NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Enabling NOAA's Mission with Glider Technology

Office of Oceanic and Atmospheric Research (OAR)










David M. Legler

(with input from Derrick Snowden (NOS/IOOS), Becky Baltes (NOS/IOOS), Gustavo Goni (OAR/AOML) Chris Meinig (OAR/PMEL), and Chris Beaverton (OAR/OER)

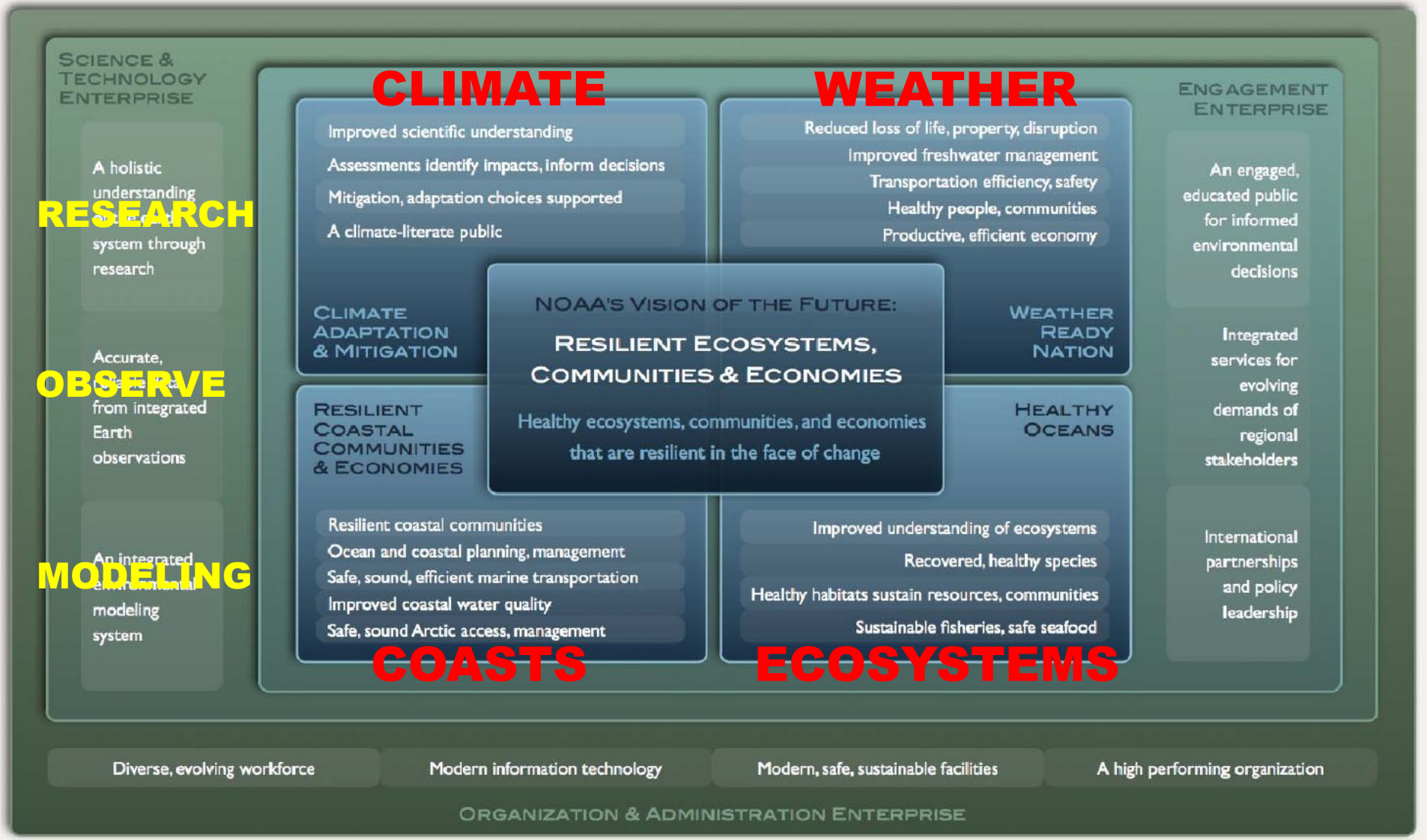
Director, Ocean Observing and Monitoring Division

Climate Program Office | OAR

January 18, 2017

NOAA's Mission:
Science, Service & Stewardship

To understand and predict changes in climate, weather, oceans, and coasts,
To share that knowledge and information with others, and
To conserve and manage coastal and marine ecosystems and resources



Role of Underwater Gliders in Meeting NOAA's Mission Goals

WEATHER READY NATION

1. Environmental Modeling Prediction
2. Hurricane/ Tropical Storms

HEALTHY OCEANS

1. Ecosystem Monitoring, Assessment & Forecast
2. Fisheries Monitoring, Assessment & Forecast
3. Habitat Monitoring & Assessment
4. Protected Species Monitoring
5. Science, Services and Stewardship

RESILIENT COASTS

1. Coastal Water Quality
2. Planning and Management

CLIMATE

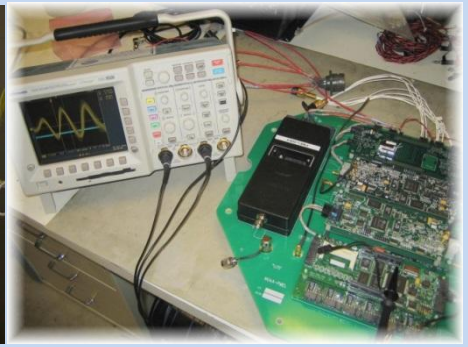
1. Climate Science and Improved Understanding
2. Ocean monitoring

Glider Missions Completed:

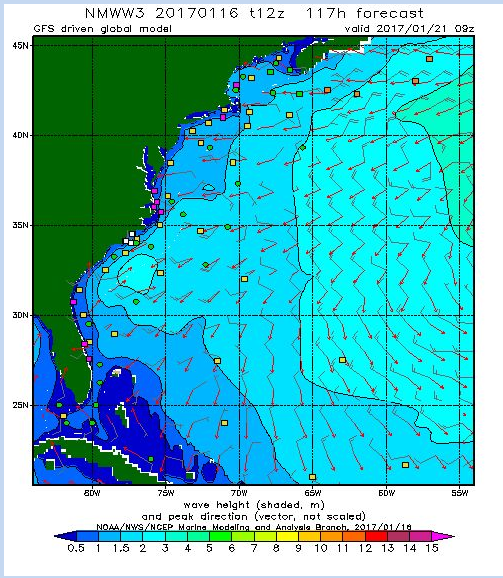
- Ecosystem dynamics monitoring
- Fish stock mapping
- Harmful Algal Bloom (HAB) mapping
- Hydrographic mapping
- Ocean acidification sampling
- Climate monitoring
- Listening to tagged fish, whale acoustics
- Sustained and targeted ocean observations for improving tropical cyclone intensity and hurricane seasonal forecasts
- Oil spill response and restoration

What is NOAA's role in the glider enterprise?

NOAA is a developer of glider technology



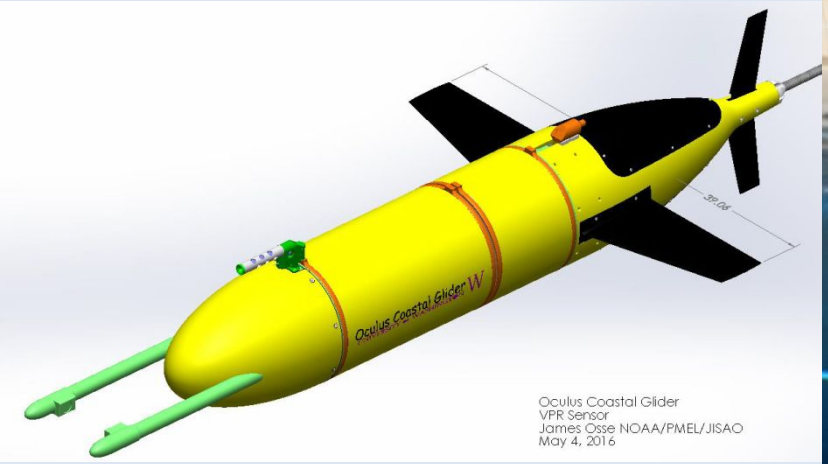
NOAA is an operator and sponsor of gliders

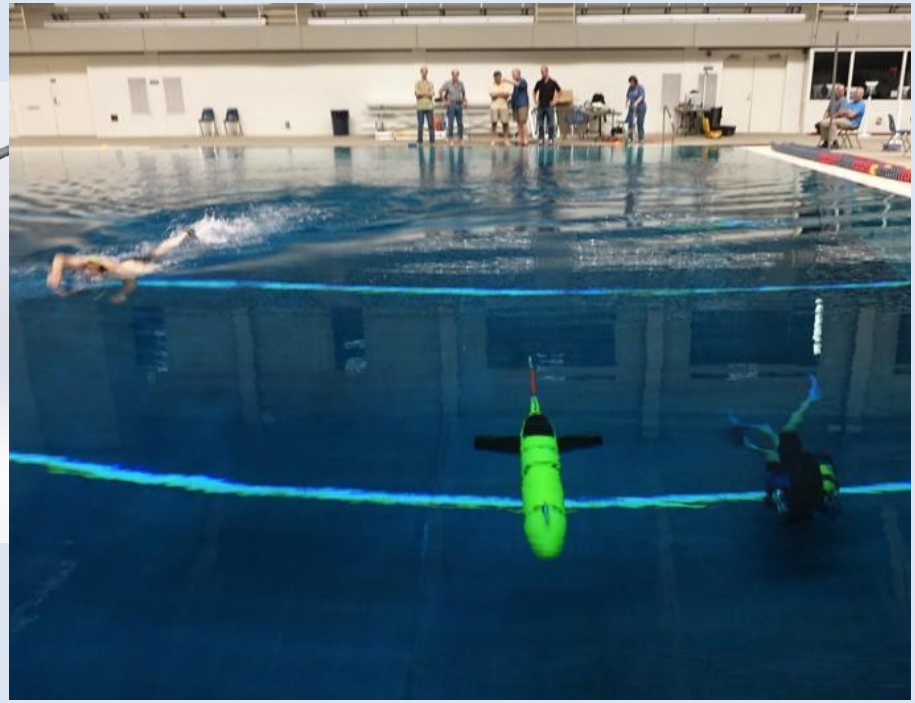


NOAA is a consumer of glider information

Oculus Coastal Glider

- Catered to the shallow depths of the Arctic
- Uses a rapid buoyancy system - can change speed and angle faster that any other glider on the market - allowing for a more efficient and adaptive Arctic survey, but transferable to a variety of markets
- Field testing (Seattle, WA) in fall 2016 and field mission in 2017 (US Arctic)



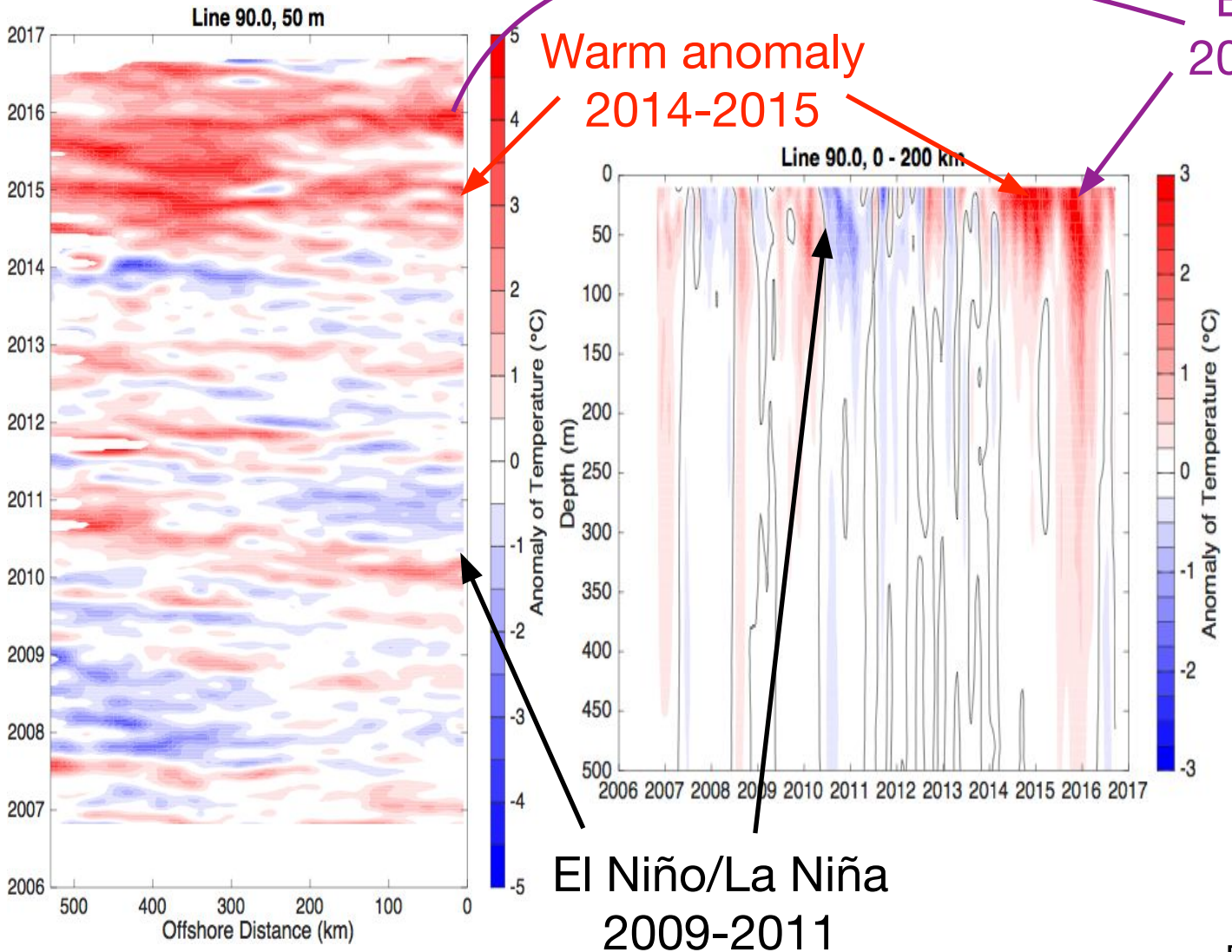


A video plankton recorder is being incorporated into this platform

Network

The SoCal Temperature Index, temperature anomaly at 50 m on line 90, averaged over the inshore 200 km, and filtered with a 3-month running mean (red), and the Oceanic Niño Index, Niño 3.4 filtered with a 3-month running mean (black). Note the strong correlation until the anomalous warming starting near the beginning of 2014. (Dan Rudnick, SIO)

Interannual Anomaly of Temperature

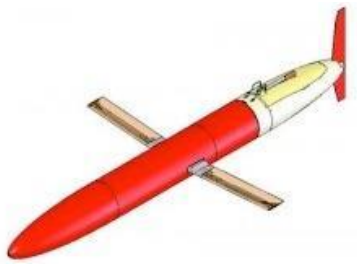


Warm anomaly 2014-2015

El Niño 2015-2016

El Niño/La Niña 2009-2011

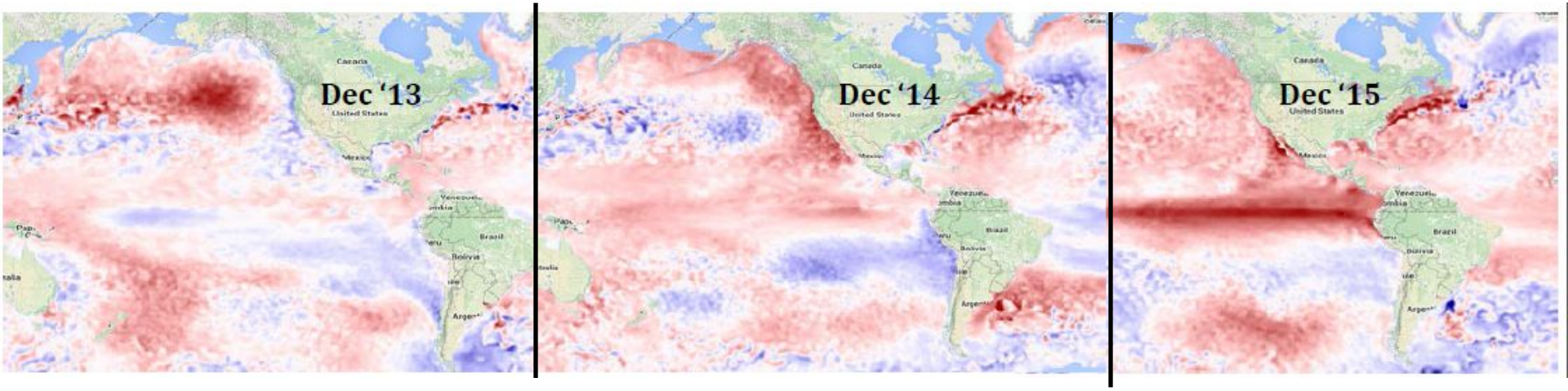
Climate events of last decade



Dan Rudnick, SIO

Pacific Anomalies Workshop 2 Report

Summary and Recommendations of the
Second Pacific Anomalies Science and Technology Workshop
University of Washington, Seattle, WA
January 2016



"In the Southern California Current System (SCCS), anomalous surface warming started at the beginning of 2014, and with the onset of El Niño conditions in 2015, this surface warming extended into the subsurface."

Newton, J.A., M. Jimenez Urias, L. Li, L. Li, K. O'Brien Beaumont, A. Shao, and H.B. Stone. 2016

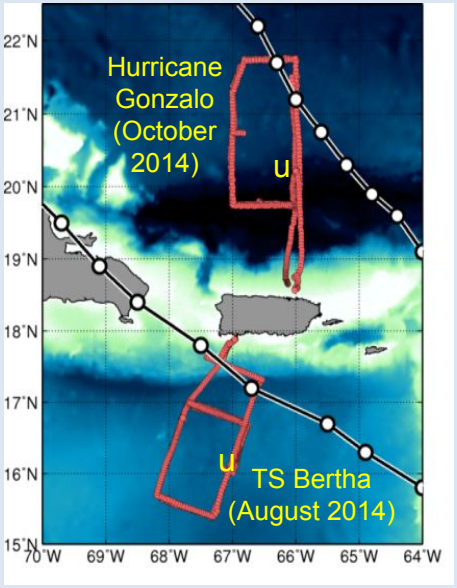
http://www.nanoos.org/resources/anomalies_workshop/workshop2.php

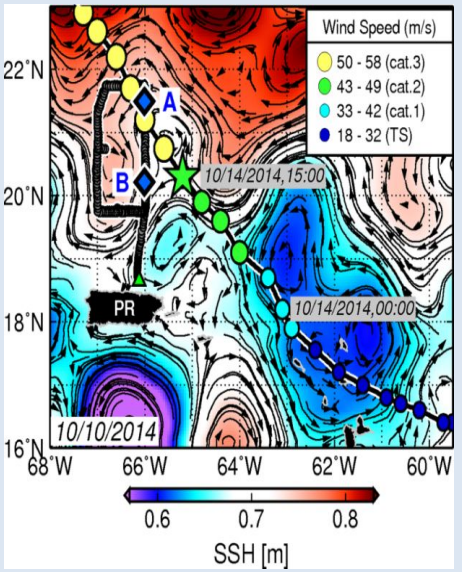
NOAA Underwater Gliders - Underwater Glider Observations in the Caribbean Sea and Tropical North Atlantic Ocean in Support of Tropical Cyclone Studies (AOML/CariCOOS)

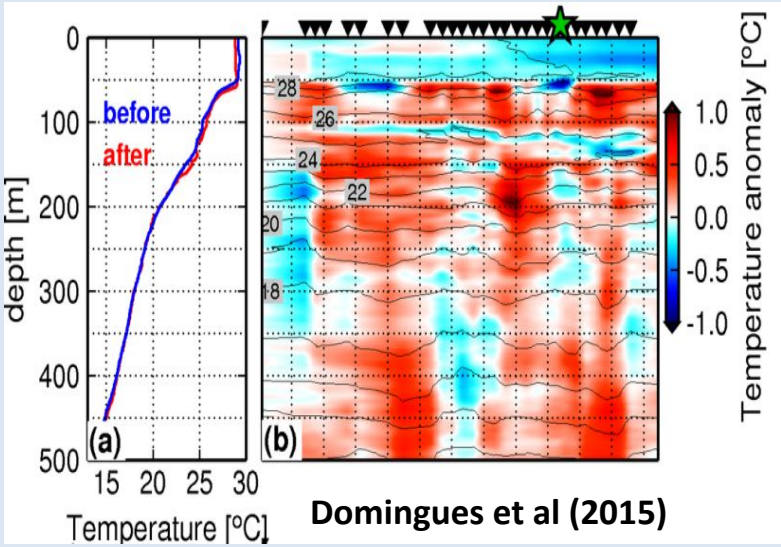
- Successful operations under hurricane force winds
- Unique time series
- Glider observations provides ocean initial conditions for models
- All data transmitted into the GTS (real-time) to be assimilated by operational forecast models, and submitted to the IOOS Glider DAC (delayed-mode)

Domingues et al., (2015), Goni et al. (2015)

Hurricane models overestimated upper ocean cooling; salinity effects were absent







Domingues et al (2015)

Harmful Algal Blooms

LIMNOLOGY and OCEANOGRAPHY

ASLO

Limnol. Oceanogr. 60, 2015, 754–764
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doi: 10.1002/lno.10052

Subsurface seeding of surface harmful algal blooms observed through the integration of autonomous gliders, moored environmental sample processors, and satellite remote sensing in southern California

Bridget N. Seegers,[*1] James M. Birch,[2] Roman Marin III,[2] Chris A. Scholin,[2] David A. Caron,[1] Erica L. Seubert,[1] Meredith D. A. Howard,[3] George L. Robertson,[4] Burton H. Jones[1,5]

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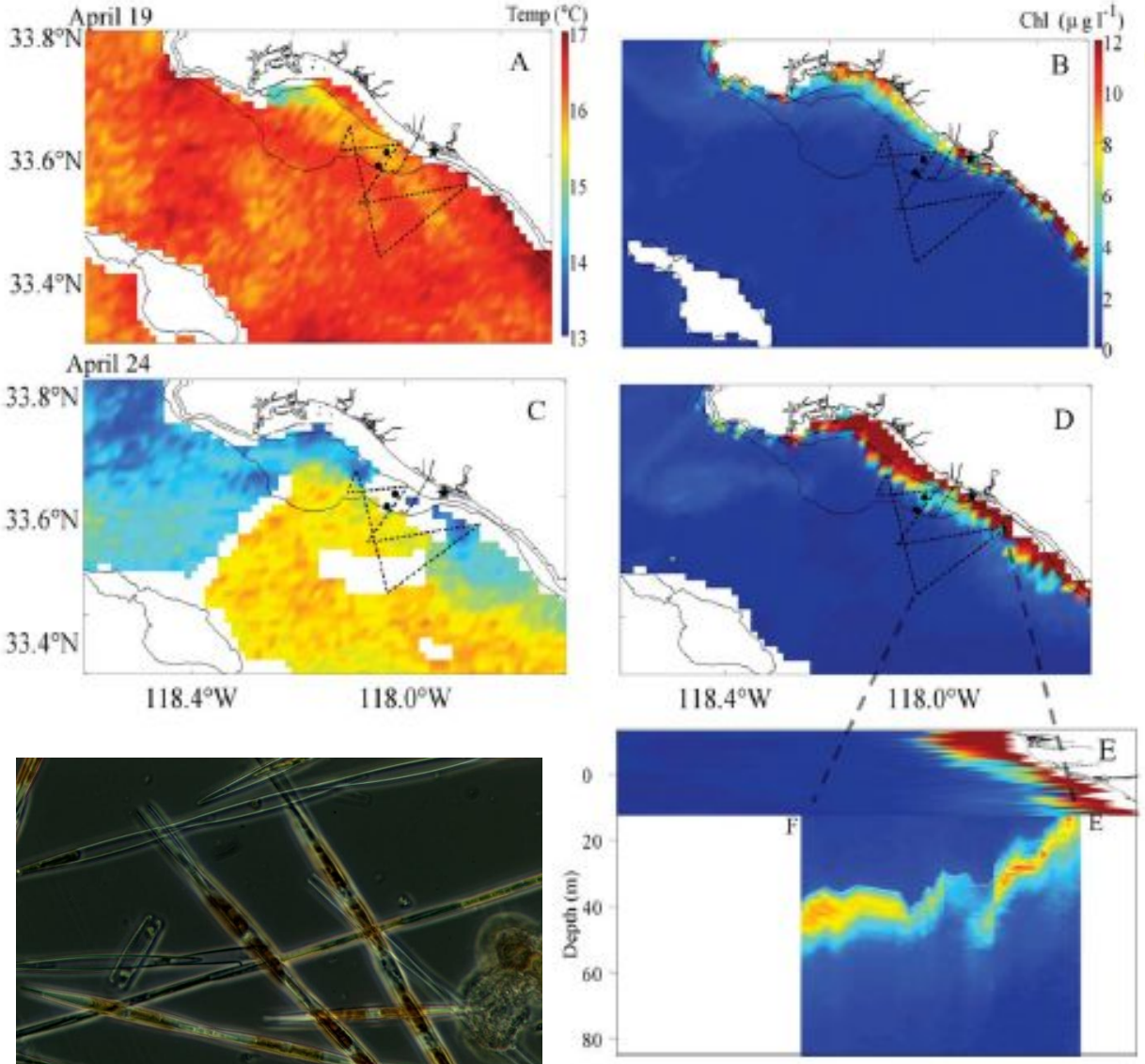
[2]Monterey Bay Aquarium Research Institute (MBARI), Moss Landing, California
[3]Biogeochemistry Department, Southern California Coastal Water Research Project, Costa Mesa, California
[4]Ocean Monitoring Program, Orange Country Sanitation District, Fountain Valley, California
[5]Red Sea Research Center, King Abdullah University of Science and Technology, Thuwal, Kingdom of Saudi Arabia



MODIS images of SST (A, C) and chl a (D, E) from San Pedro Bay for 19 April and 24 April. The glider track and the OCSD outfall are indicated by dashed black lines, black dots indicate ESP mooring locations and the Newport Pier is indicated by the star symbol. Panel E shows the MODIS chlorophyll image overlaid three-dimensionally on the southernmost glider transect, line E–F, from 27 April.

Blooms can develop offshore and subsurface prior to their manifestation in the surface layer and/or near the coast.

Seegers et al, 2015

Fish Tracking

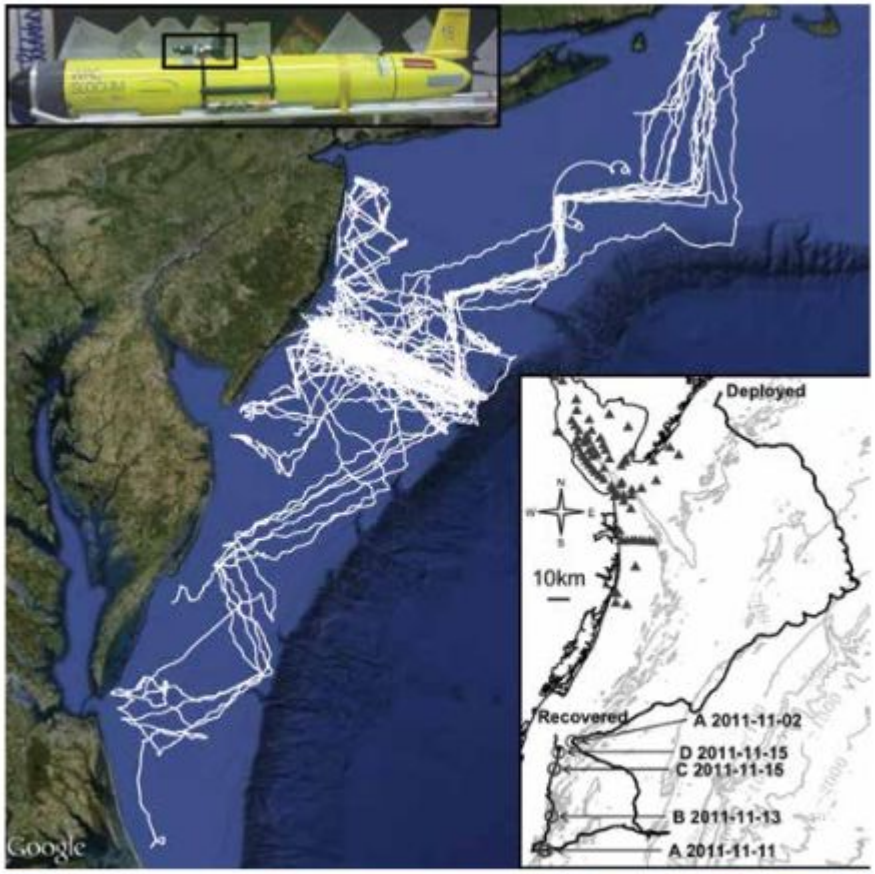


Figure 1. Tracks of the 71 Slocum glider missions between 2005 and 2011 (white lines) show the potential to develop mobile listening assets in the Mid-Atlantic. A VMT was attached to the dorsal side of a Slocum glider (upper inset) and deployed for 1 month. Telemetered Atlantic Sturgeon were detected in nearshore coastal waters along the Delmarva Peninsula (lower inset). Triangles represent the location of ACT hydrophones during the glider deployment.

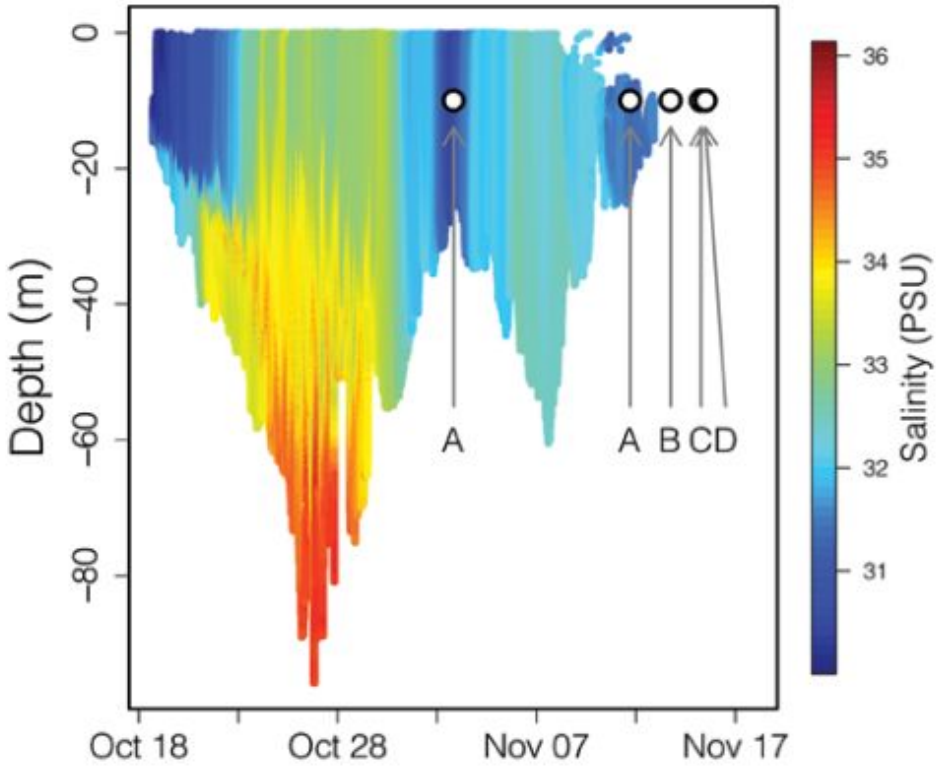
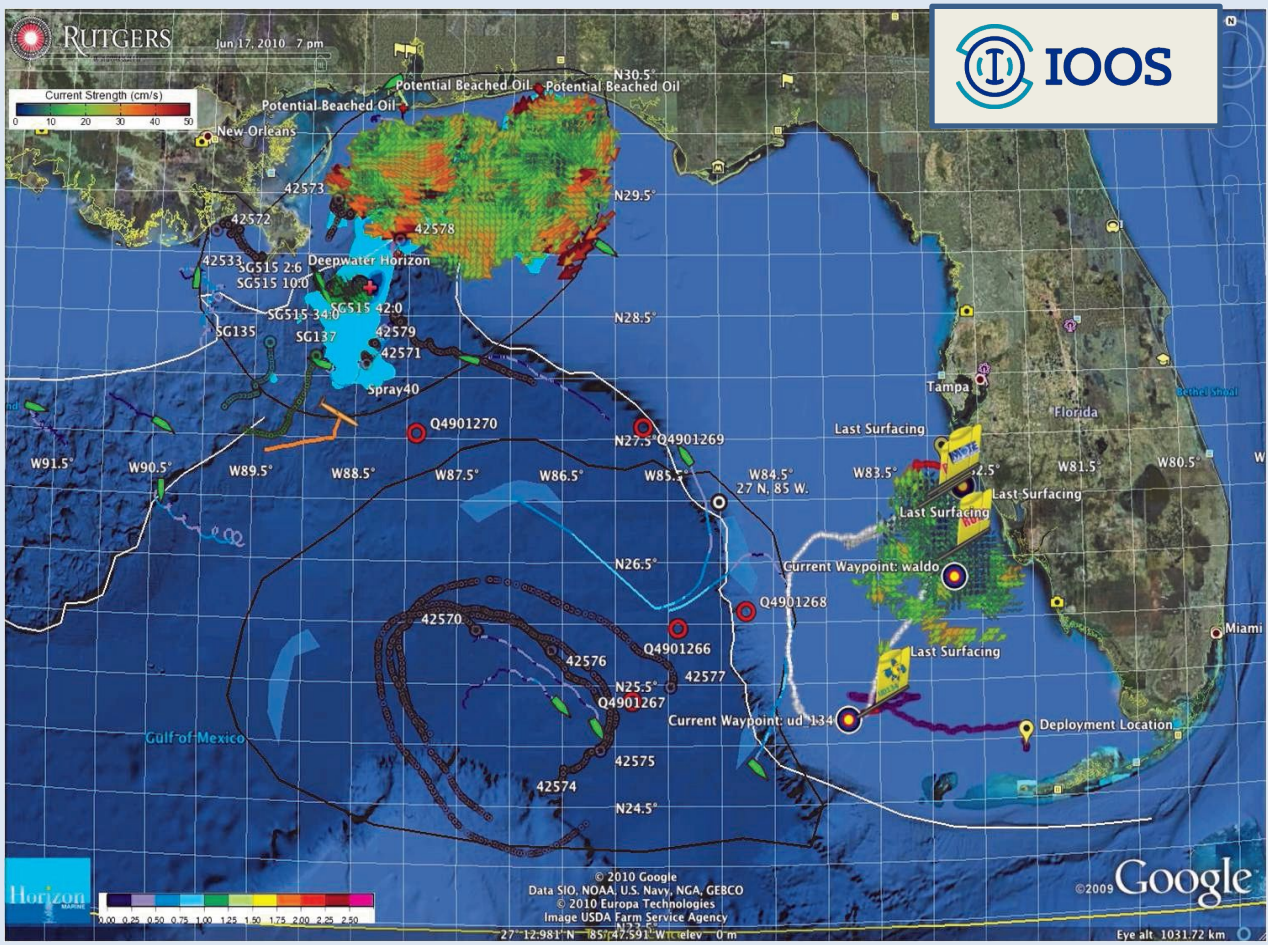


Figure 2. In situ salinity profiles from the glider show that Atlantic Sturgeon detections occurred in fresher, well-mixed coastal water.

"Therefore, AUVs can be used in a dynamic seascape to explore the relationship between Atlantic Sturgeon and the specific water masses they encounter." (M. J. Oliver et al., 2013, Fisheries)

U.S. IOOS Underwater Gliders - Part of a coordinated support effort during Deep Water Horizon

- 7 gliders w/ sensors to indicate presence of oil in water column
- IOOS RAs (Mid-Atlantic, Gulf Coast, S. California, Southeast) offered gliders
- Narrowed search zone and answered questions about potential oil movement
- Measured add'l variables for use in ocean models for emergency response teams
- DWH was first U.S. oil spill to apply this technology



IOOS | Integrated Ocean Observing System

IOOS: Glider Program

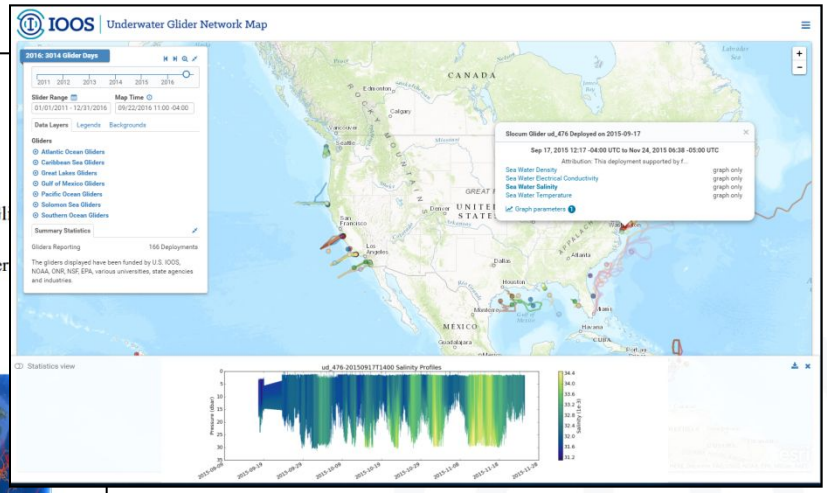
- Regional Associations provide glider observations and presence
- In 2013 Established a National Glider Data Assembly Center (NGDAC)
- In 2014 Released a Glider Network White Paper


IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

Toward a U.S. IOOS® Underwater Gl
Network Plan:
Part of a comprehensive subsurface obser
system

August 2014

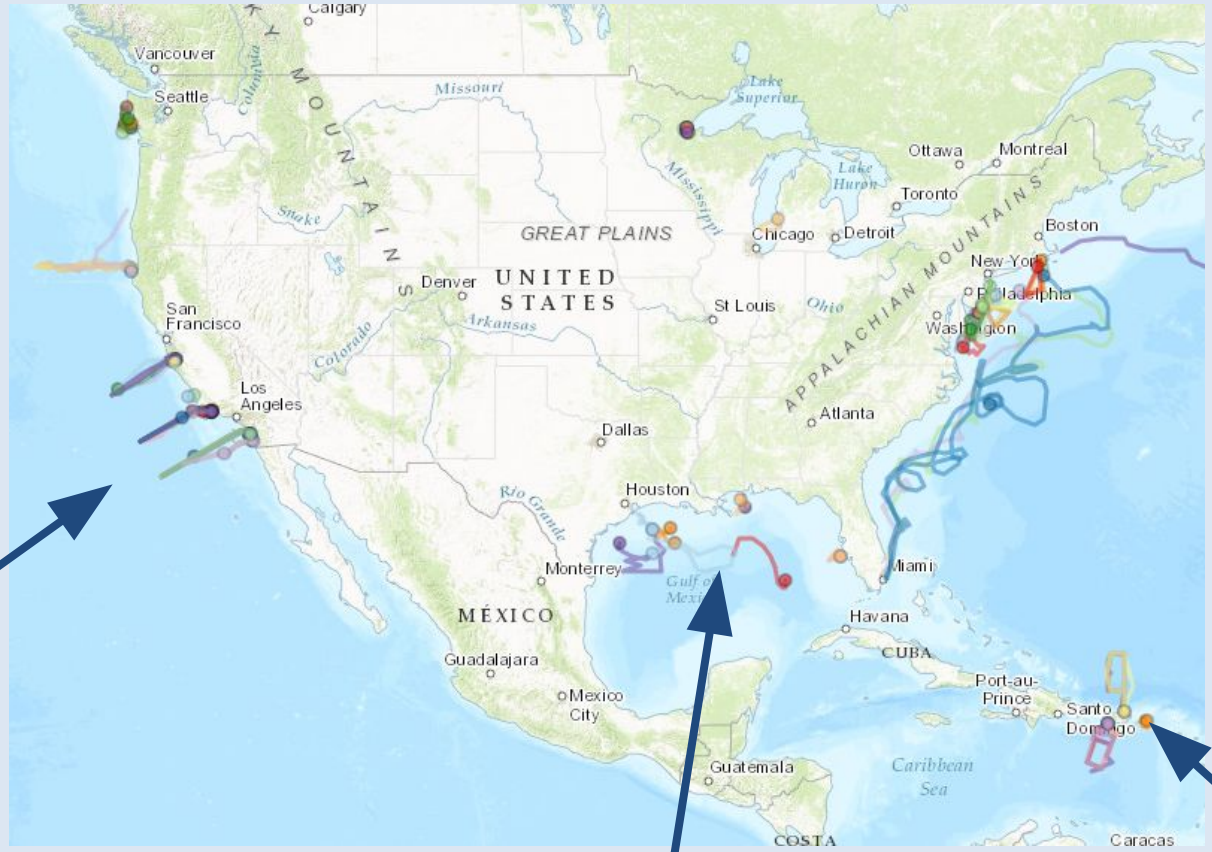
Glider tracks along the U.S. coast since 2002.



IOOS | EYES ON THE OCEAN™

NOAA Underwater Gliders – A flexible platform with an established coordination network in place

> 45000 glider days with capabilities in all 11 IOOS regional associations



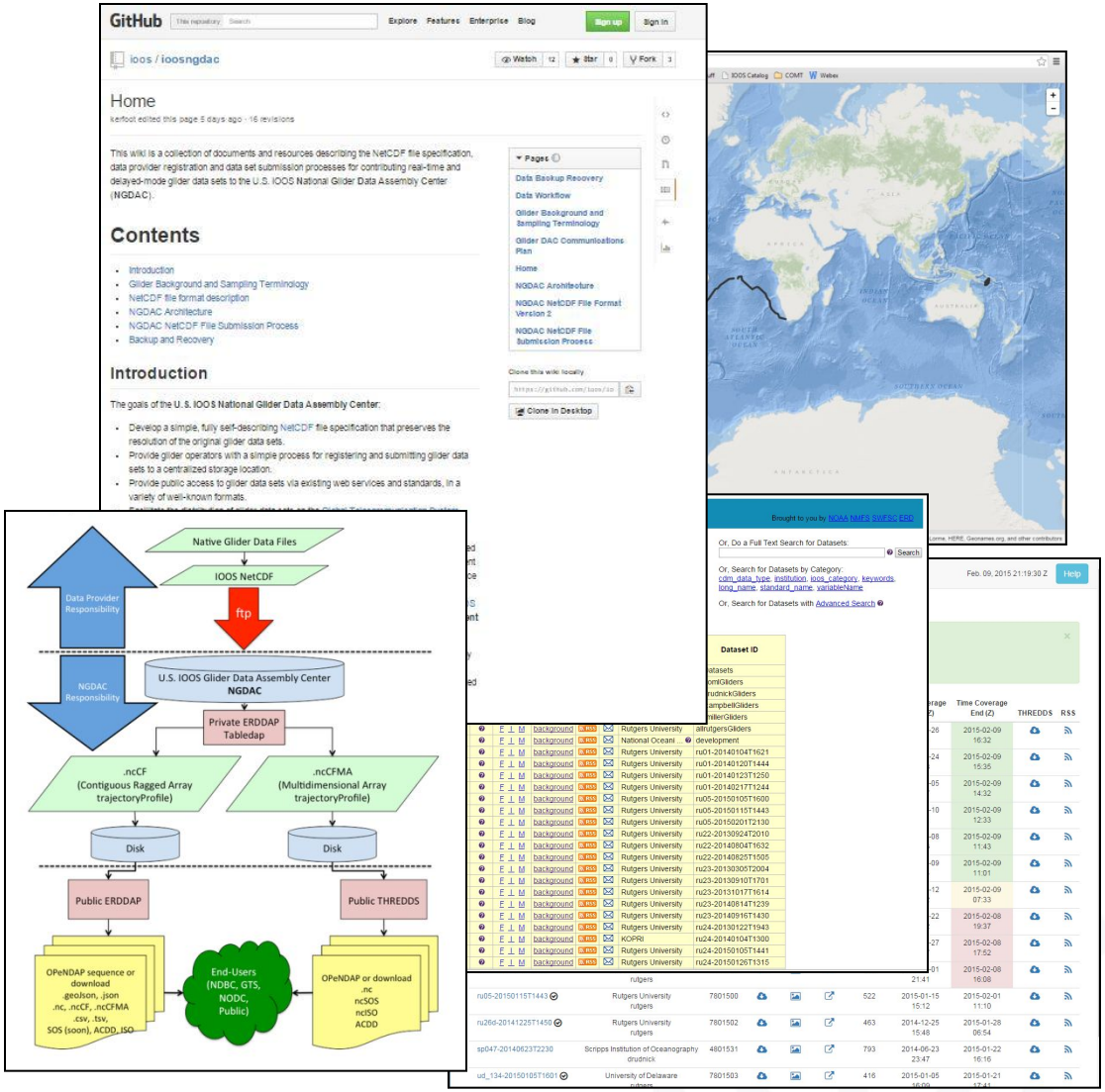
Sustained ocean and ecosystem monitoring

Fast response to crisis: Deepwater Horizon

Understanding the ocean's role in hurricane intensification

Glider DAC

- National standards to ease exchange of data from regional glider operators
- Real-time distribution to non-federal and federal partners (GTS)
- Archiving (NCEI)
- QC processing
- Share your data!



IOOS | EYES ON THE OCEAN

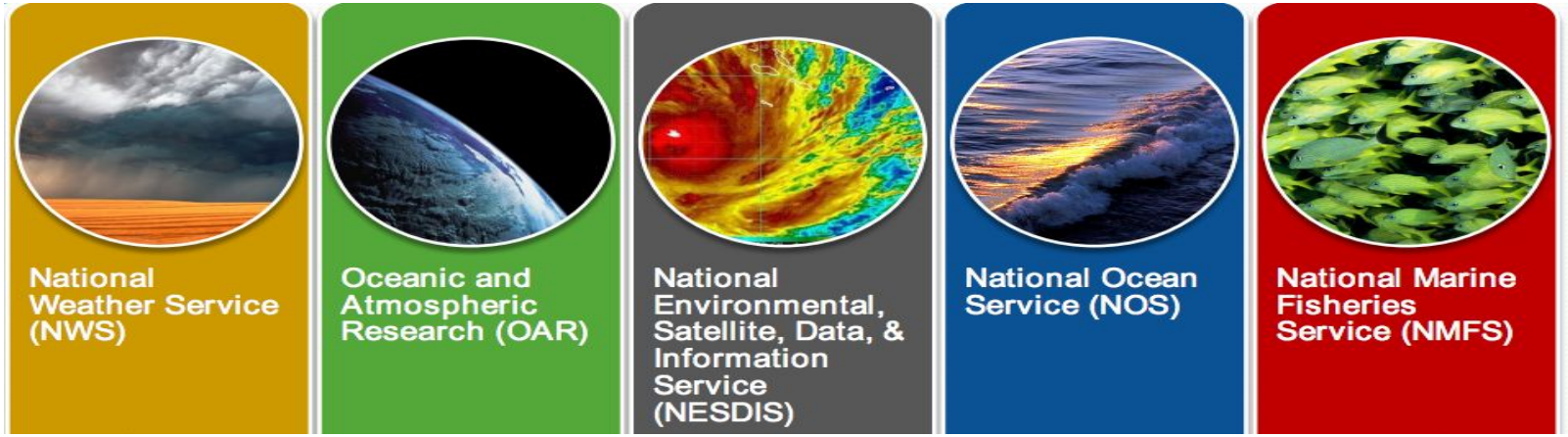
Future Activities

- NOAA will continue to assess the integration of gliders into its observing strategies, identifying the best uses of gliders to address its goals
- NOAA will increase collaboration with the national and international community to develop global standards for the assembly and exchange of data and address territorial issues (e.g. EEZs) to improve access to important regions
- NOAA will continue to develop and explore new glider technologies (e.g., sensors) and capabilities
- NOAA will continue to improve data system for gliders to enhance data access and discoverability

Many challenges and opportunities ahead…

Thank You

Capabilities linking environmental intelligence to resilience



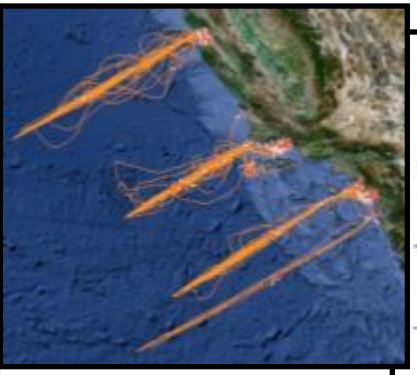
- Observing Systems, Climate Monitoring, and Data Stewardship
- Understanding and Modeling
- Predictions and Projections
- Assessments
- Informing Decisions
- Communication and Education

Research

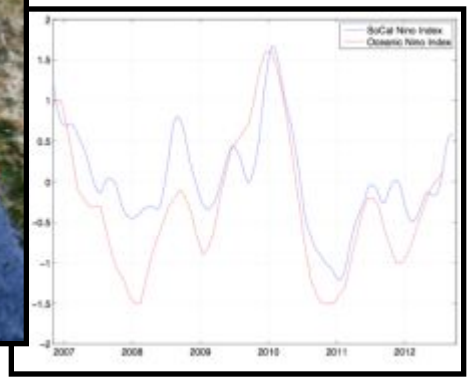
Services

Profiling Glider Missions

Climate/Ecosystem/Fisheries Management/Water Quality

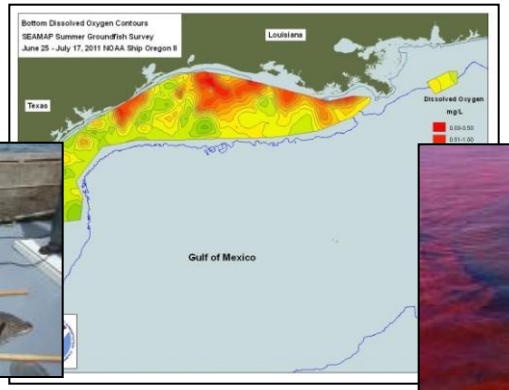


CalCOFI



SoCal Niño Index

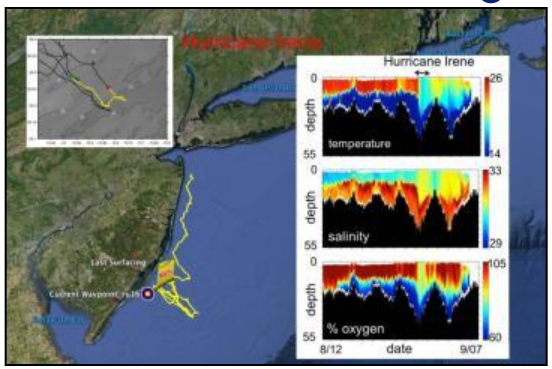
Fish Tracking



Hypoxia

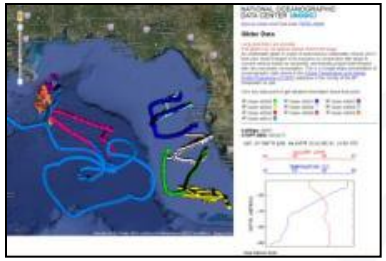
HAB

Hurricane Forecasting

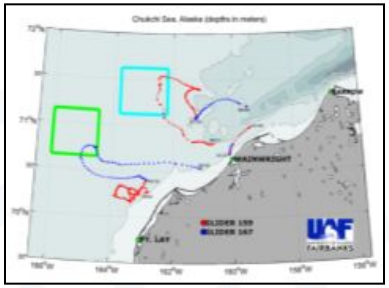


Exercising the Network

Response to Oil Spill



Deep Water Horizon



Alaska

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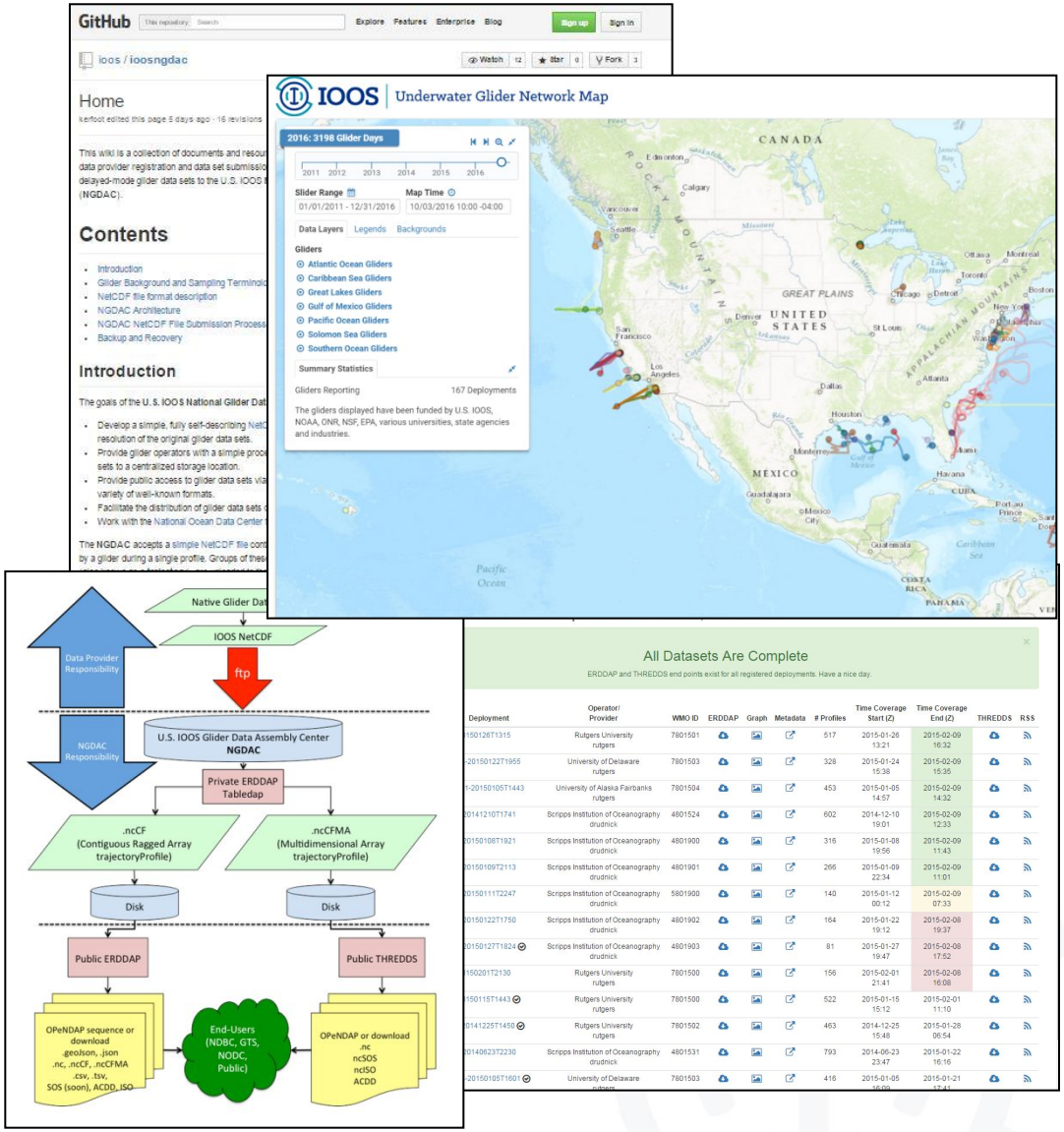
Glider DAC FY17 Outlook

- Complete initial implementation of QC using QARTOD standards
- Improve visualization. Add analysis tools for operators
- Maintain real-time distribution (GTS), access, Archive (NCEI)



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