ConnectinGEO

GEO

Defining essential ocean variables (EOVs) for biogeochemistry

11-12 June 2015, Bari-Italy

Societal Benefit Area: Ecosystems

Name(s):Iris Kriest, with a lot of input from Toste Tanhua

Institution:GEOMAR

Coordinating an Observation Network of Networks EnCompassing saTellite and IN-situ to fill the Gaps in European Observations

GEOMAR

Helmholtz Centre for Ocean Research Kiel

Questionnaire

Describing the monitoring networks currently operational:

- Is your community developing a set of area-specific EVs? – Yes.
- How do you define EV? – **See separate slides.**

The process underlying EV definition:

- What criteria, methodology, and processes are used to identify EVs? Bottom up or top-down? – **Both ways. See seperate slides.**
- Do you have a template to document a EV? – **Yes. See separate slides.**

EVs validation and use:

- To what extent these EVs are validated and used?
- Are the EVs linked to applications and users?
- Who are the users?
- How is a community agreement reached? **Townsville, 2013, and follow ups**
- Is a community review process in place? Yes.
- Are the EVs linked to an international body (i.e. a UN convention or similar) and is this body involved in accepting the EVs? – **FOO/GOOS/IOCCP/IOC/**

Questionnaire, continued:

Status of existing EVs in the domain:

- Do you have a database with information on the EVs? – Website.
- Do you know network currently operational for medium-term/long-term monitoring? – (Yes, e.g., GO-SHIP/repeat hydrography, time series, ...)
- Are the current operational networks operated by your community measuring the EVs?

Assessing EV observational needs and readiness:

- For some Use Case, have you already focused on EV's features (temporal and spatial resolution, accuracy? – **Yes, see slides**
- Challenges and how these are addressed (if any).

Gaps and requirements:

- Have you already carried out a gap analysis utilizing the EVs to identify gaps and priorities (data availability, extraction, respositories, ...)

Conclusions

Essential Ocean Variables For Biogeochemistry

See also www.ioccp.org/foo

A brief timeline / some milestones of EOV definition

- 2009: OceanObs ’09, Venice, Italy
  Call for international integration and coordination of interdisciplinary ocean observations. Sponsors commissioned Task Team to develop

- **2012: Integrated Framework for Sustained Ocean Observing (FOO)**
  Three Ocean Observing System Panels (Physics, Biology/Ecology and Carbon/Biogeochemistry), interacting through virtual and in-person meetings and workshops, to propose a set of **Essential Ocean Variables** (**EOV**s). Each panel has a lead organization, which is tentatively tasked to consult the community and create a loose consortium of relevant and interested experts and/or organizations, helping to justify and negotiate the inclusion of certain parameters in the final list of EOVs.

- Task Team asked IOCCP to lead Biogeochemistry Panel for EOV
  To kick-start the process, the Global Ocean Observing System (GOOS) sponsored, through IOCCP, an expert meeting which was carried out side by side with the Biology and Ecosystem Panel meeting.

- **2013: First Technical Experts Workshop for Biology and Ecosystem and Biogeochemistry Panels, Townsville, Australia, 2013**
  Starting from identification of major societal and scientific challenges that require sustained observations of ocean biogeochemistry variables; identification of candidate biogeochemical Essential Ocean Variables (EOVs).

- 2014: Town Hall Meeting Ocean Science Meeting, Honululu, US
  Input of a wider community was invited before, during and after the town hall meeting organized during the OSM'14 in Honolulu.

- 2014: GOOS Webinar

2012: Framework for Sustained Ocean Observing (FOO)

GOOS Steering Committee

Observing System Panels

Physics

Carbon/Biogeochemistry (IOCCP)

Biology/Ecosystems

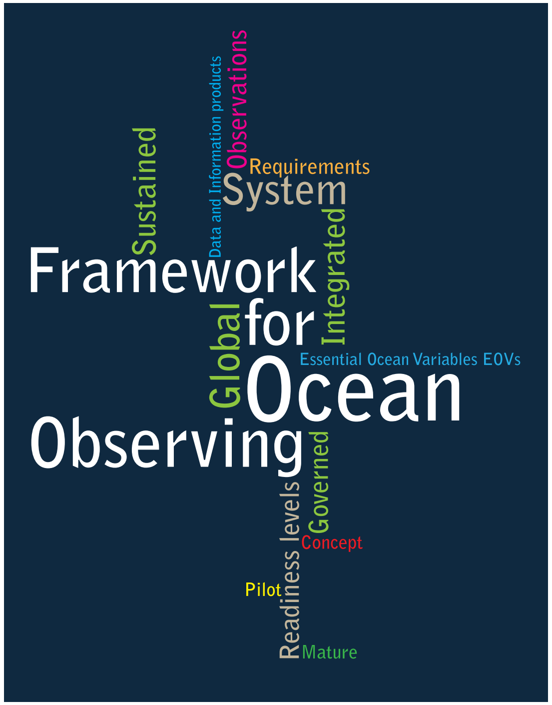
coordination for observing system elements

Technical Advisory Groups

observing technologies and networks

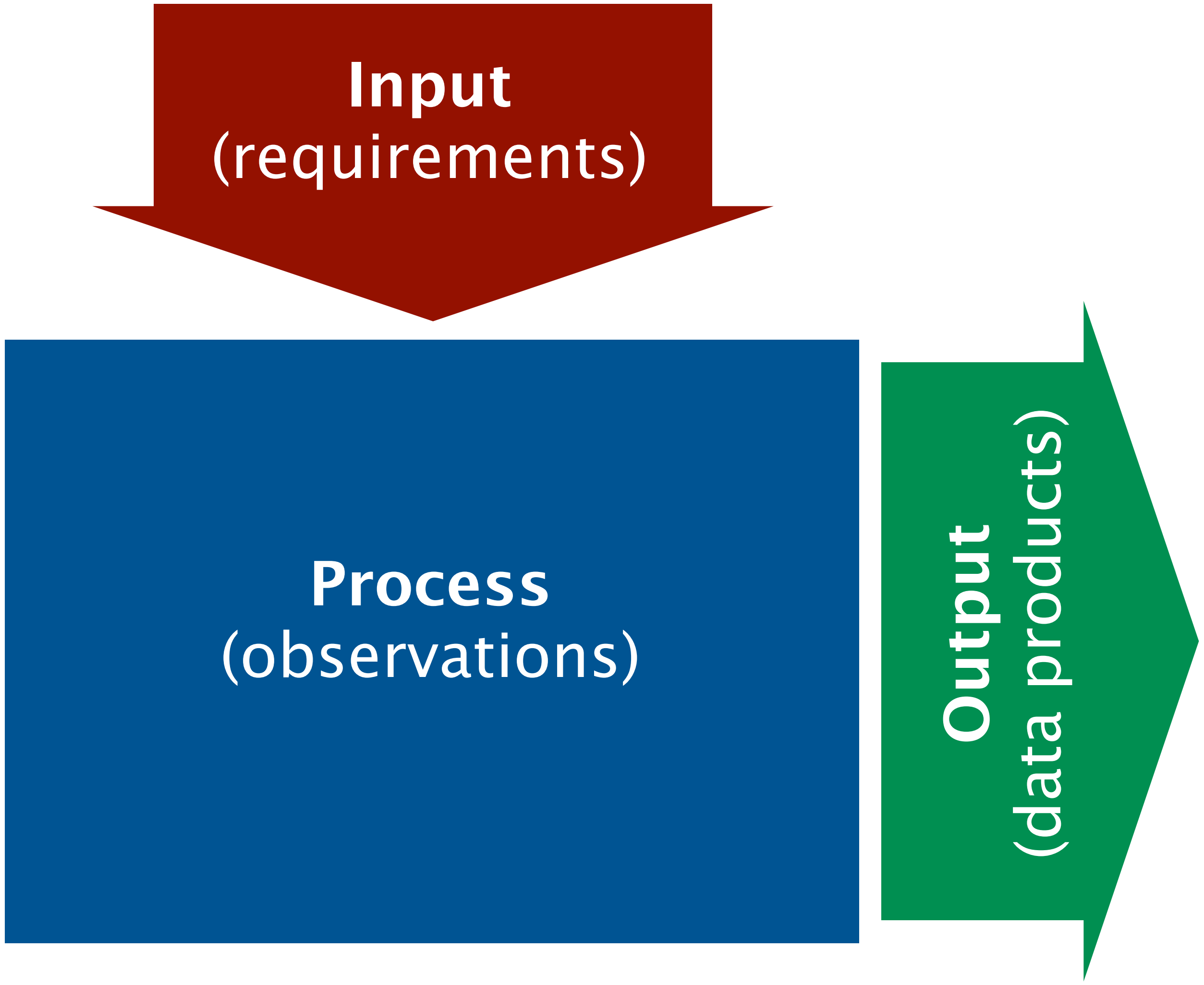
data and products

synthesis, link to models

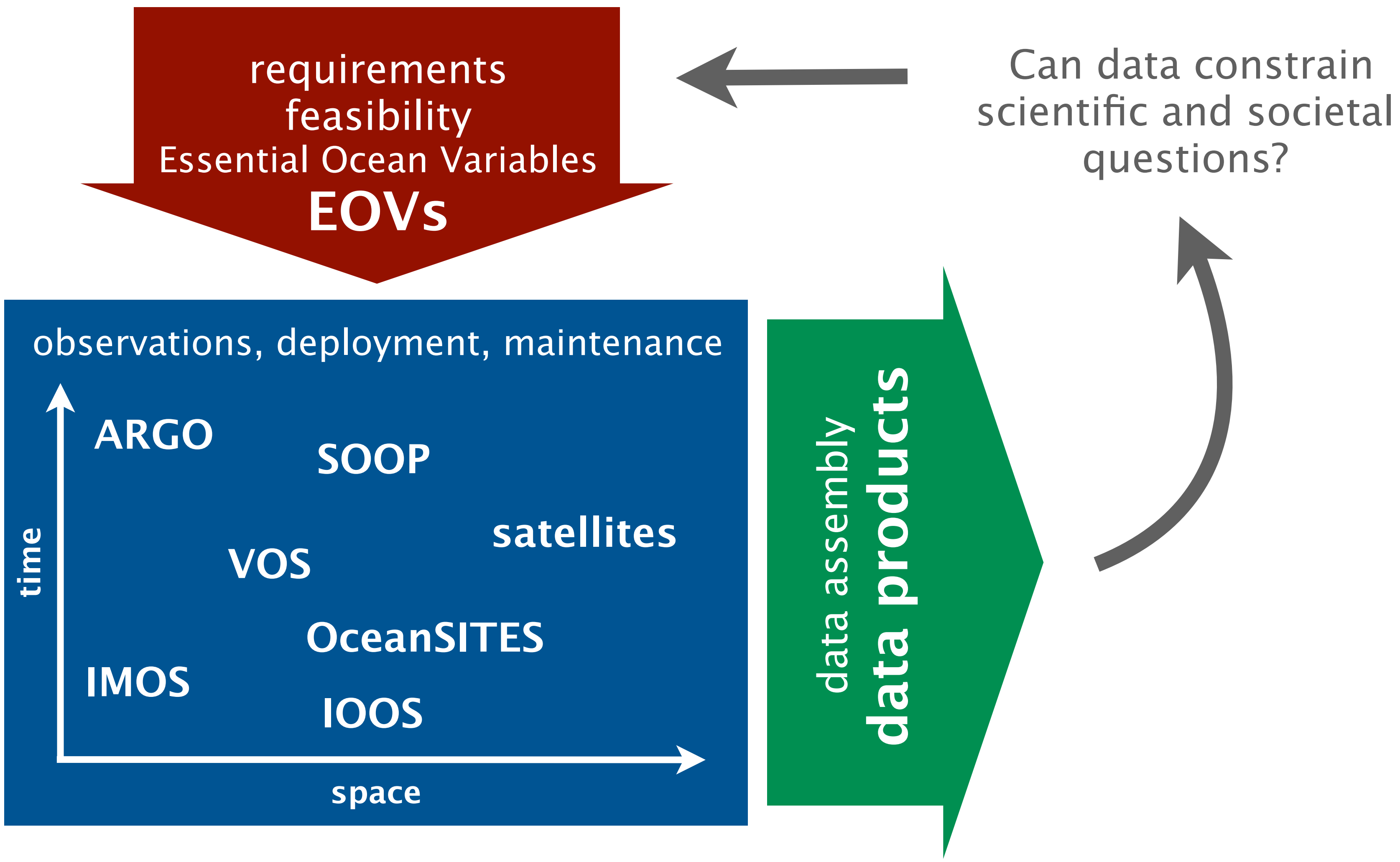


see www.ioc-goos.org

FOO: Structure of Framework



FOO: Structure of Framework



Workshop 2013

First
Technical Experts Workshop of the GOOS Biogeochemistry Panel: Defining Essential Ocean Variables for Biogeochemistry

13-16 November 2013, Townsville, Australia

- agreed on EOVs for biogeochemistry: well-reasoned, widely-reviewed, community-shaped
- implementation driven by feasibility and impact

The process underlying EOV definition

What are the relevant topics and questions on a societal and scientific basis?

- The role of ocean biogeochemistry in climate
  - Q1.1 How is the ocean carbon content changing?
  - Q1.2 How does the ocean influence cycles of non-CO_2 greenhouse gases?

- Human impacts on ocean biogeochemistry
  - Q2.1 How large are the ocean's "dead zones" and how fast are they changing?
  - Q2.2 What are rates and impacts of ocean acidification?

- Ocean ecosystem health
  - Q3.1 Is the biomass of the ocean changing?
  - Q3.2 How does eutrophication and pollution impact ocean productivity and water quality?

The process underlying EOV definition

What are the relevant variables to address these questions?

The role of ocean biogeochemistry in climate

- **Q1.1 How is the ocean carbon content changing?**
  - Carbonate system
  - DOC
  - Transient Tracers
  - O_2
  - Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
  - ^{13}DIC, ^{14}DIC
- **Q1.2 How does the ocean influence cycles of non-CO_2 greenhouse gases?**
  - N_2O
  - CH_4 (regional)
  - DMS
  - Halocarbons/O_3-depleting substances
  - O_2

The process underlying EOV definition

What are the relevant variables to address these questions?

Human impacts on ocean biogeochemistry

- **Q2.1 How large are the ocean's "dead zones" and how fast are they changing?**
  - O_2
  - Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
  - Transient Tracers
  - Export rates and/or Ar/O_2
  - Carbonate system
- **Q2.2 What are rates and impacts of ocean acidification?**

Detection

- Carbonate system
- O_2
- Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
- Atmospheric deposition of anthropogenic sulfates
- Transient Tracers
- ^{13}DIC
- PON, POP, DON, DOP
- Ra isotopes (coastal)

Impact

- Carbonate System
- Dissolution Rates
- PIC, POC
- Phytoplankton Functional Groups
- Benthic and Pelagic Species
- ^{231}Pa, ^{230}Th

The process underlying EOV definition

What are the relevant variables to address these questions?

Ocean ecosystem health

- **Q3.1a Is production of the ocean changing?**
  - Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
  - Micronutrients (e.g.. Fe)
  - O2
  - Carbonate System
  - O_2/Ar
  - O_2 isotopes
  - Opal, POC, $CaCO_3$

Q3.1b Is biomass of the ocean changing?
  - POM (POC, PON, POP)
  - Chlorophyll
  - Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
  - Particle size spectra

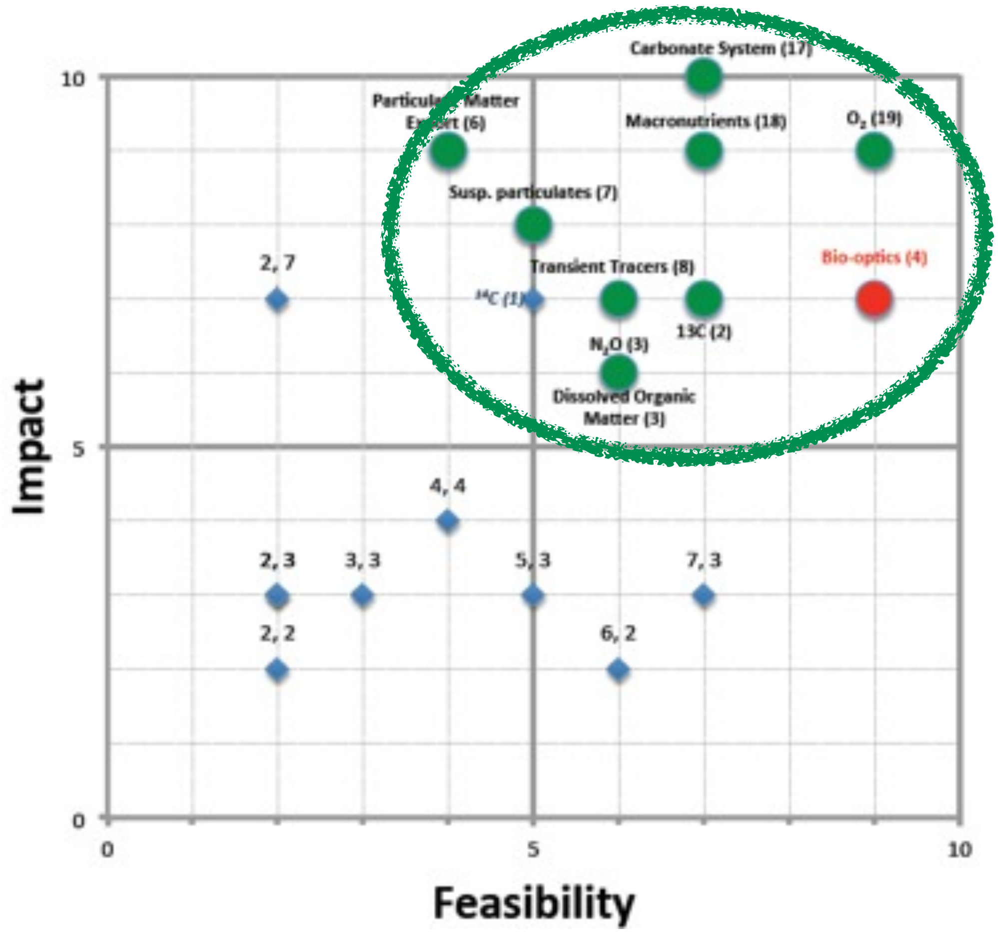
- **Q3.2 How does eutrophication/pollution impact ocean productivity and water quality?**

  Eutrophication
  - Macronutrients (NO_3, PO_4, Si, NH_4, NO_2)
  - O_2
  - POC, DOC
  - $^{18}O/^{16}O$
  - Ra isotopes (coastal)

  Pollution
  - Dioxin
  - POPs (particulate organic pollutants)
  - Plastics
  - Heavy Metals

Assessing EOVs' observational needs and readiness

So far, this is a wishlist; balance impact against feasibility

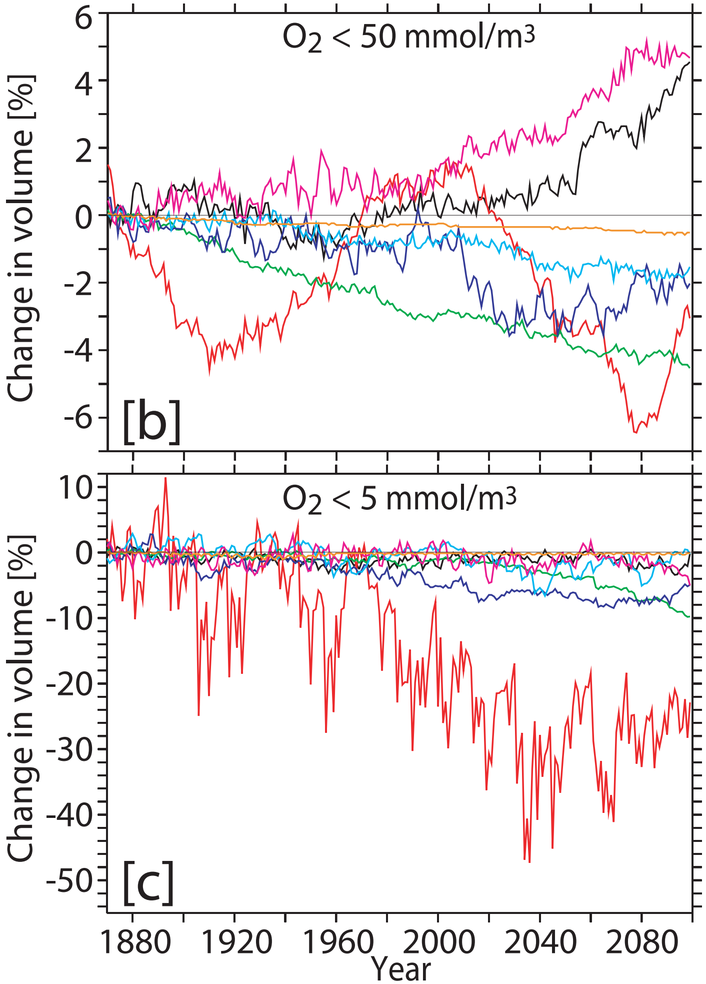


TOP 8 candidates:

1. Oxygen
2. Macro Nutrients
3. Carbonate System
4. Transient Tracers
5. Suspended Particulates
   Particulate Matter Transport
6. Nitrous Oxide
7. Carbon-13
8. Dissolved Organic Matter

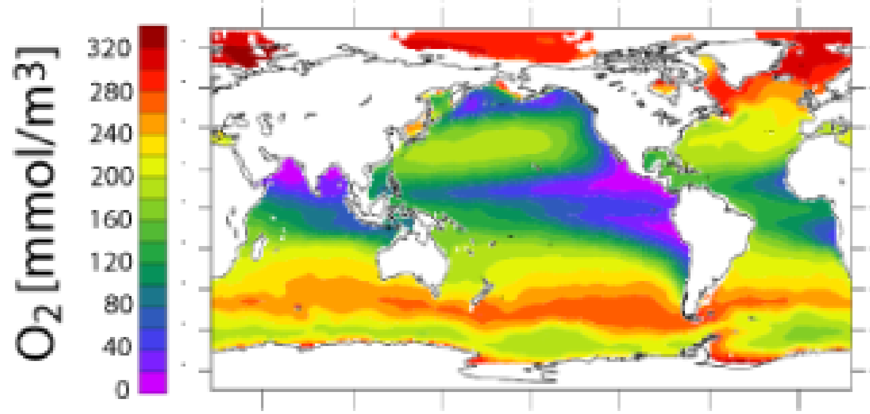
Finding, defining, and presenting an EOV: Example O_2

Model projections of future changes of ocean "dead zones" (low oxygen)



projected volume change, individual models

projected oxygen 100–600m, ensemble mean



Oxygen and indicators of stress for marine life in multi-model global warming projections

V. Cocco[1,2], F. Joos[1,2], M. Steinacher[1,2], T. L. Frölicher[3], L. Bopp[4], J. Dunne[5], M. Gehlen[4], C. Heinze[6,7,8], J. Orr[4], A. Oschlies[9], B. Schneider[10], J. Segschneider[11], and J. Tjiputra[6,7,8]

Biogeosciences, 10, 1849–1868, 2013

Finding, defining, and presenting an EOV: Example O_2

O_2 concentration changed in various oceanic regions from 1960 – 2008

Expanding Oxygen-Minimum Zones in the Tropical Oceans

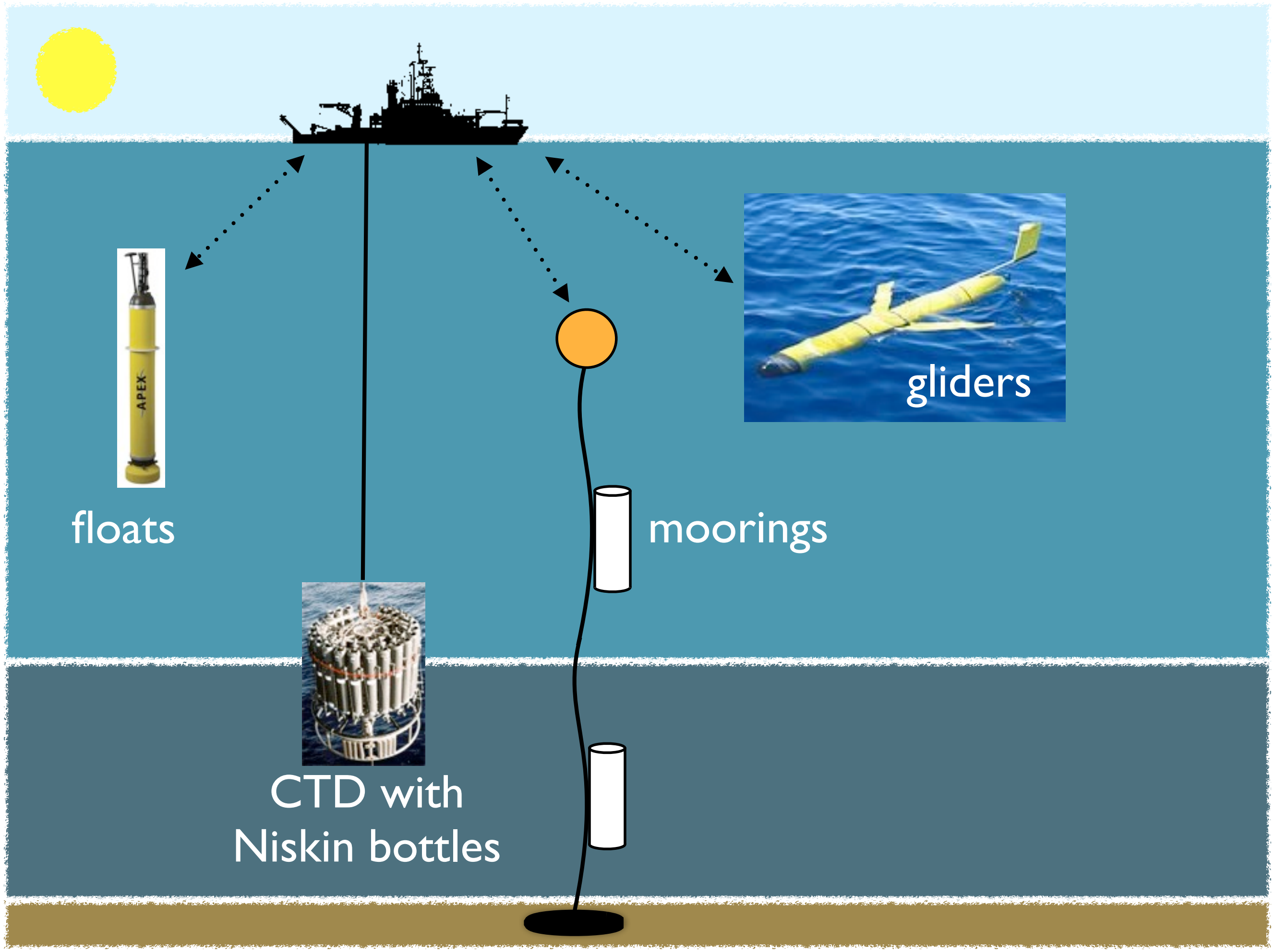
Lothar Stramma,[1]* Gregory C. Johnson,[2] Janet Sprintall,[3] Volker Mohrholz[4]

Oxygen-poor waters occupy large volumes of the intermediate-depth eastern tropical oceans. Oxygen-poor conditions have far-reaching impacts on ecosystems because important mobile macroorganisms avoid or cannot survive in hypoxic zones. Climate models predict declines in oceanic dissolved oxygen produced by global warming. We constructed 50-year time series of dissolved-oxygen concentration for select tropical oceanic regions by augmenting a historical database with recent measurements. These time series reveal vertical expansion of the intermediate-depth low-oxygen zones in the eastern tropical Atlantic and the equatorial Pacific during the past 50 years. The oxygen decrease in the 300- to 700-m layer is 0.09 to 0.34 micromoles per kilogram per year. Reduced oxygen levels may have dramatic consequences for ecosystems and coastal economies.

www.sciencemag.org **SCIENCE** VOL 320 2 MAY 2008

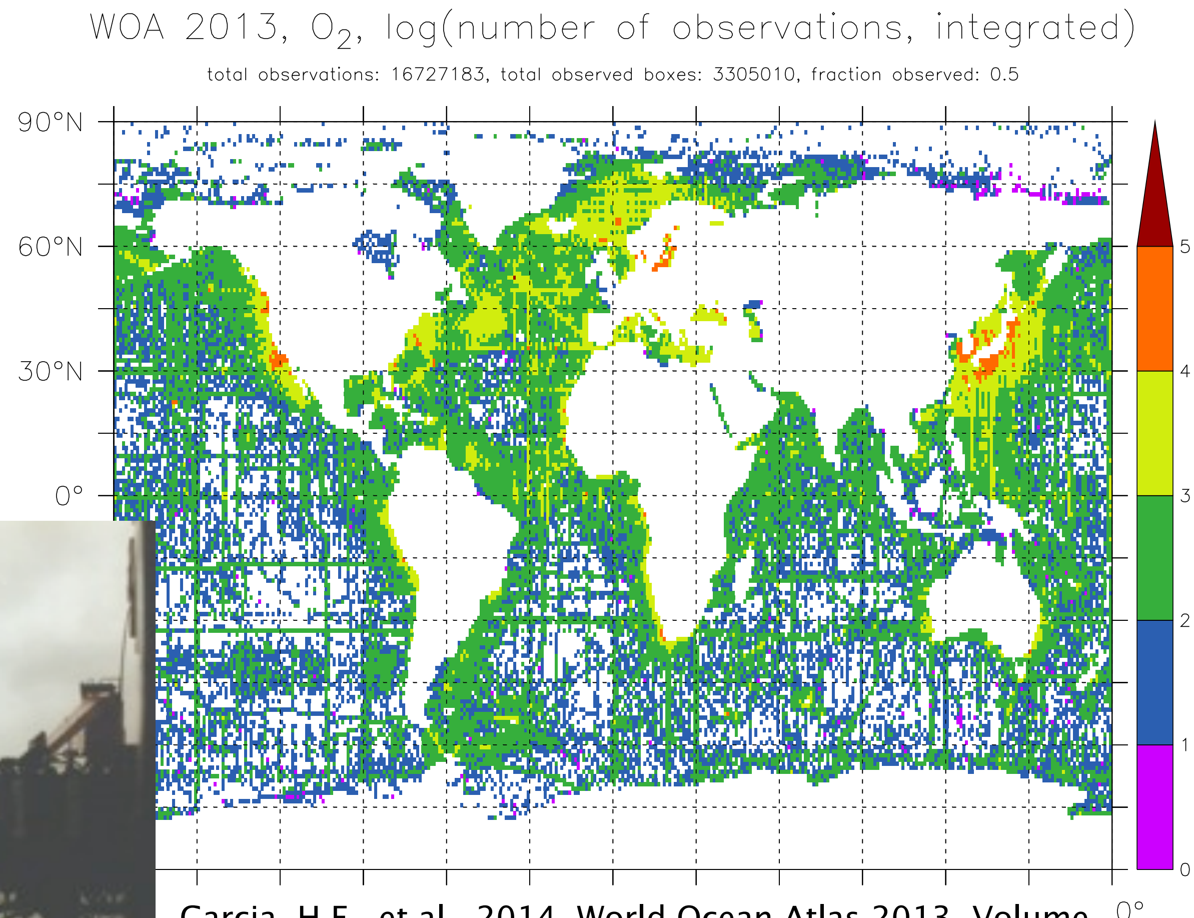
Finding, defining, and presenting an EOV: Example O_2

Types of measurements and platforms



Finding, defining, and presenting an EOV: Example O_2

Current (2013) data distribution from ship based (bottle) measurements



Garcia, H.E., et al., 2014. World Ocean Atlas 2013, Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, and Oxygen Saturation. S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 75, 27 pp.

Finding, defining, and presenting an EOV: Example O_2

Specification spreadsheets define responsibilities and derivatives, ...

Table 1: EOV Information	
Name of EOV	Dissolved Oxygen
Sub-Variables	
Derived Products	Net Community Production (NCP) and Export Production Sea-air O_2 fluxes Improved constraint on atm. O_2/N_2 (partitioning of anthropogenic CO_2) Temporal and spatial extent of hypoxic/anoxic regions
Supporting variables	Temperature (T), Salinity (S), Wind speed, Atmospheric O_2/N_2, Mixed layer depth (MLD), Stratification
Contact/Lead Expert(s)	Arne Körtzinger (GEOMAR, Germany), Richard Wanninkhof (NOAA AOML, USA)

Finding, defining, and presenting an EOV: Example O_2

Table 2: Requirements Setting				
Responsible GOOS Panel	Biogeochemistry Panel			
Societal drivers	1. The role of ocean biogeochemistry in climate 2. Human impacts on ocean biogeochemistry 3. Ocean ecosystem health			
Scientific Application(s)	Q 1.1. *How is the ocean carbon content changing?* Q 2.1. *How large are the ocean's "dead zones" and how fast are they changing?* Q 3.1. *Is the biomass of the ocean changing?* Q 3.2: *How do the eutrophication and pollution impact ocean productivity and water quality?*			
Readiness Level	Mature			
Phenomena to capture	**1** **Air-sea fluxes of O_2**	**2** **Changes in storage of O_2**	**3** **Extent of hypoxia**	**4** **Net community production (NCP)/export**
Temporal scales of the phenomenon	Monthly	Seasonal-decadal	Coast: seasonal OO: annual	Weekly to Monthly
Spatial scales of the phenomenon	Rossby radius; 2-100 km	100-1000 km	Coast: 0.1-100 km OO: 100-1000km	Coast: 1-100 km OO: 100-1000km
Magnitudes/range of the signal	100 Tmol yr^{-1}	0.4 Pmol $decade^{-1}$	Number of/ areal extent of hypoxic regions (400)	8 Pg C $year^{-1}$
Desired detection limit relative to the signal	+- 10 %	+- 10 %	+- 10 %	+- 25 %

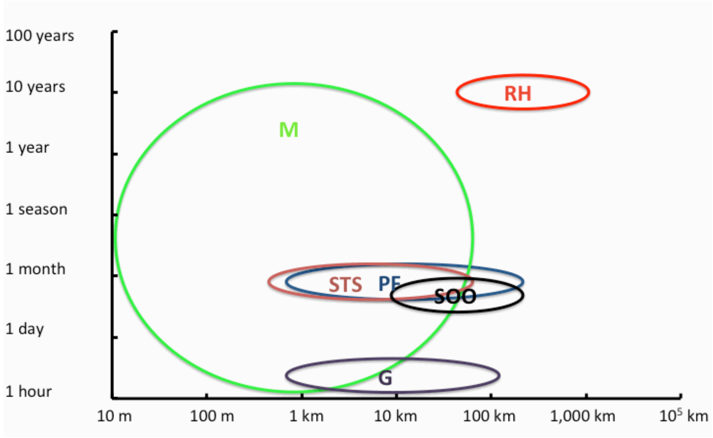
..., applications, spatial and temporal scales, sensitivity and desired accuracy, ...

Finding, defining, and presenting an EOV: Example O_2

Table 3: Current Observing Elements						
Observing Element	Profiling Floats	Repeat Hydrography	Moorings	Gliders	Ship based Time-Series	Ships Of Opportunity
Phenomena addressed	1,2,3,4	2	1,4	1,3,4	3,4	1,4
Readiness Level of a network (as defined in the FOO)	Pilot/ Mature	Mature	Mature	Mature	Mature	Mature
Spatial scales captured by the observing element	Global Every 3°	Global Along section: 30nm Section spacing: 20 degrees	Local	Coastal (10-100 km)	Local	Coastal and Open Ocean (10-100km)
Temporal scale captured by the observing element	Bi-weekly	Decadal	Hourly	Hourly	Monthly	Sub-weekly to Monthly
Supporting variables measured[1]	T, S, MLD, Stratification	T, S, MLD, Stratification	T, S,	T, S, MLD, Stratification	T, S, MLD, Stratification	T, S, MLD, Stratification
Sensor(s)/ Technique	Optical Oxygen Sensor	Wet chemistry (Winkler)/ Polarographic	Optical Oxygen Sensor	Optical Oxygen Sensor/ Polarographic	Wet chemistry (Winkler)/ Polarographic	Optical Oxygen Sensor
Accuracy/Uncertainty estimate (units).	+- 2 $\mu mol\ kg^{-1}$	+- 0.5 $\mu mol\ kg^{-1}$	+- 2 $\mu mol\ kg^{-1}$	+- 2 $\mu mol\ kg^{-1}$	+- 0.5 $\mu mol\ kg^{-1}$	+- 2 $\mu mol\ kg^{-1}$
Reporting Mechanism(s)	GOOS Implementation Plan. IOCCP Report.					

... methodology and platforms, with links to phenomena captured, their spatial and temporal scales.

Phenomena to capture	1 Air-sea fluxes of O_2	2 Changes in storage of O_2	3 Extent of hypoxia	4 Net community production (NCP)/export
Temporal scales of the phenomenon	Monthly	Seasonal-decadal	Coast: seasonal OO: annual	Weekly to Monthly
Spatial scales of the phenomenon	Rossby radius; 2-100 km	100-1000 km	Coast: 0.1-100 km OO: 100-1000km	Coast: 1-100 km OO: 100-1000km



Finding, defining, and presenting an EOV: Example O_2

Authorities responsible for coordination, quality control and data stream delivery are presented platform-wise.

Table 5: Data & Information Creation					
Responsible entity and readiness level in each category per observing element	**Oversight & Coordination**	**Data Quality Control**	**Data Management**	**Data Stream delivery**	**Data Product**
Profiling floats	Bio-Argo			CORIOLIS	Global NCP maps Global O_2 flux maps Global eutrophication maps
	Pilot			Pilot	
Repeat Hydrography Cruises	GO-SHIP	National Programs	CCHDO	National data centres	
	Mature	Mature			
Moorings		Principal Investigators		National data centres CORIOLIS/GODAE	

Finding, defining, and presenting an EOV: Example O_2

Finally, links point towards the corresponding websites for further information.

Table 6: Links & References	
Links (especially regarding Background and Justification)	http://www.solas-int.org/files/solas-int/content/downloads/pdf/reports/SOLAS-IMBER/o2_argo_whitepaper.pdf http://www.oceanobs09.net/proceedings/cwp/cwp39/ http://www.oceanobs09.net/plenary/files/draft%20papers/Gruber_Koertzinger_Draft_Plenary_18JAN.pdf
Links for Contributing Networks	http://www.coriolis.eu.org/ (ARGO/profiling floats) http://cchdo.ucsd.edu/ (repeat hydrography) http://www.bco-dmo.org/ (time series)
Data References	http://www.coriolis.eu.org/ (ARGO) http://cchdo.ucsd.edu/ (repeat hydrography) http://www.bco-dmo.org/ (time series)

Conclusion

Although still in draft mode, definition of EOVs for biogeochemistry quite advanced, due to community effort.

Have a look at www.ioccp.org/foo for further information and updates.

In case of questions, also contact

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Head, Ocean Observations and Services Section – GOOS Project Office