A Viable Low Carbon Footprint Alternative for Eastern Oyster (*Crassostrea virginica*) Reef Substrates

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Abstract

- ~85% of oyster reefs are now extinct.
- Current oyster shell supply can't meet reef restoration needs.
- Concrete artificial reef structures are often used.
- Concrete production, however, accounts for 7% of global CO_2 emissions.
- Sustainable artificial reef structures are needed.
- For 2 months, larval settlement and juvenile oyster attachment strength were evaluated on:
  - A low carbon footprint cement
  - Oyster Castle®
  - Natural oyster shell
- Overall, the low carbon footprint material performed as well as oyster shell.
- Oyster attachment strength was weaker on low carbon footprint cement and concrete.

Introduction

- Oysters sustain estuaries, filtering 30+ gallons daily.
- Oysters grow best on oyster shells, which are becoming costly and rare.
- However, oysters will successfully set on a variety of hard substrates:
  - Non-oyster shell, dredged shell
  - Non-calcium stone, porcelain
  - Limestone
  - **Concrete**
- Concrete is more affordable, but it is not an eco-friendly product to produce (~7% of world's CO_2 emissions).
- More affordable, sustainable reef materials are needed.
- Sustainability can be reached through:
  - Reducing CO_2 from cement production
  - Waste heat recovery (WHR)
  - Utilizing lower-clinker and **lower-carbon cements**
  - Alternative fuels, digitalization, carbon capture and storage (CCS)
- In this study, a lower carbon material is evaluated for larval settlement and juvenile oyster attachment strength.

References

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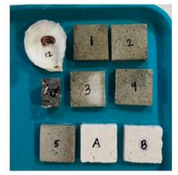
3. Vakifahmetoglu, Cekdar, Jean Francois Anger, Vahit Atakan, et al. "Reactive Hydrothermal Liquid-Phase Densification (rHLPD) of Ceramics – A Study of the BaTiO3[TiO2] Composite System." *Journal of the American Ceramic Society* 99, no. 12 (2016): 3893–901. https://doi.org/10.1111/jace.14468.

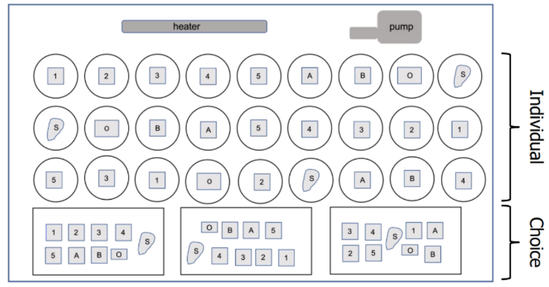
Methods and Materials

Sample fabrication

Proprietary Processing



Label	Substrate
1	100% cement
2	75% slag
3	75% slag, 1.5% PCL
4	75% slag, 1.5% PLA
5	75% slag, 1.5% PHA
A	Low carbon cement w/ 10% wt. oyster shell (1-5mm crushed)
B	Low carbon cement w/ 50% wt. oyster shell (1-5mm crushed)
O	Oyster Castle
S	Oyster Shell



Individual & Choice Oyster Evaluations

Results

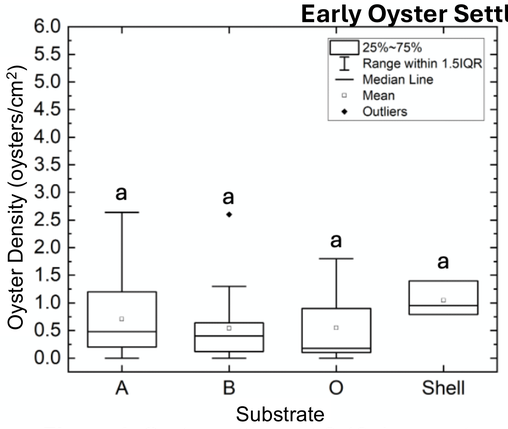


Figure 1. Oyster settlement 8-13 days post larval release in choice experiments.

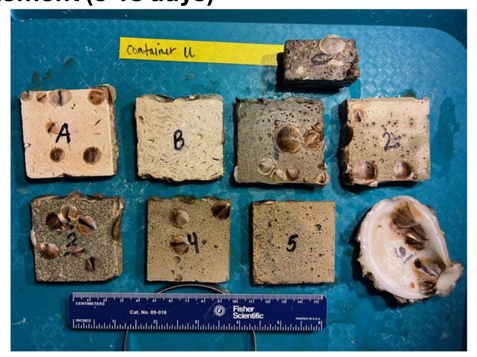


Figure 2. Oyster settlement 1 month post larval release in choice experiments.

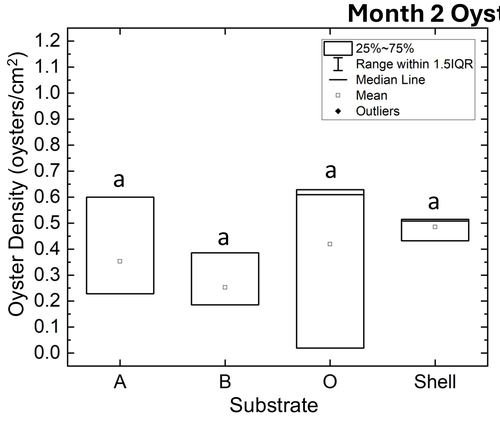


Figure 3. Oyster settlement 2 months post larval release choice experiments.

Figure 4. Oyster settlement 2 months post larval release choice experiments.

Discussion

- Findings suggest that low carbon cements offer a promising eco-friendly alternative for oyster reef restoration.
- Further enhancements to attachment strength are needed.

Figure 5. Technicians removing oysters shell on substrates.

	C	CS	OC	Shell
Mean Strength Ranking	1.2	1.0	3.6	3.2

Table 1. Attachment strength of oyster shells to low carbon cement and concrete, conducted in 2021.

	Low Carbon Cement	Low Carbon Concrete
Mean Strength Ranking	3.17	2.0

Table 2. Attachment strength of oyster shells to low carbon cement and concrete, conducted in 2024.

Acknowledgements

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