Effects of Groundwater on Salinity in Biscayne Bay

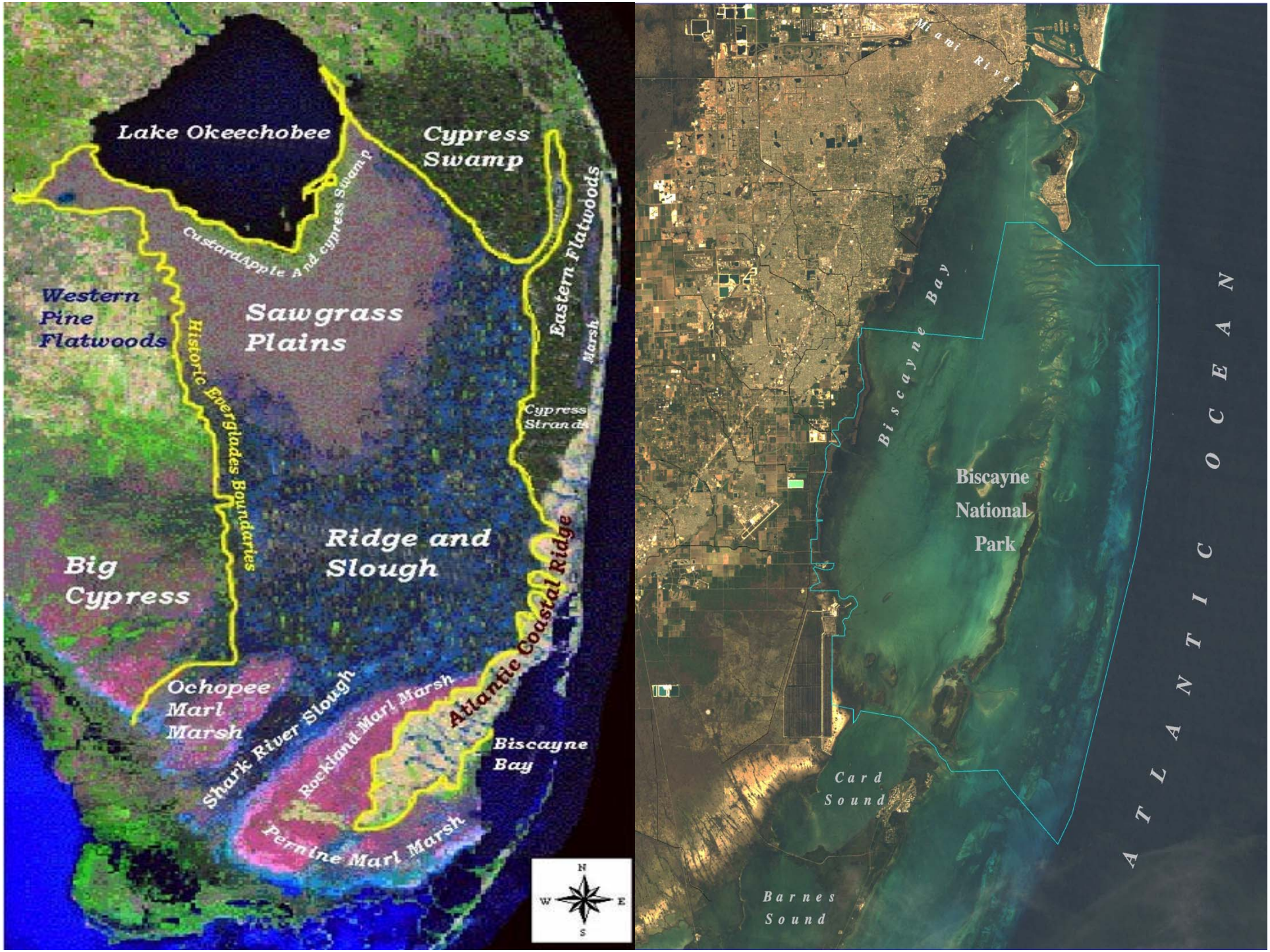
Sarah Bellmund1, Greg Graves2, Steve Krupa2, Herve Jobert3, Greg Garis1, and Steve Blair4

1Biscayne National Park Salinity Monitoring Program, Biscayne National Park, 9700 SW 328th St, Homestead, FL., 33033. USA.

2South Florida Water Management District, 3301 Gun Club Rd. West Palm Beach, FL 33406. USA

3Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, 4800 Rickenbacker Causeway, Miami, FL 33149. USA

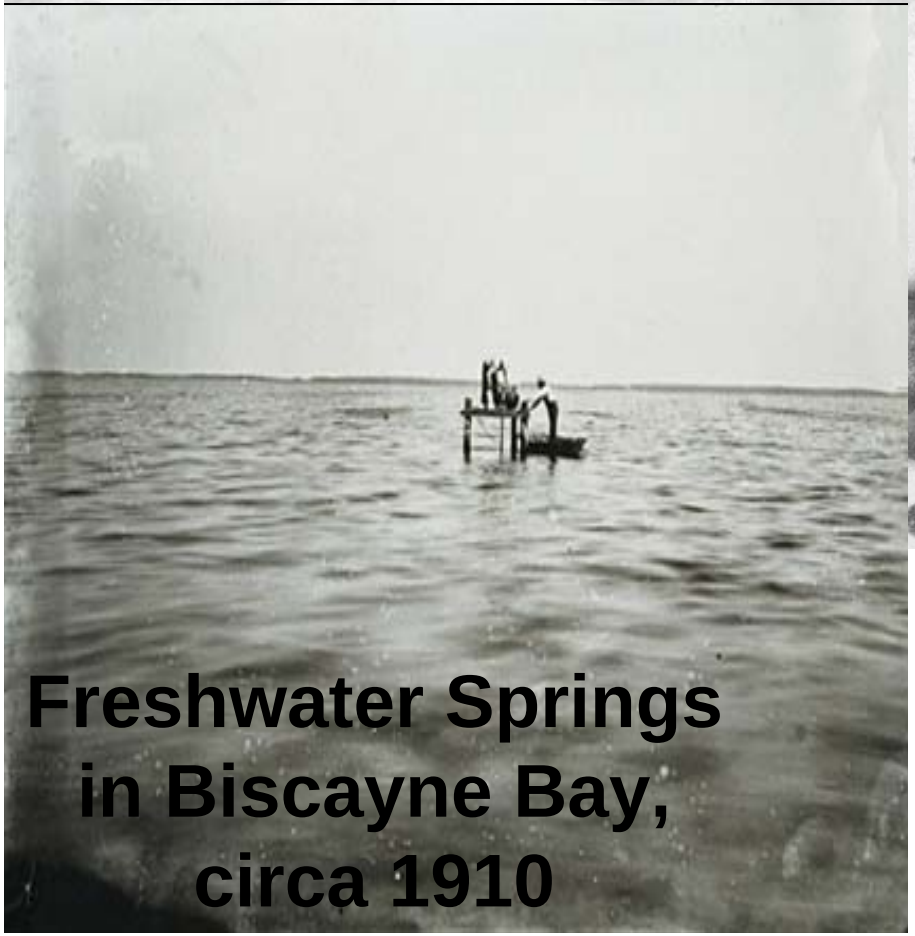
4Miami-Dade County Department of Resources Management, 701 NW 1st Ct., Miami, FL 33136. USA


Lake Okeechobee
Cypress Swamp
Custard Apple And cypress Swamp
Eastern Flatwoods
Marsh
Western Pine Flatwoods
Sawgrass Plains
Historic Everglades Boundaries
Cypress Strands
Ridge and Slough
Big Cypress
Atlantic Coastal Ridge
Ochopee Marl Marsh
Shark River Slough
Rockland Marl Marsh
Biscayne Bay
Pennine Marl Marsh
N
W
E
S
Miami River
Biscayne Bay
Biscayne National Park
ATLANTIC OCEAN
Card Sound
Barnes Sound

Historical Sources of Freshwater to Central and Southern Biscayne Bay

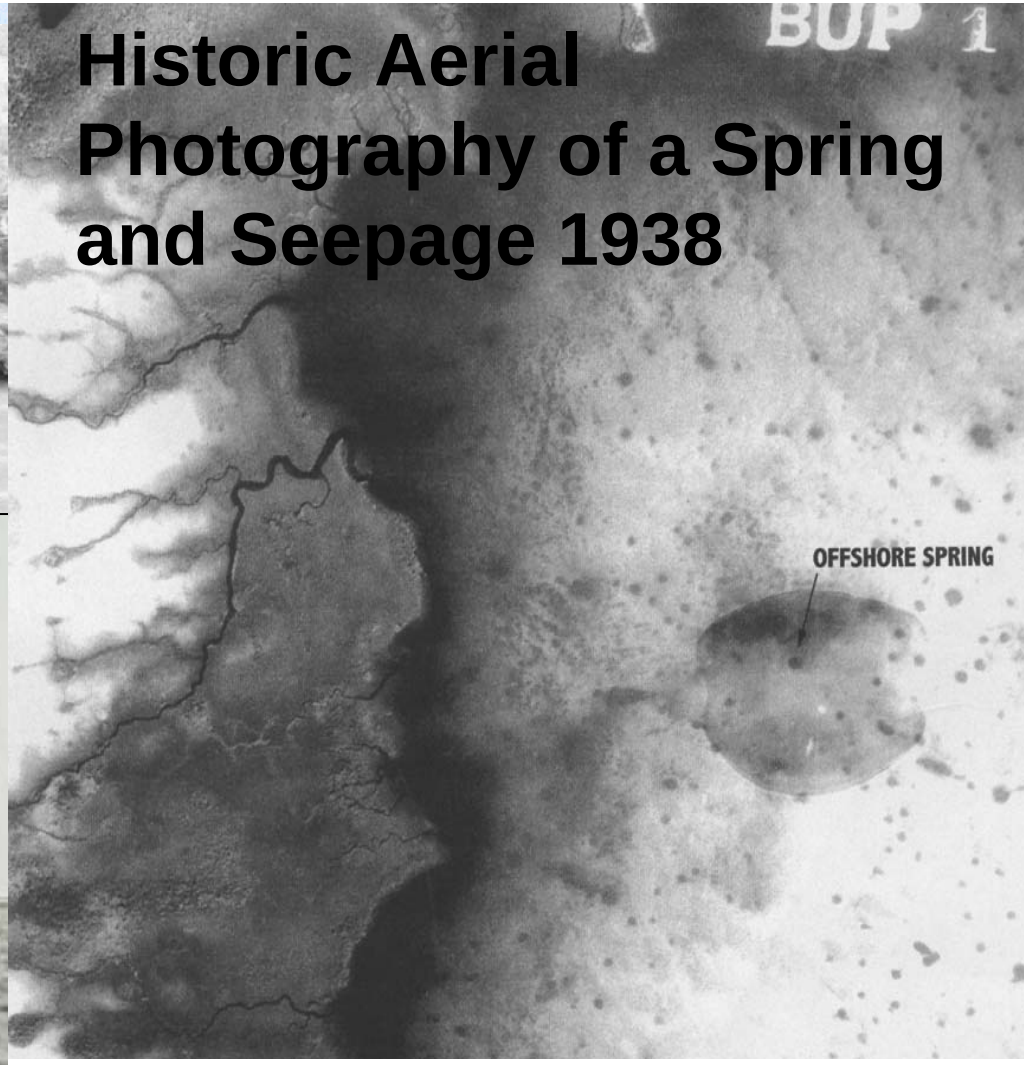
- Rainfall
- Springs and direct groundwater discharge
- Transverse Glade – Creek discharge
- Sheet flow – surface runoff

Karst Features



Freshwater Springs in Biscayne Bay, circa 1910

Historic Aerial Photography of a Spring and Seepage 1938



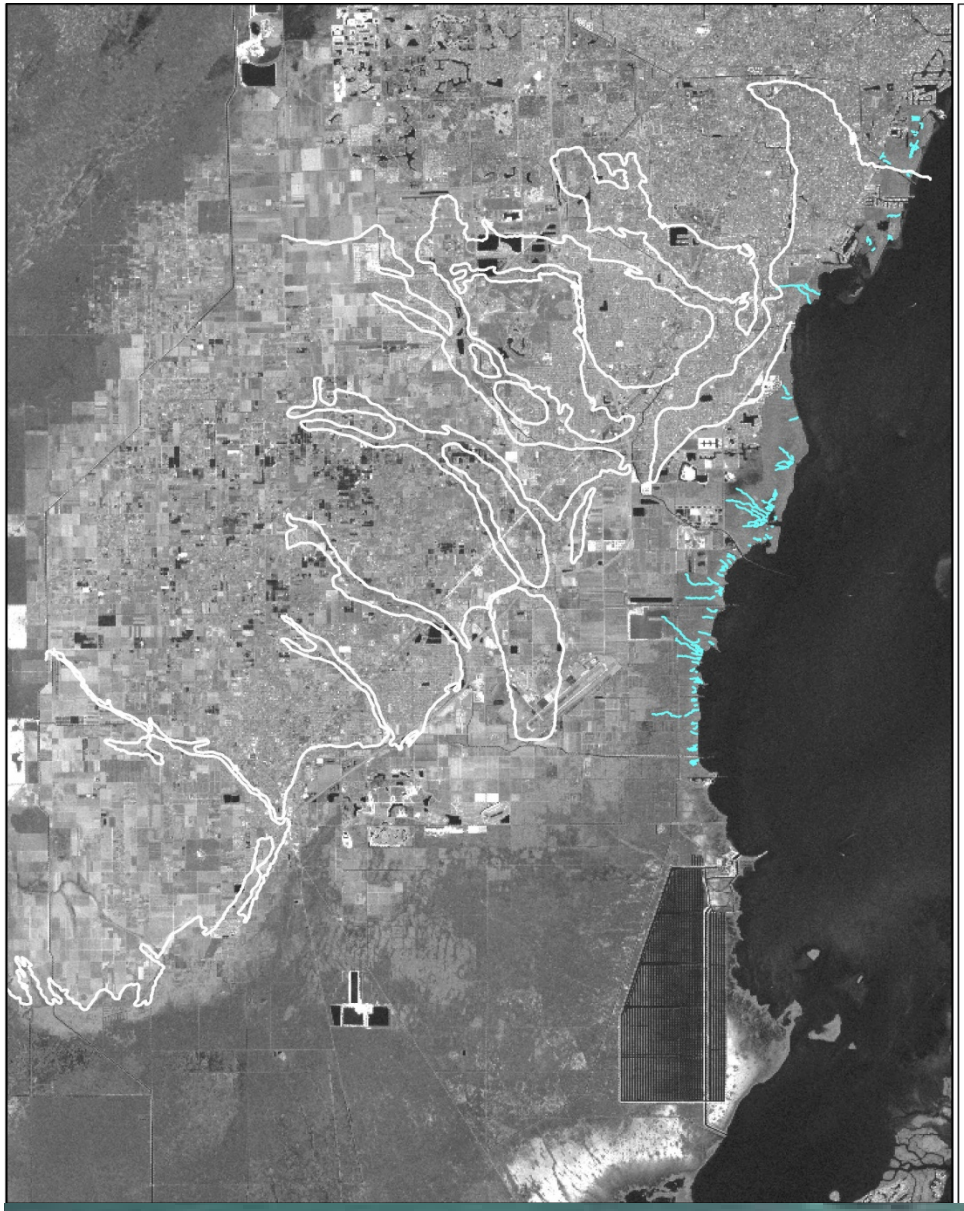
"Springs of good water are common and wells are to be had by a comparatively small amount of digging. Many springs burst up through the bottom of the bay, and we see fresh water boiling up through the salt." J. Buck, 1877 (Buck, reprinted 1979)

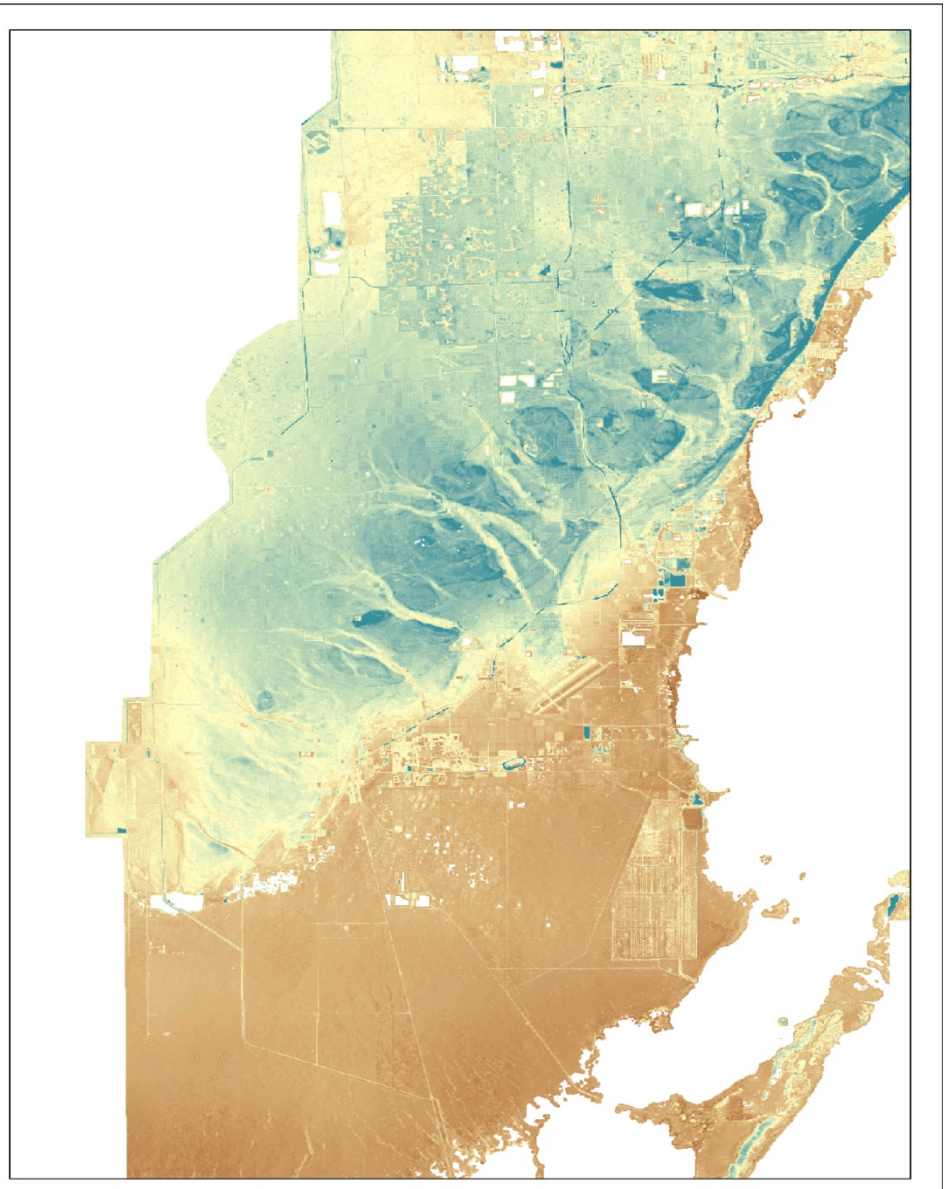
Changes in Biscayne Bay

Central Bay: From River, creek overland sheet flow and ground water springs to an area dominated by seasonal pulses of discharge from canals with permanently maintained openings to the ocean.

South Bay: From short coastal stream, surface sheet flow and groundwater flows to pulsed canal discharge

Extreme South Bay: Loss of overland flow due to construction of the railroad and then US Highway 1

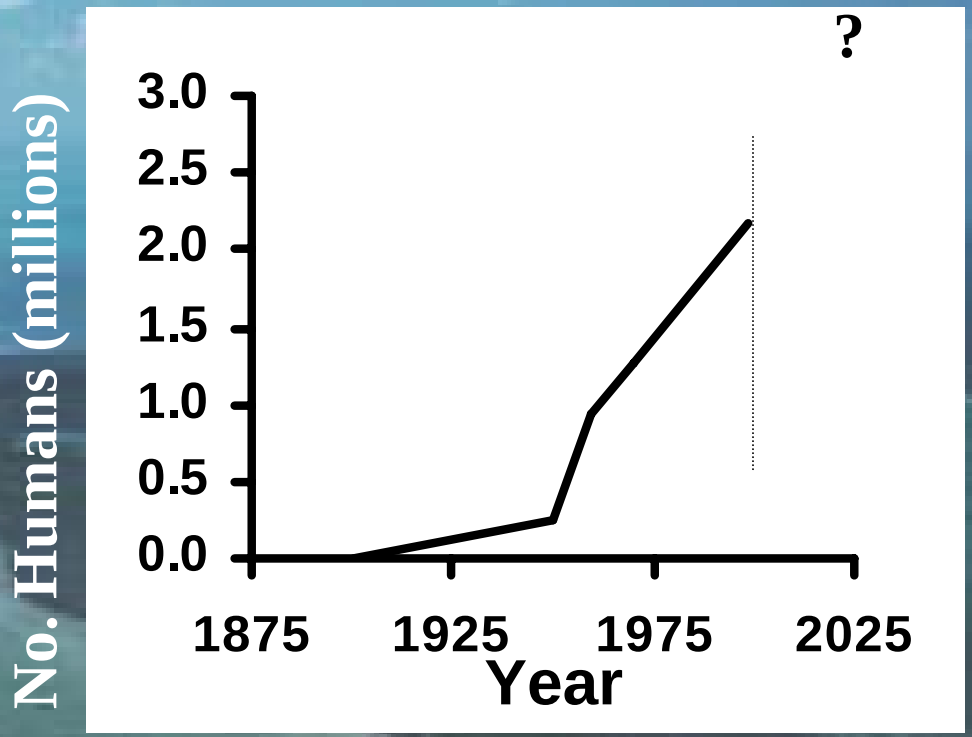




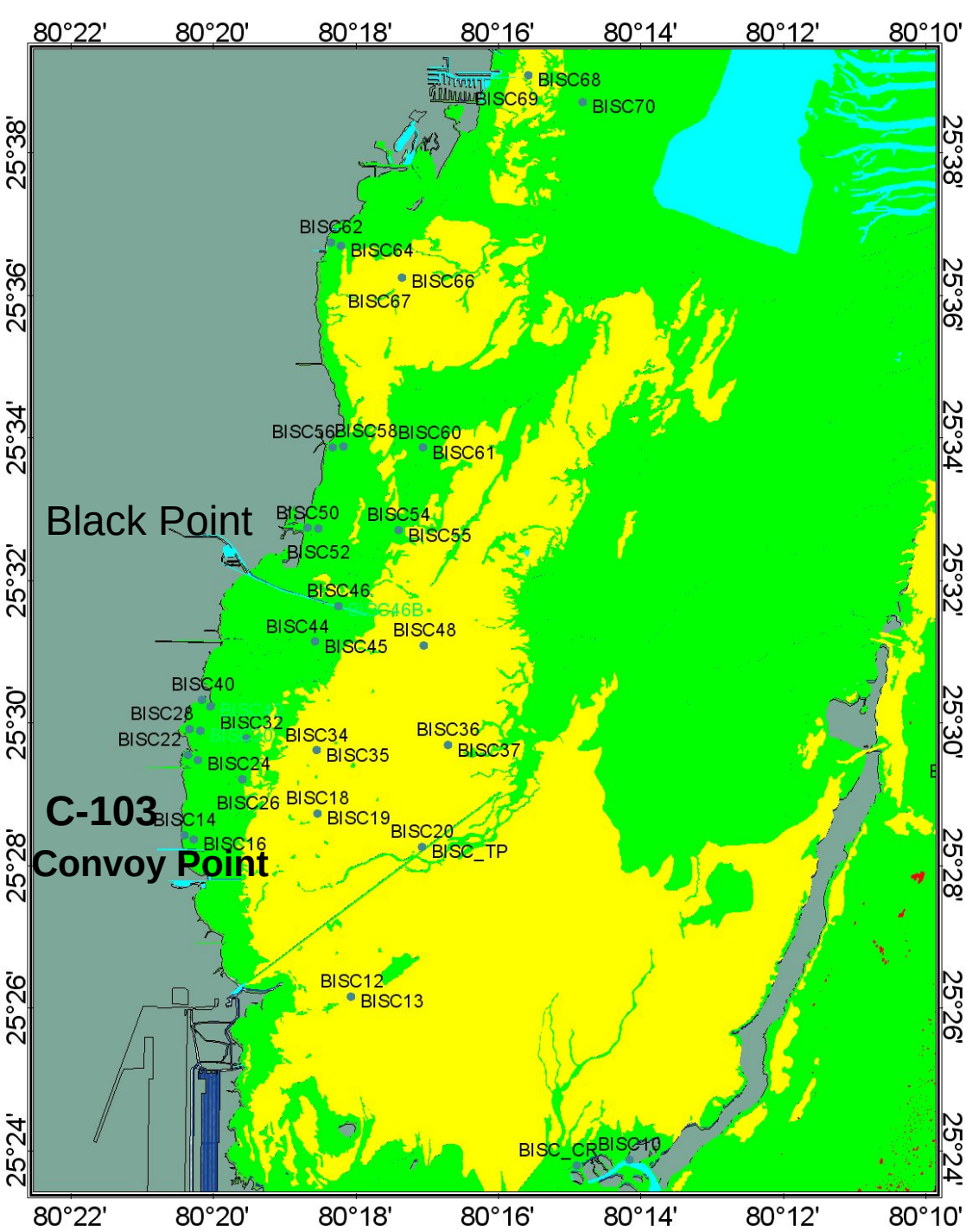
Coastal Ridge and Transverse Glades

Courtesy Dr. John Meeder and Peter Harlem and the South Florida Natural Resources Center

Changes Affecting the Ecosystems of Biscayne Bay

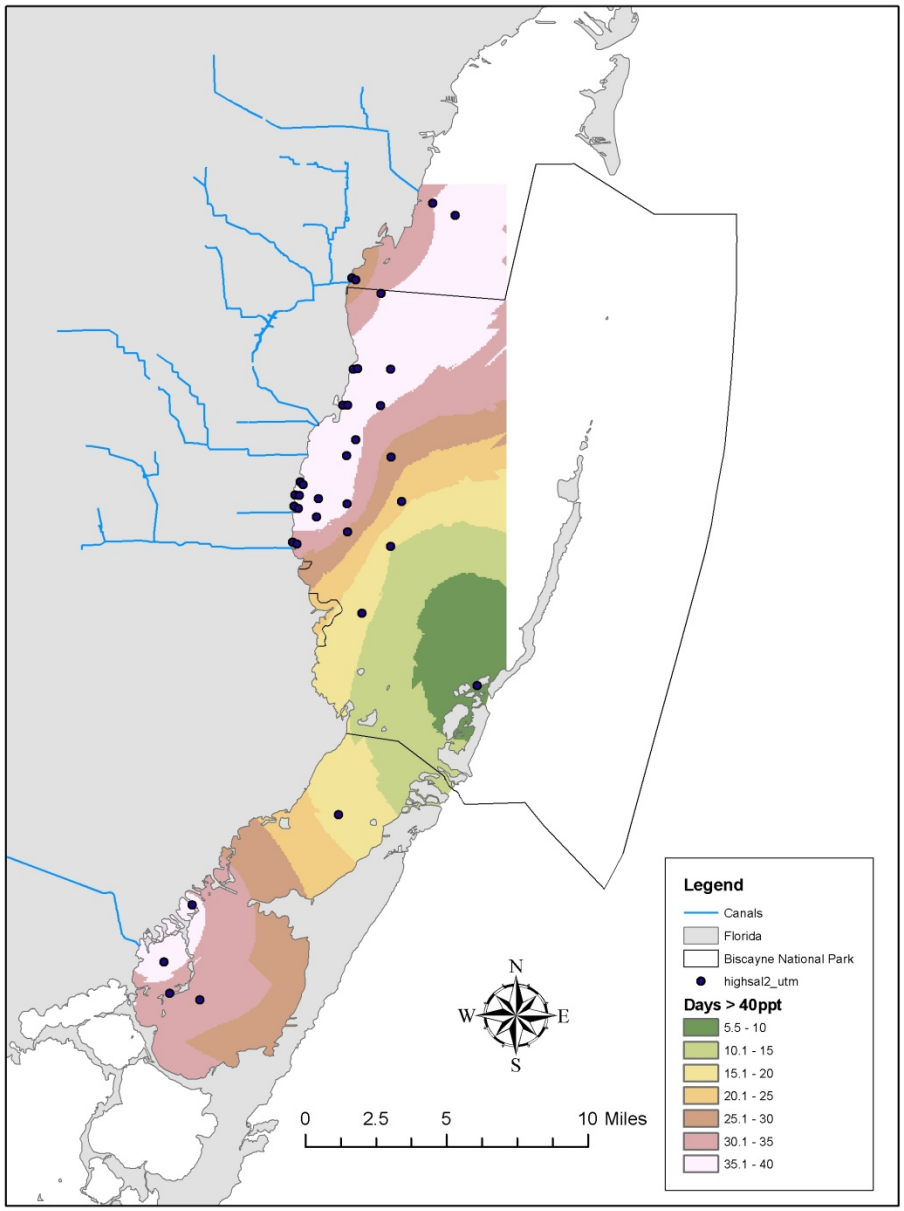


1900-2000: Miami-Dade population increased over 3 orders of magnitude.



Biscayne Bay Continuous Salinity Monitoring Network

with seagrass coverage



High Salinity Areas 2004-2005

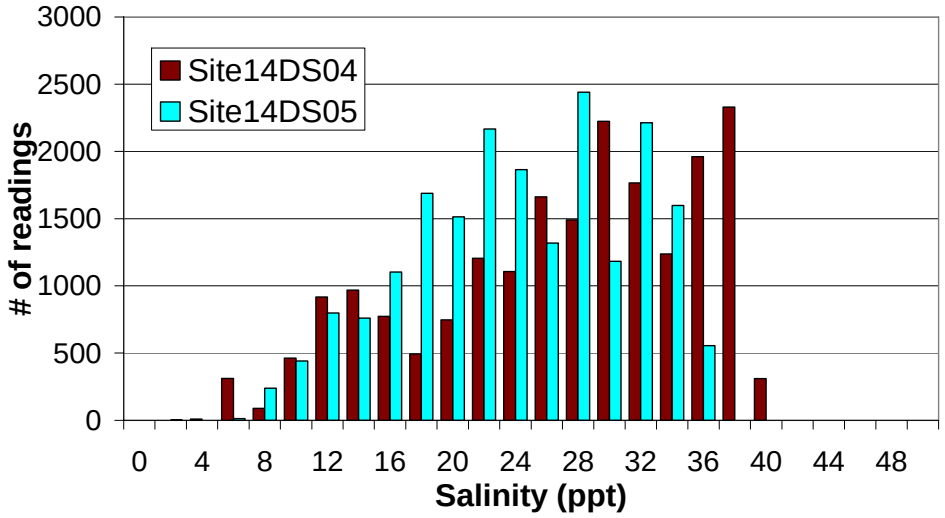
Average Days Greater than 40 psu

- 5.5-10 days
- 10.1-15 days
- 15.1-20 days
- 20.1-25 days
- 25.1-30 days
- 30.1-35 days
- 35.1-40 days

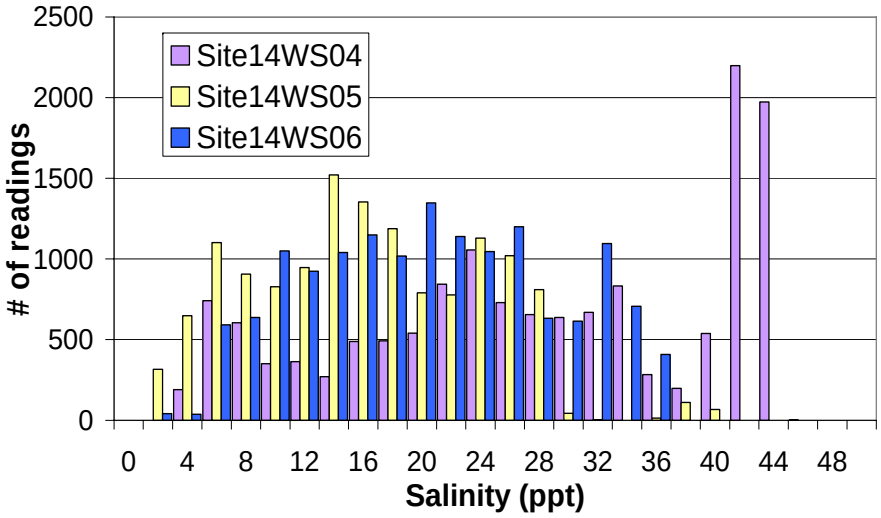
Lighter colors are longer and higher hypersaline conditions

Grouped Salinity Convoy Point and Fender Point

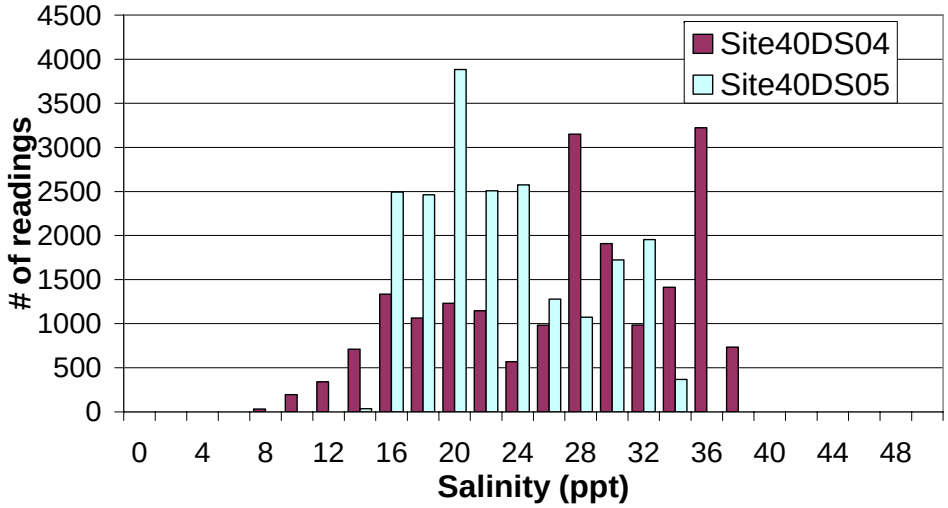
Convoy Point Mangroves Site 14: Dry Season
Salinity in 2 ppt bins



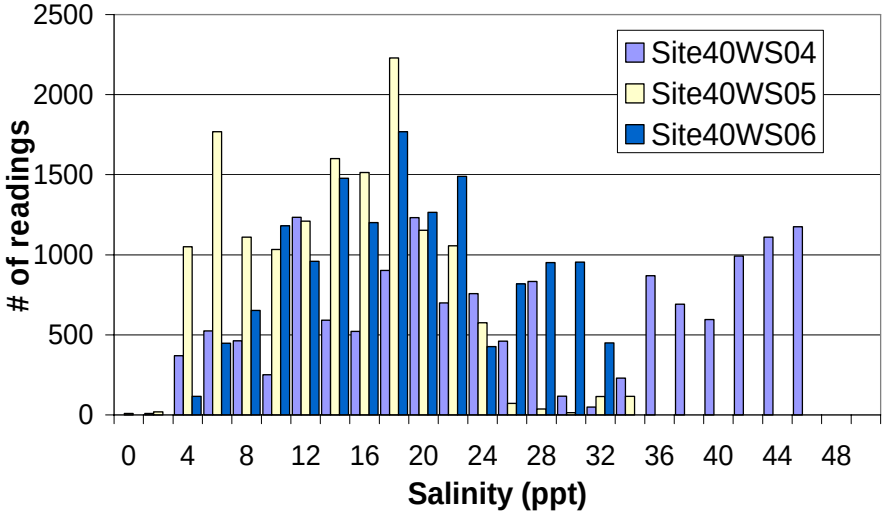
Convoy Point Mangroves Site 14: Wet Season
Salinity in 2 ppt bins



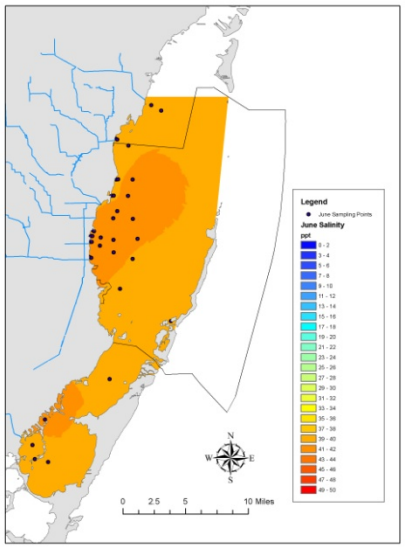
Fender Point Mangroves Site 40: Dry Season
Salinity in 2 ppt bins



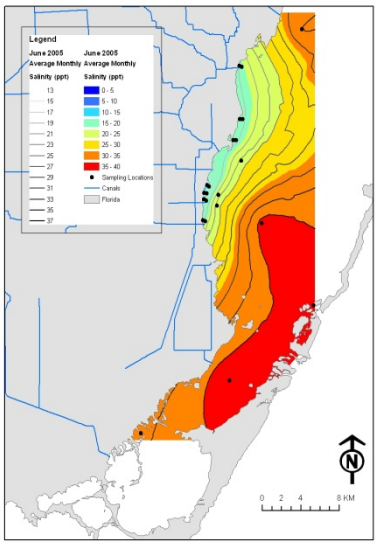
Fender Point Mangroves Site 40: Wet Season
Salinity in 2 ppt bins



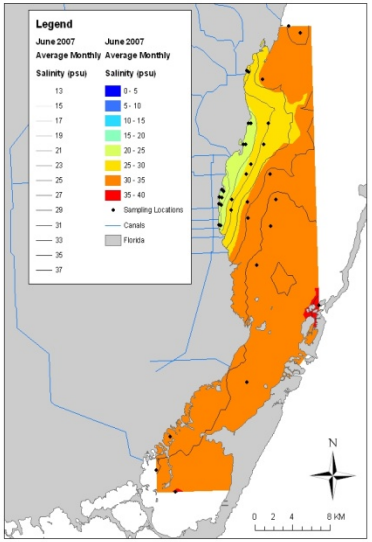
Salinity Early Wet Season Compared to Peak Wet Season and October Drawdown



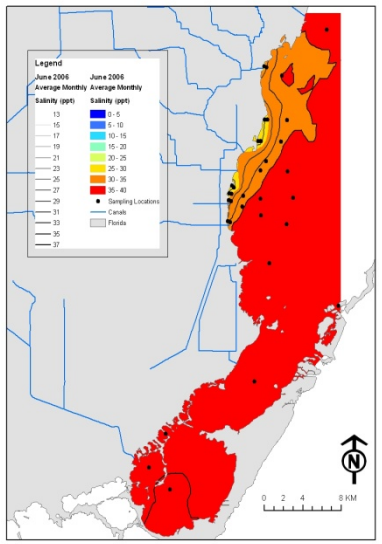
June 2004



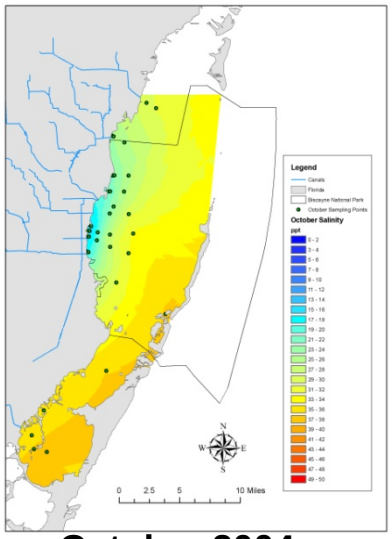
June 2005



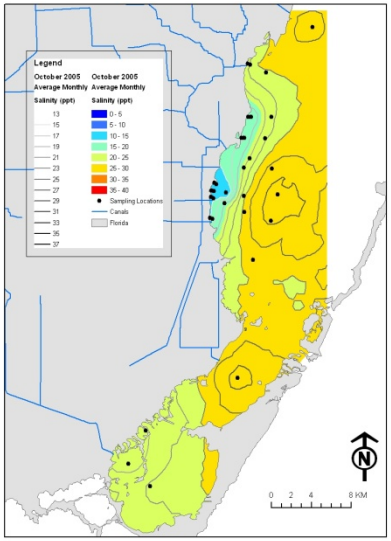
June 2006



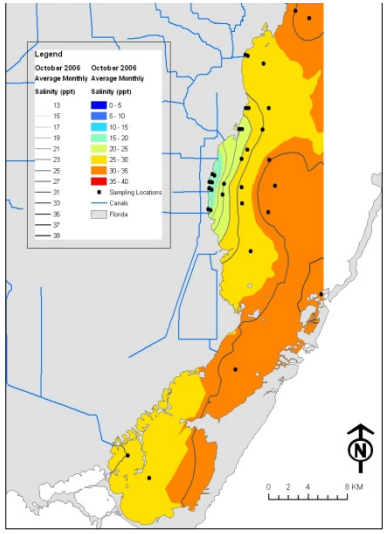
June 2007



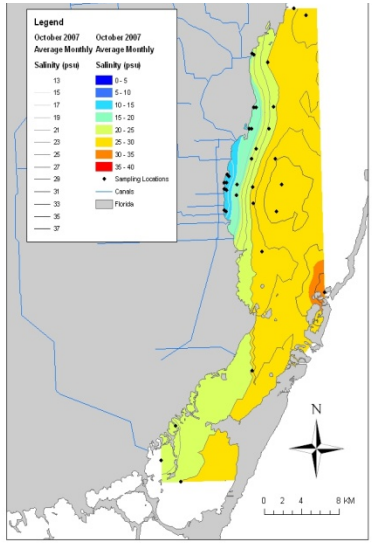
October 2004



October 2005

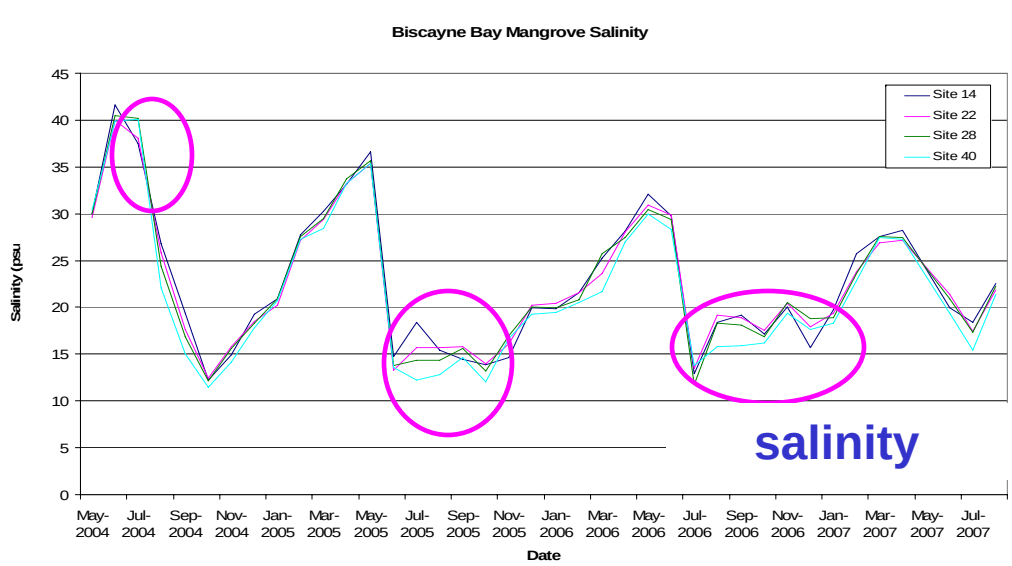


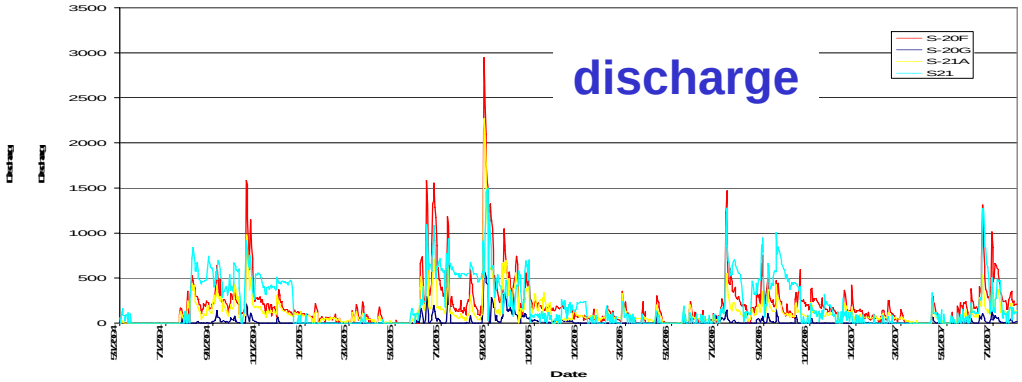
October 2006

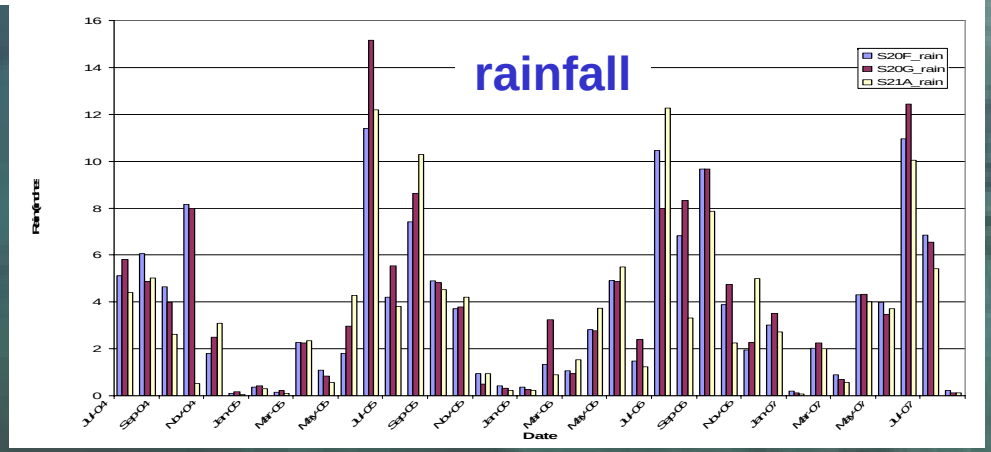


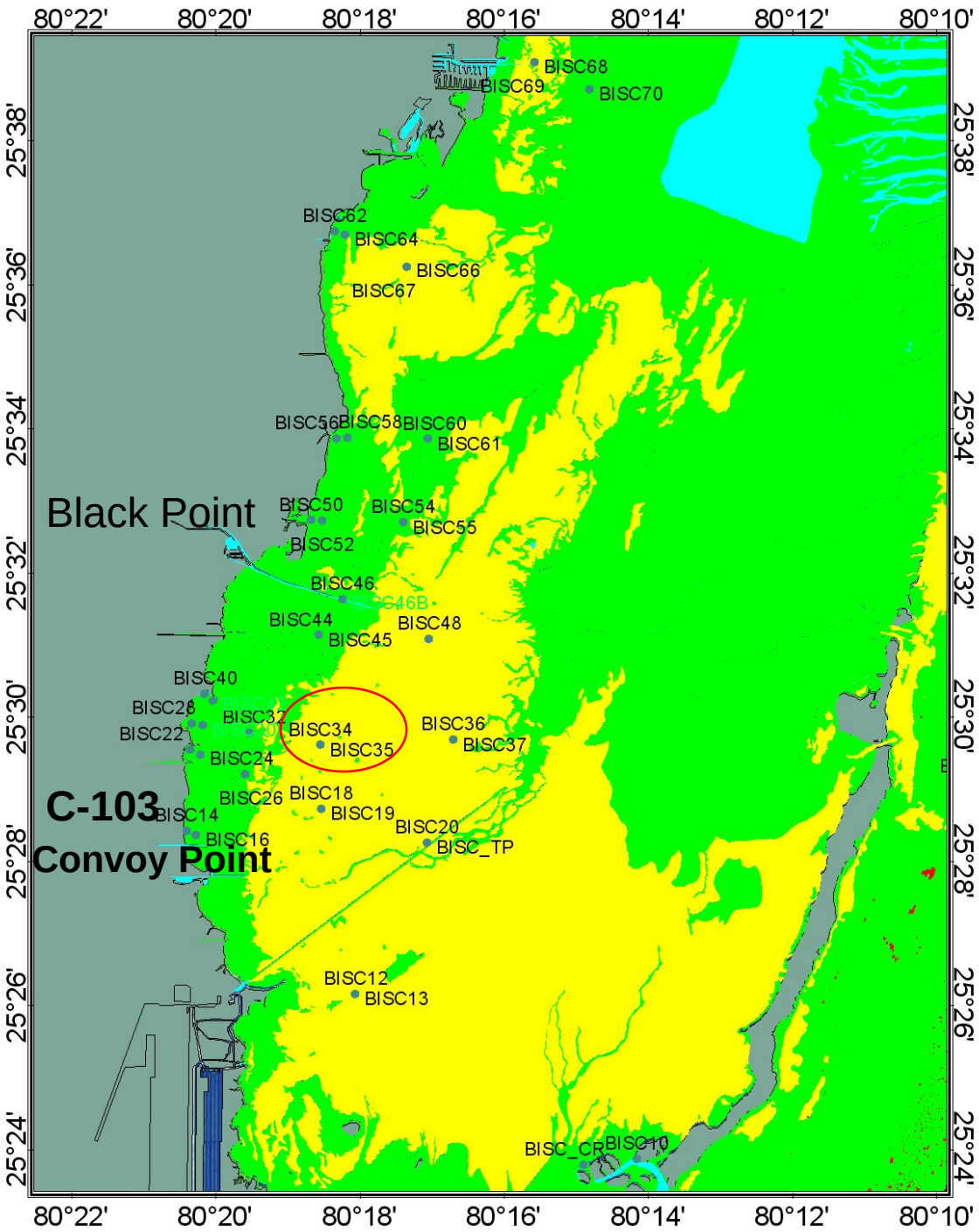
October 2007

How the managed coastal southern Biscayne Bay system operates





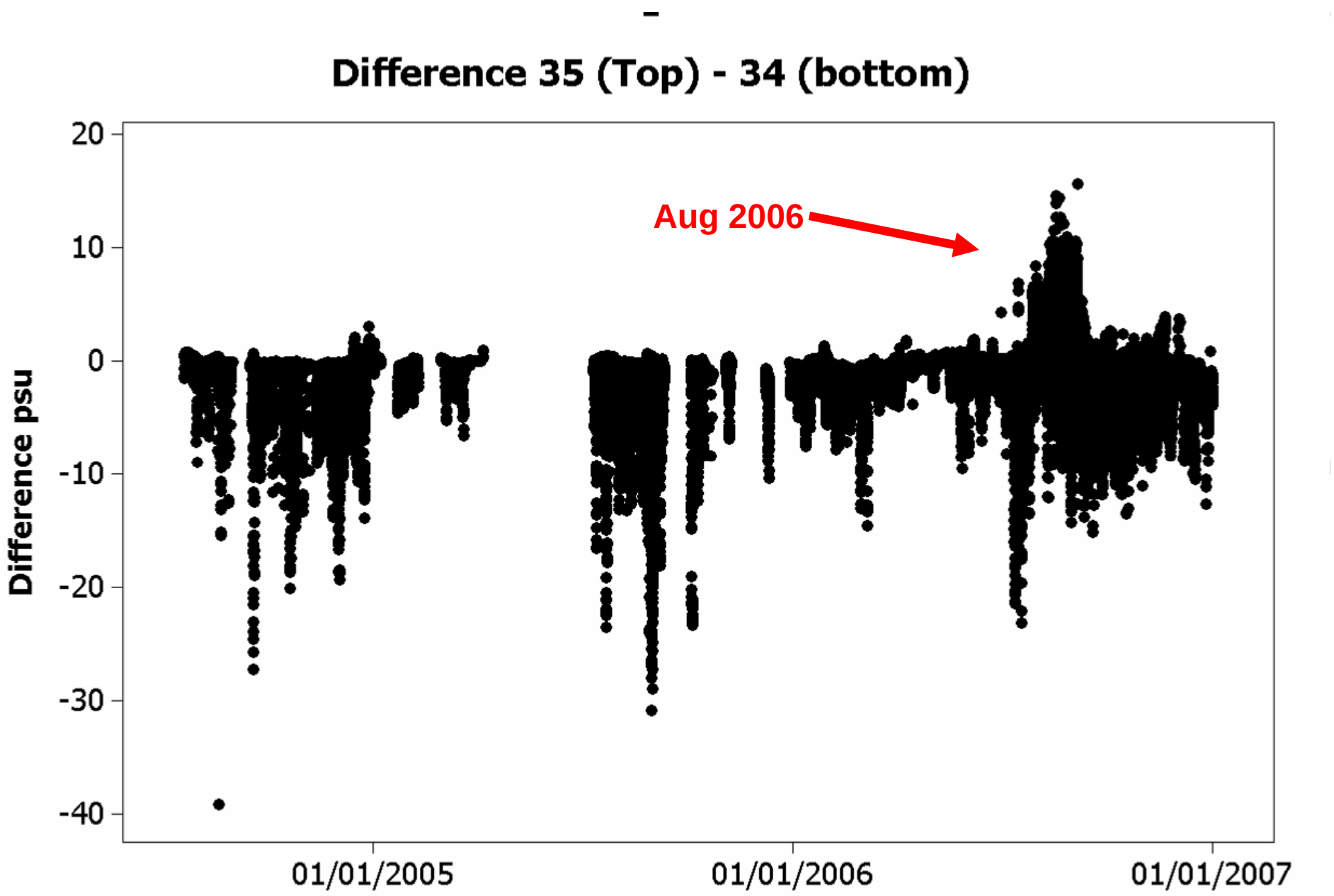




Biscayne Bay Continuous Salinity Monitoring Network

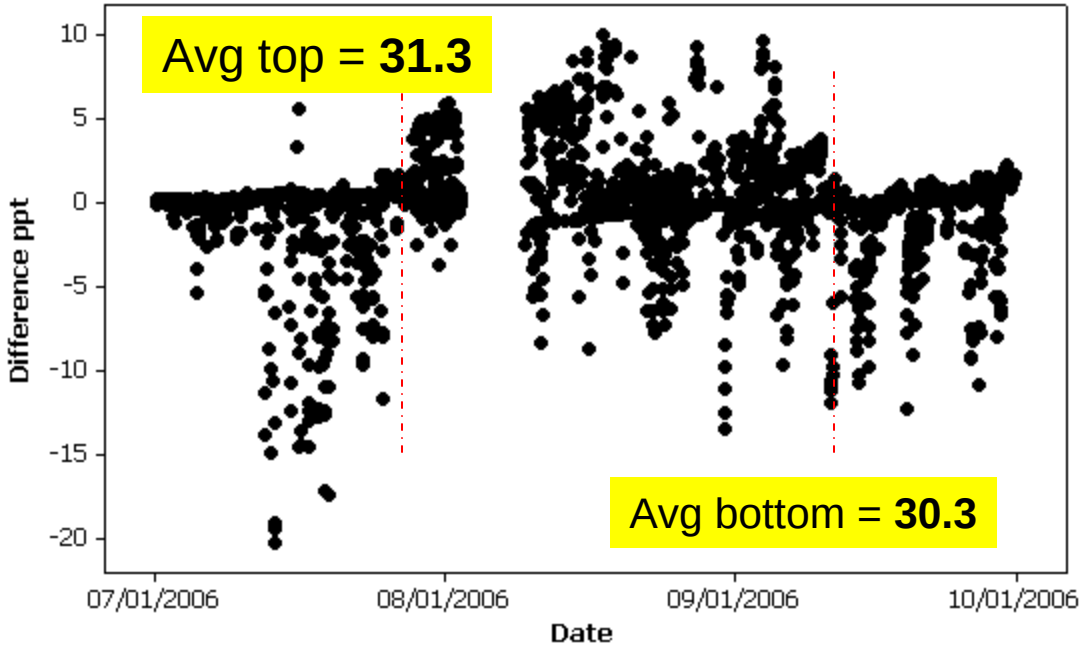
with seagrass coverage

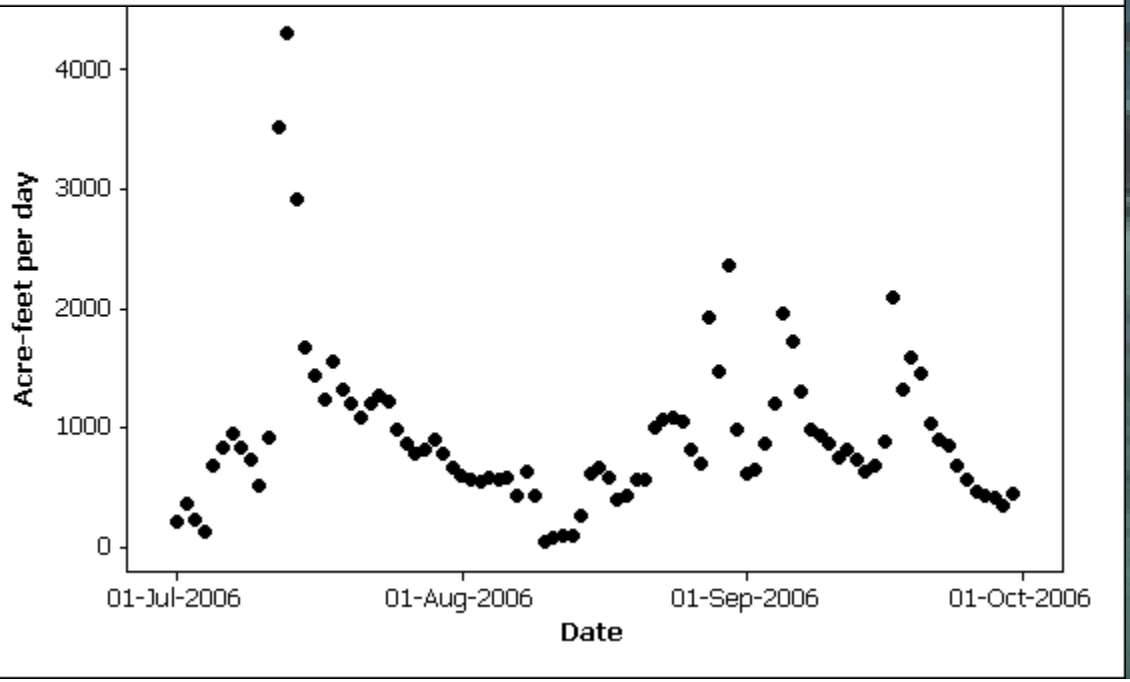
Site 34/35



Phenomenon of “fresher on bottom”

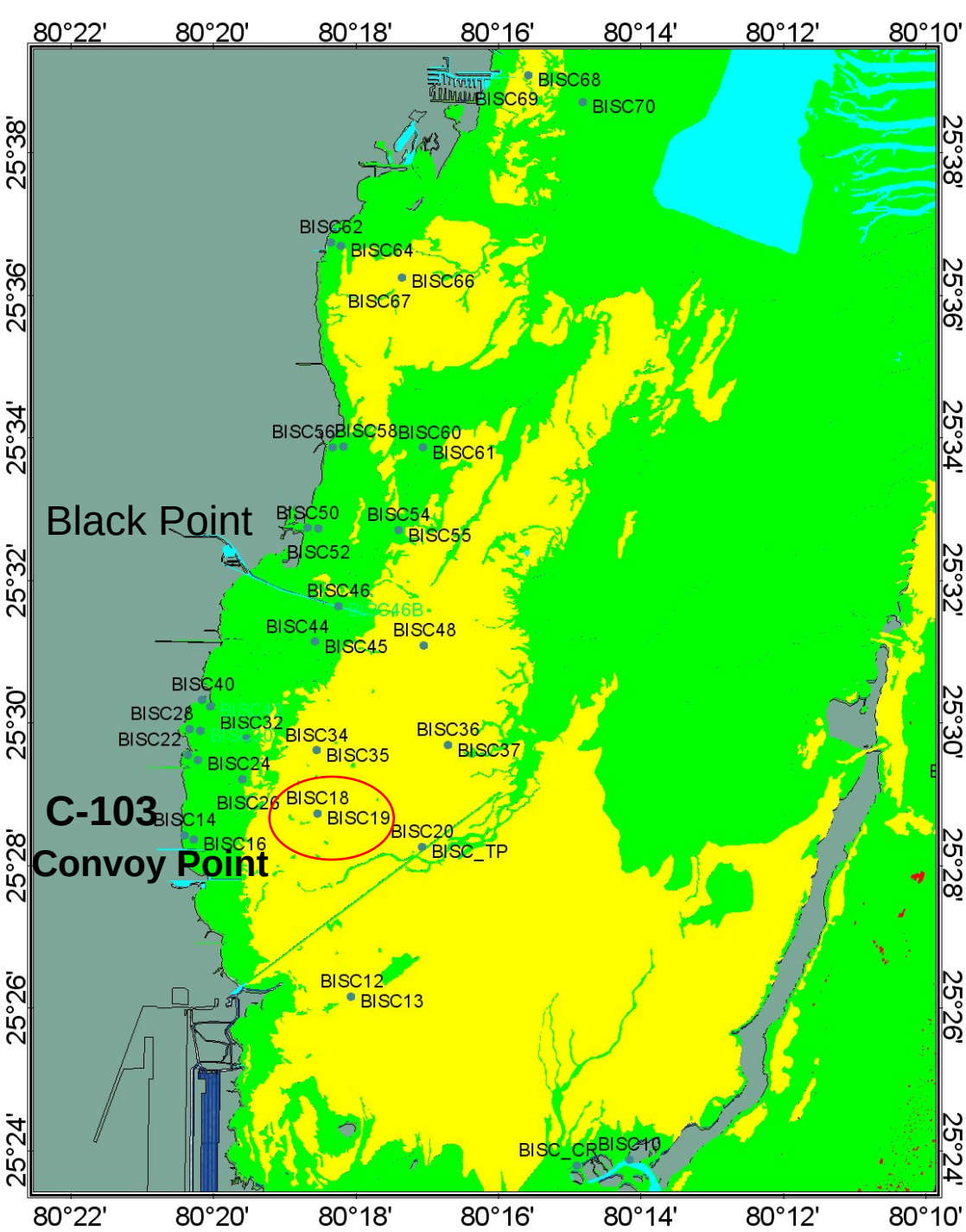
Zoomed in Aug 1 thru Sept 5, 2006





Difference 35 – 34 (top – bottom) Salinity

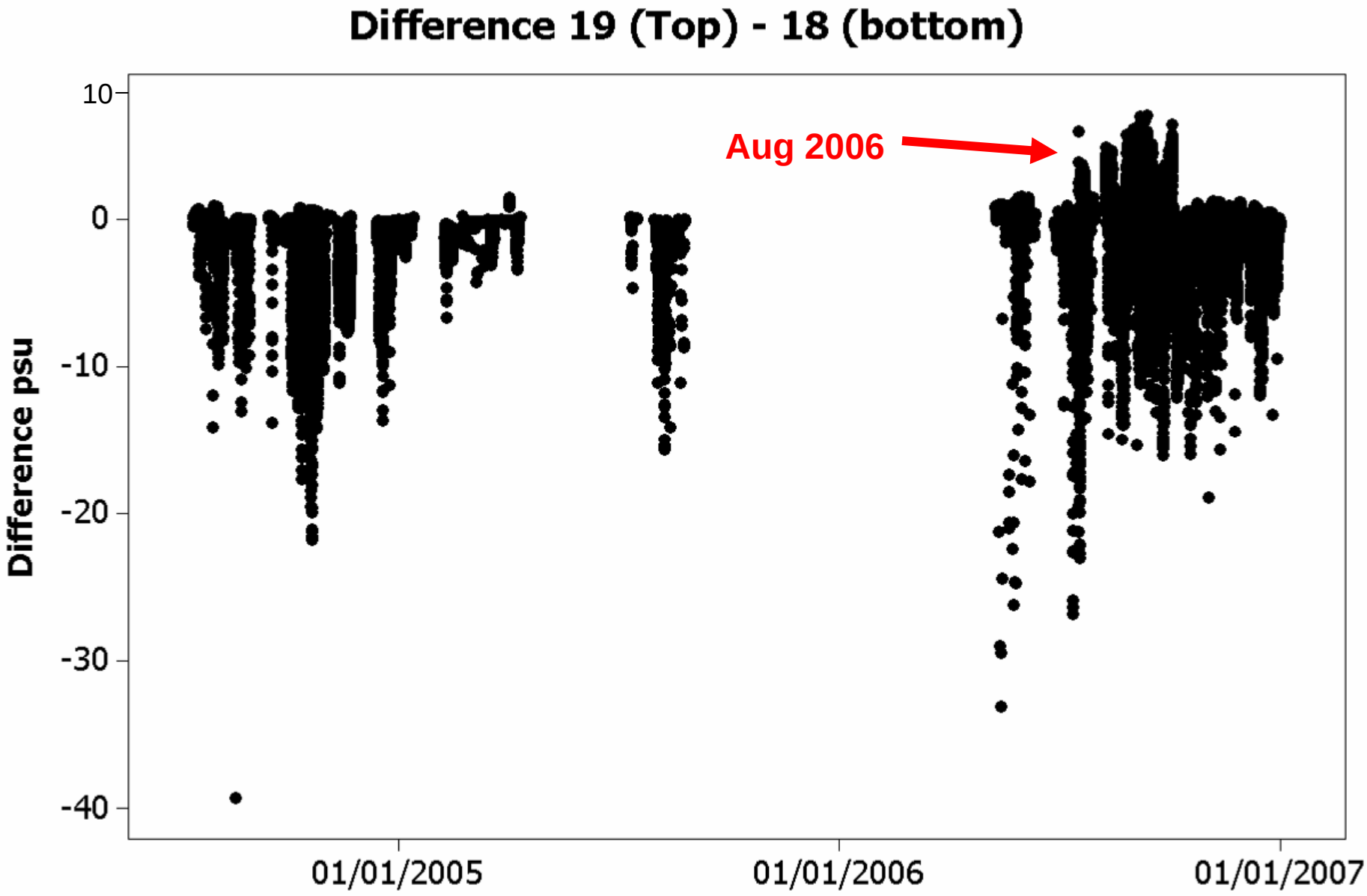
Daily Canal Discharge Volume



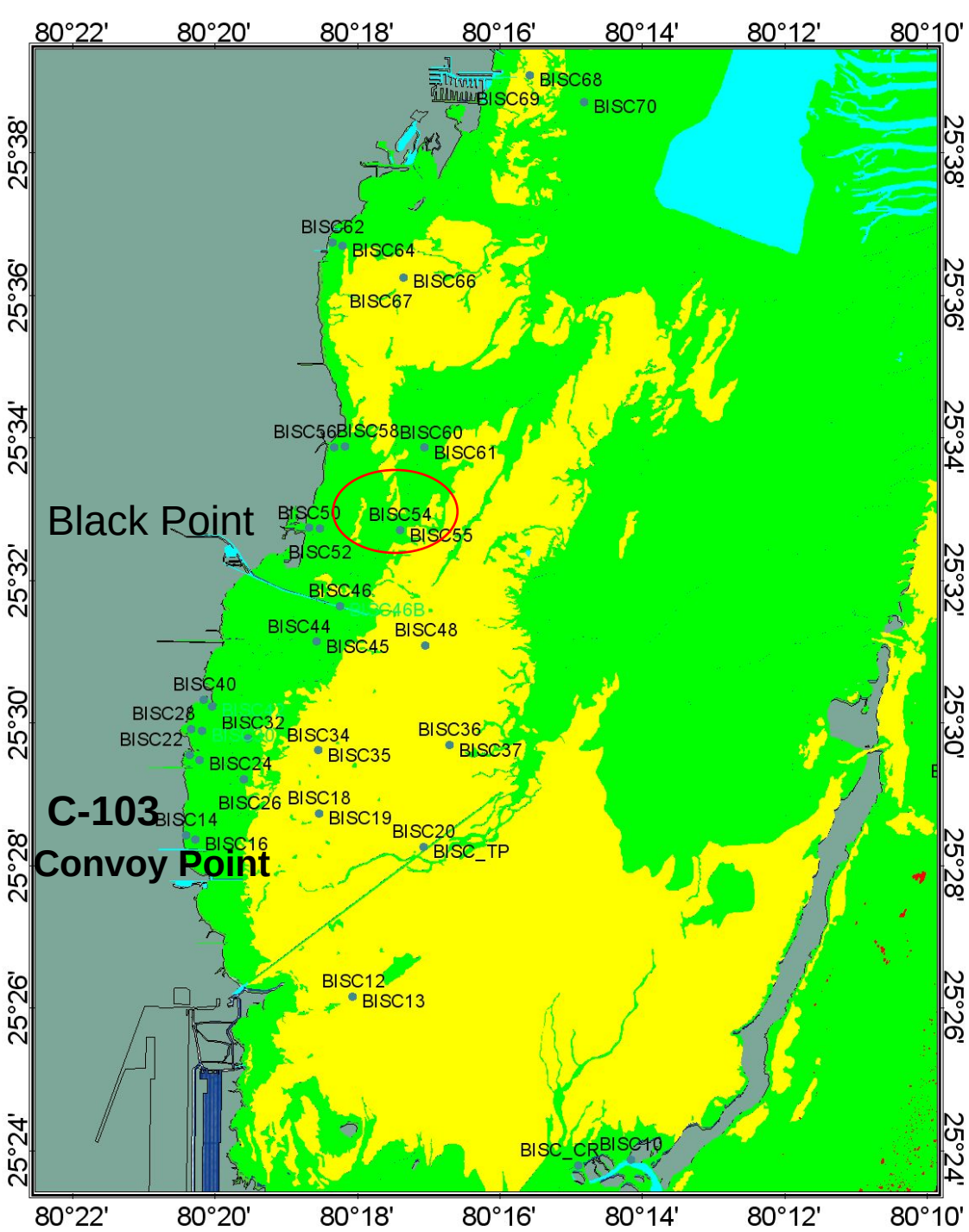
Biscayne Bay Continuous Salinity Monitoring Network

with seagrass coverage

Site 18/19



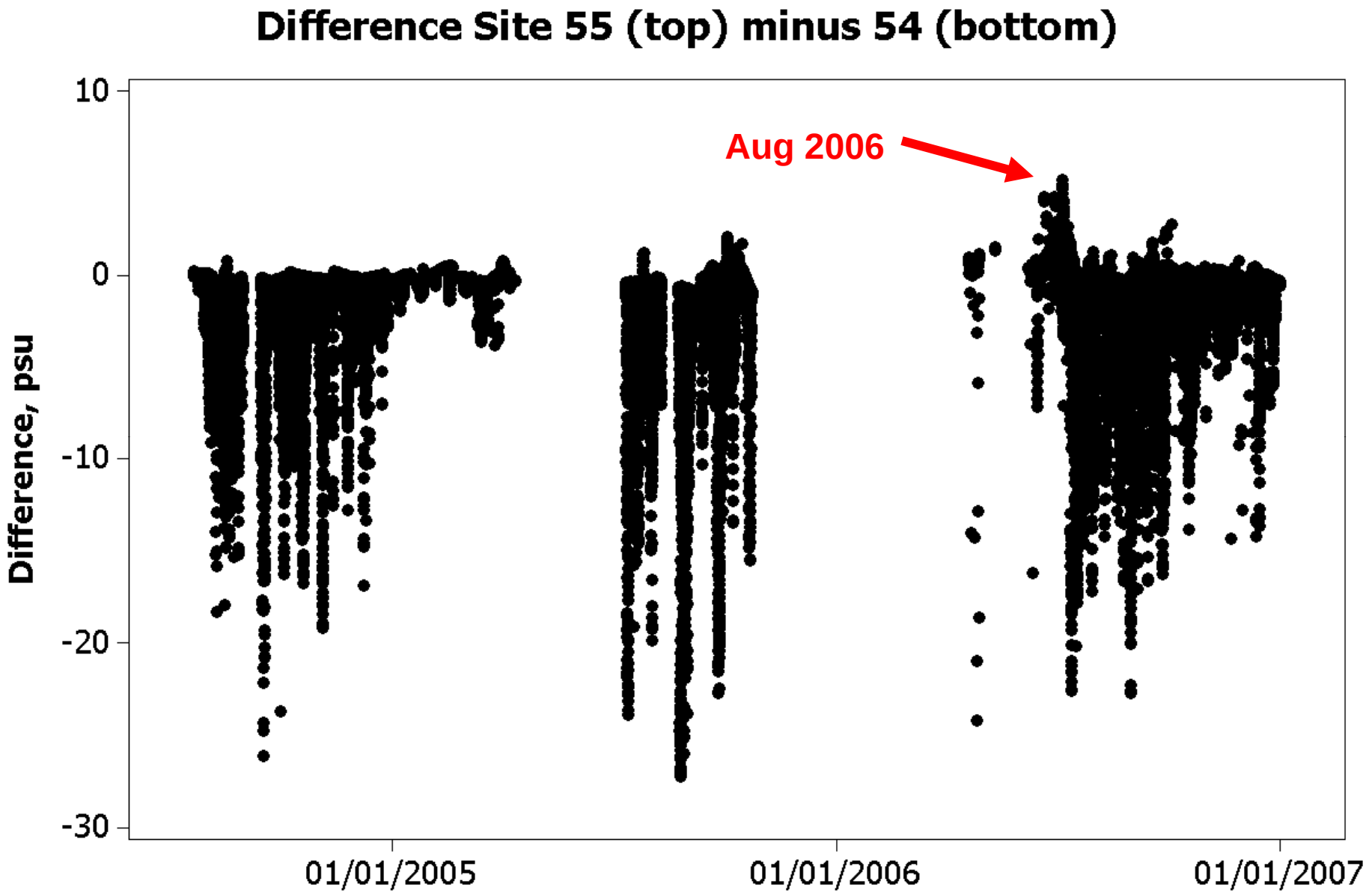
Phenomenon of “fresher on bottom” occurs elsewhere in Bay



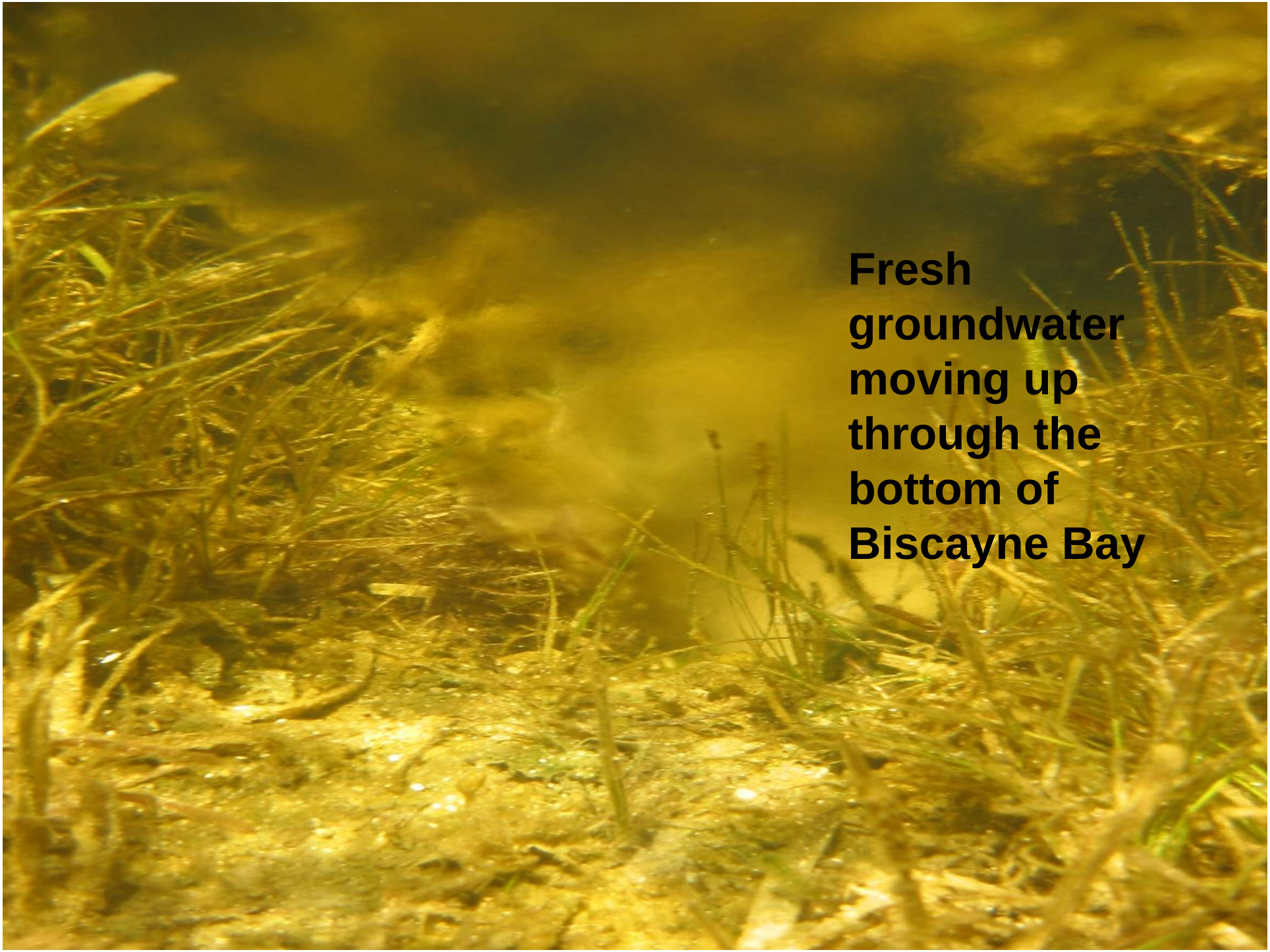
Biscayne Bay Continuous Salinity Monitoring Network

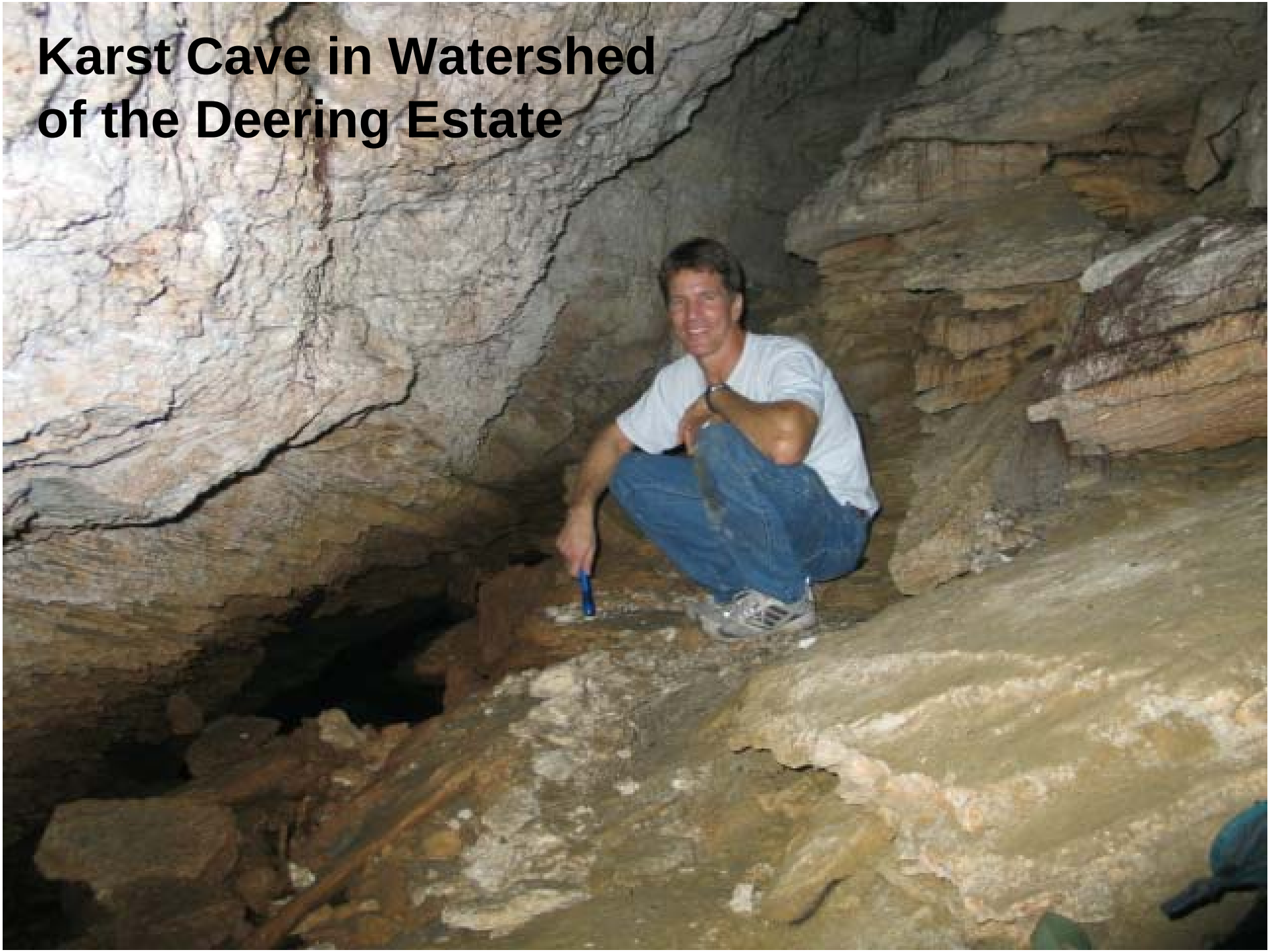
with seagrass coverage

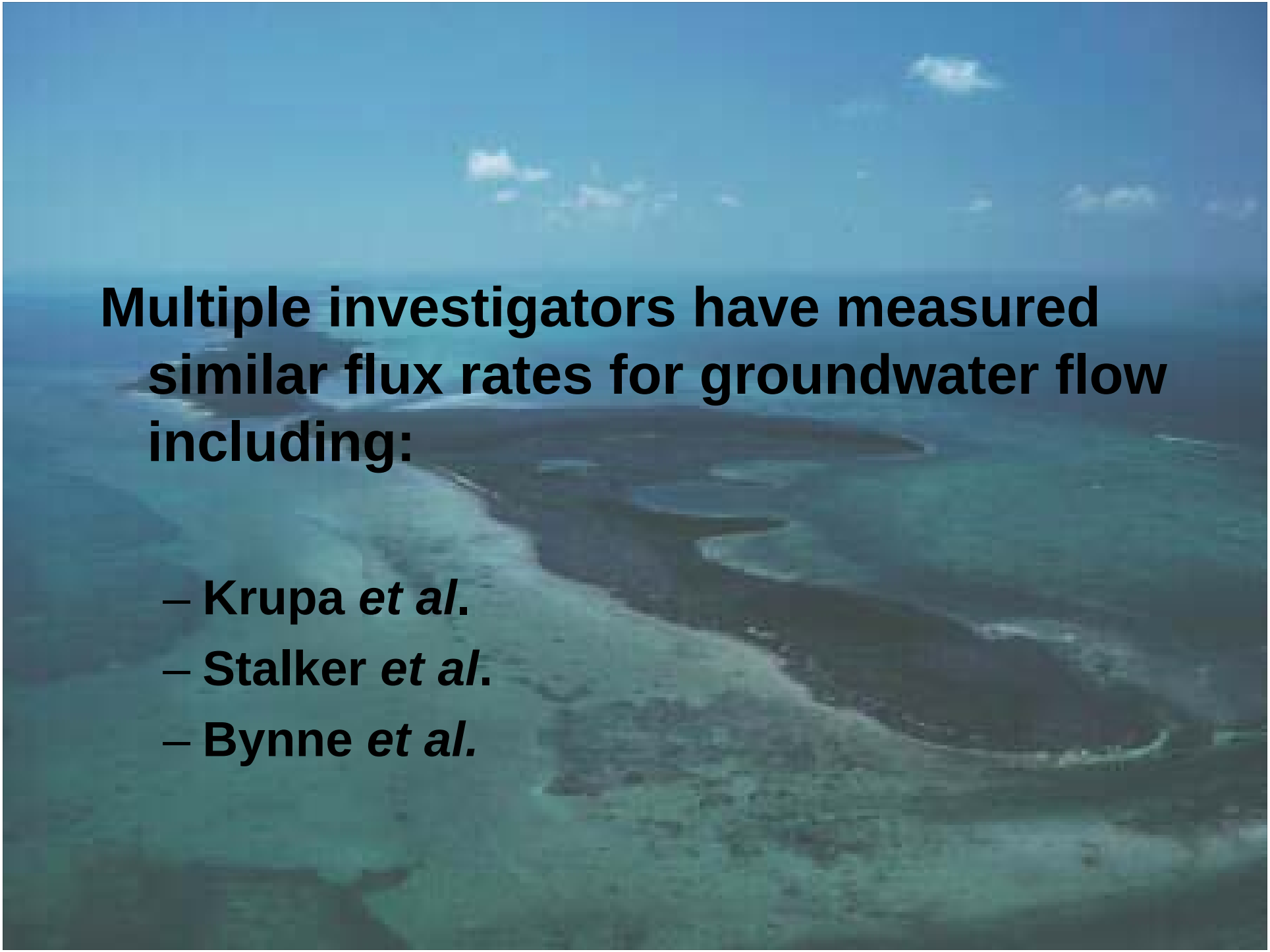
Site 54/55



Phenomenon of "fresher on bottom" occurs elsewhere in Bay


Fresh groundwater moving up through the bottom of Biscayne Bay

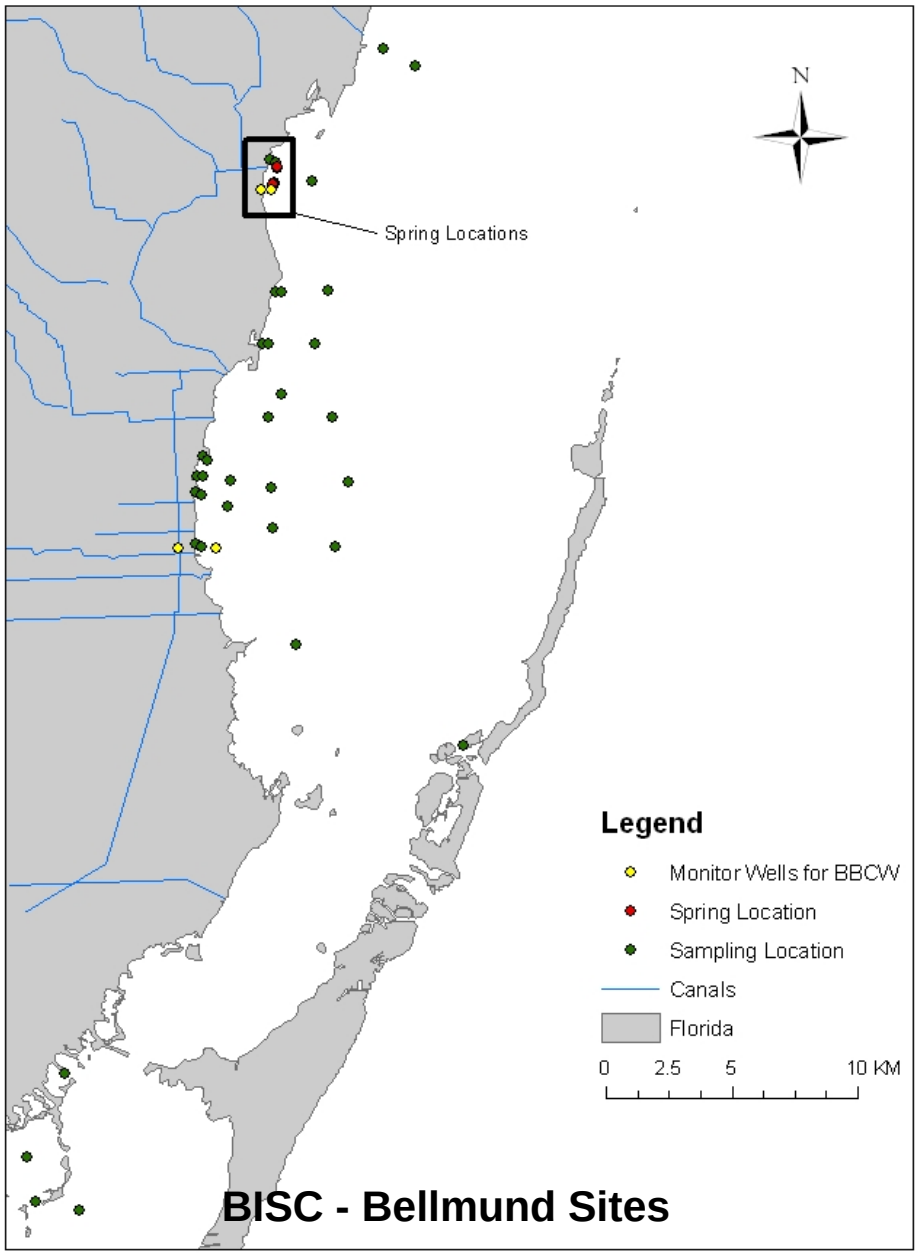

Karst Cave in Watershed
of the Deering Estate



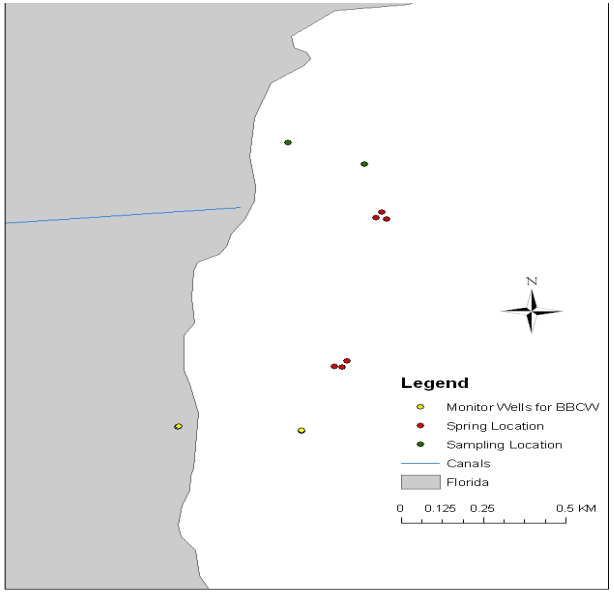
Multiple investigators have measured similar flux rates for groundwater flow including:

- **Krupa *et al*.**
- **Stalker *et al*.**
- **Bynne *et al.***

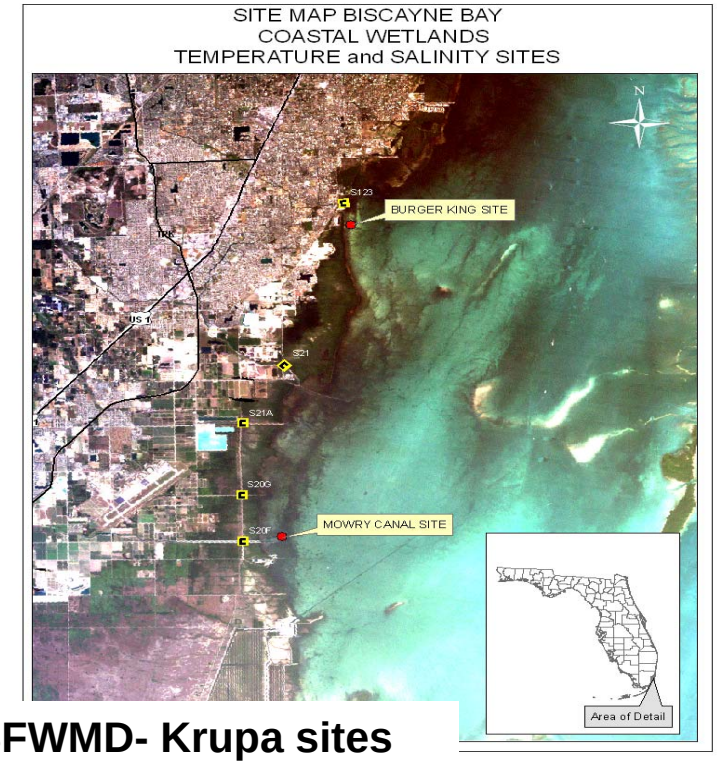

Seepage Rates and Salinity
in Biscayne Bay
from
August 2005 through February 2006



BISC - Bellmund Sites



AOML-Proni *et al* sites



SFWMD- Krupa sites

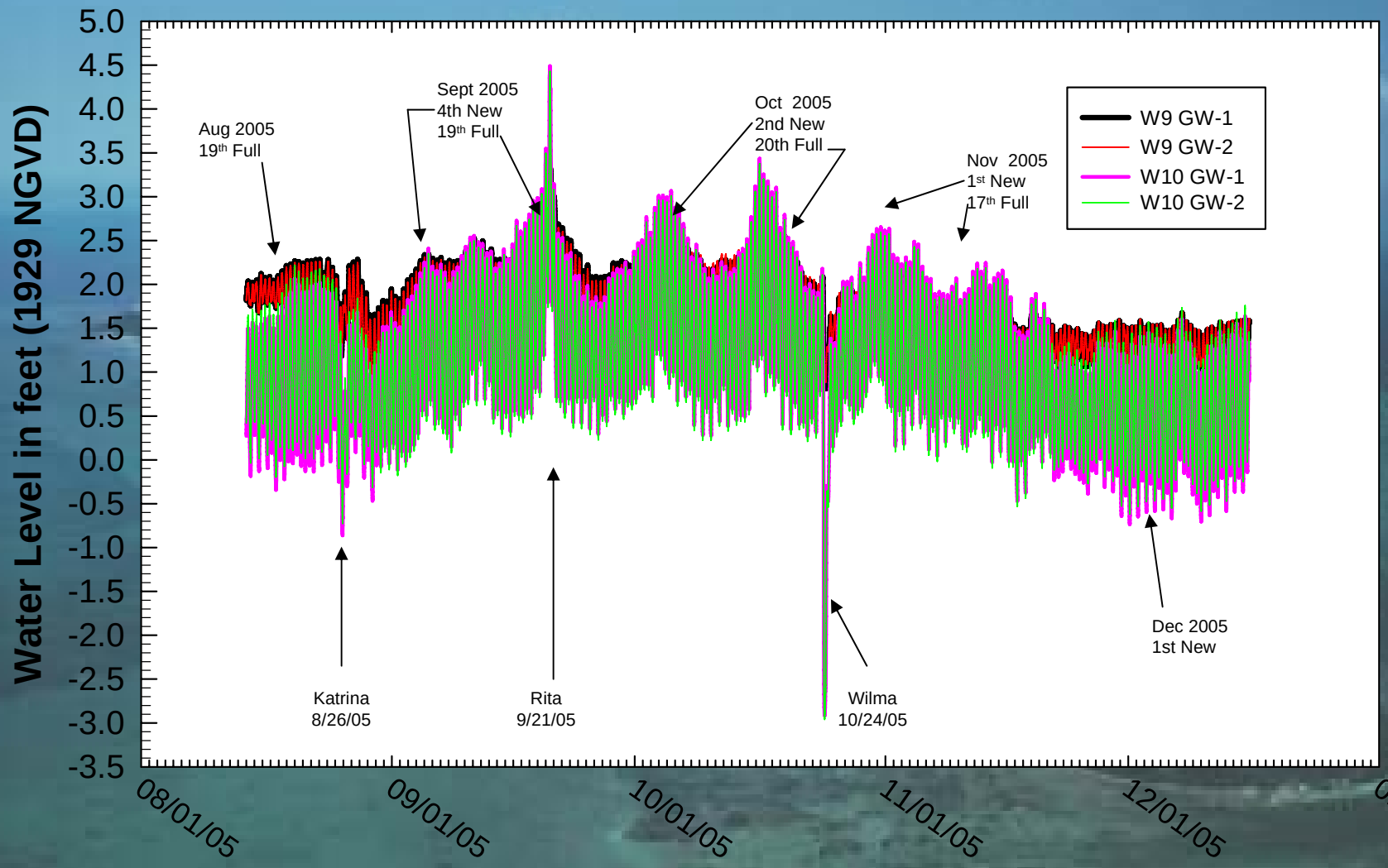
SFWMD Southern Site

SFWMD Northern Site

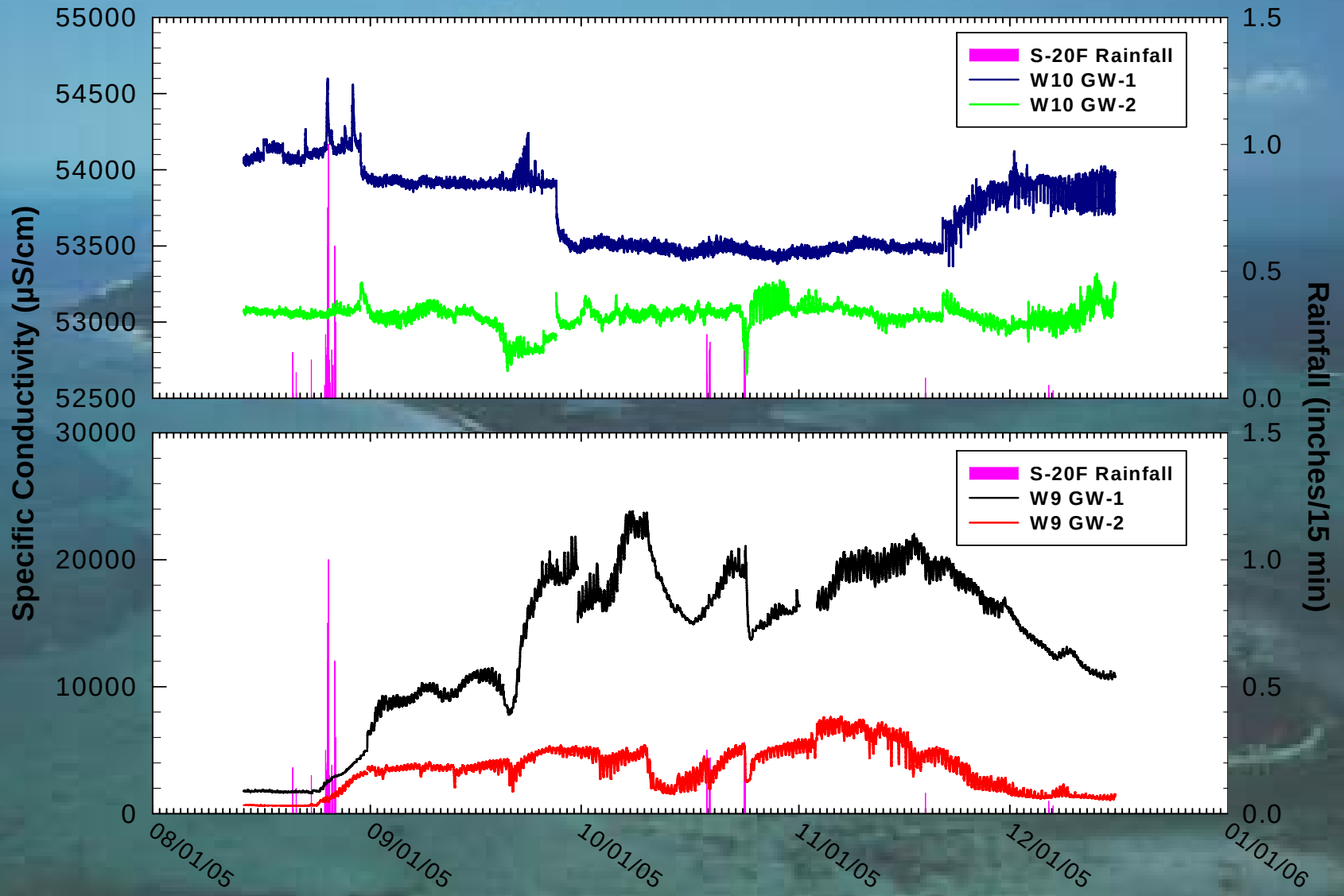
Platform at Burger King Site

Sea grasses and Seepage Meter at Burger King Site

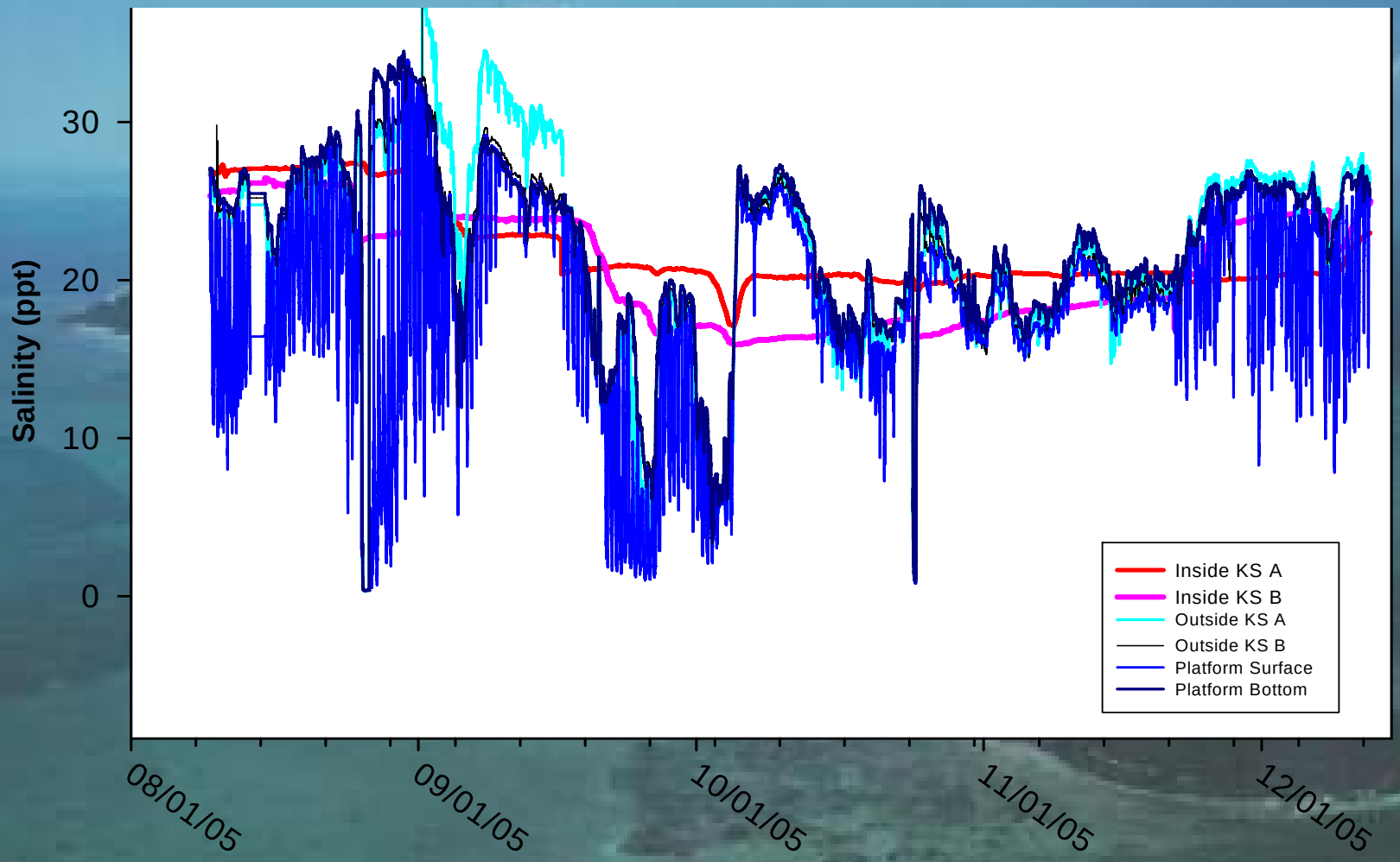
Mowry Canal
Combined Onshore and Offshore Ground Water Levels



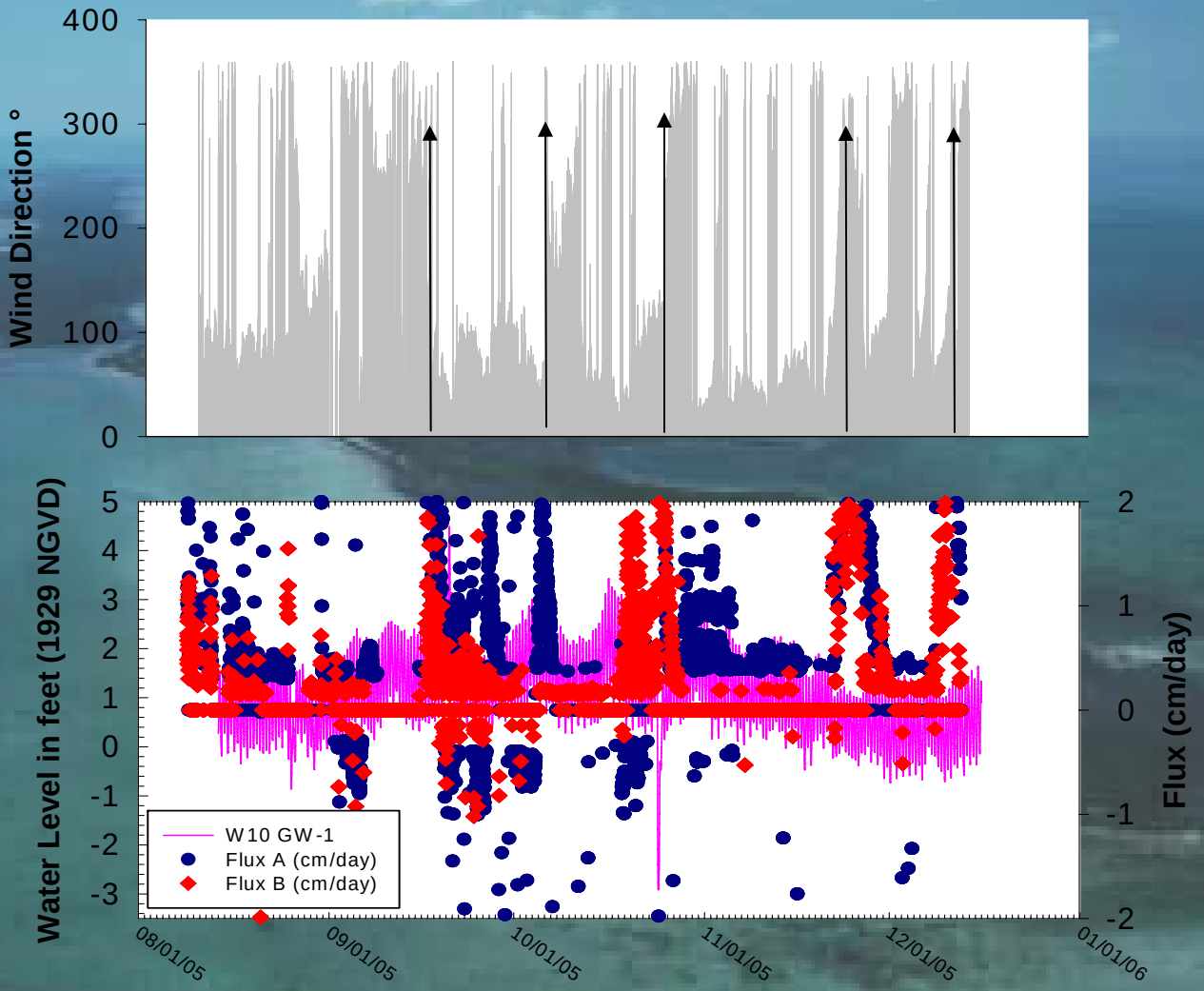
Mowry Canal
Onshore and Offshore Groundwater Well Specific Conductivity



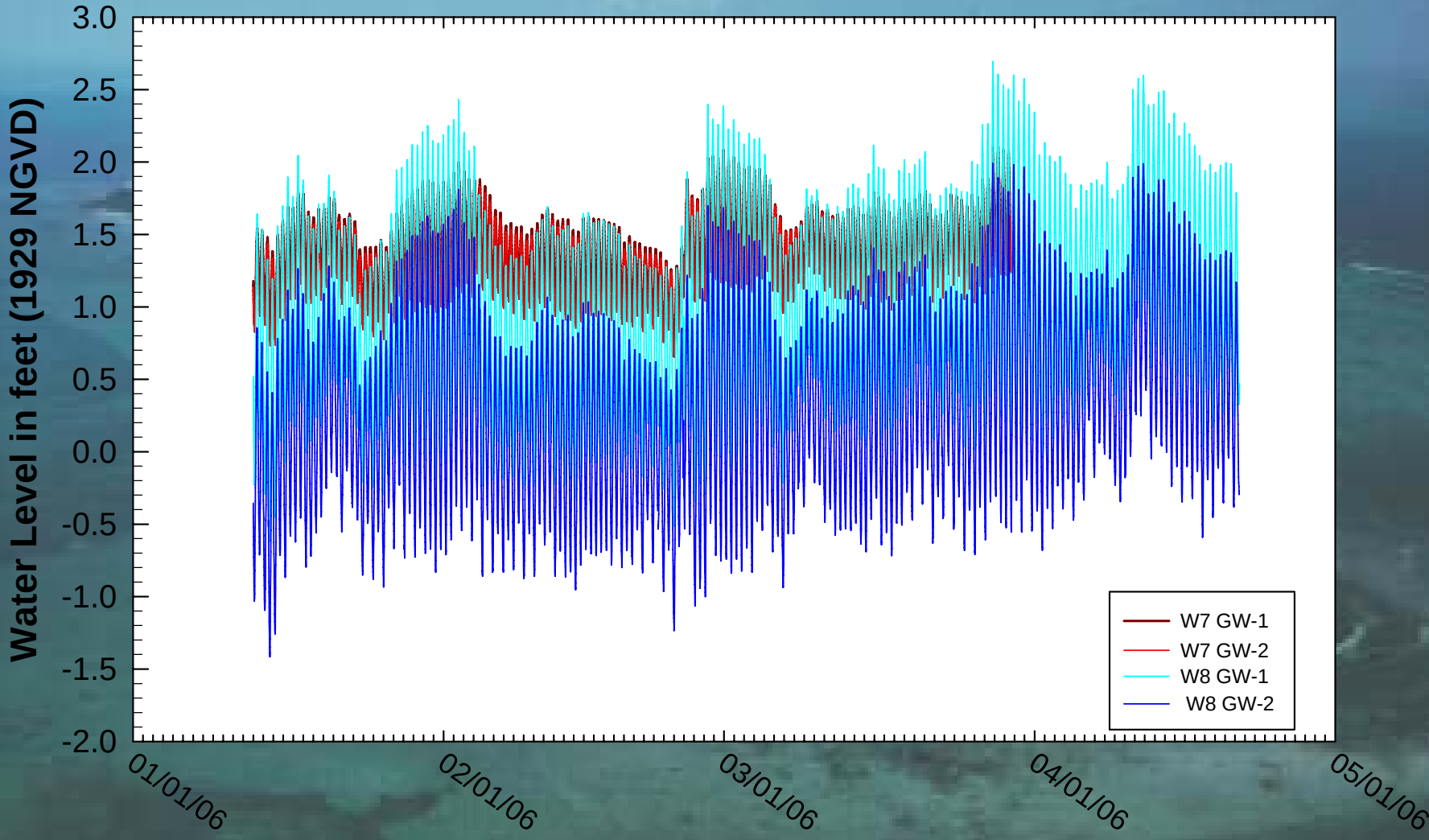
Mowry Canal Offshore Salinity



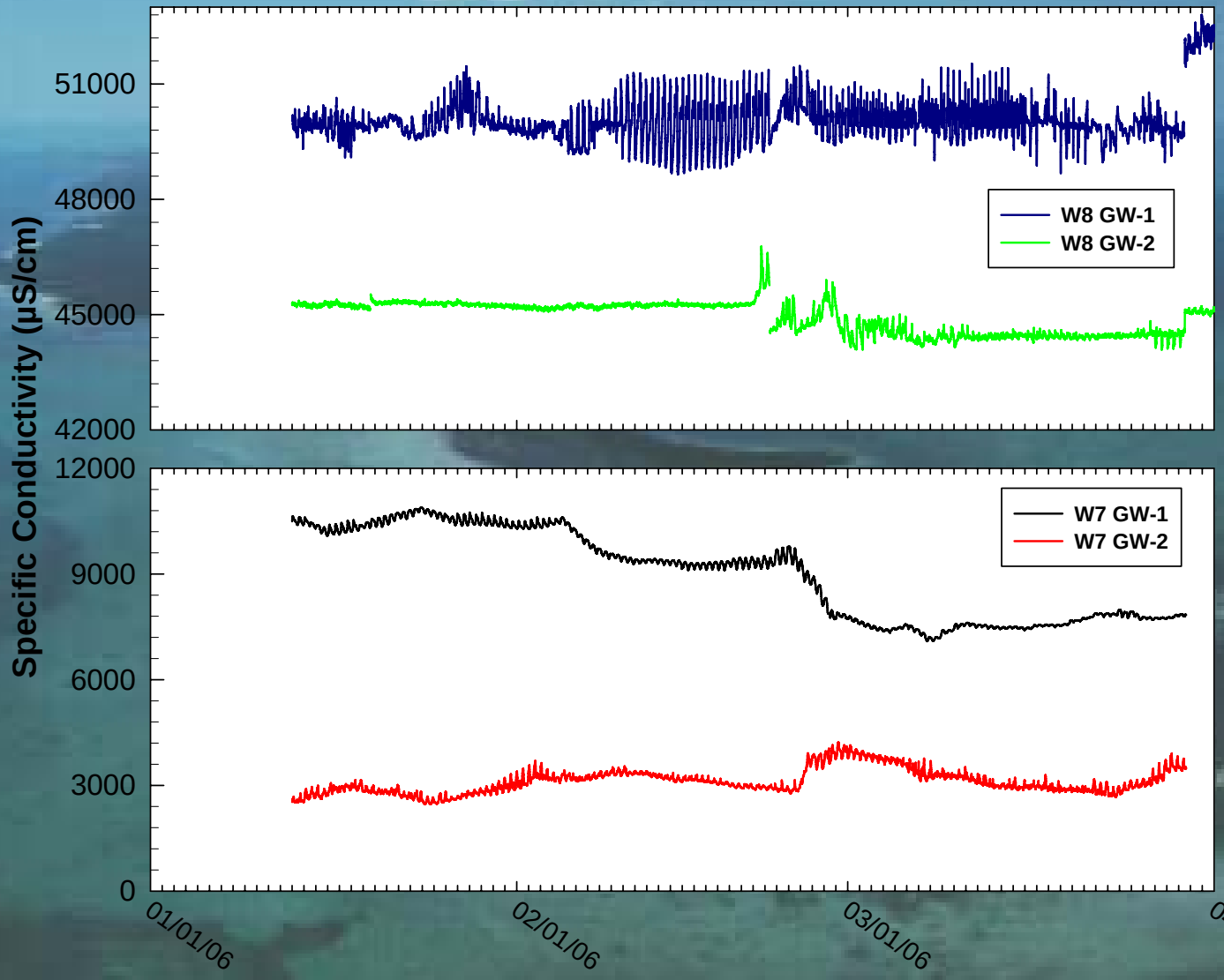
Mowry Canal
Seepage Meter Fluxes. Offshore Groundwater Levels And Wind Direction



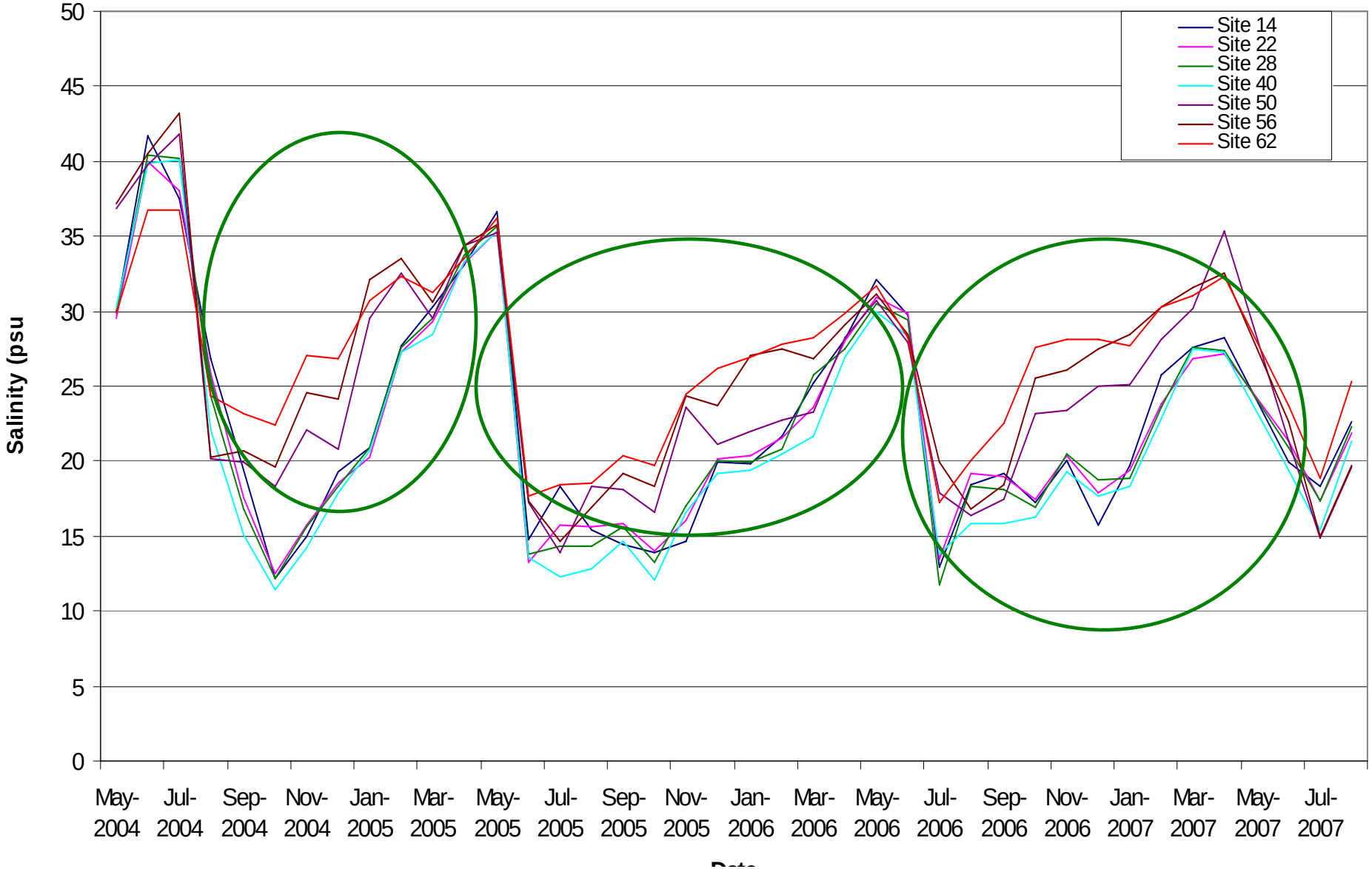
Burger King Combined Onshore and Offshore Ground Water Levels

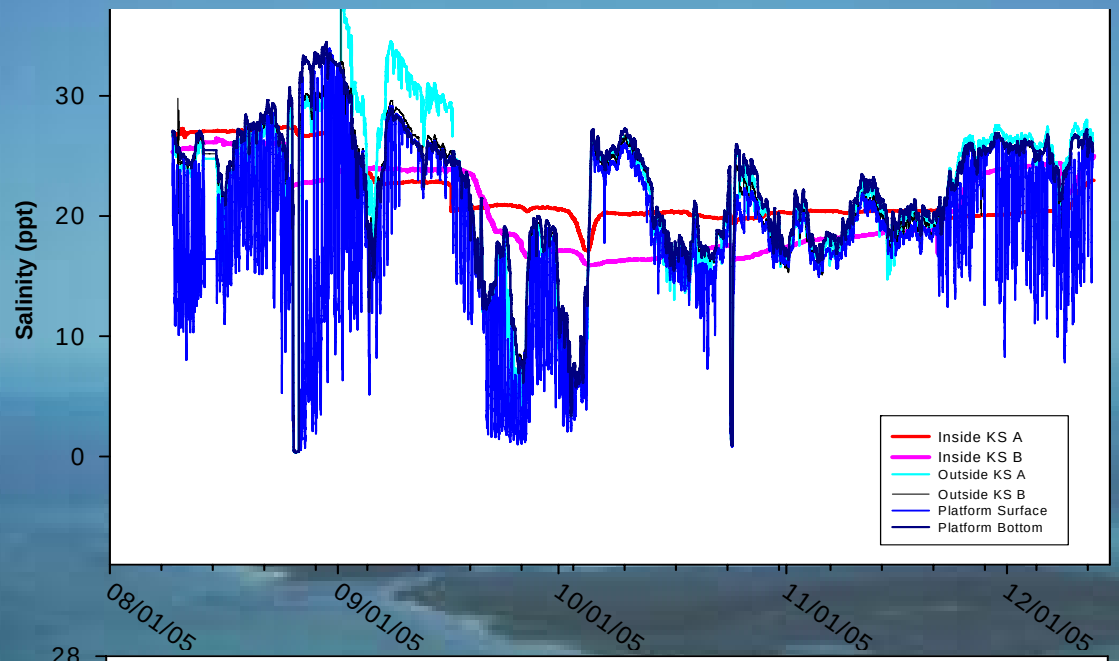


Burger King Onshore and Offshore Groundwater Well Specific Conductivity

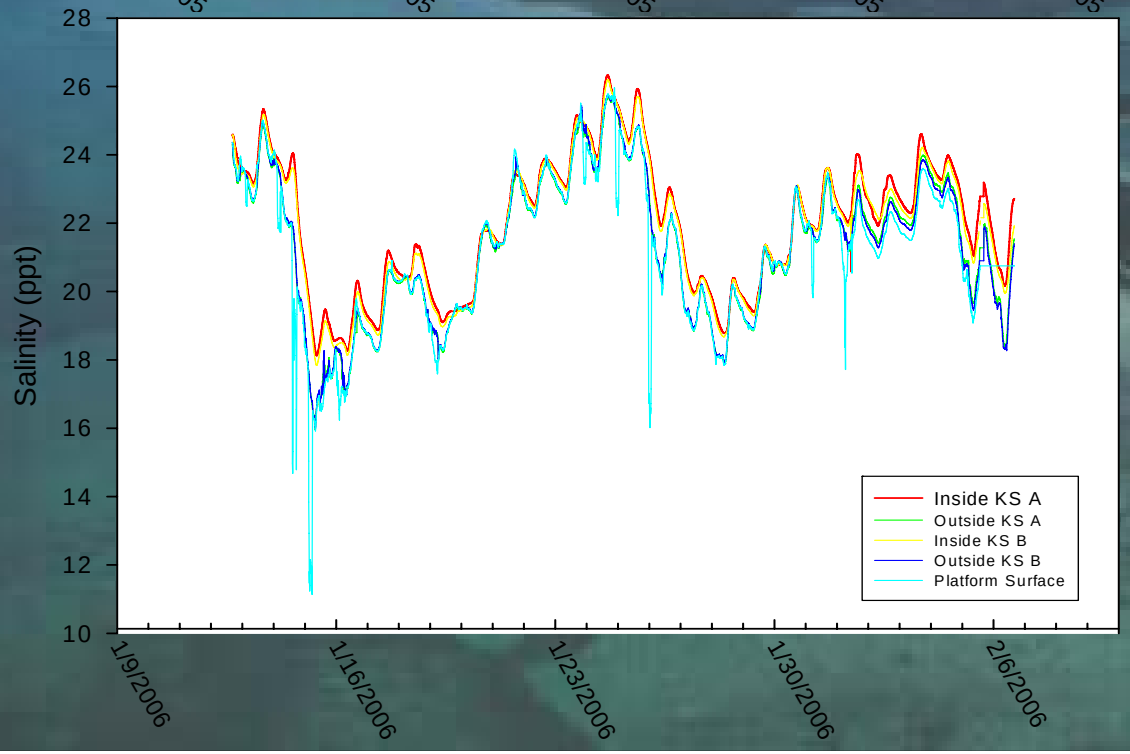


Biscayne Bay Mangrove Salinity



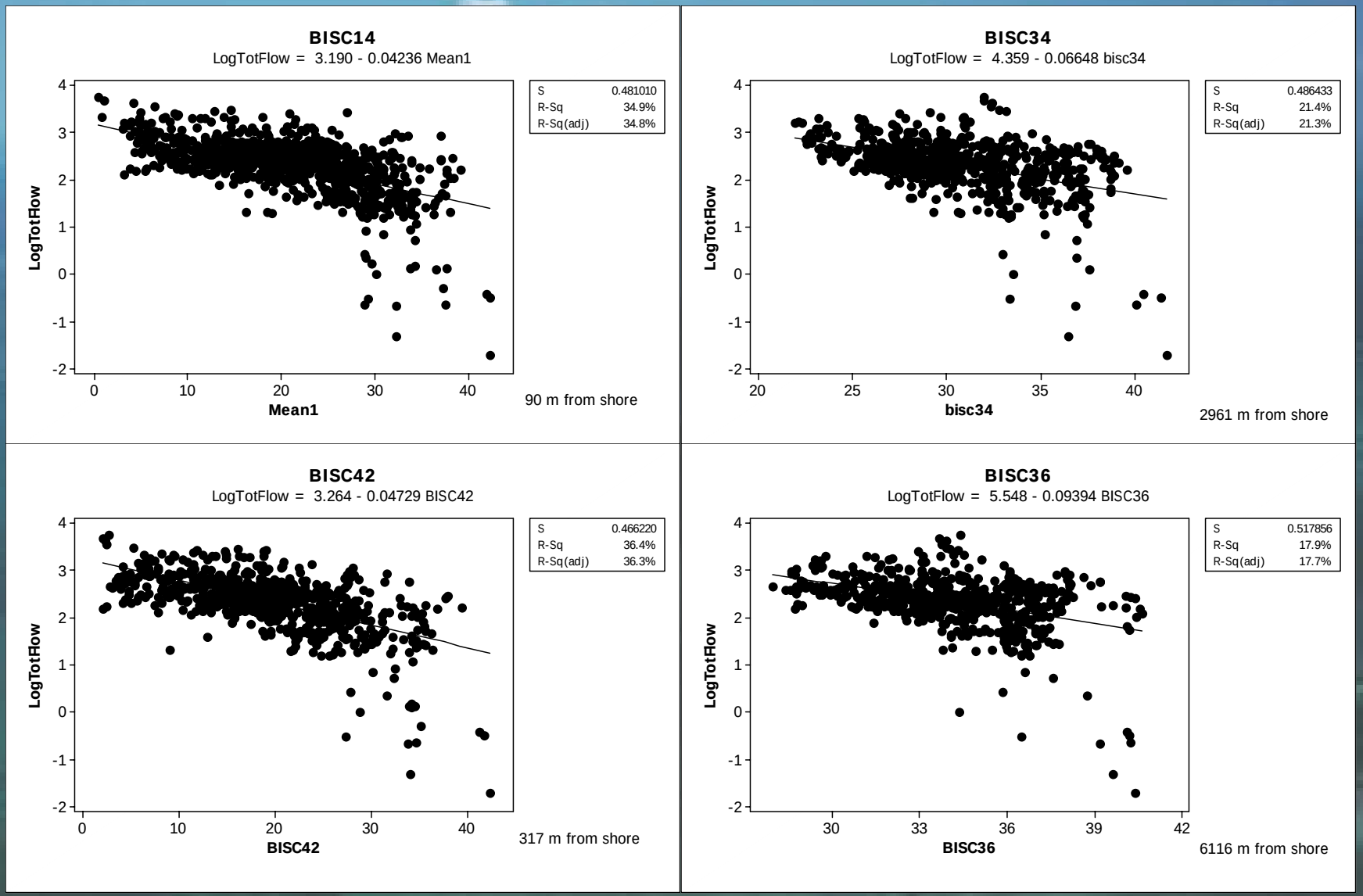


Mowry Canal Offshore Salinity

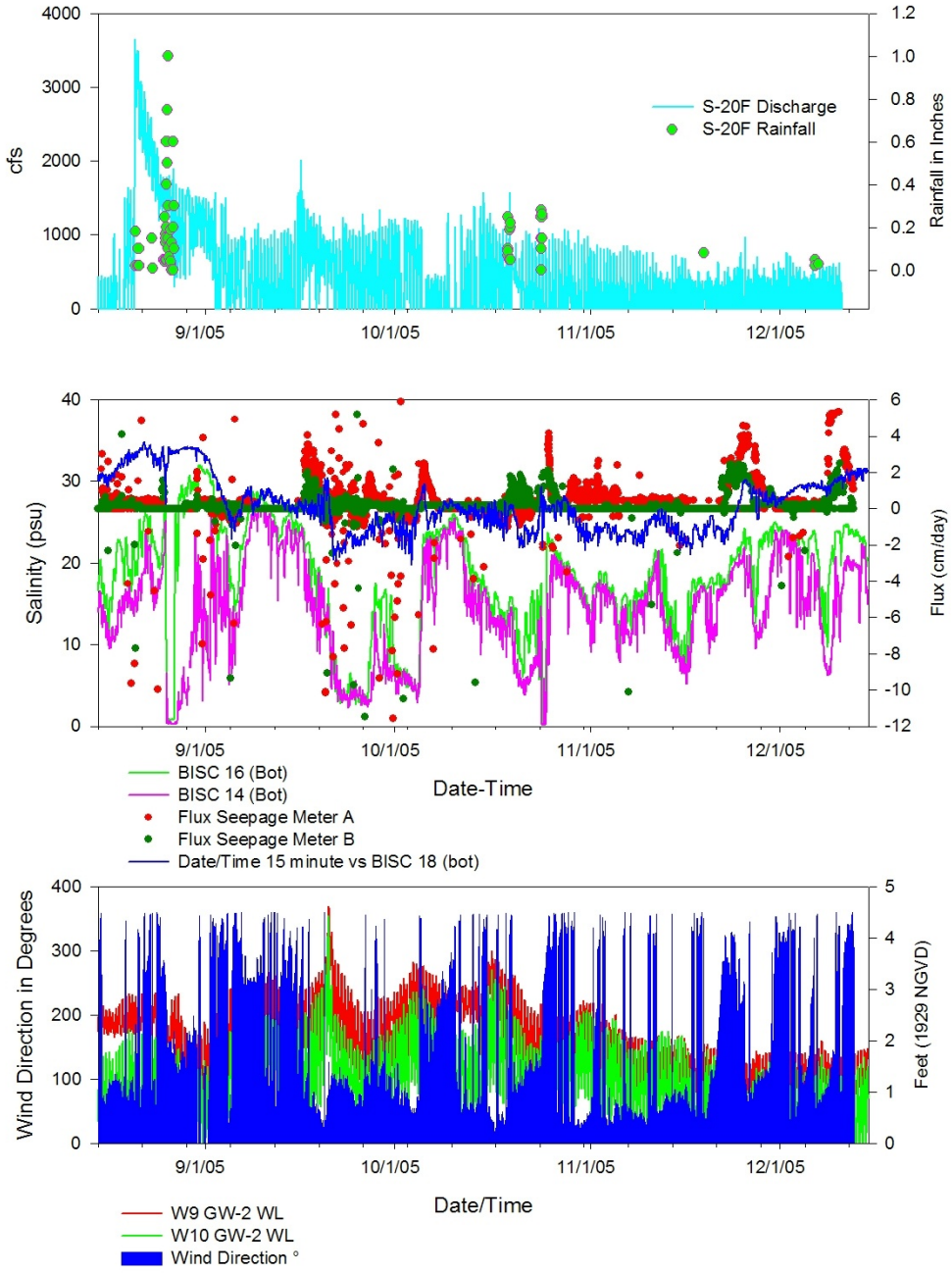


Burger King Offshore Salinity

Relationship Between Flow and Salinity from 2004-2006 at Selected Sites



2004-2006



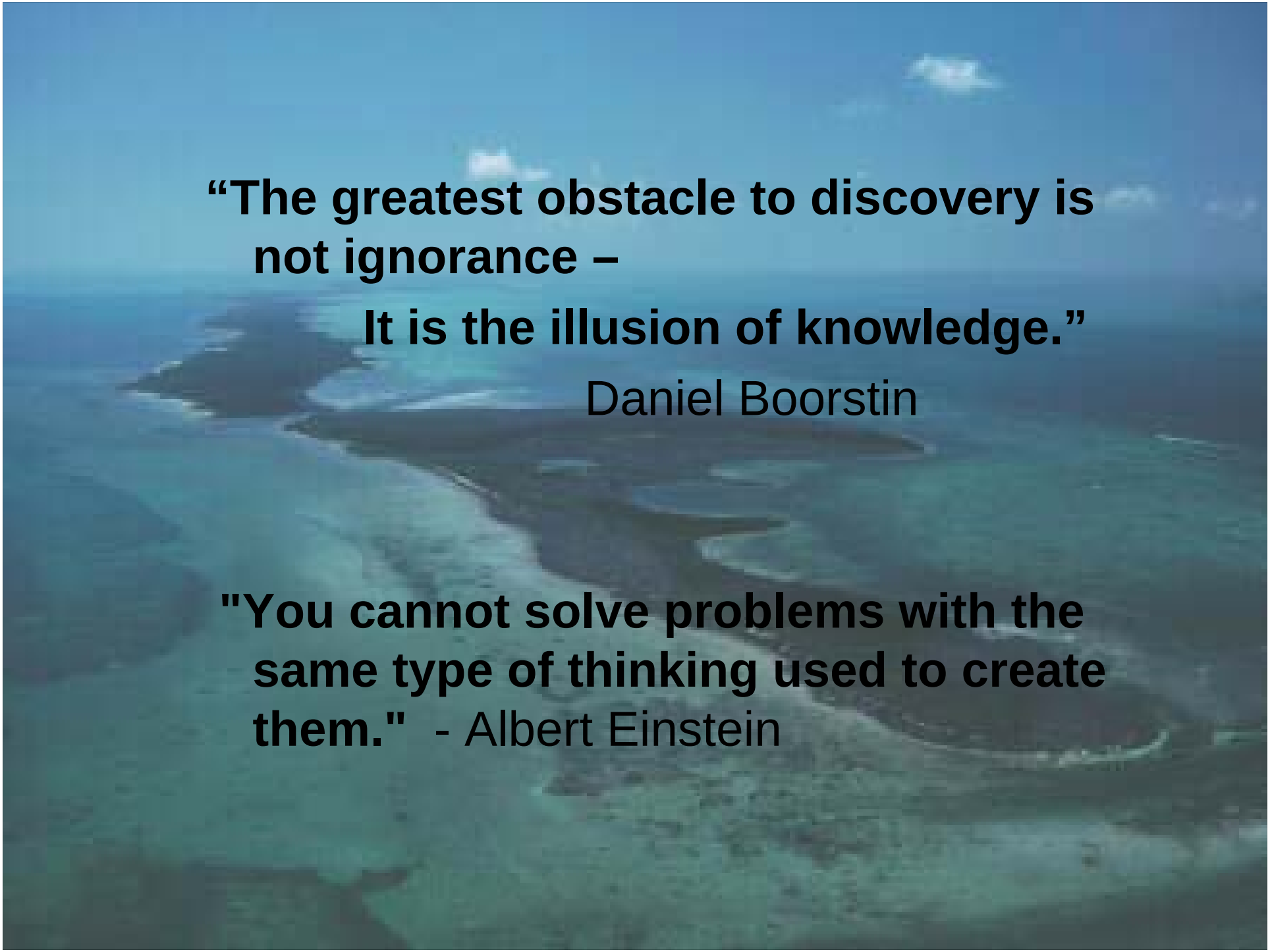
SFWMD and Biscayne National Park GW and Salinity Plotted Together

Conclusions

- Biscayne Bay was much fresher historically.
- Freshwater was and is distributed through the bay bottom as groundwater and is a source of freshwater most available to benthic communities.
- Total flux rates at the BK site are generally higher (2-3 times) than the MC site.
- Wind speed and direction plays a role in flux magnitude, direction, source of water (re-circulated SW or freshwater), and in turn the GW WQ contributions into the Bay.
- Despite large openings to the ocean the coastal environments of the bay are much fresher than expected.
- Empirical data are showing that things are very different than presupposed or modeled.
- Multiple empirical investigators show the same or very similar results, which are different than the operating hypotheses that have been applied to the Bay.

Final Conclusion:

It is important to convene a meeting of all of the groundwater and Biscayne Bay salinity investigators to compare information and compile data in the same units and format.


“The greatest obstacle to discovery is not ignorance –
It is the illusion of knowledge.”
Daniel Boorstin
"You cannot solve problems with the same type of thinking used to create them." - Albert Einstein

Acknowledgements

- **Amy Renshaw**
- **Ed Kearns**
- **Helen Mayoral**
- **Adam Wood**
- **Joe Serafy**
- **Elmar Kurzbach**
- **Rick Alleman**
- **Cynthia Gefvert**
- **National Park Service-South Florida Natural Resources Center**
- **U. S. Army Corps of Engineers**
- **Miami-Dade County DERM**
- **South Florida Water Management District**

National Park Service