The University of Texas at Austin

Icebox Model Projections for Sea Level Fall in the Gulf Coast and Caribbean Sea Region

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Introduction

Many climate scientists model a Greenhouse Effect that projects an oceanic volume increase and rise in mean sea level (MSL) related to the rise in Earth's global temperature average. While this study does acknowledge the validity of the Earth Greenhouse Effect model and projections, I intend posit a reverse hypothetical "Icebox" Effect model and explore the effect of global cooling on sea level fall.

Imagine this scenario: a catastrophic volcanic eruption ejects enough ash into the atmosphere to block out sunlight causing Earth's average temperature to cool by 6° C. Lowering the Earth's global temperature average by 6° C would produce similar conditions experienced during the last glacial maximum 20,000 years ago, called the late Wisconsin Glaciation. During this time period the MSL was about 400 feet (120 meters) lower than current MSL (www.iceagenow.com).

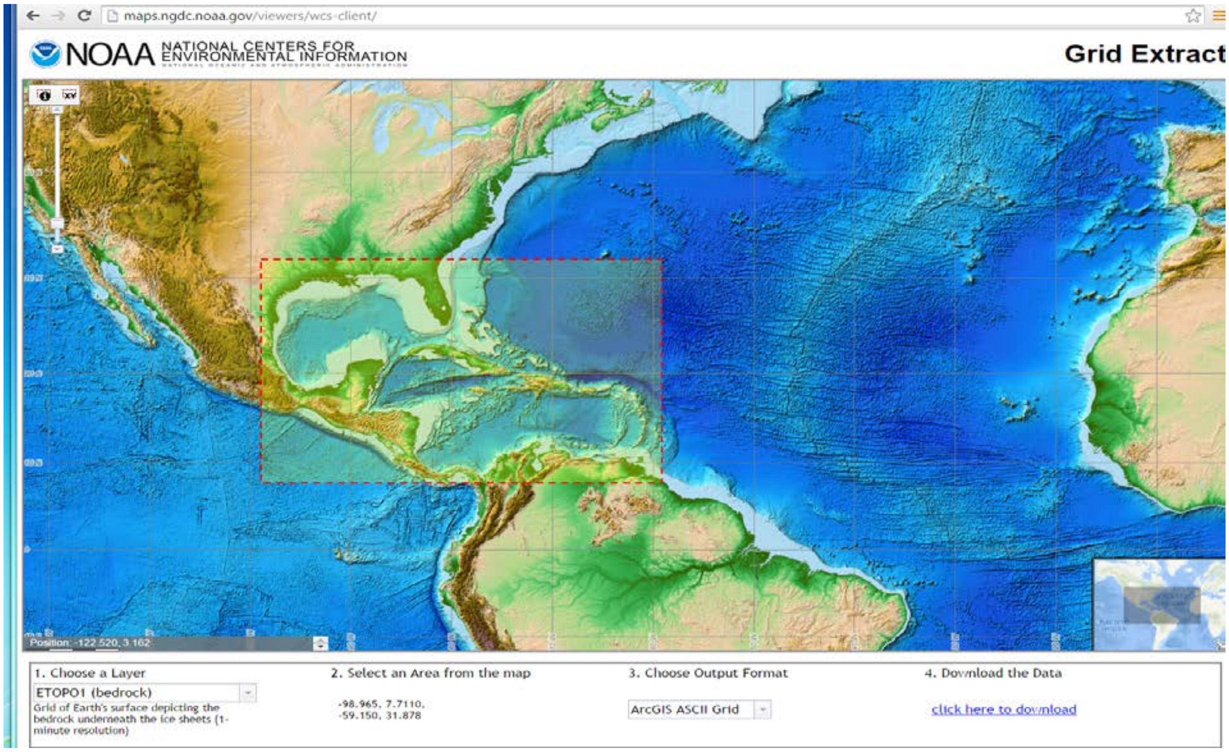
The purpose of this study is to analyze how this Icebox model effects the coastlines of Gulf of Mexico and the Caribbean Sea. What will the coastline look like? Will the coastline increase or decrease? How much newly exposed land will become available? To answer these question, this study is aimed at measuring the lengths of the new coastlines and new areas exposed by a 120 meter fall in sea level.

Data Sources

The first step was gathering the data necessary for this sea level fall analysis from online sources.

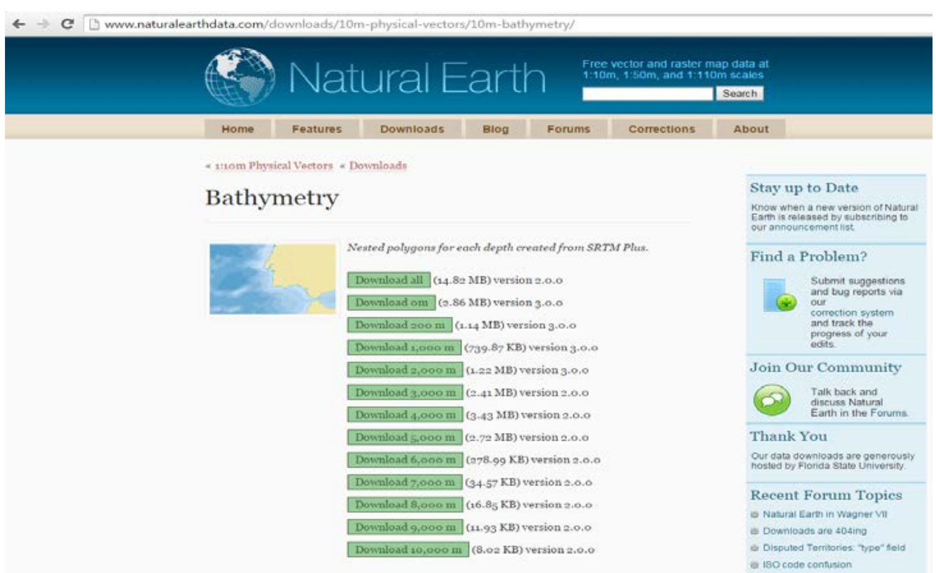
DEM Data Source: DEM was downloaded using NOAA's DEM Grid Extract Module. This interactive data window allows the user to select an area for a specific layer (e.g. ETOPO1 (bedrock)), select an output format (e.g. ArcGIS ASCII Grid), and download the dataset. The resolution of this data is 1km x 1km cells. Despite being such a low resolution, this scale is appropriate for the area of interest.

NOAA Source: www.ngdc.noaa.gov/mgg/global/global.html



Bathymetry Data Source: Bathymetry shapefiles were downloaded from the Natural Earth website. These included nested polygons at 0, -200, -1000, up to -10000 meters that were created from SRTM Plus. Only the 0-meter polygon was used to create a current shore line.

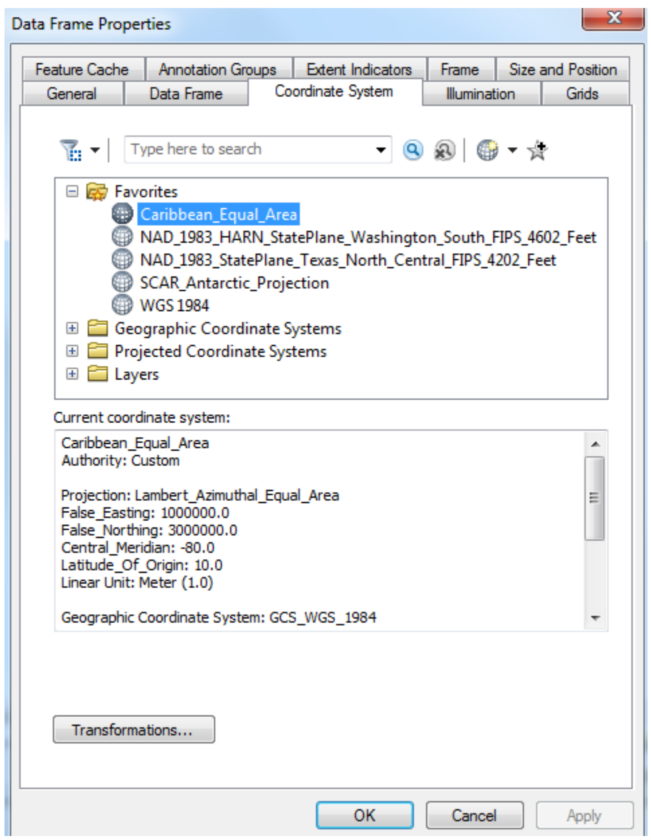
Natural Earth Source: www.naturalearthdata.com/downloads/10m-physical-vectors/10m-bathymetry/



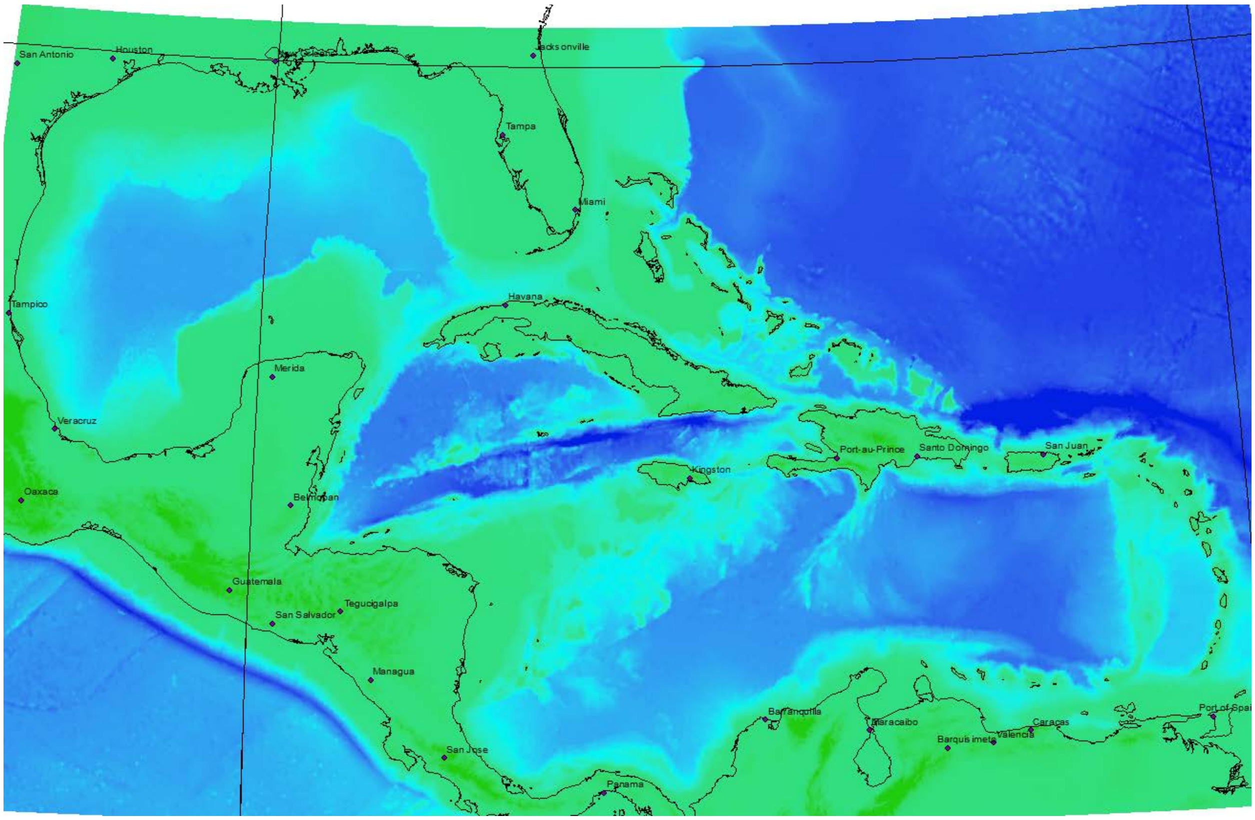
City Point Source: a city shapefile was provided by my anthropology GIS instructor to show the major cities in the study area.

Data Analysis

Defining Spatial References: The second step was to define the spatial reference frames for the DEM raster and Bathymetry shapefiles. This involved creating a new customized coordinate system for the large region of interest: Caribbean_Equal_Area. This custom coordinate system minimizes distortion of the Caribbean Sea and the Gulf of Mexico by projecting Lambert Azimuthal Equal Area to WGS 1984 geographic coordinate system. The units were set to meters, false easting to 10,000,000, the false northing to 30,000,000, and the latitude of origin to 10° with a central meridian of -80°.



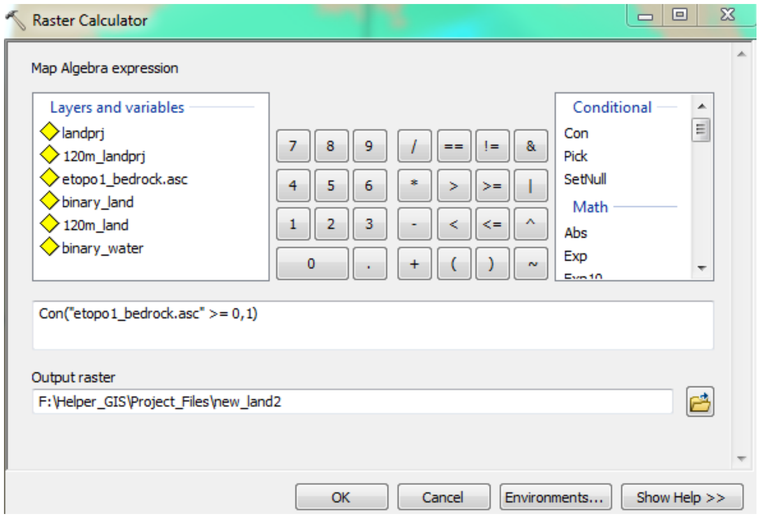
The map begins to take shape and now all the loaded files are visible:



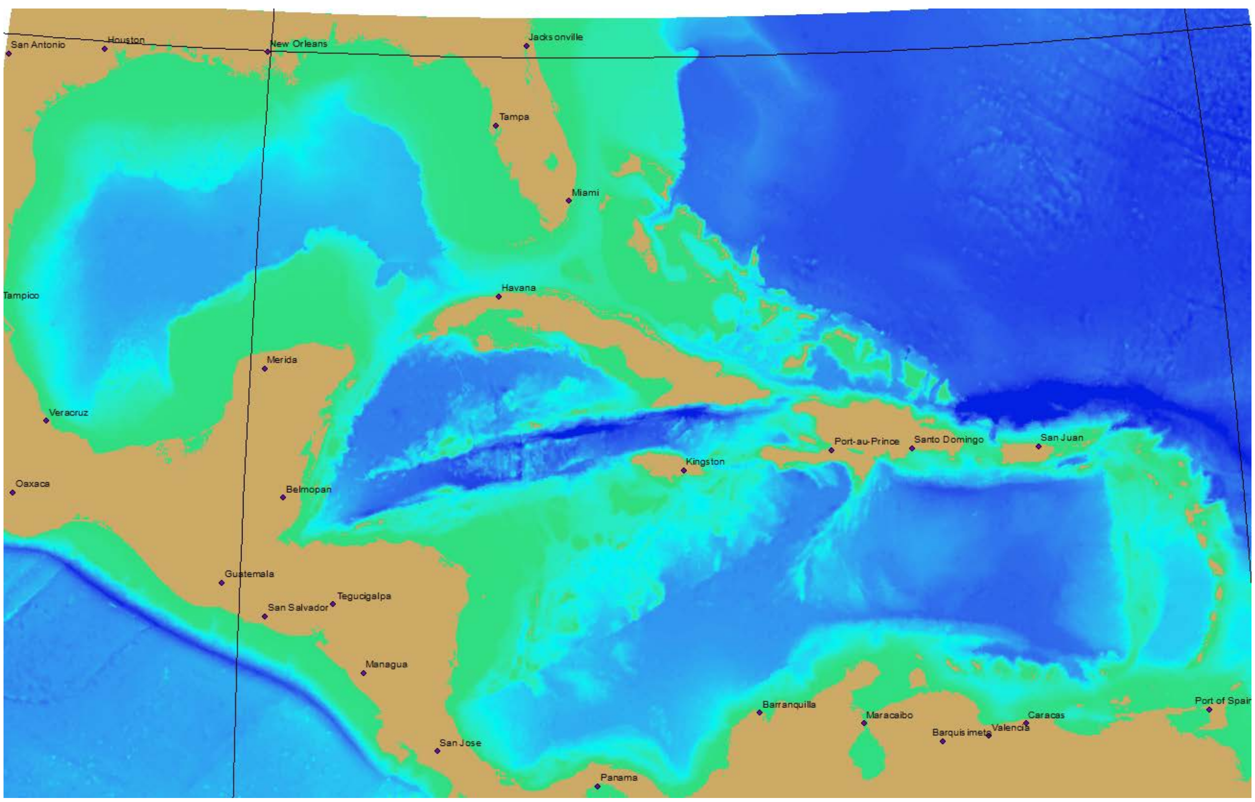
A blue-to-green color ramp was selected to display the Bedrock DEM raster and a thin black line was selected for the 0m bathymetry contour.

Defining Land: 0m-Land & -120m-Land

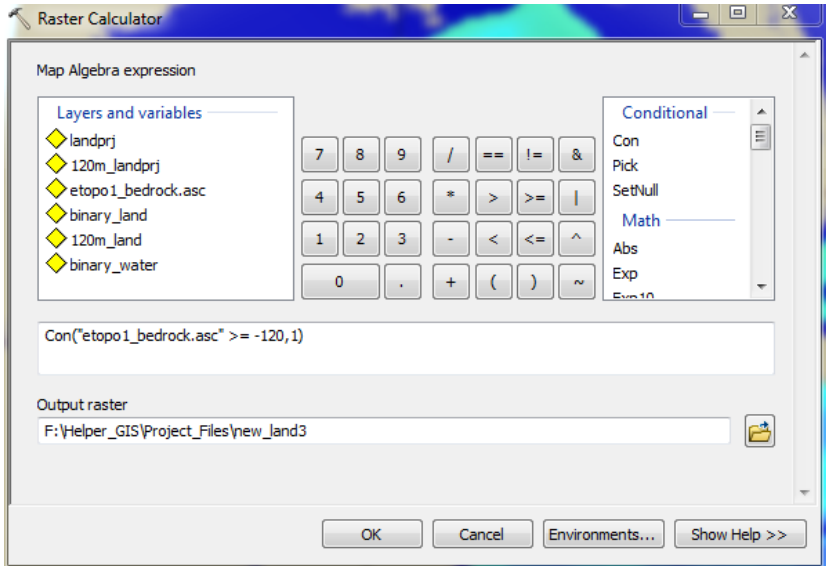
Once all the spatial references were defined, the third step was to define the land for current sea level. To do this, a binary raster was created. The Raster Calculator under Spatial Analyst toolbar was used with the Map Algebra expression Con("etopo_bedrock.asc" >=0,1). This makes all the values greater than zero equal to "no data." These "no data" cell were then colored brown.



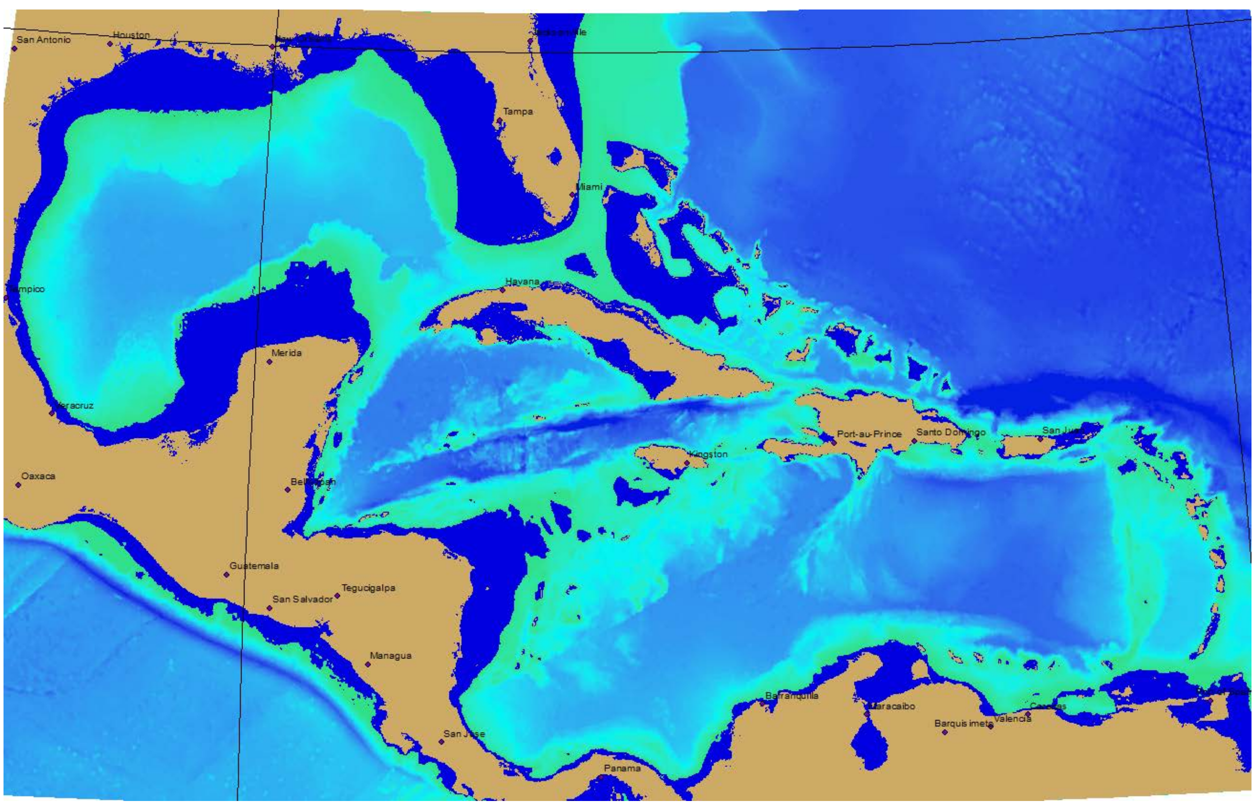
The new raster was then applied to the map:



Next, this process was repeated for the land at -120m, again using the Spatial Analyst Raster Calculator. This time the Map Algebra expression was: Con("etopo_bedrock.asc" >= - 120,1). This makes all the values greater than -120 equal to "no data" and those cells were colored blue.

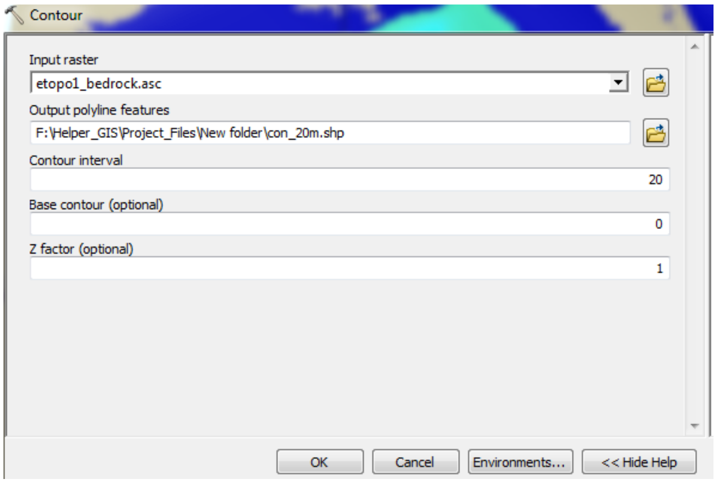


By placing the -120m-Land raster below the 0m-Land raster in the Table of Contents, the map revealed the amount of land gained by a 120 meter drop in sea level.

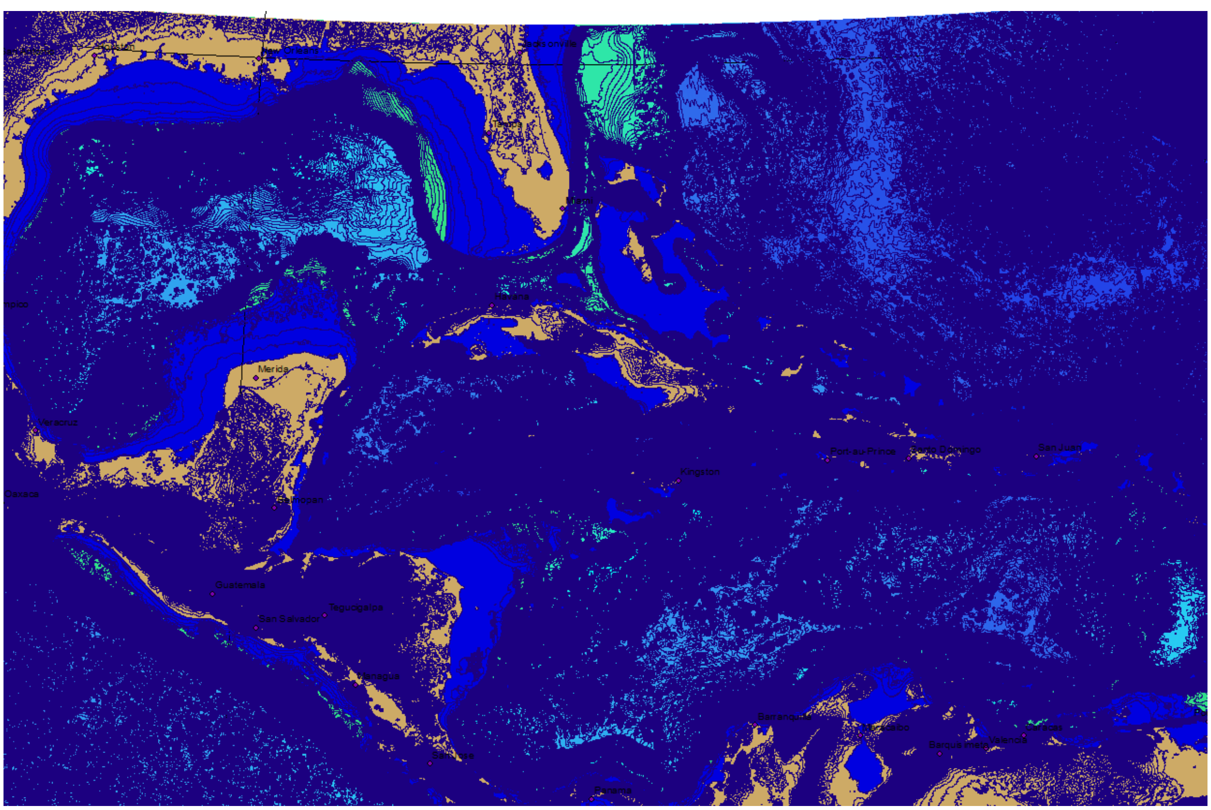


Defining Coastlines: 0m-Coastline & -120m-Coastline

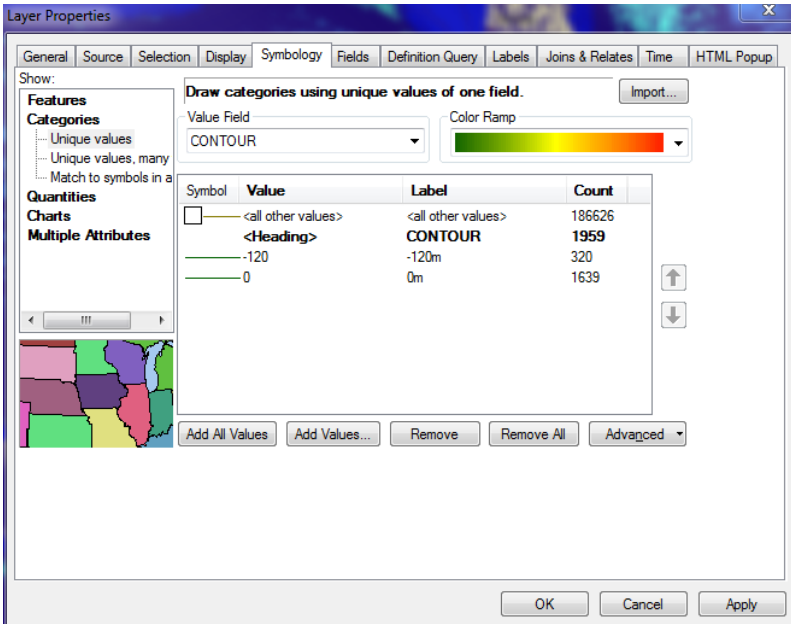
Next, a 0-line contour was created to be used to calculate the current length of the shoreline for the Gulf of Mexico and the Caribbean Sea. Using Spatial Analyst's Contour Tool, I created 20m contours.



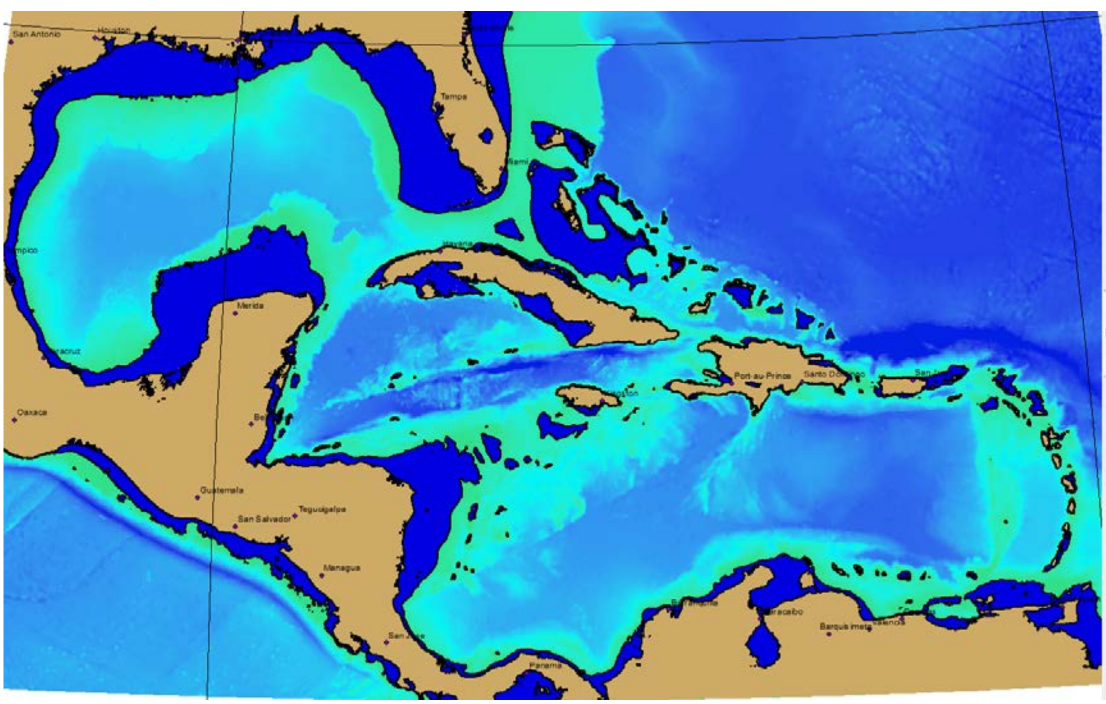
Once these contour were created, ArcMap automatically loaded it to my map. This created a cluttered mess. The only contours of interested are the 0m and -120m.



To clean up this contour mess, under Properties → Symbology →Unique Values, Contour was selected under Value Field, <all other values> was deselect, and then -120m and 0m contour lines were added.

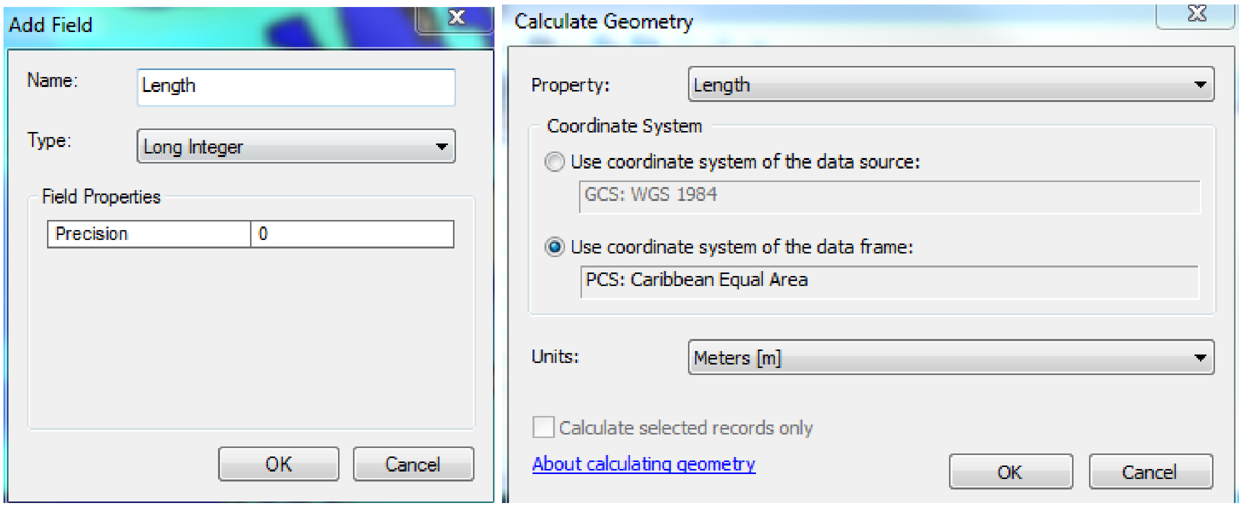


Now the map only displays the -120m and 0m contour lines. To make them more visible, the 0m-contour was colored black with an increased line width of 1.15 and -120m-contour was colored yellow.

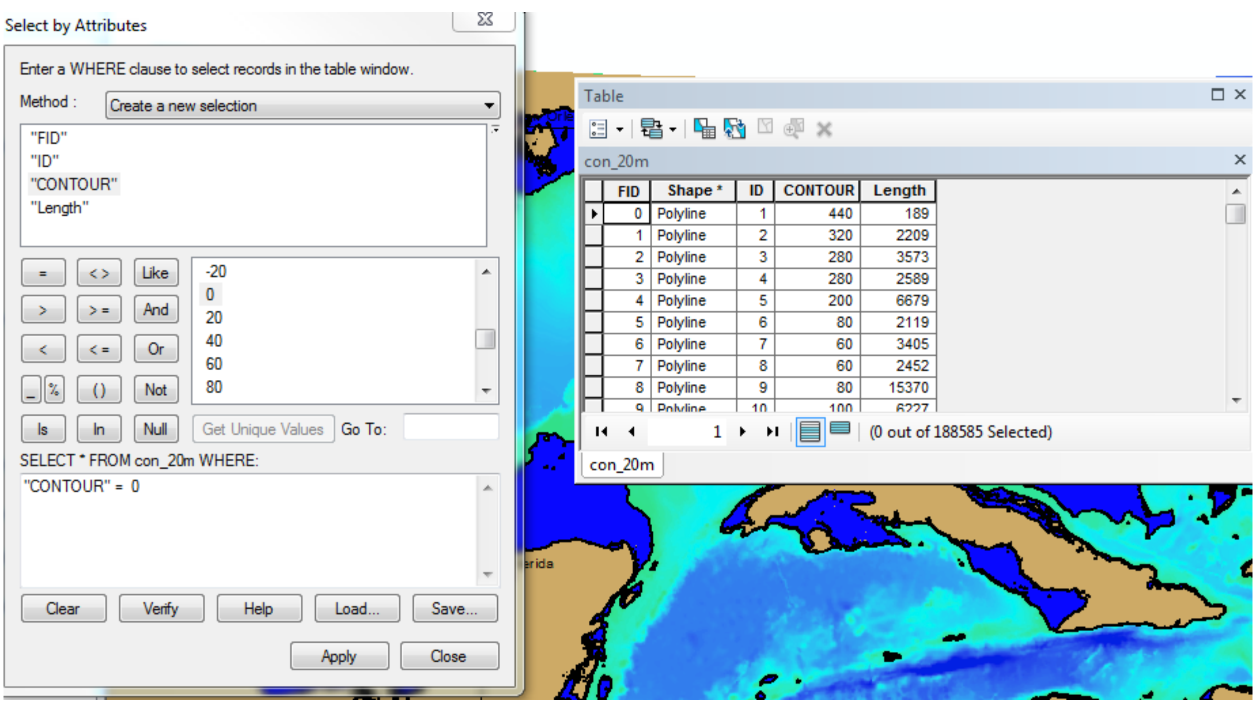


Calculating Coastline Lengths

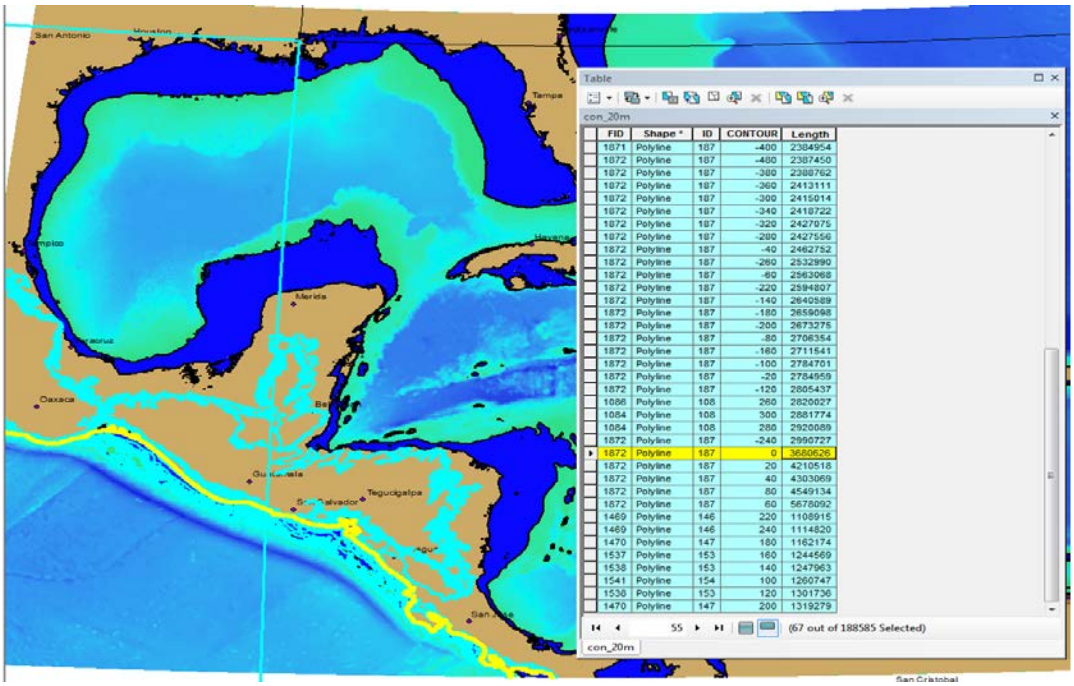
With this new shapefile, the shoreline lengths were calculated. First, the length of the current shoreline was calculated adding a Length field to my attribute table. Under this new field, the Calculate Geometry tool was used to measure length in meters.



Once the Length field was calculated the Select by Attributes tool was used to select only the 0m contour line lengths.



Since the Pacific coast of Mexico and Central America was also capture in the map extent, these lengths need to be excluded from the calculation. The Select Features tool was used to select contour lines and looked up the values to be subtracted from the coastline calculation for the Gulf of Mexico and the Caribbean (3680626m, 600325m).



FID	Shape *	ID	CONTOUR	Length
1871	Polyline	187	-400	2384954
1872	Polyline	187	-480	2387450
1872	Polyline	187	-380	2388762
1872	Polyline	187	-360	2413111
1872	Polyline	187	-300	2415014
1872	Polyline	187	-340	2418722
1872	Polyline	187	-320	2427075
1872	Polyline	187	-280	2427556
1872	Polyline	187	-40	2462752
1872	Polyline	187	-260	2532990
1872	Polyline	187	-60	2563068
1872	Polyline	187	-220	2594807
1872	Polyline	187	-140	2640589
1872	Polyline	187	-180	2659098
1872	Polyline	187	-200	2673275
1872	Polyline	187	-80	2706354
1872	Polyline	187	-160	2711541
1872	Polyline	187	-100	2784701
1872	Polyline	187	-20	2784959
1872	Polyline	187	-120	2805437
1088	Polyline	108	260	2820027
1084	Polyline	108	300	2881774
1084	Polyline	108	280	2920089
1872	Polyline	187	-240	2990727
1872	Polyline	187	0	3680626
1872	Polyline	187	20	4210518
1872	Polyline	187	40	4303069
1872	Polyline	187	80	4549134
1872	Polyline	187	60	5678092
1469	Polyline	146	220	1108915
1469	Polyline	146	240	1114820
1470	Polyline	147	180	1162174
1537	Polyline	153	160	1244569
1538	Polyline	153	140	1247963
1541	Polyline	154	100	1260747
1538	Polyline	153	120	1301736
1470	Polyline	147	200	1319279

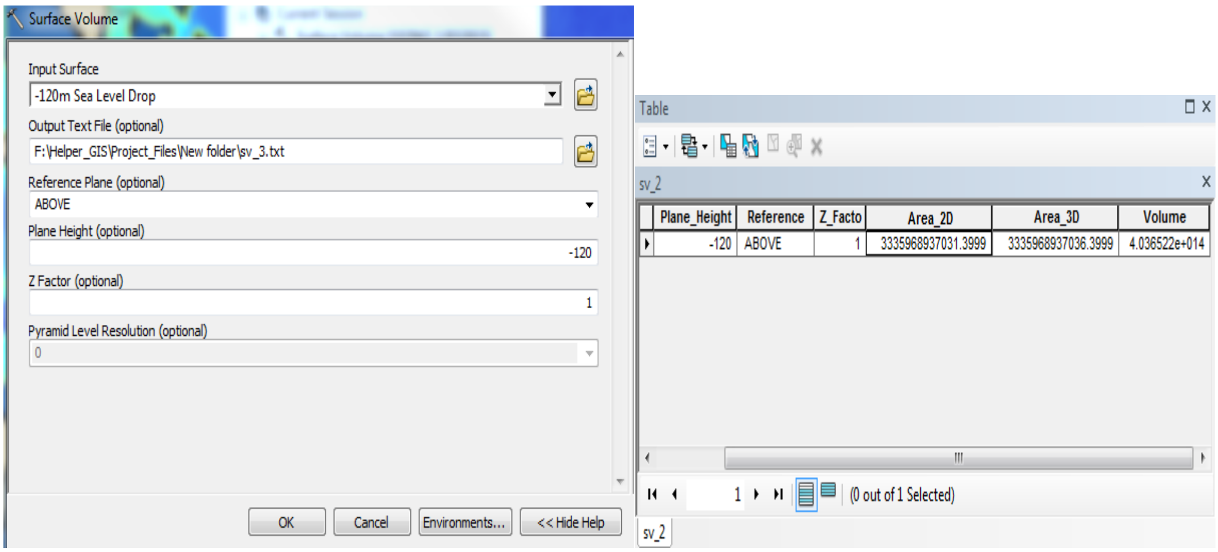
With these shore lengths recorded, the selected attribute table 0m-contour was exported as a.dbf file to excel. The lengths were summed (62118052 m) and then Pacific coastline lengths were subtracted to get the current coastline to be 57,837.101 km. This includes the 28 island and continental countries that share the Gulf Coast and the Caribbean Sea.

Next, this process was repeated for the -120m contour lines, again excluding the Pacific coast. Summed the lengths (39869931 m) and then subtracted the Pacific coastline lengths (2805437 m) to get the -120m-coastline of 37,064.494 km as the result of sea level fall.

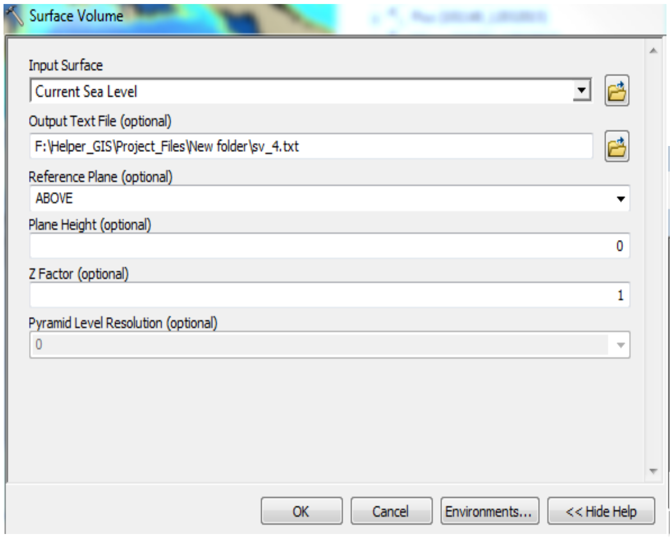
Calculating Area of Newly Exposed Land

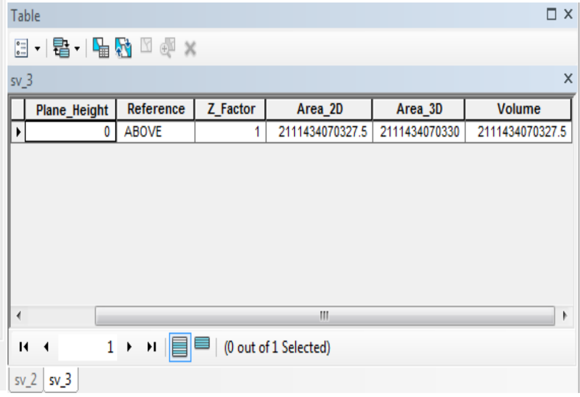
The final part of this project is to calculate the area gained by a 120 m drop in sea level. This calculation takes into account the land gained for the Gulf of Mexico, the Caribbean Sea, and the portion of the Pacific Coast of Central America featured in the map extent.

The Surface Volume, 3D Analyst tool was used to make this calculation. The Input Surface was -120m Sea Level Drop binary raster, the Reference Plane was ABOVE a Plane Height of -120. This calculated the area at -120m and the total volume above -120m as displayed in the table below. Resulting in an area of 3,335,968.973 km^2.



The next step in calculating the area gained was to repeat the Surface Volume calculation for Current Sea Level which would then be subtracted from the -120m Sea Level Drop. The Input Surface was Current Sea Level binary raster, the Reference Plane was set to ABOVE a Plane Height of 0. This calculated the area at 0m and the total volume above 0m as displayed in the table below. Resulting in an area of 211,434.070 km^2.

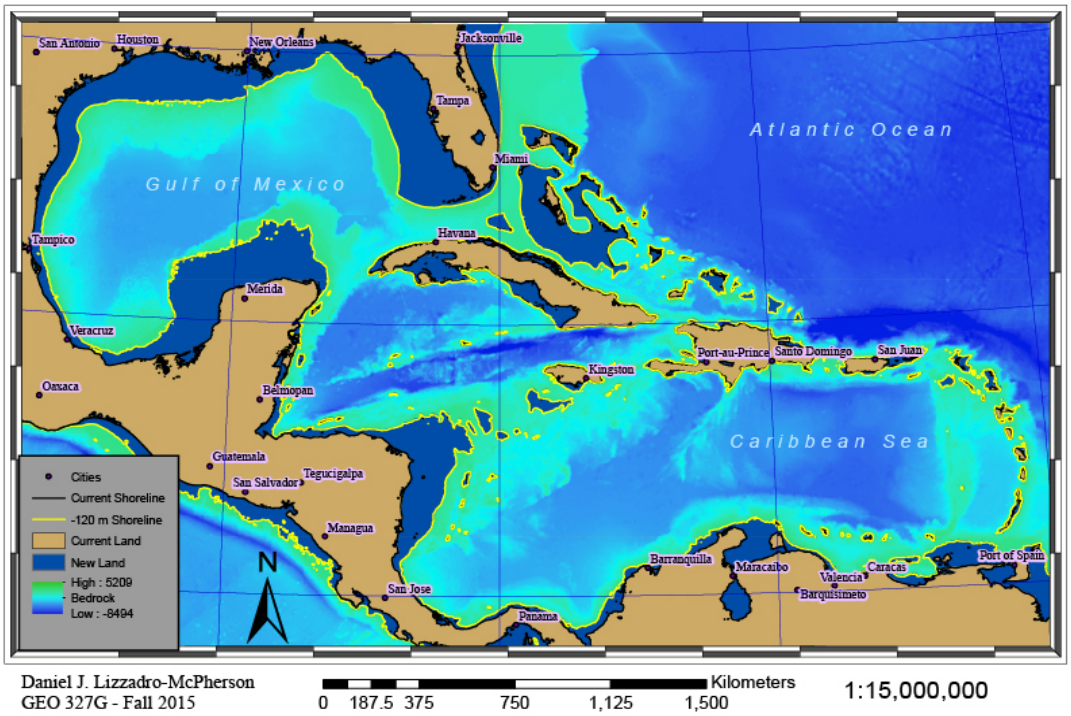




Results

The results for a MSL drop of 120 meters for the Gulf of Mexico and the Caribbean Sea are displayed in the map and table featured below (a larger page-size map is attached). The area of land gained does include the Central American Pacific coastline that is in the map extent combined with the Gulf of Mexico and Caribbean land gains.

Projected Sea Level Fall of 120m for Gulf of Mexico and Caribbean Sea



Sea Level (m)	**Coastline (km)**	**Area (km^2)**
0	57,837.101	211,434.070*
-120	37,064.494	3,335,968.937*
Net Grain (+) / Net Loss (-)	- 20,772.607	+ 3,124,534.903*

*Area of New Land Exposure in Gulf of Mexico, Caribbean, and Central America Pacific Coast

With a 120m drop in MSL, the coastline will shrink by ~36% in the Gulf of Mexico and the Caribbean Sea with a net loss of ~20,800 km. However at the local scale, all the island coastlines will increase, creating new larger beaches. In the Bahama's specifically, the carbonate platform will be exposed which would create very large islands out of the small island chains.

With a 120m drop in MSL, will increase substantially from ~211,400 km^2 to ~ 3, 125,000 km^2. The caveat here is that this statistic applies only to the map extent displayed above and it includes the land gains on the Pacific coast of Central America combined with land gains in the Gulf of Mexico and Caribbean Sea.

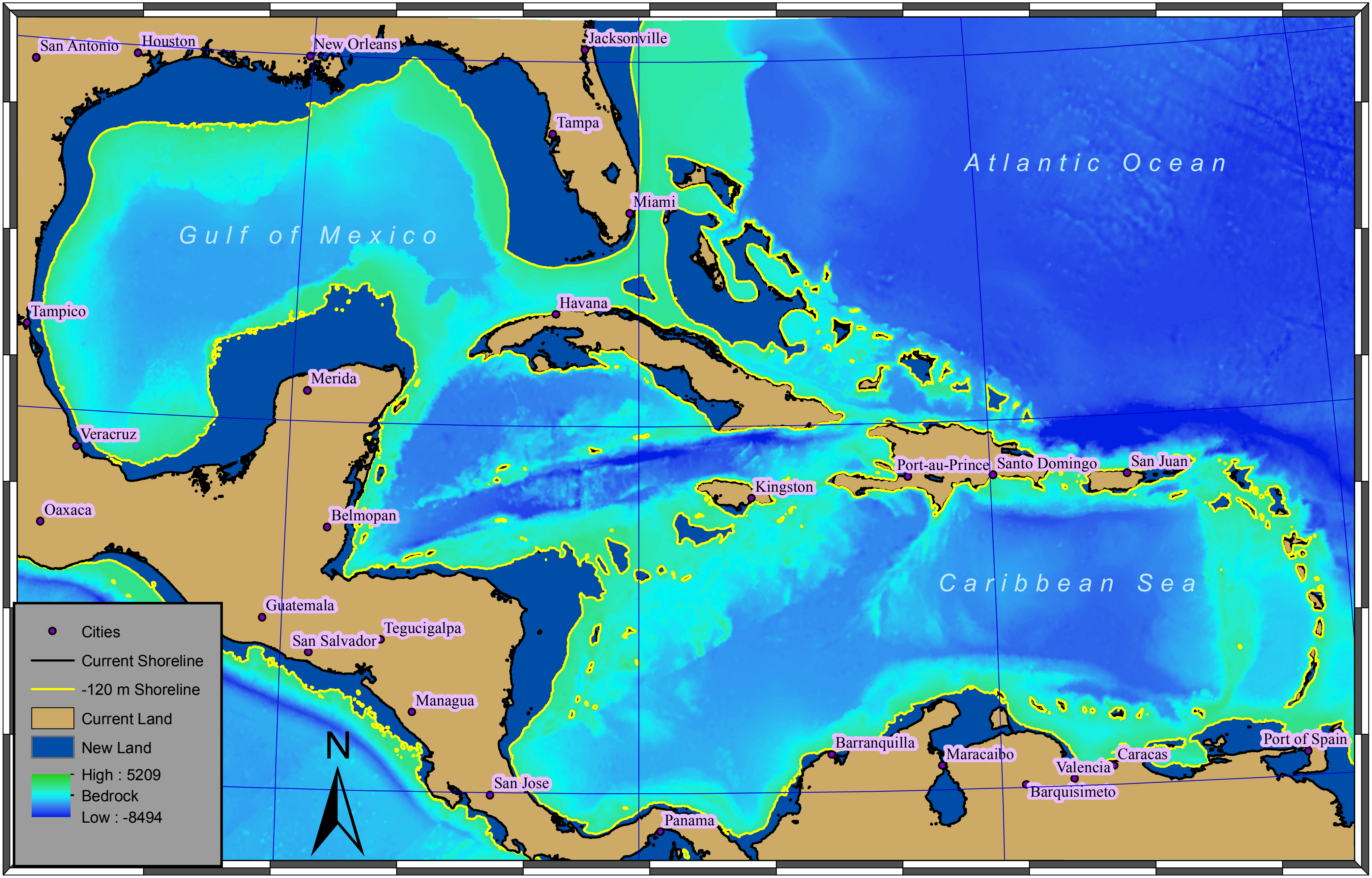
Discussion

In this hypothetical "Icebox" model there are a wide range of social and economic impacts from a significant drop in MSL. These include:

- Social:
    - Major Gulf coastal cities such as Houston, New Orleans, Tampico, and Tampa will become land locked.
    - Many of the smaller tropical islands will substantially grow in size, which could encourage a migration of people (fleeing the colder conditions) and dramatically increase the populations for these countries.
    - The emergence of new islands in the Caribbean could create international turmoil over land rights and ownership.
- Economic:
    - New land would provide opportunities for farming and agriculture to expand due to the organic rich soils that would develop.
    - New coastal cities and ports would need to be developed
    - Despite losing 36% of the beaches and coastlines, Tourism would strongly benefit because of the influx of people and land gains for smaller islands.
    - Off-shore drilling for oil, would be in much shallower waters and some wells may actually be on dry land. The oil industry would have a hay-day.
    - Less volume of water would concentrate fishing areas making the fishermen happy.

These are just a few examples of the impact a major drop in sea level would produce.

Projected Sea Level Fall of 120m for Gulf of Mexico and Caribbean Sea



Daniel J. Lizzadro-McPherson
GEO 327G - Fall 2015

0 187.5 375 750 1,125 1,500 Kilometers

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