OCEAN SCIENCE IN SUPPORT OF SUSTAINABILITY

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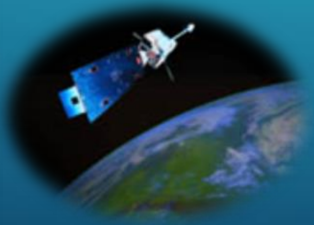
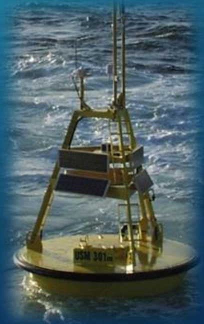
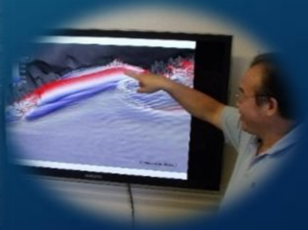
SCHOOL FOR MARINE SCIENCE AND TECHNOLOGY



OVERVIEW

- Role of the oceans for global sustainability
- Societal benefits of the ocean
- Ocean change and implications for sustainability
- UN proposed targets for ocean sustainability
- Ocean science needs in support of sustainability
  - Gaps
  - New Technologies
  - Data management and computation
  - Integrated modeling approaches for decision support

THE CRITICAL ROLE OF OCEANS FOR GLOBAL SUSTAINABILITY

- Climate and weather engine
- Ecosystem services
  - Greenhouse gas uptake and oxygen source
  - Reservoir of biodiversity
  - Water resource
  - Critical habitat
  - Coastal protection
- Food security
- Human health
- Marine resources
- Economic benefits

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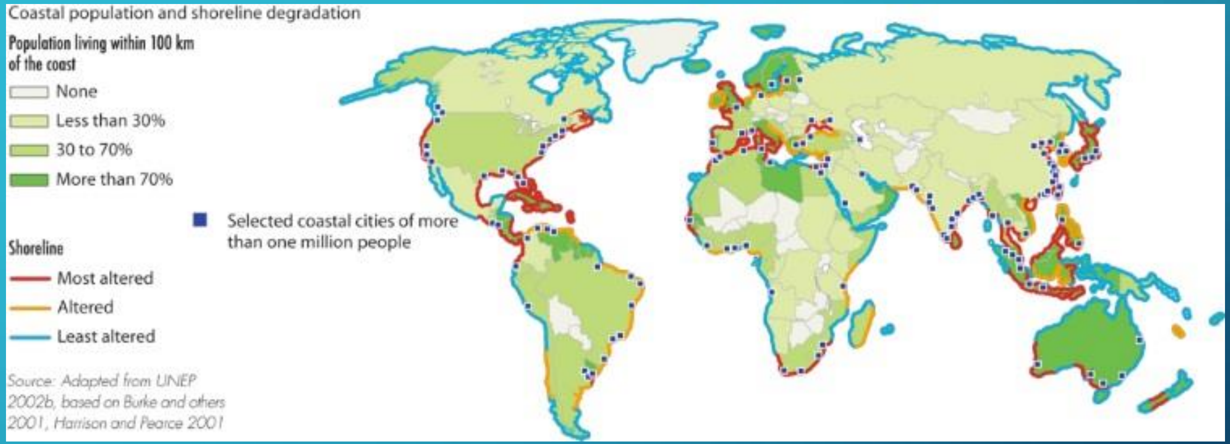
SOCIETAL BENEFITS OF THE OCEANS

- Population distributions – dependence of human population on oceans
- Key to poverty eradication
- Critical for maritime commerce and transportation
- Essential to global food supply
- Blue carbon and blue economy
- Energy resource



Bounford.com and UNEP/GRID-Arendal

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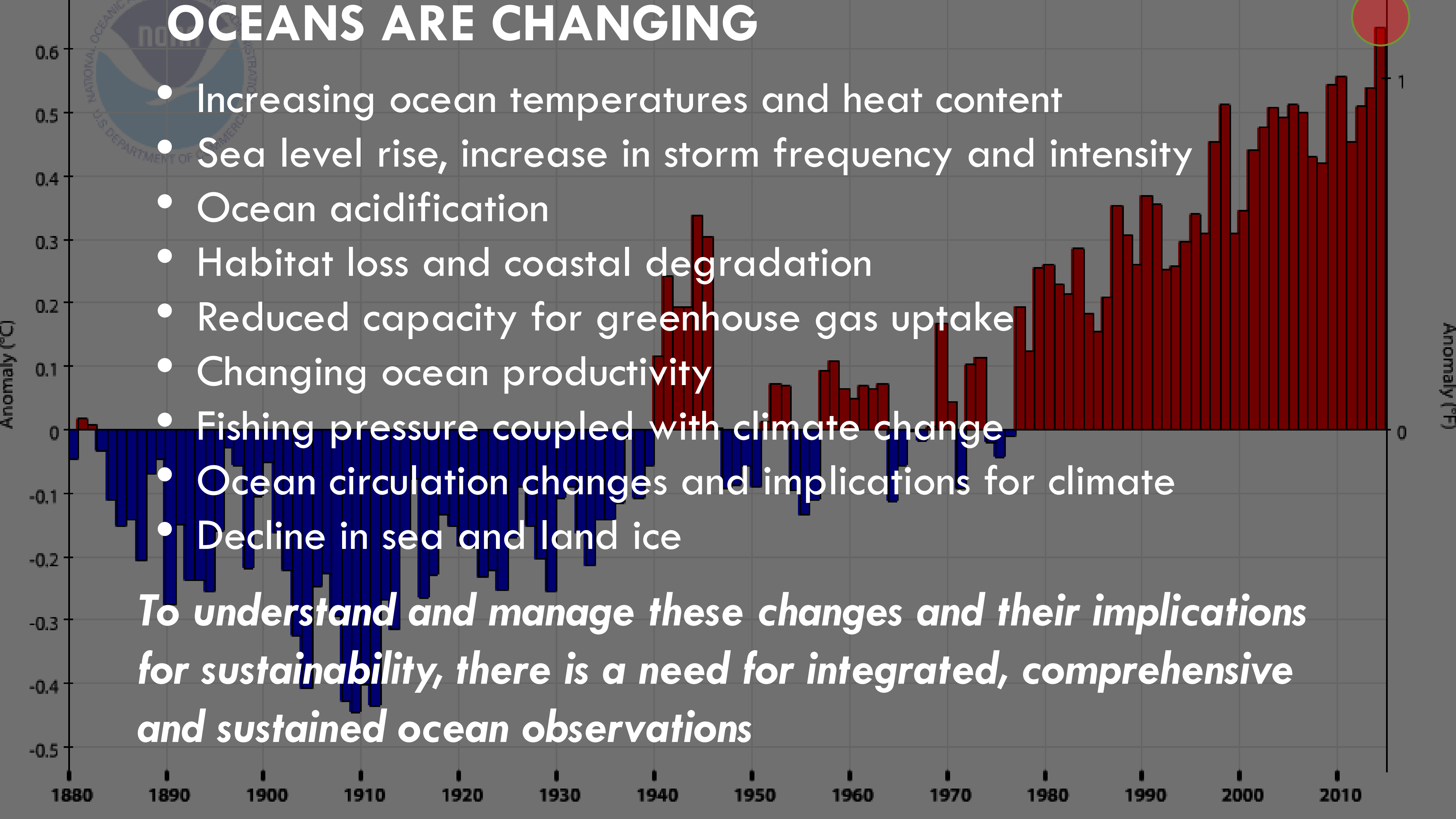
OCEANS ARE CHANGING

- Increasing ocean temperatures and heat content
- Sea level rise, increase in storm frequency and intensity
- Ocean acidification
- Habitat loss and coastal degradation
- Reduced capacity for greenhouse gas uptake
- Changing ocean productivity
- Fishing pressure coupled with climate change
- Ocean circulation changes and implications for climate
- Decline in sea and land ice

To understand and manage these changes and their implications for sustainability, there is a need for integrated, comprehensive and sustained ocean observations



UN GOAL 14: CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT – PROPOSED TARGETS

- Prevent and reduce **marine pollution**, particularly from land-based activities
- Manage and protect **marine and coastal ecosystems**, including strengthening resilience and achieving restoration
- Minimize and address impacts of **ocean acidification**
- Regulate harvesting, and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices and **implement science-based management** to restore fish stocks to produce maximum sustainable yield
- **Conserve** at least 10 per cent of **coastal and marine areas**
- Prohibit certain forms of fisheries subsidies which contribute to **overcapacity and overfishing, and IUU fishing**, recognizing appropriate and effective special and differential treatment for developing and least developed countries
- **Promote transfer of marine technology** to developing countries
- Increase the economic benefits to SIDS and LDCs from the sustainable use of marine resources, including through **sustainable management of fisheries, aquaculture and tourism**

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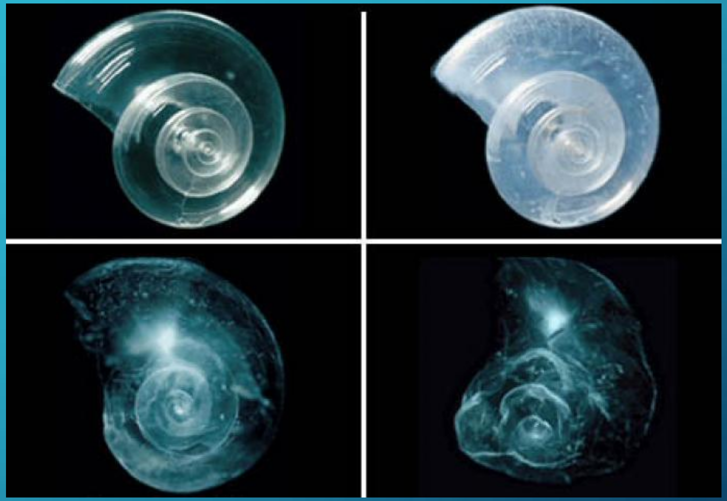
OCEAN OBSERVING NEEDS

- Ocean acidification
- Carbon monitoring
- Sea level rise and improved coastal forecasting
- Harmful algal bloom monitoring
- Estuarine and benthic habitat conservation
- Status of fisheries and critical habitat
- Oil spill monitoring and response
- Safe navigation (wave and current monitoring)
- Human health and water quality
- Marine biodiversity
- Support for Ecosystem-Based Management



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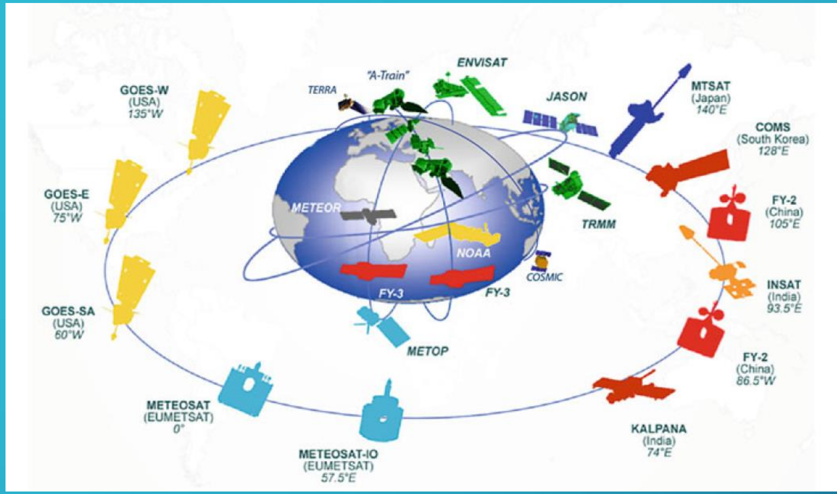
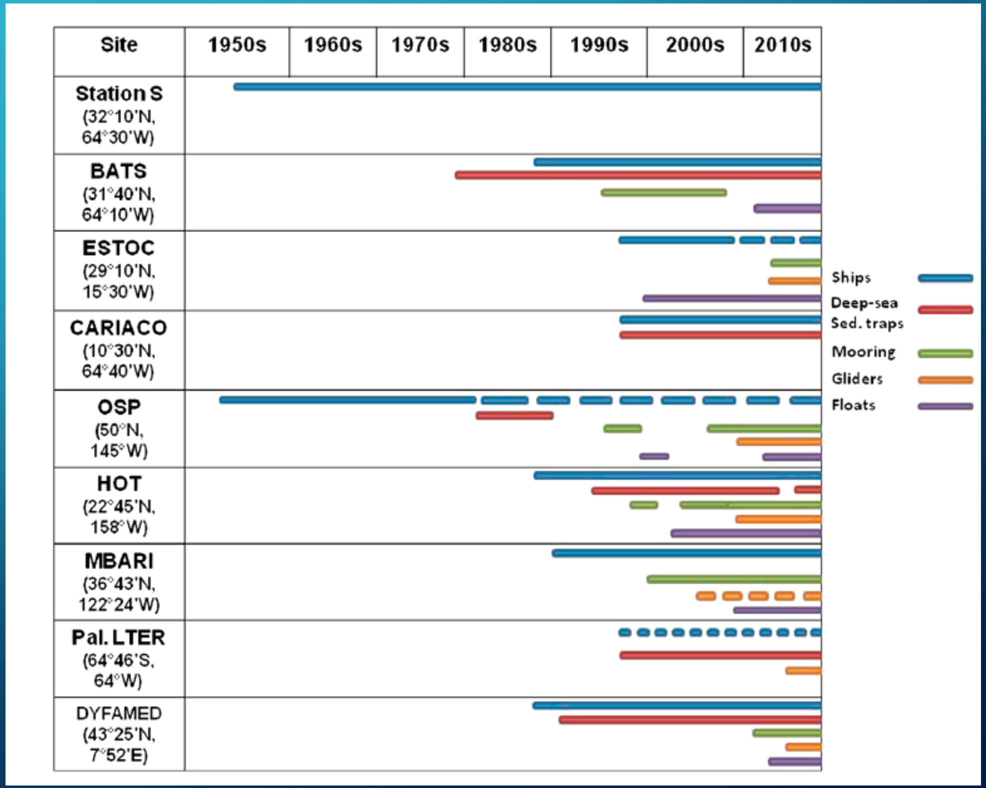
OCEAN OBSERVING NEEDS

- The need for a comprehensive, integrated climate observing capability (Trenberth et al., 2002; 2013)
  - Need for long-term climate data records of essential climate variables
  - Challenges of continually changing observing systems
  - Data computation, archiving, accessibility, and management requirements
- Sustained ocean time-series
  - HOTS, BATS, CARIACO (Church et al., 2013)
  - Some measurements still require ship-based methods





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THE GLOBAL OCEAN OBSERVING SYSTEM (GOOS)

- A sustained, coordinated international system for gathering data about the oceans and seas of the Earth,
- A system for processing such data, with other relevant data from other domains, to enable the generation of beneficial analytical and prognostic environmental information services, and
- The research and development on which such services depend for their improvement.

GOOS is part of an Integrated Global Observing Strategy (IGOS) in which the UN agencies (UNESCO and its IOC; WMO, UNEP, and FAO) are working together and with ICSU and the satellite agencies (via the Committee on Earth Observation Satellites - CEOS). In that context, the GOOS forms the ocean component of GCOS (the Global Climate Observing System) and the marine coastal component of the GTOS (the Global Terrestrial Observing System). GOOS itself is sponsored by the IOC of UNESCO, WMO, UNEP and ICSU.

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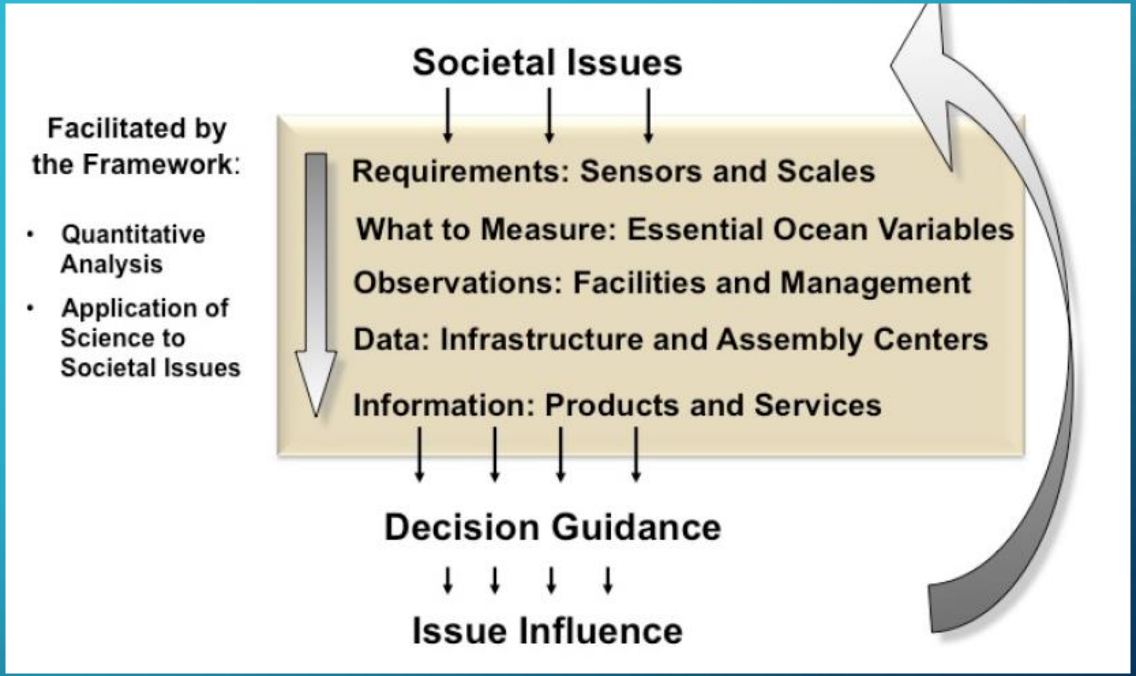
ECOSYSTEM-BASED APPROACHES

- UNESCO (2012) makes recommendation for coastal ocean observing on both global and local scales

- Data needs for ecosystem-based management of coastal ecosystem services (Malone et al., 2013, 2014) – need for localized observing systems



Natural Resources Forum 38 (2014) 168–181 DOI: 10.1111/1477-8947.12045

Enhancing the Global Ocean Observing System to meet evidence based needs for the ecosystem-based management of coastal ecosystem services

Thomas C. Malone, Paul M. DiGiacomo, Emanuel Gonçalves, Anthony H. Knap, Liana Talaue-McManus, Stephen de Mora and Jose Muelbert

Contents lists available at SciVerse ScienceDirect
Marine Policy
journal homepage: www.elsevier.com/locate/marpol

A global ocean observing system framework for sustainable development

Thomas C. Malone[a,*], Paul M. DiGiacomo[b], Emanuel Gonçalves[c], Anthony H. Knap[d], Liana Talaue-McManus[e], Stephen de Mora[f]

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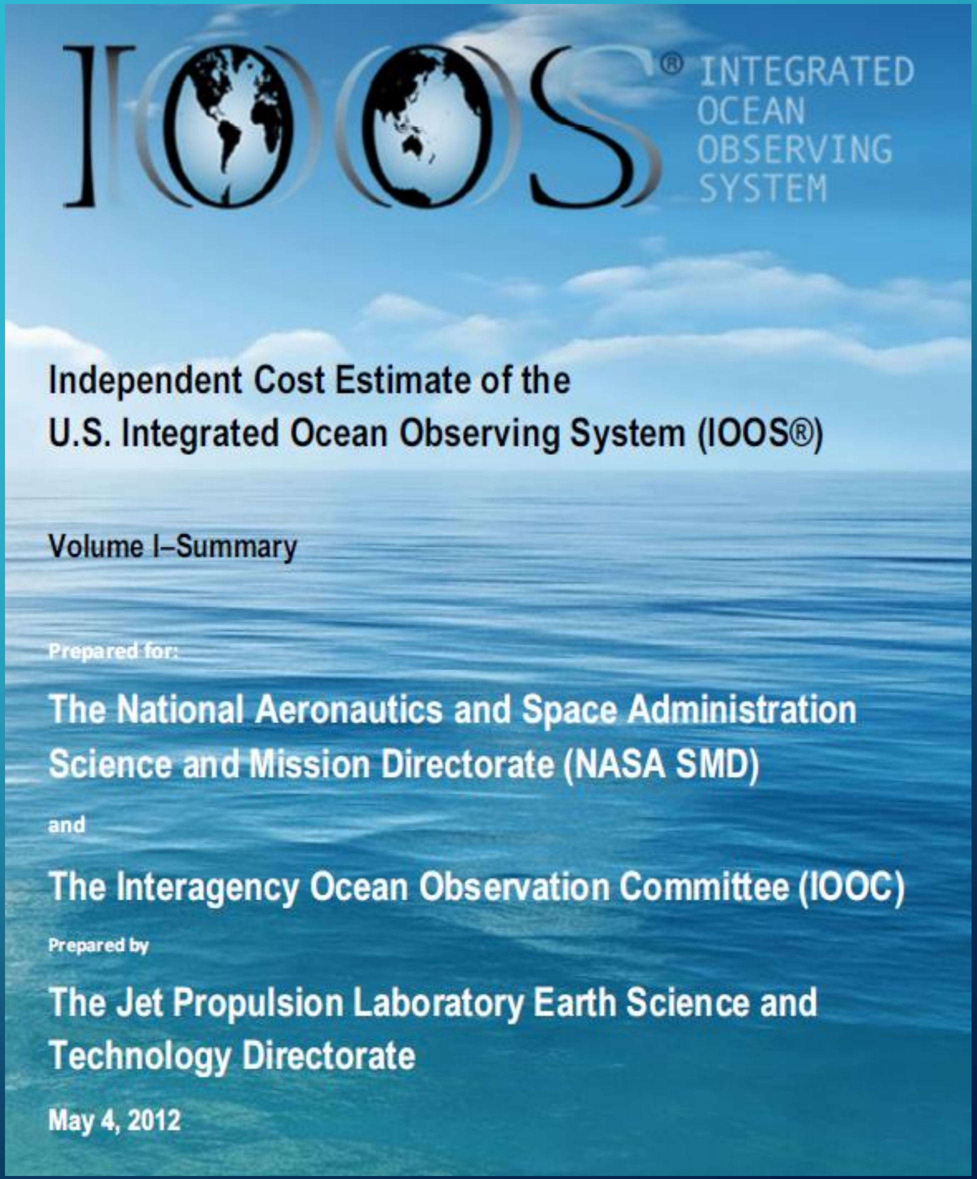
GAPS

- An independent Cost Estimate done by NASA JPL for the IOOS Program Office to fulfill a requirement of the ICOOS Act estimates that to build out the needed capacity over the next 15 years for the federal (NOAA, NASA, Navy, ACOE, EPA, etc., including satellites) and non-federal is $54B.
- Major unmet needs in the country's observing capacity.


IOOS® INTEGRATED OCEAN OBSERVING SYSTEM

Independent Cost Estimate of the
U.S. Integrated Ocean Observing System (IOOS®)

Volume I–Summary

Prepared for:

The National Aeronautics and Space Administration
Science and Mission Directorate (NASA SMD)

and

The Interagency Ocean Observation Committee (IOOC)

Prepared by

The Jet Propulsion Laboratory Earth Science and
Technology Directorate

May 4, 2012

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GAPS (CONT.)

- IOOS Regional Build Out Plans
  - Lay out a strategy for expanded observing capabilities
  - IOOS framework can be used to integrate existing and new capacity across federal and non-federal partners


Synthesis of Regional IOOS Build-out Plans for the Next Decade

Prepared for the

Integrated Ocean Observing System Association

by

Holly Price and Leslie Rosenfeld

December 2012

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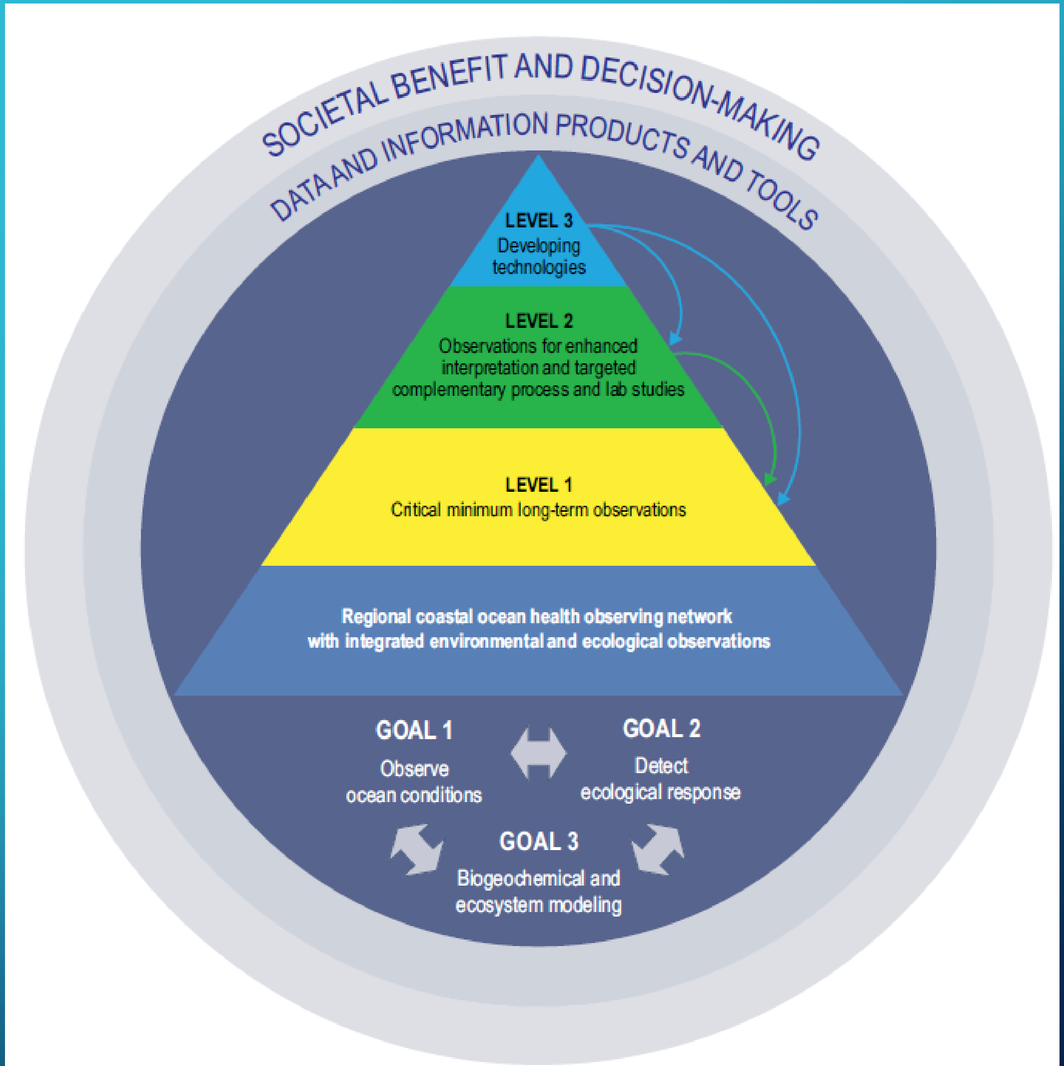
GAPS (CONT.)

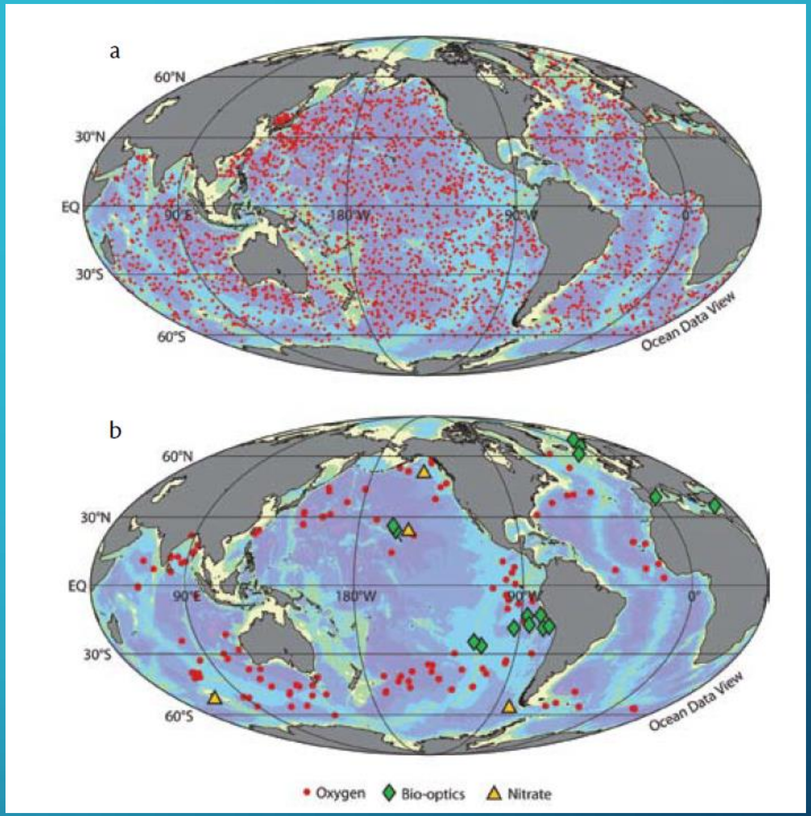
- Other activities/resources to assess gaps and observing needs
  - NOAA Space Platform Requirements Working Group (SPWRG)
  - The 2017-2027 National Academy of Sciences Decadal Survey for Earth Science and Applications from Space (follow on to the 2007 Decadal Study)
  - Recommendations for ocean acidification networks (Alin et al., 2015)



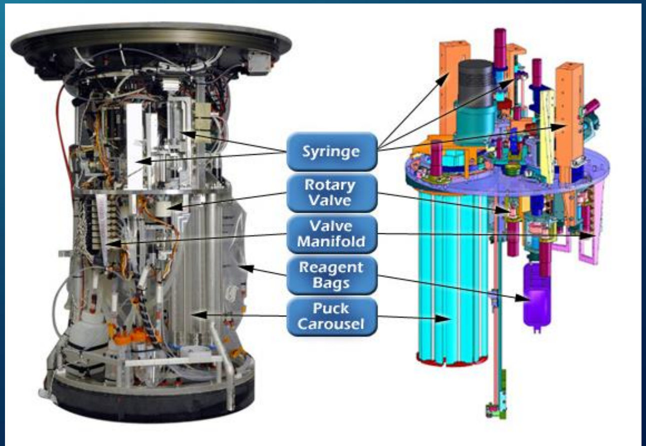
Schematic diagram of the parts of the Global Ocean Acidification Observing Network (Alin et al., 2015)

NEW TECHNOLOGIES

- Profiling floats and gliders (Johnson et al., 2009)
- Sensor innovation
  - IOOS Marine Sensor Innovation Project
    - Imaging Flow CytoBot (IFCB)
    - Environmental Sample Processor (ESP)
    - Nutrient Sensors
  - Schmidt Ocean XPrize Competition pH Sensor Development
  - Shell Ocean Discovery Xprize
- Ocean Observatories Initiative (OOI) technology advances



IFCB



NEW TECHNOLOGIES (CONT.)

- Integrated surface, undersea and airborne approaches
- Novel communications and telemetry approaches
- Utilizing citizen sensor/data networks, crowd sourcing, and "Internet of Things"
- Cloud computing/centralized servers/virtual computing
- "Lower cost, greater efficiency and accuracy" Bamford and Kavanagh (MTS Journal, 2015)

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FUTURE DATA MANAGEMENT/ COMPUTATIONAL NEEDS

- “Even with new computational tools, challenges remain to provide adequate analysis, processing, meta-data, archival, access, and management of the resulting data and the data products. As volumes of data continue to grow, so do the challenges of distilling information to allow us to understand what is happening and why, and what the implications are for the future” (Trenberth et al., 2013)
- Data products need to support “information-based actions and decisions”

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DATA MANAGEMENT/ COMPUTATIONAL NEEDS

- IOOS DMAC Strategy
  - Comprehensive data management strategy
  - Certification of Regional Associations requires adherence to data management policies
- Ocean Observatories Initiative
  - The OOI comprises five interconnected systems spanning Global, Regional, and Coastal scales; Cyberinfrastructure; and Education and Public Engagement
  - A coherent strategy that enables the integration of marine data streams across disciplines, institutions, time scales, and geographic regions

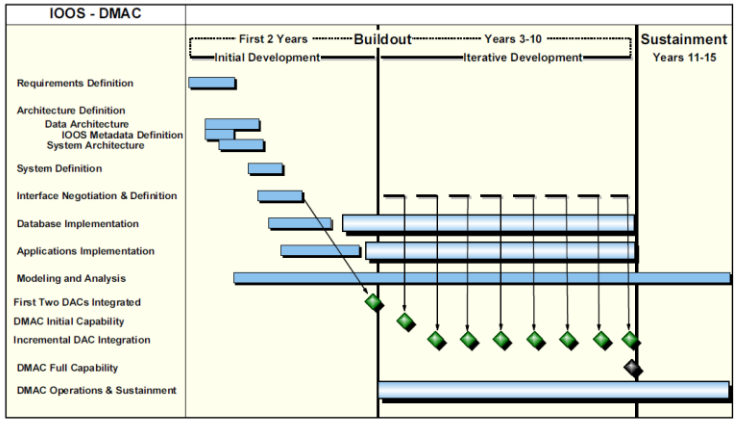

Figure 1.3-1. *The DMAC requires a 10-year buildout incorporating four remote Data Assembly Centers (DACs) by the end of the first 3 years to achieve Initial Capability. This is followed by a 7-year effort to negotiate, define, and integrate the remaining DACs to achieve Full Capability.*

OCEAN OBSERVATORIES INITIATIVE

DATA MANAGEMENT PLAN

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NEED FOR INTEGRATED MODELING APPROACHES LINKED TO DECISION SUPPORT

- Integrated atmosphere-land-ocean modeling approaches
- Models linking atmosphere, terrestrial and aquatic systems
- Model products for decision support
  - Carbon and nutrient management
  - Water quality
  - Hydrologic modeling

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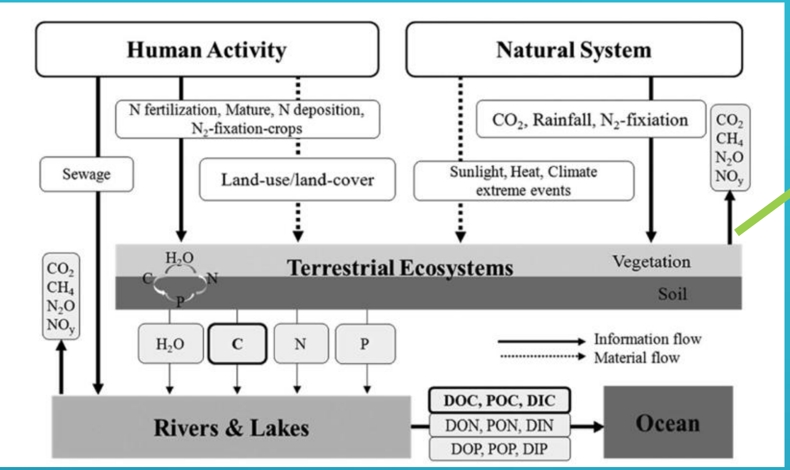
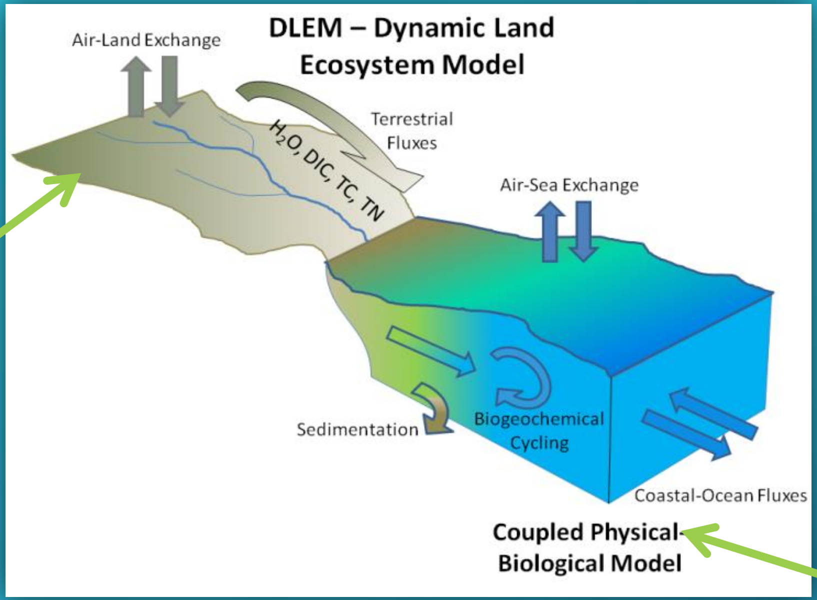
EXAMPLE: COUPLED TERRESTRIAL-OCEAN MODELS



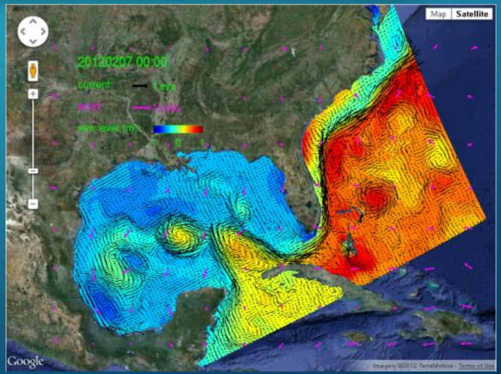


DLEM terrestrial outputs linked to a physical-biogeochemical model (SABGOM) to characterize coastal carbon fluxes and ecosystem dynamics

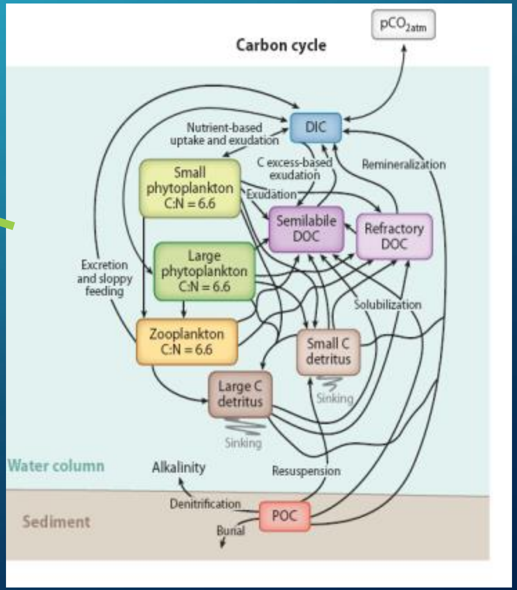
Dynamic Land Ecosystem Model (v2.0) used to estimate spatial and temporal patterns of land-air carbon fluxes and lateral transport of water, carbon, and nitrogen

Tian et al., 2010a,b; Tian et al.,2011; Tian et al.,2012 ; Zhang et al., 2012

Modeling efforts supported by field survey-based and satellite-based observations of carbon fluxes and other biogeochemical processes



Hyun and He (2010); Xue et al., 2013, 2014



Hoffman et al., Ann. Rev., 2011; Fennel et al., 2011, 2013

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MODEL APPLICATIONS

- Model development will provide decision support for issues related to carbon management, water quality, and ecosystem sustainability.

Land

Carbon Management
Land Use Practices
Water and Forest Management
Agriculture, Fertilizer
GHGs
Energy and Biofuels
Development

River Export

Coastal Margin

Air-sea flux of CO_2
Nutrients and Hypoxia
Ocean Acidification
Wetlands Loss
Coastal Restoration
Water Quality
Fisheries Habitat
Sea Level Rise

Export

Ocean Carbon Reservoir

Long term Sequestration of Carbon?

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SUMMARY

- Address gaps in critical observations and ensure continuity and consistency of data records
- Localized, regional approaches are needed for coastal ecosystems
- Address observing needs using low cost, efficient and accurate methodology
- Take advantage of sensor innovation where possible, recognizing that some critical measurements still require in situ and ship-based approaches
- Couple observational efforts with sound data management approaches to ensure that information is archived, analyzed, and accessible to users
- Need for comprehensive, integrated modeling and observational approaches

http://celebrating200years.noaa.gov/visions/ioos/obs_system.html

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