Abstracts of Technical Presentations

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Key Note Address

Oyster Restoration in the Indian River Lagoon: Past, Present & Future

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Studies on the decline of intertidal oyster reefs (*Crassostrea virginica*) in Mosquito Lagoon began in 1998 at the request of John Stiner, the Resource Management Specialist for Canaveral National Seashore. What was expected to be a simple, straightforward problem, took on a life of its own over the past 20 years. Research has included historical GIS mapping of the area, diseases, predation, competition, invasive species, algal blooms including multiple brown tides, eco-hydrology, sea level changes, hyper-salinity, and boring sponge infections. *C. virginica* has proven to be incredibly resilient to these stressors. One anthropogenic factor that oyster clusters have not been able to withstand are repetitive wakes from boats/wind that remove sediments holding oyster clusters in place on reefs. When combined with previously-listed stressors, wake-related oyster losses can be huge. Restoration with the help of community volunteers and dozens of organizations has returned over 10 million oysters to Mosquito Lagoon to date. Over 49,600 individuals have assisted with restoring 83 reefs. To ensure all participants understand the importance of their efforts and how much we rely on the Indian River Lagoon, 8 children's books, a phone app, citizen science project, and oyster storytelling yoga have been developed; all have been shared at no cost to community members.

Contributed Papers (Oral and Poster Presentations)
(The presenting author is the first author, unless indicated by underlining.)

Organic Contaminants as Ecological Markers in Young-of-the-Year Scalloped Hammerhead Sharks
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Since young sharks are expected to reflect their mother's contaminant signature for a period of time due to maternal offloading, we can infer maternal niche partitioning differences based on contaminants measured in young-of-the-year (YOY) sharks. We investigated if YOY sharks occupying nurseries in different geographic regions could be distinguished based on organic contaminant signatures, using this technique as an ecological marker of differential habitat use by their mothers. Liver contaminant signatures of YOY sharks from Bulls Bay, South Carolina and Cape Canaveral, Florida were compared using random forest models. Sharks from these two locations were distinguishable based on their contaminant signatures with a misclassification rate of only 6.67%. Our results suggest adult females contributing pups to these two nursery areas likely exhibit differences in their habitat utilization, and possibly feeding ecology, indicating that females of a purported single population experience different exposures to environmental contaminants.

Go with the Tide: Impact of High Water on Boring Sponge Establishment
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Boring sponges are bioeroders that dissolve through calcium carbonate substrates including oyster shells. Live sponges and broken oyster clusters showing boring sponge degradation have been observed on oyster reefs in Mosquito Lagoon. These sponges may erode the reef edges by weakening attachment points of oyster clusters. Clusters may wash up onto intertidal sections of reefs via wind or boat wakes. Mosquito Lagoon's high water season may allow dispersed sponge to persist on and degrade intertidal portions of reefs that are exposed daily throughout the rest of the year. We conducted aquarium experiments to quantify the length of time boring sponge takes to transfer between shells via physical contact and larval dispersal. Data suggests that the 3-month high water season may be sufficient time to allow sponge to infect reefs. This adds to our understanding of why sponges are eroding oyster reefs and may inform dispersal-mitigation strategies for future restoration efforts.

Identification of Bottlenose Dolphin Prey within the IRL, Utilizing Images Collected during Observed Dolphin Feeding Behaviors
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Identification of dolphin prey is fundamental to understanding the ecological function of dolphins within the IRL. In addition, dolphin prey species associated with sport/commercial fisheries are of vast importance to highlight mutual benefits of the conservation of IRL habitats and fish species consumed by both humans and dolphins, and health concerns associated with those shared resources. This study utilized image archives of dolphin prey documented during observed feeding behaviors of dolphins from

2003 to 2015 to determine prey of significance, and is the first to incorporate long-term in-situ observation and documentation of prey ingestion.

Assessing the Role of Estuarine Impoundments and Marine Mammal Exclusion Devices on Red Drum Movement Patterns

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One of the most economically valuable sportfish in the Indian River Lagoon is the red drum (*Sciaenops ocellatus)*. Previous local studies of red drum document strong site fidelity, with some mature individuals residing and spawning within the lagoon. Intra-estuarine spawning is uncommon in other portions of their geographic range, suggesting future abundance and harvest of red drum is partially dependent on continued spawning success within the lagoon. The Integrate-Transfer-Launch (ITL) complex impoundments located within the Kennedy Space Center security zone are known spawning sites of red drum. However, recent construction of manatee exclusion bollards around culverts leading into these impoundments may impact movement to and from these historic spawning sites. This study utilizes passive acoustic telemetry to quantify patterns of red drum movement and habitat use within and around the ITL impoundments to assess how manatee exclusion bollards may potentially impact movement and spawning of red drum.

Effect of Water Quality Sterilization Methods on Survival and Growth of Seagrass Fragments

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The Florida Oceanographic Society seagrass restoration program maintains a seagrass nursery to contribute to the recovery of seagrass beds in the Indian River Lagoon (IRL). *Halodule wrightii* fragments that have been uprooted and washed ashore in the IRL are grown out creating a new source of seagrass for restoration. However, these fragments can introduce new microorganisms and pathogens to the nursery. We tested different sterilization methods to determine the least detrimental one to seagrass fragments. For the sterilization process, *H. wrightii* fragments were dipped into the following treatments: Freshwater, Low Chlorine, High Chlorine, Potassium Permanganate, and Saltwater (control). Treated fragments were planted into individual trays in the nursery where survival and growth was measured for six weeks. All *H. wrightii* fragments survived. Freshwater and saltwater showed the best seagrass growth. Low chlorine had the largest impact, with high chlorine and $KMnO_4$ showing similar declines in seagrass growth.

Hurricane Irma Effects on St. Lucie Estuary Water Quality Assessed by a Surface Water Flow through System

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Surface water quality data were collected in the St. Lucie Estuary prior to and after Hurricane Irma using a continuous, ship-board, *in situ*, flow-through system. Surveys were conducted from the St. Lucie Inlet to the S-80 control structure, including the North Fork, in March, July, October and November of 2017. Increased freshwater inputs from control structures and the tidal basin after Hurricane Irma dramatically altered the salinity, chromophoric dissolved organic matter, turbidity, and chlorophyll *a* characteristic

within the estuary. This data will help describe post-hurricane water quality patterns in the estuary and may inform potential impacts to the ecosystem.

Spatiotemporal Changes in the Indian River Lagoon Microbiome

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Microbes have high sensitivity to low levels of contaminants, consequently effects on populations will be seen at the microbial level before being observed in higher trophic levels. Molecular techniques are used to determine the taxonomic composition of microbial populations; the diversity of these microbiomes can be correlated with environmental conditions. We have conducted a baseline study across diverse environments within the Indian River Lagoon and explored how the microbial populations change as a result of environmental factors. The study was repeated to allow sampling at two time points within a single year to determine how the microbiome changes temporally. After establishment of the baseline, we identified specific members of the population that can be monitored to determine the ecological health of an area. These indicators can be used as an early warning system that can allow a restoration or mitigation response to be launched before higher trophic levels are affected.

The Application of Ultraviolet Exposure to Prevent Biofilm Formation and Reduce Invasive Species Transport

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Invasive species transport on ships has been noted as a major threat to marine environments via biofouling on ship hulls. They result in the disruption of habitats and ecosystems, and decreased biodiversity. The estimated cost associated with invasive species management is $137 billion per year, for the U.S. alone. Biofilms (e.g., bacteria, diatoms, algae) influence macrofouling community structure through cues that larvae use for settlement. It has been hypothesized that the prevention of biofilm formation will reduce the risk for invasive macrofouling species' from settling and dispersing through the marine environment on ships. This study investigated the efficacy of ultraviolet light exposure to prevent biofilms and biofouling from growing on ship hulls. Three frequencies of UV light were applied to two ship hull coatings: continuous, one minute per six hours, and one minute per day. The lowest exposure time of one minute per day was effective at preventing biofouling settlement.

Mitigating Harmful Algal Blooms in the Indian River Lagoon: How Effective Were the Fertilizer Bans?

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Since 2011, 37 local fertilizer bans were implemented along the Indian River Lagoon in an effort to improve water quality and mitigate harmful algal blooms. To assess the effects, comparative water samples and macroalgae were collected at 20 sites in 2011-2012 and 2016-2017. Water samples were analyzed to determine concentrations of nutrients. Also, macroalgae were analyzed for stable carbon and nitrogen isotopes, as well as elemental composition (C:N:P). The data showed an increase in $\delta^{15}N$ values, indicating a stronger wastewater signal. The largest increase in $\delta^{15}N$ occurred in Brevard County, where brown tide (*Aureoumbra lagunensis*) blooms occurred in 2012 and 2016. Nutrient concentrations and $\delta^{15}N$ from the brown tides indicated that the 2016 bloom was more P-limited than the 2012 bloom, and wet season $\delta^{15}N$ increased from the range of fertilizers in 2012 (< +3 o/oo), to enriched values (> +7 o/oo) in 2016 characteristic of wastewater.

Evaluating the Effectiveness of Living Shorelines in Mitigating Non-point Source Pollution and Increasing Soil Carbon Storage in the Mosquito Lagoon

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Non-point source pollution or runoff is a growing problem leading to many water quality issues, including algal blooms, fish kills, and hypoxic zones in Florida's waterbodies. The amount of carbon dioxide in the atmosphere stemming from human activities is also increasing, resulting in rising sea levels, and climate disturbances. Living shorelines and other restored shorelines may be capable of reducing the amount of nutrients entering waterbodies while storing carbon in their sediments and plant tissues. Living shorelines and restored wetlands employ native vegetation which are capable of stabilizing coastal shoreline, absorbing nutrients, and storing large amounts of carbon in their soils. During this study, restored shorelines' immediate in-situ benefits in sequestering nutrients are evaluated in contrast with dominant turf grass shorelines, while probing for future benefits by determining the amount of carbon stored in the restored shorelines.

A Review of Dolphin Disentanglements in the Indian River Lagoon for 2017

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The Florida Atlantic University Harbor Branch Marine Mammal Rescue Team responds to marine mammal strandings and disentanglements under a National Marine Fisheries Services permit. In 2017, we participated in several multi-agency dolphin interventions that occurred throughout the Indian River Lagoon. After each dolphin intervention, the local responding agency continues to monitor the animals' health and recovery. Stranding groups also conduct outreach programs to help educate the public on how to avoid entangling dolphins, and how to notify officials when they see an entangled dolphin in the Indian River Lagoon.

Friend or Foe: Effects of Wrack Accumulation on Mangrove Growth in Mosquito Lagoon

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Mangroves are essential for preventing shoreline erosion. Two studies were conducted on how wrack accumulation within Mosquito Lagoon affects the growth of *Laguncularia racemosa* (white mangroves) and *Avicennia germinans* (black mangroves). The first experimental goal was to determine seasonal wrack abundance and diversity in Mosquito Lagoon. We found that during the summer months there was very little wrack on the shorelines. In the fall, wrack abundance increased on all shorelines throughout our study sites. The second experiment focused on the impact of wrack on mangrove propagule survival and growth. Each pot contained one *A. germinans* or *L. racemosa* propagule. Propagules were either floating in water, or covered with wrack or mimic wrack. Biweekly measurements included wrack/mimic wrack height, propagule survival, propagule dimensions, and propagule weight. Wrack positively influenced both species of mangrove propagules. This study offers insight for restoration efforts in areas with high seasonal wrack.

Living Docks: Promoting the Growth of Benthic Communities for Improved Water Quality

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The Living Dock Program is a citizen science initiative to raise awareness on the health of the Indian River Lagoon (IRL) with the goal of improving water quality. The Living Dock Program creates living ecosystems out of docks and pilings. These hard structures are wrapped with a mat of recycled oyster shell to promote the growth of oysters and other benthic organisms (such as barnacles, sea squirts, and sponges) which all have the potential to filter water. This leads to an increase in not only the biodiversity and additional habitats in the IRL, but also an increase in amount of nutrients processed. The Living Dock program started in 2013 at the Florida Institute of Technology, and has resulted in numerous community involved deployments around Brevard County, with over 150 mats placed in the IRL. Current studies are underway to quantify the impacts of Living Docks on the IRL ecosystem.

Creating Positive Environmental Attitudes and Connections with Nature through Youth Outdoor Exploration and Adult Environmental Education Training

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The focus of the Environmental Learning Center (ELC) is to educate diverse audiences about the health of the Indian River Lagoon and raise their awareness about the surrounding environment. The ELC's *Tiny Seedlings* grant-funded program serves 252 pre-kindergarten children (3-5 years old) enrolled in 15 low-income Indian River County HeadStart classrooms. These children are engaged in hands-on, "feet-wet" outdoor play activities on the ELC's lagoon island while parents and teachers receive tools and trainings on the importance of nature play and ways to adopt practices that promote outdoor exploration. Such direct outdoor experiences can create connections with local nature and motivate youth to gain conservationist attitudes and become environmental stewards. Overall, participation in this education program raises early-childhood environmental awareness, creates a foundation of appreciation for the Indiana River Lagoon ecosystem, and motivates teachers and parents to adopt environmental education approaches in their everyday lessons and interactions with youth.

Influence of Culverts on Mangrove Fouling Communities in the Coastal Oaks Preserve

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The Indian River Lagoon houses a variety of species that are vital to its ecosystem. Many of these species can be found in mangrove fouling communities that are affected by culverts – pipes that connect the lagoon with impounded wetlands. In the Coastal Oaks Preserve, new culverts are proposed to improve this connectivity by increasing the natural water flow. Baseline research is being conducted to analyze fouling communities before and after the installation of new culverts. Collection plates were installed near existing and proposed culverts, along with two control sites, to track the recruitment and growth of species in mangrove communities. Images of the plates were taken each week and analyzed using CPCe software to quantify the different species. Dominant growth consisted of algae, barnacles, snails, amphipods, and serpulid worms. The results of this experiment foreshadow changes in composition of mangrove communities after restoration.

Baseline Habitat Characterization within the Coastal Oaks Preserve

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In this investigation, vegetation was surveyed in the Coastal Oaks Preserve (COP), a property of the Indian River Land Trust (IRLT) in Vero Beach, Florida. The vegetative community composition and presence of exotic vegetation within the COP are of great interest to the IRLT in guiding management decisions. The density, frequency, abundance and basal area within hydric and maritime hammock habitats were determined by the point-centered quarter sampling method. Within the same habitat types, large variations exist spatially. This variability within the forest structure and associated understory will be used to help the IRLT determine the placement of long-term monitoring sites and prioritize exotic vegetation control.

Use of Surface Elevation Tables to Measure Sediment Elevation Changes Due to Living Shoreline Restoration

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Oyster reefs act as natural buffers, protecting shorelines through wave energy absorption, reduced erosion and sediment trapping. Restoration of oyster reefs aims to improve ecosystem function and, as part of living shoreline restoration, slow and/or reverse erosion. Surface elevation tables (SETs) are a fine scale method used to examine sediment elevation changes used extensively in intertidal wetlands. Small changes in sediment elevation can alter species occurrence and interactions, driving ecosystem function. However, few studies have examined the effects of intertidal oyster reefs on sediment elevation and the effectiveness of SETs in these high energy systems. Using SETs, we tested the effects of restored oyster reefs on adjacent sediment elevation. Initial results indicate that surface elevation was positively affected by the presence of restored oyster reefs. However, between sampling variability was greater than what is found in lower energy wetland systems indicating a need for more frequent sampling in these systems.

Tracking the Changes in Quality of Water as It Moves through the Coastal Oaks Preserve

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We are testing how the quality of water is affected as it moves through the impounded wetlands found within the Coastal Oaks Preserve, owned by the Indian River Land Trust. The data collected will be used as a baseline before additional culverts are installed as part of a restoration effort. We sampled seven sites and tested nutrients (nitrogen and phosphorus), pH, salinity, dissolved oxygen (DO), temperature, and *Enterococci* count. *Enterococci* can be used as an indicator for microorganisms which pose a risk to human health. We discovered that the impoundment sites tend to have lower DO, lower pH, lower salinity, lower nutrient concentration, and higher *Enterococci* count than the IRL related sites. We predict that the installation of culverts will improve the tidal exchange and water quality in the impoundments.

Extent of Shoreline Degradation in Urbanized Areas on the East Coast of Central Florida

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Estuarine shorelines form a critical habitat at the transition zone of marine and terrestrial ecosystems, supporting a diverse group of organisms. Shoreline communities provide ecosystem services including water filtration, carbon sequestration, reduced sediment erosion, and nutrient cycling. Shoreline degradation has contributed to increased flooding and erosion of adjacent terrestrial property, greater nutrient inputs, and the decline of native species. We worked with local governments to evaluate the current extent of shoreline degradation in the Indian River Lagoon. Here, we will present our preliminary analyses from 220 miles of shoreline, framework for a shoreline management plan, and progress on expanding assessments to fill regional data gaps. Our most significant finding in our initial survey was the absence of any shoreline without some type of alteration or impact, with 60% of the shoreline currently hard-armored. These findings emphasize the need for shoreline assessments to improve future management of this important habitat.

Coastal Restoration: A Florida Master Naturalist Special Topic Program

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The mission of the Florida Master Naturalist Program is to promote awareness, understanding, and respect of Florida's natural world among Florida's citizens and visitors. The Florida Master Naturalist Program is an adult education UF/IFAS Extension program developed by the University of Florida and provided by many Extension offices and participating organizations throughout the state of Florida. FMNP training benefit persons interested in learning more about Florida's environment or wishing to increase their knowledge for use in education programs as volunteers, employees, ecotourism guides, and others. The FMNP Coastal Restoration module provides instruction on Florida estuarine habitat restoration including oyster reefs, mangroves, saltmarsh grasses, and living shorelines. Presentations focus on biology and ecosystem services, site design and implementation, and monitoring to evaluate success.

Movement and Habitat Use of Spotted Eagle Rays, *Aetobatus narinari*, along Florida's East Coast: Implications for Bivalve Restoration and Fisheries in the Indian River Lagoon

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Despite a demonstrated capacity to interact with bivalve restoration and commercial shellfish operations worldwide, the movement ecology of molluscivorous rays remains unstudied in the Indian River Lagoon (IRL). The objective of our study is to examine habitat use and multi-scale movement patterns of the spotted eagle ray (*Aetobatus narinari*), a demonstrated predator of bivalve and gastropod mollusks, along the IRL. To achieve this, we attached acoustic transmitters to 22 individuals and tracked visitation patterns in the IRL with an array of passive acoustic receivers. These receivers cover a continuum of habitats, including two major leases of hard clam (*Mercenaria mercenaria*) near Sebastian Inlet. Preliminary data suggest rays exhibit high fidelity to the IRL, and that residency times in clam leases can last up to several hours. Further active tracking efforts will provide additional fine-scale habitat information for these predators, which can help guide the location of future bivalve restoration sites.

Left in Their Wake: Impacts of Boating and Bioeroders on Oyster Reef Restoration

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Boring sponges are subtidal bioeroders capable of degrading bivalve shells. Live sponges and sponge-degraded loose oyster clusters have been observed on natural and restored intertidal oyster reefs in Mosquito Lagoon, Florida. These sponges may drive erosion on seaward edges of reefs by weakening oyster cluster attachment points. Our previous work shows that boring sponge damage reduces oyster shell compressive strength significantly. This reduction may allow wind and boat wakes to further erode reefs and disperse subtidal sponge onto intertidal sections of reefs. We conducted transect surveys to determine how sponge abundance and impact vary with reef height on natural and restored oyster reefs. Overall, boring sponges, wave forces, and seasonal high water appear to drive the cycle of observed reef erosion and boring sponge persistence.

Impacts of Dredging, Hurricanes and Seasonality on Fluxes of Nitrogen and Phosphorus from IRL Sediments

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Restoration of the IRL depends on a reduction in fluxes of nitrogen (N) and phosphorus (P) from sediments to the overlying water. Quantifying improvements associated with restoration efforts such as dredging can be complicated by spatial and temporal variations in nutrient fluxes and the influence of hurricanes. Results from environmental dredging in Turkey Creek, a tributary to the IRL show a range of N fluxes of 0.1 to 8.6 mg $N/m^2/hr$ before dredging and 0.2 to 4.4 mg $N/m^2/hr$ after dredging. Improvements were identified for sites where muck was removed completely; however, fluxes of N increased at some sites due to muck redistribution during and following dredging with similar patterns identified for P. Spatial variations in the effectiveness of dredging necessitated high resolution data to accurately characterize improvements. Overall, we calculated a load reduction after dredging of ~50% or ~3 tons N/year from Turkey Creek sediments.

Using Saltmarsh Grasses and Groundcovers to Support Natural Mangrove Recruitment on Appropriate Shorelines

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Since 1995, the Indian River Lagoon (IRL) Shoreline Restoration Project (SRP) has been implementing living shoreline techniques and native plantings to naturally promote shoreline stabilization. Young red mangroves (*Rhizophora mangle*) have been planted in the past to stabilize shoreline sediments and promote presence of native vegetation. Such techniques are usually limited in their success, with planted red mangroves experiencing low survivability. The SRP is now planting saltmarsh grass and groundcover species at appropriate restoration sites to support local mangrove recruits. The extensive rhizome systems of these species may act as a capturing mechanism and support system for washed up propagules and planted individuals, increasing populations more than mangrove planting alone.

The Potential of Bivalves to Restore the Indian River Lagoon (FL) after *Aureoumbra lagunesis* Brown Tides

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Since 2012 the Indian River Lagoon (IRL) has developed dense brown tides caused by *Aureoumbra lagunensis* with negative ecological consequences. To investigate whether native bivalve species from the IRL would be good candidates for algal bloom mitigation we conducted field and laboratory experiments during a brown tide that lasted from December 2015 to April 2016. Field experiments with oysters (*Crassostrea virginica*) and clams (*Mercenaria mercenaria*) revealed that oysters only cleared 0.07±0.03 L h-1, whereas the clams did not seem to filter. To understand if native bivalves could bio-remediate pre-algal bloom conditions we exposed oysters, clams and the hooked mussel (*Ischadium recurvum*) to a series of brown tide dilutions. The three species reduced their clearance rates when algal concentration increased ($p<0.01$). Importantly, stable isotope analyses demonstrated that the threes bivalve species used the brown tide as a food source. Therefore, bivalves could be useful in the bioremediation of brown tides.

Assessing Genetic Diversity within Populations of Smooth Cordgrass to Ensure Effective Restoration Efforts

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The Indian River Lagoon (IRL) is one of the most biodiverse estuary systems in North America making it a conservation priority. Smooth cordgrass (*Spartina alterniflora*) is a keystone species that naturally occurs along the shorelines of the Mosquito Lagoon (ML). *Spartina alterniflora* is often used in shoreline restoration due to its extensive rooting capacity and ability to halt shoreline loss. Clonal species, such as *S. alterniflora*, are easy to raise with regard to the number of clones reared, but using clonal species for restoration may lead to genetically depauperate populations. To understand the genetic diversity of restored populations, we quantified the genetic diversity present within natural and restored *S. alterniflora* populations within the ML. Overall, restored populations of smooth cordgrass exhibit reduced genetic diversity compared to natural populations, indicating there is a need to investigate how the reduced levels of genetic diversity may impact long-term survival in the restored range.

Habitat Use by Bottlenose Dolphins in the Indian River Lagoon

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Habitat use by dolphins in the IRL will be examined from 2003-2016 based on movements of photo-identified individuals, prey availability and environmental conditions, focusing on the influence of spatial and temporal abiotic and biotic factors. Prey and environmental samples were collected by the FWC Fisheries-Independent Monitoring program. Kernel density estimation will be used to determine the magnitude-per-unit area of dolphins in the IRL; these densities will be used as response variables in a classification and regression tree analyses with fish community and environmental factors as predictors. Understanding how dolphins respond to environmental factors could be used to predict future responses and prioritize IRL conservation and restoration actions.

Investigating Causes of Changing Tidal Range and Timing in U.S. Harbors

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The Center for Operational Oceanographic Products and Services (CO-OPS) collects and disseminates water level, current, and meteorological data from over 200 real time stations along the U.S. coastline. In an effort to provide the coastal communities and mariners with the most impactful information and products, CO-OPS aims to better understand how changes to an estuary such as dredging, shoreline hardening, geomorphology, and long term sea level rise impact tidal harmonics. The data sets show a gradual change in the timing and amplitude of tide over decades. Hourly water level data at 100 tidal stations were analyzed using harmonic analysis to examine changes in tidal constituents over observed time. Regional patterns of constituent amplitude changes were identified using GIS. Dredging events were correlated with significant amplitude changes using historic coastal survey charts. Understanding how constituent amplitude changes correlate with anthropogenic alterations to an estuarine environment will support procedures in tidal prediction.

The IRL as a Vehicle to Integrate STEM and the Humanities in Secondary Education

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In 2017 The Pine School's (Hobe Sound) InvenTeam received a grant from the Lemelson-MIT Program to build "eyes and ears" for one of ORCA's Kilroy monitors. One STEM and one humanities teacher at The Pine School in Hobe Sound formed a student team to study the lagoon and design and build a solar-powered hydrophone and camera system, using wireless communication to transmit data to and from the site. The device is deployed off of a channel marker in the Manatee Pocket in Port Salerno, the same channel marker used by ORCA for one of their Kilroys. The students' experiences are creating powerful learning opportunities, which integrate rigorous research from the humanities and STEM fields.

Interannual Variability in the Indian River Lagoon, Florida, Measured by a Network of Environmental Sensors

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The Indian River Lagoon Observatory Network of Environmental Sensors (IRLON). IRLON has 10 sites in the Indian River Lagoon (IRL) and St. Lucie Estuary (SLE) that provide real-time, high-accuracy, and high-resolution water quality and weather data through an interactive website (http://fau.loboviz.com/). This presentation will contrast two years (2016-2017) of water quality conditions in the IRL and SLE. 2016 was a very “wet” year, including nine months of freshwater releases from Lake Okeechobee and the nearby passage of Hurricane Matthew, which caused much shorter-term impacts in water quality. 2017 was a “dry” year, with Florida experiencing a significant drought early in the year; major water quality parameters were substantially different than in 2016, until the nearby passage of Hurricane Irma. IRLON enables scientists, managers, educators, students, and the public to directly observe both long-term ecosystem changes and those driven by events, such as freshwater discharges, droughts, storms, and algal blooms.

The Junior Scientists Program: Research by the Next Generation to Preserve Our Natural Resources for All Generations

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Our two organizations have a unique partnership to fully engage high school students in the research and care of the environmentally sensitive 191-acre Coastal Oaks Preserve (COP) acquired by the Indian River Land Trust in 2011. Since 2013, a team of scientists and educators is sharing their expertise about problems facing our Lagoon and mentoring research conducted by students from Indian River County's three public high schools. Each year 3-4 team projects have provided scientific information needed for conservation management of the COP and the adjacent Lagoon. These projects have included studies of fish, seagrass, land crabs, mosquito larvae, other invertebrates, and vegetation and serve as important baselines for the management of the COP. We are developing a long-lasting network of young people with authentic scientific research experiences in lagoon environmental management that will result in the next generation having capabilities to make wise decisions for the Lagoon's resources.

Harmful Algal Blooms in the IRL: Plenty to Choose from

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So far there are at least 67 species of phytoplankton and microalgae that are found in the IRL system, which have been harmful to humans and/or marine life in other places. Only a very few have actually done so. With all the continuing stressors on the IRL, have we been just lucky, or are we just waiting for more?

Oyster Reef Restoration and Living Shoreline Stabilization: Impacts on Infaunal Communities in Shallow-Water Estuaries

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Infaunal organisms are critical to aquatic food webs and are good indicator taxa to document the transition from dead to live oyster reefs and eroded to stable shorelines after restoration has occurred. Research was conducted in Mosquito Lagoon, of the northern Indian River Lagoon system. Six replicate samples were collected from 12 intertidal oyster reefs (4 dead, 4 live, 4 restored), and 7 shoreline sites (3 control, 4 restored). Samples were collected 1-week pre-restoration and 1 week, 1 month, and then quarterly post-restoration. Infauna was sorted out from the sediment in the samples and identified down to the lowest possible taxonomic level. Species density, biomass, and species diversity data were collected. Results to date show the organism density and diversity on restored oyster reefs and shorelines are greatly fluctuating, as the infaunal communities adjust to the restoration efforts.

A Mechanical Method to Prevent Invasive Species Recruitment

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Biofouling on ship hulls is one of the primary vectors of non-indigenous species transport. In the Indian River Lagoon (IRL), there are a number of biofouling, or sessile benthic organisms, which are considered to be invasive. Grooming has been proposed as a mechanical approach, which employs the frequent and gentle wiping of the ship hull, to work in synergy with ship hull coatings to prevent the growth of these benthic organisms. A long-term grooming study was undertaken to assess the performance of several commercially available ship hull coatings. The ungroomed coatings had the presence of several IRL invaders: *Balanus amphitrite, Bugula neritina, Hydroides elegans, Watersipora subtorquata complex,* and *Zoobotryon verticillatum.* Grooming was able to decrease the overall density of the invasive species on the coatings, and prevent them from becoming established. By incorporating grooming into the maintenance regime, invasive species recruitment and transport is prevented.

How Does Restoration Influence Carbon Cycling in Oyster Reefs? An Evaluation of CO_2 Emissions and Microbial Activity in Restored Oyster Reefs of the Indian River Lagoon

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Oyster reefs provide a wide range of ecosystem services, including wave attenuation, shoreline protection, and water quality improvement. Despite their many benefits, over 20% of oyster reefs in Mosquito Lagoon, located in the northern region of the Indian River Lagoon, have been degraded, primarily due to boat wakes that redistribute oysters above the tidal zone. Ongoing reef restoration in the lagoon provides an important opportunity to analyze the impact of oysters on nutrient cycling, particularly its effect on C emissions and microbial activity. Sediment cores were collected in dead, live, and restored reefs and analyzed to elucidate changes in C cycling that occur in the first two years following restoration. Sampling utilized a BACI (Before-After-Control-Impact) design, which allows for the evaluation of restoration impacts while accounting for naturally occurring changes. Evaluating how reef restoration effects C release and storage can offer insight in to the biogeochemical benefits of restoration efforts.

MarineGEO: A Smithsonian-led Global Observatories Network Designed to Understand Change in Coastal Ecosystems

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The Marine Global Earth Observatory (MarineGEO) is a collaborative global network designed to understand the causes of change in biodiversity and ecosystem function in the coastal marine zone. MarineGEO is unique and complementary to other observatory networks due to integrating long-term monitoring with standardized experiments across regions. The strength of the program relies on collaboration with its partners, however, there exists a strong focus on research at the local level. The program utilizes a wide range of approaches with the end product to inform policy makers and managers with current information to assist in conservation and restoration efforts. The goals of this talk are to introduce MarineGEO to the IRL community and to demonstrate the program's local research goals with examples of local long-term monitoring as well as results from a standardized experiment done in multiple regions, including the IRL, examining the response of a community to a disturbance.

Hydrodynamic Modeling of the Indian River Lagoon

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A high-resolution hydrodynamic model based on the Delft3D modeling system has been developed for the Indian River Lagoon (IRL). The model has been calibrated with available hydrological data (temperature, salinity, sea level and tides). The results show a strong N-S gradient of water residence time, which is low in the southern IRL and northern Mosquito Lagoon, but high in the northern IRL, Banana River and southern Mosquito Lagoon. Surface winds particularly the N-S component are critical to the ventilation of northern IRL. Numerical experiments were also run to understand the impacts of climate change including sea level rise and surface warming under IPCC RCP8 scenario. The results suggest that sea level rise would significantly reduce the lagoon's residence time, whereas an increase of air temperature would likely increase the probability of hypersalinity in the northern IRL.

The Effects of Nutrient Treatments on *Rhizophora mangle* Growth and Survival

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Rhizophora mangle, an ecosystem engineer, is utilized in shoreline restoration projects. Harbor Branch provided us with seedlings, grown in an integrated multi-trophic aquaculture system, to investigate nutrient effects on survival and growth of *R. mangle*. Initial transplant occurred in May 2017 at Marine Discovery Center (New Smyrna) and monitored until November 2017. Seventy *R. mangle* seedlings were planted within the marsh's intertidal zone. Survival was indicated by green meristem and leaf presence. We observed 71% survival of high nutrient as opposed to 20% low nutrient. High nutrient had average change of 2.5 cm in height and average change of 0.2 leaves. Low nutrient displayed an average change of 2.3 cm in height and average change of 0.5 leaves. Hurricane Irma's devastation in September 2017 could explain the decrease in survival and leaf counts in subsequent surveys. Overall, results revealed that *R. mangle* exposed to high nutrient treatment was successful.

The Search for Florida East Coast Diamondback Terrapins (*Malaclemys terrapin tequesta*) in the Southern Indian River Lagoon

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The Florida East Coast Diamondback Terrapin is a terrapin subspecies found from St. Johns County to Biscayne Bay. Almost no work has been done on the biology of this subspecies since the 1980s and a recent project headed by the Brevard Zoo has begun studying populations in the northern IRL. However, very little is known about terrapins in the southern IRL, with only a very few sightings known. There is concern about the conservation status of this turtle, because there was a substantial fishery for it along the Atlantic coast of Florida and this species is still allowable for take according to state rules. We are conducting searches for this subspecies and participating in a larger population genetics study of this species. Our goal is to create baseline information on the current status of this species in our area and provide more ecological information.

Light in St. Lucie Estuary before and after Irma: A Snapshot

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Presented data are from field measurements of water column light characteristics collected at 13 sites along the St. Lucie Estuary at incoming and outgoing tides May 15 and 22 and October 20 and 29, 2017. Data include light attenuation coefficients calculated from subsurface PAR profiles, chromophoric dissolved organic matter, turbidity, and chlorophyll *a*. May 2017 data exhibit a strong empirical relationship between salinity and CDOM, and stable trends in light attenuation characteristics; spatially with distance from the inlet and temporally between incoming versus outgoing tides. Post-Irma October 2017 data provide evidence that post-storm patterns in the estuary maintain unusual patterns in light environment and salinity characteristics, both spatially and temporally and that benthic light availability remained below seagrass minimum light requirements at these sites for at least seven weeks after the September 10 hurricane.

Relationships between Dissolved Nutrients, Environmental Variables, and Acidification in the Indian River Lagoon

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In the eutrophic waters of the Indian River Lagoon (IRL), reported decreases in overall shellfish size may be related to coastal acidification. To better understand the relationship between acidification and eutrophication, water samples from 20 sites spanning the IRL were collected and analyzed for dissolved nutrients and acidity (omega values) in spring (dry season) and fall (wet season), 2016. Additionally, three sites were sampled weekly to observe temporal variability of nutrients and acidity. For the IRL-wide dry season, sites with a higher nitrogen concentration were more acidic (some with omega values <2) with a slight negative relationship ($p=0.09$; $r^2=0.12$). The time series data showed temporal variability in salinity and acidity with an overall positive linear relationship ($p=<0.0001$; $r^2=0.52$). This preliminary work suggests that salinity and dissolved nutrients have implications for acidification in the IRL and underscore the importance of water quality restoration to shellfish production.

Utilizing a Molecular Protocol for the Identification of Hybrid Western Atlantic Seahorses, *Hippocampus erectus* × *H. reidi*

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The purpose of this study is to identify possible hybrid offsprings between two species of seahorses. The lined seahorse, *Hippocampus erectus*, and the longsnout seahorse, *Hippocampus reidi*, are two well-known and distinct species that are found in the Indian River Lagoon and frequently displayed in zoos and aquariums. Although these two species are different and distinguishable, they are able to produce viable hybrid offspring. Due to the wide range of the physical characteristics of seahorses, it is impossible to confidently identify hybrid organisms solely through the use of morphometrics. Therefore, a molecular protocol, involving polymerase chain reaction restriction fragment length polymorphism (PCR-RFLP), is used to identify both the parent species and the hybrids. The data collected from this study will confirm the presence of hybrids, identify their locational origin, and potentially help to understand the possible risks and benefits of this recently identified hybridization.

Flow-Biota Interaction in Restored Shorelines and Oyster Reefs: An Ecohydraulic Analysis of Restoration in Mosquito Lagoon

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This study assesses the impact of living shoreline and oyster reef restoration to near-shore hydrodynamics, sediment transport, and retention of organic matter. Acoustic Doppler and sonic sensors were used to observe high-resolution hydrodynamics of currents (100 Hz) and waves (32 Hz) in restored, reference, and degraded sites. Incoming velocity and wave profiles were compared to simultaneous observations onshore or on-reef. Hydrodynamic gradients from off to onshore reflect attenuation by vegetation and oyster; onshore velocities in restored and reference sites were orders of magnitude lower than offshore. Onshore velocities at degraded sites were similar in magnitude to offshore, with high variability. Near-bed shear stress gradients were likewise flat in degraded sites and increased as water flowed through vegetation and oysters in restored and reference sites. Variable shear stress patterns observed at restored and reference sites likely attribute to differences in dominant biota-water interactions, mediated by roughness, stem densities and plant morphologies.

A Conceptual Ecological Model for the Northern Estuaries and Southern Coastal Systems Regions of the Comprehensive Everglades Restoration Plan (CERP) REstoration, COordination, VERification (RECOVER) Program

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The Comprehensive Everglades Restoration Plan (CERP) REstoration, COordination, VERification (RECOVER) Program is responsible for the coordination and application of science to support CERP project implementation. RECOVER finalized its 2017-2021 Five-Year Plan (FYP) and identified several major tasks to review the science program. One task in the FYP is to update regional conceptual ecological models (CEMs) first published by RECOVER scientists in a special edition of the journal *Wetlands* in 2005. CEMs as applied to CERP are non-quantitative planning tools to identify ecological and anthropogenic drivers and stressors on systems, the ecological effects of stressors, and the biological attributes or indicators affected. The RECOVER Northern Estuaries (which includes southern Indian River Lagoon) and Southern Coastal Systems regions combined efforts to create a single Everglades Coastal Systems (ECS) CEM. Next steps include finalizing the CEM, developing hypotheses of cause-effect relationships affecting RECOVER ecological indicators, and a vulnerability analysis of RECOVER system attributes.

Assessment of Oyster (*Crassostrea virginica*) Health in Natural vs. Restored Reefs in the Northern, Central and Southern Indian River Lagoon, Florida

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Oyster restoration efforts are an important component to maintaining the health of the Indian River Lagoon (IRL). Monitoring efforts are typically structural in nature although the ability to contribute to functional habitat is ultimately dependent upon organismal health. The aim of this study was to investigate the health of natural and restored oyster reefs in the IRL from the Mosquito Lagoon to the Jupiter Inlet over a one year period. Parameters assessed included size, physiological condition, prevalence of pests and parasites. Geographical region and seasonality had a greater impact on health than did reef type. In general, central reefs were less healthy, and natural reefs fared better than restored reefs; however reef age was a determining factor. This study complements previous studies that examined IRL oyster health and it is recommended that periodic health monitoring would supplement standard structural monitoring efforts that help inform decisions regarding future restoration efforts.

Impacts of Coastal Restoration on Population and Community Dynamics of Sportfish in the Indian River Lagoon

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Coastal ecosystem restoration increases the quality and quantity of habitats affected by anthropogenic disturbances, thereby improving ecosystem structure and function. The Indian River Lagoon (IRL) is a biologically diverse estuary in North America, benefiting the region's economy through myriad ecosystem services, including recreational fishing. However the IRL has experienced significant declines in oyster reefs and seagrasses, potentially impacting recreational and commercial fishing opportunities. As such, oyster reef and living shoreline restoration is occurring to improve benthic habitat, thereby benefiting fish communities. To explore how sportfish population and community dynamics respond to restoration, we quantified sportfish diversity, relative abundance, and body size prior to and following habitat restoration in a Before-After-Control-Impact experiment, across several spatial and temporal scales. Sportfish gut contents were also analyzed to assess restoration impacts on trophic interactions. Thus, this study can generate knowledge to develop restoration-based solutions to inform management and conservation of sportfish in the IRL.

Early Impacts of Restoration on Nutrient Cycling of Oyster Reefs in Mosquito Lagoon

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The effect of oyster reef restoration on nutrient cycling was analyzed within the first year of oyster recruitment. Using a before-after-control-impact (BACI) design, four sediment cores and one surface water sample were taken on each dead, restored, and natural/reference reefs. Samples were analyzed to observe changes in physiochemical properties (bioavailable nutrients NO_3^-, NH_4^+, PO_4^{3-}, and DOC; TC, TN, TP, organic matter; bulk density; and sediment pH) before restoration, and one week-, one month-, and six months-post restoration. Continuous monitoring over the next several months will improve the

understanding of nutrient storage and cycling on oyster reefs and the time after restoration required to restore biogeochemical function.

Bivalves at Work: How Effective Are Oysters at Cleaning the St. Lucie River?

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Oyster restoration projects are common throughout the Indian River Lagoon, but the effects of oysters on water quality are rarely assessed after reefs have been placed. We measured the feeding behavior of oysters (*Crassostrea virginica*) and hooked mussels (*Ischadium recurvum*, a common oyster reef associated bivalve) at two sites in the St Lucie River and one site in the southern Indian River Lagoon. Oysters and mussels did not differ in their clearance or absorption rates, though mussels had higher filtration rates. However, both species fell well below the touted 50 gallons/day clearing a maximum of 15 gallons/day.

Source Tracking Agricultural and Urban Nutrient Inputs into the North Fork of the St. Lucie River

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The North Fork of the St. Lucie River (North Fork) has a Basin Management Action Plan to reduce nitrogen and phosphorous pollution caused by urbanization utilizing septic systems, and agriculturally influenced freshwater input from the C-24 and C-23 canals, and Five and Ten Mile Creeks. Monitoring sites (13 surface water and 5 groundwater) were selected along the North Fork system as land use transitioned from agricultural to high-density septic residential. Water samples were analyzed to determine concentrations of ammonium, nitrate + nitrite, and soluble reactive phosphorous. Particulate organic matter, a proxy for phytoplankton, and water lettuce *Pistia stratiotes*, a common macrophyte, were collected at the surface water sites to identify the stable carbon and nitrogen isotope signatures. These data will allow for source tracking of nitrogen inputs. Results of this study will help local resource managers improve water quality in the North Fork and downstream in the Indian River Lagoon.

Juvenile *Tursiops truncatus* Case Study: Monofilament Entanglement Damage and Recovery

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Florida Atlantic University Harbor Branch staff received a report of a juvenile bottlenose dolphin (*Tursiops truncatus*) in the Indian River Lagoon, FL, entangled with monofilament fishing line wrapped around the maxilla. National Marine Fisheries Service and several veterinarians deemed this entanglement life threatening and a multi-agency disentanglement effort was successful. Over two years later, this dolphin's freshly dead carcass was recovered. The carcass was taken for immediate radiographic imaging. Photos and measurements of the scarring left from the entanglement were taken prior to necropsy. Bilateral maxillary dental arcade deformation was noted. The cleaned skull revealed a 4.0-4.2 cm long by 0.5 cm deep groove from the entanglement damaging the lateral edges of the maxilla. This case provides learning opportunities for the effects of monofilament line in future live animal entanglement cases.

Cradle to Grave Records of IRL Dolphins

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Assessment of mortality is needed to complete life history records and understand population trajectory for management strategies. Dorsal fin photographs from IRL photo-identification and stranding datasets (2002-2016) were compared to determine 1) whether carcasses were resident dolphins, 2) survey efficiency in detecting live dolphins, 3) whether dolphins die within their home ranges, and 4) estimate a calf recovery factor. Between Sebastian and Jupiter Inlets, 55 dolphins were recovered: 41(74%) were residents, 13(24%) were decomposed/unmarked and 1(2%) unknown. This suggests carcasses belong to the IRL-estuarine stock and survey coverage was adequate to identify most dolphins. Among residents, 95% (38/40) were identified within their home ranges, suggesting site fidelity throughout lifespan. Only 8/57 (14%) of calves $\leq$1 year that disappeared were recovered, suggesting high newborn mortality and shark predation/scavenging.

Can Elevated Salinity Trigger the Viable But Nonculturable State in the Marine Pathogen *Vibrio vulnificus*?

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Bacteria from the genus *Vibrio* are responsible for 80,000 illnesses in the United States every year, the majority of which occur in Florida. One species, *V. vulnificus*, can cause potentially fatal wound infections in a select group of the population. This pathogen shows a strong negative correlation with salinity, rarely being found in areas approaching 35 ppt. I will be conducting a laboratory experiment designed to see the effect of elevated salinity on these bacteria. Rather than dying, it is possible that these cells will undergo a stress response known as Viable But Non-Culturable (VBNC) allowing them to survive in a dormant state. This research is highly significant to the Indian River Lagoon, where these bacteria thrive. With salinity fluctuations occurring due to tides, rainfall and freshwater releases, these pathogens can be brought in and out of their optimal salinity range, potentially triggering the Viable But Nonculturable State.

Habitat Suitability for Snook in Indian River Lagoon using GIS and Acoustic Telemetry

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Understanding the relationship between snook habitat utilization and water quality is critically important information for wildlife managers. The study's objective was to utilize quantitative and spatial analysis techniques to map habitat suitability throughout Indian River Lagoon. Passive acoustic telemetry was used to study movements of 115 tagged common snook *(Centropomus undecimalis)* from January 2008 to December 2014. To identify which water quality factors correlates highest with snook detections we used BEST (Biota-Environment and Stepwise) methodology. Afterwards, we used GIS-based spatial analysis to map the relationships between significant water quality and snook detections. The spatial analysis tools we used were Cluster, Inverse Weighted Distance (IDW), and Ordinary Least Squares (OLS). The OLS gave us the optimal value where snook detections were significantly higher than chance alone. Finally, we reclassified these areas based on suitability. The areas in red are most suitable, and the areas in blue are least suitable.

Nutrient Content and Restoration Ability of Wrack on Living Shorelines in the Indian River Lagoon

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Wrack is decomposing marine vegetation that washes up along the shores of coastal systems. While wrack is omnipresent in estuarine ecosystems, the effects of wrack on shoreline vegetation health and nutrient status is unknown. This research project took place in the Indian River Lagoon (Atlantic coast, Florida) at three living shoreline restoration sites in Canaveral National Seashore. This project will help determine the restoration ability of wrack and its effects as a nutrient source to the shoreline. I have collected samples of fresh and old wrack along the shoreline of the Indian River Lagoon, separated the wrack by species, dried it, ground it, and conducted total carbon and total nitrogen (TC, TN) procedures which measure the carbon and nitrogen content in each sample. Along with this procedure, the samples were ashed to measure total phosphorus (TP). Afterwards, I completed a photodegradation study to understand nutrient loss via leaching from wrack into the water.

What Was Up Is down and What Was Down Is Up … How Do We Regain the Balance?

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We've always considered seagrass as the indicator of the health of the Indian River Lagoon, but now the system is out of balance. With seagrass loss beyond historical levels, the slower growing, stable seagrasses have been replaced by the faster growing phytoplankton and drift macroalgae. These latter primary producers may compete with seagrasses for light and nutrients, making natural recovery more difficult. Decades old diagrams showing regime shifts from seagrass to macroalgae and phytoplankton predicted our new reality. To reverse this situation, nutrient loads may have to be reduced lower than pre-bloom conditions and hands-on seagrass restoration may be required. Fortunately, data indicate that seagrasses can recover when supportive conditions persist long enough. Hopefully, this response combined with the counties' herculean efforts and sustained commitments to decreasing nutrient loads will restore the former balance among primary producers.

Integrating Flow-Cytometric and Molecular Tools to Characterize Bloom Dynamics of Nano- and Picoplanktonic Algae in the Indian River Lagoon

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A brown tide event in the Indian River Lagoon (IRL) caused by *Aureoumbra lagunensis* began in January 2016. The bloom endured for ~10 months, peaked at 10^6 cells mL^{-1}, and resulted in extensive fish kills. Taxon-specific identification tools – flow cytometric and molecular approaches – were integrated with light microscopy to enhance routine monitoring and better resolve pico-, nano-, and microplankton dynamics in weekly/biweekly samples collected between 2015 and 2017. Transitions in bloom taxa and their abundance were captured before, during, and after the 2016 bloom event and interestingly, *A.*

lagunensis and picocyanobacteria occurred at nearly all time points sampled. In contrast, the dinoflagellate *Pyrodinium bahamense* and the diatom *Pseudo-nitzschia* spp. generally occurred seasonally and displayed distinct spatiotemporal distribution patterns relative to each other and smaller phytoplankton size classes. These efforts highlight the utility of integrating sensitive assays within phytoplankton monitoring to better understand potential drivers of IRL blooms.

Assessing Treatment Wetland Efficacy in Stormwater Treatment Utilizing Native Wetland Plants

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A treatment wetland is being constructed in an existing diversion pond with of an outfall canal that drains the urban Daytona Beach and South Daytona areas into the Halifax River. The goal of this restoration project funded by IRL-NEP is to improve existing stormwater discharge management programs within the Reed canal, which receives untreated urban runoff totaling 1,252 acres from the drainage area. This project will create stormwater treatment wetland using native plants with an added dry pond diversion system. Expected outcomes will be a 20% reduction in total nutrients, a 30% reduction in total sediment in the stormwater discharge evidenced by monitoring water quality. Public education programs will be conducted to gauge awareness knowledge of stormwater pollution, fertilizer ordinance, and how they impact the estuarine systems.

Quantifying Movement Patterns and Nursery Habitat Use of Endangered Scalloped Hammerhead Sharks along the Canaveral Bight

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Neonate scalloped hammerheads (*S. lewini* and the newly discovered S. *gilberti*) appear annually near Port Canaveral starting in April, but by August these juvenile sharks are gone (E. Reyier, pers. comm.). It is hypothesized that this coastal zone acts as critical nursery habitat for these endangered species, yet we lack fundamental understanding of how juvenile scalloped hammerhead sharks use this area as they grow; if, when, and why they disperse from this region; and how these populations and essential habitat can be managed and conserved. To address these knowledge gaps, we propose to use active acoustic telemetry to quantify daily movement patterns and nursery habitat use of these two closely related species around Port Canaveral. This project will generate knowledge regarding the nursery value of this region, inform the development of effective conservation and management strategies for these species, and create a blueprint to move scalloped hammerhead sharks toward sustainability.

Impact of Wrack Accumulation on Living Shoreline Stabilization

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Mangroves and marshgrass are key parts of estuarine ecosystems, preventing erosion of shorelines. Wrack, organic material that accumulates along shorelines, is not well studied along estuarine shorelines. The aims of this study were to document wrack accumulation and see how wrack abundance affects plant survival after living shoreline restoration. The study was conducted in Mosquito Lagoon at four restored and three control sites. Wrack thickness was examined 1 week, 1 month, 3 months, and 6 months post-restoration. A $0.25m^2$ quadrat was used to measure wrack thickness at 1m intervals along 4 transects (5 random locations/quadrat). To evaluate the effect of wrack on plant survival, wrack thickness was also

measured around 5 *L. racemosa*, 5 *R. mangle*, and 5 *Spartina alterniflora* plants at five random points in each quadrat. Survival of these plants was noted. This study will provide insight into the role of wrack and effects on restoration success.

Effectiveness of Public Education at Controlling Nonpoint Source Pollution along the Mosquito Lagoon

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Surface runoff from waterfront homes and ponds within the watershed of the northern part of the Mosquito Lagoon adds direct sources of nutrients and pollutants into the estuarine system. The research goal is to assess and enhance the waterfront communities' perception on their roles in contributing to and controlling nonpoint source pollution in the Mosquito Lagoon ecosystem. Public education through workshops, exhibits, and long-term engagement with homeowners involved in the project focused on benefits of living shorelines using native plants and reducing amounts of fertilizer and water. Pre and post surveys were conducted to assess effectiveness of the public education on their awareness of factors affecting the health of the lagoon, and their willingness to change the behavior in their yard.

Internal Nutrient Cycling in the Indian River Lagoon: Is Nitrogen Fixation an Overlooked Source for Blooms?

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Ecosystem-disruptive harmful algal blooms (HABs) are becoming increasingly more common in many estuaries, including the northern Indian River Lagoon (IRL). Long-term water quality monitoring data shows a disproportionate increase in total and dissolved P in the water-column in the IRL since 2010. We hypothesized that increased available P levels, and in turn lower N:P ratios, favored picocyanobacteria and resulted in significant water column N_2 fixation rates, in advance of "brown tide" events. Additionally, uptake experiments suggest that internal recycling of ammonium and dissolved organic forms of N may select for certain species of nano- and pico-planktonic algae that have recently dominated IRL blooms. This shift in nutrient pools from benthic communities to the water-column likely enhances the turnover of available nutrients via the microbial loop, and could lead to a "new" ecosystem state favoring widespread and sustained blooms of nano- and picoplanktonic algae.

Nekton Response to Habitat Restoration: A Case Study from Lake Worth Lagoon, Florida

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We present results of over two years of quarterly monitoring (August 2014 – November 2016) to document fish community changes in Lake Worth, Florida following muck capping and sub- and inter-tidal habitat creation. At each of three sites (new restoration, mature restoration, and unimproved control) seven seine nets were pulled (4 21.3-m and 3 40-m seines), per sampling event. While economically important taxa utilized all areas similarly, forage taxa (anchovies, shrimps, clupeids) differed markedly among the three sites. Community differences were primarily attributable to higher abundance of *Anchoa mitchilli*, *Diapterus auratus*, *Farfantepenaeus* spp., and *Callinectes sapidus* at the restoration sites, higher abundance of *Eucinostomus gula* and *E. harengulus* at the mature site, and higher abundance of juvenile *Eucinostomus* spp. and *Harengula jaguana* characterized the unimproved control site. These data provide

an inventory of habitat use by estuarine-dependent taxa essential for measuring success of the restoration and guiding future projects.

Studying Seahorses through Collaboration, Education, and Citizen Science

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Seahorses are one of the most popular aquatic animals in aquarium collections, yet little is known about their wild population status in the Indian River Lagoon. While conducting informal seahorse biology presentations to local educators and club organizations, stories of seahorse sightings from attendees were often shared. These serendipitous findings sparked the idea of having seahorses serve as advocates for the Indian River Lagoon. In 2013, under the guidance of the late Dr. Junda Lin, a project titled, "Studying seahorses through citizen sightings" was established. By collaborating with over 100 citizens, local schools, and three dozen public aquariums, over 450 wild seahorse sightings were sighted along the United States Atlantic and Gulf coasts. The findings of this study such as global positioning system locations, genetic data, and photos will be placed on iNaturalist to be used freely by any interested party.

Hydrodynamic Limitations to Mangrove Recruitment and the Implications for Living Shoreline Restoration

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Hydrodynamic forces, such as boat and wind waves, can erode mangrove seedlings, affecting the success of mangrove species and restoration programs. Previous research has not provided quantitative thresholds to establishment in relation to these potentially limiting forces. We addressed this by quantifying the rooting strength in the early-life stages of the red mangrove *Rhizophora mangle* and the black mangrove *Avicennia germinans*. In-field and in-greenhouse lateral pull-tests allowed us to simulate hydrodynamic forces exerted on these species, observing how rooting strength changed through time and across different conditions. Significant increases (GLM: $p<0.05$) in rooting strength occurred with increased belowground biomass at early-life stages, as well as differences ($p=0.08$) between species. These measurements allow for the direct comparison of forces that seedlings experience in nature, improving our understanding of seedling susceptibility to uprooting and informing restoration methods.

"Livin for the Lagoon", an Outreach Program to Promote Homeowners to Adopt Lagoon Friendly Landscaping Practices

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The ultimate aim of environmental education and outreach goes beyond raising public knowledge and awareness to equip them with skills that help them to make informed decisions and take responsible action. "Livin for the Lagoon', an outreach program at Environmental Learning Center (ELC), targeted local communities throughout Indian River County that are governed by Homeowner Associations (HOAs). The aim of this program is to empower communities to adopt practices that lead to decreases in nutrient and sediment pollution entering the Indian River Lagoon to improve seagrass bed health. During this 23 week-long program, ELC staff and a professional horticulturist trained liaisons and homeowners to monitor the water quality and adopt lagoon friendly landscaping practices. The result of the program showed that some participants were actively engaged in conducting weekly water quality testing in their community storm water ponds to track changes in nutrient concentrations from January to June of 2017.

The Impacts of Major Weather Events on Oyster Populations in the St. Lucie Estuary

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Oysters in many south Florida estuaries frequently encounter dynamic changes in water quality associated with natural weather events and the resultant rainfall, runoff and managed water releases. The severity of impacts to oysters from these events can vary depending on prior estuarine conditions and overall health of the oysters. For example, in the summer months oysters are regularly exposed to warm temperatures and high salinities near their upper physiological tolerance limits. If a major storm event occurs, estuarine salinity or other water quality characteristics can rapidly change causing additional stress to the oysters. In several instances over the past 12 years, this has led to a partial or complete die-off of oysters in the St. Lucie Estuary (SLE). Hurricane Irma is the most recent major weather event to negatively impact oysters in the SLE.

Inspiring at-Risk Middle-School Girls to Achieve STEAM Careers through a Summer Mentorship Program

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Inspiring the next generation of leaders in STEAM (Science, Technology, Engineering, Arts & Math) fields is a key factor to the restoration of the Indian River Lagoon. The Environmental Learning Center (ELC) in Vero Beach is pioneering to collaborate with local organizations to provide an opportunity for low-income middle school girls to build their skills in STEAM fields through a repeat visitation summer mentorship program. During a 10-day workshop, middle school girls were engaged in variety of STEAM oriented activities through hands-on, integrative, engaging workshops led by local experts. Two of the measurable outcomes were the level of confidence in their ability to achieve in STEAM careers and improvement in their skill set in STEAM subject areas. By the end of the summer, 90% of the girls indicated that they could achieve in a STEAM field, a 15% increase from the beginning of the summer.

Plastics under a Microscope: Accumulation of Microplastics in Oyster Spat in Mosquito Lagoon

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Microplastics are less than 5 mm pieces of plastic that originate from either synthetically manufactured microbeads or larger pieces of plastic broken down into smaller pieces. The eastern oyster *Crassostrea virginica* is a filter-feeder that consumes microplastics which may affect reproduction, slow growth rates, and produce thinner shells. To determine if juvenile *C. virginica* were ingesting microplastics in Mosquito Lagoon, we collected spat at 1, 2, and 6 months from 4 different restored reefs. Individuals were measured and weighed then placed into hydrogen peroxide to breakdown organic tissue using NOAA protocols. 1-month old spat had an average of 7.3 microplastics (fibers + fragments) per oyster and 2-month spat had an average of 13.3 per oyster. We need to better understand the abundance, distribution and impact of microplastics in all species, but especially in organisms that are vital for water filtration and consumption by many species.

Relationships between Water Quality and the Microbiome of Elasmobranchs in the Southern Indian River Lagoon

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The microbial communities associated with elasmobranchs (i.e., sharks and rays) are likely necessary for organismal function but may also include opportunistic pathogens. Despite the myriad anthropogenic impacts on Florida's Indian River Lagoon (IRL), there has been no characterization of elasmobranch microbiomes. The aim of this study is to determine the culturable biome of IRL elasmobranchs and evaluate correlations between water quality and microbial assemblages. Oral and urogenital swabs have been collected across 8 species of elasmobranchs yielding an array of microbial species. The most prevalent bacteria cultured included potential human pathogens; *Pseudomonas fluorescens*, *Plesiomonas shigelloides*, and *Aeromonas hydrophila*. Preliminary analysis found significant differences in the culturable biome associated with multiple water quality measures including temperature, salinity and dissolved oxygen. Continued sampling will provide a more comprehensive understanding of microbial diversity and may provide insight as to antibiotic resistance in microbial species.

Characterization of Elasmobranch Distribution and Habitat Use in the Southern Indian River Lagoon

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Elasmobranchs (i.e., sharks and rays) are ecologically important predators that occupy high trophic positions in estuaries worldwide. However, there is a substantial data gap surrounding the status of elasmobranchs inhabiting the southern Indian River Lagoon (IRL), an "estuary of national significance" that has experienced recent anthropogenic impacts affecting water quality and ecosystem health. Thus, we have implemented a long-term fishery-independent survey (bottom longline, gill net) to characterize the abundance and distribution of elasmobranch communities from Sebastian to St. Lucie Inlet. Since July 2016, over 300 individuals of 14 species have been sampled and tagged, including two critically endangered smalltooth sawfish, a species once thought to have been extirpated from the lagoon. As the survey continues, assessment of abiotic parameters (e.g. temperature, salinity) may help predict the assemblage dynamics of elasmobranchs and estimate how major anthropogenic events (freshwater releases, harmful algal blooms, etc.) influence elasmobranch distribution in the southern IRL.

The Pine School Lemelson-MIT InvenTeam: Giving "Eyes and Ears" to ORCA's Kilroy"

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The Pine School's InvenTeam received a grant from the Lemelson-MIT Program and designed and built a mechanical/ electronic device consisting of two key components: A hydrophone with full audio range detection and transmission via cell technology and a simple, off-the- shelf camera, both enclosed in a sealed and salt-water resistant housing. It is installed at nearby locations of water- quality monitors, or a system called "Kilroy", currently deployed by ORCA, along the length the Indian River Lagoon. Due to the required bandwidth, video transmission has posed particular challenges. However we have solved those issues by installing a land-based server at a volunteer's house, who lives within easy reach (2,000 ft) for an affordable transmitter/receiver system. The team designed the system to be remote controlled and able to operate off of a power source that is battery-based, with solar cells for ongoing recharging.

Assessing the Effects of Oyster Reef Restoration on Macroinvertebrate Assemblages in Mosquito Lagoon, FL

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Mosquito Lagoon (ML), the northernmost basin of the Indian River Lagoon (IRL), is home to hundreds of oyster reefs, which provide essential habitat for fishes and invertebrates. Oyster reef restoration is believed to benefit coastal ecosystems by increasing habitat availability. However, previous studies on the effects of restoration on benthic species assemblages in coastal estuaries have been equivocal. To address this issue experimentally, four dead oyster reefs in ML were restored in Summer 2017. To quantify species assemblage dynamics (i.e. changes in species diversity, composition, and relative abundance) in response to restoration, restored reefs and control sites were sampled before and after restoration. All motile macroinvertebrates were identified and statistical analyses performed to assess spatial and temporal differences in benthic communities following restoration to more robustly quantify the effect of oyster reef restoration on macroinvertebrate diversity in the Mosquito Lagoon.

A Post-Restoration Analysis: How Does Intertidal Oyster Reef Restoration Effect Avian Community Structure and Behavior in Mosquito Lagoon?

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Oyster reef restoration began in Mosquito Lagoon in 2007. It was our goal to understand how this restoration effort impacted estuarine bird community structure and behavior. Beginning in September 2016, bird surveys were conducted monthly during morning low tides on 24 reefs of the following types: 1) restored reefs, 2) natural reefs, and 3) damaged reefs. Restored reefs contained four restoration year classes: 2009, 2012, 2015, and 2016. Four replicate reefs were monitored for each reef type monthly, including each restoration year class. Bird surveys on each reef lasted 20 minutes and involved alternating scan samples and focal observations, during which abundance, diversity, and behavior of each bird was recorded. Results indicate similar bird abundances and diversity across all reef types; however, foraging behavior was more prevalent on natural and restored reefs. This study is important in that it connects oyster reef restoration with improved estuarine bird success in Mosquito Lagoon.

Growth-Irradiance Relationships of *Pyrodinium bahamense*

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Pyrodinium bahamense is a harmful alga that blooms annually in the Indian River Lagoon. This dinoflagellate produces neurotoxins called saxitoxins that can cause paralytic shellfish poisoning and saxitoxin puffer fish poisoning in humans if consumed. Despite recurring summer blooms, the factors favoring *P. bahamense* dominance in the IRL are not yet well known especially since cultivated *P. bahamense* grows relatively slowly. Based on work with Pacific strains, it is suggested that *P. bahamense* may be adapted for growth at low light levels but there is little information on the light requirements for Florida strains. We performed experiments with an Indian River Lagoon isolate to determine growth responses at nine ecologically relevant irradiance levels ranging from 7-1400 µmol photons m^{-2} s^{-1}. The observed varied growth responses illustrate the significance of certain compensatory mechanisms that help this bloom-forming alga compete with other phytoplankton in the Indian River Lagoon.

How Destructive is Lake Okeechobee Outflow? A Comparison of Watershed Runoff and Lake Okeechobee Releases on Macrobenthic Communities

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Benthic infauna are important indicators of water quality and are used in a variety of monitoring programs to assess overall estuarine health and to follow long-term trends in estuarine communities related to anthropogenic impacts. Fauna and environmental variables have been quantitatively monitored quarterly since February 2005 from 9 sites in the SLE and the IRL. Considerable negative conditions exist in the South Fork and SLE, which receive frequent freshwater discharges from Lake Okeechobee and runoff from the St. Lucie River Watershed. Lake Okeechobee often bears the brunt of local ire for the state of the St Lucie River, however local basin discharge is more likely the culprit. Community responses to Lake Okeechobee releases and watershed runoff are compared using the flow rates from S80 in the South Fork of the St. Lucie River (total inflow) and S308 near Lake Okeechobee (lake inflow).

A Tale of Two Summers: Using IRLON Data to Compare the Effects of the Lake Okeechobee Discharges of 2016 and 2017 on the St. Lucie Estuary

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The watershed of the St. Lucie Estuary (SLE) is comprised of natural rivers and an extensive network of artificial canals that drain much of St. Lucie and Martin counties. One of the most important of these canals is the C-44, which connects Lake Okeechobee to the SLE. Major discharges through this canal at the start of the 2016 summer wet season were followed by a severe algae bloom in the SLE, though similar discharges following Hurricane Irma in 2017 did not. However, algae blooms are not the only hazard associated with persistent freshwater discharges into the SLE. Observation networks and complimentary sampling are providing invaluable information regarding the past and current health of the estuary. This data can then be used to help predict how water management decisions will impact the ecosystem and verify expected outcomes in order to help mitigate ecological and economic harm.

Seagrass Restoration Influenced by Small-Scale Distances to Nearby Restored Oyster Reefs

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Seagrass declines in the Indian River Lagoon are ongoing due to decreased water quality and light availability. Restoration of these seagrass habitats has been met with variable success, making the need for improved restoration critical to seagrass persistence. Oyster reefs can improve water quality and attenuate wave action for seagrass habitats. However, few studies have simultaneously coordinated the restoration of oysters and seagrasses. We tested the effects of distance to restored oyster reefs and initial seagrass shoot density on the survival and growth of restored seagrass plots. Initial results prior to Hurricane Irma indicate that distance to oyster reefs was an important factor on shoot density, with fewer shoots lost nearer to the reefs and, when including expansion outside the plot, gains in total standing shoots. These effects occurred over small-scales (< 2 m) indicating that restored oyster reefs may provide additional benefits not directly related to light availability for seagrasses.

Highlights from a Two-Year Time Series for Chemical Forms of Nitrogen and Phosphorus in Tributaries to the Northern Indian River Lagoon (IRL)

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Successful restoration of the IRL requires knowledge about the amounts and forms of N and P entering the system from rivers and other sources such as muck to confirm mitigation targets. Grand means for total N and P in St. Sebastian River, Turkey Creek, Crane Creek (CC) and the Eau Gallie River (EG) were 890±120 µg N/L and 110±60 µg P/L with dissolved organic N and phosphate as leading chemical species at 57±13% and 55±17% of total N and P, respectively. During the beginning of stormflow, concentrations of nitrate+nitrite, dissolved solids and particulate-Fe decreased whereas phosphate and suspended solids increased. These trends seem linked to the relative influence of baseflow versus stormwater runoff. Fluxes of all ions were certainly greater during stormflow. Data from November-December for urban CC and EG showed varied, but enhanced, inputs of different forms of dissolved N, a possible response to termination of summer fertilizer bans.

Community-Scale Enhancement and Restoration of the Rose Bay Watershed in Volusia County

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More than half of the 5,800 acre Rose Bay watershed in East Volusia County, Florida is developed. Rose Bay benefitted from two decades of multiagency restoration activities totaling $50 million, which removed septic, connected the adjacent Harbor Oaks community to sewer, and removed earthen causeways and muck. As a result, Rose Bay's water quality improved and shoreline habitats began to recover. However, intertidal areas remain degraded along the hardened northern shoreline. Intertidal zones of oyster shell and native vegetation will be augmented or created waterward of existing armor along 1.6 miles containing 52 parcels. The project also entails exotic vegetation control; stormwater conveyance retrofit; upland landscape management; and long-term, community-led monitoring and management. Multiple partners are engaged, and community residents have a vital role in achieving the first community-wide living shoreline in Florida. We hope to encourage community-scale estuarine restoration and management in coastal neighborhoods throughout the region.

Dynamics of Fish Community Diversity within the Indian River Lagoon

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Changes in the marine environment, including temperature, salinity, and pH have been documented globally, potentially resulting in the poleward shift of species distributions, and tropicalization of formerly temperate zones. The Indian River Lagoon (IRL) has the most diverse fish community of any estuary in North America due in part to the biogeographic transition zone it encompasses at approximately 28°N. However, it is unclear if species assemblages and community diversity have altered since the seminal work of Gilmore (1977) and Snelson (1983). Here we use a 25-year dataset collected by the Florida Fish and Wildlife Conservation Commission Fisheries Independent Monitoring program to quantify metrics of diversity to improve our understanding of IRL fish communities. Trends in diversity are quantified across spatial and temporal scales, and provide insight into how species assemblages have

changed, and how these changes may influence the development of conservation and management strategies for fishes inhabiting the IRL.

Survey of Mosquito Populations in the Crab Burrows of the Coastal Oaks Preserve

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The goal of this study was to understand the commensal relationship between the Land Crab (*Cardisoma guanhumi*) and the Crabhole Mosquito (*Deinocerites cancer*). This particular species of mosquito lays its eggs in the burrows of the Land Crab. The burrows also provide shelter for the Mangrove Rivulus, *Kryptolebias marmoratus*, a unique species of fish that preys on mosquito larvae, as well as other invertebrates that fall into the burrow. Throughout the duration of this study, crab burrows were sampled from an artificial site (impoundment dikes) and a natural site in the Coastal Oaks Preserve with a hand pump to count the larvae population. Each burrow was flooded, then a pump was used to extract the contents of the burrow into a sieve to trap the larvae. On average, more mosquito larvae were found in burrows on the artificial site. By analyzing the composition of the fauna within the crab burrows in the artificial and natural sites, managers can use this data to help develop new mosquito management efforts in the future.

Development of a Statistical Model to Predict Percent Cover of Benthic Organisms Present in the Indian River Lagoon

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A statistical model to predict temporal changes in the benthic community is being developed as a part of an Office of Naval Research project to better manage the maintenance of vessels and equipment in the marine environment. The model will predict organism percent cover based on water quality parameters (nitrate, phosphate, dissolved oxygen, chlorophyll a, temperature, and salinity). Benthic community data were collected monthly from February 2014 to July 2017 at a test site located in the central Indian River Lagoon just north of Sebastian Inlet, and water quality data were downloaded from two online databases. Generalized linear models or, if autocorrelation was detected, generalized linear mixed models were used to determine relationships between water quality parameters and some benthic organism functional groups (biofilm, barnacles, encrusting bryozoans and arborescent bryozoans). Once validated, these models may be used to help manage sensors or equipment deployed in the central Indian River Lagoon.

Microbial Source Tracking of Bacterial Pollution in the North Fork of the St. Lucie Estuary

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The North Fork of the St. Lucie Estuary (SLE hereafter) has experienced degraded water quality, including bacterial pollution, leading to multiple closures of the water body for recreational use. To determine the sources of this bacterial impairment, a microbial source tracking (MST) study was conducted through a collaborative effort with the City of Port St. Lucie, St. Lucie County, and FDEP. MST studies target host-specific gene fragments and source-specific chemicals as indicators to determine the source of bacterial pollution. Furthermore, the North Fork drains into the middle and lower SLE, and Indian River Lagoon. Widespread blooms of *Microcystis* sp. in the SLE occurred in 2016, resulting in negative financial impacts for the local economy and potential health issues for exposed individuals. Therefore, there is great value in minimizing not only microbial pollution, but also nutrient pollution that can impact other water.

Living Shoreline Designs for Lagoon-front Residents: Living Shoreline Demonstration Site and Wave Tank Modeling

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Brevard Zoo in partnership with Florida Institute of Technology (FIT) and Brevard County built a Living Shoreline Demonstration Site in Indialantic, FL. This site educates Lagoon-front residents about design options for Living Shorelines on their properties utilizing native vegetation and/or oyster reefs. Living Shorelines provide a host of benefits to the properties and to the IRL including: water filtration, denitrification, erosion control, wildlife habitat, and wave attenuation. FIT modeled three shoreline types in a wave flume; natural, rip-rap, and seawall. These existing shorelines were modeled at two water elevations, wet and dry season. Oyster breakwaters, oyster revetments, marsh grass and mangrove configurations were tested as a means of controlling erosion and reducing wave energy. A novel design for scaling and testing mangrove roots was developed and tested against live mangroves. Evaluation of sediment transportation and significant wave height was used to provide guidance for wave attenuation at the Demonstration Site.