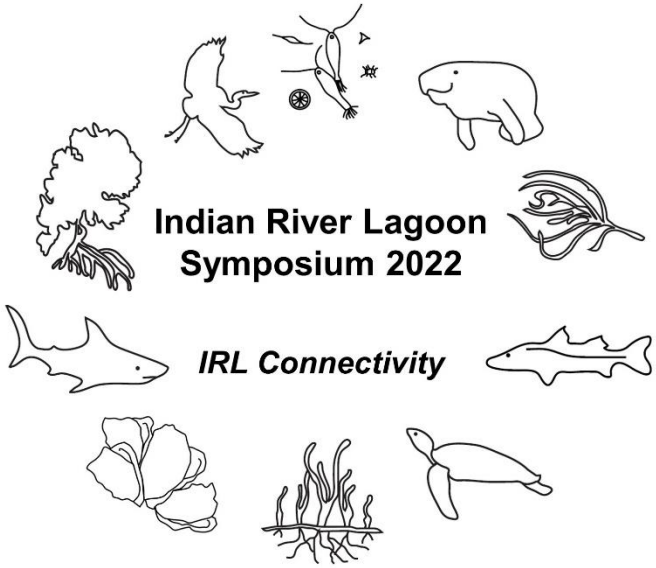
Abstracts of Presentations



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Key Note Address

A Decade of Florida Manatee Mortality Events in the Indian River Lagoon: How Manatee and Estuary Health Connect

Martine de Wit[1], Margaret E. Barlas[1], Charles J. Deutsch[2], and Leslie I. Ward-Geiger[1]
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The northern Indian River Lagoon (IRL) provides critical habitat for the threatened Florida manatee (*Trichechus manatus latirostris*) in all seasons and has supported up to 70% of the east coast population (estimated at 4,000 animals in 2016) in the spring. Four Unusual Mortality Events (UMEs) related to environmental factors have affected this population of manatees since 2010. Extreme cold weather in early and late 2010 led to mass mortality from cold stress. The effects of this unusual cold reached far beyond manatees, and these low temperature extremes were also implicated in triggering a cascade of phytoplankton blooms, fueled by excess nutrient loading, that led to extensive seagrass losses. This loss of seagrass caused a dietary shift in IRL manatees to then predominant macroalgae, which triggered a UME from dysbiosis (i.e., imbalance in gut microflora) with toxic *Clostridia* in 2013. Further unprecedented declines in seagrass and macroalgae from repeated and long-lasting phytoplankton blooms related to many factors ultimately culminated in a manatee UME related to starvation, starting in December 2020, which is ongoing. The consequences of starvation extend well beyond the IRL, and malnourished manatees have been documented all along the Atlantic coast as they migrate in and out of the IRL with the seasons. Connecting manatee health with that of the IRL estuary through the years emphasizes that this has been an ecosystem in distress, and the present starvation UME in manatees is not only a striking manifestation of the lagoon's ill state, but it has also heightened awareness for the dire need to restore the health of this biologically diverse estuary.

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

Biodiversity of Vegetation in Coastal Wetlands Following Removal of Brazilian Pepper
Lucas Acosta[1,4], Ava Kopchak[1,4], Pjark Sander[1,4], Zachary Mansell[2,4], and Michael Price[3,4]
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A nine-acre wetland restoration site at the Coastal Oaks Preserve was mechanically mulched by Indian River Land Trust to remove all invasive Brazilian Pepper trees. We determined occurrence and abundance of plant species three months after that removal. Our work assessed the health and canopy conditions of remnant oak trees and the recruitment of ground cover. The majority of the oak tree canopy was heavily stressed or dead. >40 plant species were recorded in the ground cover; 12 of which were non-native. To achieve successful restoration, there will have to be continuous management of exotic plant species, as well as reintroduction of native plants.

Status and Future of the FACT Network in the Northern Indian River Lagoon
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Continued expansion of passive acoustic telemetry networks is allowing the movements of aquatic animals to be monitored over ever-larger distances and extended time periods. From modest beginnings in east-central Florida, the collaborative FACT Network has grown into one of the largest animal tracking networks in the world, with partners working throughout the southeastern US, Bahamas, and Caribbean. In the IRL region, tracking stations deployed across a continuum of habitats are revealing the behavior and habitat needs of our region's most valuable sportfish, shark, and sea turtle species. This talk will summarize the status of the FACT Network as of 2022. Several ongoing and upcoming studies in the Cape Canaveral region will be highlighted including those designed to understand the export of economically valuable sportfish from protected waters of Kennedy Space Center, inshore-offshore movements of spawning red drum, seasonal migrations of coastal sharks, and habitat use of juvenile IRL sea turtles.

Exploring the Geospatial Distribution of Water Quality Data for the 2016 Harmful Algal Bloom and Fish Kill in the Indian River Lagoon, Mosquito Lagoon, and Banana River Lagoon
Kirsten Jo (KJ) Ayres[1], Duane De Freese[1], Daniel Kolodny[1], Charles Jacoby[2], and M. Dennis Hanisak[3]
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The IRLNEP is partnering with the St. John's River Water Management District (SJRWMD) and Florida Atlantic University (FAU) on the Florida Department of Environmental Protection's (FDEP) innovative technology grant to explore Harmful Algal Blooms (HABs) within the IRL system. This presentation will explore the beginning progress of this project, highlighting the many organizations already collecting data pertaining to HABs, the work involved with quality assurance and quality control within the datasets (QA/QC), publishing data into useable and useful formats, while also identifying limitations and challenges of combining datasets from multiple stakeholders. A centralized data hub will showcase opportunities for those already collecting data to collaborate and potentially integrate datasets. This will allow for improved partnership opportunities, identification of databases, and expanded research cooperation's. HABs and fish kills are major concerns for local governments; so a centralized data hub will maximize opportunities for future research.

Porifera Biodiversity in the Indian River Lagoon: Evaluating the Latitudinal Ecotone and Similarities with St. Lucie Reef

Greer Babbe[1], Maria Cristina Diaz[1], Iris Segura-García[1,2], John Reed[1], and Andia Chaves-Fonnegra[1,3]
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Ecotones harbor species that are often near the limit of their physical and competitive tolerances, therefore, those species serve as sensitive indicators of climate change. Within ecotones, species and populations with greater phenotypic plasticity, such as sponges (Porifera), may have a greater probability of adapting. This study evaluated 1) if the biodiversity of sponge assemblages reflects the latitudinal ecotone between subtropical and warm-temperate biomes in the Indian River Lagoon (IRL), and 2) if similar species occur in St. Lucie Reef (SLR) and the IRL. Presence/absence and relative abundance of sponges and environmental factors were compared between ecosystems, locations, and habitats included in this study. Our results will show if sponge assemblages reflect a transition in sponge diversity over the IRL and possible overlap in species between the IRL and SLR, demonstrating the environmental range ability of the most cosmopolitan species.

Effectiveness of Culverts on Sustaining Life within the Indian River Lagoon (IRL)

Madison Barsalou, Sally Jane Lloyd, Anthony Marzouk, Owen Stanton, and Jillian Van Dyke
Vero Beach High School, Vero Beach, FL and the Junior Scientists Program

Within the IRL, organisms rely on water to provide stable temperature, salinity, pH, and oxygen levels. Maintaining water quality is of utmost importance to preserve life in the lagoon. The IRL's system of culverts was originally designed to improve its connectivity with impounded wetlands. We measured the effect of culverts on water quality within the Coastal Oaks Preserve bordering the IRL. We monitored key water quality parameters at six impoundment sites and at each side of four culverts over Fall 2021. We observed a drastic increase in dissolved oxygen concentration after the culverts were opened. Culvert opening provided a more optimal condition for life to thrive within the impoundment and the IRL.

Initiating Seagrass Restoration in Mosquito Lagoon: Suitability Modeling and *Halodule wrightii* Fragment Retention Adjacent to Living Shorelines and Restored Intertidal Oyster Reefs

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Between 2009 and 2019, SJRWMD determined seagrass coverage in southern Mosquito Lagoon declined by 97%. This represents a substantial ecosystem disturbance. To potentially co-locate seagrass restoration efforts with ongoing living shoreline stabilization and oyster reef restoration, our goals were to model seagrass suitability and determine stabilized fragment survival/retention in Mosquito Lagoon. The field study compared the success of field-collected *Halodule wrightii* fragments (5-9.9 cm length; minimum of 5 shoots) attached with wire to biodegradable BESE™-elements versus garden staples. Treatments were deployed in September 2021 (5 shorelines, 5 oyster reefs), and monitored bi-weekly. No fragments were retained adjacent to oyster reefs after 7 weeks. Along shorelines, the BESE treatment was more effective in retaining live seagrass than the garden staple treatment (7% vs 0% retention). Further study during the plant's growing season, guided by the suitability model, will work towards the development of an effective seagrass restoration protocol for Mosquito Lagoon.

Tracking Young Bull Shark Activity in a Coastal Lagoon with Frequent Harmful Algal Blooms

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The bull shark is a euryhaline elasmobranch that frequents estuaries worldwide. Despite this, there is little understanding of how sharks respond to fluctuating conditions (e.g., harmful algal blooms [HABs]) in these ecosystems. We report movement and activity data from fifteen bull sharks fitted with custom built tags in the St. Lucie Estuary, Florida, a highly impacted sub-component of the Indian River Lagoon (IRL) with recurring HABs. Preliminary results suggest hour of the day, water temperature, depth, and cyanobacteria abundance influence activity. Space use varied but on average sharks used a total of 3.75 km^2 (SD = 1.06) per day. This is an ongoing study that aims to provide the first fine-scale body movement data of immature bull sharks under normal conditions and in response to HABs in the IRL. This is important as the IRL is a bull shark nursery and therefore the species is likely integral to ecosystem structure.

***Caulerpa prolifera* Specific Food Webs Reveal a Lack of Connectivity in the Northern Indian River Lagoon and Banana River**

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Important seagrass habitat in the Indian River Lagoon (IRL) has declined due to poor water quality and light limitation. In the northern IRL and Banana River, large-scale blooms of the rhizophytic macroalgae *Caulerpa prolifera* may create a visually similar habitat, but the ecological functionality is relatively unknown. Food web interactions allow for assessment of habitat function, thus in this study primary producers, invertebrates, and small fishes were collected from *C. prolifera* beds at four sites for analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope values. Differences in $\delta^{13}C$ and $\delta^{15}N$ were observed by season, trophic level, and site. Palm Shores generally had the most enriched $\delta^{15}N$ for all sample types, while differences in $\delta^{13}C$ were more variable. Differences by site suggest a low level of habitat connectivity. These data will help managers to understand how *C. prolifera* functions as habitat in the IRL, in the relative absence of seagrass.

Iron is a Dominant Control of CDOM in the North Fork of the St. Lucie Estuary

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The IRL is an estuary system that hosts a complex array of geochemical processes that control optical properties and nutrient cycling. In the southern IRL, the St. Lucie Estuary is a dominant feature that receives flow from a relatively natural North Fork of the St. Lucie River. In this area, water quality and light penetration, controlled by Color Dissolved Organic Matter (CDOM) and suspended sediments, is critical in regulating frequent harmful algal blooms and aquatic vegetation. While Color Dissolved Organic Matter (CDOM) is conventionally thought to be controlled by dissolved organic carbon (DOC) in natural waters, the CDOM in this region is instead better correlated with dissolved iron. We observe similar relationships in underlying sediments, suggesting sediment-derived pore waters or groundwater may be responsible. However, this phenomenon does not appear to necessarily be the case in the IRL proper, likely because of a greater array of CDOM inputs and transformation.

Exposure to Algal Biotoxins: Exploring Health Effects in Green Sea Turtles (*Chelonia mydas*)

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Juvenile green turtles utilize Florida's coastal seagrass beds as developmental foraging grounds. Inhabiting urbanized areas such as the Indian River Lagoon, FL (IRL) makes turtles susceptible to anthropogenic pollutants. This study aimed to address an existing knowledge gap on how biotoxin exposure and heavy metals influence the health status of green turtles including Fibropapillomatosis (FP) presence. Liver and kidney samples were retrospectively analyzed from stranded turtles IRL between 2015-2021 for biotoxin exposure using inductively coupled plasma-mass spectrometry (ICP-MS). Necropsy and histology reports were used for retrospective analysis of health condition. Preliminary results show that FP was present in 55% (N=40) of turtles stranded in the IRL, nine (22%) of which were euthanized for severe FP. High concentrations of arsenic and lead were found in 17.5% and 42.5% of turtles respectively. Data of biotoxin exposure is still being analyzed and future work will include further statistical analysis and tests of association. We hope to share this data with researchers and ecosystem managers to help prevent and mitigate further negative effects of HABs on turtle populations.

The Effects of Coastal Wetland Restoration on Land Crabs within the Indian River Lagoon

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In June of 2021, invasive Brazilian Pepper trees were removed by a Brontosaurus mower in the Coastal Oaks Preserve. Our goal was to compare the land crab population in the restored area to undisturbed areas. During the study we measured the frequency, temperature, diameter, and activity of burrows, as well as characterized the pseudo-feces which determined the sex. Due to the Brazilian Pepper debris from the restoration, the quantity of burrows was limited when compared to the undisturbed areas. This suggests the necessity of debris removal after the restoration process which would benefit Land Crabs as they are a key species in the wetland ecosystem.

Analysis of Stormwater Outfalls on Microplastic Abundance in the Indian River Lagoon

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Oysters *(Crassostrea virginica)* in the Indian River Lagoon (IRL) are documented to have very high concentrations of microplastics (MP) when compared to other bivalves globally. Stormwater outfalls were hypothesized to be an important source of this MP pollution. IRL water samples were collected by citizen-scientists from 24 stormwater outfalls and 6 control sites monthly for 1 year. Significantly more MP per liter of water (GLM: $p=0.02$) were found in stormwater outfalls when compared to controls. Fibers dominated collections (92%). More MP were collected in the fall than other seasons ($p < 0.01$ for all), and south IRL had the lowest MP densities ($p < 0.01$ for all). Culverts and open outfalls had similar MP densities ($p = 0.60$); both had more MP than controls ($p < 0.001$). Attenuated Total Reflectance - Fourier Infrared Spectroscopy (ATR-FTIR) was used to determine MP polymer composition; polypropylene was the most common material (29%).

Assessing Mesopredator Residency around Clam Leases in Eastern Florida

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Shellfish aquaculture "grow-out" sites for Northern Quahog (*Mercenaria mercenaria*) clams have substantially higher densities than the surrounding ambient environment and thus can attract local molluscivores to these areas. Inspired by clammer reports of damaged grow-out gear, our objective was to examine the potential interactions between two highly mobile mollusk predators—whitespotted eagle rays (*Aetobatus narinari*) and cownose rays (*Rhinoptera bonasus*)—and two clam lease sites near Sebastian Inlet using passive acoustic telemetry. Visitation patterns of telemetered rays to these sites were compared to other reference sites in the region and modeled using local environmental data. While both species spent greater time elsewhere, we observed many instances in which rays remained within range of clam grow-out sites for extended periods (>60 minutes). These results justify the need for continued monitoring of mobile mollusk predators in the region, including additional experimentation to assess behaviors (e.g., foraging) exhibited at the clam lease sites.

Microplastics in the Indian River Lagoon Sediments

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Sediments are the ultimate resting place of plastics in the ocean and give information on what is being introduced through freshwater input, marinas, and agricultural runoff. Sediment samples taken as part of a previous study in the Indian River Lagoon may shed light on the speculation of microplastics in this environment. These samples were taken in four seasons (2 wet and 2 dry) during 2016, 2017, and 2018 in Jensen Beach, Fort Pierce, and Vero Beach areas. Plastic particles were extracted from the sediments with >95% efficiency through density separation, filtration, and analyzed using infrared spectroscopy. Analysis can identify plastics as small as 20 μm, the most common polymers being ~100 μm. This study has gained evidence of microplastics in a majority of the sediments analyzed.

Connecting the Dots: Young Whitespotted Eagle Ray Movement and Habitat Connectivity in the Indian River Lagoon

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Nursery habitats for Florida's protected whitespotted eagle ray (*Aetobatus narinari*) have not yet been described. To fulfill this knowledge gap, we initiated a study in the Indian River Lagoon (IRL) where we have been targeting young individuals (young-of-the-year to juvenile stage) for acoustic tagging. Rays are fitted with both active and coded transmitters to track multi-scale movements and habitat use across the region. Alongside acoustic tracks, environmental variables such as depth, habitat, and a variety of water quality parameters are recorded to help facilitate habitat modeling. To date, two individuals have been tagged near the Pelican Island National Wildlife Refuge, with tracks revealing connections between the intracoastal waterway and adjacent shorelines and spoil islands. While tagging will continue through 2022, these data provide the first insights into the habitat requirements for young stages of the whitespotted eagle ray and potential interactions between these animals and anthropogenic activities within the IRL.

Getting to Know the IRL Dolphins: Establishing a Photo-identification Program in the Southern Indian River Lagoon

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The Marine Mammal Stranding and Population Assessment Program at FAU Harbor Branch began vessel-based photo-identification surveys of bottlenose dolphins in the southern region of the Indian River Lagoon (IRL) in June of 2021. Surveys are conducted from Sebastian Inlet to Jupiter Inlet, photographing individuals and collecting associated behavioral and environmental data. Goals include establishing a catalogue and assessing health, effects of anthropogenic activities, spatiotemporal trends, life history, and population dynamics of the bottlenose dolphins utilizing the southern IRL. The Indian River Lagoon Estuarine System (IRLES) stock has been affected by several unusual mortality events and the analysis of photo-ID data can aid in health and disease surveillance of this strategic stock. Continued survey efforts, data analysis, and collaboration with other researchers will help us better understand the IRLES stock as a whole.

Survival and Growth of Sponge Recruits in a Land-Based Nursery

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Sponges (Porifera), are a diverse ancient phylum of animals providing numerous ecosystem functions (e.g., water filtration, habitat, food source) and commercial applications (e.g., bath sponges and pharmaceuticals). However, mass mortality events in Florida Bay have drastically impacted sponge communities and the ecosystem services they provide. To restore habitats, sponges are being cultured in a land-based nursery at FAU Harbor Branch. We aim to determine survival and growth of sponge recruits in that nursery. Larvae from five species were collected from the Indian River Lagoon and the Florida Keys from July to October 2021. Larval settlement and metamorphosis, survival of recruits, morphological development, and growth were observed and measured. Morphological characteristics including oscula, canals, and filament extensions were identified on recruits. Preliminary results show that survival varies among species. Filamentous algae fouled recruits grown indoors under full spectrum light. Culture conditions have been modified to reduce fouling and improve growth.

Baseline Monitoring of Benthic Communities to Verify the Efficacy of Restoration Efforts

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The degradation of Florida's Indian River Lagoon (IRL) is exemplified by accumulation of fine-grained organic-rich sediments, poor water quality, and increased frequency of Harmful Algal Blooms related to anthropogenic eutrophication. Ecological monitoring throughout the IRL is crucial for detecting ecosystem changes that result from continued system degradation or restoration efforts. One such effort, The *Restore Lagoon Inflow* (RLI) project, would enhance the influx of coastal ocean water into the Banana River (Florida Atlantic coast) at approximately 28°24'25" N latitude for the intent of improving water quality and estuarine habitat. Benthic biological community data are being monitored at stations focusing on the point of proposed inflow. These data include abundances (densities) of benthic infauna, seagrasses, and drift algae. These numbers form a baseline for comparison with shifting community conditions in the event of a pilot inflow project. Comparisons will help identify positive and negative impacts of restored coastal inflow on benthic populations.

Real-time Estimation of Aragonite Saturation in the Indian River Lagoon

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Aragonite saturation state is traditionally calculated from two or more carbonate parameters determined from discrete samples. While high quality, collection of discrete samples provides low temporal resolution and does not capture rapid changes in a dynamic environment like estuaries. The Indian River Lagoon Observatory Network of Environmental Sensors (IRLON) deployed pCO2 sensors through the Indian River Lagoon (IRL) and St. Lucie Estuary (SLE) in 2021. The pCO2 sensor coupled with pH and nutrient sensors allows for the real-time estimation of aragonite saturation. From July to September 2021, estimated aragonite saturation state (Ω_{ar}) varied both spatially and temporally throughout the network. Long-term monitoring of pCO2 and pH with co-located dissolved oxygen, nutrient, and chlorophyll sensors will enable a better understanding of the drivers of coastal acidification in the IRL.

Porifera in the Indian River Lagoon: Cryptic Biodiversity and Potential Ecological Implications

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Species diversity in the Indian River Lagoon (IRL) is changing and affecting ecosystem function. However, the biodiversity of some phyla (e.g., Porifera) is still unknown. During summer 2020 and winter 2021, an intensive collection of sponges in mangrove, seagrass, oyster reef, sandy bottom, and artificial habitats was carried out at 29 locations along the IRL. Our initial evaluation from the summer collection increased known species richness from 48 to 76. The winter collection added 23 morphospecies, bringing our estimate of sponge biodiversity to 99 species. DNA barcoding data (COI and 28S genes) were obtained and allowed the discovery of higher diversity than expected, with unique and/or unknown affinities to the sponges in the region. Here we present the most updated assessment of Porifera biodiversity in the IRL, which includes more genera and species than previously found, explores their potential ecological role, and adds new DNA-barcode records in public databases.

Influence of Coastal Ocean Water Levels on Currents in the Banana River Estuary

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Prevailing understanding of estuarine dynamics suggests that the circulation pattern of the brackish water in the Banana River Estuary is largely driven by the winds. This assumption is challenged following two years of data collection of water levels and current speeds using 3 Acoustic Doppler Current Profilers at 3 locations in the Banana River: Syke's Creek, Barge Canal, and Dragon Point. Based on these data, wind speed has low impact on either current speed or direction. Inter-day and longer, low frequency shifts of water level in the nearshore coastal ocean driven by variations Gulf Stream flux influence current velocity and the diurnal tide is an important factor for determining current direction. These conclusions are evidenced by distinct spectral patterns found in the time series of water level and current speed.

Restore Lagoon Inflow Research: Phase 2 Project Findings and Next Steps

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The multi-phase Restore Lagoon Inflow Research project builds upon ongoing efforts to identify effective restoration measures with assessment and modeling of the lagoon system to determine whether enhanced ocean inflow could be a tool to address declining water quality and ecosystem degradation. Phase 2 of the project was recently completed with a focus on (1) establishing the foundation for a pilot pumping project to investigate the impacts of restoring periodic historical ocean inflows and (2) further development of baseline data and modeling on existing water quality, biological parameters, and hydrologic conditions at the proposed pilot system location. The results of the full Restore Lagoon Inflow Research project will provide information and analysis to state agencies and appropriate decision-makers to help determine the viability and potential impacts of a full-scale, permanent ocean inflow system.

Potential Exposure of Young Bull Sharks to Multiple Algal Toxins in an Important Florida Nursery

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Bull sharks (*Carcharhinus leucas*) commonly use estuarine nurseries, which are thought to increase survival of young life stages. However, this habitat association may also make young sharks vulnerable to anthropogenic stressors. This study explored spatiotemporal patterns in movement and algal toxin concentrations in immature bull sharks of the Indian River Lagoon (IRL), an important bull shark nursery that has been considerably impacted by toxic harmful algal blooms. Multi-year (2017-2020) spatial use of the system was assessed for 29 acoustically tagged bull sharks. Tissue samples were collected from a separate cohort of 50 individuals from 2018-2020 and screened for 14 algal toxins using UPLC-MS/MS. Young bull sharks displayed high residency in the IRL, with small daily and monthly activity spaces. Multiple phycotoxins were also detected in screened tissues. Together, this information suggests young bull sharks in the IRL may be exposed to algal toxins while they reside in this important nursery.

Environmental DNA in Practice: eDNA Biodiversity Assessments across Diverse Florida Coastal Ecosystems

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Florida's diverse coastal ecosystems include a wide range of habitats that are routinely surveyed by both state and federal agencies to inform regional resource management and conservation decisions. Despite the intensive labor and cost required to run these surveys, methodological biases lead to key species being systemically overlooked. Community-wide surveys using environmental DNA (eDNA) – DNA passively shed by aquatic organisms into the water column – is a novel approach that has been shown to increase species detections and avoid some of the biases and challenges of traditional methods. Here we present data from a statewide eDNA survey of nearshore communities, including the Indian River Lagoon, and discuss the relevance of this data to conservation and management of these systems. We assess eDNA as a

biogeographic tool, examine known faunal breaks, and leverage these data to garner new insights on fish community structure throughout Florida's coastal waters.

Dissolved Oxygen and the Influence of Hypoxia on Nutrient Cycling in the Indian River Lagoon

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Benthic fluxes of nitrogen and phosphorus from anoxic mud (muck) contribute ~40% of the total nutrient (N and P) loading to the northern and central IRL. In contrast, "healthy" sandy sediments act as both a source and a sink for these nutrients, largely depending on oxygen availability. Managing and modeling nutrient inputs to guide restoration efforts requires an understanding of spatial and temporal variations of dissolved oxygen (DO). To that end, we have begun establishing a network of dissolved oxygen sensors managed by multiple institutions following strict QA/QC protocols to address the overarching question: what is the aerial extent of hypoxia in the IRL? Lagoon restoration projects are connected through a reliance in some way on DO whether it be selecting degraded, anaerobic sites with high nutrient fluxes for muck removal or selecting sites with sufficient oxygen to mitigate accumulation of toxic hydrogen sulfide thereby supporting oyster and seagrass restoration.

Phytoplankton Assemblages in the C44 Canal and St. Lucie Estuary

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Phytoplankton abundance, composition and water quality measures were determined in the C44 canal and St. Lucie estuary during 2019 to 2021. Phytoplankton compositions were determined using pigment-based chemtaxonomy and microscopy. Cell counts were produced using Utermöhl settling chambers. Water temperature, salinity, turbidity, chlorophyll-a, and underwater irradiance were measured *in-situ*. Nutrients, silicate, and colored dissolved organic matter were measured from water samples. Spatial and temporal variation was observed in all measured parameters. Over 250 phytoplankton taxa were observed. Freshwater taxa were observed in the C44 canal while estuarine and marine taxa were observed downstream in the main body of the estuary. Diatoms were most abundant in winter-spring months while summer-fall phytoplankton assemblages were often dominated by dinoflagellates in more marine areas and chlorophytes at freshwater sites. Filamentous cyanobacteria and cryptophytes were also sporadically common during the warmer months. Relationships between phytoplankton and water quality will be discussed.

Leveraging Natural Processes and Community Engagement for Removal of Nitrogen and Phosphorus

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Restoring ecosystem services that naturally remove nitrogen and phosphorus are essential to minimizing occurrences and the severity of HABs, hypoxic events, and fish kills throughout the IRL. We have developed an eco-friendly, cost-effective biological nutrient treatment system using repurposed plastic bottle caps collected by the community as an alternative to commercially available denitrification media (bioballs). Throughout the duration of this research, the bioreactor has been modified and optimized to improve N and P removal. To date, the bioreactor removes >80% ammonium (NH_4) and significant quantities of total dissolved phosphorus (TDP) as well as significantly decreases microplastics counts from IRL water. In addition to cost-effective nutrient removal, immense public support for this project has promoted environmental stewardship and education across all age groups and educational backgrounds,

serving as an opportunity to educate the community of essential, yet less known about, ecosystem services like the significance of sand versus mud.

Assessing the Biological Performance of Living Docks – A Citizen Science Initiative to Improve Coastal Water Quality through Benthic Recruitment within the Indian River Lagoon, Florida

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Due to anthropogenic activities, oysters in the Indian River Lagoon (IRL) have declined, thus impacting the filtration capacity of the system. An ecological solution to restore oyster populations has been the introduction of restoration mats through a program called Living Docks. Working with local communities and citizen scientists, these oyster mats are secured to dock pilings to attract oyster larvae as well as other filtering benthic organisms to help improve local water clarity. Four Living Docks, located throughout the northern IRL, were assessed for the presence of benthic organisms to determine succession over a year**.** Across three sampling periods, docks showed a difference in community diversity and oyster abundance amongst locations. Overall, the Living Docks mats have proven to be a method which is conducive to citizen science and successful at promoting the growth of benthic filter feeding organisms for improved water clarity as well as habitat structure.

What's CERP Got to Do with It? The Role of the Comprehensive Everglades Restoration Plan in Tracking IRL Benthic Biodiversity

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The Comprehensive Everglades Restoration Plan (CERP), established in 2000, aims to restore Florida's hydrology to balance ecological needs with human demands. To monitor how CERP implementation and releases from Lake Okeechobee affect biotic communities throughout the St. Lucie Estuary (SLE) and the Indian River Lagoon (IRL), the Smithsonian Marine Station Benthic Ecology Lab (SMS-BEL) collects infaunal invertebrate samples and environmental data from 15 sites quarterly. Since 2005, SMS-BEL has collected a total of 2,820 infaunal samples that contain $>7.9 \times 10^5$ individuals belonging to 440 taxa and 16 phyla. This work increases the resolution of benthic diversity in the SLE and IRL, provides insight into the ecological implications of depressed salinity and increased sedimentation, and serves to identify taxa as indicators of habitat quality and as targets for restoration. This poster will discuss the role of CERP and summarize overarching trends from >16 years of monitoring these pervasive IRL benthic communities.

Detecting Coastal Acidification in the Indian River Lagoon

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Coastal acidification (CA) is a serious threat to estuaries. The Indian River Lagoon Observatory Network of Environmental Sensors (IRLON) has 10 stations in the Indian River Lagoon (IRL) and St. Lucie Estuary (SLE). New capabilities in 2020-2021 addressed CA. For example, there is a striking pCO2 gradient in the SLE. From July-September 2021, lowest mean [pCO2] (568 ppm) was near St. Lucie Inlet. Values increased rapidly at three upstream stations, ranging from 2,880 to 4,143 ppm; the freshest station had a mean of 7,578 ppm. IRLON is measuring key CA parameters (pH, pCO2) necessary to detect CA trends in the IRL and to guide management efforts on how to identify impacts of CA (e.g., on shellfish) and possible mitigation strategies (e.g., seagrass restoration).

Impact of Mangrove-Driven Acidification on Intertidal Oyster Reefs

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Mangroves drive local acidification through decaying organic matter and root respiration, creating carbonic and sulfuric acids within surrounding sediments. Tropicalization has allowed mangroves to expand poleward and increase abundance in their historical range. In Mosquito Lagoon, Florida mangrove abundance on intertidal oyster reefs has increased by 198% since 1984. Acidification negatively impacts oysters by causing shell dissolution. It was hypothesized that mangrove presence increases acidity on oyster reef habitats. Water from within the sediment (i.e., pore-water) was collected from oyster reef sites and pH was immediately measured with a portable pH meter. Five replicate pH measures were obtained monthly at all sites, and one-time pH landscape grids were conducted across all reef sites. Results to date suggest that pore-water pH is more acidic on oyster reefs with mangroves (pH: 7.03), compared to oyster reefs without mangroves (pH: 7.41). This data suggests mangrove encroachment on oyster reefs can negatively impact oysters.

Quantifying *Caulerpa prolifera* Nutrient Uptake in a Flow Through System

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Caulerpa prolifera is a historically abundant macroalgae in the Indian River Lagoon (IRL) and provides many of the same habitat functions as seagrasses, including sediment stabilization, nutrient uptake, and shelter for juvenile fish. Although several studies have examined *C. prolifera*'s interaction with seagrasses, such as *Cymodocea nodosa* and *Halodule wrightii*, its role in carbon fixation and nutrient cycling within the IRL has received less focus. Given *C. prolifera*'s broad range of suitable environmental conditions, it was identified as a potential candidate for future intensive cultivation in an algal turf scrubber water treatment system. *C. prolifera* was evaluated for its ability to remove nitrogen and phosphorous from lagoon water and its effect on dissolved oxygen and pH.

Occupancy and Habitat Use of the Florida East Coast Diamondback Terrapin in the Mid Indian River Lagoon

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Diamondback terrapins (*Malaclemys terrapin*) are an exclusively brackish water turtle found along the East Coast of the United States and considered a Species of Greatest Conservation Need in Florida. Very little is known about the Florida east coast diamondback terrapin (*M. t. tequesta*). This study used acoustic monitoring to investigate the occupancy and habitat use of a population of diamondback terrapins in the mid Indian River Lagoon. Twenty-one terrapins were fitted with VEMCO V9 acoustic tags and passively monitored between 2019 and 2021. Seasonal occupancy of the study site and habitat use within the study site were characterized. As the state of Florida continues to improve conservation of diamondback terrapins, understanding their movement patterns can help guide these efforts.

Expanding Public Outreach for the Indian River Lagoon Observatory Network of Environmental Sensors

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Since 2013, the FAU Harbor Branch Indian River Lagoon Observatory Network of Environmental Sensors (IRLON) has been monitoring water quality and weather conditions along the Treasure Coast. IRLON data is freely accessible to both scientists and members of the general public through a dedicated website, www.irlon.org. This project seeks to increase public awareness of this program through targeted outreach efforts. First, an IRLON display at the Ocean Discovery Visitors Center was updated to include new signage and an educational module. Next, a variety of social media and blog posts were created to educate people about IRLON and the data captured. By facilitating the use of this information, our goal is to improve environmental literacy and stewardship.

Winds and Topographic Controls on the Connectivity in the Northern Indian River Lagoon

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A high-resolution hydrodynamic model is used to study the patterns of connectivity in the northern Indian River Lagoon (IRL). A one-year (2015) simulation is conducted and sub-tidal residual currents are computed. In addition, neutrally buoyant (virtual) particles were released in key areas and tracked for months to illustrate the residual patterns of water connectivity on weekly to intra-seasonal timescales. The results suggest that, due to the complex coastline and man-made features such as narrow passages under bridges and canals, surface winds drive complex yet coherent residual circulation patterns within each individual subbasin. The patterns may include single or multiple circular cells depending on the prevailing winds. These patterns, however, generally promote re-circulation of waters within each sub-basin, leading to long water residence time and limiting the connectivity between sub-basins. Implications of these to understanding water quality, nutrient cycles, and phytoplankton blooms in this region are discussed.

Remote Sensing of Harmful Algal Blooms in the Indian River Lagoon and Connected Waterways in Brevard County

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With an increasing frequency of Harmful Algal Bloom (HAB) in the Indian River Lagoon (IRL) over the last decade the identification of triggers and behaviors is vital to efforts to manage the watershed. The use of satellite and Unmanned Aerial System (UAS) remote sensing technologies was identified as a cost-effective and encompassing approach to provide rapid identification of HAB formation, the lifecycle of the HAB, and then identify hotspots of HAB occurrences. The purpose of this project is to provide the framework for the use of the European Space Agency (ESA) Sentinel-2 and Sentinel-3 satellite data over the IRL. In 2022 AEI will be flying a UAS equipped with a hyperspectral camera which will provide additional data needed to improve the analysis of the satellite imagery. This presentation will outline the project and provide a snapshot of historical patterns of HAB activity in the IRL from the Sentinel satellites.

Skin Tumors of Striped Mullet (*Mugil cephalus*) in the Indian River Lagoon

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Striped Mullet (*Mugil cephalus*) with grossly visible, nodular skin lesions were collected by the Fish and Wildlife Research Institute's field laboratory in the Indian River Lagoon (IRL). Routine monitoring continues and has been conducted since 2000, but mullet with these lesions (n = 3) were documented only during the period from 2015 through 2018. Based on histological examination, the skin tumors were putatively diagnosed as overgrowth of fibrous tissues, with characteristics ranging from those of benign dermatofibromas to those of malignant fibrosarcoma. Anthropogenic factors might have contributed to the development of these tumors. It is important to continue monitoring these and other fish lesions occurring in the IRL region, especially those occurring epizootically because they can act as sentinels for threats to animal, human, and ecosystem health.

The RECOVER Northern Estuaries Salinity Performance Measure Update: Connecting CERP Science, Restoration, and Management

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The St. Lucie Estuary (SLE), Southern Indian River Lagoon (S-IRL), and their watersheds are highly modified and channelized, significantly impacting freshwater inflow and salinity regimes. Comprehensive Everglades Restoration Plan (CERP) projects aim to improve the quantity, timing, and distribution of inflows to these systems, improving conditions for key eco-indicator species including the Eastern oyster and seagrasses. An updated Northern Estuaries Salinity Envelope Performance Measure establishes optimum flow targets for restoration, describes stressful and damaging conditions for eco-indicators, and outlines a protocol for evaluating CERP alternative designs which managers use in planning, construction, and adaptive management. In this new era of CERP when project components are nearing completion or operational phase (e.g., the C-44 Reservoir and STA, which store and treat C-44 basin runoff), connecting CERP science to regional water management, assessments of project success, and operations will be critical for meeting CERP long-term goals.

Engaging the Community to Restore Populations of *Mercenaria mercenaria* in the Indian River Lagoon

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Brevard Zoo has partnered with University of Florida's Whitney Lab and Florida Oceanographic Society to restore *Mercenaria mercenaria* populations in the Indian River Lagoon. Declining IRL shellfish populations has resulted in reduced lagoon water filtration and contributes to lower water quality today. 100 lagoon-front sites have been volunteered by the community to plant clams from University of Florida's Super Clam project. 8 million clams will be distributed between the 100 sites from November 2021 to January 2022. Clam bed monitoring will occur twice in the year of 2022. By planting 100 clam beds within the IRL, spanning from New Smyrna to Sebastian, this project is hoping to identify areas of the lagoon where clam restoration is possible and can be funded in the future.

Assessing the Trophic Dynamics of Juvenile Sportfish to Oyster Reef Restoration
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Coastal habitat restoration theoretically provides foraging opportunities for predators, thereby improving trophic structure, but this relationship is understudied. To assess the impact of habitat restoration on sportfish trophic structure in the Indian River Lagoon, we quantified gut contents and stable isotopic signatures of sportfish species that were caught prior to and following oyster reef restoration at restored and control reefs for up to three years. Stable isotope analyses of oysters and common sportfish prey were also analyzed. Stable isotopic signatures of fish and most prey at live reefs were carbon enriched and had a smaller niche compared to dead reefs, while restored reefs were intermediate. These results can be utilized to develop more effective restoration-based solutions to guide management and conservation of IRL sportfish.

Implications for Co-restoration: Assessing Health of *Halodule wrightii* Grown in Conjunction with *Mercenaria mercenaria* Clams
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Seagrasses and clams provide valuable coastal and estuarine ecosystem services including improved water quality, carbon sequestration, and sediment stabilization. Unfortunately, these populations are declining due to anthropogenic impacts. Widespread restoration projects are being undertaken, however restoration which targets multiple species has demonstrated greater success, stability, and recovery of threatened ecosystems. Positive interactions between infaunal bivalves and plants may be especially important in areas under high environmental stress. Seagrasses have high light requirements, thus light reduction via eutrophication or anthropogenic activity is a key threat. We established a fully crossed mesocosm experiment to observe potential interactions between *Halodule wrightii* and *Mercenaria* under varying light levels. Our findings showed a distinct relationship between seagrass health and light stress but limited interactions between seagrass and clams. As we see further declines in water quality and continued loss of foundational species, understanding species relationships will provide a targeted approach to co-restoration.

Monitoring the Impact of Seasonal Freshwater Inflows to St. Lucie River Estuary for CERP: Habitat and Resource Connectivity to Health Physiology of Fish
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Quantity and timing of freshwater flow through Florida's coastal estuaries is correlated with water quality, which influences habitat and resource use by resident fish communities. With high freshwater inflows, fishes that prefer higher salinities at various life stages may be displaced from river systems and seek refuge in adjacent lagoons where salinities are more preferable. These temporary migrations may alter community and food web structures (e.g., changes in predation rates of displaced predators and prey), resulting in physiological stress and related health impacts. To understand how the Comprehensive Everglades Restoration Plan (CERP) projects will improve the ecosystem for proposed fish indicator species (i.e., Snook, Spotted Seatrout, and Red Drum) multi-tissue stable isotope analysis, health parameters, and acoustic telemetry in the St. Lucie Estuary and Southern Indian River Lagoon will be monitored to track food web structure and basal-resource usage, physiological stress responses, and movement patterns in relation to freshwater inflows.

Preliminary Insights on the Occurrence and Movements of the Brazilian Cownose Ray (*Rhinoptera brasiliensis*) along the East Coast of Florida

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In the western North Atlantic, recent studies have found the Brazilian Cownose Ray (*Rhinoptera brasiliensis*) co-occurring within the range of the American Cownose Ray (*Rhinoptera bonasus*). However, due to the inability to definitively distinguish between species in the field, little is known about the ecology of *R. brasiliensis* in this region. As part of a larger study assessing the population structure of both species, 26 genetic samples were provided from cownose rays collected from the Indian River Lagoon (IRL) and five samples (~19.2%) were positively identified as *R. brasiliensis*. All five rays were acoustically tagged and acoustic detection data suggest movements are largely restricted to the east coast of Florida, with frequent exchanges between the IRL and coastal waters off Cape Canaveral, FL. Though limited, these data suggest that *R. brasiliensis* is present year-round along east coast Florida and may have different migration patterns than *R. bonasus*.

Coastal Acidification and Carbonate Chemistry: Pilot Data from St. Lucie Reef

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Ocean acidification has been a hot oceanography topic recently. While science has come a long way to quantify carbonate chemistry changes, most data is positioned on the west coast of the United States in the Pacific Ocean. The St. Lucie Reef represents the northern extent of the Florida Reef Tract, marking an important ecological habitat zone of transition. This research creates a pilot, baseline set of data to examine the status of carbonate chemistry and coastal acidification at the St. Lucie Reef in the Atlantic Ocean. Water column dissolved inorganic nutrients, pH, total alkalinity, and physical water quality profiles help inform the status of carbonate chemistry and its potential impacts on this critical habitat.

Effect of Associated Bacteria on the Physiology of IRL *Pyrodinium bahamense*

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The increasing incidence of *Pyrodinium bahamense* blooms in the Indian River Lagoon (IRL) prompts research to understand elements influencing bloom formation and dynamics. Phytoplankton blooms are impacted not only by abiotic factors such as nutrient availability and temperature, but also biotic factors including the bacteria surrounding an algal cell. Here, the effect of bacteria on the physiology of IRL *P. bahamense* was investigated through culturing isolates with and without their bacterial associates using antibiotics. Differences in photosystem health, saxitoxin production, and growth rates were measured throughout the growth cycle. These results provide a basis for future work to determine how changes in bacterial abundance and chemistry influence *P. bahamense* physiology as well as bloom formation, magnitude, and collapse.

Manatee Habitat Restoration Funding Update

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The Indian River Lagoon (IRL) has historically provided essential habitat for a resident manatee population year-round, and during the cold, winter months, supported an even larger population as many individuals depend on warm water refuges within the area. During the winter of 2020/21, an unusual manatee mortality event (UME) was declared by the Florida Fish and Wildlife Conservation Commission (FWC) and the U.S. Fish and Wildlife Service (USFWS) and attributed to starvation due to the lack of forage within the IRL. In response, $8 million from the State's General Revenue Fund was allocated to FWC to *"restore manatee access to springs and provide habitat restoration in manatee concentrated areas".* Staff is currently working with partners to develop and implement warm water and seagrass habitat restoration projects to benefit manatees within the affected area. This presentation will summarize the latest UME data and provide an update on the funded projects.

Oyster Restoration with Community Oyster Reef Enhancement (CORE) Modules

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Eastern Oysters, *Crassostrea virginica*, are a foundation species providing food and habitat for other species in the Indian River Lagoon (IRL). Oysters also protect the shoreline from storm-induced erosion. As filter feeders, oysters also remove excess nutrients from the water column. Diminishing populations of oysters are negatively impacting the health of the IRL. Oyster reef restoration is a critical component of protecting the IRL. Various structures have been tested to promote oyster attachment. In this study, we deployed modules made from a mix of concrete and wood chips with recycled oyster shells at four oyster reef sites in Indian River County, Fl. Quarterly, we measured the growth of the first 25 adult oysters and 10 spat found on the 24 modules. In the early spring 2021, minor spat settlement was observed. Over the summer of 2021 and throughout the fall, oyster recruitment steadily increased. This project will continue to monitor the performance of CORE modules as substrate for oyster reef restoration.

Leveraging Natural Selection for Restoration of Clam Populations and Water Quality in the Indian River Lagoon

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Hard clams (*Mercenaria mercenaria*) have historically been significant contributors to healthy water quality in the Indian River Lagoon (IRL) via filter-feeding that reduces turbidity from algae and detritus which in turn allows greater light penetration needed for seagrasses to grow. Furthermore, through bio-filtration, clams remove particulate organic nutrients from the water column depositing them in sediments, contributing to sediment consolidation and 'benthic-pelagic coupling' that further reinforces water quality and clarity. To date, we have successfully collected broodstock from impacted areas of the IRL, spawned and raised over twelve million clams to out-plant size in nursery facilities and repatriated these native hard clams to strategic locations in the northern IRL. Monitoring of clam growth and survival suggests that clams can withstand significantly degraded water quality. This work represents a unique collaborative effort between the University of Florida, Blair Wiggins Outdoors, Coastal Conservation Association, Florida Fish and Wildlife Conservation Commission, IRL Council,

St. Johns River Water Management District, Space Coast Office of Tourism, Premium Seafood Inc, Ducks Unlimited, Florida Oceanographic Society, Riverside Conservancy, and the public.

Identification of Fish Habitat Hotspots and Suitability for Use in Prioritizing Conservation and Restoration Projects in Coastal Rivers

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Coastal rivers of southeastern Florida have been ranked high for restoration by conservationists, because of the potential for projects to benefit human assets and aquatic communities. A fisheries-independent monitoring dataset was analyzed to identify fish habitat using hotspot analysis and habitat suitability. Initial testing for broad seasonal changes (high vs. low flow) in species distributions showed little change suggesting habitat was important for supporting fishes in this system. A river section (23-45 km from the river mouth) comprised of braided river channels and mangrove backwaters was a hotspot for Common Snook and Red Drum. The same low salinity section supported several regionally unique tropical species including Opossum Pipefish, Smallscale Fat Snook, and Bigmouth Sleeper. Restoration efforts can be prioritized by maintaining low salinity (<15 PSU), reconnecting floodplains and riverine backwaters in areas comprised of fish hotspots and exploring strategies to improve fish habitat in other areas currently less used.

Please Call Us: Using the U.S. Sawfish Recovery Hotline as a Tool to Promote Recovery of the Smalltooth Sawfish in the Indian River Lagoon

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Historically, the endangered smalltooth sawfish, *Pristis pectinata*, has been reported in U.S. waters from Texas to North Carolina. Over the last century, substantial reductions in range and population size have occurred and the core range is now in southwest Florida. In the late 1990s, scientists began collecting encounter reports from public sources such as anglers, boaters, and charter captains. These reports laid the groundwork for the current U.S. Sawfish Recovery Hotline (1-844-4SAWFISH) and the associated U.S. Sawfish Recovery Database, which helps researchers and managers collect information on when and where sawfish are encountered throughout the southeastern U.S., including the Indian River Lagoon. Encounter data have played, and will continue to play, important roles in the success of research and management decisions that foster recovery. This talk will discuss mechanisms for reporting encounters and how these data are needed to enhance research in data-poor, non-core range regions such as the lagoon.

Substrate Preferences and the Influence of Distance from Parent Populations on Marine Fouling Organisms

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Understanding the factors facilitating non-native species spread away from introduction points is necessary to determine species' borders and manage further expansion. This project aims to determine if a settlement substrate preference is present in the fouling community at Port Canaveral and if those preferences change based on proximity to the parent population. Substrate preference was examined at two proximities, one directly next to the pontoon with the parent populations and one at a distance. PVC and red oak panels were deployed with a staggered start and collected after four weeks. Visual assessment was performed on each panel, and the percent cover was quantified for each fouling group or individual species where applicable. By understanding the interaction between substrate preference and proximity to parent populations, decisions regarding substrate type and placement may be used to influence the fouling community and minimize the spread of non-indigenous species.

Using Continuous Monitoring of Bottom Water Oxygen to Help Guide Restoration Efforts in the Indian River Lagoon

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As efforts to reestablish oyster habitats continue in the IRL, the Brevard Zoo has collaborated with Florida Tech to utilize a network of bottom water sensors (10-30 cm above the sediments) to monitor in-situ conditions on both existing oyster reefs and potential project sites. These data will help to understand what areas may be viable for long term success of restored oyster habitat. Prior research has shown near-sediment dissolved oxygen can be much lower than surface waters at the same location. Oysters are found in regions that are vulnerable to hypoxic and anoxic events. By contributing to a broad network of bottom water dissolved oxygen sensors, site selection can be improved helping to mitigate oyster die-offs as well as provide insight to what conditions are at successful oyster reefs, including natural reefs, helping to improve future site selection.

Modeling Settlement of the Indian River Lagoon Benthic Community, with an Emphasis on Living Dock Restoration Mats

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The Living Docks is a Florida Institute of Technology outreach program for Indian River Lagoon restoration. Community docks are volunteered to become Living Docks, where oyster mats are wrapped around dock pilings and provide the preferred substrate for benthic filter feeders. Benthic community growth on the oyster mats boosts water filtration and improves overall lagoon water quality. The goal of this project is to model the benthic growth of prominent organisms on the oyster mats with specific environmental factors (e.g., temperature, salinity, pH, dissolved oxygen) to determine how abiotic changes will influence recruitment and succession of the benthic community. Monthly assessments of the benthic settlement on oyster mats at four Living Dock sites are currently being conducted, and water quality data is collected from the docks with various sensors and water stations. The results of this study can be utilized to further the lagoon restoration efforts of the Living Docks.

Youth Fishing Clinic to Educate the Next Generation of Indian River Lagoon Users

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The UF/FAMU Extension Community Voices, Informed Choices (CIVIC) program faculty partnered with Florida Sea Grant and the Ocean Research Conservation Association (ORCA) to offer a youth fishing clinic that served multiple purposes. The effort was the direct result of concerns raised during a resident-attended deliberative forum focusing on water quality in the Indian River Lagoon. A Fort Pierce City Commissioner suggested the event to raise awareness for subsistence fishers frequenting tributaries leading to the lagoon about water quality and the human health impacts of regular fish consumption from those waters. Area youth learned fishing skills and environmental stewardship from Extension and volunteers representing the Coastal Conservation Alliance. Sponsors provided equipment the youth could keep so they could continue to develop their skills. Youth participants were encouraged to support ORCA's on-going fish monitoring citizen science project by donating caught fish in exchange for a farm-raised fish sandwich.

Oyster Recruitment on Brevard County's Save Our Indian River Lagoon (SOIRL) Oyster Breakwaters

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Shallow, subtidal oyster breakwaters have been constructed, many with gardened oysters (*Crassostrea virginica*), in the Indian River Lagoon as part of Brevard County's Save Our Indian River Lagoon (SOIRL) program to increase oyster habitat and improve water quality. Post-initial deployment, no gardened oysters have been added. Third-party monitoring of 10 breakwaters, from Cocoa Beach to southern Melbourne Beach, provides up to 2 years of data on oyster recruitment, growth, and survival. Results document both recruitment and survival were lowest in man-made canals in the Banana River. Recruitment from natural sources was highest in the southern part of Brevard County along shorelines facing the Indian River, however, survival of gardened and naturally recruited oysters was variable with time and location. Where there were adequate larval supplies, recruitment occurred with and without gardened oysters. Results suggest long-term success of oyster breakwaters depend on locations suitable for both recruitment and survival of oysters.

Samsons Island Submerged Lands Restoration (SISLR): Creating a "Habitat Mosaic Pilot Project" to Determine the Feasibility of Habitat Restoration Techniques in the Indian River Lagoon

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Satellite Beach has partnered with multiple regional partners to lead a community-based habitat restoration project that engaged over 1,000 Brevard County residents to create a Habitat Mosaic Pilot Project in the Indian River Lagoon. The city coordinated the deployment of 30 TONS of repurposed oyster shell as a breakwater, the planting of 13,500 seagrasses, *Halodule wrightii,* and the dispersal of 36,000 hard clams, *Mercenaria*. After 3 months and multiple volunteer workdays the habitat mosaic was completed. Monitoring began monthly where staff and partners collected information on oyster recruitment, growth rates and survivability of the clams and seagrasses and other site data on the feasibility and effectiveness of the methodologies used. A final report was provided to the granting agency, the National Estuary Program. Data collected and lessons learned are being applied the next phase of the SISLR project, funded by the Brevard County Tourism Development Council.

Pseudo-nitzschia in the Indian River Lagoon: An Emerging Threat for Florida

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The Indian River Lagoon (IRL) faces numerous harmful algal blooms. The diatom *Pseudo-nitzschia*, which can produce the neurotoxin domoic acid (DA) has been observed throughout the IRL. This study's goal was to identify *Pseudo-nitzschia* species present and understand factors contributing to population dynamics and toxin production in the southern IRL system. Twice monthly water samples were collected for three years from five locations. Cell counts enumerated all microphytoplankton, and environmental data was collected by the Indian River Lagoon Observatory Network. *Pseudo-nitzschia* cells were isolated and characterized through 18S Sanger sequencing and Scanning Electron Microscopy. *Pseudo-nitzschia* dominated the microphytoplankton community occasionally, with peak densities nearing 2,000 cells/mL, and showed a preference for higher salinities. All isolates and many water samples showed DA presence by ELISA. We report the first known occurrence of *Pseudo-nitzschia* cf. *micropora* and cf. *fraudulenta* in the IRL, and the first known DA production from *Pseudo-nitzschia* cf. *micropora*.

Oyster Reef Restoration Facilitates the Recovery of Macroinvertebrate Abundance, Diversity, and Composition in Estuarine Communities

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Globally, oysters have declined 85% over the past two centuries, jeopardizing their productivity and habitat function within estuarine systems. In response, scientists have employed oyster reef restoration as a means to reverse this trend. Yet, we understand little about the impact of restoration on ecologically valuable organisms utilizing these habitats. Macroinvertebrates were collected from restored, live, and dead reefs to elucidate the impact of restoration on these communities. Species diversity and composition on restored reefs shifted towards states similar to live reefs within 12 months of restoration. The recovery of species abundance occurred within 18 months. The results presented herein quantify the effect of restoration on resident macroinvertebrates and provide timelines of recovery for each attribute of these communities. Furthermore, this study presents an actionable framework for identifying single-species metrics of restoration success. The application of this framework will provide scientists with tools to improve the efficiency of post-restoration monitoring.

Seagrass Impacts on Predator and Forage Fish Dynamics in the Indian River Lagoon, FL

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From 2011-2013 an algal bloom occurred throughout the Indian River Lagoon (IRL), causing major seagrass die-offs. These harmful algal blooms (HABs) are now commonplace within the IRL, threatening the complete loss of seagrass as Essential Fish Habitat. Little is known about how this loss of seagrass will impact economically important predators and their forage fish prey in the IRL. Using abundance and environmental data collected by Florida's Fisheries-Independent Monitoring program, we evaluated the influence of abiotic variables and seagrass habitat on predator and forage fish abundance and distribution, with particular emphasis on the reduction of seagrass habitat after the 2011 HABs. Study findings suggest the loss of seagrass habitat has variable impacts on the abundance and distribution of predators and their

prey over various temporal and spatial scales. The results of this study will aid IRL resource managers in developing management strategies that help maintain recreationally important fish populations.

Does *Sargassum* Macroalgae Affect Mangrove Growth?
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Global climate change has led to a proliferation of pelagic *Sargassum* macroalgae with a subsequent increase in the amount that strands in coastal habitats in tropical and subtropical regions. These macroalgae blooms pose a major threat to public health and economic development, in addition to the health of coastal ecosystems. Mangroves are located in the coastal niche that *Sargassum* can strand in and decaying *Sargassum* biomass may increase the availability of nutrients and heavy metals in these systems. In this study, we quantified *Avicennia germinans* seedling growth under varying *Sargassum* densities (0, 50, 100, 150, and 200 g) in a mesocosm experiment. Preliminary results suggest that increases in *Sargassum* density increase mangrove growth (height, internodes, branching). The nutrient input provided by decaying *Sargassum* may help to alleviate nutrient limitation, thereby altering biomass allocation of these important foundation species.

Observations in Model Ecosystem Aquariums as Mesocosms
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Within established model ecosystem aquaria, there are opportunities to observe behaviors and interactions that are, at best, seldom seen in the wild. Having modeled several aquaria after Florida ecosystems, there has been an opportunity to observe multiple of these interesting events as the exhibits can be used as a refuge for species that are rarely seen or considered uncommon. In the exhibits it's been observed that filefish prey on sea hare species, particularly *Bursatella* spp. by biting off their villae, but are also exceptionally good at keeping *Aiptasia* anemones curbed. It's also a regular occurrence for the seagrass in the seagrass exhibit to saturate the tank with oxygen by about 11 a.m. every day. Some seastars can act more as predators than scavengers, and mud crabs may prefer eating fiddler crabs. It's worth pondering if some of these events are worth further research.

Plastic Pellet Pollution on Florida's Space Coast
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Plastic pellets, also known as nurdles, are primary microplastics forming the basis of the plastic production economy. Nurdles are lost to the environment through transport and manufacturing processes. The spatial and temporal distribution of plastic pellet pollution on Space Coast beaches was investigated using 15-minute searches which included community participants. Temporal trends indicated the importance of storm events in bringing nurdles to shore. Spatial trends indicated similar abundance of nurdles geographically. Education was an important component of this study and nurdle hunts were useful for engaging students and adults. Transfer of plastic pellets to the Indian River Lagoon is possible but appears to be minimal based on published microplastic studies in the IRL and thus impacts likely limited to seaward facing beaches and the sandy shore community.

Bird Interactions with Oyster Reef Restoration Materials Using Wildlife Trail Cameras

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Wildlife cameras are a useful tool for monitoring animals following habitat restoration. We used them to document coastal bird species, behaviors, and how they interacted with different types of oyster reef restoration materials. We hypothesized birds would not be negatively affected by plastic-free, restoration materials. Cameras were placed on different oyster reefs in Mosquito Lagoon: 1) restored with cement-jute tiles, 2) with cement-jute patties, 3) with BESE mats, 4) natural reefs, and 5) dead reefs. 27,169 total video clips were recorded from May to August 2021 that included both pre- and post-restoration. 13 bird species were identified. Most common behaviors were loafing (60%) and foraging (23%). Most behaviors were observed on dead reefs (43%). Interaction with materials represented 0.1% of behaviors during both pre- and post-restoration, with no observations of direct avoidance. Observing how birds interact with restoration materials is important in determining their suitability for future habitat restoration.

Water Quality Modeling, a Simple Box Model Theory, and Its Applications in a Shallow Subtropical Estuary in Florida

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Analytical solutions were developed from a simple box model for nutrients and phytoplankton under the assumptions of steady flow and loading conditions and first order kinetics. The solutions consist of a steady state solution and non-steady state solution. The steady state solution is a typical mixing equation for a conservative constituent modified by the first order kinetic rate. For phytoplankton, the non-steady solution is an exponential growth or decay depending on the difference between the net growth rate (k) and the flushing rate (f). The solutions were applied to the St. Lucie Estuary (SLE) for the period from 1999 to 2017. Modeled and observed R^2 ranged 60-70% for nutrients and 45% for chlorophyll-*a*. Results highlight the importance of residence time, transport and mixing in moderating nutrients and external sources of phytoplankton from upstream.

Planting Seeds: Shifting Hands-on Service Learning to Highlight Lagoon and Upland Connectivity

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The community surrounding the Indian River Lagoon is eager for restoration; however, successful estuarine restoration often requires vigorous research and largescale elements inappropriate for small groups of citizens. To effectively utilize community engagement in lagoon restoration, Indian River Lagoon Aquatic Preserves established a coastal native plant pollinator garden to promote estuarine friendly landscaping and highlight lagoon-upland connectivity. The roadside public demonstration site adjacent to the lagoon showcases the benefits of upland habitat enhancement for native pollinators and lagoon health. The project established by volunteers engages the community in perpetuity via maintenance and monitoring. Similar small-scale upland projects can be useful to provide hands-on service-learning opportunities focusing attention to sources of lagoon degradation.

Connecting the Dots: Using DNA Barcoding to Explore the Biodiversity and Distribution of Infauna in the Indian River Lagoon System

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Infaunal invertebrate communities are anchored in the benthos and highly responsive to environmental change, making them informative benchmarks of ecosystem health. Since 2005, the Benthic Ecology Lab at the Smithsonian Marine Station has collected infauna, along with water and sediment quality data, at 209 sites from the Mosquito Lagoon to the St. Lucie Estuary. A DNA barcoding initiative was launched in 2020 to supplement ongoing morphological identification and enhance our knowledge of infaunal biodiversity and distribution in the Indian River Lagoon watershed. During this initial effort, 140 specimens from 8 phyla were barcoded using the COI gene. Our collections included both sensitive and opportunistic taxa from different functional groups, non-native species, and new records for the Indian River Lagoon Species Inventory. Here we present details on how we pair molecular and traditional morphological approaches to study estuarine infauna and our plans to share these data with the community.

Prevalence of the Indicator Bacteria, *Enterococcus* species, and Their Antibiotic Resistance in Indian River Lagoon Fish

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An increasing population and degradation of wastewater infrastructure systems have resulted in sewage discharges containing infectious microorganisms, including antibiotic-resistant bacteria into the Indian River Lagoon (IRL). The fecal indicator bacteria, *Enterococcus* species, are opportunistic pathogens that can also be resistant to antibiotics. In this study, we isolated *Enterococcus* spp. from the feces of six IRL fish species with different feeding behaviors. *Enterococcus* prevalence was 43% (n=97), with significantly higher prevalence (53%) in bottom feeders. Among the *Enterococcus* isolates, the highest prevalence of antibiotic resistance was found against quinupristin-dalfopristin (21%), followed by erythromycin (10%) and tetracycline (6%). Multidrug-resistant isolates were only found in bottom feeders. Our findings indicate that feeding behavior and/or physiology influences the colonization of *Enterococcus* spp. in the intestines of fish and suggests that bottom feeders might serve as reservoirs of antibiotic resistant bacteria, threating both human health and the health of the IRL ecosystem.

Novel Generation of Benthic Flux Data: Implications for Large-scale Sediment Monitoring in the Indian River Lagoon

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We have developed and tested an autonomous benthic lander that provides critical in situ insights into diagenetic processes that influence aquatic ecosystem health and functioning. The lander facilitates the measurement of, for example, total water column/sediment oxygen demand, benthic nutrient fluxes, benthic water quality, and sediment diagenetic conditions (i.e., oxygen, iron, and sulfur cycling). A test of the lander was conducted in the Indian River Lagoon (IRL) and demonstrated intense nutrient fluxes. Moreover, dissolved oxygen consumption was not only linked to respiration but also to the oxidation of hydrogen sulfide fluxes, a potentially underappreciated IRL oxygen sink. Ultimately, we envision the lander being

used to probe a wide array of ecological problems that burden the IRL including HABs, eutrophication, and hypoxia.

Predicting Responses of Fishes to Changes in Water Quality in the Indian River Lagoon

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It is well known that the covariation between fish physiology and environmental conditions is high. To inform programs designed to restore the health of fish habitats in key areas of the Indian River Lagoon (IRL), we developed fish population models using historical data to predict potential changes in fish distribution and abundance in response to changes in environmental conditions in the IRL. These models were then used to build predictive models that enable simulation of fish population responses to projected water quality changes. Investigations into the dynamic relationship between fish populations and harmful algal blooms (HABs) were also initiated. Salinity, temperature, and dissolved oxygen, among all the physical parameters collected along with fish abundance, consistently emerged as the key determinants of fish community structure in the IRL. Model projections suggest a complex, species specific response to water quality in the IRL, with several species increasing and several decreasing in abundance over a known period. Although these retrospective models are powerful predictors of observed, historical data, they are limited to only being able to predict changes within the realm of what has been seen in the IRL in the past. Future studies designed to advance these models and increase our ability to predict future conditions as well are discussed.

Connecting Environmental DNA Profiles to Community Diversity Assessments: An IRL Case Study

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The Indian River Lagoon (IRL) hosts critical aquatic habitats that support significant biodiversity in addition to the well-being of coastal communities through a multitude of ecosystem services. Understanding how ecological communities within these ecosystems respond to stressors is key to management and conservation. Environmental DNA (eDNA) sampling is growing in popularity as a fast, cheap, non-destructive method of censusing biodiversity, but it is unclear how eDNA sampling methods may bias their resulting metabarcoded community profiles. We sampled eDNA from the St. Lucie Estuary and southern IRL at five long-term benthic monitoring stations to assess the effect of filter size and barcode choice on the diversity detected from surface waters. Benchmarking these data to traditional samples, such as infaunal surveys using benthic grabs, will inform the future deployment of eDNA as a management and conservation tool.

Changes in Light Availability and Benthic Macrophyte Cover in the Indian River Lagoon

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The decline of the overall health of the Indian River Lagoon (IRL) is evidenced by increased macroalgal blooms, phytoplankton blooms, seagrass losses, and wildlife mortalities. The aim of this study was to increase our understanding of these ecosystem shifts by investigating the relationship between benthic macrophytes, phytoplankton, and light limitation. Chlorophyll *a*, light attenuation (K_d), and benthic cover

of macrophytes (seagrass and macroalgae) was monitored at four sites in the IRL in 2021. Water clarity and benthic macrophyte cover was highest in the spring. Macroalgae were the dominant macrophytes while little seagrass was observed. Loss of benthic macrophyte cover was observed in the fall following periods of increased chlorophyll *a* and decreased water clarity over the summer months. These fluctuations may result in loss of habitat and food resources for larger animals and contribute to wildlife mortalities.

Microplastics in the Waters and Sediments of the Indian River Lagoon

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Plastics are ubiquitous on Planet Earth. Once the production of plastics ramped up in the 1950s and the costs of manufactured plastics was greatly reduced, the numbers of macroplastic and microplastic (<5 mm) pieces of debris began to increase and continues to increase on land and in the water. Estuaries, in particular, are microplastic hotspots and many animals have reduced survival, growth, and reproduction as a result of consuming microplastics. Our goal is to understand the abundance and diversity of microplastics in the surface waters and surface sediments of the Indian River Lagoon. Specifically, we will compare areas where living shoreline stabilization has occurred vs control areas with limited erosion. We will provide data from replicate sites, including microplastic densities, fragment dimensions, and colors (as a proxy for polymer type). To obtain a global understanding of microplastics in estuaries, we need as many studies of this type as possible.

IRL Connectivity *ad infinitum* versus Key Connections

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A basic tenet of ecology is that everything is connected to everything else. In the extreme, this can lead to absurdity. As an example, I'll show how seagrass is ecologically connected to St. Augustine grass, snowbird migration, and hamburgers. The key task, however, is determining and quantifying the most ecologically meaningful connections.

Development of a Numerical Model for Hg transport and transformation in the Indian River Lagoon for Understanding the Impacts on Wild Dolphin

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Exposure to mercury (Hg) in coastal waters presents a serious health risk to apex predators including bottlenose dolphins and humans. Previous studies have documented that Hg concentrations in the skin and blood of bottlenose dolphins in the Indian River Lagoon (IRL) were among the highest reported worldwide. Yet to date we have very limited information of in-water Hg distribution in the lagoon. To address this, we developed a simple Hg transport and transformation model and coupled it with an existing hydrodynamic-biological model that simulates the water movement and basic nutrient and planktonic processes in the IRL. The formulations of Hg transformations follow the EPA WASP model, which includes three groups: elemental mercury (Hg0), total mercury II (HgII), and total methylmercury (MeHg). The model incorporates atmospheric, river, and sediment Hg inputs based on limited field observations. Preliminary model results for a one-year (2015) simulation are presented and implications are discussed.

Variable Species Response to Environmental Fluctuations within an Urbanized Estuary

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Recently, the waters of the southern portion of the Indian River Lagoon (IRL) and St. Lucie River (SLR) have suffered from multiple stressors. Discharges from Lake Okeechobee into the SLR, and corresponding harmful algal blooms, have damaged seagrass beds and negatively affected the health of this important ecosystem. The degradation of seagrass beds and loss of mangrove habitats due to urbanization have altered recruitment patterns and assemblages of important fish species that support recreational and commercial fisheries. Spotted Sea Trout (n=30), Sheepshead (n=20), and juvenile Goliath Grouper (n=30) were implanted with acoustic tags in both the IRL and SLR to investigate the effects of salinity and temperature changes on the movement patterns and habitat use of these species. The results of our research will provide critical information for management decisions on restoration efforts and water quality control measures to aid in improving the health of the lagoon.

Assessing the Habitat Usage and Movement Patterns of Juvenile Atlantic Tarpon (*Megalops atlanticus*) Associated with Mosquito Impoundments in the Southern Indian River Lagoon

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Proper nursery habitat is essential for the recruitment and survival of fish species. The Jensen Beach Impoundment (JBI) has been identified as an area of use by juvenile Atlantic Tarpon. These fish endure extended periods of low dissolved oxygen content and fluctuations in salinity that can occur when impoundments are closed. JBI is currently an open system during restoration, and juveniles can move within the system freely. Juvenile Tarpon (n=4) and Common Snook (n=1) were tagged with acoustic tags. Acoustic receivers were arranged to increase the likelihood of detecting fish moving in and around the system. The goal of this study is to assess the value of JBI as a nursey habitat for juvenile Tarpon, determine size composition, movement patterns, and habitat preferences of fish that use the impoundment, and to evaluate how restoration efforts will affect recruitment, residency, and timing of emigration of these fish to other habitats.

Monitoring Phytoplankton Communities to Document the Impacts of Estuarine Restoration Efforts

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Eutrophication in the Indian River Lagoon estuary is driving harmful algal blooms. Some lagoon restoration efforts are intended to neutralize/dilute nutrients or remove nutrient sources. While experimental restoration efforts are underway, phytoplankton communities need monitoring to document critical responses to changes in nutrients and other aspects of water quality. One proposed water quality restoration project is restoring lagoon inflow, which would add coastal water to the Banana River Lagoon (28°24'24N, 80°38'17W) to react with, dilute, or displace excess nutrients. Phytoplankton communities are being monitored near the proposed inflow site to establish a baseline of community composition and bloom dynamics. Control sites away from the proposed inflow site are also being monitored. These baseline data will allow for comparisons with phytoplankton communities as coastal inflow or other projects are undertaken, with the primary objective being to identify positive and negative impacts of restoration efforts.

Preliminary Smalltooth Sawfish Data from the Southern Indian River Lagoon: Is a Nursery Re-establishing?

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Historical data show that the Indian River Lagoon (IRL) once acted as a nursery for the endangered smalltooth sawfish, *Pristis pectinata*, and supported large numbers of individuals from multiple life stages. However, the species was extirpated from the estuary by the mid-20th century. In the last several years, the U.S. Sawfish Recovery Hotline (1-844-4SAWFISH) has received increased numbers of reports from the public in the southern IRL. As a result, 12 sawfish have been tagged by permitted researchers in the southern IRL, including 7 small juveniles. We will summarize preliminary acoustic monitoring data from the southern IRL and compare with habitat use patterns from well-established nurseries. Continued reporting by the public, together with scientific research (e.g., sampling, acoustic monitoring, genetic analyses) will help us learn more about the re-emerging importance of the IRL to the population of smalltooth sawfish found in Florida waters.

The Microbial Diversity of the IRL from a Metagenomic Perspective

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The microbial diversity of the IRL may hold the key to understanding HABs that exacerbate poor water quality. In this study, we investigated the spatiotemporal variation of microbial communities in the IRL during wet/dry seasons and HABs. Metagenomic DNA from microbial cells >0.45µm were shotgun sequenced and *de novo* assembled to produce functional and taxonomic profiles and MAGs. Chao-1 richness estimates 3,984 microbial species in the IRL—comparable to other estuarine systems. The core microbial community of the IRL is composed of 36 taxonomic groups (13 bacteria, 7 viral, 7 eukaryotic, 9 archaea). Interestingly, viral reads made up 13% of the dataset and were located at every site, suggesting extensive microbial viral infections. Many cyanophages were identified, including from the rare Siphoviridae family, which may be controlling lysis of toxic cyanobacteria. Overall, our study sheds light on IRL microbial diversity and distribution, and the role viruses play in HABs.

Environmental Hypoxia in the Indian River Lagoon (IRL) and Its Effects on Native Fish Species during Early Development

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The Indian River Lagoon (IRL) is the most biologically diverse estuary in North America. However, the distribution and intensity of hypoxia (low dissolved oxygen, DO) is increasing due to eutrophication, algal blooms, etc. Effects of coastal hypoxia are well-studied in adult fish, yet gaps of information remain in terms of early life stages, including potential consequences to the development, hatching success, or future recruitment of economically important native species. These include Florida pompano, red drum, snook, and grey snapper. To test effects of severe hypoxia, fertilized eggs will be incubated in 10, 20, and 100% DO saturation. Lipids will be extracted and separated into neutral (used for energy) and polar (used for membranous development) fatty acids. Concentration of fatty acids will inform us of the potential effects of severe hypoxia on energy demand and membrane remodeling. A decrease in hatch rate, survival, and development under severe hypoxia treatments is expected.