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Spatial Patterns and Habitat Structure Influence on Seagrass Invertebrate Communities Across the Florida Keys

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Seagrasses are a foundational coastal ecosystem, maintaining several key ecosystem functions such as providing valuable foraging grounds for a diversity of consumers. Invertebrate communities are an essential element of seagrass ecosystems due to their ability to transfer energy from primary producers to higher-level consumers, subsequently increasing seascape connectivity through trophic linkages. Yet, despite their key role as secondary producers, tropical seagrass invertebrate communities are largely understudied. Here, we conducted a series of seagrass habitat structure and benthic invertebrate community surveys across the Florida Keys National Marine Sanctuary (FKNMS) to increase our understanding of the proximate drivers shaping seagrass invertebrate communities across tropical ecosystems. Preliminary analyses suggest that invertebrate density exhibits the strongest positive correlation with seagrass canopy height in comparison to other seagrass structure metrics (shoot density). Invertebrate density also varies spatially across the FKNMS, with significant differences between the upper, middle, and lower regions, indicating that broader environmental factors may also influence patterns of invertebrate abundance. Currently, seagrasses and their associated invertebrate communities are at risk due to rapidly changing environmental conditions, therefore understanding the drivers of variation in invertebrate density will be crucial to predict how critical ecosystem functions may change in the future.

Spectroscopic Tracking of the Dissolved Organic Carbon (DOC) Conversion to Carbon Dioxide (CO_2) for Isotopic Analysis and Carbon Fate Tracking

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Dissolved Organic Carbon (DOC) quantification of isotopic ^{14}C and $\delta^{13}C$ using Accelerator Mass Spectrometry (AMS) and Isotope Ratio Mass Spectroscopy (IRMS) plays a critical role in understanding carbon cycling between terrestrial and aquatic ecosystems. Research studies over the past few decades have contributed to a deeper understanding of the carbon cycle and may suggest residence time of the organics in water when used as a relational tool to interpret hydrogeologic differences for water resource management in aquifers, groundwater dependent ecosystems, Blue Carbon ecosystems, and landfill leachates. However, accessing the DOC pool can be challenging due to the halogen ion (e.g. Cl^-, Br^-, Fl^-, etc.) species present in natural coastal waters. Here, we present spectroscopic tracking of the photomineralization of DOC using UV oxidation (UVox) from a medium pressure mercury lamp along a surface freshwater to marine water gradient collected in South Florida. The UVox photochemical conversion efficiency and real-time tracking of product CO_2 and CO gases using a halogen trap were determined via Ultraviolet-Visible (UV-Vis) and Cavity Ring Down Spectroscopies (CRDS). Additionally, a thermal stress test was conducted with two recommended bottle types and filters of different pore sizes. It confirmed that there was little variation between Nalgene HDPE and amber glass bottles, regardless of filter pore size, in how effectively they served as water storage containers without the risk of leaching or contaminating samples due to long-term heat stress. Such novel tools allow for a deeper understanding of coastal resilience and can be used in concert with other carbon species (CH_4, Dissolved Inorganic Carbon, and carbon bearing sediments) to predict and respond to disturbances in the carbon cycle that threaten the health of coastal ecosystems.

Novel Methods for Tracking Shell-Crushing Predation in the Florida Keys

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The effects of large, mobile predators on marine benthic communities remain unclear in many coastal ecosystems. While dynamic and challenging to study, key behaviors such as shell-crushing predation can be used as proxies of ecological interactions for molluscivorous species (crabs, fishes, turtles, etc.). Additionally, due to the highly audible nature of this process, these elusive interactions can be captured in real-time using passive acoustic technology. In this presentation we recount our recent (2023–2025) research efforts to assess the dynamics of this process in the Upper Florida Keys, targeting queen conch (*Aliger gigas*) aggregations in back-reef habitats. There, passive acoustic recorders were deployed and paired with underwater time-lapse cameras, both of which provided near-continuous monitoring of the surrounding environment over an approximately 2-week period. Thus far, our recorders have successfully documented foraging in multiple species including the whitespotted eagle ray (*Aetobatus narinari*) and nurse shark (*Ginglymostoma cirratum),* with confirmed predation on queen conch by loggerhead sea turtles (*Caretta caretta*). These validated predation events are providing acoustic “templates” to facilitate the development of detection-classification systems to identify additional predation events that cannot be confirmed with camera footage (e.g., nighttime). Such developments will enable us to study predation patterns over broad temporal and spatial scales. Many shell-crushing predators regurgitate shell fragments after foraging events, so we have also been opportunistically collecting these regurgitates for forensic analysis. This aspect entails swabbing fragments for trace predator DNA (presumably shed from the buccal cavity during consumption), which we have developed proof-of-concept for in captive experiments. Taken together, we hope our multi-faceted approach will support unprecedented opportunity to study patterns of predation on queen conch and other shelled invertebrates in the Florida Keys and beyond.

Development of a Comprehensive Decision Support System for Florida's Coral Reef

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Florida's Coral Reef has experienced a series of widespread disturbances, including an extreme heating event and lethal coral disease outbreak. The loss of coral cover across the reef has led to a large investment in management and restoration activities. In response, the Florida Fish and Wildlife Research Institute, Nova Southeastern University, and The Spatial Collaborative have developed the Coral Reef Decision Support System (CRDSS) — a modern, scalable, and interactive tool for coral reef conservation and restoration planning. A decision support system is built to access and leverage information — containing a combination of raw and derived data, documents, and personal knowledge. The CRDSS is built on the SeaSketch platform, a cloud-based system for spatial planning customized to support the selection, evaluation, and documentation of restoration sites across the full extent of Florida's Coral Reef. Construction of the tool within SeaSketch allowed for the rapid deployment of core GIS functionality and a greater focus on the development of customized features. The platform equips managers, scientists, and practitioners with tools for data visualization, interactive filtering, sketch-based site planning, and automated reporting. These features collectively enable a rigorous and collaborative decision-making environment where inputs can be saved and shared for replicability and transparency. At the heart of the CRDSS is a high-resolution, hexagon-based planning grid (using Uber's H3 spatial index), which supports real-time, sub-second analysis across 7.4 million planning units. A custom-built filtering engine, powered by the DuckDB analytical database, allows users to interactively explore and isolate potential restoration areas based on physical, ecological, and human-use criteria. To support site-specific planning, CRDSS users can digitize restoration areas directly on the map. Each polygon is automatically analyzed against a suite of data layers, with tailored reports summarizing conditions such as depth, habitat type, and nearby human impacts. This process enables users to evaluate sites quickly and refine their plans based on immediate data-driven insights. The CRDSS represents a significant advancement in Florida's reef restoration toolkit and provides a foundation for more data-informed, transparent, and collaborative restoration strategies.

Tracking Sea Turtles with Photos: A Citizen Science Photo-ID Initiative in the Florida Keys

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Understanding the movement and site fidelity of sea turtles is critical for effective conservation, particularly in heavily visited reef ecosystems like those of the Florida Keys. Traditional methods for monitoring individual turtles, such as tagging or telemetry, can be invasive, costly, and logistically complex. To address these challenges, we launched a novel photo-identification (photo-ID) project that combines citizen science and machine learning to monitor individual sea turtles in a non-invasive, cost-effective manner. Divers and snorkelers are invited to submit photographs of sea turtles encountered during their time on the reef. Submitted images are processed using software that employs machine learning algorithms to identify individuals based on the unique scale patterns on the sides of their heads—akin to a fingerprint. This approach allows us to build a growing catalog of identified turtles and track their presence, re-sightings, and movement patterns over time. While data collection is ongoing, the project has already garnered strong interest from the diving community and has established a workflow for photo submission, quality control, and image processing. This framework creates the foundation for a scalable, community-powered monitoring program with the potential to improve our understanding of turtle residency, movement, and site fidelity across the Keys. Our poster will outline the project design, software tools, citizen engagement strategies, and future plans for data analysis and ecological interpretation. This work demonstrates how emerging technologies, and public participation can be combined to advance sea turtle research and conservation in dynamic reef environments.

Florida's Marine Aquarium Fishery: Integrating Regulatory Strengths with Fisher Engagement for Coral Reef Conservation

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Florida's coral reefs and associated marine aquarium fisheries are under increasing pressure from climate change, population growth, coastal development, pollution, runoff, and resource extraction. Recent restrictions and closures of marine aquarium fisheries elsewhere highlight the need for robust, adaptive management frameworks to ensure both ecological sustainability and socioeconomic viability in Florida. This presentation synthesizes a comparative regulatory assessment of Florida's commercial marine aquarium fishery with an innovative fisher engagement initiative designed to bolster reef resilience. Our regulatory analysis reveals that Florida, through the Florida Fish and Wildlife Conservation Commission (FWC), has developed one of the world's most comprehensive management systems for marine aquarium fisheries. This system employs a limited-entry framework, co-management with fishers, spatial and temporal closures, gear and catch restrictions, and rigorous fisheries-dependent and -independent monitoring programs. The majority of aquarium fish taxa demonstrate stable or increasing catch-per-unit-effort (CPUE) and abundance trends, contrasting with the depletion of under-managed fisheries seen in other major source countries. Moving forward, the fishery can benefit from an assessment of the economic impacts of the regulatory framework on its fishers, a statewide fisheries management plan specific for the fishery, the further development of a comprehensive program for fisheries data collection and analysis to address data gaps, an assessment of resources at hand and those needed to implement these recommendations, and the elevation of marine aquarium fisheries for support at the national level to support state-level management. Building on this regulatory foundation, our Florida Fisher Engagement Program offers a holistic, value-chain approach to further strengthen reef conservation outcomes. The program seeks to empower fishers with additional professional training in best practices for animal husbandry, handling, and transport. By shifting from a volume-driven to a value-driven market paradigm, we aim to incentivize fishers to improve efficiency, reduce post-capture mortalities, and command premium prices for higher-quality, well-cared-for livestock. This approach not only enhances fisher livelihoods and business viability, but also reduces fishing pressure on wild populations, allowing critical reef species to continue providing essential ecosystem services that underpin coral recovery and resilience. Together, Florida's strong regulatory framework and participatory engagement initiatives offer a scalable model for balancing conservation and livelihoods in marine aquarium fisheries. By integrating adaptive management with fisher empowerment, Florida is charting a path towards a sustainable value chain for marine aquarium fisheries in the face of accelerating environmental change.

Length-Based Risk Analysis of Management Options for the Southern Florida USA Multispecies Coral Reef Fish Fishery

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Exploitation impacts and management options for 15 coral reef fish species central to the commercial and recreational fisheries of the southern Florida USA coral reef ecosystem were evaluated using a length-based risk analysis (LBRA) framework. Population abundance-at-length composition data were obtained from several regional federal-state sampling programs. These updated life history demographic data were integrated into a length-based numerical cohort model to generate LBRA fishery sustainability metrics from a probabilistic perspective. Three of five groupers, eight of eight snappers, and two of two grunts were below the 40% spawning potential ratio (SPR) stock sustainability minimum; ten of these stocks are at < 20% of their historical spawning biomass, some as low as 5%. Therefore, to ameliorate overfishing for the 13 stocks with sustainability risks ≥ 98%, fisheries management requires increased minimum sizes of first capture (*Lc*) and significant reductions in fishing mortality (*F*). To achieve sustainability and reduce sustainability risks, area-time protections are also needed. While lack of data often limits the evaluation of management options, this paper establishes benchmarks from which data-limited approaches can move forward. In addition, the approach can be used to cross-check other data-rich analyses. A goal of this work is to effectively balance sustainability risks with fishery production to mitigate overfishing likelihoods and to increase the probability of sustainable fisheries.

Mesoconsumer Trophic Linkages Across Reef-Seagrass Seascapes Within Sanctuary Preservation Areas in the Florida Keys

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Tropical marine ecosystems comprise of mosaic habitats, and many fish species move across these complex seascapes for various reasons, including foraging. Sanctuary Preservation Areas (SPAs) within the Florida Keys are explicitly designed to protect fish populations but currently protect only a fraction of seagrass compared to reef and hardbottom habitats. However, many reef fish species targeted by SPA fisheries management plans have been shown to extensively forage on surrounding seagrass beds, functionally linking reef-seagrass systems. This study investigates four reef mesoconsumers trophic dynamics and examines their reliance on seagrass derived energy sources. Fin clips of four target species and basal energy sources (i.e., seagrass, macroalgae) were collected and sampled for stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$). These data were incorporated into Bayesian mixing models to quantify each mesoconsumers relative basal resource contribution. Further, the model's output was used for a hypervolume niche analysis to assess trophic niche properties. Results revealed that reef mesoconsumers exhibited distinct trophic positions, with Great Barracuda occupying the highest trophic level, followed by Mutton Snapper, White Grunt, and Yellowtail Snapper. Bayesian mixing model analysis demonstrated that all four species showed greater reliance on inshore seagrass resources (flats seagrass) compared to offshore seagrass located closer to reef areas. Great Barracuda showed the highest contribution from flats seagrass (~40-50%), while Yellowtail Snapper displayed the most diverse diet with significant contributions from multiple sources including mangrove, flats seagrass, and reef resources. Trophic niche size analysis revealed species-specific patterns, with some species exhibiting broader niche breadths than others, indicating varying degrees of dietary specialization. These findings demonstrate that reef mesoconsumers depend more heavily on seagrass resources located farther from reef zones, suggesting that effective SPA conservation strategies should expand protection to include inshore seagrass habitats. Further, identifying mesoconsumers niche space allows a better understanding of their resource utilization, identifying niche overlap, and inferring trophic relationships.

The Dance of Death Returns: Keys Spinning Fish Event, Historical Context, and Overview from FWC

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Abnormal swimming behavior of marine fish described as spinning has long been observed in South Florida, often in association with exposure to brevetoxin, the neurotoxin produced by the Florida red tide organism, *Karenia brevis*. However, red tide was not associated with an event that gained public attention in the early 1970's when large numbers of fish in areas of Biscayne Bay were reported to twirl and die, a behavior sensationally dubbed the "Dance of Death" by the contemporaneous national media. Researchers of the day arrived at conflicting conclusions, blaming either algal toxins or bacterial brain infections, and ultimately no cause was definitively identified. Later in that decade, the Dance of Death returned to Biscayne Bay on a smaller scale, and isolated cases of spinning have been documented periodically over the ensuing years, but 2023 saw the beginning of an even larger-scale, longer-lasting, spinning fish event in the Florida Keys. In 2024, the event became further noteworthy because it involved mortalities of critically endangered smalltooth sawfish that, for a period of months, died at rates well above any previously documented for this species. The FWC Fish Kill Hotline and Sawfish Hotline reporting apparatus played a critical role in promoting collaborative scientific response to the event by compiling and harnessing public report data to track temporal and spatial distribution of cases in a statewide context and disseminate timely information to partnering agencies, researchers, and lawmakers. Further, FWC scientists specializing in aquatic animal health, toxicology, harmful algal blooms, and sawfish biology were instrumental in narrowing the focus of inquiry by helping to essentially rule out acute water quality problems, red tide, and communicable pathogens as suspected causes. A growing body of evidence supports the hypothesis that the recent abnormal swimming behavior was the result of exposure to neurotoxins produced by microscopic algae other than *K. brevis*, but this has not been fully resolved, and collaborative investigation continues.

Spatiotemporal Analyses of the Biological Condition Gradient Model on Florida's Coral Reef

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Historically, Florida has experienced major stressor events that have increased coral mortality through time. Major stressors take the form of either anthropogenic or natural events such as massive bleaching events, disease outbreaks, port expansion projects, and sewage outfalls, which prompt the need for the development of a management tool to can rapidly assess the condition of Florida's coral reefs. A conceptual model known as the Biological Condition Gradient (BCG) was adopted for use on coral reefs as the frequency and scale of these various stressors has been gradually increasing over time making it inherently difficult to track and effectively manage. The BCG relates biological condition to increasing levels of anthropogenic stress and can be used to identify biological attributes and measurable increments of change from biological condition assessments. Narrative qualitative rules from the consensus of grading reef condition by a diverse expert panel provided a framework for developing quantitative rules using long-term monitoring program data from 1996-2024. The expert panel prioritized characteristics related to species size-structured abundance, benthic habitat composition, and community structure that assisted in forming the foundation for the numeric decision-making rules that drive the BCG's scaling system. Numeric rules were then combined in the BCG expert decision model which accurately and transparently replicates the decisions that the experts expressed during review of the coral samples. The BCG model was run on the first set of historical data from 2005-2021, which was graded at each site by the model on a numeric 1-6 scale based on anthropogenic stress levels. Level 1 on the scale is representative of an entirely pristine, undisturbed environment while level 6 reflects sites with extreme environmental stress due to major changes in biotic structure along with major losses of ecosystem functions. This project will be utilizing newly collected monitoring data from 2022 through 2024 and running it through the BCG model to get updated scores for further spatiotemporal analysis of the BCG assessments to elicit broader patterns of reef conditions across the system through time. To help justify some of the differences exhibited in scores, other long term historical environmental data such as temperature and water quality data, will be statistically tested against the BCG scores to help explain some of the differences seen in the scores through time. The historical and current BCG scores will also be spatially analyzed to identify consistent disturbance zones, that otherwise would not have been distinguishable without the use of this model, to better direct restoration activities.

The National Coral Reef Monitoring Program's Environmental Monitoring in the Florida Keys National Marine Sanctuary

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The National Coral Reef Monitoring Program (NCRMP) was established in 2013 by the National Oceanic and Atmospheric Administration (NOAA) to monitor the status and trends of coral reefs across US jurisdictions in both the Atlantic and Pacific, including fish communities, benthic composition, environmental drivers and impacts, as well as socioeconomic indicators. NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) is responsible for the environmental components of this monitoring within the Atlantic and Caribbean, including South Florida and the Florida Keys. Here, we will provide an overview of the monitoring efforts and share some of the research produced from this data. This monitoring is organized according to a tiered approach to capture both spatial and temporal variability. To describe spatiotemporal trends in ocean acidification and carbonate chemistry in the Florida Keys, water samples are collected every two months at 38 sites across the reef tract. Samples are analyzed for dissolved inorganic carbon (DIC), total alkalinity (TA), and pH (total scale), which are used to solve the carbonate system. To characterize higher frequency variation in carbonate chemistry (e.g., diel and episodic fluctuations), a MAPCO2 buoy at Cheeca Rocks measures the partial pressure of carbon dioxide (pCO2) every three hours. Spatiotemporal variation in temperature is assessed using subsurface temperature recorders (STRs), which are programmed to collect high-precision temperature measurements every five minutes at four different depths (1-25m) in each of five biogeographic regions (Biscayne National Park, Upper Keys, Middle Keys, Lower Keys, and Dry Tortugas), encompassing a total of 24 sites. Finally, reef ecosystem responses to these environmental drivers are assessed using an array of metrics known to be sensitive to acidification and temperature. Changes in benthic community composition and reef structure are quantified using landscape photomosaics and diver-based carbonate budget surveys. Environmentally sensitive biological processes underlying these trends include coral growth and bioerosion. The growth rates of five species of reef-building coral are quantified using coral cores, which are CT-scanned to determine linear extension, density, and calcification. Bioerosion is quantified using micro-CT scans of bioerosion monitoring units (BMUs) at 12 sites throughout the Florida Keys. All monitoring data, including environmental conditions as well as biological responses, are compiled into regional assessments that provide an overview of the status and trends of reefs in the Florida Keys National Marine Sanctuary. They are also used for a variety of management-relevant science projects that aim to synthesize and project reef ecosystems persistence. This data is publicly available and provides an opportunity to further our understanding of Florida's Coral Reef.

The Aquarius Coral Reef Observatory: A Flexible Remote Sensing Solution for the Florida Reef Tract

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Monitoring spatiotemporal patterns of environmental conditions in sensitive marine habitats – such as the Florida Reef Tract – is critical for informing conservation, restoration, and adaptive management strategies. In recent years, the advancement of remote sensing technologies has improved our capacity to reliably collect data over extended time periods at lower costs; the perfect solution for efficient environmental monitoring. Improvements in battery performance, communication solutions, sensor accuracy, and onboard processing have also driven down cost while simultaneously expanding potential applications. More than ever, designing affordable remote sensing networks with real-time communications is possible, providing an opportunity to collect time-series data from vast areas for monitoring and to support early warning systems responding to environmental disturbances. Here, we introduce the Aquarius Coral Reef Observatory (ACRO) – an open-source, internally-developed remote sensing system designed to accommodate a wide range of sensors. ACRO was conceived as both a working observatory and an adaptable prototype to enable greater access to real-time marine data and as a test bed for research and development. The current system is built around a Windows-based operating system to support instrument-specific requirements and edge-processing capabilities but integrates microcontroller-based systems for greater flexibility in the future. The observatory currently supports an ADCP, two wideband echosounders, a water quality sonde, multiple cameras, a hydrophone, imaging sonar, and expansion capacity for additional tools. The ACRO itself represents a single node in a network of over 15 FIU managed platforms distributed across Biscayne Bay and the Florida Keys that stream data to a centralized web repository developed by the FIU Institute of Environment. Our objectives with the ACRO system specifically, are twofold: 1) to leverage Aquarius Reef Base infrastructure as a testbed for scalable observatory design across reef sites such as those identified by Mission: Iconic Reefs, and 2) to foster collaboration and innovation in marine sensing through a low-cost, customizable observatory model. Collectively the overarching goal of the monitoring network is to deliver accessible, real-time environmental data to stakeholders and managers throughout South Florida as a public service and in an effort to inform future management practices.

Helping the Reef Biome Emigrate Away from Florida's Dying Reefs

Timothy Birthisel

*T*he Ohio State University, Columbus, Ohio, USA, and Terra Sub Aqua, the Ocean Farm, EEZ outside the barrier reef, Upper Keys

- The Terra Sub Aqua Tripod (TSAT) is a module designed for installation on sand or sediment seafloors to support biological activity. The TSAT uses rebar legs to anchor stacks of porous mineral substrates, such as shell rock coquina. These substrates are drilled onshore to boost their surface area, form habitats for marine organisms, and make it simple to thread them onto the rebar. The TSAT parts are prepared onshore and assembled on the seafloor using the sand or sediment as anchor, allowing for small vessel/hand deployment.
- TSAT is sturdy and offers vertical habitat like mature Elkhorn coral. The drilled coquina shell rock supports a microbiome that forms over the first year, comprised of anaerobic bacteria internally and aerobic bacteria, protozoans, algae, larvae, eggs, fish fry and invertebrates near and on the rock surface.
- New hard-bottom habitat is created in the sand flats, triggering development of a diverse coral reef ecosystem with all trophic levels, from microbes to apex predators, represented. TSATs withstand hurricanes, while plankton settling creates a diverse reef microbiome during the initial months. This microbiome supports small organisms like copepods, isopods, and rotifers, which provide food for juvenile fish on and within the rock's porous surfaces. The TSAT serves as a stable holdfast and protective cover for a food web which develops over time resulting in a complete marine biome in 5-10 years. As the community matures, fish schools begin to extend beyond the TSAT habitat and attract and support larger species that depend on cleaning stations, shelter, and food resources.
- TSATs may be arranged in dense linear formations which function as hatcheries and nurseries for fish. The TSAT structure is built for durability and features a vertical design that withstands hurricane-strength force. The coquina shell rock, with approximately 30% porosity, develops a microbiome in the first year that includes internal anaerobic bacteria and external aerobic bacteria, along with protozoans, algae, larvae, eggs, fish fry, and upright cover for fish maturation. Sessile organisms including corals, sponges, bivalves, macroalgae, coralline algae, and various invertebrates typically reach maturity within 2 to 10 years.
- TSATs can be set up as separate patch reefs with, for example, 6-meter geometric spacing. This encourages mobile herbivores like Tangs, Hogfish, and Goatfish to clean the seafloor across a broad area, helping prevent Blue-green Algae growth, harmful algal blooms, and excessive seafloor heating caused by the Albedo effect.
- TSATs may create reef habitat farther offshore and north along the Atlantic coast. The TSAT is applicable to reefs surrounded by sand bottom and in decline due to human activity as a dynamic refuge. TSATs are appropriate for establishing Marine Protected Areas (MPAs), as sand flats typically remain unused for fishing activities except in locations where shipwrecks or other debris are present.

Mapping Undiscovered Bonefish Spawning Aggregation Sites in the Florida Keys

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Traditional approaches to manage fishing Fish Spawning Aggregations (FSAs) generally focus on known FSAs that are experiencing overfishing or overfished. Protecting these fished FSAs can lead to conflicts between managers and fishers due to the loss of fishing access. And come with socially hard to accept decadal long lags between management actions and improvements to adjacent fishery resources. Instead, identifying and protecting unfished aggregations should result in less impact fishers, thus enabling protection with less conflict. The Florida Keys Bonefish fishery is now experiencing a phenomenal recovery following an economic fishery collapse in 2010. The demography of the fishery now indicates that populations should be forming exploitable aggregations again. Here, our objective is to discover Florida Keys bonefish FSAs (otherwise referred to as Pre-spawning Aggregations) and assess needs for proactive conservation strategies to protect them. Using multiple methods that include local ecological knowledge, novel acoustic telemetry technology, and visual surveillance, we discovered one bonefish FSA in the Upper Keys. Through this discovery, we documented the time, depth and location of spawning, mapped the space use of the FSA across two spawning seasons, habitat characteristics at the FSA site, and modelled the larval local retention during one spawning event. Last, we contrast the Upper Keys FSA spatial temporal characteristics with another Florida Keys Bonefish FSA in Key West, and implications for prioritizing spatial management.

The Elusive Hawksbill Turtles *(Eretmochelys imbricata)* of The Florida Keys National Marine Sanctuary

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The Florida Keys National Marine Sanctuary (FKNMS) protects over 2,900 sq. miles of marine habitats in the waters of Monroe County, Florida. Among the diverse array of species to be found within its boundaries, hawksbill turtles are regularly observed on or near shallow hard bottom and/or coral reef habitats. However, no large-scale effort had ever been undertaken to seek details concerning their relative abundance or distribution. In an effort to fill in data gaps for this species in Florida, approximately 300 hours of in-water surveys were conducted across 70 reef sites from Key Largo through the Marquesas Keys. Over a ten year period, 61 hawksbill turtles were hand captured, weighed, measured, and sampled, in some cases multiple times. Body sizes ranged from 18.8 cm - 75.3 cm straight carapace length at minimum (SCL) with an average of 38.1 cm ± 10.2 cm SD. Hawksbill growth rates were calculated from 10 recapture events that occurred among 9 individuals, which ranged in size from 29.3 - 46.0 cm straight carapace length, and averaged 6.16 cm/y ± 2.35 cm/y SD (SCL). Preliminary results indicate that small juveniles temporarily take up residence in the shallow rocky habitats of the Sanctuary as they make the shift from pelagic to nearshore environments, likely arriving via prevailing oceanic currents. As such, these locations represent key entry points for successive generations of young hawksbills integrating into Florida's larger reef ecosystems, where they may remain until reaching adulthood. Here, we provide a summary of our data concerning the abundance, distribution, growth rate, and behavior of immature hawksbill turtles in the FKNMS.

From Nurseries to Reefs: Spiny Lobsters as Lenses of Habitat Degradation in the Florida Keys

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The spiny lobster, a species of ecological and economic importance in the Caribbean and Florida, provides a vital lens for understanding the impacts of habitat degradation on marine ecosystems. Florida's coral reefs and nearshore hardbottom habitats are experiencing severe degradation, leading to shifts in ecological function. Initial surveys of 350 nearshore hardbottom and seagrass sites across the Florida Keys reveal significant habitat changes, including the loss of sponges and gorgonians, with many previously hardbottom-dominated sites now transitioning to seagrass communities. This degradation critically affects the Caribbean Spiny Lobster (*Panulirus argus*), which relies on hardbottom habitats as nurseries before migrating to coral reefs. Structural losses and reduced prey availability in these nursery areas likely hinder the growth, survival, and ecological role of *P. argus*. The impacts of habitat degradation also extend to coral reefs, where the Spotted Spiny Lobster (*Panulirus guttatus*), a reef-obligate species, plays a distinct trophic role. To evaluate these effects, we surveyed 24 reefs across the Florida Keys, assessing habitat quality, lobster nutritional condition, and trophodynamics using DNA metabarcoding of gut contents. Our findings indicate that *P. guttatus* occupies a higher trophic position than *P. argus* and that its diet is more sensitive to reef habitat quality. These results suggest that the phase-shift from coral- to macroalgae-dominated reefs alters food web dynamics, with more pronounced effects on species that depend heavily on coral reefs. This study highlights the cascading consequences of habitat degradation, from nearshore nursery areas to offshore coral reefs, emphasizing the need for targeted conservation efforts to mitigate ecological and economic consequences in the Florida Keys.

Shallow Seas and Shifting-Baselines: A Glimpse of the Florida Keys Undersea History

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Shifting baselines describes a phenomenon where successive generations, based on their personal worldview, accept a progressively degraded environment as the new normal, leading to a gradual lowering of expectations for the natural world. So, it is instructive to occasionally peer back in time to see how the natural world once was especially if, through preservation or restoration, we are to envision a realistic future. The Florida Keys formed and morphed over the past 125,000 years. Indigenous peoples first immigrated to the Keys from the mainland a few thousand years ago, followed by colonization by Bahamians and New Englanders in the early 1800’s who furthered exploitation of the marine environment with predictable declines in coastal megafauna: seals, sea turtles, manatees, and large fishes. More profound changes ensued at the turn of the 20th century with the construction of the Overseas Railway and the draining of the Everglades. Following World War II, commercial fishing shifted from sponges decimated by disease and devalued by the invention of plastics to large-scale fisheries for shrimp, lobsters, crabs, and fishes. Protected zones and fishery management measures were still few, so the ecologies of those species were gradually transformed by over-exploitation. The region’s coral reefs largely resisted change despite abuse by avaricious or ignorant users, whose impacts were largely localized but foretold a growing danger. It was the start of the Keys being “loved to death”. From 1950 – 1970, the population of the Keys tripled and by 1970 tourism dominated the economy. Within the next decade (1975-1985) the marine ecosystem began to teeter-todder. Coral diseases erupted, pulling down the Acroporid skyscapers of the reef. Released from grazing, reef macroalgae proliferated with the disappearance of *Diadema*, also from disease. Climate change was formally recognized in 1988, coinciding with another tilt in the stability of the Keys marine ecosystem. Episodic, massive die-offs of seagrasses and sponges along with blooms of cyanobacteria swept through Florida Bay with dire implications for the region’s water quality and ecosystem resilience. Crises prompt attention, so funds and researchers poured into the region along with the establishment of the Florida Keys National Marine Sanctuary (1990), the Aquarius Reef Base (1993), and the Everglades Comprehensive Restoration Plan (2000). Still, marine ecosystems are collapsing. Coral loss continues its downward trajectory – corals are >90% fewer than in 1970. Coastal fishes spin to their death from disease. Florida Bay is now largely devoid of sponges and octocorals due to persistent algal blooms and rising temperatures. We now embark on the restoration of this ailing ecosystem against the backdrop of an unbated change in climate. Perhaps an appreciation of the history of the region’s shifting marine environment will help inform our decisions about its future.

Migratory Patterns and Seasonal Habitat Use of Great Hammerhead Sharks (*Sphyrna mokarran*) in the Southeastern United States

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The great hammerhead shark (*Sphyrna mokarran*) is a highly mobile shark species whose population in the United States declined dramatically through the early 2000s. Their spatial ecology is poorly understood, creating challenges for effective conservation of this enigmatic marine predator. Using acoustic telemetry and network analyses, we describe the movement patterns of 15 mature great hammerhead sharks (207–331.5 cm fork length) primarily within the waters of the southeastern United States from April 2019 to December 2022, including identifying movement corridors, core use areas and seasonal shifts in habitat use. Great hammerheads exhibited partial migration; some sharks undertook consistent, repeatable, round-trip migrations between the tagging site in the Florida Keys and northern points in the Gulf of Mexico and Atlantic coast. Conversely, others remained in the Florida Keys year-round. Network analysis coupled with community detection algorithms revealed that individual great hammerheads displayed oceanic basin affinity, favoring migration to either the Atlantic Ocean or Gulf of Mexico. Great hammerheads that remained in the Florida Keys shifted their habitat use seasonally from inshore channels (spring and summer) to offshore artificial reefs and the natural reef tract (summer through winter). These shifts may be driven by prey availability, as core use areas often corresponded to known locations of seasonal spawning aggregations for reef fish. These data fill an important knowledge gap for great hammerhead migratory patterns that can improve spatial management strategies for this historically overexploited species. We discuss the importance of drawing upon data from multiple tagging locations for highly mobile species management, particularly in the designation of essential fish habitat.

From Top to Bottom: Rethinking Coral Reef Community Structure After Decades of Disturbance

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Coral reefs are one of the most biodiverse ecosystems on the planet and ecological theory predicts that diverse communities are the most resistant to change and resilient to disturbance. So why are coral reefs declining at alarming rates? Some have suggested that reefs exist in either one of two alternate stable states, hard coral dominated or macroalgae dominated, for which the transition is rapid and reversal difficult. Alternatively, others have suggested that coral reefs occur along a gradient of coral/macroalgae dominance which can be reversed through a combination of active interventions to reduce macroalgae and accelerate coral recruitment. Here we evaluate the predictions of these two hypotheses using more than a decade of reef community data from the middle Florida Keys. The rapid loss of coral cover has been most dramatic on offshore reefs where the dominant *Acropora* spp. branching corals are now all but extinct. But nearshore patch reefs dominated by massive boulder corals (*Siderastrea siderea, Orbicella faveolata*) have fared much better retaining higher live coral cover and higher rugosity. We used this baseline difference in coral composition and structural complexity to test the predictions of these two models by measuring rates of community change over the past decade. We conducted annual surveys of substrate composition, parrotfish biomass, coral disease / bleaching, along with measures of diversity for reef fishes and cryptoinvertebrates on 30 reefs in the middle Florida Keys from 2012-2025. Shallow nearshore reefs are characterized by higher coral cover, and higher *Halimeda* spp. algae also experience more variation in temperature having both hotter summer and colder winter temperatures, whereas deeper offshore reefs are characterized by higher soft coral cover and higher *Dictyota* spp. algae. Abiotic disturbances such as Hurricane Irma of 2017 and the marine heat waves of 2015 and 2023 caused the greatest changes in reef substrate composition through mortality of soft corals. The stony coral tissue loss outbreak of 2017 caused high mortality in brain corals, but only sublethal damage to other species of massive corals. Reef fish biomass, richness, and diversity are different between nearshore and offshore reefs, but have remained relative constant over the decade. Herbivorous parrotfishes vary positively with the abundance of fleshy algae suggesting a lack of top-down regulation. Cryptofauna abundance, richness and diversity increases from nearshore to offshore as rubble abundance increases. Reef community stability and resilience in the face of multiple disturbances over the past decade strongly support the hypothesis of an altered stable state made up of soft corals / weedy hard corals versus thickets of branching corals. Furthermore, we find little evidence that hard coral cover is sensitive to changes in top-down forces due to direct impacts of herbivory or indirect impacts through structural complexity or trophic cascades.

Optimizing Invertebrate Herbivore Restocking Strategies to Enhance Coral Recruitment

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The Florida Keys Reef Tract has experienced severe degradation in recent decades, leading to substantial declines in coral populations. A majority of reefs in the region are comprised of less than 5% live coral cover, leaving space for the proliferation of macroalgae. Beyond macroalgal competition, the accumulation of sediments has the potential to limit reef recovery via pathways such as reducing herbivory or reducing coral settlement and survival. Restoration efforts are pairing coral outplanting with invertebrate grazers, such as the Caribbean King Crab (*Maguimithrax spinosissimus*) and the long-spined sea urchin (*Diadema antillarum*), to promote substrate quality and boost coral recovery. The ability to produce large quantities of these grazing invertebrates through mariculture makes them prime candidates for large-scale reef restoration; however, there is limited information regarding the optimal stocking densities and grazer assemblages that will best facilitate coral success. Using aquaria-based experiments, we tested the ability of *M. spinosissimus* and *D. antillarum* to reduce macroalgal biomass. In addition, we tested whether different sediment loads (low, medium, and high) mediate herbivory. Treatments consisted of five different grazer assemblages plus control groups: (1) 1 *D. antillarum*, (2) 2 *D. antillarum*, (3) 1 *M. spinosissimus*, (4) 2 *M. spinosissimus*, or (5) 1 *D. antillarum* and 1 *M. spinosissimus*. We then used the tiles from two of the experimental runs for settlement assays with coral larvae from *Diploria labyrinthiformis* and *Acropora palmata* to determine their influence on settlement rates. We found that macroalgal removal varied by grazer assemblage and that sediments mediated herbivory particularly at higher levels. We also observed evidence that grazer assemblage and sediment load influenced the settlement rate of coral larvae, highlighting the potential for these two factors to shape the recovery of coral populations on Florida reefs.

Length Distributions of Aggregating Permit (*Trachinotus falcatus*) in Response to the Western Dry Rocks Seasonal Closure

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Many coral reef-associated fishes participate in fish spawning aggregations (FSAs) as their sole reproductive opportunity, which recur annually on discrete reef promontories during the same season and/or lunar phase. The predictability of these aggregations makes them an easy target for fishers. In the Florida Keys, permit (*Trachinotus falcatus*) are a recreationally important coastal jack species that aggregate for spawning on offshore natural and artificial reefs from March through August, peaking around the full moons. Permit FSAs are often targeted by catch-and-release anglers during the spawning season when harvest is prohibited. Although post-release mortality is near zero, reports of high depredation rates by sharks threaten the sustainability of this fishery. In response, the Western Dry Rocks (WDR) seasonal closure (April 1-July 31) was implemented in 2021 to protect a multi-species spawning site, including a prominent permit FSA in the Lower Florida Keys. This study therefore aimed to monitor the status of the permit FSA in response to the closure at WDR. Fishery-independent surveys to determine permit size composition were conducted during the full moon periods between March and June from 2019-2025. Length distribution data can be used to determine temporal variation in 1) new recruitment and 2) spawning stock biomass when integrated with fecundity, length-weight, and abundance estimates. Most individuals were measured during peak spawning aggregation sizes in April and May. Mean fork length of permit has increased since 2019, indicating a positive shift in size distribution at this FSA. These results will contribute to evaluating the efficacy of the WDR seasonal closure and help identify other abiotic and biotic factors that may affect recruitment and size composition within this FSA.

Mapping Seagrass-Coral Reef Mosaics Using Satellite Imagery to Quantify Seascape Structure in the Florida Keys

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Seagrass meadows are vital benthic habitats that support biodiversity, facilitate biogeochemical cycling, and provide nursery and foraging grounds for a range of ecologically and economically important species. In the Florida Keys, seagrasses form dynamic mosaics with coral reef habitats, shaping the structure of benthic ecosystems across the seascape. Understanding the spatial structure of these mosaics (i.e., how seagrass and reef patches are distributed, shaped, and arranged) is critical for informing management decisions. However, these structural patterns remain under-characterized, especially at fine spatial resolutions. This study aims to quantify the seascape structure of seagrass–coral reef systems across three areas of interest along the Florida Keys Reef Tract: the Upper, Middle, and Lower Keys. These regions span a gradient of environmental conditions and disturbance regimes and were selected to reflect spatial heterogeneity within the broader reef tract. By integrating high-resolution PlanetScope satellite imagery (3-meter spatial resolution) with *in situ* ground-truth data, we developed benthic habitat maps tailored to the ecological characteristics of each area. The mapping approach combined supervised classification with a machine learning Random Forest algorithm, trained using field-based observations of benthic cover collected by the project team. The resulting maps varied in thematic resolution across the three regions, depending on local complexity and spectral properties of both habitats and data. Habitat classes include seagrass meadows, coral reef structures, bare sand, and hardbottom features. Classification schemes were customized per region to ensure ecological coherence and maximize classification accuracy. From the classified maps, we derived a suite of spatial pattern metrics to characterize the structural properties of seagrass beds as well as their spatial relationship to adjacent coral reef features. These metrics provide quantitative insight into habitat configuration, heterogeneity, and connectivity, which are critical drivers of ecological interactions such as species movement, trophic linkages, and resilience to disturbance. By integrating satellite remote sensing with field-based validation and landscape ecology techniques, this study advances our capacity to assess benthic habitat structure in complex seascapes. The resulting spatial data products and metrics offer valuable tools for resource managers aiming to protect and sustain the ecological integrity of the Florida Keys coastal seascapes.

Marine Debris Characterization of the Marquesas, Florida

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Marine debris has well-documented negative impacts on marine life, including abrasion, entanglement, entrapment, ingestion, and crushing. Previous studies conducted on Florida's Coral Reef have identified trap fisheries as the primary source of in-water marine debris in the Florida Keys, followed by non-trap fishing debris. However, these studies have not included reef areas west of Key West, particularly near the Marquesas Keys. This study presents preliminary findings of debris type, abundance, and density on benthic habitats west of Key West to Rebecca Shoal. Underwater debris removals were conducted by scuba divers in 2023, 2024, and 2025. The influence of reef rugosity, habitat type, and depth on debris was also assessed. Consistent with findings from other regions of the Florida Keys, our study indicates that the majority of marine debris in the Marquesas Keys is associated with trap fisheries, both in terms of abundance and the linear distance of line recovered.

Rapid Increases in Tolerance of Surviving Corals Across Extreme Heatwaves

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Climate change poses an existential threat to coral reefs as mass bleaching and mortality from marine heatwaves become more frequent and severe. Understanding how corals respond to recurrent heatwaves, and in particular whether heat tolerance increases in the surviving community, is critical for forecasting reef futures, but suffers from a lack of data. Here, we used observations of >59,000 individual corals in Florida to assess bleaching responses across three marine heatwaves in the last decade, including the most extreme on record in 2023. We found significant variation in current heat tolerance within and among species, with bleaching thresholds ranging from <2 to >20 degree heating weeks (DHWs). Moreover, we found that median bleaching thresholds increased from 3.9 DHWs in 2014 to 11.5 in 2023, reflecting an increase in heat tolerance of 0.96°C in under a decade—ten times higher than previous estimates. Species experiencing larger population declines and hosting higher symbiont diversity showed even greater increases (up to 1.6°C), indicating that differential mortality and symbiont shifts are driving these rapid gains. Despite bleaching of up to 90% of corals in 2023, these findings reveal the potential for unanticipated rapid responses to warming on depleted reefs, which may extend the survival window for remaining corals and stimulate action to maximize reef resilience until climate stabilization.

Pioneering a First-in-Kind Guide-Led Model for Rapid Scientific and Ecological Response

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Fishing guides are uniquely positioned as both first sentinels and first responders in coastal ecosystems. Their daily presence on the water, extensive local knowledge, and deep connection to the environment allow them to detect early signs of ecological disturbance that others might miss. In 2023, guides across the Florida Keys began reporting an unusual phenomenon: several species of nearshore fish exhibiting erratic spinning behavior. Recognizing the potential ecological significance, the Key West and Lower Keys Fishing Guides Association (dba Lower Keys Guides Association or LKGA) mobilized quickly, forming the Guide Rapid Response Network (GRRN)—a grassroots, guide-led effort to detect, document, and respond to marine anomalies in real time. Backed by funding from the Ocean Reef Conservation Association, the GRRN recruited and equipped over 30 guides throughout the Keys to contribute their skills to scientific response. These guides collected water samples, documented unusual behavior, provided tissue specimens, and helped coordinate access for follow-up investigation. Their capacity to operate swiftly and independently on the water made them invaluable in the immediate response effort. In its first year, the network logged 127 hours of guide-led fieldwork and established five strategically placed freezer depots from Key West to Key Largo to support sample storage and transport. Equipment and protocols developed through GRRN have since been shared with peer groups in South Carolina, Mississippi, and Montana, demonstrating the network's scalability and impact. The LKGA Rapid Response Network represents the first program of its kind in the United States—built by fishing guides, for fishing guides, to serve science. This initiative flips the script on traditional research models—placing trusted watermen and women at the helm of both observation and action. These guides are not passive participants; they are proactive stewards with the insight, access, and skills needed to detect and respond to ecological change in real time. Since its inception, the LKGA Guide Rapid Response Network has expanded to include guides from the Florida Keys Fishing Guides Association (FKFGA), strengthening its reach across the entire island chain. Together, this growing network of professional guides stands ready to assist any scientific, academic, or management entity with research question development, logistical on-water support, and, in some cases, direct implementation of research activities. Their frontline perspective, operational flexibility, and deep-rooted conservation ethic make them indispensable partners in monitoring, mitigation, and marine resilience. The LKGA GRRN represents a new standard in community-led science—proving that real solutions often begin with those who know the water best.

Mapping Spatial-Temporal Changes in Restored Coral Reefs using Multiple Mapping Technologies

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In the Anthropocene, coastal ecosystems have experienced greater transformations than any other marine region, primarily due to their proximity to land-based sources of disturbance. Because of their economic and ecological importance, multiple agencies around the globe are focused on restoring coral reefs using various mechanisms, including coral outplanting. However, monitoring the long-term success of coral outplants is a time-intensive task as divers measure each coral individually. This method also complicates the evaluation of the relative health of a reef at spatial-temporal scales that are relevant for management purposes. Consequently, it is becoming increasingly important to evaluate multiple mapping technologies for effective, cost-efficient monitoring across a range of spatial and temporal scales. Since 2021, we have acquired annual datasets of six coral reef sites in the Florida Keys, USA using uncrewed aircraft systems (UAS), multibeam echosounders (MBES), and diver collected underwater imagery. The datasets collected from the different platforms are enabling multiple comparisons between both different years and different combinations of data sets. We discuss how we use and integrate the datasets to assess and map changes in corals and fishes in the restored reefs. Analysis of the data is providing insight into the changes occurring at the six reefs included in this study, as well as helping to inform recommendations for how to efficiently and cost-effectively monitor coral reef restoration sites across a range of spatial and temporal scales using various mapping technologies.

Investigating the Potential Sublethal Physiological Impacts of the 'Spinning Fish Condition' for Coastal Sharks in the Lower Florida Keys

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The Lower Florida Keys has been identified as an important area for multiple species of teleosts and elasmobranchs. In recent years, the area has been experiencing unprecedented marine environmental challenges. In late 2023 and early 2024, fishers and researchers began reporting an 'anomalous spinning fish' condition throughout the Lower Florida Keys. This condition has been documented to affect a number of teleost and elasmobranch species, and initial findings suggest that neurotoxins produced by the algae *Gambierdiscus* could be linked to spinning fish behavior. The physiological impact for elasmobranchs is still uncertain. Our study aims to investigate the potential sublethal physiological impacts of this condition for coastal sharks in the area. Blood panels of *Negaprion brevirostris*, *Carcharhinus limbatus*, and *Ginglymostoma cirratum* were analyzed for a variety of metabolites and biomarkers to assess physiological condition. Samples were collected prior to, during, and following the peak of the reported 'spinning event' allowing us to conduct a preliminary comparison of these markers across time. This study provides insight into how this anomalous environmental condition may impact local shark stocks, if the impacts perpetuate, and determines if adjustments to local conservation management efforts may be warranted in the future.

Eighteen Years of Goliath Grouper Research in Florida: Documenting the Recovery of an Iconic Fish

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The Atlantic Goliath Grouper (*Epinephelus itajara*) population in US waters has shown substantial recovery following the closure of the fishery to all harvest in 1990. Since then, increased abundance of both adults and juveniles in state waters, including regularly occurring aggregations of spawning adults have been reported. Since 2007 researchers with the Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) and colleagues have been studying this iconic reef species to better understand outstanding gaps in Goliath Grouper life history information. Targeted research efforts have included long-term visual surveys of adult abundance, movement studies of adults offshore and juveniles in estuaries, an age-and-growth comparison of calcified structures collected from individuals following incidental mortality events, and a state-wide cooperative angler program to collect genetic samples. Over the past eighteen years, these efforts have grown in scope and provided novel data and results. For example, the Great Goliath Grouper Count, now in its 16th year, is a cooperative effort between FWC and Florida Sea Grant that has grown from a regional initiative focused on southwest Florida to a state-wide effort that collects information on Goliath Grouper abundance across the state each summer. Comparing ages counted from otoliths to dorsal fin-rays and spines collected from dead specimens allowed us to confirm that this non-lethal sampling method has utility for assessing population age-structure. Fin clips collected in cooperation with commercial and recreational fishers has provided the basis for multiple genetic studies and continues to be a focus of ongoing research. Through these volunteer fin clip submissions, we have documented siblings and parent-offspring-pairs of Goliath Grouper, results that help inform our understanding of population recovery. As Goliath Grouper are increasingly encountered by the public and captured and sampled by ongoing FWRI fishery dependent and independent monitoring programs, we will continue to document their increasingly expanded role as part of the native Florida marine ecosystem. Here we report on some of the successes of this research and identify future research directions that are needed to fill remaining gaps in our understanding of the species and its recovery.

Characterizing and Forecasting Ecosystem Responses to Multiple Stressors Across the Florida Keys National Marine Sanctuary

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The Florida Keys are a dynamic patchwork of interconnected ecosystems that are critically important to the local economy and highly sensitive to human influence. As part of the four-year, multi-institution Florida Regional Ecosystems Stressors Collaborative Assessment (FRESCA), we comprehensively characterize water quality throughout the Florida Keys National Marine Sanctuary via bi-monthly cruises over nearly three decades, supplemented by periodic satellite observations. These long-term records are then integrated into a regional biogeochemical model (MOM6-SIS-COBALT) to forecast future conditions under different management scenarios. In parallel, we apply a novel high-resolution modeling approach to trace water movement through the Keys as it is influenced by the local benthos. Using these data and a new state-of-the-art experimental system that allows us to simultaneously manipulate dissolved oxygen, pH, and temperature in real time, we explore the sensitivities of seventeen key habitat-altering species, including corals, bioeroders, seagrass, and algae. Next, we employ annotated large area imagery and a novel automated data pipeline to calculate carbonate budgets at Mission Iconic Reef sites. Finally, we synthesize projected stressor distributions, unique species sensitivities, and carbonate budget models to forecast coral reef persistence into the future under different management and coral restoration strategies. Throughout, we will focus on high-level project outputs, data integration and availability, as well as relevance to local management scenarios.

Population Demographics of *Xestospongia muta* on Ten Florida Keys Reefs from 2014 to 2024

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Giant barrel sponges, *Xestospongia muta*, are important components of Florida's Coral Reef (FCR), and provide essential functions like increased rugosity, habitat for other reef organisms, and water filtration. The Coral Reef Evaluation and Monitoring Project (CREMP) has assessed the trends and conditions of benthic reef organisms at 40 sites throughout the Florida Keys since 1996. Since 2014, *Xestospongia* muta surveys have been conducted at a subset of 10 deep forereef sites: Molasses, Conch, Alligator, Tennessee, Sombrero, Looe Key, Eastern Sambo, Western Sambo, Rock Key, and Sand Key. Demographic data collected within the two ~66m^2 survey transects at each site include size measurements and health condition metrics (e.g., the presence of disease, tissue loss, damage, predation, and other conditions) on each colony. This presentation will summarize 11 years of demographic data and enumerate changes in population size, including colony survival, growth, and recruitment between 2014 to 2024. During this timeframe, multiple disturbances have impacted FCR including the 2014/2015 thermal stress, Hurricane Irma in 2017, Hurricane Ian in 2022, and the 2023 marine heatwave. Like corals and octocorals, *X. muta* is vulnerable to many of these stressors but the *X. muta* community has demonstrated greater resiliency than their marine counterparts with the overall population surveyed within the CREMP transects being largely unchanged over the last decade.

Nutrient Sources and Climate Oscillations Drive Nutrient Availability and Seagrass Abundance in the Florida Keys

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Although seagrass ecosystems are valued for the services they provide, anthropogenic impacts have led to global declines in seagrass area. The Florida Keys support one of the most extensive and iconic seagrass landscapes in the world. Although this seascape is faring better than many across the globe that have seen significant loss of seagrass, historic losses and changes in nutrient delivery still threaten its integrity. At scale of the Florida Keys, seagrass abundance and species composition are controlled by phosphorus availability in Florida Bay and close to shore in the Florida Keys, while nitrogen availability is the driver in the immediate back-reef areas. Over 25 years of seagrass monitoring indicate most stations in the Keys have remained stable, however, recurring hurricanes have led to seagrass losses with little recovery at the decadal scale at some sites. At other anthropogenically nutrient-enriched nearshore sites, we observed a shift towards fast-growing *Halodule wrightii* meadows at the expense of slow-growing *Thalassia testudinum*. In addition to long-term trends, seagrass abundance and trajectories also vary intra- and interannually as a function of season and water quality. Seagrass abundance is driven by interannual variations in nutrient concentrations, which are ultimately controlled by climate oscillations (El Niño Southern Oscillation Atlantic Multidecadal Oscillation) via regional rainfall-runoff relationships. Nutrient delivery from runoff can have spatially-diverging impacts on benthic communities. Our study suggests that climate oscillations drive interannual variations in seagrass cover on a regional scale, with high-rainfall years leading to increased nitrogen availability and higher seagrass abundance in typically nitrogen-limited backreef meadows. Conversely, these periods are associated with reduced seagrass cover at the more P-limited inshore sites and in Florida Bay, with yet unknown consequences.

Presence, Abundance, and Distribution of Common Invasive and Non-Native Species in the Florida Keys National Marine Sanctuary

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Florida's warm, humid climate makes it an incredibly hospitable location for life. Boasting an already well-established range of native biodiversity, any newly introduced species can also easily find a way to survive and thrive. These types of plants and animals are known as non-native species. Non-native species can be further classified as invasive if they are detrimental to native species and play a deleterious role in impacting their newly established ecosystems. Lacking natural predators to keep their populations in check, both non-native and invasive species can outcompete residents that provide valuable ecosystem services, potentially fueling the extinction rate of the native species. Here, this poster will focus on the potential occurrence and abundance (or absence) of five (5) non-native and invasive marine organisms in the NOAA Florida Keys National Marine Sanctuary (FKNMS), as well as one species of seagrass, which is known to occur just outside the FKNMS boundary at this time. Primarily, *Pterois spp.*, commonly known as lionfish, are an invasive species from the tropical waters of the Indo-Pacific. The combination of their venomous spines and appetite to eat anything that can fit in their mouth makes them pose a significant threat to sanctuary resources. In FKNMS, two species of lionfish, *Pterois miles* and *Pterois volitans*, have been known to occur at various depth ranges and across different habitat types. Additionally, this poster will also analyze the distribution of four non-native and potentially invasive coral species: *Tubastraea coccinea*, *Tubastraea faulkneri, Unomia spp.*, and *Xenia* spp. To obtain this data, scuba surveys are presently being conducted and will continue until the end of the Summer of 2025. Both natural and artificial reef locations will be investigated to describe and quantify the distribution and abundance of these species within FKNMS. If encountered during a dive, size, age, and surface area/quantity estimations will be recorded and tracked over time. If possible, these species will also be removed and taken back to the lab for further analysis. Understanding how these species interact with plants and animals can give insight into how harmful they can be to the local environment. By the time of the conference in the Fall of 2025, the datasets collected will be analyzed, and a formal discussion will be presented along with recommendations for future research and potential management strategies. The information learned from this study could have direct sanctuary management and policy-making implications by potentially increasing regulations of marine transportation methods, which commonly serve as the source of invasive species, as well as providing an initial reference for researchers interested in studying these species further within FKNMS.

Prototyping a Modular Autonomous Data Buoy for Video and Data Monitoring in the Florida Keys

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Florida Keys researchers and managers identified a need for near real-time data collection and alert systems for monitoring reef habitats and restoration efforts. The Florida Fish and Wildlife Research Institute (FWRI) has developed a modular, autonomous data buoy for underwater video and data collection in the Florida Keys National Marine Sanctuary (FKNMS). Developed to support an array of environmental and acoustic sensors, the project is being prototyped with a single video camera. This passive underwater camera system can be deployed for long-term or short-term monitoring projects and is designed to be easily built, replicated, and modified without highly specialized technical experience. The design of the data buoy system consists of a benthic-mounted camera housed within a waterproof casing, communication and mooring cables, and a surface buoy equipped with onboard solar panels and a cellular modem. This cellular modem is programmed to send scheduled emails indicating the status of the buoy computer systems (e.g., time of last video, internal temperature, memory storage) as well as a frame of the latest video to check for biofouling and camera orientation. Retrieving the full videos currently requires removing only the camera to exchange USB drives in the field, although the videos can be accessed remotely based on cellular signal strength and data costs. This system is built using readily available, low-cost Raspberry Pi computers and associated components, making it more accessible, reproducible, and flexible than out-of-the-box industry options. The entire buoy set-up can be deployed and retrieved by a team of 4-5 people, doesn't require specialized equipment, infrastructure, or personnel for routine use, storage, or operation, and can easily accommodate a variety of field settings. Following the current short-term deployments to Delta Shoal in FKNMS, videos will be used to develop a generalized machine-learning algorithm for field-based research and detection (e.g., coral bleaching, herbivory, fish detection). Future development includes installation of the algorithm on the buoy camera and the integration of additional sensors for multimodal data collection.

Dear Sloane — A Letter to My Granddaughter

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Milestones in life invite reflection on the past and consideration of the future. At retirement, I came to a disturbing conclusion: I had played a part in the failed effort to protect coral reefs — particularly those in the Western Atlantic, where most of my work was done — from decades of stressors driven or intensified by human development and exploitation. Those of us responsible for management didn't do enough to control them, and reefs paid the price.

An apology to my granddaughter is an admission that my dream career ultimately left her generation with less than they deserve. But was it all for naught? Can we still restore biodiversity and health to the world's reefs?

We know the causes of decline, and we have decades of coral reef science and management experience to guide us. We also have powerful new technologies — and an ally in Nature itself, which has a remarkable capacity for recovery when stressors are reduced. Nassau grouper restoration in the Cayman Islands provides a compelling example. And there are still a few coral reefs in remarkably good condition. From their protection we can learn what works and use them as targets for restoration elsewhere — reminders of what's possible under current environmental conditions.

Will Stone Crab Larvae Be Able to Swim Away from Their Future Climate Troubles?

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South Florida's watersheds have suffered from decades of urbanization, which has disrupted regional hydrology and increased nutrient-rich runoff into coastal systems. These excess nutrients can result in extreme fluctuations in coastal pH. Further, coastal habitats, where the volume of water is less than offshore regions, are also subject to rapid and extreme changes in temperature. The largest changes in pH and temperature occur during the summer months, which coincides with the stone crab reproductive season. The stone crab is a $30 million per year commercial fishery in Florida and the sustainability of this fishery relies on successful reproduction, larval development, and recruitment to nearshore habitats. For example, under ambient conditions larvae exhibit behaviors that promote advection to offshore areas where predation is low, before eventually settling in nearshore habitats. Despite the popularity of the fishery, no studies have modeled how exposure to reduced pH and elevated temperature may change larval swimming and the species vertical distribution. Here we tested the stage-specific survival, growth, and geotactic swimming behavior of stone crab larvae during exposure to reduced pH (8.0, 7.8, 7.6) and elevated temperatures (28°C, 30°C, 32°C) in a fully crossed experiment that mimicked present day, mid-century, and end-of-century conditions. We then combined geotaxis behavior, survival, and molt-stage duration to visualize potential changes in vertical distribution throughout a simulated water column under end-of-century conditions. Our results suggest that end-of-century conditions will accelerate larval development and simultaneously position mid to late-stage larvae deeper in the water column. This earlier shift to deeper distributions will expose larvae to onshore currents, potentially resulting in local retention, limiting the populations' ability to move north with changes in climate.

Integrated Science for Atlantic Tarpon Conservation in the Florida Keys

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Atlantic tarpon (*Megalops atlanticus*) are a culturally and economically important gamefish across Florida and a flagship species, particularly in the Florida Keys. However, their conservation in this region faces mounting challenges from habitat loss, climate-driven stressors, boater and angling pressure, and the interconnectivity of disparate ecosystems. Drawing from multiple scientific approaches, including from electronic telemetry, predator-prey research, foraging landscape modeling, interviews with fishing guides, and climate projections, this synthesis provides a comprehensive overview of tarpon ecology and conservation needs in the Florida Keys. Telemetry data reveal consistent site fidelity and repeatable timing of individual tarpon during the spawning season and to overwinter. Furthermore, these data identify the Florida Keys as a mixing zone for two distinct migratory contingents: one that migrates up Florida's west coast (Eastern Gulf of Mexico Contingent) and another along the east coast (Eastern US Seaboard Contingent), each reaching summer foraging areas outside of Florida that are managed with different fishing regulations. As depredation intensifies across all fisheries, these nearshore pre-spawning aggregations, particularly in channels like Bahia Honda, face high shark depredation rates. Approximately 15% of tarpon fought at this site are lost each day during peak fishing activity, underscoring the need for improved fishing guidelines and targeted outreach. When combined with stable isotope analyses, telemetry data highlight not only the importance of the Florida Keys as a pre-spawning aggregation site but also the role of distant foraging ecosystems, spanning thousands of kilometers away. Expert fishing guide interviews reveal a 62% reduction in large tarpon habitat since the early 1980s, potentially attributed to rising wet season water temperatures (+2°C since 1982) and intensifying vessel traffic. Incorporating the estimated optimal temperature range for tarpon (20–29°C) and climate projections via CMIP6, our findings suggest a shortening of the tarpon fishing season in the Florida Keys, with major consequences for the cultural and economic vitality of this iconic fishery. This integrated synthesis highlights the urgent need for targeted habitat restoration and protection, water quality improvements, refined catch-and-release practices, and enhanced boater use management within the Florida Keys National Marine Sanctuary to mitigate disturbance, habitat loss, and depredation risk, thereby supporting the sustainability of tarpon populations and the fisheries they support. It also highlights key research gaps, including spawning locations and larval retention, genetic composition, prey availability, post-release mortality, behavioral responses to environmental variability, and inter-ecosystem connectivity, that must be addressed to ensure the long-term resilience of the tarpon fishery in the face of ongoing ecosystem change.

Smalltooth Sawfish: 15 Years of Research to Promote Recovery of a Critically Endangered Species

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The sawfishes (Family Pristidae) include five species of large coastal rays that are among the most imperiled groups of marine fishes. All are listed as Critically Endangered in the IUCN Red List of Threatened Species and Appendix I of CITES (banning all international trade). The smalltooth sawfish (*Pristis pectinata*) is endemic to the Atlantic Ocean and historically was widely distributed in subtropical to tropical waters on the east and west sides of the basin. The species has been extirpated from much of its range due to overfishing and habitat loss with few viable populations remaining. Bycatch remains the largest source of direct mortality and continued habitat loss from urban development, agriculture, and freshwater diversion likely hinders recovery. The U.S. harbors the largest population of smalltooth sawfish, concentrated in Southwest Florida. The persistence and continued viability of this population reflects a number of conservation actions. Smalltooth sawfish have been protected in Florida since 1992 and commercial gillnets were banned in Florida in 1995, likely decreasing juvenile mortality. In 2003, smalltooth sawfish became the first native marine fish listed as *Endangered* under the United States Endangered Species Act. In addition, substantial habitats important to sawfish in Florida are under some level of conservation protection within areas such as Everglades National Park (ENP), Ten Thousand Islands National Wildlife Refuge, and Florida Keys National Marine Sanctuary (FKNMS). Since 2011, we have used fishery-independent longline surveys (>1,200 sets, >60,000 hooks) in these regions to assess community structure and relative abundances of smalltooth sawfish and sharks, study movements, migration and bycatch risk of large sawfish using acoustic and satellite telemetry, determine sawfish mating areas, and collect samples needed for assessing reproductive status, trophic ecology, and toxicological responses. Over 5,000 sharks and rays from 17 species have been captured, including 147 large smalltooth sawfish (48% in FKNMS, 50% in ENP, 2% outside of this region). Telemetry data highlighted areas of high use by adult smalltooth sawfish that may warrant designation of Critical Habitat as well as regions where sawfish are vulnerable to fishery interactions, including potential bycatch mortality in shrimp trawls. By 2023, Following 30 years of protection in Florida and 20 years since the ESA listing, the sawfish population appeared to be recovering. This recovery has been hindered by the "spinning fish" phenomenon in the Florida Keys that disproportionately affected sawfish, leading to more than 60 known sawfish mortalities to date. Our research is now focused on assessing what proportion of the sawfish population was affected by these mortality events, collecting sampled needed for toxicological and pathological analyses, and determining the magnitude of the associated setback to sawfish population recovery.

Diversity in Disguise: Leveraging Cryptic Coral Diversity for Conservation in South Florida

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Modern sequencing technologies have revealed widespread, previously undescribed cryptic diversity—the presence of genetically distinct but morphologically similar lineages—within Cnidaria. In the Western Atlantic Ocean, several common coral species, including *Agaricia grahamae*, *Diploria labyrinthiformis*, *Montastraea cavernosa*, *Orbicella faveolata*, *Pseudodiploria clivosa*, *Siderastrea siderea*, and *Stephanocoenia intersepta*, are now known to comprise multiple co-occurring cryptic lineages. These lineages may represent distinct (sub) species with limited reproductive compatibility, which has important implications for estimating population sizes and reproductive potential, particularly in the Anthropocene. These cryptic lineages are often structured by depth or habitat and commonly associated with distinct algal (Symbiodiniaceae) and bacterial partners. Experimental studies further reveal that these lineages frequently differ in their ecological niches and susceptibility to thermal stress. In this presentation, we draw on research from cryptic coral lineages in Panama and Palau to explore the opportunities and challenges posed by cryptic coral diversity in South Florida. We also outline future research directions to understand and apply this hidden diversity to support local coral conservation and restoration initiatives.

Determining Ranging Patterns and Association Preferences of Bottlenose Dolphin Communities in Southeast Florida

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Understanding individual ranging patterns and social preferences within a population is critical for identifying stock boundaries and population structure. In Biscayne Bay (southeast Florida), bottlenose dolphins have been monitored since 1990 using photo-identification methods. Residency patterns suggest that the vast majority of individuals are resident to the bay and that two communities exist based on their ranging patterns: one occurring in the northern portion of the bay and another in the southern portion, with limited spatial overlap between the two. However, the spatial boundaries of the "southern" community of Biscayne Bay are not well understood, as movements of individuals are suspected between this area, Florida Bay and the Florida Keys. To further investigate the extent of the southern community, a collaboration was established with the Dolphin Research Center (DRC) in the Florida Keys (study area from Marathon to Islamorada). Using a novel approach incorporating scar pattern analysis, in addition to the standard dorsal fin comparison methods, a total of 41 matches were identified between the Biscayne Bay and the DRC catalogs; encompassing 8% and 25% of the total marked individuals for each catalog, respectively. Preliminary analyses suggest a possible southward extension of the southern community home range and therefore potential spatial and social overlap with the (DRC) community. Using SOCPROG and kernel density estimations (KDEs), we investigated the ranging patterns of these individuals and showed that the southern community includes individuals ranging far beyond the limits of Biscayne Bay. This work highlights the importance of local/regional collaborative research beyond the geographic boundaries (e.g., bay, sound, estuary) of a study area, which can have major impacts for stock boundary assessment and management.

The Influence of Structural Complexity on the Fine-Scale Diurnal Space Use of Reef Fishes

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The habitat preferences of many reef fishes are well established, but the use of space within these habitats by non-site-attached species is poorly studied. These movement patterns are likely to be influenced by a range of factors, particularly structural complexity. Critically, new insights into the effect of complexity on fish movement are now possible using structure-from-motion technology that allows high-resolution modeling of reef structure. These models allow the derivation of metrics such as viewshed, the amount of the surrounding reef that can be seen from any location. This study examined the space use of a functionally important mesopredator, graysby (*Cephalopholis cruentata*) and herbivore, juvenile striped parrotfish (*Scarus iseri*), on six patch reefs in the Florida Keys. A 1 m^2-scale grid was constructed on each reef and 16 individual *C. cruentata* were tracked diurnally *in situ* to identify space use, along with ~80 5-min focal follows of individual *S. iseri* per reef that recorded space use and spatial bite patterns. At the patch reef scale, larger *C. cruentata* were more active and had larger observed home ranges, although home ranges were also affected by fish density and the abundances of prey and predators. The total time in each grid cell was only significantly positively correlated with the height of carbonate structures, likely because the cavities they enclose are particularly suitable for predator avoidance, resting, and ambushing prey. In addition to examining spatial patterns, we analyzed *C. cruentata* waiting times in each grid cell before moving. These times were best approximated by a truncated power-law (heavy-tailed) distribution, indicating a “bursty” pattern of relatively long periods of inactivity interspersed with multiple periods of activity. Such a pattern has previously been identified in a range of temperate ambush predators, and we extend this move-wait behavior, which may optimize foraging success, to a reef fish for the first time. For *S. iseri*, metrics of high complexity including increased grazeable area and maximum height positively correlated with cell use and foraging, but significant correlations with viewshed and fish group size suggest that predation risk may also affect behavior. In particular, the effect of viewshed highlights the importance of structure for shaping predator-prey interactions on reefs. Since three-dimensional complexity affects small-scale grazing decision-making it is likely in turn to shape the distribution of macroalgae on patch reefs. Understanding how predators, prey, and functionally important groups like grazers use space and time is critical to fully identify their functional role and better predict the implications of fishing and loss of reef structure on the functioning, resilience, and ecosystem services of Caribbean reefs.

Evaluating Atlantic Goliath Grouper (*Epinephelus itajara*) on Florida Reefs Using 25 Years of Visual Surveys

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Atlantic goliath grouper (*Epinephelus itajara*) is one of the world's largest grouper species, growing to 3 m in length and weighing more than 400 kg. Intense fishing pressure of this trophy-sized fish in the late 20th century led to steep population declines. In response to these declines, goliath grouper landings were prohibited in US waters in the 1990s by both state and federal agencies. In recent decades, goliath grouper have supported Florida's booming ecotourism economy, drawing divers from all over the world to witness and photograph this gigantic fish. In 2023, the Florida Fish and Wildlife Conservation Commission (FWC) implemented a limited-entry, lottery-based harvest program for goliath grouper. For the first time since 1993, up to 200 juvenile goliath grouper (slot size of 61 – 91 cm total length) can be legally landed in US waters. Harvest program critics are concerned that the goliath grouper population did not sufficiently recover and, unfortunately, limited data exists to assess the population's status. The National Coral Reef Monitoring Program's (NCRMP) Reef Visual Census (RVC) dataset (1999 – 2024) was used to evaluate the status and trends of goliath grouper on coral reefs. The RVC dataset, which mainly surveys adult habitat, showed a low occurrence of goliath grouper in all survey years. A period of population growth was observed from 2005 to 2010, followed by a decline in densities similar to when the survey began in 1999 in both the Florida Keys and Dry Tortugas. The highest density of goliath grouper was observed in Southeast Florida near Jupiter, consistent with known spawning aggregation areas. While low detection of apex predators is common in fishery-independent surveys, these long-term data provide valuable context for managers implementing and assessing management actions.

National Coral Reef Monitoring Program's Reef Fish Surveys Support Diverse, Multi-Agency Fisheries Management Efforts

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Effective fisheries management requires long-term, high-quality data to detect population-level trends and support science-based regulatory decisions. Along Florida's coral reef tract, the Reef Fish Visual Census (RVC) provides the most comprehensive fishery-independent dataset available for reef-associated fishes. For more than 25 years, RVC surveys have been conducted on hardbottom habitats in shallow water (<33 m) using a statistically rigorous survey design and consistent methodology. Surveys were generally conducted annually from 2001 to 2013 and then biennially from 2014 to 2024 as part of NOAA's National Coral Reef Monitoring Program (NCRMP). While NCRMP currently coordinates this effort, RVC surveys are collected collaboratively by federal, state, and local agencies, as well as institutional partners throughout the Dry Tortugas, Florida Keys, and Southeast Florida. RVC data provide precise estimates of abundance, density, biomass, species richness, and length composition of reef fish populations. The status and trends of individual species and trophic and taxonomic groups are variable over time and largely dependent on their resilience to environmental perturbations and fishing pressure. The RVC survey was designed to collect data on fishery-targeted, economically valuable species; however, the non-extractive methods similarly collect data on a variety of species of interest, such as invasive species, species prohibited by the fishery, forage fishes, and ecologically important species that are integral components of the reef fish community. The wide breadth of the RVC dataset has been used by individual agencies and in multi-agency efforts to address regional fisheries and ecosystem-related issues. These include several diverse management efforts such as informing stock assessments and the implementation of fisheries regulations (e.g., minimum length, slot, and bag limits), designing and evaluating spatial closures (e.g., marine protected areas, seasonal closures, zones), assessing the efficacy of local efforts (e.g., habitat restoration), and informing large-scale condition reporting. These long-term, high-quality RVC data will remain essential to inform regional management strategies that support sustainable fisheries and ecosystem health now and, importantly, emerging and adaptive management strategies in the future.

Disturbance Response Monitoring: Two Decades Spent Documenting Stressors Impacting Coral Populations Across Florida's Coral Reef

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The Disturbance Response Monitoring (DRM) program, made up of an extensive network of collaborating partners throughout Florida's Coral Reef (FCR), has been documenting the severity of coral bleaching and disease for the past 20 years. Over that time, the program has surveyed 292,751 corals at 5,174 sites, providing a long-term dataset for understanding the impact of significant disturbances on coral reef communities. DRM data has been utilized in numerous publications to understand the direct impacts of severe thermal stress, coral disease outbreaks, and other disturbances on the reef community, as well as long-term changes in coral population metrics. During its tenure, DRM has adapted its methods to document the extent and severity of the changing stressors on the reef. Stony coral tissue loss disease (SCTLD), widely accepted as the most extensive and damaging disease outbreak on (FCR), resulted in the loss of millions of coral colonies over a nine-year period. In response to the alarming reductions in coral diversity and abundance, the DRM program adjusted its design to increase the effort of observing species that became rare following the outbreak of SCTLD. A juvenile coral census was also included for SCTLD-susceptible taxa to evaluate the potential for recovery via natural recruitment in the aftermath of the disease. The marine heatwave in 2023, following the conclusion of the epidemic stage of SCTLD, resulted in widespread bleaching and heat shock mortality, particularly in the Florida Keys and Dry Tortugas, capping a ten-year period of unprecedented stress to FCR. The severity of this event, due to the early onset of temperatures above the bleaching threshold and combined with extreme elevated temperatures resulted in direct, heat-associated tissue loss, bypassing the bleaching stage on many species. To evaluate the effects of this event, the DRM program deployed temporary markers at a subset of 2023 survey sites and revisited them to assess the survival and condition of the colonies during the winter of 2024. The post-bleaching surveys documented significant declines after the 2023 heatwave, especially for 'weedy' coral species that are less thermally tolerant. Over the last two decades, the DRM program has provided stakeholders with an understanding of how coral bleaching prevalence on FCR has changed in response to increased thermal stress and which coral species have been resilient to SCTLD and bleaching. The DRM program continues to serve as a critical asset for the stewardship of FCR, aiding management agencies in understanding the detrimental, reef-wide impacts from marine diseases, catastrophic hurricanes, and ongoing periods of thermal stress.

Biodiversity Hotspots of Satellite-Tracked Marine Turtles in the Florida Keys National Marine Sanctuary

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Use of marine protected areas (MPAs) to preserve habitat for imperiled marine vertebrates is an important tool for conservation managers. The Florida Keys National Marine Sanctuary (FKNMS), one of the MPAs that comprises the U.S. National Marine Sanctuary System, was designated in 1990 in response to a series of ship groundings, mounting threats from coral disease, and declining water quality. The sanctuary covers 9,947 square kilometers of waters surrounding the Florida Keys; these waters are part of the Greater Everglades Ecosystem and include the third largest coral barrier reef ecosystem in the world with more than 6,000 species of marine life and important cultural resources. In order to assess the use of habitats within FKNMS by marine turtles, we satellite-tracked 200 imperiled marine turtles from 2008-2021 including threatened loggerheads (*Caretta caretta*), endangered green turtles (*Chelonia mydas*), endangered hawksbills (*Eretmochelys imbricata*), and endangered Kemp's ridleys (*Lepidochelys kempii*). Tagging sites were located in Florida (Florida Keys, Dry Tortugas National Park, Everglades National Park, Biscayne National Park, Broward County), Alabama (Gulf Shores), and the Yucatan, Mexico. We used various movement modeling tools including a switching state-space model, utilization distributions, and kernel density estimation (KDE) techniques to quantify turtle habitat use. We overlaid individual turtle KDE polygons onto a 5 km x 5 km grid of the study area, which covered the continental shelf on both coasts of Florida from Tampa Bay in the north to ~ 75 km south of Key West. We then summed overlapping polygons in each non-zero grid cell and enumerated these values visually to show counts of species and diversity of tagging locations. Finally, we visualized the turtle high-use zones within FKNMS. Multispecies hotspots were located both inside (60%) and outside (40%) currently designated national wildlife refuges, FKNMS, and national park boundary lines. Several important hotspots serve as year-round habitat for adult marine turtles, including Dry Tortugas and an area to the east of the Marquesas in the Key West National Wildlife Refuge. This unique geospatial dataset provides managers with a marine spatial planning tool, as currently proposed sanctuary protection areas and other areas of human use may be evaluated against high biodiversity zones that have persisted across 14 years of telemetry studies.

Modeling the Impacts of Coral Reef Restoration on Wave Energy Dissipation at Eastern Dry Rocks, Florida

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On many tropical coasts coral reefs are the primary form of coastal defense and significantly reduce wave energy that would otherwise impact shorelines. However, coral reefs' capacity to provide coastal protection is being reduced due to a range of local and global stressors and disturbances. Declines in living coral and reef structure translate to reduced reef elevation and hydrodynamic roughness, which has the potential to reduce wave dissipation. Here we report on a study of the interactions between coral restoration and wave attenuation at Eastern Dry Rocks in the Florida Keys, which is undergoing large scale restoration as part of the Mission: Iconic Reefs project. Co-located with the restoration sites, we deployed an array physical oceanographic sensors (ADCPs, pressure sensors, thermistors) at 14 sites along two across-reef transects (one on restored reef and one on a control reef) aligned across the reef flat, and down the reef slope parallel to existent reef spur and groove formations; thus spanning the wave shoaling, breaking, and dissipation zones. The array was deployed continuously from 2021-2024 and designed to provide the data required to quantify wave attenuation across the reef. The data span a wide range of conditions including six hurricanes that passed near Eastern Dry Rocks during the observational period. We are using the measurements to provide field data verification and boundary conditions for a high spatial resolution model to hindcast and predict future wave attenuation by the reef. We are using the spectral wave model SWAN with a 2.5 x 2.0 km domain centered on Eastern Dry Rocks with 5 m x 5 m computational cells. The model includes high resolution bathymetry from airborne lidar and ship-based multibeam surveys. Bottom roughness was derived from extensive Structure-from-Motion surveys. The SWAN model was validated against in situ observations under both typical and storm conditions and then used to better understand future reef properties under different restoration scenarios, including no restoration. Preliminary results suggest that, under the 2040 MIR restoration targets and conservative coral accretion scenarios, cumulative reef restoration over 25 years could enhance wave energy dissipation by approximately 10-20% through increased bottom roughness. In contrast, given that current coral substrate accretion rates at Eastern Dry Rocks are negative, the absence of restoration would likely result in a roughly 10% decrease in wave dissipation capacity. These results highlight the important role that coral restoration may play in enhancing coastal resilience over decadal timescales. Ongoing work focuses on better integrating coral growth rates into reef roughness parameterizations to improve predictive capacity under both normal baseline and extreme wave conditions.

Connectivity and Adaptation of South Atlantic Coastal Fisheries Populations: A Genomic Perspective

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Coastal fisheries in the U.S. South Atlantic face mounting pressures from overfishing, habitat loss, and environmental change. To effectively manage these resources, it is essential to understand how populations are connected across geographic scales and how they adapt to environmental variability. This project applies population and seascape genomics to four model fisheries species with diverse life history strategies—white grunt (*Haemulon plumierii*), gray snapper (*Lutjanus griseus*), hogfish (*Lachnolaimus maximus*), and black grouper (*Mycteroperca bonaci*). Using thousands of genome-wide single nucleotide polymorphisms (SNPs), we will quantify neutral genetic structure, evaluate isolation by distance, estimate effective population size, and assess genetic diversity to identify potential stock boundaries, source populations, and demographic bottlenecks. In parallel, gene–environment association analyses will integrate molecular data with environmental features such as temperature, salinity, turbidity, depth, and estuarine influence to identify alleles linked to local conditions. These analyses will reveal adaptation hotspots where populations may be particularly resilient to environmental change or vulnerable to shifting oceanographic regimes. By combining genetic connectivity with signatures of adaptation, this research will provide a comparative, multi-species perspective on the evolutionary and ecological processes shaping South Atlantic coastal fisheries. The results will strengthen the scientific basis for refining management units, prioritizing conservation actions, and anticipating population responses to future environmental challenges, ultimately supporting sustainable fisheries management across the region.

Getting the Water Right: Economic Links Between Everglades Restoration and the Florida Keys

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Monroe County's economic prosperity fundamentally depends on its aquatic resources and a thriving tourism economy, forming a critical component of South Florida's larger Clean Water Economy. Classified as a recreation-dependent economy by the USDA Economic Research Service, Monroe County tourism contributed approximately $3.5 billion in visitor spending in 2023, a major contributor to the county's total GDP of $7.65 billion. This economic vitality relies heavily on healthy marine and estuarine ecosystems sustained by freshwater inflows from the Everglades ecosystem. Florida Bay serves as the crucial ecological link between upstream freshwater marshes and coastal estuaries, and downstream coral reefs, seagrass habitats, and economically valuable fisheries. Ensuring water security is essential to maintaining the region's ecological stability and economic resilience. This requires consistent water availability, high water quality, effective management of risks and variability, ecosystem and biodiversity protection, and equitable access through strong institutional coordination. Historical disruptions in Everglades hydrology have triggered significant ecological threats, including extensive seagrass die-offs and harmful algal blooms, jeopardizing fisheries, tourism revenue, and community livelihoods. This presentation reviews past and current economic research, emphasizing the critical links between natural capital and economic outcomes. Attendees will gain insights into how integrated management across freshwater, estuarine, and marine ecosystems supports critical economic sectors such as tourism and fisheries. Emphasizing the essential role of the Comprehensive Everglades Restoration Plan and the theme "Getting the Water Right," this talk underscores the foundational importance of integrated freshwater management for ecological integrity and the long-term prosperity of Monroe County and South Florida.

Water Mass Histories Modulate Reef Carbonate Chemistry: A High-Resolution Model for the Florida Keys

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Understanding how upstream benthic communities influence local carbonate chemistry on coral reefs is essential for predicting present-day stress exposure and anticipating escalating environmental stressors in the future, including ocean acidification. We developed a regional statistical modeling framework to predict site-level carbonate chemistry across coral reefs in the Florida Keys. This approach integrates the composition of the local benthic community, seawater connectivity between habitats, and source water chemistry. Using a SLIM 2D hydrodynamic model, we reconstructed water mass histories for 10 reef sites. These trajectories delineate the upstream areas traversed by water prior to sampling—spatial footprints we refer to as "flowsheds." By overlaying flowsheds with benthic habitat maps, we quantify the metabolic influence of upstream seagrass, calcifiers, and noncalcifying algae. This benthic context, combined with environmental parameters (light, temperature, salinity, chlorophyll-a, nitrate) and source water chemistry, informs predictive models of change in dissolved inorganic carbon (DIC) and total alkalinity (TA) at each reef. We use a sensitivity analysis to explore how changes in upstream habitat composition may influence downstream reef chemistry. This approach improves our ability to assess biogeochemical consequences of benthic change and informs scenario-based planning for habitat restoration and resilience in the Florida Keys.

Hydrodynamic and Salinity Modeling in Florida Bay

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Florida Bay is a large and shallow lagoon, characterized by its high productivity as an estuary and its abundance of seagrass communities which play an important role in supporting economically critical recreational fisheries. This area of approximately 2,200 square kilometers is bounded by the Everglades National Park (ENP) to the north, the Florida Keys to the south and east, and the Gulf of Mexico to the west. Salinities in Florida Bay are highly dependent upon evaporation, direct precipitation and freshwater inputs and flows. This study focuses on developing a hydrodynamic and salinity model for Florida Bay. The model will be used for a comprehensive understanding of the salinity patterns in Florida Bay. This understanding is critical to water management and hydrologic restoration actions necessary to protect and support this critical ecosystem in terms of quantity, quality, and timing and distribution of freshwater deliveries. There is a significant gap in knowledge when it comes to the connectivity between groundwater and the bay, and the relationship between groundwater and salinity level in Florida Bay. In response to this knowledge gap, the Groundwater Exchange Modeling and Monitoring (GEMM) Plan was created to provide a proposed framework to address the uncertainties associated with landscape-scale flow patterns, surface-groundwater interactions, impacts of seepage eastward on groundwater movements south to Florida Bay, and the influence of water management on the development of hypersalinity (>40 psu) in Central Florida Bay. Phase I of this study is Model Potential and Capabilities Demonstration. It aims to investigate the functionalities of the Delft3D model, with a primary focus on its hydrodynamic module and the D-Water Quality process library. A preliminary and uncalibrated Delft3D-based modeling framework has been developed to simulate hydrodynamics, waves, salinity, temperature, sediment transport and other water quality processes in Florida Bay. The D-Water Quality processes are integrated in D-Flow FM. Phase II of this study is ongoing. The model system will be calibrated and used to forecast hydrodynamic, ecological, and hydrological responses to different climatic (e.g., storm surge events), operational, and environmental conditions in Florida Bay and its upstream watershed. These responses will be integrated with water management operations to minimize the occurrence of hypersalinity events in Florida Bay. In support of the GEMM program, the model system will serve as a quantitative platform for evaluating various factors in Florida Bay, including the vertical barrier to lateral flow, interactions between vertical and horizontal flows, ecological parameters, current and future water management practices, as well as the impact of sea-level rise on the integrated surface water and groundwater hydrologic systems.

Hydrologic Connectivity Between the Everglades and the Florida Bay Through Coastal Mangroves and Freshwater Sloughs

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Coastal mangroves are important to the southern Everglades' natural drainage systems that provide a hydrologic link between the upland freshwater wetlands and the downstream estuaries and coastal ocean. Both Shark River and Taylor Sloughs are vulnerable portions of the Florida Coastal Everglades due to the combined presses of accelerated sea level rise and pulses of severe weather like tropical cyclones. Furthermore, both Sloughs undergoing intensive hydrological rehydration through the Comprehensive Everglades Restoration Program to restore freshwater flow. Therefore, having a detailed understanding of the hydrologic connectivity between the Shark River and Taylor River Slough with the downstream coastal zones, including Florida Bay, is important. In this study, we conduct rigorous numerical modeling with an advanced three-dimensional hydrodynamic model to simulate the inundation depth and inundated areas, water level, flows, and particle trajectories of the land-to-ocean continuum of Florida coastal Everglades with a focused areas along Shark and Taylor Sloughs, Florida Bay and the Gulf of Mexico. The well-validated model results provide qualitative and quantitative analysis of the hydrologic connectivity between landscapes with heterogeneity across multiple scales along the creek-to-ocean gradient. The model's results calibrated to stage gauges located throughout south Florida and surrounding coastal areas are used to examine the seasonal variation of the hydrologic connectivity between the watershed and the coastal ocean through the freshwater sloughs with anthropogenic modification by canal water management and restoration plans. The results of this work shed light on the impact of environmental and anthropogenic stressors on the hydrologic changes and material exchanges across the land-to-ocean continuum.

Octocoral Population Response and Recovery to Reef Disturbances

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Among the many changes occurring on Florida Keys reefs are the shifting dynamics of octocoral (soft coral) communities, which in some areas are increasing in benthic cover and density following the decline of scleractinian corals. While the response of the scleractinian community to disturbances such as hurricanes and marine heatwaves is well-studied, the response of octocorals to specific disturbances receives less attention. The Coral Reef Evaluation and Monitoring Project (CREMP) annually surveys fixed sites throughout the Florida Keys and Dry Tortugas, with sites in the Keys stratified across patch reef, shallow forereef and deep forereef habitats, and sites in the Dry Tortugas spanning shallow patch reef, pinnacle reef, and deep reef habitats. Octocoral specific CREMP surveys conducted since 2011 include an assessment of the density of the entire arborescent octocoral community and population demography of a few target species: *Antillogorgia americana, A. bipinnata, Eunicea flexuosa, Gorgonia ventalina,* and *Pseudoplexaura porosa*. Declines in density on Keys forereefs after Hurricane Irma in 2017 were followed by significant increases in the subsequent two years. Within the target species populations, this rapid recovery was driven by successful recruitment events, particularly among *A. americana* and *G. ventalina*. Whereas the octocoral community was relatively resilient to the 2014-2015 marine heatwave, widespread mortality occurred during the 2023 marine heatwave, with target species population declines ranging from ~20-90% between the summer of 2023 and the winter of 2024. Declines were focused on patch reefs that sustained higher temperatures than forereef habitats and among *P. porosa* colonies, which are primarily found at patch reefs. Evidence of widespread recruitment was not observed in the summer of 2024, indicating recovery will be slower following the marine heatwave than was seen following Hurricane Irma. Continued impacts and recovery of octocorals will likely depend on the frequency and severity of disturbances.

Murky Waters, Clear Signals: The Behavioral and Epigenetic Responses of Bicolor Damselfish to Increased Turbidity

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Coral reefs in the Florida Keys face increasing challenges from anthropogenic impacts, including bleaching, disease, overfishing, and decreasing water quality. A key element of decreasing water quality is increased chronic and acute turbidity as a result of coastal development, dredging and boating activity, as well as more frequent and stronger storms. While the effects of sediment on corals are relatively well studied, the effects on fishes are poorly understood. Here we use an aquarium experiment to examine the effects of increased turbidity on both the behavior and epigenetics of a common reef fish, bicolor damselfish (*Stegastes partitus*). Epigenetics is the study of heritable changes to gene expression within an organism that do not affect the genotype or nucleotide sequence of the genome. These changes allow the potential for rapid response and adaptation to environmental stimuli and, while the epigenetics of corals is being explored, the epigenetics of fishes is largely unknown. However, in a social and mobile species, epigenetics can provide a rare insight into the underlying molecular mechanisms associated with behavioral changes. In aquarium experiments bicolor damselfish were exposed to either control (0-1 NTU), medium (5-15 NTU), or high (20-30 NUT) turbidity for “pulse” durations of either one, six, or twelve hours. A cohort of 36 damselfish allowed 4 replicates of each treatment, and food consumption, reaction time to food, and maximum distance traveled from shelter were recorded for each fish. These behavioral experiments found that not only was there reduced reaction time to food from the control group compared to any of the medium or high turbidity treatments, but that fish in the high and medium turbidity groups also consistently consumed less food than fish in the control. In the turbid tanks bicolor damselfish also decreased the maximum distance they were willing to swim from shelter, consistent with observations made in the wild. After each trial, damselfish were dissected and tissues preserved for epigenetic analysis that used Methylation-Sensitive Amplification Polymorphism (MSAP) to investigate epigenetic modifications, focusing on three genes associated with stress response, neuroplasticity, and oxygen transport. The results of these analyses, as well as an optimized protocol for utilizing reef fish tissues in MSAP preparations, will be discussed. This research represents one of the first applications of both behavioral and epigenetic responses to a stressor of a reef fish in the Western Atlantic. Epigenetics potentially offers researchers and managers a novel framework for understanding and quantifying rapid environmental adaptation in marine ecosystems. This work underscores the importance of improving water quality in the Florida Keys as the behavioral and epigenetic impacts may affect the fitness of bicolor damselfish as well as many other fish species.

Seascape and Food Web Impacts of the Fish Spinning Phenomenon in the Florida Keys

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Foraging behavior and habitat use strongly influence a fish's risk of exposure to environmental stressors, including toxins. In the Florida Keys, recent fish mortality events linked to abnormal spinning behavior are suspected to be caused by toxins produced by *Gambierdiscus*, a benthic dinoflagellate common on seagrass and macroalgae. Because of its association with submerged aquatic vegetation, risk is likely uneven across the seascape and dependent on the degree to which a fish relies on nearshore benthic food webs. This project investigates if fish spinning behavior can be predicted from habitat composition and fragmentation, how prey communities are altered in affected areas, and whether reliance on benthic food webs increases susceptibility. First, high-resolution benthic habitat maps were developed using satellite imagery and field data to classify vegetation cover and fragmentation at sites with reported fish spinning behavior to assess links between habitat structure and spinning events. Second, prey community composition and biomass were surveyed at across the Florida Keys and Biscayne Bay, for temporal and spatial comparisons between affected and unaffected communities. Third, stable isotope analysis was be used to compare the trophic pathways of two species impacted by the 2024 mortality event, Crevalle Jack and Smalltooth Sawfish, to test how the reliance on benthic versus offshore food webs influences risk of exposure. Our results integrate seascape ecology, prey community dynamics, and trophic pathways to understand potential risk and exposure to fish spinning. This work provides valuable insight for forecasting future events and guiding conservation of vulnerable fish species in nearshore ecosystems.

Regional Differences in Permit Diet and Resource Use Suggest Shifts in Seagrass Flat Food Webs

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Shallow seagrass flats across the Florida Keys support important recreational fisheries. However, guides and anglers have reported declines in catch quality, especially in Key West, along with changes in fish behavior from active feeding to cruising or schooling. Preliminary findings suggest that reduced prey availability may explain these changes. To explore this further, we partnered with guides to collect non-lethal samples from permit (*Trachinotus falcatus*) across the Florida Keys and Biscayne Bay. We analyzed permit fin tissue and fecal DNA to assess resource use and diet composition, which differed across regions. Permit in the Lower Keys consumed more crabs and relied on pelagic sources. In contrast, fish from the Upper Keys and Biscayne Bay consumed more snails and relied on seagrass-based food webs. This study supports the need for further research on prey availability to determine whether it drives spatial differences in diet and resource use. Understanding these patterns can inform future efforts to monitor fishery health and habitat condition.

Site Selection for Florida’s Coral Reef Restoration & Recovery (FCR3) Initiative

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Florida’s Coral Reef forms the basis of our economy and way of life; and yet it faces human-induced and natural threats that have caused a significant decline in this critical ecosystem. Over the past two decades, scientists and practitioners have developed and refined coral reef restoration techniques as one tool to help reverse the decline. Florida’s Coral Reef Restoration & Recovery (FCR3) initiative was established by Governor DeSantis to develop the resources and expertise needed to support the long-term recovery of Florida’s Coral Reef. In an effort to better direct these resources, the state of Florida identified a need for comprehensive restoration planning. Florida’s Tier 1 Strategy focuses on ecological goals to restore ecosystem structure and function and recommends places along Florida’s Coral Reef where restoration is likely to have more impact based on long-term ecological data and larval connectivity modeling. Focal areas identified in Tier 1 were further refined to select priority areas to ground-truth by incorporating environmental data, including climate and water quality, and additional ecological data, such as bleaching history, disease risk and coral colony survival. A standard operating procedure was developed to guide data collection at priority ground-truthing sites so that metrics considered or known to influence coral outplant survival and restoration success can be statistically evaluated. Data collection includes capturing information on coral health, population size structure, coral diversity and habitat structure. These priority areas are currently being ground-trothed to determine recommended restoration sites for FCR3.

Restoring Balance: Tracing Nutrient Patterns from Ridge to the Reef

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Water column nutrient concentrations are the result of interactions between biota and the environment in response to long-term and episodic changes to the system transposed over decadal or multi-decadal climatic forcing factors. Long-term, or press events, include eutrophication, sea-level rise, and warming. Meanwhile, episodic events can include hurricanes/tropical activity, drought, fire, and cold snaps. Over the last three decades, the southern Everglades, Florida Bay, and Reef track have undergone significant changes in water quality conditions in response to long-term and episodic changes while experiencing climatic shifts, whilst also undergoing restoration and water management operational changes. Using a multi-decadal dataset from 1996 to 2025 with monitoring locations across the freshwater Everglades to the outer marine reefs along the Florida Keys, trends and potential drivers were evaluated for Chlorophyll-a (Chl-a), total phosphorus (TP), total nitrogen (TN), and nutrient stoichiometry. Relative changes in Chl-a, TP, and TN concentrations were highly dynamic across space and time, with several periods of significant changes occurring in cyclic patterns. Periods of significant sharp increases and subsequent decreases correspond to tropical storms and hurricanes while periods of change with smaller amplitude occurred relative to other events such as droughts, fires, and high water levels. Persistent and significant changes in Chl-a and TN:TP stoichiometry have also occurred in regions of the study area that have experienced dynamic changes due to sea-level rise, reduced hydrologic connectivity, and warming. Changes in water quality parameters are important indicators of environmental change. Nutrient concentrations along the ridge-to-reef continuum are inherently dynamic; however, this effort will demonstrate that the system exhibits measurable responses to both long-term environmental shifts, such as ecosystem restoration or climate forcings, and shorter-term event-based fluctuations. Combined, this highlights the connectivity of these ecosystems and the resulting cascade of effects and processes.

Queen Conch and Marine Conservation Through Signage

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The project aims to enhance public awareness and protective measures for the Queen Conch, leveraging research in design, policy, and humanistic approaches. The main goal is to develop effective educational strategies that can be implemented in public spaces. Additionally, the project experiments with different visual media formats to acknowledge the changing attention spans in an age of social media in addition to the resources (or lack thereof) put into sign conservation. By placing signs with different variations in fonts, placements, layouts, media, and languages in nature centers and public beaches in South Florida, data was collected on which signs are most effective in engaging the public and conveying conservation messages. The research paper will analyze which sign variations and elements proved most effective. The outcome of this project includes research-backed educational signs installed at strategic coastal locations supported by iNaturalist data. This is an experimental project, as it explores the intersection of design, policy, and humanistic approaches. With the Queen Conch as a case study, this project serves as a foundational model for any marine species or conservational message.

Artificial Reefs in the Florida Keys: Opportunities to Support Fisheries Management Objectives

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Artificial reefs are structures that are intentionally placed on the seafloor to achieve a variety of goals, including enhancing marine habitat and providing recreational fishing and diving opportunities. Despite comprising a small percentage of habitat compared to naturally occurring habitats, these artificial structures disproportionately influence fishing effort and fish behaviors. Yet, artificial reefs are seldom seen as tools for supporting fisheries management objectives. Recently, shifts in public perception and funding allowed for the formation of the Monroe County Artificial Reef Program, which aims to implement artificial reefs to benefit diverse groups of stakeholders and ecosystems within the Florida Keys. Here, we identify how these new resources provide an opportunity to utilize intentional marine spatial planning to support specific fisheries management objectives while also achieving socio-economic goals. The vast majority of existing artificial reefs in the Florida Keys were constructed in the 1980s, utilizing decommissioned materials from bridges, vessels, and barges to create new fishing and diving opportunities. The few artificial reefs that have been constructed since range from small-scale school projects to high-profile dive sites, such as the Spiegel Grove and Vandenberg. Several of these existing artificial reefs illustrate the potential biological and socio-economic benefits that intentionally placed structures can have in this type of dynamic environment. For example, high-relief artificial reef sites are known aggregation sites for permit (*T. falcatus*) and barracuda (*S. barracuda*), and low-profile artificial reef modules off Long Key are documented habitats for red grouper (*E. morio*). Additionally, the deployment of the Vandenberg has been estimated to generate a 20-year return of at least $7.7 million, due in part to the robust dive industry in the Keys. Strategic placement of artificial reefs in relation to currents, existing closed areas, and biological pathways could impact a broad number of fish species and life history stages while also generating socio-economic benefits. We aim to understand how to best leverage the unique ecological and socio-economic attributes of the Florida Keys with scientific evidence on artificial reefs in support of Florida’s Strategic Artificial Reef Plan while minimizing unintended consequences.

Using Habitat Support Structures to Address Habitat Deficits Within Bayside Nearshore Hardbottom of the FKNMS

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Reductions in the quality and structural complexity of physical habitat are occurring across the Florida Keys marine ecosystem, including shallow nearshore hardbottom. Nearshore hardbottom (NH) communities are the most extensive type of hardbottom community in South Florida, covering about ~30% of the entire nearshore habitat in the Florida Keys. They occur in shallow, coastal waters -both bayside and oceanside but primarily bayside- within approximately 2km of shore on top of consolidated limestone substrate. Historically, the structural complexity of the NH bayside community was characterized by a complex assemblage of low-relief organisms including sessile benthic invertebrate species (sponges and octocorals) and macroalgae, as well as variously sized solutions holes (cavities in the limestone). This shallow low-relief habitat is essential for fish and invertebrate foraging and refuge, as well as nursery habitat for juvenile reef fish and spiny lobsters. Newly settled and juvenile fishes account for over 80% of fishes found in these habitats in southeast Florida and therefore represent a vital source of fish that eventually move into offshore habitats as they mature and migrate (i.e., ontogenetic movements). However, long-term monitoring of these communities in the Keys has revealed substantial changes in habitat landscape, community composition, and ecology. Since the early 1990s, acute disturbance events like cyanobacterial blooms have caused spatially extensive mortality of many sponge species, especially those that provide structure. This is problematic because habitat structural complexity is a key factor shaping marine communities; structurally complex environments have more microhabitats and niches available for organisms to refuge, feed, breed, settle, shelter, and forage, thereby increasing the potential persistence of populations and promoting biodiversity. Conversely, loss of structural complexity is linked to ecosystem declines in biodiversity and resilience. Resulting from these reductions in sessile benthic invertebrate densities are further reductions in niche diversity, food resources, refuge space, and fish diversity. Present-day fish species richness is just 30%–40% of what it was when surveying began in the 90's. To address the habitat deficits as related to fish and invertebrate life histories in this area, Monroe County and the Florida Fish & Wildlife Conservation Commission (FWC) have partnered together to create a pilot program that will design, deploy, and evaluate habitat support structures. Our poster will showcase our science-based, ecosystem-focused approach for conducting a pilot study off the bayside Middle Keys with the ultimate goal to improve conditions and resources within the Florida Keys National Marine Sanctuary.

Using Habitat Support Structures to Address Habitat Deficits Within the Florida Keys National Marine Sanctuary

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Reductions in the quality and structural complexity of physical habitat are occurring across the Florida Keys marine ecosystem. Habitat structural complexity is a key factor shaping marine communities; structurally complex environments have more microhabitats and niches available for organisms to refuge, feed, breed, settle, shelter, and forage, thereby increasing the potential persistence of populations and promoting biodiversity. Conversely, loss of structural complexity is linked to ecosystem declines in biodiversity and resilience. Monroe County and the Florida Fish & Wildlife Conservation Commission (FWC) have partnered together to create a pilot program that will design, deploy, and evaluate habitat support structures for improving conditions and resources within the Florida Keys National Marine Sanctuary. Our science-based, ecosystem-focused approach will include 1) a characterization of marine habitats and their structural deficits as related to fish and invertebrate life histories, 2) the deployment of structures designed to address different habitat deficits, and 3) a comprehensive monitoring plan to evaluate net ecological outcomes and identify optimal designs that may be upscaled. Thus far, five habitat deficit areas have been identified across shallow nearshore hardbottom (predominantly bayside), southern Gulf of Mexico offshore waters, Atlantic side nearshore patch reefs, Atlantic side offshore coral reefs, and Atlantic side deep reefs. Our talk will begin with a discussion of contemporary marine environmental challenges related to reductions in habitat quality, followed by a general description of the five different habitat deficit areas, and end with an introduction into the first of our pilot studies for the nearshore hardbottom habitat that will be presented in more detail during the poster presentation session. Finally, a long-term goal of this program is to create networks of sites extending from near to offshore on both Gulf and Atlantic sides to support ontogenetic movements of fish as they mature and migrate across different habitats. Starting with a series of pilot studies for determining optimal size, design, configuration, and placement in each habitat deficit area serves to aid us in achieving this larger goal where structures can be used by marine life across interconnected habitats.

What Happens in Florida Bay Does Not Stay in Florida Bay: Seagrass Die-Off Under Climate-Change

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Climate change is ushering in a less predictive environment in which to manage natural resources, including shallow nearshore habitats that influence water quality on the Florida Reef Tract. Future climate scenarios for Everglades' Coastal Marine Foundation Communities assessed a decade ago by the authors identified seagrass ecosystem stress from multiple drivers that coalesce to enhance hypoxia in the system. These drivers, elevated temperature, salinity and recurring algal blooms that reduce light to the benthos and cause hypoxia, also stimulate sulfide toxicity in tropical carbonate seagrass systems such as Florida Bay. This is consequential, as hypoxia and sulfide toxicity have been reported to be one of the leading causes of recurrent large-scale seagrass mortality events in Florida Bay, as well as globally. Our research over the last 25 years has been focused on gaining a more complete understanding of seagrass internal and water column oxidation and factors leading to seagrass decline and die-off events in Florida Bay that lower water quality. However, we now require a vehicle to translate these data into climate change driven projections. We present a synthesis of experiments and field microsensor studies that define the fundamental triggers of seagrass die-off and a modeling tool where we integrate these data for seagrass and water quality management under various scenarios of climate change within south Florida shallow nearshore habitats.

Developing a Machine Learning-Powered Boat Detector for Underwater Acoustic Data

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Passive acoustic monitoring is a valuable and versatile tool that is widely used in marine research to record the underwater soundscape. Passive acoustics can collect data in marine environments where cameras or field monitoring are inadequate due to high turbidity, distance from shore, or large spatial areas. The relatively low cost of hydrophones and small size of audio files allow for the collection of large volumes of data, but processing and analyzing such a substantial amount of sound requires significant personnel time. Incorporating machine learning techniques into analysis is critical to effectively harness the continuously growing inventory of passive acoustic data. Since 2021, researchers with the collaborative MERR lab at the Florida Fish and Wildlife Research Institute and University of Florida have been collecting acoustic data at three sites off the west coast of Florida that have been identified as gag grouper (*Mycteroperca microlepis*) spawning habitats. Two sites are subject to seasonal fishing closures and the third is permanently closed to fishing as a marine protected area. Their distance from shore and wide spatial extent make passive acoustics the most effective way to monitor boater use during the on- and off-seasons and evaluate the protected area for potential poaching activity. However, processing the thousands of hours of audio has been extremely time-consuming, resulting in a significant backlog. Thus, researchers are working to develop a general machine learning model for boat noise. Instead of developing a model from scratch, transfer learning is being used to build upon a pre-trained underwater acoustics model to focus specifically on boat noise. The boat detector model is built from Google Research's SurfPerch model, which was trained on a variety of terrestrial and marine audio data to detect more than 20 classes of underwater noises. Transfer learning reduces the amount of training data necessary to develop a base model, and the incorporation of an active learning loop can rapidly improve detection. Active learning is a component of agile modeling, which reduces the amount of manual training by focusing human effort on the audio segments that are most challenging for the model to identify. Combining transfer learning and active learning techniques has resulted in an accurate and precise prototype of the boat detector model with a 96% accuracy and 2.5% false negative rate within one site where training data was available. The model continues to be trained using data from the two other west Florida sites with a combination of active learning and previously annotated data. Further, additional acoustic data from Western Dry Rocks in the Florida Keys will be incorporated to generalize the model across Florida. Ultimately, the development of a general boat detector machine learning model will greatly enhance the capabilities of passive acoustics for monitoring human use of large and remote marine environments.

Horror, Homing, and Habituation: Effects of Translocation Between Aggregations of Queen Conch in the FKNMS

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Overharvest has reduced queen conch (*Aliger gigas*) populations. However, the Florida Keys present a case study for repopulation: conch were nearly eliminated, resulting in a fishery closure for recovery and enabling the evaluation of conservation actions. One action to enhance reproduction is the translocation of non-breeding conch in poor habitat to breeding aggregations. Translocation is currently the remediation action of choice for conch in harm's way. However, fine-scale shifts in behavior and the long-term fate of sexually mature animals when moved between areas of optimal habitat have not been quantified. To fill this knowledge gap, we conducted a multiscale translocation between breeding populations separated by 2, 5 and 17 km in the Florida Keys National Marine Sanctuary. A shorter-distance within-aggregation translocation of 1 km was conducted near Port Everglades. The movement and behavior of 38 adult queen conch were tracked with active acoustic tags and accelerometers for up to a year between June 2024 and 2025. Initially, translocated animals displayed significantly greater activity and displacement than controls. Over short distances, apparent homing behavior occurred. Through time, translocated conch suffered greater mortality than control animals, although displacement and death rates decreased as surviving animals joined new aggregations and began to breed within them. Perhaps differences in camouflage and unfamiliarity with the landscape were initially barriers for translocated animals, and acclimation could help.

A Regional Survey of Clypeasteroid and Spatangoid Echinoids of the Central Florida Keys

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We report the results of SCUBA surveys of clypeasteroid and spatangoid echinoids conducted in 2020 and 2021 along the central part of the Florida Keys. Documenting present-day distribution of those widespread organisms, which perform important ecosystem services, is important for understanding their regional ecological significance. Both live and dead remains were included in the survey. Echinoids and/or their dead skeletal remains (tests or test fragments) were found at 17 out of 27 examined sites (63%) across multiple habitats including coastal seagrass meadows, the Hawk Channel, backreef sands, and deeper forereef habitats. The species included *Clypeaster rosaceus* (four sites), *Clypeaster subdepressus* (five sites), *Encope michelini* (three sites), *Leodia sexiesperforata* (eight sites), *Meoma ventricosa* (nine sites), and *Plagiobrissus grandis* (four sites). Whereas most sites were dominated by one species, some sites included as many as five echinoid species. The agreement between live and dead echinoids was high, including spatial distribution, species composition, and rank abundance of dominant species. The high fidelity (i.e., high live-dead concordance) suggests that irregular echinoid populations can also be tracked using skeletal remains found around seafloor surface. Our recent bio-inventorying effort is consistent with past regional surveys (dating back to 1960s) in terms of the identity of observed species, their rank abundance, and their spatial distribution patterns. The results indicate that despite widespread human-driven impacts (tourism, urban development, increasingly frequent hurricanes, and seasonal fisheries), irregular echinoid populations continue to be widespread and abundant across a wide range of habitats where they provide diverse ecosystem services by recycling organic matter, oxygenating sediments, hosting commensal organisms, and supporting predators. The reported results document the present-day status of echinoid populations in central Florida Keys and may serve as a reference point for assessing future regional changes in distribution and abundance of echinoid populations.

A Decade of Rapid Coral Community Change on the Florida Reef Tract: Insights from NCRMP

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Coral reef ecosystems throughout the Florida Reef Tract have continued to deteriorate in the face of persistent chronic and more frequent acute stressors. Over the past decade, coral mortality on the Florida Reef Tract has been primarily driven by widespread coral disease, particularly Stony Coral Tissue Loss Disease (SCTLD), and repetitive heat stress events. To assess the impact of these stressors, changes in coral community structure and species-specific population structure from 2014 to 2022 were evaluated using coral demographic data from NOAA's National Coral Reef Monitoring Program (NCRMP). NCRMP uses a stratified random sampling design to biennially survey hardbottom coral populations in the Southeast Florida Region, Florida Keys, and Dry Tortugas. Results indicated significant declines in hard coral cover across all regions, with the Florida Keys exhibiting the highest reduction at a >60% loss in scleractinian cover. Disease prevalence remained relatively low across all regions and years, averaging 2.5 ± 2.2% in prevalence. Notable exceptions to low disease prevalence occurred in 2016 in Southeast Florida (12.7%) and in 2022 in the Dry Tortugas (5.96%), both corresponding with SCTLD introduction to those areas. Despite the generally low overall prevalence, the greatest declines in coral density were observed among species known to be highly susceptible to SCTLD: *Meandrina meandrites* (88.3 ± 5.2%), *Colpophyllia natans* (84.3 ± 6.7%), *Pseudodiploria strigosa* (80.2 ± 2.0%), and *Dichocoenia stokesii* (74.1 ± 4.1%). In contrast, bleaching was considerably more widespread, with an average prevalence of 19.9 ± 9.2% across all regions and years. Additionally, coral species that bleached most frequently (*Siderastrea* spp., *Agaricia* spp., *Porites* spp., and *Stephanocoenia intersepta)* experienced the greatest absolute declines in density. These results highlight the impacts of multiple interacting threats: while disease events are reducing the biodiversity and density of susceptible species, persistent and increasingly severe heat stress events are further reducing the resilience and density of remaining species. Together, these stressors continue to reshape coral community dynamics and threaten the long-term stability of reef ecosystems across the Florida Reef Tract.

The Potential of South Florida Seagrass Meadows as Natural Climate Solutions

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Seagrass meadows have long been regarded as carbon sinks of global significance, mainly due to their potential to accumulate organic carbon-rich sediments. However, the large apparent variability in organic carbon stocks and burial rates among different seagrass systems, as well as their environmental controls, are still poorly understood. As the restoration and protection of these habitats are being proposed as natural climate solutions, there is an urgent need to identify the characteristics of seagrass meadows that provide the best return on investment in terms of either avoided emissions or additional carbon sequestration. Complicating the assessments of carbon fluxes in tropical to subtropical latitudes is the role of carbonate formation, which produces CO_2 that may offset the potential of seagrass meadows as carbon sinks. Here, we take advantage of the varied seagrass habitats found in the Florida Keys to assess their potential role as natural climate solutions, by examining their carbon stocks, as well as organic and inorganic carbon burial fluxes using 18 ^{210}Pb-dated sediment cores spanning a range of geomorphic settings from estuarine to backreef environments. We find considerable variability in sediment carbon stocks and burial fluxes across the seascape, with carbonate production either offsetting or enhancing organic carbon burial, modulating the status of south Florida seagrass meadows as net sinks or sources of carbon to the atmosphere. In addition, we found that hotspots of seagrass carbon stocks are spatially decoupled from hotspots of carbon burial, suggesting that different seagrass meadow characteristics should be targeted for habitat protection than for seagrass restoration. Using south Florida as a microcosm, our study highlights that not all seagrass meadows have equal value as natural climate solutions, and that the success of different conservation strategies is likely linked to meadow characteristics as well as their position in the seascape.

Microbiome Manipulation: Using Beneficial Microorganisms of Coral (BMCs) to Increase Disease Resilience

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Populations of the Caribbean staghorn coral have markedly declined since the 1980s due primarily to infectious diseases. We have identified a strong linkage between disease susceptibility in this coral species with high abundance of a known bacterial parasite in the genus *Aquarickettsia*. In contrast, naturally disease-resistant staghorn genotypes harbor a more diverse microbiome. We hypothesized that the microbiome of these staghorn genotypes contains potential beneficial microorganisms for corals (BMCs) that may confer some of the observed disease resistance. Additionally, we hypothesized that the rapid, significant loss of the parasite *Aquarickettsia* through experimentally-induced bleaching would allow for the introduction of beneficial bacterial taxa to fill the niche left open by the loss of this parasite. To date, we have isolated and characterized over 186 bacterial isolates from disease-resistant staghorn genotypes and found that 72 show beneficial properties against a known coral pathogen, *Serratia marcescens*. We further screened and tested these potential BMCs using the coral model *Aiptasia* (sensu *Exaiptasia diaphana*). Individual BMC cocktails were validated in Aiptasia to ensure non-virulence and beneficial properties against the coral pathogen. To manipulate the existing microbiome of disease-susceptible staghorn genotypes, we investigated two methods to reduce populations of *Aquarickettsia*: thermal- and menthol-induced bleaching. After significant loss of *Aquarickettsia* through these methods, we tested different approaches to introduce beneficial bacterial taxa. We found that adding the BMC cocktail to the coral food was the best inoculant. The microbiomes pre- and post-inoculation of the BMCs were analyzed by 16S rRNA sequencing. Our results represent the first microbiome replacement study in *Acropora cervicornis* and pave the way for continued trials of microbiome replacement with a greater number of coral genotypes, species, and life stages. The use of coral food as the inoculant of the BMCs is a scalable method and the ability to use BMCs to replace a known bacterial parasite will almost certainly improve disease outcomes and will be transformative for coral restoration efforts.

Sponge Restoration Aquaculture: Reproductive Viability Following Propagation for Nearshore Spongiidae Species in the Florida Keys

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Since 2010, a coalition of state natural resource managers and scientists have engaged in sponge restoration to mitigate a series of sponge die-offs in the nearshore hardbottom habitats of the Florida Keys. Sponge restoration aquaculture is a viable tool to accelerate the natural progression of sponge recolonization following ecological disturbances (e.g., algal blooms, heatwaves, hurricanes). For sponge restoration aquaculture to be successful, it is important that these aquacultured propagules become reproductive to sustain future populations. We surveyed the reproductive capacity of restored sponges to evaluate recruitment dynamics in Florida Fish and Wildlife Conservation Commission sponge nurseries. Using histology and light microscopy, we evaluated 4 Spongiidae species (*Hippospongia* cf. *lachne, Spongia barbara, Spongia graminea, and Spongia (S.) tampa*) for gametogenesis 3-6 years following *in situ* asexual aquaculture propagation near Key West, Florida. Eighty-eight percent of the sampled Spongiidae propagules (n=95) were in gametogenesis. Sex ratios were highly skewed in favor of spermatogenesis. From April through June 2023, 94% of the *H. lachne* propagules (n=16) were reproducing compared to 55% of the adult donor sponges (n=60) sampled the previous year. Restored sponge propagules had higher rates of gametogenesis and were more fecund. This study will answer key questions about sponge reproductive biology in support of the current state of Florida restoration and management efforts.

The Last Genotypes: Elkhorn Coral Demography, Genotypic Diversity, and Restoration in Florida

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The Elkhorn coral (*Acropora palmata*) population in the Florida Keys has suffered devastating losses in recent years. Since 2004, our ongoing demographic monitoring has documented losses not only in abundance and spatial distribution but also in genotypic diversity, over 90% in the past two decades. Sexual reproduction in this species requires distinct neighboring genets with ramets that are large enough to spawn. However, based on the size distribution of the remaining population we estimate that only half of the remaining genotypes have a viable chance to sexually reproduce. In the 20-year duration of this study, no recruitment of new genotypes (larval recruitment) has been observed in our monitoring plots which underscores the urgency for intensive intervention to preserve *A. palmata* in the Florida Keys. Restoration efforts need to address the sparse distribution, low genotypic diversity, and increasingly frequent thermal stress events impacting this species.

Florida's Coral Reef Water Quality Data Compilation, Analysis, and Decision Support

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Florida's Coral Reef (FCR) has experienced extensive declines in coral cover driven by a combination of anthropogenic and biophysical stressors. Among these, degraded water quality has been identified as a primary driver of this decline, which is influenced by nutrient enrichment, altered hydrology, land-use intensification, and episodic disturbances. However, existing water quality monitoring efforts across FCR are decentralized, encompassing discrete field-based programs, autonomous sensor arrays, and satellite-derived data products, each with differing temporal resolutions, spatial extents, and measured parameters. This lack of regional data integration and consistent methodology has historically hindered large-scale analyses and the ability to assess impacts of restoration or management efforts. For the past five years, research scientists from the Florida Fish and Wildlife Conservation Commission and the University of South Florida have addressed these challenges by integrating disparate water quality monitoring datasets, enabling enhanced visualization of spatio-temporal trends and the identification of monitoring gaps. These efforts resulted in the development of a unified water quality monitoring database containing nutrient and water clarity data from eight monitoring programs. This comprehensive dataset has been used to determine baseline conditions and identify historical pulse events, such as hurricanes or large-scale precipitation events, which may have resulted in persistent water quality degradation. Development of the unified water quality monitoring database has also allowed our team to perform gap analyses, highlighting locations with insufficient data coverage, and has supported managers in integrating unified water quality information into their decision-making processes. This includes the multi-agency Florida Coral Reef Coordination Team (FCRCT), who tasked our team to assist in developing a coordinated monitoring network aimed at assessing the impacts of Everglades restoration initiatives on FCR, and the effects of water quality on coral reef health. To support this objective, we created two inventories of monitoring programs and methods analyses for 'abiotic water parameters' (salinity, Dissolved Oxygen, temperature and pH), and biological and ecological parameters. These inventories included interactive web maps that allow users to quickly and easily visualize sampling locations and better understand the state of monitoring across the FCR and adjacent coastal ecosystems. Collectively, these efforts will help inform future recommendations, guide funding and actions for restoration, monitoring and management.

The Human Side of Spiny Lobsters: Situation Assessment of the Commercial Fishery

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Research that supports fisheries management often focuses on the analysis of catch data and monitoring of fish stocks. The success of management actions, however, often depends on social factors, such as trust, social capital, perceptions of fairness, shared mental models, or strong local leaders. We present a methodological framework for understanding fisheries and especially fisheries conflicts. A situation assessment is a qualitative, structured approach to analyzing management situations with a focus on human dimensions. We introduce the foundational concepts and methodologies and present our application of this process to the commercial spiny lobster fishery in the Florida Keys. The spiny lobster fishery is an important fishery and beyond its economic value, it is of social, cultural, and esthetic importance in the Forida Keys. We conducted 40 in-depth, semi-structured interviews with stakeholders in the commercial spiny lobster industry. We solicited input from a variety of stakeholders to form a comprehensive understanding of the fishery, including fishers, scientists, management personnel, and product distributers (i.e. fish houses, exporters). Open ended questions explored five broad themes: Current circumstances, who is involved and how, concerns, vision for the future, and wishes for future engagement. Thematic analysis of the interview materials reveals the presence, meaning, and relationships among themes and concepts in the interview data. Our results provide insights into the relationships between stakeholders, perceptions of power and influence, and help differentiate between positions and interests. This assessment increases our understanding of the Florida spiny lobster fishery, but we also reflect on the limitations of this study and identify potential next steps.

Multidecadal Analysis of Fish Community Change Across the Florida Keys Reef Tract

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Ecological communities are changing. Biotic and abiotic factors determine community structure and function. As temperatures continue to warm and habitats are degraded in many regions, it is important to assess how and at what rate communities are changing over time. Both environmental and biotic interactions drive community diversity, structure, and stability. Here we evaluated regional community stability, identified the drivers of species richness patterns, and quantified how environmental factors interact to shape short-term (annual) and long-term (decadal) changes in fish community diversity and structure across the Florida Keys Reef Tract. Broadly community stability was negatively correlated with increasing synchrony. Fish species richness increased with habitat complexity, and both species richness and habitat complexity decreased annual community change, including species turnover and rank shifts. Further, fish communities demonstrated resilience to acute, annual-scale disturbances such as thermal stress events. However, long-term fish communities were becoming less similar over time when assessed over depth, with deeper sites exhibiting the most rapid shifts in community composition despite being less exposed to extreme temperatures. Geographic factors, including the influence of ecotones and tropicalization in transitional reef zones, may be contributing to observed community shifts. Changes in the fish community due to an increased number of species available in the regional species pool may be more apparent in desirable sites such as those that are thermally stable and highly complex. These findings highlight the need to consider temporal scale when assessing community change, as short- and long-term dynamics are likely driven by different processes. Rising temperatures that reduce habitat complexity and destabilize communities may be obscured by annual gains in species richness and biodiversity variability. Overall, the results emphasize the central role of diversity, habitat complexity, and environmental change in shaping community dynamics and resilience.

Collaborative Fisheries Science with a SMILE (Size Matters: Innovative Length Estimates)

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As global fisheries experience intense pressure, there is a need to further modernize fisheries sampling methods that are non-extractive and non-destructive, yet comprehensive, cost effective, and accurate to optimize management. Traditionally, collecting fish length data requires handling or harvesting the fish, which can impact local fish populations and require significant investments and science/management capacity that are often limited. Additionally, harvested fishes frequently represent a limited distribution of sizes and species due to harvest restrictions. The collaborative SMILE (Size Matters: Innovative Lengths Estimates) project will help expand fish length data sources into stock and ecosystem assessment processes using single laser-mounted cameras ("FishSense"). As a companion to the REEF Volunteer Fish Survey Project, SMILE equips recreational scuba divers or citizen scientists with a low-cost camera system to capture images of select target species of management priority (grouper, snapper, hogfish, and parrotfish) through roving diver surveys. Fish lengths were extracted from the images via an AI workflow. Here, we discuss preliminary outcomes from development of this project, including validation through multiple approaches including known size objects and paired surveys with a roving stereo-video system and video belt-transects. Length distributions were comparable between these methods. In addition, to better understand the citizen science interaction with the project, a formal survey has been disseminated to evaluate motivations, barriers, and user experiences related to citizen science in the context of marine conservation, conservation technology, and the SMILE project.

Photogrammetric Analysis Reveals Distinct Topographic Footprints for Stony Coral Genera in Dry Tortugas National Park

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Structural complexity is well understood to influence the biodiversity, productivity, and ecosystem functionality of coral reefs through niche diversification. Conventional *in situ* techniques for measuring rugosity, such as the tape-and-chain method, are insufficient for characterizing reef complexity. Digital surface models (DSMs) created through photogrammetric techniques enable a more accurate reef characterization through raster metrics such as variability, slope, and curvature. Massive reef-building corals are highly susceptible to stressors and are typically replaced by weedier corals post-disturbance that decelerate calcification rates and result in reef-flattening. Therefore, generating topographic footprints of stony corals with these structural metrics is critical to advance our understanding of how disturbances might alter reef function. This study utilizes Structure-from-Motion photogrammetry to create orthomosaics and DSMs of five monitoring sites in the Dry Tortugas, collected as part of The Florida Fish and Wildlife Conservation Commission's Coral Reef Evaluation and Monitoring Program (CREMP). From the models, coral colonies were then identified to genus and annotated as polygons in ArcGIS Pro. This study found that when divided into functional groups (i.e., massive reef-builders vs. weedy opportunistic species), stony corals were topographically distinct with varying levels of contribution to the reefs' overall structural complexity. Massive corals such as *Orbicella*, *Colpophyllia*, *Montastraea*, and *Pseudodiploria* had the highest relative abundance and were also shown to provide the highest structural complexity. Specifically, they had the highest topographic position index, slope, and profile curvature, all of which together are indicative of rugose, steep, and convex forms. We also found that within the massive reef-builders, there was a clear topographic distinction between star corals (*Orbicella*, *Montastraea*) and brain corals (*Colpophyllia*, *Pseudodiploria*) based on their differing growth morphologies. Using this information, we can begin to create 'topographic signatures' for coral genera, which could be utilized in large-scale mapping efforts to efficiently characterize benthic community structure or serve as the foundation for machine learning capabilities to automate species identification in DSMs. With the emergence of stony coral tissue loss disease in the Dry Tortugas in 2021 and a mass bleaching event in 2023, it is also critical to determine how a potential loss of reef-building corals will impact reef functionality and ecosystem services moving forward.

Movement, Home Range, and Habitat Selection of Mesopredators in the Florida Keys National Marine Sanctuary

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Seagrass habitats are important coastal ecosystems that support biodiversity and provide multiple ecosystem services. Many fishes rely on seagrass meadows as essential foraging grounds, moving between reefs and seagrasses in search of prey. Despite their ecological importance, seagrass habitats are often under-represented in marine management and spatial planning. In the Florida Keys seagrasses comprise a small portion of protected habitats within Sanctuary Preserve Areas (SPAs). Our multi-disciplinary project, FISHSCAPE, aims to identify how much seagrass area is needed to support foraging reef fishes. A key component of this project involves characterizing fish movement and habitat selection across regions where seagrasses are either abundant and relatively contiguous or sparse and fragmented. While fishes make choices on where to live and forage based on multiple abiotic and biotic factors, the seascape context where these decisions are made is often overlooked. Here, we explore how differences in seascape context, and in particular seagrass configuration, impacts the habitat selection and movement behaviors of four mesopredatory fishes in the Florida Keys National Marine Sanctuary. We tagged and tracked the movements of white grunt (*Haemulon plumierii*), yellowtail snapper (*Ocyurus chrysurus*), mutton snapper (*Lutjanus analis*), and great barracuda (*Sphyraena barracuda*) in the Upper, Middle, and Lower Keys. Fine-scale movement tracks were modeled using a time of arrival and random walk movement model framework via the YAPS package (Yet Another Positioning Solver). Broad-scale patterns of space use were evaluated using centers of activity (COAs) based on two-hour time bin intervals, which were then used to estimate home ranges and assess habitat selections using resource selection functions. Results from this study reveal that fish movement and habitat selection vary among species and across the Florida Keys in response to differences in seascape context. These findings improve our ability to predict how much seagrass is needed to support healthy fish populations under current and future habitat conditions. As such, FISHSCAPE provides critical insights to guide management decisions in the Florida Keys and similar systems. Future work will integrate additional components of the FISHSCAPE project and extrapolate habitat selection models across the Florida Keys National Marine Sanctuary. Project results will feed into a decision support tool designed to equip managers with project findings and aid conservation planning.

Quantifying and Modeling the Spatial Patterns of the Florida Keys Recreational Reef Fishery

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The impacts of overfishing on fish populations and their ecosystem functions have been well documented on coral reefs. However, much of the fisheries research and data collection has been focused on the commercial sector. In addition, recreational fishing is a popular activity throughout the Florida Keys that is a key component of the tourism economy. The coral reef component of this recreational fishery focuses on the economically important snapper-grouper complex, and there is a large body of human-dimensions work analyzing the economic and social impact of fishing to communities and stakeholders. To better quantify the reef fishery, the Marine Recreational Information Program was created to collect fisheries-dependent data through mail-in and dockside surveys with the help of state partners. However, the spatial component of these data is often coarse, making understanding the distribution of recreational fishing effort and its management difficult. To improve our understanding of recreational fishing pressure in the Upper Keys, we first used satellite imagery to detect individual vessels in the fishery. Satellite imagery is an emerging data resource for determining the spatial distribution and patterns of commercial and recreational fishing vessels throughout the globe. We analyzed two years of high-resolution satellite imagery to identify vessels within the reef fishery and linked those detections to biophysical and spatial-temporal covariates. We developed a map of vessel detections at a 1km^2 spatial resolution that showed most fishing activity on the Islamorada reef edge. Additionally, statistical analysis found that habitat, windspeed, and existing marine infrastructure were important drivers of the spatial distribution of vessels. Secondly, we used agent-based modeling to imitate the behavior of recreational anglers throughout a single-day of fishing and simulate their spatial distribution. We used dockside open-ended dockside interviews to help calibrate the behavior of anglers within the model. This agent-based model can be used to help simulate the spatial distribution of anglers in the Upper Florida Keys. Additionally, it gives researchers and managers a tool to test how changes to the environment (e.g., loss of structural complexity) and management policies (e.g., new protected areas) could affect how anglers utilize space.

Drivers of Spiny Lobster (*Panulirus argus*) Population Trends and Emerging Risks to Sustainability in Florida

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The Caribbean spiny lobster (*Panulirus argus*) stock in Florida is a small fraction of the pan-Caribbean population exhibiting both regional and local influences. Genetic studies suggest that spiny lobster stocks from the Caribbean region comprise a single pan-Caribbean population. Landing trends in Florida mirror those of the region and have declined by approximately 20% in the last 30 years. Annual spiny lobster landings in Florida are typically high or low and not well described by the mean. largely based on fluctuation in the local lobster population. Recent research attributes these fluctuations in landings to the quantity of pueruli, the postlarval phase of spiny lobster, arriving in the Florida Keys each spring. It appears highly likely that upstream sources of pueruli in the Caribbean may be the primary driver of the spiny lobster population in Florida. Over 30 years of postlarval settlement data in the Florida Keys indicates that pueruli settlement has declined by approximately 30%, nearly matching the scale the Caribbean-wide landings decline. While the spiny lobster population in Florida appears to be recruitment driven, the pueruli to landings relationship has more variability in years with tropical weather disturbances. A secondary role of post-settlement processes affecting Florida's population seems likely in these extreme environmental circumstances. The increased frequency of other environmental disturbances including algal blooms and marine heat waves have caused broad scale loss of habitat for juvenile lobsters. There is considerable concern that loss of juvenile lobster habitat may emerge as an additional driver of the local lobster population. More research is needed to improve our understanding of how these localized factors affect Florida lobster population and the broader-scale trends in the Caribbean.

Restoration Under Stress: Understanding Bleaching Risk in Large-Scale Coral Outplanting

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The effectiveness of coral restoration depends on the ability of outplanted corals to withstand bleaching stress. Identifying the drivers of bleaching susceptibility is essential for improving coral restoration outcomes. This study used fate-tracking data from 1,152 outplanted colonies of three boulder coral species (*Montastraea cavernosa*, *Orbicella faveolata*, and *Pseudodiploria clivosa*) monitored over two years at 24 sites across Florida's Coral Reef. Colonies represented 99 unique genotypes and were grown in either in situ (57.8%) or ex situ (42.2%) nurseries prior to outplanting. Bleaching prevalence was modeled using a generalized additive model (GAM) and cumulative link mixed model (CLMM) to evaluate the effects of genotype, species, nursery grow-out location prior to outplanting (ex situ vs. in situ), region, site, and time since outplanting. Model results revealed statistically significant genotypic differences in bleaching susceptibility, with some genotypes showing consistently low predicted bleaching probabilities across time and space. Species-level patterns also emerged, as *M. cavernosa* exhibited greater overall resistance and *O. faveolata* showed higher variability and susceptibility. Regional and site-level variation in observed bleaching reflected differences in localized environmental differences. Observed bleaching was most frequent within the first two months post-outplant and declined over time, suggesting early stress responses. Nursery grow-out method prior to outplanting had a marginal effect, as ex situ colonies showed higher predicted bleaching and experienced a second observed bleaching peak after approximately 15 months. Together, these results highlight the importance of combining ecological, genetic, and environmental data to guide adaptive coral restoration. By identifying bleaching-resistant genotypes and evaluating how environmental context influences performance, this work supports more informed decisions on coral restoration practices. These findings emphasize the need for long-term, standardized monitoring to distinguish short-term vulnerability from lasting resilience.

Marine Lens Florida Keys: Empowering Participatory Scientists to Explore Marine Habitats via Zooniverse

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The Florida Fish and Wildlife Conservation Commission (FWC) increasingly utilizes underwater video technology to study animal behavior, habitat use, and spawning events in Florida's marine ecosystems. Advances in camera and battery technology now enable continuous, multi-day deployments, that capture detailed ecological data with minimal disturbance to cryptic species. While this expanded data collection enhances ecological insights, it also generates substantial video footage, making the identification of rare but critical events, such as fish spawning aggregations or predation, highly labor intensive. To address this challenge, the FWC's Fish and Wildlife Research Institute (FWRI) has launched pilot projects leveraging the Zooniverse participatory science platform. Through Zooniverse, multiple online participants identify animals, behaviors, and maximum number of each species in the videos. The two pilot projects currently focus on characterizing fish spawning aggregations in the Lower Florida Keys and measuring diversity and abundance of fish and invertebrates at solution holes, the karst rock depressions and dominate structural feature in Florida Bay and the Lower Keys. This participatory approach not only accelerated data processing, but it also provides an opportunity for individuals to engage in important conservation efforts as well as plays a critical role in fostering public awareness and appreciation of Florida's marine habitats. This initiative aims to reduce the burden of researchers but also strengthens the connections between the public and marine science. By comparing crowd-sourced data against expert-reviewed footage, the project validates the reliability of this collaborative approach while advancing habitat conservation efforts. Overall, this innovative project supports evidence-based management, conservation of Florida's marine ecosystems, and broadens public awareness of the importance of these critical habitats.

Decades of Dedication: Fish Spawning Aggregation Research in the Florida Keys

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Research on fish spawning aggregations in the Florida Keys has spanned several decades, evolving through collaborative efforts among federal and state agencies, non-governmental organizations, academic institutions, resource users, and other interested parties. Given these diverse partnerships, sustaining long-term, standardized datasets across the region remains a significant challenge. Shifting management priorities and variable funding have led to uneven resource allocation and related scientific focus among aggregation sites, resulting in data gaps—especially with respect to long-term biomass trends. While some locations have robust time-series data, others remain under-documented or only studied during limited periods. Here we provide a comprehensive overview of historic and ongoing fish spawning aggregation research in the Florida Keys, including focal species, geographic coverage, participating partners, and techniques employed. We also discuss how selected datasets have informed fisheries management at places such as Riley's Hump and Western Dry Rocks and highlight opportunities to strengthen data continuity and integration moving forward.

Restoration Strategies are Preventing the Local Extirpation of Two Critically Endangered Coral Species

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The unprecedented marine heatwave of 2023 and 2024 caused widespread coral bleaching and mortality throughout the Caribbean. In the Florida Keys, two foundation species that particularly suffered were the elkhorn coral, *Acropora palmata,* and the staghorn coral, *A. cervicornis* (Lamark, 1816), which have been the primary focus of reef restoration in Florida for decades. Substantial losses of these species occurred in outplanted populations, ocean-based nurseries, and among remnant wild colonies. The near extirpation of these species on Florida's Coral Reef leads to uncertainty over their future in the Florida Keys and their utility as restoration species given the observed trends in climate conditions. However, we posit that the past two decades of restoration activity created a community of experts, a network of ocean-based and land-based coral-rearing infrastructure, and two independent land-based coral gene banks, which prevented regional extirpation and preserved much of the genetic richness of these critically endangered coral species. Without the past decades of effort and the emergency response associated with the 2023 bleaching event, Florida acroporids would largely have been lost. This outcome afforded by the restoration network in Florida demonstrates the value of proactively establishing resources prior to major disturbances. We identified several critical strategies that may be applied in other regions prior to major threats to prevent local extirpation of coral species including: i) extending collaborative restoration efforts to solidify a network of trained experts, ii) establishing trust-focused relationships among management agencies and restoration groups, iii) testing direct interventions to reduce light/temperature stress early during thermal anomalies, iv) developing redundant ocean-based and land-based nurseries, and v) establishing living coral gene banks prior to major threats to prevent the local extirpation of coral species.

Assessing Genetic Connectivity of the Permit (*Trachinotus falcatus*) Between South Florida and Belize

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The permit (*Trachinotus falcatus*) is a popular recreationally targeted fish that holds significant ecological and economic value across South Florida and Belize. Compared to their inshore recreationally fished counterparts, bonefish (*Albula vulpes*) and tarpon (*Megalops atlanticus*), permit have only garnered more attention recently. Although declines in bonefish and tarpon populations have been documented, data on permit population trends remain insufficient. Given that permit face similar threats; including depredation, fishing pressure, habitat degradation, pollution, and climate change, parallel declines are plausible. Conservation efforts, such as the establishment of the Special Permit Zone in South Florida (2011) and the seasonal fishing closure at Western Dry Rocks (WDR), aim to protect critical spawning aggregations, yet gaps persist in understanding how regional permit populations may influence each other. This study evaluates the genetic connectivity between permit populations in South Florida and Belize. In spring 2025, we collected fin clip samples from Belize, then compared the extracted DNA with samples collected in South Florida from 2022-2025, ranging from Biscayne Bay to the WDR. Our objective was to assess the extent of gene flow and determine whether Belize serves as a source of genetic connectivity and diversity for Florida permit, likely from larval dispersal via Gulf Stream-mediated transport. We expect to find high genetic connectivity between Belize and South Florida permit populations, suggesting that larval dispersal plays a key role in regional recruitment. These findings will have implications for international fisheries management and conservation strategies, especially if permit populations in South Florida benefit from an influx of genetic diversity from the western Caribbean, and if populations in each location are genetically healthy. Ultimately, this research aims to inform management of permit populations across their range.

Hot-Spot Cluster Analysis of Large Parrotfish in the Florida Reef Tract to Inform Restoration

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Herbivory is a primary function on coral reefs as it controls macroalgae cover and facilitates coral recruitment. The Diadema urchin die-off in the 1980's has left parrotfish as the primary herbivores on Caribbean reefs. While assemblages with parrotfish of over 25cm in length have shown to remove exponentially higher amounts of macroalgae than those without large individuals, they also contribute to higher rates of corallivory. High abundance of large corallivorous parrotfish can have adverse effects on coral restoration by direct consumption of outplants. Previous studies have revealed that densities of these larger parrotfish differ in three main ecoregions in the Florida reef tract, with the Dry Tortugas and Florida Keys having substantially higher abundances than Southeast Florida. Despite their protected status, these populations have undergone severe declines due to hurricanes and habitat loss, leaving the Florida reef tract dominated by small individuals. Here, using National Coral Reef Monitoring Program reef fish visual census from the years 2014-2024, we conduct site-level hotspot cluster analysis to analyze spatiotemporal patterns of the large parrotfish population. We aim to find patterns through space and time that can guide restoration strategies by identifying sites that may require precautions to avoid losses due to parrotfish corallivory. We also expand on previous work to further analyze distributions of these large individuals among the three ecoregions with updated survey data and explore potential factors of population declines. Preliminary analysis shows that losses and shifts of large parrotfish hotspots have occurred in all three Florida ecoregions.

Seagrass Non-Cryptic Fish Assemblage Across the Florida Keys National Marine Sanctuary-USA Seascape

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Seagrass ecosystems in the Florida Keys National Marine Sanctuary (FKNMS)-USA provide critical habitat for diverse fish communities, yet comprehensive understanding of spatial patterns of mesopredators and upper predator fish biodiversity remains limited. The main objective of this study was to characterize the fish assemblage of non-cryptic fish communities across seagrass habitats with particular emphasis on understanding how environmental and spatial factors, including habitat continuity, water depth, distance to shore, and turbidity, influence fish assemblage, abundance and species distribution. Using Baited Remote Underwater Video Stations (BRUVS), we assessed fish abundances with MaxN across seagrass habitats in the Upper (n=42), Middle (n=32), and Lower Keys (n=28) regions (n=102 deployments total). The 102 BRUVS units were deployed during morning hours primarily in summer, positioned ≥500m apart for independence, with each recording for ~ 170 minutes. Environmental covariates included seagrass continuity, distance to shore, water depth/temperature, and turbidity. Our results revealed significant regional differences in community composition (ANOSIM: $R = 0.131$, $p = 0.001$), with distinct assemblages characterized by commercially important species such as Yellowtail Snapper (*Ocyurus chrysurus*; frequency of occurrence 60-80%) and White Grunt (*Haemulon plumieri*; 45-80%), followed by Yellow Jack (*Carangoides bartholomaei*; 45-85%) and Great Barracuda (*Sphyraena barracuda*; 55-60%). Species richness totaled 95 species across all regions: Upper Keys (69 species), Middle Keys (53), and Lower Keys (51). Despite the Upper Keys having the highest total species count, the Middle Keys sites supported more diverse fish communities at the individual site level (13.1 ± 2.8 species vs. 11.1 ± 3.0 in Lower Keys and 8.3 ± 3.2 in Upper Keys), with similar patterns for Shannon diversity and evenness metrics. Environmental drivers analysis revealed that water depth showed a significant positive relationship with species richness ($p < 0.001$), while distance to shore exhibited a significant negative relationship ($p < 0.05$). Turbidity showed no significant relationship with diversity metrics. Notably, contrary to our predictions, seagrass continuity did not significantly influence community structure (PERMANOVA: $p = 0.197$), indicating that other environmental factors may be more important in shaping fish assemblages. This study demonstrates the effectiveness of BRUVS as a non-invasive monitoring tool for assessing fish biodiversity patterns, focusing on mesopredators and upper predators which are not commonly recorded by other monitoring methods such as visual census or trawling. These results contribute to the understanding of spatial biodiversity patterns in FKNMS seagrass habitats and can inform marine spatial planning and ecosystem-based management strategies aligned with global biodiversity conservation targets.

Keywords: Seagrass ecosystems, BRUVS, Non cryptic fish, top predators, mesopredators.

Florida Keys Aquatic Preserves Seagrass Monitoring Program

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The Florida Keys Aquatic Preserve Seagrass Monitoring Program was established in 2021 in Lignumvitae Key Aquatic Preserve (LKAP) to create a long-term, high-quality data set of seagrass community species and analyze temporal changes. LKAP is situated between Lower Matacumbe and Upper Matacumbe key and consists of 6,700 acres of submerged land overlapping with Lignumvitae Key Botanical State Park. This area is the first major tidal connection site between Florida Bay and the Atlantic Ocean. Benthic monitoring at a high resolution allows for close study of changes in the community and variance between different seagrass flats. Seagrass monitoring occurs semiannually, taking measurements including the Braun Blanquet Cover Abundance (BBCA) scoring, percent coverage, and shoot counts to contribute to the overall assessment of seagrass health in the aquatic preserve. Shoots are collected at each site to analyze morphometric attributes, nutrient content, and isotope ratios. Data analysis is ongoing and will reveal trends as they become apparent. Seagrasses in Florida Bay have experienced die-off in previous years which had not reached LKAP, however the creation of this long-term dataset along with analysis of seagrass samples can reveal shifts in seagrass health, sources of eutrophication, and reduce response time to seagrass loss events by environmental managers.

Refining Nursery-to-Reef Restoration Practices for Resilient Stony Coral Enhancement of Florida's Coral Reef

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On Florida's Coral Reef (FCR), the increased prevalence and severity of acute thermal events, storm events, and chronic disease outbreaks have exacerbated the deterioration of the reef framework by directly impacting reef-building stony coral populations. The summer of 2023 was marked by an unprecedented marine heatwave that resulted in a mass coral bleaching event on FCR as well as the extensive loss of corals within the region's network of in-situ nurseries, including the one operated by the FWC in the middle Florida Keys. In response, the FWC developed a nursery restocking strategy that incorporates the selection and propagation of corals with potentially resilient traits to improve restoration success. The goal of this project was to refine FWC's restoration practices for threatened stony corals by scaling-up nursery production of genetically diverse stony corals with potentially resilient traits to improve the growth and long-term survival of outplanted corals on FCR. In 2024, six species of wild stony coral (*Montastraea cavernosa*, *Pseudodiploria clivosa*, *Pseudodiploria strigosa*, *Orbicella faveolata*, *Colpophyllia natans*, and *Diploria labyrinthiformis*) that persisted through the 2023 thermal event were collected, genotyped, propagated, and grown within FWC's Coral Nursery. Nearly 6000 corals have been propagated from 126 collected corals, and more than 800 new coral fragments have been outplanted off the upper and middle Florida Keys. Preliminary survival analyses for two brain coral species suggest that mortality after serial propagations and during nursery grow-out varied between and within species and was driven by genotype. Propagated coral health and growth observations during nursery grow-out, outplanting and monitoring stages will continue to inform genotypic selection for the nursery-to-reef pipeline and the refinement of husbandry methods to support the increased production of coral biomass for FCR restoration efforts.

Benthic Dinoflagellates, Spinning Fish, and Sawfish Mortalities: Is There a Connection?

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Fish exhibiting erratic behavior (e.g., spinning) and mortalities were observed in the lower Florida Keys in winter 2023 and spring 2024. An examination of water samples did not reveal the presence of any likely stressors (i.e., red tide, low oxygen, pollutants) and red tide toxins (brevetoxins) were not detected in fish tissue samples. The toxigenic benthic dinoflagellate, *Gambierdiscus*, was reported at concentrations of 1,000 cells L^{-1}, far above baseline levels measured by the authors over the previous ten years sampling in the Florida Keys (averaging 39 cells L^{-1}). With over 50 taxa of fish affected, coupled with the lack of other potential stressors and potentially elevated levels of *Gambierdiscus*, a more extensive survey was undertaken in the lower Keys to determine if a "benthic bloom" of *Gambierdiscus* was occurring in the region. Over one thousand seagrass (*Thalassia testudinum*), macroalgae (*Dictyota*, *Halimeda*, and *Laurencia*), and water samples were collected and examined to quantify *Gambierdiscus* cell densities in addition to other, co-occurring benthic dinoflagellates. A comparison of samples collected in spring 2024 with baseline samples (2011 – 2023) collected elsewhere in the Keys indicated that *Gambierdiscus* cell densities were up to 7 times higher on average at sites exhibiting erratic behavior versus baseline levels. *Gambierdiscus* densities returned to baseline levels in summer 2024 and have remained low since then to present. Working in tandem with toxin analyses of algae, water, and fish samples, the leading hypothesis is that the erratic fish behavior and sawfish mortalities were due (in part) to exposure to toxins produced by elevated densities of *Gambierdiscus*, indicating that a threshold may have been breached, suggesting that a "benthic bloom" of *Gambierdiscus* was achieved, in which acute exposure to the produced toxins elicited the deleterious effects exhibited in the fish. The cause of this bloom remains unknown, although the extreme temperatures in summer 2023 in the region may have been a factor. Research is ongoing to further understand this phenomenon.

Diadema antillarum Production and Distribution to Florida Partners – Creating a Growout and Stocking Network

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Severe degradation throughout Florida's Coral Reef has resulted in >90% coral cover loss since the 1980s and actively threatens the identity, culture, and economy of this region. This reality has spurred the development and rapid expansion of in-water coral propagation and outplanting activities intended to restore live coral cover; unfortunately, restoration has been unable to keep up with the rate of ecosystem decline in the face of widespread and continued coral bleaching and disease. Overcoming this immense problem requires an adaptive approach involving holistic ecological intervention strategies.

One such strategy is re-establishing missing functional herbivory to prevent competitive overgrowth of corals by fast growing benthic algae. In response to this desired capacity, the University of Florida and The Florida Aquarium have been working since 2018 to develop technologies for large-scale aquaculture of the keystone long spined sea urchin *Diadema antillarum*. These efforts have been successful, with nearly 3,000 juvenile urchins distributed to Florida partners to date and collaborators in the Caribbean now producing *D. antillarum* as well. An emerging issue has been identifying facilities with the space and expertise to rear urchins from small juveniles to larger, reef-ready (~4-5cm test diameter) animals. This presentation will detail the development of a network of collaborators making efforts to address this bottleneck. Juvenile transport and grow-out investigations that occurred in both in-water and land-based enclosures will be discussed, along with future directions and opportunities for upscaling the program. Finally, new data coming from Florida and elsewhere are offering clues about best practices for the acclimatization and stocking of *D. antillarum* to consume macroalgae on coral reefs.

Utilizing Alkalinity Enhancement to Increase Growth Rates of Corals in Ex-Situ Nurseries

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Studies have shown that coral growth rate can be increased 50-100% by increasing seawater saturation state. Maximizing coral growth rates in ex-situ nurseries is highly desirable, as it can significantly accelerate the production of outplantable-size corals for restoration efforts. Ex-situ nurseries offer a controlled, stable environment that supports coral growth and genetic diversity, and provides a reliable pipeline of corals for coral reef restoration projects. Given the critical depletion of coral populations in the Florida Keys and other regions, optimizing coral production in these nurseries for effective restoration is essential. At the University of Miami Experimental Hatchery, we have six aquaria within three raceway tanks, each of which has 43 corals for a total of 129 corals. This experiment includes six coral species with six replicates each: *Siderastrea siderea, Acropora cervicornis, Montastraea cavernosa, Pseudodiplora clivosa, Acropora prolifera, and Acropora palmata*. Coral growth was assessed utilizing the alkalinity anomaly method, which allowed for quantification of net calcification across all corals. Preliminary data reveal that calcification increased 67% as the aragonite saturation state was increased from the ambient seawater level of 4.0 up to 8.0, above 8.0 which the response stabilized and no further increase in growth was observed. These results reflect the collective response of all corals in the aquaria rather than species-specific trends. Future work will examine the species-specific responses. These findings demonstrate that the growth of corals in ex-situ nurseries can be increased ~1.7-fold by the simple addition of sodium carbonate and bicarbonate to the seawater, cutting the time for a new sexual coral recruit to reach outplantable size by approximately half.

Spinning Sawfish in the Florida Keys: Weather Conditions, Movements, and Mortality

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The smalltooth sawfish (*Pristis pectinata*) is an endangered ray historically found in warm Atlantic waters. It is one of only five sawfish species worldwide, and its U.S. range once extended from Texas to the Carolinas. The species has been protected in Florida waters since 1992 and was the first marine fish to be listed as endangered under the U.S. Endangered Species Act in 2003. South Florida is the last remaining stronghold. In recent years, the Florida Keys have emerged as a consistent winter mixing area for large (>10 feet total length) juveniles and adults from points north on both coasts. For this reason, the unprecedented mortality events (UME) in 2024 and 2025 due to the "spinning fish" phenomenon are concerning. Recent population viability analyses that include current sources of mortality, including the 2024 UME, show the species going extinct in one or two generations. This talk will discuss weather conditions associated with hotline reports from the public of disoriented sawfish in shallow water, their movements before, during, and after the 2024 UME, and the fate of acoustically tagged individuals from the 2024 UME. This research was and is highly collaborative, and this aspect of the project will be a theme. The smalltooth sawfish is in trouble and needs our help now more than ever.

Developing Realistic Science-Based Performance Standards for *Acropora* Relocation Efforts

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To date, there are no published records of long-term, successful nursery outplant projects, or transplanting of *Acropora* spp. into natural reef habitats or successful *Acropora*-based reef restoration programs in Florida. While there has been exceptional success in growing and propagating *Acropora* in both land-based and in-water nurseries, outplanting efforts have been met with poor results.

For instance, at the Aquarius Research Station on Conch Reef in the FKNMS, *A. cervicornis* survivorship was low for coral transplants obtained from the local Coral Restoration Foundation (CRF) field nursery (> 50%). Mortality was even higher for transplants obtained from other nurseries and wild populations, while transplants cultured in a land-based aquarium had the highest mortality at the Aquarius site. Analysis of early CRF outplants in the FKNMS and noted there is high initial survivability of *Acropora* outplants from nursery grown corals, however, fewer than 20% of these corals have lived longer than about four years and those that survived have exceedingly high levels of tissue loss and partial mortality. More recently, all *Acropora* restoration projects in the Florida Keys were catastrophically impacted by the summer of 2023 marine heatwave and coral bleaching event with many sites recording 100% mortality, especially in the lower Keys.

Thus, understanding the cause of potential outplanting bottlenecks must be unraveled through hypothesis-driven experimental programs and long-term efficacy monitoring before they can be considered "successful." A key portion of this experimental work is to potentially select for disease resistant, bleaching resistant, predator resistant, cold-water tolerant, and/or rapid growth genotypes of *Acropora* that may be most suitable for site-specific restoration programs. For instance. little is known as to why *A. cervicornis* survivorship of the same genotypes is highly variable with respect to depth and habitat on the same reef, even those presumed to be heat tolerant and bleaching resistant. Even outplants that survive bleaching stress one year many later be impacted by a subsequent bleaching event. Same has been seen with corals that are apparently white-band disease resistant only later to succumb to the same (?) disease. Until these basic questions are answered, restoration and mitigation using *Acropora* species in Florida will be a Sisyphean task.

Effect of Elevated Temperature on Oxygen Consumption and Survival in Caribbean King Crab (*Maguimithrax spinosissimus*) Larvae

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Since the 1970s, Florida's coral reefs have significantly declined due to bleaching, disease, and hurricanes, leading to increased macroalgae dominance in some locations. Herbivory helps maintain coral-dominated ecosystems by limiting macroalgal growth and opening space for new coral recruits. The Caribbean king crab (*Maguimithrax spinosissimus*) is an effective native algal grazer of chemically defended macroalgae, making it a promising candidate for reef restoration. However, their ability to tolerate stressful environmental conditions, such as warmer sea surface temperatures, remains unknown. This study examined larval survival and oxygen consumption under a control temperature (28°C) and an elevated temperature (32°C). Results showed increased larval mortality but reduced oxygen consumption under the elevated temperature treatment relative to the control. Our results suggest that elevated temperatures negatively impact the early life stages of Caribbean king crabs by increasing mortality and suppressing metabolic activity, which may limit their potential effectiveness in large-scale reef restoration efforts under future climate change scenarios.

Identifying Nutrient Sources Driving Algal Blooms in Florida Bay: A Causal Modelling Approach

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Over the past century, Florida Bay has experienced a number of disturbances, both presses and pulses, which have significantly altered ecosystem structure, function and the provisioning of services. These major anthropogenic and natural disturbances include the chronic reduction of freshwater inputs from water management practices, large-scale seagrass die-offs, and a number of hurricanes and tropical storms. The loss of seagrass coupled with strong storms has led to s shift from a clear water state to one dominated by sediment plumes and algal blooms. The bloom we are presently experiencing has increased in size and intensity each year after the 2015 seagrass die-off and have been hypothesized to be driven by a combination of factors such as rainfall and a shift in water chemistry. However, the sources of nutrients causing these blooms have yet to be identified. Using Empirical Dynamic Modelling (EDM), our research aims to determine the cause of the northcentral Florida Bay algal blooms by leveraging long-term data collected in northcentral Florida Bay along with 1 year of new data collection (water and sediment stable isotope and nutrient data along with algal identification). The results of this research will provide managers and policy makers with crucial information on the cause of algal blooms in Florida Bay with the goal of reducing blooms in the future.

Uncovering the Fate of Tagged Reef Fish Through Marina Telemetry and Angler Participation

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Fish spawning aggregations are critical events for the reproductive success of many reef fish species, but these aggregations are often targeted by fishers due to their spatial and temporal predictability. To mitigate fishing pressure and protect multiple fish species during this vulnerable reproductive period, a seasonal closure was established at Western Dry Rocks, 10 miles SW of Key West, FL. To evaluate the effectiveness of this management decision, the Florida Fish and Wildlife Conservation's Fish and Wildlife Research Institute implemented a comprehensive monitoring strategy, with acoustic telemetry playing a key role in tracking fish movements. The fates of many acoustically tagged fish were unknown until the implementation of two complementary initiatives: 1) an angler participation program to increase voluntary reporting of harvested tagged fish, and 2) a marina detections project to identify the discard of tagged fish carcasses. These initiatives have provided valuable insight to the fate of tagged fish and demonstrated that involving stakeholders in collaborative research is valuable and provides information that would otherwise be absent. Our efforts demonstrate the value of using multiple data streams to better understand fish movement and anthropogenic interactions with tagged fish.

From Cryptofauna to Cleaners: Effects of Mission: Iconic Reef Restoration on Invertebrates and Fish

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Healthy coral reefs are comprised of abundant and diverse species assemblages. Coral reefs' most abundant inhabitants are small (<5 centimeters) "cryptobenthic" invertebrate species, or cryptofauna, that live hidden within reef crevices. Cryptofauna are critically important because they constitute the base of reef trophic webs and nutrient cycles. They have high microhabitat specificity and small home ranges, which allow them to serve as predictive markers of ecosystem change. From 2022–2024, we inventoried motile cryptofauna collected during annual sampling of 14 Autonomous Reef Monitoring Structures deployed on nearshore, mid-channel, and offshore reefs in the Middle Florida Keys. A significant correlation was found between reef condition and cryptofauna biodiversity. Offshore reefs (characterized as more degraded with relatively low rugosity, high turf algae cover, low coral cover, and high heat loading during marine heating events) yielded a significantly larger abundance and species richness of polychaete worms compared to crustaceans and gastropods. The reverse pattern was observed in less degraded mid-channel and nearshore reefs. These findings suggest that cryptofauna biodiversity patterns, and specifically the ratio of polychaete worms to crustaceans and gastropods, have the potential to serve as bioindicators of reef health. Further planned cryptofauna research in the Florida Keys National Marine Sanctuary includes: (1) 2-year long deployments of 14 Autonomous Reef Monitoring Structures to compare cryptofauna biodiversity within restoration and control sites at the seven Mission: Iconic Reefs, and (2) a time-series deployment of 8 Autonomous Reef Monitoring Structures in the Middle Florida Keys with immersion durations of 6 months, 1 year, 2 years, and 3 years to investigate settlement patterns and effects of immersion duration on cryptofauna. These projects will provide a baseline understanding of cryptobenthic invertebrate biodiversity patterns throughout the sanctuary. We will apply a ratio-based cryptofauna health index to evaluate underlying reef health and restoration progress. In addition, research is planned on neon goby (*Elacatinus oceanops*) cleaner fish at the Mission: Iconic Reefs. Neon goby abundance and client-cleaner interactions are positively associated with coral cover, size, and health, and can provide insights into reef fish biodiversity, trophic dynamics, and overall reef health. Our project will compare neon goby occurrence patterns and cleaning behaviors between restoration and control sites. We will evaluate neon goby plasticity in selection of host size, species, and health condition. Combined, the planned projects will provide valuable information to help address priority monitoring and research objectives of the Mission: Iconic Reefs program, including improving our understanding of how restoration affects reef-associated invertebrate species and reef fish productivity.

Permit Spatial Ecology at Western Dry Rocks: Insights from a Newly Established Seasonal Fishing Closure in the Florida Keys

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The movement patterns of Permit (*Trachinotus falcatus*) in the Florida Keys have been extensively tracked for over a decade using acoustic telemetry. Early research identified Western Dry Rocks (WDR) as a critical spawning site along the Florida Reef Tract, supporting reproduction of over 70% of Permit that spend the remainder of their annual cycle on nearshore flats. These findings contributed to establishment of the WDR seasonal fishing closure in 2021, which aims to protect spawning Permit from angling pressure during their peak reproductive period each year from April through July. To assess the effectiveness of the seasonal fishing closure, we tracked Permit movements before and after its implementation. Here, we present key metrics of spatial ecology across spawning sites in the Florida Keys, including (1) the extent of space use in and around the WDR closure boundaries, (2) residency time at WDR and nearby spawning sites, and (3) connectivity between spawning sites in the Lower and Middle Keys. Our results indicate that the WDR fishing closure is largely fulfilling its primary goal of protecting spawning Permit. However, there remains room for improvement. Some Permit spend time outside the current boundaries during the closure period, and residency increases as early as March. These findings suggest that adjusting the spatial boundaries and timing of the closure could enhance protection. Moreover, our results indicate that connectivity between WDR and sites in the Middle Keys (i.e., Thunderbolt Wreck, Seven Mile Bridge Rubble) is low, and therefore the protective measures provided by the seasonal fishing closure may not be equally effective across the broader Permit population in the Florida Keys. Given the 7-year sunset provision on the WDR closure, we hope these findings will be valuable to decision makers during the initiative's evaluation and contribute to a deeper understanding of Permit ecology in the Florida Keys.

Moving Beyond Ecology: Valuing Restoration Success with Socioeconomics

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Coral reefs are crucial ecosystems currently facing alarming decline, impacting nearly 1 billion people who rely on them for survival and subsistence. Traditionally, restoration success has been evaluated based on ecological impact, assuming that the survival of corals equates to maintaining ecosystem services. However, the challenges facing restoration, including acute and chronic stress events, limit ecological success. Without evolving how we value restoration, its success and impact will always be limited. Considering the socioeconomic effects on local communities offers an alternative way to value restoration work, revealing societal benefits beyond traditional ecological and ecosystem services. The Coral Restoration Foundation's work in the Florida Keys serves as a case study for understanding coral restoration programs' socioeconomic impact. The socioeconomic framework of coral restoration programs encompasses various direct, indirect, induced, and total effects on local economies. This comprehensive understanding is crucial for informing policy decisions, securing funding support, and ensuring that coral restoration programs are designed and implemented in a manner that maximizes their positive impacts on both ecosystems and economies.

Population Genetics of Sponge Restoration in Florida Bay

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Sponges are crucial benthic animals and dominate the heterotrophic biomass of Florida Bay's hard bottom habitats. They serve as habitats for commercially important invertebrates like spiny lobsters and stone crabs and provide foraging grounds for juvenile fish. However, in the past century, sponges have experienced significant die-offs due to overfishing, diseases, cyanobacterial blooms, and thermal stressors. In response, the Florida Fish and Wildlife Commission (FWC) initiated a sponge propagation project targeting six key species in Florida Bay. This sponge nursery was built only from fragments of donors (clones), and the levels of clonality, inbreeding, and genetic diversity remain unclear. Our aim is to assess the genetic diversity and the effectiveness of the sponge propagation restoration efforts. Four key sponge species were targeted from both FWC sponge nursery and wild populations. Tissue samples were collected from larvae, recruits and adults to analyze genotypes, clonality, inbreeding, heterozygosity, and genetic diversity. Preliminary results suggest that *Spongia barbara* and *S. graminea* clones are fecund and therefore genetic diversity at the sponge nursery might be higher than expected, though larval settlement success is low. This study enhances FWC's restoration efforts by identifying genetic patterns and strategies for spatially distributing sponge individuals, which would increase sponges' genetic diversity and resilience to climate change.

Evening Movement Patters in Permit Pre-Spawn Aggregations as Observed by Active Acoustic Tracking

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Reef-associated fish species often form transient, site-specific pre-spawning aggregations, synchronized with lunar cycles and environmental cues. Among these, the Permit is ecologically significant and economically valuable to recreational fisheries across the western Atlantic, including South Florida. Permit exhibit complex life history strategies involving habitat shifts, utilizing mangrove flats and seagrass beds during juvenile stages and adults are known to migrate between these flats and offshore reefs. Permit are known to aggregate in the Lower Keys near the Western Dry Rocks (WDR) reefs in 20m of water from March to June each year, with peaks in abundance coinciding with full moons each month. Ongoing research has revealed that schools are persistent on the reef until 1500-1600 EST each day, at which time they leave the immediate area and can no longer be observed. This study aims to improve our understanding of the movement patterns of permit spawning aggregations at the WDR aggregation site. Permit aggregations were tracked using a VR100 directional hydrophone and common acoustic telemetry tags with long delays (1-3min) that had been previously implanted in more than 140 permit at WDR since 2020. We tracked permit schools from 1200-2000 EST on 5/13 – 5/15 to understand where they go in the evening hours. Data suggests that permit move off the reef shelf into deeper habitats near 25-30m, but additional analysis is being performed to understand the specifics of when and where this permit aggregation goes during these later hours. An acoustic doppler current profiler and split beam echosounder were deployed simultaneously with the hydrophone, which will allow us to infer whether environmental factors influence their movement to deeper depths. The findings will contribute to the broader understanding of pre-spawning behaviors of permit and could promote sustainable recreational fisheries practices when expanded to include interactions and behaviors in the presence of anglers and predators.

Overview of the State's Water Quality Monitoring Program in the Florida Keys National Marine Sanctuary and Aquatic Preserves

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DEP's water quality monitoring program in the Florida Keys National Marine Sanctuary is comprised of two different programs to monitor short- and long-term variation and trends. The discrete water quality monitoring program assesses sub-watersheds to identify water quality impairments and establish numeric nutrient criteria. Collection analyzes Chlorophyll-a, Turbidity, Total Kjeldahl Nitrogen, Nitrate-nitrite, Pheophytin a, and Total Phosphorus through bottle grab samples as well as pH, Dissolved Oxygen, Temperature, Specific Conductivity, and Salinity using a YSI ProDSS. The continuous water quality monitoring program assesses pH, Dissolved Oxygen, Temperature, Specific Conductivity, Salinity, Total Algae, and Turbidity using YSI EXO2 sondes that collect data readings every 15 minutes. Permanent sonde stations are located in both of the Florida Keys Aquatic Preserves.

The two aquatic preserves managed are Lignumvitae Key Aquatic Preserve (LKAP) and Coupon Bight Aquatic Preserve (CBAP). In 1969 Florida legislature designated approximately 6700 acres (10.5 miles2) of water, just off the southwestern shore of Islamorada, as LKAP. Pervaded with seagrass flats, mangrove forests, and hard-bottom communities, this protected area spans across both the bay and oceanside of the Keys. Also, established in 1969, CBAP is located in the southern portions of Big Pine Key and is the Florida Keys' southernmost aquatic preserve. Spanning over 5400 acres (8.5 miles squared), this protected area consists of both lagoon and oceanside waters. The Newfound Harbor Keys separates the inner sheltered waters of the bight from its outer oceanic portion. This diverse area is inhabited by mangrove forests, seagrass beds, mixed hardbottom, and patch reef communities which bring forth a vast array of aquatic and marsh wildlife including the iconic Key Deer.

The major benthic habitats, seagrasses and hardbottom, found in both aquatic preserves rely on oligotrophic water. Water quality impairments can weaken seagrasses and encourage outcompeting algae growth. The monitored parameters and the subsequent data collected are vital for source tracking and future environmental regulation and enforcement.

Building Capacity for Resilience on Florida's Coral Reef Through Coral Rescue and Propagation

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In response to Stony Coral Tissue Loss Disease (SCTLD), 19 coral species were collected along Florida's Coral Reef (FCR) by the Florida Coral Rescue project for live gene banking to prevent mortality, preserve genetic diversity, and propagate offspring for use in future restoration. Over 2,500 coral colonies have been collected over seven years and have been expertly cared for in land-based facilities across the USA. Most species have never been held under human care before, but the Rescue project has provided a unique opportunity to learn husbandry needs, develop treatment options, and advance spawning and settlement techniques for each species. Now, after the creation of novel genetic markers (SNPs), breeding and propagation plans are being developed to guide spawning activities to increase genetic diversity and build resilience within Florida coral populations to provide a sustainable source of corals for outplanting. The use of rescue offspring will be a focus of outplanting for species enhancement on the FCR and pathways are being developed to connect rescue partners conducting spawning and propagation with Florida restoration practitioners for grow-out and outplanting. Currently, millions of rescue larvae are being produced within land-based rescue facilities each year and thousands have already been outplanted on the FCR within restoration and research activities. Closing the circle from coral rescue to the outplanting of offspring will dramatically assist in scaling up restoration efforts and promoting the recovery of Florida's Coral Reef.

Identify and Widen Bottlenecks in the Asexual Restoration of Endangered *Orbicella* Boulder Corals

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Landscape scale coral reef restoration is constrained by our understanding of context-dependent responses of corals to environmental and ecological conditions throughout a region. Asexual propagation of corals for restoration is dependent upon rapid tissue regeneration following the relatively traumatic fragmentation process. The propagation process can, however, decrease a colonies' fitness by fragmenting colony resources, creating open wounds, and diverting resources to healing, which increases the potential for disease incidence. Nonetheless, high volume asexual propagation and the culture of corals is presently needed to scale up coral reef restoration efforts and identify factors affecting the growth and survival of key reef-building species and any context-dependent effects therein are necessary.

Orbicella faveolata (OFAV) is a major reef-building coral species whose mass reproduction has been designated as critical to restoration efforts on Florida's Coral Reef. Unfortunately, the species is also susceptible to SCTLD, and there is strong evidence that the source of the parent colony (genotype), culture conditions (nursery location and system type), and the interaction of these factors affect the growth, survival, and fitness of OFAV cultured for restoration. This research proposes to evaluate the effect of source coral colony location (ECA and Florida Keys) and genotype, *ex-situ* nursery system characteristics (five systems between Nova Southeastern University, University of Miami, and Mote Marine Laboratory), and *in-situ* nursery placement (Florida Keys, Key Biscayne, and Broward County) on tissue regeneration and survival of OFAV after fragmentation. The experiment involved the synchronized collection of corals of opportunity, source colony exchange between facilities, synchronized fragmentation, and standardized water quality testing and fragment monitoring across the five facilities.

This study will provide insights into optimal nursery systems and conditions for OFAV propagation and rearing based on source colony location, and allow the standardization of materials, methods, and general workflows. This will aid in determining the regional capacity and infrastructure needs for scaling up OFAV production to enhance the resilience of Florida's Coral Reef ecosystems.

Assessing Coastal Blue Carbon Residence Times Using Radiocarbon Techniques

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Coastal Blue Carbon (CBC) is carbon stored in the ocean and surrounding ecosystem and includes seagrass beds, mangrove forests, and salt marshes. The quantification of this potential carbon sink presents an opportunity to boost funding towards Coastal Resilience projects by having coastal ecosystems enter carbon sustainability markets. These areas are often protected and maintained to ensure that the ecosystem services they provide, such as improved coastal resilience to storm surge and erosion, are conserved. It is well understood that CBC is an opportunity for the carbon sustainability market. However, the challenge lies in how to account for the carbon residence times in these dynamic ecosystems and to be able to assign a dollar amount to their sequestration services. We propose that by measuring the radiocarbon activities of the carbon entering, residing in, and exiting these systems, we can suggest a mean residence time for the sequestered carbon. These studies can also be used to help rehabilitate natural coastal ecosystems based on increasing carbon storage potential. Preliminary data from a case study conducted in South Florida will be presented, including our findings and an overall methodology for carbon residence time accounting. By collecting surface and pore water samples containing Dissolved Inorganic Carbon (DIC), Dissolved Organic Carbon (DOC), sediment (solid organic carbon), and gas (CO_2 and CH_4, bulk and separated) and measuring their respective radiocarbon pools, a mass balance approach can be used to apply a mean residence time for carbon in these environments. The measurements from these research projects can be used to provide guidance on the monetary value of these ephemeral environments based on their ability to capture and store carbon. Furthermore, regular monitoring of the radiocarbon activities in these protected areas can help identify any changes to the local ecosystem and provide critical data needed to understand the extent and nature of any land-based disturbances, manmade or otherwise.

Incorporating Mutton Snapper Spawning Aggregation Length Demographics Reveal Disparities Between Physiological and Functional Maturity in Snapper

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Snapper form spawning aggregations that are predictable in time and space making them susceptible to over-exploitation. To address this, a seasonal fishing closure at Western Dry Rocks in the Florida Keys was implemented to protect multiple reef fish species, including mutton snapper (*Lutjanus analis*) and gray snapper (*Lutjanus griseus*), during this critical life stage. The Fish and Wildlife Research Institute is currently monitoring the efficacy of this management action and has developed an interdisciplinary science plan focused on monitoring changes in spawning activity within the closure and surrounding area. By incorporating long-term population-level data sets – such as reef fish point count surveys, commercial and recreational landings – with targeted research at the closure site, FWRI identified gaps in our understanding of spawning contributions to spawning stock biomass. Site specific methodologies to the spawning closure including acoustic telemetry networks, underwater point count surveys, transect surveys, hydroacoustic mapping and targeted lethal sampling. Notably, utilizing these techniques at spatial and temporal scales different from traditional methodologies has enhanced our understanding of current data limitations and highlighting the value of focused information collection. Overlaying datasets from these multiple techniques uncovered previously unknown trends in biological and behavioral reproductive characteristics. Traditional stock assessments utilize granular information population wide to calculate age/size-at-maturity and spawning stock biomass. Contrasting results from population surveys with observations of spawning aggregations appear to show a decoupling of the physiological and functional maturity of mutton snapper. We propose the reliance on physiological size at maturity as a regulatory threshold for minimum size regulations might be improved by developing measures of size at functional maturity.

Utilizing eDNA Metabarcoding to Monitor Biodiversity at Mission: Iconic Reef Sites in the FL Keys

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Mission Iconic Reefs (M:IR) is an ambitious restoration initiative to outplant corals on degraded reefs in the Florida Keys National Marine Sanctuary. This collaborative effort combines resources from government agencies, state bodies, universities, and non-profit organizations. The primary goal of M:IR is to increase coral cover from 2% to 25% and enhance reef biodiversity. However, more frequent surveys are needed for quantifying ecosystem changes from coral restoration efforts, and traditional surveys are too labor intensive for frequent biodiversity assessments. The goal of this study is to develop and test environmental DNA (eDNA) methods and metabarcoding protocols to characterize biodiversity and relative abundance changes in invertebrates, fish, and microbes specific to Florida's Coral Reefs (FCR). By using eDNA, quarterly biodiversity assessments can be conducted to identify changes from restoration. This work can give unique insights to presence/ absence of keystone or indicator species across time and provide a view of relative composition in the ecosystem over time. The purpose of this study is to implement these tools at M:IR sites for biomonitoring and to transition biodiversity assessments to M:IR managers. With these eDNA tools, restoration efforts and managers will have a more holistic assessment of success and shortcomings. This work will provide foundational tools, which can be used in other Florida coral biomonitoring studies.

Development of a Sponge Restoration Strategy for Florida Bay

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The South Florida watershed is a complex and highly altered ecosystem composed of a diverse mosaic of upland, wetland, and estuarine habitats that culminate downstream in Florida Bay and, ultimately, Florida's Coral Reef. Decades of alterations to the hydrology of the South Florida watershed have resulted in a cascade of ecological perturbations in Florida Bay. One of the most conspicuous drivers of Florida Bay's altered ecosystem function has been the repeated occurrence of cyanobacteria blooms that have been associated with mortality of sponges in the Bay. First documented in the early 1990s, these blooms have resulted in the loss of sponge communities over large areas of Florida Bay. In one well-studied event, a bloom resulted in the loss of ~98% of the sponge biomass in one semi-isolated basin in the central Bay. Sponges historically dominated the heterotrophic biomass of Florida Bay's hard-bottom habitat, and the ecological services they provided have long been recognized. Large structure-forming sponges provide shelter for the juveniles of coral reef-associated species of fishes and invertebrates. The loss of the sponge communities and the ecological services they provide inspired efforts to restore Florida Bay's sponge communities. For more than a decade, the foundational components of a sponge restoration strategy, grounded in basic ecological tenants, have been developed. Underpinning this effort has been the development of sponge propagation methods and the establishment of in-water nurseries, mirroring coral restoration efforts in South Florida and elsewhere. Our present efforts are focused on refining this process such that assisted sponge restoration in Florida Bay can be conducted at an ecologically relevant scale. Collectively, these advances in our understanding of sponge ecology will support a sponge restoration strategy to guide local resource managers implementing large-scale sponge restoration in Florida Bay. This strategy is designed to maximize the potential for positive restoration outcomes, even under the potential of continued cyanobacterial blooms. This strategy will outline the composition and spatial distribution of sponges derived from historical data, the location, duration, and intensity of historic cyanobacterial blooms via satellite imagery, and cost estimates of sponge restoration based on present efforts. By integrating continuous research designed to refine restoration activities, implementing this strategy represents a practical direction towards restoring the ecosystem services provided by sponges in the presently degraded hardbottom habitat of Florida Bay.

Assessing the Impact of Elevated Temperatures on Caribbean King Crab Physiology

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Increasing ocean temperatures have caused a decline in Florida's coral reef health and growth, resulting in reduced coral cover and greater macroalgal cover. The grazing activity of Caribbean king crabs has gained interest by reef managers and made them attractive to coral restoration efforts, yet no studies have determined their tolerance to the same thermal stress that corals are now facing. We determined how thermal stress may impact the physiology of ovigerous king crabs at two temperature treatments: 28°C and 32°C. Hemolymph samples were collected at: 1, 5, and 10 days exposure to determine thermal stress and measured for lactate and protein serum. Crab external stress levels were determined using a righting test which accounts for the durations in seconds it takes for the crabs to right themselves after being flipped over. Closed respirometry was then used to monitor metabolic rates after 7 days of exposure to the experimental treatments. Crabs in 32°C had higher lactate and protein levels consuming 31% more oxygen than at 28°C. Crabs at 32°C also took longer to right themselves. Our results suggest that thermal extremes cause sublethal physiological stress but low mortality indicates the species can tolerate acute anaerobic metabolism which may be beneficial for coral restoration efforts.

Movement, Habitat Use, and Seasonality of Coastal Sharks in the Lower Florida Keys

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Collaborative passive acoustic arrays have provided robust coverage throughout the Western North Atlantic, allowing for the long-term monitoring of sharks with wide scale movement patterns. Through this research, research groups have identified the Florida Keys National Marine Sanctuary as important habitat for several large coastal shark species. In addition, data has revealed that significant numbers of sharks from The Bahamas and East Coast of Florida transit to the Florida Keys, with many continuing to the Gulf of Mexico. The complete drivers of this movement is not fully understood, but seasonality and parturition are significant factors. However, past telemetry data relied heavily upon individuals tagged outside of the Florida Keys, and therefore monitored individuals may have been more transient in nature. In recent years, tagging efforts have focused on the Lower Florida Keys in order to better represent local shark behavior and understand the long-term space use, movement, and distribution of coastal sharks in the area. Sharks have shown a seasonal residency pattern for the area, which peaks in the winter through spring months and is followed by dispersal to both the east and west coasts of Florida. This data helps to improve our understanding of the extent to which the Florida Keys National Marine Sanctuary is used by multiple coastal shark species, and the importance of this area in connecting shark stocks from the Gulf of Mexico and the Atlantic Ocean.

Quarry-Based Mariculture of the Caribbean King Crab to Support Reef Restoration

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Scaling up herbivore populations is a critical component of Florida's coral reef restoration strategy. As part of the Mission: Iconic Reefs initiative, the Florida Keys National Marine Sanctuary plans to stock hundreds of thousands of grazers—primarily the long-spined sea urchin (Diadema antillarum) and the Caribbean King Crab (*Maguimithrax spinosissimus*)—to suppress macroalgal overgrowth and promote coral recovery. However, current production of these grazers relies heavily on resource-intensive land-based larviculture systems, which face bottlenecks in terms of cost, labor, space, and scalability.

This study explores quarry-based mariculture as a complementary grow-out strategy to support existing land-based hatchery operations. We tested the feasibility of using abandoned saltwater quarries in the Florida Keys to rear *M. spinosissimus* juveniles in semi-natural conditions. Across three experimental trials, we compared survival and growth between laboratory and quarry environments, evaluated performance across quarry sites and maternal clutches, and assessed the effects of stocking density. Environmental monitoring and algal community assessments were conducted to track seasonal variation in grow-out conditions.

While survival was low across all trials, early evidence suggests that quarry systems can support comparable juvenile growth and survival to traditional lab systems. Growth varied significantly by site and clutch, highlighting the importance of environmental conditions, while high stocking densities negatively impacted crab performance. Seasonal algal abundance and stable water conditions suggest quarries could provide a suitable, food-rich environment for cost-effective grow-out.

Quarry-based mariculture offers a scalable, distributed grow-out solution that can help relieve pressure on land-based systems. By bridging the gap between larval rearing and reef deployment, this approach enhances restoration capacity and supports broader ecological recovery goals for Florida's Coral Reef.

Baseline Mapping of Florida's Largest Yellow Finger Coral, *Madracis auretenra*, Patches Amidst Environmental Stress

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Coral reefs that persist in degrading environments offer critical insights into resilience capabilities under shifting climate and anthropogenic stressors. This study focuses on a set of four unique continuous dense patches of *Madracis auretenra* in 20 m water depth off Delray Beach, which are the largest known in Florida. Similar patches are found in the Flower Gardens National Marine Sanctuary at 30 m depth. Residing in a subtropical to temperate transitional zone, the presence of this tropical coral raises questions about its adaptability to higher latitudes. Additionally, this species is presumed to be susceptible to Stony Coral Tissue Loss Disease (SCTLD), yet it has persisted in the endemic region for over a decade, suggesting potential resistance or environmental buffering. Anecdotally, the condition of several patches have declined. Establishing a baseline for long-term monitoring is needed to provide valuable data on growth patterns, habitat stability, and potential stress responses. Utilizing structure-for-motion (SfM) photogrammetry, we generated high-resolution 3D reconstructions to document coral condition, reef morphology, structural complexity, and potential resilience mechanisms. Given their size and persistence in a highly impacted environment, these patches may serve as a model for understanding coral adaptability and inform future conservation strategies. The findings from this study could have significant management implications, contributing to broader efforts in marine spatial planning and reef restoration. By integrating advanced mapping techniques with ecological assessment, this research aligns with ongoing efforts to bridge science and management for sustainable marine ecosystems in a changing world.

Assessing the Long-Term Growth and Survival of Boulder Corals Outplanted in the Florida Keys

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Coral reef restoration has increasingly been using reef building boulder corals to restore the structure and function of the reef, however multiyear monitoring remains rare. The coral outplanting experiment discussed here monitored three boulder coral species routinely used in restoration (*Montastrea cavernosa*, *Pseudodiploria clivosa*, and *Orbicella faveolata*) over a six-year period (2019-2025). We outplanted 120 colonies of each species in equal numbers at two reef habitats (offshore and inshore) across three reef locations in the upper and middle Florida Keys. We sourced half of the corals from an in situ coral nursery and half from an ex situ facility. In total there were 10 outplants of each species from each source per site. Colonies at each site were randomly distributed equidistant from each other in an approximately 4m by 20m rectangular matrix along the reef edge and then monitored regularly for growth and survival at 1-week, 2-weeks, 6-weeks, and 12-weeks post-outplant with particular interest in the presence of disease and other sources of potential mortality. Colonies showed evidence of intense finfish predation during the initial surveys, but predation had decreased by 12-weeks post-outplant, and many colonies demonstrated tissue healing and recovery. After the initial 12 weeks, we periodically surveyed these corals through 287 weeks post-outplant. Surveys documented longer-term coral survival rates, colony growth, incidence of disease, and other sources of mortality. Initial analyses indicated that coral survival and growth were dependent on a variety of factors, many of which interacted, including coral species, site location, reef habitat, coral source (in situ vs ex situ), and early predation. We saw intense bleaching in 2023 which resulted in species specific mortality but also total recovery in corals originally thought to be dead. This study highlights the importance of long-term outplant monitoring that can track corals as they are exposed to a suite of stressors including predation, disease, and bleaching over time to better assess restoration success.

Crumbling Coral: Investigating How Changes in Structural Complexity Impact Cryptofauna Communities

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Coral reefs are undergoing rapid change in the Anthropocene due to global climate change, disease outbreaks, and other factors. These impacts have been especially felt in the Florida Keys where the loss of live corals have caused a scale-shift in habitat complexity. What were once highly rugose, three-dimensional reef environments have since shifted into flattened rubble beds, which offer highly complex microhabitat for small organisms. This research aims to explore how the transition from large-scale reef complexity to interstitial microhabitat complexity impacts marine cryptofauna: the most diverse metazoan community of organisms on coral reefs. This was done through a series of field experiments across sites in the middle Florida Keys. The influence of reef-wide habitat complexity on cryptofauna communities and recruitment were assessed with Autonomous Reef Monitoring Systems (ARMS) and Structure-from-Motion photogrammetry. Additionally, field manipulations were used to simulate varying degrees of three-dimensional complexity around coral rubble habitats and assess its influence on motile cryptofauna community composition. Preliminary results found that cryptofauna vary by region and respond to changes in structural complexity across multiple scales. Structurally complex environments immediately around coral rubble had a positive effect on cryptofauna biodiversity, while microhabitat metrics such as the quantity and shape of rubble pieces influenced the abundance and species richness of these communities. These results provide a much-needed perspective on how changes in habitat complexity across multiple scales impact an integral community in the Florida Reef Tract.

Bleaching and Recovery of Boulder Corals on a Patch Reef in the Middle Florida Keys

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The 2023 marine heatwave brought persistent, extreme water temperatures to Florida, triggering the most severe coral bleaching event ever documented on Florida's Coral Reef. While *Acropora* species suffered high mortality, boulder coral species exhibited greater resilience at most sites in the Florida Keys, highlighting the need to understand species-specific recovery dynamics. This study investigated coral bleaching incidence, mortality, and recovery in a nearshore patch reef off Marathon, FL using photomosaic imagery. Nearly all boulder coral species at the site bleached in July 2023, but site-wide recovery was observed after nearly two years, and ongoing analysis will assess recovery patterns in relation to species, size, spatial factors, and environmental context. These findings will inform restoration and conservation strategies amid ongoing climate change and recurring thermal events.

The Boom and Bust of Coral Reef Accretion Potential Associated with Restoration and Coral Bleaching

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Coral reefs are critical habitats that support essential ecosystem services, such as shoreline protection and fisheries production, that are valued at >$8.5 billion in south Florida alone. The persistence of reef habitats, and the ecosystem services they support, relies on the balance between the processes of reef growth (or "accretion") and erosion. In the Florida Keys, where the subtropical climate has limited reef accretion for millennia, the impacts of recent coral-reef degradation have been especially severe. Erosion is now the dominant process on many of Florida's reefs and the reef structure that took thousands of years to build is now rapidly eroding away. Because reef habitats serve as the structural foundation for the essential ecosystem services reefs provide to society, reviving the reef-accretion process is the most fundamental conservation challenge in coral-reef science. It is also a challenge that coral restoration is uniquely poised to address because coral outplanting directly enhances both coral cover and structural complexity; however, despite the potential for coral restoration to enhance the essential reef-accretion process *in theory*, few studies to date have quantified how restoration affects reef-accretion potential and reef structural complexity *in practice*. We addressed that important knowledge gap by conducting paired carbonate budget and structure-from-motion surveys at outplanted or "restored" and non-restored areas of eight offshore fore reefs and three inshore patch-reef sites in the Lower Florida Keys where Mote Marine Laboratory researchers have been outplanting corals since 2016. We found that in just 2–6 years, restoration reversed long-term declines in reef-accretion potential at offshore reefs where fast-growing *Acropora cervicornis* was outplanted, leading to a 16-fold increase in gross carbonate production and significant increases in structural complexity. Although there was no detectable impact of restoration at the inshore patch reefs where slower-growing massive corals were outplanted, those corals fared significantly better in the wake of the devastating 2023 mass coral-bleaching event. Whereas coral bleaching drove near-complete mortality of *A. cervicornis*, ~60% of massive coral outplants survived, demonstrating the importance of considering trade-offs between coral growth and survival to improve restoration efficacy. Although there remain important questions about whether and how restoration can meaningfully improve reef-scale ecosystem function in the face of future disturbances, our findings demonstrate its potential for rapid, localized reef accretion gains. Moreover, our carbonate-budget and structure-from-motion modeling approach provides a powerful tool for quantifying the impact of restoration on the essential reef-accretion function that could allow coral-reef managers to design restoration strategies that optimize functional outcomes in an uncertain future.

Closed-System Saltwater Aquarium as a Model of the Florida Keys Ecosystem: Real-Time Monitoring Applications

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The Florida Keys marine ecosystem integrates coral reef, seagrass beds and mangrove forests which function as an integrated whole, and which face severe threats from ocean warming, acidification, pollution and habitat loss. This poster presents a mixed-reef saltwater aquarium as a microscale model for applying emerging monitoring technologies and experimental interventions to examine the stabilizing dynamics of this ecosystem. In this 230-gallon aquarium, corals and live rock replicate the basic reef habitat composed of small and large polyp stony corals representing the reef-building framework species. Soft corals simulate octocoral diversity, adding structure and habitat for other life. A macro- and microalgal refugium serves as an analog for seagrass nutrient cycling, and mangrove seedlings mimic coastal filtration and stabilization. Marine fishes, invertebrates and microbial communities further parallel natural trophic linkages and provide insight into complex behavioral dynamics, while a regulated light cycle with moonlight simulation mimics energy flow, influencing the biological rhythms of the reef ecosystem as a whole. A real-time aquarium monitoring system coupled with periodic testing of the elemental water composition allows for a comprehensive assessment of water quality, chemical and ionic disturbances and nutrient import/export. DNA sequencing of both microbiomic (prokaryotic) and eukaryotic inhabitants provides insight into potential disease dynamics. Beyond these basic parameters, this model also offers a platform to gather anecdotal evidence for more abstract influences, such as acoustic and electromagnetic inputs to coral health, including potential links to oxidation-reduction potential and nutrient metabolism. By characterizing the interplay among species and environmental dynamics, this saltwater aquarium serves as a small-scale model which may provide novel insights into the effects of controlled parameter changes with potential relevance to the Florida Keys ecosystem. In addition, it highlights opportunities for citizen science, bridging innovative aquarium management technology with broader ecological research.

Developing SNP Based Genomic Markers for 20 Scleractinian Caribbean Corals

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Stony Coral Tissue Loss Disease has caused major declines in coral populations throughout Florida's Coral Reef since 2014 with lesions and mortality confirmed in >20 species of corals. As a response to this disease outbreak, the Florida Coral Rescue Plan was developed with the goal of collecting and gene banking representative colonies from each susceptible species. Healthy corals from ahead of the disease boundary were collected and are in holding at land-based facilities to prevent them from being infected, to preserve genetic diversity, and to propagate for future restoration. A target of at least 50 unique genotypes per species was established as an adequate level of genetic variation for future restoration, however 200 colonies per species were targeted for collection to ensure genetic goals would be met. Many of the rescued species have no prior genetic testing therefore, we are discovering single nucleotide polymorphism (SNP) based genomic markers and creating genotyping assays for each species. Furthermore, propagation of rescued corals using genetic based breeding plans has begun and a subset of resulting recruits are being genotyped before outplanting efforts to assist with genetic management planning and strategies. This data will allow propagation facilities and restoration managers to re-establish populations with high levels of genetic diversity.

Warming Sea Surface Temperature Trends in the Florida Keys: Implications for Queen Conch Population Persistence

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The world's warming oceans pose a distinct threat to organisms that inhabit shallow marine waters. We have previously demonstrated that queen conch (*Aliger gigas*) occurring along the offshore reef tract of the Florida Keys are reproductively active and the main source of larvae for the population, while those occurring in shallow nearshore waters are reproductively inactive and commonly exhibit histological anomalies. Our subsequent research implicated extreme water temperatures in those nearshore environs as the potential cause. With further warming, those queen conch occurring in the offshore areas may become similarly affected, particularly since most of the spawning aggregations occur in the shallowest areas along the reef tract. To identify areas where queen conch reproductive activity may be deleteriously affected by rising ocean temperatures, we applied the Emerging Hot Spot Analysis tool in ArcPro 2.8 on sea surface temperature (SST) data from 2004 to 2020 extracted from the Florida Keys Hybrid Coordinate Ocean Model. Mean SST and extreme temperatures (i.e., percentage of readings > 30°C) showed statistically significant increasing trends. As anticipated, extreme temperatures were clustered in the shallow nearshore waters of the Florida Keys, but new hot spots emerged along the offshore reef tract as well. If SST trends continue their current trajectory, the reproductive activity of queen conch located in the spawning aggregations along the shallow waters of the reef tract could become negatively affected like those nearshore, with serious consequences for the persistence of the queen conch population in the Florida Keys.

Spatiotemporal Abundance of Whitespotted Eagle Rays in the Florida Keys

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The endangered whitespotted eagle ray (*Aetobatus narinari*) is a protected species commonly found in nearshore waters throughout Florida. Prior research suggests subpopulation structuring, with migratory behavior observed in the Gulf of Mexico, whereas individuals around the Indian River Lagoon on the Atlantic appear to remain resident. However, information on the spatiotemporal abundance of *A. narinari* is limited to the east and west coasts of the state and is lacking within the Florida Keys. Therefore, the goal of this study was to assess the seasonal abundance and spatial distribution of *A. narinari* in the middle and upper Florida Keys. Manned aerial surveys were conducted biweekly from March to June 2023 and January 2024 to the present, covering a 195 km transect from Government Cut, Miami to West Summerland Key. Preliminary findings show that rays are present in the Keys year-round, with a peak in abundance during April–May. Spatial distribution varied along the transect, with high concentrations of rays near the Seven Mile Bridge, Tavernier Key, and Biscayne National Park. These preliminary results suggest a seasonal influx of *A. narinari* into the Florida Keys, with high abundances in specific nearshore areas indicating selective habitat use and temporal variation in distribution. Continued surveys through 2026 will enhance our understanding of temporal and spatial patterns, informing conservation strategies for *A. narinari* and the coastal ecosystems it inhabits.

Decreasing Water Quality Unmasked on Florida's Coral Reef

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Reduced water quality on Florida's Coral Reef (FCR) from anthropogenic sources has long been implicated in the decline of the reef system. Over a century of replumbing the Everglades and coastal development has altered the historic water flows, leading to large scale ecosystem changes in south Florida. Residing downstream of the hydrographic flow, the FCR has experienced significant declines in the last 50 years, including the loss of over 25% live coral cover. Most of the coral losses were attributed to various extreme temperate and disease events beginning in the late 1970's and becoming more frequent over time, including stony coral tissue loss disease, which continues to decimate populations. In dynamic ecosystems like coral reefs, pulse events of decline are easier to attribute to losses than slower incremental changes in water quality, which are much harder to detect. Analyses of *in situ* water quality data are confounded by a myriad of factors that affect analyte concentrations at specific times and locations. These factors must be accounted for before trends in the data can emerge.

This study uncovered annual increases in analyte concentrations previously masked by the dynamic nature of water quality sampling. Using machine-learning modeling, the relationships between water quality from reef sites and measured land-based outflow from the coastal inlets, rainfall and wind over the same period (2018 to 2023) were tested. The models explained 41.5 – 78.9% of the variation in the water quality concentrations (training data) and 21.8 – 63.9% of the variation within data the model had not previously seen (test data). Many factors contributed to the changes various analytes including inlet outflow, rainfall, and high winds, however year had a high influence in almost every test (8.1% for nitrate – 37% for orthophosphate). In almost every case, while holding all other predictors in the model (inlet outflow, wind, and rainfall over various temporal windows and a series of space/time categorical predictors) at their mean, the modeled relationship of each analyte showed increases by year. This suggests that some other factor not accounted for in the models was affecting yearly increases in analyte concentrations. One factor not in the models that might account for this effect is population growth. Miami-Dade and Broward are Florida's most populous counties totaling 4.88 million. From 2022 and 2024, they had a combined net increase of 270,353 new residents. Increases of this magnitude on already stressed infrastructure could account for temporal decreases in water quality.

The effects of these analytes are unknown and deserve significant research attention. Efforts are ongoing to expand this analysis to obtain a more complete picture of FCR's water quality dynamics, which is key to designing effective local mitigation strategies, prioritizing resources, and identifying areas suitable for restoration.

Treating All Roadway Stormwater Runoff to Remove Contaminants.

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It is well known that roadway surfaces collect contaminants from vehicle exhaust including heavy metals and oils and greases. However, a loophole in federal and State roadway funding will not cover installation of stormwater treatment when a project does not increase the footprint of the roadway. Therefore, government agencies responsible for roadway maintenance often go to great lengths to limit projects to the existing footprints. The EPA Water Quality Steering Committee for the Florida Keys National Marine Sanctuary identifies roadway stormwater second only to wastewater leakage as a cause of nearshore water quality degradation. The Committee adopted a resolution in 2023 urging the Florida Department of Transportation and the National Highway Administration to alter their funding programs to provide funding for design and implementation of roadway stormwater treatment systems for all projects, whether roadway footprints were altered or not, to encourage removal of contaminants prior to runoff entering nearshore waters.

Core Healing in Orbicella faveolata as an Indicator of Colony Health Across Multiple Gradients

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Anthropogenic (anchors, scuba divers, tissue sampling) and natural disturbances (corallivory, storm damage) can wound living coral tissues, negatively affecting their life processes and impacting their ecosystem function. Wounding can impair coral growth, reproduction, and increase disease susceptibility, yet it can also increase growth rates through microfragmentation, which is the main principle behind asexual coral propagation. Tissue regeneration rates are indicative of a colony's condition, but they vary inter- and intraspecifically depending on intrinsic factors (lipid stores, colony size, symbionts) and extrinsic factors (temperature, light, nutrients). Understanding the relationship between the factors that affect tissue regeneration is needed for it to be a useful indicator. Experimental coring is a common practice when studying coral biology, but its long-term effects and downstream effects remain understudied. This study opportunistically assessed the tissue regeneration rates and impacts of core sample lesions across latitudinal gradients, stages of gametogenesis, and terrestrial nutrient exposure on the reef-building species *Orbicella* in Florida. In 2021-22, eighty-seven colonies across SE Florida and the two reefs in the Keys were sampled over three periods corresponding to different environmental conditions and stages of gametogenesis (1,717 cores). Image analysis was used to calculate the daily regeneration rates and assess the long-term effect of core sampling. Results found that 24% of all tissue biopsied healed, of which 20.69% of cores healed completely, 24.14% of cores were predated, and 3.45% were diseased as a result of coring. Regeneration rates decreased with latitude, and both Keys' locations had significantly lower regeneration rates than SE Florida colonies. Patterns in the regeneration rate were similar to spatial gradients in protein expression, lipid levels, and fecundity scores taken on the same colonies. There were no significant differences between genotypes, disease resistance categories (classified by previous stony coral tissue loss disease lesions), or live tissue area.

Losing Levels: Shifts in Reef Fish Trophic Dynamics Across a Coral Habitat Gradient

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Climate change is significantly altering coral reef ecosystems by reducing structural complexity. As a result, coral reefs are shifting from highly complex, hard coral-dominated habitats to degraded, soft coral-dominated habitats. These changes have led to a decline in reef fish biodiversity and a shift in the trophic structure of reef fish communities. However, empirical links between habitat complexity and trophic structure remain limited. In this study, we quantified the relative abundance of reef fish trophic groups across a natural environmental gradient ranging from shallow and rugose nearshore reefs to deeper and flatter offshore reefs in the Middle Florida Keys during the summers of 2022, 2023, and 2024. Our results indicate that the abundance of fish occupying lower trophic positions remained stable across sites, while fish in higher trophic positions were less abundant on offshore (degraded) reefs. These findings suggest that top predators may be disproportionately affected by the loss of coral reef structural complexity, resulting in a shortening of the food chain. To investigate this further, we are integrating stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) with food availability. We will compare trophic niche width and isotopic variability in four representative species (*Scarus iseri*, *Thalassoma bifasciatum, Balistes capriscus,* and *Pterois volitans*) from distinct functional groups (Herbivore, Omnivore, Invertivore, and Piscivore) across nearshore, mid-channel, and offshore reefs. We hypothesize that nearshore reefs, with greater structural complexity, will support a broader range of $\delta^{13}C$ values, reflecting diverse resource use, and lower $\delta^{15}N$ overlap, indicating a more complex trophic structure. In contrast, we hypothesize that offshore reefs will exhibit greater overlap in $\delta^{13}C$ and $\delta^{15}N$ values, reflecting limited resource availability and compressed trophic dynamics. Given that climate change is driving reefs toward flatter, degraded, less complex states, offshore reefs may serve as proxies for the future condition of coral reef ecosystems in the Middle Florida Keys. This research will enhance our understanding of how climate-driven habitat degradation affects the trophic structure of reef fish on coral reefs within the Florida Keys National Marine Sanctuary. Ultimately, the findings will contribute to a broader understanding of reef ecosystem resilience by supporting strategies to preserve coral reef biodiversity in the face of climate change.

Paving the Way to Sponge Restoration in Florida Bay: Evaluating Sponge Restoration Techniques

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The sponge communities in Florida Bay have become severely degraded in recent decades, primarily due to periodic cyanobacterial blooms. The loss of sponges and the ecological services they provide inspired the development of an assisted sponge restoration effort in the region. A fundamental strategy of this effort has been the creation of sponge biomass for use in restoration efforts via vegetative fragmentation. Sponge tissue from a ‘donor’ sponge is propagated into smaller pieces and attached to a baseplate, typically a cement paver or a natural limestone rock, using a plastic cable tie. In the interest of optimizing this technique to more efficiently scale-up the restoration process, we compared the survival and attachment rates of two species of sponges, *Spheciospongia vesparium* and *Ircinia campana*, propagated onto either cement pavers or natural limestone rock. After six months, the survival rate of *S. vesparium* was 96% on pavers and 84% on limestone rocks. The survival rate of *I. campana* was 92% survival on pavers and 68% on limestone rocks. The percentage of surviving *I. campana* that had attached to their bases was 97%. The attachment rate of *S. vesparium* was 76%. Observations of tissue necrosis around cable ties and subsequent sponge loss in nursery-reared sponges prompted a separate experiment comparing the survival rates of *I. campana* and *Spongia graminea* attached to cement pavers using standard cable ties and beaded cable ties. Initial surveys revealed survival rates were similar, but we are continuing to monitor the potential longer-term effects of these attachment methods. These experiments will be used to guide future sponge restoration techniques in hopes to restore ecosystem function in near shore hard bottom communities of Florida Bay.

Longterm Use of a Shark Breeding Ground: Three Decades of Mating Site Fidelity in the Nurse Shark

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The Dry Tortugas, Florida has been known as a courtship and mating ground for nurse sharks, *Ginglymostoma cirratum*, for over a century. In a study spanning over thirty years, we have documented long-term site fidelity to this area with data from 137 adult sharks (89 female, 48 male) tagged with PIT, fin, and acoustic tags. Of 118 sharks tagged from 1993 to 2014, at least 80 (68%) returned to the site in subsequent years during the June-July mating season. Known individuals returned in up to 16 different mating seasons and over periods of up to 28 years, revealing that lifespan extends at least into the forties for this species. Of all returning sharks, 59% (N = 47) have been monitored for over 10 years and 13% (N = 10) have been monitored for over 20 years. The small (5-hectare) mating ground has been seasonally protected from human activity since 1996, but storms in 2022 and 2023 substantially altered the site, and this appears to be impacting the way that sharks utilize the area. In our ongoing work, we are monitoring the behavioral ecology of this population using mark-recapture, acoustic telemetry, and advanced datalogging tags including accelerometers and animal-borne cameras. The long-term mating site fidelity of this shark population reveals the importance of identifying and protecting mating sites for this and other elasmobranch species.

Monitoring Thermally Preconditioned *Pseudodiploria clivosa* Post-Outplanting

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Florida's coral reefs have experienced widespread bleaching and mortality during thermal stress events in recent years, emphasizing the urgent need for innovative restoration strategies. This study evaluates whether thermal preconditioning of *Pseudodiploria clivosa* recruits, produced and reared in an ex situ spawning facility, improves thermal resistance and resilience once outplanted to the Florida Keys. In the months prior to outplantation, 144 recruits were periodically exposed to an elevated temperature of 32 °C, a threshold where mass mortality has been observed. The same number of recruits were maintained at an ambient temperature of 28 °C. Following laboratory preconditioning, corals were outplanted to two Mission Iconic Reef sites, Newfound Harbor and Looe Key Reef. Field monitoring spans four seasonal timepoints—July, October, January, and May—to assess growth, survival, bleaching, and physiological health. In addition to standard monitoring protocols for outplants, a noninvasive instrument known as the Coral In Situ Metabolism and Energetics (CISME) system was used to quantify respiration and photosynthesis of coral recruits underwater. The CISME requires a seal around the recruit for accurate measurements. Therefore, we opted to use Coral Loks by Reef Cells which allow temporary removal of the recruit from the receiver that is secured to the reef. Additionally, using this project as an example, we collaborated with Seacamp to develop coral restoration curriculum and student engagement activities that allow hands-on participation in coral conservation. By combining controlled laboratory treatments with in situ physiological monitoring and outreach, this project aims to identify cost-effective restoration approaches that enhance coral tolerance to future ocean warming events. It also aims to educate students about the threats to corals and strategies to restore them. Findings will contribute to science-based guidelines for integrating pre-exposure techniques into active restoration. They will also inform scalable practices that may promote coral survival under increasing climate stress, thus supporting the long-term recovery of Florida's Coral Reefs.

Honoring the Past, Exploring the Future: Human Dimensions of the Caribbean Spiny Lobster Fishery

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The Florida spiny lobster (*Panulirus argus*) fishery has been emblematic of the Florida Keys' culture and economy for over 100 years. Today, it faces a shifting landscape of economic, environmental, and social pressures including rising fuel and gear costs, inflation, trade tariffs, a decline in fish houses, and the ongoing loss of working waterfronts. We present the shifting role and vision of this fishery based on historic information and 40 interviews with commercial fishers, fish house operators, scientists, and managers. We highlight the significant structural changes in the fishery over the last few decades and how these changes shape the concerns and hopes of fishers today. The findings highlight the importance of incorporating human dimensions and community values into future research and decision-making. As pressures mount, supporting those who depend on the fishery and drawing from their firsthand experience will be critical to shaping a more adaptable, inclusive, and enduring future.

Sexual Reproduction and Seedbanks of the Seagrass *Syringodium filiforme* as a Tool for Seagrass Restoration

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To date, most seagrass restoration efforts in Florida and in the Florida Keys have relied on transplanting adult seagrass plants from healthy meadows into restoration areas, a practice that damages the donor meadow. Furthermore, most efforts have been focused on transplanting the slow-growing climax species *Thalassia testudinum*. Low transplant survival because of the high light requirements of *T. testudinum*, coupled with slow rates of clonal expansion, has hindered restoration success. Furthermore, natural seagrass colonization of Florida's seagrass meadows usually features the early arrival of early-successional, faster-spreading seagrasses like *Halodule wrightii* and *Syringodium filiforme*. The morphology and natural history of *S. filiforme* suggest that this species could be a better candidate than *T. testudinum* for both large-scale and small-scale seagrass restoration efforts. To explore the potential for seed-based restoration of *S. filiforme*, we investigated the phenology of sexual reproduction and the seed production of *S. filiforme* across the Florida Keys seascape. We found that the flowering season begins in November and persists until June with higher *S. filiforme* abundance and flower production on the bay side of the Florida Keys, with densities of flowering shoots ranging from 3 shoots m^{-2} to 411 shoots m^{-2}. Our observations also indicate a positive correlation between flowering and vegetative shoot density, with a male-sex bias often present in flowering meadows, however, exploration of individual flowers shows that females, on average, have a higher number of inflorescences per shoot compared to males. Observations of the early phases of recovery of Keys seagrasses from overgrazing suggest that there may be a viable seedbank to help *S. filiforme* recolonize denuded areas. We evaluated seedbanks across the seascape and found evidence of *S. filiforme* seedbanks on both bayside and oceanside of the Florida Keys as well as the Dry Tortugas. Seed densities across all sites varied between 14 seeds m^{-2} and 3056 m^{-2}; however, the proportion of potentially viable seeds was markedly low. Next steps in this project are, through a series of germination experiments, to seek to understand the factors that influence germination in *S. filiforme* seeds, provided from both the seedbank and recently developed fruits. Through manipulating both biotic and abiotic factors, we will ultimately provide deeper insight into the potential to utilize *S. filiforme* in future restoration efforts.