The Challenger Glider Mission: A Collaborative Global Network for Ocean Science and Education

Scott Glenn, Oscar Schofield, Josh Kobut & Janice McDonnell

Rutgers University Coastal Ocean Observation Lab

http://rucool.marine.rutgers.edu/





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<u>Dive</u>: Pump In, Batteries Forward

Glider Flight

Rudder for Steering

<u>Climb</u>: Pump Out, Batteries Back







Glider Communications

GPS for Position, Iridium for 2-Way, ARGOS for Emergencies

Glider Surfaces

2-Way Satellite Communications in Tail

0000000

INA

Data Ribbon Transmitted to Shore





Glider Sensors

Inside Payload Bay or External









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Figure 1: TRDI Explorer DVL





INTEGRATED OCEAN OBSERVING SYSTEM

U.S. Integrated Ocean Observing System



http://ioos.gov

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http://ioos.gov



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MARACOOS Operations Center Rutgers University - Coastal Ocean Observation Lab





Satellite Data Acquisition Stations

CODAR Network

MARACOOS

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Glider Fleet

3-D Forecasts



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Satellite Data Acquisition Stations

MARACO

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3-D Forecasts



Mid-Atlantic Bight HF Radar Network







Regional to Global Scale – High Frequency Radar



Mid-Atlantic Regional Scale HFR Network



Search And Rescue Operational 2009





U.S. National HFR Network



Global HFR Network



Korea & United States HF Radar Collaboration





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Ongoing HF Radar Collaboration with South Korea



MARACOOS Glider Network





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Many Missions, Many Agencies



328 deployments - 135367.44km flown - 6224 days 90 -**60** 30 -0 --30 --60 · -90 -180 -150 -120 -90 -60 -30 180 90 150 60 120 **Rutgers Glider Deployments**



U.S. Navy Operational Fleet - 2011





U.S. IOOS Glider Asset Map

5th EGO Meeting and Glider School

2011 March 14th-18th Gran Canaria /// SPAIN ego2011.plocan.eu



Oceans Institute

Australian National Facility for Ocean Gliders

The Australian National Facility for Ocean Gliders (ANFOG) is a facility of the Australian Integrated Marine Observing System (IMOS).

ANFOG is resposible for the operation and maintenance of the ocean glider fleet.

It has nine autonomous ocean gliders which provide a great opportunity to undertake routine measurements of the oceans and coastal ecosystems at a fraction of the costs associated with shipheard eventame



Emerging Global Glider Network



Korea & United States Antarctic Glider Collaboration











Current Collaborations Between Korea & Rutgers with Gliders Aaron Expedition in 2014 in the Amudsen Sea

Professor Lee Sanghoon will be leading the Araon Expedition in 2014 with a focus on the biological dynamics at the marginal ice zone.





-4 -3 -2 -1 0 1 2 3 4

As part of that effort, Rutgers is Hosting Glider school for Korean scientists June 10-15, 2013.





Trans-Atlantic Glider Challenge – May 24, 2006 – UNESCO E.U./U.S. Baltic Sea Conference in Lithuania

RISING ABOVE THE GATHERING Energizing and STORM

EXECUTIVE SUMMARY

Energizing and C Employing America for a Brighter Economic Future





Dr. Rick Spinrad Assistant Administrator NOAA Office of Oceanic and Atmospheric Research

"I have something you need to do for the good of your country."

"Take one of your gliders, modify it, and fly it across the Atlantic, inspiring students along the way."





Technology Challenges for a Trans-Atlantic Glider Mission







Technology Challenges for a Trans-Atlantic Glider Mission







RU27 Trans-Atlantic Mission: Ocean Model Assessment



Sea Surface Temperature

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Scarlet Knight's Trans-Atlantic Mission Summary



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Same Port where Columbus' *Pinta* made landfall in 1493



Baiona's Mayor unveils Scarlet Knight's Plaque



U.S. & Spanish Secretaries of Commerce





Scarlet Knight's victory lap around the Pinta



Scarlet Knight swarmed by Baiona's school children



Atlantic Crossing: A Robot's Daring Mission

An Award-Winning Feature-Length Documentary by Rutgers Filmmaker Dena Seidel



TV version broadcast over 350 times nationwide on PBS Stations starting April 29, 2011





Dena filming the recovery of RU27 offshore Baiona, Spain



Rutgers Students, Fabien Cousteau & Dena at the Blue Ocean Film Festival



The Scarlet Knight's Ribbon Cutting Ceremony at the Smithsonian: Dec. 9th, 2010 Rutgers Students are



The *Scarlet Knight* in her display case at the Smithsonian's National Museum of Natural History, Ocean Hall, Washington, DC



Rutgers Students share Ocean Exploration stories with Fabien Cousteau



Advice From Some Friends:

Margaret Leinen – Geological Oceanography – Assoc. Provost, Florida Atlantic U. Good news – Geoscience Majors are more likely to remain in their field. Key to success – Mentorship – But there remains a mentorship gender gap.

Shirley Tilghman – Molecular Biology - President, Princeton U. Good news – We know what works. Keys to success – Turn the pyramid upside down. Start living the life of a scientist early. Distribution classes taught within discipline.

<u>Catherine Halversen</u> – Lawrence Hall of Science – NSF COSEE has resources.

<u>Chris Parsons</u> – Word Craft – Don't forget to layer-on the assessment cycle.













Needs Assessment

- Example: How should universities educate the future ocean workforce?

• <u>Graduate Programs:</u> need strong science/math backgrounds, and increasingly look for research experience.

• *Federal Agencies*: Also needs Bachelors & Masters graduates. Not just Ph.D. Researchers.

• <u>Companies</u>: seeking people with a range of technical abilities and Team Working Skills. Not just Ph.D. Researchers.

MATES & NPS Assessment of Marine related Jobs

• Nationally in 2007, only 4000 (0.3% of the 1,542,000) Bachelors Degrees were in Earth/Ocean/Atmospheric Sciences.

• Need to increase STEM interest within a diverse K-12 pipeline.

• Provide Undergrads real-world working-team experience. Cognitive Apprenticeship.

• Strong written and verbal communication skills emphasized by employers

• Cross-disciplinary training highly desired (Oceanography combined with other disciplines Atmospheric Science, Computer Science, Engineering, Economics, Communication, Foreign Language)

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Workforce of future industries



Formative Assessment – Continuous Re-evaluation and Redesign of: Cognitive Apprenticeship Model: *Watch One > Do One > Teach One*

Ocean Observatories Research Course



Dark blue are the students in the light blue course





Summative Assessment – Did we have an impact?



Ocean Observatories Course

Spring 2012 Course: >70 Students



Increase in Number & Scope of Research Internships

Locations: Australia, Antarctica, Svalbard, Spain, Canaries, Azores, California, Florida, New Jersey

Sponsors: NSF, DHS, Alumni

Number of Marine Science Majors



Trans-Atlantic Glider Challenge – May 24, 2006 – UNESCO E.U./U.S. Baltic Sea Conference in Lithuania



Innovate, Incubate, Integrate **noaa research**



Dr. Rick Spinrad Assistant Administrator NOAA Office of Oceanic and Atmospheric Research

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Glider Research Course 80 70 **Students** 50 40 30 Trans-Atlantic Glider Challenge 20 of 10 # 0 2006 2007 2008 2009 2010 2011 2012 2013 Years



A Global Challenge – The Challenger Glider Mission December 9, 2009 – Baiona, Spain



Ralph Rayner & Rick Spinrad's Global Challenge:

Build a Global Glider Fleet and Coordinate the First Robotic Circumnavigation.

Revisit the Historic Track of the HMS Challenger – And inspire a global network of students along the way.



HMS Challenger Voyage First Scientific Circumnavigation 1872-1876



128,000 km =

= 16 gliders x 8,000 km/glider









Operational Models for Global Circulation and Heat Transport





Science & Education **Drivers**

How accurate are these global models? Do I need to embed a regional model? How much data do I need to assimilate?

Broaden the workforce Improve ocean literacy Develop a global perspective



National Weather Service

http://polar.ncep.noaa.gov

/global/nctest/viewer.shtml



Global Challenger Glider Mission



5 Ocean Gyres: 16 gliders x 8,000 km/glider = 128,000 km

MARACOOS

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Ocean Observatories Research Course: Spring 2013 Project Titles

- 1. Exploring the South Atlantic
- 2. Challenger Mission Hazards
- 3. Antarctic Circumpolar Currents
- 4. Challenger Mission: The Pacific Leg
- 5. MAB Spring Bloom: A Game of Oxygen
- 6. Challenger Path Planning with Migratory Patterns
- 7. Antarctic Sea Ice: A Comprehensive Look at the Impact of Sea Ice
- 8. Changes in the Trophic Structure, Species Richness & Biodiversity in Antarctica
- 9. Comparing the RTOFS (U.S.) & MyOcean (Euro) models with Global Gliders Missions







Ocean Observing Initiative (OOI) Education and Public Engagement (EPE) Concept Maps generated for each team project.









Challenger Pacific Leç Roadmari





Reviewed with Students by Fabian Cousteau.





Dr. Louis Uccellini, Director National Weather Service

Crowd-sourced comparisons between U.S. & European Models & Gliders





SALINITY 8 APR 2013 Visualization by Universidad de Las Palma de Gran Canaria









Model-Glider comparisons of the Amazon outflow fresh water distribution with NSF OOI EPE Visualization Tools.



Companion Course at **Plataforma Oceanica de Canarias**

- Shared Glider Missions Iceland to Azores;
 Azores to Canaries; Canaries to Brazil?
- Skype Sessions between classes
- Two-way International Exchange programs
- Students Learn Science from their teachers
- Students Learn Culture from their peers











North Atlantic Gyre: Silbo

Deployments: 3 Initial Deployment: June 23, 2011 Days at Sea: 164 + 76 + 294 = 534 Kilometers Flown: 10,404 Speed: 20 km/day

Temperature









Date (mm/dd

700

800 -





State Geographe 13 MapLink 13 Google

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Challenger Glider Mission: South African Launch of RU29 University of Cape Town, Nansen-Tutu Centre





Students Sinekhaya, Ashley, JP Launch Challenger

Challenger rides an eddy



Glider Challenger (RU29): >192 km since January 11, 2013



South Atlantic Gyre: Challenger

Initial Deployment: Jan. 11, 2013 Days at Sea: 124 Kilometers Flown: 3,033 Speed: 24 km/day

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US Dept of State Geographer © 2013 MapLink © 2013 Inav/Geosistemas SRL SIO, NOAA, U.S. Navy, NGA, GEBEO

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Googlerearth

INTEGRATED OCEAN OBSERVING



Korean & United States Potential Collaborations





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Conclusions:

- MARACOOS / IOOS has developed and sustained a Regional Scale Observation & Forecasting System.
- Demonstrated value for Science & Education.
- Global HF Radar & Glider Networks are emerging.

Challenger Glider Mission:

- 2 Gliders deployed
- Leverage existing programs
- Build a global community

http://challenger.marine.rutgers.edu



