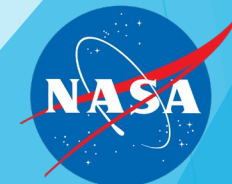


Consensus Field Protocols: Lessons Learned

Joaquín Chaves
SSAI, Inc.
NASA GSFC
Ocean Ecology Laboratory
Field Support Group

GODDARD
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NASA-Goddard Space Flight Center Field Support Group (FSG)

Technical lead:

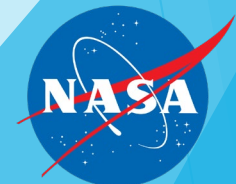
Antonio Mannino

Core members:

Joaquin Chaves, Scott Freeman, Chris Kenemer, Chelsea Lopez, Aimee Neeley, Mike Novak, Harrison Smith & Crystal Thomas

Other contributors to FSG activities:

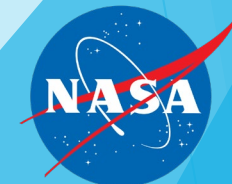
Andrea Andrew, Dirk Aurin, Ryan Vandermeulen



What we do:

- Our mission is to provide Field and Lab Measurement expertise, capability, and data to enable NASA to deliver the best quality ocean color data
- Develop consensus protocols for field and lab optical and biogeochemical measurements
- Provide HPLC pigment analysis and data to NASA PIs
- Perform SeaBASS data quality evaluation
- Conduct field instrument intercalibration and measurement uncertainty assessments
- Collect *in situ* optical and biogeochemical datasets for ocean color validation (SeaBASS) and algorithm development (NOMAD)
- Evaluate new instrument technologies and measurement approaches in collaboration with the US and international scientific community

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Field equipment:
optical instruments
and other field gear

Labs in GSFC
for wet chemistry,
optics, etc.



Phytoplankton Pigment Analysis Lab

Why?

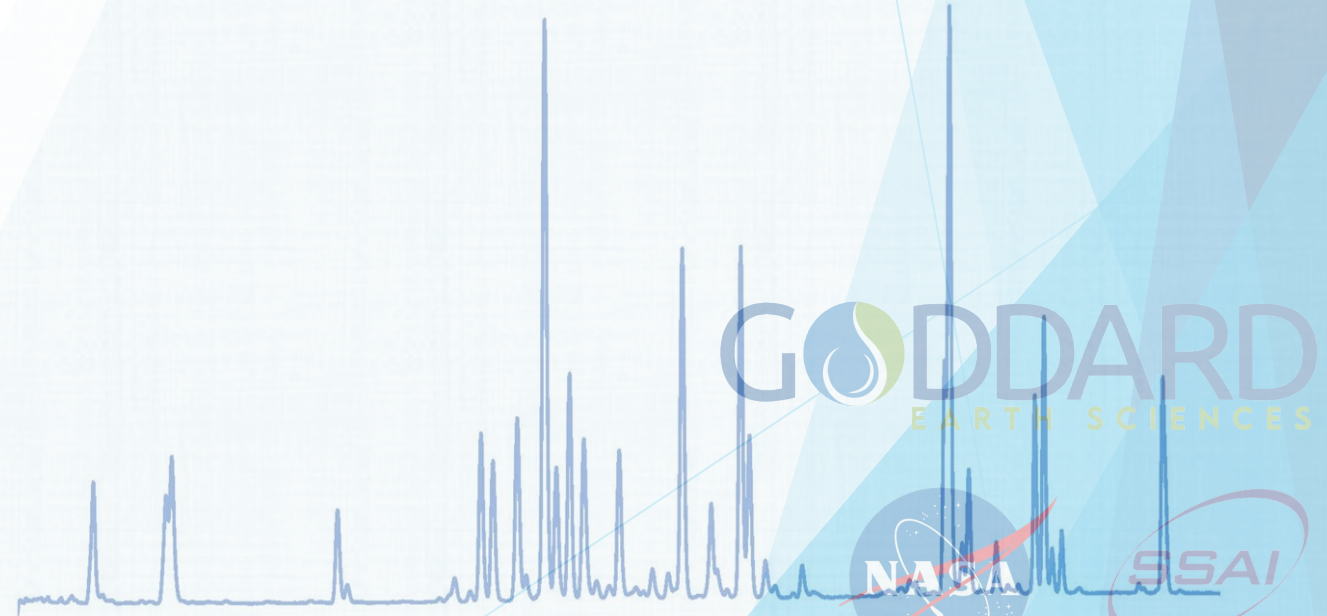
- Pigments influence ocean color in much of the ocean and inform on phytoplankton community composition
- Chlorophyll-a relates to biomass and physiology
 - Used in Primary Productivity models
- Maintain NASA's long-term ocean color Climate Data Record since SeaWiFS in late 1997.
- Dedicated quality-assured lab necessary for validation and maintenance of chl-*a* CDR.

What?

- Process ~3000 HPLC pigment samples per year
- On-going efforts to maintain and improve data quality and analytical efficiency:
 - cross-calibration with Horn Point Lab (UMD), international round robins, analysis on sources of uncertainty
- Methods development for phycobilin pigments
- Methods development for uHPLC and uHPLC-LC-MS



Chromatogram of pigments from High-Performance Liquid Chromatography (HPLC)

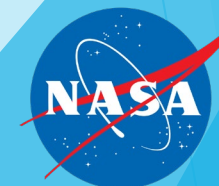


Technical lead contact: crystal.s.thomas@nasa.gov

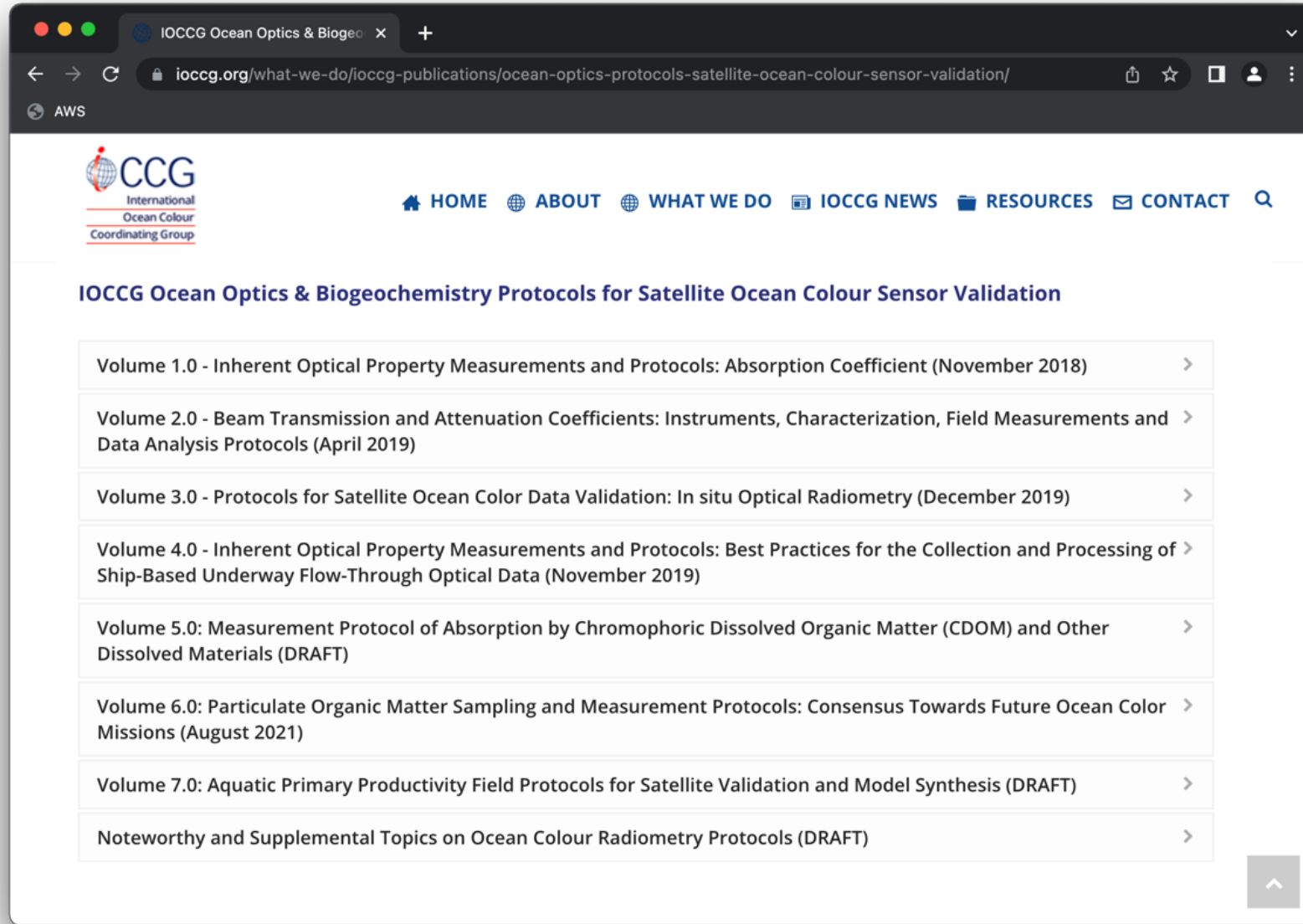
Protocols, protocols, protocols...

The screenshot shows a web browser window with the URL ioccg.org/what-we-do/ioccg-publications/ocean-optics-protocols-satellite-ocean-colour-sensor-validation/. The page features the IOCCG logo (International Ocean Colour Coordinating Group) and a navigation menu with links for HOME, ABOUT, WHAT WE DO, IOCCG NEWS, RESOURCES, and CONTACT. The main heading is "IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation". Below the heading is a breadcrumb trail: Home » What We Do » IOCCG Publications » IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation. The text on the page discusses the importance of *in situ* optical and biogeochemical measurements for satellite calibration and validation, and mentions NASA's role in commissioning and updating these protocols. It also notes that newly drafted protocols will be available for testing and public comment before being accepted as international reference standards.

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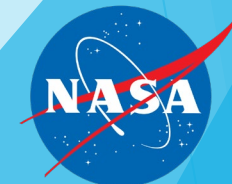
Protocols, protocols, protocols...



The screenshot shows a web browser window with the URL ioccg.org/what-we-do/ioccg-publications/ocean-optics-protocols-satellite-ocean-colour-sensor-validation/. The page features the IOCCG logo (International Ocean Colour Coordinating Group) and a navigation menu with links for HOME, ABOUT, WHAT WE DO, IOCCG NEWS, RESOURCES, and CONTACT. The main content is titled "IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation" and lists eight protocol volumes, each with a right-pointing chevron icon:

- Volume 1.0 - Inherent Optical Property Measurements and Protocols: Absorption Coefficient (November 2018)
- Volume 2.0 - Beam Transmission and Attenuation Coefficients: Instruments, Characterization, Field Measurements and Data Analysis Protocols (April 2019)
- Volume 3.0 - Protocols for Satellite Ocean Color Data Validation: In situ Optical Radiometry (December 2019)
- Volume 4.0 - Inherent Optical Property Measurements and Protocols: Best Practices for the Collection and Processing of Ship-Based Underway Flow-Through Optical Data (November 2019)
- Volume 5.0: Measurement Protocol of Absorption by Chromophoric Dissolved Organic Matter (CDOM) and Other Dissolved Materials (DRAFT)
- Volume 6.0: Particulate Organic Matter Sampling and Measurement Protocols: Consensus Towards Future Ocean Color Missions (August 2021)
- Volume 7.0: Aquatic Primary Productivity Field Protocols for Satellite Validation and Model Synthesis (DRAFT)
- Noteworthy and Supplemental Topics on Ocean Colour Radiometry Protocols (DRAFT)

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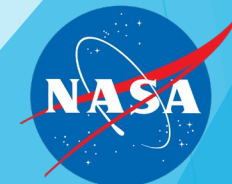


Protocols, protocols, protocols...

The screenshot shows a web browser window with the following details:

- Browser Tab:** Ocean Optics and Biogeochem
- Address Bar:** repository.oceanbestpractices.org/handle/11329/1716
- Navigation:** Back, Forward, Refresh, Home, Search, Share, Star, Print, User, Menu
- Header:** Ocean best practices logo, Repository of community practices in Ocean Research, Applications and Data/Information Management, About, FAQs, Login
- Breadcrumbs:** Repository OceanBestPractices / IOCCG: International Ocean-Colour Coordinating Group / IOCCG Protocol Series / View Item
- Title:** Ocean Optics and Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation, Volume 6.0: Particulate Organic Matter Sampling and Measurement Protocols: Consensus Towards Future Ocean Color Missions.
- Image:** Cover image of the document, featuring a satellite map of the ocean with a color scale and the IOCCG logo.
- Text:** This document is the product of a multi-year effort that started with a two-and-a-half-day workshop organized by the NASA Ocean Ecology Lab Field Support Group and hosted at NASA Goddard Space Flight Center from November 30–December 2, 2016. The original objective was to produce community consensus protocols for sample collection, filtration, storage, analysis, and quality assurance for particulate organic carbon in all natural waters, emphasizing marine ecosystems, appropriate for satellite algorithm development and validation. Given the close link between global cycles of carbon and nitrogen and that current analytical protocols usually are geared towards their simultaneous measurement, recommendations for analysis of nitrogen in particles are also included. The hope is that the protocols presented here can be widely adopted by the academic scientific community engaged in aquatic C and N cycle research, particularly in activities that support ocean color validation. The resulting pro.....
- View/Open:** Main article (2.662Mb)
- Date:** 2021
- Resource URL:** https://ioccg.org/what-we-do/ioccg-publications/ocean-optics-protocols-satellite-ocean-colour-sensor-validation/
- Publisher:**
- Search:** Search bar with a magnifying glass icon.
- Search Options:** Search OceanBestPractices, This Collection
- What results are displayed?:** Perform Semantic Advanced Search.
- BROWSE:** All of OceanBestPractices, Communities & Collections, By Issue Date, Authors, Titles, Subjects, This Collection, By Issue Date

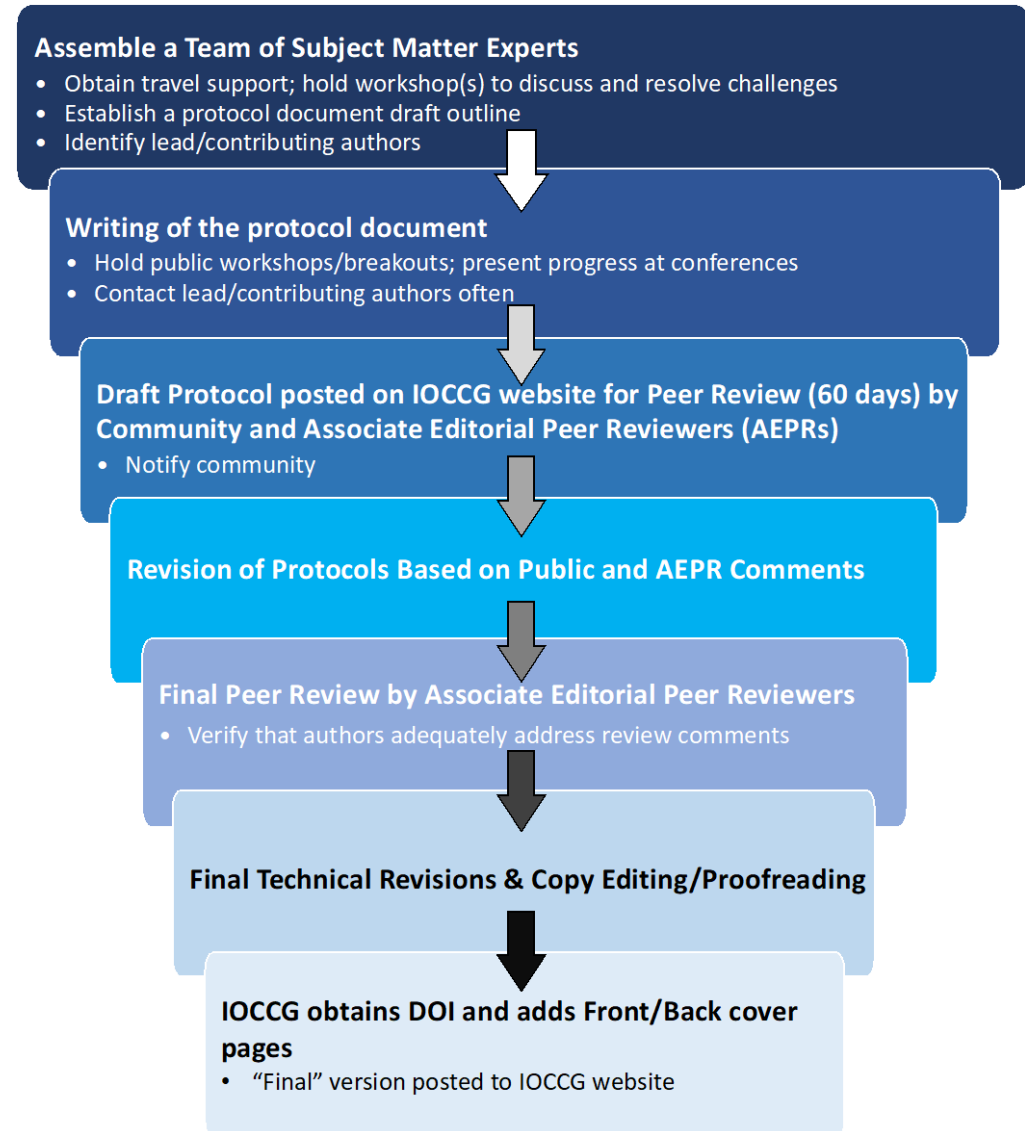
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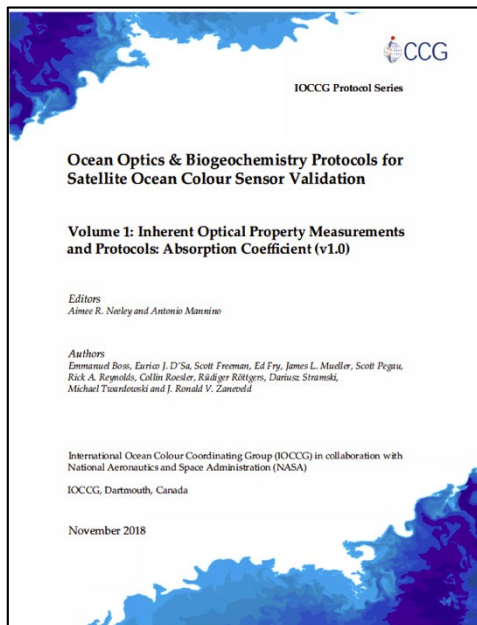
Process for Development of Field Measurement Protocols

Under the auspices of the IOCCG

Systematic development, revision, testing, and dissemination of field data collection protocols in collaboration with experts in academia and other federal agencies.



Status of Protocols - Published



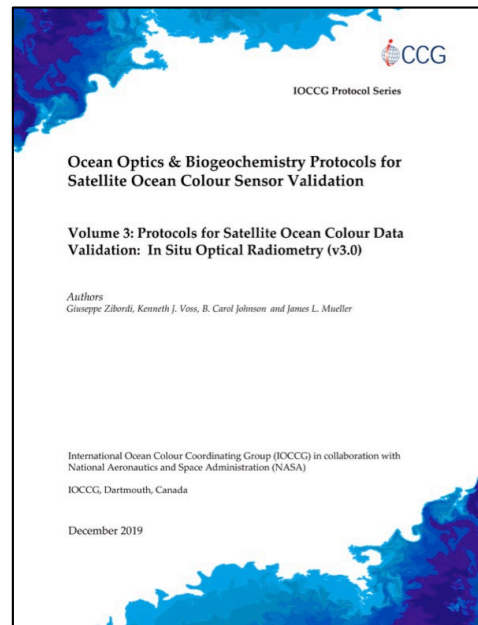
Vol. 1.0
Absorption
(particles)

Nov. 2018



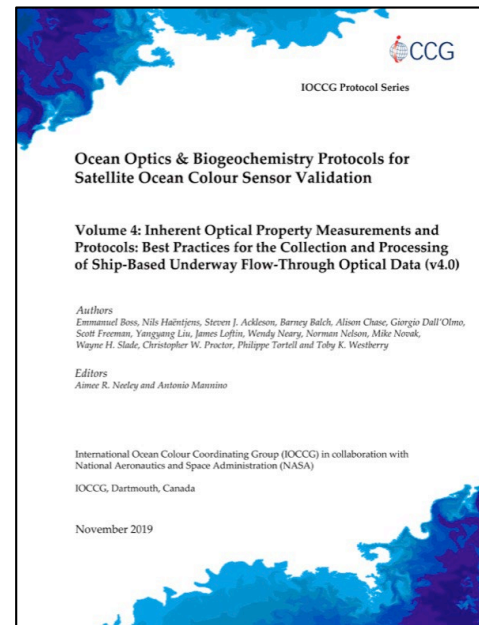
Vol. 2.0
Beam
Attenuation

April 2019



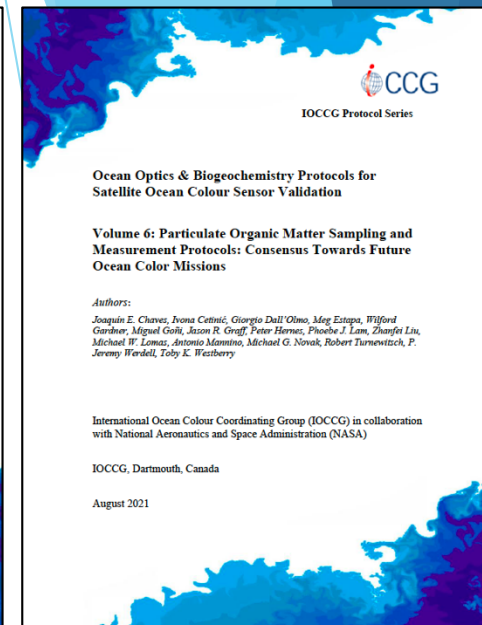
Vol. 3.0
Radiometry
for
Validation

Dec. 2019



Vol. 4.0
Inline Flow-
Through
IOPs

Nov. 2019



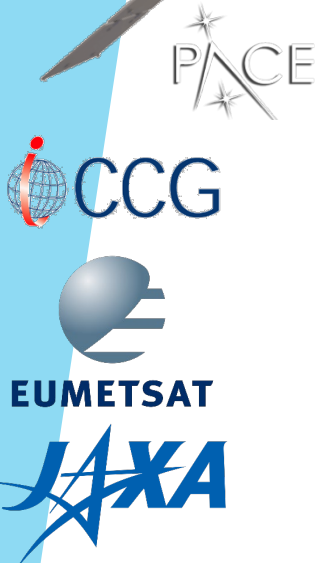
Vol. 6.0
Particulate
Organic
Carbon
August
2021



- Protocol has undergone review by AEPRs & Community
- Currently being revised per those comments
 - Updating CDOM reference material to SRFA-III
 - Merging of LWCC UV-Vis and spectrophotometer UV
- Back to AEPRs *circa* Dec. 2021
- Final version in 2022



Status of Protocols - Primary Productivity



IOCCG Protocol Series

CCG

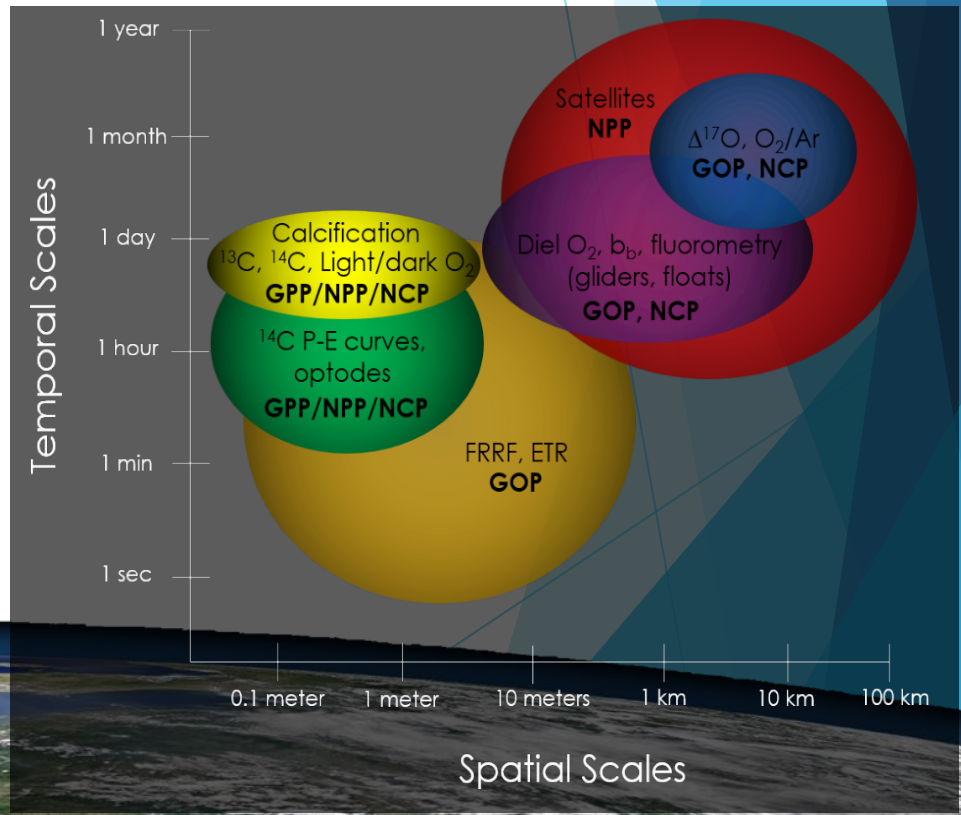
Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Vol. 7.0 Aquatic Primary Productivity

Contributors
 Balch, W.M., Carranza, M., Cetinic, I., Chaves, J.E., Duhamel, S., Erickson, Z., Fassbender, A., Fernandez-Carrera, A., Ferrón, S., García-Martín, E., Goes, J., Gomes, H., Gorbunov, M., Gundersen, K., Halsey, K., Hirawake, T., Isada, T., Juranek, L., Kulk, G., Langdon, C., Letelier, R., López-Sandoval, D., Mannino, A., Marra, J., Neale, P., Nicholson, D., Silsbe, G., Stanley, R., Vandermeulen, R.A.
 edited by R.A. Vandermeulen, J. E. Chaves

Coming out in late 2022

- Protocol posted for community & AEPR review in August 2021





Top row, left to right: Solange Duhamel, Mary Jane Perry, Helga Gomes, Maxim Gorbunov, Gemma Kulk, Greg Silsbe, Roo Nicholson, Rachel Stanley, Patrick Neale, John Marra, Mark Brzezinski, Barney Balch, Tomonori Isada, Laurie Juranek, SeungHyun Son, Toru Hirawake; Bottom row, left to right: Joaquim Goes, Ana Fernandez Carrera, Antonio Mannino, Ryan Vandermeulen, Ricardo Letelier, Kimberly Halsey, Priscila Kienteca Lange, Joaquín Chaves. Other workshop participants (not pictured): Joe Salisbury, Susanne Craig, Jeremy Werdell, Paula Bontempi.

Screenshot

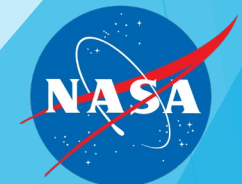
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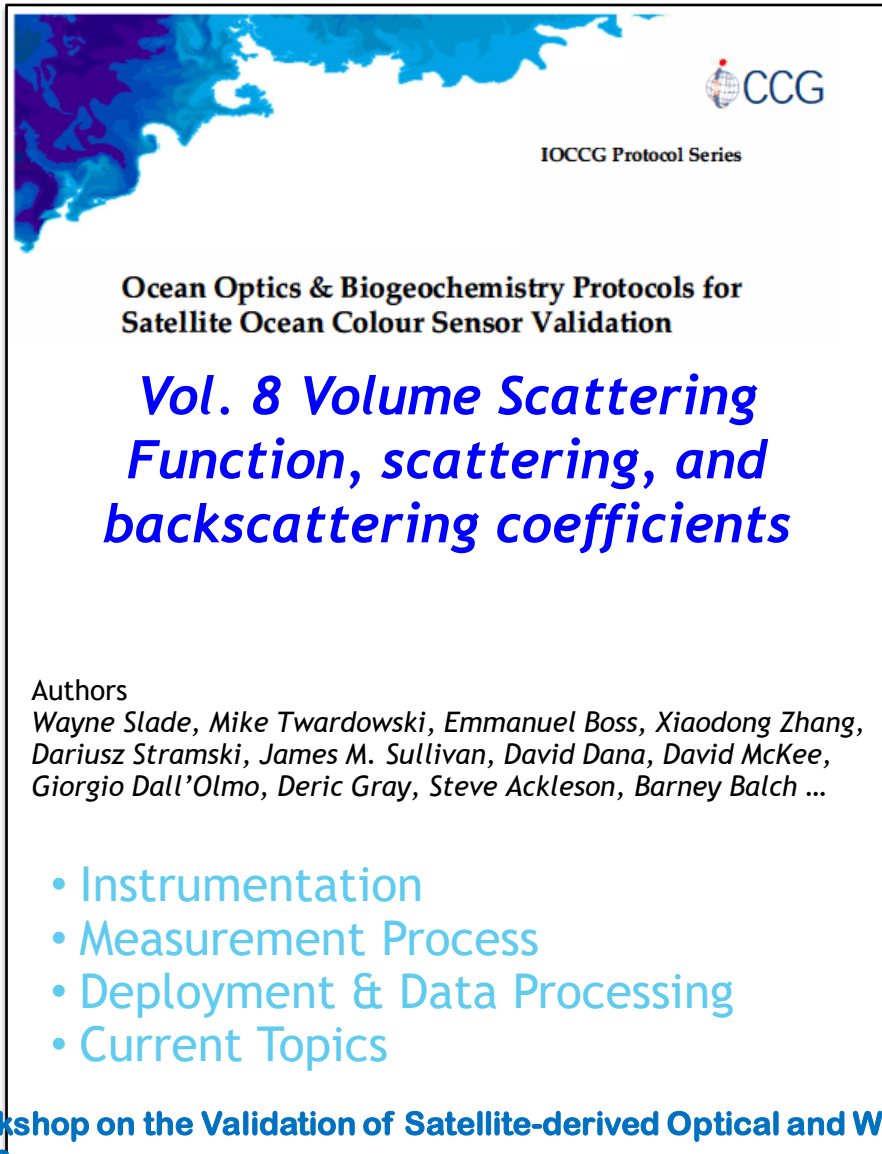
Table of Contents

- [1. Reconciling Estimates of Oceanic Primary Productivity from Cells to Satellite](#)
- [2. The Metabolic Continuum of Primary Productivity](#)
- [3. Carbon-Based Incubations](#)
- [4. The H₂¹⁸O incubation method for the determination of gross oxygen production](#)
- [5. Light and dark dissolved oxygen rate measurements using the Winkler method.](#)
- [6. Calculating Net Community Production and Respiration from Continuous Optode Measurements](#)
- [7. In Situ Gross Primary Production from Triple Oxygen Isotopes](#)
- [8. In situ Net Community Production with dissolved O₂/Ar](#)
- [9. The use of variable fluorescence for assessment of phytoplankton photophysiology and rates of primary production](#)
- [10. Autonomous Platforms](#)

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Status of Protocols - Scattering Properties



CCG
IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

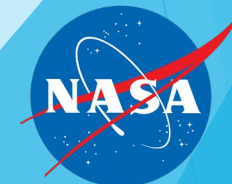
Vol. 8 Volume Scattering Function, scattering, and backscattering coefficients

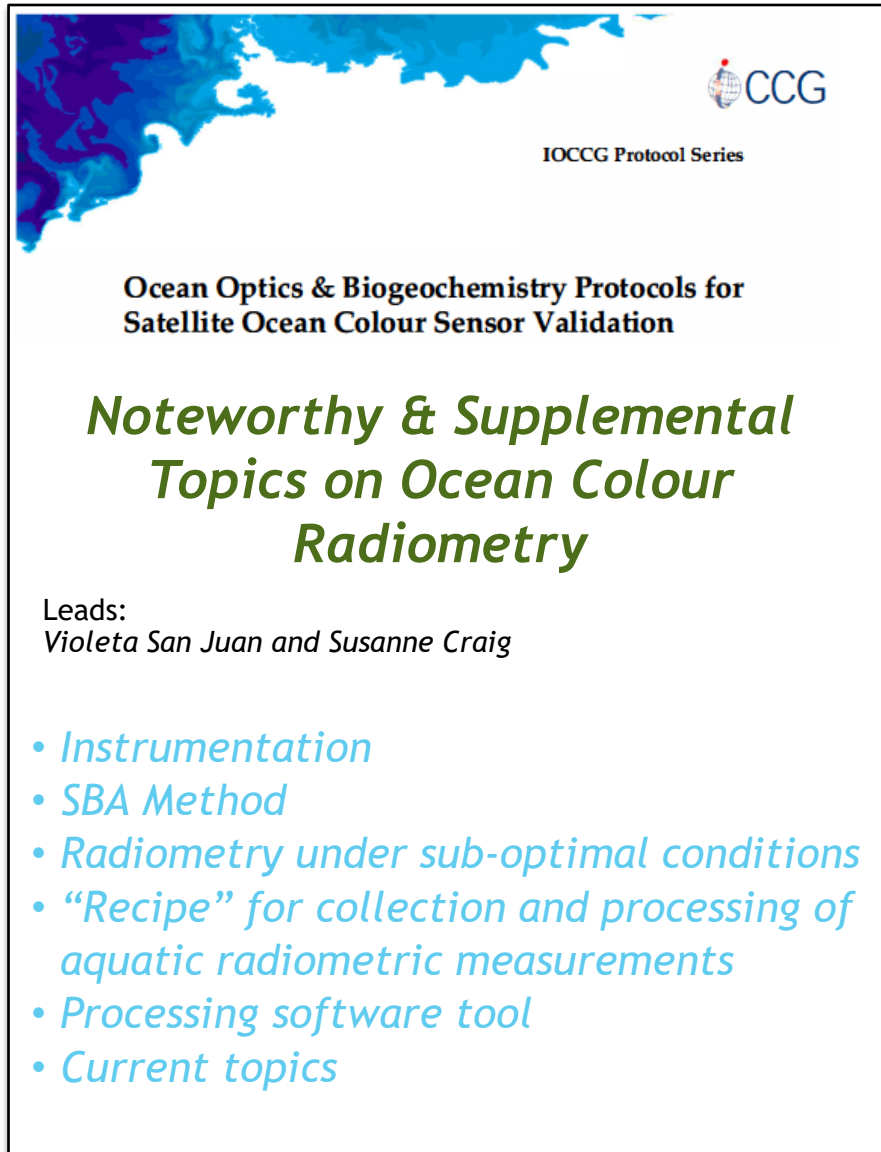
Authors
Wayne Slade, Mike Twardowski, Emmanuel Boss, Xiaodong Zhang, Dariusz Stramski, James M. Sullivan, David Dana, David McKee, Giorgio Dall'Olmo, Deric Gray, Steve Ackleson, Barney Balch ...

- Instrumentation
- Measurement Process
- Deployment & Data Processing
- Current Topics

- Draft protocol in preparation
- Post protocol for community & AEPR review by end of 2021/early 2022.

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CCG
IOCCG Protocol Series

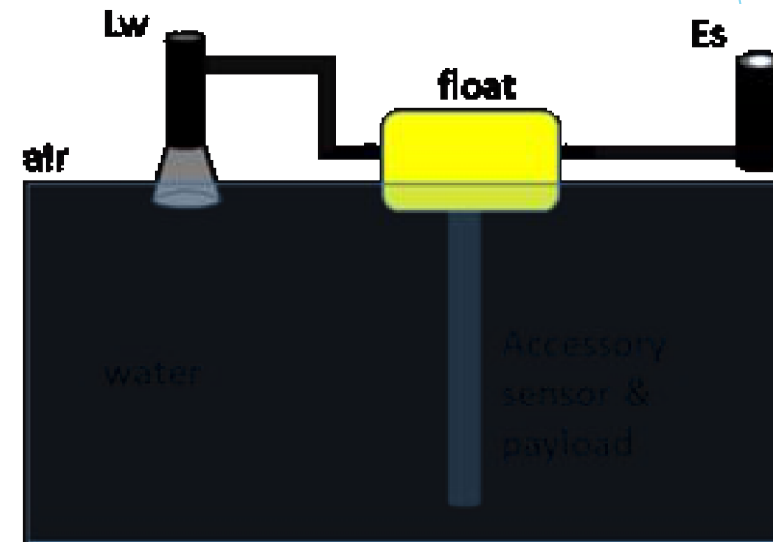
Ocean Optics & Biogeochemistry Protocols for
Satellite Ocean Colour Sensor Validation

**Noteworthy & Supplemental
Topics on Ocean Colour
Radiometry**

Leads:
Violeta San Juan and Susanne Craig

- *Instrumentation*
- *SBA Method*
- *Radiometry under sub-optimal conditions*
- *“Recipe” for collection and processing of aquatic radiometric measurements*
- *Processing software tool*
- *Current topics*

- Document is in planning stages
- A chapter describing the “on-water” skylight-blocked approach (SBA) by Lee et al. is posted on the IOCCG website

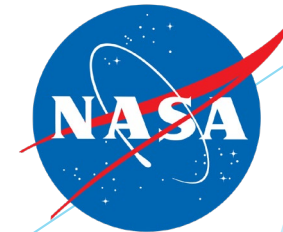
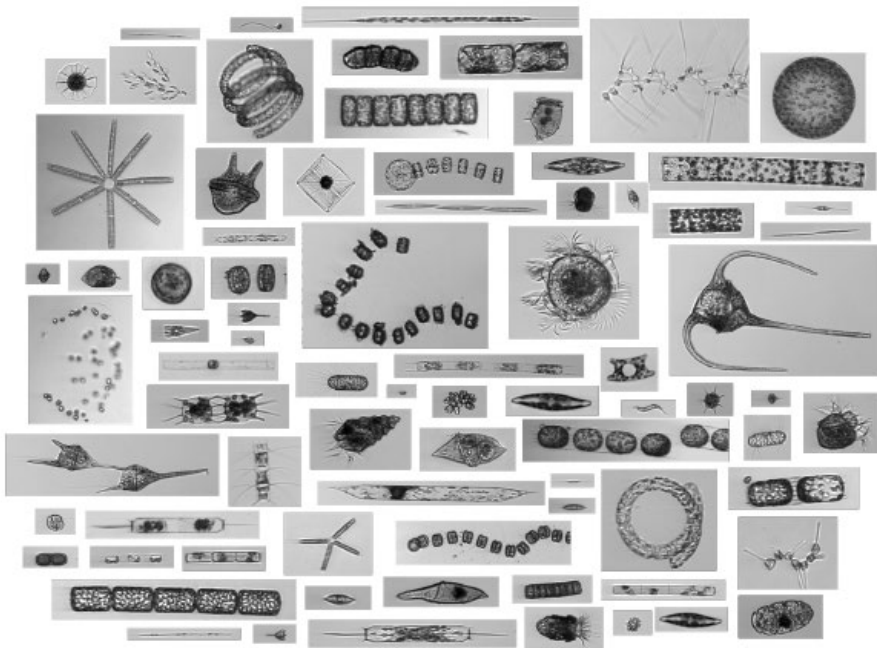


Reporting Data from Particle Images

Published August 2021

Neeley, Aimee, Beaulieu, Stace E., Proctor, Chris, Cetinić, Ivona, Futrelle, Joe, Soto Ramos, Inia, Sosik, Heidi M., Devred, Emmanuel, Karp-Boss, Lee, Picheral, Marc, Poulton, Nicole, Roesler, Collin S., Shepherd, Adam, "Standards and practices for reporting plankton and other particle observations from images", 2021-07-26, DOI:10.1575/1912/27377, <https://hdl.handle.net/1912/27377>

**Standards and practices for reporting plankton
and other particle observations from images
Technical Manual**

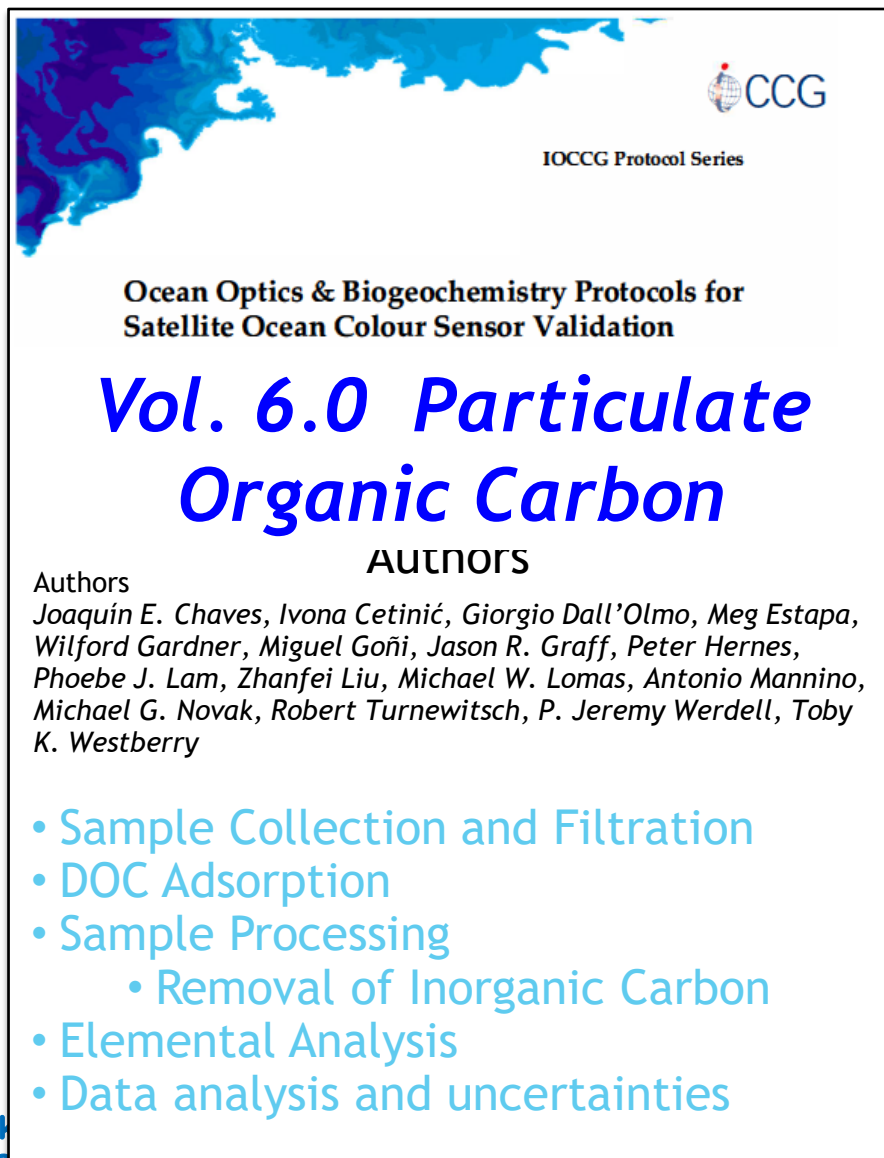




- ▶ Future Protocols
 - ▶ Phytoplankton community composition & biovolume - kicking off soon
 - ▶ Phytoplankton Carbon - kicking off soon
 - ▶ HPLC Pigments update - in-house activity underway
 - ▶ Suspended Particulate Matter (in house literature review)
 - ▶ Dissolved Organic Carbon (in house)
 - ▶ Phycobilin Pigments - in-house activity underway
 - ▶ Optical and Biogeochemical Properties in Very Turbid Waters
 - ▶ Particle Size Distribution (with PCC ?)
 - ▶ Particulate Inorganic Carbon
 - ▶ Fluorescence properties
 - ▶ Review ship-based atmospheric aerosol and trace gas measurement protocols
- ▶ Updates to current IOCCG protocols as required

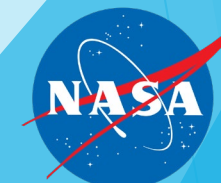
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- Workshop at GSFC in Nov 2016
- Published in Aug 2021

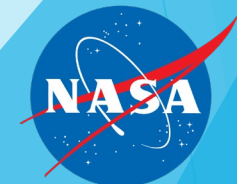
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“ ”

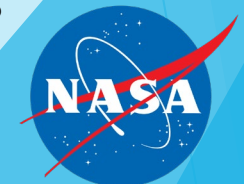
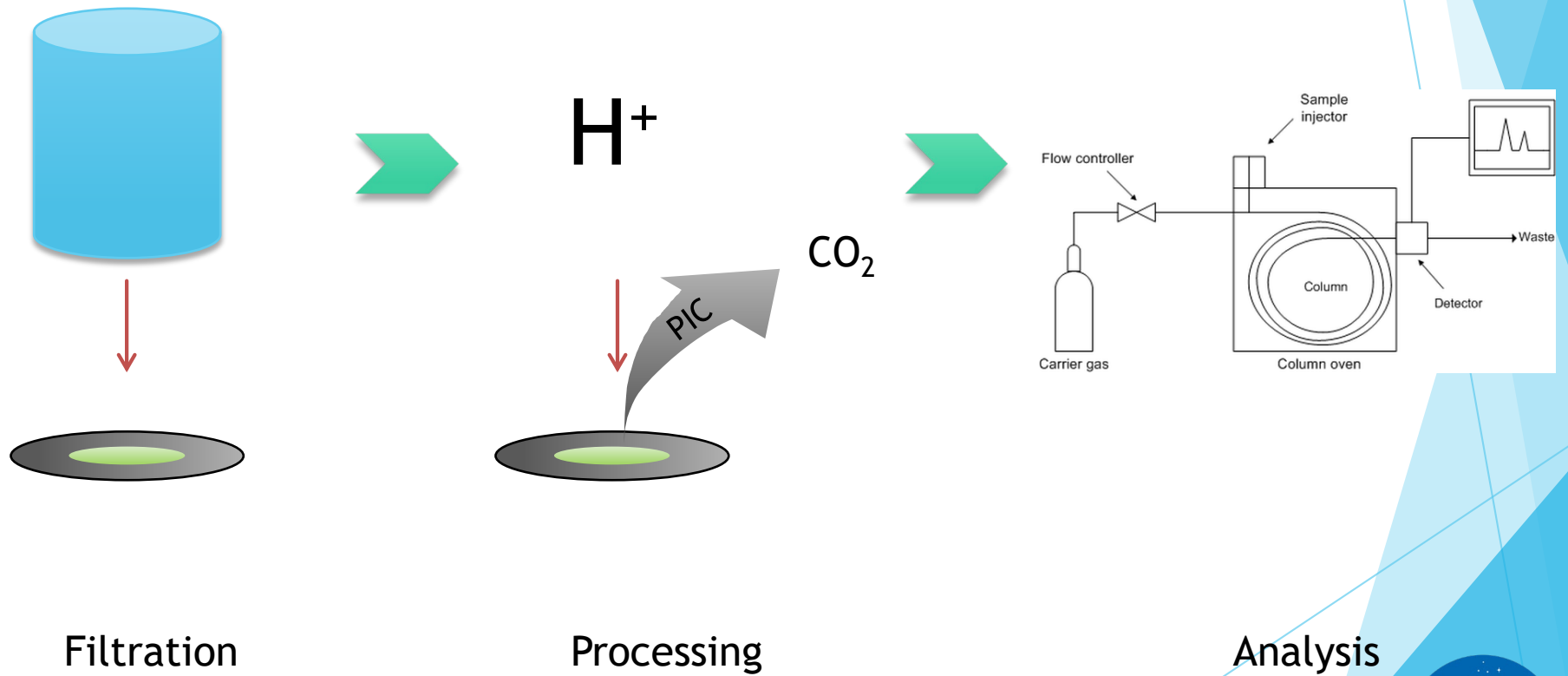
- ✓ “Since carbon is the “coin of the realm” for [...] future programs seeking to understand biogeochemical processes, it is imperative that we come to closure on the methods used to measure particulate carbon”. *Gardner, 2003*
- ✓ “As present procedures do not exist to correct for all possible biasing effects due to artificial particle formation and/or miss/loss of filterable material, uncertainties of filtration-based estimates of POC concentrations need further testing”. Turnewitsch et al. 2007
- ✓ “the mechanisms leading to such a large POC difference are still unclear and need to be further investigated”. Liu et al. 2009

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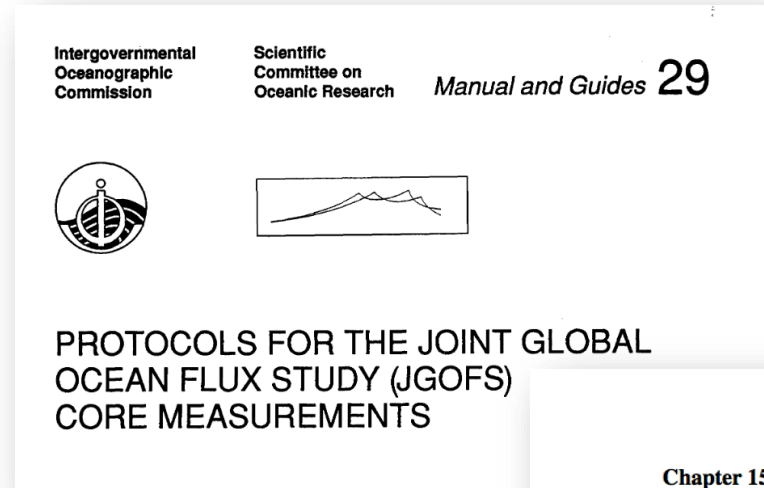


POC Methods: Persistent uncertainties

Basic POC Method:



Legacy POC Methods:



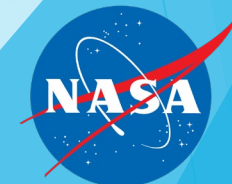
Chapter 15. Determination of Particulate Organic Carbon and Particulate Nitrogen

1.0 Scope and field of application

This procedure describes a method for the determination of particulate organic carbon and particulate nitrogen in seawater. The assay is appropriate for measuring oceanic levels of particulate organic carbon (5.0 - 500.0 $\mu\text{g C/kg}$) and particulate nitrogen (0.5 - 100.0 $\mu\text{g N/kg}$). The principles for this method were first described by Gordon (1969) and Kerambrun and Szekiolda (1969). Sharp (1974) describes a number of useful modifications to the existing method applied here. Detailed description of the analytical procedure is given by the manufacturer (Control Equipment Corporation 1988). Some of the details of the actual measurement of carbon and nitrogen in this method are specific to the Control Equipment Corporation (CEC) 240-XA Elemental Analyzer hardware used at the Bermuda Atlantic Time-series Study. Scientists who employ this or other methods to measure POC and PN should make themselves aware of the current and historical issues that surround these techniques and make appropriate decisions about specific methodologies for their application based on the scientific requirements and constraints of their individual programs.

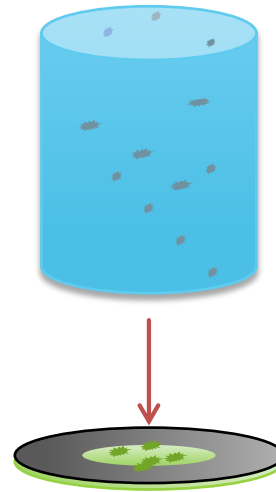
2.0 Definition

Knap, A. H., A. Michaels, A. R. Close, H. Ducklow & A. G. Dickson, 1994. Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements JGOFS Report. UNESCO, 170.



POC Methods: Persistent uncertainties

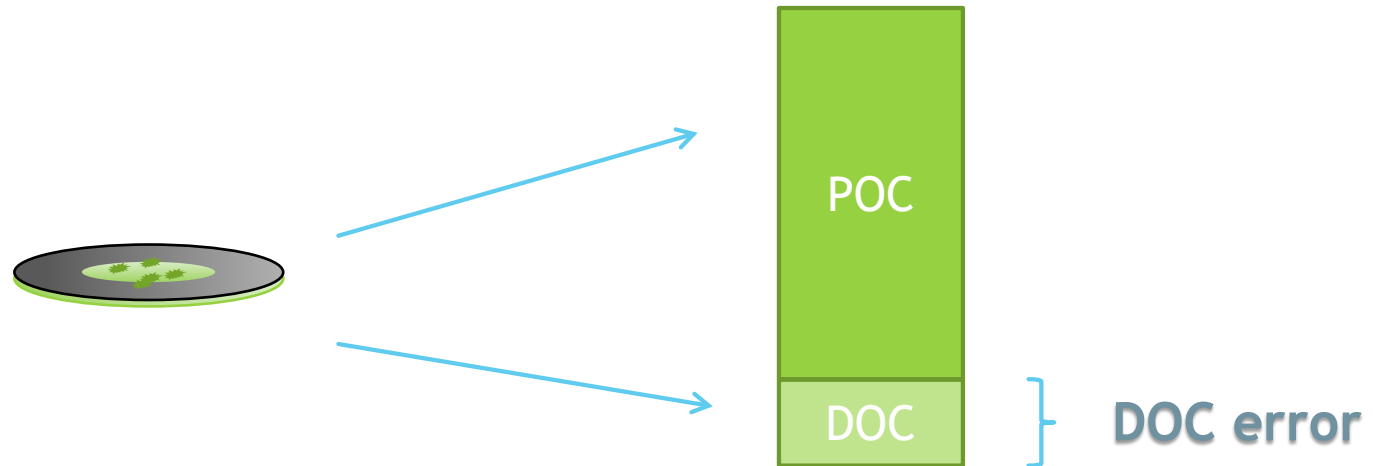
*Dissolved Organic Carbon Artifact
(colloidal fraction ?)*



Filtration

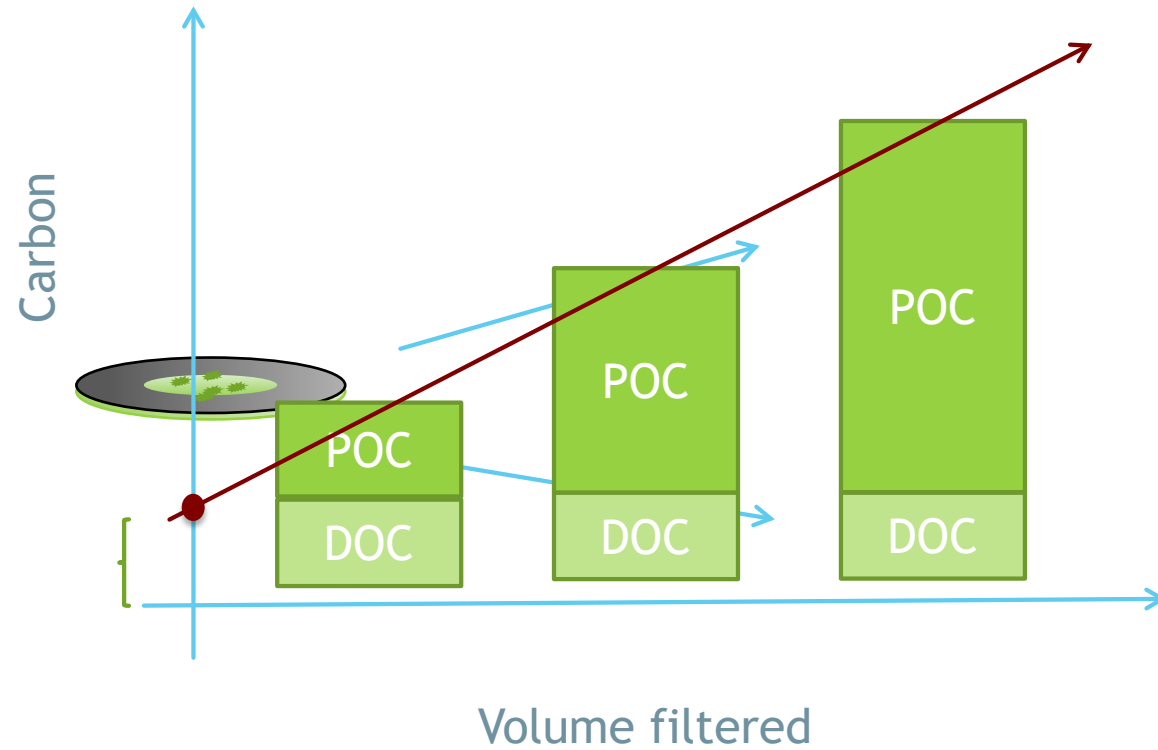
POC Methods: Persistent uncertainties

Dissolved Organic Carbon Artifact



POC Methods: Persistent uncertainties

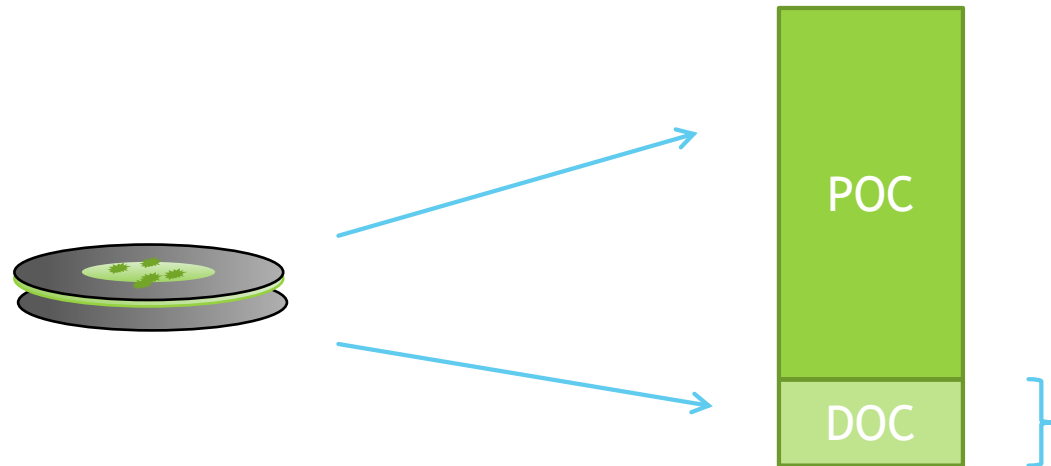
Dissolved Organic Carbon Artifact



Different volume replicates

POC Methods: Persistent uncertainties

Dissolved Organic Carbon Artifact



In-line double filters

Basic measures of uncertainty and performance metrics for POC/PN

et al. (2019) can provide further guidance.

6.4.1 Uncertainty Budget

For a quantity derived from addition or subtraction of independent variables a and b , $y=a+b$ or $y=a-b$, the combined uncertainty in y , u_y , is given by

$$u_y = \sqrt{u_a^2 + u_b^2}, \quad (16)$$

which is the sum in quadrature of the uncertainties u_a and u_b for the quantities a and b used to calculate y . For quantities, q , derived from a product or quotients of measured magnitudes a, \dots, f

$$q = \frac{a \times \dots \times c}{d \times \dots \times f}, \quad (17)$$

the fractional or relative uncertainty of q , provided that the uncertainties in a, \dots, f are independent and random, is given by the sum in quadrature of their respective fractional uncertainties

$$\frac{u_q}{|q|} = \sqrt{\left(\frac{u_a}{a}\right)^2 + \dots + \left(\frac{u_c}{c}\right)^2 + \left(\frac{u_d}{d}\right)^2 + \dots + \left(\frac{u_f}{f}\right)^2}. \quad (18)$$

Given that in (9), the mass of C as POC, $M_{\text{POC}}^{\text{C}}$, is derived from the total uncorrected mass of C, $M_{\text{T}}^{\text{C}*}$, measured on sample filters, by subtracting the blank signals described in 6.3.2. from (16) it follows that the propagated uncertainty for $M_{\text{POC}}^{\text{C}}$ is given by

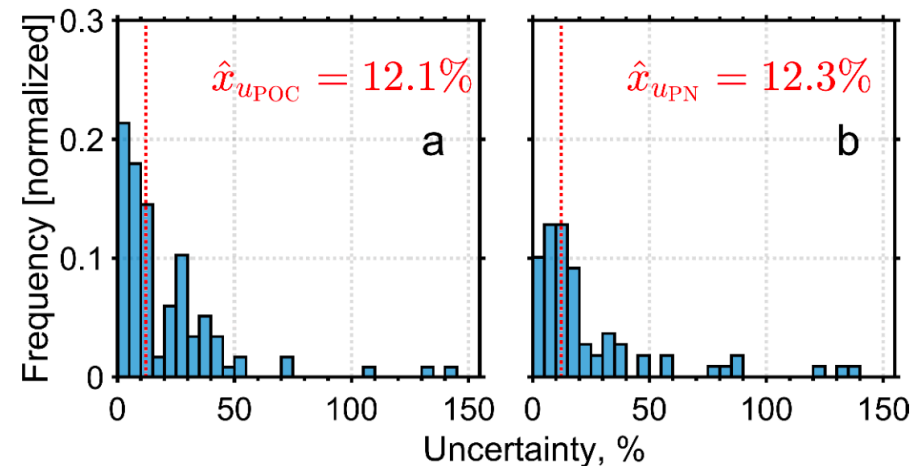
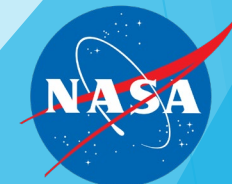


Figure 14. Histograms of fractional uncertainty as percentages for (a) POC and (b) PN for samples collected during the GO-SHIP P06 Leg 2 2017 campaign. Vertical red lines depict the median fractional uncertainties in each case.

Screenshot



Uncertainty budgets for a POC/PN dataset

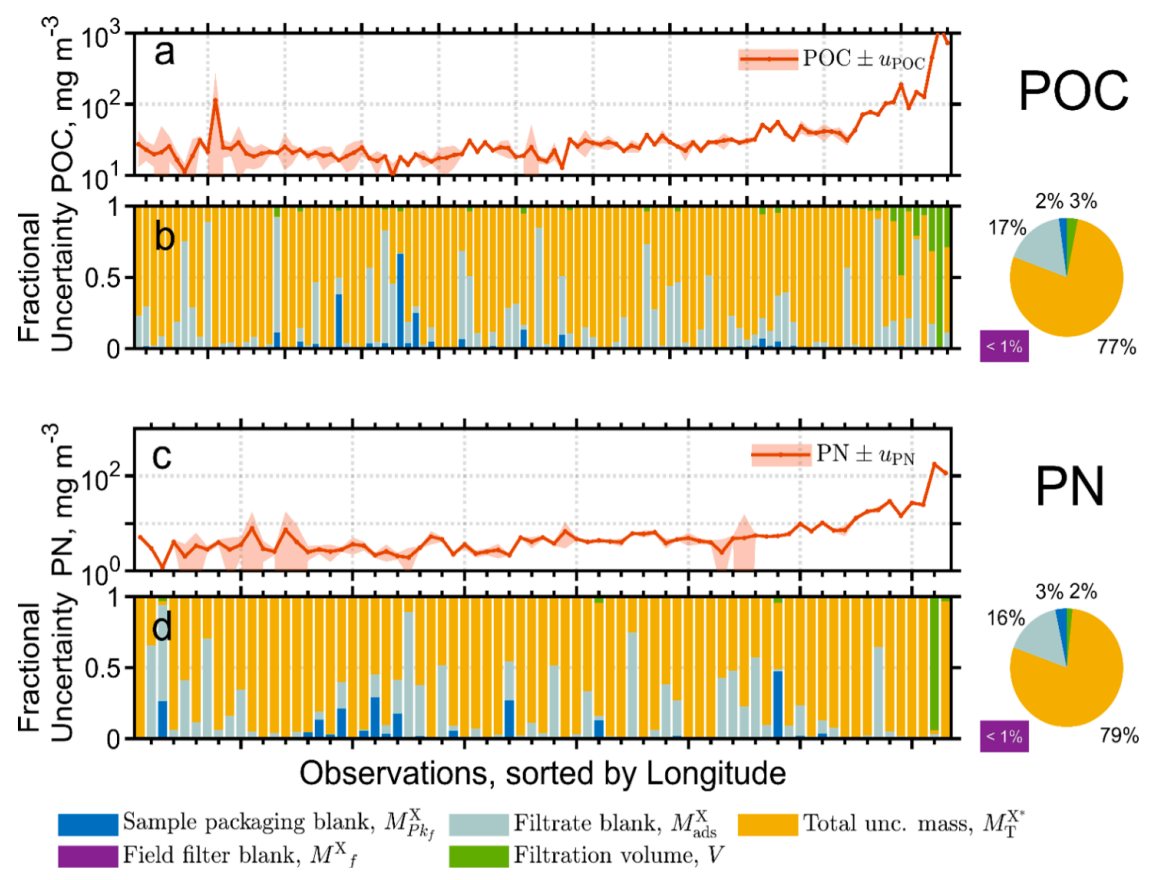
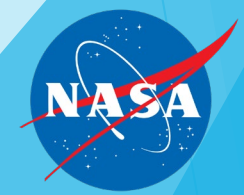


Figure 15. (a, c) Concentration of POC, PN during the GO-SHIP P06 Leg 2 2017 sorted in ascending order by station longitude along sampling transect in the South Pacific Ocean across the Gyre to the Peru-Chile upwelling region. Shaded regions depict the best estimate of concentration \pm the propagated uncertainty. (b, d) Bar plots depict the contribution to measurement uncertainty (i.e., uncertainty budget) for each of the values in panels a and c by the variables in equations 17, 18. The respective mean uncertainty budgets for POC and PN are depicted in the pie charts to the right on panels b and d.



Questions?

