Nutrient Mass Flux Through the Florida Keys Tidal Channels

Patrick J. Gibson and Joseph N. Boyer
Florida Coastal Everglades LTER and
Southeast Environmental Research Center, Florida International University

Objective

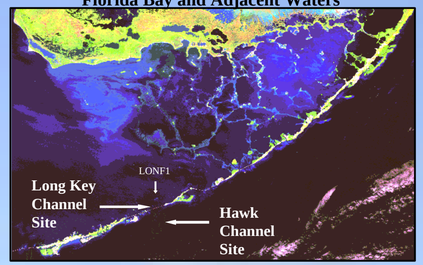
Recent ecological changes have made water quality in Florida Bay a primary concern (Fourqurean & Robblee 1999, Boyer et al. 1997). Since the late 1980's Florida Bay has experienced mass die-off of seagrass (Robblee et al. 1991), increased occurrence of algal and cyanobacterial blooms (Phlips & Badylak 1996), increased turbidity, a near 100% mortality of sponges, and a decline of recreational gamefish (Tilmant 1989). Water quality is greatly affected by the interaction of Florida Bay waters with its boundary systems and the circulation dynamics within the bay itself. For example, Florida Bay may be outwelling nutrients across its southern and eastern boundaries contributing to eutrophication of the barrier reef community on the Atlantic side of the Florida Keys. Large-scale nutrient budgets for total nitrogen (TN) and total phosphorus (TP) for Florida Bay have been developed (Boyer and Kellar 2003, Rudnick et al. 1999). These budgets are largely unbalanced and have admitted uncertainties in the material flux estimates to and from the estuary. Material exchange has never been directly measured and estimates are based on monthly nutrient data applied to hourly flow measurements. These calculations underestimate the impact of meteorological events such as tropical storms, cold fronts, or exceptional tidal amplitude on material transport to and from Florida Bay. **The objective of this study is to collect one year of measurements of volume transport and nutrient concentrations that allow accurate calculation on a tidal time scale of material flux through Long Key Channel in the Middle Keys.** These measurements will serve to help balance nutrient budgets for Florida Bay, calculate the contribution of its waters to the Keys coral reef community, and allow us to test the concept of outwelling in the system.

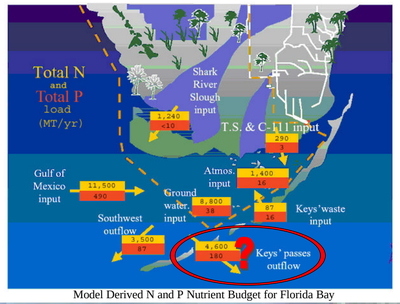
The hypotheses for the study are:

•Florida Bay is outwelling a significant source of nutrients to the coastal waters of the Florida Keys.

•Episodic meteorological events are a significant force driving the exchange of material through the Keys tidal passes.

Florida Bay and Adjacent Waters





Model Derived N and P Nutrient Budget for Florida Bay

Proposed Methods

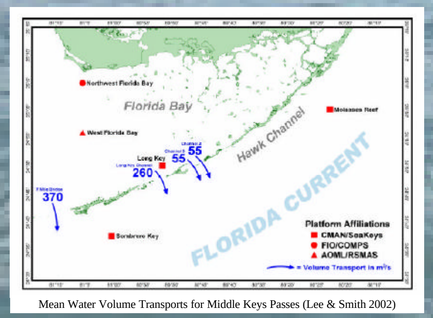
A one-year high-resolution study of water volume transport and nutrient flux will be conducted in Long Key Channel. Volume transport through the channel will be calculated from measurements of current speed, direction, and water depth collected from a mid-channel SonTek Argonaut acoustic Doppler current meter. To collect measurements of nutrient concentrations, an underwater autosampler will also be deployed in Long Key Channel. This instrument has been engineered specifically for this project. The instrument will be anchored near the current meter station and programmed to collect water samples on various time series from hourly to daily. YSI Extended Deployment System instrument packages will also be deployed to log data on temperature, salinity, dissolved oxygen (DO), pH, and turbidity. Nutrient samples will be analyzed for TN, TP, and total organic carbon (TOC). In addition, grab samples and CTD casts will be collected from a series of five across-channel monitoring stations, including the mid-channel study site, whenever instruments are serviced, approximately bi-weekly. The grab samples will be analyzed for dissolved nutrients NO_3^-, NO_2^-, NH_4^+, soluble reactive phosphorus (SRP), $Si(OH)_4$, TN, TP, TOC, and chlorophyll *a* (CHLA). Another station will be concurrently established in Hawk Channel near Long Key with an acoustic Doppler profiler (ADP), autosampler, YSI instrument, and grab samples. The NOAA operated Long Key C-MAN station will collect atmospheric data including wind speed and direction, barometric pressure, air and sea temperatures, and salinity from a location just north-west of the long key channel sample site.

Expected Results

This project will produce a direct measurement of exchange of water and nutrients through the major tidal pass between Florida Bay and Hawk Channel. These values will be compared against previous estimations of material flux and provide quantitative information for modeling efforts. The results of this study will allow us to compare mass flux over annual, seasonal, and tidal cycles, and to characterize the response to weather-related events. In addition we will able to compare estimates to terrestrial loading numbers and nutrient loading estimates from deep-water upwelling onto the reef tract (Leichter et al 2003).

Previous Research

Volume transports between Florida Bay and Hawk Channel through the Keys tidal passes have been quantified in previous investigations (Smith 1998, Lee and Smith 2002). The bulk of direct transport between these two bodies of water occurs through Long Key channel in the Middle Keys (Smith 2001). Flow through all the major Keys tidal channels has been calculated a mean outflow of about 800 m^3s^{-1} (Lee et al. 2002), however episodic outflow events as great as 7000 m^3s^{-1} have been observed during the passage of winter cold fronts (Smith 1998). Long Key Channel specifically has shown transport values during wind events of up to 2000 m^3s^{-1} for the duration of the event, typically from 1 to 10 days. This project is designed to directly measure nutrient mass flux in conjunction with these wind events and the long term tidal and sub-tidal mechanisms.



Mean Water Volume Transports for Middle Keys Passes (Lee & Smith 2002)

Instruments to be Used for this Project:

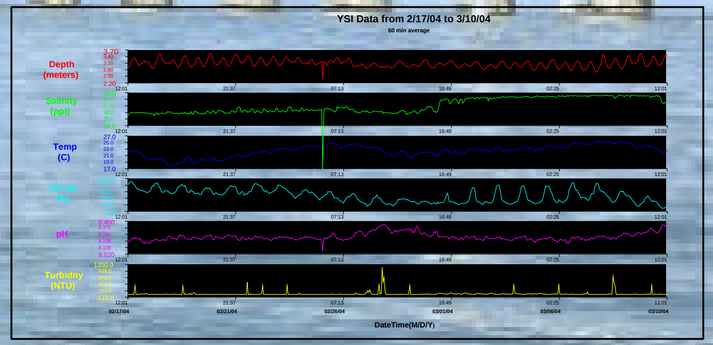
LONF1 C-MAN Data Buoy

Underwater Autosampler – Engineered specifically for this project

SonTek Doppler Current Meter

YSI Extended Deployment Environmental Sensor

Data Source	Frequency	Parameters
Underwater Autosampler	Hourly or tidally (6hr) for 2 to 3 weeks a month	TN, TP, TOC
Grab Samples	Bi-weekly or more	NO_3^-, NO_2^-, NH_4^+, SRP, $Si(OH)_4$, TN, TP, TOC, Chl-a
YSI 6600 EDS Sensor	Continuous	Temperature, Depth, Salinity, pH, DO, Turbidity
SonTek Argonaut Current Meter	Continuous	Water Flow Velocity and Direction
LONF1 C-MAN Data Buoy	Continuous	Wind Speed and Direction, Atmospheric Pressure, Air and Water Temperature, Salinity, Tide Height



Acknowledgements:

We would like to thank Ned Smith, Dan Childers, and Jim Fourqurean for their ideas and input on the project. The field work is only made possible by the exceptional help of Chris Humphrey and Lisa Giles of the SeaKeys project and the staff of the Keys Marine Lab.