Size Matters: The Role of Smaller Oysters on Filtration Services in the GTM Estuary

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A. Background, Objective, and Method

Objective

Design a new algorithm to evaluate the filtration services of oyster size classes in a waterbody.

Gap/Relevance

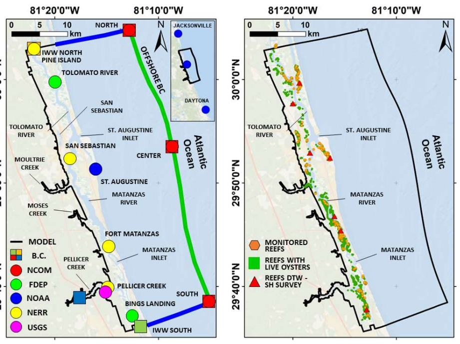
Oysters can filter large amount of water and pollutants in a very short time. Oyster with different size have different effect on filtration services. However, there is **no simple way to determine how much pollutants can be filtered by each oyster size class.**

Method

- Evaluate the size class distribution of oysters in the Guana-Tolomato-Matanzas (GTM) estuary
- Create an algorithm to evaluate the filtration of each oyster class
- Evaluate how different stressor influences the filtration rate of the reefs in the GTM estuary

Example of an oyster reef in Florida, USA (Courtesy of GTMNERR)

B. Study Area and Dataset



Oyster reefs datasets

- ~ 4300 reefs with alive oysters (Fish and Wildlife Research Institute, FWRI)
- ~ 400 reefs with dead oysters (FWRI)
- ~ 250 reefs surveyed by the GTMNERR

Oyster properties

- D_O: Oyster density [oysters/m²]
- SH: Shell length [mm]
- DTW: Dry Tissue Weight [grams]

C. Oyster Metrics Distribution [1]

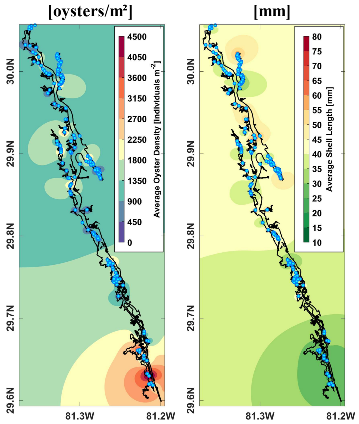
A green cell indicates that oyster data were collected by the GTMNERR in that season and year

Categorize SH into 24 size classes (0-240 mm at 10 mm intervals) and assigned D_O to each class

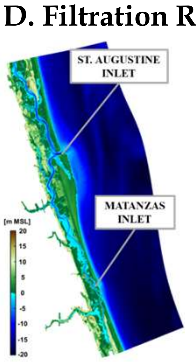
An inverse distance weighted interpolation method is used to calculate the distribution of D_O and SH classes on the not surveyed reefs, using data from the neighboring surveyed locations (blue dots in the figures).

Survey periods

Year	Summer	Winter
2014	green	
2015	green	green
2016	green	green
2017		green
2018		
2019		
2020		green
2021		
2022		green
2023		green



D. Filtration Rate Calculation [2]



Delft3D - FLOW

Cells:

- Estuary: ~15×20 m
- Ocean: ~50×100 m

Delft3D - PART

- Particle injected on a regular grid 50 m×50 m on the domain
- 2 injections, 1 every two hours from t_0

Model Scenario

- 9th May – 10th June 2018
- 1 minute time step

Filtration Rate Oyster (FR_O)

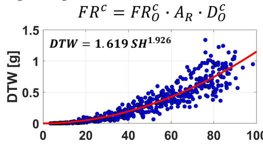
Volume of seawater filtered per unit time by each animal [L oyster h^{-1}]

$$FR_O = 8.02 \cdot DTW^{0.58} e^{-0.015(T-27)^2}$$

Filtration Rate Oyster Class (FR^c)

Volume of seawater filtered per unit time by each oyster size class in a reef [L h^{-1}]

$$FR^c = FR_O^c \cdot A_R \cdot D_O^c$$



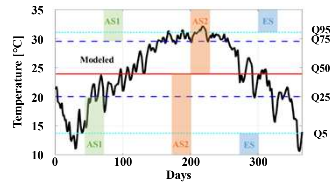
Principal Assumptions

- Each particle is initialized with a particle concentration (of mass, x) of 100 %
- At each time step, x is reduced by oyster reefs proportionally to FR

$$dx = \sum_{c=1}^{N_C} dx^c = -\frac{x}{V}\, dt \sum_{c=1}^{N_C} FR^c$$

- There is no increase of x in time
- Particles are filtered only when passing over a reef

E. Model Scenarios

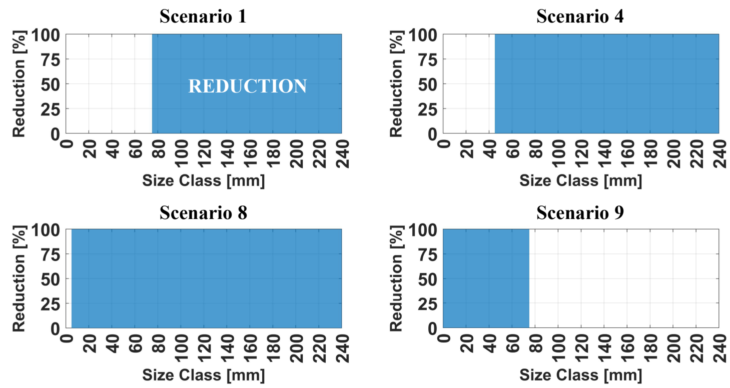


Temperature Scenarios

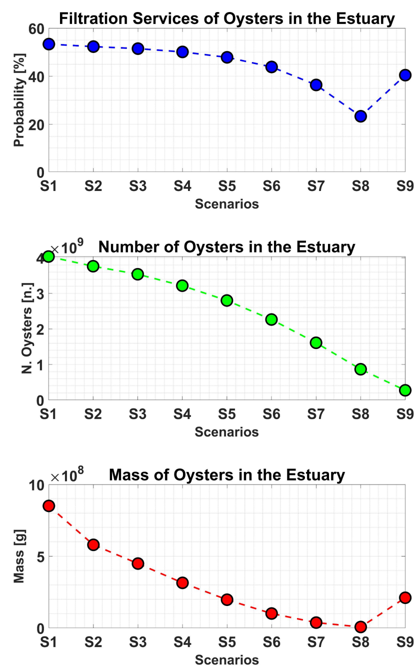
- Yearly average temperature
- Extreme temperature scenarios (ES)
- Average seasonal with one quantile temperature (AS1)
- Average seasonal with two quantiles temperature (AS2)

Oyster Harvesting [3]

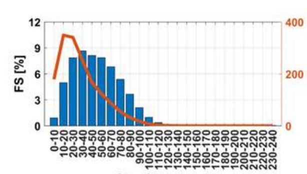
- 9 Scenarios
- In scenarios 1 – 8 all oysters with a shell height larger than 75, 65, 55, 45, 35, 25, 15, and 5 mm are removed from the reefs
- In scenario 9, all oysters with a shell height smaller than 75 mm are removed from the reefs



F. Results



- A decline in the oyster population caused by harvesting up to the current size limit (SH = 75 mm) is unlikely to result in a significant decrease in Filtration Services (FS) in the estuary. This is because the estuary contains a large number of smaller oysters that effectively filter water and pollutants (the estuary is already "overfiltered" by oysters, see [2]).
- A significant reduction in Filtration Services occurs only when the majority of oysters, particularly those smaller than 75 mm, are removed from the estuary, constituting the majority of the population.



G. Future Work

Low Recruitment

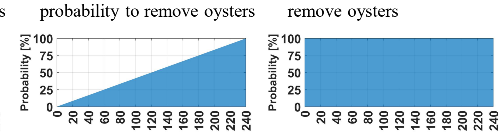
- Decrease of total oyster population: 25, 50, 75, and 90% to 0%
- Linearly decreasing probability to remove oysters

Oyster Predation

- Decrease of total oyster population: 25, 50, 75, and 90% to 0%.
- Linearly increasing probability to remove oysters

Disease

- Decrease of total oyster population: 25, 50, 75, and 90% to 0%.
- Uniform probability to remove oysters



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References

[1] Dix, N., Dunnigan, S., Lee, J., Tomazinis, J., 2019. Guana Water Quality Two-Year Summary Report July 2017 - June 2019. Tech. Rep. 16.

[2] Gray, M.W., Pinton, D., Canestrelli, A., Dix, N., Marcum, P., Kimbro, D., Grizzle, R., 2021. Beyond Residence Time: Quantifying Factors that Drive the Spatially Explicit Filtration Services of an Abundant Native Oyster Population. Estuaries and Coasts 45, 1343–1360. https://doi.org/10.1007/s12237-021-01017-x

[3] Fla. Admin. Code R. 68B-27.015, 2001.