Analyzing the Future of Ecologically Based Coastal Defenses in Two Case Study Cities, Newport News Virginia and Charleston South Carolina

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Saltmarsh

SPECIES: A wide variety of coastal grasses, include saltmarsh cordgrass (Spartina alterniflora), salt hay (Spartina patens), giant cordgrass (Spartina cynosuroides), and saltgrass (Distichlis spicata)

CLIMATE: Saltmarshes can tolerate average temperatures above 0 Celsius and average winter temperatures below 20 Celsius(Zedler et al, 2008). These climatic conditions are present in both case study cities and should be present under even the most severe climate change scenarios through 2100.

DEFENSIVE UTILITY: Saltmarsh defensive utility increases with cross shore width of marshland, peaking at an 80% reduction in incoming wave energy with 160 m of wetland under ideal conditions (Möller et al, 2002).

Oyster Reefs

SPECIES: We're looking at the Eastern Oyster (Crassostrea virginica) the most common oyster species on the North American Atlantic coast.

CLIMATE: Eastern oysters can tolerate temperatures between -2 and 38 Celcius (Marshall et al, 2021) and salinities between 15 and 30 ppm (Hijuelos et al, 2017). These climatic conditions are present in both case study cities and should be present under even the most severe climate change scenarios through 2100.

DEFENSIVE UTILITY: Oyster defensive utility increases as the depth of water the oyster lives in decreases. This peaks at a 50% reduction in incoming wave energy with a near surface oyster reef in less than 0.5 m of water (Wilberg et al, 2019).

Mangroves

SPECIES: We are looking at the Black Mangrove (Avicennia germinans), the most cold resistant of the United State's three extant mangrove species.

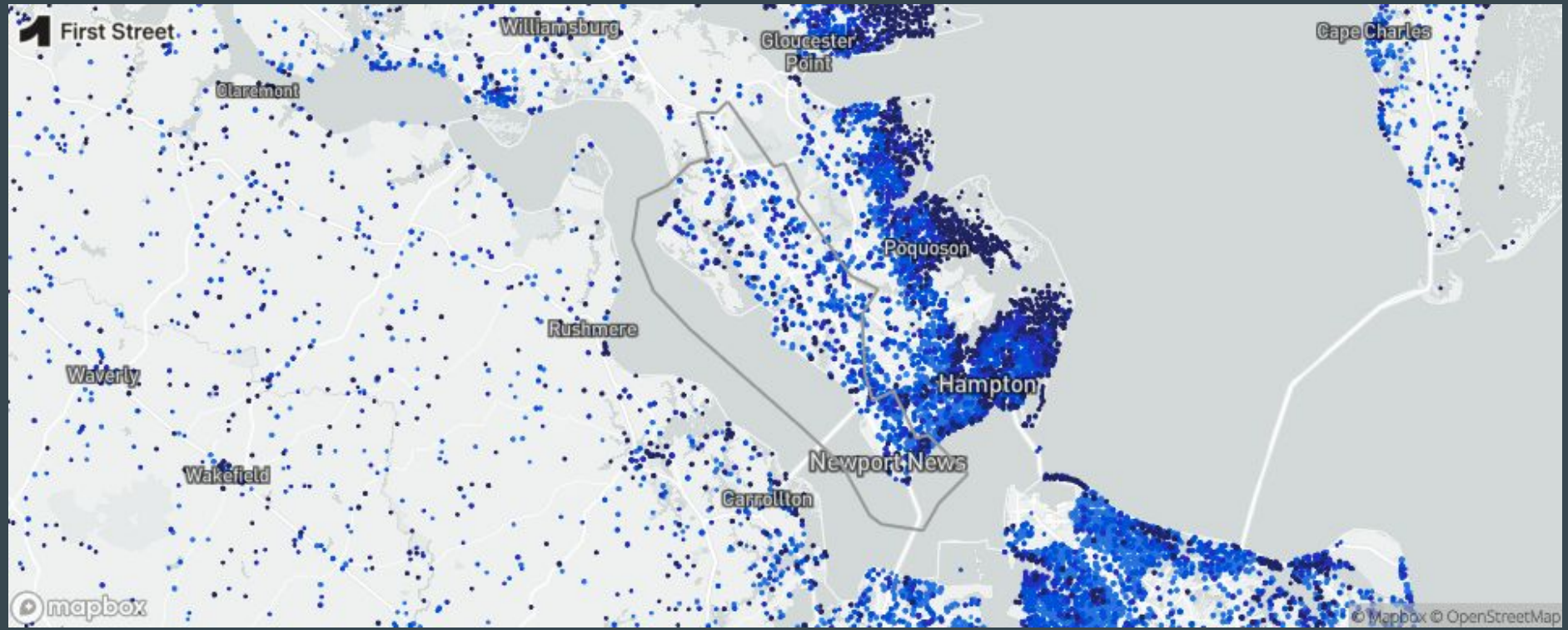
CLIMATE: Avicennia reqiore temperatures above 19 Celsius (University of Florida). These climatic conditions are beginning to be present in Charleston, SC and may be present in Newport News, VA by the end of the century under more extreme climate change scenarios.

DEFENSIVE UTILITY: Mangrove defensive utility increases with cross shore width of marshland, peaking at a 92% reduction in incoming wave energy with 50 m of mangroves under ideal conditions (Herison et al, 2024)

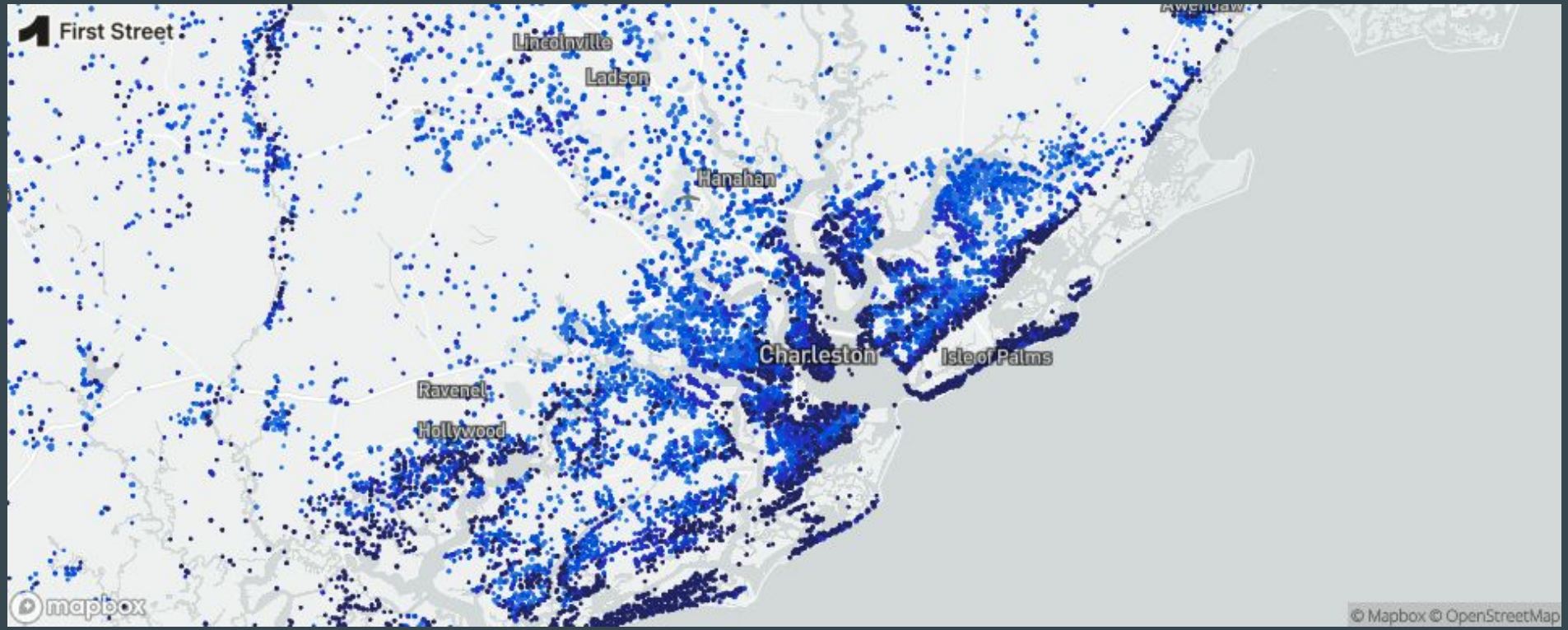
Case Study Cities

- Newport News, VA
  - Largest shipyard in the United States
  - Population of 183,000
  - Newport News is currently at a moderate risk of flooding, with 24% of properties at risk over the next 30 years (First Street).
  - Newport News currently primarily experiences flooding during notable storms (First Street)
- Charleston, SC
  - Population of 155,000
  - Charleston is under extreme flood risk, with 77% of properties at risk over the next 30 year (First Street).
  - Average of 60 flood events per year in Charleston Harbour from 2015-2024
  - Average of 4 flood events per year in Charleston Harbour from 1965-1974 (NWS)

Newport News, VA Flood Risk Map from First Street



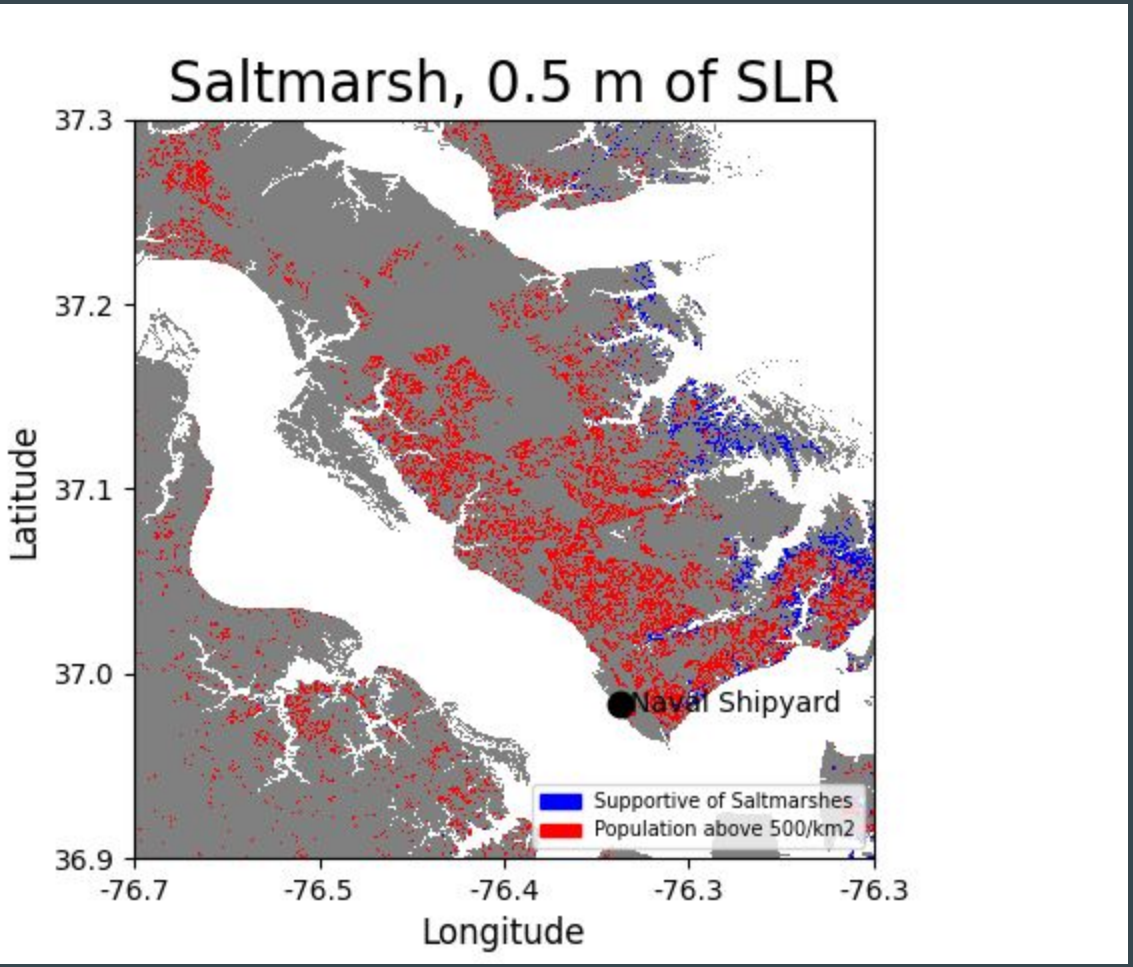
Charleston, SC Flood Risk Map from First Street

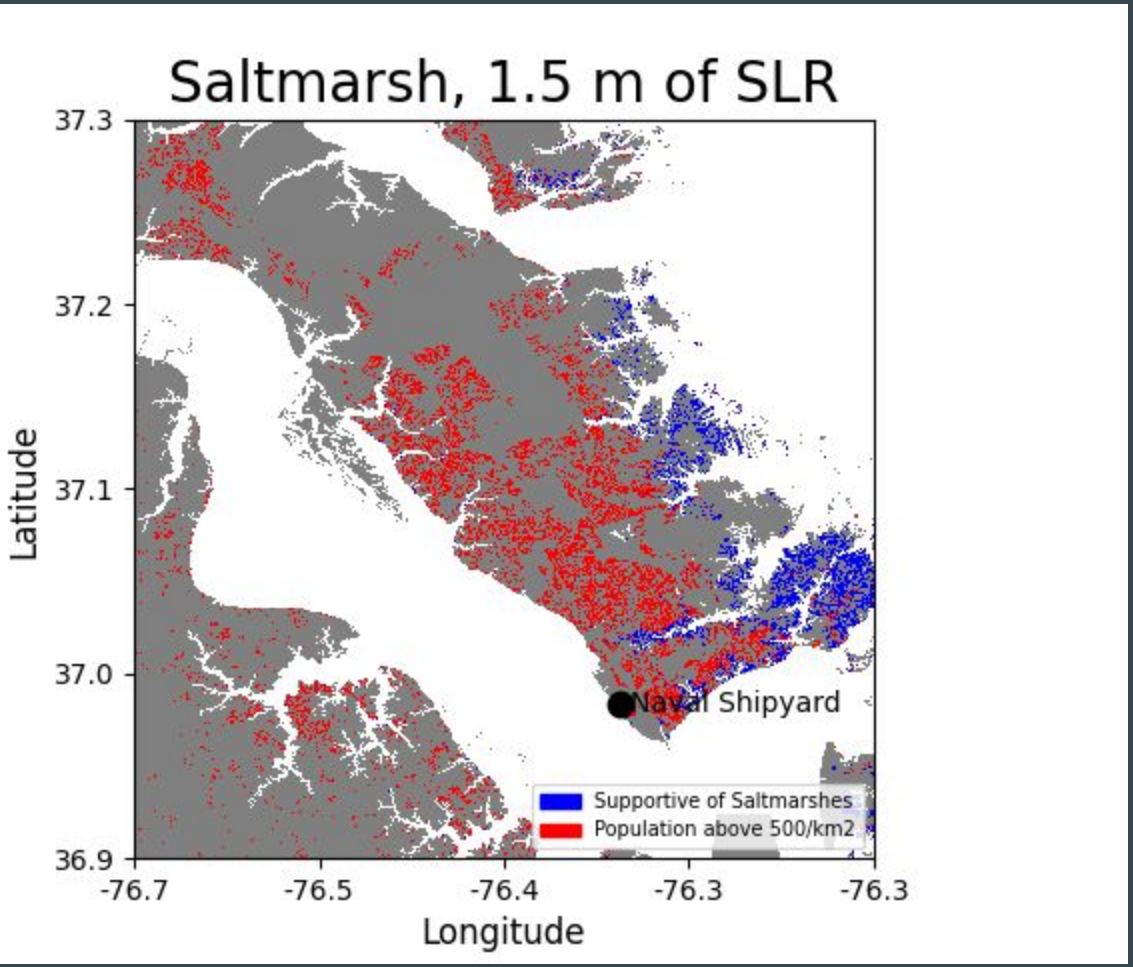


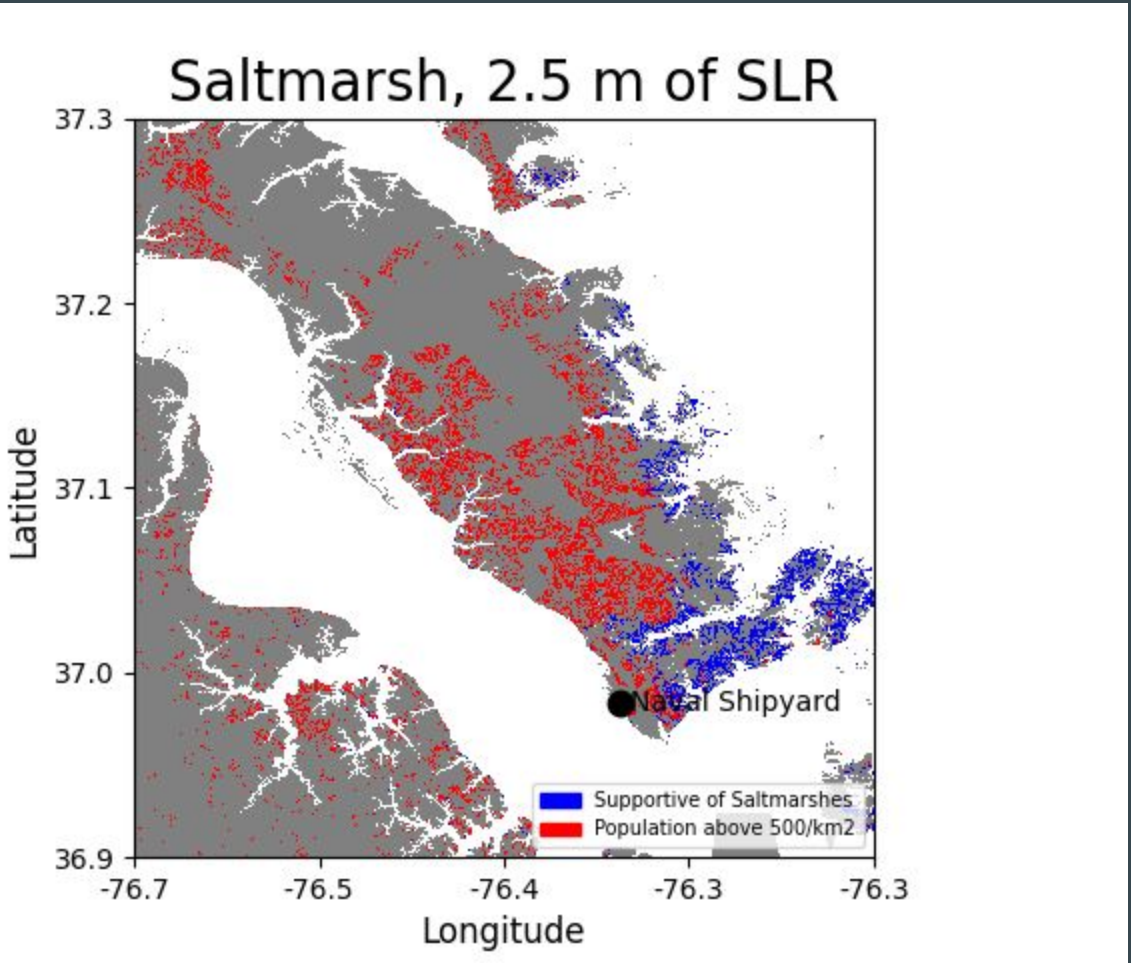
Methodology & Datasets

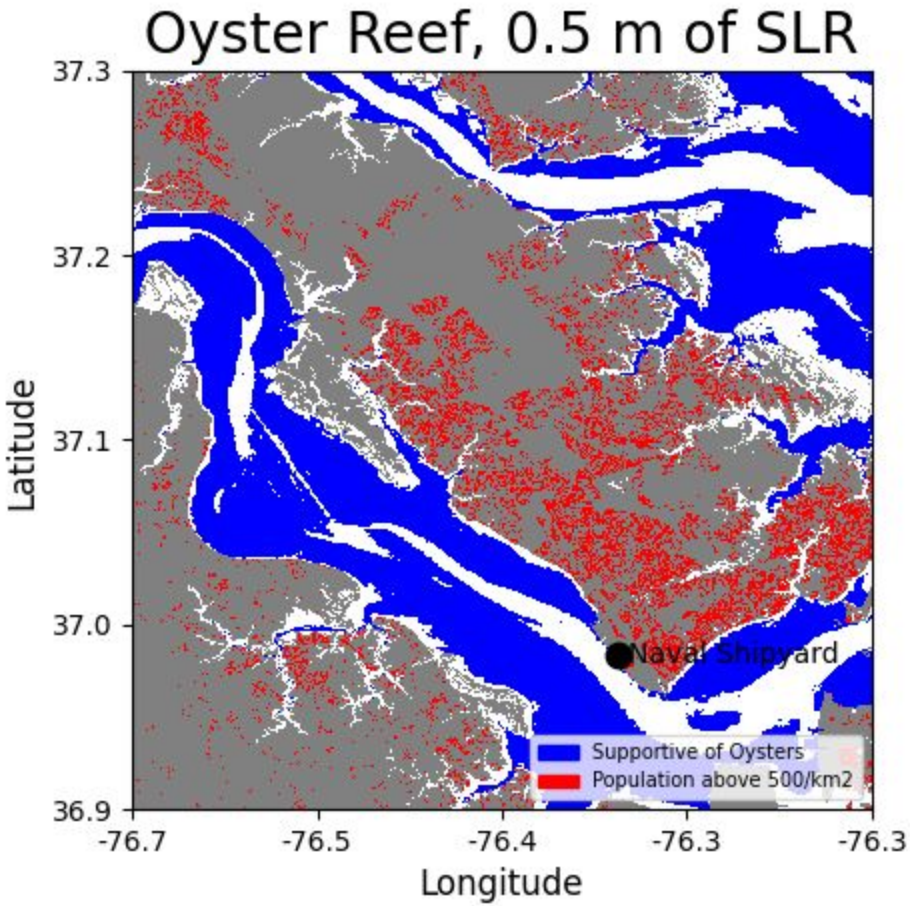
1. Assemble the following key datasets and re-grid them into 10 m by resolution grid points.
    a. USGS 3D Elevation Program 1/3 arc-second Digital Elevation Model
    b. NOAA NCEI data includes gridded bathymetry data
    c. Parcel Land Use Data shows current human built infrastructure
    d. Data for Good by Meta's high resolution population and demographics data
2. Determine which grid points can support an Eco -Defense in a given SLR scenario. Then check to make sure the grid point isn't already set aside for anthropogenic use population, land use).
3. Determine which coastal grid points are protected by the maximum extent of each Eco-Defense under a given scenario.

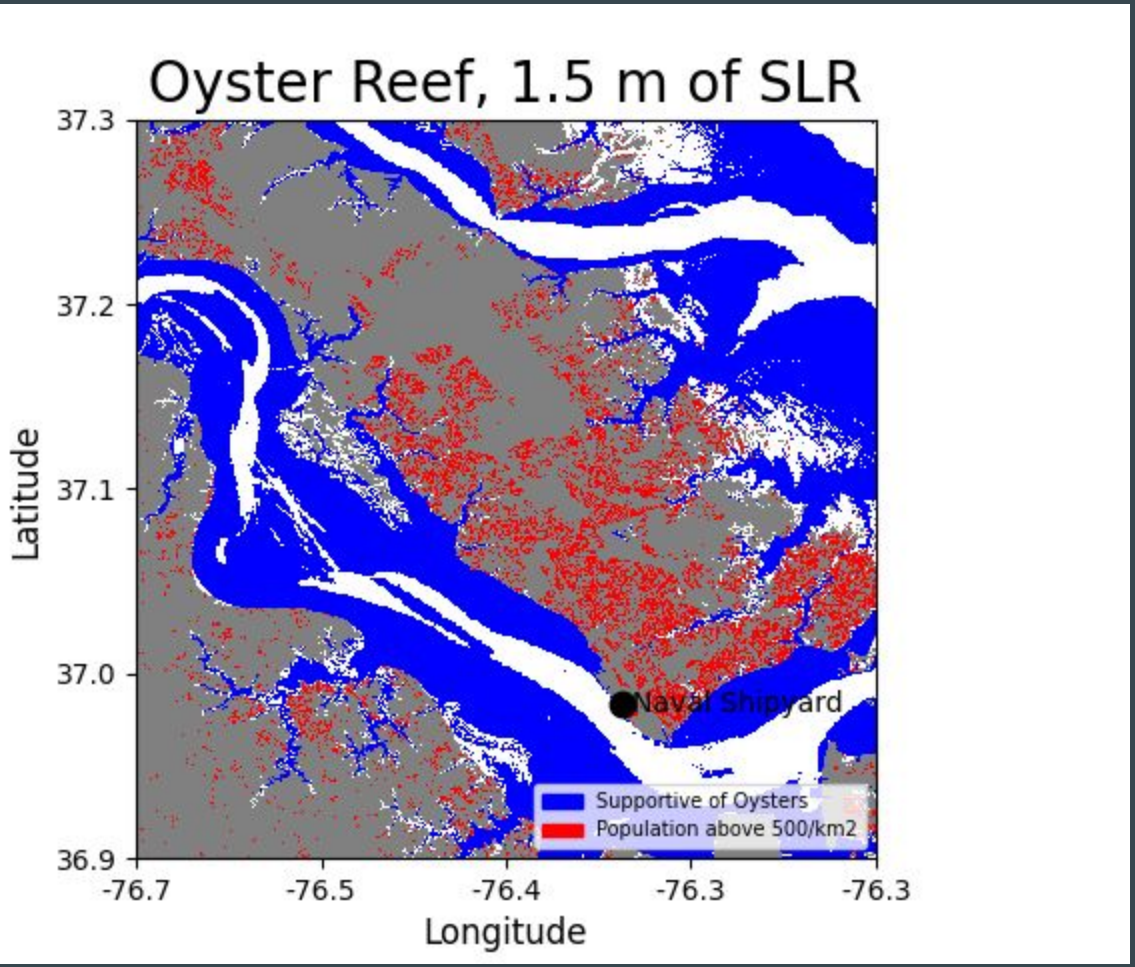
Newport News Maps

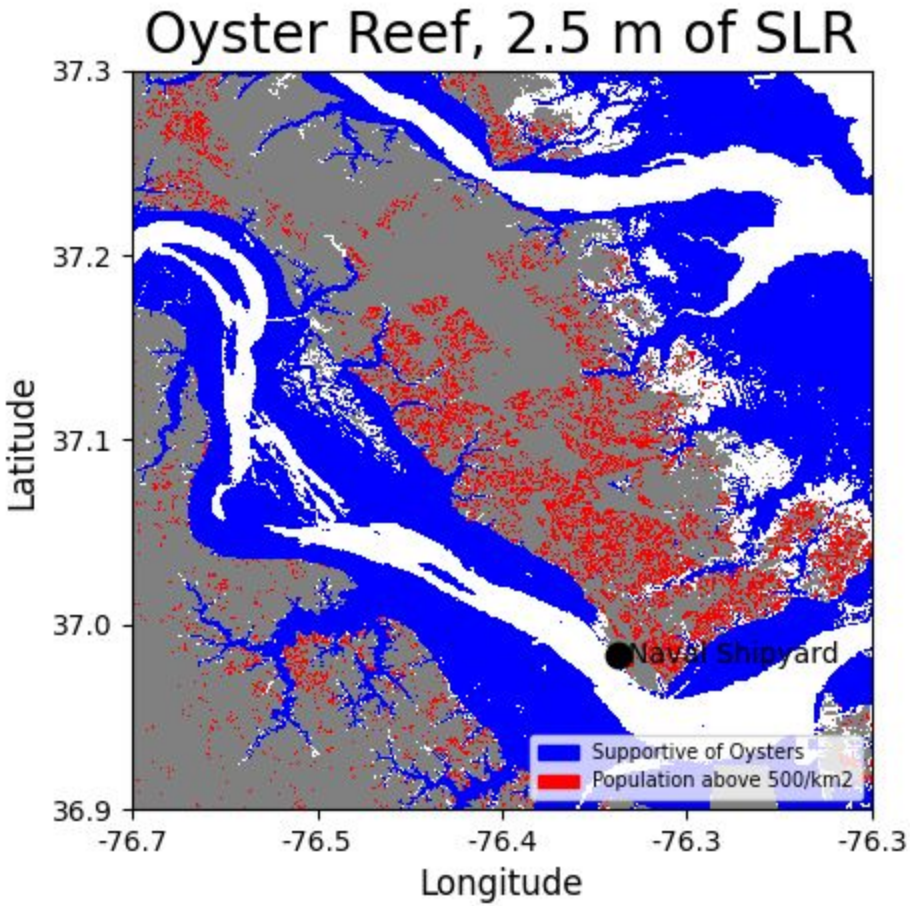

Saltmarsh, 0.5 m of SLR
37.3
37.2
37.1
37.0
36.9
Latitude
-76.7
-76.5
-76.4
-76.3
-76.3
Longitude
Naval Shipyard
Supportive of Saltmarshes
Population above 500/km2

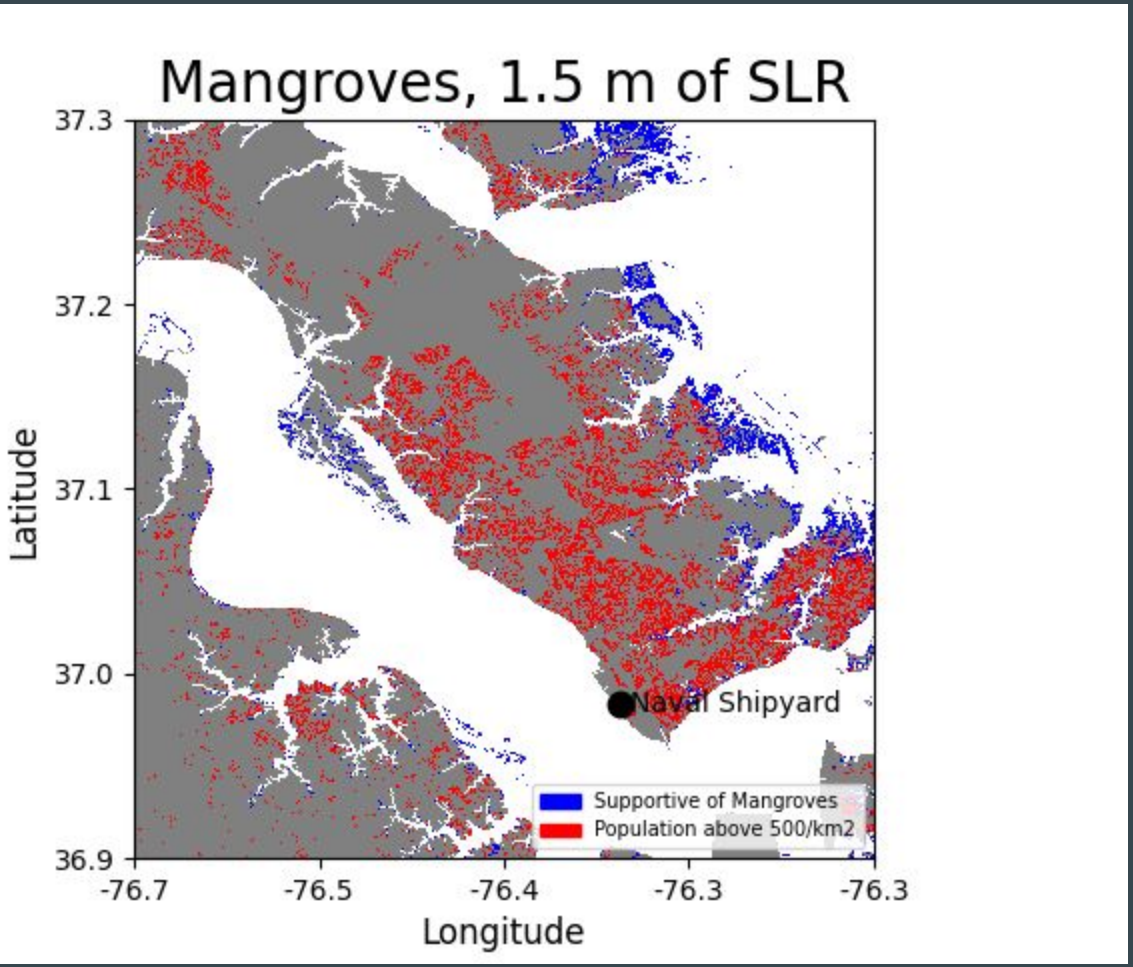

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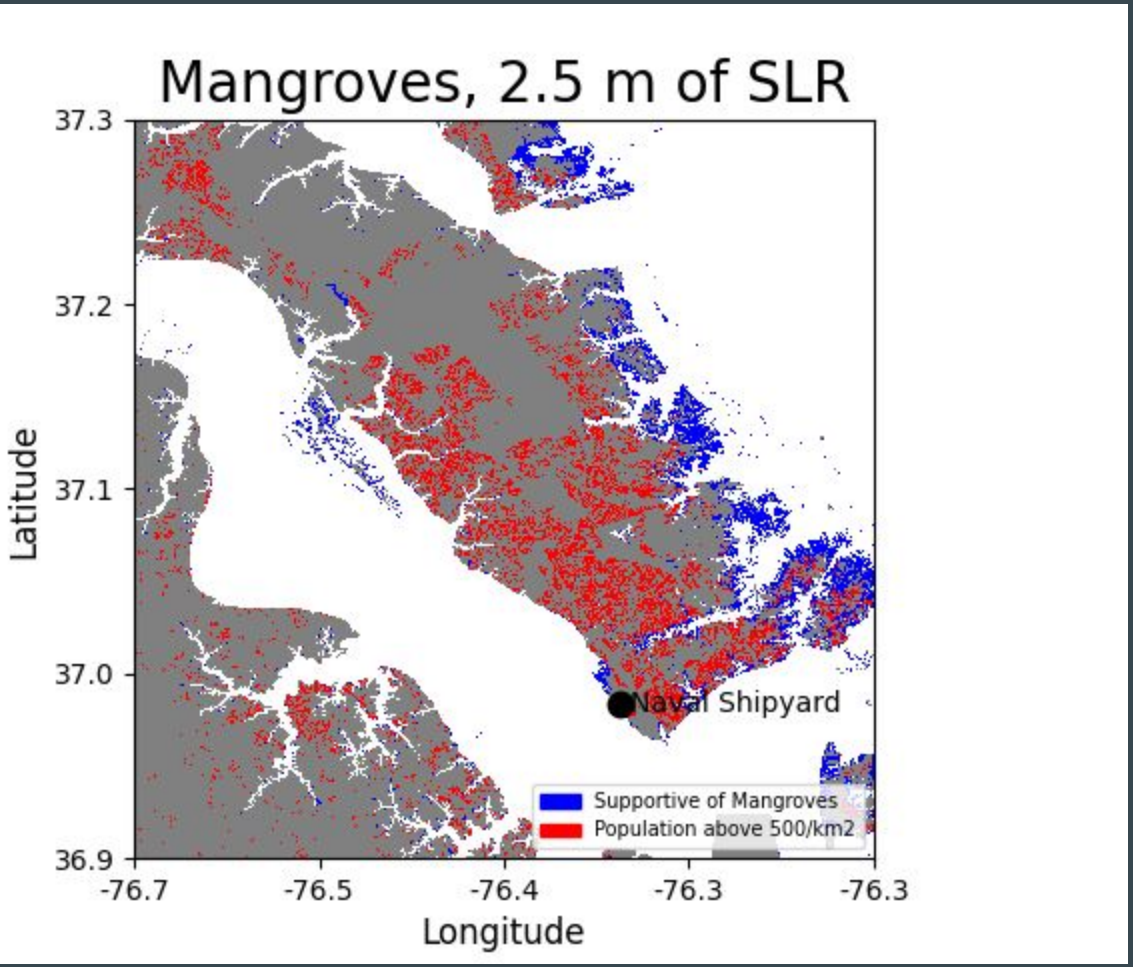

Saltmarsh, 2.5 m of SLR
37.3
37.2
37.1
37.0
36.9
Latitude
-76.7
-76.5
-76.4
-76.3
-76.3
Longitude
Naval Shipyard
Supportive of Saltmarshes
Population above 500/km2


Oyster Reef, 0.5 m of SLR
37.3
37.2
37.1
37.0
36.9
Latitude
-76.7
-76.5
-76.4
-76.3
-76.3
Longitude
Naval Shipyard
Supportive of Oysters
Population above 500/km2

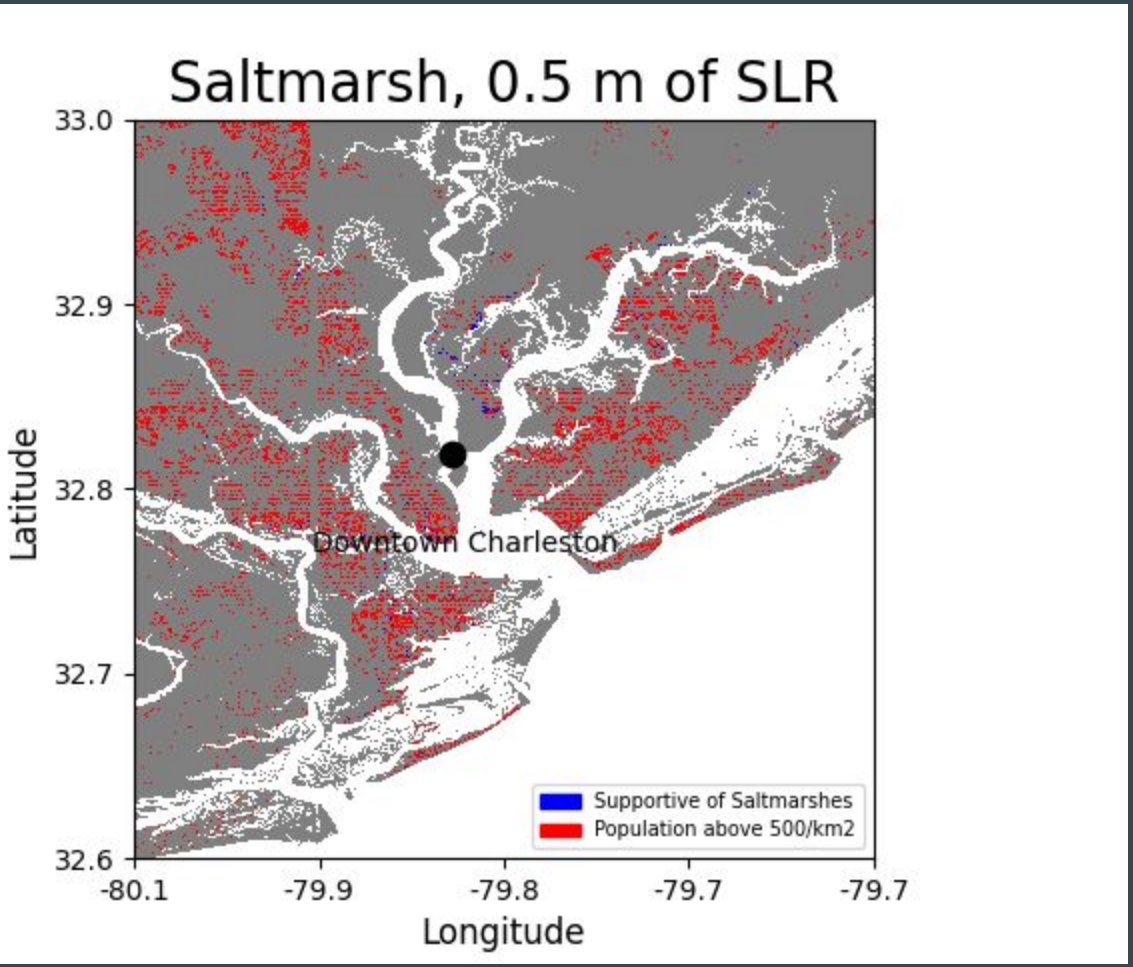

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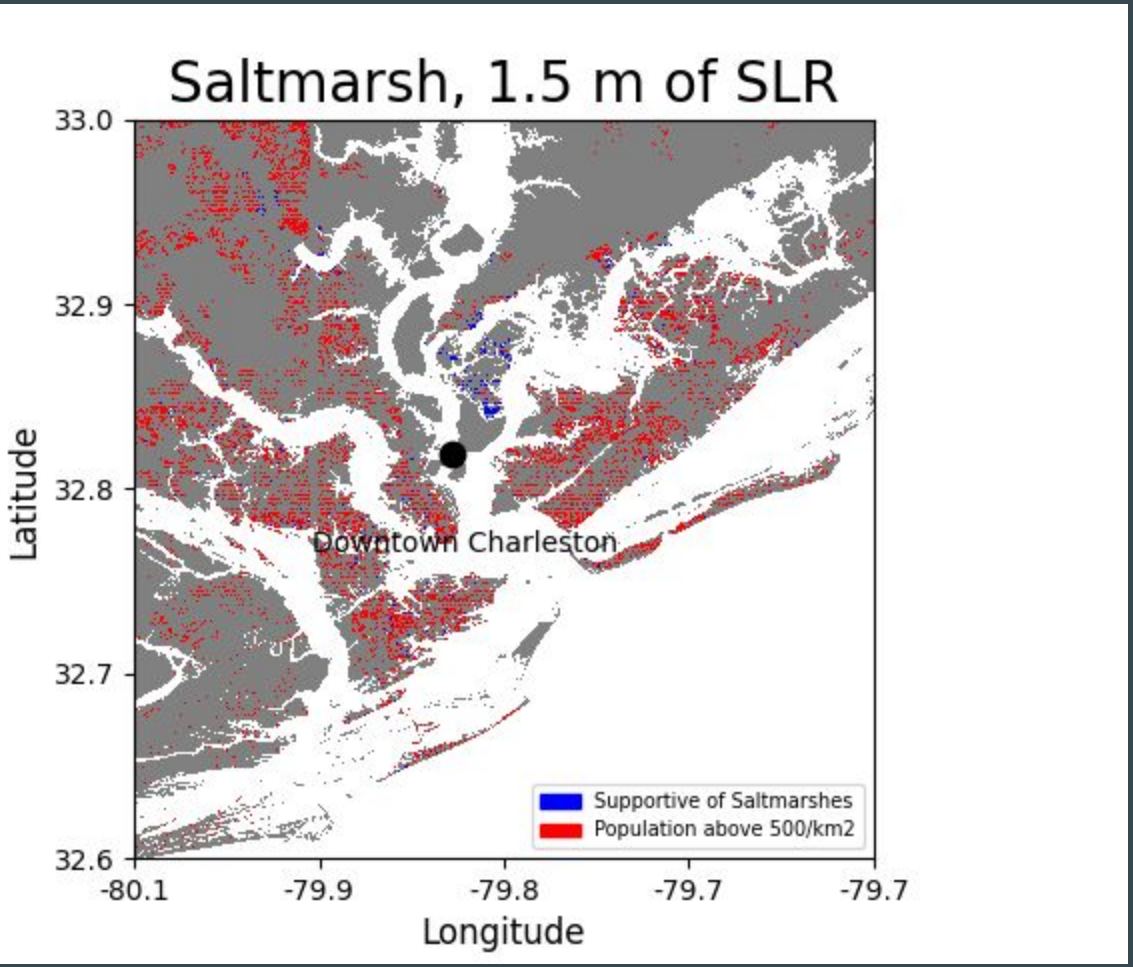

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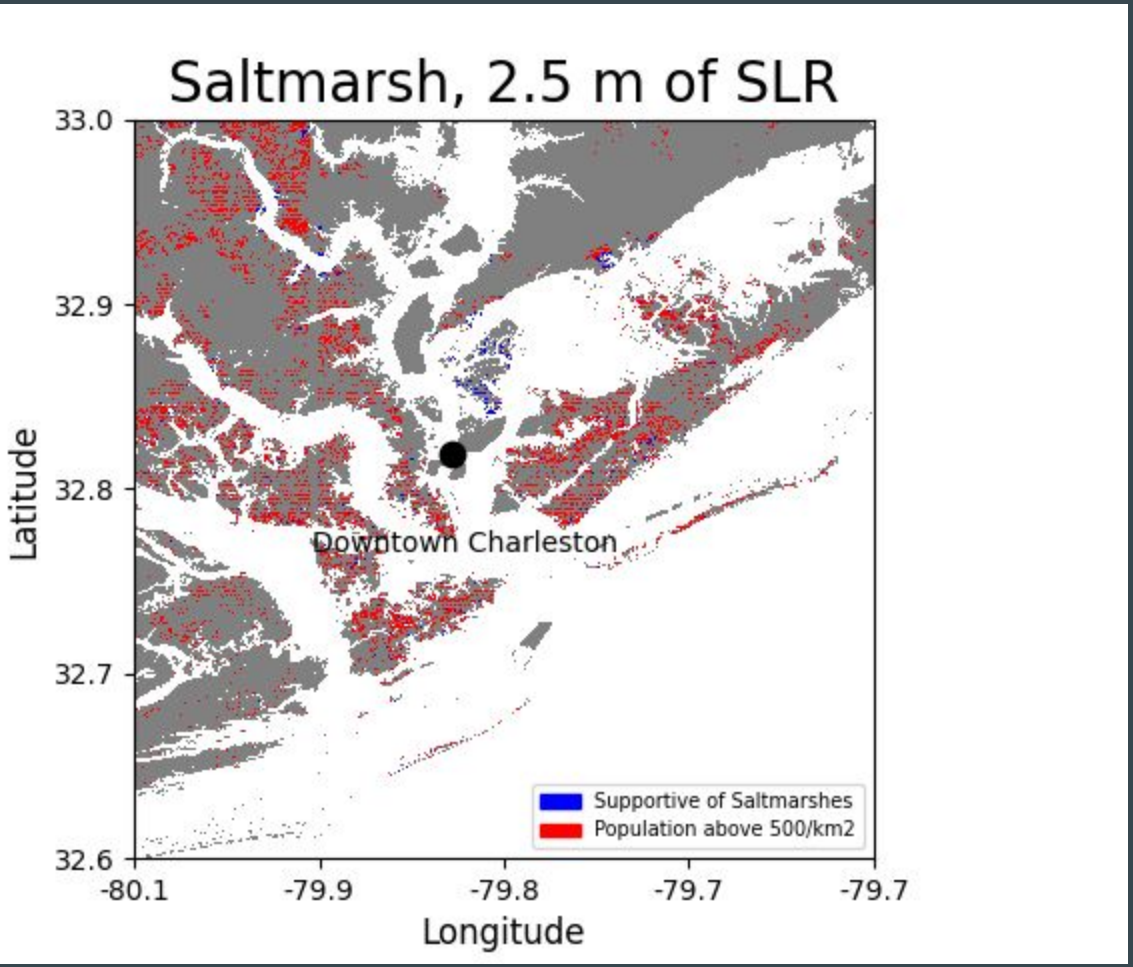

Mangroves, 1.5 m of SLR
37.3
37.2
37.1
37.0
36.9
Latitude
-76.7
-76.5
-76.4
-76.3
-76.3
Longitude
Naval Shipyard
Supportive of Mangroves
Population above 500/km2

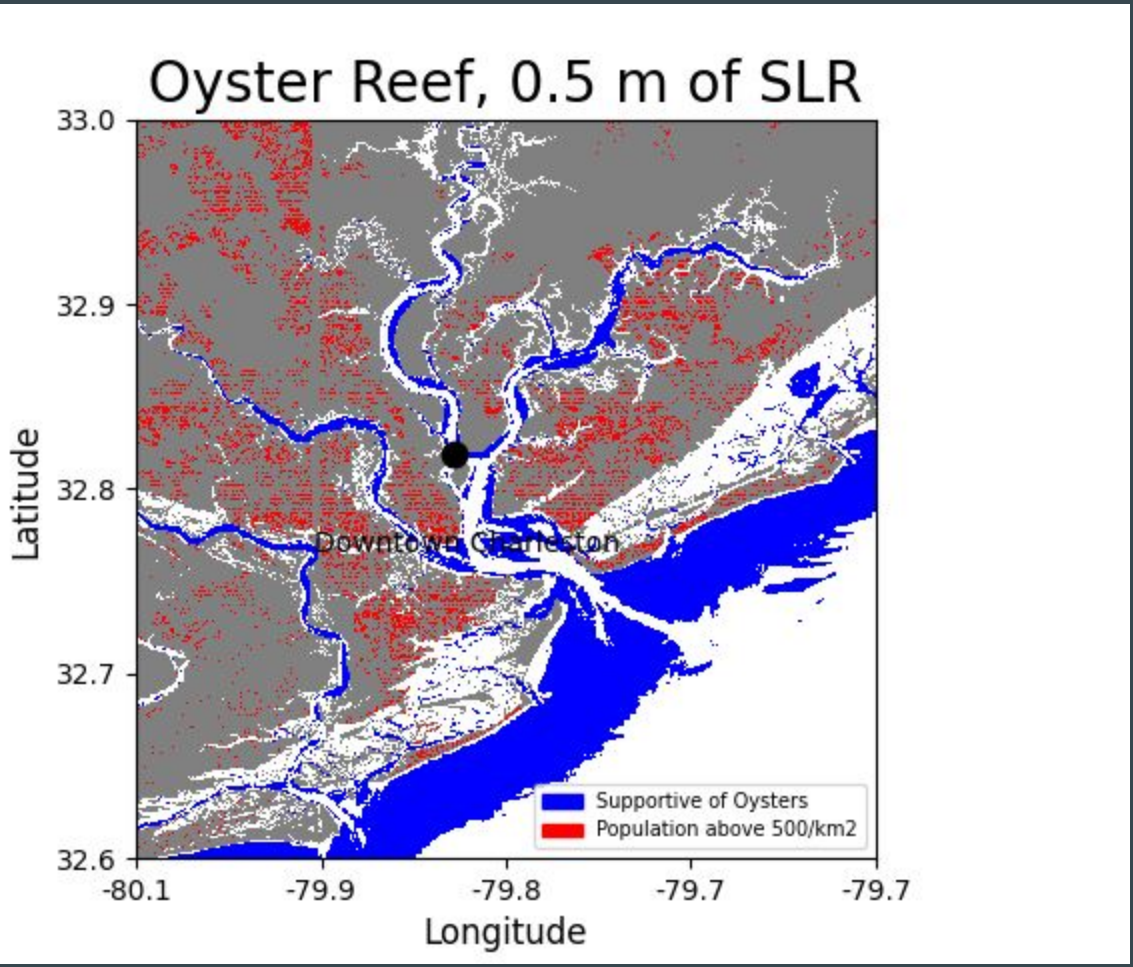

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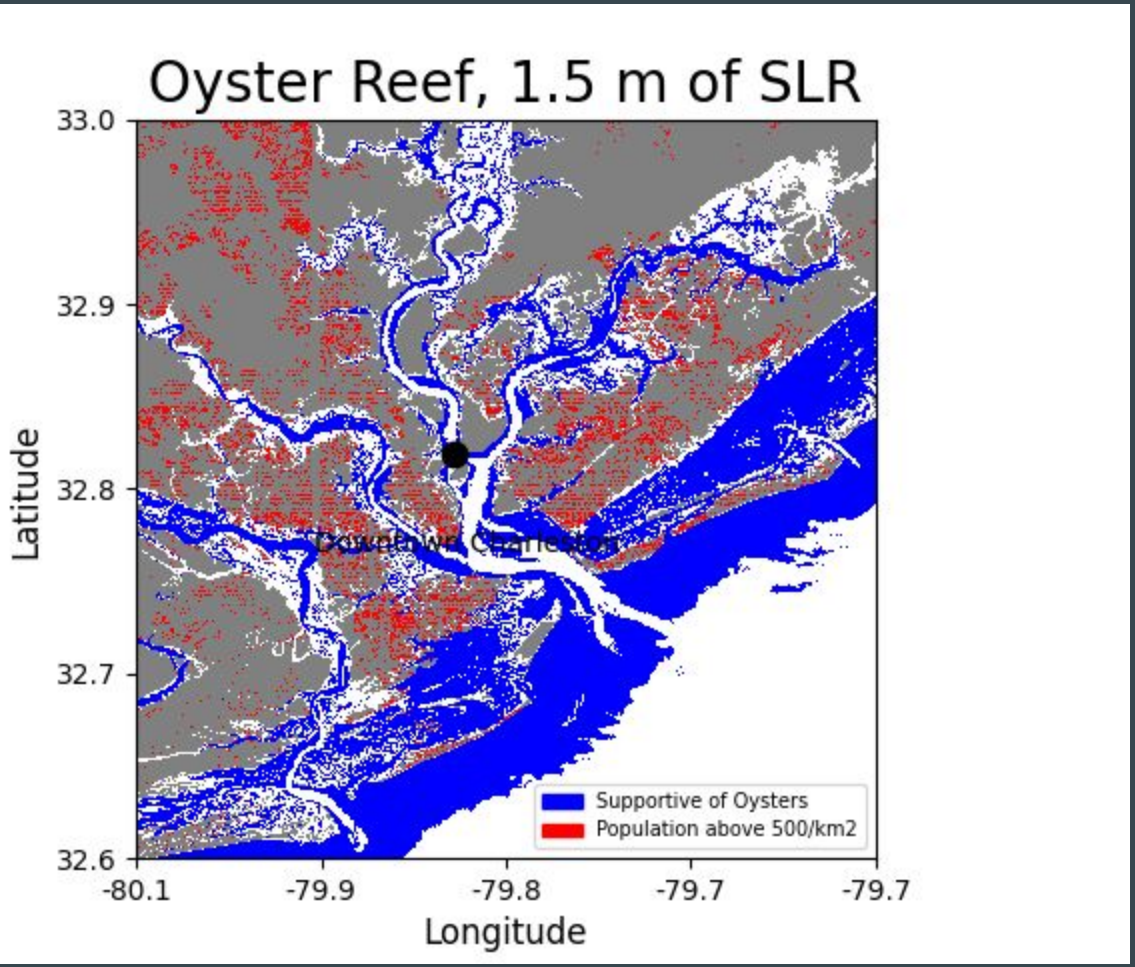
Charleston Maps

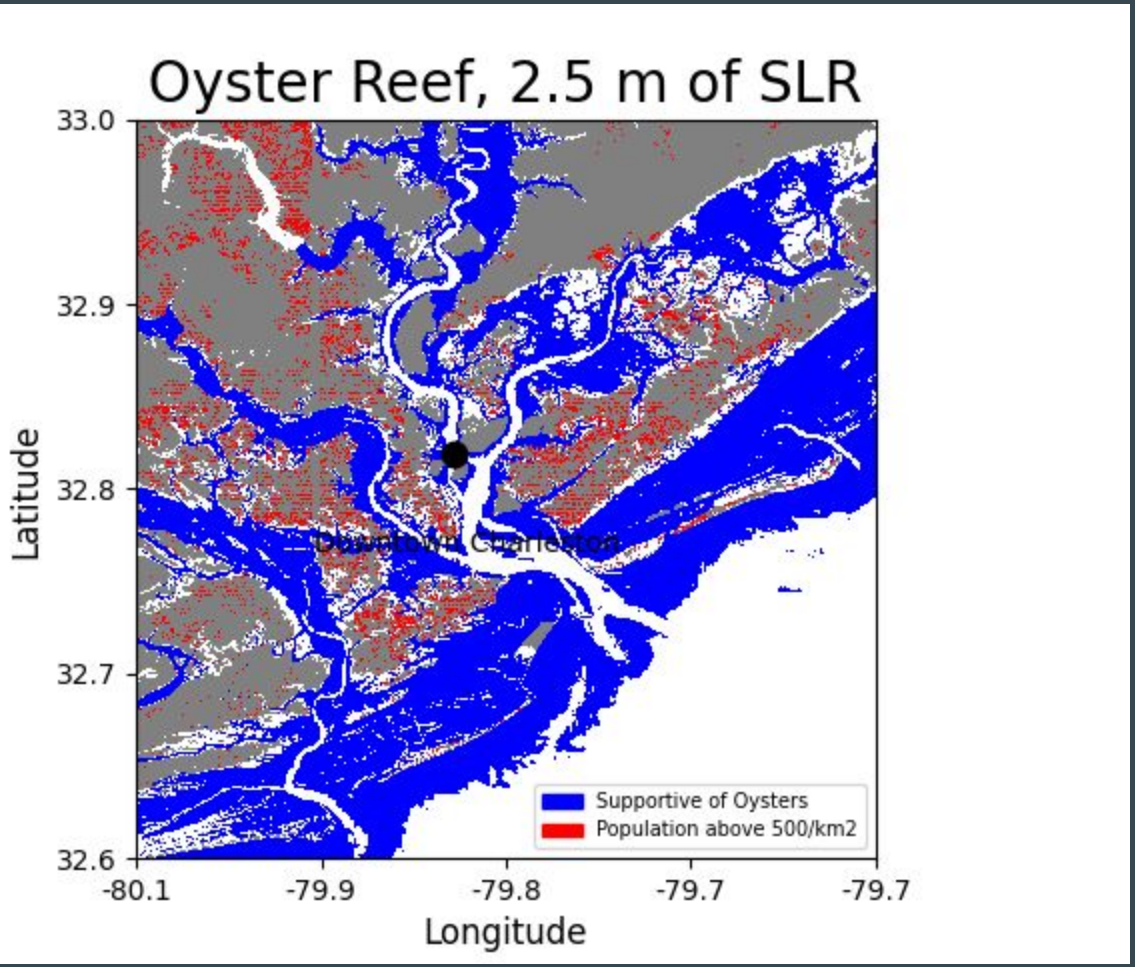

Saltmarsh, 0.5 m of SLR
33.0
32.9
32.8
32.7
32.6
Latitude
Downtown Charleston
Supportive of Saltmarshes
Population above 500/km2
-80.1
-79.9
-79.8
-79.7
-79.7
Longitude

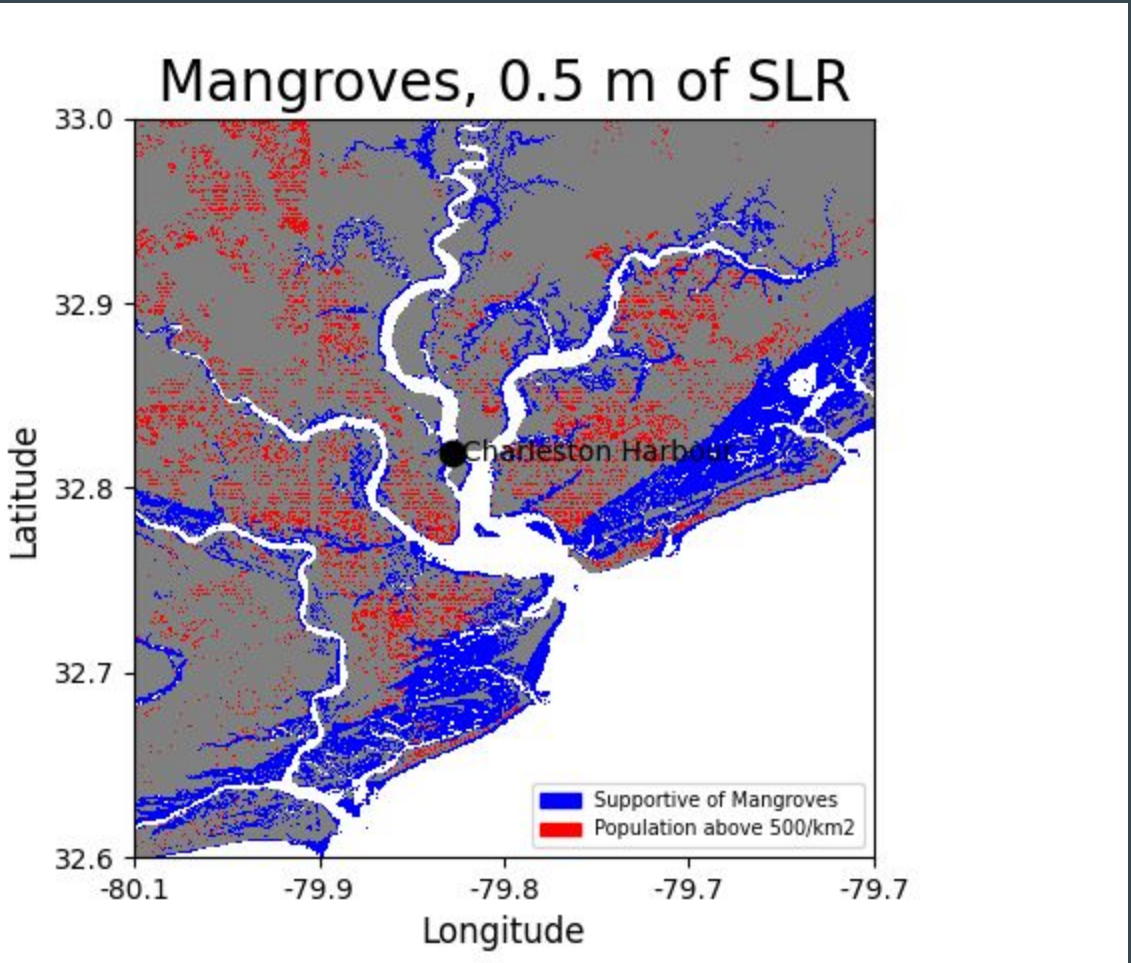

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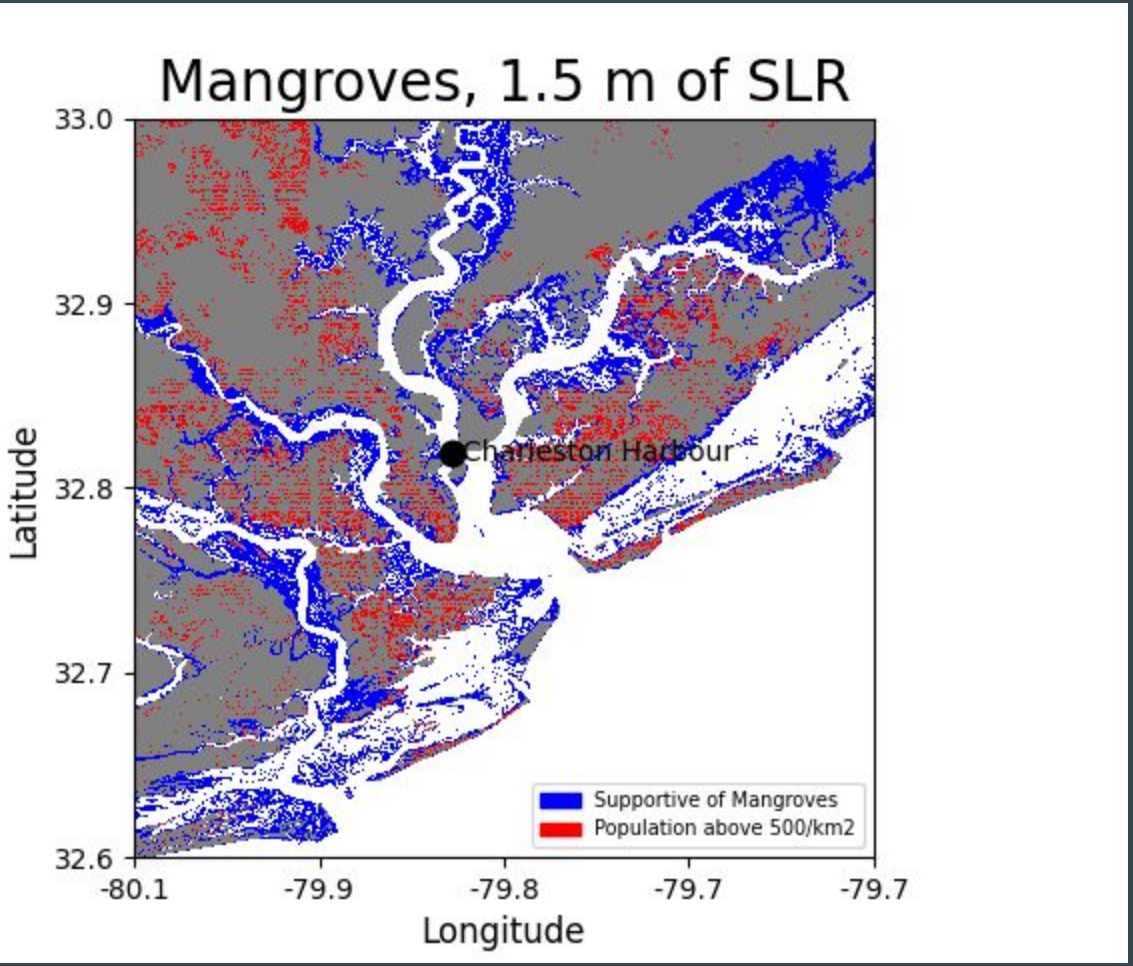

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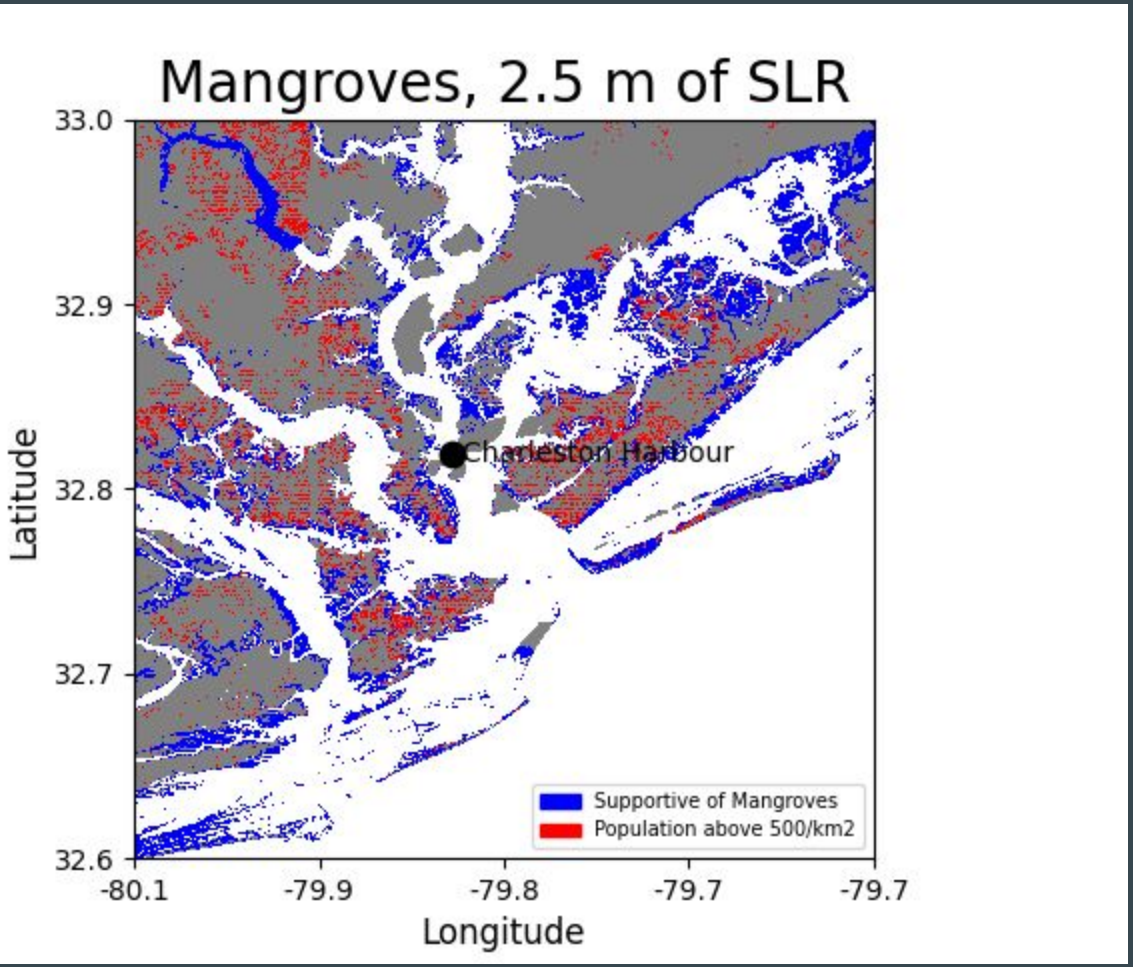

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Works Cited

- Data for Good. United states: High resolution population density maps + demographic estimates - humanitarian data exchange. (n.d).
- First Street. (n.d.). Charleston, SC flood map and climate risk report. Retrieved January 9, 2025, from https://firststreet.org/
- First Street. (n.d). Newport news, VA flood map and climate risk report.. Retrieved January 9, 2025, from https://firststreet.org/
- Herison, A., Bengen, D. G., Putra, A. D., Romdania, Y., & Arief, F. D. (2024). Effects of avicennia marina mangrove sedimentation on wave attenuation. Jurnal Teknologi (Sciences & Engineering), 86(2), 9–15.
- Hijuelos, A. (2017). 2017 Coast Master Plan: Attachment C3-12: Eastern Oyster, Crassostrea virginica, Habitat Suitability Index Model. Coastal Protection and Restoration Authority.
- Koch, E. W. et al. (2009). Non-linearity in ecosystem services: temporal and spatial variability in coastal protection. Front. Ecol. Environ. 7, 29–37.
- Land Use Parcel Data. (2023). Boundary Soloutions.
- Marshall, D. A., Coxe, N. C., La Peyre, M. K., Walton, W. C., Rikard, F. S., Pollack, J. B., Kelly, M. W., & La Peyre, J. F. (2021). Tolerance of northern Gulf of Mexico eastern oysters to chronic warming at extreme salinities. Journal of Thermal Biology, 100, 103072.
- Möller, I. & Spencer, T. (2002). Wave dissipation over macro-tidal saltmarshes: Effects of marsh edge typology and vegetation change. J. Coast. Res. 36, 506–521.
- National Weather Service, US Department of Commerce. (n.d.). Coastal flood event database. Retrieved January 9, 2025, from https://www.weather.gov/chs/coastalflood
- South Florida Aquatic Environments: Habitat requirements. (n.d.). University of Florida. Retrieved June 3, 2023, from https://www.floridamuseum.ufl.edu/southflorida/habitats/mangroves/requirements/
- Topographic Grid Extract. NOAA National Center for Environmental Information.
- United States Geological Survey. OpenTopography—USGS 1/3 arc-second Digital Elevation Model. (n.d.).
- Wiberg, P. L., Taube, S. R., Ferguson, A. E., Kremer, M. R., & Reidenbach, M. A. (2019). Wave attenuation by oyster reefs in shallow coastal bays. Estuaries and Coasts, 42(2), 331–347.
- Zedler, J.B., Bonin, C.L, Larkin, D.J., Varty, A.. (2008). Salt Marshes. Editor(s): Jørgensen, S.E., Fath, B.D.. Encyclopedia of Ecology. Academic Press. pp 3132-3141. ISBN 9780080454054.