FAU Harbor Branch Indian River Lagoon LOBOs: A Primer
M. Dennis Hanisak, FAU Harbor Branch, October 2013

Part 1 Introduction

The Indian River Lagoon (IRL) is a unique, highly diverse, shallow-water estuary of national significance stretching along 40% of Florida's east coast. IRL's economic value to Florida is enormous (more than $3.7 billion per year). Urbanization, excessive freshwater releases, degradation of water quality, contaminant loading, loss of habitat (e.g., seagrasses, mangroves), decline of fisheries, and emerging diseases in marine mammals are increasingly important issues in the IRL, as they are throughout the world's estuaries and coastal waters.

FAU Harbor Branch is using Land/Ocean Biogeochemical Observatory (LOBO) instrumentation to measure important environmental or water quality parameters in the IRL as part of the Indian River Lagoon Observatory (IRLO). The goal of IRLO is to acquire and disseminate data and knowledge on components of the IRL critical to its ecological function and its sustainable management. In short, we wish to better understand how this unique system works, how we humans impact its natural functions, and how we can make the Lagoon and its resources better for current and future generations. The more we know about the dynamics of the IRL and the effects of human activities on its ecosystem, the better we can protect this irreplaceable natural asset that also serves as an essential engine for Florida's economy. With more than 40 years of Harbor Branch research in the IRL, we are well-positioned to create a long-term, multi-disciplinary, ecosystem-based approach to study and conserve one of Florida's most significant assets.

Three key ingredients of IRLO are:

- Long-term, multi-disciplinary, ecosystem-based approach
- A network of advanced observing stations
- Collaboration among organizations

To be on the cutting edge of scientific innovation, IRLO needs to integrate scientific research with innovative technology development. Data collected by our LOBOs will be directly used by Harbor Branch scientists (and we hope by other scientists from any organization) as part of what we see as a network of observing stations that is in its infancy, not only in the IRL, but also in estuaries and coastal areas in general. This network is not something we can do alone; indeed, collaboration among many individuals and organizations will make the Observatory a reality. Our LOBOs are not an end point, but a beginning and only a part of what we need to do to better understand the science and improve the management of the Lagoon.

LOBO frame with representative sensors, data logger, and battery pack. (http://fau-hboi.loboviz.com/about/)

The LOBO was developed by leading scientists from the Monterey Bay Aquarium Research Institute (MBARI) with competitive funding provided by the National Science Foundation. We selected the LOBO for use in the IRL as this technology has been scientifically proven over time by oceanographers and estuarine researchers to produce the highest caliber needed for oceanographic and coastal data. LOBOs have a national and international presence (in California, Oregon, Delaware, Maine, the west coast of Florida, and Canada) the LOBO units are ideal multi-sensor packages that increase the efficiency of environmental monitoring. LOBOs have the flexibility to substitute or add different sensor instruments as new scientific needs are identified.

Currently we are measuring temperature, salinity, dissolved oxygen, turbidity, CDOM (colored dissolved organic matter, or more simply, water color), chlorophyll (indicative of algae in the water column), nutrients (phosphate, nitrate), and current speed and direction. LOBOs are designed to reduce fouling that rapidly occurs in anything deployed into an estuary, minimize operational and maintenance expenses, and provide real-time and retrospective high-accuracy and high-resolution data via a dedicated interactive website. LOBOs can collect data 24/7 and allow real-time observation of significant events, such as water discharge, algal blooms, and storm events so that researchers can determine how these events are related to ecosystem change. Data from our LOBO units in the IRL will integrate into the nationwide Integrated Ocean Observing System (IOOS) through Southeast Coastal Ocean Observing Regional Association (SECOORA), allowing comparative studies both within Florida and in the nation.

Harbor Branch's first LOBO site is in the Indian River Lagoon, just outside the Harbor Branch Channel.

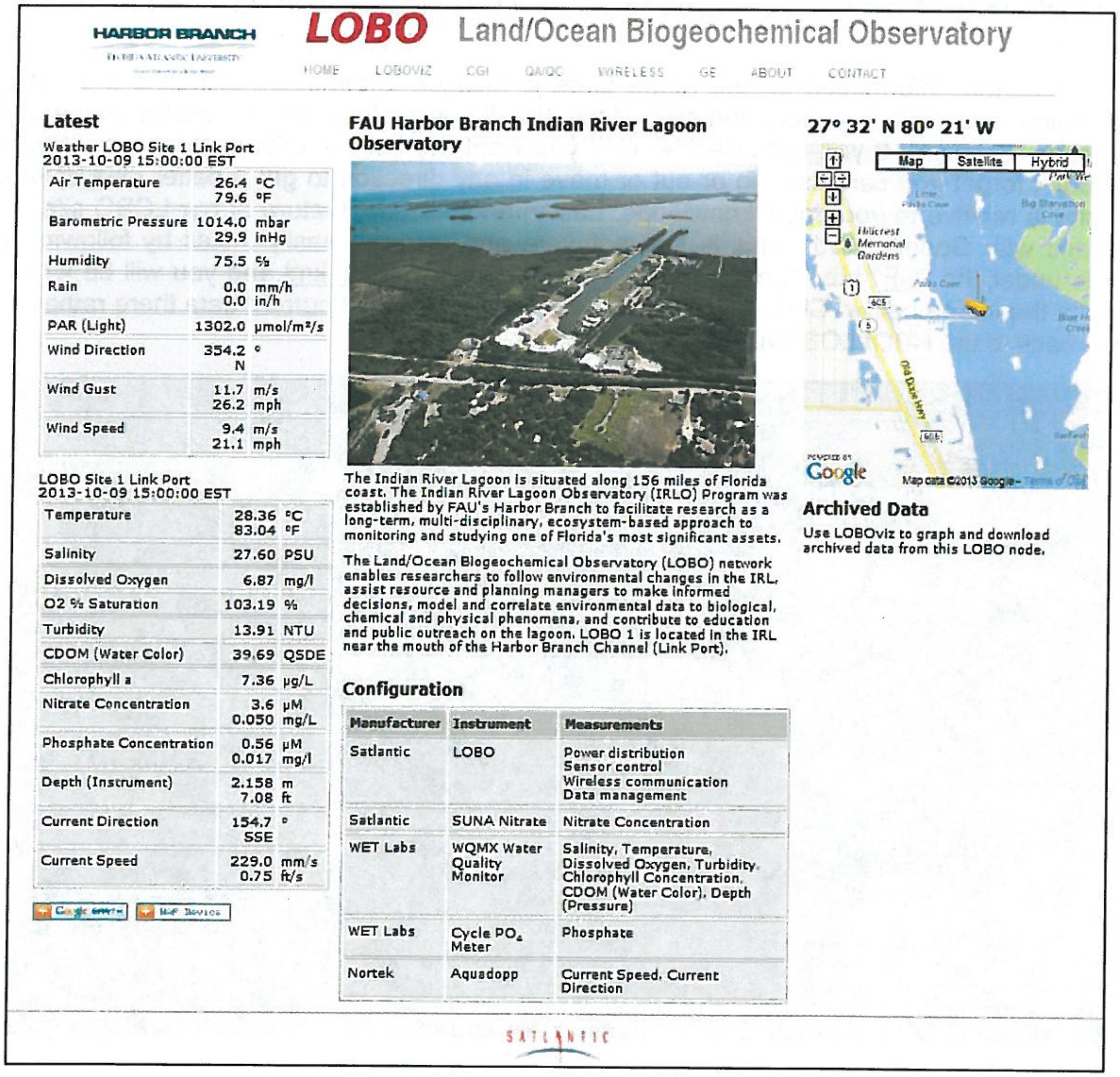
Harbor Branch's first LOBO went live to the public on June 11, 2013. We chose to put this first unit in the IRL just outside Harbor Branch's Channel, near what has historically been called the "Link Port Station" and near some other long-term research sites we are working at. The Link Port site is important in scientific studies of the IRL as its proximity next to Harbor Branch has facilitated long-term research at that site since the 1970's by researchers from many different institutions.

The Link Port LOBO site also has a weather station which allows direct linkage of local weather with water quality data.

The installation and maintenance of the LOBO network is being done by a group of Harbor Branch scientists, engineers, and support staff. The data being collected will be directly used by Harbor Branch researchers and be freely available, at any time, from any computer or mobile device to all who wish to view or use the data – scientists from other institutions, managers of the IRL, educators, students, and the interested public – simply by going to the following website: http://fau-hboi.loboviz.com. With four months of hourly data now available, we invite you to click to that website and begin your explorations of water quality of the Indian River Lagoon!

Part 2 HBOI LOBOviz Home Page: Current Data and Portal for More Information

When you go to http://fau-hboi.loboviz.com (see example below), along the left hand side of the home page you will see all of the most recent readings from our weather station and our sensors below the water:



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LOBO Land/Ocean Biogeochemical Observatory

HOME LOBOVIZ CGI QA/QC WIRELESS GE ABOUT CONTACT

Latest

Weather LOBO Site 1 Link Port
2013-10-09 15:00:00 EST

Air Temperature	26.4 79.6	°C °F
Barometric Pressure	1014.0 29.9	mbar inHg
Humidity	75.5	%
Rain	0.0 0.0	mm/h in/h
PAR (Light)	1302.0	µmol/m²/s
Wind Direction	354.2 N	°
Wind Gust	11.7 26.2	m/s mph
Wind Speed	9.4 21.1	m/s mph

LOBO Site 1 Link Port
2013-10-09 15:00:00 EST

Temperature	28.36 83.04	°C °F
Salinity	27.60	PSU
Dissolved Oxygen	6.87	mg/l
O2 % Saturation	103.19	%
Turbidity	13.91	NTU
CDOM (Water Color)	39.69	QSDE
Chlorophyll a	7.36	µg/L
Nitrate Concentration	3.6 0.050	µM mg/L
Phosphate Concentration	0.56 0.017	µM mg/l
Depth (Instrument)	2.158 7.08	m ft
Current Direction	154.7 SSE	°
Current Speed	229.0 0.75	mm/s ft/s

FAU Harbor Branch Indian River Lagoon Observatory

The Indian River Lagoon is situated along 156 miles of Florida coast. The Indian River Lagoon Observatory (IRLO) Program was established by FAU's Harbor Branch to facilitate research as a long-term, multi-disciplinary, ecosystem-based approach to monitoring and studying one of Florida's most significant assets.

The Land/Ocean Biogeochemical Observatory (LOBO) network enables researchers to follow environmental changes in the IRL, assist resource and planning managers to make informed decisions, model and correlate environmental data to biological, chemical and physical phenomena, and contribute to education and public outreach on the lagoon. LOBO 1 is located in the IRL near the mouth of the Harbor Branch Channel (Link Port).

Configuration

Manufacturer	Instrument	Measurements
Satlantic	LOBO	Power distribution Sensor control Wireless communication Data management
Satlantic	SUNA Nitrate	Nitrate Concentration
WET Labs	WQMX Water Quality Monitor	Salinity, Temperature, Dissolved Oxygen, Turbidity, Chlorophyll Concentration, CDOM (Water Color), Depth (Pressure)
WET Labs	Cycle PO_4 Meter	Phosphate
Nortek	Aquadopp	Current Speed, Current Direction

27° 32' N 80° 21' W

Map Satellite Hybrid

Google

Archived Data

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

SATLANTIC

We report some parameters in two sets of units; one that scientists are more likely to use, while the other is more likely to be used by the public. So, for example, the temperature above on October 9, 2013, at 15:00 Eastern Standard Time was 26.4°C (Celsius) or 79.6°F (Fahrenheit). We use a 24-hour clock, which is the most commonly used time notation in the world: the day runs from midnight to midnight, divided into 24 hours, and indicated by the hours passed since midnight, from 0 to 23. In the U.S., this convention is commonly called "military time", while most of us use the 12-hour clock (with a.m. and p.m.). Scientists, like the military, prefer to use the 24-hour clock in our work to prevent any ambiguity in time. We also often use Standard Time year-round for consistency and to facilitate use of our data by colleagues in other time zones.

Note that you can click on any of the envirnomental parameters and go to a page outside the website which provides information on what that parameter means. For example, click on "Salinity", and you will go to the Wikipedia entry for salinity, and you can read a brief tutorial on salinity: what it is, how we use salinity to classify water bodies, environmental considerations, references, and further reading. More than you might want to know at one time, but this is an opportunity to fine tune your understanding of what these different parameters are and why they are important.

Other important information on the home page is location information, including a short site description, and an aerial photo and map of the site. If you prefer to see a satellite image of the site, click "Satellite". If you can't decide, or if you want the best of both worlds, click "Hybrid"! And don't forget you can zoom in or out or move in any direction to get a better idea of where this site is relative to your local knowledge. Lastly, another cool feature of our LOBO site is its interface with Google Earth. This is free software and you can easily install by following the details under the "GE" tab. Then click http://fau.loboviz.com/0035.kml and you will be whisked away to the image below. Click our icon and you can get our most current data there rather than going back to the HBOI LOBOviz site.

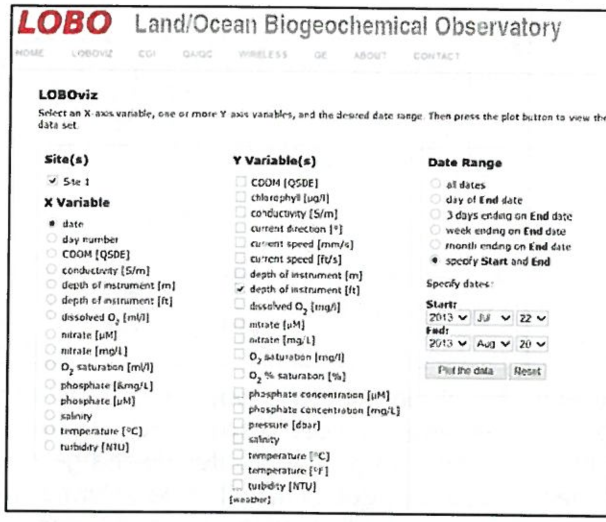
But that is just the start of what you can do with our data. Our home page provides you with current data, but most of us are also interested in patterns and relationships among the different types of data over time. When you are ready, click the next tab at the top (LOBOVIZ) of the home page. Now the fun really begins!

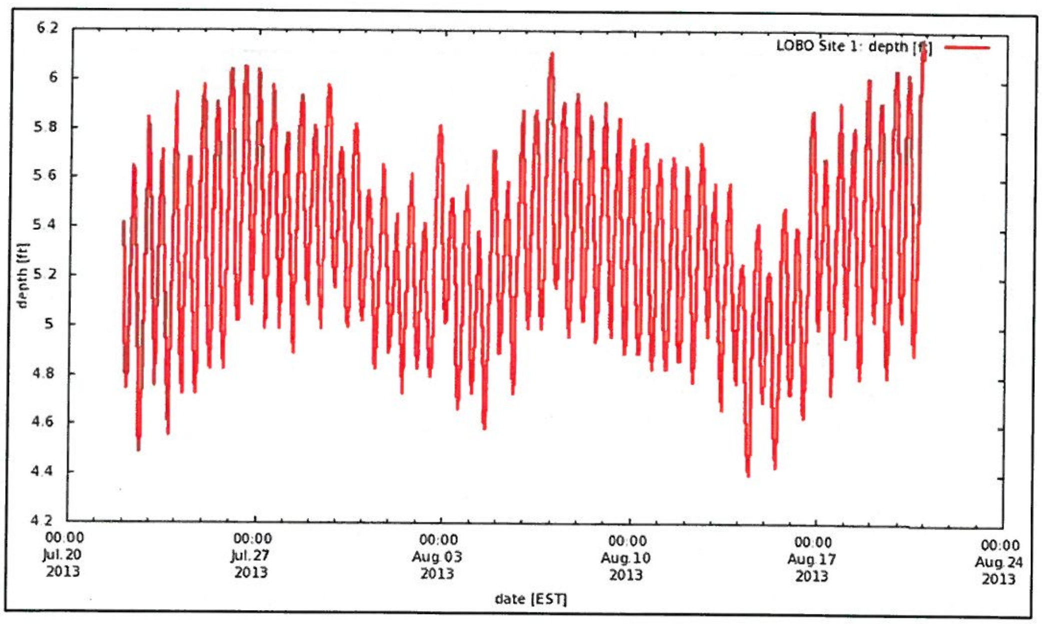
Part 3 Exploring LOBOviz: Tides and Salinity

A significant component of the LOBO system is LOBOviz, a data visualization and display package for an entire network of monitoring sites. This powerful tool allows users to access and view real time or archived data, comparing multiple sensors at a site or multiple sites simultaneously though a simple web interface. This gives system users rapid and easy access to the monitoring network to help make informed decisions.

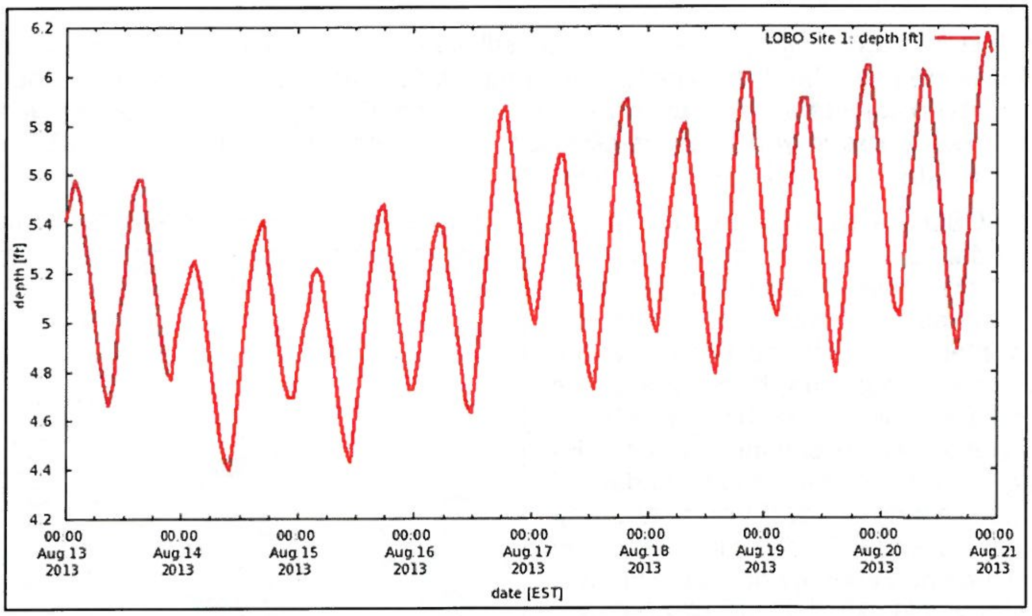
On our Harbor Branch LOBOviz page, you can still see our most recent data records on the left hand side of the page, but the majority of the page is devoted to a list of variables (the various environmental parameters we measure) and provides multiple options for selecting what dates you would like to use in your data visualization. As we add more LOBOs in the IRL, you can select any or all stations to be plotted at one time.

Our first LOBO, near Harbor Branch, is located about five miles north of Fort Pierce Inlet, the largest of the Lagoon's five inlets. That inlet is one of the main reasons that our local waters are so rich with life. Given the dynamic interaction that the tides have on water exchange near the inlets, one of the first questions a user might have is: what is the tidal pattern at this site through time? By selecting "depth of instrument" under "Y Variable(s)", either in feet (ft) or meters (m), and "date" under "X Variable", you can visualize the tide through time over whatever period you would like. For the plot below, I selected depth in feet and the period of July 22 to August 20, one lunar month, from full moon to full month, as tides are primarily linked to the phases of the moon. Then I clicked "Plot the data":

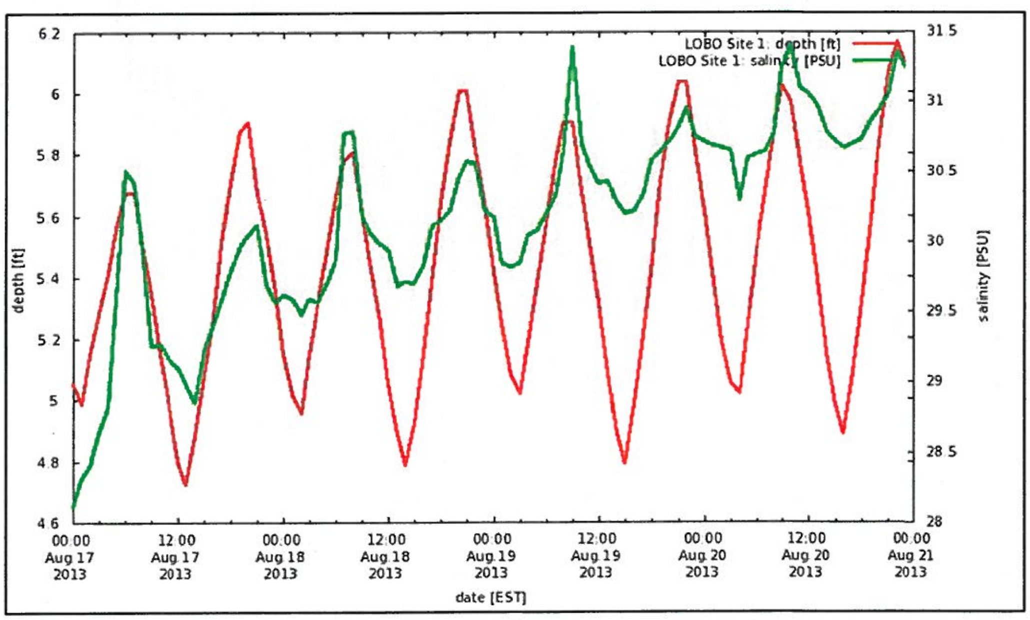




Notice how quickly LOBOviz processes each request! This plot shows exactly how the water level changes at this site and time, including twice-a-day high- and low-water points, the highest amplitude (difference between high and low tide) near full moon and new moon (August 6), and the two tides on a particular day not being exactly equal. This last point is better visualized by taking just the last week of data (so go back to Harbor Branch LOBOviz page and select "week ending on End Date" and set "End" as "2013 Aug 20"):



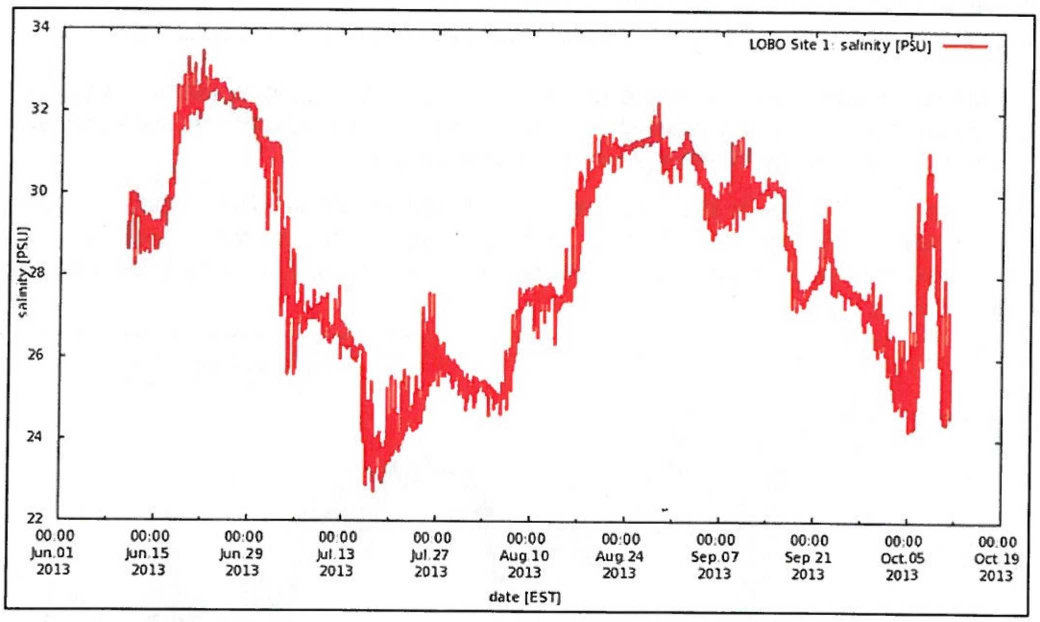
At this site, at high tide, we would expect to see more water flowing from Fort Pierce Inlet. At low tide, we would expect to see more flow from further up the lagoon, specifically Vero Beach, which has three major freshwater discharge canals that drain Indian River County. Thus, we expect to see changes in salinity (the saltiness of the water) as the tide raises and falls. To see the relationship of salinity with tide height, one can add a second Y variable to the visualization, by checking "salinity" as well as "depth of instrument". For this time series, we do see the expected pattern:



Part 4 Exploring LOBOviz: Salinity

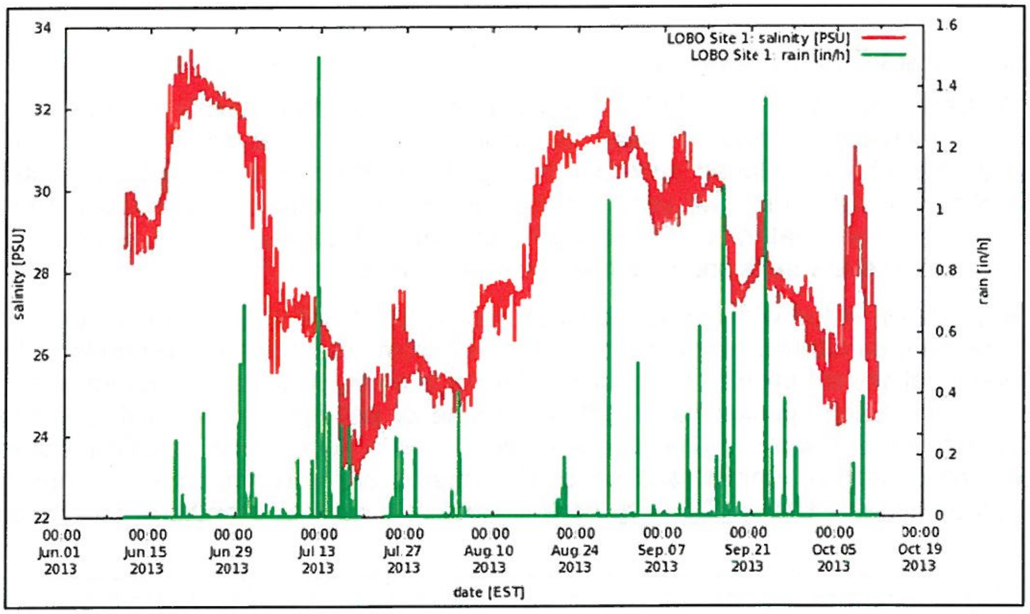
Salinity is the concentration of salt dissolved in water. Salinity traditionally has been expressed as parts per thousand or grams of salt per 1000 grams of water sample (ppt, o/oo). More recently scientists have replaced parts per thousand with PSU (Practical Salinity Units) as the units of salinity, or not even used units, as the definition of the salinity is actually a ratio, thus without units. Ocean water, or full-strength seawater, typically has a salinity of 35-36. Freshwater contains few salts and thus has low salinity (less that 0.5).

In the IRL, salinity varies widely depending on location, time of year, and year to year, being highly dependent on rainfall, evaporation, and run-off from the land in the watershed. The long-term average salinity at Link Port is about 30. Salinity is a very important factor for all organisms living in the IRL. Each species has a different range of salinities for survival and a narrower range for optimal conditions. Some species tolerate wide fluctuations in salinity; others only tolerate small variations. Annual and seasonal patterns are very important in understanding impacts on organisms. Using LOBOviz, here is what our first four months of salinity data look like:



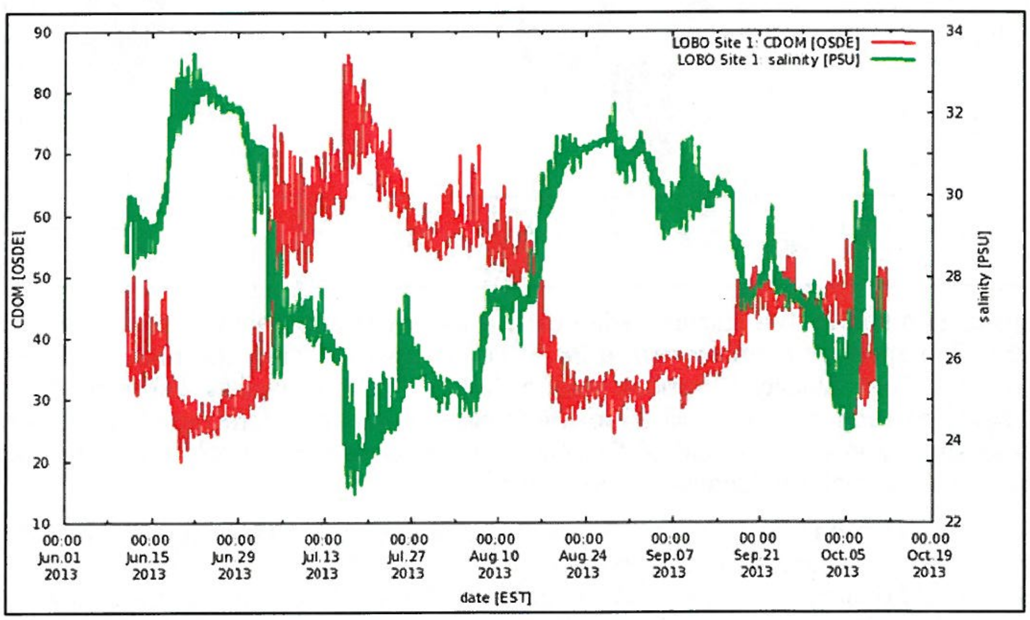
This visualization shows that salinity varied quite a lot at this site, ranging from a low of 23 to a high of 33. The salinity record started at 30, which is approximately the historical average for salinity at Link Port. Salinity increased through June, but then rapidly decreased in July. In August, salinities recover, but declined for most of September, before rapidly increasing, then decreasing sharply in the first part of October. Salinity clearly is an environmental factor that varies quite a lot, at just one location in the Lagoon!

How might we get a handle on what causes these changes in salinity at this site? Since our LOBO station has a weather station, an immediate approach is to look at the pattern of rainfall during this period of time. Rain data can be found by clicking "[weather]" at the bottom of the "Y Variables" on the LOBOviz page and then clicking "rain":



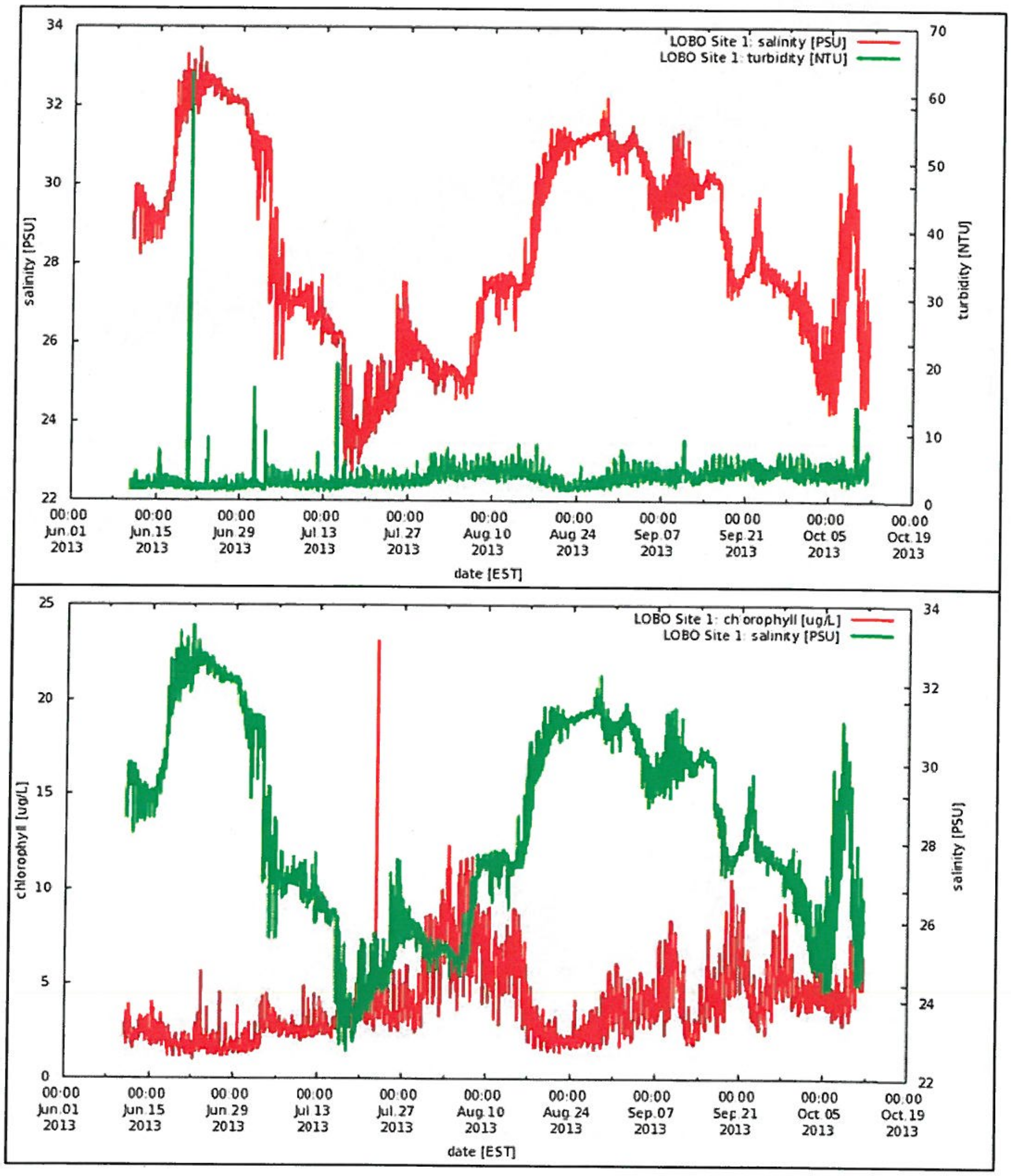
This visualization clearly shows that the drops in salinity are related to rainfall patterns and, by extension, runoff from the IRL's watershed. The more rain and discharge from the watershed, the lower the salinity. Salinity increases when conditions are drier.

Many environmental factors in the IRL are directly tied to salinity (and hence to rainfall and runoff from land). Water color (CDOM) is primarily due to tannins from the natural decay of aquatic and terrestrial vegetation. A plot of water color and salinity vs. time shows a very strong inverse relationship:



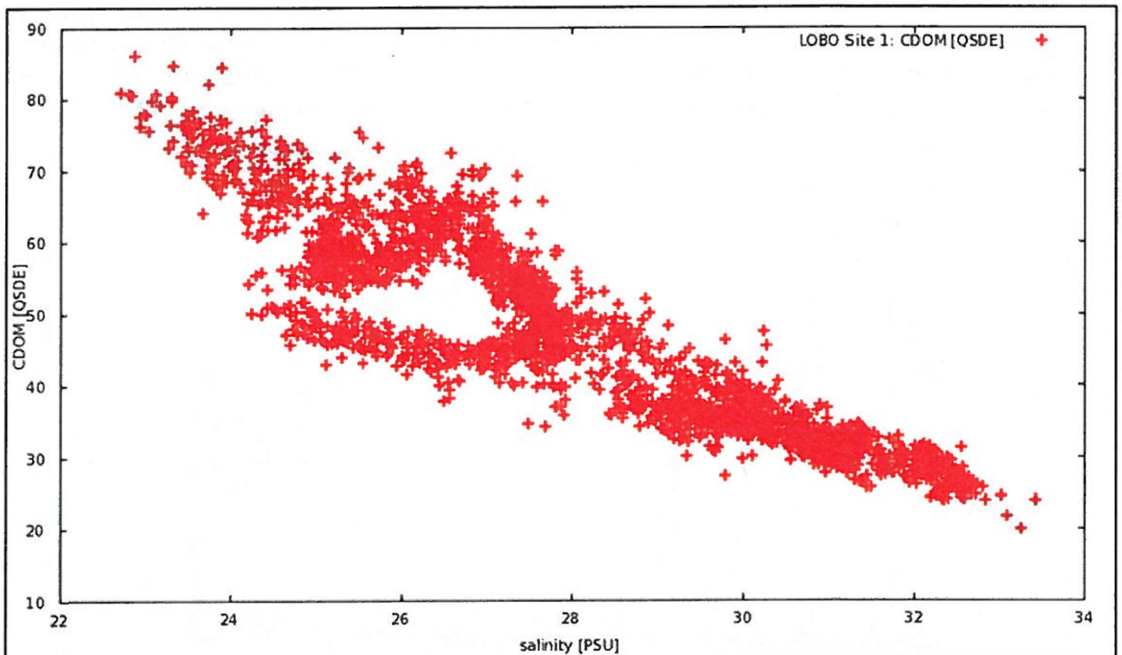
Part 5 Light Attenuators: Turbidity, Water Color, and Chlorophyll

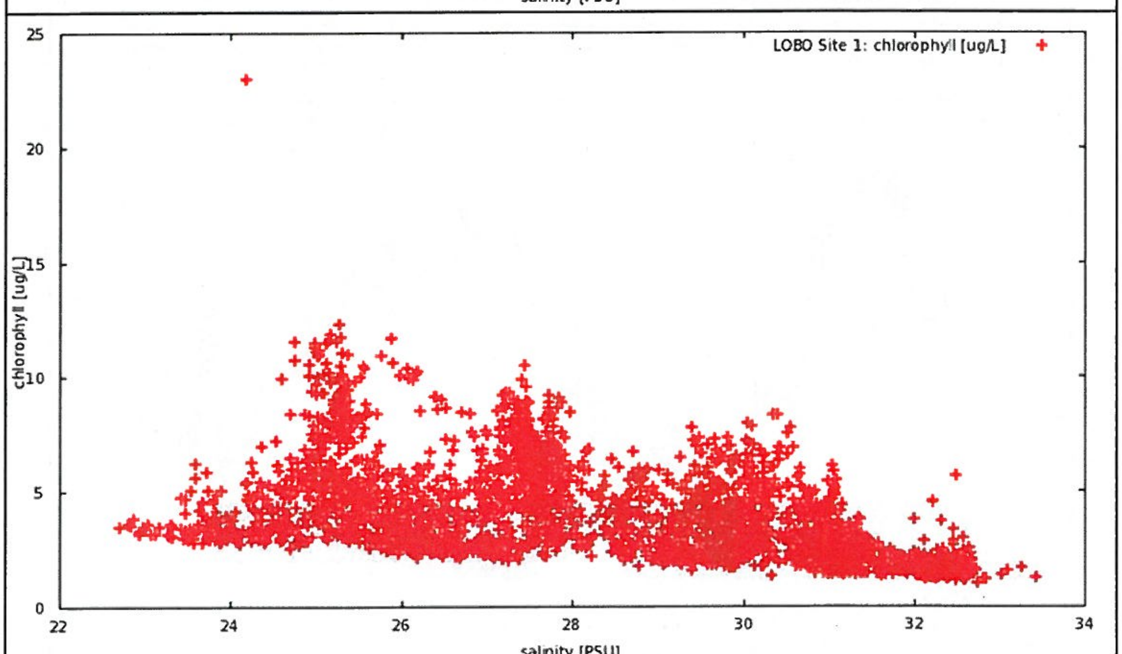
Seagrass is critical to the productivity and biodiversity of the Lagoon. In short, healthy seagrass beds lead to a healthy IRL! Seagrasses have a high light requirement to be healthy and productive. Significant reductions in light negatively impact seagrasses, such as we have seen since 2011 with massive losses of seagrass in the northern half of the IRL. In a Lagoon-wide study 20 years ago, I demonstrated that the water quality factors most responsible for light attenuation to IRL seagrass were (in order of importance): turbidity (suspended particles, that mostly originate from poor land use), water color (previously described), and chlorophyll (algal pigment in the water). Chlorophyll is linked to nutrient levels, especially nitrogen and phosphorus. How are these attenuators related to fresh water inputs? We have already plotted color vs. salinity. Here are LOBOviz visualizations for salinity with turbidity and chlorophyll:



So, for this period of time at this site, there is a nice inverse relationship with chlorophyll (like we saw for water color), but not for turbidity. This suggests that currently fresh water impacts are attenuating light availability by water color and algae in the water column, but not by turbidity.

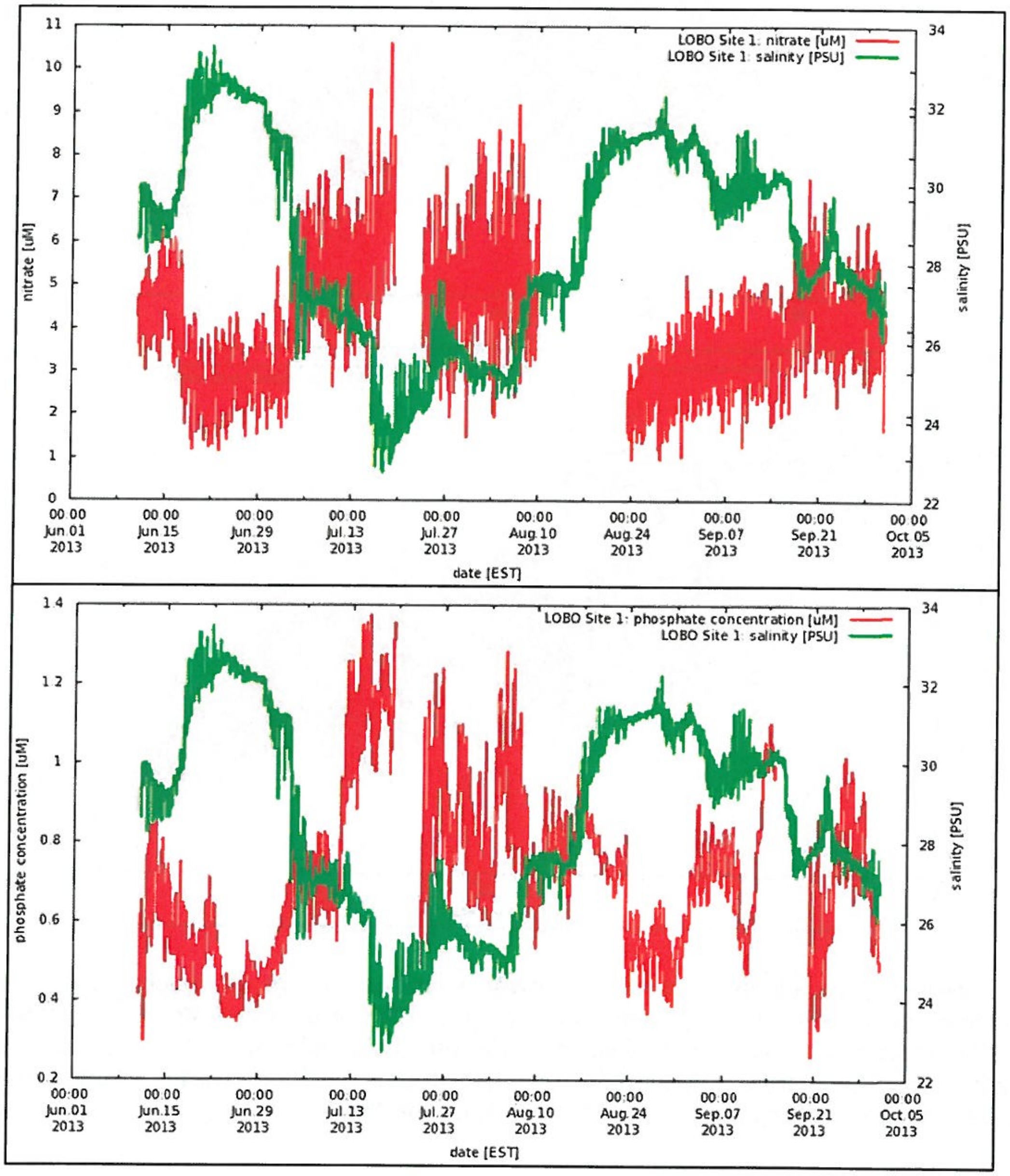
Another use of LOBOviz is to visualize the relationship between two parameters, how is one directly related to the other? For example, for these data on light attenuators, we can take time ("date") out of consideration and plot CDOM ("Y variable") vs. salinity ("X variable"), and then do the same for chlorophyll:



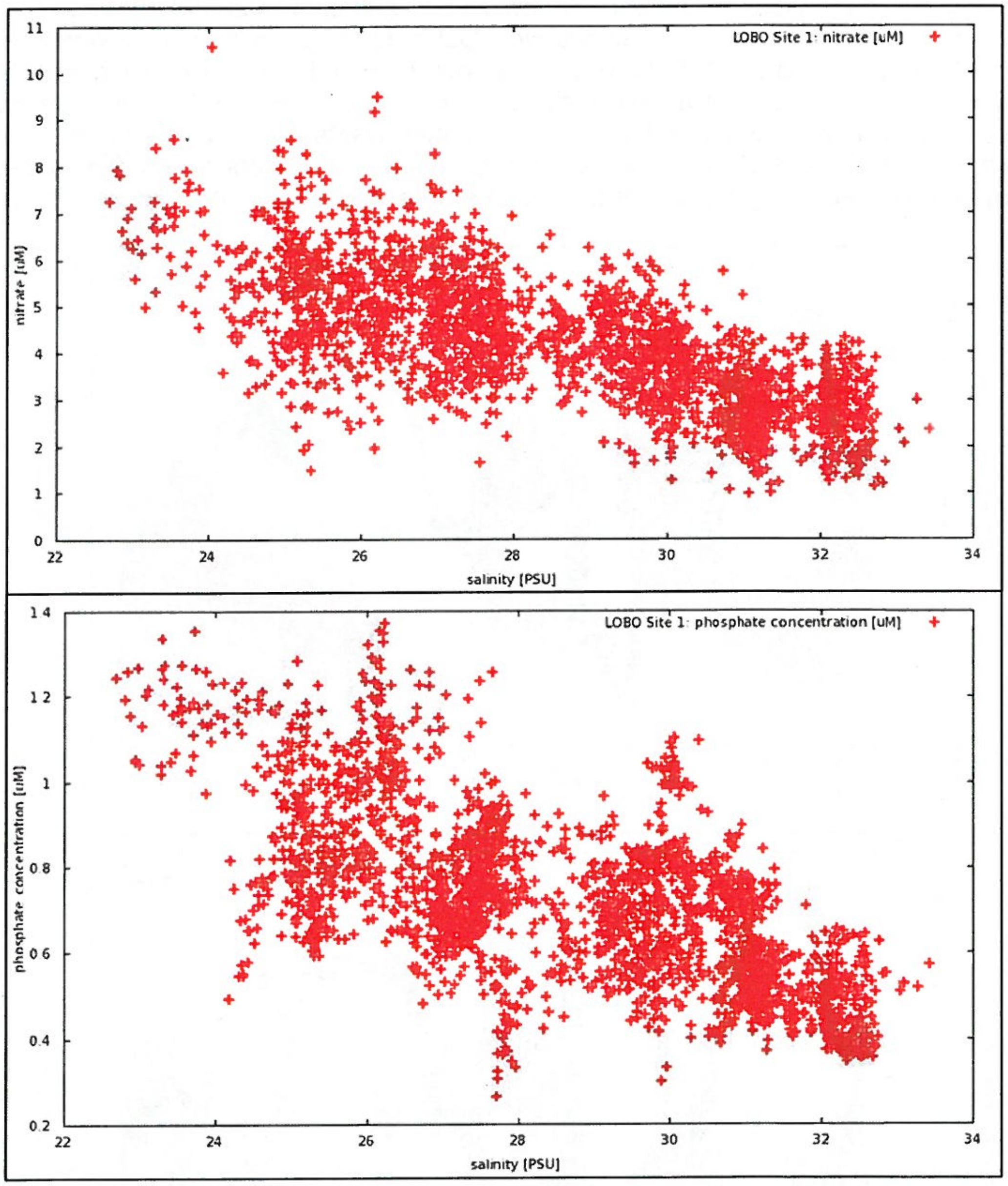


Part 6 Nutrients: Nitrate and Phosphate

All organisms need nitrogen and phosphorus. In estuaries these nutrients are taken up by plants, such as seagrasses and algae. At low levels, nutrients increase productivity. At high levels of nutrients, they can cause excessive algal blooms, such as we experienced in the northern IRL in 2011 and 2012. Estuaries throughout the world are experiencing problems with excessive nutrients, a result of human activities in the watersheds. Sources include too much fertilizer (both by home owners and agriculture), human waste (sewage and septic tanks), and other byproducts of our society. In the IRL, a major source of nutrient enrichment is freshwater discharges. Here are LOBOviz visualizations of nitrate and phosphate with salinity over four months:



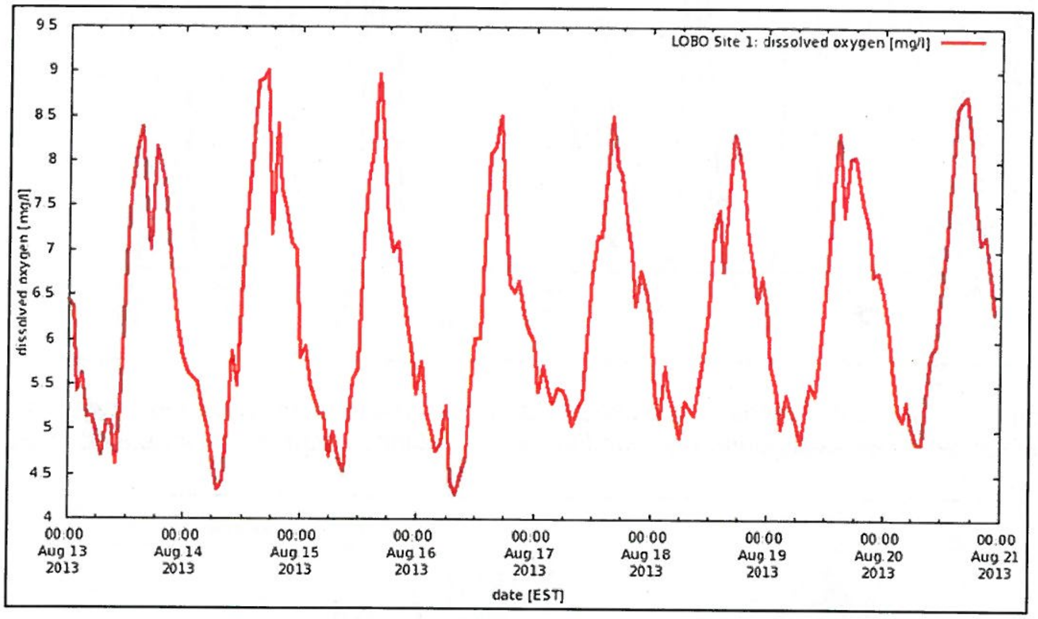
Here are LOBOviz visualizations that show the relationship of nitrate vs. salinity and phosphate vs. salinity:



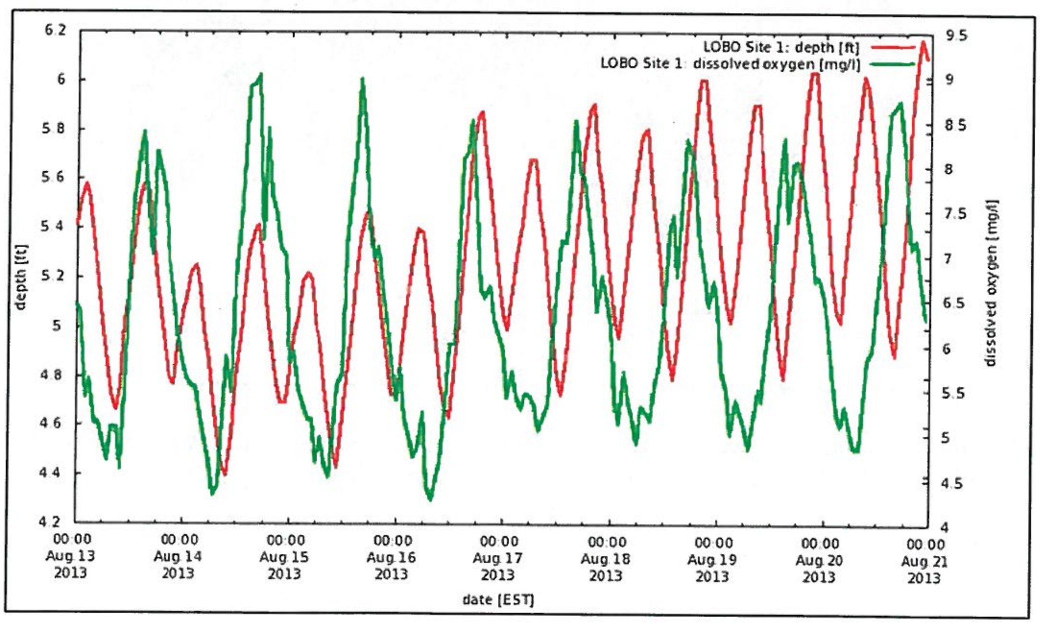
Both nutrients show elevated levels at lower salinities. There is much interest in local communities in reducing nutrient loads into the IRL. This real-time water quality time series using LOBO technology will provide a strong water quality baseline to quantify expected positive improvements in estuarine health following the reduction of freshwater inputs, which are recognized as the most significant human impacts on the IRL.

Part 7 Dissolved Oxygen

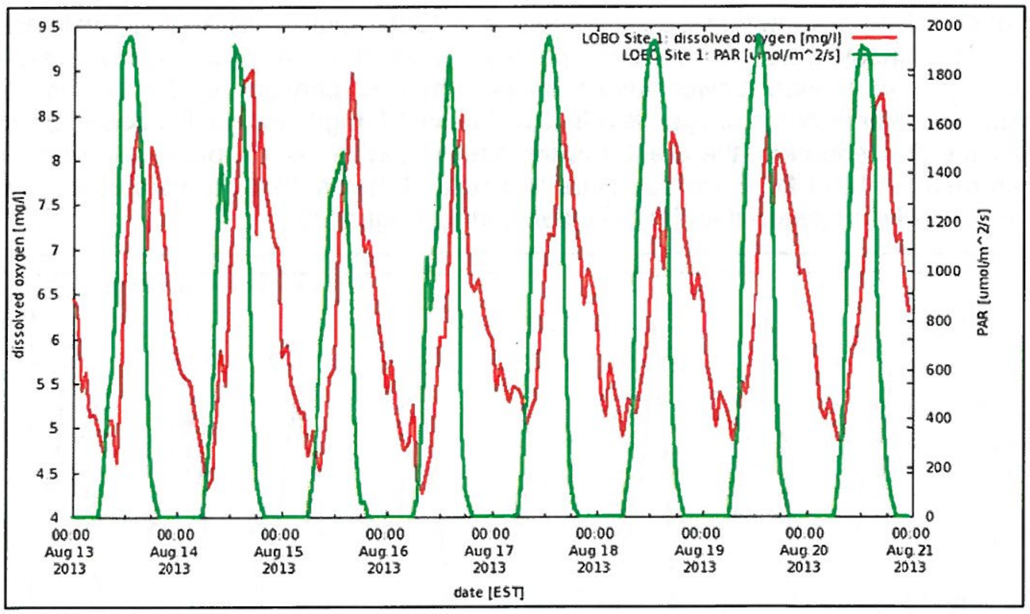
All animals need oxygen to survive. At any given salinity and temperature, there is a certain amount of dissolved oxygen that we expect to see (=100% saturation). Higher levels are due to high levels of photosynthesis, which is the process by which most oxygen is made available to organisms on the planet. Lower levels occur when respiration in the system exceeds photosynthesis. As dissolved oxygen levels drop below 4.0 mg/l, aquatic life becomes stressed. The lower the concentration, the greater is the stress. Oxygen levels below 1-2 mg/l for a few hours can result in fish kills. Each day there is a natural rhythm that occurs as can be seen by plotting the dissolved oxygen data for the week ending August 20:



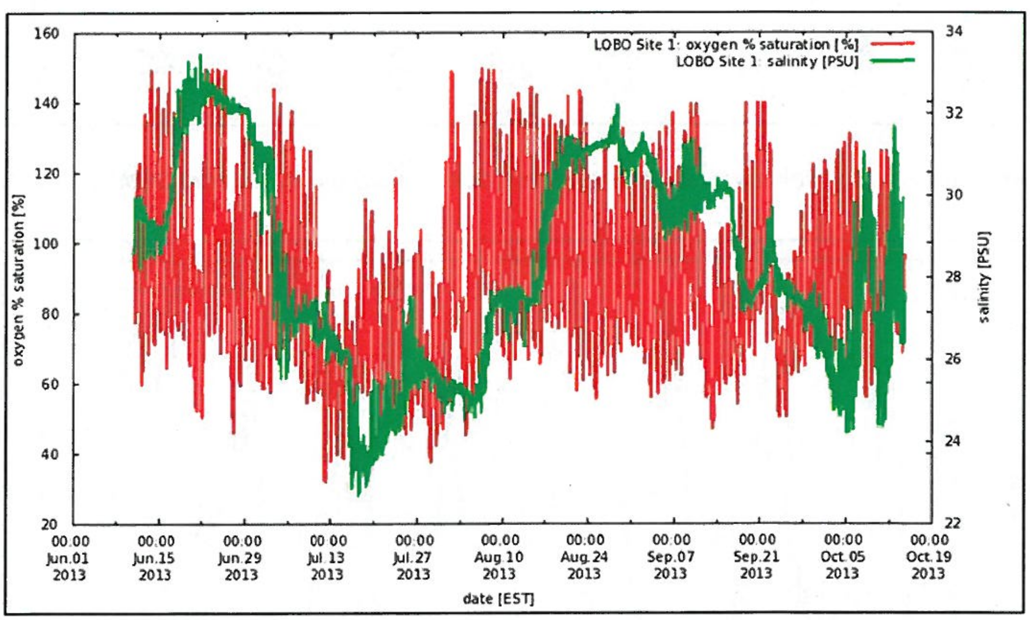
Unlike what we saw for salinity, this pattern is not due to tidal cycle; adding depth to this plot, we see:



Instead dissolved oxygen follows the daily light availability, which we can visualize by plotting "solar radiation" under "[weather]" with the dissolved oxygen data:



A visualization of our 4 months of data shows a strong relationship dissolved oxygen saturation with salinity, with low levels primarily found in the low-salinity water we experienced in July:



This visualization suggests that productivity of the IRL was lower during periods of reduced salinity during July; community respiration was greater than photosynthesis.

Part 8 Concluding Remarks

While four months is a very short time series in a dynamic estuary like the Indian River Lagoon, the above "primer" shows how LOBO technology is making important environmental data available to all users, real time, any time. We hope that you will continue to use our time series to get a better understanding of how the Indian River Lagoon functions and how it is impacted by changes in water quality.

While LOBOviz provides a terrific visualization tool, anyone can download any or all of the available data from any of the graphs, by clicking "Data as text" and saving the file on your computer. Another important feature is our Quality Assurance/Quality Control (QA/QC) program, which you can review by clicking on the "QA/QC" tab on our LOBOviz home page. QA/QC refers to the process or set of processes used to measure and assure the quality of a product (QA) and the process of meeting products and services to consumer expectations (QC). The data made available on this website should be considered provisional for all use. Each year metadata files will be made available to all interested parties.

Working with various partners we will continue to expand our LOBO network of sensors. These capabilities will enable HBOI and other researchers and educators to understand seasonal and long-term variability in water chemistry on the ecosystem functions of the Lagoon. These long-term environmental datasets are needed to observe and predict how these functions are affected by climate change, storms, droughts, and other complex chemical, geological, and biological interactions. In addition, having greatly enhanced, real-time detection of hydrologic and nutrient variability will expand the ability to determine triggers and consequences of acute events (e.g., tropical storms and hurricanes) and help dictate sampling events and experimental designs related to other elements of ecosystem function that might be impacted, such as zooplankton grazing, fish movements, and animal health.

We hope that all interested parties will find our developing network of environmental sensors in the IRL to be useful. To receive metadata information and request any other information, please contact FAU Harbor Branch at: HBOI_IRLO@fau.edu.

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