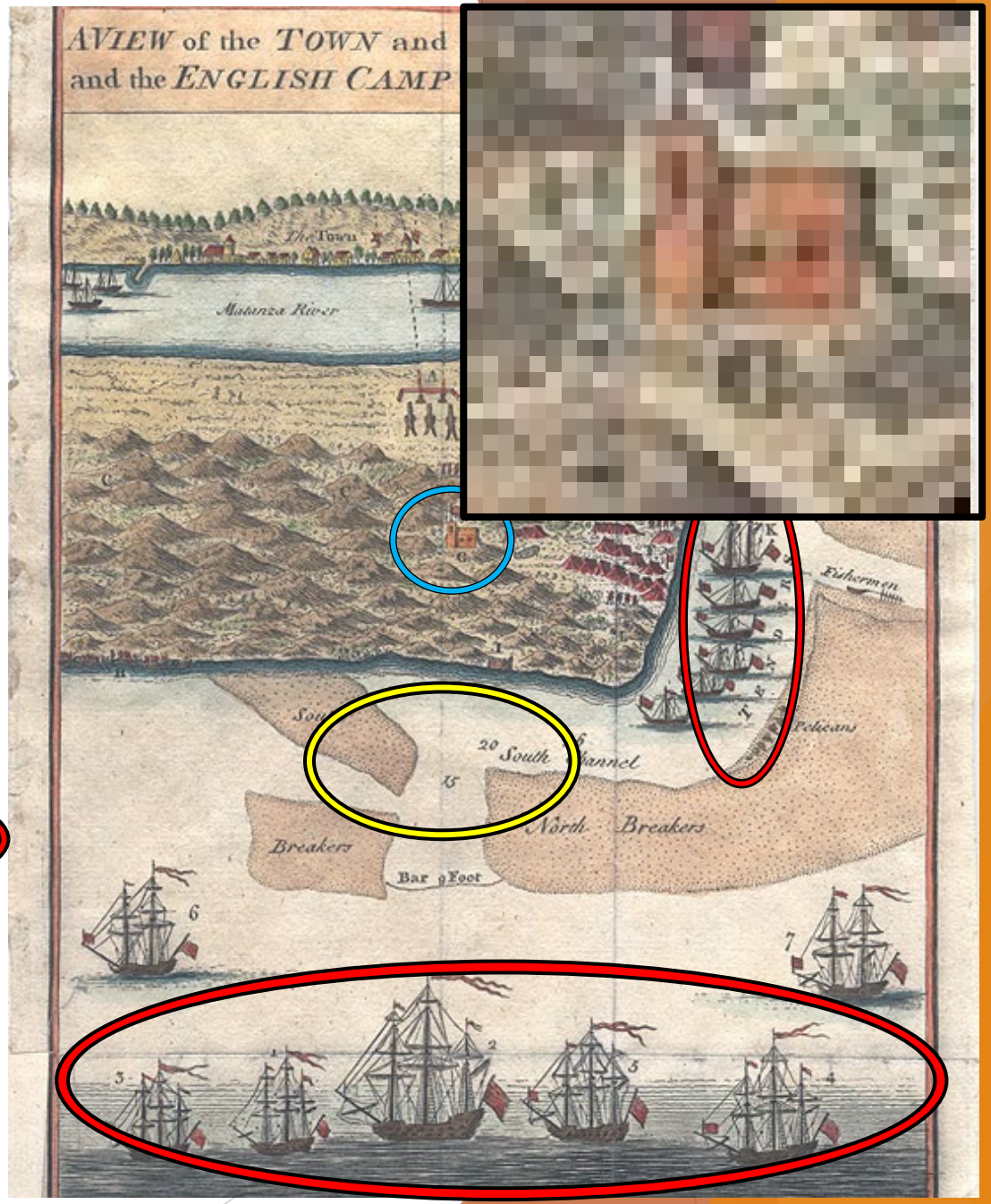
First Spanish Period (1513 - 1763)

- This period is synonymous with the interactions of the Spanish empire's first attempts to colonize the "New World".
  - First surveys of the region
  - Early European and indigenous conflicts and negotiations
  - Colonial settlement

Image courtesy of The Miriam and Ira D. Wallach Division of Art, Prints and Photographs: Picture Collection. "Laying Out St. Augustine", W. Sheppard, 1876-1881



Map of St. Augustine depicting the 1586 raid by Sir Francis Drakes English Forces. Produced by Boazio, Baptista, 1589. Note how the larger vessels of the English ships are anchored off the coastline, indicating that the inlet was not navigable by larger ships (drafts > 5ft).

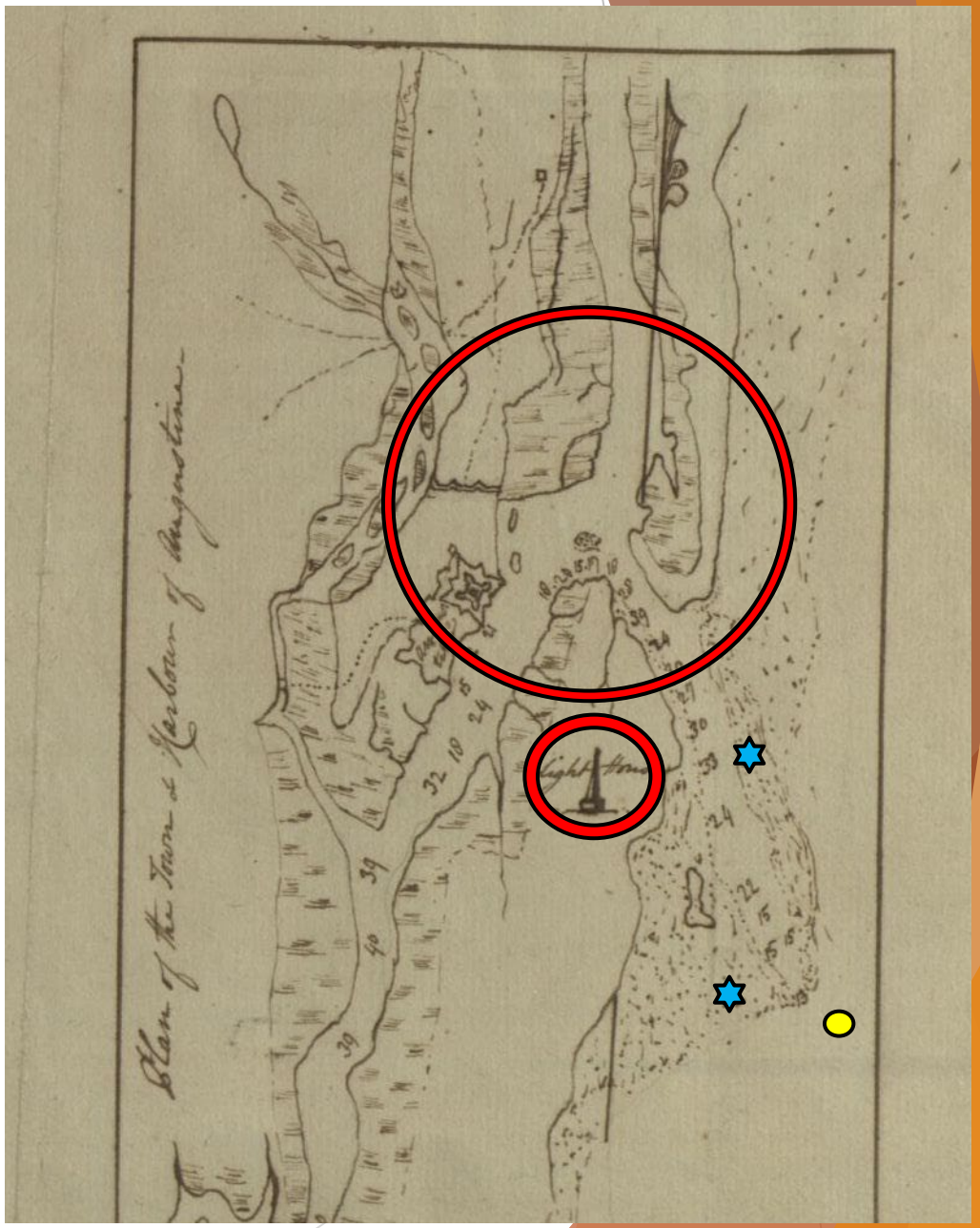


Thomas Silver 1740 map depicting the English bombardment of St. Augustine. Source, the St. Augustine Historical Society.

British Period (1763 – 1783)

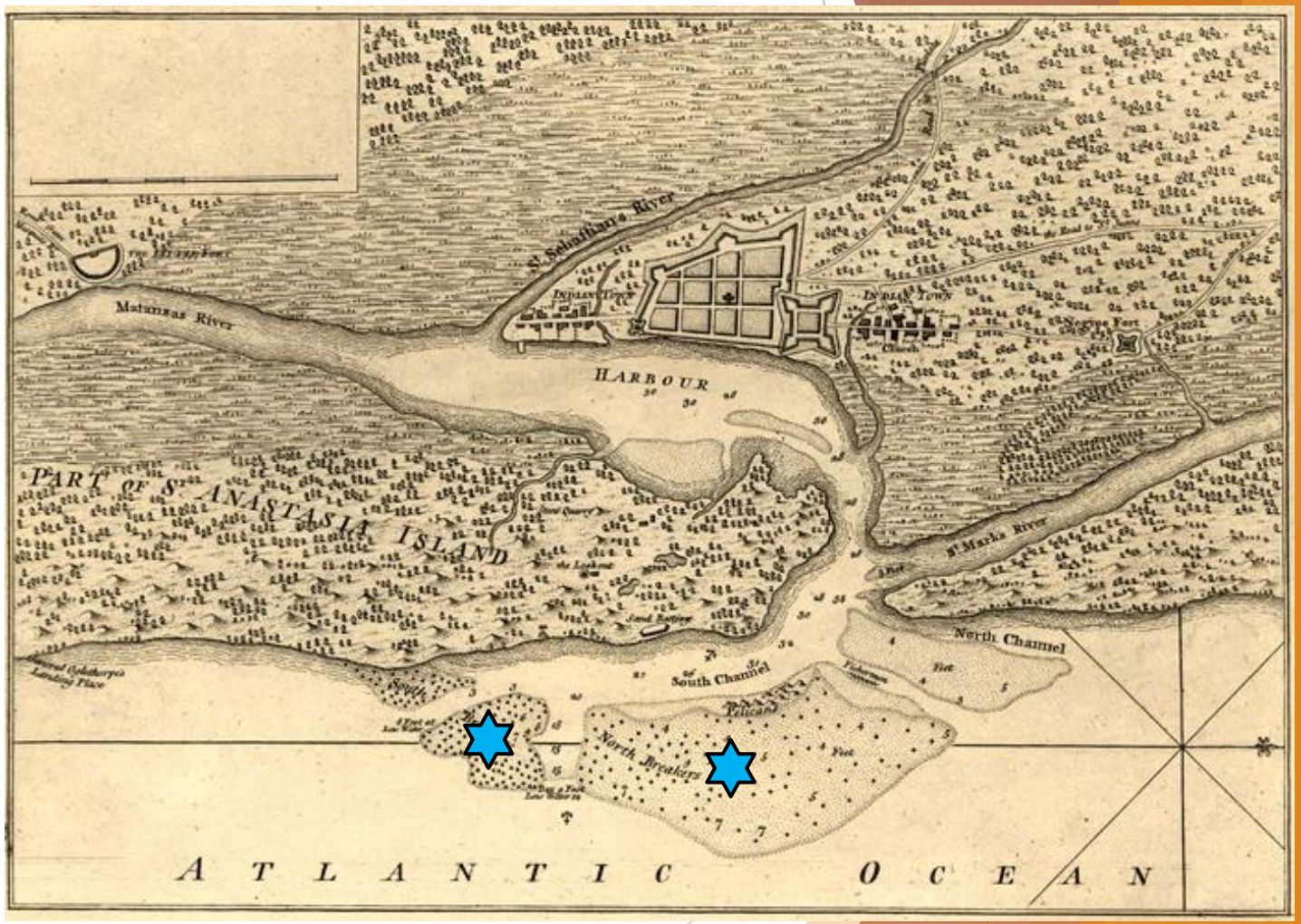
- Better map data produced a more defined route to enter the port.
- Maps begin to show the presence of large swaths of shallow shoals in the area that would go on to become the Anastasia State Park.

A reenactment of the British forces taking control of the Casitllo de San Marcos. Photo courtesy of the Castillo de San Marcos



Plan of the town and Harbor of St. Augustine; Hurd, 1756-1773)

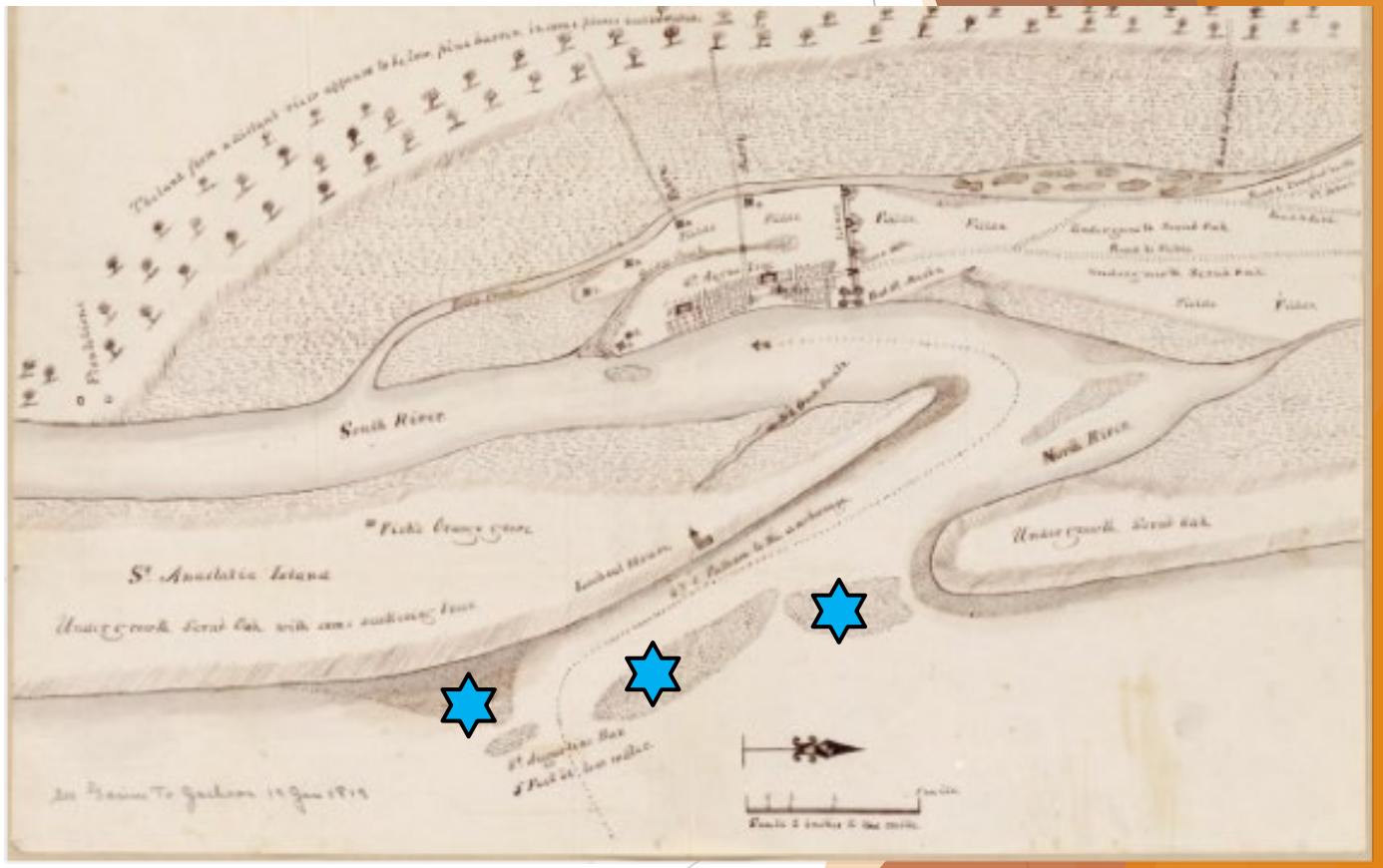
Plan of the town and Harbor of St. Augustine; Hurd, 1756-1773)



Plan of the Town and Harbour of St. Augustine, 1762, William Roberts

Second Spanish Period (1784 – 1821)

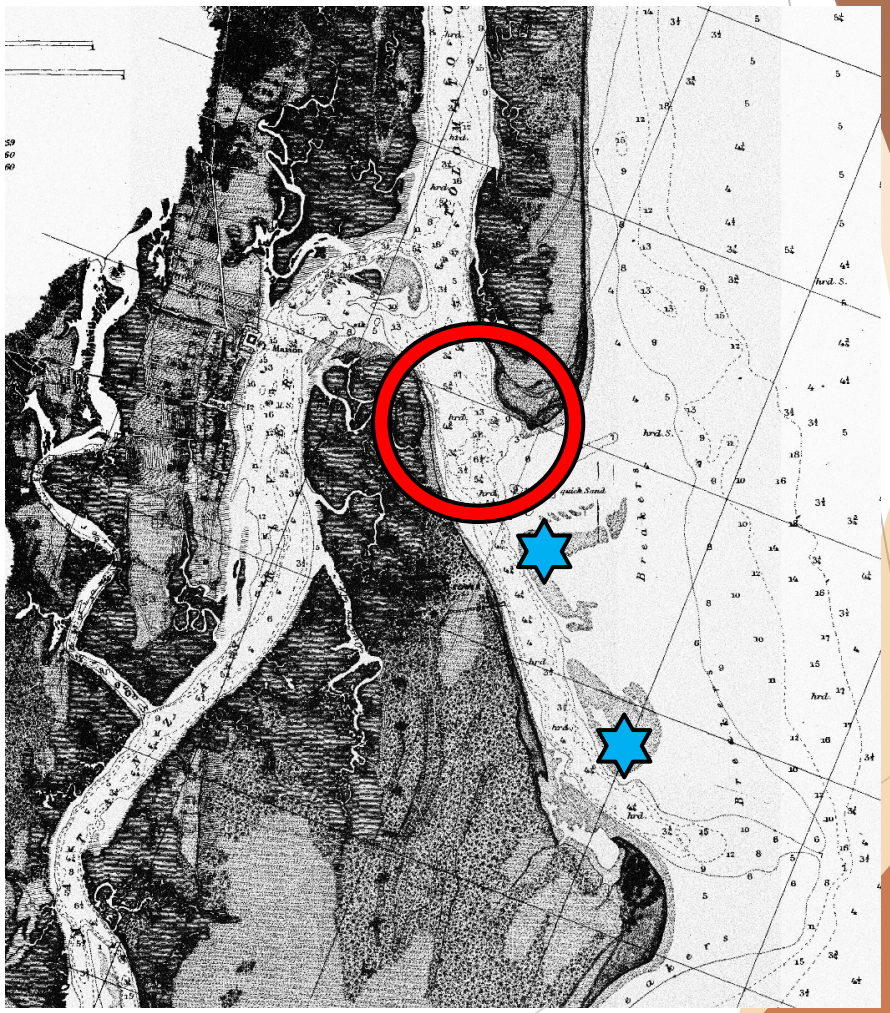
- The second Spanish period was marked by sluggish economic development and little consideration by the empire. This regression is also reflected in the quality of maps and cartographic data.
- We can see in the Birch, 1812 map however that the shoals and coastline around the inlet continue to migrate south.



Simplified early map of the Second Spanish period; St. Augustine, FL; Birch, 1819

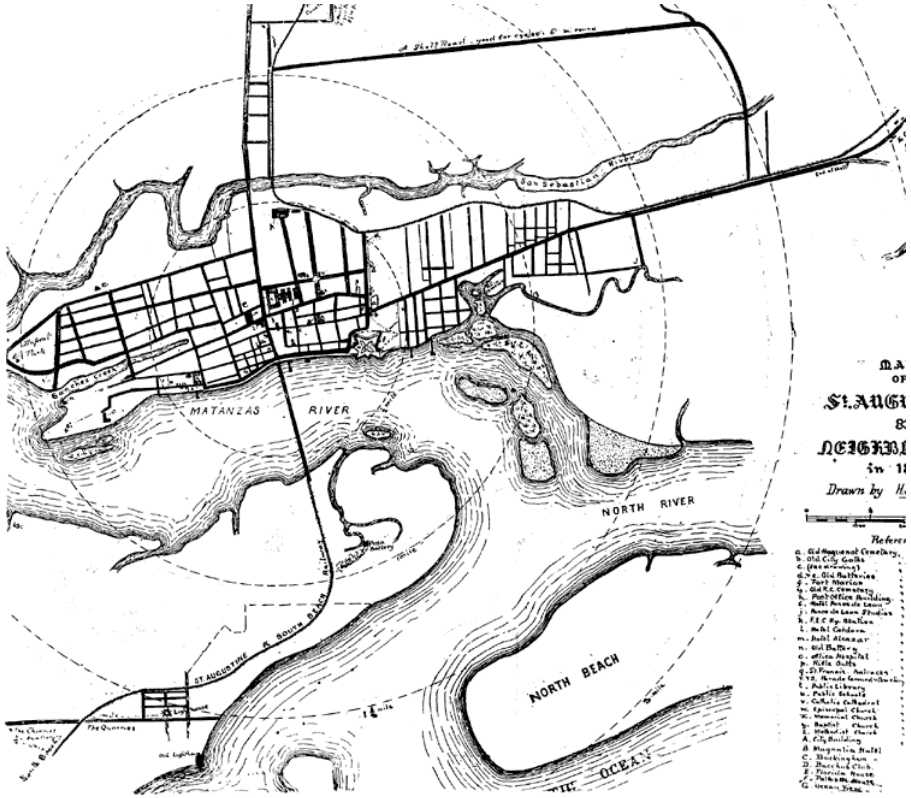
American Territory and Statehood Period (1821 – 1865)

- The first trigonometrically accurate pre-industrial revolution map of the inlet. Despite the greater of accuracy, surveyors continued to indicate the difficulty of crossing over the sand bars and shoals surrounding the inlet.



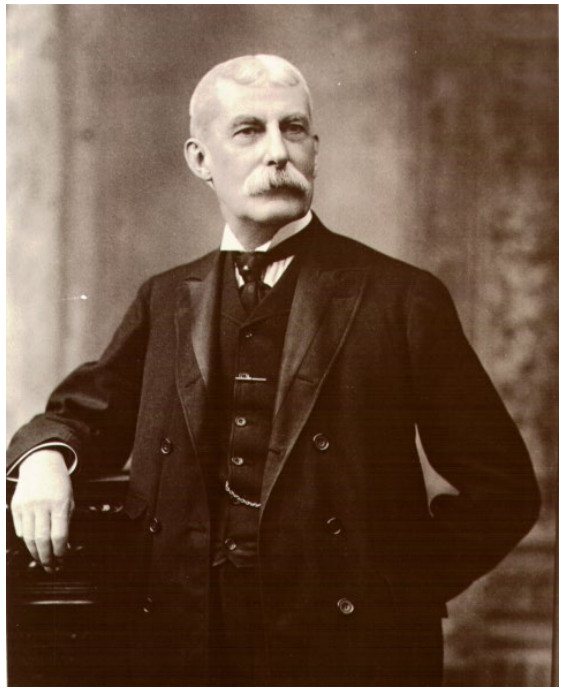
The first scientifically produced survey of the North Florida area. St. Augustine, FL; US Coastal Survey, 1861

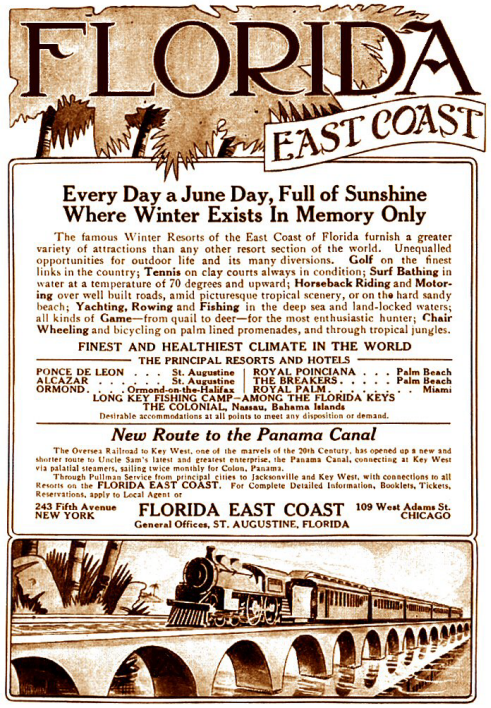
Reconstruction and Resort Period (1865 -1920)



Map of St. Augustine and its Neighborhoods, H.S. Wyttie, 1898

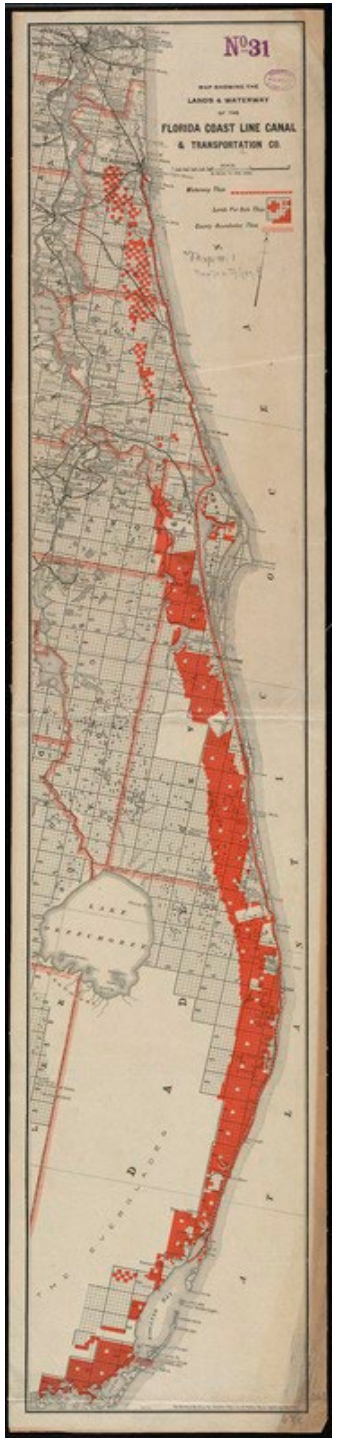
- The inlet continued to move to the south, and heavy boat activity was limited due to the shifting shallow shoals.
- The southern shoals begin to more consistently form into the sandy coastal islands known as Bird and Conch island.



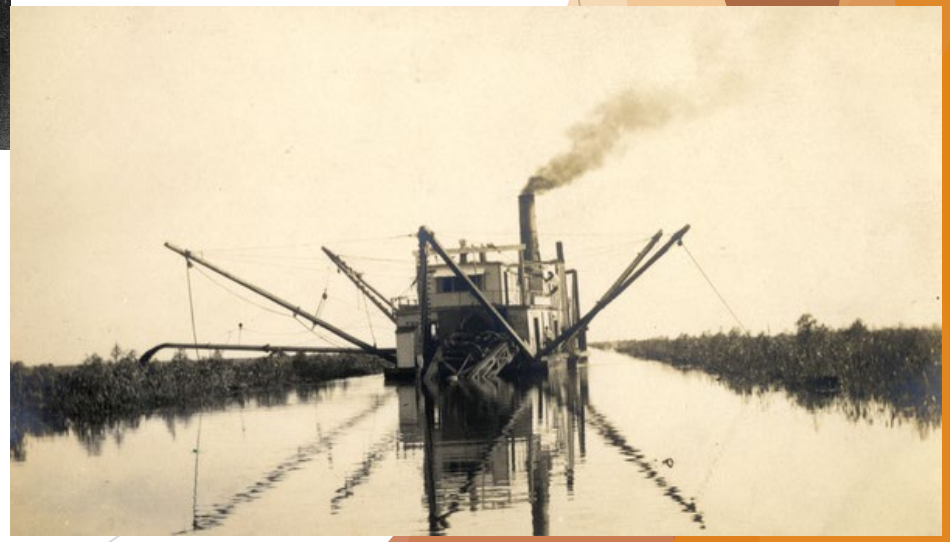


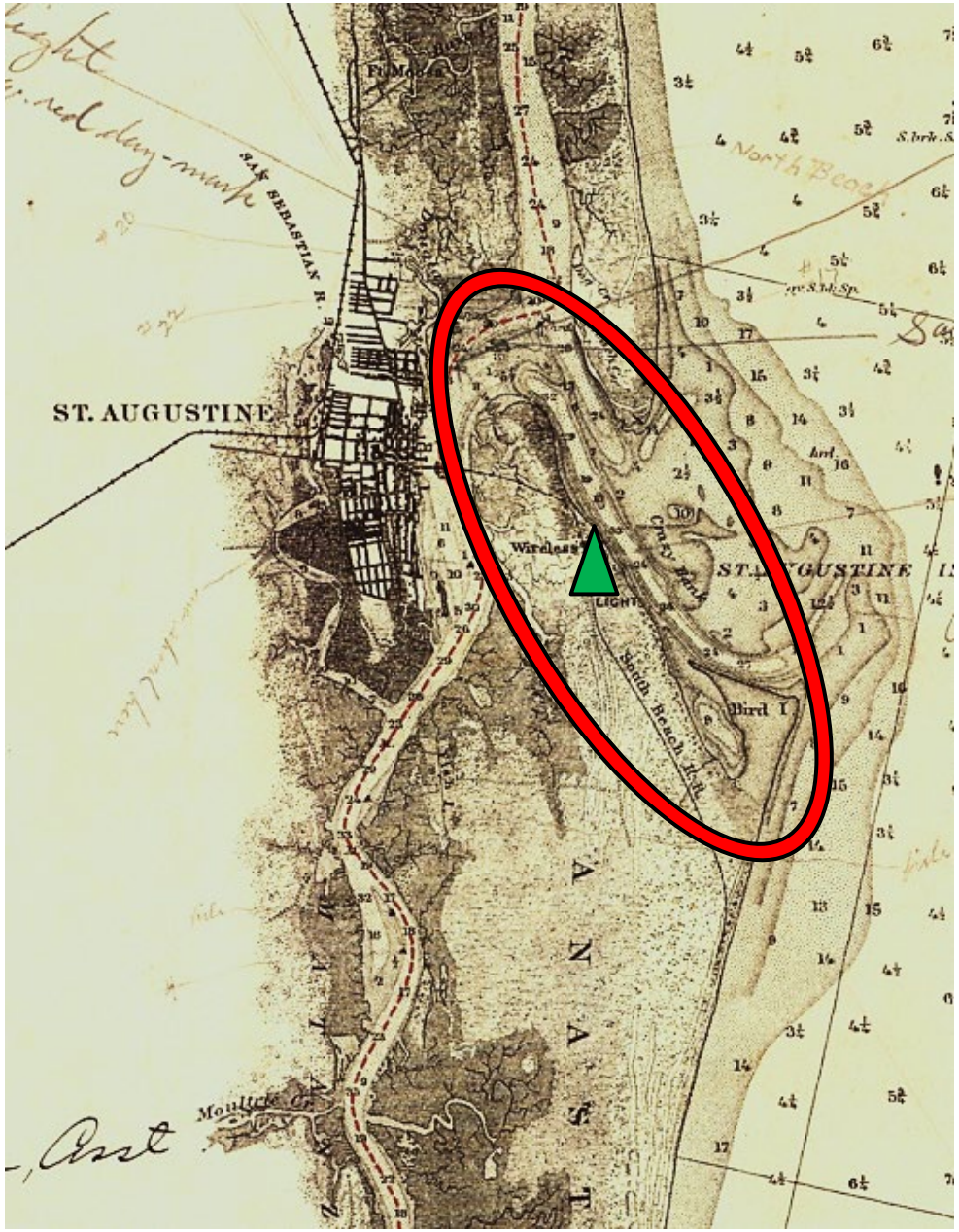
Henry Morrison Flagler, Founder of the Florida East Coast Railway and developer of the majority of St. Augustine as it is today.

From left to right, Hotel Ponce de Leon, Hotel Cordoba, Hotel Alcazar

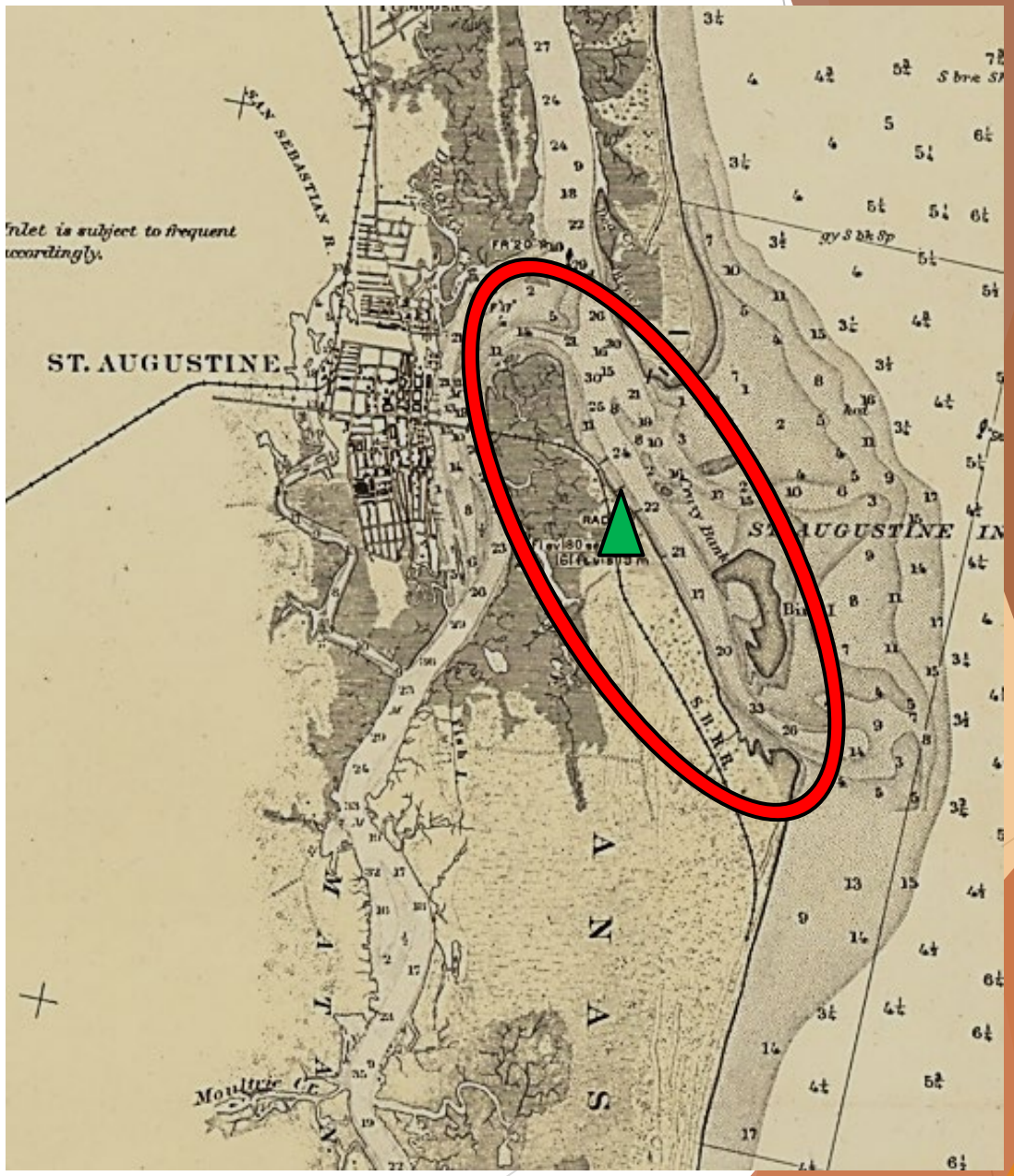


Florida Inland Navigation District & the Florida Intracoastal Waterway System





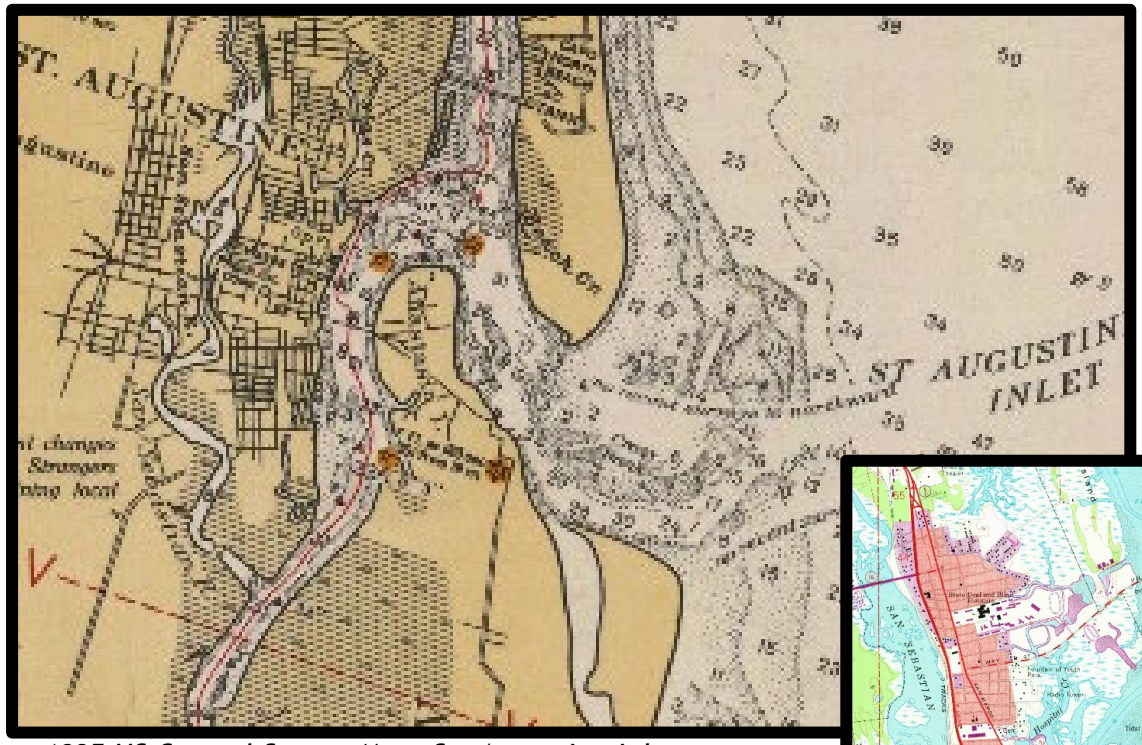
1890 US Coastal Survey, St. Augustine Inlet



1911 US Coastal Survey, St. Augustine Inlet

The Modern Industrial Period (1920 – 1960)

- This period also saw the most dramatic geomorphologic changes to the inlet in the form of the dredging of the inlet in 1943 by the USACE.



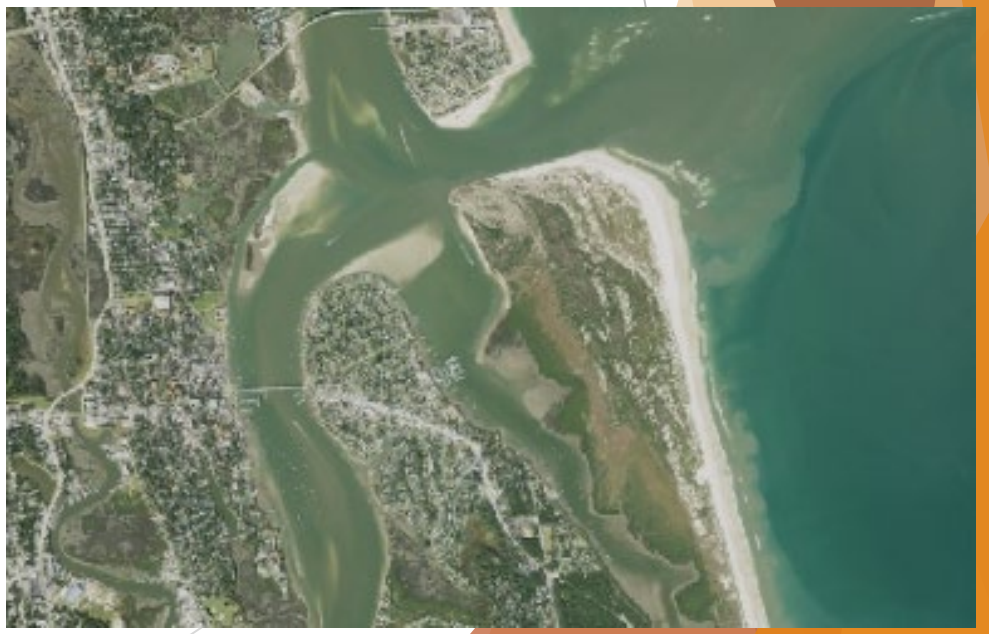
1935 US Coastal Survey Map, St. Augustine Inlet

1945 US Coastal Survey Map, St. Augustine Inlet

Present Day (1960 – 2022)

- Today the St. Augustine Inlet is a relatively safe commercial and recreational marine traffic lane. The inlet is characterized by routine dredging and beach restoration efforts that take place every 5 to 7 years.

St. Augustine Inlet, 2019.



St. Augustine, FL; Google Maps, 2022

Methodology

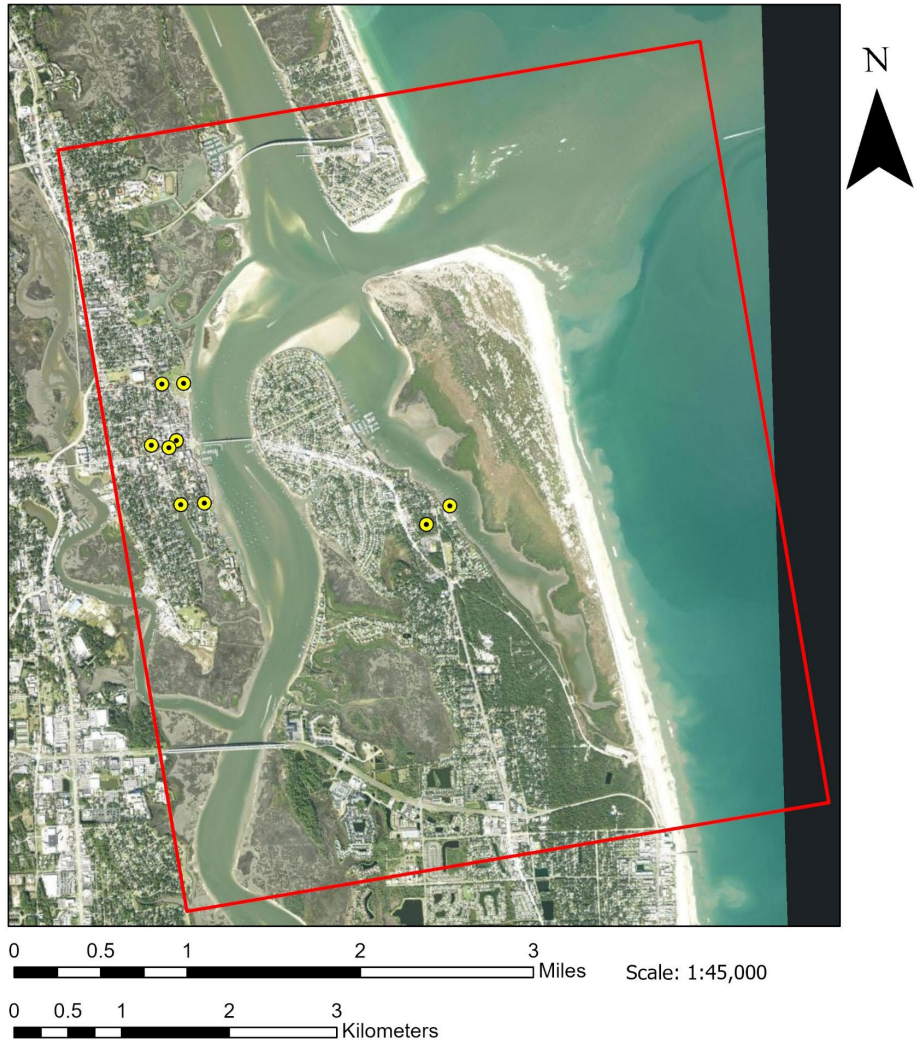
- The methodology used in this study reflects the processes employed in similar studies:
  1. Gather Data
  2. Georeference Historic Maps
  3. Digitize Shoreline and Bathymetry Sounding Points or Contours
  4. Generate TIN/Bathymetric grids (horizontal resolution 3 to 10 meters)
  5. Convert TINs to Common Vertical Datum
  6. Interpolate TIN Datasets to Elevation (Bathymetry) Rasters
  7. Conduct Error Analysis For Years When Reasonable Data Exists
  8. Conduct Change Analysis
  9. Export Finished Maps to User Interface

Technology & Software Used

- This project will use a combination of computer software and web platforms
  - ArcGIS Pro
  - ArcGIS Online
  - Web applications
    - USGS Topo Map Viewer
    - Office of Coastal Survey Historical Maps Web Viewer

Methodology: Data Gathering and Georeferenceing

Control Point Name	Coordinates (Latitude, Longitude)	Date of Origin
Castillo de San Marcos	29.8964959 N, -81.3138931 W	1565*, 1672
Cathedral Basilica of St. Augustine	29.8921360 N, -81.3137017 W	1793
St. Augustine North Gate	29.8861250 N, -81.3429791 W	1808*
St. Francis Barracks	29.8329116 N, -81.3561607 W	Mid-1700s
Old St. Augustine Lighthouse	29.8463383 N, -81.3269041 W	1733
Modern St. Augustine Lighthouse	29.8473136 N, -81.3232015 W	1871
Governor's House	29.8638086 N, -813346164 W	1598
Hotel Ponce de Leon (Flagler College)	29.8721146 N, -81.3417055 W	1888



The Governor's House (1598)

St. Augustine North City Gate, (1808)

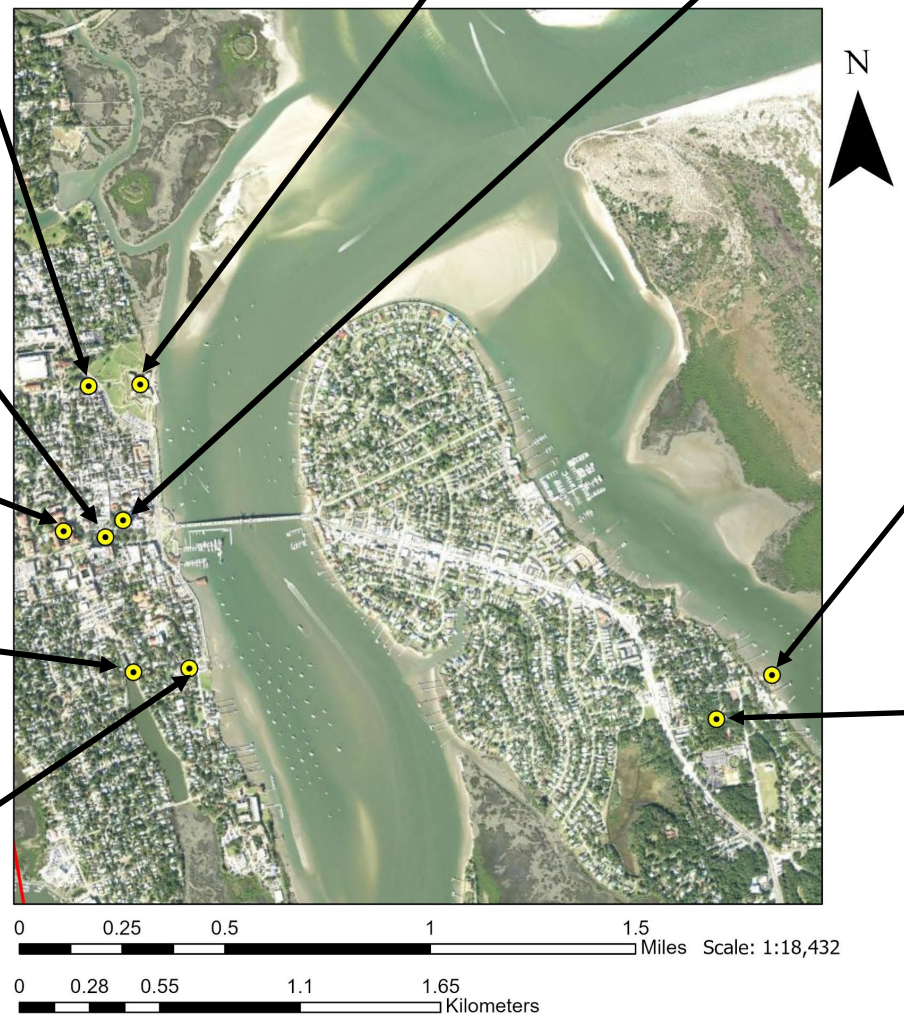
The Castillo de San Marcos (1565*, 1672)

The St. Augustine Catholic Basilica (1793)

Hotel Ponce de Leon (Flagler College), (1888)

Southwest Fortification (1672)

Franciscan Barracks, (mid-1700s)

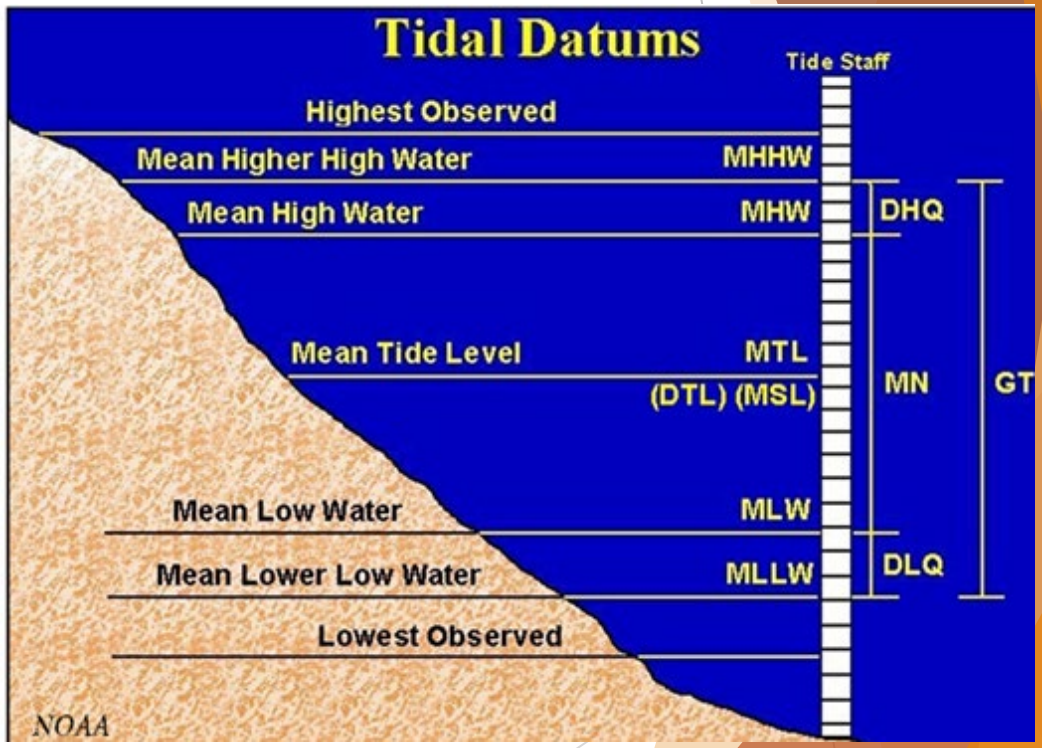


The Old St. Augustine Lighthouse (1733 – 1880)

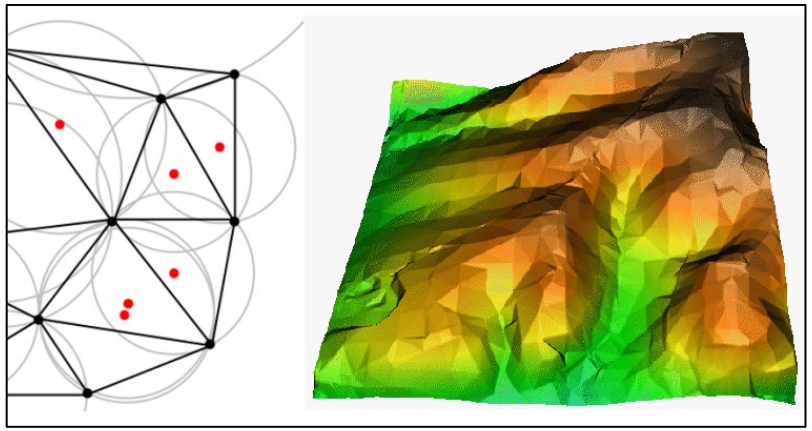
The Current St. Augustine Lighthouse (1874 – Present)

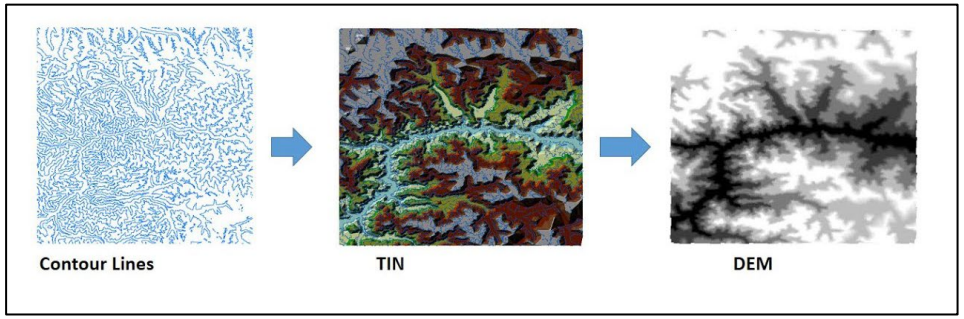
Methodology: Digitization of Coastlines and Bathymetry Soundings

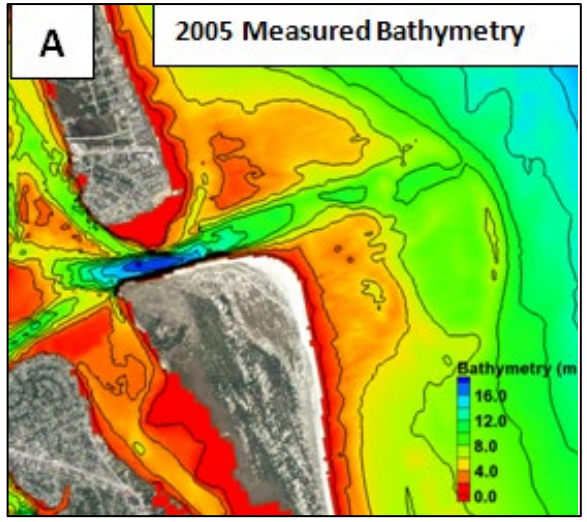
- Coastlines will be uniformly determined using Mean Low Water (MLW) vertical datum.
- The bathymetry soundings will be used to create point datasets that reflect approximate depth.
- For bathymetry contours, these lines will be digitized and have their depth values applied to them.



NOAA illustration of tidal datums, (2012).







Methodology: Point and Contour Lines to TIN and DEM Raster Datasets

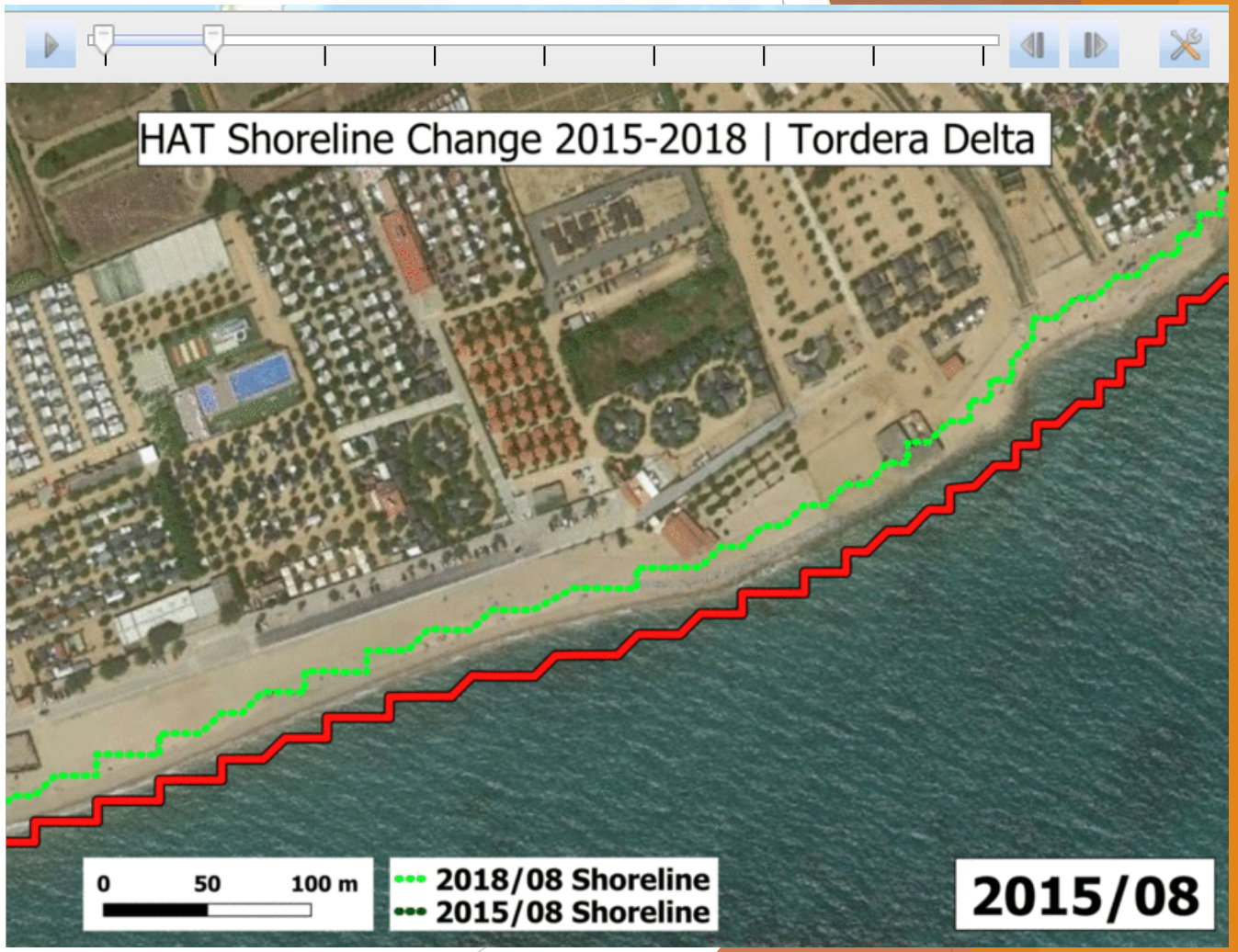
- Sounding Points and Contour lines will be used to generate TIN files using the ArcPro 3D Analyst Toolbox.
- These TIN files will then be interpolated to form digital elevation map (DEM) rasters for the inlet's bathymetry, while the historically georeferenced coastlines will represent the areas above MLW or sea level.

Concerns & Considerations

- Incomplete bathymetry datasets
- Bathymetric sounding accuracy for earlier maps may be sub-par or nonexistent in some instances
- Irregularity with tidal datums
- The lack of control points in many of the older maps could produce errors or inaccuracies

Methodology: Export to Web Application

- Target users:
  - Archaeologists
  - Historians
  - Researchers
  - Local, state, and federal government agencies
  - The general public



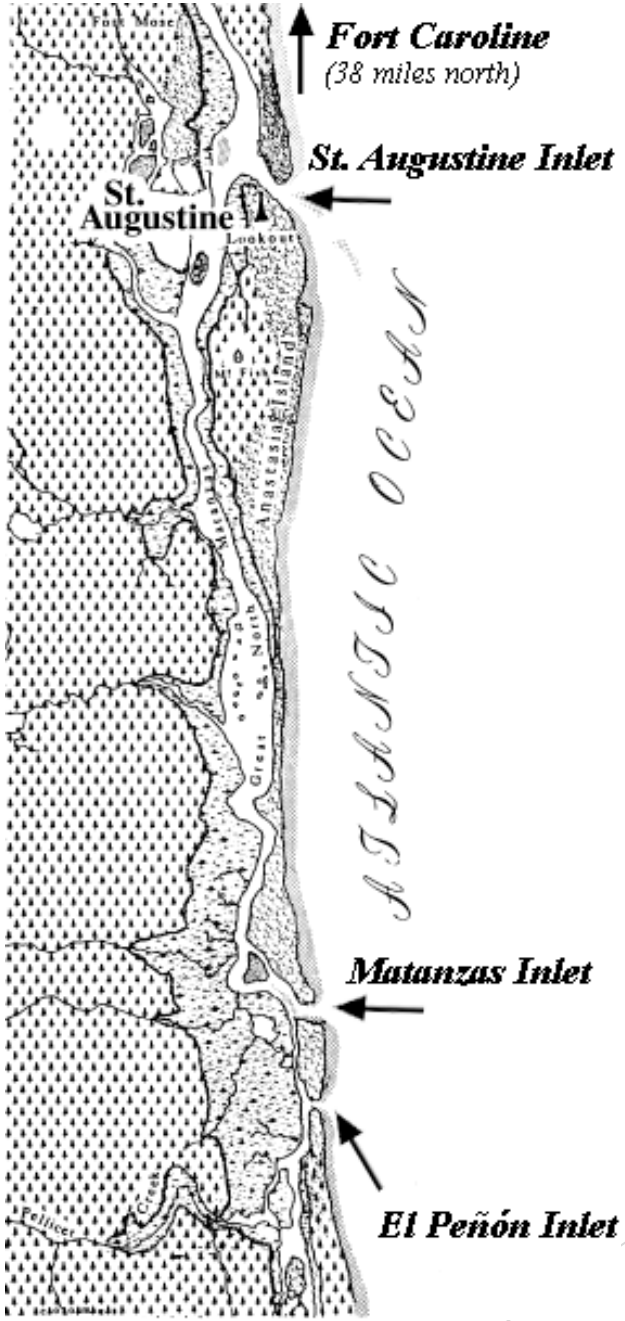
Time Frame	Tasks
March – April 2022	Literature Review and Capstone Project Proposal Development
April 2022	Additional Research and Literature Review, Prepare Project Proposal
May 2nd, 2022	Present Project Proposal
May – June 2022	Secure additional historic and modern navigational maps. Begin the process of georeferencing historic maps
June – July 2022	Generate historic coastline shapefiles, contour bathymetry line shapefile, and sounding point datasets.
July – August 2022	Generate TIN layers and raster bathymetry detests to conduct spatial analysis for time periods.
August – September 2022	Review results and assess accuracy.
September – October 2022	Prepare web-viewer, slider tool, and other final product for release.
November 2022	Prepare official project paper.
December 2022	Present project and findings to capstone committee and separate scholarly organization.

Anticipated Results

- Greatest geomorphic variety will exist in time periods before the dredging operations of the 1940s.
- The location of the inlet throughout time will match with the presumed age of shipwrecks uncovered by LAMP.
- Some degree of sea level rise is likely to have taken place in the past 6 decades of the modern inlet.
- A publicly accessible time slider web application that will allow researchers and local stakeholders to understand the geomorphology of the inlet from the past 400 years.

Future Work

- Matanzas Inlet
  - The southern entrance to the port of St. Augustine has similar hydrological characteristics. Similarly, it has also been the location of several LAMP shipwreck discoveries that could indicate the presence of additional wreck sites. This location however, has fewer historical maps and data available.



The Matanzas Inlet in relation to St. Augustine, FL.

Aerial footage of the Matanzas Inlet, LAMP 2019

Chuck Miede, lead archaeologist of LAMP examines a shipwreck found less than 200 yards north of the Matanzas inlet. LAMP, 2021

Thank you for your time and consideration

Questions or Comments

References:

- Boldt, J. (2016, July). *Bathymetric surveys active*. Bathymetric Surveys | U.S. Geological Survey. Retrieved March 30, 2022, from https://www.usgs.gov/centers/ohio-kentucky-indiana-water-science-center/science/bathymetric-surveys
- Buker, G. E., Bushnell, A., Dow, R. N., Graham, T., Griffin, J. W., Griffin, P., Schafer, D. L., & Waterbury, J. P. (1983). *The oldest city St. Augustine, saga of survival*. St. Augustine Historical Society.
- Budsburg, N. (2022, February 29). Personal communication [Personal interview].
- Cappiella, K., Malzone, C., Smith, R., & Jaffe, B., (1999). USGS, *"Sedimentation and Bathymetry Changes in Suisun Bay :1867-1990"*. Reston, VA. https://pubs.usgs.gov/of/1999/0563/pdf/of99-563.pdf
- Davis, R. E., & Dolan, R. (1993). Nor'easters. *American Scientist*, *81*(5), 428–439. http://www.jstor.org/stable/29775010
- Dierssen, H. M. (2014). (rep.). *Bathymetry: History of Seafloor Mapping* (pp. 1–5). Groton, CT: Univeristy of Connecticut.
- Fitzgerald DM, Fenster MS, Argow BA, Buynevich IV (2008) Coastal impacts due to sea-level rise. Annu Rev Earth Plane Sci 36:601–647. https://doi.org/10.1146/annurev.earth.35.031306.140139
- Fernández-Montblanc, T., Del Río, L., Izquierdo, A., Gracia, F. J., Bethencourt, M., & Benavente, J. (2018). Shipwrecks and man-made coastal structures as indicators of historical shoreline position. an interdisciplinary study in the sancti petri sand spit (bay of Cádiz, SW Spain). *Marine Geology*, *395*, 152–167. https://doi.org/10.1016/j.margeo.2017.10.005
- Foxgrover, A. C., Higgins, S. A., Ingraca, M. K., Jaffe, B. E., & Smith, R. E. (2004). Deposition, erosion, and bathymetric change in South San Francisco Bay: 1858–1983. *US Geological Survey Open-File Report*, *1192*, 25.
- Harrington, J. C. (1955) "Archeological Excavations in the Courtyard of Castillo de San Marcos, St. Augustine, Florida," Florida Historical Quarterly: Vol. 34 : No. 2 , Article 4. Available at: https://stars.library.ucf.edu/fhq/vol34/iss2/4
- Laurel Gorman, Andrew Morang, & Larson, R. (1998). Monitoring the Coastal Environment; Part IV: Mapping, Shoreline Changes, and Bathymetric Analysis. *Journal of Coastal Research*, *14*(1), 61–92. http://www.jstor.org/stable/4298762
- Legault, K., Rosati, J. D., Engle, J., & Beck, T. M. (2012). (tech.). *St. Johns County, St. Augustine Inlet, FL Report 1: Historical Analysis and Sediment BUdget* (pp. 5–7). Vicksburg, MS: Coastal and Hydraulics Laboratory.
- Jakobsson, M., Armstrong, A., Calder, B., Huff, L., Mayer, L., & Ward, L. (2005). On the Use of Historical Bathymetric Data to Determine Changes in Bathymetry: An Analysis of Errora nd Application to Greate Bay fEstuary, NH. *International Hydrographic Review*, *6*(3), 25–41. https://doi.org/https://scholars.unh.edu/cgi/viewcontent.cgi?article=2016&context=ccom
- Jeffrey H. List, Jaffe, B. E., Asbury H. Sallenger Jr., & Mark E. Hansen. (1997). Bathymetric Comparisons Adjacent to the Louisiana Barrier Islands: Processes of Large-Scale Change. *Journal of Coastal Research*, *13*(3), 670–678. http://www.jstor.org/stable/4298662

References:

- Meide, C., Burke, B., Turner, S., Coxx, S., McDaniel, O., & Ropp, A. (2011). (rep.). *First Coast Maritime Archaeology Project 2010: Report on Achaeological Investigations* (pp. 1–100). St. Augustine, FL: Lighthouse Archaeological Maritime Program Inc.
- Meide, C., Burke, B., Turner, S., Coxx, S., McDaniel, O., & Ropp, A., Thomson, A., Andes, E., Burkett, M., McCarron, C., Carter, A.E., Brendel, H., Mollema, I., Veilleux, C. (2018). (rep.). *First Coast Maritime Archaeology Project 2013: Report on Archaeological Investigations* (pp. 1–47). St. Augustine, FL: Lighthouse Archaeological Maritime Program Inc.
- Passeri, D.L., Bilskie, M.V., Plant, N.G. *et al.* Dynamic modeling of barrier island response to hurricane storm surge under future sea level rise. *Climatic Change* **149,** 413–425 (2018). https://doi.org/10.1007/s10584-018-2245-8
- Perrault, P. H. (1830). Report to Andrew Jackson, President and J.H. Eaton. St. Augustine, FL; USA.
- Rayner R. F, (1993) Field studies and data analysis in Abbott, M.B., & Price, W.A. (Eds.). (1994). Coastal, Estuarial and Harbour Engineer's Reference Book (1st ed.). CRC Press. https://doi.org/10.1201/9781482267020
- Robinson, A. H. W. (1957). Marine Surveying in Britain during the Seventeenth and Eighteenth Centuries. *The Geographical Journal*, *123*(4), 449–456. https://doi.org/10.2307/1790346
- Rumsey, D., & Williams, M. (2002). *Historical maps in GIS* (pp. pp-1). na.
- Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Up-dated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA, Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean, Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos, techrpt01-global-regional-SLR-scenarios-US.pdf
- Turner, S. (2013). Juan Ponce de Leon and the Discovery of Florida Reconsidered. *The Florida Historical Quarterly*, *92*(1), 1–6.
- Van der Wal, D., & Pye, K. (2003). The Use of Historical Bathymetric Charts in a GIS to Assess Morphological Change in Estuaries. *The Geographical Journal*, *169*(1), 21–31. http://www.jstor.org/stable/3451537
- Zlinszky, A., & Timar, G. (2013). *Historic Maps as a Data Source For Socio-hydrology: A Case Study of the Lake Balaton Wetland System, Hungary.* Hydrology and Earth System Sciences. Retrieved March 15, 2022, from https://hess.copernicus.org/articles/17/4589/2013/hess-17-4589-2013.pdf

Image Source Citation:

- Jefferys, T. (1762) *Plan of the town and harbour of St. Augustine*. [London? ?] [Map] Retrieved from the Library of Congress, https://www.loc.gov/item/75693262/.
- University of Virginia. (2010), *Sanborn Fire Insurance (1910), Georeferencing*. [Digital Photo] Retrieved from the University of Virginia Library: Sholars' Lab, https://spatial.scholarslab.org/making-historic-maps-spatial-georeferencing/
- United States Coast Survey, Huger, B. & Dorr, F. W. (1862) *Preliminary chart of St. Augustine harbor, Florida*. [Washington, U.S. Coast Survey] [Map] Retrieved from the Library of Congress, https://www.loc.gov/item/99447281/.
- Harris Co, C. C. (ca. 1910) *Alcazar, Cordova & Ponce de Leon, St. Augustine, Fla*. United States Florida Saint Augustine, ca. 1910. [Photograph] Retrieved from the Library of Congress, https://www.loc.gov/item/2007660783/.
- Boazio, B. & Hans And Hanni Kraus Sir Francis Drake Collection. (1589) *S. Augustini: pars est terra Florida, sub latitudine 30 grad, ora vero maritima humilior est, lancinata et insulosa*. [Map] Retrieved from the Library of Congress, https://www.loc.gov/item/2004629176/.
- The Miriam and Ira D. Wallach Division of Art, Prints and Photographs: Picture Collection, The New York Public Library. (1876 - 1881). *Laying out of St. Augustine* Retrieved from https://digitalcollections.nypl.org/items/510d47e0-f30e-a3d9-e040-e00a18064a99
- NASA. (2019). *St. Augustine Inlet, FL [*Photo]. St. Augustine, FL. https://ocean.floridamarine.org/boating_guides/flagler_st_johns/index.html
- USCG. (2020). *Approaching St. Augustine, Florida Inlet* [Photo]. Marinas.com. https://marinas.com/view/inlet/rqinp_St_Augustine_Inlet_St_Augustine_FL_United_States#&gid=1&pid=3
- Talegon, M. (2016). *Andalucia Galeon* [Photo].Fundacion Nao Victoria, *https://www.fundacionnaovictoria.org/el-galeon/*
- Ogden, R. (1890). *"A Loyal Little Red-Coat: A story of Child-life in New York a Hundred Years Ago"*. Rederick A Stokes Company. New York, NY.
- Lopez, T. (1783), *"Plano de la Ciudad de San Agustin de la Florida, 1783"*. University of South Florida: Maps ETC,
- Pan, E.(1950). **Mural painting of Spanish explorer and conquistador Hernando de Soto at the Manatee National Bank in Bradenton, Florida. Retrieved from: Florida Memory State Library and Archives of Florida. https://www.floridamemory.com/items/show/259045**
- http://fcit.usf.edu/florida/maps/pages/4100/f4167/f4167.htm

Data Used

- This study will utilize 19 historical and modern navigational maps, datasets, and charts of the area for georeferencing and addition written and records to help piece together the past 400 years of change in the inlet.

Name	Date / Year	Source
Boazio 1585 Sir Francis Drakes Raid on St. Augustine Port and Town	1589	Library of Congress, Baptista Boazio
A View of the Town and Castle of St. Augustine and the English Camp Before June 20, 1740	1740	Thomas Silver
Plan of the Town & Harbour of Augustine	1756-1777	William Hurd
Deline atio munimenti et Portus S. Augustini	1759	Homann
Plan of the Town and Harbour of St. Augustine, 1762	1762	William Roberts
St. Augustine Inlet and Town	1765 and 1766	W. Gerard DeBrahm, Esq.
Plano de La Ciudad Y Puerto De San Augustin, De La Florida	1783	Tomas Lopez
Preliminary Chart of St. Augustine Harbor	1862	B. Huger Jr., & F.W. Dorr
Prliminary Chart of St. Augustine Harbor Florida	1879	B. Huger Jr., & F.W. Dorr
St. Augustine Coastal Survey	1911	USGS
Bird's -Eye View of Saint Augustine and Vicinity	1916	Unknown, Florida Memory State Library and Archives of Florida
Florida Intracoastal Waterway St. Augustine To Titusville	1935	USGS
Intracoastal Waterway Tolomato River to Palm Shores 1943	1943	USGS
Intracoastal Waterway Tolomato River to Palm Shores 1956	1956	USGS
Intracoastal Waterway Tolomato River to Palm Shores 1976	1976	USGS
Intracoastal Waterway Tolomato River to Palm Shores 1995	1995	USGS
Intracoastal Waterway Tolomato River to Palm Shores 2005	2005	USGS
Intracoastal Waterway Tolomato River to Palm Shores 2017	2017	USGS
Intracoastal Waterway Tolomato River to Palm Shores 2022	2022	USGS

Methodology: Data Sources

- Data was sourced depending on the type of map:
  - Historical Maps: 1585 - 1940
    - USGS Historical Map Archive
    - Library of Congress
    - National Archives
    - St. Augustine Historical Society
    - University of Florida's Historic Map Library
    - University of Southern Florida's Digital Map Library
    - LAMP's Research Library
  - Modern Maps: 1940 – Present
    - United States Geologic Survey
    - United States Army Corps of Engineers
    - National Oceanic and Atmospheric Administration
  - Aerial and LiDAR Datasets
    - NOAA
    - USGS/NRCS
    - Florida Geospatial Open Data Portal

USGS

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