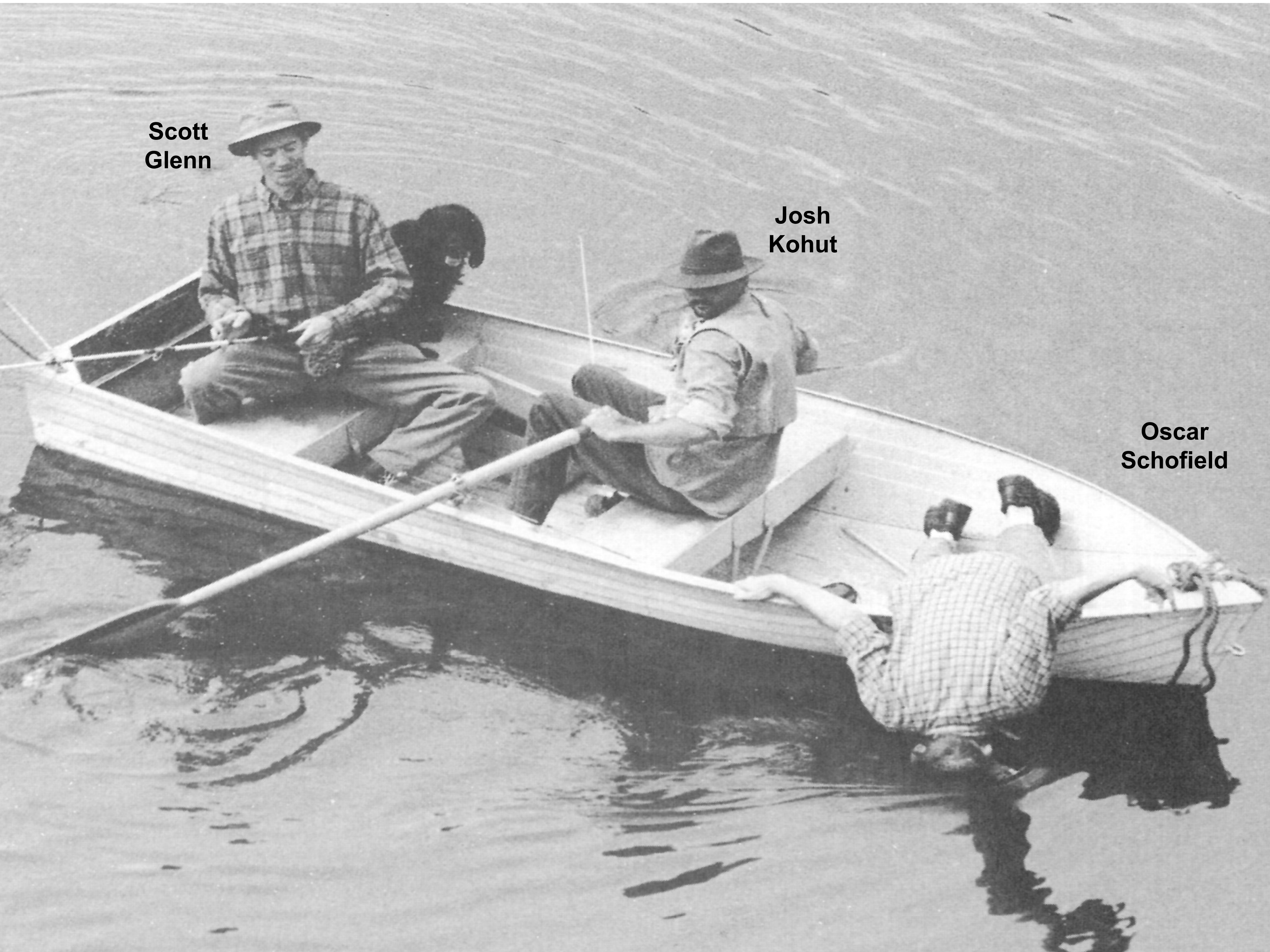
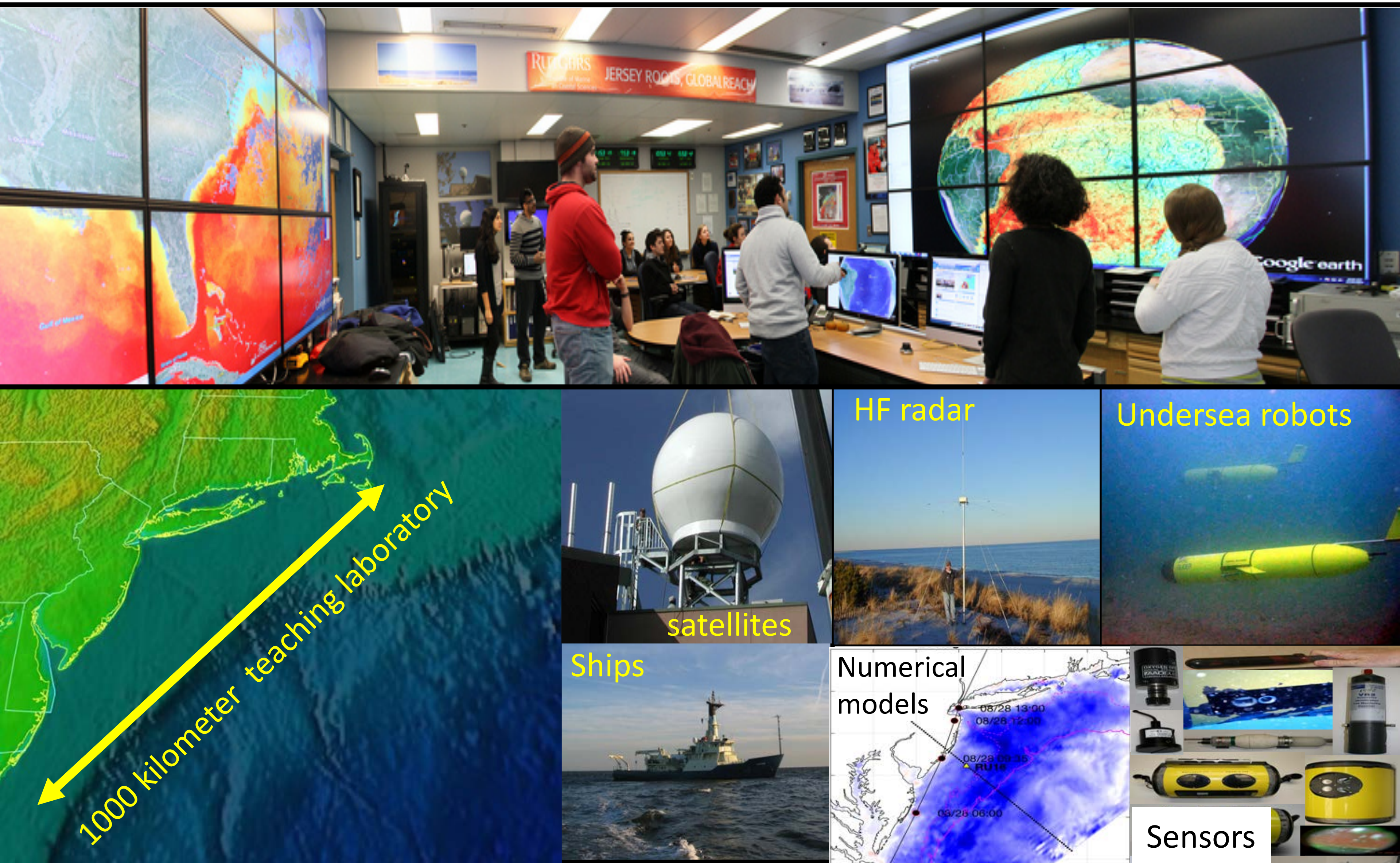
Dawn of ecosystem sampling using autonomous gliders

Oscar Schofield on behalf of many

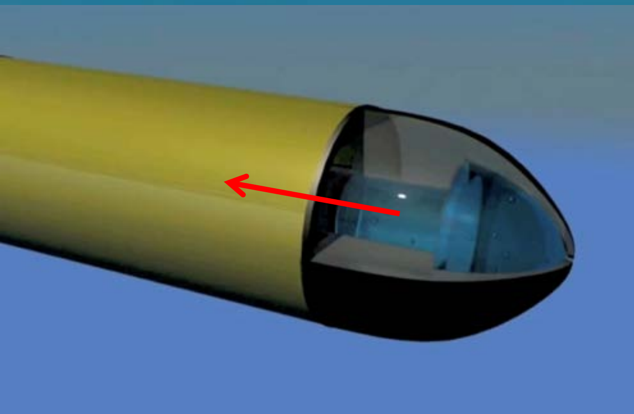

Scott
Glenn
Josh
Kohut
Oscar
Schofield

The Path Forward: 24:7 365 4-D sampling of the system, make the ocean your lab

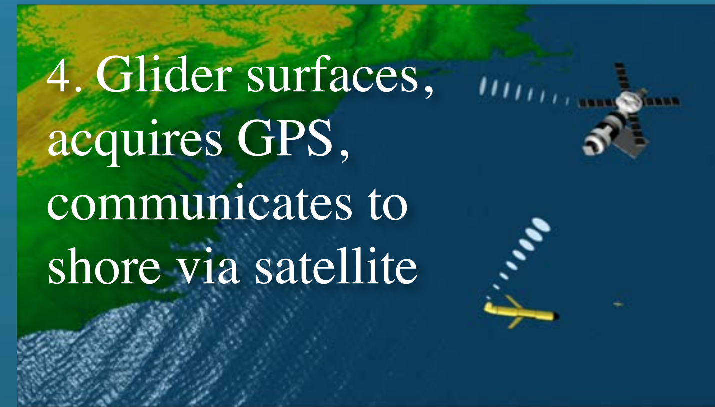
Rutgers University's Coastal Ocean Observation Lab (RU COOL)



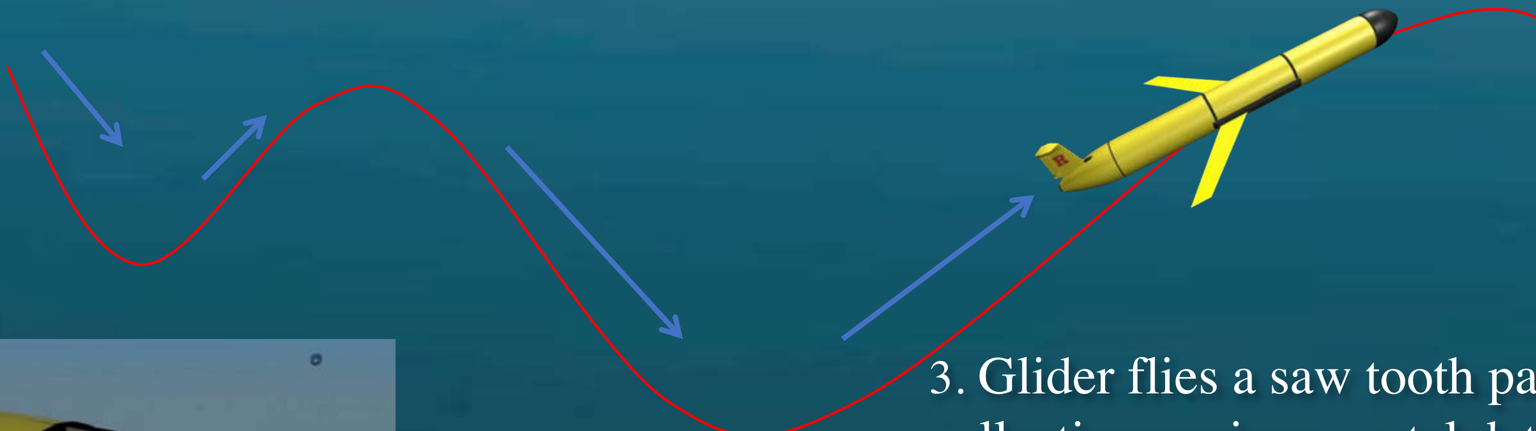
How an underwater Glider works…



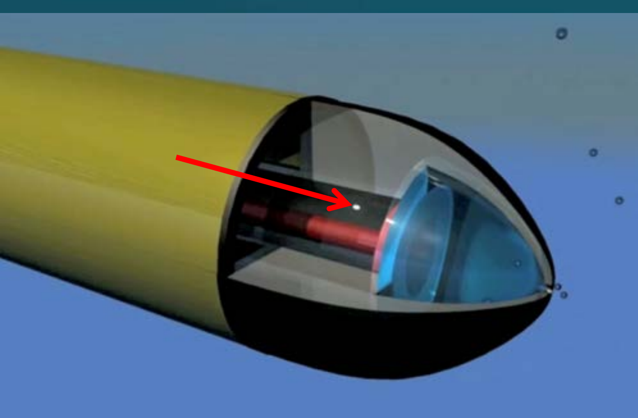
1. At surface, pump/diaphragm decreases volume, Glider descends



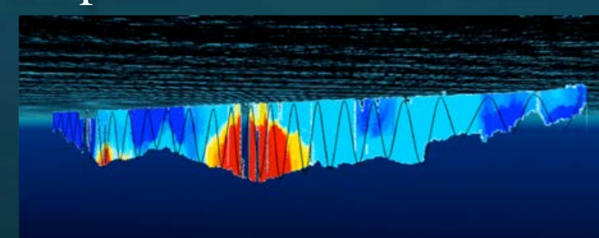
4. Glider surfaces, acquires GPS, communicates to shore via satellite



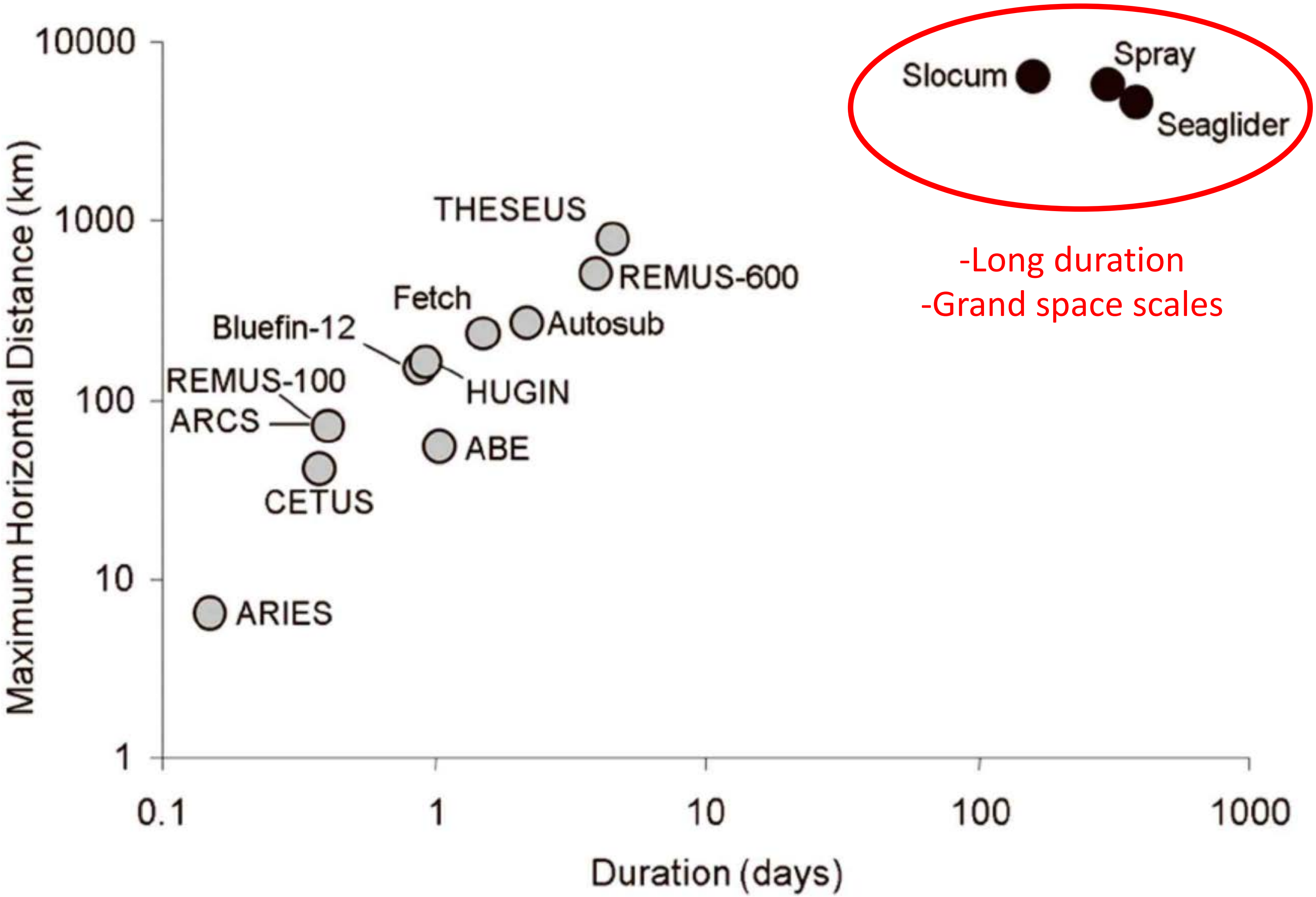
3. Glider flies a saw tooth pattern, collecting environmental data along it’s path



2. At depth pump/diaphragm increases volume, Glider ascends

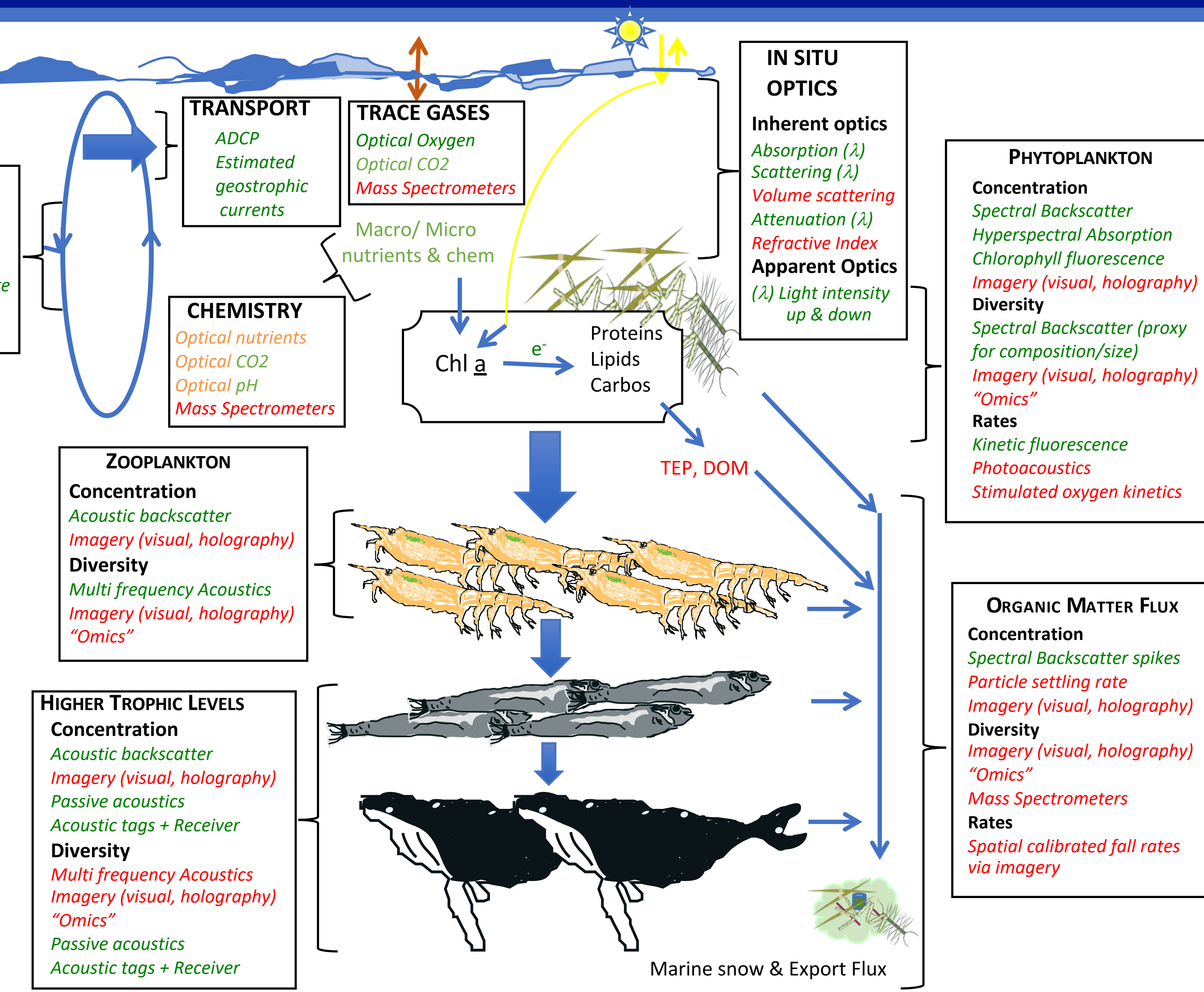


Glider's are "steerable" underwater vehicle with real-time communications that can cover great distances over long periods



Moline et al. 2009

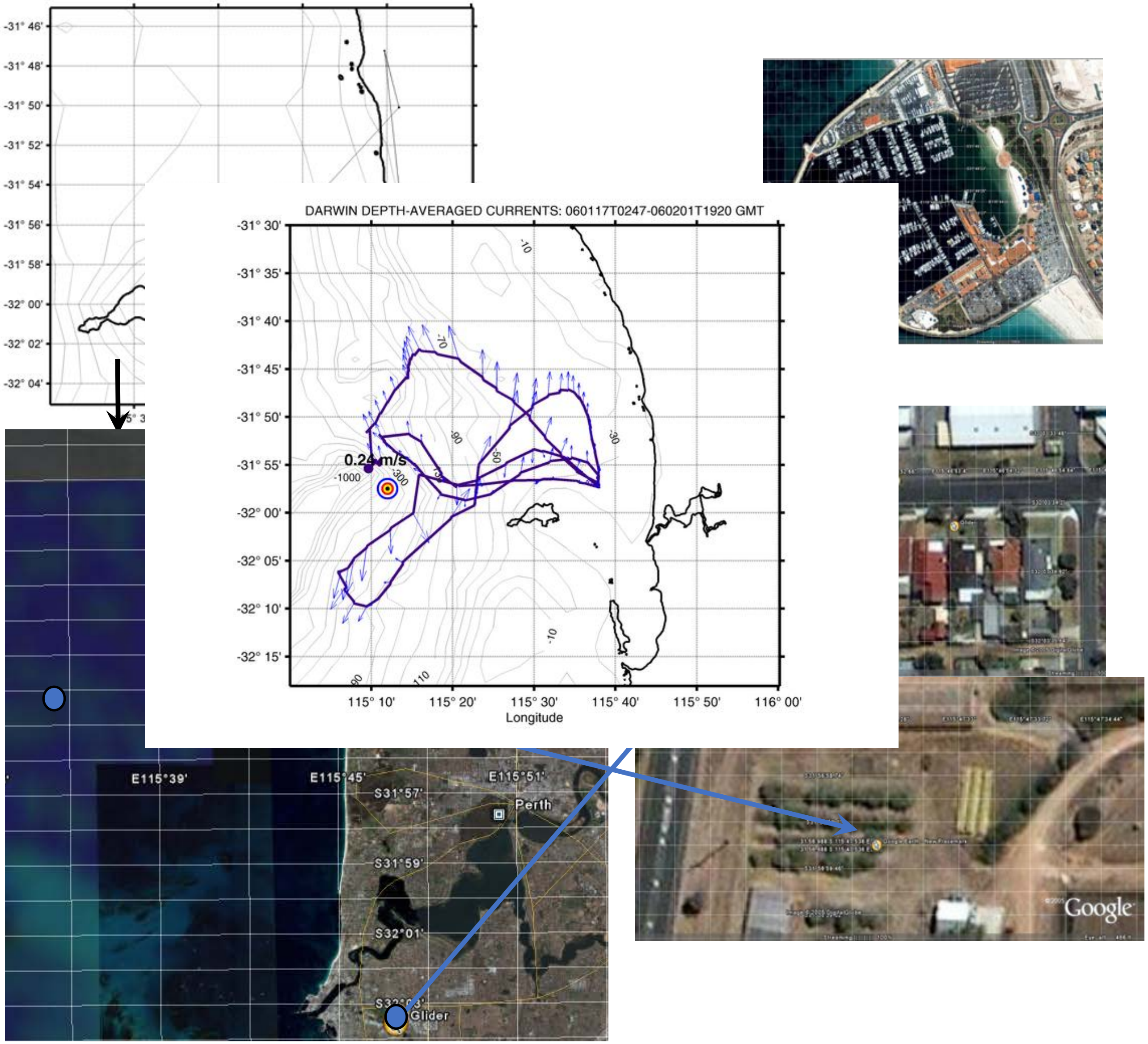
What can science data can be collected by gliders?



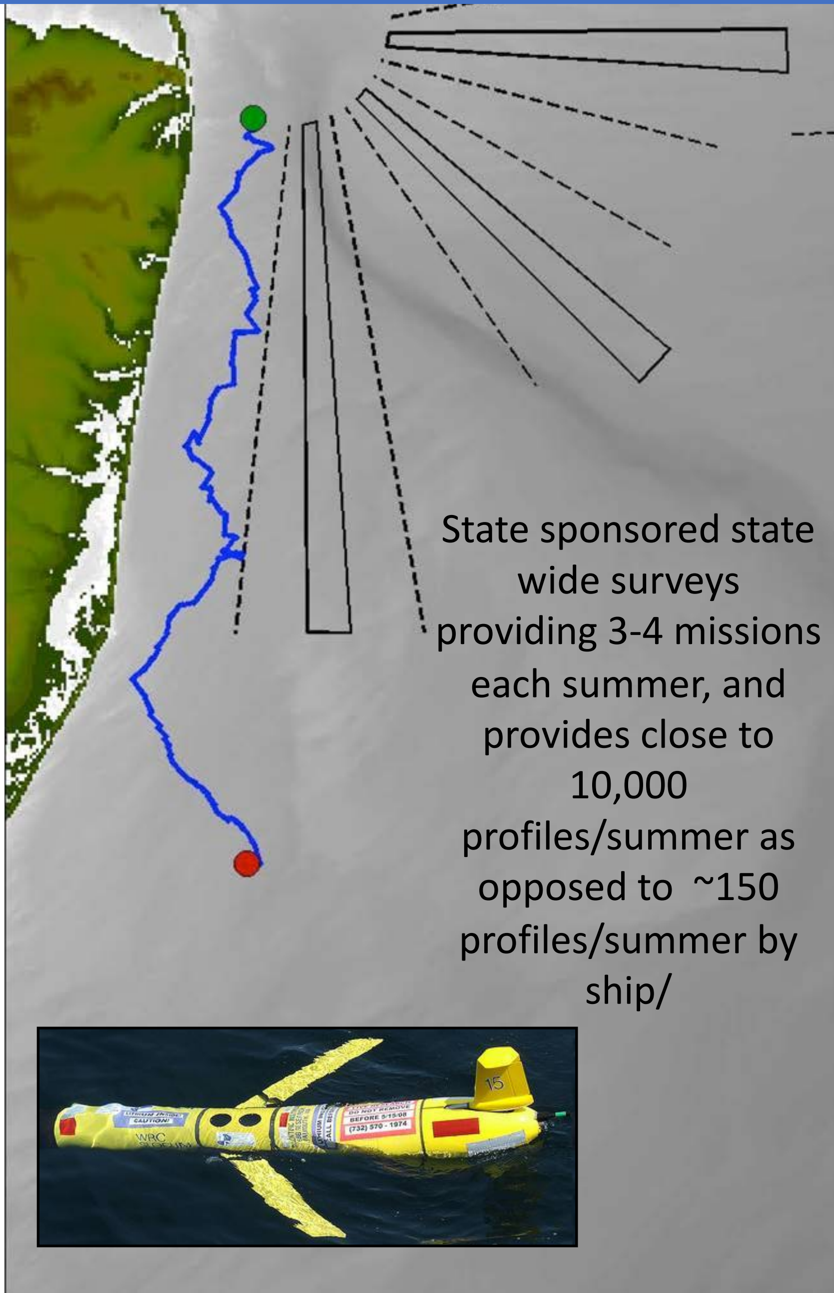
RUTGERS
Center for Ocean Observing Leadership

Schofield et al. MTS 2015

Darwin's Odyssey

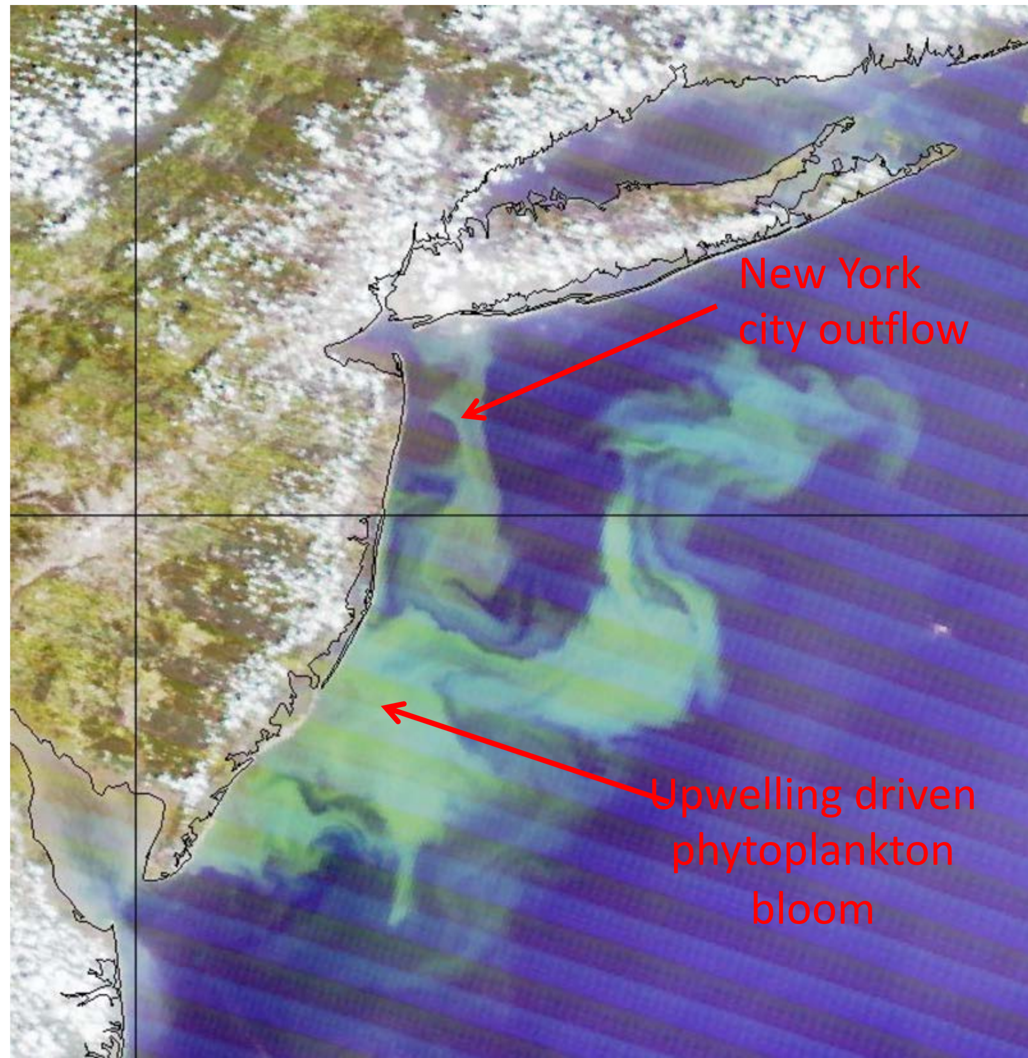


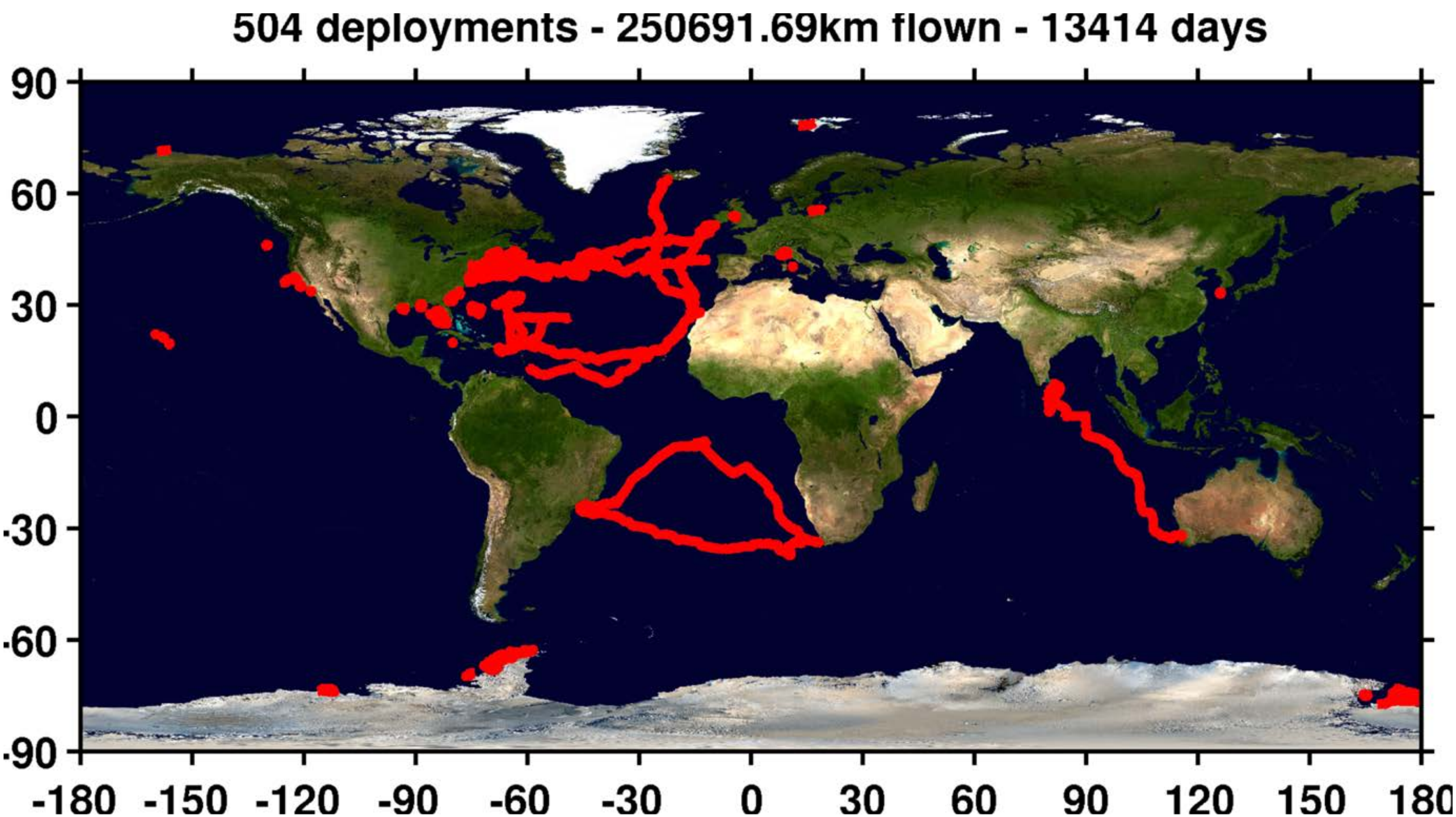
Ability to link phytoplankton to watercolumn biogeochemistry



State sponsored state wide surveys providing 3-4 missions each summer, and provides close to 10,000 profiles/summer as opposed to ~150 profiles/summer by ship/

State of New Jersey is now using gliders to map summer water quality. Is low bottom water oxygen due to outflows from the New York city or is a naturally driven by natural dynamics.



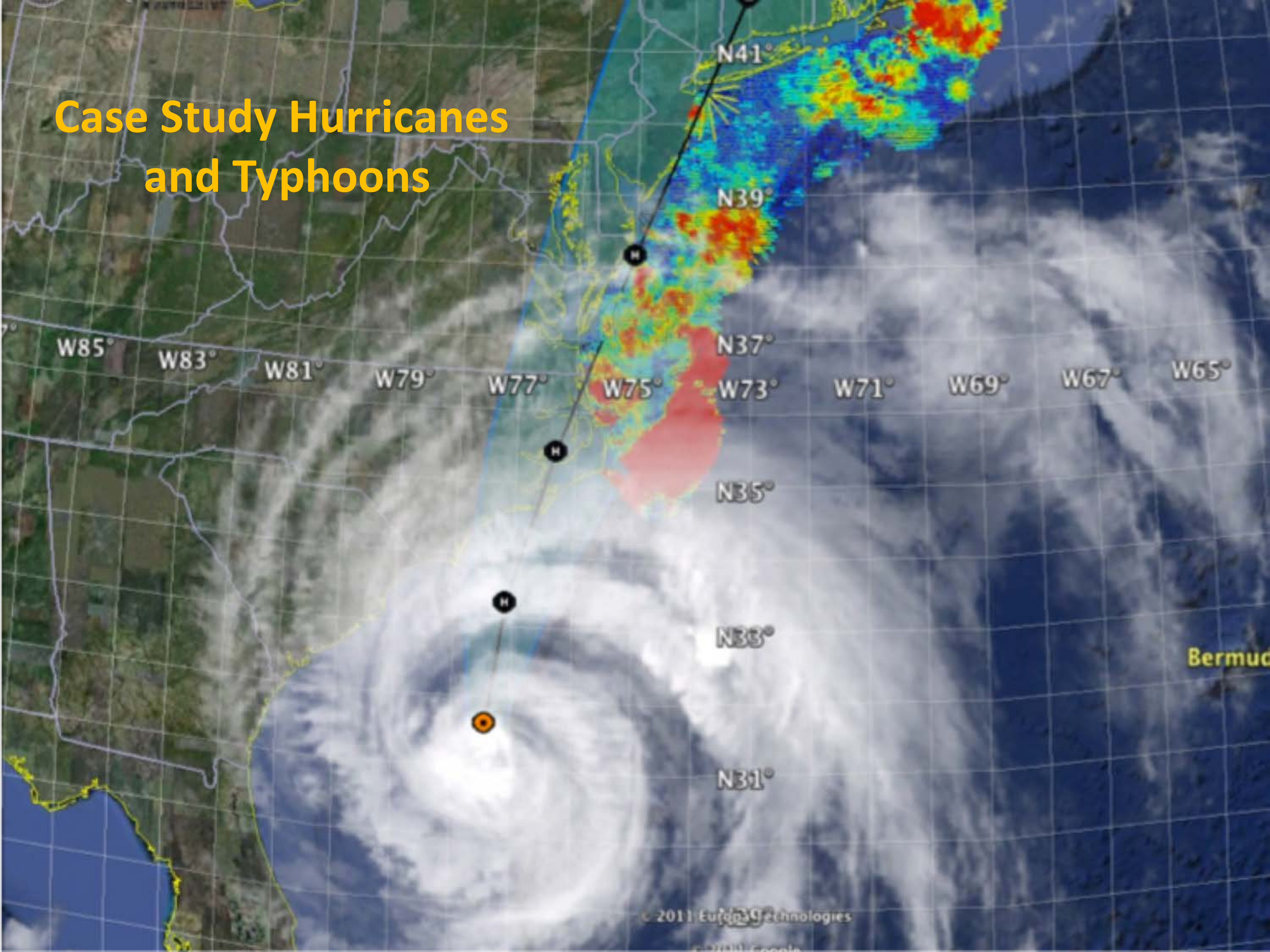


Since 2003

Represents 36 years at sea

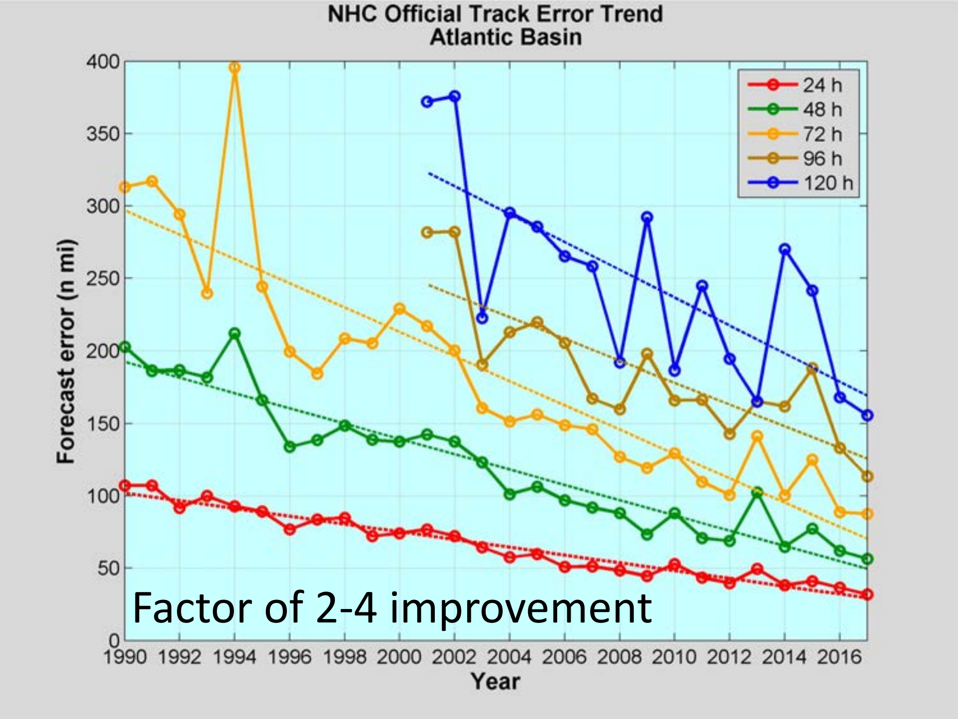
6 times around the planet

Case Study Hurricanes and Typhoons

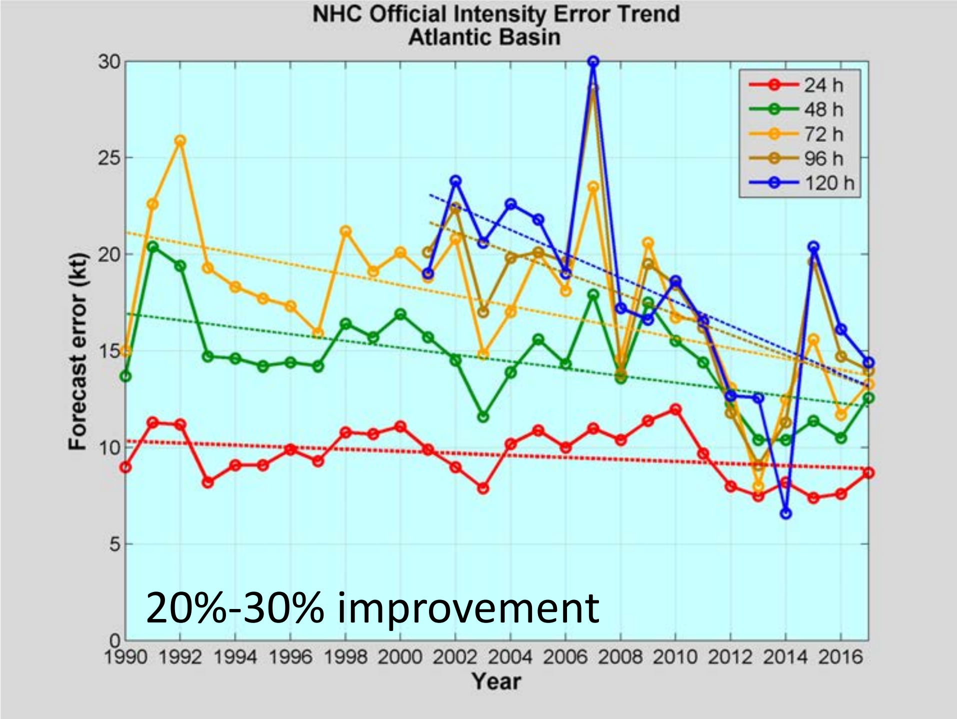


NOAA Annual Operational Suite Review

Average Track Errors: Atlantic Basin



Average Intensity Errors: Atlantic Basin



Evacuate vs **Shelter-In-Place** decisions are often made 3-5 days ahead based on the forecast intensity at landfall

Close the gap from both sides: forecasting and response

Tropical Cyclone Heat Potential - Rapid Intensification Proxy

But published research shows …

Irene & Sandy $87 B

Glenn et al., 2016 Nature Comms

Seroka et al., 2016 MWR

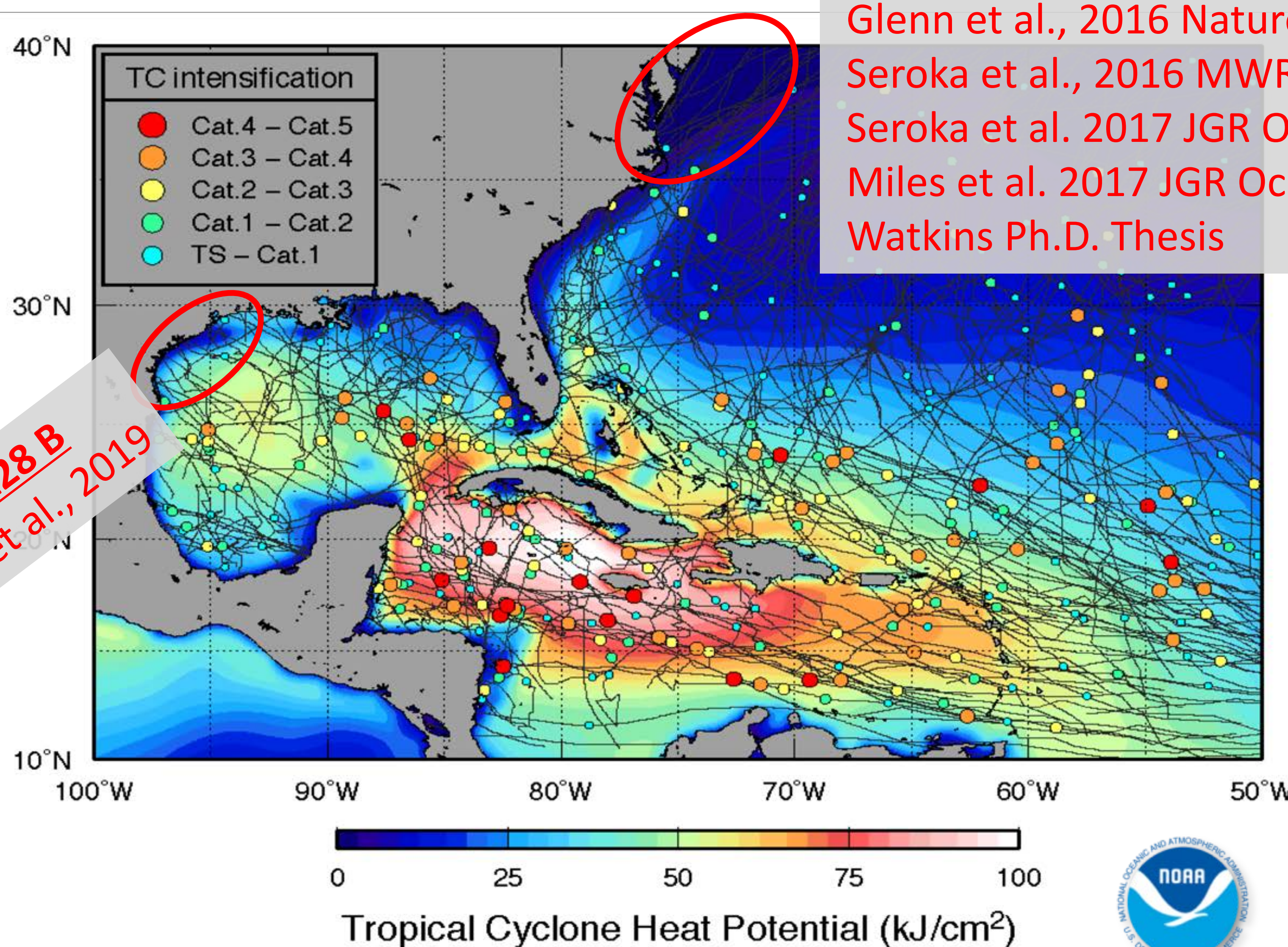
Seroka et al. 2017 JGR Oceans

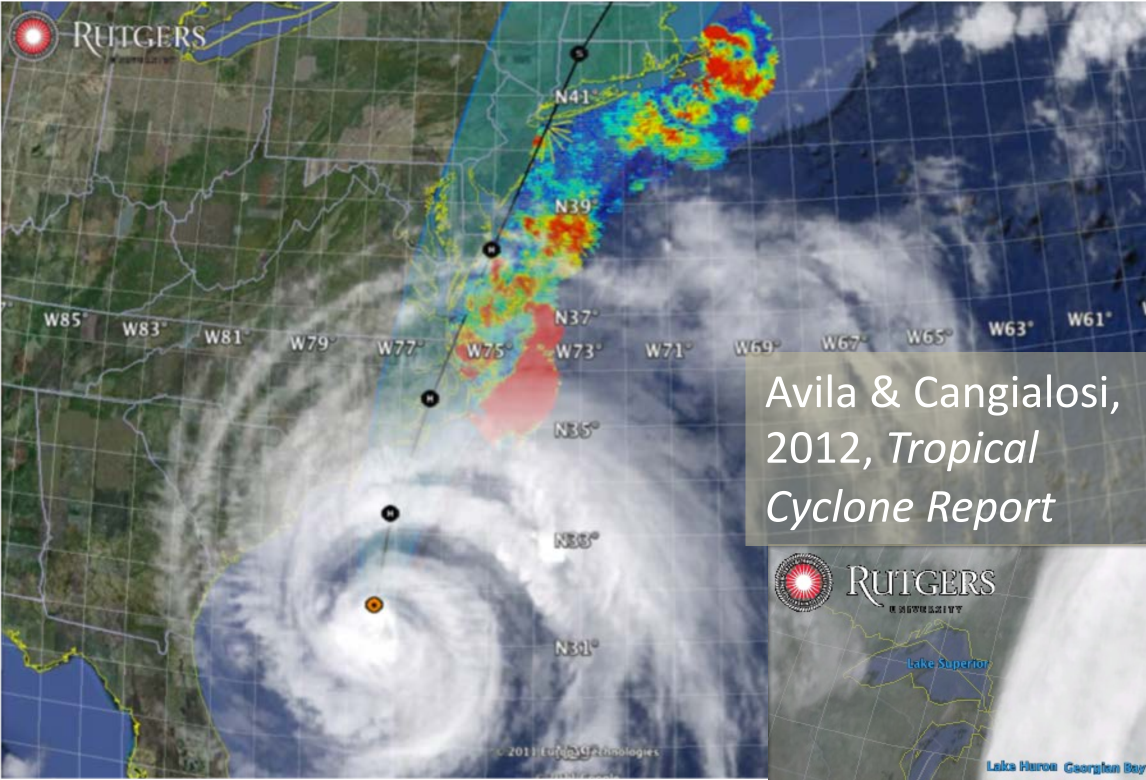
Miles et al. 2017 JGR Oceans

Watkins Ph.D. Thesis

Harvey $128 B

Potter et al., 2019



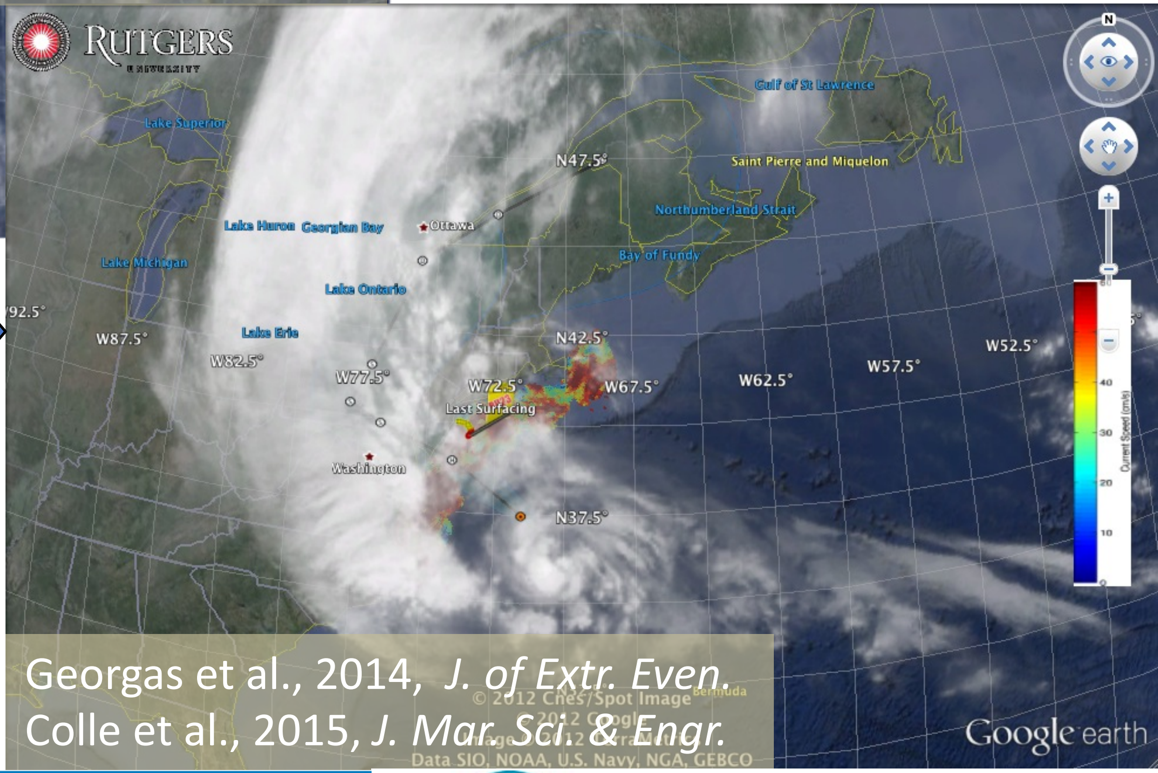


Avila & Cangialosi, 2012, *Tropical Cyclone Report*

Hurricane Irene
August 28, 2011

NOAA/NHC Damage:
>$15 Billion, #15.

Track Accurate;
Intensity Over-predicted.



Georgas et al., 2014, *J. of Extr. Even.*
Colle et al., 2015, *J. Mar. Sci. & Engr.*

Hurricane Sandy
October 29, 2012

NOAA/NHC Damage:
>$72 Billion, #4.

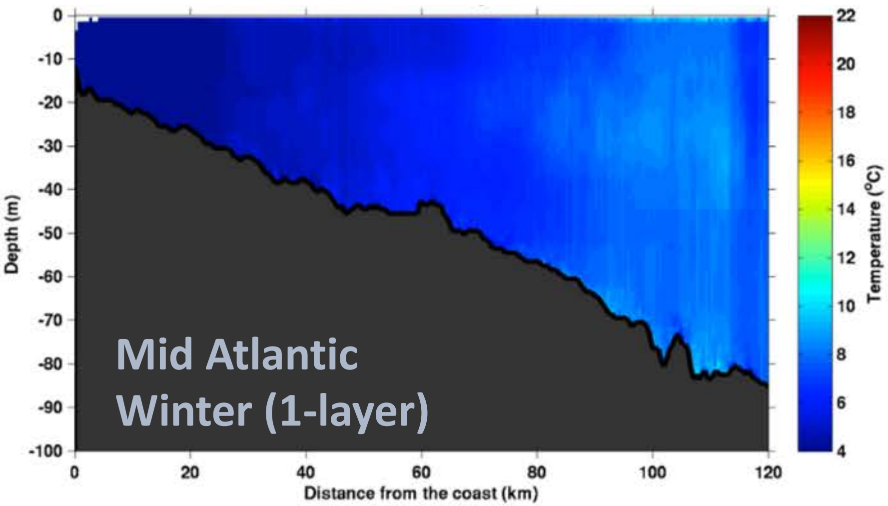
Track Accurate;
Impacts Under-predicted.

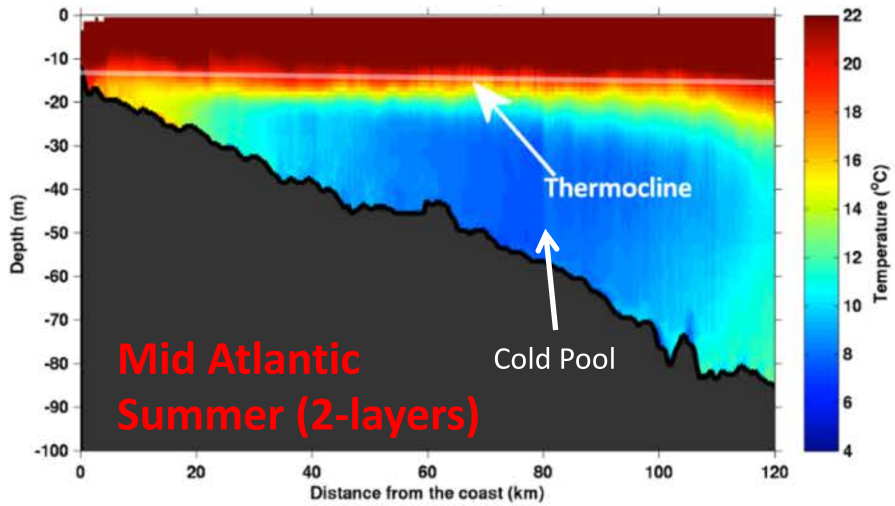
MARACOOS
Ocean Information for a Changing World

IOOS Integrated Ocean Observing System

Essential Ocean Feature - Mid-Atlantic's Cold Pool

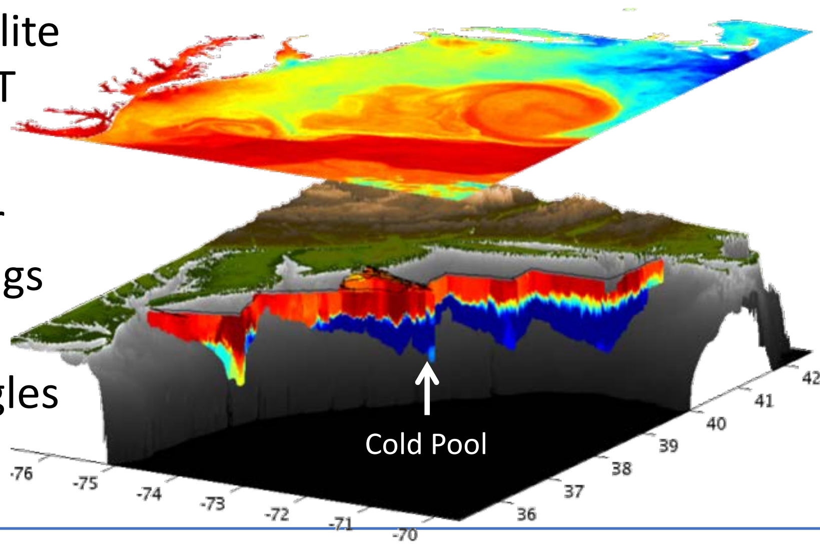
A continental shelf-wide cold bottom layer beneath a warm summer surface layer





Satellite SST

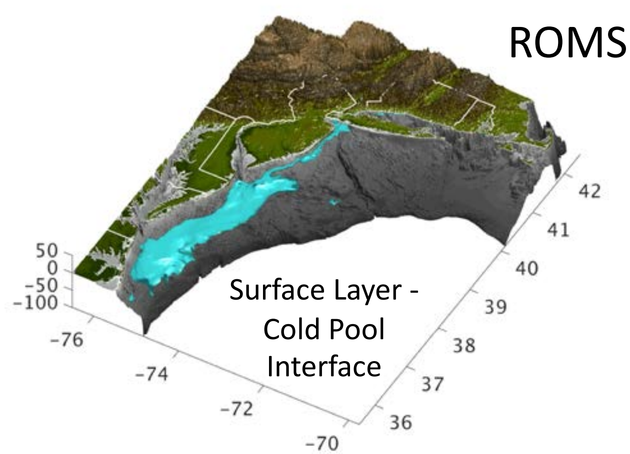
Glider Zig-Zags or Triangles



Assimilated into Regional Ocean Models

12° C on May 15, 2017

ROMS



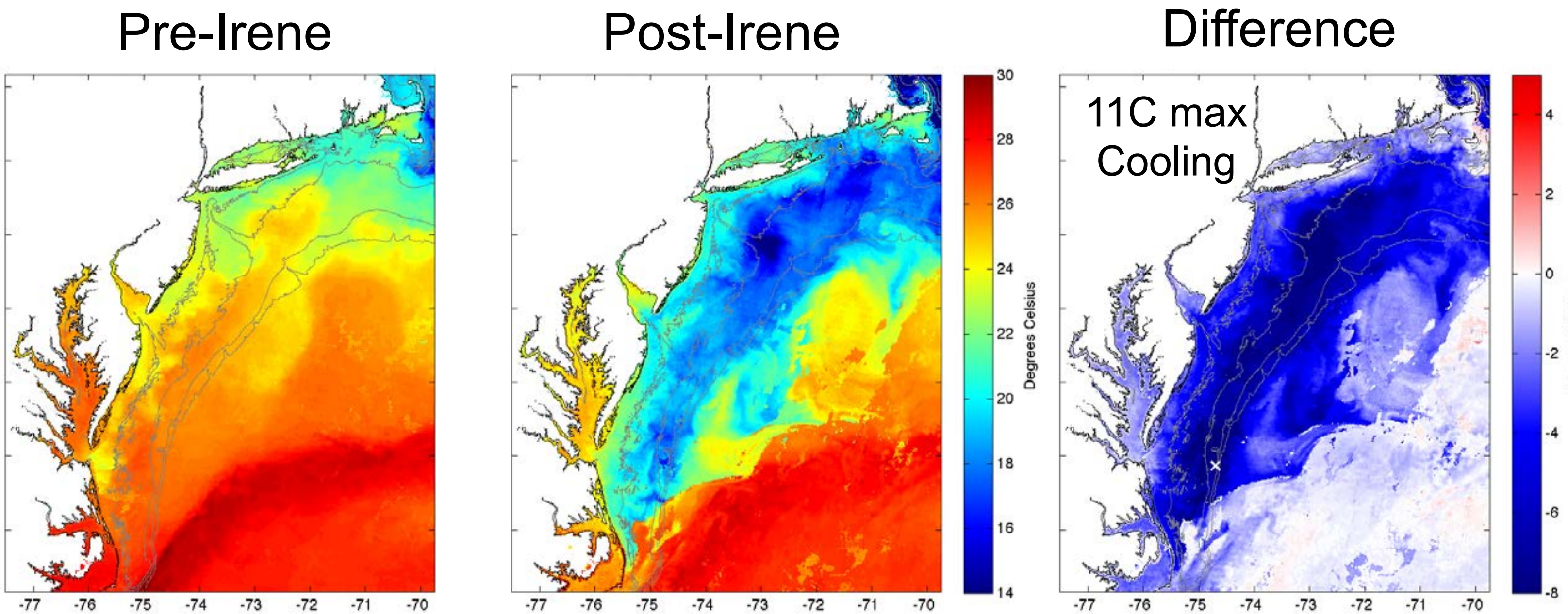
The Cold Pool is not monitored from space – we use Gliders, HF Radar, and Models

MARACOOS
Ocean Information for a Changing World

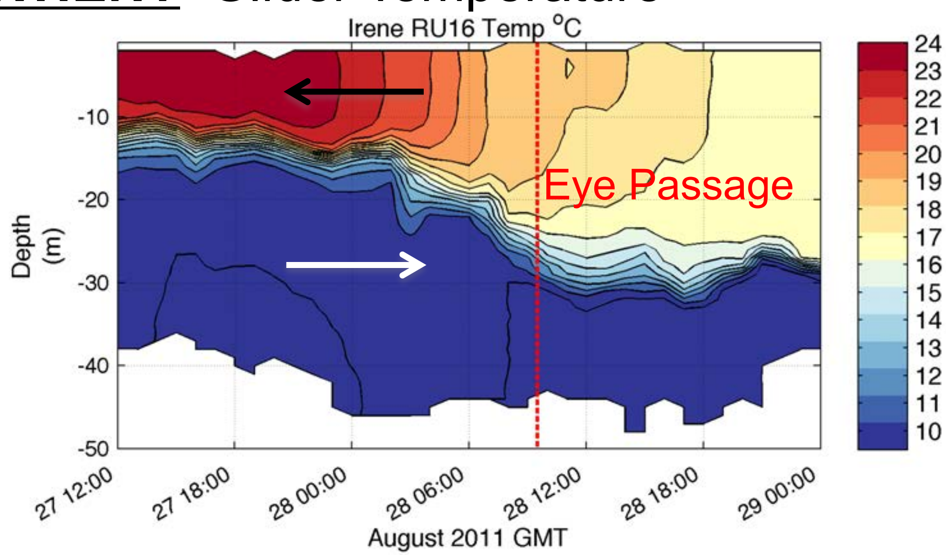
IOOS Integrated Ocean Observing System

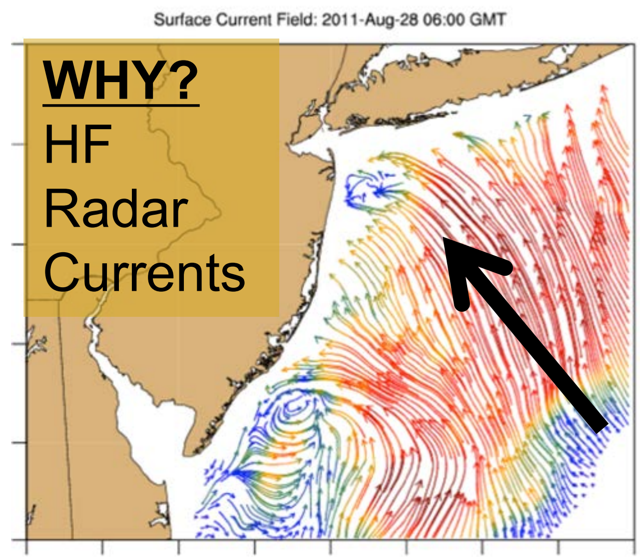
WHAT?

Satellite SST



WHEN? Glider Temperature



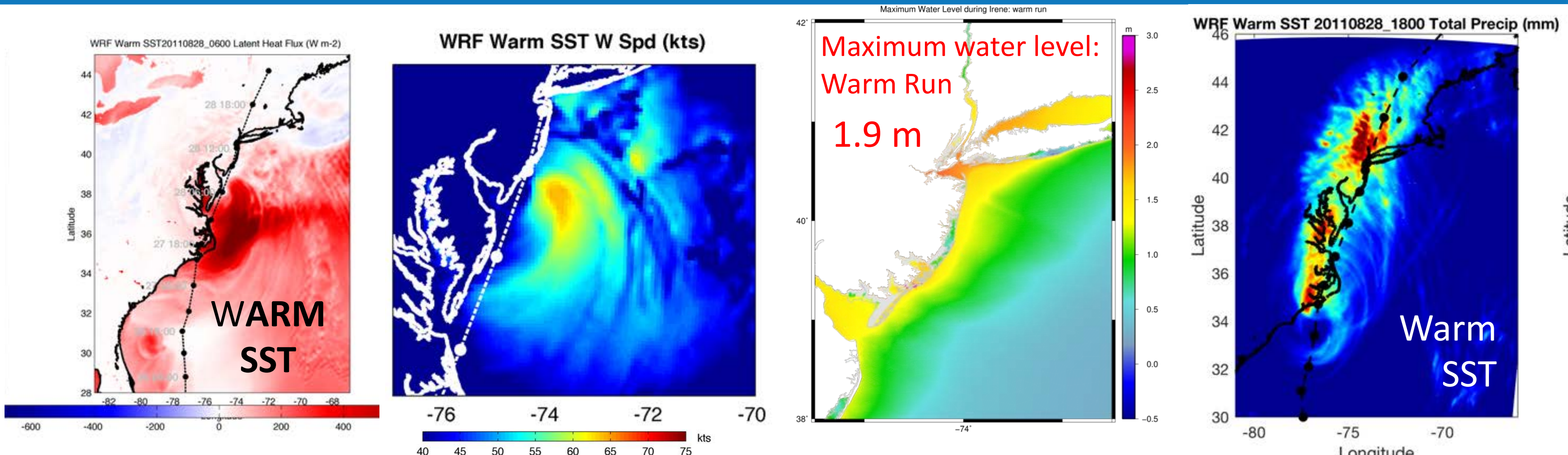


Glenn et al., Nature Comms, 2016

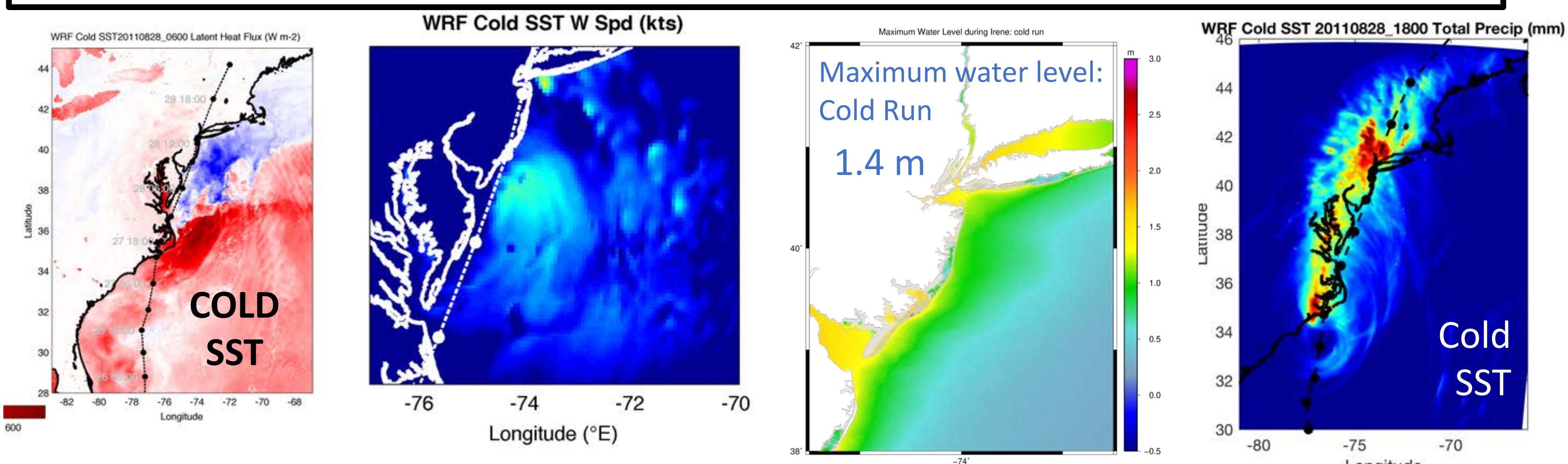
Essential Ocean Processes in Hurricane Irene:

Ahead of eye center – Vertical Shear > Mixing > Cooling > Weakening

Irene - Impacts of Warm (top row) vs Cold (bottom row) SST



Surface Heat Flux | **Wind Speed** | **Storm Surge** | **Total Rainfall**



Sign Change as observed

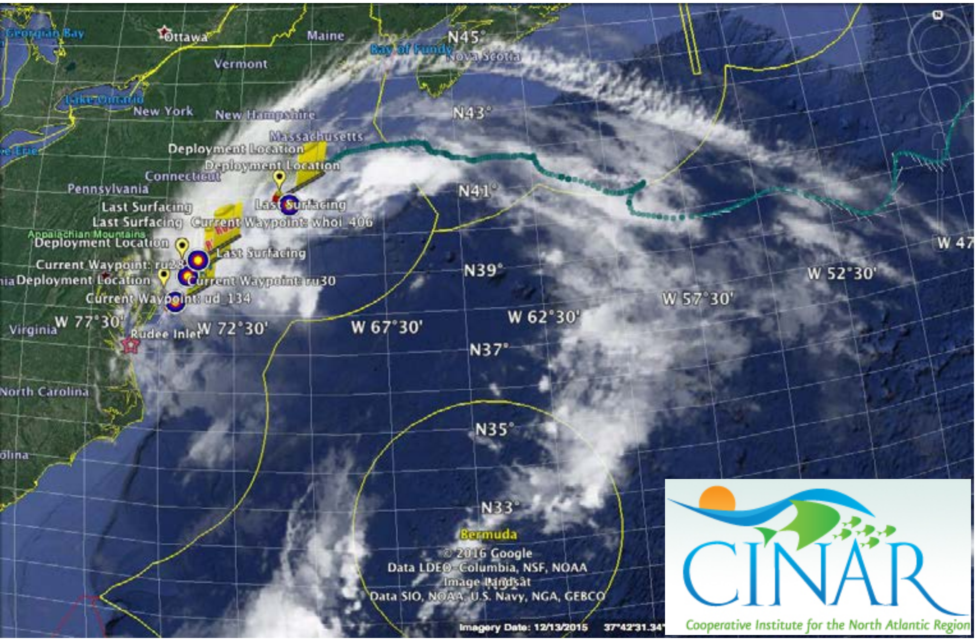
10 knot reduction to observed

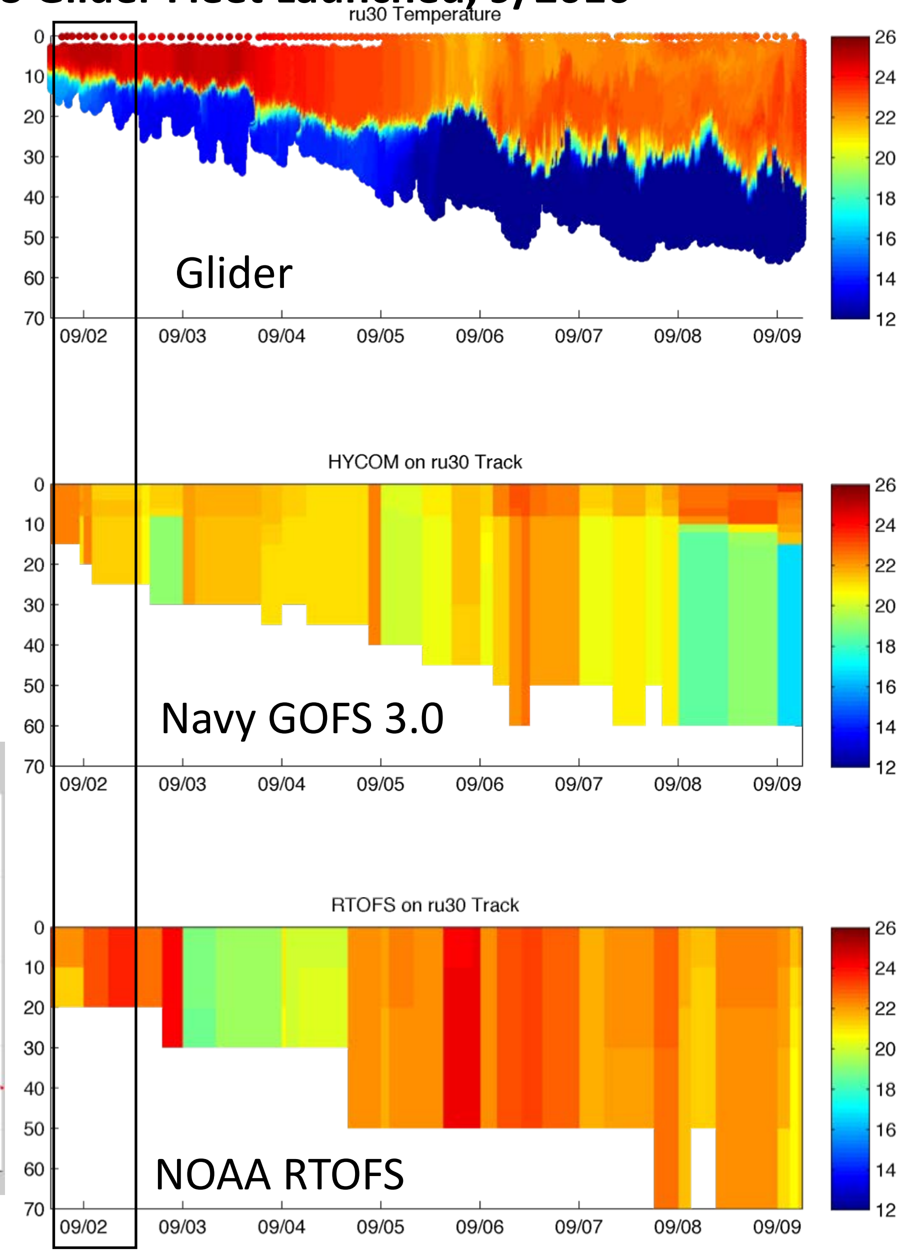
0.5 m reduction to observed

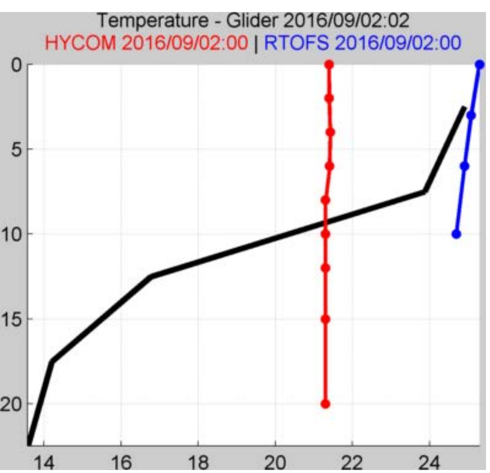
35 mm reduction to observed

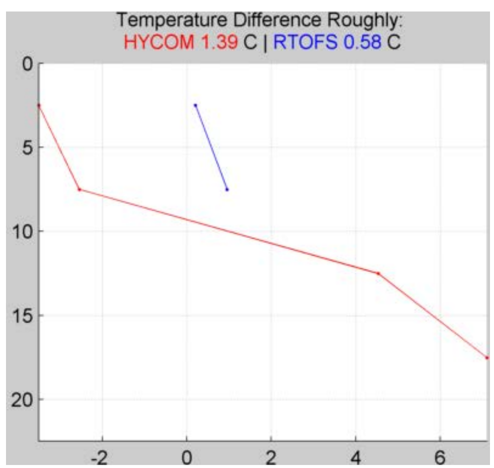

One year later…
Superstorm Sandy
October 2012

Hurricane Hermine Response: CINAR/MARACOOS Glider Fleet Launched, 9/2016





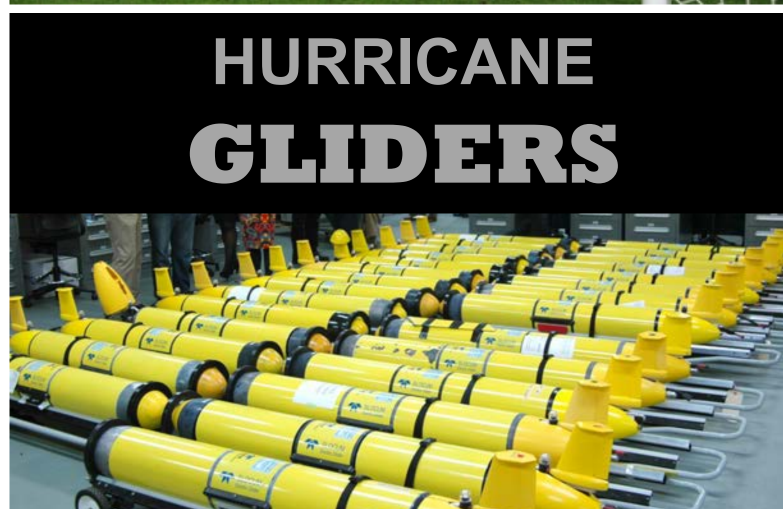




GOFS 3.0 = Navy's operational Global Ocean Forecast System

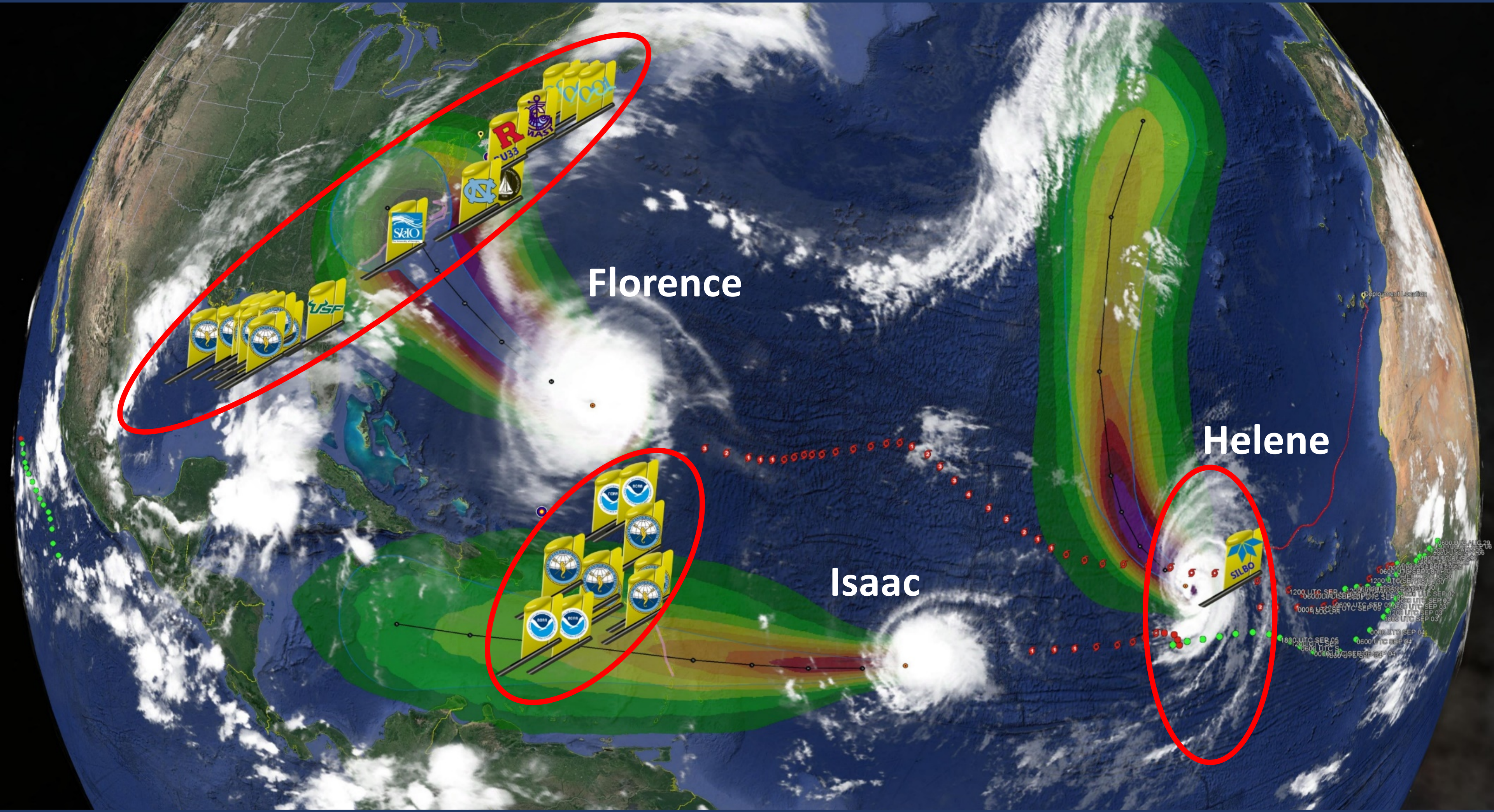
RTOFS = NOAA's operational global Real Time Ocean Forecast System

Since
1946



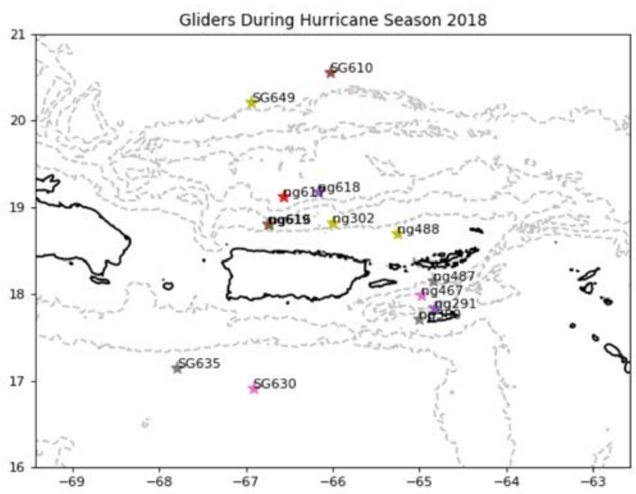
Starting
2018

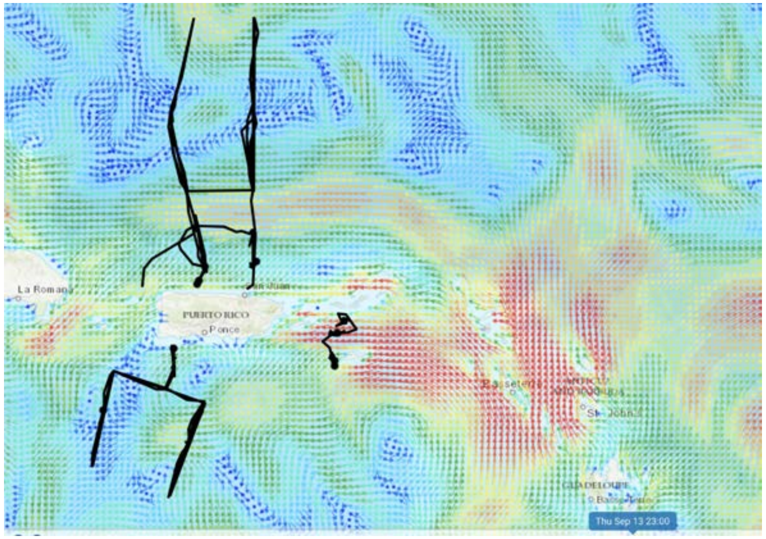
2018 Community Gliders deployed in 3 Picket Lines

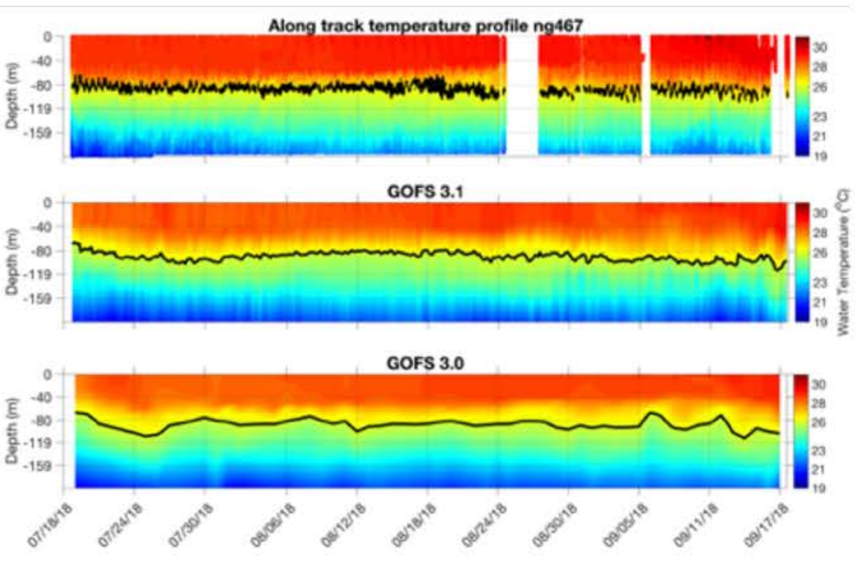


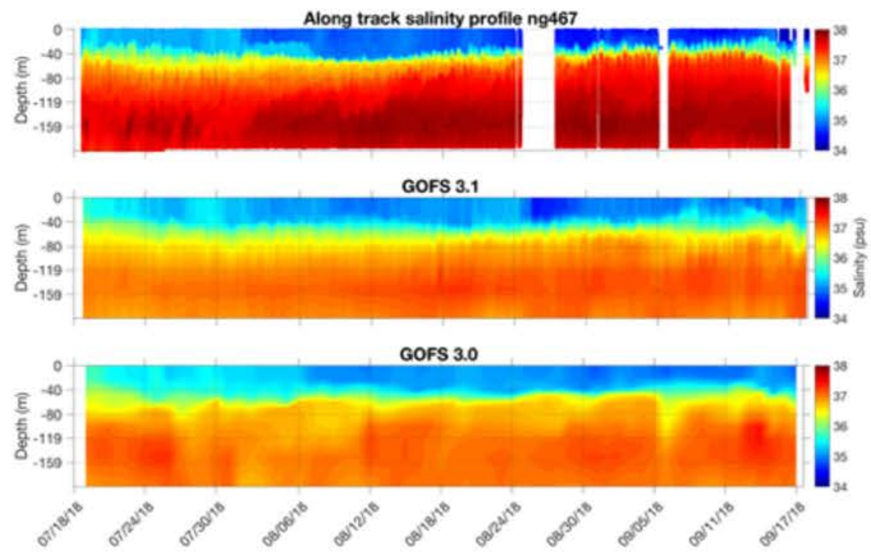
>30 Hurricane Sentinel Gliders from the Navy, NOAA, NSF, Academic & Industry Partners reporting ocean conditions through the U.S. IOOS Glider Data Assembly Center (DAC) ahead of Hurricanes Florence, Isaac and Helene on September 11, 2018.

Caribbean – NG467

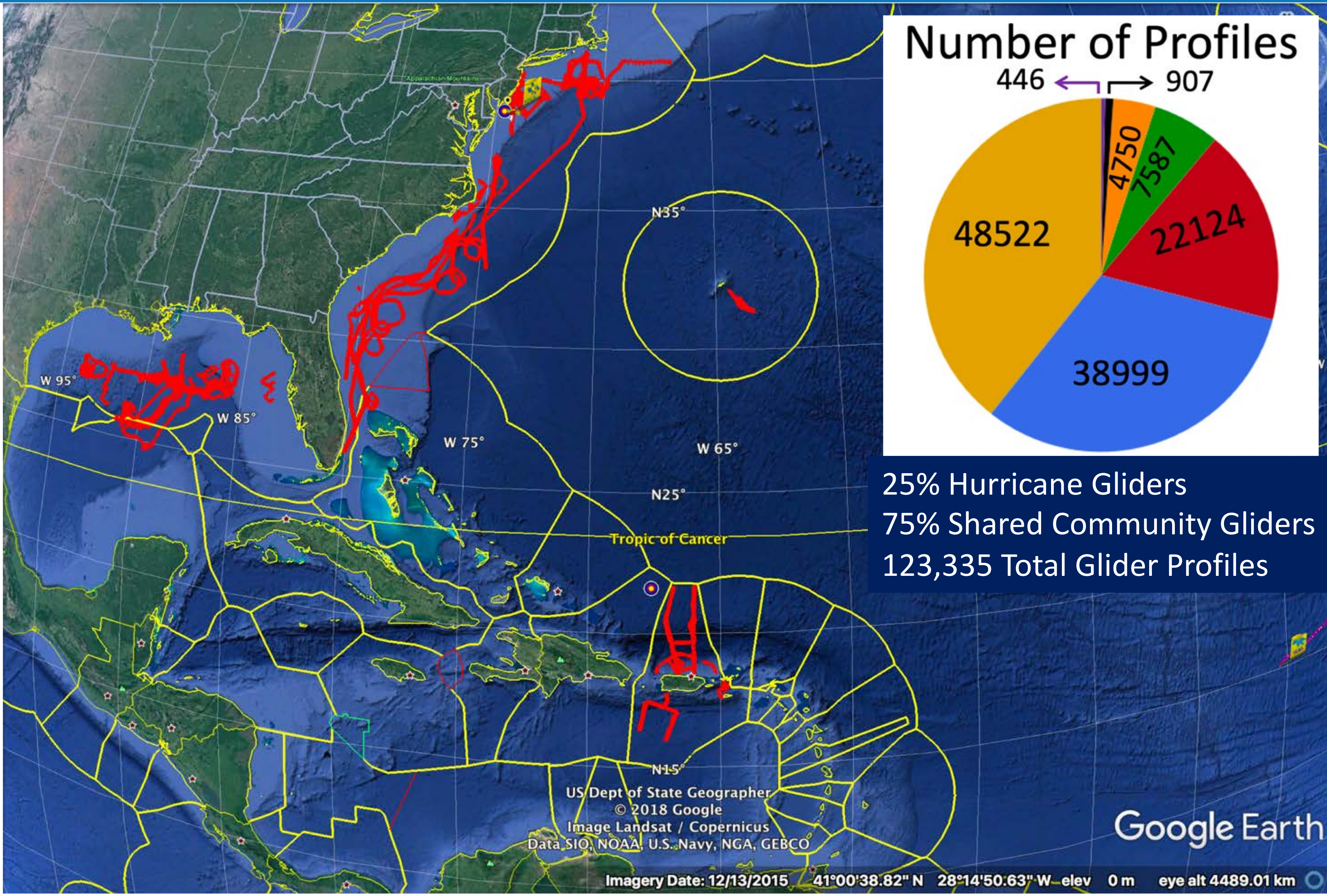






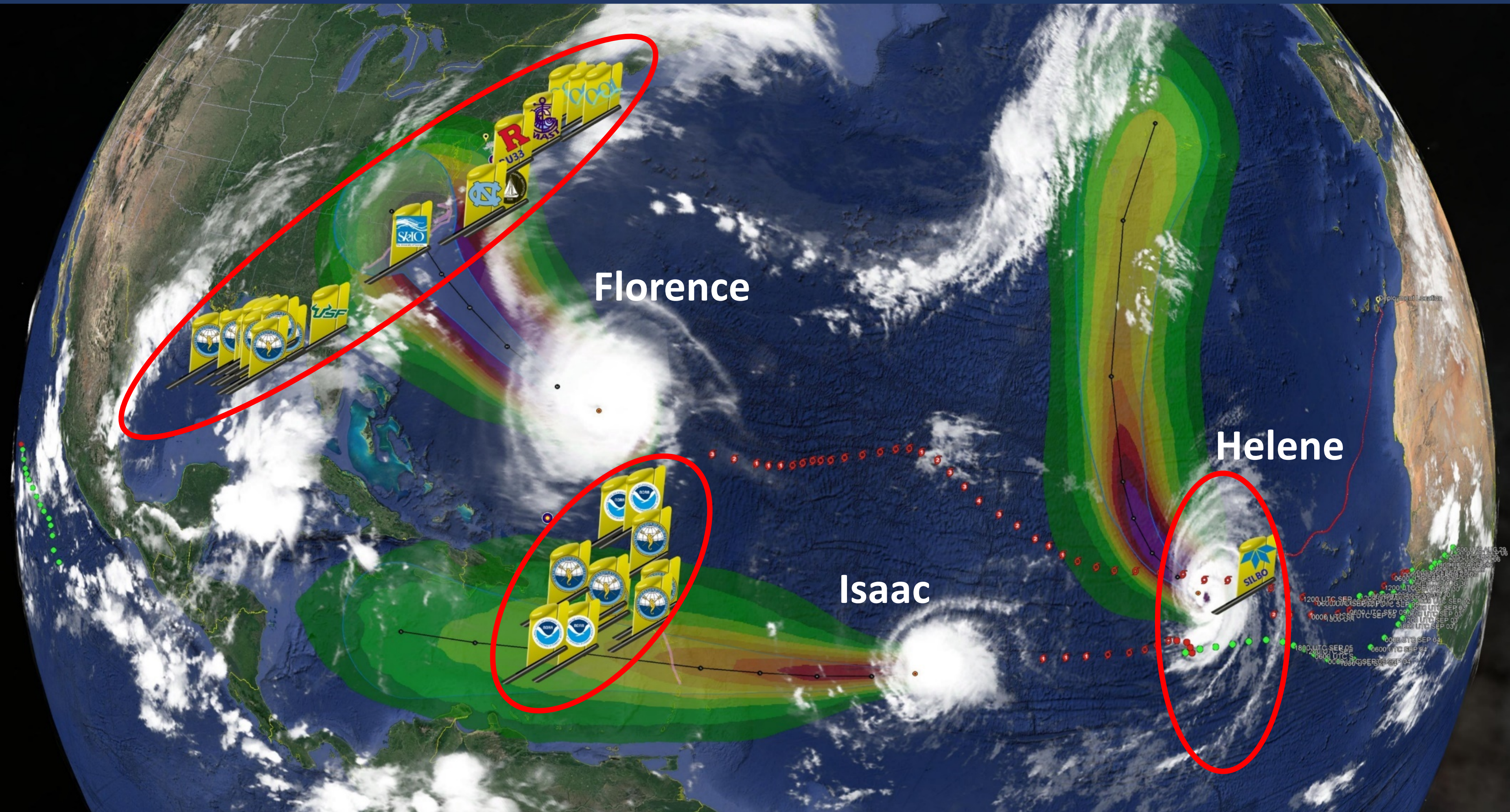


2018 Hurricane Season – 62 Gliders in IOOS Glider DAC



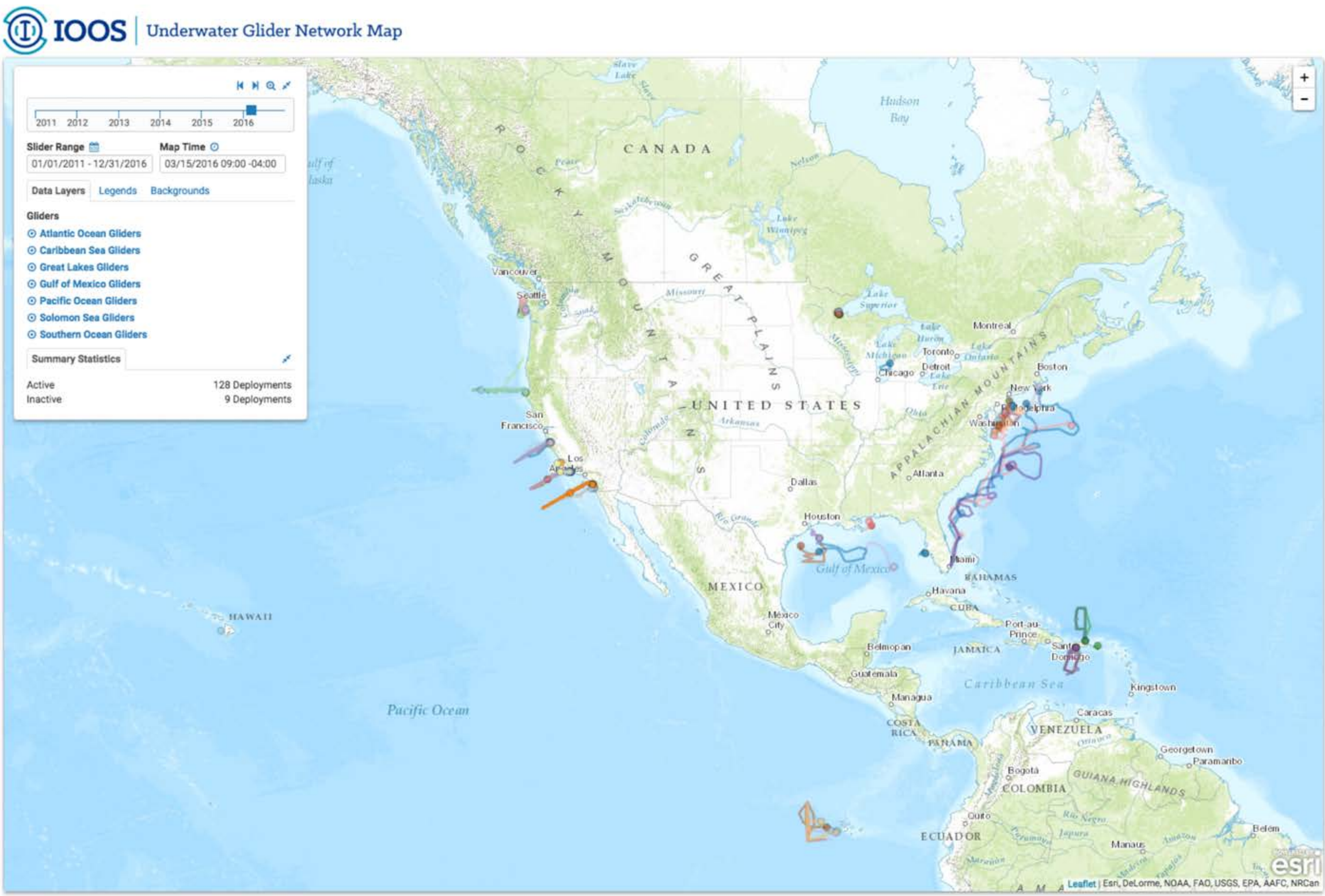
25% Hurricane Gliders
75% Shared Community Gliders
123,335 Total Glider Profiles

Hurricane Sentinel Gliders deployed in 3 Picket Lines

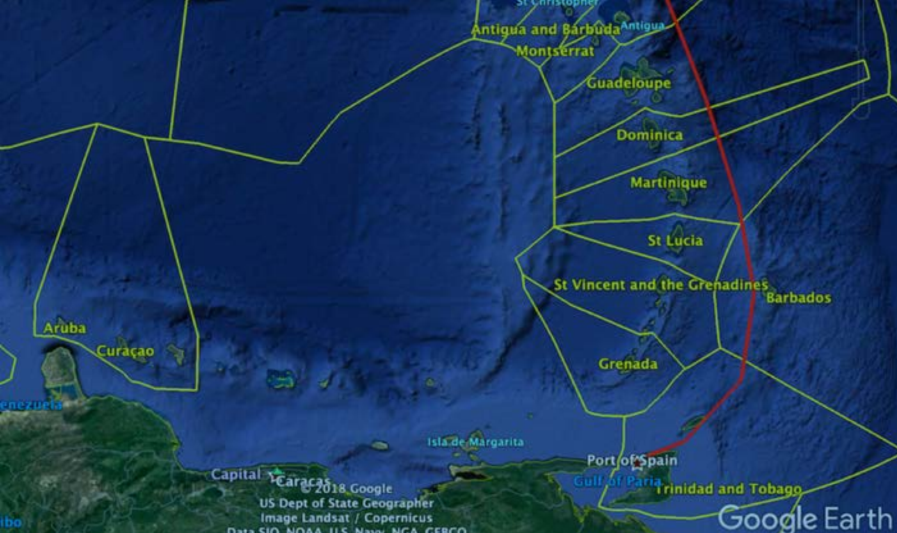


>30 Hurricane Sentinel Gliders from the Navy, NOAA, NSF, Academic & Industry Partners reporting ocean conditions through the U.S. IOOS Glider Data Assembly Center (DAC) ahead of Hurricanes Florence, Isaac and Helene on September 11, 2018.

Data Availability



Leveraging Global Tropical Cyclone Expertise



Moving

1) Maximize collaboration and partnersips
2) Capacity Building