Corals Meet Oysters: The Optimum Geometric and Chemical Design for Restoration

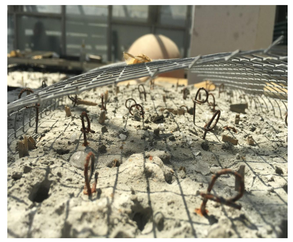
W. Taylor Wilson and Matt Cowan

Sponsor: Dr. Thomas Manning

Department of Chemistry

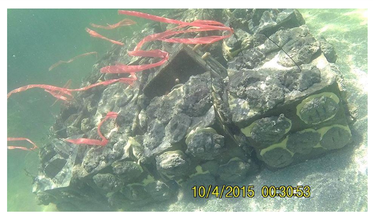
Worldwide coral reefs and oyster bars are under attack by human generated chemical and physical parameters, ranging from ocean acidification and pollution to tourism and overharvesting. In order to bring back these reefs and bars, a technique that can be scaled up is needed. Current techniques for corals such micro-fragmentation have shown some promise to rejuvenate coral populations but the ability to scale up for a large application are not promising at this point. Oyster restoration now often includes recycle oyster shells from restaurants, cleaning them, placing in perforated plastic bags and deploying them. This approach works on a small scale but has little chance of being scaled up to work along the entire Chesapeake Bay or the Southern coast of Louisiana. At VSU we have developed a material called NEC or Nutrient Enriched Concrete as an economical and green approach for coral and oyster restoration. This presentation will outline current designs for the coast of Georgia and north Florida for oysters and the Florida Keys for corals. (below, corals growing on VSU NEC in Florida Keys).

(Upper left): This will be inserted in the sand leaving a 3 inch gap below the NEC Plate. (Upper right) the layers provide protection for coral larvae when they settle, sand strips will quickly fall out in water leaving additional crevices (left) during construction, sand is used to create layers of the NEC surfaces.



What is NEC (Nutrient Enriched Concrete) and how is it delivered:
1. Organic nutrients (sugars, citric acid Starches, nucleic acids, amino acids, Vitamins, fatty acids, triglycerides, Lipids, etc. are absorbed in the wood Pieces and inserted;
2. Inorganic nutrients such as iron, Nitrate, ammonia, sulfate, phosphate Potassium, calcium, manganese and copper Are absorbed at low levels into the paper
3. The concrete is soaked in a bath of eggs, oranges and potatoes.
4. Iron metal is used so it rusts (forms Iron oxides and hydroxides) and generates a weak electrical current (redox reactions are a sign of life).
5. Fresh sawdust is included in the concrete And provides nutrients, allows the concrete To degrade with time, needed microbes Will grow in it.
6. Rock Salt is included. It will dissolve In water and leave needed indentations For polyps to grow free from predators.

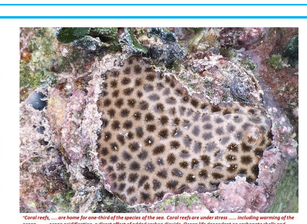
Tiles are used in one experiment. They will be colored (red, yellow, blue, Green, black, brown and white) to Observe if larvae have a color preference For settlement.

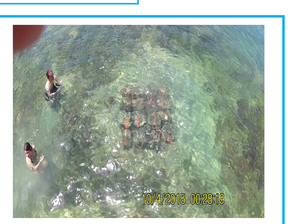


We have been hit by hurricanes. – in the Keys, along the Georgia coast and the Florida panhandles.

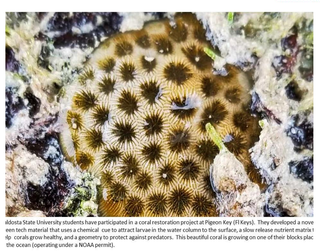
Pigeon Key in a small Island in the Florida keys Where our group does their work. We currently have a NOAA permit for the research project. Hundreds of VSU students have visited Pigeon key with Dr. Manning over 20 plus years.

VSU Student moving coral restoration material at Pigeon Key, where we have our Permit. Over a thousand pounds of materials were moved to Pigeon Key, a remote island, by a large boat. It is than transferred to a small boar, in pieces, to take it to shallow water.





"Coral reefs, ...are home for one-third of the species of the sea. Coral reefs are under stress ..... including warming of the ocean, ... ocean acidification, a direct effect of added carbon dioxide. Ocean life dependent on carbonate shells and skeletons is threatened by dissolution as the ocean becomes more acid." James Hansen



aldosta State University students have participated in a coral restoration project at Pigeon Key (Fl Keys). They developed a nove een tech material that uses a chemical cue to attract larvae in the water column to the surface, a slow release nutrient matrix t rip corals grow healthy, and a geometry to protect against predators. This beautiful coral is growing on one of their blocks plac the ocean (operating under a NOAA permit).

The most common corals we observe in our grow outs are *Siderastrea radians*. Colonies are massive, usually less than 300 mm. They sometimes occur as free-living mobile balls. Corallines are rounded, deep, usually irregular and 2.5-3 mm. Habitat: Shallow reef.

Page 2

Valdosta State University Coral Research

Over the past year, Doctor Thomas Manning and his students (Weldon Lane, Shannon Pendleton, Matt Cowan, and Erin Manning) from Valdosta State University located in Valdosta, Georgia have been testing new coral restoration techniques in the waters near Pigeon Key. After receiving a grant for his research, the techniques are now being tested in collaboration with the Florida Fish & Wildlife Commission, Florida State University marine lab and supported by the Schmidt Marine Technology Partners, USA. They have also received a permit from NOAA (National Oceanic and Atmospheric Administration) to test the material in the Florida Keys National Marine Sanctuary. Dr. Manning and his students are striving for an economical green approach that can be implemented on a large scale.

Dr. Manning's group has developed a material described as biodegradable concrete. Inside each one of these concrete blocks is a 4x4x4 inch cube loaded with nutrients and chemical cues. After being exposed to water, the nutrients and chemical cues slowly diffuse out of the center of the block in a few months. The nutrients include vitamins, amino acids, proteins, sugars, starch, cellulose, urea, citric acid and chitin. These nutrients serve two general purposes in the structure. First, they allow a bacterial film to form quickly (hours to days) on the surface of the material. This is critical for coral larvae settlement. Second, the inclusion of organic species weakens the concrete structure and allows marine creatures to attach to or bore into it. You may also notice in the pictures the concrete "cookies" on the surface. These provide an irregular surface and gaps for larvae to settle on or in. The goal of the project is to place the biodegradable pieces of concrete on a hard bottom near Pigeon Key, where they can be monitored on a regular basis. If successful, this novel material could be utilized for coral restoration in the Florida Keys National Marine Sanctuary as well as other locations worldwide.

Executive Director Kelly McKinnon states, "Everyone involved with this project at Pigeon Key is very excited about the possibility of being able to establish a base line for invertebrate and coral growth at an accelerated rate. We see this as a great way to combat ever changing new diseases found by our coral researchers and a way to establish new colonies thereby spreading out the stress of an ever growing tourist economy on our oceans. The Pigeon Key Foundation is honored to be a part of the research conducted by Dr. Manning and his students."

Like our Facebook page for the most up to date info!

Stay Connected

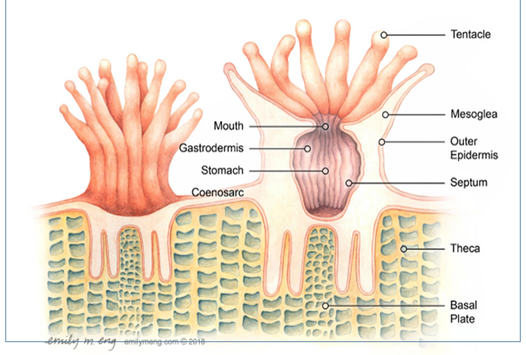
Pigeon Key is Hiring for 2018!

Fire Coral (Chemical defense). Many creatures in nature, from tobacco plants and nicotine to bacteria and antibiotics, defend themselves with chemicals. Humans test many of these chemicals to see if they have cancer, antibiotics, antifungal, etc. activity.

Most corals have chemical defense systems that have no impact on humans. An exception is fire coral. This causes a stinging sensation and a rash in most people, when they touch it. There are three types of toxins involved; Saxitoxins, which interfere with sodium channels (in marine creatures it can cause paralysis). Palytoxins impact cell membrane activity'; and can impact kidneys and red blood cells, and can result in heart failure; Lophototoxin, cause muscle contractions and sometimes paralysis.

Coral are colonies of polyps – an animal that is only surpassed by sponges as being the simplest animal in the ocean. Corals tentacles gather food at night, and digest it. The polyps is embedded in the limestone structure. There are different methods of breeding that corals follow.

Corals can reproduce asexually and sexually. In asexual reproduction, new clonal polyps bud off from parent polyps to expand or begin new colonies.
About three-quarters of all stony corals produce male and/or female gametes. Most of these species are broadcast spawners, releasing massive numbers of eggs and sperm into the water to distribute their offspring over a broad geographic area . The eggs and sperm join to form free-floating, or planktonic, larvae called planulae.



We would like to thank VSU Chemistry department, UGA marine Lab, Pigeon Key Marine Lab, and all of our classmates that helped make materials, and travel To the keys.

Taylor (cap) and Matt (blue coat) prepped for and ran the Learning in Retirement activity during the spring, 2020 semester (along with Jenu, Yalanda, Thomas)

Coral and Oyster Restoration - Bailey Science Center

VSU Professor of Chemistry, Dr. Thomas Manning, and his students have been testing new techniques as they strive for an economical green approach to coral restoration which can be implemented on a large scale. They make their own materials in the Bailey Science Center (BSC) greenhouse. This session includes a trip to the greenhouse on the 4th floor for a demo, but bring a pair of garden gloves as you will be able to participate hands-on, also. The greenhouse (rooftop) is wheel chair accessible. Elevator and ramps. (Class max - 12)

Park next to the building if spaces are open, or in the lot across Georgia Ave. from the BSC. Meet in the atrium on the first floor..

20SLIR207 | Sat, Feb 1 | 9 AM - 12 PM
Dr. Thomas Manning, Instructor

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Florida Keys National Marine Sanctuary
33 East Quay Road
Key West, Florida 33040

FLORIDA KEYS NATIONAL MARINE SANCTUARY
PERMIT TO OTHERWISE FURTHER SANCTUARY PURPOSES

Permittee:
Dr. Thomas Manning
Valdosta State University
1500 Patterson Avenue, BSC
Valdosta, GA 31698

Permit Number: FKNMS-2019-085
Effective Date: August 5, 2019
Expiration Date: December 31, 2022

Project Title: Coral Reef Regeneration Material

This permit is issued for activities in accordance with the National Marine Sanctuaries Act (NMSA), 16 USC §§ 1431 *et seq.*, and regulations thereunder (15 CFR Part 922). All activities must be conducted in accordance with these regulations and law. No activity prohibited in 15 CFR Part 922 is allowed except as specified in the activity description below.

Our group has a NOAA permit, tough To get, for work at a specific spot in The Florida keys.

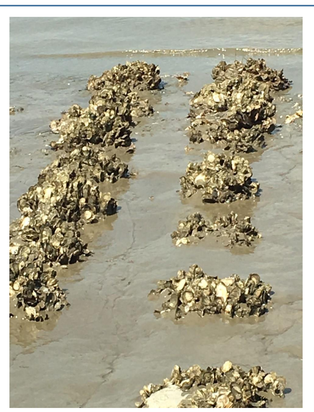
The Use of Microbial Coatings, Nutrients and Chemical Defense Systems in Oyster Restoration

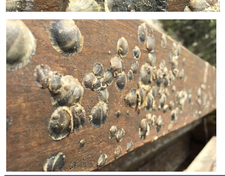
AUTHORS
Thomas J. Manning
Weldon Lane
Richard Darren Williams
Matt Cowan
Marcus Diaz
Christopher Adam Slaton
Konnor MacKey
Pavan Patel
Sydney Plummer
Brittany Butler
Tess Baker
Department of Chemistry, Valdosta State University

ABSTRACT

Many oyster species are keystone species that help mitigate shoreline erosion, provide habitats for juvenile fishes, and improve water quality. A number of human-driven factors have led to a decline in their populations worldwide. This article focuses on the chemistry of a novel substrate (nutrient-enriched concrete, or NEC) used to induce settlement and colonization of wild diploid oyster spat and is divided into four sections: (1) composition of the bulk material used for oyster restoration, (2) nutrients added to stimulate growth of bacterial and or algal biofilms, (3) nutrients included for the recently settled oyster spat, and (4) the potential use of natural chemical defense systems to control predators and competing marine life. The goal is to develop a material that can be manufactured and used on a large scale.

Keywords: oyster restoration, keystone species, concrete, nutrient, spat settlement





(above) oysters are selectively growing on treated wood , Typically barnacles quickly dominate this surface. The welch above is one of many oyster predators.

Worldwide Oyster populations have decreased by almost 90% in modern times. One Oyster can filter up to 50 gallons of water per day; an oyster bar is a critical marine ecosystem and oysters are the keystone species; and oyster bars prevent shoreline erosion. Currently groups collect oyster shells from restaurants, pace them in plastic mesh bags and deploy. This can only work for small scale projects. Similar small scale techniques are being used for coral restoration. Our goal is to develop and economic and green technology approach that can be used on a large scale.

Diseases such as black band and white Band disease have hit coral reefs around the world. They impact the symbiotic algae Zooxanthellae that give corals their color and provide it with nutrients. We are testing several natural chemical defense systems to minimize this effect.

The chemical defense in a pine tree is resin, a mixture of terpenoid compounds; also alpha-pinene (C10H14) and calcium oxalate, other chemical defense systems being considered (i) Urushiol acts as a defense mechanism in poison oak, poison ivy, and poison sumac. (ii) Pyrethrins found in the flower Chrysanthemum cinerariifolium (iii) Nicotine, extracted from the tobacco plant, (iv) Juglone from the leaves, fruit, roots, and bark of black walnut. (v) Jack-in-the-pulpit has a flower and red berries that are toxic. Known defense system in over 1,000 plants. (vi) Solanine is a glycoalkaloid poison that serves as a natural defense in potatoes, tomatoes and tobacco, among other plants. (v) Oleandrin is a toxic glycoside found in oleander, (vi) Blueberry extracts are rich in anthocyanins. (VII) fatty acids have some toxicity against bacterial and viral species.