



# Coastal Coupling Community of Practice Webinar Series

## NOAA'S CONTINUALLY UPDATED SHORELINE PRODUCT (CUSP)

January 21, 2020

## Outline

- ✓ Why is shoreline important?
- ✓ Why does shoreline not have a well-defined length that can easily be measured?
- ✓ Why do we have another NOAA shoreline with CUSP?
- ✓ What are the sources for CUSP?
- ✓ Who are the users of CUSP?
- ✓ How do I get CUSP?

# Why is shoreline important?



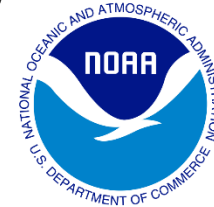
# America's Coasts

**40%** of the population, **10%** of the land mass\*

**\$8.3** trillion in goods and services annually

**55.8** million employed

**\$3.4** trillion in wages annually



\*Excluding Alaska

Source: Bureau of Labor Statistics and Bureau of Economic Analysis



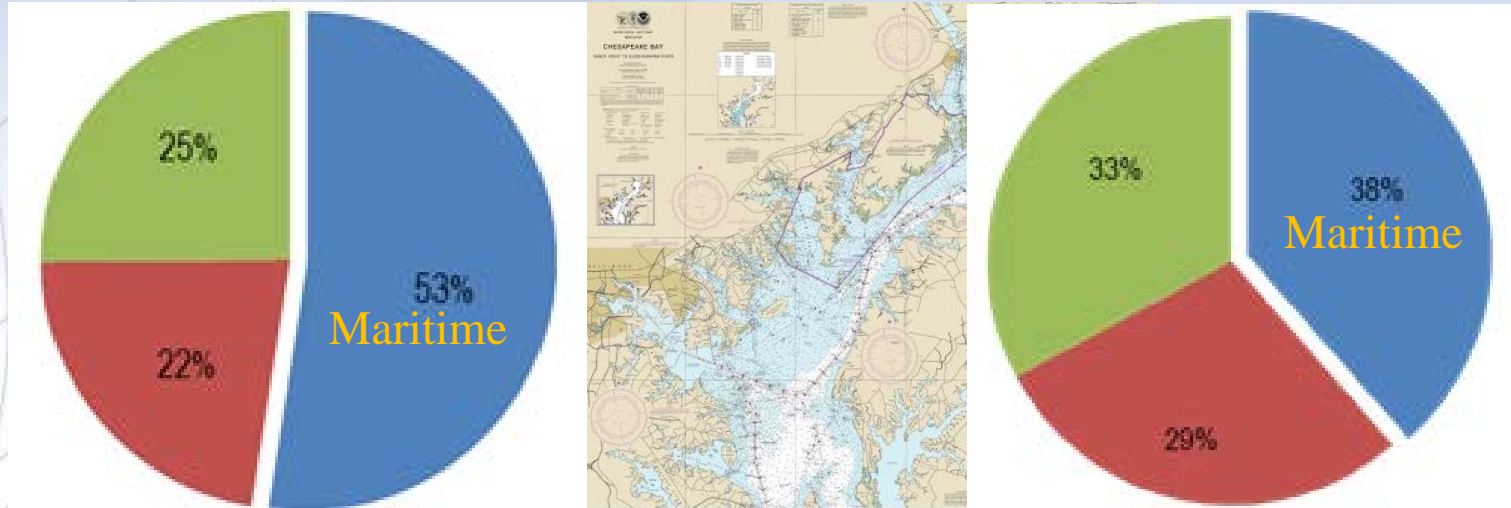
# City Lights of the United States 2012



NASA Earth Observatory composite image acquired by the Suomi NPP satellite between April and October 2012



# Bureau of Transportation Statistics U.S. Import and Export Value by Mode



U.S. Import Value by Mode of Transportation, 2011

■ Vessel ■ Air ■ Land

U.S. Export Value by Mode of Transportation, 2011

■ Vessel ■ Air ■ Land



# NOAA's Coastal Mapping Program 2012 Socio-Economic Scoping Study

- **Navigation safety**
- Shoreline modification
- Environmental protection (including precise coordinates of sensitive and protected areas)
- GIS applications in coastal zone management
- On-shore development
- Recreation
- Fish habitat mapping
- Energy exploration, development and production
- Underwater exploration and construction
- Offshore aquaculture
- Planning and response to natural disasters and environmental emergencies
- Coastal and ocean jurisdiction mapping and dispute prevention and resolution
- Marine spatial planning
- Legal and insurance applications
- Homeland and port security
- Monitoring sea level change
- Scientific research
- National and international standards
- Archaeology and cultural heritage
- Military activities

**“Direct economic benefits alone are 15 times the cost of the CMP program.”**

(\$35 in direct and secondary benefits)

# The Top Ten Costliest U.S. Natural Disasters

1. \$166.3 billion - **Hurricane Katrina**, 2005, **1,833 deaths**
2. \$128.8 billion – **Hurricane Harvey**, 2017, **> 100 deaths**
3. \$92.7 billion – **Hurricane Maria**, 2017, **~ 3000 deaths**
4. \$76.9 billion - Northridge earthquake, 1994, **> 60 deaths**
5. \$72 billion – **Superstorm Sandy**, 2012, **~160 deaths**
6. \$51.5 billion – **Hurricane Irma**, 2017
7. \$49.7 billion - **Hurricane Andrew**, 1992, **65 deaths**
8. \$44 billion - Drought and heat wave, 1988, 5,000 to 10,000 deaths
9. \$37.3 billion - Midwest floods, 1993, 48 deaths
10. \$36 billion - **Hurricane Ike**, 2008, **112 deaths**

Crew boat upside down, half on and half off dock. Louisiana, Southeast coastal parishes. 2005 October 15.

Credit: Collection of Wayne and Nancy Weikel, FEMA Fisheries Coordinators.



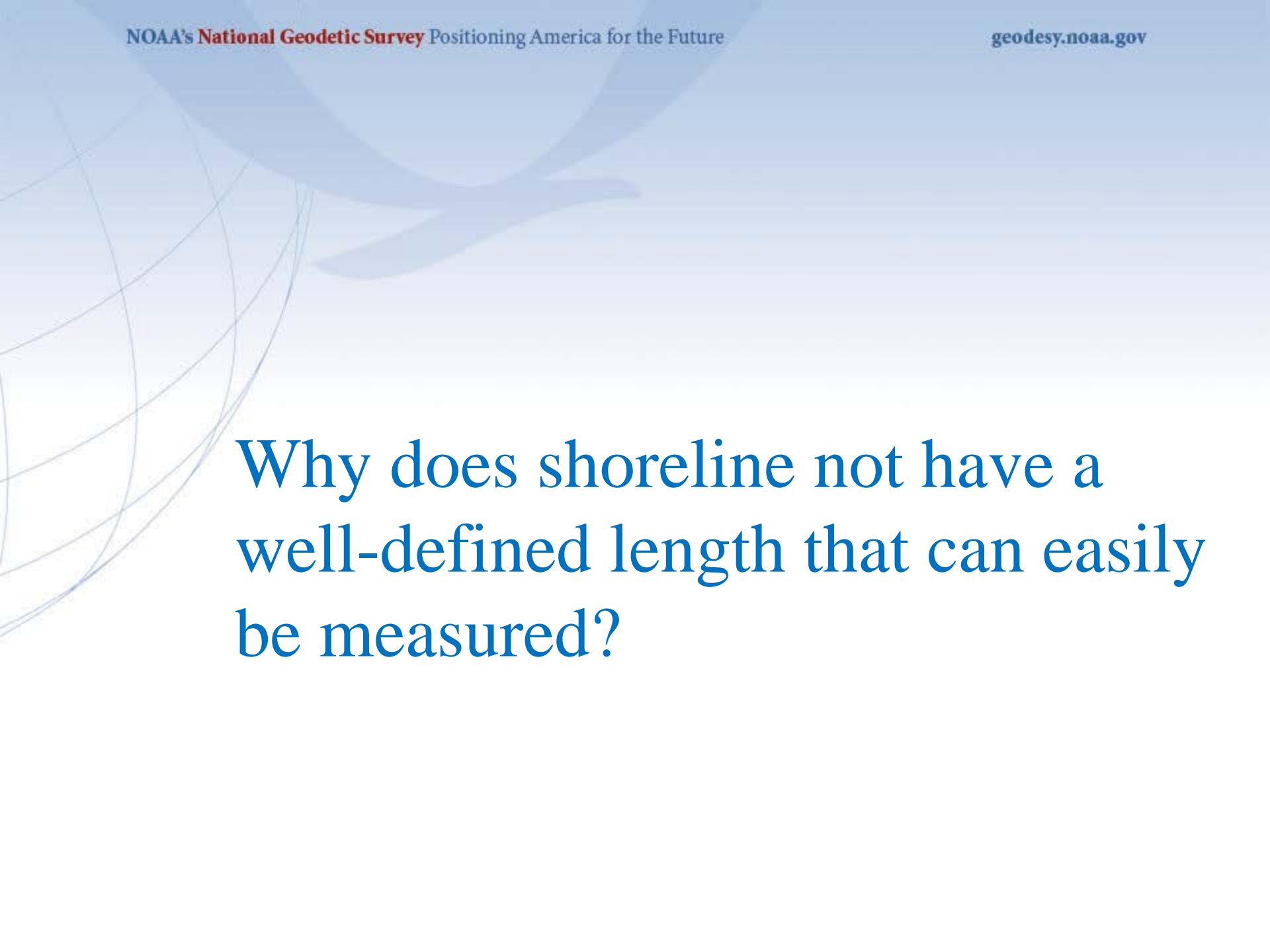
Destruction caused by Hurricane Katrina - a collapsed house, downed trees, and downed powerlines. Mississippi. September, 2005. Photographer: Barbara Ambrose NOAA/NODC/NCDDC.



## Hurricane Katrina Photos

Source: MoneyWise, May 29, 2019 (National Weather Service and the Insurance Information Institute) in 2019 dollars





Why does shoreline not have a well-defined length that can easily be measured?

# The Coastline of the United States

	General Coastline*	Tidal Shoreline*
<b>UNITED STATES</b>	<b>12,383</b>	<b>88,633</b>
Continous only	4,993	59,577
<b>Atlantic</b>	<b>2,069</b>	<b>28,673</b>
Maine	228	3,478
New Hampshire	13	121
Massachusetts	192	1,519
Rhode Island	40	384
Connecticut	—	618
New York	127	1,850
New Jersey	130	1,792
Pennsylvania	—	89
Delaware	28	381
Maryland	31	3,190
Virginia	112	3,215
North Carolina	301	3,375
South Carolina	187	2,576
Georgia	100	2,344
Florida (Atlantic only)	590	3,331
Florida (Atlantic and Gulf)	1,350	8,428
<b>Gulf of Mexico</b>	<b>1,531</b>	<b>17,141</b>
Florida (Gulf only)	770	5,095
Alabama	53	607
Mississippi	44	359
Louisiana	397	7,721
Texas	367	3,359
<b>Pacific</b>	<b>7,623</b>	<b>40,298</b>
California	840	3,427
Oregon	296	1,410
Washington	157	3,026
Hawaii	750	1,052
Alaska (Pacific only)	5,580	31,383
Alaska (Pacific and Arctic)	6,640	39,904
Alaska (Arctic only)	1,060	2,521
<b>EXTRATERRITORIAL</b>		
Canal Zone	20	129
<b>Atlantic</b>		
Navassa	5	5
Puerto Rico	311	700
Swan Islands	8	10
Virgin Islands	117	175
<b>Pacific</b>		
Baker Island	3	3
Guam Islands	78	110
Howland Island	4	4
Jarvis Island	5	5
Johnston Island	5	5
Midway Island	20	33
Palmyra Island	9	16
Samo Islands	76	126
Wake Island	12	20

\*Statute miles.



### Lengths of Great Lakes Shorelines and Connecting Rivers, Including Islands\*

These shoreline lengths were measured in 1970 by the International Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. A precision instrument called a Map and Plan Measure, designed especially to determine the lengths of broken or irregular lines, was used on topographic maps and navigation charts. The scale of the maps was mainly 1:50,000 with a few larger scale maps. The scale of the charts varied from 1:30,000 to 1:120,000.

Shoreline	United States	Canada
Lake Superior	1250	1480
St. Marys River	120	130
Lake Michigan	1640	0
Lake Huron	840	2990
St. Clair River	30	40
Lake St. Clair	140	110
Detroit River	70	60
Lake Erie	470	400
Niagara River	70	40
Lake Ontario	530	380
St. Lawrence River		
above Iroquois Dam	220	260
above Power Dam	320	140

\*All numbers are rounded to nearest 10 miles.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402—  
Price \_\_\_\_\_ cents.



NOAA/PA 71046 (Rev. 1975)

## The Coastline of the United States



U.S. DEPARTMENT OF COMMERCE  
National Oceanic and  
Atmospheric Administration

# Shoreline Length Measurements Based on Scale

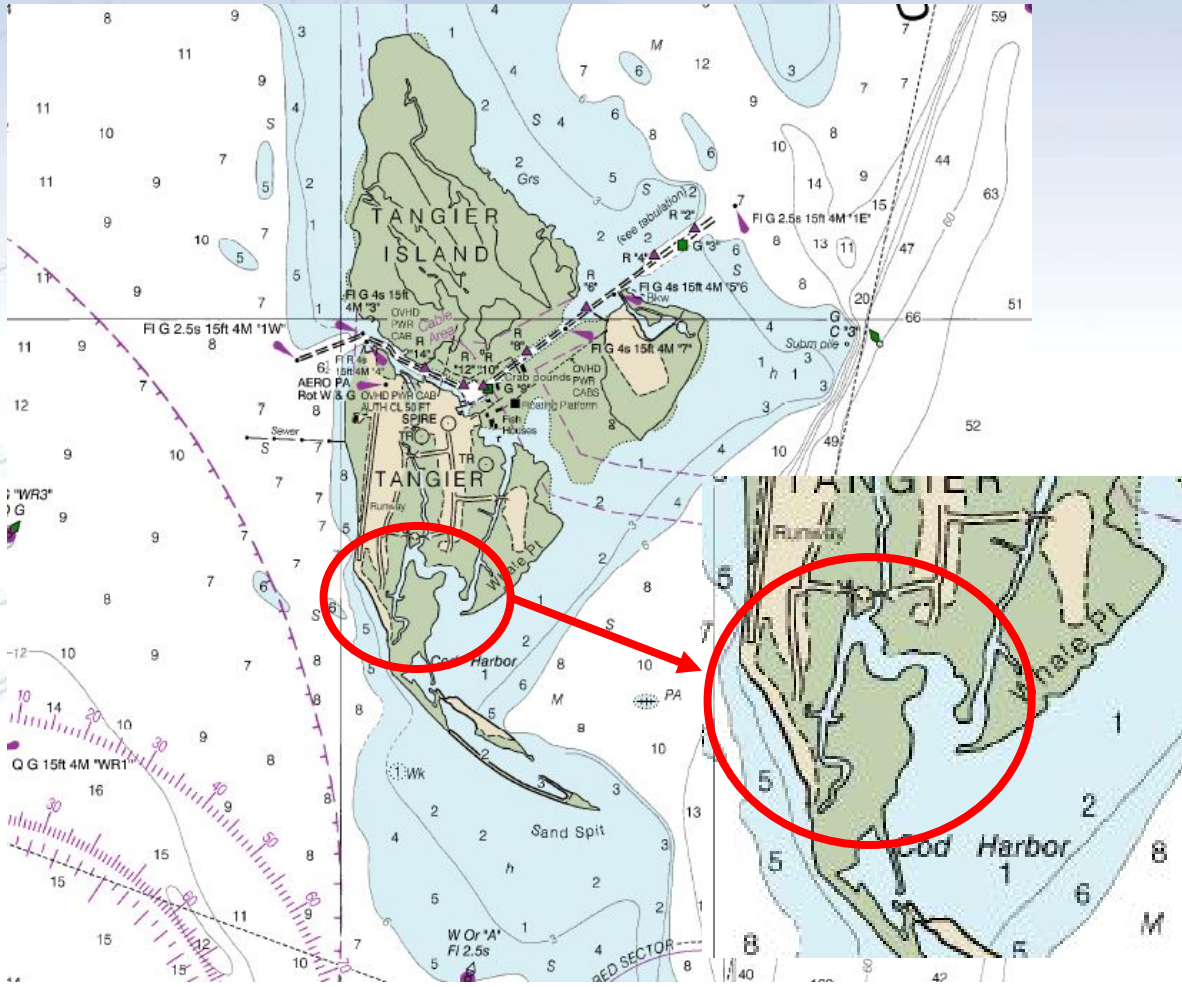


Chart No 12228 @ 1:40,000



Chart No 12280 @ 1:200,000



## Shoreline Length Measurements Based on Fractal Dimensions

Red line compiled at 1:1,000 scale

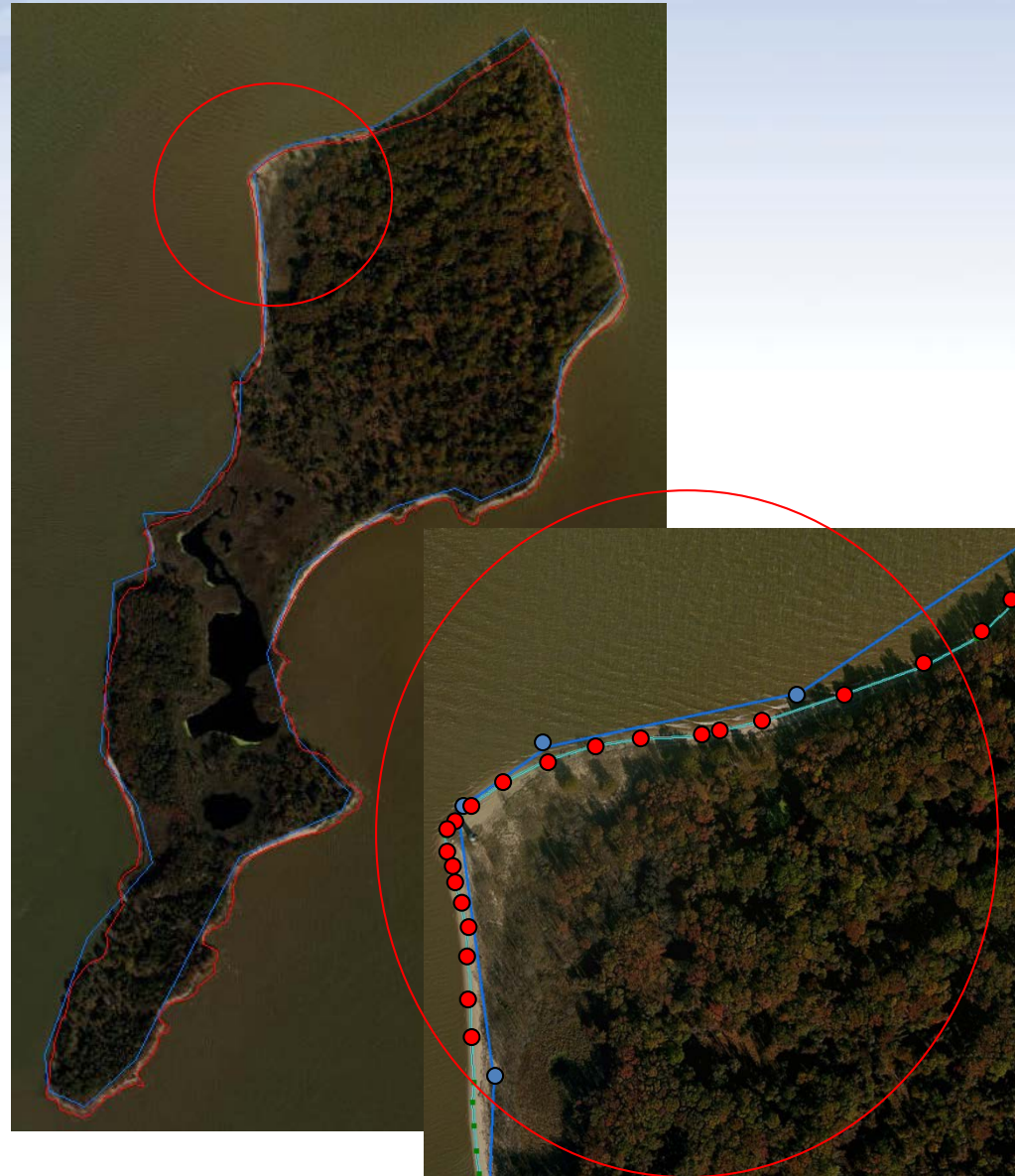
Number of vertices: 356

Length: 5,883 meters (+6%)

Blue line compiled at 1:24,000 scale

Number of vertices: 40

Length 5,574 meters







Why do we have another NOAA  
shoreline with CUSP?

# Need for an Updated Continuous Shoreline

No continuous U.S. shoreline exist that includes all of the following:

- Attributed
- Referenced to a tidal datum
- Maintained
- Up to Date

## NOAA Shoreline Website

*A Guide to National Shoreline Data*

Mapping History Applications Data Access Policy and Management

### DOWNLOAD SHORELINE DATA

By Name

By Application

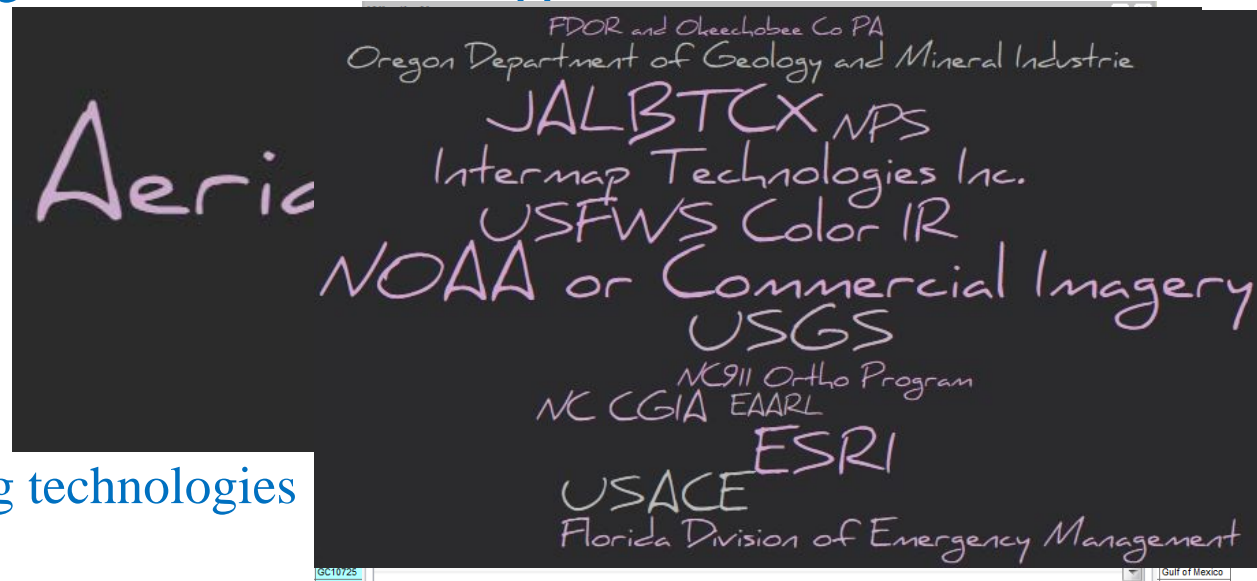
By Scale

- ▶ NGA Prototype Global Shoreline
- ▶ NGA World Vector Shoreline
- ▶ NOAA Medium Resolution Shoreline
- ▶ NOAA Historic Surveys (T- sheets)
- ▶ NOAA Continually Updated Shoreline Product
- ▶ NOAA Composite Shoreline
- ▶ NOAA National Shoreline
- ▶ NOAA OCS Shorelines
- ▶ USGS Vector Shorelines

[shoreline.noaa.gov/](http://shoreline.noaa.gov/)

# Continually Updated Shoreline Product Overview

- Most current shoreline representation
- Referenced to Mean High Water datum where applicable
- Attributed shoreline
- Continuous shoreline
- Frequent updates
- Multiple remote sensing technologies
- NOAA and non-NOAA contemporary sources

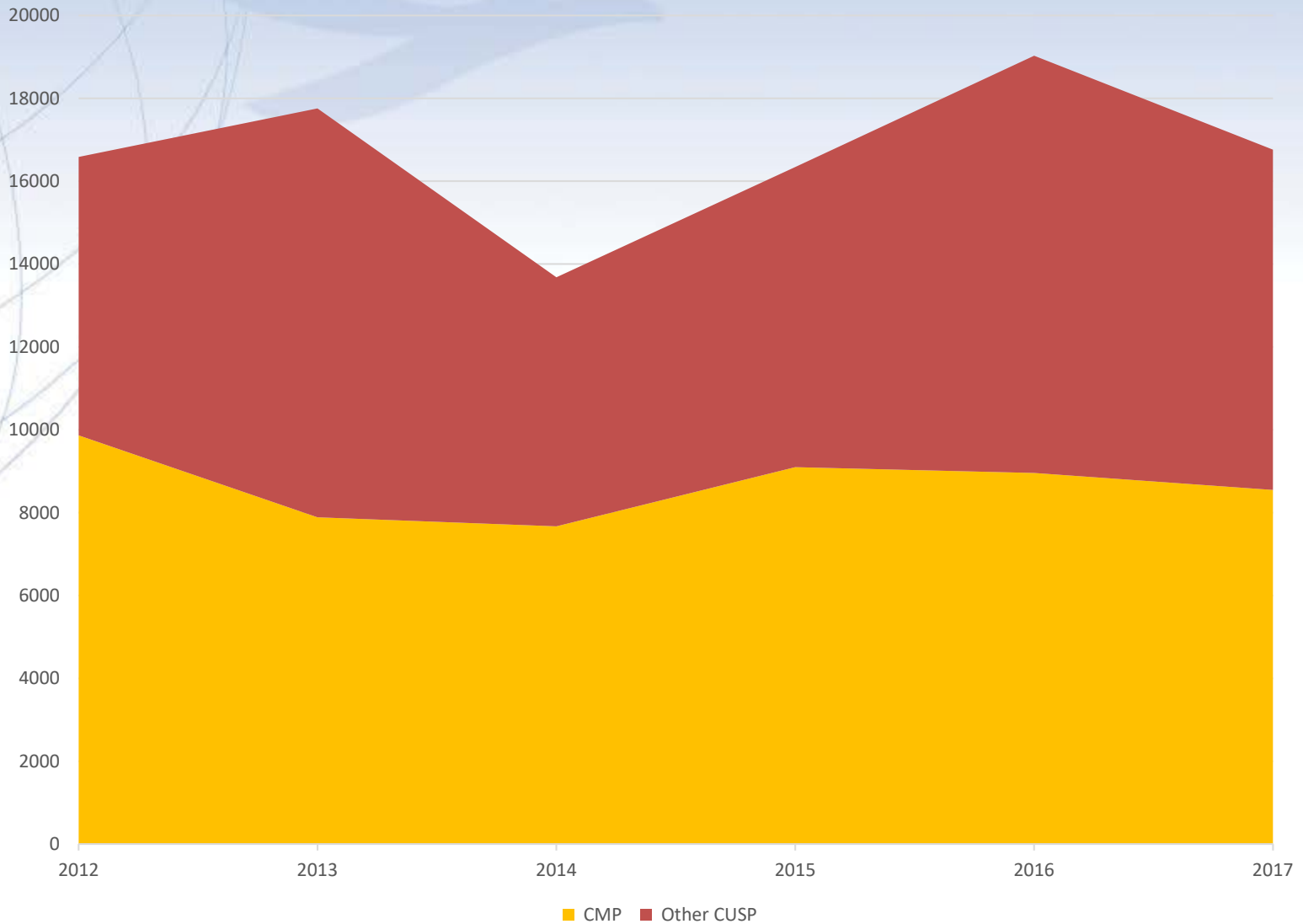


# Right Timing for a Continually Updated Shoreline Product

- Fulfills desire for a consistent federal continuous shoreline
- “Map Once, Use Many Times”
- Increase Availability of Commercial Satellite Imagery and lidar data
- Increase availability of multiple imagery datasets for verification



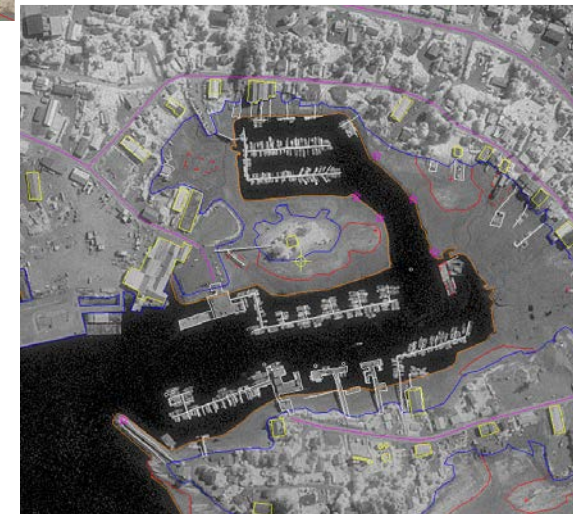
# Nautical Miles of CUSP by Fiscal Year



# What are the sources for CUSP?

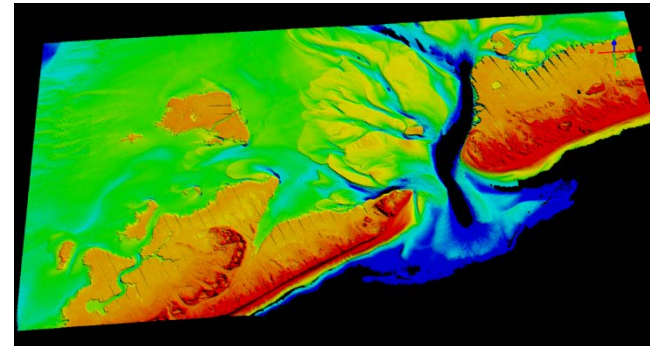
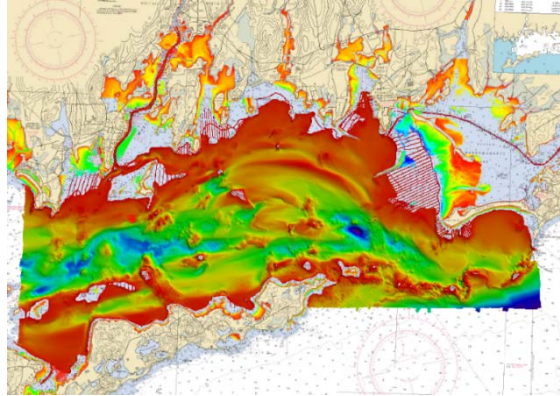
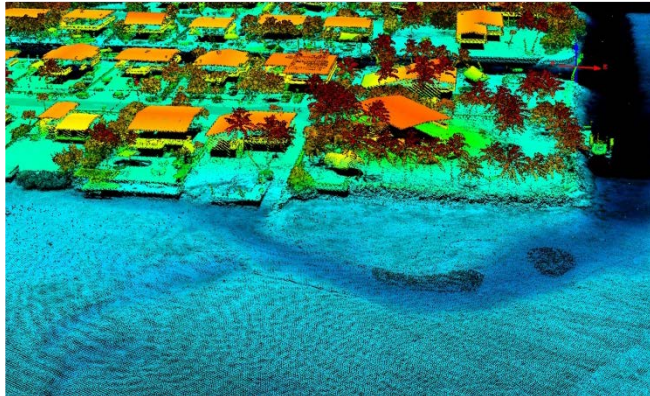
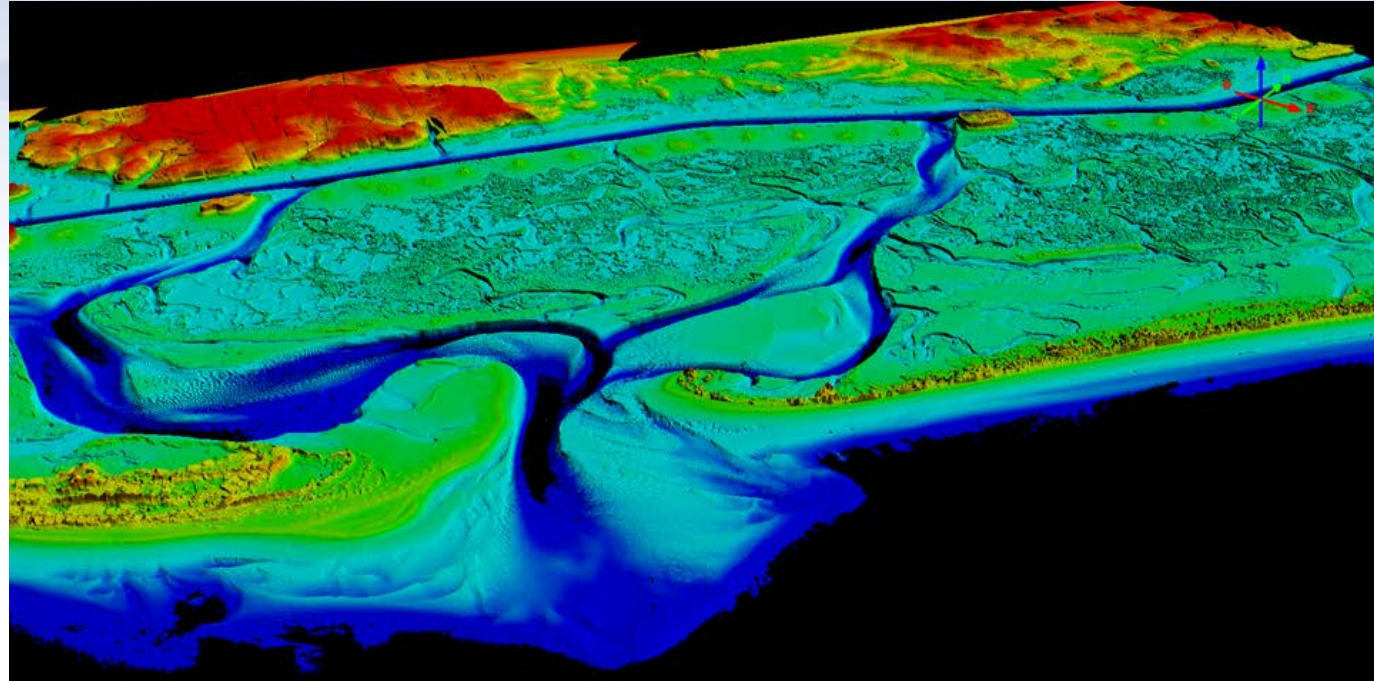
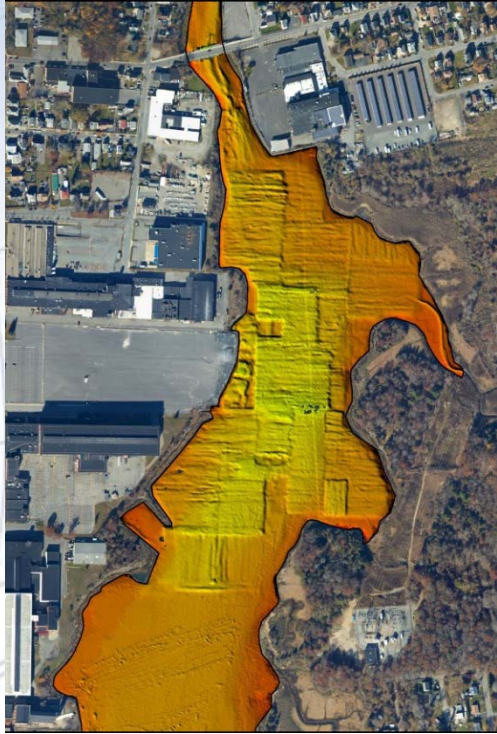
# National Geodetic Survey Shoreline Mapping Photogrammetric Surveys: Stereoscopic

## National shoreline from a softcopy compilation



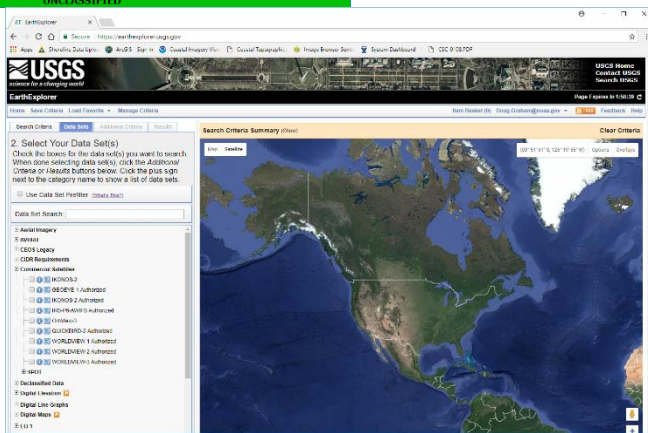
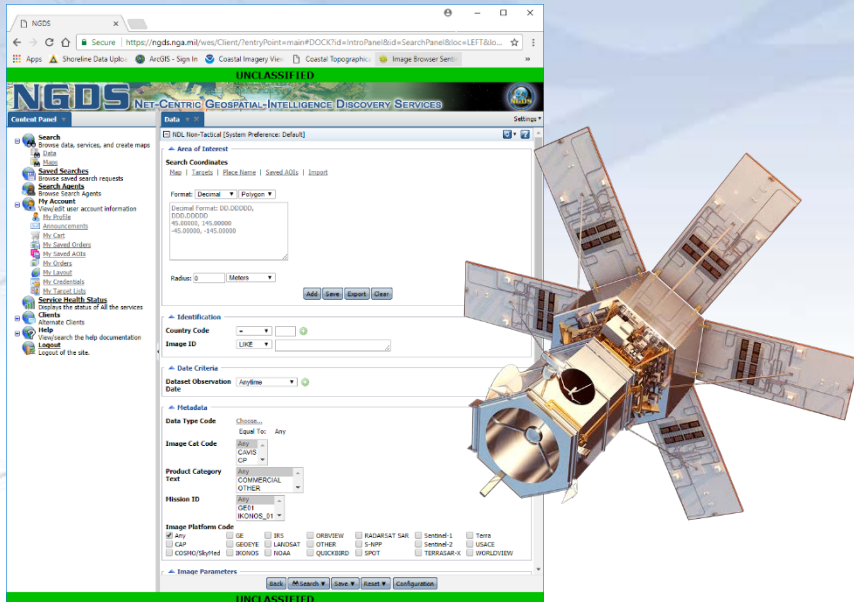


# NGS's Topobathy Lidar Data for National Shoreline





# Access to DigitalGlobe Minimally Processed Satellite



## Worldview-4

Metric Accuracy: Predicted <5 m CE90 without ground control  
 Panchromatic Nadir: 0.31 m  
 Multispectral Nadir: 1.24 m

## Worldview-3

Metric Accuracy: Predicted <3.5 m CE90 without ground control  
 Panchromatic nadir: 0.31 m  
 Multispectral nadir: 1.24 m

## GeoEye-1

Metric Accuracy: 5 m CE90, 3 m CE90 (measured)  
 Panchromatic: 41 cm GSD at nadir  
 Multispectral: 1.65 m GSD at nadir

## Worldview-2

Metric Accuracy: Demonstrated <3.5 m CE90 without ground control  
 Panchromatic: 0.46 m GSD at nadir  
 Multispectral: 1.85 m

## Worldview-1

Metric Accuracy: Demonstrated <4.0 m CE90 without ground control  
 50 cm Ground Sample Distance (GSD) at nadir

## QuickBird

Metric Accuracy: 23 m CE90, 17 m LE90 (without ground control)  
 Panchromatic: 61 cm GSD at nadir  
 Multispectral: 2.16 m GSD at nadir

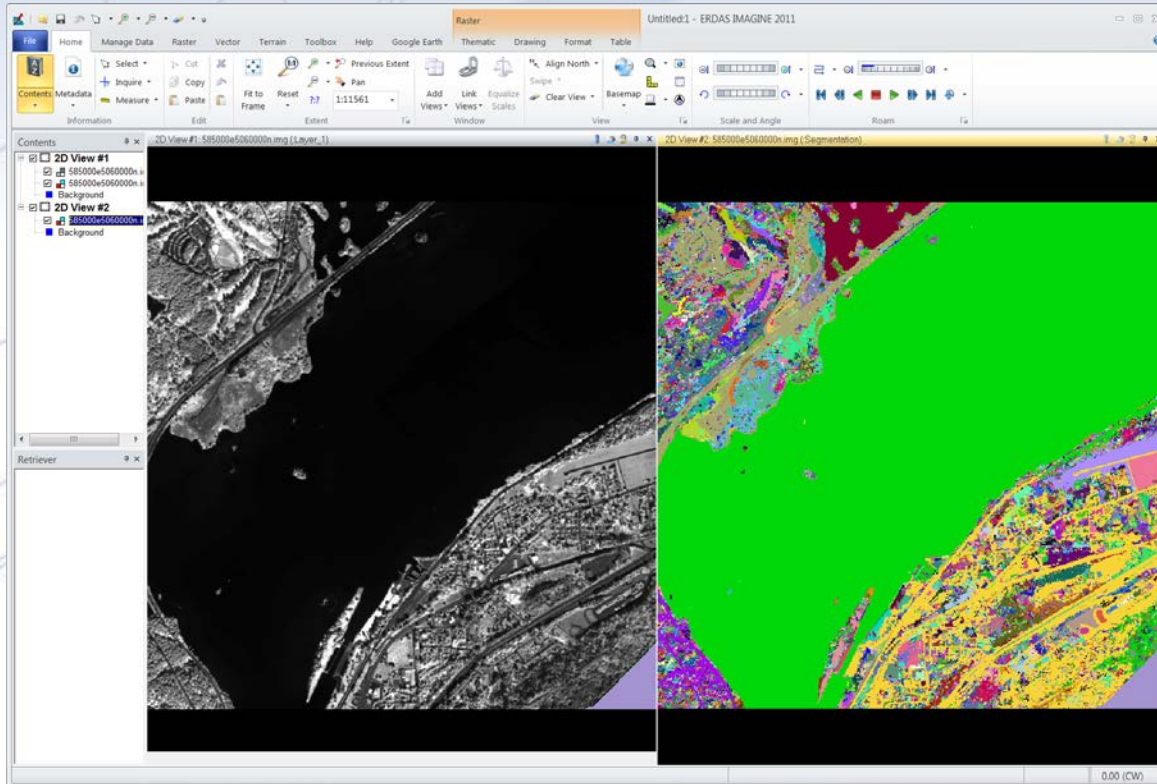
## DigitalGlobe EnhancedView Web Hosting Service Orthorectified Satellite Imagery



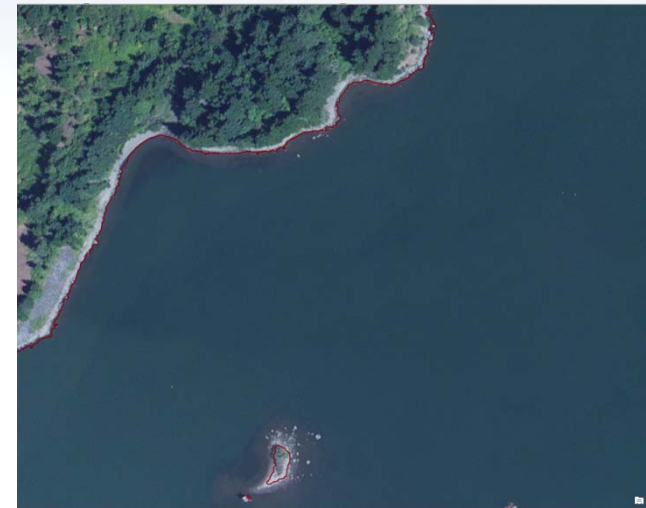
CE90 Accuracy 8.4 meters



# Automated Feature Extraction



ERDAS IMAGINE Image Segmentation



Vectors verified with independent imagery (stereo or mono)

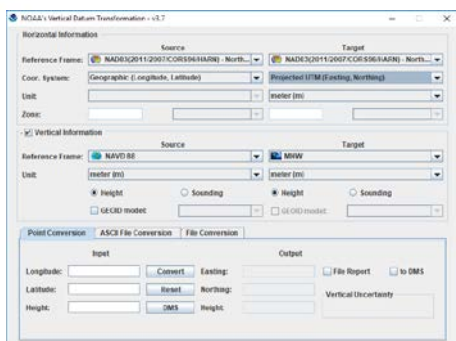
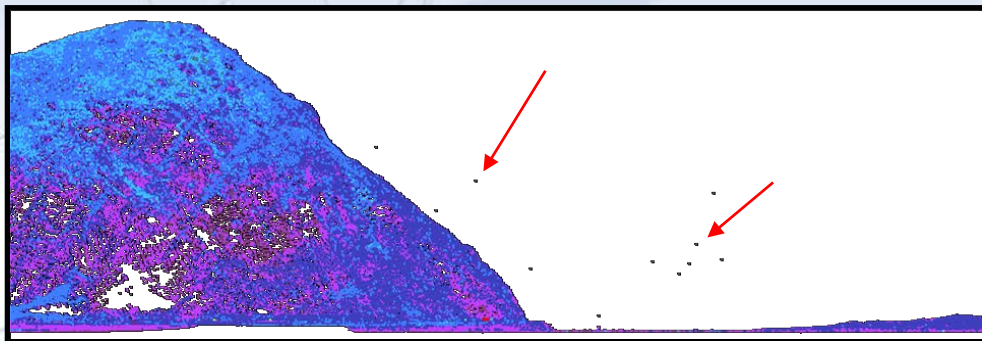
Software Packages:  
ERDAS IMAGINE  
ENVI Zoom  
ESRI  
Quantum GIS



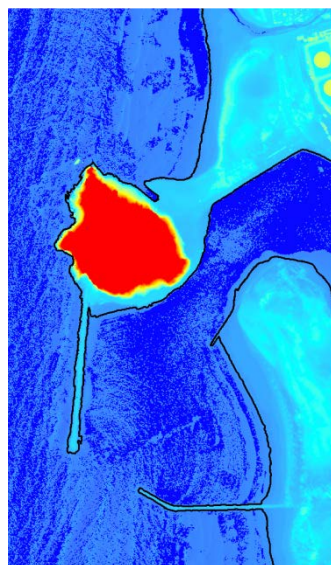
# Current National Geodetic Survey Shoreline Mapping

## Lidar Shoreline Extraction

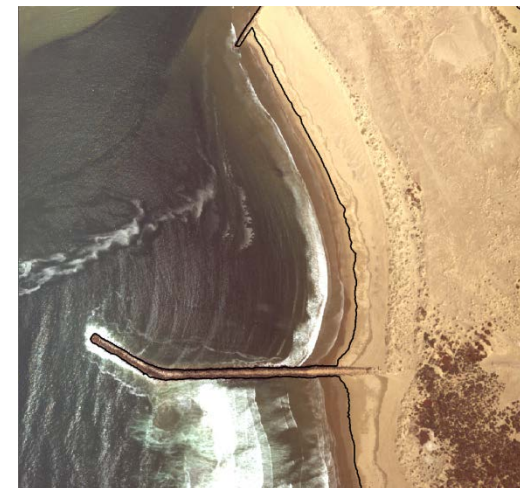
Edit Lidar Point Cloud



VDatum



Contour Shoreline from DEM



Quality Control & Feature Attribution

# Digital Coast Coastal Lidar Availability



# VDatum Tool

NOAA's Vertical Datum Transformation - v4.0.1

\* Region : Contiguous United States

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**Horizontal Information**

Source	Target
Reference Frame: <span style="border: 1px solid gray; padding: 2px;">WG S84(G1674) - use ITRF 2008</span>	<span style="border: 1px solid gray; padding: 2px;">NAD83(2011)</span>
Coord. System: <span style="border: 1px solid gray; padding: 2px;">Geographic (Longitude, Latitude)</span>	<span style="border: 1px solid gray; padding: 2px;">Geographic (Longitude, Latitude)</span>
Unit: <span style="border: 1px solid gray; padding: 2px;"></span>	<span style="border: 1px solid gray; padding: 2px;"></span>
Zone: <span style="border: 1px solid gray; padding: 2px;"></span>	<span style="border: 1px solid gray; padding: 2px;"></span>

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**Vertical Information**

Source	Target
Reference Frame: <span style="border: 1px solid gray; padding: 2px;">EGM2008(WG S84_G1674)</span>	<span style="border: 1px solid gray; padding: 2px;">MHW</span>
Unit: <span style="border: 1px solid gray; padding: 2px;">meter (m)</span>	<span style="border: 1px solid gray; padding: 2px;">meter (m)</span>
<input checked="" type="radio"/> Height <input type="radio"/> Sounding	<input checked="" type="radio"/> Height <input type="radio"/> Sounding
<input type="checkbox"/> GEOID model: <span style="border: 1px solid gray; padding: 2px;">EGM2008</span>	<input type="checkbox"/> GEOID model: <span style="border: 1px solid gray; padding: 2px;">GEOID12B</span>

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Point Conversion
ASCII File Conversion
File Conversion

Input	Output
Longitude: <span style="border: 1px solid gray; padding: 2px;">-73.99636</span>	Longitude: <span style="border: 1px solid gray; padding: 2px;">-73.9963540821</span>
Latitude: <span style="border: 1px solid gray; padding: 2px;">40.40998</span>	Latitude: <span style="border: 1px solid gray; padding: 2px;">40.4099705168</span>
Height: <span style="border: 1px solid gray; padding: 2px;">0.288</span>	Height: <span style="border: 1px solid gray; padding: 2px;">-0.000</span>
Vertical_Area: NYNJhbr34_8301:4:3	

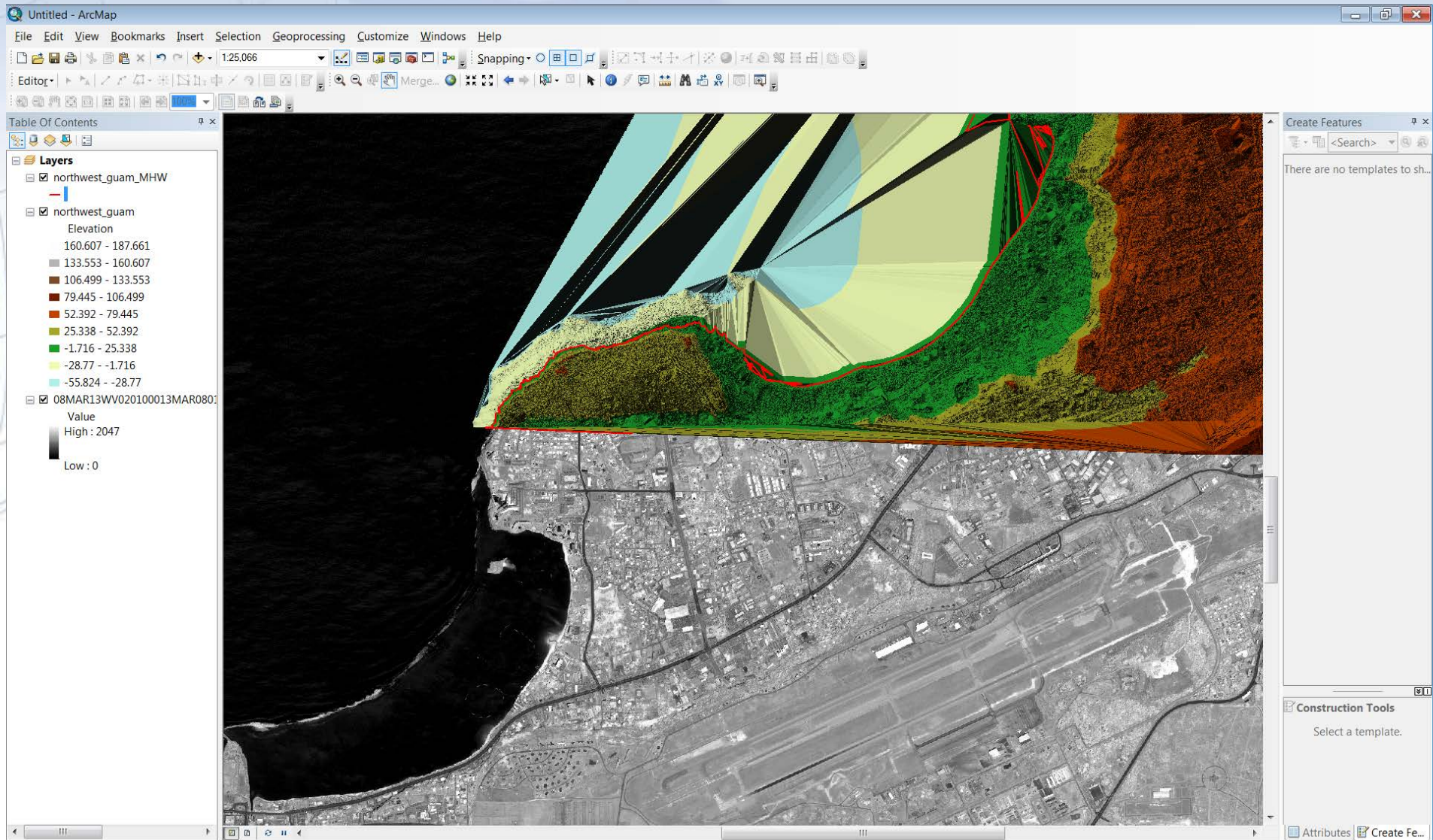
Convert
Reset
DMS
File Report
to DMS

Vertical Uncertainty (+/-)  
 17.82105cm



# Digital Coast

## GUAM Coastal Lidar Data Set



# Lidar Derived Shoreline in CUSP



# CUSP Attribution

## SOURCE\_ID

Source Identification of feature.

## SRC\_DATE

Date of source imagery or Lidar for the feature

## VER\_DATE

YYYYMMDD

## HOR\_ACC

Horizontal positional accuracy (meters)

## DATA\_SOURC

Aerial Photography  
Satellite Imagery  
Lidar  
IFSAR  
SAR  
HyperSpectral  
Multispectral

## EX METH

Derived  
Mono  
Stereo

## ATTRIBUTE

Breakwater.Bare  
Groin.Bare  
Jetty.Bare  
Man-made  
Man-made.Bulkhead Or Sea Wall  
Man-made.Bulkhead Or Sea Wall.Ruins  
Man-made.Canal.Navigable  
Man-made.Canal.Navigable.Approximate  
Man-made.Canal.Non-navigable  
Man-made.Drydock.Permanent  
Man-made.Lock  
Man-made.Ramp  
Man-made.Rip Rap  
Man-made.Slipway  
Man-made.Wharf Or Quay  
Man-made.Wharf Or Quay.Ruins  
Natural  
Natural.Apparent.Marsh Or Swamp  
Natural.Apparent.Mangrove Or Cypress  
Natural.Glacier  
Natural.Great Lake Or Lake Or Pond  
Natural.Great Lake Or Lake Or Pond.Approximate  
Natural.Mean High Water  
Natural.Mean High Water.Approximate  
Natural.Mean Water Level  
Natural.River Or Stream  
Natural.River Or Stream.Approximate  
Undetermined  
Undetermined.Approximate  
Undetermined.Estimated

## INFORM

Ancillary Information (e.g. Describing or defining a feature)

## SRC\_RESOLU

Resolution of source (imagery or grid) used for compiling shoreline.

## DAT\_SET\_CR

Data Set Credit of original compiled shoreline

## SRC\_CITA

Source Citation used for compilation

## FIPS\_ALPHA

Two- letter FIPS State Alpha Code

## NOAA\_Regio

NOAA Regional Collaboration



**Required Attribute**



# Elements of CUSP

- Technology dictates map scale
  - 1:1,000 scale - Imagery at 0.5 m resolution
    - 1:10,000 scale – Manual compilation of imagery
  - 1:1,000 scale – Lidar
  - 1:10,000 to 1:50,000 scale - IFSAR
- Strive towards 20 meter (95% confidence level) or better horizontal uncertainty
- CUSP generally ends upstream of coastal rivers at approximately 10 miles upstream or to the end of the river.
- Attribution generally consistent with the National Wetland Inventory.
- Polyline that is topologically structured

# Differences of National Shoreline and CUSP Compilation

National Shoreline	CUSP
More accurately tidal-referenced shoreline. Water levels included in Project Completion Report	Where applicable, CUSP will reference a mean-high water shoreline based on vertical modeling or image interpretation using both water-level stations and/or shoreline indicators
Focus on supporting Nautical charting applications (ports and approaches)	Includes National Shoreline and additional compilation of less navigationally significant areas
Greater generalization of non-navigationally significant features like marsh	Attribute of actual shoreline Greater detail in Marsh shorelines (connectivity)
Generally at 1:24,000 scale	Scales range from 1:1,000 to 1:24,000
Discrete geographic area and dates within survey	Continuous and multi-temporal
Includes Shoreline and associated data	Only Shoreline
Three or more stages of review	Typically one review
Documentation	No documentation

# Differences of National Shoreline and CUSP Compilation

## National Shoreline Discrete geographic area and dates

NOAA Shoreline Data Explorer

National Geodetic Survey

Information for identified feature

Proj ID	Proj Description	Proj Date	GCs
<a href="#">NJ1802-GS-N</a>	Naval Weapons Station Earle, Leonardo, NJ	2019	GC11534
<a href="#">NJ1402D-TB-C</a>	Metedeconk Neck to Sandy Hook, NJ	2016	GC11243

## CUSP Continuous

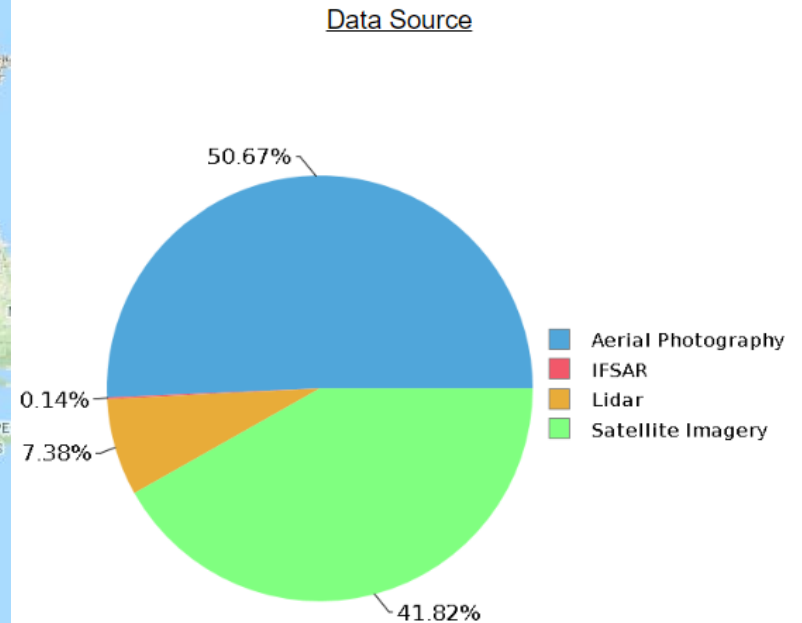
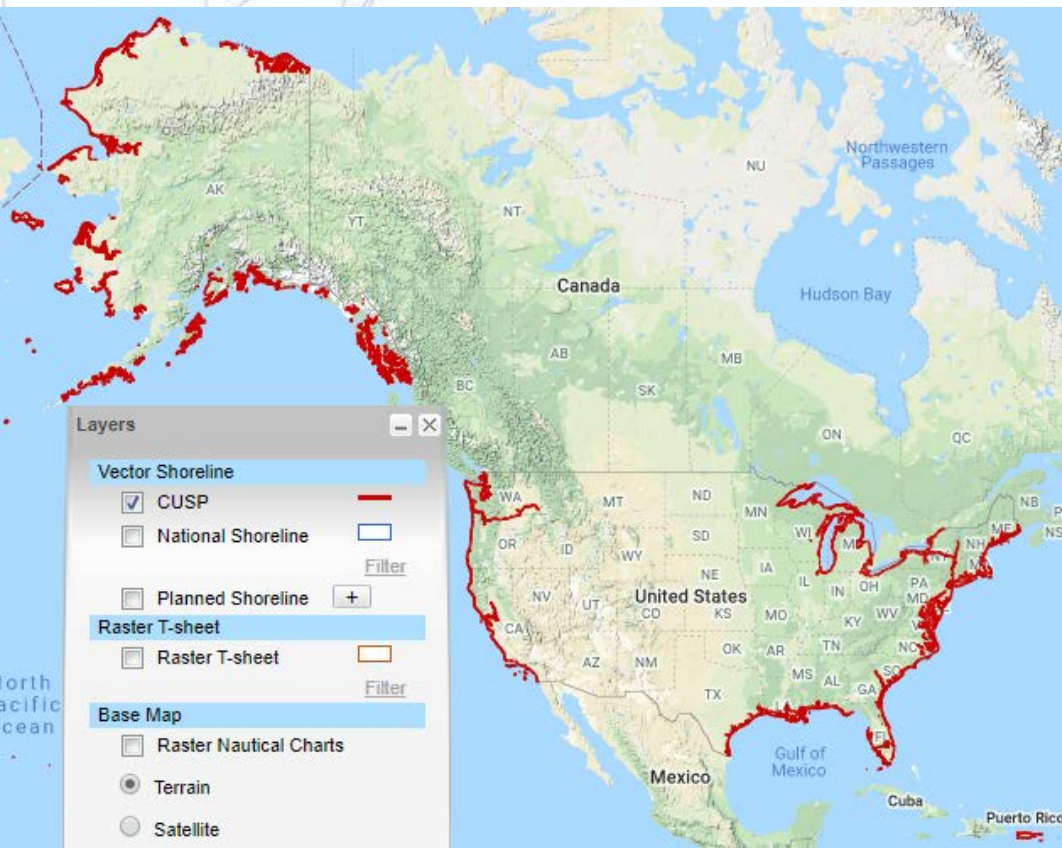
NOAA Shoreline Data Explorer

National Geodetic Survey



# Continually Updated Shoreline Product Completed and Data Sources

Approximately 62 % of CUSP shoreline is completed



# Continually Updated Shoreline Product (CUSP) Status

Percentage of CUSP Completed by State

North Atlantic		
State	Percent	Avg. Age
Connecticut	99	<a href="#">6.7</a>
Delaware	85	<a href="#">7.9</a>
Maine	87	<a href="#">9.8</a>
Maryland	87	<a href="#">11.5</a>
Massachusetts	92	<a href="#">9.8</a>
New Hampshire	49	<a href="#">10.2</a>
New Jersey	82	<a href="#">8.2</a>
New York	85	<a href="#">10.4</a>
Pennsylvania	86	<a href="#">14.2</a>
Rhode Island	100	<a href="#">12</a>
Virginia	91	<a href="#">10.2</a>
<u>Percent Completed for Region</u>	88	<a href="#">9.7</a>

Gulf of Mexico		
State	Percent	Avg. Age
Alabama	99	<a href="#">6.8</a>
Florida	55	<a href="#">7.4</a>
Louisiana	57	<a href="#">11.3</a>
Mississippi	74	<a href="#">8.9</a>
Texas	58	<a href="#">7.7</a>
<u>Percent Completed for Region</u>	58	<a href="#">9</a>

Southeast and Caribbean		
State	Percent	Avg. Age
Florida	53	<a href="#">7.6</a>
Georgia	87	<a href="#">11.3</a>
North Carolina	61	<a href="#">7.7</a>
Puerto Rico	95	<a href="#">4.1</a>
South Carolina	55	<a href="#">6.2</a>
Virgin Islands of the U.S.	100	<a href="#">7.9</a>
<u>Percent Completed for Region</u>	63	<a href="#">6.9</a>

Western		
State	Percent	Avg. Age
California	94	<a href="#">8.6</a>
Oregon	85	<a href="#">7.9</a>
Washington	91	<a href="#">6.4</a>
<u>Percent Completed for Region</u>	91	<a href="#">7.7</a>

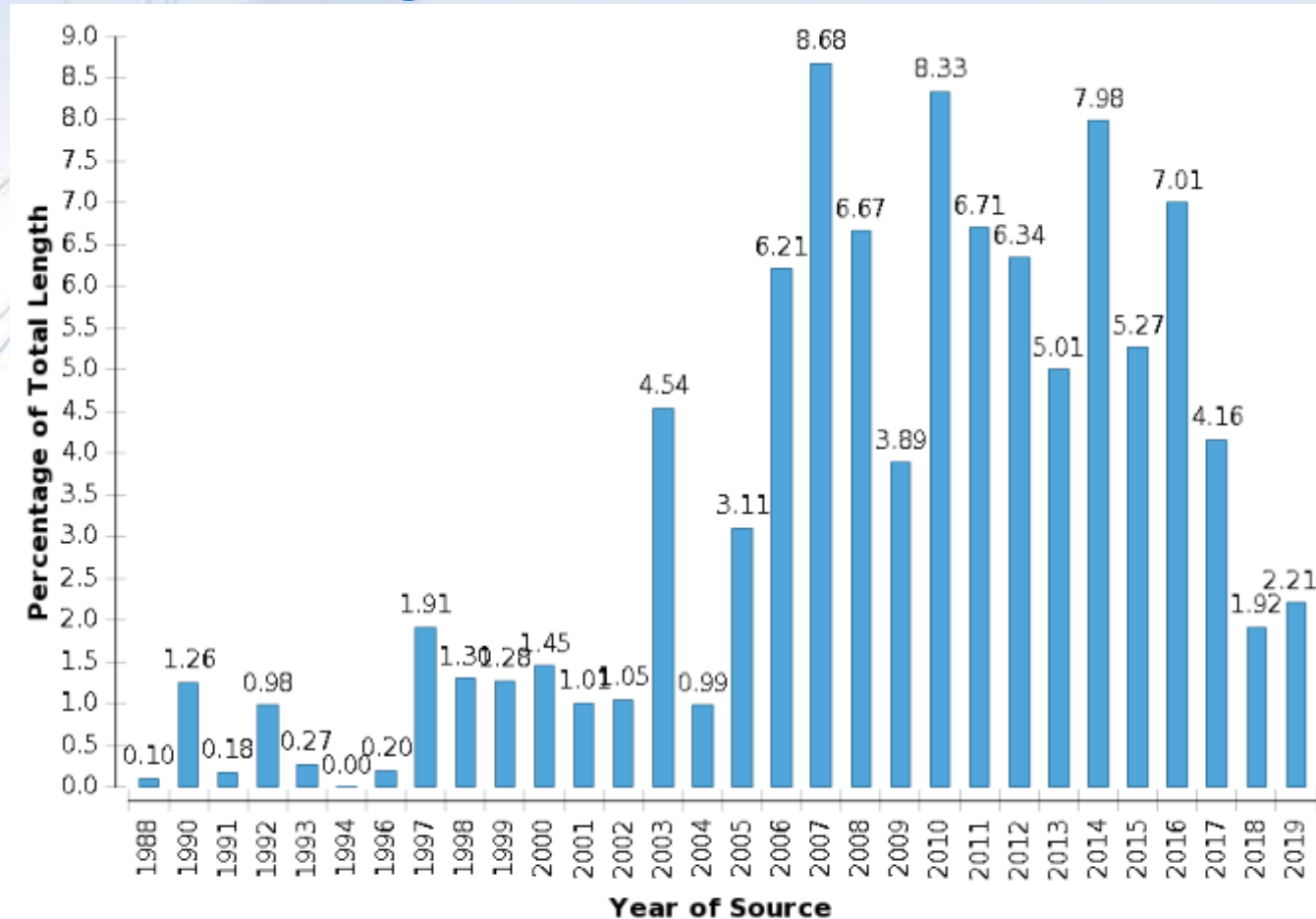
Alaska		
State	Percent	Avg. Age
Alaska	47	<a href="#">12.6</a>

Great Lakes		
State	Percent	Avg. Age
Illinois	96	<a href="#">9.2</a>
Indiana	84	<a href="#">9.4</a>
Michigan	93	<a href="#">10.8</a>
Minnesota	92	<a href="#">11</a>
New York	97	<a href="#">10.3</a>
Ohio	94	<a href="#">11.2</a>
Pennsylvania	100	<a href="#">12.7</a>
Wisconsin	96	<a href="#">9.4</a>
<u>Percent Completed for Region</u>	94	<a href="#">10.4</a>

Pacific Islands		
State	Percent	Avg. Age
American Samoa	5	<a href="#">18.1</a>
Guam	100	<a href="#">6.7</a>
Hawaii	44	<a href="#">7.1</a>
Northern Mariana Islands	73	<a href="#">8.8</a>
U.S. Minor Outlying Islands	77	<a href="#">13.1</a>
<u>Percent Completed for Region</u>	49	<a href="#">7.4</a>

**U.S. Total: 62.13%**

# Continually Updated Shoreline Product Age of Shoreline



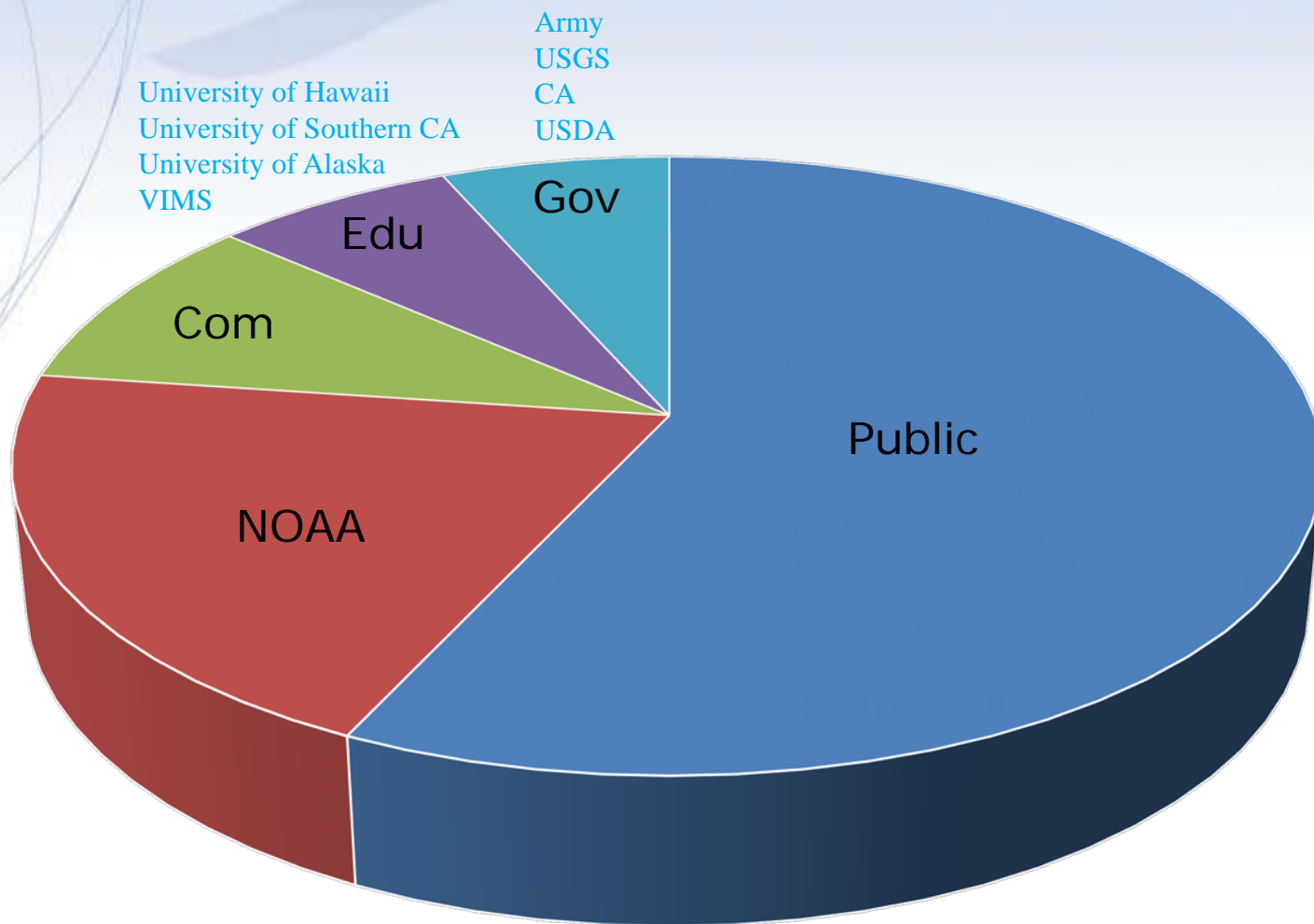
Mean Age: 10.1; Standard Deviation: 4.9

Data Retrieval Date: 01/16/2020



# Who are the users of CUSP?

# Users Based on Website Views

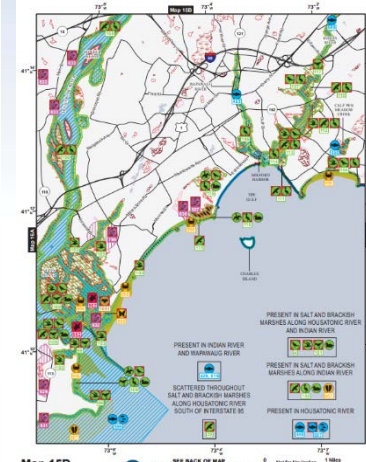


# Direct Uses of CUSP within NOAA

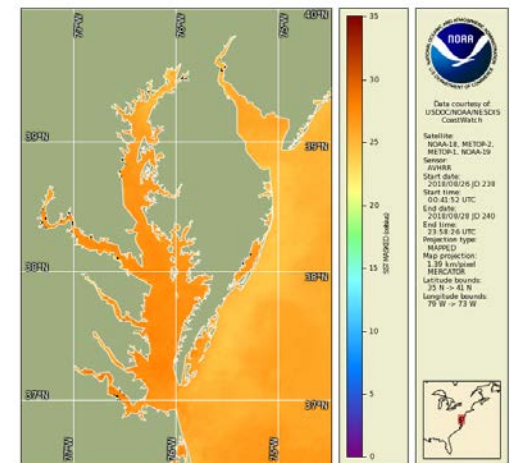
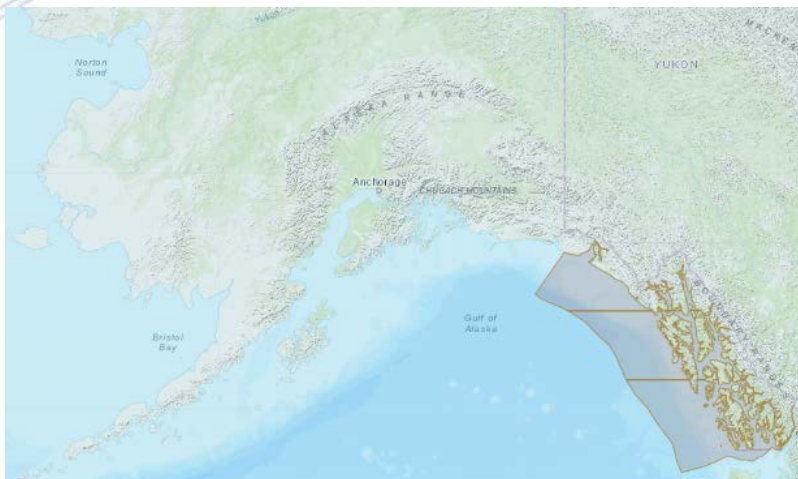
- "Provisional" Navigational Charts
- Environmental Sensitivity Index
- VDatum
- Global Self-consistent, Hierarchical, High-resolution Geography Database
- Sea Surface Temperature Modeling



This screenshot shows the western entrance to the Yukon River on ENC US4K98M. The dotted lines show approximate shoal areas.



Map 15D Long Island Sound

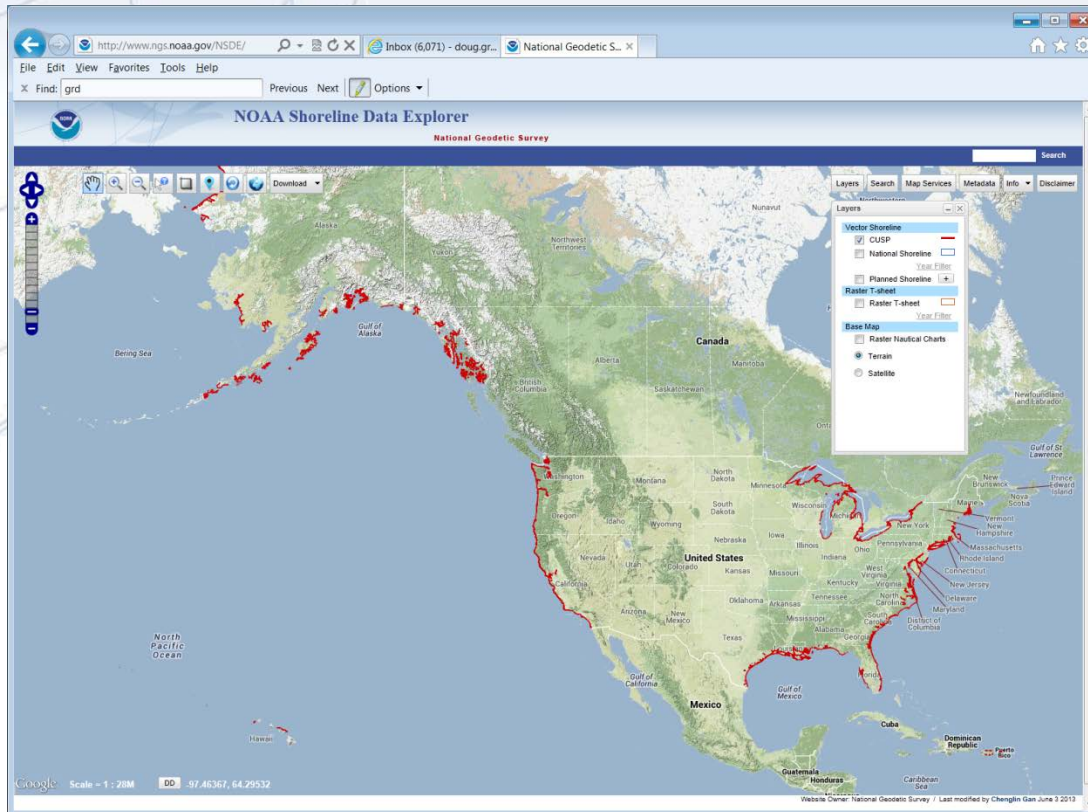




# How do I get CUSP?

# NOAA Shoreline Data Explorer Application

<http://www.ngs.noaa.gov/NSDE/>

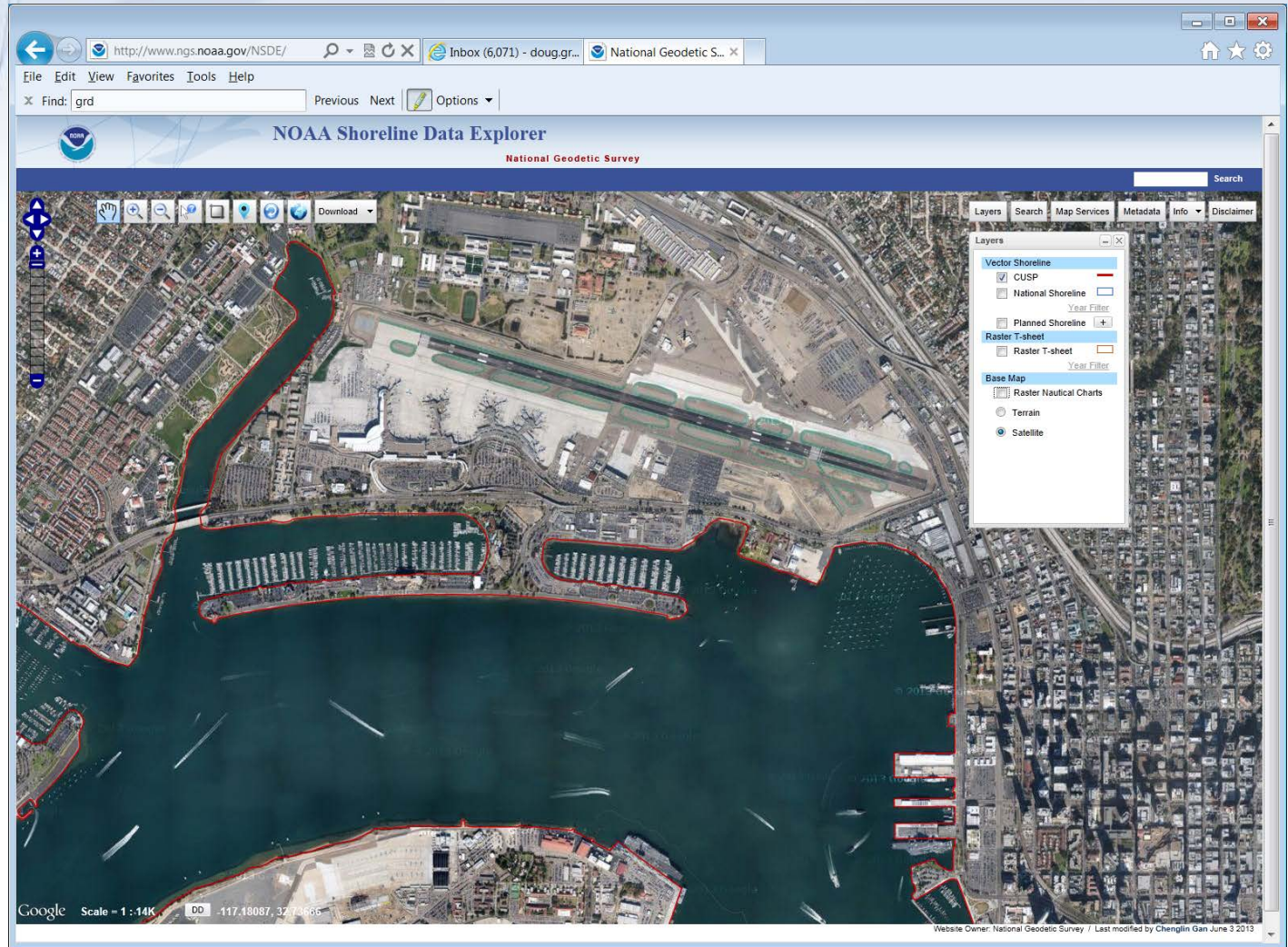


- Data Layers
- Search Capabilities
- Web Mapping Service
- Metadata (FGDC & ISO)
- Description of CUSP
- Most Recent Releases
- Help
- Disclaimer

# NOAA Shoreline Data Explorer Application

## Data Layers:

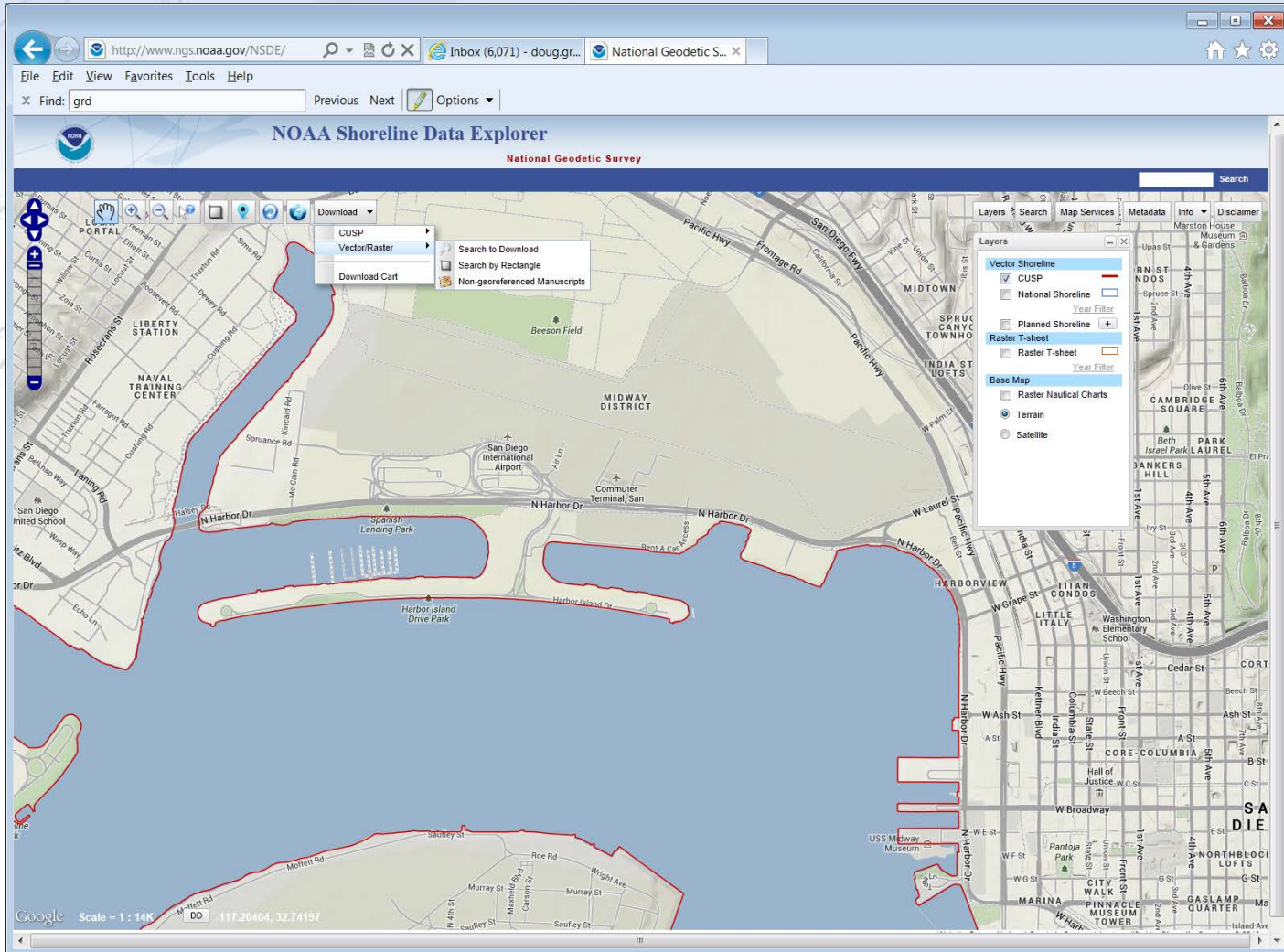
- CUSP
- National Shoreline
- Raster T-Sheets
- Planned Shoreline





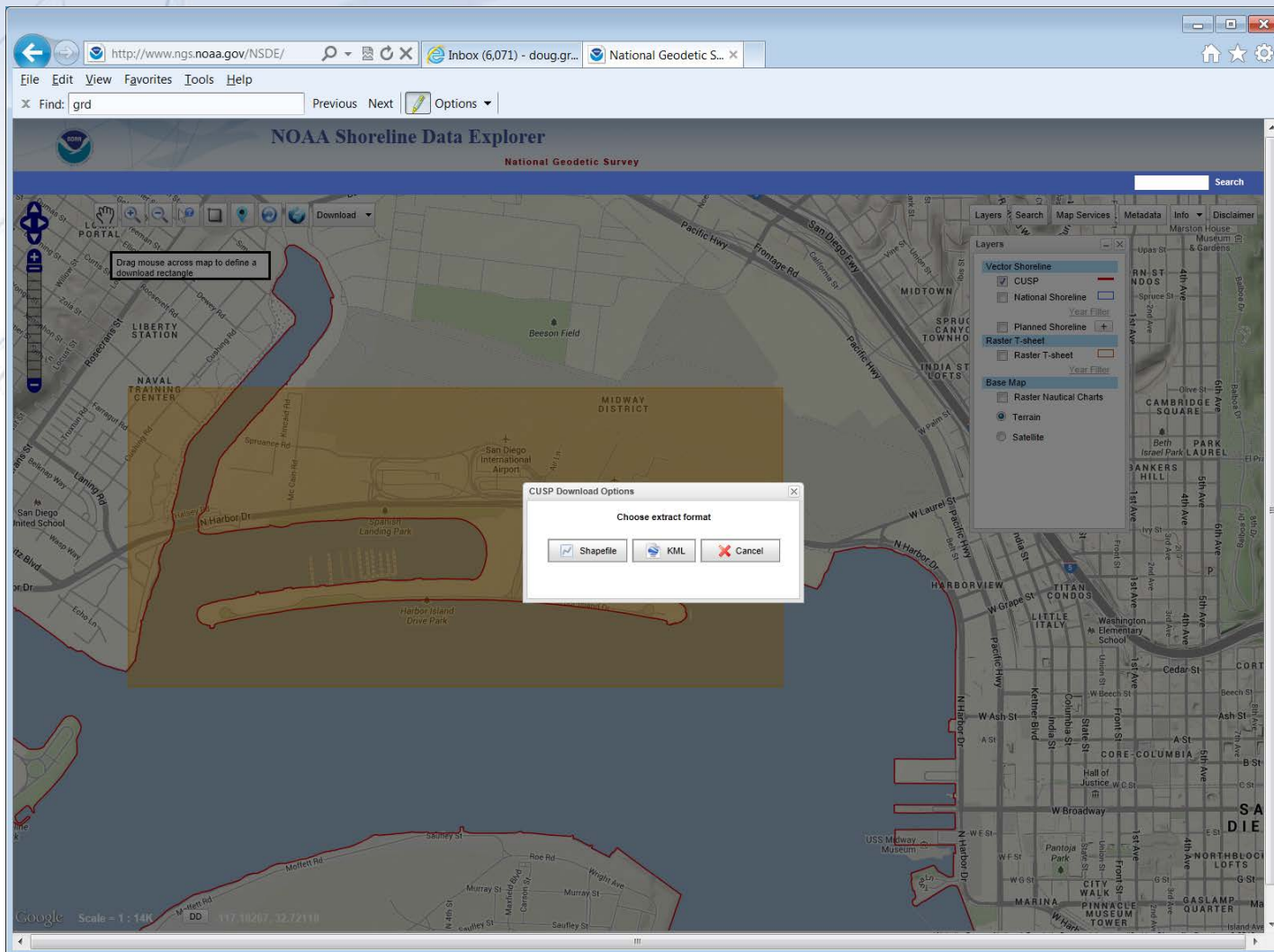
# NOAA Shoreline Data Explorer Application

## Download by Rectangle or Region



# NOAA Shoreline Data Explorer Application

## Download Area Of Interest by Rectangle





# NOAA Shoreline Data Explorer Application

## Download by Regions

The screenshot displays the NOAA Shoreline Data Explorer web application. The browser address bar shows the URL <http://www.ngs.noaa.gov/NSDE/>. The application title is "NOAA Shoreline Data Explorer" with the "National Geodetic Survey" logo.

The interface includes a search bar at the top right and a "Download" menu. The "Download" menu is open, showing options for "CUSP", "Vector/Raster", and "By Region". The "By Region" option is selected. A "Download by Region" dialog box is also open, listing various regions for selection:

- Alaska
- Great Lakes
- Gulf of Mexico
- North Atlantic
- Pacific Islands
- Southeast & Caribbean
- West Coast

The main map area shows a detailed view of San Diego, including the San Diego International Airport, Harbor Island, and the city center. The map is overlaid with a red outline representing the shoreline data. The bottom left corner shows a Google logo and a scale of 1:14K.



# Questions and Additional Information

NOAA Shoreline Data Explorer Application:

<http://www.ngs.noaa.gov/NSDE/>

<http://www.ngs.noaa.gov/CUSP/>

Future of the NOAA Shoreline Data Explorer Application  
Webinar: Thursday February 20th

Contact: [Doug.Graham@noaa.gov](mailto:Doug.Graham@noaa.gov)

