IOOS INTEGRATED OCEAN OBSERVING SYSTEM

OOI OCEAN OBSERVATORIES INITIATIVE

The Ocean is Our Classroom -

Expanding Opportunities for Undergraduate Science Education

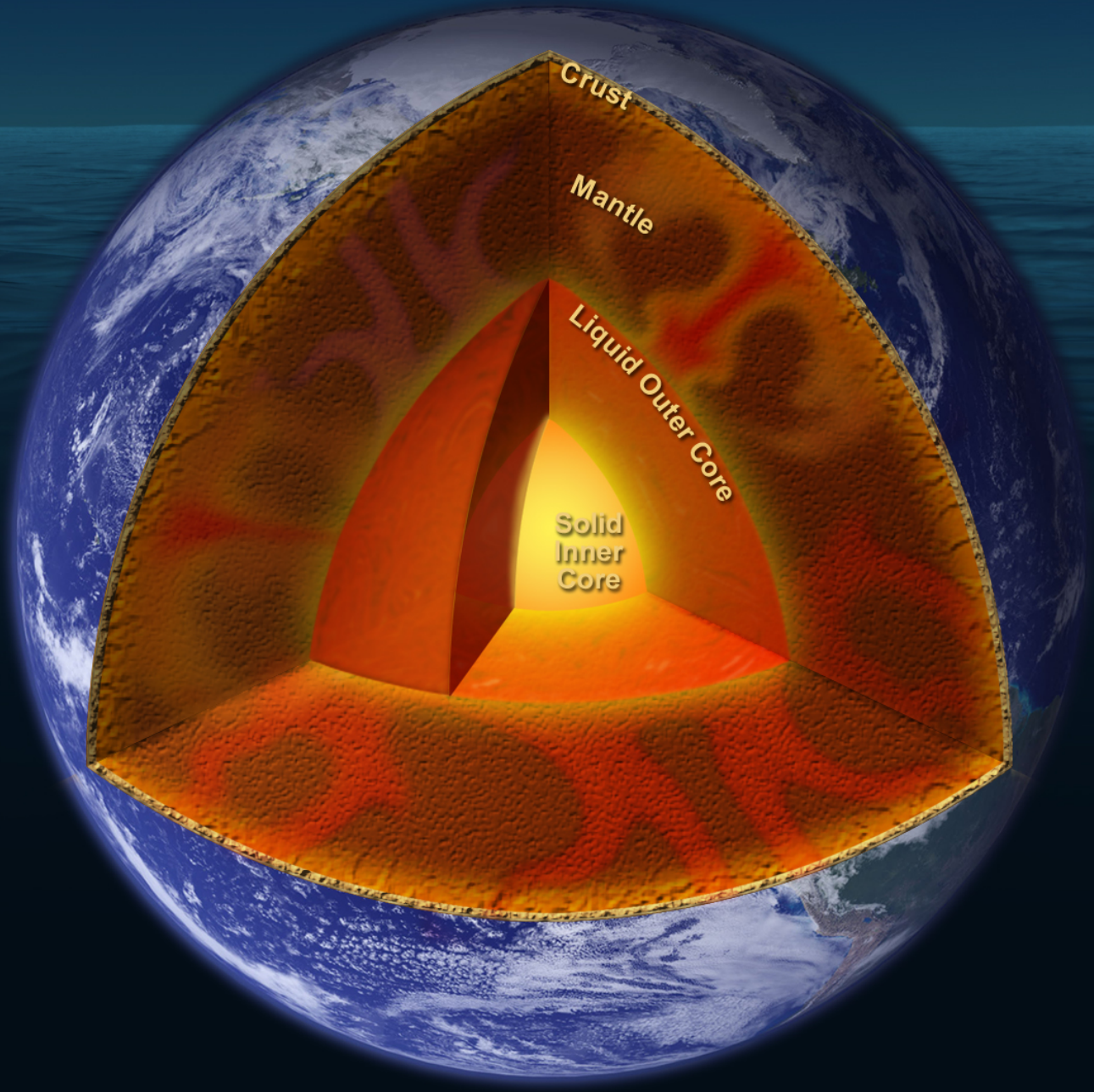
Professors Scott Glenn, Oscar Schofield & John Delaney

Rutgers University, New Brunswick, New Jersey, USA &
University of Washington, Seattle, Washington, USA

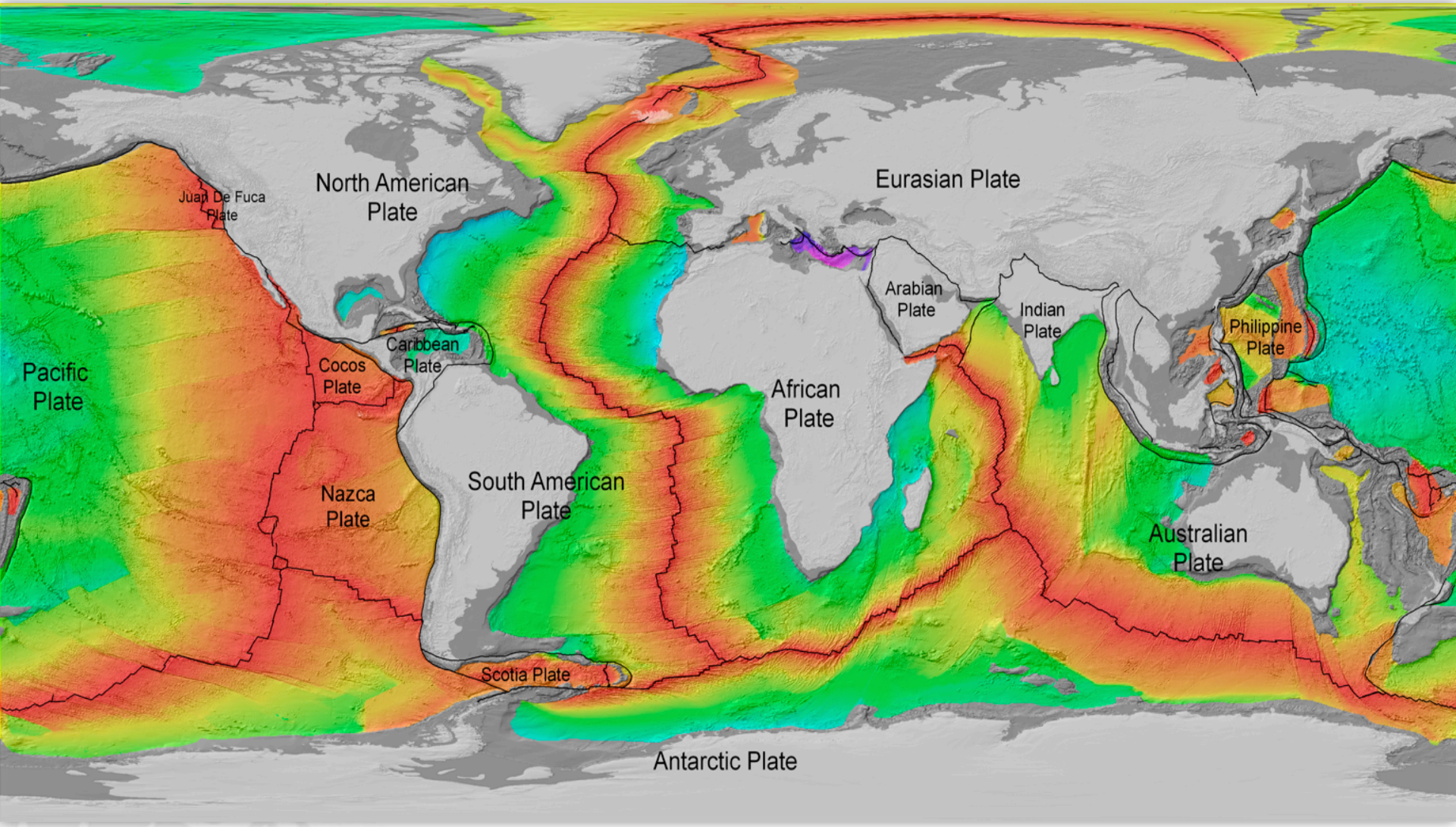
The Earth System

Our Grand Challenge:
To optimize the benefits and mitigate the risks of living on a planet driven by two basic energy sources -

Internal Energy

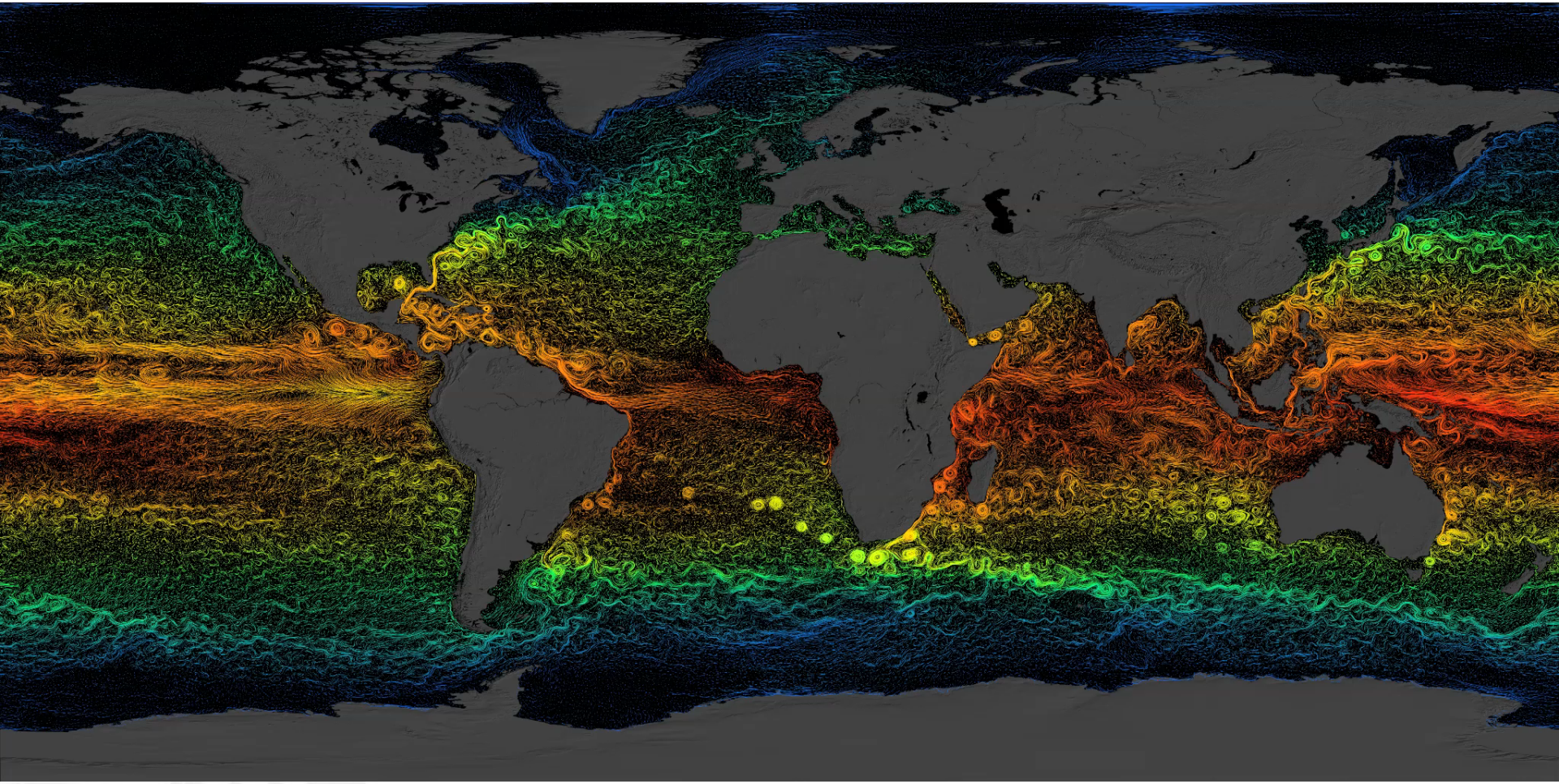


Geologic Plates that define the Ocean Basins

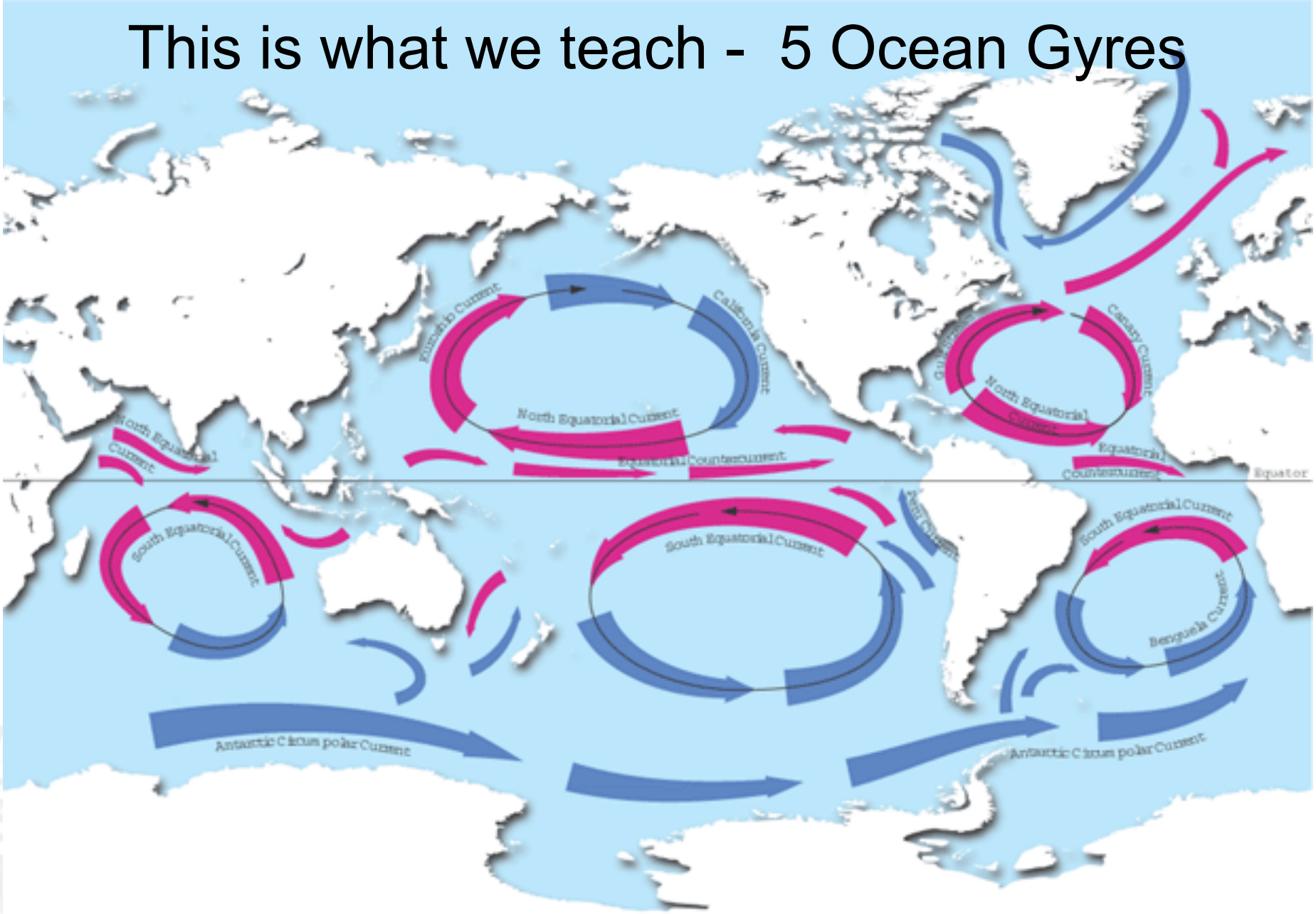


Solar Energy

Global Circulation that defines the Ocean Gyres



This is what we teach - 5 Ocean Gyres



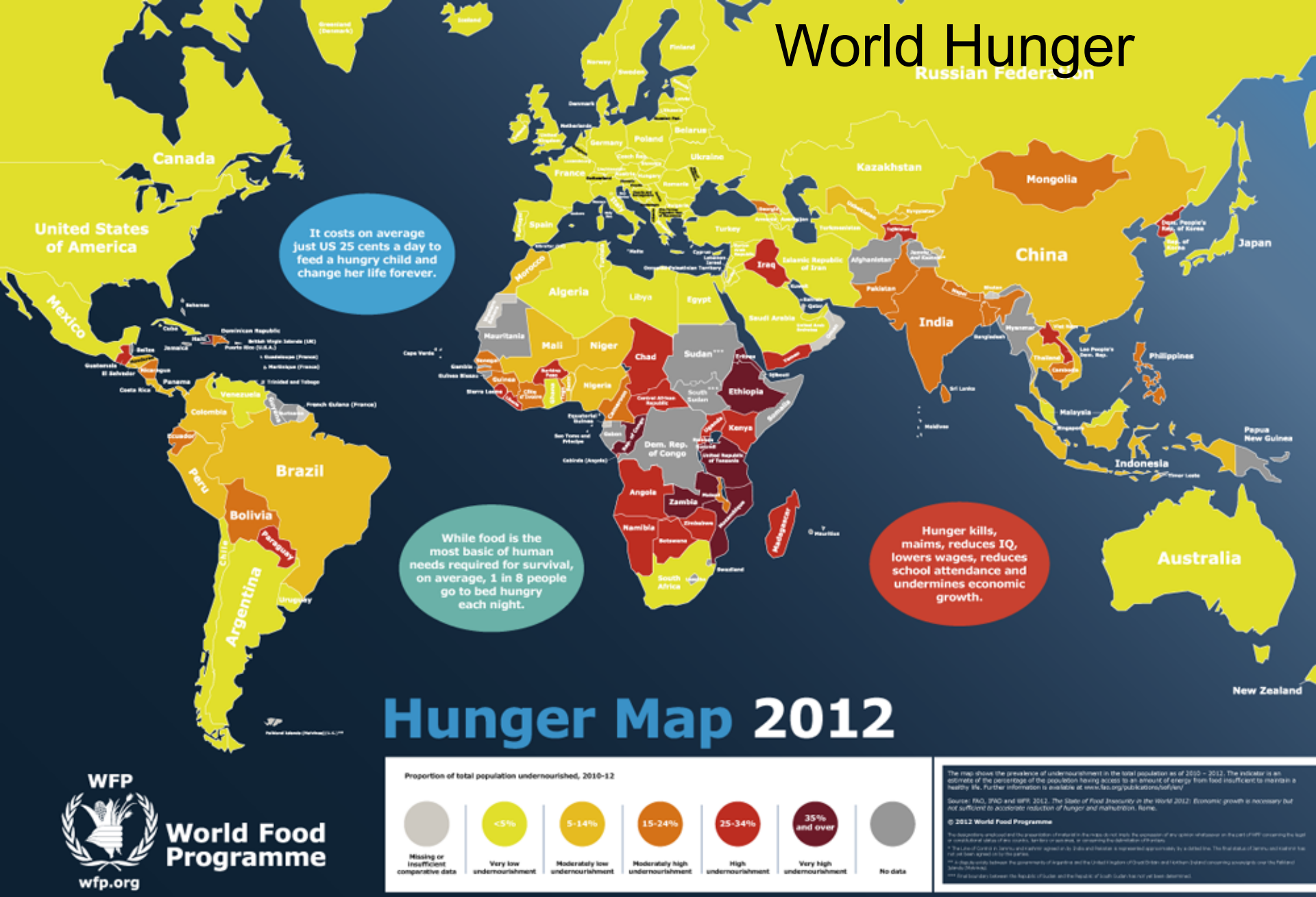
The Earth at Night as Observed from Space

Data Source: Defense Meteorological Satellites Program

The Earth at Night based on Global Population

Data Source: SEDAC

World Hunger



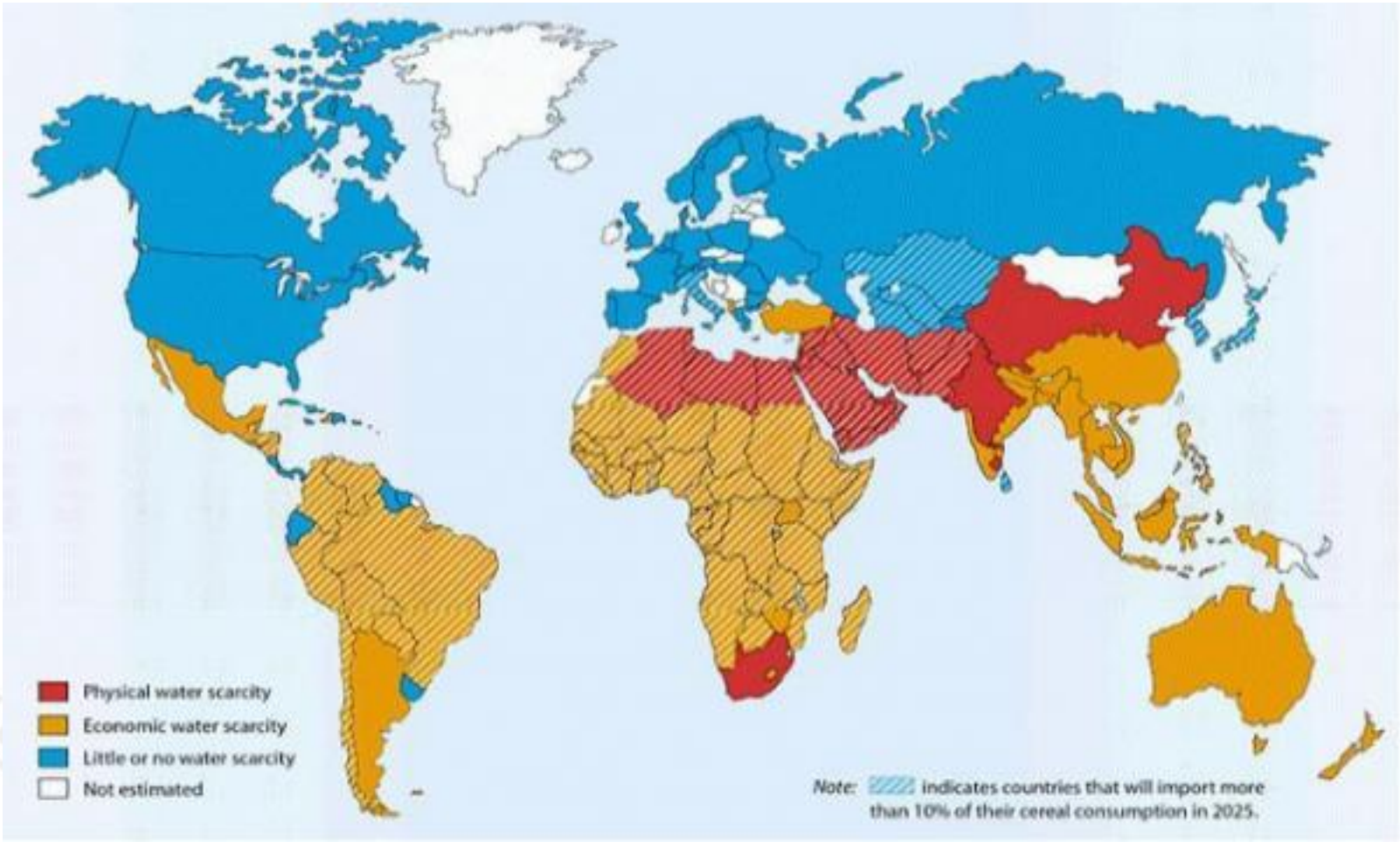
Hunger Map 2012

WFP World Food Programme
wfp.org

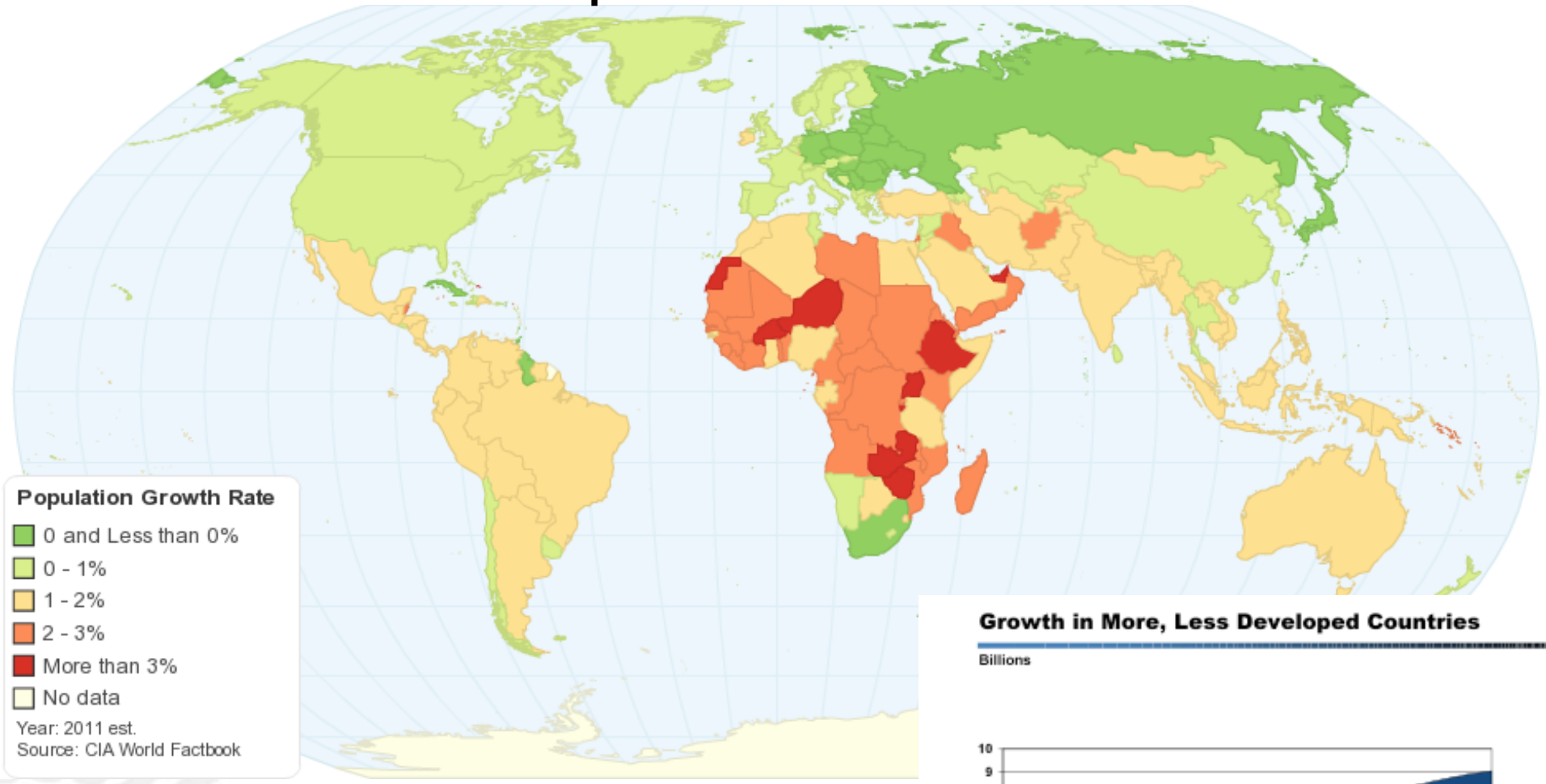
The map shows the prevalence of undernourishment in the total population as of 2010 – 2012. The indicator is an estimate of the percentage of the population having access to an amount of energy from food insufficient to maintain a healthy life. Further information is available at www.fao.org/publications/sofi/en/

Source: FAO, IFAD and WFP. 2012. *The State of Food Insecurity in the World 2012: Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition.* Rome.

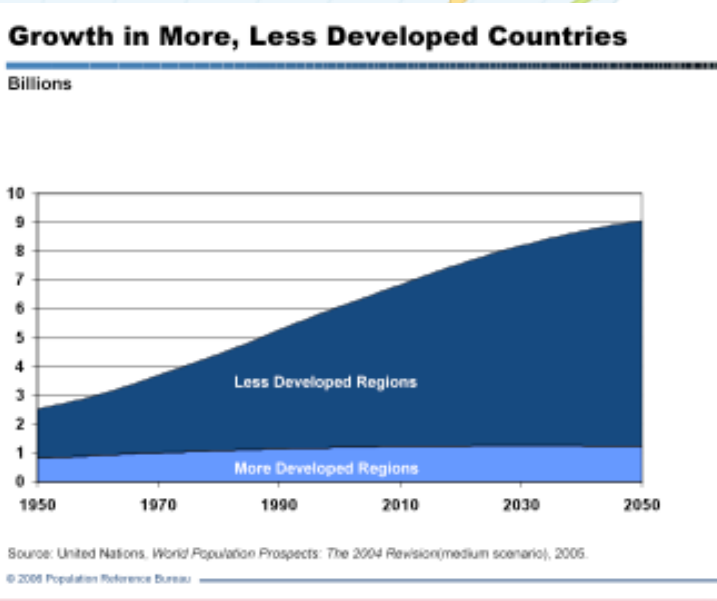
Global Water Scarcity



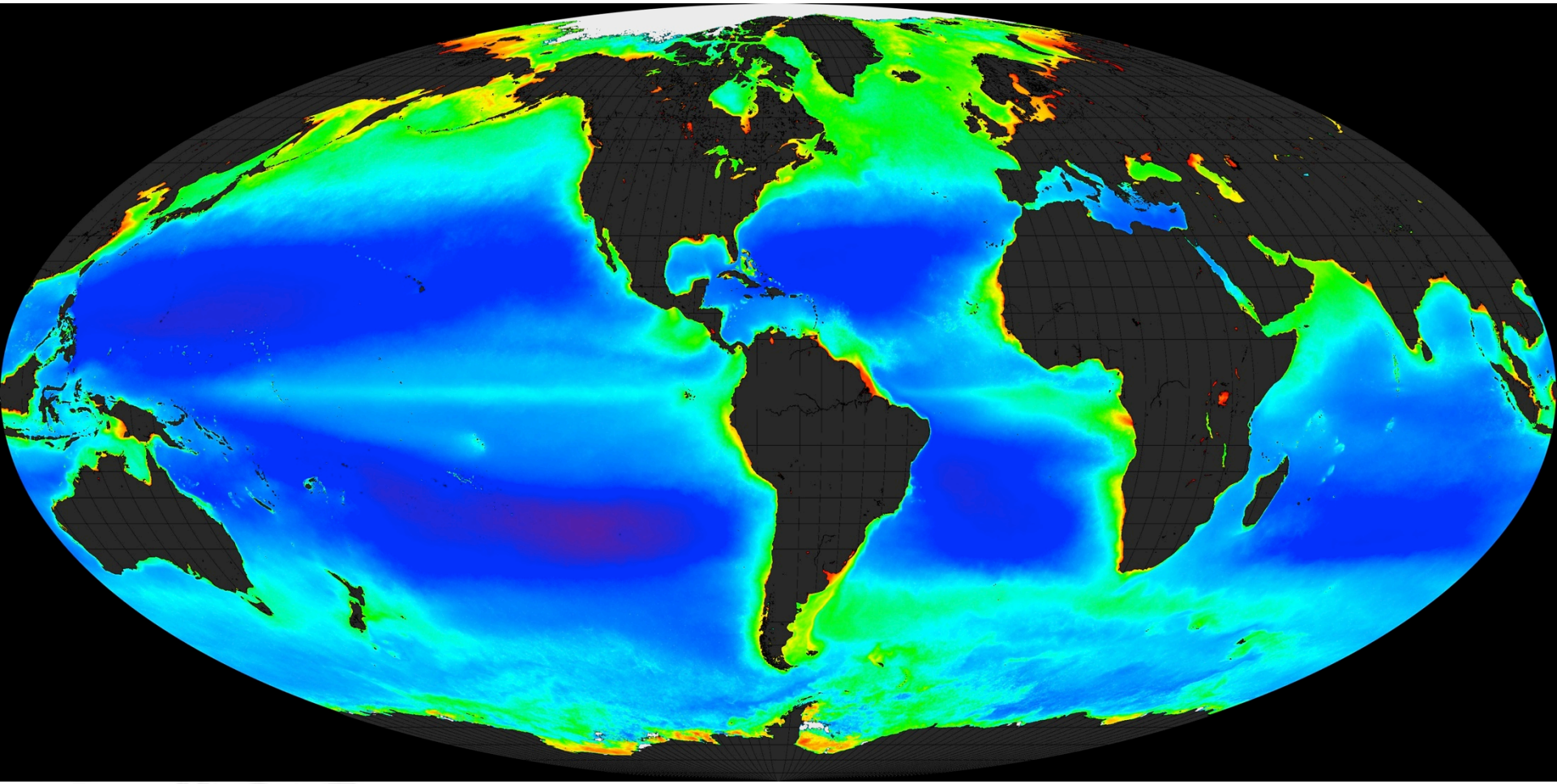
Global Population Growth Rates



From 7 Billion to 9 Billion People by 2050
Concentrated in less developed countries



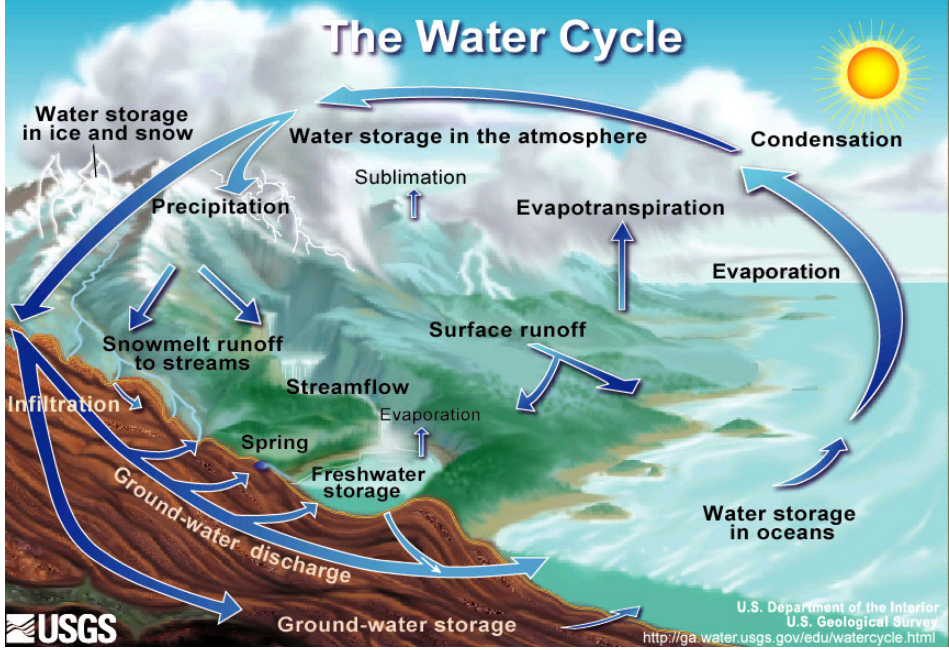
Global Phytoplankton from Space



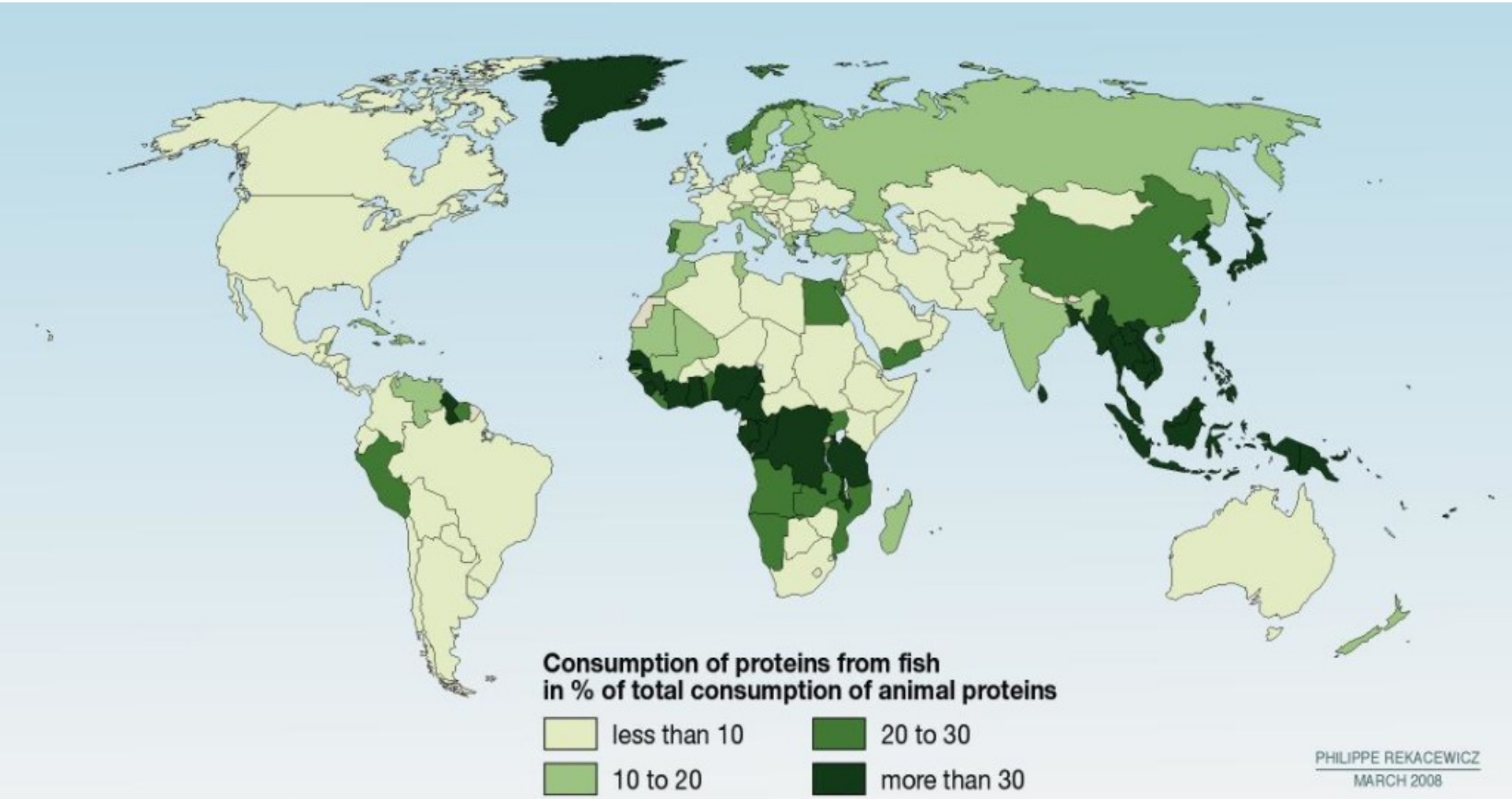
50% of the oxygen we breathe is from the ocean

The Ocean:

- Covers 71% of the Earth's surface
- Contains 97% of the Earth's water
- Dominates the Earth's Water Cycle



Global Fish Consumption



Source: Earthtrend database, World Resources Institute (WRI), Washington ; Faostat, Food and Agriculture Organization of the United Nations (FAO).

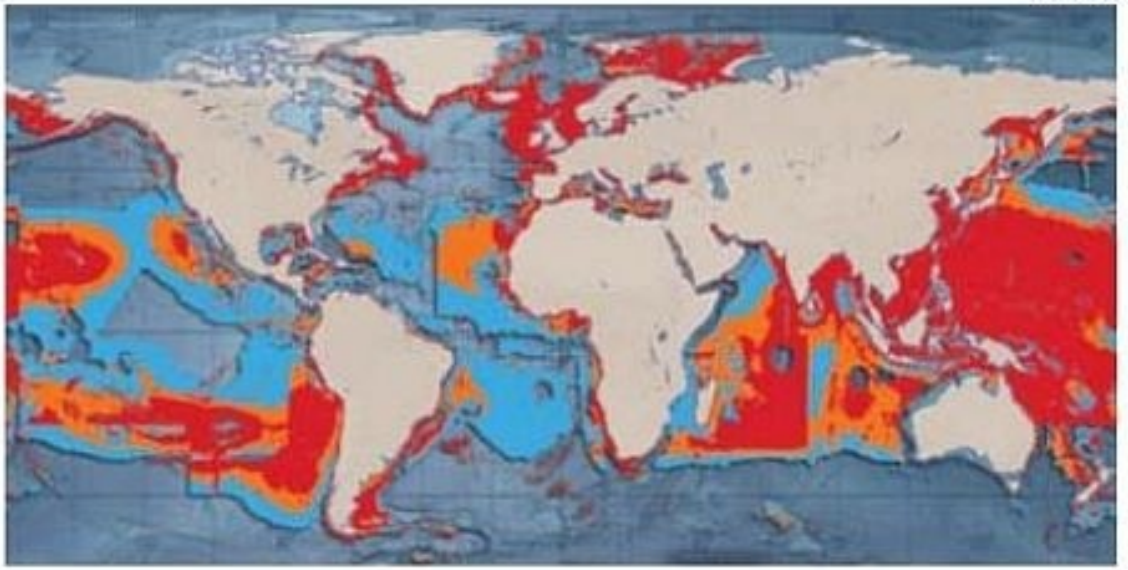
Shift in Overfishing from Local to Global

"In the last 50 years we have lost 90 percent of the big fish in the sea."

- Sylvia Earl
- Time Magazine's 1st Hero for the Planet
- St. Petersburg Junior College (1953)

1950

2006



Key

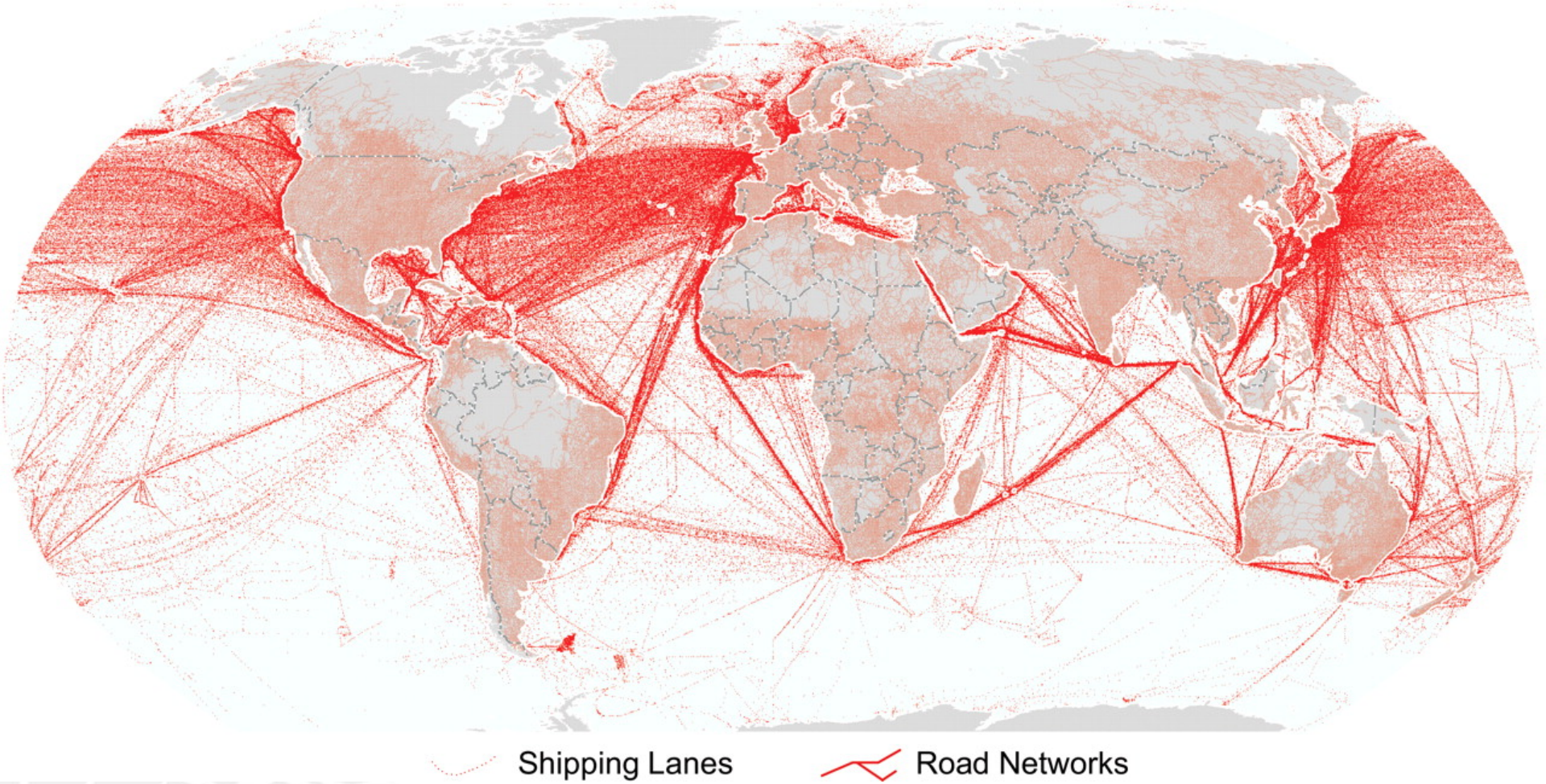
- At least 10% PPR extraction
- At least 20% PPR extraction
- At least 30% PPR extraction

PPR is a value that describes the total amount of food a fish needs to grow within a certain region.

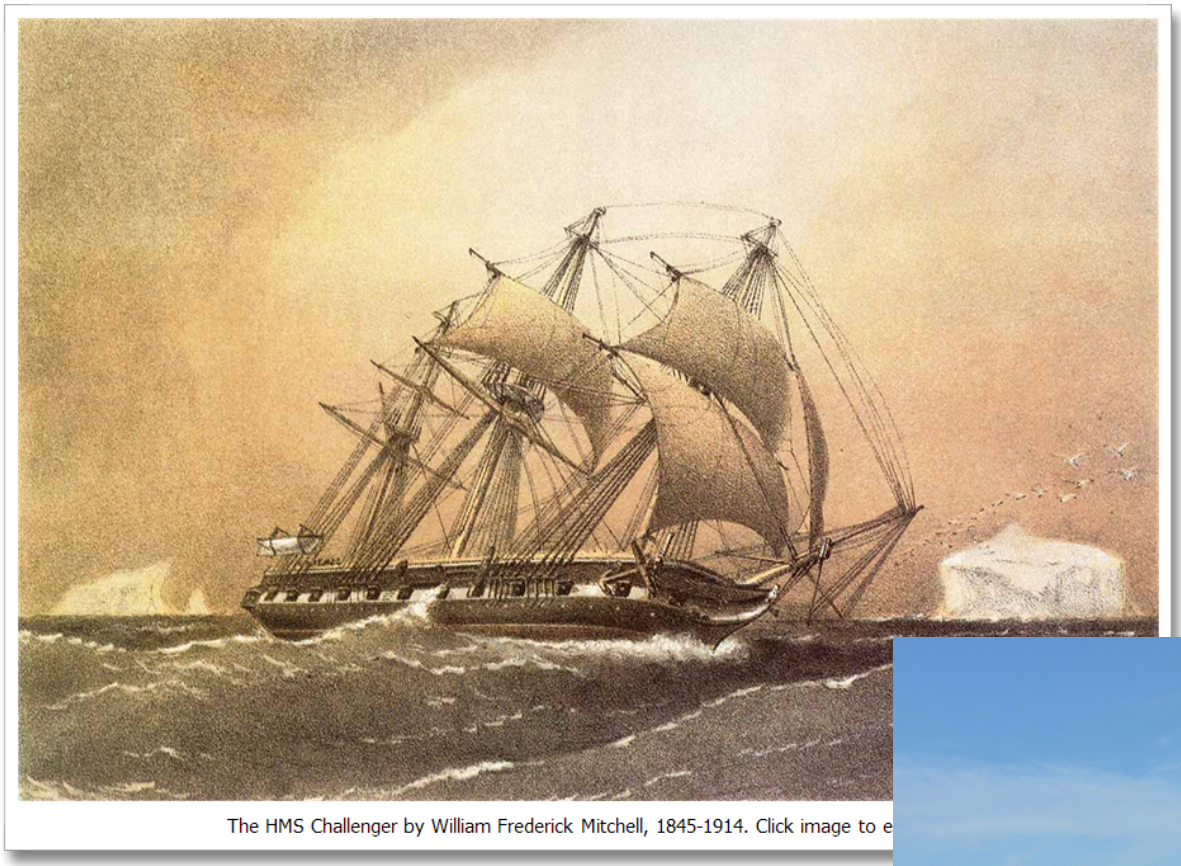
Figure 51: The expansion and impact of world fishing fleets in a) 1950 and b) 2006

RUTGERS

Global Commerce Depends on Maritime Shipping



95% of the Ocean remains Unexplored



The HMS Challenger by William Frederick Mitchell, 1845-1914. Click image to e

HMS Challenger
1872-1876
Telegraph

First Ocean Science
Circumnavigation

Okeanos Explorer
2010 -> Future
Telepresence

The Historic Flight of RU27: *The Scarlet Knight*

The First Underwater Robot to Cross the Atlantic

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

Scott Glenn

Coastal Ocean Observation Lab
Institute of Marine and Coastal Sciences
School of Environmental and Biological Sciences
Rutgers, The State University of New Jersey

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

What is a Robotic Underwater Glider?

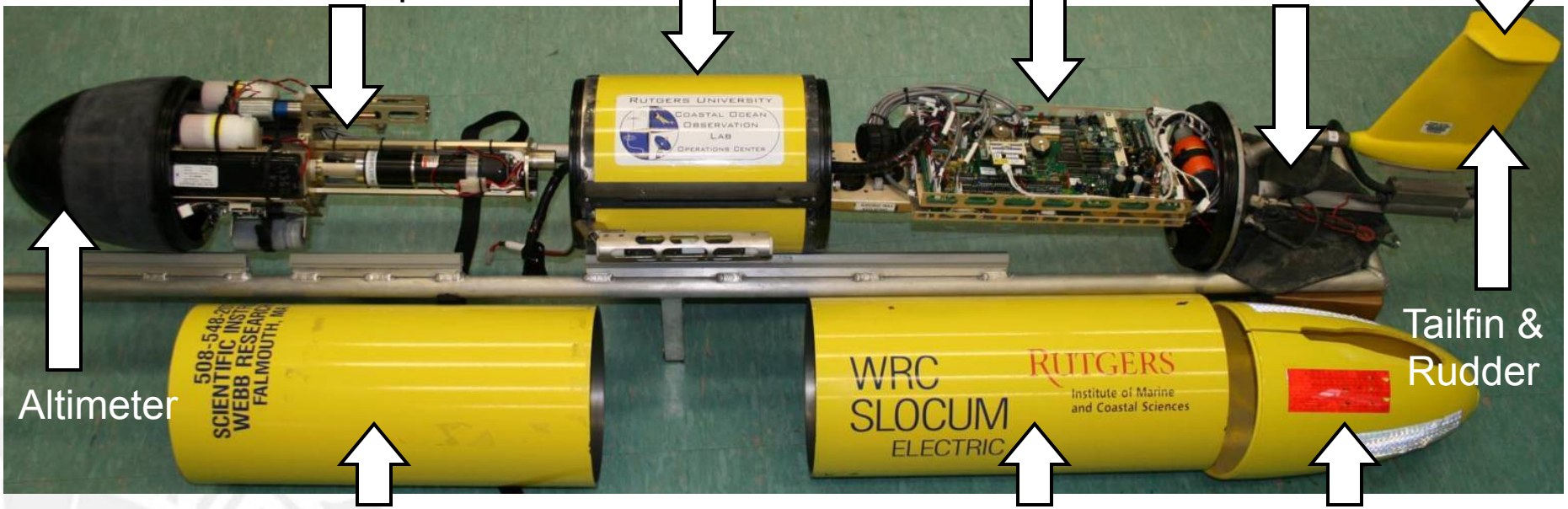
Antenna
(Iridium, Freewave,
GPS & Argos)

Buoyancy
Pump

Science
Payload Bay

Control
Board

Air Bladder



Altimeter

Tailfin &
Rudder

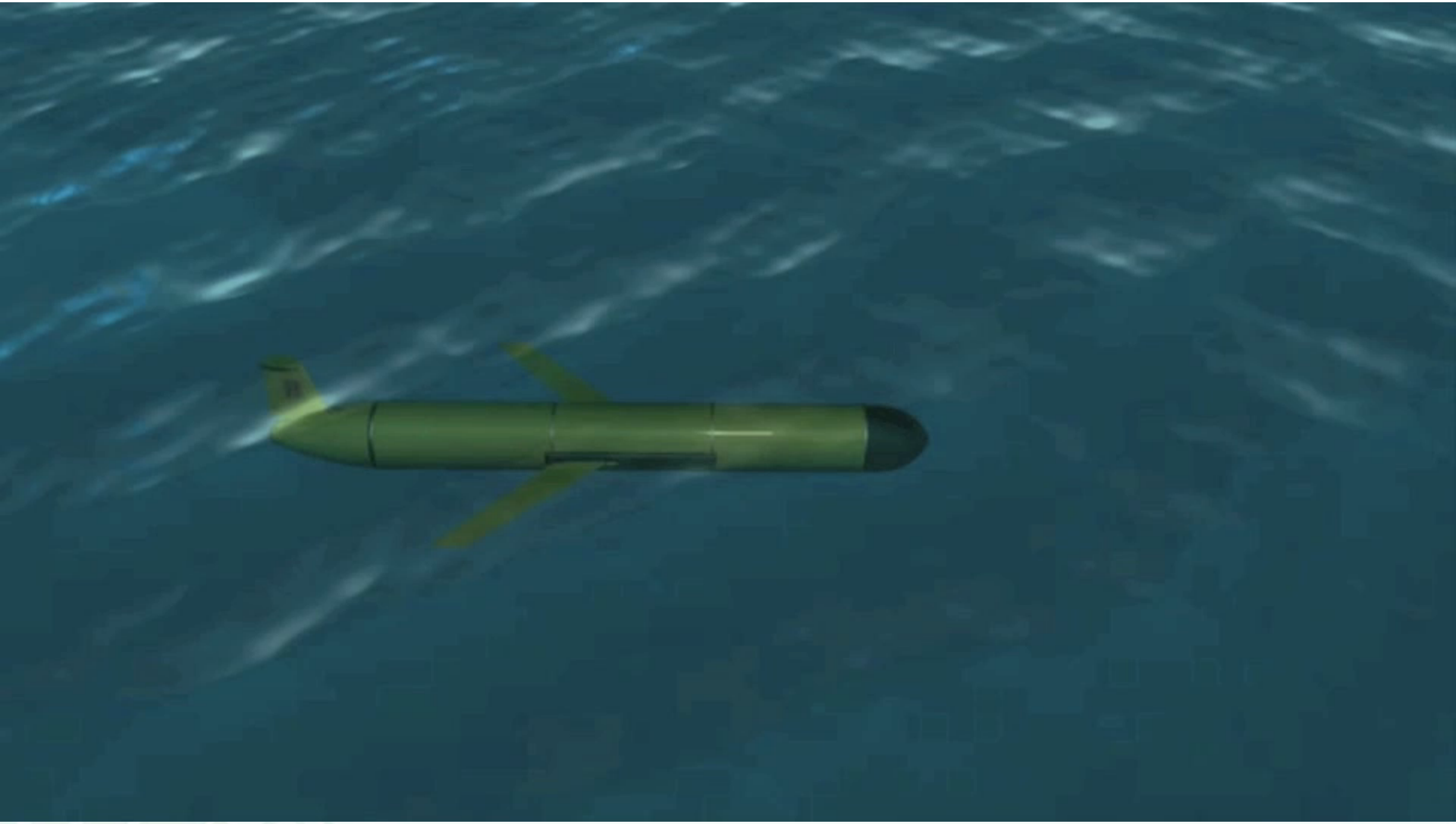
Fore Hull

Aft Hull

Cowling

Glider Diving Behavior

Buoyancy Pump pulls water in, Batteries are pushed forward



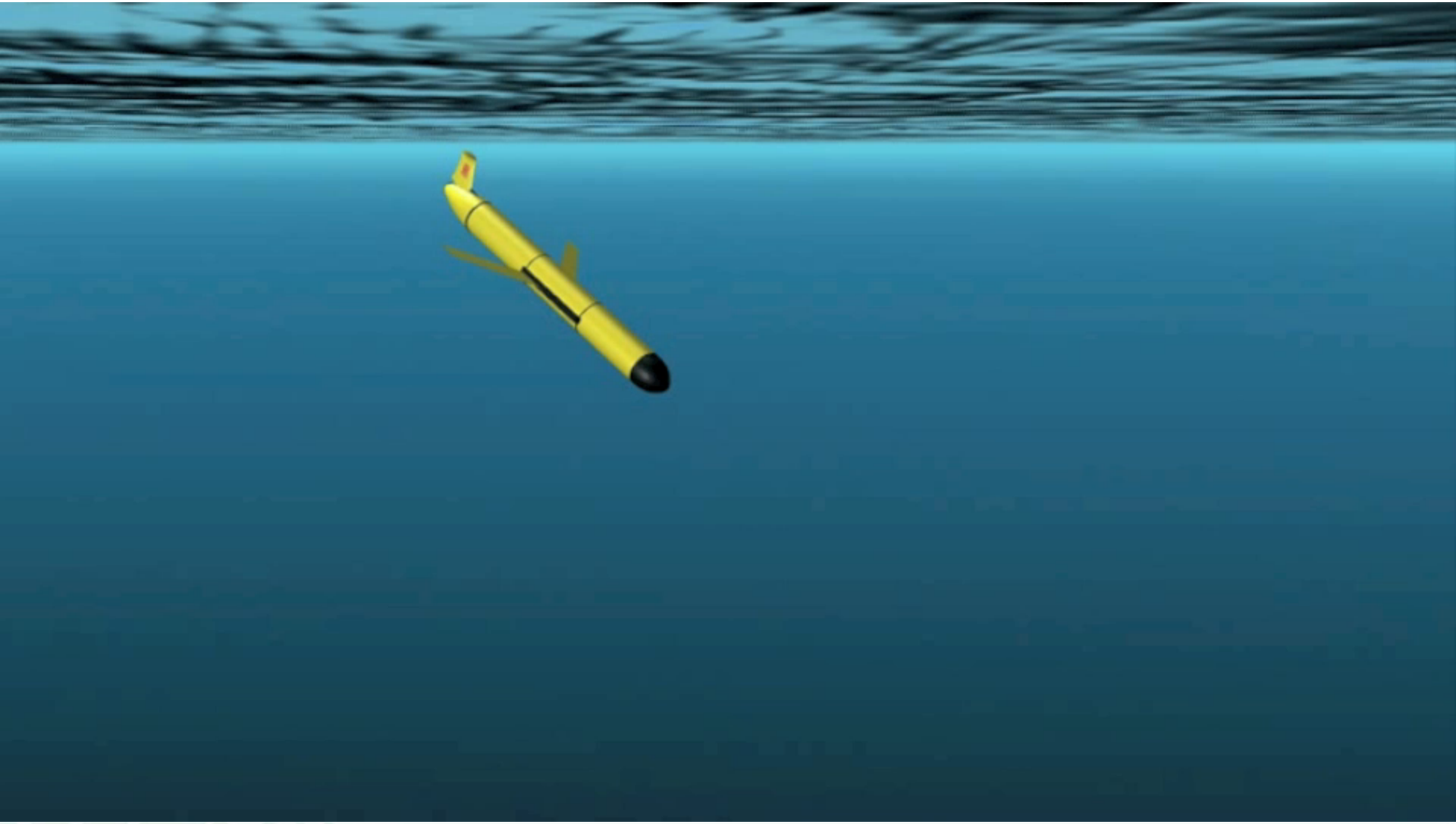
Glider Underwater Navigation

Rudder used to steer a compass heading

Glider Climbing Behavior

Buoyancy Pump pushes water out, Batteries are pulled back

Glider Flight Path & Communications
Alternating Dives & Climbs, Surfacing to Phone Home

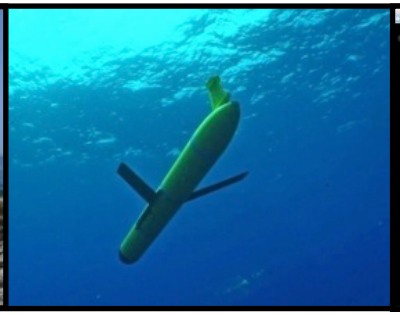


Observatory Operations Center

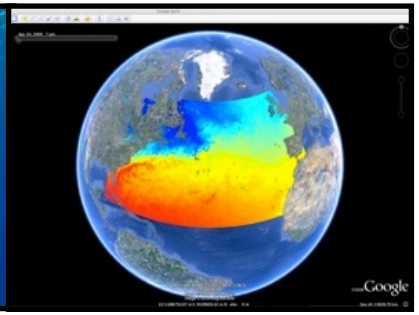
Rutgers University - Coastal Ocean Observation Lab

Satellite Data Acquisition Stations

CODAR Network

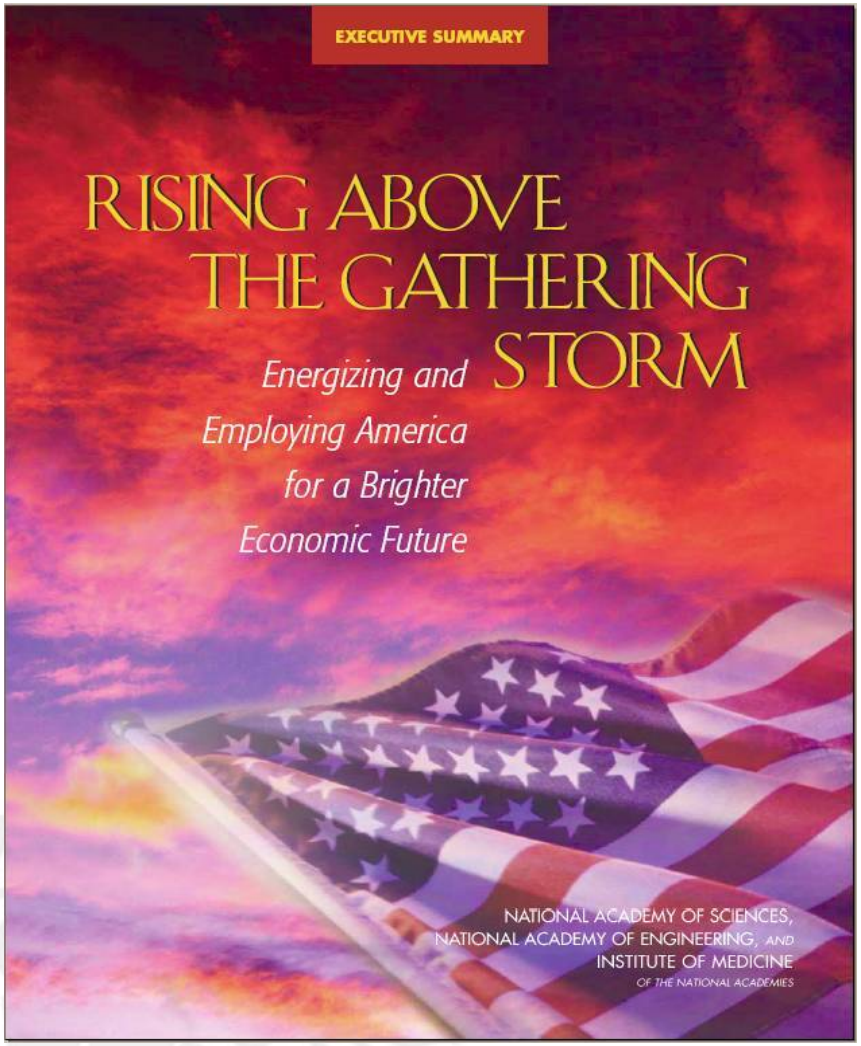


Glider Fleet



3-D Forecasts

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



Innovate, Incubate, Integrate
noaa research
NOAA's OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

Dr. Rick Spinrad

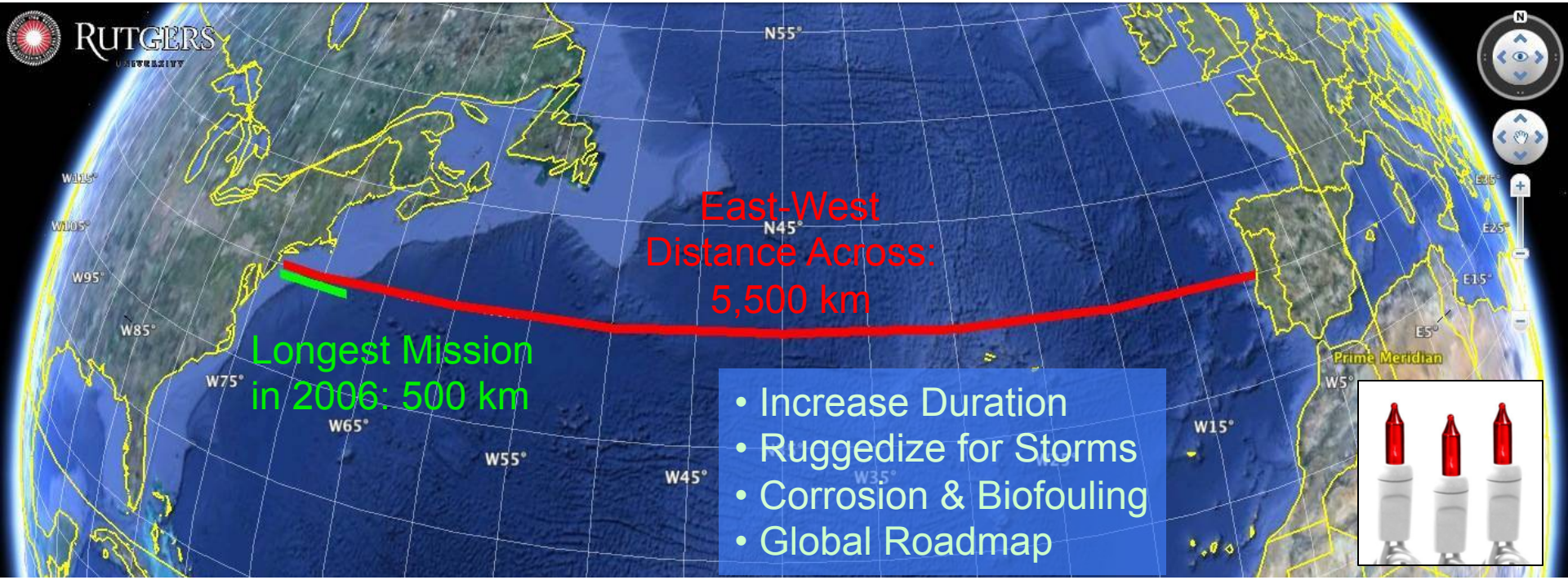
Assistant Administrator

NOAA
Office of Oceanic and Atmospheric Research

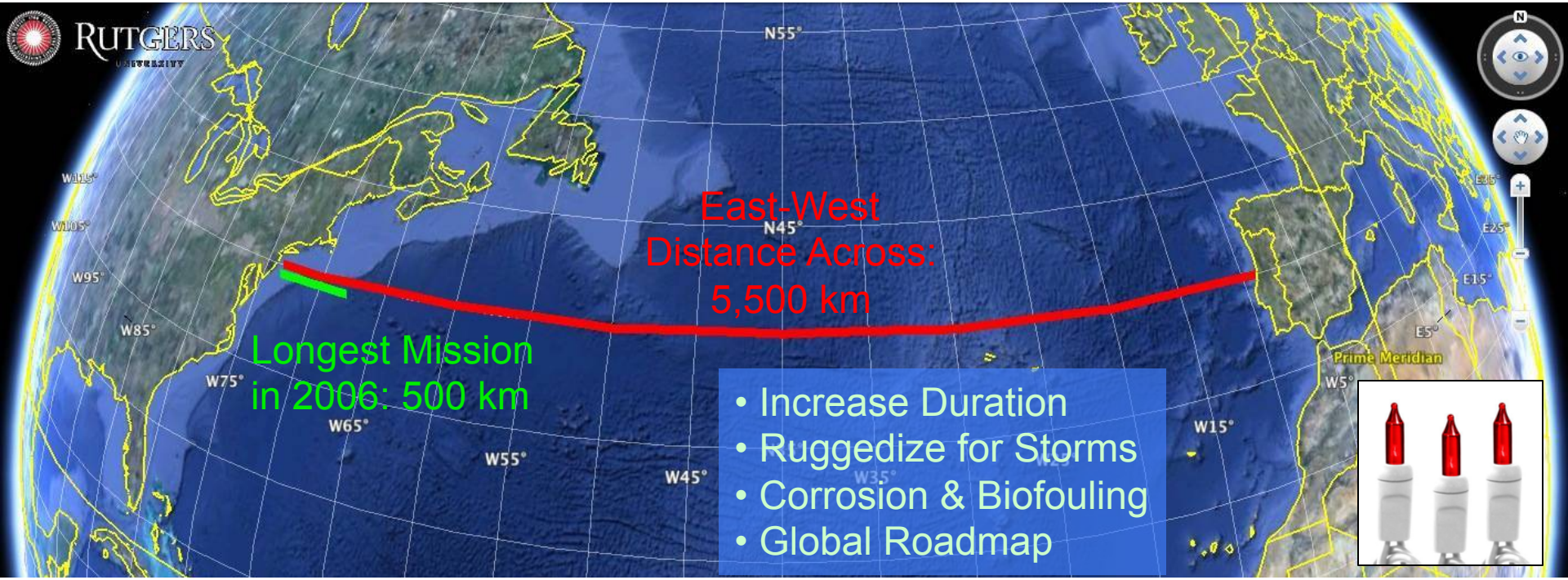
"I have something you need to do for the good of your country."

"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

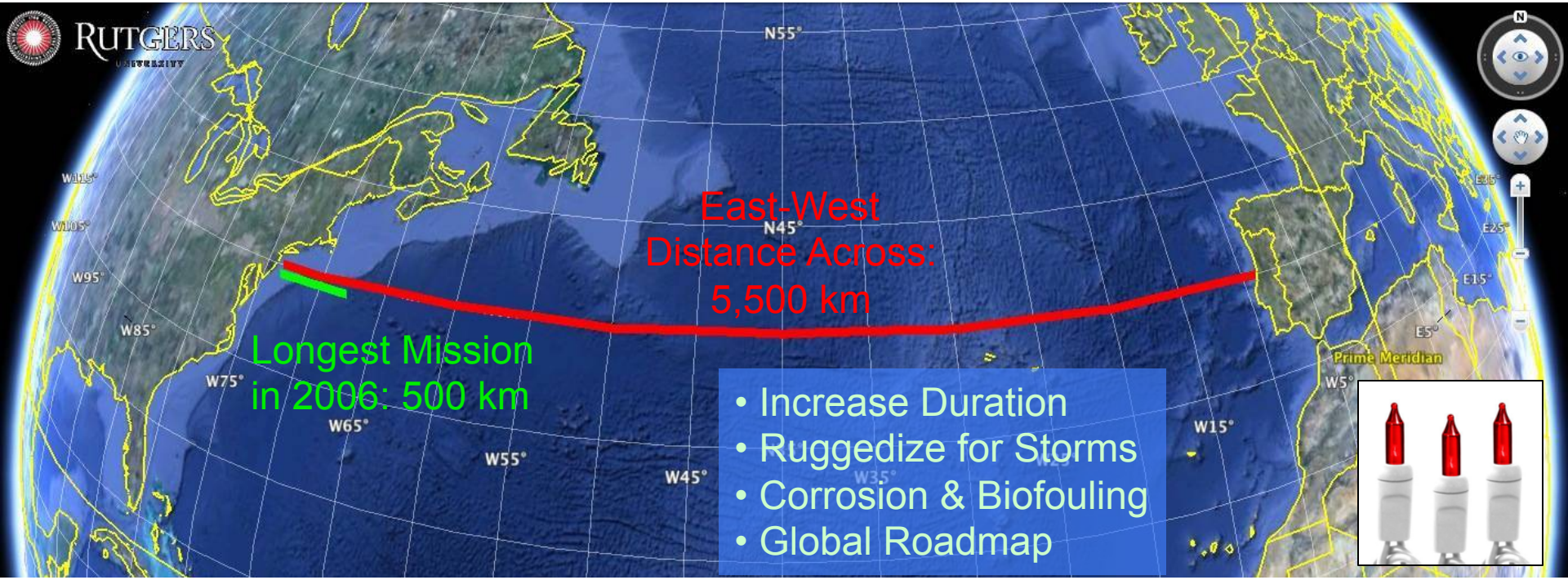


Technology Challenges for a Trans-Atlantic Glider Mission



Federal Research
Agency Response:
Too Risky
for Research

Technology Challenges for a Trans-Atlantic Glider Mission



Federal Research Agency Response: *Too Risky for Research*

Rutgers Alumni Support

Technology Challenges for a Trans-Atlantic Glider Mission

East-West Distance Across: 5,500 km

Longest Mission in 2006: 500 km

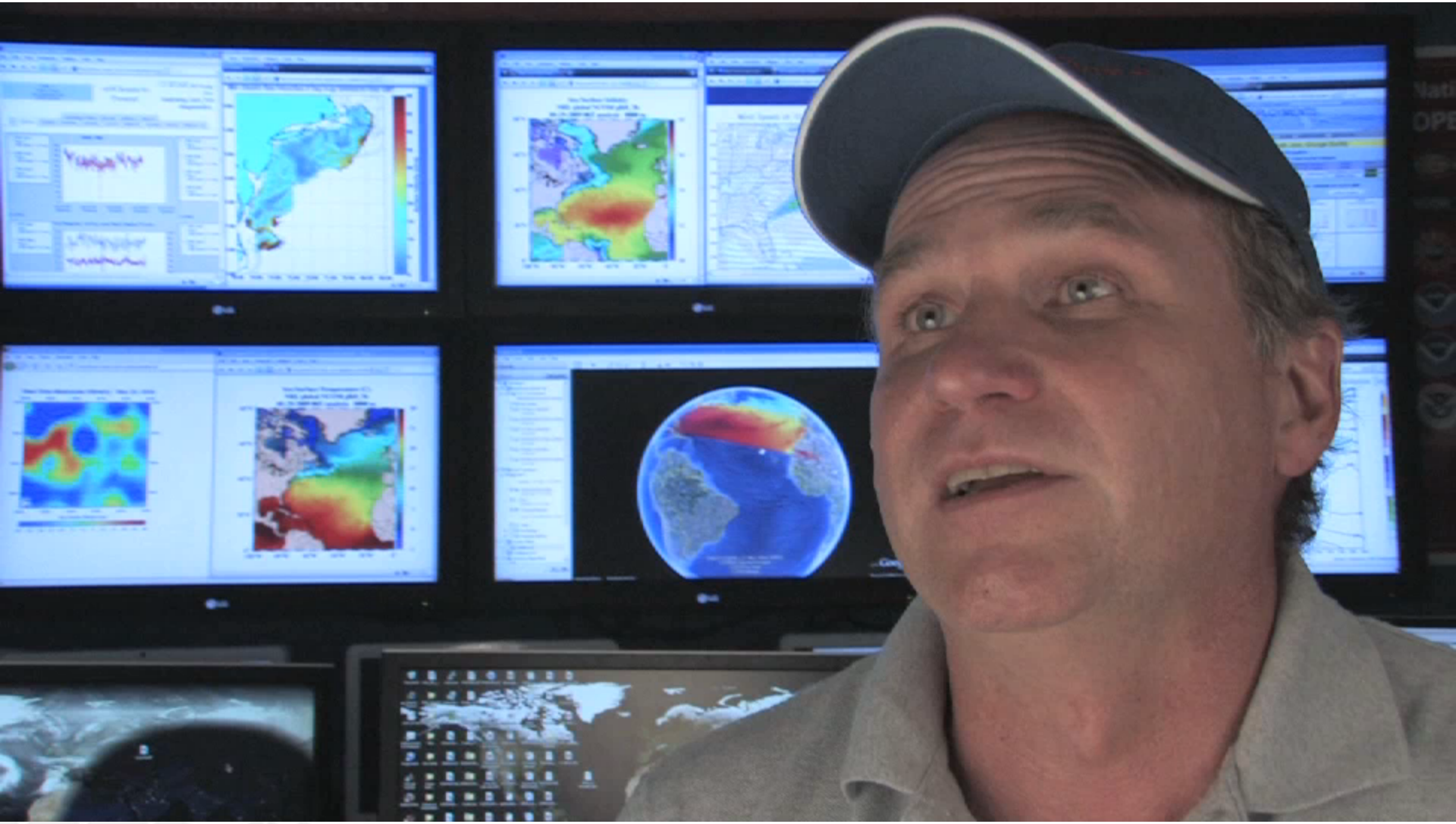
- Increase Duration
- Ruggedize for Storms
- Corrosion & Biofouling
- Global Roadmap

Federal Research Agency Response: *Too Risky for Research*

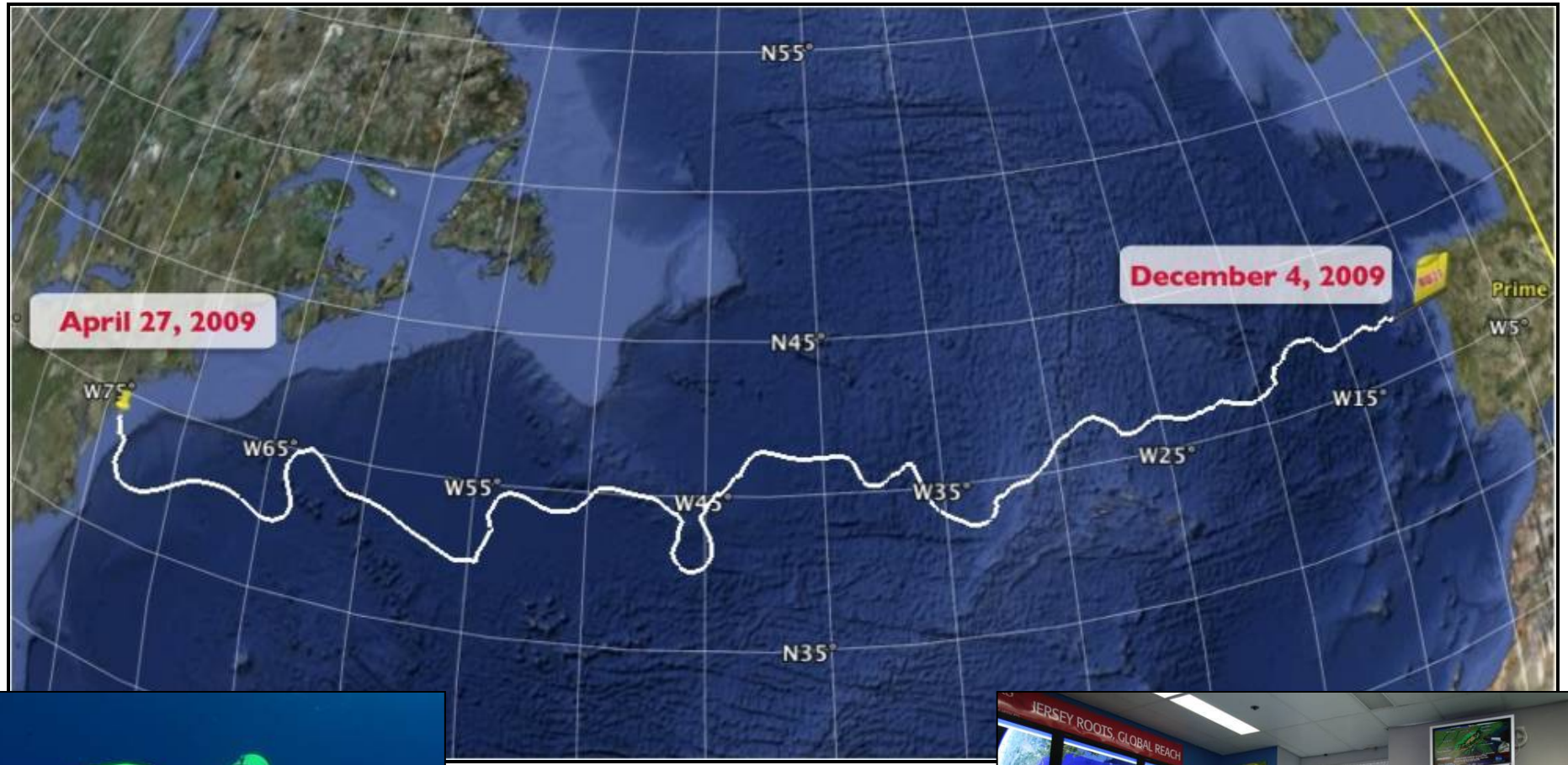
Rutgers Alumni Support

- RU15 – NJ to Halifax - 2008
- RU17 – NJ to Azores - 2008
- RU27 – NJ to Spain - 2009


DR. SCOTT
GLENN



Scarlet Knight's Trans-Atlantic Mission Summary



Time at Sea: 221 days
Track Length: 7,400 kilometers
Undulations: >11,000
Students Directly Involved: >40

Scarlet Knight's recovery by the Spanish Vessel *Investigador*

Investigador approaches *Scarlet Knight* at dawn

International Team returns from First Contact

Scarlet Knight pulled aboard *Investigador's* Zodiac

Science & Ship's Crew poses for Recovery Photo

Scarlet Knight's Landfall in Baiona, Spain

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

Baiona's Mayor unveils *Scarlet Knight's* Plaque

Scarlet Knight's victory lap around the *Pinta*

U.S. & Spanish Secretaries of Commerce

Scarlet Knight swarmed by Baiona's school children

Scarlet Knight - The first underwater robot to cross an ocean:

A Hero's Welcome in Baiona, Spain - December 9, 2009

Los investigadores Glenn Scott (tercero por la izquierda) y Clayton Jones (primero por la derecha), junto a otros miembros del equipo,

Atlantic Crossing: A Robot's Daring Mission

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

57 minute TV version distributed Nationwide to all 350 PBS Stations on 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

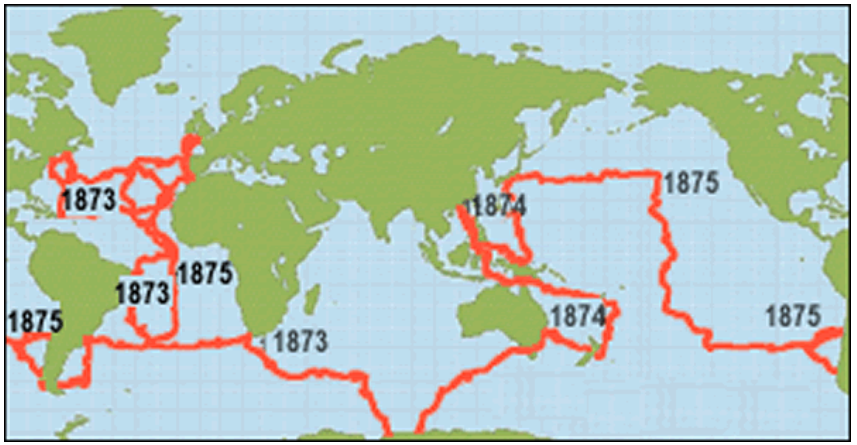
The *Scarlet Knight* in her display case at the Smithsonian's National Museum of Natural History, Ocean Hall, Washington, DC

Rutgers Students are welcomed by White House Science & Technology Advisor Shere Abbott

Rutgers Students share Ocean Exploration stories with Fabien Cousteau

A Global Challenge – The Challenger Glider Mission

December 9, 2009 – Baiona, Spain

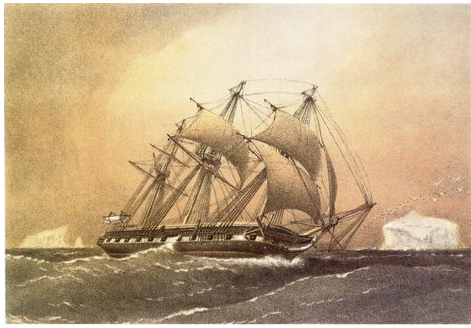


Ralph Rayner & Rick Spinrad's Global Challenge:

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

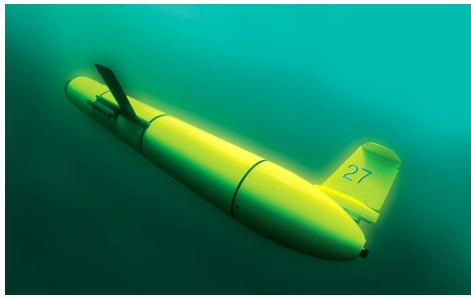
Revisit the Historic Track of the HMS Challenger –
And inspire a global network of students along the way.

HMS Challenger Voyage
First Scientific Circumnavigation
1872-1876

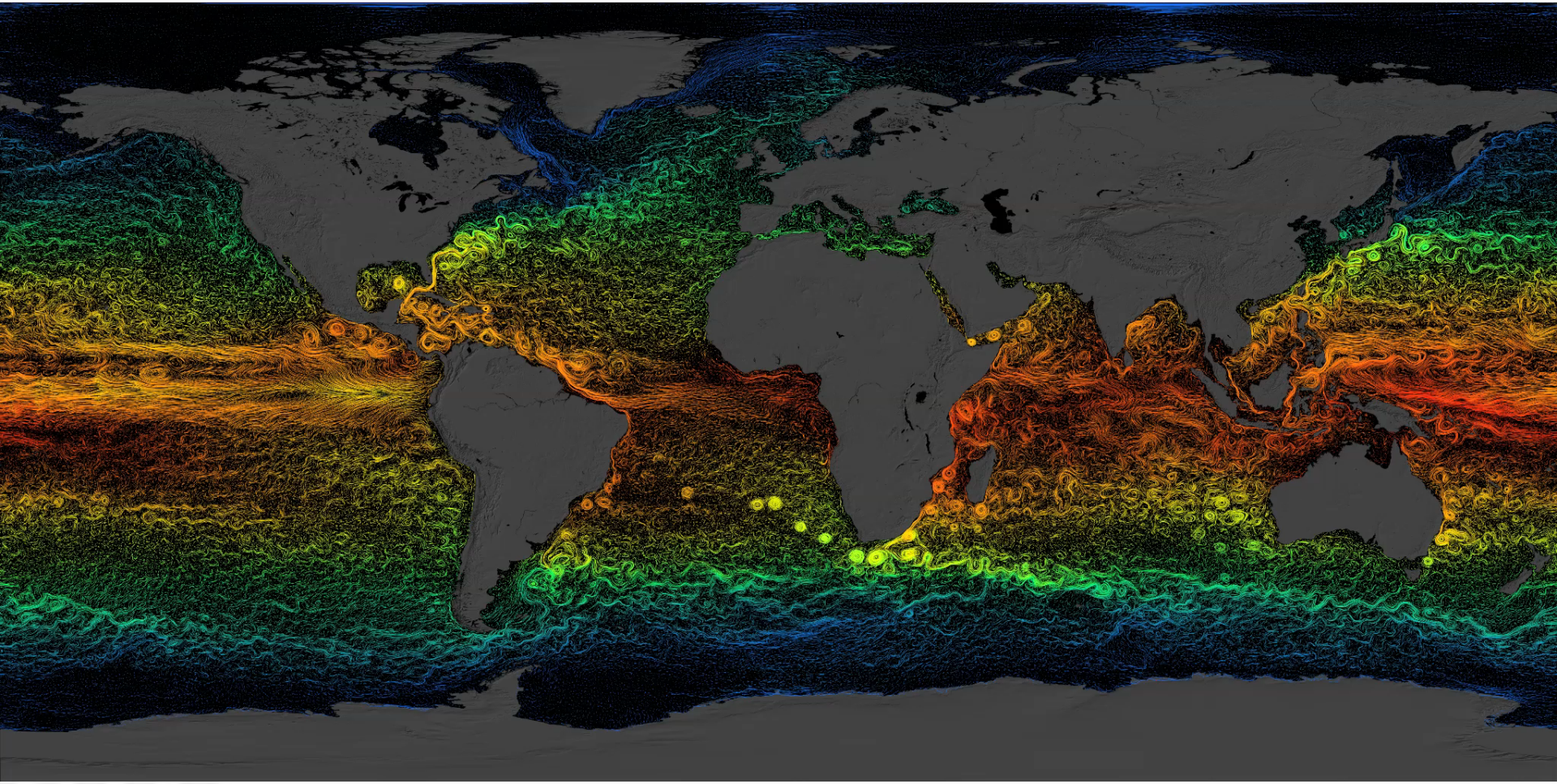


128,000 km =

= 16 gliders
x 8,000 km/glider



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?

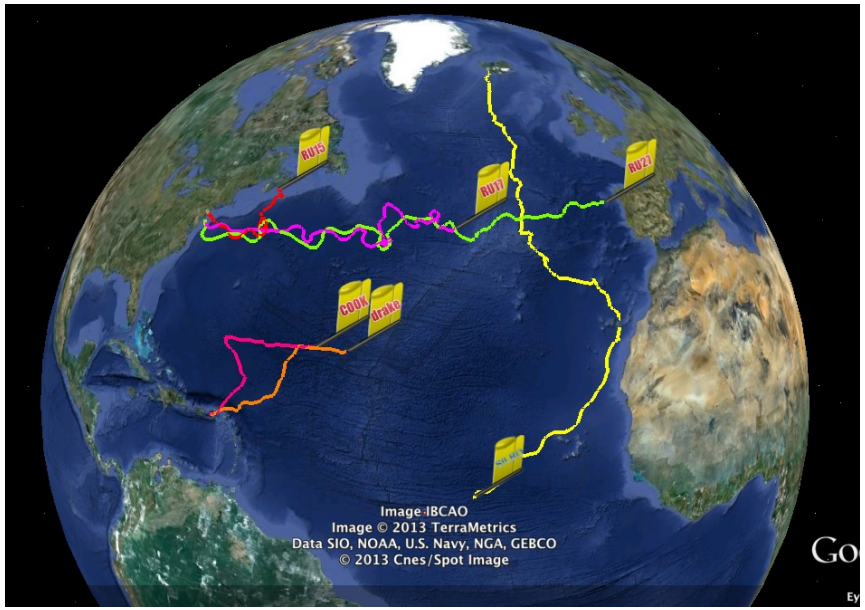
Broaden the workforce
Improve ocean literacy
Develop a global perspective

PLOCAN consorcio

PLATAFORMA OCEÁNICA DE CANARIAS

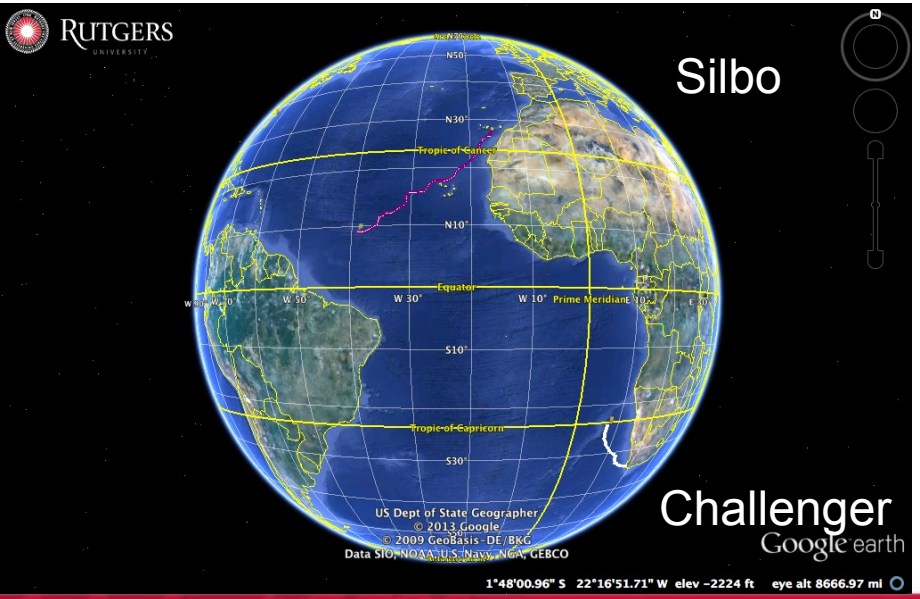
Companion Course at
Plataforma Oceanica de Canarias

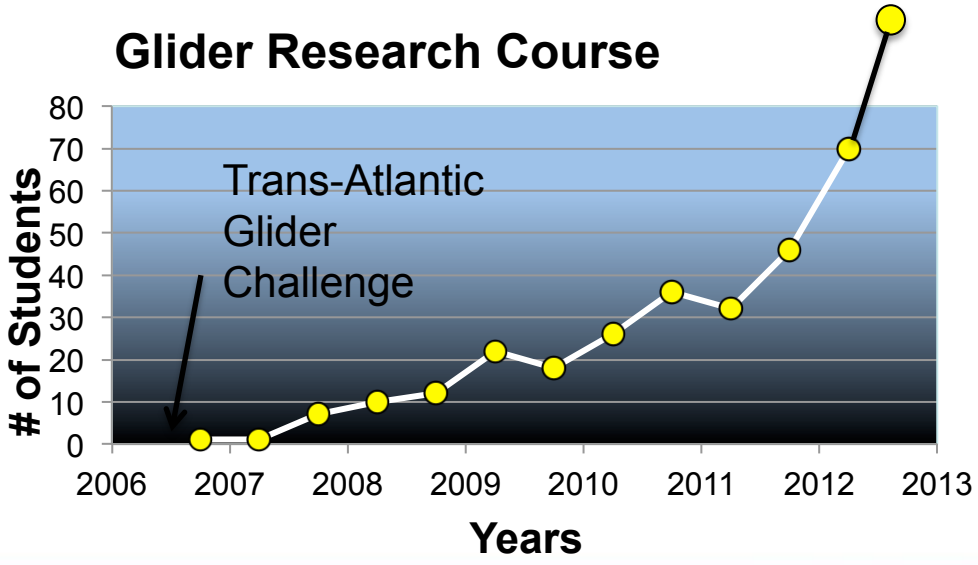
- Shared Glider Missions – Iceland to Azores; Azores to Canaries; Canaries to Caribbean
- Skype Sessions between classes
- Two-way International Exchange programs
- Students Learn Science from their teachers
- Students Learn Culture from their peers



Global Challenger Glider Mission

Challenger Test Flights Have Begun



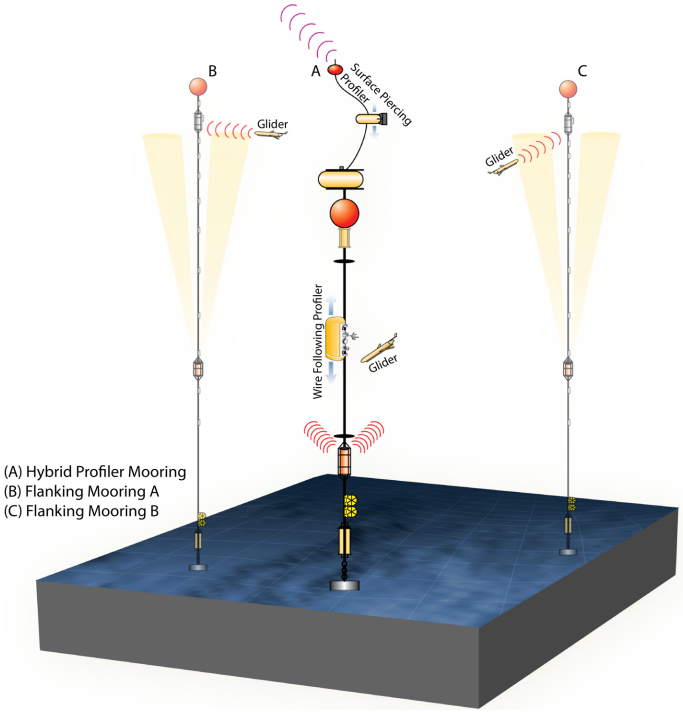


NSF Ocean Observing Initiative

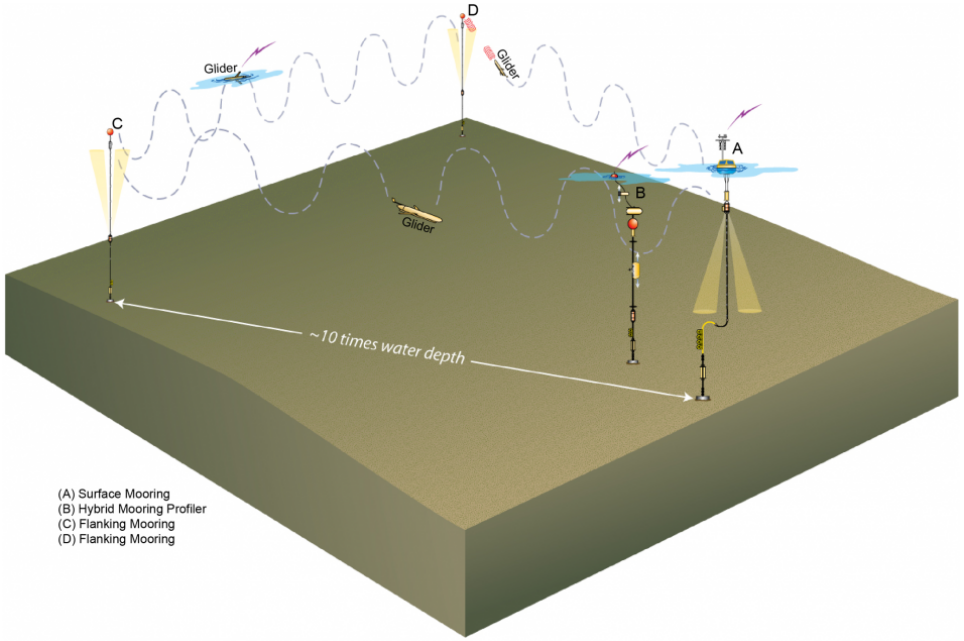
Five Integrated Transformational Themes

- High Latitude Global Sites
- Regional Plate-scale Cable
- Coastal Dynamics Arrays
- Cyber-Space Data Delivery & Sensor Interactivity
- Education and Public Engagement

Global Scale Nodes

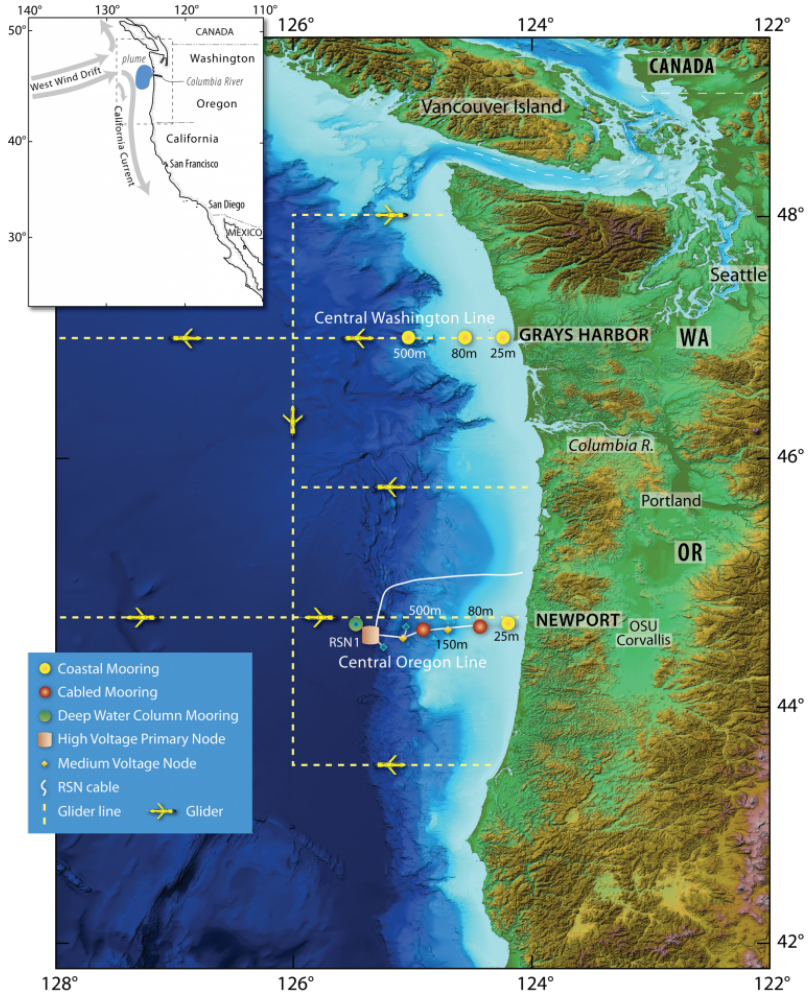


Station Papa

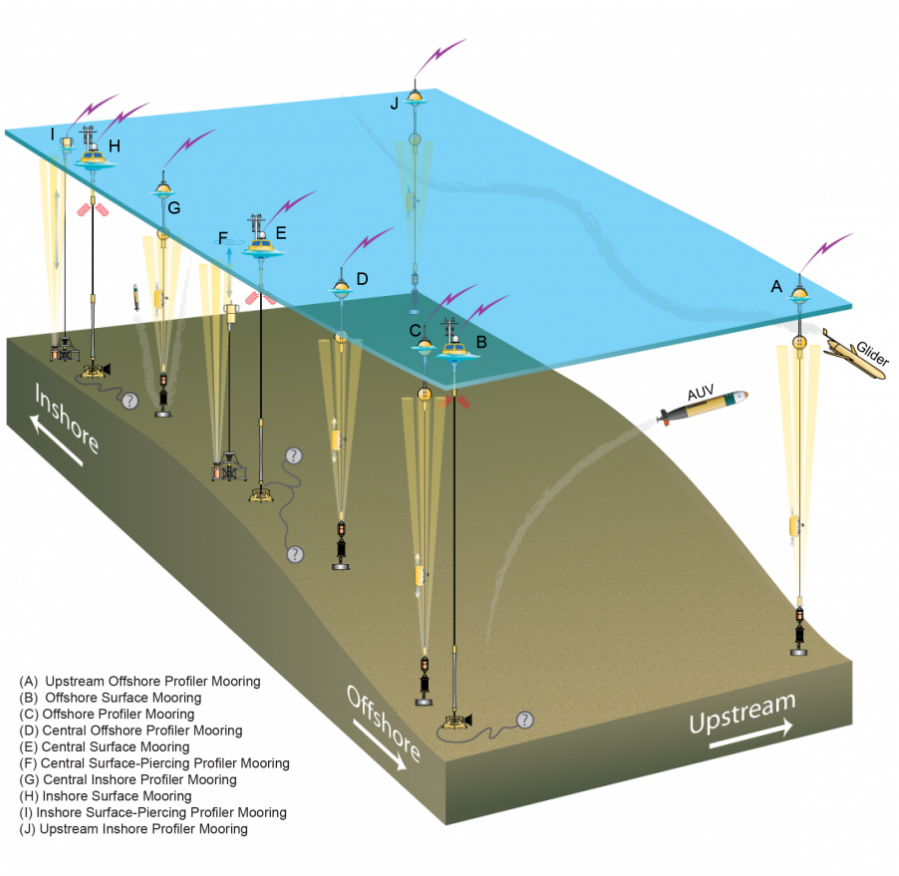


Irminger Sea, Southern Ocean, Argentine Basin

Coastal Nodes – Endurance & Pioneer Arrays

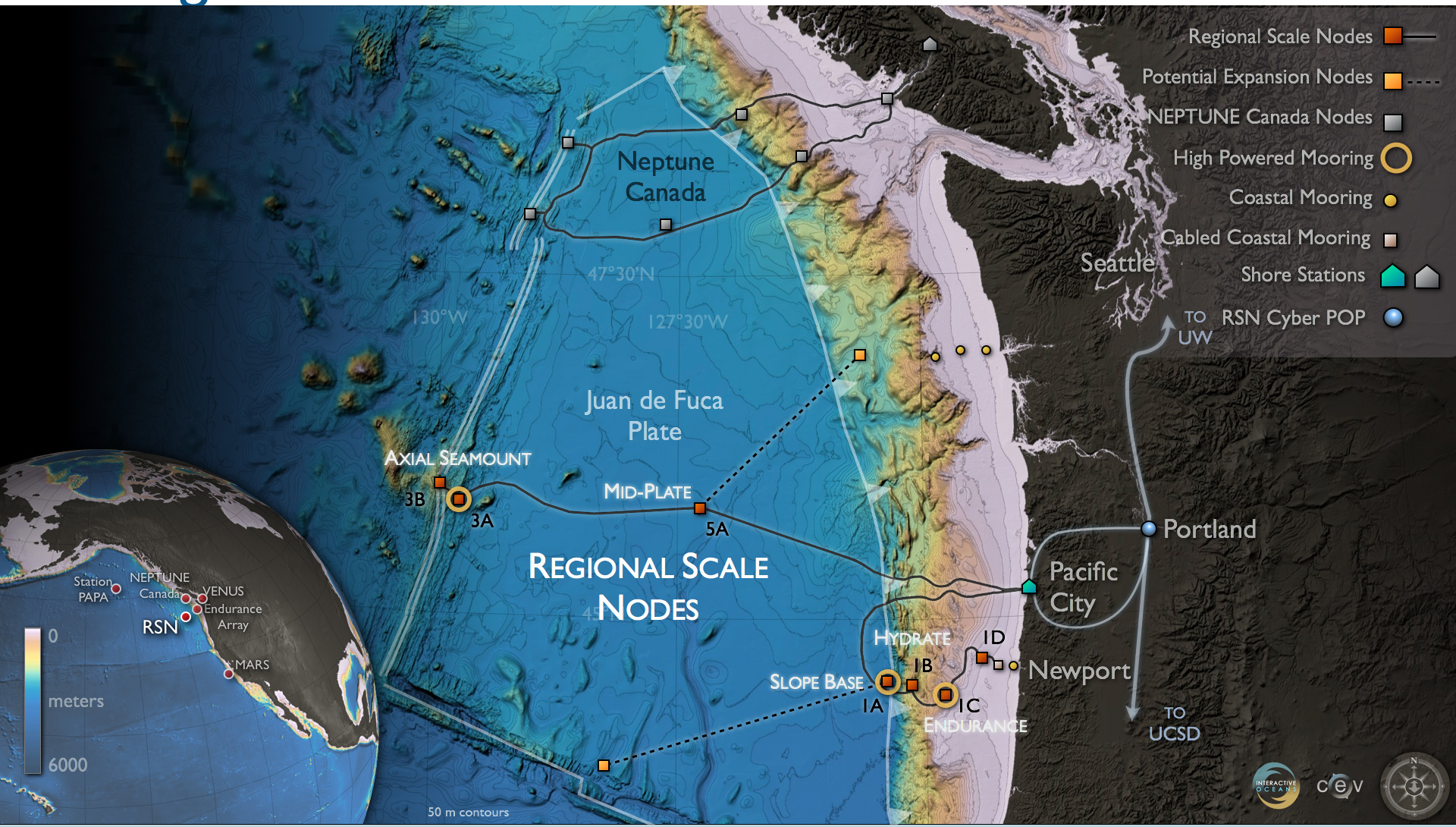


Endurance Array – West Coast

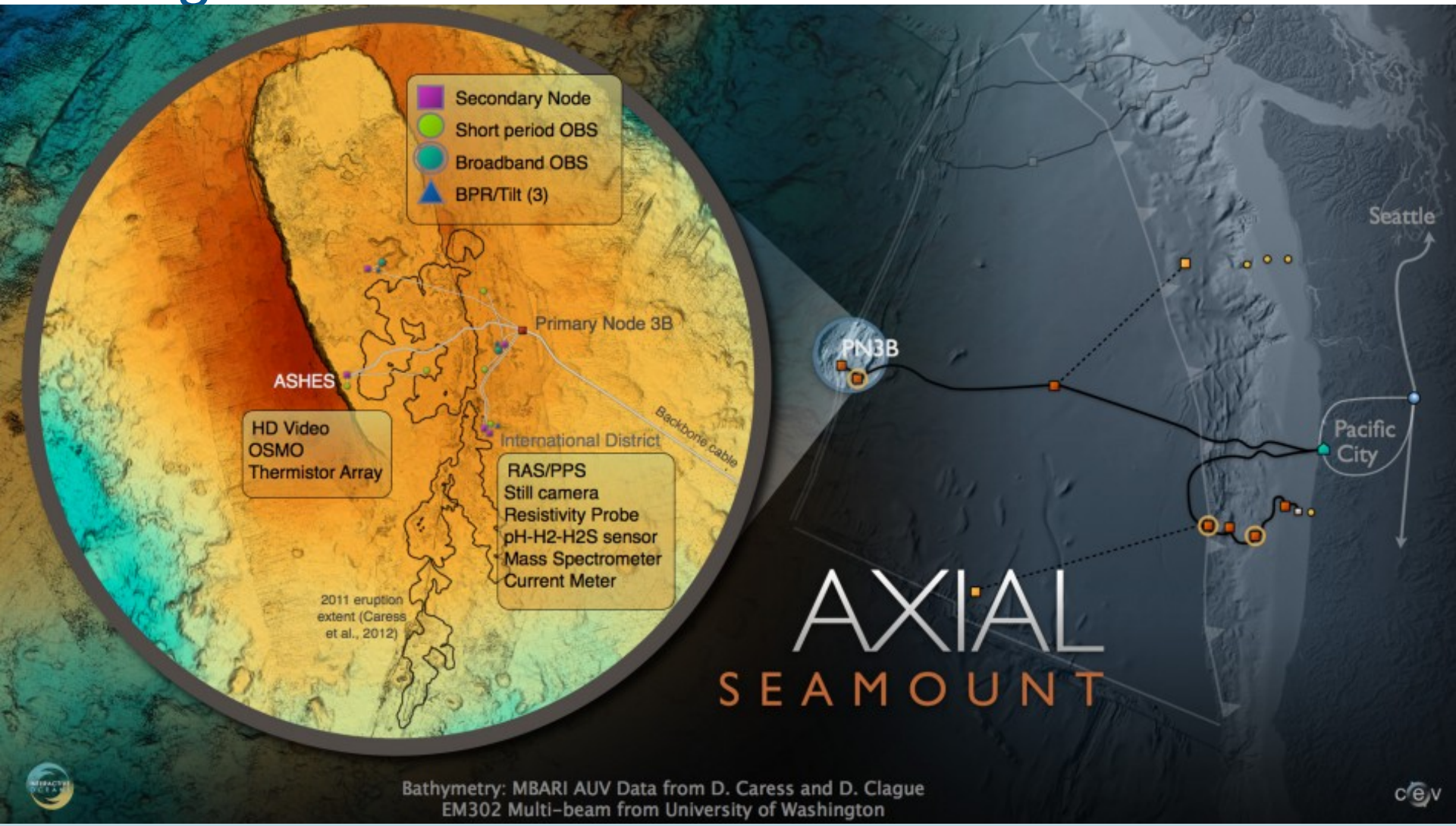


Pioneer Array – East Coast

Regional Scale Node – Cable Routes

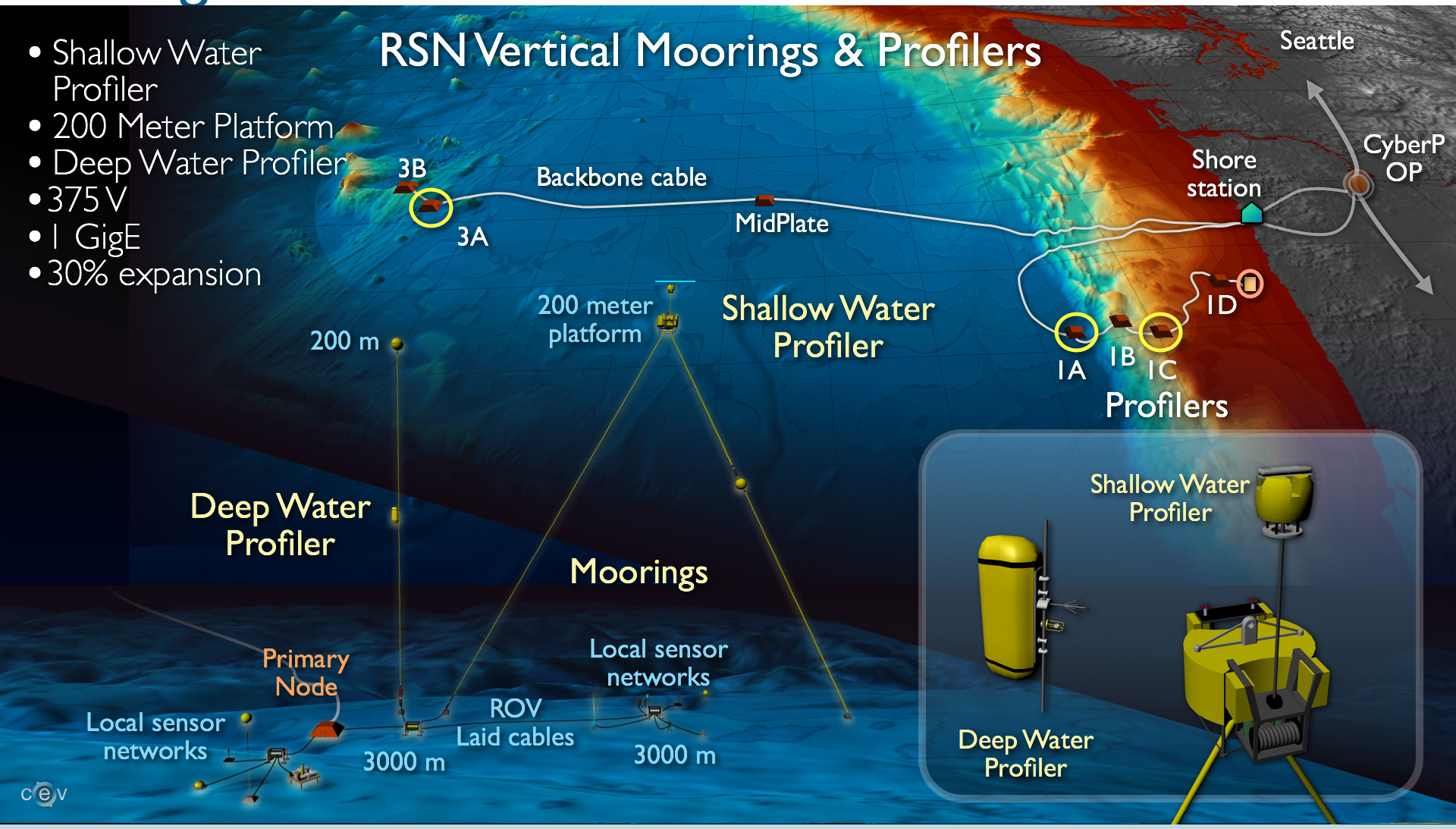


Regional Scale Node – Axial Seamount

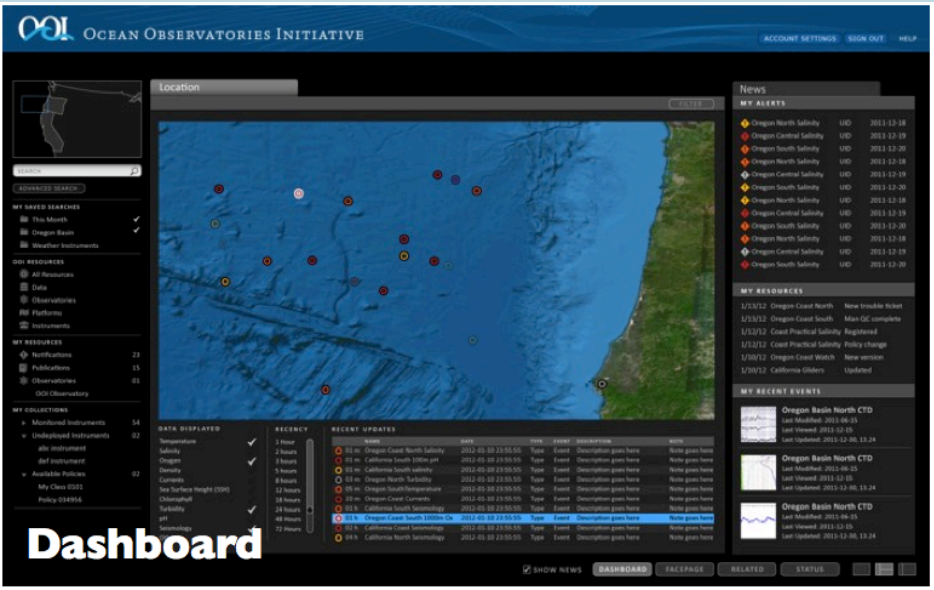


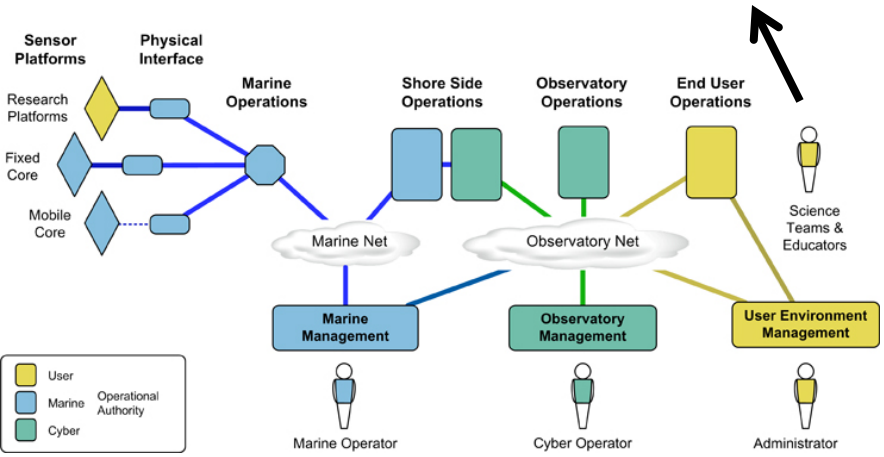
Regional Scale Node – Water Column Sensors

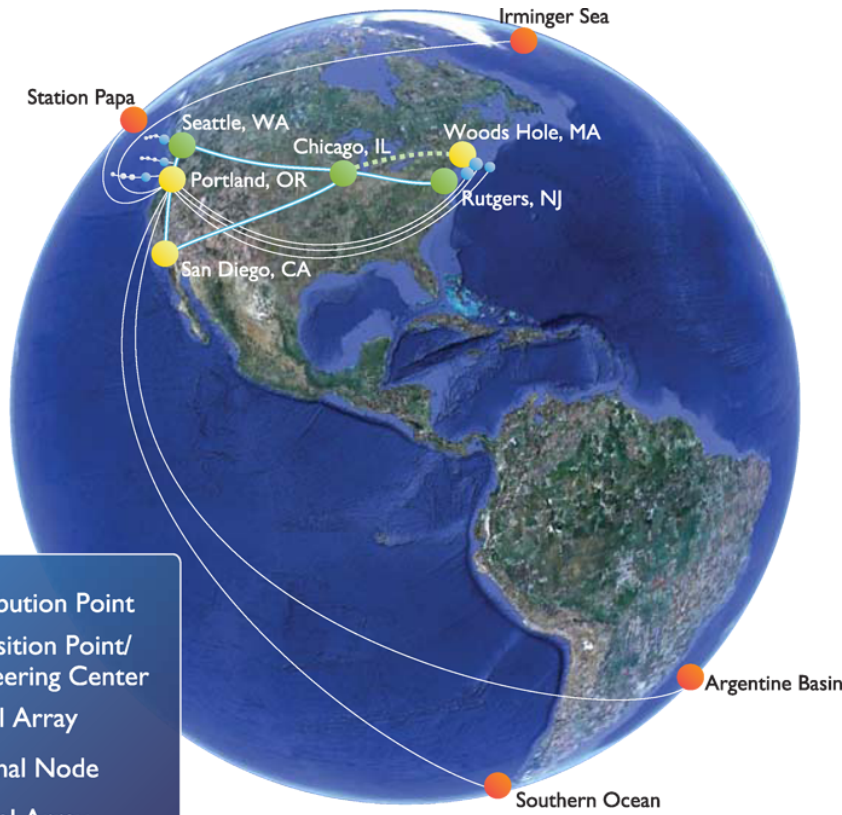
- Shallow Water Profiler
- 200 Meter Platform
- Deep Water Profiler
- 375 V
- 1 GigE
- 30% expansion



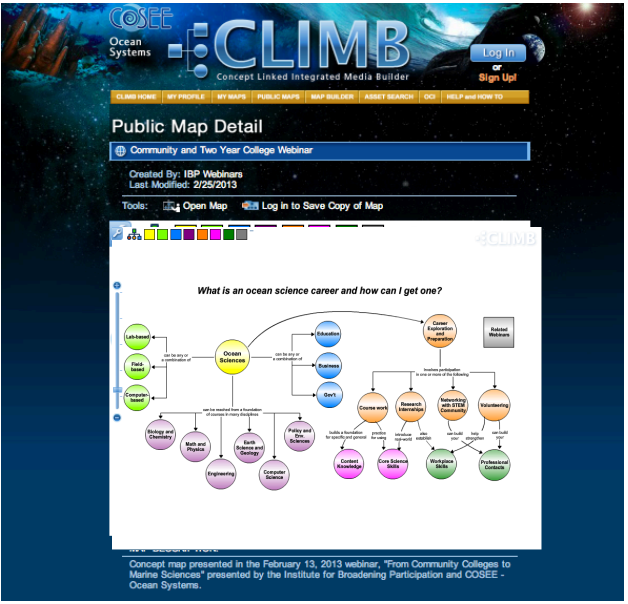
Cyber Infrastructure





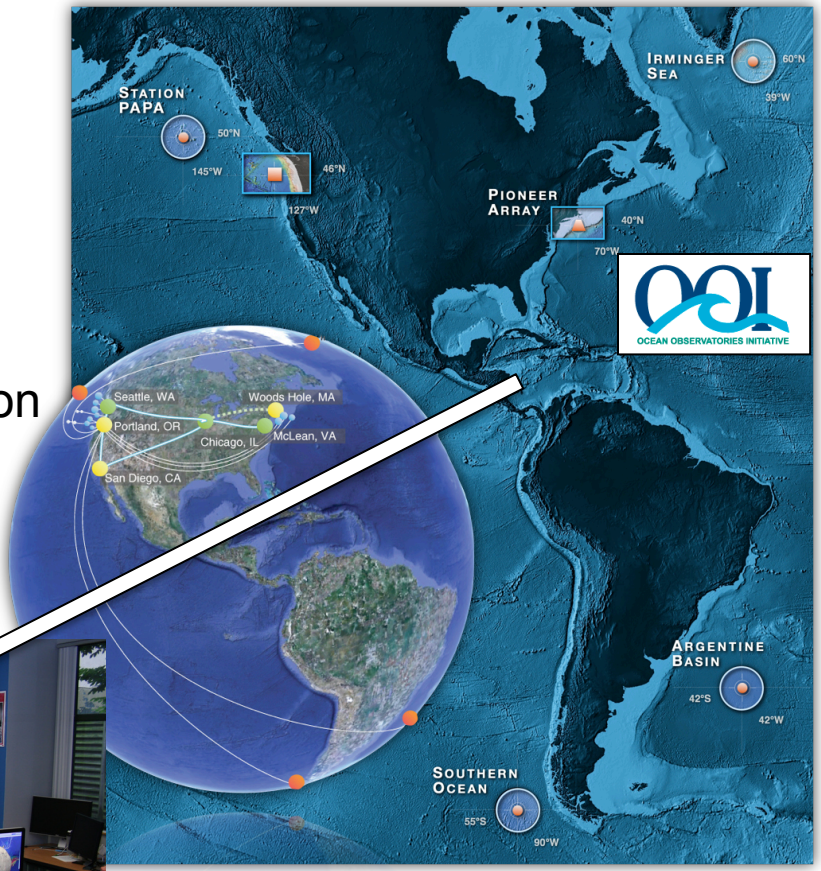


Education & Public Engagement (EPE)



Primary Audience:
Undergraduate Educators & their Students

Primary Purpose:
Broaden Participation



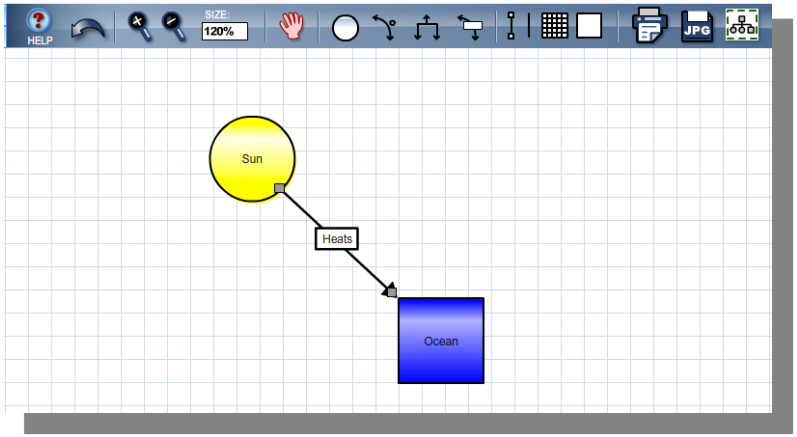
EPE User Interfaces:

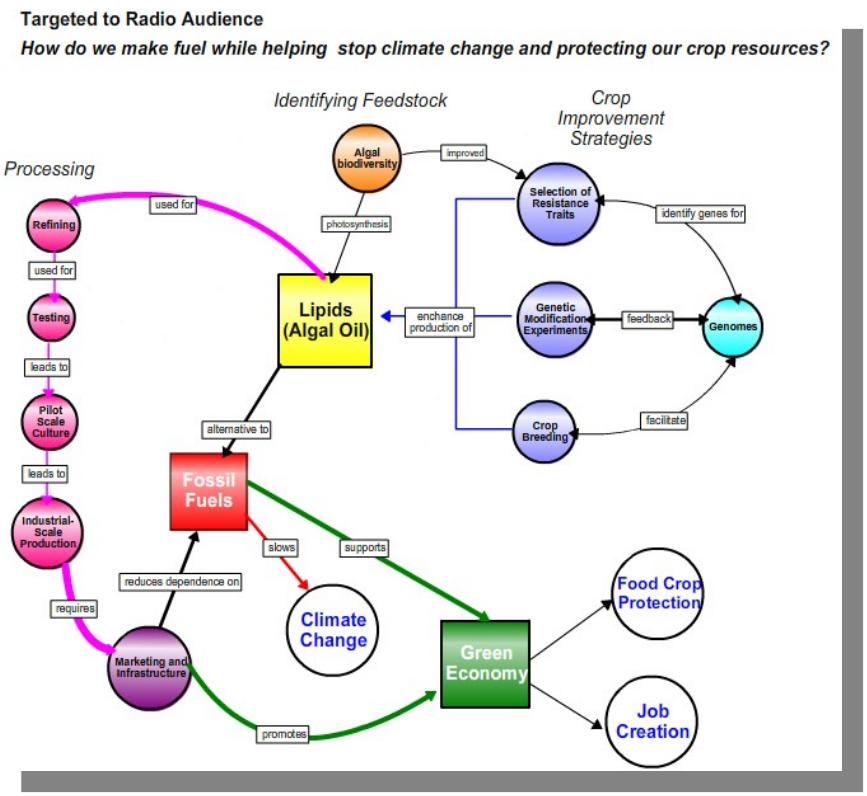
1. Concept Maps
2. Visualization Toolkit
3. Lab/Lesson Builder
4. Resource Database
5. Collaboration Portal

Contact: Mike Crowley
crowley@marine.rutgers.edu

EPE Concept Mapping Service

- Concept Map Builder & Viewer
- Concept and linking phrase suggestions
- Semantic based recommendations
- Embedded content resources

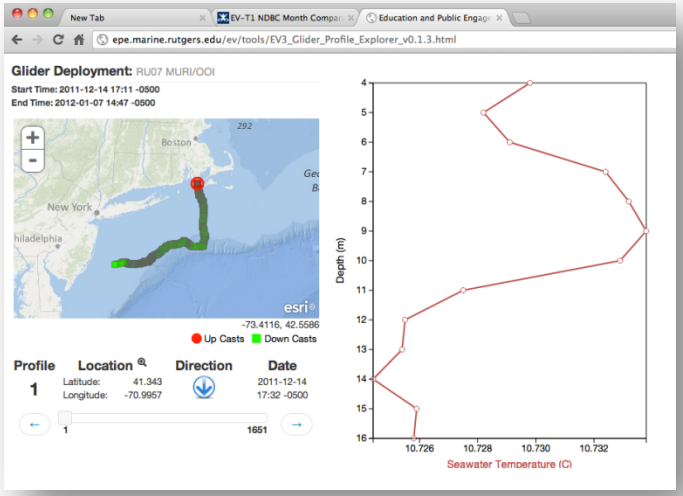




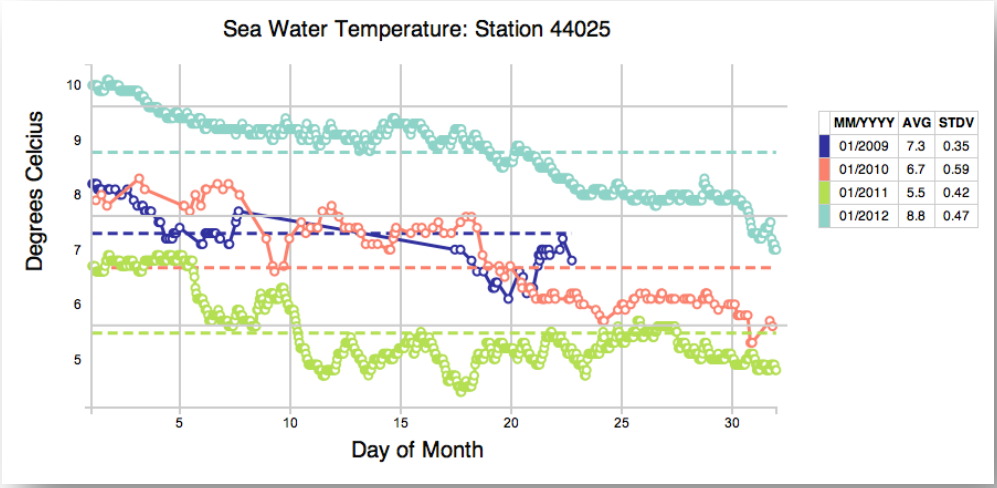
Developed by U. Maine

EPE Educational Visualization Service

- Visualization tools
- Web portal that enables user to customize/save/share tools



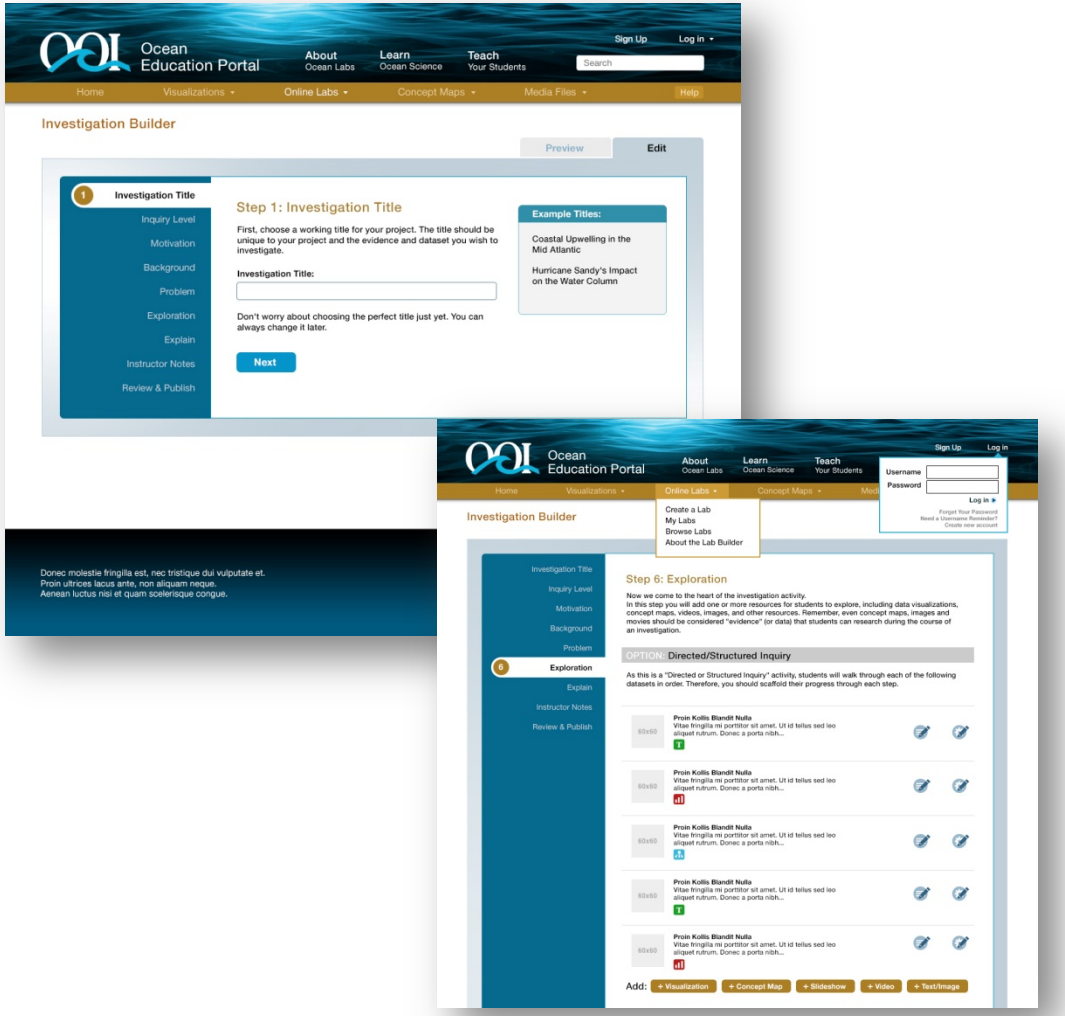
Slocum Gliders



Short term weather & long term climate

EPE Lab/Lesson Builder Service

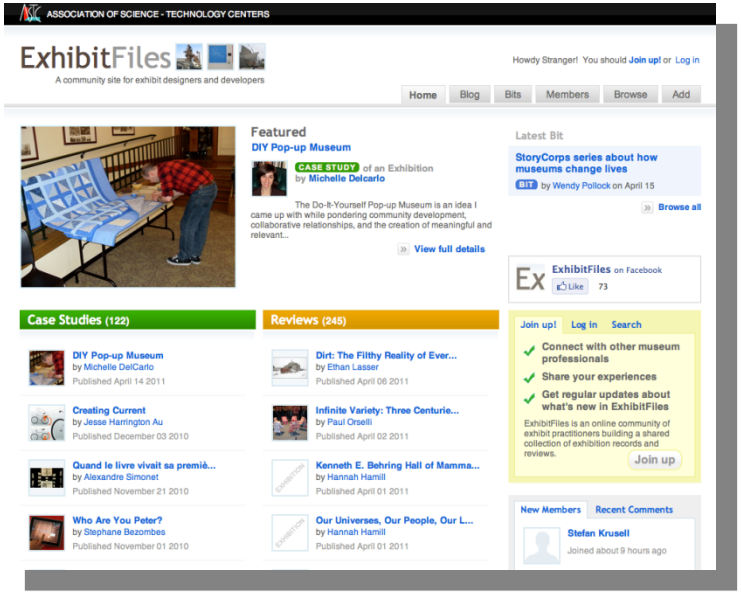
- Online Lesson Units
- Collaboratively Editable
- EPE Resource Integration
- Content Templates

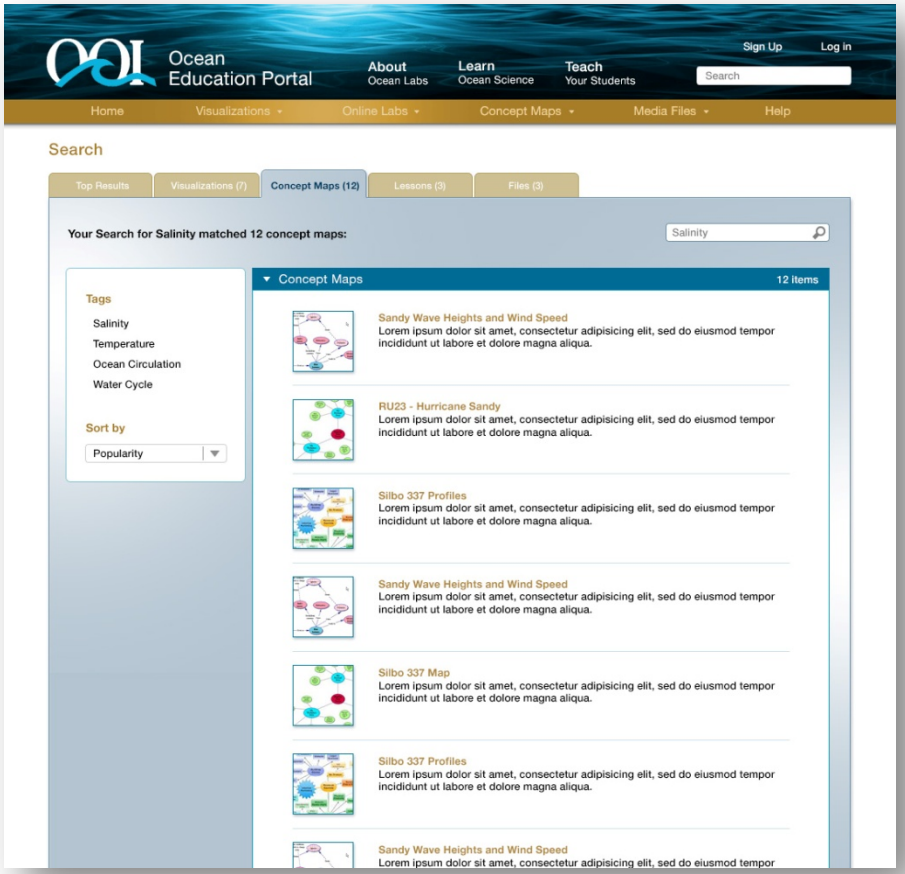


e.g. Link lab studying regional temp changes to lab studying biological productivity change

EPE Educational Resource Database

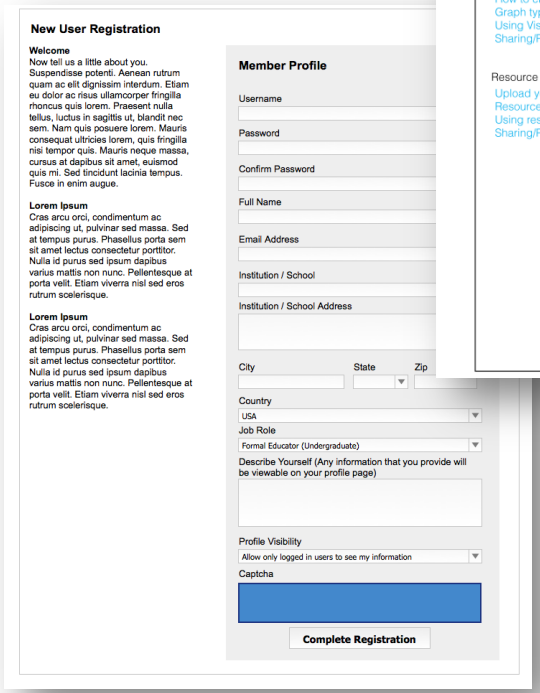
- Supports content storage for Tools
- Collects user supplied content
- Index of EPE user generated tools, education-ready OOI datasets, & visualization tools

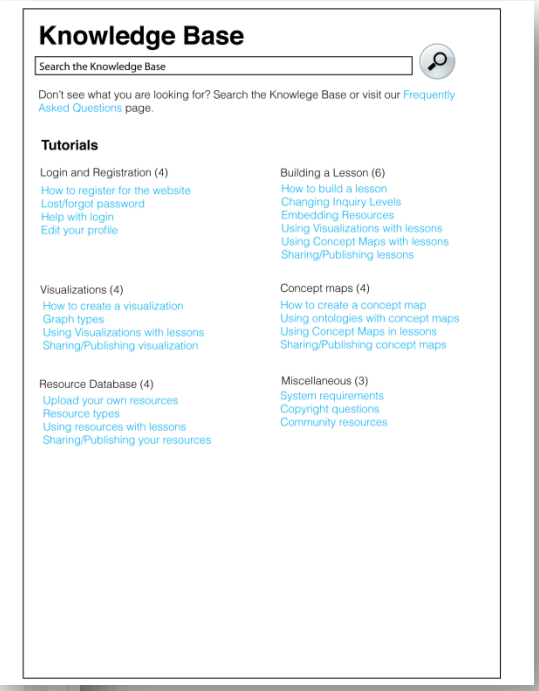




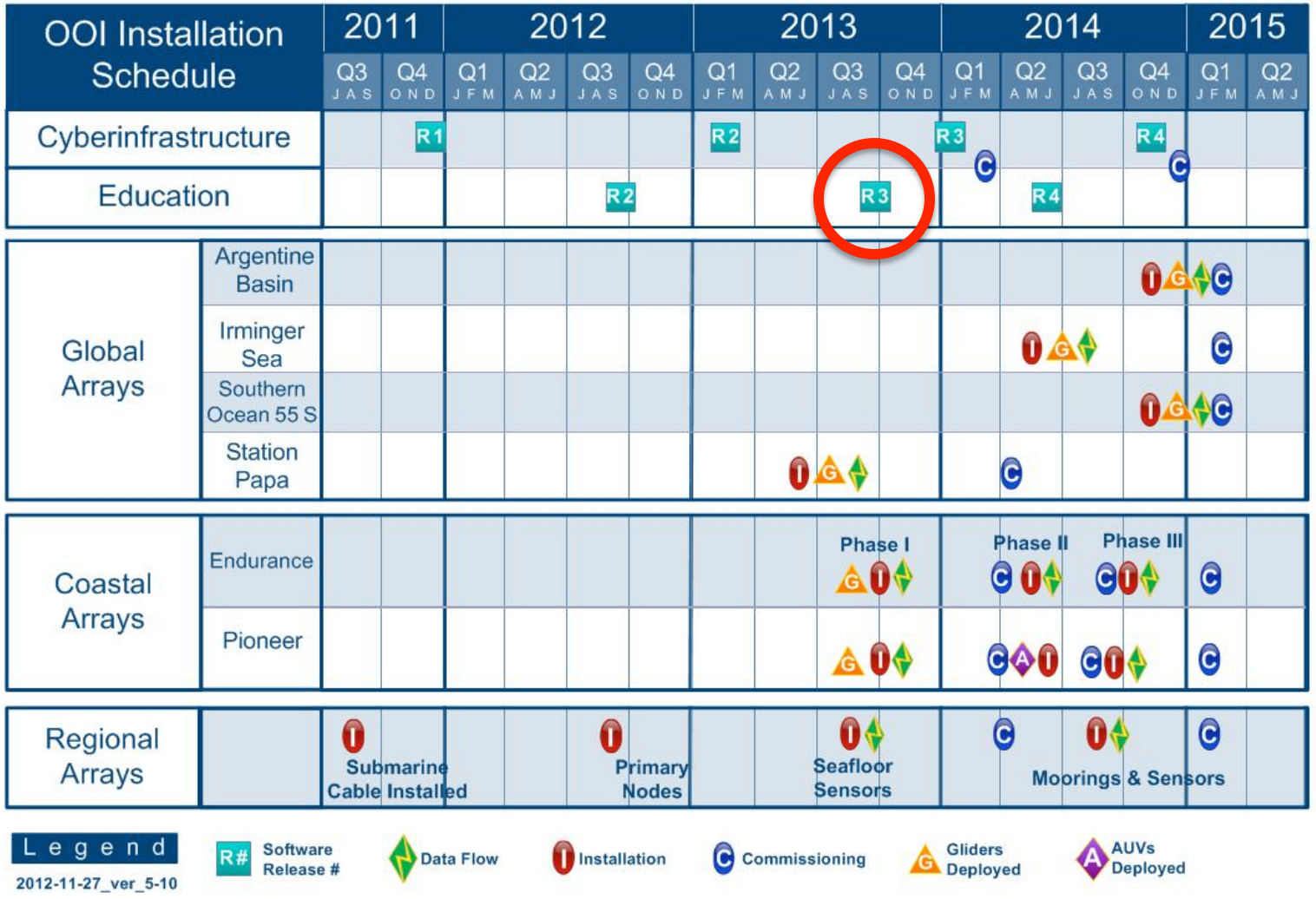
EPE Web Portal

- Workgroup support
- User profiles
- Community Blogs
- User support
- Webinars/training





OOI Installation Schedule



IOOS INTEGRATED OCEAN OBSERVING SYSTEM

OOI OCEAN OBSERVATORIES INITIATIVE

Our Planet is Changing:

Population is Growing

Resource Demands are Increasing

We will turn to the Sea for Solutions

New **Interactive** Technologies enable a New Era of **Integrated** Ocean Exploration:

Cables - At-Sea Telepresence

Gliders - At-Sea Omnipresence

Cyberspace - Global Collaboration

Our Students will Live this Change:

Broaden Opportunities

Globalize Science & Discovery

Promote Cultural Interactions

IOOS INTEGRATED OCEAN OBSERVING SYSTEM

OOI OCEAN OBSERVATORIES INITIATIVE

What can we do together?

1. *Continue to Teach for the Fire*
   (Taylor Mali)

2. *Join the EPE Early Adopters*
   crowley@marine.rutgers.edu

3. *Help with OOI EPE Release 3*
   Usability Testing starting Fall 2013

CCURI
COMMUNITY COLLEGE UNDERGRADUATE RESEARCH INITIATIVE

Partner Login

"What we have to learn to do, we learn by doing"
Aristotle

Community Roots, Global Reach