Site Recommendations and Design Options for Nearshore Oyster Structures Specific to Mobjack Bay, Virginia, and its Tributaries.

Sustainable Fisheries Goal Implementation Team Meeting

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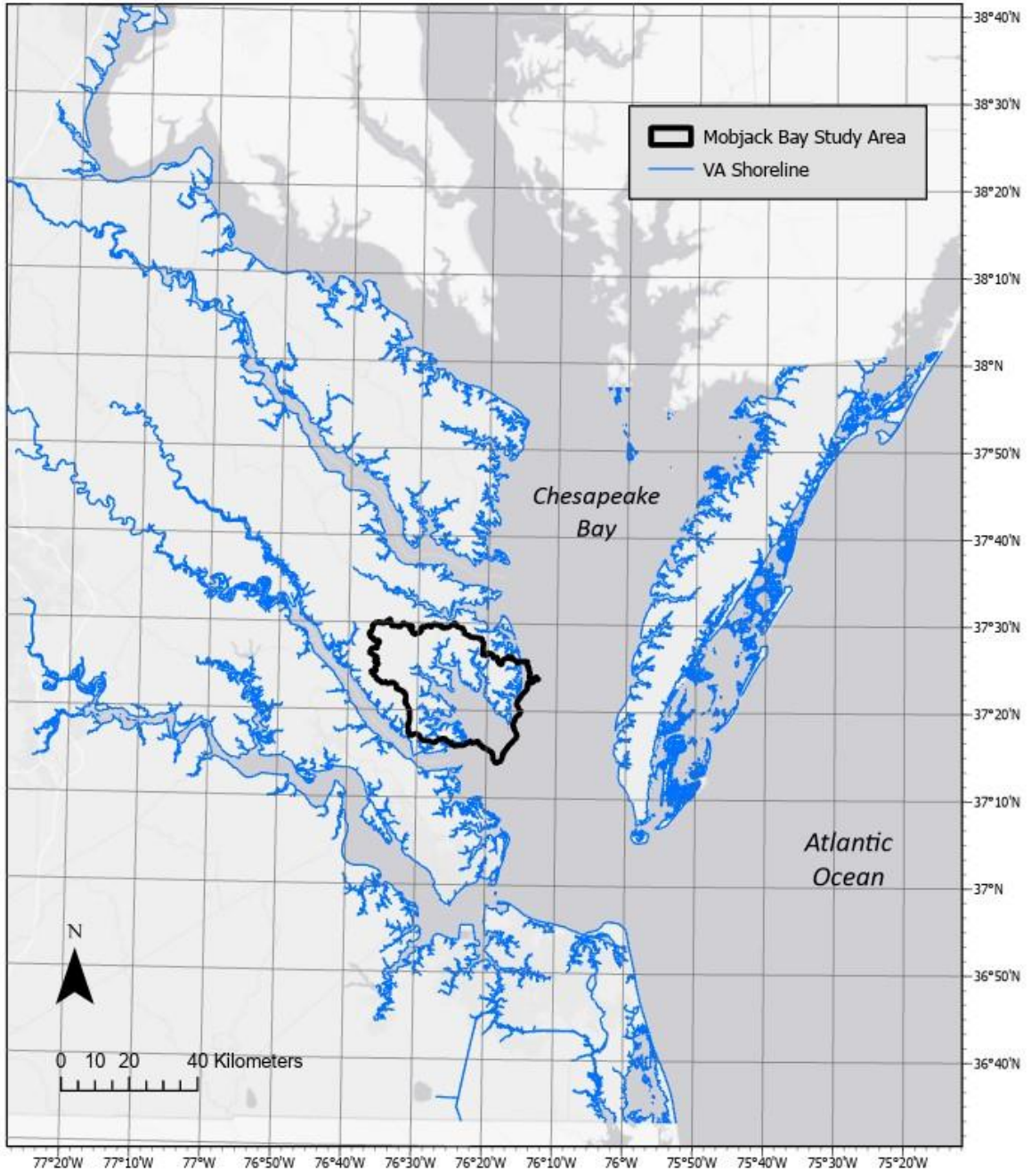
Project Scope

MAIN GOAL: identify specific sites in Mobjack Bay, Virginia, and its tributaries, where nearshore oyster structures can be most effective in protecting shorelines (reduced wave energy and erosion) while promoting oyster growth (co-benefit).

OBJECTIVES:

1) Site recommendations and design options for nearshore oyster structures specific to this system within an erosion control context (**site suitability**).
2) A **tiered ranking** specifying sites where nearshore oyster structures can be most effective for restoration purposes.

Study Area



Service Layer Credits: World Light Gray Canvas Base: Esri, HERE, Garmin, USGS, EPA, NPS

Shoreline: 531.5 miles

Shoreline associated with **development**: **184.5 miles**

Shoreline associated with **natural areas**: **347 miles**

Shoreline associated with **marshes**: **468 miles**

Shoreline associated with **beaches**: **16.6 miles**

Shoreline Management Model (SMM)

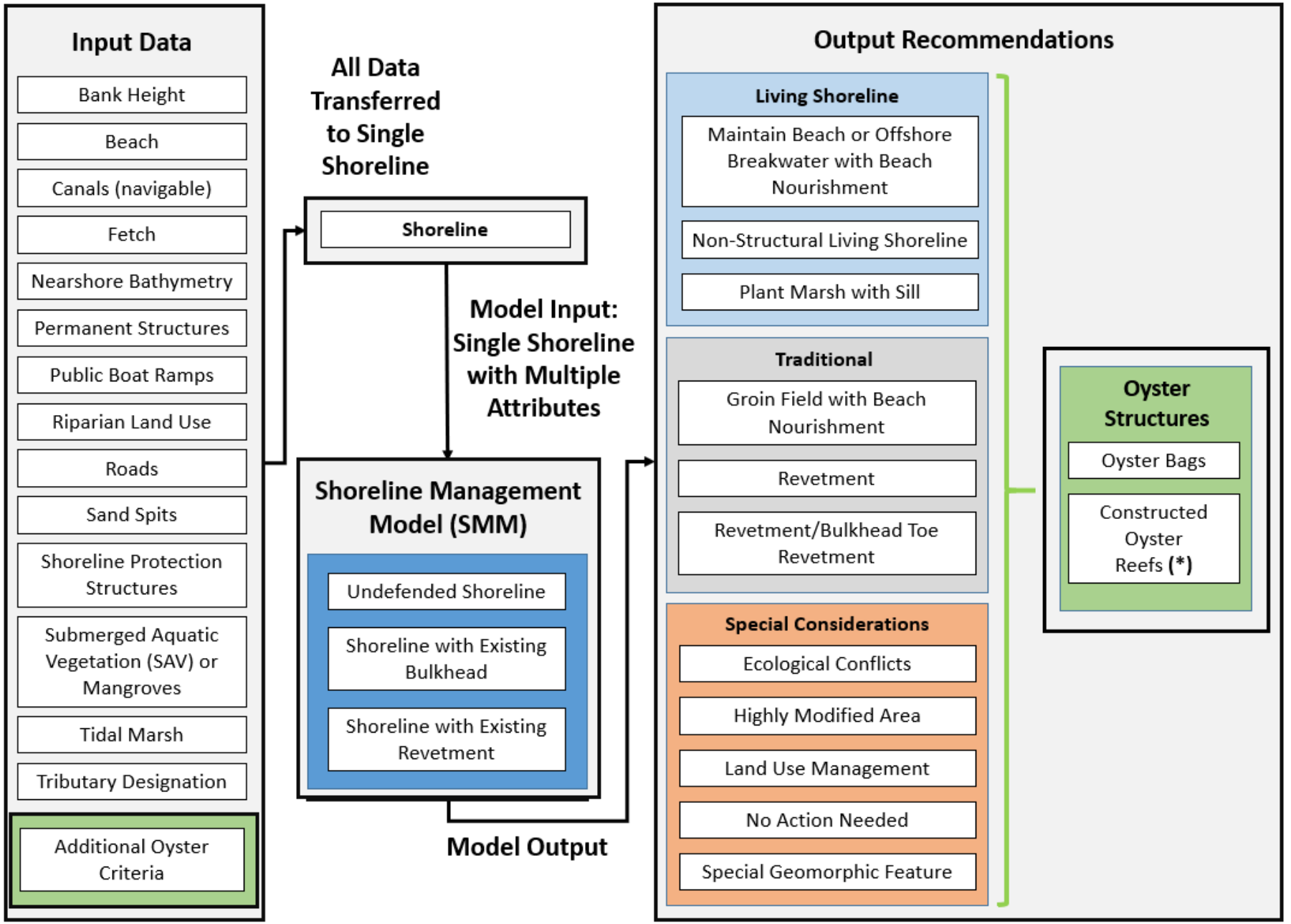
SMM is a geospatial model used to assess conditions along a shoreline, and **recommend best management practices for defended and undefended shorelines,** including areas where the use of **living shorelines would be suitable to address shoreline erosion**.

Based on the **Shoreline Management Model** developed at CCRM, VIMS, we developed a spatially explicit **model extension** to identify oyster structure suitability based on site-specific conditions.

Nunez, K., Rudnicky, T., Mason, P., Tombleson, C., Berman, M. (2022). A geospatial modeling approach to assess site suitability of living shorelines and emphasize best shoreline management practices.. Ecological Engineering. 179. 106617. ***https://doi.org/10.1016/j.ecoleng.2022.106617***

1 - Site suitability

Shoreline Management Model



SMM Recommended Oyster Structures

Oyster Bags

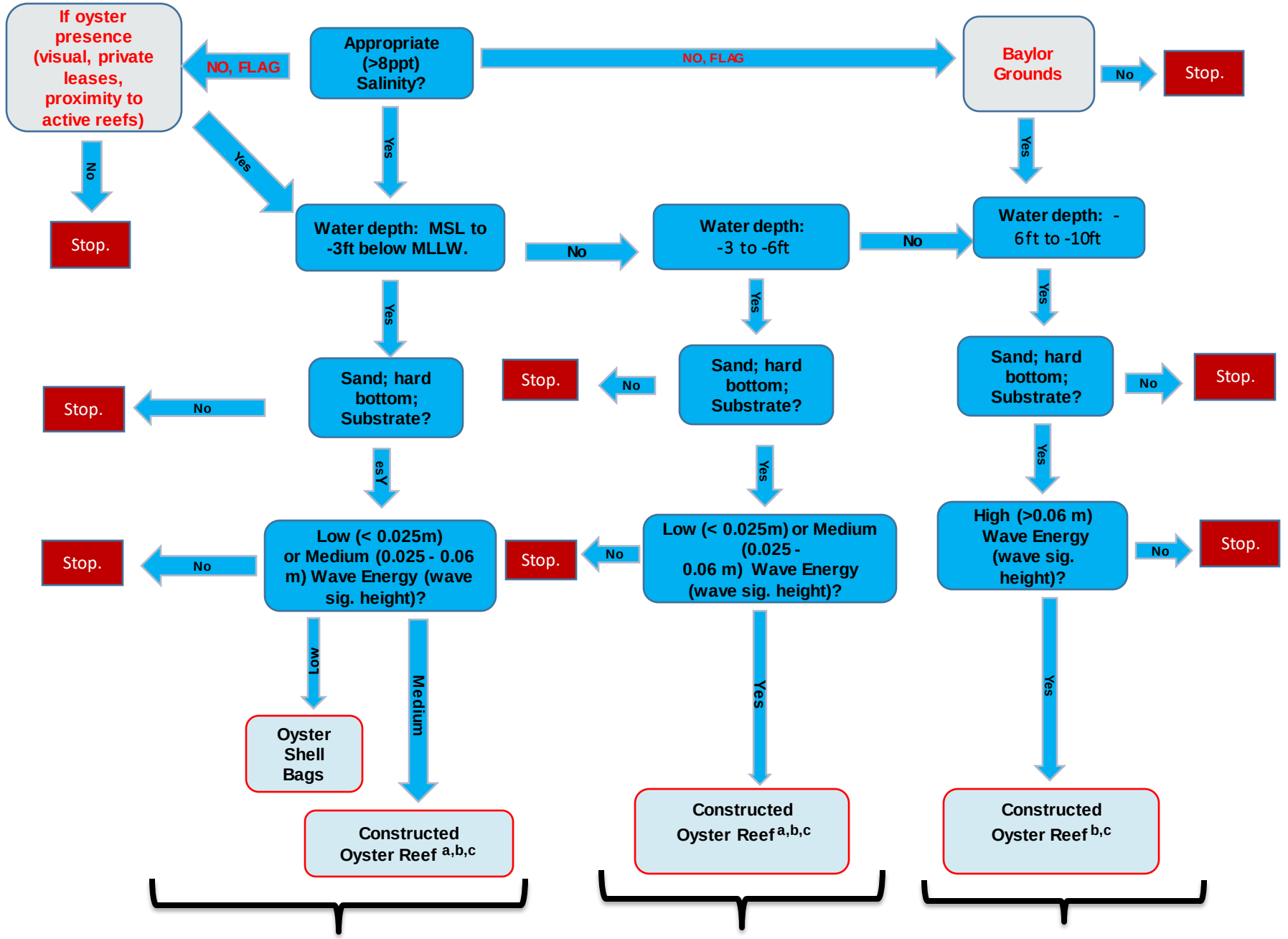
Constructed Oyster Reefs (*)

- ***Manufactured***
  - **Interlocking units (*examples include*)**
    - *Oyster Castles* [a]
    - *Grow Oyster Reefs* [b]
    - *Natrx* [b]
  - **Free-standing**
    - *Oyster Reef Balls* [b]
- ***Natural material***
  - *Stone/shell reefs* [c]

Photo Credits: CCRM, Natrx, Grow Oyster Reefs, USACE.

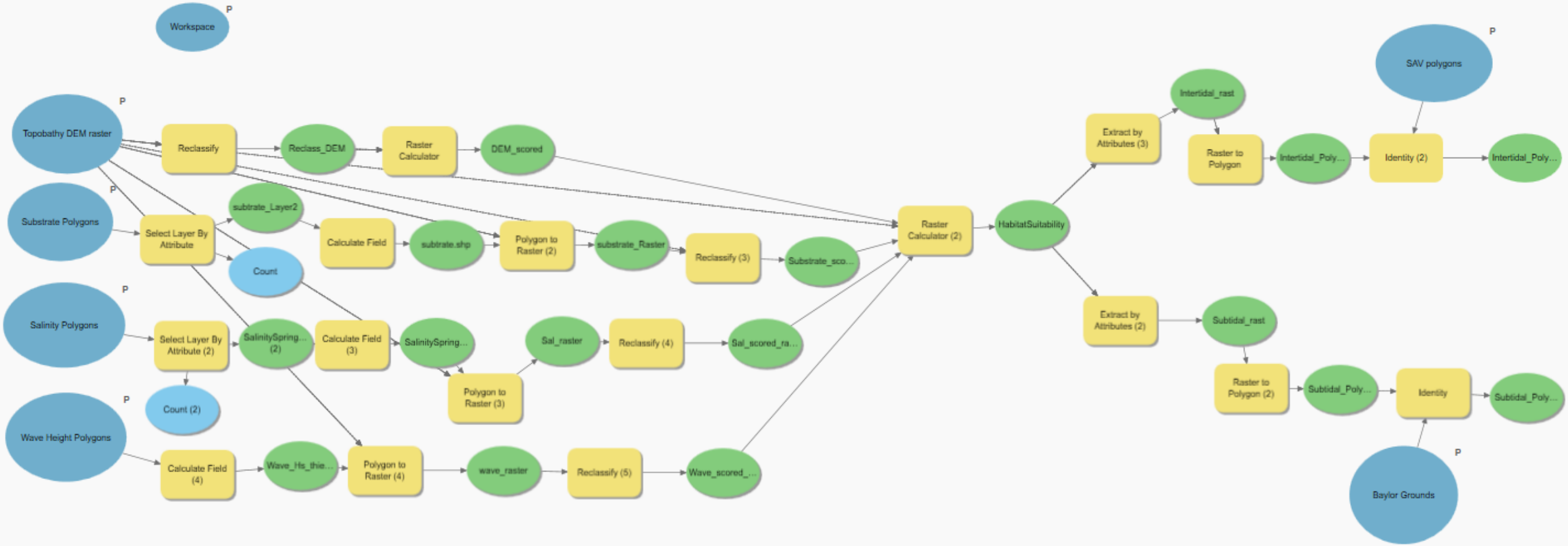
SMM - Oyster Structure Branch

Site Suitability



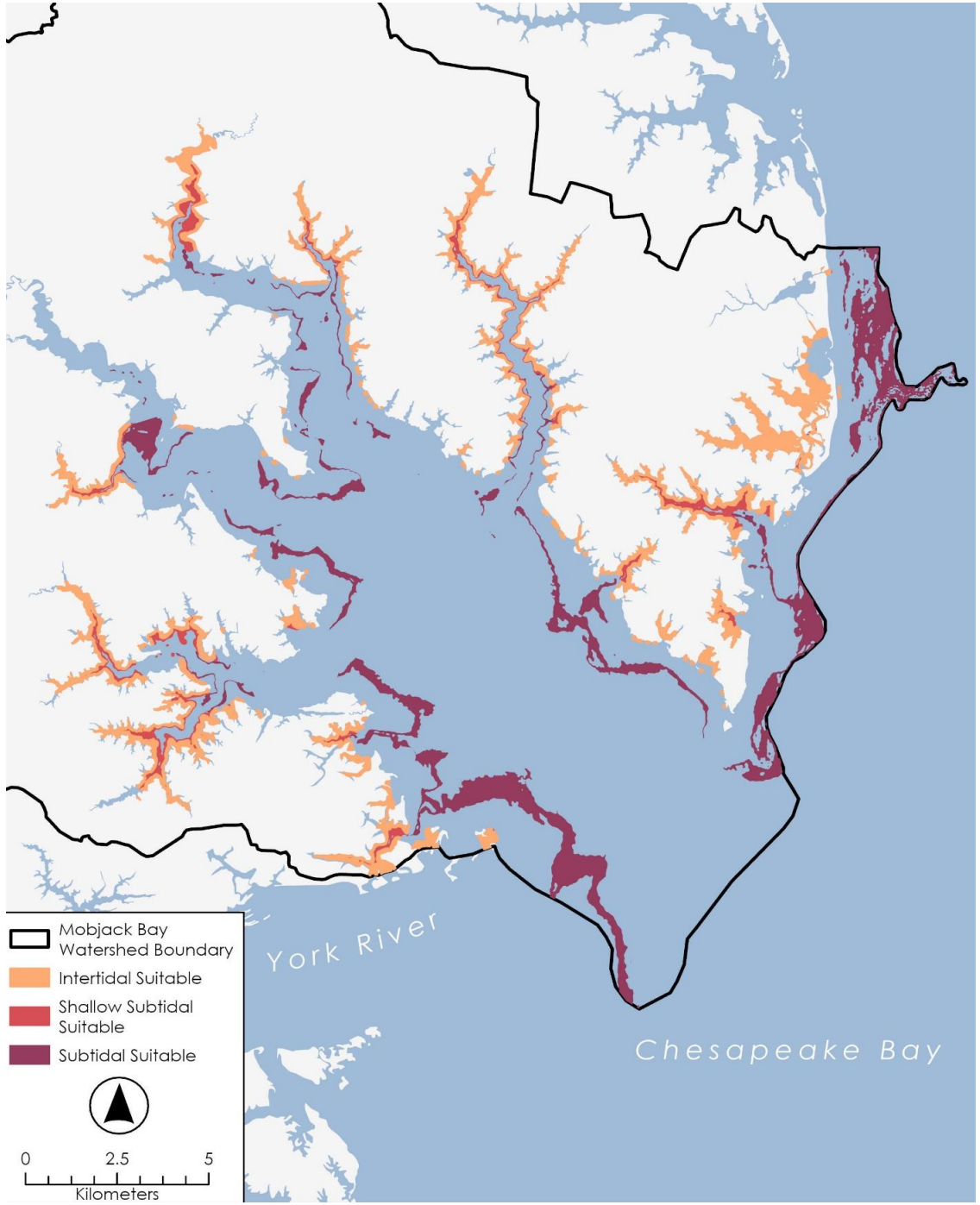
Constructed Oyster Reef [a] *-> example: oyster castles*
Constructed Oyster Reef [b] *-> examples: oyster reef balls, Grow Oyster Reefs, Natrx*
Constructed Oyster Reef [c] *-> example: stone/shell reefs*

Site Suitability Model – Branch: Oyster Structures



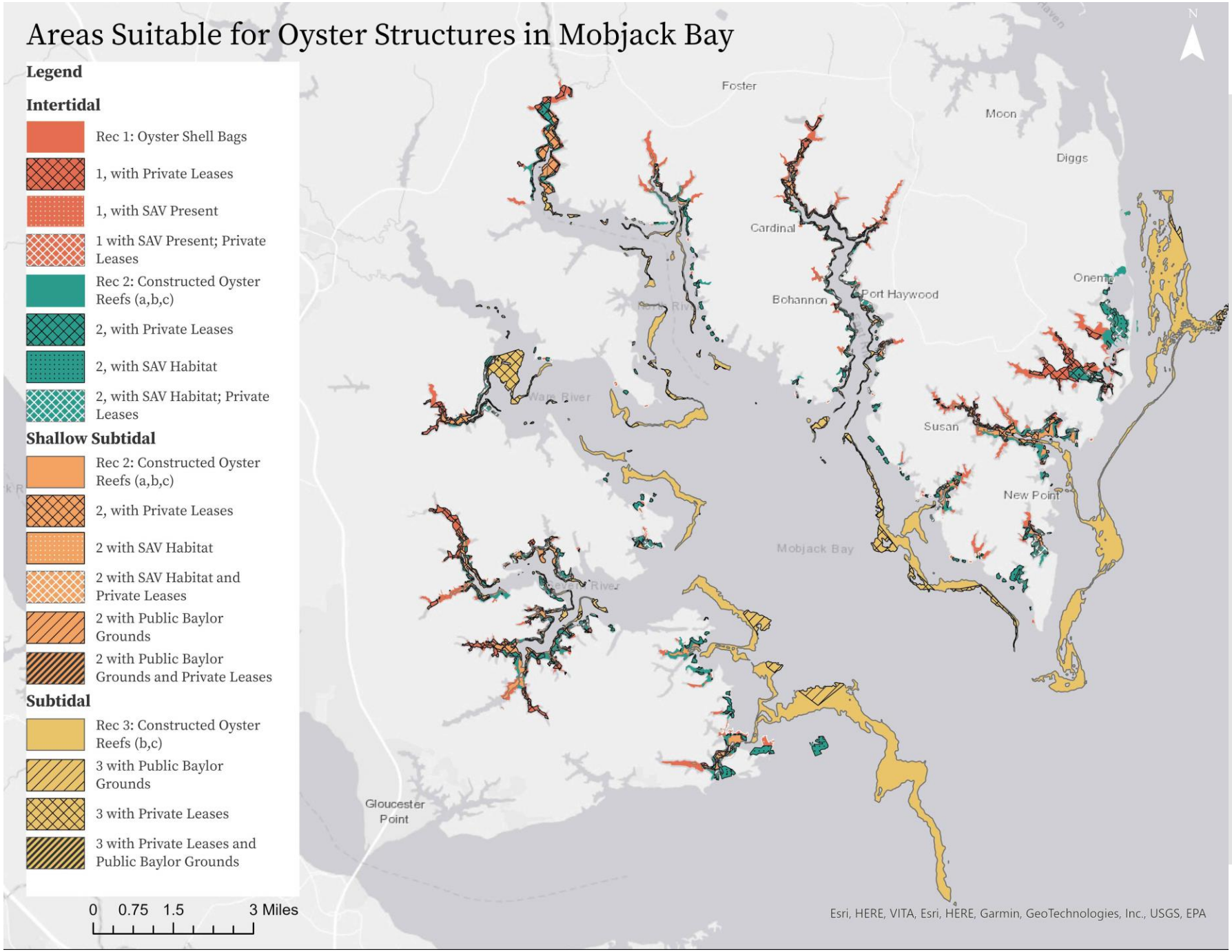
Site Suitability

Oyster Structure Suitable Habitats

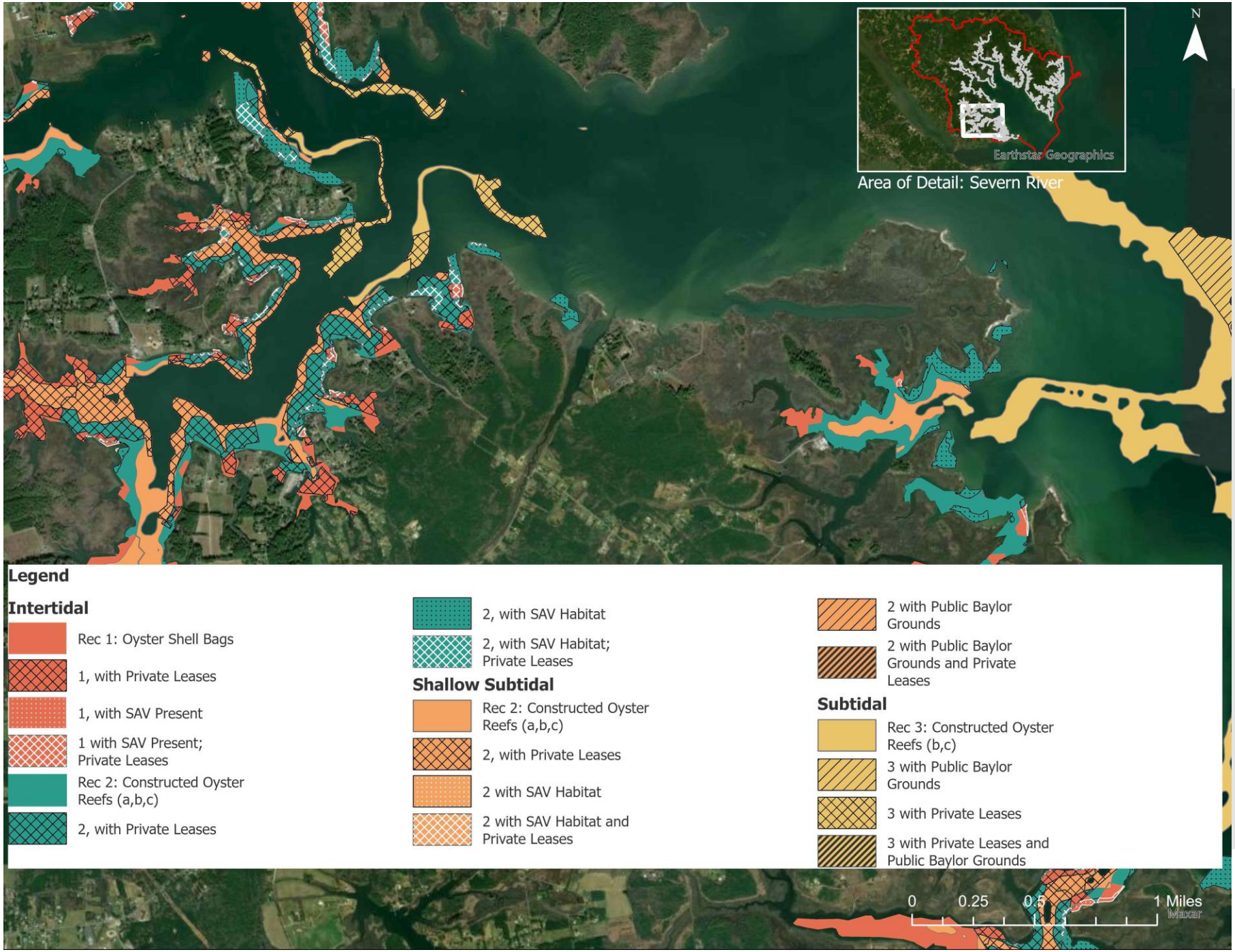


Zones	Suitable Areas (acres)
Intertidal	3,451
Shallow Subtidal	771
Subtidal	5,164

Site Suitability model outputs displaying different recommendations



Suitable sites in the Severn River area



2 - Tiered Ranking for Oyster Restoration Purposes

- Intertidal, shallow subtidal, and subtidal polygons that have been classified as "suitable" move forward for prioritization.
- Site-level prioritization is based on a combination of metrics (from literature/field) and steering committee-assigned weights.
- Based on feedback and priorities provided by the steering committee, we developed an "Oyster Restoration Index." This index is a GIS layer, which would allow the end user to target particular sites for specific restoration co-benefits.

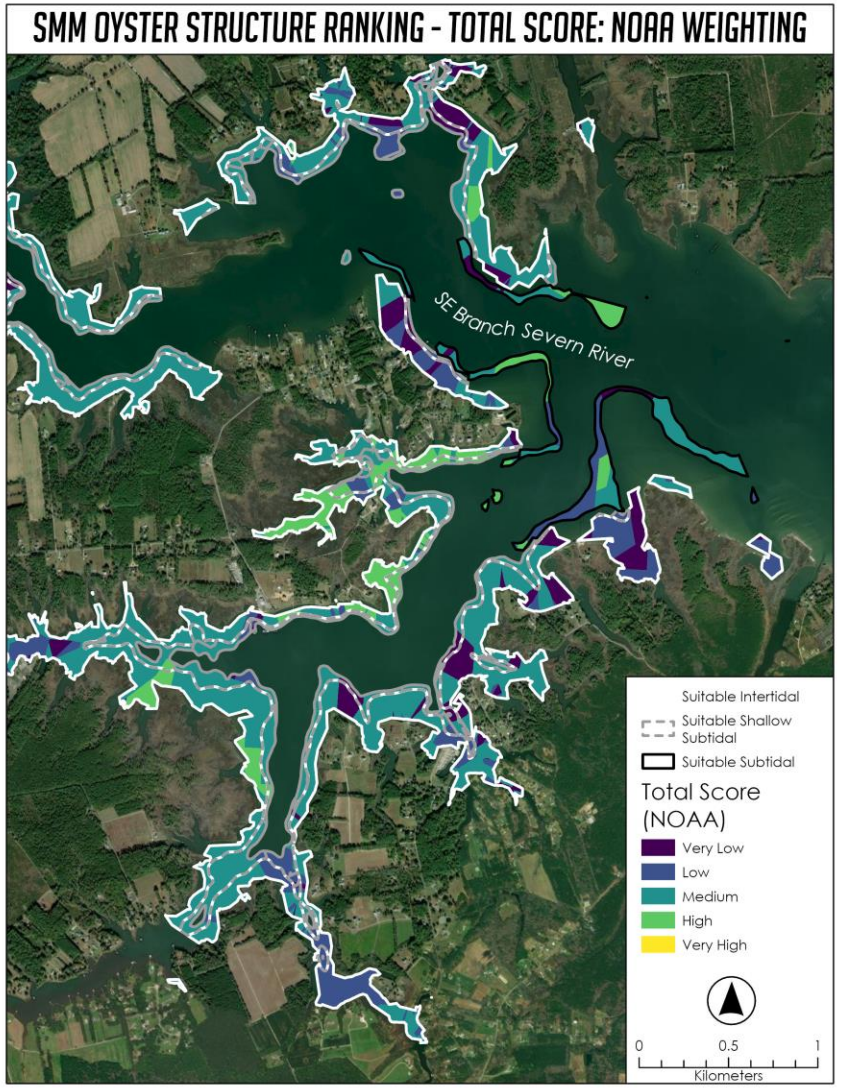
Site Ranking

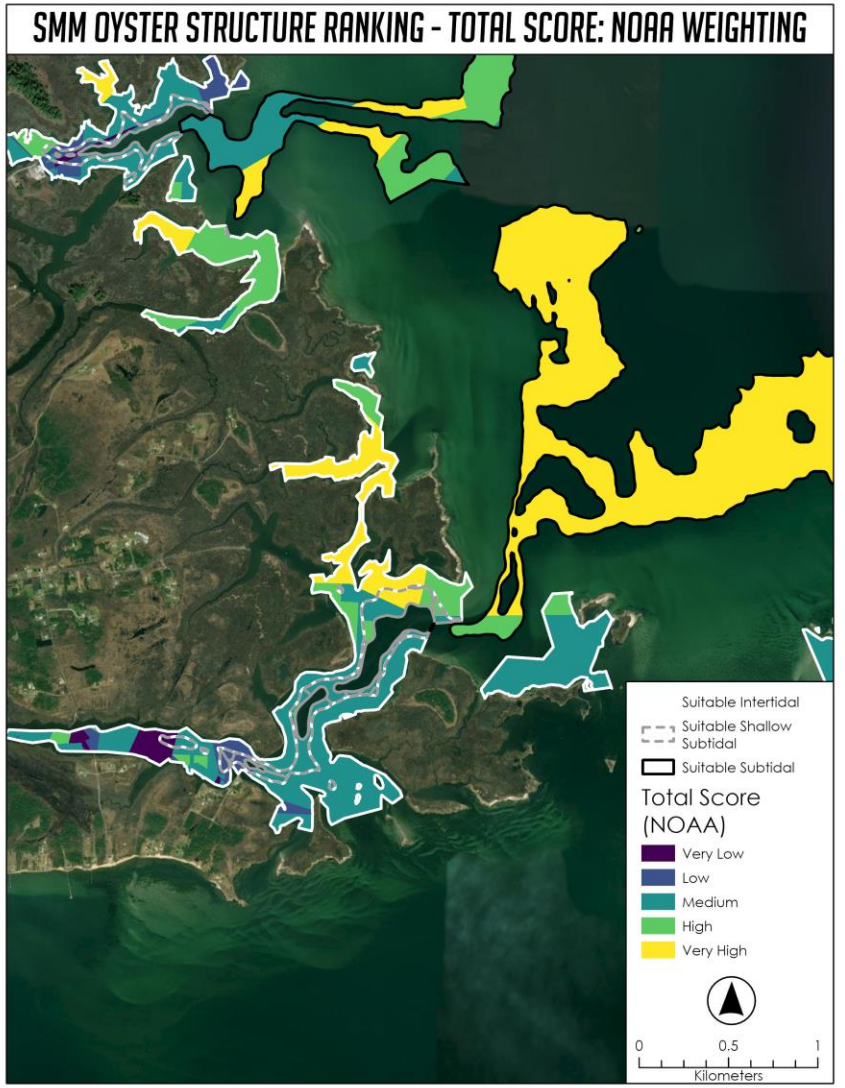
- Barge Access
- Demographic Index
- Environmental Justice Index
- Erosion Rates
- Marsh Migration Potential
- Oyster Restoration Proximity
- Priority Conservation Areas
- Project Area
- Public Access
- Recreational Potential
- SAV Proximity
- Substrate Type
- Wetland Size

Site Ranking

- Weighted ranking approach allows NOAA & VMRC to identify which metrics will carry the highest priority.

- Dynamic weighting schemes available in future iterations.





Ranking Classification	Area (acres)	%
Very Low	934	10.0
Low	1390	14.8
Medium	4662	49.7
High	1496	15.9
Very High	904	9.6

Estimation of Wave Attenuation

(geospatial approach)

APPROACH: Use a wave transmission coefficient to estimate wave attenuation by structures.

- The output of this layer shows the wave transmission coefficient and can inform where the placement of structures will have an impact on wave attenuation.

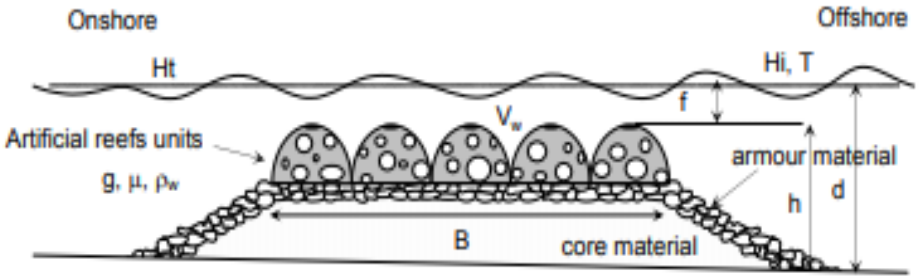
$$K_t = 1.616 - 31.322\frac{Hi}{gT^2} - 1.099\frac{h}{d} + 0.265\frac{h}{B}$$

•Variables

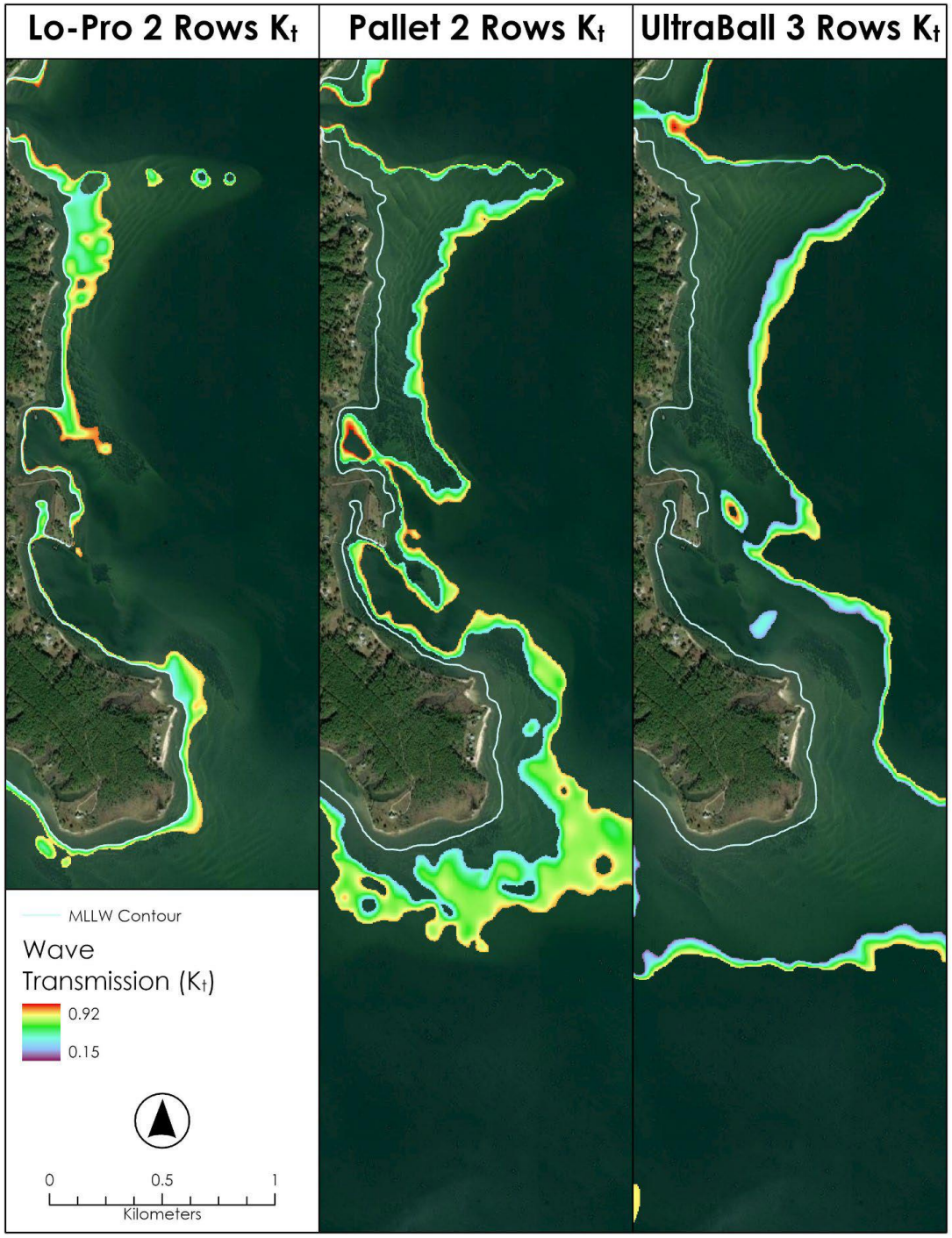
- Kt = Transmission Coefficient
- Hi = Incident Significant Wave Height
- g = 9.81 m/s2
- T = Period
- h = Initial Crest Height of Structure (m)
- d = depth (m)
- B = Crest Height Diameter (m)

•Inputs

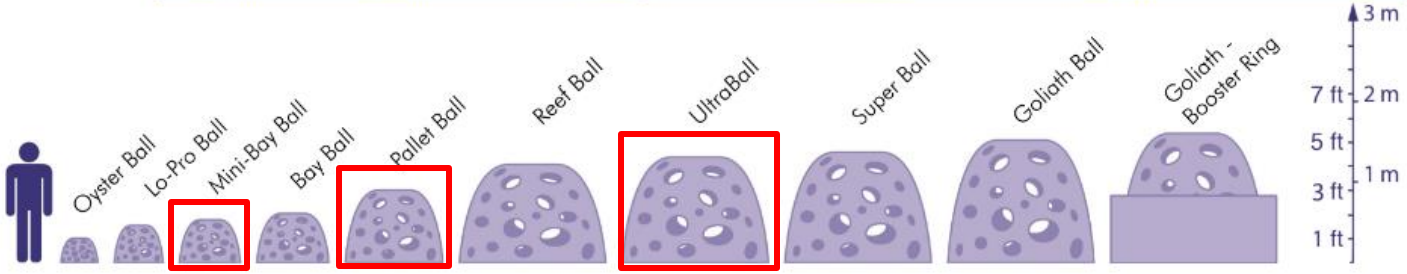
- Hi = SCHISM 2010 Average Conditions
- T = Period (3 seconds, can be changed)
- h = 1 (change depending on structure)
- d = CB Topobathy
- B = 3 (change depending on structure)



Armono, H. D., & Hall, K. R. (2003) Wave transmission on submerged breakwaters made of hollow hemispherical shape artificial reefs [Paper Presentation]. Proceeding of Canadian Coastal Conference, Kingston, Ontario, Canada.



	WIDTH	HEIGHT	WEIGHT	CONCRETE VOLUME	SURFACE AREA	# OF HOLES
Goliath - Booster Ring	6′ 6″ (2 m)	3′ (0.91 m)	4000 - 6000 lbs (1800 - 2727 kg)	1.3 yd3 (0.99 m3)	180 ft2 (16.7 m2)	15 - 25
Goliath Ball	6′ (1.83 m)	4′10″ (1.46 m)	4000 - 6000 lbs (1818 - 2727 kg)	1.3 yd3 (0.99 m3)	230 ft2 (21.4 m2)	25 - 40
Super Ball	6′ (1.83 m)	4′6″ (1.37 m)	4000 - 6000 lbs (1818 - 2727 kg)	1.3 yd3 (0.99 m3)	190 ft2 (17.6 m2)	22 - 34
UltraBall	5′ (1.52 m)	3′10″ (1.83 m)	3000 - 4000lbs (1360 - 1818 kg)	0.75 yd3 (0.57 m3)	150 ft2 (14 m2)	22 - 34
Reef Ball	6′ (1.83m)	3′8″ (1.12m)	3000 - 4200 lbs (1360 - 1905 kg)	0.75 yd3 (0.57 m3)	130 ft2 (12 m2)	22 - 34
Pallet Ball	4′ (1.22m)	2′11″ (0.88m)	1200 - 1800 lbs (544 - 816 kg)	0.33 yd3 (0.25 m3)	75 ft2 (7 m2)	15 - 20
Bay Ball	3′ (1.91 m)	2′ (0.61m)	375 - 750 lbs (170 - 340 kg)	0.16 yd3 (0.12 m3)	40 ft2 (3.7 m2)	11 - 16
Mini-Bay Ball	2′6″′ (0.76m)	1′9″ (0.53m)	250 - 400 lbs (113 - 181 kg)	0.09 yd3 (0.07 m3)	30 ft2 (2.8 m2)	9 - 14
Lo-Pro Ball	2′ (0.61m)	1′6′ (0.46m)	100 - 200 lbs (45 - 90 kg)	0.05 yd3 (0.04 m3)	17 ft2 (1.6 m2)	8 - 12
Oyster Ball	1′6″ (0.46m)	1′ (0.30m)	40 - 60lbs (18 - 27 kg)	0.016 yd3 (0.012 m3)	8 ft2 (0.74 m2)	6 - 8



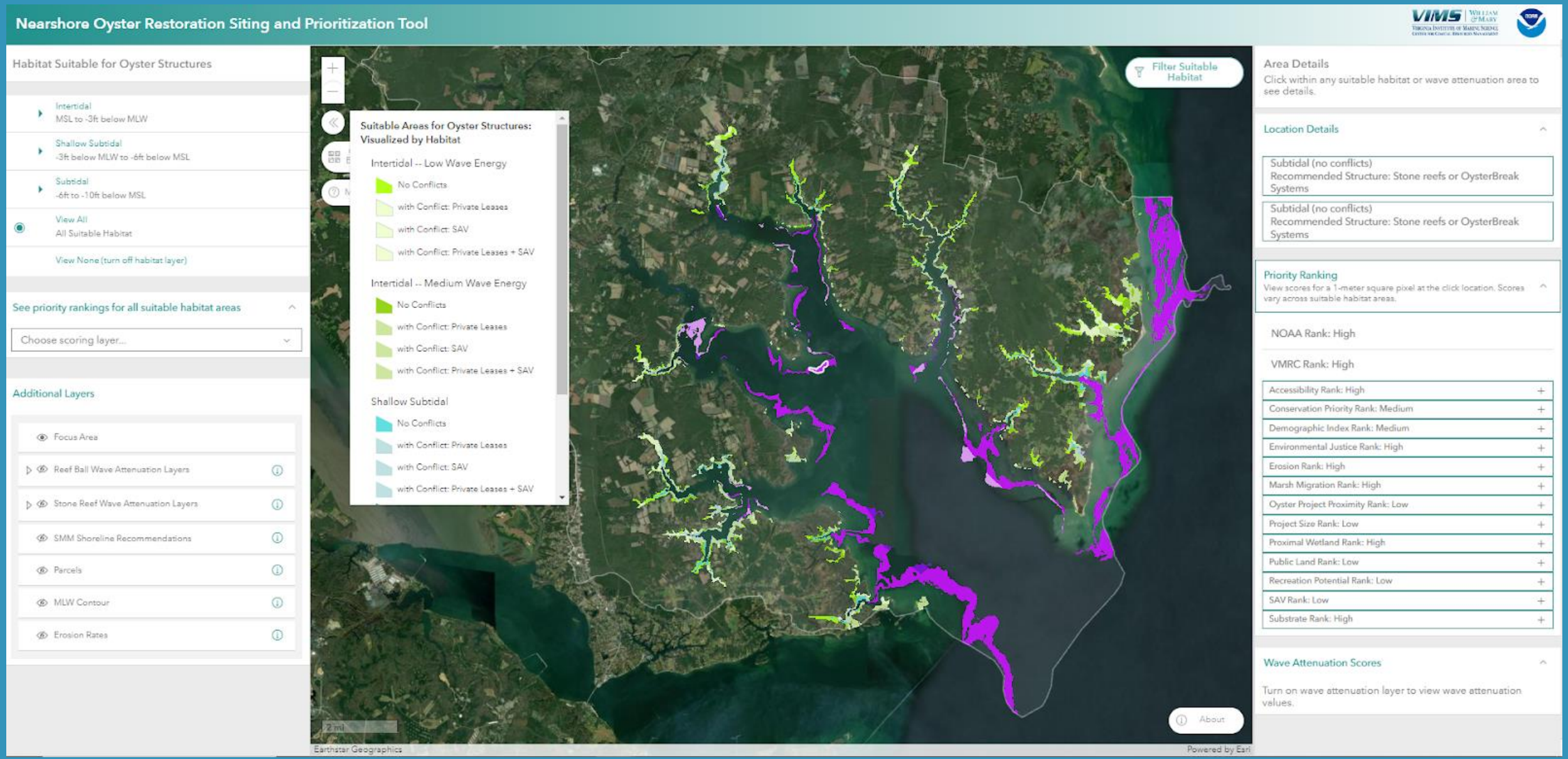
(source: Reef Ball Foundation)

Areas with a K_t close to zero will be optimal for the creation of an oyster structure with the purpose of attenuating wave energy, as a K_t value close to zero indicates that the structure is able to significantly reduce the height of an incoming wave.

Project Products

- Model outputs will be served via a web-based **interactive map viewer.**

- From their desktops, end-users will be able to determine suitable areas for oyster structures and identify the criteria incorporated in the modeled outputs.



https://cmap22.vims.edu/OysterRestoration/index.html

Future Work

- Validation of SMM-oyster structure branch with field measurements and on-site visits to determine the degree of agreement between the model outputs and observations.

- Conduct further studies that model configurations and designs of oyster structures, both in the short and long term.

Using hydrodynamic models that can measure wave field and tidal-driven flow, as well as biological interactions between oysters and their environment will enable scientists and stakeholders to determine what structures will be most effective at addressing erosion in the short and long term.

Thank you!

Steering committee and stakeholders:

NOAA, VMRC, VA-DEQ, VA-DCR, VA-DWR, Hampton Roads PDC, Middle Peninsula PDC, Wetland Watch, Green Fin Studio.

Credit: Aileen Devlin/Virginia Sea Grant

Questions? ***karinna@vims.edu***