Linking Science to Management

A Conference & Workshop on the Florida Keys Marine Ecosystem

October 19-22, 2010

Hawk's Cay • Duck Key, Florida

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

NATIONAL MARINE SANCTUARIES

NATIONAL PARK SERVICE

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

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USGS science for a changing world

Welcome to the Conference and Workshop on the Florida Keys Marine Ecosystem – *Linking Science to Management*

On behalf of the steering committee, we are delighted you are here to participate in this first ever conference devoted exclusively to science and management of the Florida Keys Marine Ecosystem. Your response to this conference has far exceeded our expectations. We look forward to the next few days of what promises to be a suite of sessions with many interesting and some provocative presentations, as well as two exciting poster sessions. We trust each and every one of you will take full advantage of this conference to learn up-to-the-minute information, renew old connections and make new ones. To that end, daily breaks, the opening reception and evening poster sessions are programmed to allow time for colleagues to network and exchange valuable information.

Our friend and colleague, Brian Keller, developed the first vision for this conference. He recognized that even though considerable progress toward effective management has occurred, considerable challenges remain and high quality, comprehensive, plus bold science must serve as the underpinnings for the next phase of management action.

The steering committee has tried to stay true to his vision by developing sessions on topics that are part of Brian's passion. We encourage everyone to celebrate Brian's life during these few days and to take some time to share remembrances of him with friends.

This conference marks the beginning of the twentieth year for the Florida Keys National Marine Sanctuary. It is time for both celebration and reflection. As we celebrate the successes that have occurred over the past two decades, we simultaneously reflect on the many challenges we will continue to face over the next twenty years. We trust each of you will leave this conference with renewed purpose, and that you will use what you learn and experience during the next few days to continue making a positive difference for management of the Florida Keys Marine Ecosystem.

Appreciation goes to everyone who contributed toward the success of this conference, including our session organizers and moderators, those who submitted abstracts and prepared talks and poster presentations as well those who made time to attend. We would also like to express gratitude to our partnering organizations for their ongoing commitment and financial support, including the National Oceanographic and Atmospheric Administration, the National Park Service, the United States Geological Survey, and the Florida Fish and Wildlife Conservation Commission.

Finally, we would like to thank our friend and colleague, Beth Miller-Tipton, for her tireless efforts and those of the entire staff at the University of Florida, Office of Conferences and Institutes (OCI). Without OCI managing this conference, it would have never become a reality.

Once again, we welcome all of you and look forward to a week of productive interaction.

On behalf of the Conference Steering Committee,

John H. Hunt
Conference Co-Organizer
Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute

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Steering Committee

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Conference Partners Acknowledgement

The following agency partners have dedicated time, expertise, funding and participation to the Conference. We thank all of them for their contributions, support and ongoing assistance during the planning process.

Florida Fish and Wildlife Conservation Commission (FWC)

National Oceanic and Atmospheric Administration (NOAA) – Office of National Marine Sanctuaries

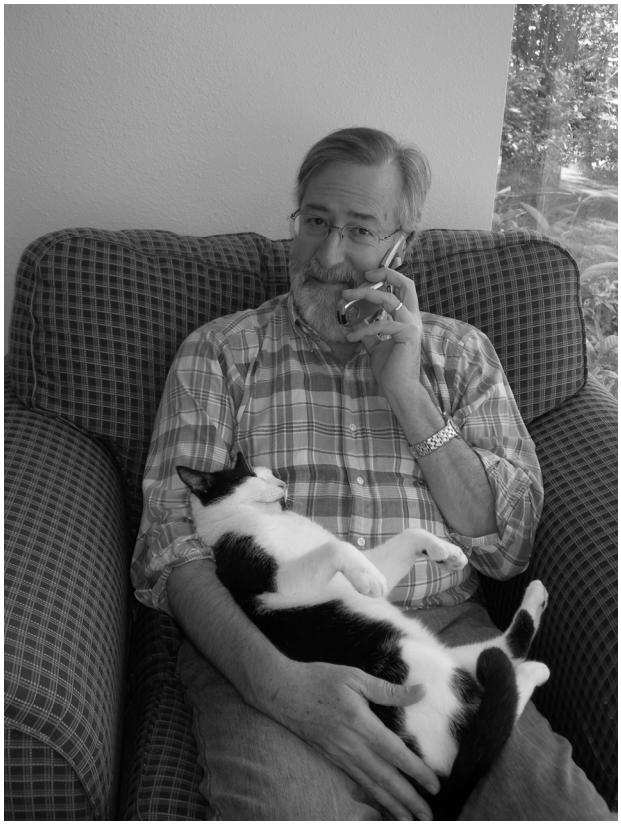
National Park Service (NPS)

United States Geological Survey

University of Florida / IFAS

Tribute to Brian Keller

A Tribute to a Friend and Colleague



Brian D. Keller, a sage scientist, patient mentor and committed conservationist, friend to many, and beloved husband to Fiona Wilmot, passed away on March 10, 2010. Brian touched countless lives with his science and his humanity over the course of an outstanding 40-year career in the Caribbean and Florida Keys.

Born in Boston, Massachusetts on April 26, 1948, Brian received a B.S. in Biochemistry from Michigan State University in 1970 and earned his M.A. and Ph.D. in Ecology and Evolution from Johns Hopkins University in 1973 and 1976, respectively. In 1985, he met Fiona while living and working in Jamaica, and the two married soon after.

Brian was trained as an evolutionary ecologist at John Hopkins University under the direction of Jeremy Jackson, where he researched the ecology and coexistence of sea urchins in Jamaican seagrass meadows in the 1970s. He did postdoctoral research on coral and alpheid shrimp with Nancy Knowlton in the early 1980s in Jamaica, Venezuela, and Panama. Brian was a Director and Research Fellow at Discovery Bay Marine Laboratory, Jamaica, from 1984-1986, and the Manager of the Smithsonian Tropical Research Institutes Oil Spill Project from 1987-1994 in Panama.

The monumental Panamanian oil spill study, published in Science in 1989, was a major factor in the closure of the Florida coast to oil exploration or extraction. Very few studies exist detailing the impact of oil spills on tropical marine environments. This work was influential in its day, and will continue to be influential as we look to the Gulf of Mexico.

As the first Executive Director of the Ecological Society of America in Washington, DC, Brian was indeed first and foremost an ecologist with a deep understanding of basic theory that guided his thinking throughout his career. His wisdom as a conservationist and manager, and the respect and high regard of his peers, stemmed directly from that ecological sophistication as well as his exceptional maturity of judgment.

Brian joined the Nature Conservancy in the Florida Keys from 1997-2000 before accepting a position with NOAA in 2000 as Science Coordinator of the Florida Keys National Marine Sanctuary. During his time with the sanctuary program, he helped lay the foundation for management zones in the Florida Keys and led efforts to measure their effectiveness. He was the architect of the sanctuary's research and monitoring plans and, in a soon-to-be-published report, he highlights a decade of success for sanctuary management of the Keys.

His wisdom impacted management decisions locally, regionally, and worldwide. His influence can be seen in courses that are taught on MPA management and science, and the implementation of science-based programs especially in the Caribbean. He remained focused on the ecosystem and, in particular, what constituted a healthy ecosystem. He was wholly committed to developing strategies to restore those that were degraded both from natural and man-made causes. Brian introduced many to the principles of "connectivity" long before it was a common concept.

The ocean science community lost a giant in the study, management and conservation of the marine ecosystems of the Florida Keys, Gulf of Mexico and Caribbean. In his role as science coordinator with the Office of National Marine Sanctuaries, Brian dedicated himself to finding innovative ways to understand marine ecology and to create new tools for conserving the ocean world he loved. Brian used these tools every day to promote science for management, and used his experience and knowledge to mentor others.

There was no greater advocate for sound science-based management than Brian. His knowledge of the relevant literature was unsurpassed and he knew what constituted good science and what did not. Most importantly, he knew how sound science could be applied to make the wisest and best-informed decisions for the conservation of the resources he so treasured.

Brian and his wife Fiona were committed to being as low-impact as possible and this was reflected in the house they designed, the car they drove, and the issues they supported. There was no greater role model for sustainable living than he.

Brian was a rare combination of warmth and intelligence. We will miss his accessibility, his intellectual generosity and his unflappable, calm demeanor. These traits, combined with his ability to listen (and hear), and his FM classical station-announcer voice, made him a powerful communicator. Accomplished scientist, ocean advocate, close friend, Brian's memory will live on in the hearts and scientific work of his friends and colleagues in the Florida Keys and beyond.

Program Agenda

Tuesday, October 19, 2010

5:00pm - 7:00pm	Registration Opens *[Ballroom Foyer & Reef Room]*
5:00pm - 6:30pm	Informal Welcome Social - Session One Poster Presenters Put up Displays *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
6:30pm - 7:30pm	***Remembering Brian Keller***
8:00pm - 10:00pm	Screening of the movie **"Sizzle: A Global Warming Comedy"** by Randy Olson

Wednesday, October 20, 2010

7:00am - 5:30pm	Registration Opens *[Ballroom Foyer & Reef Room]*
7:00am - 8:00am	Morning Refreshments *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
8:00am - 10:00am	**Session I: Opening Plenary** Moderator: *John Hunt*, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Marathon, FL
8:00am	**Welcome, Introductions, Remembrances — *John Hunt***, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Marathon, FL
8:05am	**Keynote Presentation — *Jeremy Jackson,*** Ritter Professor of Oceanography and Director of the Center for Marine Biodiversity and Conservation at the Scripps Institution of Oceanography, La Jolla, CA
9:00am	**Today's Management Challenges: Issues for the Keys Marine Ecosystem — *Billy Causey***, NOAA's Office of National Marine Sanctuaries, Southeast Atlantic, Gulf of Mexico and Caribbean Region, Key West, FL
9:30am	**Human Dimensions and the Florida Keys National Marine Sanctuary (FKNMS): Reflections of Two Decades of Change in the Wider Socioeconomic Environment and Stakeholders in the Florida Keys — *Manoj Shivlani***, NTVI, Center for Independent Experts, Miami, FL
10:00am	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
10:30am - 12:00pm	**Session II: Large-Scale Processes Affecting the Keys Marine Ecosystem** Moderator: *John Hunt*, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Marathon, FL
10:30am	**Physical Factors Driving the Oceanographic Regime around the Florida Keys — *Villy Kourafalou*,** Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL
11:00am	**Geological Underpinnings of Keys Reefs, from Jurassic Park to the Conch Republic — *Gene Shinn***, University of South Florida, St. Petersburg, FL
11:30am	**Florida's Coral Reefs in a Caribbean Context — *Rich Aronson***, Florida Institute of Technology, Melbourne, FL
12:00pm	Lunch Provided *[The Terrace Restaurant]*

Wednesday, October 20, 2010 (continued)

1:10pm - 3:15pm	**Session III: Present State of the Keys Marine Ecosystem** Moderator: *Sarah Fangman*, NOAA's Office of National Marine Sanctuaries, Southeast Atlantic, Gulf of Mexico and Caribbean Region, Savannah, GA
1:10pm	**Session Introduction** —***Sarah Fangman***, NOAA's Office of National Marine Sanctuaries, Southeast Atlantic, Gulf of Mexico and Caribbean Region, Savannah, GA
1:15pm	**Compound Interest: The Value of Long-Term Water Quality Monitoring in the FKNMS** — ***Joe Boyer***, Florida International University, Southeast Environmental Research Center, Miami, FL
1:45pm	**Long-Term Monitoring of Benthic Community Structure Points Decadal-Scale Increases in Nutrient Availability in the Florida Keys — *Jim Fourqurean*,** Florida International University, Biological Sciences and SERC , North Miami, FL
2:15pm	**Long-Term Changes in Benthic Community Composition Observed by CREMP in the FKNMS** — ***Rob Ruzicka,*** Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, FL
2:45pm	**Population Assessments of Benthic Coral Reef Organisms in the Florida Keys: 1999-2009 — *Steven Miller*,** UNC Wilmington, Key Largo, FL
3:15pm	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
3:30pm - 5:30pm	**Session III: Present State and Change Over time of the Keys Ecosystem** (continued) Moderator:*Sarah Fangman*, NOAA's Office of National Marine Sanctuaries, Southeast Atlantic, Gulf of Mexico and Caribbean Region, Savannah, GA
3:30pm	**Fishery Dynamics of the South Florida Marine Ecosystem — *Jerry Ault*,** Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL
4:00pm	**Science and Policy Considerations for Coastal and Marine Spatial Planning in Florida and the Wider Caribbean** — ***John Ogden****,* University of South Florida, St. Petersburg, FL
4:30pm	Panel Discussion
5:30pm - 8:00pm	Poster Session One & Networking Social *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]* ***NOTE: Session One presenters to remove poster displays upon conclusion.***

Thursday, October 21, 2010

7:00am - 5:30pm	Registration Opens *[Ballroom Foyer & Reef Room]*
7:00am - 8:00am	Morning Refreshments *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
8:00am - 10:00am	**Session IV: Coral Reef Ecology and Restoration** Moderator: *Kim Ritchie*, Mote Marine Laboratory, Sarasota, FL
8:00am	**Spatial Dynamics of Scleractinian Coral Populations in the Florida Keys — *Dione Swanson,*** Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL
8:15am	***Acropora* Coral Species Status and Trends in Dry Tortugas National Park (DTNP) — *Douglas Morrison***, Dry Tortugas National Park, South Florida Natural Resources Center, Homestead, FL
8:30am	***Acropora cervicornis* Restoration: Coral Restoration Foundation's Seven-Year Summary for the Upper Keys — *Katie Grablow***, Coral Restoration Foundation, Tavernier, FL
8:45am	**Testing Coral Transplant Performance: Aquarius Coral Restoration/Resilience Experiments (ACRRE) — *Margaret Miller***, NOAA/NMFS, Southeast Fisheries Science Center, Miami, FL
9:00am	**Drivers of Population Decline in *Acropora palmata* in the Florida Keys National Marine Sanctuary — *Dana Williams***, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL
9:15am	**Coral Reefs of the Lower Florida Keys (1970-1974): A Re-analysis** — ***Steven Miller*,** UNC Wilmington, Key Largo, FL
9:30am	**Fertilization Ecology and Early Life Stages in Threatened Caribbean Acroporid Corals** — ***Nicole Fogarty***, Smithsonian Marine Station, Fort Pierce, FL
9:45am	**Variation in the Genetic Response to High Temperatures in *Montastraea faveolata* Embryos from the Florida Keys and Mexico — *Nicholas Polato***, Penn State University, Department of Biology, University Park, PA
10:00am	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
10:30am - 12:45pm	**Session IV: Coral Reef Ecology and Restoration** (continued) Moderator:*Kim Ritchie*, Mote Marine Laboratory, Sarasota, FL
10:30am	**Towards a Better Understanding of Coral Recruitment — *Raphael Ritson-Williams***, Smithsonian Marine Station, Fort Pierce, FL
10:45am	**Using Early Life Stages of Hard Corals to Understand Coral-Bacterial Relationships — *Koty Sharp***, Ocean Genome Legacy, Ipswich, MA
11:00am	**Gene Transfer Agents in the Reef Environment — *John Paul***, University of South Florida, College of Marine Science, St. Petersburg, FL
11:15am	**Using Microarrays to Compare Bacterial Community Changes between Healthy and Diseased Corals — *Christina Kellogg***, US Geological Survey, St. Petersburg Coastal and Marine Science Center, St. Petersburg, FL
11:30am	**Black Band Disease Pathogenesis and Impacts in the Florida Keys — *Joshua Voss*,** Harbor Branch Oceanographic Institute at Florida Atlantic University, Fort Pierce, FL

Thursday, October 21, 2010 (continued)

11:45am	**Ecological Impacts of Sponge Nutrient Cycling on the Florida Keys Reef Ecosystem — *Patrick Gibson***, University of North Carolina at Chapel Hill, Department of Marine Sciences, Chapel Hill, NC
12:00pm	**Florida's "Redwood of the Reef": Growth, Age, Demographics and Bleaching of the Caribbean Giant Barrel Sponge, Xestospongia — *Joseph Pawlik***, University of North Carolina Wilmington, Wilmington, NC
12:15pm	Panel Discussion
12:30pm - 2:00pm	Lunch Provided *[The Terrace Restaurant]*
2:00pm - 3:45pm	**Session V: Climate Change and the Florida Keys Marine Ecosystem** Moderator: *Jim Fourqurean*, Florida International University, Biological Sciences and SERC, North Miami, FL
2:00pm	**Ocean Heat Budget for the Florida Reef Tract: Methods, Climatology, and the Thermal Siphon — *Lewis Gramer***, University of Miami, Cooperative Institute for Marine and Atmospheric Studies, Miami, FL
2:15pm	**Sea Surface Temperature, Salinity, and Chlorophyll Variability in the Florida Keys and Surrounding Coastal Waters, 1997 - 2010: Means, Seasonal Patterns, Interannual Variability, and Extreme Events — *Elizabeth Johns*,** NOAA/AOML, Miami, FL
2:30pm	**Application of Downscaled Climate Models to the Florida Keys and Florida Bay Marine Ecosystems — *Barbara Muhling***, University of Miami, Cooperative Institute for Marine and Atmospheric Studies, Miami, FL
2:45pm	**Responses of a Nearshore Seagrass Community to In Situ CO2 Fertilization — *Justin Campbell,*** Florida International University, Biological Sciences, North Miami, FL
3:00pm	**Halimeda Dynamics Relative to Nutrients Availability in the Florida Keys National Marine Sanctuary: A Good Indicator of Productivity and Acidification — *Ligia Collado-Vides*,** Florida International University, Biological Sciences and SERC, Miami, FL
3:15pm	**Calcification in a Changing Ocean Environment — *Ilsa Kuffner*,** US Geological Survey, St. Petersburg, FL
3:30pm	**Coral Sclerochronology in the Florida Keys: Historical Variability, Climate Change, and Ocean Acidification — *Kevin Helmle***, University of Miami, Cooperative Institute for Marine and Atmospheric Studies and NOAA/AOML, Miami, FL
3:45pm-4:15pm	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*

Thursday, October 21, 2010 (continued)

4:15pm - 5:30pm	**Session V: Climate Change and the Florida Keys Marine Ecosystem** (continued) Moderator: *Jim Fourqurean*, Florida International University, Biological Sciences and SERC, North Miami, FL
4:15pm	**Forecasting Coral Bleaching Weather for the Florida Reef Tract — *Tyler Christensen***, NOAA Coral Reef Watch, Silver Spring, MD
4:30pm	**An Assessment of Five Years of Large Scale Coral Bleaching Monitoring across the South Florida Reef Tract — *Meaghan Johnson***, The Nature Conservancy, Sugarloaf Key, FL
4:45pm	**Catastrophic Mortality on Inshore Reefs of the Florida Keys: Cold Water Physiology of Three Common Reef-Building Corals — *Dustin Kemp***, University of Georgia, Odum School of Ecology, Athens, FL
5:00pm	Panel Discussion
5:30pm - 8:00pm	Poster Session Two & Networking Social *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*

Friday, October 22, 2010

8:00am - 9:30am	**Session VI: Food Webs, Trophic Cascade, and Population Ecology** Moderator: *Kristen Hart*, US Geological Survey, Southeast Ecological Science Center, Davie, FL
8:00am	**How to Disassemble a Coral Reef: Historical Declines in Florida Keys' Reef Ecosystems — *Loren McClenachan*,** Scripps Institution of Oceanography, La Jolla, CA
8:15am	**From the Macro to the Micro: Testing the Cascading Effects of Nutrient Pollution and Over-Fishing on Multiple Levels of Coral Reef Biodiversity — *Deron Burkpile***, Florida International University, Biological Sciences, North Miami, FL
8:30am	**A Bay Anchovy Induced Trophic Cascade in Florida Bay — *Christopher Kelble***, University of Miami, Cooperative Institute for Marine and Atmospheric Studies and NOAA/AOML, Miami, FL
8:45am	**Impacts of the Spotted Spiny Lobster (*Panulirus guttatus*) on Coral Patch Reef Communities of the Florida Keys — *Meredith Kintzing***, Old Dominion University, Norfolk, VA
9:00am	**Impact of Mass Sponge Mortality and Juvenile Density on Spiny Lobster Recruitment in Florida Bay — *Michael Childress***, Clemson University, Biological Sciences, Clemson, SC
9:15am	**Thirty Years of Change in Reef Fish Communities in the Florida Keys: Results from a Long-Term Monitoring Program — *Benjamin Ruttenberg***, NOAA/NMFS, Southeast Fisheries Science Center, Miami, FL
9:30am	Panel Discussion

Friday, October 22, 2010 (continued)

9:45am - 10:30am	**Session VI: Connectivity and the Efficacy of No-take Marine Reserves** Moderator: *David Hallac*, Everglades and Dry Tortugas National Parks, Homestead, FL
9:45am	**Spawning Aggregations and Migration Patterns of Mutton Snapper in Dry Tortugas, Florida — *Michael Feeley*,** Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, Marathon, FL
10:00am	**Connectivity, Environmental Degradation, and Behavioral Influences on Disease in Lobster — *Donald Behringer***, Program in Fisheries & Aquatic Sciences, University of Florida, Gainesville, FL
10:15am	**Persistence of Dispersal Kernel Features in the Florida Keys under Average and Extreme Climatic Conditions — *Claire Paris***, Applied Marine Physics, Miami, FL
10:30am - 11:00am	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]* ***NOTE: Session Two presenters to remove poster displays upon conclusion.***
11:00am - 12:30pm	**Session VI: Connectivity and the Efficacy of No-take Marine Reserves** (continued) Moderator: *David Hallac*, Everglades and Dry Tortugas National Parks, Homestead, FL
11:00am	**Larval Reef Fish Assemblages in the Florida Keys and the Influence of Mesoscale Eddies — *Kathryn Shulzitski*,** Rosenstiel School of Marine and Atmospheric Science, University of Miami, Marine Biology and Fisheries Department, Miami, FL
11:15am	**Condition of Coral Reef Fish Larvae along the Florida Keys Shelf: Implications for Connectivity — *Martha Hauff***, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Marine Biology and Fisheries Department, Miami, FL
11:30am	**Population Connectivity of Coral Reef Fishes along the Florida Keys Shelf: An Integrated Field and Modeling Analysis — *Su Sponaugle***, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Marine Biology and Fisheries Department, Miami, FL
11:45am	**Why Sanctuary Preservation Areas (SPAs) are Necessary for the Sustainable Management of Queen Conch in the Florida Keys — *Robert Glazer***, Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, Marathon, FL
12:00pm	**Spiny Lobster Movement and Population Metrics at the Western Sambo Ecological Reserve — *Rodney Bertelsen*,** Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, Marathon, FL
12:15pm	**Coral Reef Fishes within the Dry Tortugas National Park: Effects of Three Years of Protection by the Research Natural Area — *Sean Keenan*,** Florida Fish & Wildlife Conservation Commission, Fish & Wildlife Research Institute, Marathon, FL
12:30pm-2:00pm	Lunch Provided *[The Terrace Restaurant]* ***NOTE: Poster boards will be removed by exhibit services vendor at this time.***

Friday, October 22, 2010 (continued)

2:00pm - 3:15pm	**Session VI: Connectivity and the Efficacy of No-take Marine Reserves** (continued) Moderator: *David Hallac*, Everglades and Dry Tortugas National Parks, Homestead, FL
2:00pm	**Biodiversity and Ecosystem Function of Shallow Bank Systems within the Florida Keys National Marine Sanctuary — *John Burke***, NOAA, NOS, CCFHR, Beaufort, NC
2:15pm	**Responses of Benthic Coral Reef Organisms to the Zoning Action Plan for the Florida Keys National Marine Sanctuary — *Mark Chiappone***, University of North Carolina-Wilmington, Center for Marine Science, Key Largo, FL
2:30pm	**Coral Loss and the Long-Term Effects of No-Take Reserves on Florida's Coral Reefs — *Lauren Toth***, Florida Institute of Technology, Biological Sciences Department, Melbourne, FL
2:45pm	Panel Discussion
3:15pm - 3:45pm	Break *[Key Deer, Sea Turtle, Manatee & Dolphin Deck]*
3:45pm - 5:00pm	**Session VII: Science Synthesis for Managers** Moderator: *John Hunt*, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Marathon, FL
3:45pm	**A Decision Support System for Ecosystem-Based Management of Tropical Coral Reef Environments — *Frank Muller-Karger*,** University of South Florida, College of Marine Science, St. Petersburg, FL
3:55pm	**Incorporating Ecosystem Services into Coastal and Watershed Management — *Patricia Bradley*,** US EPA, Office of Research and Development, Key West, FL
4:05pm	**Ecological Scorecards: A Powerful Communication Tool Capable of Distilling Complex Technical Information into a Format Useable by Many — *Robert Brock***, National Oceanic & Atmospheric Administration, National Marine Protected Areas Center, Silver Spring, MD
4:15pm	**Methods and Benefits of Incorporating Human Dimensions into Integrated Conceptual Ecosystem Models — *Grace Johns***, Hazen and Sawyer, Hollywood, FL
4:25pm	**An Assessment of Science Needs Based on an Integrated Conceptual Ecosystem Model of the Florida Keys: The MARES Project — *Peter Ortner***, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL
4:35pm	Panel Discussion
5:00pm	Conference Concludes

Poster Directory

Poster Session One

Wednesday, October 20, 2010, 5:30pm - 8:00pm

Poster Number	Presenter	Organization	Title	Topic
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41	Brian Barnes	University of South Florida, St. Petersburg, FL	An Improved High-Resolution Sea Surface Temperature Climatology to Assess Cold Events in the Florida Keys	Cold Water Event of 2010
52	Donald Behringer	University of Florida, Gainesville, FL	The Florida Keys Spiny Lobster Fishery, Environmental Change, and their Interaction with Lethal Lobster Virus PaV1	Climate Change and the Florida Keys Marine Ecosystem
42	Brendan Biggs	Florida State University, Tallahassee, FL	Cold Shock Event Reinforces Value of Monitoring Coral Reef Sponges	Cold Water Event of 2010
9	Vanessa Brinkhuis	Florida Fish and Wildlife Research Institute, St Petersburg, FL	Distribution and Long Term Trends of Clionid Sponges in the Florida Keys, 2001-2008	Coral Reef Ecology and Restoration
46	Cesar Reinert Bulhoes de Morais	University of Miami-RSMAS, Miami, FL	Eddy Variability Along the Florida Keys	Oceanography
43	James Byrne	The Nature Conservancy, Sugarloaf Key, FL	Florida Reef Resilience Program (FRRP)'s Disturbance Response Monitoring of the January 2010 Cold Water Event.	Cold Water Event of 2010
10	Magan Celt	Walt Disney World, Lake Buena Vista, FL	Coral Reefs: A Model for Restoration and Management	Coral Reef Ecology and Restoration
5	Mark Chiappone	University of North Carolina-Wilmington, Key Largo, FL	Where are the Diadema in the Florida Keys?	Coral Reef Ecology and Restoration
6	Mark Chiappone	University of North Carolina-Wilmington, Key Largo, FL	Population Density, Size Structure, and Condition of Staghorn *(Acropora cervicornis)* and Elkhorn Corals (A. *palmata)* in the Florida Keys	Coral Reef Ecology and Restoration

Poster Number	Presenter	Organization	Title	Topic
7	Mark Chiappone	University of North Carolina-Wilmington, Key Largo, FL	Where are the Baby Corals? Species Composition and Density of Juvenile Scleractinian Corals Across the Florida Keys Seascape	Coral Reef Ecology and Restoration
44	Michael Colella	Florida Fish and Wildlife Research Institute, St. Petersburg, FL	Extreme Water Temperature Anomalies of Winter 2010 Correlate with Severe Declines in Stony Coral and Octocoral Cover on Near Shore Patch Reefs of the Florida Keys	Cold Water Event of 2010
45	Whitney Crowder	Florida Fish and Wildlife Conservation Commission, Marathon, FL	The Effect of the 2010 Cold Water Event on the Middle Keys Coral Nursery	Cold Water Event of 2010
11	Gabriel Delgado	Florida Fish and Wildlife Conservation Commission, Marathon, FL	The Feasibility of Using Hatchery-Raised *Diadema antillarum* in Coral Reef Restoration: The Prickly Prologue	Coral Reef Ecology and Restoration
12	Daniel Distel	Ocean Genome Legacy, Ipswich, MA	The Coral Reef Genomic Biorepository Archive at Ocean Genome Legacy	Coral Reef Ecology and Restoration
47	Karen Earwaker	NOAA, Silver Spring, MD	Current Meter Reconnaissance from the Dry Tortugas National Park to Florida Key's Long Key	Oceanography
13	William Fitt	University of Georgia, Athens, GA	Health of Reef Corals in the Caribbean	Coral Reef Ecology and Restoration
53	Jennifer Flannery	U.S. Geological Survey, St. Petersburg, FL	A Century-Long SST Record from *Montastraea faveolata* from the Dry Tortugas National Park	Climate Change and the Florida Keys Marine Ecosystem
54	Dale Gawlik	Florida Atlantic University, Boca Raton, FL	Feasibility of Evaluating the Impacts of Sea Level Rise on Foraging Habitats of the Little Blue Heron in the Great White Heron National Wildlife Refuge	Climate Change and the Florida Keys Marine Ecosystem
14	David Gilliam	National Coral Reef Institute, Dania Beach, FL	Long-Term Monitoring of the Northern Region of the Florida Reef Tract: A Partnership between Academia and Resource Management	Coral Reef Ecology and Restoration

Poster Number	Presenter	Organization	Title	Topic
15	Gretchen Goodbody-Gringley	Mote Marine Laboratory, Summerland Key, FL	Effects of Grazer Presence on Larval Settlement by *Porites astreoides*	Coral Reef Ecology and Restoration
16	William Goodwin	NOAA, FKNMS, Key Largo, FL	Emergency Coral Restoration in the Florida Keys National Marne Sanctuary	Coral Reef Ecology and Restoration
17	Katie Grablow	Coral Restoration Foundation, Tavernier, FL	Comparative Growth and Survival of *Acropora cervicornis* on Concrete Disk versus Line Nurseries	Coral Reef Ecology and Restoration
55	Lewis J. Gramer	University of Miami, Miami, FL	Climatological Significance of Sea Temperature Extremes on the Florida Reef Tract in 2010	Climate Change and the Florida Keys Marine Ecosystem
66	David Hallac	Everglades and Dry Tortugas National Parks, Homestead, FL	Underwater Wonders of the National Park Service – A New Dimension	Human Dimensions
18	Pamela Hallock	University of South Florida, St Petersburg, FL	What Do Reef-Dwelling Foraminifera Reveal about Stressors of Coral Reefs?	Coral Reef Ecology and Restoration
19	Harmony Hancock	Nova Southeastern University Oceanographic Center, Dania Beach, FL	Developing a Non-Invasive Technique to Measure Coral Health	Coral Reef Ecology and Restoration
20	Malcolm Hill	University of Richmond, Richmond, VA	Clionaids Provide Key Insights into Ecological and Evolutionary Forces Shaping Zooxanthella-Symbioses in Invertebrates	Coral Reef Ecology and Restoration
56	Kimmaree Horvath	NOAA Hollings Scholar, Akron, OH	Seawater CO2 Variability of the Florida Reef Tract: An Acidification Refugia Hypothesis	Climate Change and the Florida Keys Marine Ecosystem
48	Elizabeth Johns	NOAA/AOML, Miami, FL	Oil Spill Response Activities Conducted by NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) during Summer 2010	Oceanography

Poster Number	Presenter	Organization	Title	Topic
21	Alison Johnson	Florida Fish and Wildlife Conservation Commission, Marathon, FL	Habitat Preferences of Redband Parrotfish *(Sparisoma viride)* and Stoplight parrotfish, *(Sparisoma aurofrenatum)* as Determined by Fishery-Independent Visual Census Surveys in the Florida Keys	Coral Reef Ecology and Restoration
49	James Kidney	Florida Fish & Wildlife Conservation Commission, Marathon, FL	Long-Term Benthic Temperature Monitoring at Coral Reefs in Florida Keys National Marine Sanctuary	Oceanography
64	Kristie Killam	Florida Keys National Wildlife Refuges Complex, Big Pine Key, FL	Status of Freshwater Resources and Future Management Implications of Sea Level Rise in the Lower Florida Keys	Climate Change and the Florida Keys Marine Ecosystem
50	Villy Kourafalou	University of Miami/RSMAS, Miami, FL	Modeling the Pathways of Particles Related to the Deepwater Horizon Oil Spill Accident toward the Florida Keys	Oceanography
22	Ilsa Kuffner Herzfeld	US Geological Survey, St Petersburg, FL	USGS Research on Coral Reef Ecosystem Studies (CREST)	Coral Reef Ecology and Restoration
51	Yonggang Liu	University of South Florida, St. Petersburg, FL	Water Pathways from the Deepwater Horizon Oil Spill Site to the Florida Keys	Oceanography
23	Caitlin Lustic	The Nature Conservancy, Sugarloaf Key, FL	*Acropora* Restoration in Florida and the U.S. Virgin Islands	Coral Reef Ecology and Restoration
24	Kevan Main	Mote Marine Laboratory, Sarasota, FL	Effect of Light on the Growth of Four Corals Species in Land-Based Nursery Systems	Coral Reef Ecology and Restoration
25	Cheryl McGill	U.S. Environmental Protection Agency, Gulf Breeze, FL	Effects of Bleaching Stress on Wound Repair in *Montastrea faveolata*	Coral Reef Ecology and Restoration
26	Meredith Meyers	University of Georgia, Athens, GA	Applying a Multi-Disciplinary Approach to Investigate Species Relationships in the Genus *Agaricia*	Coral Reef Ecology and Restoration

Poster Number	Presenter	Organization	Title	Topic
27	Martin Moe	Mote Marine Laboratory, Islamorada, FL	Returning the Keystone Herbivore, *Diadema antillarum,* to Florida Coral Reefs	Coral Reef Ecology and Restoration
58	Anne Morkill	Florida Keys National Wildlife Refuges Complex, Big Pine Key, FL	Changes in Fish Communities of Ponds and Lagoons of the Florida Keys	Climate Change and the Florida Keys Marine Ecosystem
28	Douglas Morrison	Dry Tortugas National Park, Homestead, FL	Effects of the 2004-2005 Hurricanes on Dry Tortugas National Park Coral Reefs and Seagrass Meadows	Coral Reef Ecology and Restoration
29	Ken Nedimyer	Coral Restoration Foundation, Tavernier, FL	Producing *Acropora palmata* in Offshore Coral Nurseries for Reef Restoration	Coral Reef Ecology and Restoration
30	John Parkinson	Pennsylvania State University, University Park, PA	High Clonality of Host and Symbionts Characterizes Florida *Acropora palmata* Populations	Coral Reef Ecology and Restoration
31	Christy Pattengill-Semmens	Reef Environmental Education Foundation (REEF), Key Largo, FL	Integrating Time-Series of Community Monitoring Data	Coral Reef Ecology and Restoration
32	Valerie Paul	Smithsonian Institution, Fort Pierce, FL	Effects of Natural Products from Benthic Cyanobacteria on Coral Larvae	Coral Reef Ecology and Restoration
33	Esther Peters	George Mason University, Fairfax, VA	Thirteen Years Of Investigating Florida Keys Reefs through the Course “Diseases Of Corals and Other Reef Organisms”	Coral Reef Ecology and Restoration
59	Richard Poore	U.S. Geological Survey, St. Petersburg, FL	A 50-Year Record of Linear Extension Rates in *Montastraea faveolata, Diploria strigosa* and *Siderastrea siderea* from the Dry Tortugas National Park, Florida	Climate Change and the Florida Keys Marine Ecosystem
1	James Porter	University of Georgia, Athens, GA	The 2009 White Pox Outbreak and Recovery among Elkhorn Coral in the Florida Keys	Coral Reef Ecology and Restoration

Poster Number	Presenter	Organization	Title	Topic
2	William Precht	NOAA, FKNMS, Key Largo, FL	Historical Reconstruction of Population Density and Size Structure of the Echinoid *Diadema antillarum* on Florida Keys Shallow Bank Reefs	Coral Reef Ecology and Restoration
3	William Precht	NOAA, FKNMS, Key Largo, FL	Seascape-Scale Approaches to Restoring Coral Reefs and the Future of Restoration in the Florida Keys National Marine Sanctuary	Coral Reef Ecology and Restoration
4	William Precht	NOAA, FKNMS, Key Largo, FL	First Report of *Acropora palmata* from the Pleistocene Key Largo Limestone	Coral Reef Ecology and Restoration
34	Lindsey Precht	Gulliver Preparatory School, Pinecrest, FL	Assessing Populations of the Threatened Elkhorn Coral, *Acropora palmata*, at Horseshoe and South Carysfort Reefs within the Florida Keys National Marine Sanctuary	Coral Reef Ecology and Restoration
60	Karsten Shein	NOAA, Asheville, NC	IMPACT – A Climate Assessment Resource for the Florida Keys	Climate Change and the Florida Keys Marine Ecosystem
35	Eugene Shinn	University of South Florida, St. Petersburg, FL	Fifty Years of Serial Photos Depicting Coral Growth and Decline	Coral Reef Ecology and Restoration
36	Anastasios Stathakopoulos	National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL	Geomorphology and Paleoecology of Holocene Coral Reefs from the SE Florida Shelf	Coral Reef Ecology and Restoration
37	Christy Stephenson	University of South Florida, St. Petersburg, FL	Foraminifera Assemblages on Reef Rubble vs. Sediments on Conch Reef, Florida Reef Tract	Coral Reef Ecology and Restoration
57	Kevin Strychar	Texas A&M University - Corpus Christi, Corpus Christi, TX	Survival of the Fittest: A Comparative Assessment of Heat Stress on *Montastrea cavernosa* from the Florida Keys versus the Flower Garden Banks National Marine Sanctuary	Climate Change and the Florida Keys Marine Ecosystem
38	Max Teplitski	University of Florida, Gainesville, FL	Microbial Interactions on Coral Surfaces and Their Role in Coral Health	Coral Reef Ecology and Restoration

Poster Number	Presenter	Organization	Title	Topic
39	Tali Vardi	Scripps Institution of Oceanography, La Jolla, CA	Lessons from Jamaica? Initial Signs of *Acropora palmata* Recovery Using Population Matrix Modeling	Coral Reef Ecology and Restoration
40	Craig Watson	UF/IFAS, Ruskin, FL	The Application and Evaluation of Land-Based Aquaculture for Coral Reef Restoration Efforts	Coral Reef Ecology and Restoration
61	Tom Wilmers	U.S. Fish and Wildlife Service, Big Pine Key, FL	Population Trend of the Great White Heron *(Ardea herodias occidentalis)* in the Florida Keys National Wildlife Refuges, 1986-2009	Climate Change and the Florida Keys Marine Ecosystem
62	Tom Wilmers	Florida Keys National Wildlife Refuges, Big Pine Key, FL	Severe Long-Term Decline in the Number of Loggerhead Nests in the Key West National Wildlife Refuge	Climate Change and the Florida Keys Marine Ecosystem
63	Tom Wilmers	Florida Keys National Wildlife Refuges, Big Pine Key, FL	Potential Effects of Climate Change on the Imperiled Miami Blue Butterfly in Key West National Wildlife Refuge	Climate Change and the Florida Keys Marine Ecosystem
65	Kimberly Yates	U.S. Geological Survey, St. Petersburg, FL	Community Calcification and Carbonate Sediment Accumulation in Florida Bay and Biscayne National Park: Keeping Up with Sea Level Rise in the Face of Climate Change	Climate Change and the Florida Keys Marine Ecosystem

Poster Session Two

Thursday, October 20, 2010, 5:30pm - 8:00pm

Poster Number	Presenter	Organization	Title	Topic
15	Alejandro Acosta	Florida Fish & Wildlife Conservation Commission, Marathon, FL	Mutton Snapper *(Lutjanus analis)* Abundance Indices Based on a Fishery-Independent Visual Census Surveys from the Florida Keys, Florida	Exploited Species
24	Elsa Alvear	Biscayne National Park, Homestead, FL	Incorporating Science into a Proposed Visitor-Focused Marine Reserve at Biscayne National Park	Human Dimensions
35	Joshua Anderson	University of Florida, Gainesville, FL	PaV1 Detection by the Caribbean Spiny Lobster *(Panulirus argus)* and its Effect on Population Spatial Structure	Food Webs, Trophic Cascades, and Population Ecology
16	J. Antonio Baeza	Old Dominion University, Norfolk, VA	Molecular Phylogeny of "Peppermint" Shrimps from the Genus *Lysmata,* an Important Group of Crustaceans for the Aquarium-Trade in Florida and the Caribbean	Exploited Species
5	Paul Barbera	Florida Fish and Wildlife Conservation Commission, Florida Fish and Wildlife Research Institute, Marathon, FL	Finfish Movement Patterns and Habitat Use within a Marine Protected Area in the Florida Keys National Marine Sanctuary	Connectivity and No-Take Marine Reserves
43	Tim Bargar	U.S. Geological Survey, Gainesville, FL	Organic Wastewater Contaminant Levels in Canal Waters Entering Biscayne National Park and the Potential for Concordant Endocrine Disruption in the Resident Biota	Water Quality
57	Donald Behringer	University of Florida, Gainesville, FL	Sponge Community Restoration Research in the Everglades and the Florida Keys National Marine Sanctuary	Restoration
17	Benjamin Binder	Florida Fish & Wildlife Conservation Commission, Marathon, FL	Estimating Fishing Intensity on Spawning Aggregation Sites by Means of Aerial Survey in the Florida Keys	Exploited Species

Poster Number	Presenter	Organization	Title	Topic
4	James Bohnsack	SEFSC National Marine Fisheries Service, Miami, FL	Impacts of the 1997 FKNMS Management Zones on Coral Reef Fish Populations over 10 Years	Connectivity and No-Take Marine Reserves
42	Henry Briceno	Florida International University, Miami, FL	Derivation of Protective Nutrient Concentration Thresholds for the FKNMS Waters	Water Quality
47	John Brock	USGS National Center, Mail Stop 915-B, Reston, VA	Blue-Green Airborne Lidar for Mapping Benthic Habitat Complexity: An Emerging Tool for Coral Reef Resource Managers	Remote Sensing
3	Joan Browder	Southeast Fisheries Science Center, Miami, FL	Modeling Transport as a Function of Tide and the Behavior of Pink Shrimp Postlarvae	Connectivity and No-Take Marine Reserves
2	John Burke	NOAA, Beaufort, NC	Impact of the Tortugas North Ecological Reserve on the Fish Community	Connectivity and No-Take Marine Reserves
18	Mark Chiappone	University of North Carolina-Wilmington, Key Largo, FL	Large-Scale Surveys of Lost Fishing Gear and Other Marine Debris in the Florida Keys	Exploited Species
48	Jessica Craft	Coastal Planning & Engineering, Inc., Boca Raton, FL	Benthic Habitat Mapping of the Marquesas / Quicksands Area: Management Implications and Lessons Learned	Remote Sensing
19	Michelle Dancy	Florida Fish & Wildlife Conservation Commission, Marathon, FL	Abundance, Spatial and Recruitment Patterns of Reef Fish in the Middle Florida Keys, Florida	Exploited Species
25	Scott Donahue	Florida Keys National Marine Sanctuary, Key West, FL	Integrating the Florida Keys National Marine Sanctuary Research Permit Database with ArcGIS to Visualize Scientific Utilization Patterns	Human Dimensions
55	Crawford Drury	University of Miami, Miami, FL	Abundance and Distribution of Submerged Aquatic Vegetation (SAV) in Biscayne Bay: The Impacts of Freshwater Input	Restoration
36	Robert Ellis	Florida State University, Tallahassee, FL	Investigating the Structure of Faunal Communities Associated with Juvenile Red Grouper *(Epinephelus morio)* Excavations in Florida Bay	Food Webs, Trophic Cascades, and Population Ecology

Poster Number	Presenter	Organization	Title	Topic
49	Andy Estep	Department of the Interior, Palmetto Bay, FL	Benthic Habitat Mapping in Biscayne National Park: Use of Remote Sensing Techniques and In Situ Investigations	Remote Sensing
56	Thomas Frankovich	Florida International University, Key Largo, FL	Seasonal Patterns in Benthic Macrophytes and Water Quality Parameters in the Mangrove Lakes Region of Florida Bay	Restoration
26	Sarah Frias-Torres	Ocean Research & Conservation Association, Fort Pierce, FL	Social Perceptions Confronting Science in an Endangered Reef Fish	Human Dimensions
37	Christina Gabriel	Nova Southeastern University, Dania Beach, FL	Evaluating the Role of Seagrass Beds as a Nursery Habitat and Food Source in Port Everglades, Florida	Food Webs, Trophic Cascades, and Population Ecology
20	Amber Garr	Harbor Branch Oceanographic Institute at Florida Atlantic University, Fort Pierce, FL	Availability and Toxicity of Copper and Zinc in the Florida Keys: Implications for Queen Conch Larval Recruitment	Exploited Species
1	David Hallac	Everglades and Dry Tortugas National Parks, Homestead, FL	Progress Implementing the Dry Tortugas Research Natural Area Science Plan: the 3-Year Report	Connectivity and No-Take Marine Reserves
27	Thomas Harmon	USF-St. Petersburg, St Petersburg, FL	Anthropogenic Changes in Dove Lake (Tidal Lake) in the Upper Florida Keys over the Last 100 Years	Human Dimensions
9	Kristen Hart	USGS, Davie, FL	Use of Protected Areas by Threatened and Endangered Marine Turtles Tagged in the Dry Tortugas	Connectivity and No-Take Marine Reserves
41	Darrell Herbert	Florida International University, North Miami, FL	Phosphorus Discharge and Ecosystem Integrity: How Much is Safe?	Water Quality
21	Walter Ingram	NOAA, NMFS, SEFSC, Pascagoula, MS	A Multinomial Delta-Lognormal Approach to Multi-Species Abundance Index Development	Exploited Species
40	Christopher Kelble	UM/RSMAS & NOAA/AOML, Miami, FL	Florida Keys Water Quality Integrated Conceptual Ecosystem Sub-Model (ICEM) with Potential Indicators	Water Quality

Poster Number	Presenter	Organization	Title	Topic
28	Li-Pin Lin	Texas A & M University, College Station, TX	Building a Tentative GIS Model to Predict Wetland Loss: A Case Study of Florida Keys	Human Dimensions
29	Li-Pin Lin	Texas A & M University, College Station, TX	The Conservation Contribution of Ecotourism to Wetland Rehabilitation in Florida	Human Dimensions
50	Stanley Locker	University of South Florida, St. Petersburg, FL	High-Resolution Seafloor Mapping of the Dry Tortugas National Park Using Side-Scan Sonar and Swath Bathymetry	Remote Sensing
58	Jeffry Marcus	C3TS, Coral Gables, FL	Seagrass Recruitment 15 Months after Removal of the Lake Surprise Causeway	Restoration
39	Christopher Martens	UNC Chapel Hill, Chapel Hill, NC	Cabled Observatory Measurements of Temporal Variability in Benthic Biogeochemical Processes and Water Quality on Conch Reef, Florida Keys	Water Quality
6	Kerry Maxwell	Fish and Wildlife Conservation Commission, Marathon, FL	Evaluation of Marine Reserves for Spiny Lobsters, *Panulirus argus,* Using Transect Surveys in the Florida Keys National Marine Sanctuary, USA	Connectivity and No-Take Marine Reserves
22	Kevin McCarthy	NOAA Fisheries, Miami, FL	Depth Distribution of Commercial Grouper and Snapper Catches off the Florida Keys	Exploited Species
23	Chris McHan	Florida Fish and Wildlife Conservation Commission, Marathon, FL	Assessment and Amelioration of the Impact of Lobster Traps on Coral Reef and Hardbottom Habitat in the Florida Keys	Exploited Species
38	Steven Miller	University of North Carolina-Wilmington, Key Largo, FL	Multiple Spatial Scale Sampling of Benthic Coral Reef Organisms in the Florida Keys	Food Webs, Trophic Cascades, and Population Ecology
11	Danielle Morley	Florida Fish and Wildlife Conservation Commission, Marathon, FL	Assessment of Geomorphological Characteristics and Reef Fish Utilization of Reported Reef Fish Aggregation Sites in the Florida Keys, USA	Exploited Species

Poster Number	Presenter	Organization	Title	Topic
30	Elizabeth Moses	SCUBAnauts International, St. Petersburg, FL	SCUBAnauts International: A Decade of Youth Education and Research in the Florida Keys National Marine Sanctuary	Human Dimensions
31	Andy Northrop	Coral Restoration Foundation, Tavernier, FL	Strategy for Stewardship: Coral Restoration Foundation's Approach to Regional Reef Management via Volunteerism and Community-Based Stewardship Programs	Human Dimensions
32	Matt Patterson	National Park Service, Palmetto Bay, FL	Counters and Killers - The National Park Service's South Florida/Caribbean Inventory and Monitoring activities in the Florida Keys Marine Ecosystem	Human Dimensions
44	Felicia Orah Rein	Watershed Solutions, Inc., Boca Raton, FL	Protecting Everglades Resources: Conserving Water Quality	Water Quality
45	Reza Savabi	USDA-ARS, Tifton, GA	Hydro-Physical Characteristics of Selected Media Used for Containerized Agriculture Systems in South Florida	Water Quality
51	Eugene Shinn	University of South Florida, St. Petersburg, FL	Benthic Habitats of the Florida Keys and Reef Tract	Remote Sensing
33	Manoj Shivlani	NTVI, Miami, FL	A 10-Year Replication Study of the Florida Keys Commercial Fishing Industry, Dive Operations, and Selected Environmental Groups on Their Knowledge, Attitudes, and Perceptions (KAP) on the Effectiveness of the Florida Keys National Marine Sanctuary (FKNMS) Management	Human Dimensions
12	Steven Smith	University of Miami RSMAS, Miami, FL	Multispecies Survey Design for Assessing Reef-Fish Stocks, Spatially-Explicit Management Performance, and Ecosystem Condition	Exploited Species
13	Marie-Agnès Tellier	Florida Fish and Wildlife Conservation Commission, Marathon, FL	Nearshore Hard-bottom, a Critical Habitat for Juvenile Fish in the Florida Keys	Exploited Species

Poster Number	Presenter	Organization	Title	Topic
46	Eric D. Thosteson	Ocean Research & Conservation Association, Fort Pierce, FL	Marine Water Quality Monitoring with the ORCA Kilroy Network	Water Quality
52	Robert Waara	South Florida/Caribbean I&M Network, Palmetto Bay, FL	The New and Improved Dry Tortugas National Park 2010 Benthic Habitat Map	Remote Sensing
53	Brian Walker	Nova Southeastern University, Dania Beach, FL	Accuracy Assessment and Monitoring for NOAA Florida Keys Mapping	Remote Sensing
14	Christine Ward-Paige	Dalhousie University, Halifax, NE	Relative Success of Management in Florida for the Preservation of Shark Populations	Exploited Species
10	Craig Watson	UF/IFAS, Ruskin, FL	Florida Marine Ornamental Pathway Risk Analysis	Exploited Species
7	Samantha Whitcraft	University of Miami, Miami, FL	Larval Fishes, Connectivity, and Management: A Mesoamerican Reef Case Study	Connectivity and No-Take Marine Reserves
8	Nick Whitney	Mote Marine Laboratory, Sarasota, FL	Fine-Scale Aspects of Shark Behavior Revealed by Animal-Borne Accelerometers	Connectivity and No-Take Marine Reserves
54	Dave Zawada	U.S. Geological Survey, St. Petersburg, FL	A High-Resolution, Digital-Imaging System for Rapid Benthic Surveys	Remote Sensing
34	Tracy Ziegler	Everglades and Dry Tortugas National Parks, Key Largo, FL	Management Plan for the Introduced Indo-Pacific Lionfishes *(Pterois volitans* and *Pterois miles)* in Everglades and Dry Tortugas National Parks, Florida	Human Dimensions
59	Patrick Zuloaga	Tetra Tech EC, Stuart, FL	Seagrass Restoration in Everglades National Park	Restoration

ABSTRACTS

Listed in alphabetical order by presenting author's last name

Mutton Snapper (*Lutjanus analis*) Abundance Indices Based on Fishery-Independent Visual Census Surveys from the Florida Keys, Florida

A. Acosta[1]*, P. Barbera*[1] *and J. Colvocoresses*[2]
[1]Florida Fish and Wildlife Conservation Commission, Fish Wildlife Research Institute/S. FL. Regional Lab. Marathon, FL
[2]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, FL

Fisheries management is often based on data collected from multiple survey programs. However, fisheries independent monitoring programs for commercially important reef fish species are scarce due in large part to the difficulty of achieving an effective sampling design and the cost involved in conducting these surveys. Abundance and size structure data for mutton snapper (*Lutjanus analis*) collected from underwater visual surveys from 1999 to 2007 in the Florida Keys were used to estimate density and elucidate spatial and temporal distribution patterns. Monthly mean densities of mutton snapper were similar throughout the sampled years; however, mean lengths observed were greater in April (at the beginning of the spawning season) with the exception of 2002 when larger individuals were observed in June. We observed and measured mutton snapper on 539 counts; 422 contained potentially mature (>35 cm) mutton snapper. Within 77% of those counts only a solitary individual was observed whereas 22% contained two to five fish and only 3 of the counts had more than 5 fish; no counts exceeded 10 fish. Overall, there were more mutton snappers observed in the Upper and Lower Keys than in the Middle Keys, with more juveniles being observed per dive in the Lower Keys and more adults in the Upper Keys.

The principal goal of our visual census survey was to evaluate the relative abundance, size structure, and habitat utilization of the reef fish species that comprise local, commercial and recreational fisheries in the Florida Keys reef ecosystem. The primary attainable criteria for a successful fishery monitoring program using a visual census sampling approach is to establish and maintain a consistent sampling methodology which will track relative changes in abundance and generate sample sizes adequate to allow meaningful statistical comparisons within the observed range of abundance levels. We feel that our sampling protocol had produced robust density estimates and enough information to meet those two criteria.

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Incorporating Science into a Proposed Visitor-Focused Marine Reserve at Biscayne National Park

Elsa Alvear[1]*, Vanessa McDonough*[1]*, Ben Ruttenberg*[2] and *Matt Patterson*[3]
[1]Biscayne National Park, Homestead, FL
[2]Formerly South Florida and Caribbean Network, Inventory and Monitoring Program; currently NOAA Fisheries
[3]South Florida and Caribbean Network, Inventory and Monitoring Program

Biscayne National Park is in the planning stages of its General Management Plan. Multiple alternatives include proposed marine reserves designed to afford visitors to the largest marine park in the NPS the opportunity to experience unfished coral reefs. With no standard planning guides for the DOI regarding marine reserves, the park identified the factors that would lead to enhanced visitor experience (fish diversity, abundance, and large size, and coral diversity and health). Fortunately, a number of these types of datasets already exist for BISC. The planning team used data from CESU cooperators (University of Miami, University of North Carolina-Wilmington), NPS SFCN Inventory and Monitoring Network, NOAA, and the park in order to plan the size, shape, and location of the reserve(s), as well as propose long-term monitoring in and out of the reserve(s) in order to evaluate the effectiveness in increasing or maintaining the parameters that contribute to visitor enjoyment.

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PaV1 Detection by the Caribbean Spiny Lobster (*Panulirus argus*) and its Effect on Population Spatial Structure

Josh Anderson and *Donald C. Behringer*
Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, USA

PaV1 (*Panulirus argus* virus 1) is a lethal contact-transmitted pathogen that infects the gregarious Caribbean spiny lobster (*Panulirus argus*). Juvenile spiny lobsters appear more susceptible to infection, which causes tissue degradation, lethargy, and eventually mortality. However, studies have shown that *P. argus* has the ability to detect and avoid shelters inhabited by infected conspecifics, thereby reducing infection risk. Based on its role in many other aspects of lobster ecology (e.g., conspecific interactions, mate searching, and homing events), we hypothesized that olfaction was the most likely mechanism by which lobsters detect PaV1. To test this and determine the source of the olfactory cue, we are employing a series of y-maze experiments. We are also exploring the effect of disease on lobster population spatial structure and the effect water flow has on this structure by manipulating shelter and disease in high and low flow environments. Preliminary y-maze results showed that diseased lobster avoidance is driven by olfaction, and moreover, the olfactory cue alone was equivalent in effectiveness to having a diseased lobster present and visible. Focal lobsters were twice (63.33%) as likely to choose shelters emitting water from a head tank containing a healthy lobster than shelters emitting water from a head tank containing a diseased lobster (29.41%). Thus, even when a diseased lobster is not visible, the avoidance behavior is a strong one. However, in shelter-limited environments, as can occur with sponge die-offs in the Florida Keys, this additional loss of shelter due to disease avoidance could result in population bottlenecks that affect future adult population size. This research is in progress and additional results regarding the effects of flow on disease detection and spatial structure will be available soon.

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Florida's Coral Reefs in a Caribbean Context

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[1]Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL
[2]NOAA, Florida Keys National Marine Sanctuary, Key Largo, FL

Florida's living coral reefs are located near the northern limit of reef-framework construction in the western Atlantic. Their latitude subjects them to winter temperatures colder than reefs of the Caribbean proper, an attribute that Floridian reefs share with reefs of the northern Bahamas, Bermuda, and the Flower Garden Banks off Texas. Despite certain latitudinal idiosyncrasies, the ecology of Florida's modern reefs is in many ways typical of the rest of the Caribbean. During the last interglacial high-stand of the Pleistocene, ~125,000 years ago (MIS 5e), *Acropora palmata* and *A. cervicornis* were essentially absent from the reefs of Florida, due to the discharge of inimical waters from an expanded Gulf of Mexico across the submerged Florida platform. *Montastraea* spp., *Diploria* spp., and *Porites astreoides* were the primary framework builders at that time. In contrast, reef frameworks of the insular and continental Caribbean were dominated by *Acropora* spp. Acroporids dominated ecologically and geologically during the mid-Holocene climatic optimum, ~9,000–6,000 years ago. Cooling temperatures suppressed framework construction by acroporids, and excluded the two *Acropora* species themselves, along the Florida Peninsula north of Biscayne Bay around 6,000 years ago. Climatic warming now appears to be fostering a northward range re-expansion of *Acropora* spp. along the east coast of Florida, and to the northern Bahamas and the Flower Garden Banks.

Acroporids dominated reefs of the Florida Keys from the time of the first rigorous ecological observations in the late 1800s until the 1980s. Hard freezes and other extreme events have killed local populations of *Acropora* at certain times and places. The scale of turnover increased from the reef to the reef tract and beyond when the two *Acropora* species succumbed to a regional outbreak of white-band disease in the 1980s–1990s. Coral populations in the Keys have been affected by subsequent, large-scale disease outbreaks and bleaching events. Despite these subregional to regional influences, coral assemblages have remained variable from reef to reef, reflecting spatial variation in physiographic drivers along the reef tract.

A scientific consensus is emerging on the role of herbivory in the resilience of acroporids and other corals. Regional mass mortality of the sea urchin *Diadema antillarum* in the early 1980s, accompanied by overfishing of 'scarids' and acanthurids, has increased macroalgal cover on some Caribbean reefs. In a number of locations where fish are protected, macroalgae have also increased, because coral mortality has overwhelmed the capacity of herbivorous fishes to control them. Macroalgal growth follows coral mortality and not vice versa, but macroalgae are not as abundant in Florida and the Caribbean as was once supposed. Where macroalgae dominate, they can suppress coral recruitment and hence the recovery of coral populations.

Marine protected areas (MPAs) enhance populations of target species of fish and mobile invertebrates, but they appear to have only weakly positive effects on coral assemblages. To date, long-term monitoring in the Florida Keys National Marine Sanctuary (FKNMS) has not shown an effect of no-take regulations over background levels of protection. Whether the lack of effect on the benthos stems from the locations or sizes of the MPAs, their youth, the saturating effect of background protection in the FKNMS, or other reasons remains to be seen.

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Fishery Dynamics of the South Florida Marine Ecosystem

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Coral reef ecosystems in southeastern Florida and the Florida Keys provide the ecological foundation for vital fisheries and a tourism-based economy that generated an estimated 91,000 jobs and US$6 billion of economic activity in 2009. They also contributed to the designation of Florida as the “fishing capital of the world” by the state legislature. But these fishery resources are experiencing Increasing threats from exploitation, water management, loss of key habitats and prey-bases, and the potential for oil contamination. This talk will focus on the population and community dynamics of a range of key fishery resources (e.g., reef fish, tarpon-bonefish, billfish) extending from the coastal land margin out beyond the deep coral reefs. It will explore the spectacular range of fish life history, population dynamics, movements and migrations, and habitat-use strategies that underlie regional fishery productivity and resiliency. An emphasis on ecosystem management will guide exploration of the inter-connectivity of resources, habitats, ocean physics and humans relative to requirements for reliable metrics and benchmarks of fishery sustainability. The future of sustainable fisheries will be discussed in context of new perspectives in sensor technologies, spatial management and data assimilation, and integration of improved statistical survey designs that include integrated networks of monitoring and assessment that require unique public-private partnerships.

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Multi-locus Molecular Phylogeny of "Peppermint" Shrimps from the Genus *Lysmata*, an Important Group of Crustaceans for the Aquarium-Trade in Florida and the Caribbean

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Shrimps from the colorful and ecologically diverse genera *Lysmata* are rare among invertebrates because they are protandric simultaneous hermaphrodites: shrimps initially mature and reproduce solely as males and later in life become functional simultaneous hermaphrodites. Several outstanding issues of systematic nature remain to be addressed in this group. Here, a molecular phylogeny of these shrimps was used to examine the overall evolutionary relationship within and between species and other related genera. The present phylogenetic analyses, including 53 sequences and 26 species of *Lysmata*, indicate that semi-terrestrial shrimps (genus *Merguia*) represent the sister group to a second natural clade composed by shrimps from the genera *Lysmata* and *Exhippolysmata*. The phylogenetic analysis confirmed that the genus *Lysmata* is paraphyletic and includes the genus *Exhippolysmata*,. The separation of species with or without a developed accessory branch into two different subgenera (*Lysmata* and *Hippolysmata* having or not a well developed accessory branch, respectively) is partially supported. Genetic distances of the cleaner shrimps *L. amboinensis* and *L. grabhami* were smaller than those observed between other sister species. On the other hand, the topology of the trees indicates that these two entities are reciprocally monophyletic. Thus, this latter result together with minor but constant differences in the color pattern reported for these two entities indicates that there is no reason to stop treating them as different valid species. In the future, this phylogeny will help revealing the conditions favoring the origins of several behavioral and morphological novelties in these unique shrimps.

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Restoration of an Injury due to a Vessel Grounding upon Stony Coral in the Florida Keys

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This poster presents the results of a restoration and four subsequent monitoring events designed to track the recovery of habitat restored after injury involving a nearshore patch reef within the boundaries of the Florida Keys National Marine Sanctuary. The 13 m cabin cruiser, the *Lagniappe II*, ran aground on a patch reef near Boca Chica Key in August 2002. The damage to the reef involved a path of injury which dislodged approximately 33 m^2 of living coral. The majority of the resulting coral fragments were quickly triaged and used in subsequent restoration activities that attempted to recreate the benthic structure as it had existed prior to the grounding. The majority of the stony coral injured consisted of *Montastraea faveolata*, a primary reef building species in the Florida Keys. Structural restoration was completed in October 2002 and permanent quadrat stations were established for long-term, digital photographic comparisons of impacted and adjacent “un-impacted” areas, in order to track patterns of recovery. The digital imageries were analyzed by using Coral Point Count (CPC) analysis for both coral and macroalgal benthic coverage. The monitoring events occurred at zero, two, seven, and eight years after the restoration was completed. Generally, the trajectory of the restored coral’s status closely parallels that of the reference area coral as does the condition of the macroalgae within the two areas. Our results show that the methodology used to restore the injury at the *Lagniappe II* vessel grounding site reflect the restoration objectives proclaimed by the Sanctuaries Act.

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Finfish Movement Patterns and Habitat Use within a Marine Protected Area in the Florida Keys National Marine Sanctuary

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Acoustic tagging and monitoring methods were used to evaluate a marine protected area established 10 years ago within the Florida Keys National Marine Sanctuary. The objective was to document finfish movement patterns, habitat use and determine spatial applicability of reserve design using forty eight sonic receivers (VR2s) deployed in a series of rings around large habitat features within and offshore of the Western Sambo Ecological Reserve (WSER). Movements of thirty nine acoustically tagged groupers and snappers were tracked between June 2006 and April 2007. Seven groupers, 5 red grouper *Epinephelus morio*, 1 gag *Mycteroperca microlepis*, and 1 goliath grouper *Epinephelus itajara*, were detected on 3 or more acoustic receivers for a period of more than 3 months. Individual detection frequencies ranged from as few as 178 detections to 14,095 for red grouper, 5,645 detections of the gag, and 23,605 detections for the goliath grouper. Estimated home range varied from 0.49 Km^2 to more than 1.95 Km^2 for red grouper, 1.08 Km^2 for the gag, and 1.71 Km^2 for the goliath. Groupers that were captured on patch reefs remained on patch reefs; however, grouper captured in the fore reef zone and at the deeper outlier reef exhibited substantial movement between these habitats. Preliminary results indicate that the large reserve design (30 km^2) is effective in providing adequate protection of patch reef habitat for groupers. However, fish that utilized the fore reef zone often moved across the southern reserve boundary to and from the open fishing area of the outlier reef. To improve information on habitat usage and movement, future work should focus on the spur and grove sections of the fore reef and integrate these results with the broad-scale movements established in the WSER and outlier reef.

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Organic Wastewater Contaminant Levels in Canal Waters Entering Biscayne National Park and the Potential for Concordant Endocrine Disruption in the Resident Biota

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A component of the Comprehensive Everglades Restoration Plan is rehydration of the coastal wetlands adjacent to Biscayne Bay (Bay). The plan was to simply divert water from adjacent canals into the wetlands, but it was determined that the canals had an insufficient water volume to adequately rehydrate the wetlands throughout the year. As a result, water managers are planning to use treated wastewater from the South District Wastewater Treatment Plant (WWTP) to supplement the canal waters. However, treated wastewater could adversely impact biota in the coastal wetlands and in the Bay. Even though treatment of water entering the WWTP reduces organic wastewater contaminant (OWC) concentrations in the effluent, it still contains detectable OWC concentrations. Before the planned rehydration of the wetlands begins (~2012), Biscayne National Park (Park) wants to understand the existing threats to its resources from OWCs. During September of 2009, passive samplers (Polar Organic Chemical Integrative Sampler [POCIS] and Semi-Permeable Membrane Devices [SPMD]) were deployed at the mouths of nine different canals where they enter into the Bay and at three locations within the Bay for the purpose of determining OWC introduction into and presence within the Bay prior to the planned wetland rehydration. Those samplers were retrieved approximately 30 days after deployment and analyzed for OWCs. In addition, extracts from a subset of the POCIS from each location were subjected to the Yeast Estrogen Screen to determine the estrogenicity of the chemical mixture in the aquatic system. Data from this pilot study will give an indication of the background OWC levels in the Bay and Park as well as the potential for adverse impacts to the aquatic organisms due to any detected contamination.

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An Improved High-Resolution Sea Surface Temperature Climatology to Assess Cold Events in the Florida Keys

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Assessing thermal stress in coral reef communities over large regions in a synoptic manner requires accurate measurement of sea surface temperature (SST) from satellite sensors, including the NOAA AVHRR and NASA MODIS. Although their accuracy under cloud-free conditions has been validated using *in situ* measurements, contamination by thin clouds can lead to significant negative bias in SST estimates. A preliminary cloud filter has been developed by examining the long- and short-term variability of SST for the Florida peninsula between 1993 and 2010 at 1 km resolution. This method is effective for correcting clouds in most images, yet during anomalously low temperature events, valid SST data can be misidentified as clouds and discarded. This artifact masks cold water events such as that experienced in the Florida Keys in January 2010, and leads to a cold bias in SST climatologies constructed for the region.

In response to the cold event experienced in January, 2010, the existing AVHRR-derived SST climatology and the individual cloud-filtered images for the month of January, 1995-2010, and spanning the waters surrounding the Florida Keys (24 to 26 N, 80 to 83 W) were examined. Of the 2,703 images analyzed, we determined that the filter underperformed in 500 images (18.5 %). The majority of the images that required re-processing were from passes during extreme cold events in 2001 and especially 2010, indicating that the autonomous filter was primarily cutting cold SST data. During such events, the filter masked pixels with SST of <14 °C when the true SST was 10 °C or lower. Our analysis showed that warm data were sometimes also incorrectly masked, especially during the warm spells of 1997 and 2002. The images containing erroneous masking were reprocessed with both cloud-filtering and manual delineation. Weekly climatologies created with reprocessed images showed 0 - 2 °C lower SST than the original climatologies, with the most extreme deviations occurring at inshore pixels.

The improved SST climatology was used to assess the January 2010 cold event around the Florida Keys and Florida Bay. Florida Bay showed the highest negative SST anomaly, reaching 12^{o}C below the normal temperature for January. Anomalies across the Florida Keys Reef Tract also showed high-spatial heterogeneity. This emphasizes the need for high-resolution SST maps to assist in assessing the scope of cold events and planning response and management strategies. Although the manual filtering method developed for this study is impractical for widespread implementation, it nonetheless represents the best high-resolution SST climatology and highlights the need for improved autonomous cloud-masking techniques.

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Connectivity, Environmental Degradation, and Behavioral Influences on Disease in Lobster

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The Caribbean Spiny Lobster (*Panulirus argus*) is an iconic species in the Florida Keys, where it supports one of the region's most valuable fisheries and plays an important ecological role as an abundant benthic predator. Lobsters are subject to a lethal, pathogenic virus (PaV1) that kills an estimated 25% of the lobsters in Florida annually and we have been studying its dynamics, pathobiology, and effects on lobster behavior and ecology for over a decade. Recent results demonstrate that lobster behavior plays a crucial role in disease transmission, even under scenarios of extreme environmental degradation. We also have discovered a novel mechanism by which PaV1 may be transmitted among Caribbean populations via larval connectivity.

Periodic sponge die-offs have occurred in Florida Bay and the Florida Keys since at least the mid 1800's, the most recent ones caused by cyanobacteria blooms. In 2007, blooms returned to the region and again destroyed hard-bottom sponge communities over > 1500 km^2, compromising the filtering capacity of the system and impacting species that use sponges as shelter, such as spiny lobster. The PaV1 virus is spread by contact, so we anticipated that its prevalence might skyrocket among the normally social lobsters now that sponge shelters were limited. Yet, our experiments revealed that changes in lobster behavior in response to diseased conspecifics are effective in thwarting the spread of disease even in the face of habitat degradation.

Combining laboratory experiments, field studies, and biophysical oceanographic modeling we also have investigated larval behavior and its effect on population connectivity in lobster and are now incorporating disease dynamics as well. Dispersal modeling and independent genetic studies both indicate that larvae arriving in Florida come from throughout the Caribbean, although three or four sources may supply most of the new recruits. We also found that female lobsters infected by PaV1 can transmit the virus to their young, that some of the postlarvae entering the Florida Keys carry the PaV1 virus, and that different viral strains exist that may vary among Caribbean regions. Thus, connectivity of the PaV1 pathogen to the Florida Keys via a larval "vector" appears possible, altering in fundamental ways our view of marine disease dynamics. Our findings also reveal the subtle interplay between host behavior, both as larvae and adults, and large-scale environmental features in altering disease dynamics in this species that is so well-known and important in the Florida Keys.

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The Florida Keys Spiny Lobster Fishery, Environmental Change, and their Interaction with Lethal Lobster Virus PaV1

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The Caribbean spiny lobster (*Panulirus argus*) is one of the most economically valuable fisheries in the Florida Keys and tops this list for most of the Caribbean. In 2001, the fishery in Florida experienced a major decline in landings of approximately 30% from which it has not recovered. This decline was coincident with discovery of a lethal viral pathogen, PaV1, found infecting juvenile lobsters in the Florida Keys. *P. argus* has a complex life history and is exploited throughout its range – two factors that have made it difficult to determine the cause of the decline. Here we describe the first assessment of PaV1 within the fished segment of the population. We used PCR analysis to measure PaV1 prevalence from lobsters caught in commercial lobster traps throughout the Florida Keys. We also tested the effect of diseased lobsters within traps on the attractiveness of that trap to other lobsters and its effect on the transmission of PaV1 to other trapped, but healthy, lobsters. We found a mean prevalence of 11% in the fished population with PCR+ lobsters as large as 95 mm carapace length (76 mm is legal). We also found that traps harboring an infected lobster catch significantly fewer lobsters than traps containing healthy lobsters. Furthermore, healthy lobsters confined in traps with diseased lobsters became infected with PaV1 more frequently than those confined with other healthy lobsters. However, there appears to be an unidentified source of infection in the wild as some healthy lobsters confined with only other healthy lobsters became infected during the course of the experiment. This study demonstrates the indirect and subtle effects that pathogens can have on fishery function through altered animal behavior and the unintended consequences of fishery practices on pathogen epidemiology.

Whether PaV1 has recently emerged or recently risen to detectable prevalence is unclear. However, for other pathogens, disease prevalence or infection intensity have been linked to physiological stress driven by environmental change. To determine if environmental change may be driving PaV1 infection dynamics we tested the effects of hyper (25 psu) and hypo (45 psu) salinity and variable temperature (20°C, 26°C, and 31°C) conditions on PaV1 susceptibility and intensity. Early benthic juvenile lobsters have been shown to be the most sensitive benthic stage to environmental alterations, so we focused primarily on them. We found salinity to have no measurable effect, but lobsters held at 26° and 31°C had significantly higher infection intensity than those at 20°C. Prevalence may also be driven by the persistence of a pathogen in the water column, so we began a series of experiments to determine if altered salinity, temperature, or pH affect the time PaV1 remains viable outside of the host. These latter experiments are underway now. Climate change is having a dramatic effect on many ecosystems and these studies show that increasing ocean temperatures could enhance the effects of PaV1 on Caribbean spiny lobsters.

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Sponge Community Restoration Research in the Everglades and the Florida Keys National Marine Sanctuary

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The ecological function of hard-bottom communities in large portions of the Florida Keys National Marine Sanctuary (FKNMS) and Everglades National Park (ENP) has been severely degraded in recent decades by mass die-offs of sponges associated with episodic blooms of cyanobacteria, the most recent of which occurred in fall 2007 and impacted an area > 1000 km^2. Large sponges normally dominate hard-bottom animal community biomass and their nearly complete decimation in many areas greatly diminishes natural filtration of the water column, threatens commercial sponge fishing, and weakens the function of hard-bottom as a back-reef nursery habitat where sponges provide shelter to numerous animals. At the most severely impacted sites, in the north-central Florida Keys, 22 of 24 species of sponges monitored experienced >90% mortality including all of the commercial and large, structure-forming sponges. Natural recovery of sponge communities was slow following previous blooms in the early 1990's, presumably due to the limited larval dispersal of most sponge species along with poor settlement success and high post-settlement mortality. Although our previous research suggests that restoration of sponge communities may be possible, there is scant information on key aspects of sponge biology or restoration procedures necessary to maximize the probability of success for such an effort. Thus, we have begun a demonstration study to quantitatively test the efficacy of sponge restoration at representative hard-bottom sites using four sponge species chosen for their ecological and economic importance.

With the assistance of a cadre of volunteers, we successfully transplanted > 3000 sponges of three species (Loggerhead Sponge, Vase Sponge, Brown Branching Sponge) and two experimental sizes to 16 study sites in the ENP and FKNMS; half moderately impacted by the sponge die-off and half severely impacted. A fourth species of sponge (Glove Sponge) destined for transplantation succumbed to the severe cold in the winter/spring of 2010, so those additional transplants (>1000) were lost as was much of the wild stock. We mapped the size, species, and position of naturally occurring sponges and other taxa on each of the 16 experimental sites prior to transplantation, as well as 11 control sites (8 impacted control and 3 donor control sites). Over the next few years, we will be monitoring the recovery of the sponge communities on all of these study sites, and will measure key attributes of the transplanted sponges (e.g., growth, survival, filtration) in comparison with natural controls. We anticipate that this project will permit us to quantitatively test the efficacy of restoration at representative hard-bottom sites, and do so in a way that also yields information on the factors that promote long-term sustainability of these communities.

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Spiny Lobster Movement and Population Metrics at the Western Sambo Ecological Reserve

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Established in 1997, the Western Sambo Ecological Reserve (WSER) is a large (30 km^2) MPA in the Florida Keys. One management goal regarding its creation was to preserve marine ecosystems. As such, WSER contains the range of habitats from sand, grassbeds, and hardbottom nearshore to the patchreefs and spur and groove near the southern boundary. Approximately 1 km south of the WSER boundary is a deeper outlier reef that is unprotected.

Since 1997, divers have surveyed spiny lobsters yearly for size and abundance within and outside the reserve. Between 2003 and 2007, we also conducted a series of acoustic studies to evaluate spiny lobster movement with respect to habitat and the boundaries of the reserve. And finally, during 2001-2003, we measured the neurolipofuscin levels of spiny lobsters within the reserve and the fishery. Neurolipofuscin has been used to estimate age. Each of these projects has provided evidence that WSER has retained a portion of the resident lobster population; however, the acoustic data have also provided evidence as to how they are protected and have revealed some specific vulnerabilities of lobsters with respect to the boundaries of WSER.

Evidence from diver based surveys that suggest WSER retain some lobsters include; (1) the persistent presence of large (> 100 mm CL) lobsters in fished areas near WSER, (2) the generally higher abundance of legal sized lobsters inside WSER, and (3) the increased average size difference between male and female lobsters within WSER. The neurolipofuscin data suggest that older lobsters can be found within WSER than are commonly found in the fishery.

Acoustic data have revealed several factors and movement behaviors of lobsters that favor some retention within WSER. Daily movement and monthly home range sizes of lobsters vary greatly; however, WSER is large enough to contain the spatial extent of these movements whereas small MPA's such as Eastern Sambo are too small to contain these movements. Also, some individual lobsters exhibit a very repetitive daily pattern, visiting the same foraging ground at night and returning to the same section of reef. And finally, larger lobsters change their shelter location less frequently than smaller lobsters. Two factors that disfavor retention are reproductive migrations and nomadic movements. Nearly all females undergo multiple reproductive migrations each spawning season that takes them past the southern boundary of WSER. Nomadic movements can result in a lobster leaving WSER in any direction; however, one confirmed destination is the outlier reef. Because the outlier reef has been shown to be an integral part of the WSER lobster population, extending the boundary to include this habitat will appropriately protect all major life stages and lead to a greater likelyhood of affecting the ecosystem management effectiveness of the WSER.

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Cold Shock Event Reinforces Value of Monitoring Coral Reef Sponges

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Surpassing Caribbean corals in both number of species and volume of living tissue, sponges contribute heavily to both the biodiversity and biomass of living coral reefs and perform numerous functions critical to both reef maintenance and resilience. For example, sponges efficiently clear the water column of bacteria and bacterial sized particles, act as food and habitat for numerous species, protect corals from bioeroding organisms, anchor corals to the substratum, rework carbonate, provide a coupling between primary production in the water column and the benthic community, and mediate coral reef rejuvenation. Additionally, sponges are often eye catching, and aesthetic appeal is not insignificant in a time when public support for reef conservation is as important as it is now. Despite the critical functions they perform, many of which are not covered by other reef organisms, sponges continue to be ignored in assessment and monitoring regimes. Avoidance of sponges in such efforts stems in part from the difficulty in accurately identifying and quantifying these reef dwellers. Nevertheless, while monitoring and assessing sponges can be challenging, increasing reports of rapid changes in distribution and declines in abundance of common Caribbean reef sponge species suggests it is time to overcome these challenges in order to include these organisms, which directly affect coral survival and reef health, more comprehensively in monitoring and assessment regimes.

Unlike corals, sponges leave no trace behind when they die, making it difficult to quantify loss without making repeated complete censuses of permanent plots, with every individual identified to species, mapped, and measured for calculation of volume. Such efforts are well rewarded however, as depicted by data collected on the impact of the recent cold shock on the sponge fauna of the lower Florida Keys. Seven months prior to the cold shock, in June 2009, the sponge community within the Looe Key Existing Management Area (Looe EMA), a typical low relief, rocky reef in the middle of Hawks Channel, Florida Keys, was censused using 1 m^2 quadrats (N=17). All non-cryptic sponges found within each quadrat were enumerated, mapped, measured (volume), and identified. Within the 17 m^2 area, a total of 1, 215 individuals representing 68 species were indentified, accounting for 99,808.1 cm^3 of sponge biomass. On February 3, 2010, roughly two weeks after the end of the cold shock, the permanent quadrats were recensused; the number of individuals in the post shock census had dropped to 827, a loss of 31%, while total sponge biomass had fallen by 26%, to 73, 410 cm^3. Combined information from the census and roving diver surveys suggest injury and mortality were species specific (e.g., some species suffered losses as high as 90% while others appeared unaffected), and were associated with particular growth forms (e.g., erect branching and tube shaped sponges suffered greater injury and mortality). Though the loss of life resulting from the disturbance is concerning, this “natural experiment” provided the opportunity to collect information on how sponges respond to such shocks and to the bare substrata left behind (e.g., our June 2010 census uncovered a plethora of new recruits) that otherwise would not have been possible without such baseline information.

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Estimating Fishing Intensity on Spawning Aggregation Sites by Means of Aerial Survey in the Florida Keys

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To effectively manage and prevent overexploitation of commercially important reef fish species, a variety of data gathering techniques have been employed during the last ten years within the Florida Keys. In addition to diver visual census surveys and acoustic mapping, we are now conducting aerial surveys to quantitatively estimate fishing pressure on known snapper and grouper spawning sites and to identify possible new spawning sites based on observations of intense repetitive fishing pressure. Flights are between two and two and a half hours long and are conducted during the new and full moons across the Florida Keys reef tract from Carysfort Reef Lighthouse (Key Largo area) to the west of Western Sambos Ecological Reserve (Key West area). The surveys are conducted from a small aircraft flying at low altitude to enable vessel identification A geographic information system and Tracking Analyst is used to store the flight track data along with observed vessel type, destination, position, and vessel activity (e.g., anchored and fishing, trolling, diving, etc.). Understanding the degree of fishing impact on spawning aggregation sites in the Florida Keys waters is an important consideration for the conservation of these habitats and for future management efforts directed to the sustainability of these fish resources.

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Impacts of the 1997 FKNMS Management Zones on Coral Reef Fish Populations over 10 Years

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The Florida Keys National Marine Sanctuary (FKNMS) established a network of 23 “no-take” marine reserves (MRs) from Key Largo to Key West on July 1, 1997. Changes in populations and communities were analyzed from data collected inside and outside MRs and from before (1994-1997) and after FKNMS reserves were established (1998-2007).

As predicted by marine reserve theory, mean densities of exploited reef fish species increased significantly in reserves over the next decade, including three grouper, three snapper, and a wrasse. Mean densities of black grouper (*Mycteroperca bonaci*), for example, increased significantly above the baseline starting in 2000 and remained there throughout the remainder of the study. By 2004 mean abundance peaked at approximately 32 fold above the pre-reserve baseline level and its average increase during the study was 15 fold above the baseline. Also, mean black grouper density was about two orders of magnitude higher in MRs than in fished areas from 2000 through 2007. Significantly mean density increases were also observed in reserves for other exploited species, including yellowtail snapper (*Ocyurus chrysurus),* gray snapper (*Lutjanus griesus)*, mutton snapper (*L. analis)*, red grouper (*Epinephelus morio*), graysby (Cephalopholis cruentata), and hogfish (*Lachnolaimus maximus*). Mean density also increased significantly for five exploited species in fished areas, although with the exception of hogfish, the increases were significantly less than those observed in MRs,. No biologically significant increases were detected for two reference species not targeted by fishing: the stoplight (*Sparisoma viride)* and stripped (*Scarus iseri)* parrotfish.

Disturbance from six hurricanes in 2004 and 2005 resulted in significantly reduced population density of all exploited species in MRs the year after hurricanes, although densities remained significantly higher than areas open to fishing. Hurricane disturbance appears to disperse and mix normally residential populations causing a net pulsed dispersal from high density areas in marine reserves to lower density areas outside of reserves. Evidence also indicates that more restrictive fishery regulations, including minimum size limits and bag limits, the seasonal spawning closures at Riley’s Hump, and the Tortugas Ecological Reserves, established up-current of the study area in 2001, had beneficial influences on size structure and density of mutton snapper and hogfish.

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Compound Interest: The Value of Long-Term Water Quality Monitoring in the FKNMS

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The objective of the SERC Water Quality Monitoring Network is to characterize the status and trends in water quality in South Florida coastal areas. Since 1995, quarterly field sampling was performed at 150+ sites throughout the FKNMS. Combining this data with other monitoring information for adjacent bays and shelf gives us a quasi-synoptic "big picture" as to what is happening in the South Florida coastal waters. As an ongoing process, we analyze the data for spatial trends, temporal trends, land-based sources of pollution, and importance of external influences in an effort to extend our understanding of the system by developing new hypotheses as to the underlying driving processes which may reflect ecosystems change with climate and management strategy.

The data has been critical in verifying relative influence of land-based vs farfield nutrient inputs to the FKNMS. Both the Carrying Capacity model and the EPA Florida Keys Reasonable Assurance Document (in lieu of TMDL) have relied heavily on data generated from this project. In addition, this information supports the FKNMS Marine Zoning Program, NPS Dry Tortugas Marine Ecosystem Monitoring Program, FKNMS Management Plan, ACOE Florida Keys Water Quality Improvement Program, and Comprehensive Everglades Restoration Program (CERP).

Spatial statistical analysis of water quality parameters has allowed us to define regions of the Sanctuary with distinct differences in water quality. We have proposed this zoning approach as a model to aid both FDEP and EPA in their efforts to develop numeric nutrient criteria for estuaries and coastal waters of South Florida.

Our time series analyses have shown some significant changes in water quality have occurred since initiation of sampling. For example, total organic carbon concentrations have declined consistently across the region. Nitrate has generally declined while ammonium and total nitrogen have increased in the western region. Total phosphorus has increased offshore in the Upper Keys while chlorophyll *a* has declined in all other regions. Turbidity and salinity have increased in the northern areas of the Sluiceway, Backcountry, and Marquesas – areas most influenced by Florida Bay and the SW Shelf.

The large scale of this monitoring program has allowed us to assemble a much more holistic view of broad physical/chemical/biological interactions occurring over the South Florida hydroscape. The results are useful in helping to define restoration targets and will be even more valuable in determining whether these goals are met. All data and interpretive reports are available at http://serc.fiu.edu/wqmnetwork/.

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Incorporating Ecosystem Services into Coastal and Watershed Management

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Coral reefs provide valuable natural benefits that are often overlooked by social policies and human activities in the watershed and coastal zone. These benefits (ecosystem services) include harvestable fish and invertebrates, natural products like pharmaceuticals, unique biota to attract tourism, protection of shorelines from storms, and a diverse community of organisms for education, research and cultural fulfillment. Yet, human activities and decisions both direct (fishing, tourism) and indirect (watershed pollution, climate change) heavily influence the type, quantity and the potential for sustainable delivery these services.

The U.S. Environmental Protection Agency Ecosystem Services Research Program (ESRP) develops tools and information to better incorporate ecosystem services into decision processes. An aim of the ESRP Coral Reef Project is to quantify and forecast changes in delivery of coral reef ecosystem services under different watershed and coastal management scenarios. This requires several areas of investigation, including 1) links between coral reef condition and delivery of services, 2) links between human activity and coral reef condition, 3) contributions of different policies, decisions and socioeconomic drivers that motivate human activities, 4) intended and unintended consequences of decisions on delivery of coral reef ecosystem services and 5) methods to communicate and incorporate information and analyses into future decisions.

The ESRP Coral Reef Project has engaged a commonly-used systems framework (Driving Forces-Pressures-State-Impact-Response, or DPSIR) to allow consideration of both ecological and socioeconomic factors. Ecological approaches include reef assessments that incorporate ecosystem service indicators, dose-response characterization of human-generated stressors on coral growth and survival, and empirical relationships between coral reef condition and human watershed activities (such as fishing and land-based sources of pollution). Socioeconomic approaches include quantification of reef ecosystem services (including fisheries, tourism, shoreline protection and potential natural products), legislative mapping, social network analyses, Bayesian Belief Networks, and decision scenario analyses.

One goal of the ESRP Coral Reef Project is to engage clients early and often so that information and methods developed will not only be useful to, but used by, the community. To achieve this, workshops have been held in three target jurisdictions (U.S. Virgin Islands, Puerto Rico, Florida) to better understand the threats to coral reefs, the management approaches and decisions, the types of information that contribute to those decisions and how it is delivered. Simultaneously, concepts that are potentially useful to clients (such as the DPSIR systems framework, social network analyses and Bayesian Belief Networks) are introduced and used to develop collaborative projects. Client interactions shape the direction of research and influence the tools developed.

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Derivation of Protective Nutrient Concentration Thresholds for the FKNMS Waters

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The State of Florida and EPA are in the process of developing numerical nutrient criteria for estuaries and marine waters of Florida. The Water Quality Monitoring Project for the FKNMS is well poised to help in this process. Quarterly monitoring at 155 fixed sites in the FKNMS began in 1995 and continues to be performed under the auspices of the Water Quality Protection Plan (WQPP). Monitoring includes field measurements of surface and bottom salinity, temperature, dissolved oxygen, and turbidity. Surface and bottom water samples are collected and analyzed for total organic carbon (TOC), total nitrogen (TN), total organic nitrogen (TON), total phosphorous (TP), chlorophyll a (CHLa), soluble reactive phosphate (SRP), nitrite-N (NO_2^-), nitrate-N (NO_3^-), and ammonium (NH_4^+), and silicate (SO_2).

We have statistically characterized and subdivided the FKNMS waters into six biogeochemically and spatially coherent groups, including Dry Tortugas, Marquesas, Ocean, Backcountry and Bay clusters. Statistical analysis included a combination of Principal Components and Hierarchical Clustering methods. Traditionally, EPA has used a 75th percentile approach to setting criteria. We have approached the derivation of TN and TP concentration thresholds for the FKNMS waters with z-score cumulative CHLa charts (Z-Cusum), calculated along nutrient gradients. In these charts an increasing CHLa trend along the nutrient gradient renders a “V” or “U”-shaped line plot, where the minimum point corresponds to the threshold between below average and above average CHLa concentration for the period of record. In order to be protective the numeric nutrient criteria should fall at or below the nutrient concentration corresponding to the inflexion of the line plot. This methodology is being suggested as an alternative for the derivation of numeric nutrient criteria in South Florida coastal and estuarine waters.

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Distribution and Long Term Trends of Clionid Sponges in the Florida Keys, 2001-2008

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Clionid sponges are known to be aggressive coral bioeroders and effective spatial competitors. In 2001, the Coral Reef Evaluation and Monitoring Program (CREMP) began monitoring the abundance and benthic cover of three bioeroding clionid sponges *Cliona delitrix*, *C. lampa*, and *C. caribbaea* at all CREMP stations within the Florida Keys National Marine Sanctuary. Three 22m x 1m belt transects are surveyed within existing CREMP stations. For each clionid colony, the location, species, area, and coral species affected are recorded. Individual clionid area is estimated by using a quadrat frame divided into 25 cm^2 grids and total clionid surface area is pooled for each station. Results presented here include annual data from 109 CREMP stations since 2001. Due to the broader spatial coverage and a greater mean area and abundance of *C. delitrix* compared to *C. caribbaea* and *C. lampa* this species was used for analysis of long term trends of clionids throughout the Sanctuary. Mean *C. delitrix* area data were grouped by region (Upper, Middle, and Lower Keys and the Dry Tortugas) and habitat (Patch, Offshore Shallow, Offshore Deep, and Back Country Patch). Trends in *C. delitrix* area were calculated from a mixed model Kenward-Roger regression and the slope of the line was determined as positive, negative, or non-directional. Based on the Bonferroni corrected p values for repeated sampling (adjusted $p \leq 0.004$), three of the regional*habitat groups, Middle Keys Offshore Deep, Upper Keys Offshore Deep and Lower Keys Patch experienced a significant decreasing trend in mean *C. delitrix* area between 2001 and 2008. The Lower Keys Back Country Patch, Lower Keys Offshore Deep and Dry Tortugas Offshore Deep groups experienced decreasing slopes trends in mean *C. delitrix* area but were not significant after the Bonferroni p value correction. In all, the majority of CREMP stations did not show a significant change in slope trend from 2001 to 2008. Of the 109 stations, 89 showed no change, 19 showed a significant decreasing trend and 1 station experienced a significant increasing trend. Contrary to previous hypothesis that supported an increasing cover of clionid sponges with increasing nutrient concentration, CREMP data suggest that clionid cover has remained relatively stable and even declined in some areas during the last 8 years.

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Blue-green Airborne Lidar for Mapping Benthic Habitat Complexity: An Emerging Tool for Coral Reef Resource Managers

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Numerous prior lidar applications to benthic mapping have focused on coral reef tracts, because reefs are typically rich environments proximal to land in clear shallow waters that are amenable to optical mapping techniques. The aggradation and maturation of coral reefs creates bottom roughness, resulting in topographic complexity ranging from centimeters to kilometers in spatial scale that both influences and reflects many ecological variables. Experiments with blue-green airborne lidar sensing of topographic complexity have revealed capabilities to 1) identify, map, and monitor massive coral colonies and their derivative high rugosity substratum, 2) define the morphology of spur-and-groove structures on fringing reefs, 3) capture the multiscale morphologic structure of coral reef ecosystems, and 4) predict reef fish community structure on shallow patch reefs. Blue-green airborne lidar sensing of benthic topographic complexity shows great promise as a proxy for habitat complexity, a fundamental ecological factor on coral reefs that is relevant to species diversity and richness, herbivore shelter, predation, recruitment, metabolic processes, hydrodynamics, and nutrient fluxes. This paper will describe ongoing technological advances towards the realization of that potential.

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Ecological Scorecards: A Powerful Communication Tool Capable of Distilling Complex Technical Information into a Format Useable by Many

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The North American Marine Protected Areas Network (NAMPAN) is a tri-national effort among Canada, Mexico, and the United States to enhance collaboration and more effectively monitor, manage, and conserve regional marine resources. One of the most comprehensive NAMPAN products developed to date has been ecological scorecards for select marine protected areas (MPA's) along the Pacific coast of North America (dubbed Baja to Bering, or B2B). The ecological scorecard process effectively summarizes and distills large amounts of complex technical scientific data and information into an understandable format amenable to non-technical audiences. This 'ecological scorecard assessment' pilot project has been enthusiastically received by the environmental leaders of the three countries and NAMPAN has received approval to expand this type of project into the Atlantic to Caribbean region (dubbed A2C). Consisting of a series of 14 questions among three categories (Water Quality, Habitats, Living Marine Resources), we use marine ecosystem monitoring data from Dry Tortugas National Park (DRTO) to develop a prototype NAMPAN-like ecological scorecard to address some key Living Marine Resource questions for DRTO. The DRTO scorecard development will highlight the utility of communicating information in this matter and serve as an invitation for other MPA's to collaborate on this project in the future.

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Modeling Transport as a Function of Tide and the Behavior of Pink Shrimp Postlarvae

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A coupled biophysical Individual-Based Model (IBM) has been developed to simulate the life history and migratory movements of pink shrimp (*Farfantepenaeus duorarum*) in south Florida. Pink shrimp migrate from spawning grounds on the southwest Florida shelf off the Dry Tortugas and nursery grounds in Florida Bay. The model will help determine the main environmental factors that affect their journey and successful recruitment to the bay.

The Regional Ocean Modeling System (ROMS), a coastal hydrodynamic model with tidal flux, is the physical hydrodynamic component of the biophysical model. This model has been adapted and tested for the region. A 2-grid-level model was developed for the Florida Keys region. First, a parent circulation simulation grid at 2.8 km horizontal resolution grid was set up and then a 0.7 km horizontal resolution grid was nested within the parent model. The circulation model is forced at the surface by the NCEP North American Regional Reanalysis (NARR) which provides a very accurate wind speed and direction in the coastal waters of South Florida. The model's lateral boundaries are provided by the HYCOM TOPAZ Atlantic Ocean 1989-to present reanalysis.. Freshwater input is a critical component of the regional dynamics and affects the circulation in Florida Bay and the inner SW Florida Shelf. Therefore, the current simulation now includes the southern Florida watersheds up to the Peace and Myakka Rivers, the Big Cypress and Shark Slough drainages, and water flow to Florida Bay from Everglades National Park. The biophysical model simulates the selective tidal stream transport (STST) of pink shrimp larvae on the SW Florida shelf. In STST transport, pink shrimp postlarvae move up in the water column during the flood tide to progress forward and sink to the bottom of the water column during ebb tide to avoid being carried backwards. Our previous research suggested that STST was important to pink shrimp migration across the SW Florida Shelf. The pink shrimp model is tide driven and based on the phase of the tide and larval developmental stage at each individual particle (shrimp larvae) location.

A test-run of the IBM and transport model was conducted with the input of a 1-wk simulation with hourly outputs of the physical model. Results showed that larval transport patterns varied substantially in direction and distance, even when starting from nearby locations, compared to passive particles that all seemed to go the same way. Future simulations will be longer because the literature suggests it takes about 30 days for young pink shrimp to reach the bay.

Decadal ROMS simulations coupled with the pink shrimp IBM will be used to assess the effect of environmental factors on pink shrimp stock variability over the 1995-2005 period

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Eddy Variability along the Florida Keys

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The Florida Keys Coastal Zone is a narrow, curving shelf with complex topography, especially because of its shallow coral reef tract. This region is affected by the Florida Current (FC) with its meanders and eddies. The FC is part of a complex ocean circulation that includes the Loop Current (LC) at the Gulf of Mexico. Understanding the physical mechanisms that drive water exchanges is this area is an important tool to marine resource managers' strategies. These tools include providing model predictions of currents to support management tactics in response to ecological disasters. A recent example involves the Deepwater Horizon oil spill that may affect the Florida Keys fragile ecosystem.

This study is focused on processes that influence the evolution of cyclonic eddies along the Florida Keys. It employs hydrodynamic parameters from three-dimensional fields generated by numerical simulations using a multi-nested, high resolution (~900m) regional application of the Hybrid Coordinate Ocean Model (HYCOM). The eddy identification method consists of analysis of velocity, temperature, Sea Surface Height (SSH) maps in tandem with the Okubo-Weiss (OW) parameter to identify and characterize the cyclonic eddies. The domain was divided in four subregions (Western Keys, Lower Keys, Middle Keys and Upper Keys) according to flow properties, physical characteristics and species composition to facilitate this analysis. Using this approach it is possible to identify if there is a preferred location for eddy formation along the Florida Keys.

A total of 394 eddies were identified and tracked in the domain. Estimating the baroclinic Rossby radius of deformation at ~30 km in this region, 205 mesoscale (diameter larger than 30 km) and 210 submesoscale (diameter less than 30km) cyclonic eddies were identified in the Florida Keys (FKEYS) domain throughout the five years (2004-2008). The results reveal that eddy activity does not have a seasonal signal. On the other hand, annual histograms presenting eddy activity by subregion reveal that the submesoscale activity is dominant in the Upper Keys subregion throughout the five years. Additionally, the cumulative distribution of eddies by subregion suggests that mesoscale eddies are locally generated in the Upper Keys and reinforces the argument that the Upper Keys subregion concentrates most of the submesoscale activity. It also suggests that submesoscale at the Western Keys is much less frequent. It was also observed that the Florida Current location and the topographic constraints affect eddy evolution. Evidences for the latter are presented using case studies.

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Biodiversity and Ecosystem Function of Shallow Bank Systems within the Florida Keys National Marine Sanctuary

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Systems of shallow banks, associated with tidal passes, are distinctive benthic features of the Florida Keys National Marine Sanctuary (FKNMS). These “seagrass banks”, formed approximately 2000 years ago, as aggregation of *Porites* coral rubble and *Halimeda* sand. Banks provide a mosaic of essential fish habitat; juvenile nurseries, foraging and sheltering grounds for adults, including high densities of economically important reef fishes. Comparison of Red Bay Banks, Bamboo Banks and Channel Key Banks to their surrounding basins showed that bank fish assemblages consistently resembled assemblages of coral reefs and had higher diversity and biomass than the surrounding basins. As in most reef fish assemblages a high proportion of the biomass of the bank community consists of “homing” species that shelter during the day and forage nocturnally in surrounding habitats. The species composition, high density and diversity of the bank fish assemblage indicate banks provide a key structural component supporting the biodiversity and productivity of the FKNMS and should be considered for Sanctuary Preservation Area (SPA) status.

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Impact of the Tortugas North Ecological Reserve on the Fish Community

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Monitoring of the Tortugas North Ecological Reserve (TNER) and sampling focused around its boundaries indicates that the reserve provides an effective refuge for exploited species. Fish communities within three management zones were monitored from the time of reserve designation (2001) thru 2009. Ten randomly selected permanent stations within the TNER (no fishing), Dry Tortugas National Park (DTNP, recreational fishing) and Exclusive Economic Zone (EEZ, commercial and recreational fishing) were surveyed visually at the eco-tone between the Tortugas Banks and surrounding shelf. A significant increase in total biomass of both reef and shelf associated fishes occurred during the sampling period. Benthic carnivore, invertivore and herbivore biomass was significantly higher within the TNER than in the EEZ. Biomass of yellowtail snapper which dominates reef fish landings from the region increased approximately an order of magnitude from 2001 to 2007 within the TNER. Increases in biomass of other targeted species included; hogfish (TNER), Gray snapper (DTNP) and mutton snapper (all zones). Geographically focused stratified random sampling showed a change in the fish community around the TNER boundary. Piscivore, benthic carnivore and herbivore biomass was higher within the TNER than outside the boundary. The relatively high biomass of herbivores within the TNER may represent an indirect effect of reduced fishing pressure and can be expected to positively affect the coral community within the reserve.

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From the Macro to the Micro: Testing the Cascading Effects of Nutrient Pollution and Over-Fishing on Multiple Levels of Coral Reef Biodiversity

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Coral reefs in many areas of the Caribbean Sea have undergone declines in coral abundance and increases in macroalgae, due in large part, to anthropogenic impacts such as global climate change, pollution, and overfishing. Key questions remain, however, regarding how anthropogenic forces alter reef biodiversity across levels of biological organization and how these changes impact coral success and reef resilience. In particular, few studies have addressed the links between increases in macroalgal abundance and diversity and changes in the diversity of coral-associated microorganisms. Since microbial diseases are strong drivers of the decline in coral abundance, it is important to understand the mechanisms that control the taxonomic, functional, and genetic diversity of coral-associated microbes. This proposed research will experimentally alter macroalgal diversity and abundance through manipulations of herbivore pressure and nutrient concentrations (individually and in combination) in a field setting.

Currently, we are monitoring the community dynamics of algae, corals, and coral microbial symbionts in response to experimental manipulations of nutrient enrichment and removal of large herbivorous fishes on a reef in the Florida Keys. Using eight $9m^2$ plots (4 nutrient enriched and 4 control) with $1m^2$ herbivore exclosures and open areas nested within these large plots, we have created a factorial nutrient enrichment/herbivore exclusion experiment. Within each treatment (control, no herbivores, nutrient addition, and no herbivores plus nutrient addition), we will monitor changes in: (1) algal community dynamics (abundance, functional guild, richness), (2) coral species richness, genetic diversity, growth, survivorship, and disease prevalence, (3) microbial taxonomic and functional diversity, as well (4) the genetic diversity of coral symbionts (*Symbiodinium*) on resident and transplanted corals.

To date, our data show that both nutrient enrichment and herbivore removal significantly affect the overall abundance of upright macroalgae (e.g. *Dictyota*, *Amphiroa*, *Sargassum*, etc.) with significant interactions between both forces. Further, nutrient availability and herbivore pressure both significantly affect bacterial communities over time. Bacterial abundance increased following treatment initiation except in control (uncaged, ambient nutrients) colonies. Bacterial diversity increased in uncaged treatments compared to corals in treatments where herbivores were excluded. Although the patterns for coral growth and survivorship are not yet clear, to date we have seen coral mortality only in herbivore exclosures and coral disease incidents only in combined herbivore exclosure/nutrient enrichment plots. The results of this work will ultimately reveal how anthropogenic impacts cascade through several levels of macro- and microbial diversity, and ultimately increase coral disease.

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Florida Reef Resilience Program (FRRP)'s Disturbance Response Monitoring of the January 2010 Cold Water Event

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Following the cold water event in early to mid January, the Florida Reef Resilience Program (FRRP) partners initiated a Disturbance Response Monitoring (DRM) effort to determine the extent of the impact on stony corals in subregions (i.e. lower Keys, middle Keys, upper Keys, etc.) and zones (i.e. inshore patch reefs, mid channel patch reefs, offshore patch reefs, forereef, etc.). Survey sites were randomly selected from a pool of 2005-2009 DRM sites. High resolution sea surface temperature data provided by the University of South Florida was used to further stratify the sample design between sites that experienced temperatures at or below the lethal limit for stony corals (59 degrees) and sites and that did not experience lethally cold conditions.

From January 25 through February 12, 78 sites were surveyed across the Florida Reef Tract from the Lower Keys to Martin County by 31 surveyors from 13 organizations. The impact of the cold water was very spatially explicit. The areas that were impacted the greatest were the inshore and mid channel zones from Summerland Key in the lower Keys through Biscayne National Park. Forereef zones region-wide, reefs west of Summerland Key and reefs north of Biscayne National Park were, much less affected.

Contrary to warm water induced coral bleaching events, the main impact on the stony corals was direct mortality. From frequent observations on specific corals during the event, the corals would generally pale for a day then die. There is not a strong bleaching signal from this event. The mortality occurred across all species.

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Responses of a Nearshore Seagrass Community to *In Situ* CO_2 Fertilization

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To address anticipated changes in coastal dissolved CO_2 concentrations associated with future climate change, the response of a nearshore seagrass community to *in situ* CO_2 fertilization was studied for 6 months during the summer of 2009 in the Florida Keys. Clear 'open-top' chambers were utilized to establish three enrichment treatments (CO_2 enrichment within chambers; no CO_2 enrichment within chambers; and unchambered controls). During the enrichment period, seagrass productivity (leaf growth rates), elemental content (leaf C:N and C:P ratios), sugar content (rhizome soluble carbohydrates), and stable carbon isotope values ($\delta^{13}C$) were measured on a monthly basis. Carbonate alkalinity and pH were additionally measured to monitor CO_2 enrichment levels within the chambers.

For all dates, enriched chambers demonstrated significantly lower pH values and higher CO_2 concentrations as compared to the unenriched chambers and control plots. Seagrass productivity was not significantly impacted by CO_2 enrichment during any sampling date. Enriched chambers displayed an overall average productivity of 20.0 ± 3.8 mg g^{-1} d^{-1}, while unenriched chambers and control plots displayed average productivities of 18.6 ± 2.4 and 20.4 ± 2.5 mg g^{-1} d^{-1} respectively. Seagrass leaf C:P ratios were moderately impacted by CO_2 enrichment during the October sampling period, with significantly higher values for the enriched chambers (1210.4 ± 110.9) as compared to the unenriched chambers (918.6 ± 53.9). Seagrass leaf C:N ratios were not impacted by CO_2 enrichment. Rhizome soluble carbohydrates additionally showed no significant difference between treatments. Seagrass leaf stable carbon isotope values were significantly impacted by CO_2 enrichment for all sampling dates, with enriched chambers displaying an average $\delta^{13}C$ values of -15.1 ± 0.7 ‰, and unenriched and control plots displaying values of -9.9 ± 0.2 and -9.5 ± 0.1, respectively.

While our stable isotope results demonstrate the effectiveness of our treatments, we have found relatively moderate responses by the seagrass community to long term benthic CO_2 enrichment. Similar to terrestrial studies, marine plant communities might not strongly respond to increased CO_2 concentrations if alternate resources (i.e nutrients) becoming increasingly limiting. Our detected shifts in C:P ratios with CO_2 enrichment might suggest such a mechanism, and warrants further study as to how alternate resources may constrain seagrass response to increased CO_2 concentrations.

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Today's Management Challenges: Issues for the Keys Marine Ecosystem

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Before identifying and understanding the management challenges and issues for the Florida Keys marine ecosystem, it is important to understand the natural and social setting. The coral reefs of the Florida Keys and the rest of the Wider Caribbean are far less biologically diverse than those of the Indo-west Pacific region. Geographically, they exist in a far-more enclosed system than that the Pacific. The Wider Caribbean is considerably smaller and comprised of two semi-enclosed basins, influenced by watersheds from South America, Central America and North America. Situated at the crossroads of the Wider Caribbean, and influenced by tropical currents from the Caribbean Sea and more sub-temperate waters in the Gulf of Mexico, the Florida Keys coral reef ecosystem has existed in a precarious environmental setting for 10's of thousands of years. Today these same coral reefs exist at the southern extent of the South Florida ecosystem and on the door-step of 6 million people receiving over 4 million visitors every year. Managing the activities of humans and the impacts their uses have on the environment are among our greatest management challenges. The four major threats to the coral reefs of the world are climate change, land-based sources of pollution, habitat loss and degradation and overfishing. Knowing the complexity of how these four major stressors interact and exacerbate one another has presented one of the major management challenges for the Florida Keys coral reef ecosystem. Scientists and managers alike have sometimes ignored or overlooked the synergistic effect of more than one of these stressors on the coral reefs of the Keys. The tendency has been to look solely at the local stressors on the coral reefs, while ignoring the greater influences of the regional and global stressors and the synergistic complexities of the four major sources of stress. Now, through improved remote sensing capabilities, coral reef managers and scientists comprehend the vast connectivity that exists within the Wider Caribbean, and the far reaching influences of stressors on our coral reef ecosystems. We have to apply an ecosystem-based approach to management, working across domestic and international boundaries by utilizing our remote technologies and our ability to monitor marine environments on large spatial scales. In recent years, great strides have been made in improving scientific collaborations at all spatial and temporal scales. Herein lays the success to overcoming the issues that we faced in the past, as managers and scientists of today focus on the threats or issues affecting coral reefs with the utmost attention to the synergistic complexity that exists, from the microbial to ecosystem scales.

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Coral Reefs: A Model for Restoration and Management

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The coral reefs around southern Abaco, The Bahamas have been affected by a number of natural and anthropogenic stresses leading to their decline. The ecosystem's inability to recover from these impacts suggests that they have undergone a phase shift to an algal dominated state. This decline is evident in terms of the area's low coral cover, scarcity or absence of key reef building corals. The goals of this project were to (1) determine baseline health of patch reefs surrounding Castaway Cay through fish and benthic surveys, (2) investigate whether the introduction of *Diadema antillarum* on certain patch reefs would decrease algal cover and in turn increase coral diversity and abundance and (3) use coral transplanting to accelerate coral repopulation.

This project uses an ecosystem approach and incorporates adaptive restoration methods. This includes the translocation of key grazers on coral reefs, the long-spined black sea urchin, *D. antillarum* and maximizing reef recovery through transplantation of healthy reef-building coral fragments, such as *Acropora palmata* and *Acropora cervicornis*, collected from the wild. In 2007 the project began by collecting baseline data. Benthic, fish and *D. antillarum* surveys were used to assess overall condition of coral reefs surrounding Castaway Cay and establish an experimental site. *D. antillarum* was collected from one to two donor sites and translocated to the experimental site, Glassbottom reef. Beginning 2008 corals were harvested, fragmented and transplanted to Glassbottom from five donor sites. In 2009 behavioral differences in *D. antillarum* from different donor sites were observed; in 2010 an observational study on *D. antillarum* behavior was incorporated to the project.

Yearly monitoring of reef sites from 2008-2010 showed that fish and benthic communities remained fairly stable. Throughout the study approximately 900 *D. antillarum* and 90 corals have been translocated and transplanted respectively. Despite the annual loss (through emigration or predation) of over half of the *D. antillarum* transplanted on Glassbottom Reef, *D. antillarum* densities on the reef remained more than 3 times higher than before translocations. Corals transplanted to Glassbottom Reef in 2008 and 2009 showed high survival rates of at least 67% and 88% respectively.

Results from this study show that adaptive management is needed. Current management strategies include 1) educating the community and tourists on appreciation of the marine environment, snorkel etiquette, advantages of moorings and importance of coral reefs for livelihood, 2) increasing *D. antillarum* translocations, and 3) using human interference to remove snails while investigating ecological approaches. Regular evaluation of current management strategies is critical to coral reef ecosystem restoration.

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Large-scale Surveys of Lost Fishing Gear and Other Marine Debris in the Florida Keys

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Fishing constitutes one of the most significant threats to marine biodiversity and ecosystem function, documented by a growing body of information on the numerous impacts to populations, community structure, and habitats. Besides the more obvious effects on species population structure, fishing activities may also reduce the structural complexity of habitats or cause corresponding changes in ecological processes. These patterns are most obvious in areas where explosives, poisons, or other destructive fishing methods are used, but impacts to organisms can be expected in any area where traps, mobile fishing gear such as trawls, and potentially, even large numbers of recreational fishers operate. Marine debris, especially lost fishing gear, can destroy benthic organisms and entangle both benthic and mobile fauna, and the loss and disposal of fishing gear is internationally recognized as a major environmental issue.

The Florida Keys have a long a long history of commercial and recreational fisheries that target a great diversity of fish and invertebrate species using a multitude of gears. There are also significant, but largely undocumented effects of tens of thousands of recreational fishers, who target hundreds of species using mostly hook-and-line and spear guns. Data on marine debris and the impacts to benthic organisms are particularly timely because the Florida Keys continue to experience a growing number of recreational fishers, and both commercial and recreational fishers exploit hundreds of invertebrates and fish species. The ecological effects caused by marine debris that is lost when cut or broken after snagging on the bottom is a continual concern of resource managers and scientists. Baseline data on fishing gear and other marine debris were collected in the Florida Keys during 2000 at 45 sites and during 2001 at 86 sites. A follow-up assessment was conducted at 145 sites Keys-wide during 2008. The sampling design incorporated cross-shelf habitat type from 1-17 m depth, as well as areas inside and outside of FKNMS no-take marine reserves. Debris was quantified in four 15-m x 4-m belt transects per site. During 2008, a total of 686 pieces of debris were recovered from 34,800 m^2 of sampled benthic habitat, with ~443 kg removed. Most of the recovered debris was hook-and-line gear (53%, 0.5 km total length) and lobster/crab trap gear (35%, ~1 km total length). These debris types caused most (94%) of the 448 documented impacts to benthic invertebrates such as corals, gorgonians, and sponges. Statistical differences in debris density among management areas were not detected, indicating that lost fishing gear was pervasive. Monitoring marine debris can help to assess compliance and biological effects, but also highlights the challenge to patrolling a large marine protected area.

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Population Density, Size Structure, and Condition of Staghorn (*Acropora cervicornis*) and Elkhorn Corals (*A. palmata*) in the Florida Keys

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Population declines of staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*) are often-cited examples of Caribbean reef change since the 1970s, due, in part, to disease and localized effects from storms and predation. Both corals were listed as threatened on the U.S. Endangered Species List based upon range-wide decline and poor recovery. A spatially intensive survey undertaken in the Florida Keys quantified habitat distribution, colony abundance, size, and condition during 1999-2009 from the northern Florida Reef Tract at Fowey Rocks to the Marquesas Keys. A two-stage stratified sampling design using belt transects incorporated cross-shelf habitats from the nearshore island platform to the deeper fore-reef slope to ~27 m depth, as well as along-shelf position and sites inside and outside of no-take marine reserves. A total of 4,212 transects encompassing 1,053 sites and 66,920 m^2 of benthic habitat were surveyed for site presence and transect frequency of occurrence. Focused surveys of colony density, colony size (live tissue surface area), and condition (disease and predation) were undertaken at 341 sites. A re-assessment of these corals continues in 2010, with another large-scale effort planned in 2011.

Acropora cervicornis is the most widely distributed among habitats and is particularly abundant on patch reefs. Transect frequency of occurrence is significantly greater ($P < 0.05$) on inshore patch reefs (19%), offshore patch reefs (16%), and mid-channel patch reefs (13%) compared to most other habitats sampled. Colony densities are as high as 1.22 colonies/m^2, with surface area coverage upwards of 2%. The greatest colony densities and live tissue surface area tend to be found on mid-channel and offshore patch reefs in the lower Keys and Biscayne National Park. Population abundance estimates for *A. cervicornis* indicate a population size of ~13.7 ± 12.0 million colonies in the habitats surveyed, but ~67% of the colonies are less than 150 cm^2 in surface area. In contrast, *A. palmata* is less widely distributed across the south Florida shelf, only being found on offshore patch reefs, shallow hard-bottom, and high-relief spur and groove. Mean transect frequency of occurrence is significantly greater ($P < 0.05$) on high-relief spur and groove reefs (12%) compared to all other habitats investigated, with upwards of 1.25 colonies/m^2 and surface area coverage of 25%. Interlocking stands of this species remain in only a few locations and abundance estimates indicate that there are perhaps ~1.6 ± 1.4 million *A. palmata* colonies in the sampling domain, with nearly over 80% occurring on high-relief spur and groove reefs . Although the prevalence of disease-like conditions is relatively low, both *Acropora* species continue to suffer tissue damage from damselfishes and corallivorous snails, as well as physical impacts from lost fishing gear. Predicting the future of these corals in Florida requires information about both their present-day ecology and geologic history in the region.

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Responses of Benthic Coral Reef Organisms to the Zoning Action Plan for the Florida Keys National Marine Sanctuary

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The Florida Keys National Marine Sanctuary (FKNMS) was created in 1990 to help preserve and restore this unique ecosystem, while facilitating multiple uses. After six years of public comment, the Final Management Plan included 23 no-take marine reserves (NTRs), designated as Sanctuary Preservation Areas, Ecological Reserves, and Special Use/Research Only Areas from northern Key Largo to Key West. One of the research and monitoring objectives for the zoning action plan is to track changes in benthic communities that may result from trophic interactions that result from no-take protection. The zoning plan in 1997 encompassed < 5% of the total FKNMS area, thus assessing spatial and temporal patterns at larger spatial scales is need to place the performance of the NTRs into a regional context. In addition, the NTRs include a diversity of habitats and along-shelf positions. To assess and monitor the responses of benthic coral reef organisms to the zoning action plan, a stratified random sampling design was implemented that incorporates cross-shelf habitat type, along-shelf position, and management zones. In addition to typical measurements of coral species richness and cover, the program also evaluates cover, richness, density, and size of other benthic organisms such as sponges, gorgonians, juvenile corals, other cnidarians, urchins, selected mollusks, and algae. Not including surveys in 2010, as well as those in the Tortugas region, a total of 1,053 sites were sampled during 1999-2009 to support this effort.

Comparisons between NTRs and corresponding reference sites reveal a complex pattern dependent upon habitat type and benthic variable, as well as the pre-existing conditions that reflect the original non-random placement of the zones into mostly high-relief reef areas along the platform margin, many of which had pre-existing *Acropora palmata* stands, or several unique patch reef areas such as Newfound Harbor and Cheeca Rocks. Results indicate that mid-channel patch reefs, offshore patch reefs, shallow hard-bottom, high-relief spur and groove, and deeper (6-15 m depth) fore-reef slope habitats have either remained relatively stable over the sampling period for certain variables (e.g. species richness of sponges and benthic cnidarians), or NTRs have become more similar to corresponding reference areas with lower coral cover. To date, changes in the variables we measure over time are best explained by storm events, bleaching, and disease that reflect larger spatial-scale phenomena that presently over-ride any potential reserve effects that might result from no-take protection.

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Where are the Baby Corals? Species Composition and Density of Juvenile Scleractinian Corals across the Florida Keys Seascape

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Recruitment is critical in the maintenance of coral populations, yet many previous studies, especially in the Florida Keys, have been limited in geographic scope and habitats sampled. Juvenile corals, defined as early post-settlement individuals from ~1 mm up to 4 cm in maximum diameter, are an important component of the population dynamics of corals, yet are often overlooked due to their small size and cryptic nature. This study, part of a larger sampling program for benthic coral reef organisms in the Florida Keys, investigated patterns in density and species composition of juvenile scleractinian corals during 1999-2001 (211 sites), 2005 (195 sites), and 2009 (160 sites) distributed from the northern reef tract to the Marquesas Keys. A stratified sampling design incorporated cross-shelf habitat types, along-shelf position, and areas inside and outside of no-take marine reserves. Underwater visual surveys were used to identify, enumerate, and measure the maximum diameter of juvenile corals by sampling ten 0.65-cm x 0.48-cm quadrats along two replicate transects per site. A total of 566 sites encompassing ten coral reef and hard-bottom habitats and 4,643 m^2 of substratum was sampled. At least 40 coral taxa were present among the 27,495 juveniles enumerated.

Mean densities of juvenile corals exhibit significant variations among habitat types, with significantly greater ($P < 0.05$) mean densities on mid-channel (7.3 juveniles per m^2) and offshore patch reefs (7.1 per m^2), as well as on the fore-reef slope at 6-15 m depth (5.8 per m^2) and 15-21 m depth (10.7 per m^2), compared to inshore patch reefs, back reef rubble, shallow hard-bottom, and high-relief spur and groove. In addition, significantly ($P < 0.05$) greater numbers of taxa per site were observed on mid-channel (7.2 taxa) and offshore patch reefs (7.1), as well as the fore-reef slope at 6-15 m depth (7.5), compared to other habitats. Juveniles of corals in the genera *Porites* and *Siderastrea* were generally the most abundant across all habitats, with notable shifts in species composition corresponding to differences in depth, topographic complexity, and the established coral assemblage. On both mid-channel and offshore patch reefs, two broadcast spawning species, *S. siderea* (33%) and *Stephanocoenia michelini* (11%), as well as two brooding species, *S. radians* (23%) and *P. astreoides* (14%), comprised more than 80% of all juveniles encountered. *Agaricia agaricites* was relatively more abundant on shallow hard-bottom and high-relief spur and groove, along with *Favia fragum* in the latter habitat. In many habitats, the most abundant juveniles tended to correspond with the most abundant established corals. In addition, juvenile *Acropora* and *Montastraea* corals are present, but rare.

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Where are the *Diadema* in the Florida Keys? Spatial and Temporal Patterns in Density and Size Structure since the 1983 and 1991 Mortality Events

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The demise of the once ubiquitous echinoid *Diadema antillarum* Philippi is considered one of several factors responsible for the changes observed on Florida Keys reefs. Historical surveys of *D. antillarum* prior to the 1983-84 Caribbean-wide mass mortality event are limited for this area and consist of data collected at a few seagrass and fore-reef sites, mostly from Indian Key to reefs offshore of Key Largo. However, the available data indicate that densities were at least as high as four individuals/m^2 on shallow spur and groove reefs and upwards of 0.6 individuals/m^2 on the lower-relief fore-reef slope to 10 m depth. The Caribbean-wide mass mortality began in the Florida Keys during the summer of 1983 and presumably led to a 90% or greater reduction in population size. From 1983 to 1990, we are not aware of any published studies of *D. antillarum* density and size structure. Surveys carried out in the early 1990s suggest that the population was recovering, with densities on shallow spur and groove reefs approaching $1/10^{th}$ (i.e. 0.5-0.6 individuals per m^2) of their pre-1983 level, and a size distribution dominated by larger (> 5 cm TD) individuals. In contrast to other wider Caribbean reef ecosystems, a second mortality event struck the Florida Keys *D. antillarum* population beginning in April 1991, with similar morbidity symptoms as the 1983 event that reduced the population to $1/100^{th}$ of its pre-1983 level. Surveys conducted within one year of the 1991 mortality indicate that very low densities (< 0.1 per m^2) and small test sizes (< 3 cm) in shallow fore-reef habitats characterized the *D. antillarum* population, a pattern that continued for the next decade.

Over an 11-year period (1999-2010), we examined densities and test sizes of *Diadema antillarum* and other urchins at over 1,100 Florida Keys sites, excluding the Tortugas region, that span ~350 km of the archipelago, encompassing multiple habitat types from inshore to the deeper fore-reef slope. Underwater visual surveys along belt transects were used to enumerate numbers of individuals and test sizes in a stratified random sampling design. Surveys since 1999 indicate that current densities are still well below one individual per m^2 and the maximum site-level density recorded during the 11-year period was only 0.33 individuals per m^2. However, there has been a notable shift in the average and maximum size of *D. antillarum*. Regression analysis indicates that recovery of densities to pre-1983 levels could take decades, if not longer. Algal assemblages, in most habitats, despite reduced *D. antillarum*, are dominated by diminutive algal turfs, crustose coralline, and to a lesser extent, macroalgae, suggesting that herbivorous fish grazing is critical for maintaining low algal standing crop on Florida Keys reef.

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Impact of Mass Sponge Mortality and Juvenile Density on Spiny Lobster Recruitment in Florida Bay

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Caribbean spiny lobsters utilize the shallow waters of Florida Bay as their primary nursery in the Florida Keys. Settlement occurs in vegetated seagrass and hardbottom communities and structures such as corals, octocorals, sponges, and solution holes play an essential role in reducing predation by providing crevice shelters. When lobster settlement levels are high, population density is mostly limited by the availability of these crevice shelters. However, recent mass sponge mortalities due to cyanobacteria blooms have reduced the availability of crevice shelters thought to be essential to early juvenile survival.

Previous research has found that juvenile lobster density does not always decrease after loss of sponge shelters. This is due, in part, by the ability of larger juvenile lobsters to redistribute themselves to locations where adequate shelter is still available. But it is unclear what happens to newly settled juveniles with limited dispersal ability. In this study, I investigated the role of conspecific settlement cues and sponge shelters loss by conducting a mark-recapture field experiment of newly settled juvenile lobsters on experimental plots with high and low juvenile lobster density before and after mass sponge mortality.

Prior to the mass sponge mortality, recapture rate of marked recruits was similar on high and low density sites, but settlement of unmarked recruits was significantly increased with increased juvenile density. After the mass sponge mortality, recapture rate of marked recruits increased on impacted sites over non-impacted sites regardless of lobster density. Impacted sites also experienced increased lobster densities due to the presence of artificial shelter blocks that served as alternative shelters in the absence of sponges. This effect was present for all size of juveniles including those that had recently recruited to the site.

These results suggest that sponge shelters play two additional roles in regulating juvenile lobster settlement in the Florida Bay nursery. First, they provide shelters to larger juveniles that potential signal the suitability of the habitat for new recruits, and second, they provide a corridor for dispersal when juveniles begin to migrate from the nursery. Emigration from the nursery to the adult reef habitat is a gradual process whereby individuals gradually increase their range of movement seeking new crevice shelters as they go. Conspecific odor cues provide a reliable guide that naïve individuals can follow to find crevice shelters and reduce exposure time to predators. As patches of the Florida Bay hardbottom community lose their structural complexity to mass seagrass and sponge die-offs, the chain of suitable crevice shelters from nursery to reef is broken, leading to decreased rates of movement, increased mortality during migration, and decreased population density of adult spiny lobsters.

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Forecasting Coral Bleaching Weather for the Florida Reef Tract

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Coral bleaching is a major threat to coral reef ecosystems worldwide. The main cause of mass bleaching events is elevated sea surface temperature and solar radiation. Near-real-time alerts from NOAA's Coral Reef Watch (CRW) program use satellite data to pinpoint areas of accumulated bleaching-level thermal stress. A new global seasonal outlook from CRW, based on NOAA models, gives an indication where thermal stress may occur up to 3 months ahead. However, what has been missing is a local-scale short-term outlook for developing bleaching conditions. CRW and the National Weather Service (NWS) Forecast Office in Key West have teamed up to develop an experimental "bleaching weather" forecast for the Florida reef tract. In the summer, low winds and sunny skies can set up conditions conducive to coral bleaching: abundant sunshine, high sea surface temperature, clear water, and little water movement around corals. Using elements from the NWS National Digital Forecast Database, an experimental gridded forecast has been developed to predict bleaching weather conditions over the coming week. This forecast can be used in conjunction with the CRW satellite alerts, allowing local managers to assess whether bleaching conditions will continue or abate over the short term.

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Extreme Water Temperature Anomalies of Winter 2010 Correlate with Severe Declines in Stony Coral and Octocoral Cover on Near Shore Patch Reefs of the Florida Keys

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South Florida experienced one of its coldest 12-day periods on record this past January 2010, when two arctic cold fronts depressed water temperatures of the Florida Keys below the lethal limit for corals (~16°C). Water temperatures remained below this threshold and persisted four to five days. The coldest temperatures were observed at exchanges between Florida Bay and the Atlantic; however, many patch reefs inshore of Hawk Channel were exposed to lethal temperatures for four consecutive days. In February 2010, the CREMP team conducted video transects and demographic surveys at a subset of eight stations within four sites to assess acute changes in benthic cover. Three patch reefs in the Middle Keys and one in the Upper Keys were surveyed, and a Wilcoxon paired sample test on arcsine square root transformed data was used to compare benthic fauna cover between summer 2009 and February of 2010. The most significant coral mortality was observed at sites closest to shore. Although shallow and deep fore-reef habitats were not selected for comparison, temperature data collected from these sites indicated they were not subjected to lethal water temperatures. Mean coral cover across the eight survey stations significantly declined by ~7%, dropping from ~17% in summer of 2009 to ~10% in February 2010. Mortality varied by station due to species composition, where the *Montastraea annularis* species complex, *M. cavernosa* and *Porites astreoides* were the most severely impacted species. In many instances, declines in octocoral cover exceeded those of stony corals. Mean octocoral cover across the eight survey stations significantly declined by ~12%, dropping from ~25% in the summer of 2009 to ~13% in February 2010. Both encrusting and branching growth forms were affected. This acute loss in both stony coral and octocoral cover represents a devastating set-back to the diverse, high cover, near shore patch reefs in the Florida Keys which have previously shown resilience to climatic and anthropogenic events.

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Halimeda Dynamics Relative to Nutrients Availability in the Florida Keys National Marine Sanctuary: A Good Indicator of Productivity and Acidification

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The FKNMS are carpeted by seagrass communities of varying density and species composition, strongly controlled by nutrient availability (Ferdie and Fourqurean, 2004. Macroalgae are the characteristic non-vascular flora found in seagrass communities. Results from our seagrass monitoring program show that calcareous green species of the genus *Halimeda* are increasing in the FKNMS (Collado-Vides et al 2005, 2007. *Halimeda* is a genus of considerable importance in coral reef areas, contributing both organic production and significant amounts of calcareous sediment (Drew and Abel 1985). Our studies aim to understand the spatial and temporal dynamics of the genus *Halimeda* in the seagrass beds in the FKNMS, evaluate its productivity as a function of nutrient availability, and evaluate the potential use of *Halimeda* as an indicator for changes in productivity and acidification.

Halimeda specimens were collected in three quadrats along 30 permanent sites quarterly during 2006. Species, frequency, density and abundance, were obtained for each quadrat, dry weight, CaCO3 content, and diverse morphometric variables for each thallus. Correlations with TN and TP values for the region were conducted to detect any relationship between nutrients and *Halimeda* dynamics. In Sprigger Bank, growth rates were studied using Alizarin red technique, and standing crop has been monitored for the last 3 years in order to evaluate *Halimeda* productivity through time.

Nine *Halimeda* species were found present in all 30 sites, however only *H. incrassat*a was present in all sites. A higher number of plants were found during summer. A positive correlation was found between biomass and TN. Standing crop showed 2 picks one in spring and a second one in fall with values up to 63 gr/m2 of mass corresponding to 51 gr/m2 of CACO3. *Halimeda* mass productivity average for all seasons was 8.52 mg/day, s.e.1.56, with a high season at summer (20.14 mg/day, s.e. 8.83) and low season at fall (6.72 mg/day, s.e. 1.41), this are high values compared with Davis and Fourqurean (2001), but similar to other regions (Tussenbroek 2007. Thalli CaCO3 content showed a linear relation with biomass (carbon content) indicating a constant relationship between CaCO3 fixation and algae size-biomass; changes to this allometric relationship need to be explored as a function of acidification. Our data set is a base-line that will allow us detect potential changes in CaCO3 in *Halimeda* as a consequence of predicted acidification of the oceans; and changes in abundance as a function of nutrient availability. We suggest that *Halimea* should be included in long term monitoring programs as indicators of productivity and acidification at large scales in the FKNMS.

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Benthic Habitat Mapping of the Marquesas/Quicksands Area: Management Implications and Lessons Learned

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Benthic habitats in the Marquesas/Quicksands investigation area were digitized using high-resolution, pan-sharpened, color IKONOS imagery. These images were loaded into ESRI's ArcGIS10© software and visually interpreted to create maps of the area's coral reefs, hardbottoms, seagrass beds, mangrove keys, and other habitats utilizing the National Ocean Service (NOS) classification scheme for mapping south Florida coral ecosystems. The project is an on-going 3-year mapping effort that will ultimately digitize and identify benthic habitats over a total area of 1,354 km^2.

Preliminary digitization and classification of habitat polygons are followed by ground validation efforts in the field that are used to ensure thematic accuracy. Year 1 field work was conducted in June of 2009, and mapped a total of 423 km^2. Year 2 field work will be conducted in September 2010, and will cover approximately 490 km^2. Results will not only provide large-scale habitat maps for utilization by regional managers, but may also illustrate changes over time caused by natural variation as well as stochastic events such as the extreme cold period that occurred during the 2009-2010 winter season.

In addition to the deliverable, the mapping process also helps to identify inherent differences between regions that are not necessarily reflected in the current classification scheme. While the underlying topographic structure and geologic history of different regions may be well known and the resultant benthic cover variations understood, translating these differences within a standardized classification system that accurately describes each unique habitat can be difficult. Throughout the development of these benthic maps, we attempt to identify limitations of the existing classification scheme and reconcile inconsistencies.

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The Effect of the 2010 Cold Water Event on the Middle Keys Coral Nursery

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Since the late 1970's, the abundance of staghorn coral (*Acropora cervicornis*) has undergone a catastrophic decline on Florida and Caribbean reefs. During 2009, the Florida Fish and Wildlife Conservation Commission established an *in situ* coral nursery in the middle Florida Keys to propagate and grow fragments of *A. cervicornis* collected from colonies along the reef tract of the middle Keys. The establishment of this nursery is part of a larger collaborative effort led by The Nature Conservancy and the National Oceanographic Atmospheric Administration and funded through the American Recovery and Reinvestment Act that includes other organizations and academic institutions that expands existing coral nurseries in the Florida Keys and establishes additional ones in the wider Caribbean region. The goal of this effort is to use nursery-reared *A. cervicornis* to re-establish viable colonies on the region's offshore reefs. The middle Keys nursery is of particular interest because of its proximity to Florida Bay and its highly dynamic hydrologic regime. The influence of Florida Bay is thought to be a primary cause for the relative paucity of hermatypic corals along the middle Keys reef tract, and consequently, *A. cerviornis* genotypes successfully propagated within this nursery may be especially adapted to a highly dynamic environment. Consequently, corals propagated in this nursery may be particularly well suited for coral reef restoration efforts throughout the Florida Keys, especially in the face of climate change.

During the fall of 2009, fragments of *A. cervicornis* from 10 different parent colonies in the middle Florida Keys were placed in our coral nursery. However, in January 2010 the Keys experienced an extended period of atypically cold weather that resulted in water temperatures at the nursery reaching as low as 13ºC and remaining below 16ºC for 5 days.

Inspection of the nursery after this event revealed no surviving coral fragments, and further inspection of the parent colonies revealed that more than half were completely or partially dead. Additional observations revealed that many other large, presumably long-lived coral colonies had been affected, underscoring how uncommon this event was.

Following the event, we restocked our nursery with 20 genetically distinct *A. cervicornis* and are monitoring their survival and growth with the goal of identifying those genotypes best suited to use in a comprehensive coral reef restoration and conservation effort.

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Abundance, Spatial and Recruitment Patterns of Reef Fish in the Middle Florida Keys, Florida

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We examined the distribution, abundance, and recruitment variation of the young-of the year (0-100 mm standard length (SL)). for four snappers: lane snapper (*Lutjanus synagris*), gray snapper (*L. griseus*), mutton snapper (*L. analis*) and schoolmaster (*L. apodus*), two grunts: white grunt (*Haemulon plumierii*) and bluestriped grunt (*H. sciurus*) and the great barracuda, (*Sphyraena barracuda*), from June 2006 through December 2009. Ten sites were sampled monthly in the shallow (<1.3m deep) mixed-species seagrass beds of the Atlantic side of the middle Florida Keys using a 21.3 meter seine net. We collected and measured 972 snappers at which 959 were juvenile snapper from 450 hauls. Approximately 96% (n=918) of the snapper collected were young juveniles (< 100mm SL). Of these, 53% (n=509) were settlement-stage individuals (< 40mm SL), including 427 early-stage juveniles (> 20mm to < 40mm SL), and 82 new recruits (< 20mm SL). Gray snapper (n=307) was the most abundant snapper collected followed by schoolmaster (n=279), lane snapper (n=120), and mutton snapper (n=112). Juvenile abundance for snappers peaked from July through November suggesting that higher numbers of adult snappers were spawning from the early summer to the early fall. White grunt and bluestriped grunt were among the top 10 most abundant species collected accounting for 9% (n=3,969) and 4.4% (n=1,995) of the catch and occurred in 44 % and 43% of the samples respectively. Ninety-nine percent of these two species were juveniles (< 100mmSL) and only 2 and 5 % were new recruits (< 20mm SL). White grunt and bluestriped grunt were most abundant from June to October and these were positively correlated with the spawning season for these species (May to June). We collected and measure 158 great barracuda. Sixty-nine percent of the great barracuda collected were juveniles (< 100mm SL) and only 1 fish was a new recruit (< 20 mm SL). Peak of abundance for great barracuda was during June and July suggesting that spawning takes place during the spring and early summer.

Besides the preliminary recruitment patterns, the survey yields valuable data on spatial and temporal patterns, and community structure of reef fishes. The results indicated that these taxa showed strong preference for these habitats and temporal variations in juvenile fish density can be attributed to the spawning season and their juvenile recruitment periods.

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The Feasibility of Using Hatchery-Raised *Diadema antillarum* in Coral Reef Restoration: The Prickly Prologue

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Coral reefs have become progressively degraded during the last thirty years due, in part, to the mass mortality of the key herbivore *Diadema antillarum*. To date, *D. antillarum* have not recovered to pre-mass mortality levels in the Florida Keys, and it has been posited that the return of *D. antillarum* to the Keys reef tract is one factor that is critical to the recovery of these reefs. Recent advances in the ability to culture *D. antillarum* have given rise to the concept that hatchery-raised urchins can be used as part of a comprehensive coral reef restoration effort. However, observations of the initial stock of hatchery-raised urchins revealed that, unlike their wild counterparts, they often remained exposed during daylight hours, raising concerns that hatchery-reared urchins released into the wild would be subject to predation rates sufficient to undermine their effectiveness in reef restoration. Therefore, we initiated research to identify behavioral deficiencies that may exist in hatchery-reared *D. antillarum* that would compromise their survival in the wild.

We conducted a series of preliminary *ex situ* experiments comparing the shelter use and predator avoidance behavior of wild and hatchery-cultured *D. antillarum*. First, we examined the diurnal shelter use of wild urchins within 155-cm mesocosms containing standardized shelters that mimicked the crevice shelter typically utilized by *D. antillarum*, and confirmed that urchins displayed diurnal sheltering behavior typical of those in reef habitat, utilizing the artificial habitat during the day and emerging to forage at night. We then compared shelter usage between hatchery and wild urchins in separate mesocosms and between wild and hatchery urchins within the same mesocosms. In both trials, there were clear differences in diurnal sheltering behavior, with wild urchins using shelter during the day and hatchery-raised individuals remaining in the open during both day and night. We then compared predator avoidance behavior between wild and hatchery-raised urchins within 81-gallon mesocosms by simulating a predation event (macerating a conspecific). Both hatchery and wild urchins exhibited an escape response. We note that these trials are preliminary, but the clear differences in the diurnal sheltering behavior between hatchery-raised and wild urchins merit further investigation before efforts to establish ecologically functional populations of hatchery-raised *D. antillarum* can be considered part of a comprehensive reef restoration strategy.

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The Coral Reef Genomic Biorepository Archive at Ocean Genome Legacy

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Molecular methods are rapidly transforming many fields of biology, including the study and management of coral reef ecosystems. DNA and specimen biorepositories can accelerate molecular research by allowing researchers broad access to well-documented and well-preserved genomic materials that may be available in very limited quantities, while at the same time ensuring the long-term archival of these same materials and minimizing the ecological impact of their collection. In 2008, OGL established the Coral Reef Genomic Biodiversity Archive (CRGBA) in order to document and store the biological diversity of fragile coral reef ecosystems and to promote research that will inform reef conservation and management efforts. The CRGBA collection includes tissues and purified DNA representing nearly 2000 reef organisms from Bermuda, Australia, and the Florida Keys. As part of its CRGBA, OGL is focusing on working with marine scientists in the Florida Keys to collect and preserve DNA from diverse coral reef organisms. The archive that we are establishing will be a valuable and lasting resource similar to a museum collection or public library. It will provide genetic material to scientists for non-commercial research, supporting projects aimed toward improving our understanding of marine ecosystems and planning conservation and restoration efforts in the Florida Keys, so that we may learn more about the diversity, biogeography, and the health of the highly threatened species in the Florida Keys ecosystems. In the first phase of this project, OGL is working with scientists from Mote Marine Laboratory to archive and preserve the genetic diversity of specimens of the threatened staghorn coral, *Acropora cervicornis*. To continue expanding the archive, OGL is mobilizing and coordinating researchers, managers, and collectors in Florida to contribute to the CRGBA as soon as possible. Our goals for this project include creation of outreach to new collaborators, coordination of meetings with new and current collaborators, development and implementation of field collections, accession of materials to the DNA archive, development of an online interactive database, and development of a long-term plan to maintain continuity of this resource. Like all activities of OGL, the CRGBA will be operated as a public service on a not-for-profit basis to support DNA- and genome-based research on the valuable, unique environmental resources within the Florida Keys.

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Integrating the Florida Keys National Marine Sanctuary Research Permit Database with ArcGIS to Visualize Scientific Utilization Patterns

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Because most scientific activities occurring within the Florida Keys National Marine Sanctuary are not exempt from the Sanctuary regulations, the FKNMS issues approximately 60-70 research-based permits a year to allow scientists to conduct their work. Despite the high species richness due to diverse community types, most consumptive research is known to focus on the vulnerable coral reefs. Generally, coral reef scientists keep their consumptive “foot print” to a minimum, but resource managers are beginning to monitor these activities to facilitate research collaboration if it results in reduced impact to the resources. As a result, this project tests whether ArcGIS can be used to assess spatial patterns in consumptive research within the FKNMS and evaluate trends in resource (taxonomic) utilization. In relation to the main hypothesis, this work will suggest whether or not scientists potentially miss out on collaborative opportunities based on their overlapping interests and/or spatial coverage. These two questions drive the need for the creation of visual aids to help resource managers reduce and/or reassess potential impacts. The success of not only displaying permitted locations on a map, but identifying “hot spots” of high consumption *and* heavy use will allow Sanctuary resource managers the insight to reduce permitting to these areas of high interest. This could effectively spread the research footprint to more of the Florida Keys or encourage the sharing of data between scientists to reduce the overall human impact on the reef. Lastly, statistics for permittee compliance with other permit requirements (e.g., validating their permits and submitting the necessary reports) were quantified in order to examine ways the permitting process could be improved.

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Abundance and Distribution of Submerged Aquatic Vegetation (SAV) in Biscayne Bay: The Impacts of Freshwater Input

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Submerged Aquatic Vegetation (SAV) communities composed of seagrasses and macroalgae are the dominant benthic communities on Biscayne Bay, extending from the leeward keys all the way to the western mangrove coastline of this shallow subtropical lagoon. Prior research has shown that nearshore (< 500 m from shore) SAV community structure and distribution are influenced by salinity patterns and the inflow of freshwater from water management canals along the mainland shoreline. This study evaluates if the abundance and distribution of SAV is affected by salinity (and other physical factors) beyond the very nearshore littoral habitats where freshwater release from canal systems prevail. This is accomplished by conducting seasonal surveys of SAV abundance and distribution along inshore-to-offshore 1-km transects located from Matheson Hammock to Barnes Sound. Spatial and seasonal patterns of SAV abundance and distribution along these transects were documented in 2009 and 2010. Initial analyses indicate that the patterns previously established for *Thalassia* (higher abundance in areas with high and stable salinity) and *Halodule* (higher abundance in areas with low and variable salinity) within nearshore habitats (< 500 m from shore) are indeed maintained beyond these shallow habitats (< 1 m of depth) and in areas up to 1 km from shore. Our research suggests that the area of influence of salinity patterns (and the influence of overland, canal, and groundwater discharges) is not limited to 500 m from shore (a restoration target) and, more importantly, that future changes in salinity patterns caused by CERP may be observed in deeper habitats further away from shore.

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Current Meter Reconnaissance from the Dry Tortugas National Park to Florida Key's Long Key

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NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) is responsible for updating and maintaining the U.S. Tidal Current Tables. In June 2010 CO-OPS conducted a reconnaissance of the 126 mile chain of islands that make up the Florida Keys to determine optimal locations to deploy current meters in the upcoming years. Using updated acoustic current meter technology, new predictions will be established at stations in Key West Harbor, Fleming Key Cut, Safe Harbor, Loggerhead Key, Sawyer Key, Cow Key Channel, Dry Tortugas National Park, and Long Key after the current survey is completed in 2012 or 2013. CO-OPS utilized new instrumentation to evaluate the bottom substrate at twenty-seven distinct locations in the Keys. The underwater video camera captures non-invasive video allowing us to characterize the bottom substrate at most of the locations without causing damage to the habitat and avoiding areas of known endangered species such as Staghorn and Elkhorn coral. A few areas were physically sampled using a bottom sampler if the video didn't provide adequate detail. Results of the findings, including GPS data, photos and videos, are available to the public upon request to CO-OPS. An updated NOAA policy now requires offices to obtain permits of concurrence to temporarily or permanently deploy instrumentation within marine protected areas and endangered species areas. The purpose of the policy is to ensure the deployments will have no environmental impact on the local ecosystem. These permits must include concurrence from office coordinators who oversee the National Environmental Policy Act (NEPA) and others as appropriate from the Endangered Species Act (ESA), Marine Mammals Protection Act (MMPA), Endangered Fish Habitat (EFH), National Parks Service (NPS), National Marine Sanctuaries (NMS), US Fish & Wildlife Service refuges, and State and Historical Preservation Society. Acquiring permits from the NPS, NMS, and NEPA may take up to 90 days. Twenty-five of the stations are within the jurisdiction of the Florida Keys NMS. Seven stations require concurrence from USF&WS since they are within Key West, Great White Heron, and Key Deer wildlife refuges.

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Investigating the Structure of Faunal Communities Associated with Juvenile Red Grouper (*Epinephelus morio*) Excavations in Florida Bay

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In Florida Bay juvenile red grouper (*Epinephelus morio*) actively remove sediment and debris from limestone solution holes. This excavation activity creates complex benthic habitat where little otherwise exists and as a result red grouper excavations are colonized by numerous other organisms. In June, 2010, red grouper excavations were identified at three locations north of Marathon, FL. The abundance and diversity of mobile fauna, sessile invertebrates, and amount of benthic cover at each excavation was enumerated by divers and recorded by video survey. Sediments samples were collected from within and outside excavations to determine the infaunal communities present. When compared to other complex structure found at the same locations, both the abundance and diversity of organisms present was higher at active red grouper excavations. Differences within the community assemblages were also observed between active red grouper excavations and other complex structure. The patterns of abundance and distribution found here will guide future study into the mechanisms which regulate these faunal communities and the interaction strengths between community members.

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Benthic Habitat Mapping in Biscayne National Park: Use of Remote Sensing Techniques and In Situ Investigations

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The South Florida/Caribbean Network (SFCN) in 2006 established a cooperative agreement with Fish and Wildlife Research Institute (FWRI), in collaboration with the South Florida Water Management District (SFWMD) to produce a current, consistent, accurate and reproducible benthic habitat map for Biscayne National Park (BISC).

The benthic habitat mapping project was completed in 2008 under contract with Avineon, Inc. using 30cm aerial photographs of the area of interest (AOI) and a set of 39 control points. In 2009, with the acquisition of high resolution LiDAR, the 30cm aerial photo dataset , and over 600 field data points SFCN refined the 2008 Avineon benthic habitat map to enhance the integrity of the map, and its ability to delineate habitats in BISC.

Revisions to Avineon's map revealed an increase in the park's individual patch reefs and a subsequent decrease in aggregated patch reefs. A new map class "Aggregate Reef Remnant" was added to delineate the intermediate phase of linear reefs, along the pavement to aggregate reef continuum. Significant decreases in the pavement class were exchanged for increases in low relief spur and groove and aggregate reef remnant.

A set of 82 control points were visited to enhance confidence in the interpretation of habitat signatures observed in LiDAR and aerial photograph datasets. These observations defined the difference in similar LiDAR signatures between certain seagrass habitats and aggregate reef remanant/pavement habitat classes. The primary benefit of these observations was an added level of confidence in discerning the difference in habitat signatures which share attributes of more than one habitat.

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Spawning Aggregations and Migration Patterns of Mutton Snapper in Dry Tortugas, Florida

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The Dry Tortugas region includes a network of four marine reserves and provides an excellent system to address the efficacy of marine reserves as an ecosystem-based management tool and measure their effect on fisheries in surrounding open use areas. For most reef fishes, the indirect benefits of marine reserves ultimately depend on either spawning activities within reserve boundaries or connectivity between populations within reserve boundaries and transient fish spawning aggregation sites. The no-take Tortugas South Ecological Reserve (TSER) was established in 2001 by the Florida Keys National Marine Sanctuary, partially because visual surveys suggested that by 1999, the heavily fished Riley's Hump aggregation of mutton snapper, *Lutjanus analis,* had been drastically reduced and possibly had ceased to exist. In June 2009, we documented a large mutton snapper aggregation (~4,000 fish) on Riley's Hump and directly observed the spawning of this species for the first time in Florida and USA waters. In addition, spatial and temporal rates of movement of acoustically tagged snappers and groupers are being measured in the Tortugas region, including annual spawning migratory movements between Riley's Hump and the Dry Tortugas National Park (DRTO), including the no-take Research Natural Area (RNA). A multi-agency managed array of approximately 80 VEMCO VR2 omnidirectional hydrophones is being used to assess habitat utilization patterns, residence times, migration patterns and timing of multispecies aggregations. Inshore to offshore spawning migration movements of adult mutton snapper indicate a possible corridor exists between the DRTO/RNA and the TSER, providing a link between marine reserves. Individual fish have been documented making repeated migratory round trips (≤ 3 trips/fish) of up to 50 kms to spawning grounds during the spawning season (May to August). Individual fish stay on the spawning grounds approximately 10 days surrounding the full moon before returning to home forage grounds within DRTO/RNA. The inclusion of deep-water offshore spawning habitat into a marine reserve network design provides critical shelter for medium range seasonal movements of this species.

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Health of Reef Corals in the Caribbean

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The health of reef corals is reflected in how much tissue biomass is present. Corals tend to add tissue biomass in the cool season, and lose biomass in the warm season. When corals reach a minimum biomass, usually at the end of the warm season, they are at risk of dying, especially during an El Nino. We have tracked tissue biomass and zooxanthellae densities in the Florida Keys, the Bahamas and in Mexico for up to fifteen years. Tissue biomass for some of the deeper *Montastrea* and *Acropora cervicornis* has decreased to a minimum value and the corals have died. *Montastrea annularis* and *M. franksi* may be on the brink of local extinction at some sites.

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A Century-Long SST Record from *Montastraea faveolata* from the Dry Tortugas National Park

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A century-long (1895-2008) Sr/Ca proxy record of sea-surface temperature (SST) variability has been developed from a massive coral *Montastraea faveolata* from the Dry Tortugas National Park (DTNP). The SST estimates were derived from a 12-year modern calibration (r= -0.93) of coral Sr/Ca to an *in-situ* hourly SST record from NOAA National Data Buoy Center (C-MAN) stations PLSF1 and DRYF1. This record captures SST variability for over 100 years in the DTNP and surpasses any existing instrumental records in this region.

Annual Sr/Ca cycles range in amplitude between ~0.3 to 0.4 mmol/mol; the most recent interval exhibits an amplitude of ~0.4 mmol/mol (0.03 mmol/mol = 1°C SST). Winter months demonstrate the highest variability, whereas summer maxima tend to be more stable, which is also evident in instrumental SST records from the Florida Keys. The mean annual SST over 5-to-10 year intervals between 1895 and 1920 is ~1^{o}C cooler than modern mean annual SST. Another cool interval between ~1950 and 1980 coincides closely in time with an overall cooling in global temperature reconstructions. Our preliminary interpretation is that Sr/Ca from *M. faveolata* has high potential for providing records of past SST in the DTNP.

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Fertilization Ecology and Early Life Stages in Threatened Caribbean Acroporid Corals

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Recruitment from sexual reproduction in threatened corals, *A. palmata* and *A. cervicornis*, has been limited in recent years. This is likely a result of the Allee effect, where a decrease in gamete density can lead to depressed fertilization rates; yet, decreased larval supply, lack of suitable settlement substrate, and early post-settlement mortality may also contribute to decreased recruitment. Little is known, however, about the fertilization ecology and early life cycle stages of threatened acroporids. Here, I examine (1) fertilization success over varied sperm concentrations and gamete ages, (2) larvae survival, (3) settlement rates, and (4) post-settlement success in Caribbean acroporids. I found that *A. palmata* eggs are more difficult to fertilize, needing an order of magnitude more sperm to maximize fertilization than *A. cervicornis* eggs. The ease of fertilization in *A. cervicornis* eggs appears to make them susceptible to polyspermic and self fertilization. After eggs and sperm had aged four hours, fertilization was significantly lower in *A. palmata* eggs but no difference in fertilization was seen in *A. cervicornis* crosses. Larval survival and settlement rates were higher in *A. palmata* larvae than *A. cervicornis,* but six weeks after settlement these species did not differ in post-settlement survival. Although both acroporid species have undergone drastic declines, *A. palmata* is recovering at some sites. The limited recovery of *A. cervicornis* could be a result of lower larvae survival and settlement success than their congener. Because high sperm concentrations are needed for fertilization in *A. palmata*, managers need to protect high densities of genotypically diverse colonies of this species. *Acropora cervicornis* with its ease of fertilization over long periods of time are more likely to have successful fertilization at lower densities but less likely to survive the larvae period and successfully settle; therefore, managers should focus on restoration techniques to protect and propagate existing genets.

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Long-term Monitoring of Benthic Community Structure Points to Decadal-scale Increases in Nutrient Availability in the Nearshore Waters of the Florida Keys

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Long-term monitoring (1995-preent) of species composition, elemental content and stable isotopic content of benthic marine plants from 35 permanent monitoring locations across the south Florida seascape indicate widespread increases in nutrient availability, but there have been no large-scale changes in the distribution of seagrasses over that same period. Species composition, elemental composition, and stable isotopes of carbon and nitrogen are all superior tools for monitoring the status of tropical benthic marine plant communities compared to the spatial extent of primary producers, as the former measures provide leading indicators of nutrient-driven change in community structure that can detect change in nutrient supply before such change causes change in community distribution. Further, these benthic community leading indicators are more sensitive sentinels of change in nutrient supply than measures of concentrations of nutrients in the water column in tropical-subtropical, clearwater shallow marine ecosystems like those found in south Florida.

Many, but not all, permanent monitoring sites within the Florida Keys National Marine Sanctuary have experienced increases in the relative abundance of fast-growing seagrass species and macroalgae at the expense of slow-growing Thalassia testudinum. Such shifts in species dominance have not been detected in Florida Bay, however. The spatial pattern in ratio of nitrogen to phosphorus in seagrass leaves indicates a qualitative difference in the limiting nutrient across the seascape, from N-limited offshore areas to P-limited inshore areas. N:P has shifted towards a value of 30:1 at many sites, suggesting that seagrasses are becoming more light-limited, and less nutrient-limited, over the observation period. Stable carbon isotope ratios of seagrasses have also trended towards isotopically lighter values, suggesting decreased light availability at many monitoring locations. Stable nitrogen isotopes, despite their promise as useful indicators of nutrient source and availability in aquatic systems, tell a more complicated story that species composition, elemental content, or stable carbon isotope ratios, as stable N ratios have trended heavier at some sites and lighter at others.

The seascape of south Florida is a naturally low-nutrient, oligotrophic one. Because of this, any increase in nutrient supply is likely to cause a change in the status of the benthic plant communities that underlie the ecosystem.

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Seasonal Patterns in Benthic Macrophytes and Water Quality Parameters in the Mangrove Lakes Region of Florida Bay

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The Mangrove Lakes region of the coastal Everglades is a focus of the Comprehensive Everglades Restoration Plan (CERP). Extensive submerged aquatic vegetation (SAV) beds, supporting large populations of wading birds and wintering waterfowl, once characterized these areas. Present SAV, waterfowl, and wading bird abundances are all greatly reduced from historical (1931 - 1946) levels. These reductions are coincident with increased salinities, and possibly nutrients, in this region caused by diminished freshwater inflows due to water management practices. With a management goal of restoring historic SAV abundances, increased deliveries of freshwater to these mangrove estuaries are proposed to maintain lower salinities as part of CERP. *Chara* and *Halodule* communities are structured seasonally by environmental variables, some of which may change with restoration actions. It is necessary to understand seasonal SAV/water quality relationships in order to predict possible community changes and to restore the critical seasonal energy sources for wildlife provided by these communities.

The focus of this investigation is to describe the seasonality of the SAV communities in the Mangrove Lakes region and to relate observed seasonalities to seasonal changes in environmental variables (i.e., salinity, temperature, nutrient concentrations, light availability, and phytoplankton abundance). Two distinct SAV communities within two drainage systems characterized by differing nutrient status and light availabilities were observed. The alga *Chara hornemannii* is dominant in the upstream brackish "lakes" while the vascular macrophyte *Halodule wrightii* is dominant in the downstream coastal embayments. Differences in wet versus dry season cover were only observed in the *Chara* community within the drainage characterized by chronic low light availabilities. Greater dry season *Chara* coverage was coincident with unique greater dry season light availability within that drainage.

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Social Perceptions Confronting Science in an Endangered Reef Fish

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The recovery of endangered marine megafauna faces several challenges beyond inadequate scientific knowledge. Social perceptions of the species impact in the human world often overrule fact-based science. Worldwide, culling of ocean predators has been proposed as a means to overcome depleted fisheries.

The goliath grouper, Epinephelus itajara, the largest grouper fish in the Atlantic Ocean is critically endangered throughout most of its distribution range. The species has been protected in the United States since 1990. In Florida, some commercial and recreational fishers consider E. itajara a top voracious predator of fish and lobster. Fishers advocate the culling of the protected E. itajara population as a solution to recover declining stocks.

Here I examine the scientific evidence against culling E. itajara and outline the potential ecosystem services of a recovering E. itajara population. Analyses of the E. itajara's commercial extinction event in the late 1980s, coupled with dietary and morphological studies reveal that its recovering population is not the cause of declining fishery stocks in Florida. Instead, E. itajara could provide valuable ecosystem services for local ecotourism and become a biological agent to control the invasive Indo-Pacific red lionfish (Pterois volitans) in Atlantic reefs.

The persistence of the myth—goliath groupers eating all the fish and lobsters of the reef— distracts attention from the real problem of overfishing, and emphasizes the need of science outreach among stakeholders

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Evaluating the Role of Seagrass Beds as a Nursery Habitat and Food Source in Port Everglades, Florida

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Seagrass beds are highly productive ecosystems providing a nursery area for commercial fishes as well as food source for a number of valuable marine organisms. Potentially damaging human activities such as dredging can negatively impact local seagrass populations. The US Army Corps of Engineers (contract no. DACW 17-99-d-0043) has submitted a proposal to dredge, fill, and modify the turning basins, Intracoastal Waterway, and the Dania cut-off canal of Port Everglades, Florida which will directly impact the local seagrass beds. The following data are the result of an ongoing study to identify the trophic dynamics and refuge of the primary seagrass species and associated vertebrates and invertebrates inhabiting three seagrass sites in the anticipated area of impact. Seagrasses and their associated animal assemblages have been collected manually since July 2009 using minnow traps, purse seine nets and plankton nets. All flora and associated fauna are analyzed for carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) stable isotopes ratios to determine the trophic contribution of seagrass communities to the food web.

The predominant seagrass species are *Halodule wrightii, Halophila decipiens,* and *Halophila johnsonii.* These species were senescent during the unusually cold winter of 2010. Surveys and collections resumed in April 2010 when seagrass flowering was observed. The seagrasses reached maximum growth during the summer months at which time the greatest diversity of associated organisms occurred (July>Nov.). The most abundant juvenile and adult animals recorded were *Sphoeroides testudineus* (checkered pufferfish), *Haemulon sciurus* (bluestriped grunt), *Lagodon rhomboides* (pinfish) and *Callinectes sapidus* (Atlantic blue crab). The greatest numbers and diversity of large transient fish species, while present at all three sites, were predominantly found at the deeper site (3 m) during the flood tides. Preliminary stable isotope analyses of the flora and fauna at these locations indicate that the seagrasses are not being utilized as a primary food source.

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Availability and Toxicity of Copper and Zinc in the Florida Keys: Implications for Queen Conch Larval Recruitment

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The Florida Keys is a popular destination that has been affected by development and increased tourism activities over recent decades. Drastic changes to the environment due to dredging, canal construction, and commercial development have impacted the flora and fauna in the surrounding waters. An important seagrass species in the Florida Keys, the queen conch, *Strombus gigas*, has not recovered to acceptable levels despite a 25 year fishery closure. The limited numbers of juvenile queen conch that settle in the Keys nearshore regions are not capable of reproduction, but can recover within six months when they are moved to offshore areas. Additionally, conch in nearshore waters have reduced external sex organs, a shortened lifespan, and instances of imposex. Recent studies have shown an increase in Cu and Zn levels in adult queen conch found in nearshore habitats in comparison to conch found offshore. It is possible that the toxicity effects of Cu and Zn may be linked to the reproductive impairment and lack of recruitment observed in these nearshore habitats.

Although there have been extensive nutrient monitoring programs in the Florida Keys, there is very little data currently available on the impact of copper and zinc to marine organisms in this ecosystem. It is predicted that elevated Cu and Zn in the Florida Keys nearshore environment contributes to impaired growth, development, and recruitment of conch larvae and young juveniles. The goal of this research is to determine the extent of bioavailability and toxic effects that Cu and Zn have on the early life stages of queen conch. Four site-pairs, two nearshore and two offshore, which are important larval recruitment areas in the Florida Keys, are being sampled throughout the conch reproductive season (April – October 2010). Cu and Zn levels in the water, sediment, phytoplankton, and seagrass epiphytes are being analyzed using ICP-MS and results will be presented. Cu and Zn LC_{50} and EC_{50} is being determined for conch larvae and compared to metal concentrations observed in the field. Additional research goals involving chronic exposure and bioavailability will also be discussed. Results from this project will be useful for the Florida Keys National Marine Sanctuary, Florida Fish and Wildlife Conservation Commission, and the Environmental Protection Agency when addressing management and fisheries topics.

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Feasibility of Evaluating the Impacts of Sea Level Rise on Foraging Habitats of the Little Blue Heron in the Great White Heron National Wildlife Refuge

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Habitats in the Great White Heron National Wildlife Refuge (hereafter Refuge) sustain local avian diversity and play a large role in supporting regional or statewide populations of wading birds, many of which are in decline. A major threat to these species in the Refuge comes from likely changes in habitat as a result of sea level rise. Quantifying the degree of climate-driven habitat change for sensitive wading bird species is a precursor to long-term conservation planning, but it is fraught with difficulties. Wading birds forage heavily in the intertidal zone where estimates of future sea levels must be coupled with the predicted elevation of intertidal ground surface, which is dynamic and affected by sea levels.

Here we evaluate the feasibility of predicting changes in Little Blue Heron foraging habitat as a function of sea level rise in a test area of the Refuge. We first define an envelope of Little Blue Heron foraging habitat based on water depth preferences in the Everglades and vegetation preferences from the literature. The change in foraging habitat over time will be quantified by combing sea surface elevations under several climate scenarios (including the Intergovernmental Panel on Climate Change 2001 scenarios) with estimates of intertidal ground surface elevation from the Sea Level Affecting Marshes Model (SLAMM), a widely used model for estimating the impacts of sea level rise on the Atlantic coast.

Model fit will then be assessed by comparing predicted habitat suitability in the test area based on current water levels and habitat distributions, to the distribution of Little Blue Herons observed on field surveys. Surveys will be conducted by boat using the double observer method. The presence and absence of birds in grid cells will be compared to predictions from the model using confusion matrices. Confusion matrices will be further processed to generate receiver operating characteristic (ROC) and the collective area under the curve (AUC) plots, which provide a measure of model usefulness.

A sensitivity analysis will be conducted on model parameters to assess the effects of uncertainty related to habitat definitions, vegetation characterization, ground surface elevation, and sea level. Results will be used to both assess the prospects for improving the model in the future and for focusing future research efforts. The results of this project will address whether the available data and their associated uncertainties could lead to a wading bird model that is sound enough to guide management decisions in the Florida Keys related to sea level rise.

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Ecological Impacts of Sponge Nutrient Cycling on the Florida Keys Reef Ecosystem

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The Florida Keys reef tract has undergone dramatic ecosystem change over the past several decades. Population densities of reef building hard corals have declined while sponge and macroalgal populations have flourished. Evidence for ecologically significant impacts of C and N biogeochemical cycling by Florida Keys sponge populations implicates a complimentary feedback loop between sponges and macroalgal populations that is detrimental to hard coral growth and recruitment. Sponges have the capacity to pump massive volumes of water (over $5x10^4$ L L_{sponge}^{-1} day^{-1}) and to quickly alter the chemical makeup of the water as it is processed by their tissues and associated microbial communities. Acting as biogeochemical factories, sponges rapidly respire and remineralize available organic matter yielding diminished O_2, elevated CO_2, decreased pH and elevated DIN. Much of this sponge effluent lingers in the benthic boundary layer thus creating environmental conditions prohibitive to coral growth and recruitment. Comparisons of analyte concentrations in ambient water with that of sponge excurrent water reveal complex biogeochemical transformations of C and N associated with variations in pumping rates and O_2 consumption. We observed DOM consumption by sponge species abundant in the Florida Keys featuring DOC uptake rates approximately an order of magnitude greater than rates of particulate uptake (mean difference of 17□M DOC vs. 1□M POC for *Xestospongia muta*), implicating DOM as their dominant C source. Only sponge species hosting High Microbial Abundances (HMA) were found to consume significant DOC. Sponge species hosting Low Microbial Abundances (LMA) did not significantly alter the DOC concentration of the ambient reef water. Nitrification in HMA sponges is rapid and coincident with respiration rates resulting in large NO_3^- fluxes to surrounding near bottom waters. Controlled incubation experiments reveal direct utilization of sponge derived NO_3^- by reef macroalgae, including unpalatable *Dictyota sp*. In addition, our experiments provided direct evidence for sponge utilization of algal derived DOM by an HMA sponge. This feedback loop, where sponges and algae each benefit from the other's waste products, promotes growth of both populations on the limiting resource of available space in reef ecosystems and thus has profound ecological implications. The ecological consequences of this loop are further exacerbated by impacts of boring sponges eroding reef structure, rapid respiration by sponges resulting in localized acidification and reduced calcification, and the resistance of *Dictyota* to herbivore pressure. Studies of Florida Keys reef environments should recognize and monitor these sponge-algal associations as a potentially resilient new ecosystem state.

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Long-term Monitoring of the Northern Region of the Florida Reef Tract: A Partnership between Academia and Resource Management

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Significant shallow-water coral reef community development exists along the eastern shelf of the United States from the Dry Tortugas northward through the Florida Keys (Monroe County) and Southeast (SE) Florida (Miami-Dade, Broward, Palm Beach, and Martin Counties). State and county resource managers have partnered with academia to monitor the health of the northern extension of the Florida Reef Tract. Since 2000, more than 20 fixed sites have been monitored annually offshore Broward County. Quantitative data includes stony coral species cover, colony size, density, and condition (bleaching, disease, etc.) and octocoral and sponge density. The SE Florida Coral Reef Evaluation and Monitoring Project (SECREMP) was established in 2003 as an expansion of the Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP). Seventeen SECREMP sites within the northern region of the Florida Reef Tract are monitored annually across the 4 SE Florida counties. The stony coral, octocoral, sponge, and other functional group cover data collected within the SECREMP sites and the Keys CREMP sites provides status and trend information for the entire Florida Reef Tract. The SE Florida region typically has 2-4% stony coral cover with more than 30 stony coral species and a diverse assemblage of octocoral, sponges, and fishes. In general, monitoring efforts show relatively stable levels in community metrics sampled. There are many stressors to the SE Florida regional ecosystem resulting from its proximity to the highly developed and urbanized SE Florida coast. These reefs are influenced by many factors including commercial and recreational fishing and diving, major shipping ports, wastewater outfalls, ship groundings, and coastal construction activities. SE Florida's coral reef ecosystems generate $3.5 billion in annual sales and income and support 36,000 jobs in the region. The uniqueness and value of these natural resources to the community demands sustained cooperative monitoring efforts and increased investigations into limiting environmental/ecological processes. In addition, these monitoring efforts provide resource information in support of a holistic resource management approach for the greater Florida Reef Tract. Linking research and science to support management of the Florida Reef Tract is a top priority identified in Florida's Coral Reef Management Priorities.

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Why Sanctuary Preservation Areas (SPAs) are Necessary for the Sustainable Management of Queen Conch in the Florida Keys

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In the Florida Keys, the queen conch (*Strombus gigas*) once constituted significant commercial and recreational fisheries – in 1965, landings of conch meat into Key West peaked at nearly 24,000 kg. Subsequently, the population declined until commercial harvest was prohibited in 1977; in 1986, based on continuing declines as perceived by the local citizens, the ban was extended to the recreational fishery.

In Florida, all spawning occurs offshore in close association to the reef within spatially discrete aggregations of up to 5 hectares. In many cases, the aggregations are juxtaposed closely to sanctuary preservation areas (SPAs). Since 1992, our research has examined the recovery of conch within offshore aggregations with a particular emphasis on reproductive output. We have demonstrated that an absolute minimum density of 185 adult conch/ha is required for reproduction to occur within these aggregations. Furthermore, the proportion of individuals reproducing within the aggregation increases with density and peaks at approximately 800 adult conch/ha. Based on these results, we subdivided the aggregations into those that are pre-recovery (i.e. < 185 adult conch/ha), those recovering (≥ 185 ≤ 800 adult conch/ha) and those that are recovered (> 800 adult conch/ha). Since our monitoring program began, the proportion of recovered aggregations has increased and the proportion of pre-recovery aggregations has declined.

Given that research now suggests that conch recruits to the Florida Keys likely originate to a great extent from local sources, local source populations must be conserved at densities that exceed the minimum reproductive threshold. Thus, spatially explicit protected areas are necessary to ensure that this density is exceeded in all future scenarios with a goal towards a reopened recreational fishery because any management practice that allows fishing will likely reduce densities below 185 adult conch/ha. Given the present size of the aggregations, even smaller SPAs are adequate to support and protect conch aggregations at sufficiently high densities to achieve reproduction. However, many of the aggregations fall at least partially outside the boundaries of the existing SPAs. Therefore, extending or relocating many SPA boundaries is essential to protect local source populations in any future scenario in which conch fishing is allowed. Based on the minimum reproductive threshold, any sustainable management strategy for conch in Florida and, indeed, the Caribbean region should consider marine reserves to ensure sufficiently high densities for reproduction.

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Effects of Grazer Presence on Larval Settlement by *Porites astreoides*

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Processes that directly or indirectly affect the number of larvae that settle have a fundamental impact on the population ecology of a species. Previous studies have found the presence of herbivores to be both beneficial and detrimental to coral health. In this study we examined how the presence of an herbivorous snail (*Astraea sp.*) affects settlement rates of *Porites astreoides*. Larvae collected from *P. astreoides* adult colonies were placed in settlement chambers with a preconditioned substrate containing either a live snail, tissue free snail shell particles, ground tissue smeared on the settlement substrate, or substrate surface only (control). The number of larvae to attach and metamorphose within each container was assessed after 72 hours and percent settlement compared among treatments and among substrate surfaces within each treatment. We found significantly less larval settlement in treatments containing ground snail tissue than in all other treatments. Settlement was significantly higher, however, in the presence of live snails compared to the control and tissue treatments. Within the control and live snail treatments, settlement was significantly higher on the conditioned substrate surface than on the plastic chamber walls. No differences were found, however between the conditioned substrate surface and snail shell surfaces in either the shell or live snail treatments. These data indicate that the presence of a grazer has a positive effect on larval settlement, while the presence of dead tissue has a negative effect. Increased settlement in the presence of the live snails is likely due to the grazing activity of the herbivore creating preferred substrate for settlement, as there was no effect of the shell alone. Reduced settlement in response to dead tissue, however, may be due to the presence of bacterial and chemical compounds associated with decomposition or to changes in water chemistry. Information on induction cues for larval settlement will aid in future coral reproductive studies, aquaculture and restoration.

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Emergency Coral Restoration in the Florida Keys National Marne Sanctuary

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One of the primary goals of the FKNMS Damage Assessment, Restoration and Resource Protection (DARRP) program is to assess injuries to coral reefs within the Sanctuary that have been impacted by vessel groundings, develop a restoration plan that addresses the scale and nature of the injuries sustained by the reef, and ultimately implement the plan as quickly and efficiently as possible to minimize the lost use of the resource to the public and to the coral reef ecosystem that was compromised. Timing is often critical in terms of restoration of organisms injured at a grounding site. In cases of a recent injury, coral reef triage (emergency restoration) can be an effective tool. In the case of groundings on coral reefs, triage can be righting and reattachment of displaced or broken corals, the removal and/or stabilization of loose rubble and sediment, and the stabilization of structural fractures. Triage in the form of uprighting and reattaching of corals to the substrate is most effective when performed shortly after an injury. There may, however, be instances where structural repair or replacement of reef framework must be implemented in order to provide a stable substrate for reattachment of dislodged coral colonies and fragments. In these cases, loose corals may need to be “warehoused” temporarily either somewhere nearby on a suitable, stable substrate, or kept within a coral nursery or holding facility set up for that purpose. The goal of triage is to effectively eliminate further damage and degradation to corals that were dislodged or and other intact corals in the surrounding and adjacent areas. In many cases it is the most immediate and cost effective way to begin the restoration process. Reestablished corals may also serve as a future source of recruitment in recolonizing the surrounding substrate. In other cases, the removal of toxic hull paint smears or the uprighting and reattachment of dislodged coral colonies was all that was necessary to return the injured reef to its pre-grounding condition. Sometimes, living corals and nonliving reef framework elements were broken, crushed or excavated, and the subsequent restoration involved reaggregating the pieces into a replacement structure that replicates the original in look and function.

FKNMS/DARRP personnel continue to routinely collect monitoring data at these and other reef restoration sites within the Sanctuary. It is the goal of the DARRP program to use these findings, coupled with the best science that the relatively new disciplines of reef restoration and coral husbandry have to offer, to develop and implement future reef restorations that replicate, as closely as possible, the ecological functionality, habitat quality, substrate stability and aesthetic appeal of the natural reef prior to the grounding incident.

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Acropora cervicornis Restoration: Coral Restoration Foundation's Seven-Year Summary for the Upper Keys

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In the Florida Keys, reef condition has severely degraded over the past 30 years. The structure building Acroporid corals were once common in U.S. waters, but their sheer decline over the last 30 years has caused them to be listed as "Threatened" on the US Endangered Species List. The Coral Restoration Foundation (CRF) has developed a successful offshore nursery and restoration program focusing on restoring these valuable corals to the reefs within the Florida Keys National Marine Sanctuary. Staghorn coral, *Acropora cervicornis*, is one of the fastest growing, reef building corals found in the Caribbean and is an ideal coral species to propagate and replant on reefs. Of the several thousand staghorn corals propagated and grown at CRF's offshore coral nursery, over 500 corals have been transplanted to 20 reef restoration sites in the Upper Keys since 2003. Three different staghorn coral genotypes were used in the restoration projects, and growth rates, resistance to disease, and temperature tolerance were monitored at each location for 12 months after the initial planting dates. High survival of transplanted corals and impressive growth rates at restoration sites are evidence that staghorn coral thickets can be successfully reestablished in areas where they previously existed.

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Comparative Growth and Survival of *Acropora cervicornis* on Concrete Disk Versus Line Nurseries

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The Coral Restoration Foundation (CRF) offshore nursery was established in 2001 adjacent to a live rock aquaculture farm owned and operated by Ken Nedimyer. The initial set of staghorn corals grown at the nursery were fragments obtained from corals that settled on the live rock farm in 1996 and 1997. Three distinct genotypes have been identified and tracked over the years, and the number of clones of those original corals now number over 4,000 at the nursery and another 500 planted elsewhere on reefs in the Upper Keys. CRF has been testing new and innovative ways to grow staghorn coral, *Acropora cervicornis*, more efficiently. Most corals are grown in our disk nursery, where coral fragments are epoxied to concrete disks and attached to an anchored concrete structure on the seafloor. However, we have been testing a structure similar to a clothesline vertically supported with buoys, called a line nursery, which suspends coral fragments mid-water allowing for 3D growth. We have designed an experiment to test seasonal growth and survival using the two nursery techniques. The experiment consists of cutting 20 staghorn corals fragments, then attaching 10 corals to concrete disks and hanging 10 corals on monofilament lines nurseries every week for 1 year. Coral growth and survival will be monitored weekly for one year after initial cutting. With these data we will determine an optimal growing season and propagation strategy to maximize survival and growth of coral fragments.

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Climatological Significance of Sea Temperature Extremes on the Florida Reef Tract in 2010

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South Florida experienced abnormally cold weather during the winter of 2010 that was followed by many reports of mass fish, sea turtle, manatee, and coral mortality. The last such event occurred during the winter of 1976-1977, when up to 96% of shallow-water corals died in the Dry Tortugas after exposure to sea water temperatures of 14°C. In the wake of the 2010 cold event, some reefs of the Florida Keys were then further subjected to anomalously warm sea temperatures during the month of June. In this study, we examine in situ and satellite-derived sea temperatures relative to global-scale climate indices, to establish the climatological significance of both the magnitude and duration of these cold- and warm-water events of 2010.

Expert system software generated automatic alerts of extreme cold water temperatures beginning in January at the C-MAN/SEAKEYS Long Key station in the shallow waters of Florida Bay. At this site, monthly mean sea temperatures from January to March (JFM) were statistically colder in 2010 than in any prior year of sampling (1993-2010) by 1-2°C, with January mean below the 3% percentile rank for all *hourly* winter data. Sea temperature offshore on the Florida Reef Tract (FRT) was less affected by the cold weather, with January's mean for 2010 at Molasses Reef no different than three prior Januaries (2001, 2003, and 2009) since 1988. Yet hourly extremes in January 2010 were 2°C lower than in any other year, and February and March were statistically colder than all prior years (with the sole exception of Feb 1996) by as much as 1°C. Farther north, at Fowey Rocks, JFM monthly mean and hourly sea temperatures were warmer than in several prior years since 1993. In June 2010 this pattern differed, with monthly mean and hourly extreme sea temperature at both Molasses and Fowey statistically higher than any prior year, while at Long Key mean sea temperature was high, but still cooler than for one prior year (1998).

These spatial patterns match the general observation that nearshore shallow waters respond more rapidly to atmospheric forcing, while reef-crest locations may be subject to cross-shore flow and horizontal convective exchange with deeper waters offshore. This also coincides with what was observed for coral communities during the cold event – those near shore (e.g., Hawk Channel patch reefs) suffering greatest mortality while those offshore were less affected. Although infrequent, the spatially varying impact of cold weather events likely helps to explain the limited and highly variable reef development of the FRT as suggested by several previous workers (e.g., Mayer, Shinn, Porter). In situ physical data are presented alongside high resolution (1x1 km) satellite Sea Surface Temperature (SST) maps for the FRT during January-March and June of 2010, to elucidate spatial patterns. The relationship of these regional sea temperature extremes to climate-scale variability, including the Arctic Oscillation (AO) atmospheric pressure anomaly, and El Niño-Southern Oscillation (NINO) equatorial Pacific SST anomalies, is also examined.

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Ocean Heat Budget for the Florida Reef Tract: Methods, Climatology, and the Thermal Siphon

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Thermal and photo-thermal stresses are major considerations in managing coral reef ecosystems in the Florida Keys. Physical insights into sea temperature variability offer a way to identify reefs or larger areas in the Keys that may be more prone to temperature extremes under varying light and weather conditions. SEAKEYS is a network of autonomous stations jointly maintained by Florida Institute of Oceanography and NOAA's National Data Buoy Center. For over two decades, these stations have measured hourly wind speed and direction, barometric pressure, air and sea temperature, and in some cases dew-point temperature, tide height, and incident light, both on the shallow reef crest and near-shore bay-side in the Florida Reef Tract (FRT).

These quality-controlled, in situ data have been combined with a high resolution atmospheric reanalysis (NOAA North American Regional Reanalysis, NARR), models, and satellite data to estimate surface radiative and turbulent heat fluxes and heat advection for the FRT. This *ocean heat budget* is used to evaluate the effectiveness of bulk formulae and reanalysis in explaining observed sea temperature variability at coral reef sites. Based on the heat budget, evidence is presented for another dynamic process, previously undocumented in the Keys, that accounts for more than 40% of sea temperature variability at intraday and longer periods. This process is horizontal convection – thermally induced exchange currents between the crest and the deeper waters of the reef slope, also known as the *thermal siphon* (Monismith et al., 2006). Total heat budget predictions are compared to observed sea temperature variability at four SEAKEYS sites.

A total ocean heat budget for these shallow sites is modeled as $T_t = -\mathbf{u}\cdot\nabla_h T + (Q_0/\rho C_p h) + Q_{HC}$. Here T_t is Eulerian time-rate of change in sea temperature; $\mathbf{u}$ the horizontal ocean current; $\nabla_h T$ horizontal sea temperature gradient; Q_0 net heat flux; Q_{HC} heating from horizontal convection; h varying water depth; and ρ and C_p density and heat capacity of sea water, resp. Net heat flux has five constituents: $Q_0=\gamma Q_{SW}+Q_{LW}+Q_{SH}+Q_{LH}+Q_{RH}$. Short- and longwave radiative fluxes, Q_{SW} and Q_{LW}, are derived from NARR, with comparisons to available in situ data; factor γ models radiation absorption by the water column and reef floor. Tropical Ocean Global Atmosphere – Coupled Ocean-Atmosphere Response Experiment (COARE 3.0a) algorithms are used to estimate sensible (Q_{SH}), latent (Q_{LH}), and rain (Q_{RH}) heat fluxes directly from in situ data, using NARR for insolation, long-wave flux, and precipitation. Heat advection is estimated using the operational Global HYCOM analysis and high-resolution (1km square) Sea Surface Temperature fields from University of South Florida (USF IMaRS). Finally, the thermal siphon term Q_{HC} is calculated assuming unsteady thermal and momentum balances, as a lagged function of air-sea heat flux, Q_0, and sea-floor topography from NOAA NGDC's 3-arcsecond Coastal Relief Model.

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Progress Implementing the Dry Tortugas Research Natural Area Science Plan: the 3-Year Report

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In 2007, the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) developed a science plan, *Assessing the conservation efficacy of the Dry Tortugas National Park Research Natural Area*, specifically to assess the effectiveness of a 46-square mile Research Natural Area (RNA). The RNA is a no-take, no-anchoring marine reserve that was implemented to protect shallow water habitats and reef fish species in conjunction with two nearby existing marine reserves, the Tortugas Ecological Reserves, North and South. We prepared a three-year interim report to summarize the progress of the science plan activities to date. Progress in implementing the science plan has been largely due to a number of cooperative relationships between Federal and State agencies, academic scientists, and coordination by the FWC and NPS. While the results presented are part of a 3-year commitment, most contributing scientists went through the process of preparing project proposals and competing for grant funding prior to being able to initiate work. Nevertheless, work has begun on all major topics described in the science plan and a total of 18 projects are underway. Each project works towards assessing the conservation efficacy of the RNA under one of the following 6 performance areas:

1. Quantify changes in the abundance and size-structure of exploited species within the RNA relative to adjacent areas.

2. Monitor the immigration and emigration of targeted species in the RNA.

3. Monitor changes in species composition and catch rates of exploited species throughout the surrounding region.

4. Evaluate the effects of RNA implementation on marine benthic biological communities.

5. Assess reproductive potential of exploited species by evaluating egg production and larval dispersal.

6. Incorporate social sciences into the research and monitoring program.

A summary of the progress implementing RNA science projects is presented and new stressors that may impact RNA performance, including the establishment of invasive marine fish, climate change, and ocean acidification are discussed.

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Underwater Wonders of the National Park Service – A New Dimension

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The National Park Service (NPS) has always strived to create a visitor experience that both educates and engages the public within our visitor centers. With advancements in technology surrounding multimedia and video presentations, how we communicate our message of resource stewardship, diversity and protection should evolve to stimulate a new generation of visitor – today's tech savvy youth. For the past two years, the National Park Service's (NPS) Submerged Resources Center (SRC) has had a formal partnership with the Advanced Imaging and Visualization Laboratory (AIVL) at Woods Hole Oceanographic Institution (WHOI) to create a new path in how our visitors experience the vast underwater resources within our National Parks. This technology has recently been used to capture underwater wonders, including the endangered elk horn corals of Virgin Islands National Park, the massive shipwrecks of Isle Royale National Park, the kelp forests of Channel Islands National Park, geothermal vents in Yellowstone National park, and submerged B29 Superfortress aircraft in Lake Mead National Recreation Area. The production team will bring these submerged resources to the public through the immersive experience of three-dimensional (3D) high definition (HD).

In July, 2010, a multi-day filming expedition was completed at Dry Tortugas National Park (DRTO). The expedition acquired hours of 3D HD video footage. After substantial editing, a brief summary highlighting the wonders of the underwater world at DRTO is presented. Results provide a new and innovative way to communicate the beauty and complexity of coral reef ecosystems and educate the public on the importance of marine stewardship.

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What Do Reef-Dwelling Foraminifera Reveal About Stressors of Coral Reefs?

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Reef-dwelling benthic Foraminifera (BF) include species that host algal symbionts; these BF are typically relatively large in size (>1 mm) and long-lived (several months) compared to smaller, shorter-lived, purely heterotrophic taxa. Thus the former are commonly referred to as “larger” (LBFs) and the latter as “smaller” (SBFs). Studies of BF assemblages in the 1970s to 1990s revealed that LBFs declined relative to SBFs in areas where water quality declined. Based on water clarity and sediment texture, one can predict where abundant populations of LBFs can be found. That and pre-1990s observations that the best developed coral reefs also tended to occur in clear oceanic waters, were the basis for the Foraminifera in Reef Assessment and Monitoring (FORAM) Index as a simple bioindicator of water quality suitability for coral-reef recovery.

In summer 1991, bleaching was found in Florida populations of the abundant LBF *Amphistegina* and subsequently was documented in *Amphistegina* populations worldwide. Monitoring through the 1990s showed that bleaching began each spring, peaked with the summer solstice and was declining by the late summer temperature maximum. Acute bleaching tended to be fatal, while chronic bleaching often resulted in microbial infestations or attack by parasites and predators. During the 1990s, when new coral disease outbreaks were reported with increasing frequency, *Amphistegina* populations also were afflicted by opportunistic infestations.

Over the past decade, populations of LBF have rebounded; Keys-wide surveys revealed highest abundances and diversities were still found in the clearest offshore waters, even though *Amphistegina* exhibited some chronic bleaching. In contrast, the Florida Keys Coral Reef Evaluation and Monitoring Project has found that coral cover declined most dramatically on the offshore reefs and more slowly on inshore patch reefs. Moreover, the overall rate of decline in coral cover peaked in 1997-98, with limited decline over the past decade until the cold events in winter 2009-10. Interestingly, *Amphistegina* tended to exhibit less bleaching on patch reefs and offshore reefs such as Tennessee Reef, where outflow from Florida Bay reduces water transparency, though population densities are generally lower than at clearer offshore sites.

The solution to these apparent paradoxes provides hope for the future of Florida reefs. Bleaching in *Amphistegina* is induced by sunlight rather than elevated temperatures. These LBFs began bleaching soon after the Mt. Pinatubo eruption accelerated stratospheric ozone depletion. The consequent higher UV-B accelerated breakdown of photoprotective colored dissolved organic matter (CDOM), increasing transparency of seawater to high energy wavelengths (UV and blue) of sunlight. Ozone depletion peaked in the late 1990s and recovery has begun. While rising sea surface temperatures will continue to induce photo-oxidative bleaching stress, ozone recovery plus adaptation by corals and zooxanthellae may promote recovery of coral populations. Preservation of CDOM-producing mangroves shorelines should augment such recovery.

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Developing a Non-Invasive Technique to Measure Coral Health

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An important aspect of reef management is continued monitoring of coral status to ensure that conservation/restoration efforts are successful. Coral pigments have been identified as the best indicator of coral status (i.e., health and/or stress). Currently, coral status is assessed in a variety of ways; however, most of these are either visual, thus subjective, or highly invasive. There is a need for a technique to quantify coral status rapidly and non-invasively. The use of bio-optical modeling of coral pigments offers a potential solution. Terrestrial pigment literature is replete with indices and pigment ratios to assess plant status. A variety of indices and pigment ratios found in the terrestrial literature can be applied to coral spectra to determine the relationship between coral pigment concentrations and spectral signatures. Because the fundamental concept is the same (i.e., link optical spectra to plant pigment content) these indices can be applied to optimize bio-optical modeling for corals. Here, a variety of these, as well as novel, indices are investigated to determine the relationship between coral pigment concentrations and spectral reflectance signatures. Results are encouraging for development of a method for routine optical in-situ measurement of coral status.

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Anthropogenic Changes in Dove Lake (Tidal Lake) in the Upper Florida Keys over the Last 100 Years

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The sediment record in Dove Lake is used to document ecological shifts in response to anthropogenic modifications occurring over the last 100 years. A sub-aqueous sediment cores was collected from Dove Lake, a marine tidal lake, located in Tavernier, Florida. Dates and accumulation rates for the sediment cores were established through ^{210}Pb dating. Lead-210 is an ideal tracer for determining dates and accumulation rates on a 100 year time scale, which is the most relevant time scale for examining consequences of recent change. It is during this time that major anthropogenic modifications have taken place within the Upper Florida Keys and surrounding areas. Tidal lake deposits are a good archive for correlating historical changes in productivity associated with these anthropogenic modifications. Total nitrogen, organic carbon, δ^{15}N, δ^{13}C and sedimentary photosynthetic pigments (chlorophylls and carotenoids) are proxies used to better interpret past ecological conditions within this system. Historical information associated with anthropogenic changes within the geographical location coupled with an examination of ecological proxies within the sediment record can be used to determine the influence of those anthropogenic changes on water quality.

The ^{210}Pb dating model indicates mass sedimentation rates were less than 7 mg cm^{-2} yr^{-1} from approximately1875 through the early 1950s with a noticeable increase beginning after the early 1950s. The mass sediment accumulation rate increased to greater than 20 mg cm^{-2} yr^{-1} by approximately1980. The sediment accumulation rates continued to increase until the 1990s when values reach a plateau of approximately 30 mg cm^{-2} yr^{-1}.

Percentage of organic matter increases along with sediment accumulation suggesting the acceleration in sediment accumulation is the result of enhanced productivity possible due to increased nutrient loading. Anthropogenic influences on the Dove Lake system have increased both the mass accumulation rate as well as the fraction of organic matter.

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Use of Protected Areas by Threatened and Endangered Marine Turtles Tagged in the Dry Tortugas

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Establishment of marine protected areas (MPAs) is one tool for protecting both natural and cultural resources from significant pressure by human activity. In the Dry Tortugas National Park (DRTO) located 112 km west of Key West in the Florida Keys, a Research Natural Area (RNA) was designated in January 2007 to set aside ~74 km^2 of the Park as a no-take preserve to restore ecological integrity by minimizing human influences. The DRTO harbors several key benthic habitats that are important for federally protected marine turtles, including threatened loggerheads (*Caretta caretta*), endangered hawksbills (*Eretmochelys imbricata*), and endangered green turtles (*Chelonia mydas*). In addition, the sandy beaches of DRTO provide suitable nesting habitat for all three species.

To address whether and to what extent the no-take area of the RNA is used by marine turtles, we initiated a study in 2008 to 1) characterize the size classes of each species present in the Park, and 2) quantify the amount of time tagged individuals of all three species spend within various zones of DRTO, and 3) determine regional linkages to other foraging sites and nesting beaches. Methods of turtle capture include intercepting reproductive females on one of two major nesting beaches and capturing additional turtles of various sizes and both genders using in-water capture techniques (i.e., rodeo, dip nets). Tracking methods include satellite and acoustic telemetry to determine movements of individuals over time and space.

To date, satellite-tracking of reproductive loggerhead females revealed that the inter-nesting habitat used by loggerheads in both 2008 and 2009 was outside the RNA, but still within the Park boundary. Additionally, these female loggerheads departed DRTO after approximately 2.5 to 3 months of residence and migrated to locations off the southwest coast of mainland Florida and the Bahamas. Satellite-tracking of hawksbills since August 2008 revealed that all three turtles were resident in the Park until May 2009 and June 2010, when two turtles departed DRTO waters and migrated to Cuba; the other hawksbill is still transmitting from within DRTO, where it appears to be resident. Finally, satellite-tracking of subadult and adult green turtles captured in the water in June 2009 revealed that all six individuals are resident within the Park thus far, in an area of lush, relatively shallow-water seagrass that is outside the RNA. Additionally, none of the mature females appeared to nest within the Park in 2009.

These data represent the first satellite-tracking data for turtles at DRTO, and results show a new understanding of regional connectivity of marine turtles and their habitats. Such data will contribute to determining the effectiveness of the RNA for protecting threatened and endangered marine turtles and their requisite habitats, and the development of more effective decision-support tools to adaptively manage coral ecosystems and MPAs in South Florida.

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Condition of Coral Reef Fish Larvae along the Florida Keys Shelf: Implications for Connectivity

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In coastal marine organisms with protracted pelagic larval durations, there is potential for long distance dispersal and extensive population connectivity. Yet, recent research indicates that local retention of larval coral reef fish may be more important in replenishing populations than influx of larvae from distant sources. The degree of connectivity among populations is governed not only by whether larvae are physically transported from one reef to another, but also by whether larvae reach a settlement site in adequate nutritional condition to recruit and contribute to a population. As a part of a multifaceted study investigating the relative importance of local retention and long-distance dispersal in maintaining reef fish populations, we are analyzing the condition of reef fish larvae collected during two cruises in the summer of 2007. On each cruise, ichthyoplankton and environmental measurements (MOCNESS and CTD) were collected at 90 stations on cross-shelf transects along the Florida Keys (FK) reef tract, and in the Loop Current upstream of the FK. MOCNESS tows at each station yielded larvae from a broad range of coral reef fish taxa. For a subset of larvae (including bluehead wrasse, great barracuda, reef bass, wenchman, and vermillion snapper), RNA/DNA ratios were used to evaluate condition of individual larvae collected across different water masses. While results varied among species, data indicate that, for some taxa (bluehead wrasse, razorfish), larvae collected closer to shore exhibit significantly higher RNA/DNA ratios compared to larvae collected offshore. These findings suggest that larvae that are retained nearshore may have a greater chance of survival than larvae transported from offshore waters.

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Coral Sclerochronology in the Florida Keys: Historical Variability, Climate Change, and Ocean Acidification

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Climate change and ocean acidification have the potential to influence and inhibit coral growth rates through increasing sea surface temperature (SST) and decreasing carbonate ion (CO_3^{2-}) concentrations of surrounding seawater (*i.e.*, aragonite saturation state, Ω_{arag}). Cyclic variations in the porosity of accreted coral skeleton produce annual density bands when X-radiographed, similar to annual growth rings in trees. Coral density banding provides an annual record of linear extension, bulk density, and calcification over the lifespan of reef-building corals which can be several centuries. Identifying historical baseline growth rates and natural variability provides an important context for interpreting changes in coral growth over recent decades.

More than 250 coral cores have been collected from the Florida Keys (144 cores, Hudson 1981; 108 cores, Swart et al. 1999) with an additional 100+ coral samples collected from Biscayne National Park (38 cores, Hudson et al. 1994) and Broward County, Florida (76 samples, Dodge 1987). Common trends are present in the extension rate data from these studies which include a reduction in extension rates from 1960 to 1970 and a general recovery from 1970 to the date of collection. It is important to note that the coral cores in these studies were most recently collected in 1997.

Linear extension, bulk density, and calcification data from seven cores from the upper Florida Keys with a 60-yr common period of 1937 to 1996 were compared against environmental and climatic records consisting of SST, rainfall, modeled Ω_{arag}, Atlantic Multidecadal Oscillation (AMO) and North Atlantic Oscillation (NAO) indices. Annual calcification rates were weakly related with SST while the highest correlations were between coral growth parameters and the AMO. Linear trends over the 60-yr period from 1937 to 1996 indicate that extension increased, density decreased, and calcification remained stable; further, the most recent decade was not significantly different than decadal averages over the preceding 50 years for extension and calcification. The results suggest that coral growth rates in these nearshore upper Keys corals have been tolerant to climatic changes up to the time of collection. However, the measured change as of 1996 does not preclude declines in growth rates over the subsequent decade which needs to be assessed.

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Phosphorus Discharge and Ecosystem Integrity: How Much is Safe?

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Phosphorus (P) introduction to the coastal waters of South Florida becomes cumulative in the benthos and may have with long-term or permanent effects. This should bring into question the water quality standards for P discharges to coastal waters that have been designed to protect native flora and fauna and maintain ecosystem integrity. Natural sources for P delivery to the coastal waters of South Florida, including ground water, oceanic mixing, and bird colonies, have historically defined the spatial structure and function of its benthic communities. Using Florida Bay as an example we have demonstrated that biomass, productivity, and ratio of aboveground to belowground biomass of *Thalassia testudinum* populations are positively correlated with P availability, and that population structure becomes simplified with elevated P.

Here we present the results of experimental nutrient manipulations with nitrogen (N) and P in field sites selected to represent a range in native P availability. In one experiment we show the long-term storage and effects of P in an oligotrophic ecosystem that was fertilized for three years and then left unfertilized for 23 years. More than two decades after fertilization the impacts to the benthos included altered species composition and greatly elevated sediment P concentrations, biomass, and productivity. In a second experiment regionally differential responses to P additions in the benthos were demonstrated. In that experiment there were large increases in seagrass biomass and benthic metabolism in response to P in oligotrophic regions of Florida Bay. Changes in species composition were observed throughout the bay but the rate of change varied regionally, perhaps a result of the availability of propagules in addition to the change in nutrient availability. These results suggest that any amount of P introduction to the coastal waters of South Florida can contribute to long-term accumulations and induce structure and function altering changes in the benthos.

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Clionaids Provide Key Insights into Ecological and Evolutionary Forces Shaping Zooxanthella-symbioses in Invertebrates

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We are interested in better understanding host: symbiont relationships in marine sponges that associate with zooxanthella dinoflagellates. While recent work has helped clarify the nature of the association, we still know little of integration between host and symbiont, the ecological consequences of that integration, nor the stability of these associations under environmentally stressful conditions. We have been studying the relationship between *Cliona varians* and its Clade G zooxanthellae. Here we present data on photophysiological aspects of the association, physiological integration of the partners, and genetic regulatory pathways utilized during acquisition and maintenance of symbionts. We contextualize these findings in light of current increases in sea surface temperature, and highlight how sponges provide essential and novel ways to think about zooxanthella symbioses. Our surveys of the diversity of zooxanthellae harbored by sponges, as well as the surveys of other sponge biologists, indicate that sponges form symbioses with a broad diversity of zooxanthellae. We will present detailed data on the diurnal changes in photophysiological performance of the zooxanthellae found in *C. varians*, and the consequences of the photophysiology for host performance. We will also discuss data on the integration of the host and symbiont in terms of materials transmitted between partners, and the evolutionary consequences of these physiological linkages. Finally, we will present data on the genetic regulatory pathways that are likely involved in the sponge: zooxanthella symbiosis. Given that zooxanthellae perform vital physiological functions for several sponge species, there is growing need to understand these symbioses given projected increases in sea surface temperatures.

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Seawater CO_2 Variability of the Florida Reef Tract: An Acidification Refugia Hypothesis

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The world's oceans have acted as a sink for approximately one third of the carbon dioxide (CO_2) discharged into the atmosphere since the industrial revolution. The resultant increase of dissolved CO_2 in seawater has led to a decrease in ocean pH. This process, termed ocean acidification, has been shown in laboratory studies to depress the rate of calcification for nearly every organism that builds a calcareous shell or skeleton, including reef-building corals. Despite these concerns, there have been a limited number of studies on the seawater CO_2 system of reef waters at the spatial and temporal scales necessary to resolve and understand the sources of ambient variability.

It has been estimated that during preindustrial times, average surface seawater conditions in the tropics were characterized by a mean partial pressure of CO_2 (pCO_2) equal to 280 µatm and aragonite saturation state (Ω_{arag}) of 4.6 ± 0.2 (1 Std. dev.). The present day tropical surface ocean has an average pCO_2 of approximately 387 µatm and $\Omega_{arag} \leq 3.8$. This study sampled waters along inshore to offshore transects in the upper, middle, and lower Florida Keys. Preliminary data have shown that offshore reef sites in the upper Keys are essentially experiencing "average tropical surface seawater conditions" as mean pCO_2 is 368 ± 15.0 µatm and Ω_{arag} is 3.8 ± 0.10. However, conditions on inshore patch reefs were significantly different and more favorable for coral calcification as they had an average pCO_2 of 236 ± 5.1 µatm and Ω_{arag} of 4.6 ± 0.05. We hypothesize that photosynthesis by seagrass and algal communities are taking up CO_2 and may potentially create localized acidification refugia. These gradients will be important in the future trajectory of these different reef habitats as climate change progresses and could already be playing a role in the differing levels of recent decline observed for inshore versus offshore coral communities of the Florida Reef Tract.

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A Multinomial Delta-Lognormal Approach to Multi-Species Abundance Index Development

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Current fisheries stock assessments require inputs of abundance indices to provide inference on changes in catch rates and, presumably, population trends over time. Primarily, stock assessments are conducted on single species; however, NOAA Fisheries emphasizes the need for ecosystem-level assessment and management. In recent years, the delta-lognormal method of modeling indices of abundance has become a standard approach in data preparation for use in stock assessment models, but this approach can only be applied to single species. The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data. The multinomial delta-lognormal method generalizes the binomial submodel of the delta-lognormal method to a multinomial submodel, which allows the occurrence of multiple species and species groups to be simultaneously modeled. The total nonzero catch of all species and species groups combined is then modeled using the lognormal submodel. The combination of these submodels result in indices of abundance simultaneously produced for the multiple species and species groups in relation to one another. This new approach will be illustrated using both fishery-independent and dependent data from the Florida Keys and Dry Tortugas (i.e. fish abundance data from the Dry Tortugas collected during SEAMAP Reef Fish Video Surveys, conducted by NOAA Fisheries; and catch data based on self-reported commercial fishing logbook reports, respectively). Using both of these data sets, the catches or observations of multiple species of snappers and groupers will be modeled and discussed.

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The Future of the Florida Keys

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There is clear scientific consensus that the coral reefs and associated shallow water ecosystems of the Florida Keys are on the verge of ecological collapse, although there is still debate about the relative importance of the different drivers of decline. But regardless of the comparative roles of overfishing, pollution, and climate change, and their myriad cascading consequences, there is no rational basis for doubt that people are the problem. In the words of the immortal Pogo, “We have met the enemy and he is us.”

In spite of the overwhelming scientific evidence of ecocatastrophe, and the courageous efforts of managers and conservationists, management has failed to stem the tide of decline. A paltry 6 percent of the Florida Keys Marine Sanctuary is off limits to fishers, vast amounts of sewage still make their way into coastal waters, and coastal development and virtual traffic jams of watercraft continue virtually unchecked. Comparison with the remarkable achievements of Australia to protect the Great Barrier Reef is painfully embarrassing. Very simply, the crisis in the Florida Keys is a crisis in failed governance at the local, State and Federal levels.

But the tables are about to turn dramatically because of sea-level rise, in ways that portend vast suffering for displaced humanity but augur extremely well for the future of the marine life of the Keys. Sea-level rise is among the most serious potential impacts of climate change for human wellbeing, but there is still remarkable public complacency about changes that are perceived as miniscule and far off in the future. The public is not entirely at fault because of the highly conservative predictions of the Intergovernmental Panel on Climate Change. But there is now increasingly convincing evidence of a tight empirical relationship between global temperature and sea level that projects a rise in sea level of at least 1 and very possibly 2 meters above 1990 levels by 2100. Even 1-meter rise will submerge the entire Florida Keys. Far from being radical fear mongers, as portrayed by climate change skeptics, the IPCC has been too cautious.

The human costs of even 1 meter of sea-level rise are inconceivably great, and we urgently need to talk openly about the consequences and to plan for strategic retreat the way the Dutch are already preparing in the Netherlands. But regardless of whether Floridians choose to act in their own rational self interest, or not, the future looks increasingly bright for the marine life that will be left behind in what was once the Florida Keys.

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Oil Spill Response Activities Conducted by NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) during Summer 2010

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The British Petroleum Deepwater Horizon oil spill presented a great risk to the sensitive ecosystems surrounding the Gulf of Mexico, including the coral reefs, beaches, wetlands and mangrove shorelines of south Florida and the Florida Keys. The response from the oceanographic community, including universities, local, state and federal government, commercial entities, and non-governmental organizations, was rapid and comprehensive.

AOML's response to the oil spill included consulting with NOAA's Office of Response and Restoration (ORR) and hosting a two-day workshop bringing together experts from the regional oceanographic community. AOML and the University of Miami (UM) are collaborating on ocean-modeling research to improve the model products used to forecast oil spill dispersion. They are also using NOAA P3 hurricane research aircraft to obtain weekly synoptic three-dimensional temperature, salinity and current fields for a portion of the Gulf of Mexico near the Loop Current and the Deepwater Horizon well site, to improve and evaluate the ocean model forecasts for the oil spill. AOML is also monitoring for crude oil in the Florida Keys through the real-time ICON/SEAKEYS network, and providing observations of tar and oil accumulation on beaches in the northern Gulf coast.

Oceanographic research cruises to the near- and far-field of the oil spill were conducted by AOML personnel with partners at NOAA's Southeast Fisheries Science Center and UM to observe surface and subsurface oil, evaluate the abundance and condition of ichthyoplankton, and to map the Loop Current, "Eddy Franklin", and other mesoscale features of the circulation to assess connectivity between these features and the oil spill site. Satellite-tracked surface drifters were deployed, and their trajectories used to delineate the complicated and evolving circulation patterns over time. At-sea observers engaged in efforts to assess the condition of pelagic birds, sea turtles, and marine mammals. Water samples were collected to determine the source of any weathered oil encountered, and net tows (for fish larvae, Sargassum, and tar balls), deep fluorometer profiles, and Winkler titrations for dissolved oxygen were used to provide ecological information about the impact and extent of the oil.

AOML has developed an oil spill response web site (http://www.aoml.noaa.gov/phod/dhos) to integrate the above and to display daily real-time data products for the Gulf such as satellite imagery, surface currents derived from altimetry, research cruise data, drifter trajectories, and numerical model results, and is moving toward the development of an interdisciplinary coastal ocean observing system.

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Sea Surface Temperature, Salinity and Chlorophyll Variability in the Florida Keys and Surrounding Coastal Waters, 1997 - 2010: Means, Seasonal Patterns, Interannual Variability and Extreme Events

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The surface properties of the Florida Keys coastal waters vary on a wide range of spatial and temporal scales in response to changing meteorological and oceanographic forcing as well as anthropogenic influences. The geographic proximity of the southwest Florida shelf, Florida Bay, Biscayne Bay, the southern estuaries, the Loop Current and the Florida Current all add to the observed variability in the Keys. Herein, data from nearly 15 years of interdisciplinary oceanographic cruises covering the coastal waters from Miami to the Dry Tortugas and northward to Charlotte Harbor are used to examine and quantify the mean and varying sea surface temperature (SST), sea surface salinity (SSS), and sea surface chlorophyll (CHL) in the Keys and adjacent coastal marine and estuarine regions.

In situ cruise data originally collected along a series of standard transects and the transits between them were objectively spatially interpolated onto a .02 by .02 degree latitude/longitude grid, which was then used to analyze the overall mean distributions of the water properties and their characteristic seasonal and interannual patterns of variability. Extreme events in the parameter records are identified and put into a larger temporal and spatial context using the gridded data time series within various sub-regions, and compared with regional SST and ocean color satellite imagery.

Processes and events most relevant to the resource management of the Florida Keys National Marine Sanctuary (FKNMS) such as extreme high and low SST events over the coral reef, unusual freshwater river or canal outflows into surrounding waters, sudden or prolonged algal blooms, episodic low salinity or high salinity intrusions from Florida Bay through the Keys passages, and the sporadic arrival of anomalous water from remote sources such as the Mississippi River, will be highlighted. Possible future effects from the Comprehensive Everglades Restoration Program (CERP) will also be discussed in the context of the observed SST, SSS, and CHL variability.

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Methods and Benefits of Incorporating Human Dimensions into Integrated Conceptual Ecosystem Models

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This presentation will describe how human dimensions are incorporated into an Integrated Conceptual Ecosystem model (ICEM) of the Florida Keys – Dry Tortugas marine ecosystem (FK-DT) which is currently being developed by a team of physical and social scientists under the MARES program. MARES is a three year collaborative effort with contributions from academic, federal, state, local, public, and private organizations. The project is led by the Cooperative Institute for Marine and Atmospheric Science at the University of Miami and is funded by NOAA.

ICEMs organize existing scientific information on the regional ecosystem in a manner that assists coastal managers in identifying ecosystem policy and management needs. ICEMs are consistent with ecosystem based management which is adaptive, geographically specific, takes into account ecosystem knowledge and uncertainties, considers multiple external influences and strives to balance diverse societal objectives. The MARES project adopted a Driver-Pressure-State-Ecosystem Services-Response (DPSER) framework for developing ICEMs. The DPSER framework explicitly represents the interdependence between human dimensions and environmental attributes through feedback loops in the model structure. A human dimensions component of these models links human needs, values, and responses associated with the ecosystem. The trends in human dimensions indicators help to identify ecosystem aspects in need of attention.

The presentation will demonstrate how human dimensions are incorporated into the FK-DT ICEM's five sub-models: (1) water quality; (2) fish & shellfish; (3) seagrass; (4) mangroves; and (5) coral & hard bottom communities. Topics to be covered include: identifying Ecosystem Attributes and how they relate to Ecosystem Services that people care about; how to measure the value of these services to people; and how to choose human dimensions indicators. The presentation will provide examples of relevant values that have been estimated in the past and how they benefit policy and management decisions.

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Habitat Preferences of Redband Parrotfish (*Sparisoma viride*) and Stoplight Parrotfish,(*Sparisoma aurofrenatum*) as Determined by Fishery-Independent Visual Census Surveys in the Florida Keys

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We used underwater reef visual census methods to quantify the distribution, abundance, and size of two parrotfishes: the redband (*S. aurofrenatum*); and the stoplight (*S. viride*) across the Florida Keys reef system. Spatial patterns in fish distribution were examined using a reef habitat classification scheme. This classification scheme accounts for features that correlate with reef fish distributions, including topographic complexity (low-relief, mid-relief, high-relief), and the proportion of sand interspersed among hard-bottom structure (e.g., isolated reef, spur and groove, continuous patch reef). Of these seven reef types, we classified “reef” as being any habitat that contained calcareous structure including: spur and groove; continuous patch reef, isolated reef, artificial reef (man-made) and reef rubble (dead reef interspersed with living reef organisms). Sand and seagrass/sand matrix were considered “non-reef”.

During 2008 and 2009, a partnership between four institutions completed 3,584 surveys throughout the Florida Keys reef tract. During this time, we observed 19,664 redband and 5,315 stoplight parrotfish. Redband parrotfish were more often found on reef than non-reef structures [2,703 of 3,258 (83%) reef sites and 190 of 326 (58%) non-reef sites]. Likewise, stoplight parrotfish were more often associated with reef than non-reef habitat [1,718 of 3,258 (53%) reef sites and 56 of 326 (17%) non-reef sites]. In light of these differences in parrotfish presence/absence among reef versus non-reef habitats, we will further investigate whether a difference exists between parrotfish presence/absence among all seven reef types. Finally, we will analyze which type of reef is preferred habitat for both the redband and stoplight parrotfish and if ontogenetic factors contribute to this preference. The usage patterns described for these species provide useful information for the conservation and management of parrotfish resources.

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An Assessment of Five Years of Large Scale Coral Bleaching Monitoring across the South Florida Reef Tract

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The Florida Reef Resilience Program (FRRP) is a collaborative effort among managers, scientists, conservation organizations and reef users to develop resilience based management strategies for coping with climate change and other stresses on Florida's coral reefs. Since 2005, The Nature Conservancy has coordinated a Disturbance Response Monitoring (DRM) effort, consisting of a probabilistic sampling design and a stony coral condition monitoring protocol, implemented during peak thermal stress across the entire South Florida reef tract that extends from Martin County to the Dry Tortugas.

Each year, 13 teams from federal, state, and local government agencies, non-profit organizations, and universities completed surveys across the entire South Florida reef tract within a six to eight week period. Two independent 1x10m belt transects were randomly placed within a 200x200m sampling site. Sites were stratified randomly, allowing information gathered on the coral population's size frequency, size structure, and bleaching prevalence to be extrapolated for different sub-regions and zones. Within each transect, four main parameters were recorded for each stony coral >4cm: 1) live coral cover, 2) hard coral density, 3) hard coral size, 4) hard coral condition.

From 2005 to 2009, 977 surveys were completed. Results from these five years of surveys show spatial and temporal patterns in coral bleaching and colony size frequency distribution, indicating that some reef areas or coral species may be more resilient to stress than others. Minor to moderate bleaching occurred within varying reef areas in 2005, 2007, 2008 and 2009. While the causes of this variability remain poorly quantified, projected increases in coral bleaching due to climate change makes identification of these resilient reef areas and species important for long-term coral reef conservation and future management strategies.

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Coral Reef Fishes within the Dry Tortugas National Park: Effects of Three Years of Protection by the Research Natural Area

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Management of living and cultural resources within Dry Tortugas National Park (DTNP) relies extensively on the use of area closures in which fishing and other potentially-destructive activities have been restricted or eliminated. In 2007, the Research Natural Area (RNA) was established that, combined with two ecological reserves established in 2001, brings the total protected area with DTNP to over 67,000 ha. As part of a cooperative effort to evaluate the efficacy of the RNA in protecting coral reef fishes, we initiated a fisheries-independent survey of reef fishes using baited chevron traps and hook-and-line sampling to characterize reef fish populations within the RNA as well as proximate open-use areas. Beginning in 2008, seasonal (spring and fall) stratified-random surveys were conducted within the southern portion of DTNP (south of 24º 40' N) in which sampling effort was randomly-allocated among three generalized reef habitat types (isolated reef, continuous reef – spur and groove, and continuous reef – non-spur and groove) common to both the RNA and adjacent open-use areas. Data from five seasonal surveys (spring 2008 – spring 2010) were examined to compare the abundance, frequency of occurrence, size structure, and overall community structure of exploited reef fishes between the RNA and open-use areas. To date, trapping surveys have been conducted at approximately 300 stations and hook-and-line surveys have been conducted at approximately 150 stations, with effort evenly distributed between RNA and proximate open-use areas. Within these surveys, approximately 10,000 individuals have been collected. Among exploited reef species, the most frequently collected taxa in the trapping surveys were yellowtail snapper, lane snapper, red grouper, and gray snapper while the most frequently collected taxa in hook-and-line surveys were yellowtail snapper, red grouper, mutton snapper, gray snapper and black grouper. Results from preliminary statistical analyses indicate that, although habitat-specific differences are evident for various population- and community-level metrics, there does not appear to be substantial differences in reef fish populations between the RNA and open-use areas following RNA establishment. Both the RNA and open-use areas support reef fish populations that include a substantial proportion of legal-sized individuals. Given the relative longevity of many reef fishes these results are not entirely unexpected since benefits from the establishment of marine protected areas often take many years to be reflected in population-level metrics.

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A Bay Anchovy Induced Trophic Cascade in Florida Bay

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A shift in small adult fishes from benthic species (*Lucania parva, Eucinostomus spp., Lagodon rhomboids*) to pelagic species (*Anchoa mitchilli*) was observed in the mid-1990s in Florida Bay. This shift lead to a hypothesis that the base of the Bay's food web had also shifted from benthic to pelagic dominance (Thayer et al. 1999). The shift in primary production was not apparent in subsequent analyses (c.f. Chasar et al. 1999). However, *A. mitchilli* accounts for 97% of the planktivorous fish community in Florida Bay. Thus, this period of heightened *A. mitchilli* abundance likely caused a significant increase in predation upon mesozooplankton. The evidence for this trophic cascade will be presented using both observational data and model results.

The interaction between *Anchoa mitchilli* and mesozooplankton is closely correlated to salinity in sub-tropical bays and variability in this relationship can propagate throughout the trophic-network. This key interaction was investigated in Florida Bay, USA with a mechanistic model. From 1994 through May 1997, salinities were lower, modeled *A. mitchilli* populations were significantly larger, and modeled mesozooplankton populations were significantly smaller than after May 1997 accurately reflecting observed population patterns. During this early period, the model suggests predation was the dominant control on mesozooplankton. After May 1997, salinities were higher, *A. mitchilli* abundance decreased, mesozooplankton abundance increased, and the model suggested resources limited mesozooplankton. The model also displayed the presence of a trophic cascade initiated by high *A. mitchilli* abundance during the early part of the simulation. This is supported by observations of higher phytoplankton biomass during this period that may in part be due to decreased grazing by mesozooplankton. However, omnivory by mesozooplankton alters the microzooplankton population and thus microzooplankton grazing on phytoplankton. This confounds the trophic cascade's affect on phytoplankton abundance. Changing salinity patterns associated with climactic cycles or anthropogenic activities could have significant impacts on the abundance of A. *mitchilli*, which through a trophic cascade could influence the abundance of mesozooplankton and phytoplankton.

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Florida Keys Water Quality Integrated Conceptual Ecosystem Sub-Model (ICEM) with Potential Indicators

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An Integrated Conceptual Ecosystem sub-Model (ICEM) was developed to depict our existing scientific knowledge of water quality in the Florida Keys as part of the Marine and Estuarine goal setting in South Florida (MARES) project. MARES is a three-year collaborative effort with contributions from academic, federal, state, local, public, and private organizations. The project goal is to reach a science-based consensus about the defining characteristics and fundamental regulating processes of a South Florida coastal marine ecosystem that is both sustainable and capable of providing the diverse ecosystem services upon which our society depends. MARES ICEMs utilize the DPSER (Driver, Pressure, State, Ecosystem Service, Response) framework. This framework presents complex scientific knowledge in a manner that is easily utilized by resource managers for implementation of ecosystem-based management. Moreover, it can identify both key gaps in our scientific knowledge and indicators of water quality status in the Florida Keys.

The water quality sub-model encompasses the physical, chemical and biological characteristics of the water column, including benthic sediment, phytoplankton and zooplankton suspended in the water column. The Florida Key's unique geophysical setting produces dynamic oceanographic conditions, including intricate re-circulating gyres and among the quickest surface currents in the world. Depending on the prevailing oceanographic conditions and location, water quality in the Florida Keys can be dominated by near-field (e.g. Mississippi River and southwest Florida shelf runoff) or far-field processes (e.g. sediment and nutrient loading from the Florida Keys). Regardless of the source, Florida Keys water quality must remain oligotrophic to support the highly valuable and characteristic benthic habitats, such seagrass, sponges and coral reefs.

The water quality ICEM begins with the ecosystem attributes that people care about. These attributes feed into another sub-model of the MARES ICEM that derives ecosystem services and valuation. The attributes that people care about derive from the water quality attributes that scientist measure. These water quality attributes describe the state of water quality; thus, the indicators of water quality are located within this compartment. The water quality ICEM will be presented along with potential indicators and a discussion of relevant gaps in scientific knowledge.

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Using Microarrays to Compare Bacterial Community Changes between Healthy and Diseased Corals

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Coral disease is one of the major causes of reef degradation and is therefore of concern to management and conservation efforts. Mitigation of impacts from coral diseases and syndromes requires better diagnostic techniques to detect the onset of, and correctly identify, disease. Distinguishing diseases based on macroscopic lesions can be difficult and may not be diagnostic. While a few primary causative pathogens have been identified, there is some question as to whether most coral disease is caused by a single pathogen or multiple opportunistic pathogens. This makes it imperative to be able to examine and understand the community-wide microbial changes that occur as a coral shifts from a healthy to a diseased state. The PhyloChip G3 is a new tool that allows an unprecedented overview of coral-associated microbial communities. This microarray is a small chip on which 1.1 million DNA probes have been printed, representing nearly 60,000 operational taxonomic units (OTUs) ranging from family to species.

Samples of *Montastraea annularis* that were visibly healthy or appeared to have white plague were collected from the Dry Tortugas National Park and Virgin Islands National Park in July and August 2009. Microbial-community DNA was extracted from these samples, amplified using bacterial-specific primers, and applied to PhyloChips. Preliminary results indicate a clear distinction between the healthy and diseased communities. The samples do not cluster based on collection location, indicating the absence of region-specific pathogens. There is evidence for the association of *Aurantimonas coralicida* with three of the nine diseased samples. These data are still being analyzed and are expected to reveal previously unknown patterns underlying the diseased state of coral communities.

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Catastrophic Mortality on Inshore Reefs of the Florida Keys: Cold Water Physiology of Three Common Reef-Building Corals

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Much attention has been given to the connection between increased seawater temperature and mass coral bleaching events, but low temperature effects on coral reefs have received less consideration. Coral reefs of the Florida Keys typically experience seasonal high and low seawater temperatures of 30-31°C and 20-21°C, respectively. Deviation outside of this range reduces coral physiological performance, potentially leading to colony death. In January and February 2010, Arctic air masses moved through the eastern United States resulting in two closely spaced cold fronts that caused sudden and severe seawater temperature declines in the Florida Keys. Shallow inshore coral reefs (e.g., Admiral Reef; 1-2 m depth) experienced lower sustained temperatures (at or below 12°C) than those further offshore (e.g., Little Grecian Reef; 3-4 m depth). During February and March 2010, we surveyed Admiral Reef and observed mass mortality of reef-building corals. Little Grecian Reef, which experienced only a brief decline below 18°C, did not exhibit any coral mortality, in stark contrast to Admiral Reef 12 km away. Following this event, the physiological effects of low temperature stress on three common reef-building corals (*Montastraea faveolata, Porites astreoides, Siderastrea siderea*) were experimentally investigated. Coral dark respiration, gross photosynthesis, and maximum photosynthetic efficiency of the photosystem II of endosymbiotic zooxanthellae were measured during experimental replication of the observed cold-water anomaly (20°C to 12°C and back to 20°C over four days). In addition to physiological measurements, the genetic identity of the coral's *Symbiodinium* community, *Symbiodinium* densities and chlorophyll *a* were quantified. Species-specific physiological responses were found among tested corals indicating different cold tolerances of coral and/or zooxanthellae (measured at 20°C, 16°C, 12°C, and 20°C). All corals were significantly affected at 12°C and upon return to 20°C *P. astreoides* and *M. faveolata* appeared to be most negatively affected by the cold-water stress, showing significant reductions in gross photosynthesis and dark respiration. Interestingly, *S. siderea* recovered to pre-treatment rates of dark respiration and gross photosynthesis. These results corroborate with visual surveys from inshore reefs where *S. siderea* was found to be one of the few reef-building corals to be minimally affected by the cold-water anomaly.

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Long-Term Benthic Temperature Monitoring at Coral Reefs in Florida Keys National Marine Sanctuary

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The Florida Fish & Wildlife Conservation Commission's Coral Reef Evaluation & Monitoring Project (CREMP) has been monitoring coral reefs at fixed sites in the Florida Keys National Marine Sanctuary (FKNMS) since 1996. Monitoring sites are in all three regions of the Keys (Upper, Middle, & Lower), and encompass a variety of different reef habitats, including deep & shallow reef, patch reef, and hardbottom. Two main components of CREMP are video transects and species richness surveys. Both methods are used to assess reef health, however, no environmental parameters were initially measured to link causality. In December 2002, CREMP began deploying Hobo® water temperature loggers at selected sites. Water temperature is a physical parameter that can trigger coral bleaching, accelerate coral disease, and impact growth and survival. Initially, individual temperature loggers were placed at two sites within each region of the Keys (Upper, Middle, & Lower). Loggers are secured to the seafloor and record water temperatures hourly. Temperature loggers are downloaded semi-annually when possible. As the monitoring program has expanded, temperature loggers have been added at additional sites throughout Florida Keys reefs, including the Dry Tortugas. There are currently 32 temperature loggers deployed at reefs between Upper Key Largo and the Dry Tortugas. The goal is to create a network of temperature loggers in multiple habitat types (shallow reef, deep reef, hard bottom, patch reef) throughout FKNMS.

Many coral species have narrow thermal tolerances, the threshold of which is usually between 16-30^{o}C. Deviance from these temperature ranges can lead to stress and often death. Temperature data collected by CREMP has been effective at documenting extreme thermal events. For example, during the second week of January 2010, temperatures at multiple patch reefs throughout the Keys sustained temperatures below 16^{o}C for more than three consecutive days. CREMP subsequently documented declines of ~50% coral cover at these sites. CREMP temperature data has also been used to create water profiles of various reefs and habitat types. In general, nearshore waters are subject to greater temperature extremes than deep reefs, while sites adjacent to cuts into Florida Bay have greater temperature variability. Finally, temperature data collected from these loggers can aid in more accurately describing benthic water conditions than satellite observations or surface temperature recordings from observing stations. This long term data set can be used to augment coral and other benthic research in the Florida Keys.

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Status of Freshwater Resources and Future Management Implications of Sea Level Rise in the Lower Florida Keys

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The Miami oolite limestone formation found in the lower Florida Keys allows for the development of subsurface freshwater lenses as well as extensive surface freshwater wetlands. Rainwater collects in shallow, impermeable limestone basins and solution holes distributed throughout the lower Keys, supporting a diversity of endemic flora and fauna. Two hundred seventy-seven freshwater solution holes in the lower Florida Keys (No Name Key to Sugarloaf Key) were re-surveyed during 2010. Water chemistry data collected included salinity, temperature, and dissolved oxygen. Evidence of fish and wildlife was recorded for each solution hole and in the surrounding vicinity and included birds, fish, mammals, reptiles and amphibians. Presence of invasive exotic flora and fauna were also documented. This data was compared to baseline inventories from the late 1980's to assess whether the holes still existed, their condition (salinity changes, sedimentation, human impacts), and continued suitability for native fish and wildlife. Future impacts of sea level rise, saltwater intrusion, and storm surges on quality and quantity of freshwater will also be evaluated to develop strategies for restoration and protection of this vital resource.

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Impacts of the Spotted Spiny Lobster (*Panulirus guttatus*) on Coral Patch Reef Communities of the Florida Keys

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Caribbean coral reefs have undergone a phase shift from a system dominated by corals to one where algae are pervasive and, as detailed in Florida's Comprehensive Wildlife Conservation Strategy, the reefs of the Florida Keys are no exception. This shift was in large part precipitated by the loss of herbivores, including the mass mortality of the long spined sea urchin (*Diadema antillarum*), coupled with disease and recruitment failure of hermatypic corals. Whereas some areas of the Caribbean have experienced recovery of *Diadema* populations and associated reef recovery, the Florida Keys still have *Diadema* populations well below historical levels, likely due to low larval supply coupled with predation on juveniles. Spiny lobsters are sea urchin predators in other systems and in the Florida Keys, the spotted spiny lobster (*Panulirus guttatus*) is likely to impact *Diadema* and shallow patch reef communities given that it is an obligate reef dweller. Thus, we investigated the role of *P. guttatus* on patch reef communities in the Florida Keys via field and laboratory experiments. We found that high densities of *P. guttatus* decrease the abundance of invertebrates on coral patch reefs. Additionally, we found that *P. guttatus* consumes herbivorous invertebrates including sea urchins and crabs. Furthermore, we discovered that *Diadema* consumed significantly less algae and fled from chemical cues produced by *P. guttatus*. Lobsters also destabilized rubble substrate that they overturn while foraging, which may inhibit coral recruitment. Through its negative impact on the abundance and behavior of herbivores as well as substrate stability, high densities of *P. guttatus* potentially contribute to coral-to-algae phase-shifts on coral reefs.

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Modeling the Pathways of Particles Related to the Deepwater Horizon Oil Spill Accident toward the Florida Keys

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The oil spill accident in the Northern Gulf of Mexico during the spring-summer of 2010 has been an event of historic proportions, expected to have long term ecological impacts. Although the Northern Gulf has been in the immediate vicinity of the spill and under direct threat, the South Florida coastal areas have also been under consideration for possible influence of oil related substances. Given the environmental and socioeconomic importance and the fragile conditions of the Florida Keys National Marine Sanctuary and the Dry Tortugas Ecological Reserve, this study examines the probability and variability in the pathways connecting these remote ecosystems to the Deepwater Horizon (DH) oil spill site.

A high resolution (~3.7 km) numerical model has been employed to provide the circulation needed for the calculation of particle pathways. The model covers the entire Gulf of Mexico (GoM) and the Florida Straits, encompassing the Florida Keys and Florida Bay; it is based on the Hybrid Coordinate Ocean Model (HYCOM) and hence called GoM-HYCOM. The model assimilates all available data, including observations that were reported in real time as part of the NOAA response to the DH oil spill. Particle trajectories were simulated using the HYCOM model Lagrangian particle package. Initial conditions were updated frequently, using the oil patch observed through satellite imagery. Both surface and sub-surface particle trajectories were calculated, using the GoM-HYCOM velocity fields at appropriate depths.

Particles were released at all model grid points that contained oil data. The hydrodynamic model forecasts were then used to project particle pathways in time. The probability of particles reaching the various interior and shelf areas in the Gulf and South Florida were also calculated. We will demonstrate the variability in the large scale Loop Current/Florida Current system and the associated frontal eddies that controlled the pathways toward the Florida Keys. In particular, we will discuss the various stages of formation and detachment of the Loop Current eddy Franklin, which had a large impact on the connectivity pathways. Results from this study aim toward showcasing a methodology that connects local and remote environmental impacts, thus enhancing the efforts of a sustainable ecosystem management approach for the Florida Keys.

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Physical Factors Driving the Oceanographic Regime around the Florida Keys

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The circulation around the Florida Keys is controlled by local and regional forcing mechanisms. The narrow Atlantic Florida Keys shelf is wind and tidally driven, while waters of Southwest Florida Shelf and Florida Bay origin enter through the Keys passages. Shelf break processes are dominated by exchanges with offshore waters coming to the Florida Straits from the Gulf of Mexico and the Wider Caribbean. The variability of the Loop Current/Florida Current system is a major factor in the characteristics of the oceanographic regime around the Florida Keys and the related biophysical interactions. Management of the socioeconomically important, environmentally fragile ecosystems extending along the Florida Keys and the Dry Tortugas requires the understanding of both local and regional circulation driving mechanisms and their variability.

The Florida Straits and the South Florida coastal and shelf areas surrounding the Florida Keys are very important as the cross-roads between the Gulf of Mexico (GoM) and the Atlantic Ocean. The GoM circulation is dominated by the Loop Current (LC), entering from the Yucatan Channel and continuing to the Florida Straits, where it becomes the Florida Current (FC). The LC/FC system is part of the powerful Atlantic western boundary current, namely the Gulf Stream, linking the Caribbean to the North Atlantic. It is thus a component of the Atlantic Meridional Overturning Circulation, which plays a key role in the global climate regulation and evolution. The LC water masses transport phytoplankton, zooplankton, and fish larvae from the Caribbean into the GoM and the Florida Straits. The LC/FC system is thus the major conduit of the connectivity between the Florida Keys and the Wider Caribbean. The connectivity pathways and time scales are affected by the variable extension of the LC and the meandering of the FC. Changes in LC extension modify the length of the flow from the Yucatan Channel to the Florida Straits. When the LC is extended far north into the Gulf, it may even reach the Mississippi River outflow and advect low salinity, nutrient-rich waters to the Florida Keys. The extended position eventually changes to a retracted position, when the LC turns from Yucatan to the FC branch in the Florida Straits, with very little northward extension. This follows the closing of the LC clockwise circulation through the formation of a large, warm core, anticyclonic eddy. This newly formed eddy, called a ring or Loop Current Eddy detaches and drifts westward into the Gulf, while the LC retracts southward. The FC meandering is influenced by the evolution of cyclonic (counter-clockwise), cold core eddies entering from the GoM and/or formed/intensified in the Dry Tortugas area. These structures, often called Tortugas eddies, later translate into the Florida Straits, changing size/shape and being crucial for the Florida Keys dynamics and biology. In addition, upwelling driven by the proximity of the FC to the Florida Keys shelf and by the cyclonic eddies compensate for the prevailing downwelling favorable winds along the Florida Keys. Examples from observational and modeling studies elucidate the above interactions between the local and regional drivers of the Florida Keys oceanographic regime.

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Calcification in a Changing Ocean Environment

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Calcification rates of coral and algae are sensitive to temperature, water motion, and ocean chemistry. In shallow-reef environments, these variables are dynamic on diurnal, seasonal, and super-annual timescales. Long-term trends in ocean warming and declining pH (ocean acidification) are confirmed in instrumental records around the globe. The purpose of this study is to examine whether corresponding long-term trends are visible in coral and algal calcification records against a background of high spatial and temporal variability, as is expressed in the dynamic reef environments of the Florida Keys. In 2009, four calcification monitoring sites were established adjacent to oceanographic and meteorological monitoring sites at Fowey Rocks, Molasses Reef, and Sombrero Reef in the Keys, and Pulaski Shoals in the Dry Tortugas. Forty colonies of the most abundant reef-building coral species in the Keys, Siderastrea siderea, were transplanted to fixed stations that allow them to be weighed buoyantly on a semi-annual basis. The corals are also stained annually with alizarin red-S to reveal temporal growth patterns that are usually deduced from skeletal density bands. Preliminary results indicate that S. siderea calcification is seasonal; calcification rates in summer were nearly double those in winter, showing a positive relationship with ocean temperature. Site effects were also apparent and could not be explained by temperature alone, with Dry Tortugas corals calcifying at a higher rate. On an areal basis, coral calcification was more than an order of magnitude greater than crustose coralline algal calcification (mean ± 1 SD, S. siderea: 2.65 ± 0.75 mg day-1 cm-2; encrusting algal community: 0.103 ± 0.037 mg day-1 cm-2). These preliminary measurements will serve as an important baseline for Florida Keys resource managers and scientists as we try to discern the impacts of global climate change on Florida's coral reefs in the coming decades.

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USGS Research on Coral Reef Ecosystem Studies (CREST)

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In 2008, the USGS established a new five-year research plan for coral reef-related work with guidance from reef managers in the Florida Keys. A common message from managers was that existing programs were doing a reasonable job of resource monitoring using standard techniques. However, since most of their institutions lack a research mandate, they thought the USGS could best contribute by focusing on the *mechanisms* causing coral reef decline, and investigating the potential of advanced technologies to improve mapping and monitoring efforts. The purpose of this poster is to outline our five-year program in response to these suggestions, and to report current progress of the CREST project. Our team has initiated research through a blend of process-oriented studies and new applications of advanced technology for monitoring activities relevant to understanding the health and resilience of shallow-water reef environments. Current geographical areas of research include Dry Tortugas National Park, Biscayne National Park, and selected areas of the Florida Keys National Marine Sanctuary. Our overall goal is to improve understanding of coral reef stressors, with specific focus on global climate change (warming and ocean acidification) and coral diseases, and to advance the ability to document and forecast changes in coral reef environments.

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Building a Tentative GIS Model to Predict Wetland Loss: A Case Study of Florida Keys

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Wetlands are considered to be one of the richest ecosystem on biodiversity and a variety of values, but extensively vulnerable. Wetland loss is a nation-wide concern in the U.S., and Florida is incurring some of the country's greatest wetland losses. In particular, coastal wetlands are of great importance of biodiversity, flood mitigation, shoreline erosion control, fishery industries, and ocean water quality, and disappearance of coastal wetlands has resulted in subsequent damages on human society. Those make conservation of wetlands extraordinarily worthy.

After experiencing great threats from recreation developments, population growth, and urban expansion in the past centuries, around 50% of original wetlands in Florida still exist. However, only one-fifth of existing wetlands are under protection of national park or reserve systems. The urgent task for environmental planners and natural resource managers is protecting those wetlands from being altered or developed, and the key to the success is gaining the spatial data about where the wetlands in the high risk of loss are.

This research focuses on urban sprawl and recreational development which are identified by the literature as the major forces to wetland loss in Florida. The tentative GIS model established by the research incorporated those social and economic factors, including population density, urban sprawl, and park preservation. It was used to predict the locations of wetlands in different categories of loss risk in Sarasota County, FL and validated for its high accuracy by the NOAA C-CAP imagery data (1996-2002). This research will employ the previously established model, and add the tourism development factor, which will be operated by geo-coding the locations of accommodations listed on the VisitFlorida website. The purpose is to understand the spatial distribution and characters of wetlands which are in high risk of loss in Florida Keys through examination of the tentative GIS model.

The study is expected to create an efficient tool through incorporating more relevant predictors and modifying the tentative GIS model in order to effectively divide the wetlands into the appropriate threaten categories. The produced spatial data will be a useful reference for different levels of governments, NGOs, and national park, preserve, or sanctuary agencies to implement their protection plans, such as land buying, and other conservation programs.

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The Conservation Contribution of Ecotourism to Wetland Rehabilitation in Florida

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Florida is one of the most popular nature-based and outdoor tourism destinations in the U.S. However, threats from recreation development, population growth, and urban expansion are increasing on Florida's natural environment, which is considered one of the richest on biodiversity and valued ecosystems. In response to negative effects caused by mass tourism, the state adopted the state-wide ecotourism policy to protect pristine natural environments, promote well-beings of local communities, and provide quality of visitor's experiences. For planners and natural resource managers, the challenge is recognizing conservation outcomes of ecotourism when larger-scale assessment and monitoring on land use changes remain relatively lacking.

This research focuses on costal wetland ecosystem in Florida, which is considered one of the states experiencing the alarming rate of wetland loss in the past century in the U.S. Hence, coastal wetlands are of great importance to biodiversity, flood mitigation, shoreline erosion control, fishery industries, and ocean water quality, which makes conservation of wetlands extensively worthy. The primary interest of this research is to understand whether ecotourism is an effective tool toward generating favorable environmental outcomes when ecotourism is greatly advocated because of the goal of tourism-conservation symbiosis. The research intends to answer the following questions: (1) does involvement in ecotourism significantly contribute to minimize negative environmental outcomes on wetland ecosystem? (2) does involvement in ecotourism significantly contribute to generate positive environmental effects on wetland ecosystem? (3) which elements of ecotourism (e.g. education and professionalism, collaboration in natural resource management and planning, economic incentive, and sociocultural benefits) are significant predictors of conservation contribution of ecotourism?

This research will employ quantitative method of data collection through on-line survey which investigates nature-based tour operators for their involvement in ecotourism and conservation behaviors or practices. The stratified sampling will be applied to select nature-based tour operators from around 500 operators in Florida by tourism areas (e.g. Key West and Key Largo) for the questionnaire survey. The future findings of the quantitative analysis will be provided as important references for environmental management and land use policies. They may suggest what part of the current participation or partnership in natural resource management needs to be reviewed, how to effectively incorporate ecotourism into regional environmental plan and national park plan, and what kind and what extent ecotourism incentives or elements can encourage conservation contributions of ecotour operators.

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Water Pathways from the Deepwater Horizon Oil Spill Site to the Florida Keys

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The Deepwater Horizon oil spill continues to present an unprecedented threat to the Gulf of Mexico and its coastal marine ecosystems. Beginning at spill onset we began simulating the movement of oil both at the surface and at depth by tracking virtual particles. At the surface we used our eastern Gulf of Mexico model (ROMS nested in HYCOM) and subsequently added five other models, each initialized by satellite imagery inferred oil location, to provide daily ensemble forecasts. At depth we used our eastern Gulf of Mexico model. Water pathways from the spill site to the Florida Keys continue to be identified from both the trajectory models and satellite-tracked drifters deployed in the Gulf of Mexico, plus observations of West Florida Shelf currents from moored buoys. The movement of oil and the connective pathways between the oil spill region and the entire southeast are related to the Loop Current (LC) system itself, the interactions of the LC and its eddy structure with the shelf slope, and the local winds. All of these influence the connections with the Florida Keys and have important implications to the management of the Florida Keys marine ecosystem.

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High-Resolution Seafloor Mapping of the Dry Tortugas National Park Using Side-Scan Sonar and Swath Bathymetry

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In an effort to support federal and state interests for habitat assessment and reef monitoring in the Dry Tortugas National Park (DRTO), a high-resolution swath bathymetry and side-scan sonar mapping project was recently completed using a Teledyne-Benthos C3D system that acquires co-registered side-scan backscatter (200 kHz) and swath bathymetry (decimeter-scale resolution). Almost all areas of the DRTO have been mapped, except for small areas along the northeast and east margins of the Park. These data provide detailed assessments of benthic habitats and morphology. The Florida Fish and Wildlife Research Institute is merging the C3D bathymetry coverage with previous LIDAR coverage to provide a seamless topo-bathymetric map at 1 m resolution. The National Park Service is using these data to upgrade their benthic habitat map.

The high-resolution side-scan backscatter provides detailed characteristic of bottom types such as seagrass, varying sediment texture, current influences, and types of coral/hard bottom settings that can be classified using ground truthing. The decimeter-scale bathymetry reveals detailed features as small as individual coral heads. The merging of backscatter and bathymetry provide unique perspectives on habitats. These data provide a baseline data set to assist change detection studies and ecosystem management within DRTO.

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Acropora Restoration in Florida and the U.S. Virgin Islands

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Due to significant declines in living coral coverage within the Florida Keys National Marine Sanctuary (and worldwide) and the recent listing of both *Acropora cervicornis* and *Acropora palmata* under the Endangered Species Act, the need for active restoration of coral reefs has become apparent. In 2009, under the American Recovery and Reinvestment Act, NOAA recognized this need and funded a large-scale coral restoration project. The aim of this project is to enhance degraded coral reefs throughout Florida and the U.S. Virgin Islands. The long-term goal is to increase acroporid larval production and genetic diversity by increasing the likelihood of successful cross-fertilization between genetically distinct colonies located on outplanted restoration sites.

To date, nurseries have been maintained or established within eight distinct subregions with the purpose of propagating the species and creating as many new coral colonies as possible given limits on resources. Nursery-reared corals will later be transplanted onto reefs that are known to have supported acroporid communities, with the hope that these corals will contribute to the reseeding of natural reefs.

This project represents an active form of coral reef management. The end goal is to strategically outplant at least 5,000 coral colonies to reefs that once supported large thickets of acroporid corals throughout South Florida, the Florida Keys and the U.S. Virgin Islands. Through careful site selection, this outplanting could help to increase the chances of successful sexual reproduction, thereby encouraging the reseeding of natural reefs. Additionally, the nurseries may serve as a repository of genotypes, as was the case this winter when fragments in the nursery survived even as their wild parent colonies died from the cold water.

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Effect of Light on the Growth of Four Corals Species in Land-Based Nursery Systems

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Corals reefs are becoming increasing threatened by biological and physical factors world wide, making the need to raise corals in the land-based nursery systems for restoration purposes a critical tool for conservation of these valuable ecosystems. In this study, we examined the effect of various light levels on the growth rates of four important reef-building corals in the Florida Keys. *Acropora cervicornis, A. palamata, Montastraea annularis*, and *M. cavernosa* were raised in our environmentally-controlled, recirculating aquaculture systems to determine the optimal light levels for growth of each species. Corals of each species were secured at 6 different light levels in three 378-L tanks (1 coral species per light level per tank) and relative change in surface area were measured using digital images that were analyzed using the imaging analysis program SigmaScan®. The 12-week experiment was conducted in the fall of 2008 and in the spring of 2009 (n=6). We found low level light between 38 – 44 µmol m^{-2} s^{-1} resulted in the highest growth of *A. cervicornis* colonies, whereas mid to high level light (≥ 49 µmol m^{-2} s^{-1}) resulted in reduced growth rates. Alternatively, *A. palmata* experienced the highest growth rates under mid level light (49 – 60 µmol m^{-2} s^{-1}), compared to high (≥ 76 µmol m^{-2} s^{-1}) and low (≤ 44 µmol m^{-2} s^{-1}) level light. *M. annularis* and *M. cavernosa* showed no clear pattern of growth in response to the light levels examined in this study. These data indicate that *A. cervicornis* colonies grown in laboratory or aquaria settings should be kept under light levels below 49 µmol m^{-2} s^{-1}, while *A. palamata* colonies should be exposed to light between 49 – 60 µmol m^{-2} s^{-1}. Understanding the parameters that promote the highest growth and survival of corals in captivity will benefit future coral aquaculture, restoration, and conservation efforts.

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Seagrass Recruitment 15 Months after Removal of the Lake Surprise Causeway

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As a component of improvements to State Road 5/US 1 between Florida City and Key Largo, the "Lake Surprise Causeway" was replaced with a bridge. The causeway removal was completed in March 2009. The causeway footprint is approximately 4.6 acres; 3,000 feet long and 60 feet wide. It was scraped-down to -2 NGVD. The upper foot of peat material was replaced with a layer of heavy sand to promote stabilization and suitable substrate for natural recruitment of adjacent seagrasses. The elevation is approximately 1.5 feet higher than the adjacent natural seagrass bed to the west; however, the slope between the two elevations is very gradual. The shallower depth was chosen to discourage boaters from entering Lake Surprise which is adjacent to the Crocodile Lake National Wildlife Refuge. The adjacent habitat to the scrape-down area is an abundant *Thalassia testudinum* and *Halodule wrightii* community to the west. The new bridge parallels the eastern boundary.

FDOT is conducting a 5-year monitoring program to determine seagrass abundance and distribution in the restored area using transect sampling stations and the Braun-Blanquet cover-abundance scale. It is evident after 15 months that the substrate and elevation are suitable for active natural recruitment. *H. wrightii* has actively recruited into 80 percent of the restoration area, with densities ranging from sparse to dense. Colonization by macro-algae is also evident and is being monitored. Current observations confirm that recruitment by *H. Wrightii* is not affected by the changes in elevation from the natural elevation in Lake Surprise to the restored area, as demonstrated by rapid and consistent colonization of the connecting slope. Site conditions under the new bridge are also being documented. The area directly under the new Lake Surprise Bridge is void of any benthic vegetation. *Halophila engelmanni* and macro-algae are colonizing under the western edge of the bridge indirect light.

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Cabled Observatory Measurements of Temporal Variability in Benthic Biogeochemical Processes and Water Quality on Conch Reef, Florida Keys

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Changes in biogeochemical parameters observed in real time on scales of hours to months using newly developed cabled instrumentation and live communication technologies reveal new insights into processes controlling benthic C and N cycling on Conch Reef, Florida Keys. The cabled observatory measurements at Aquarius Reef Base (ARB) enabled live monitoring of ocean acidification and sponge respiration and N cycling experiments plus continuous observations of ambient water quality parameters including oil-derived light hydrocarbons. The Life Support Buoy (LSB) at ARB provided power and live communications for up to three months with instrumentation that included multiple chemical and other sensors, an underwater Membrane Inlet Mass Spectrometer (MIMS) and underwater SEASII pH and nutrient analyzers. While observing ambient water quality parameters, we used multiple optode oxygen sensors to continuously measure temporal variability in the respiration of giant barrel sponges (*Xestospongia muta*), a species which dominates benthic nitrogen cycling on the Florida Keys outer reef tract. Using MIMS and SEASII we determined *in situ* rates of nitrification and denitrification by the High Microbial Abundance (HMA) species *X. muta, Ircinia strobilina* and *Cliona aprica* (boring sponge) under varying dissolved oxygen concentrations. Nitrate concentration increases were proportional to O_2 decreases during initial stages of sponge respiration followed by nitrate loss and N_2 production during increasing hypoxia. Benthic respiration significantly lowered pH within the benthic boundary layer (BBL) relative to the overlying water column with lowest values occurring at night. Light hydrocarbon measurements revealed no impacts from petroleum releases and transport along the reef tract.

All sponges are net exporters of Dissolved Inorganic Nitrogen (DIN), however, HMA sponge N_2 production represents a potential pathway for DIN removal where HMA sponges are abundant. Changes in sponge biomass and speciation should thus have significant consequences for dissolved as well as particulate matter N cycling in these ecosystems. Continuous cabled sensor monitoring has revealed previously unknown biogeochemical cycling processes at Conch Reef and provides new opportunities for quantifying their impacts.

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Evaluation of Marine Reserves for Spiny Lobsters, *Panulirus argus*, Using Transect Surveys in the Florida Keys National Marine Sanctuary, USA

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The performance of marine protected areas (MPAs) in the Florida Keys National Marine Sanctuary (FKNMS) for spiny lobsters, an important Florida fishery, has been evaluated by means of diver-based surveys since their creation in 1997. Performance measures have been the following: (1) Do lobsters become more abundant in MPAs than in the fishery and (2) Does the size of the lobsters increase inside the MPA relative to the fishery? The Florida Fish and Wildlife Conservation Commission (FWC) used to employ timed surveys for this research, but to improve the accuracy of our data, we have used area-based surveys since 2004. The two Lower Keys MPAs we focused on are the large (30 km^2) Western Sambo Ecological Reserve (WSER), and the smaller (0.3 km^2), Eastern Sambo Special Use Area (ESSUA). We have conducted size distribution surveys and 500 m^2 belt transect surveys of lobsters inside these marine reserve zones and their exploited reference areas (Middle Sambo and Pelican Shoal) during the closed fishing season to determine lobster size distribution, sex ratios, and abundance. More recently we have begun surveys of lobsters at the outlier reef just beyond the WSER southern boundary.

In general, the mean size of male and female lobsters and the difference in size between sexes was highest in the large reserve, WSER, and decreased with distance from WSER. Additionally, the incidence of recurrent large lobsters found in ESSUA and Middle Sambo suggests spillover from nearby WSER. Based on acoustic studies, the home range of most lobsters exceeds the size of ESSUA, therefore protection of lobsters there is extremely limited and the size of its lobsters is similar to Middle Sambo. The sex ratio at the outlier reef was more skewed towards females than at other locations. Acoustic tracking of reproductively active females suggest that the outlier reef is a destination for the release of eggs. This observation is consistent with the female skewed sex ratio found during the breeding season (Mar-Sept) on the outlier reef. Continued surveys of these MPAs and reference sites, as well as the unprotected outlier reef off of WSER, will be useful for sanctuary managers considering rezoning plans.

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Depth Distribution of Commercial Grouper and Snapper Catches off the Florida Keys

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We examine the depth distribution of fishing effort, landings, catch-per-unit-effort (cpue), and individual size of several grouper and snapper species in the Florida Keys using data from the National Marine Fisheries Service's coastal (reef fish) logbook program. The impetus was two-fold: (1) to reveal the relative importance of the mesophotic zone (i.e., substrate between the 30 and 100 m isobaths) for each species; and (2) to gauge for each species the appropriateness of using conventional scuba-based visual survey data for stock assessment purposes. The vast majority of visual reef fish surveys are limited to shallow water, typically less than 30 m. For some species, depths < 30 m this may represent only a small portion of the depth range of the sizes targeted by the fisheries. While it is often acknowledged that a given species may occur at depths greater than those reached in a diver survey, the proportion of the total population beyond the depth range of a visual survey is usually not quantified. Here, analyses were based on data derived from commercial hand-line and electric reel (bandit rig) fishing. Effort, landings, and individual lengths were aggregated into three depth zones (≤ 30 m, >30 - 100 m and >100 m) and are presented for the time period 1995 - 2009. Proportional landings by depth, as reported by commercial fishers, suggest that conventional, visual fish surveys sample depth ranges heavily utilized by some species (e.g., lane and yellowtail snappers), thus diver-collected size and density information from shallow waters may well be reflective of population abundance and size/age structure. However, for several other species (e.g., scamp and yellowedge grouper), the proportion of landings was in waters < 30 m was exceedingly small, indicating poor overlap between the fished population and most diver-based surveys. Clearly, fishery independent surveys of habitats > 30 m are needed. Until then, analysis of the depth distribution of catch and size data of individual species is a means towards weighting species-specific abundance indices according to degree of overlap between the diver-survey and depths of fish removals.

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How to Disassemble a Coral Reef: Historical Declines in Florida Keys' Reef Ecosystems

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Undisturbed tropical marine ecosystems are rare, and the timing and degree of disturbance has been difficult to assess because data are limited over long time scale. Even in the well-studied Florida Keys, the sequence and severity of long-term changes coral reef, mangrove, and seagrass communities are unknown. The objectives of this research were to compile previously unused historical documents and extract data on the abundance, distribution of marine organisms, and intensity of exploitation in order to: (1) create population baselines for marine organisms in the Florida Keys over the last 500 years, (2) analyze the sequence and causes of population change, and (3) assess the effects of exploitation in tropical marine ecosystems more generally. We assessed hunting intensity and population change for marine mammals, reptiles, birds, fish, mobile invertebrates, and structure builders.

The first evidence of depletion of any group occurred in the 1830s and species within each group sustained population declines of 50% to 100%. Populations of marine tetrapods, including birds, turtles, and monk seals, were depleted first, and there was no evidence that the sequence of exploitation followed trophic level as it has in temperate and pelagic ecosystems. Reductions instead corresponded to ease of capture and value in local, regional, and global markets. Our results suggest that (1) depletion of vulnerable species can occur with low densities of people fishing for subsistence only; (2) rapid and sequential declines occur in response to fishing and hunting for export markets; (3) population recoveries have occurred historically and are likely to continue in the future, but recovery of the whole ecosystem is unlikely.

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Effects of Bleaching Stress on Wound Repair in *Montastrea faveolata*

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The dominant Caribbean scleractinian species in the genus *Montastrea* have been shown to bleach during exposure to elevated temperature and solar radiation, but there is limited information on how bleaching affects short term tissue regrowth during wound repair. We investigated wound repair responses of *Montastrea faveolata* specimens to temperature and solar radiation stress, both individually and in combination. Two separate experiments were conducted whereby three or four-sided coral fragments were cut to bare surfaces and then exposed to experimental bleaching regimes over 5 or 18 days. Changes in live tissue surface area were quantified using two dimensional photogrammetry following experimental bleaching and during a recovery period in culture. Changes in photosystem II quantum yield, pigment concentrations, and zooxanthellae density were also assessed. Tissue regrowth was inhibited during exposure to elevated solar radiation in both experiments. Some tissue retractions were observed immediately following solar radiation treatments that were significantly correlated with reduction in quantum yield, pigment concentration, and zooxanthellae density. Tissue regrowth occurred in all corals except for cases of severe tissue retraction indicating that bleaching events likely has variable impacts on wound repair and tissue regrowth in scleractinian corals.

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Assessment and Amelioration of the Impact of Lobster Traps on Coral Reef and Hardbottom Habitat in the Florida Keys

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Lobster traps have been implicated as one factor related to the loss of sessile fauna (corals, gorgonians, and sponges) in coral reef and hardbottom habitats. Surveys of traps in the Atlantic waters of the Florida Keys indicated that 14% of traps were on reef or hardbottom habitat. Routine retrieval and placement of these traps resulted in 3 injuries/m^2 that averaged 52 cm^2 each, but little reduction in percent cover of sessile fauna. Significantly greater habitat damage occurred as traps moved in response to high winds. When traps placed in 8 m of water or less were exposed to 15 knot or greater winds for two days the average area of impact increased to 3.4m^2. These areas had a 14.2% loss of sessile fauna in reef habitat and 10% loss in hardbottom habitat. Given the long history of trap use combined with the high number of traps (~250,000 in ocean side waters) and an average of 18.5 high wind events per fishing season, it seems likely that there are few areas remaining which represent the undisturbed state of this habitat. It also seems likely that sessile fauna that are more resilient to periodic trap impacts may now be the most dominant in these habitats.

There are several alternatives being investigated to ameliorate the impact of traps on reef and hardbottom habitats: the commercial fishing industry and natural resource managers have been working together to explore the option of closing some marine areas in order to better protect endangered Acroporid corals, the number of traps are currently being reduced to a target number of 400,000, and, in a cooperative research program between fishermen and ourselves alterations of buoy, rope, and trap construction material were tested for their effect on reducing trap movement. In the latter study, results indicated that buoy style, buoy size, and rope diameter had no significant effect on trap movement. Increased trap weight resulted in reduced movement, however, the weight increase required was impractical for use by fishermen. The trap modification with the greatest potential to reduce trap movement was the use of wire to replace the wooden lath currently used in most traps in the fishery. On average, the more wire used in trap construction, the less traps moved. Ongoing research is examining lobster and bycatch capture rates and trap debris issues associated with using several partial wire-trap designs. Alternatives to reduce the impact of traps on marine habitat need to be considered within the broad context that includes historic fishing techniques, bycatch, debris accumulation, and sources of nonharvest fishing mortality.

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Applying a Multi-disciplinary Approach to Investigate Species Relationships in the Genus Agaricia

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The biological diversity of coral reefs is renowned, and yet much of that diversity is inadequately quantified and poorly understood. Coral taxonomy has traditionally relied on skeletal morphological variation to describe species relationships, but modern molecular analyses have sometimes produced alternate phylogenies that conflict with traditional systematics. We are using multiple tests to examine taxonomic relationships within the genus *Agaricia* with the goal of determining the species among the wide phenotypic variants. First, phylogenetic relationships are explored using several nuclear and mitochondrial loci. Results thus far show a two clade divergence within *Agaricia* with further molecular classification in progress. Second, morphological comparisons are made by examining fine-scale skeletal variations among species. Finally, the ecological niches of each putative species are compared, including their preferred growth positions, light habitats, and associations with symbiotic photosynthetic algae.

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Testing Coral Transplant Performance: Aquarius Coral Restoration/Resilience Experiments (ACRRE)

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In recent years, as the capacity to culture corals and the availability of 'rescued' corals has grown, there is interest in utilizing available corals over a wider range of proactive transplant and restocking applications. However, very little is known about the underlying biological reasons why one coral may thrive when transplanted to a reef while another may sicken and/or die nor about the potential health or genetic risks posed by restocking reef coral populations from 'foreign' or cultured sources. ACRRE is testing the performance of differently-sourced corals in a long term transplant experiment and examining potential impacts between 'foreign' and 'local' transplants. Coral fragments of two species from different sources, including wild colonies from nearby reefs, rescued corals from distant reefs, and corals that have been cultured in aquaria or field nurseries were transplanted in June 2008 to Aquarius and an adjacent shallow site and a range of ecological and physiological performance parameters are being assessed. Both *Acropora cervicornis* and *Montastraea faveolata* transplants and from several sources have suffered significant mortality at the Aquarius site, while different groups have performed well at a nearby shallower site. No difference in survival has occurred, however, between fragments that were transplanted among other transplants from the same source, versus those that were transplanted amongst corals from distant sources. Mechanistic insights should result from further analyses of interactions among coral host genotypes, the diversity of their microbial communities, the photosynthetic performance of their symbionts and gene expression of the host. Companion experiments have focused on dynamics of corallivores (snails and fireworms) and disease as they have been the primary sources of mortality observed in coral transplants. Both the density and identity of neighboring corals are important in determining levels of corallivore damage to *A. cervicornis* transplants.

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Multiple Spatial Scale Sampling of Benthic Coral Reef Organisms in the Florida Keys

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The Florida Keys National Marine Sanctuary (FKNMS), encompassing over 9,000 km^2 of subtidal habitats, was created in 1990 to help preserve and restore this unique coastal ecosystem, while facilitating multiple uses. One of the principal features of the final management plan, implemented in 1997 after six years of public comment, was the creation of 23 no-take marine reserves (NTRs), most of which are distributed along the offshore reef tract. The monitoring plan for the FKNMS zoning was designed to assess two important hypotheses related to zoning: 1) fishery target species such as reef fishes and spiny lobster will increase in density and size within the NTRs, and 2) increases in predator density and size will result in changes in benthic community structure from trophic interaction effects. To help address the second hypothesis, pilot studies initiated in 1998 were used to develop a sampling program implemented in 1999. The objectives are to quantify the distribution, abundance, size, and condition of coral reef benthos at multiple spatial scales, with a focus on comparing the responses of variables between NTRs and corresponding reference sites. A novel application of statistical survey design principles is used to guide large-scale sampling of benthic coral reef organisms in the region.

Excluding similar efforts in the Tortugas region, this program has amassed an impressive data set from surveys since 1999 at 1,053 sites distributed throughout the Florida Keys. Replicate linear point-intercept and belt transects are used in a two-staged stratified random sampling design that partitions the study area by habitat type, along-shelf position, and management zones. The variables measured include: depth and topographic complexity; species richness and frequency of occurrence of stony corals, gorgonians, and sponges; benthic cover; density, size, and condition of stony corals; density of juvenile corals, gorgonians, and other cnidarians (anemones and corallimorpharians); density and size of urchins; and density and size of selected mollusks. Sampling has also intermittently focused on Acropora coral populations, as well as the abundance and impacts of marine debris. Survey design techniques provide a robust framework for estimating population-level metrics and optimizing sampling efficiency. To date, most variables exhibit significant spatial differences by habitat type or between individual NTRs and reference sites, although some regional differences are also apparent. Many of the differences among the NTRs and reference sites reflect the placement of the NTRs in well-developed offshore reefs, and for many of the variables targeted, individual zones are as different from one another as from reference sites. The results emphasize the need to address spatial variations at multiple scales, and to consider a range of variables beyond common metrics such as coral cover.

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Population Assessments of Benthic Coral Reef Organisms in the Florida Keys: 1999-2009

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This program assesses and monitors the responses of benthic coral reef organisms to the Florida Keys National Marine Sanctuary Zoning Action Plan, which in 1997 (when buoys were installed) established 23 no-take reserves (NTRs). A stratified random sampling design was implemented that incorporates multiple cross-shelf habitat types, along-shelf position, and management zones. The program evaluates topographic complexity, cover, richness, density, and sizes of corals (and condition), sponges, gorgonians, juvenile corals, other cnidarians, urchins, selected mollusks, and algae. Not including surveys in 2010 (120 sites), as well as those in the Tortugas (121 sites), a total of 1,053 sites were sampled during 1999-2009 to support this effort.

Comparisons between NTRs and reference sites reveal a complex pattern dependent upon habitat type and benthic variable, as well as pre-existing conditions that reflect the non-random placement of the NTRs into mostly high-relief reef areas along the platform margin or several unique patch reef areas. Results indicate that mid-channel patch reefs, offshore patch reefs, shallow hard-bottom, high-relief spur and groove, and deeper (6-15 m depth) fore-reef slope habitats have either remained relatively stable over the sampling period for most variables or NTRs have become more similar to corresponding reference areas with initially lower coral cover. Regarding population estimates, three examples follow.

For *Acropora cervicornis*, results indicate 13.7 ± 12.0 million colonies in the habitats surveyed, but nearly 70 percent of colonies are less than 150 cm^2 in surface area. The greatest colony densities (1.22 colonies/m^2) and live tissue surface area tend to be found on mid-channel and offshore patch reefs in the lower Keys (few of which are NTRs) and Biscayne National Park. In contrast, stands of *A. palmata* remain in only a few locations and abundance estimates indicate that there are 1.6 ± 1.4 million colonies from Key West to Key Biscayne. Nearly 80% of colonies occur on high-relief spur and groove reefs (1.25 colonies/m^2), most of which are in NTRs.

Population assessments for *Diadema antillarum* indicate that current densities remain well below one individual per m^2. The maximum site-level density recorded was 0.33 individuals per m^2. However, there has been a notable upward increase in the average and maximum size of *D. antillarum*. Regression analysis indicates that recovery of densities to pre-1983 levels could take decades, if not longer, despite population numbers on the order of millions of individuals.

Results of this ten-year monitoring program indicate that reefs in Florida appear to be on similar trajectories as reefs found elsewhere in the Caribbean. Discouraging signs: 1) all the usual stuff. Encouraging signs: 1) there is still *Acropora* left 2) *Diadema* are slowly making their way back; and 3) multiple coral species still recruit to the system. Important notes: 1) this past January was a reminder that cold fronts can cause significant mortality in a matter of days; and 2) excluding the Tortugas NTRs, the FKNMS zones make up less than 5% of the total Sanctuary area.

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Returning the Keystone Herbivore, *Diadema antillarum*, to Florida Coral Reefs

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The loss of a keystone herbivore, the long-spined sea urchin of the western Tropical Atlantic, *Diadema antillarum*, to an unprecedented plague occurred in 1983 close to the beginning of the great decline of Atlantic coral reefs. Although there are a great many stressors to the ecology of these coral reefs, the loss of the herbivory provided by these urchins was the tipping point for the phase shift from coral domination to algae overgrowth. Over the past decade, several studies have demonstrated that the return of *Diadema antillarum* to coral reef habitats in numbers that are ecologically functional results in a great diminution of algae growth and a return of coral dominance. Yet there has been little recovery of *Diadema* so far in the Florida Keys.

There are many possible reasons for the failure of *Diadema* to return in ecologically functional numbers to the Florida reefs, including lack of suitable substrate for larvae settlement and survival, lack of reproductive success, predation on juveniles, and low numbers of larvae. It may be possible to speed the return of *Diadema* to our reefs through blending the emerging science of responsible and accountable marine fisheries enhancement with modern marine aquaculture science. Mote Marine Laboratory, the University of Miami, and the Florida Fish and Wildlife Conservation Commission are uniquely positioned to apply both of these sciences to the ecological restoration of coral reefs through propagation and careful reestablishment of *Diadema* on our coral reefs.

Our team has already developed the basic technology for spawning adults on demand and rearing the larvae in large numbers. Metamorphosis of a limited number of larvae into surviving juvenile urchins has been achieved, but reliable methods for early juvenile survival still need to be developed. Laboratory studies have been initiated to evaluate behavioral differences between wild and cultured urchins and field studies have been conducted to investigate survival of transplanted urchins on natural and artificial reefs. As of July 2010, a critical step, obtaining survival of large numbers of early juvenile urchins into the stable feeding stage, has yet to be accomplished. Development of the basic equipment and protocol for spawning and rearing of *Diadema* is now at an intermediate stage of development. Achieving reliable mass-production aquaculture technology for *D. antillarum* will provide a critical tool for ecological restoration of specific coral reefs and may in time lead to the wide spread return of herbivory to the reefs and enhancement of reef resilience to aid survival of our coral reefs in the critical years that lie ahead.

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Changes in Fish Communities of Ponds and Lagoons of the Florida Keys

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Data collected on shallow water (0.5m) marine fishes is examined. A distinctive resident pond and shallow lagoon fish community is described in two time periods, first with data from sampling in the 1970's, and then data from 2010 are compared to historical aerial photographs from the 1950's and 1960's. Several changes in the mangroves, salt marshes, and fish communities are documented and discussed in relation to rising sea levels. The impact of these changes on species living in these habitats is discussed including impacts to endangered species and wading birds.

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Assessment of Geomorphological Characteristics and Reef Fish Utilization of Reported Reef Fish Aggregation Sites in the Florida Keys, USA

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Fish spawning aggregations (FSAs) are a vital part of the life cycle of many commercially and recreationally important reef fish species. In many cases, a lack of knowledge of the location of FSA sites prohibits their effective management and practical approaches to identify those sites and assess their utilization by aggregating species are needed. We are using acoustic technologies and diver observations at reported FSA sites in the Florida Keys to accomplish two objectives: (1) assess whether reported FSA sites are characterized by similar habitat characteristics, with a focus on geomorphological features, and (2) determine levels of fish utilization of these sites, including whether sites reported to have been "fished out" in previous decades are currently utilized by remnant or recovering aggregations. Our work demonstrates the potential for acoustic technologies coupled with visual assessments to provide relevant and timely information regarding the formation, distribution and sizes of FSAs in the Florida Keys.

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Acropora Coral Species Status and Trends in Dry Tortugas National Park (DTNP)

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Acropora dominated reefs, especially *Acropora cervicornis*, have historically been common in DTNP. In 1881, a survey by Agassiz found 461 hectares of Acropora reefs, mostly *A. cervicornis*, in DTNP. In 1976 Davis and other NPS scientists measured the spatial extent of park Acropora reefs to be 478 hectares. *A. cervicornis* accounted for 55% of all DTNP coral reefs in 1976. However, *Acropora palmata* reefs had decreased by >99% from 1881. Our project objectives are to assess the current spatial extent and distribution of *Acropora* reefs in DTNP and to tract the ecological condition of *Acropora* species in the park.

To assess the spatial extent and distribution of *Acropora* reefs, we first re-surveyed the areas identified as *Acropora* dominated reefs in 1976 (the last survey). We did this mainly snorkeling with a GPS unit using in-water scooters. In deeper water (>9m), paired SCUBA divers with scooters were followed by a boat recording the GPS tract. We have four *Acropora* reef monitoring sites to assess the ecological condition of *A. palmata, A. cervicornis*, and *A. prolifera*. *Acropora* live percent cover is measured using Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Program videographic methods. Disease and bleaching assessments and fate tracking of individual colonies are also conducted.

Acropora reefs in DTNP have decreased substantially since 1976. Currently there is <1 hectare of *Acropora* thickets, a >99% loss since 1976. There are only two known remaining *Acropora* reefs: the *A. prolifera* and *A. palmata* patches. *Acropora* live cover is $\leq$5% on these reefs. The last known *A. cervicornis* reef was destroyed by Hurricanes Charley (2004) and Wilma (2005).

A cold event in 1977 caused nearly 90% mortality of *A. cervicornis*. However, *A. cervicornis* started recovering in the 1980's. Then, disease outbreaks caused more *Acropora* loss in the 1990s and early 2000,s. For example, *A. prolifera* experienced about 90% mass mortality in 2003 from disease. *Acropora* was then impacted by five hurricanes in a 14 month period in 2004-2005; an unprecedented event in the 130 year history of Tortugas science. However, by 2009 *A. prolifera* and *A. palmata* live cover were not statistically different from 2004, suggesting recovery from 2005 hurricane effects. In contrast, *A. cervicornis* decreased 98% from 1999-2009 ($p<0.001$) and 96% from 2004-2009 ($p<0.05$) at the two staghorn monitoring sites. Assessments of the 2010 cold event found no effect on *Acropora* species in DTNP.

NPS has implemented multiple stewardship and science activities addressing *Acropora* loss. For example, in 2004 the park installed more effective wastewater treatment facilities. After this action, disease occurrence on nearby *Acropora* decreased substantially. DTNP is partnering with The Nature Conservancy to grow, transplant, and thus restore *Acropora.*

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Effects of the 2004-2005 Hurricanes on Dry Tortugas National Park Coral Reefs and Seagrass Meadows

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Dry Tortugas National Park (DTNP) was affected by five hurricanes and a tropical storm in a 14 month period from August 2004 through October 2005; an unprecedented event in the 130 history of Tortugas science. Our project objective is to assess the effects of, and any recovery from, these natural disturbances on DTNP coral reefs and seagrass beds.

We used park coral reef and seagrass monitoring sites, plus satellite imagery, to evaluate the effects of these hurricanes. The live percent cover of stony corals and other reef benthic biotic and functional groups was determined using Florida Fish and Wildlife Research Institute Coral Reef Evaluation and Monitoring Program videographic methods. Pre (2003) and post (2007) hurricane satellite imagery, with ground truthing, was used to assess seagrass loss on a large spatial scale. Seagrass and benthic macroalgal percent cover in haphazardly located 0.25m^2 quadrats was used to ascertain hurricane effects at monitoring sites (small scale). Echinoids (sea biscuits and sea urchins) in grass beds were counted in haphazardly located 1m^2 quadrats.

Only two reef sites, Bird Key Reef and White Shoal, were being monitored annually before Hurricane Charley struck DTNP in August 2004. Total stony coral percent cover decreased 20% on Bird Key Reef and 55% on White Shoal from 2003 to 2004 ($p=0.05$), after Charley. Statistical analyses of stony coral data collected at seven monitoring sites from 2004 to 2009 revealed significant differences among years ($p<0.001$). There was a 25% decline in stony coral from 2005 to 2006. However, stony coral cover in 2009 was statistically greater than in 2006 and not significantly different than in 2004 or 2005, indicating statistical recovery from 2005 hurricane impacts. These conclusions apply to only these seven sites and should not be extrapolated park-wide.

Over 55 hectares of seagrass meadows were destroyed from April 2003 to May 2007 just around the four major islands in DTNP. This is greater than the total area of all the Tortugas islands (40 hectares). Seagrass and total macrophyte percent cover decreased significantly ($p<0.05$) at all six shallow ($\leq$3m) seagrass monitoring sites from June 2005 through September 2005; three hurricanes affected DTNP during this period. Seagrass cover was significantly lower in July 2006 than June 2005. Density of the sea biscuit *Clypeaster* declined significantly after the 2005 hurricanes. In contrast, there was little or no effect of these hurricanes on seagrass beds deeper than 10 meters. Seagrass has begun recovering at most shallow sites. However, additional seagrass loss from Hurricane Ike in September 2008 occurred at some sites.

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SCUBAnauts International: A Decade of Youth Education and Research in the Florida Keys National Marine Sanctuary

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Engaging youth in coral reef research plays a significant role in increasing awareness and appreciation of these important ecosystems, while providing youth with the opportunity, knowledge and tools to become the next generation of ocean explorers and ocean stewards. SCUBAnauts International (SNI) is a non-profit 501(c)3 informal education program that consists of a diverse group of young men and women (ages 12-18) mentored by professional reef scientists. The mission of SNI is to expand and promote opportunities for emerging explorers by involving them in the marine sciences through underwater exploration and research activities, such as environmental and undersea conservation projects that educate, promote active citizenship, and develop effective leadership skills. SNI currently has four chapters, all of which have conducted research in the Florida Keys National Marine Sanctuary (FKNMS). Dr. Brian Keller, in particular, was always very supportive of SNI youth's research within the sanctuary. Since 2001, SCUBAnauts have been learning about the complexity of reef ecosystems and actively participating in reef research in FKNMS. SCUBAnauts have been trained in a variety of scientific protocols for collecting data on water quality, optics, and reef community condition. The SNI youth collect research quality data that provides useful information to the NOAA/NMS resource managers, who designate boundaries for protecting ecologically important areas. For example, in July 2009, the youth of SNI surveyed the benthic cover and fish populations on an inshore patch reef, "Nauty Reef" (24˚33.579' N, 81˚39.780' W), off the coast of Key West, Florida, USA. The SCUBAnauts recorded a mean coral cover of 52±9%, which is unusual compared to the low coral cover typical of reefs in the Florida Keys (mean of 6% coral cover). In addition, the SCUBAnauts have participated in coral restoration projects by helping maintain coral nurseries in collaboration with NOAA in Key West and the Coral Restoration Foundation, a non-profit conservation organization, in Key Largo. On several occasions, SCUBAnauts have had the rare privilege to tour the world's only underwater laboratory, Aquarius, which is deployed approximately 5.6 km offshore of Key Largo, FL, at a depth of 18 m. While SCUBAnauts only had a brief visit of 40 minutes in Aquarius, this allowed them to explore the facilities where scientists work, sleep and eat underwater and learn about the reef studies that this unique laboratory has made possible. Through these experiential learning opportunities, the SCUBAnauts have shown a significant improvement in their understanding of biological, chemical, physical, and geological oceanography and developed a strong appreciation for reef ecosystems.

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Application of Downscaled Climate Models to the Florida Keys and Florida Bay Marine Ecosystems

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Over the past 45 years, mean water temperatures in the upper 300m of the oceans have increased by 0.3°C, and are expected to continue increasing throughout the remaining portion of the 21st century. A warming climate will result in regional environmental changes relevant to marine ecosystems, including changes in precipitation and evaporation rates, changes in riverine discharge, loss of coastal habitat through flooding, changing oceanic circulations, and increasing ocean acidification.

Existing IPCC climate models have a typical horizontal resolution of around 100km, which is too coarse to estimate climate change impacts on smaller, regional areas such as the Florida Keys. In order to achieve this, climate models must be downscaled. This can be completed using statistical downscaling, which exploits existing relationships between large-scale climate processes and regional conditions, or by dynamical/physical downscaling, which forces existing high resolution ocean models along their domain boundaries with data from global climate models. A coupled ocean-atmosphere approach may also be used.

This presentation will introduce the concept of global climate model downscaling in the context of the Florida Keys marine ecosystem, and discuss potential issues and products. Appropriate methods for predicting future climate change impacts will be included, as well as potentially useful outputs for the management community.

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A Decision Support System for Ecosystem-Based Management of Tropical Coral Reef Environments

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We review a new collaborative program established between the University of South Florida (USF), National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA) to augment the NOAA Coral Reef Watch decision-support system. NOAA has developed a Decision Support System (DSS) under the Coral Reef Watch (CRW) program to forecast environmental stress in coral reef ecosystems around the world. The website is: http://coralreefwatch.noaa.gov/satellite/research/nasa_dss.html.

This DSS uses models and 50 km Advanced Very High Resolution Radiometer (AVHRR) to generate "HotSpots" and Degree Heating Weeks coral bleaching indices. These are used by scientists and resource managers around the world, including National Marine Sanctuary managers, many of whom have expressed the need for higher spatial resolution tools to understand local issues.

The project will develop a series of coral bleaching products at higher spatial resolution using Moderate Resolution Imaging Spectroradiometer (MODIS) and AVHRR data. We will generate and validate products at 1 km resolution for the Caribbean Sea and Gulf of Mexico, and test global assessments at 4 and 50 km. The project will also incorporate the *Global Coral Reef Millennium Map*, a 30-m resolution thematic classification of coral reefs developed by the NASA Landsat-7 Science Team, into the CRW DSS. The Millennium Maps help understand the geomorphology of individual reefs around the world. The products will be available through the NOAA CRW and UNEP-WCMC web portals.

The augmented DSS has a global scope, yet it addresses the needs of local resource managers. The work complements efforts to map and monitor coral reef communities in the U.S. territories by NOAA, NASA, and the USGS, and is a contribution to international efforts in ecological forecasting of coral reefs under changing environments, coral reef research, resource management, and conservation.

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Producing *Acropora palmata* in Offshore Coral Nurseries for Reef Restoration

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Acropora palmata, a once dominant reef framework building coral found throughout the Caribbean, Bahamas, and Florida Keys, is now rare in most areas of its native range and is struggling to survive. Disease, storm damage, periodic bleaching events, predation, algal overgrowth, as well as direct and indirect human pressures, have all contributed to this precipitous decline in the Florida Keys, leaving the remaining populations are highly fragmented and are not functionally reproductive. In 2008, an effort to protect the species and to focus some attention on developing a recovery plan for the Caribbean acroporid species; *Acropora palmata*, was listed as threatened under the US Endangered Species Act. In the spring of 2009 the Coral Restoration Foundation (CRF) received a permit to develop an in situ nursery program for *Acropora palmata* in the Florida Keys. Following an approved criteria for collecting fragments of opportunity and at risk remnant coral colonies, coral fragments were collected from 9 distinct reefs off the Upper Keys and permanently mounted on specially designed concrete structures cemented to the sea floor at the designated nursery site. New growth from outer edges of the mounted fragments were trimmed once or twice during the first year and epoxied onto smaller, pre-labeled concrete mounts. These first generation corals will be grown to a size suitable for use in restoration projects at degraded reef sites.

In the spring of 2010, fragments trimmed from the new growth of each genotype created 200 new corals in the nursery. We have experimented with a variety of fragment sizes and found that cuttings with as little as 1 sq cm of live tissue have survived and are now thriving at the nursery. Most fragments were cut into two dimensional 2 x 2 cm square "tiles", however some fragments were three dimensional end cuttings. Survival from both types of cuttings has been over 98% for the first two months, and none of the donor colonies experienced any observed mortality or tissue loss. Healing on cut surfaces for both types of fragments and the donor colonies has been rapid, with most cut surfaces healing completely within a month. The rapid healing of cut surfaces and high survival observed in both the original fragments and the small, first generation fragments demonstrates that these techniques are effective at rehabilitating and propagating this important reef building coral.

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Strategy for Stewardship: Coral Restoration Foundation's Approach to Regional Reef Management via Volunteerism and Community-based Stewardship Programs

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The Coral Restoration Foundation (CRF) has developed and sustained a successful offshore nursery and restoration program by merging SCUBA diving, education, and volunteerism into supervised, community-based stewardship programs strategically designed to help CRF manage and restore endangered corals to reefs within the Florida Keys National Marine Sanctuary (FKNMS). CRF's strategy for stewardship educates, trains, and empowers participants by incorporating classroom exposure and field work into one program under CRF supervision. This direct involvement has helped CRF transplant over 500 corals to 20 reef restoration sites in the Upper Keys since 2003, provided constructive, responsible tourism-based activities, as well as contributed to local businesses. Our strategy for developing local stewardship for the coral reefs of the Florida Keys will continue to support the management goals of the FKNMS, magnify on-the-ground restoration efforts, support local businesses, and contribute immensely to the growing global awareness, conservation, and importance of coral reefs.

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Science and Policy Considerations for Coastal and Marine Spatial Planning in Florida and the Wider Caribbean

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The global decline of coral reefs and tropical coastal ecosystems is entering at least its 5th decade. The best science documenting the decline and investigating its causes has been done in the Wider Caribbean including Florida. Informed by the science, conservation pioneers promoted marine protected areas (MPAs) which spread rapidly throughout the region. Unfortunately, many had little or no enforcement and were too small to be effective.

Inspired by MPA developments particularly in Australia, the Florida Keys National Marine Sanctuary still stands as our nation's most complete plan for governance of a significant marine region. Yet since its inception in 1997 and with the addition of significant protected areas in the Dry Tortugas in 2001, we have had a tendency to rest on our laurels. The unsuccessful Islands in the Stream proposal of networked Gulf of Mexico MPAs and the recent NOAA announcement of a national network of 254 MPAs have a much more comprehensive management strategy that science has already told us will be necessary, particularly in the coming decades of climate change and relentless growth of the human footprint.

It is past time for scientists and managers to join together as activists to increase the scale of management to encompass the broad geographic scales of human impact and the far-reaching ecological processes that influence tropical coastal ecosystems and adjacent land areas. There is ample evidence that the Caribbean functions as a large marine ecosystem-- in other words it is a planning unit. Furthermore, it can be sub-divided into large, eco-regional planning units, analogous to any large land-planning project.

While scientific considerations are an important part of the selection of a region as a planning unit, humans are a key component of any ecosystem and it is critical that it is an area of concern by engaged groups of stakeholders. The planning process proceeds in five general phases: (1) resources and human uses assessment; (2) outreach and education; (3) marine spatial planning; (4) implementation of the plan; and, (5) a monitoring program to assess progress, model future scenarios and adaptively manage.

The driving force behind this participatory process is economics, since a healthy tropical coastal environment is critical to sustaining a broad array of tourism-driven businesses. The Meso-American Barrier Reef project and the Caribbean Large Marine Ecosystem project provide two examples of projects elsewhere which could help guide a pilot project in the U.S. An extension of the Keys Sanctuary and a plan for the Puerto Rico-Virgin Islands Shelf are two possible places to start.

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An Assessment of Science Needs Based on an Integrated Conceptual Ecosystem Model of the Florida Keys: The MARES Project

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The overall goal of our NOAA-funded, Marine and Estuarine Goal Setting for South Florida (MARES) Project is to form a consensus about the key characteristics that define South Florida coastal marine ecosystems and goals for coastal management in the region. The Florida Keys is the first of three regions that MARES is studying. Identifying priorities for research is an part of articulating management goals. We preview some of the science priorities that have emerged with the objective to stimulate discussion and feedback from the conference attendees.

The MARES Project has adopted a Driver-Pressure-State-Ecosystem Services-Response (DPSER) framework for developing integrated conceptual ecosystem models. The DPSER framework explicitly represents the interdependence between human dimensions and environmental attributes through feedback loops in the model structure. Human dimensions aspects of the ecosystem are also represented in the Ecosystem Services component of the DPSER model.

Linking conditions in the ecosystem to “services” allows human use values, activities, and impacts to be modeled explicitly. This approach also brings into focus areas where managers require objective, scientific information about peoples’ behavior, perceptions and preferences regarding the marine environment. The result will be publication of Integrated Conceptual Ecosystem Models (ICEMs) for the Florida Keys Reef, SW Florida Shelf, SE Florida Coral Reef, and Total Marine Ecosystem of South Florida.

In addition, we are developing Quantitative Ecosystem Indicators (QEI) for these regions. Their development involves articulates desired conditions for the ecosystem it terms of metrics and quantitative targets, based on the ICEMs. Development of the ICEMs and QEIs involves a synthesis of the available scientific information on South Florida’s coastal ecosystems, and this leads directly to identifying gaps in current understanding and related priorities for research.

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Persistence of Dispersal Kernel Features in the Florida Keys under Average and Extreme Climatic Conditions

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In an effort to assess the impact of extreme climatic events on the persistence of local populations (i.e., their replacement over space) in the Florida Keys coral reef ecosystem we quantify the spatial variability of dispersal kernels (the function that describes the probability of dispersal) over time and examine the stability of these features during the passage of hurricanes.

Circulation along the Florida Keys is very dynamic, with eddies translating along the strong Florida Current, which makes it difficult to identify processes that are important for local retention. These processes are revealed by coupling a 900 m resolution circulation model (South Florida and Florida Straits) with a multi-scale Lagrangian stochastic model (Connectivity Modeling System) to generate probabilistic simulations of larval transport over many ensembles of bi-weekly releases of inert and biotic particles over five consecutive years (2004-2008). We compute the Probability Density Function (PDF) of particle displacement for a series of advection times for under normal conditions and during the passage of nine hurricanes.

This analysis reveals distinct, non-overlapping dispersal features (PDFs) related to the eddy field, which allow the accumulation of particles over space and time. Important processes for the Keys are the Tortugas eddy in the western Keys, a smaller eddy trapped in the Upper Keys, and the counter-current in the lower and middle Keys. The two eddy-like dispersal kernel features do not overlap, while the lower and middle Keys act as a corridor between the two. Passive water parcels are more diffused than biotic particles (virtual larvae) simulating the vertical migration of the bicolor damselfish (*Stegastes partitus*), a typical coral reef fish that spawns year-round. Biotic particles are also more likely to survive dispersal than passive particles, as a greater proportion is locally retained. The cumulative effect of hurricanes decreases the density of the dispersal kernels (decreased local retention) and the connectivity between dispersal features. However, single events generate transient features that contribute to long distance dispersion and/or punctuated local retention (important for storage effect). These results suggest that an increased incidence of hurricanes in South Florida will result in decreased local coral reef fish populations in the Florida Keys and a cascade of biological shifts over time.

These features can be used to anticipate potential areas of accumulation of pollutants such as oil products in the Florida Keys area and the overall effect of hurricanes on their redistribution.

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High Clonality of Host and Symbionts Characterizes Florida *Acropora palmata* Populations

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Cnidarians and dinoflagellates in the genus *Symbiodinium* combine to form one of the most important symbioses on the planet. Realizing the significance of their diversity and ecology is vital for understanding how these associations will respond evolutionarily to climate change. Genotyping to the level of "individual" addresses questions of specificity and stability at the finest scale of genetic resolution and is the ultimate resolution of individual "holobionts." Data acquired through genotyping are critical for deducing evolutionary processes that are ongoing between host and symbiont populations and how these partner combinations are co-evolving in the face of climate change. We investigated the clonal diversity of *Symbiodinium* populations that associate with one of the most important Caribbean reef-building corals, *Acropora palmata.* This animal is highly specific for *Symbiodinium A3* despite the fact that its larvae must acquire symbionts from environmental pools. In recent work describing the population genetic structure of *A. palmata*, thousands of samples were genotyped for the animal and then archived. These specimens provide an exceptional resource for intensive analyses of *Symbiodinium* genotype diversity within an individual colony, among separate colonies of the same animal genotype (ramets), among large stands of genetically unique colonies (genets), and across populations of *A. palmata* throughout much of its Caribbean distribution. Initial genotyping of 96 specimens from nine Florida reefs based on seven variable microsatellite loci indicates that each colony contains a single dominant symbiont genotype (clone). This one-to-one host-symbiont genotype correspondence allows for direct comparison of host population genetic structure with that of the symbiont genetic structure to identify and then model how dispersal barriers, environmental conditions, and life history strategies influence the co-evolution of corals and dinoflagellates. Of the 96 samples, there were 11 unique symbiont genotypes and 16 unique host genotypes. Some symbiont clones were found on more than one reef while host clones were reef-specific. Only four of the nine reefs harbored more than one zooxanthellae or host clone. This low diversity of host and zooxanthellae might indicate selection for certain host/symbiont combinations. Comparative physiological studies and infection experiments of coral larvae will investigate the stability and ecological significance of low diversity host populations with low diversity symbiont populations.

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Integrating Time-Series of Community Monitoring Data

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Assessing population trends, evaluating management actions, and identifying community responses to anthropogenic impacts all require an accurate time-series of populations. In practice, such data are often scarce or of varying quality due to the limited resources of managing agencies. In such situations, analyses that integrating multiple data sources (e.g. agency monitoring programs, citizen science observations, fisheries catch records) can yield dramatic improvements in the estimation of population trajectories. To do so effectively, however, such integrative models must account for differences in observation errors across data sources. We used multivariate state space models (MSSMs) to assess the population trajectories of reef fish species from the Florida Keys National Marine Sanctuary based on data from 1) point count surveys conducted through academic institutions and 2) citizen-science monitoring surveys conducted by volunteer Scuba divers. By developing competing models and applying information theory, we demonstrate how MSSMs can be used to compare and integrate multiple monitoring time series, and ultimately improve estimates of the true states of populations though time. Additionally, we demonstrate that by combining multiple time series, it is possible to recover method-specific observation error estimates even for very short time series of data.

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Counters and Killers - The National Park Service's South Florida/Caribbean Inventory and Monitoring Activities in the Florida Keys Marine Ecosystem

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The National Park Service's South Florida/Caribbean Inventory and Monitoring Program (SFCN) assists the four National Parks in South Florida (Everglades National Park, Biscayne National Park, Dry Tortugas National Park, and Big Cypress National Preserve) with Natural Resource monitoring activities, or Vital Signs. The SFCN developed a list of more than 40 Vital Signs, or environmental indicators that are either monitored in house, or in collaboration with partners. Marine Vital Signs include marine benthic community monitoring of corals and seagrass, marine fish community monitoring, marine exploited invertebrate monitoring, water temperature monitoring, benthic habitat mapping, and marine invasive species monitoring and eradication.

The SFCN is currently working to develop a variety of protocols and standard operating procedures for each of the Vital Signs to ensure consistency of data collection over time. Data management is extremely important for the program, with a significant portion of our program focused on database creation and maintenance, data QA/QC, data archival, and data visualization. SFCN relies on Geographic Information System software to help organize and visualize multiple data layers to help provide insight towards multiple Vital Sign interactions.

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Gene Transfer Agents in the Reef Environment

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Bacteria play a complex yet not fully understood role in the coral reef environment. The α-proteobacteria are a dominant component of reef bacterial communities, and are known for symbiotic/commensal relationships with dinoflagellates, including the coral symbiont *Symbiodinium.* Most α-proteobacteria contain a viral-like element within the host chromosome termed a Gene Transfer Agent (GTA). GTAs are believed to be defective prophages, and they function by packaging random fragments of the bacterial host genome rather than their own. These elements serve as a type of "genetic escape pod" for the host cell. We observed relatively large amounts (10^8 to 10^9/ml) of GTAs produced by two α-proteobacteria, *Roseovarius nubinhibens* ISM and *Reugeria mobilis* 45A6, in culture. We produced genetically marked variants of these strains by inserting the transposon Tn5 that encodes resistance to the antibiotics kanamycin, bleomycin, and streptomycin. We investigated gene transfer by GTAs to the ambient community in Looe Key by adding purified GTAs to natural communities incubated in situ in sterile tissue culture bags. Gene transfer was detected by resistance to antibiotics encoded in Tn5. Frequencies of transfer ranged from $2.5x10^{-2}$ to $1.1x10^{-1}$ transductants per recipient. The GTA mediated frequency of horizontal gene transfer was 700,000 to 7 million times the frequency of transduction measured in Tampa Bay using marine bacteriophages. In separate experiment we determined the effect of purified GTAs on larval settlement for the coral *Porites asteroides.* Treatments receiving GTAs had greater larval settlement than those lacking GTAs or those receiving microwave inactivated GTAs. The positive impact on larval settlement and the high rates of horizontal gene transfer ensures a genetic flexibility in reef α-proteobacterial populations that may enable rapid adaptation to environmental change and contribute to coral reef resiliency.

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Effects of Natural Products from Benthic Cyanobacteria on Coral Larvae

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A major concern on coral reefs worldwide is overgrowth of corals by macroalgae and benthic cyanobacteria. Benthic cyanobacteria are becoming increasingly abundant on reefs and produce nitrogenous secondary metabolites that can deter feeding by generalist herbivores such as fishes and sea urchins. Nuisance blooms of *Lyngbya* and *Symploca* occur regularly throughout Florida and on the Belizean barrier reef. In this study, we examined the function of allelopathy (chemical inhibition) in mediating the interactions between chemically rich species of cyanobacteria and different life history stages of corals including *Porites astreoides* and *Acropora palmata*. Extracts and isolated compounds (microcolins A and B, curacin D, largazole, grassypeptolide, and molassamide) from *Lyngbya* spp., *Symploca* spp., and *Dichothrix utahensis* were tested, and some compounds negatively influenced the settlement and metamorphosis of *P. astreoides* larvae and caused sublethal stress to the larvae. On reefs experiencing increased abundance of benthic cyanobacteria, the restocking of adult coral populations may be slowed due to recruitment inhibition caused by cyanobacterial natural products.

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Florida's "Redwood of the Reef": Growth, Age, Demographics and Bleaching of the Caribbean Giant Barrel Sponge, *Xestospongia muta*

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Sponges are now the dominant habitat-forming organisms on Florida's coral reefs, with one particularly prominent species, *Xestospongia muta.* We understand less about basic aspects of the biology of sponges than most other animal groups. How old are they? How fast do they grow? Are their populations increasing? What are their recruitment rates? Since 1997, my students and I have studied the demographics of over 600 giant barrel sponges, *Xestospongia muta,* in 12 permanent plots on the coral reefs near Aquarius Reef Base off Key Largo, Florida. Over a 4.5-year interval, we measured the volume of 104 tagged sponges using digital images to determine growth rates of *X. muta*. Five models were fit to the cubed root of initial and final volume estimates to determine which best described growth. The mean specific growth rate was 0.52 ± 0.65 per year, but sponges grew as fast or slow as 404 or 2% per year. Growth of *X. muta* was best described by the general von Bertalanffy and Tanaka growth curves. The largest sponge within our transects was estimated to be 127 years old, and age extrapolations for photographs of the largest *X. muta* are in excess of 2,300 years, placing this species among the longest-lived animals on earth.

From 2000 to 2006, population densities of *X. muta* significantly increased at sites on Conch Reef by a mean of 46% and on Pickles Reef by a mean of 33%. In 2006, densities of *X. muta* on Conch Reef ranged from 0.134 to 0.277 sponges/m^2, with the largest size class of sponges constituting 75% of the total sponge volume. Increased population density resulted from a significant increase in the number of sponges in the smallest size class. Recruit survival did not significantly change through time; however, a significant interaction between season and year on recruitment suggests large recruitment pulses are driving population increases. Using a stage-based matrix model, projections indicate that populations of *X. muta* will continue to increase under present conditions, but population growth may be negatively affected by continued mortality of the largest individuals from "sponge orange band" (SOB), a pathogenic syndrome.

Like other sponge species, surface tissues of *X. muta* contain cyanobacterial symbionts that give the sponge its brownish coloration. Beginning in the 1990s, two types of bleaching of *X. muta* was observed on Caribbean reefs: non-fatal cyclic bleaching, and fatal bleaching, synonymous with SOB. To determine if sponge bleaching is caused by stress, as in reef-building corals, we quantified expression of the stress indicator gene *hsp70* in healthy and bleached sponge tissue and in sponges subjected to temperature and salinity extremes. Heat-shock protein expression was higher for sponges with SOB, but not those undergoing cyclic bleaching. This and other studies suggest that the cyanobacterial symbionts of *X. muta* are commensals, rather than mutualists on which the sponge is dependent.

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Thirteen Years of Investigating Florida Keys Reefs through the Course "Diseases of Corals and Other Reef Organisms"

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Since 1997 we have taught an annual 8-day course at Mote Marine Laboratory's Tropical Research Laboratory (TRL) for 151 students, which has provided an opportunity to observe and examine diverse reef phenomena, with an emphasis on microbiology and the role of bacteria in health and disease, lecturing on the reported diseases of reef organisms, and practicing field data and sample collection. Most of the students have been professionals from state and government agencies, universities, and nongovernmental organizations in the areas of marine biology, ecology, microbiology, veterinary medicine, science policy, and coastal or reef management (49%); graduate students working on master's or doctoral degrees in similar fields (43%); and a few undergraduates (8%). Although many came from Florida universities, agencies, or offices of federal agencies (e.g., NOAA/Florida Keys National Marine Sanctuary [FKNMS], U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency), we have had students from other institutions in the United States, its territories, and possessions (79%), and from 19 other countries (21%). This course is supported by Mote's Center for Coral Reef Research, combining coral disease research and working with the FKNMS on education, public outreach and understanding of reef dynamics, reef restoration, and coral reef ecology, as well as with the Coral Disease and Health Consortium (CDHC).

During the last three decades, severe impacts to coral reef populations and communities have been reported due to diseases affecting corals, fishes, coralline algae, sea urchins, and sea turtles, sometimes with wide-ranging results. The Florida Keys have been particularly hard hit by coral diseases. Our understanding of coral diseases has changed and identification of diseases based on field signs is not sufficient. We have used this venue to explore new field and laboratory, multidisciplinary diagnostic techniques. With permits provided by the FKNMS, students have collected radial-belt transect data at Looe Key and samples from other sites of coral mucus, diseased and healthy coral tissue, microbial consortia (e.g., black-band mat), and other materials to provide hands-on training in the study of diseases using microbiological, histopathological, and molecular techniques. While too few samples have been diligently analyzed for a peer-reviewed publication, observations of new diseases based on field signs include new parasites and pathogens discovered in applying these techniques. By bringing together a bright group of students interested in the pathobiology of coral reefs each summer, a few pieces can be fit into the puzzle, or those that don't fit can be discarded, to contribute insights to help FKNMS and other reef managers develop more effective conservation strategies over time.

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Variation in the Genetic Response to High Temperatures in *Montastraea faveolata* Embryos from the Florida Keys and Mexico

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Adaptation to climate change depends in part upon the standing genetic variation present in wild populations. In corals, the dispersive larvae are particularly vulnerable to the effects of stress. Larval survival and stress-response during dispersal and settlement will play a key role in the persistence of coral populations. To test the hypothesis that larval transcription profiles reflect population specific responses to thermal stress, symbiont-free gametes of the scleractinian coral *Montastraea faveolata* were collected from Florida and Mexico and raised under mean and elevated temperatures. These populations have been shown to exchange larvae frequently enough to prevent significant differentiation of neutral loci. Differences among 1,310 unigenes were simultaneously characterized using custom cDNA microarrays allowing investigation of gene expression patterns among larvae generated from wild populations under stress. Results show both conserved and location-specific variation in key processes including energy metabolism, and response to stress, in embryos of a reef-building coral. These results provide first insights into location-specific variation in gene expression in the face of gene flow, and support the idea that restoration efforts should consider the presence of locally adapted genotypes when selecting fragments for outplanting. Efforts to similarly characterize variation in another species, *Acropora palmata*, are currently underway.

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A 50-Year Record of Linear Extension Rates in *Montastraea faveolata*, *Diploria strigosa* and *Siderastrea siderea* from the Dry Tortugas National Park, Florida

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Cores from living massive corals were collected from Dry Tortugas National Park in the summer of 2008 to assess if any changes in linear extension rates (the distance between each high density band) were related to variations in sea-surface temperature and/or ocean pH. Linear extension rates were measured using Adobe Photoshop on high-resolution (12-bit per pixel, 20 pixels per mm) X-radiographs taken from 0.5-cm-thick slabs cut from the center of the cores. Multiple paths were measured along the growth axis for each coral from 1958 to 2008.

Linear extension rates from 1958 to 2008 were 0.64 cm yr^{-1} in *Siderastrea siderea* and approximately 1.0 cm yr^{-1} for both *Montastraea faveolata* and *Diploria strigosa*. Linear extension rates in all three corals increased from 1958 to 2008; however, inter-annual variability was evident in all three records. From 1958 to 1985 linear extension rates in *M. faveolata* and *D. strigosa* were similar, but from 1986 to 2004 linear extension rates in *M. faveolata* were greater than in *D. strigosa* by ~25%. *Diploria strigosa* linear extension rates rapidly increased to > 1.4 cm yr^{-1} from 2004 to 2008, whereas linear extension rates of *M. faveolata* rapidly decreased to 0.8 cm yr^{-1} during the same time.

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The 2009 White Pox Outbreak and Recovery among Elkhorn Coral in the Florida Keys

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In epidemiological investigations, it is most unusual to observe the development, spread, and recovery from an epizootic on a previously marked host population. Such an opportunity occurred during the 2008-2009 white pox outbreak on Looe Key Reef in the Florida Keys. In 2008, 305 individual colonies of *Acropora palmata* were photographed at seven sites in the Florida Keys and the Dry Tortugas. White pox signs were absent from all survey locations in June, 2008; however, by June 2009, 44% of Looe Key *A. palmata* colonies exhibited white pox signs. We followed this outbreak with monthly surveys from June to November, 2009, and rephotographed the site in May, 2010. Disease prevalence increased to 60% by August, 2009, but began falling thereafter to 38% in September. By November, there were no active signs of the disease at Looe Key.

Disease severity (% of colony surface area affected by the disease) rose to nearly 50% for most *A. palmata* colonies. Over the six-month course of the disease, however, most of the white-pox-affected colonies regained at least some of the tissue lost prior to August, 2009. Of the 32 Looe Key colonies with white-pox in June, none had died by November. By November, whole colony recovery occurred in only 1 of the 32 colonies (2.7%); partial recovery occurred in 15 (46.9%). The remaining 16 affected colonies (50%) suffered moderate to severe net tissue loss. Some partial mortality occurred on all but one specimen, but whole-colony mortality did not occur on any. These data, demonstrating rapid recovery from white pox, are in striking contrast to previous assessments of this disease.

The 2010 resurvey revealed that 83% of colonies exhibiting significant partial mortality had white pox in 2009. Two-thirds of all colonies followed in this fate-tracking study showed substantial growth between 2009 and 2010. Colonies with white pox signs in 2009 were just as likely to exhibit substantial growth by 2010 as continuously healthy colonies. This demonstrates that even white pox-affected colonies are capable of recovery and growth.

Substantial recovery from this epizootic could be interpreted as evidence for the acquisition of resistance to white pox by Florida Keys elkhorn corals, as a decrease in virulence in the disease itself, or as a combination of both. Regardless of the reason, these data demonstrate that current white pox outbreaks are not necessarily as lethal as previous outbreaks.

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Assessing Populations of the Threatened Elkhorn Coral, *Acropora palmata,* at Horseshoe and South Carysfort Reefs within the Florida Keys National Marine Sanctuary

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Recent declines in coral reefs from across the region underscore the need for the development and validation of new scientific tools to better understand ecological patterns. Given that numerous factors are typically responsible for changes within reef ecosystems, the monitoring of reef corals must be performed at multiple spatial and temporal scales and yet still be cost-effective and statistically robust. Specifically, corals from the genus *Acropora* have experienced a drastic decline in the last few decades and both *Acropora palmata* and *A. cervicornis* have been listed as Threatened under the Endangered Species Act. *Acropora* colonies grow in thickets that are not easily surveyed and their branching morphology makes them susceptible to breakage. In addition, it has been difficult to quantify and track population declines and expansion in time and space. Accordingly, there is a need to develop a methodology tailored to survey and map these Threatened corals effectively and with minimal impact to the extant colonies.

Video mosaics are ideal tools because they provide a landscape view of the substratum so that large colonies and whole thickets can be imaged and analyzed. Specific objectives of this study include: (1) the application of an advanced two-dimensional digital video processing technique to construct geo-referenced photo-mosaics of *Acropora palmata* thickets in the FKNMS; (2) extract ecological indices of *Acropora* condition from mosaics and validate them using independent diver-based monitoring methods; and (3) assess the ability of the video-based system to systematically characterize the status and trends of *Acropora* communities. The video-based mosaic technology offers numerous advantages over traditional, diver-based video transects, producing single, plot-scale, high-resolution images that are geo-referenced and undistorted. The data presented in this study show that landscape-scale video-mosaics provide a new tool that can accurately assess the status of *Acropora* populations and provide a significant addition to traditional underwater survey techniques.

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Coral Reefs of the Lower Florida Keys (1970-1974): A Re-Analysis

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In an attempt to achieve the first ever integrated ecological view of the reefs of the Lower Florida Keys, one of us (DLK formerly of SUNY Binghamton and 11 of his graduate and undergraduate students) completed over 190 days of underwater field studies on reefs in these reefs from June 1970 to January 1974. During this 3 ½ year study, over 1,000 pages of field notes and data were compiled integrating hydrological, sedimentological and ecological elements of nine reef areas located from Looe Key to Sand Key. These data form the oldest detailed, quantitative ecological record for reefs of the Florida Keys. However, since these data were collected some four decades ago, numerous disturbances have dramatically altered the way these reefs look and function. Major disturbances have included cold water coral mortality events, significant warm-water coral bleaching events, regional coral and sea urchin disease outbreaks, and others both natural and anthropogenic. Coral cover has plummeted and in some areas the biomass and cover of macroalgae have increased. Because of the dramatic changes that have occurred, we are now performing comparative studies of DLK's original data with on-going, long-term monitoring programs within the FKNMS. The initial results of these comparative studies are striking. When completed, this project will form an accurate historical picture for the way Florida's reefs used to look and function. This "then and now snapshot" will ultimately serve as a valuable tool for restoring the reefs of the Florida Keys.

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First Report of *Acropora palmata* from the Pleistocene Key Largo Limestone

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The Pleistocene Key Largo Limestone (KLL) crops out in an arcuate pattern, forming the present-day islands of the upper and middle Florida Keys. These coral-rich limestones were formed during the last interglacial high sea-level stand of Marine Isotope Stage 5e (MIS 5e). Age determinations for this unit give an estimate of between 120 and 135 ka. The KLL was originally described by Agassiz in 1896. Since then it has been noted that all the coral species identified in the KLL are living today in the waters of the Florida reef tract. However, not all of the corals living today have been found in the KLL. These early descriptions all noted an absence of the shallow reef-crest species *Acropora palmata*, a paucity of the more thinly branching *A. cervicornis*, and an assemblage dominated by massive *Montastraea annularis, Diploria strigosa*, *Diploria labrynthiformis*, and *Porites astreoides*.

During the past five decades at least six different interpretations have been developed to explain the depositional facies and environmental setting of the KLL. The most important aspect of the various explanations has been reconciling the purported absence of *A. palmata* in the Pleistocene of Florida with an abundance of *A. palmata* found on the Florida reef tract in the recent past. Here we report the first-ever discovery of fossil *A. palmata* from the KLL. Outcrop samples from two locations, both in northern Key Largo, reveal *A. palmata* in reef crest positions. This discovery confirms that the location and orientation of the reef tract during the formation of the KLL was in the position of the present day islands that form the spine of the Florida Keys. This KLL “barrier reef tract” separated a large shallow carbonate platform to the north and west (Gulf of Mexico) from the open Atlantic (Straits of Florida) to the south and east.

Because of the varying descriptions as to the origin of the KLL, the known life-history strategies employed by *A. palmata,* the sensitivity of this coral to extreme temperature fluctuations, and the expansion and contraction of this species range in time and space along the Florida shelf, we are certain that this discovery will re-invigorate the debate as to the mode of formation of the KLL and shed new light on the surprising persistence of this coral.

Finally, the last interglacial period has been cited as a possible analog for future climate and rapidly changing sea levels. Thus, understanding the response of individual species of reef corals in the KLL to changing environmental conditions during MIS 5e may hold a key to predicting the future of corals and coral reefs in a rapidly changing world. This discovery could help in this regard.

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Historical Reconstruction of Population Density and Size Structure of the Echinoid *Diadema antillarum* on Florida Keys Shallow Bank Reefs

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The 1983-84 Caribbean-wide mass mortality of the long-spined sea urchin *Diadema antillarum* Philippi was followed by a second mortality event in the Florida Keys in 1991. The demise of this once ubiquitous echinoid is considered one of several factors responsible for the changes observed on Florida Keys reefs, yet there is a paucity of data to ascertain pre-mortality densities. Pre-mortality urchin and habitat surveys were conducted during 1970-72 on nine reefs in the lower Keys with shallow (< 6 m) spur and groove topography. Quadrat data collected at one of these reefs (Middle Sambo) during 1972 yielded densities as high as ~6 individuals per m^2, comparable to values reported for many wider Caribbean reefs. By the early 1990s, densities at the same reef were one-tenth this level, but apparently recovering from the 1983 mortality event before a second mortality event began in April 1991. By 1992, *D. antillarum* densities were two orders of magnitude lower and remained so through 2009, although maximum sizes of individuals are increasing. Although total algal cover remains high as of 2009 relative to total stony coral cover (mean = 4.2%, range of 1.1-8.5%) among nine reefs, the algal assemblage is dominated by diminutive algal turfs (mean = 68.5%, range of 50.9-86.3%) and crustose corallines (mean = 2.8%, range of 0.8-10.6%) instead of macroalgae (mean = 11.7%, range of 2.3-19.3%). While *D. antillarum* has been recovering rapidly at many sites throughout the Caribbean over the past decade this has not occurred in the Florida Keys. Possible explanations for the relatively slow recovery of *D. antillarum* to pre-1983 densities include poor larval survivorship, high predation, lack of suitable recruitment sites, and/or reduced fertilization success.

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Seascape-Scale Approaches to Restoring Coral Reefs and the Future of Restoration in the Florida Keys National Marine Sanctuary

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Although the specific goal of reef restoration is to restore the ecological function of the system, a seascape-scale approach is needed to ensure the successful integration of restored sites into the ecosystem as a whole. This approach can ensure that stressors to the reef ecosystem are removed or accounted for and that critical ecological processes have been successfully introduced. To date, however, most restoration programs in the FKNMS have concentrated on reconstructing the reef structure at specific injured sites. One of the missing links to the restoration process has been the lack of an active live coral restoration program following site rehabilitation. Specifically, the reintroduction and reestablishment of the corals lost in the injury. New techniques in offshore coral husbandry and aquaculture are now allowing for significant transplantation of cultured, sub-adult coral colonies at the seascape scale. Numerous pilot projects with the ESA listed Threatened corals *Acropora palmata* and *Acropora cervicornis* performed within the Sanctuary have yielded significant, positive results and these projects continue to grow in size and scope. One such project is an on-going, large-scale (>1,000 colonies) *Acropora* transplantation effort at the Wellwood restoration site at Molassess Reef. Combining lessons learned from past projects and using these in conjunction with new methods are forging new and exciting directions for reef restoration within the FKNMS.

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Protecting Everglades Resources: Conserving Water Quality

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In this study, we have focused on reintroducing native plant populations and investigating their ability to prevent sediment loss. Previous research on vegetative buffer strips (VBS) suggests that VBS reduce agricultural nonpoint source pollution inputs into adjacent water bodies. We investigated changes in vegetation composition of different grass buffer strips in a fragmented coastal agricultural landscape to evaluate the potential for native grass restoration of sites that receive agricultural runoff. We compared the effectiveness of VBS containing native perennial grasses and non-native annual grasses at capturing sediment and particulate-bound nonpoint source pollutants from conventional row-cropped agriculture and preventing erosion.

Vegetative buffers bordering Elkhorn Slough, draining into Monterey Bay, California, were seeded with grasses to test if they would establish, survive and become effective at reducing sediment loss and prevent the associated sediment-bound pollutants from entering receiving water bodies. Species seeded included: 1) native perennial grasses (a mix of *Nassella pulchra, Bromus carinatus* and *Deschampsia cespitosa)*, 2) non-native annual barley grass (*Hordeum vulgare*), and 3) an unseeded treatment consisting of volunteer weedy vegetation. We present data on VBS effectiveness in plant survival, biomass, rooting depth, gully formation, and sediment capture.

Our results suggest that some species of native perennial grass can establish on former agricultural lands, but long-term survival may be difficult without extensive management. We evaluate our results and link them to environmental management recommendations to guide VBS composition and maximize its effectiveness. Morphology of the plant was important in sediment capture and rooting depth was important in nutrient uptake. Longevity of the species is an important consideration for long term restoration goals.

In the sediment transport study, gully erosion rates were significantly affected by VBS composition. Native perennial grasses were most effective in the second year at trapping sediments originating from the agricultural field, measured as deposition. Timing of vegetation establishment, rainfall intensity and slope steepness were important factors influencing sediment loss. We conclude by examining sediment deposition into receiving water bodies, such as ports and rivers and provide environmental management strategies for dredging those sediments and the potential beneficial uses of that dredged material.

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Microbial Interactions on Coral Surfaces and their Role in Coral Health

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Microbial communities associated with aquatic and terrestrial animals play important roles in health and nutrition of their hosts, and thus ultimately contribute to the stability of the entire ecosystem. In coral reef ecosystems, microorganisms contribute to cycling of nutrients and they produce antimicrobials capable of inhibiting bacterial pathogens. Distinct bacterial communities appear to be associated with corals of the same species across depth and spatial gradients, suggesting that microbial assemblages on coral surface and endolith are fairly specific to different coral species. Even though we are beginning to catalogue the taxonomic diversity of coral-associated microbes and recognize the important roles they play in stability or decline of coral reef ecosystems, we know little about how interactions between coral hosts and their associated microbiota are initiated and maintained. Here, we report that a coral pathogen *Serratia marcescens* was able to efficiently colonize mucus surfaces of the host coral, *Acropora palmata.* Some native coral associated micro-organisms were able to interfere with the ability of the pathogen to utilize coral mucus and attach to it. The mechanism of this inhibition is due, at least in part, to their ability to inhibit enzymatic activities in the pathogen and to disrupt cell-to-cell signaling. Further characterization of the native coral-associated microbiota and their interactions with the invading pathogens will help develop better management strategies for promoting coral health and stability of the reef ecosystems.

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Towards a Better Understanding of Coral Recruitment

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As coral reefs continue to be degraded by multiple stressors, one critical process for recovery is coral recruitment. Successful recruitment involves three life history stages that are necessary for new corals to be added to a population: larval supply, larval settlement, and post-settlement survival and growth. Our recent research has tested which benthic species facilitate or inhibit coral larval survival and settlement. Work with crustose coralline algae showed that some species, such as *Titanoderma prototypum* or *Hydrolithon boergesenii* facilitated larval settlement for a variety of coral species. Some macroalgae, including *Dictyota* spp. caused larval mortality and inhibited coral settlement. In some cases these competitive interactions were driven by the secondary metabolites found in these macroalgae. A better understanding of how benthic species influence coral larval ecology will help us to set management criteria for increased coral recruitment.

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Thirty Years of Change in Reef Fish Communities in the Florida Keys: Results from a Long-Term Monitoring Program

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The Florida Keys contain a suite of ecologically and economically important communities, but there are increasing indications that these communities have been dramatically altered by human activities. Historical ecology has documented declines in a number of measures of ecosystem condition in the Keys, including declines in trophy fish size and abundance and loss of live coral cover. Many of these findings mirror those in other systems, and provide powerful approaches to address broad questions and large changes over extensive spatial and temporal scales, but they can lack the precision of more traditional ecological data sets. As the management focus in marine systems is increasingly shifting to more holistic approaches and ecosystem-based management, more precise data on the status and trends of whole communities are needed. Fortunately, a program to evaluate the status trends of reef fish communities in the Florida Keys was initiated in the late 1970s and has continued annually since 1979 with consistent survey methodology.

This study uses these data from the long-term reef visual census (RVC) reef fish monitoring program to examine trends and changes in reef fish communities over the past 30 years. Because these data have been collected using a consistent methodology, they give us a unique opportunity to examine large scale temporal changes in reef fish communities throughout the Florida Keys. We found a variety of individual trajectories for different species and different functional groups over this time period, including significant increases and decreases in abundance and frequency of occurrence. Despite the variety of single-species patterns, multivariate analyses demonstrated that reef fish communities have been changing in clear and consistent manner over the past 30 years.

Our data suggest as number of different hypotheses to explain observed patterns, including 1) loss of live coral reef habitat and decline of species directly or indirectly dependent on live coral as habitat; and 2) slight recovery of the most heavily targeted commercial species, likely resulting from the combination of marine protected areas and increased fishery management regulations. However, despite the increase in abundance of some commercial species, the Florida Keys is still a heavily exploited ecosystem that will require continual improvements in management and a long time frame to restore ecosystem functions of these reef fish communities.

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Long-Term Changes in Benthic Community Composition Observed by CREMP in the FKNMS

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The Coral Reef Evaluation and Monitoring Project (CREMP) is part of the EPA Water Quality Protection Program for the Florida Keys National Marine Sanctuary (FKNMS). The goal of this project is to utilize broad spatial coverage, repeated sampling, and statistically valid findings to document status and trends of coral reef communities within the Sanctuary. Sampling site locations were chosen in 1994 using a stratified random sampling procedure according to the EPA Environmental Monitoring and Assessment Program (EMAP). Spatial stratification initially included four habitat types; nearshore hardbottom, patch, and shallow and deep spur and groove reefs in three regions; Upper, Middle, and Lower Keys. A total of forty sites were installed in 1995 with three additional sites installed in the Dry Tortugas in 1999. Each site consists of two to four monitoring stations delineated by permanent markers. Stations are approximately 2 x 22 meters. Within each station, field sampling consists of species richness surveys; three 22m x 40cm video transects, and targeted benthic surveys. Over time stations and hardbottom sites were removed from the sampling effort without compromising the project's ability to statistically detect change. This presentation highlights results from 109 stations at 37 sites sampled from 1996 and 1999 through 2009 in the Florida Keys and Dry Tortugas, respectively. Long-term trends in benthic cover (stony corals, macroalgae, octocorals, and sponges) from 1996-2009 were identified using generalized mixed model regressions (to account for repeated sampling and numeric variability of stations across sites) on square root transformed percent cover data pooled for each station. The overall trend for mean percent cover of stony corals and sponges has significantly declined; octocorals has significantly increased, and no change in macroalgae has been observed. In the Florida Keys, coral cover has declined ~41% from 12.3% in 1996 to 7.3% in 2009. Since 1999, following the mass bleaching of 1997 and 1998, a declining trend in cover is most apparent at sites in the Lower Keys and Dry Tortugas regions, where 84% of all sites showed a decreasing trend. In contrast, eight of the nine Atlantic patch reefs showed no difference in cover over the last 10 years. Macroalgae has been highly variable but mean cover appears to be ~11% averaged for all years. Octocoral cover has been steadily increasing after reaching a low point in 1999. Octocoral cover has significantly increased at 54% of sites since 1999. This pattern is most evident at the shallow spur and groove sites. Ten of 12 shallow forereef sites demonstrate a strong positive trend ($p<0.001$) in octocoral cover and the increase in cover may coincide well with the loss of *Acropora palmata* and *Millepora complanata* from these habitats. Although sponges provide the smallest contribution to biotic cover, sponges have shown a negative trend since 1996. Multiple stressors have contributed to the observed changes in benthic cover during the last 14 years. Acute disturbances such as the mass bleaching event of 1997 and 1998, hurricanes, and periodic disease outbreaks are the most notable causes of declines but not all habitats or regions appear equally affected. Specifically, shallow spur and groove habitats appear to be undergoing a phase shift toward soft coral dominated communities while patch reefs appear more resilient to stressors that have caused extensive coral mortality in other habitats.

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Hydro-Physical Characteristics of Selected Media Used for Containerized Agriculture Systems in South Florida

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Considering the three national parks (Everglades, Biscayne and Big Cypress) in south Florida, a major challenge for managing a profitable and sustainable agricultural system is maintain environmental quality. Florida is the second leading horticulture state in the United States with greenhouse/nursery sales of more than $1.6 billion annually. Containerized plant production represents an extremely intensive agricultural practice with large amounts of water and fertilizer application. Hydro-physical characteristics such as water infiltration, texture and structure, particle size distribution affect the quality of the media used in containerized agricultural systems and the water availability to plants. Characterization of the plant growing media can allow modeling of soil-water interactions and development of best management practices for more efficient use of water and agrochemicals by nurseries. The objectives of this study were to characterize the selected hydro-physical properties of plant growth media that are commonly used by nurseries near the Everglades National Park in South Florida. Experimental analyses were performed to characterize the plant growth mixtures in terms of particle size distribution and hydraulic conductivity using three different methods (i.e., constant head permeability, falling head permeability test, and tension infiltrometer test). The results were analyzed in relation to particle size distribution characteristics of the samples. These hydro-physical characteristics could assist development of Best Management Practices (BMP) for containerized agricultural systems for more efficient management of irrigation water and agrochemical use.

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Monitoring and Mapping of Threatened Acroporid Corals in U. S. Jurisdiction: Development of a Multi-State Conservation Program

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Following established *Acropora* spp. monitoring protocols (Williams et al. 2006), this collaborative effort will provide cross-jurisdictional, comparable monitoring data for *Acropora* spp. Standardized quarterly demographic and synoptic surveys of *A. palmata* and *A. cervicornis* will be conducted by the regional Principal Investigators at 50 sites throughout the northernmost range of the species off the southeast Florida coast (Broward County), throughout Biscayne National Park, the Florida Keys National Marine Sanctuary and the Dry Tortugas, to the U.S. Virgin Islands and Puerto Rico. This work, which has been successfully funded by NOAA as an Endangered Species Act Project, will identify and fill data gaps on the demographics of *Acropora* spp. throughout U.S. jurisdiction, and will expand existing *Acropora palmata* monitoring efforts currently conducted in the Florida Keys. Additional synoptic efforts to map critical habitat for *Acropora palmata* and its congener *Acropora cervicornis* will provide researchers and managers with readily accessible data in a usable format for informing management decisions, as all fate-track, synoptic, photographic, and critical habitat mapping data will be uploaded to a publically-available electronic database to be maintained at Florida Fish and Wildlife Institute (FWRI). The goal of these actions is to assist managers in assessing the species' status and promote their recovery. In lieu of a final National Marine Fisheries (NMFS) Recovery Plan, the demographic monitoring, synoptic surveys and mapping will address the focal areas in the NMFS Recovery Strategy Outline. Specifically, data collected will fill gaps on distribution and abundance, and by using one established monitoring protocol, will provide directly comparable data for individual colonies to estimate threat prevalence, threat impact and change in colony size. This program will also provide data for management of these threatened corals newly added to the Florida Section Six Program and FWC's State Wildlife Action Plan, which has designated coral reef a priority habitat.

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Using Early Life Stages of Hard Corals to Understand Coral-Bacterial Relationships

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Hard corals harbor diverse, complex assemblages of bacteria in their tissues and on their surface mucus layers. The staggering diversity of bacteria in adult corals makes it challenging to identify the extent to which coral-bacterial associations are species-specific, to determine how stable these bacterial communities are, and ultimately, to assess what role bacteria play in coral health and fitness. Our studies show that characterization of bacterial diversity in early life stages may be more tractable and informative. In the work we present here, we are using early life stages of corals (gametes, larvae, and juvenile recruits) to address major questions in the microbial ecology of hard corals. We determine the timing of onset of bacterial-coral associations in several species of hard corals from the Florida Keys; we demonstrate that the coral *Porites astreoides* maintains consistent, specific associations with certain bacterial groups by transmitting them to offspring via larvae; and we show that certain bacteria play a role in coral larval behavior and settlement. In a survey of brooding and broadcast spawning corals from the Florida Keys, we show that the onset of coral-bacterial interactions occurs first either in swimming larval (planula) stages, or after the larvae have settled and developed into juvenile polyps. In contrast, the live brooding coral *Porites astreoides* transmits bacteria to offspring via its larvae, and bacteria are associated with the ectoderm layer during swimming larval stages. After settlement, bacteria are present around the newly forming septa of the developing polyps. DNA-based analyses show that at least two species, belonging to the genera *Roseobacter* and *Marinobacter*, are consistently detectable throughout all tested *P. astreoides* larval specimens. These specimens represent multiple early *P. astreoides* developmental stages, three collection locations in the Florida Keys, and four collection years. This demonstration that bacteria are transmitted from parent colony to offspring, and that a few bacterial taxa are consistently and stably associated with *P. astreoides* against a complex, dynamic background of microbial associations, suggests that at least some components of the microbial community found in *P. astreoides* are indigenous and likely impact host health and survival. We assayed the influence of coral-associated bacterial cultures on *P. astreoides* larval settlement. These cultures, which include a *Marinobacter* strain and a *Roseobacter* strain isolated from corals, significantly increase *P. astreoides* larval settlement success rates. Our results suggest that corals interact with bacteria at their earliest stages, and these bacteria may have profound affects on coral fitness and overall ecosystem health. Improved understanding of the nature of coral-bacterial associations will lay the foundation for informed, effective management in the face of global climate change and as bacterial diseases in corals pose an increased threat to the Florida Keys marine ecosystems.

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IMPACT – A Climate Assessment Resource for the Florida Keys

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A difficulty in any assessment of climate change impact is extracting the climate change signal from the climate record for a location and relating it correctly to complex ecosystem responses. Without a comprehensive understanding of the rate, magnitude and behavior of the changes in both environment and ecosystem, it is difficult to quantify a comparison between a changing climate and attributed impacts. Unfortunately, the core of climate change knowledge exists at the global and regional scales, while what is needed is information at sub-regional scales. To address this, output from global or regional scale computer models may be downscaled to provide future climate scenarios at a local scale. However, the scenarios are largely meaningless without a clear understanding of the existing climate as a baseline for comparison. We discuss the steps taken to develop a comprehensive, baseline climatology for the Florida Keys National Marine Sanctuary and surrounding areas, which combines atmospheric, oceanic and ecological data to provide a starting point for evaluating climate impacts, and thereby establish a context for quantifying impacts under future climate scenarios. This climatology forms the basis of an evolving climate stress decision tool for managers of marine protected areas (the Integrated Marine Protected Area Climate Tool, or IMPACT), and is being developed with the Florida Keys National Marine Sanctuary as the pilot area.

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Benthic Habitats of the Florida Keys and Reef Tract

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A highly detailed map of the Florida Keys and shallow shelf, compiled from interpreted high-quality aerial photomosaics and more than 100 years of combined experience and ground truthing between the authors, depicts regional onshore and offshore habitats in a 3,140.5-km^2 area. The mapped area extends from north Key Largo to the Marquesas Keys in the Gulf of Mexico and from the seaward edge of Florida Bay to a 40-m-deep upper-slope terrace at the toe of the shelf margin. The most extensive seabed habitat (27.5%) is one of seagrasses and lime mud in Hawk Channel, followed by patchy seagrasses on carbonate sand (18.7%), and patchy bare carbonate sand (17.3%). Both patchy habitats are found on the outer shelf and in The Quicksands west of the Marquesas Keys.

The geologic record as derived from coral cores and seismic profiles shows that corals thrived shelf-wide in the past and accreted cumulative reef structures of ~30 m in seismic relief during the Pleistocene. Holocene accretions average ~2 m. The habitat map demarcates present sites of live coral patch reefs (0.7%) and senile or non-accretionary coral reefs (2.2%). The two habitats combined indicate that less than 3% of the entire reef tract mapped consists of live corals today.

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Fifty Years of Serial Photos Depicting Coral Growth and Decline

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Select corals at Carysfort Reef and Grecian Rocks reef, first photographed in 1960, have been photographed annually for the past 50 years through 2010. Only 2 years in the mid-1960s were missed. The underwater photographs depict healthy heads of species of *Montastrea, Diploria,* and *Colpophyllia* and document rapid expansion of fast-growing *Acropora cervicornis* in the 1960s and early 1970s. These events were followed by total collapse between 1983 and 1984. The serial photographs also depict ongoing demise of the same heads of *Montastrea*, *Diploria*, and *Colpophyllia* during the 1990s.

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From Jurassic Park to the Conch Republic

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The Florida Keys ride atop a giant limestone plate that detached from what is now Africa and Europe during the Jurassic Period ~200 million years ago. The giant continent, “Pangaea,” split apart, creating a rift that has become the ever-widening Atlantic Ocean. As the plates that now contain Florida and the Bahamas drifted apart, they also slowly began to sink into the underlying molten basalt. While drifting, the plates thickened with addition of lime sediments produced in overlying sunlit marine waters. Numerous lime-secreting organisms, including corals, continued to accumulate on the settling plates, causing their surfaces to accrete upward. Oil test wells at Newfound Harbor and the Marquesas Keys revealed limestone thicknesses >15,000 ft.

Of more immediate interest to marine scientists are the much younger geologic events of the past 1.5 million years, the time span in which the Florida Keys evolved. Bathed by the warm Florida Current, corals grew rapidly, relative to geologic time, along the arcuate windward margin of the Florida Platform. Growth and sediment production were intermittent, however. Productivity ceased periodically as sea level fell and exposed the platform and shelf for long periods. At times, sea level dropped as much as 400 ft when Polar ice caps expanded, drawing up ocean waters. Then ~125,000 years ago, the sea rose as much as 26 ft above present when the ice caps melted. What is now the upper and middle Florida Keys was a flourishing coral reef and the lower Keys were tidal bars of lime sand. Since then, global sea level has fluctuated at least four times and dropped more than 300 ft during its most recent fall. By 18,000 years ago, sea level was on the rise again and re-submerged the Florida shelf from ~8,000 to 6,000 years ago, the time when growth of corals, mollusks, and sediment-producing plants on the modern reef tract began. In some locations, accumulations have kept pace with the rising sea. Lighthouses stand on many such topographic highs that are at or just below present sea level. By 3,000 years ago, the area of the Everglades that existed west of the Keys gradually flooded and formed Florida Bay and tidal passes of the lower Keys. Sea level continues to rise today, moving the northern shore of the bay ever northward. The sea has risen as much as 1 ft at Key West (the “Conch Republic”) during the past 100 years. Nothing indicates that sea level will not continue to rise and repeat events of the geologic past. However, over much of the reef tract, reef growth has slowed in the last 2,000 years or has been intermittent. During the past 30 years, greatly reduced reef growth has been documented, not only in the Florida Keys but also throughout the greater Caribbean. The causes of decreased productivity and increased diseases during historical times have been varied and are scientifically controversial. It is with this geologic past and widespread natural waxing and waning of reef evolution that reef-management personnel must contend to determine how much, if any, of the observed degradation is man-made and can be mitigated.

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A 10-Year Replication Study of the Florida Keys Commercial Fishing Industry, Dive Operations, and Selected Environmental Groups on Their Knowledge, Attitudes, and Perceptions (KAP) on the Effectiveness of the Florida Keys National Marine Sanctuary (FKNMS) Management, Regulatory, and Zoning Strategies

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This study replicated a 1995-96 baseline study on the knowledge, attitudes, and perceptions (KAP) of the then proposed Florida Keys National Marine Sanctuary (FKNMS) management strategies and regulations of three main stakeholder groups. Conducted from 2004-07 with a representative sample of commercial fishers, dive operators, and selected environmental group members, the 10-year replication study made comparisons on the previous baseline use, understanding, and expectations of FKNMS management strategies and regulations, and the study established a new baseline for future monitoring efforts. The replication study obtained information on the socioeconomic/demographic profiles of each stakeholder group, the sources of information and the perceived usefulness of information on the FKNMS, attitudes towards the FKNMS management strategies and regulations, views on the FKNMS zoning strategy and its outcomes, and support for the FKNMS.

The project findings showed that support for various aspects of FKNMS management had increased among the commercial fishing community, with a shift from a majority of commercial fishers stating opposition to FKNMS management approaches in 1996 to a plurality starting support or maintaining a neutral position to FKNMS management approaches in 2007. Also, while a plurality of commercial fishers still did not support the FKNMS zones, the level of support increased significantly between the two baseline studies. By contrast, a majority of dive operators and environmental group members supported the FKNMS zoning strategy in both baseline studies. A plurality or greater among all three stakeholder groups believed that the Florida Keys environment and economy had both benefited from the FKNMS, and while none of the groups agreed that the FKNMS zones had been effective in restoring the region's coral reefs, the groups acknowledged that reef conditions are driven by factors outside the control of the FKNMS. Finally, most stakeholders in all three groups felt that the FKNMS had made a difference in improving certain conditions in the archipelago, ex., by implementing the mooring buoy program and addressing vessel groundings, and that most resource conditions had not deteriorated since the establishment of the FKNMS.

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Human Dimensions and the Florida Keys National Marine Sanctuary (FKNMS): Reflections of Two Decades of Change in the Wider Socioeconomic Environment and Stakeholders in the Florida Keys

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In the twenty years since the designation of the Florida Keys National Marine Sanctuary (FKNMS), stakeholder participation in and views concerning the FKNMS have changed considerably. Results from socioeconomic monitoring and replication studies demonstrate greater support for the FKNMS and its management strategies since its designation. Over the same time period, profound shifts have occurred in the Florida Keys, in terms of the region's demography, economy, and culture. To better understand the reasons for changes in stakeholder uses in and attitudes on the FKNMS, it is important to consider the wider socioeconomic environment and its complex interactions with the physical environment, especially on how non-FKNMS issues - as related to fishery management, waterfront availability and uses, housing and cost of living issues, and the rise of a tourism monoculture - have influenced and indeed shaped views on resource protection and management. Thus, results from stakeholder studies on FKNMS issues reflect as much the changes in the socioeconomic environment as they do the efficacy of the management strategies.

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Larval Reef Fish Assemblages in the Florida Keys and the Influence of Mesoscale Eddies

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Mesoscale eddies are a dynamic component of the hydrographic system of the Florida Keys (FK). The passage of these oceanographic features through the Straits of Florida is accompanied by upwelling and increased primary productivity. Eddies have also been implicated in delivering large pulses of fish larvae to FK reefs, though they can also transport larvae away from the reef tract. In addition to their role in transporting larvae, the high productivity and retention potential of mesoscale eddies suggest that they may serve as essential larval habitat. Yet there is an absence of empirical data on the distributions and growth rates of larvae associated with these significant features. The objective of this study is to characterize distributions and abundances of reef fish larvae in the context of their physical environment to gain insight into the role of mesoscale eddies in larval growth and population replenishment. Ichthyoplankton samples and physical data were collected during three cruises on the R/V Walton Smith. Satellite imagery, a shipboard ADCP, satellite-tracked drifters, and stationary current meters were all used to locate and describe eddies that were present in the FK during our sampling effort. Each sampled water mass was associated with a distinct larval assemblage. Taxon-specific larval distributions were variable across a large eddy during the second cruise. Length and age distributions of larvae in and around the eddy as well as differences in daily growth allow us to test the contributions of eddies to larval survival. A greater understanding of larval distributions and growth in relation to the dynamic physical environment in the FK is critical to elucidating the role of mesoscale eddies in population replenishment.

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Population Connectivity of Coral Reef Fishes along the Florida Keys Shelf: An Integrated Field and Modeling Analysis

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Population replenishment of reef fishes in the Florida Keys is an oceanographically complex process. Our interdisciplinary study is designed to integrate empirical data on larval age-specific distributions into a coupled particle-tracking individual based model and high-resolution hydrodynamic model to quantify the relative contributions of upstream versus local sources of reef fish larvae to the Florida Keys. These transport results are then compared to field collections of settling larvae and recruited juveniles. During three summer cruises, we sampled ichthyoplankton on multiple cross-shelf transects, both along and well upstream of the Keys. Transects extended from inside the reef tract out into the Florida Current front and intercepted ephemeral mesoscale frontal eddies. Settling larvae and recruited juveniles were sampled simultaneously during and following each cruise at two locations in the upper and lower Keys. Cruise results indicate that reef fish larvae were most abundant in the mid-shelf and offshore regions compared to the near-reef region. Larval settlement to the lower Keys consistently exceeded that to the upper Keys, reflecting more recirculation of shelf water in the lower Keys as captured by the hydrodynamic model and predicted by the biophysical model. Analysis of otoliths and condition indices of pelagic and settlement-stage larvae and settled juveniles are being used to test whether growth and condition varies among larvae in different water masses, and to identify characteristics of survivors. These data will be incorporated into the transport history of the larvae from the coupled biophysical model to hindcast and forecast the probabilities of spawning sources and successful settlement areas.

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Geomorphology and Paleoecology of Holocene Coral Reefs from the SE Florida Shelf

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The southeastern US Florida shelf is a well studied coral reef region that has been used in the development of western Atlantic/Caribbean sea-level curves and examinations of Pleistocene and Holocene coral reef geomorphology and paleoecology. The SE Florida continental reef tract and the better studied Florida Keys reef tract located further south are situated on the shelf. Coral reefs variably accreted throughout both tracts during the Holocene to the present day. Dynamic local and regional reef terminations, backstepping, and re-initiation have occurred in response to climate-induced sea-level rise and subsequent flooding of structures conducive for reef growth. The SE Florida continental reef tract is a ~125 km long Holocene fringing/barrier coral reef complex, composed of three shore-parallel linear reefs ('outer', 'middle', and 'inner' reefs) of varying age. Few detailed stratigraphic/geologic descriptions exist when compared to the Florida Keys reef tract, thus reef cores were extracted to further analyze its composition, taphonomic characteristics, ^{14}C ages, and Holocene accretion history. Results suggest that the outer reef accumulated from ~10.6–8.0 ka cal BP, the middle reef from at least ~5.8–3.7 ka cal BP, and the inner reef from ~7.8–5.5 ka cal BP. The outer reef is better developed than the inner reef, and the middle reef may not have any appreciable framework buildup at all. A lack of significant age overlaps and new data from this study confirm that reef backstepping from the outer to the inner reef occurred within a few hundred years after outer reef termination. Similar spatial and temporal scales of Holocene reef backstepping were reported from Puerto Rico and St. Croix. We also observed that the Caribbean reef builder *Acropora palmata* was present but not always dominant throughout the majority of the Holocene on both reef tracts. Geomorphology of reefs was strongly determined by the dominance and length of presence of this species, with the size and shape of reef bodies clearly reflecting its declining importance throughout the Holocene in Florida. Perceived gaps in reported ^{14}C ages are most likely artifacts of limited sampling and emphasize the need for more precise sampling and dating. Large-scale geomorphic and ecological changes to Florida's Holocene coral reefs occurred on at least centennial timescales and were largely dependent on the rate of sea-level rise and availability of colonizable substrate.

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Foraminifera Assemblages on Reef Rubble vs. Sediments on Conch Reef, Florida Reef Tract

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Benthic foraminiferal assemblages are widely used to illuminate responses of the benthic communities to environmental stresses or conditions, including, temperature, anthropogenic pollutants including nutrient input, changes in salinity and solar radiation. Studies of larger reef-dwelling foraminifers have revealed their utility in all subtropical/tropical oceans. Foraminifers have been even more widely used as biostratigraphic and paleoenvironmental indicators because their shells are commonly preserved in sediments and sedimentary rocks. An understanding of how the total fossil assemblage differs from the living assemblage is essential for informed paleoecologic reconstructions, including interpreting recent environmental changes as reflected in sediment cores.

Our study compares epibiotic foraminiferal assemblages with those from sediments at Conch Reef, Florida reef tract. Conch Reef is the site of the Aquarius underwater habitats research facility and includes areas protected and used only for scientific studies. Taxa with more robust shells tend to be more common in well sorted sands while smaller taxa are in finer sediments. Attached taxa are much less common in the sediments than attached to hard substrata; attached taxa tend to be much more common in sediments where seagrass and other macriphytes provide temporary substratum. The sediment-rubble assemblage comparison will contribute to the ongoing debates concerning how representative assemblages from sediment samples are of overall assemblages in an area and specifically what taxa tend to be over- or under-represented in reef-sand samples. In addition a species list will be compiled that will contribute to biodiversity assessments for Conch Reef and the Florida reef tract.

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Multispecies Survey Design for Assessing Reef-Fish Stocks, Spatially-Explicit Management Performance, and Ecosystem Condition

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In southern Florida, the coral reef ecosystem supports lucrative fishing and tourism industries. Management concerns over the productivity of reef-fish stocks include non-sustainable rates of exploitation for target species, the impacts of fishing on ecosystem trophic structure, and non-fishing human threats from habitat and water quality alterations. To alleviate these threats, resource managers have enacted regulatory measures ranging from traditional fishing quotas and size limits to spatial zoning, including no-take marine reserves (NTMRs). Principles of statistical sampling design were used to develop and conduct an annual-biannual fisheries-independent diver visual survey of species composition, population abundance and size structure of exploited and non-target fishes in the Florida coral reef ecosystem. The survey was tailored to provide data to: (1) support multispecies stock assessments; (2) evaluate the effectiveness of NTMRs and other spatially-explicit management issues; and, (3) estimate metrics of ecosystem condition of the reef fish community.

Reef habitat features (e.g., rugosity, depth) were used to partition the 885 km^2 sampling domain into sub-areas or strata of low to high variance of fish density. Spatial management zones were incorporated as a second stratification variable. Sampling effort was spatially allocated according to both stratum size and stratum variance of fish density. Sampling efficiency of the stratified random design was improved over time via an iterative learning process by which past survey data was used to refine the stratification and allocation schemes of future surveys.

For the period 1999-2008, estimates of coefficient of variation (CV, standard error expressed as a proportion of the mean) for population density and abundance ranged from 7% to 20% for 9 of 13 principal exploited species in the Florida Keys region and for 7 of 13 species in the Dry Tortugas. Estimates of average length of the exploited life stage, a population sustainability metric, were comparable between our fishery-independent survey and fishery-dependent catch-sampling in the southern Florida region, suggesting that our visual survey is sampling the same reef-fish stocks as the commercial and recreational fisheries. Although the survey design focused on exploited species, it also performed well for principal non-target species of the reef-fish community, yielding CVs of population density between 6% and 15% in the majority of cases (27 of 36 species) during 1999-2008. The spatial framework of the survey design enabled evaluation of population-wide effects of NTMRs as well as local, inside-outside effects. Our findings suggested that a better understanding of fish-habitat relationships may improve the performance of future surveys via more effective stratification schemes.

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Survival of the Fittest: A Comparative Assessment of Heat Stress on *Montastrea cavernosa* from the Florida Keys *versus* the Flower Garden Banks National Marine Sanctuary

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Globally, climate change is causing increasing sea water temperatures and subsequently, resulting in corals world-wide to bleach. We hypothesize that coral exposed to short durations of repetitive events of high heat stress are better adapted than corals lacking similar experiences. In this study, we compare populations of *Montastraea cavernosa* (Linnaeus, 1767) from the Florida Keys National Marine Sanctuary (FKNMS) to coral from the Flower Garden Banks National Marine Sanctuary (FGBNMS). Coral from the FKNMS are known to experience frequent annual events of high temperatures, whilst coral from the FGBNMS have had fewer exposures to anomalous temperatures.

In this study, coral fragments ~2.5 cm^2 in size were collected from both locations and exposed to temperatures of 27ºC, 31ºC, and 35ºC for 72 h. Every 6 h, sampling consisted of collecting live, dead, and mitotic expelled zooxanthellae cells. Cells were examined using a light microscope to determine zooxanthellar density, mitotic index, and viability. Flow cytometry was also used to differentiate between four cell death categories: viable, necrotic, apoptotic, and post-apoptotic.

Statistical analysis consisted of a Model I, repeated-measures, three-way orthogonal experimental design. All data were tested for significant variation due to sphericity using the Greenhouse-Guyser or the Huynh-Feldt correction. Since the data lacked sphericity, Tukey's and Games-Hollow *post hoc* tests were applied after analysis *via* GLM repeated measure ANOVAs to examine differences between individual means. Data displaying significant variations over time were Bonferroni-corrected.

Here, coral collected from the FKNMS lost significantly (ANOVA; $p < 0.01$) fewer viable, dead, and/or necrotic symbiont cells across all experimental temperatures than coral from the FGBNMS. The mean percentage of viable expelled cells observed at 35ºC was significantly lower than those at 27ºC and 31ºC ($p < 0.05$, Games-Hollow *post-hoc* tests). The mean percentage of necrotic cells expelled was greatest at 35ºC ($p < 0.01$, Games-Hollow *post hoc* test) culminating in the greatest loss (40%) within 24 h. There was no significant variation in the loss of apoptotic or post-apoptotic (ANOVA; $p > 0.05$) cells between temperatures or time.

Our data indicated that *M. cavernosa* from FKNMS may be less susceptible to heat stress and bleaching than coral at the FGBNMS. We speculate that this 'fitness' is a regional adaptation likely associated with numerous temperature anomalies.

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Spatial Dynamics of Scleractinian Coral Populations in the Florida Keys

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Natural and anthropogenic disturbances have caused major changes in reef species composition worldwide during the past few decades resulting in significant decreases in coral cover and abundance. Decoupling the factors causing coral population and community decline that have led to the degradation documented on reefs can be difficult. Understanding natural population variability is critical to ascribe causes to observed fluctuations in population abundance. Although many studies have incorporated relatively large spatial scales to account for spatial variation in community structure, few studies have implemented population-level assessments of individual coral species which are essential components of ecosystem management. Spatially-explicit estimates of these metrics allow for tracking changes over time and can provide the fundamental data necessary for in-depth investigations of population dynamics and community ecology to assist explorations of the reasons for observed changes occurring on coral reefs globally. To address coral population structure and recruitment of individual species in the Florida Keys, adult (colonies >4 cm in diameter) and juvenile (colonies < 4 cm diameter) abundance were estimated using a two-stage stratified random sampling survey design. Primary sample units (sites) were allocated among sixteen reef-types (habitat strata) within the Florida Keys reef tract (survey domain). Design features included strategic sampling that produced relatively precise population estimates and the ability to statistically compare multiple sites within and among benthic habitats over relatively broad spatial scales. From 1999-2006, surveys of coral colonies were conducted at sites which spanned the range of habitats along Florida Keys reef tract through the Dry Tortugas (96 percent of mapped coral habitat area). Quantitative analyses addressed coral population structure in three categories: 1) habitat use analysis to describe spatial pattern of abundance for both juvenile and adult life stages; 2) size frequency analysis to infer spatial variation in processes; and 3) descriptive analysis to illustrate spatial and size related patterns of partial mortality. These results help to discern the influence of habitat type and location on demographic processes that regulate coral population size structure and facilitate inferences concerning the consequences of the current coral population distributions in the Florida Keys.

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Nearshore Hard-bottom, a Critical Habitat for Juvenile Fish in the Florida Keys

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In the Florida Keys, aerial surveys have estimated the combination of hard-bottom and hard-bottom mixed with seagrass to be approximately 67,000 ha or 29% of nearshore habitats. These communities consist of a diverse assemblage of large sponges and octocorals that provide a highly complex structural environment for many fish and invertebrates. As such, these communities have the potential to be essential fish habitat.

We sought to detail the abundance and size-structure of ecologically and economically prominent fish species that dwell in shallow hardbottom habitats throughout the Florida Keys with a focus on the following seven species: red grouper (*Epinephelus morio*), gag grouper (*Mycteroperca microlepis*), white grunt (*Haemulon plumierii*), pinfish (*Lagodon rhomboids*), gray snapper (*Lutjanus griseus*), lane snapper (*L. synagris*), and yellowtail snapper (*Ocyurus chrysurus*). We surveyed 32 sites quarterly from fall 2003 to summer 2004, then bi-annually from fall 2005 to spring 2007. Abundance and size were collected using two methods, linear transects and roving divers.

We counted and sized 56 red groupers, 48 gag groupers, 4,855 white grunts, 4,312 pinfishes, 3,545 gray snappers, 925 lane snappers, and 117 yellowtail snappers, out of 32,864 fish in 186 taxa. Those seven species represented 42 % of all fish censused. Overall, the size distributions obtained from both sampling methods were similar with the distributions showing a predominant abundance of smaller fish (89.08 % of the fish surveyed were smaller than 150 mm TL, 79.62 % were smaller than 100 mm TL, and 69.20 % were smaller than 80 mm TL). About three quarters of the fish did not reach 25 % of their maximum size. In addition, 80 % of the individuals of the seven species listed above were smaller than the minimum size at which maturity was first observed and reported in literature (67.86 % for red grouper, 91.67 % for gag grouper, 95.45% for white grunts, 75.32 % for pinfish, 60.31 gray snapper, 99.24 % for lane snapper, and 80.34 % for yellowtail snapper).

Nearshore hard-bottom communities are a critical nursery habitat and a vital migration corridor for juvenile fish as they move through their ontogeny. We recommend that future ecosystem and fishery management decisions recognize that hardbottom habitat, like seagrass habitat, plays a vital role in the life history of commercially and ecologically important fish species.

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Marine Water Quality Monitoring with the ORCA Kilroy Network

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Effective water quality monitoring for marine ecosystem management requires high temporal frequency and spatial density, with measurements available in near real time. A transition from hand-sampling to automated monitoring should deliver these improvements while reducing overall cost. In an effort to make automated marine water quality monitoring accessible to the conservation and resource management communities, the Ocean Research & Conservation Association (ORCA) has developed and is testing the ORCA Kilroy Network, an observatory designed as a whole system down to the sensors at the component level. The ORCA Kilroy Network consists of a wireless network of proprietary remote semiautonomous marine sensor systems. This is coordinated by a central supervisory system that directs operations of the remote systems, collects data, and relays them via the Internet through a standard web service interface to a geospatial database in near real time.

The network designed as an industrial control system. The central computer monitors and coordinates remote and semi- autonomous systems. The coordination and data transfer are over GSM cellular Internet connections on a wide scale and cabled connections at the station scale. To date, four remote subsystems of the ORCA Kilroy network are in use: 1) a sensor suite measuring flow speed, flow direction, package orientation, water temperature, water level, wave height, wave period, speed of sound, and salinity; 2) a GPS/power/telemetry unit; 3) a network interface unit to simplify off-the-shelf sensor integration into the network and 4) a flow-through bathyphotometer to provide a direct biological measurement of bioluminescence intensity. Each subsystem is integrated at the component level to lower cost, reduce size, and improve efficiency, sharing the communications infrastructure and power from a solar-charged battery.

Tests of ORCA's sensor systems and third-party sensor integrations have been conductedin the Floriday Keys, north of Key Largo and at several sites along the Indian River Lagoon in Florida. A nine station test is ongoing in the Chesapeake Bay. The latest measurements are broadcasted to the web, with clickable color-coded icons positioned on a Google Map based upon the most recent GPS readings. Correlating measurements of water flow, water quality, biological indicators (through bioluminescence) and local weather conditions (particularly storm water events) can provide resource managers critically needed data 24/7 for effective ecosystem based management.

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Coral Loss and the Long-Term Effects of No-Take Reserves on Florida's Coral Reefs

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Worldwide declines of reef corals and the threat of global climate change have led to an increased focus on effective management of coral reef ecosystems. The vast majority of such efforts have relied on establishing no-take reserves, which are designed primarily to protect commercially important fish species. For management efforts to be effective in the long term, however, they must go beyond protecting target species and protect the ecological and geological integrity of the reef. Theory suggests that the positive fisheries impacts of no-take marine reserves could translate to the benthos, but this hypothesis is largely predicated on the assumption that overfishing is the cause of coral declines. Since the establishment of no-take areas throughout the Florida Keys National Marine Sanctuary (FKNMS) in 1997, coral reef managers have observed marked increases in some important fish stocks, but the impacts on the benthos have been less clear. This study sought to determine the impacts of no-take reserves on the benthic assemblages of coral reefs in the FKNMS coral reefs.

Benthic communities in four no-take areas and four reference sites in the FKNMS were surveyed using underwater video transects from 1998 to 2010. We used the data to track changes in the percent cover and species composition of benthic organisms through time and in relation to level of protection and depth. There was a significant decline in overall coral cover, and although the decline was site-specific, no-take status did not account for the variation among sites. All sites experienced marked changes over time in the relative abundance of coral species, driven primarily by a significant decline in *Montastraea* spp. The cover of macroalgae was highly variable through time, but there was no consistent distinction between no-take and reference sites. The first 11 years of no-take protection in the FKNMS do not appear to have had a significant impact on the benthic assemblages. Factors beyond overfishing, some of which operate at regional to global scales, are responsible for reef degradation in the FKNMS and elsewhere. Management efforts should take account of large- as well as small-scale forcing functions to ensure the persistence of FKNMS reefs into the future.

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Lessons from Jamaica? Initial Signs of *Acropora palmata* Recovery Using Population Matrix Modeling

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In Jamaica, corals reefs were all but destroyed first by Hurricane Allen in 1980, and next in 1983, by an epizootic that removed the last remaining herbivore, *Diadema antillarum*. Since then, Jamaica has been largely written off as a casualty - a lesson for the plight of modern coral reefs. Recently, scientists and managers conducting long-term research in Jamaica, have reported *Acropora palmata* stands in areas that had been razed, as well as the return of *D. antillarum*. Based on these reports we began conducting annual surveys of both *A. palmata* and *D. antillarum* on the north west shore of Jamaica in 2007.

Population matrix modeling based on these surveys shows that population density in Jamaica appears stable when projected 20 years into the future – remaining at 99% of the starting population (+/- .001 standard error). This figure drops to 92% (+/- .002 SE) when projected 100 years into the future. When we compare these rates to those of the upper Florida Keys during the same time period (2007 to 2009), we see similar results. Population density increases slightly, by 6% (+/- .005 SE) for 20 years and 3% (+/- .004 SE) in 100 years. All results are based on 10,000 simulations of population projections, in which each transition matrix has an equal and random chance of being chosen in any particular year.

This comparison, however, leaves an important aspect of demography unrevealed. In coral population biology, it is essential to examine not only the resulting population abundance, but also the resulting size class distribution. In Jamaica, though the population declines slightly over time, the two largest size classes remain dominant. In contrast, Florida's *A. palmata* population shifts from dominance by large individuals in 2004 to dominance by small individuals, resulting from fragmentation and partial mortality. This has implications for percent cover and structural complexity of the reef, as well as sexual and asexual reproduction, as smaller colonies yield fewer fragments and may not be large enough to produce gametes.

Demographic monitoring in Florida began in 2004. Because of multiple hurricanes and disease outbreaks, the upper Florida Keys *A. palmata* population suffered dramatic losses in 2005. Taking into account annual surveys from 2004 to 2009 (as opposed to just 2007 to 2009 as above), reveals a grimmer snapshot of *A. palmata* in Florida. Only 40% (+/- .01 SE) of the population remains after 20 years, and less than one individual remains after 100 years.

Meanwhile, *D. antillarum* density at our sites in Jamaica has been constant at $3/m^2$, as opposed to Florida where densities are at least an order of magnitude less. Can Jamaica offer us a lesson about reef recovery or resilience? If so, the lesson might simply be, sea urchins.

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Black Band Disease Pathogenesis and Impacts in the Florida Keys

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Despite the establishment of many coral health monitoring programs and documented increases in coral disease prevalence and geographic range, the short- and long-term impacts of diseases on coral communities are poorly known. The research presented here specifically examines the spatial and temporal dynamics of black band disease (BBD) infections in the Florida Keys, as well as the effects of BBD-induced mortality on population size class and scleractinian community structure. In addition to more than a decade of annual monitoring through the Florida Keys National Marine Sanctuary's annual Coral Health and Disease Cruise, the Robertson Coral Reef Program at Harbor Branch has tracked infected colonies quarterly from 2007 to 2009 with visual surveys, photographs, bacterial community and gene expression profiling. Total colony mortality resulting from BBD infections was rare, and occurred only in colonies with annually recrudescent infections. Partial colony mortality to BBD significantly reduced mean colony size. Therefore, while reported BBD prevalence rates may often be low in many field observations, BBD can nonetheless notably modify population and community structure. This and numerous other reports have demonstrated that both BBD incidence and prevalence increase during summer months with increased seawater temperatures and light irradiance. However, the mechanisms that underlie this pattern are still not well understood. An ex situ controlled experiment was also conducted to investigate the relative effects of temperature, light, and host coral colony on the progression rates of BBD, coral gene expression, and coral bacterial communities. Significant differences in BBD progression rates among fragments from different coral host colonies suggest that host coral fitness may play a more important role than immediate environmental conditions in the pathogenesis and severity of BBD.

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The New and Improved Dry Tortugas National Park 2010 Benthic Habitat Map

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The South Florida Caribbean Network (SFCN) in 2007 established a cooperative agreement with Fish and Wildlife Research Institute of the Florida Fish and Wildlife Conservation Commission to produce a current, consistent, accurate and reproducible benthic habitat map for Dry Tortugas National Park (DRTO), which will be accomplished by using the best available technology and appropriate methods. This marine benthic habitat mapping was completed in 2008 under contract with Avineon. In 2009, with the acquisition of high resolution side scan sonar data, as well as over 3000 field data points SFCN refined the Avineon 2008 benthic habitat map and build upon it to create a new map.

This new mapping product was able to eliminate all of the unknown polygons that the 2008 benthic map contained, along with a refinement of the line work, patch reef and hard bottom habitats by using the additional data sets. There were two new subclasses added to the 2010 product, low relief spur and grove and aggregate reef remnant, which added to the classification scheme descriptors of the larger reef habitat areas. In addition, for the first time a bathymetry data set with a horizontal 1m resolution was produced for over 91% of the park.

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Accuracy Assessment and Monitoring for NOAA Florida Keys Mapping

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As part of a regional mapping and monitoring effort in the Florida Keys, NOAA required an independent accuracy assessment to statistically test the accuracy of the GIS-based benthic habitat map recently produced for the Lower Keys. Resources, budgets, and logistical constraints precluded a comprehensive assessment of the entire mapped area, thus biogeographically-representative corridors within the total benthic habitat map area were selected for performing the accuracy assessment. The corridors not only captured a wide diversity of habitats, but were also characterized by frequent transitions between habitat types ensuring a well-distributed, representative set of survey locations. Two accuracy assessment corridors have been conducted to-date between Cudjoe Key and Sand Key that extended from the shoreline intertidal zone, through Hawk Channel and the reef tract, before terminating on the outer bank/shelf escarpment at a depth of approximately 33m. A total of 1036 sampling stations were visited, of which 957 were used in the accuracy assessment. The sites were selected using a stratified random sampling protocol that equally distributed sampling points amongst the detailed structure categories. Most sites were sampled by deploying a weighted drop camera with the vessel drifting in idle and recording 30-120 seconds of dGPS-referenced video. The shallowest sites were sampled by snorkel, waverunner, or kayak, using a hand-held dGPS for navigation and a housed camera to record video. Each sampling station was assigned a classification in the field. These field classifications were reevaluated post-survey during a systematic review of video and photographic data. The efficacy of the benthic habitat map was assessed by a number of classification metrics derived from error matrices of the Major and Detailed levels of Geomorphological Structure and Biological Cover. The known map proportions were used to remove the bias introduced to the producer's and user's accuracies by differential sampling intensity. The overall, producer's, and user's accuracies were computed directly from the error matrices. Corridors were evaluated separately and combined. The regional map accuracy of the combined accuracy assessments was 91.3% and 84.5% at the Major and Detailed levels of Structure respectively, and 74.4% and 70.5% at the Major and Detailed levels of cover. Adjusting to the map proportions improved the overall accuracies to 94.0% and 86.5% at the Major and Detailed levels of Structure, and to 80.2% and 78.0% at the Major and Detailed levels of cover. The Tau coefficients of the combined efforts were 0.827 ± 0.036 and 0.828 ± 0.025 at the Major and Detailed levels of Structure, and 0.701 ± 0.032 and 0.688 ± 0.031 at the Major and Detailed levels of cover.

Comparison of accuracy results between corridors showed that map accuracy is different throughout the region, therefore as the Florida Keys benthic habitat mapping effort proceeds, it is important to evaluate new areas to understand both local and regional map accuracies.

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Relative Success of Management in Florida for the Preservation of Shark Populations

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Sharks still exist on reefs in Florida, albeit at a fraction of their original abundance. Their status relative to other areas in the greater-Caribbean, however, is largely unexplored. We examined the contemporary distribution and sighting frequency patterns of sharks on reefs in Florida and throughout the greater-Caribbean and assessed the possible role of human pressures on such patterns.

We analyzed 76,340 underwater surveys carried out by volunteer divers between 1993 and 2008. Surveys were limited to reef-type habitats and grouped within 1-km^2 cells, which allowed us to determine the contemporary geographical distribution of sharks. Sharks were analyzed first as a group (all species combined) and then excluding the most commonly sighted nurse shark – the species with the least commercial value. Next, we compared the sighting frequency of sharks to the number of people in the reef vicinity as a proxy for anthropogenic stressors. Sighting frequency was calculated as the ratio of surveys with sharks to the total number of surveys in each cell. To explore the effects of exploitation we used species' life-history characteristics to conduct population viability analyses under a range of fishing mortalities. Finally, using range maps, habitat suitability models and historical records we explored past distribution and relative abundance of sharks throughout the greater-Caribbean.

Our results indicate that sharks should exist on reefs throughout the greater-Caribbean; yet contemporary sharks are largely absent, a pattern that was more pronounced with the exclusion of nurse sharks. Comparison of sighting frequency to the number of people in close proximity to the reefs showed that sharks, with the exception of nurse sharks occurred mainly in areas with very low human population. The few cells with a relatively high sighting frequency of sharks as well as high human population (>1000 people) occurred in Florida, Bahamas, and the U.S. Virgin Islands – all of which have strong fishing regulations such as prohibition of shark finning, extensive marine protected areas and in the case of the Bahamas, prohibition of long-line and gillnet fishing. Our population viability analysis suggests that exploitation alone could explain the large-scale absence of sharks. Even with relatively conservative levels of fishing mortality (10%) 13 of 14 species (all except the bonnethead shark) declined to <1% of the original population in <40 years. This pattern of decline would be exacerbated by additional anthropogenic stressors, such as pollution and habitat degradation that also correlate with human population density.

Overall, the limited distribution and low sighting frequency of contemporary sharks on reefs in the greater-Caribbean indicates that urgent management measures are necessary to protect sites where sharks still exist. Sharks still occur on reefs in Florida and the Bahamas where human density is high and where strong fishing regulations are in place, highlighting the possibility of success and encouraging the implementation and enforcement of conservation measures.

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The Application and Evaluation of Land-Based Aquaculture for Coral Reef Restoration Efforts

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Culture of corals for restoration purposes is a rapidly expanding concept with efforts occurring globally to investigate best management practices. Most efforts are focused on the use of non-sexual reproduction in open water sites, utilizing fragments from donor corals, a period of “grow-out”, or stabilization, and subsequent out-planting on restoration sites.

Florida has access to numerous land-based opportunities for coral culture, and a well established history of tropical aquaculture success. However, early suggestions of utilizing land-based aquaculture presented two fundamental issues that needed to be addressed; 1) corals produced in-vitro locations would be unable to survive when introduced into in-situ sites; and 2) introduction of land-based corals could potentially introduce coral diseases when returned to in-situ sites.

This presentation will provide an overview of the methods used to approach these fundamental questions, including results from two out-plantings on Western Sambo Reef utilizing a variety of corals from the Truman Annex site, and an overview of current studies with *Acropora cervicornis*.

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Florida Marine Ornamental Pathway Risk Analysis

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The Florida Department of Agriculture and Consumer Services, Florida Fish and Wildlife Conservation Commission, and University of Florida cooperatively responded to a state Comprehensive Wildlife Conservation Strategy which called for a risk assessment on all commercially available exotic marine/estuarine animals in Florida's pet trade by organizing and managing a risk analysis of Florida's marine ornamental trade. The agencies recruited importer, wholesaler, retailer, producer, research and agency representatives to implement a methodology described in a federal publication: *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process* (Aquatic Nuisance Species Task Force 1996). Eighteen participants produced a pathway description, determined the level of risk at each link or node in the trade pathway, and recommended risk management activities for specific public or private entities. This pathway risk analysis was a funded by the Florida Fish and Wildlife Conservation Commission, Florida's Wildlife Legacy Initiative, and the U.S. Fish and Wildlife Service, State Wildlife Grants program.

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Larval Fishes, Connectivity, and Management: A Mesoamerican Reef Case Study

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Since 2004, the Early Life History Unit of the NOAA Southeast Fisheries Science Center, in partnership with El Colegio de la Frontera Sur (ECOSUR), Mexico has conducted *ichthyoplankton* surveys to determine transport and recruitment patterns along the Mesoamerica reef system from Belize to the northern tip of the Yucatan peninsula. Initial results of these investigations reveal areas of larval fish diversity, concentrated recruitment to nursery areas, transport mechanisms via near-shore and offshore currents, and new spawning aggregations of commercially important species. Concurrently, there has been an increased focused in the scientific literature on the application of connectivity studies to marine resources management and to both the design and functioning of networks of marine protected areas at a regional scale. We present examples of the kinds of management questions and needs that may be addressed with our initial results and on-going research including: 1) developing recruitment indices for resilience planning; 2) comparing sources-sink dynamics at terminal ends of a regional ecosystem; 3) coordinating national and international management depending on cross-boundary transport – specifically between the Mesoamerican and the Florida Keys reef tracts; and 4) out-reach and capacity-building via workshops with managers, stakeholders, and scientists to provide for regional goal-setting. We focus on the potential value of combining long-term results revealing large-scale patterns in transport and recruitment with the cooperative implementation of an international network of prioritized marine protected areas (MAR Fund) that emphasize ecological function to support both habitat protections and viable local fisheries. We conclude with suggestions of how a similar approach may be applied in the wider Caribbean.

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Fine-Scale Aspects of Shark Behavior Revealed by Animal-Borne Accelerometers

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The annual mating aggregation of nurse sharks (*Ginglymostoma cirratum*) in the Dry Tortugas, FL has been the subject of 18 years of ongoing study and is the main source of what is known about shark reproductive behavior. Since 2008, we have expanded our ability to monitor these animals by tagging them with three-dimensional acceleration/depth/temperature data-loggers that can reveal continuous, fine-scale aspects of their behavior for days at a time. We applied data-loggers to six adult sharks for periods of 23 to 104 h (59 ± 35 h, mean ± SD). Four of the six animals were simultaneously tagged with coded acoustic transmitters to acquire the sharks' location from an array of acoustic receivers and thus provide spatial context to acceleration data.

Mating behavior was clearly identifiable from acceleration data, as were behaviors such as swimming, resting, diving, fast-starts, and rolling. Thirty-seven of 53 (70%) mating events took place during the day, with only 2 (3.7%) events between the hours of 22:00 and 05:00. No events occurred in water deeper than 4 m, and nearly all were in 2 m or less. One animal showed repetitive diving behavior between the surface and 20-32 m for 27 h after tagging; a behavior previously unobserved in this species. Accelerometry provides means for quantifying behavior and relative energy expenditure for animals at sub-second intervals for days at a time, and can thereby shed new light on the behavioral underpinnings of mating systems and the impact of these apex-level predators on reef ecosystems.

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Drivers of Population Decline in *Acropora palmata* in the Florida Keys National Marine Sanctuary

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In 2004 a demographic monitoring program was implemented aimed at determining the relative importance of the various threats facing *Acropora palmata* in the FKNMS and their role in driving population change. Study plots (n=15) were established at five fore-reef sites from Carysfort to Molasses Reefs. All colonies in the study plots were mapped and assessed annually and a randomly selected subset was tagged for more comprehensive assessments three to four times per year. Annual whole plot surveys were aimed at identifying new recruits and losses from the study plot as well as the overall abundance of live tissue and colonies. Quarterly surveys of tagged colonies were aimed at documenting the prevalence and impact of disease, predation, physical damage and other sources of tissue loss. Additionally infestation of pest species including the corallivorous snail *Coralliophila abbreviata* was recorded. A 'live area index' (LAI) was calculated based on the dimensions and condition of the colony and was used to track the changes in live tissue. Threats such as disease and predation are ranked according to their impact on live tissue and the ranks are used to attribute the tissue loss associated with each threat. Similarly, the amount of live area lost to fragmentation is calculated and compared to other threats. Based on the data collected to date, the study plots experienced a >50% decline in live area during the 2005 hurricane season and have only shown modest signs of recovery since then. Throughout the monitoring period (n=17 surveys), in all but 3 surveys, the top 3 threats causing tissue loss were white disease, fragmentation and predation by *C. abbreviata*. White disease and skeletal damage were nearly equal in causing loss of live area (37% and 39% respectively) while *C. abbreviata* predation accounted for 15% of the live area loss. These proportions are strongly skewed by the 2005 hurricane season; between July and December 2005, 56% of the live area lost was attributed to skeletal breakage and 37% was attributed to white disease. Excluding the surveys from the 2005 hurricane season, to reveal chronic impact of these threats, the impact of fragmentation is reduced to 25% of the estimated live area loss and the impact of *C. abbreviata* feeding increases to 23% while white disease remains constant at approximately 36%. On average one third of the *A. palmata* colonies in the study plots are infested with *C. abbreviata* and those infested colonies have on average 4 snails per colony. Thus a relatively small number of snails are capable of causing substantial tissue loss. Although *C. abbreviata* predation ranks as 3rd in reducing live tissue cover it presents as the threat that is most amenable to immediate management action. Removal of *C. abbreviata* from *A. palmata* could directly reduce nearly one quarter of the loss of live tissue directly. Additionally, as a vector of white disease, removal of *C. abbreviata* may indirectly reduce the live tissue lost to white disease.

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Population Trend of the Great White Heron (A*rdea herodias occidentalis*) in the Florida Keys National Wildlife Refuges, 1986-2009

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For 22 years, Great White Heron (*Ardea herodias occidentalis*) nests were monitored systematically on 42 islands or named chains of islands in two adjacent national wildlife refuges: Key West (KWNWR) and Great White Heron (GWHNWR). Nesting occurred one or more years on 38 islands, with a marked interannual variation in rookery size among islands. An average of 187.9 nests (range = 98-336) and 23.8 rookeries (range=17-31) were recorded. Fifteen islands accounted for 81% of all nests. Yearly turnover in rookery site use was low (mean = 15.5%). Nesting occurred for 19 or more years on 15 islands, 5 of which were used for 22 nesting seasons. The annual number of nests declined over time (P = 0.02). The number of nests found during the first 11 nesting seasons was significantly greater (P< 0.005) than the second 11-year period when an average of 65.0 fewer nests was found annually. Total nests for the latter period declined at 28 (74%) of 38 islands, with the largest declines at Bay (n=173) and Cottrell Keys (n= 132). More nests and rookeries and a greater (P < 0.001) mean number of nests per rookery were found in GWHNWR than KWNWR. Hurricanes Georges and Wilma severely damaged refuge islands and altered the distribution of rookeries in GHWNWR. After the latter storm's passage, the number of nests for 2 consecutive years was lower than that of any other year. Given an extremely limited range, a serious long-term decline in the number of nests, and a projected rise in the number of severe hurricanes, the Great White Heron is imperiled.

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Potential Effects of Climate Change on the Miami Blue Butterfly in Key West National Wildlife Refuge

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The Miami Blue butterfly (*Cyclargus thomasi bethunebakeri*) declined to near extinction during the 1990s and was known to survive only on Bahia Honda Key. In November 2006, we discovered this species in the Key West National Wildlife Refuge (KWNWR) on Boca Grande Key, 76 km west of Bahia Honda Key. During the following 8 months, we examined 15 additional areas, 6 islands in the Great White Heron National Wildlife Refuge (GWHNWR) and 9 areas in the KWNWR. This species was not found in GWHNWR, but was present on 8 of 10 sites in KWNWR. Seven of the occupied locations were on islands in the Marquesas Keys.

Eustatic sea level is an acute threat to the Miami Blue at all the sites, 7 of which are < 1 m above sea level. Beach erosion, even in the absence of tropical storms, continues to progressively narrow the dunes and thus reduce Miami Blue habitat, particularly on Boca Grande Key.

Although allogenic succession generated by lesser hurricanes like Hurricane Wilma may temporarily enhance Miami Blue habitat by promoting herbaceous flowering plants, a stronger hurricane could extirpate this species in KWNWR. The last Category 4 or higher hurricane in the Florida Keys was Hurricane Donna in 1960, but its strongest winds occurred more than 130 km nearest Miami Blue Boca Grande Key. Although Hurricane Wilma (2005) was at most a Category 3 hurricane in the Florida Keys, (National Oceanic and Atmospheric Administration 2005), its winds and storm surge washed away a part of the southern dune on Boca Grande Key, creating a breach that has progressively widened. The number and severity of hurricanes are projected to increase because of global warming, ominously further threatening the Miami Blue population in KWNWR.

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Severe Long-Term Decline in the Number of Loggerhead Nests in Key West National Wildlife Refuge

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Systematic monitoring of loggerhead turtle (*Caretta caretta*) nests was performed from 1990- 2009 on Woman, Boca Grande and Marquesas Keys in the Key West National Wildlife Refuge (KWNWR). Chronology, distribution, density, productivity, and population trend were assessed. An average of 40.4 nests (range = 15-70) was found annually with marked variation between and among years. Time-series trend analysis for the 20-year period revealed a downward trend in the number of nests ($P < 0.0001$). More nests were found annually from 1990-1999 (Period 1) than 2000-2009 (Period 2) ($P < 0.001$). At all beaches, the percent of crawls that were nests was lower during Period 2 than Period 1. The number of nests, eggs laid, and hatchlings produced declined 52%, 56%, and 49%, respectively during Period 2, with the steepest declines occurring in the Marquesas Keys. Significantly fewer nests were found during Period 2 than Period 1 on Boca Grande Key ($P = 0.04$) and at 3 of 4 beaches in the Marquesas Keys: Long ($P = 0.002$), Main ($P = 0.002$), and Short ($P = 0.008$). For 803 nests of a known outcome, 467 (58%) nests were on dunes and 336 (42%) were on beaches (Table 9). Turtles that nested in the dunes produced more hatchlings per nest than those that nested on beaches ($P < 0.001$). As a group, dune nests produced 15.6 more hatchlings per nest than beach nests. Assuming a 2-year nesting interval and 3 annual clutches per breeder, the number of breeders declined by 53% during Period 2. Means for clutch size and hatchlings produced were greater ($P < 0.05$) on Woman Key than on the other beaches. The hatching rate (45%) was low and the proportion of false crawls (63%) was high during the study period. Sea water inundation of nests negatively affected hatching rates and productivity. The marked decline in the number of breeders and nests, low productivity, a high proportion of false crawls, tidal flooding coupled with ongoing beach erosion, and sea level rise collectively threaten the future of the nesting loggerhead turtle population in KWNWR.

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Community Calcification and Carbonate Sediment Accumulation in Florida Bay and Biscayne National Park: Keeping Up with Sea Level Rise in the Face of Climate Change

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The ability of coastal carbonate ecosystems to keep up with rising sea level depends on 1) the rate at which calcium carbonate producing organisms generate skeletons, 2) accumulation rate of sediments generated from breakdown of skeletal material, 3) amount of carbonate lost to sediment dissolution, 4) amount of sediment exported from the ecosystem via physical transport, and 5) how climate change and ocean acidification may impact these processes. Carbonate system parameters and net community calcification were measured on representative substrate types in Florida Bay and Biscayne National Park between 1999 and 2009 to estimate rates of carbonate sediment accumulation relative to changes in seawater chemistry (including pH and pCO_2) and sea level rise.

An underwater benthic incubation chamber was used to measure *in situ* rates of community calcification on patch reefs, seagrass, mixed substrata, and hard bottom communities. Temperature, salinity, and dissolved oxygen were measured every minute, and seawater samples were collected from the chamber every 4 hours throughout 24-hour incubation periods. Prior to 2002, pH was measured using Orion Ross glass electrodes, and total alkalinity (TA) was measured using an automated Gran titration method. After 2002, pH and TA were measured using spectrophotometric techniques. Total dissolved inorganic carbon (TCO_2) was measured using a UIC carbon coulometer. Rates of community calcification were calculated using change in total alkalinity as a proxy. Carbonate ion and pCO_2 thresholds for calcium carbonate sediment dissolution were determined from linear equations that relate net calcification rate to pCO_2 and carbonate ion concentration. Sediment accumulation rates were calculated from 24-hour net calcification rates, sediment porosity, and density of calcium carbonate.

Results showed that net community calcification occurred during daylight hours while net dissolution of carbonate sediments was observed during dark hours at all study sites. The average 24-hour, daylight, and night calcification rates for measurements in Florida Bay (n = 18) were 0.3, 0.8, and -0.5 g $CaCO_3$ m^{-2} d^{-1}, respectively. Average 24-hour, daylight, and night calcification rates for measurements in Biscayne National Park (n = 7) were 1.4, 1.7, and -0.3 g $CaCO_3$ m^{-2} d^{-1}, respectively. Average pCO_2 and CO_3^{2-} thresholds for carbonate sediment dissolution were 467 matm and 260 mmol kg^{-1} SW for Florida Bay, respectively, and 559 matm and 208 mmol kg^{-1} SW for Biscayne National Park, respectively. Average net sediment accumulation rates were 0.3 mm yr^{-1} for Florida Bay and 1.4 mm yr^{-1} for Biscayne National Park. Results indicate that considerable sediment dissolution is occurring in both coral reef and estuarine communities of South Florida. Dissolution may increase with increasing atmospheric CO_2. Sediment accumulation rates in many benthic communities are not keeping up with current rates of sea level rise reported by the Intergovernmental Panel on Climate Change.

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A High-Resolution, Digital-Imaging System for Rapid Benthic Surveys

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Pictures of the seafloor capture important information about the sediments, exposed geologic features, submerged aquatic vegetation, and animals found in a given habitat. With the emergence of marine protected areas as a favored tactic for preserving coral reef resources, knowledge of essential habitat is critical to designing effective management strategies. To expedite documenting benthic habitat components, the USGS Coastal and Marine Geology Program developed the Along-Track Reef-Imaging System (ATRIS). Designed to rapidly acquire geo-located, high-resolution digital images, ATRIS can be deployed in either “shallow” or “deep” configurations from boats at least 7.6-m in length. Shallow ATRIS is a pole-mounted system suitable for imaging in water depths ranging from 2 to 6 m. Deep ATRIS is a towed system that can operate down to 27 m. The same camera and acquisition software are used for both configurations. The imagery and associated GPS data are integrated using an image server that allows for interactive browsing, dynamic mosaicking, and zooming within the appropriate geographic region. During subsequent analysis, benthic features and fauna are characterized in terms of shape, planar size, color, relief, genus, and percent cover. Currently, ATRIS imagery is supporting novel research on threatened loggerhead sea turtles in Dry Tortugas National Park. Little is known about the habitat requirements of female loggerhead sea turtles during the time between nesting events, called the inter-nesting period. Based on satellite tracking of the turtles, specific habitats used during this critical time period were mapped using the shallow configuration of ATRIS. The imagery is providing an understanding of the benthic habitat diversity within these zones preferred by the female loggerheads.

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Management Plan for the Introduced Indo-Pacific Lionfishes (*Pterois volitans* and *Pterois miles*) in Everglades and Dry Tortugas National Parks, Florida

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The Indo-Pacific lionfishes (*Pterois miles* and *P. volitans*) are documented as being established along the U.S. southeast coast, Bermuda, Bahamas, and are becoming established in the Caribbean, Florida Keys, and adjacent waters. At present, lionfish are not known to occur in Everglades National Park (EVER) waters; however, several sightings have recently occurred in Florida Bay, near the of EVER border. In addition, several lionfish have been reported within Dry Tortugas National Park (DRTO). Their rapid establishment and potential adverse affects on the ecosystem is of great concern as lionfish pose a serious threat to reef fish and invertebrate communities. Lionfish are predators that consume native fish and invertebrate species and possess poisonous spines that could injure visitors to the parks. Impacts to fish and invertebrate populations conflict with management goals, particularly the goals developed for the Park's Research Natural Area, a no-take, no-anchor marine reserve. In response to this threat, Everglades and Dry Tortugas National Parks are developing a plan with alternative management actions for mitigating the negative impacts of lionfish. Actions range from no action, to continuous control/suppression, to park-wide eradication. The goals of this management plan are to evaluate the feasibility of several alternatives in their ability to: 1) maintain numbers of introduced lionfish in EVER/DRTO at an acceptable level through periodic and repeated monitoring and removal efforts; 2) minimize potential resource impacts (such as out-competing native fauna) caused by the introduced lionfish within EVER/DRTO; 3) minimize the spread of introduced lionfish to additional areas in the park previously unoccupied by lionfish; 4) reduce threats to visitor health and safety; and 5) increase opportunities for visitors to experience native ecological communities. This plan is needed to prevent the fundamental alterations to population, community and ecosystem processes that can result from non-indigenous species introductions in marine habitats, as well as prevent health and safety threats to visiting fishermen, snorkelers and divers.

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Seagrass Restoration in Everglades National Park

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Vessel groundings and propeller scarring are common occurrences in the seagrass communities of Florida Bay and Everglades National Park. To mitigate for some of these impacts, Tetra Tech EC, Inc, (TtEC) was contracted by the National Park Service to perform seagrass restoration in Everglades National Park. Prior to restoration implementation, TtEC performed initial site assessments to determine the current conditions at each grounding site. Information collected during these assessments was used as the basis for evaluating site-specific restoration alternatives. The alternatives selected for project implementation consisted of topographic restoration, seagrass transplanting, and bird stake placement. Topographic restoration entailed filling burlap bags with an approved sediment mixture and subsequently placing the bags within each restoration area. Immediately following topographic restoration, bird stakes were placed within the restoration sites to encourage roosting of waterfowl and provide natural fertilizer to the restoration sites. Seagrass transplanting activities were conducted in late fall, approximately 30 days following sediment placement, using a coring a method that minimized disturbance to the above and below ground biomass. Six-inch diameter planting units of *Thalassia testudinum* and *Halodule wrightii* were harvested from adjacent donor areas using sealed coring tubes. Harvesting occurred at densities no greater than one planting unit removed per $1m^2$ of healthy donor material so as not to cause unnecessary impacts to any single part of the donor area. Subsequent to harvest, planting units were placed onto a fabricated float capable of storing and transporting the planting units. The objective of the methodology used was to minimize disturbance to the biogeochemical processes associated with the below-ground biomass (e.g., rhizome mat) and sun and heat stress to the above-ground biomass that may occur during the transport process. Both monospecific (*T. testudinum*) and mixed species (*T. testudinum* and *H. wrightii*) plantings were conducted. Seven months following project completion, TtEC conducted an initial monitoring event to document the status of the restored sites. The overall survival of transplanted planting units determined by viability was 90 percent; average seagrass percent coverage determined using the line-intercept method ranged from 23 percent to 69 percent. Sites planted with mixed species had the highest percent seagrass coverage, recruitment, and planting unit expansion of all of the transplanted sites. During an informal site visit approximately one year later (19 months post-restoration), complete seagrass coverage (100 percent) was observed at several of the sites. The planting unit percent survival and seagrass percent coverage within transplanted sites indicate that the transplanted seagrass species—particularly *T. testudinum*—can not only be successfully transplanted using the sealed core method, but can also be done late in the growing season (i.e., early November). The project goal of restoring impacted seagrass communities within three years was achieved in one and a half years, as documented during the aforementioned site visit.

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Notes

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