Grow Oyster Reefs LLC

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GROW Oyster Reefs llc designs and manufactures biomimetic calcium carbonate aquatic ecosystem restoration substrates to jumpstart native oyster reefs — attenuating wave energy, protecting shorelines, restoring the seabed, balancing pH, while sequestering carbon.

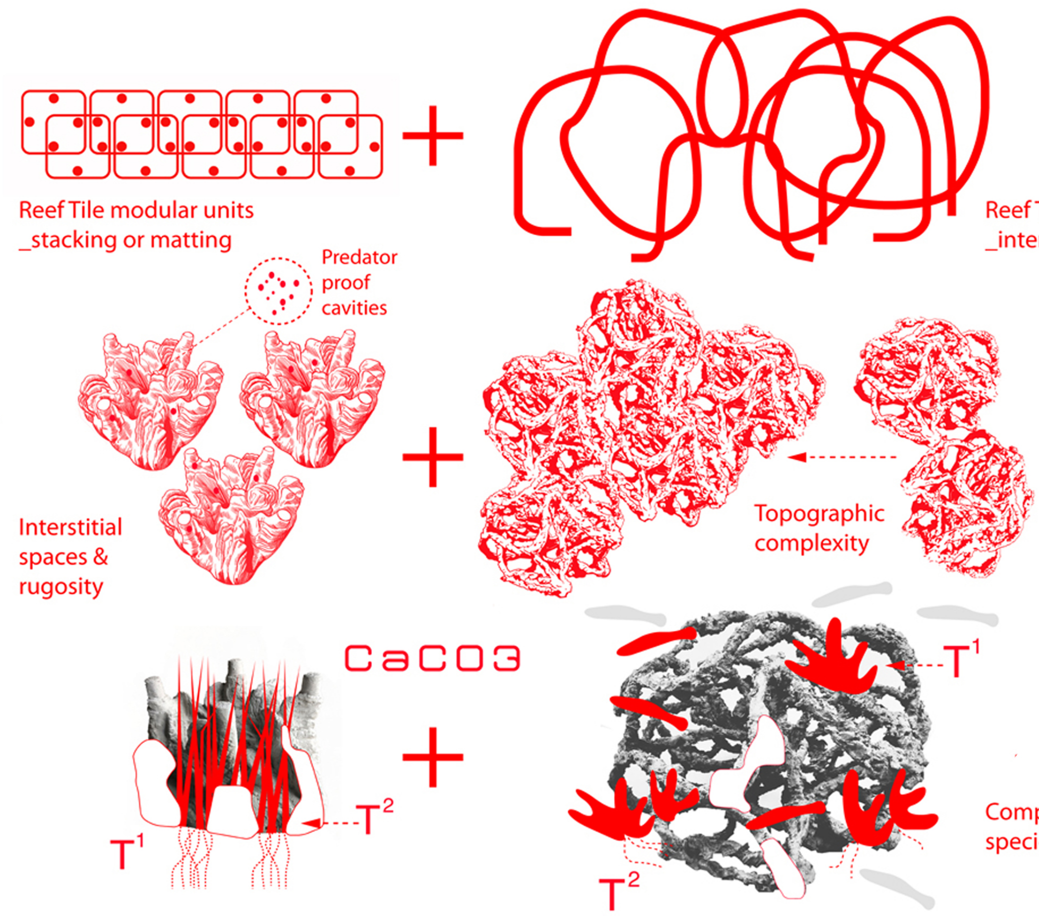
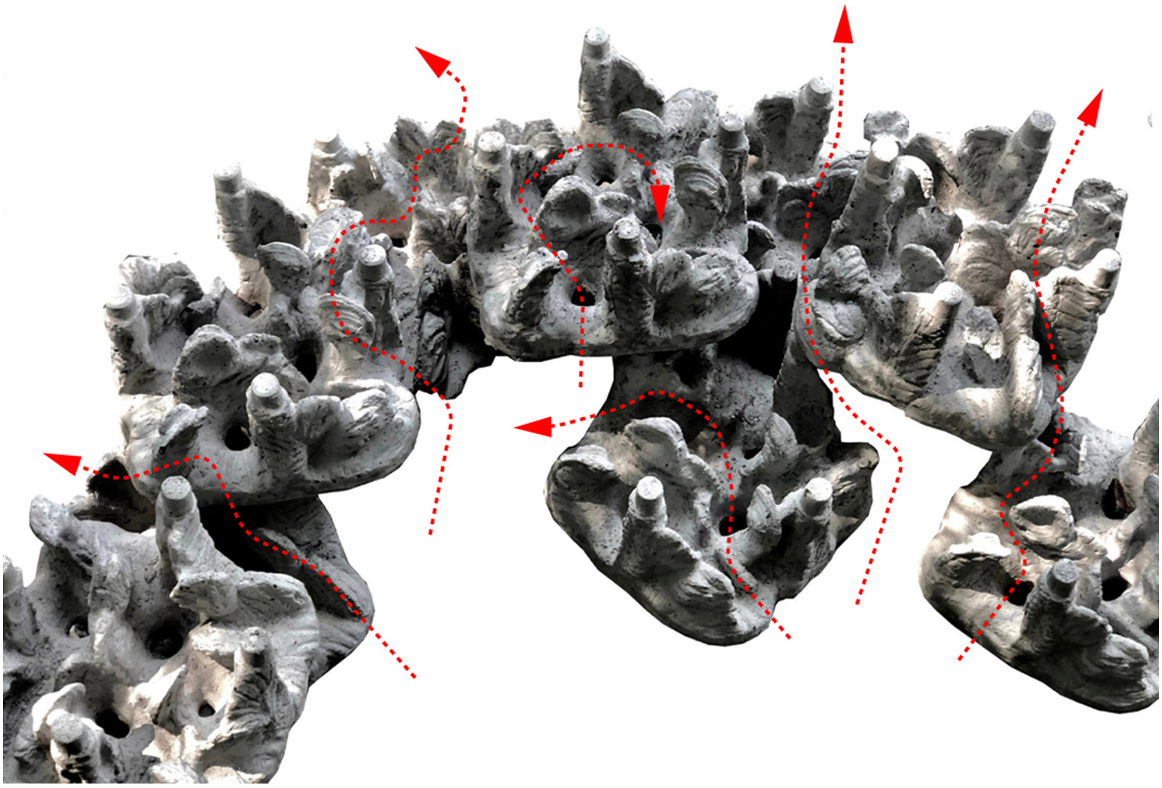
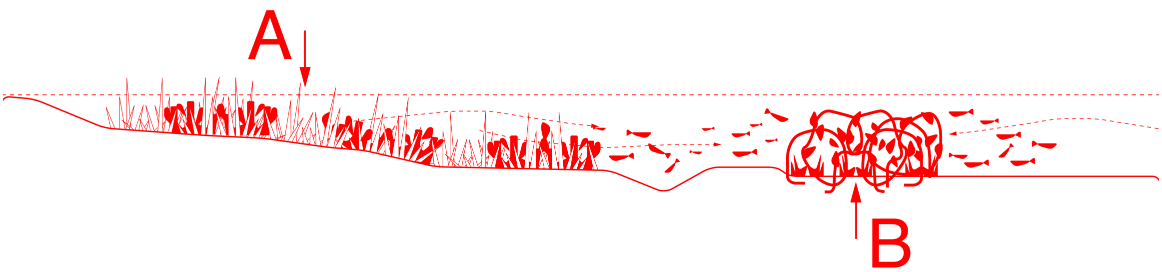


figure 01: GROW_biomimetic reef substrates / Reef Tiles (left), and Reef Tangles (right), based on the native oyster reef and mangrove prop-roots respectively, restoring benthic roughness, supporting companion species, increasing biodiversity.

The oyster, a keystone species, in decline by 85% since the 1850's, has been protecting coastlines around the world for thousands of years. GROW products work with the oyster to build self-healing coastal defense infrastructures, attenuating wave energy and sequestering carbon. For the same price as rip-rap (per cubic metre), **GROW** modular reef building products can be deployed to protect shorelines and restore aquatic ecosystems in intertidal and sub-tidal zones, working with, not against nature, producing self-healing infrastructures that ensure long term resilience.

GROW Oyster Reefs' biomimetic reef substrates are modular and mimic nature in their form, material, and performance. Their complex configuration and enhanced surface characteristics provide a haven for the embryonic oyster, supporting the oysters' reef-building capacities. They are fabricated using our proprietary CaCO3 concrete mix, 85% calcium carbonate, formulated to closely resemble the mature oyster shell, producing an attractive chemical environment for oyster growth; providing a porous infrastructure with interstitial spaces at many scales, designed to facilitate the long-term recruitment and survival of embryonic oysters, and the rapid recruitment of non-reef building organisms from crabs to young fish, protecting the oysters from larger predators.





figures 02 & 03: GROW_Reef Tiles, providing a porous infrastructure to attenuate wave energy, with integrated sea-grass planting, A and GROW_Reef Tangles, as a sub-tidal 'toe' to protect the shoreline reef and tide-pools, B.

GROW Oyster Reefs' products provide complex interstitial spaces and surface indentations that protect the embryonic oyster, slowing the water flow through the substrate, dampening wave energy, allowing them to thrive. Carefully configured cavities reduce the volume and embodied energy of the concrete form and provide an array of niches for compatible species of sea-creatures and plants. Co-designing with the oyster, **GROW** concrete reef substrates are based on the principle that a kinship can be facilitated that allows the substrate to be used as a catalyst for the construction of a reef form that is responsive to the hydrodynamic and topographic context, stimulating the oysters' innate reef-building capabilities, allowing the oyster to form the self-healing, connective complexity of a native reef.

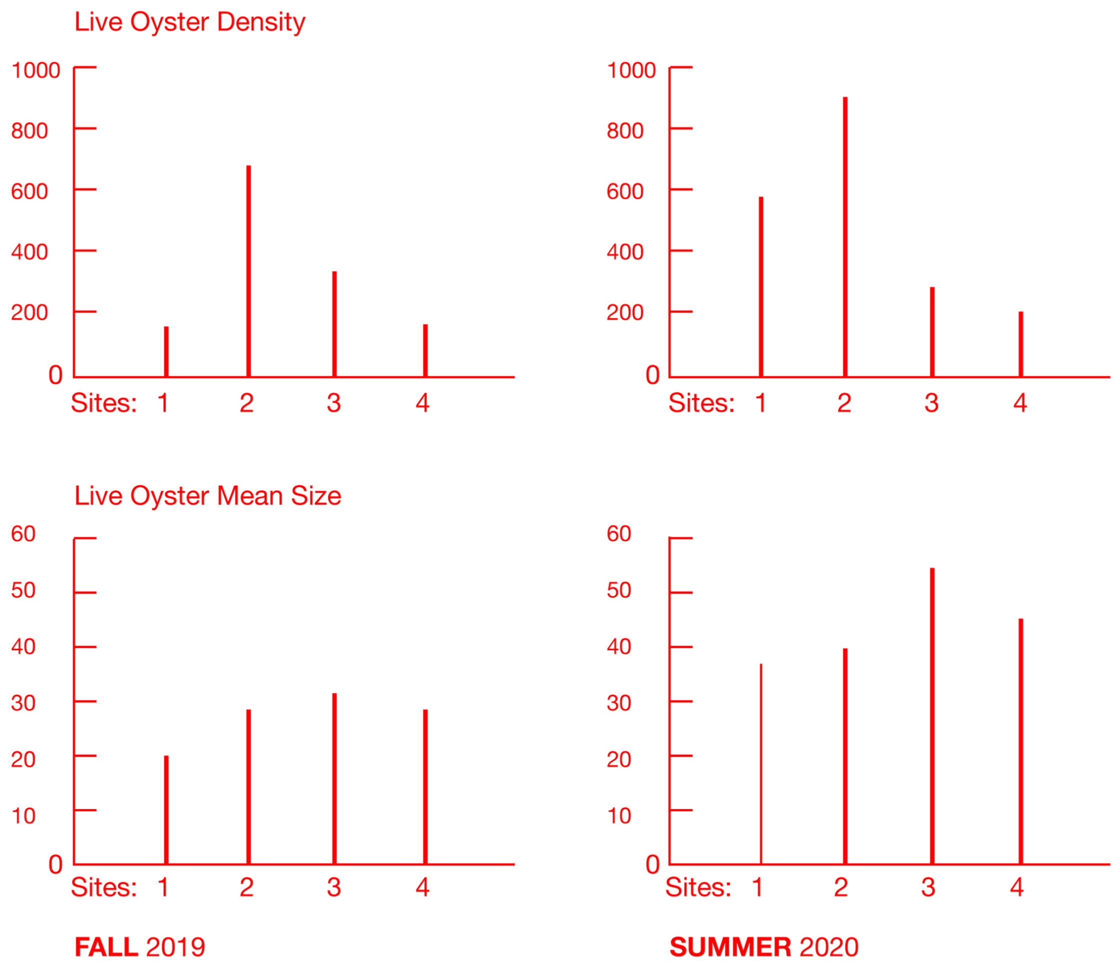


figure 04: graphs based on data collected by VIMS — fieldwork in the Chesapeake Bay (2019 - 20); density, oysters / m2, size in mm, measured using Vernier callipers. Results published in — Rochelle Seitz et al "Successful Eastern Oyster Recruitment on Two Alternative Settlement Substrates in Virginia Tributaries" (2020), Virginia Institute of Marine Science.

Testing by the Virginia Institute for Marine Science (VIMS) between 2019 and 2020, on four sites in the Chesapeake Bay, demonstrated the capacity of GROW Reef Tiles to yield between 200 and 900 oysters per square meter in one year — greater than 490 oysters per square meter, average, compared to a target density of 50 oysters per square meter for a successfully restored oyster reef, at six years post restoration.

**see below—note 4.*

GROW reefs are less carbon intensive than current approaches which require the production of concrete for seawalls, quarrying operations for rip rap, manufacturing of steel for piled protection approaches and marine construction, and less intrusive compared to long linear shore protection structures that must be tall, extending several meters above mean sea level, to provide necessary protection from waves. Uniquely, GROW reef building materials provide suitably scaled openings, designed into the substrate, facilitating the inclusion of sea-grasses and other marine plants, increasing wave attenuation and bio-diversity, producing a hybrid 'blue carbon' vegetated marine habitat, providing localised mass burial of excess organic carbon, playing an important role in mitigating the build-up of atmospheric CO_2.

Notes:

1. *from: Taylor Goelz, Bruce Vogt, and Troy Hartley "Alternative Substrates Used for Oyster Reef Restoration: A Review," Journal of Shellfish Research 39(1), 1-12, (14 April 2020). https://doi.org/10.2983/035.039.0101*

'Engineered reefs can also be designed to enhance vertical relief, allowing them to sit higher in the water column, which has been demonstrated to improve oyster settlement (Breitburg 1999, Klotzbach 2013). Last, engineered substrates can be designed with irregular surfaces and rugged textures to enhance the available interstitial space to benefit oyster recruitment and settlement (Tickle 2019).'

2. 'Enhancing the chemical acceptability of substrates inspired the design of Grow Oyster Reefs concrete oyster reef restoration tiles and concrete oyster reef restoration discs products. They are made with CaCO3 concrete, a concrete mix formulated to match oyster shell bio-chemical makeup (Tickle 2019). GROW products demonstrate that chemical elements of substrates can be incorporated into engineered options. In addition, the use of new materials for the construction of many engineered reefs limits chemical leaching concerns from these substrates.'

3. from: Georgette Tso "A Comparison of Durability and Recruitment for Reef Mimics Constructed from Marine Concrete and $CaCO_3$ Enriched Concrete." (February 2021), Masters of Environmental Engineering Thesis supervised by Heidi Nepf, Donald and Martha Harleman Professor of Civil and Environmental Engineering, at MIT.

'. . . chemical cues are not the only important factor in mollusk recruitment, as the presence of live conspecifics and low-shear surface pockets are also hypothesized to increase recruitment of mollusks (Crisp 1967, Vasquez et al. 2013, Mullineaux and Butman 1991). The presence of larger mussels on GROW discs from the 420-day retrieval was encouraging, as it implied that the GROW discs support the health and

survival of adult mollusks. The leaching potential calcium and carbonate ions from GROW discs was demonstrated in turbulent flume conditions to be more than adequate for shell precipitation.'

4. Maryland Department of Natural Resources — evaluation criteria used to determine the restoration success of an oyster reef and tributary / Harris Creek Study (2013).

- *A successfully restored reef should have:*
    - *A 'minimum threshold' of 15 oysters and 15 grams dry weight per square meter covering at least 30 percent of the target restoration area at six years post restoration;*
    - *A 'target' of 50 oysters and 50 grams dry weight per square meter covering at least 30 percent of the target restoration area at six years post restoration;*
    - *Two or more oyster year classes present; and*
    - *Stable or increasing spatial extent, reef height, and shell budget.*

- *A successfully restored tributary is one where:*
    - *50 to 100 percent of the currently restorable oyster habitat (CROH) has oyster reefs that meet the reef-level metrics above. Restorable habitat is defined as area that, at a minimum, has appropriate bottom quality and water quality for oyster survival AND*
    - *8 to 16 percent of historic habitat (Yates Bars), and preferably more, has oyster reefs that meet the reef-level metrics above.*

About us:

GROW Oyster Reefs' proprietary biomimetic concrete mix and substrate prototypes have been validated in coastal and estuarine waters from Maine to the Gulf of Mexico, underwater for periods of more than one year, in partnership with The Nature Conservancy (Maine), U.S. Fish and Wildlife, and VIMS, the Virginia Institute of Marine Sciences and the Elizabeth River Project, MIT, UMass Boston, and the University of Maryland, and on the West Coast, with Oregon State University. New projects have been initiated with the Chesapeake Bay Foundation (CBF), Reti Center, New York, and the South Carolina Floodwater Commission (SCFC). A prototype reef-tangle has been installed in the Gulf of Mexico since July 2018. Schmidt Marine Technology Partners are funding increased production capacity, output, and reef building with GROW products specifically designed to support and protect submerged aquatic vegetation, in the Chesapeake Bay and the Gulf of Mexico, for multi-year testing of carbon burial and nitrogen reduction potential. Grow Oyster Reefs' products have been installed in the UK's first biomimetic coastal defence infrastructure, delivering remarkable results.

GROW is a woman owned company committed to social inclusion and equity. GROW Oyster Reefs' concrete reef building substrates can positively impact the lives of everybody living in coastal communities, more than a billion people, worldwide, contributing to the local economy at all levels, encouraging entrepreneurship, building community and fostering a healthy environment. Light weight and small scale, allowing anyone, young and old, to participate in their installation, GROW ecosystem restoration systems are deployed incrementally, with multiple ownership potentials, from the aquaculture specialist to the private landowner, to Federal Agencies, Industrial landowners and NGOs acting on behalf of these communities.

Evelyn **Tickle**; CEO (full-time), Founder, Inventor — has more than 20 years of experience in the concrete fabrication industry. Invented GROW Oyster Reefs' biophilic concrete mix. Educated as an Architect, with a specific interest in biomimicry. Evelyn's concrete oyster reef restoration products have established GROW as an internationally recognized leader in the fields of coastal resilience and aquatic ecosystem restoration. She is a Fellow of the American Academy in Rome, was selected as an MIT Solver in 2019, and a RISE Innovation Fellow in 2020.