Slocum Glider
First At-Sea Deployment
Tuckerton, NJ
July, 1999

2000-2010: Large Scale Integration of Ocean Observing Systems
Scott Glenn + Thousands
An early slide from Dave Martin:

“Ocean.US” is established under the auspices of NOPP

NORLC-commissioned reports in 1998 & 1999 recommended establishment of a national capability for **integrated** and **sustained** ocean observations & prediction.

In May 2000:  
(1) The NORLC directed the establishment of Ocean.US 
(2) Formation of Ocean.US announced to Congress.

To manage the development of an **Integrated and Sustained Ocean Observing System (IOOS)** for **research** & **operations** in the following areas:

- Detecting and Forecasting Oceanic Components of Climate Variability
- Facilitating Safe and Efficient Marine Operations
- Ensuring National Security
- Managing Marine Resources
- Preserving and Restoring Healthy Marine Ecosystems
- Mitigating Natural Hazards
- Ensuring Public Health

**Estimated costs from the 1999 Frosch Report:**

“~30M per year to start, ramping up to ~$100M per year when it is fully operational.”

An historical timeline:  
https://ioos.noaa.gov/about/ioos-history/
U.S. Integrated Ocean Observing System (IOOS)

Partnership effort that leverages dispersed national investments to deliver ocean, coastal and Great Lakes data relevant to decision-makers.

Global Component
- US contribution to Global Ocean Observing System (GOOS)
- 1 of 15 Regional Alliances of GOOS

National Component
- 17 Federal agencies

Regional Component
- 11 Regional Associations
  - Stakeholder driven
  - Academia, state/local/tribal government, private industry
  - Government Certified
NEOS
2003

Ocean.US
Poster Request

Developed from
March 2003
Maryland
Workshop

Numerous
Existing
Sub-Regional
Observatories
Fred Grassle & LEO
Long Term Observatory

Henry Stommel & The Slocum Mission
The Slocum Mission Control Center on Nonamesset Island.

Alan Robinson & The Harvard Model

Transitioning Forecasts to Operations 1986-1989

A Look Back
“If I were to choose a single phrase to characterize the first century of modern oceanography, it would be a century of under-sampling.”

Walter Munk, 2000

A Look Forward
Technology is Enabling Scientists to Improve Our View

1. Satellites in Space (Beginning in 1980’s)
2. + Subsurface Ocean Arrays (Now!)
3. Well Sampled Ocean
Longterm Ecosystem Observatory

HF Radar & Gliders

1 + 1 = 3
Shore-based Communication Center Enabling Adaptive Sampling
13 Ships/Boats, 4 Aircraft & 2 AUVs
# of participating scientists

1991 1993 1995 1997 1999 2001

Year

LEO Collaborations & Partnerships

Nowcast/Forecast efforts

Sediment Study

Upwelling Study

CPSE ends

# of Research Institutions

0 10 20 30 40

0 50 100 150 200 250 300
Scientific Publications by Year for Selected Field Experiments

Time between the final mooring recovery and publication of the special issue is still 3 years.

The Observatory transforms the publication step function into a ramp.

Thanks to Steve Ramberg
Can a scientist be operational?

YES and they should have substantial role in the operational observatories.

No!

Glenn and Schofield 2003, Oceanography
“The ocean sciences are now on the threshold of another major technological advance as the scientific community begins to establish a global, long term presence in the ocean…”

Robert Detrich – National Research Council
Enabling Ocean research in the 21st Century
Rutgers University
Coastal Ocean Observation Lab

CODAR Network
L-Band & X-Band Satellite Systems
Glider Fleet
Mission Planning
Operations & Communications Station
A “Stommel” View of the Ocean: WWW & Interactive 3-D
Observatory-Enabled Collaborative Research Campaigns in the Mid-Atlantic Bight
Collaborative Campaign Science in the Middle Atlantic Bight: The Shallow Water 2006 Joint Experiment (SW06)

- 62 Moorings
- 7 Ships
- 1 Aircraft
- 10 Gliders
- >12 Satellites
- 3 Ground-stations
- 48 Senior PI's & PM's
Collaborative Campaign Science in the Middle Atlantic Bight: The Shallow Water 2006 Joint Experiment (SW06)

- 48 Senior PI's & PM's
- 7 Ships
- 10 Gliders
- 1 Aircraft
- >12 Satellites
- HiSeasNet
- 3 Ground-stations
- 62 Moorings
SW06 Glider Statistics (as of 10/02/2006)

Deployments: 17
Km Flown: 6,683
CTD Profiles: 51,933
Calendar Days: 94
Glider Days: 360

Glider Costs:
- Support Vessels: $41,404.50 (< 4 UNOLS Ship Days)
- Batteries: $17,000 (<2 UNOLS Ship Days)
- Iridium Communications: $65,000
Total Costs: $123,404.50

5 People for 3 months - none full time ~ 1 person year

Equivalent Ship Cost Estimate:
360 days x $10,000/day = $3,600,000

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.”

Positive risk-taking is required for innovation in STEM careers!
The Trans-Atlantic Glider Challenge
December 9, 2009 – Baiona, Spain

RU27: 7,400 km in 221 days

With real data we can improving undergraduate education through living the science in real-time

Increased Enrollment

Increased Diversity

Increased Hands-on Research

Funded by University Donor & NOAA
FY2007 Regional Integrated Ocean Observing System Development

Letters of Intent (LOIs) due January 31, 2007. Top LOIs were recommend to go forward.

Full Proposals due April 17, 2007.

“NOAA views this announcement as an opportunity to demonstrate the regional observing system concept.”

Three Focus Areas

1. Regional Coastal Ocean Observing Systems (RCOOS) development
   $500,000 to $2,000,000 per year for up to 3 years.
   On March 28, 2007, years 2 & 3 were increased to $3,500,000 per year.

2. IOOS application and product development for regional stakeholders.
   $100,000 to $500,000 per year for up to 3 years.

3. Data management and communication by local data network nodes.
   $100,000 to $300,000 per year for up to 3 years.
Regional Coastal Ocean Observing Systems (RCOOS) development guidance:

- Demonstrate the approach and benefits of integration at the scale of the Regional Association.
- Implement an end-to-end RCOOS that addresses regional needs.
- Further the development of RCOOSs through integration and operation of regional observing system assets.
- Any existing or proposed assets would be deployed and managed as part of a regional deployment design.
- Proposals should address the following:
  (a) regional deployment, operation and maintenance of sensors and platforms;
  (b) regional integration of data streams, quality assurance procedures, and data delivery; and
  (c) generation of regional products, including data products and model output, that facilitates the development of value added products for identified users.
Established 2007: 35 Co-PIs, 25 Institutions, 10 States

Regional Priorities:
1) Safety at Sea – Search and Rescue
2) Ecosystem Decision Support – Fisheries
3) Water Quality
4) Coastal Inundation
5) Offshore Energy
## Regional Observation & Modeling Capabilities

<table>
<thead>
<tr>
<th>Capabilities</th>
<th>Weather Mesonet</th>
<th>HF Radar Network</th>
<th>Statistical STPS</th>
<th>Satellite Imagery</th>
<th>Glider Surveys</th>
<th>Dynamical Ocean Forecasts</th>
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</thead>
<tbody>
<tr>
<td><strong>Theme 1. Maritime Safety</strong></td>
<td>Operational Input to USCG SAROPS</td>
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<td>SST for survivability planning</td>
<td>Assimilation dataset for forecast models</td>
<td>Surface currents for SAROPS</td>
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<tr>
<td><strong>Theme 2. Ecological Decision Support</strong></td>
<td>Weather forecast ensemble validation</td>
<td>Circulation and divergence maps for habitat</td>
<td></td>
<td>SST &amp; Color for habitat</td>
<td>Subsurface T &amp; S for habitat</td>
<td>3-D fields of T, S, circulation for habitat</td>
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<tr>
<td><strong>Theme 3. Water Quality</strong></td>
<td>Winds for transport, river plumes, &amp; upwelling</td>
<td>Surface currents for floatables, bacteria, spill response</td>
<td>Surface currents for floatables, bacteria, spill response</td>
<td>Ocean color for river plumes</td>
<td>Nearshore dissolved oxygen surveys</td>
<td>Surface currents for floatables, bacteria, spill response</td>
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<tr>
<td><strong>Theme 4. Coastal Inundation</strong></td>
<td>Weather forecast ensemble validation</td>
<td>Current forecast model validation</td>
<td></td>
<td>SSTs assimilation into forecast models</td>
<td>Assimilation dataset for forecast models</td>
<td>Nested forecast ensembles</td>
</tr>
<tr>
<td><strong>Theme 5. Offshore Energy</strong></td>
<td>Historical analysis &amp; wind model validation</td>
<td>Historical current analysis &amp; wind model validation</td>
<td></td>
<td>Historical analysis surface fronts &amp; plumes for siting</td>
<td>Historical analysis of subsurface fronts &amp; plumes</td>
<td>Coupled ocean-atmosphere models for resource estimates</td>
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Our Innovative Approach: The Integration Matrix
Capabilities Support Multiple Themes

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Optimizing HF Radar for SAR using USCG Surface Drifters

Art Allen
U.S. Coast Guard

Scott Glenn
Rutgers

and Mid-Atlantic Regional Association
Coastal Ocean Observing System

Based on a Defined Need, a Process for Positive Impact –

1. Observations + Scientific Analysis > Understanding (Models)
2. Models + Observations > Forecasts
3. Forecasts + Decision Aids > Actionable Information
4. Actionable Info + Knowledgeable User > Positive Impact

MARACOOS
Ocean Information for a Changing World

IOOS
Integrated Ocean Observing System
May 4, 2009: After a year of USCG testing, NOAA announces on U.S. Department of Commerce Website that MARACOOS CODAR is Operational in USCG SAROPS 2009-2010 Activity:

Bring all sustained regional-scale HFR networks up to operational status in USCG SAROPS

3 West Coast Regions for California & Oregon are ready.
Responding to Crisis: Deepwater Horizon

2010

U.S. IOOS partnership demonstrated ability to:

- Quickly deploy technologies: Gliders and HF radar, saving resources/improving safety
- Models/Imagery ingested into NOAA/Navy models
- Data assimilation improved spill response decision-making and public understanding

HFR validation of SABGOM Forecast combined with satellite detected oil slicks

Briefing Blog 127 Briefs

HFR data informed NOAA trajectory forecasts
U.S. National HFR Network Today

The Growing Challenge:
Maintaining the Baseline on which we Build
Lessons Learned:
• People – Leaders & Followers, Teachers & Students, Scientists & Storytellers
• Passion - Set Noble Goals, Embrace Grand Challenges
• Persistence - Work on the Hard Things, Take a Risk

Proven Pathways:
• Form Partnerships, Bridge Barriers
• Communicate, Mentor, Inspire

Pathways to Discover:
• Sustainability

Slocum Glider RU27 - The Scarlet Knight
Departs Tuckerton, NJ - April, 2009
Arrives Baiona, Spain – December, 2009
First Glider to cross an ocean basin