



U.S. ARMY

UPDATE - DIGITAL GRAIN-SIZE IMAGERY ANALYSIS AND CITIZEN SCIENCE

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Kelsey Fall, Doug Krafft**

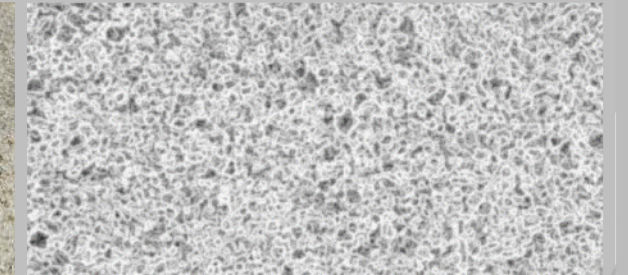
Coastal & Hydraulics Laboratory

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Alesha Melendez**

James Madison University

Daniel Buscombe

Northern Arizona University, USGS



19 November 2019



US Army Corps
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ERDC

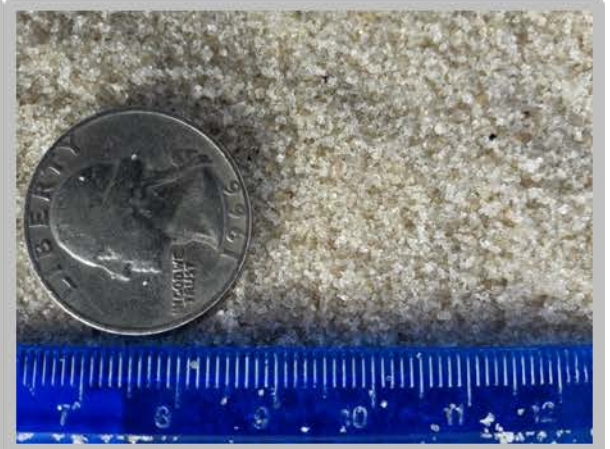
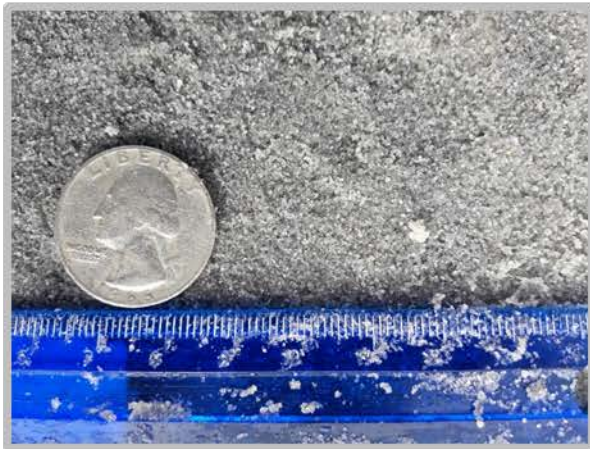
ENGINEER RESEARCH & DEVELOPMENT CENTER

DISCOVER | DEVELOP | DELIVER

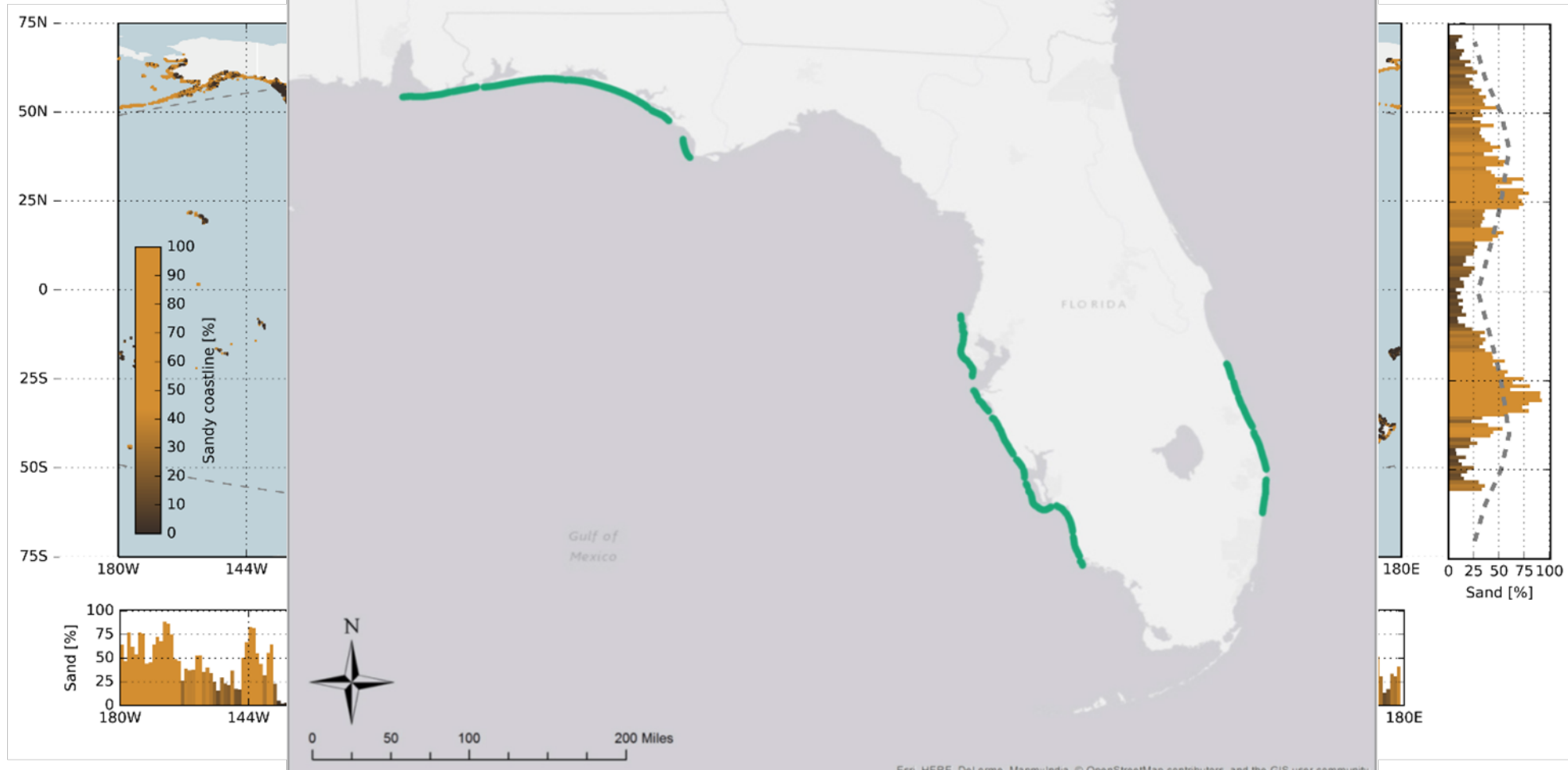
BLUF



National citizen scientist collected grain size database could enhance regional predictive capabilities and improve public engagement. Techniques were collaboratively investigated and appear promising.



Motivation



Depth of Closure for Large Regions from Airborne Lidar (Hartman and Kennedy, 2016)

Existing Efforts



CoastSnap

December 5 at 1:28 AM · 🌐

...ne analysis at Manly Beach indicates that there was 10m due to last week's storm. The red line shows the ...e as it was before the storm hit and the blue line ...st two days ago (after the storm). Both shorelines are

...nd Jenny Harley for the two CoastSnaps!

— 22/11/2018
— 03/12/2018

Nags Head:
- Ian Conery
- Kate Brodie



ons with iNaturalist.

Comment

Share



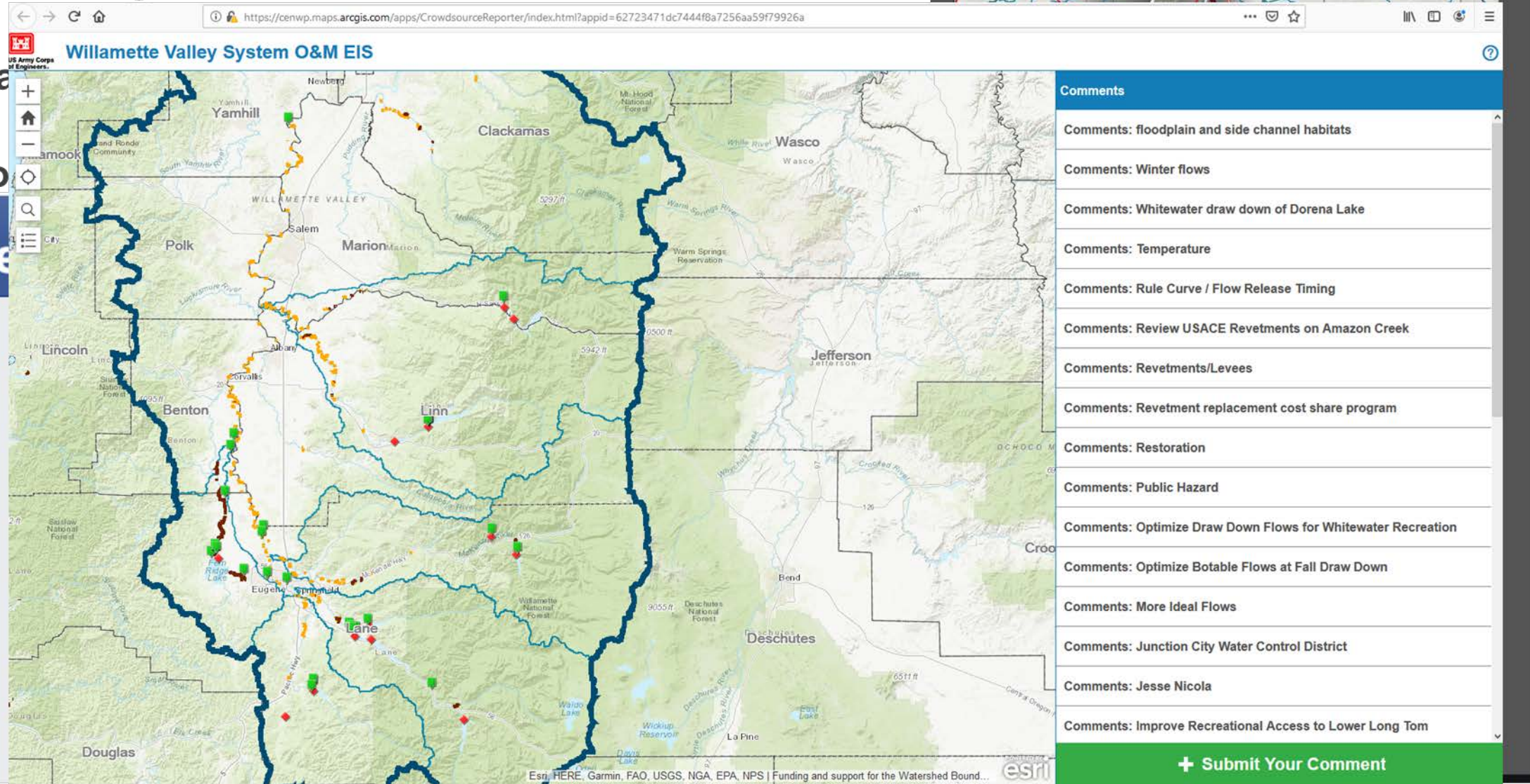
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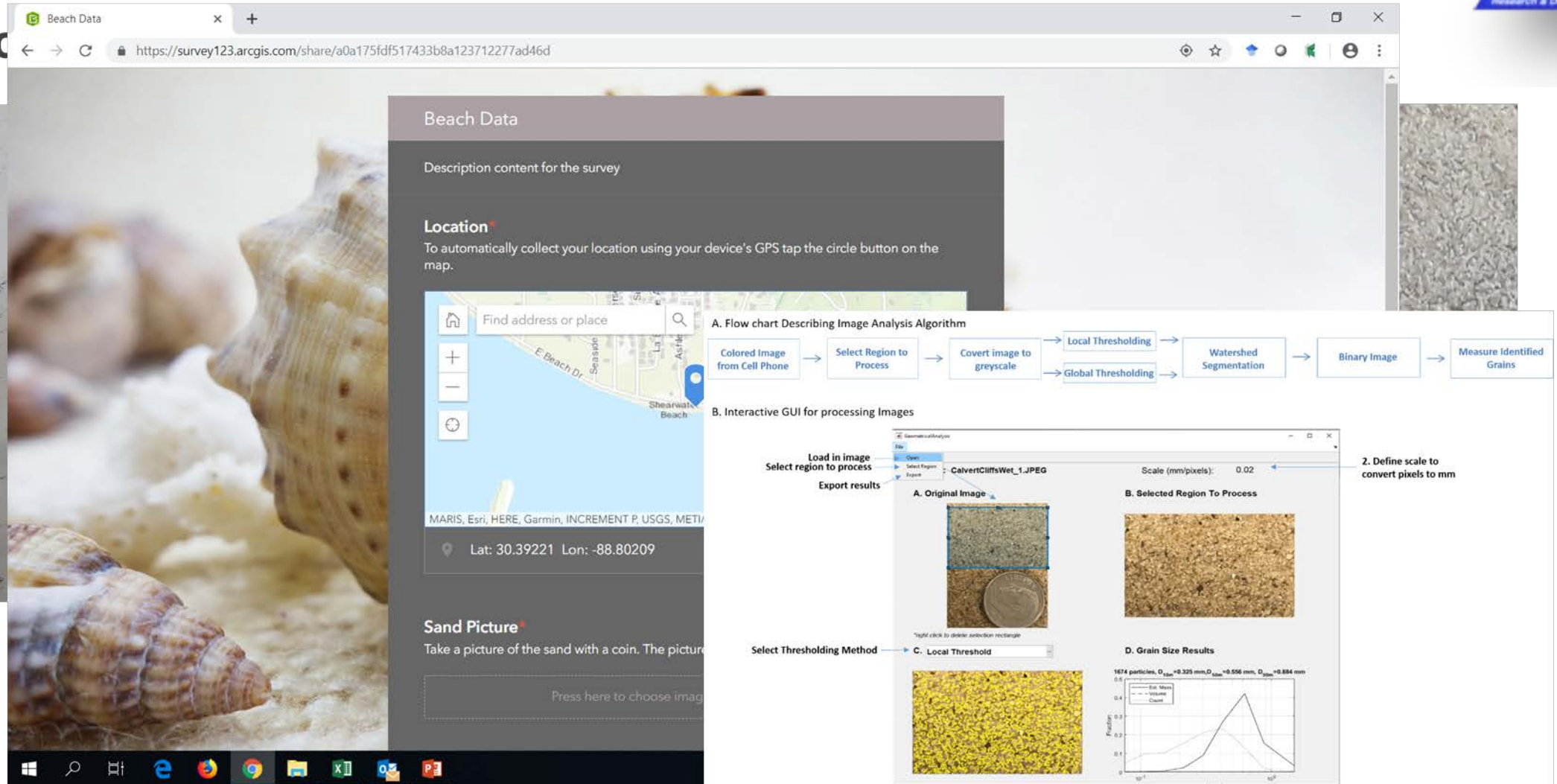
Existing Efforts

Colla
- Cro
face



Methodology and Methods Investigated

• Conc



Beach Data

Description content for the survey

Location*
To automatically collect your location using your device's GPS tap the circle button on the map.

Find address or place

E Beach Dr
Shearwater Beach

MARIS, Esri, HERE, Garmin, INCREMENT P, USGS, METI

Lat: 30.39221 Lon: -88.80209

Sand Picture*
Take a picture of the sand with a coin. The picture

Press here to choose image

A. Flow chart Describing Image Analysis Algorithm

```

    Colored Image from Cell Phone → Select Region to Process → Covert image to greyscale → Local Thresholding → Watershed Segmentation → Binary Image → Measure Identified Grains
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```

B. Interactive GUI for processing Images

Load in image
Select region to process
Export results

File
Open
Select Region
Export

CalvertCliffsWet_1.JPG

Scale (mm/pixels): 0.02

2. Define scale to convert pixels to mm

A. Original Image

B. Selected Region To Process

*right click to delete selection rectangle

C. Local Threshold

D. Grain Size Results

1674 particles, $D_{10}=0.325$ mm, $D_{50}=0.556$ mm, $D_{90}=0.884$ mm

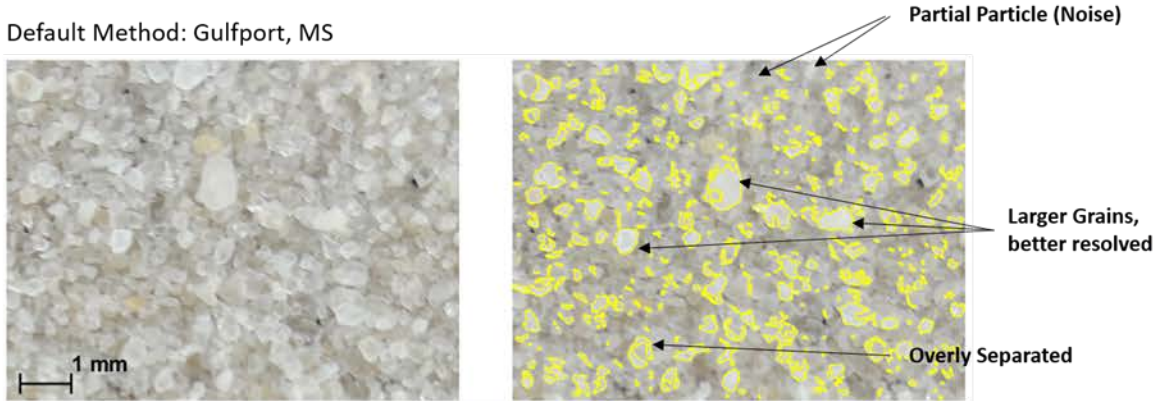
Fractal

Est. Mean
Volume
Count

Geometrical Analysis

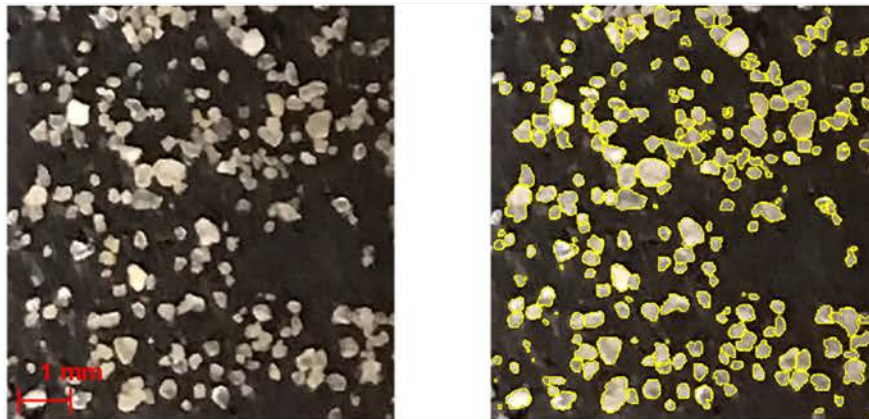


A. Default Method: Gulfport, MS



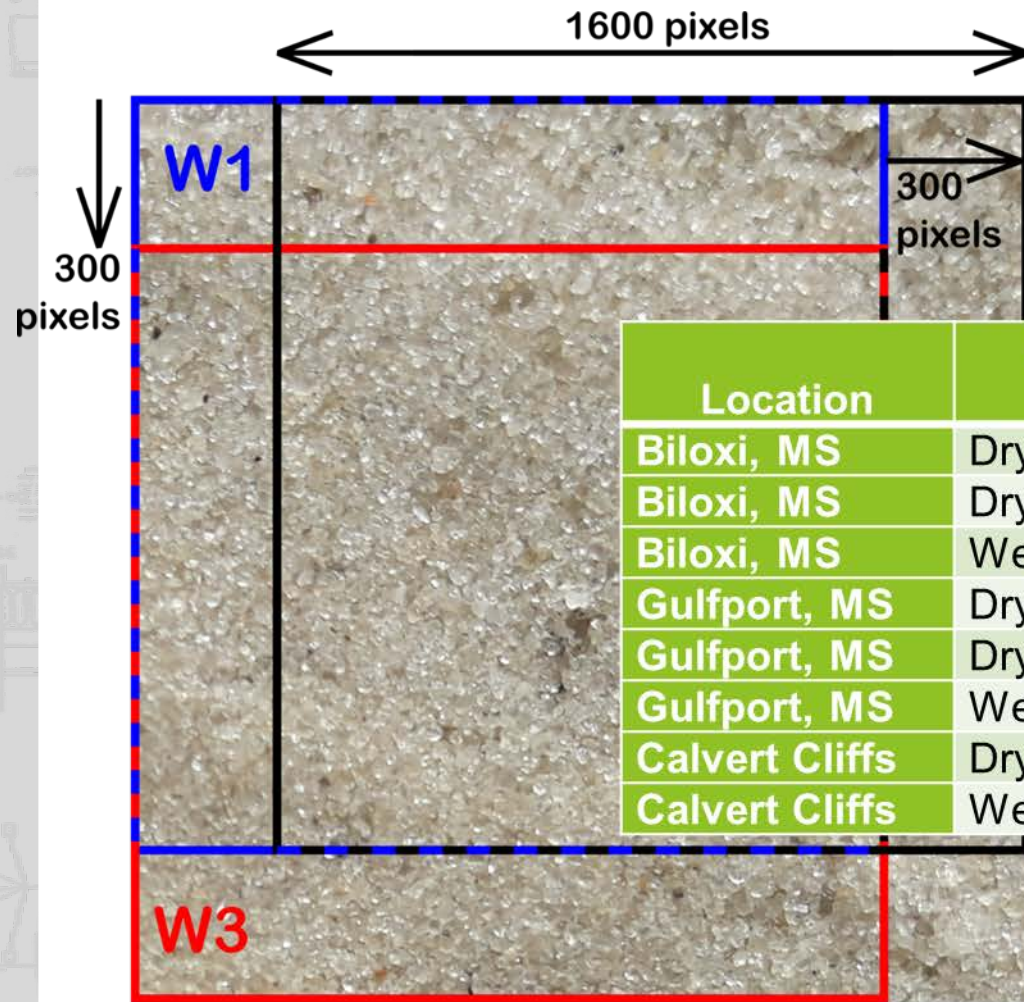
Beach Images				
Location	mm/pixel range	Image d_{50} (μm)	Sieve d_{50} (μm)	Percent error
Calvert Cliffs, MD	0.01-0.02	529 ± 7	405	30.5
Biloxi, MS	0.02-0.03	484 ± 17	293	64.9
Ocean Springs, MS	0.02	367	298	33.7
Gulfport, MS	0.01	317	531	-40.3

B. Method 2: Gulfport, MS



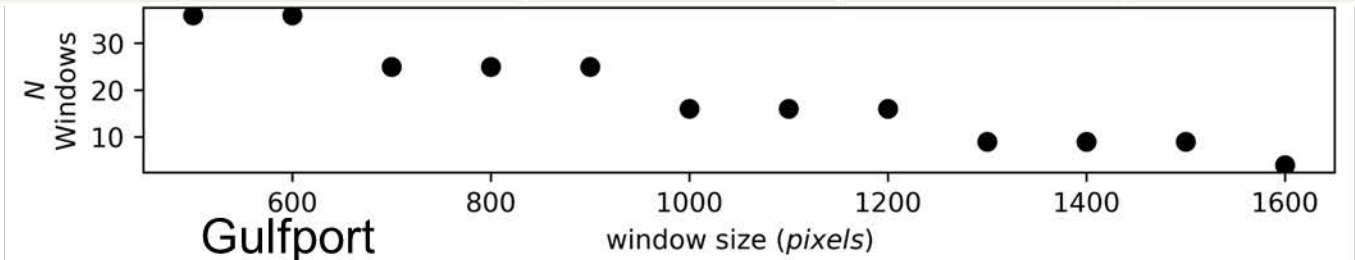
Separated Grains Images				
Location	mm/pixel range	Image d_{50} (μm)	Sieve d_{50} (μm)	Percent error
Calvert Cliffs, MD	0.01-0.03	506 ± 5	405	24.9
Biloxi, MS	0.01	304 ± 1	293	3.7
Ocean Springs, MS	0.01	302 ± 10	298	1.1
Gulfport, MS	0.01	442 ± 3	531	-16.8

Statistical Analysis



- Uses spectral techniques to determine spatial wave lengths
- Uses Morlet wavelet rather than Fourier-derived power spectrum
- Based on Buscombe (2013)

Location	Material state	mm/pixel range ($\times 10^{-2}$)	Image d_{50} (μm)	Sieve d_{50} (μm)	Percent error
Biloxi, MS	Dry	1.1 - 4.8	468	260	79.9
Biloxi, MS	Dry/Surface	1.4 - 4.2	367	268	36.8
Biloxi, MS	Wet	1.5 - 6.5	269	297	9.6
Gulfport, MS	Dry	1.3 - 3.7	286	265	8.1
Gulfport, MS	Dry/Surface	1.3 - 4.7	229	285	19.8
Gulfport, MS	Wet	1.5 - 1.4	338	443	23.6
Calvert Cliffs	Dry	1.7 - 5.0	484	306	58.4
Calvert Cliffs	Wet	1.3 - 4.4	630	411	53.2



Machine Learning Analysis

SediNet (Buscombe, 2019)

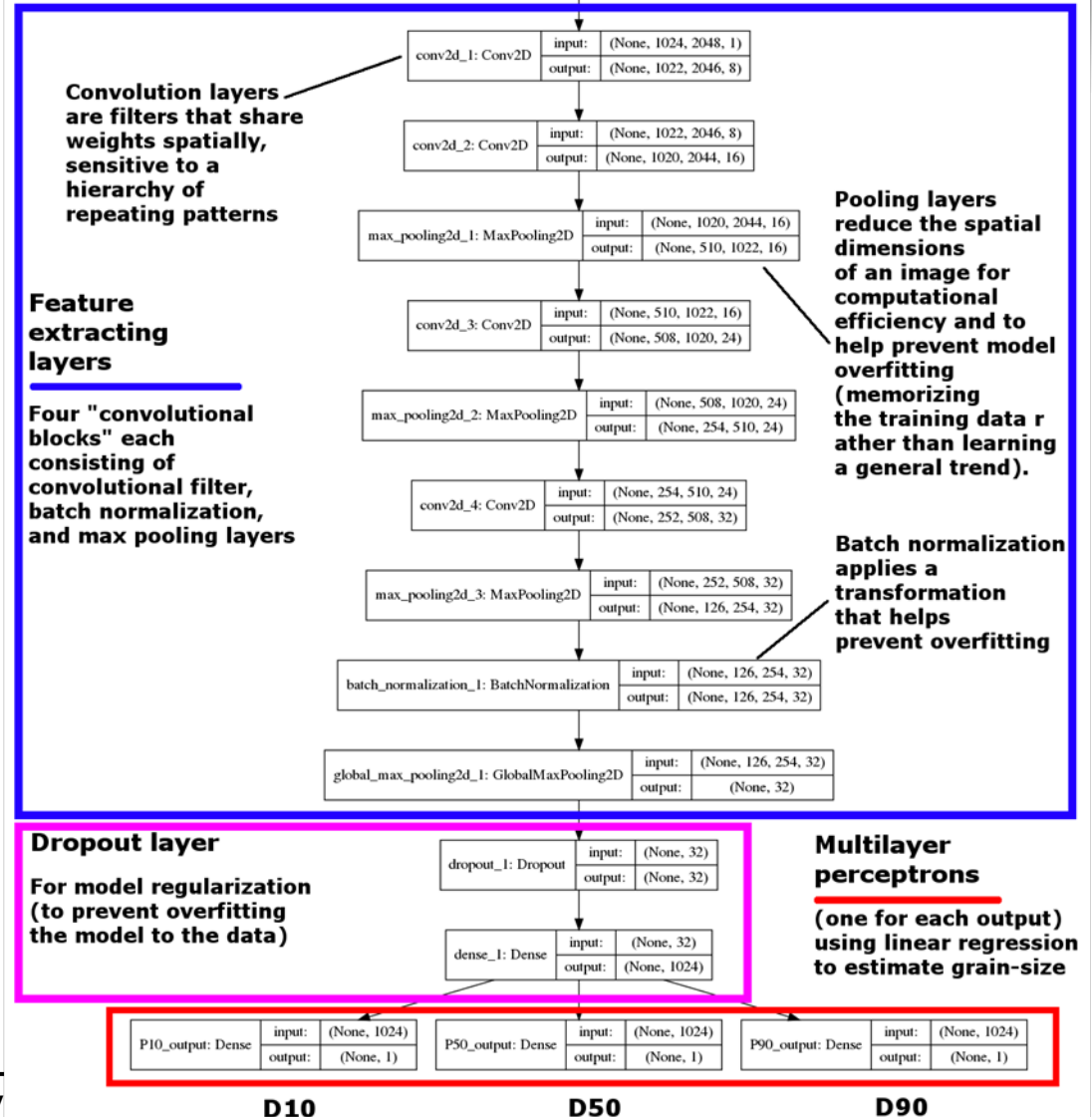
- Deep Neural Network Framework

- Numbers in input and output layers correspond to the size in pixels of the image features used by that layer.
- By the final layer, the information in the image has been reduced to a vector of length 1024 that is used to make grain size predictions.

Input image
(1024 x 1024 x 3 pixels)



SediNet model
for beach grain size

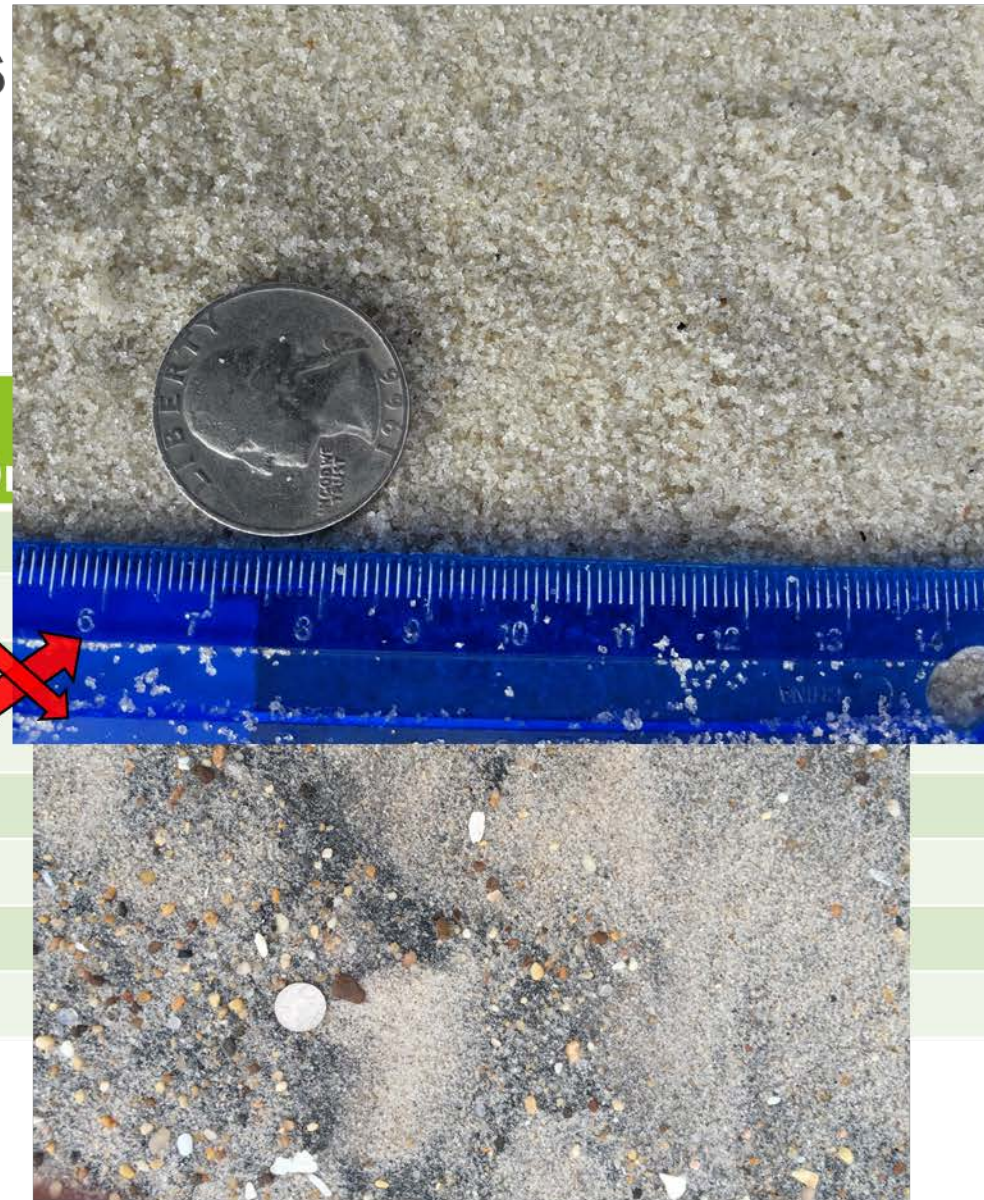


Machine Learning Analysis

- 63 Images
- Cropped to 1024x1024 pixels to Avoid Coin
- Flipped Horizontally
- Total of 517 Images



Site Name	
Assateague, MD	On
Biloxi, MS	
Calvert Cliffs, MD	
False Cape, VA	
Gulfport, MS	
Ocean Springs, MS	
Outer Banks, NC	
Total/overall:	



Mean error
in d_{50}

62.3 %

14.5 %

17.1 %

47.8 %

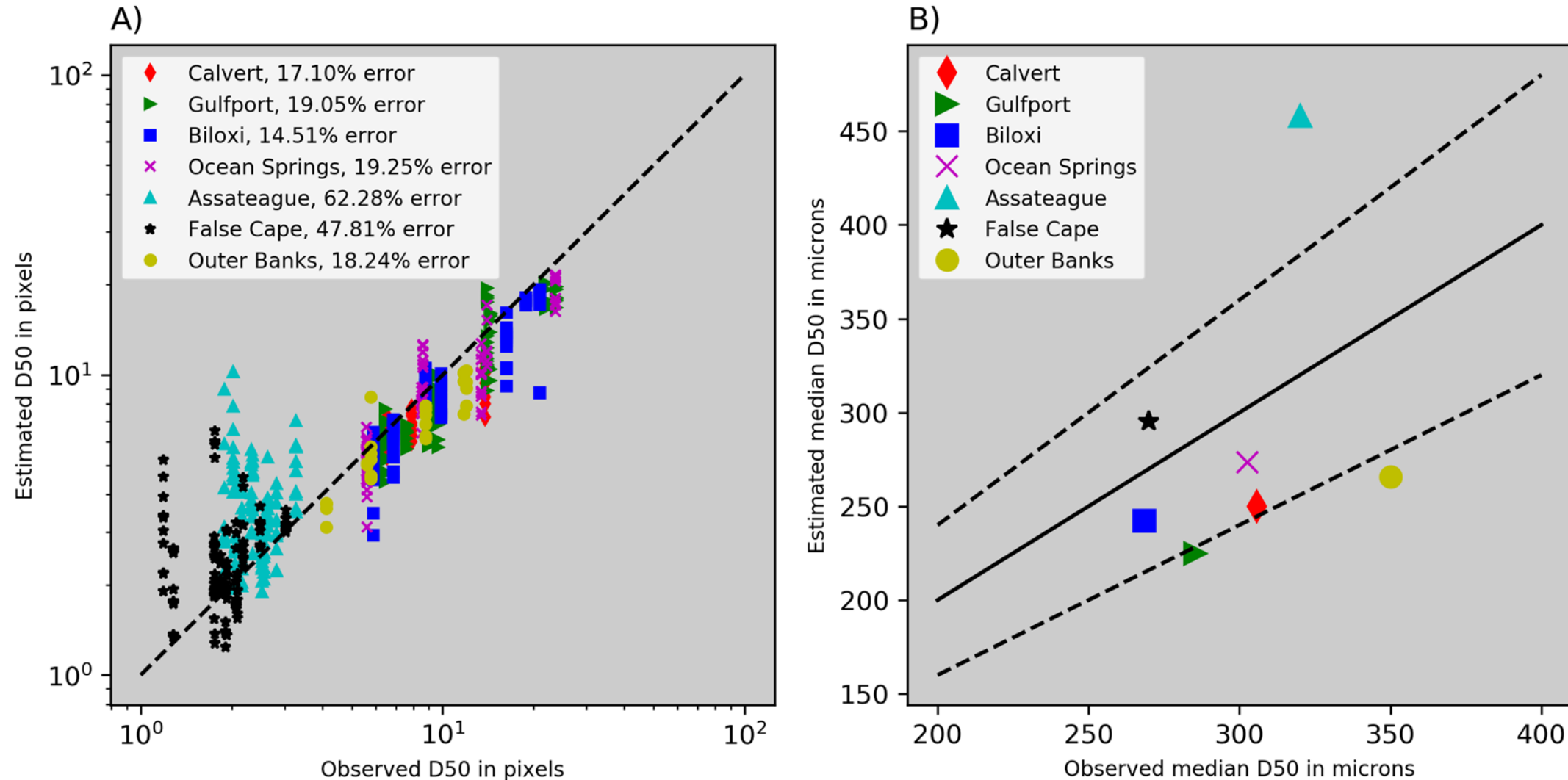
19.05 %

19.2 %

18.2 %

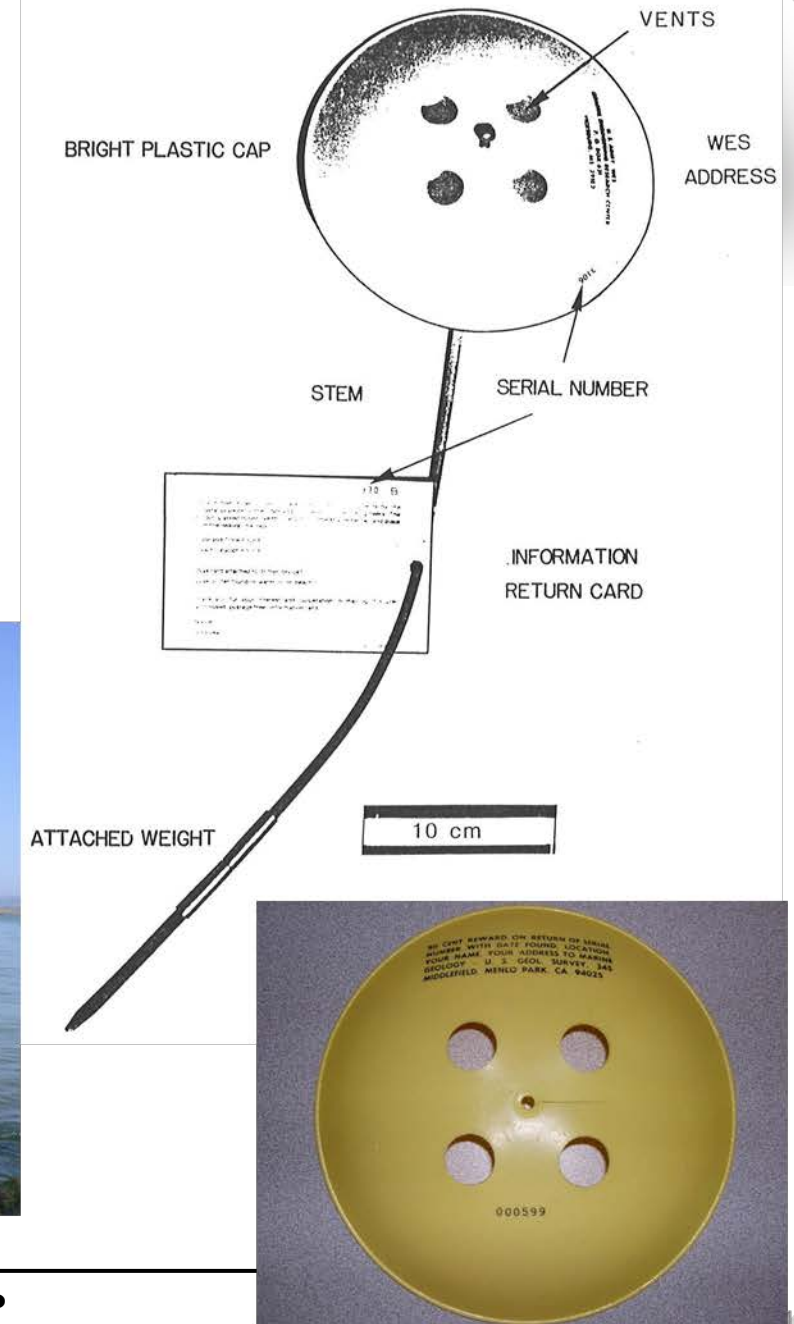
33.5 %

Machine Learning Analysis



Physical Shipment and Analysis

- Best Accuracy – Least Scalable
- Pre-paid Shipping Containers
- Very Useful in Combination with Images
 - Validate, Re-train, Improve Machine Learning



Path Forward

- We Created Sample Instructions
 - Tested with Non-Coastal Researchers
- Collect More Samples to Train
 - Have 21 more samples to test (Atlantic, Gulf of Mexico, Lake Michigan)
 - CHL Researchers Headed to Beaches
 - CWG Sample Request
 - Test with Coastal University
 - Test at State Park

Elementary School Teacher



School & Citizen Engagement



Opportunity to participate in an authentic research!

Next Generation Science Standards encourage educators and students to spend more time analyzing data (National Research Council 2012) and emphasizes:

- asking questions,
- planning and carrying out investigations,
- analyzing and interpreting data,
- using mathematical and computational thinking,
- constructing explanation,
- engaging in argument from evidence, and
- obtaining, evaluating, and communicating information



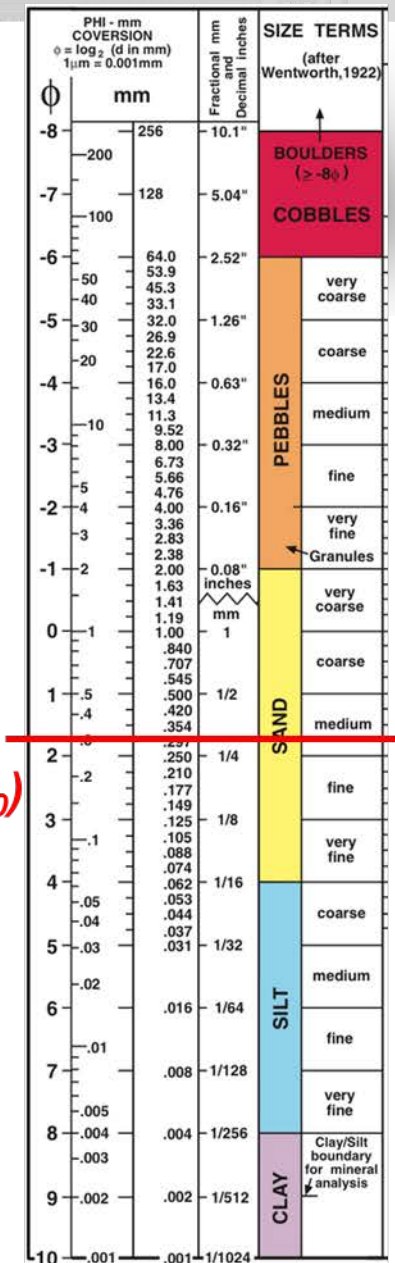
Students could test relationship between grain size and wave conditions or width of continental shelf

Future Work

- **IS THIS TECHNICALLY FEASIBLE? – YES!**
- **School and Community Engagement**
 - Phase 1: University students, Identified State Parks, Coastal Districts
 - Phase 2: Promote at conferences: ASBPA, GSA, etc. and promote with nature-centric groups: Master Naturalist Association, Audubon Society, Coastal State Parks
- **App or Website Creation**
- **Identify Storage Location and Data Access (Link with SAGA?)**
- **Identify Best Ways to Keep Citizens Engaged:**
 - Reply Email with Results from Photo
 - Online Scoreboard for Most Submissions



*Your Sample's
Median Size (d_{50})*



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What science could you do
with **10,000** volunteers?

Goddard
SPACE FLIGHT CENTER Citizen Science Task Group