NOAA Technical Memorandum NOS CS 28

Mobile Bay Collaborative Survey: 2010 - 2011

Silver Spring, Maryland
May 2012

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Coast Survey Development Laboratory

Office of Coast Survey
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The Office of Coast Survey (OCS) is the Nation's only official chartmaker. As the oldest United States scientific organization, dating from 1807, this office has a long history. Today it promotes safe navigation by managing the National Oceanic and Atmospheric Administration's (NOAA) nautical chart and oceanographic data collection and information programs.

There are four components of OCS:

> **The Coast Survey Development Laboratory develops new and efficient techniques to accomplish Coast Survey missions and to produce new and improved products and services for the maritime community and other coastal users.**
>
> **The Marine Chart Division acquires marine navigational data to construct and maintain nautical charts, Coast Pilots, and related marine products for the United States.**
>
> **The Hydrographic Surveys Division directs programs for ship and shore-based hydrographic survey units and conducts general hydrographic survey operations.**
>
> **The Navigational Services Division is the focal point for Coast Survey customer service activities, concentrating predominately on charting issues, fast-response hydrographic surveys, and Coast Pilot updates.**

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Mobile Bay Collaborative Survey: 2010 -2011

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May 2012

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NOTICE

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ABSTRACT

Three offices of NOAA's National Ocean Service, the Center for Operational Oceanographic Products and Services (CO-OPS), the National Geodetic Survey (NGS), and the Office of Coast Survey (OCS) have developed complementary capabilities and expertise in defining and managing a national geospatial coordinate system; supporting national requirements for mapping and charting; and providing information to ensure safe and efficient use of coastal waterways. These three offices are referenced as NOS Tri-Offices, hereafter. The Mobile Bay region was selected to conduct a collaborative project because the region is ecologically stressed; sensitive to sea level change from both synoptic meteorological and decadal time scales; and need to address potentially conflicting recreational and commercial issues. In addition, the Tri-Offices had a series of ongoing efforts already underway for the region.

To support obtaining baseline environmental information and to provide needed measurements to support the planned new operational forecast system for the region, an observation program was designed among the three offices that was executed over a course of three months from November 2010 to February 2011. The survey measurements consisted of water levels; shallow water bathymetry; three dimensional currents; and salinity and water temperatures.

This report is a summary of the measurement program and provides a description of the project database. The purpose of the report is to facilitate public accessibility to and potential usages of the data sets. In addition to the Mobile Bay survey data, the database also includes observations of water levels, currents, salinity, and meteorological parameters from the NOS' Physical Oceanographic Real-Time System (PORTS®).

The database organizes data sets according to physical parameters such as water levels, bathymetry, current velocity, conductivity, temperature, and salinity (CTD), and meteorological data. Water levels were collected from Mobile Bay PORTS, GPS water level buoy, and Mobile Bay survey; Bathymetry covers Weeks Bay and Grand Bay, AL and Point Aux Chenes Bay, MS; Currents velocity were from Mobile Bay survey and Mobile Bay PORTS measurements; CTD data were from autonomous underwater vehicle (AUV) and portable CTD casts; and meteorological data were from Mobile Bay PORTS.

Associated with this report is a project dataset spreadsheet file: ***NOS_MobileBay_circulation_study.xlsx***. The file includes metadata and survey data, data locations sites, readme files, and additional supplementary information. Both the spreadsheet file and survey datasets are available online at:

ftp://ocsftp.ncd.noaa.gov/NOS_MobileBay_Circulation_Survey_Nov2010_Feb2011.

The datasets will be transferred to NOAA's National Oceanographic Data Center (NODC) for official archive.

1. Introduction

Coastal communities require high quality data products and services to address increasing challenges which include: monitoring and maintaining a healthy coastal zone; responding to threats, both natural and man-made to mitigate the short term consequences and the long lasting effects to the environment; resolving conflicts between commercial and recreational use of the coastal zone; addressing the issues and consequences of the deployment of new emerging technologies; quantifying the consequences of sea level change in the coastal zone; and evaluating the restoration needs of both watershed and critical habitats. These challenges are not an exhaustive list of all the challenges on the coastal regions, but represent the wide spectrum of issues. They demonstrate the need for comprehensive and fundamental data, information, and tools to answer today's challenges.

Traditionally, different organizations and government agencies have developed separate lines of expertise and data streams. To successfully address these important coastal challenges, however, requires a comprehensive, integrated suite of data products and services that are by their nature multidisciplinary. A promising approach, therefore, is to develop collaborative partnerships to leverage different, but complementary capabilities and expertise. As an example of the types of collaborations needed, the NOAA National Ocean Service's, Center for Operational Oceanographic Products and Services (CO-OPS), the National Geodetic Survey (NGS), and the Office of Coast Survey (OCS) established a Coastal and Climate Team (CCT) to focus its vast capabilities on these coastal challenges. These capabilities include defining and managing a national geospatial coordinate system; supporting national requirements for mapping and charting; and providing information to ensure and safe and efficient use of coastal waterways. This NOS collaboration can be extended to other NOAA organizations as well.

To illustrate this extensible collaborative process, Mobile Bay and its vicinity was selected. Even before the Deep Water Horizon event, this region was ecologically stressed, sensitive to sea level change from both synoptic meteorological and decadal time scales, and having the potential of conflicting recreational and commercial issues. The CO-OPS, NGS, and OCS already had several ongoing efforts that through a formal collaboration, both within NOAA and the Mobile Bay community would result in improved products and services. The initial step was to identify those planned activities for Mobile Bay, establish where strategically placed resources would address critical data gaps and would result in an expanded suite of products and services, and then determine whether complementary activities, such as research and technology evaluation could be accelerated by participating in this planned effort.

The conceptual design of the collaborative survey was to collect a comprehensive suite of measurements of the physical setting of Mobile Bay and vicinity. These fundamental observations would support data needs of the users of the Bay system, who require an understanding of the physical processes to address the challenges in the region, and provide observations to validate a new suite of NOS Operational Forecast System for the northern Gulf of Mexico. This forecast system is called the Northern Gulf of Mexico Operational Forecast System (NGOFS). The observation period was selected from November 2010 to February 2011. The measurements consisted of: water levels; shallow water bathymetry; three dimensional currents; and salinity and water temperatures. Figure 1 provides a station location overview.

This report is a summary of the survey data and a description of the project database. In addition to the observations that were deployed during this three-month survey, this document includes measurements collected routinely from Physical Oceanographic Real-Time System (PORTS®). The PORTS® supports safety and efficiency of maritime commerce and coastal resource management by the integration of real-time environmental observations, forecasts and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, and meteorological parameters (e.g., winds, atmospheric pressure, air and water temperatures) that mariners need to safely navigate U.S. Coastal waterways.

The purpose of this report is to facilitate public accessibility to and potential usages of the data sets. The data sets are organized according to physical parameters. The following sections will provide measurement information for each of these parameters.

- Section 2: Water levels from Mobile Bay PORTS, GPS Water Level Buoy, and Mobile Bay survey
- Section 3: Bathymetry in Weeks Bay and Grand Bay, AL and Point Aux Chenes Bay, AL
- Section 4: Currents velocity from Mobile Bay survey and Mobile Bay PORTS measurements
- Section 5: Conductivity, temperature, and salinity (CTD) from autonomous underwater vehicle (AUV) and portable CTD casts
- Section 6: Meteorological data from Mobile Bay PORTS

Associated with this report is a project dataset spreadsheet file:
NOS_MobileBay_circulation_study.xlsx.

The file includes both metadata and survey data, data locations sites, readme files, etc. Both the spreadsheet file and survey datasets are available online at:

ftp://ocsftp.ncd.noaa.gov/NOS_MobileBay_Circulation_Survey_Nov2010_Feb2011.

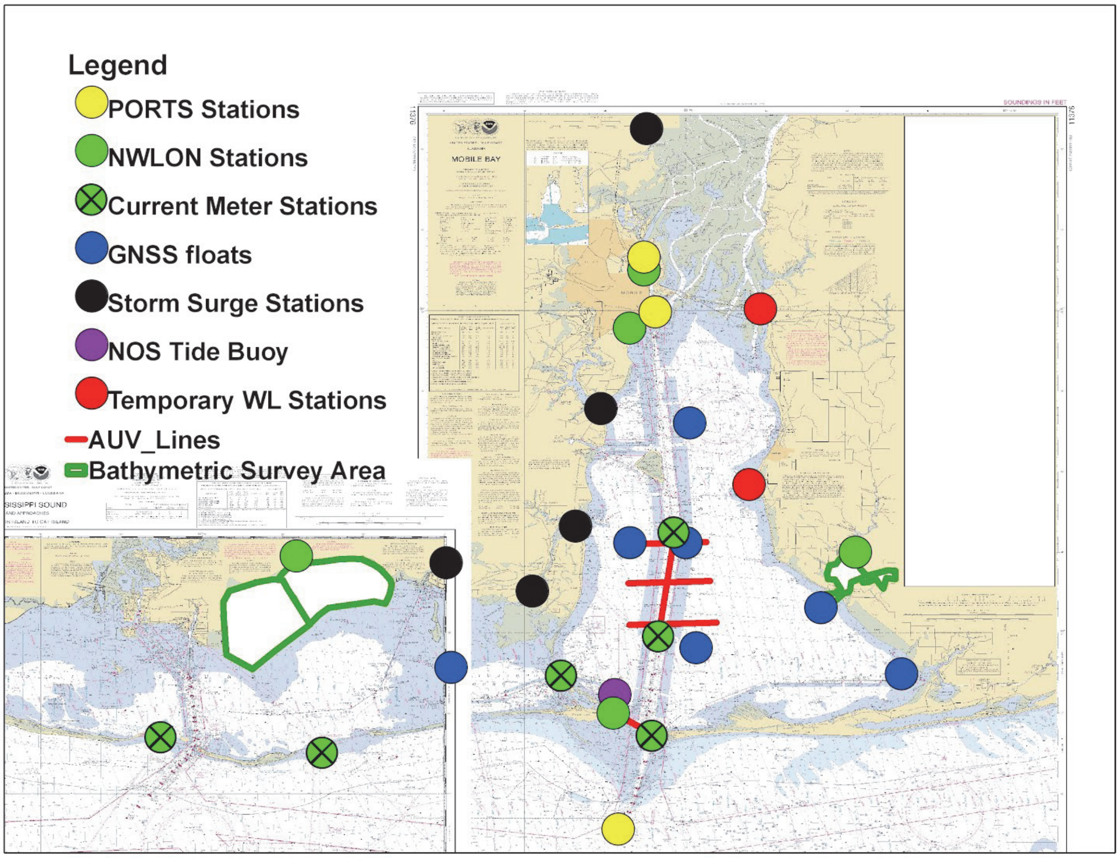


Figure 1. A composite chart of the Mobile Bay observational program.

2. Water Level Data

Water level data provided in this report are from four sources: NOS NWLON stations in Mobile Bay; PORTS; GPS water level buoy measurements; and two temporary water level gauges deployed in the eastern Mobile Bay during the three-month survey.

2.1. Mobile Bay PORTS

To provide a comprehensive set of observations collected by NOS, included in the survey datasets are the NWLON stations located in Mobile Bay. These data were downloaded from Mobile Bay PORTS Website maintained by NOAA's CO-OPS. The site address is:
http://tidesandcurrents.noaa.gov/ports/index.shtml?port=mb.

2.1.1. Station Location and Survey Period

Figure 2 shows the water level station locations and Table 1 lists the station IDs, station names, longitudes and latitudes, and data period.

Figure 2. Water level stations in Mobile Bay PORTS.

Table 1. Mobile Bay PORTS water level data.

Station ID	Station Name	Latitude (°N)	Longitude (°E)	Data Period
8737048	Mobile State Docks	30° 42.5'	88° 2.6'	2010/11/01-2011/2/28
8736897	Coast Guard Sector Mobile	30° 38.9'	-88° 3.5'	2010/11/01-2011/2/28
8735180	Dauphin Island	30° 15'	-88° 4.5'	2010/11/01-2011/2/28
8740166	Grand Bay Nerr	30° 24.7'	-88° 24.1'	2010/11/01-2011/2/28
8732828	Weeks Bay	30° 25'	-87° 49.5'	2010/11/01-2011/2/28

2.1.2. Sample Plots

Figure 3 shows a sample display of water level time series at station 8735523 printed from the Mobile Bay PORTS Web site.

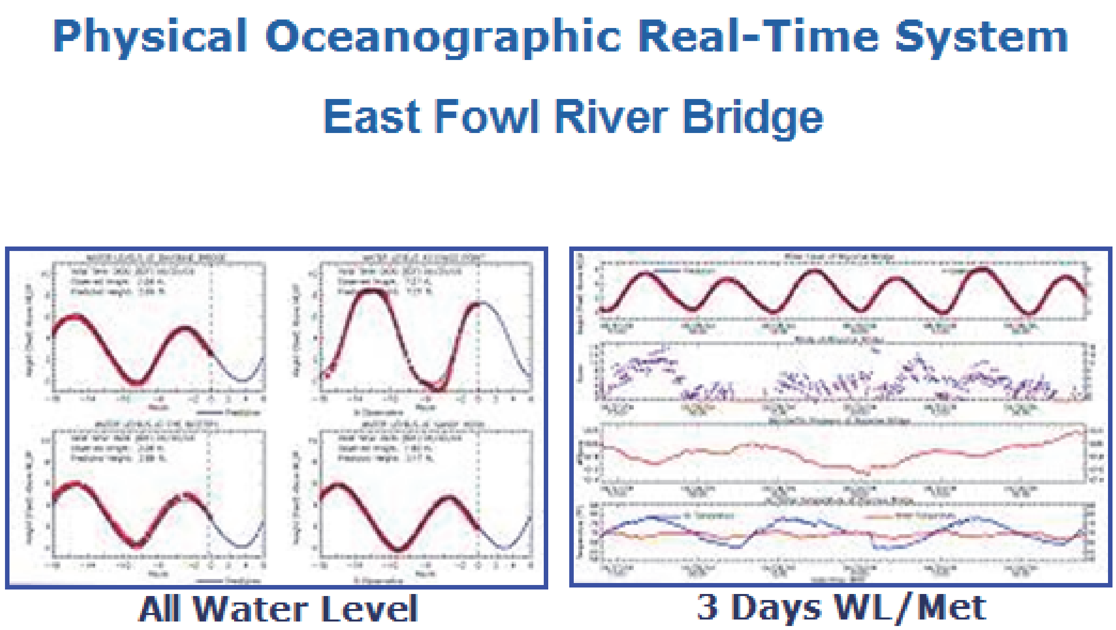


Figure 3. Sample plots of Mobile Bay water level station data.

2.1.3. Database

The database information is provided in the worksheet 'WaterLevel' in the project spread sheet.

2.2. GPS Water Level Buoy

A long standing challenge for meeting NOAA's goals of advancing accurate and efficient processing of hydrographic survey has been the inability to probe water levels within outbound water ways. Traditionally, water level observations have been limited to shore-based tide observations. NOAA is currently testing the accuracy and efficiency of the GPS water level buoy technology within outbound waterways to determine spatial differences in tidal datum relative to the ellipsoidal. AXYS Technology's AXYS HydroLevel™ Buoy was the GPS water level system used as part the Mobile Bay Project. The AXYS HydroLevel™ Buoy is designed to capture differential GPS and tilt sensor data. Figure 4 illustrates the deployment of a GPS water level buoy.

As part of the overall testing of the GPS water level system, several sea environments have been identified to exercise the system. These environments include: (1) high diurnal range, (2) low diurnal range (high noise), (3) high wave heights and (4) low wave heights. The Mobile Bay project provided a prime opportunity to test this new technology in one of these conditions. Mobile Bay is an area characterized by low tidal diurnal range relative to noise from non-astronomical effects. Diurnal tidal range is defined as the vertical difference between the tidal datums, Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW).

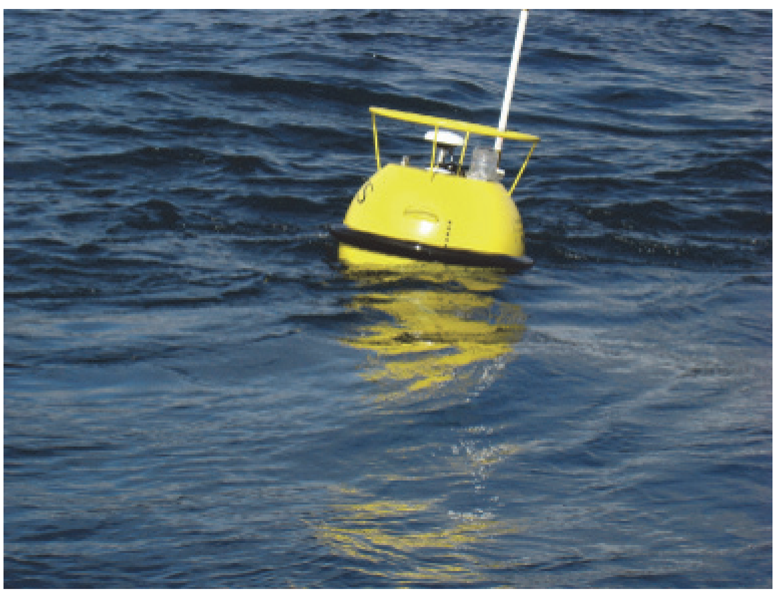


Figure 4. Deployment of a GPS water level buoy.

The GPS water level buoys was deployed for at least 30-days near a traditional NOAA water level station. A period of 30 day is sufficient to acquire a vertical tidal datum. After deployment, the GPS raw observables were collected and were post-processed by applying post-processed kinematic techniques and tilt sensor corrections to obtain time-stamped water level measurements and a vertical datum. Further analysis was performed comparing parameters with a nearby shore based tide station 8735180 on Dauphin Island, AL. Particular attention centered on identifying any system anomalies with respect to tidal datum, ranges and frequency. The results of GPS water level buoy can be used to provide corrections to the Vertical Datum (VDatum) model of Mobile Bay and other areas once this technology has been validated. Additionally, it is anticipated that the use of a network of GPS water level buoys would allow hydrographic surveys to be conducted with vertical reference on the ellipsoid using shipboard GPS.

2.2.1. Station Location and Data Period

The GPS water level buoy was deployed near the NOS NWLON station 8735180. Table 2 lists the two data files. The two data sets differ in sampling frequency, corresponding to a 6-minute and 1-second data point intervals, respectively.

Table 2. An inventory of GPS water level buoy data.

No.	Filename	Latitude (^oN)	Longitude (^oE)	Survey Period
1	Sta_8735180_NAD83CORS96_6min_time Interval.txt	30.26778	-88.07471	12/03/2010 – 01/09/2011
2	Sta_8735180_NAD83CORS96_1Hz.txt	30.26778	-88.07471	12/03/2010 – 01/09/2011

2.2.2. Database

The database information is provided in the worksheet 'WaterLevel' in the project spread sheet.

2.3. Water Level Mobile Bay Survey Deployment

CO-OPS standard tertiary tide station consists of a Sutron data collection platform (DCP) with mounting stand, solar panels, and GOES antenna which are mounted on a mast attached to the DCP support stand. The Aquatrak water level sensor and protective well are secured to a bulkhead or pier piling near the DCP. The DCP acquires and stores water level measurements, computes and stores the standard deviation of the discrete water level samples, and transmits the data every six minutes. The Aquatrak is a self-calibrating air acoustic sensor that samples discrete water level data for 181 seconds and assigns the measurement to the tenth of an hour timestamp.

2.3.1. Station Location and Survey Period

Water level time series were measured at two eastern Bay stations, Point Clear, Mobile Bay, AL and Meaher State Park, Mobile Bay, AL (See their locations marked as filled red circles in Figure 1). Table 3 list data file names, station locations, and survey periods. The purpose of adding these two water level gages to the existing NWLON locations were to supplement the water level existing information by providing water level heights on the eastern side of the Mobile Bay. This additional information is necessary to quantify both the tidal variations and the response of the Bay to river and meteorological events across the Bay.

Table 3. Water level data from two Eastern Bay gauges.

File name	Latitude (^oN)	Longitude (^oE)	Survey period
Station_8733821.txt	30 29.2	-87 56.1	2010-11-16_2011-02-05
Station_8733839.txt	30 40.0	-87 56.2	2010-11-09_2011-02-10

2.3.2. Database

The database information is provided in the worksheet 'WaterLevel' in the project spread sheet.

2.4. Storm Surge Monitoring Network

In FY2010, the CO-OPS received two-year funding to establish a real-time storm surge monitoring network for Mobile County. Figure 5 indicates the locations of the storm surge monitoring network. The CO-OPS conducted an oceanographic and meteorological assessment of this area, in collaboration with other federal offices, to determine actual requirements for a comprehensive storm surge network. A detailed site reconnaissance was performed based on the results of this assessment, and project sites were recommended to the customer (Mobile County Commission). The CO-OPS worked closely with the customer to assess the requirements for this project, and provided guidance on the development of this network.

The timing of this project aligned with a Tri-Offices Coastal and Climate Team proposed project for FY10-11. Pending approval of that project, opportunities to align planning and execution of the respective projects were explored. Ultimately, the two projects were combined to demonstrate the benefits to CO-OPS' internal partners and the customer of integrated oceanography, leverage of resources, and effective joint planning. The project manager coordinated with the COASTAL Program Manager and the Tri-Offices planning team on the storm surge project, planned hydrography, shoreline mapping, and hydrodynamic modeling efforts. Unfortunately, because of logistical issues, the installation occurred subsequent to the three-month survey.

The storm surge network consists of five stations. Table 4 lists their identification numbers, names, and locations. The Dog River, East Fowl River, and West Fowl River stations were installed in June 2011 by a CO-OPS field crew; the Bayou LaBatre and Chickasaw Creek stations were installed in November 2011 by contractor. Since the network did not start to collect data until after the Mobile Bay survey period,this project database does not include any data sets from these stations.

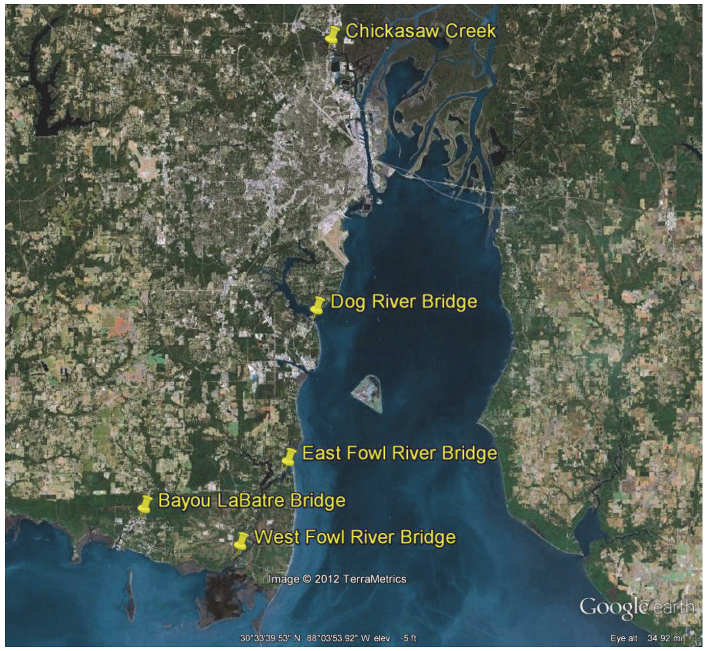


Figure 5. Storm Surge Monitoring Network.

Table 4. Stations in the Mobile County Storm Surge Monitoring Network.

Station ID	Station name	Latitude (N)	Longitude (E)
8735391	Dog River Bridge, AL	30° 33′ 53.1″	88° 05′ 16.7″
8735523	East Fowl River Bridge, AL	30° 26′ 38.5″	88° 06′ 51.4″
8738043	West Fowl River Bridge, AL	30° 22′ 35.9″	88° 09′ 30.8″
8739803	Bayou LaBatre Bridge, AL	30° 24′ 20.4″	88° 14′ 51.7″
8737138	Chickasaw Creek, AL	30° 46′ 54.8″	88° 04′ 25.0″

3. Bathymetric Data

As a component of this project, the Office of Coast Survey conducted single beam bathymetric survey operations in Weeks Bay, Pt aux Chenes Bay, and Grand Bay, along the Alabama and Mississippi coasts (Figure 6). These new data provided bathymetry within the region which were applied to various nautical products within Weeks Bay, AL and Grand Bay, AL/MS, while providing needed hydrographic data for the planned implementation of a NGOFS Mobile Bay finer resolution operational forecast system for the region.

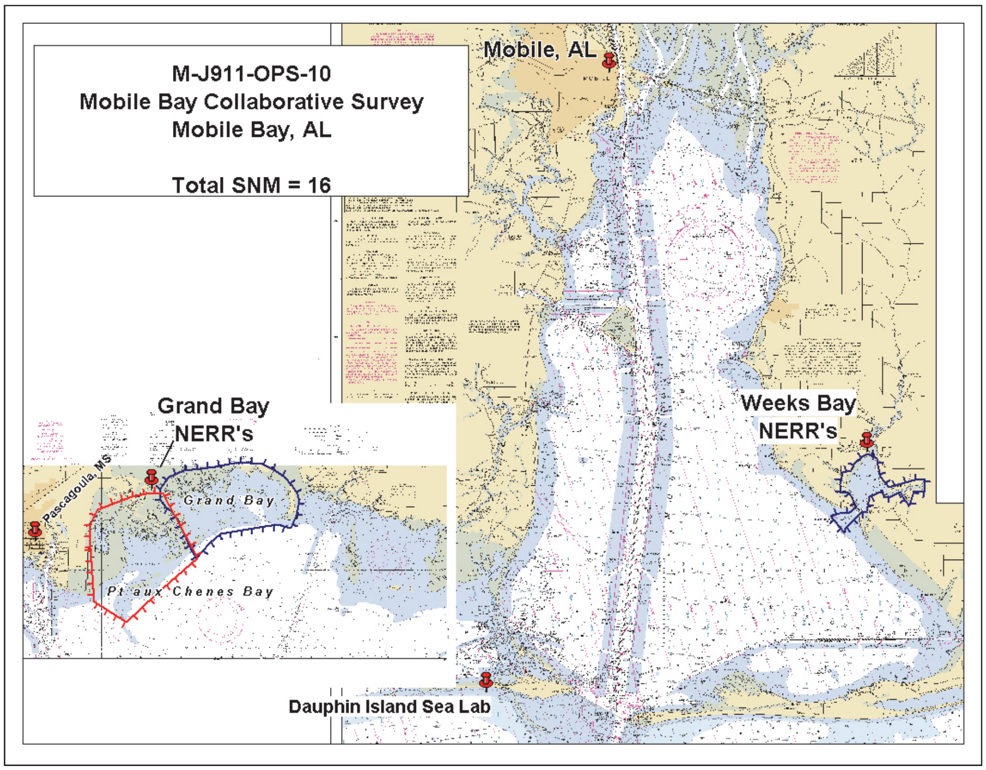


Figure 6. Mobile Bay bathymetric survey map.

3.1. Weeks Bay

The first segment of the project was conducted at the Weeks Bay National Estuarine Research Reserve in Alabama on the southeast side of Mobile Bay as shown in Figure 7(a). In support of the survey, the National Estuarine Research Reserve (NERR) in Weeks Bay provided the field team with a shallow water survey launch, docking/launching facilities, and on-site lodging for the duration of the project. Hydrographic survey operations for this portion of the project began on Monday April 12 and ended on Saturday April 17th. The vessel was integrated with an Odom "Fly-Away System" consisting of a single-beam sonar and GPS receiver which was pole mounted and affixed to the starboard side of the boat. The Weeks Bay survey provided 63 Linear Nautical Miles (LNM) and roughly 3 Square Nautical Miles (SNM) of coverage lasting six project days.

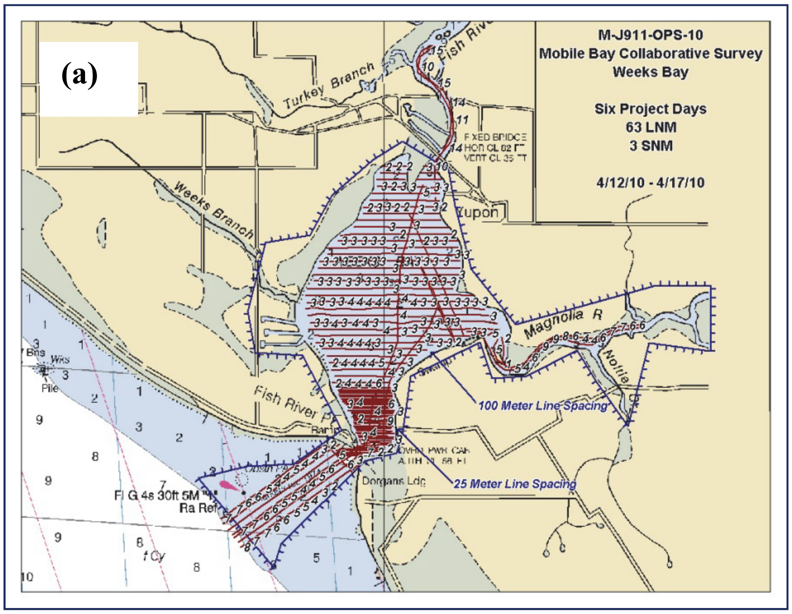
3.2. Grand Bay and Point Aux Chenes Bay

Following the Weeks Bay survey, the project team relocated to the Grand Bay area as shown in Figure 7(b) and began survey operations on Monday, April 19th. The Grand Bay National Estuarine Research Reserve (NERR's) provided logistical support and a 16ft. aluminum skiff, very similar to the boat that was used in Weeks Bay, which was outfitted and served as the primary survey launch. This area was divided into two survey areas (Pt aux Chenes Bay and Grand Bay) as a result of the size of the area and the logistics involved in accessing the working grounds. The Grand Bay area was far more challenging than Weeks Bay, being far more remote, exposed to the wind and seas, with long transit times to the working ground.

The Grand Bay and Pt aux Chenes Bay survey provided 178 Linear Nautical Miles and 18 Square Nautical Miles of coverage, which includes Bangs Lake and Middle Bay. Operations consisted of 200 meter line spacing predominately in an East/West azimuth beginning at the most sea-ward extent and working shoreward. In general, the survey area was consistently deeper than what is currently charted and the portrayed shoreline is badly off in many of the areas. Extreme shoreline erosion is very noticeable throughout the entire region, especially in northern portions of Grand Bay where relatively large islands has been entirely eroded. The survey team was on site for 29 project days resulting in 19 survey days as a result of the consistent and strong SE winds, malfunctioning equipment, software issues, and the Gulf of Mexico oil spill

3.3. Database

The database worksheet 'Bathymetry' is in the project spread sheet.



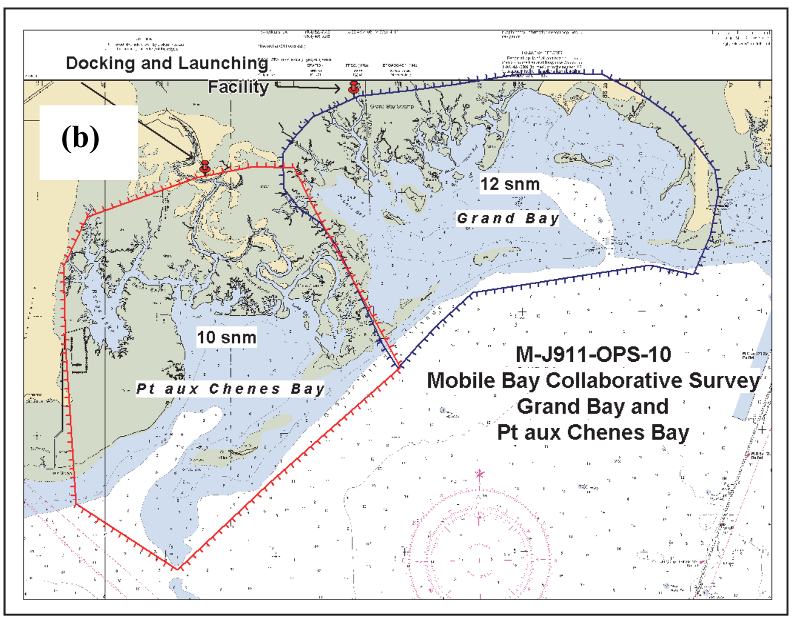


Figure 7. Survey areas in (a) Weeks Bay and (b) Grand Bay and Point Aux Chenes Bay.

4. Current Data

Current data were collected using Acoustic Doppler Current Profilers (ADCPs). The data consists of measurements from two sources: 1) those collected routinely from the Mobile Bay PORTS, and 2) additional instruments deployed as a component of the three-month survey.

4.1. Mobile Bay Survey

The ADCP is a scientific instrument that sends out an acoustic pulse through the water column, and then measures the shift in the sound frequency to determine the speed of the water at regular distances from the head of the instrument.

NOAA/NOS's CO-OPS deployed six ADCP. Figure 1 illustrates that the survey region included locations throughout Mobile Bay and Mississippi Sound. The survey period was from November 2, 2010 to February 2, 2011. Unfortunately, the two ADCP deployed along the Mobile Bay navigational channel as shown in Figure 1 were lost. Figure 8 is a photo showing an ADCP and its associated deployment hardware

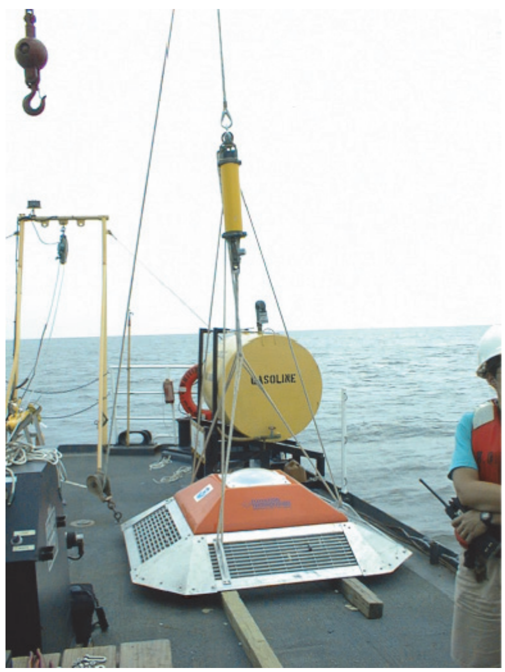


Figure 8. An ADCP mooring.

The key current meter station MOB1101 as shown in Table 5 served as the reference station at Mobile Point. This station also serves as a reference to a large number of subordinate stations in the northern Gulf of Mexico. The currents at this location are reasonably strong and predictable. Contemporary data at this location is needed because present tidal current predictions are based on drifting current pole observations collected for only 5 days in the 1930s.

The ADCP data described in the following sections were downloaded from the TIDES&CURRENTS Website maintained by NOAA's CO-OPS. The site address is: http://tidesandcurrents.noaa.gov/cdata/StationList?type=Current%20Data&filter=survey&pid=14.

4.1.1. Station Location and Data Period

Figure 9 shows the station locations of the four successful ADCP deployments (Section 4.1). Table 5 gives details of ADCP deployments; and Table 6 provides station IDs, station names, locations, and survey periods.

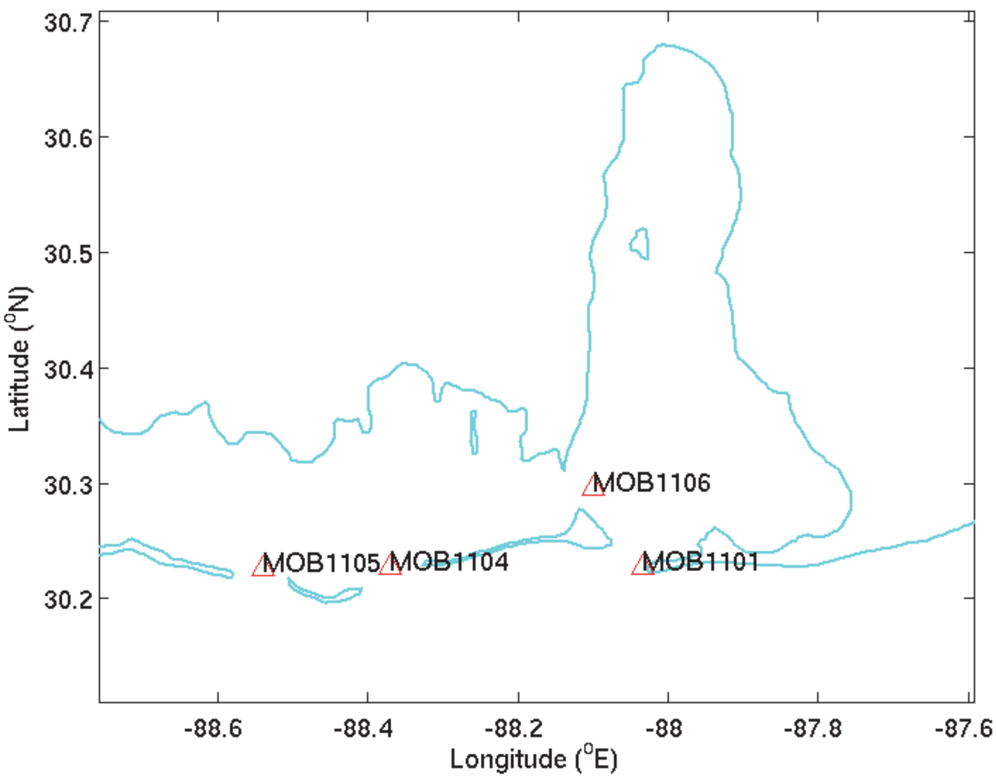


Figure 9. Locations of ADCP deployments during the Mobile Bay survey.

4.1.2. Database

The database worksheet 'Currents_ADCP' is provided in the project spread.

Table 5. Meta data of four ADCP deployments.

MOB1101 – Mobile Point

Data Type	Currents
Station ID	MOB1101
Station Name	Mobile Point
Project	Mobile Bay 2011 Circulation Survey
Latitude	30° 13.622' N
Longitude	88° 2.075' W
Approximate Station Depths (m) below the surface at MLLW	2.99, 3.51, 3.99,4.48,5.00,5.49, 6.00,6.49,6.98,7.50,7.99,8.50,8.99,9.48, 10.00,10.49,11.00,11.49,11.98, 12.50
Sensor Orientation	Down (Buoy-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	
Approximate Flood Direction (deg true)	0.0

MOB1104 – Entrance to Mississippi Sound – East

Data Type	Currents
Station ID	MOB1104
Station Name	Entrance to Mississippi Sound - East
Project	Mobile Bay 2011 Circulation Survey
Latitude	30° 13.307' N
Longitude	88° 22.248' W
Approximate Station Depths (m) below the surface at MLLW	0.43, 0.94, 1.43, 1.95
Sensor Orientation	Up (Bottom-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11374
Approximate Flood Direction (deg true)	0.0

MOB1105 – Entrance to Mississippi Sound - West

Data Type	Currents
Station ID	MOB1105
Station Name	Entrance to Mississippi Sound - West
Project	Mobile Bay 2011 Circulation

	Survey
Latitude	30° 13.541' N
Longitude	88° 32.396' W
Approximate Station Depths (m) below the surface at MLLW	0.73, 1.22, 1.74, 2.23, 2.74, 3.23
Sensor Orientation	Up (Bottom-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11375
Approximate Flood Direction (deg true)	0.0

MOB1106 – Dauphin Island Causeway

Data Type	Currents
Station ID	MOB1106
Station Name	Dauphin Island Causeway
Project	Mobile Bay 2011 Circulation Survey
Latitude	30° 17.356' N
Longitude	88° 7.722' W
Approximate Station Depths (m) below the surface at MLLW	0.52, 1.01, 1.52, 1.52, 2.01, 2.50, 3.02, 3.51
Sensor Orientation	Up (Bottom-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11376
Approximate Flood Direction (deg true)	80.0

Table 6. An Inventory of ADCP data from the Mobile Bay survey.

Station ID	Station Name	Latitude (°N)	Longitude (°E)	Data Period
MOB1101	Mobile Point	30.22703	-88.03458	2010/11/11-2011/2/6
MOB1104	Entrance to Mississippi Sound - East	30.22178	-88.37080	2010/11/5-2011/2/12
MOB1105	Entrance to Mississippi Sound - West	30.22569	-88.53994	2010/11/5-2011/2/6
MOB1106	Dauphin Island Causeway	30.29556	-88.09956	2010/12/7-2011/2/6

* The two lost stations are MOB1103 at (30.43649 °N, -88.01342 °E) and MOB1102 at (30.33010 °N, -88.02948 °E), respectively.

4.2. Mobile Bay PORTS

In order to provide a comprehensive set of observations during the three-month survey, included in the survey datasets are those currents measurements collected routinely by the Mobile Bay PORTS. These data were downloaded from the PORTS Website maintained by NOAA's CO-OPS. The site address is:

http://tidesandcurrents.noaa.gov/ports/index.shtml?port=mb.

4.2.1. Station Location and Data Period

Figure 10 displays the Mobile Bay currents stations locations; Table 7 provides the station metadata; and Table 8 presents station IDs, their locations, and survey periods.

4.2.2. Sample Plots

Sample plots of currents velocity time series from the Mobile Bay PORTS are shown in Figure 11.

4.2.3. Database

The database information for 'Currents_ADCP' is provided in the project spread sheet.

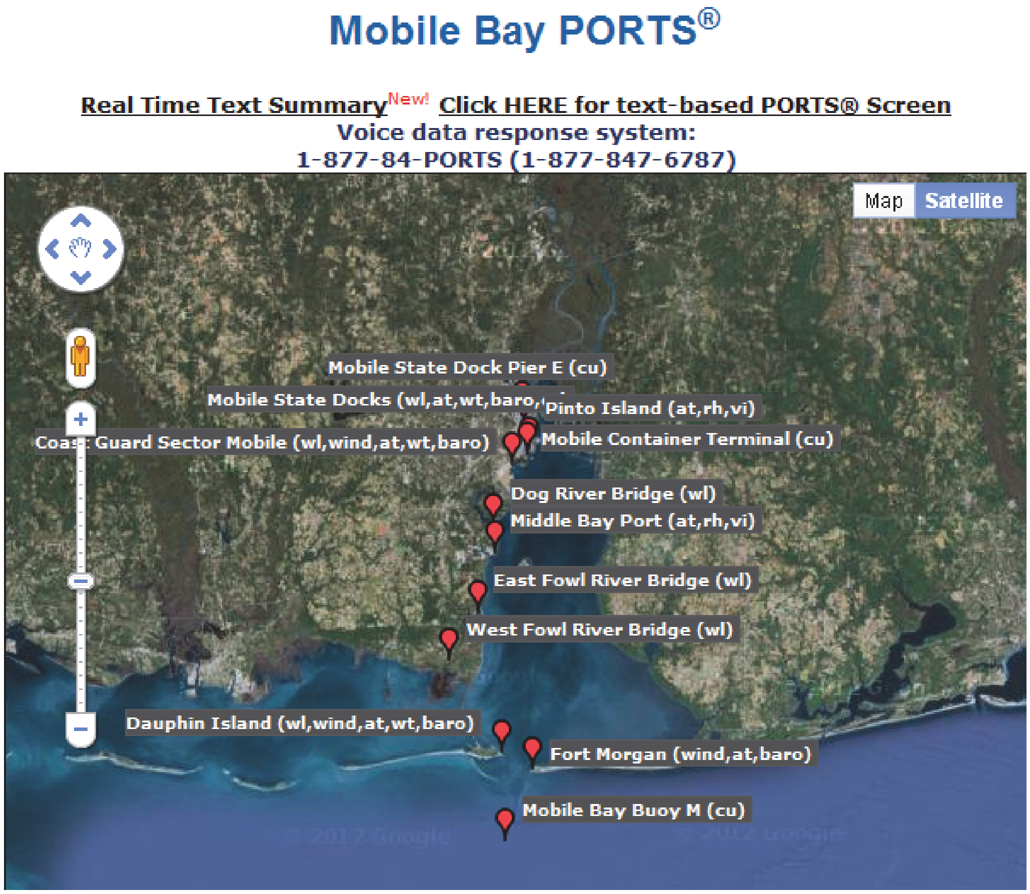


Figure 10. Currents velocity stations in Mobile Bay PORTS.

Table 7. Meta data of currents stations in Mobile Bay PORTS

Mobile State Dock Pier E

Attribute	Value
Data Type	Currents
Station ID	mb0301
Station Name	Mobile State Dock Pier E
Project	Mobile Bay PORTS
Latitude	30° 43.267' N
Longitude	88° 2.567' W
Deployment/Recovery Dates (UTC)	Aug 17, 2010 15:00:00 / not recovered
*Approximate Sensor Depth **	16.4ft / 5.00m
Sensor Orientation	Side (Shore-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11376
Approximate Flood Direction (deg true)	348.0

Mobile Bay Buoy M

Attribute	Value
Data Type	Currents
Station ID	mb0101
Station Name	Mobile Bay Buoy M
Project	Mobile Bay PORTS
Latitude	30° 7.518' N
Longitude	88° 4.122' W
Deployment/Recovery Dates (UTC)	Mar 15, 2012 13:28:00 / not recovered
Approximate Station Depth *	58.1ft / 17.70m
Sensor Orientation	Down (Buoy-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11376
Approximate Flood Direction (deg true)	111.0

Mobile Container Terminal

Attribute	Value
Data Type	Currents
Station ID	mb0401
Station Name	Mobile Container Terminal
Project	Mobile Bay PORTS
Latitude	30° 39.866' N
Longitude	88° 1.933' W
Deployment/Recovery Dates (UTC)	Mar 14, 2012 22:00:00 / not recovered
Approximate Sensor Depth *	20.0ft / 6.10m
Sensor Orientation	Side (Shore-Mounted)
Time Zone	UTC -6
Sample Interval	6 min
Time Meridian	90 W
NOAA Chart #	11376
Approximate Flood Direction (deg true)	355.0

Table 8. An inventory of ADCP data from Mobile Bay PORTS stations.

Station ID	**Station Name/**	**Latitude (^{o}N)**	**Longitude (^{o}E)**	**Survey Period**
mb0101	Mobile Bay Buoy M	30° 7.518'	-88° 4.122'	2010/12/1-2011/1/31
mb0301	Mobile State Dock Pier E	30° 43.267'	-88° 2.567'	2010/11/1-2011/2/28
mb0401	Mobile Container Terminal	30° 39.866'	-88° 1.933'	2010/11/1-2011/2/28

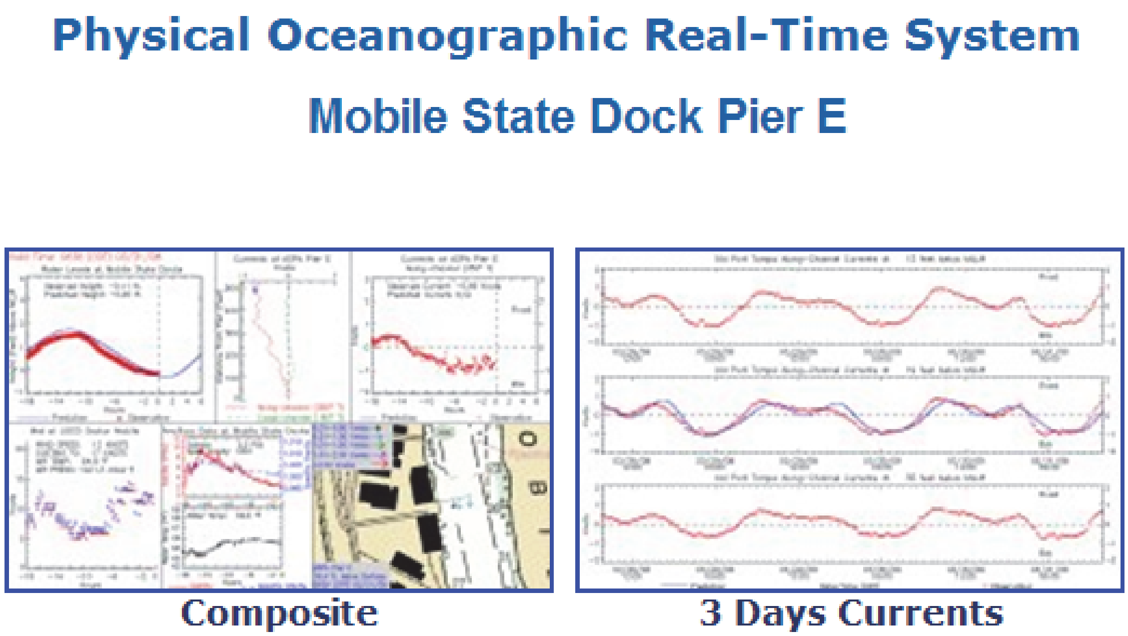


Figure 11. Sample plots of currents velocity from a Mobile Bay PORTS station.

5. Conductivity, Temperature, and Depth (CTD) Data

5.1. AUV-CTD

Autonomous Underwater Vehicles (AUVs) are unmanned, underwater robots that can be programmed to operate without remote control from shore or a ship as shown in Figure 12. NOAA's Office of Coast Survey continues to evaluate the use of AUVs to support hydrographic surveying in support of NOAA's nautical charting and navigation safety missions. The Office of Coast Survey is currently evaluating AUVs for three different missions: Emergency Response, Bathymetric Mapping, and routine side scan sonar surveys. The project demonstrated the value of collecting continuous CTDs and this instrumentation package deployed on AUVs can support CTD requirements for future NOAA surveys.

NOAA has used its Emergency Response AUV to search for hazards and obstructions deposited in shipping channels following Tropical Storms and Hurricanes. The Bathymetric Mapping AUV is in development and will continue be tested to ensure that the data it collects meet NOAA and international standards for nautical charting. In 2010, NOAA began evaluating oceanographic data collection capabilities of AUV's in support of hydrographic survey operations.

OCS's Emergency Response AUV, REMUS 100, is equipped with a high resolution scientific conductivity and temperature probe. Using the vehicle's onboard pressure and depth sensors, continuous CTD data were collected along six transects (Figure 13). The AUV was programmed to travel in a sine wave (undulating) pattern along these transects to collect data throughout the full water column. AUV operations were planned at max ebb and flood tides when condition allowed. NOAA surveyors use CTD to compute sound velocity in water to improve the accuracy of sonar measurements used for create nautical charts. Additionally, CTD can be used by other scientists to evaluate biological conditions or support oceanographic models.

5.1.1. Survey Transect and Date

To supplement individual CTD casts collected during the three-month survey, AUV surveys were conducted along seven transects (see thin white lines in Figure 13). Table 9 provides an inventory of seven data sets, including file names, survey dates, recorded physical parameters, and survey locations.

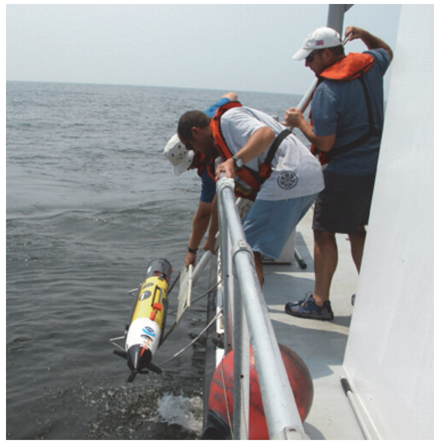


Figure 12. Deployment of AUV.

Figure 13. Transects of AUV-CTD surveys (thin white lines).

Table 9. An inventory of AUV-CTD data.

File name	Survey Date	Recorded Parameter	Survey Location
10_NOV_CTD_1.csv	Nov. 10, 2010	latitude, longitude, mission_time, depth, conductivity, temperature, salinity, sound_speed	See thin lines in Figure 13.
10_NOV_CTD_2.csv	Nov. 10, 2010		
11_NOV_CTD_1.csv	Nov. 11, 2010		
11_NOV_CTD_2.csv	Nov. 11, 2010		
12_NOV_CTD.csv	Nov. 12, 2010		
13_NOV_CTD.csv	Nov. 13, 2010		
14_NOV_CTD.csv	Nov. 14, 2010		

5.1.2. Database

The database information for 'CTD' is provided in the project spread sheet.

5.2. Portable CTD Casts by OCS/Navigation Services Division (NSD)

As a component in a comprehensive CTD program, RBR's Profiling marine CTD, the XR-620CTDmF was deployed to profile CTD at selected locations as shown in Figure 14. The system possesses a fast response thermistor to provide synchronous measurement with conductivity, and a sampling capability of up to 6Hz. The system has a software wet-switch, which turns off the sampling when the logger is not in the water, to save batteries and memory between casts.

It is available in delrin polymer or titanium pressure cases, allowing deployment up to 740m or 6600m respectively. If required, external connectors can be selected for data and power connections underwater. Pressure sensors are optional.

To measure conductivity the system uses an inductive sensor, suitable for deployment in any water. There are no exposed contacts, which avoid susceptibility to corrosion, and the housing is capable of being frozen. It is characterised for the mechanical effects of both temperature and pressure to allow for accurate correction in salinity derivation. These coefficients are provided for customers who prefer to calculate their own corrections. In addition, it is suitable for use outside the usual realms of PSS-78 practical salinity scale, in applications such as desalination brine monitoring.

To measure temperature the sensor is built and calibrated in-house using an aged thermistor. Options include internal or external placement, depending on the intended conditions, and standard or fast time constants (3 seconds or 95 milliseconds for external types). Standard range is -5° to +35°C, though this can be extended on request.

To measure pressure the system uses a piezo-resistive transducer with Hastelloy diaphragm to avoid corrosion. The system accuracy is 0.05% of the full scale rating and achievable resolution is 0.001%.

Figure 14. RBR's Profiling CTD, model XR-620CTDmF.

5.2.1. Survey Location and Date

CTD casts were conducted on January 16, 18-20, 2011. Figures 15-18 display the location of the CTD casts on each of the four days, respectively. Tables 10-13 lists the station locations, and survey date/time.

5.2.2. Database

The database information is listed in the worksheet 'CTD' of the project spread sheet.

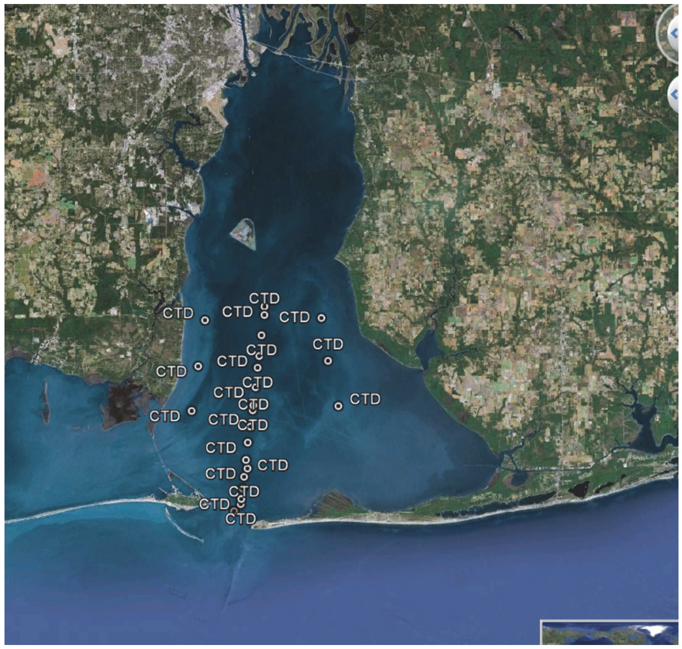


Figure 15. CTD survey stations on December 16, 2010.

Table 10. OCS/NSD CTD surveys on December 16, 2010 Survey.

STATION	Latitude (^{o}N)	Longitude (^{o}E)	Survey Time (GMT)
1	30 14 7.80	-88 2 49.58	17:50
2	30 20 14.3	-88 05 39.1	17:58
3	30 22 48.6	-88 05 13.2	18:15
4	30 25 27.7	-88 04 45.9	18:24
5	30 25 35.4	-87 56 59.7	18:43
6	30 23 07.5	-87 56 33.5	18:51
7	30 20 31.1	-87 55 52.2	19:02
8	30 26 15.0	-88 00 48.0	19:23
9	30 25 45.8	-88 00 48.1	19:28
10	30 24 35.8	-88 00 59.7	19:33
11	30 23 24.2	-88 01 09.0	19:38
12	30 22 43.8	-88 01 15.4	19:42
13	30 21 36.2	-88 01 23.5	19:48
14	30 20 33.8	-88 01 32.4	19:53
15	30 20 16.7	-88 01 35.1	19:57
16	30 19 20.5	-88 01 43.8	20:01
17	30 18 25.3	-88 01 54.6	20:06
18	30 17 25.0	-88 02 01.8	20:10
19	30 16 26.8	-88 02 09.4	20:15
20	30 15 46.1	-88 02 15.3	20:19
21	30 15 10.3	-88 02 20.4	20:22
22	30 14 52.6	-88 02 22.7	20:25
23	30 14 28.7	-88 02 48.7	20:30
24	30 16 55.6	88 01 55.8	20:38

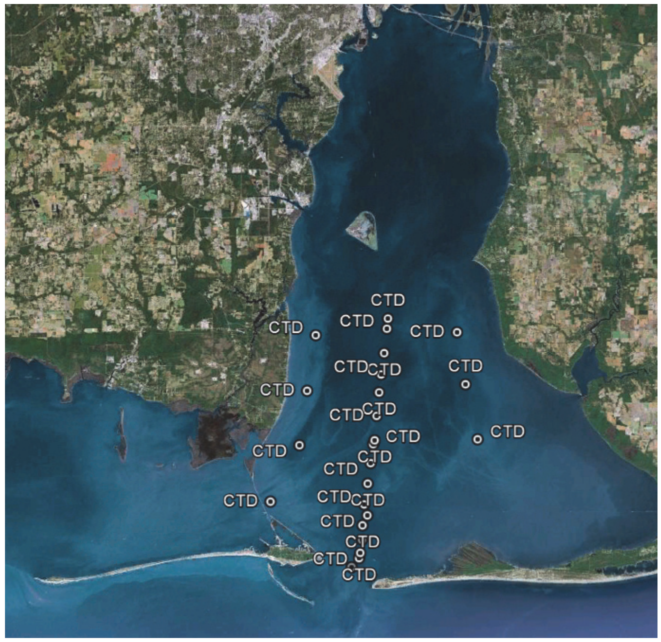


Figure 16. CTD survey stations on December 20, 2010.

Table 11. OCS/NSD CTD surveys on December 20, 2010 Survey.

STATION	Latitude (^oN)	Longitude (^oE)	Survey Time (GMT)
1	30 17 33.8	-88 07 14.4	8:19
2	30 20 14.3	-88 05 39.3	8:28
3	30 22 49.1	-88 05 14.1	8:38
4	30 25 27.1	-88 04 45.7	8:45
5	30 25 35.4	-87 57 00.5	9:04
6	30 23 07.5	-87 56 32.9	9:11
7	30 20 31.2	-87 55 53.3	9:19
8	30 26 14.5	-88 00 48.2	9:37
9	30 25 45.6	-88 00 51.5	9:41
10	30 24 36.1	-88 01 00.6	9:46
11	30 23 35.6	-88 01 10.5	9:50
12	30 22 44.5	-88 01 17.2	9:54
13	30 21 37.7	-88 01 25.6	9:59
14	30 20 28.3	-88 01 32.0	10:04
15	30 20 17.3	-88 01 36.8	10:07
16	30 19 23.6	-88 01 45.1	10:12
17	30 18 25.2	-88 01 54.8	10:16
18	30 17 26.1	-88 02 6.4	10:21
19	30 16 26.6	-88 02 11.9	10:31
20	30 15 45.7	-88 02 13.3	10:35
21	30 15 8.3	-88 02 19.3	10:39
22	30 14 53.3	-88 02 23.2	10:43
23	30 14 27.6	-88 02 47.8	10:47
24	30 16 54.9	-88 01 55.9	10:55

Figure 17. CTD survey stations on January 18, 2011.

Table 12. OCS/NSD CTD surveys on January 18, 2011 Survey.

STATION	Latitude (^{o}N)	Longitude (^{o}E)	Survey Time (GMT)
1	30.29297	-88.12029	20:23
2	30.33736	-88.09418	20:34
3	30.37988	-88.0869	20:42
4	30.42377	-88.07957	20:50
5	30.42477	-88.04082	20:56
6	30.42604	-87.99477	21:03
7	30.4265	-87.95004	21:11
8	30.38541	-87.94263	21:18
9	30.38644	-87.99471	21:26
10	30.3849	-88.04169	21:33
11	30.34157	-88.05038	21:41
12	30.34276	-87.99261	21:51
13	30.34198	-87.93124	22:00
14	30.43733	-88.01446	22:18
15	30.40986	-88.01736	22:24
16	30.3436	-88.02086	22:29
17	30.3436	-88.02545	22:36
18	30.32247	-88.02998	22:39
19	30.29054	-88.03366	22:45
20	30.2627	-88.03764	22:45
21	30.24853	-88.03936	22:50
22	30.24287	-88.04697	22:55
23	30.28221	-88.03204	23:05

Figure 18. CTD survey stations on January 19, 2011.

Table 13. OCS/NSD CTD surveys on January 19, 2011 Survey.

STATION	Latitude (°N)	Longitude (°E)	Survey Time (GMT)
1	-88.12038	30.29303	8:42
2	-88.09453	30.3369	8:51
3	-88.08726	30.37935	8:58
4	-88.07931	30.42405	9:05
5	-88.04144	30.42494	9:11
6	-87.99529	30.42579	9:18
7	-87.9504	30.42635	9:24
8	-87.94243	30.38497	9:31
9	-87.99556	30.38465	9:40
10	-88.04198	30.38482	9:47
11	-88.05071	30.34058	9:55
12	-87.99232	30.34274	10:04
13	-87.93145	30.34169	10:13
14	-88.01461	30.43744	10:30
15	-88.0172	30.41085	10:34
16	-88.02149	30.3795	10:40
17	-88.02747	30.33881	10:46
18	-88.0321	30.30744	10:51
19	-88.03606	30.27441	10:56
20	-88.03986	30.24902	11:00
21	-88.04713	30.24066	11:03
22	-88.03195	30.28202	11:10

5.3. Portable CTD Casts by OCS/Coast Survey Development Laboratory (CSDL)

The comprehensive CTD program also consisted of deploying a YSI CastAway-CTD. The system is lightweight, easy to deploy, and collects accurate conductivity, temperature, and depth profiles. The system utilizes a unique six-electrode array and a flow-through cell, the CastAway makes use of commercial Bluetooth and GPS technology to make an instrument that is as usable as it is accurate.

The palm-sized CastAway-CTD can easily be deployed by hand as shown in Figure 19. Each cast is referenced with both time and location using its built- in GPS receiver. Latitude and longitude are acquired both before and after each profile. Plots of conductivity, temperature, salinity and sound speed versus depth can be viewed immediately on the CastAway's integrated color LCD screen in the field. Table 14 lists the output parameters of the YSI CastAway-CTD.

Figure 19. Palm-sized CastAway-CTD.

Raw data can be easily downloaded via Bluetooth to a Windows computer for detailed analysis and/or export at any time. Rugged, non-corrosive housing, AA battery power and tool-free operation reflect the technician-friendly pedigree of the CastAway-CTD. In summary, the CastAway-CTD, is a lightweight, easy to use hydrographic instrument designed for quick and accurate conductivity, temperature, and depth profiles.

Table 14. Output parameters of the YSI CastAway-CTD.

The CastAway-CTD Output Parameters				
	Range	Resolution	Accuracy	Measured or Derived
Conductivity	0 to 100,000 µS/cm	1µS/cm	± 0.25% ± 5 µS/cm	Measured
Temperature	-5° - 45° C	0.01° C	± 0.05° C	Measured
Pressure	0 to 100 dBar	0.01 dBar	± 0.25% FS	Measured
Salinity	Up to 42 (PSS-78)	0.01 (PSS-78)	± 0.1 (PSS-78)	PSS-78[3]
Sound Speed	1400 - 1730 m/s	0.01 m/s	± 0.15 m/s	Chen-Millero[4]
Density[1]	990 to 1035 kg/m^3	0.004 kg/m^3	± 0.02 kg/m^3	EOS80[5]
Depth	0 to 100 m	0.01m	± 0.25% FS	EOS80[5]
Specific Conductivity[2]	0 to 250,000 µS/cm	1µS/cm	± 0.25% ±5 µS/cm	EOS80[5]
GPS			10 m	

5.3.1. Survey Location and Period

There were total of 82 hand deployed casts. The locations of the casts are depicted in Figure 20. The CTD survey was conducted during two periods, 11/4/2010, and 11/10/2010-11/14/2010. The associated metadata such as cast time, location, etc. are summarized in Hand_deployed_CTD_Casts_Summary.csv as listed in the worksheet 'CTD' of the project spread sheet.

Figure 20. Station locations of OCS/CSDL CTD casts.

5.3.2. Database

The database information is listed in the worksheet 'CTD' of the project spread sheet

5.4. Portable CTD Casts by CO-OPS

To provide additional information on the density structure at the ADCP locations, CO-OPS conducted five CTD casts before its ADCP deployment (Section 4.1). These casts used the same type of CTD profilers as that deployed during the OCS/NSD survey (Section 5.2).

5.4.1. Survey Location and Period

The locations of the CTD casts are shown in Figure 21, and Table 15 provides the corresponding data file names, locations in longitude and latitude, and survey periods.

5.4.2. Database

The database information is listed in the worksheet 'CTD' of the project spread sheet.

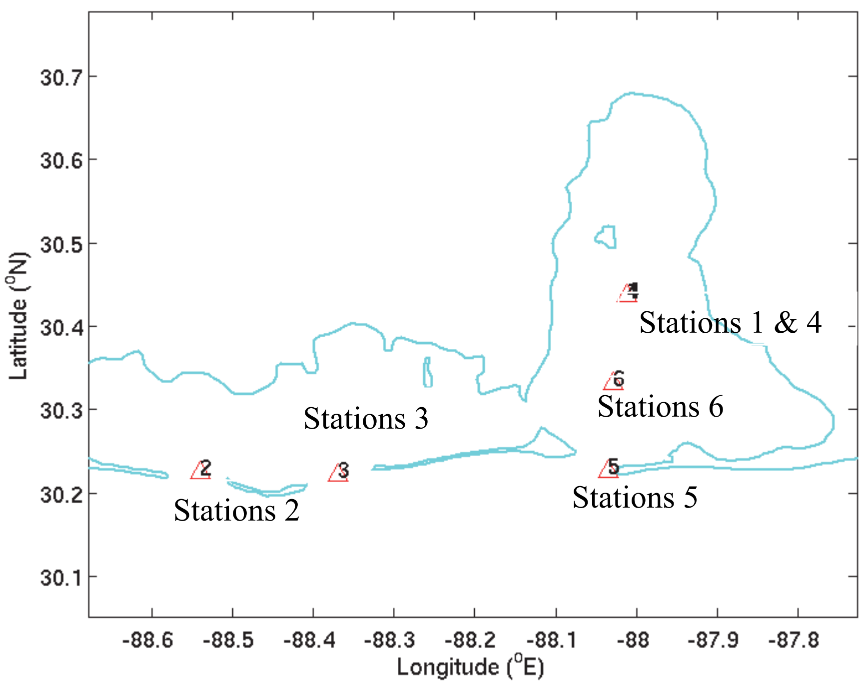


Figure 21. CO-OPS CTD cast stations.

Table 15. Inventory of CO-OPS CTD casts data.

Deployment ID	File name	Latitude (^oN)	Longitude (^oE)	Survey Data/time
1	2010-11-05 1438 25.txt	30.43730	-88.01189	2010/11/05 14:38:25
2	2010-11-05 1857 20.txt	30.22486	-88.53919	2010/11/05 18:57:20
3	2010-11-05 1949 32.txt	30.22142	-88.37009	2010/11/05 19:49:32
4	2010-11-05 2034 14.txt	30.43730	-88.01189	2010/11/05 20:34:14
5	2010-11-03 1855 02.txt	30.22703	-88.03458	2010/11/03 18:55:02
6	2010-11-03 2125 40.txt	30.33144	-88.02900	2010/11/03 21:25:40

6. Meteorological Data

The meteorological data includes air temperature, relative humidity, wind speed and direction, visibility, and barometric pressure. To provide a comprehensive, integrated suite of physical parameters during the three-month survey period, these data were downloaded from the Mobile Bay PORTS at:

http://tidesandcurrents.noaa.gov/ports/index.shtml?port=mb.

6.1. Survey Location and Data Period

Figure 22 displays station locations and Table 16 lists station names, IDs, locations in longitude and latitude, and survey periods.

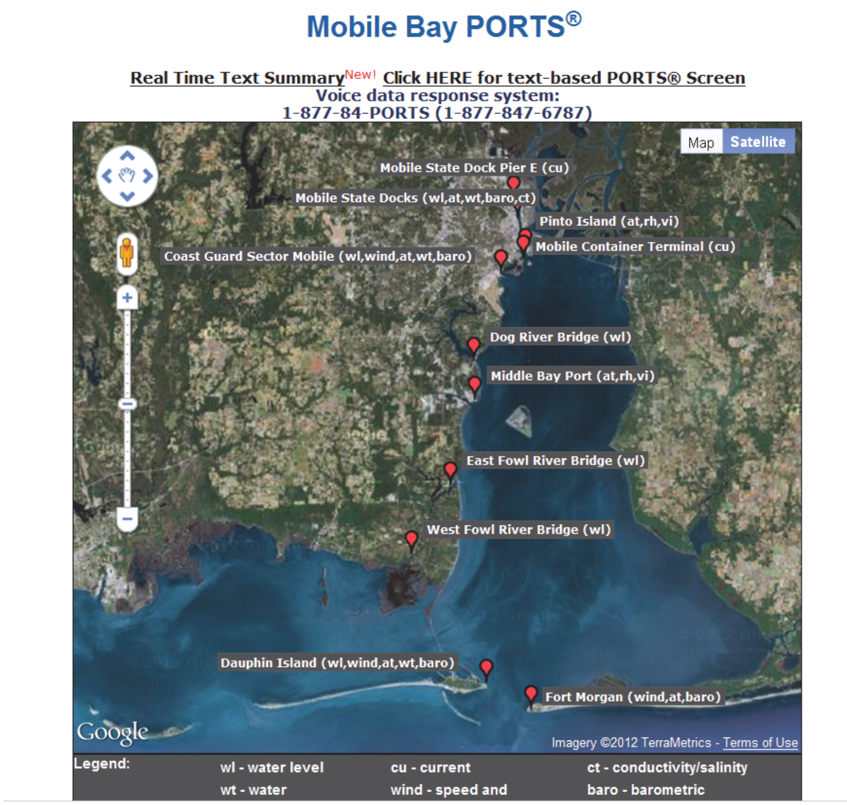


Figure 22. Meteorology stations in Mobile Bay PORTS.

Table 16. Inventory of meteorological data from Mobile Bay PORTS stations.

Station Name/	Station ID	Latitude (^{o}N)	Longitude (^{o}E)	Survey Period
PintoIsland, AL	8737005	30° 40.2'	-88° 1.8'	2010/11/01-2011/2/28
Mobile State Docks	8737048	30° 42.5'	-88° 2.6'	2010/11/01-2011/2/28
Coast Guard Sector Mobile	8736897	30° 38.9'	-88° 3.5'	2010/11/01-2011/2/28
Middle Bay Port	8736163	30° 31.6'	88° 5.1'	2010/11/01-2011/2/28
Dauphin Island	8735180	30° 15'	-88° 4.5'	2010/11/01-2011/2/28
Fort Morgan	8734673	30° 13.7' N	-88° 1.5'	2010/11/01-2011/2/28

6.2. Sample Plots

Figure 23 is a sample time series plot of some meteorological parameters at station 8734673. The plot is obtained from the Mobile Bay PORTS Web site.

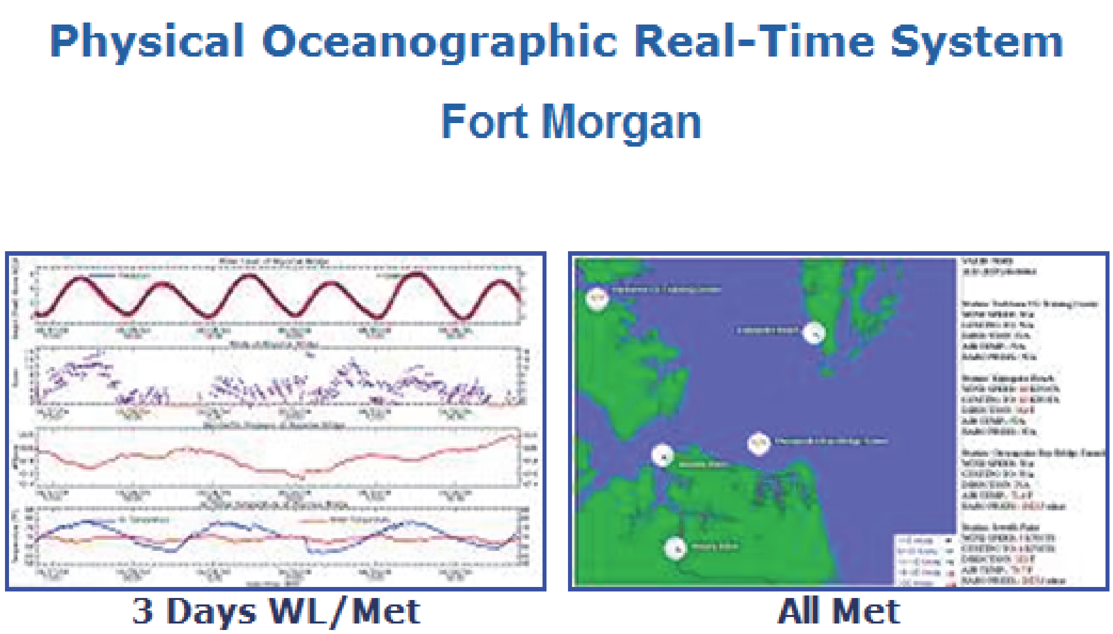


Figure 23. Sample plots of meteorological data from Mobile Bay PORTS stations.

6.3. Database

The database information is listed in the worksheet ‘PORTS_Meteorology’ of the project spread sheet.

7. Acknowledgements

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