UG²/EGO 8th Ego Meeting and International Glider Workshop

21 May 2019

# Applications of Buoyancy Gliders in the Western Gulf of Mexico

## Loop Current Dynamics, Coastal Hypoxia, Ocean Noise, Acidification, and Hurricane Intensification


*Steven F. DiMarco*

Department of Oceanography and

Geochemical and Environmental Research Group

Texas A&M University

K. Whilden, S. Mahmud, A. H. Knap


RV Manta: 21 June 2014

# Glider Research in the Western Gulf of Mexico

- TAMU Capability
- Local Challenges
- Applications
  - Loop Current
  - Coastal Hypoxia, a.k.a. the Deadzone
  - Coral Reef Water Quality
    - Flower Garden Banks
  - Hurricane Harvey (2017)

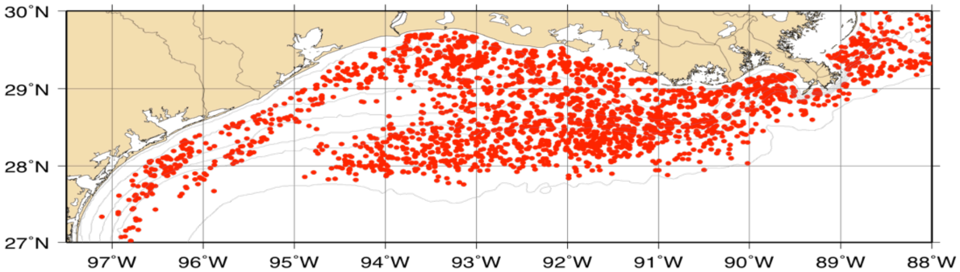
# TAMU Glider Capabilities

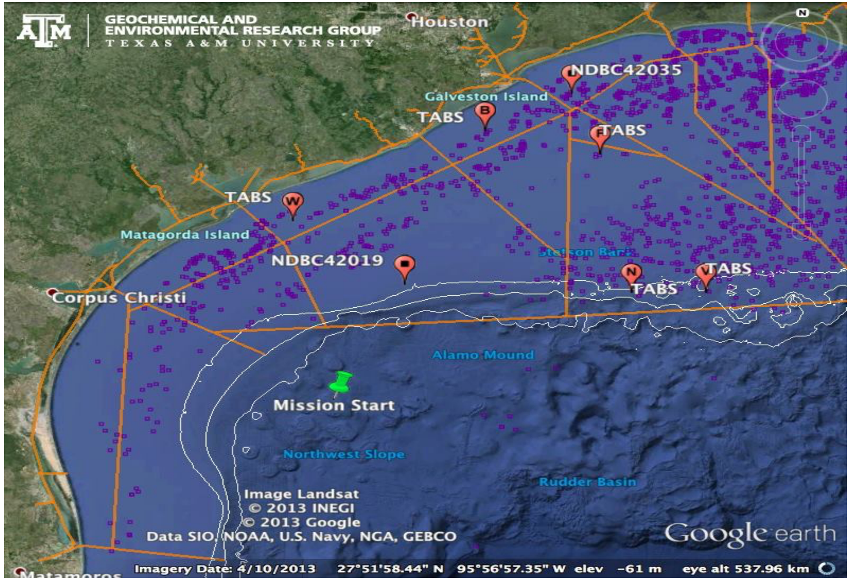
- GERG Center for Autonomous Vehicle Engineering
  - 5000 sq ft
  - Two ballasting tanks
  - Est. 2012
  - 4 Slocum, 1 Waveglider, 1 Autonaut

- Research Foci
  - Hypoxia, HAB
  - Oil spill response
  - Upper ocean heat content, hurricane response
  - Improvements to prediction
  - Ocean Acoustics

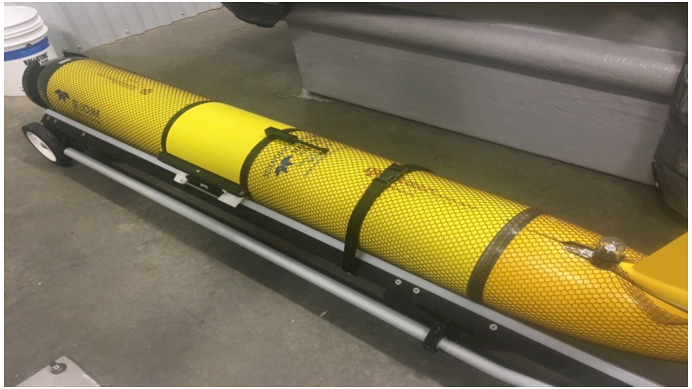
- Western Gulf of Mexico
  - Texas-Louisiana Shelf
  - DWH Spill Site
  - Deep Gulf of Mexico

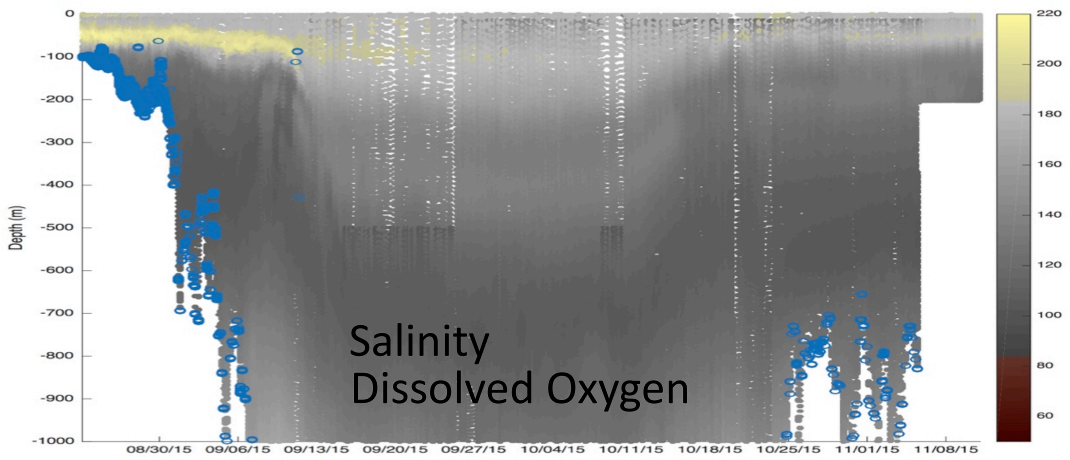
# Glider Challenges

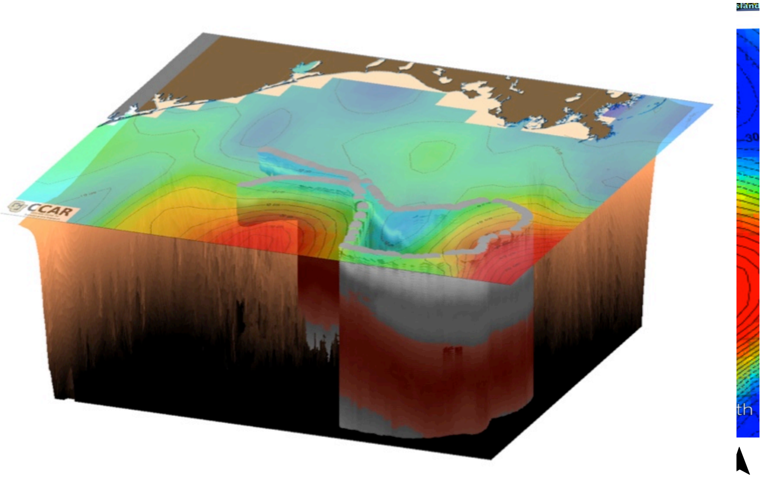




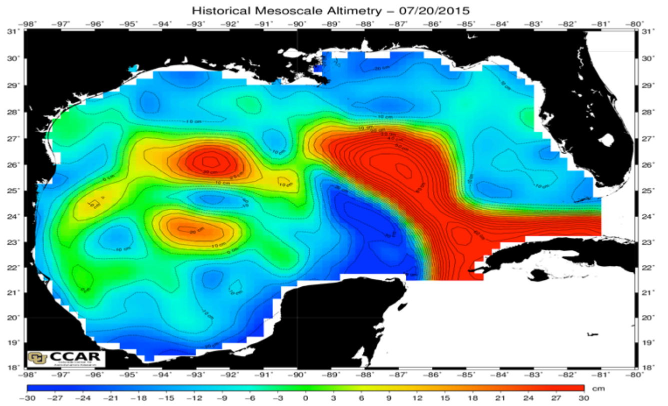





Glider Applications

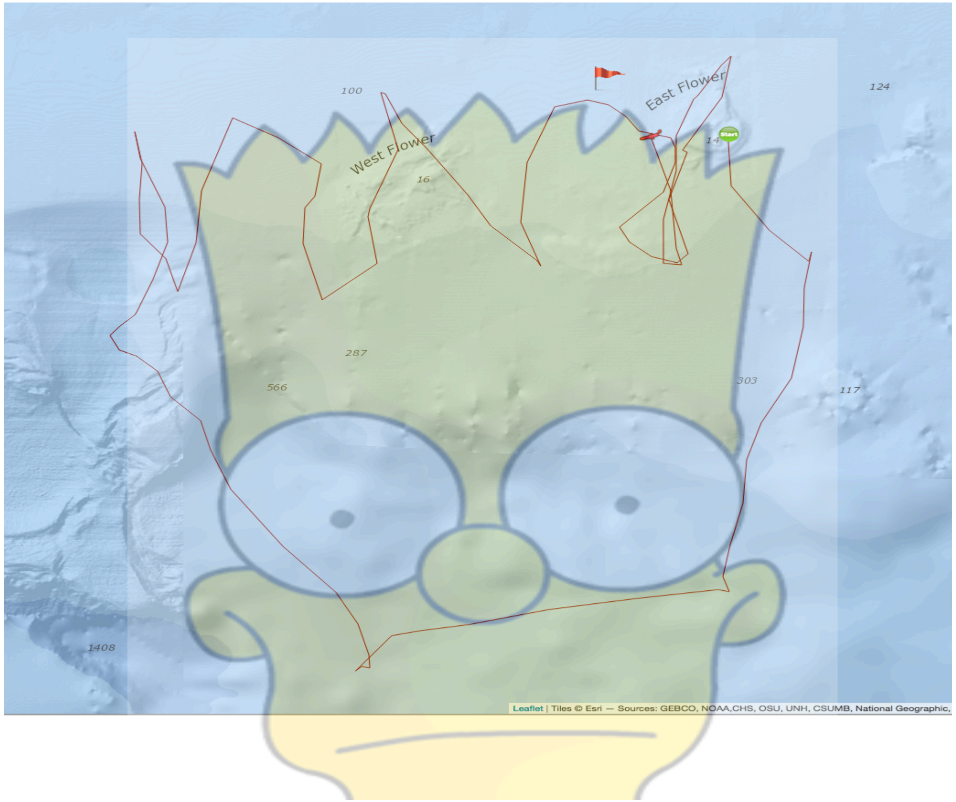
# PREDICTION: UPPER OCEAN HEAT CONTENT AND EDDY DYNAMICS

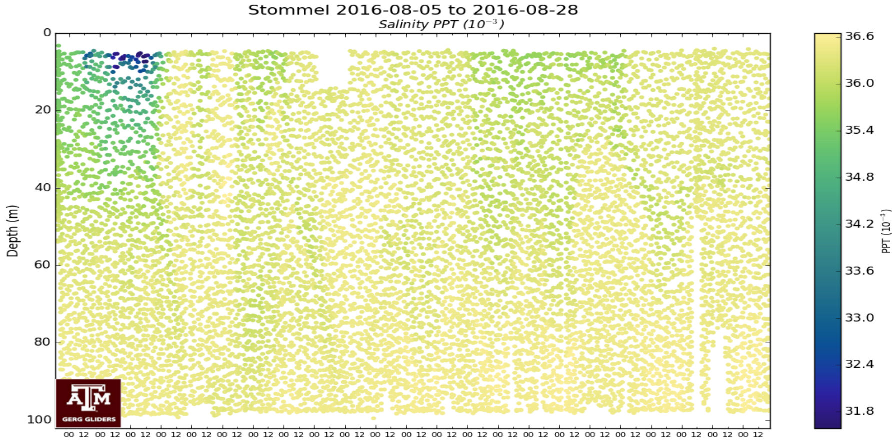


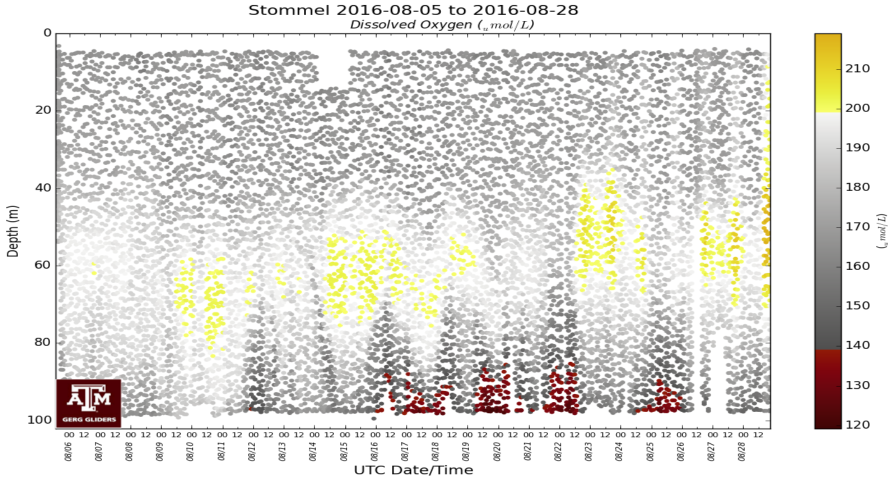
Glider Applications

# RESPONSE: FLOWER GARDEN BANKS NMS MORTALITY EVENT

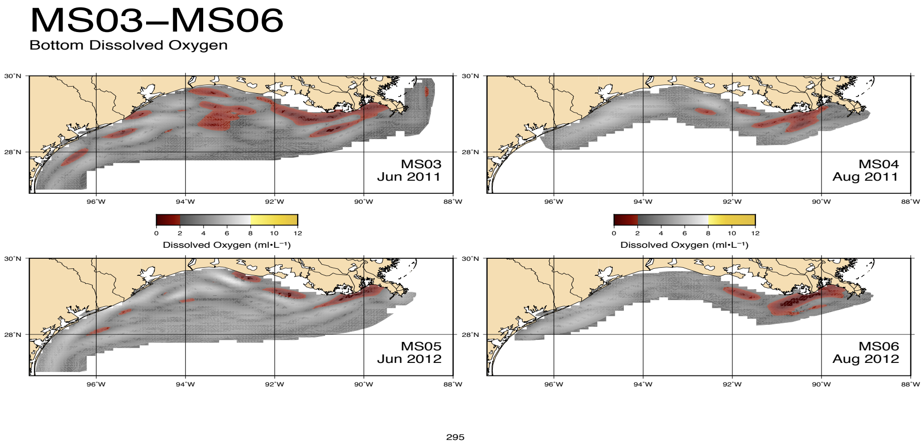
# FGB: mortality event track; 2016



http://mchatlas.tamu.edu



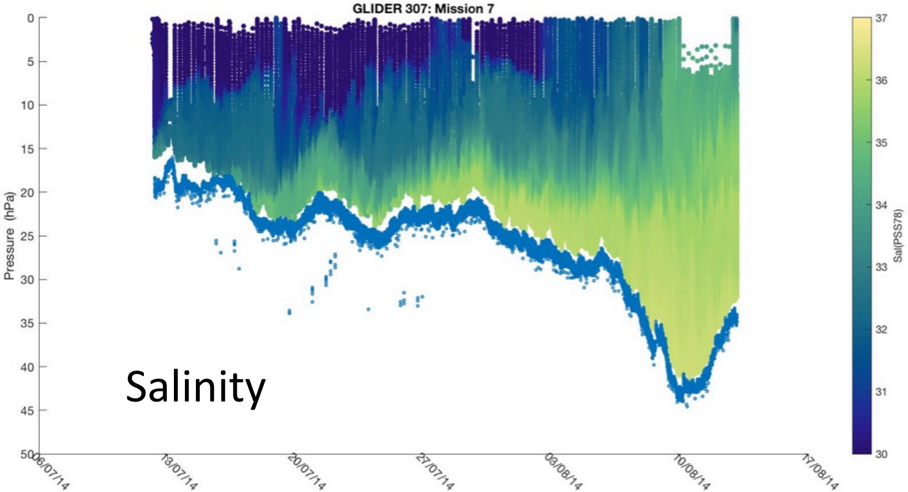


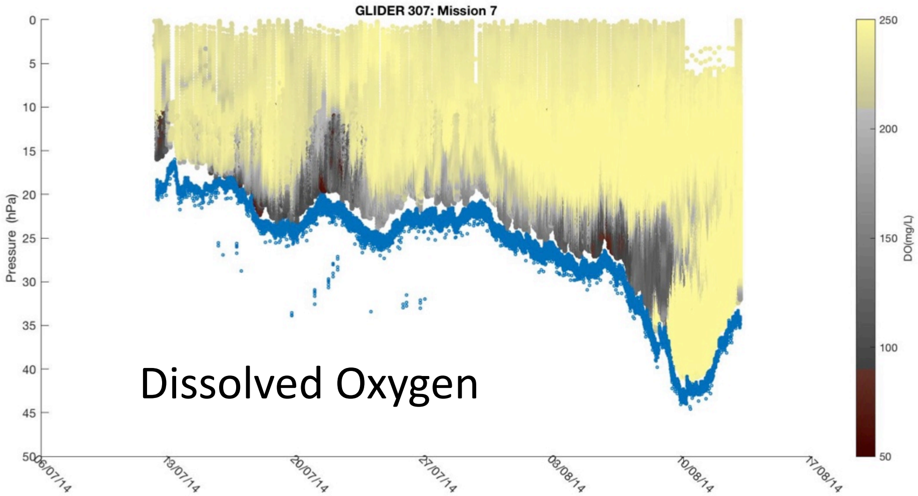
Glider Applications

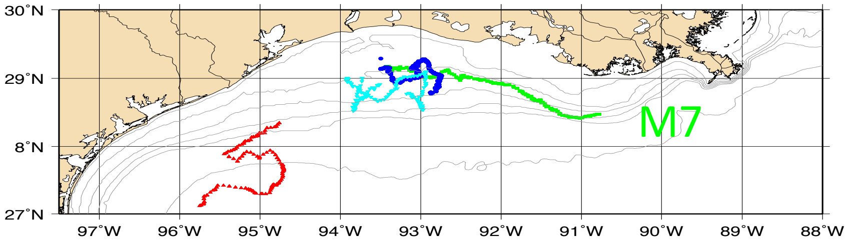
# COASTAL HYPOXIA

# Gulf Glider Hypoxia Experiment

## Summer 2014

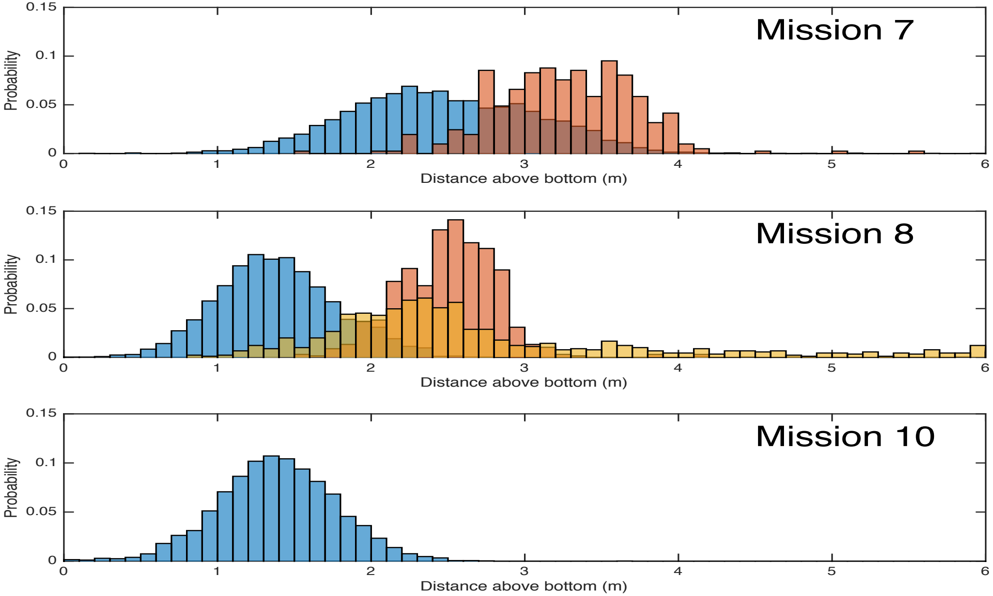


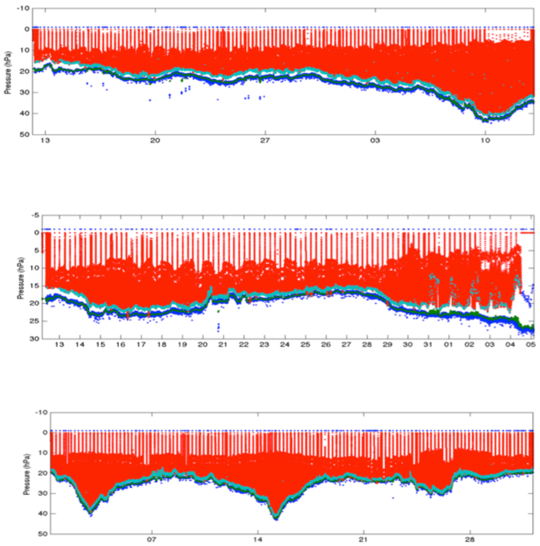




Ramey et al. 2017 (MTSJ)

# How close to the bottom?

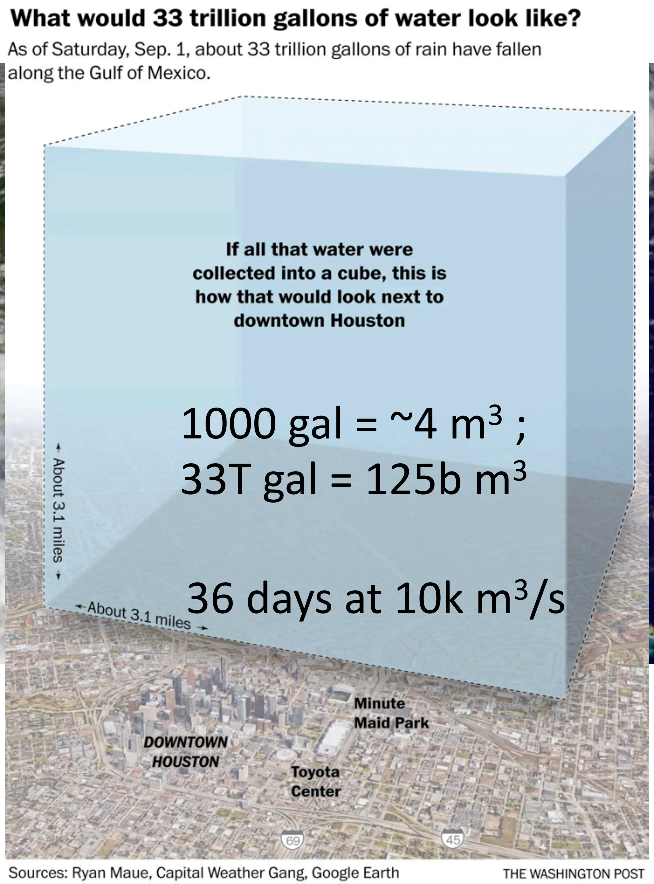


Ramey et al. 2017 (MTSJ)

# Hurricane Harvey: 25 August 2017

Intensification: Potter et al. 2019 (JGR-Oceans)


1000 gal = ~4 $m^3$ ;

33T gal = 125b $m^3$

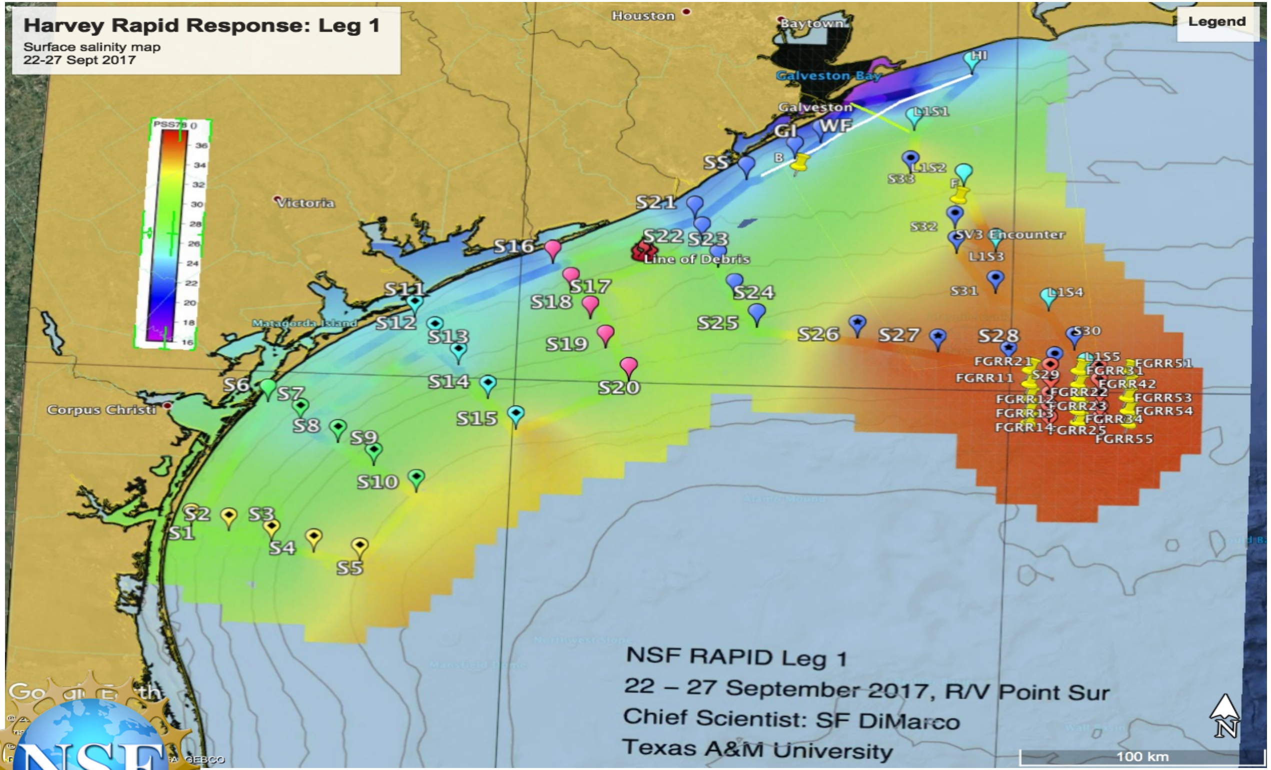
36 days at 10k $m^3/s$

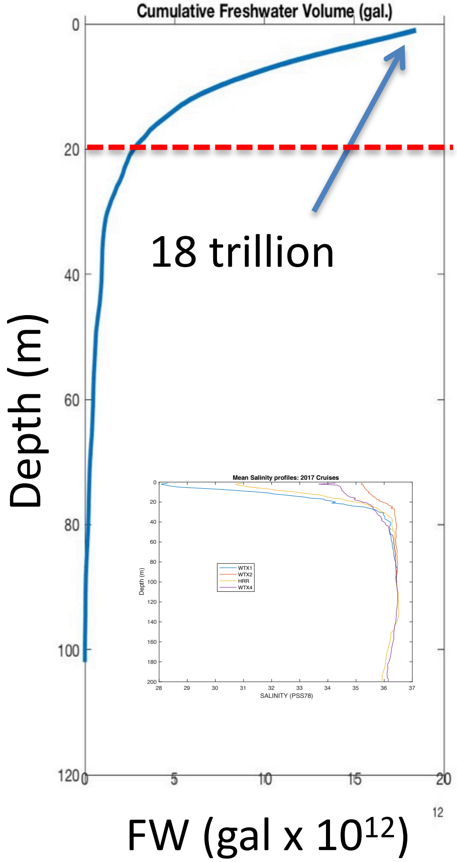
First landfall near Rockport TX

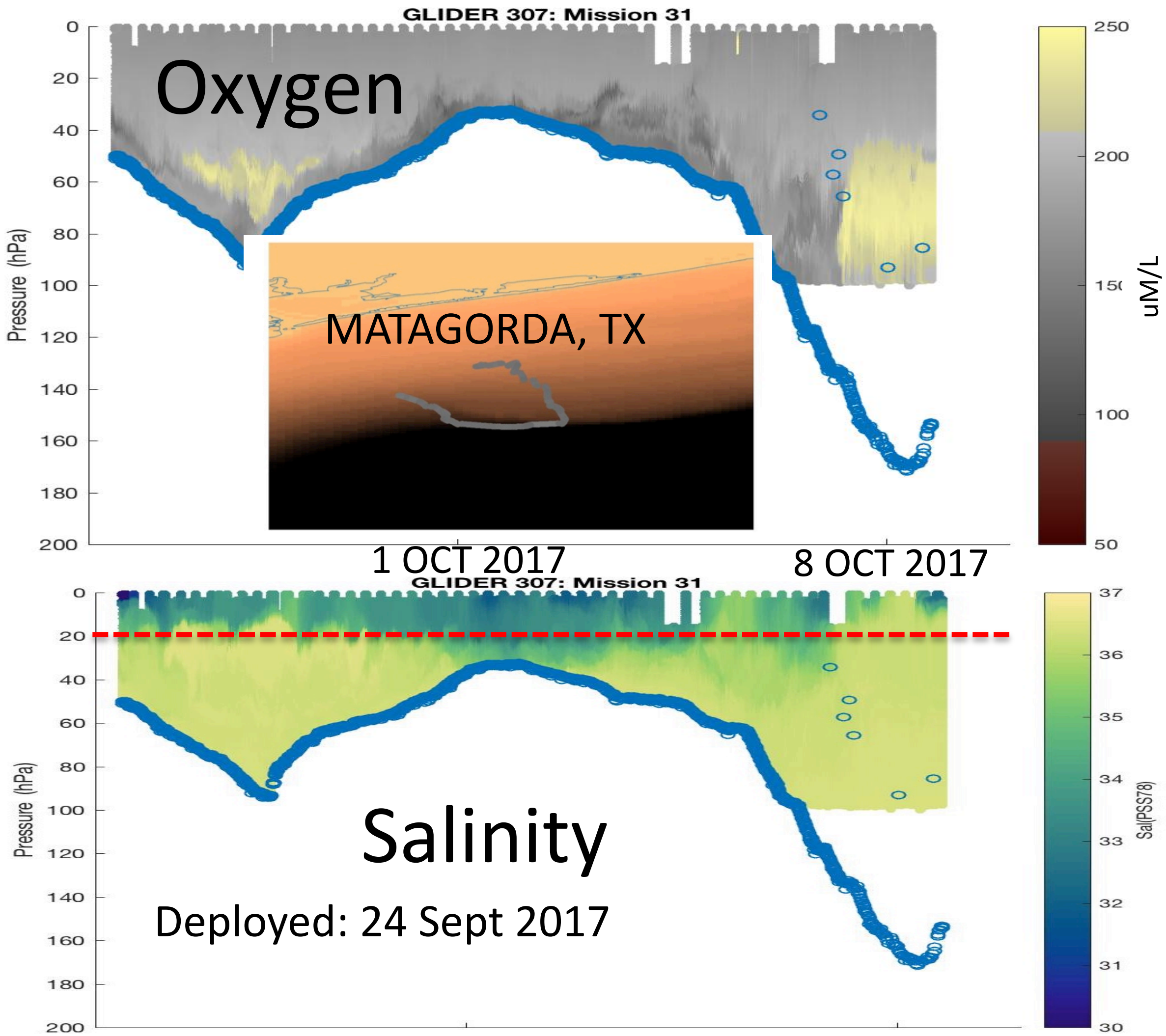
Cat 4 Hurricane on 25 August 2017

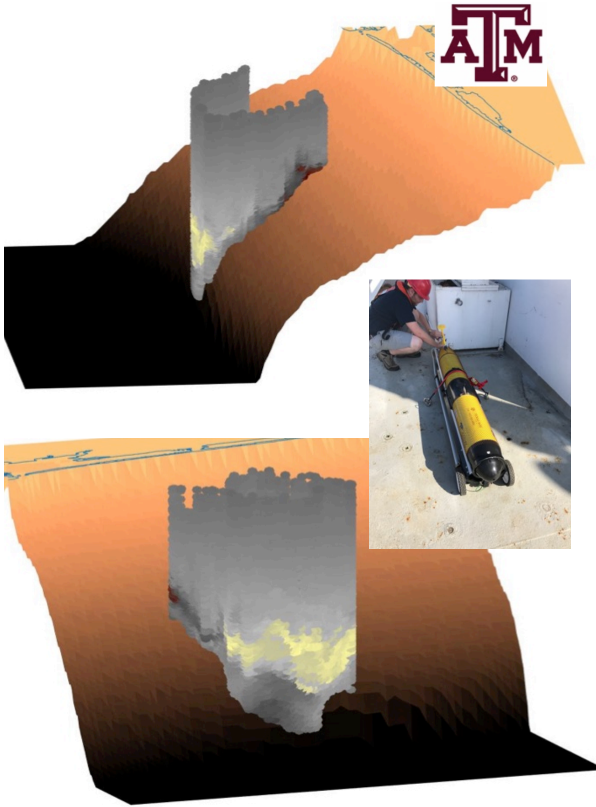
Second landfall near Cameron, LA on 29 August 2017

# Hurricane Harvey: Freshwater Volume

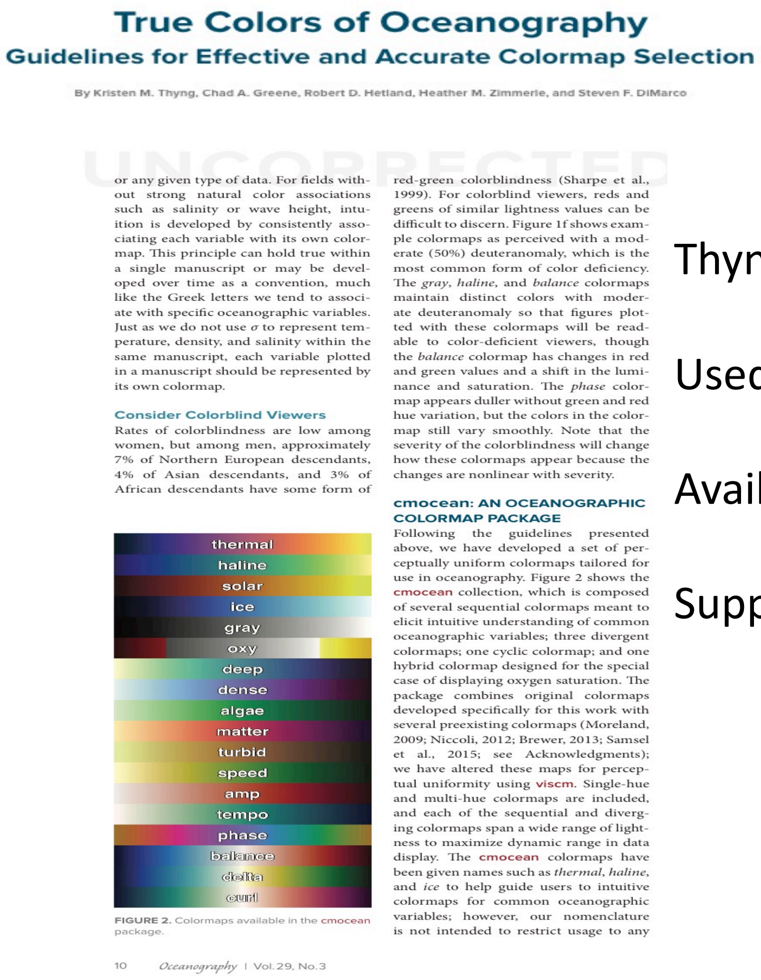




# Slocum Glider Mission



# True Colors of Oceanography

## Guidelines for Effective and Accurate Colormap Selection

By Kristen M. Thyng, Chad A. Greene, Robert D. Hetland, Heather M. Zimmerle, and Steven F. DiMarco



or any given type of data. For fields without strong natural color associations such as salinity or wave height, intuition is developed by consistently associating each variable with its own colormap. This principle can hold true within a single manuscript or may be developed over time as a convention, much like the Greek letters we tend to associate with specific oceanographic variables. Just as we do not use σ to represent temperature, density, and salinity within the same manuscript, each variable plotted in a manuscript should be represented by its own colormap.

### Consider Colorblind Viewers

Rates of colorblindness are low among women, but among men, approximately 7% of Northern European descendants, 4% of Asian descendants, and 3% of African descendants have some form of red-green colorblindness (Sharpe et al., 1999). For colorblind viewers, reds and greens of similar lightness values can be difficult to discern. Figure 1f shows example colormaps as perceived with a moderate (50%) deuteranomaly, which is the most common form of color deficiency. The *gray*, *haline*, and *balance* colormaps maintain distinct colors with moderate deuteranomaly so that figures plotted with these colormaps will be readable to color-deficient viewers, though the *balance* colormap has changes in red and green values and a shift in the luminance and saturation. The *phase* colormap appears duller without green and red hue variation, but the colors in the colormap still vary smoothly. Note that the severity of the colorblindness will change how these colormaps appear because the changes are nonlinear with severity.



FIGURE 2. Colormaps available in the cmocean package.

### cmocean: AN OCEANOGRAPHIC COLORMAP PACKAGE

Following the guidelines presented above, we have developed a set of perceptually uniform colormaps tailored for use in oceanography. Figure 2 shows the cmocean collection, which is composed of several sequential colormaps meant to elicit intuitive understanding of common oceanographic variables; three divergent colormaps; one cyclic colormap; and one hybrid colormap designed for the special case of displaying oxygen saturation. The package combines original colormaps developed specifically for this work with several preexisting colormaps (Moreland, 2009; Niccoli, 2012; Brewer, 2013; Samsel et al., 2015; see Acknowledgments); we have altered these maps for perceptual uniformity using viscm. Single-hue and multi-hue colormaps are included, and each of the sequential and diverging colormaps span a wide range of lightness to maximize dynamic range in data display. The cmocean colormaps have been given names such as *thermal*, *haline*, and *ice* to help guide users to intuitive colormaps for common oceanographic variables; however, our nomenclature is not intended to restrict usage to any



# Color Maps

Thyng et al. 2016: *Oceanography* 29(3): 9-13

Used by US Glider DAC, Austrian Glider DAC, GCOOS

Available at [https://github.com/matlabplotlib/cmocean](https://github.com/matlabplotlib/cmocean)

Supported languages:

- python
- MATLAB
- ODV (Ocean Data View)
- GMT (Generic Mapping Tools)

# Acknowledgements

Private/Public Partnerships