

Downstream Water Quality as a Indicator of Restoration Conditions and Ecosystems Change for Biscayne Bay

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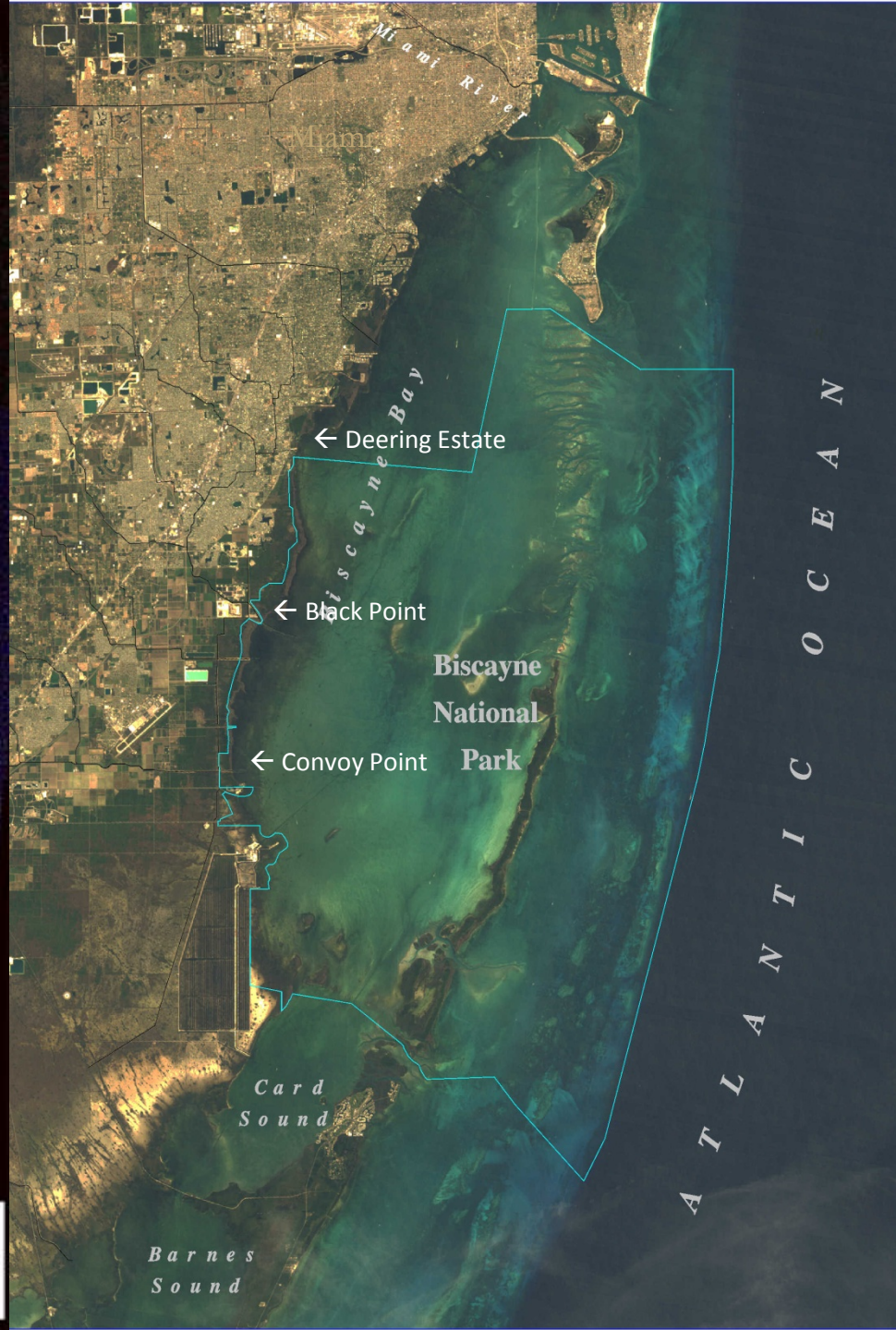
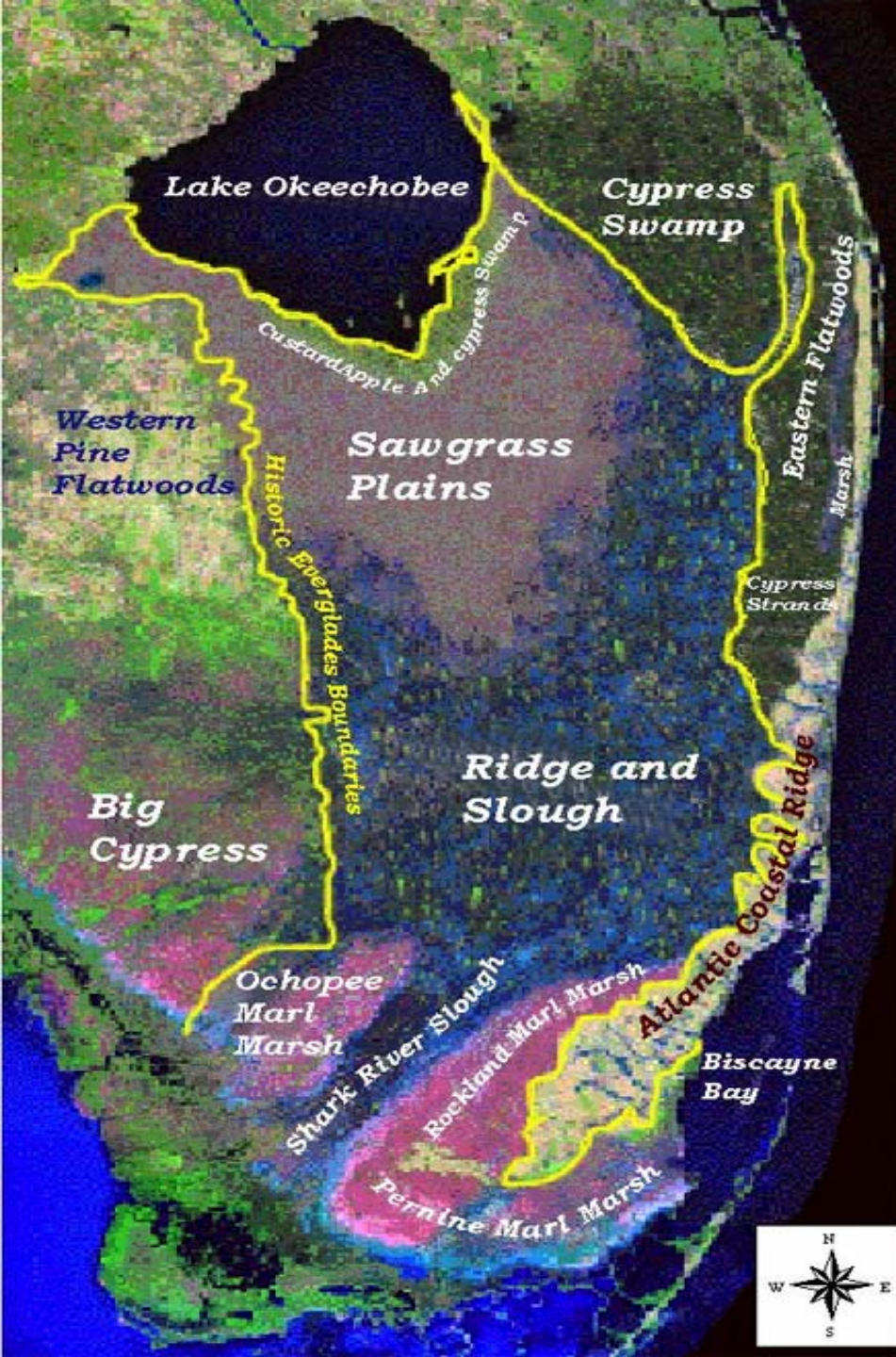
³NOAA National Marine Fisheries Service, Miami, FL 33149

National Conference on Ecosystem Restoration

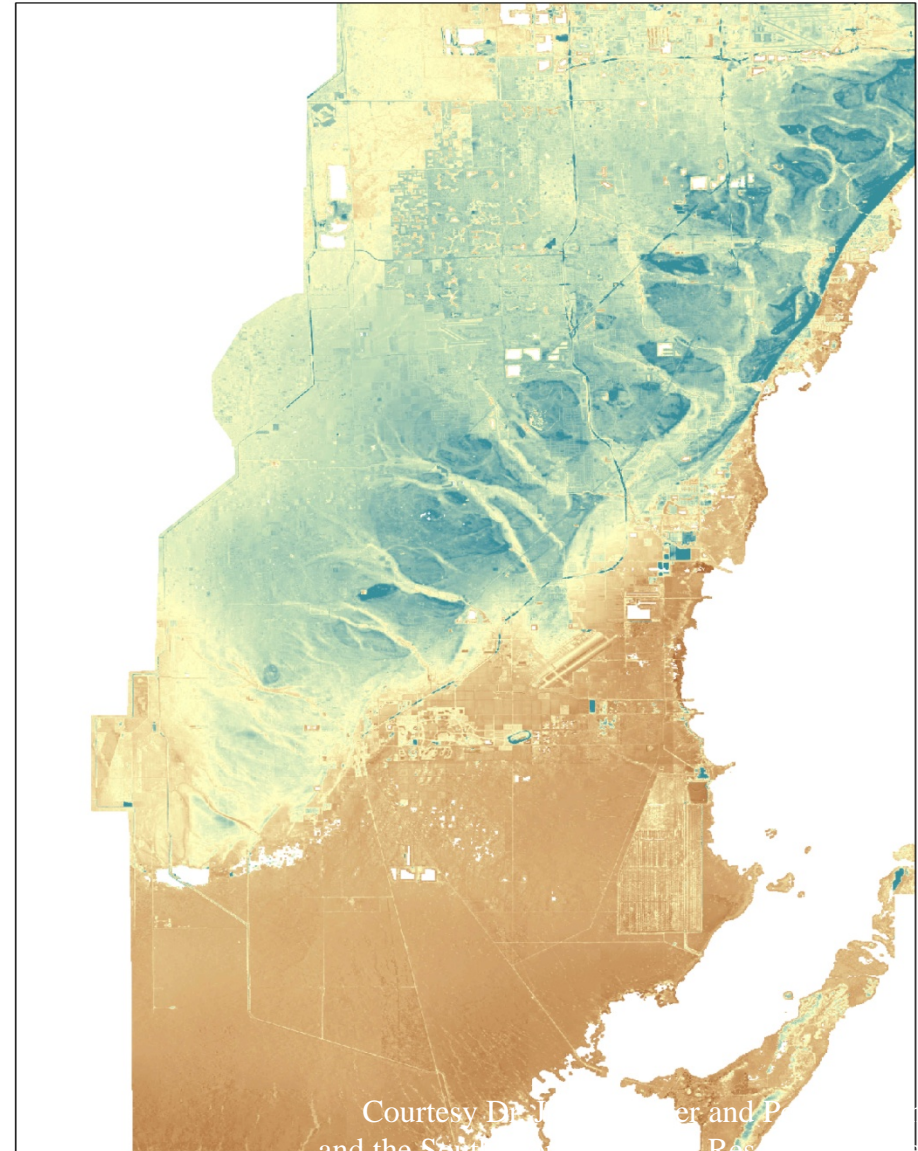
Plantation Florida

April 18-22, 2015





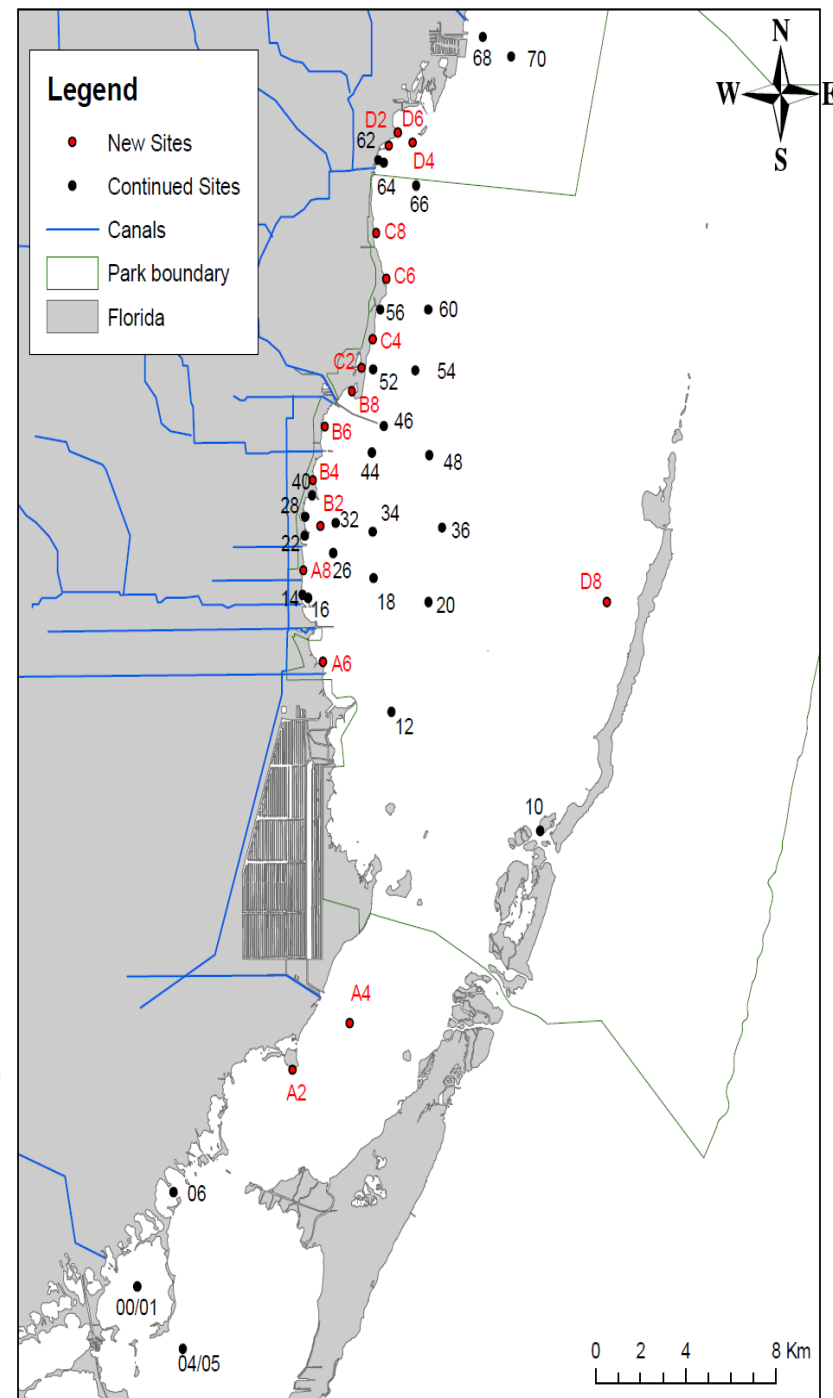
Coastal Ridge and Transverse Glades Using Lidar Data



Integrated Biscayne Bay Ecological Assessment Monitoring (IBBEAM)

Salinity Patterns in Southern Biscayne Bay

- More persistent high salinity north of Black Point
- Stratification is a normal occurrence even in shallow water
- Hypersalinity along the western shoreline
- Three distinct areas of the Bay:
 - 1) Deering Estate to Black Point
 - 2) Black Point to Convoy Point
 - 3) Convoy Point to Manatee Bay
- Rapid Changes in salinity which return to pre-event levels over short periods of time
- Estuarine zone develops every year that is more or less persistent depending on operations



Water Delivery to the Bay

Sources of Water

Quantity

Quality



Climatic



Operations



Groundwater



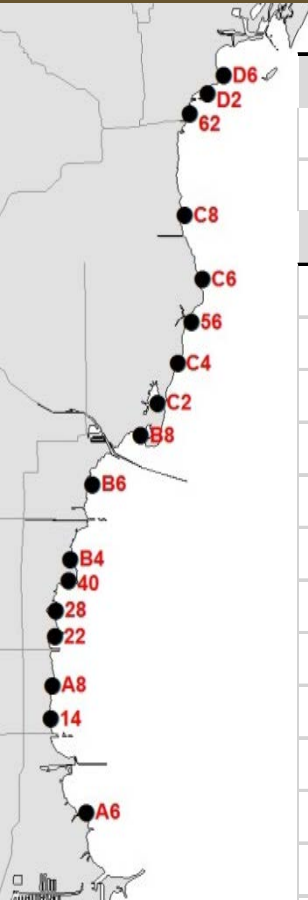
Timing

Distribution



EXPERIENCE YOUR AMERICA

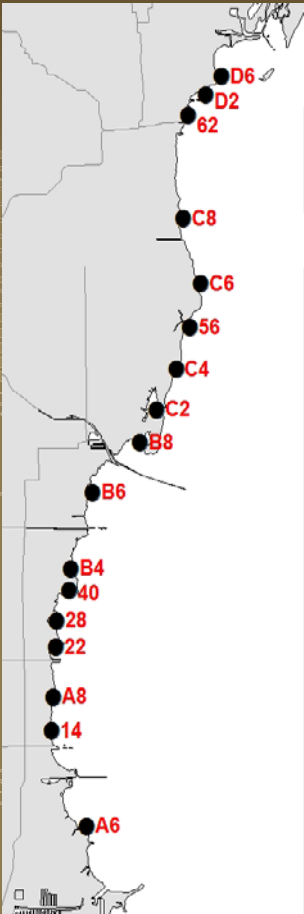
Mesohaline Index



WYR	2008		2009		2010		2011		2012		2013		2014		2015		2016		Mean	
CYR	2007	2008	2008	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016		
Month	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
D6							0.00	0.00	0.01	0.01	0.07	0.00	0.07	0.00	0.00	0.00	0.00		0.03	0.00
D2							0.00	0.00	0.01	0.00	0.08	0.00	0.07	0.00	0.00	0.00	0.00		0.03	0.00
62	0.09	0.00	0.11	0.00	0.01	0.00	0.10	0.00	0.02	0.02	0.25	0.00	0.22	0.00	0.00	0.00	0.01		0.09	0.00
C8							0.11	0.00	0.02	0.03	0.34	0.00	0.22	0.01	0.00	0.00	0.01		0.12	0.01
C6							0.11	0.00	0.03	0.04	0.58	0.00	0.38	0.00	0.00	0.00	0.00		0.20	0.01
56	0.35	0.01	0.21	0.00	0.05	0.01	0.14	0.00	0.07	0.04	0.65	0.00	0.45	0.01	0.01	0.00	0.00		0.23	0.01
C4							0.22	0.00	0.09	0.05	0.65	0.00	0.50	0.01	0.07	0.00	0.00		0.26	0.01
C2							0.34	0.04	0.19	0.09	0.69	0.01	0.42	0.11	0.08	0.00	0.02		0.28	0.05
B8							0.29	0.05	0.06	0.14	0.78	0.01	0.72	0.17	0.05	0.08	0.00		0.32	0.09
B6							0.65	0.14	0.37	0.40	0.67	0.44	0.53	0.43	0.33	0.13	0.16		0.45	0.31
B4							0.46	0.14	0.28	0.54	0.74	0.19	0.56	0.42	0.19	0.34	0.14		0.38	0.33
40	0.40	0.19	0.42	0.26	0.29	0.22	0.49	0.14	0.37	0.53	0.83	0.17	0.73	0.40	0.14	0.12	0.10		0.42	0.25
28	0.35	0.16	0.39	0.20	0.16	0.17	0.52	0.11	0.23	0.43	0.78	0.11	0.59	0.33	0.11	0.13	0.07		0.36	0.21
22	0.35	0.17	0.49	0.15	0.24	0.16	0.60	0.12	0.25	0.45	0.72	0.11	0.60	0.29	0.11	0.07	0.05		0.36	0.20
A8							0.44	0.12	0.19	0.42	0.60	0.14	0.51	0.24	0.09	0.14	0.06		0.32	0.21
14	0.42	0.28	0.38	0.26	0.24	0.23	0.44	0.13	0.21	0.57	0.57	0.22	0.53	0.13	0.11	0.18	0.09		0.33	0.27
A6							0.09	0.04	0.06	0.18	0.22	0.01	0.09	0.03	0.02	0.01	0.04		0.09	0.05
DJ					0.82	0.30	0.56	0.22											0.26	0.69

Mesohaline Index by water-year (WY), calendar-year (CY), and season (Wet=May-Oct; Dry=Nov-Apr). (MI=proportion of salinity observations ≥ 5 < 18).

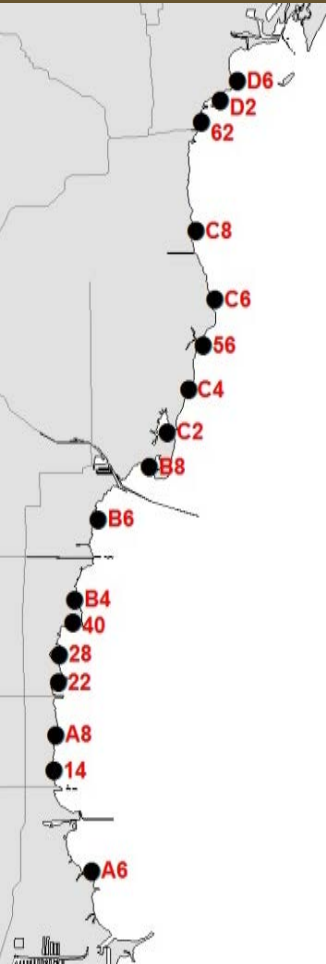
Variability Index



WYR	2008		2009		2010		2011		2012		2013		2014		2015		2016		Mean			
CYR	2007	2008	2008	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016				
Month	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr		
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry		
D6							0.00	0.01	0.03	0.05	0.12	0.03	0.06	0.08	0.04	0.01	0.01			0.05	0.03	
D2							0.00	0.01	0.04	0.06	0.16	0.07	0.10	0.03	0.00	0.00	0.04			0.07	0.04	
62	0.27	0.03	0.17	0.10	0.23	0.13	0.41	0.18	0.13	0.08	0.36	0.03	0.19	0.04	0.09	0.03	0.13			0.24	0.10	
C8							0.12	0.00	0.05	0.09	0.17	0.01	0.09	0.02	0.01	0.00	0.02			0.07	0.02	
C6							0.14	0.08	0.10	0.07	0.38	0.02	0.18	0.06	0.04	0.01	0.01			0.14	0.05	
56	0.18	0.02	0.18	0.03	0.02	0.07	0.16	0.06	0.13	0.07	0.24	0.03	0.10	0.12	0.07	0.02	0.07			0.13	0.05	
C4							0.07	0.00	0.09	0.04	0.08	0.01	0.03	0.03	0.05	0.02	0.04			0.06	0.02	
C2							0.53	0.19	0.40	0.25	0.43	0.13	0.26	0.18	0.32	0.13	0.28			0.34	0.18	
B8							0.17	0.24	0.21	0.23	0.29	0.23	0.09	0.05	0.04	0.01	0.02			0.13	0.15	
B6							0.29	0.03	0.24	0.17	0.35	0.07	0.32	0.14	0.40	0.08	0.23			0.30	0.10	
B4							0.29	0.08	0.21	0.21	0.21	0.10	0.29	0.25	0.18	0.14	0.15			0.21	0.16	
40	0.05	0.02	0.11	0.02	0.08	0.03	0.08	0.02	0.10	0.18	0.08	0.13	0.09	0.10	0.06	0.01	0.03			0.08	0.05	
28	0.08	0.04	0.14	0.06	0.04	0.09	0.21	0.39	0.48	0.08	0.10	0.06	0.14	0.12	0.03	0.01	0.03			0.13	0.10	
22	0.10	0.09	0.23	0.06	0.13	0.07	0.47	0.19	0.19	0.12	0.21	0.10	0.16	0.02	0.10	0.01	0.03			0.17	0.08	
A8							0.27	0.07	0.23	0.21	0.30	0.18	0.28	0.18	0.28	0.14	0.28			0.27	0.16	
14	0.57	0.61	0.54	0.34	0.47	0.44	0.57	0.23	0.41	0.41	0.62	0.56	0.59	0.38	0.48	0.29	0.31			0.49	0.39	
A6							0.12	0.08	0.10	0.05	0.19	0.10	0.27	0.06	0.18	0.01	0.03			0.15	0.06	
DJ					0.02	0.01	0.00	0.01													0.01	0.01

Variability Index by water-year (WY), calendar-year (CY), and season (Wet=May-Oct; Dry=Nov-Apr). (Variability proportion of observations where daily salinity range >5).

Salinity Regime Suitability Index



WYR	2008		2009		2010		2011		2012		2013		2014		2015		2016		Mean	
CYR	2007	2008	2008	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016		
Month	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
D6							0.00	0.00	0.16	0.18	0.40	0.00	0.41	0.00	0.00	0.00	0.08		0.21	0.04
D2							0.00	0.00	0.23	0.13	0.40	0.00	0.40	0.00	0.00	0.00	0.00		0.21	0.03
62	0.40	0.06	0.44	0.00	0.22	0.11	0.39	0.05	0.25	0.27	0.54	0.00	0.56	0.14	0.13	0.06	0.20		0.37	0.08
C8							0.46	0.00	0.27	0.31	0.65	0.00	0.59	0.20	0.12	0.00	0.22		0.37	0.10
C6							0.46	0.14	0.28	0.32	0.71	0.00	0.68	0.07	0.15	0.00	0.06		0.38	0.11
56	0.66	0.20	0.56	0.00	0.35	0.24	0.49	0.15	0.37	0.34	0.79	0.08	0.74	0.20	0.17	0.00	0.00		0.49	0.14
C4							0.59	0.13	0.42	0.37	0.84	0.00	0.78	0.24	0.39	0.00	0.00		0.49	0.15
C2							0.54	0.31	0.46	0.40	0.73	0.17	0.68	0.44	0.36	0.11	0.24		0.49	0.29
B8							0.63	0.33	0.35	0.47	0.82	0.21	0.87	0.54	0.35	0.44	0.11		0.50	0.40
B6							0.77	0.51	0.61	0.69	0.76	0.74	0.72	0.72	0.58	0.49	0.49		0.65	0.63
B4							0.69	0.50	0.54	0.75	0.84	0.56	0.74	0.68	0.54	0.67	0.48		0.63	0.63
40	0.73	0.57	0.72	0.64	0.62	0.60	0.77	0.51	0.66	0.76	0.91	0.53	0.87	0.71	0.51	0.50	0.44		0.70	0.61
28	0.69	0.54	0.70	0.57	0.52	0.54	0.74	0.40	0.45	0.73	0.89	0.47	0.80	0.67	0.48	0.50	0.38		0.64	0.57
22	0.68	0.54	0.72	0.52	0.58	0.53	0.68	0.45	0.53	0.74	0.83	0.46	0.79	0.66	0.47	0.41	0.34		0.63	0.55
A8							0.69	0.48	0.49	0.69	0.75	0.48	0.72	0.58	0.39	0.50	0.33		0.56	0.55
14	0.57	0.48	0.56	0.56	0.49	0.51	0.58	0.47	0.44	0.69	0.60	0.46	0.60	0.43	0.38	0.51	0.37		0.52	0.53
A6							0.43	0.32	0.33	0.55	0.56	0.19	0.40	0.30	0.24	0.23	0.30		0.37	0.32
DJ						0.93	0.67	0.83	0.59										0.63	0.88

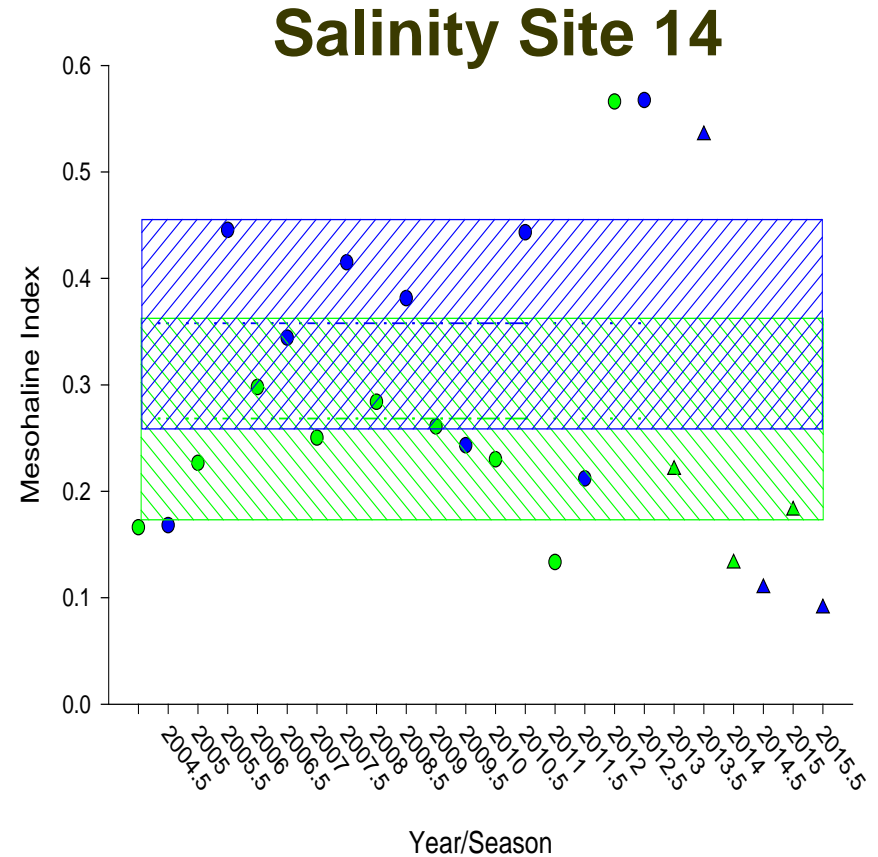
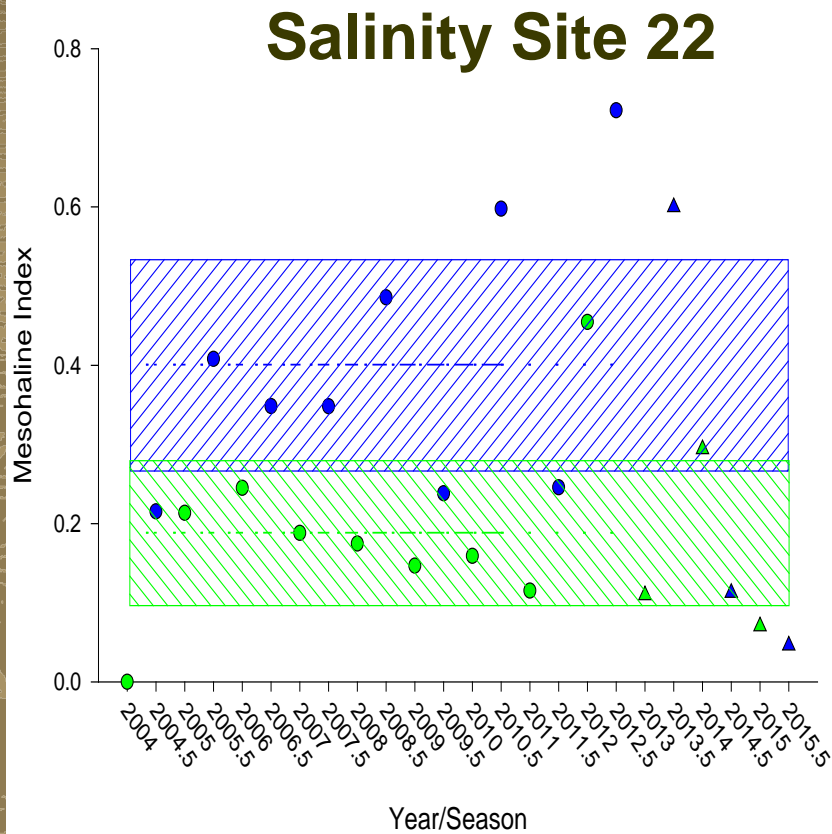
Salinity Regime Suitability Index by water-year(WY), calendar-year (CY), and season (Wet=May-Oct; Dry=Nov-Apr). This index is a composite of the mesohaline, hypersaline and variability indices



Salinity Sites Convoy Point to Black Point

Mesohaline Index Values

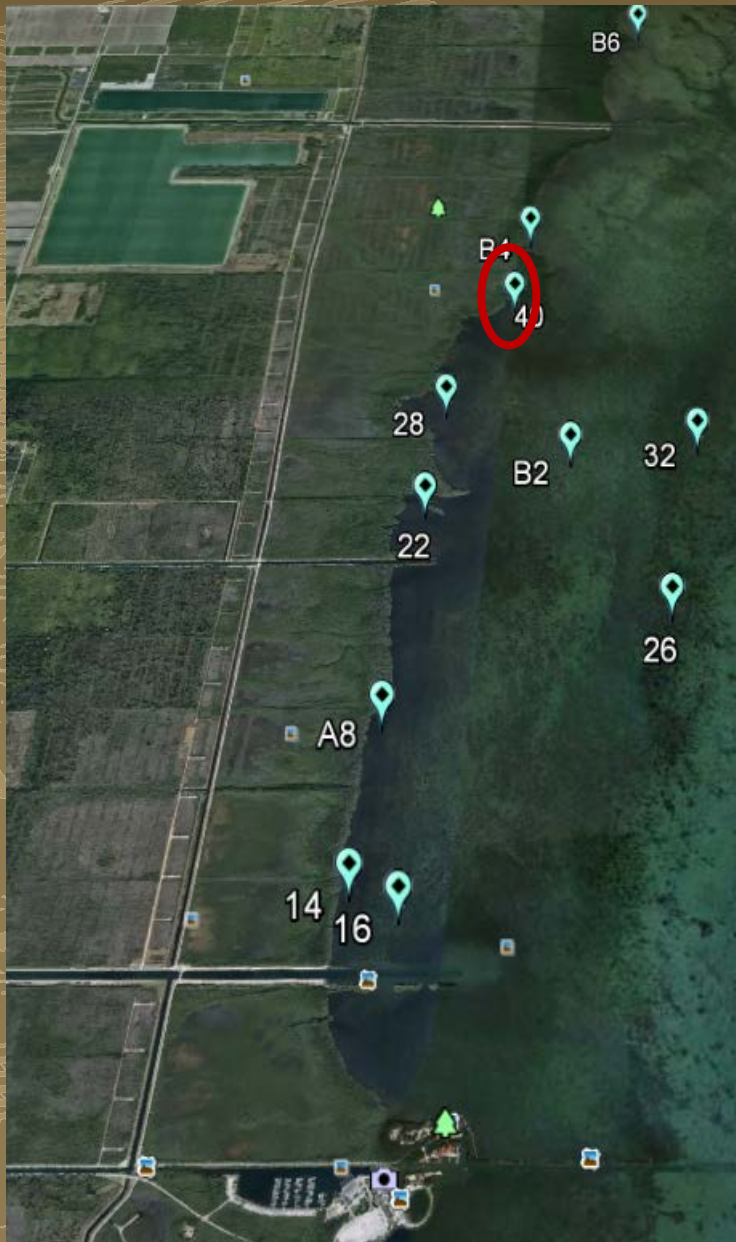
2010-2012 wet and dry season
Mean & 95% confidence intervals



- Index wet season 2004-2012 (May-Oct)
- Index dry season 2004-2012 (Nov-Apr)
- ▲ Index wet season 2013-2015 (May-Oct)
- ▲ Index dry season 2013-2015 (Nov-Apr)
- - - Mean index wet season 2004-2012 (May-Oct)
- - - Mean index dryseason 2004-2012 (Nov-Apr)
- ▨ CI 95% wet season
- ▨ CI 95% dry season

- Index wet season 2004-2012 (May-Oct)
- Index dry season 2004-2012 (Nov-Apr)
- ▲ Index wet season 2013-2015 (May-Oct)
- ▲ Index dry season 2013-2015 (Nov-Apr)
- - - Mean index wet season 2004-2012 (May-Oct)
- - - Mean index dryseason 2004-2012 (Nov-Apr)
- ▨ CI 95% wet season
- ▨ CI 95% dry season

Salinity Sites Convoy Point to Black Point

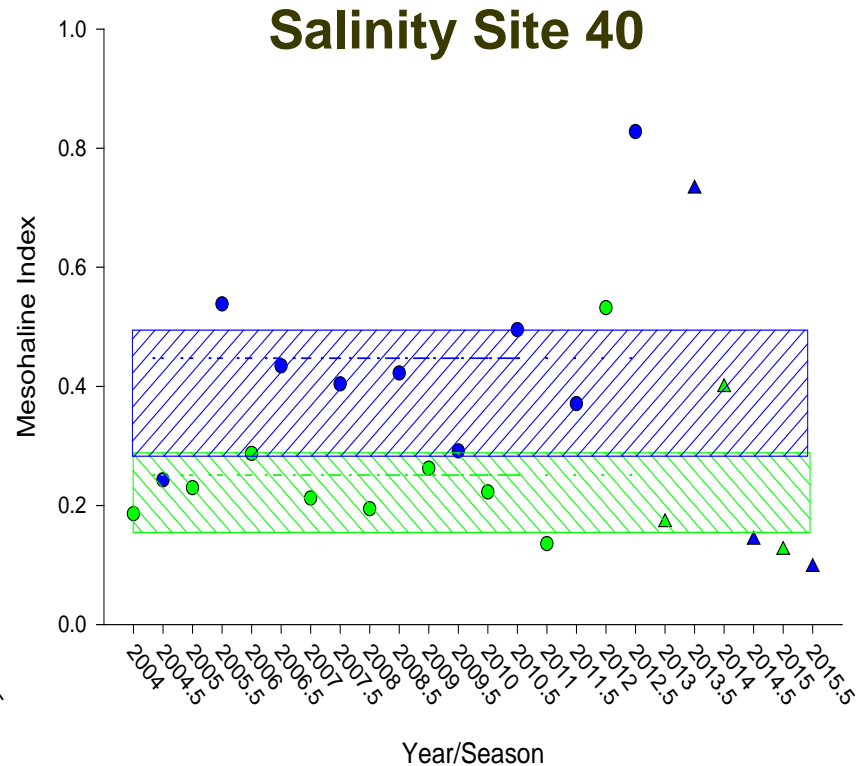
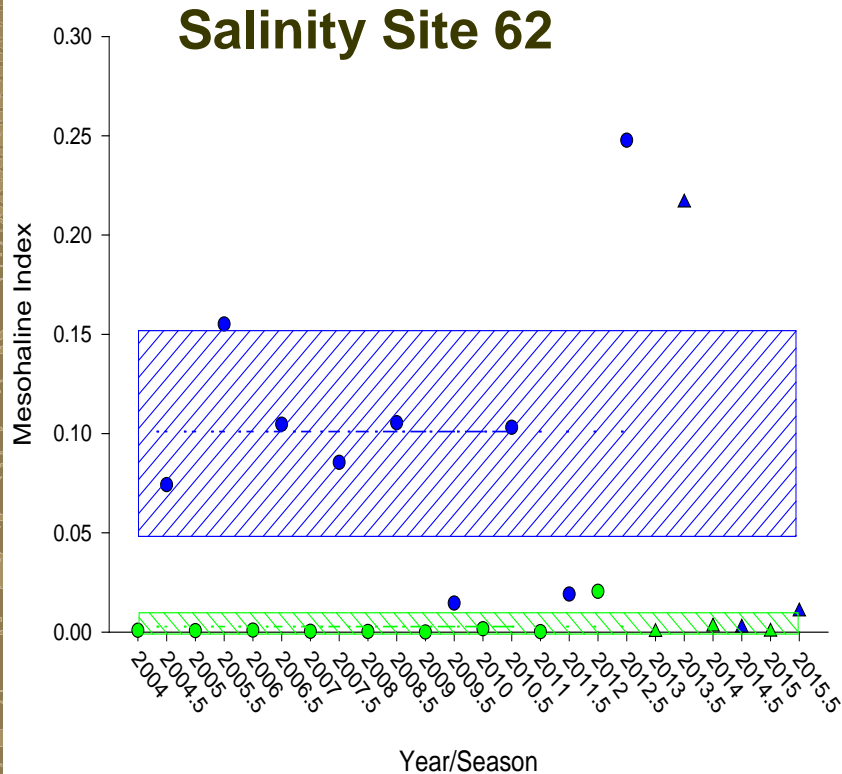


Salinity Sites Black Point to Deering Estate



Mesohaline Index Values

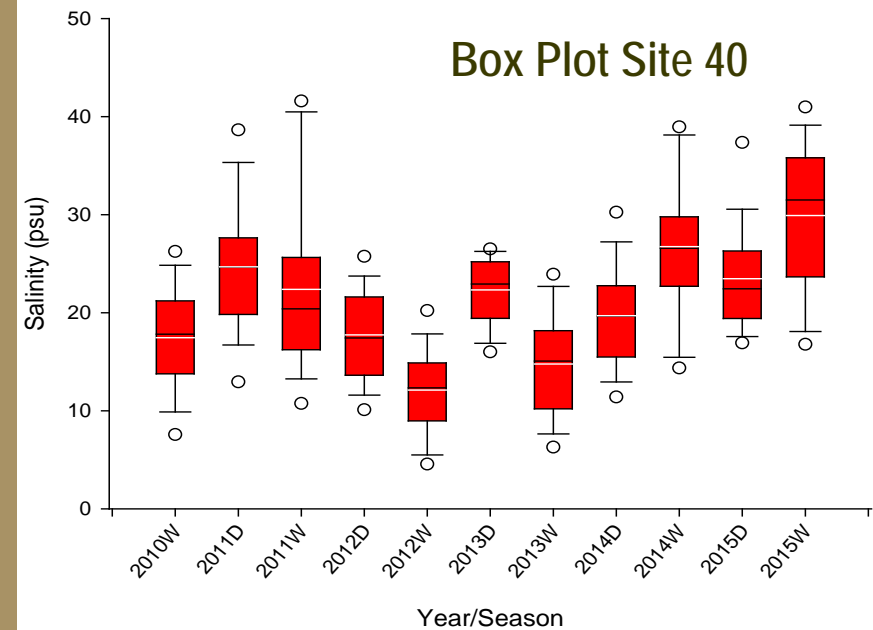
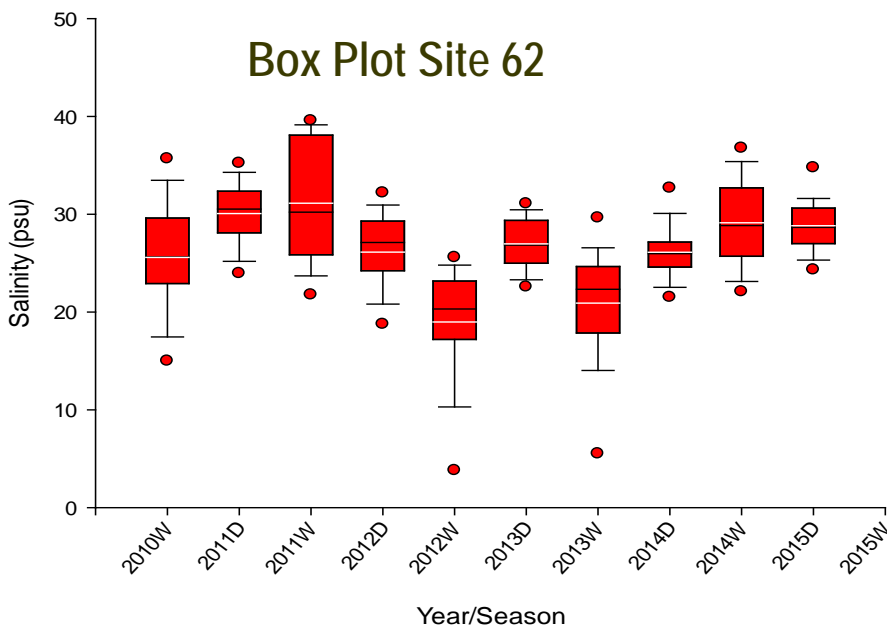
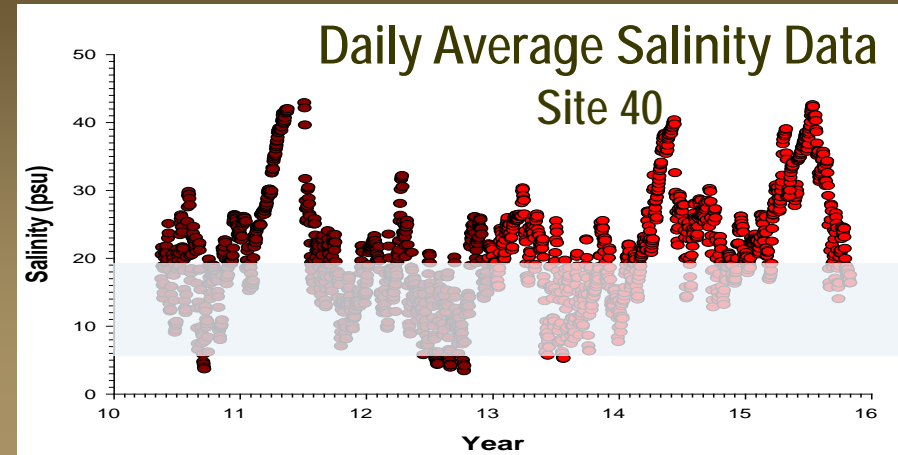
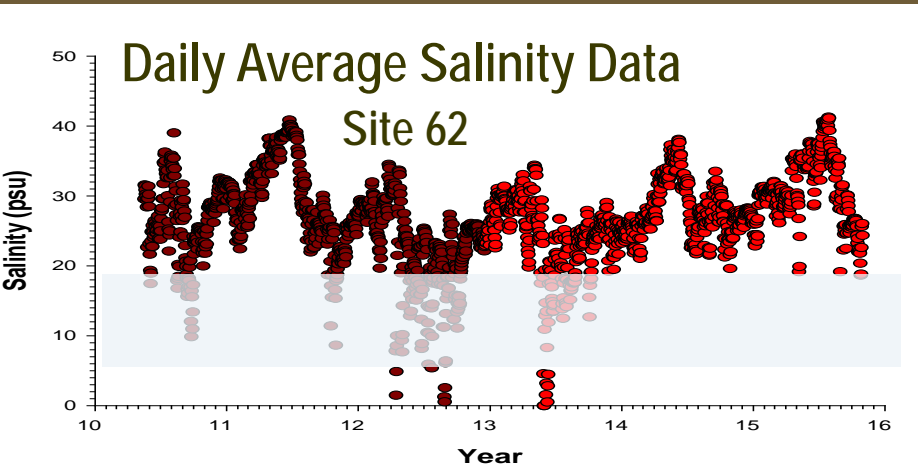
2010-2012 wet and dry season Mean & 95% confidence intervals



- Index wet season 2004-2012 (May-Oct)
- Index dry season 2004-2012 (Nov-Apr)
- ▲ Index wet season 2013-2015 (May-Oct)
- ▲ Index dry season 2013-2015 (Nov-Apr)
- - - Mean index wet season 2004-2012 (May-Oct)
- - - Mean index dryseason 2004-2012 (Nov-Apr)
- ▨ CI 95% wet season
- ▨ CI 95% dry season

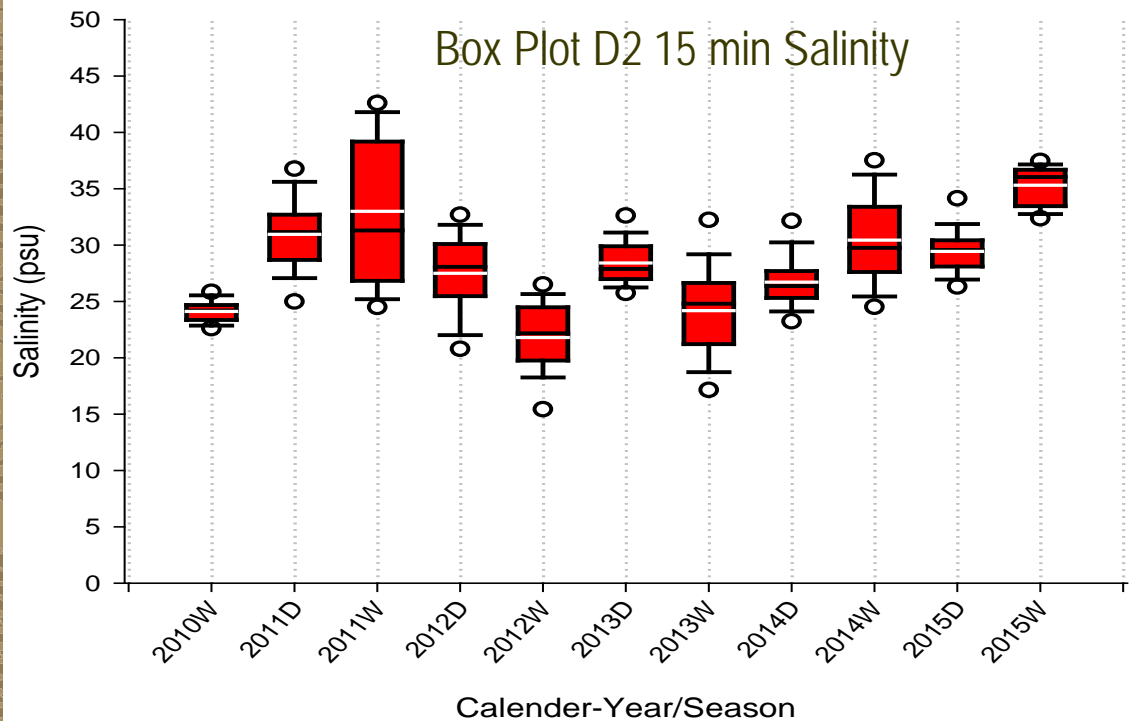
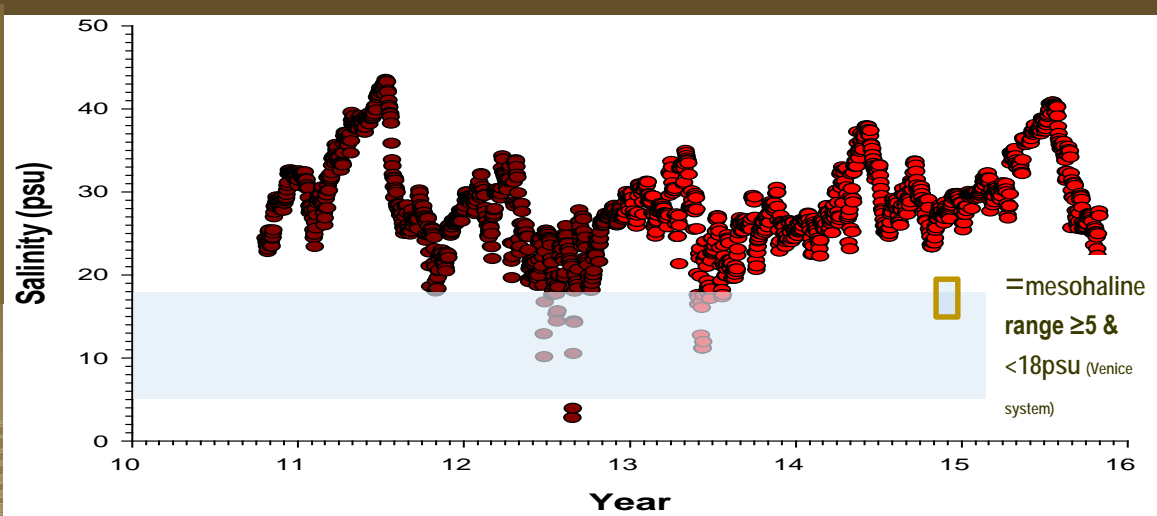
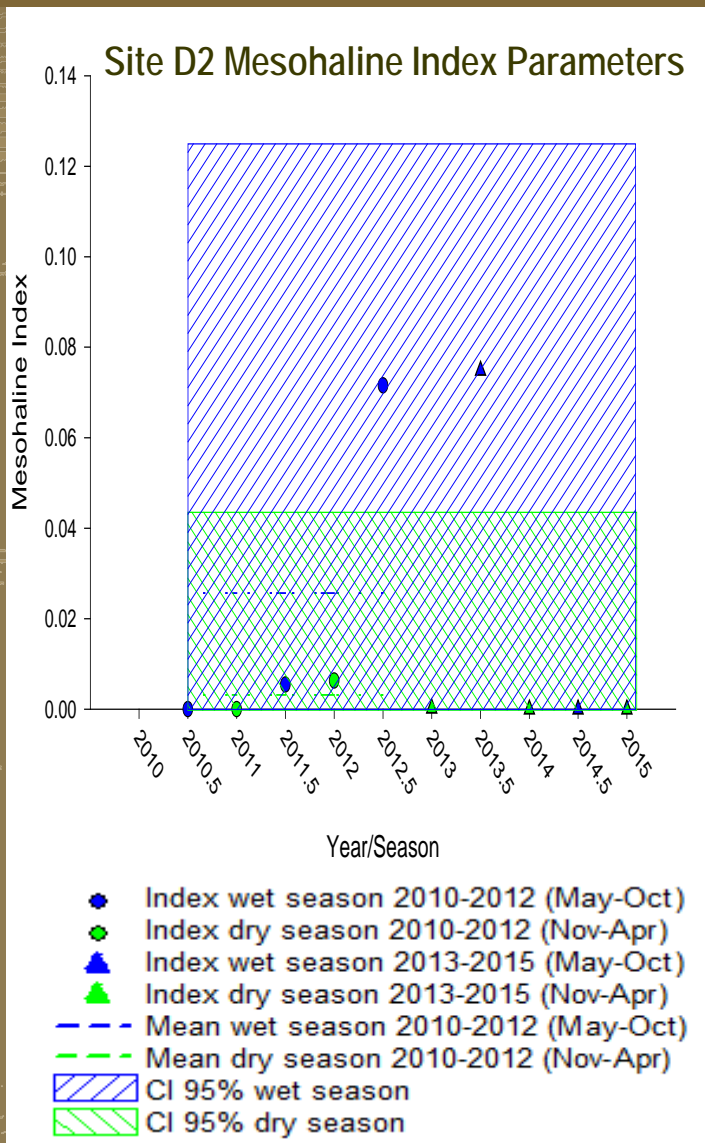
- Index wet season 2004-2012 (May-Oct)
- Index dry season 2004-2012 (Nov-Apr)
- ▲ Index wet season 2013-2015 (May-Oct)
- ▲ Index dry season 2013-2015 (Nov-Apr)
- - - Mean index wet season 2004-2012 (May-Oct)
- - - Mean index dryseason 2004-2012 (Nov-Apr)
- ▨ CI 95% wet season
- ▨ CI 95% dry season

Mesohaline Target Sites



White Line = Mean, Black Line = Median ; black circles = 5th/95th percentile, red box = 25th/7th percentile, black vertical lines = minimum/maximum

Site D2 Deering Estate Mesohaline Conditions



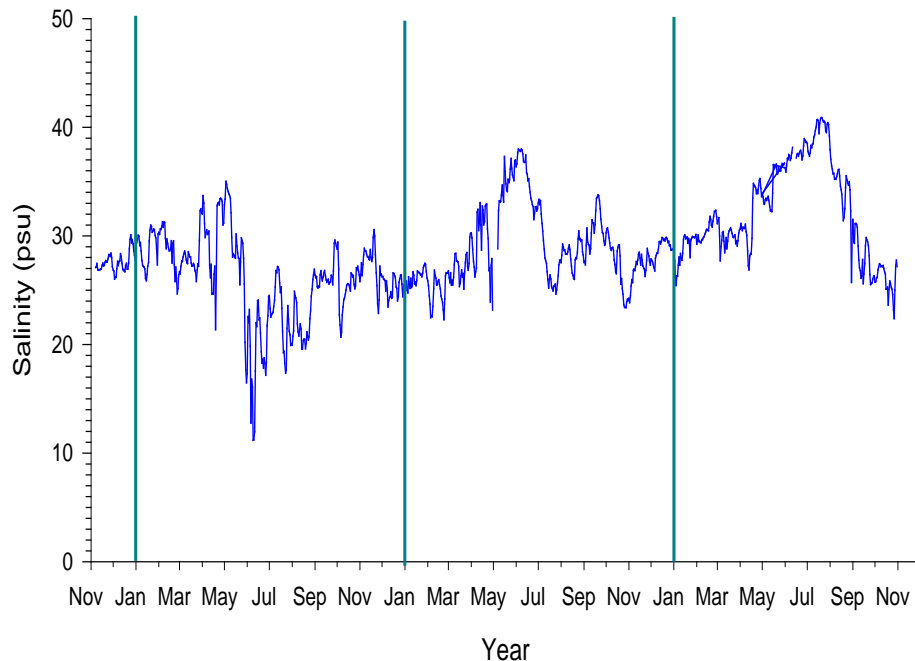
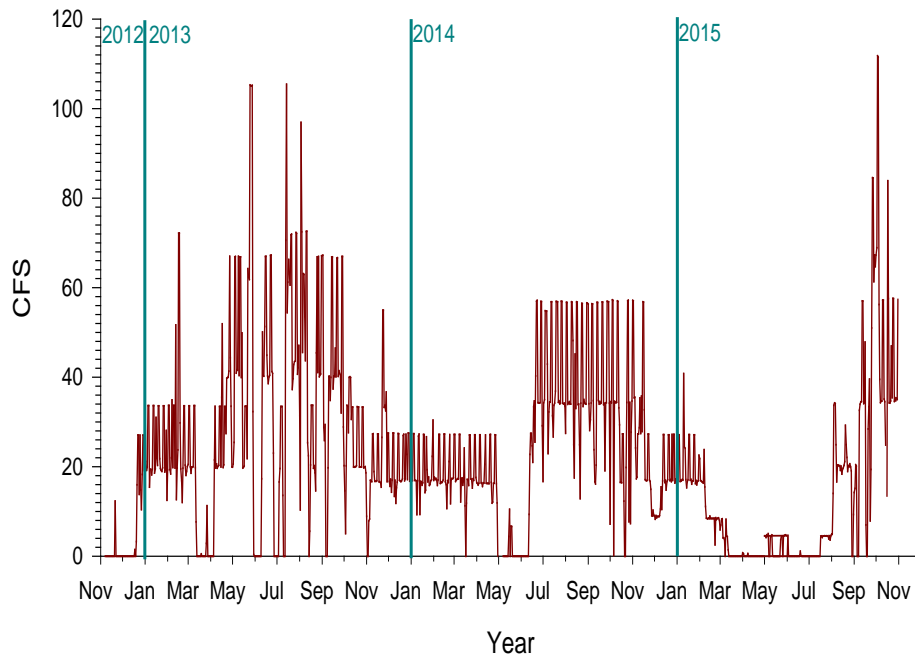
White Line = Mean, Black Line = Median ; black circles = 5th/95th percentile, red box = 25th/75th percentile, black vertical lines = minimum/maximum.

Benefits of Water Delivery

Resulting Downstream Response

- Two test action water deliveries to Biscayne Bay during dry season...small amounts of water was delivered to Biscayne Bay through canals not involved in the Seasonal Agricultural Drawdown.
- Tests were in 2009 (first informal test) and a formal study in 2011-12.
- Delivery was through the C-1 and C-100.
- Resulted in measurable downstream changes in benthic salinity patterns and responses.
- Structure S-700 was installed and began operating at Deering Estate in stable operations late 2012.

Flow and Salinity Deering Estate

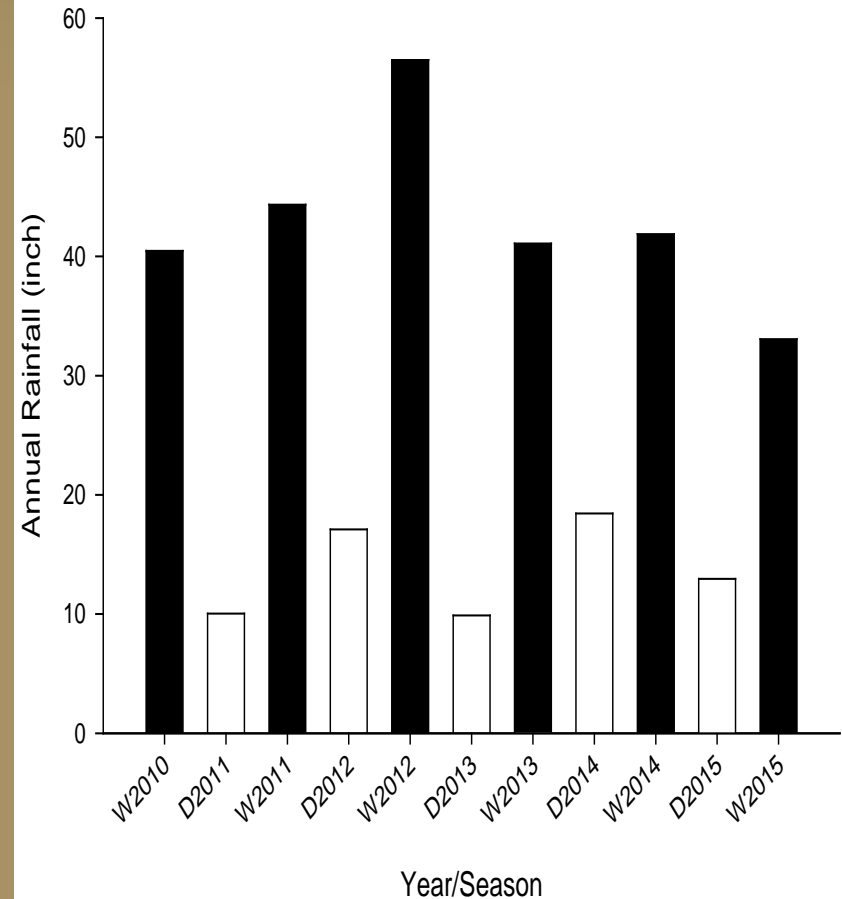
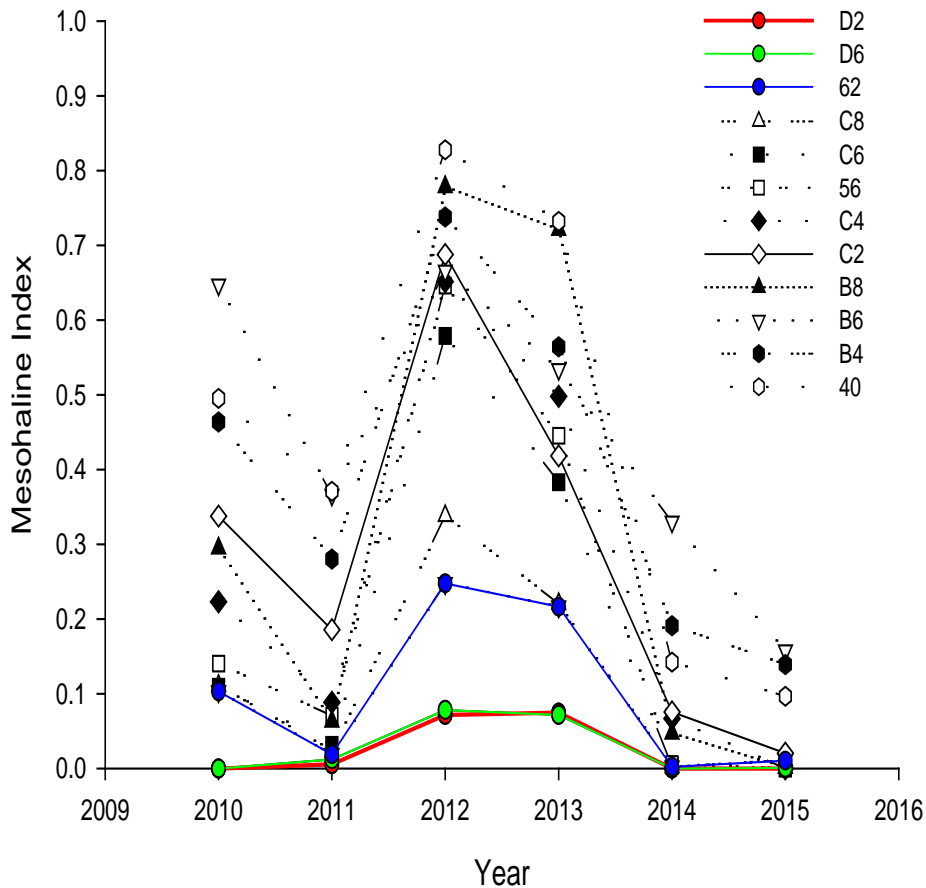


**Comparison of
flow (cfs) from S-
700 with salinity
data from site
D2. November
2012 to October
2015.**

datasource: http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu. (DBkey A1615)

Wet Mesohaline Index Values by Site

Total Annual Rainfall Miami-Dade County CYR 2010 to CYR 2015 (wet season to wet season)

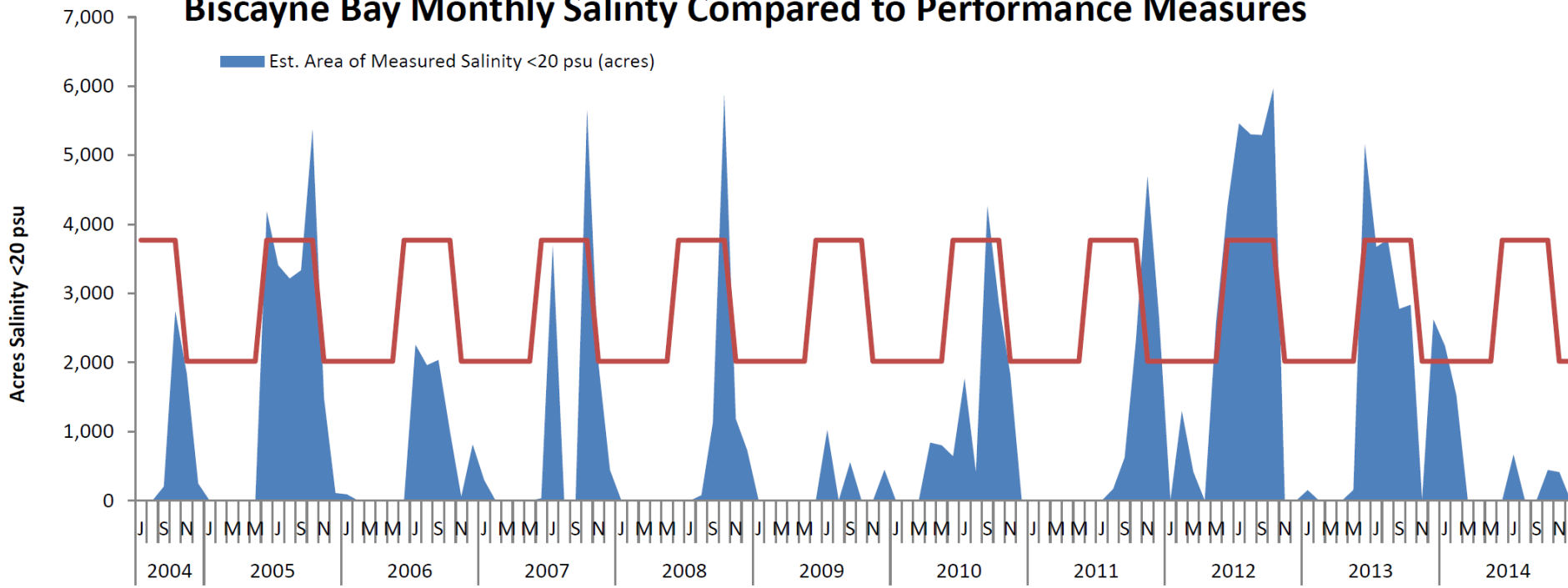


Colored lines present data from sites near Deering Estate

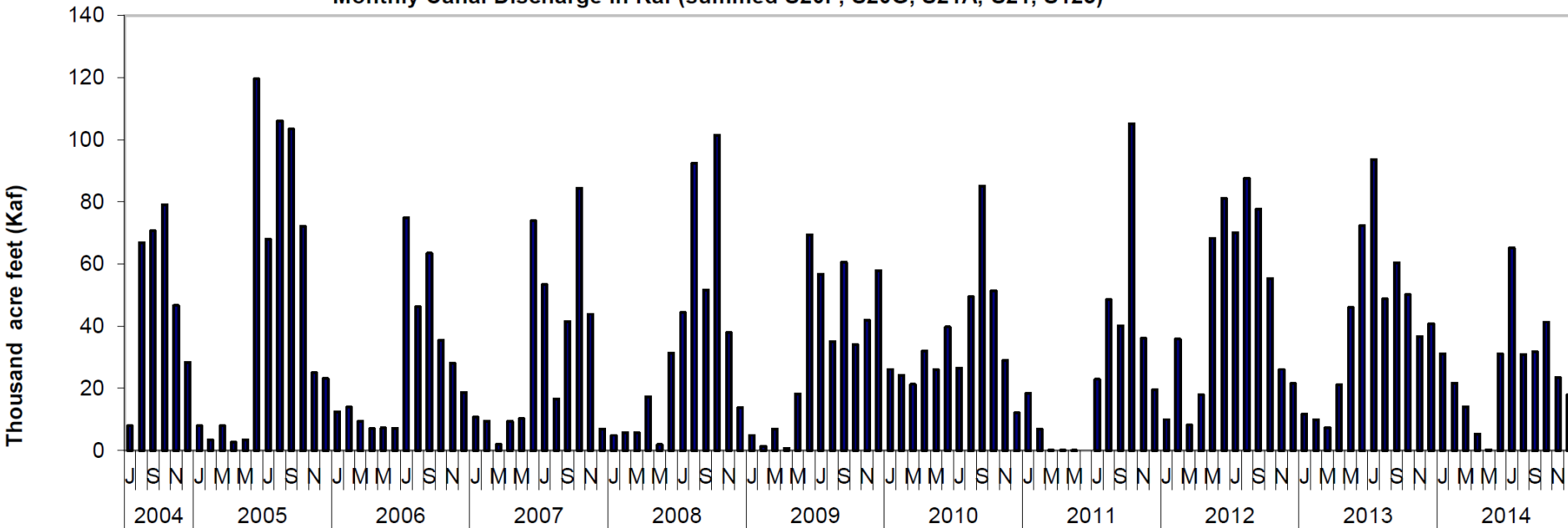
Data source: <http://www.sfwmd.gov/>

Biscayne Bay Monthly Salinity Compared to Performance Measures

Est. Area of Measured Salinity <20 psu (acres)



Monthly Canal Discharge in Kaf (summed S20F, S20G, S21A, S21, S123)



Getting the Water Right

Quantity

Quality

Q

Q

T

D

Timing

Distribution



Conclusions

- Water provided during the initial operations of the structure for the Deering Estate portion of the Biscayne Bay Coastal Wetlands showed downstream improvement.
- 2014-15 were bad years for water delivery and estuarine zones off of Deering Estate and north of Black Point.
- Additional freshwater delivered through the canal system to Biscayne Bay in the dry season improved the salinity conditions in the late wet season and early dry season.
- Even small amounts of water delivered to the Biscayne Bay benefit the bay salinity conditions.
- Operational changes can benefit the bay when made in conjunction with downstream salinity conditions.

Recommendations.....Next Steps

- Investigate why there was so little downstream mesohaline zone in 2014 off of Deering Estate.
- Determine whether the reduction of flow to Biscayne Bay was due to climatic, groundwater, or operational sources
- Revisit delivery schedules to Biscayne Bay to provide freshwater during the dry season when possible.
- Work with the South Florida Water Management District to Evaluate Different Operations for water delivery to Biscayne Bay
- As operational plans are developed add dry season needs for Biscayne Bay to all operational plans.
- Evaluate the impacts of removal of water for the Florida Power and Light Turkey Point Plant from coastal Miami-Dade County and the C&SF system

Questions ?



Assistance and Special Thanks :

- Erik Stabenau, NPS
- Ania Wachnica, FIU
- Bahram Charkhian, SFWMD
- U. S. Army Corps of Engineers