
Coastal Retreat in Texas Counties from 1850 to 2000

By: Jacob Taylor

Problem:

Coastlines in Texas have been changing over time, both receding and accreting, which changes the vegetation profiles as well as the available land. Sea-level rise is considered a major factor in changing shorelines globally, and Texas Coastlines are no exception (Paine et al., 2014). Other factors such as erosion, subsidence, and storm damage also affect the shoreline and have caused considerable change over time. Historic rates of change of shorelines are important because Texas has approximately 350 miles of coastline. Coastlines are being developed for industrial and recreational uses, which means that knowing rates of change of coastlines allows for predictive planning. Texas coastlines are also important locations for many threatened and endangered animals like shorebirds, turtles, and fish that live in specific areas of the coast (Pickens & King, 2014; Seney & Landry, 2008). Understanding how habitat loss is going to affect these animals is important in conservation efforts along the coast.

This project is specifically trying to understand what the historical rates of change for the Texas shoreline were from 1850 to 2000 to understand what the implications are for shoreline change in the future. The results from the shoreline rate of change will be used in terms of vegetation changes along the coastline and suggests what development along the coastlines may look like in the future. The primary tool used in this study is the Digital Shoreline Analysis System (DSAS) by the United States Geological Survey (USGS)(Henderson et al., 2020). The DSAS tool allows for rates of change to be calculated given current and historic shoreline data in terms of meters per year.

Data Collection:

Current and historical data was necessary for this project. Data for coastlines was collected from the USGS Coastal & Marine Geology Program (Miller et al., 2004). The DSAS tool is pivotal to this project because it allows for large data sets like the entirety of the Texas coastline to be analyzed for shoreline change. High resolution imagery for Texas coastlines was found on Texas Natural Resources Information System(TNRIS) (USDA, 2014). This is important more current comparisons of how Texas coastlines have changed since 2000.

1. USGS Coastal & Marine Geology Program data:
tx1850_1883 – shapefile, -97.379847, 29.703577 and -93.850282, 25.946469
tx1930_1938 – shapefile, -97.378536, 29.692942 and -93.844998, 25.949100
tx1970_1975 – shapefile, -97.379115, 29.683125 and -93.904948, 25.951408
tx2000_2001 – shapefile, -97.379029, 29.682701 and -93.837821, 25.922811
tx_baseline – shapefile, -97.373952, 29.673165 and -93.907110, 25.957144
2. DSAS v5 Tool:
DSASAddin_v5 – Extension installation
DSAS sample data – sample data to practice using the DSAS tool
3. TNRIS data:
naip14_nc_aransas_007 - .sid file, -97.320516, 28.385984 and -96.742764, 27.804154

naip14_nc_calhoun_057 - .sid file, -96.951547, 28.762620 and -96.306031, 28.049985
naip14_nc_galveston_167 - .sid file, -95.258863, 29.640434 and -94.302133, 29.055795
naip14_nc_matagorda_321 - .sid file, -96.443788, 29.267486 and -95.478297, 28.351517

Data Preprocessing:

The data for the coastlines, DSAS tool, and high resolution images was downloaded and stored in the file system for the project. The DSAS tool that was utilized in this project required a personal geodatabase to work out of, so one was created within the file structure for the project. The data files were imported into the geodatabase by using the “Import->Feature Class (multiple)...” function. The DSAS tool is downloaded as a .zip file from the source, and was then extracted to the file location of the project. The file contained another file called DSASAddin_v5.zip, which was unzipped to give the DSASAddin Esri AddIn File. Clicking this gave a pop up window to install the addin (Figure 1). Installing the tool put the tool into the extension tab of ArcMap and was enabled by going to Customize->Extensions...->DSAS v5 Extension. The toolbar was added by opening Customize->Toolbars->DSAS v5 Toolbar.

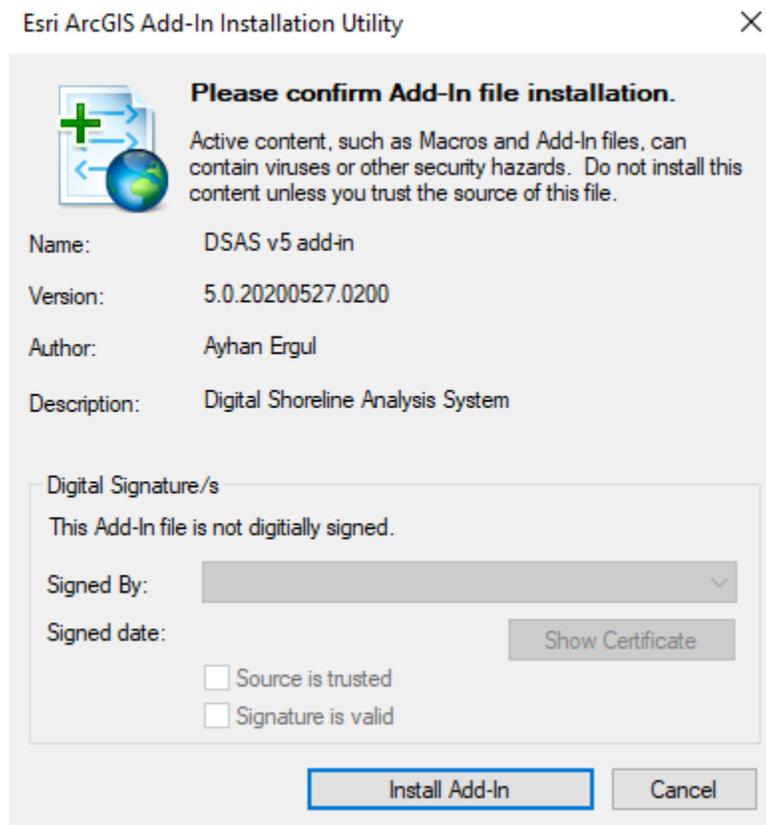


Figure 1. DSAS addin installer. Clicking Install Add-In installed the DSAS tool to ArcMap.

Data gathered for this project had to be projected into the same projected coordinate system. The coordinate system chosen was NAD84, UTM Zone 14N because that is what the

high resolution images of the Texas coastline were already in. The DSAS tool required a projected coordinate system instead of a geographic coordinate system to work, which means that switching the coordinate systems for the USGS data was required anyway.

The data was changed by using the project tool, inputting the shoreline data, selecting NAD83, UTM Zone 14N, and pressing ok (Figure 2). The project tool was found by going to ArcToolbox->Data Management->Projections and Transformations->Project or searching “Project” in the search bar and find the Project tool under Data Management.

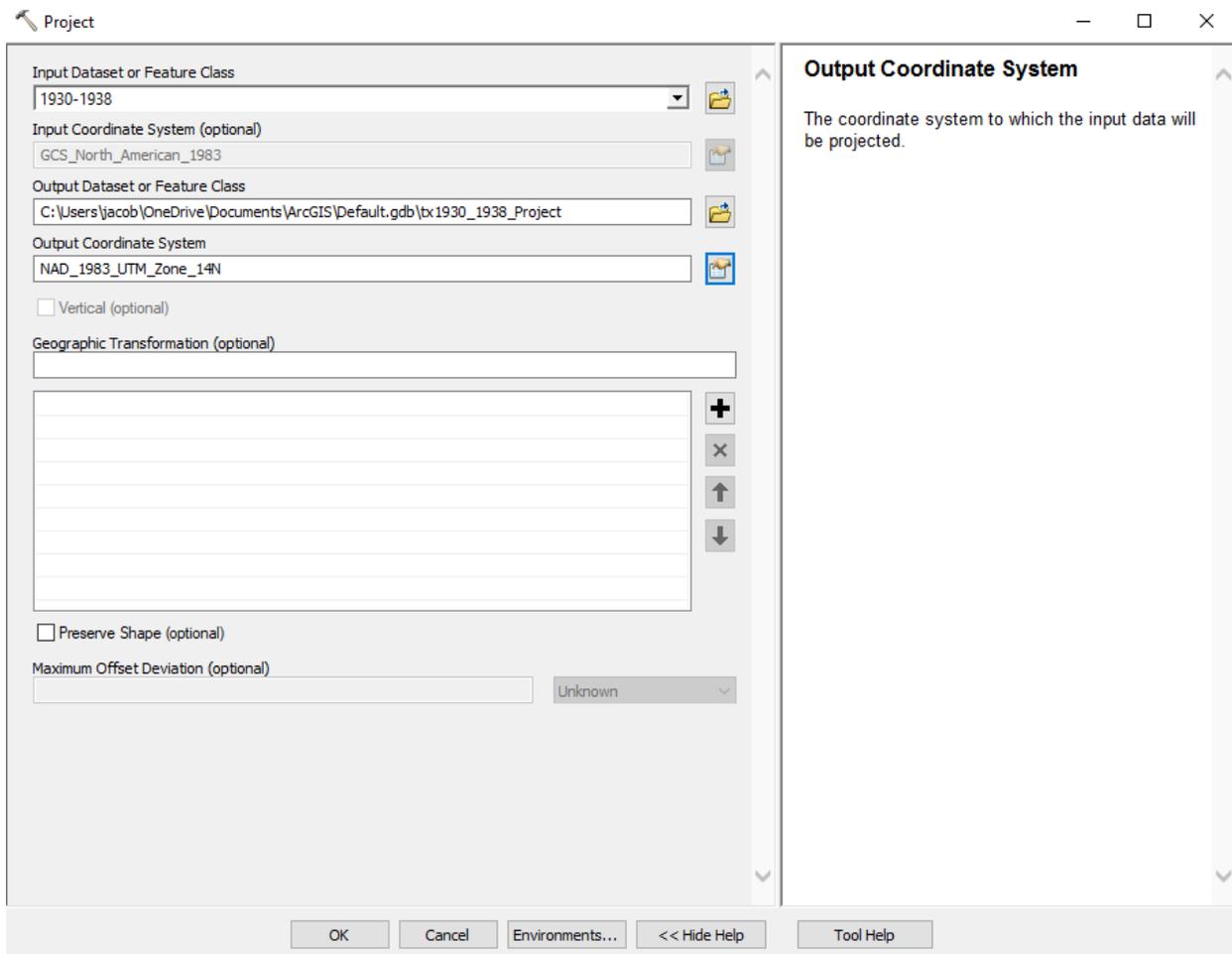


Figure 2. This is the Project Tool used to change the projected coordinate system of the shoreline data. The input data set is the desired feature class to be changed and the output coordinate system is the desired coordinate system.

The DSAS tool also required that the data being evaluated was in meter units rather than decimal degrees, which was done by changing the display units from Decimal Degrees to Meters under the general tab of the Data Frame Properties. The feature classes and high resolution image were dragged into the table of contents and symbolized appropriately (Figure 3)



Figure 3. Shoreline and Baseline data added into ArcMap and symbolized appropriately to show differentiation of feature classes.

The final requirement to use the DSAS tool was that the shoreline data being measured is merged into one file. This was done by using the merge tool by going to ArcToolbox->Data Management->General->Merge. The input was the shoreline data and the output was set to the geodatabase that the DSAS tool was working out of (Figure 4). The merged shoreline data (Figure 5) was then dragged under the original shoreline data to allow for differentiation.

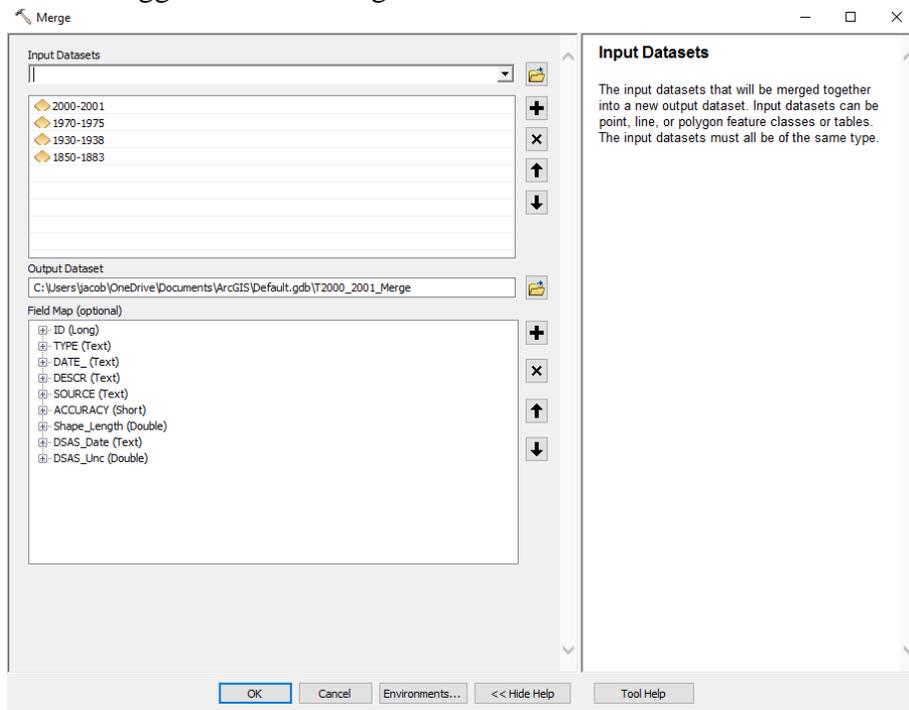


Figure 4. The Merge tool menu with the desired shoreline data added and output set to the geodatabase.



Figure 5. Merged shoreline data before it is dragged under the original shoreline data for differentiation purposes.

If additional fields such as the date the data was recorded needed to be added to the attribute table of the merged data, the “Attribute Automator” tool on the DSAS v5 Toolbar was used (Figure 6). The merged shoreline data that was being changed was selected and the desired names of the fields that need to be added could be entered and added(Figure 7). This can be done for the baseline layer as well.



Figure 6. “Attribute Editor” button on the DSAS v5 Toolbar.

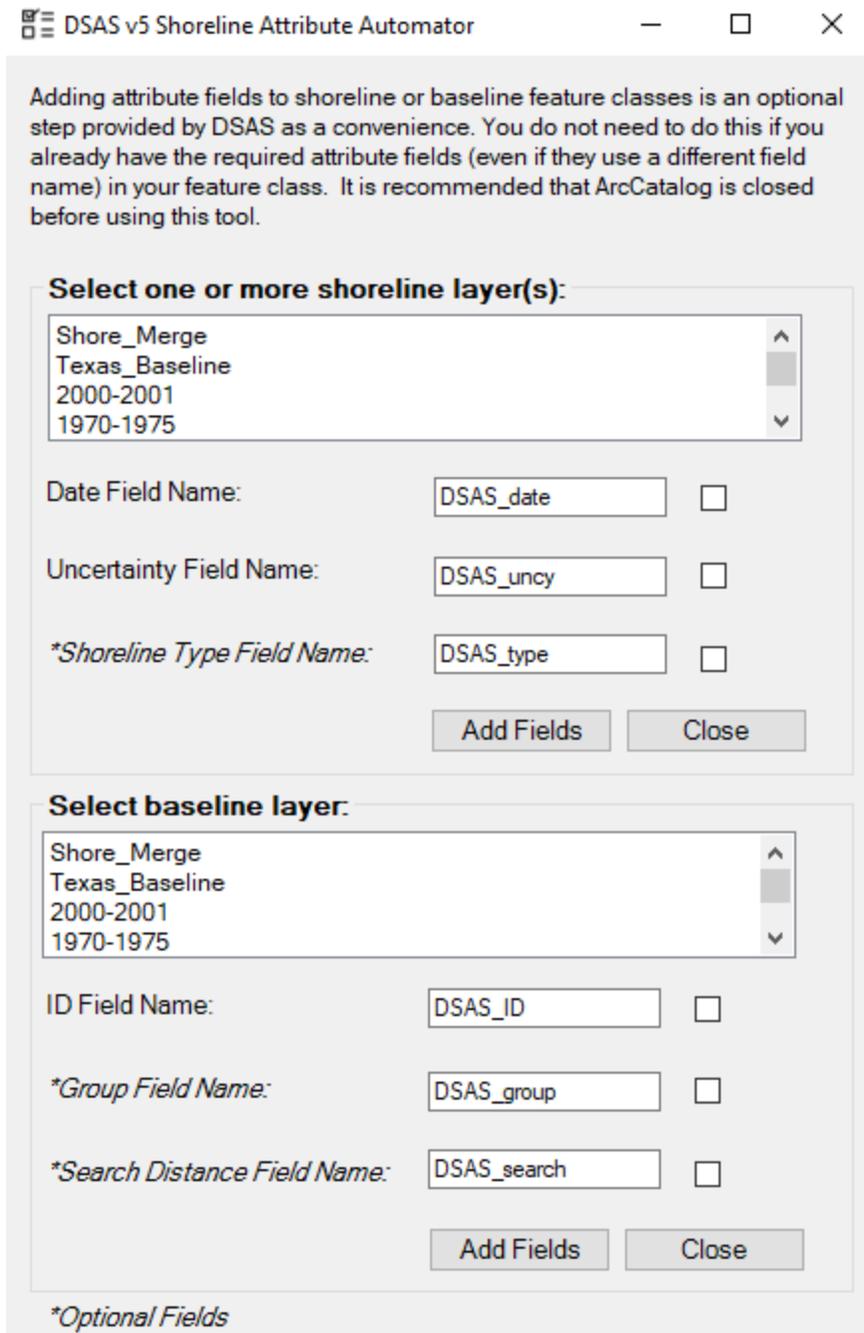


Figure 7. Attribute Editor menu from the DSAS v5 Toolbar. The data being changed is selected from the menu, the desired fields are entered where available, and then clicking add fields changes the attribute tables accordingly.

Data Processing:

1. Set the baseline settings, shoreline settings, and metadata settings by clicking the “Default parameters” button on the DSAS v5 toolbar (Figure 8). The baseline layer should be selected from the drop down next to “Baseline Layer” and the ID field should be ID. Depending on the data, the orientation as well as the placement can be changed here (Figure 9). The merged

shoreline data can be selected from the dropdown next to the “Shoreline Layer” line, the date field of the data is selected from the next drop down menu, and the uncertainty or accuracy of the measurements can be selected here (Figure 10). The metadata settings should be set here to generate metadata when the tool is used (Figure 11). This is where the specifications for the data used in the calculations is set and is required before using the tool.

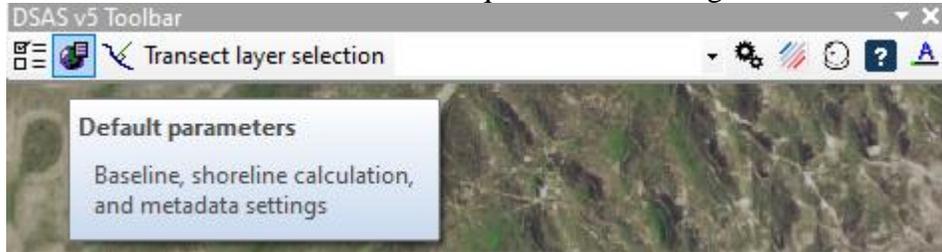


Figure 8. The “Default parameters” button on the DSAS toolbar.

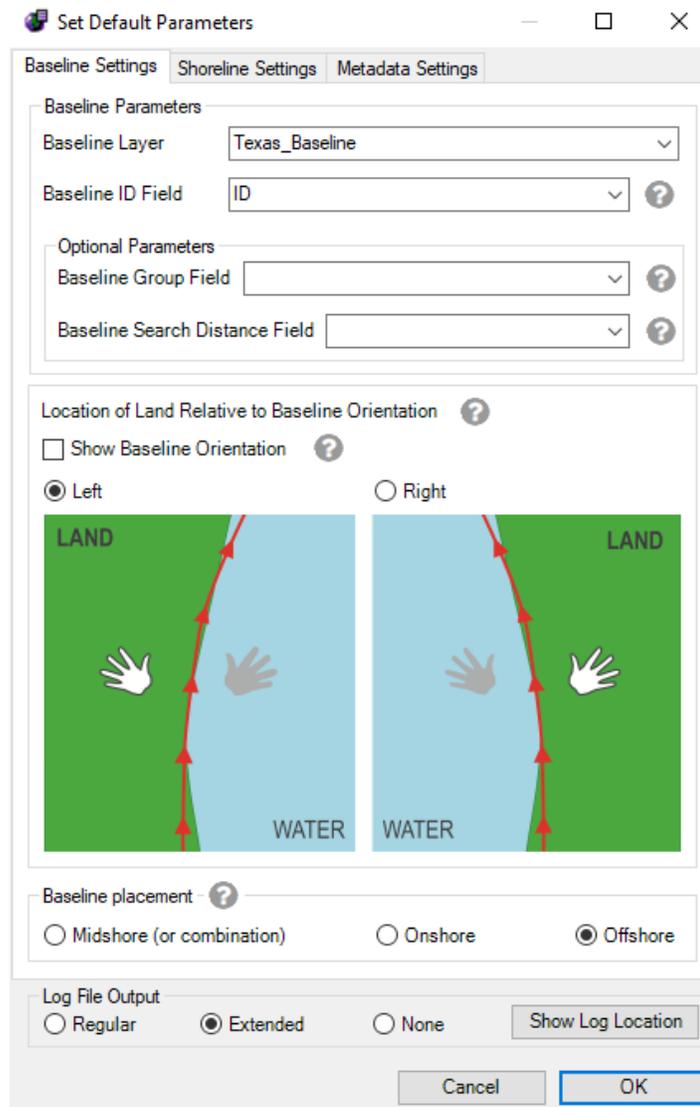


Figure 9. Baseline Settings tab in the “Default parameters” window. This allows for the baseline layer, the baseline ID field, land orientation, and baseline placement to be changed

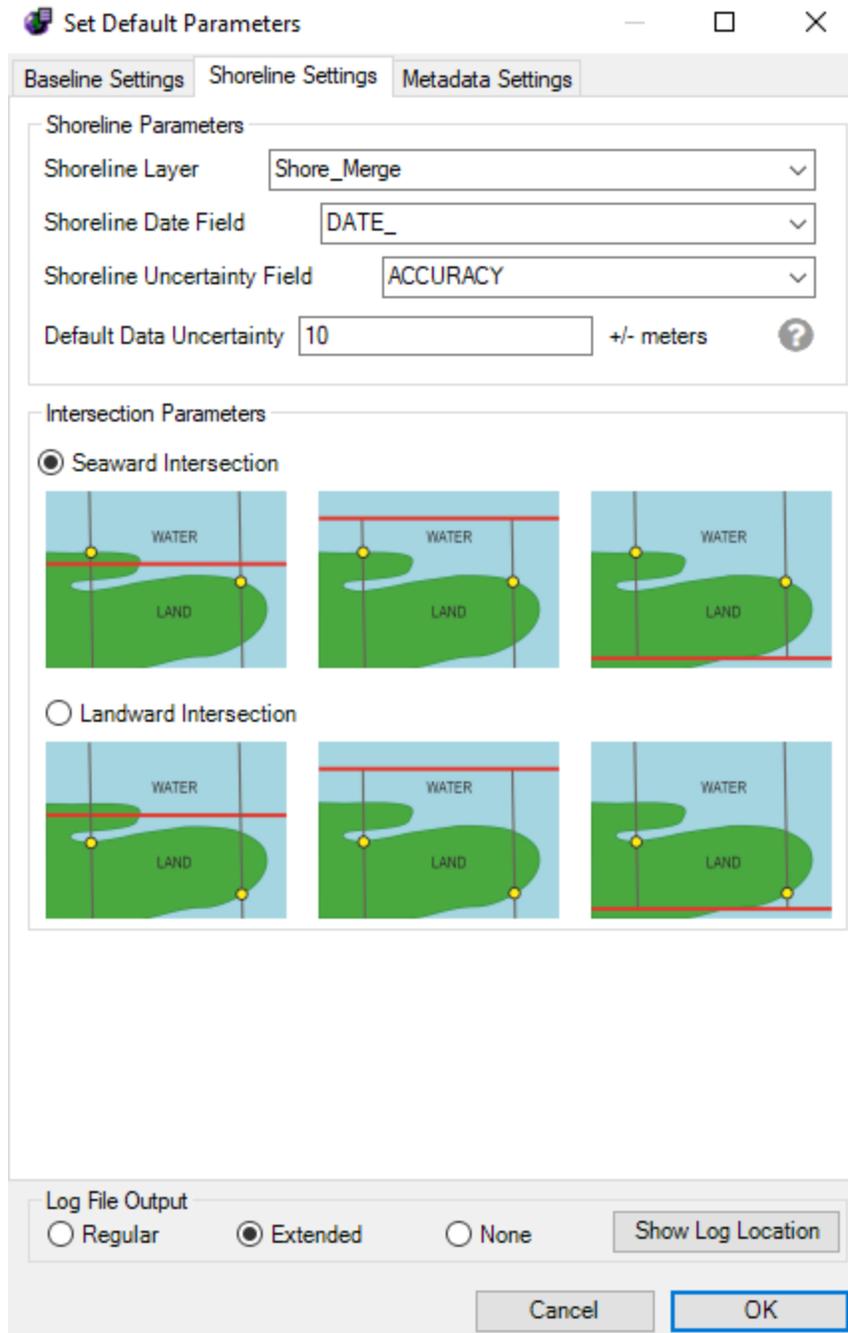


Figure 10. Shoreline Settings tab in the “Default parameters” window. This allows the shoreline layer, shoreline date field, shoreline uncertainty field, and the data uncertainty to be specified. Intersection parameters can also be changed here.

Set Default Parameters

Baseline Settings | Shoreline Settings | Metadata Settings

General Information

Originator

Abstract

Purpose

Data Update and Access Information

Update Frequency Progress

What are Data Current to?

Constraints on Access

Contact Information

Organization

Person

Address

City State Zip

Phone Email

Log File Output

Regular Extended None

Figure 11. Metadata Settings tab in the “Default parameters” window. This allows for the metadata to be set for the transects and intersections points that are generated by this tool.

2. Check the Attribute Table of the baseline data to ensure that the “ID” does not have any repeated values. If there are repeated values, edit the attribute table to give unique values (Figure 12).

Table		
Texas Baseline		
OBJECTID *	Shape *	ID
1	Polyline	1
2	Polyline	2
3	Polyline	3
4	Polyline	4
5	Polyline	5
6	Polyline	6
7	Polyline	7
8	Polyline	8
9	Polyline	9
10	Polyline	10
11	Polyline	11
12	Polyline	12
13	Polyline	13
14	Polyline	14
15	Polyline	15
16	Polyline	16
17	Polyline	17
18	Polyline	18
19	Polyline	19

Figure 12. Attribute Table for the baseline feature class. Any repeats in the ID column will cause an error message saying that there are repeat calculations for a single ID.

- Once all settings are set, press the “Cast Transect” button (Figure 13). A dialog box may pop up asking for metadata settings to be completed (Figure 14). If the metadata is not completed, press cancel and go back to the metadata settings. If metadata fields are not all filled but cannot be filled, press ok and bring up the cast transect window.

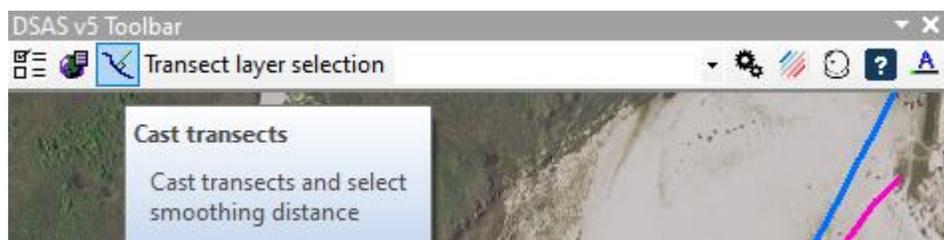


Figure 13. Cast transects button on the DSAS v5 Toolbar.

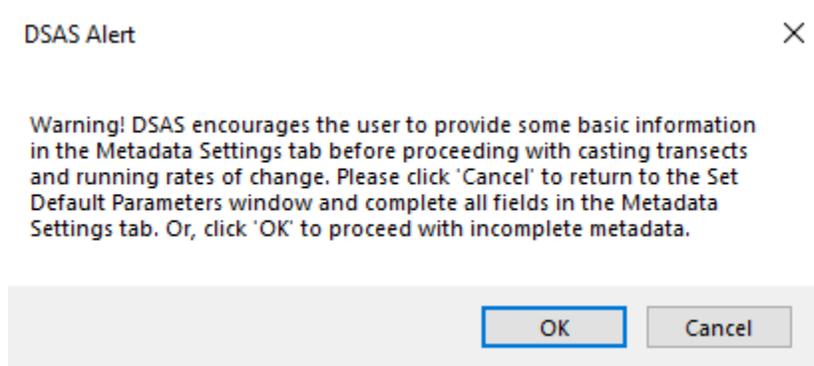


Figure 14. Error message is the metadata settings are not completely filled in.

4. In the Cast transects window that appears (Figure 15), change the search distance as desired depending on where the baseline is. The transect spacing can be adjusted depending on how close together the transects should be for clarity. The smoothing distance affects how long the transects are when created. This means that for a longer value, the transects may be longer, but this can cause intersection on curves on the shorelines, which is undesirable. This value should be adjusted to give the best fit of the shoreline with a preference to smaller values if possible. Once the values are entered, ensure that the geodatabase created earlier is selected, enter a name for the transect, and press ok. This will take several minutes to create all the transects. The output should be a feature class that is automatically put into the Table of Contents. Adjust the color of the transects as necessary to improve visibility (Figure 16).

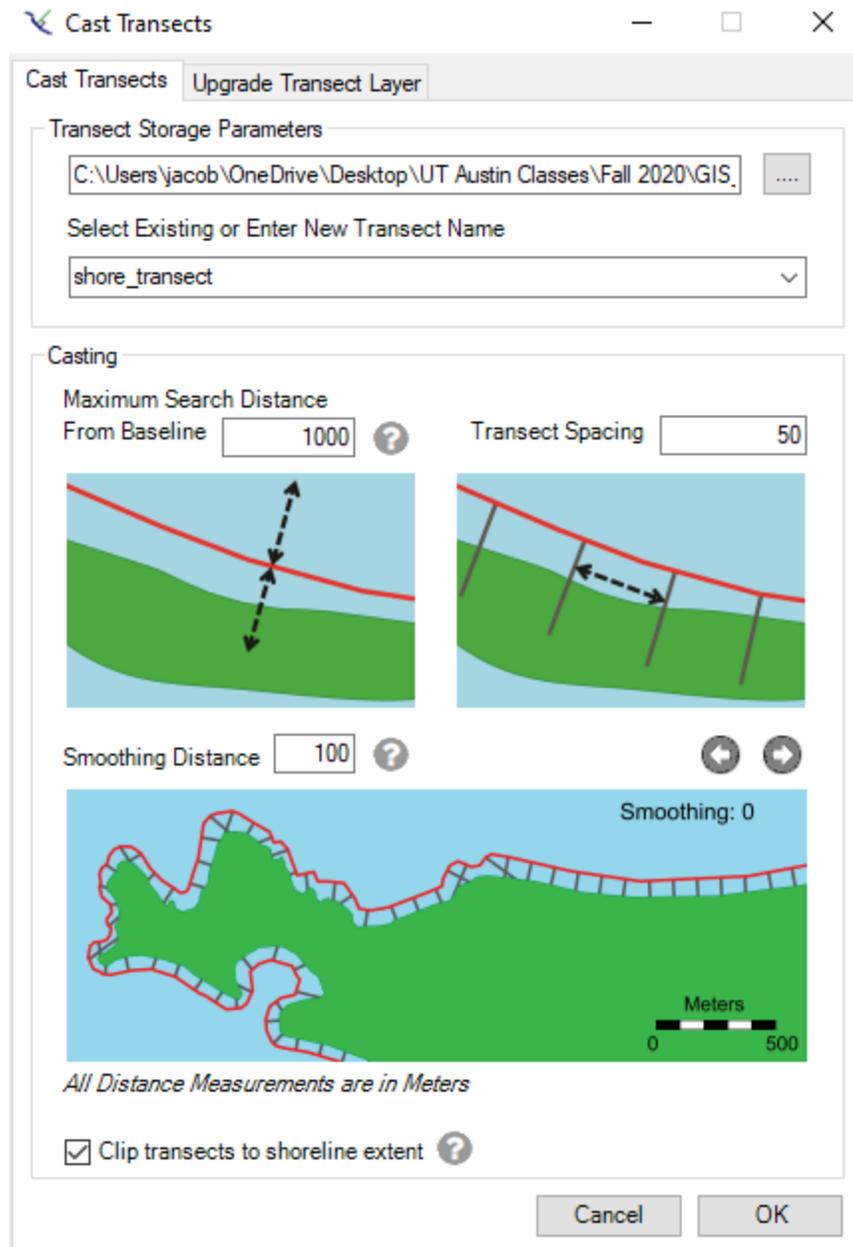


Figure 15. Cast transects window. The name of the new feature class to be created, the search distance, transect spacing, and smoothing distance are specified here.

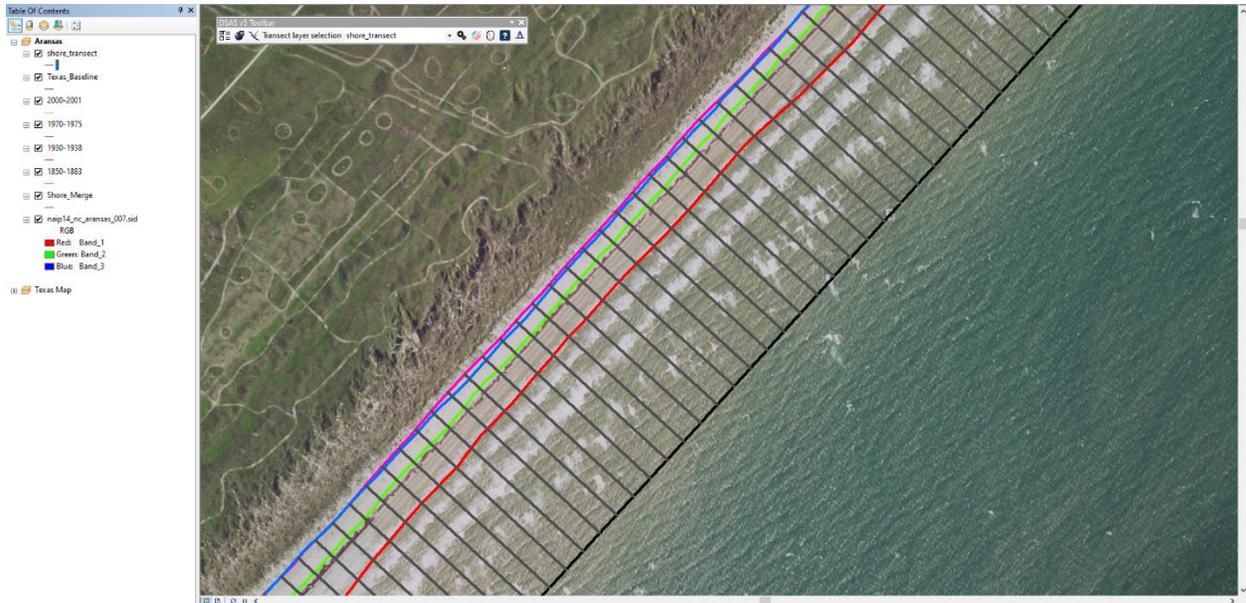


Figure 16. Cast transects function has been run for the data and transects have been symbolized appropriately for visibility against the coastline.

- From the DSAS v5 Toolbar, select the transect feature class that was created from the drop down menu, then press the “Calculate Rates” button (Figure 17). Select the tests that you want to test from the options given (Figure 18). The intersection threshold can be set so that transects that do not meet a minimum number of lines transected are not included in the calculations. The confidence interval can be changed in the confidence interval section. Specify a location for the summary report and click ok. This will take several minutes to calculate data if the dataset is large, like it is in this example. This creates a feature class that yields points where the transects intersect the shoreline data as well as a feature class that shows the rates as a line (Figure 19). Symbolize appropriately and ensure that data can be viewed easily from further away.

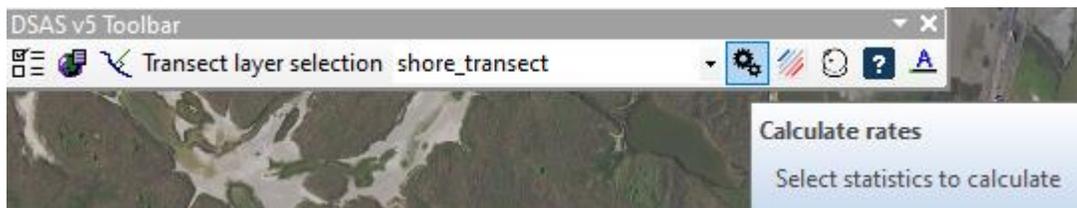


Figure 17. Calculate rates button on the DSAS v5 Toolbar.

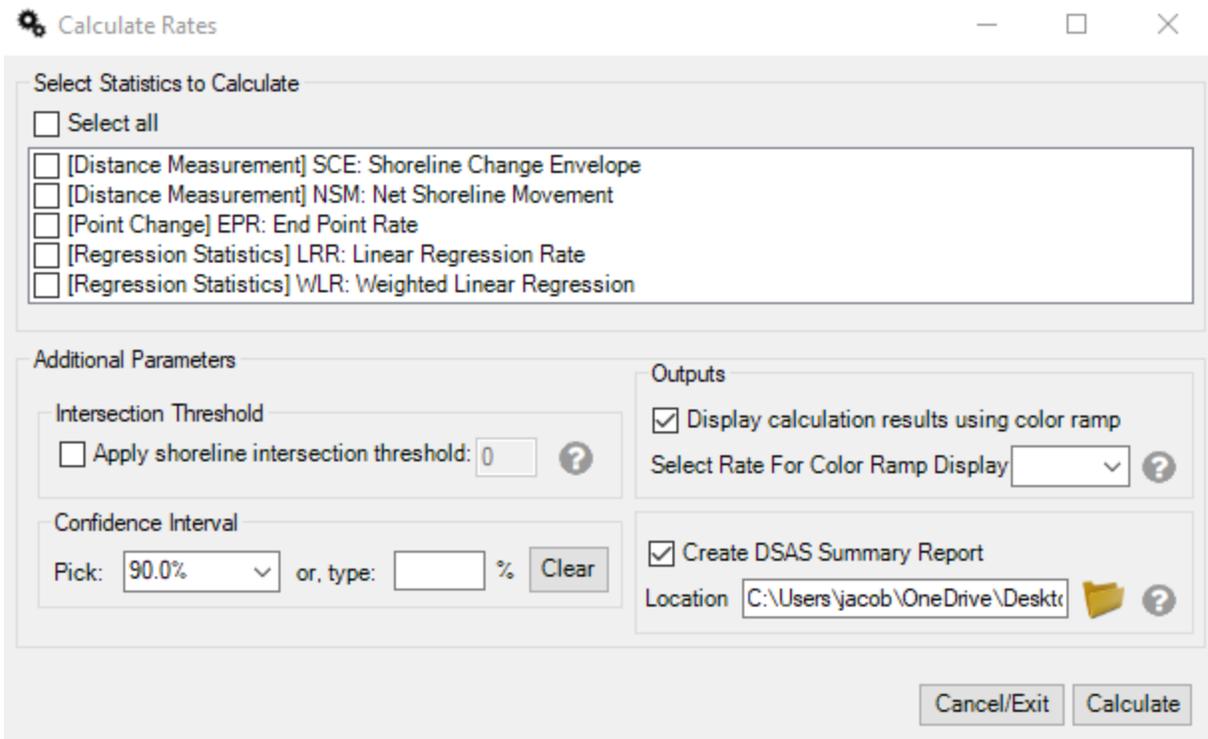


Figure 18. Calculate Rates window from the DSAS v5 Toolbar. The tests that are desired can be selected from the top menu. The intersection threshold, confidence interval, color ramp used, and the location for the summary report can be specified below the test selection.

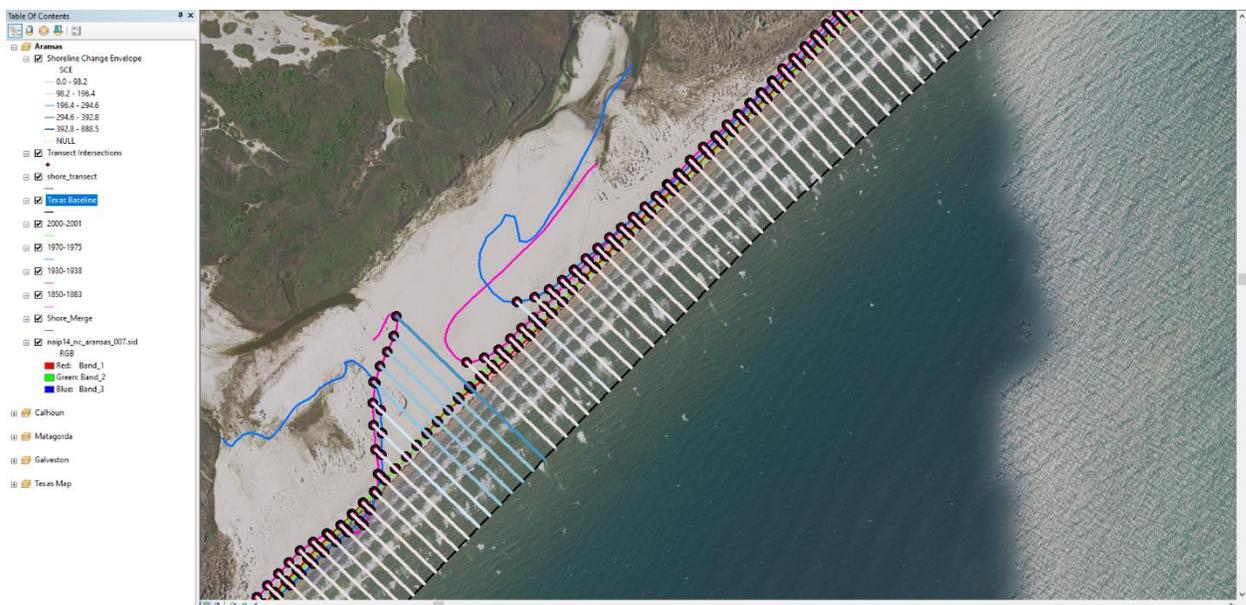


Figure 19. The intersection points and shore change envelope have been created in the Table of Contents and are visualized on the map.

6. The Summary Report (Appendix 2) that is created has data regarding the Net Shoreline Movement, the Shoreline Change Envelope, End Point Rate, a Linear Regression Rate, and a

Weighted Regression Weight. The net shoreline movement is the distance between the first and latest shoreline data points for each transect. The shoreline change envelope is the change in distance between the oldest and the latest shoreline data, rather than the rate of change. The end point rate is calculated by taking the distance between the oldest and more recent shoreline and dividing it by the time difference between the two. The linear regressions done are using least squares methods, with the weighted linear regression being more accurate because it is putting more focus on the best fit line.

Conclusion:

The Texas coastlines have been receding by approximately 0.8m/year from 1850 to 2000 according to the summary report generated by the DSAS tool. Approximately 38.61%, or 135 miles, of all the transects that were created showcased statistically significant erosion, while only 6.56% showed statistically significant accretion with a weighted linear regression. The greatest change between 1850 and 2000 was 888.47 meters of erosion. The maximum accretion at one site was 685.83 meters. The average new shoreline movement was -103.24 meters, meaning the average shoreline in Texas has decreased by 103.24 meters in the last 150 years.

This 103.24 meter recession of the coastline means that the historical vegetation profiles of the shorelines may have been drastically different than what they currently are (Appendix 1). Vegetation that is unable to grow underwater has lost habitat due to receding coastlines and rising sea levels. Given the rate of change, the coastlines will recede another 8 meters on average in the next 10 years which means that developments directly on coastlines and protected habitats will be in danger. The 6.56% of areas that showed accretion are safe for development, but that is only 23 miles out of the 351 miles of coastline. The 135 miles that show significant recession will not be safe to be developed and any developments already in those locations will likely face challenges going forward. There is approximately 22.5 square miles of land lost due to recession since 1850 on the Texas coastlines, and that will increase as sea levels continue to rise. Recession also poses problems for barrier islands that are integral for storm protection along the coastlines as they will be slowly eroded until there is nothing left. Slowing down the recession of the Texas coastlines is going to be important for the safety of the developments and habitats located directly on the coast.

References:

Henderson, Rachel. *Digital Shoreline Analysis System (DSAS)*, 2020, www.usgs.gov/centers/whcms/science/digital-shoreline-analysis-system-dsas?qt-science_center_objects=0.

Miller, Tara L, et al. "The National Assessment of Shoreline Change: A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the U.S. Gulf of Mexico." *GIS Data Layers - The National Assessment of Shoreline Change: A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the U.S. Gulf of Mexico - USGS Open File Report 2004-1089*, USGS, 2004, pubs.usgs.gov/of/2004/1089/gis-data.html.

Paine, J. G., Caudle, T. L., & Andrews, J. (2014). Shoreline movement along the Texas Gulf Coast, 1930's to 2012. *Austin, Texas: The University of Texas at Austin, Bureau of Economic Geology Final Report prepared for General Land Office Under Contract, 09-074.*

Pickens, B. A., & King, S. L. (2014). Multiscale habitat selection of wetland birds in the northern Gulf Coast. *Estuaries and Coasts, 37*(5), 1301-1311.

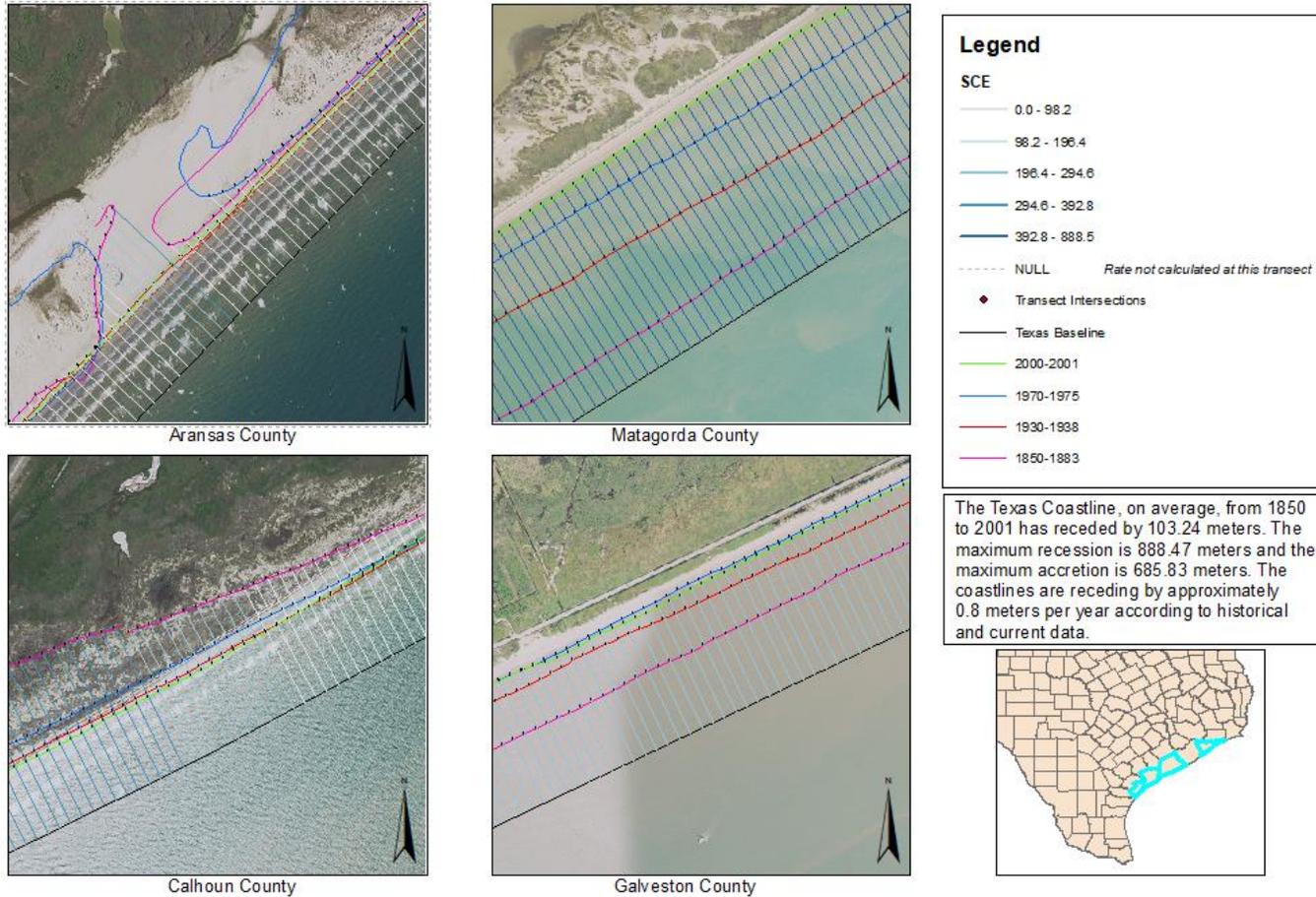
Seney, E. E., & Landry Jr, A. M. (2008). Movements of Kemp's ridley sea turtles nesting on the upper Texas coast: implications for management. *Endangered Species Research, 4*(1-2), 73-84.

United States Department of Agriculture (USDA). Texas NAIP Imagery, 2014-10-31. Web. 2020-12-07.

Appendix:

Jacob Taylor
11/17/2020

Coastline Changes in Texas Counties from 1880 to 2000



Projection system is NAD83, UTM Zone 14N

Appendix 1. Final map depicting transects and shoreline data for Aransas County, Calhoun County, Galveston County, and Matagorda County. Shoreline data is from 1850 to 2001.

Appendix 2. Full Summary Report generated by the DSAS v5 Tool.

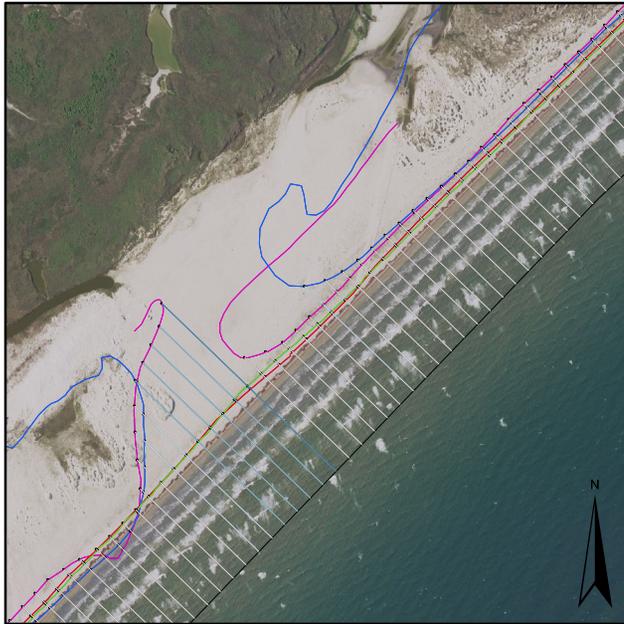
Timestamp of rate calculation: 12/01/2020 22:47:33 DSAS version: 5.0.20200527.0200 ArcGIS version: 10.6 Rate types run: SCE, NSM, EPR, LRR, WLR Baseline layer: Texas_Baseline Shoreline layer: Shore_Merge Shoreline dates used: 1/1/1850, 1/1/1851, 1/1/1852, 1/1/1853, 1/1/1854, 1/1/1855, 1/1/1856, 1/1/1857, 1/1/1859, 1/1/1860, 1/1/1866, 1/1/1867, 1/1/1879, 1/1/1881, 1/1/1882, 1/1/1883, 1/1/1930, 1/1/1931, 1/1/1934, 1/1/1937, 1/1/1938, 1/1/1970, 1/1/1973, 1/1/1974, 1/1/1975, 1/1/2000, 1/1/2001 Shoreline threshold: 0 Confidence Interval (CI) selected: 90 Default Uncertainty: 10 Transect spacing length: 50 Smoothing distance: 100 Coordinate system: NAD_1983_UTM_Zone_14N Is bias applied: NO All rates reported are in meters/year, distance values are in meters. DISTANCE: SCE (Shoreline Change Envelope, m)	
SCE OVERALL AVERAGES:	
total number of transects: 10999	
average distance: 205.41	
maximum distance: 888.47	
maximum distance transect ID: 6931	
minimum distance: 3.24	
minimum distance transect ID: 8187	
DISTANCE: NSM (Net Shoreline Movement, m)	
NSM OVERALL AVERAGES:	
total number of transects:	10999
average distance:	-103.24
number of transects with negative distance:	7156
percent of all transects that have a negative distance:	65.06%

maximum negative distance:	-888.47
maximum negative distance transect ID:	6931
average of all negative distances:	-221.94
number of transects with positive distance:	3843
percent of all transects that have a positive distance:	34.94%
maximum positive distance:	685.83
maximum positive distance transect ID:	2525
average of all positive distances:	117.78
RATE: EPR (End Point Rate, m/yr)	
EPR OVERALL AVERAGES:	
total number of transects:	10999
average rate:	-0.79
average of the confidence intervals associated with rates:	0.11
reduced n (number of independent transects):	44
uncertainty of the average rate using reduced n:	0.02
average rate with reduced n uncertainty:	-0.79 +/- 0.02
number of erosional transects:	7156
percent of all transects that are erosional:	65.06%
percent of all transects that have statistically significant erosion:	60.68%
maximum value erosion:	-14.24
maximum value erosion transect ID:	6870
average of all erosional rates:	-1.77
number of accretional transects:	3843
percent of all transects that are accretional:	34.94%
percent of all transects that have statistically significant accretion:	32.31%
maximum value accretion:	20.41
maximum value accretion transect ID:	6606
average of all accretional rates: 1.02	1.02

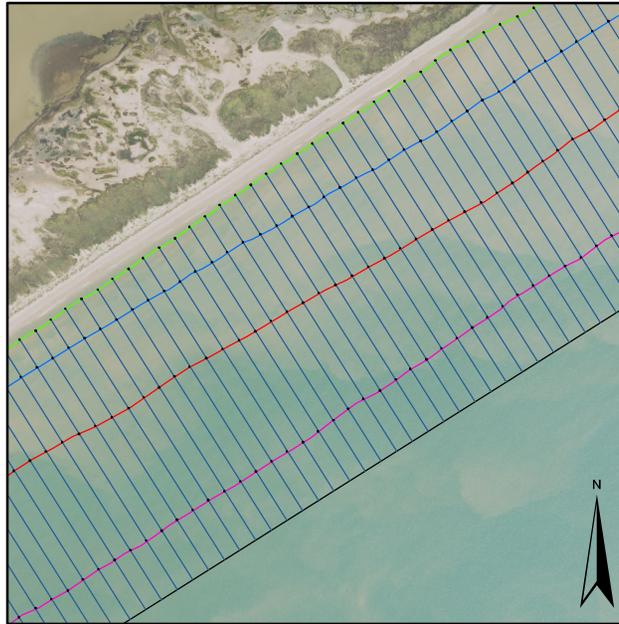
RATE: LRR (Linear Regression Rate, m/yr)	
LRR OVERALL AVERAGES:	
total number of transects:	10756
average rate:	-0.82
average of the confidence intervals associated with rates:	1.4
reduced n (number of independent transects):	79
uncertainty of the average rate using reduced n:	0.16
average rate with reduced n uncertainty:	-0.82 +/- 0.16
number of erosional transects:	7120
percent of all transects that are erosional:	66.2%
percent of all transects that have statistically significant erosion:	38.61%
maximum value erosion:	-7.82
maximum value erosion transect ID:	10285
average of all erosional rates:	-1.68
number of accretional transects:	3636
percent of all transects that are accretional:	33.8%
percent of all transects that have statistically significant accretion:	6.56%
maximum value accretion:	9.02
maximum value accretion transect ID:	11110
average of all accretional rates:	0.88
RATE: WLR (Weighted Linear Regression, m/yr)	
WLR OVERALL AVERAGES:	
total number of transects:	10756
average rate:	-0.82
average of the confidence intervals associated with rates:	1.4
reduced n (number of independent transects):	79
uncertainty of the average rate using reduced n:	0.16
average rate with reduced n uncertainty:	-0.82 +/- 0.16

number of erosional transects:	7120
percent of all transects that are erosional:	66.2%
percent of all transects that have statistically significant erosion:	38.61%
maximum value erosion:	-7.82
maximum value erosion transect ID:	10285
average of all erosional rates:	-1.68
number of accretional transects:	3636
percent of all transects that are accretional:	33.8%
percent of all transects that have statistically significant accretion:	6.56%
maximum value accretion:	9.02
maximum value accretion transect ID:	11110
average of all accretional rates:	0.88

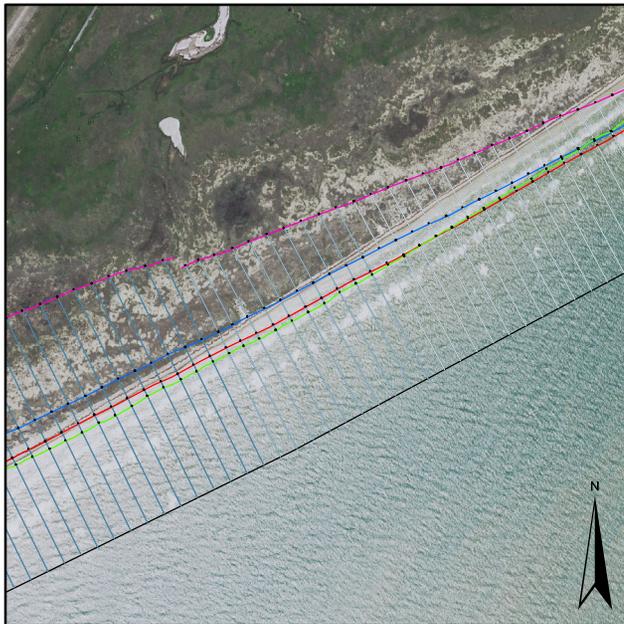
Coastline Changes in Texas Counties from 1880 to 2000



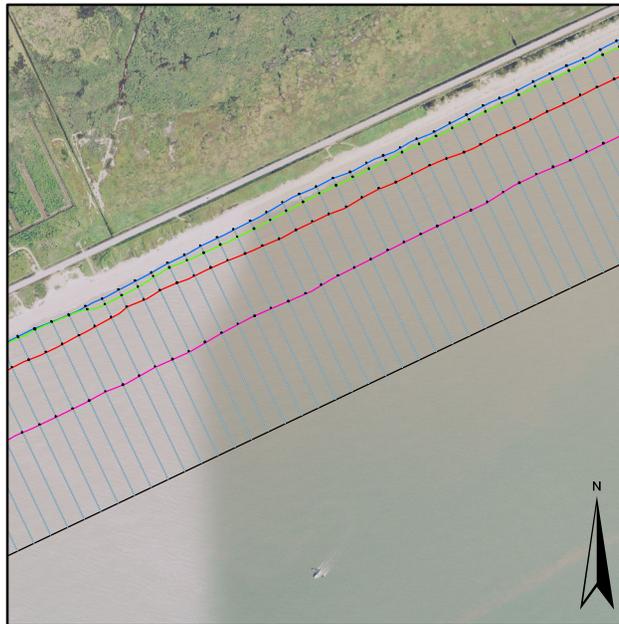
Aransas County



Matagorda County



Calhoun County



Galveston County

Legend

SCE

- 0.0 - 98.2
- 98.2 - 196.4
- 196.4 - 294.6
- 294.6 - 392.8
- 392.8 - 888.5
- NULL *Rate not calculated at this transect*
- Transect Intersections
- Texas Baseline
- 2000-2001
- 1970-1975
- 1930-1938
- 1850-1883

The Texas Coastline, on average, from 1850 to 2001 has receded by 103.24 meters. The maximum recession is 888.47 meters and the maximum accretion is 685.83 meters. The coastlines are receding by approximately 0.8 meters per year according to historical and current data.

