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Oral Presentations

Opportunities & Challenges for private-sector participation in IRL water quality solutions, *Duane DeFreese, Ph.D.* Ecosystem health and water quality of Indian River Lagoon are threatened by a variety of stressors at multiple spatial and temporal scales. Traditionally, IRL ecosystem restoration has largely been driven by publically-funded initiatives implemented by public agencies and/or non-profit organizations. This presentation will discuss broad opportunities and challenges for industry participation in IRL water quality solutions. Specific examples of industry opportunities and challenges will be presented from a pilot water quality remediation project on Lake Jesup, FL.

Innovative Ferrate (VI) Treatment of Dredge Water to Remove Nutrients and Contaminants.
Dr. Thomas D. Waite, Florida Institute of Technology. Ferrates are oxy-anions of iron, and have been synthesized in laboratories since the mid-nineteenth century, with the iron in oxidation states of between two and eight (FeO_2^{2-} and FeO_5^{2-}). While several different ferrates have been studied for commercial exploitation, only Ferrate(VI), i.e. (FeO_4^{2-}) has been utilized for environmental applications. Over 400 published studies have demonstrated the unique treatment capability of Ferrate(VI) for both water and wastewater, as it can simultaneously perform oxidation, and disinfection, and because it is unstable, it is quickly reduced to Fe^{3+} which is a coagulant. Ferrates can be synthesized in several ways, utilizing an oxidation process to convert metallic, ferrous, or ferric iron to a higher valence. The most efficient and cost-effective way to generate ferrate is by aqueous chemical oxidation of ferric iron utilizing chlorine in a caustic medium. $2FeCl_3 + 3NaOCl + 10NaOH \rightarrow 2Na_2FeO_4 + 9NaCl + 5H_2O$ (1) When added to aqueous systems, Ferrate(VI) is a powerful oxidant which readily decomposes to ferric iron [$Fe(OH)_3$] and oxygen according to: $2FeO_4^{2-} + 5H_2O \rightarrow 2Fe(OH)_3 + 1.5O_2 + 4OH^-$ (2) Dredging of muck from selected areas of the Indian River Lagoon (IRL) and adjacent creeks will begin by mid-2015, and the dredging "process" includes solids-settling and de-watering of the pumped muck (>90% water content) in near-by pits. Previous analyses of this material (muck) have shown that there are extremely high concentrations of nutrients (especially N, e.g. >40 mg/L) and possibly other contaminants. These nutrients and contaminants are highly soluble, and most will remain in the spoil water after the solids have been settled out, requiring treatment. Ferrate application to treat the dredge water (and possibly sediments) would allow safe re-use or disposal of the dredged residuals.

Simulation of Flushing Response of Banana River to the Construction of a Low-Crested Weir in the vicinity of Port Canaveral, Florida. *Atousa Saberi and Dr. Robert. J Weaver, Florida Institute of Technology*. Indian River Lagoon (IRL) is a restricted estuary along the east coast of Florida. Although Banana River, a 50 km long sub-basin of IRL, has an outlet to the ocean through the Port Canaveral locks, the locks remain closed when there is no passing vessel resulting in limited circulation, long flushing time and poor water quality. In this study, the extent to which constructing a low crested weir adjacent to Port Canaveral can improve flushing in this region is determined. ADCIRC 2DDI is used to simulate the hydrodynamic properties of the study area and determine the velocity field. Passive particles are placed in the Banana River portion of the domain, and the movement of these particles is tracked using LPTM. Results indicate an improvement in flushing in both the Banana River and the central IRL. In the portion of the Banana River to the south of the port complex, the flushing time (R50), is decreased from over 200 days down to 38 days, after the addition of the weir to the domain.

Assessment of muck movement, discharge water quality and biological impacts at FIND Dredging Site IR-1: Sebastian River to Wabasso Bridge. *Dr. Robert J. Weaver[2], Dr. John H. Trefry[2], Dr. Charles R. Bostater Jr. [2], Dr. Jonathan Shenker[2], and Dr. Kevin B. Johnson[2], Coraggio Maglio[1], Shelley Trulock[3], Jase Ousley[1], Paul Cotter[3], Paul DeMarco[3]. (1): U.S. Army Corps of Engineering, Vicksburg, MS, (2): Florida Institute of Technology (3): U.S. Army Corps of Engineering Jacksonville District.* In a groundbreaking study designed to help establish the environmental effects of dredging and determine the extent regular navigational maintenance dredging impacts restoration efforts, our research group evaluated three inter-related components in relation to the F.I.N.D. IR Reach 1 dredging project: *Assessing Muck & Fluidized Mud Movement, Removal Efficiency for Fine-Grained Sediment and Nutrients, and Assessment of Biological Impacts.* The net positive environmental benefits associated with traditional navigation maintenance dredging projects are rarely identified and almost never quantified. This project was monitored to determine the ultimate fate of the dredged material and associated nutrient load through the dredging and dewatering operations. Navigation dredging took place in the Indian River Lagoon, an impaired waterbody and an important estuary. The IRL was the focus of international attention due to harmful phytoplankton blooms in 2011 and large die-off events of not only seagrasses but also marine mammals. A partnership between the local sponsor, the Florida Inlet Navigation District, the U.S. Army Corps of Engineers, and the Florida Institute of Technology, was formed to monitor the dredging operations. The project removed approximately 276,000 cubic yards of material and included in this volume was an estimated 210 tons of nitrogen and 110 tons of phosphorus. Minimal return water was released back into the lagoon. This dredged material was permanently removed from the aquatic system and placed in the upland dredged material management area. This project not only restored required navigational depth but also removed hundreds of tons of nutrients from the IRL.

Geospatial Stormwater Analysis to Develop an Efficient Stormwater Management Plan. *Philip Bellamy and Dr. Hyun Jung Cho, Bethune Cookman University.* Surface runoff is rainwater or snowmelt that travels through land surface before entering into nearby waterbodies. Surface runoff is al so increased by the percentage of impervious surfaces from development, and transports pollutants and other substances into waterbodies in the forms of non-point and point source pollutants that alter turbidity, nutrient concentration, and organic matter content in major water bodies. This in turn, affects the organisms living within these systems. The Halifax River runs southward along the east coast of Daytona Beach, FL connecting to the Indian River Lagoon; and is a large diverse estuarine system that supports a plethora of wildlife. The project goal is to delineate the stormwater drainage area of the Halifax River, flow accumulation, and develop a map of the percentage of impervious surfaces within the major cities along the Estuary. A Digital Elevation Model of the area was downloaded from United States Geological Survey National Elevation Dataset.

The Living Dock Program. *Dr. Kelli Hunsucker[1], Dr. Robert Weaver[1], Holly Sweat[1], Abby Meyers[2], Avery Bethurum[2], Anastacia Devlin[2], Anna Grenevicki[2], Kaylee Kraver[2], Kate Longoria[2], Sabrina Bethurum[2], Marsha Lewis Meyers[2], Kody Lieberman[1], Sandra Bruner[2], Inga Devlin[2], Amy Grenevicki[2], Tina Kraver[2]. (1) Indian River Lagoon Research Institute, Florida Institute of Technology, Melbourne, FL 32901, U.S.A. (2) Girl Scout Troop 156, Turtle Tracks Unit of Citrus Council, Brevard County, Florida.* Oyster reefs were once very common in the Indian River Lagoon (IRL). It is thought that increasing their numbers will improve water quality and help prevent large scale algal blooms. Oyster restoration projects in the IRL typically involve attaching oyster shells to mats, which are then deployed on the Lagoon bottom. Our research team hypothesized there might also be benefit to attaching these same oyster shells to docks and other submerged surfaces. The goal was to develop a simple, low-maintenance method that

would have real and significant results improving water quality. A pilot project was conducted in Fall 2013, in which Girl Scouts and local volunteers attached 18 oyster mats around dock pilings and hung 18 oyster bags from the same dock. The bags and mats were monitored over a 15 month period, from November 2013 through January 2015. After one year there was an average of 32 live oysters per bag, with a maximum of 63 live oysters in one bag. During that same time period, live oysters were also found in the mats wrapped around pilings. With the filtration rates for oysters being 50 gallons/day/oyster, a community with healthy living docks can potentially filter 57000 gallons/day or about 21 million gallons/year/dock. In addition to the oysters, the total living systems had grown on both the bags and mats. Healthy populations of barnacles, sponges, algae, bryozoans, tunicates, as well as crabs, shrimp, cephalopods, and fish were found in and on both the bags and the mats.

A Data Mining Approach to Develop Hyperspectral Model for Bathymetry. *Forrest Gasdia[1], Benedict Pineryo[1], and Dr. H.J. Cho[2] (1) Embry-Riddle Aeronautical University, (2)Bethune-Cookman University* Modern hyperspectral imagers offer close to or more than 100 spectral bands which greatly increases the amount of data to detect subtle variations of spectral signals from objects available for bathymetry and benthic mapping. Indian River Lagoon bathymetric point data and the atmospherically corrected Hyperspectral Imager for Coastal Oceans (HICO) satellite data wereused as a test case for development of a data mining approach for bathymetry mapping using hyperspectral data. The goal of this technique was to maximize use of all of the available spectral bands, to conduct data mining to select spectral features important for and efficient for bathymetry reformation even in the presence of combined water column and bottom signals. Statistical attributes, including slope, ratio, and average intensity, were calculated for every possible band combination – leading to over 12,000 attributes represented at every pixel. A selection process then rejects attributes which were redundant or only weakly dependent on water depth. Finally, a regression model was built using ground-truth training data (point depth data) in order to test each of the attributes at the entire water areas in the image. After depth correction, the same attribute set can also be clustered and classified for bottom type identification and debris detection. Initial results were promising in the clear water condition (Turbidity < 7 NTU), and the technique should extend to turbid water as well. Performance can be improved by increasing the number of ground truth samples.

Indian River Lagoon Numerical Model Flushing Experiments, *Gary A. Zarillo, Ph.D., PG, Florida Institute of Technology.* In order to examine the potential for improved flushing of the Indian River Lagoon (IRL) were constructed to cover the Indian River Lagoon System from the north end of the Mosquito Lagoon (ML) in Volusia County. FL to the Wabasso area of Indian River County. The model boundaries were forced with historical time series of water level and with discharge at major creeks and rivers entering the west bank of the IRL. Wind speed and direction were applied over the surface of the model grid. A total of 10year-long model model runs were conducted, including runs to simulate existing conditions. Model performance was validated by comparing predicted and measured water levels. Five model runs included hypothetical new tidal inlets, pumping stations, and hypothetical widening of Sebastian inlet. Flushing rates were predicted by establishing an initial numerical tracer concentration of 20 parts per thousand over the entire model domain. Tracer concentrations at the model boundaries were then set to zero. Among the hypothetical alterations to the model grids, additional tidal inlets and pumping station connections to the coastal ocean across narrow sections of the barrier island produced the best flushing results in the model grids. Either a narrow tidal inlet or pumping station located in the south compartment of the Mosquito Lagoon produced complete flushing of the ML within about 70 days or less. A tidal inlet across the South Cocoa Beach barrier island segment also substantially improved flushing of the Banana River.

The Indian River Lagoon Observatory Network of Environmental Sensors. *Dr. Dennis Hanisak, FAU Harbor Branch.* The Indian River Lagoon Observatory (IRLO), based at Florida Atlantic University's Harbor Branch Oceanographic Institute, is conducting long-term, multi-disciplinary, ecosystem-based research on this nationally significant estuary. IRLO research and education activities are being enhanced by deployment of an estuarine observation network of land/ocean biogeochemical observatory (LOBO) units and weather sensors to provide real-time, high-accuracy and high-resolution water quality/weather data through a dedicated interactive website (http://fau.loboviz.com/. Currently LOBOs are deployed at nine sites in the IRL and St. Lucie Estuary. All of these sites are ecologically important because of the dynamic interface between oceanic water from the inlets with freshwater inputs from the river, canals, and Lake Okeechobee. The sensors are compact and the water quality sensor packages can be modified according to research and resource management needs. We selected sensor packages based on studies being conducted in the IRL, with physical parameters that include temperature, conductivity (salinity), pressure (depth) to measure tidal fluctuations, and turbidity (particles in the water); chemical parameters that include chromophoric dissolved organic matter (CDOM or water color), dissolved oxygen (DO), pH, and nitrate and phosphate (important nutrients for primary producers); and a biological parameter, chlorophyll fluorescence, that is a measure of algal chlorophyll in the water. This estuarine network enables researchers to follow environmental changes in the IRL, assist resource and planning managers to make informed decisions, model and correlate environmental data to biological, chemical and physical phenomena, and contribute to education and public outreach on the lagoon.

The key role of umanned multi-sensor systems in monitoring the Indian River Lagoon.
Dr. Claudia Listopa, Dr. Brian Ormiston, Dr. Kevin Cooper, Applied Ecology, Inc; Brian G. Ormiston Ecological Consulting; Indian River State College. Established techniques to monitor seagrass or water quality rely heavily upon field sampling or a limited number of static remote electrochemical which limit the spatial extent and the type of data collected. The Indian River Lagoon (IRL) covers 353 square miles, yet there are only about 100 stations that are regularly monitored for water quality. Seagrass cover is typically mapped by an aerial photointerpretation process that is slow, subjective, error prone, and does not reveal density, differentiate species or macroalgae. We often are unaware of water quality problems until after harmful algal blooms occur. These issues can be overcome through the development and testing of an inexpensive, rapidly deployed and more efficient unmanned remote sensing system platform that will employ multiple sensors to simultaneously acquire and provide for rapid analysis of Hyperspectral (HSI) and LiDAR data to create mapping imagery about coastal water quality and vegetation. Airborne imaging systems weighing less than 5 lbs. have been developed and used in mapping seagrass (including density/photosynthetic biomass), chlorophyll A, and Harmful Algae Blooms. We present initial results from our proof of concept research currently underway in the IRL for seagrass selective species determination and seagrass density cover mapping. Optimizing the use of multisensor techniques, including HSI and LiDAR, from miniature drone/submersible platforms, will allow for improved and more cost-effective monitoring of water quality indicators and decision making. Applications include prioritization of dredging locations and stormwater runoff treatments placement.

Simplified Water Correction for Improved Benthic Mapping using Satellite-borne Hyperspectral Data. *Benedict Pineyro and Hyun Jung Cho. Embry-Riddle Aeronautical University and Bethune-Cookman University.* Benthic mapping employs field surveys, hydroacoustic measurements, aerial photography, and satellite images. An effective way to do benthic mapping involves removing overlying water effects from the atmospherically corrected remotely sensed data to enhance signals from seafloor. Our previous water correction algorithms depend on controlled laboratory measurements of substrates in clear water. A more simplified water correction

algorithm has been developed which uses only a few pixels from the image. Spectral profiles were extracted from four pixels in a HICO (Hyperspectral Imager for Coastal Oceans) image that was acquired in February 2014. The four locations were chosen based on the assumption there were two types of homogenous substrates at two depths (0 and 1.0 meter). Our new algorithm calculates water column reflectance (R_r) and water absorption (A_w) from the four pixel values. The Simple Ratio (SR) index was applied using two bands, 668 nm and 719 nm, which served as the red and Near-Infrared (NIR). The corrected pixel values show a good correlation of an R^2 =0.7658 and a p-value of p = 9.3917e-05 with the field transect data that measured the total amount of seagrass and macroalgae, and also with the pixel values of the same image but with different locations selected for the parameters of the correcting algorithm (R^2 = 0.5352, p = 0.0029).

Mangrove recruitment in Indian River Lagoon shoreline restoration sites and the role of sediment size. *Dr. Kelly Kibler and Christian Pilato, University of Central Florida*. Living shoreline restoration in Indian River Lagoon takes place at interfaces of terrestrial and aquatic systems. Stabilization of intertidal areas, water quality improvement, and habitat creation are typical project objectives. Restoration techniques include placement of intertidal species such as mangrove, marsh grasses and oysters. In restoring shorelines with native species, practitioners wish to induce physical-biological feedbacks, wherein the structure of placed or planted species reduces tidal and wave velocities, lessens substrate shear stress, and promotes deposition of sediments and organic matter retention. The resulting hydraulic and benthic environment ideally encourages expansion of the community, through propagation and natural recruitment. As the restored community expands, it should thus engineer conditions that lead to further success of the community. Restoration success therefore ultimately hinges upon natural recruitment of desired species into restored areas. Recruitment of first mangrove propagules may indicate that a restoration site has achieved a critical tipping point in habitat suitability with respect to sediment quality and hydraulic forcings. Here we test the relationship between shoreline sediment texture and recruitment success of red mangrove (*Rhizophora mangle*) in natural and restored sites in Indian River Lagoon. We sample sites characterized by native vegetation, including red mangrove, and restoration plots planted with red mangrove. In both natural and restored sites, we sample areas containing implanted propagules and areas that contain no propagules. We detect differences in propagule recruitment, root structures and above- and below-ground biomass of propagules, and grain size distributions of benthic sediments between natural and restored sites, and within sites.

Spoil Island Ambassador Program. *James Burke. FLDEP, Indian River Lagoon Aquatic Preserves, FIND*. Friends of the Spoil Islands, Inc. is a Florida nonprofit Citizen Support Organization dedicated to the preservation, restoration and enhancement of the Indian River Lagoon Aquatic Preserve spoil islands and educating others about the importance of the spoil islands as valuable educational, recreational and conservation resources. The Spoil Island Ambassador Program has been successful in engaging the public to actively become involved with the interest and care of these islands. This presentation explains to the audience the FOSI policy, model, and procedure that has been successful in convincing the public of this worthy cause.

Poster Presentations

Living Dock. *Girl Scout Troop 156*. Scouts, with the help of FIT scientists in November 2013, suspended oyster bags of plastic mesh filled with dead, non-seeded oyster shells, on a dock in the IRL near Ballard Park. Initial failure of mesh required reconstruction using heavy mesh in January of 2014. The Living Dock was monitored every 6 weeks for water quality (pH, T, DO, S, Turbidity) and organism growth. A record of general observations and organisms was kept and photographs of shells were taken. Oyster recruitment was determined by sorting through shells. Three bags were monitored each sample date. Photos with clear graph overlays were used to measure percent coverage of biofilm and organisms on the shells which increased to 100% by the last sampling date in January of 2015. The following organisms were found to colonize the shells and bags: colorful macroalgae, sponges, bryozoans, sea squirts, amphipods, isopods, barnacles, skeleton shrimp, grass shrimp, porcelain crabs, mud crabs, stone crabs, pistol shrimp, flatworms, soft tube worms, hard tube worms, gobies, blennies, skillet fish, oyster fish, slipper shells, jingle shells, and oysters. In January of 2015, six bags were examined and these counts of live juvenile oysters were obtained: 73, 38, 18, 23, 17, and 63. This is an average of 39 live juvenile oysters per bag for these 6 bags sampled. Despite problems involving weight of the bags, Girl Scouts recruited live oysters with dead, non-seeded oyster shells in bags suspended from a dock, demonstrating that this part of the IRL has viable oyster larvae.

Bioremediation Platforms, *Kate Beckett and Dr. Robert J. Weaver, Florida Institute of Technology,* Water quality has been a topic of concern for the Indian River Lagoon (IRL) in Florida. Between the Superbloom in 2011, the 60 percent seagrass loss from 2009 to 2012, 99.8 percent reduction in clamming and 99.3 percent reduction in oyster harvesting in Brevard County (alone) from 1986 to 2013, restoration has been kicked into high gear. Successful oyster reef restoration has been accomplished in northern sections of the Lagoon; however, new methods have to be used to create oyster reefs in central and southern sections of the Lagoon due to lack of viable reefs to restore. As of July 2013, test plugs of seagrass were placed out in the Lagoon to test viability. Water conditions seemed favorable to the transplanted grass; however, predation on the new beds posed a new problem. To accommodate these issues in restoration and assist in water quality improvement in the IRL, four bioremediation platforms were engineered and deployed in the Lagoon. The platforms contain red mangroves, *Spartina*, oysters, clams and seagrass. Weekly monitoring of the platforms as well as examination of the plants and bivalves will help indicate feasibility of using the platforms as a means for initiating restoration, especially seagrass transplanting and oyster seeding. Turbidity, phosphate, ammonia and nitrate-nitrite measurements will be used to test water quality with the implementation of the platforms.

Graphical User Interface for Improved Benthic Mapping using Satellite-Borne Hyperspectral Data. *Shizhen Huang[1] and Dr. Hyun Jung Cho[2]. (1) Embry-Riddle Aeronautical University, (2) Bethune-Cookman University*. A simplified water correction algorithm was derived from our previous water correction equations that were modeled for measuring light reflectance above the shallow water. This new water correction algorithm eliminates the previously complex controlled darkroom procedures to obtain water scattering absorption. A Graphical User Interface (GUI) was built utilize the simplified water correction algorithm using Interactive Data Language (IDL) to provide the prospective users with a user friendly interface that can be applied to perform water correction configuration of hyperspectral images that contain shallow estuary. Users can now choose four sampling pixels from the hyperspectral image that represent the two types of homogenous substrates at two depths (e.g. 0 and 1.0 meter) to administer the water correction process to the entire water area pixels.

Newly Adjusted Hyperspectral Algorithm for Brown Algal Bloom Mapping in Indian River Lagoon, FL. *Kwanza Johnson and Dr. Hyun Jung Cho. Bethune-Cookman University*. Over the last few years, climactic events sparked a shift in phytoplankton communities resulting in elevated levels of harmful algal blooms (HABs). The Indian River Lagoon (IRL) lost over 40,000 hectares of seagrasses after the recent superblooms. In 2012-2013, the blooms were dominated by a brown algae species *Aureoumbra lagunensis*; a species that contains a series of accessory pigments which make it appear golden brown to yellow-orange in color. One of the pigments also has average absorption peaks within the 444.5 nm region when tested in several different solvents. A satellite based spectral algorithm for early detection the brown bloom for the IRL had not yet been developed. The project goal was to calibrate, adjust and validate existing Chlorophyll Indices for the 2012-2013 blooms in the IRL using Hyperspectral Imager for Coastal Oceans (HICO) data taken over the lagoon during October 2013. Water quality data of September 2013 were obtained through Florida Fish and Wildlife Conservation Commission and overlaid onto the HICO image after land and ocean pixels were masked. For calibration, spectral data and the major pigment, Chlorophyll *a*, values were randomly extracted from 150 HICO pixels to determine wavelength locations for the combined pigments' absorption and scattering. These wavelengths were then used to calibrate a new HICO algorithm $((R_{690}-R_{668})/(R_{690}-R_{668}))$. Additional 150 sites were extracted for validation. The previously used Chlorophyll algorithm did not work with the brownbloom species (R=-0.63), but the newly adjusted algorithm increased the correlation with the field algal data (R.=0.351, P<0.001).