

**RUTGERS**  
THE STATE UNIVERSITY  
OF NEW JERSEY



# The Voyage of the Scarlet Knight

# Ship-based Oceanography

## Advantages

- We can see exactly what's going on at that moment.
- We can make many measurements at once.
- We can obtain “high-resolution” data.

## Disadvantages

- It's expensive!
- During storms, even Oceanographers can get seasick.
- We only see what's going on when we're out there.

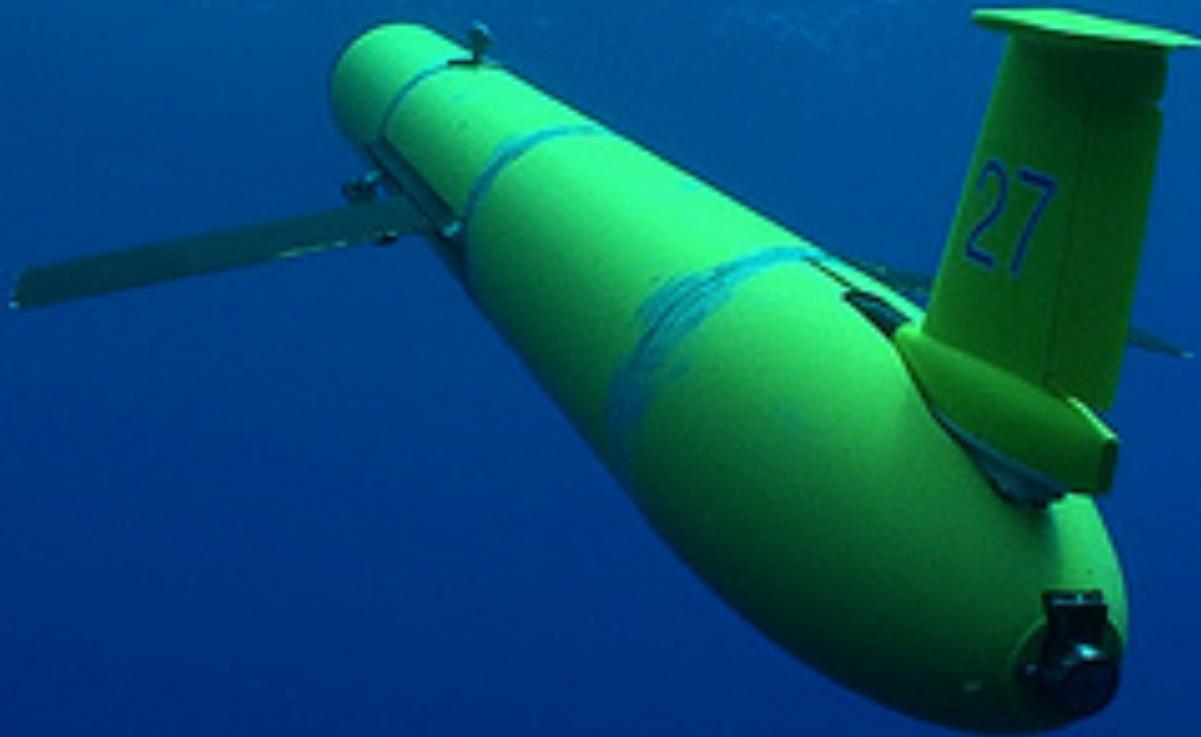


A New Way to Explore the Ocean

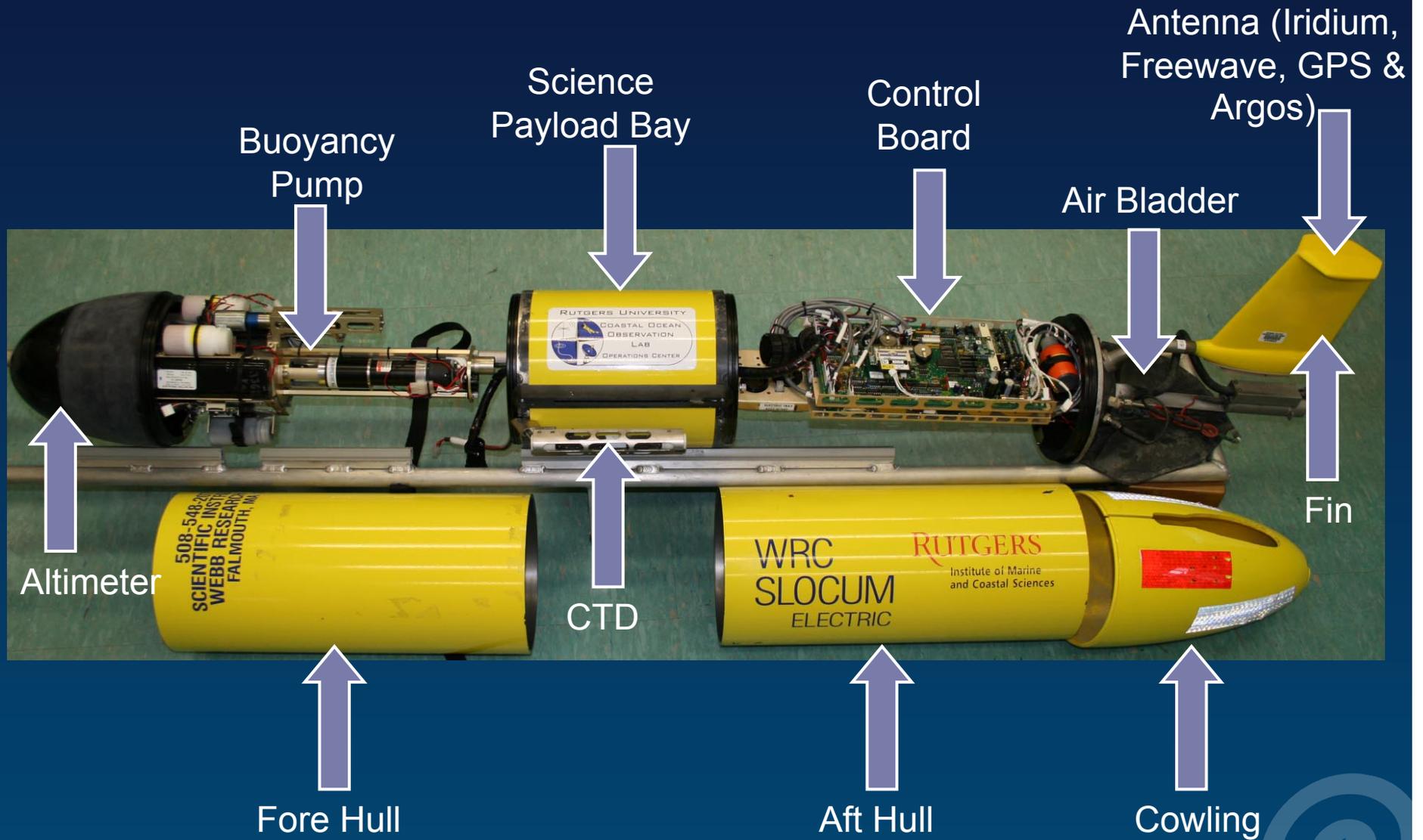
**Underwater Gliders**



How does a  
**Glider**  
work?



# Anatomy of a Glider







# How do Gliders "Fly"?

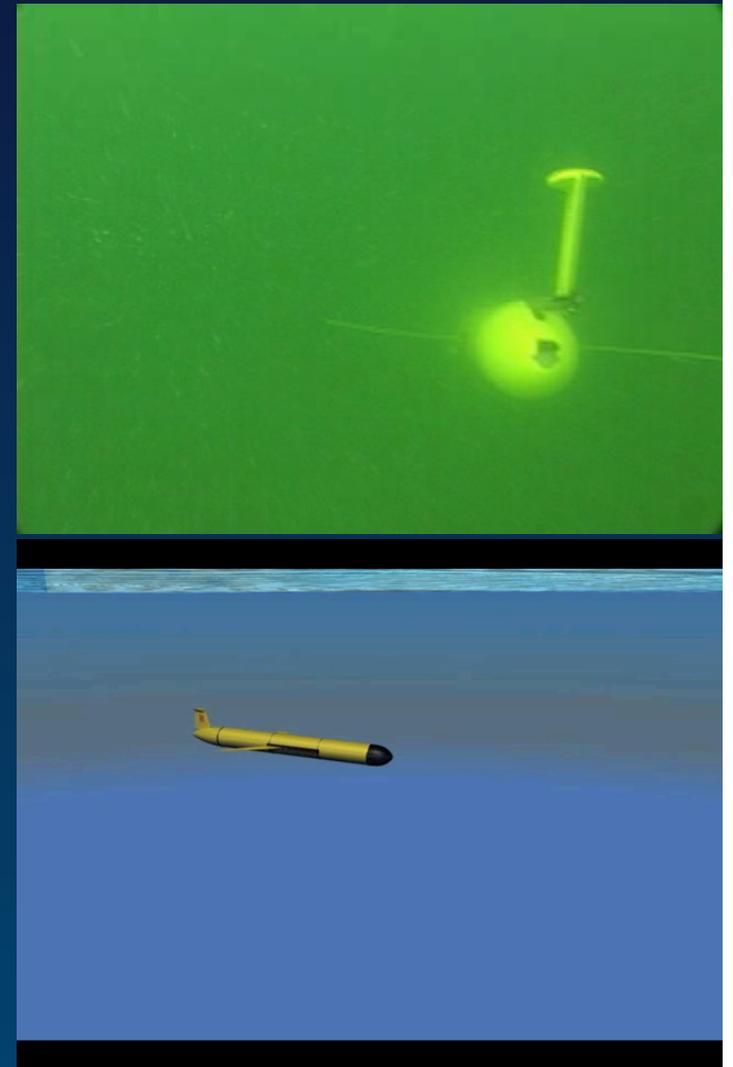
Buoyancy pump in ← the glider pulls in 0.5 L of water

When surfacing to connect glider inflates air bladder

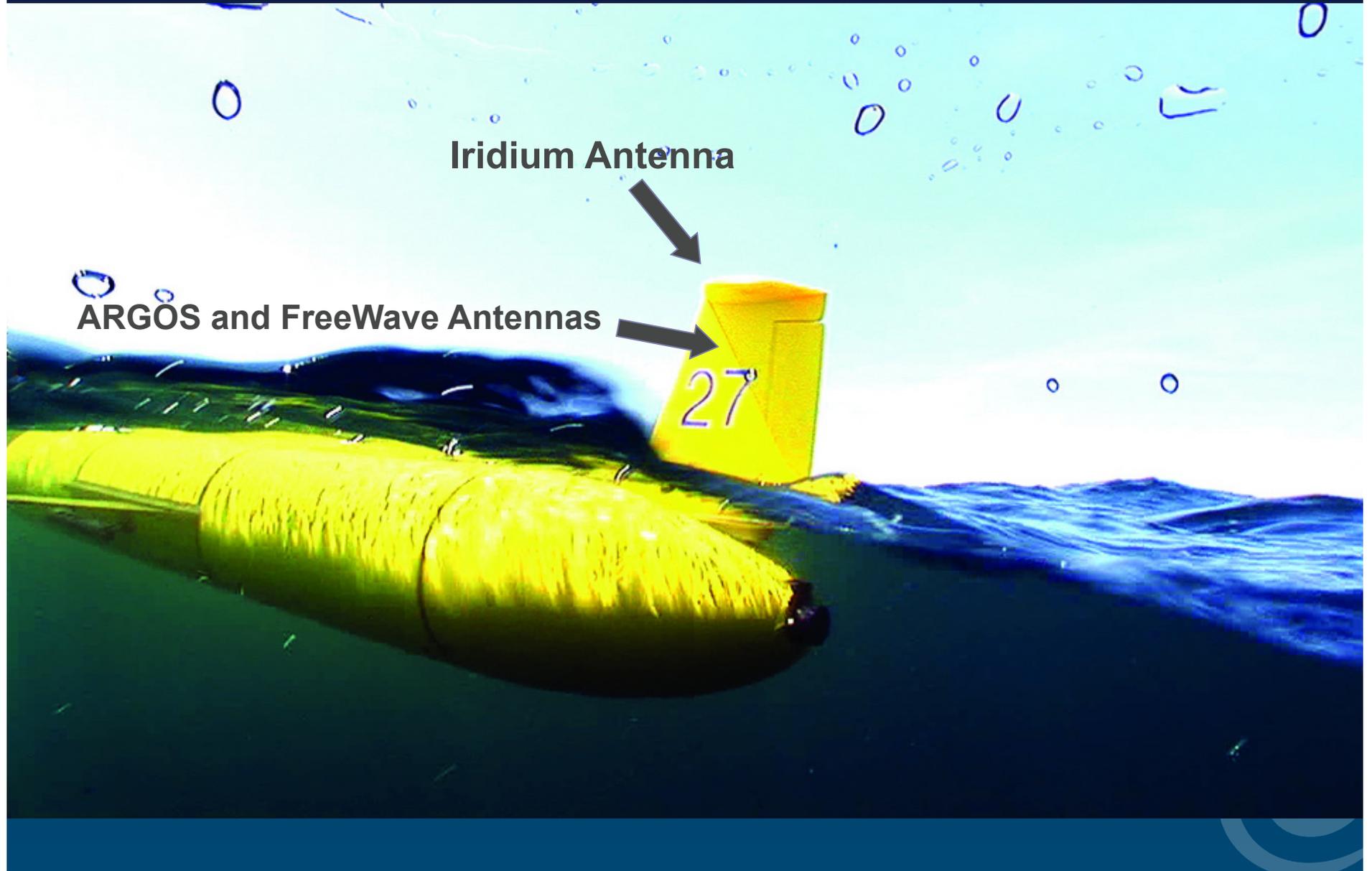
Glider begins to dive downward

Push pump out → glider inflects and begins to climb to the surface

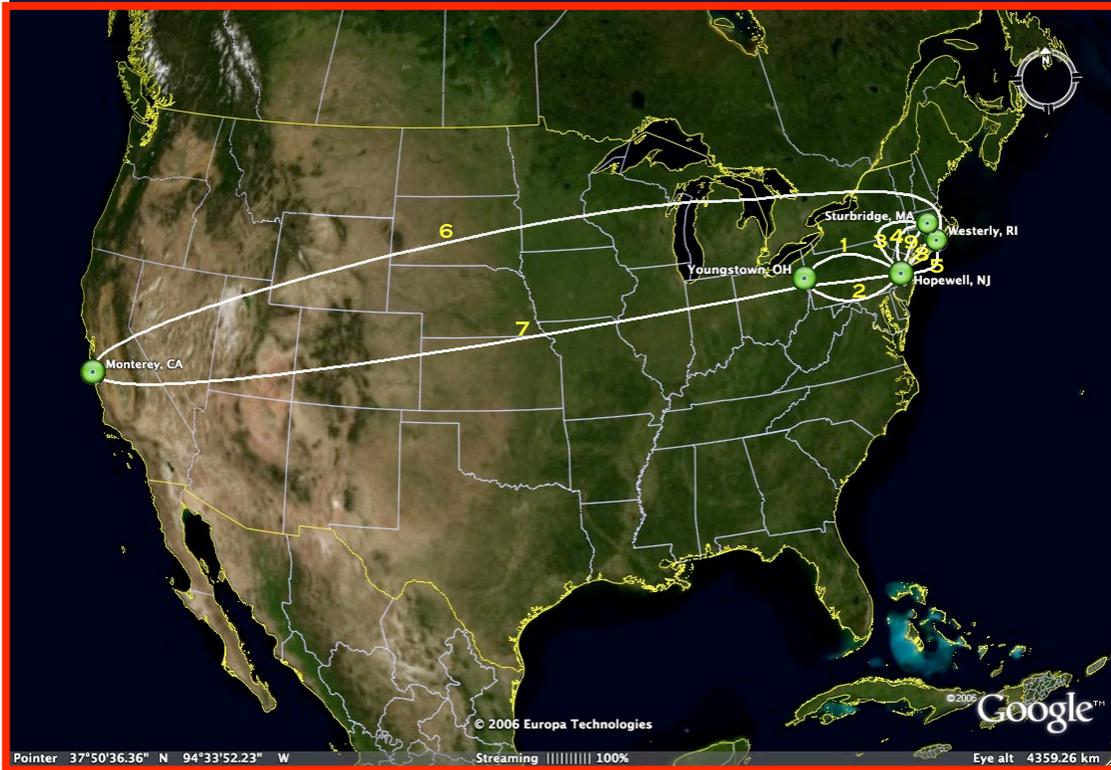
one dive and one climb is called a 'yo'



# How do Gliders Communicate?



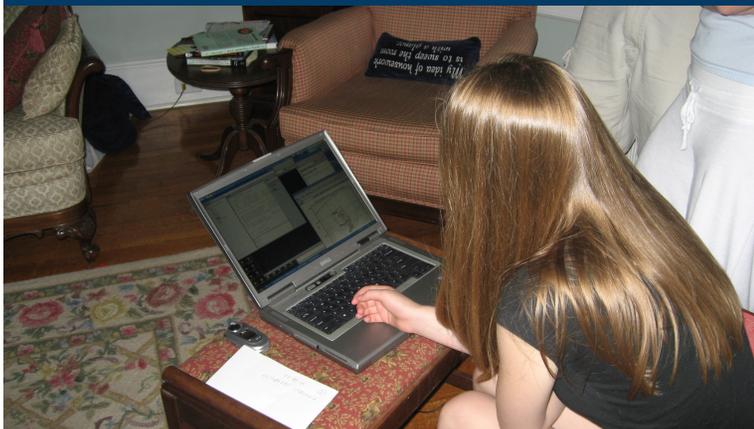
# Sustained Observatory Operations from Multiple Locations



## McDonald's WiFi



## My Living Room – Glider Recovery in Hawaii



# Glider Development: Enabling science over many scales (Beginning 1999)

Inner-Shelf (30 km)

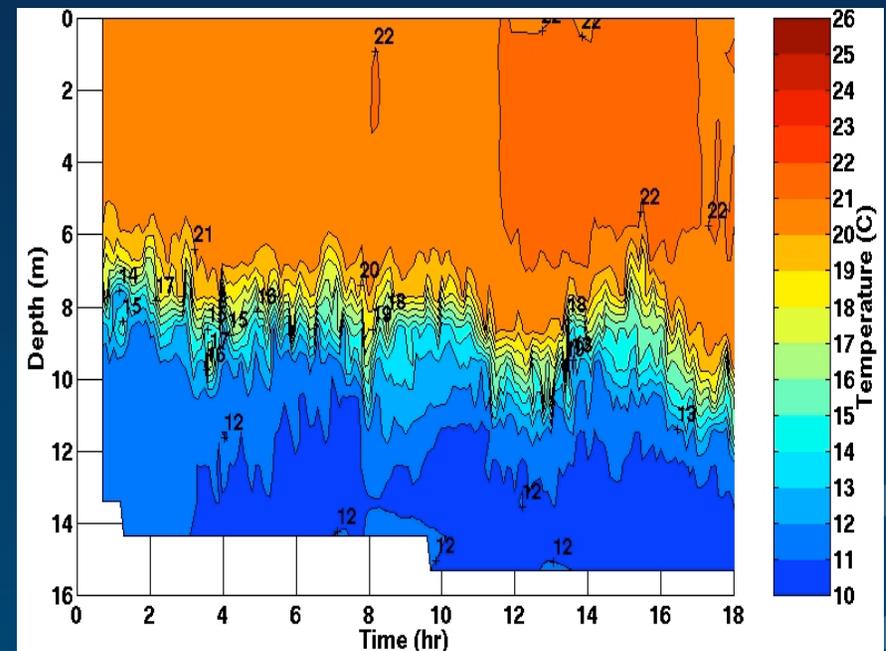
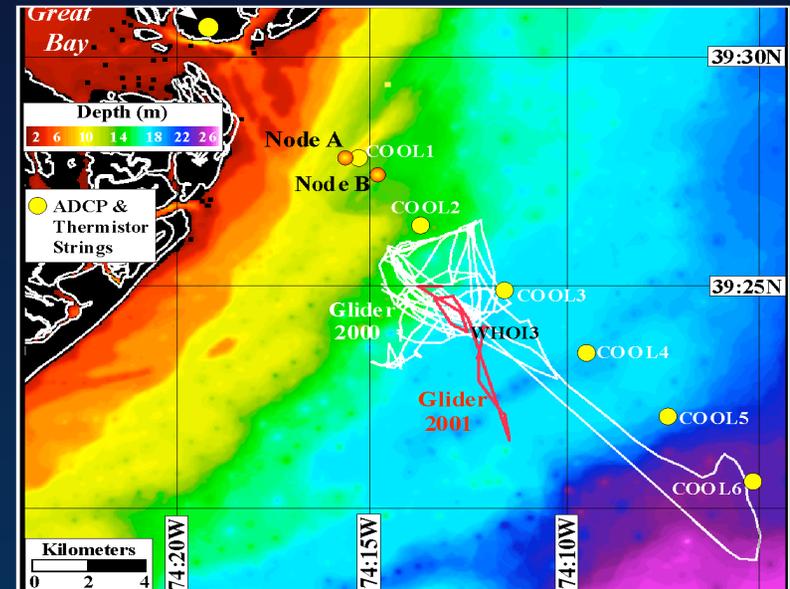
10 day missions



**Enabling Technology:** Line of sight communication, CTD, alkaline batteries

**Scientific Impact:**

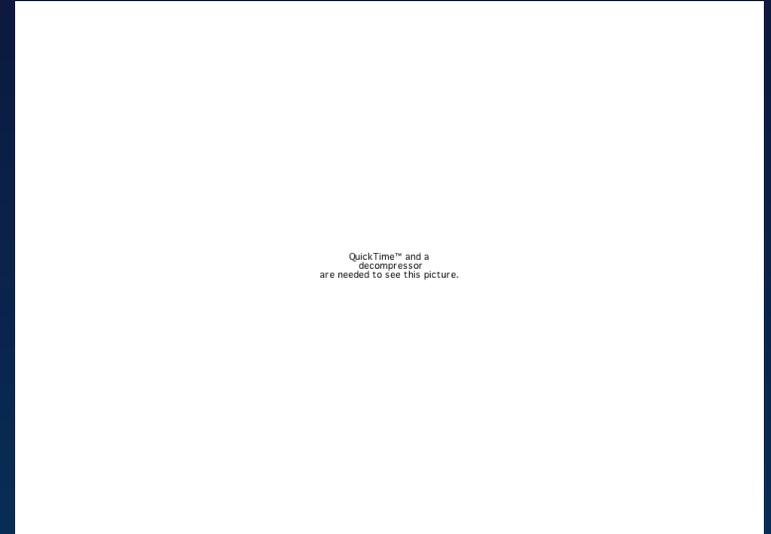
- Coastal upwelling
- Inner shelf sediment transport
- Near-shore phytoplankton blooms



# Glider Development: Enabling science over many scales (Beginning 2003)

Mid-Atlantic Bight (500 km)

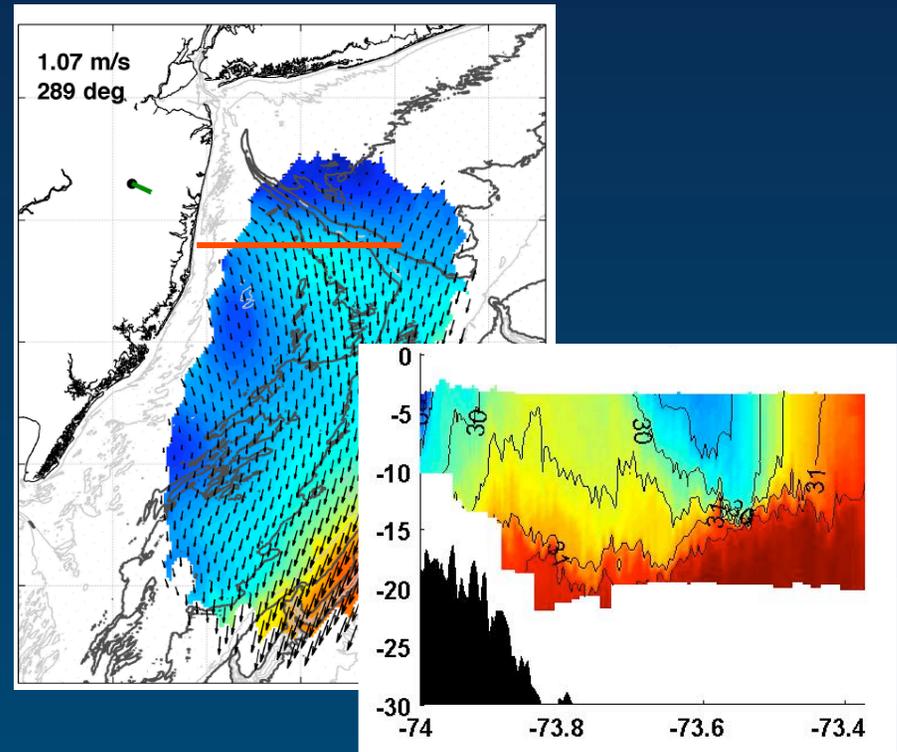
30 day missions



**Enabling Technology:** Satellite communication, CTD, alkaline batteries, modular science payload

**Scientific Impact:**

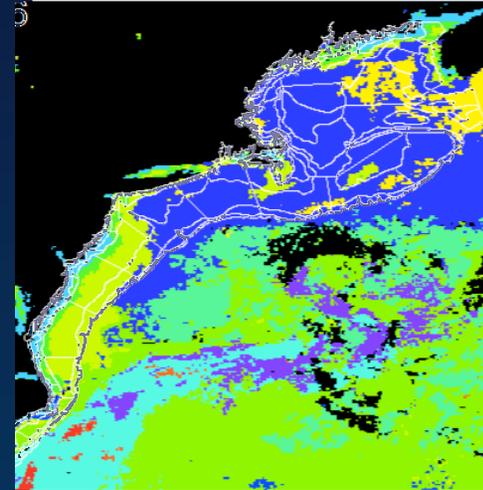
- River Plumes
- Ecological indicators for migratory fish
- Role and response of the ocean to tropical storms and nor'easters



## Glider Development: Enabling science over many scales (Beginning 2008)

Large Marine Ecosystems (2500 km)

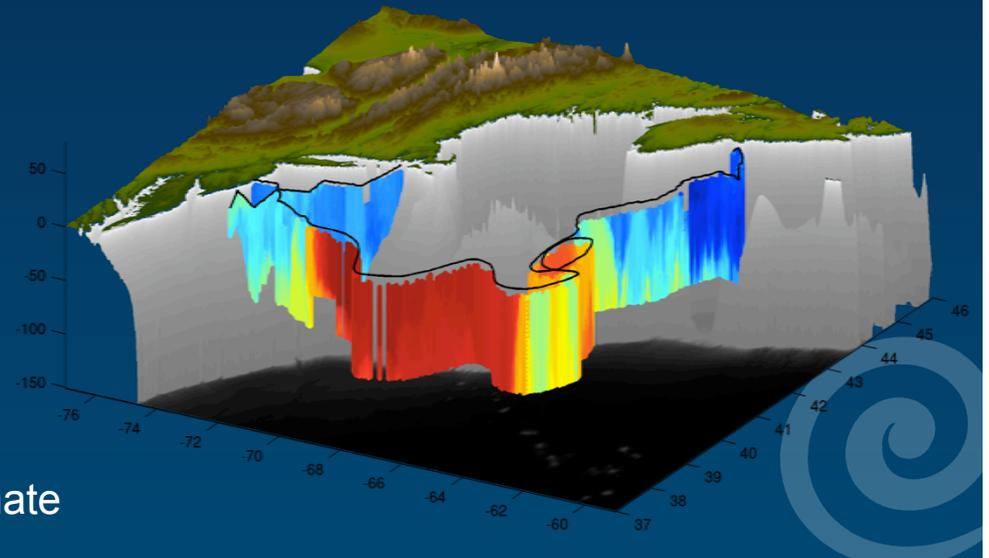
60 day missions



**Enabling Technology:** Satellite communication, CTD, *lithium batteries*, *Digifin*, modular science payload

### **Scientific Impact:**

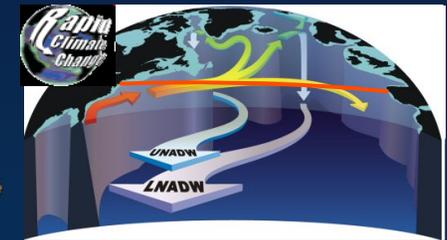
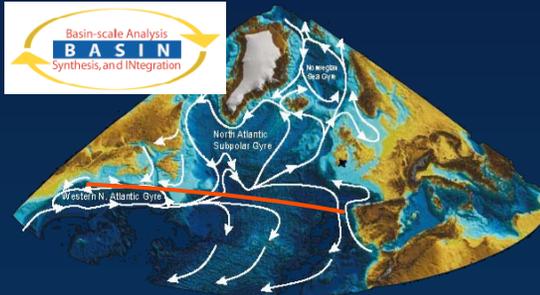
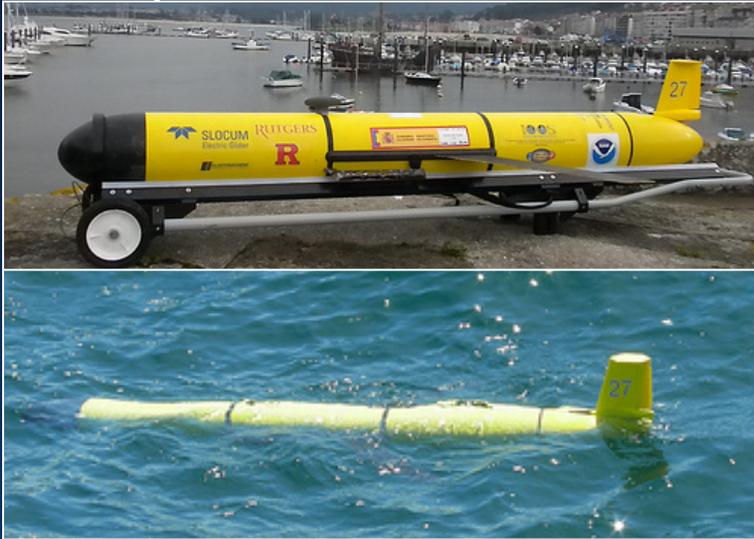
- Flux of heat and freshwater from the north by the Labrador Current
- 'Coldpool' life cycle and impact on ecosystem dynamics
- Multi-decadal oscillations and impact on climate



# Glider Development: Enabling science over many scales (Beginning 2009)

North Atlantic Basin (5000 km)

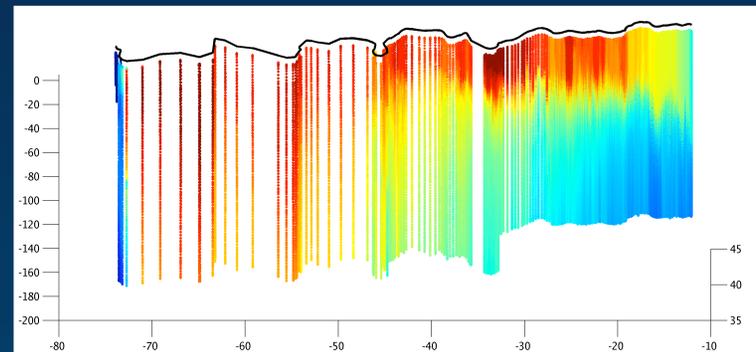
300 day missions



**Enabling Technology:** Satellite communication, CTD, lithium batteries, Digifin, *stretch science payload*

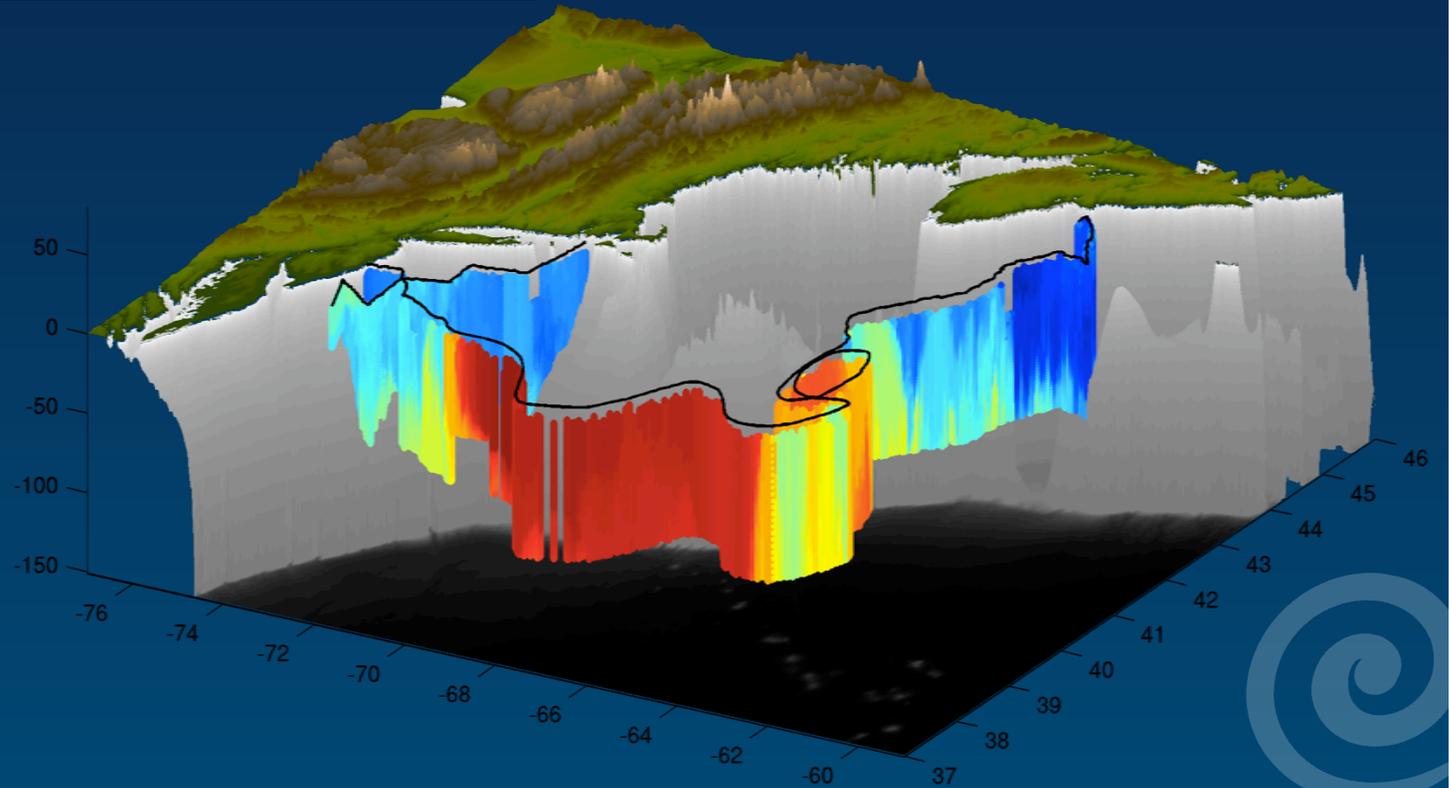
## **Scientific Impact:**

- Feedback loop between climate and ecosystems
- Impact of rapid climate variability on ocean circulation
- Tropical storm generation and intensification (ocean/atmosphere exchange)



# RU15

The first glider to fly from one country to another



**The voyages of**

**RU17**

**&**

**RU27**

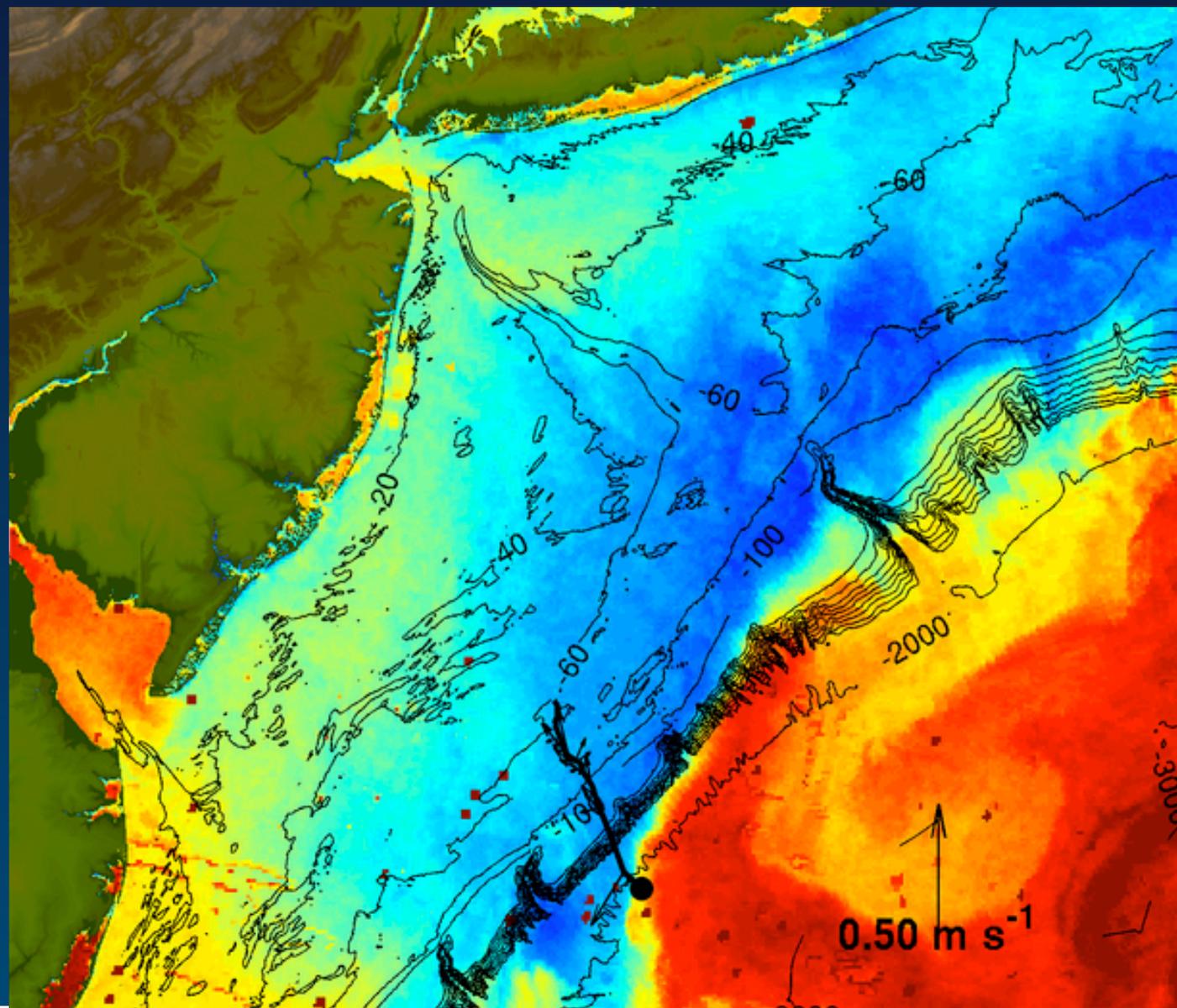


# The Adventure Begins...

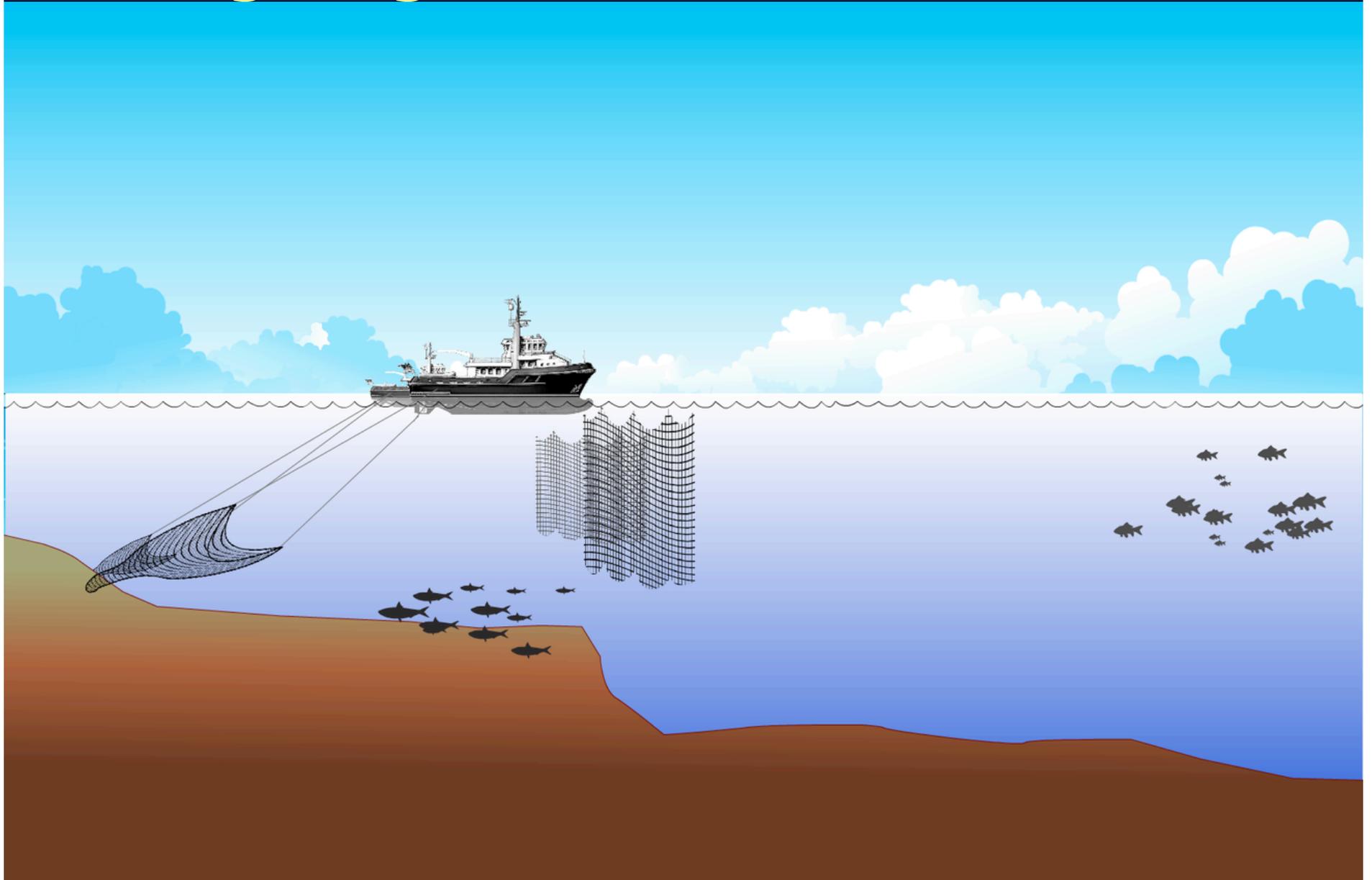


The Voyages of RU17 and RU27

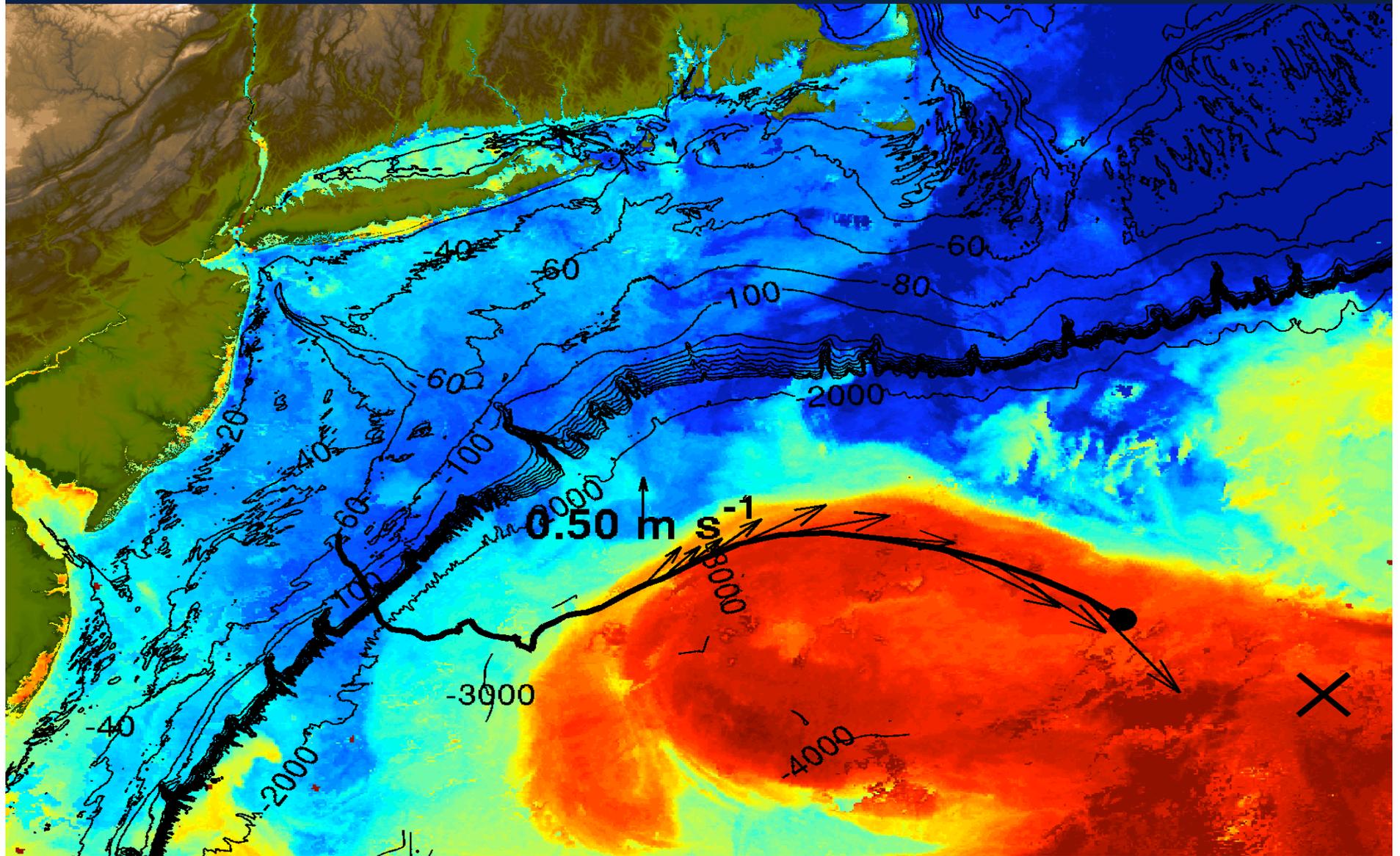
# Crossing the Shelf Break



# Navigating the Shelf Break



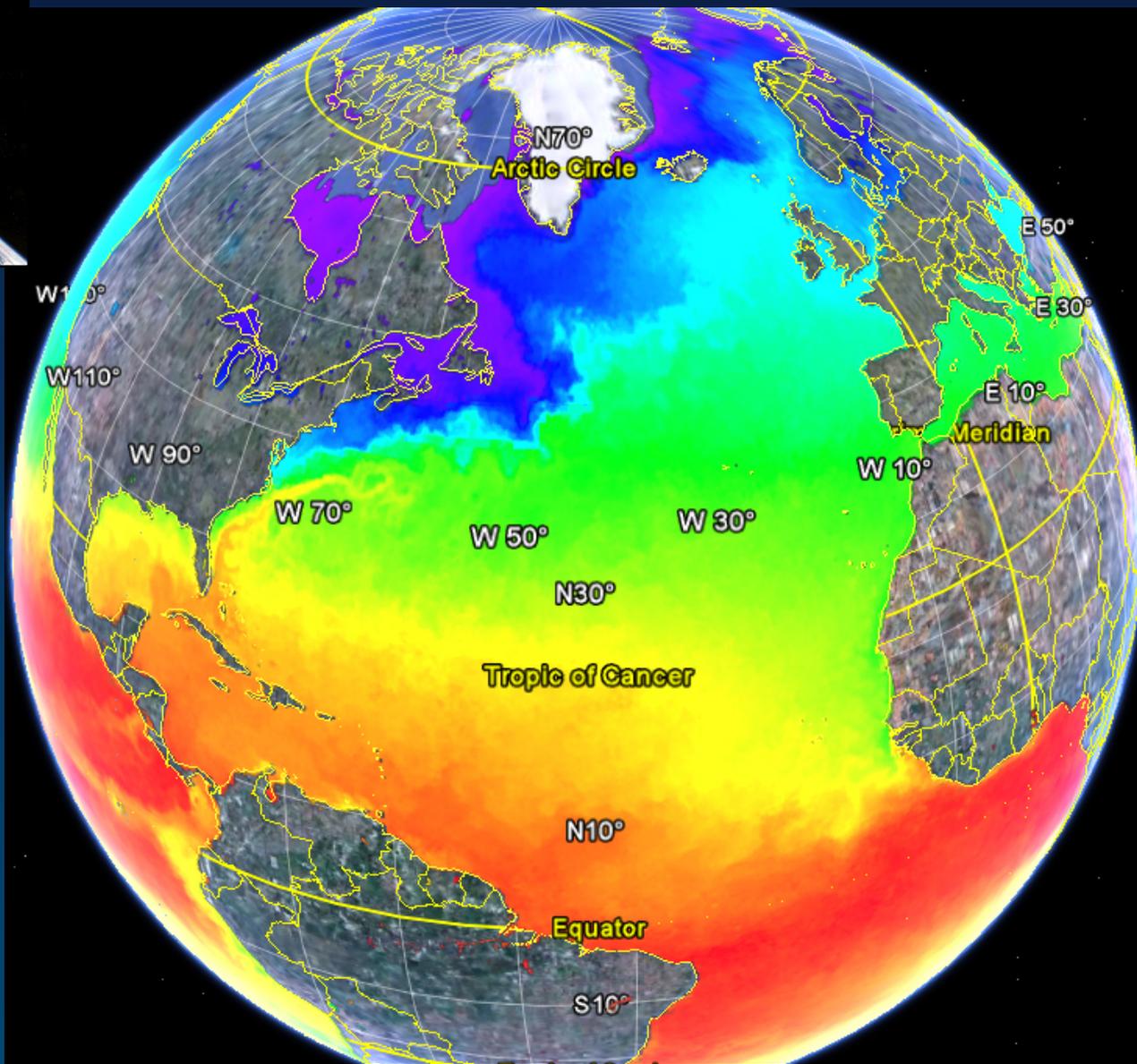
# Catching a ride on the Gulf Stream



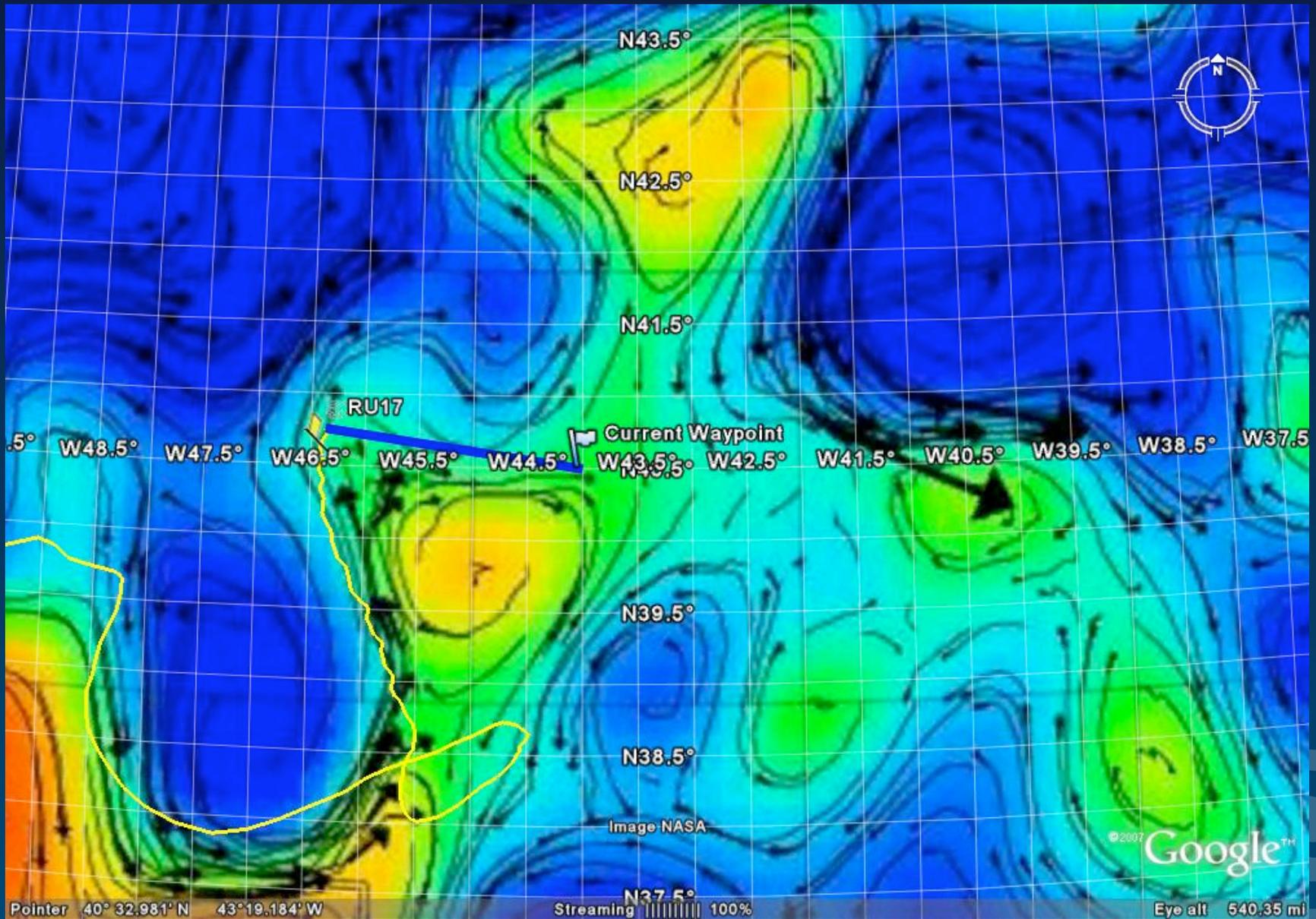


# Satellite Data

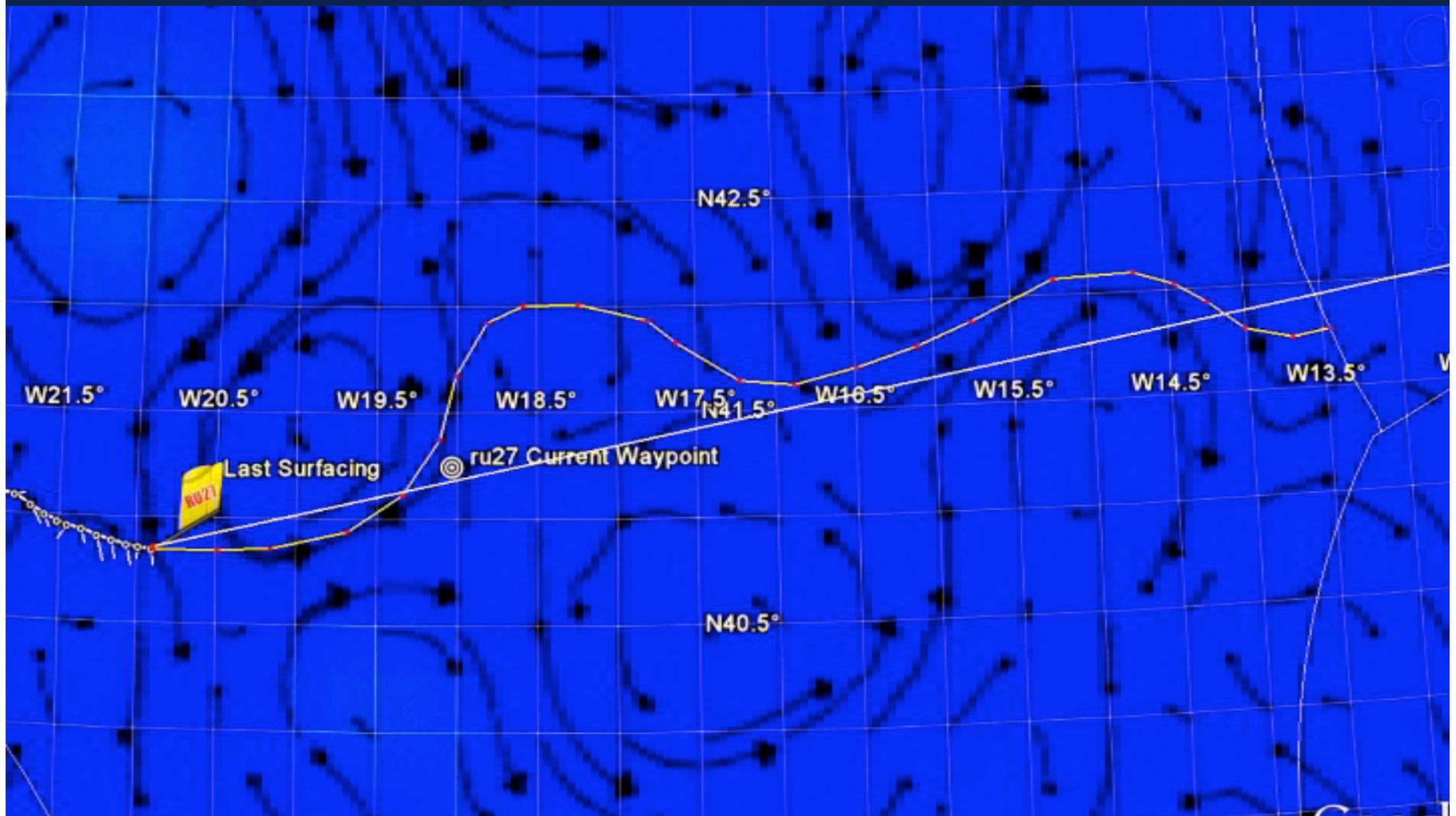
## Sea Surface Temperature



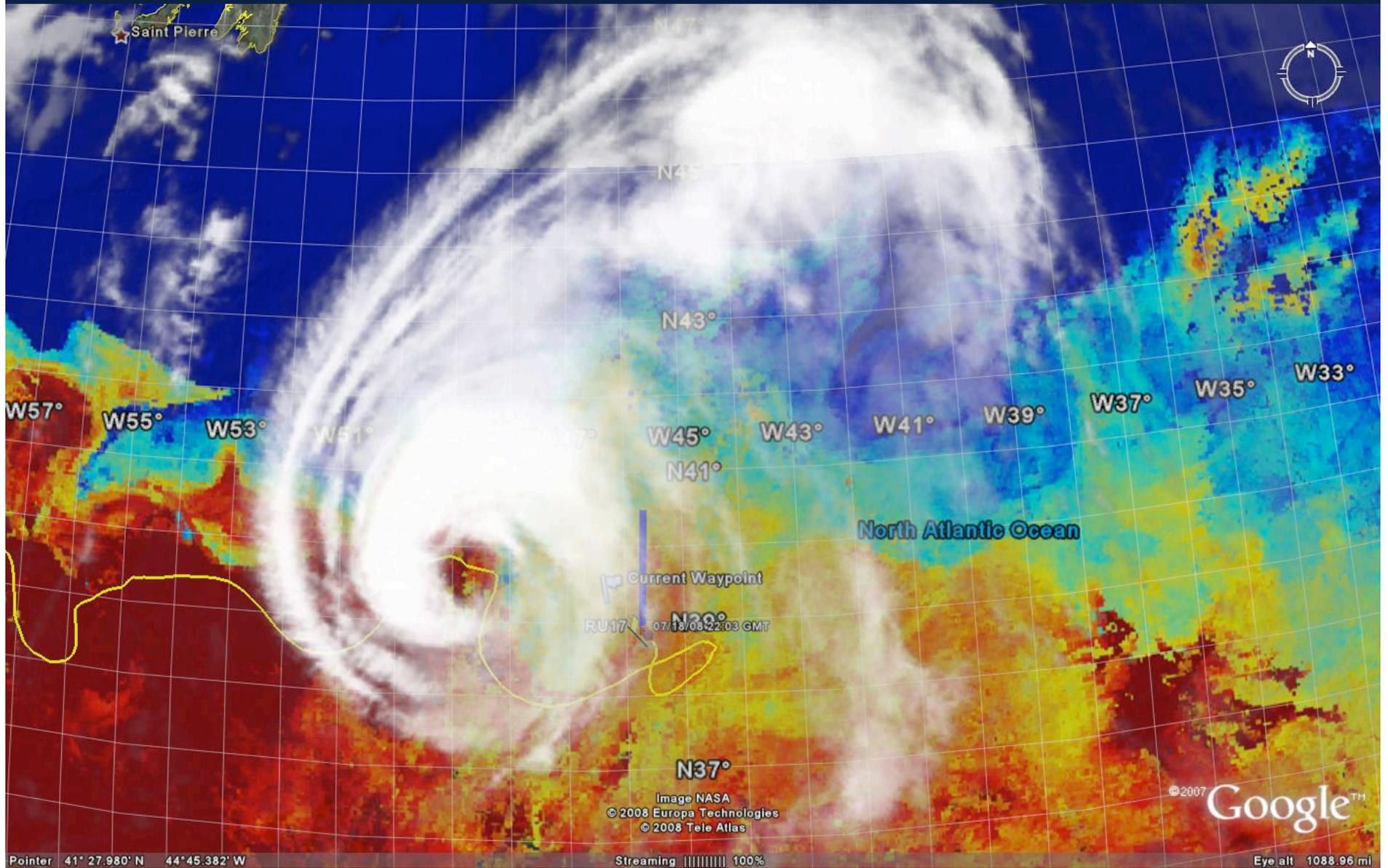
# Flying in Eddies



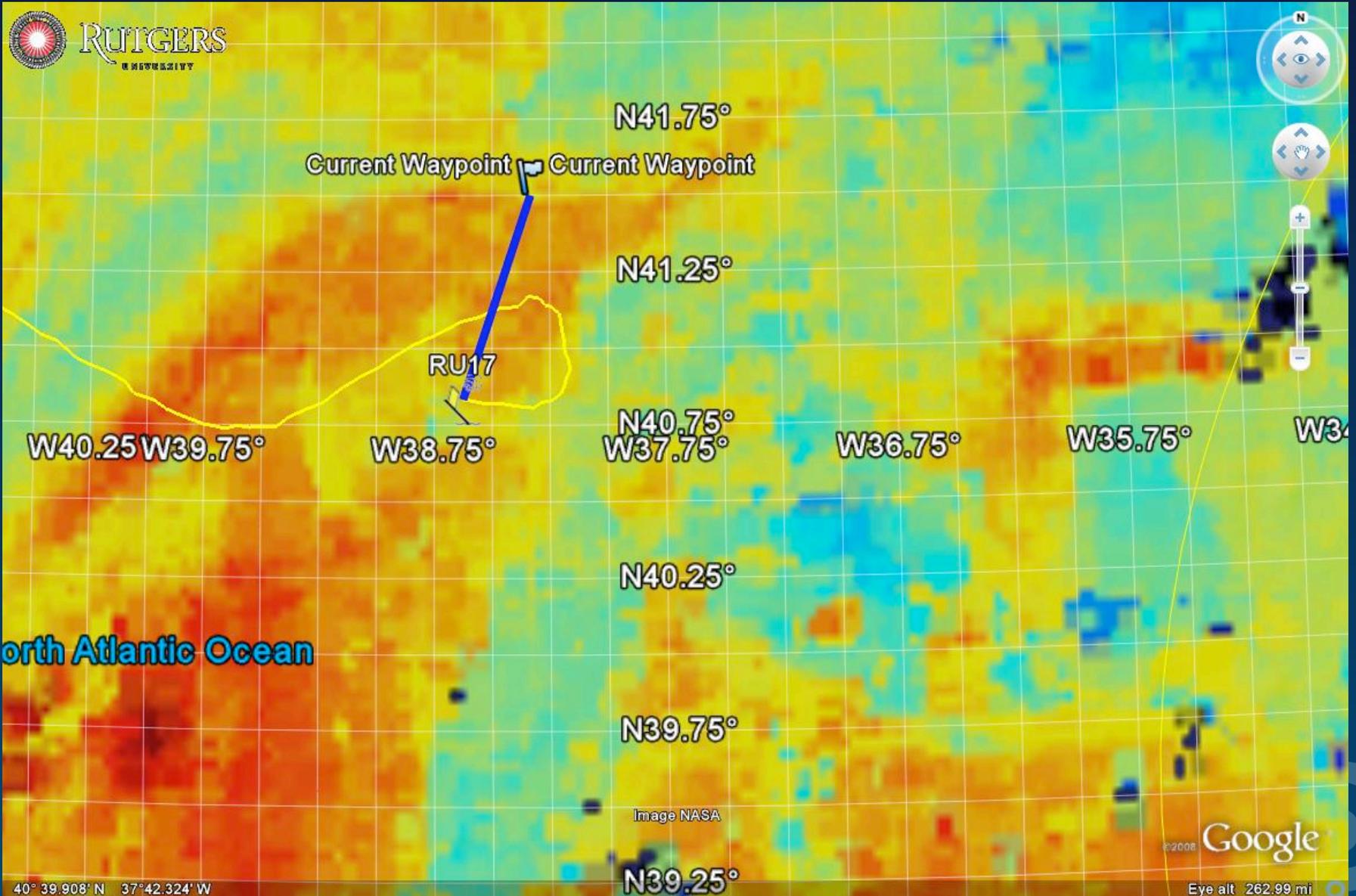
# Flying in Eddies



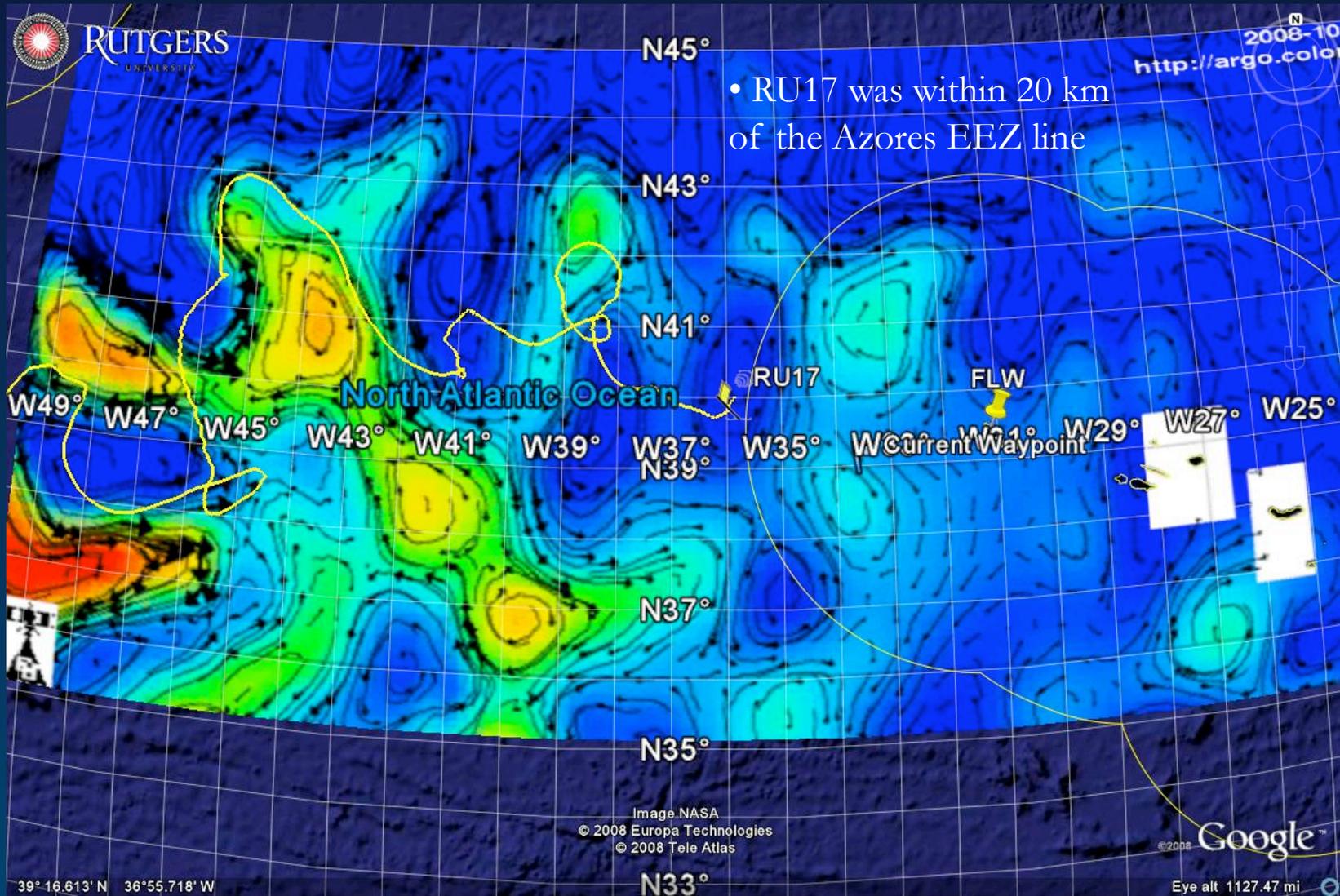
# On July 19<sup>th</sup>, 2008 Tropical Storm Bertha passed over RU17



# On September 22<sup>nd</sup> RU17 gets stuck in an eddy



# On October 28<sup>th</sup> we lost connection with RU17

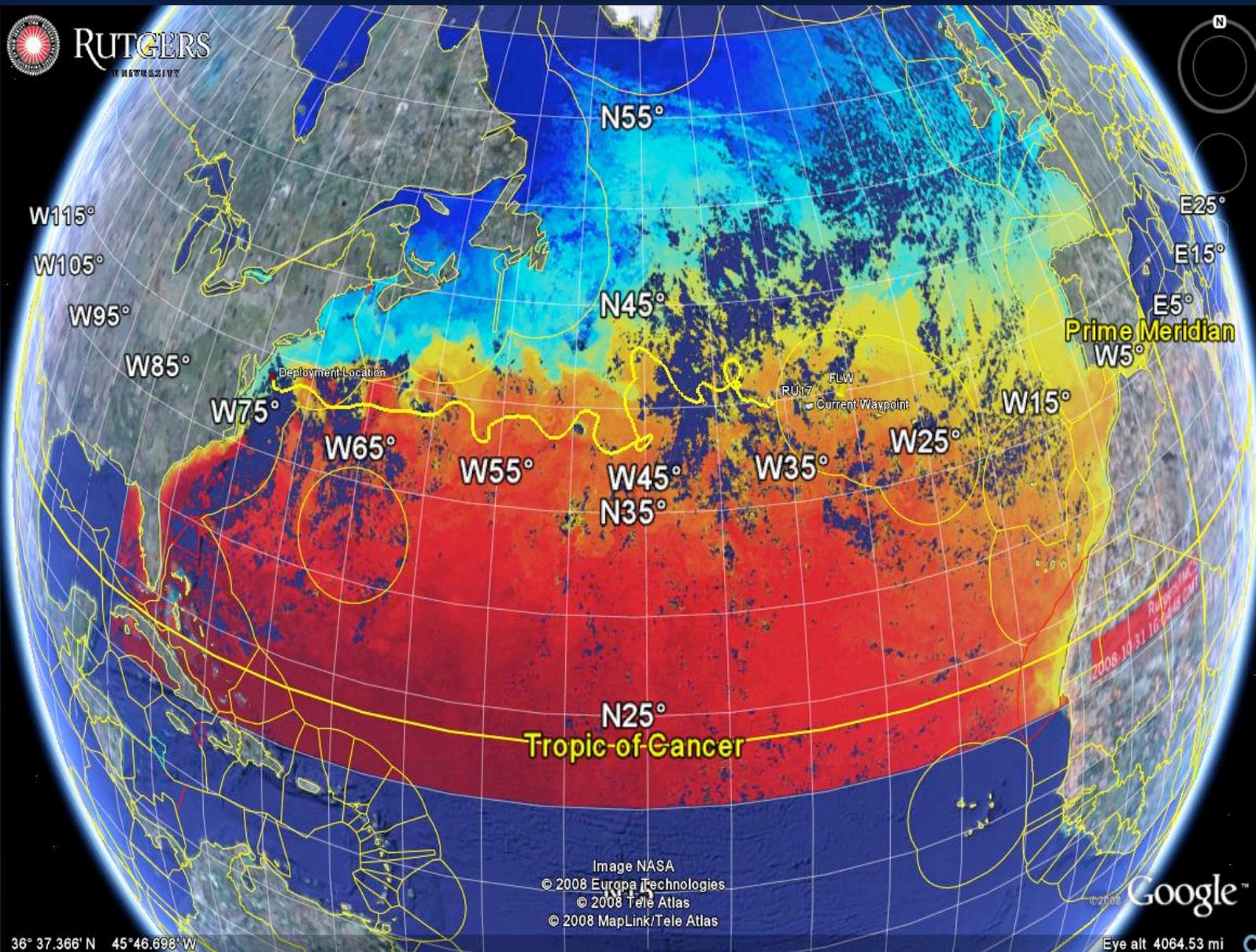


- RU17 was within 20 km of the Azores EEZ line

- Leak detect voltage drops to 0.42 volts
  - Lost connection with RU17

SCIENTIFIC RES

# RU17's full path



# RU17 Accomplishments

- RU17 flew a record breaking distance of 5,700.59 km
- RU17 spent 160 days at sea (5 months and 1 week)
- Increase in student involvement, partnership, and outreach

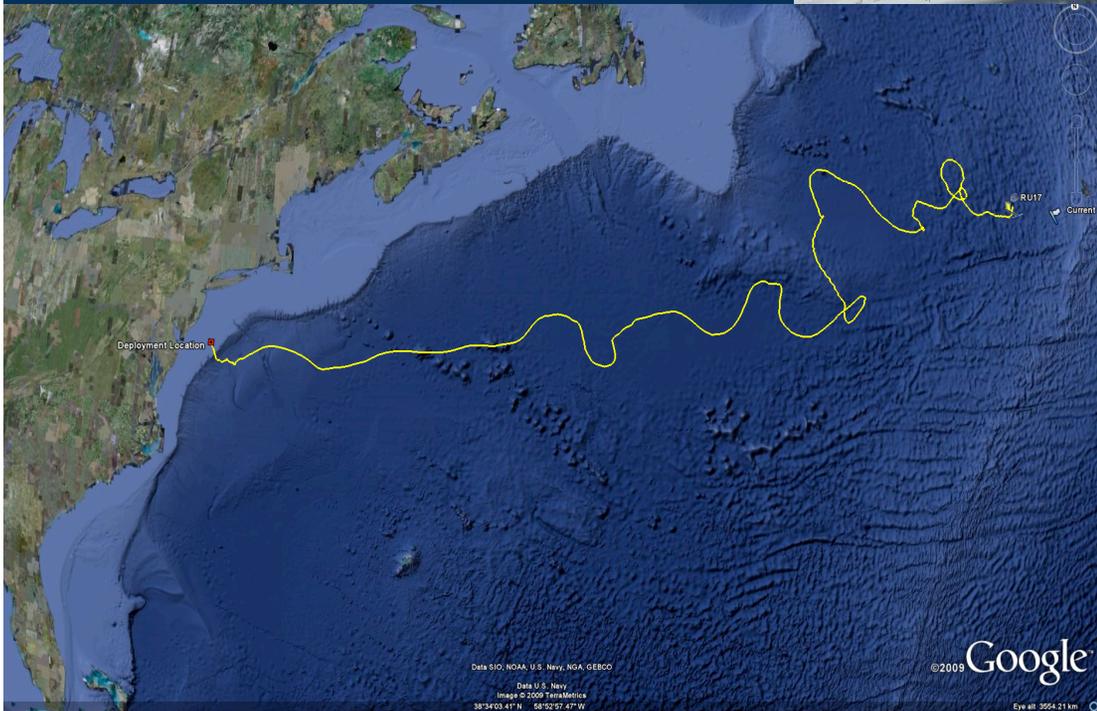


# Changes made to RU27

- Reinforced CTD Mount
  - CTD mounts to glider on both ends so it is sturdier
- Pressure Sensors
  - Now plastic rather than metal to prevent corrosion
- 200 meter pump
  - RU17 had a 100 meter pump
- Biofoul Precautions
  - Rubberized hull coating
  - Biofoul paint
- Aerodynamic Wingrails
- Coulomb Meter
  - Measures the amount of power left in the batteries
- Software
  - Better software for flying deep

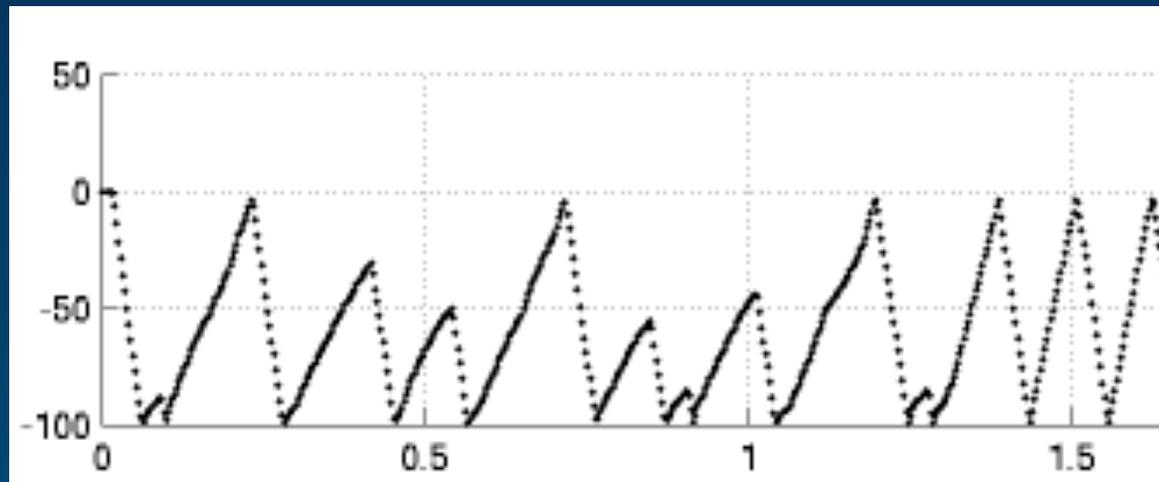


# Biofouling



# Remoras

Remora are visual predators, and cannot see well at night. To help move through the night, they attach themselves to other fish to get a free ride.



# Mission Complete: Scarlet Knight is the first underwater robot to cross an ocean basin

221 Days  
7,409 km  
11,000 Dives  
11,000 Climbs



*Energy equivalent of 8 minutes of power for lights on the Rockefeller Center Tree.*



Tuckerton, New Jersey, USA



Baiona, Galicia, Spain



# Mission Complete: Scarlet Knight is the first underwater robot to cross an ocean basin

*A hero's Welcome, December 9, 2009*



# Documenting the Story

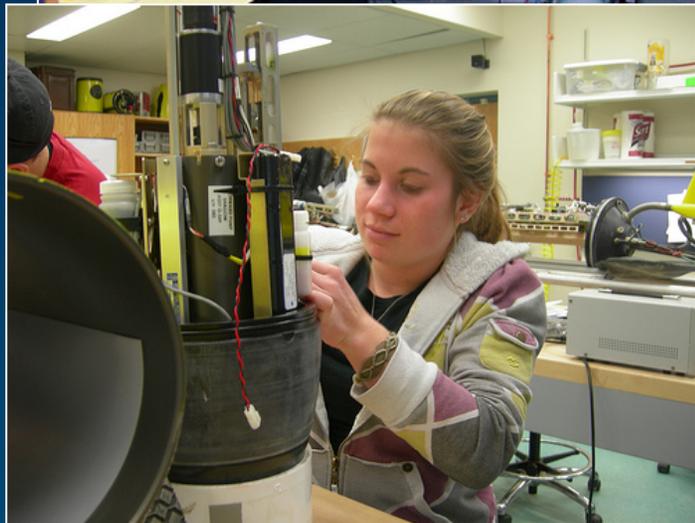
Dena Seidel, Writers House

*Rutgers, The State University of New Jersey*



# Exciting the Next Generation in Science and Engineering

## Building an International Community



# HMS Challenger Mission – 1872-1876

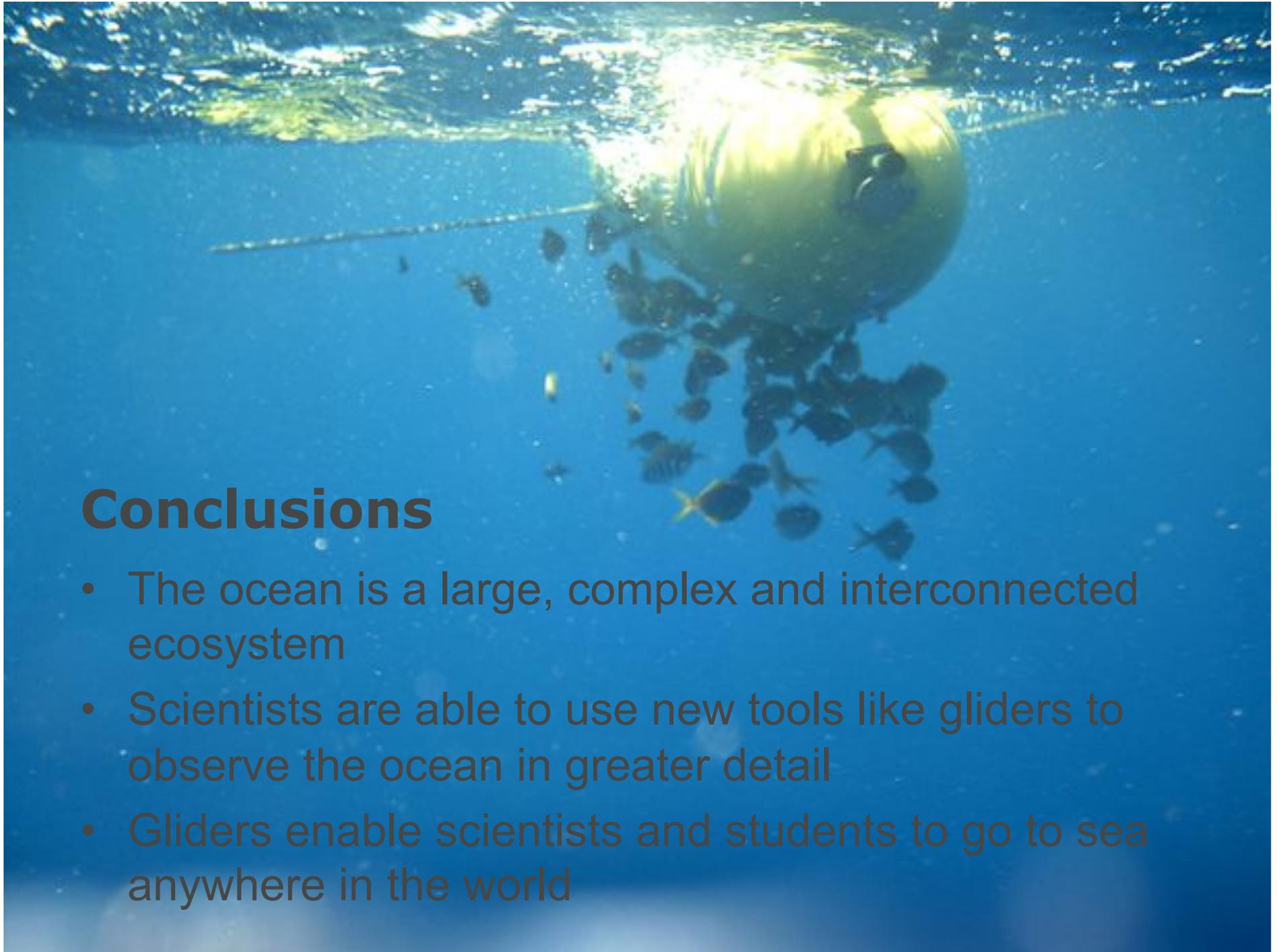
## First Dedicated Global Ocean Science Cruise



Can a globally distributed network of early career scientists & students repeat the Challenger Mission with a coordinated fleet of underwater robotic gliders?



2012 - ????



## Conclusions

- The ocean is a large, complex and interconnected ecosystem
- Scientists are able to use new tools like gliders to observe the ocean in greater detail
- Gliders enable scientists and students to go to sea anywhere in the world