The Health of the US Coastal Observing System

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Carl Gouldman (NOAA/NOS/IOOS)  Recent presentation in Korea
Colleen Mouw (URI)
ESA coastal altimetry (2017) workshop participants
Assigned Questions

WHAT
• What is the status of the current system?
• What elements are there?

HOW
• How robust is in terms of funding and technology?
• Where might it be expanded and what might be gained?

WHY
• What are the gaps?
• What are some unobserved key weather/climate processes that could be addressed with an expanded observing system, and what would we need for this?
IOOS - National Backbone has consistency in coverage/data/access

Buoys, Water Level Gauges, Coastal and Estuary stations

Satellites

Stream Gauges

Water Quality e.g. EPA Beaches

PORTS®

OOI Research Infrastructure
E.g. NOAA NDBC buoys and stations

- Coastal weather buoys (106) [SST, wave height & period] + [wind speed, direction, pressure, airT]
- Land-based C-Man (46) [wind speed, direction, pressure, airT]
- Possibly underfunded – concerns about data gaps – rely on coastguard activities for maintenance and rescue

http://www.ndbc.noaa.gov/
HF Radar Network

- National data center
- Regional coverage increasing
- Possibly underutilized in science community

$5M Annual Budget
~140 Radars
Owned by Non-Federal Partners
HF Radar used to detect submesoscale eddies that can be linked to flow and topography

Anti-cyclonic eddy count

Cyclonic eddy count

Submesoscale eddies persisting 1-7 days, and translating at 4-15 cm/sec. Spatial heterogeneity as a function of vorticity.
S-Y Kim 2011 Continental Shelf Res.
IOOS: Glider Program

- Regional Associations provide glider observations and presence
- Certification program – standardizing best practices
- Gliders run very differently regionally – routinely, sustained, event driven

Glider DAC

- National standards to ease data exchange from regional operators
- Real-time distribution to partners (GTS)
- Archiving (NCEI)
- QC processing
Mid Atlantic Bight Gliders used to determine how subsurface stratification, missing in models, reduce hurricane intensity (Irene) or ... not (Sandy).

Miles et al, JGR Oceans 2017
Remote Sensing is evolving to better represent coastal regions – Ocean Color

- Geostationary platforms - resolve coastal variability
- Increased spectral resolution - functional groups, remove bottom contamination, total suspended matter
- Atmospheric corrections continue to be a challenge
- Gaps in number of in-water measurements needed to validate and refine algorithms?
HICO instrument detects HAB: Western Long Island Sound

Dierssen et al, 2015 PNAS

(A) elevated Chl a fluorescence from MODIS Terra sensor (B) HICO yellow fluorescence of the ciliate M. rubrum.

A topological approach for quantitative comparisons of ocean model fields to satellite ocean color data, R. Heister et al, 2015 Methods in Oceanography.
New technologies enabling better coastal applications using altimetry

- CryoSat-2, HY-2, AltiKa, Jason-3 and Sentinel-3A,B Improvements in resolution!
- Atmospheric corrections and tides (resolution plus bathymetry) remain challenging, and it will take time to survey mean sea surface over new track areas.
- Data retrievals 0-4km offshore remain challenging
- Gaps in communication between model and satellite topography communities could be facilitated by providing various level 2 and 3 products for survey vs in depth analysis

ESA coastal altimetry (2017) workshop participants
SMAP surface salinity & soil moisture: May-2015 extreme flooding event in Texas

Multi-variate satellite observations (e.g., SMAP, GPM/TRMM, MODIS, JASON-2, GRACE, and SMOS) provide integrated assessment of land/sea impacts associated with flooding.

Unusually large freshwater plume in the central Gulf of Mexico was caused by runoff to Texas shelf (Fournier, Reager, Lee, et al. 2016)
Accessing regional IOOS datasets

Regional Association Data Portals

The IOOS Catalog

Integrated Ocean Observing System (IOOS) Archive Data Portal

Environmental Data Server Model Viewer

The Environmental Sensor Map
Modeling

Global Forecast System

Hurricane
GFDL
HWRF

Coupled

Oceans
HYCOM
WaveWatch III

NOS – OFS
• Great Lakes
• Northern Gulf of Mex
• Columbia R. Bays
• Chesapeake
• Tampa
• Delaware

Regional Modeling

CariCOOS Wave Model

Sea Nettle Forecast
Environmental Data Server

- Requirement for publicly accessible integrated model information
- IOOS invested in a capability; provides platform for collaboration opportunities with other NOS offices
- Provides RAs a solution for hosting model output
- Demonstrates RA modeling capabilities
Local ↔ National

“We are tied to the Ocean. And when we go back to the sea, whether it is to sail or to watch - we are going back from whence we came.”

- John F. Kennedy
## MARACOOS

**Themes:**
- Maritime safety
- Ecological decision support
- Water quality
- Coastal inundation
- Offshore energy

### Regional Observation & Modeling Capabilities

<table>
<thead>
<tr>
<th>Regional Priority Themes</th>
<th>Regional Observation &amp; Modeling Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theme 1. Maritime Safety</strong></td>
<td>Operational Input to USCG SAROPS, Operational input to USCG SAROPS, Operational input to USCG SAROPS, SST for survivability planning, Assimilation dataset for forecast models, Surface currents for SAROPS</td>
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<tr>
<td><strong>Theme 2. Ecological Decision Support</strong></td>
<td>Weather forecast ensemble validation, Circulation and divergence maps for habitat, SST &amp; Color for habitat, Subsurface T &amp; S for habitat, 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, Surface currents for flotables, bacteria, spill response, Surface currents for flotables, bacteria, spill response, Ocean color for river plumes, Nearshore dissolved oxygen surveys, Surface currents for flotables, bacteria, spill response</td>
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<tr>
<td><strong>Theme 4. Coastal Inundation</strong></td>
<td>Weather forecast ensemble validation, Current forecast model validation, SSTs assimilation into forecast models, Assimilation dataset for forecast models, Nested forecast ensembles</td>
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<tr>
<td><strong>Theme 5. Offshore Energy</strong></td>
<td>Historical analysis &amp; wind model validation, Historical current analysis &amp; wind model validation, Historical analysis surface fronts &amp; plumes for siting, Historical analysis of subsurface fronts &amp; plumes, Coupled ocean-atmosphere models for resource estimates</td>
</tr>
</tbody>
</table>
The major societal goals of the GCOOS-RA are:

- Safe and Efficient Marine Operations
- Mitigation of Effects of Coastal Hazards
- Public Health and Safety
- Healthy Ecosystems and Water Quality

### Table 3.1 Variables for recommended initial monitoring from moorings and AUVs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Phase II Moorings</th>
<th>Phase III Moorings</th>
<th>Phase I AUVs</th>
<th>Phase II AUVs</th>
<th>Phase III AUVs</th>
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<tbody>
<tr>
<td><strong>Water Properties</strong></td>
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<td>Temperature</td>
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<tr>
<td>Conductivity/Salinity</td>
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<td>Sub-surface Currents</td>
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<tr>
<td>Pressure</td>
<td>X</td>
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<tr>
<td>Dissolved Oxygen (esp., Hypoxia areas)</td>
<td>X</td>
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<td>Backscattering</td>
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<td>Colored dissolved organic matter (CDOM)</td>
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<tr>
<td>Acidity (pH)</td>
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<td>Partial pressure of carbon dioxide (pCO₂)</td>
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<td>Dissolved Nutrients (Nitrogen)</td>
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<tr>
<td>Dissolved Nutrients (Phosphorus)</td>
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<tr>
<td>Dissolved Nutrients (Other; e.g., urea)</td>
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<td><strong>Light and optical conditions</strong></td>
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<tr>
<td>Light attenuation/transmission</td>
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<td>Fluorometry (including chlorophyll-a)</td>
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<tr>
<td>Turbidity</td>
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<td><strong>Marine Meteorology</strong></td>
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<td>Wind speed and direction</td>
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<tr>
<td>Air Temperature</td>
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<td>Barometric Pressure</td>
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<tr>
<td>Humidity</td>
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<tr>
<td><strong>Other</strong></td>
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<tr>
<td>Real-time telemetry</td>
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<td>OPD or flow-cytobot (HAB-prone areas)</td>
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<tr>
<td>Sampling for HABs at selected piers</td>
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<tr>
<td>Hydrocarbon detectors</td>
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<tr>
<td>Passive acoustic listening for animal tracking</td>
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<td>?</td>
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</tbody>
</table>
NERACOOS

• Maritime Safety and Security
• Ocean and Coastal Ecosystem Health
• Ocean Energy
• Coastal Hazards Resiliency
Regional commonalities:
- Maritime safety
- Ecosystems/water quality – in different flavors
- Coastal inundation
- Highly leveraged funding

Regional Differences:
- Emphasis on energy
- Technologies: buoy vs glider etc.
- Strategy: opportunistic vs monitoring
- Level of implementation

Potential gaps:
- Leveraged funding means that new investigators may be disadvantaged
- Many regional groups are highly dependent on individual PI’s (funding, priorities). Planning for succession?
- Lack of standardization in model skill assessment – but multiple models in each region.
Opportunities:

1. Gap in communication: CLIVAR <-> coastal oceanographers – would increase potential for linking CLIVAR to coastal concerns and vice versa. (CERF Nov 9, 2017 Providence, RI)

2. Differences in regional programs allow them to address diverse and differing priorities. Connecting to CLIVAR community more challenging possibly.

3. Multiple regional models and missing standardized skill assessment make assessing model design decisions challenging. Regional models could collaborate, e.g. share boundary conditions to enhance spatial coverage.