



SEA-BIRD
SCIENTIFIC

HARBOR BRANCH

FLORIDA ATLANTIC UNIVERSITY®

Ocean Science for a Better World®

A year and a Hurricane Apart: Nutrient Loading in the St. Lucie Estuary in the Summers of 2016 and 2017

Ian Walsh

October 3, 2017 / SECOORA Webinar Series

This presentation could and would not happen without the expertise and hard work of Dr. Dennis Hanisak and Kristen Davis and their team.

They keep IRLON funded and running, and we all benefit.

Dennis and Dr. Brian Lapointe contributed their their understanding of the estuary in multiple conversations.

Data are presented courtesy of Indian River Lagoon Observatory Network of Environmental Sensors

fau.loboviz.com

2016 Algal Blooms

SCIENCE

Got muck? Florida residents can report algae blooms with new hotline.

After declaring a state of emergency this week, Florida officials have turned to citizens to help control the outbreak.

By APNewsNow, Associated Press | JULY 5, 2016

Save for later



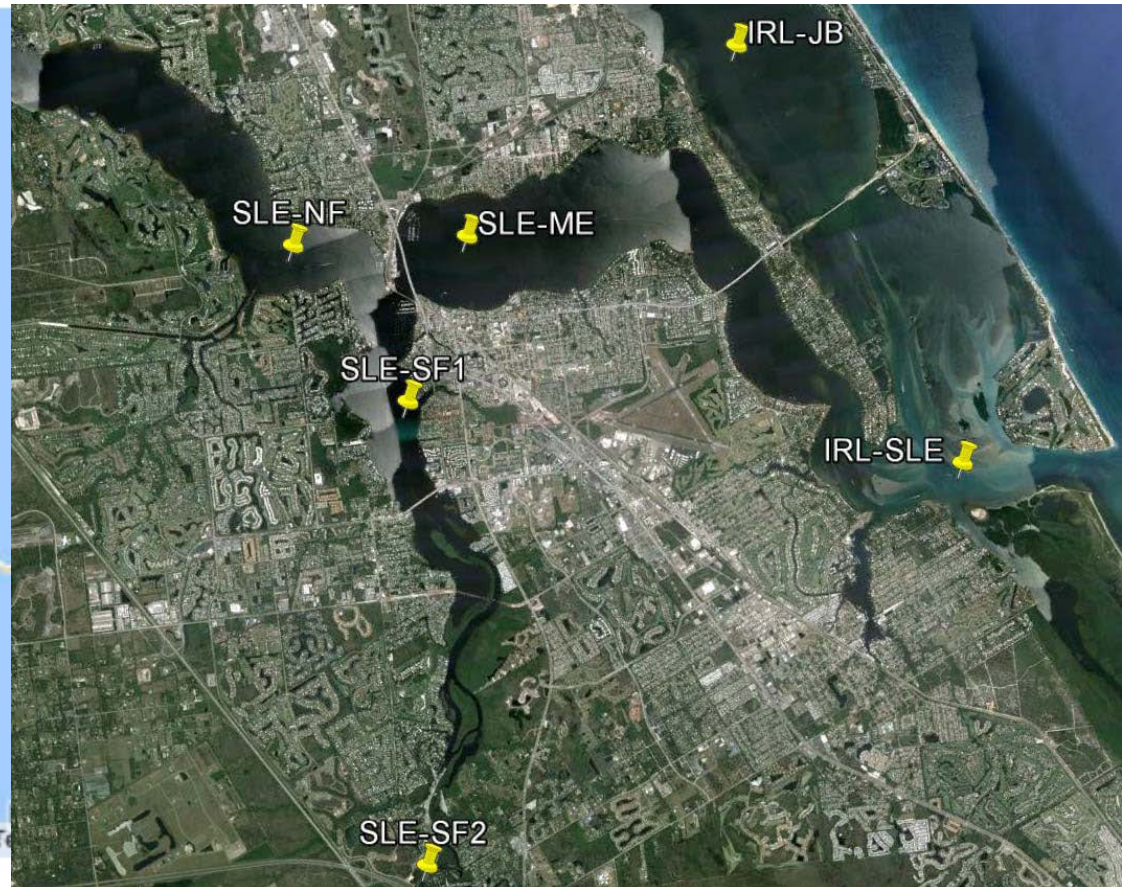
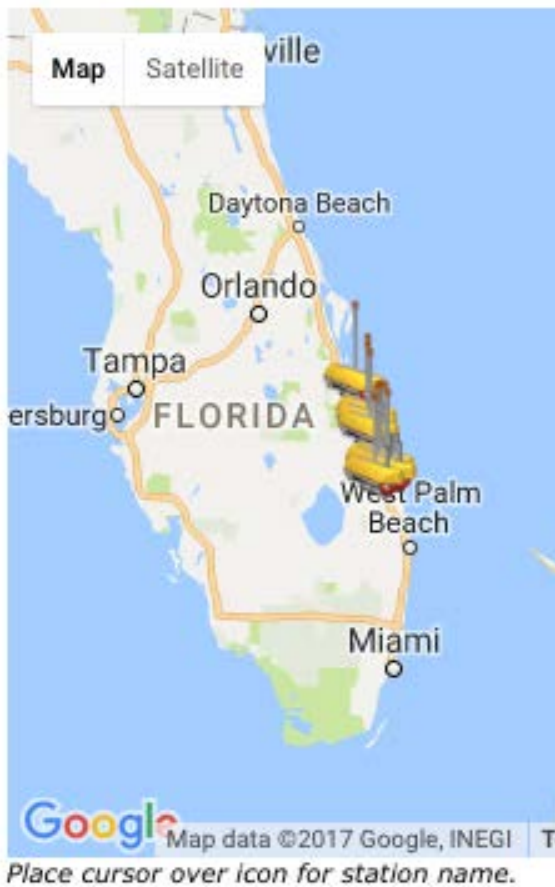
TALLAHASSEE, Fla. (AP) — The state has launched a hotline to help residents give updates on the massive algae bloom fouling some of Florida's southern rivers and beaches.

Residents can call a toll-free at 1-855-305-3903 or report information online at www.reportalgalbloom.com. The smelly muck comes just in time for the holiday weekend.

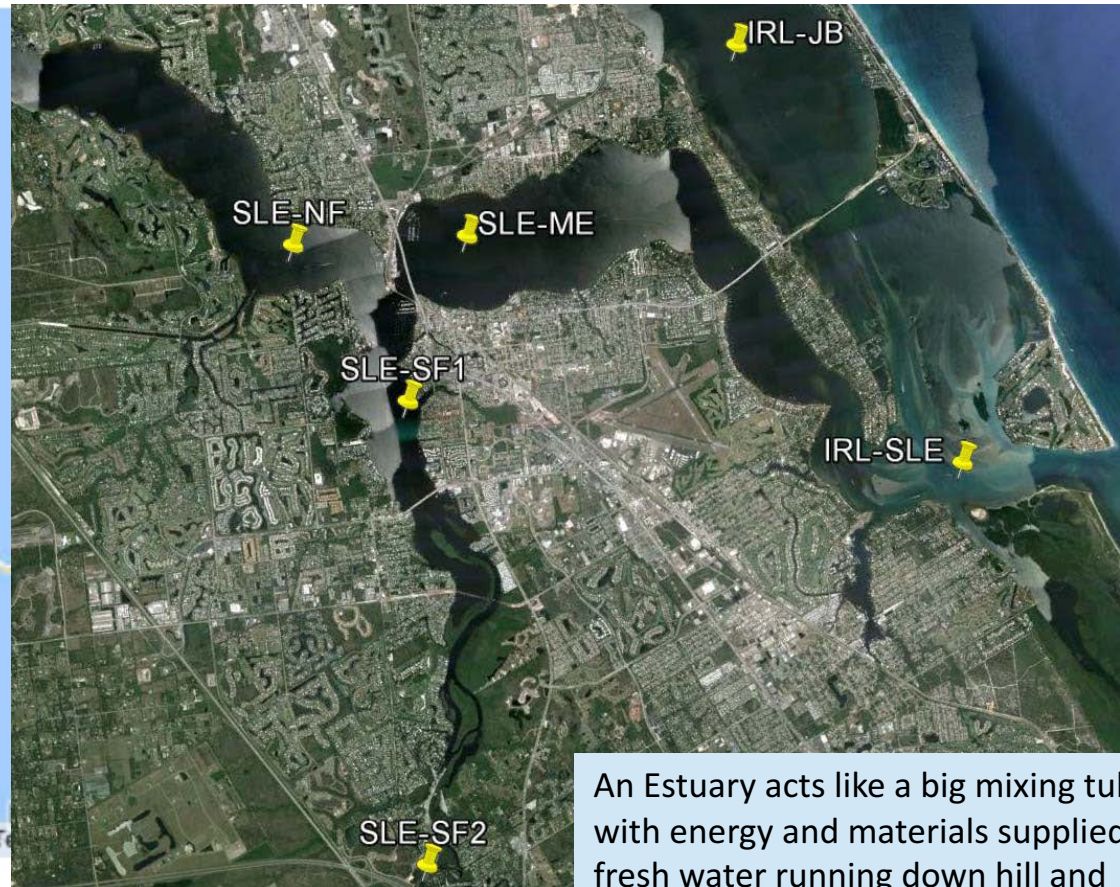
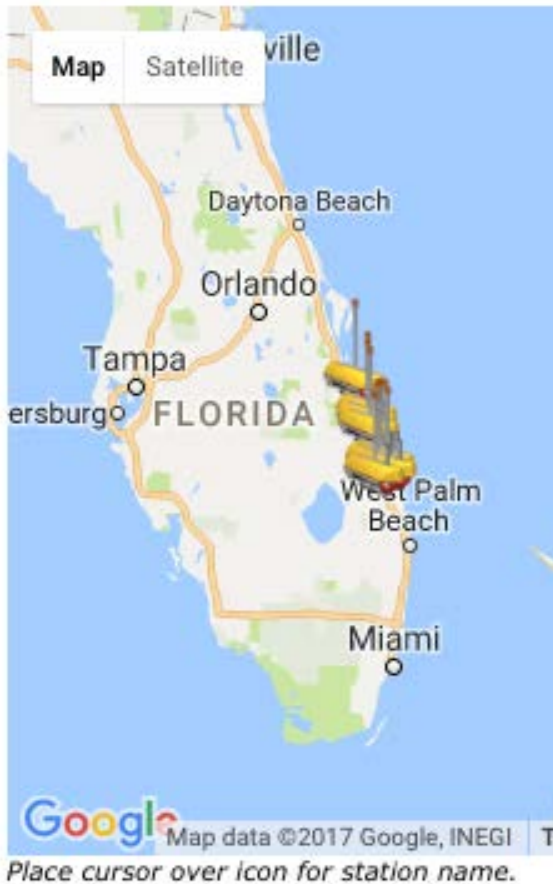
What We Will Cover Today

- Estuaries and Biogeochemical Processes
 - Sources
- IRLON sites in the St. Lucie Estuary
 - How I got the data
- Nutrients in the summer of 2016:
 - Blue green algae bloom
- Nutrients in the summer of 2017
- September 2017:
 - Irma

IRLON Locations

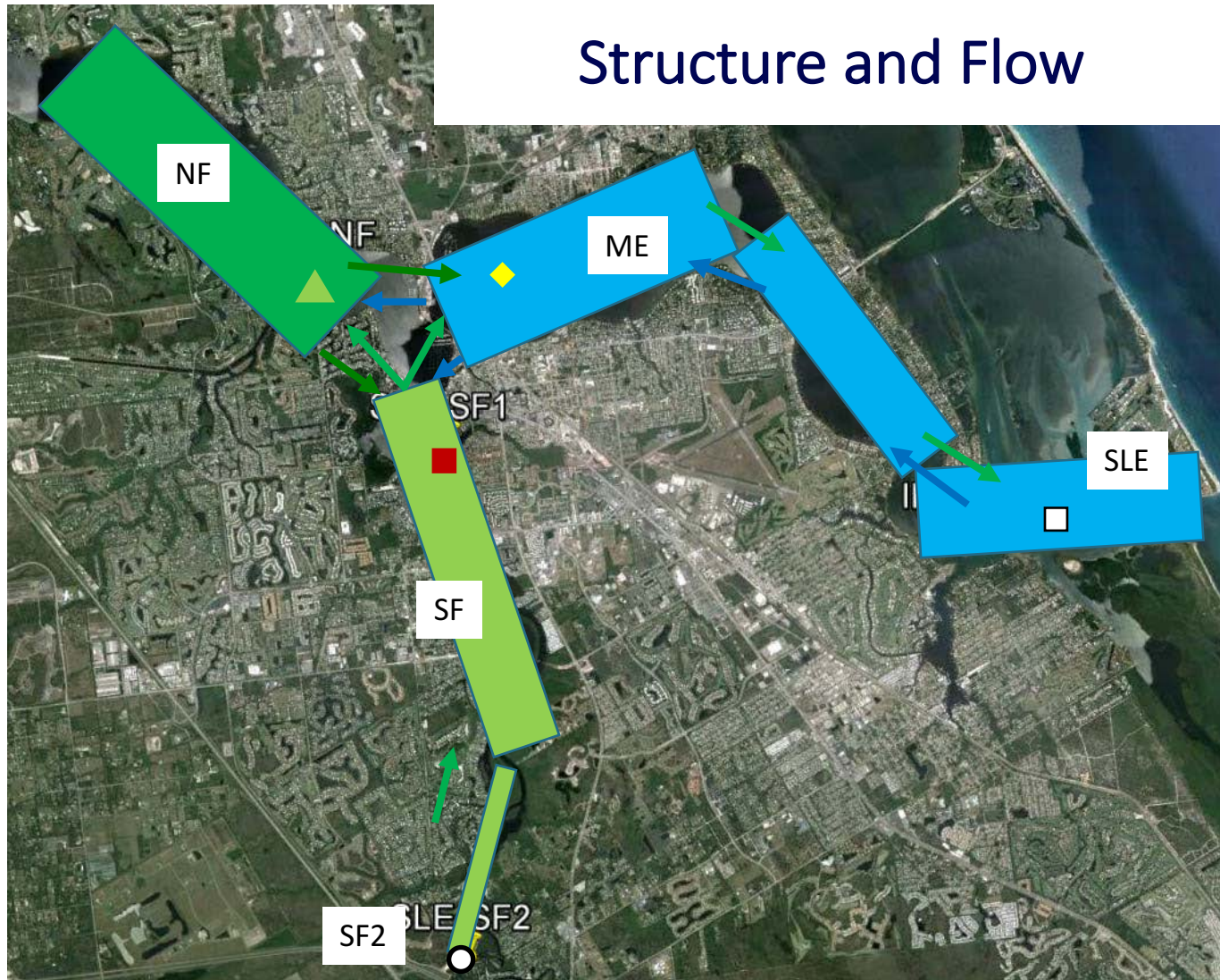


IRLON Locations

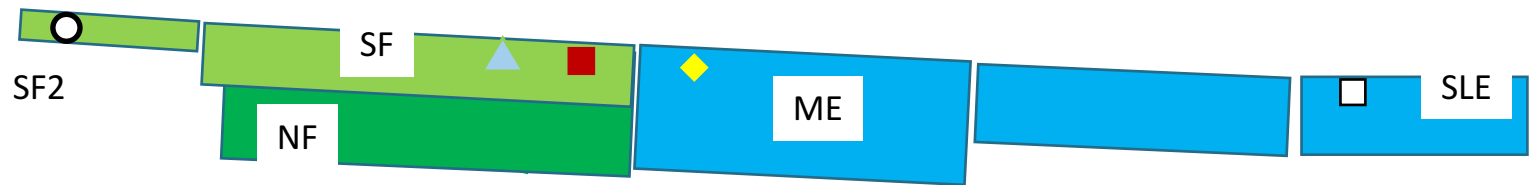


An Estuary acts like a big mixing tub, with energy and materials supplied by fresh water running down hill and seawater driven by the Moon

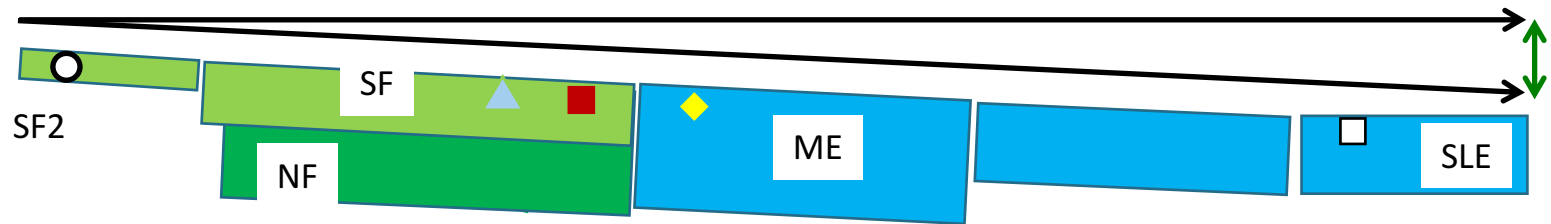
Structure and Flow



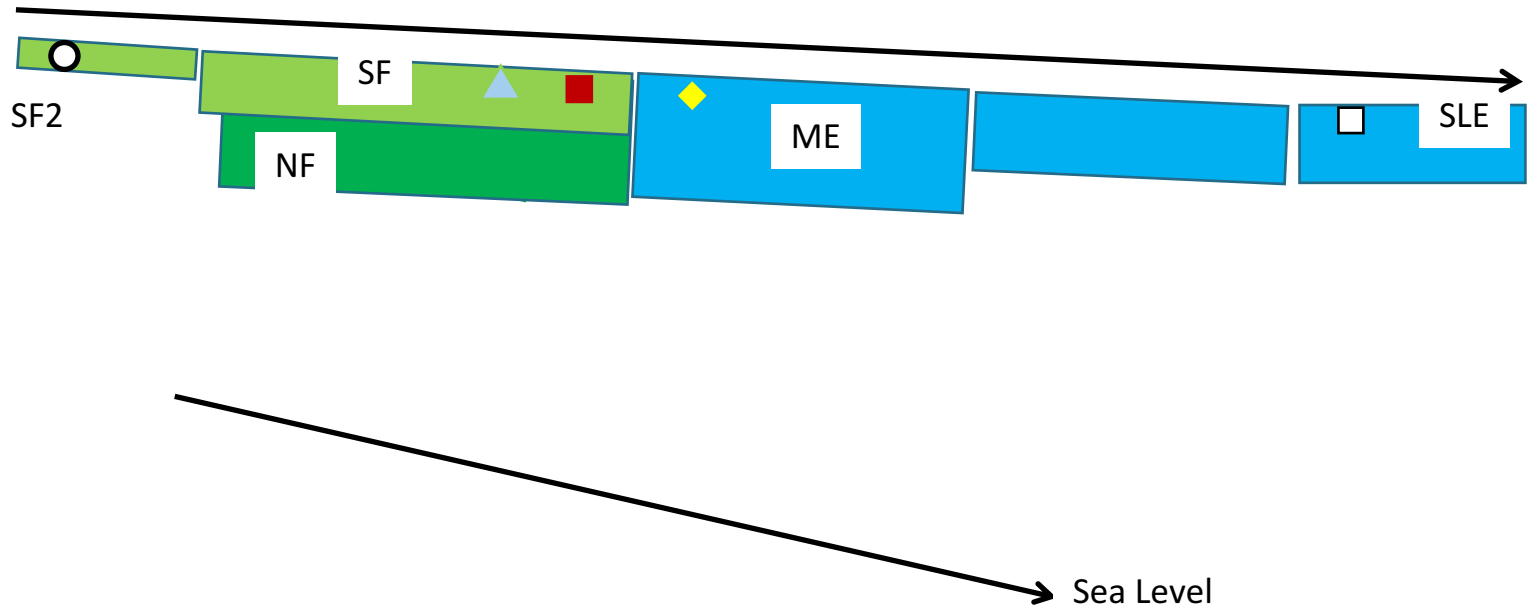
Water Flows Down Hill



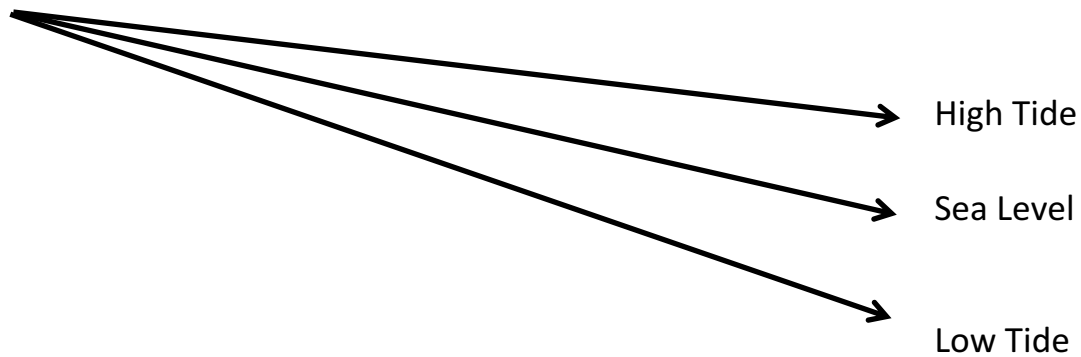
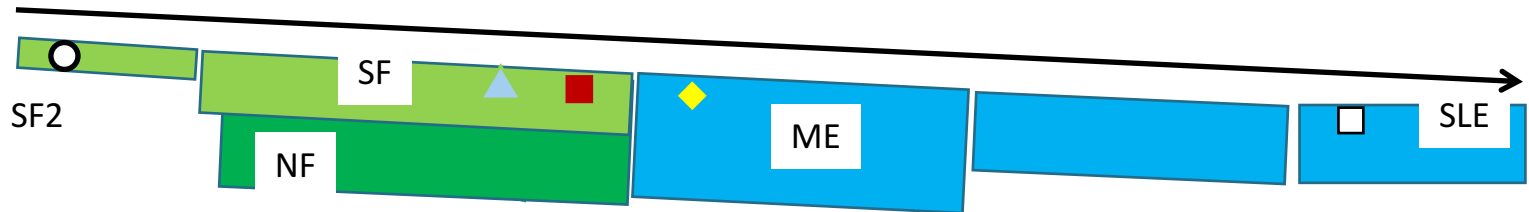
Water Flows Down Hill



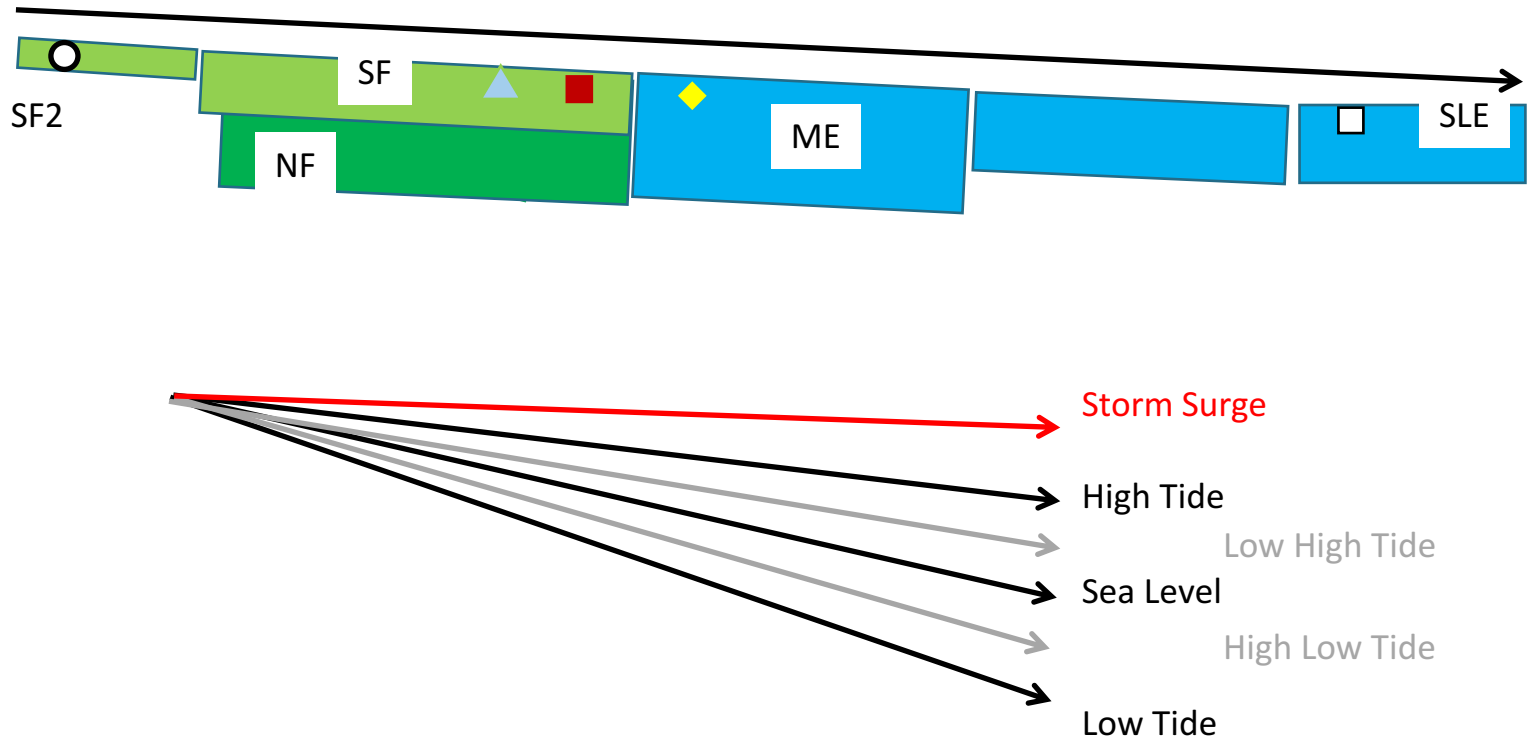
Water Flows Down Hill



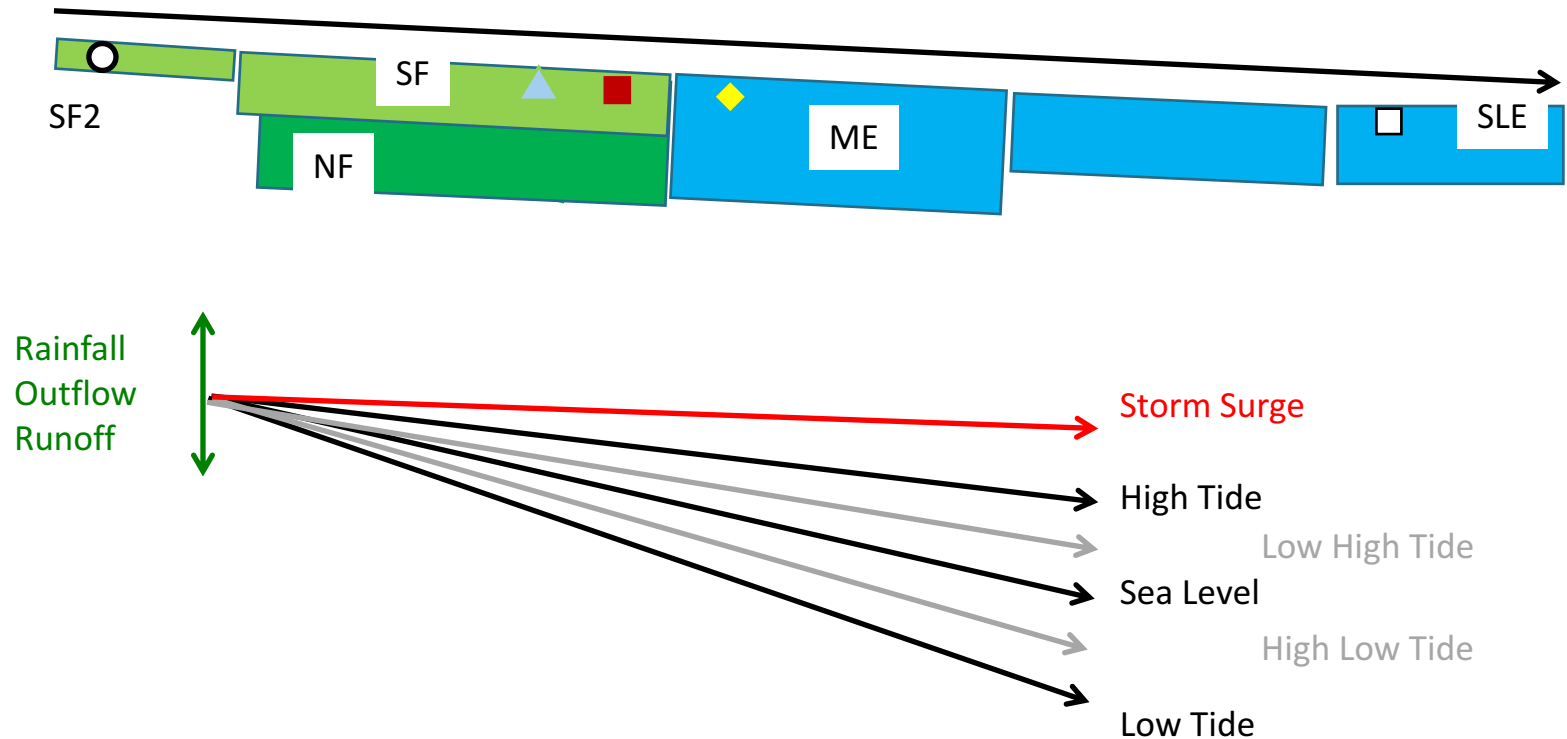
Water Flows Down Hill



Tides and Storms change the gradient

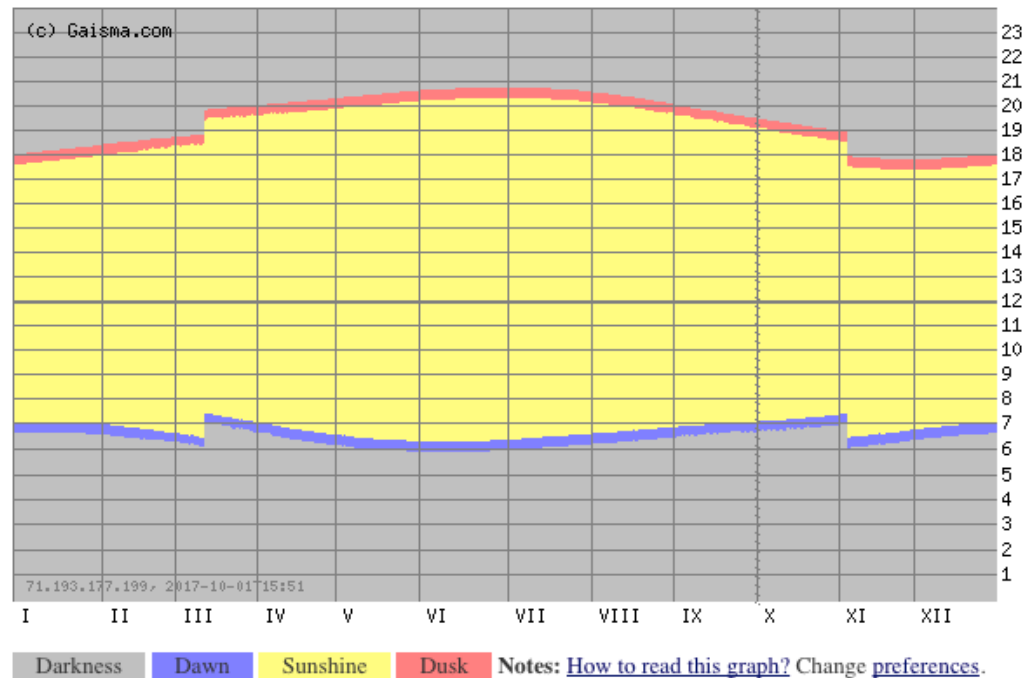


Tides and Storms change the gradient



Plants Growth: Light, Nutrients, Time

Fort Pierce, [Florida, United States](#) - Sunrise, sunset, dawn and dusk times, graph



<https://www.gaisma.com/en/location/corvallis-oregon.html>

Plenty of light in Florida

Warm Year Round, Wet Summers

Fort Pierce, **Florida, United States** - Solar energy and surface meteorology

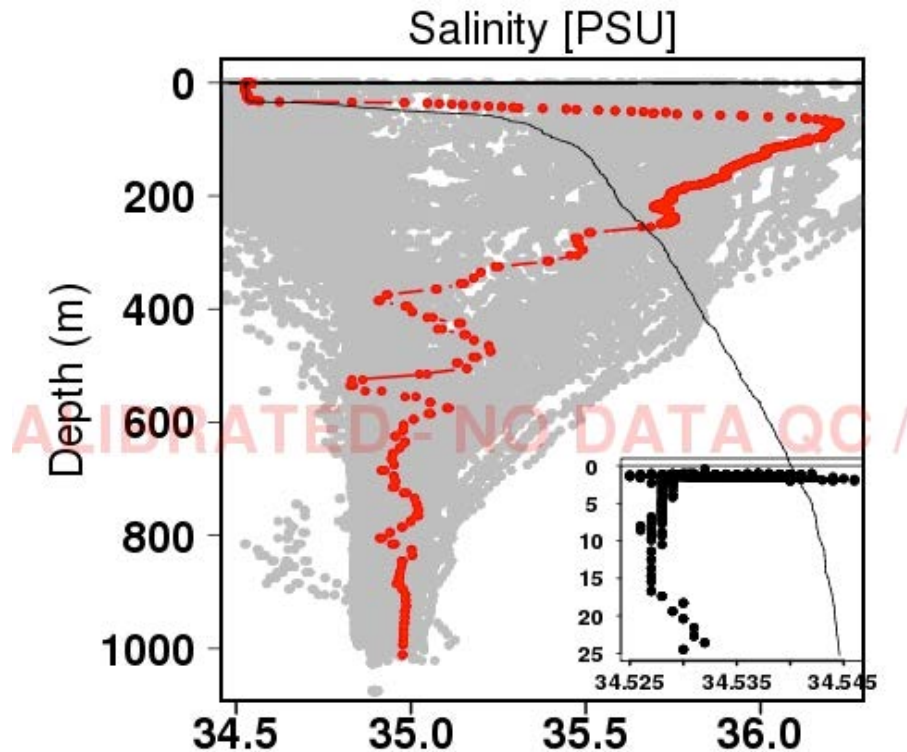
Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insolation, kWh/m ² /day	3.43	4.34	5.30	6.42	7.05	6.57	6.82	6.32	5.38	4.56	3.71	3.18
Clearness, 0...1	0.54	0.58	0.59	0.62	0.64	0.58	0.61	0.60	0.57	0.57	0.56	0.54
Temperature, °C	20.84	21.09	21.75	22.50	24.42	26.03	26.85	27.01	26.81	25.73	23.98	21.92
Wind speed, m/s	6.22	6.22	6.24	5.47	4.76	4.03	3.84	3.53	4.44	5.54	6.17	5.71
Precipitation, mm	2.23	2.83	3.19	2.12	4.66	5.87	5.76	5.61	7.56	5.90	3.09	2.22
Wet days, d	7.8	7.5	7.7	5.3	10.3	14.5	15.2	16.1	15.8	11.0	8.6	7.4

These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center; New et al. 2002

Notes: [Help](#). Change [preferences](#).

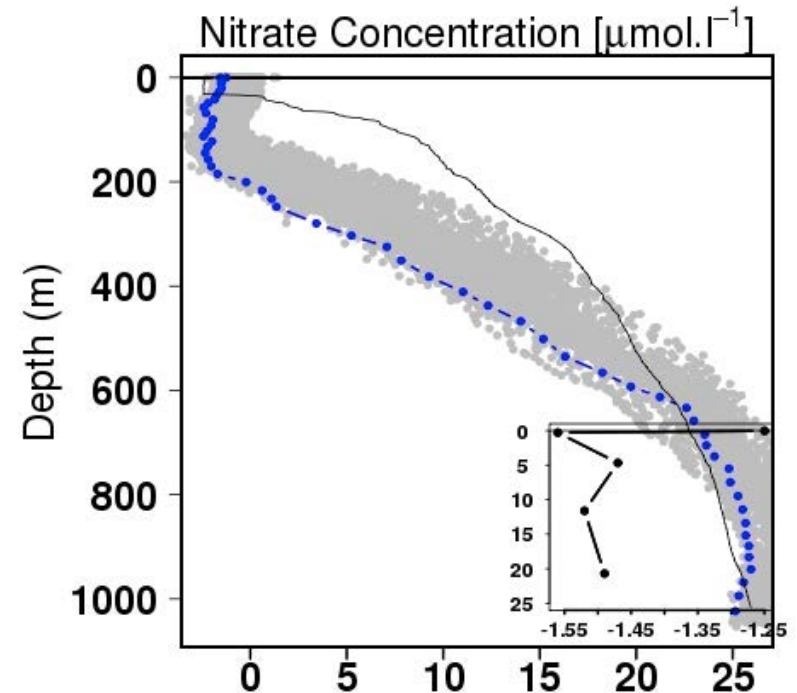
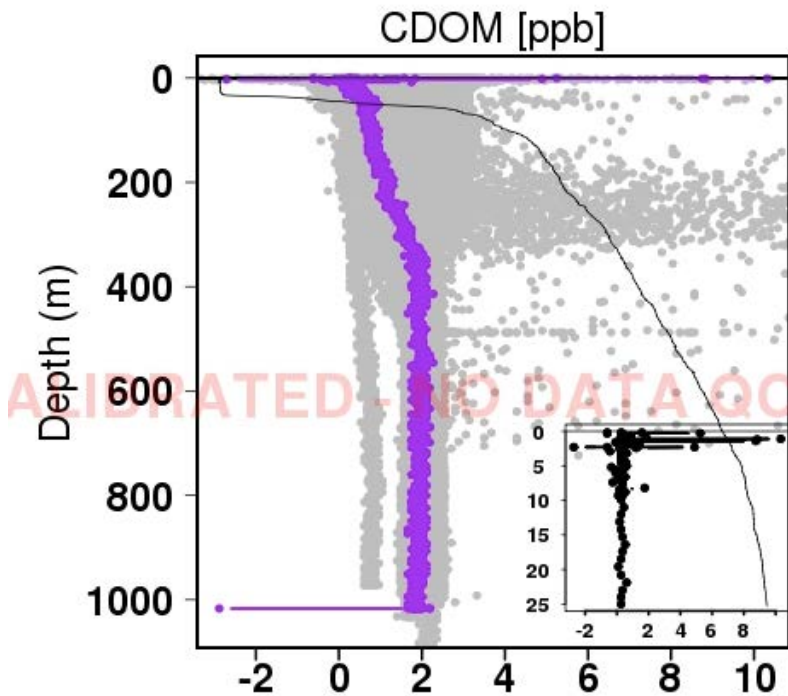
<https://www.gaisma.com/en/location>

The ocean is salty



<http://www.oao.obs-vlfr.fr/bioargo/PHP/lovbio006b/lovbio006b.html>

The surface ocean is very low in organics and nutrients

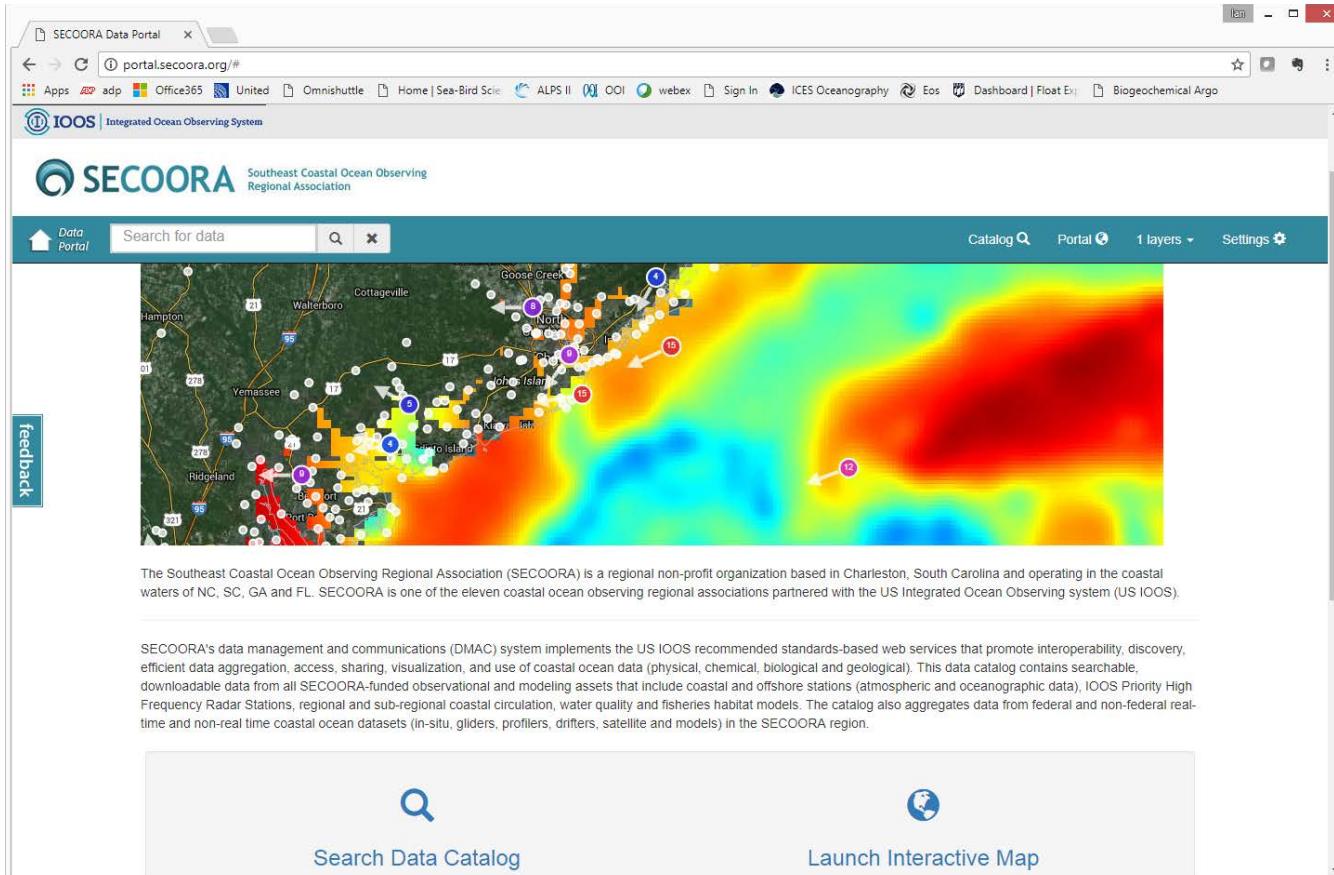


<http://www.oao.obs-vlfr.fr/bioargo/PHP/lovbio006b/lovbio006b.html>

Estuary Flow Tracers

- Fresh Water: Colored Dissolved Organic Matter
 - Decayed organic matter
 - High nutrients
- Ocean Water
 - Salts: Salinity
 - Low nutrients

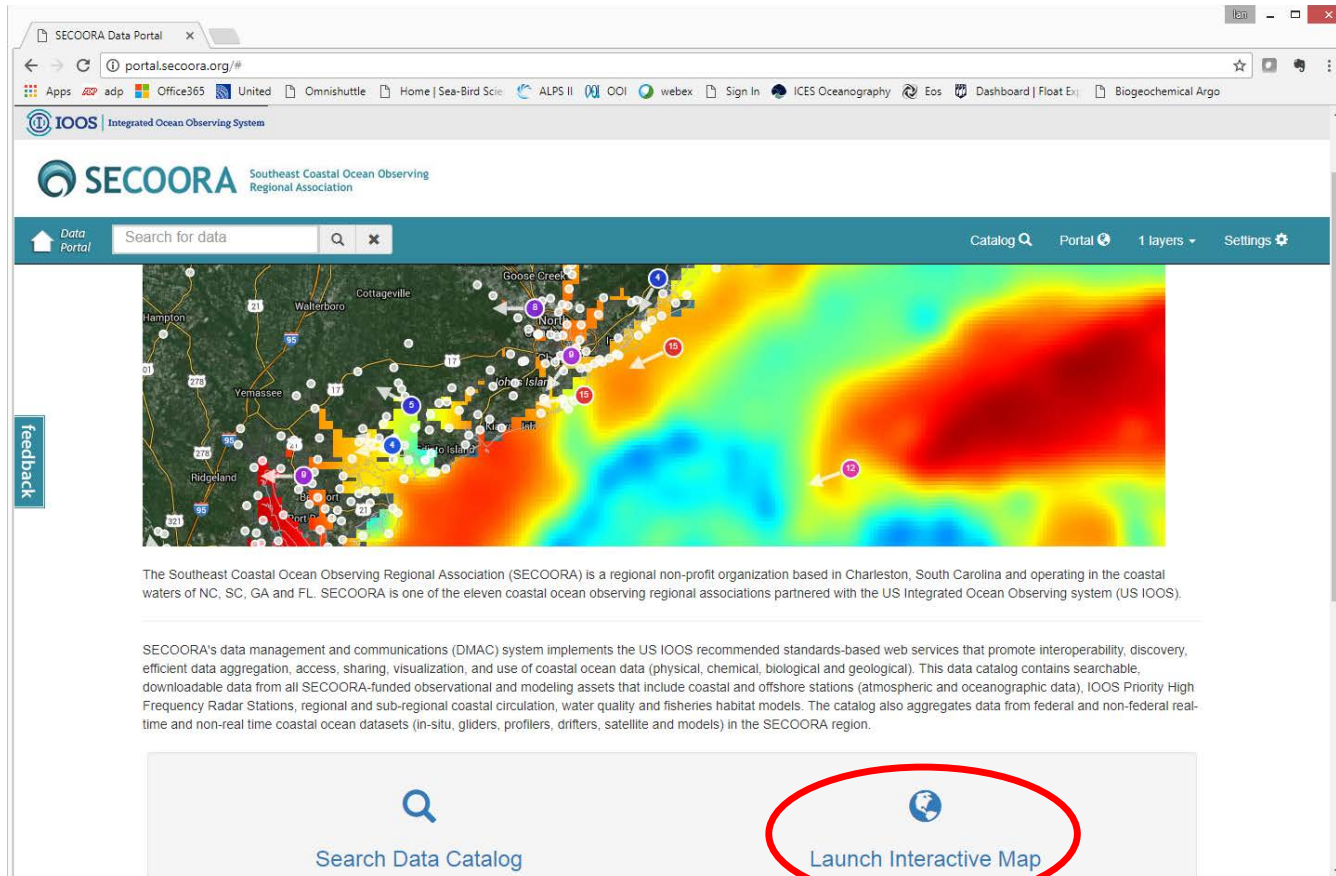
IRLON Data Access: SECOORA



The screenshot shows the SECOORA Data Portal interface. At the top, there is a navigation bar with the IOOS logo and the text "Integrated Ocean Observing System". Below this is the SECOORA logo and the text "Southeast Coastal Ocean Observing Regional Association". A search bar is present with the placeholder text "Search for data". To the right of the search bar are links for "Catalog", "Portal", "1 layers", and "Settings". The main content area features a map of the Southeastern United States (North Carolina, South Carolina, Georgia, and Florida) with a color-coded overlay representing data. The map shows various coastal and offshore stations marked with colored circles and arrows. Below the map, there is a "feedback" button on the left. The text below the map reads: "The Southeast Coastal Ocean Observing Regional Association (SECOORA) is a regional non-profit organization based in Charleston, South Carolina and operating in the coastal waters of NC, SC, GA and FL. SECOORA is one of the eleven coastal ocean observing regional associations partnered with the US Integrated Ocean Observing system (US IOOS)." Below this text is a paragraph describing SECOORA's data management and communications (DMAC) system. At the bottom of the page, there are two buttons: "Search Data Catalog" and "Launch Interactive Map".

portal.secoora.org

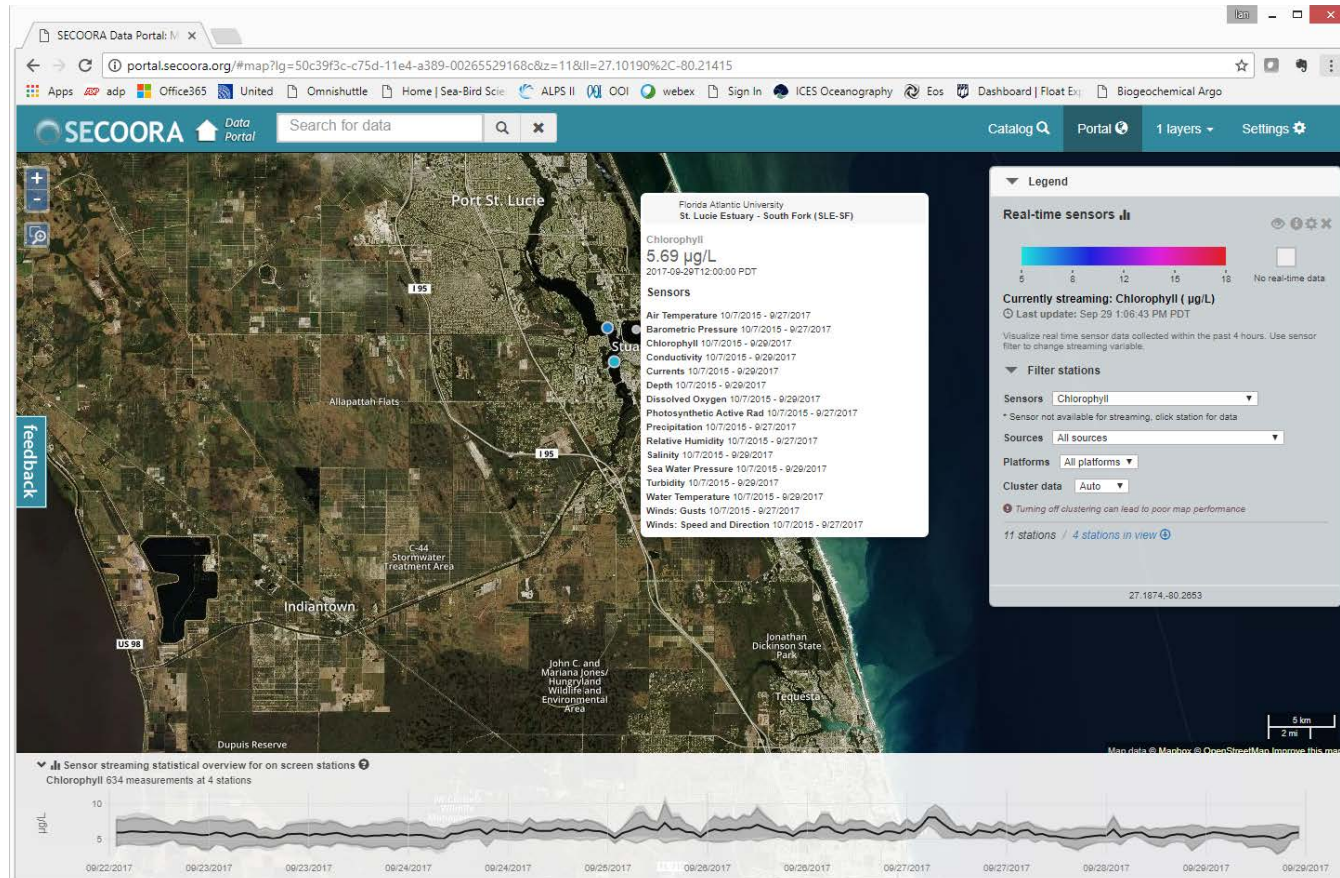
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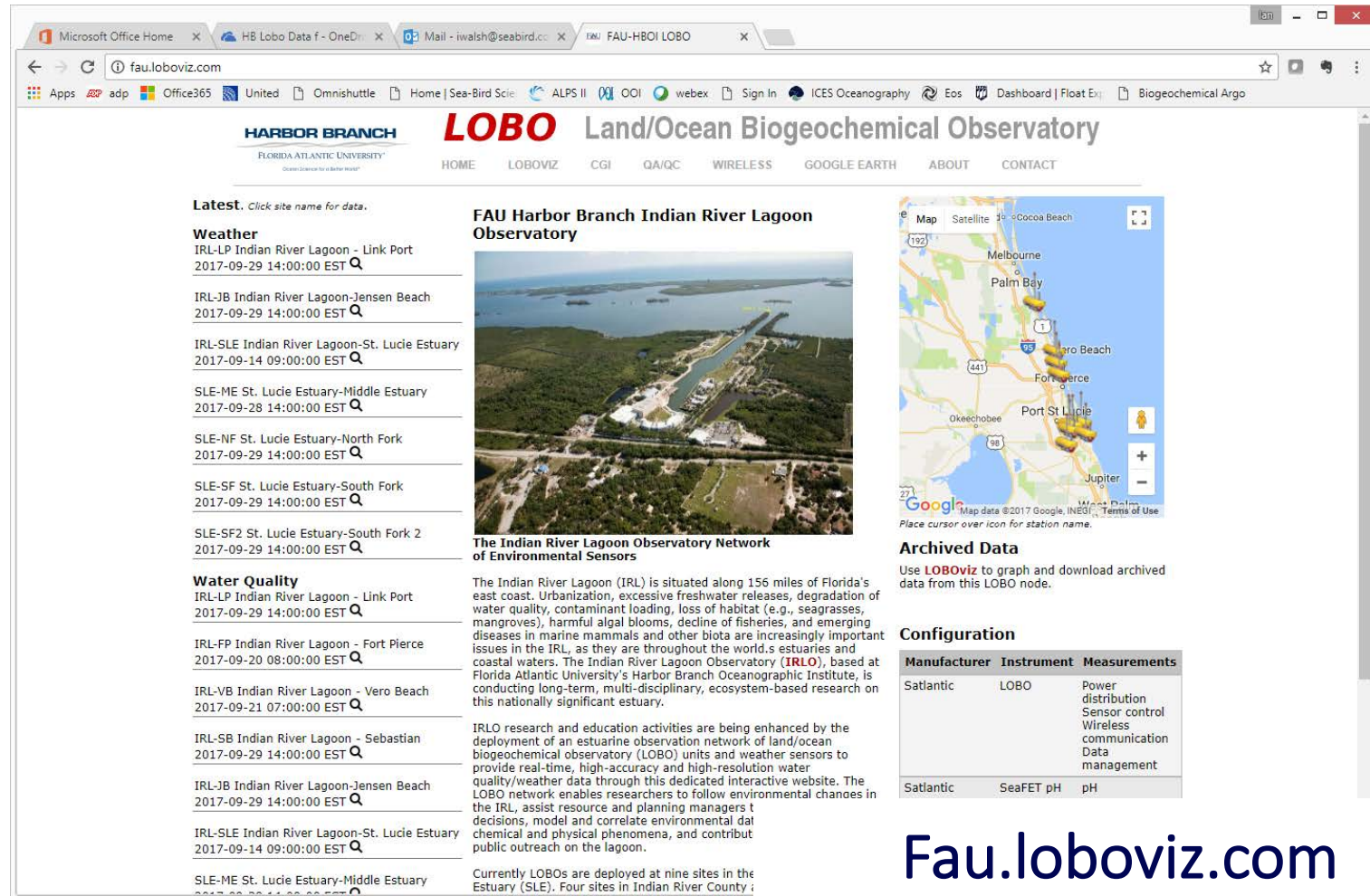
portal.secoora.org

IRLON Data Access: SECOORA



Interactive Map

IRLON Data Access



HARBOR BRANCH **LOBO** Land/Ocean Biogeochemical Observatory

FLORIDA ATLANTIC UNIVERSITY®

HOME LOBOVIZ CGI QA/QC WIRELESS GOOGLE EARTH ABOUT CONTACT

Latest. *Click site name for data.*


Weather

- IRL-LP Indian River Lagoon - Link Port
2017-09-29 14:00:00 EST [Q](#)
- IRL-JB Indian River Lagoon-Jensen Beach
2017-09-29 14:00:00 EST [Q](#)
- IRL-SLE Indian River Lagoon-St. Lucie Estuary
2017-09-14 09:00:00 EST [Q](#)
- SLE-ME St. Lucie Estuary-Middle Estuary
2017-09-28 14:00:00 EST [Q](#)
- SLE-NF St. Lucie Estuary-North Fork
2017-09-29 14:00:00 EST [Q](#)
- SLE-SF St. Lucie Estuary-South Fork
2017-09-29 14:00:00 EST [Q](#)
- SLE-SF2 St. Lucie Estuary-South Fork 2
2017-09-29 14:00:00 EST [Q](#)

Water Quality

- IRL-LP Indian River Lagoon - Link Port
2017-09-29 14:00:00 EST [Q](#)
- IRL-FP Indian River Lagoon - Fort Pierce
2017-09-20 08:00:00 EST [Q](#)
- IRL-VB Indian River Lagoon - Vero Beach
2017-09-21 07:00:00 EST [Q](#)
- IRL-SB Indian River Lagoon - Sebastian
2017-09-29 14:00:00 EST [Q](#)
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2017-09-29 14:00:00 EST [Q](#)
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2017-09-14 09:00:00 EST [Q](#)
- SLE-ME St. Lucie Estuary-Middle Estuary
2017-09-28 14:00:00 EST [Q](#)

FAU Harbor Branch Indian River Lagoon Observatory



The Indian River Lagoon Observatory Network of Environmental Sensors

The Indian River Lagoon (IRL) is situated along 156 miles of Florida's east coast. Urbanization, excessive freshwater releases, degradation of water quality, contaminant loading, loss of habitat (e.g., seagrasses, mangroves), harmful algal blooms, decline of fisheries, and emerging diseases in marine mammals and other biota are increasingly important issues in the IRL, as they are throughout the world's estuaries and coastal waters. 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 the 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 this dedicated interactive website. The LOBO network enables researchers to follow environmental changes in the IRL, assist resource and planning managers to make decisions, model and correlate environmental data with chemical and physical phenomena, and contribute to public outreach on the lagoon.

Currently LOBOs are deployed at nine sites in the Indian River County Estuary (SLE). Four sites in Indian River County :

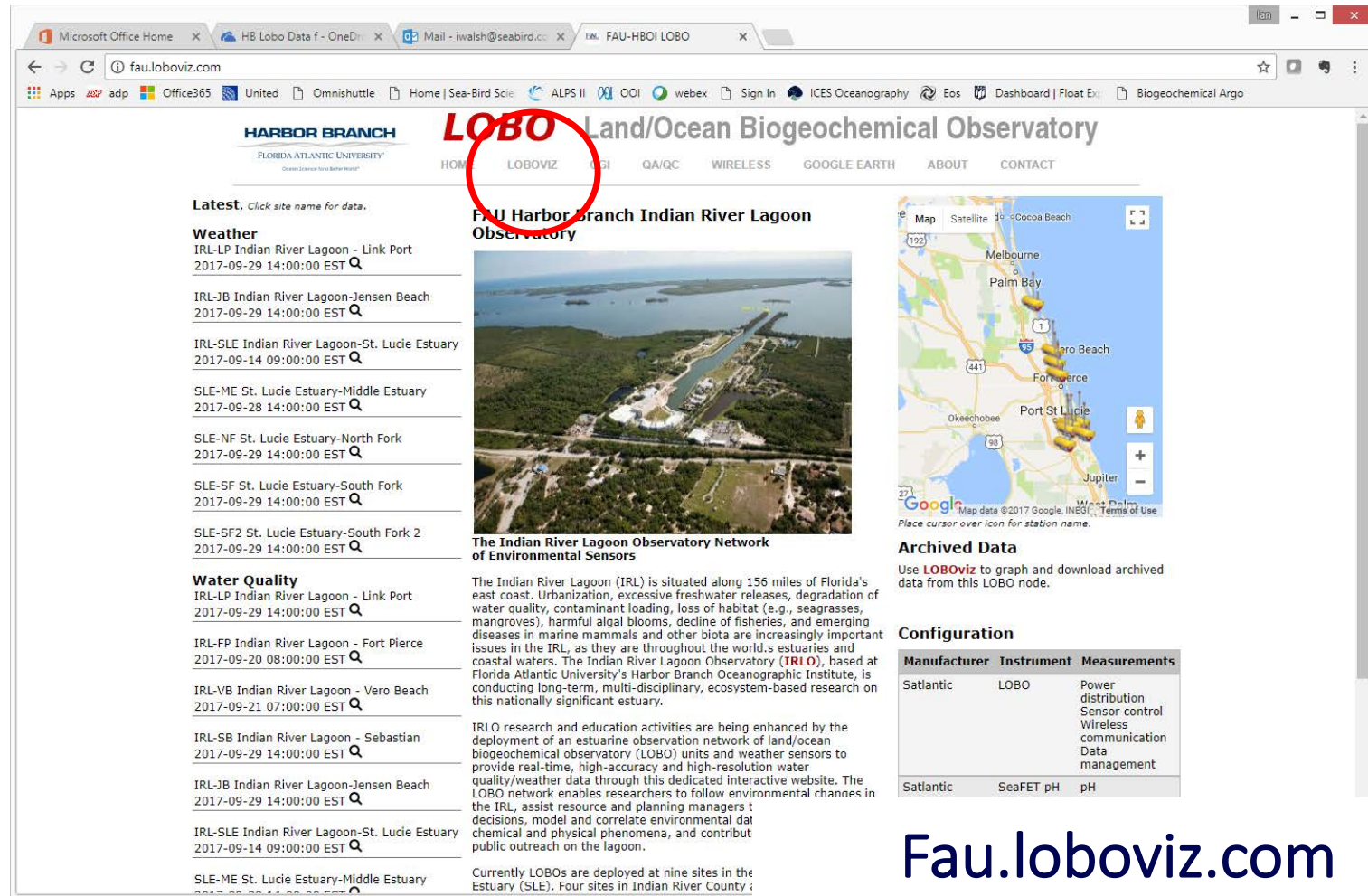
Archived Data
Use **LOBOviz** to graph and download archived data from this LOBO node.

Configuration

Manufacturer	Instrument	Measurements
Satlantic	LOBO	Power distribution Sensor control Wireless communication Data management
Satlantic	SeaFET pH	pH

Fau.loboviz.com

IRLON Data Access



HARBOR BRANCH **LOBO** Land/Ocean Biogeochemical Observatory

FLORIDA ATLANTIC UNIVERSITY®

Navigation: HOME | **LOBOVIZ** | OOI | QA/QC | WIRELESS | GOOGLE EARTH | ABOUT | CONTACT

Latest. *Click site name for data.*

Weather

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Water Quality

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- IRL-FP Indian River Lagoon - Fort Pierce 2017-09-20 08:00:00 EST [Q](#)
- IRL-VB Indian River Lagoon - Vero Beach 2017-09-21 07:00:00 EST [Q](#)
- IRL-SB Indian River Lagoon - Sebastian 2017-09-29 14:00:00 EST [Q](#)
- IRL-JB Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST [Q](#)
- IRL-SLE Indian River Lagoon-St. Lucie Estuary 2017-09-14 09:00:00 EST [Q](#)
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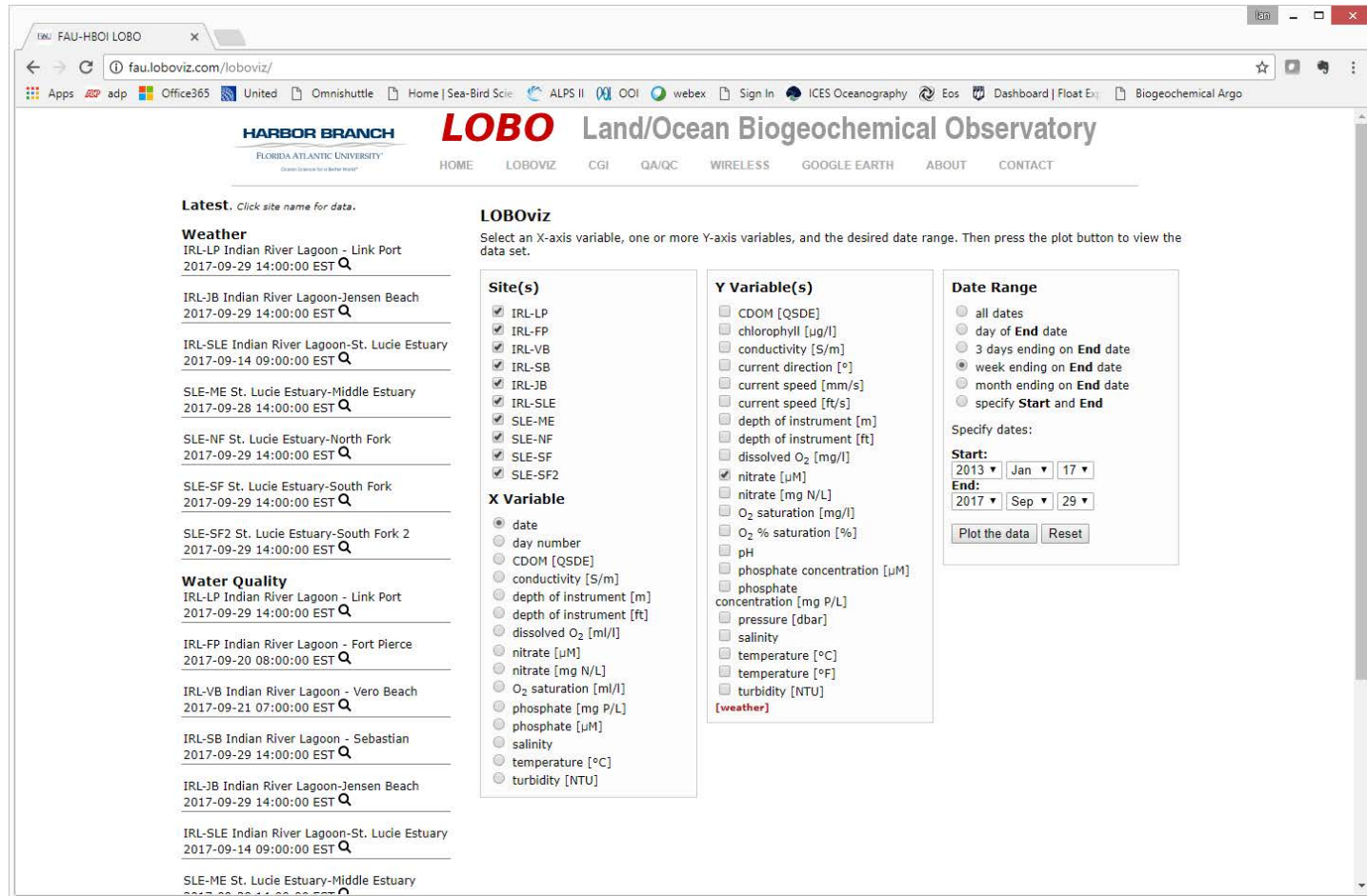
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Configuration

Manufacturer	Instrument	Measurements
Satlantic	LOBO	Power distribution Sensor control Wireless communication Data management
Satlantic	SeaFET pH	pH

Fau.loboviz.com

LOBOviz: Downloading



The screenshot shows the LOBOviz web interface. The browser address bar is `fau.loboviz.com/loboviz/`. The page header includes the Harbor Branch logo and navigation links: HOME, LOBOVIZ, CGI, QA/QC, WIRELESS, GOOGLE EARTH, ABOUT, CONTACT.

Latest. *Click site name for data.*

Weather

- IRL-LP Indian River Lagoon - Link Port
2017-09-29 14:00:00 EST [Q](#)
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2017-09-14 09:00:00 EST [Q](#)
- SLE-ME St. Lucie Estuary-Middle Estuary
2017-09-28 14:00:00 EST [Q](#)

LOBOviz

Select an X-axis variable, one or more Y-axis variables, and the desired date range. Then press the plot button to view the data set.

Site(s)

- IRL-LP
- IRL-FP
- IRL-VB
- IRL-SB
- IRL-JB
- IRL-SLE
- SLE-ME
- SLE-NF
- SLE-SF
- SLE-SF2

X Variable

- date
- day number
- CDOM [QSDE]
- conductivity [S/m]
- depth of instrument [m]
- depth of instrument [ft]
- dissolved O₂ [ml/l]
- nitrate [µM]
- nitrate [mg N/L]
- O₂ saturation [ml/l]
- phosphate [mg P/L]
- phosphate [µM]
- salinity
- temperature [°C]
- turbidity [NTU]

Y Variable(s)

- CDOM [QSDE]
- chlorophyll [µg/l]
- conductivity [S/m]
- current direction [°]
- current speed [mm/s]
- current speed [ft/s]
- depth of instrument [m]
- depth of instrument [ft]
- dissolved O₂ [mg/l]
- nitrate [µM]
- nitrate [mg N/L]
- O₂ saturation [mg/l]
- O₂ % saturation [%]
- pH
- phosphate concentration [µM]
- phosphate concentration [mg P/L]
- pressure [dbar]
- salinity
- temperature [°C]
- temperature [°F]
- turbidity [NTU]
- [weather]**

Date Range

- all dates
- day of **End** date
- 3 days ending on **End** date
- week ending on **End** date
- month ending on **End** date
- specify **Start** and **End**

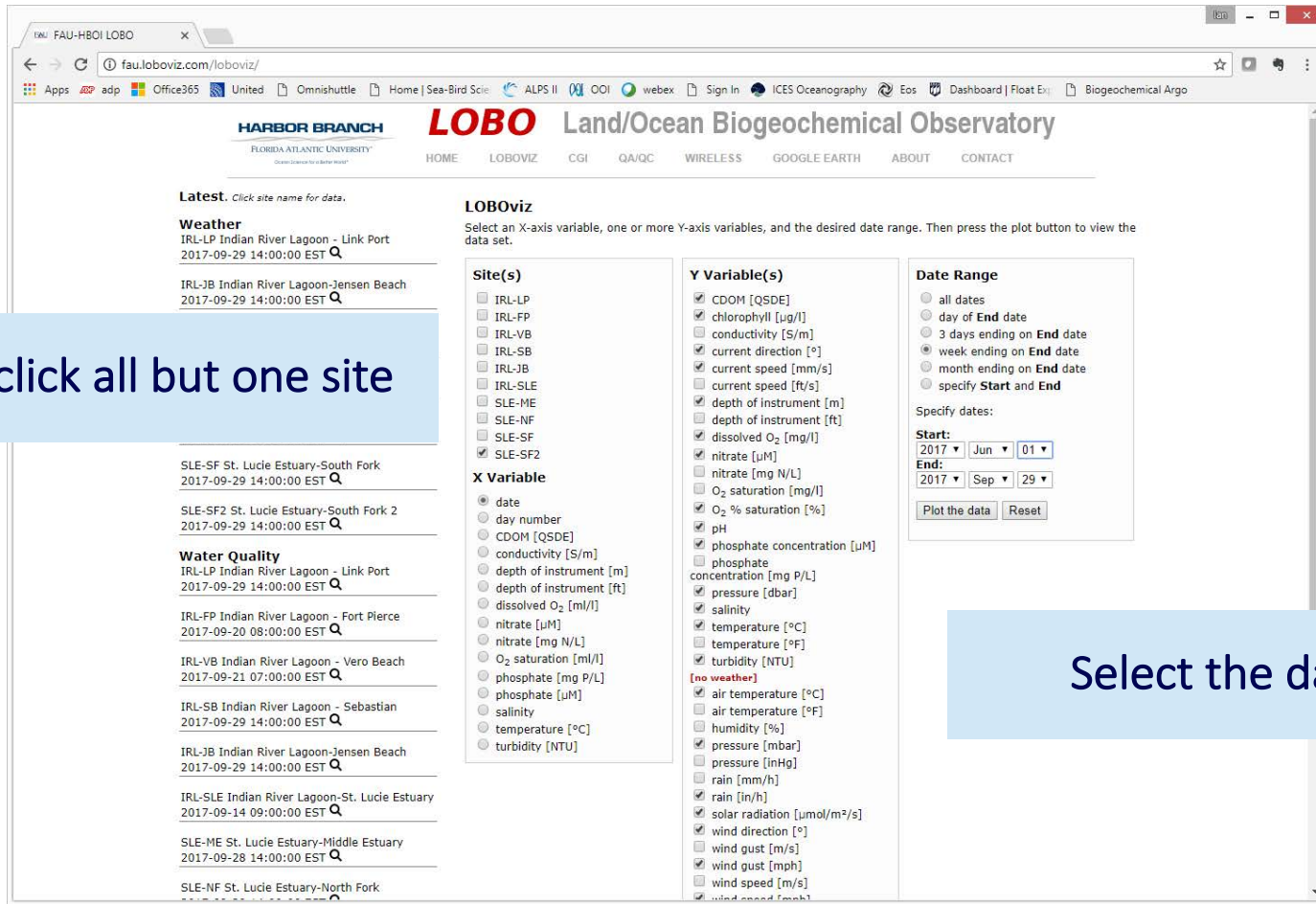
Specify dates:

Start: 2013 ▾ Jan ▾ 17 ▾

End: 2017 ▾ Sep ▾ 29 ▾

[Plot the data](#) [Reset](#)

LOBOviz: Downloading



The screenshot shows the LOBOviz web interface with the following sections:

- Latest:** Click site name for data.
- Weather:**
 - IRL-LP Indian River Lagoon - Link Port 2017-09-29 14:00:00 EST
 - IRL-JB Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST
- Water Quality:**
 - SLE-SF St. Lucie Estuary-South Fork 2017-09-29 14:00:00 EST
 - SLE-SF2 St. Lucie Estuary-South Fork 2 2017-09-29 14:00:00 EST
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 - IRL-SB Indian River Lagoon - Sebastian 2017-09-29 14:00:00 EST
 - IRL-JB Indian River Lagoon-Jensen Beach 2017-09-29 14:00:00 EST
 - IRL-SLE Indian River Lagoon-St. Lucie Estuary 2017-09-14 09:00:00 EST
 - SLE-ME St. Lucie Estuary-Middle Estuary 2017-09-28 14:00:00 EST
 - SLE-NF St. Lucie Estuary-North Fork 2017-09-28 14:00:00 EST
- LOBOviz:** Select an X-axis variable, one or more Y-axis variables, and the desired date range. Then press the plot button to view the data set.
- Site(s):**
 - IRL-LP
 - IRL-FP
 - IRL-VB
 - IRL-SB
 - IRL-JB
 - IRL-SLE
 - SLE-ME
 - SLE-NF
 - SLE-SF
 - SLE-SF2
- X Variable:**
 - date
 - day number
 - CDOM [QSDE]
 - conductivity [S/m]
 - depth of instrument [m]
 - depth of instrument [ft]
 - dissolved O₂ [ml/l]
 - nitrate [µM]
 - nitrate [mg N/L]
 - O₂ saturation [ml/l]
 - phosphate [mg P/L]
 - phosphate [µM]
 - salinity
 - temperature [°C]
 - turbidity [NTU]
- Y Variable(s):**
 - CDOM [QSDE]
 - chlorophyll [µg/l]
 - conductivity [S/m]
 - current direction [°]
 - current speed [mm/s]
 - current speed [ft/s]
 - depth of instrument [m]
 - depth of instrument [ft]
 - dissolved O₂ [mg/l]
 - nitrate [µM]
 - nitrate [mg N/L]
 - O₂ saturation [mg/l]
 - O₂ % saturation [%]
 - pH
 - phosphate concentration [µM]
 - phosphate concentration [mg P/L]
 - pressure [dbar]
 - salinity
 - temperature [°C]
 - temperature [°F]
 - turbidity [NTU]
 - [no weather]**
 - air temperature [°C]
 - air temperature [°F]
 - humidity [%]
 - pressure [mbar]
 - pressure [inHg]
 - rain [mm/h]
 - rain [in/h]
 - solar radiation [µmol/m²/s]
 - wind direction [°]
 - wind gust [m/s]
 - wind gust [mph]
 - wind speed [m/s]
 - wind speed [mph]
- Date Range:**
 - all dates
 - day of End date
 - 3 days ending on End date
 - week ending on End date
 - month ending on End date
 - specify Start and End

Specify dates:

Start: 2017 Jun 01

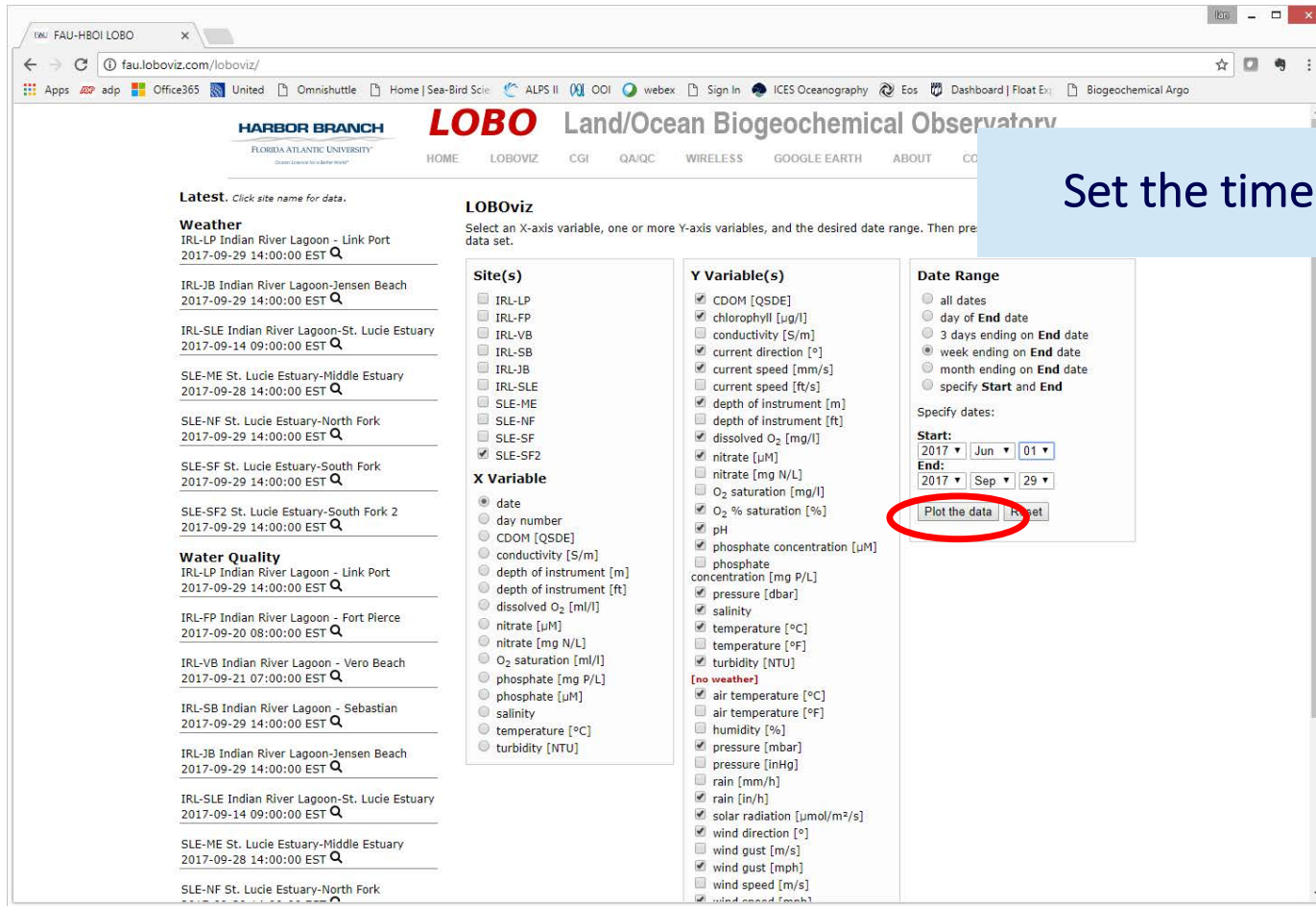
End: 2017 Sep 29

Plot the data Reset

Unclick all but one site

Select the data

LOBOviz: Downloading



The screenshot shows the LOBOviz web interface. On the right side, there is a 'Date Range' section with a 'Plot the data' button circled in red. A blue callout box with the text 'Set the time range' points to this button. The interface includes sections for 'Weather', 'Water Quality', 'Site(s)', 'X Variable', and 'Y Variable(s)'.

LOBOviz
Select an X-axis variable, one or more Y-axis variables, and the desired date range. Then press the Plot button.

Site(s)

- IRL-LP
- IRL-FP
- IRL-VB
- IRL-SB
- IRL-JB
- IRL-SLE
- SLE-ME
- SLE-NF
- SLE-SF
- SLE-SF2

X Variable

- date
- day number
- CDOM [QSDE]
- conductivity [S/m]
- depth of instrument [m]
- depth of instrument [ft]
- dissolved O₂ [m/l]
- nitrate [µM]
- nitrate [mg N/L]
- O₂ saturation [m/l]
- phosphate [mg P/L]
- phosphate [µM]
- salinity
- temperature [°C]
- turbidity [NTU]

Y Variable(s)

- CDOM [QSDE]
- chlorophyll [µg/l]
- conductivity [S/m]
- current direction [°]
- current speed [mm/s]
- current speed [ft/s]
- depth of instrument [m]
- depth of instrument [ft]
- dissolved O₂ [mg/l]
- nitrate [µM]
- nitrate [mg N/L]
- O₂ saturation [mg/l]
- O₂ % saturation [%]
- pH
- phosphate concentration [µM]
- phosphate concentration [mg P/L]
- pressure [dbar]
- salinity
- temperature [°C]
- temperature [°F]
- turbidity [NTU]

[no weather]

- air temperature [°C]
- air temperature [°F]
- humidity [%]
- pressure [mbar]
- pressure [inHg]
- rain [mm/h]
- rain [in/h]
- solar radiation [µmol/m²/s]
- wind direction [°]
- wind gust [m/s]
- wind gust [mph]
- wind speed [m/s]
- wind speed [mph]

Date Range

- all dates
- day of End date
- 3 days ending on End date
- week ending on End date
- month ending on End date
- specify Start and End

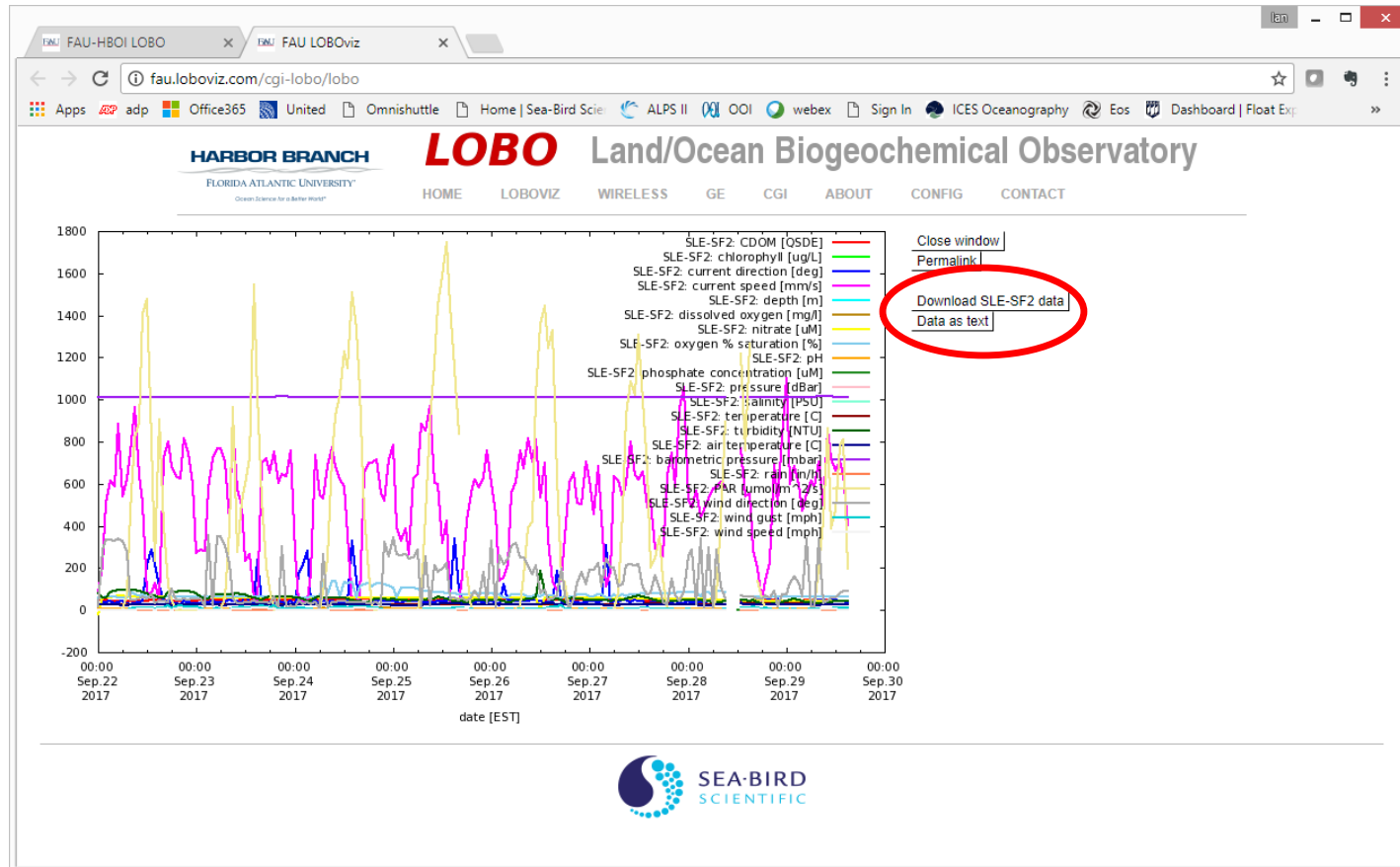
Specify dates:

Start: 2017 Jun 01

End: 2017 Sep 29

Plot the data | **Reset**

LOBOviz: Downloading



LOBOviz: Downloading

fauloboviz.com/cgi-data/nph-data.cgi?x=date&y=cdom,chloraophyll,current_direction,current_speed,depth,oxygen_mgl,nitrate,oxygen_percent,ph,phosphate,pressure,salinity,temperature,turbidity,weather_temperature,weather_pr...

fauloboviz.com/cgi-data/nph-data.cgi?x=date&y=cdom,chloraophyll,current_direction,current_speed,depth,oxygen_mgl,nitrate,oxygen_percent,ph,phosphate,pressure,salinity,temperature,turbidity,weather_temperature,weather_pressure,weather_rain_in,weathe...

Sensor 0068 - SLE-SF2
St. Lucie Estuary-South Fork 2

date [EST]	CDOM [QSDI]	chlorophyll [ug/L]	current direction [deg]	current speed [mm/s]	depth [m]	dissolved oxygen [mg/l]	nitrate [uM]	oxygen % saturation [%]	pH	phosphate concentration [uM]											
pressure [dBar]	salinity [PSU]	temperature [C]	turbidity [NTU]	air temperature [C]	barometric pressure [mbar]	rain [in/h]	PAR [umol/m^2/s]	wind direction [deg]	wind gust [mph]	wind speed [mph]											
2017-09-22 00:00:00	47.30	5.37	98.3	82.9	3.100	4.42	-19.1	57.37	7.250	1.63	3.100	0.15	28.70	81.06	26.1	1013.9	0.0	0.0	16.9	1.8	0.1
2017-09-22 01:00:00	51.17	5.33	32.8	210.5	3.090	4.51	61.3	58.48	7.309	1.63	3.090	0.15	28.65	59.15	25.6	1013.7	0.0	0.0	285.0	0.5	0.0
2017-09-22 02:00:00	50.62	5.26	36.1	509.7	3.120	4.90	60.9	63.48	7.325	1.55	3.120	0.15	28.64	60.90	25.4	1013.2	0.0	0.0	333.4	0.0	0.0
2017-09-22 03:00:00	45.23	5.20	42.6	614.3	3.110	4.79	61.3	62.09	7.316	1.44	3.110	0.15	28.65	83.97	25.1	1012.7	0.0	0.1	334.0	0.0	0.0
2017-09-22 04:00:00	43.36	5.09	35.3	586.8	3.090	4.78	61.9	61.93	7.324	1.40	3.090	0.15	28.66	91.70	24.9	1012.6	0.0	0.0	331.1	0.0	0.0
2017-09-22 05:00:00	42.00	5.02	40.2	882.1	3.080	4.72	68.5	61.24	7.330	1.01	3.080	0.15	28.65	97.62	25.1	1012.5	0.0	0.1	338.4	2.2	0.4
2017-09-22 06:00:00	41.69	4.96	41.3	540.6	3.050	4.75	67.4	61.54	7.325	1.35	3.050	0.15	28.63	98.53	24.5	1012.8	0.0	0.2	329.0	1.2	0.1
2017-09-22 07:00:00	41.86	4.91	31.7	621.9	3.040	4.77	63.6	61.81	7.326	0.99	3.040	0.15	28.63	97.06	24.5	1013.2	0.0	76.7	277.7	1.5	0.2
2017-09-22 08:00:00	41.79	4.88	28.9	744.8	3.020	6.93	63.2	89.81	7.323	1.02	3.020	0.15	28.63	97.23	28.5	1013.5	0.0	466.0	47.6	4.5	0.5
2017-09-22 09:00:00	41.79	4.88	30.3	963.5	3.000	5.59	63.9	72.59	7.324	1.02	3.000	0.15	28.73	96.31	29.2	1013.5	0.0	819.0	51.3	9.3	2.9
2017-09-22 10:00:00	43.16	4.92	38.0	641.1	3.060	5.39	64.7	70.11	7.329	0.95	3.060	0.15	28.79	89.95	29.2	1013.8	0.0	889.0	53.5	11.4	4.2
2017-09-22 11:00:00	44.21	4.98	43.7	506.4	3.150	5.94	59.7	77.38	7.329	0.75	3.150	0.15	28.88	84.63	29.6	1013.7	0.0	1407.0	64.5	11.1	5.2
2017-09-22 12:00:00	45.66	5.10	217.1	82.8	3.140	4.79	61.5	62.45	7.269	1.19	3.140	0.15	28.97	81.00	29.8	1013.1	0.0	1479.0	54.5	14.0	6.5
2017-09-22 13:00:00	48.08	5.10	288.9	80.3	3.125	4.42	64.2	57.66	7.303	1.02	3.125	0.15	29.02	65.44	29.3	1012.8	0.0	798.3	73.8	12.6	5.5
2017-09-22 14:00:00	48.87	5.11	217.8	129.0	3.080	4.44	62.4	57.95	7.312	1.10	3.080	0.15	29.00	69.55	28.8	1012.6	0.0	132.9	34.6	8.7	3.4
2017-09-22 15:00:00	49.41	5.10	114.1	41.6	3.020	4.46	62.2	58.23	7.302	1.19	3.020	0.15	29.08	58.85	28.9	1011.8	0.0	904.0	42.9	11.3	4.2
2017-09-22 16:00:00	49.21	5.04	41.3	724.2	3.017	4.51	62.8	58.89	7.351	1.19	3.017	0.15	29.07	60.33	29.0	1011.7	0.0	397.6	42.5	11.8	6.2
2017-09-22 17:00:00	44.13	5.01	45.7	800.5	3.100	4.91	62.7	64.19	7.359	0.68	3.100	0.15	29.07	83.42	26.2	1011.5	0.1	118.2	38.2	21.6	7.0
2017-09-22 18:00:00	42.91	4.95	40.3	681.8	3.060	4.92	63.1	64.19	7.369	0.67	3.060	0.15	29.01	90.01	24.6	1011.8	0.1	48.3	103.8	4.7	1.4
2017-09-22 19:00:00	43.13	4.87	31.8	637.7	3.070	4.95	63.4	64.47	7.377	0.82	3.070	0.15	28.91	88.06	25.4	1011.9	0.0	2.5	46.4	14.6	5.8
2017-09-22 20:00:00	42.67	4.85	27.5	624.9	3.060	4.95	65.2	64.36	7.380	0.68	3.060	0.15	28.85	90.39	26.3	1012.1	0.0	0.1	49.2	20.6	10.4
2017-09-22 21:00:00	42.86	4.83	42.6	814.6	3.085	4.90	61.8	63.66	7.347	0.62	3.085	0.15	28.75	90.16	26.6	1012.4	0.0	0.0	54.0	14.3	8.3
2017-09-22 22:00:00	43.59	4.85	39.7	747.1	3.150	4.86	62.4	63.05	7.354	0.68	3.150	0.15	28.69	88.43	26.5	1012.4	0.0	0.0	49.4	14.6	8.0
2017-09-22 23:00:00	43.64	4.85	33.5	599.6	3.161	4.87	62.3	63.13	7.348	0.63	3.161	0.15	28.68	86.85	26.7	1012.1	0.0	0.0	56.1	15.2	7.3
2017-09-23 00:00:00	45.54	4.99	33.2	268.8	3.140	4.92	62.6	63.75	7.330	0.63	3.140	0.15	28.64	78.49	26.8	1011.8	0.0	0.0	55.4	16.5	7.0
2017-09-23 01:00:00	47.79	4.95	35.0	285.7	3.180	4.92	60.7	63.79	7.353	0.73	3.180	0.15	28.64	67.02	26.7	1011.5	0.0	0.0	52.5	9.7	3.5
2017-09-23 02:00:00	51.00	5.01	37.7	279.4	3.120	5.13	59.8	66.44	7.356	0.69	3.120	0.15	28.58	54.90	25.9	1011.1	0.0	0.0	16.8	3.4	0.5
2017-09-23 03:00:00	50.41	5.02	40.6	579.4	3.090	5.16	59.6	66.77	7.371	0.65	3.090	0.15	28.56	56.54	25.5	1010.6	0.0	0.0	353.3	2.3	0.4
2017-09-23 04:00:00	47.08	5.01	41.3	719.2	3.090	5.10	61.9	65.95	7.361	0.59	3.090	0.15	28.56	71.53	25.4	1010.2	0.0	0.0	22.3	1.6	0.3
2017-09-23 05:00:00	46.18	5.00	38.1	757.8	3.110	5.02	59.5	64.91	7.351	0.41	3.110	0.15	28.54	75.52	25.1	1010.5	0.2	0.0	352.6	12.6	1.4
2017-09-23 06:00:00	46.08	5.01	36.6	770.6	3.080	5.01	59.9	64.77	7.352	0.51	3.080	0.15	28.46	75.88	24.8	1010.8	0.0	0.1	351.4	2.4	0.4
2017-09-23 07:00:00	46.81	5.00	38.0	703.9	3.070	5.27	58.8	67.95	7.339	0.50	3.070	0.14	28.38	73.87	24.8	1011.4	0.0	56.7	300.1	0.5	0.0
2017-09-23 08:00:00	46.23	4.96	46.3	425.8	3.051	4.96	58.9	64.04	7.325	0.66	3.051	0.15	28.37	75.96	26.4	1011.7	0.0	381.1	225.7	2.5	0.5
2017-09-23 09:00:00	46.72	4.93	41.5	884.1	3.060	4.93	60.2	63.71	7.323	0.62	3.060	0.15	28.47	74.38	28.6	1011.9	0.0	963.0	56.5	12.9	3.9
2017-09-23 10:00:00	45.28	4.87	41.9	570.8	3.110	4.94	58.2	63.94	7.335	0.16	3.110	0.15	28.51	78.21	26.1	1012.4	0.0	278.8	35.2	14.2	4.5

LOBOviz: Downloading

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
3	date	[EST]	CDOM	chlorophy	direction	current	depth	DO	[mg/l]	[uM]	nitrate	DO %Sat	pH	phosphat	pressure	salinity	temperat	turbidity	Date/Time	Redfield	Chl/Turb	direction	current	e5 pt sm	7 pt sm	
866			46.97	4.16	34.7	31.6	2.65	0.73	-16.8	10.72	6.879	8.23	2.65	16.59	30.71	4.86	6/1/2017 16:00	-6	0.855967	0.385556	12.18356	18.69849	45.56667			
867			45.75	3.94	15.9	65.5	2.7	0.06	-23	0.85	6.955	8.62	2.7	20	30.5	4.85	6/1/2017 17:00	-9	0.812371	0.176667	11.57167	29.57378	44.73333			
868			44.93	4.32	121.3	26.9	2.69	0.06	-24	0.84	6.965	8.27	2.69	19.73	30.58	3.7	6/1/2017 18:00	-9	1.167568	1.347778	36.25522	29.44378	37.46667			
869			45.01	4.28	164.2	47.8	2.61	0.06	-3.1	0.85	6.967	8.51	2.61	19.59	30.59	4.33	6/1/2017 19:00	-1	0.988453	1.824444	87.20844	48.92293	38			
870			45.73	4.23	0	14	2.53	0.06	-18.8	0.85	6.982	8.41	2.53	19.88	30.66	4.52	6/1/2017 20:00	-7	0.935841	0	0	51.03704	34.3			
871			45.6	4.33	233.7	42.2	2.48	0.06	-10.5	0.84	6.995	9.7	2.48	19.87	30.65	4.06	6/1/2017 21:00	-4	1.066502	2.596667	109.5793	43.786	26.05			
872			44.89	4.4	212	9.4	2.43	0.06	-24.2	0.84	7.011	9.4	2.43	20.15	30.57	3.76	6/1/2017 22:00	-10	1.170213	2.355556	22.14222	42.12276	24.93333			
873			43.89	4.71	0	16	2.36	0.06	-15.6	0.84	7.022	9.79	2.36	20.28	30.55	3.32	6/1/2017 23:00	-7	1.418675	0	0	50.34084	19.95			
874			44.88	4.85	351.5	20.2	2.332	0.06	-43.5	0.84	7.023	9.21	2.332	20.18	30.56	3.44	6/2/2017 0:00	-19	1.409884	3.905556	78.89222	43.75271	25.98333			
875			45	4.72	206.6	17.9	2.42	0.06	-23.4	0.84	7.027	9.96	2.42	20.15	30.57	3.68	6/2/2017 1:00	-10	1.282609	2.295556	41.09044	40.30427	19.18333			
876			45.27	4.74	137.4	50.2	2.516	0.06	-27.4	0.84	7.027	9.72	2.516	20.11	30.58	3.53	6/2/2017 2:00	-11	1.342776	1.526667	76.63867	40.43138	19.78333			
877			45.68	4.58	315	1.4	2.6	0.06	-28.5	0.84	7.03	9.69	2.6	20.07	30.57	3.3	6/2/2017 3:00	-11	1.387879	3.5	4.9	34.03587	21.13333			
878			44.41	4.93	4.4	13	2.67	0.06	-29.3	0.84	7.034	8.89	2.67	20.17	30.59	2.17	6/2/2017 4:00	-11	2.271889	0.048889	0.635556	33.14578	27.66667			
879			45.72	4.67	175.2	24.1	2.738	0.06	-34.1	0.84	7.023	8.12	2.738	20.19	30.53	2.93	6/2/2017 5:00	-12	1.593857	1.946667	46.91467	22.41804	24.61667			
880			43.76	4.67	91.6	36	2.74	0.06	-33.9	0.84	7.036	9.83	2.74	20.79	30.47	2.85	6/2/2017 6:00	-12	1.638596	1.017778	36.64	65.46804	30.41667			
881			45.27	4.31	90	23	2.67	0.06	-0.5	0.84	7.022	8.9	2.67	20.38	30.56	2.85	6/2/2017 7:00	0	1.512281	1	23	79.2636	41.68333			
882			46.39	4.22	233.1	85	2.59	0.06	-4.6	0.85	7.023	8.44	2.59	19.63	30.59	3.72	6/2/2017 8:00	-2	1.134409	2.59	220.15	83.44351	46.65			
883			46.32	3.91	90.8	69	2.52	0.06	-7.5	0.85	6.992	9.14	2.52	19.37	30.6	2.9	6/2/2017 9:00	-3	1.348276	1.008889	69.61333	81.42851	49.05			
884			45.38	3.88	142.6	42.8	2.47	0.06	-38.5	0.84	6.989	9.38	2.47	20.06	30.57	2.93	6/2/2017 10:00	-16	1.324232	1.584444	67.81422	80.88618	46.96667			
885			44.29	3.97	62.1	38.5	2.39	0.06	-16.1	0.84	6.983	9.14	2.39	20.53	30.57	3.29	6/2/2017 11:00	-7	1.206687	0.69	26.565	38.03391	46.78333			
886			45.05	3.98	77.7	23.5	2.33	0.06	-30.4	0.84	6.931	8.9	2.33	20.51	30.54	3.79	6/2/2017 12:00	-13	1.050132	0.863333	20.28833	35.97916	36.63333			
887			43.93	3.9	24.2	21.9	2.41	0.06	-21.7	0.85	6.874	9.39	2.41	19.87	30.54	3.74	6/2/2017 13:00	-9	1.042781	0.268889	5.886667	42.56211	31.51667			
888			44.78	3.91	221.6	24.1	2.44	0.06	-50	0.84	6.898	9.27	2.44	20.56	30.5	4.28	6/2/2017 14:00	-20	0.913551	2.462222	59.33956	40.9588	29.51667			
889			46.19	4.07	236.7	38.3	2.55	0.06	-39.7	0.85	6.865	8.97	2.55	19.82	30.57	4.51	6/2/2017 15:00	-16	0.902439	2.63	100.729	56.06947	33.95			
890			44.22	3.92	54.2	30.8	2.64	0.06	-56.1	0.84	6.909	9.94	2.64	20.61	30.52	3.61	6/2/2017 16:00	-21	1.085873	0.602222	18.54844	62.98333	34.98333			
891			45.77	3.91	132.5	65.1	2.71	0.06	-43.5	0.85	6.889	9.83	2.71	20.26	30.58	3.41	6/2/2017 17:00	-16	1.46628	1.472222	95.84167	59.73867	39.7			
892			44.48	3.97	122.6	29.7	2.75	0.06	-44.4	0.85	6.966	9.43	2.75	20.36	30.55	3.85	6/2/2017 18:00	-16	1.031169	1.362222	40.458	47.0026	47.58333			
893			43.9	3.99	77.3	50.2	2.759	0.06	-52.8	0.84	6.975	9.8	2.759	20.91	30.53	3.59	6/2/2017 19:00	-19	1.111421	0.858889	43.11622	43.29291	42.2			
894			44.99	4.03	46.7	71.4	2.71	0.06	-62.7	0.84	6.967	9.25	2.71	21.04	30.46	3.51	6/2/2017 20:00	-23	1.148148	0.518889	37.04867	33.62324	41.4			
895			45.44	4.07	0	6	2.6	0.06	-65.1	0.84	6.905	10.09	2.6	20.74	30.56	3.12	6/2/2017 21:00	-25	1.304487	0	0	28.23513	36.56667			
896			45.92	4.09	164.4	26	2.55	0.06	-57.9	0.84	6.927	10.7	2.55	20.78	30.54	3.1	6/2/2017 22:00	-23	1.319355	1.826667	47.49333	26.66611	33.68333			
897			45.93	4.1	33.7	36.1	2.48	0.06	-52.9	0.84	6.932	10.77	2.48	20.49	30.6	3.3	6/2/2017 23:00	-21	1.242424	0.374444	13.51744	51.9746	32.48333			
898			45.36	4.03	256	12.4	2.41	0.06	-62.4	0.84	6.946	10.73	2.41	20.36	30.59	3.09	6/3/2017 0:00	-26	1.304207	2.844444	35.27111	52.35856	23.3			
899			45.07	4.04	342.4	43	2.38	0.06	-30.8	0.85	6.954	10.56	2.38	20.27	30.59	2.95	6/3/2017 1:00	-13	1.369492	3.804444	163.5911	77.46416	32.26667			
900			45.44	4.05	10.6	16.3	2.44	0.06	-27.8	0.85	6.975	10.43	2.44	20.19	30.58	3.12	6/3/2017 2:00	-11	1.298077	0.117778	1.919778	103.0712	39.46667			
901			45.25	4.08	260.4	59.8	2.54	0.06	-22.2	0.84	6.997	10.7	2.54	20.2	30.58	3.43	6/3/2017 3:00	-9	1.189504	2.893333	173.0213	113.9743	39.61667			

2016 Algal Blooms

SCIENCE

Got muck? Florida residents can report algae blooms with new hotline.

After declaring a state of emergency this week, Florida officials have turned to citizens to help control the outbreak.

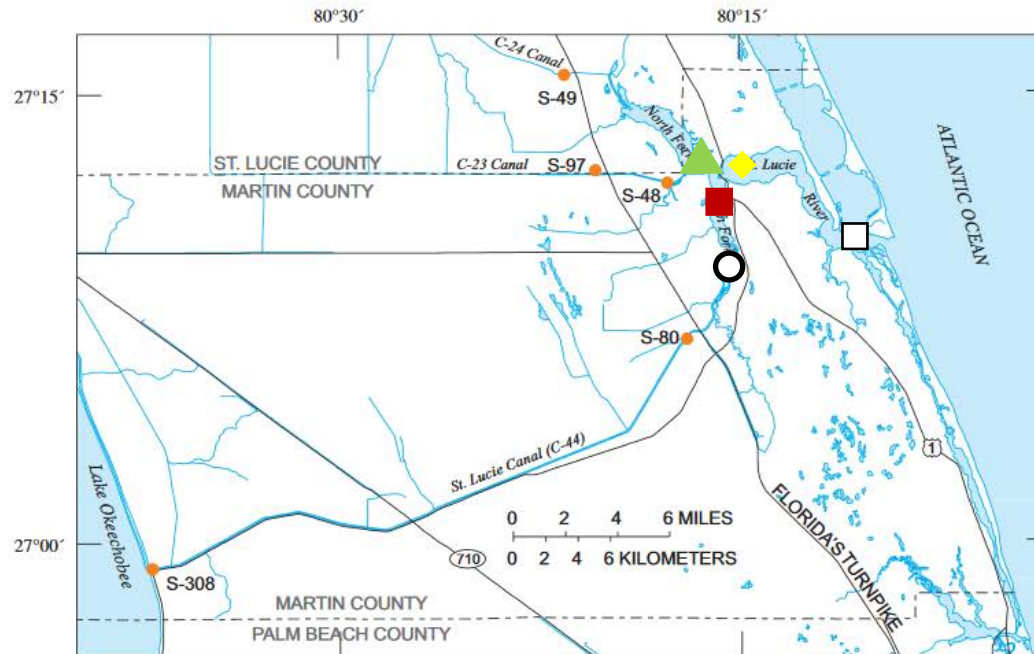
By APNewsNow, Associated Press | JULY 5, 2016

Save for later



TALLAHASSEE, Fla. (AP) — The state has launched a hotline to help residents give updates on the massive algae bloom fouling some of Florida's southern rivers and beaches.

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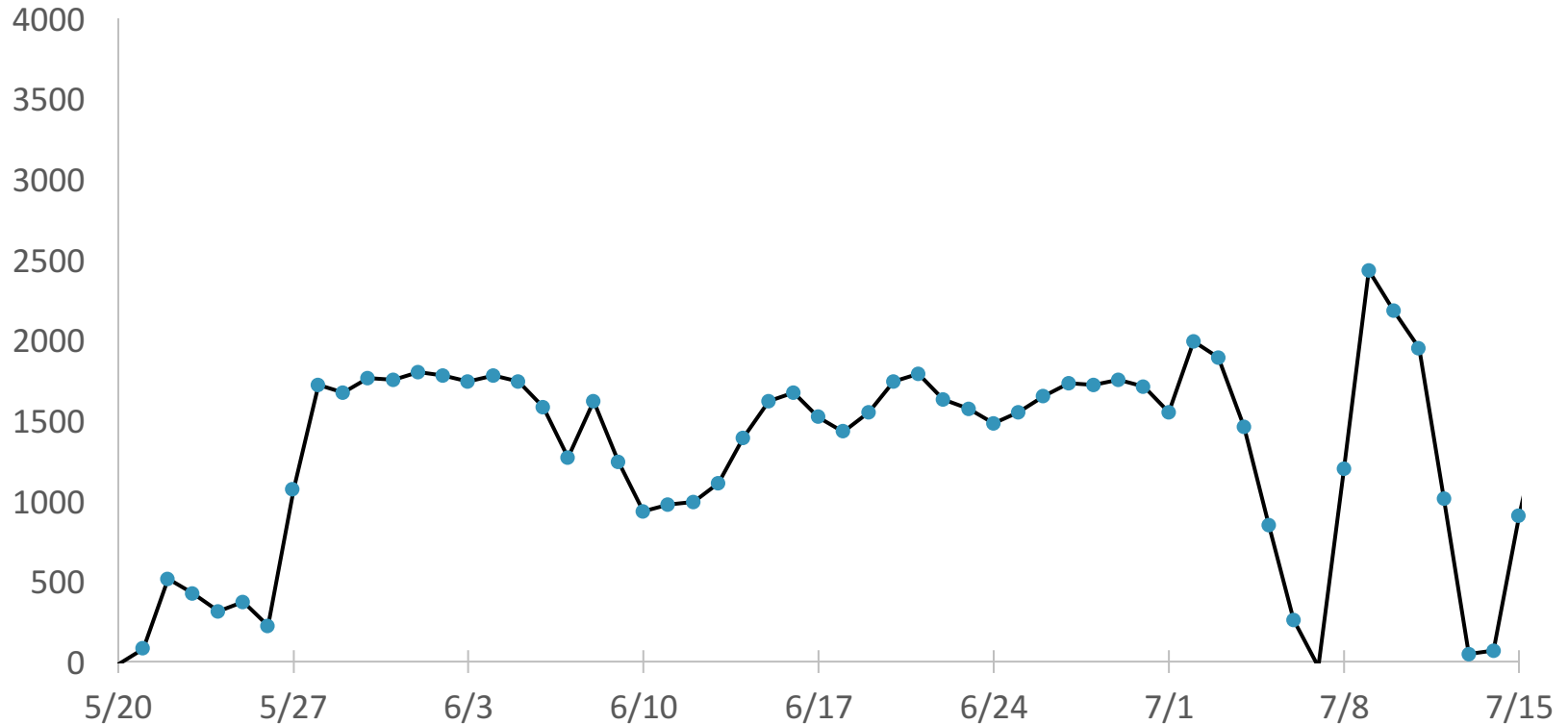
EXPLANATION

- CONTROL STRUCTURE AND NUMBER

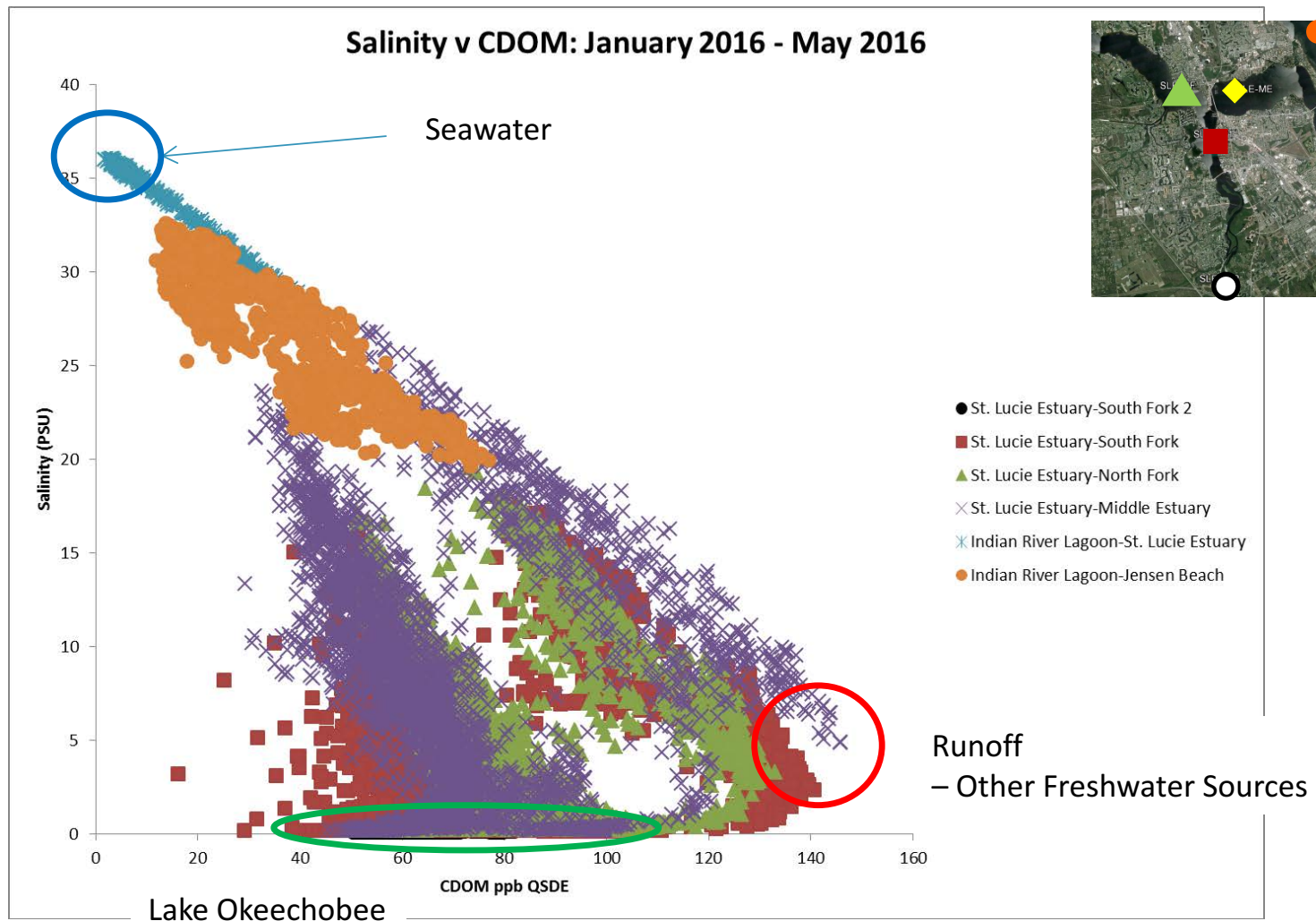
Figure 2. South Florida Water Management District control structures providing flow to the St. Lucie River Estuary.

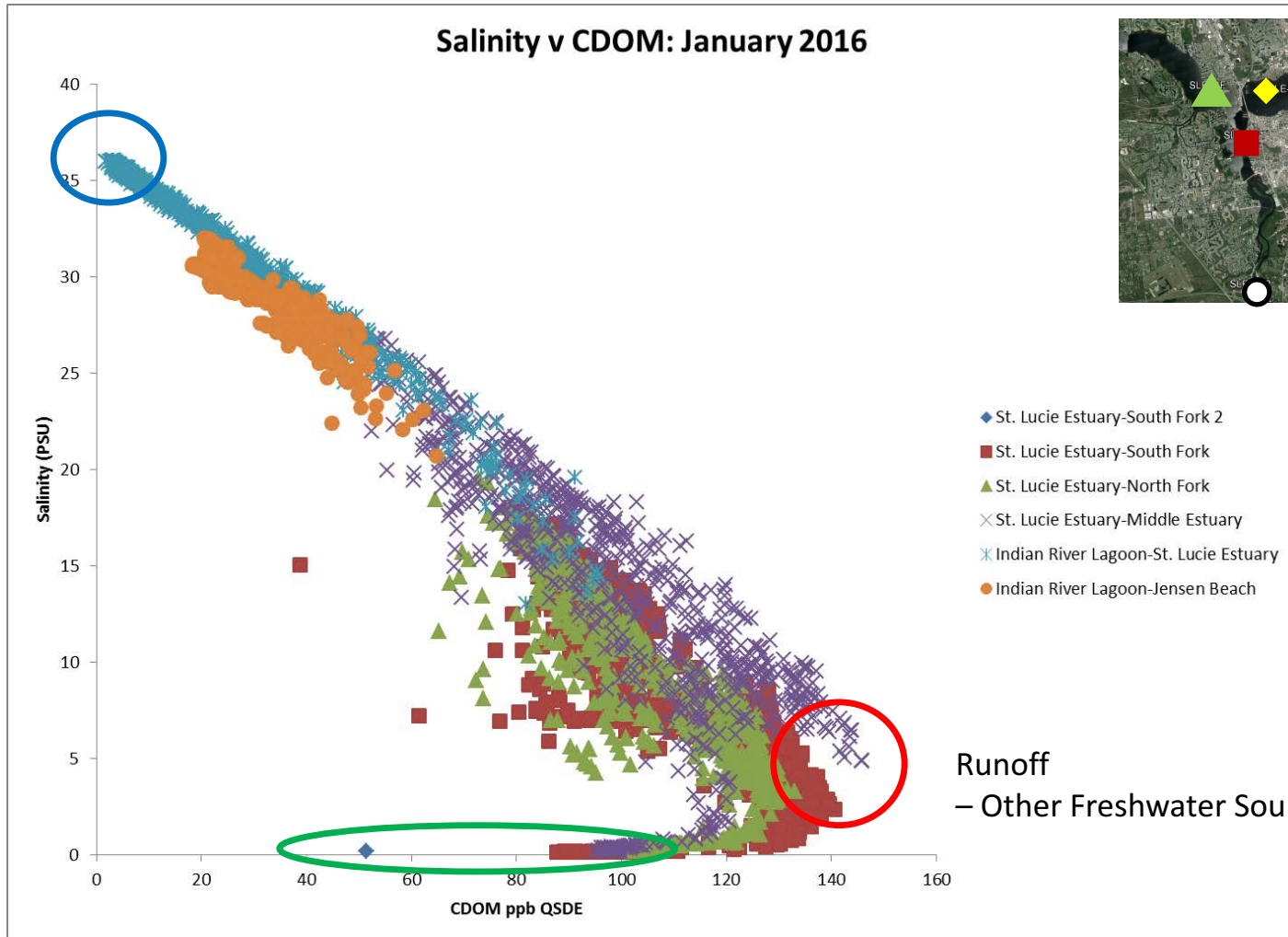
https://pubs.usgs.gov/of/2004/1265/resources/ofr2004_1265_byrne.pdf

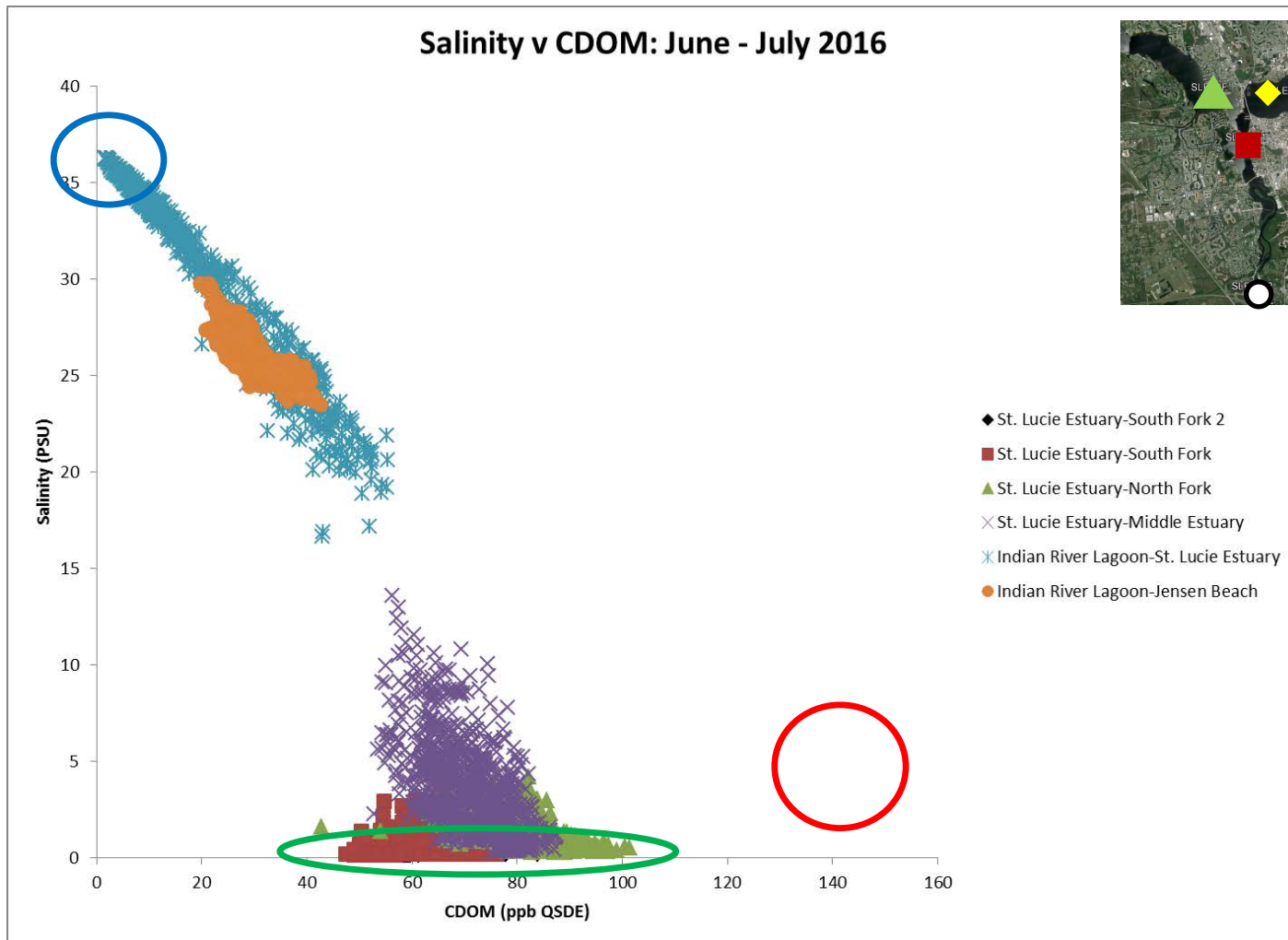
2016 S-308 Discharge (ft³/sec)

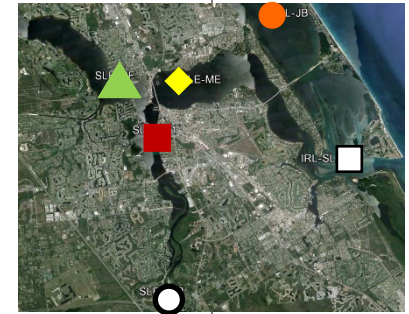
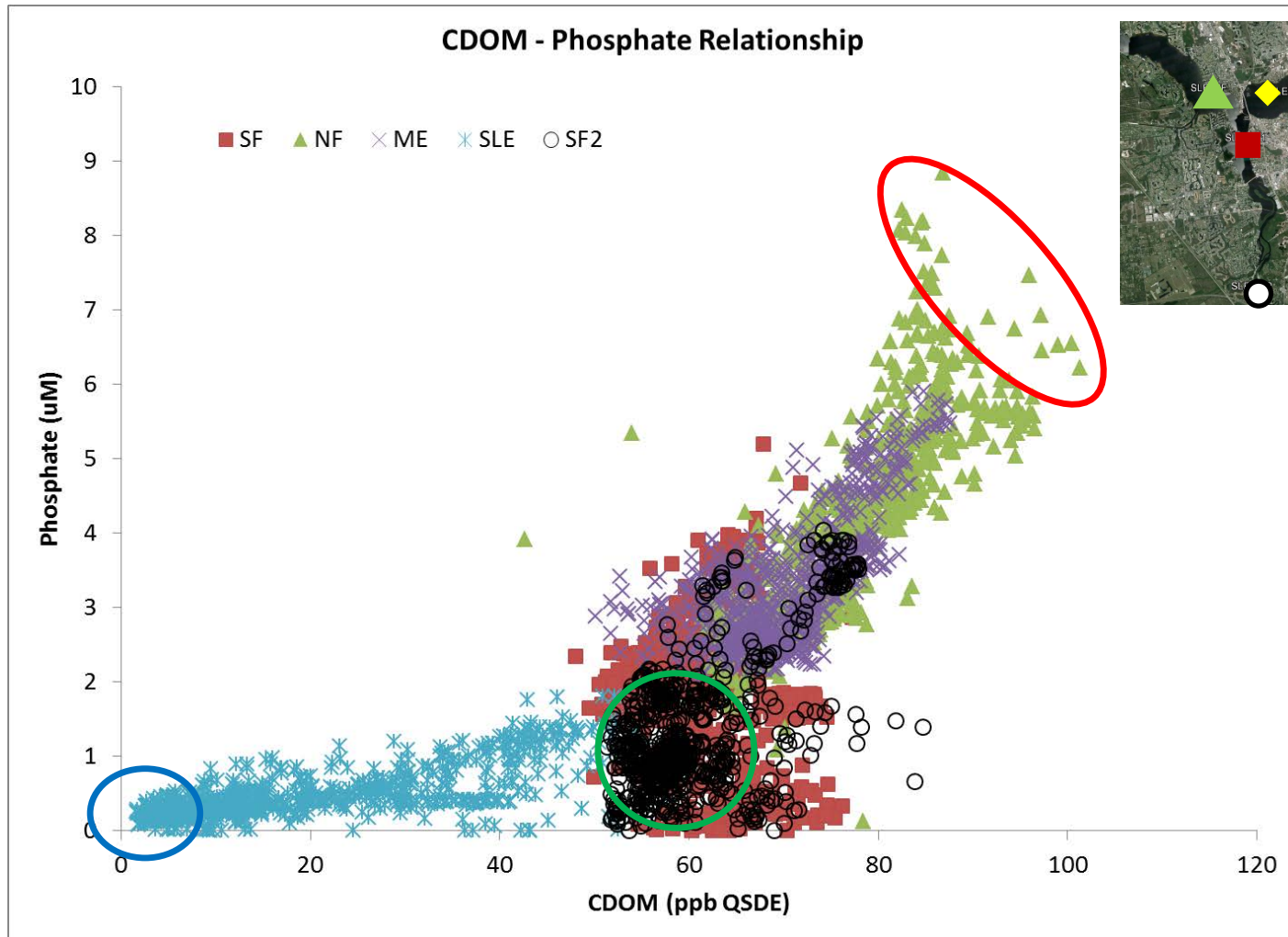


https://waterdata.usgs.gov/fl/nwis/wys_rpt/?site_no=02276877&agency_cd=USGS









Estuary Flow Tracers

- Fresh Water: Colored Dissolved Organic Matter
 - Decayed organic matter
 - High nutrients
- Ocean Water
 - Salts: Salinity
 - Low nutrients

Nutrient Concentration and Sources

- Ocean
 - Salinity 35 PSU
 - CDOM 10 ppb QSDE
 - Phosphate < 1 uM
- Lake Okeechobee
 - Salinity < 1 PSU
 - CDOM 60 ppb QSDE
 - Phosphate 1 uM
- Runoff
 - Salinity 10 PSU
 - CDOM 100 ppb QSDE
 - Phosphate > 6 uM
- IRLON data during this event confirms previous work

Journal of Coastal Research	28	6	1345-1361	Coconut Creek, Florida	November 2012
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Effects of Hurricanes, Land Use, and Water Management on Nutrient and Microbial Pollution: St. Lucie Estuary, Southeast Florida

Brian E. Lapointe, Laura W. Herren, and Bradley J. Bedford

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ABSTRACT

Lapointe, B.E.; Herren, L.W., and Bedford, B.J., 2012. Effects of hurricanes, land use, and water management on nutrient and microbial pollution: St. Lucie Estuary, southeast Florida. *Journal of Coastal Research*, 28(6), 1345-1361. Coconut Creek (Florida), ISSN 0749-0208.

Multiple hurricanes impacted southeast Florida during 2004 and 2005, producing record rainfall and large-scale stormwater runoff into the urbanized St. Lucie Estuary (SLE). To assess effects on water quality, field samples were taken in June and November 2005 and March 2006 along the SLE's three main segments: the South Fork, connected via the C-44 canal to Lake Okeechobee; the North Fork, which receives residential and agricultural runoff from the C-23 and C-24 canals; and the Middle Estuary, which flows into the Indian River Lagoon and Atlantic Ocean. Salinities were <1‰ throughout the normally brackish estuary during the 2005 samplings, but returned to near-normal levels by March 2006 in all but the South Fork. Low salinities in 2005 correlated with low dissolved oxygen, high turbidity, elevated nitrogen and phosphorus concentrations, and high fecal and total coliform counts. Highest turbidity (84.4 NTU), nitrate (37.9 μM), and total dissolved nitrogen (130.8 μM) concentrations occurred in the South Fork, whereas the highest ammonium (15.4 μM), soluble reactive phosphorus (10.5 μM), and total dissolved phosphorus (13.8 μM) concentrations occurred in the North Fork. High fecal and total coliform counts occurred in tidal creeks adjacent to dense residential areas that rely on septic tanks for on-site sewage disposal. The data suggest that increased stormwater retention, minimization of freshwater releases from Lake Okeechobee, and enhanced treatment of both stormwater and sewage are needed to mitigate future stormwater-driven water quality perturbations in the SLE.

ADDITIONAL INDEX WORDS: *Rainfall, stormwater, salinity, nitrogen, phosphorus, coliform, bacteria.*

INTRODUCTION

The St. Lucie Estuary (SLE) comprises one of the largest estuaries on the east coast of Florida and is a primary tributary

SLE had a relatively small natural watershed. However, the network of locks and water control structures constructed during the past century to allow drainage for expanding urban growth and agriculture has artificially enlarged that

Harmful Algae 43 (2015) 82–102



Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal



Evidence of sewage-driven eutrophication and harmful algal blooms in Florida's Indian River Lagoon



Brian E. Lapointe*, Laura W. Herren, David D. Debortoli, Margaret A. Vogel

Harbor Branch Oceanographic Institute at Florida Atlantic University, Harmful Algal Bloom Program, 5600 US 1 North, Fort Pierce, FL 34946, USA

ARTICLE INFO

Article history:

Received 17 October 2014
Received in revised form 27 January 2015
Accepted 28 January 2015

Keywords:

HAB
Nitrogen
Phosphorus
Indian River Lagoon
Eutrophication
Stable isotopes

ABSTRACT

Nutrient pollution is a primary driver of eutrophication and harmful algal blooms (HABs) in estuaries and coastal waters worldwide. In 2011–2012, 20 sites evenly distributed throughout the 251-km long Indian River Lagoon (IRL) were assessed during three sampling events for dissolved nutrients (DIN, SRP, TDN, TDP) and chlorophyll *a*. Benthic macroalgae were also analyzed for $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and C:N:P contents to identify potential nutrient sources and gauge the type and degree of N and P limitation. The mean DIN and SRP concentrations throughout the IRL were high, averaging 4.24 ± 0.45 and 0.68 ± 0.06 μM , respectively, explaining the widespread occurrence of HABs during the study. High TDN concentrations (up to 152 μM) and TDN:TDP ratios (>100:1) in the poorly flushed northern IRL, Mosquito Lagoon and Banana River segments reflected the accumulation and cycling of N-rich groundwater inputs that produce P-limitation. These enriched nutrient conditions were associated with unprecedented chlorophyll *a* concentrations (>100 $\mu\text{g/L}$), dominated by *Resulitor* sp. \emptyset . Moestrup in the Banana River in 2011 and *Aureoumbra lagunensis* D.A. Stockwell, DeYoe, Hargraves and P.W. Johnson in the Mosquito Lagoon and northern IRL in 2012. C:N, C:P, and N:P ratios in macroalgae averaged 15.9, 698.9, and 40.6, throughout the

2015 MARTIN COUNTY WATERSHED TO REEF SEPTIC STUDY

FINAL REPORT



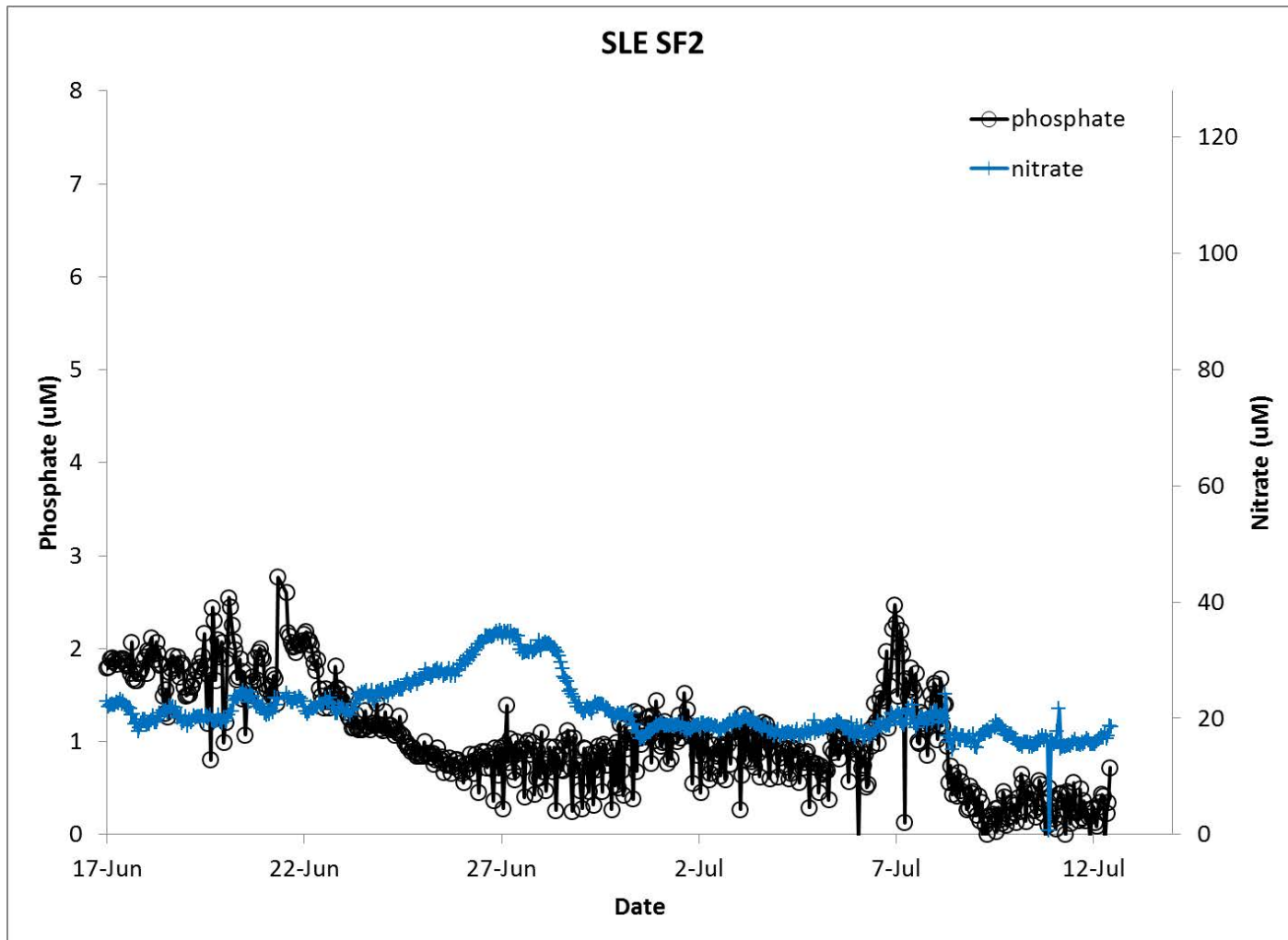
Prepared by:
Brian E. Lapointe, Ph.D. and Laura W. Herren
Marine Ecosystem Health program
Harbor Branch Oceanographic Institute
Florida Atlantic University
5600 U.S.1 North
Fort Pierce, FL 34946

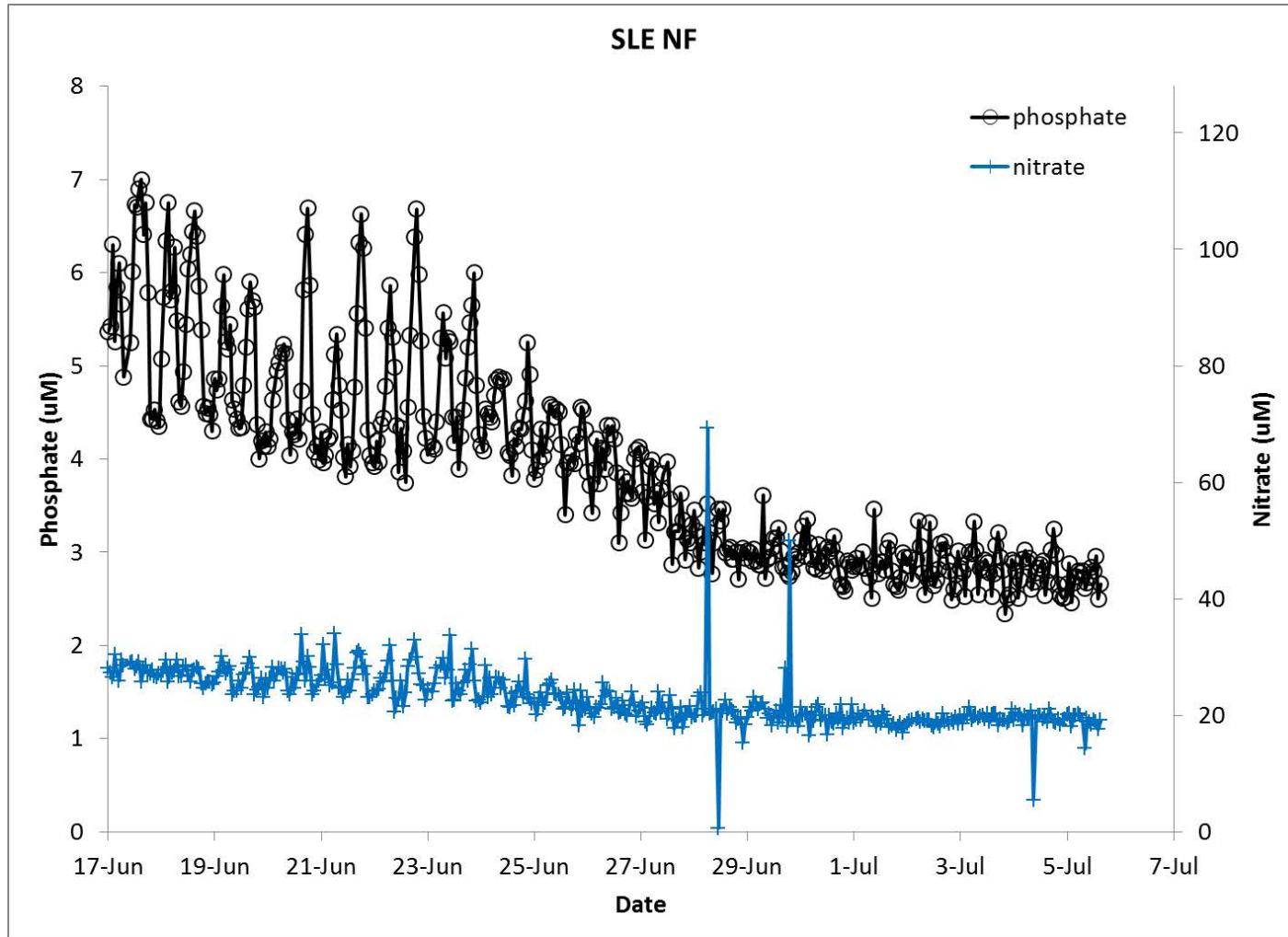
For:
Martin County Board of County Commissioners
Martin County Utilities Department
2401 S.E. Monterey Road
Stuart, Florida 34996

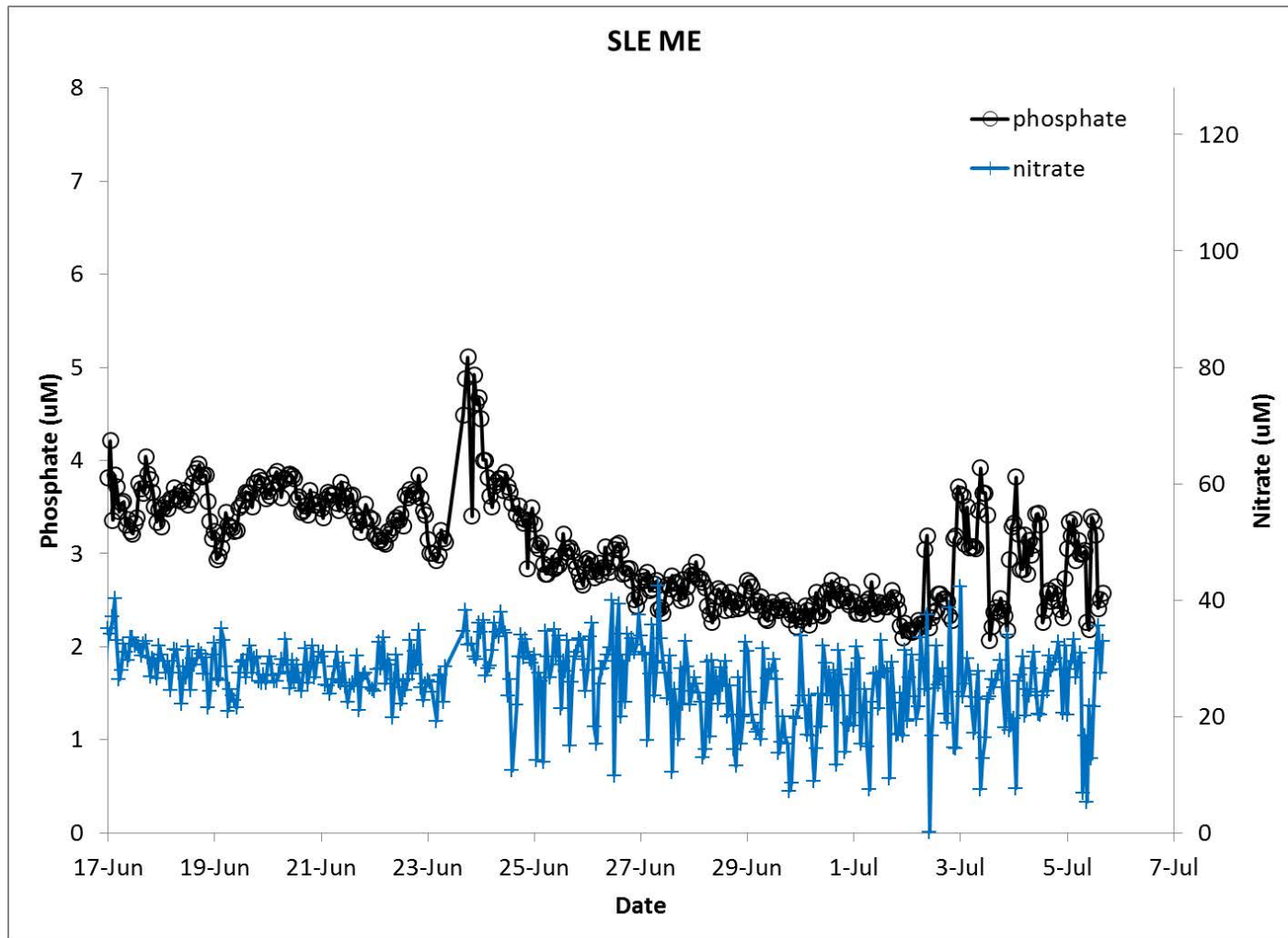
March 4, 2016

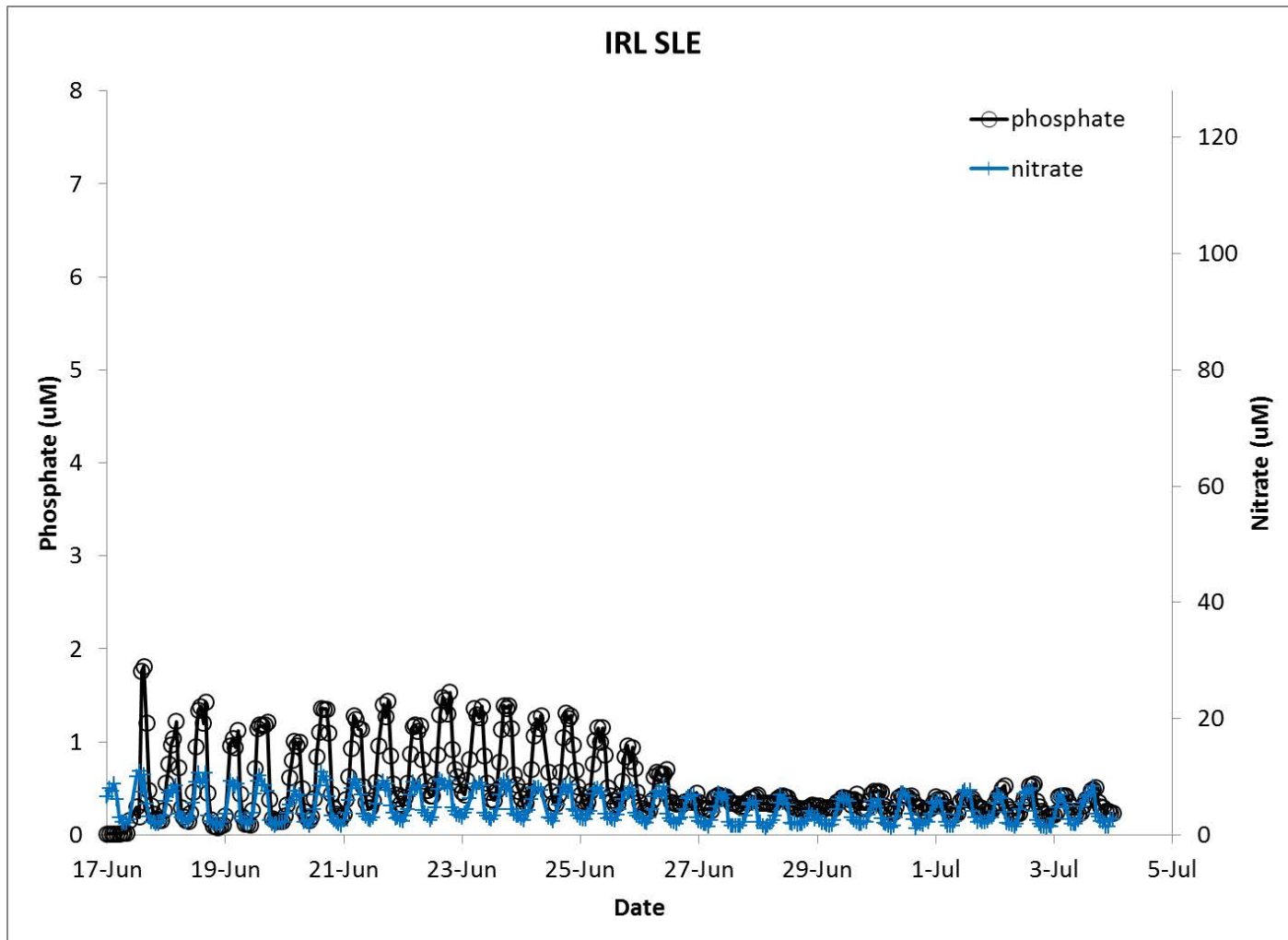
Nutrient Loads At the IRLON Sites

- Phosphate and Nitrate In Situ Data
- Redfield Ratios:
 - Molar Ratio of Phytoplankton: Single cell plants in water
 - 16 Atoms of Nitrogen (N, NO₃) for every atom of Phosphorus (P, PO₄)
- Blue Green Algae tend to out-compete when phosphate (PO₄) is abundant



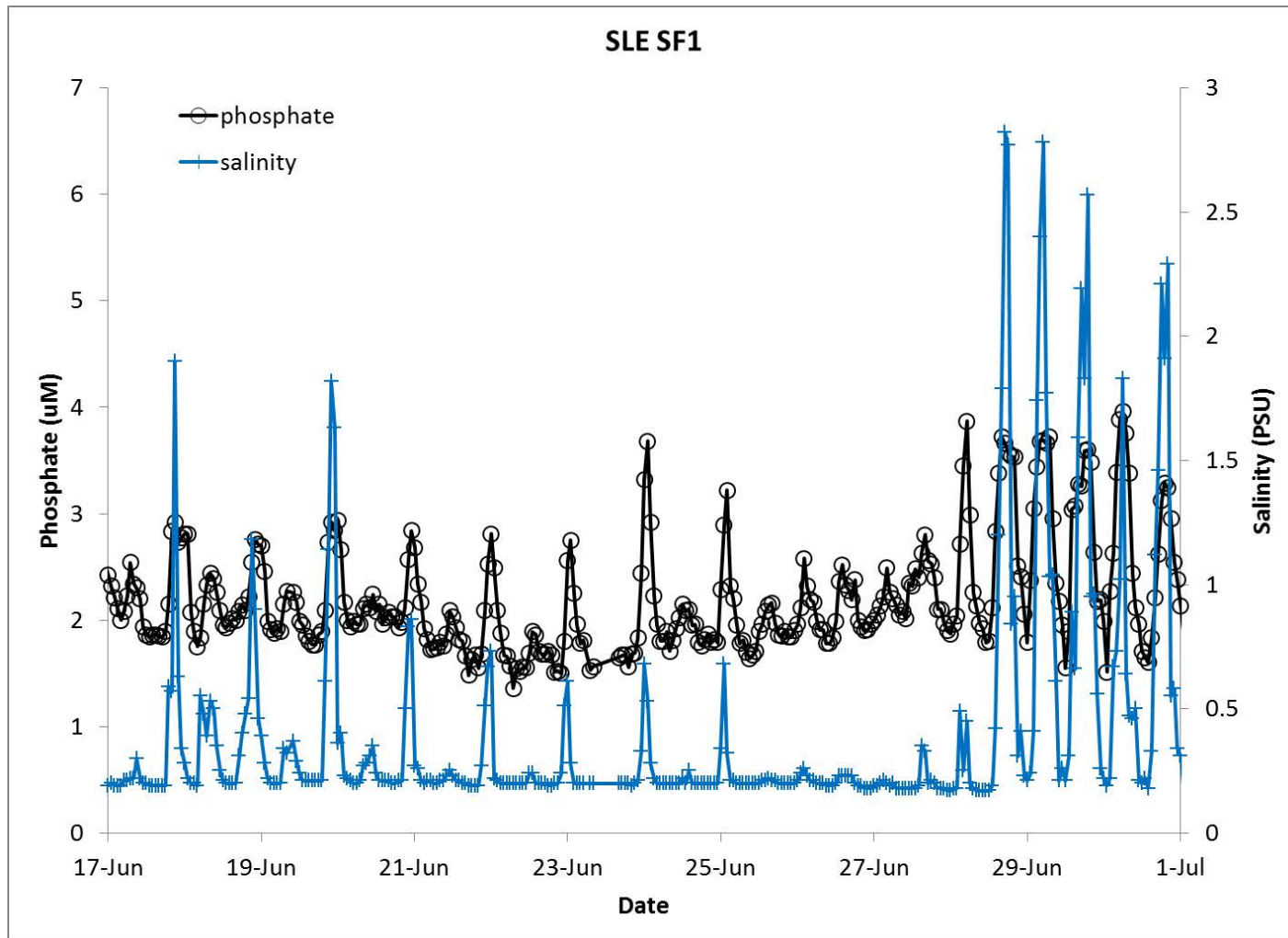


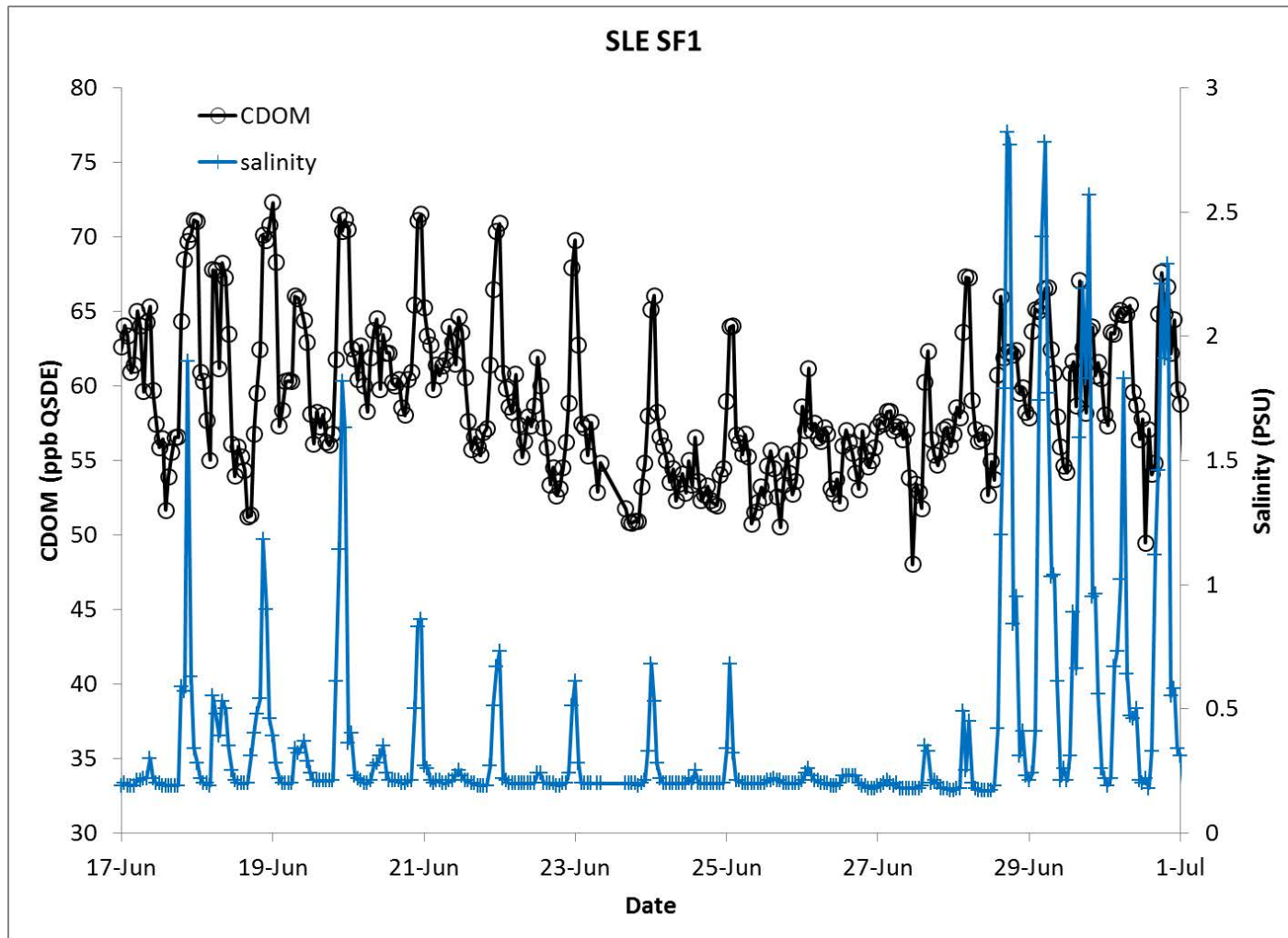




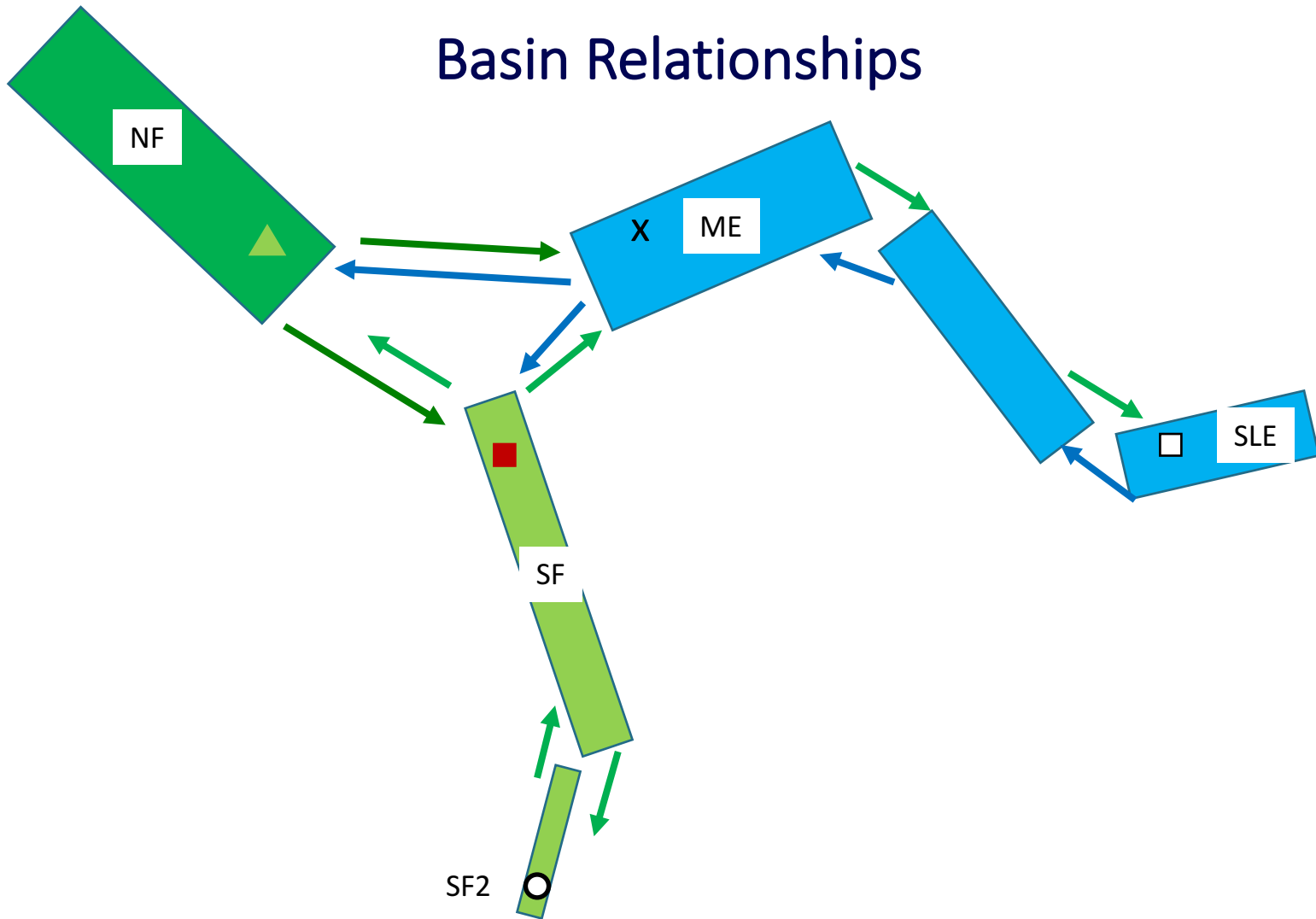
Curious Spikes at the South Fork LOBO

- Positive correlations between
 - Salinity
 - CDOM
 - Phosphate

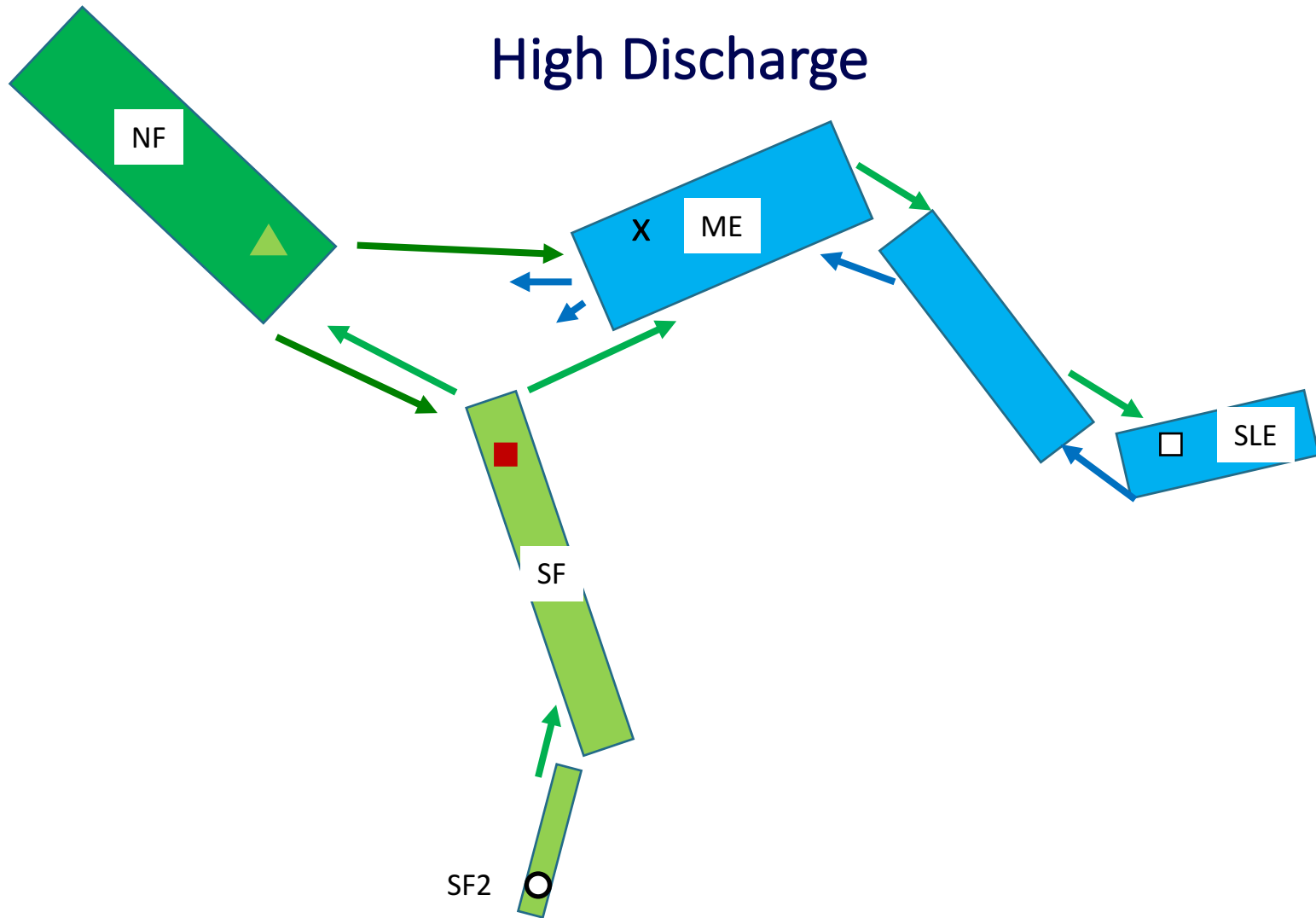


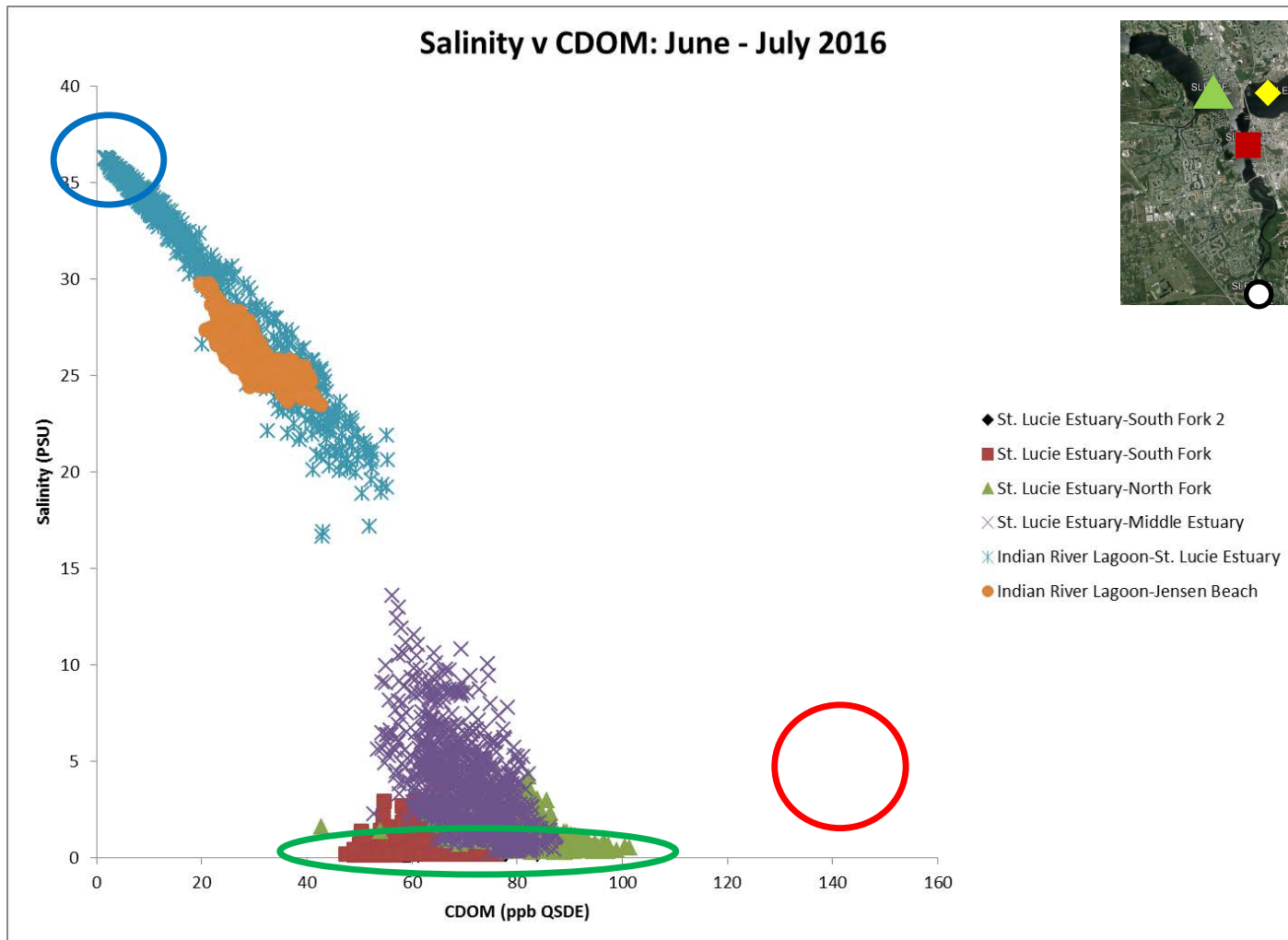


Basin Relationships



High Discharge





2016 Algal Blooms

SCIENCE

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By APNewsNow, Associated Press | JULY 5, 2016

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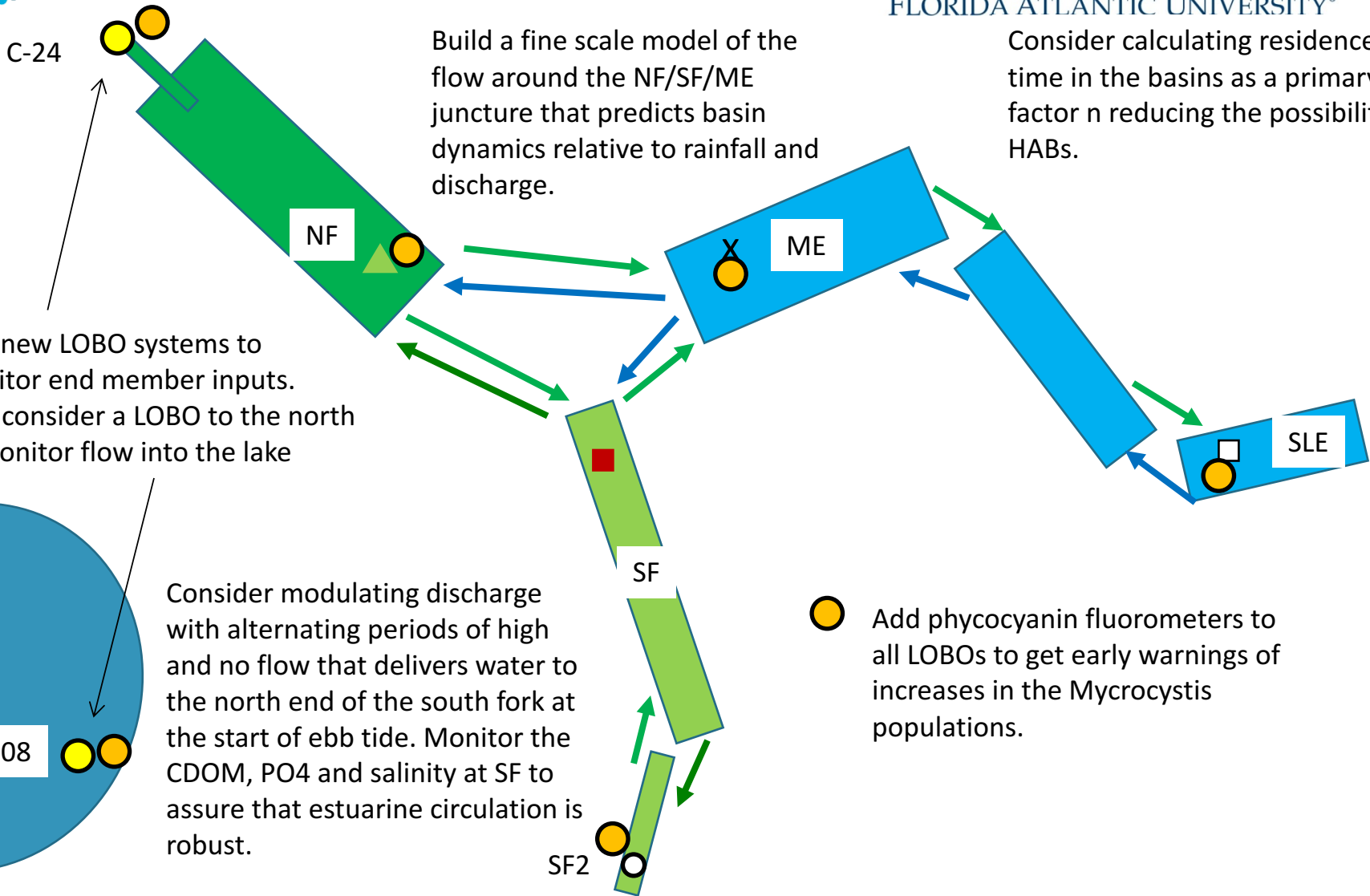
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Residents can call a toll-free at 1-855-305-3903 or report information online at www.reportalgalbloom.com. The smelly muck comes just in time for the holiday weekend.

Recommendations

Consider calculating residence time in the basins as a primary factor in reducing the possibility of HABs.

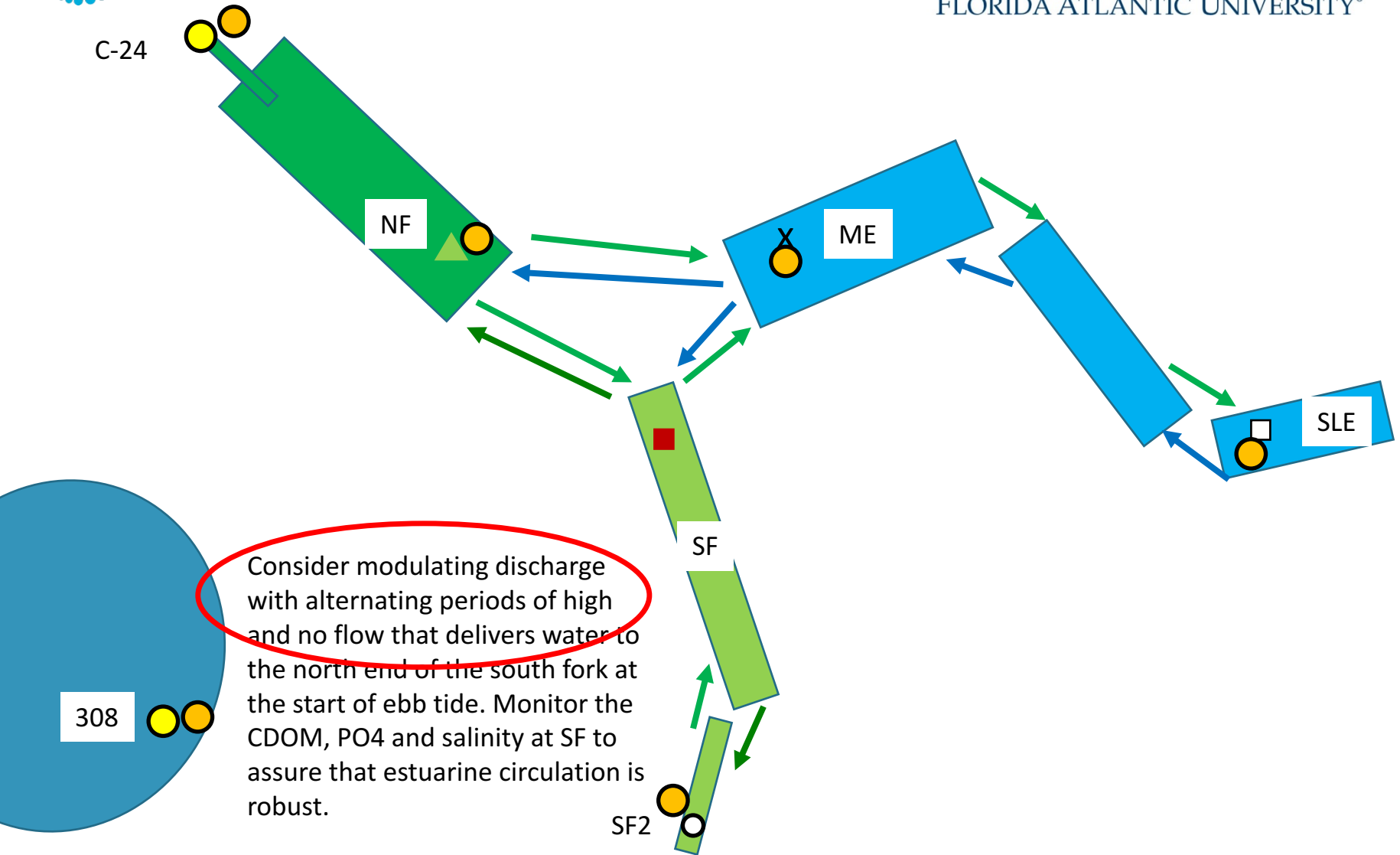
Build a fine scale model of the flow around the NF/SF/ME juncture that predicts basin dynamics relative to rainfall and discharge.



Two new LOBO systems to monitor end member inputs. Also consider a LOBO to the north to monitor flow into the lake

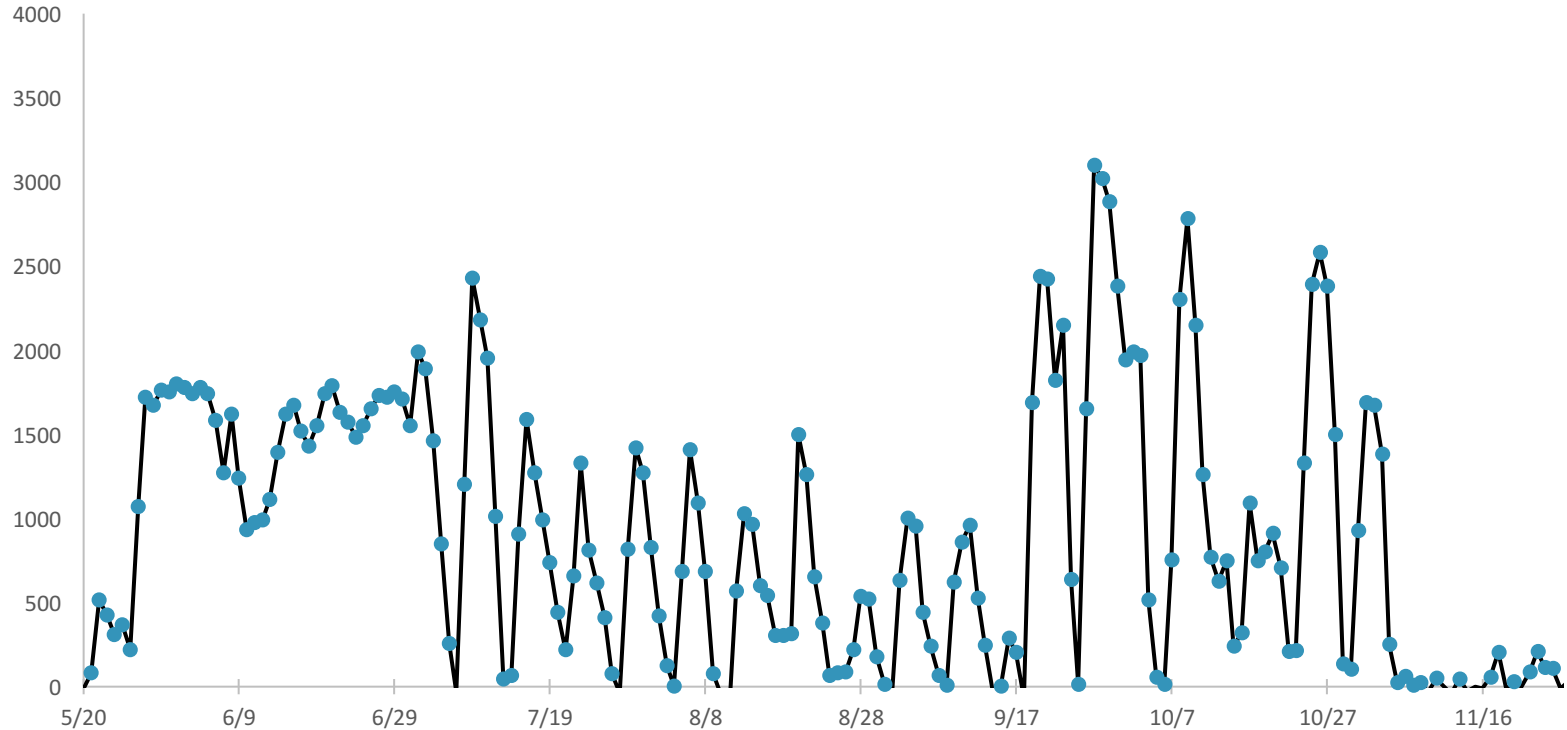
Consider modulating discharge with alternating periods of high and no flow that delivers water to the north end of the south fork at the start of ebb tide. Monitor the CDOM, PO₄ and salinity at SF to assure that estuarine circulation is robust.

C-24



308

2016 S-308 Discharge (ft³/sec)

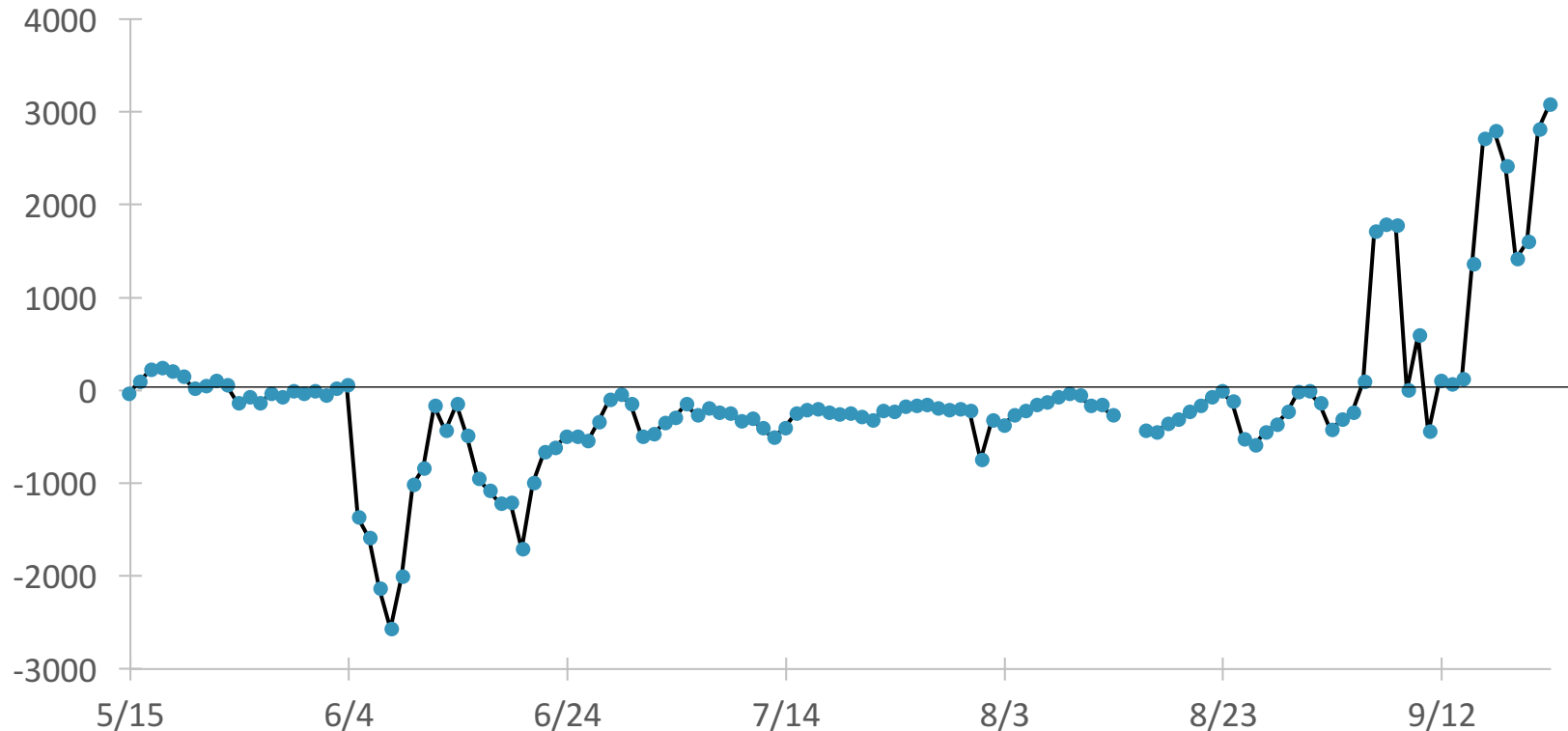


https://waterdata.usgs.gov/fl/nwis/wys_rpt/?site_no=02276877&agency_cd=USGS

Summary

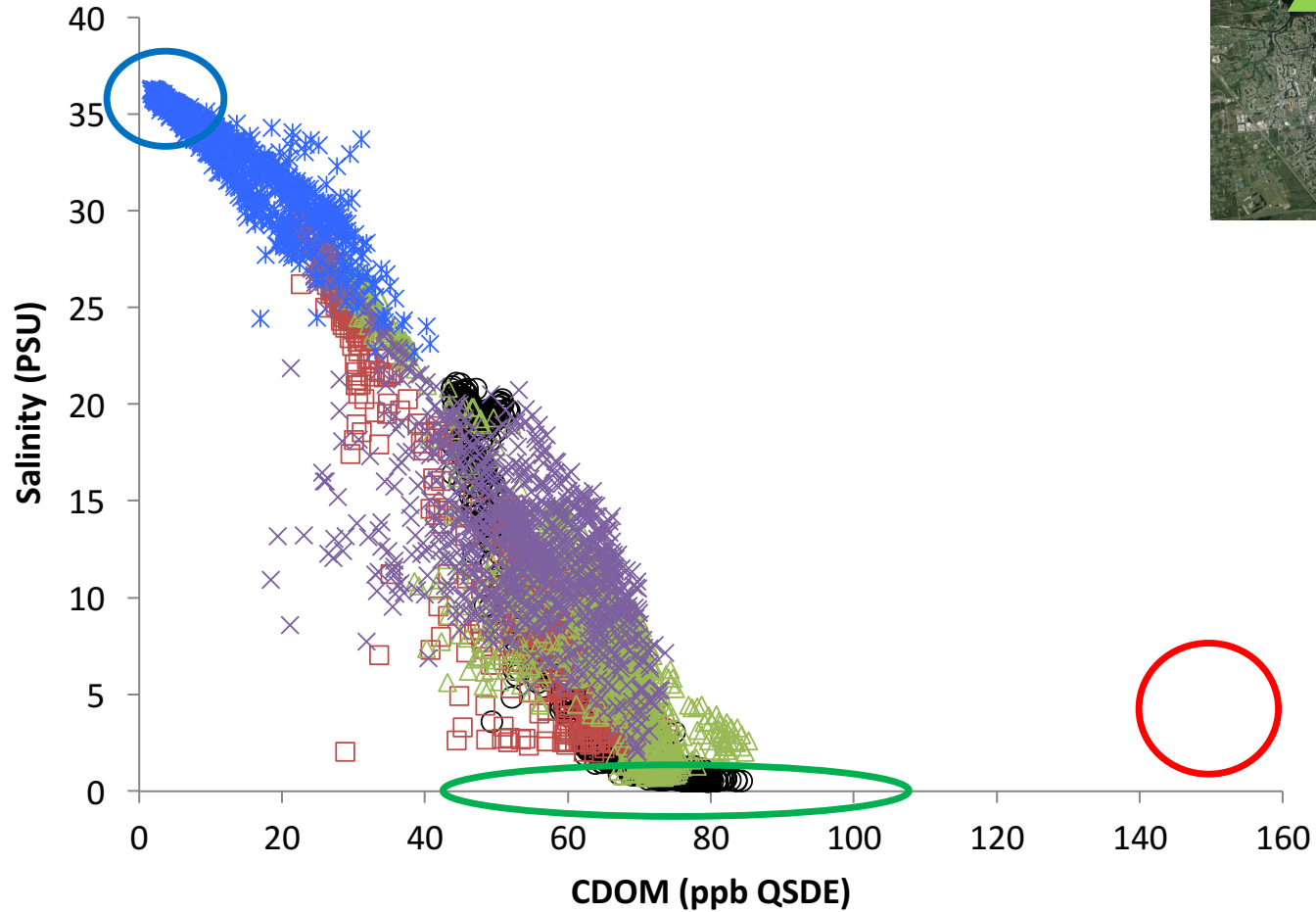
- Live data from IRLON drives understanding of the estuary
- Discharges from Lake Okeechobee alter estuarine circulation
- Higher freshwater residence time and excess phosphate leads to blooms

2017 S-308 Discharge (ft³/sec)



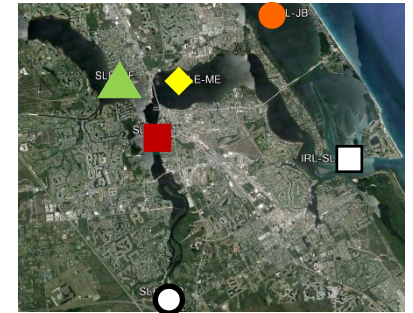
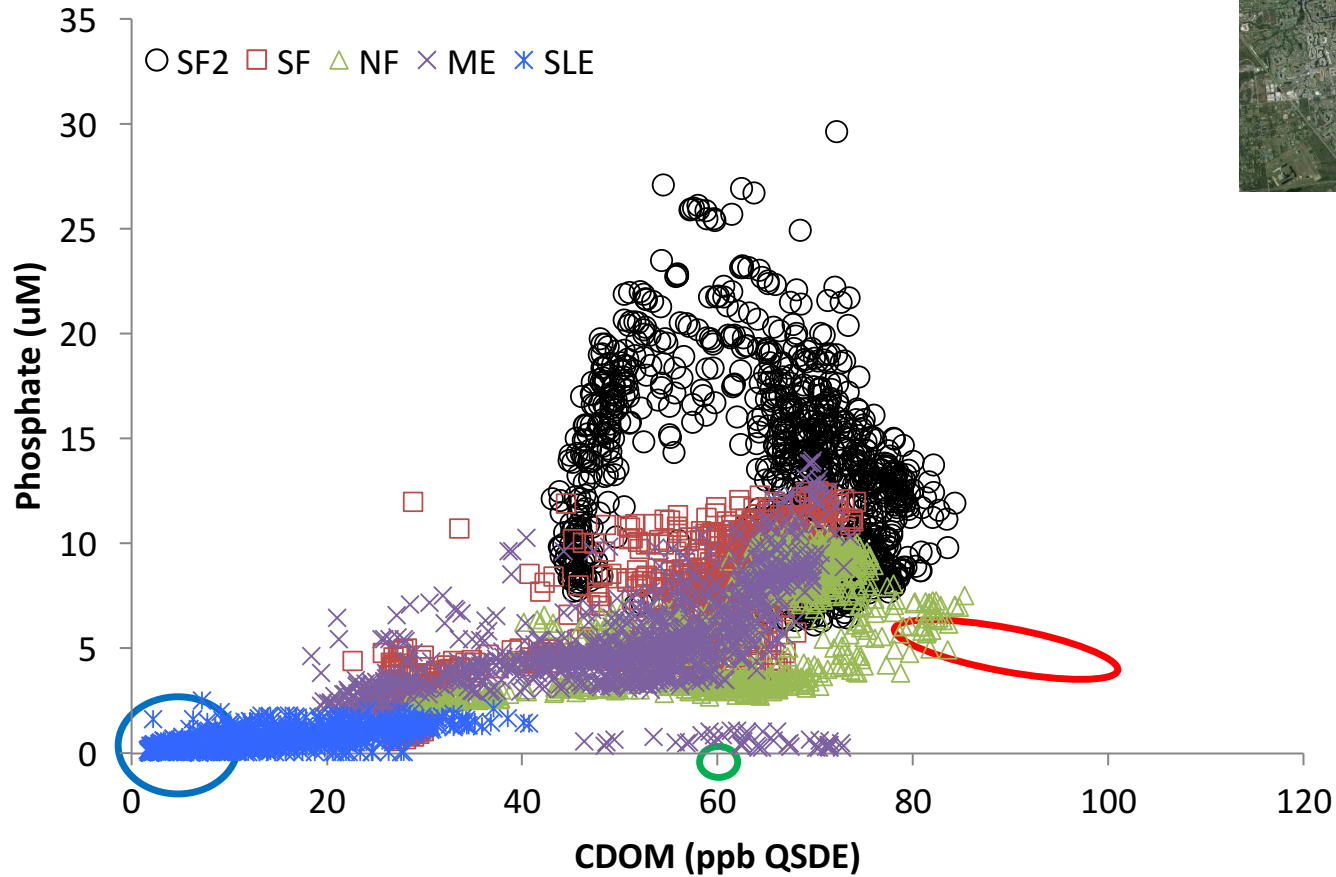
REMARKS - Flow regulated by control structure 308 gates and lock at Lake Okeechobee. Flow frequently reverses during and after periods of heavy rainfall by pumpage into the canal from agricultural lands in the Everglades (negative figures indicate reverse flow towards Lake Okeechobee).

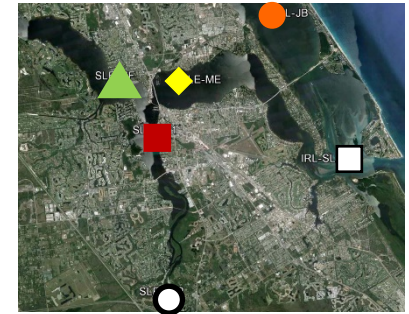
Salinity - CDOM Relationship



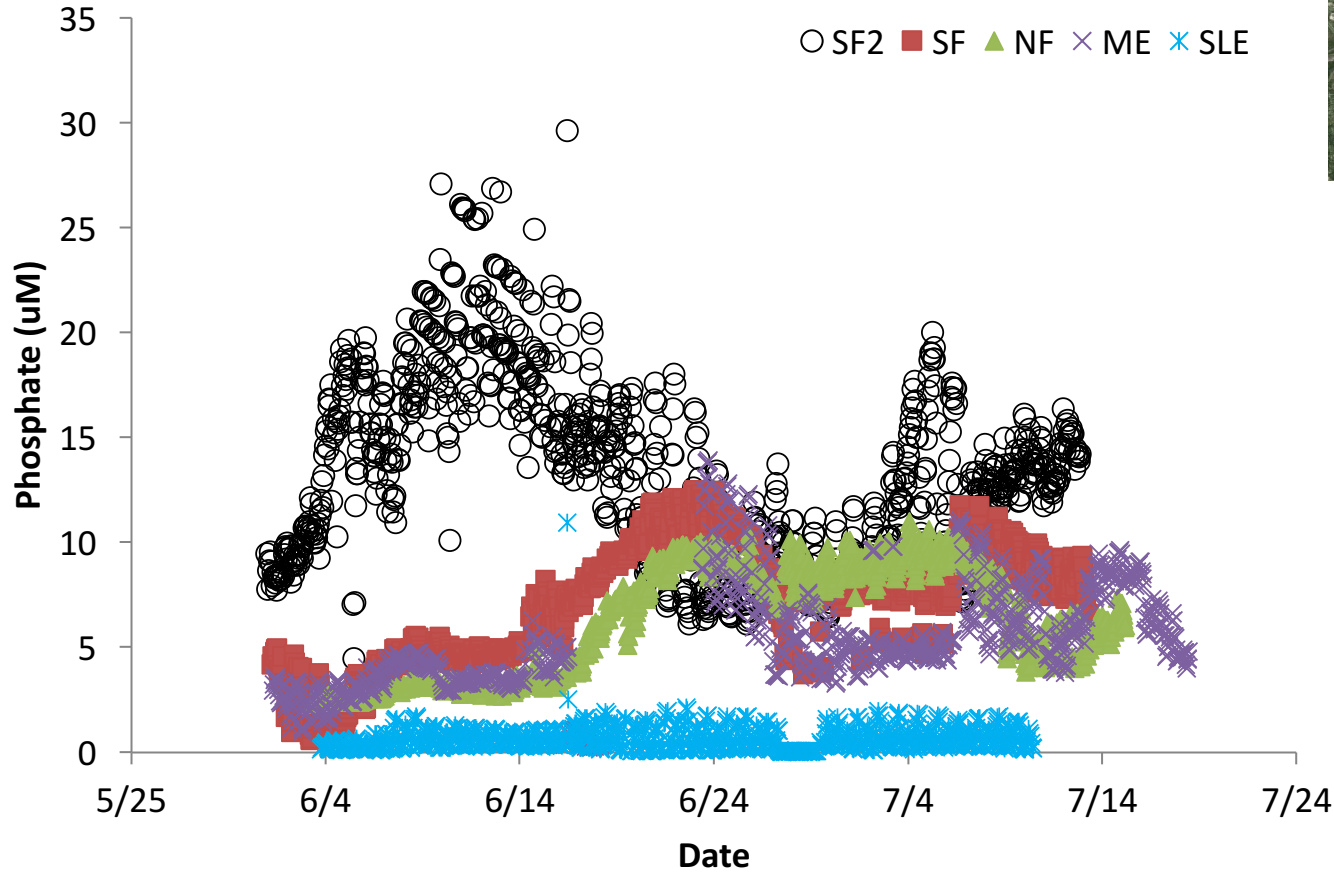
- SF2
- SF
- △ NF
- × ME
- * SLE

CDOM - Phosphate Relationship

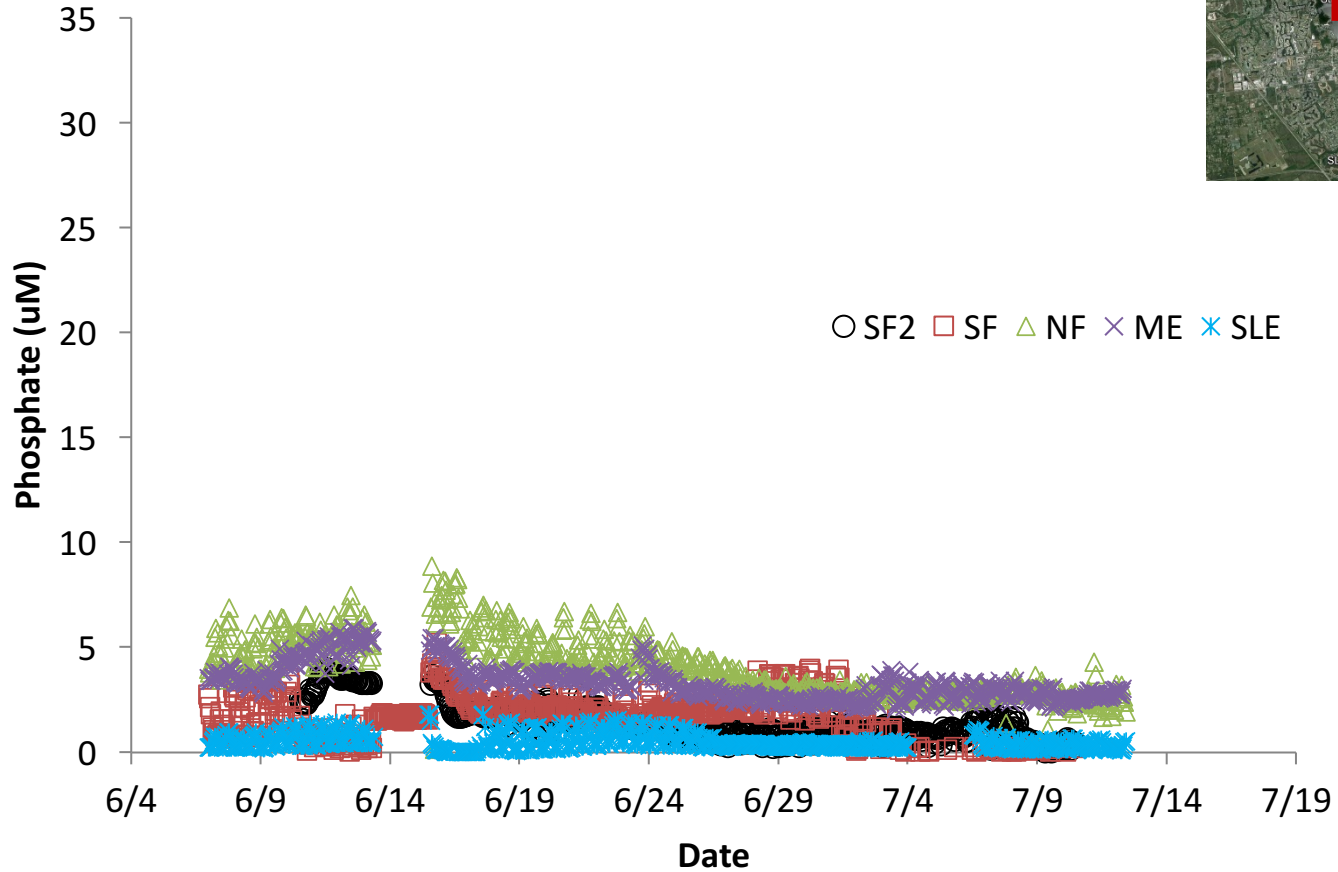
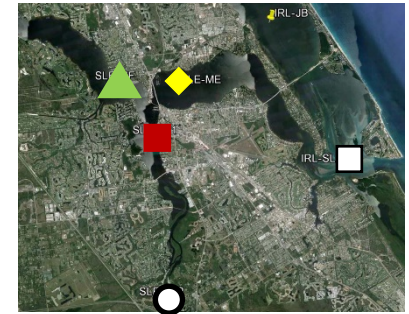




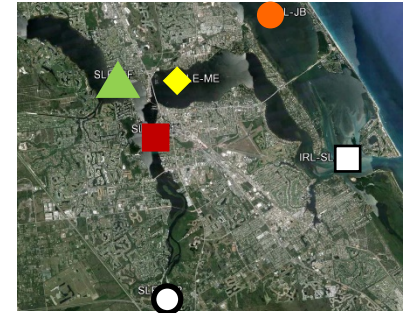
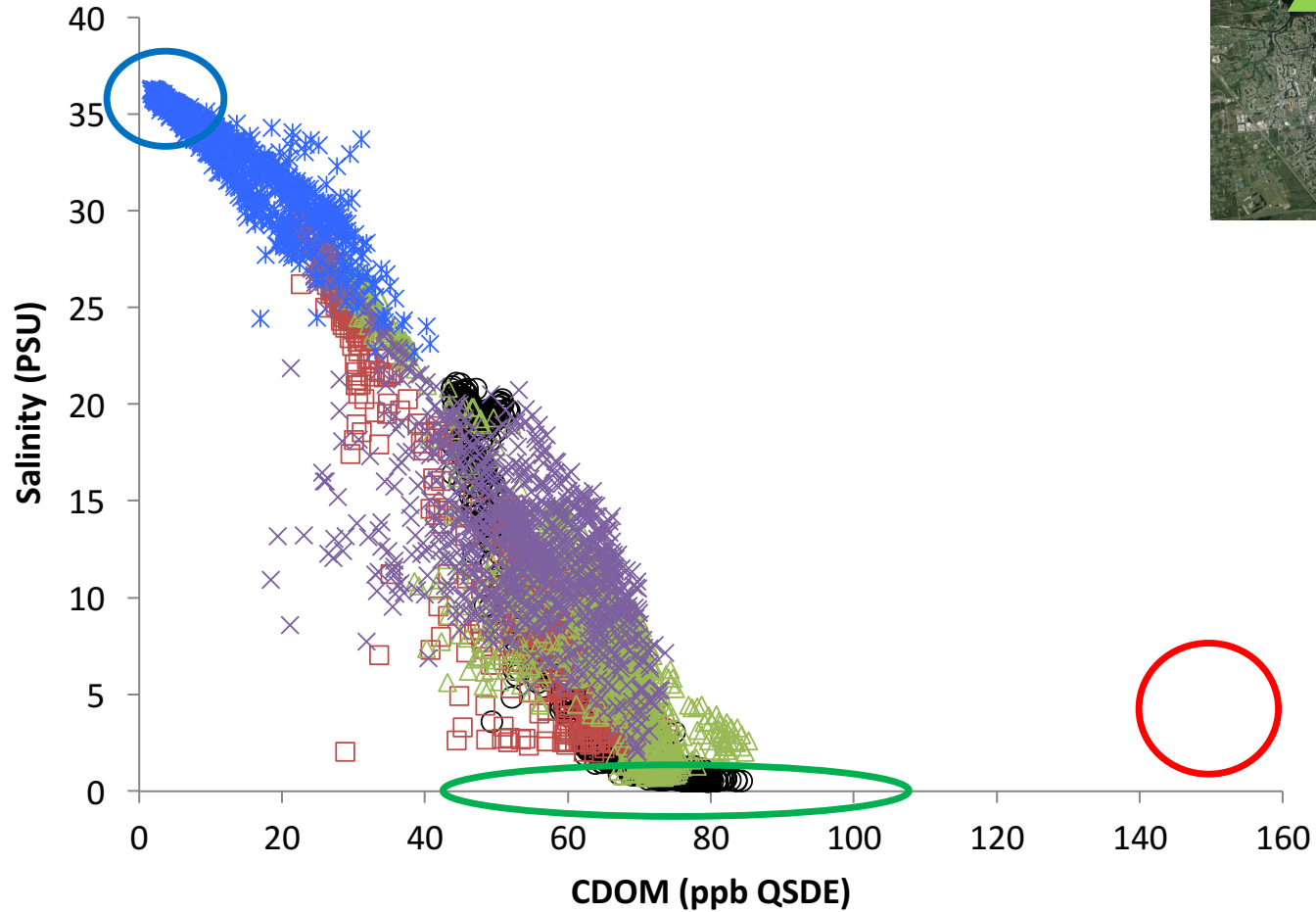
Phosphate Concentration



Phosphate Concentration



Salinity - CDOM Relationship

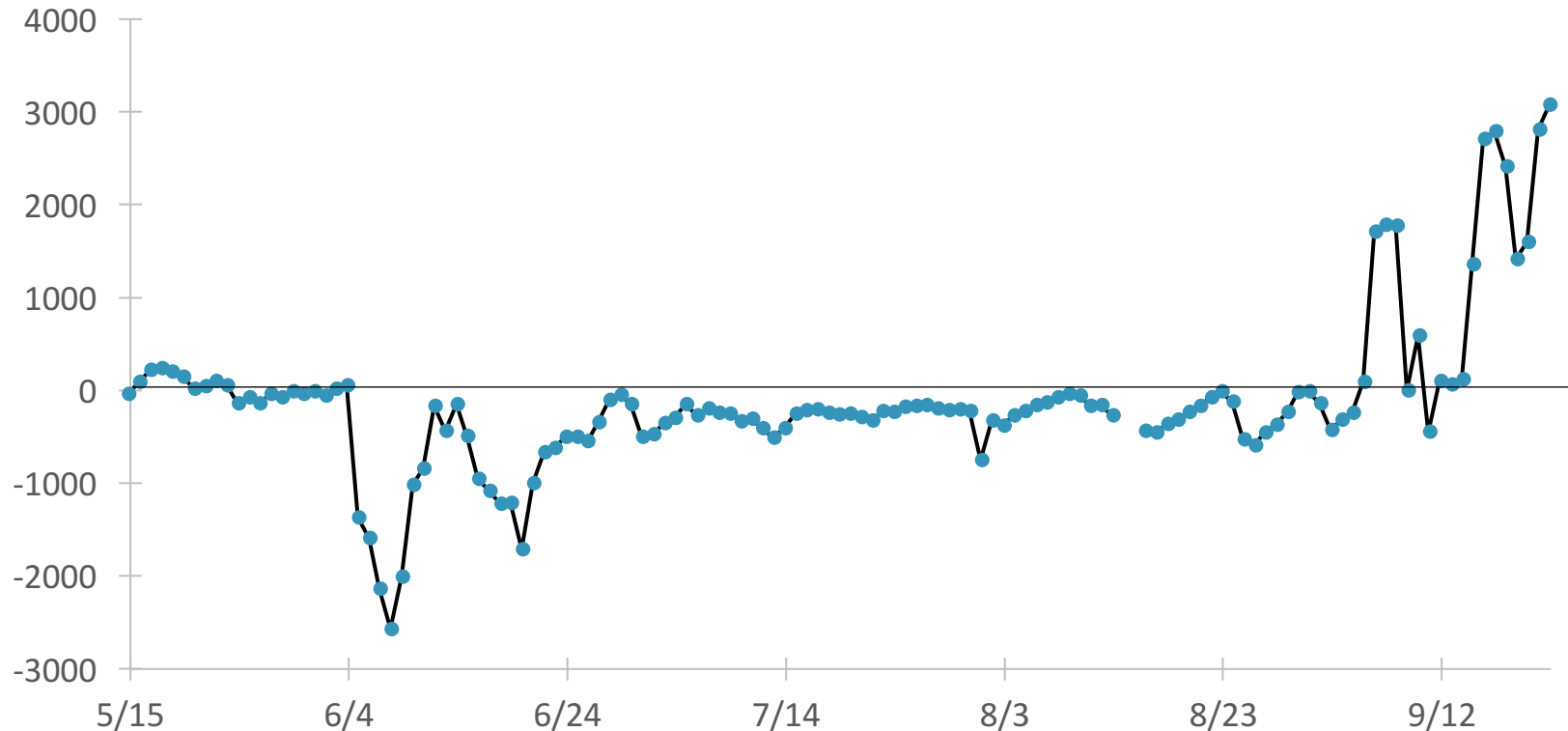


- SF2
- SF
- △ NF
- × ME
- * SLE

Summer 2017

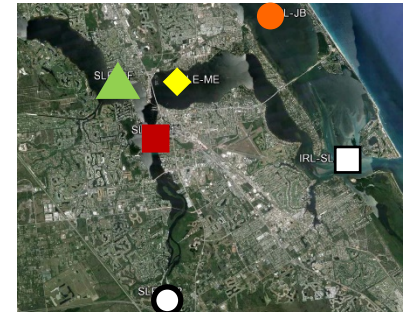
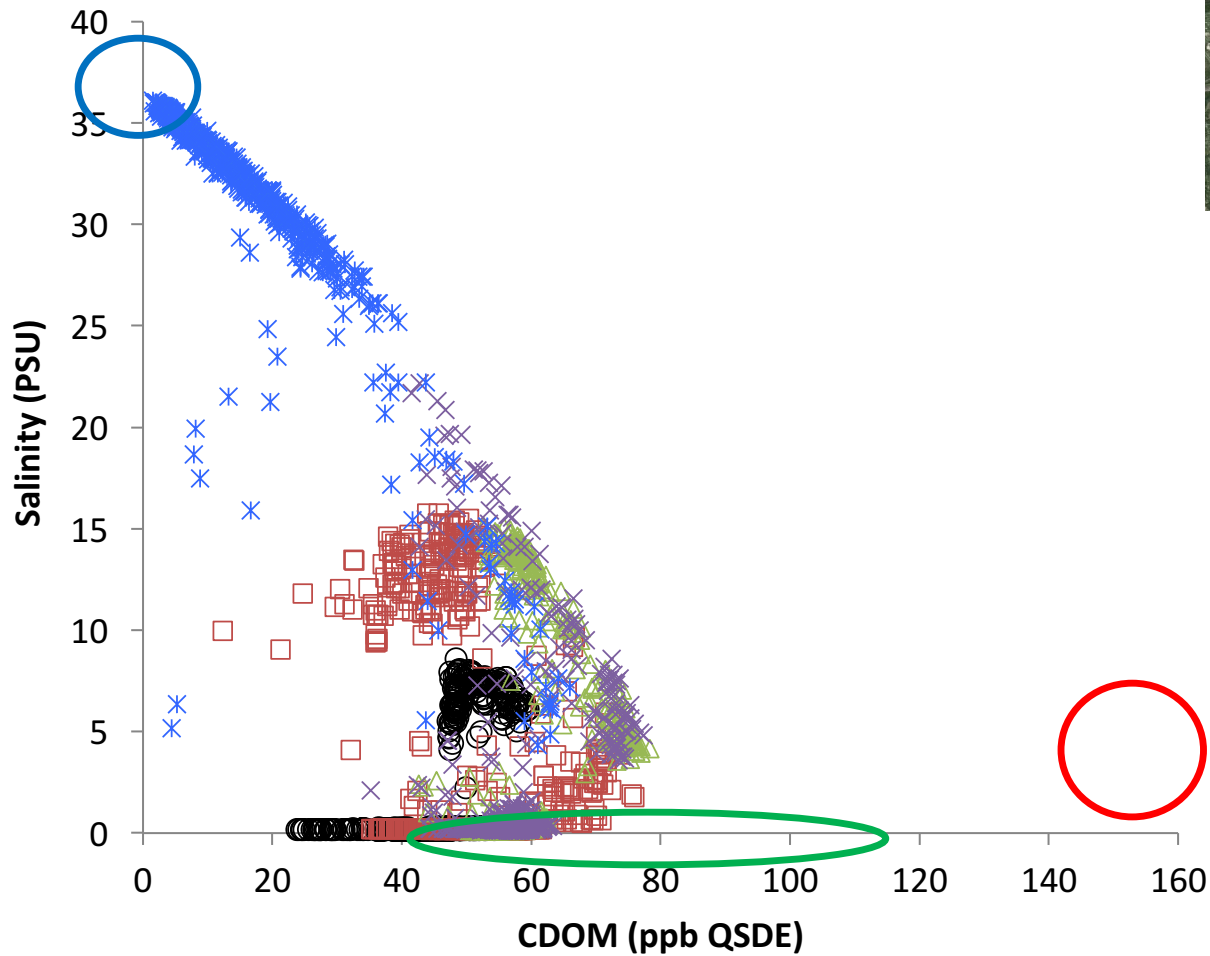
- Higher nutrient concentrations did not lead to HAB event
- Residence Time – Tidal flushing is more important than nutrient loading

2017 S-308 Discharge (ft³/sec)



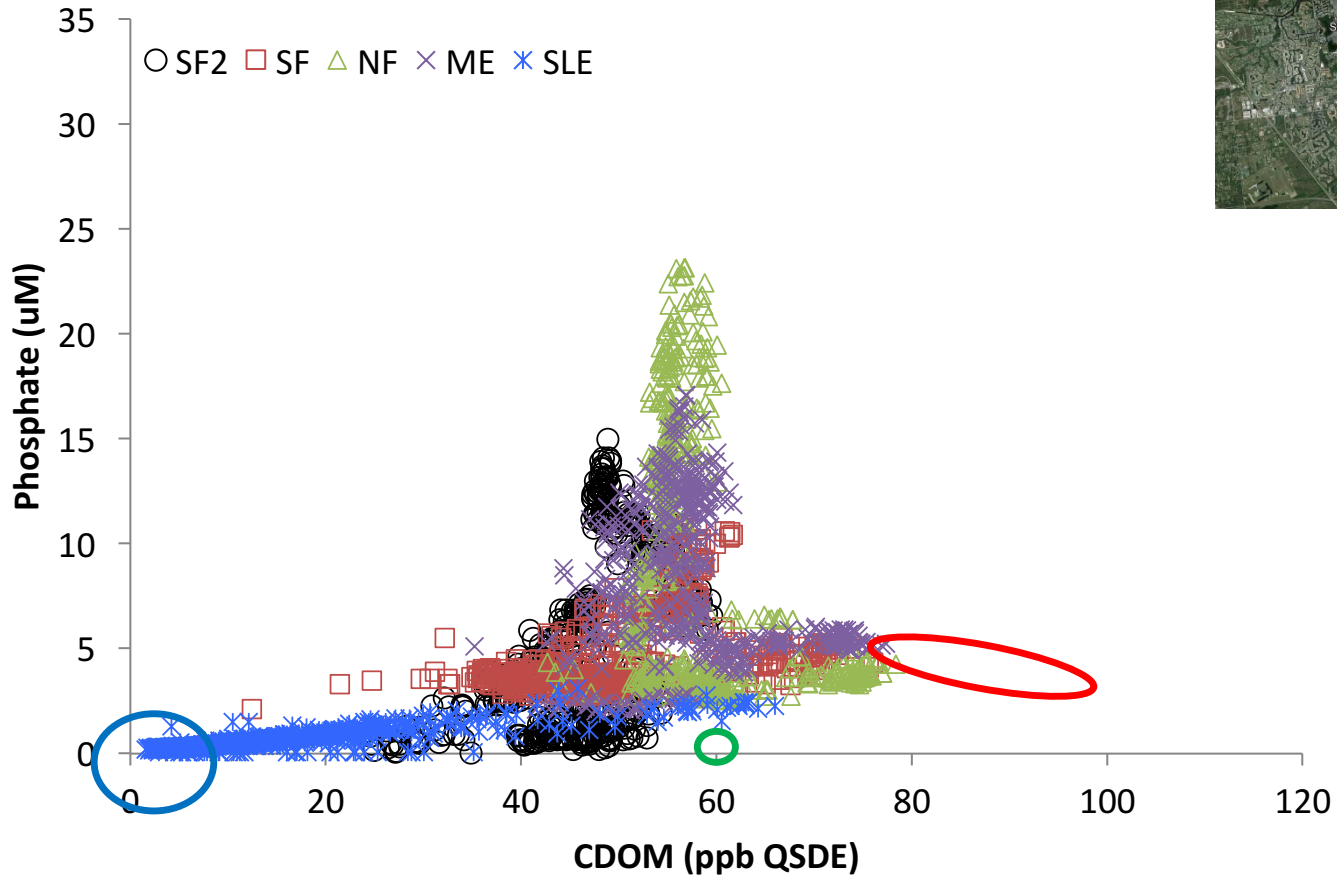
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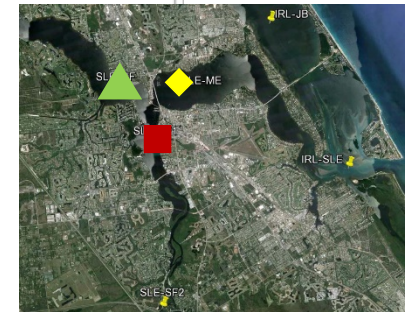
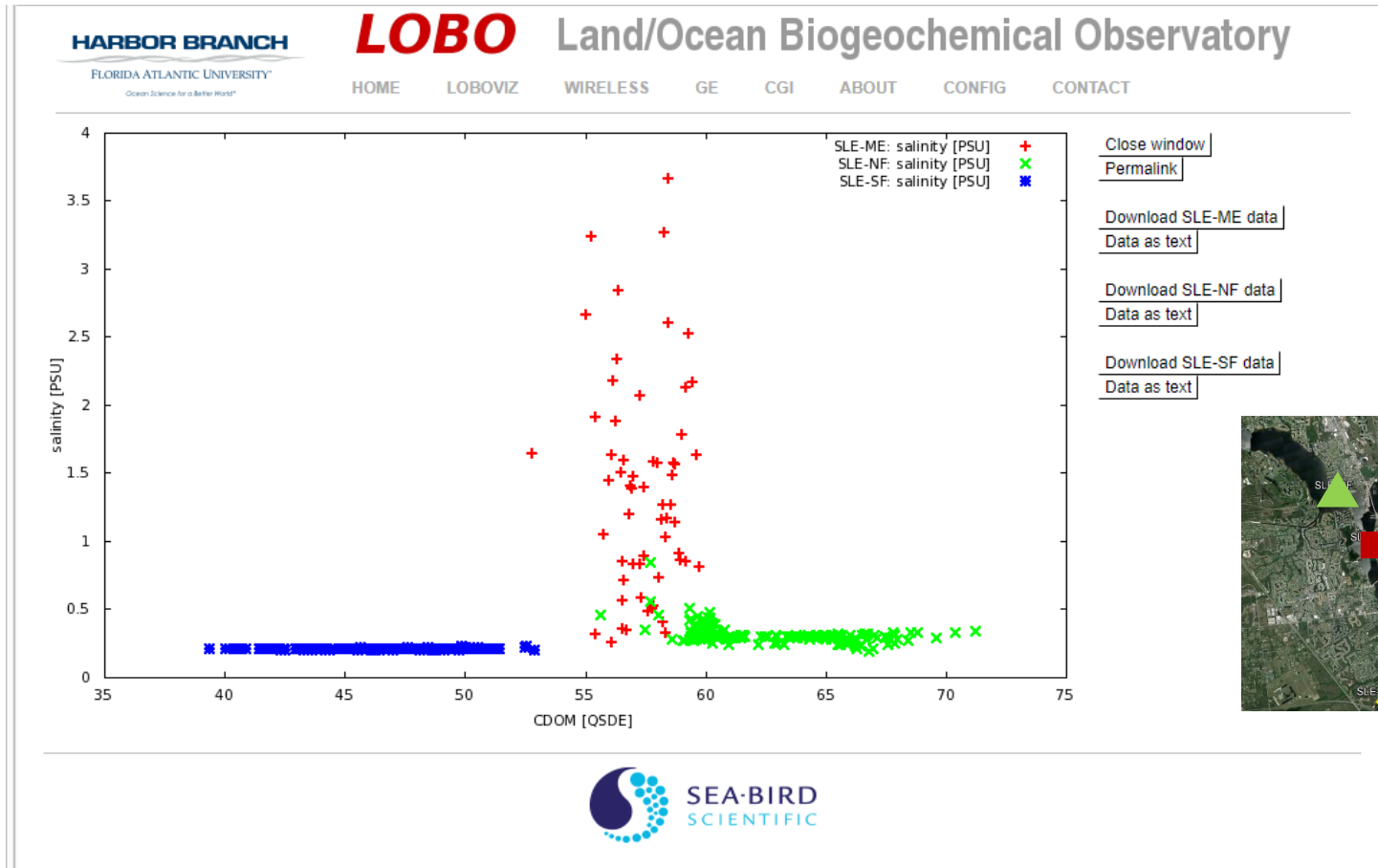
Salinity - CDOM Relationship



- SF2
- SF
- △ NF
- × ME
- × SLE

CDOM - Phosphate Relationship



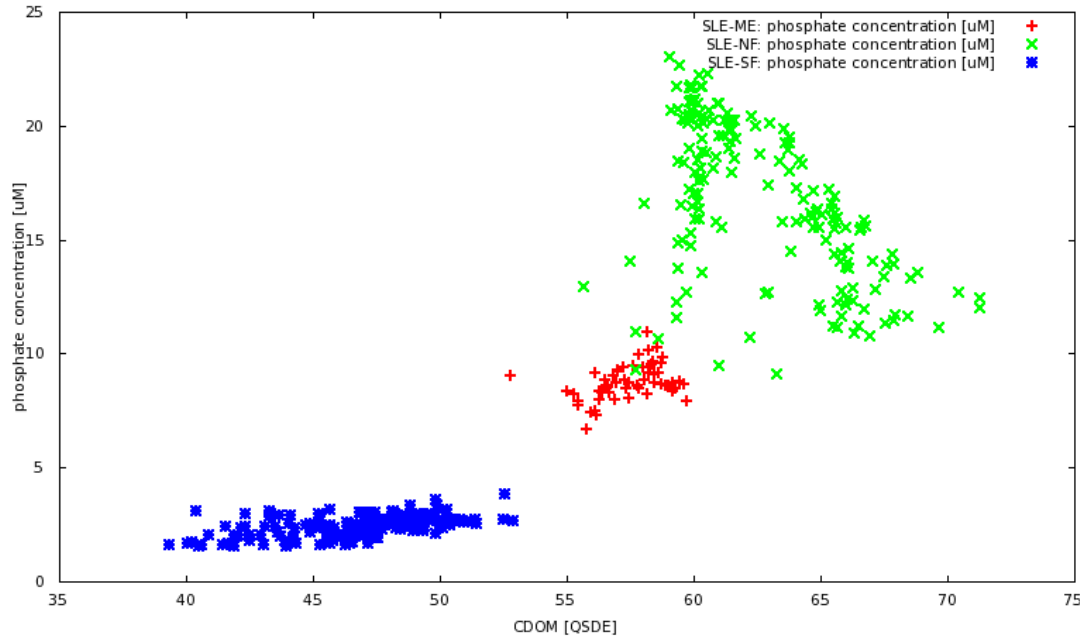


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