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> WORKSHOP REPORT

DATA NEEDS FOR HYPERSPECTRAL DETECTION OF ALGAL DIVERSITY ACROSS THE GLOBE

By Heidi Dierssen, Astrid Bracher, Vittorio Brando, Hubert Loisel, and Kevin Ruddick

74 Oceanography | Vol.33, No.1

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The Euromarine Foresight Workshop

- The objective of this workshop was to develop recommendations for comprehensive, efficient, and effective laboratory and field programs to supply data for development of algorithms and validation of hyperspectral satellite imagery for micro-, macro- and endosymbiotic algal characterization across the globe.
- A group of 38 experts specializing in hyperspectral remote-sensing methods for aquatic ecosystems met in Ostend, Belgium, June 4–6, 2019.

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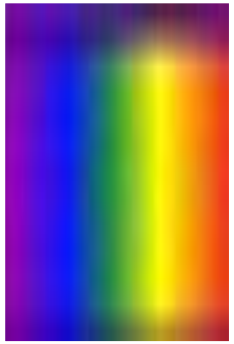
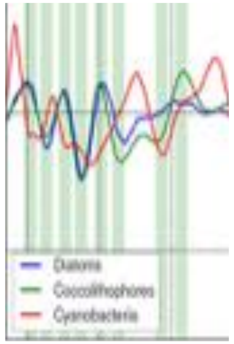
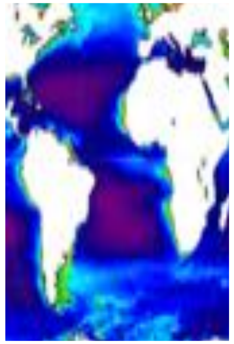
What is the overarching problem?



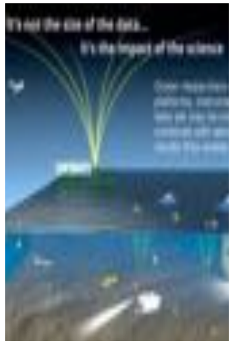
Hyperspectral sensors provide a means to better differentiate phytoplankton groups from space.



Local/Regional algorithms have been developed to identify phytoplankton groups, genus and even species.



Global hyperspectral datasets with phytoplankton composition are needed for algorithm development.

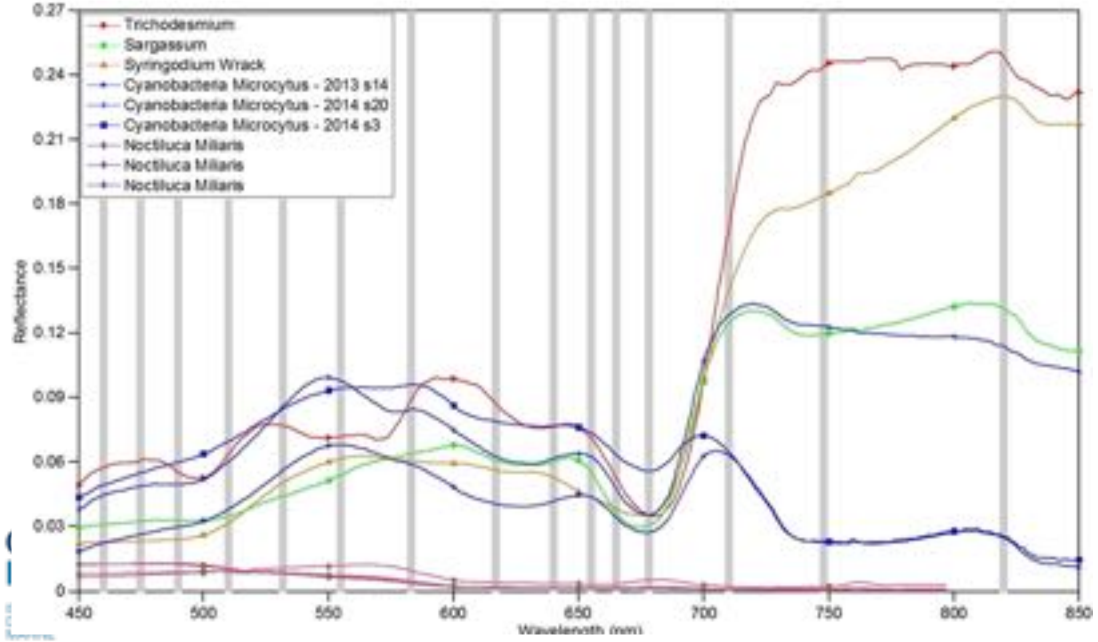


Strategic plan is needed to validate satellite-derived phytoplankton products

What phytoplankton metrics can be linked to hyperspectral imagery?

Phytoplankton Groups (PGs) are :

- a clustering of species (irrespective of taxonomic affiliation) that can be optically differentiated using remote sensing methods (Bracher et al. 2017).
- do not necessarily have to serve different ecological or biogeochemical functional roles (i.e., “phytoplankton functional groups”).
- based on taxonomic criteria are phytoplankton types (PT) or on size classes.



Applications for hyperspectral algal characterization

Biogeochemical Modeling	• Species composition • Nutrient cycling • Export of carbon, nitrogen, etc.
Ecological Indicators	• Hypoxia • Eutrophication • Informed monitoring and assessment
Ecological Processes	• Primary producers • DMS producers • Trophic dynamics and food web efficiency
Global Change	• Latitudinal distributional shifts • Phenology shifts
Fisheries	• Finding fish • Locations/monitoring for aquaculture • Shellfish food safety
Harmful Algal Blooms (HABS) and Human Health	• Detecting types of blooms • Finding probabilistic toxin production • Forecasts and warnings to communities
Environmental Reporting	• Assessing compliance to thresholds • Species identification • Detecting anomalies

FIGURE 2. Potential applications for differentiating the fractional composition of various phytoplankton groups in aquatic ecosystems using hyperspectral imagery. DMS = Dimethyl sulfide.

The end users for such diverse applications include scientists, environmental managers, government agencies, private industry, and the general public.

Data needs for remote sensing of phytoplankton groups

- Develop a Hyperspectral Database Architecture
- Create Standardized Metadata Protocol
- Evaluate the Spectral Resolution Required for Phytoplankton Studies
- Provide Guidance for Identifying Phytoplankton Groups Using High-Performance Liquid Chromatography

- Hyperspectral Water-leaving Reflectance (Rrs)
  - Field data from ships, moorings, etc…
  - Algal culture data
  - Satellite or airborne data (e.g., HICO, CHRIS-PROBA, AVIRIS, PRISM) after atmospheric correction
  - Simulated data
- Hyperspectral optical properties (IOPs) when available, absorption by phytoplankton (aphyt) most useful
- Phytoplankton Dominant Taxa (WORMS classification)
- Phytoplankton Dominant Taxa Method
- Concentration metric (carbon/L, cells/L, etc..)
- Fractional composition of major Phytoplankton Groups (PGs)
- PG method
- Relevant metadata (location, date, time)
- Relevant ancillary data (temperature, salinity, nutrients, etc…)

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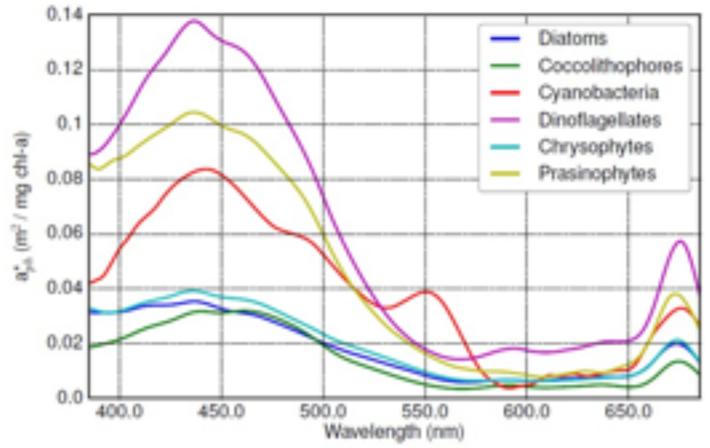

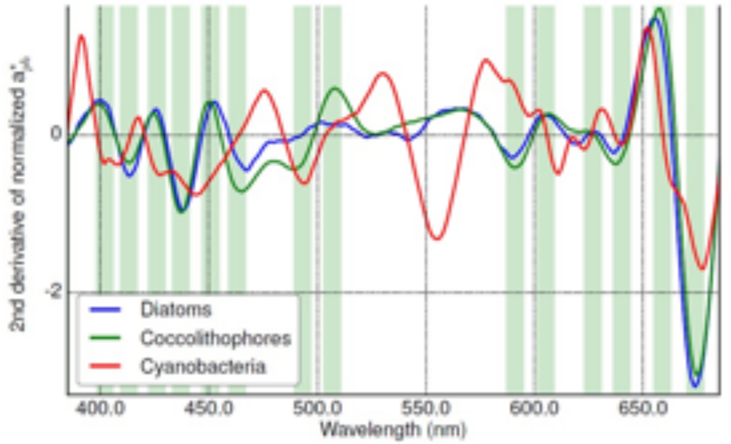

Spectral band requirements to differentiate multi-species mixture (Wolanin et al. 2016)

How do we rapidly develop a global hyperspectral database needed for algorithm development and validation?

- Provide Funds for Historic Data Reanalysis
- Add Hyperspectral Optics to Ongoing Coastal Observatories
- Target New Platforms
- Provide Shared Instrument Pools and Protocols

Application of an Ocean Color Algal Taxa Detection Model to Red Tides in the Southern Benguela

Collin S. Roesler[1], Stacey M. Etheridge[2], and Grant C. Pitcher[3]
[1]*Bigelow Laboratory for Ocean Sciences, PO Box 475, West Boothbay Harbor, ME 04575, USA;*
[2]*Department of Marine Science, University of Connecticut, 1084 Shennecossett Rd., Groton, CT 06340, USA;*
[3]*Marine and Coastal Management, Private Bag X2, Rogge Bay 8012, Cape Town, South Africa*

Steidinger, K. A., J. H. Landsberg, C. R. Tomas, and G. A. Vargo (Eds.). 2004. Harmful Algae 2002. Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and Intergovernmental Oceanographic Commission of UNESCO.

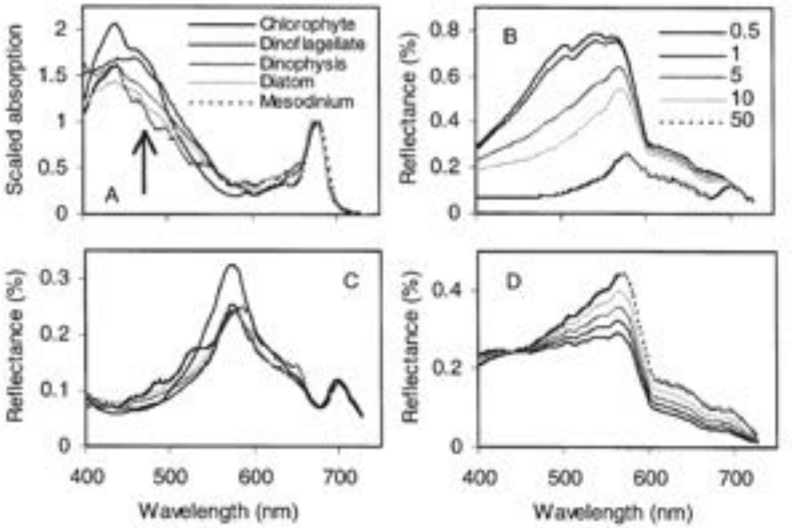

Figure 1 **A** Scaled taxon-specific absorption spectra for 5 separable groups based upon spectrophotometric analysis of size-fractionated samples and corresponding microscopic species counts (in decending order at arrow). Reflectance simulations as a function of **B** algal biomass (μg chl L^{-1}), **C** algal composition at 50 μg chl L^{-1} concentrations, symbols as in part A, **D** particle size distribution, where long wavelength reflectance increases as particle size increases.

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Hyperspectral autonomous radiometer system (PANTHYR) on RT1 platform

Contents lists available at ScienceDirect

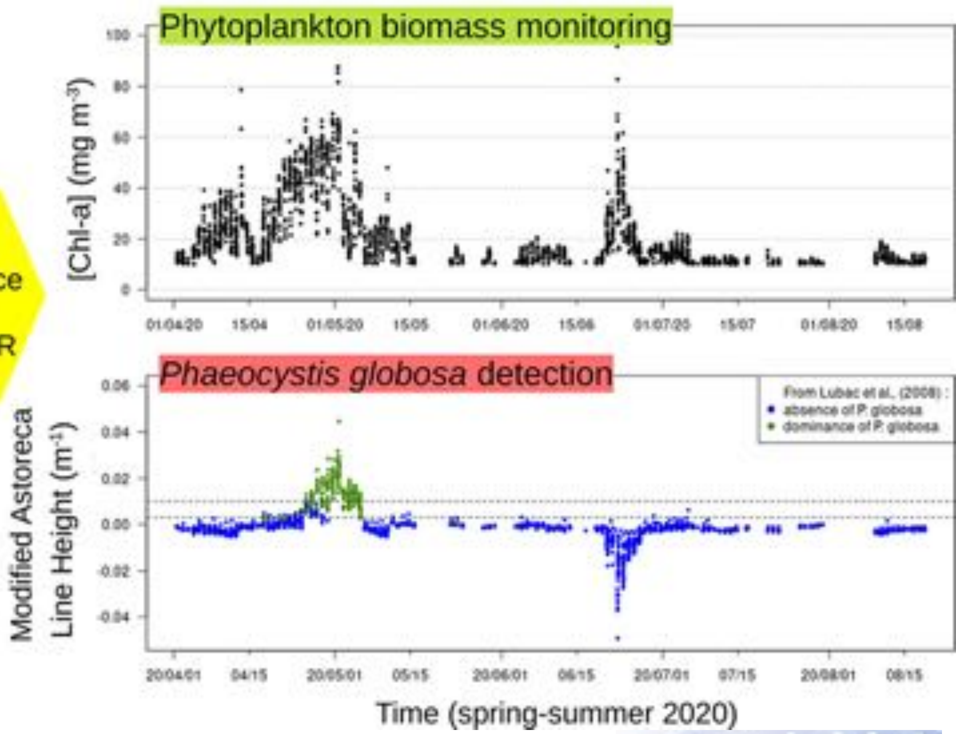
Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Monitoring of high biomass *Phaeocystis globosa* blooms in the Southern North Sea by in situ and future spaceborne hyperspectral radiometry

Héloïse Lavigne, Kevin Ruddick, Quinten Vanhellemont

Water reflectance from PANTHYR



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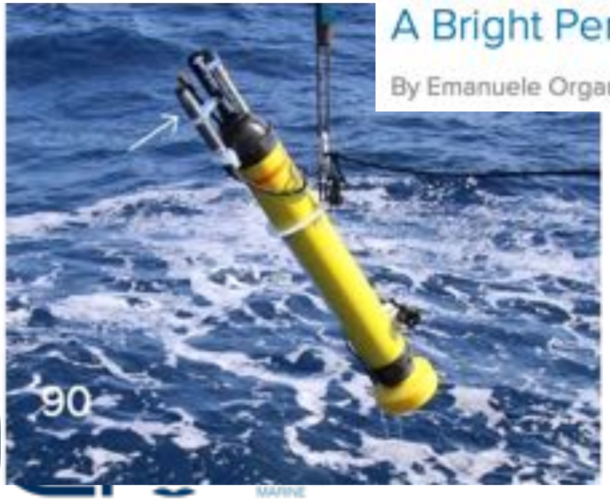
Hyperspectral Radiometry on Biogeochemical-Argo Floats: A Bright Perspective for Phytoplankton Diversity

By Emanuele Organelli, Edouard Leymarie, Oliver Zielinski, Julia Uitz, Fabrizio D'Ortenzio, and Hervé Claustre

December 2021 Supplement to *Oceanography*



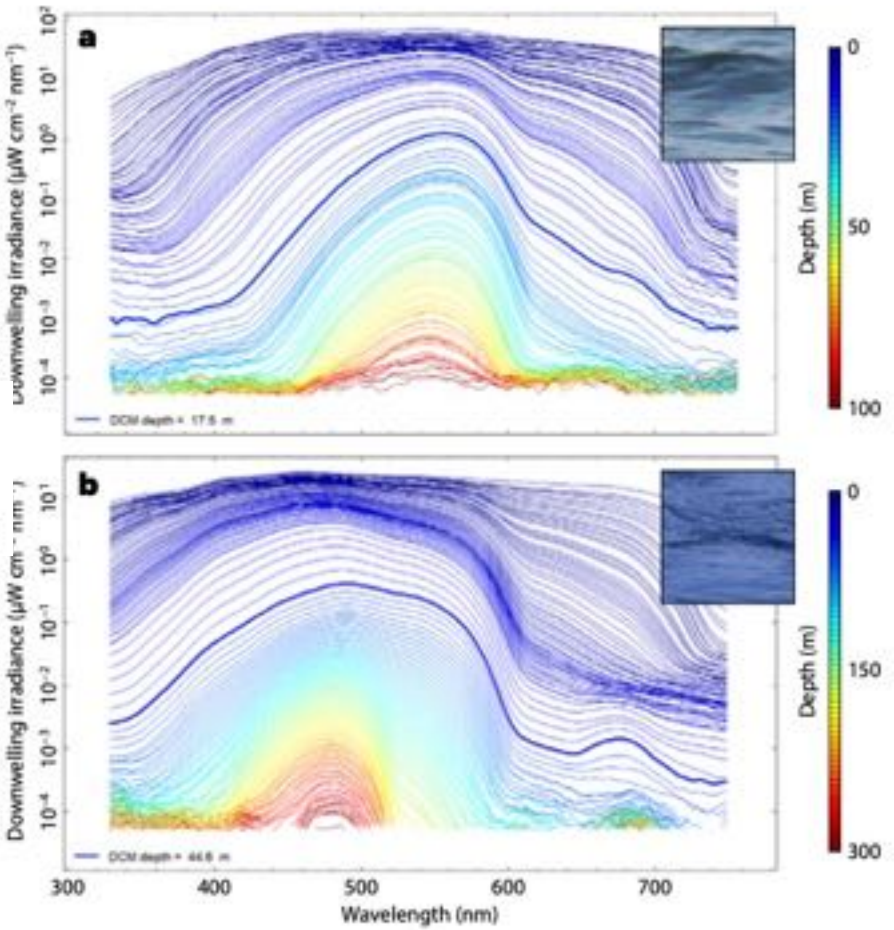


FIGURE 2. BGC-Argo floats equipped with hyperspectral radiometers capture the optical signatures of phytoplankton communities and their compositions. The spectral bands at which light disappears provide information on pigments and thus on phytoplankton types present. Vertical profiles of hyperspectrally resolved downwelling irradiance (radiant energy from the sun) show, at the level of the deep chlorophyll maxima (DCM; thick blue line), a maximum of the remnant light around 560 nm for the brownish waters of the Baltic Sea (a), and around 480 nm for the blue Mediterranean (b).

Maximize the utility of hyperspectral imaging for assessing marine ecosystem biodiversity

The next generation of hyperspectral ocean color satellites has been launched recently or is being developed for the next decade.

Given the international nature of the missions, there is the need to develop international follow-on organizational task forces that would allow free and open data exchange and policy formulation.

Providing a more comprehensive understanding of marine biodiversity is critical for assessing responses to environmental change.

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