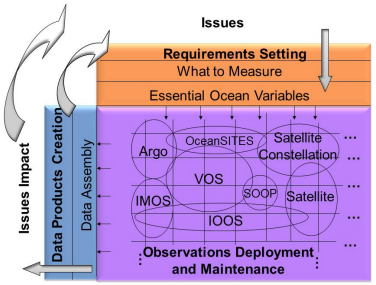



# A **Framework for Ocean Observing**: Best Practices for the Global Ocean Observing System

**Eric Lindstrom**

Physical Oceanography Program, NASA

**John Gunn**

*CEO, Australian Institue of Marine Science*

**Albert Fischer**

*Director, GOOS Project Office, IOC/UNESCO*

*US CLIVAR Summit, July 2012, Newport Beach, CA, USA*



Conference co-chairs Julie Hall, Ed Harrison, and Detlef Stammer


Patriocio Bernal, Executive Secretary of the IOC, opens the conference

# Building a **common vision** for ocean observations

Provision of routine and sustained global information on the marine environment sufficient to meet society's needs for describing, understanding and forecasting marine variability (including physical, biogeochemical, ecosystems and living marine resources), weather, seasonal to decadal climate variability, climate change, sustainable management of living marine resources, and assessment of longer term trends

# OceanObs'09: Calls for Action

(1) Calls on all nations and governments to **fully implement** by 2015 the **initial physical and carbon global ocean observing system** originally envisioned at OceanObs'99, and refined at OceanObs'09.

(2) Calls on all nations and governments to **commit to the implementation** and international coordination of **systematic global biogeochemical and biological observations**, guided by the outcomes of OceanObs'09, and taking into account regional variations in ecosystems.

# OceanObs'09: Calls for Action

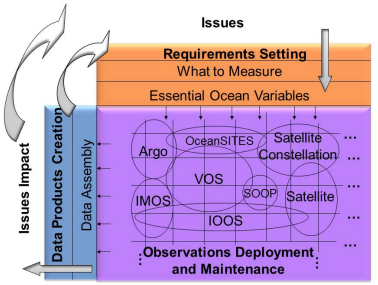
(3) Invites governments and organizations to embrace **a framework for planning and moving forward with an enhanced global sustained ocean observing system over the next decade**, integrating new physical, biogeochemical, biological observations while sustaining present observations. Recommendations on this Framework, considering how to best take advantage of existing structures, will be developed by an **post-Conference working group of limited duration**.

(4) Urges the ocean observing community to **increase our efforts** to achieve the needed level of timely data access, sensor readiness and standards, best practices, data management, uncertainty estimates, and integrated data set availability.

(5) Asks governments, organizations, and the ocean observing community to increase their efforts in **capacity-building and education**.

Framework for Ocean Observing

# Sponsors and Team

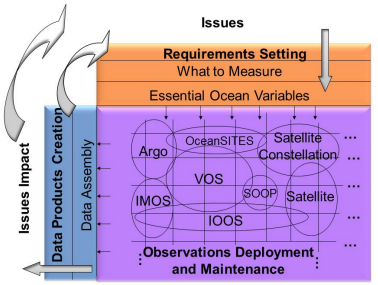



Keith Alverson, Bee Berx, Peter Burkill, Francisco Chavez, Dave Checkley, Candyce Clark, Vicki Fabry, Albert Fischer, John Gunn (co-chair), Julie Hall, Eric Lindstrom (co-chair), Yukio Masumoto, David Meldrum, Mike Meredith, Pedro Monteiro, José Mulbert, Sylvie Pouliquen, Carolin Richter, Sun Song, Mike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

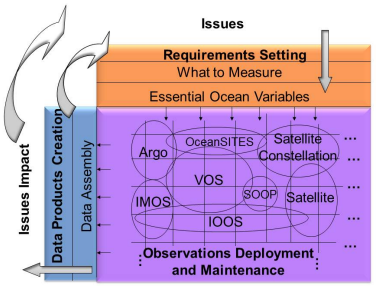
# High Level Objectives

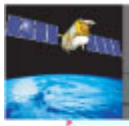



- Take lessons learned from successes of existing observing efforts – **best practices**
- **Guide** observing community as a whole to sustain and expand the capabilities of the ocean observing system
- Deliver and observing system that is **fit-for-purpose**
- Promoting **collaborative alignment** of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

Ocean observing system for climate – drawing from best practices

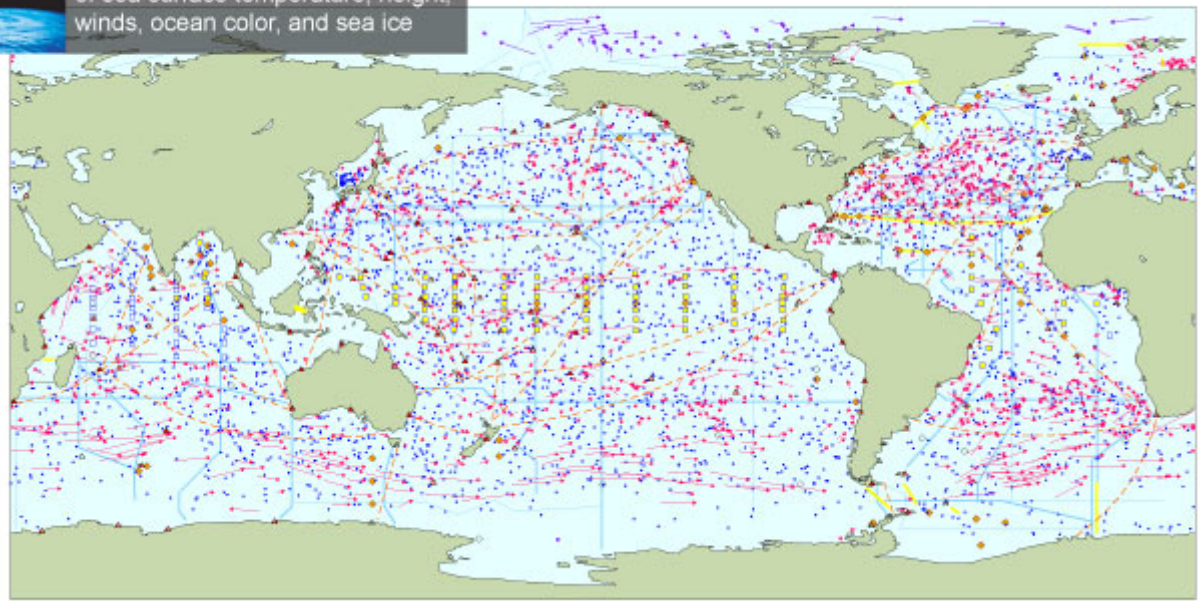
# Requirements for Essential Climate Variables



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

Total *in situ networks* **62%** December 2011



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

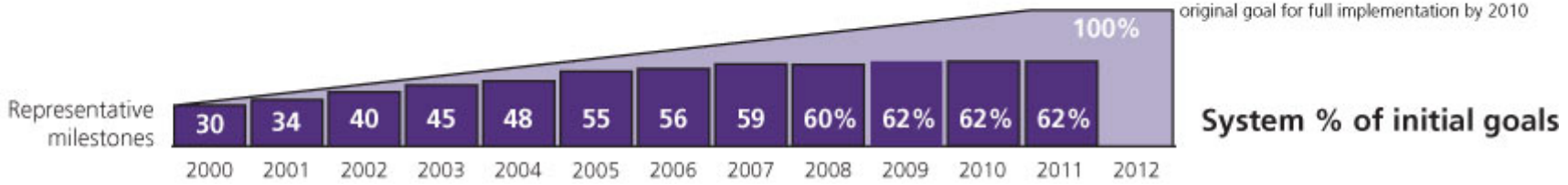
58 moorings planned

79% Global tropical **moored buoy** network

119 moorings planned

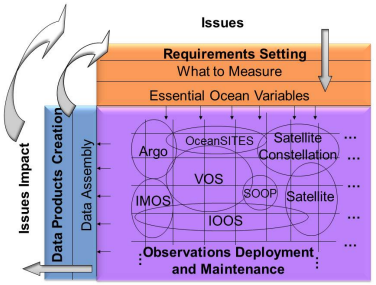
62% Repeat **hydrography** and **carbon inventory**

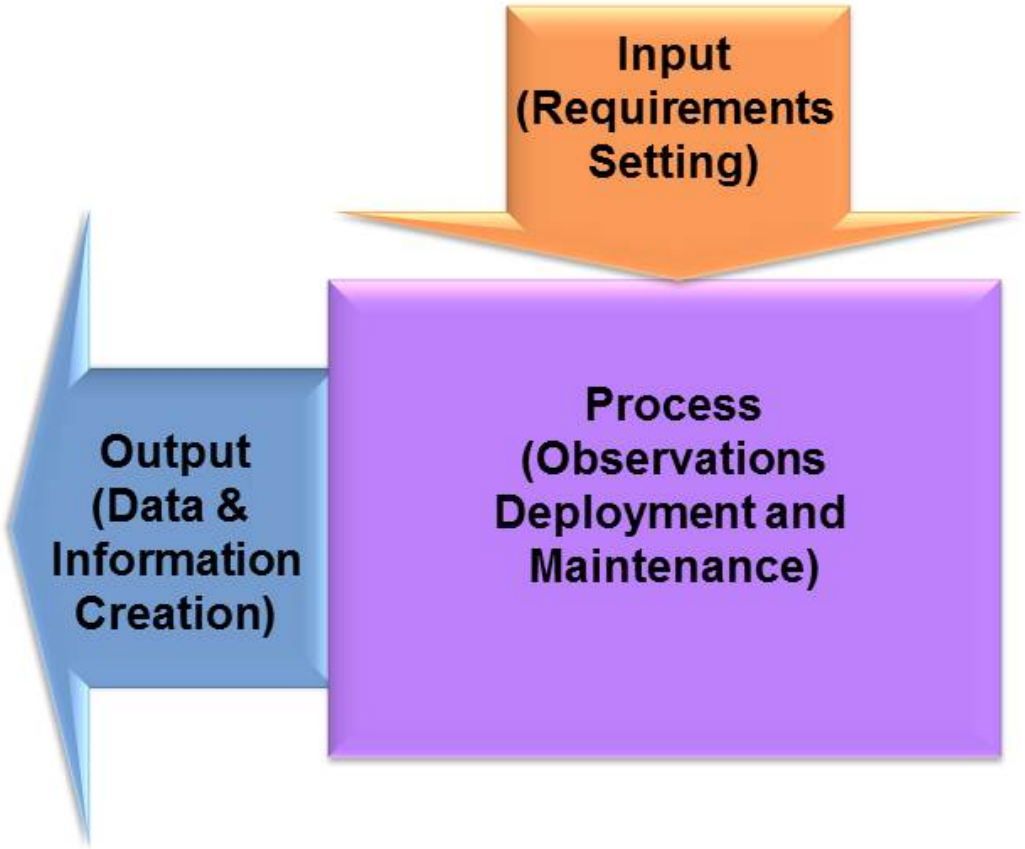
Full ocean survey in 10 years



Framework for Ocean Observing

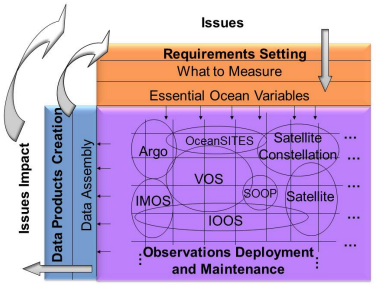
# A Simple System

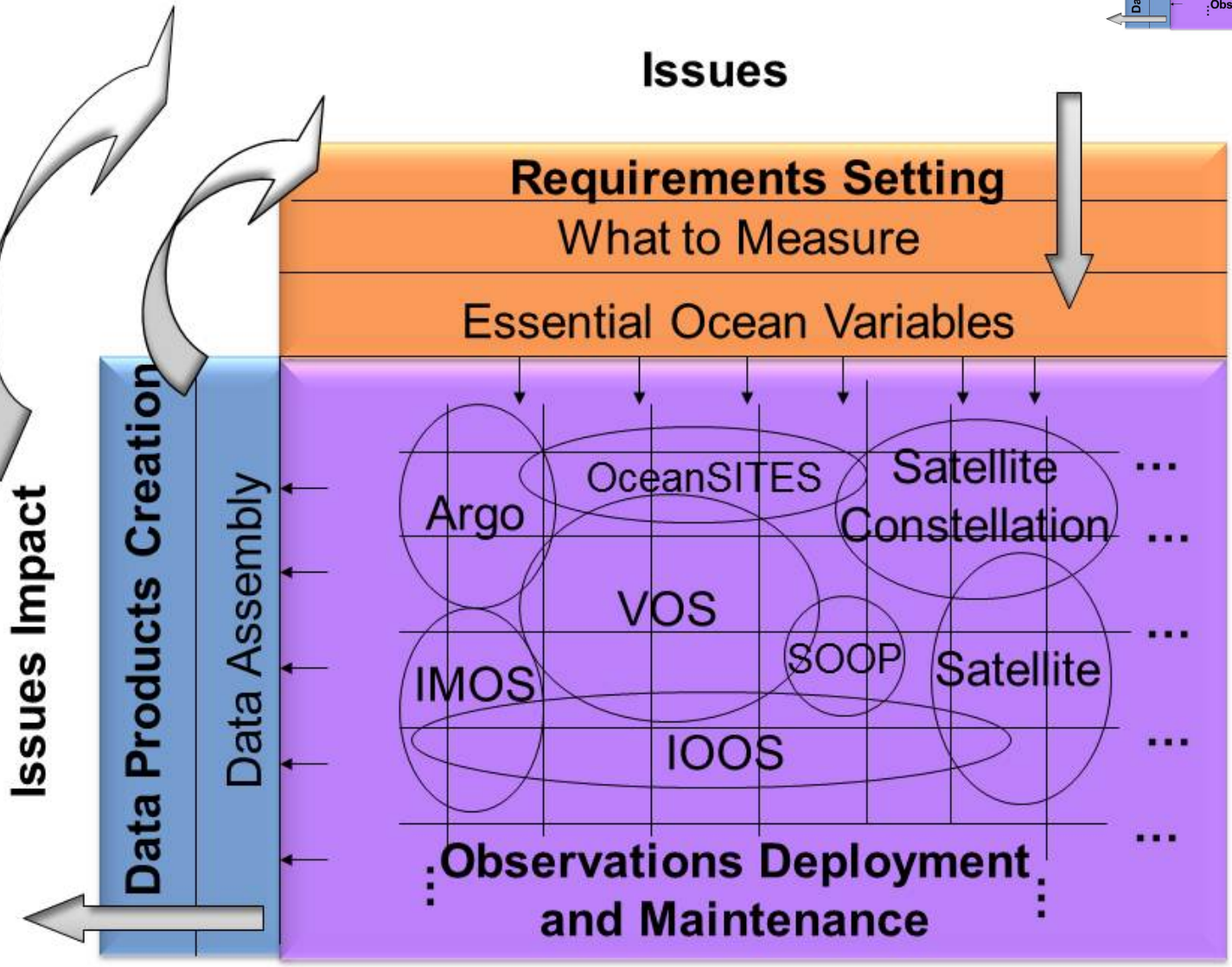


Framework for Ocean Observing

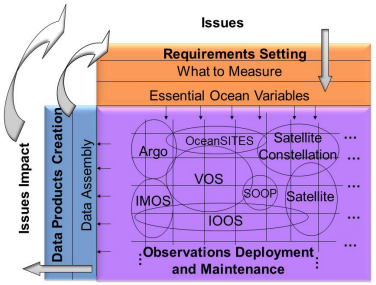
# Structure of the Framework

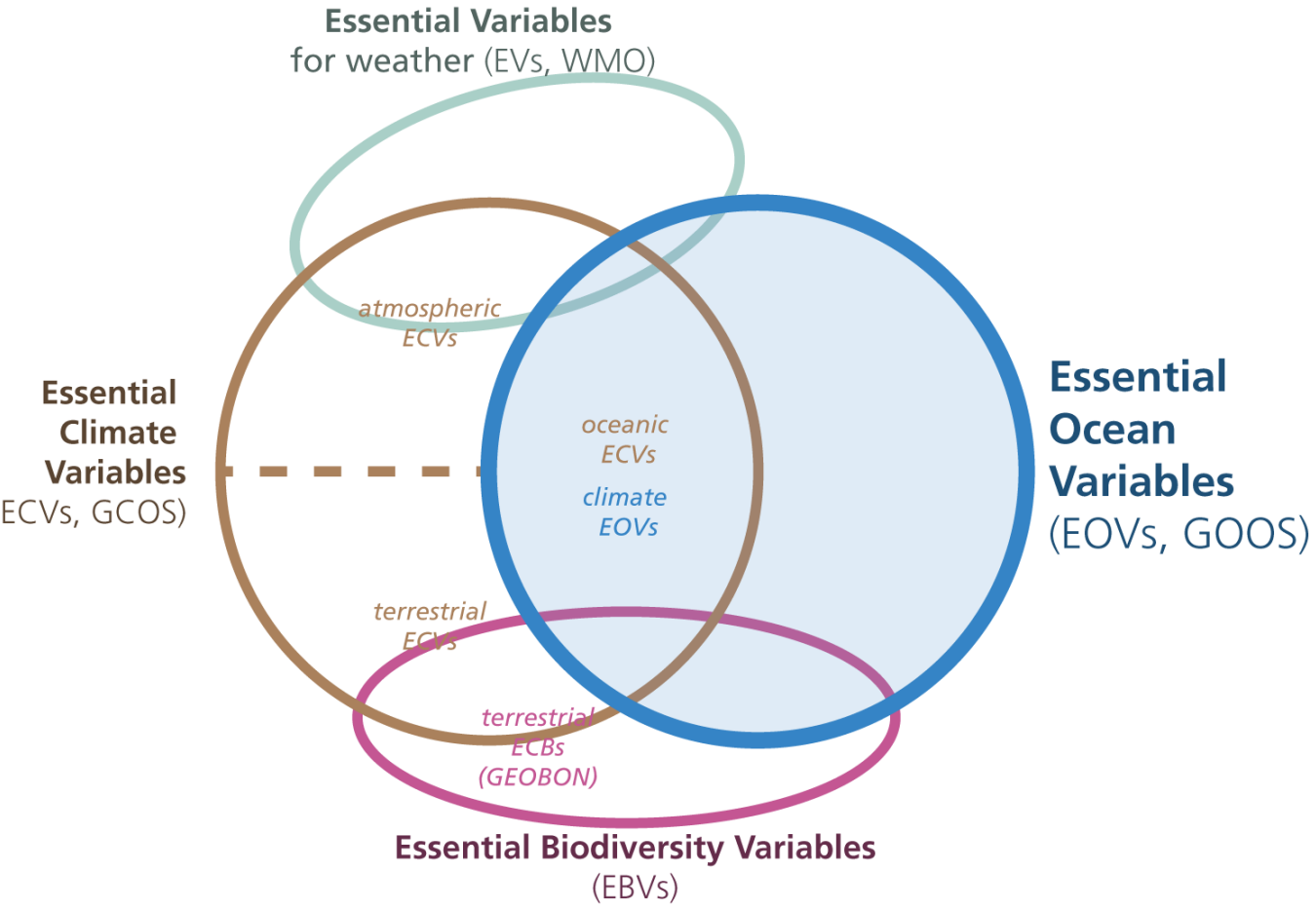


Driven by requirements, negotiated with feasibility

# Essential Ocean Variables

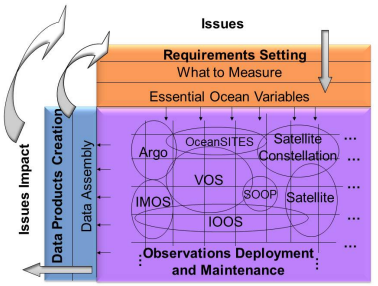



- **We cannot measure everything, nor do we need to**
- basis for including new elements of the system, for expressing requirements at a high level
- Driven by requirements, negotiated with feasibility
- Allows for innovation in the observing system over time

Framework for Ocean Observing

# Readiness




**Mature:**
Requirements, systems, and data become elements of the sustained global ocean observing system.

**Pilot:**
Plans evolve from draft to projects and vetted in real-world implementation.

**Concept:**
Initial articulation of ideas, and appropriate feasibility studies.

**Increasing Readiness Levels**

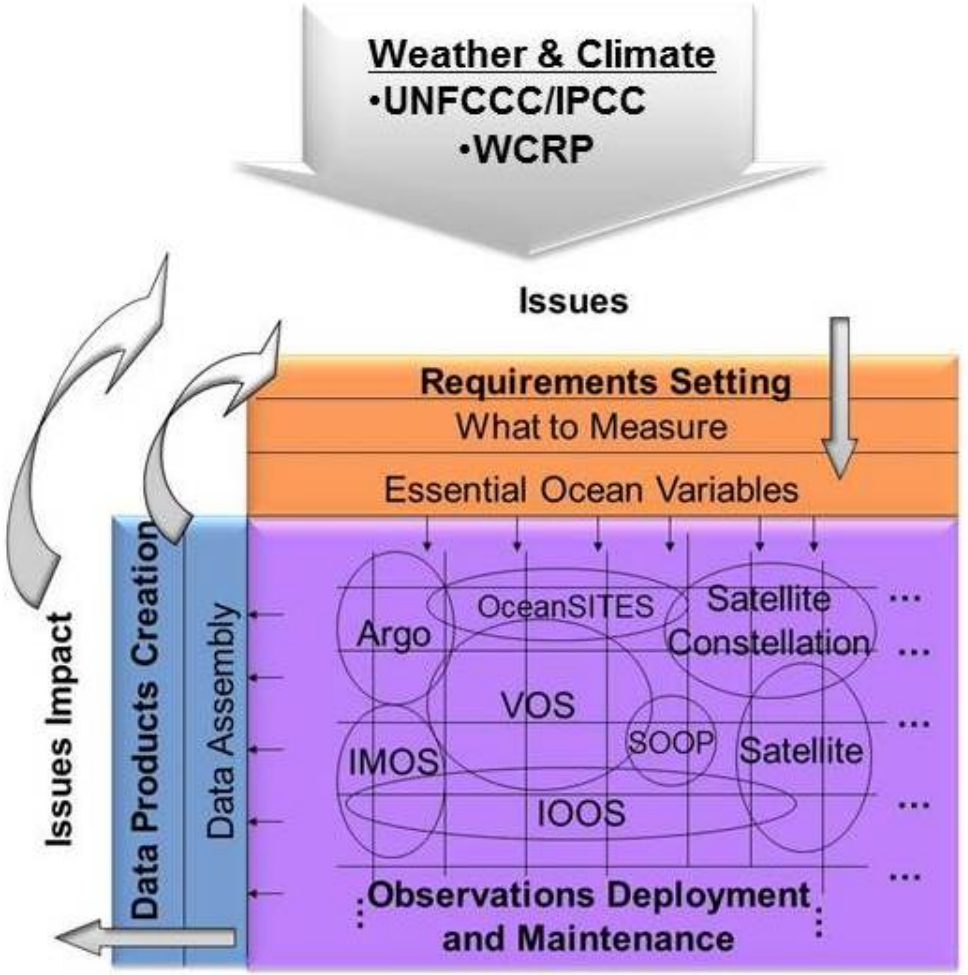
**Attributes:**
Products of the global ocean observing system are well understood, documented, consistently available, and of societal benefit.

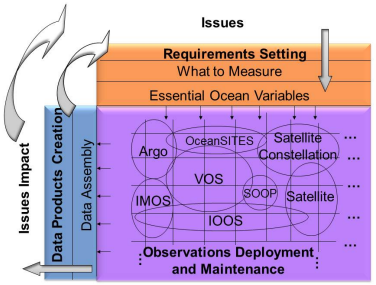
**Attributes:**
Planning, negotiating, testing, and approval within appropriate local, regional, global arenas.

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

Framework for Ocean Observing

# Societal Drivers 2012



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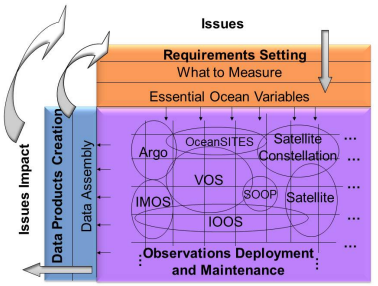
# Societal Drivers Next Decade




**Regional**
- Regional Seas
- CCAMLR

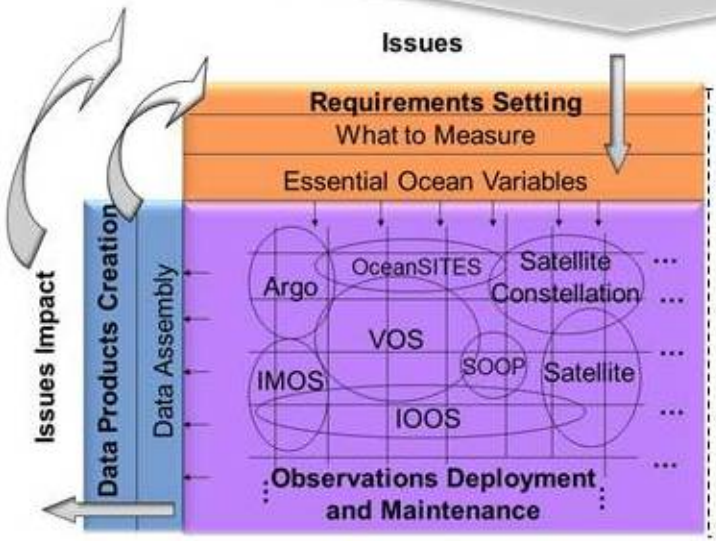
**Fisheries**
- FAO
- RFMOs

**Ecosystem services/ Biology**
- CBD
- CSD
- WSSD

**Assessments**
- Global Marine (UN)
- TWAP (GEF)
- Regional

**Weather & Climate**
- UNFCCC/IPCC
- WCRP
- Climate services

**Real-time services**
- Emergency support
- Ocean forecasting

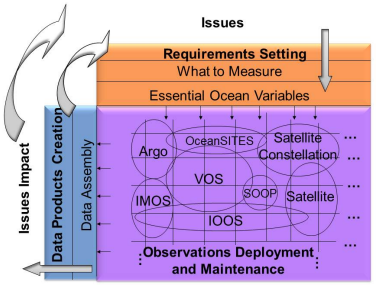



Additional

Requirements
Observations Elements
& Data Products

Framework for Ocean Observing

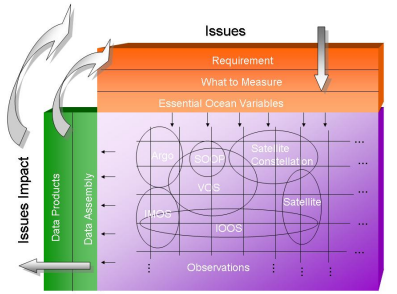
# Characteristics




- **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



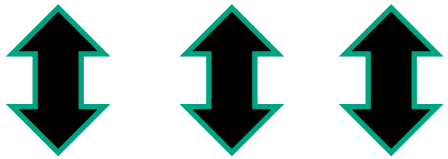

- For Ocean Observing Communities
  - **Focus on variables allows innovation**, research, while sustaining the key output of the observing system
  - Clear path to **selling utility** of observations to high level, articulation of societal importance
  - **learn from** best practices and principles of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

# Proposed Governance Structure

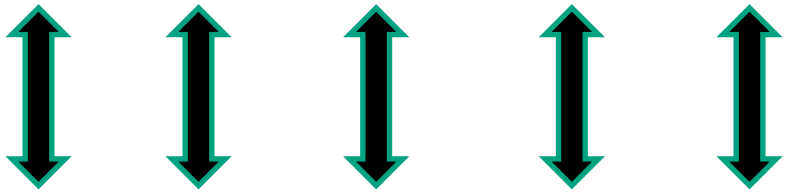
## GOOS Steering Committee

(Peak Bodies, Sponsors, Observing Panel Chairs,
Observing System leaders)



## Observing System Panels

(focused on EOVs e.g. Physics, Carbon/Biogeochemistry,
Biology/Ecosystems); Coordination for observing system elements



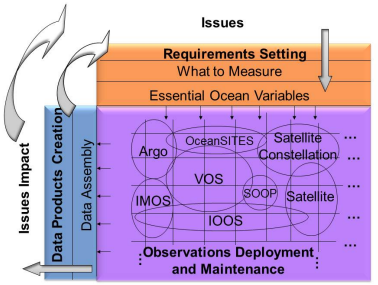
## Technical Advisory Groups

(Observing technologies and networks,
Variable focus: data and products, synthesis, link to models)

# The Future of GOOS

- 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

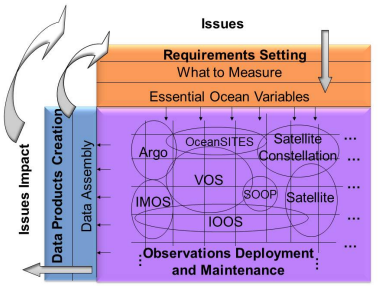
- the GOOS programme
  - advocacy for all elements of the system
  - provide a **platform for collaboration**
  - promote **global participation**
  - animating Framework for Ocean Observing processes
    - in **collaboration** with other partners, adapting structures in stable and stepwise way, assessing and encouraging the readiness of components
    - **integrating** new observations while **sustaining** present ones




# BACK-UP SLIDES

Framework for Ocean Observing

# Governance Structure




## Governance Structure for Sustained Global Ocean Observing

**Framework Steering Group Members / Appointed by Sponsors**

**Oversight & Coordination**

- Management
- Review/Development of Requirements
- Convention Negotiation
- Facilitate Community-wide Coordination and Alignment
- Endorsement of Mature Elements

---

**Ocean Observing Panels / Appointed by Steering Group**

| Physical Panel | BioGeoChem Panel | Bio/Ecological Panel |
|---|---|---|
| • Build on OOPC | • Build on IOCCP and related projects | • Could draw on PICO Plan |

**Expert Reviews**

- Develop new EOVs
- Articulate Best-practices
- Assess Readiness Levels
- Review and ensure fit-for-purpose system outputs among EOVs
- Develop Implementation Strategies
- Coordinate National, Regional, Local Activities

---

**EOV Expert and Implementation Teams / Identified by Steering Group & Panels**

EOVs: SST / Sea Level / pCO2* / Plankton*/ Alkalinity* / Transport* / Other* (*-potential)

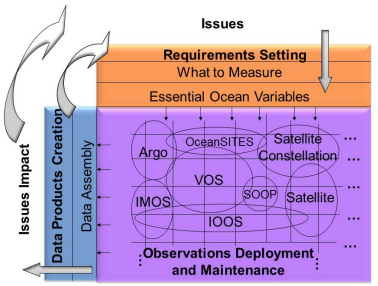
**Observing Element Implementation Teams**

- Improve Readiness Levels (Design Pilots, New Products)
- Develop Implementation Plans
- Improve Literacy (Train experts, Educate Users, Facilitate Integration)
- Coordination

IOC

Framework for Ocean Observing

# Boundary




**Outside the Framework**

**Facilitated by the Framework:**

- **Quantitative Analysis**
- **Application of Science to Societal Issues**

---

- **Qualitative Analysis**
- **Policy Questions**

Societal Issues

**Requirements: Sensors and Scales**

**What to Measure: Essential Ocean Variables**

**Observations: Facilities and Management**

**Data: Infrastructure and Assembly Centers**

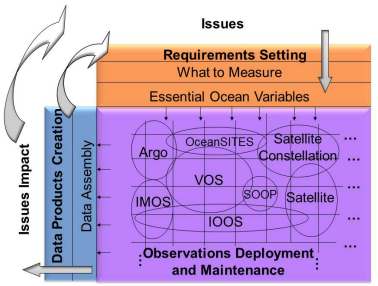
**Information: Products and Services**

Decision Guidance

Issue Influence

Framework for Ocean Observing

# Roles

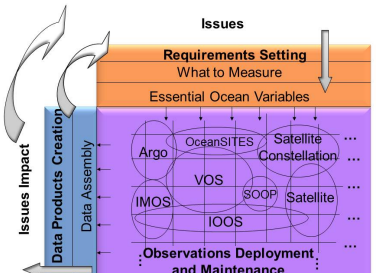



| Functional Groups | Primary Activities |
|---|---|
| Oversight & Coordination | Groups that have as their primary purpose to review the development of information requirements in response to societal needs align ocean observing activities accordingly. These groups will also bring partners together to coordinate and align their activities. |
| Expert EOV Reviews | Groups that align to evaluate best-practices, and to design and assess the feasibility of building and managing the ongoing measurements required to study and understand an EOV. They respond to needs for information and review or develop the requirements of EOVs. Through evaluation of the needs for standardization and innovation along with readiness levels they then develop EOV an implementation strategy. |
| EOV Implementation | These groups are the basic unit and core of the observing system. They are communities that form around common challenges on a type of observing platform, steering the development of particular networks. They can also be communities that focus on data management challenges, or the production of integrated data products focused on a particular EOV. They can also have a regional focus. Their inclusion in the Framework is mutually beneficial, providing the team with guidance and connection to societal benefits, and providing the Framework with substance. |

Key Linkages to Stakeholders Outside of the Framework

Framework for Ocean Observing

# Data and Information Products

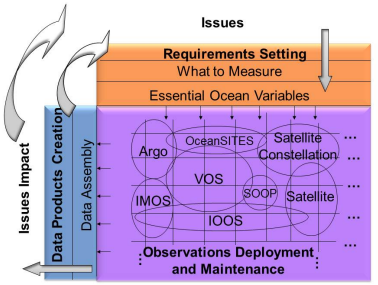



## Data Management & Information Products Activities within the Framework

| Functional Groups | Primary Activity |
|---|---|
| Oversight Panel *(Oversight & Coordination)* | • Feedback Into Requirements<br>• Process & Validation of Requirements |
| Expert Teams *(Expert EOV Reviews)* | • IT & Data Management Teams (Global, GTS, CEOS)<br>• Latency, Aggregation<br>• Promotion of Standards & Interoperability |
| Implementation Communities *(Observing Element Teams)* | • Verification and Validation<br>• Definition & Data QC<br>• Product Development |

Framework for Ocean Observing

# Observations

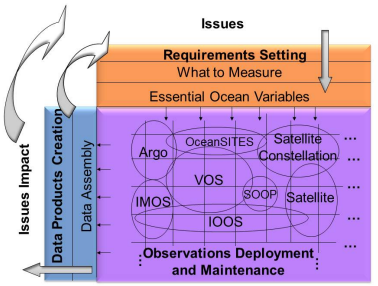



## Coordination of Observation Element Activities within the Framework

| Functional Groups | Primary Activity |
|---|---|
| Oversight Panel *(Oversight & Coordination)* | • Governance<br>• Deployment<br>• Commitments |
| Expert Teams *(Expert EOV Reviews)* | • Identify Synergies & Best Practices<br>• Promote Standards<br>• Technology Infusion |
| Implementation Communities *(Observing Element Teams)* | • Trade-Space Determination<br>• Quality Control<br>• Technology & Standards Maturation<br>• International Cooperation |

Framework for Ocean Observing

# Requirements

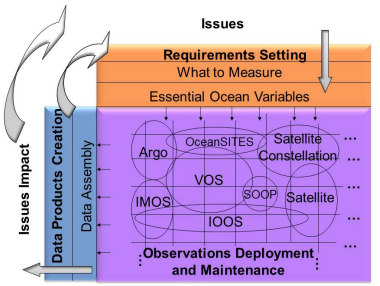



## Requirements Activities within the Framework

| Functional Groups | Primary Activity |
|---|---|
| Oversight Panel *(Oversight & Coordination)* | • Requirements<br>• What to Measure<br>• Variables (EOVs) |
| Expert Teams *(Expert EOV Review)* | • Sampling Requirements<br>• Implementation Strategies |
| Implementation Communities *(EOV Implementation)* | • Feasibility Assessment<br>• How to Measure |

Framework for Ocean Observing

# Readiness Levels and Elements




Highest Readiness Level

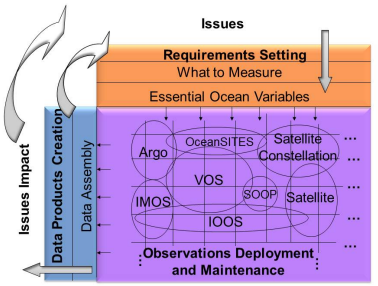
Lowest Readiness Level

| | Requirements | Observations | Data & Information |
|---|---|---|---|
| **Mature** | • **Sustained:** standard quality, periodic review, interoperable<br>• **Mission-qualified:** stability, scalability, utility<br>• **Fitness-for-purpose:** validation, peer review | | |
| **Pilot** | • **Operational:** refinement, implementation plans, demonstration<br>• **Verification:** sampling, governance, standardization<br>• **Trial:** at sea, operational projects, management practices | | |
| **Concept** | • **Proof-of-concept:** feasibility, scalability, credibility<br>• **Documentation:** strategic and tactical descriptions, socialization<br>• **Idea:** identification, formulation, specification | | |

IOC

Framework for Ocean Observing

# Readiness and Elements



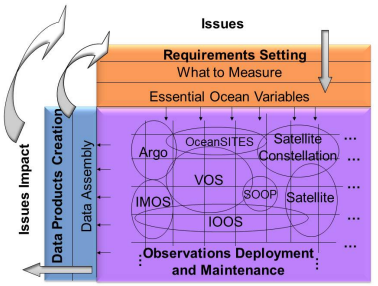

Highest Readiness Level

Lowest Readiness Level

| | Requirements | Observations | Data & Information |
|---|---|---|---|
| Mature | • Requirements: Sensors & Scales<br>• What to Measure: Essential Ocean Variables<br>• Observations: Facilities & Management<br>• Data: Infrastructure & Assembly Centers<br>• Information: Products and Services | | |
| Pilot | | | |
| Concept | | | |

Framework for Ocean Observing

# Readiness and Requirements



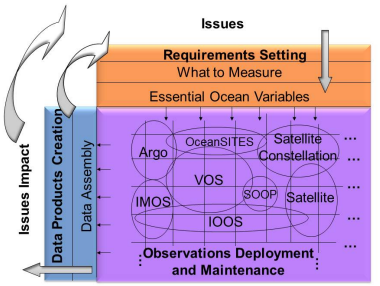

Highest Readiness Level

Lowest Readiness Level

| | Requirements |
|---|---|
| **Mature** | • Sustained implementation and under periodic review<br>• Mission qualified at regional and/or global scale<br>• Consensus on observation impact or fitness-for-purpose |
| **Pilot** | • Deployment in an operational environment<br>• Verification of the spatial and temporal sampling strategy<br>• Measurement strategy verified by sea trial |
| **Concept** | • Proof-of-concept determined via feasibility study<br>• Measurement strategy documented<br>• Environment information identified |

Framework for Ocean Observing

# Readiness and Observations



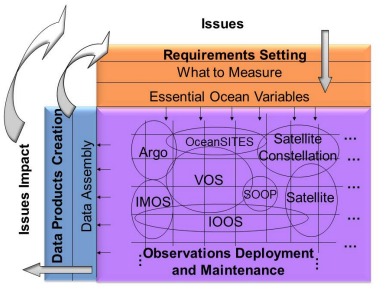

Highest Readiness Level

Lowest Readiness Level

| | Observation Deployment & Maintenance |
|---|---|
| **Mature** | • System is sustainable globally and under periodic review<br>• Implementation details fully qualified<br>• Peer review and deployment demonstrate fitness-for-purpose |
| **Pilot** | • Maintenance and servicing logistics operationalized<br>• International commitments to sustaining components verified<br>• Trial project in an operational environment |
| **Concept** | • Operational, scalable, and technology proof-of-concept<br>• Observing platforms technology and design are documented<br>• Idea for measuring system is formulated |

Framework for Ocean Observing

# Readiness and Data and Info Products




Highest Readiness Level

Lowest Readiness Level

| | Data Management and Products |
|---|---|
| **Mature** | • Sustained products available and under user group review<br>• Data globally available and of service to the community<br>• Data management and distribution determined to be fit-for-purpose |
| **Pilot** | • Data operational through system-wide availability and use<br>• Data and archival plans and practices verified<br>• Data management practices determined and tested for quality and accuracy throughout the system |
| **Concept** | • Data model proven to meet observational needs<br>• Interoperability model is documented and socialized<br>• Data model is identified and articulated |

Alberto Piola, Susan Wijffels, Ray Schmitt, and Anny Cazenave in Session 2A


Conference co-chairs Julie Hall, Ed Harrison, and Detlef Stammer


Patriocio Bernal, Executive Secretary of the IOC, opens the conference

# 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

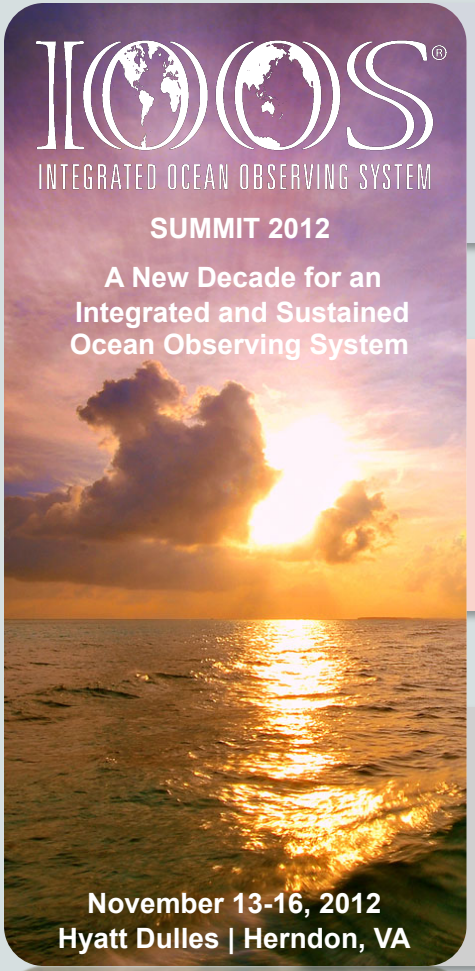
# IOOS Summit

A New Decade for an Integrated and Sustained Integrated Ocean Observing System
November 13-16, 2012 | Hyatt Dulles, VA

ERIC LINDSTROM
IOOS SUMMIT CO-CHAIR

Presentation at US CLIVAR Summit
19 July 2012

# IOOS Summit Vision




## Why an IOOS Summit?

- To bring together community leaders to develop a coordinated strategy
- To better integrate regional, national, and global efforts

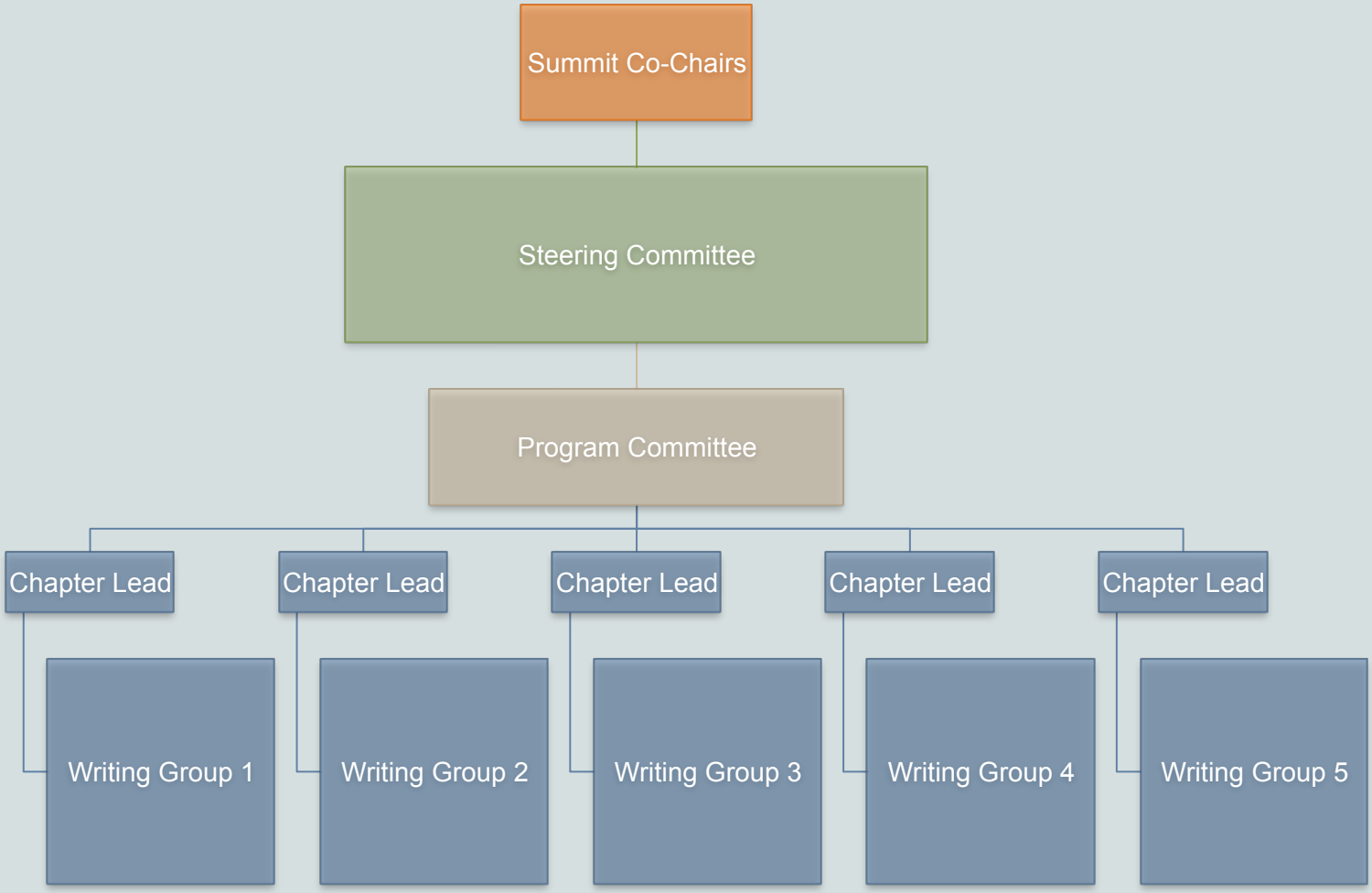
## What do we want to achieve?

- A clear understanding of progress made toward achieving IOOS in the last decade
- A fundamental understanding of the requirements needed to maintain IOOS
- A strong community consensus on the way forward for the next decade

## How do we ensure success?

- Solicit the community through written submissions prior to the meeting
- Ensure broad representative participation at the meeting
- Identify strategies for enhancing IOOS capabilities in the next decade

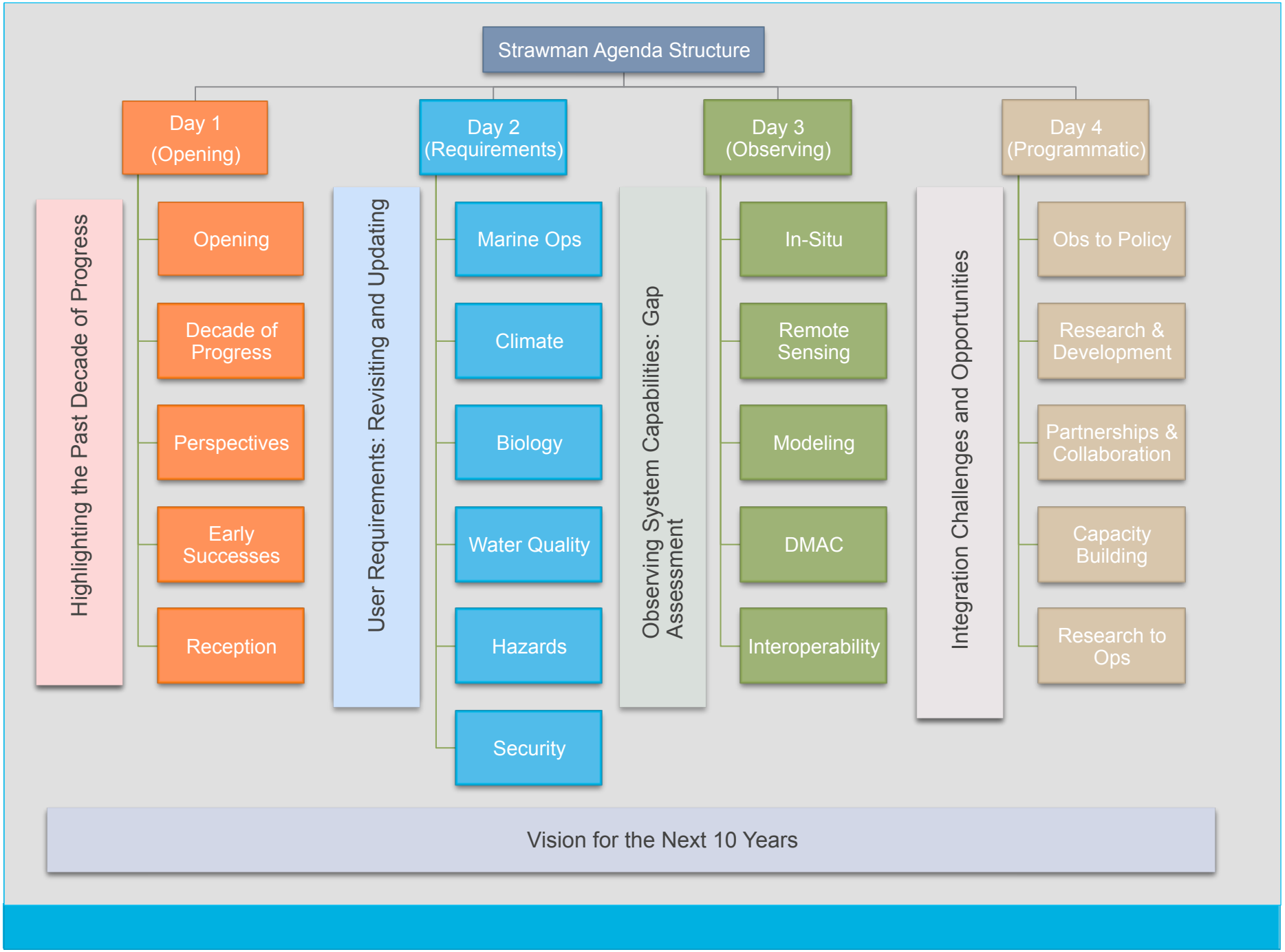
# Summit Planning Bodies



# Summit Outcomes

IOOS Summit Proceedings

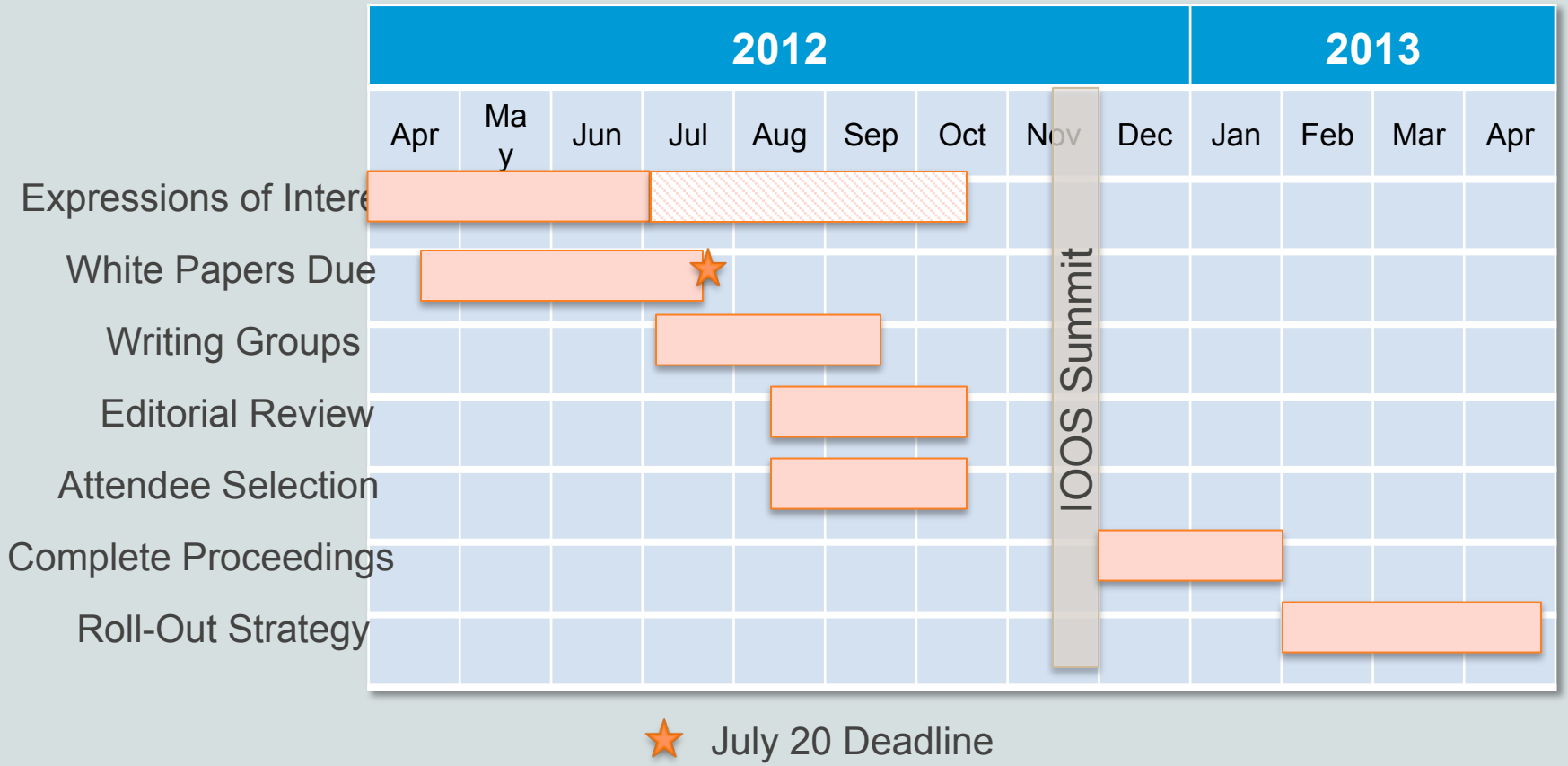
| | | Leads |
|---|---|---|
| Chapter 1 | • Highlighting the Past Decade of Progress | Dave Martin<br>Zdenka Willis |
| Chapter 2 | • User Requirements: Revisiting and Updating | Debra Hernandez<br>Cara Wilson |
| Chapter 3 | • Observing System Capabilities: Gap Assessment | Harvey Seim |
| Chapter 4 | • Integration Challenges and Opportunities | Michael Bruno |
| Chapter 5 | • Vision for the Next 10 Years | Rick Spinrad |


Strawman Agenda Structure
Day 1 (Opening)
Day 2 (Requirements)
Day 3 (Observing)
Day 4 (Programmatic)
Highlighting the Past Decade of Progress
Opening
Decade of Progress
Perspectives
Early Successes
Reception
User Requirements: Revisiting and Updating
Marine Ops
Climate
Biology
Water Quality
Hazards
Security
Observing System Capabilities: Gap Assessment
In-Situ
Remote Sensing
Modeling
DMAC
Interoperability
Integration Challenges and Opportunities
Obs to Policy
Research & Development
Partnerships & Collaboration
Capacity Building
Research to Ops
Vision for the Next 10 Years

# Community White Papers

- Basic Template
  - Introduction/background/history/accomplishments
  - Technical and user requirements
  - State of the observing system and technology
  - Integration within IOOS modeling and DMAC
  - The way forward for the next ten years
- 5 Pages Max, 5 Figures
- DUE 20 JULY 2012

# Summit Timeline



# QUESTIONS

# Backup Slides

# White Paper Process

# Community White Papers

- Informs a U.S. IOOS strategy over the next decade
  - Be “forward-looking”
  - Express new opportunities
  - Refresh existing plans
  - Explore new and evolving technology and information
  - Examine future requirements for user-needs
  - Identify contributions from new communities

# Community White Papers

- Highlight benefits to IOOS Subsystems

Functional

- Observing
- Data Management & Communications
- Modeling & Analysis

Cross-Cutting

- Governance and Management
- Research & Development
- Training & Education

# Community White Papers

- Style Guide (Recommended)
  - Opportunities for a specific element of U.S. IOOS
  - Specific requirement(s) for a U.S. IOOS user need
  - New technologies and their potential contribution to U.S. IOOS
  - Relevant partners required for the successful implementation
  - Actions for U.S. IOOS implementation over the next decade
  - Concise and action-oriented recommendations

# Community White Papers

- Review Criteria
  - Quality (1-10)
  - Relevance (1-10)
  - Format (1-10)
- Scored by Chapter Leads and Summit Co-Chairs
- 30 top-rated submissions receive invitations

# Community White Papers

1. How do you or your community currently interact with IOOS?
2. For you or your community what aspects of IOOS are critical to sustain?
3. What are your anticipated IOOS-related needs in the next ten years?

OOPC Ocean Observations Panel for Climate

# Towards a Deep Ocean Observing Strategy

**Eric Lindstrom**

*US CLIVAR Summit, 18-20 July 2012*

GCOS Global Climate Observing System

GOOS Global Ocean Observing System

WCRP World Climate Research Programme

jcomm Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology

IOC WMO UNEP ICSU

# Deep Ocean Observing Strategy Workshop

- 30 March - 1 April 2011, Paris

- Objective: Develop a common statement of requirements and a first strategy for sustained global deep ocean observations for climate; considering all Essential Climate Variables, regions, and technologies to extract high priority and feasible actions for the next 5-10 years.

- Framework experiment in integration across disciplines: physics, carbon/biogeochemistry, biology/ecosystems

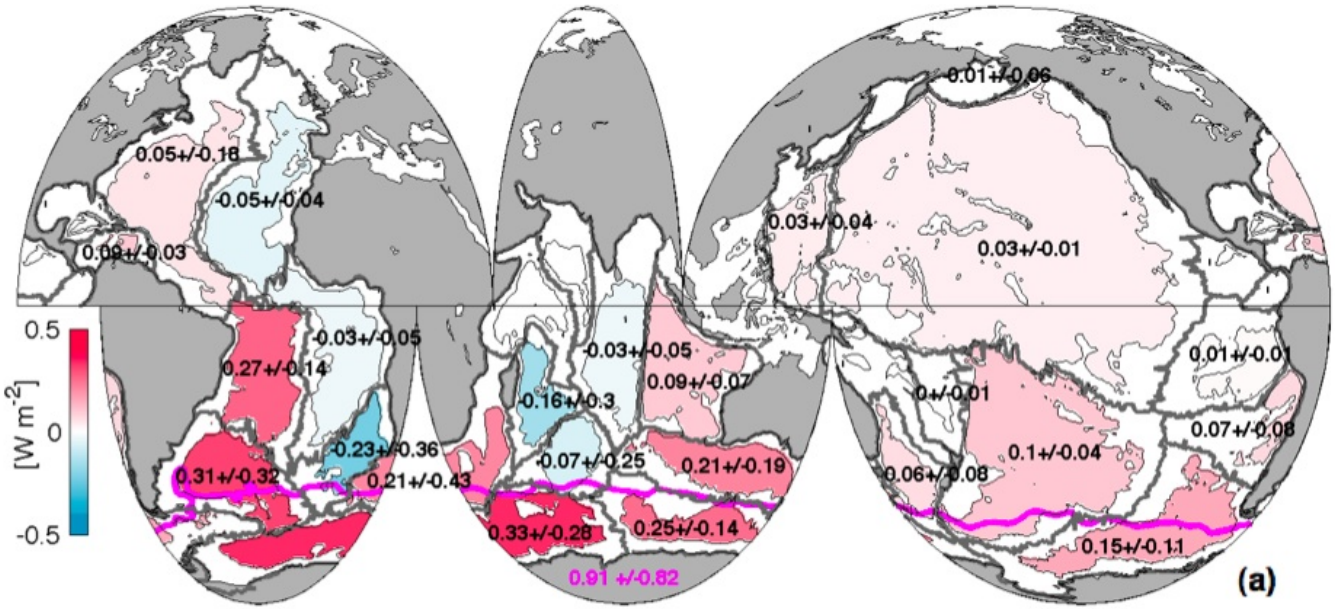
# Relationship to Framework for Ocean Observing

- Framework structure being used to coordinate the writing team activities
- Readiness levels will be used to assess the fitness-for-purpose as related to the EOVs and associated observations and data products
- Oversight Panels, Expert Teams, and Implementation Communities structure will be used to organize conversation related to requirements, observations, and data products needs going forward

# Rationale for deep ocean observations

## Abyssal & Deep Heat Content Changes

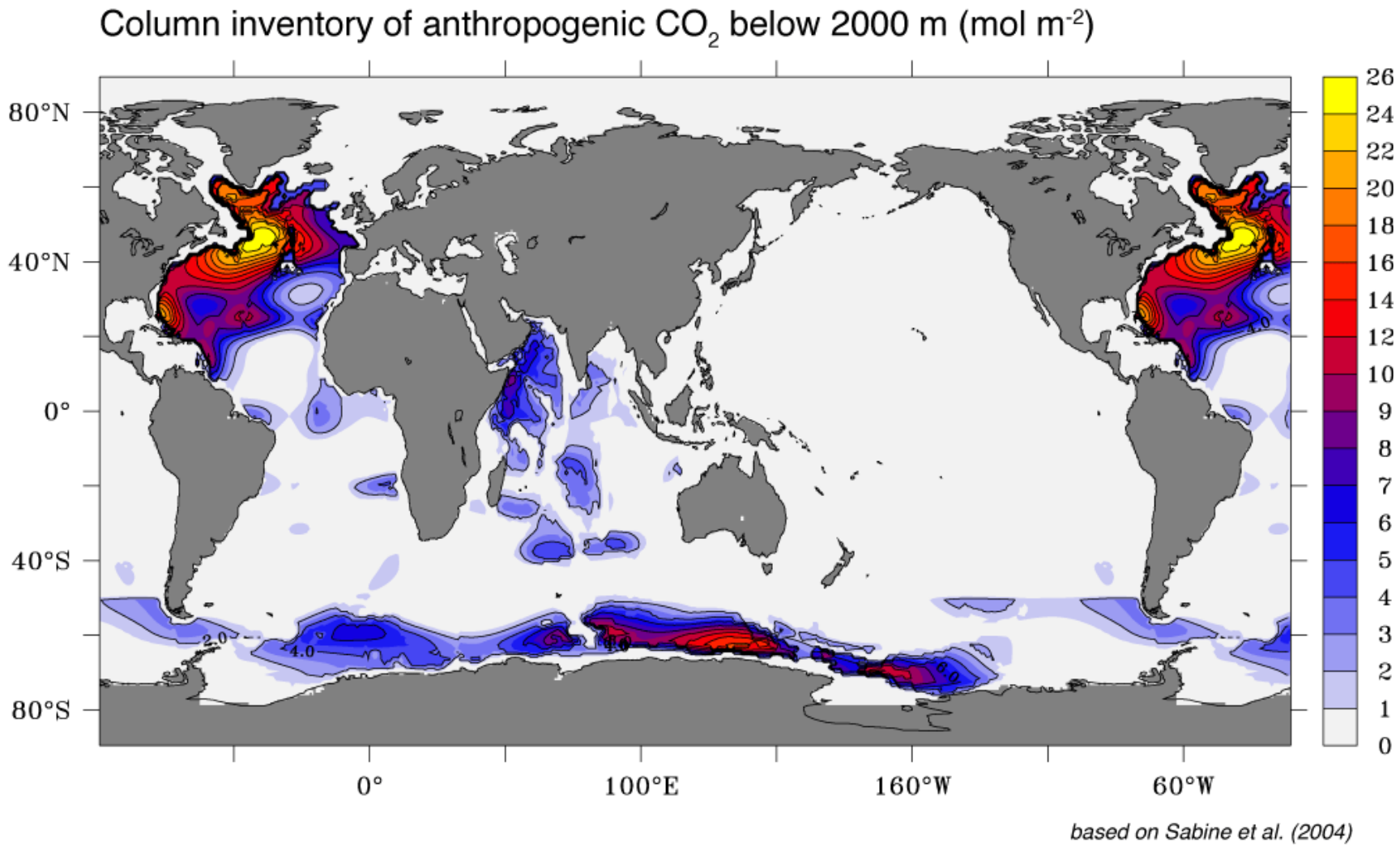
(Purkey & Johnson, 2010)




| Region | Global Heat Gain (W $m^{-2}$) |
|---|---|
| Abyssal Ocean (z > 4 km) | 0.027 (±0.009) |
| Southern Ocean (1 > z > 4 km) | 0.068 (±0.062) |
| Total (Abyssal + Southern) | 0.095 (±0.062) |

Deep ocean ~1/7 of upper ocean change 1990s-2000s:
source or limit to predictability?

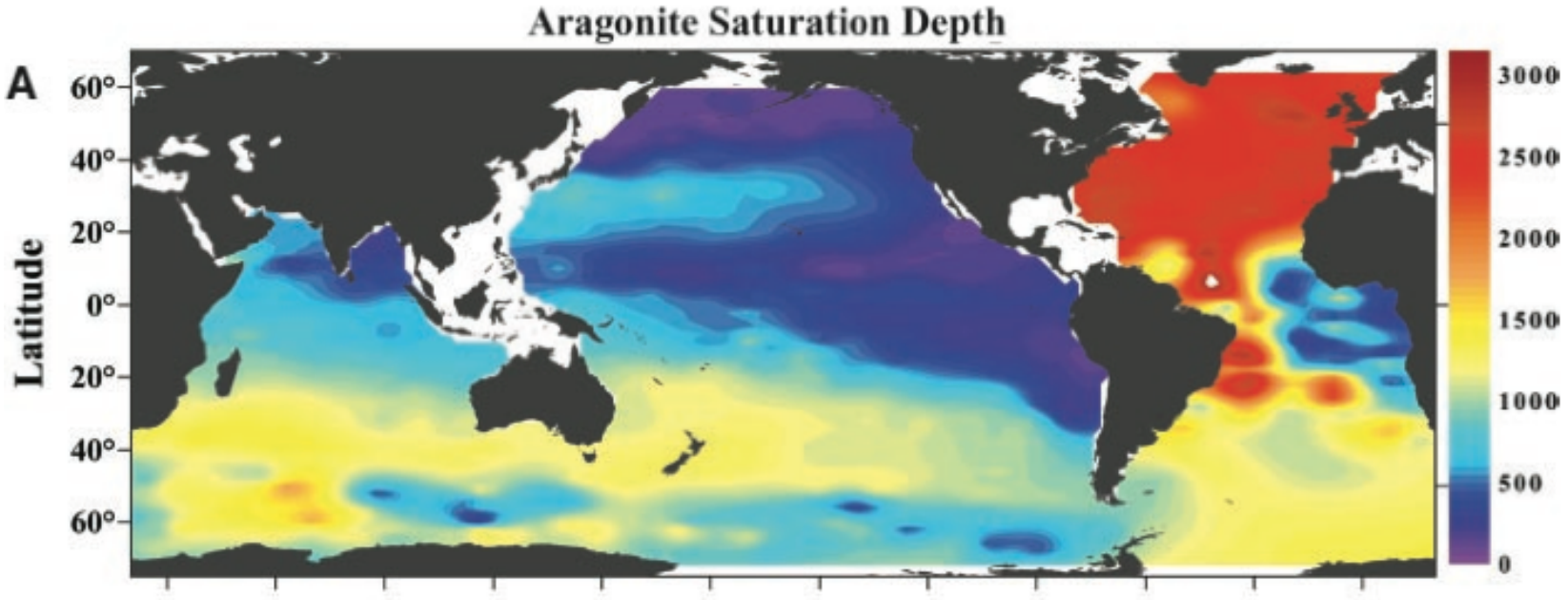
# Rationale for deep ocean observations




*based on Sabine et al. (2004)*

# Rationale for deep ocean observations

Naturally low saturation state at depth requires only little $C_{anthro}$ to reach the “tipping point”



CoML

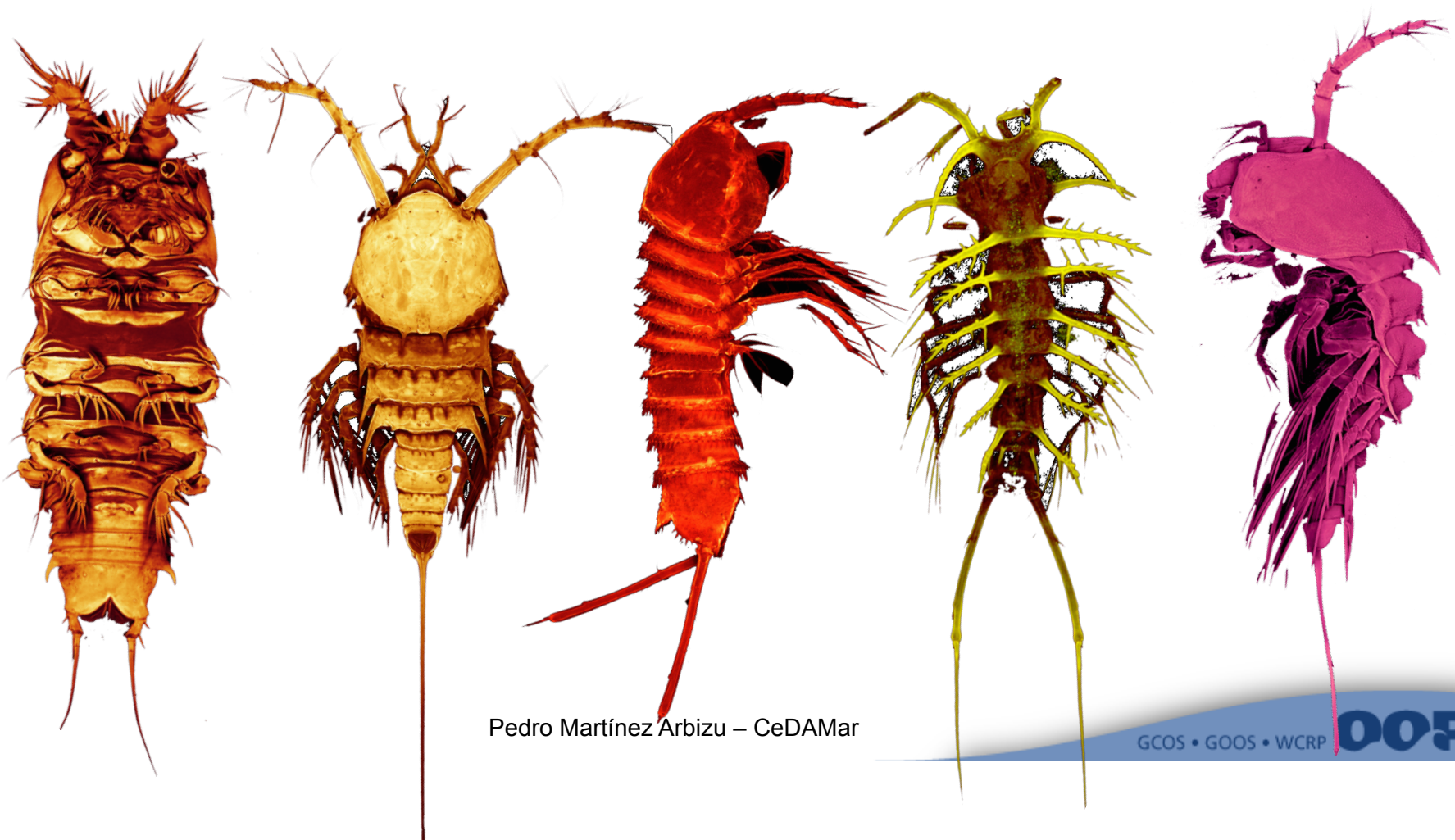
# Rationale for deep ocean observations

Over 180 new species, 25 new genera and 2 new families have been described from deep-water chemosynthetic ecosystems since 2002

# Diversity never imagined

Angola Basin: > 800 different copepods, most new to science

Southern Ocean: > 700 different isopods, > 500 new to science



# Observations

- Existing
  - Repeat hydrography and other deep hydrography
    - platform for many variables
  - Moored arrays (timeseries)
- Scaleable
  - OceanSITES moored array
  - Argo / deep profiling floats
  - Sensors for biogeochemical variables
- Potential
  - Deep gliders
  - Moored water sampling
  - Tomography?

## Developing and selling a strategy

- Message the “unique challenges” of the deep ocean
- Need to get message to higher levels of government and science funding agencies about priority for deep ocean observations
- Need for disciplinary breadth – physics/climate, biogeochemistry, ecosystem, geophysics
- Formulate a global strategy for deep ocean from component elements (SOOS, Euro, USA, Japan, etc)

# Deep Ocean Observing Strategy

Executive committee responsible for monitoring progress

- Eric Lindstrom (OOPC/FOO)
  Bob Molinari (WCRP/CLIVAR)
  Albert Fischer (OOPC)
  Kathy Tedesco (IOCCP)
  Bill Westermeyer (GCOS)
  Myriam Sibuet (post-CoML)

Three writing teams:

Climate and Physical Observations
Gregory C. Johnson
Bernadette Sloyan

Carbon, Biogeochemistry Observations
Rik Wanninkhof
Toste Tanhua

Biodiversity and Ecosystem Observations
Myriam Sibuet
Antje Boetius
Lisa Levin

## Report Outline

- Societal Issues that the observations will address
- Science questions that the observations will address
- Articulation of EOVs for each group
- Overview of current and required observing platforms, technologies and programs
- Data management strategy
- Strategies for integration through expert panels and implementation teams

## What is our timeline and measure of success?

- Year One: June 2011 to June 2012
  - Created small writing teams
  - Held several teleconferences
  - Materials placed on OOPC website
  - Drafted initial text for the plan
  - Initiated informal roll-out of the concept to high-level groups
- In next two years:
  - Establish a development program
  - Incorporated into GCOS, CLIVAR, IMBER, COML-follow on activities
- In five years:
  - Pilot program underway
- OceanObs 2019
  - Global sustained coverage in sight