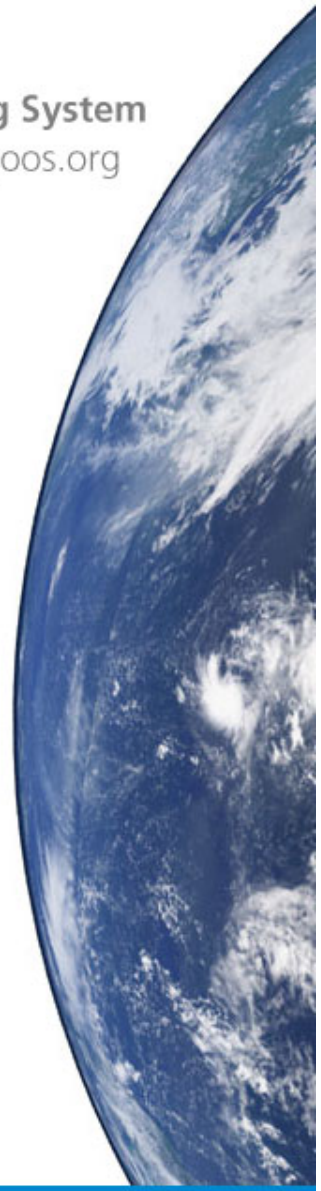
The Global Ocean Observing System
www.ioc-goos.org



GOOS and a Framework for Ocean Observing

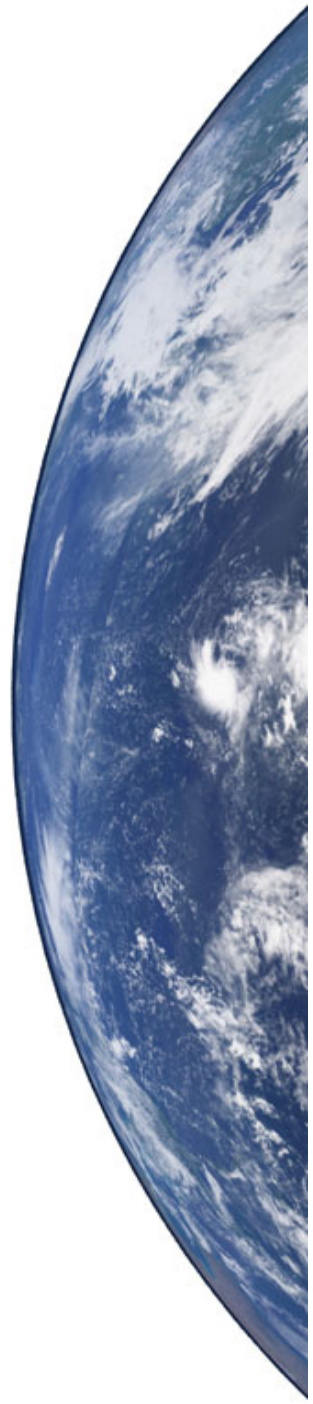
Eric Lindstrom
GOOS Steering Committee co-chair; Physical Oceanography Program, NASA

US CLIVAR Summit, 10 July 2013

UNESCO IOC WMO UNEP ICSU

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
Climate
Water
Oxygen
Nitrogen
Carbon

The anthropocene

A new age of human impact

Science *7 October 2011*

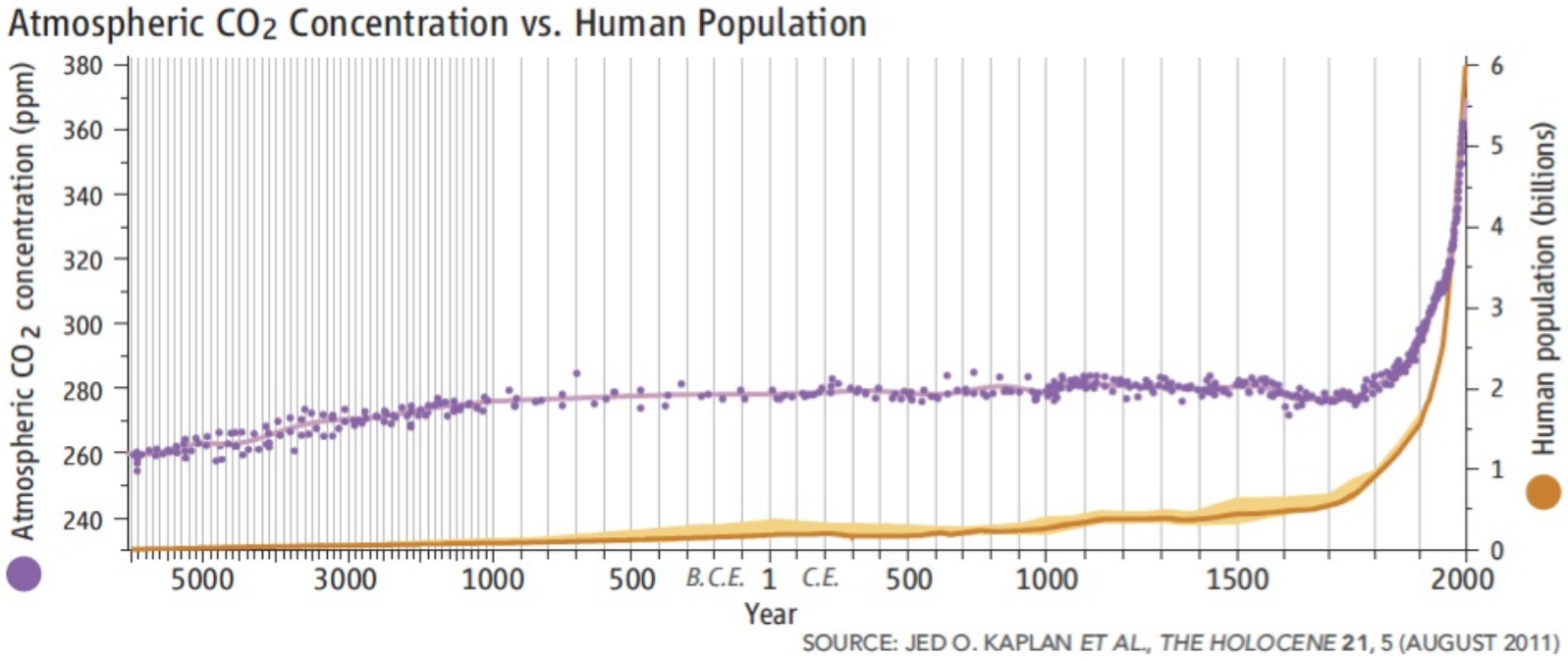
26 May 2011

The anthropocene

One planet, one ocean

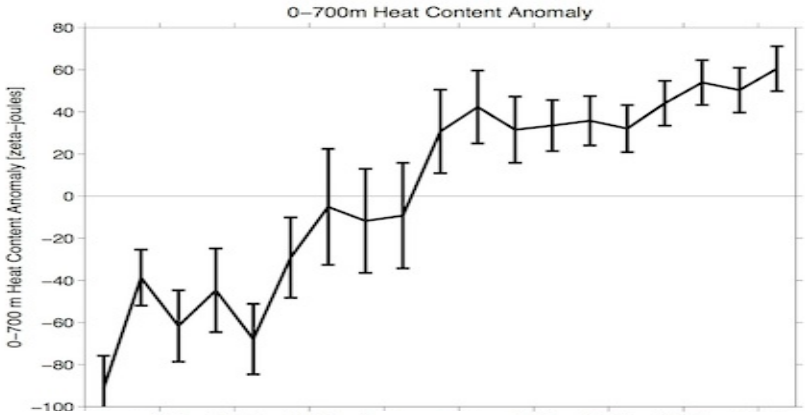
The anthropocene

Population and CO_2



The anthropocene: changing ocean environment

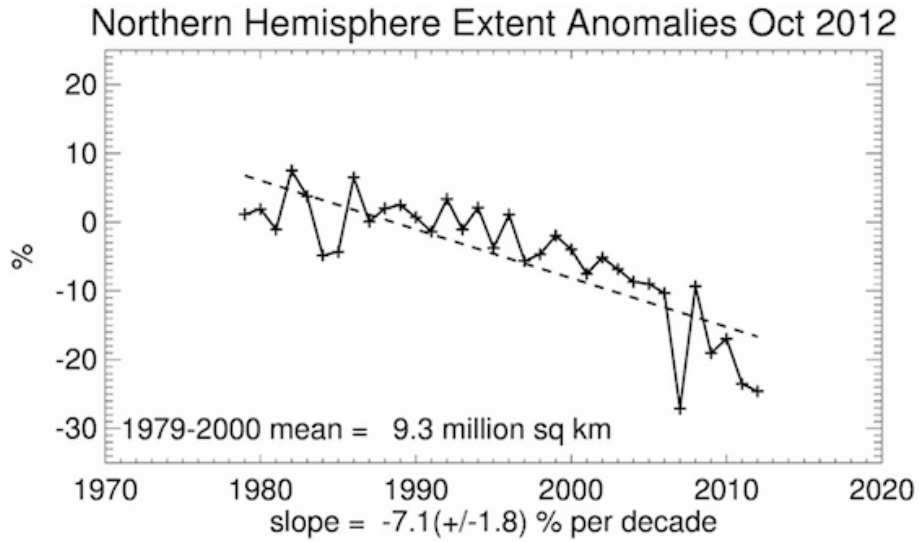
Hot



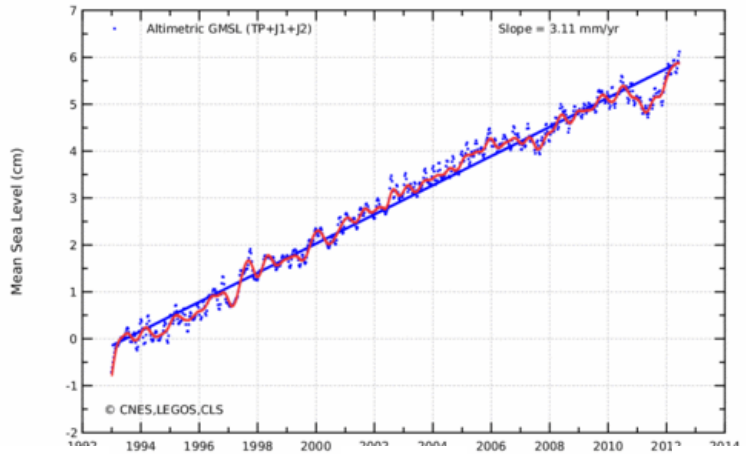
Heat content anomaly

sources: PMEL, NSIDC, AVISO

Arctic summer sea ice

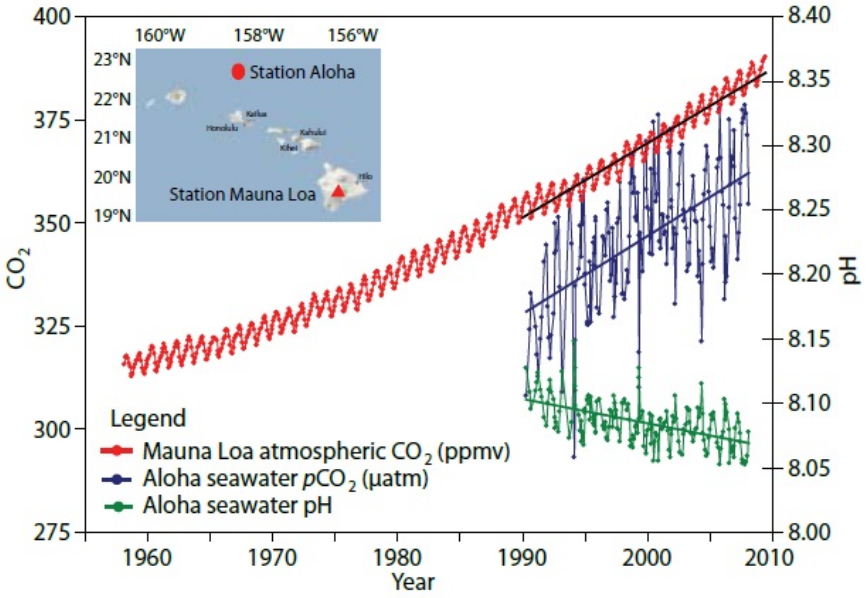


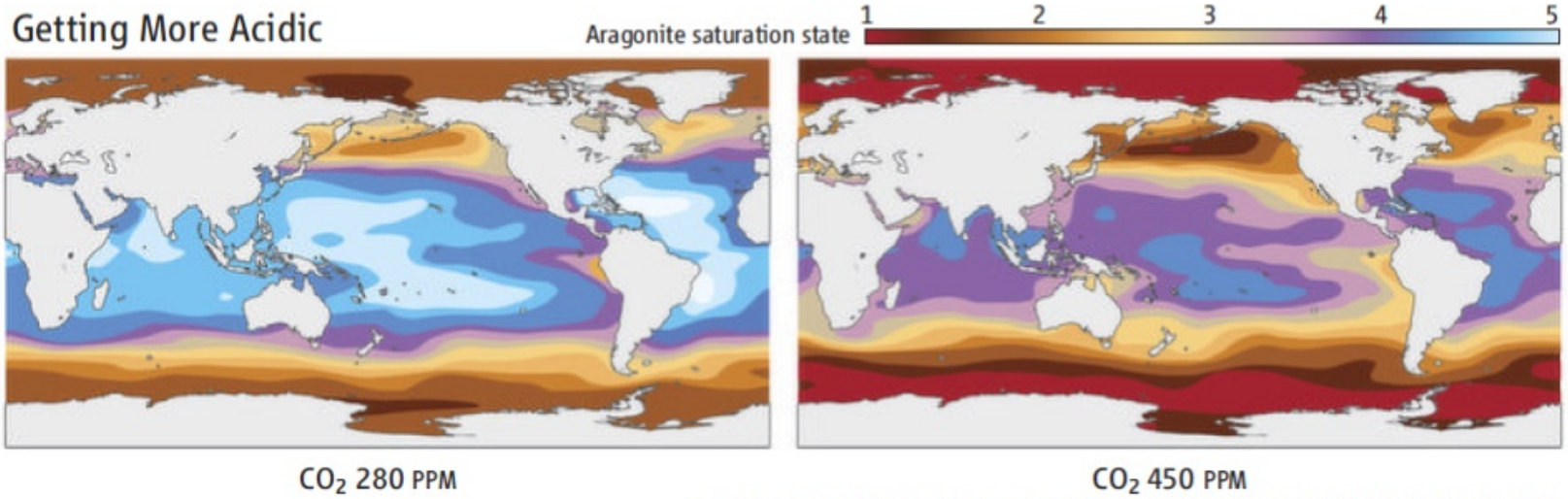
Global sea level



The anthropocene: changing ocean environment

Sour:
Ocean acidification

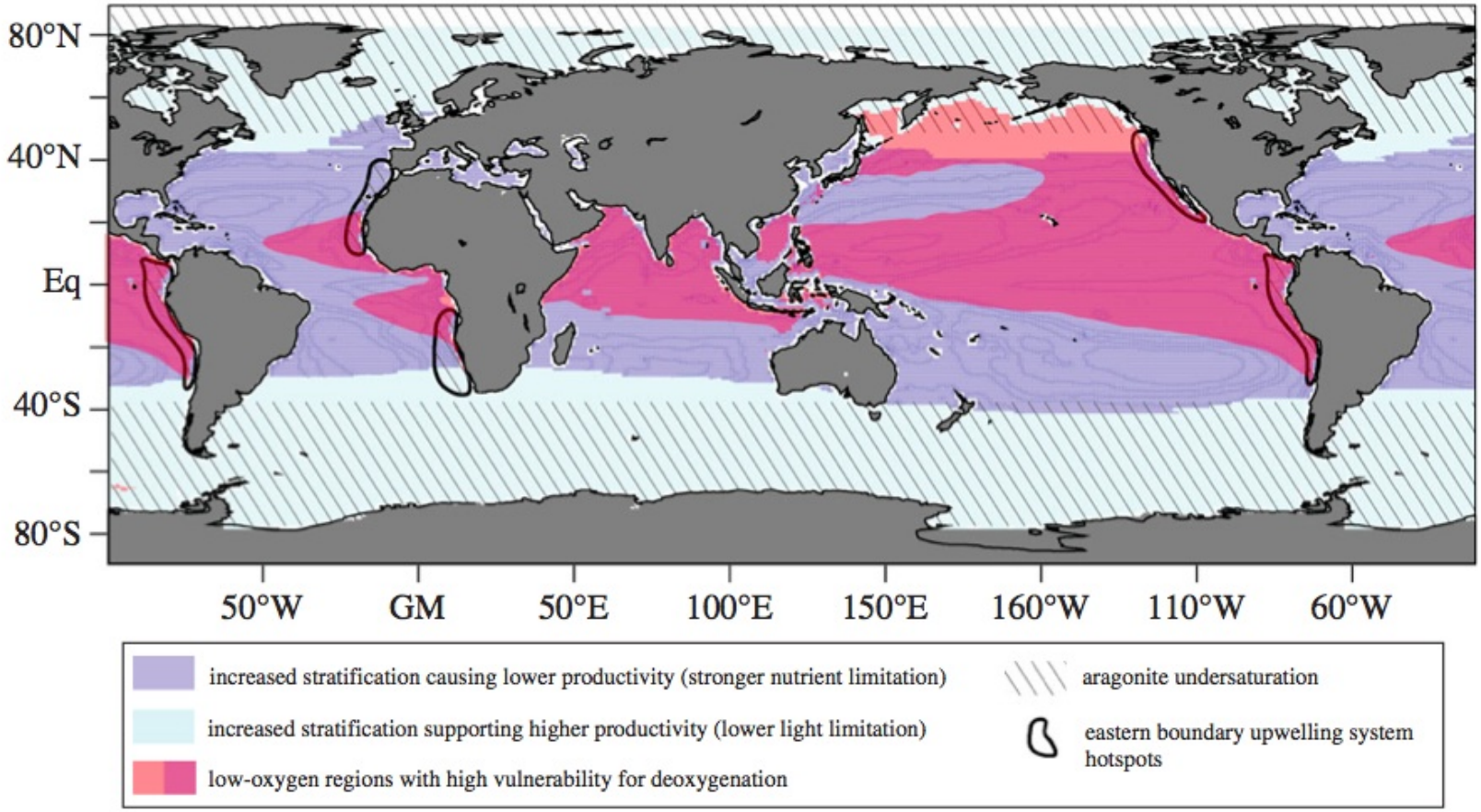




above: Doney et al., ***Oceanography****, 2009*

The anthropocene: changing ocean environment

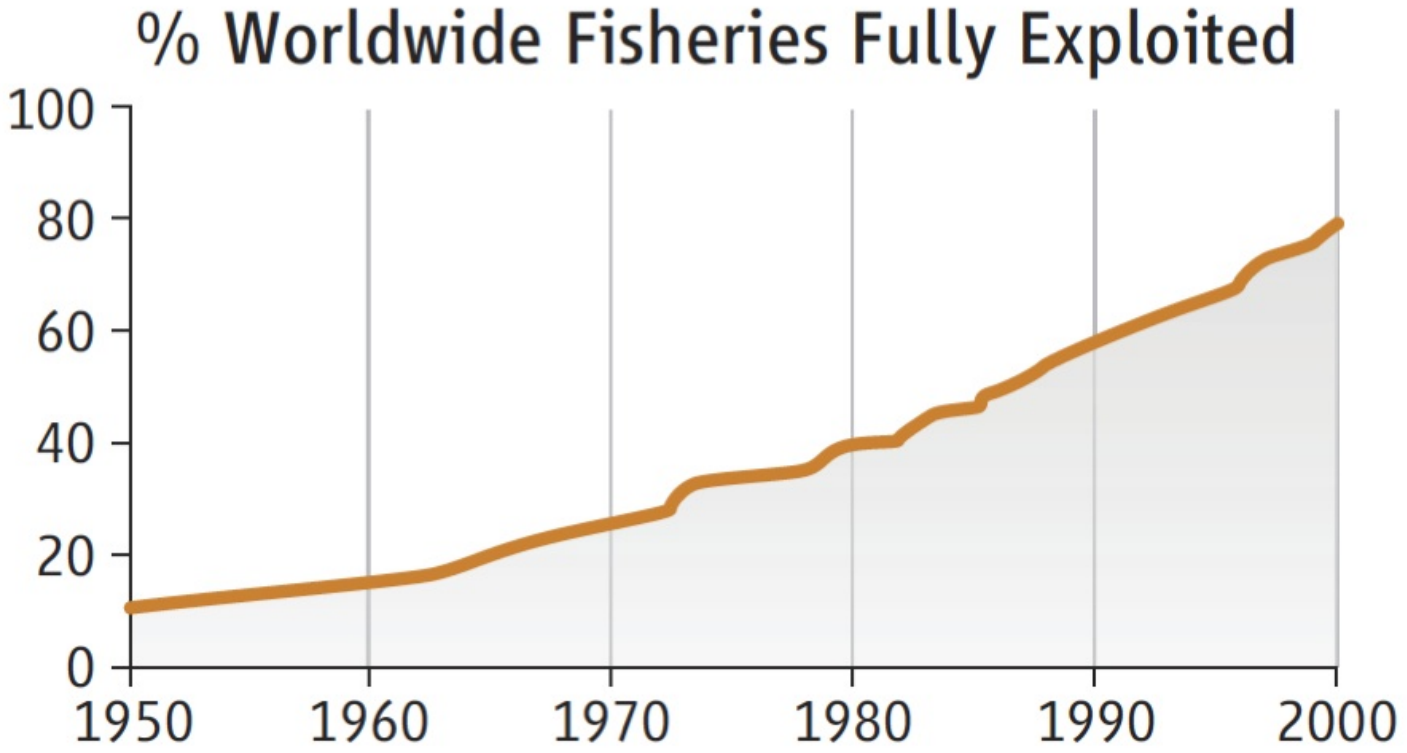
Breathless: deoxygenation



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

The anthropocene

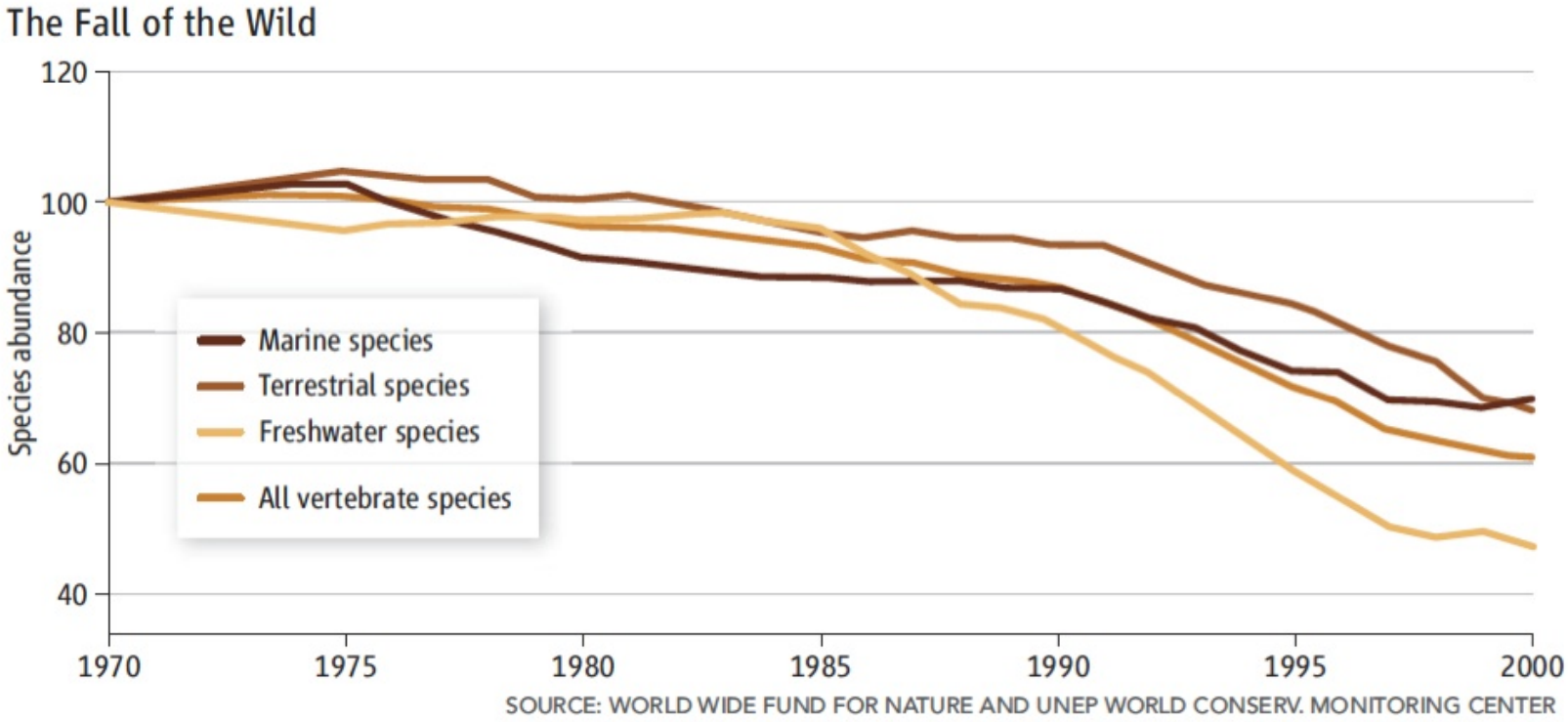
Fishing



SOURCE: WILL STEFFEN *ET AL.*, *PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A* **369** (2011)

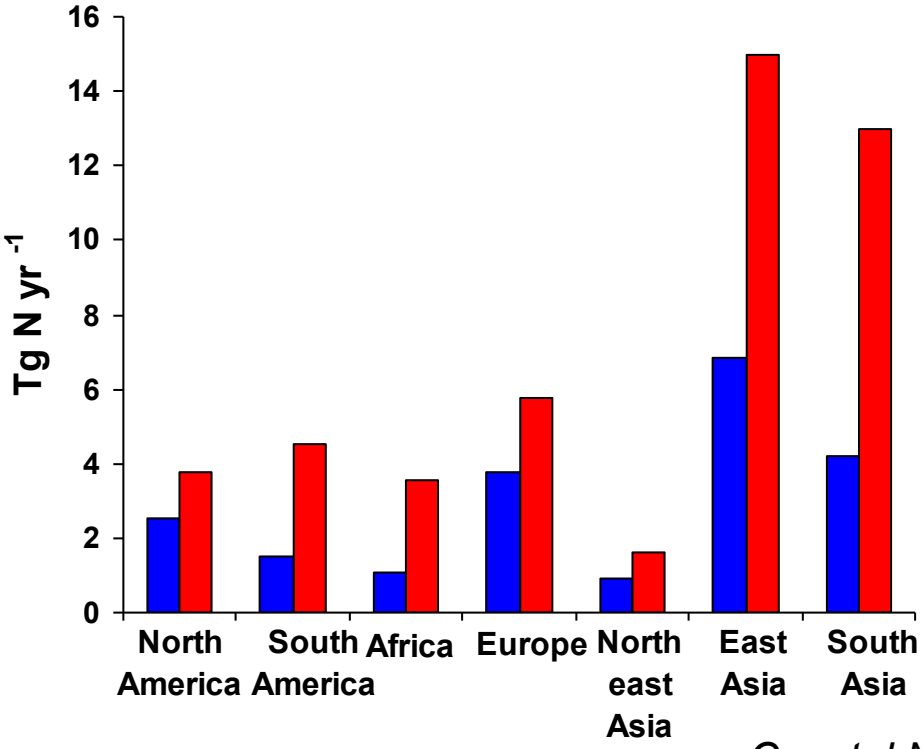
The anthropocene

Fall of the wild



The anthropocene

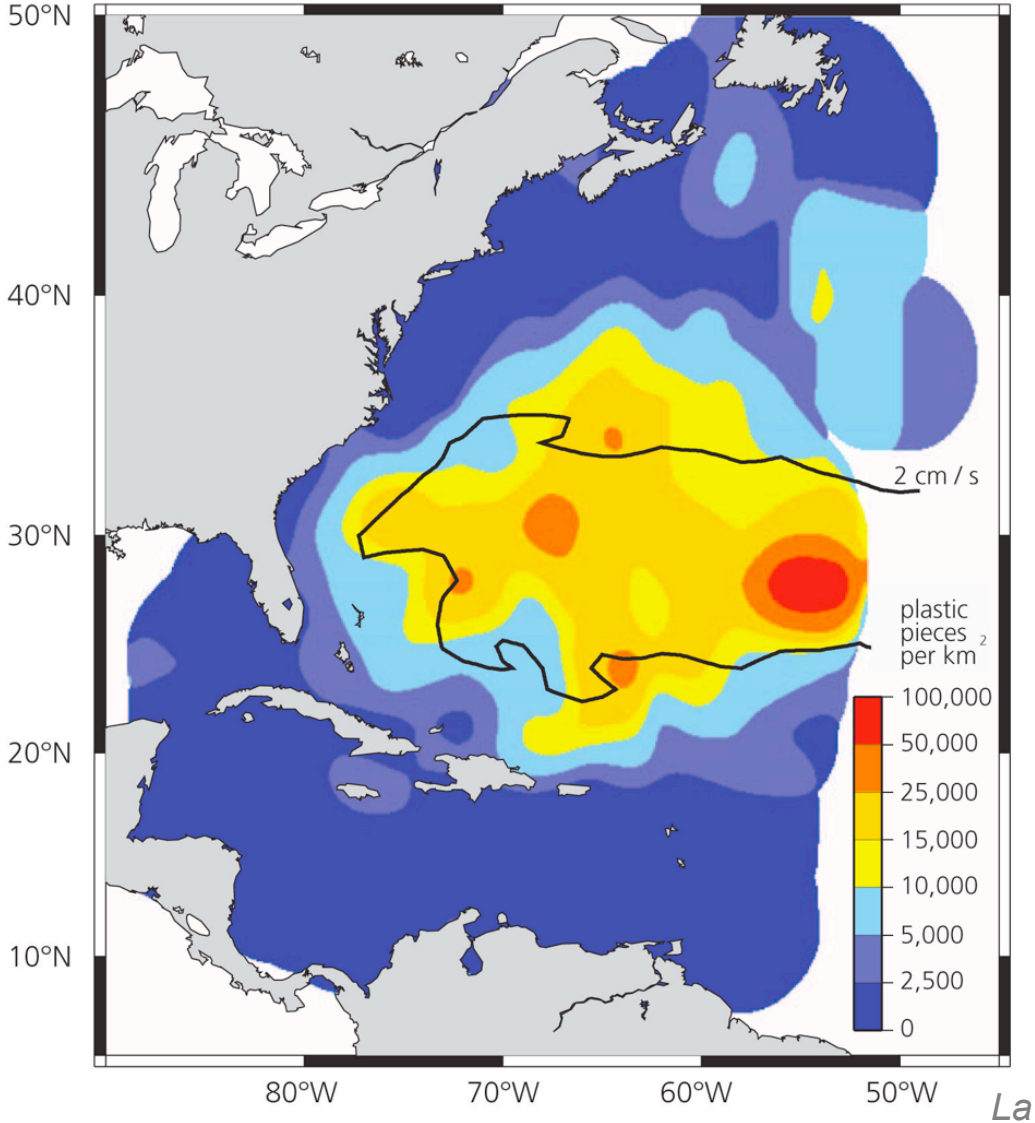
Population and nutrients



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

The anthropocene

Plastics



Law et al., Science, 2010

The anthropocene

Sound

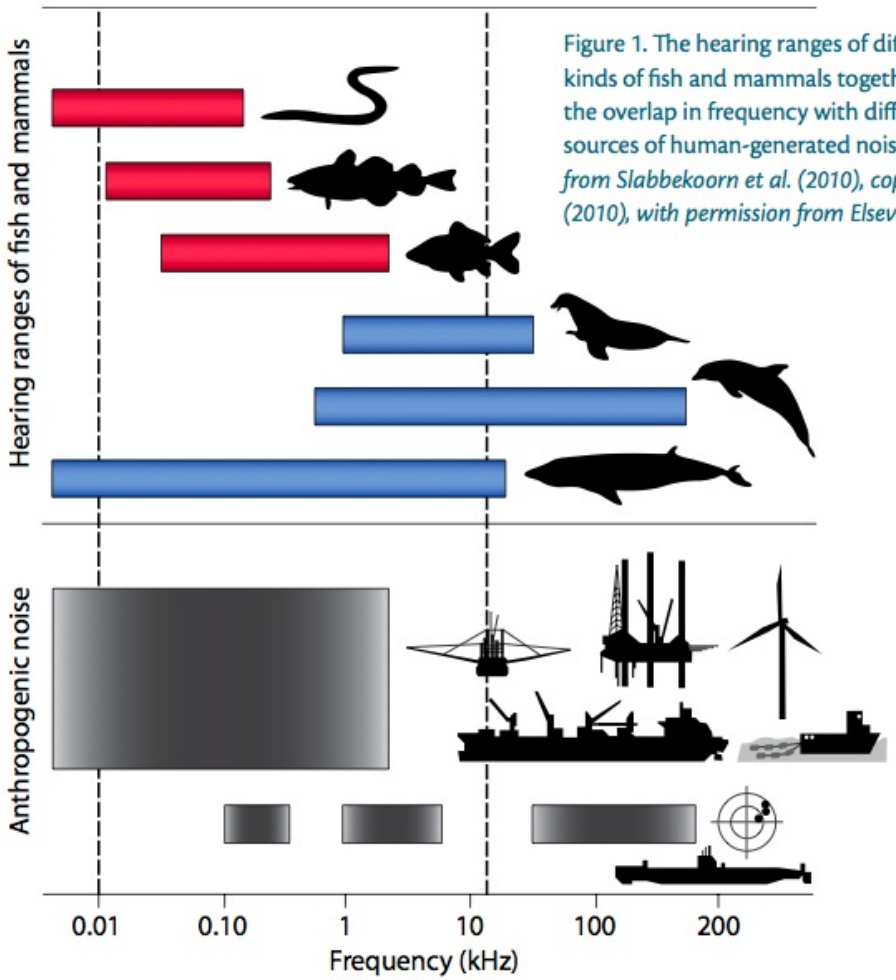
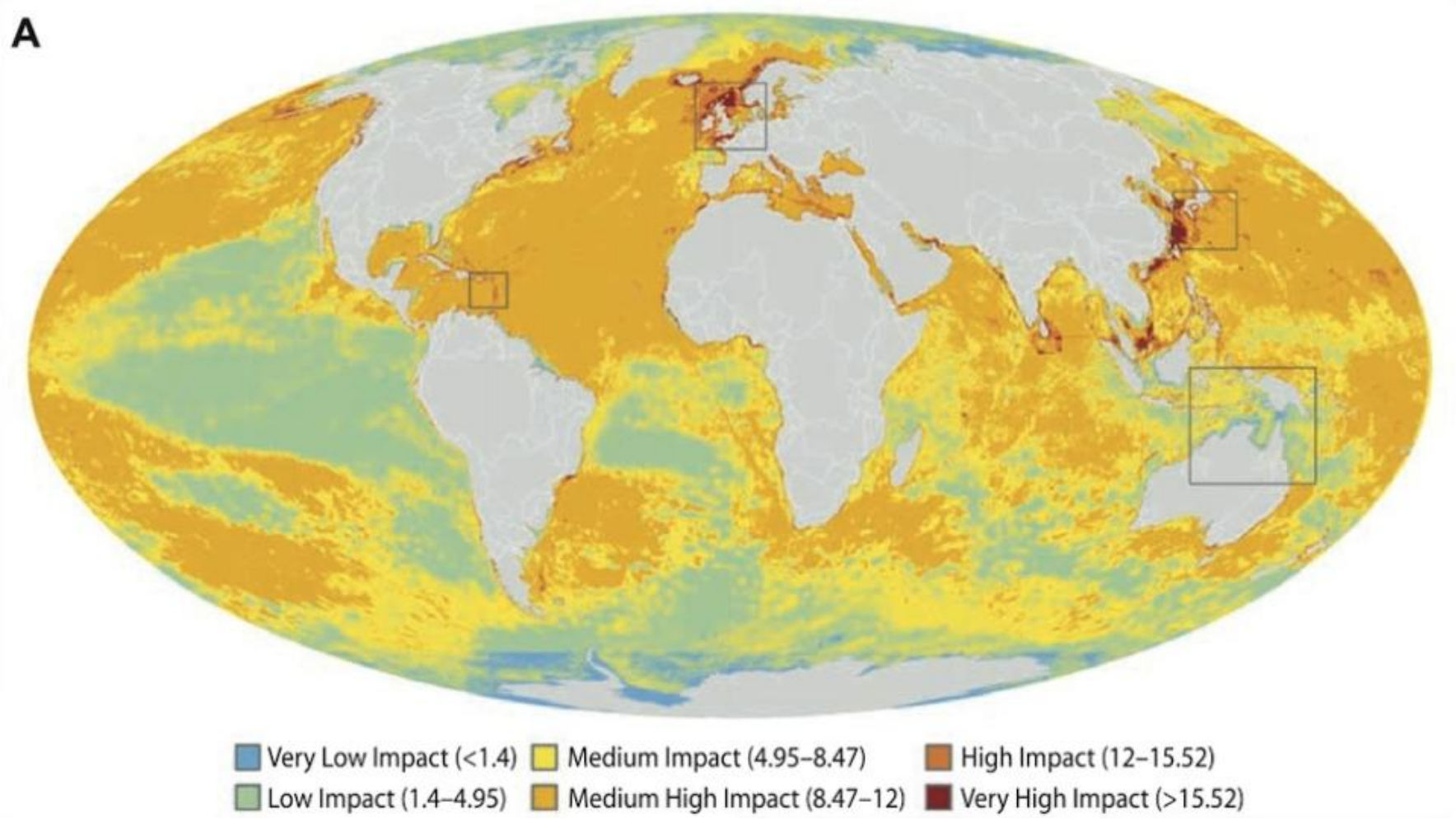


Figure 1. The hearing ranges of different kinds of fish and mammals together with the overlap in frequency with different sources of human-generated noise. *Modified from Slabbekoorn et al. (2010), copyright (2010), with permission from Elsevier*

Boyd et al., Oceanography, 2011

The anthropocene

Cumulative impact



Halpern et al., Science, 2008

Human vulnerability and the ocean

Coastal hazards

Human vulnerability and the ocean

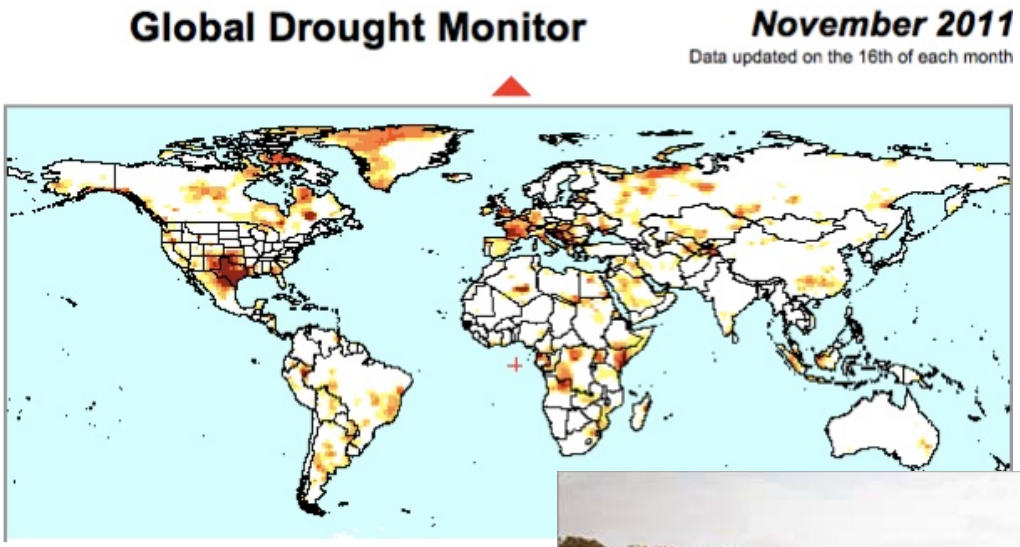
Coastal livelihoods and ocean economy

Human vulnerability and the ocean

Ecosystem health

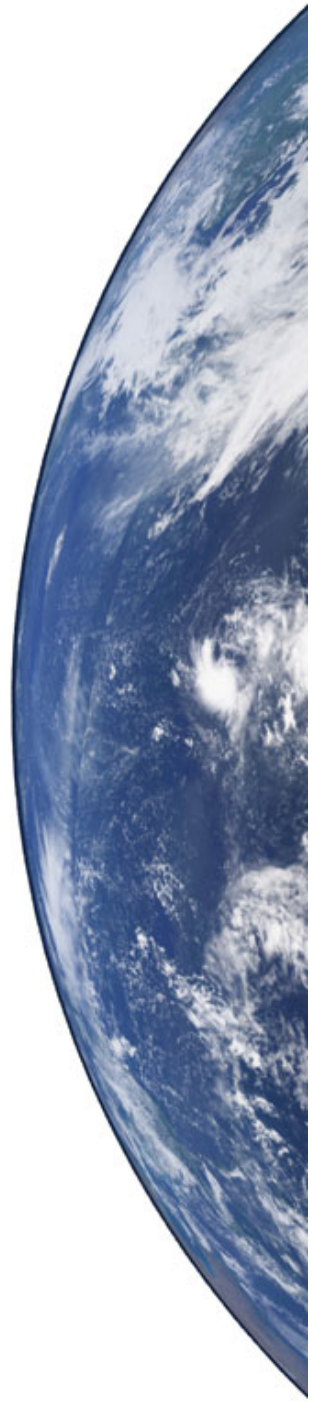
Human vulnerability and the ocean

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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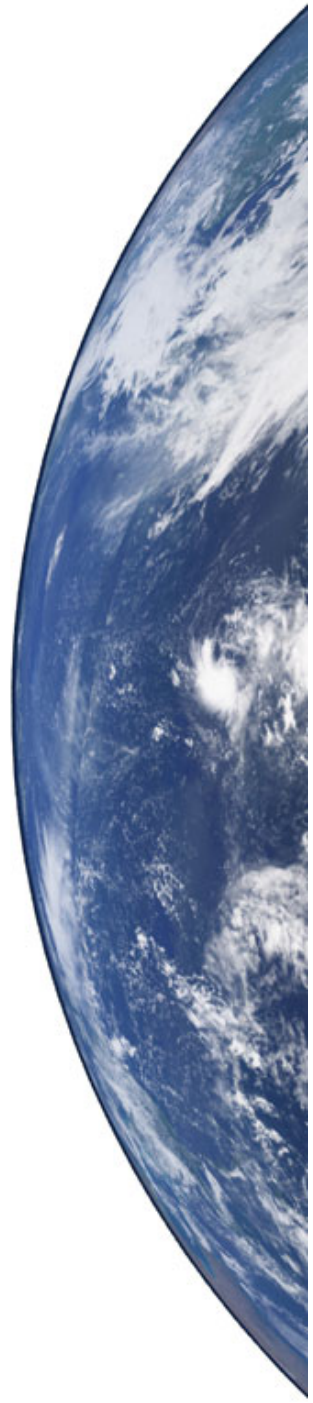


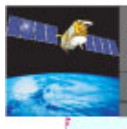
the Global Ocean Observing System

- 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 programme
  - advocacy for all elements of the system
  - provide a **platform for collaboration**
  - promote **global participation** through capacity development

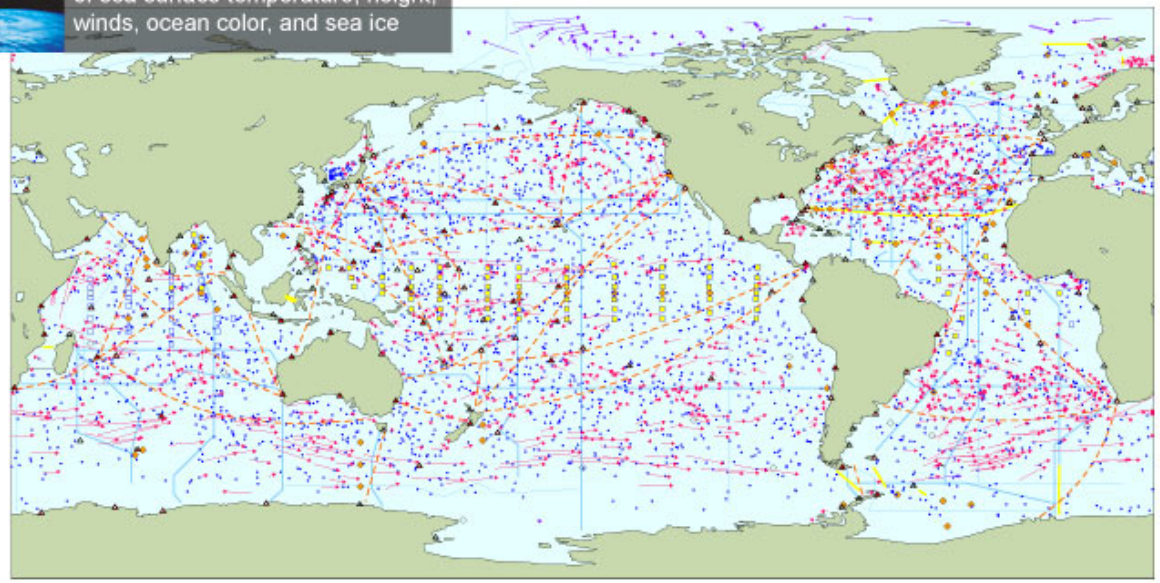
Ocean observing system for climate – drawing from best practices

Requirements for Essential Climate Variables



continuous satellite measurements of sea surface temperature, height, winds, ocean color, and sea ice

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



100% **Surface measurements** from volunteer ships (VOS)

250 ships in VOSclim pilot project

100% Global **drifting surface buoy** array

ice buoys

5° resolution array: 1250 floats

66% **Tide gauge** network (GCOS subset of GLOSS core network)

170 real-time reporting gauges

81% **XBT** sub-surface temperature section network

51 lines occupied

100% Argo **profiling float** network

3° resolution array: 3000 floats

Transport monitoring 48%

29 sites

34% Global **time series** network

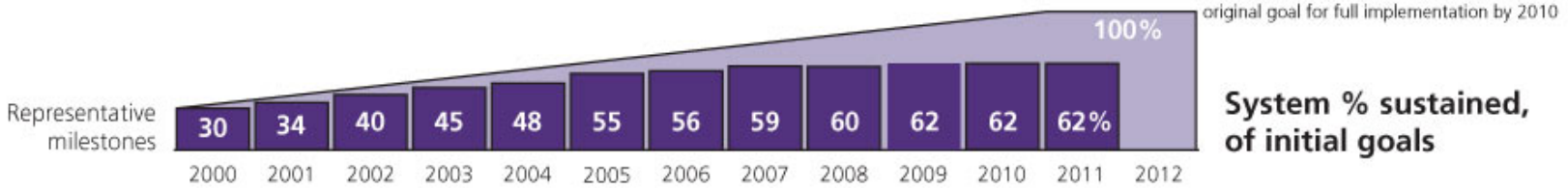
58 moorings planned

79% Global tropical **moored buoy** network

119 moorings planned

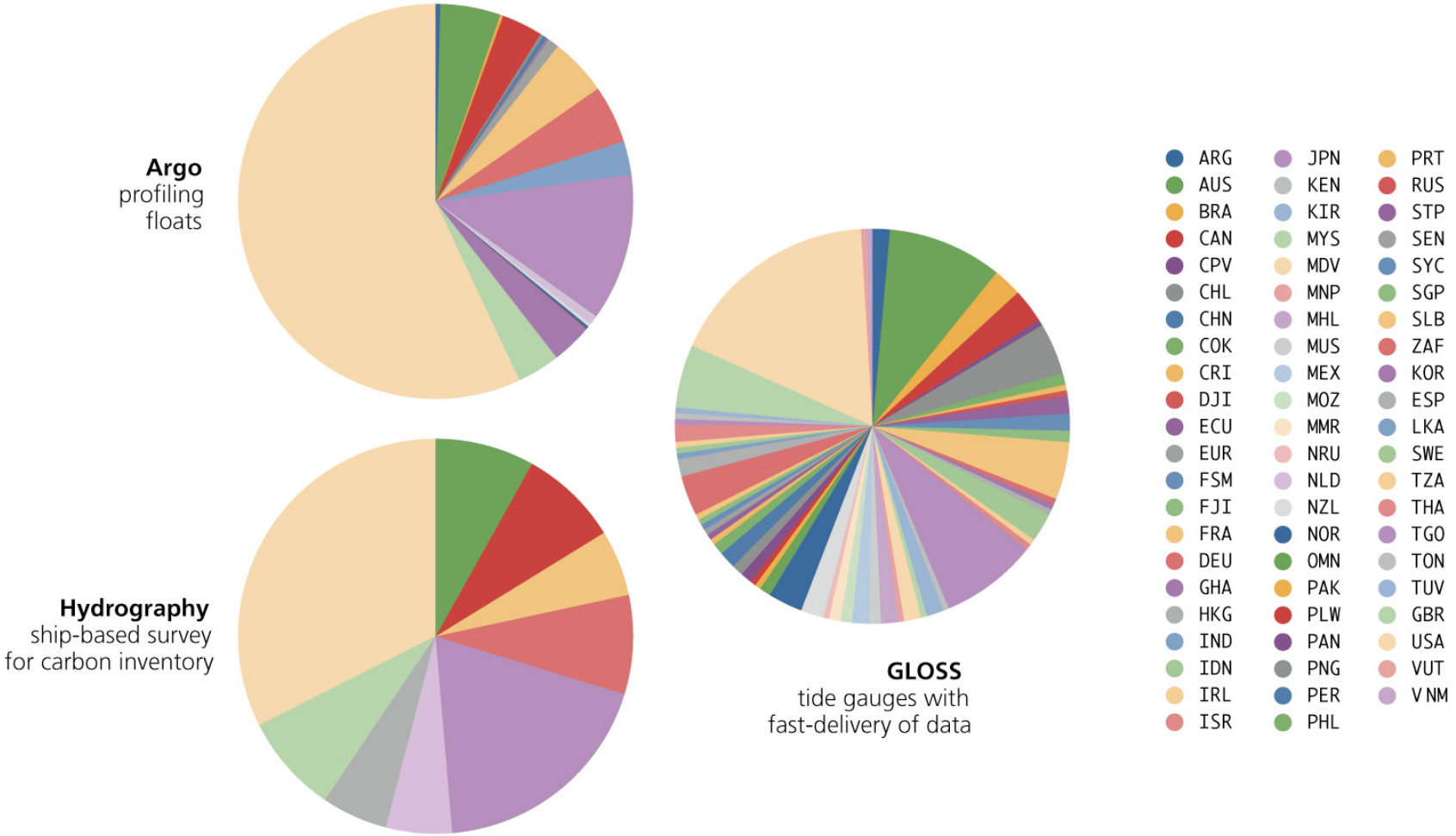
62% Repeat **hydrography** and **carbon inventory**

Full ocean survey in 10 years



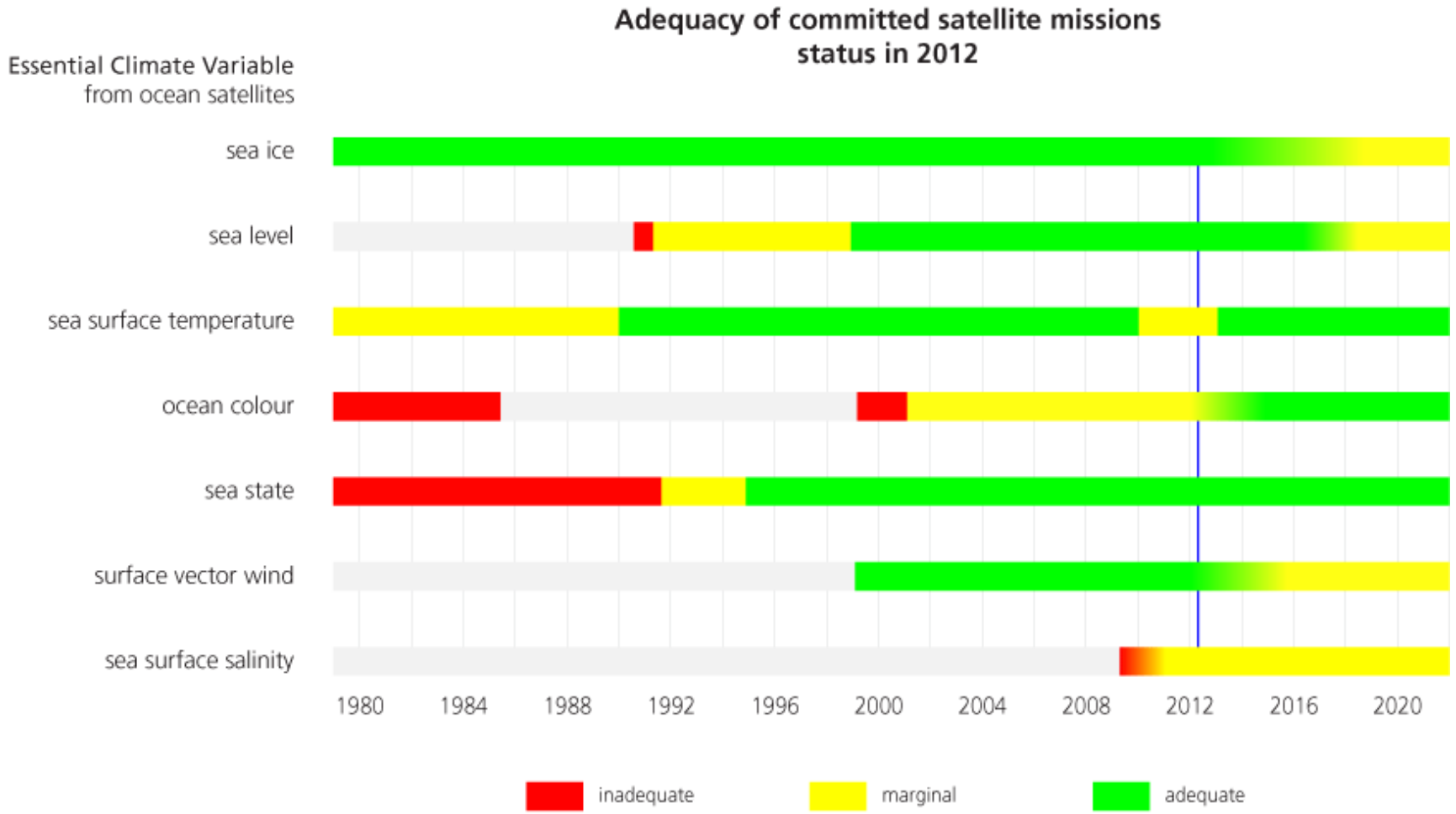
GOOS for climate

global participation varies by network

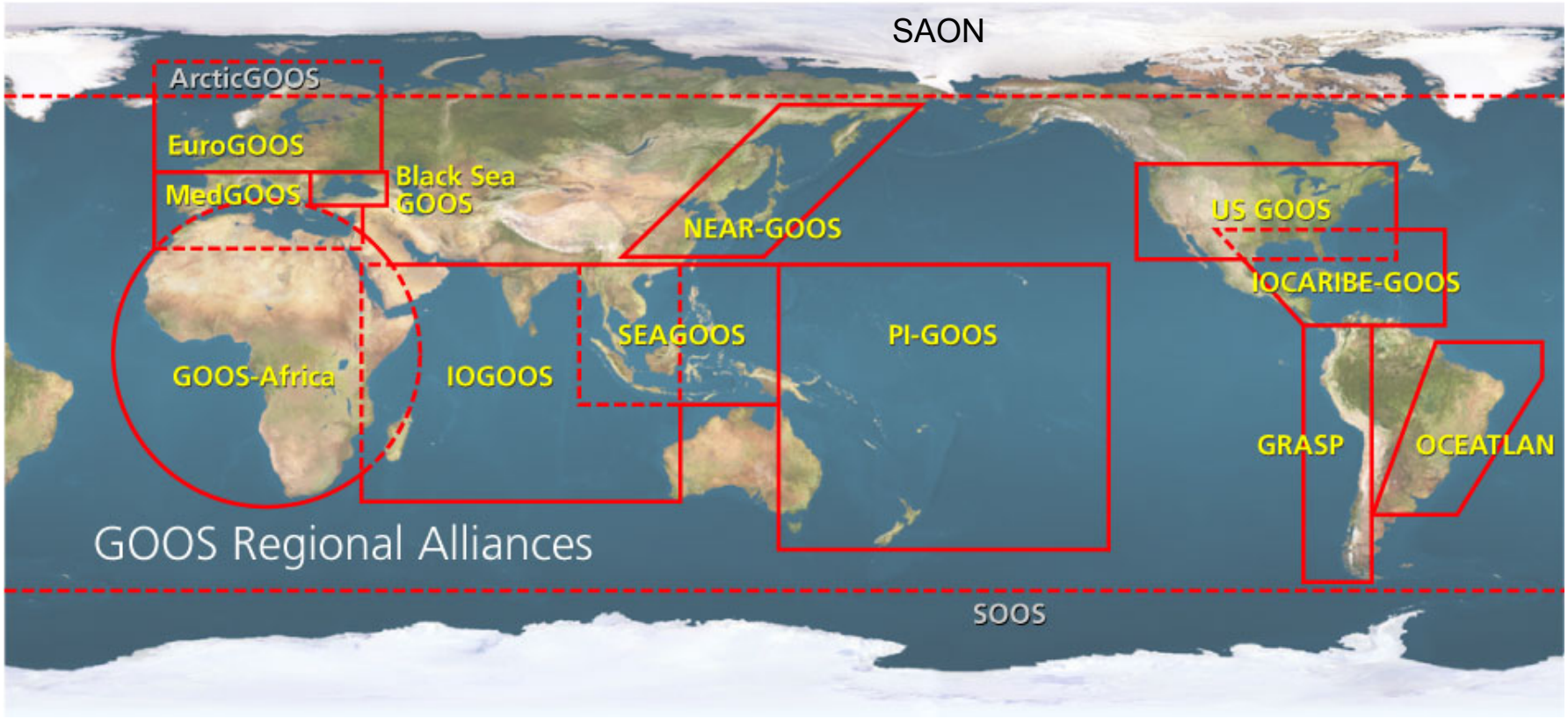


GOOS for climate

adequacy of satellite observations of ECVs



Regional implementation of GOOS




Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

The Global Ocean Observing System (GOOS) Regional Alliances Forum (GRF)

Fourth Session
25-27 November 2008
Guayaquil, Ecuador

GOOS Report No. 174 UNESCO

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

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**
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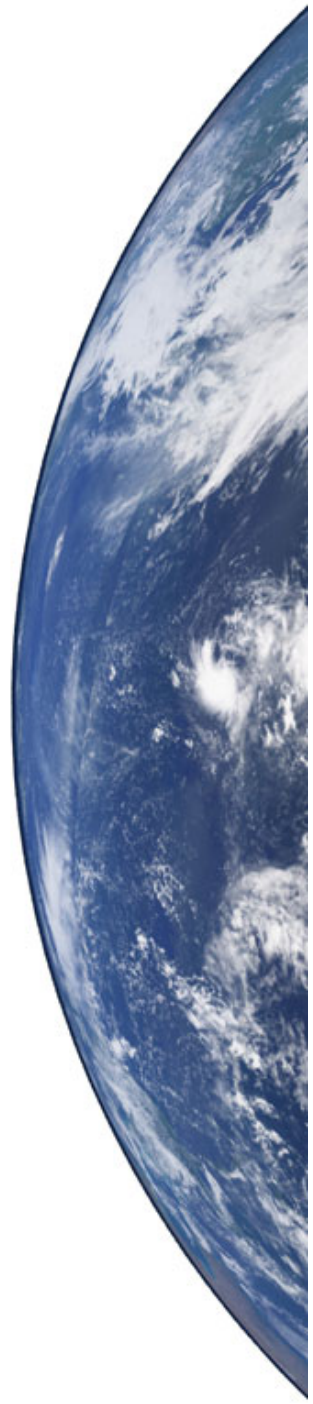


OceanObs'09

Ocean information for society: sustaining the benefits, realizing the potential

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

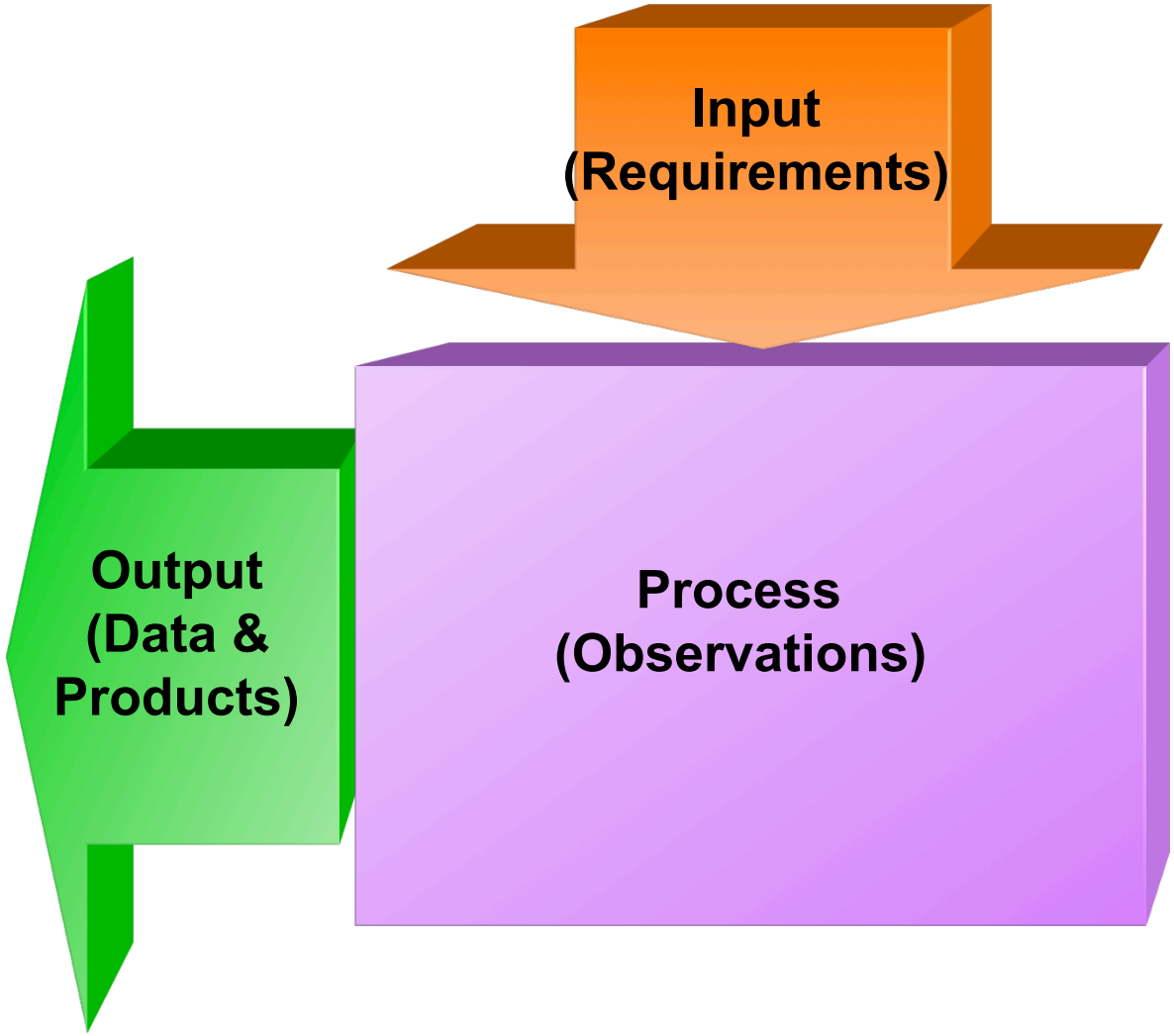
Framework for Ocean Observing

High level objectives

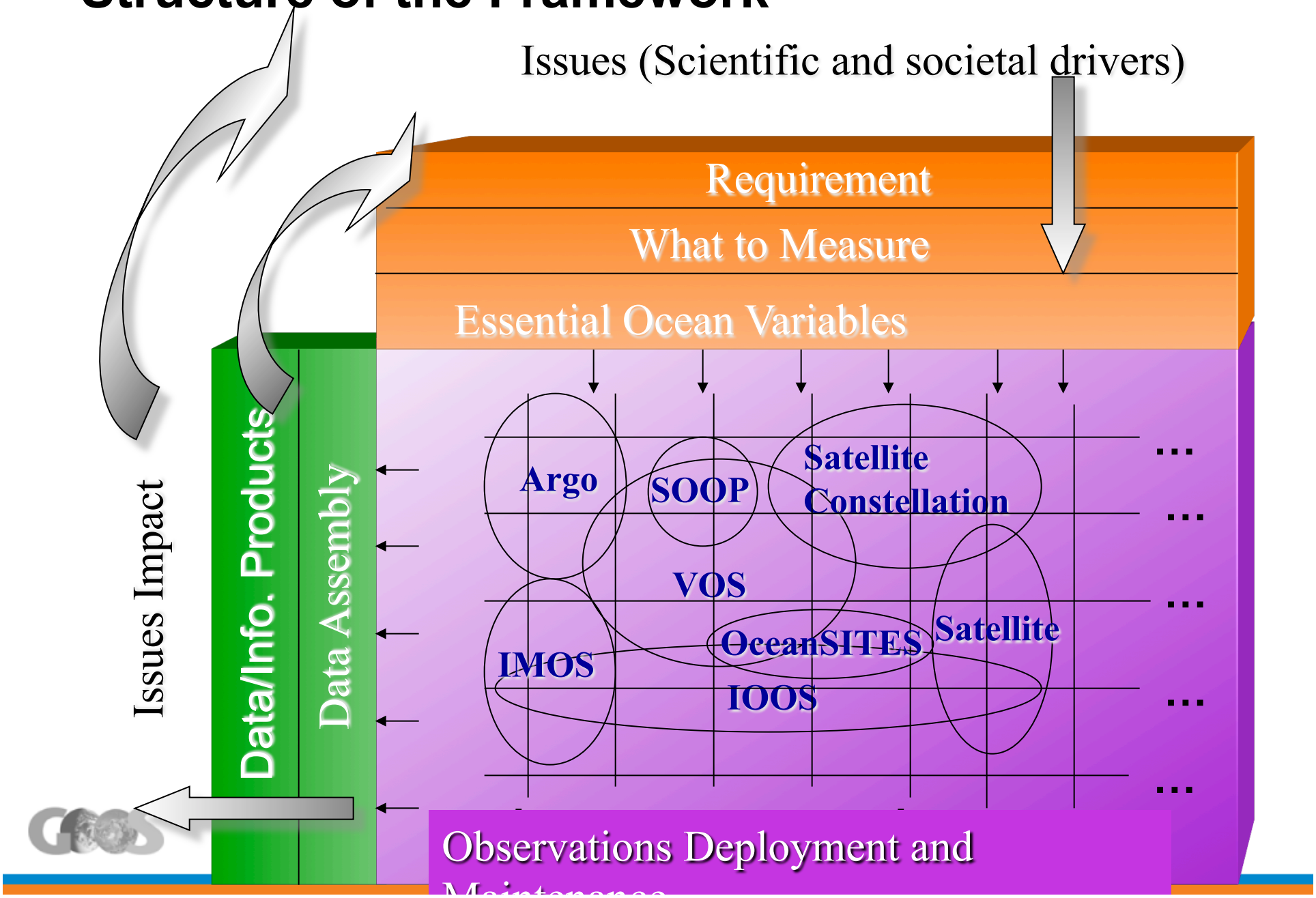
- Take lessons learned from successes of existing observing efforts – **best practices**
- **Guide** observing community as a whole to sustain and expand the capabilities of the ocean observing system
- Deliver and observing system that is **fit-for-purpose**
- Promoting **collaborative alignment** of independent groups, communities and networks, **building on existing structures** as much as possible

Framework for Ocean Observing

A simple system

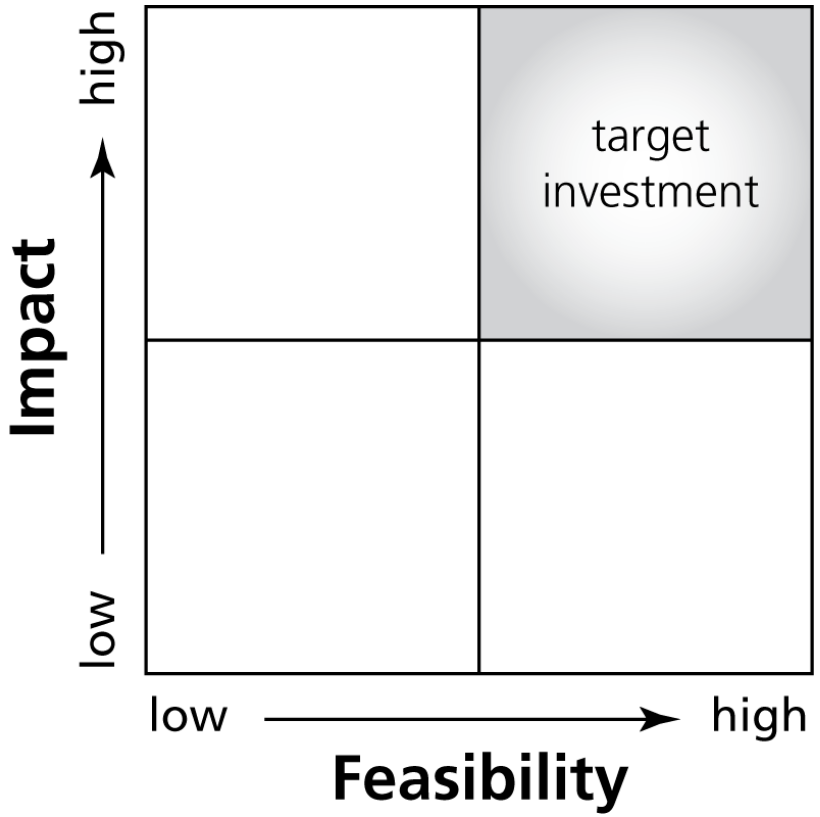


Structure of the Framework



Driven by requirements, negotiated with feasibility

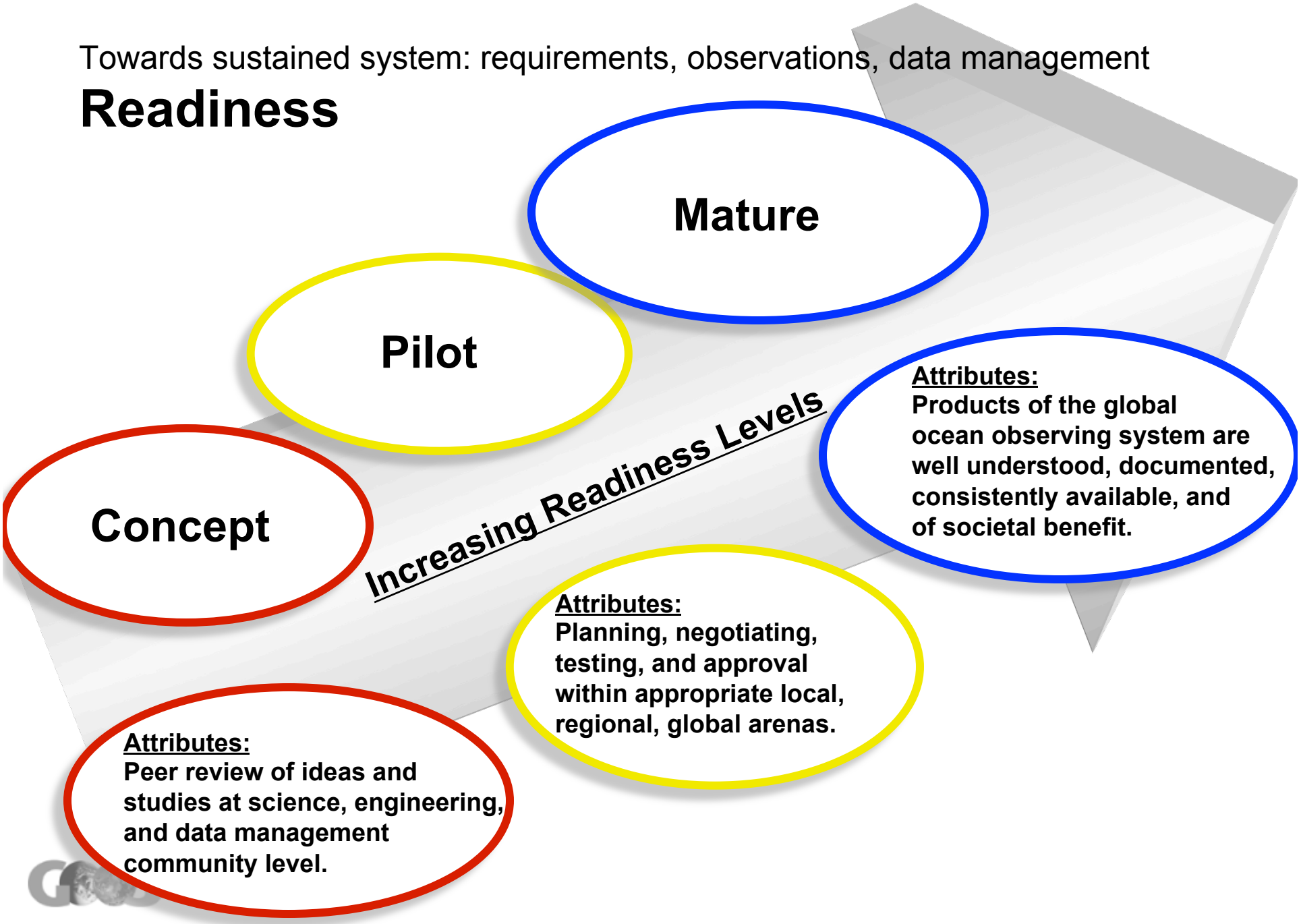
Essential Ocean Variables



- **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

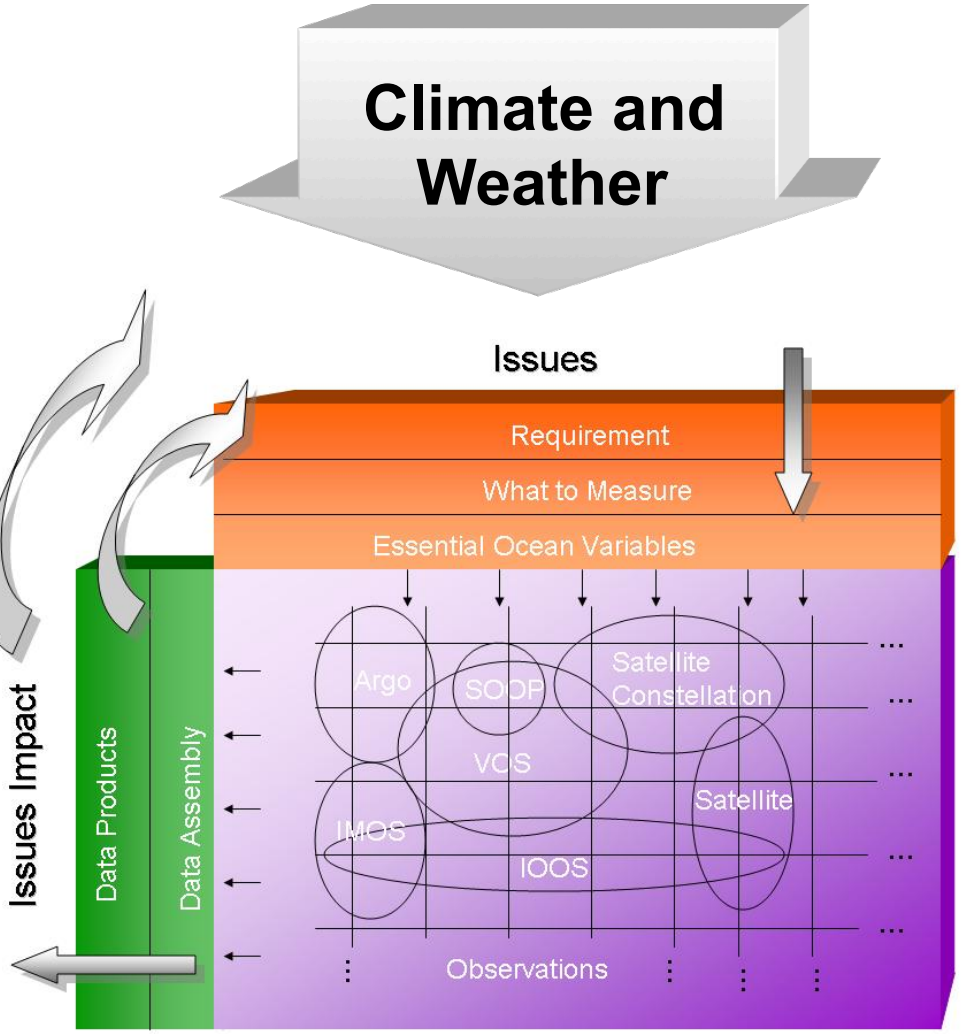
Towards sustained system: requirements, observations, data management

Readiness



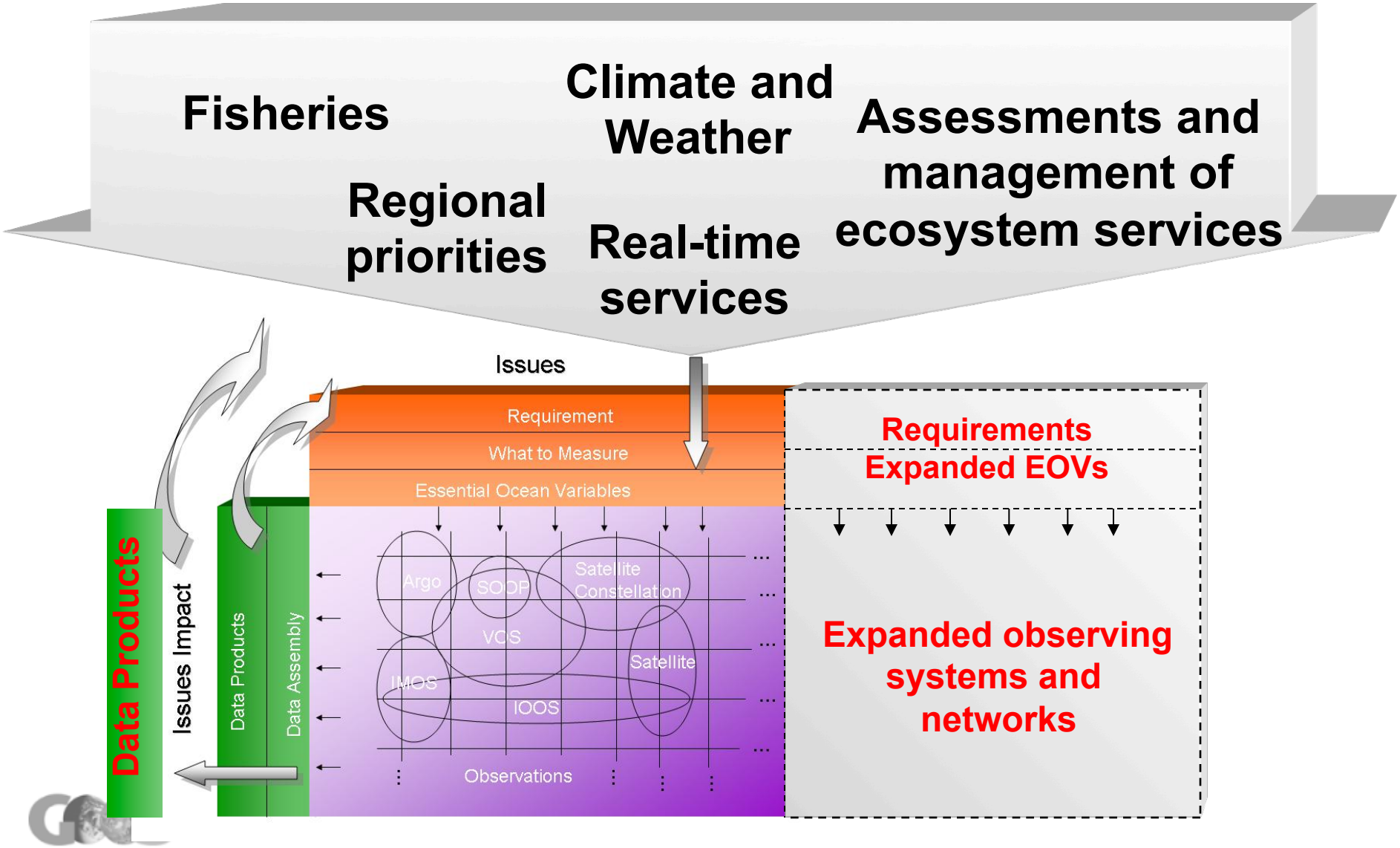
Framework for Ocean Observing

Societal drivers 2012



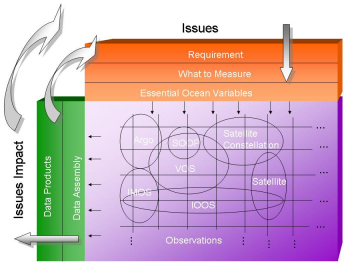
Framework for Ocean Observing

Societal drivers next decade



Framework for Ocean Observing

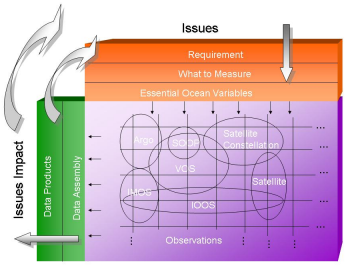
Characteristics



- **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



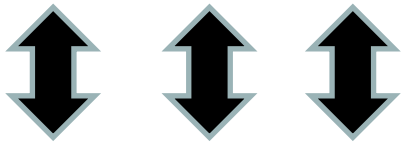
- For Ocean Observing Communities
  - **Focus on variables allows innovation**, research, while sustaining the key output of the observing system
  - Clear path to **selling utility** of observations to high level, articulation of societal importance
  - **learn from** best practices and principles of **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

Framework for Ocean Observing

Governance structure

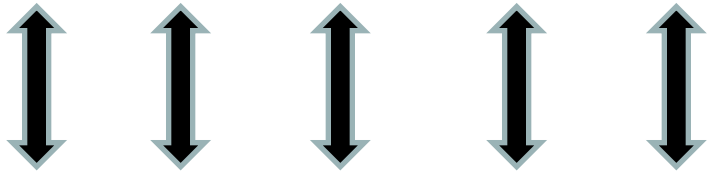
GOOS Steering Committee

(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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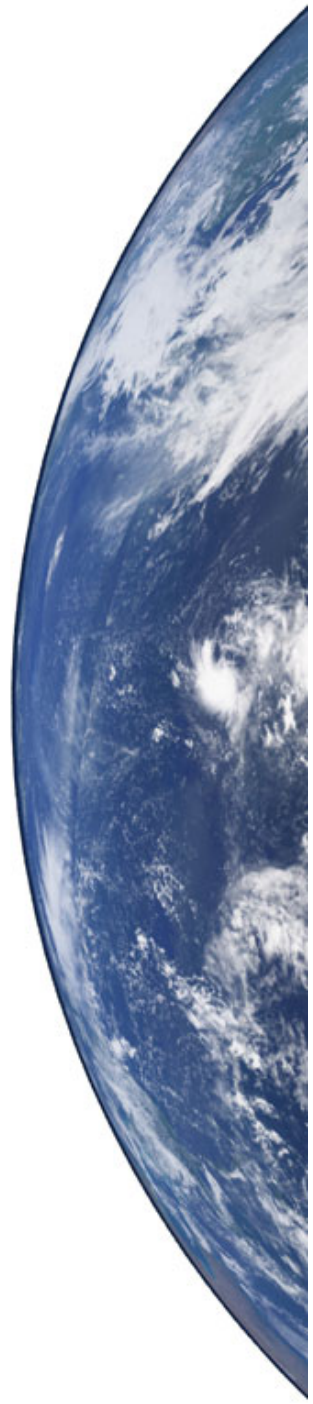

The future of GOOS

GOOS SC-1, 20-22 June 2012, http://ioc-goos.org/goos-sc-1

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

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

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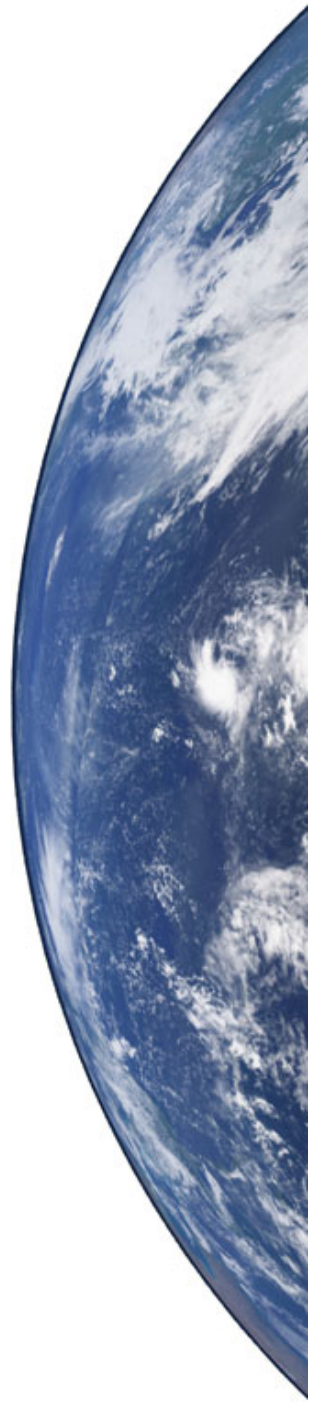

GOOS and IOOS

- 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

glynnApprick.co.uk

GLOBAL OCEAN OBSERVING SYSTEM

www.ioc-goos.org

The oceans are the basis of the life support system. GOOS measures ocean warming and provides an opportunity for the human system to respond.