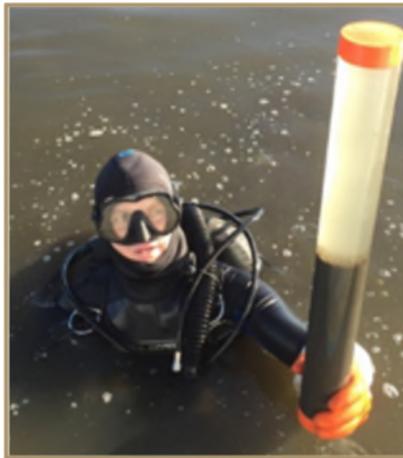


Restore Lagoon Inflow Research (Phase 1) Executive Summary



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September 2020

Acknowledgements

The Restore Lagoon Inflow research team thanks Governor Ron DeSantis; the Florida legislature especially Representative Randy Fine, Representative Thad Altman and Senator Debbie Mayfield; and the Florida Department of Education for their roles in advancing Florida's water health and research. We would also like to thank the people and organizations in Brevard and Indian River counties concerned about the lagoon's recovery who continue to advocate for one of Florida's most precious resources. A special acknowledgement of Dr. John Windsor's contributions to the coordination of this report and his career long efforts toward improving the health of the Indian River Lagoon. In addition, we thank Dr. T. Dwayne McCay, Mr. Frank Kinney, and Mr. Robert Salonen for supporting Restore Lagoon Inflow Research project communications with all stakeholders.

The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida or any of its sub-agencies.

The photographs on the cover were provided by the Florida Tech Principal Investigators on this project.

Executive Summary

The Indian River Lagoon (IRL) is not a river, it is a lagoon. A lagoon is a special type of estuary that is oriented parallel to the coast and characterized by shallow coastal waters with restricted, but free, exchange with the adjacent open ocean. It is this exchange of fresh and saltwater that makes estuaries the most productive and fragile coastal ecosystems in the world. The IRL is a microtidal system that has limited exchange with the ocean through five engineered and stabilized inlets (Ponce de Leon, Sebastian, Fort Pierce, St. Lucie, and Jupiter).



With funding of \$800,000 from the Florida Legislature, the Florida Institute of Technology (Florida Tech) completed Phase 1 of a multi-phase project to explore customized solutions for improving water quality within the IRL by restoring periodic historical ocean inflows. The project is working towards installing a temporary inflow pilot system to gather information on the feasibility of a potential full-scale, permanent system. The purpose of this first phase of the study was to gather baseline data and modeling on existing water quality, biological parameters, and hydrologic conditions at potential locations for a future permitted, temporary inflow pilot system, which may then lead to a full-scale, permanent system. The modeling and engineering proceeded in parallel with biological and water quality monitoring in advance of the temporary inflow pilot system study. This ecosystem monitoring was crucial to understanding the baseline status of the lagoon in the vicinity of the proposed inflow, so that the changes resulting from the proposed temporary inflow pilot system can continue to be monitored and evaluated.

A multi-disciplined team of research professionals, who were supported by university staff and students, was assembled to provide expertise in each area of study:

- Modeling and Engineering – Dr. Gary Zarillo, Dr. Robert Weaver, and Dr. Ashok Pandit
- Biological Monitoring – Dr. Kevin Johnson, Dr. Ralph Turingan, Dr. Jeffrey Eble, Dr. Johnathan Shenker, and Dr. Jesse Blanchard
- Geochemical Baseline – Dr. Austin Fox

Three potential inflow locations were selected for study: Port Canaveral and south Cocoa Beach in Brevard County and Bethel Creek in Indian River County.

Modeling and Engineering

The modeling and engineering objectives were aimed at testing the hypothesis that controlled water exchanges between the ocean and IRL can be engineered to provide improved flushing and water quality within local IRL compartments without the negative impacts on littoral sediment budgets linked to permeant stabilized inlets.

The modeling approach combined the Advanced Circulation (ADCIRC), Hybrid Coordinate Ocean Model (HYCOM), and Environmental Fluid Dynamics Code (EFDC) models in a nested system.

This approach focused on modeling a potential full-scale, permanent system to evaluate the movement of water on a basin-wide scale and the proposed design's effects on tides, water quality, sediment transport, and flushing rates. The modeling supported the concept of re-establishing ocean inflow to circulate the water in the IRL system, moving stagnant lagoon water and replacing it with ocean water. The inflow system would create very slow water movement toward the inlets, facilitating enhanced exchange and mixing with the larger IRL system. Localized changes in salinity are predicted near the outfalls, along with minimal changes in temperature.

Model results in the Banana River Lagoon (BRL) varied according to the location and magnitude of water inflows. The pump station option near Patrick Air Force Base reduced model simulation tracer concentrations by 65% to 75%, during the 365-day model period, in the BRL south compartment compared to a tracer reduction of about 40% under the base case. The pump station option pumping 10 cubic meters per second (m^3/s) into the BRL just north of Port Canaveral provided greater flushing due to its location. The model simulation tracer concentration in most BRL compartments was reduced by 60% to 75% under this option. The weir structure option located within Port Canaveral was predicted to have the greatest potential for exchanging water out of the BRL over a shorter period of time compared to the two pump options. The model simulation tracer concentration in the BRL central to north central compartments was 70% to 85% lower compared to the base case. In addition, an option for a 5 m^3/s pump station in Bethel Creek was modeled. This option flushed the IRL Bethel Creek compartment in days with minimal impacts on salinity and temperature. However, this pump station had minimal benefits on the surrounding IRL compartments.

Draft designs were also provided for three structure options: pipe with no pump, pump and pipe, and weir. The temporary inflow pilot system flow rate was set to a minimum of 5 m^3/s and the potential full-scale, permanent system flow rate was set to a minimum of 20 m^3/s . Each concept was focused on controlled inflow of ocean water into the BRL. For the temporary inflow pilot system, the engineering supported either an overland temporary pipe and pump or a weir in the northern BRL with a flow of 5 m^3/s . The engineering also identified two options for a full-scale, permanent system: pipe and pump or weir. The weir is most cost-effective approach that provides the greatest flexibility for flow at the lowest cost but is the most restrictive with location. The pipe and pump option is the most restrictive approach in cost as well as flow rates, but the most flexible with location. A final temporary pilot inflow system, and potential full-scale, permanent system, may be modified from the design and volume options included here based on further scientific, regulatory agency, and logistical requirements.

Biological Monitoring

The biological monitoring objectives were to document the biological characteristics of the IRL and coastal ocean near the proposed inflow locations and assess the likely biological response to an inflow system. This approach assessed seagrass and drift algae near the proposed inflow sites and evaluated the percent cover, density, and canopy height. Sediment samples collected on the lagoon and ocean sides of the proposed inflow sites evaluated the abundance, diversity, and richness of fauna as well as environmental parameters in the sediment. Larval fish and invertebrates were collected and analyzed, and environmental parameters were used to see how fish species respond to changes in the lagoon and ocean



Students conducting transect and quadrat sampling of shoal grass.

environments near the proposed inflow sites. The relationships between fish community structure and key water parameters were described using Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring database, which is the most extensive IRL fish database. Environmental deoxyribonucleic acid (eDNA) characterization was also used to identify the presence of key fish and invertebrate species.

Extensive data on species densities and distributions, and environmental and community associations, were collected as part of this baseline study. These data were used to evaluate the changes in the biological resources.

Many estuarine animals tolerate fluctuations in temperatures, salinities, turbidity, nutrients, and pollutants. By comparison, coastal ocean conditions are relatively constant and fall well within the ranges of estuarine organism tolerances. However, data are lacking on several key species of concern, such as the spawning populations of sportfish in the BRL. Indirect impacts on the estuarine community due to biotic factors, such as predation by, or competition with, organisms from the coastal ecosystem, are difficult to predict. Coastal organisms may be directly introduced via enhanced inflow, or migration into the estuary could be encouraged following a shift towards coastal-like conditions. However, the Port Canaveral shipping locks already provide a limited hydrodynamic connection and migration opportunity and the northern IRL estuary was historically connected to the coastal ocean via inlets. Reliable evaluation of the biological impacts of restored inflow would be best accomplished through a temporary inflow pilot system where biological responses are carefully monitored. This would allow a more confident projection of the likely effects of a full-scale, permanent inflow restoration.

Geochemical Baseline

The geochemical baseline objective was to identify a suite of geochemical parameters to make a comparison between the baseline and enhanced inflow conditions. These parameters are important indicators used to calibrate the models and provide predictors and causation for ecological shifts from the geochemical cycling of nutrients and other parameters. This approach deployed an array of sensors to continuously monitor bottom water conditions, including temperature, dissolved oxygen, and salinity (selected sites), near possible inflow locations. In addition, discrete nutrient samples were collected to vertically profile the areas adjacent to the potential inflow locations. Sediment samples were collected to evaluate variables that correlated with geochemical nutrient cycling. Benthic chambers equipped with sensors were deployed to evaluate geochemical changes in the sediments. These approaches were implemented at each inflow location on the ocean and lagoon side.



*Ekman Grab Sampler
(above) and ADCP (below)
deployed in the IRL*



An inflow to the IRL would result in corresponding outflows of lagoon water into the coastal ocean. These modest exchanges of water plus dissolved and particulate materials would lead to changes in water quality within the lagoon. These modest exchanges would have both direct impacts, such as conservative mixing of temperature and salinity, and indirect impacts, such as changes to geochemical nutrient cycling in response to changes to water quality. Changes to temperature and salinity would likely be small; however, the potential for stratification and the potential formation of a dense layer of seawater within the lagoon could be of significance at certain

locations. If inflow were to occur via pumping at 5 m³/s, direct exchanges of water would yield a net removal of about 50 tons of nitrogen and 6 to 10 tons of phosphorus per year from the lagoon. Laboratory experiments carried out to estimate the potential impacts of a temporary inflow pilot system on geochemical nutrient cycling showed that lower lagoon temperature and higher lagoon salinity led to significant decreases in benthic fluxes for some nutrients. Laboratory experiments showed, under anaerobic conditions, ortho-phosphate fluxes were directed out of sediments whereas under aerobic conditions, sediments often were a sink for ortho-phosphate. Based on these data, enhanced circulation and increased bottom water dissolved oxygen would likely contribute to decreasing ortho-phosphate concentrations in lagoon water.

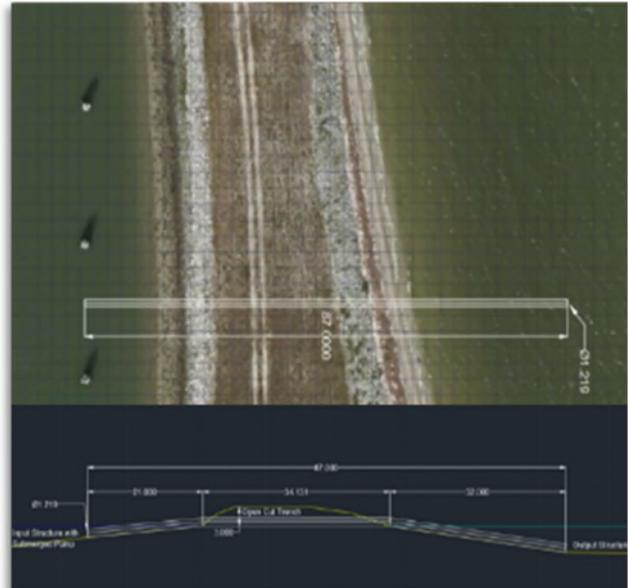
Recommendations and Next Steps

The multi-phased full research project scope is envisioned to include the baseline monitoring, design, permitting, implementation, and monitoring of a system providing temporary ocean inflow to the IRL. The results of the full Restore Lagoon Inflow Research project will provide information and analysis to the lead agency and appropriate decision-makers to help determine the viability of a full-scale, permanent ocean inflow system; identify factors that should be considered should a natural breach occur; or if further evaluation is necessary.

This report represents the foundational data collected during Phase 1 baseline monitoring and is an essential part of the project. The project team carefully evaluated the parameters required to assess the effectiveness, environmental effects, and limitations of an inflow system. These data will be invaluable not only for the inflow project but also for researchers requiring similar data for other applications in the IRL and nearshore Atlantic Ocean.

This Phase 1 monitoring represents three seasons of population dynamics in seagrasses, benthic infauna, phytoplankton, ichthyoplankton, fishes, and eDNA surveys, as well as geochemical data, but it is important to obtain at least one more year of these measurements to identify seasonal variation. Continuation of monitoring, site selection, preliminary design of the temporary inflow pilot system, and pre-application permitting meetings with regulators are planned for Phase 2. Regulatory and agency feedback will help inform analysis and data collection priorities in Phase 2 and subsequent phases of the research project.

For Phase 2, the temporary inflow pilot site location for establishing an exchange with the coastal ocean will be determined using the biological and geochemical data and modeling from this Phase 1 study and considering practicality (i.e., land ownership, utilities, distance, public roadways, zoning, noise impact, and agency permitting probability), existing exchange conditions, and how pilot flow impacts can meaningfully be extrapolated to other sites. Subsequent phases of the Restore Lagoon Inflow Research project are anticipated to involve permitting, implementation of the temporary inflow pilot system, continued monitoring, and analysis of the effects of the temporary inflow of seawater into the lagoon.



Potential pipe and pump pilot study location and conceptual design