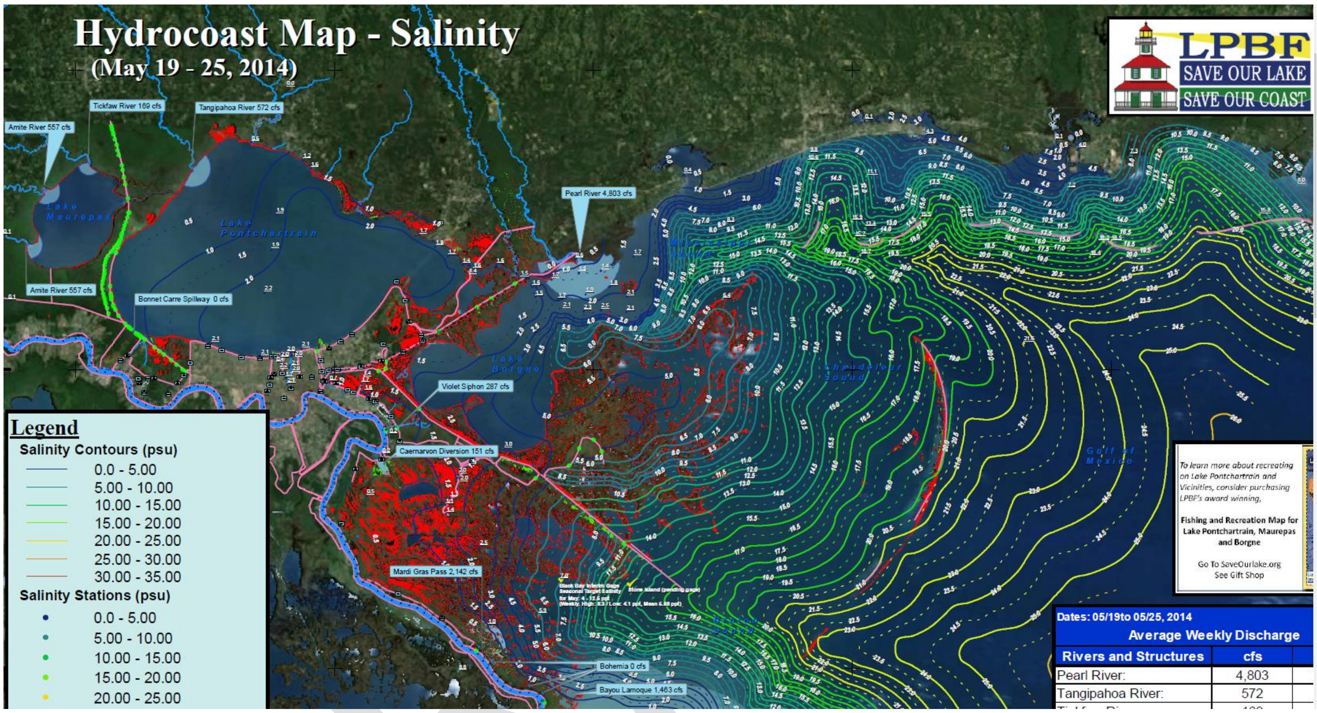
Methodology for Hydrocoast Mapping of the Pontchartrain Basin: 2012 to 2015



May 2015
Lake Pontchartrain Basin Foundation

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LPBF
SAVE OUR LAKE
SAVE OUR COAST
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Introduction

On the Louisiana coast, rainfall and riverine freshwater flows mix with seawater from the Gulf of Mexico, resulting in a coastal estuarine system. This estuarine system also coincides with the extensive deltaic (wetland) plain of the Mississippi River giving rise to Louisiana's valuable "working coast". There are many factors that affect this estuary, such as pollution, fisheries, hydrologic alterations, wetland loss, freshwater inflows, etc. These influences are dynamic and, therefore, the estuary is shifting daily, but it is also undergoing long- term changes. For example, since 1932 these wetlands have been converting to open water at an unnatural and alarming rate, giving rise to Louisiana's coastal wetland crisis.

Understanding all of these natural and anthropogenic influences on the estuary is important for local recreational and commercial fisheries, as well as for restoration scientists who may gain a deeper understanding of how the estuary functions, and its trajectory of change. This report describes the methodology of the program from 2012 to 2015 to produce bi-weekly maps referred to as Hydrocoast maps, which attempt to depict many of these estuarine influences within the Pontchartrain Basin in southeast Louisiana. (Note that many map figures have better clarity when viewed on a computer screen rather than a printed copy. For best map resolution, go to http://saveourlake.org/coastal-hydromap.php.)

Hydrocoast Map Background and Purpose

The distribution of salinity, changes in water quality, and other pertinent information across the Pontchartrain Basin can be monitored to provide a relevant, reasonably accurate, and ongoing assessment of basin conditions. To achieve this goal, the Lake Pontchartrain Basin Foundation (LPBF) developed a program (2012 to the present) which produces a bi-weekly map series that displays isohalines, freshwater discharges, water quality, impairments, fisheries activity, and a variety of estuarine-related information. These maps are called the Hydrocoast products (http://saveourlake.org /coastal-hydromap.php). The purpose for developing the maps was to provide the intended audiences with a snap shot of the condition of the estuary, such as the distribution of saline to fresh water and other relevant factors. The intended audience is the public, but more specifically commercial and recreational fishers, state and federal agency personnel that make restoration decisions, and academics. The goal was for the maps to be useful and functional for a diverse audience. **Figures 1-5** are an example of a single, complete set of the five Hydrocoast maps produced in July 2014. The survey week covered July 7 to 13, 2014.

The bi-weekly Hydrocoast map products and their initial release dates include:

1. Salinity Map - isohalines and freshwater inflows – February 2012
2. Biological Map - fisheries fleets and closures – October 2013
3. Habitat Map - wetland classification & soil salinity – August 2012
4. Water Quality Map - water quality impairments and fecal coliform counts – May 2013
5. Weather Map - cumulative rainfall, wind and tide data – June 2012

Table 1 is from LPBF's website (through 2015) of the archived Hydrocoast maps available and it illustrates the phasing in of the five map series between February 2012 and October 2013.

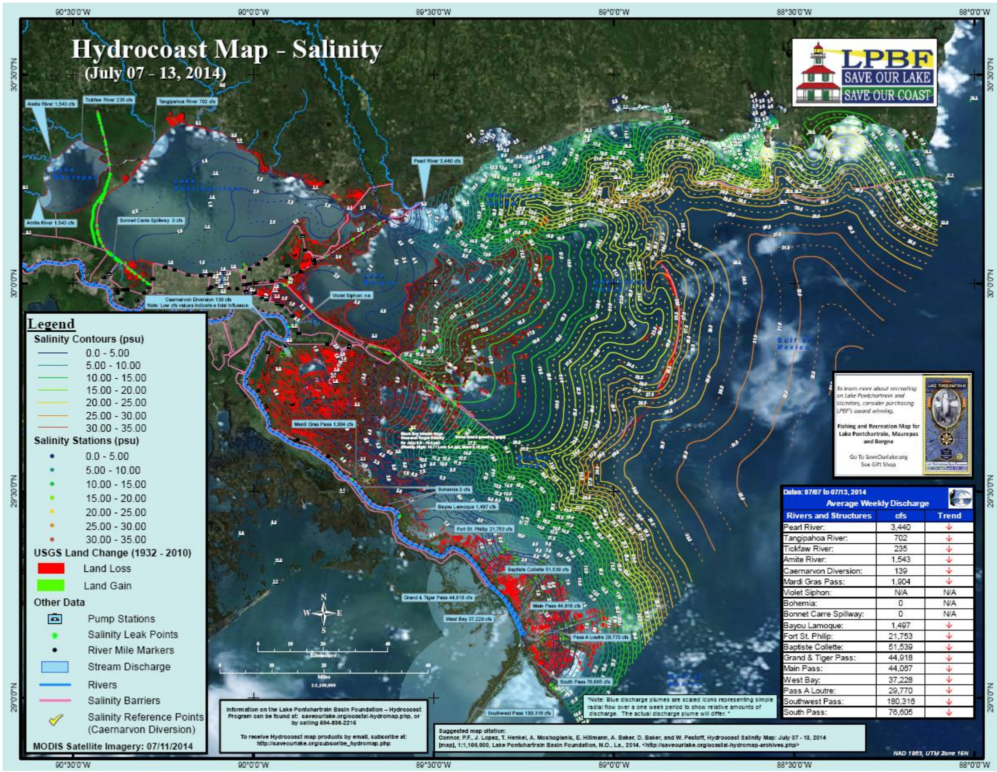

Figure 1: Hydrocoast Salinity Map with isohalines and discharges from survey week July 7 - 13, 2014.

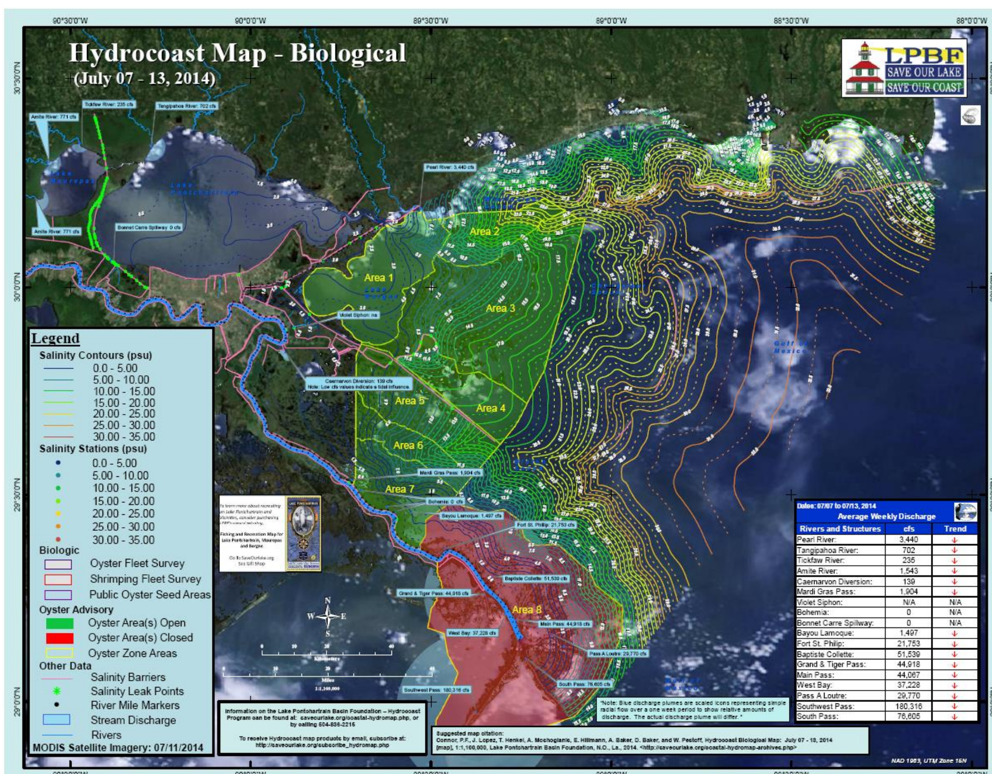

Figure 2: Hydrocoast Biological Map with biological data and isohalines from survey week July 7 - 13, 2014.

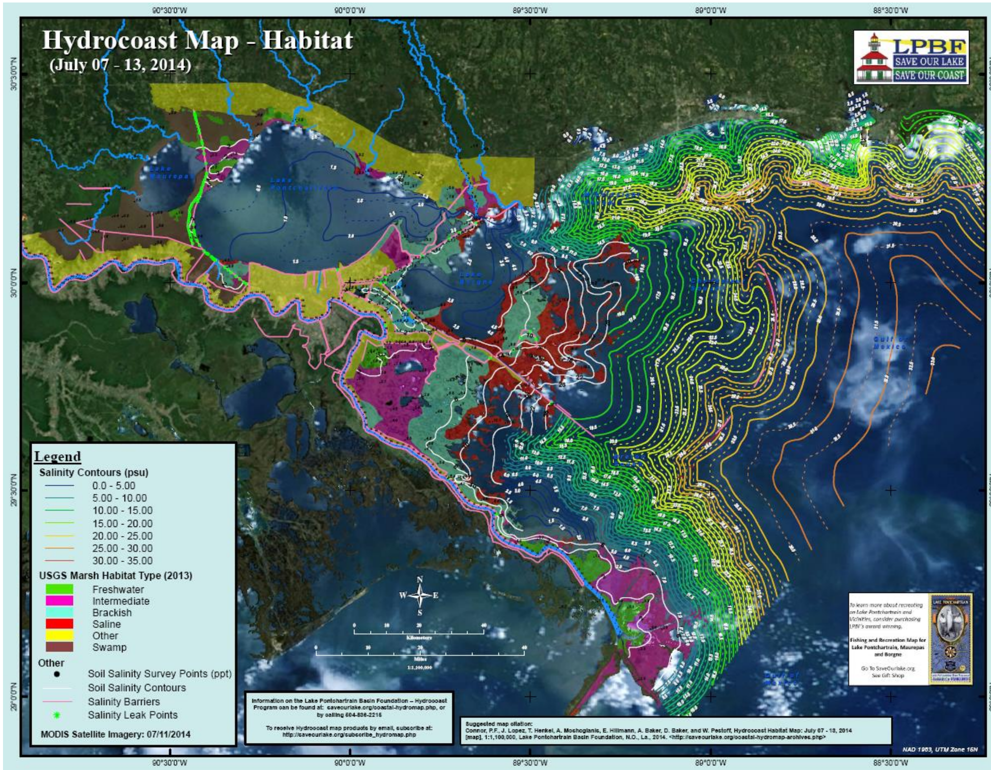

Figure 3: Hydrocoast Habitat Map with wetland habitat types, soil salinity and surface water salinity from survey week July 7 -13, 2014.

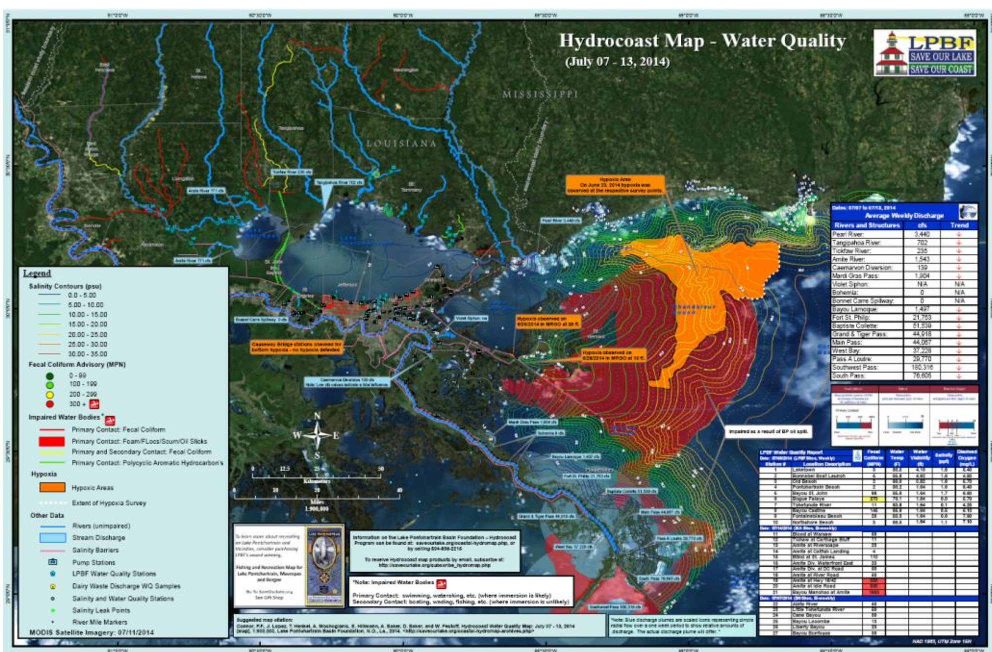

Figure 4: Hydrocoast Water Quality Map with water quality data including impaired water bodies, hypoxia, and bacteria counts from survey week July 7 -13, 2014.

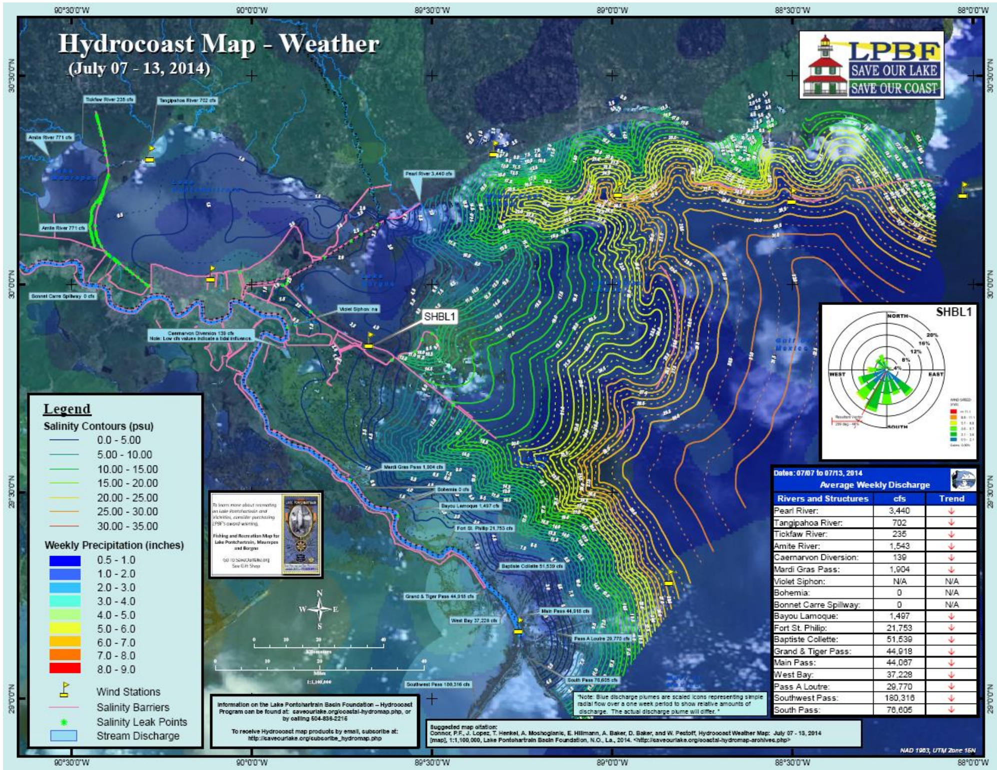

Figure 5: Hydrocoast Weather Map with mapped cumulative rainfall, wind direction and intensity and isohalines from survey week July 7 -13, 2014.

Table 1: LPBF archive of Hydrocoast maps (through April, 2015). Note that it was not until October 2013 that the full five map series was implemented.

DATE	Salinity	Water Quality	Weather	Habitat	Biology	Report
April 26, 2015	Map	Map	Map	Map	Map	Report
April 12, 2015	Map	Map	Map	Map	Map	Report
March 29, 2015	Map	Map	Map	Map	Map	Report
March 15, 2015	Map	Map	Map	Map	Map	Report
March 01, 2015	Map	Map	Map	Map	Map	Report
February 15, 2015	Map	Map	Map	Map	Map	Report
February 01, 2015	Map	Map	Map	Map	Map	Report
January 18, 2015	Map	Map	Map	Map	Map	Report
January 04, 2015	Map	Map	Map	Map	Map	Report
December 07, 2014	Map	Map	Map	Map	Map	Report
November 23, 2014	Map	Map	Map	Map	Map	Report
November 09, 2014	Map	Map	Map	Map	Map	Report
October 26, 2014	Map	Map	Map	Map	Map	Report
October 12, 2014	Map	Map	Map	Map	Map	Report
September 28, 2014	Map	Map	Map	Map	Map	Report
September 14, 2014	Map	Map	Map	Map	Map	Report
August 31, 2014	Map	Map	Map	Map	Map	Report
August 17, 2014	Map	Map	Map	Map	Map	Report
July 27, 2014	Map	Map	Map	Map	Map	Report
July 13, 2014	Map	Map	Map	Map	Map	Report
June 29, 2014	Map	Map	Map	Map	Map	Report
June 08, 2014	Map	Map	Map	Map	Map	Report
May 25, 2014	Map	Map	Map	Map	Map	Report
May 11, 2014	Map	Map	Map	Map	Map	Report
April 27, 2014	Map	Map	Map	Map	Map	Report
April 13, 2014	Map	Map	Map	Map	Map	Report
March 30, 2014	Map	Map	Map	Map	Map	Report
March 16, 2014	Map	Map	Map	Map	Map	Report
March 02, 2014	Map	Map	Map	Map	Map	Report
February 16, 2014	Map	Map	Map	Map	Map	Report
February 02, 2014	Map	Map	Map	Map	Map	Report
January 19, 2014	Map	Map	Map	Map	Map	Report
January 05, 2014	Map	Map	Map	Map	Map	Report
December 08, 2013	Map	Map	Map	Map	Map	Report
November 24, 2013	Map	Map	Map	Map	Map	Report
November 10, 2013	Map	Map	Map	Map	Map	Report
October 27, 2013	Map	Map	Map	Map	Map	Report
October 13, 2013	Map	Map	Map	Map	Map	Report
September 29, 2013	Map	Map	Map	Map	n/a	Report
September 15, 2013	Map	Map	Map	Map		Report
September 1, 2013	Map	Map	Map	Map		Report
August 18, 2013	Map	Map	Map	Map		Report
August 4, 2013	Map	Map	Map	Map		Report
July 21, 2013	Map	Map	Map	Map		Report
June 23, 2013	Map	Map	Map	Map		Report
June 9, 2013	Map	Map	Map	Map		Report
May 26, 2013	Map	Map	Map	Map		Report
May 12, 2013	Map	None	Map	Map		Report
April 14, 2013	Map	None	Map	Map		Report
March 24, 2013	Map	None	Map	Map		Report
March 3, 2013	Map	None	Map	Map		Report
February 4, 2013	Map	None	Map	Map		None
January 10, 2013	Map	None	Map	Map		None
December 13, 2012	Map	None	Map	Map		None
October 23, 2012	Map	None	Map	Map		None
August 13, 2012	None	None	Map	Map		None
July 16, 2012	None	None	Map	None		None
February 22, 2012	Map	None	None	None		None

Hydrocoast maps are provided online for free, to provide the general public or agency officials with continuous access to information about the condition of the Lake Pontchartrain Basin and estuary. Commercial and recreational fishers can use the maps to understand and predict the movement of commercial and recreational species. Coastal scientists who regulate or construct restoration projects are provided with a continuous baseline condition of the estuary that may affect coastal restoration planning or management. The cumulative Hydrocoast maps also become the basis for historical change analysis of the basin that might be related to natural or anthropogenic drivers on the estuary's condition. Such analysis will provide fresh insights into the physical and biologic function of the Pontchartrain Basin estuary.

Pontchartrain Basin

The Pontchartrain Basin, in southeastern Louisiana, is 10,000 square miles including 6,000 square miles of estuary and 4,000 square miles of upland. The Basin includes portions of 16 Louisiana parishes and four Mississippi counties and is one of the largest estuaries along the Gulf coast (Penland et al. 2002). Lake Pontchartrain is 620 square miles and is a shallow body of water, where there is a mix of freshwater from the Blind, Amite, Tickfaw, Tangipahoa and Tchefuncte Rivers and Bayous Lacombe, Bonfouca, Liberty, Cane, Castine and Chinchuba and saltwater entering the estuary through Rigolets and Chef Menteur Passes (**Figure 6**). The Lake Pontchartrain Basin is comprised of two sub-basins. The northern portion is the Lake Pontchartrain sub-basin and includes Lake Pontchartrain, Lake Borgne , the Biloxi Marshes, and Chandeleur Sound. The southern portion is the Breton Sound sub-basin and includes the Caernarvon Diversion and Breton Sound. Estuaries are important environments that many commercially and recreationally important species live in or use during some part of their life cycle. For many species, the estuary acts as a nursery where juvenile life stages feed and find refuge from predators (Beck et al. 2003). In addition, many other forms of wildlife, such as birds and mammals, use or live in the estuary to take advantage of the tremendous productivity.

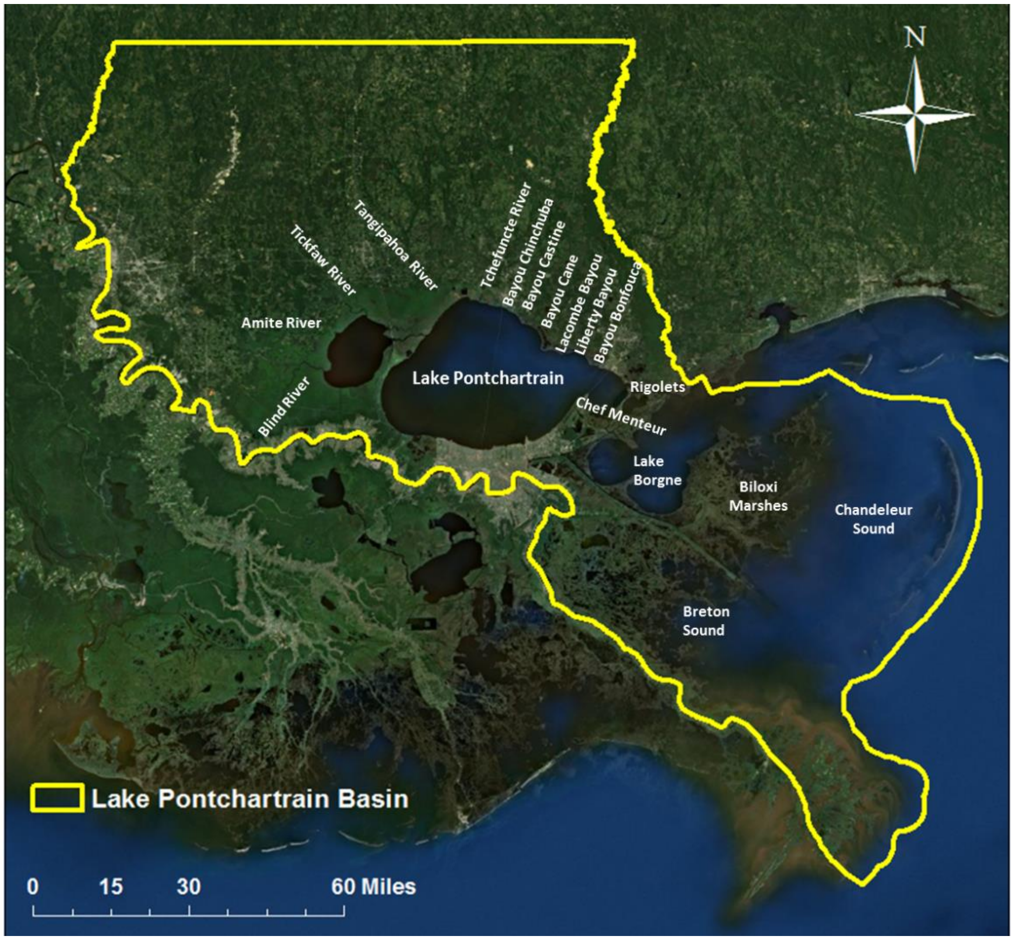

Figure 6: Map of the Lake Pontchartrain Basin with rivers, bayous and major passes.

Methods for Producing the Hydrocoast Map Series

Hydrocoast Work Flow

The original purpose of Hydrocoast was to provide a real-time snapshot of the hydrology and water quality conditions of the Pontchartrain Basin. Because of the work-effort and work-flow necessary to develop the maps, Hydrocoast maps are neither a perfect snapshot nor an instantaneous "real-time" release of the monitored conditions (see the Hydrocoast work flow illustrated in **Figure 7).**

"Week 1" is our survey week, and therefore, Hydrocoast represents week-long conditions of the basin during this week and is represented as a single set of conditions. That is, a Hydrocoast map represents average weekly conditions measured during this seven day time frame. The "snapshot" is therefore not an instant in time. The alternating "Week 2" is the mapping week, in which data are mapped through GIS. Since this work takes several days, the maps lag behind the end of the survey week by six to ten days. Data collected at the beginning of the survey week would have been acquired as much as sixteen days prior to the time of the Hydrocoast release. Therefore the maps are not perfectly real-time, but are current enough to be useful.

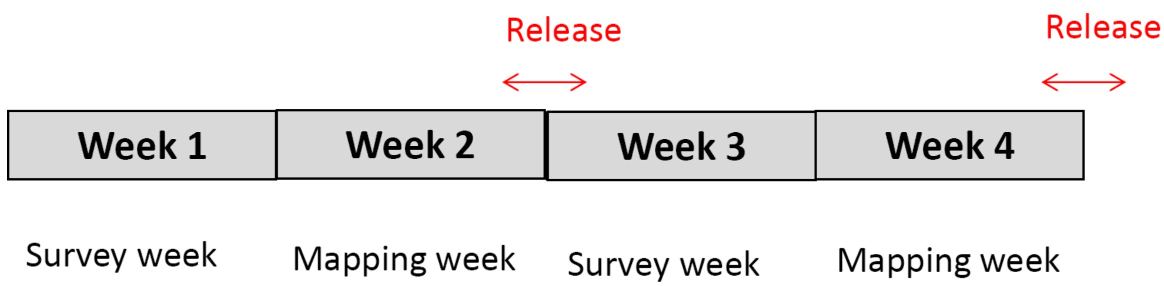

Figure 7: Hydrocoast workflow illustrating the typical lag between Hydrocoast release in "Mapping week" and data acquisition during "Survey week."

Sources of Hydrocoast Data

Data used for Hydrocoast are from internal and external sources. External data is, in almost all cases, from offical state or federal programs. Data generated internally are collected by professional scientists and stored in an ArcGIS geodatabase. In all cases, only data deemed credible and available real time are utilized. Sources of external and internal data and the types of data extracted from those sources are listed below. These data sets are decribed in more detail in the following sections.

External Data

1. USGS – Surface Salinity, wetland vegation types, gauging stations for stream/river/ diversion discharges
2. NOAA –Surface salinity, wind and rainfall
3. MODIS – Background imagery
4. NASA - Thematic mapper satellite imagery
5. Local levee boards - pump stations, Violet siphon, operational schedules
6. EPA - 305b/303d human health water body impairments for swimming, recreation and fisheries
7. Louisiana Wildlife and Fisheries - oyster leases and seed grounds
8. Department of Health and Hospitals - fishery closures

Internal/LPBF data

1. Surface salinity using standard YSI intruments
2. Soil salinity using soil sippers and standard YSI intruments
3. Solicitation of retail seafood prices
4. Aerial reconnasiance mapping of shrimp trawling and oytster fleet activity
5. Predicted discharge using discharge rating curves
6. Hydrologic barrier and leak points mapping using topography, LIDAR, and field experience
7. Bacterial counts from LPBF's established water quality program
8. Hypoxia mapping for Chandeleur and Breton Sound

Hydrocoast Map Components

Below is **Table 2** which summarizes the different Hydrocoast Map components and which maps they appear on. Each of these components are described in detail below.

Table 2: The five Hydrocoast Maps and the different components that appear on each map.

	Map Components														
	Basemap	Surface Salinity Contours	Hydrologic Barriers and Leak Points	Freshwater Discharge Icon	Land Loss	Aerial Fishing Fleet Surveys	Fishieries Management	Fisheries Impairments	Retail Seafood Prices	Wetland Habitat Type	Soil Salinity	Water Quality Impairments	Cumulative Rainfall	Wind	Hypoxia, Algal Blooms, Spills, Etc.
Salinity Map	*	*	*	*	*										
Habitat Map	*	*	*							*	*				
Weather Map	*	*	*	*									*	*	*
Water Quality Map	*	*	*	*								*			
Biological Map	*	*	*	*		*	*	*	*						

Basemap Composition

The Hydrocoast basemap is composed of two remotely sensed images; satellite data for the land areas and Moderate Resolution Imaging Spectroradiometer (MODIS) imagery for the water areas. The land/water classification is taken from USGS analysis (Couvillion et al. 2011). Any area classified as land by the USGS is presented on the base map thematic mapper image from January 22, 2010 (**Figure 8A**). This land image is static on all of the Hydrocoast maps. The areas classified by the USGS as water are presented as MODIS images that were acquired during each survey week of Hydrocoast and therefore change every time maps are released (**Figure 8B).** MODIS imagery is collected daily, and has various image processing algorithms. LPBF's GIS specialist reviews available MODIS imagery for the current survey week and selects an image that provides the best cloud-free image of the water surface. The GIS specialist and coastal geologist also screen the MODIS imagery for tell-tail signatures of discharge plumes. The final basemap is a composite of the two sets of images (**Figure 9**)**.**

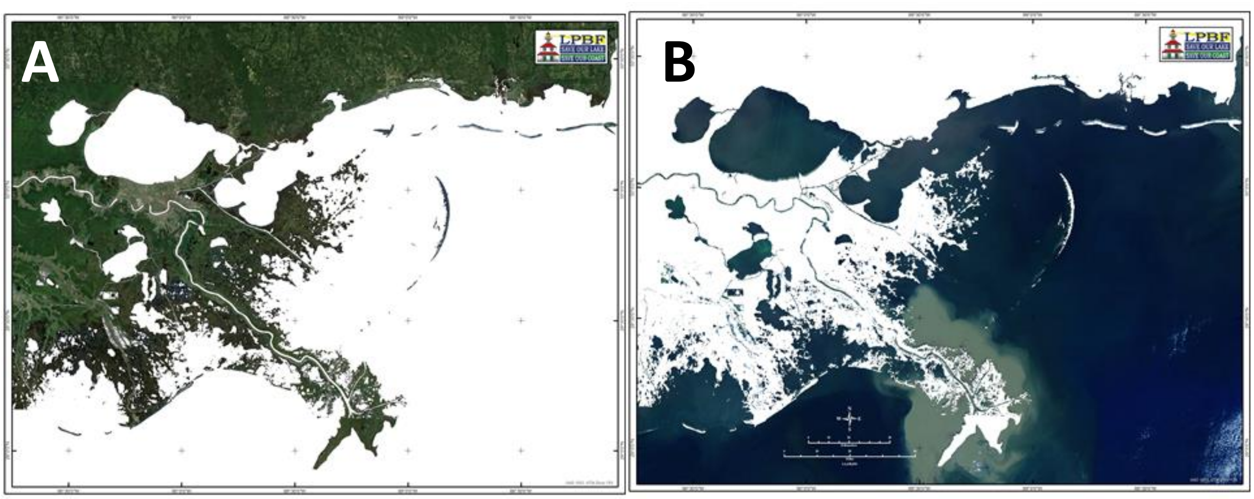

Figure 8: The two images that are merged to create a Hydrocoast base map. (A) January 22, 2010 satellite image for land area classification which is used on all Hydrocoast maps and (B) MODIS image selected for April 23, 2014 for the water area classification.

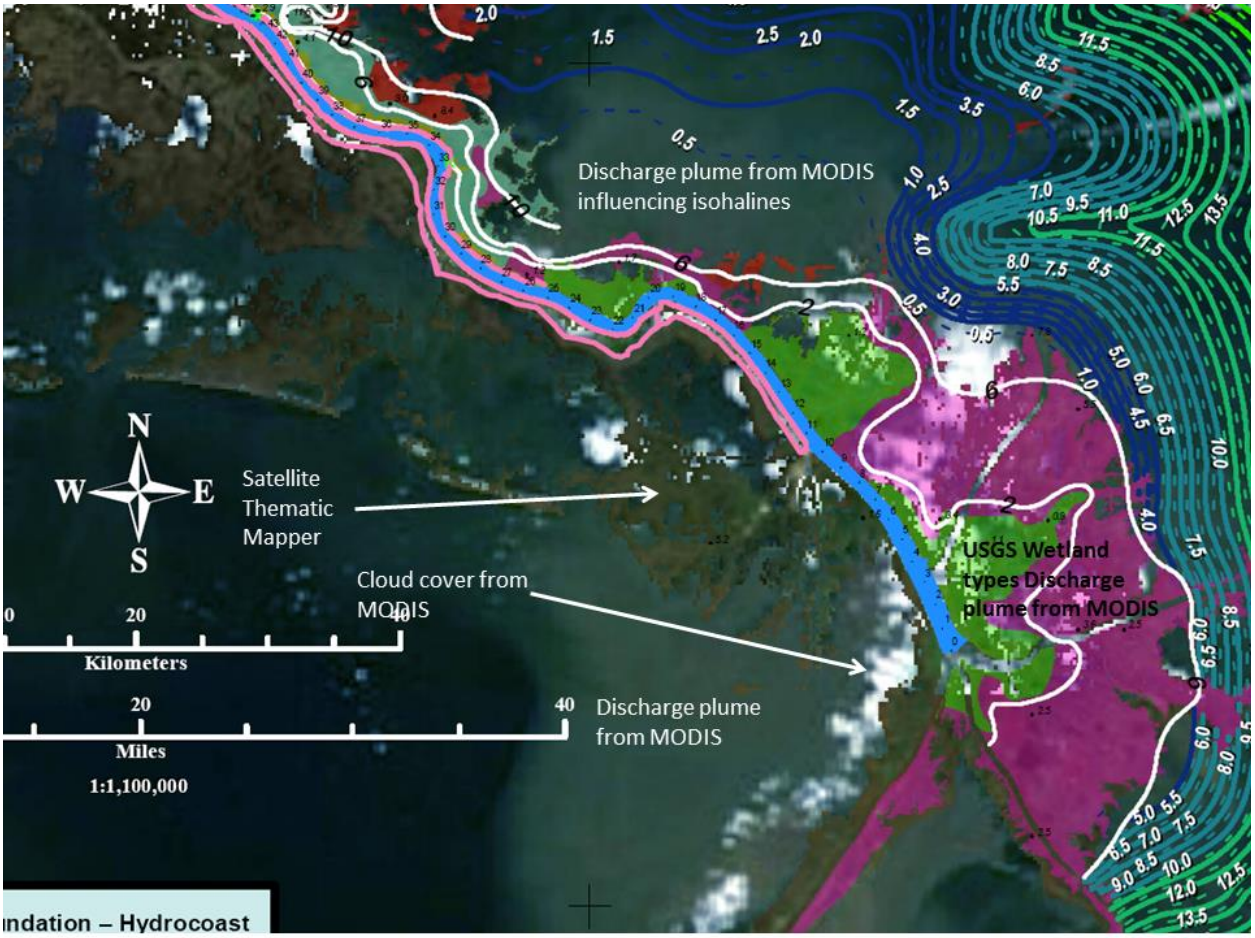

Figure 9: Hydrocoast map of Survey week of June 2- 8 and released approximately June 15, 2014: MODIS water imagery was acquired June 6, 2014. Satellite land imagery was acquired January 22, 2010, Wetland vegetation type mapping was conducted in 2013 (USGS). Note the discharge plumes emanating from the Mississippi River. (Note many map figures have better clarity viewing on a computer screen)

Data Appearing on Multiple Maps

Surface Water Salinity Contours

The surface salinity contours appear on all maps. Contours are created using salinity data from fixed stations and from supplemental data collected by LPBF. Isohalines are manually delineated by LPBF's coastal geologist using GIS software. Downloaded and sampled data are used to adjust the previous week's isohalines to reflect the latest survey week conditions. Below is a description of how the salinity data from both the fixed stations and the supplemental data is collected and used to draw salinity contours.

Surface Water Salinity Data - Station Salinity Data

Approximately 60 fixed hydrologic stations are used as water surface salinity control points for isohaline generation. LPBF uses a custom Python script to download salinity data for approximately 40 USGS and 20 NOAA stations (**Appendix 1**). The collected raw salinity data is sorted, processed, and then imported into a GIS point layer for mapping. Several hydrologic stations along the coast in Mississippi are included as they are critical to interpreting salinity patterns in nearby Louisiana waters. Fixed-station continuously recorded data is served online as either hourly or daily. After download, the data for the survey week is averaged. These salinity averages and other information are used to generate the isohalines. On occasion, when LPBF collects additional salinity data on a specific day within the survey week, downloaded station data will be averaged on a daily rather than weekly basis, corresponding to the LPBF collection day. Isohalines drawn using those averages will represent salinity patterns for that week on the Hydrocoast maps.

Surface Water Salinity Data - LPBF Supplemental Salinity Data

LPBF collects salinity data every survey week. This data is collected at one point in time, in contrast to the continuous gauge data described above. Every Hydrocoast survey week, salinity data is collected by road access (**Figure 10**). These samples are collected along the Causeway Bridge, the Triangle Wetlands adjacent to the 9th Ward, Paris Road, St. Bernard Highway and Delacroix Highway. The road salinity survey includes 13 points. Less frequently, LPBF conducts more extensive sampling from a boat in order to supplement the real-time gauge data. YSI instruments (YSI 2030, Pro Plus) are used to collect salinity values. Surface water salinity measurements are taken approximately 1 foot below the water surface. The supplemental salinity runs provide a finer depiction of the dynamics of the surface salinity, and help delineate more accurately the patterns of salinity movement. In general, two on-water runs are conducted: one at the northern end of the Basin and one at the southern end (**Figure 10**). The northern salinity run covers parts of Lake Borgne, Mississippi Sound, Chandeleur Sound and the Rigolets and Chef Menteur Passes. Depending on weather, all or part of this salinity run is conducted. There are a total of 53 sampling stations along the northern route but usually a subset of approximately 30 points is sampled on any particular run. The southern salinity run covers parts of the Central Wetlands, MRGO, Lake Borgne, Bayou la Loutre, Eloi Bay and Breton Sound. There are a total of 41 sampling stations along the southern route. Most of these points are surveyed on every run as this route is less weather dependent. Also, if LPBF scientists are in the field for other projects during a Hydrocoast data collection week then they will gather surface salinity data in the area where they are working for the Hydrocoast map.

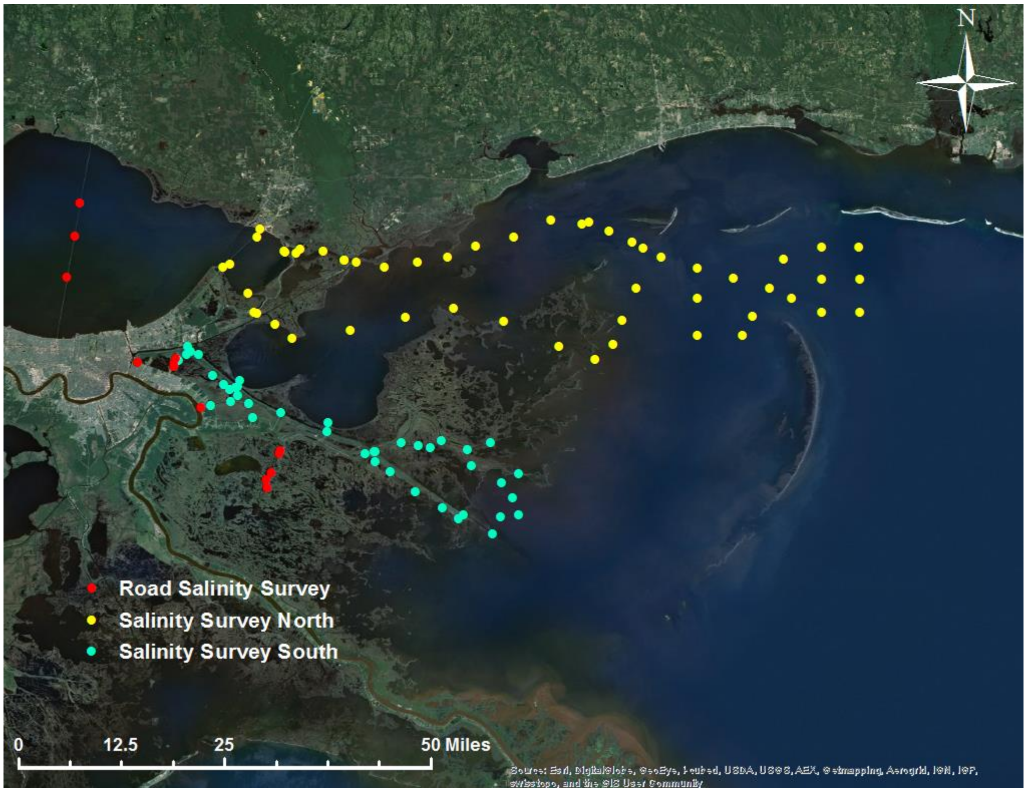

Figure 10: Location of salinity surveys that are conducted to supplement the real-time gauge data used to create the isohalines.

Supplemental Salinity Data

While real-time salinity stations are found throughout the inland waters of the Pontchartrain Basin, there are very few found in the offshore waters of the Gulf of Mexico. In an effort to produce accurate isohalines offshore, LPBF utilizes forecasted models generated by the Coastal Observing Research and Development Center – Navy Coastal Ocean Model, the Naval Research Laboratory – Ocean Dynamics and Prediction Branch, and NOAA's Northern Gulf of Mexico Operational Forecast System. Salinity models are generally run four times per day, and generate 6-hour nowcast and 48-hour forecast guidance. Products include a time series graphic depicting surface salinity (**Figures 11-13**).

These oceanographic models are scientific computer generated predictions about the present and future conditions of Gulf waters. The predictions rely on either observed data, or forecasts from large-scale numerical models. LPBF staff reviews these salinity models for the specific Hydrocoast period, and produces the offshore isohalines accordingly.

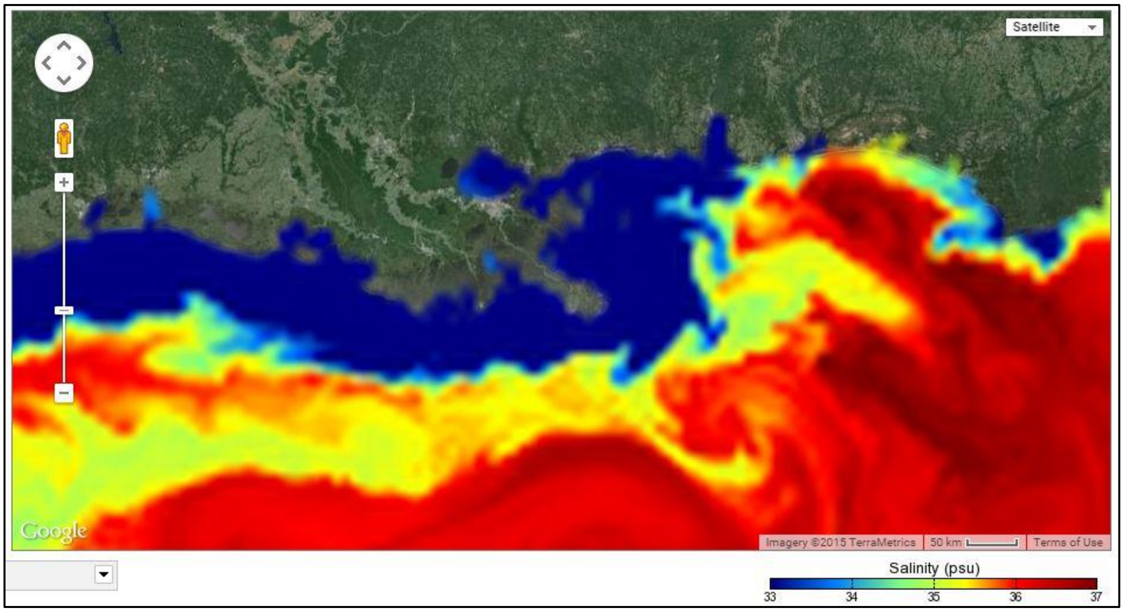

Figure 11: Coastal Observing Research and Prediction Branch – NCOM surface salinity model.

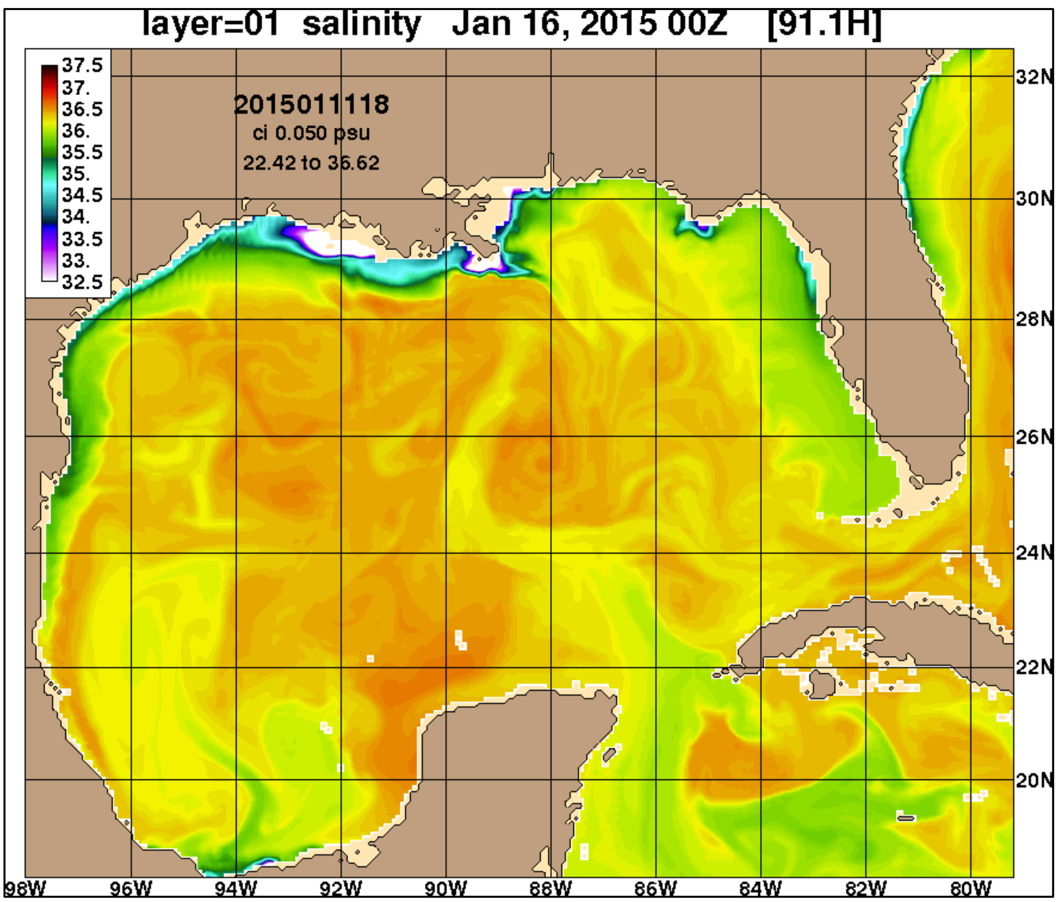

Figure 12: Naval Research Laboratory – ODPB surface salinity model.

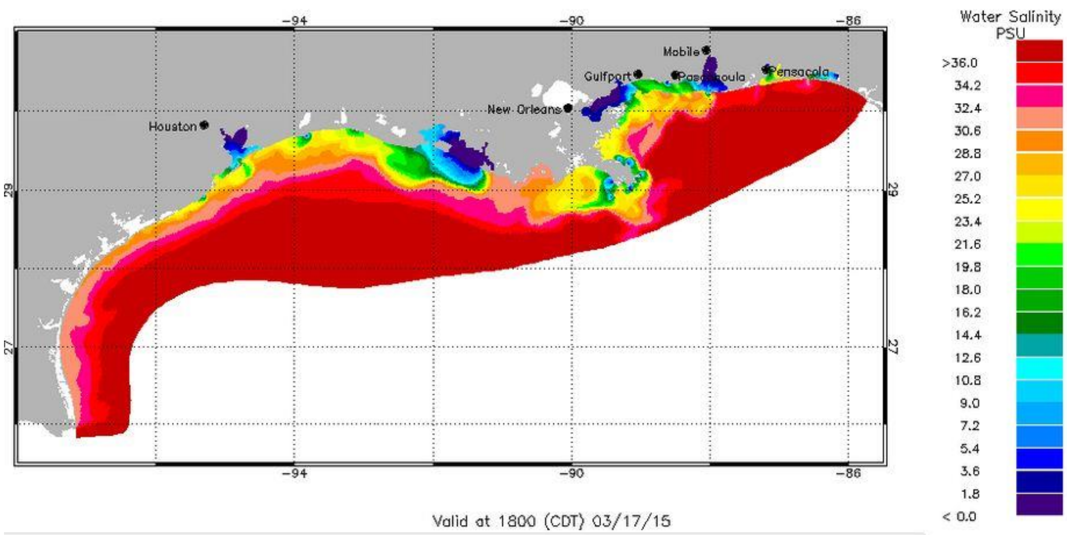

Figure 13: NOAA – NGOFS surface salinity model.

Drawing Contours

A comprehensive knowledge of coastal process, topography and hydrology, along with rainfall, wind speed, direction and duration, tides and near real-time satellite imagery are important to the isohaline contouring process. Isohalines are adjusted to conform to the most recently collected data during the survey week. It is the newly observed salinity values either from fixed gauge stations or LPBF's supplemental data that influence the contour drawing. However, other indicators of influence on salinity are utilized. For example, discharge plumes and discharge volumes from rivers or diversions can be seen on MODIS imagery and influence the geometry of local isohalines. Tides, currents, bathymetry, and land geometry are also important factors in the isohaline generation process. Rules have been established for the process of drawing and adjusting the surface salinity contours and are outlined below:

Contouring rules utilized are:

- Contours represent surface salinity gradient
- Contours cannot cross
- Uniform (1 ppt) contour interval is used
- Contour intervals are numerically consecutive unless there is a hydrologic barrier (described below)
- Contours can terminate at hydrologic barriers

Contours adjustments are influenced by:

- Most recent isohaline map
- Latest survey week salinity values
- Freshwater discharges
- Current MODIS imagery
- Hydrologic barriers and leak points (described below)
- Wind (duration, speed and direction)
- Rainfall
- Tides and currents
- Bathymetry

- Land and barrier island geometry
- Repeated patterns of isohaline contours due to repetitive hydrologic influences seen on prior Hydrocoast maps

Hydrologic Barriers and Leak Points

Hydrologic barriers and leak points are delineated on all five Hydrocoast maps and are interpreted to represent barriers in “fair weather” conditions. The hydrologic barriers were determined by using a digital elevation grid to identify linear areas of the coast which elevation was greater than +2.0 feet NAVD (**Figure 14**). It was assumed that any land mass above this elevation would block normal astronomical tidal flow across this feature. LIDAR data was used where available and detailed field knowledge was used to map certain barriers. In addition, salinity mapping showed areas of salinity discontinuity which indicated a hydrologic barrier.

Leak points are defined by narrow openings or culverts which allow some local exchange cross the hydrologic barrier (**Figure 14**). Many culvert leak points were mapped by detailed examination of high resolution aerial photography and by field knowledge. Below is a list of the types of hydrologic barriers and leak points that are considered for the Hydrocoast maps:

Hydrologic barriers include:

- Natural ridges
- On-grade highways
- On-grade railroads
- Levees
- Floodwalls
- Spoil banks
- Rock dikes
- Barrier islands

Leak points include:

- Tidal passes along barrier islands
- Culverts/weirs through ridges or roadbeds
- Canal cuts through a barrier (possibly with a bridge)
- Flood gates
- Bayous which intersect a barrier

Hydrologic barriers and leak points are used during the drawing of the isohalines. Isohalines often truncate at a hydrologic barrier, depicting a salinity discontinuity across the barrier, and also a distinctly different salinity gradient in rate and direction (**Figure 15**). A good example of this pattern is the Bayou la Loutre ridge which now includes a rock barrier on the MRGO re-establishing it as a regional hydrologic boundary. Along the ridge and at the MRGO rock dam, large differences in surface water salinity are seen across the ridge and rock barrier. In addition, isohaline trends and gradients are often different across the MRGO/Bayou la Loutre ridge.

Figure 14: Hydrocoast base map with hydrologic barriers (pink lines) and leak points (green points).

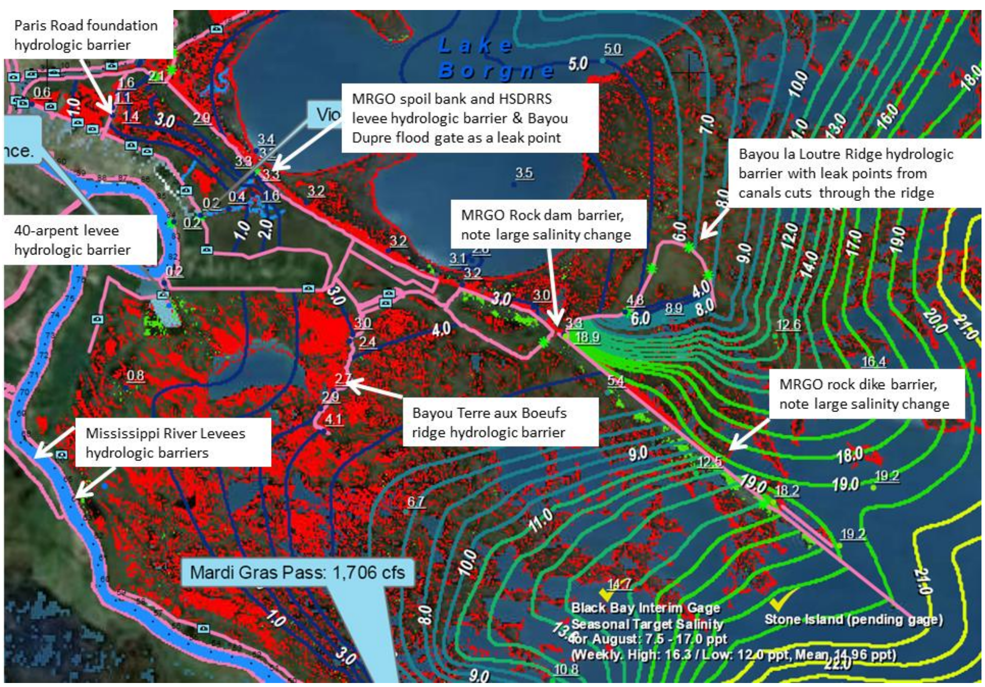

Figure 15: Examples of hydrologic barriers and leak points and their influence on isohalines.

Freshwater Discharges and Icon

Fresh Water Discharge

The freshwater discharges appear on every map except the Habitat Map. USGS gauges are utilized where available to directly report discharge from diversions, rivers or streams (**Table 2**). A custom LPBF Python program script is used to extract, sort and average the daily USGS discharge data.

Table 3: USGS river and stream discharge gauge URL's.

Location	URL
Pearl River	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=02492360
Tangipahoa River	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07375500
Tickfaw River	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07376500
Amite River	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07380120
Caernarvon Diversion	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=295124089542100

For river outlets along the east bank of the Mississippi River, including, Fort St. Philip, Baptiste Collette, Bayou Lamoque, Southwest Pass, South Pass, Pass a Loutre, Main Pass, West Bay and Grand and Tiger Passes, rating curves were provided by Dr. Alex McCorquodale at the University of New Orleans. The rating curves for these outlets on the east bank of the Mississippi River downriver of Bohemia were based on a calibrated HEC-RAS model of the Mississippi River from Tarbert Landing to the Gulf of Mexico. The model was calibrated to reproduce the stage profiles at the US Army Corps of Engineers gauging stations between South West Pass and Tarbert Landing. The model was tested with the reported flows at Tarbert Landing and checked against the USGS flows at Baton Rouge and Belle Chasse. The model was tested for the period 2007 to 2012. There are some uncertainties in the flow computations due to factors such as: the possible errors in the Tarbert Landing rating curve (especially at high flows); errors in measuring the outflows at poorly defined sections such as Fort St. Phillip; and changing River and outflow morphology. Uncertainty is reduced by the modeling which does a complete allocation of the total river discharge through all of the various river outlets and diversions. In addition, the model is calibrated to known discharges for outlets for two different flood years. The discharge through Mardi Gras Pass is calculated using a rating curve developed by LPBF based on eleven ADCP surveys and channel morphology surveys conducted from 2012 to 2014 (Lopez et al. 2014). The Mardi Gras Pass rating curve is adjusted as new data is available and as of May 2015 includes twenty ADCP surveys. The following river gauges are used to calculate discharge:

- Mardi Gras Pass, Baptiste Collette and Fort St. Philip use the West Pointe a la Hache stage (http://rivergages.mvr.usace.army.mil/WaterControl/stationinfo2.cfm?sid=01400&fid=&dt=S)
- Bayou Lamoque- uses the Empire stage (http://rivergages.mvr.usace.army.mil /WaterControl/stationinfo2.cfm?sid=01440&fid=&dt=S)
- Southwest Pass, South Pass, Pass a Loutre, Main Pass, West Bay and Grand and Tiger Passes use the USGS Belle Chasse discharge (http://waterdata.usgs.gov/nwis/uv?site_no=07374525).

The Violet Siphon discharge is calculated from a rating curve based on the stage at the Carrollton Gauge. A log is kept by the Lake Borgne Basin Levee District which documents when the siphon is open or closed. This information is provided to LPBF and the daily discharge is calculated from the rating curve, and then averaged for the week.

There are some discharges that have yet to be estimated because of data availability. This includes the Tchefuncte River, CWPPRA culverts into the Fritchie Marsh (Fritchie Marsh Restoration PO-06), Bayou Lacombe, Bayou Castine, and pump stations. The discharges from these sources are not large, but over time will be included if data becomes available.

Using the equations developed from the rating curves and the real-time river condition data retrieved online, an average daily discharge is calculated for each of the 7 days in the survey week. The discharge for each of the seven days is then averaged and one, average discharge, in cubic feet per second, is calculated for the entirety of the survey week, at each outlet.

Discharge Icon

The weekly average discharge for rivers, stream, siphons, diversions etc. are notated on the maps at the discharge point. A scalable icon has been developed to illustrate the relative weekly volume of discharge (**Figure 16**). The icon assumes radial spreading of the weekly discharge volume from the discharge point into adjacent area classified as water. An average water depth is assumed for the water area. The discharge icon is calculated by getting the average daily flow from the appropriate gauge (d) and summing these values for the entire 7-day survey week (D). The Cumulative Volume (C) equation calculates the volume of water that comes out of the river/pass over a week. This is then used to calculate the Radial Discharge Plume. The equations for these calculations are below:

Discharge (7-day sum)

$$D = d1 + d2 + d3 + d4 + d5 + d6 + d7$$

Where:

D = 7-day discharge sum (cfs)
d = daily (24-hour) average discharge value

Cumulative Volume

$$C = 7\ (days) * D\frac{cf}{sec} * 24\frac{hr}{day} * 60\frac{min}{hr} * 60\frac{sec}{min}$$

Where:

C = cumulative volume (cubic feet) over a 7-day period
D = 7-day discharge sum

Radial Discharge Plume

$$R = \sqrt{\frac{\left(\frac{C}{z}\right)}{\pi}}$$

Where:

R = radial discharge plume (extent of the icon on the map)
C = cumulative volume (cubic feet) over a 7-day period
z = water depth at the origin of the radial plume

The result of the calculated scalable icon is often a crescent-shaped icon, but each is unique due the local land water distribution. In practice, the icons are similar to actual observed plumes, but cannot be taken literally as such. If discharge is within an enclosed water body, the icon will resemble the shape of the receiving area such as Caernarvon discharge into in Big Mar Pond. Examination of the various plume icons portray the relative volumes being discharged into the estuary. As a caveat, the methodology and equations used to produce these icons are under debate internally due to the use of average depth and a possible inaccuracy in the cumulative volume equation. We are currently discussing ways to improve this current method or developing a new way to visually represent the different magnitude of discharges at different outlets in the basin. We would not recommend this exact method for displaying the icons in future iterations of this map series.

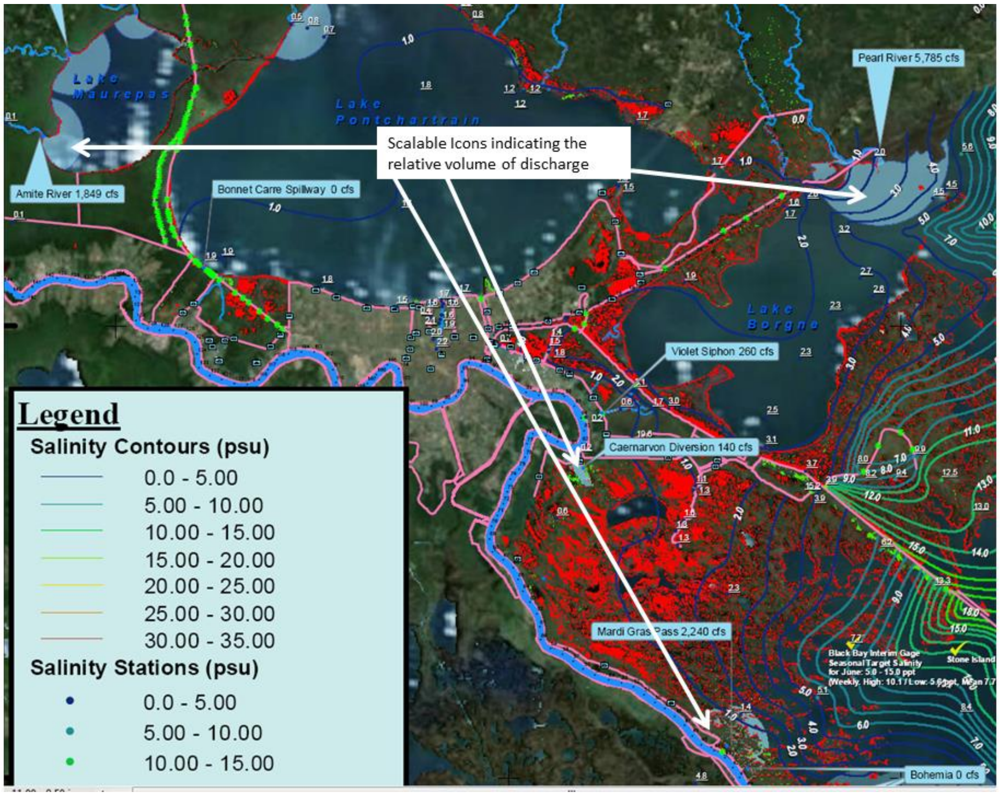

Figure 16: Light blue areas are the scalable icon used to indicate relative freshwater discharge volumes from rivers, streams, passes, diversions, river outlets etc.

Data Appearing on a Single Map

What follows is a description of those data layers that only appear on individual maps and are not found across multiple maps.

Salinity Map

The Salinity Map includes many of the features described above including the salinity contours, hydrologic barriers and leaks and the discharge icons. In addition, the salinity map also shows land loss in the basin from 1932 to 2010. Below is a description of this data set.

Land loss data

Cumulative land loss data from 1932 to 2010 is included on the Salinity Map to illustrate the change in land area. The analyzed data are derived from the USGS data set that analyzed land loss in Louisiana from 1932-2010 (Couvillion et al. 2011). The red area represents land loss, and the green represents land gain from 1932 to 2010. The USGS developed the data using is a collection of U. S. Coast Survey T-sheets, aerial photography and the supervised classification of satellite imagery when satellite imagery is available. Early years (pre 1973) used T-sheets and aerial photography and were re-sampled to similar resolution (30-meters) as satellite imagery during analysis.

Biological Map

The Biological Map shows the salinity contours, the hydrologic barriers and leaks as well as the discharge icons. Additional features that appear on the map are the results of aerial reconnaissance for shrimp and oyster fleets, fisheries management data and impaired waterbodies for fish and wildlife production and oyster production. The description of these data sets is below.

Aerial Fishing Fleet Surveys

Low-altitude aerial fleet surveys are conducted to gain a snap-shot of where the shrimp and oyster fleets are actively fishing in the Pontchartrain Basin. During shrimp trawl season (approximately late May through December) aerial survey flights are conducted for every Hydrocoast release, or every two weeks. When it is not shrimp season, oyster fleet survey is conducted for every other Hydrocoast release, or once a month. The shrimp and oyster aerial survey covers the western half of Lake Pontchartrain, Lake Borgne, the Biloxi Marshes, Eloi Bay, the MRGO, Breton Sound, Black Bay, and along the Mississippi River from Black Bay to the Bird's Foot Delta. When only the Oyster survey is conducted, the flight covers the Biloxi Marshes and the Breton Sound Marshes.

An LPBF coastal scientist is the observer and counts boats actively trawling or working oyster beds. Scientists are familiar with vessel types, fishing gear and patterns of boat movements associated with different fishing activities. During the flight, counts and notes are notated on a map. If necessary, the flight track is provided after the flight to compile the observations into GIS shapefiles. In the office, shapefile polygons of fleet locations are drawn in ArcMap and the number of boats counted and the total productive area (based on the polygons) is calculated (**Figure 17**). Southern Seaplane services have been utilized for these flights since their pilots are very familiar with the coastal marshes and common coastal activities.

Fisheries Management Data

The Louisiana Department of Wildlife and Fisheries (LDWF) has divided the coast into various Oyster Zones or areas for oyster harvest management (**Figure 17**). Within the Oyster Zones is where commercial oyster leases are located. These areas may be open or closed due to bacterial counts or other sources of pollution as determined by the Louisiana Department of Health and Hospitals. The LDWF also has a designated oyster public seed ground, where cultch or seed oyster may be taken to be placed on commercial leases (**Figure 17**). The aerial fishery surveys are useful because the salinity ranges within which fishery activity is taking place can be readily observed on the map as well as how freshwater inflows affect this location of fishery activity.

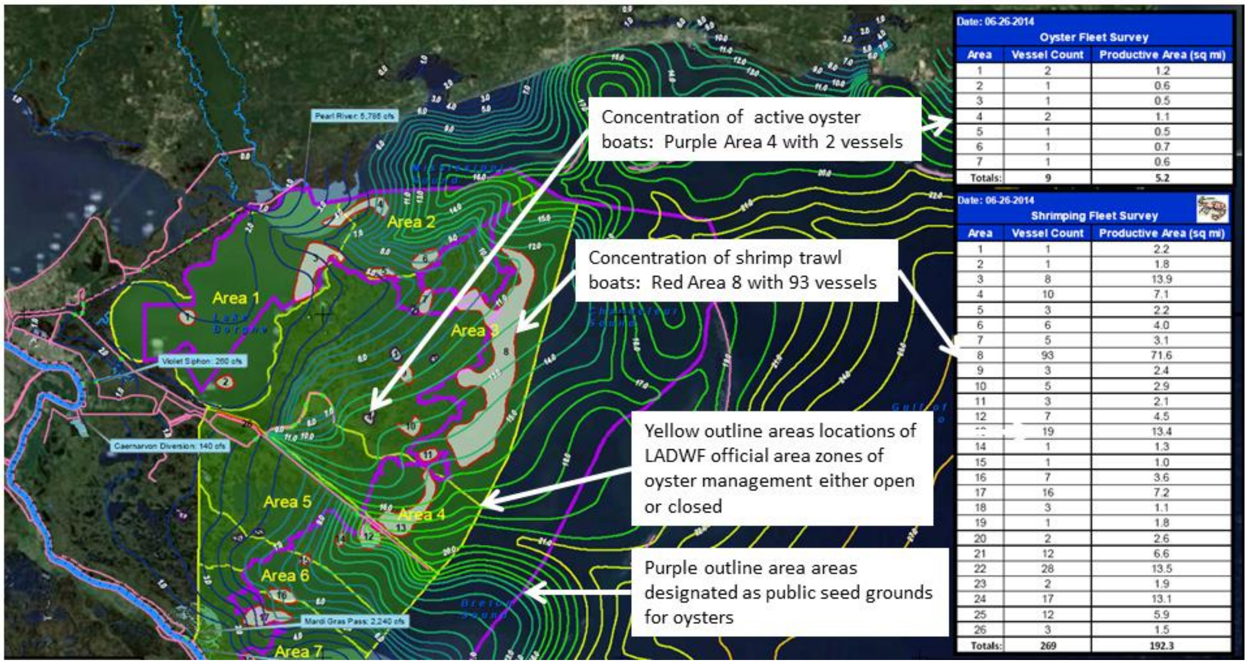

Figure 17: Hydrocoast Biologic Map highlighting the shrimp and oyster vessel surveys.

305b/303d Fisheries Impairments

The Biological Map includes the impairments to rivers and bodies of water for fishing and oyster propagation. These impairments are determined by the Louisiana Department of Environmental Quality (LDEQ) to fulfill obligations under Sections 305b and 303d of the Clean Water Act. Under these sections of the Clean Water Act, states are required to report impaired water bodies and provide a report to the USEPA which outlines impairments and a plan for bringing impaired waters under compliance. For the purposes of the Biological Map, not all impairments to fishing and oyster propagation are presented. Any impairment due to metal contamination (mercury, lead, copper) is shown as well as impairments to oyster propagation because of fecal coliform (**Figure 18**). Also shown are impairments due to “foam, flocs, scum, oil and other” which are impairments that were caused by the BP Oil Spill. The impaired waterbodies list is updated every two years. Currently, the 2012 impairments are shown while the 2014 list is under review. Impairments that are not shown on the map are total dissolved solids, dissolved oxygen, chloride, sulfates, nitrates and turbidity as these were considered to not be of the same hazard level to public health as metals and fecal coliform. The list of impaired water bodies can be downloaded from the LDEQ website (http://www.deq.louisiana.gov/portal/tabid/69/Default.aspx). From this list, the location of all impaired water bodies was determined and mapped in ArcMap according to impairment type. Three categories were determined for waterbodies, those impaired for fishing, oyster production and fishing and oyster production.

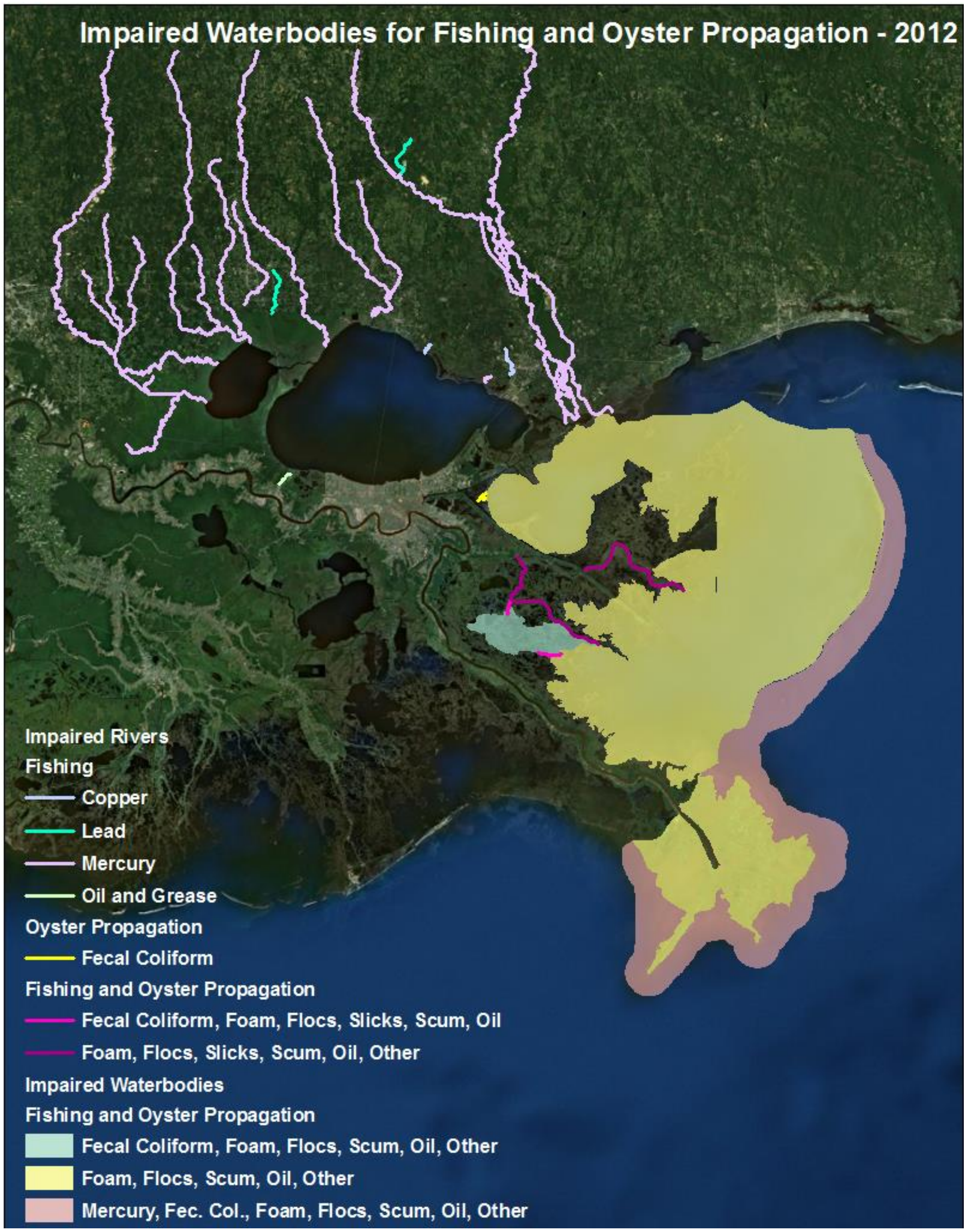

Figure 18: Map of water bodies that are impaired for fishing and oyster production in the Pontchartrain Basin, 2012.

Retail Seafood Prices

For every Hydrocoast period six seafood retailers are called. Three from the north shore and three from the south shore of Lake Pontchartrain are used to have representative prices from the area. Four different seafood item prices (oysters, live blue crabs, shrimp, and crawfish) are collected from each retailer and each is standardized. Oyster prices are reported by half sacks or about 100 oysters on the shell. Live blue crab prices are reported by the hamper or approximately 30-35 liters, and the number of crabs per hamper depends on their size (the smaller the crabs, the more per hamper). Shrimp prices are reported by the pound. Typically, prices of shrimp per pound is scaled by a count of the number of shrimp per pound. The lower the shrimp count, the larger the shrimp, and the more they typically cost per pound. Prices for 16-20 count shrimp are obtained which represents a medium to large shrimp size. If 16-20 count shrimp are not available, then the price is not reported. Crawfish price per pound is recorded. Average price per seafood item is graphed using Excel 2010 (**Figure 19**). Some of these seafood items are only available seasonally, especially crawfish. If no data are available from any of the retailers for a given seafood item, a blank space is shown. No information is given on the prices of seafood for any specific retailer.

Retail prices are tracked because they are relevant to the general public as well as commercial fishers who harvest the product. Citizens in south Louisiana might want to know the market prices for their next seafood boil. Commercial fishers have recently pointed out the large disparity that may occur between retail and wholesale prices. The high retail markup may suggest fishers do not get their fair share. LDWF tracks wholesale prices, but found no record of fluctuating retail prices over time in the New Orleans region. Although retail prices reflect the combined supply and demand of commercial fisheries, over time they may well reflect longer term trends in seafood availability and stocks.

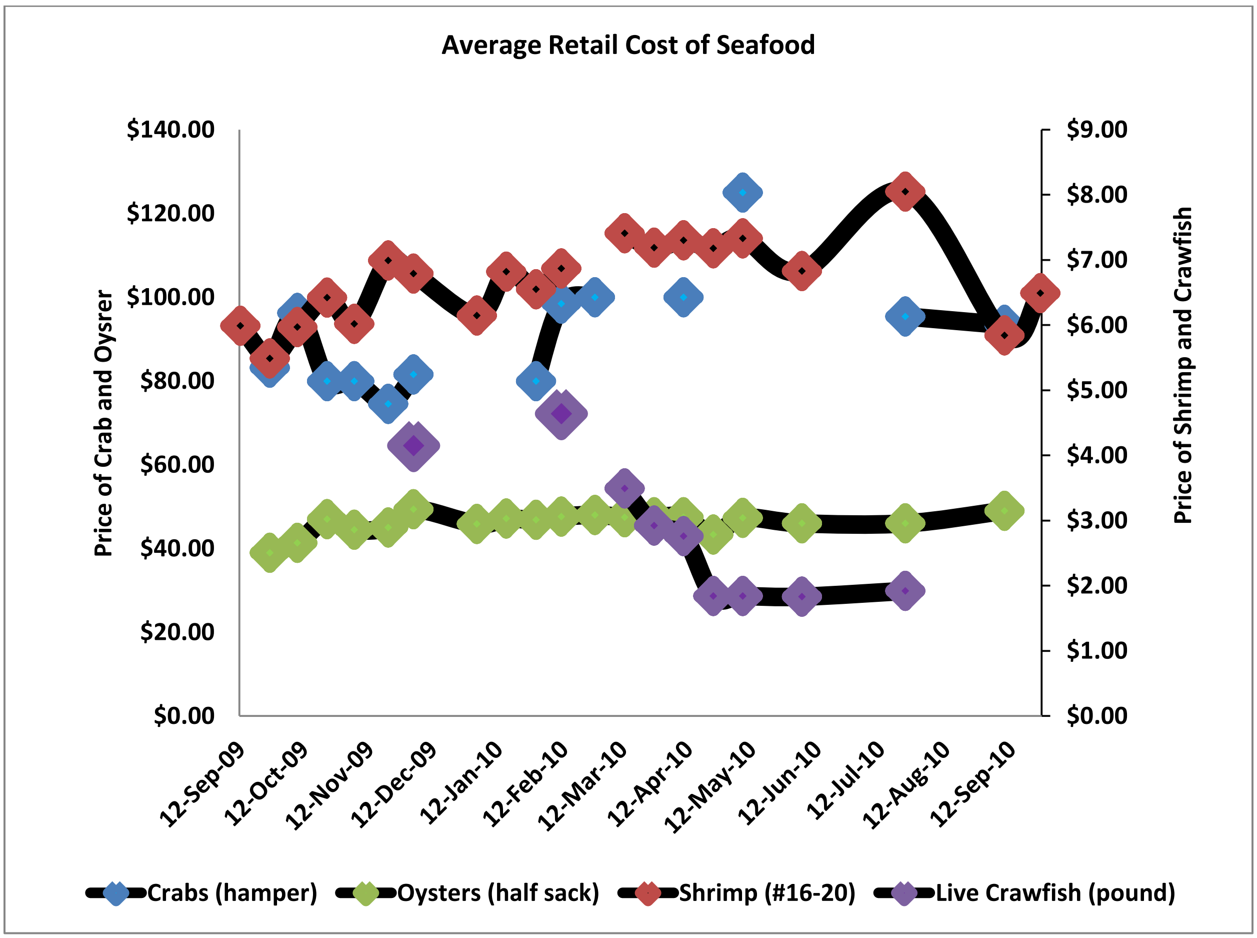

Figure 19: Graph used to show average retail price of seafood items.

Habitat Map

The Habitat Map shows the salinity contours and the hydrologic barriers and leak points. Additionally, the land areas are shown by their wetland habitat type (fresh, intermediate, brackish, salt, swamp). Overlain on the marsh (land) areas are the soil salinity contours. The data sets and processes specific to the Habitat Map are described below.

Wetland Habitat Type Map Layer Source

The Marsh Habitat Type 2013 that is delineated on the Habitat Map was created from shapefiles that were acquired from the U.S. Geological Survey (http://pubs.usgs.gov/sim/3290/). The wetland habitats are surveyed approximately every five years and are assessed from a helicopter which flies along predetermined transects that run in a north/south direction and are spaced 1.87 miles apart (Sasser et al. 2014). Along the transects, sampling sites were located every 0.5 miles. At each site, plant species were identified and abundances estimated. On the basis of species composition and abundance, the sampling station was assigned to one of the marsh types: fresh, intermediate, brackish, salt and swamp. In general, salinity in a fresh marsh is 0-2 ppt, intermediate marsh is 2-10 ppt, brackish marsh is 10-20 ppt and salt marsh is above 20 ppt. It is important to note that classification of these habitats is based on the emergent plant composition, not on actual salinity measurements in the marsh. However, the plant communities develop as a result of the salinity in any given area (among other factors) so mapping marsh type based on vegetative communities is a valid classification method.

Soil Salinity

The Habitat Map displays soil salinity contours as mapped from measured soil salinity across the Pontchartrain Basin during the course of twelve months. The soil salinity data was collected from two sources: direct measurement by LPBF and from CRMS. The LPBF data was collected throughout 2013 with one measurement taken at each site (**Figure 20**). The CRMS data has multiple measurements at each CRMS station (number of measurements varies) and for purposes of developing the contours on the Habitat Map, these values were averaged to obtain one value for 2013. LPBF and CRMS (Folse et al. 2012) both used the soil sipper method (Howes et al. 1985; Watson and Frickers 1990) to collect the soil salinity data. The soil sipper method involves inserting a rigid plastic tube with small holes drilled at the bottom, into the ground to a specific depth. The rigid tube is connected with soft plastic tubing to a suction syringe which draws pore water from the surrounding soil into the plastic tube. CRMS draws pore water salinity from 10 cm and 30 cm but only the 30 cm data was used for the Habitat Map. LPBF obtained pore water samples from 25 cm to 30 cm depending on the soil conditions (some cases soil was too hard to push the tube all the way in). LPBF began sampling soil salinity across the basin before the CRMS soil salinity data could be located. Therefore, in the future, LPBF will continue to sample locations in the basin not covered by CRMS, to obtain adequate coverage to create soil salinity contours. Over time, this information will be used to assess changes in soil salinity and associated changes in vegetative cover and composition across the basin.

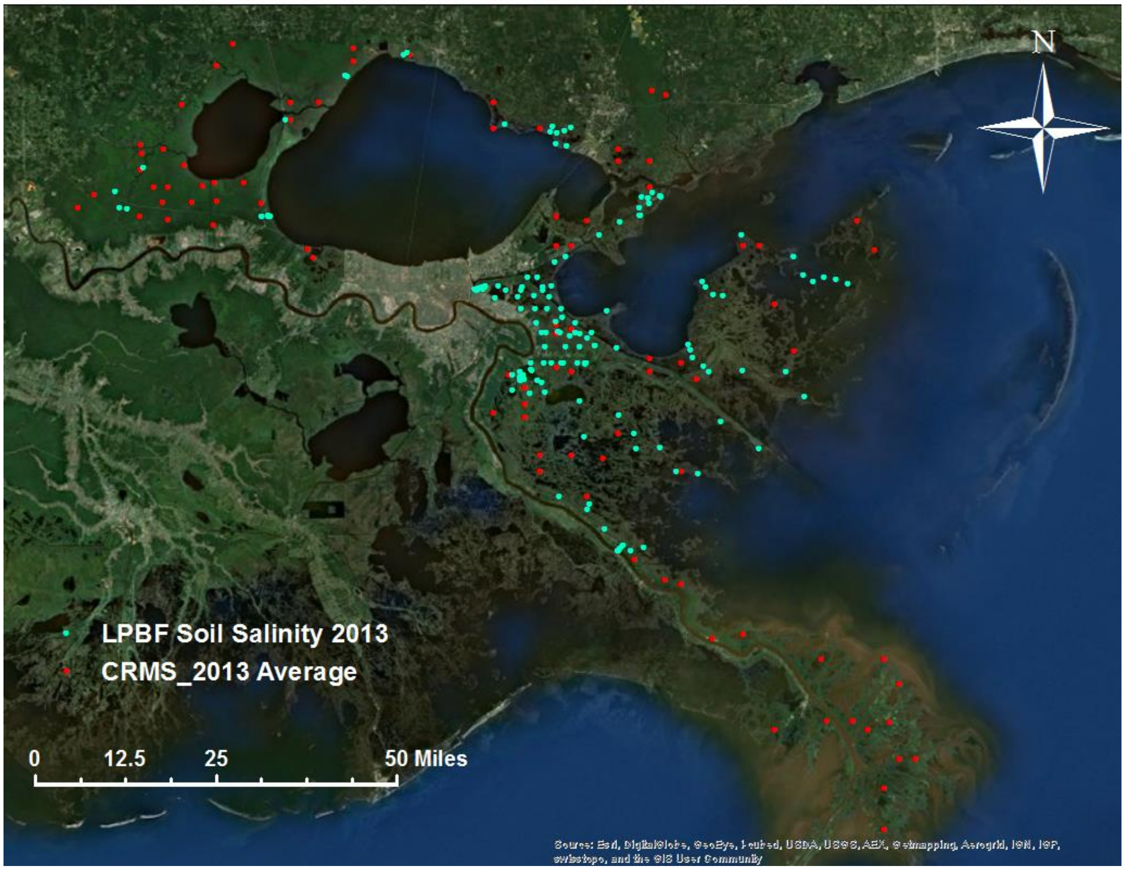

Figure 20: Location of soil salinity sample sites for data collected by the Lake Pontchartrain Basin Foundation (blue dots) and from the CRMS sites (red dots).

Comparing the surface salinity that the marshes are exposed to over time with the soil salinity conditions allows for interesting comparisons. The juxtaposition of surface water salinity with soil salinity indicates the “exposure” of wetland types and soil salinity to the fresher or saltier surface water conditions. Long-term exposure toward fresher or saltier surface water would be expected to cause long- term shifts in soil salinity and then longer-term shifts in vegetative composition (**Figure 21**). In general, long-term exposure to changing surface salinity will shift soil salinity which will affect the vegetative community and slowly shift the marsh towards a different classification. Additionally, these changes could have an effect on the resident and visiting aquatic species and force long-term shifts in population composition.

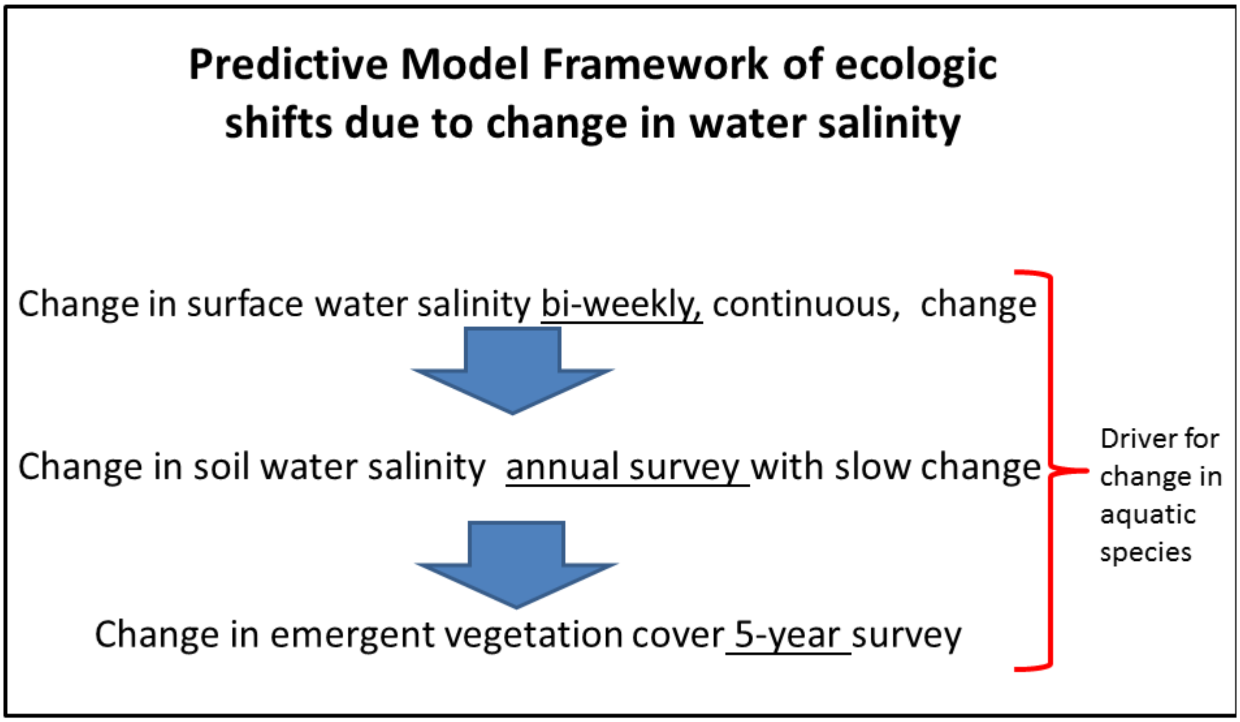

Figure 21: General relationship between surface water salinity, soil salinity and wetland vegetative cover. These physical conditions may singularly or in unison drive changes in aquatic species. Hydrocoast increments of change may provide a basis for longer-term change predictions.

Water Quality Map

The Water Quality Map contains the salinity contours, the hydrologic barriers and leaks and the scalable discharge icons other data is described below.

Water Quality Data

Water quality data is obtained from many sources. The water quality data that is always included is from water quality sampling for fecal coliform in Lake Pontchartrain and surrounding rivers and streams. This data is collected by our Water Quality Department and is also readily available online (http://saveourlake.org/weekly-report.php). We also include areas of hypoxia when they are present. LPBF surveys for hypoxia in the spring and summer in Chandeleur sound and if found we include it on the map. Also, any timely and ephemeral water quality issues are placed on the map, such as spills, leaks and algal blooms.

305b/303d Water Quality Impairments

The Water Quality Map includes the impairments to rivers and bodies of water for primary recreation (swimming) and secondary recreation (boating, wading) contact. Waters impaired for secondary contact are also impaired for primary contact. These impairments are determined by the Louisiana Department of Environmental Quality (LDEQ) to fulfill obligations under Sections 305b and 303d of the Clean Water Act. Under these sections of the Clean Water Act, states are required to report impaired water bodies and provide a report to the USEPA which outlines impairments and a plan for bringing impaired waters under compliance. For the purposes of the Water Quality Map, not all impairments for primary and secondary contact are presented. Any impairment due to fecal coliform or polyaromatic hydrocarbons (PAH's) are shown (**Figure 22**). Waters that are impaired for primary contact for reasons such as dissolved oxygen and water temperature are not shown because they do not pose the same threat to human health as the other factors. Also shown are impairments due to "foam, flocs, scum, oil and other" which are impairments that were caused by the BP Oil Spill, and only appear in bays and coastal waters. The impaired waterbodies list is updated every two years. Currently, the 2012 impairments are shown while the 2014 list is under review. The list of impaired water bodies can be downloaded from the LDEQ website (http://www.deq.louisiana.gov/portal/tabid/69/Default.aspx). From this list, the location of all impaired water bodies was determined and then was mapped in ArcMap according to impairment type.

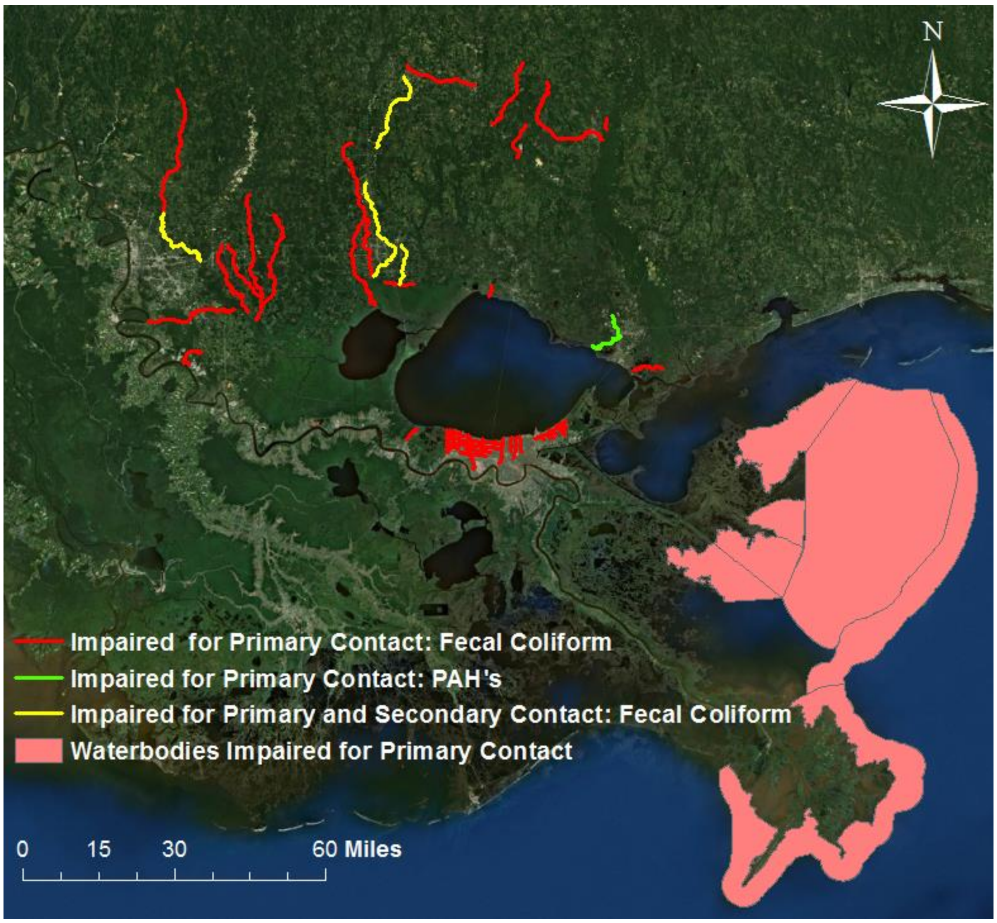

Figure 22: Location of rivers and waterbodies impaired for primary recreation contact (swimming) and secondary recreation contact (boating and wading) in the Pontchartrain Basin, 2012.

Weather Map

The Weather Map includes the salinity contours, hydrologic barriers and leaks, the rest of the data is decribed below.

Cumulative Rainfall Data

The rainfall data is derived from NOAA weather stations. The rainfall data is collected from NOAA National Weather Service as a post processed shapefile, and displayed as a gridded field with a spatial resolution of roughly 4x4 km (http://water.weather.gov/precip/download.php) (**Figures 23 and 24**). The rainfall data are quality-controlled, multi-sensor (radar and rain gauge) data. An inverse distance weighted function is performed on the grid data by a GIS specialist to produce a raster image that represents cumulative rainfall for the week (**Figure 25**).

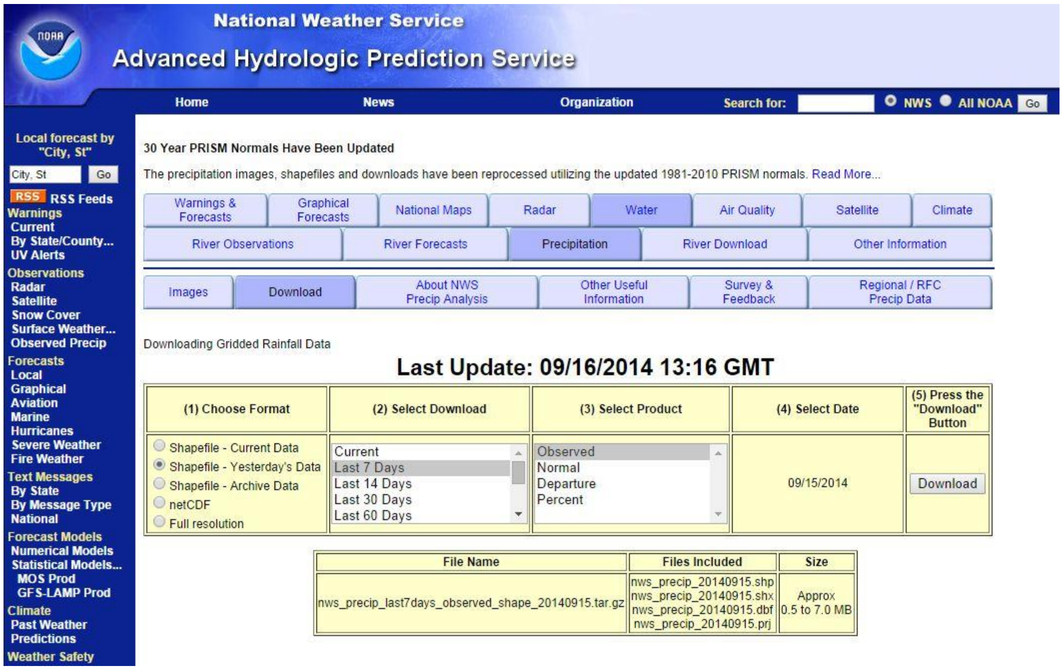

Figure 23: NOAA National Weather Service site for collecting cumulative 7-day rainfall data.

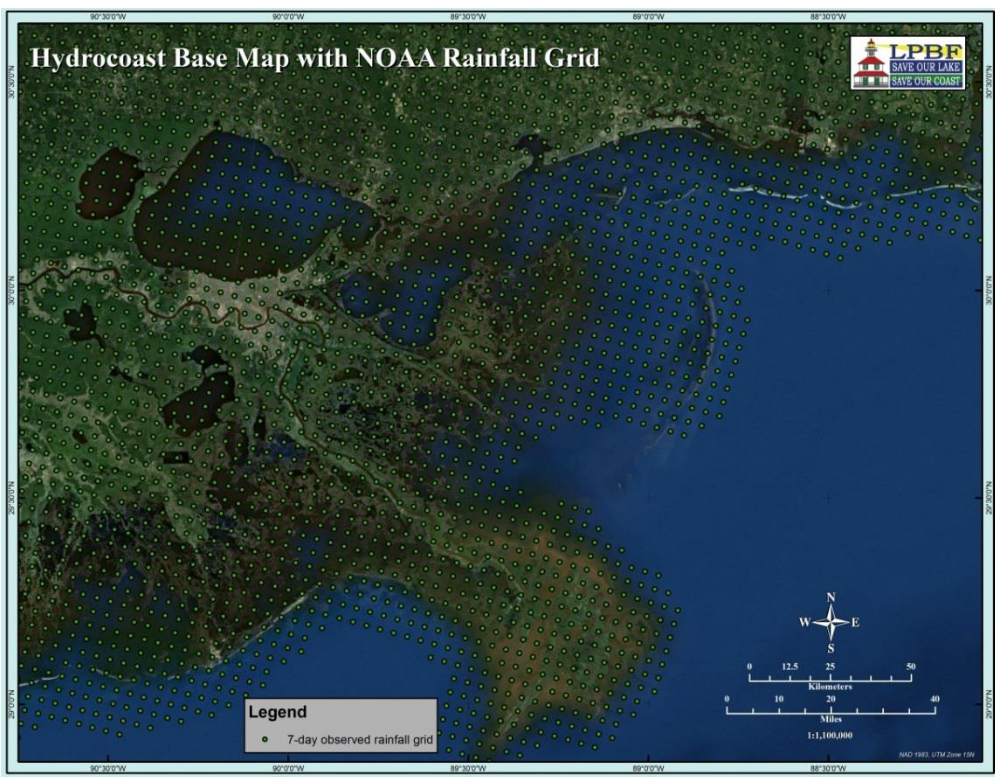

Figure 24: NOAA National Weather Service 4x4 km 7-day rainfall grid data.

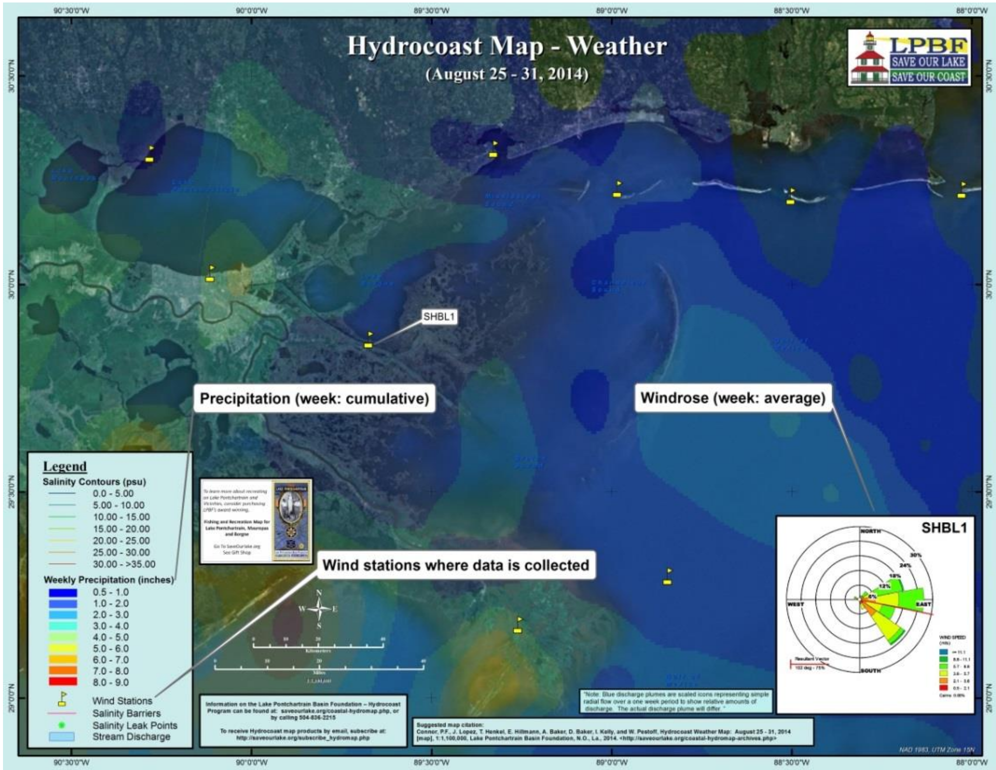

Figure 25: Hydrocoast base map with cumulative rainfall, and wind rose with average wind speed and direction for the survey week (August 25 – 31, 2014).

Wind Data

The wind data is collected from the NOAA National Data Buoy Center (http://www.ndbc.noaa.gov/) for approximately 10 weather stations throughout the Basin (Appendix 2). Utilizing a custom LPBF Python program script, raw wind data is collected, sorted and averaged for the survey week. The processed data is then imported to a statistical graphing program to produce wind roses (**Figure 25**). While only one wind rose is produced (for the Shell Beach station) for a given survey period, wind roses could be produced for any of the 10 weather stations.

Rational for Map Themes and Components

The five map products are intended to portray information that supports various themes that are relevant to the estuary. The composition is limited by what is available, but also limited by the maximum amount of information that can be shown on a static, 2-dimensional map composition without being too complex or cluttered. The fixed composition may be addressed in future releases which allow layer manipulation through acrobat, ArcMap or other software, but for now the components are fixed. The rendering is meant to be technically effective and visually appealing. The "salinity" themed map portrays the isohalines as well as the control points used to interpret the contours. It also shows the freshwater discharges and discharge icons which influence salinity. It would be ideal to also include rainfall on the map, but that is simply too much information, and so precipitation is shown with other metrological information on the weather map. The water portion of the basemap is up to date MODIS imagery which gives indication of freshwater plumes that may be influencing salinity. The wetland change is shown simply because this is an overriding issue in the estuary.

The “biologic” themed map is relevant to aquatic species, including commercial and non-commercial species. Various commercial zones are shown as opened or closed. EPA impaired waterbody listing for fish and wildlife are mapped. The aerial fleet surveys of oyster or shrimp trawl activity are shown. In the future, some cross over data may be used such as dead zones may be shown on both the water quality and biologic maps. The isohalines are also shown since they do effect the aquatic environment.

The “habitat” themed map show parameters that may affect the emergent wetlands of the estuary. The latest wetland habitat distribution is shown. Surface salinity isohalines are shown as well as soil salinity that will affect vegetation type and distribution.

The “water quality” themed map is relevant to human health. Data from the LPBF Water Quality Program shows bacterial counts at various locations around the basin which are used as an indicator for human health and therefore determines the type of contact with waterbodies that is acceptable (primary or secondary contact). Similarly the EPA impairments are determined based on their designated use for primary or secondary contact. The isohalines are shown since this is a standard water quality parameter. Discharges are also shown since they can represent “first flush” of storm water pollutants that may reduce water quality.

The “weather” themed map portrays an array of meteorologic related data, such as cumulative rainfall, wind direction and intensity, and astronomical tide information. The isohalines are also shown since they can be affected by rainfall, wind and astronomical tides.

Dissemination of Hydrocoast

The Hydrocoast map series is disseminated in a variety of ways. The most current series of Hydrocoast Maps can be downloaded from the LPBF website at http://saveourlake.org/coastal-hydromap.php. All of the archived maps that have been produced are displayed in a table on the Hydrocoast Map page or by going to http://saveourlake.org/coastal-hydromap-archives.php. A brief summation report of each Hydrocoast release is also available online. From either web page, you can subscribe to receive the Hydrocoast Map series by email immediately upon their release.

Currently, the email list for the campaign is approximately 300 people and consists of the general public, private industry, state government, federal government, university researchers and other not-for-profit organizations. When a new Hydrocoast series is released a notice has been sent out on the CWPPRA Newsflash which is an email distribution list intended to inform the public about coastal restoration. Anyone can subscribe to the Newsflash, which has a large distribution in the region. In the future, the Hydrocoast maps will only be announced on the Newsflash when there is some significant change to the maps. Additionally, when provided the opportunity, presentations are given and articles written about the Hydrocoast in order to reach a variety of audiences. Occasional Hydrocoast announcements are also made on LPBF’s Basin Bulletin via email and also through articles written for Coastal Angler magazine.

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Appendices

Appendix 1:Name and URL for the approximately 40 USGS and 20 NOAA stations that are used to collect real-time salinity data for the Hydrocoast maps. These values are collected for a week long Hydrocoast period and then averaged to get one value for the week.

Station No.	URL
USGS02480212	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=02480212
USGS02480285	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=02480285
USGS073745275	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073745275
USGS07374526	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07374526
USGS07374527	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07374527
USGS07380251	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07380251
USGS073745253	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073745253
USGS073745257	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073745257
USGS073745258	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073745258
USGS073802375	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073802375
USGS073802512	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=073802512
USGS2951190901217	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=2951190901217
USGS291929089562600	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=291929089562600
USGS292952089453800	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=292952089453800
USGS295124089542100	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=295124089542100
USGS295501090190400	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=295501090190400
USGS295827090052800	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=295827090052800
USGS295906090054200	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=295906090054200
USGS300009090051600	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300009090051600
USGS300026090050800	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300026090050800
USGS300034090055300	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300034090055300
USGS300127090045800	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300127090045800
USGS300128090045800	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300128090045800
USGS300602090375100	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300602090375100
USGS300722089150100	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=300722089150100
USGS301001089442600	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301001089442600
USGS301104089253400	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301104089253400
USGS301141089320300	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301141089320300
USGS301324090382400	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301324090382400
USGS301429089145600	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301429089145600
USGS301527088521500	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301527088521500
USGS301849088350000	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301849088350000
USGS301912088583300	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301912088583300
USGS302318088512600	http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=302318088512600
GDQM6	http://www.ndbc.noaa.gov/data/realtime2/GDQM6.ocean
MBLA1	http://www.ndbc.noaa.gov/data/realtime2/MBLA1.ocean
KATA1	http://www.ndbc.noaa.gov/data/realtime2/KATA1.ocean
CRTA1	http://www.ndbc.noaa.gov/data/realtime2/CRTA1.ocean
DPHA1	http://www.ndbc.noaa.gov/data/realtime2/DPHA1.ocean
MHPA1	http://www.ndbc.noaa.gov/data/realtime2/MHPA1.ocean
BSCA1	http://www.ndbc.noaa.gov/data/realtime2/BSCA1.ocean
WKQA1	http://www.ndbc.noaa.gov/data/realtime2/WKQA1.ocean
PPTA1	http://www.ndbc.noaa.gov/data/realtime2/PPTA1.ocean
8761305	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Shell%20Beach,%20LA&ofs=ng&stnid=8761305
8747437	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Bay%20Waveland,%20MS&ofs=ng&stnid=8747437&subdomain=0
8745557	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Gulfport%20Harbor,%20MS&ofs=ng&stnid=8745557&subdomain=gp
8745651	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=West%20Pier,%20MS&ofs=ng&stnid=8745651&subdomain=gp
8741003	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Petit%20Bois,%20MS&ofs=ng&stnid=8741003&subdomain=ps
USM3M02	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=USM3M02,%20MS&ofs=ng&stnid=NULL&subdomain=0
gp0101	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Gulfport%20Ship%20Channel%20LB22,%20MS&ofs=ng&stnid=gp0101&subdomain=gp
gp0201	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Gulfport%20Ship%20Channel%20LB26,%20MS&ofs=ng&stnid=gp0201&subdomain=gp
8744707	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Gulfport%20Outer%20Range&ofs=ng&stnid=8744707&subdomain=gp
gp0301	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Day%20Marker%2032,%20MS&ofs=ng&stnid=gp0301&subdomain=gp
42040	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=64NM%20S%20of%20Dauphin%20Island,%20AL&ofs=ng&stnid=NULL&subdomain=0
ps0101	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Pascagoula%20Harbor%20LB8,%20AL&ofs=ng&stnid=ps0101&subdomain=ps
ps0201	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Pascagoula%20Harbor%20LB17,%20AL&ofs=ng&stnid=ps0201&subdomain=ps
mb0101	http://tidesandcurrents.noaa.gov/ofs/ofs_station.shtml?stname=Mobile%20Bay%20Buoy%20M,%20AL&ofs=ng&stnid=mb0101&subdomain=mb

Appendix 2: Name, location and URL for the ten weather stations used to create the Weather Map.

Station ID	Location Description	URL
SHBL1	8761305 Shell Beach, LA	http://www.ndbc.noaa.gov/data/realtime2/SHBL1.txt
LKPL1	Western Lake Pontchartrain, LA	http://www.ndbc.noaa.gov/station_page.php?station=lkpl1
GPOM6	8744707 Gulfport Outer Range, MS	http://www.ndbc.noaa.gov/data/realtime2/GPOM6.txt
NWCL1	8761927 New Canal, LA	http://www.ndbc.noaa.gov/data/realtime2/NWCL1.txt
PILL1	8760721 Pilot Town, LA	http://www.ndbc.noaa.gov/data/realtime2/PILL1.txt
KMIS	Main Pass 140B AWOS Apache Corp, LA	http://www.ndbc.noaa.gov/data/realtime2/KMIS.txt
KVKY	Main Pass 289C Apache Corp, LA	http://www.ndbc.noaa.gov/data/realtime2/KVKY.txt
WYCM6	8747437 Bay Waveland Yacht Club, MS	http://www.ndbc.noaa.gov/data/realtime2/WYCM6.txt
PTBM6	8741003 Petit Bois Island, MS	http://www.ndbc.noaa.gov/data/realtime2/PTBM6.txt
FMOA1	8734673 Fort Morgan, AL	http://www.ndbc.noaa.gov/data/realtime2/FMOA1.txt