GOOS and a Framework for Ocean Observing:
We cannot manage what we do not measure

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Outline

1. Why observe?
   the ocean in an age of increasing human impact and vulnerability

2. What is GOOS?
   as a global collaborative system of sustained observations, and a programme supporting this objective

3. Framework for Ocean Observing

4. GOOS priorities

5. Regional cooperation
One planet, one ocean
All the cycles of life

Water
Nitrogen
Carbon
Oxygen
Climate
The anthropocene
A new age of human impact

Science 7 October 2011

The Economist 26 May 2011
The anthropocene
One planet, one ocean
The anthropocene
Population and CO$_2$

![Graph of Atmospheric CO$_2$ Concentration vs. Human Population](source: JED O. KAPLAN ET AL., THE HOLOCENE 21, 5 (AUGUST 2011))
The anthropocene: changing ocean environment

Hot

Heat content anomaly

Arctic summer sea ice

Global sea level

Heat content anomaly

sources: PMEL, NSIDC, AVISO
The anthropocene: changing ocean environment

Source:
Ocean acidification
The anthropocene: changing ocean environment
Breathless: deoxygenation

Gruber, Phil. Trans. R. Soc. A, 2011
The anthropocene

Fishing

% Worldwide Fisheries Fully Exploited

The anthropocene
Population and nutrients

Coastal Nitrogen Loading in 1990 and 2050 (Business-as-Usual Scenario)
The anthropocene
Plastics

Law et al., Science, 2010
The anthropocene

Sound

Figure 1. The hearing ranges of different kinds of fish and mammals together with the overlap in frequency with different sources of human-generated noise. Modified from Slabbekoorn et al. (2010), copyright (2010), with permission from Elsevier.
The anthropocene
Cumulative impact

Halpern et al., Science, 2008
Human vulnerability and the ocean
Coastal hazards
Human vulnerability and the ocean
Coastal livelihoods and ocean economy
Human vulnerability and the ocean
Ecosystem health
Human vulnerability and the ocean
Climate extremes
We cannot manage what we do not **measure**

- **Sustained ocean observations** are necessary to:
  - **Improve** scientific **knowledge** about the ocean climate and ecosystems, human impact, and human vulnerability
  - **Apply** that **knowledge** through:
    - early warning for ocean-related hazards
    - climate forecasts and projections
    - ecosystem assessment and management
    - good ocean governance based on sound science – ensuring a healthy ocean and a healthy blue economy
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the Global Ocean Observing System

- the system GOOS
  - collaborative system of sustained observations
    - built on requirements
    - in situ and satellite
    - operational and research funding
    - linked to data management and product generation activities
    - global-scale and coastal

- the GOOS program
  - advocacy for all elements of the system
  - provide a platform for collaboration
  - promote global participation through capacity development
Ocean observing system for climate – drawing from best practices

Requirements for Essential Climate Variables

- **Total in situ networks** 62% April 2012

- **Surface measurements** from volunteer ships (VOS)
  - 250 ships in VOSclim pilot project

- **Global drifting surface buoy array**
  - 5° resolution array: 1250 floats

- **Tide gauge network** (GCOS subset of GLOSS core network)
  - 170 real-time reporting gauges

- **XBT sub-surface temperature section network**
  - 51 lines occupied

- **Argo profiling float network**
  - 3° resolution array: 3000 floats

- **Repeat hydrography and carbon inventory**
  - Full ocean survey in 10 years

**Transport monitoring** 48%
- 29 sites

**Global time series network** 34%
- 58 moorings planned

**Global tropical moored buoy network** 79%
- 119 moorings planned

**Representative milestones**
- 30 34 40 45 48 55 56 59 60 62 62 62%

**System % sustained, of initial goals**
GOOS for climate

global participation varies by network
GOOS for climate adequacy of satellite observations of ECVs

Adequacy of committed satellite missions status in 2012

Essential Climate Variable from ocean satellites
- sea ice
- sea level
- sea surface temperature
- ocean colour
- sea state
- surface vector wind
- sea surface salinity


- inadequate
- marginal
- adequate
Regional implementation of GOOS

1st GOOS Regional Forum, Athens, Greece, 2002
2nd GRA Forum, Nadi, Fiji, 2004
3rd GRA Forum, Cape Town, S. Africa, 2006
4th GRA Forum, Guayaquil, Ecuador, 2008
5th GRA Forum, Sopot, Poland, October 2011

GOOS Regional Alliances

SAON

GOOOS-Africa

ArcticGOOS
EuroGOOS
MedGOOS

Black Sea GOOS
NEAR-GOOS
SEAGOOS
PI-GOOS

US GOOS
IOCARIB-GOOS
GRASP
OCEATLAN

GOOS Report No. 174
UNESCO
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Why a Framework?

• OceanObs’09 identified tremendous opportunities, significant challenges

• Called for a framework for planning and moving forward with an enhanced global sustained ocean observing system over the next decade, integrating new physical, biogeochemical, biological observations while sustaining present observations
Framework for Ocean Observing

Sponsors and team

Keith Alverson, Bee Berx, Peter Burkill, Francisco Chavez, Dave Checkley, Candyce Clark, Vicki Fabry, Albert Fischer, John Gunn (co-chair), Julie Hall, Eric Lindstrom (co-chair), Yukio Masumoto, David Meldrum, Mike Meredith, Pedro Monteiro, José Mulbert, Sylvie Pouliquen, Carolin Richter, Sun Song, Mike Tanner, Martin Visbeck, Stan Wilson

- **IOC** Intergovernmental Oceanographic Commission of UNESCO
- **GEO** Group on Earth Observations
- **CEOS** Committee on Earth Observation Satellites
- **POGO** Partnership for Observation of the Global Oceans
- **SCOR** Scientific Committee on Oceanic Research
- **SCAR** Scientific Committee on Antarctic Research
- **GCOS** Global Climate Observing System
- **GOOS** Global Ocean Observing System
- **JCOMM** Joint WMO-IOC Tech. Comm. for Oceanography and Marine Meteorology
- **PICES** North Pacific Marine Science Organization
- **ICES** International Council for the Exploration of the Sea
- **CoML** Census of Marine Life
- **IGBP** International Geosphere-Biosphere Programme
- **WCRP** World Climate Research Programme
Framework for Ocean Observing

High level objectives

• Take lessons learned from successes of existing observing efforts – **best practices**

• **Guide** observing community as a whole to sustain and expand the capabilities of the ocean observing system

• Deliver and observing system that is **fit-for-purpose**

• Promoting **collaborative alignment** of independent groups, communities and networks, **building on existing structures** as much as possible
Framework for Ocean Observing

A simple system
Structure of the Framework

Issues (Scientific and societal drivers)

Requirement

What to Measure

Essential Ocean Variables

Data Assembly

Data/Info. Products

Observations Deployment and Maintenance

Issues Impact

Argo

VOS

Satellite

Constellation

SOOP

IMOS

OceanSITES

IOOS
Driven by requirements, negotiated with feasibility

**Essential Ocean Variables**

- We cannot measure everything, nor do we need to
- Basis for including new elements of the system, for expressing requirements at a high level
- Driven by requirements, negotiated with feasibility
- Allows for innovation in the observing system over time
Towards sustained system: requirements, observations, data management

Readiness

- **Concept**
  - Attributes: Peer review of ideas and studies at science, engineering, and data management community level.

- **Pilot**
  - Attributes: Planning, negotiating, testing, and approval within appropriate local, regional, global arenas.

- **Mature**
  - Attributes: Products of the global ocean observing system are well understood, documented, consistently available, and of societal benefit.
Framework for Ocean Observing

Societal drivers 2012

Climate and Weather
Framework for Ocean Observing

Societal drivers next decade

Fisheries
Regional priorities

Climate and Weather
Real-time services

Assessments and management of ecosystem services

Data Products

- Climate and Weather
  - Real-time services
  - Assessments and management of ecosystem services

- Fisheries
  - Regional priorities

Issues

Essential Ocean Variables

- Requirement
- What to Measure

Expanded EOVs

Expanded observing systems and networks
Common language and consistent handling of requirements, observing technologies, and information flow among different, largely autonomous, observing elements

Seeks to support self-funding and self-managing elements

Essential Ocean Variables as common focus

Assessment and promotion of Readiness

For coastal and open ocean

An “Integrated Observing System” will be a derivative of an EOV-based approach driven by requirements.
Framework for Ocean Observing

Benefits

• For Ocean Observing Communities
  
  – **Focus on variables allows innovation**, research, while sustaining the key output of the observing system
  
  – Clear path to **selling utility** of observations to high level, articulation of societal importance
  
  – **learn from** best practices and principles of **other observing systems**
  
  – **reduce/remove duplication** of measurements
  
  – **Clearer entry points** for the needed coordination; cross-disciplinary positive **synergy**: shared platforms, data systems
  
  – other **data** available to set your data in context
GOOS Steering Committee
(Peak Bodies, Sponsors, Observing Panel Chairs, Observing System leaders)

Observing System Panels
(focused on EOVs e.g. Physics through OOPC, Carbon/Biogeochemistry through IOCCP, new Biology/Ecosystems); Coordination for observing system elements

Technical Advisory Groups
(Observing technologies and networks, Variable focus: data and products, synthesis, link to models)
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The future of GOOS
GOOS SC outcomes

• **Sustaining present observations**
  – treating sustained research and operational observations together
  – articulating multiple missions of a single observing system
  – improve link to modeling users
  – codification of additional role OOPC has played in real-time services

• **Expanding to new variables, serving new requirements**
  – work with International Ocean Carbon Coordination Project (IOCCP) as nucleus of geochemistry panel
  – develop new Biology/Ecosystems panel in cooperation with GEOBON, SCOR, IGBP projects

• **Identifying regional priorities, capacity, and addressing gaps**
  – inventory of GRA priorities and capabilities
  – improving links with coastal ocean forecasting community
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GOOS and IOOS

• US ocean observations are a large contribution to the global system
  – 50% of global ocean climate observations
  – coastal observations that are widely shared

• Data integration
  – GOOS works through:
    • IODE / national ocean data centers
    • cooperation with WMO on real-time data systems
    • coordination of data management efforts of individual global observing networks
    • work through all of these processes, and GEO/GEOSS, for standards
BACK-UP SLIDES
The anthropocene
Fall of the wild

The Fall of the Wild

Species abundance

- Marine species
- Terrestrial species
- Freshwater species
- All vertebrate species

SOURCE: WORLD WIDE FUND FOR NATURE AND UNEP WORLD CONSERV. MONITORING CENTER
GCOS SC work plan

- **Articulating 10 year goals** for GOOS, out of rich menu provided by OceanObs’09, to guide short term work
- **Engaging** with key **conventions** and **assessments** on requirements
- Improving **outreach**
- Engaging **IOC Member States**
- Identifying and engaging **donors**
- Definition and consolidation of **three panels**
  - built on OOPC, IOCCP, and new panel for biology/ecosystems
- Improving **GOOS Regional Alliance** implementation: starting with understanding priorities and capacity
- **Capacity development**
- **Data interoperability**: analysis and development of action