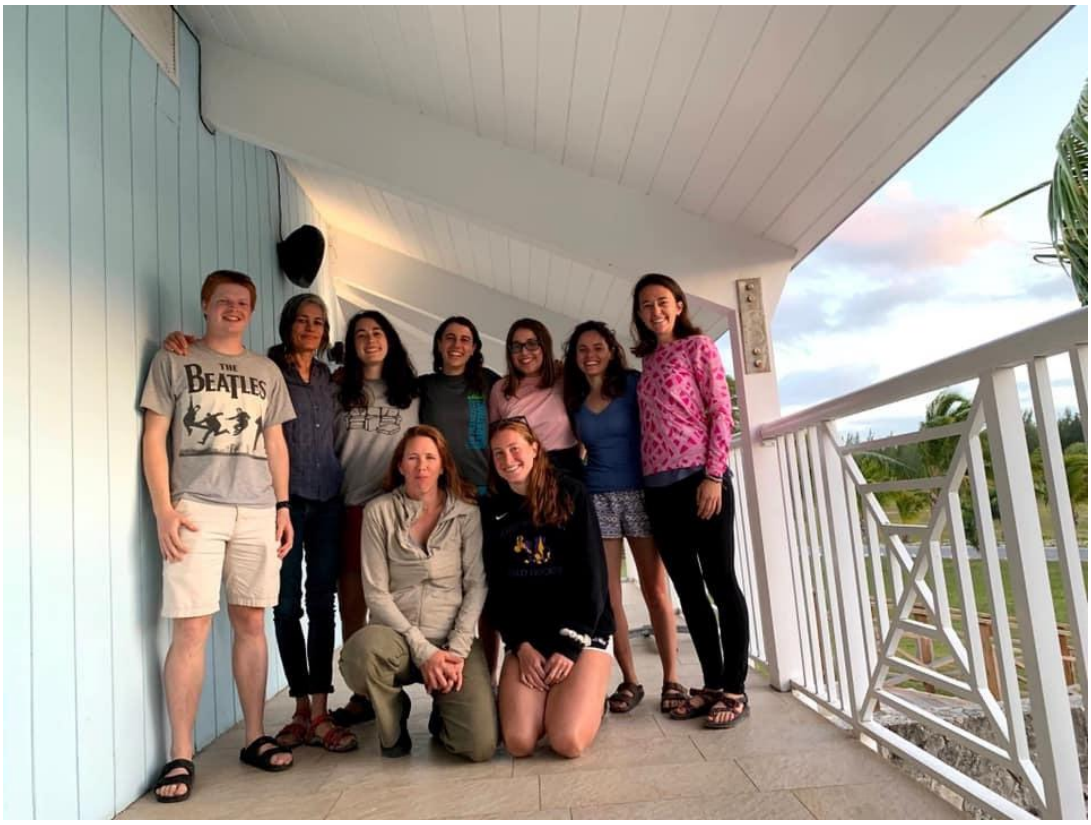
TROPICAL MARINE CONSERVATION
(BIOL/ENVI 25)

Williams College
January 2020
Eleuthera, Bahamas



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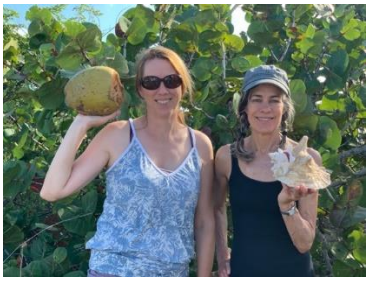
Preface

During January 2020, Williams College Tropical Marine Conservation (BIOL/ENVI 25) students immersed themselves in a hands-on course at the Cape Eleuthera Institute (CEI) on the island of Eleuthera in the Bahamas. There was never a dull moment learning and working with the researchers. We seined for green sea turtles, dissected invasive lionfish, snorkeled on healthy and less healthy reefs, studied the aquaponic and aquaculture system that grows all the greens for the school as well as tilapia for one meal a month, searched for land crabs in the moonlight, dissected road kill snakes, learned how coral is propagated in a lab and at sea, built spiny lobster lodges, measured queen conch shells from fishermen middens, scaled and fileted tilapia, inspected ooids, snorkeled in mangroves, toured Leon Levy Native Plant Preserve, studied sharks, learned to identify wrasses from basslets and the dreaded lionfish. We were also participant observers of the human ecology of the island and learned about unemployment, food security, job training, tourism, farming, hurricane displacement and the subsistence fishing culture. We visited abandoned overgrown luxury resorts from the island's heyday and new boutique resorts that are trying to survive today. We met with members of a community organization, One Eleuthera, that is working to improve the quality of life through vocational training in skills such as mechanics, engineering, and farming. More Bahamians would have survived Hurricane Dorian if they had known how to swim, so the organization also offers swim lessons. On our last day, we visited Lighthouse Beach, one of the most wild and scenic beaches in the Bahamas that is soon to be developed into a fantasy island port for Disney Cruiselines. In any free time, students explored the island, biking through the coppice and dirt roads, walking on the shore, birdwatching, snorkeling, and enjoying the beauty of the blue sea and the often-howling winds of the Bahamas in January.

We thank the wonderful researchers, teachers and interns at CEI who inspired us with everything from their knowledge of marine life to the magic of the jubilant pre-dawn run-swim: Nick, Seb, Bill, Natalia, Walter, Csilla, Adam, Casey, Anya, Anne, Colin, Angie, Andrew, Jack, and Charlotte. A big thank you to Tyler Maxey for organizing our visit and for her infectious passion for Eleuthera. Also, big thanks to Chris Maxey who had the vision to create the Island School and Cape Eleuthera Institute so that we could come here to seek knowledge, inspiration, and the egg dance.

Finally, a special thank you to the Williams College Class of 1963 Sustainable Development Fund.

Sonya Auer and Sarah Gardner



From their class on Eleuthera, each student wrote about a research experience* that inspired them during their time on the island (see below). In addition, one student compiled a short video (https://www.youtube.com/watch?v=-Rn4tpf8nml) highlighting some of their experiences on the island.

Table of Contents

* All research at the Cape Eleuthera Institute was undertaken in accordance with scientific research permits from the Government of The Bahamas. Best practices are followed at all times.

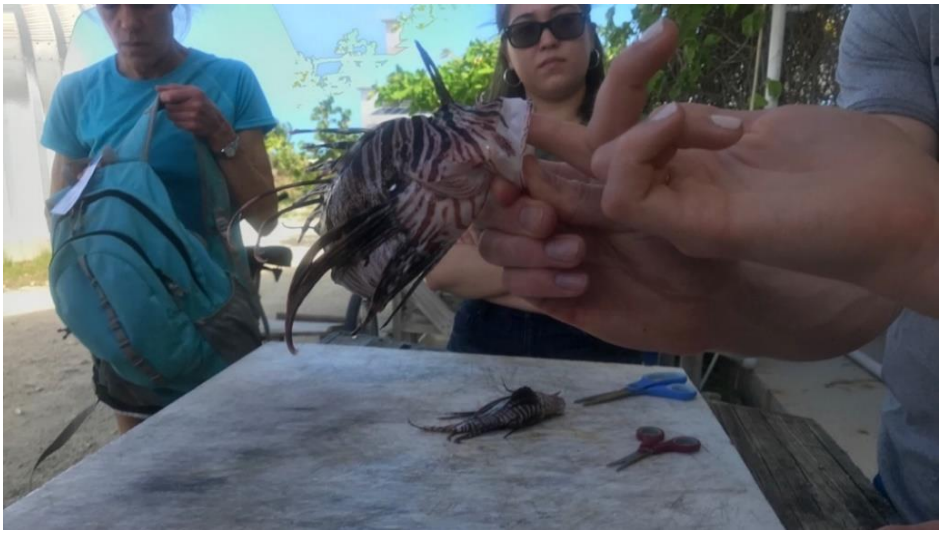
Lionfish: The Exploration of an Unnatural Predator

Emily Agreda

Every year, thousands of tourists venture to the Bahamas to enjoy its lush beaches and crystal blue water. But, under the ocean's surface lurks an invader with powerful biological adaptability. Lionfish, *Pterois volitans*, was first sighted in the Bahamas in 2004, and has since become one of the Bahamas' most notorious invasive species. In my time at the Cape Eleuthera Institute (CEI) I had the opportunity to learn about the biology and history of lionfish and observe them firsthand in a dissection.

Invasive species are non-native to the environment they inhabit, and can be harmful economically, environmentally, or to human health. In the US alone, invasive species cost $120 billion annually in management. Not all foreign species are invasive but can become invasive if they have no natural predators to limit their population size, such as the case of lionfish in the Bahamas.

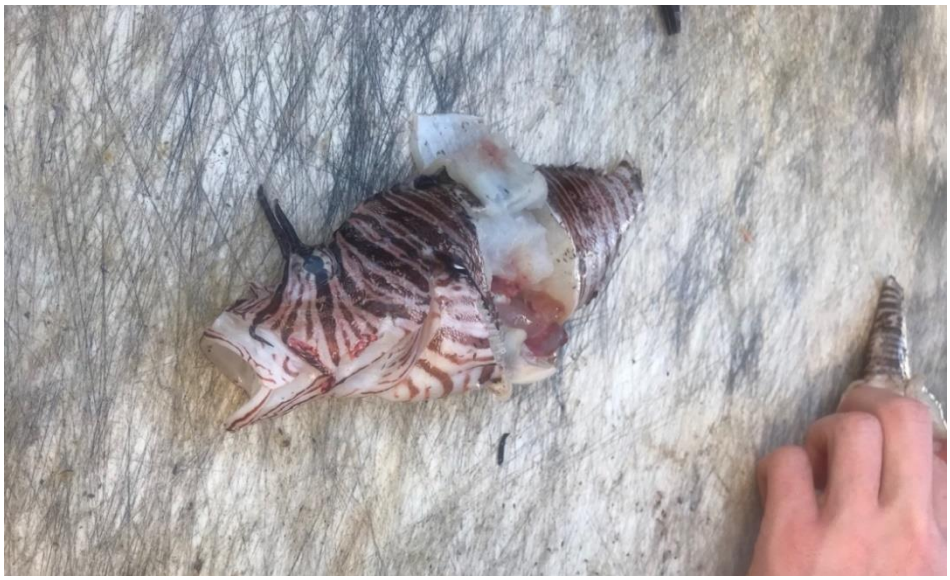
Most invasive species are thought to be introduced anthropogenically, but also traverse by marine debris, wind, ocean currents, and even bird seed dispersal. Lionfish were first sighted in Florida in 1985 and were then documented as established in the Atlantic Ocean in the early 2000s. Without any indication of how lionfish were introduced into the natural environment, they are thought to have permeated neighboring waters through egg dispersal by ocean currents.



A spearfished lionfish is dissected at CEI. Collin Love, an educator, demonstrates how a lionfish expands its mouth to vacuum in large prey. Upon feeling the roof of the lionfish's mouth, small teeth are present to keep swallowed prey from escaping.

Lionfish are native to the Indo-Pacific Ocean region, where they spend the majority of their lives alone living close to the ocean floor. They sport a crepuscular pattern, with bars extending across their eyes making them experts in camouflage at dusk and dawn, their preferred feeding times. Large mouths allow lionfish to ambush and suck in prey that are up to half of their size. Like many of us, lionfish are prone to binge eating, and can be observed consuming up to 8.9% of their body mass per day. Their large food intake, is thought to replenish their impressive fat stores that support a starvation tolerance of up to 3 months.

Not being picky eaters, lionfish are known to munch on 42 native Bahamian species along coral reefs. Through dissections they have been found to eat shrimp, crabs, juvenile snapper, juvenile grunts, and parrotfish says Charlotte Nowak, one of CEI's educators.



Lionfish collected at CEI are examined for stomach contents.
In our dissection we found three small fish and a shrimp.

While their broad diets and starvation tolerance are impressive, the lionfish's most useful tactic is its spawning capabilities. Female lionfish mature after just one year and boast rapid reproduction rates of every four days. Over the course of one year a single lionfish can spawn up to 25,000 eggs in favorable non-native conditions.

As lionfish density continues to rise, so does their impact. While their diet is broad, it mainly consists of coral reef species. Coral reefs are incredibly important as they occupy only 1% of the marine environment but support 25% of its biodiversity by providing habitat. As lionfish populations increase, important reef fishes can be affected. Coral reef fishes are important for maintaining the health of the reef, as well as serving as an important catch for fishermen.

Due to a lack of natural predators, there are no concrete methods to tame the population boom of lionfish. In recent years, many incentive programs have been created. For example, there are now lionfish derbies to incentivize the catch and practice of catching lionfish as a sport for reward in Florida. Charlotte Nowak describes programs like the CEI that work not only to raise fishing excitement, but also educational awareness of the lionfish as an invasive species. One of CEI's most recent programs involves matching the price of grouper per pound of filleted lionfish for local fisherman. Other ideas of population control include introducing the unfamiliar lionfish as prey to predators in the invaded areas or introducing the lionfish's natural predators: the bobbitt worm and frog fish.

While lionfish pose a significant threat to the biodiversity of coral reefs they inhabit, their impressive adaptability is worth researching. Recent projects at CEI include measurements of lionfish density, metabolic activity, and salinity tolerance. Hopefully with time lionfish population can be managed, but until then they provide us with a masterful example of invasion at its finest.

Walking Across Sea Turtles

Eva Castagna

When Christopher Columbus arrived in the Americas, he wrote that there were so many sea turtles in the Bahamas that you could walk across them. Well, I am currently in the Bahamas and certainly don't see the same thing. So, what happened to all the sea turtles?

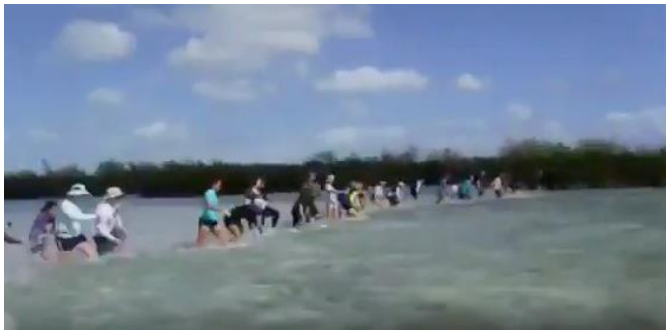
Sea turtles have been around for more than 200 million years, with seven species worldwide, three of which can be found in the Bahamas. They are hydrodynamic, have fused rib cages, and are ectotherms, meaning they get their heat from the sun. They breath air and spend three to five years traveling with ocean currents during a period known as the "lost years". Unfortunately, sea turtles have recently undergone a huge population decline due to human influence and climate change. For example, light pollution negatively affects sea turtle hatchlings, causing them to travel in the direction of cities and boardwalks instead of towards moonlight and the ocean. Luckily some states such as Florida have enforced strict laws banning indoor and outdoor lights that can be seen from the beach during sea turtle hatching season.

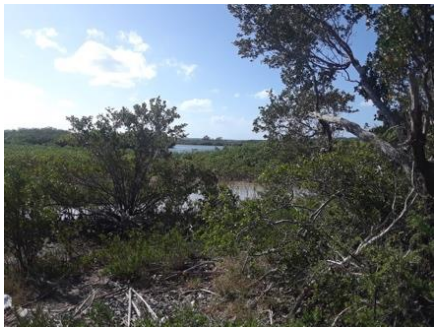
Fisheries have also posed a threat to sea turtle populations, as the turtles often get caught as bycatch. Since they breath air, getting caught in nets is fatal. Luckily, there are efforts to prevent sea turtles as bycatch, such as placing LED lights in fishing nets so the turtles can see and avoid them. There have also been efforts to use curved hooks in place of the traditional "J" hook, since unlike the latter, curved hooks can easily be removed from sea turtle's beak without damage. Destruction of mangroves also contributes to the

declining population. Juvenile sea turtles rely on mangroves for protection, so destroying this habitat leaves them vulnerable and exposed to predators.

Seb Hoefer, a scientist at the Cape Eleuthera Institute (CEI) in the Bahamas, described the purpose of his team's research as "monitoring sea turtles to see their growth and their health, while finding ways to document their ecology and behavior without harming them." At CEI, they capture the sea turtles, mainly green turtles, either on boats with around five people (where the sea turtles are chased down and caught by hand) or through seining (a process in which the turtles are chased into a large net and caught one by one). They take measurements of the turtles to document their growth, as well as tag their rear flippers to keep track of individuals.

Educational outreach is a large part of the turtle research efforts at CEI, and they are able to bring large groups out to assist with the turtle seining, measuring, and tagging while teaching the importance of conservation. On January 9th, 2020, we had the opportunity to participate in sea turtle seining with Seb and the turtle team! The purpose of this project was to capture juvenile sea turtles in a mangrove creek, take measurements, and tag them. In order to capture the turtles, a handful of people stood in a semicircle at the mouth of the creek with a net. The rest of us formed a line across the creek upstream of the net, making sure there were no gaps. Then we walked towards the mouth of the creek, splashing and creating noise to scare the turtles in the direction of the net. Once we reached the mouth, we carefully formed the net in the shape of a circle, trapped the turtles, and caught them by hand. We were able to capture six green sea turtles and took them all to the shore to be measured and tagged.





Pictured above: The scare line for turtle seining (left), The mangrove creek (right)

If the turtle is large enough, a biologger (a type of camera) is attached to its shell, which allows researchers to observe eating and swimming habits for around four hours before it falls off. However, the biologgers are large and affixing them to the turtle's back require plastic netting that remains attached for a week until eventually it falls off into the ocean.

Seb and his team are looking into alternatives, such as geck-skin, a tape modeled after geckos that uses electrostatic forces, to attach these cameras to minimize plastic pollution. Seb and his team are also working on investigating the effect of these biologgers on the turtle's swimming and eating patterns. Since the biologgers are large, they influence drag and buoyancy as the turtles move about. Drones are used to track the turtles without biologgers, and the behavior of these turtles are compared to that of turtles with biologgers.

Another project that Seb and the CEI team are working on is with facial recognition software, which will hopefully one day be an alternative to attaching metal tracking tags to the turtles. "It's there, we have the software, we just need to manipulate it for animal use" (Hoefer, 2020). Each turtle has a unique facial and flipper pattern, and the hope is to eventually create a database documenting each turtle to investigate migration patterns, therefore eliminating the use of the more invasive metal tags.

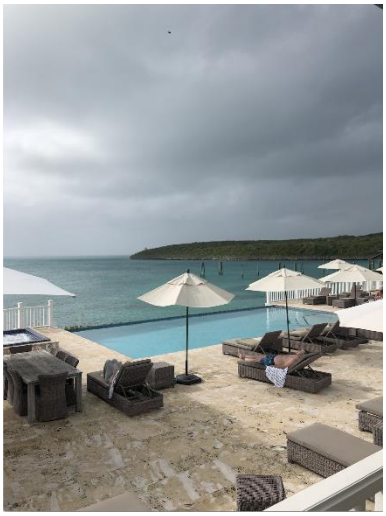
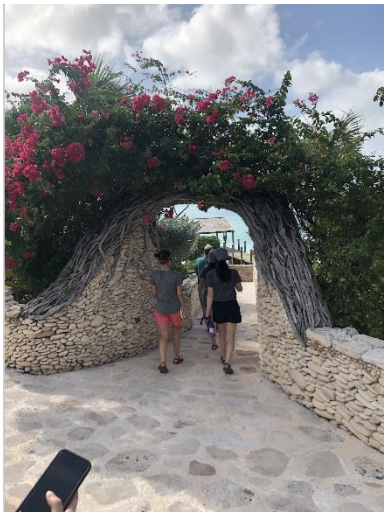
Sea turtles have heavily affected by human impact and climate change, leading to rapid species decline. However, hope lies with protective measures such as the use of curved hooks and Florida's efforts to combat light seen from beaches. Although I doubt we will ever see so many sea turtles that we can walk across them as Columbus described, steps are being made to protect these amazing species so future generations will be able to see at least some.

French Leave Resort: A Case Study of Bahamian Luxury Tourism

Emma Ticknor

The economy in much of the Bahamas is tourism-based, so locals depend upon an inflow of money from visitors. Tourism is tricky, however, because while necessary for local economies, it can be quite disruptive to local culture and the environment. On Saturday, January 11, 2020, our group visited French Leave Resort, in Central Eleuthera in the settlement of Governors Harbor. We met General Manager Chuck Donnelly in the afternoon for a tour of the resort and a discussion about tourism in the Bahamas. Chuck was incredibly hospitable to us, providing us with a friendly resource for learning much more about this subject, while French Leave was an invaluable case study for viewing these factors.

We began our visit with a tour of the resort. A middle- to upper-tier Marriott "Autograph Collection" resort, the resort was beautifully curated, with carefully trimmed shrubbery, flowers and trees lining stoned paths. A thatched awning overlooked a clear Caribbean bay, and Chuck told us that this is a popular spot for photos. We also got to see the pool area and restaurant, which were luxurious and pristine. A few guests were scattered around this area, lounging in the sun or eating and drinking.

The beautiful pool view at French Leave Resort, overlooking the Caribbean, and a thatched awning that descends to the water.

At the end of our tour, we sat on outdoor couches and enjoyed some freshly squeezed lemonade and cookies with Chuck. He spoke to us about the cultural and ecological footprint of French Leave and answered our many questions. Environmentally, there is much to be improved at this resort (and all resorts). Lots of resources are consumed in cleaning rooms and supporting basic hotel functions. French Leave's restaurant does not compost, and recycling options are scarce. This has to do with recycling in the larger Bahamas, however; the island country lacks the infrastructure to dispose of recycled material. Chuck told us that many of his guests are curious about how they can be respectful waste stewards during their stay at French Leave, and will ask him about recycling. This is an interesting example of how French Leave's guests (75% from the U.S. and 25% from European countries like France and Germany, in Chuck's estimation) bring their home countries' environmental practices with them to the Bahamas, where they are not necessarily relevant to a local model of sustainability (while certainly well-intentioned!).

While French Leave's goal is to provide a luxurious guest experience, this sometimes conflicts directly with sustainability. Although they purchase fish for their restaurant locally, two of French Leave's three fish dishes feature species whose populations are threatened in the Bahamas: queen conch or *Strombus gigas*, which are commercially threatened, and the Nassau grouper (*Epinephelus striatus*), which is on the International Union for the Conservation of Nature's "Red List" of threatened species. Guests expect fresh seafood, however, and French Leave will provide.

Solar panels, on the other hand, which Chuck plans to pursue, may be an opportunistic intersection of sustainability and guest experience. Bahamas Electric, French Leave's current provider, is notably unreliable, and Chuck told us that the resort had lost power twice the previous day. The resort has two diesel-powered backup generators, but solar panels would provide even more reliable power for guests, while also reducing the resort's carbon footprint.

Chuck did have good things to say about French Leave's cultural footprint. He recognizes that the island is small, and relationships with locals are important not only for respecting Eleutheran culture, but also for making his own job more seamless. Chuck knows he can get infrastructural help faster, for example, when he has a good relationship with the local provider. French Leave's staff is also nearly all Bahamian; Chuck and his assistant GM are the only non-locals. Chuck hired a local chef out of 70+ applications that featured Ritz-Carlton chefs from all around the world.

This visit really got me thinking about how tricky tourism really is. It's wonderful that French Leave has focused on hiring locals; this supports Eleutherans economically, reduces the cultural disruptiveness of the resort, and simultaneously helps the resort run. However, there's no escaping that tourism is a hotbed example of capitalism's faults; wealthy guests, usually white, stay at a luxury resort where they are pampered by the lower-income service workers of the island. While these black Bahamian workers are making livings there, the bulk of economic benefit and growth still goes to Marriott. Further, some researchers, like Ian Strachan, argue that a focal point of tourism is service from locals; some subconscious pleasure comes from being taken care of by a low-income, often non-white, service worker. Strachan writes in *Paradise and Plantation*, which we read before arrival on Eleuthera, that tourism exploits local culture and suppresses it into a "culture of the brochure"; in other words, elements of the Bahamas that will be seen by tourists (like physical environment, food, or people) must be shifted into servility mode for the benefit of tourists who expect a certain type of "brochure" paradise. This provides a weak look at Bahamian "culture", as visitors feel satisfied that they've experienced Eleuthera when they are served by a Bahamian staff.

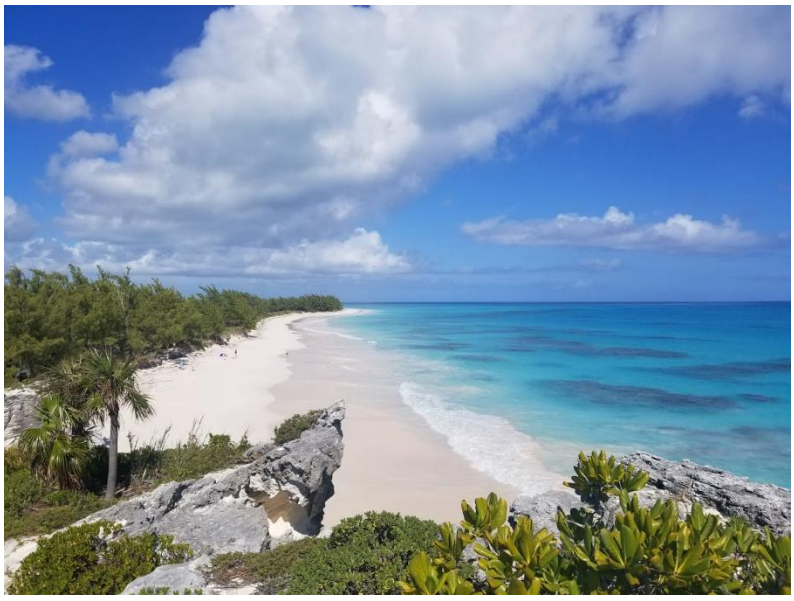
Would it better to have an all-white staff, then? Certainly not; this would segregate the resort from any local culture and create a sort of land-grab situation. The only thing I can say for sure is that our visit to French Leave Resort was the perfect place for deep reflection about the dynamics of tourism, capitalism, and sustainability.

Fighting for a future for Bahamian Reefs

Evan Wright

Coral ecosystems in the Caribbean don't seem to have much of a future. Buffeted on all sides by environmental stressors, corals are in precipitous decline nearly everywhere, and almost gone already. It's a death by a thousand cuts. Turbidity, pollution, ocean acidification, disease, searing heat, overfishing, frequent and severe storms. It's hard enough for these delicate ecosystems to deal with a single one of these problems; running the gauntlet of all of them is impossible. Once teeming with life, hulking chunks of dead limestone are now all that is left in vast swaths of coral habitat--the reefs' living, growing skins have been stripped off by human negligence. When corals die, the complex dance of life that surrounds them ends as well. In exanimate coral reefs, few organisms prosper but algae.

In the shrinking places where they still thrive, coral reefs are explosions of biodiversity. Though they cover less than one percent of the ocean floor, these three-dimensional structures hold a quarter of all marine species.[1] The nooks and crannies created by their skeletons make excellent homes for fish, crustaceans, worms, and other critters. In the sunlit warm waters, competition for survival is fierce. Complex food webs arise, beautiful symbioses emerge, and all exist in a fragile balance. The sheer volume and fecundity of life are staggering. Tropical coral reefs are nurseries for countless species, hunting grounds for many others, repositories of undiscovered biochemicals, livelihoods for people all over the world, and barriers to storm-driven waves. It's hard to imagine an ocean nearly devoid of their magnificence, but it is an ocean we may soon encounter. What would the future look like without these ecosystems? Can we salvage enough remnants to preserve some of their essential functionality? Widespread, thriving reefs is a prospect even coral researchers see as unrealistic. Nevertheless, there is hope that with human help, corals can play some role in the future of shallow seas around the world.



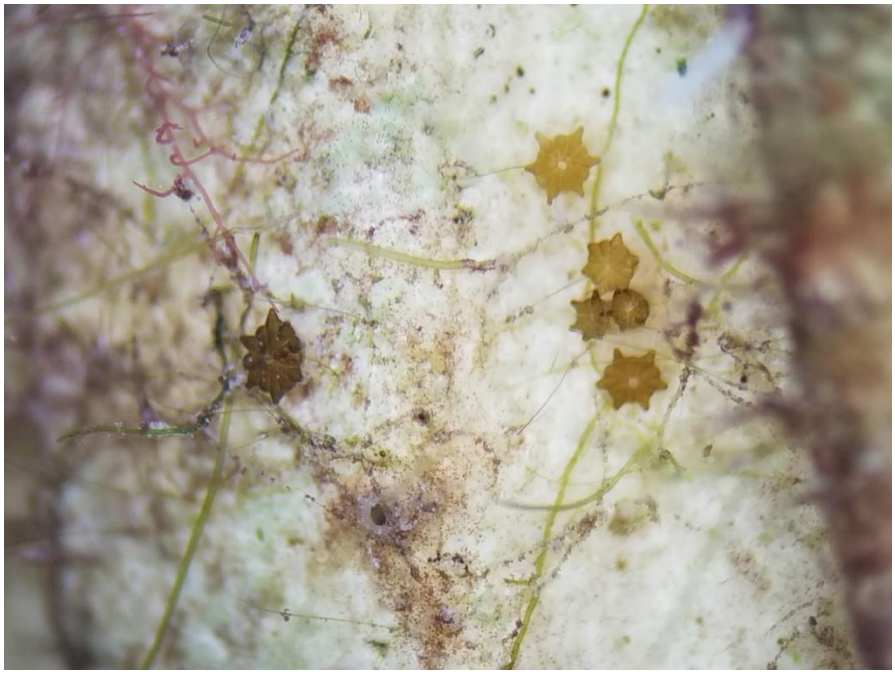
Lighthouse Beach, Eleuthera, the Bahamas. The dark patches in the water are reefs, but they are mostly dead. Our snorkeling excursion revealed almost no living corals and few fish.

I am not sure whether I would want to be a coral researcher. To me, it seems like it would be a bit like being a museum employee trying to save priceless artifacts from a building in flames, but with less adrenaline-washed panic and a more perfect, excruciating vista on the surrounding destruction. In other words, I imagine it is emotionally difficult. But it is easy to see how one could fall in love with corals. Even when degraded, reefs are indescribably beautiful. On my first snorkel over a small patch reef off the Eleuthera beach, I was entranced. Beyond the sandy shallows, rocks rose in complex geometry, algae coated patterns articulating the mostly lifeless surface. Ailing fan corals swayed in the current. Behind, around, under, over, and throughout, fish of all sizes glimmered. The dazzling colors of reef fish are what most astounded me in my first outing. That and the realization that the structures beneath me were ancient, built layer-by-layer over

[1] https://floridakeys.noaa.gov/corals/biodiversity.html

thousands of years by an organism best observed under a microscope. On subsequent explorations over much larger reefs, I kept being amazed, over and over again.

When I asked the coral researchers at Cape Eleuthera Institute what drew them to the field, they cited a similar feeling of wonder at their first sight of a reef. Natalia Hurtado, the lead scientist, fell in love on her first dive in Colombia when she was just 10 years old. Casey Harris, another researcher, pursued a graduate degree in coral reef ecology after a formative experience off the Antillean island of Bonaire. It seems that mouth-gaped, seawater-swallowing incredulity is a commonplace occurrence for reef newcomers. How could one not be enamored with such splendor?



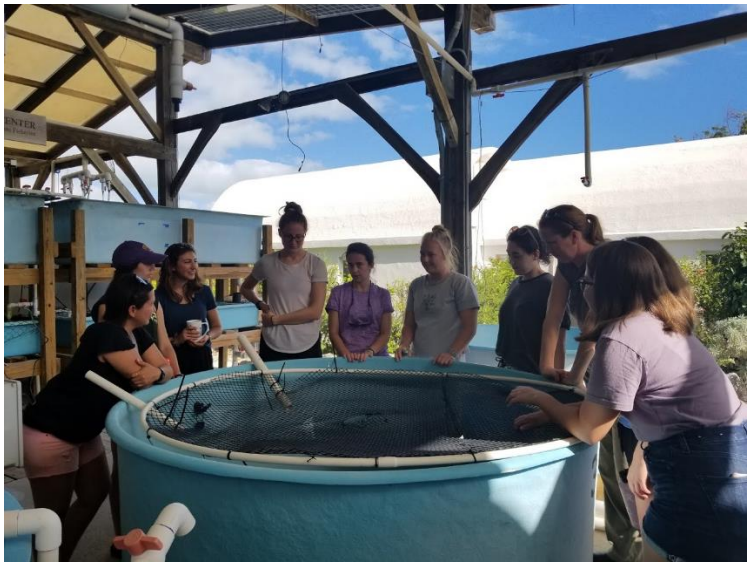
Coral polyps growing on an artificial substrate. Researchers have to scrub the algae off regularly to keep the coral healthy.

But what are these love-sick scientists actually researching at this breezy Bahamian outpost? From what I could tell, not a lot. Yet. In fact, they are hard at work constructing the tanks that they plan to use for experiments and coral breeding efforts. “We have to build everything ourselves,” Natalia explained on our tour of the half-put-together facility. In total, there were four tanks inside, and a few more under a shade tarp in the sun. A single microscope (the only one they had) was trained on a concrete substrate spotted with coral polyps. When I peered into it, I saw little green stars hiding their tentacles from the daylight.

The facility is tiny, hardly the place to reseed the vast coral colonies under duress around Eleuthera Island. Currently, the researchers are doing tests of concrete and ceramic growth substrates to see which coral prefer. They are also propagating corals in nursery trees on the ocean floor. When the tanks are up and running, the trio of scientists will be

able to test various environmental factors to better understand the best conditions in which corals grow. The hope is to collect and mix gametes from spawning coral colonies--nowadays often too far apart to breed successfully--then grow and reseed coral on dead and dying reefs. Perhaps, as lethal heat waves wreak increasing havoc, they'll be able to find some coral with a genetic predisposition towards heat tolerance.

This tiny team on this tiny scientific outpost, short on equipment and racing against the clock, won't be able to save the planet's reefs. But their work, combined with the work of thousands of other researchers around the world, could save at least something from this heat-induced holocaust of marine life. Perhaps, with human help, corals could one day reclaim the rocks they once constructed.



The coral team (Natalia Hurtado, Casey Harris, and Emily Corrigan) and the Tropical Marine Conservation Winter Study group talking over a constructed land crab habitat.

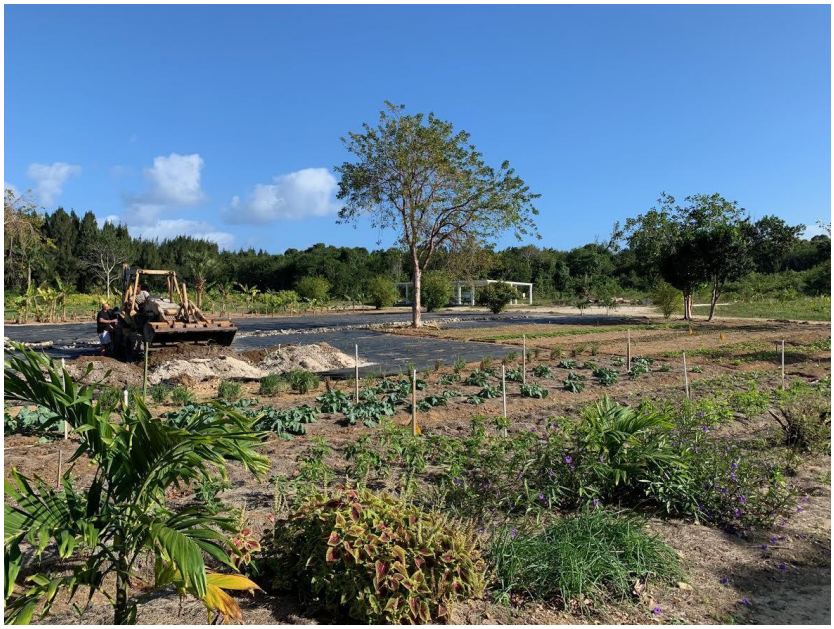
Community Building through Education, Sustainability and Development at One Eleuthera Foundation

Hayden Gillooly

Eleuthera is one of the most beautiful places that I have ever seen. Unfortunately, however, it is also stricken with poverty, infertile lands, and isolation from other parts of the world. There is a stark dichotomy in the Bahamas between wealthy tourists who arrive on cruise ships to enjoy the sun, surf, flora and fauna of the islands, and the people who live and work here year-round. One Eleuthera Foundation (OEF) is a non-profit development organization under the Commonwealth of the Bahamas. The organization has the vision to improve the economy and the community of Eleuthera through outreach, education, sustainability, and development. OEF is working intentionally towards directly addressing issues such as poverty and food insecurity on the island. OEF is the only

community organization in Eleuthera. Thus, the work it is doing is crucial for the betterment of the locals.

On our visit to OEF, we met with director James Richard who spoke with us about the projects of OEF. James had lived on the island of Abaco since 1997 until he was displaced to Eleuthera by Hurricane Dorian. In southern Eleuthera, there is an unemployment rate of 76% according to OEF director James Richard. OEF is trying to break this cycle through a vocational college with a class of around 30 students each year. This year's class includes 10 hospitality students, 10 electrical students, and 10 carpentry students. OEF pairs these students with local employment opportunities in their fields; most all of the students were hired after their yearlong internships or came back to work for OEF. Prospective students are encouraged to complete high school before attending this school, thus attempting to improve education rates in Eleuthera.



The farm at One Eleuthera Foundation. In the back are the previously used plastic weed suppressant plastics which overheat the soil, thus draining it of moisture; and do not act as long-term suppressants. At the front are raised vegetable beds with pine needle mulch. This mulch not only prevents weed growth, but it also adds vital nutrients to the soil as it decomposes.

The geology of Eleuthera is not favorable towards agriculture; there is nearly no soil on the island, but rather, limestone. Plants need nutrient-rich soil to grow; for this reason, Mike said that 98% of the food consumed on Eleuthera is imported. The food boat comes every two weeks, which can make food scarce, and means that there is not always fresh produce. It makes Eleutherans dependent upon exporters, and prices are at the hands of distributors. The Bahamas spends $80 billion annually on imported food. Additionally, transporting food thousands of miles creates a high carbon footprint.

OEF is trying to break the cycle of food insecurity through an on-site farm. In our visit, we toured the farm with a gentleman named Mike who has impressive visions for growth of

the farm. Mike, too, was displaced by Hurricane Dorian from Abaco. In Abaco, Mike had managed a farm that was thriving pre-hurricane. He had 30,000 pineapples, avocados, herbs and a plethora of other vegetables. It was no magic, however, that allowed Mike to reap such a bounty from a limestone-rich land. His father taught him the powers of composting to create nutrient-rich soil, which proved successful in Abaco. Mike said, “That hurricane was a blessing in disguise,” because it has given him the opportunity to build OEF’s farm ground up. Rather than use plastic sheets for weed prevention, Mike uses pine needles as a weed suppressive mulch. In Abaco, he used greenhouses built by the Australian company Cravo, and hopes to install them at OEF as well; these greenhouses have retractable walls and roofs which optimize temperature, humidity, and soil-moisture while minimizing the need for electrical cooling or pumping of water. Mike hopes to create a closed-loop system for local food security; this would include taking food scraps from restaurants to provide compost and nutrients to the plants and provide local, fresh produce back to the restaurants. He has spoken with supermarkets about having a fresh daily section for produce.

Repurpose vats from a tomato processing plant, which Mike plans to use to hold the compost at the OEF farm. Eleuthera works hard to repurpose items, and send as few things to the landfill as possible. This is a perfect example.

According to James Richard, OEF played a huge role in helping 587 people displaced by Hurricane Dorian from Grand Bahamas and Abaco. 65% of these people are single mothers whose husbands have gone back to their home islands to rebuild; OEF has a food pantry for these climate refugees. OEF helped them find housing by paying first and last month’s rent, as well as aiding in the job-hunting process.

Visiting this organization really opened my eyes to the power of people, and the solutions that can be found to very real and pressing issues. While I understood the geology of Eleuthera, I had not fully grasped the implications of that for economies and food security. Nor thought about the factors affecting people displaced by hurricanes in having to

completely start over. James and Mike's positivity in finding the silver lining in their situations showed me the resilience of people. The work that OEF does is inspiring and trickles into improving the lives of countless people. James and Mike both spoke of the remarkable potential for growth on the trade school and farming projects in particular. As evidenced by Mike's farming success in Abaco, knowledge, and education is really the key to breaking the cycle of poverty and food insecurity. OEF hopes to be able to replicate their visions on other Bahamian islands as well so that their impact and improvement in the lives of the Bahamians can be expanded. There truly is no better textbook than the world at our fingertips, and I am feeling changed for the better by conversations with the people of Eleuthera. In learning more, we learn that we know less than we thought we did, which is motivation to keep pursuing studying topics that ignite our fire and passions.

From Fish to Food - Pondering Aquaponics and Learning about Food Security on Eleuthera

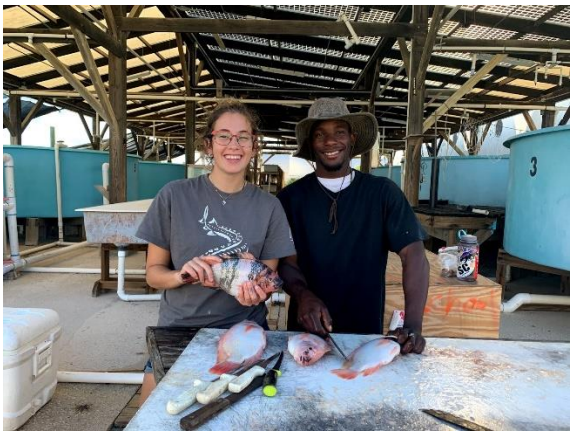
Campbell Day

Food security is a vital theme to consider, especially when living on an island. Every year, the Island School imports 98 tons of food (this is equivalent to 49 average sized cars). The Island School's goal is to increase their dependence on local food (as opposed to importing food), specifically relying more on food production right here at the Island School by further utilizing their aquaponic system, which is currently used to grow lettuce and breed fish. Eleuthera is composed of limestone, which is not a nutrient rich environment for agriculture, and water is a scarce commodity on the island. Therefore, aquaponics provides the solution to three main problems on Eleuthera: it increases food security through local production, is a way to farm without soil, and decreases the water needed for growing plants.

Aquaponics combines both the words and the work of two farming techniques: aquaculture and hydroponics. Aquaculture is the breeding, raising, and harvesting of fish, while hydroponics is a method to grow plants without soil. Aquaponics combines these two techniques by growing plants without soil by using the nutrients from farming fish to provide the plants with adequate nourishment.

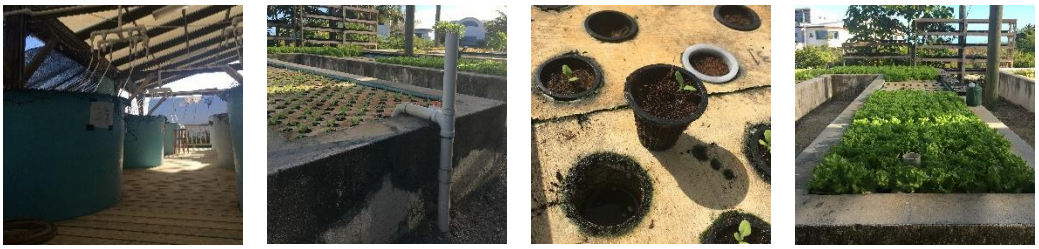
Walter Neely and Csilla Vasarhelyi run the aquaponic system at the Island School; they gave us a tour of the facility to explain how the system works. We began on the elevated platform that holds eight fiberglass tanks of tilapia. The platform is elevated because the system relies on gravity to deliver the water that the tilapia are housed in to the filtering system and then down to the plant beds. From the plant beds, there is an engine that delivers the water back to the tilapia tanks, keeping the same water in the closed loop

system. There are approximately 70-110 tilapia in each tank that are fed food meal imported from the United States. The waste from the tilapia provides nutrients for the plants, with two types of bacteria working to change the ammonia waste from the fish to nitrites and then nitrites to nitrates. However, as Walter explained, filtration must occur before the water is delivered, as some of the water is still very ammonia heavy which is toxic to the small lettuce plants. The water from the tilapia tanks first enters a large above ground tank, where Walter removes the ammonia heavy water each morning.



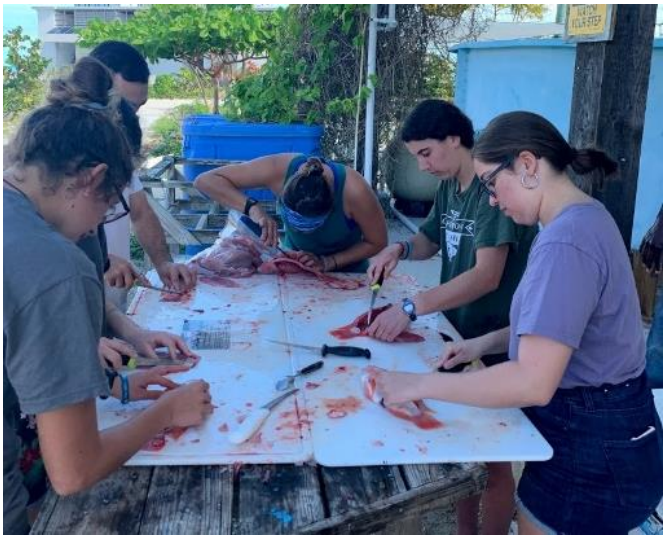
Walter and Csilla holding their fileted tilapia. Walter learned how to run the system in just two weeks and admits "I had a headache the whole time" from thinking about aquaponics 24/7.

This removes about five gallons of water from the approximately 25,000 gallon system, so additional water is added two times per week. However, the water added is still less than the amount of water the dining hall uses in one day, showing the decreased water usage by using the aquaponic system as opposed to traditional agriculture. From there, the water flows into another tank, which is filled with pasta-like objects that provide surface area for the free-floating bacteria to adhere to. This helps remove excess bacteria in the water that may be too much for the lettuce plants. In order to provide stability for the lettuce's root system, the lettuce seeds are encased in shredded coconut, keeping the plant stable, but still allowing the roots to grow into the water to receive nutrients.



From left to right: the fiberglass tanks of tilapia; the plumbing for the filtration system bringing nutrient rich water to the plants; a lettuce seedling encased in shredded coconut for stability; a lettuce bed about to be harvested for lunch!

In order to provide lettuce and fish throughout the year, the plant and fish harvesting are staggered. There are plant beds for each day of the week (excluding Saturday and Sunday) that are partially harvested on their respective day for the dining hall. The lettuce takes seven weeks to grow, so a rotation is in place to allow for maximum organization and growth. In addition, tilapia are bred on a cycle with fish living for approximately ten months and three weeks before their tank is harvested and the tank is repopulated with juvenile tilapia. We were able to help with one of the tilapia harvests by helping Walter and Csilla de-scale and filet approximately 67 fish that will be eaten in the dining hall.



Learning new skills! *Williams students fileting tilapia during the fish harvest.*

The aquaponics system at the Island School began in 2005 with just one container of fish and one bed of lettuce. Since then it has grown into a much bigger production with a bed of lettuce for each day of the week, additional basil and mint beds, and eight containers filled with grown tilapia. The aquaponic system creates 100% of the lettuce served in the dining hall in the winter and 80% of the lettuce in the summer (due to heat and weather differences). Every three weeks, the Island School also conducts a tilapia harvest of one of the containers of tilapia and serves the fish in the dining hall for meals that day.

Future Ideas! In the future, Walter hopes to diversify the plants that the aquaponic system will grow, such as introducing tomatoes, cucumbers, and additional herbs, therefore increasing local production and consumption by the Island School. The Island School's successful aquaponics system will hopefully serve as a model for other organizations to increase food security on Eleuthera while also serving as a mechanism to protect Bahamian fisheries from overfishing. In addition, their success may be a model for more far reaching communities as a way to increase food security by growing food (both plants and fish!) with minimal water and no soil.

Lobster Lodges: Luxury Real Estate on the Bahamian Coast
Sabrine Brismeur

You certainly won't find these types of condos in Florida: shelters made out of aluminum, wood or concrete, placed on the ocean floor among seagrass meadows. Legal in the Bahamas, Mexico, and Cuba, these artificial shelters (also called *casitas*, 'small houses' in Spanish) have become popular among smaller-scale commercial fishermen to catch the Caribbean spiny lobster, *Panulirus argus,* a valuable economic and cultural commodity. Yet they remain controversial and illegal in the United States, in large part because of the unknown effects these shelters may have on aggregating lobsters. Spiny lobsters are under overfishing threat from larger commercial fisheries, and it's still unsure whether the shelters help or hurt the population in the long term.

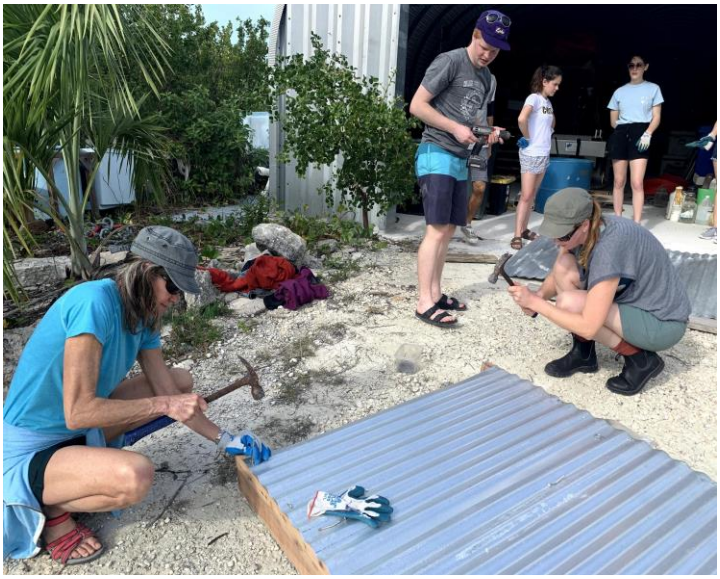
The Cape Eleuthera Institute (CEI) of southern Eleuthera, a small island of the Bahamas, is pursuing a program of several experiments centered around evaluating "how the spiny lobster fishery interacts with the wider marine ecosystem, primarily looking at how the use of artificial shelters impact the system," says CEI director Dr. Nicholas Higgs, who spearheads the project. As part of the lobster research at CEI smaller ongoing projects are focusing on how long it takes the seagrass to recover from the shelter, how discarding of lobster heads impacts the behavior of predators, and how shelters function as artificial reefs for non-target species. Given the artificial shelter's popularity with Bahamian fisherman, one of the other aspects Dr. Higgs is interested in researching is if the wood of an invasive tree species, the *Casuarina equisetifolia* (also known as the Australian pine – a misnomer), could be used to create the base of the shelters. *Casuarina* is abundant in the Bahamas, but its roots do little to hold the soil together and it outcompetes native plants for space, encouraging the erosion of the vital shoreline and sand dunes. The lumber of the *Casuarina* tree is dense, heavy, and long-lasting.

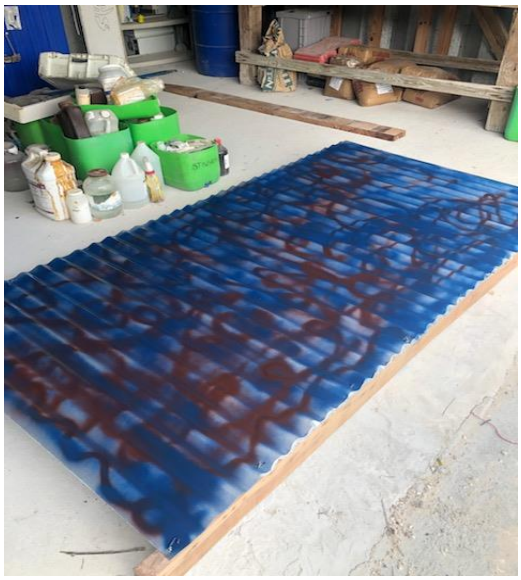
Higgs explained to us that Bahamian fishermen will place the shelters on the grassy seabed, then move them every few months, abandoning them when they begin to fall apart after four or five years. If the *Casuarina* shelters work as well as the currently preferred material — costlier pressure-treated wood — it could create a demand for the destructive invasive species. "With the *Casuarina* [shelter] in particular, we're looking to see how long the wood remains intact and capable of acting as a shelter," Dr. Higgs told us.

It took a single piece of sheet metal, two cuts of *Casuarina* wood, a dozen or so nails, and seven Williams College students to create the shelter. True to Dr. Higgs' word, the *Casuarina* wood was heavy and difficult to penetrate with the drill, but after two hours of work, the shelter was constructed and spray-painted for concealment (all shelters, once

submerged, are fair game for other fishermen). Once the shelter was placed on deck, Dr. Higgs drove a boat offshore to a spot comfortably situated in the seagrass near open patches of sand, and we pushed the lobster shelter off the boat, watching it glide to the seabed with the current. It's crucial to make sure that the shelter is positioned correctly: if placed upside down, it offers no protection for lobsters and no incentive for their aggregation. Ever the free diver, Dr. Higgs jumped into the water with a cinder block in hand to place on top of the shelter for extra placement security.

Once installed, the approximate coordinates of the *Casuarina* artificial shelter were recorded in a GPS data logger so the shelter can be found in the future. The shelter will be evaluated after six to nine months, and frequently checked thereafter for signs of marine life. While spiny lobsters might eventually call this shelter home (or for some, a hotel — as Dr. Higgs says, many are just "passing through"), other creatures such as small sharks, stingrays, crabs, and fish are often found at *casitas.*

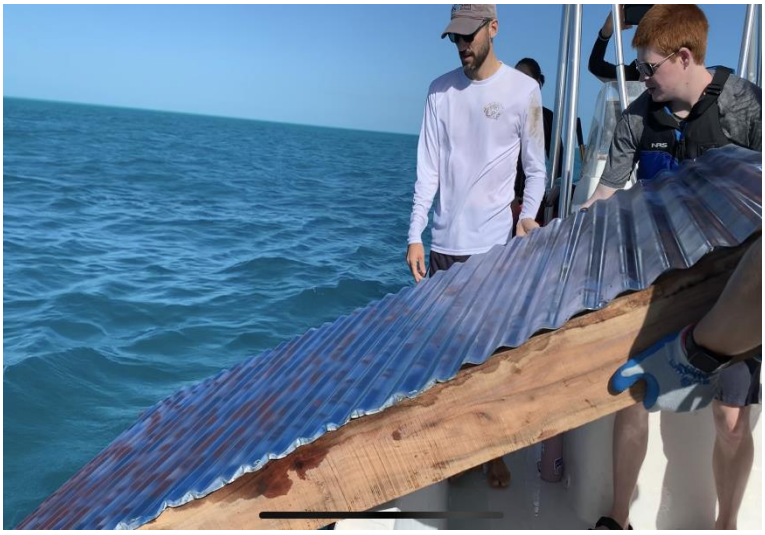


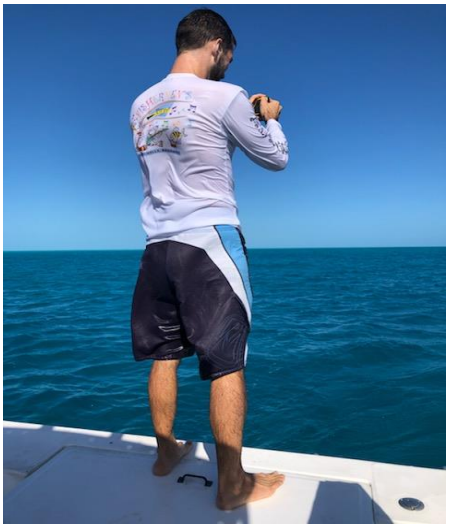


Left: Williams professors Sarah Gardner and Sonya Auer take their shot at hammering nails into the shelter as students watch. Top right: The artificial shelter is spray-painted blue and brown for better camouflage against the seagrass. Photos by Sabrine Brismeur and Hayden Gillooly.

Dr. Higgs' broader research is crucial both for the longevity of spiny lobster populations and for the future of its Bahamian fishery. Recently certified as a sustainable fishery in 2018 by the Marine Stewardship Council (MSC) after a vigorous assessment period, the certification allows Bahamian fishermen to fetch higher prices for the lobster and extend to untouched foreign markets. But the renewal of the prestigious sustainability certification is largely dependent on the research CEI puts forth. The certification is reviewed every three to five years, and by the next recertification, any "knowledge gaps" the MSC pointed

out must have been filled. CEI and Dr. Higgs help provide the scientific evidence needed to ensure that the Bahamian spiny lobster fishery can be recertified as sustainable when the time comes.





Left: Dr. Higgs and Evan (Williams '21) begin to slide the Casuarina shelter into the water. Right: Dr. Higgs inputs the coordinates of the shelter into a GPS data tracker for future reference. Photos by Sabrine Brismeur and Hayden Gillooly.

A successful *Casuarina* shelter will attract lobsters, stay upright, maintain its location, last a long time, and require little maintenance. Dr. Higgs' hope is that the *Casuarina* will prove to be a viable competitor to the pressure-treated wood, so that Bahamian fisherman will be motivated to cut costs — and the rampant invasive species for their shelters. The *Casuarina* research project is local in scale, but the experiment has implications for other nations besides the Bahamas, considering the *Casuarina* has also invaded other countries along the Atlantic where artificial shelters are used. As a born and raised Floridian who frequently spent early mornings catching lobster, I have a personal interest in all of Dr. Higgs' spiny lobster research – while the shelters are banned in my state, I'm eager to see what the research tells us about their role in the marine ecosystem.
