

Sculpture and Coral Reefs: Combining Art, Research, Tourism and Education

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 Colleen M. Flanigan* and D.L. Marrin, Ph.D.
 *Living Sea Sculpture; UCSC & ^Water Sciences & Insights

- Electrolytic Reefs** (PROOF) - Image of a reef structure with text: "Using Electrolytic Reefs to Grow Coral" - CLICK
- Zoo-A Living Sea Sculpture** (SCULPTURE & LIVELIFE) - Image of a large arch sculpture in the ocean - CLICK
- Tourism** (COURT COURTESY) - Image of a boat at a dock - CLICK
- Research & Development** (KID OPEN) - Image of coral samples in a tray - CLICK
- Framing the Challenge** (APPROACH) - Image of a presentation slide: "Sustainable Living Sea Sculpture: A Case Study in Ocean Plastic Pollution" - CLICK
- Education** (ANTHROPOLITIC) - Image of educational materials - CLICK

Experiment with Dr. Carolina Padilla Souza, Milena Leite, Ilex Canal, William BARROCA, Paulo Monteiro, ICR 2019

Colleen M. Flanigan* and D.L. Marrin, Ph.D.^

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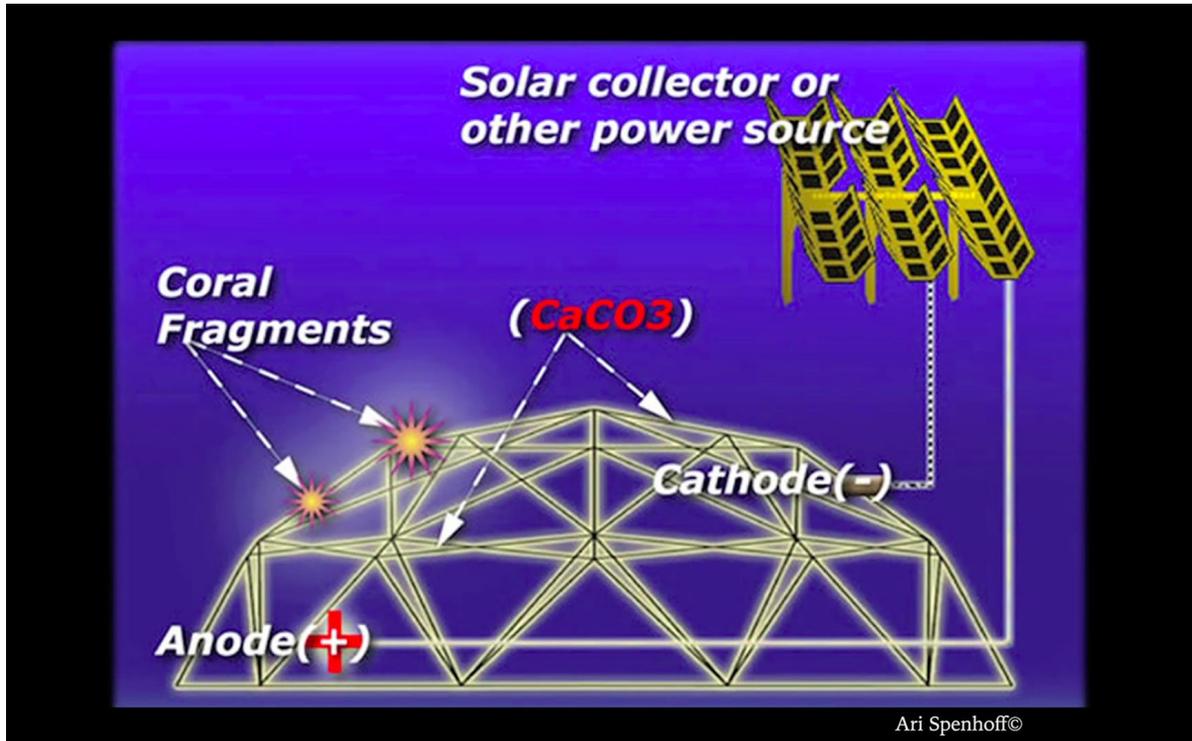
PRESENTED AT:

For a Resilient Planet

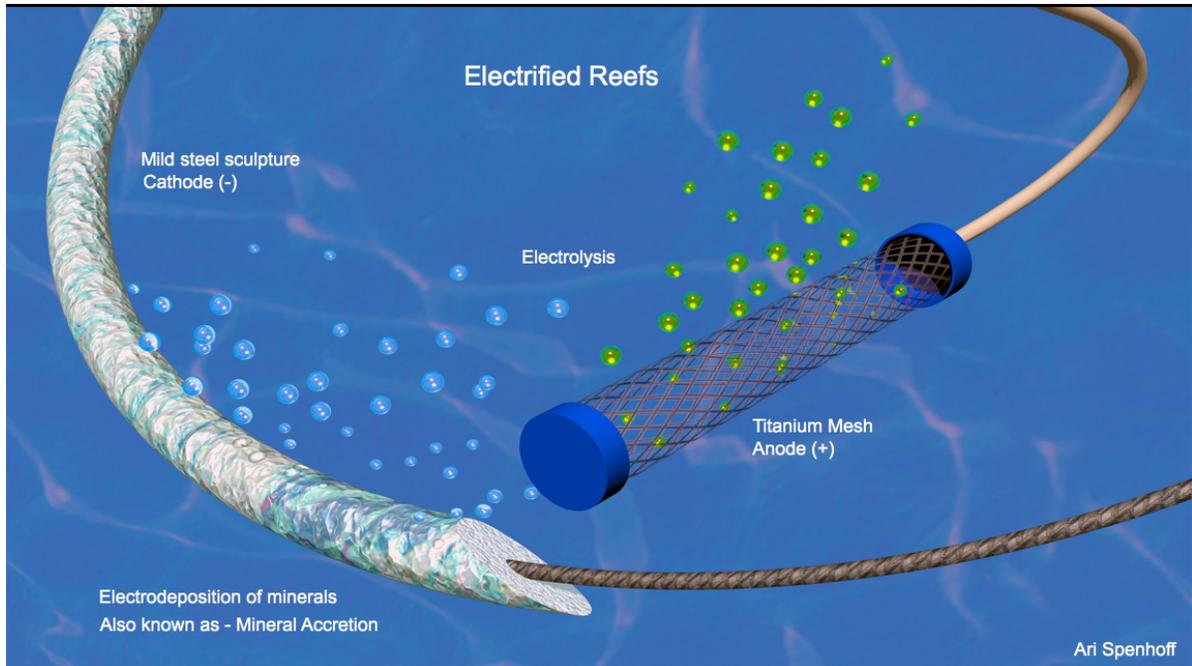
OCEAN SCIENCES MEETING | 16-21 FEBRUARY 2020 SAN DIEGO, CA, USA

ELECTROLYTIC REEFS

PROCESS



Using low volt DC through seawater, one can stimulate growth and recovery of endangered corals and dwindling biodiversity. By combining aesthetics and function, we can create marine habitats to regenerate devastated coral reef ecosystems and jumpstart dead zones.



A slight localized boost in pH through the chemical reaction precipitates calcium carbonate and other limestone minerals in the sea to deposit onto the metal surface. The fortified substrate not only strengthens the structure, it creates many microhabitats over time to attract an array of fish and invertebrates while accumulating natural calcium carbonate for coral transplants to cement to and metabolize for skeletal growth.

[VIDEO] https://www.youtube.com/embed/3dIoMMYK2_A?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0
Here is a time-lapse of electrolytic mineral accretion on a small-scale steel mesh "accumulet" at University of California, Santa Cruz's Ocean Sciences marine lab where R&D for new coral reef restoration and shore protection projects are underway.

Reef-building corals are struggling to build strong exoskeletons due to ocean acidification (decreasing alkalinity) reducing available calcium carbonate, and higher temperatures causing them to "bleach" and starve. Pollution, unsustainable fishing and development, and diseases are also thwarting their survival and resilience.

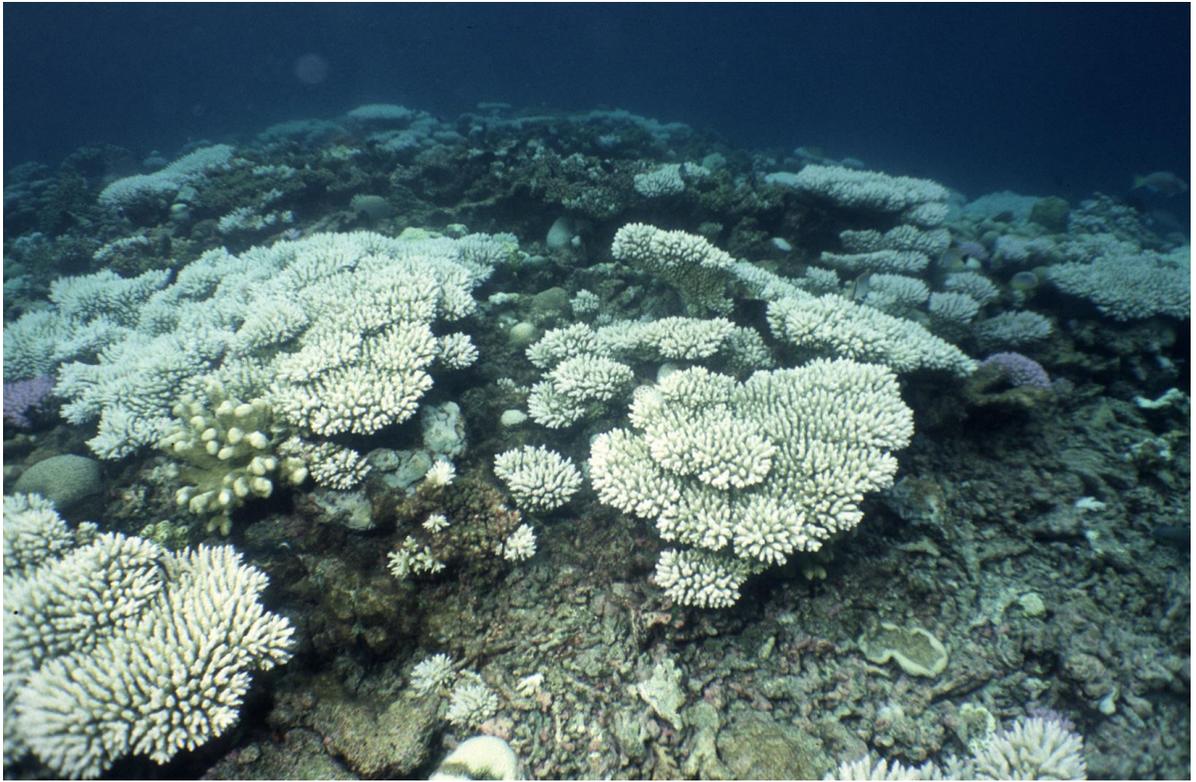


photo: World Resources © Mark Spalding

In the face of these weakened, crumbling states, one asks, can we intervene with materials to help them adapt to environmental pressures threatening to wipe them out?



The localized alkaline boost is fueling rising interest in scientific studies to measure exoskeletal density, rate of growth, and mortality on this project and others. Can we improve survival and increase growth rates (with dense skeletal structure) in deteriorating environments? According to some studies, corals on electrolytic reefs have faster growth rates and higher survival during increased temperatures that normally kill them. Once these corals reach sexual maturity and start reproducing, a multiplier effect is anticipated for the recovery of the whole reef at a local and regional scale.



October 2016



October 2018

Zoe - A Living Sea Sculpture shown here was installed in Cozumel, Mexico on September 29th, 2016. The photos above show a 2-year progression and illustrate potential for exploration of form and scale for future investigation.

With multi-dimensional surfaces that re-grow if damaged, and curvatures allowing for varying relationship to the sunlight, waves, sediment and currents, electrolytic reefs and Living Sea Sculptures have yet to be utilized for their most beneficial capacity in the field of reef restoration. With renewable energy, preferably provided by the sea, and scaled-up designs, we aim to create large regeneration projects.

Beyond the silos of coral nurseries, sculpture, aquaculture, and shore protection, we are thinking holistically in scope about the biodiverse life reliant on dynamic formations which are lacking in large areas of the ocean. By incorporating design, engineering, and artistry we can install lighter weight metal armatures that will transform to serve multiple functions that encompass adaptive needs of a broad spectrum of interconnected species, including the humans that depend on them for survival and livelihood.

ZOE-A LIVING SEA SCULPTURE

SCULPTURE & LIVESTREAM



Zoe means "life" in Greek. This DNA-inspired memorial coral refuge is a pilot electrolytic reef project in Cozumel, Mexico combining art, science, and technology.

scale: 15' x 9' x 6' ; anchored 12' deep.

[VIDEO] <https://www.youtube.com/embed/eudlh4yk29k?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>
VIRTUAL AQUARIUM



The tilt, pan, zoom livestreaming webcam was commissioned by the Zoe Anderson Memorial Fund to share the real time evolution of this artistic habitat with an international audience, which includes those who may never visit or swim in the ocean. We are capturing data which tracks interactions and changes every day with this virtual aquarium in Cozumel.

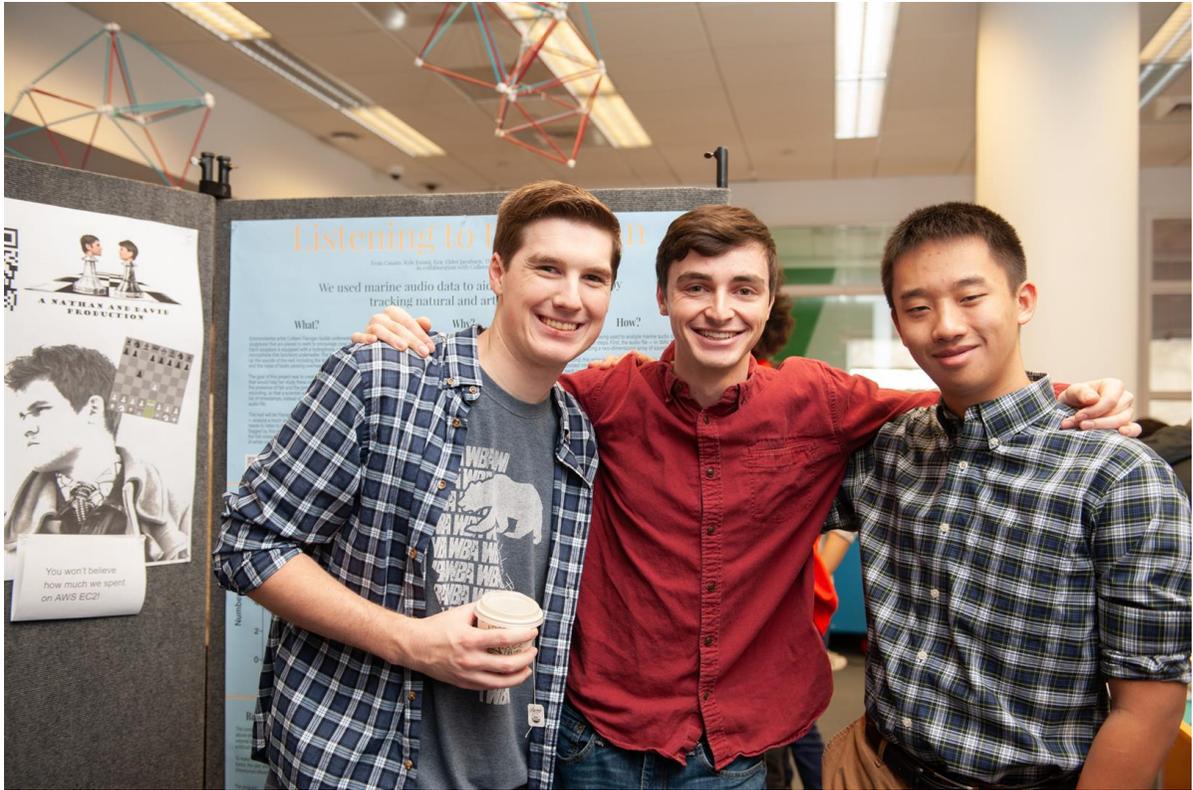
On a personal note, we are dedicated to regeneration after loss and sensitive to the fragility of life. Zoe Anderson wanted to save coral reefs. You can learn more here (<http://zoecoral.com/index.php/story>) about her.



Volunteers, Miranda Ríos González and Lemuel Vega, maintaining the cleansweep™ arm of the View into the Blue glass camera dome.

At our Living Sea Sculpture YouTube channel (<https://www.youtube.com/channel/UCDE8tQBW6z-JnuP3L92NxA?fs=1&modestbranding=1&rel=0&showinfo=0>) we have hundreds of hours of recorded footage to be reviewed for important moments and highlights that will benefit science and culture.

[VIDEO] <https://www.youtube.com/embed/Hq89LQqNXX4?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>
HYDROPHONE



Team SHRIMP - Kyle Emmi, Evan Cusato, Brandon Zhang (Eric Jacobsen and Thomas Weir not in photo)

There is a lot to learn from the audio data being recorded daily. A TED Fellows collaborative project with students in Dr. Carrie Nugent's Astronomy and Statistics course at Olin College of Engineering led to a 1st phase software program (https://docs.google.com/document/d/e/2PACX-1vRcRISrd2ViIM700rFwLXnMJis58_Egxlbp8k5pzev8YUj7iZC8HUjEs5MHP7los_yu7jfpzkhdwi3/pub) to identify and catalogue certain sounds, such as boat motors, fish, and crackling shrimp. It would be beneficial to perform statistical analysis to search for correlations between human activity and marine life activity. And of course it would be exciting to hear a unique ocean voice, like the splendid toadfish endemic to Cozumel.

CORAL PLANTING

We attach coral fragments found broken off in the sand and sediment, and have transplanted a few fragments grown in a wetlab. Below is a planting diagram overlaid onto a photo of the actual sculpture before installation.

Symbols represent specific native species. It was a way to visualize a possible planting scheme, although we have not followed this map.



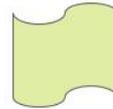
conceptual planting by Colleen Flanigan © 2015

Agaricia tenuifolia

<https://www.inaturalist.org/taxa/93528-Agaricia-tenuifolia>



Symbol



25-30 starts on 2 EMM strips

Depth 1m - 2m

Agaricia Undaria is proposed species (no photo available, but similarly lettuce-like)

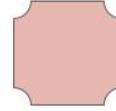
Porites divaricata

<https://www.inaturalist.org/taxa/110101-Porites-divaricata>



photo por <http://www.panoramio.com/user/6685605/tags/Porites>

Symbol



45 starts on EMM upper and biggest strip

Depth todo

Porites asteroides

<https://www.inaturalist.org/taxa/110084-Porites-astreoides>



Symbol



color #bcd43aff

30 starts on bases

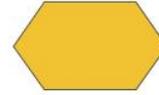
Depth .2m - 70m

Eusmilia Fastigiata

https://simec.conanp.gob.mx/photos/grande/83/83_5.jpg



Symbol

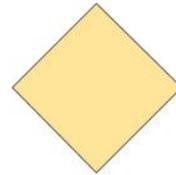


Porites furcata

<https://www.inaturalist.org/taxa/110109-Porites-furcata>



Symbol



50 starts on EMM upper & biggest strip

Depth todo (.5m - 50m)

Excerpts of coral symbol map designed by Colleen Flanigan © 2015

ARTISTIC & CULTURAL OUTREACH



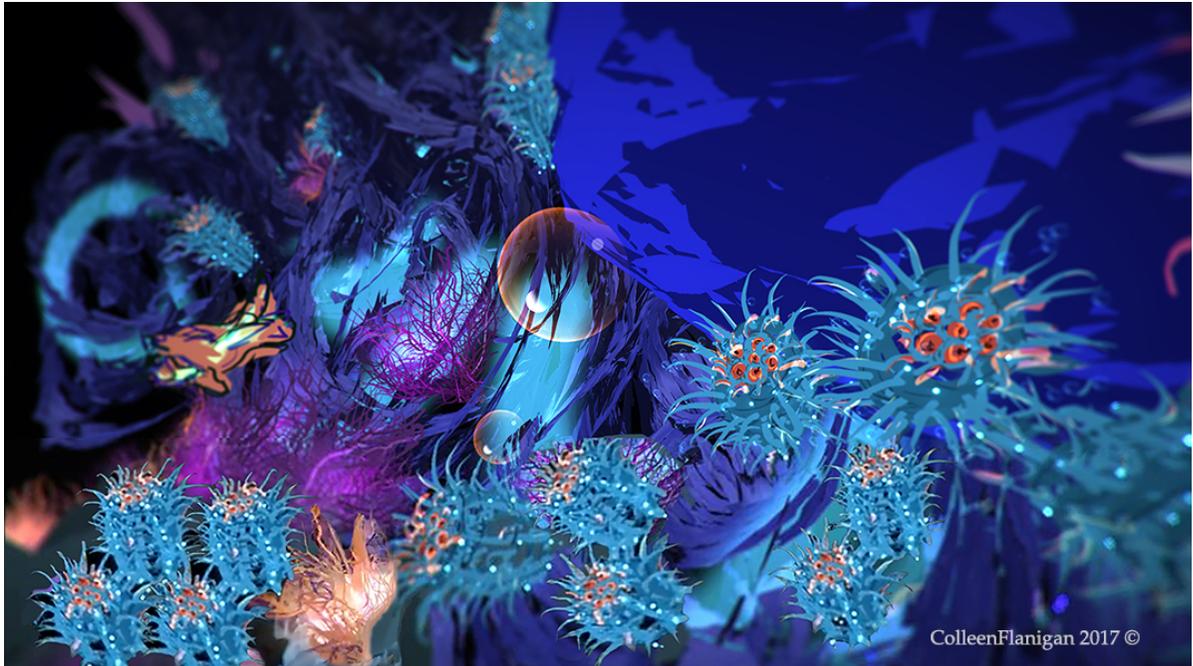
Live projection and photos at Watercolors Aquarium Gallery, Grand Rapids, MI 2018

Zoe exhibited at Watercolors Aquarium Gallery for *ArtPrize 10*, 2018 in Michigan, an example of bringing the ocean to a lake-bound and land-locked location. Our virtual aquarium (live webcam) streamed daily for the competition, along with select large underwater photographs of the project. Thousands of visitors came through, mesmerized by the glowing, artistically arranged aquarium displays coupled with our real time ocean view above. This international competition had over 1,260 entries. *Zoe* placed 25th in the Time-Based Art category.

[VIDEO] <https://www.youtube.com/embed/NcN81m7Hz9E?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>
Reality Remix, IMC Lab + Gallery, 2020

Footage of *Zoe* has been projected at various outdoor art festivals and interactive art experiences, from England's "11thour" in King's Lynn to the IMC Lab + Gallery's "Reality Remix: VR, AR+Media Art, Matisse to Mixed Reality" in New York City. Transforming space with lighting, sound, sensor-activated immersive experiences and mixed realities is a relatively young genre gaining momentum to bring ecological, interdisciplinary work related to climate change, environmental interventions, visualizations, and speculations on what the future will be - how our actions and technology will benefit or further damage the planet and us.

IMAGINATION



It is a constant question: what is our impact and how can we improve the quality of life for all species and prevent more disasters? Art is poised to dive into these uncertain scenarios, peel back emotions, and provoke new leaps in perception and possibilities.

Given time and resources to realize sublime experiences for the senses and imagination, *Zoe - A Living Sea Sculpture* could be projection-mapped live onto architecture with animated sea life responding to your breath, illuminated as a large-scale hologram for a surprise beach encounter, or imported into VR (Virtual Reality) apps as a digital sculpture (.obj) to be colonized by your own custom-made digital corals.

Mixed media has the power to spark and inspire more participation and breakthroughs to advance coral reef restoration.

TOURISM

CRUISE ECONOMY



photo from Mexico News Daily (<https://mexiconewsdaily.com/news/cozumel-about-to-break-a-record-for-cruise-ship-visits/>) June,3 2019

Cruise ships docking in Cozumel is steadily on the rise, with 1,300 in 2019 and over 4 million tourists annually. In parallel, coral reef health is on the decline, with some areas of the National Marine Park claiming 50% mortality due to the impact of Stony Coral Tissue Loss Disease (SCTLD).



This epidemic reached Quintana Roo in 2018, approximately four years after it was 1st observed in Florida. It has a 66%-100% mortality rate within weeks or months. Suspected cause - bacteria spread by direct contact and through the water column.

Scientists below shown applying antibiotic paste to try and stop the disease from killing the entire coral head.



Still, there are plans to build another international pier at this highly popular dive site, which will contribute to more coral ecosystem and ocean degradation on the world's 2nd largest barrier reef. The economic paradigm must shift and adequate water treatment systems implemented, yet changes and solutions must serve the growth of the local economy or will lead to dire consequences for many and further destabilize the region.

Closures within the National Marine Park (<https://mexiconewsdaily.com/news/tourist-services-protest-cozumel-coral-reef-closures/>) to limit damage by divers and the rapidly spreading coral diseases have led to protests and economic duress. Fortunately there is a growing consortium in the area of non-profits, government, and business focusing on both land and sea initiatives to educate and invite participation. This network is gaining traction in Cozumel and the state of Quintana Roo. We envision expanding our scope of engagement and ability to reach new audiences as a baseline of knowledge and concern reaches a tipping point and activates more in-step allies and solutions.

COLLABORATION



Zoe is a coral refuge and a tourist attraction 60 meters off shore from Sand Dollar Sports Dive Shop and Sunset Restaurant. It is easily accessible for snorkelers and divers in shallow, clear, and generally calm waters situated among other coral restoration efforts and Cozumel Scubafest's young underwater museum, MUSUBO.

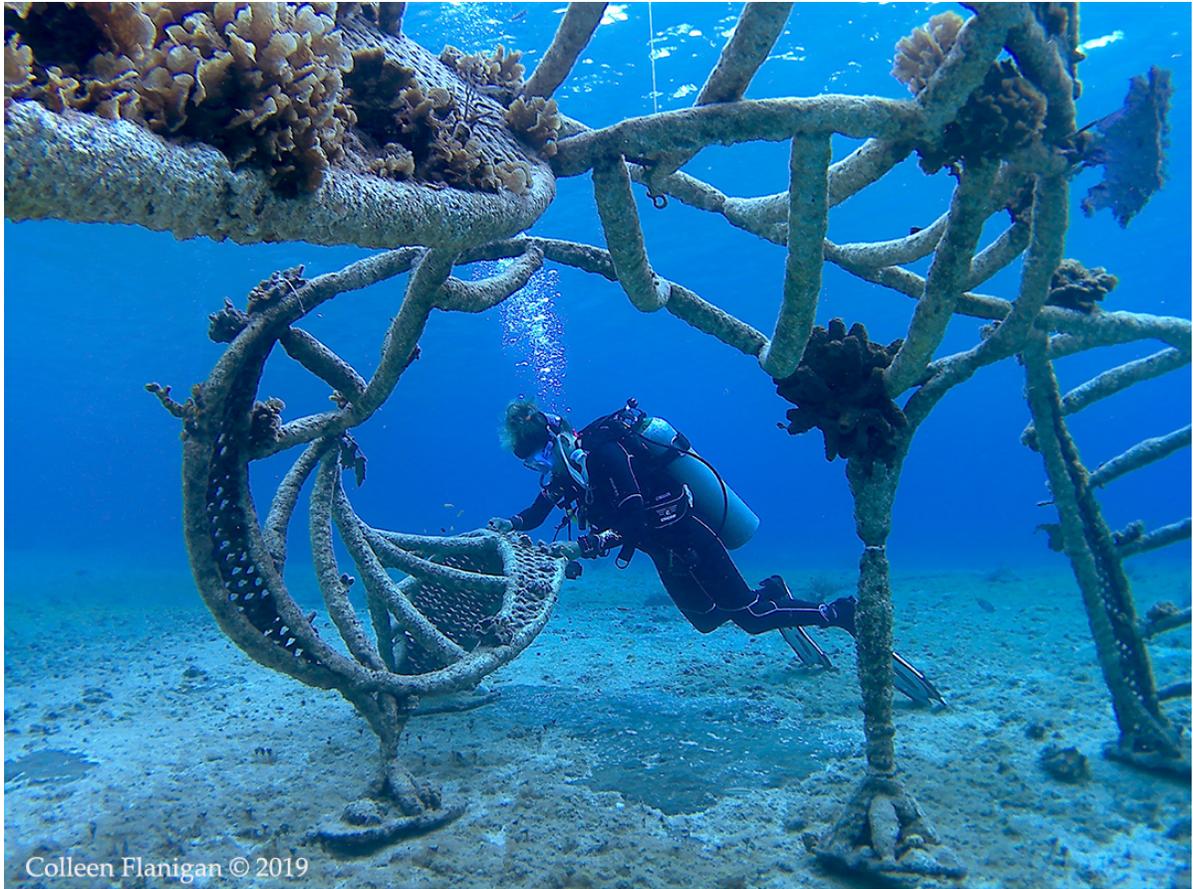
Power and wifi for *Zoe - A Living Sea Sculpture*, along with dive gear to volunteers and team members who help maintain the project are provided by Sand Dollar Sports Dive Shop, a local leader and example in the dive industry engaging and promoting an emerging business model for ecological restoration and conservation.



Zoe is sandwiched between cruise piers in this region hit hard by hurricanes, poor water quality, and millions of visitors impacting the environment. It is an invaluable opportunity to work with local and international communities to transform destructive tourism activities and development. Art, science, technology, and community participation at all levels can lead the economy towards ecological restoration and protection.

As the network of conscientious citizens grows, sectors within tourism acknowledge their need and commitment to adapt and do their part to protect ecological balance and implement programs as part of a progressive economic model.

From coral spawning courses to scientific diver classes to beach and ocean clean ups, there are many overlapping activities sponsored by businesses, universities, government, and NGO's (non-profits). Divers and dive instructors are motivated to revitalize dying coral reefs, and resorts and those that have seen the massive decline in vitality have a vested interest in their recovery. Obvious monetary and sustainability reasons coupled with a personal commitment to the health and welfare of irreplaceable wildlife inspires people to join the movement.



Zoe's dedicated team is made up of an international group of divers and volunteers. Penn Schrader (above) is a Zoe dive instructor who leads people around the area, teaching them to help maintain, monitor, and cultivate the project with introductory information and opportunities to develop deeper marine knowledge and understanding through specialized courses and hands-on activities. Her leadership skills are fostering new relationships and providing consistency needed to grow restoration programs. She works closely with Lefke Kerr, who has taken many of the photos in this presentation. Both participate as citizen scientists, representing an example of how this work is a vehicle to bring people from different countries and careers together to fulfill mutual missions for ocean conservation.

Some of our local collaborators united on the ocean health front are the Cozumel Coral Reef Restoration Program, Iberostar's *Wave of Change*, Eco Divers Cozumel, Cozumel Marine World, Liquid Motion Film, Sea Shepherd, Dive Mentor, HazloHoy, Casa Del Mar, CONANP, Coral Hero, Cozumel Scubafest, and more.

We offer and participate in experiences connecting people with the life and interdependence of ocean inhabitants. Through different modalities, we aim to open portals for individuals to care, feel hopeful, and empowered to act. We want to create the conditions for coral reefs to flourish.

[VIDEO] <https://www.youtube.com/embed/5tyWyPy606E?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>
Video by Liquid Motion Film® (<https://www.liquidmotionfilm.com/>) based in Cozumel, Mexico. They are an internationally acclaimed, world-leader in underwater filmmaking.

RESEARCH & DEVELOPMENT

BIO-DESIGN



photo Colleen Flanigan © 2020

Balanophyllia elegans coral polyp that settled onto the electro-accumulated metal surface.

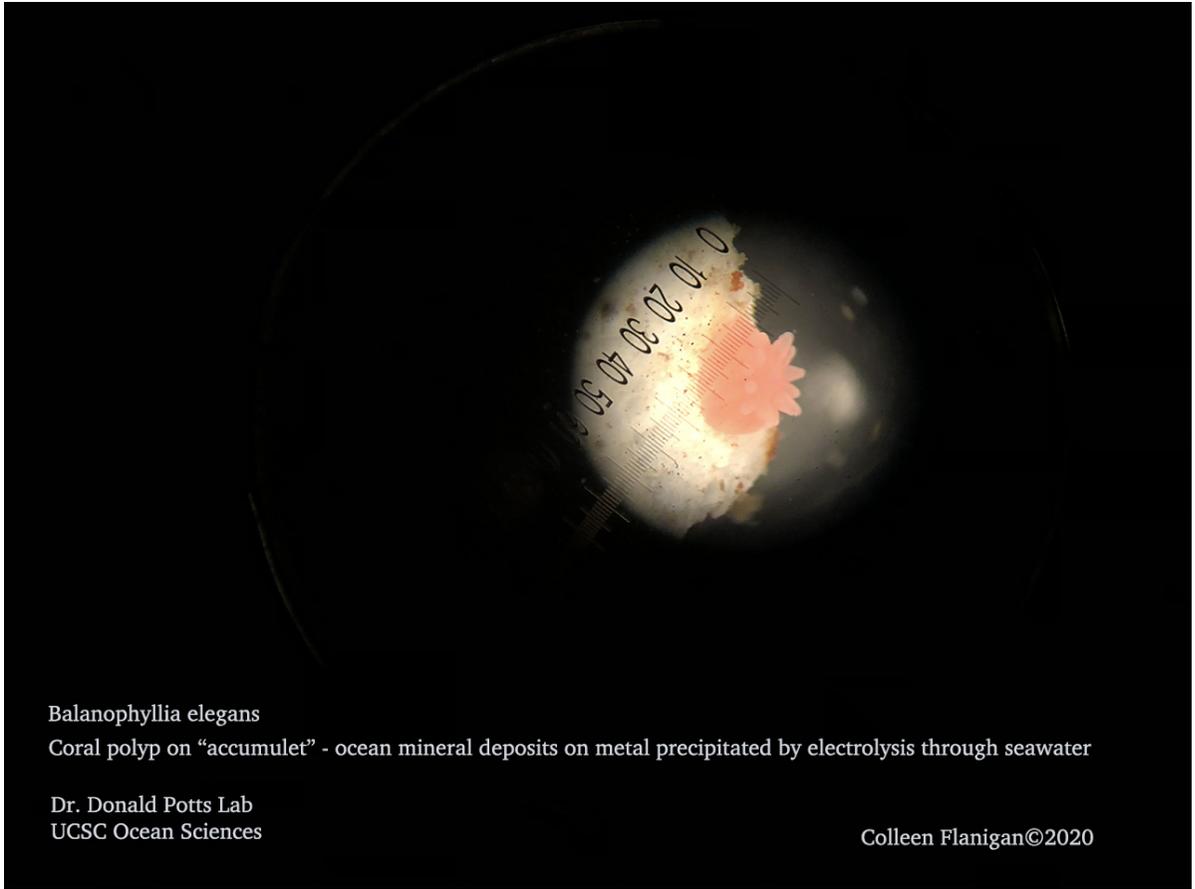
[VIDEO] <https://www.youtube.com/embed/cAbefboSkVU?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>

ACCUMULETS



Colleen Flanigan is making experimental forms as R&D for future reefscaapes, Living Sea Sculptures, and coral fragment substrates. These jewelry-scale models are like quick 3D sketches to allow for spontaneity and intuitive impulses to guide the creative process. Like a call and response, or form of dance, the ideas and materials need to have time to relate and reveal shapes, patterns, and combinations.

Some shown here are being tested for larvae recruitment with *Balanophyllia elegans*, a pacific brooding cup coral, propagated in the UCSC Marine Lab by Dr. Donald Potts.



Balanophyllia elegans

Coral polyp on "accumulet" - ocean mineral deposits on metal precipitated by electrolysis through seawater

Dr. Donald Potts Lab
UCSC Ocean Sciences

Colleen Flanigan©2020

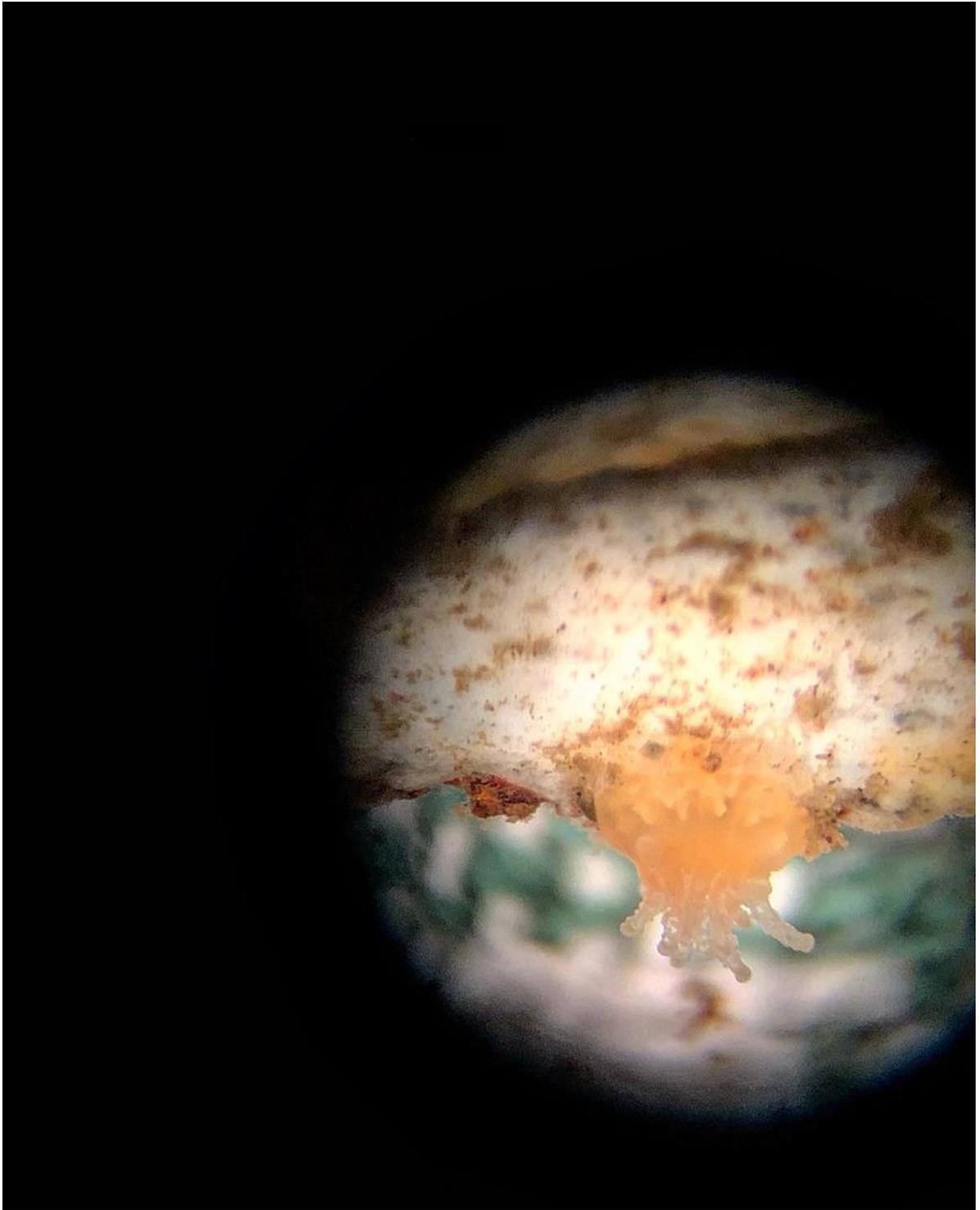


photo Colleen Flanigan © 2020

These corals are attracted to many surfaces, and some are settling onto the "accumulets." It is fascinating to observe the stages of development at this microscopic scale while simultaneously imagining large stretches of forms designed to attract a broad range of ocean life seeking much-needed habitat, food, and protection.

[VIDEO] <https://www.youtube.com/embed/5w67rs7VVtc?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>

Time-lapse of brooding cup corals eating brine shrimp and purging the exoskeletons.

With Colleen Flanigan as a volunteer in Dr. Donald Potts' Marine Lab at UCSC, unique opportunities to study coral behavior and materials for reef habitats emerge through the cross-pollination of approaches. The art of science and the science of art overlap greatly to support mutual curiosities and goals.

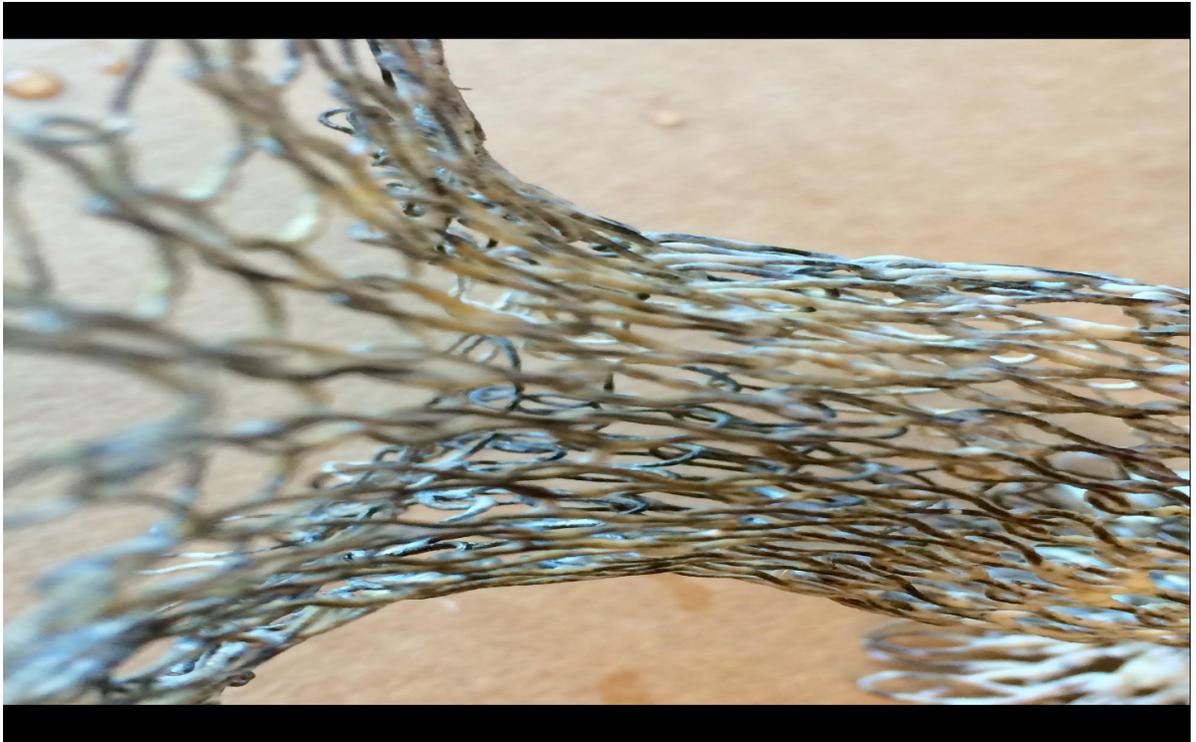
DESIGN THEORY



1" scale model of Zoe (made by Colleen) photo Clay Connally © 2011

The historic *Bauhaus* affects our modern context and understanding of Art and Design. For practical and social purposes, it plays a role in this ecological and cultural work:

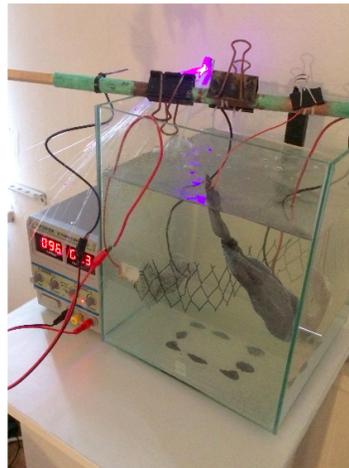
"The stress on experiment and problem-solving which characterized the Bauhaus's approach to teaching has proved to be enormously influential on contemporary art education. It has led to the rethinking of the "fine arts" as the "visual arts", and to a reconceptualization of the artistic process as more akin to a research science than to a humanities subject such as literature or history." - compiled and written by Larissa Borteh (<https://www.theartstory.org/movement/bauhaus/>) for The Art Story, Modern Art Insight



We can integrate Art and Design from this vantage point into reef rehabilitation. A greater understanding of how humans and other species resonate with perceived "beauty," line, and space as it juxtaposes with the living and built environment is a critical part of the equation for healing the ailing sea and mitigating more damage.

If we are going to intervene on behalf of one of the most beautiful, valuable, and complex ecosystems on the planet, it is essential to consider the importance of aesthetics supporting function in our endeavors.

Once I removed the rusty spiral (11/5) the knitmash began to accrete more rapidly and evenly 11/10/14.



Knitmash form lost minerals for a few days until bare metal was exposed and rusted. 12/9

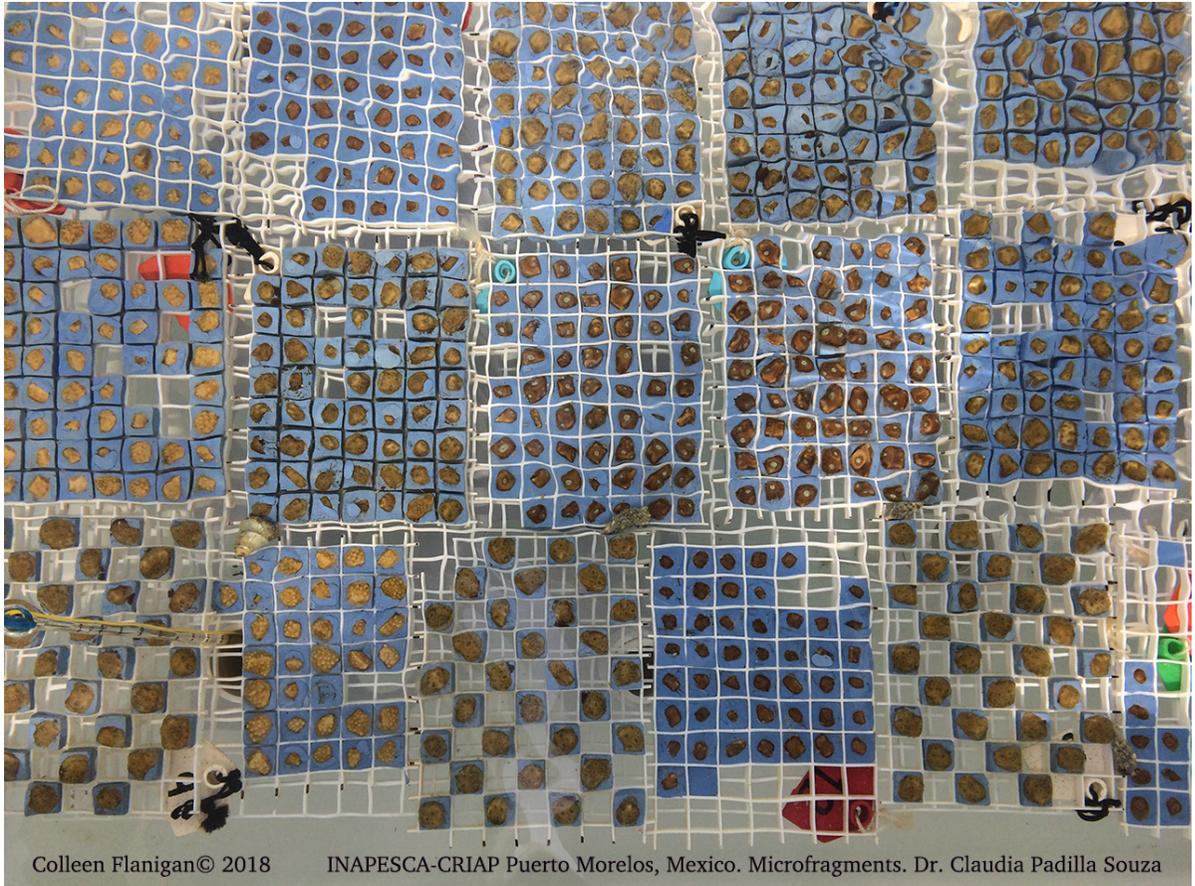
5 gallon cube at IMC from 11/25-12/9. I added a larger screen form imagining local oyster habitat. Porous pockets for small organisms to fill. As calcium carbonate builds and oysters recruit = a more solid reef to slow the waves + filter the water.

from Colleen's "ReefxRehab" exploration at Natalie Jeremijenko's *Xclinic* at NYU and IMC Lab + Gallery co-create residency 2014

MICROFRAGMENTATION

We are working with marine biologists, coral experts, and citizen scientists on analysis of *Zoe* to develop experiments to test electrolytic reefs with microfragmentation. We want to study if the combined restoration methods can enhance coral coverage.

Below are 2 images of microfragmentation work by INAPESCA-CRIAP (Regional Fisheries Research Center) Puerto Morelos, Mexico. Dr. Claudia Padilla-Souza directs these efforts to increase rate of coral growth and fusion, and is interested in what we can discover in a collaborative study on *Zoe*.





Colleen Flanigan© 2017

For our microfragment substrates, we are testing multiple materials and means to attach them to *Zoe*, including *Oceanite*® by Reef Life Foundation. Below is an *Oceanite* sample with *Balanophyllia elegans* recruits.



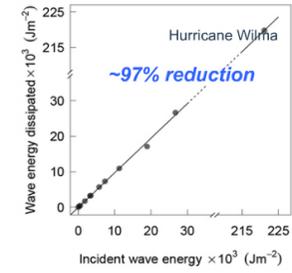
Colleen Flanigan©2020

Combining electrolytic reefs with Oceanite® in new Living Sea Sculptures and ART Reefs is a complementary approach and investigation underway to see how to maximize benefits of different materials, structures, and teams working in unison to revitalize endangered coral reef ecosystems while contributing to a healthy and prosperous economy.

FRAMING THE CHALLENGE

APPROACH

Rigorously Valuing the Role of U.S. Coral Reefs in Coastal Hazard Risk Reduction
(<https://pubs.er.usgs.gov/publication/ofr20191027>)

<p>USGS science for a changing world Pacific Coastal and Marine Science Center</p> <p>Problem</p> <p>In the U.S., we have struggled to protect and preserve coral reefs along populated coasts....usually for economic and geographic reasons</p> <p>If their innate beauty, tourism, fisheries, and species' diversity are not a compelling enough argument for the protection and restoration of coral reefs, what is?</p>	<p>USGS science for a changing world Pacific Coastal and Marine Science Center</p> <p>Problem</p>  <p>\$\$\$ and lives</p>
<p>USGS science for a changing world Pacific Coastal and Marine Science Center</p> <p>Overview</p> <p>Coral Reefs & Coastal Protection</p>  <p>Wave energy dissipated $\times 10^3$ (Jm^{-2})</p> <p>Incident wave energy $\times 10^3$ (Jm^{-2})</p> <p>Hurricane Wilma</p> <p>~97% reduction</p> <p><small>adapted from Ferrario, Beck, Storlazzi et al. 2014. Nature Communications</small></p>	<p>USGS science for a changing world Pacific Coastal and Marine Science Center</p> <p>Conclusions</p> <p>Summary</p> <p>Coral reefs - a first line of defense</p> <p>We can account for the protection that US coral reefs provide: 18,180 people and \$1,805,511,877 annually</p> <p>We can generate value-based information to guide restoration and efforts to increase resilience of coastal communities and ecosystems...<i>at management-relevant scales (10s of meters)</i></p> 

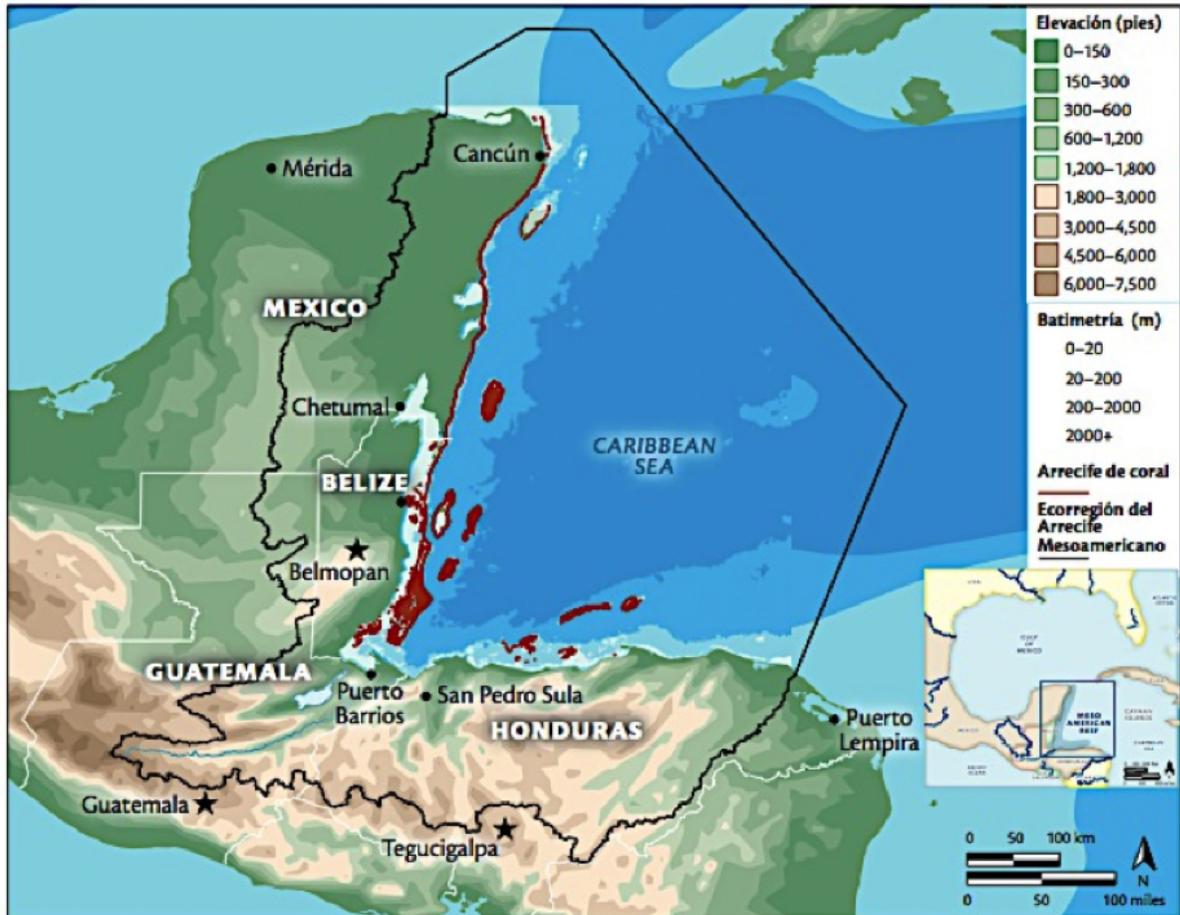
Research geologist and oceanographer for the Coastal and Marine Geology Program of the United States Geological Survey, Dr. Curt Storlazzi, and team completed studies and co-authored a report defining the value of coral reefs in lives and \$\$\$.

This is one slide from Curt's presentation for a NOAA webinar. All islands and coastal communities around the world are inundated with the crisis of climate change and sea level rise.



photo Colleen Flanigan © Cancun, MX 2014

Our currently limited visual vocabulary for manmade reefs and breakwaters does not take into account the innate architectural prowess of the reef-building animals themselves, constructing beautiful, evolving intricate masses over thousands to millions of years that house 25% of marine life, filter water, feed millions, and reduce wave impact by 70%. Electrolytic reef structures alone and in combination with other materials and methods become evolving permeable breakwaters to slow waves while increasing biomass.



Mesoamerican Barrier Reef Map - courtesy *Healthy Reefs for Healthy People*

From an ecological perspective, a living sea sculpture could be viewed as a reef patch that is less disturbed than surrounding natural reefs and able to eventually contribute larvae from the best-adapted species. Such reef patches may also have the advantage of not harboring the pathogenic or predatory organisms present in the nearby natural reefs.

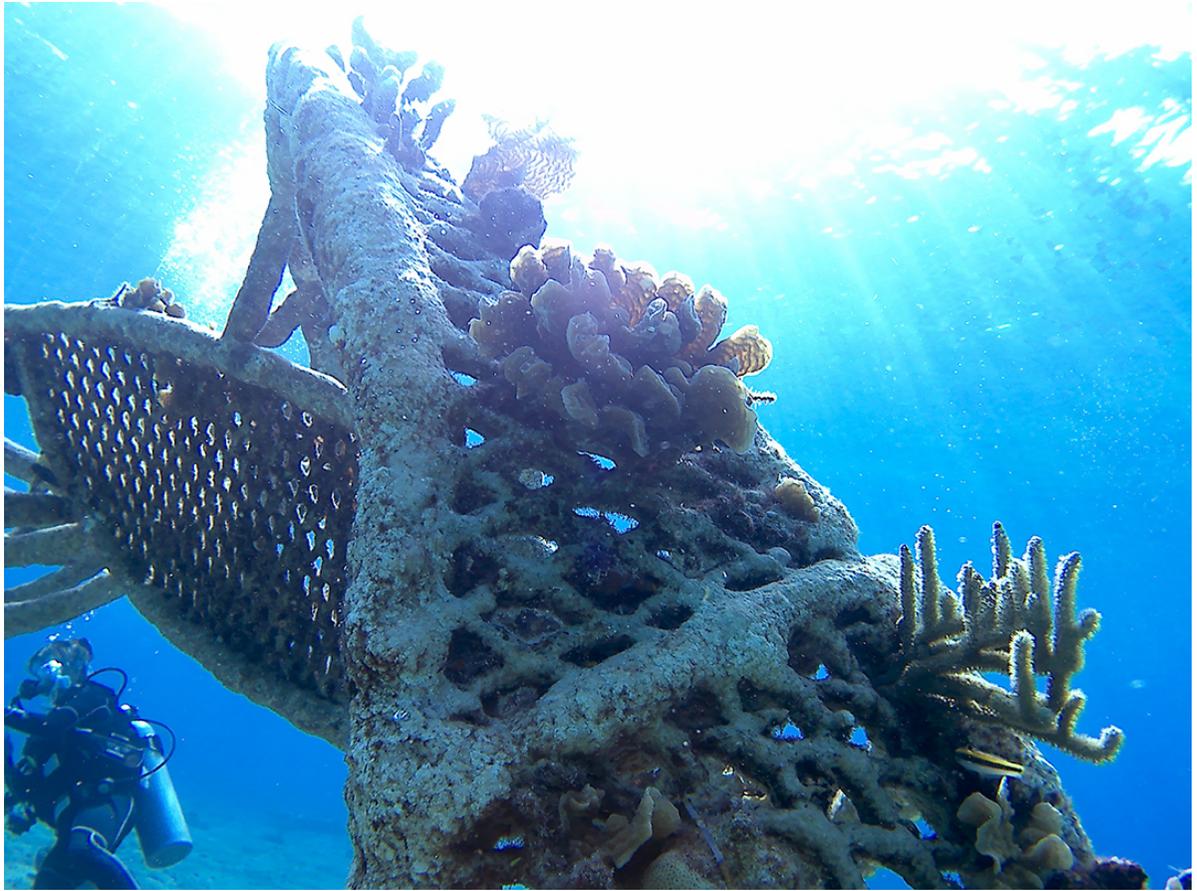


photo Colleen Flanigan © 2019

The spatial patterning of so-called resilient reef patches within a larger natural reef network is as important as the species they host. Living Sea Sculptures could be placed to optimize their connectivity with existing reefs in accordance with reported network-based approaches to restoring natural reef ecosystems.

Of considerable interest in coral reef studies are emergent properties that result from the integration of processes occurring on multiple levels of organization over a range of spatial scales. Living Sea Sculptures could permit the study of emergence at different levels of organization that are experimentally designed into the reef patch.

EDUCATION

ART, SCIENCE, & TECH



Working with universities and students of all ages, divers, scientists, activists, artists, engineers, businesses, non-profits and government agencies catalyzes transdisciplinary solutions to challenges that affect everyone and can only be solved through compassionate innovation, expanded awareness, and inclusive involvement.

Dive & Draw Cozumel



Create beautiful marine artwork UNDERWATER!

Workshop Includes:

Pre-Dive Class - basic drawing skills for all levels, aquaSketch instruction, drawing and diving techniques, use of reference materials

Underwater Drawing Class: shore dives at Zoe - Living Sea Sculpture site with instructors for guidance, instruction and introduction to coral restoration projects, aquaSketch and all art materials are provided

Painting Class - underwater artwork scanned onto heavy cotton rag watercolor paper, instruction in using the underwater artwork with various art media (watercolor, acrylic paint, and pastels), all art supplies are provided

Closing reception featuring student's artwork at Casa Del Mar, our partner hotel.

Workshop taught by artists **Mark Hagan, Patti Mollica, and Colleen Flanigan**

Requirements: Basic dive certification. **No prior drawing or art experience necessary!** Interested snorkelers and non-divers with interest in ocean life welcome!

For more information and to signup visit: LivingSeaSculptures.com/dive-and-draw





Painting by aquaSketch® inventor

© Mark Hagan



Sketch by Mark Hagan



Mark Hagan sketching *Zoe* volunteer, Miranda Ríos González. 2017



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By [AquaSketch](#) February 11, 2020

Where the Ocean, Diving, and Art Come Together in a Unique Underwater Experience Presented by and in Support of Zoe – A Living Sea Sculpture Coral Restoration Project

Cozumel, Mexico: Living Sea Sculpture is announcing its first [Dive & Draw Experience](#) taking place March 22 – 26, 2020 in Cozumel, Mexico at the Zoe – a Living Sea Sculpture Dive Site. This unique workshop will enable participants to experience underwater drawing using the [aquaSketch® waterproof](#) scrolling vellum, then transform their sketches into painted works of art once on land as well as learn more about coral reef regeneration.



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Inviting artists and naturalists into the project is a way to augment our audience and amplify our outreach through artistic expression. It gives divers and ocean lovers a means to really see, sense, and interpret as opposed to being busy or in a hurry to get through the dive.

The aquaSketch® scrolling vellum has been used by NASA, NOAA, and others for scientific purposes. In addition to the artistic angle we are promoting with this workshop, we want to use this printable waterproof vellum for mapping and surveying of *Zoe* and the area to evaluate restoration progress and better track results and changes.

Reef ReFORMed a community project for

"ArtCOP21 Global Climate Art Festival" 2015

Arrecifes Saludables
para gente saludable

Taller artístico

"Zoe: un Arrecife RE - formado"

Imparten:
Colleen Flanigan
Artista socio - ecológica
Gustavo Navarrete
Artista del papel maché

Viernes 20 y Sábado 21 de Mayo.
17:00 a 19:00 Hrs.
Aula didáctica de Ka'Yok'.

\$80 - 1 día
\$120 - 2 días

Marisol Rueda Flores.
ofrece breve charla sobre arrecifes
a los niños durante el taller.

Construyamos en comunidad un arrecife escultórico

**Niños de 4 a 10 años (acompañados
de un adulto) y hasta 14 años.**

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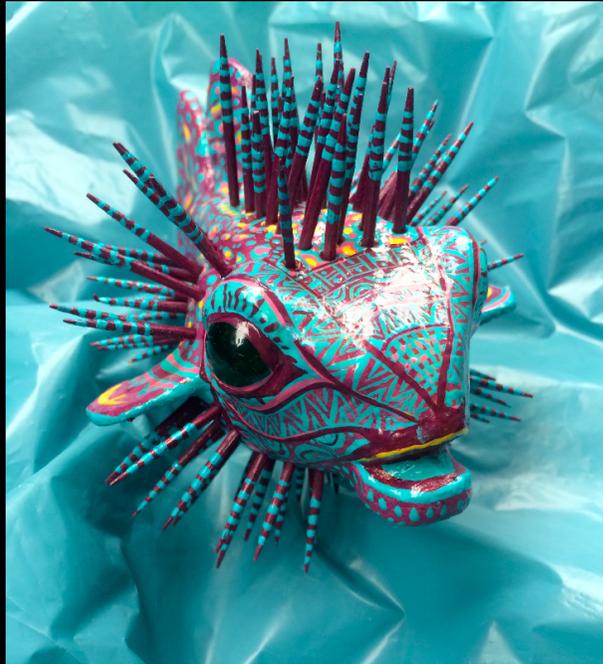
KA'YOK'
PLANETARIO
DE CANCUN

Colleen Flanigan teamed up with local alebrije artist, Gustavo Navarrete, and coral biologists to lead workshops in Puerto Morelos and Cancún. Using a half-scale *Zoe* sculpture fabricated from pvc, kids and adults learned how to make papier-mâché corals and marine organisms. We were simulating the project in the sea while teaching basics about coral reef biology, their endangerment, and restoration.



Home schoolers at Centro Bek

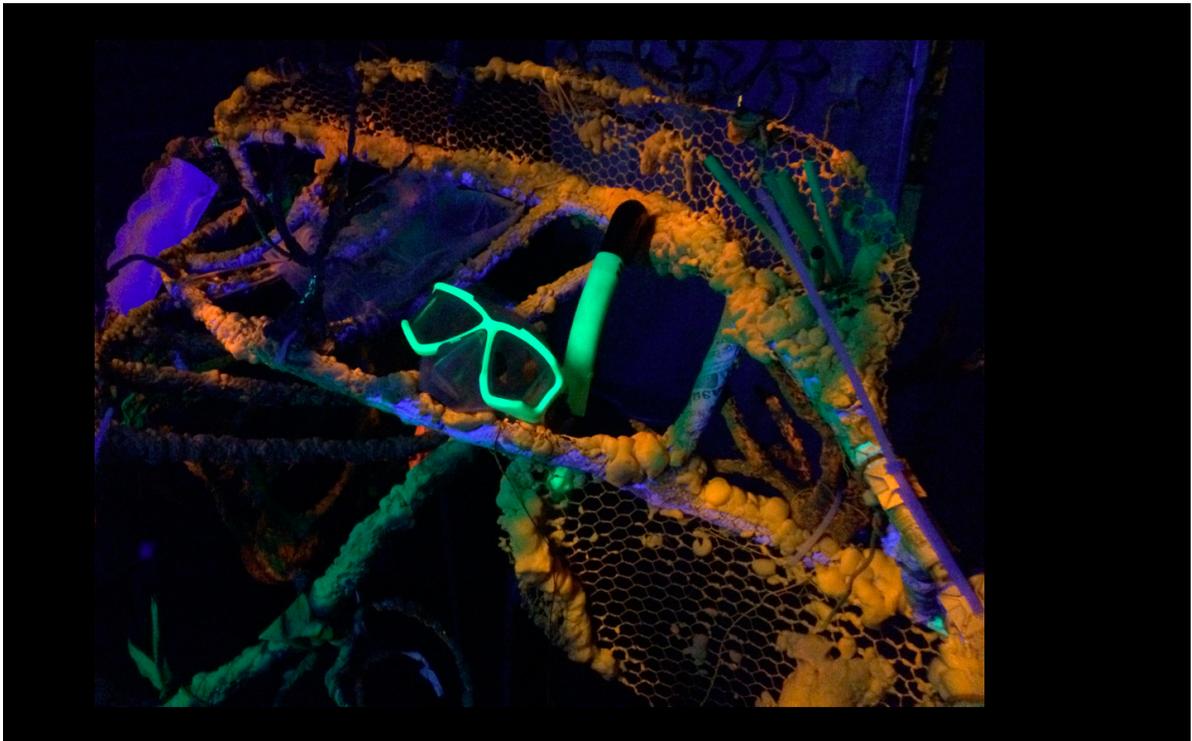




Puffer by Gustavo Navarette



Children with cancer at Fundación Aitana



The sculpture resides in Cozumel now and is being used in classrooms as part of a teaching tool about the turtles in the area.

Tecnológico de Monterrey, Campo Puebla

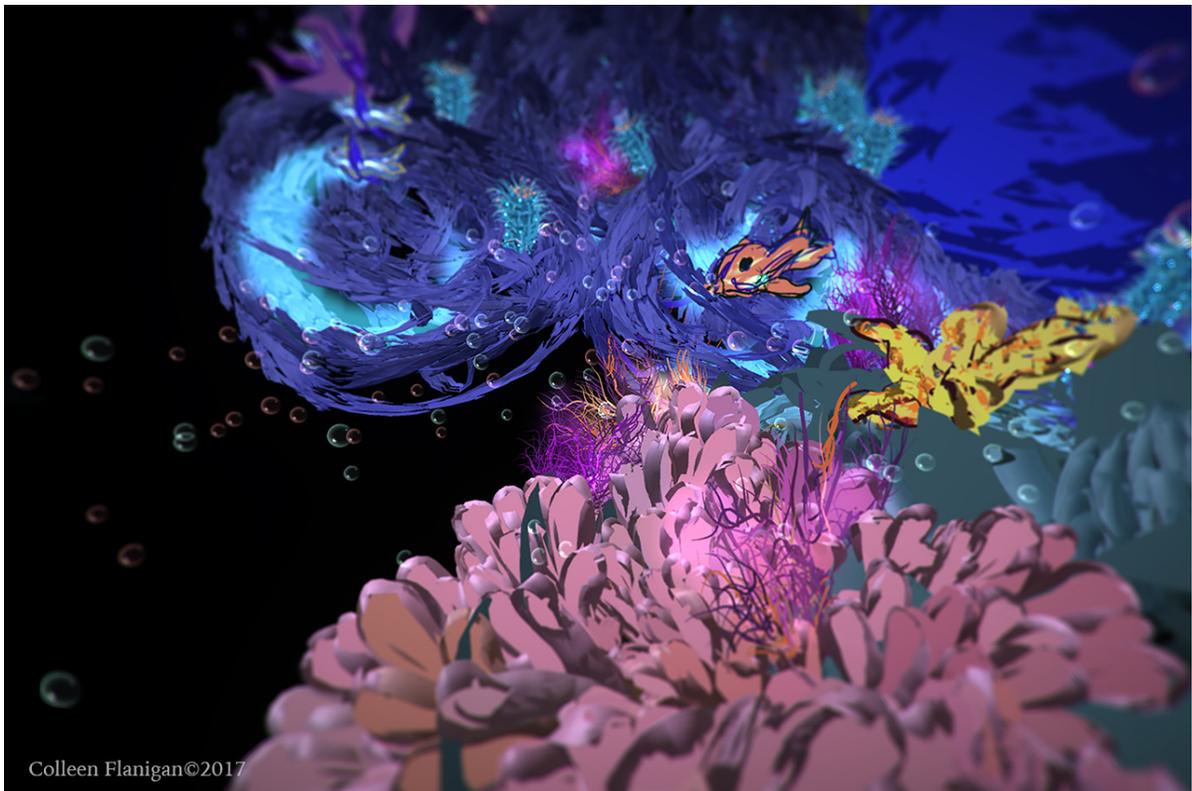
Zoe - Living Sea Sculpture Social Service Course (100 credit hours)

[VIDEO] https://www.youtube.com/embed/3A6s1dk_rHs?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0
A clip of university students on their 2nd day of diving cleaning invasive algae and planting with Colleen and Miranda as part of a 100 credit-hour university social service course.

This 5-day course, July 10th-14th, 2019 was led by Miranda Ríos González, university student at Tec de Monterrey, and Colleen Flanigan, artist and director of Living Sea Sculpture. The 15 students in this pilot program learned basic diving skills with Dive Mentor's instructors, as well as receiving presentations on recycling by HazloHoy, coral biology by Blanca Quiroga of CONANP (National Commission of Natural Protected Areas), video critique by Liquid Motion Underwater Photo and Film Academy, field trips to the landfill, the Turtle Camp, and a trash clean-up.

A beginning coral restoration training and presentation by Colleen was geared for the students of diverse studies who elected to take the class. No one was a marine biology student. The program was the brainchild of Miranda, a passionate *Zoe* volunteer who wants to raise awareness through hands-on participation resulting in short videos of land and sea activities produced by the participants with the goal to influence others to be pro-active in the face of climate change, mass extinctions, and the uncertain future of our planetary balance and own survival.

ART MOVEMENTS



still images from immersive "VR Coralization" (<https://www.youtube.com/watch?v=zaJXKntZJl8&fs=1&modestbranding=1&rel=0&showinfo=0>)

We participated in "The Universal Sea - Pure or Plastic?!" (<https://universal-sea.org/inspirations/vr-coral-reef-colleen-flanigan>) international touring events in 2018. They had great success weaving communities together through art and innovation to "stop the pollution epidemic!," and now they have been selected to represent at the coveted SXSW 2020. This fantastical VR coral

reef ecosystem by Colleen Flanigan will be featured.

[VIDEO] <https://www.youtube.com/embed/zaJXKntZJ18?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0>
ON THE HORIZON



In collaboration with the non-profit *Oceans 360*, we are going to capture *Zoe* and corals in 3D to bring the underwater sculpture and marine life to you in immersive VR on land.

"There is scientific value in 360 to evaluate reef health added to the health of each animal and plant that make up a reef. I hope we can deploy frequent 360 3D photomosaics to *Zoe* and 10 locations for the Decade of Ocean Science," says George Cummings, World Federation for Coral Reef Conservation (WFCRC) Mission Blue Ocean Ambassador for United Nations SDG14.

There are many uses to be explored with this collaboration in the arena of ocean outreach, such as calming anxious kids at the doctor, relieving pain for hospice patients, giving desert dwellers a chance to swim in the cool sea, entertaining guests at a party - a lot of therapeutic, educational, and fun experiences to be revealed.

AUTHOR INFO

Colleen Flanigan is a socio-ecological artist with degrees in Design from the University of California, Los Angeles, and Metals from the Oregon College of Art and Craft. Her background includes making armatures for stop-motion animation (*Coraline*), and being a TED Senior Fellow. She founded Living Sea Sculpture in 2011. Through visual, performing, and biological arts, she investigates contemporary issues of species endangerment and ecosystem regeneration, specifically working to restore degraded coral reefs and marine biodiversity. For the past 15 years she has been exploring ways to bridge the gap between quantitative scientific approaches to environmental issues and hands-on, life-saving actions by evolving the concepts of "art as ecology" and interactivism. Art is an integral part of the equation for cultivating healthier, long-term sustainability and curbing our enthusiasm for short-term gain. Bringing together multiple disciplines in collaboration, she stands for inviting the artistic method - a combination of sensory vision, playful imagination, and maker intelligence - into global solutions.

D.L. Marrin (nickname West) is an applied scientist specializing in biogeochemistry, water resources and water ecology. He is a consultant, R&D strategist, and former adjunct professor at San Diego State University. He also works with artists utilizing spatial/temporal patterns to communicate science and develop functional art. He has a Ph.D. in water resources from the University of Arizona, and B.S. and M.S. degrees in the biological environmental sciences from the University of California.

ABSTRACT

Whereas scientific explanations have expanded our understanding of nature, they are often inappropriate for communicating the relevance of science to a lay audience. The arts avert these intellectual hurdles in permitting people to appreciate nature, while also informing scientific endeavors. This project combines the art of sculpture with the technology of electro mineral accretion (EMA) and the science of coral reef restoration. A DNA-inspired sculpture permits the transmission of a minimal DC current that extracts minerals from seawater and deposits them on the steel surface, thus creating a habitat for transplanted corals or settling larvae. Live streaming video (via a webcam) of these processes and related ocean data is sent out worldwide from this underwater art installation in Cozumel, Mexico. Snorkelers can visit the developing reef and students can participate in planting corals or monitoring conditions in the surrounding seawater. Divers and dive instructors have shown an interest in the project, which focuses on generating, rather than exploiting, reefs and welcomes curious locals and tourists.

Mineral accretion reefs can adopt a range of shapes, sizes and arrangements on the ocean floor, thus facilitating an evaluation of how different designs influence the coral recruitment, growth, and survival, as well as how the evolving ecosystem protects shorelines and mitigates sea level rise. Research indicates that neighboring reefs are interconnected in many ways (as a network), contributing to their resilience. This sculpture serves as an artificial reef patch among the damaged natural reefs and could eventually contribute larvae from selected species. It is also an example of integrative emergence inasmuch as it substitutes for the natural growth of a reef's substrate. In uniting wildlife preservation, marine science/education and ecotourism, the project exemplifies the nexus of functional art and environmental solutions.

REFERENCES

Proceedings of the National Academy of Sciences of the United States of America/Front Matters - "Science and Culture: Artistic Endeavors Strive to Save Coral Reefs" (<https://www.pnas.org/content/115/21/5303>)

"Proceedings of the National Academy of Sciences of the United States of America - Science and Culture : Artistic Endeavors Strive to Save Coral Reefs." This is a scientifically vetted article about the "Zoe - A Living Sea Sculpture" project and illustrates my collaboration with Dr. Claudia Padilla, as well as our interest in using this pilot project to advance scientific research about electrolytic reefs. As Claudia states, there are lots of microhabitats and heights providing a multitude of conditions in this unique structure to study.

Zoecoral.com (<http://www.zoecoral.com>)

The home website of the Zoe project. You can observe the livestream and learn about the story of why it is named Zoe. The livestream is also at our Living Sea Sculpture Youtube channel.

Raising corals to help Restore the Mesoamerican Reef (<http://oyalresorts.com/news/raising-corals-to-help-restore-mesoamerican-reef/>)

A concise explanation of the work INAPESCA-CRIP is doing with Dr. Claudia Padilla as the director. She began working with microfragmentation with Dr. David Vaughan, who helped them set up their facility for this process. I am interested in testing multiple species, including the disease resistant genotypes, and furthering the creative relationship Claudia and I have cross-pollinating our scientific and artistic roots for coral and biodiversity cultivation.

SciArt Initiative - "Interview: Colleen Flanigan discusses her work in 'Submerged' "
(<https://www.sciartmagazine.com/blog/interview-colleen-flanigan-discusses-her-work-in-submerged>)

"SUBMERGED" is SciArt Center's most recent exhibition, and surrounds themes of water in its variety of forms and the creatures that inhabit it. Exhibit curator Marnie Benney asked artist Colleen Flanigan to share a bit about her work, and the artistic and scientific processes behind it:

related websites:

<https://livingseasculptures.com/> (<https://livingseasculptures.com/>)

<https://www.patreon.com/CoralReefLivingSeaSculpture> (<https://www.patreon.com/CoralReefLivingSeaSculpture>)

Living Sea Sculpture YouTube Channel (https://www.youtube.com/channel/UCDE8tQBW6z-JnuP3L92NxjA?view_as=subscriber&fs=1&modestbranding=1&rel=0&showinfo=0)