Essential Ocean Variable (EOV): Dissolved Organic Carbon

Background and Justification

Dissolved organic matter (DOM) represents one of the largest exchangeable reservoirs of organic material on Earth. At ~662 ±32 Pg (10^{15} g) of carbon (C), dissolved organic carbon (DOC) exceeds the inventory of organic particles in the oceans by 200 fold, making it one of the largest of the bioreactive pools of carbon in the ocean, second only to dissolved inorganic carbon (38,100 Pg C). The size of the reservoir (comparable to that of atmospheric carbon dioxide), as well as its role as a sink for autotrophically fixed carbon, as a substrate to heterotrophic microbes, and as a sink/source of carbon involved in climate variations over long time scales, highlights its importance in the ocean carbon and nitrogen cycles. DOC is exported from the epipelagic zone at 1.9 Pg C yr^{-1}, contributing ~20% to the biological pump via meridional overturning circulation.

For the glossary of terms and list of abbreviations please see the back of the document.

Table 1: EOV Information	
Name of EOV	Dissolved Organic Carbon
Sub-Variables	Dissolved Organic Carbon (DOC)
Derived Products	Global inventories and distribution of DOC, Contribution of DOC to net community production and to carbon export
Supporting Variables	Surface and subsurface temperature, Surface and subsurface salinity, Inorganic carbon (dissolved inorganic carbon), Nutrients (nitrate, nitrite, phosphate), Oxygen, Transient tracers (chlorofluorocarbons (CFCs)), Particulate matter (particulate organic carbon (POC), particulate organic nitrogen (PON))
Responsible GOOS Panel	GOOS Biogeochemistry Panel Contact: ioccp@ioccp.org

Table 2: Requirements Setting				
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 2.2. What are rates and impacts of ocean acidification? 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 *[as defined in the FOO]*	Mature			
Phenomena to Capture	**1 Export fluxes**	**2 Remineralization**	**3 Storage/inventory**	**4 Primary production**
Temporal Scales of the Phenomena	Annual	Annual to centennial (depending on lability fraction)		
Spatial Scales of the Phenomena	Open Ocean 1-500 km	Open Ocean 25-1000 km		
Magnitudes/Range of the Signal to Capture	2-10 µmol C kg^{-1} $year^{-1}$ (local export)	0.043-3.4 Pg C $year^{-1}$ (depending on lability fraction)		
Current Uncertainty Relative to the Signal				
Target Uncertainty Relative to the Signal	±10%	±10%		

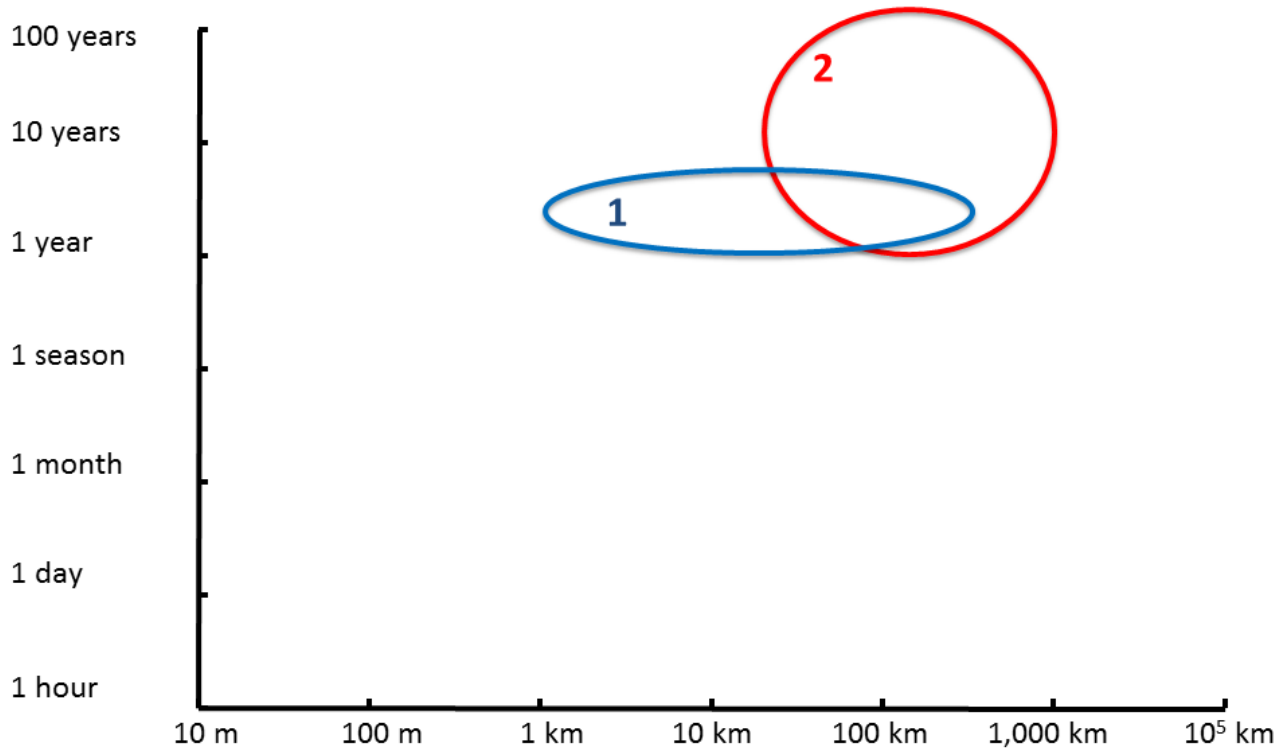

Figure 1: Spatial and temporal scales of phenomena (as color-coded and listed in Table 2 above) to be addressed.

Table 3: Current Observing Networks			
Observing Approach	**Ship-based Repeat Hydrography**	**Ship-based Fixed-point Observatories**	**Satellite Remote Sensing**
Readiness Level of the Observing Approach for this EOV	Mature	Mature	Concept
Leading Observing Network	GO-SHIP		Ocean Colour Radiometry – Virtual Constellation (OCR-VC)
Readiness Level of the Observing Network	Mature	Concept	
Phenomena Addressed	1,2,3,4	1,2,3,4	4
Spatial Scales Currently Captured by the Observing Network	Horizontal coverage: global, every 60 nm Vertical coverage: Footprint: *[to be defined for various oceanographic regimes]*	Horizontal coverage: Vertical coverage: Footprint: *[to be defined for various oceanographic regimes]*	Horizontal coverage: global Vertical coverage: surface only Footprint: *[to be defined for various oceanographic regimes]*
Typical Observing Frequency	Monthly to decadal	Monthly to decadal	
Supporting Variables Measured	DON	DON	
Sensor(s)/ Technique	High temperature detection with NDIR	High temperature detection with NDIR	
Accuracy/Uncertainty Estimate (units)	~ 1.5 µmol C kg^{-1}	~ 1.5 µmol C kg^{-1}	
Reporting Mechanism(s)	Individual Networks Annual Reports		

Table 4: Future Observing Capacity	
Observing approach	
What is the novel aspect of this observing approach?	*none at this time*
How does this novel aspect impact our observing capacity?	

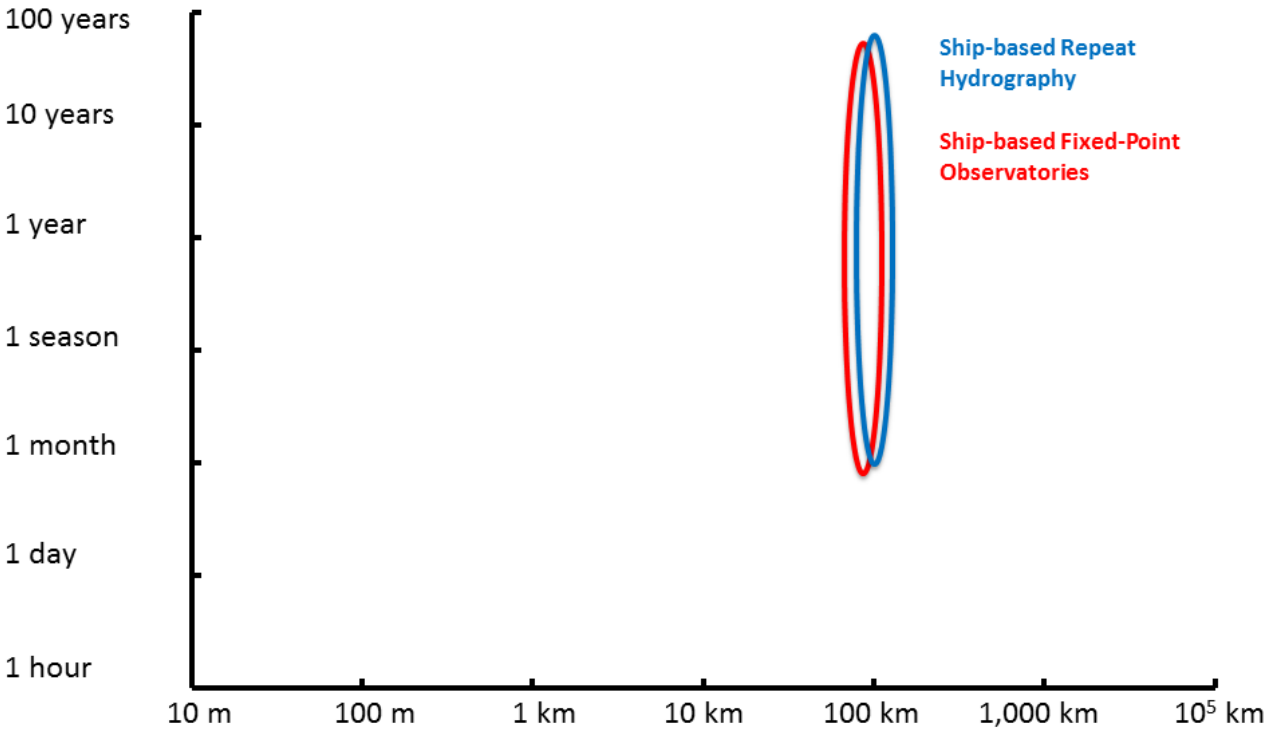

Figure 2. Spatial and temporal observation scales of component networks listed in Table 3 (thick coloured circles) and in Table 4 (thin black circles).

Table 5: Data & Information Creation					
Observing Approach	**Oversight & Coordination**	**Data Quality Control**	**Near Real-Time Data Stream Delivery**	**Data Repository**	**Data Product**
Ship-based Repeat Hydrography	GO-SHIP	CCHDO, NCEI OCADS		CCHDO NCEI OCADS	GLODAPv2 DOC time series at BATS and HOT
Ship-based Fixed-Point Observatories		BATS, HOT data systems		CCHDO BATS and HOT data systems	
Satellite remote sensing					

Table 6: Links & References	
Best Practices, Guides and Other Background Documentation	Farmer, C.T., Hansell, D.H. (2007). Determination of dissolved organic carbon and total dissolved nitrogen in sea water. In: A.G. Dickson, Sabine, C.L., Christian, J.R. (Eds.) *Guide to best practices for ocean CO_2 measurements*. PICES Special Publication 3, 191 pp. *[to be updated]*
Links for Contributing Networks	GO-SHIP: http://www.go-ship.org/index.html
Links for Near-Real Time Data Stream Delivery	
Links to Data Repositories	CCHDO: http://cchdo.ucsd.edu/ NCEI OCADS: https://www.nodc.noaa.gov/ocads/ BATS: http://batsftp.bios.edu/BATS/bottle/ HOT: http://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html
Data Product Links and References	GLODAPv2: http://glodap.info/ Olsen, A., Key, R. M., van Heuven, S., Lauvset, S. K., Velo, A., Lin, X., Schirnick, C., Kozyr, A., Tanhua, T., Hoppema, M., Jutterström, S., Steinfeldt, R., Jeansson, E., Ishii, M., Pérez, F. F., and Suzuki, T.: The Global Ocean Data Analysis Project version 2 (GLODAPv2) – an internally consistent data product for the world ocean, Earth Syst. Sci. Data, 8, 297-323, doi:10.5194/essd-8-297-2016, 2016.

Glossary of terms

A **Framework for Ocean Observing (FOO)** is a guide for the ocean observing community to establish an integrated and sustained global observing system that addresses the variables to be measured, the approach to measuring them, and how their data and products will be managed and made widely available. FOO is available from: http://www.ioccp.org/index.php/foo

A **GOOS Essential Ocean Variable** is a sustained measurement or a group of measurements necessary to assess state and change at a global level, and to increase societal benefits from the ocean *[on scales from global to regional].*

Sub-variables are components of the EOV that may be measured, derived or inferred from other elements of the observing system and used to estimate the desired EOV.

Supporting variables are other EOVs or other measurements from the observing system that may be needed to deliver the sub-variables and/or derived products of the EOV.

Derived products are calculated from the EOV and other relevant information, in response to user needs.

A **phenomenon** is an observed process, event, or property, with characteristic spatial and time scale(s), measured or derived from one or a combination of EOVs, and needed to answer at least one of the GOOS Scientific Questions.

A **footprint** is here defined as the area over which given EOV measurements performed by a single observing element (as a transect, station, track, etc.) are representative of a broader region.

List of abbreviations

EOV – Essential Ocean Variable
GOOS – Global Ocean Observing System
IOCCP – International Ocean Carbon Coordination Project
FOO – Framework for Ocean Observing
GO-SHIP – The Global Ocean Ship-Based Hydrographic Investigations Program
DOM – Dissolved Organic Matter
DOC – Dissolved Organic Carbon
DON – Dissolved Organic Nitrogen
DOP – Dissolved Organic Phosphorus
NDIR – Nondispersive Infrared Detector
nm – nautical mile = 1.852 km
CCHDO – The Clivar & Carbon Hydrographic Data Office
NCEI OCADS – National Centers for Environmental Information Ocean CArbon Data System
OCR-VC – Ocean Colour Radiometry Virtual Constellation
BATS – Bermuda Atlantic Time-Series Station
HOT – Hawaii Ocean Time-Series

List of References

Hansell, D.A., Carlson, C.A., Repeta, D.J., and Shlitzer, R., (2009). Dissolved organic matter in the ocean: A controversy stimulates new insights. *Oceanography* **22**, 202-211.

Carlson, CA., D.A. Hansell (2014). DOM Sources, Sinks, Reactivity and Budgets. *In* Biogeochemistry of Marine Dissolved Organic Matter: 2nd Edition, *eds.* DA Hansell, CA Carlson. pp. 65-216. Elsevier Inc. doi: 10.1016/B978-0-12-405940-5.00003-0

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Sexton PF, Norris RD, Wilson PA, Pälike H, Westerhold T, et al. (2011). Eocene global warming events driven by ventilation of oceanic dissolved organic carbon. Nature 471:349-53