Panel for Integrated Coastal Observations

Requirements for Global Implementation of the Strategic Plan for Coastal GOOS

- Data & information requirements for ecosystem – based approaches to
  - Managing human uses of ecosystem goods & services
  - Mitigating the impacts of natural hazards
  - Adapting to climate change

- The PICO Plan
  - The building blocks of a System of Systems
  - Requirements for implementation
The Call for “Coastal” GOOS

• Convention on the Law of the Sea & the 2009 UN session on Oceans and Law of the Sea
• Agreement on the Conservation & Management of Straddling & Highly Migratory Fish Stocks
• Convention on Biological Diversity & the Jakarta Mandate
• Global Program of Action for the Protection of the Marine Environment from Land Based Sources
• UNCED Agenda 21, Program of Action for Sustainable Development
• Implementation Plan of the World Summit on Sustainable Development
• International Convention for the Prevention of Pollution From Ships
• Ramsar Convention
• ETC
GSC-III, 2000 (GOOS Report No. 87)

- The broad area of concern [for COOP] extends from
  - semi-enclosed systems in the coastal zone to
  - the continental shelf &
  - the deep ocean as appropriate

- Changes in local ecosystems cannot be understood or anticipated without
  - Observing & modeling large scale changes in the propagation of change across scales.
  - This calls for coordinated development of basin scale & coastal GOOS through a nested approach.
Sustainable Development
1992 UNCED, Rio de Janeiro & 2002 WSSD, Johannesburg

- Ecosystem goods & services valued at > $30 trillion (U.S. dollars) globally
- Coastal marine & estuarine ecosystems account for 30 – 40% of the Earth’s goods & services but only ~ 10% of the earth’s surface area.
Indicators of Sustainable Development

Marine & Estuarine Ecosystem Goods & Services

- Food Security
- Energy Security
- Aesthetic Value
- Tourism & Recreation
- Storage of Raw Materials
- Maintenance of Water Quality
- Resilience to Pressures on Ecosystems
- Uptake & Storage of Green House Gasses
Sustained Provision of Ecosystem Goods & Services Depends on Efficiently Linking the 4 Legs of Sustainable Development Through Integrated Ocean Governance
Sustained Observations & Modeling

Coastal GOOS

Human Expansion

Marine Ecosystem Goods & Services

IMPACTS

The Global Ocean Observing System (GOOS)

Climate Change
Natural Hazards
Marine Operations

Basin Scale GOOS

IMPACTS

Marine Ecosystem Goods & Services

IMPACTS
Global Implementation of Coastal GOOS

Coastal Ocean Observation Panel (COOP)

Integrated Design

Implementation Strategy

Panel for Integrated Coastal Observations (PICO)

Action Plan for Phased Implementation

2003

2005

2011
Panel for Integrated Coastal Observations
PICO

- Paul DIGIACOMO (Co-Chair), USA
  NOAA-NESDIS Center for Satellite Applications and Research
- Jose MUELBERT (Co-Chair), Brazil
  Universidade Federal do Rio Grande, Instituto de Oceanografia
- Tom MALONE, USA
  UMCES Horn Point Laboratory
- John PARSLOW, Australia
  CSIRO Marine and Atmospheric Research
- Neville SWEIJD, South Africa
  Natural Resources & the Environment, Council for Scientific & Industrial Research
- Helen YAP, Philippines
  University of the Philippines, The Marine Science Institute
The PICO Plan
Requirements for Global Implementation of the Strategic Plan for Coastal GOOS

• A road map for expanding GOOS to inform EBAs

• The plan draws upon & builds on
  - 2003 & 2005 GOOS Reports
  - 2006 IGOS Coastal Theme Report
  - OceanObs ‘09 Plenary & White Papers
  - A Framework for Ocean Observing
  - U.N. Assessment of Assessments & the Regular Process

• The plan complements recommendations of the OOPC for the Global Ocean – Climate Observing System
The Plan

• Identifies key indicators of pressures, states & impacts of changes in state for 7 priority *Phenomena of Interest*

• Specifies end – to – end systems that are the building blocks for a System of Systems

• Identifies essential variables that should be monitored based on these specifications

• Describes the required infrastructure of the System of Systems to monitor these variables & model changes in states

• Recommends procedures for building the System of Systems
Specify the Building Blocks of a System of Systems

(1) Determine priority Phenomena of Interest (PoI) & Associated key indicators of ecosystem states

(2) For each PoI

- Identify user groups & determine their data & information requirements for products & applications
- Identify key indicators of relevant pressures, states, & impacts of changes in states
- Document observing system requirements
  - Observations (in situ & remote sensing)
  - Modeling & analysis
  - Reporting (real – time or delayed mode)
  - Data management & communications
- Assess operational status & identify gaps
## Priority Phenomena of Interest & Associated Indicators

<table>
<thead>
<tr>
<th>Phenomenon of Interest</th>
<th>Key Indicators of Ecosystem States</th>
</tr>
</thead>
</table>
| Coastal Eutrophication & Hypoxia                    | Phytoplankton biomass fields  
Dissolved oxygen fields                                   |
| Human Exposure to Waterborne Pathogens              | Distribution & abundance of waterborne pathogens                              |
| Human Exposure to Algal Toxins                      | Distribution & abundance of toxic phytoplankton species                      |
| Habitat Loss & Modification                         | Extent & condition of biologically structured habitats                      |
| Vulnerability to coastal flooding                   | Extent & condition of habitat buffers to flooding                             |
| Ocean acidification                                 | Extent & condition of coral reefs  
Abundance of calcareous plankton                            |
| Food Security                                       | Abundance of harvestable finfish & shellfish stocks                           |
Key Indicators of Pressures & Impacts

Drivers

Pressures

Responses

Impacts

States

Drivers:
- Sea level rise
- Ocean acidification
- Ocean warming
- Extreme weather
- Land-based inputs
- Harvest of LMRs
- ENSO, PDO, etc.
- Basin scale migrations of large pelagic predators

Pressures:
- Chlorophyll & dissolved O₂ fields
- Distribution of waterborne pathogen & toxic algae fields
- Spatial extent of biologically structured benthic habitats
- Abundance of calcareous plankton
- Abundance of exploitable fish stocks

Responses:
- Resiliency to coastal flooding
- Fish landings
- Public health risks
- Beach & shellfish bed closures
- Coastal real estate & infrastructure
- Tourism

States:
- Habitats & biodiversity
- Ecosystem Goods & Services
## ESSENTIAL ECOSYSTEM STATE VARIABLES

<table>
<thead>
<tr>
<th>Geophysical</th>
<th>Chemical</th>
<th>Biological</th>
<th>Biophysical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Dissolved N, P, Si</td>
<td>Chlorophyll</td>
<td>Water leaving radiances</td>
</tr>
<tr>
<td>Salinity</td>
<td>Dissolved O₂</td>
<td>Toxic phytoplankton</td>
<td>Downwelling irradiance</td>
</tr>
<tr>
<td>Current velocity</td>
<td>pH</td>
<td>Calcareous plankton</td>
<td></td>
</tr>
<tr>
<td>Surface wave height &amp; direction</td>
<td>pCO₂</td>
<td>Copepod indicator species</td>
<td></td>
</tr>
<tr>
<td>Absolute sea level</td>
<td>Total alkalinity</td>
<td>Enteric bacteria</td>
<td></td>
</tr>
<tr>
<td>Shoreline position</td>
<td>Aragonite saturation state</td>
<td>Extent of biologically structured benthic habitats</td>
<td></td>
</tr>
<tr>
<td>Bathymetry</td>
<td>Colored dissolved organic matter</td>
<td>Species diversity</td>
<td></td>
</tr>
<tr>
<td>Sea surface roughness</td>
<td></td>
<td>Exploitable fish stocks</td>
<td></td>
</tr>
<tr>
<td>Total suspended matter</td>
<td></td>
<td>Bycatch</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Large pelagic predators</td>
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</tbody>
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Example

End – to – End System for Indicators of Habitat Loss & Modification

• Target coral reefs, seagrass beds, mangrove forests & salt marshes

• Why?
  ➢ Support high species diversity & living marine resources;
  ➢ Prevent coastal erosion
  ➢ Buffer coastal communities against storm surges & flooding
  ➢ Important carbon sinks (mangrove forest in particular)
  ➢ Tourist attractions
  ➢ Important indicators of the impacts of
    • ocean warming &
    • acidification (coral reefs in particular)
A Building Block of a System of Systems
End – to – End System for Habitat Loss & Modification

Objectives

• Document changes in extent & fragmentation of habitat buffers
  ➢ Mangrove forests, Vegetated sand dunes & Tidal salt marshes
  ➢ Seagrass beds & Warm water coral reefs

• Map vulnerability to coastal flooding

• Estimate impacts of changes in habitat buffers on
  ➢ The vulnerability of future coastal populations to flooding &
  ➢ Exposure to pathogens & toxic chemicals during post-flooding runoff
Requirement Drivers – Products

• Index of Vulnerability to Flooding
  
  ➢ Digital, high resolution (≤ 1 km) maps of vulnerability to flooding updated at 1 – 5 yr intervals depending on
    • Frequency & magnitude of flooding events &
    • Coastal geomorphology
  
  ➢ Realistic scenarios for changes in vulnerability 5 – 10 yr out based on projections of
    • Sea level rise
    • Land – use practices
    • Coastal erosion
    • Loss & modification of biologically structured benthic habitats

• Post – Event Water Quality Indicators
  
  ➢ Digital maps & forecasts of water quality updated daily until event signature dissipates
Data Requirements for Products

**In Situ Measurements**

- Continuous
  - Sea level @ sentinel sites
  - Rain fall & river flows
  - Water temperature & salinity
  - Surface currents & wave fields
- Post–event, daily
  - Distribution of water quality parameters
- Seasonally
  - Validate remote sensing of the extent of habitats

**Remote Sensing**

- Continuous
  - Surface currents & wave fields
  - Sea surface temperature & salinity
- Daily
  - Rain fall & river flows
- Annually
  - Spatial distribution of habitat buffers
- Digital, high resolution maps @ 5 yr intervals
  - Land – use/cover
  - Flood zones
  - Near shore topography & bathymetry
- During the event
  - Time – space extent of flooding
- Post–event, daily
  - Temperature, salinity & chlorophyll fields

**Reporting**

- Near real time
  - Water quality parameters
  - Tides, river flows, rainfall, currents & waves
- Delayed mode
  - Land – use/cover, flood zones
  - Habitat data
  - Bathymetry – topography
  - Validation
Model Requirements

• High resolution digital elevation models of topography, shoreline position & bathymetry

• Algorithms to compute vulnerability as a function of
  - Current & predicted seasonal & annual mean sea level,
  - Near shore bathymetry – topography
  - Wave fields
  - Spatial distributions of ecological buffers
  - Spatial distribution of land use/cover

• Coastal circulation – wave models

• High resolution digital geospatial models (GIS) of levels of vulnerability

• Maps of water quality parameters
  - Temperature & salinity
  - Suspended sediments & Chlorophyll – a
  - Waterborne pathogens & chemical contaminants
The Design Plan Calls for Multi-Scale Hierarchy of Observations & Models

- Basin Scale Module
- Coastal Module
  - Global Coastal Network (GCN)
  - Regional Coastal Ocean Observing Systems

Lower Resolution → Higher Resolution
Implementation Status of Coastal GOOS

• RCOOSs are slowly being implemented by developed countries
  ➢ Examples include
    • Integrated Marine Observing System – Australia
    • EuroGOOS & the Global Monitoring for Environmental Security – Europe
    • Integrated Ocean Observing System – USA
  ➢ Global implementation of RCOOSs has been slow & uneven, especially in the developing world;
  ➢ The GCN exists in concept only;
  ➢ Most operational systems are not part of an integrated system of system, e.g.,
    • Global Coral Reef Monitoring Network
    • Continuous Plankton Recorder surveys
    • Fish stock assessments
    • Global Tracking Network

• Problems
  ➢ Insufficient sustained funding by developed countries for capacity building in developing countries & emerging economies;
  ➢ No international policies & procedures for establishing common standards & protocols;
  ➢ Lack of international coordination mechanism for global implementation
Accelerating the Delivery of Coastal GOOS

- Establish a commission, or empower the GOOS Regional Council, to
  - Coordinate phased implementation on a global scale
- Support national & international programs that
  - Target priority infrastructure for observations & predictions as set forth in the PICO plan
- Establish data management & communications systems for
  - Interoperability & integration among monitoring systems & data integration within regions
- Support sustained capacity building to
  - Fill priority spatial & temporal gaps in the Global Coastal Network in developing countries & emerging economies
- Fund a regional demonstration projects at priority super sites
The Next Step
Formulate a Proposal

• International demonstration project

➢ The super site:
  • Indonesian Archipelago-South China Sea Region

➢ Why?
  • Greatest number of pressures
  • Global epicenter of habitat & species diversity
  • Sentinel sites for human pressures & state changes for all phenomena of interest
  • Regional networks are in place to facilitate implementation
Indonesian Archipelago-South China Sea Regional Networks

- Ocean Data and Information Network for the Western Pacific
- The Southeast Regional GOOS (SEAGOOS)

- Projects funded by The Global Environmental Facility
  - Reversing Environmental Degradation Trends in the South China Sea & Gulf of Thailand (UNEP)
  - West Pacific East Asia Oceanic Fisheries Management Project
  - Arafura & Timor Seas Ecosystem Action Program
  - Sulu-Celebes Seas Sustainable Fisheries Management Project
  - Large Marine Ecosystem programs in the Gulf of Thailand, South China Sea & the Indonesian Sea

- The East and Southeast Asia Biodiversity Information Initiative
- The Coral Triangle Initiative on Coral Reefs, Fisheries & Food Security Project of Conservation International

- Pacific Institutes of Marine Science (member of the World Association of Marine Laboratories)
Global Networks for Facilitating Expansion of GOOS to Include “Operational Ecology”

• Institutional Networks
  - Partnership for Observation of the Global Oceans (POGO)
  - GOOS Regional Alliances (GRAs)
  - The World Association of Marine Stations (WAMS)
  - IOC-IODE Ocean Data and Information Networks

• Programmatic Networks
  - International network of Coral Reef Ecosystem Observing Systems (I-CREOS)
  - Seagrass Net
  - Chlorophyll Globally Integrated Network (ChloroGIN)
  - Everyone’s Gliding Observatories (EGO)
  - GEO Biodiversity Observation Network (GEOBON)
  - Global Alliance of CPR Surveys (GACS)
  - Global Tracking Network (GTN) & Global Tagging of Pelagic Predators (GTOPP)
  - Regional Marine Instrument Centers (RMICs)
  - Global Terrestrial Network for River Discharge (GTN-R)
Thank You
<table>
<thead>
<tr>
<th>Ecosystem Goods &amp; Services</th>
<th>Key Ecosystem States Upon Which the Provision of Goods &amp; Services Depends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilience to Change &amp; Coastal Erosion</td>
<td>Biologically structured benthic habitats, Species diversity</td>
</tr>
<tr>
<td>Food Security</td>
<td>Biologically structured benthic habitats, Species diversity, Primary production, Fish stocks, Iconic species, Dissolved oxygen, Aragonite saturation state</td>
</tr>
<tr>
<td>Uptake &amp; Storage of Green House Gasses</td>
<td>Biologically structured benthic habitats, Biological pump, Temperature, Thermohaline circulation</td>
</tr>
<tr>
<td>Maintenance of Water Quality</td>
<td>Biologically structured benthic habitats, Nutrient cycling, Microbial degradation of pollutants, Currents</td>
</tr>
<tr>
<td>Storage of Raw Materials</td>
<td>Biologically structured benthic habitats, Fresh water, Fossil fuels, Medicines (species diversity)</td>
</tr>
<tr>
<td>Tourism &amp; Recreation</td>
<td>Biologically structured benthic habitats, Species diversity, Iconic species, Fish stocks</td>
</tr>
<tr>
<td>Aesthetic Value</td>
<td>Biologically structured benthic habitats, Species diversity, Iconic species</td>
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</table>
Requirement Drivers

• Users of Products
  - Coastal land-use, flood plain & water quality managers
  - Infrastructure developers
  - Insurance & re-insurance industries
  - Emergency response managers
  - Scientists & teachers

• Applications of Products
  - Assessments of vulnerability to coastal erosion & flooding
  - Land – use planning & managed retreat from the shoreline
  - Management of land – based sources of pollution
  - Marine spatial planning & establishment of MPAs
  - Environmental protection & management of resources
  - Increased awareness of the importance of coastal ecosystems to the well being of human populations.
• Nations implement their contributions to GOOS by working with data providers & users in their respective regions to
  - Specify observing system requirements for products & services
  - Contributing to building the Global Coastal Network
  - Set priorities for capacity building
  - Establish R&D test beds

• Based on user specifications, nations build Regional Coastal Ocean Observing Systems (RCOOSs) by
  - Integrating existing data streams & data bases as needed,
  - Increasing spatial & temporal resolution of observations & models & measuring more variables as needed, & by
  - Implementing capacity building & research projects.
Global Coastal Network

- Measure, manage & analyze data on
  - Essential variables
  - Needed to assess pressures, states & impacts globally
- Observes the essential variables via
  - Remote sensing &
  - \textit{In situ} measurements at sentinel & reference sites;
- Implements internationally accepted standards & protocols for
  - Measurements & data telemetry;
  - Data management & communications;
  - Modeling & analysis.