FY10 Hypoxic Zone Monitoring Coordination Plan and Report

An Output from the *Workshop to Coordinate Gulf of Mexico Hypoxic Zone Research* convened on 17-18 February 2010 in Bay St. Louis, Mississippi

Summary

The *Workshop to Coordinate Gulf of Mexico Hypoxic Zone Research*, Bay St. Louis, Mississippi (17-18 Feb 2010), built on previous multi-partnered planning efforts to improve monitoring in the northern Gulf of Mexico hypoxic zone (aka "the Dead Zone"). This *Workshop* is the next phase in the plan to establish an operational monitoring program for the Gulf Hypoxic Zone, as described in the *Gulf of Mexico Hypoxia Monitoring Implementation Plan*; http://www.ncddc.noaa.gov/activities/gulf-hypoxia-stakeholders/view. The *Workshop*, sponsored by NOAA's National Centers for Coastal Ocean Science (NCCOS), National Coastal Data Development Center (NCDDC), and Gulf of Mexico Regional Collaboration Team, and the Northern Gulf Institute (NGI), brought together leading researchers and managers of the northern Gulf of Mexico region, and developed a plan to increase collaborations and coordinate hypoxia monitoring activities. The *Workshop* aimed to establish an expanded FY10 monitoring program based on commitments of partners to support a portion of the *Implementation Plan*'s Core System Requirements.

At the *Workshop,* attendees filled out a matrix to compile planned 2010 survey efforts in the northern Gulf of Mexico (including Mississippi Sound and the Texas Coast) that included a focus on characterizing dissolved oxygen conditions. Development of the matrix (Table 1 below) and post-*Workshop* distribution to attendees of the *FY10 Hypoxic Zone Monitoring Coordination Plan* helped meet the following objective of the *Workshop*: "To coordinate all FY10 monitoring efforts to reduce redundancy, and ensure that researchers and managers are aware of the suite of monitoring surveys". In October 2010, this *Plan* was distributed to the *Workshop* attendees for information on the implementation of 2010 survey efforts. These "FY10 Results" are included below to complete this *FY10 Hypoxic Zone Monitoring Coordination Plan and Report*.

Workshops to improve hypoxic zone monitoring

The mid-summer survey that measures the annual areal extent of the hypoxic zone (Rabalais et al. 2002, 2007) is the key metric of the *Gulf Hypoxia Action Plan* Coastal Goal – "to reduce…the five-year running average areal extent of the Gulf of Mexico hypoxic zone to less than 5,000 square kilometers by the year 2015…" This metric, which has been generated through mid-summer surveys since 1985, is considered a valuable indicator of 'hypoxic condition' in support of the *Action Plan*; however, greater spatial and temporal coverage was recommended to compensate for variability and pre-cruise storm events (Rabalais et al. 2007). The mid-summer surveys are part of a research project that the NOAA NCCOS has supported through extramural research programs to provide data for a series of ecosystem studies to gain understanding of, and predictive capabilities for, both the causes and consequences of hypoxia in the Gulf. These studies were not intended to be sustainable long-term monitoring programs.

A more robust, integrated, and multi-partner monitoring effort is critically needed to assess management efficacy in meeting the *Action Plan* Coastal Goal. In fact, a "long-term and sustainable hypoxic zone monitoring program was cited in the *Gulf Hypoxia Action Plan* as a critical need for achieving Action 9: "Continue to reduce uncertainty about the relationship between nitrogen and phosphorus loads and the formation, extent, duration, and severity of the hypoxic zone, to best monitor progress toward, and inform adaptive management of the Coastal Goal." To meet the need for improved monitoring, the *Summit on Long-Term Monitoring of the Gulf of Mexico Hypoxic Zone: Developing the Implementation Plan for an Operational Observation System* (30-31 January 2007 at Stennis Space Center, Mississippi; http://www.ngi.msstate.edu/hypoxia/janconference.html) was convened to develop an implementation plan for achieving a comprehensive, integrative, sustainable monitoring program for the Gulf hypoxic zone including available mechanisms for long-term funding and starting with actions that could be taken toward those long term goals as soon as possible (*Gulf of Mexico Hypoxia Monitoring Implementation Plan*, at http://www.ncddc.noaa.gov/activities/gulf-hypoxia-stakeholders/view).

On 9 December 2008 at the Northern Gulf Institute, Stennis, Mississippi, the *Gulf of Mexico Hypoxia Monitoring Implementation Plan Financial Strategy Workshop* convened, where several partners (NOAA Gulf of Mexico Regional Collaboration Team, NOAA National Environmental Satellite, Data and Information, NOAA NCCOS, NGI, Gulf of Mexico Governors Alliance, EPA Gulf of Mexico Program) provided commitments to support most of the Core System Requirements of the *Implementation Plan*. These Requirements included an expansion in the number of monitoring surveys west of the Mississippi delta, extension of the monitoring survey to waters east of the delta (Mississippi Bight), and plans to implement pilot studies with AUVs and to build up infrastructure for data management and communications.

On 17-18 February 2010, the *Workshop to Coordinate Gulf of Mexico Hypoxic Zone Research* convened in Bay St. Louis, Mississippi, to advance research in two areas central to managing the northern Gulf Hypoxic Zone: Day 1 addressed the impacts of the Hypoxic Zone on living resources with a focus on fisheries, and Day 2 addressed plans to improve Hypoxic Zone monitoring, extending outcomes from the 2007 *Summit* and 2008 *Financial Strategy Workshop* (above). **Objectives** for Day 2's activities (improving monitoring) included:

1. To coordinate all FY10 monitoring efforts to reduce redundancy, and ensure that researchers and managers are aware of suite of monitoring surveys;
2. To coordinate monitoring data exchange, and ensure timely access;
3. To develop communication strategy to coordinate Hypoxia Monitoring Stakeholders Committee with other outreach networks;
4. To revise, as needed, the Gulf of Mexico Hypoxia Monitoring Implementation Plan.

Four **outputs** are planned to meet these objectives:

1. *FY10 Hypoxic Zone Monitoring Coordination Plan* (modified as the present document, *FY10 Hypoxic Zone Monitoring Coordination Plan and Report*)
2. *2010 Gulf Hypoxic Zone Monitoring Implementation Plan* (in prep)
3. *National Hypoxia Data Management System* (in prep)

4. *Gulf Hypoxia Communications Plan* (attached)

Advances in FY10 monitoring

Considerable progress has been made towards implementation of Core System Requirements of the *Gulf of Mexico Hypoxia Monitoring Implementation Plan*. These requirements are needed to characterize the annual maximum area and volume of hypoxia as metrics to determine whether mitigation measures on nutrient reductions are having an effect on the hypoxic zone size. The two cross-shelf transects (off Atchafalaya and Terrebonne/Timbalier) are maintained for the continuity and for the relationships with river constituent data. The core requirements include dissemination of hypoxic zone magnitude to managers using web site information, archival of the data in NODC, and rapid dissemination of data with verifiable quality review. It should be noted that these advances are supported by grants from several partners (NOAA NCCOS, NCDDC, and Gulf of Mexico Regional Collaboration Team, and the NGI), and therefore the *Implementation Plan*'s ultimate goal to establish a sustainable operational monitoring program for the Gulf hypoxic zone remains a critical need.

Core System Requirement 1: Expand spatial boundaries of shelf-wide surveys.

Previously: Mid-summer survey included 80-90 sites extending from approximately 89.5˚W to 94.5˚W and offshore to 28.5˚N, to the most inshore and offshore edge of hypoxia (Fig. 1).

FY10 Plan: Hypoxia monitoring extended east of the Mississippi delta by a Northern Gulf Institute-funded study by the University of Southern Mississippi (Howden et al. "Monitoring and Assessment of Coastal and Marine Ecosystems in the Northern Gulf"). Figure 3 shows the transect that is sampled monthly from St. Louis Bay, MS to the 20 m isobaths south of the barrier islands (CenGOOS Mooring). These data will improve assessment of total hypoxia driven by Mississippi River nutrient loads, lead to development of models that determine the relative influences of other watersheds in contributing to the region's hypoxia events (Brunner et al. 2006), and advance understanding of the frequency, extent, and impacts of hypoxia in the Mississippi Bight.

FY10 Results:

- Rabalais et al.'s shelf-wide survey on 25 July to 1 August 2010 extended as far west as a transect off Galveston, TX (Fig. 1) before time constraints ended the mapping in that area.

- DiMarco et al.'s shelf-wide survey on 2-7 August 2010 extended from Galveston to as far south as Corpus Christi, TX (Fig. 2). Potential exposure to oil from the Deep Water Horizon oil spill prohibited the survey ship (R/V Manta) from entering waters east of Terrebonne, and therefore the sites colored blue in Fig. 2 were not sampled.

- Howden et al.'s monthly NGI transect survey (from the Bay of St. Louis to the offshore location of the CenGOOS buoy; Fig. 3) took place on 16 June, and 14 July 2010. The 18 August 2010 NGI cruise was cancelled due to high winds. Howden et al.'s monthly survey cruise in the Mississippi Sound (the Bonnet Carre Spillway [BCS] monitoring) was cancelled on 14 June, but took place on 12 July and 16 August 2010. Milroy's high-resolution hypoxia surveys in the eastern Mississippi Sound (Fig. 3) were repeated throughout the spring and summer of 2010 (1 April, 22 April, 28 May, 23 June, 5 August).

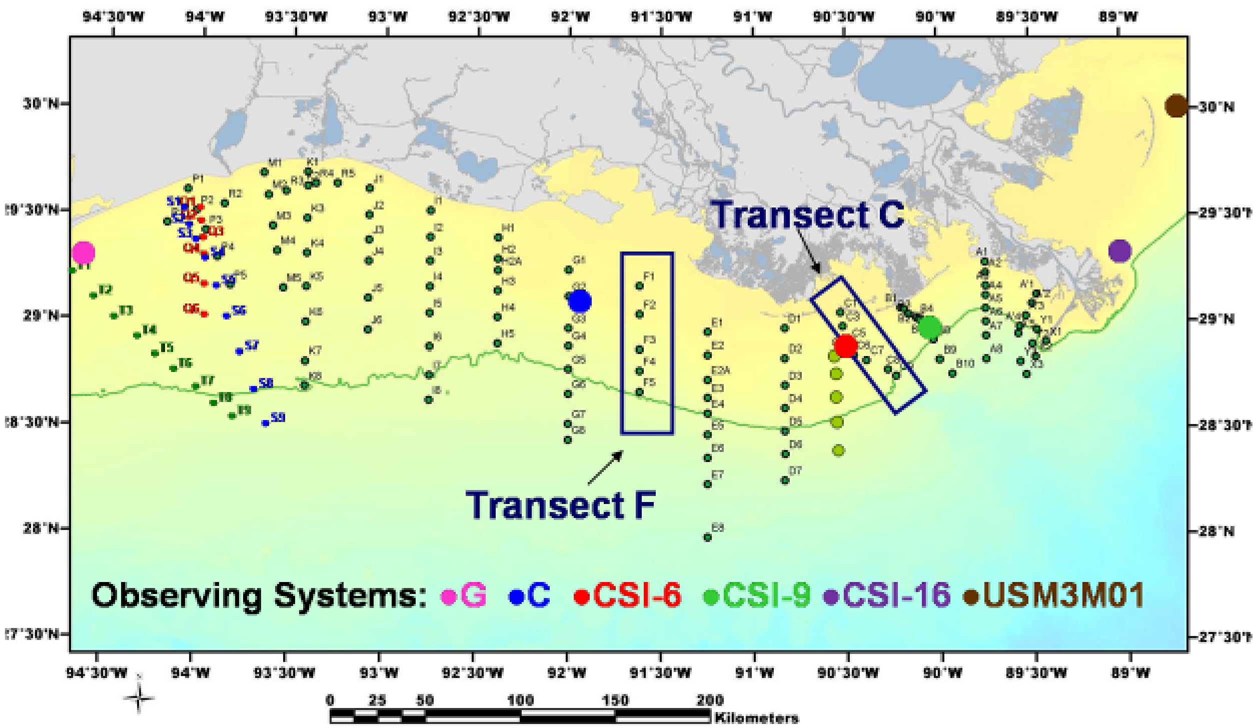


Figure 1. Site locations in monitoring sampling design for the Gulf hypoxic zone. Small circles are sites sampled during mid-summer survey to determine annual hypoxic zone areal extent, used as the *Action Plan* Coastal Goal metric. Transects C and F are the cross-shelf transects sampled monthly to bimonthly. Observing systems "G" and "C" are maintained by Texas A&M, "C6C/CSI-6" and "CSI-9" by LUMCON, "CSI-16" by LSU, and "USM3M01" by USM (CenGOOS). Adapted from map provided by N. Rabalais, LUMCON.

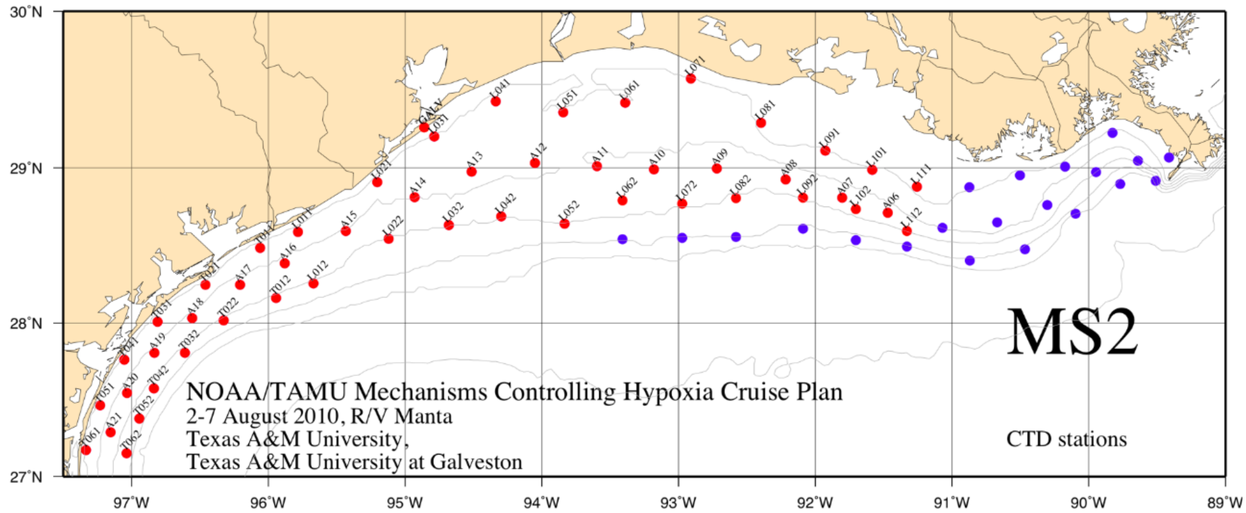


Figure 2. Station plan for 2-7 August 2010 hypoxic area survey on R/V Manta. Red dots designate CTD stations. Blue dots represent planned stations that were changed due to potential of presence of oil from Deepwater Horizon spill. Station labeled with 'L' indicate cross shelf lines where undulated towed vehicle will be deployed. "A" stations are CTD-only stations between cross-shelf lines. Map provided by S. F. DiMarco, TAMU.

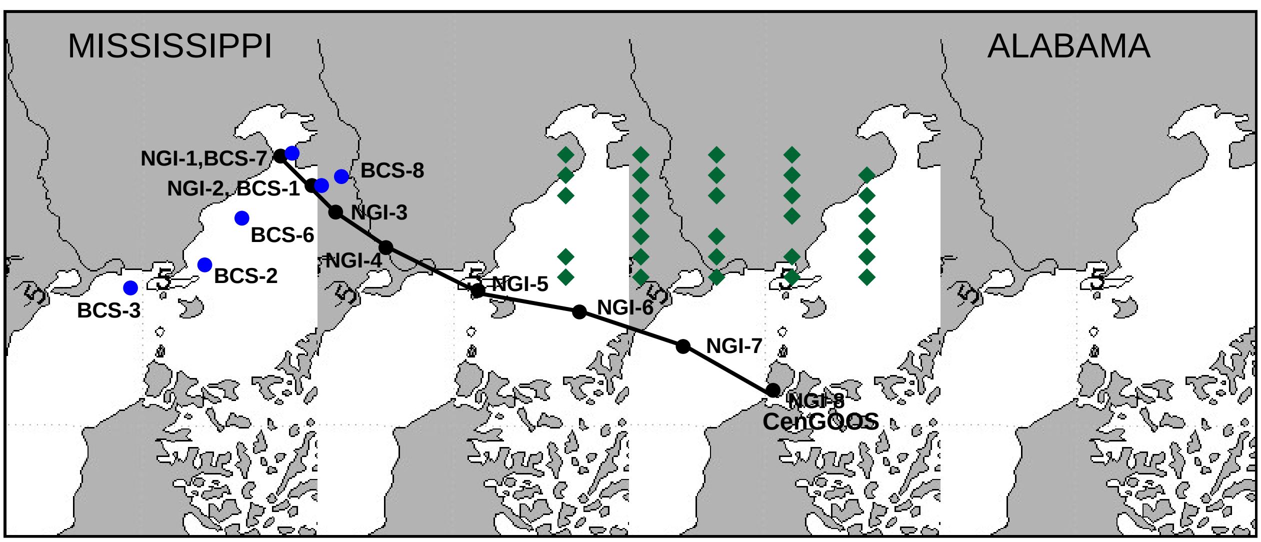


Figure 3. Sampling sites along transects sampled monthly by USM to monitor hypoxia in the Mississippi Sound/Bight, showing the Northern Gulf Institute (NGI) transect line (●), the Bonnet Carré Spillway (BCS) stations (●), and S.P. Milroy's 2010 high-resolution hypoxia stations (♦) currently sampled at monthly intervals by the Department of Marine Science, USM.

Core System Requirement 2: Include hypoxic volume measurements on shelf-wide surveys.

Previously: Estimates of hypoxia volume were developed by Rabalais et al. based on the mid-summer shelf-wide survey, but are currently not used as the metric or reporting to management entities.

FY10 Plan: Rabalais et al. and DiMarco et al. will collect measurements of the volume of the hypoxic zone during their shelf-wide surveys, and post these data on the Hypoxia Portal web site. The Howden et al. group has time-series data for the last 3 years (NGI transect in Fig. 3) showing that the Mississippi Bight had severe hypoxia in the summers of 2008 and 2010. A specific hypoxia survey in 2008 enabled the group to constrain the shelf-wide hypoxia (by volume) in the Mississippi Bight. As a part of a larger survey, the Mississippi Bight region was again spot-sampled on 23 August 2010, and this survey, together with the NGI time-series and the Milroy surveys, will enable the group to constrain the extensive 2010 hypoxia in the Mississippi Bight.

FY10 Results:

- Data quality assurance and control are still in progress from summer shelfwide cruises.

- All the hypoxia surveys performed by the Department of Marine Science, USM, are done using a fully certified Seabird CTD with a SBE43 DO sensor. Additionally, each cruise is field calibrated by Winkler DO samples collected at surface and in bottom waters (0.5 m above the sediment) using a 5L vertical Niskin bottle. Data QA/QC is done after each cruise to verify the integrity of factory calibrations.

Core System Requirement 3: Increase number of shelf-wide surveys

Previously: One mid-summer survey conducted per year (Fig. 1).

FY10 Plan: In addition to the July shelf-wide survey of Rabalais et al., DiMarco et al. plans shelf-wide surveys in June and August, using continuous monitoring with an Acrobat towfish.

FY10 Results:

- June shelf-wide survey was not conducted because the survey ship (R/V Manta) had engine problems. The July and August shelf-wide surveys were conducted but the area covered was limited by logistical constraints (see “FY10 Results” from *Core System Requirement 1* section above).

- Regular monthly hypoxia surveys along the NGI transect were augmented in 2010 by the addition of five (5) new surveys of hypoxia volume in the MS Sound/Bight.

Core System Requirement 4: Fill in temporal gaps of shelf-wide surveys with cross-shelf transects.

Previously: Monthly sampling at Transect C south of Terrebonne Bay, and bimonthly sampling at Transect F off the Atchafalaya River (11 cruises/year); Fig. 1.

FY10 Plan: Rabalais et al. will maintain monthly sampling at Transect C south of Terrebonne Bay, and bimonthly sampling at Transect F off the Atchafalaya River.

FY10 Results: In collaboration with the modeling efforts of Justić and Li (LSU/LUMCON NGOMEX09 project), transects C and F were covered in March through October (still to be completed) with standard measurements and water column and sediment process studies.

Core System Requirement 5: Add deployments of Autonomous Underwater Vehicles (AUVs) with dissolved oxygen sensors.

Previously: None.

FY10 Plan: Autonomous Underwater Vehicle will be deployed in the Mississippi Bight Bight (by USM with minimal funding) and west of the Mississippi delta (LUMCON and VIMS, without funding) in pilot studies in FY10 for future application.

FY10 Results:

- Two attempts were done to fly the USM Glider "Roxy" on the shelf and both failed due to technical complications. Due to river run-off the Mississippi Bight is characterized by extreme density gradients in summer. The Webb-Teledyne glider is limited to salinities ranging approximately 5 units and the summer pycnocline in the Bight is exceeding this number. Webb-Teledyne is currently working on expanding the density range on their gliders. In the meantime, USM is pursuing other options to investigate fine scale variability of DO. One option is to fly the glider in from further offshore where the total vertical density gradient is weaker. Another option is to tow a Sea Sciences Acrobat with an SBE CTD and Rinko III. These options however, are labor and time-consuming operations currently without a budget.

- LUMCON with Virginia Institute of Marine Science. The cruise scheduled for August 10-15 was delayed because of problems with Mark Patterson's AUV systems and personnel complications. The cruise will be rescheduled.

Core System Requirement 6: Create a portal to make data accessible and to facilitate exchange.

Previously: The Hypoxia Watch website (http://ecowatch.ncddc.noaa.gov/hypoxia), Lumcon's Hypoxia website (www.gulfhypoxia.net), Texas A & M's hypoxia website (http://hypoxia.tamu.edu/), and the Gulf Hypoxia Monitoring Stakeholder Committee website (http://www.ncddc.noaa.gov/activities/gulf-hypoxia-stakeholders) are operational, including interactive mapping capabilities. Data ingest to Hypoxia and Regional Ecosystem Data Management (REDM) portals are underway. NCDDC and IOOS Program actions are underway to assure data management best practices and adherence to accepted community standards, including IOOS DMAC, FGDC, etc.

FY10 Plan: Operations and maintenance for a National Hypoxia Monitoring Network with Data Management and technology transfer development – implementation led by NCDDC.

FY10 Results: Plans to create a National Hypoxia Portal are underway (*National Hypoxia Data Management System*, in prep).

Core System Requirement 7: Dissemination of data and findings to research and management communities.

Previously: The Gulf Hypoxia Monitoring Stakeholder Committee (GHMSC) website is operational, membership determined, and Terms of Reference developed. Communication links are established with the Gulf Hypoxia Task Force Communication Subcommittee, Gulf of Mexico Alliance Environmental Education Network, and the Gulf of Mexico Coastal Ocean Observing System (GCOOS) Education and Outreach Council.

FY10 Plan: Relevant hypoxia data and findings disseminated to management community at appropriate time scale (including near real-time) through consensus protocols designed and implemented through a hypoxia outreach network that includes the Gulf Hypoxia Monitoring Stakeholder Committee, Gulf Hypoxia Task Force Communication Subcommittee, Gulf of Mexico Alliance Environmental Education Network, GCOOS Education and Outreach Council, LUMCON, TAMU, MI/AL Sea Grant GulfQuest, and NGI Education and Outreach.

FY10 Results:

- *Gulf Hypoxia Communications Plan* completed, providing strategies to improve and coordinate hypoxia-related communications and outreach efforts.
- Data from the late July shelfwide cruise were available in near real-time from the LUMCON/LSU late July mapping and process studies, at http://www.gulfhypoxia.net
- Results of the TAMU hypoxic area survey aboard R/V Manta are available on the TAMU project site http://hypoxia.tamu.edu.
- A number of time-series data sets from the NGI, BCS transects and the hypoxia surveys (e.g. DO, salinity, temperature, turbidity, nutrients) are currently undergoing QA/QC and will be made part of the public domain.

- Hypoxia Watch: data were available in near real-time from the SEAMAP cruises on the *Oregon II*, at http://ecowatch.ncddc.noaa.gov/hypoxia

Tier 2 System Requirement 1: Maintain current continuous observation systems and increase number of observation systems.

Previously: Five observation systems, three west of the Mississippi River plume and two east of the plume (Fig. 1).

Three observing systems in hypoxic area west of Mississippi River:

1) LUMCON *C6C* or WAVCIS/BIO2 *CSI-6*: -90º29' W, 28º52' N;

2) LUMCON and WAVCIS/BIO2 *CSI-9*: -89 º58’W, 29º06’W;

3) TAMU *C*: -92º W, 29º N.

Two observing systems east of Mississippi River:

4) USM *USM3m01*: -88°39’ W, 30° N

5) LSU *CSI-16*: -89°02’ W, 29º24’ N, without oxygen sensors

FY10 Plan: Maintenance of 5 systems above and addition of 1 observation platform (TAMU *G* at -95 º W, 29º N); Fig. 1.

FY10 Results:

- LUMCON C6C and CSI-09, in collaboration with LSU/WAVCIS/BIO2 were in operation with real-time data for most of the record. Oil spill - oil and oil sheen in the vicinity of the two platforms curtailed operations and necessary maintenance and replacement of probes.

- TAMU deployed two systems during field year 2010: Sites C and G. Site C, south of Atchafalaya at 92°W,29°N, is deployed as part of the NGOMEX project was deployed in April 2010 and reported in realtime throughout the summer. The RDCP at Site C stopped reporting in mid-July. The mooring at Site G, south of Galveston, TX, was deployed using funds from TAMU. The Site G mooring reported throughout the summer, however, the mooring line received damage in August and some sensors stopped reporting. Most sensors on both moorings record data internally and data will be processed post-recovery. Moorings are scheduled to be recovered from the field in November 2010.

- USM3m02: Under repair. Will redeploy in Q4 of 2010. Funding is needed for oxygen sensors for the buoy and for a bottom package.

- LSU CSI-16: oxygen sensors remain to be added at near-surface and near-bottom

Results of Working Sessions from *Workshop to Coordinate Gulf of Mexico Hypoxic Zone Research*

Working Session 1: Coordinating FY10 Monitoring Efforts: Filling Out Month-to-Month Matrix

Objective: To identify and coordinate FY10 monitoring and survey efforts in the northern Gulf of Mexico (including Mississippi Sound and the Texas Coast) focused on dissolved oxygen.

[see Appendix 1: FY10 Hypoxic Zone Monitoring]

Working Session 2: AUVs and Observing Systems

Objective: to update the current status of observing systems and autonomous underwater vehicles (AUVs) in monitoring hypoxia, and identify the barriers, limitations, and potential uses in future monitoring programs.

Current and Planned Observing Systems

There are currently six observing systems (as part of GCOOS) active in the northern Gulf of Mexico in the area targeted for hypoxia monitoring (Fig. 1), however two (*USM3M01*, *CSI-16*) need to be outfitted with dissolved oxygen (DO) sensors at near-bottom depth, and at near-surface for CSI-16, for consistency with the two other LUMCON/LSU/WAVCIS/BIO2 observing systems. A map of all observing systems throughout the Gulf has been compiled by GCCOS (http://gcoos.tamu.edu/gom.html), which illustrates a relative lack of observing systems in the hypoxia zone area. Further, most of the Gulf observing systems are focused on monitoring surface conditions, and are not readily adaptable to near-bottom conditions. Two problems continue to limit the expansion in the number of observing systems used to monitor hypoxia - fouling and cost. Current DO sensors allow for 2-3 weeks of reliable data before they require maintenance to remove fouling. In the middle of summer, when fouling is at its highest, this should be reduced to every 10 days. Several methods and technologies have been employed to reduce sensor fouling, including the use of copper mesh and periodic chlorox wash, which have had mixed results. Current buoy systems cost ca. $70-130K to develop and deploy, with annual maintenance costs at approximately the same level. Much of the maintenance cost is due to the need for regular maintenance of the sensors, which requires ship-time and divers. These systems can also be subject to damage from weather (e.g. hurricanes) and fishing gear.

The Naval Research Laboratory (NRL) is currently refitting optical sensors on its bio-optical principal pop-up environmental reconnaissance system (BOPPERS), and although it does not contain a DO sensor, one could be added in the future. LSU has a CTD buoy at the mouth of Vermilion Bay and is interested in adding a DO sensor. Cabled observing systems that sit on the bottom are another option, but none are currently in use in the Gulf of Mexico. Preliminary systems have been installed on the east and west coasts. The benefit of cabled systems is that they likely would not require routine maintenance.

Current Status of AUV use for Hypoxia Monitoring

Currently NRL has four gliders, which is more than any other agency. Although they work well in shallow water (5 m minimum, although > 10 m is optimal), none have been tested or outfitted for measuring DO. NGI is currently planning to do a test run of a glider during the summer of 2010 to test applicability for measuring DO and the glider range. ARGO floats (carried by the currents) are currently not used in shallow water. Some ARGO floats (approximately 200) have DO sensors, but the sensor significantly shortens the life of the float.

Status of testing efforts and limitations for AUV hypoxia monitoring

For hypoxia monitoring, although gliders can measure their distance to the bottom, there are questions related to how close a glider can get to the bottom. NRL experience suggests that positioning gliders close to the bottom requires a camera in order to determine whether measurements reflect near-bottom water conditions or are the result of disturbance to the sediment-water interface. Typically, AUVs are not able to get as close to the bottom as CTD casts, and there is debate on how close a glider would need to get to the bottom in order to adequately characterize the areal extent of hypoxia.

Currently, there are several limitations to fully implementing AUVs for hypoxia monitoring, particularly with sensors and movement. As with observing systems, DO sensors on AUVs have a typical useful life of 2-3 weeks before fouling limits their use. This reduces the benefits of gliders, which can be left in the water for about 30 days. It is possible to clean the sensor *in situ* by periodically sending the glider into deep water, but this limits overall spatial coverage of the glider and is particularly difficult in relatively shallow, coastal areas. Another limitation with sensors is response time, although relatively good performance has been achieved by Japanese-manufactured sensors.

Current problems with AUV movement include both active and passive issues. AUVs that are propelled require significant battery life which, coupled with DO sensors, greatly reduces the amount of time the AUV is able to spend in the water. Gliders, which are not mechanically propelled, have limitations on where they can go. They are subject to moving off track by currents, and require good predictive models to guide them. Gliders also have difficulties moving in shallow water. Passive movement issues include entanglement with fishing gear, collisions with oil platforms and other structures, and interactions with fishermen.

Long-term vision for AUVs in monitoring

Overall, AUVs should not replace ship-based surveys for now, but the technology has shown great promise. AUVs could potentially cover the entire hypoxic area and season, providing better spatial and temporal coverage, but they are currently not ready. AUVs also have the potential to greatly reduce costs of monitoring, particularly relative to observing systems and ship-based surveys. More research and technological advancements are needed in order to fully incorporate AUVs into routine monitoring. This will require an increased funding commitment to improving AUV technologies.

References

Brunner, C.A., J.M. Beall, S.J. Bentley and Y. Furukawa. 2006. Hypoxia hotspots in the Mississippi Bight. J. Foraminiferal Res. 36:95–107.

Gundersen, K., S.D. Howden and S.E. Lohrenz. 2010. Hypoxia monitoring on the Mississippi Gulf coast. Presentation at the Workshop to Coordinate Gulf of Mexico Hypoxic Zone Research, Bay St. Louis, Mississippi, 17-18 Feb 2010.

Rabalais, N.N., R.E. Turner and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52:129-142.

Rabalais, N.N., R.E. Turner, B.K. Sen Gupta, D.F. Boesch, P. Chapman and M.C. Murrell. 2007. Characterization and long-term trends of hypoxia in the Northern Gulf of Mexico: Does the science support the Action Plan? Estuaries and Coasts 30(5): 753-772.

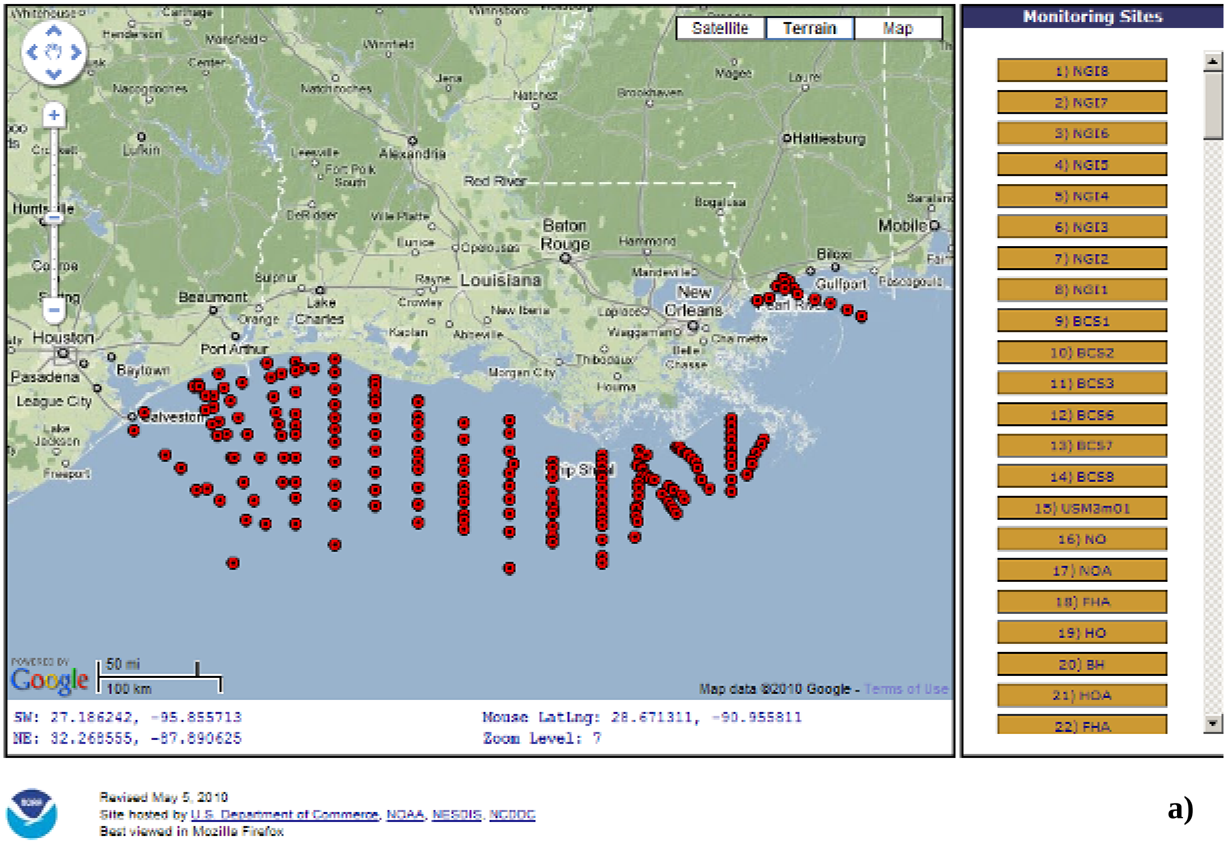
Table 1. FY10 northern Gulf of Mexico surveys that include a focus on hypoxia.

Basic Information				Spatial Extent			
PI Name	**Survey Start Date**	**Duration (days)**	**Vessel**	**Portion of Shelf Covered**	**Brief Description**	**Method / Equipment**	**Additional Measurements**
Howden	Monthly	2	LeMoyne	St. Louis Bay, MS, western Mississippi Sound, and out to 20 m isobath south of barrier islands (CenGOOS mooring)	cross-shelf transect	SeaBird SBE43 CTD with Rinko 3 Optode DO sensor	Hydrographic profiles with CTD (DO, conductivity, temperature, pH, turbidity, Chl fluorescence, backscatter). Nutrients, trace metals, CDOM, and seasonal benthic samples.
Milroy	Apr 01 Apr 22 May 28 Jun 23 Aug 05	1	LeMoyne	MS Sound/Bight, from Pascagoula to Biloxi, from 3-12 nm offshore	along- and cross-shelf transects (bounding box)	SeaBird CTD with SBE43 dissolved oxygen (DO), BB9 (scattering), and FL3 (fluorescence) sensors	Hydrographic profiles with CTD (conductivity, temperature, depth, turbidity, DO, CHL/CDOM/PhycoE fluorescence, backscatter). Bottle samples of surface/bottom chlorophyll and CDOM.
Rabalais	Mar 22-24	3	Pelican	Transect C and Transect F	monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	Hydrographic profiles with CTD (DO, conductivity, temperature, PAR, Transmission, chl fluorescence) and Biospherical light meter (% incident light, PAR). Surface and bottom chl and phaeopig at all stations and phytoplankton species composition by microscopy at surface at some stations and by HPLC at all stations. Surface and bottom dissolved inorganic nutrients, TP, TN. Underway MIDAS and ADCP. Process studies for water column and sediments. Concurrence with Atchafalaya River Delta Estuary studies (Roberts et al.).
DiMarco	Mar 31-Apr 1	2	Acadiana	Mooring C deployment, 29N, 92W	Mooring deployment		
DiMarco	Apr 6-12	7	Pelican	4 stations on LA/TX shelf from south of Atchafalaya (29 N, 92 W) to south of Galveston (29 N, 95 W)	process studies	SeaBird SBE43 CTD	Hydrographic profiles with CTD (DO, conductivity, temperature, primary productivity [FRRF], chl fluorescence, light transmission, PAR), nutrients, total particulates, DOC, DON, phytoplankton taxa by Phyto-PAM fluorometry, nutrient limitation,zooplankton composition/biomass, fecal pellet flux, sediment composition, benthic microbial respiration/productivity, ^{14}C primary productivity.

Rabalais	Apr 13-15	2	Pelican	Transect C and Transect F	transect monitoring	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
DiMarco	May 15	1	Acadiana	Mooring C Service	Mooring C Service		
Rabalais	May 17-19	3	Pelican	Transect C and Transect F	monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
Gardner	May 21-27	7	Pelican	F5, C6C, B6, Ctr2 (29 31 N 88 39 W), MRM (28 56 N 89 26 w)	Nutrient cycling, benthic processes	SeaBird 911+ CTD	Hydrographic profiles with CTD (DO, conductivity, temperature, PAR, chl fluorescence). Water column and sediment nutrients (nitrite, nitrate, ammonium, silicate, phosphate), and sediment oxygen flux, denitrification rates, dissimilatory nitrate reduction, and N fixation. Water column N transformation rates.
SEAMAP	June 8 – July 18	35	Oregon II	Brownsville, TX to east of MS River; between the 10 and 200 m isobaths	Groundfish survey	CTD + DO probe	Spring and fall plankton surveys, summer and fall groundfish and shrimp surveys, Chl, Chl a, DO, turbidity, water color, secchi, wave height, air temperature, barometric pressure, cloud cover, water temperature, and salinity.
Rabalais	June 12-13	2	Pelican	Transect C and Transect F	transect monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
DiMarco	June 14-19	6	Manta	East Matagorda Bay to Southwest Pass	continuous monitoring	SeaSciences Acrobat towfish with Seabird CTD, Winkler titration SBE-43 and Rinko DO sensors	Underway (undulating) - hydrographic profiles with CTD (DO, conductivity, temperature, chl fluorescence, turbidity).
DiMarco	July 15	1	Acadiana	Mooring C Service	Mooring C Service		
Rabalais	July 25-Aug 1	8	Pelican	MS River to northern TX shelf	shelf-wide survey and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
DiMarco	Aug 1-6	6	Manta	East Matagorda Bay to Southwest Pass	continuous monitoring	SeaSciences Acrobat towfish with Seabird CTD, Winkler	See DiMarco June 14-19

						titration SBE-43 and Rinko DO sensors	
K. Briggs	Aug 3-14	12	Pelican	89.7˚ W to 92.3˚ W; offshore to 28.4˚ N	sediment characteristics and benthic processes	SeaBird SBE 911/32+ CTD; Acoustic Sediment Classification Sonar (12 kHz)	Box cores for sediment characteristics, sediment profile images, CTD (DO, conductivity, temperature), grab sampler for grain size distribution, acoustic sediment classification.
DiMarco	Aug 15-20	6	Pelican	4 stations on LA/TX shelf from south of Atchafalaya (29 N, 92 W) to south of Galveston (29 N, 95 W)	process studies	SeaBird SBE43 CTD	See DiMarco Apr 6-12
Rabalais	Aug 22-24	3	Pelican	Transect C and Transect F	monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
DiMarco	15-Sep	2	Acadiana	Texas	Mooring C Recovery		
Rabalais	Sept 16-18	3	Pelican	Transect C and Transect F	Transect monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24
Thomas	Oct 3-9	7	Pelican	parts of transects B,C,F,H,I, east of delta	croaker sampling	CTD	CTD (DO, conductivity, temperature). HIF gene expression – biomarker for hypoxia exposure
Rabalais	Oct. 27-28	3	Pelican	Transect C and Transect F	Transect monitoring and process studies	SeaBird 911+ CTD with SBE 13-01-2 DO probe	See Rabalais Mar 22-24

Figure 4. a) Screen-shots of interactive on line map display of monitoring stations and transects http://www.ncddc.noaa.gov/website/google_maps/Hypoxia/mapsHypoxia.htm; http://www.gulfhypoxia.net and b) Hypoxia Watch sampling stations: http://ecowatch.ncddc.noaa.gov/hypoxia



a)

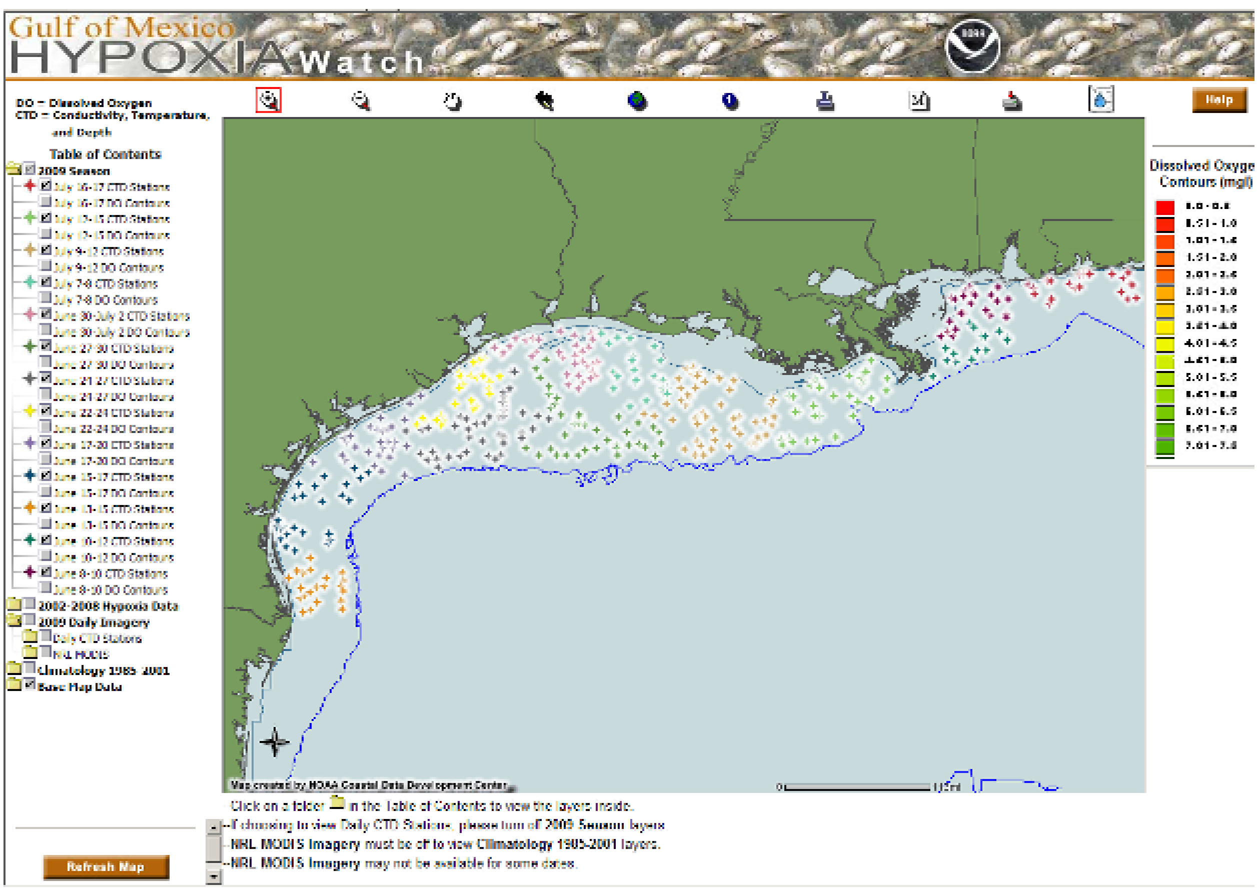


Table 2. Transect and station coordinates displayed in Figure 4.

			Station		
PI Name	**Station/Transect ID**	**Dates Surveyed**	**Lat**	**Lon**	**Descriptor**
Howden	NGI8	Monthly	30 02.549	88 38.839	
Howden	NGI7	Monthly	30 05.538	88 46.112	
Howden	NGI6	Monthly	30 07.980	88 54.432	
Howden	NGI5	Monthly	30 09.684	89 02.748	
Howden	NGI4	Monthly	30 11.874	89 10.920	
Howden	NGI3	Monthly	30 14.190	89 13.460	
Howden	NGI2	Monthly	30 17.277	89 17.924	
Howden	NGI1	Monthly	30 18.806	89 18.364	
Howden	BCS1	Monthly	30 17.277	89 17.924	
Howden	BCS2	Monthly	30 10.689	89 25.674	
Howden	BCS3	Monthly	30 09.313	89 31.339	
Howden	BCS6	Monthly	30 15.454	89 21.527	
Howden	BCS7	Monthly	30 18.806	89 18.364	
Howden	BCS8	Monthly	30 17.871	89 15.748	
Howden	USM3m01	Mooring	30.0424 °N	88.6473 °W	
Milroy	01 / 201	01-Apr, 22-Apr, 28-May, 23-Jun, 05-Aug	30.3167	-88.8159	Maximum depth = 3.2 m
Milroy	02 / 202	As above	30.2917	-88.8159	Maximum depth = 5.0 m
Milroy	03 / 101	As above	30.3167	-88.9079	Maximum depth = 4.7 m
Milroy	04 / 102	As above	30.2917	-88.9079	Maximum depth = 5.2 m
Milroy	05 / 103	As above	30.2667	-88.9079	Maximum depth = 5.6 m
Milroy	06 / 203	As above	30.2667	-88.8159	Maximum depth = 5.9 m
Milroy	07 / 204	As above	30.2417	-88.8159	Maximum depth = 4.3 m
Milroy	08 / 205	As above	30.2167	-88.8159	Maximum depth = 9.2 m
Milroy	09 / 206	As above	30.1917	-88.8159	Maximum depth = 11.5 m
Milroy	10 / 106	As above	30.1917	-88.9079	Maximum depth = 8.6 m
Milroy	11 / 107	As above	30.1667	-88.9079	Maximum depth = 9.6 m
Milroy	12 / 207	As above	30.1667	-88.8159	Maximum depth = 12.5 m
Milroy	13 / 307	As above	30.1667	-88.7230	Maximum depth = 13.8 m
Milroy	14 / 306	As above	30.1917	-88.7230	Maximum depth = 12.7 m
Milroy	15 / 305	As above	30.2167	-88.7230	Maximum depth = 10.6 m
Milroy	16 / 406	As above	30.1917	-88.6306	Maximum depth = 12.7 m
Milroy	17 / 407	As above	30.1667	-88.6306	Maximum depth = 14.4 m
Milroy	18 / 507	As above	30.1667	-88.5388	Maximum depth = 12.7 m
Milroy	19 / 506	As above	30.1917	-88.5388	Maximum depth = 10.7 m
Milroy	20 / 505	As above	30.2167	-88.5388	Maximum depth = 4.7 m
Milroy	21 / 504	As above	30.2417	-88.5388	Maximum depth = 4.6 m
Milroy	22 / 503	As above	30.2667	-88.5388	Maximum depth = 5.4 m
Milroy	23 / 502	As above	30.2917	-88.5388	Maximum depth = 3.6 m

Milroy	25 / 401	As above	30.3167	-88.6306	Maximum depth = 2.7 m
Milroy	26 / 402	As above	30.2917	-88.6306	Maximum depth = 4.8 m
Milroy	27 / 403	As above	30.2667	-88.6306	Maximum depth = 4.7 m
Milroy	27A / 404	As above	30.2417	-88.6306	Maximum depth = 4.5 m
Milroy	28 / 303	As above	30.2667	-88.7230	Maximum depth = 5.2 m
Milroy	29 / 302	As above	30.2917	-88.7230	Maximum depth = 4.2 m
Milroy	30 / 301	As above	30.3167	-88.7230	Maximum depth = 2.6 m
K. Briggs	NO	Spring/Summer	28°39.4´ N	92°22.96´ W	
K. Briggs	NOA	Spring/Summer	28°46.5´ N	92°22.99´ W	
K. Briggs	FHA	Spring/Summer	28°34.7´ N	91°59.95´ W	
K. Briggs	HO	Spring/Summer	28°36.3´ N	91°14.41´ W	
K. Briggs	BH	Spring/Summer	28°29.98´ N	90°49.99´ W	
K. Briggs	HOA	Spring/Summer	28°45.5´ N	90°13.99´ W	
K. Briggs	FHA	Spring/Summer	29°00.5´ N	89°44.99´ W	
K. Briggs	BHA	Spring/Summer	28°56.98´ N	89°34.49´ W	
Rabalais	A' 1	late-July	29:08.00'N	89:28.50'W	Off Tiger Pass; also called Z
Rabalais	A' 2	late-July	29:05.50'N	89:30.00'W	Off Tiger Pass; also called Z
Rabalais	A' 3	late-July	29:02.00'N	89:32.00'W	Off Tiger Pass; also called Z
Rabalais	A' 4	late-July	28:59.00'N	89:34.00'W	Off Tiger Pass; also called Z
Rabalais	A' 5	late-July	28:57.00'N	89:34.50'W	Off Tiger Pass; also called Z
Rabalais	A' 6	late-July	28:52.40'N	89:37.00'W	Off Tiger Pass; also called Z
Rabalais	A 1	late-July	29:17.40'N	89:45.00'W	Off Barataria Bay
Rabalais	A 2	late-July	29:14.35'N	89:45.00'W	Off Barataria Bay
Rabalais	A 3	late-July	29:10.70'N	89:45.00'W	Off Barataria Bay; near WD32E
Rabalais	A 4	late-July	29:08.00'N	89:45.00'W	Off Barataria Bay
Rabalais	A 5	late-July	29:04.20'N	89:45.00'W	Off Barataria Bay
Rabalais	A 6	late-July	29:00.50'N	89:45.00'W	Off Barataria Bay
Rabalais	A 7	late-July	28:56.50'N	89:45.00'W	Off Barataria Bay
Rabalais	A 8	late-July	28:50.00'N	89:45.00'W	Off Barataria Bay
Rabalais	A 9	late-July	28:45.00'N	89:45.00'W	Off Barataria Bay
Rabalais	B 1	late-July	29:04.60'N	90:12.47'W	Off Bell Pass, Port Fourchon
Rabalais	B 2	late-July	29:04.30'N	90:11.41'W	Off Bell Pass, Port Fourchon
Rabalais	B 3	late-July	29:02.80'N	90:09.80'W	Off Bell Pass, Port Fourchon
Rabalais	B 4	late-July	29:01.65'N	90:07.25'W	Off Bell Pass, Port Fourchon
Rabalais	B 5	late-July	29:01.25'N	90:06.35'W	Off Bell Pass, Port Fourchon
Rabalais	B 6	late-July	28:59.60'N	90:04.60'W	Off Bell Pass, Port Fourchon
Rabalais	B 7	late-July	28:57.60'N	90:02.60'W	Off Bell Pass, Port Fourchon
Rabalais	B 8	late-July	28:55.45'N	90:01.90'W	Off Bell Pass, Port Fourchon
Rabalais	B 9	late-July	28:50.00'N	90:00.00'W	Off Bell Pass, Port Fourchon
Rabalais	B 10	late-July	28:46.00'N	89:56.00'W	Off Bell Pass, Port Fourchon
Rabalais	CSI-9	Mooring	28:58.00’N	89:58.00’W	WAVCIS/BIO2, Off Caminada Ps
Rabalais	C 1	Monthly trans C & F, Mar-Oct, shelfwide	29:03.40'N	90:31.90'W	Off Cat Island Pass, Cocodrie

Rabalais	C 2	Monthly trans C & F, Mar-Oct, shelfwide	29:01.20'N	90:29.67'W	Off Cat Island Pass, Cocodrie
Rabalais	C 3	Monthly trans C & F, Mar-Oct, shelfwide	28:59.44'N	90:31.25'W	Off Cat Island Pass, Cocodrie
Rabalais	C 3A				
Rabalais	C 4	Monthly trans C & F, Mar-Oct, shelfwide	28:57.00'N	90:31.46'W	Off Cat Island Pass, Cocodrie
Rabalais	C 5	Monthly trans C & F, Mar-Oct, shelfwide	28:54.88'N	90:29.35'W	Off Cat Island Pass, Cocodrie
Rabalais	C 6B	Monthly trans C & F, Mar-Oct, shelfwide	28:52.18'N	90:28.04'W	Off Cat Island Pass, Cocodrie
Rabalais	C 6C	Monthly trans C & F, Mar-Oct, shelfwide, mooring	28:52.12'N	90:29.42'W	WAVCIS/BIO2
Rabalais	C 7	Monthly trans C & F, Mar-Oct, shelfwide	28:49.93'N	90:23.53'W	Off Cat Island Pass, Cocodrie
Rabalais	C 8	Monthly trans C & F, Mar-Oct, shelfwide	28:47.30'N	90:16.60'W	Off Cat Island Pass, Cocodrie
Rabalais	C 9	Monthly trans C & F, Mar-Oct, shelfwide	28:45.50'N	90:14.00'W	Off Cat Island Pass, Cocodrie
Rabalais	C 10B	Shelfwide	28:43.20'N	90:10.00'W	Off Cat Island Pass, Cocodrie
Rabalais	C 8A	Shelfwide	28:44.00'N	90:19.50'N	Off Cat Island Pass, Cocodrie
Rabalais	C 11B	late-July	28:41.50'N	90:08.25'W	Off Cat Island Pass, Cocodrie
Rabalais	C 9A	late-July	28:40.50'N	90:16.50'W	Off Cat Island Pass, Cocodrie
Rabalais	C 9AA	late-July	28:38.00'N	90:15.00'W	Off Cat Island Pass, Cocodrie
Rabalais	C 10	late-July	28:36.60'N	90:14.00'W	Off Cat Island Pass, Cocodrie
Rabalais	C 11	late-July	28:35.20'N	90:12.20'W	Off Cat Island Pass, Cocodrie
Rabalais	D' 0	late-July	28:48.81'N	90:31.66'W	Off Wine Island Pass
Rabalais	D' 1	late-July	28:46.50'N	90:31.70'W	Off Wine Island Pass
Rabalais	D' 2	late-July	28:43.00'N	90:31.72'W	Off Wine Island Pass
Rabalais	D' 3	late-July	28:38.50'N	90:32.00'W	Off Wine Island Pass
Rabalais	D' 3A	late-July	28:37.20'N	90:33.00'W	Off Wine Island Pass
Rabalais	D' 4	late-July	28:34.15'N	90:32.80'W	Off Wine Island Pass
Rabalais	D' 5	late-July	28:31.80'N	90:32.50'W	Off Wine Island Pass
Rabalais	D' 6	late-July	28:24.40'N	90:33.50'W	Off Wine Island Pass
Rabalais	D 0	late-July	29:00.90'N	90:50.00'W	Off Isle Dernieres Ship Shoal

Rabalais	D 1	late-July	28:59.00'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 1N	late-July	28:56.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 1A	late-July	28:53.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 1B	late-July	28:52.09'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 2	late-July	28:50.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 2A	late-July	28:46.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 3	late-July	28:43.00'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 3A	late-July	28:39.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 4	late-July	28:36.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 4A	late-July	28:34.70'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 4B	late-July	28:32.00'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 5	late-July	28:30.00'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 6	late-July	28:23.50'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 7	late-July	28:15.98'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	D 8	late-July	28:13.00'N	90:50.00'W	Off Isle Dernieres Ship Shoal
Rabalais	E 1	late-July	28:58.00'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 1A	late-July	28:55.10'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 2	late-July	28:51.50'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 2A	late-July	28:44.50'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 3	late-July	28:39.50'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 4	late-July	28:35.00'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 5	late-July	28:29.00'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 5A	late-July	28:24.50'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	E 6	late-July	28:22.50'N	91:15.00'W	Off Point au Fer Isl., Fourleague Bay
Rabalais	F 0	Monthly trans C & F, Mar-Oct, shelfwide	29:16.40	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 1	Monthly trans C & F, Mar-Oct, shelfwide	29:11.00'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 2	Monthly trans C & F, Mar-Oct, shelfwide	29:03.00'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 2A	Monthly trans C & F, Mar-Oct, shelfwide	28:56.89'N	91:34.73'W	Off Atchafalaya Bay
Rabalais	F 3	Monthly trans C & F, Mar-Oct, shelfwide	28:53.00'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 4	Monthly trans C & F, Mar-Oct, shelfwide	28:47.00'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 5	Monthly trans C & F, Mar-Oct, shelfwide	28:41.50'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 6	late-July	28:35.00'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	F 7	late-July	28:27.00'N	91:37.00'W	Off Atchafalaya Bay

Rabalais	F 8	late-July	28:10.80'N	91:37.00'W	Off Atchafalaya Bay
Rabalais	G 1	late-July	29:15.50'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 2	late-July	29:08.00'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 3	late-July	28:59.00'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 4	late-July	28:54.00'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 5	late-July	28:47.50'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 5A	late-July	28:44.40'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 6	late-July	28:40.50'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 6A	late-July	28:34.75'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 7	late-July	28:32.12'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	G 8	late-July	28:27.88'N	92:00.00'W	Off Vermilion Bay, Marsh Island
Rabalais	H 0	late-July	29:29.50'N	92:23.00'W	Off White Lake
Rabalais	H 1	late-July	29:24.50'N	92:23.00'W	Off White Lake
Rabalais	H 2	late-July	29:18.50'N	92:23.00'W	Off White Lake
Rabalais	H 2A	late-July	29:15.20'N	92:23.00'W	Off White Lake
Rabalais	H 3	late-July	29:09.50'N	92:23.00'W	Off White Lake
Rabalais	H 4	late-July	29:02.00'N	92:23.00'W	Off White Lake
Rabalais	H 4A	late-July	28:58.40'N	92:23.00'W	Off White Lake
Rabalais	H 5	late-July	28:54.50'N	92:23.00'W	Off White Lake
Rabalais	H 6	late-July	28:47.20'N	92:23.00'W	Off White Lake
Rabalais	H 7	late-July	28:39.40'N	92:23.00'W	Off White Lake
Rabalais	H 8	late-July	28:31.00'N	92:23.00'W	Off White Lake
Rabalais	I 0	late-July	29:34.50'N	92:45.00'W	Off Grand Lake
Rabalais	I 1	late-July	29:32.00'N	92:45.00'W	Off Grand Lake
Rabalais	I 1A	late-July	29:27.80'N	92:45.00'W	Off Grand Lake
Rabalais	I 2	late-July	29:24.50'N	92:45.00'W	Off Grand Lake
Rabalais	I 3	late-July	29:17.70'N	92:45.00'W	Off Grand Lake
Rabalais	I 4	late-July	29:10.50'N	92:45.00'W	Off Grand Lake
Rabalais	I 5	late-July	29:03.00'N	92:45.00'W	Off Grand Lake
Rabalais	I 6	late-July	28:53.50'N	92:45.00'W	Off Grand Lake
Rabalais	I 7	late-July	28:45.50'N	92:45.00'W	Off Grand Lake
Rabalais	I 8	late-July	28:38.50'N	92:45.00'W	Off Grand Lake
Rabalais	J 0	late-July	29:43.64'N	93:05.00'W	Off Creole
Rabalais	J 1	late-July	29:38.00'N	93:05.00'W	Off Creole
Rabalais	J 2	late-July	29:30.50'N	93:05.00'W	Off Creole
Rabalais	J 3	late-July	29:23.50'N	93:05.00'W	Off Creole
Rabalais	J 4	late-July	29:17.50'N	93:05.00'W	Off Creole
Rabalais	J 4A	late-July	29:12.30'N	93:05.00'W	Off Creole
Rabalais	J 5	late-July	29:07.00'N	93:05.00'W	Off Creole
Rabalais	J 6	late-July	28:58.00'N	93:05.00'W	Off Creole
Rabalais	J 6A	late-July	28:53.00'N	93:05.00'W	Off Creole
Rabalais	J 7	late-July	28:48.00'N	93:05.00'W	Off Creole
Rabalais	J 8	late-July	28:39.00'N	93:05.00'W	Off Creole
Rabalais	K 1	late-July	29:42.40'N	93:25.00'W	Off Cameron

Rabalais	K 2	late-July	29:38.50'N	93:25.00'W	Off Cameron
Rabalais	K 3	late-July	29:29.30'N	93:25.00'W	Off Cameron
Rabalais	K 4	late-July	29:19.50'N	93:25.00'W	Off Cameron
Rabalais	K 4A	late-July	29:14.50'N	93:25.00'W	Off Cameron (closer to M4A)
Rabalais	K 5	late-July	29:10.00'N	93:25.00'W	Off Cameron
Rabalais	K 6	late-July	29:00.00'N	93:25.00'W	Off Cameron
Rabalais	K 7	late-July	28:49.00'N	93:25.00'W	Off Cameron
Rabalais	K 8	late-July	28:42.00'N	93:25.00'W	Off Cameron
Rabalais	K 9	late-July	28:30.20'N	93:25.00'W	Off Cameron
Rabalais	M 1	late-July	29:42.00'N	93:39.30'W	Off Sabine to E
Rabalais	M 2	late-July	29:35.80'N	93:37.75'W	Off Sabine to E
Rabalais	M 3	late-July	29:27.00'N	93:36.20'W	Off Sabine to E
Rabalais	M 4	late-July	29:20.00'N	93:34.70'W	Off Sabine to E
Rabalais	M 4A	late-July	29:15.01'N	93:33.59'W	Off Sabine to E
Rabalais	M 5	late-July	29:09.50'N	93:32.50'W	Off Sabine to E
Rabalais	M 6	late-July	29:00.17'N	93:31.19'W	Off Sabine to E
Rabalais	M 7	late-July	28:49.23'N	93:31.55'W	Off Sabine to E
Rabalais	P 1	late-July	29:37.00'N	94:04.00'W	Off Sabine to W
Rabalais	P 2	late-July	29:31.00'N	94:01.00'W	Off Sabine to W
Rabalais	P 3	late-July	29:25.50'N	93:58.00'W	Off Sabine to W
Rabalais	P 4	late-July	29:18.00'N	93:54.00'W	Off Sabine to W
Rabalais	P 5	late-July	29:10.00'N	93:49.70'W	Off Sabine to W
Rabalais	P 6	late-July	29:00.11'N	93:42.60'W	Off Sabine to W
Rabalais	Q 1	late-July	29:31.32'N	94:13.87'W	Near High Island
Rabalais	Q 2	late-July	29:27.64'N	94:06.46'W	Near High Island
Rabalais	Q 3	late-July	29:22.23'N	94:06.40'W	Near High Island
Rabalais	Q 4	late-July	29:16.28'N	94:03.60'W	Near High Island
Rabalais	Q 5	late-July	29:10.56'N	93:59.99'W	Near High Island
Rabalais	Q 6	late-July	28:59.97'N	93:55.72'W	Near High Island
Rabalais	S 1	late-July	29:31.80'N	94:16.20'W	Off High Island
Rabalais	S 2	late-July	29:27.50'N	94:14.50'W	Off High Island
Rabalais	S 3	late-July	29:21.00'N	94:10.50'W	Off High Island
Rabalais	S 4	late-July	29:15.00'N	94:07.20'W	Off High Island
Rabalais	S 5	late-July	29:09.50'N	94:04.50'W	Off High Island
Rabalais	S 6	late-July	29:00.00'N	93:57.20'W	Off High Island
Rabalais	S 7	late-July	28:49.00'N	93:51.50'W	Off High Island
Rabalais	S 8	late-July	28:41.00'N	93:46.00'W	Off High Island
Rabalais	S 9	late-July	28:30.20'N	93:40.00'W	Off High Island
Rabalais	T 1	late-July	29:12.00'N	94:47.00'W	Off Galveston
Rabalais	T 2	late-July	29:08.00'N	94:41.20'W	Off Galveston
Rabalais	T 3	late-July	29:01.00'N	94:31.00'W	Off Galveston
Rabalais	T 4	late-July	28:55.20'N	94:23.00'W	Off Galveston
Rabalais	T 5	late-July	28:45.42'N	94:15.20'W	Off Galveston
Rabalais	T 6	late-July	28:46.00'N	94:10.07'W	Off Galveston

Rabalais	T 7	late-July	28:41.00'N	94:03.50'W	Off Galveston
Rabalais	T 8	late-July	28:37.00'N	93:56.50'W	Off Galveston
Rabalais	T 9	late-July	28:32.40'N	93:50.05'W	Off Galveston

DiMarco: Station locations for R/V Manta cruises

CTD station locations are given in R/V Manta cruises in planned in June 2010 but unable to conduct (Table 3) and conducted in August 2010 (Table 4). Stations in Table 3 are listed west to east for cross shelf lines (L-stations) and for along-shelf stations (A-stations) which are located at the 20-m isobath and between the cross shelf lines. Cross shelf lines planned to be done first and in order, i.e., L011-L012-L021-L022-L031-etc., and the A stations conducted on the transit back to Galveston.

Table 3. Planned station locations for June 2010 Hypoxia Cruise

Station	*Longitude °W*	*Latitude °N*
L011	-95.7829	28.5899
L012	-95.6705	28.2567
L021	-95.2043	28.9083
L022	-95.1209	28.5442
L031	-94.7881	29.2009
L032	-94.6803	28.6317
L041	-94.3366	29.4269
L042	-94.2974	28.6884
L051	-93.8429	29.3554
L052	-93.8329	28.6425
L061	-93.3905	29.4173
L062	-93.4086	28.5404
L071	-92.9096	29.5715
L072	-92.9733	28.5509
L081	-92.3972	29.2898
L082	-92.5787	28.5564
L091	-91.926	29.1107
L092	-92.0914	28.608
L101	-91.5828	28.9879
L102	-91.7021	28.5365
L111	-91.2572	28.8803
L112	-91.3304	28.4957
L121	-90.874	28.8756
L122	-90.8713	28.4038
L131	-90.503	28.9527
L132	-90.4654	28.4758
L141	-90.1724	29.0094
L142	-90.0953	28.7069
L151	-89.8255	29.225
L152	-89.7713	28.8969
L161	-89.4125	29.0664
L162	-89.5103	28.9176
A15	-95.4346	28.5953
A14	-94.9308	28.811

A13	-94.514	28.9754
A12	-94.0499	29.0322
A11	-93.5971	29.012
A10	-93.1791	28.9918
A09	-92.7205	28.9973
A08	-92.2152	28.9258
A07	-91.8024	28.8082
A06	-91.471	28.7109
A05	-91.0699	28.6139
A04	-90.6696	28.6501
A03	-90.3046	28.7631
A02	-89.9459	28.9737
A01	-89.6387	29.0457

Table 4. Station locations conducted on August 2010 Hypoxia Cruise

Station	Latitude		Longitude	
GALV	29	15.6000	94	51.6000
A13	28	58.5240	94	30.8400
A12	29	1.9320	94	2.9940
A11	29	0.7200	93	35.8260
A10	28	59.5080	93	10.7460
A09	28	59.8380	92	43.2300
A08	28	55.5480	92	12.9120
A07	28	48.4920	91	48.1440
A06	28	42.6540	91	28.2600
L111	28	52.8180	91	15.4320
L112	28	35.7420	91	19.8240
L102	28	44.1900	91	42.1260
L101	28	59.2740	91	34.9680
L091	29	6.6420	91	55.5600
L092	28	48.4800	92	5.4840
L082	28	48.3840	92	34.7220
L081	29	17.3880	92	23.8320
L071	29	34.2900	92	54.5760
L072	28	46.2540	92	58.3980
L062	28	47.4240	93	24.5160
L061	29	25.0380	93	23.4300
L051	29	21.3240	93	50.5740
L052	28	38.5500	93	49.9740
L042	28	41.3040	94	17.8440
L041	29	25.6140	94	20.1960
L031	29	12.0540	94	47.2860
L032	28	37.9020	94	40.8180
L022	28	32.6520	95	7.2540
L021	28	54.4980	95	12.2580
L011	28	35.3940	95	46.9740
L012	28	15.4020	95	40.2300
A16	28	23.1480	95	52.7940

A17	28	14.8680	96	12.3780
A18	28	1.8060	96	33.3840
A19	27	48.3180	96	49.9560
A20	27	32.6580	97	2.0700
A21	27	17.4300	97	9.2640
T061	27	10.4580	97	20.0100
T062	27	9.1740	97	2.2740
T052	27	22.6620	96	56.5320
T051	27	27.8640	97	13.8240
T041	27	45.6960	97	3.2160
T042	27	34.4040	96	50.2800
T032	27	48.3240	96	36.6660
T031	28	0.4920	96	48.6300
T021	28	14.8560	96	27.6420
T022	28	0.9480	96	19.5900
T012	28	9.6660	95	56.5560
T011	28	29.2200	96	3.6960
A15	28	35.7180	95	26.0760
A14	28	48.6600	94	55.8480
GALV	29	15.6000	94	51.6000