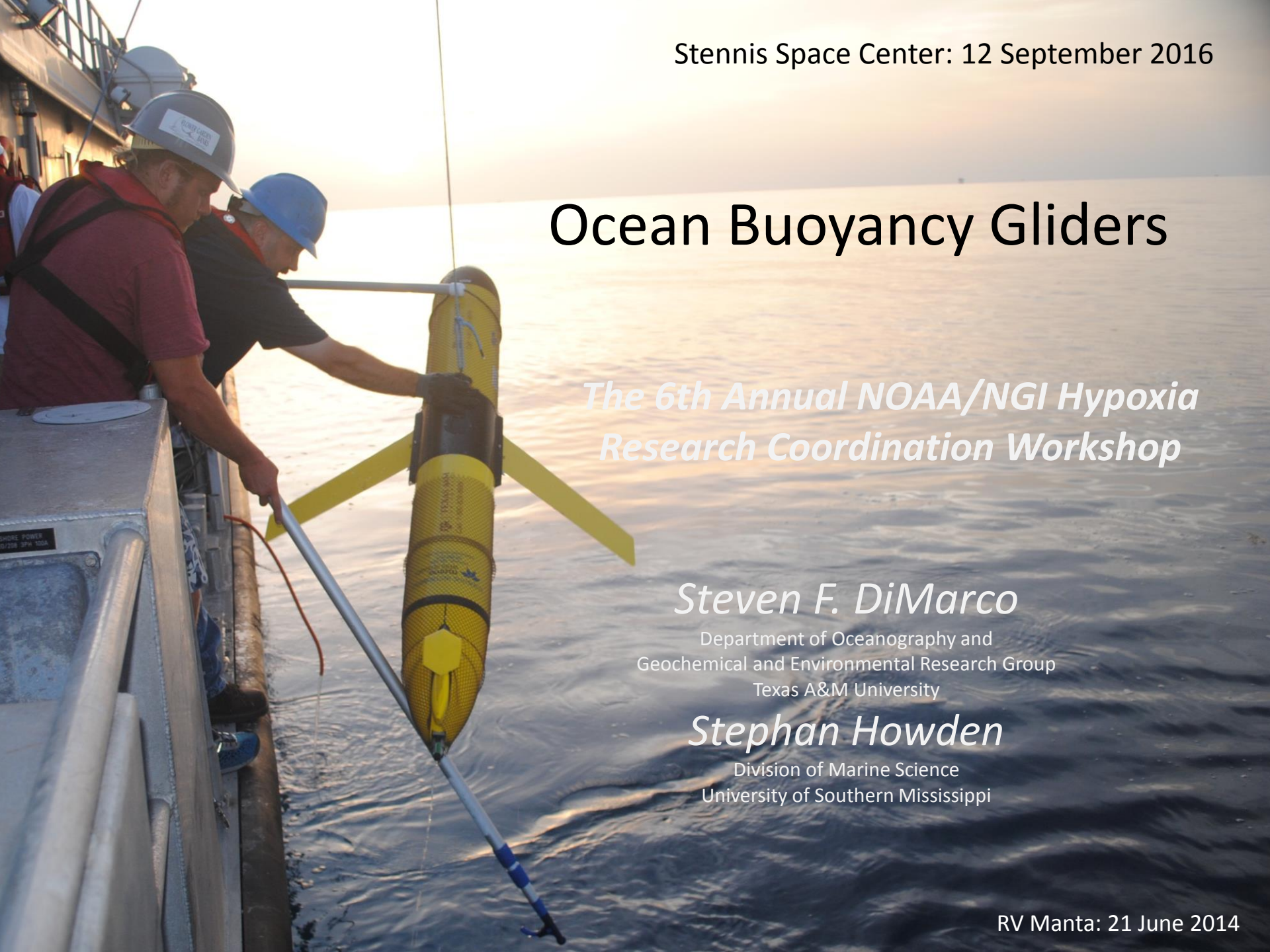


Stennis Space Center: 12 September 2016

Ocean Buoyancy Gliders

The 6th Annual NOAA/NGI Hypoxia Research Coordination Workshop

Steven F. DiMarco

Department of Oceanography and
Geochemical and Environmental Research Group
Texas A&M University

Stephan Howden

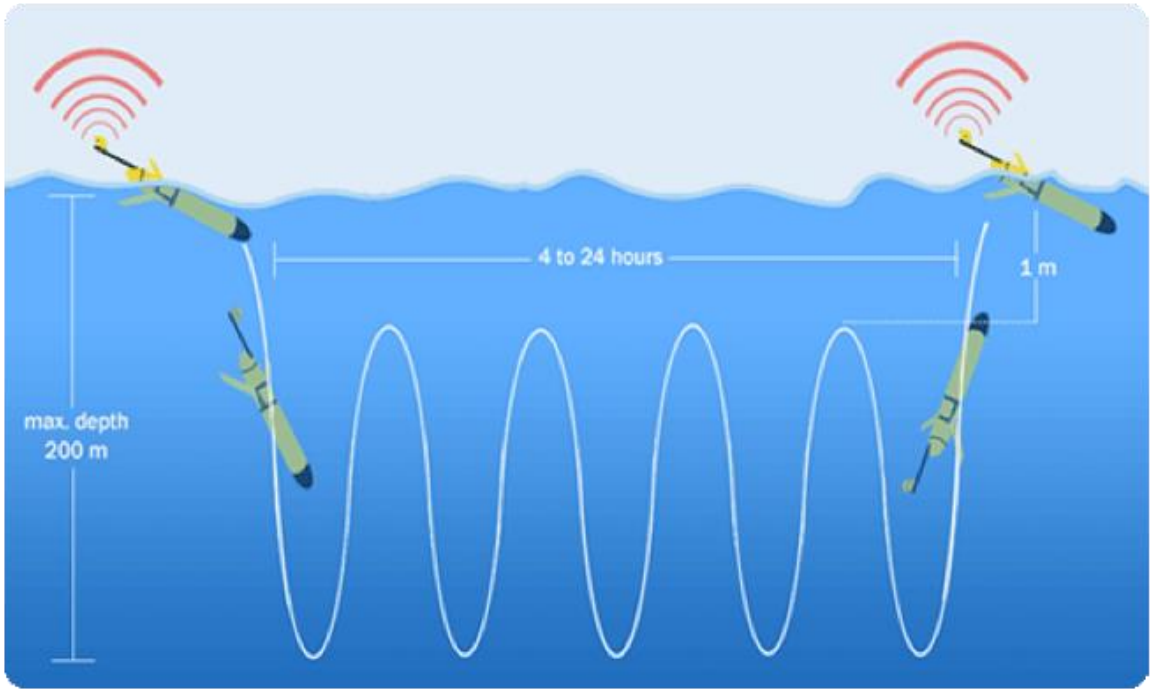
Division of Marine Science
University of Southern Mississippi

RV Manta: 21 June 2014

Mission characteristics

TELEDYNE WEBB RESEARCH
Everywhereyoulook™

Glider Flight Fundamentals



or to
1000 m

Facilities

- GERG
  - 833 Graham Road, CS
- Glider Lab
  - aka the Center for Autonomous Vehicle Exploration

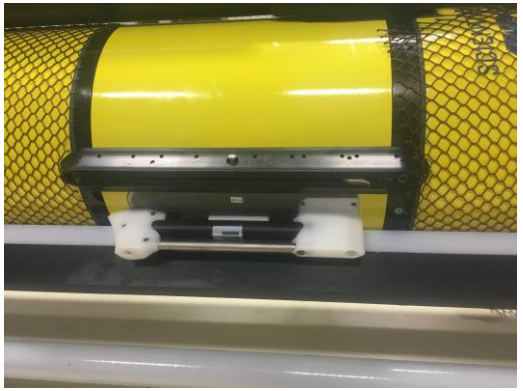
TAMU Slocum Gliders (G2)

- 307:Reveille
- 308:Howdy
- 540:Stommel
- 541:Sverdrup
- 199:Dora (the Explora)
  - TAMUG (GERG/MARS MOU)

www.webbresearch.com/**slocumglider.aspx**

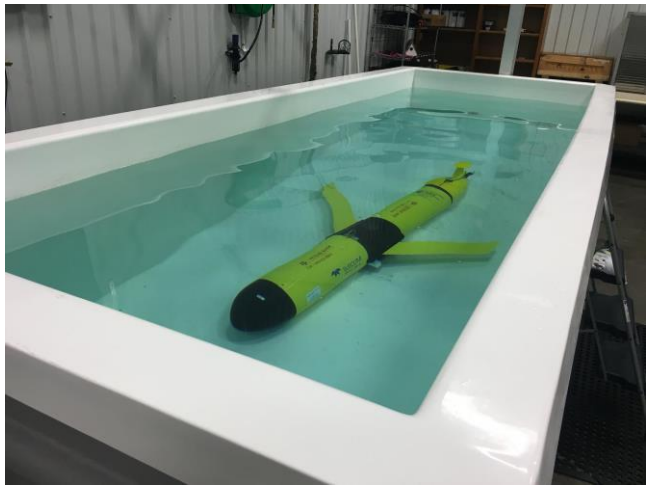
Glider Outfitting

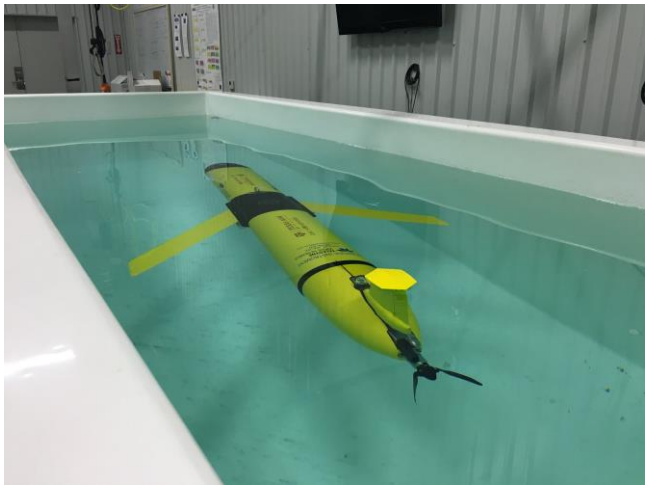
- Scientific Sensors
  - SeaBird gCTD:
  - Wetlabs ECO Puck (triple)
    - Chlorophyll Fluorometer
    - CDOM Fluorometer
    - Turbidity
  - Dissolved Oxygen
    - Seabird SBE-43 or RINKO (Rockland Scientific)



- Mission Sensors
  - Dozens…GPS, leak, battery, vehicle health
  - BIG Data: more than 2100 parameters reported every second
- Enhancements
  - Coastal Buoyancy Pump
  - Thruster Assembly
  - MicroRider Cradle (Rockland Scientific)
- Communications
  - Free-wave, Cellular ($), Iridium Satellite ($$$)

Ballasting





Enhanced Buoyancy Control

Depth, Density, Speed

Optimized depth operations:

- Shallow family: 30, 50, 100, 200 meters (shallow as 4 m depth)
- Deep family: 350, 1000 meters

Density ranges:

- 800 cc drive: 12 kg/m³ available (reduced by 100 cc drive)
- Thruster: 17 kg/m³ available
- Combined: 29 kg/m³ available

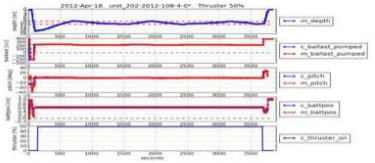
Speed:

- From buoyancy: up to 1 knot (dependant upon density, operational depth, pump speed, and total displacement).
- From thruster: 2 knots (can be combined with buoyancy).
- Energy: Speed adversely impacts endurance.

Slocum G2 Hybrid Glider

- Greater speed – over 2 knots
- Increased vehicle capability using the standard mission construct
- Freshwater lens penetration for surfacing events

HYBRID CAPABLE

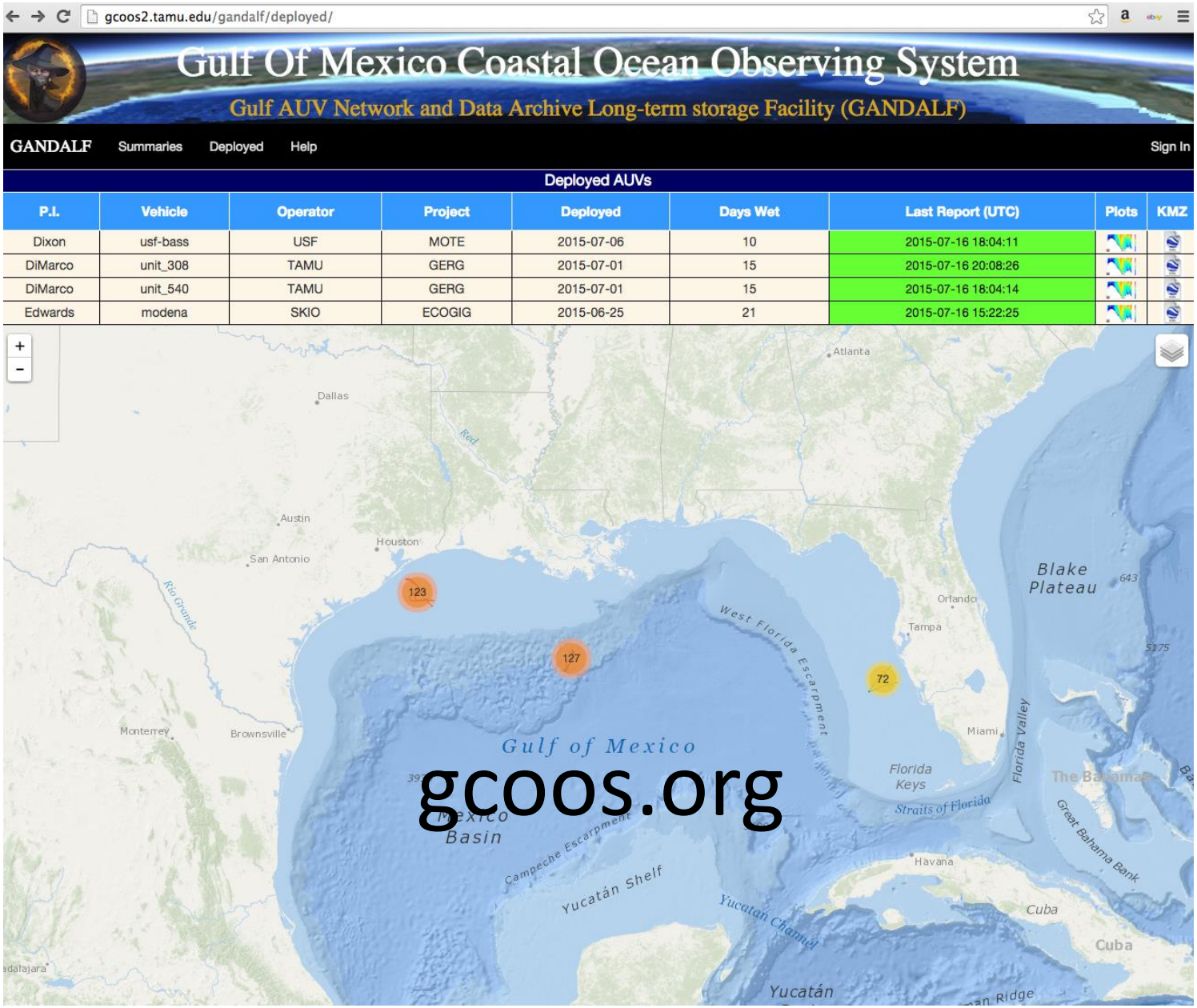


IMAGING • INSTRUMENTS • INTERCONNECT • SEISMIC • VEHICLES
TELEDYNE MARINE Everywhereyoulook
11
Approved for public release FAL# 16-012

Glider Personnel

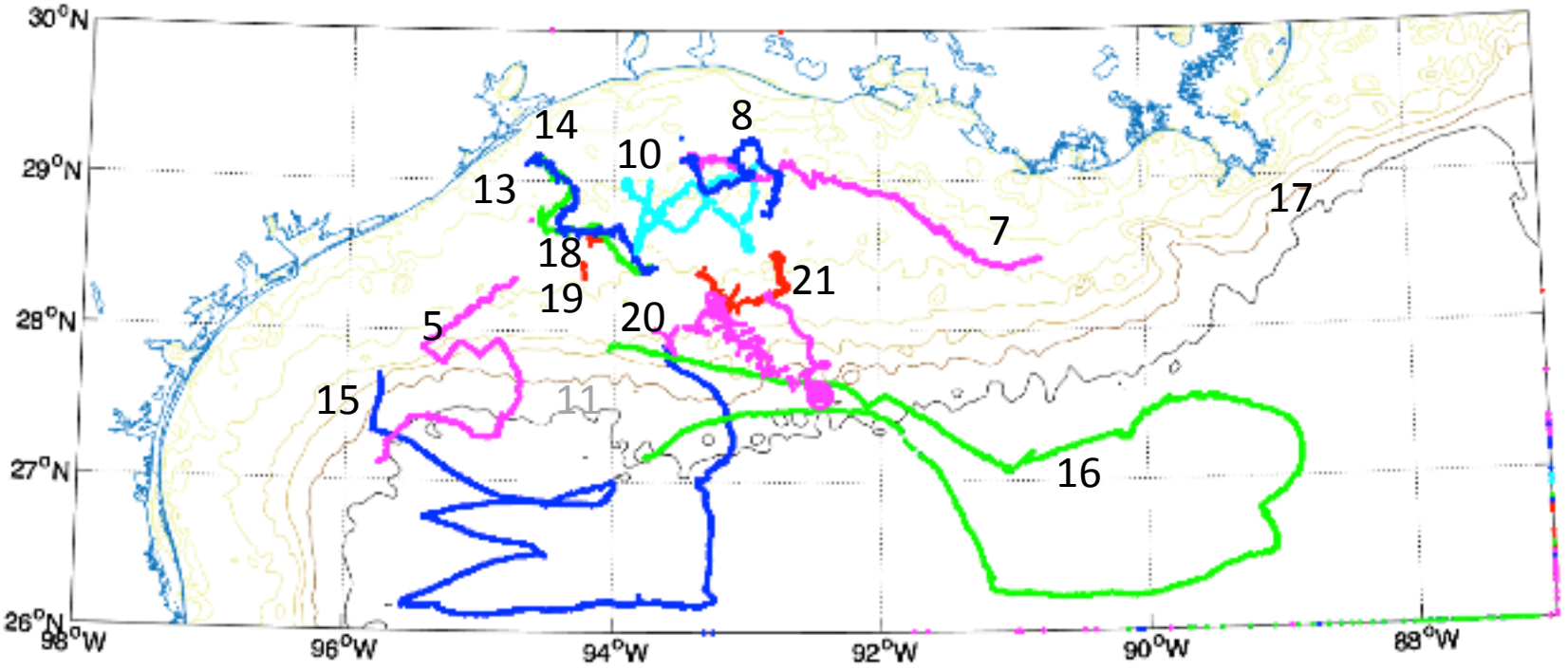
(It takes a village)

- Glider Pilots
  - Karen Dreger
  - Andrew King
  - Tyler Byrne
- Relief Pilots
  - Andy Dancer, Eddie Webb
  - Woody Lee
- Data Dissemination (GCOOS)
  - Matt Howard, Shin Kobara, Bob Currier
- Recovery Specialist
  - Adam Luedke
- Temporary Relief Glider Pilots
- Honorable mention
  - John Walpert, Tony Knap, Zhankun Wang, Ruth Perry, Bark Kirkpatrick
  - NOAA-CSCOR, FGBNMS, TxGLO, TPWD, TCEQ, GoMRI, TxOneGulf


gcoos2.tamu.edu/gandalf/deployed/
Gulf Of Mexico Coastal Ocean Observing System
Gulf AUV Network and Data Archive Long-term storage Facility (GANDALF)
GANDALF
Summaries
Deployed
Help
Sign In
Deployed AUVs
P.I. | Vehicle | Operator | Project | Deployed | Days Wet | Last Report (UTC) | Plots | KMZ
Dixon | usf-bass | USF | MOTE | 2015-07-06 | 10 | 2015-07-16 18:04:11
DiMarco | unit_308 | TAMU | GERG | 2015-07-01 | 15 | 2015-07-16 20:08:26
DiMarco | unit_540 | TAMU | GERG | 2015-07-01 | 15 | 2015-07-16 18:04:14
Edwards | modena | SKIO | ECOGIG | 2015-06-25 | 21 | 2015-07-16 15:22:25
Atlanta
Dallas
Austin
Houston
San Antonio
Rio Grande
Monterrey
Brownsville
123
127
72
Orlando
Tampa
Miami
Blake Plateau
West Florida Escarpment
Florida Keys
Straits of Florida
Florida Valley
The Bahamas
Great Bahama Bank
Gulf of Mexico
gcoos.org
Campeche Escarpment
Yucatán Shelf
Yucatan Channel
Havana
Cuba
Yucatán

TAMU Glider Deployment Map

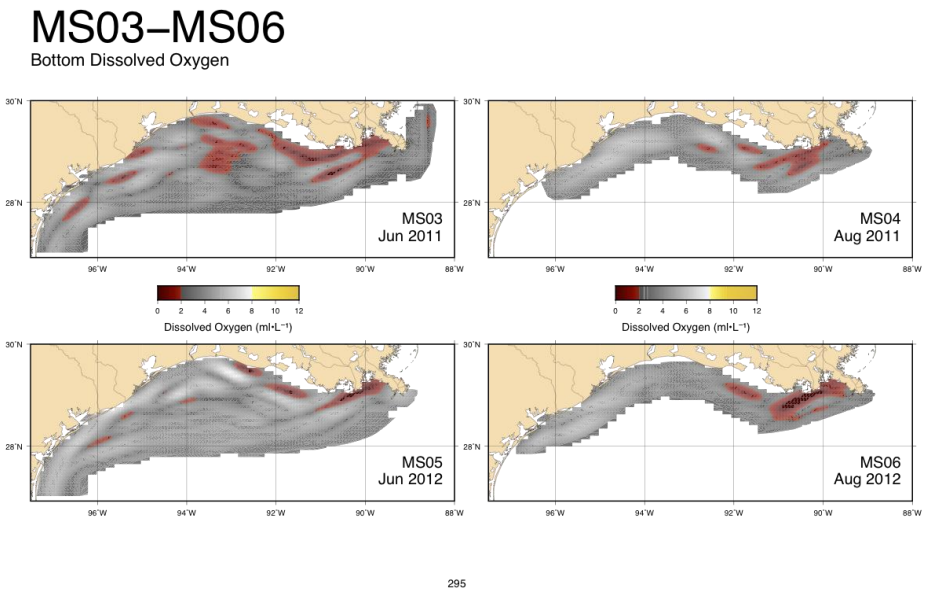
2014-2016



Glider Deployment Statistics

Year	Mission	Glider S/N	Days Wet
2013	3	307	33
	2	308	5
2014	1	307	32
	2	308	57
	2	199	8
2015	1	307	23
	2	308	26
	2	540	**87**
	1	541	79
2016 (So far…)	2	307	22
	2	308	21
	1	540	24
	0	541	0
	1	199	2

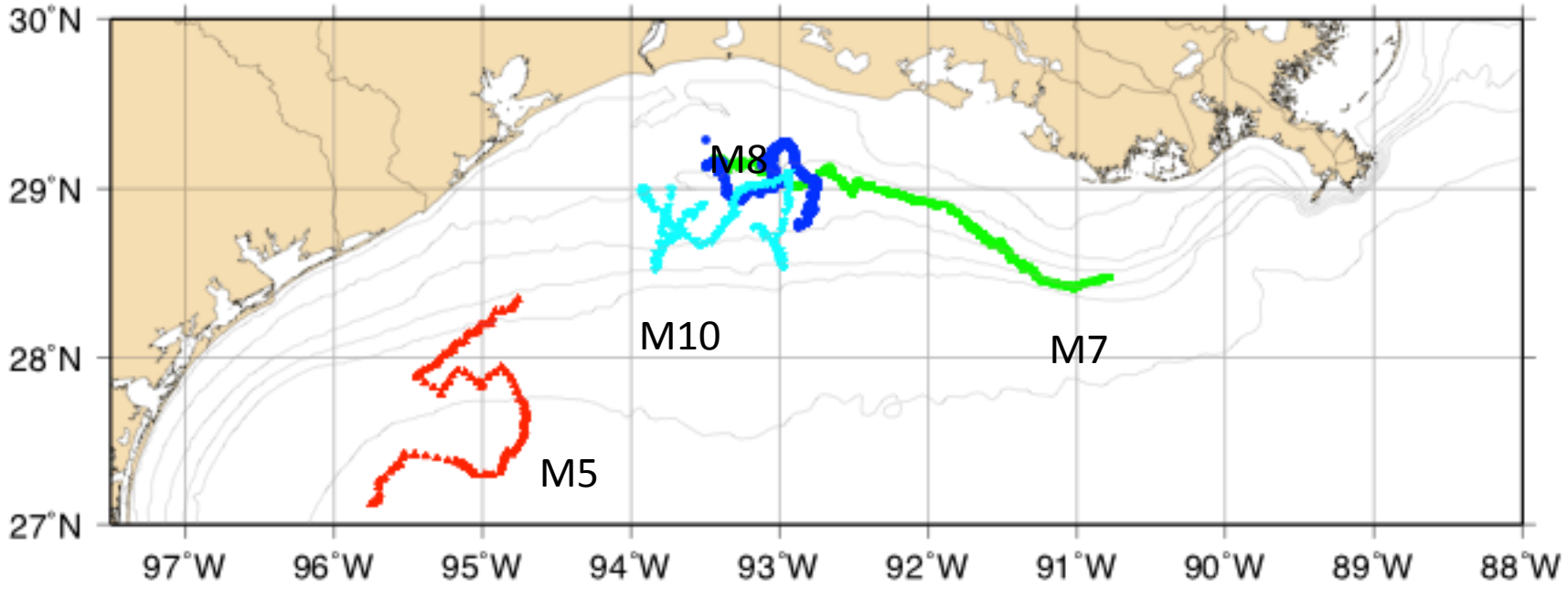
	2013	2014	2015	2016a	2016-2017
Glider days	38	97	215	69	144
	10%	20%	33%	29%	58%



Hypoxia

GLIDER APPLICATIONS

Gulf Glider Hypoxia Experiment Summer 2014

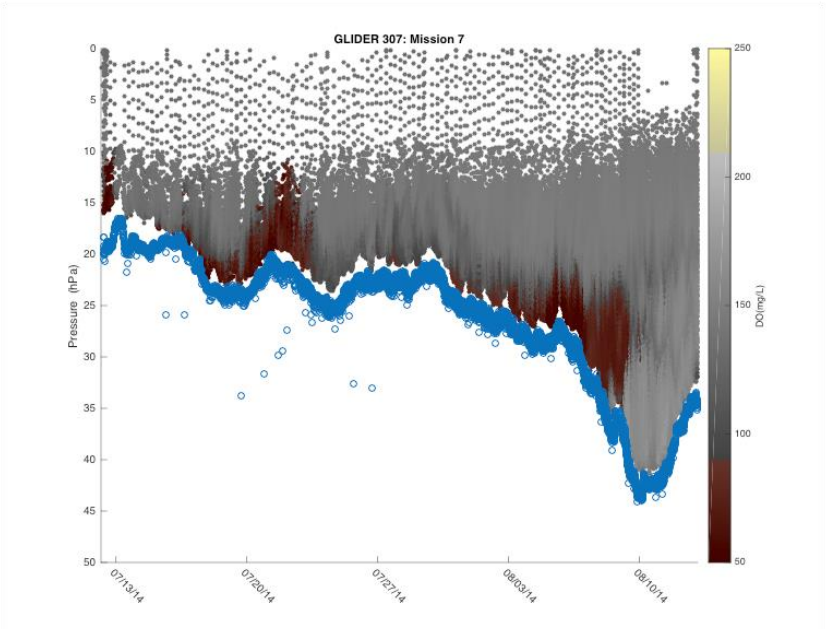


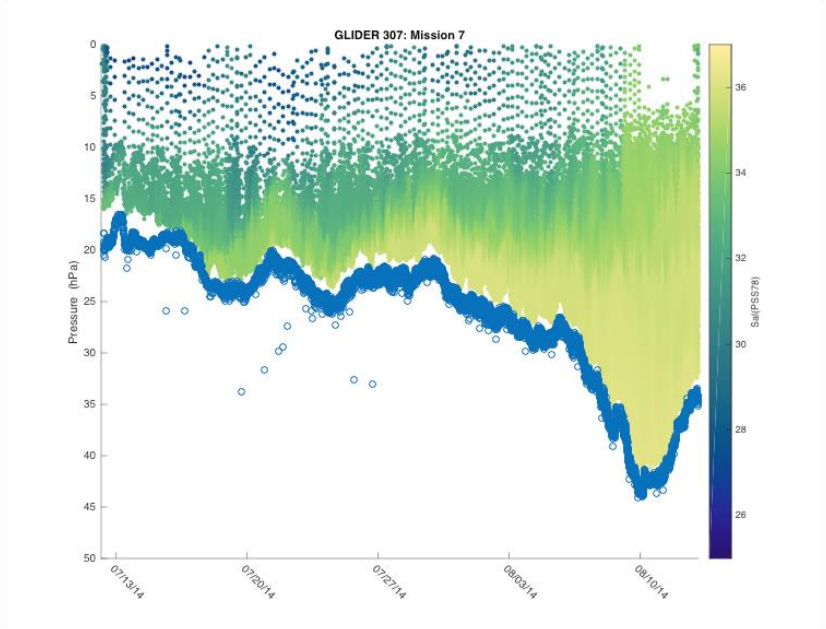
- To coordinate and operate multiple autonomous buoyancy ocean vehicles in the northern Gulf of Mexico hypoxic area during summer 2014
  - Sub-objective: map the hypoxic zone
- Quantify average distance from bottom for glider yo

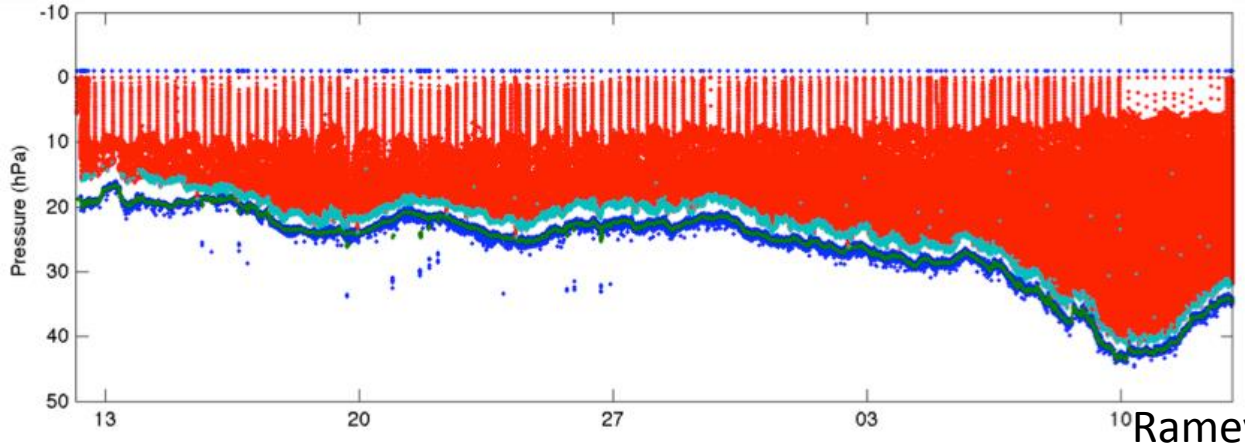
TEXAS A&M UNIVERSITY

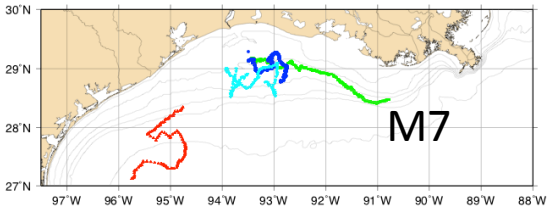
More information on the MCH project at http://hypoxia.tamu.edu

M7: Environmental Variables



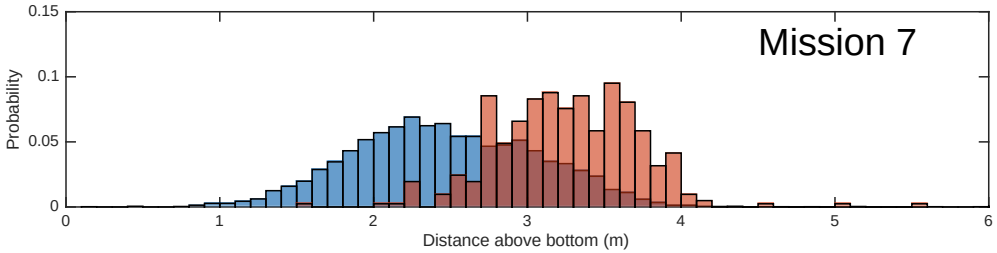


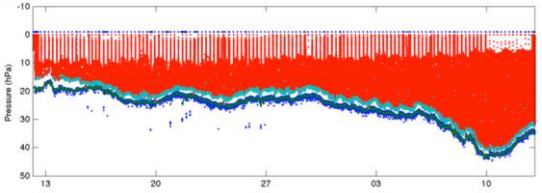


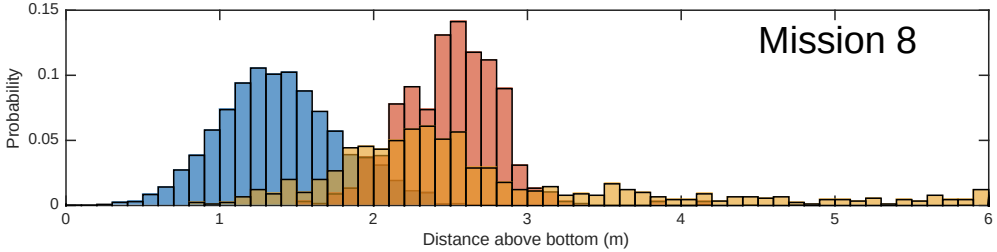


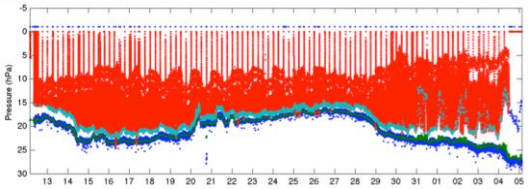
Ramey et al. 2016 (to be submitted)

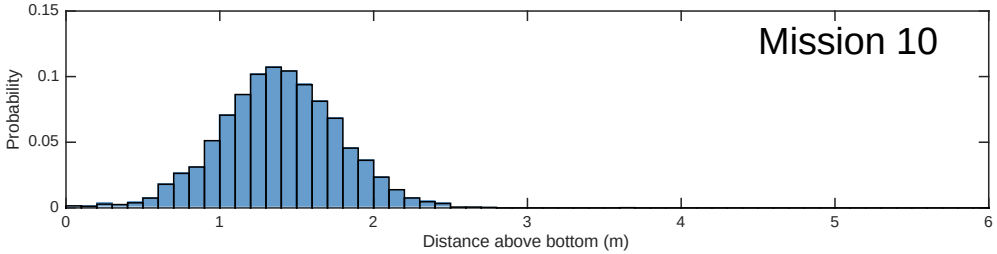
How close to the bottom?

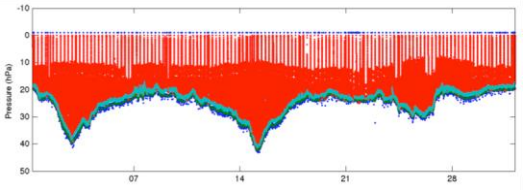






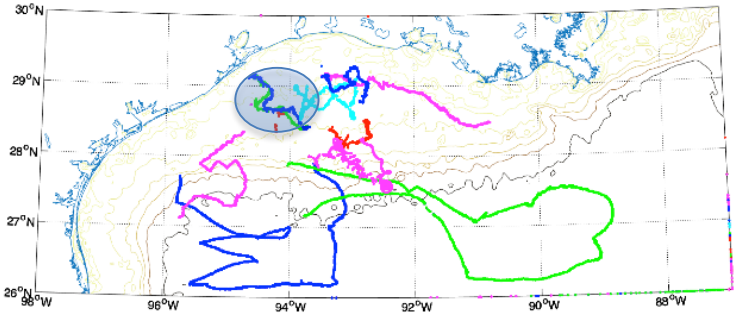


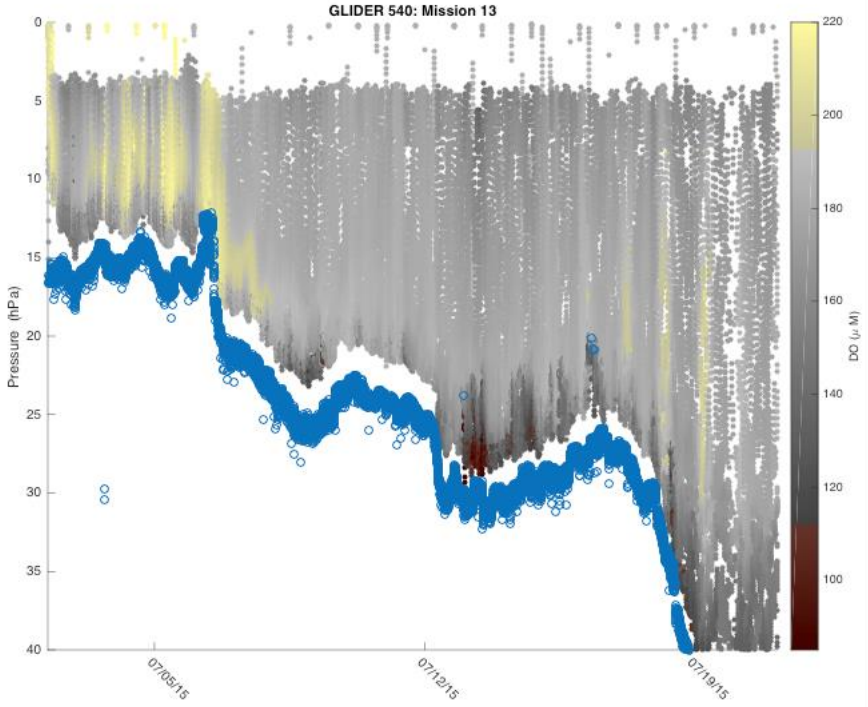


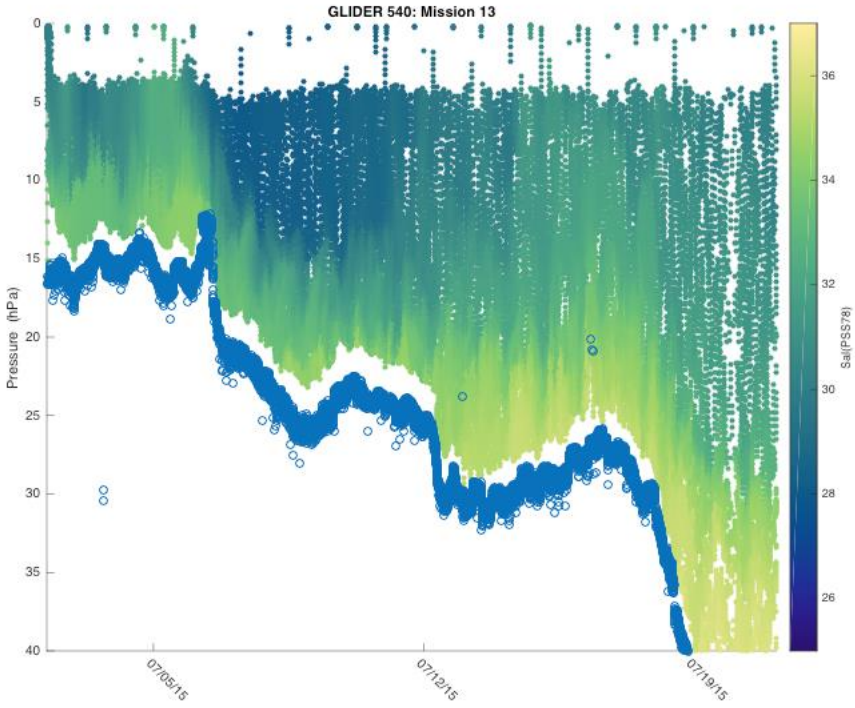


Ramey et al. 2016 (to be submitted)

Texas Flood 2015

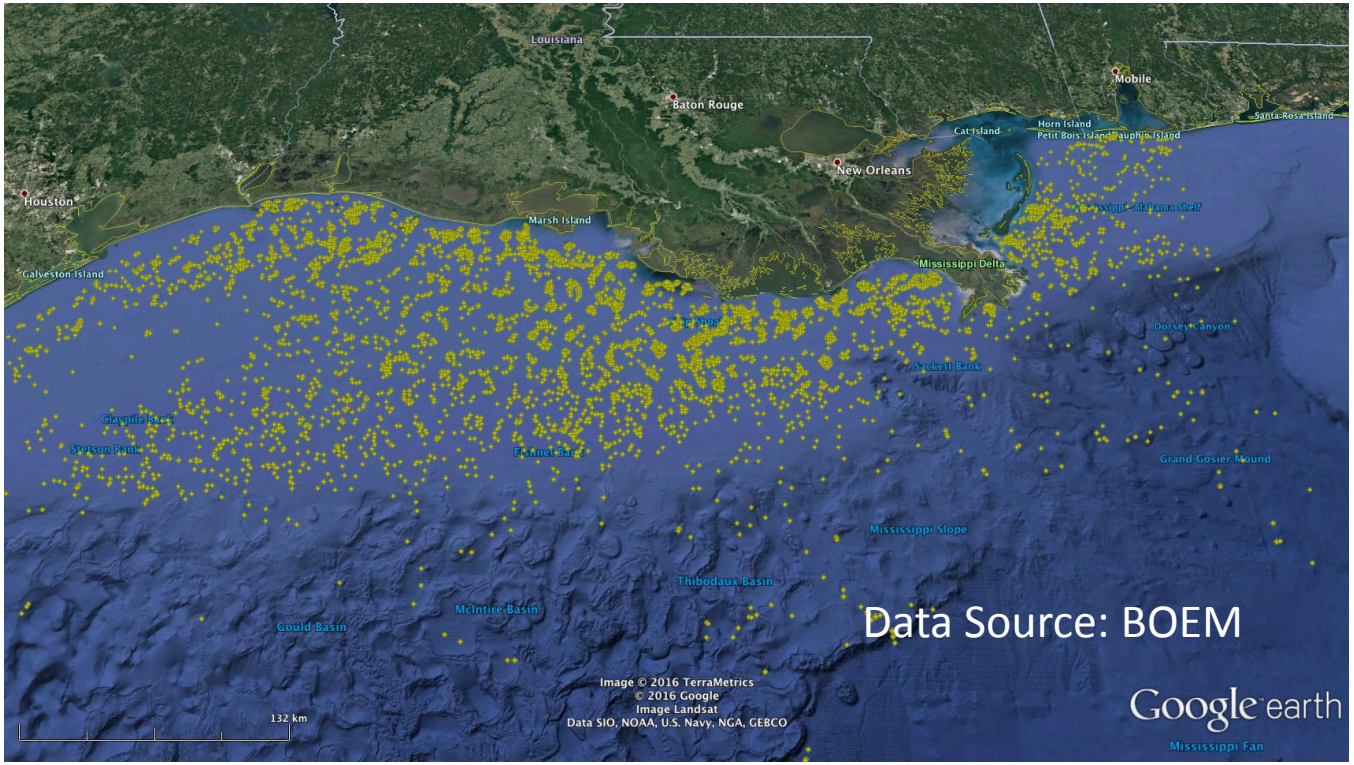




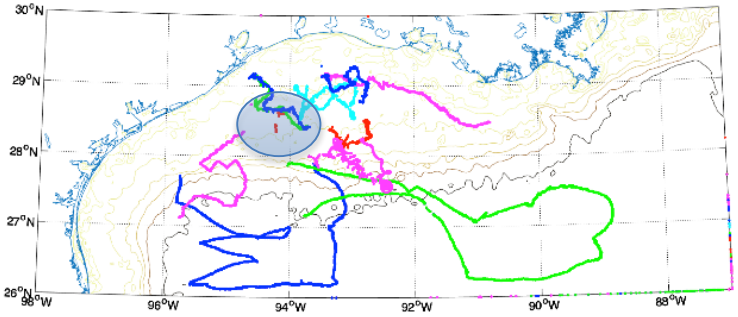


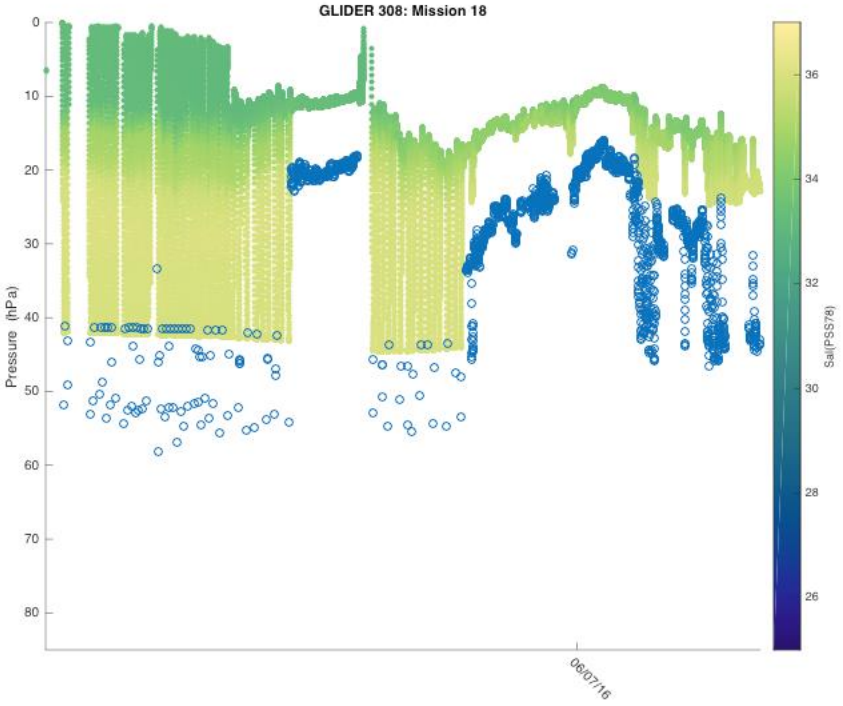
- Exceptional vertical performance; little horizontal control
- Mission emphasized the importance of capturing temporal variability of oxygen structure

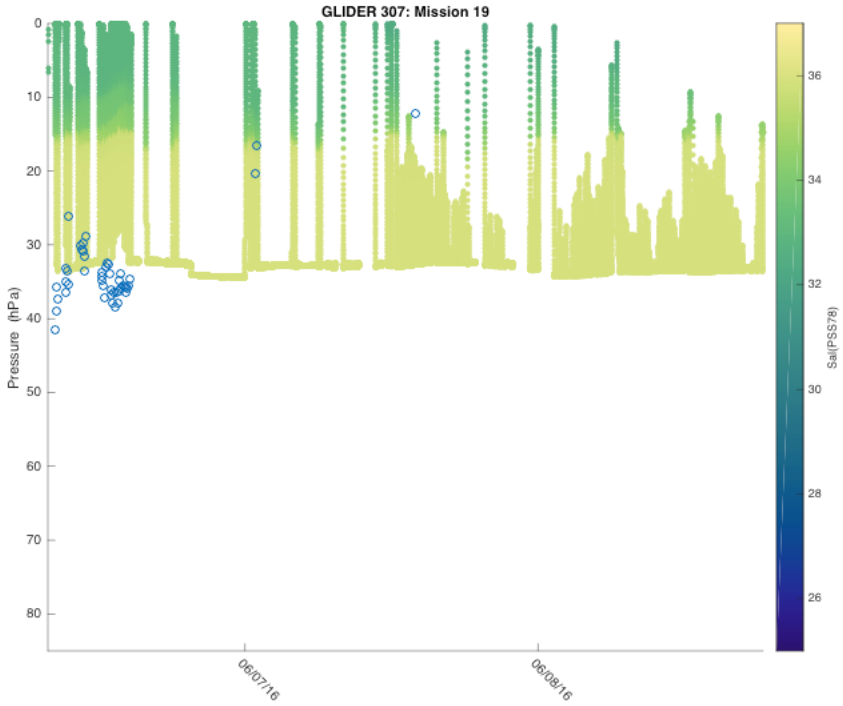
Glider Challenges



My sediments exactly

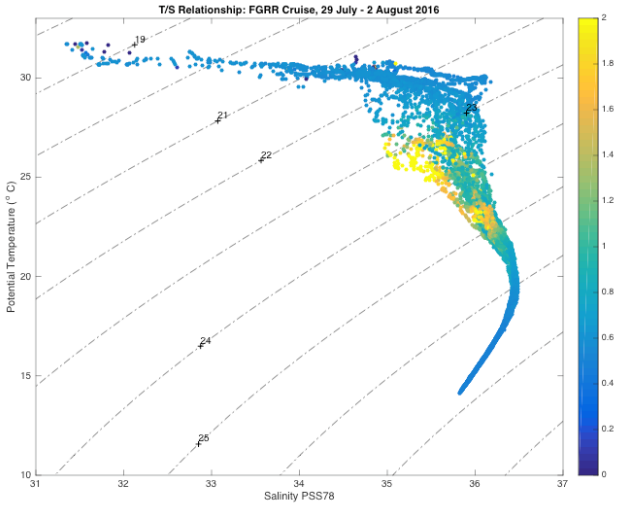


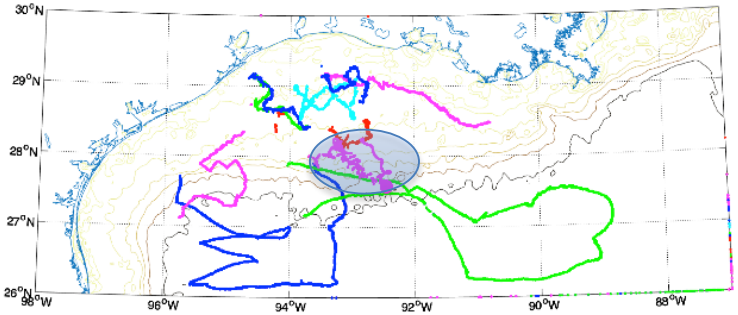


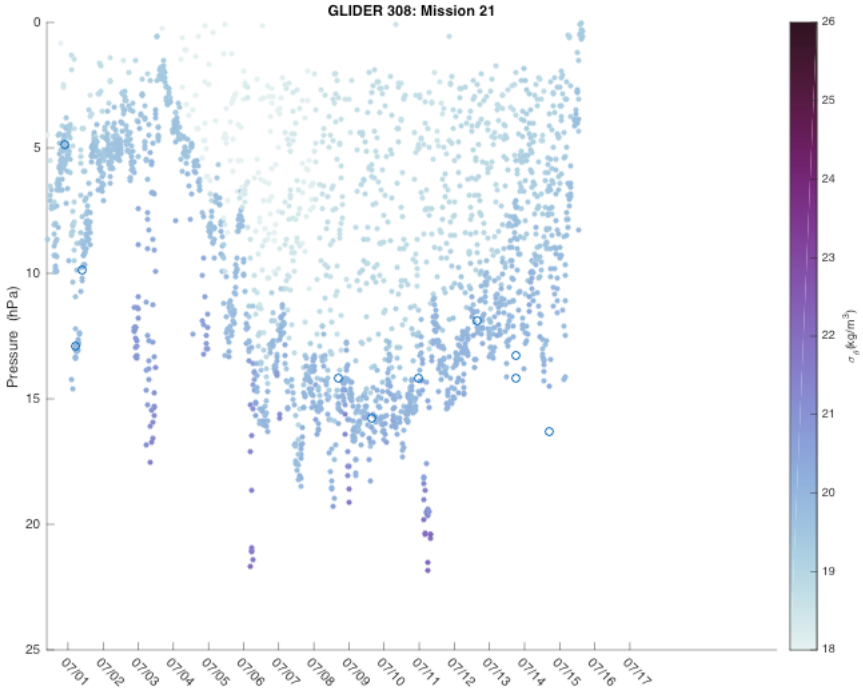


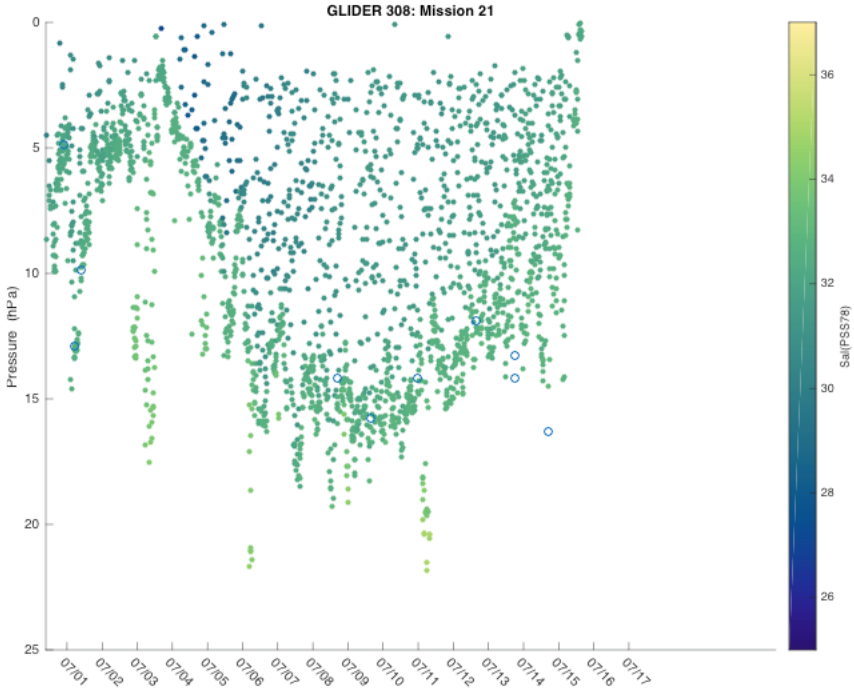
- Accumulation of sediment in the glider nose cone of both gliders led to mission aborts after a couple of days

FGBNMS July 2016







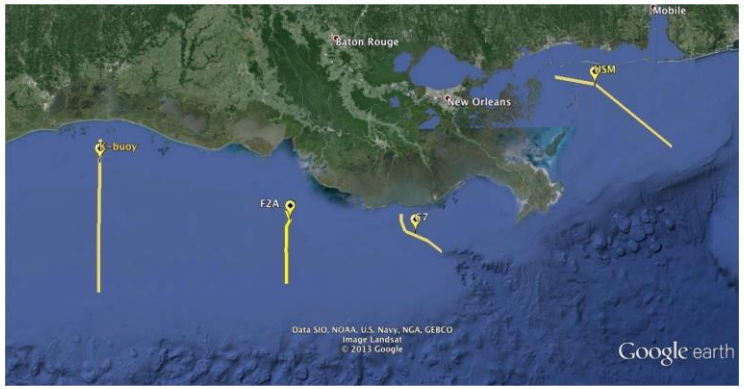


Despite being in water depths > 100 m, the glider was unable to penetrate the pycnocline at 10-15 m.

Gliders on the Shelf

- Gliders can get close to the bottom to capture subpycnocline variability
- Only gliders with enhanced buoy and thruster capability can navigate with reasonable expectation of track or transect following
- For this application, only deploy with Li-ion batteries, alkaline batteries do not last long with thrusters and shallow water
- There will be times and locations gliders will not be able to navigate, due to shallow depth, high stratification, strong current

Possible Approaches

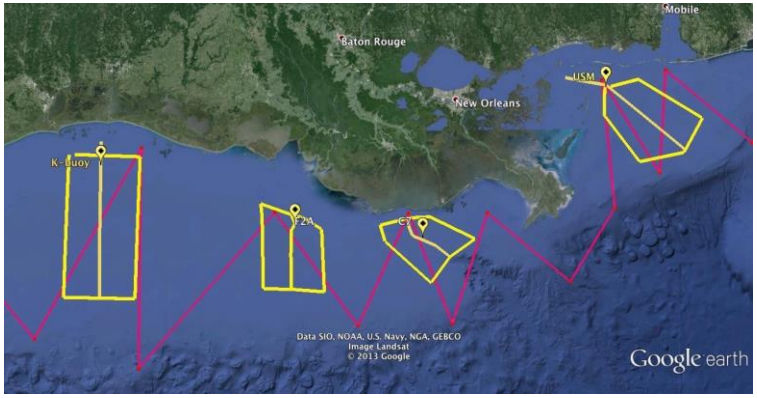


Repeat lines (Tier 1)

- Logistically easy
- Fewer gliders required
- Easier to analyze
  - More rapid repeat times
  - Same lines for comparison

Repeat Survey Sections (Tier 2)

- Logistically easy
- Still fairly rapid repeat interval
- More coverage

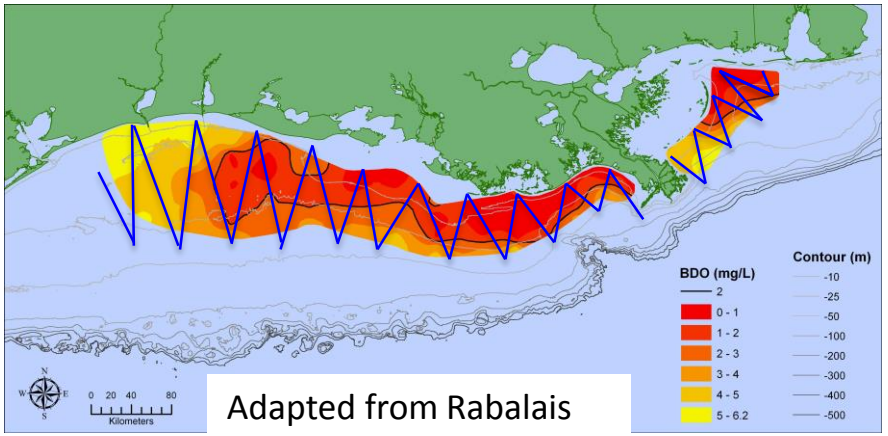


GCOOS Conveyor Belt (Tier 3)

- Broader coverage
- Better constraints on extent of hypoxia
- Wide spacing of lines

Hypoxia Mapping (Tier 3/4)

- Determine extent of hypoxia
- Glider changes path based on depth and dO level: Adaptive sampling
- Need to ensure glider measures close to seafloor
- More gliders required



Adapted from Rabalais


Questions
RV Pelican : June 2014

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GCOOS KMZ

Available Sensors

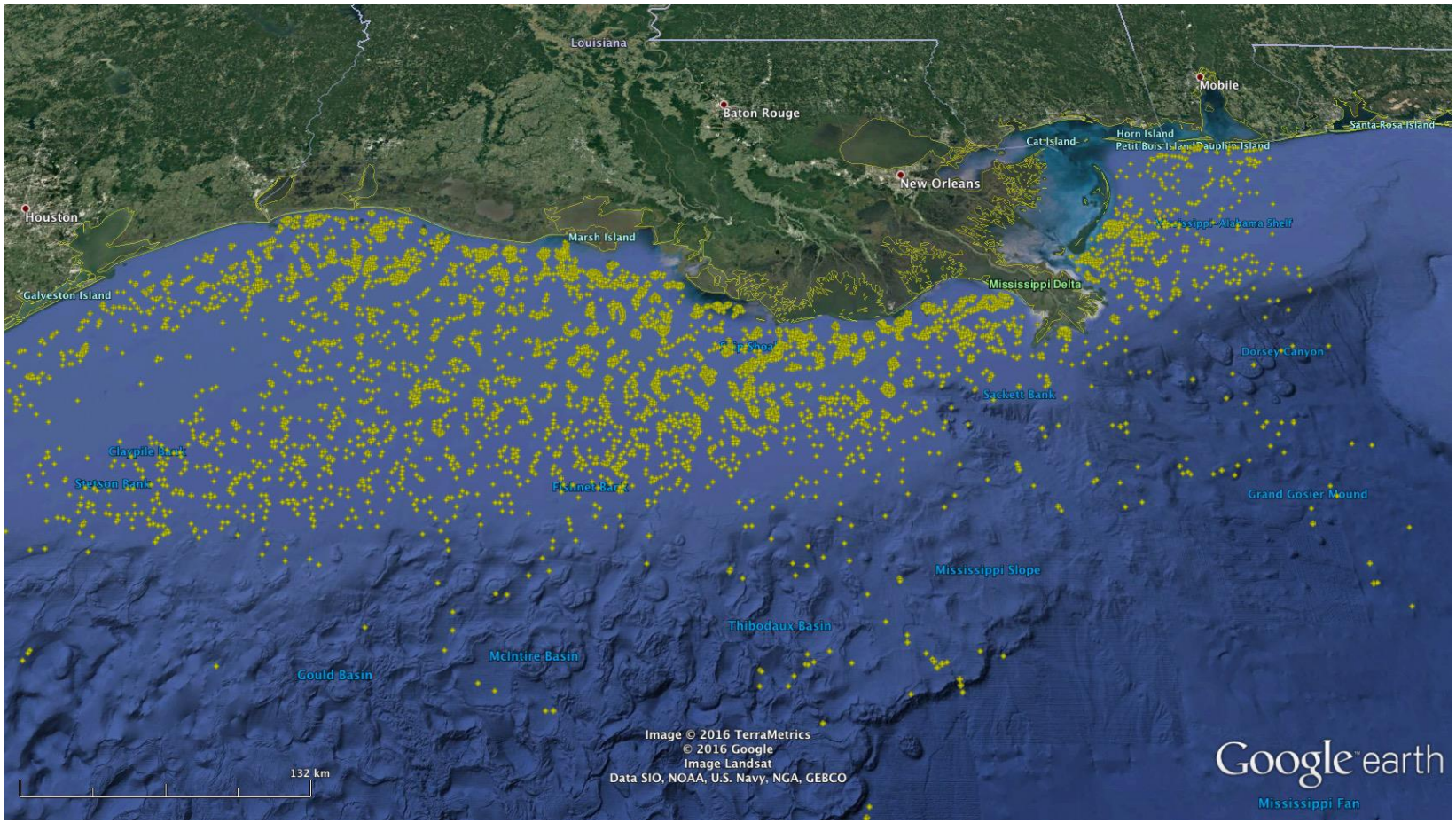
Sensor Suites

Acoustic Modem
ADCP/DVL
Altimeter
Bathyphotometer (bioluminescence)
Beam Attenuation Meter
Conductivity, Temperature, Depth
Echo Sounder
Nitrate
Optical Backscatter
Optical Attenuation
Oxygen
Fish Tracking
Fluorometer
Hydrocarbon
Hydrophones
PAR sensor
Radiometer
Scattering Attenuation Meter
Spectrophotometer (red tide detection)
Turbulence

Modular 6 L Payload Bay
Nominally 3 – 6 kg air weight
Customized for a variety of acoustic, optic and chemical sensors

Science Bays can be stacked or stretched.

Fixed Platforms in the Gulf



Data Source: BOEM