An Application of Microtopography: Using UAS LiDAR to Quantify Burrowing Shrimp Mounds in Willapa Bay

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Background

- Tidal mudflats in Willapa Bay contain aquaculture operations (oysters/clams)
- Burrowing shrimp create burrows and mounds in mud that liquefy it
- Can cause shellfish to sink into mud and die
- Shrimp are native but populations have grown
- Better understanding of shrimp population number is needed to assess impacts of removing shrimp or letting them multiply unchecked
- Quantifying shrimp mounds can serve as proxy for shrimp population
- Using UAS for this would reduce cost/increase availability of data

Shrimp Mound

Goals and Research Question

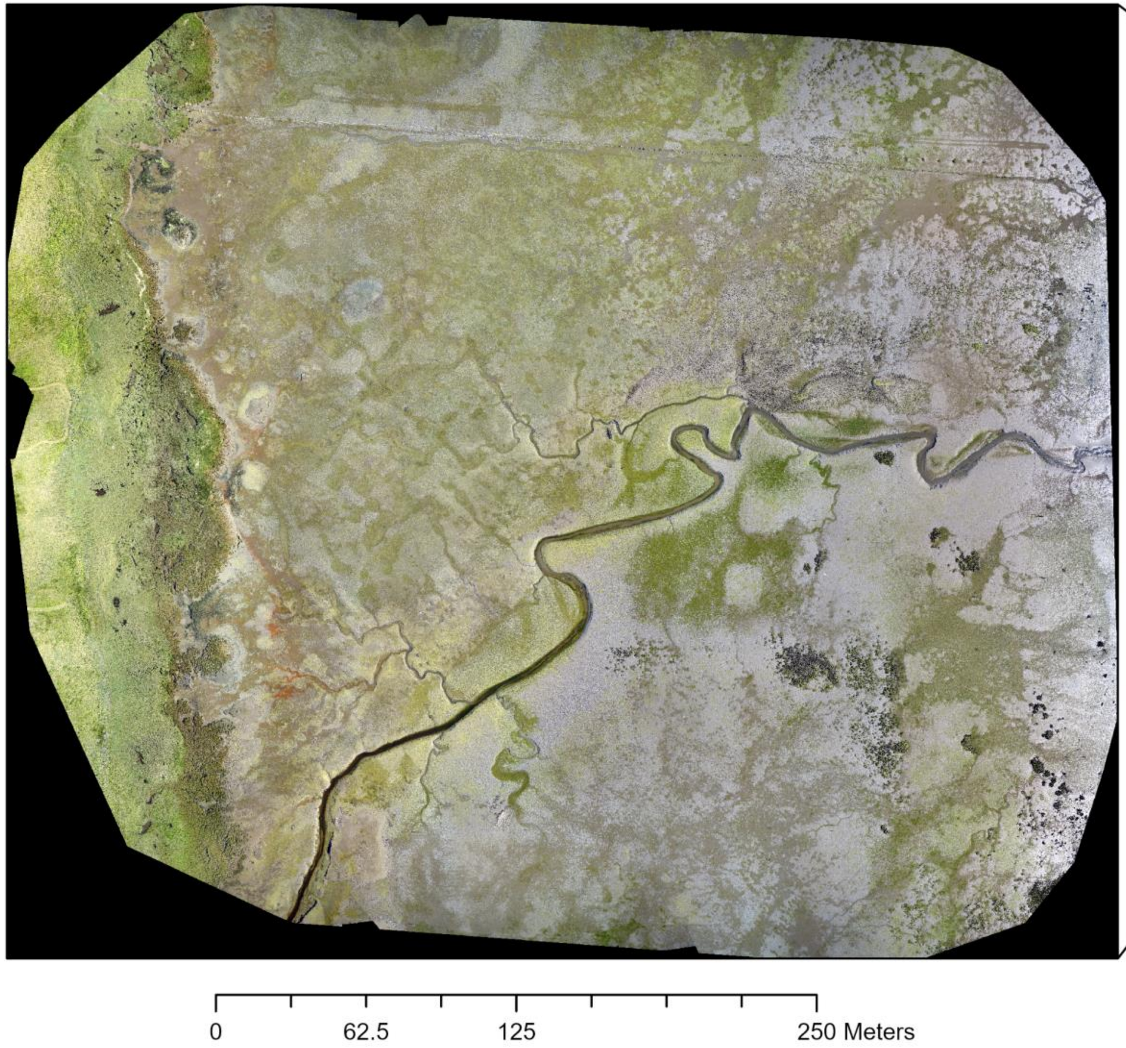
Overarching research goal:

Develop a method to quantify burrowing shrimp mounds using UAS remote sensing, including LiDAR as well as RGB and hyperspectral imagery.

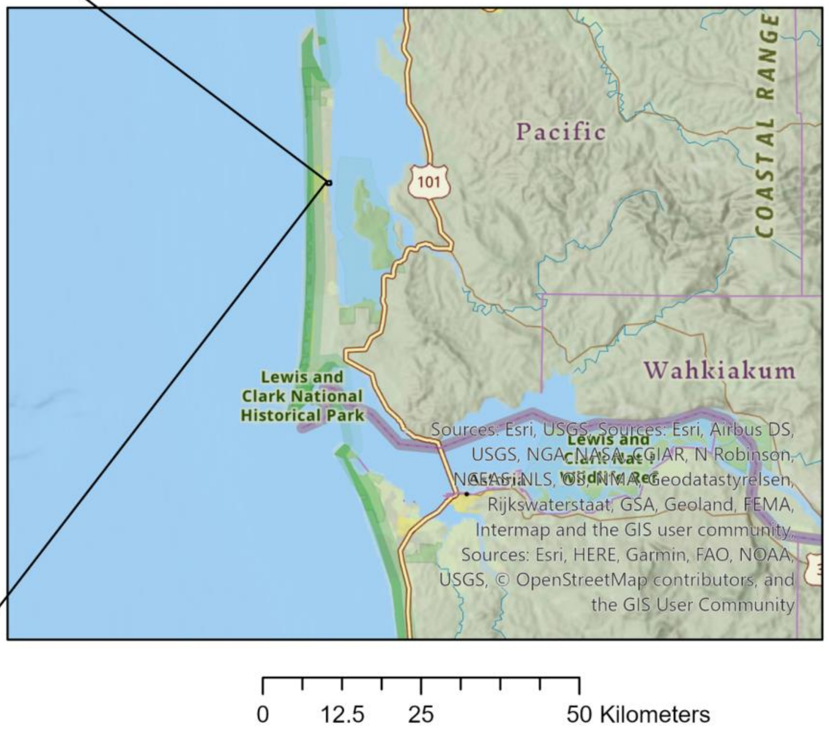
Research question for this project:

Can shrimp mounds be detected and quantified using the high-resolution LiDAR data collected?

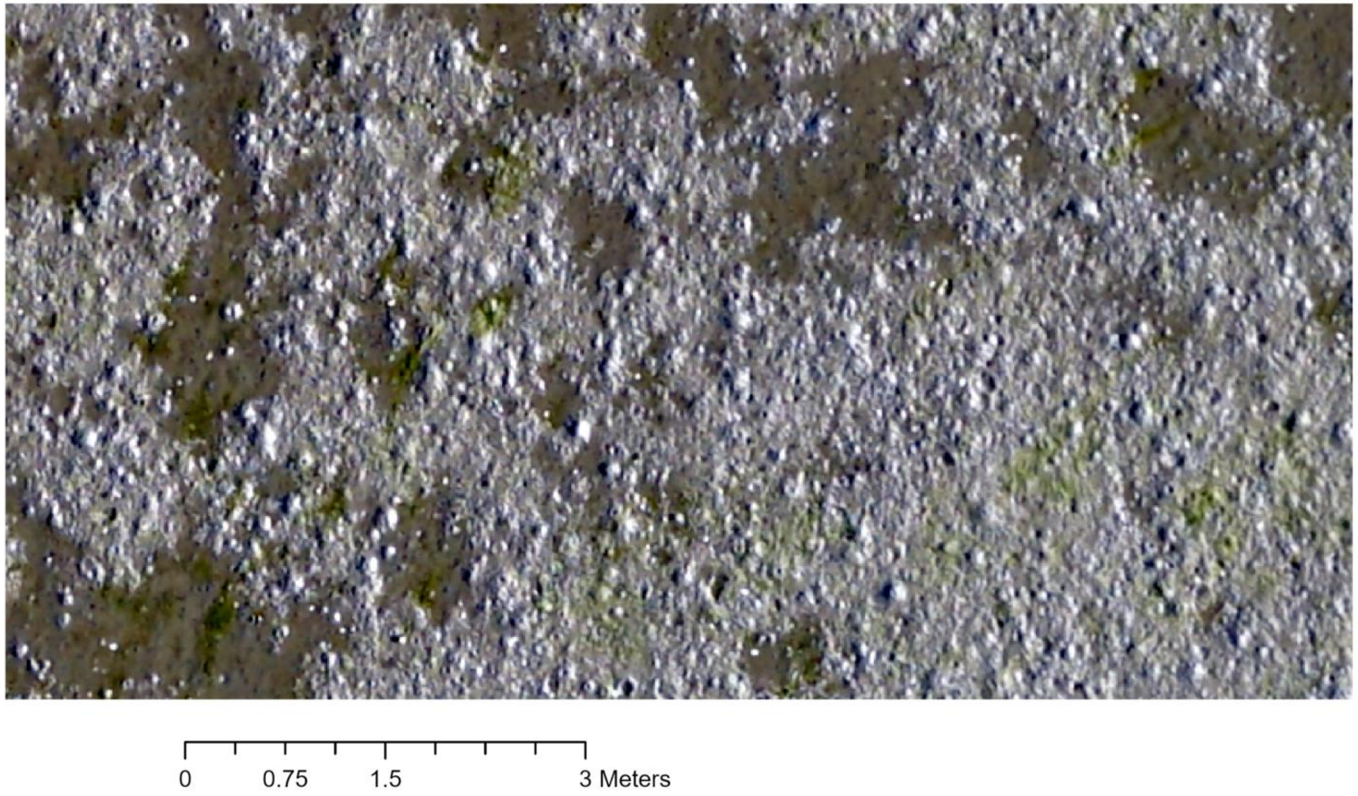
Data Coverage Area

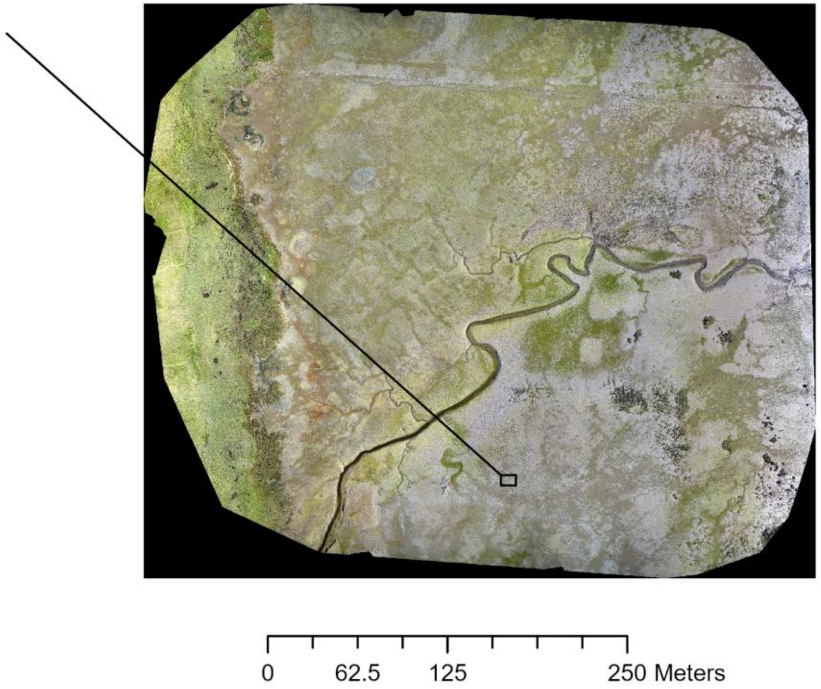


Nahcotta on
Willapa Bay



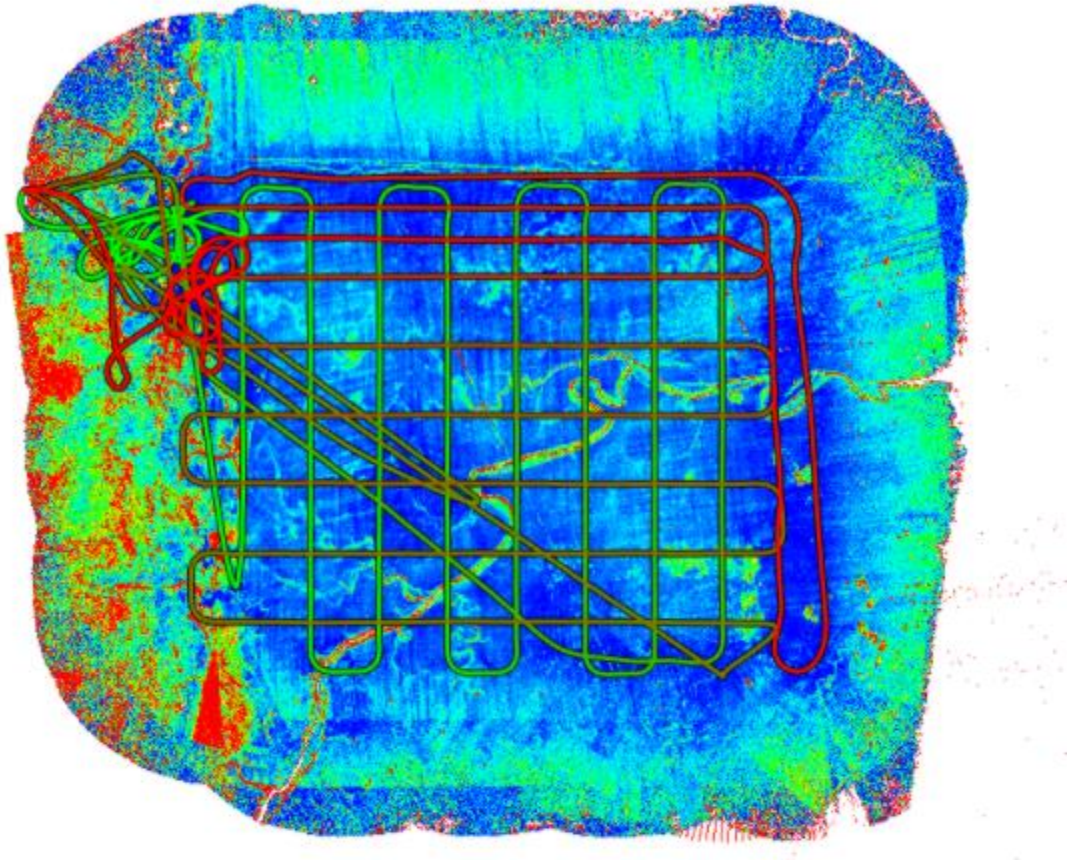
Study Area for Current Project





Data

- 5 return UAS LiDAR point cloud
  - ➢Average point spacing ≈ 4 cm
- RGB UAS imagery
  - ➢1.33 cm pixel size
- Data collected on 6/23/2020



LiDAR flight path

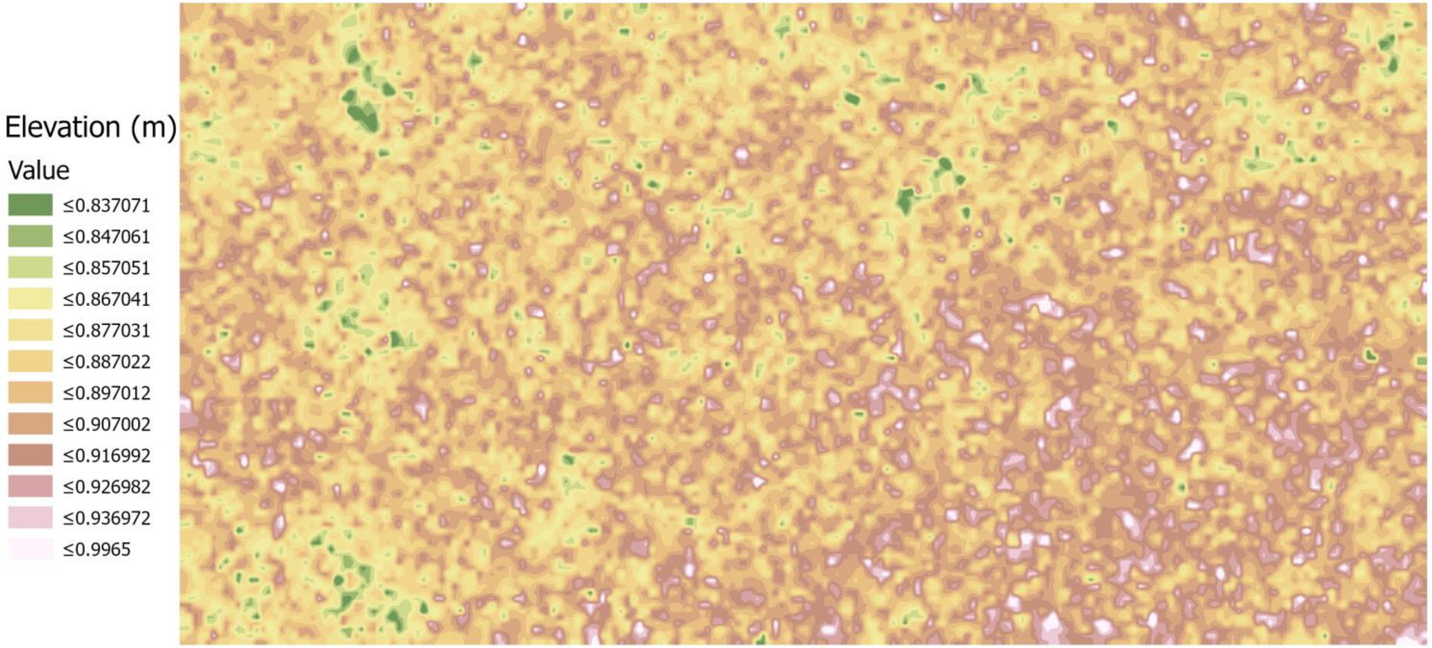
Drone used for LiDAR and the operators

Methods

- Produce DSMs by various interpolation methods and compare
  - ➢Final result was a 5 cm raster DSM produced using kriging
- Visually/qualitatively assess whether mounds are distinguishable
- Apply a variety of algorithms/filters to attempt to classify mounds
  - ➢Final result used SAGA GIS vertical distance to channel tool along with a threshold
- Calculate mound density and compare with ground data (insofar as possible)

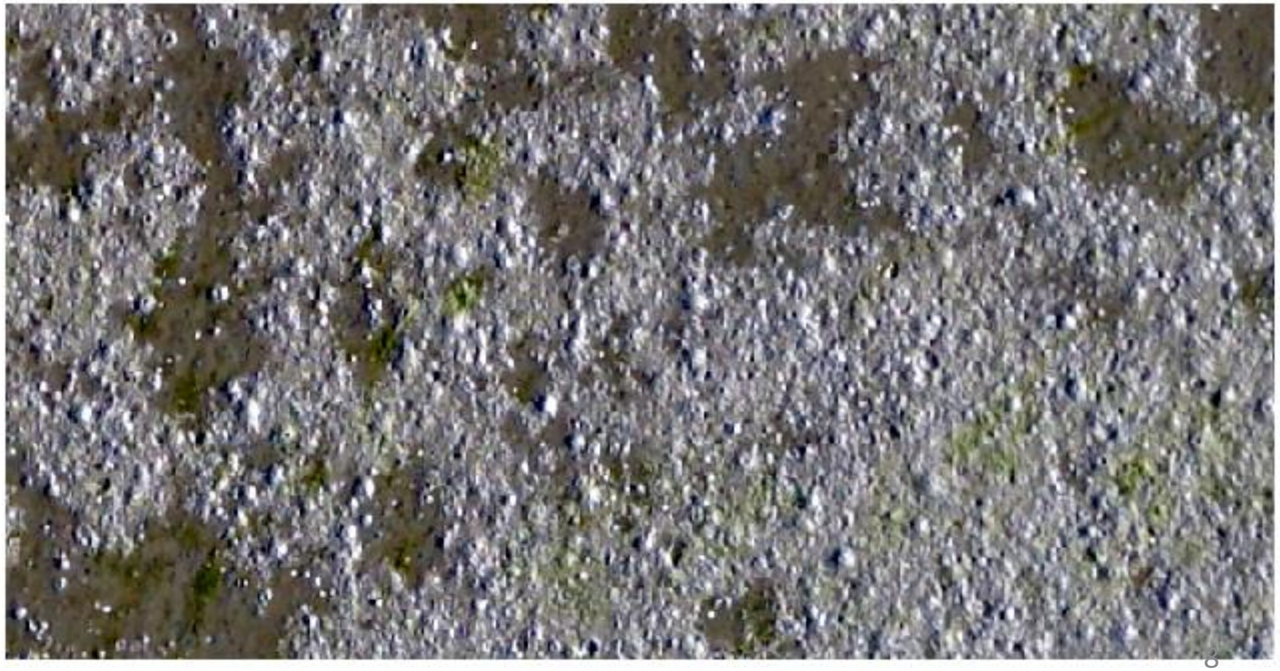
DSM Production

Kriging 5 cm Resolution



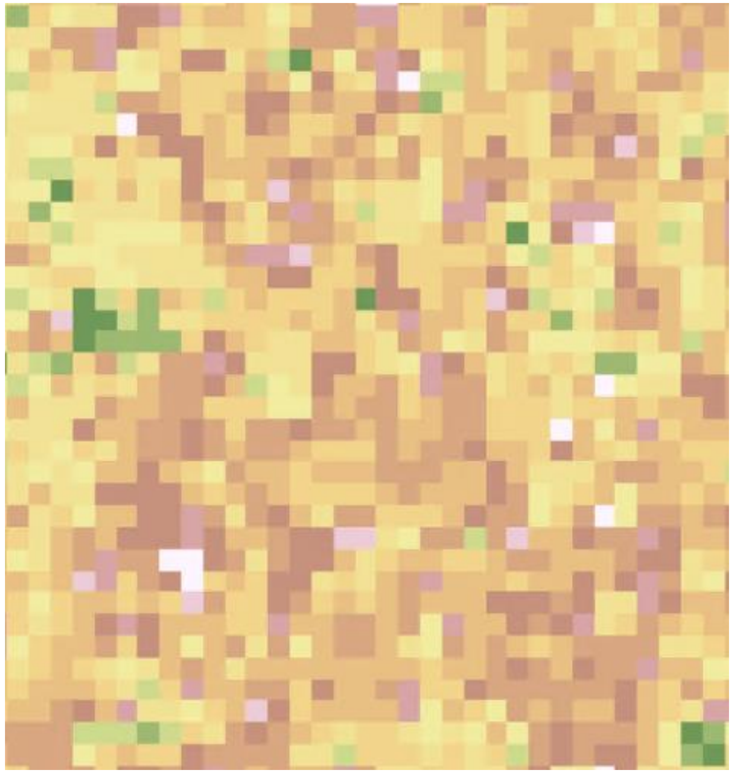
- Tried multiple methods
  - Spline
  - IDW
  - TIN
- Tried multiple resolutions and parameters for each method
- Kriging had best visual results
- Issues with identifying mounds in some areas where surrounding ground is higher

True Color Image



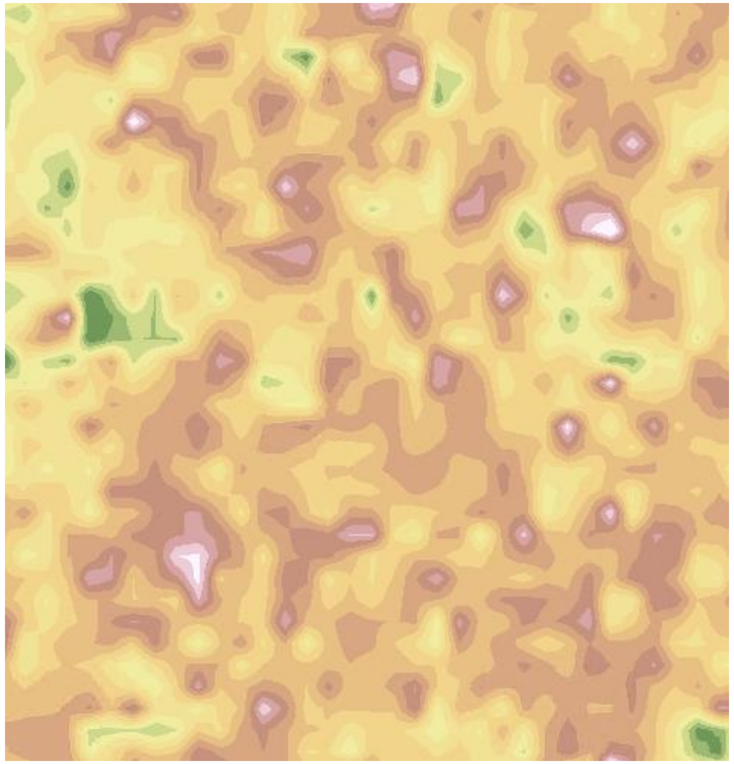
ArcGIS Interpolation Surface Display

Raster after Exporting



Same Rasters!

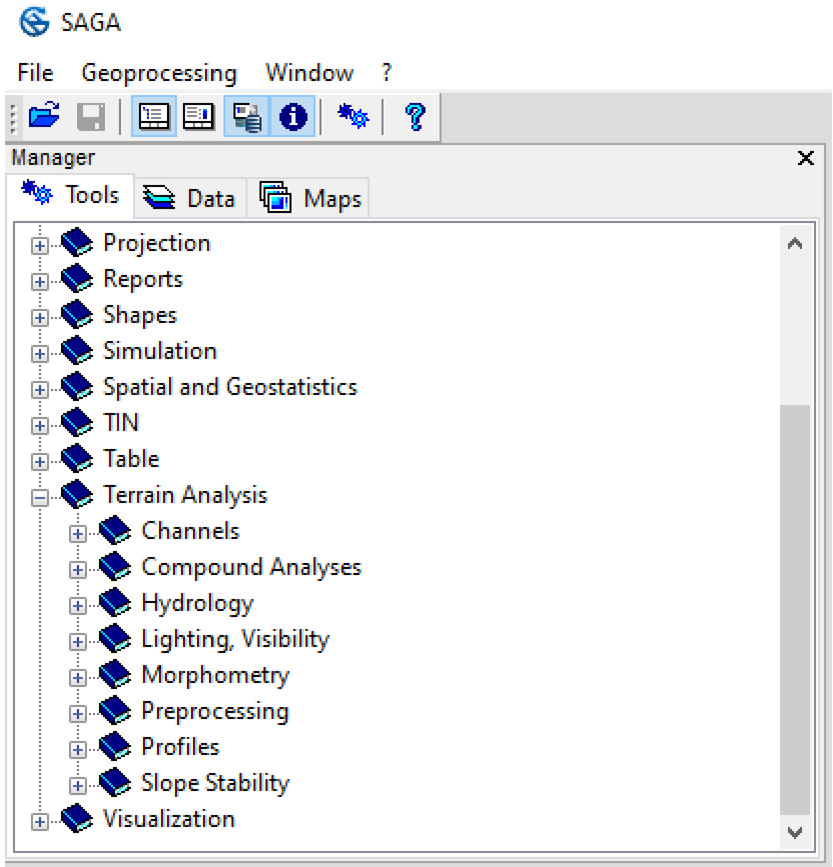
Raster as Displayed after Running Tool



- ArcGIS seems to display full continuous surface initially (right), with sub-pixel detail
- Can be misleading if you do not realize it
- Actual raster resolution is shown on left
- All analysis done on raster will be at the resolution of the left image

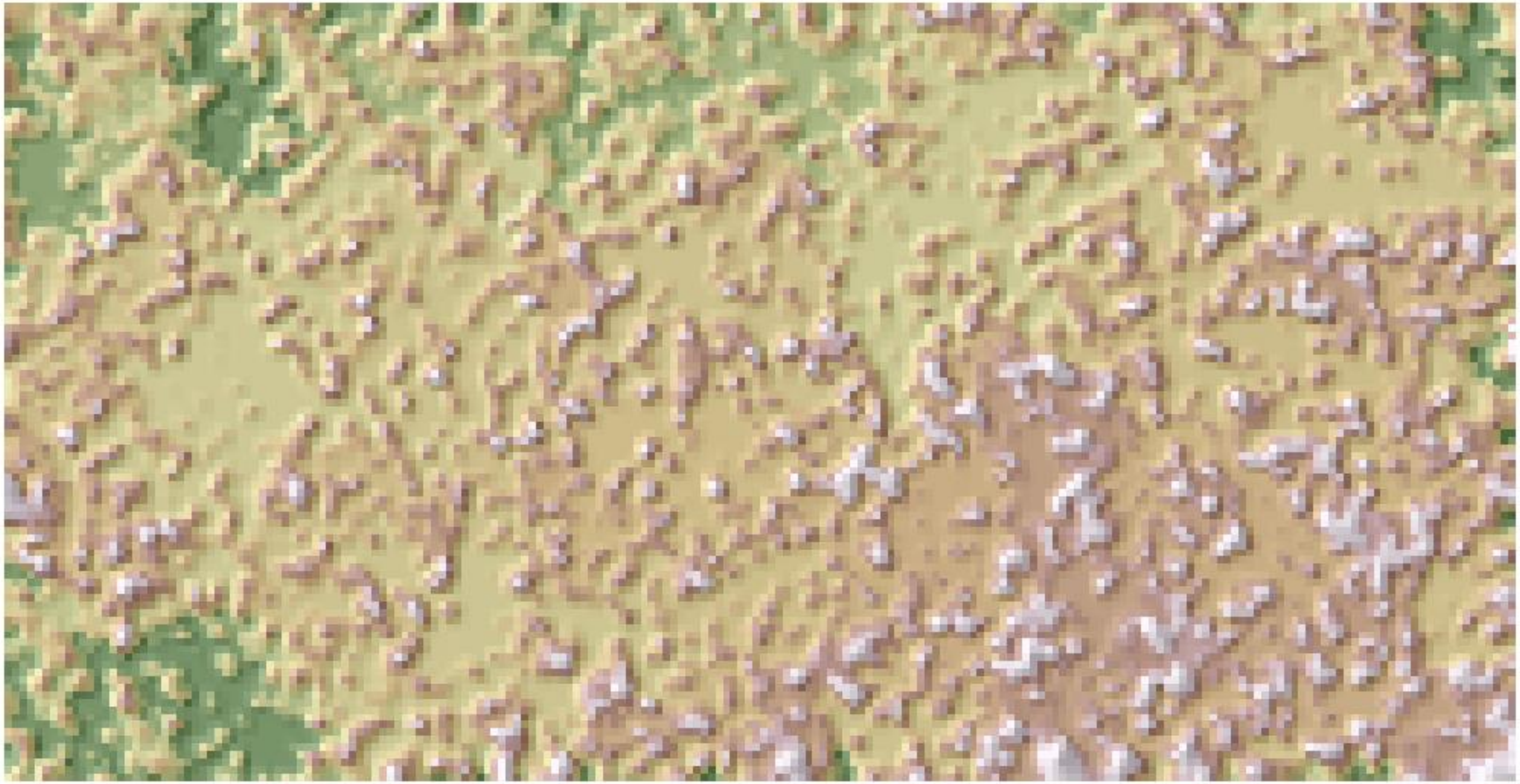
Isolating Mounds

- Several tools tried:
  - Focal statistics & map algebra to identify relief
  - Kernel filters
  - Texture analyses
- Most effective seemed to be hydrologic tools
- Makes some sense, since these are tidal flats and terrain is constantly affected/shaped by water



I ended up using some SAGA GIS algorithms

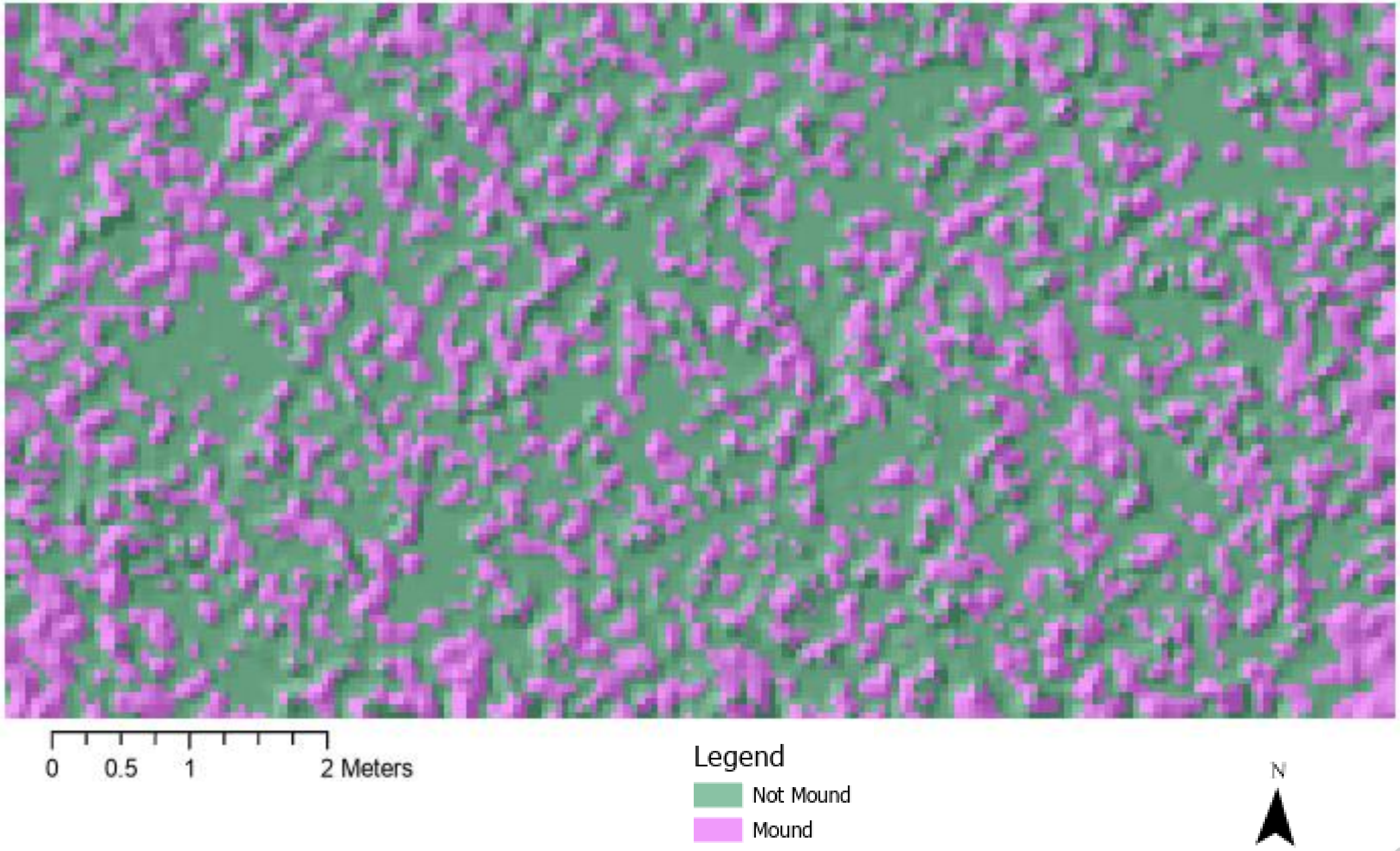
Sinks Removed DSM with Hillshade



- Areas without mounds are more clearly distinguishable
- Relative relief more apparent (e.g. in SE)
- Used SAGA GIS Wang & Liu algorithm

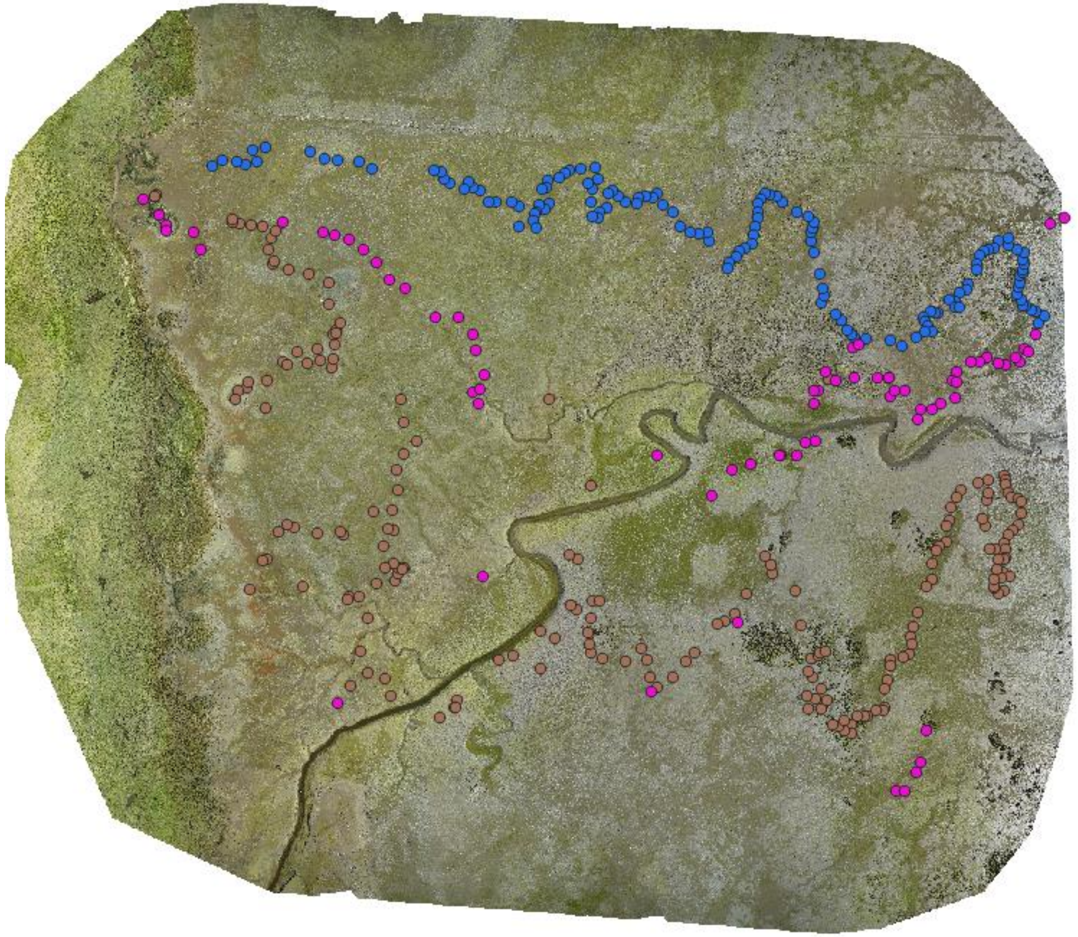
Vertical Distance to Channel Network

- SAGA GIS Tool
- Calculate channel network first
- Then vertical distance from that network
- Then used Reclassify tool to implement threshold and identify mounds as those above threshold



Quadrats

A Quadrat



Quadrat Points

Quantification and Validation

- Density/percent cover of shrimp mounds identified by this process can be calculated
  - Mound cells/total cells
- Validation is difficult without comprehensive ground truth data
- Have some ground truth – quadrat observations were made throughout site and mounds were counted
- Using an approximate average shrimp mound size, density value can be derived
- But very sensitive to radius of mound chosen – difficult to determine average radius precisely

Quadrat Area (cm^2)	Number of Quadrat Samples	Average Number of Mounds per Sample	Mound Percent Cover From LiDAR
625	100	6.35	37.5

Quadrat Sample Coverage and Comparison

Average Mound Radius (cm)	Mound Percent Cover	LiDAR Percent Difference
3	28.7	+30.5
3.5	**39.1**	**-4.1**
4	51.1	-26.6
4.5	64.6	-42.0
5	79.8	-53.0

Conclusion and Future Direction

- Many mounds are individually identifiable with LiDAR data, but several are not, especially small ones
- Quantification of density more achievable than actual mound count
- Accuracy seems potentially reasonable but uncertain. Requires more ground truth or other reference data to assess with confidence
- Variety in shrimp mound size and uneven spatial distributions add difficulty
- Classification using the RGB imagery and/or the hyperspectral imagery—possibly in conjunction with terrain analysis—shows promise

Acknowledgments

- Funding for this work, including data acquisition, was provided by NOAA UAS
- My participation in the work is as an intern at PNNL

Me in the field (different site but same overall project)

References

- Shrimp/oyster overview media articles
  - https://beyondpesticides.org/dailynewsblog/2019/10/agreement-protects-willapa-bay-and-the-willapa-national-wildlife-refuge-from-highly-toxic-neonicotinoid-pesticides/
  - https://www.opb.org/news/article/washington-willapa-bay-oysters-ghost-shrimp/
  - https://www.seattletimes.com/seattle-news/environment/back-to-the-drawing-board-for-control-of-oyster-killing-shrimp/
- SAGA GIS Tools
  - http://www.saga-gis.org/saga_tool_doc/2.1.3/ta_preprocessor_4.html
    - Fill Sinks
  - http://www.saga-gis.org/saga_tool_doc/2.2.0/ta_channels_0.html
    - Channel Network
  - http://www.saga-gis.org/saga_tool_doc/2.2.0/ta_channels_3.html
    - Vertical Distance to Channel Network

Questions?