International Ocean Colour Science Meeting 2025

Advancing Global Ocean Colour Observations

From Genes to Pixels: Towards Biodiversity from Space

Roy El Hourany, Junior Professor at ULCO-LOG

Contribution: Ziad Sari El Dine, Christophe Guinet, Lucile Duforêt-Gaurier, Hubert Loisel, Cedric Jamet, Marie Montero, Maximiliano Arena, Alain Fumenia, Rimi Kobeissi, Pedro Junger, Juan Pierella Karlusich, Lucie Zinger, Marina Levy, Luther Ollier, Chris Bowler, Lola Daboussy, Colomban de Vargas, Margaux Crédeville, Olivier Jaillon

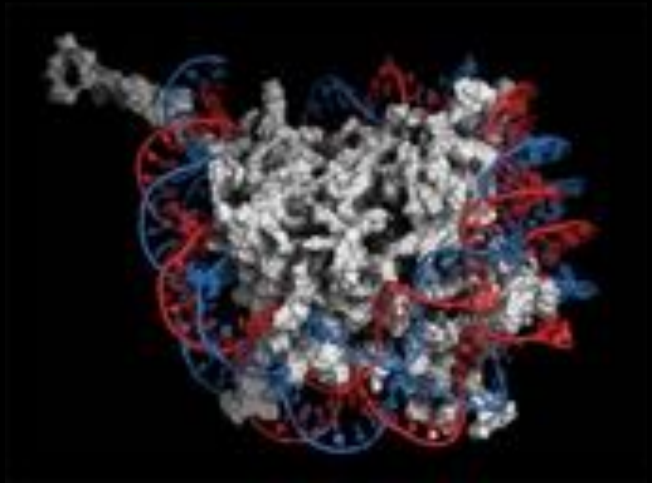
Darmstadt, Germany

1-4 December 2025

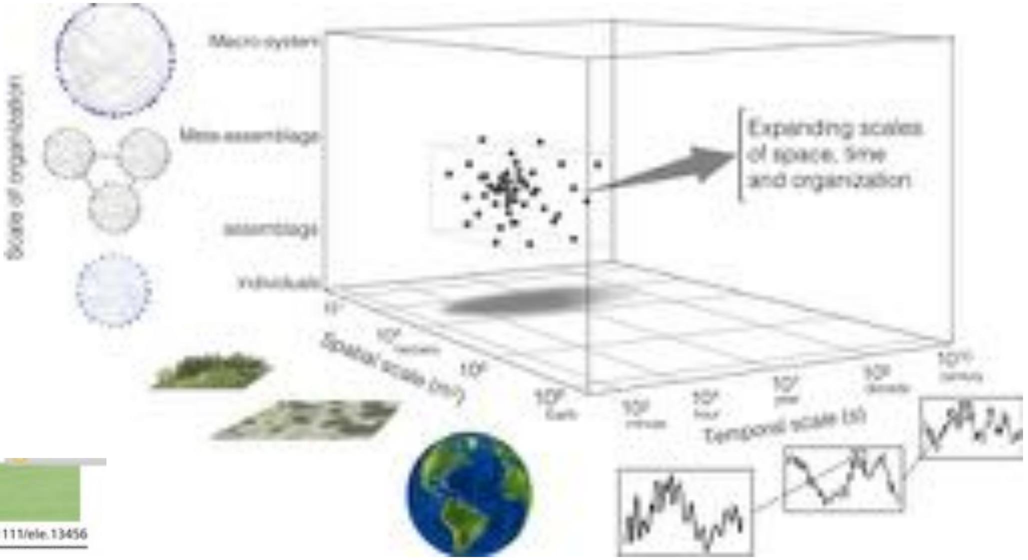
LOG

ulco Université Littoral Côte d'Opale

Biodiversity Across Scales



Biodiversity Across Scales: From Gene to Globe




ECOLOGY LETTERS

Ecology Letters, (2020) **23**: 757–776 doi: 10.1111/ele.13456

REVIEWS AND SYNTHESES

Scaling-up biodiversity-ecosystem functioning research

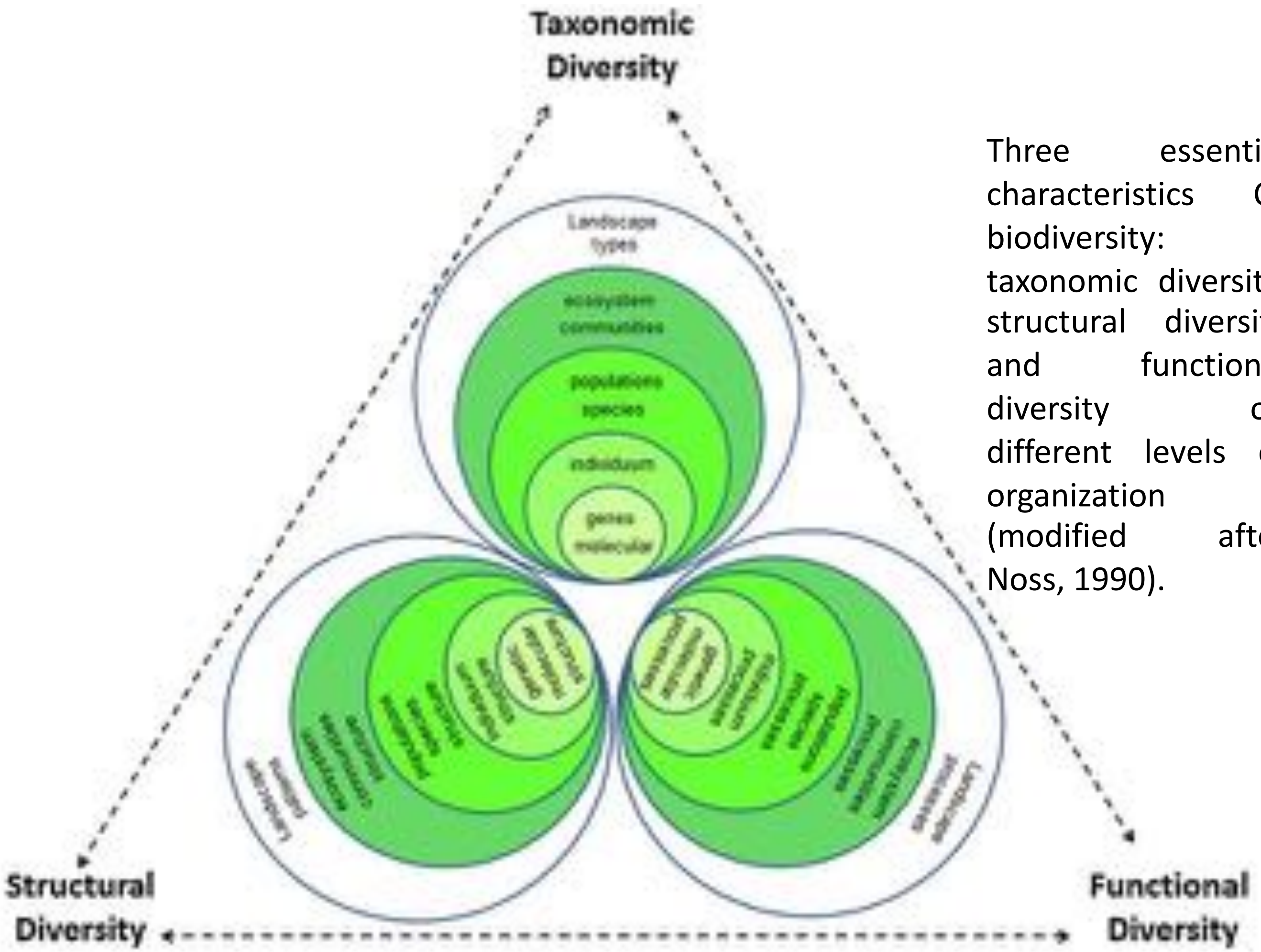
Gonzalez et al. 2020

The three dimensions of scale in Biodiversity-Ecosystem function (BEF) research: time, space and organisation

Defining Biodiversity

Biodiversity, the variability among living organisms from all sources, underpins all life on Earth. This includes diversity within species, between species and across ecosystems, representing the genetic makeup of plants, animals, microorganisms and the complexity of ecosystems (WHO, 2025).

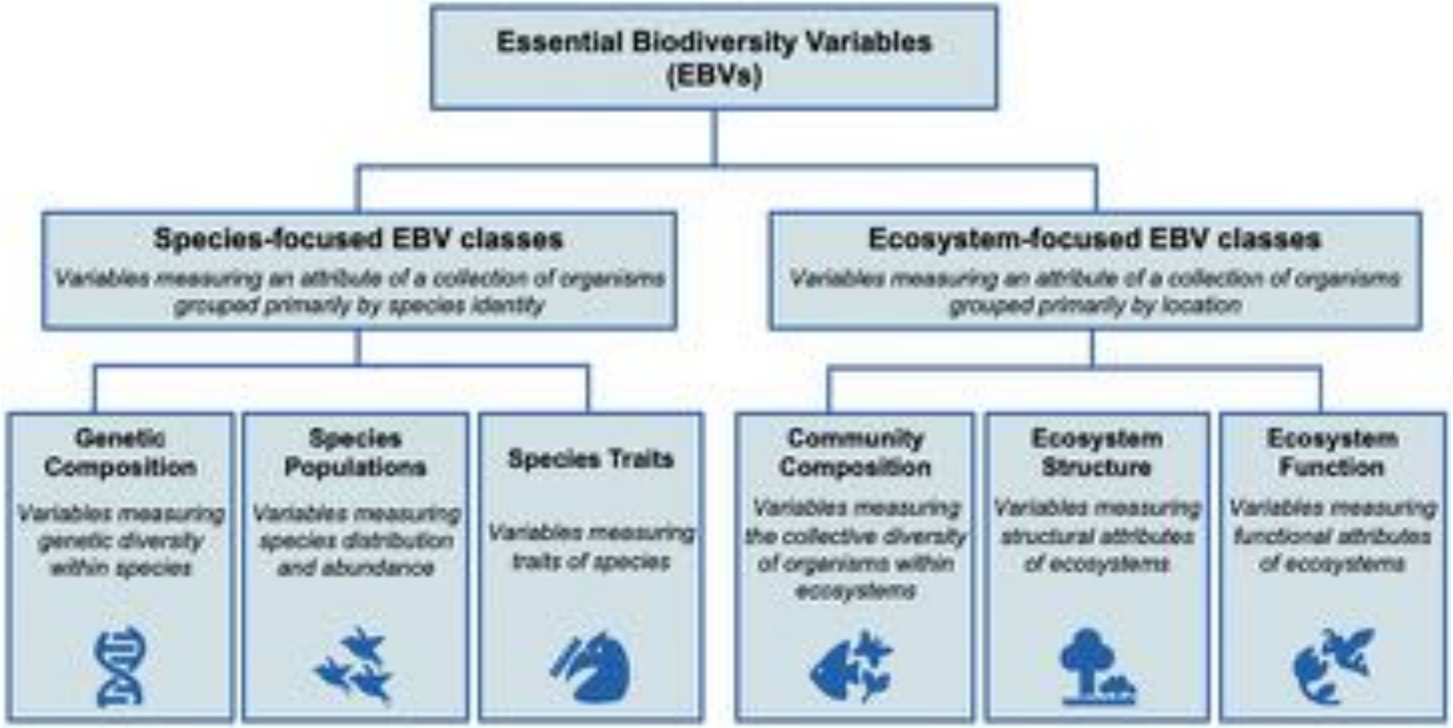
- Genetic diversity (within and between populations)
- Taxonomic / species diversity (who is there?)
- Functional diversity (what can they do?)
- Structural and temporal diversity (how communities are organised in space and time)

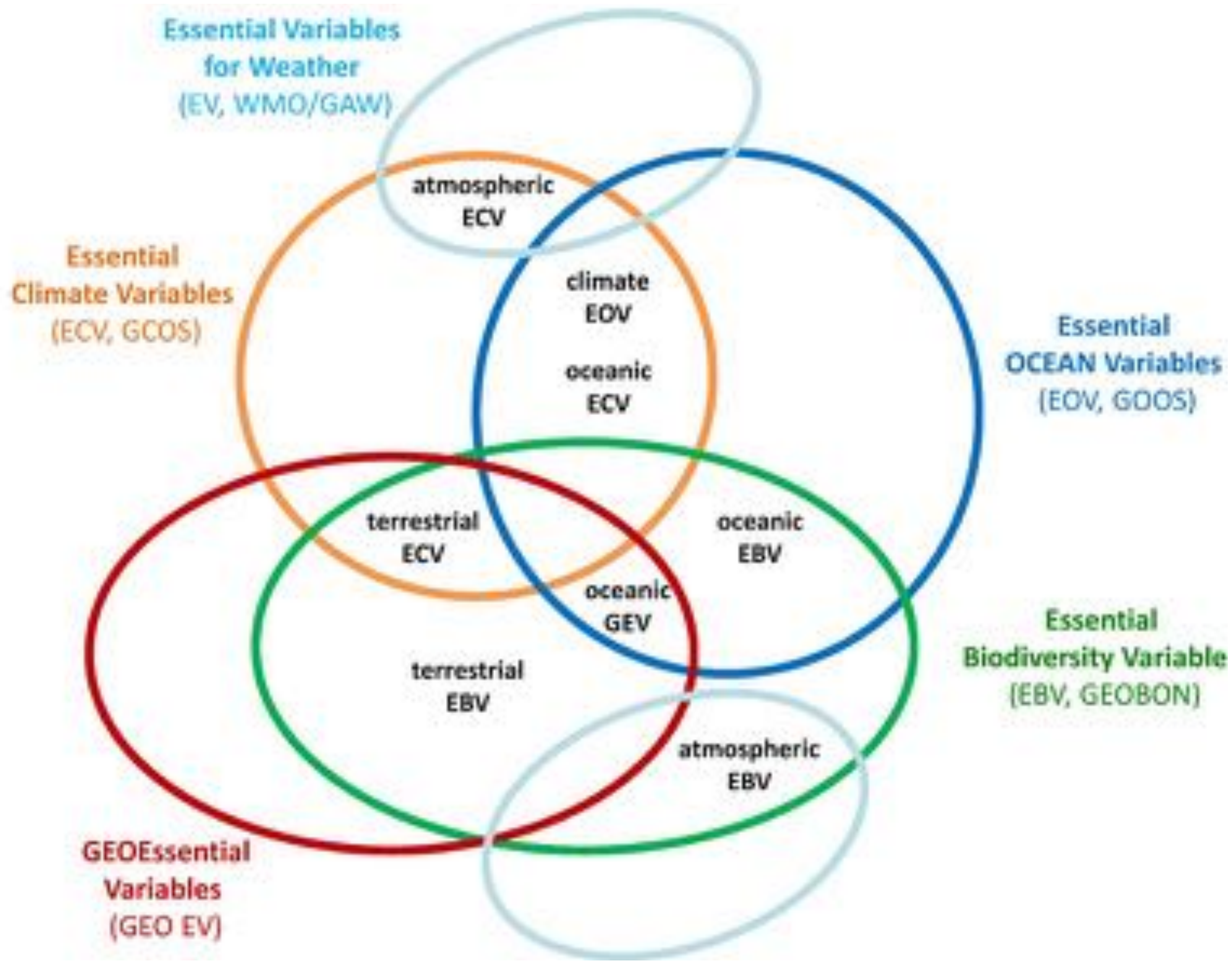


Three essential characteristics Of biodiversity: taxonomic diversity, structural diversity and functional diversity on different levels of organization (modified after Noss, 1990).

Essential Biodiversity Variables

Essential Biodiversity Variables (EBVs) are a set of standardized biological measurements that help scientists study, report and manage changes in biodiversity across time, space, and biological level. They bridge the gap between raw biodiversity data and derived policy-relevant indicators, and have the potential to serve as a foundation for biodiversity monitoring programs around the world (Pereira et al. 2013).

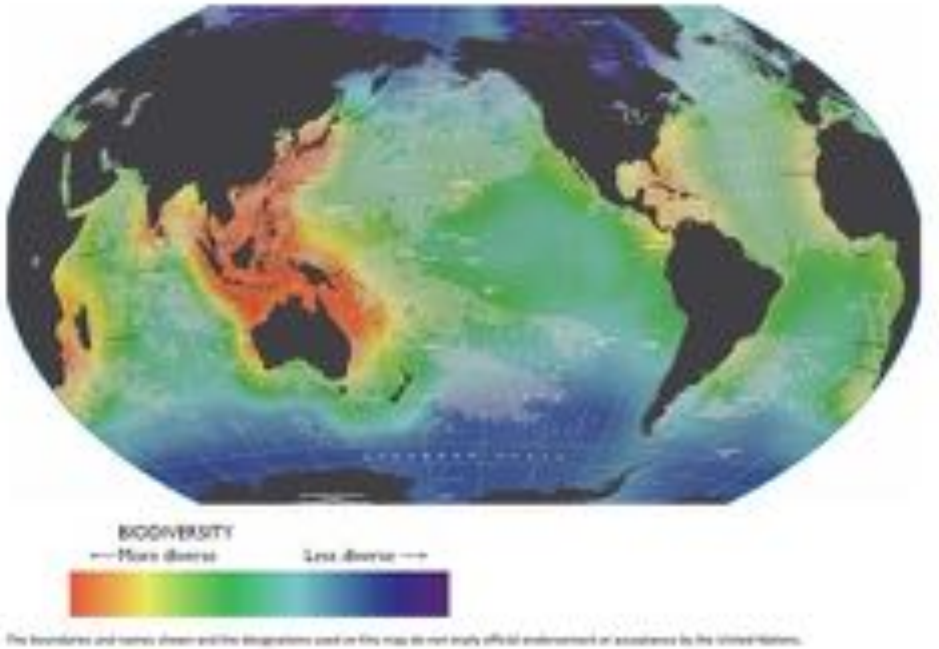




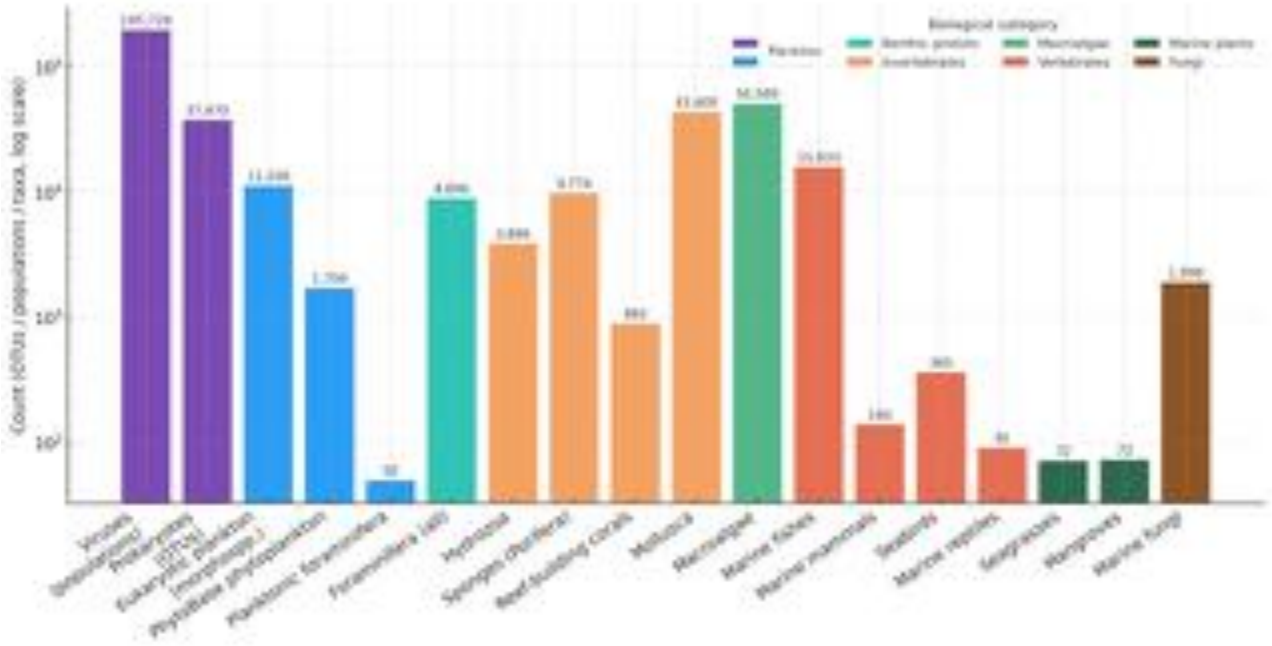
Conceptual overlap of all projects for defining Essential Variables

Essential Variables for Weather-EVW, (led by WMO/GAW–World Meteorological Organization/Global Atmosphere Watch, Essential Ocean Variables-EOV (led by the GOOS-Global Ocean Observing System), Essential Climate Variables-ECV (led by GCOS–Global Climate Observing System), Essential Biodiversity Variables-EBV (led by GEOBON-Group on Earth Observations Biodiversity) and the GeoEssential Variables-GEO EV (led by the actual project (http://www.geoessential.net/) (modified after Lindstrom et al.).

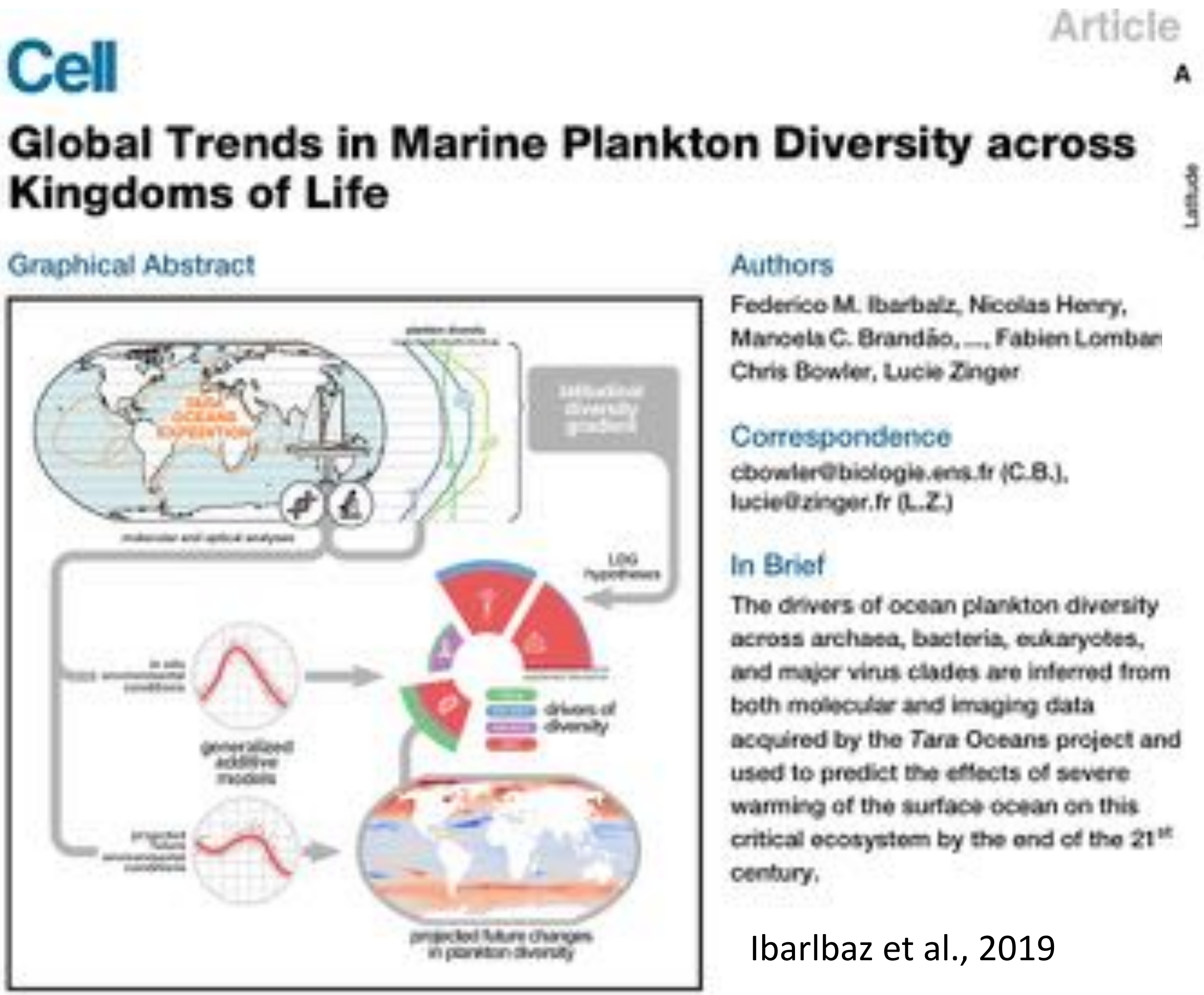
Distribution of biodiversity in the oceans



Distribution of biodiversity in the oceans. Biodiversity data: tittensor et al., 2010. Map: census of marine life (2010); ausubel et al. (2010); national geographic society (2010).” Appears in world ocean assessment I, part II, chapter 1: introduction- planet, oceans and life.



de Vargas et al., 2015; Righetti et al., 2020; Righetti et al., 2019; Brummer & Kučera, 2022; Holzmann et al., 2024; World Hydrozoa Database (WoRMS), 2025; Rosenberg, 2014; World Porifera Database (WPD), 2025; IUCN, 2024; Guiry, 2024; Short et al., 2011; West et al., 2016; Duke et al., 1998; Spalding et al., 2010; FAO, 2020; Humphries et al., 2023; BirdLife International, 2025; BirdLife Seabird Tracking Database Team, 2024; Society for Marine Mammalogy Committee on Taxonomy, 2025; Avila et al., 2024; Sunagawa et al., 2015; Gregory et al., 2019.



Cell

Article

Global Trends in Marine Plankton Diversity across Kingdoms of Life

Graphical Abstract

Authors

Federico M. Ibarbalz, Nicolas Henry, Manoela C. Brandão, ..., Fabien Lombar
Chris Bowler, Lucie Zinger

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cbowler@biologie.ens.fr (C.B.),
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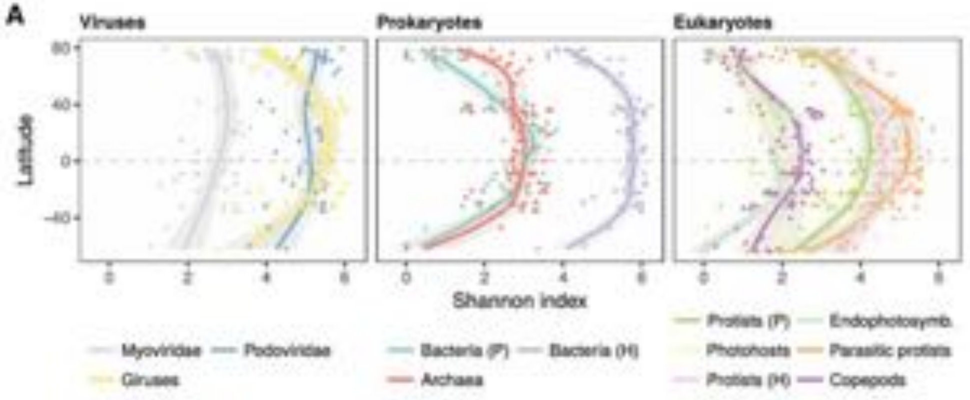
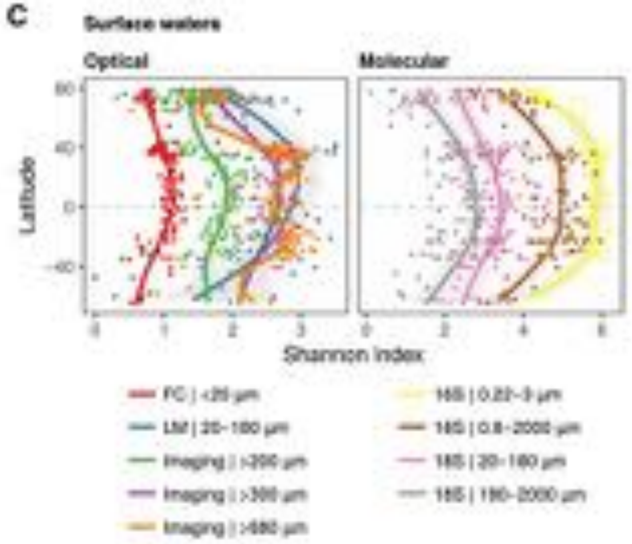
In Brief

The drivers of ocean plankton diversity across archaea, bacteria, eukaryotes, and major virus clades are inferred from both molecular and imaging data acquired by the *Tara Oceans* project and used to predict the effects of severe warming of the surface ocean on this critical ecosystem by the end of the 21st century.





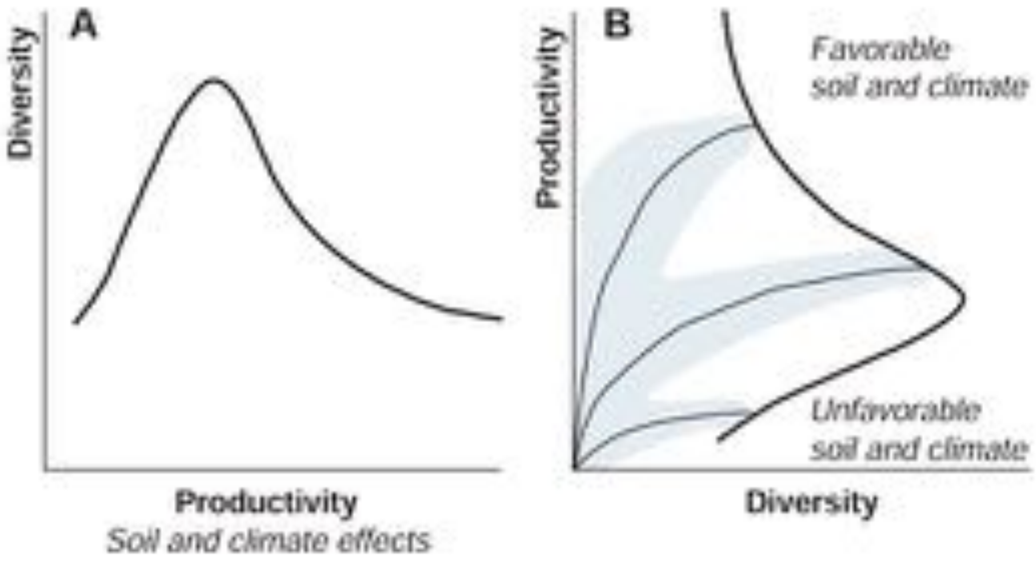
Ibarlbaz et al., 2019

SCIENCE'S COMPASS • REVIEW

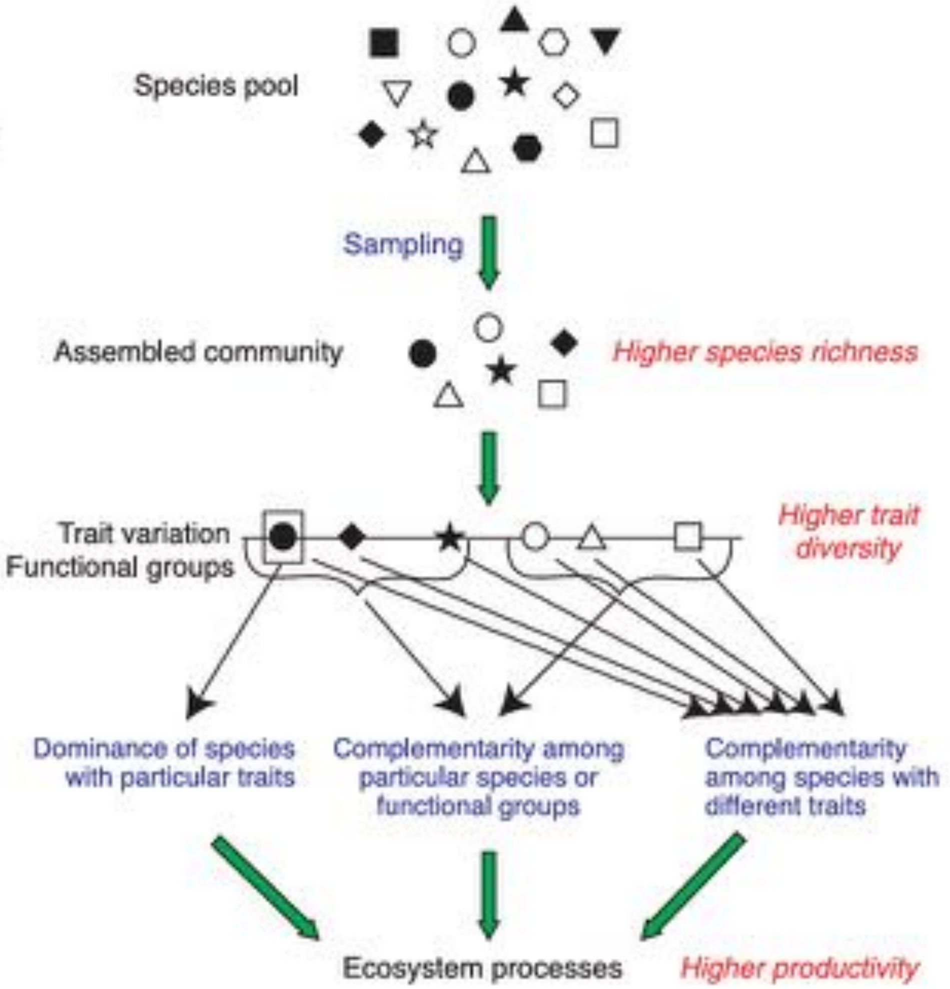
REVIEW: ECOLOGY

Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges

M. Loreau,[1*] S. Naeem,[2] P. Inchausti,[1] J. Bengtsson,[3] J. P. Grime,[4] A. Hector,[5] D. U. Hooper,[6] M. A. Huston,[7] D. Raffaelli,[8] B. Schmid,[9] D. Tilman,[10] D. A. Wardle[4]



Hypothesized relation ships between (A) diversity productivity patterns driven by environmental conditions across sites, and (B) the local effect of species diversity on productivity in a grassland ecosystem.

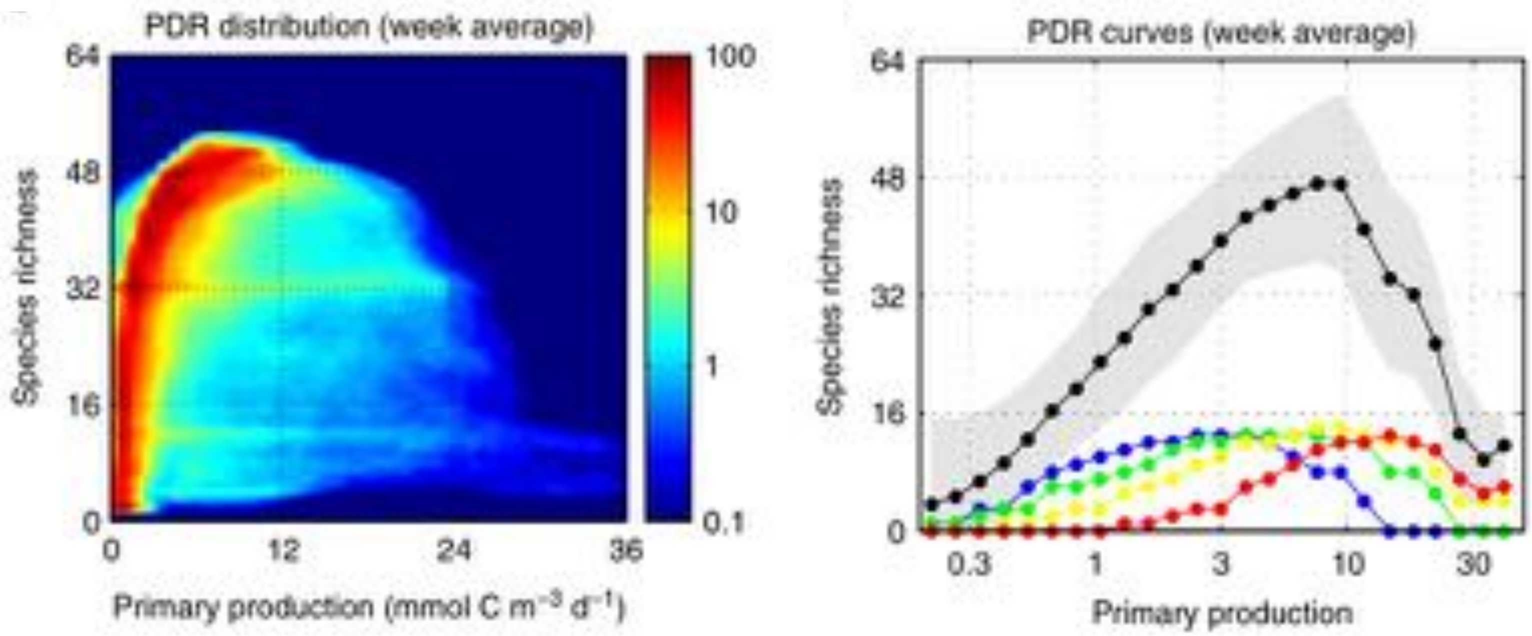


ARTICLE

Received 29 Jan 2014 | Accepted 4 Jun 2014 | Published 1 Jul 2014 DOI: 10.1038/ncomms5299 OPEN

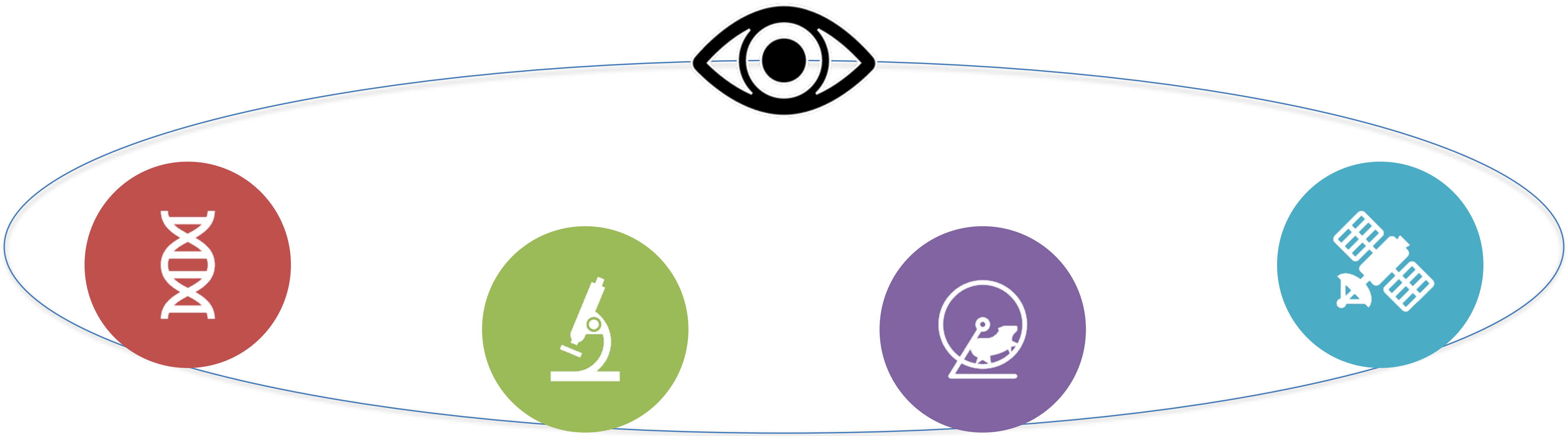
Global relationship between phytoplankton diversity and productivity in the ocean

S.M. Vallina[1,2], M.J. Follows[1], S. Dutkiewicz[1], J.M. Montoya[2], P. Cermeno[2] & M. Loreau[3]



Global PDR distribution of model outputs using weekly averaged data. Units: primary production (mmol Cm 3d 1); phytoplankton diversity (# species) (contributing 41% total biomass. **Global PDR curve of model outputs using equally spaced log10 bins of primary production using weekly averaged data.** Units: primary production (mmol Cm 3d 1); phytoplankton diversity (# species) (contributing 41% total biomass). Colour legend: Prochlorococcus (blue line), Synechococcus (green line), f lagellates (yellow line) and diatoms (red line).

Observing Tools Along the Biodiversity Scale Ladder



Omics: genes, cells, organisms, function, communities

Microscopy, cytometry, pigments, optics: cells, traits, organisms, communities

Autonomous platforms & animal-borne sensors: 4D context and behavior

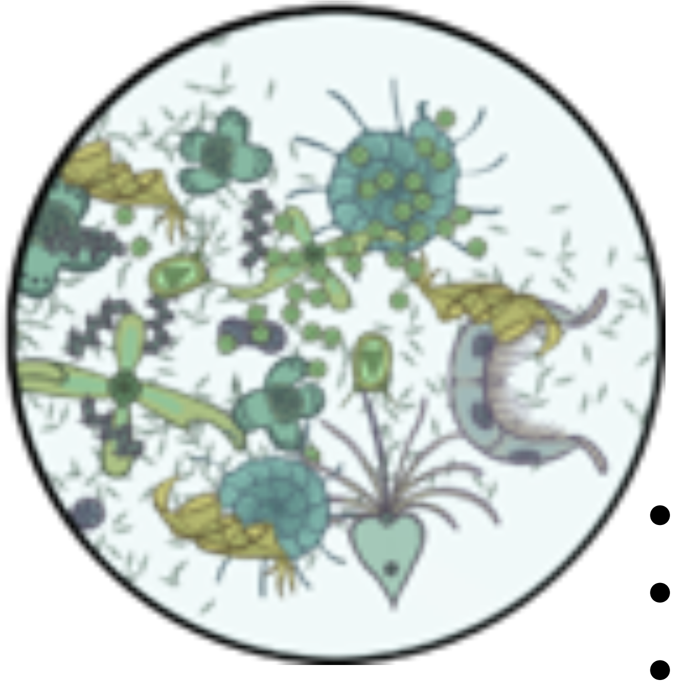
Satellites: continuous coverage of surface environment and optical properties

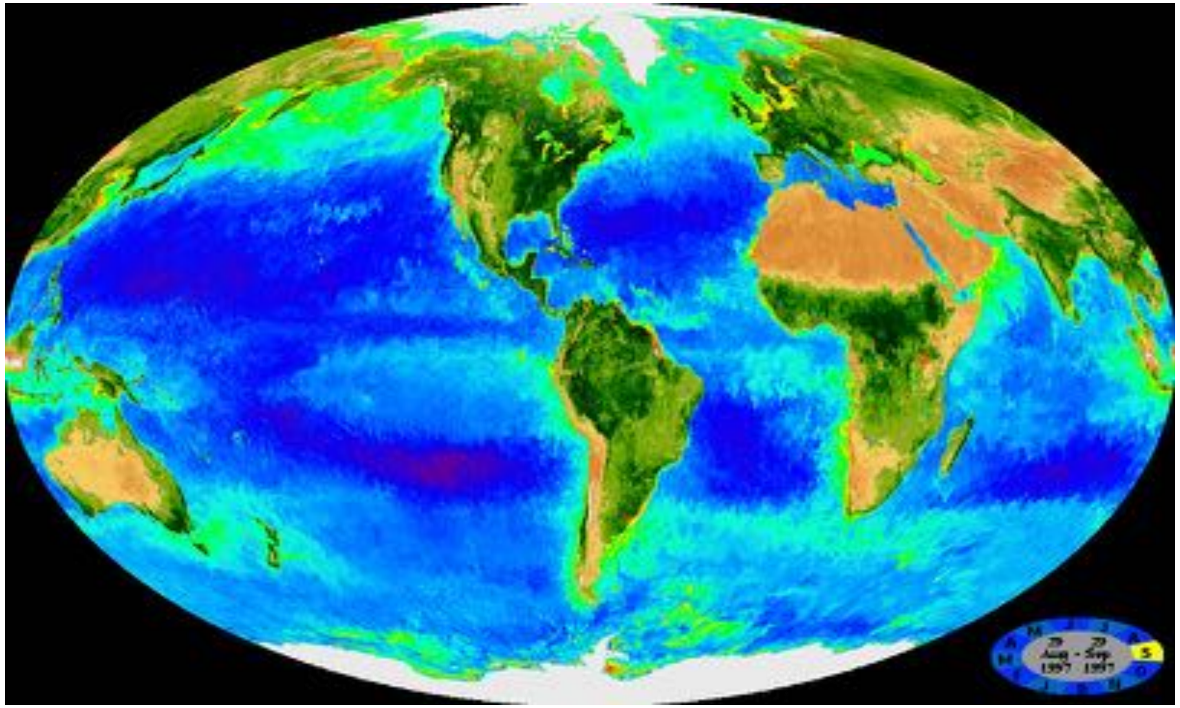
What Satellites OC Actually Measure

Satellites see proxies and context for biodiversity, not species directly

- **Spectral reflectance**
- Derived environmental variables: PAR temperature,
- Derived optical properties (a, bb),
- Derived biogeochemical variables (Chla, Kd, SPM, POC…)

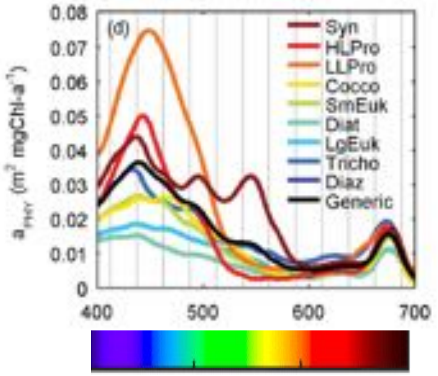
Phytoplankton interaction with light depends on:



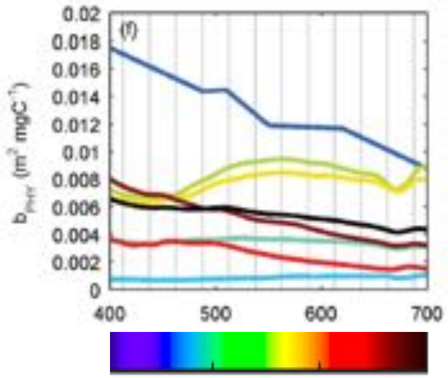


- Cell Concentration
- Pigment composition
- Taxonomic composition
- Size, morphology and physiology.

Absorption

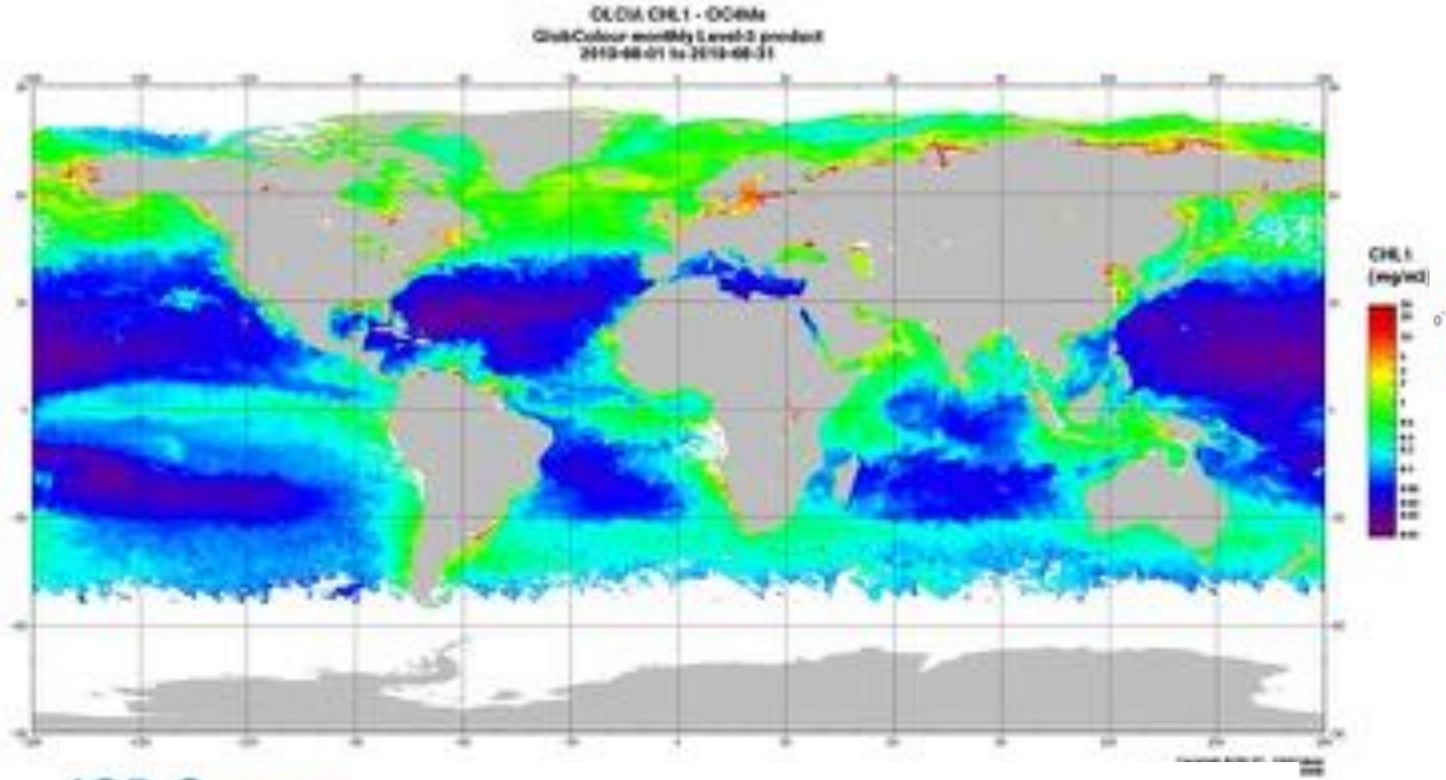


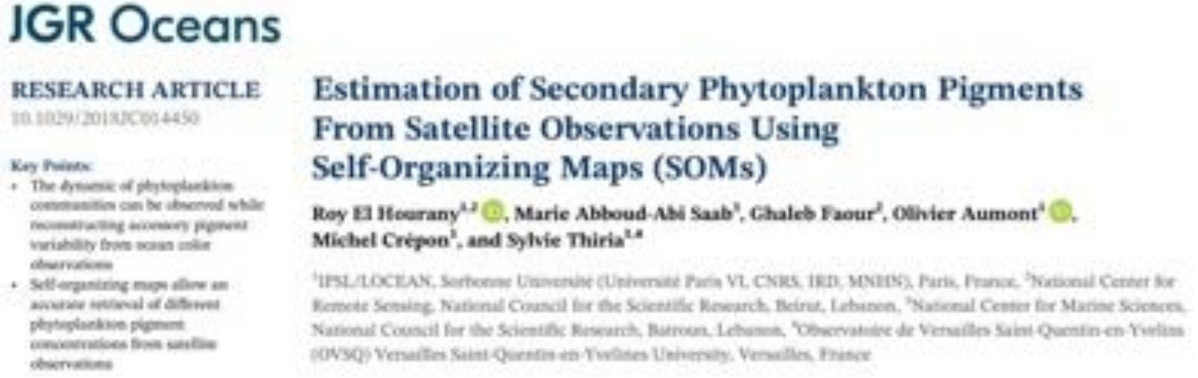
Back-scatter



Dutkiewicz et al., 2015

Beyond Chlorophyll-a




JGR Oceans

RESEARCH ARTICLE
10.1029/2018JC014450

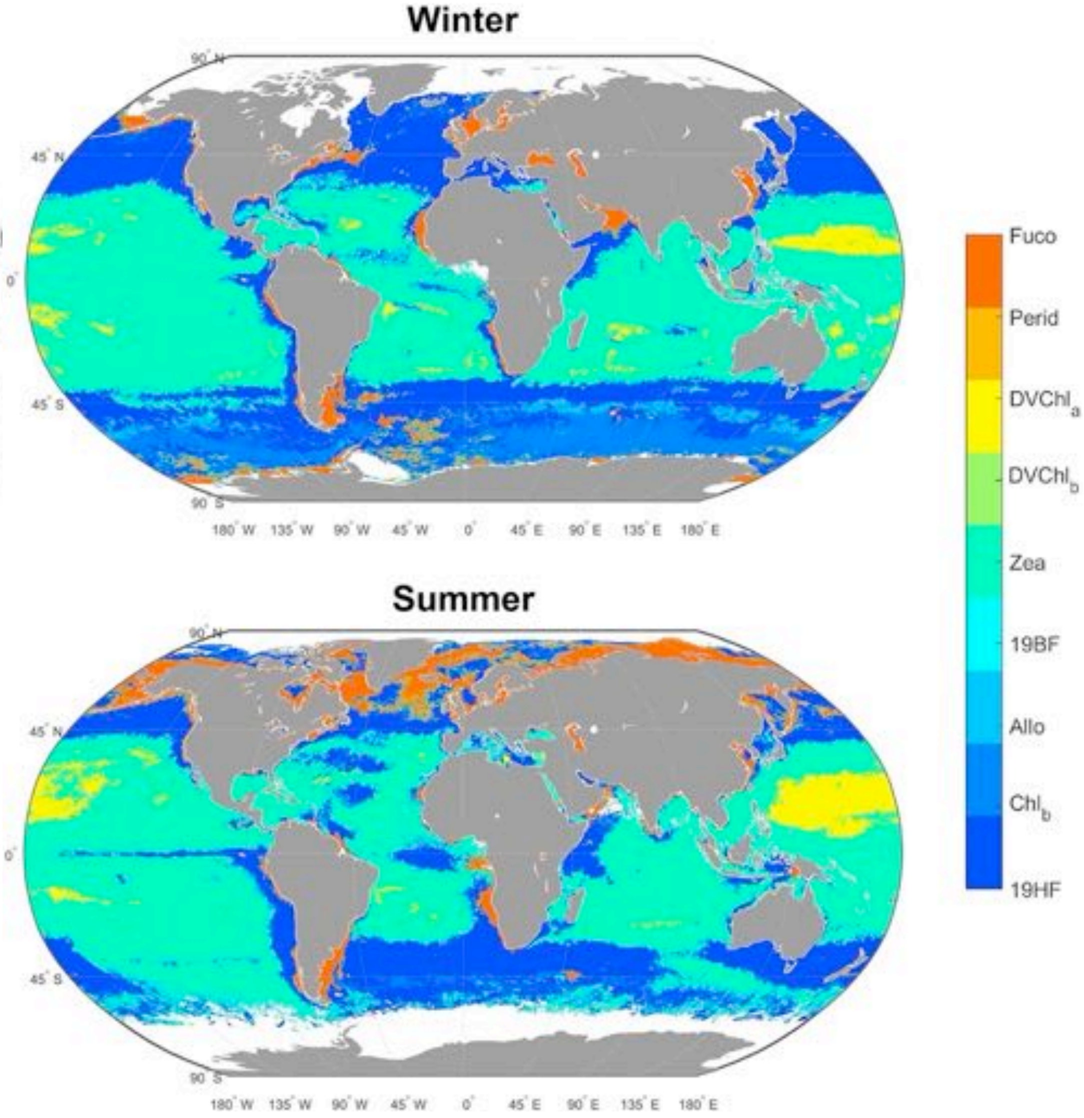
Estimation of Secondary Phytoplankton Pigments From Satellite Observations Using Self-Organizing Maps (SOMs)

Roy El Hourany[1,2], Marie Abboud-Abi Saab[3], Ghaleb Faour[2], Olivier Aumont[1], Michel Crépon[1], and Sylvie Thiria[1,4]

[1]IPSL/LOCEAN, Sorbonne Université (Université Paris VI, CNRS, IRD, MNHN), Paris, France, [2]National Center for Remote Sensing, National Council for the Scientific Research, Beirut, Lebanon, [3]National Center for Marine Sciences, National Council for the Scientific Research, Batroun, Lebanon, [4]Observatoire de Versailles Saint-Quentin-en-Yvelines (OVSQ) Versailles Saint-Quentin-en-Yvelines University, Versailles, France

Key Points:

- The dynamic of phytoplankton communities can be observed while reconstructing accessory pigment variability from ocean color observations
- Self-organizing maps allow an accurate retrieval of different phytoplankton pigment concentrations from satellite observations

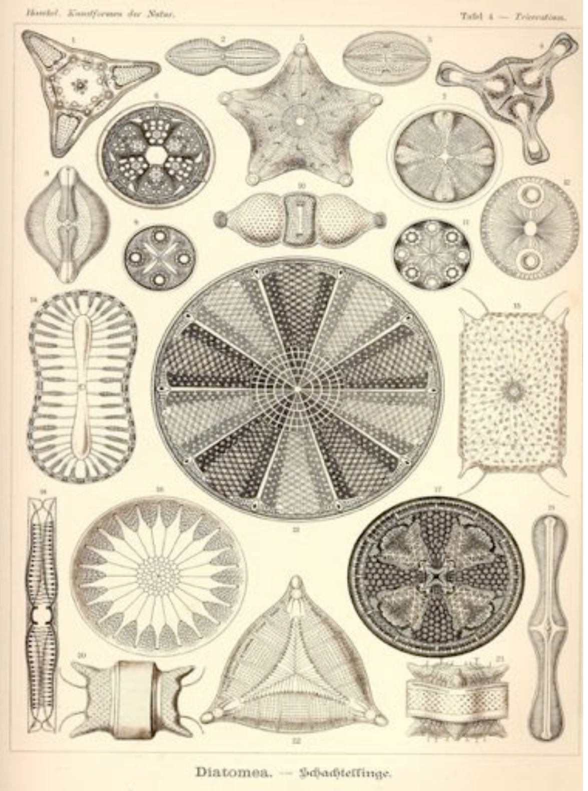


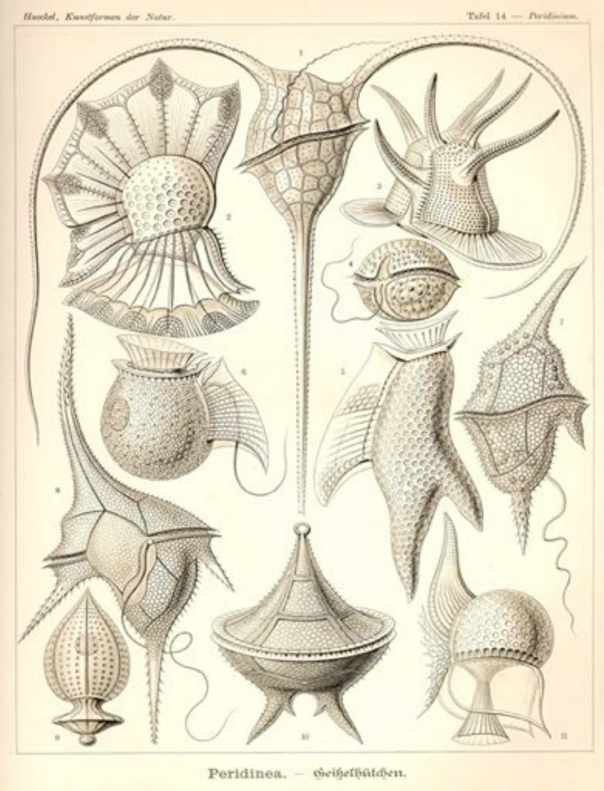
Phytoplankton Community structure

PG =Phytoplankton Groups

Taxonomic groups PG

Diatoms
Dinoflagellates
Green Algae
Haptophytes
Cyanobacteria…





Ernst Haeckel, “Kunstformen der Natur” (Art forms of nature),1904

Phytoplankton Community structure

PG =Phytoplankton Groups

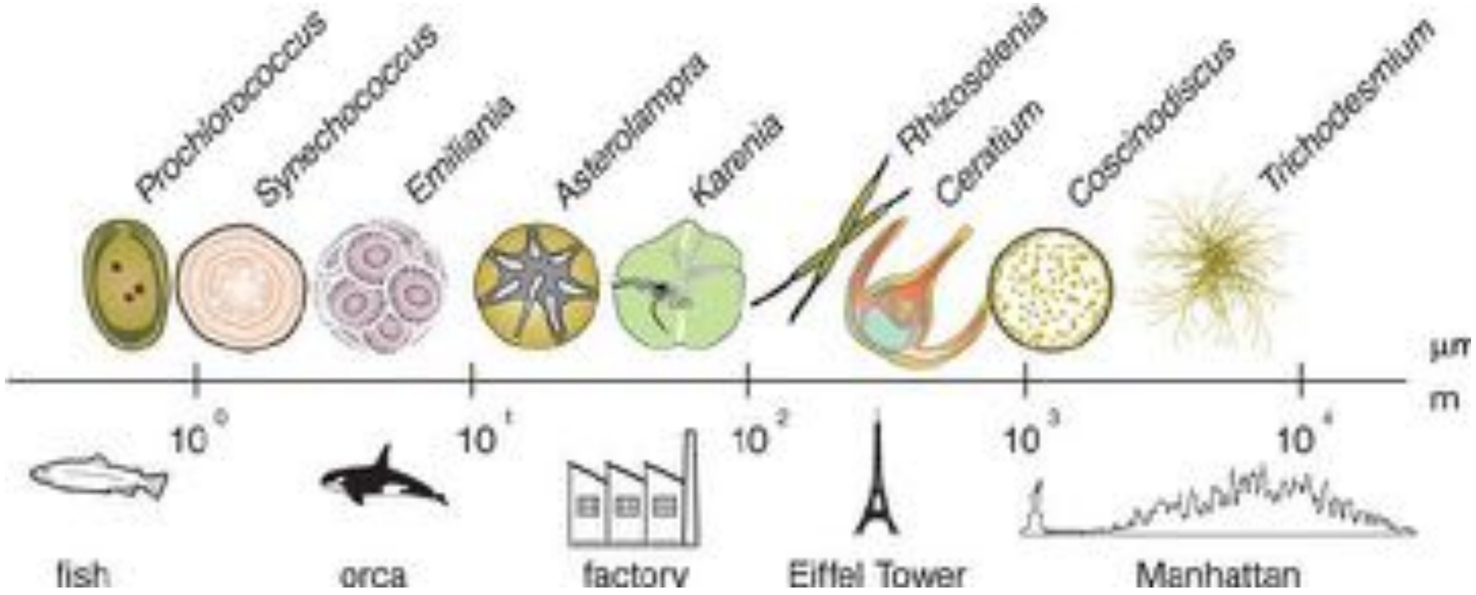
PSC =Phytoplankton Size Classes

Taxonomic groups PG

Diatoms
Dinoflagellates
Green Algae
Haptophytes
Cyanobacteria…

Size ranges PSC

Micro-phytoplankton 20 - 200 um
Nano-phytoplankton 2 - 20 um
Pico-phytoplankton 0.2 - 2 um



Finkel et al. 2010

Phytoplankton Community structure

PG =Phytoplankton Groups

PSC =Phytoplankton Size Classes

PFT =Phytoplankton Functional Types

Taxonomic groups PG

Diatoms
Dinoflagellates
Green Algae
Haptophytes
Cyanobacteria…

Size ranges PSC

Micro-phytoplankton 20 - 200 um
Nano-phytoplankton 2 - 20 um
Pico-phytoplankton 0.2 - 2 um

Ecosystem functions PFT

Primary producers
Silicifiers
Calcifiers
N2 fixer etc…

The ISME Journal (2013) 7, 2054–2056
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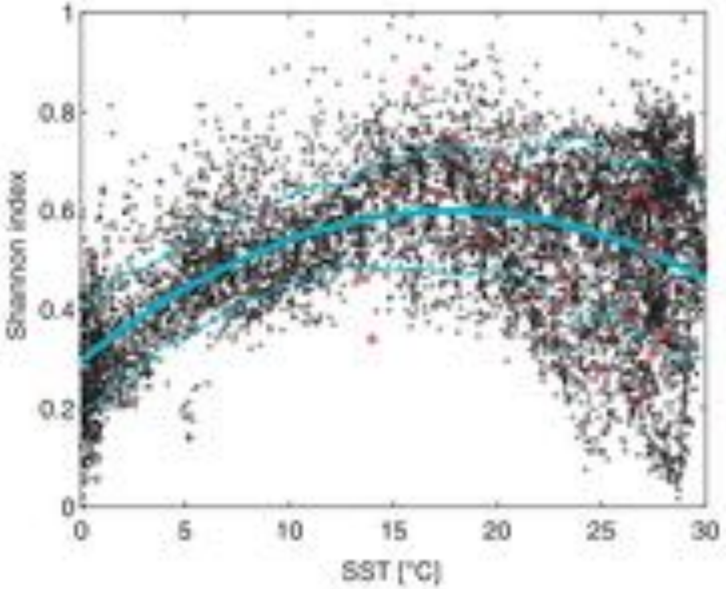
www.nature.com/ismej

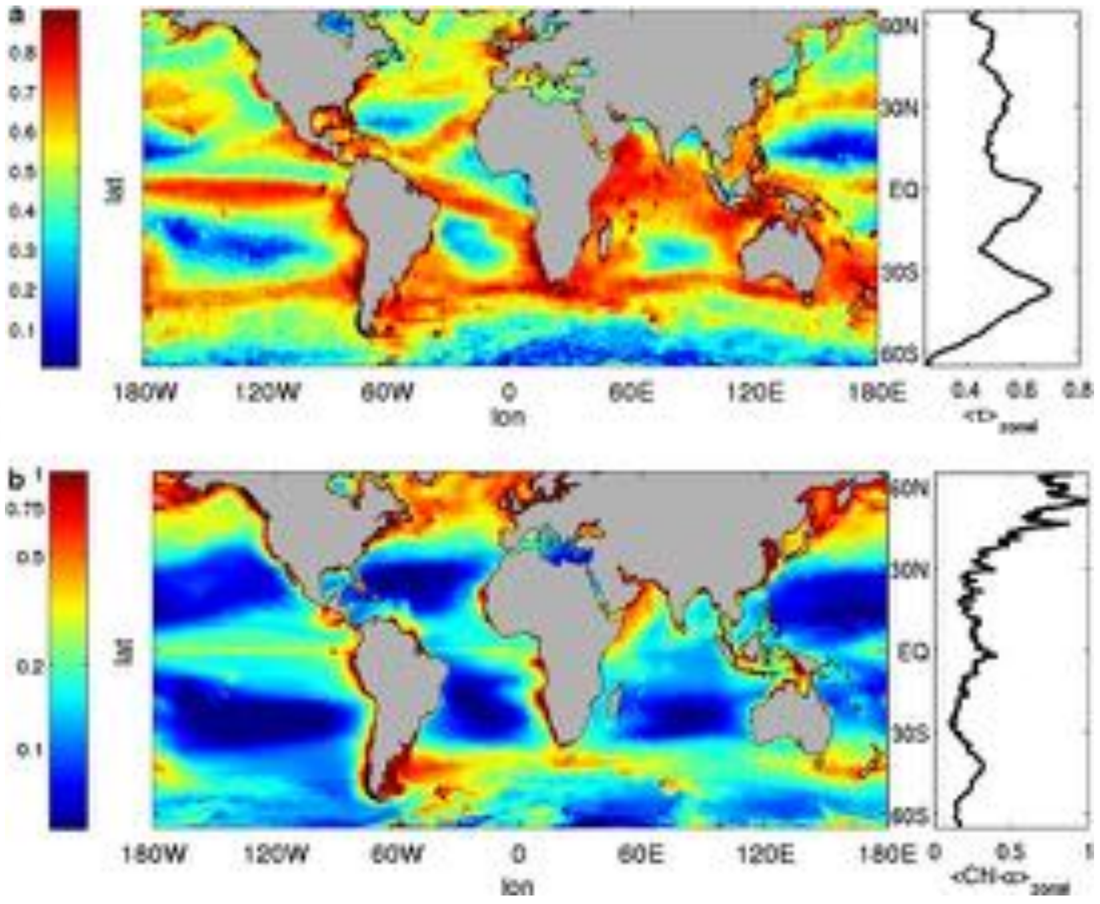
SHORT COMMUNICATION

Can we detect oceanic biodiversity hotspots from space?

Silvia De Monte[1,2,3], Alice Soccodato[4], Séverine Alvain[5] and Francesco d'Ovidio[4]
[1]Ecole Normale Supérieure, Ecologie et Evolution, Paris, France; [2]Université Pierre et Marie Curie-Paris 6, Ecologie et Evolution, Paris, France; [3]CNRS, Ecologie et Evolution, Paris, France; [4]Laboratoire d'Océanographie et du Climat: Expérimentation et Approches Numériques, LOCEAN-IPSL, CNRS/MNHN/IRD/UPMC, Paris, France and [5]Laboratoire d'Océanologie et de Géosciences, CNRS-ULCO-Université Lille Nord de France, Wimereux, France

De Monte et al., 2013





(a) Shannon Index for the global ocean: average of daily maps of the index computed over 7-day composites of PHYSAT data for the period 2003–2010. The hotspots emerging from this analysis characterize regions with a standing representation of several nearby communities, as identified by their dominant phytoplankton types (PHYSAT algorithm applied to SeaWiFS radiances). (b) Average of daily chlorophyll-a maps (SeaWiFS, 2003–2010).


Available online at www.sciencedirect.com
SCIENCE DIRECT
Deep-Sea Research I 52 (2005) 1989–2004
DEEP-SEA RESEARCH Part I
www.elsevier.com/locate/dsr

Remote sensing of phytoplankton groups in case 1 waters from global SeaWiFS imagery

S. Alvain[a], C. Moulin[a,*], Y. Dandonneau[b], F.M. Bréon[a]
[a]IPSL/LSCE, CEA Saclay, Gif-sur-Yvette 91191, France
[b]IRD-IPSL/LOCEAN, 4 place Jussieu, Paris 75252, France

Received 12 July 2004; received in revised form 6 May 2005; accepted 6 June 2005
Available online 9 September 2005

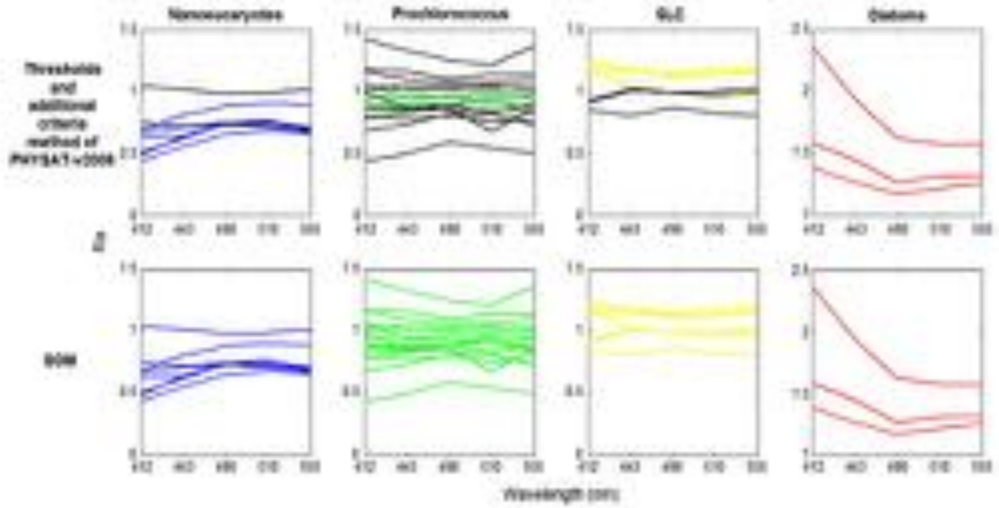

Remote Sensing of Environment 146 (2014) 97–112
Contents lists available at ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

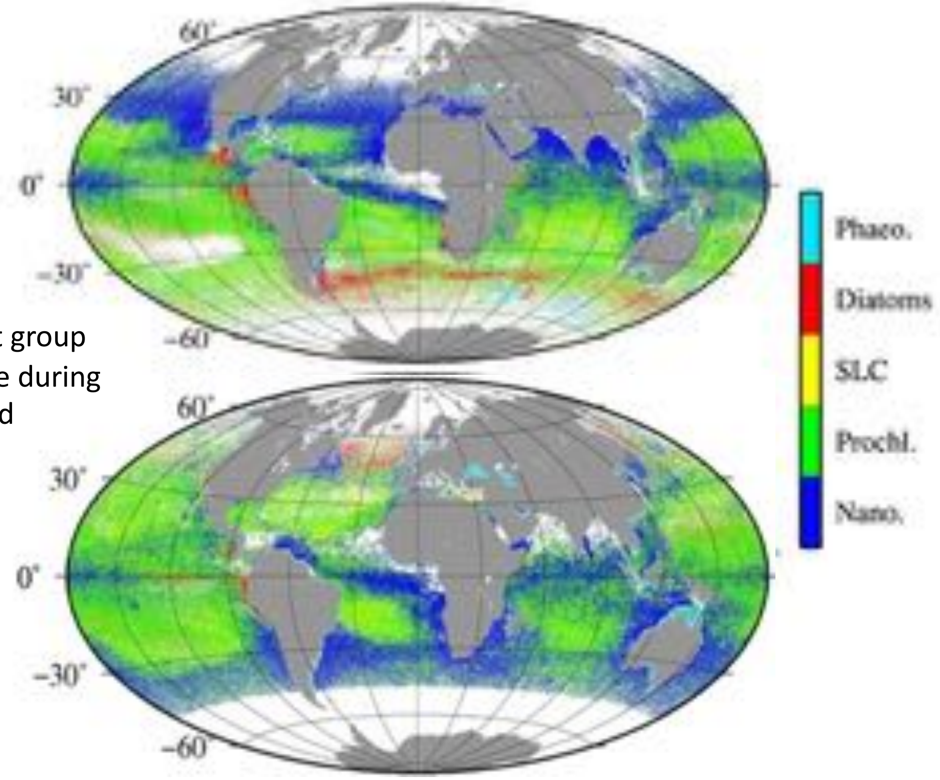
Automatic classification of water-leaving radiance anomalies from global SeaWiFS imagery: Application to the detection of phytoplankton groups in open ocean waters

Zied Ben Mustapha, Séverine Alvain *, Cédric Jamet, Hubert Loisel, David Dessailly

Alvain et al., 2005, Ben Mustapha et al., 2014

Water leaving anomaly per dominant group

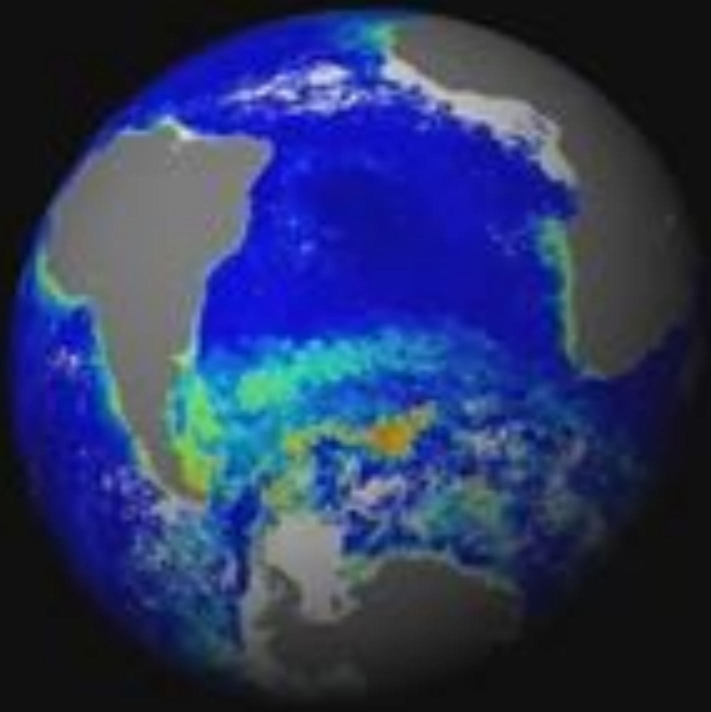




Dominant group composite during winter and summer

Taxonomic groups seen from space

El Hourany, R. *et al.*, 2019



Phytoplankton community structure from space: integration of diagnostic pigment concept in ocean color studies

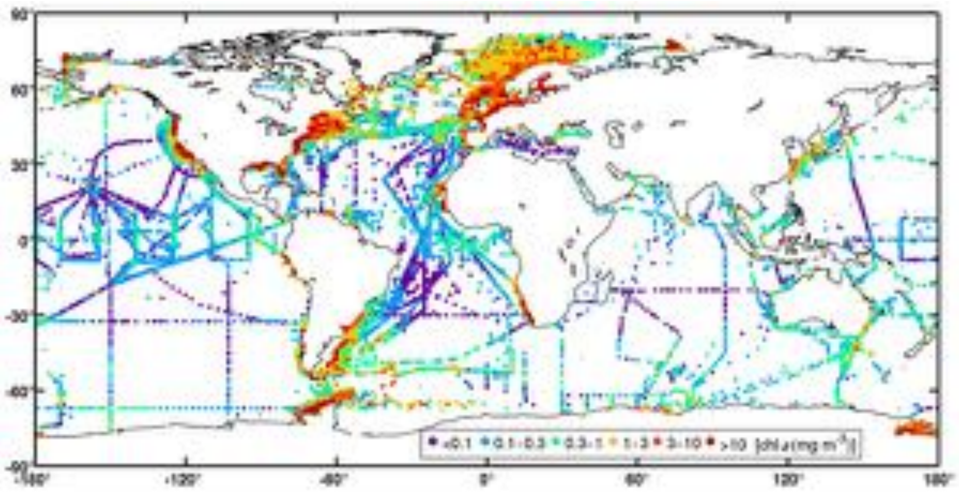
Compilation of published algorithms to assess phytoplankton community composition

Application	PCC product(s)	Algorithm validation data	Remote sensing approaches
Global	Taxonomic group(s)	Direct cell observation (cultures and/or field microscopy)	Subramaniam et al. (2001); Westberry et al. (2005) Subramaniam and Carpenter (1994)
		Pigment concentrations	Alvain et al. (2005); Alvain et al. (2008); Ben Mustapha et al. (2014); Bracher et al. (2009); Hirata et al. (2011); Losa et al. (2017); Moore et al. (2012); Palacz et al. (2013); Sadeghi et al. (2012); Soppa et al. (2014); Xi et al. (2020)
		Spectral signatures	Brown and Yoder (1994)
	Size classes, size index, or PSD	Pigment concentrations	Brewin et al. (2010); Brewin et al. (2015); Devred et al. (2006); Devred et al. (2011); Fujiwara et al. (2011); Hirata et al. (2008); Hirata et al. (2011); Kostadinov et al. (2010); Li et al. (2013); Moore and Brown (2020); Mouw and Yoder (2010); Roy et al. (2013, spectral a_{ph} also used in development); Uitz et al. (2006)
		Mie modeling, Coated Spheres model	Kostadinov et al. (2009); Kostadinov et al. (2022)
		Spectral signatures	Bricaud et al. (2012)
	Accessory pigments	Pigment concentrations	O'Shea et al. (2021); Wang et al. (2018)
Regional /Local	Taxonomic group(s)	Direct cell observation (microscopy of cultures and/or field data or imaging-in-flow cytometry)	Chase et al. (2022); Raitsos et al. (2008) Rêve-Lamarche et al. (2017)
		Pigment concentrations	Di Cicco et al. (2017); Kramer et al. (2018); Palacios et al. (2015); Sathyendranath et al. (2004); Werdell et al. (2014)
		Spectral signatures	
	Size classes, size index, or PSD	Pigment concentrations	Gittings et al. (2019)
		Spectral signatures	Ciotti and Bricaud (2006)
	Accessory pigments	Pigment concentrations	Bracher et al. (2015); Pan et al. (2010); Sun et al. (2022)

Cetinić et al.,2024

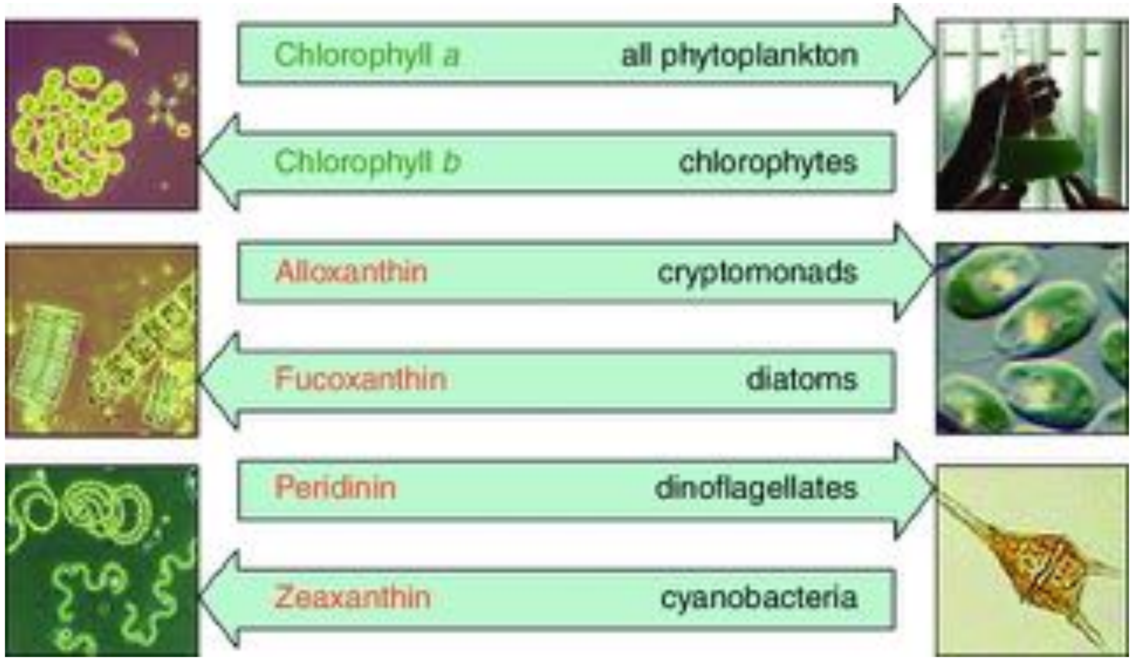
>70% PCC studies from satellite are based on pigments

Phytoplankton community structure from space: integration of diagnostic pigment concept in ocean color studies



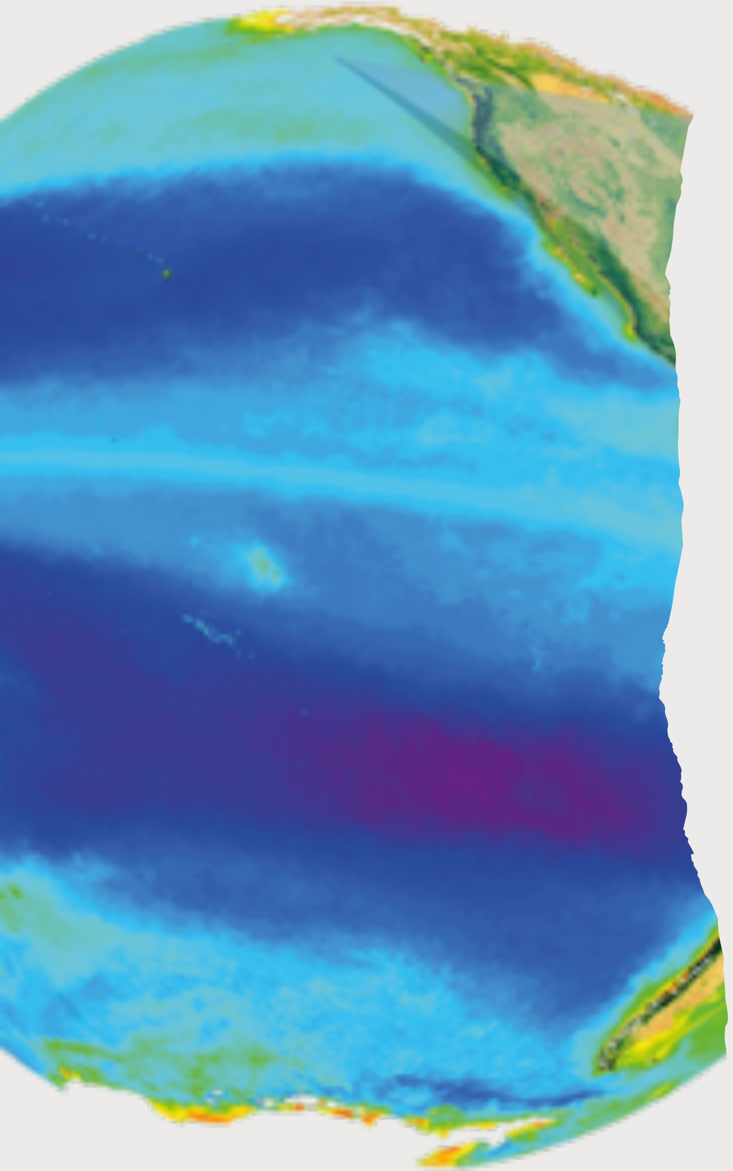
A methodology covering Prok to Euk phytoplankton

Over 20K obs compiled HPLC dataset of Chla and several pigments measured at the surface (<30m), (Valente et al., 2019; Kramer et al., 2019)

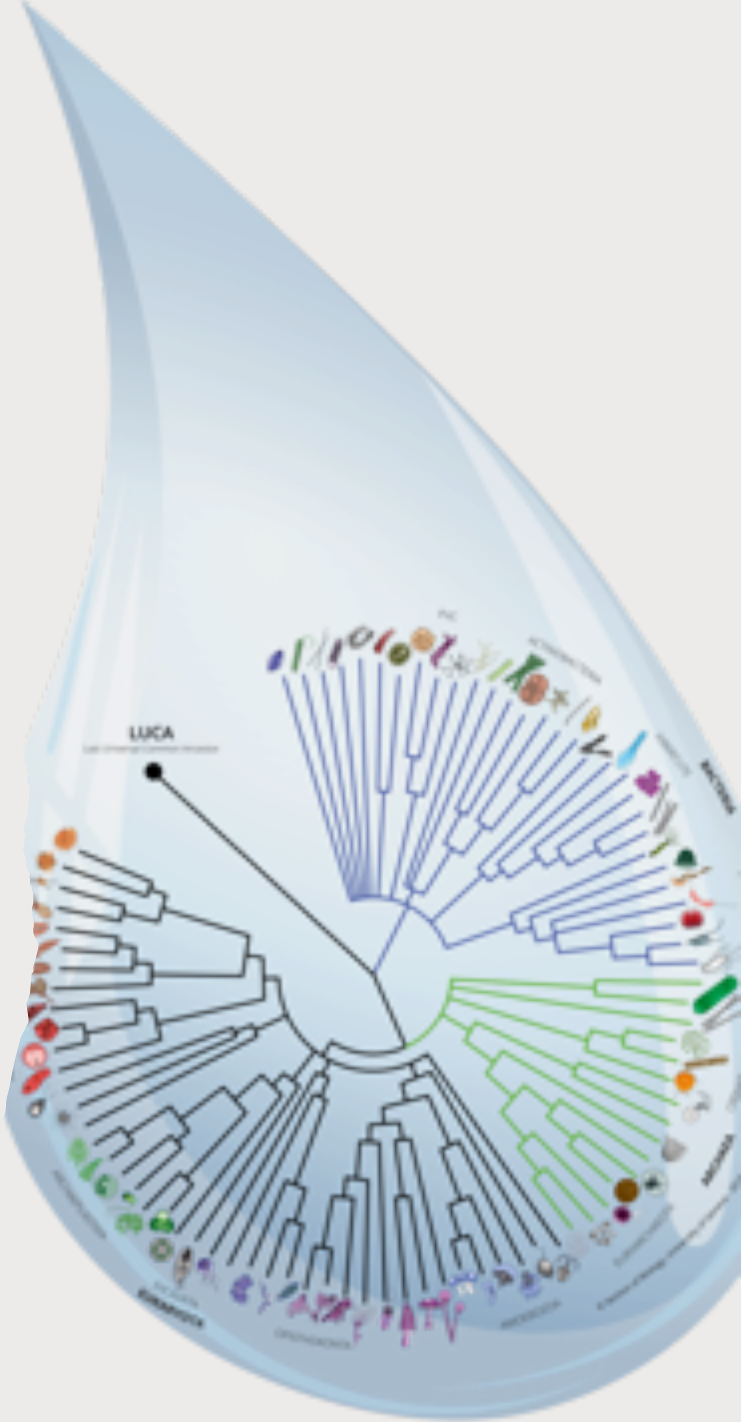


Examples of the major phytoplankton groups and their diagnostic photopigments. From Paerl, H.W., Valdes, L.M., Pinckney, J.L., Piehler, M.F., Dyble, J., Moisander, P.H., 2003. Phytoplankton photopigments as indicators of estuarine and coastal eutrophication. BioScience 53 (10), 953-964.

Broad taxonomic resolution, physiology-dependent



Complexity in a drop:
The Omics Toolbox



TARA OCEANS 2009 - 2014

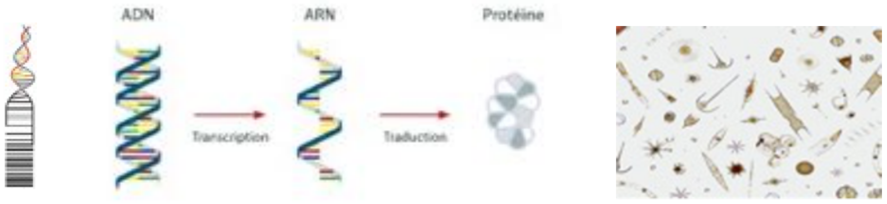
tara PACIFIC 2016 - 2018

Mission Microplastiques 2019

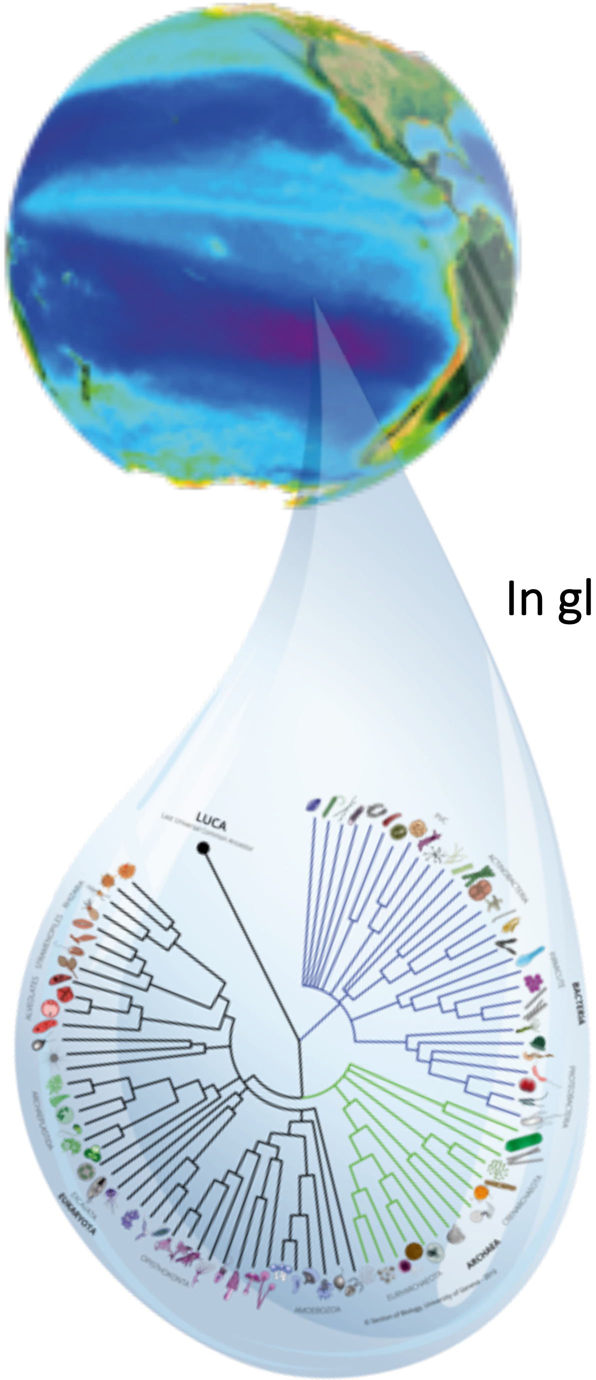
Mission Microbiomes 2021 - 2022

tara EUROPA 2023 – 2024

The Omics Toolbox



MetaBarcoding MetaGenomics MetaTranscriptomics

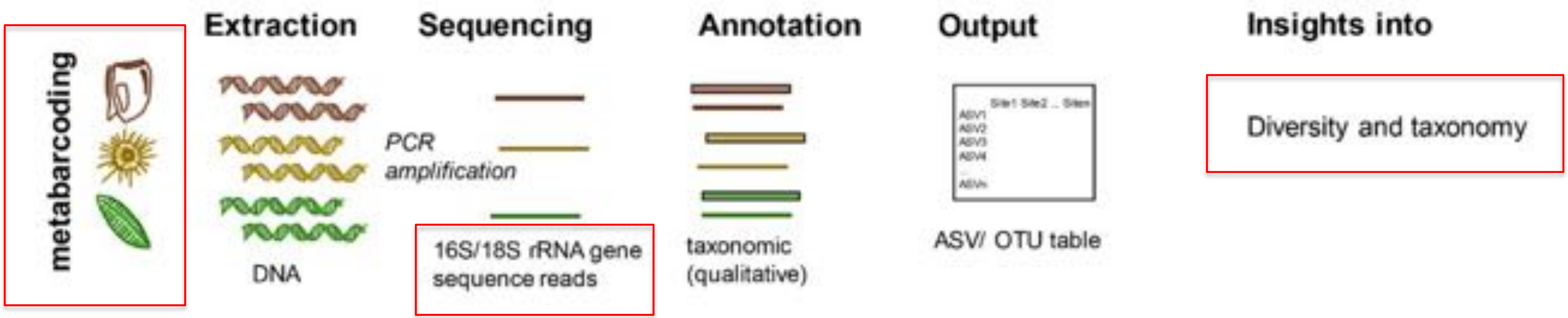


Diversity uncovered

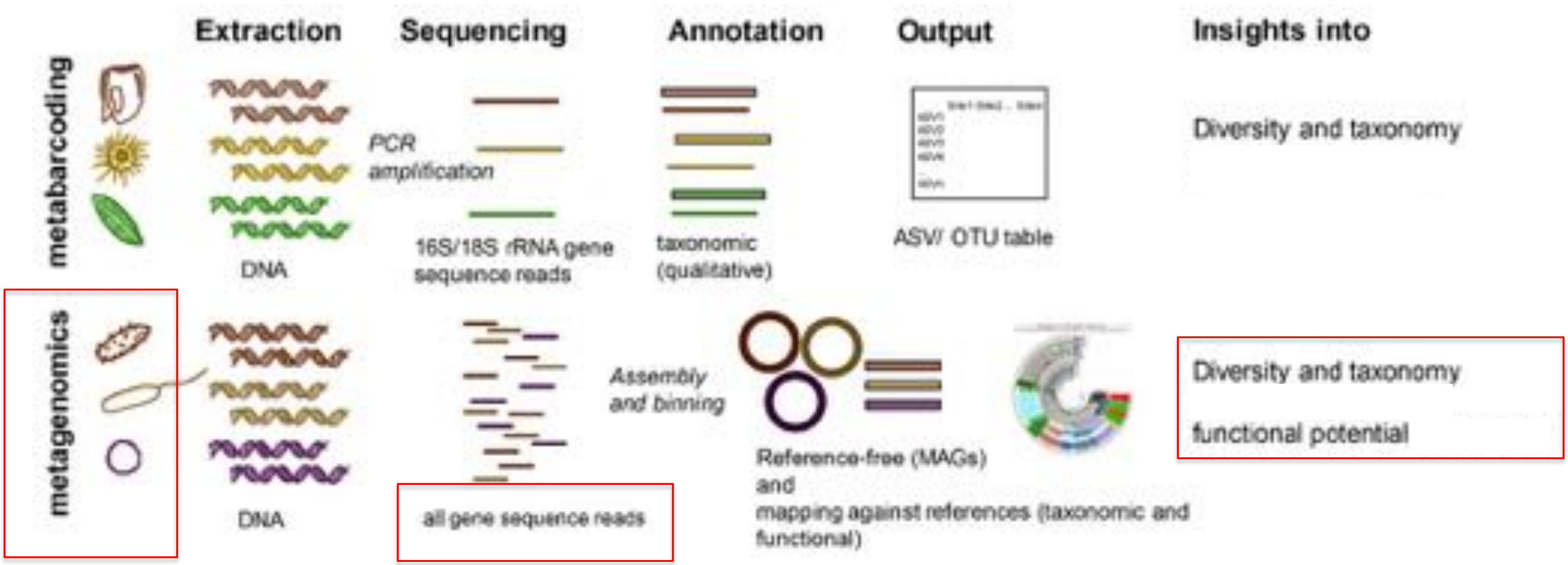
In global ocean surface waters:

- ✓ Hundred thousands of DNA and RNA virus 'species'.
- ✓ Hundred thousands of eukaryotic genera
- ✓ Tens of millions of prokaryotic genes
- ✓ Hundreds of millions of eukaryotic genes
- ✓ Billions of metabolites

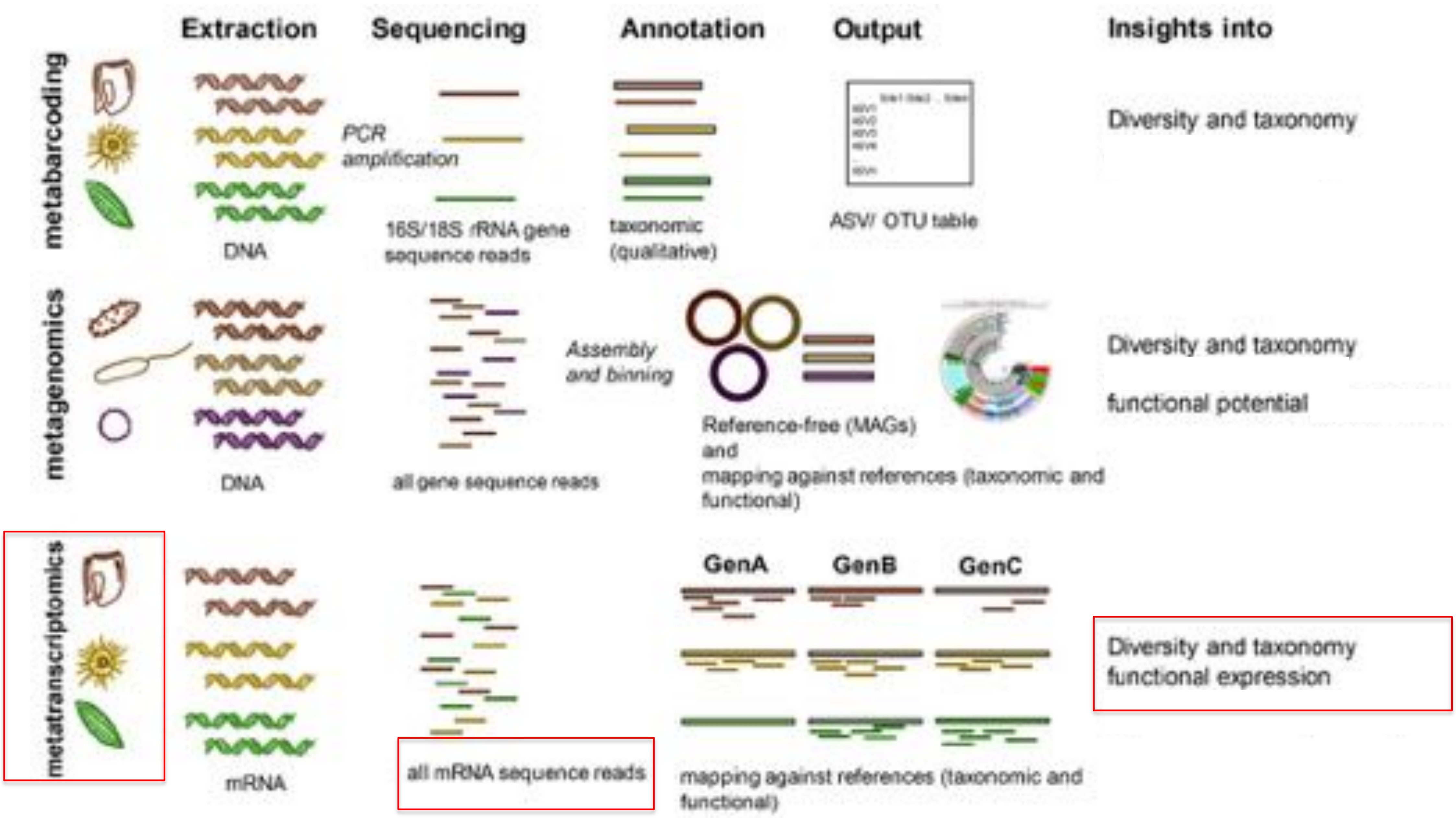
Metabarcoding, Metagenomics and Metatranscriptomics



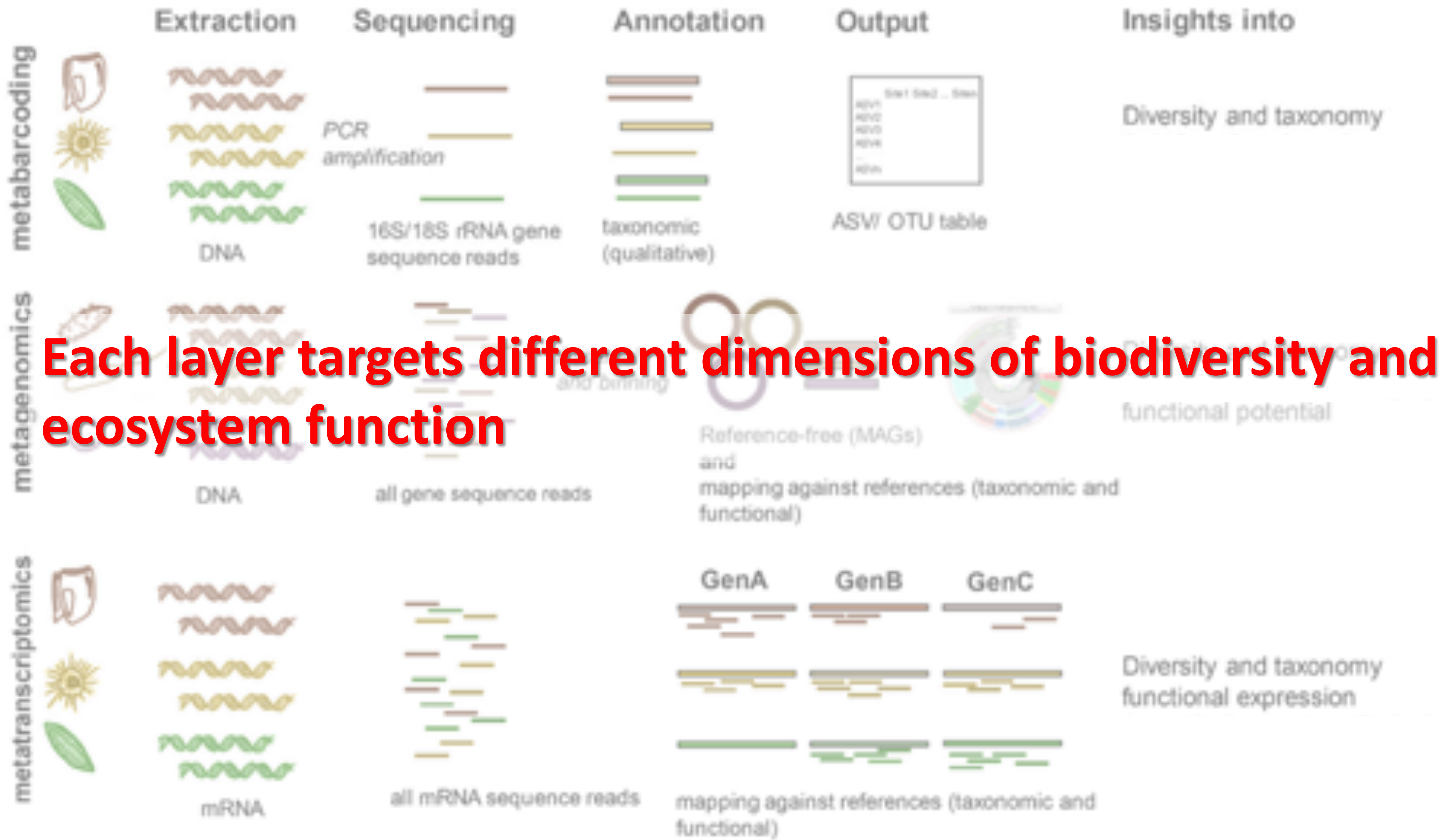
Metabarcoding, Metagenomics and Metatranscriptomics



Metabarcoding, Metagenomics and Metatranscriptomics



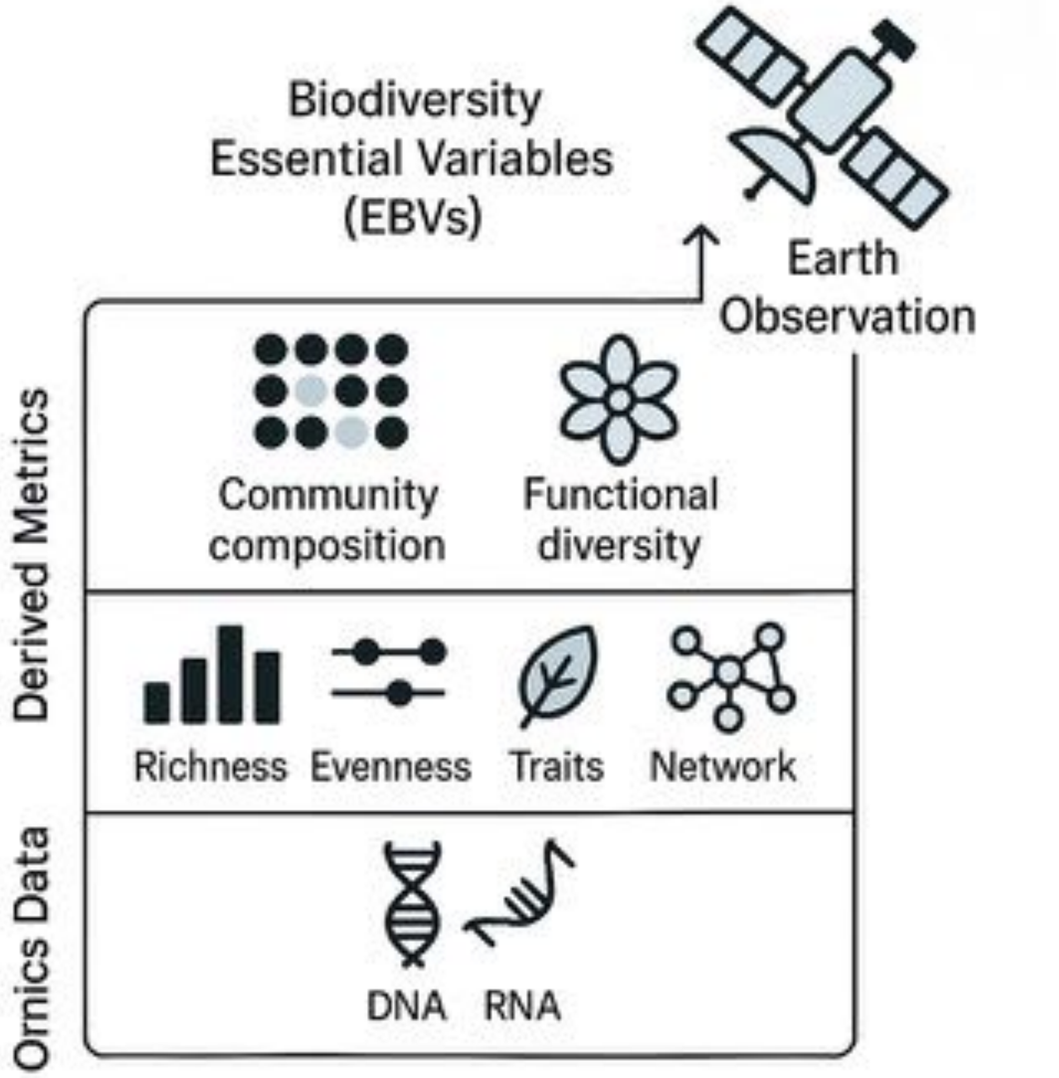
Metabarcoding, Metagenomics and Metatranscriptomics



Each layer targets different dimensions of biodiversity and ecosystem function

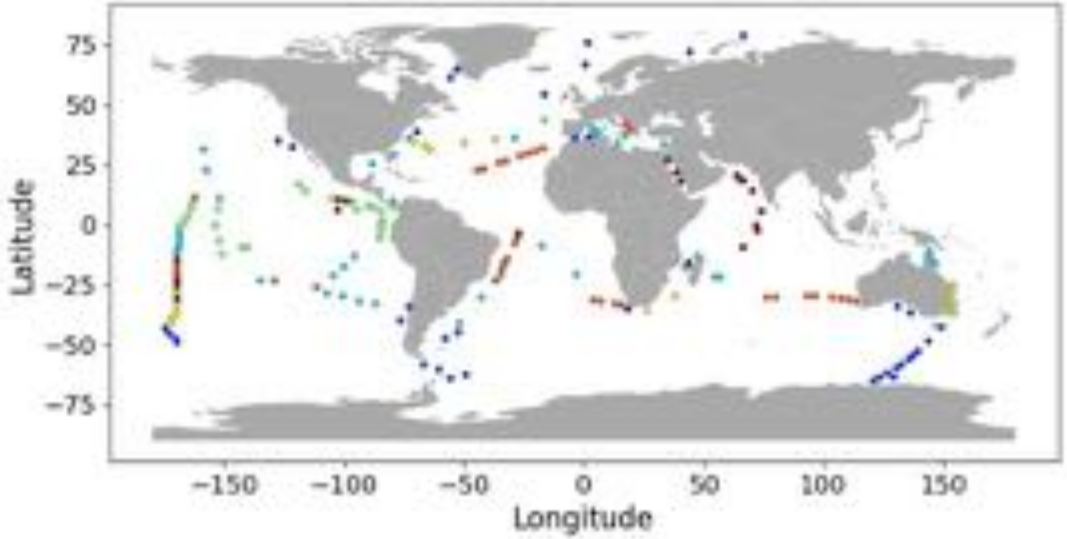
From Sequences to Satellites

- **Derive metrics**: richness, evenness, traits, network structure, functional diversity, and Translate these metrics into candidate EBVs (e.g., community composition),
- These omics-derived metrics become training data for EO-driven models



Linking Omics and Satellites: Metabarcoding approach

- Global 18S rRNA gene, decodes a part of the ribosomal RNA in **eukaryotes**, collocated with satellite data,



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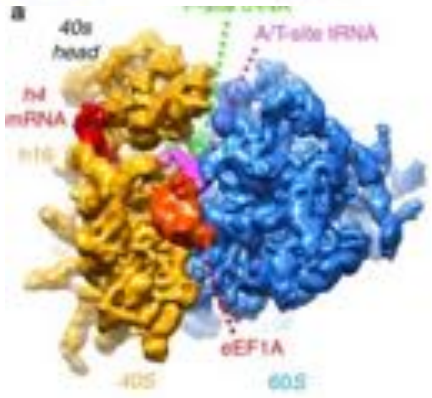
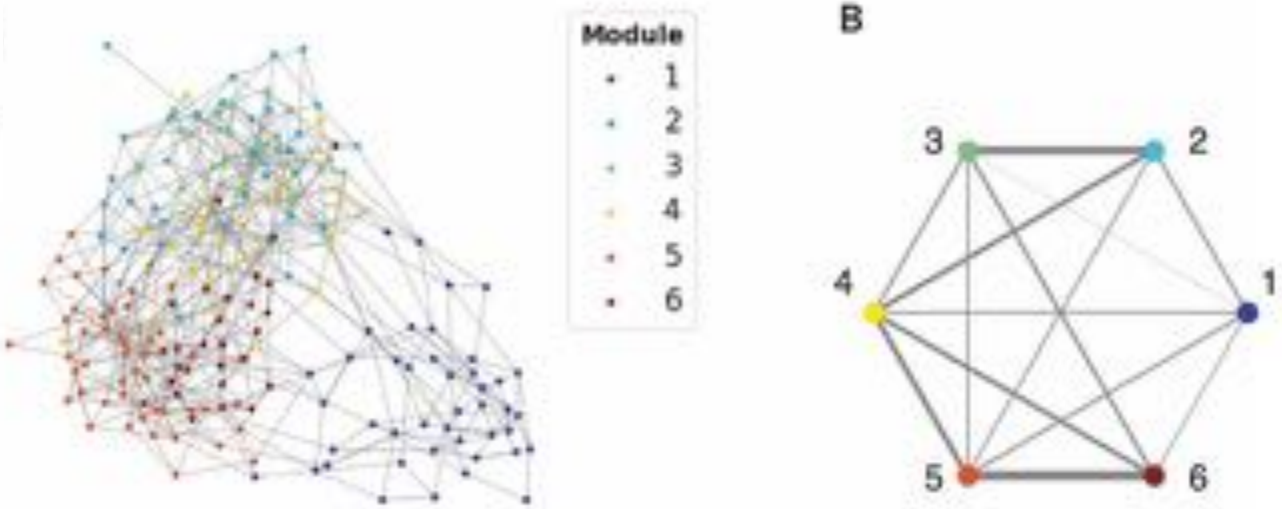
Predicting global distributions of eukaryotic plankton communities from satellite data

Hiroto Kaneko[1], Hisashi Endo[1], Nicolas Henry[2,3], Cédric Berney[2,4], Frédéric Mahé[5,6], Julie Poulain[7], Karine Labadie[8], Odette Beluche[8], Roy El Hourany[9,10], Tara Oceans Coordinators*, Samuel Chaffron[3,11], Patrick Wincker[7], Ryosuke Nakamura[12], Lee Karp-Boss[13], Emmanuel Boss[13], Chris Bowler[3,10], Colomban de Vargas[2,4], Kentaro Tomii[14], and Hiroyuki Ogata[1]





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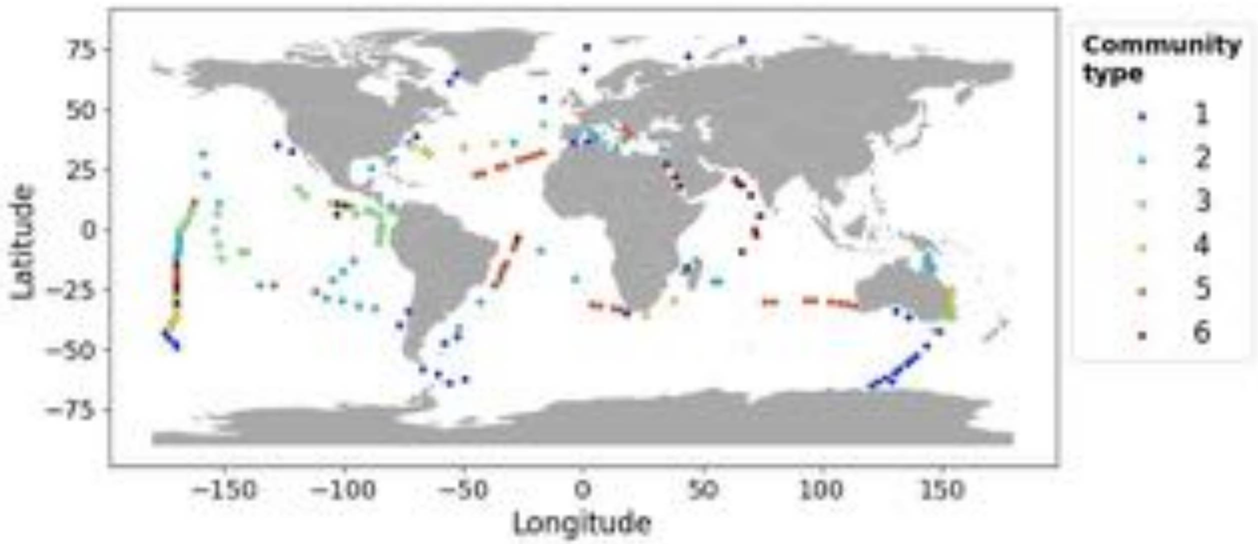

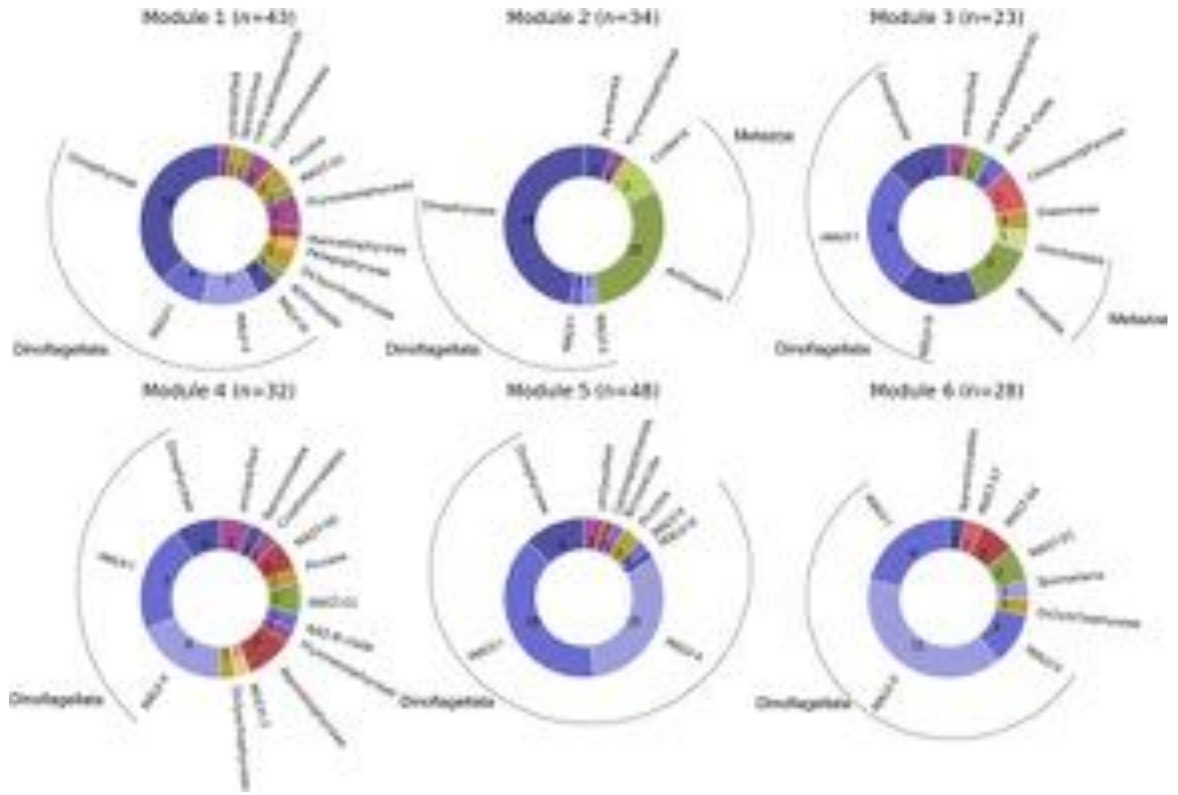

653 samples, 177 monthly matchups with 17 satellite variables from MODIS: Rrs(412), Rrs(443), Rrs(469), Rrs(488), Rrs(531), Rrs(547), Rrs(555), Rrs(645), Rrs(667), Rrs(678), Chla, Kd490, POC, PIC, PAR, nFLH, SST

Linking Omics and Satellites: Metabarcoding approach


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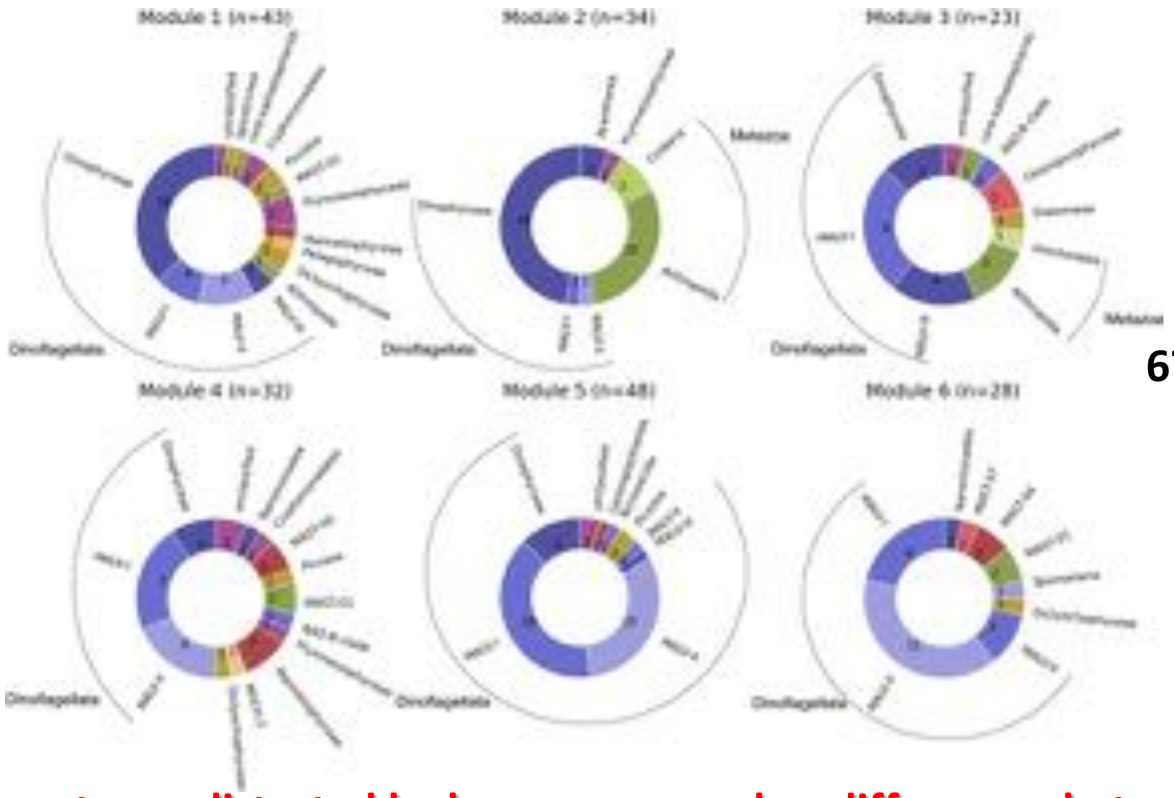
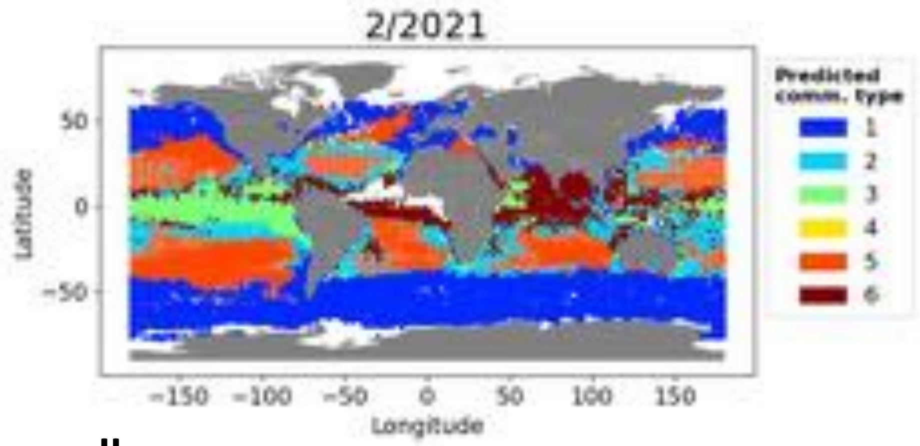
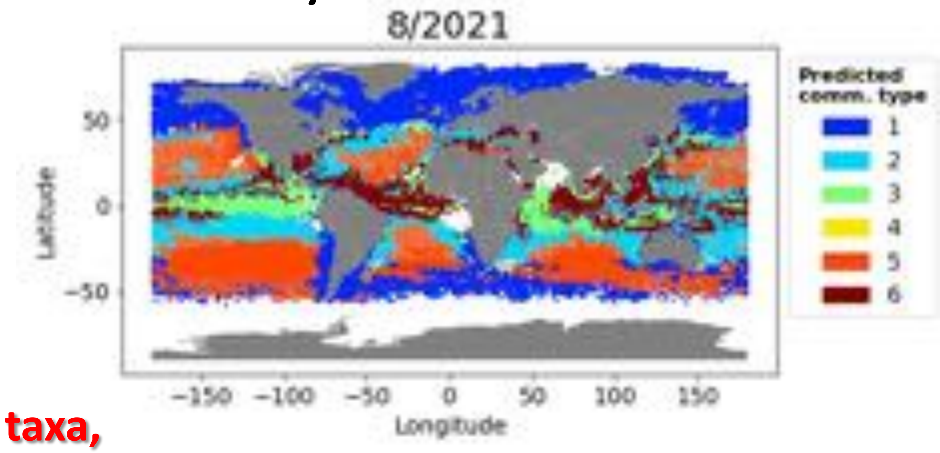
- Global 18S rRNA gene, decodes a part of the ribosomal RNA in **eukaryotes**, collocated with satellite data,
- Classification ML algorithm to predict plankton community types Produces maps of community type,
- Demonstrates feasibility of EO-informed biodiversity predictions.





67 % overall accuracy



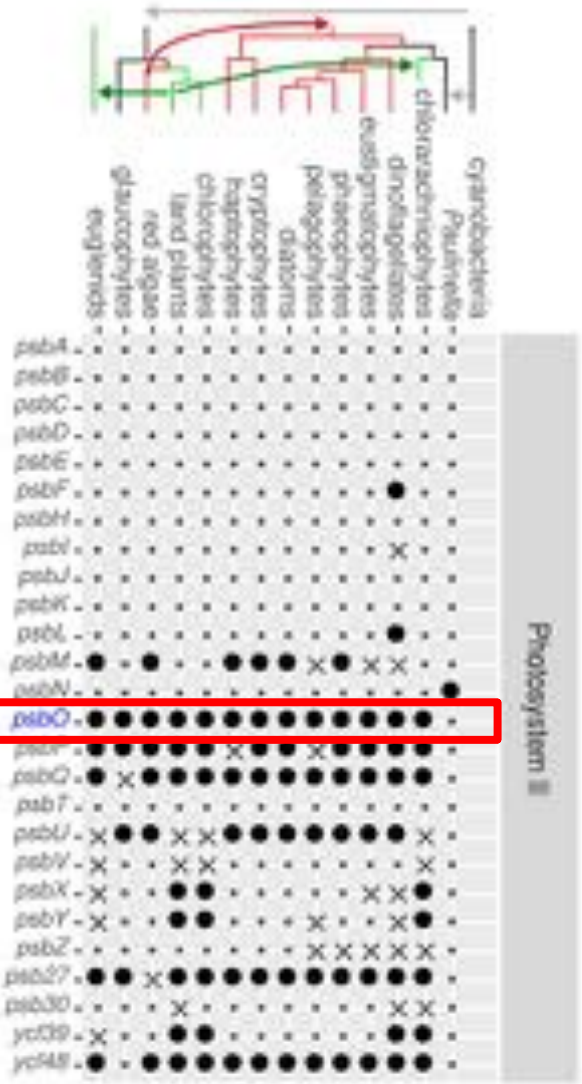
18S read counts are distorted by huge copy-number differences between taxa, so they don't scale linearly with cell abundance.

Linking Omics and Satellites:
Searching for an unbiased approach using metagenomics

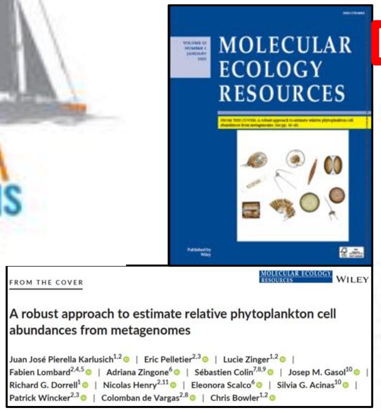
The *psbO protein*; a core subunit of photosystem II (PSII), unique to organisms that carry out oxygenic photosynthesis.

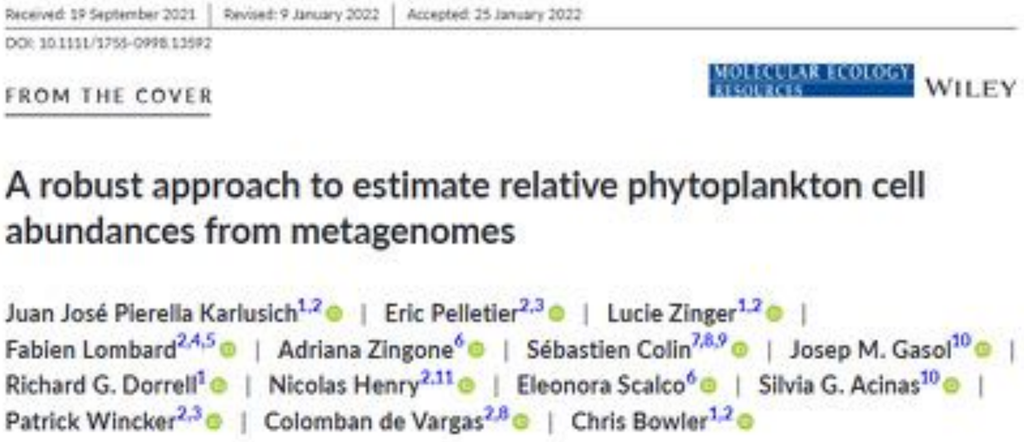
The *psbO* is* a single-copy gene, present in both eukaryotes and prokaryotes groups

= Proxy of cell abundance



TARA OCEANS





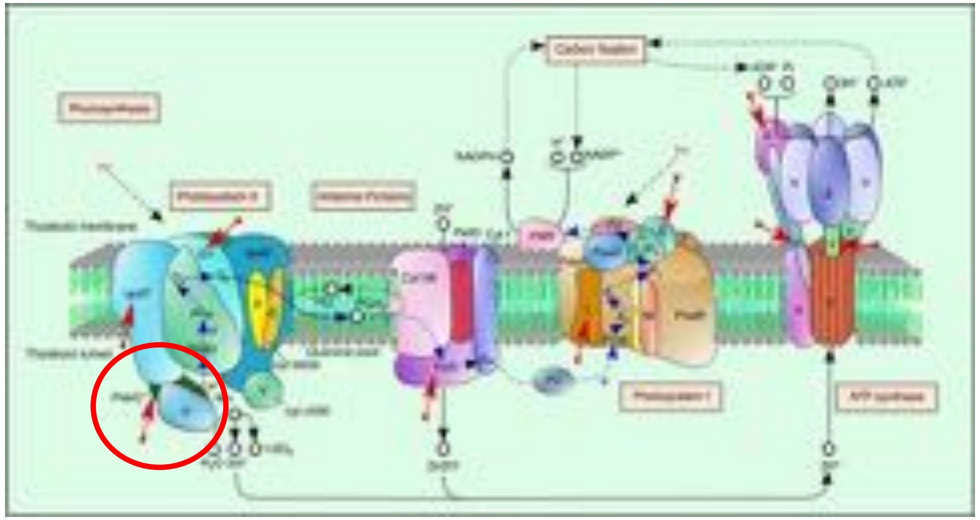
Received: 19 September 2021 | Revised: 9 January 2022 | Accepted: 25 January 2022
DOI: 10.1111/1755-0998.13592

FROM THE COVER

MOLECULAR ECOLOGY RESOURCES WILEY

A robust approach to estimate relative phytoplankton cell abundances from metagenomes

Juan José Pierella Karlusich[1,2] | Eric Pelletier[2,3] | Lucie Zinger[1,2] | Fabien Lombard[2,4,5] | Adriana Zingone[6] | Sébastien Colin[7,8,9] | Josep M. Gasol[10] | Richard G. Dorrell[1] | Nicolas Henry[2,11] | Eleonora Scalco[6] | Silvia G. Acinas[10] | Patrick Wincker[2,3] | Colomban de Vargas[2,8] | Chris Bowler[1,2]



[Pierella et al., 2022, https://doi.org/10.1111/1755-0998.13592](https://doi.org/10.1111/1755-0998.13592)

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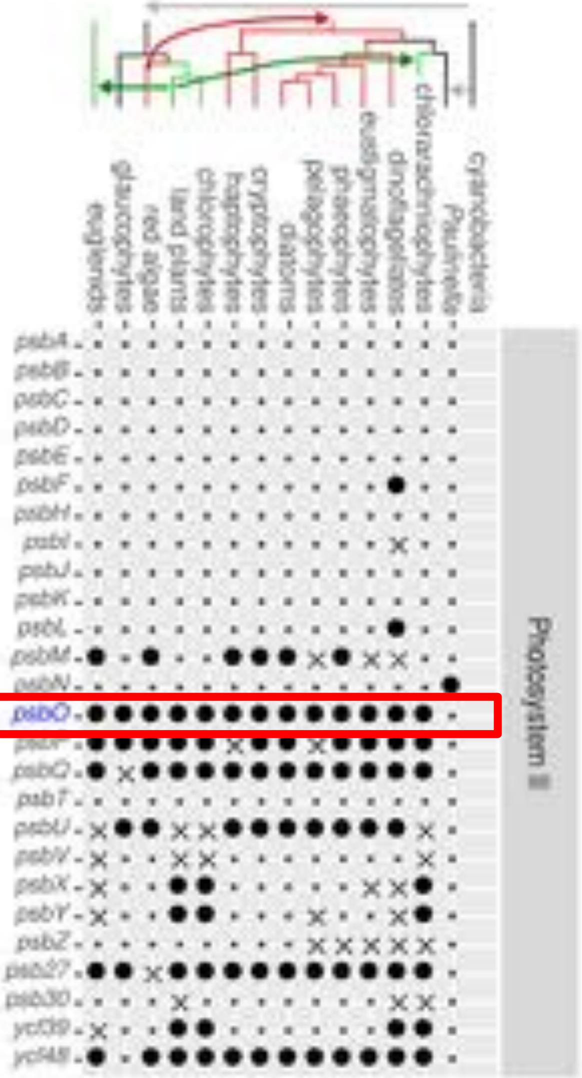

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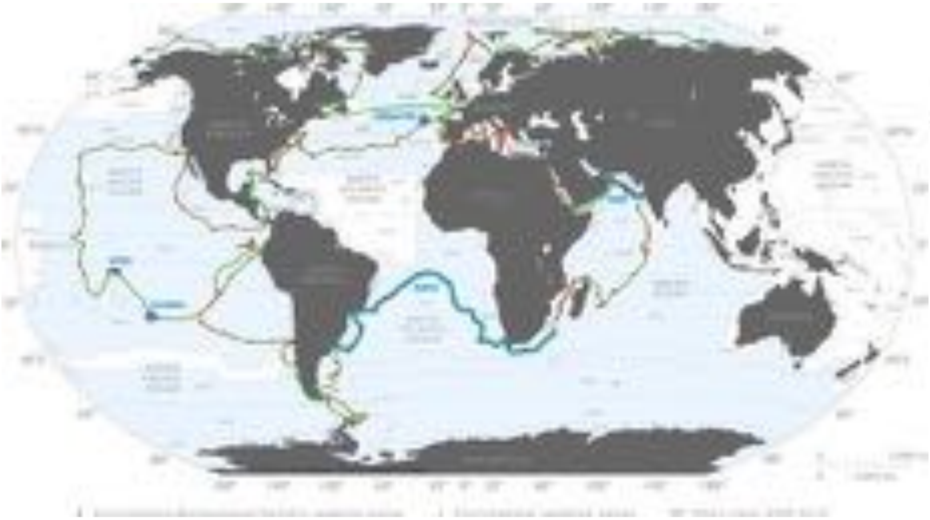

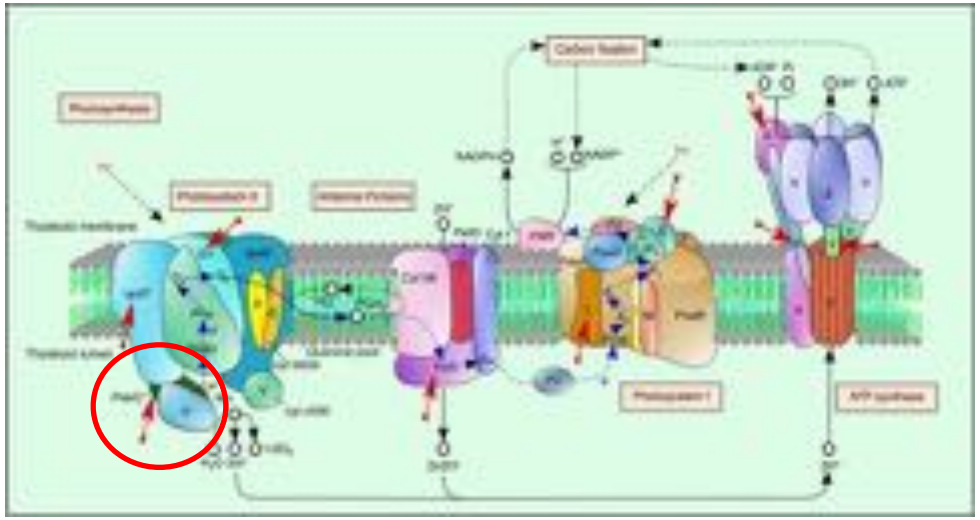

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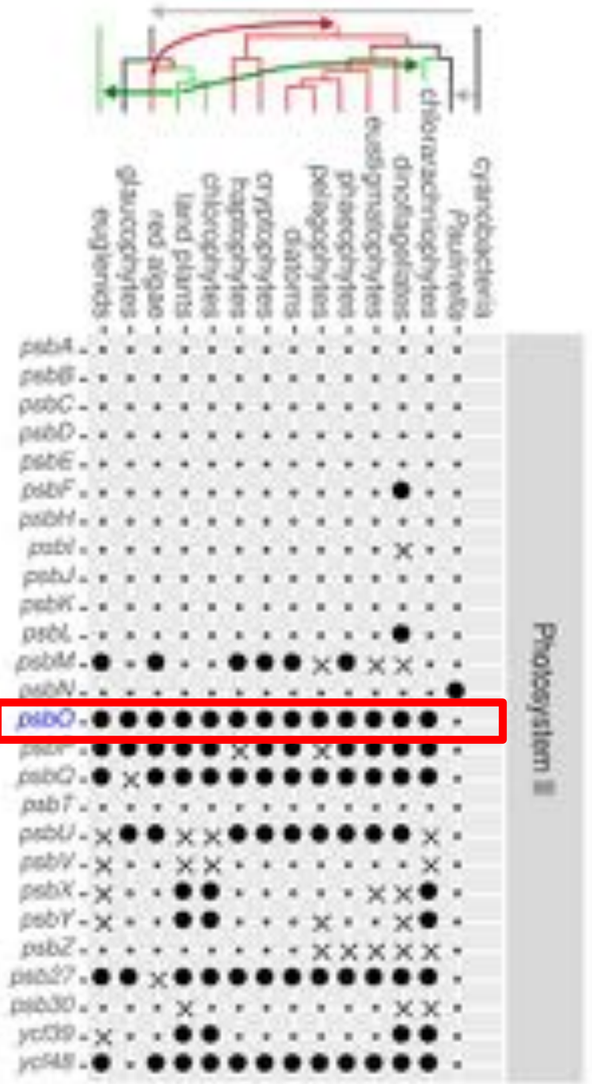

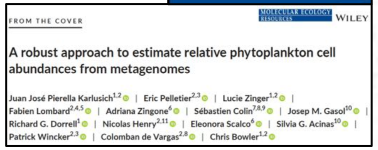
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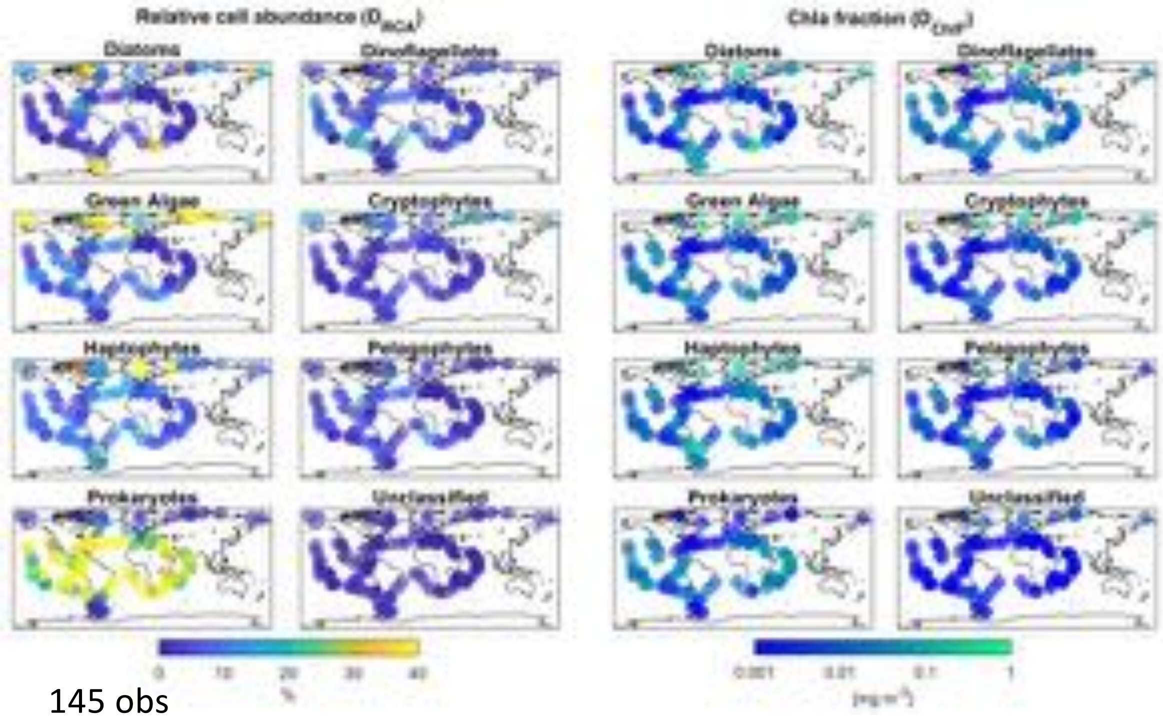

145 obs

*integrating size fractions (4 sizes)

El Hourany, R., 2024,
Zenodo. https://doi.org/10.5281/zenodo.10361485

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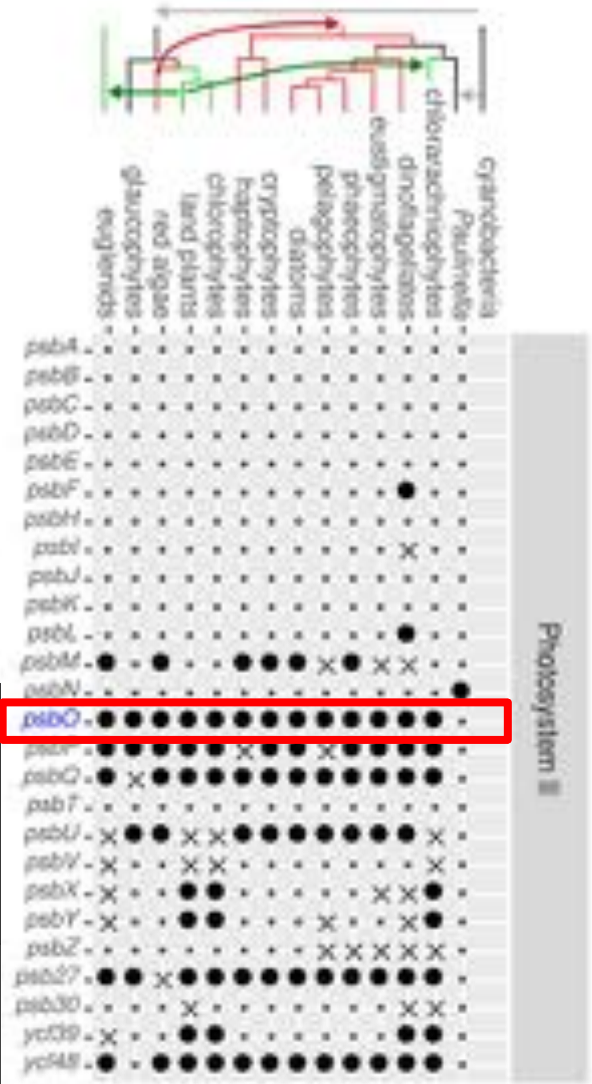
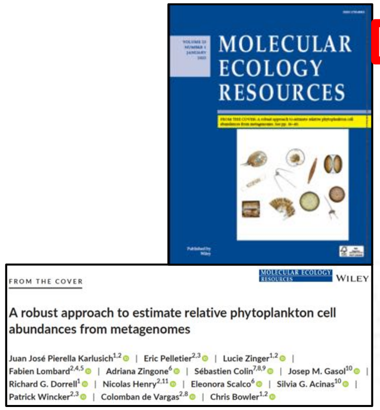
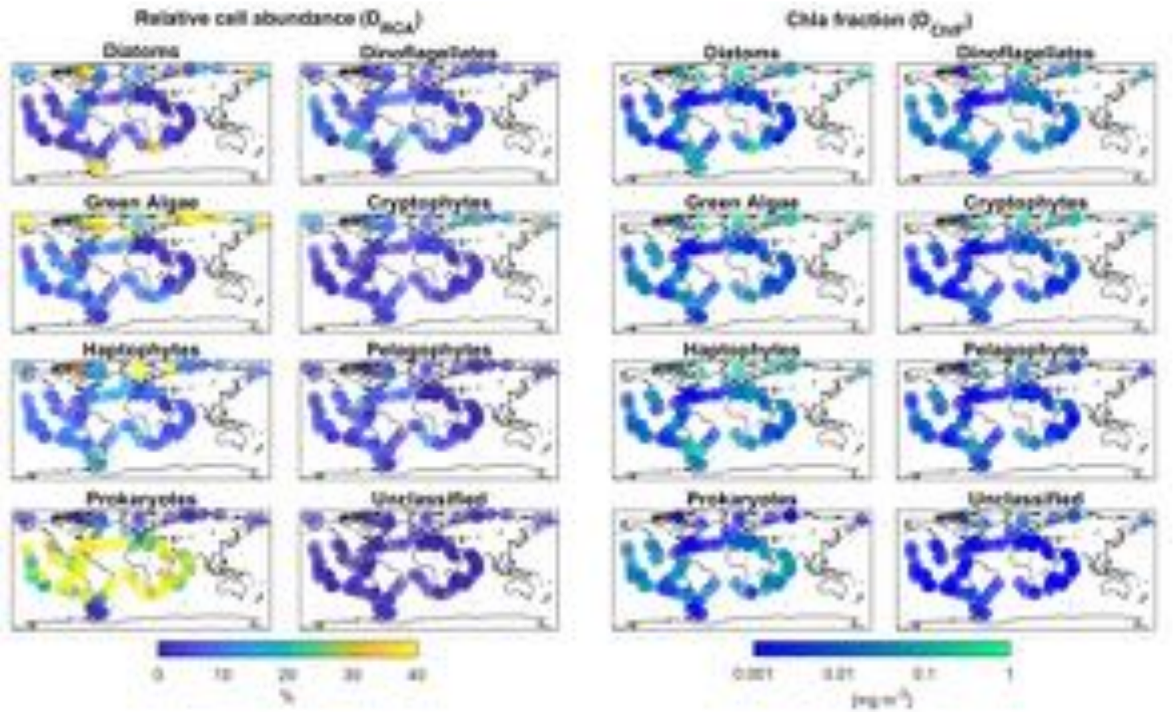




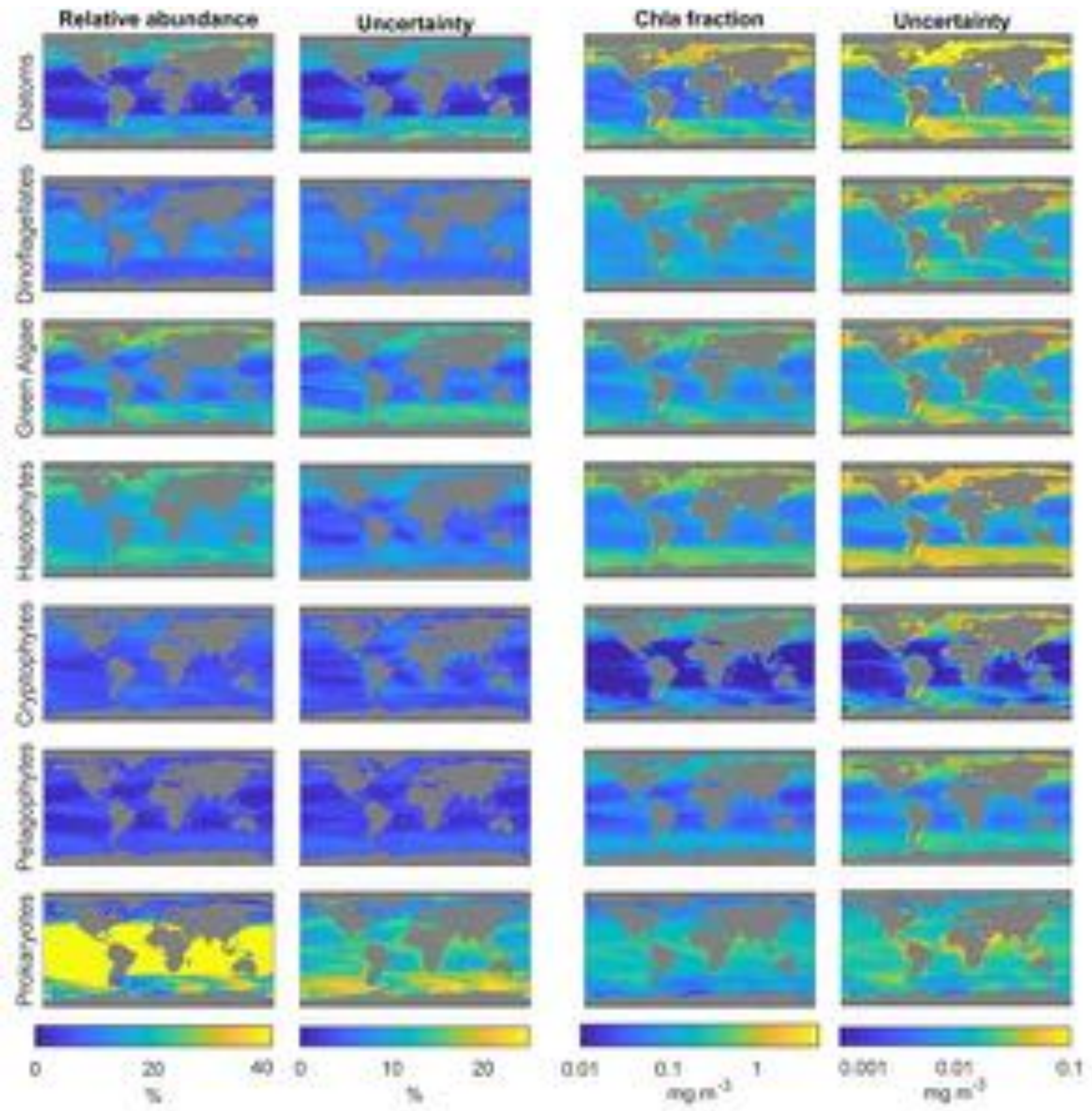


145 obs

Satellite matchups (at daily or +-3 days, 4km resolution)

(Reflectance at several wavelengths, Chlorophyll-a, sea surface temperature, PAR, Fluorescence, bbp (443), attenuation coefficient)

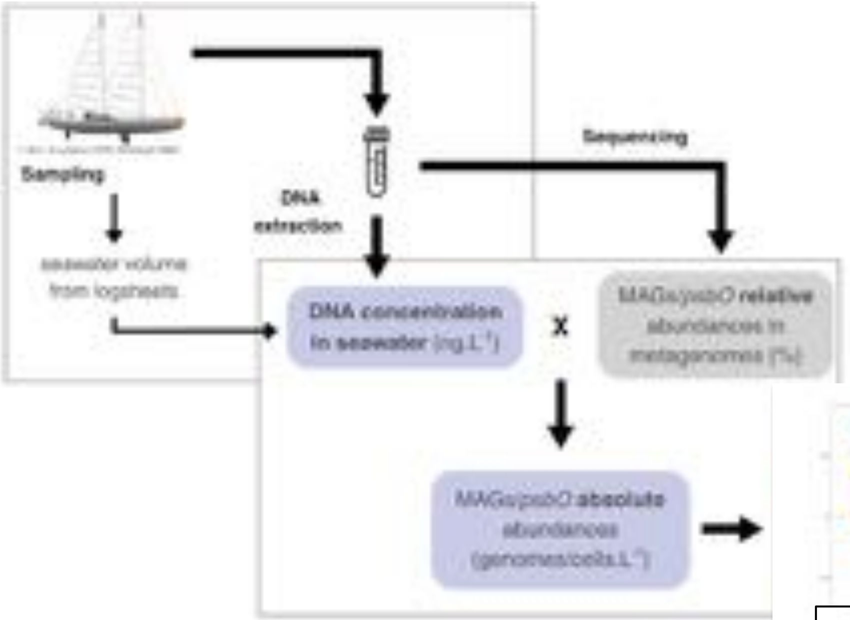
Linking Omics and Satellites:
Searching for an unbiased approach using metagenomics



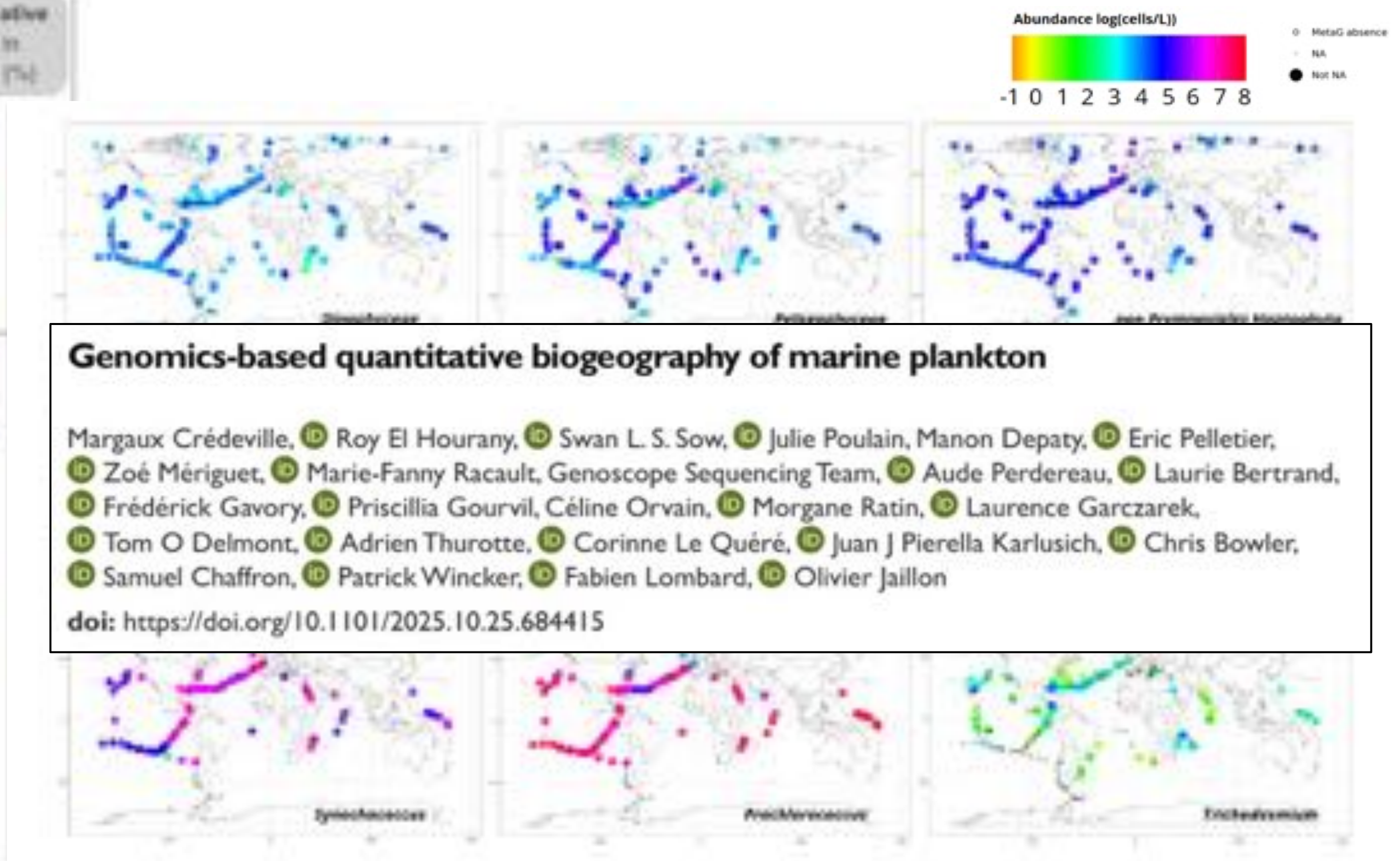
65 % overall accuracy

El Hourany, R. et al., Linking satellites to genes with machine learning to estimate phytoplankton community structure from space, Ocean Sci., 20, 217–239, https://doi.org/10.5194/os-20-217-2024, 2024.

From DNA to Cell abundance



- Convert DNA concentration into absolute cell concentrations per lineage
- Focus on psbO marker gene to quantify 17 photosynthetic lineages over 3 size filters



Genomics-based quantitative biogeography of marine plankton

Margaux Crédeville, Roy El Hourany, Swan L. S. Sow, Julie Poulain, Manon Depaty, Eric Pelletier, Zoé Mériguet, Marie-Fanny Racault, Genoscope Sequencing Team, Aude Perdereau, Laurie Bertrand, Frédérick Gavory, Priscillia Gourvil, Céline Orvain, Morgane Ratin, Laurence Garczarek, Tom O Delmont, Adrien Thurotte, Corinne Le Quéré, Juan J Pierella Karlusich, Chris Bowler, Samuel Chaffron, Patrick Wincker, Fabien Lombard, Olivier Jaillon

doi: https://doi.org/10.1101/2025.10.25.684415

TARA OCEANS **2009 - 2014**

tara PACIFIC **2016 - 2018**

Crédeville, El Hourany, Jaillon et al, Genomics-based quantitative biogeography of marine plankton
bioRxiv 2025.10.25.684415; doi: https://doi.org/10.1101/2025.10.25.684415

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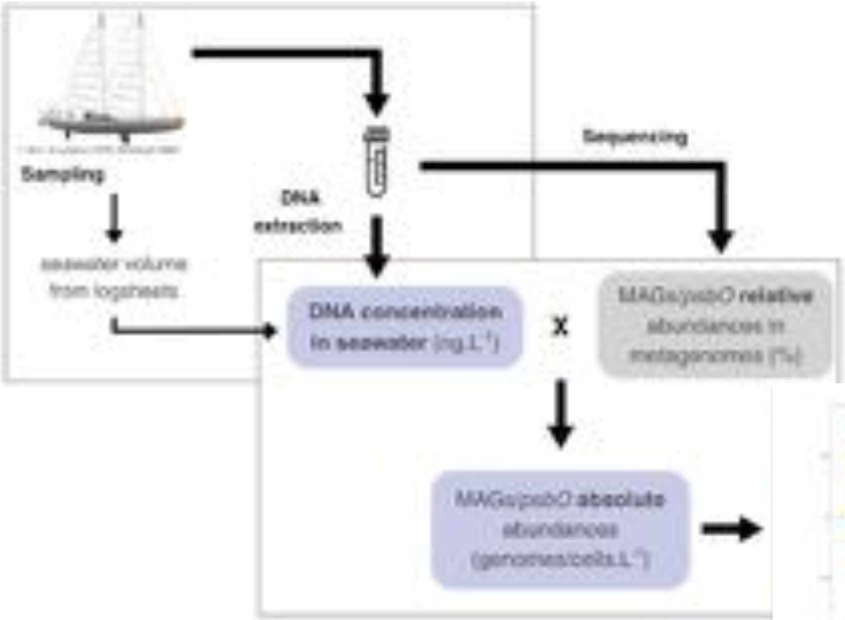

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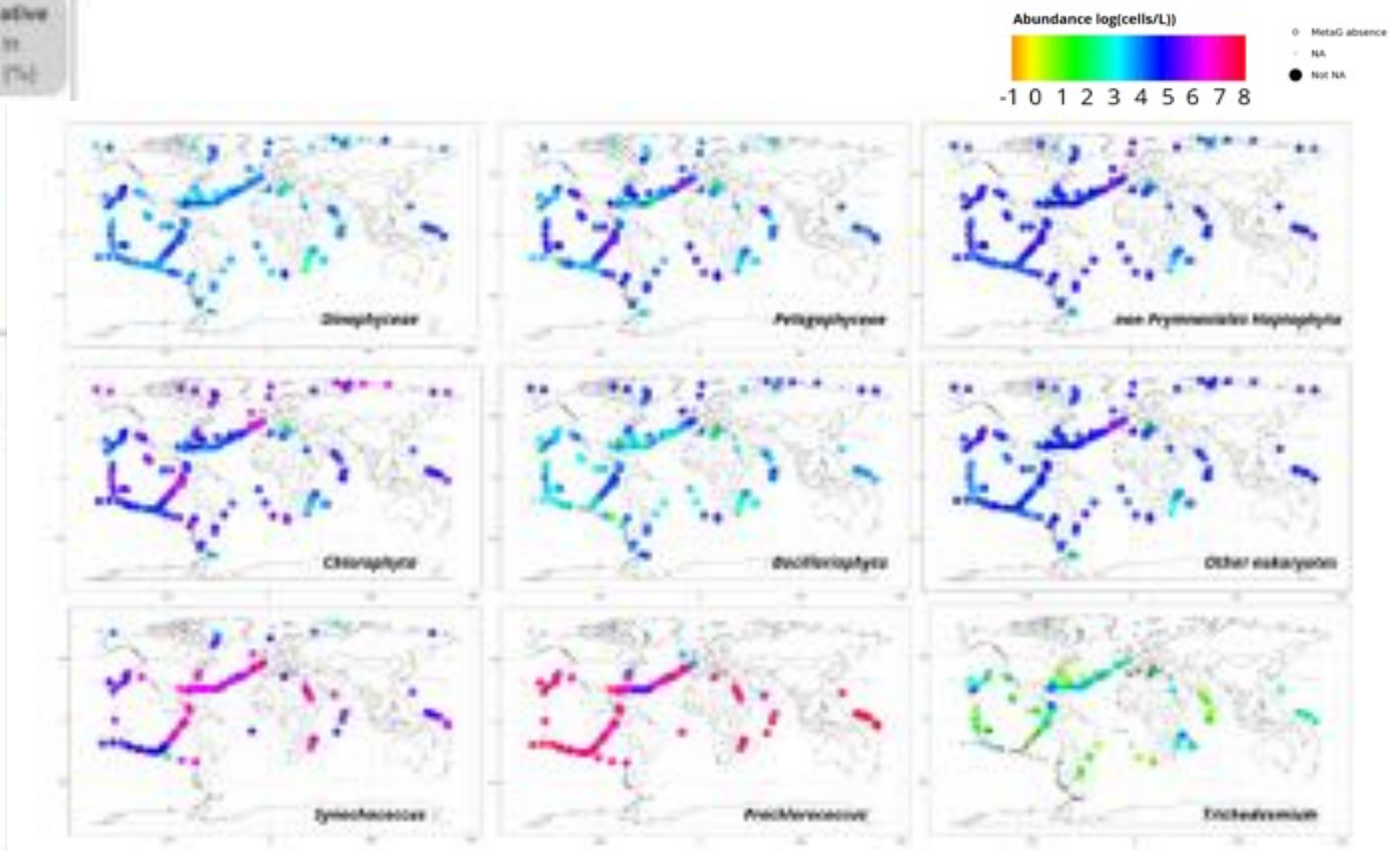

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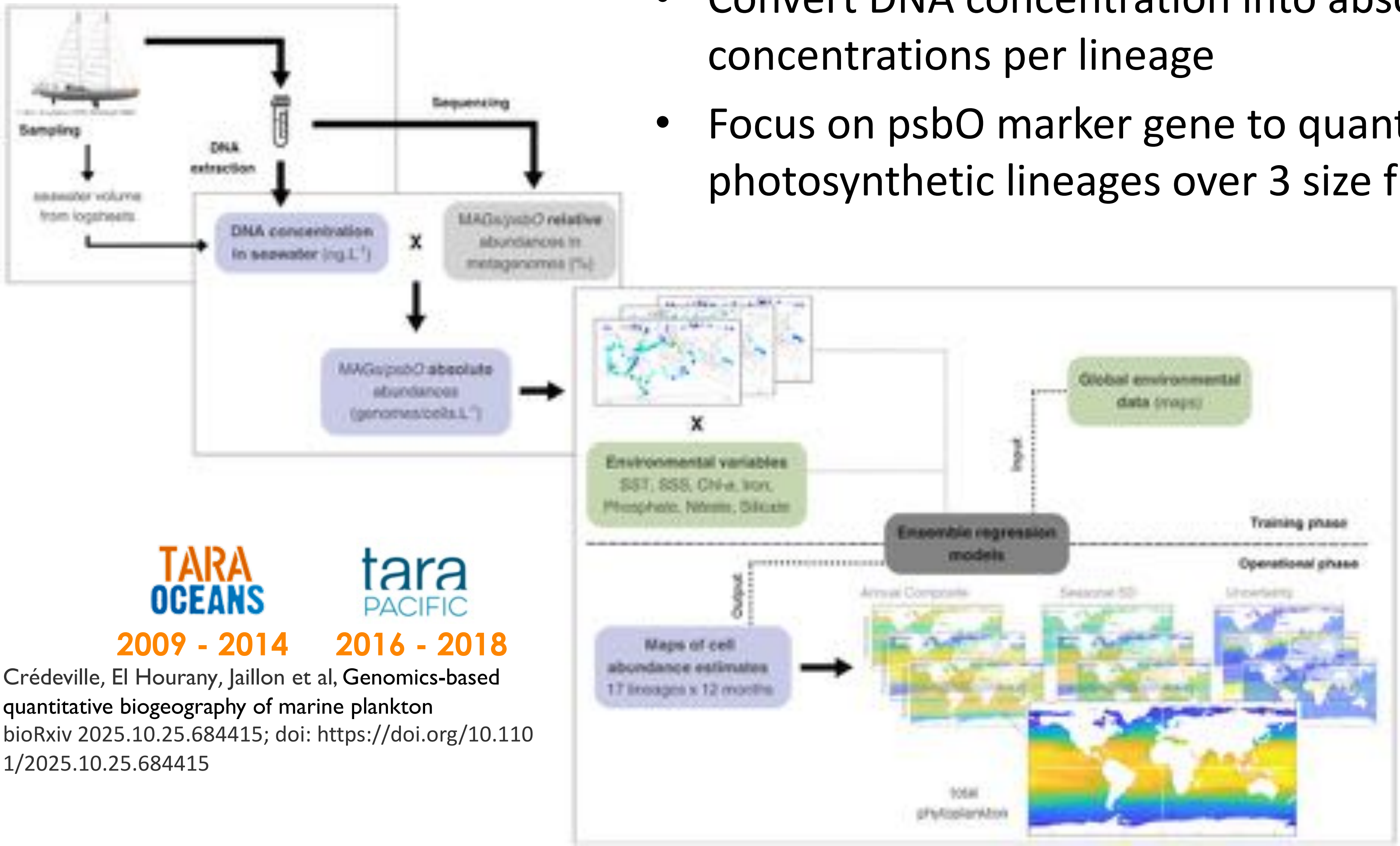

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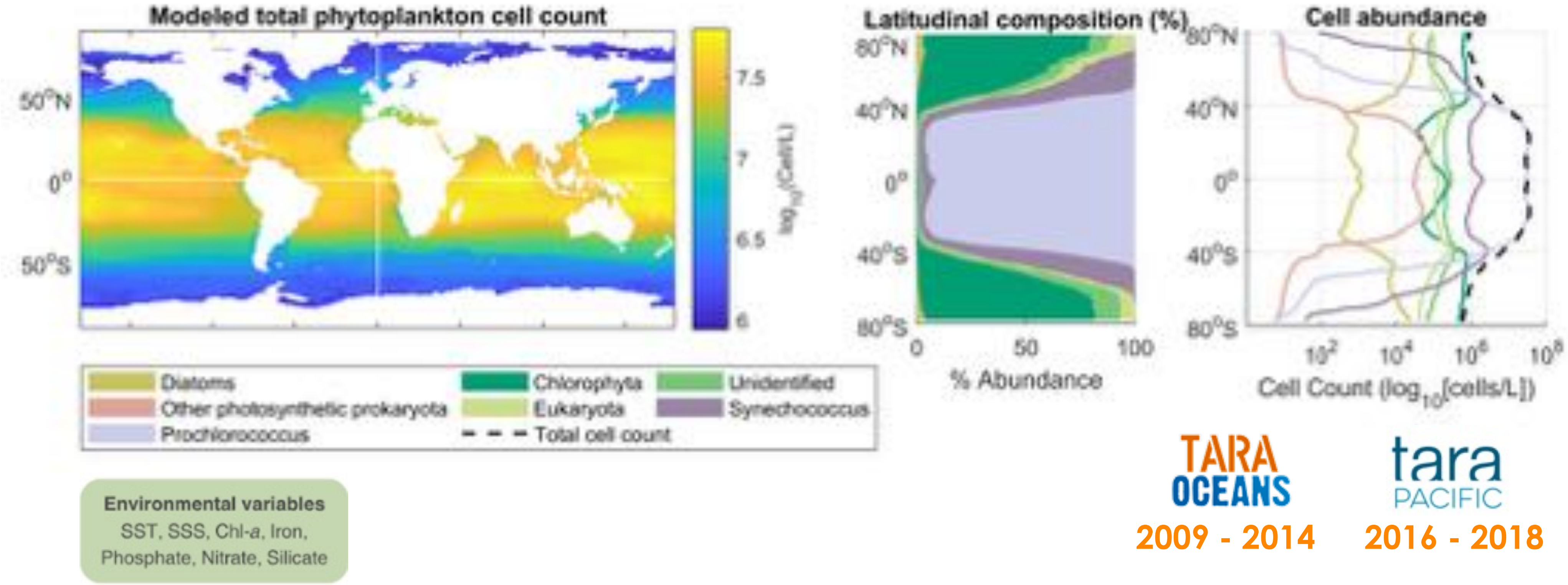
From DNA to Cell abundance

Build phytoplankton community maps based on absolute cell abundance



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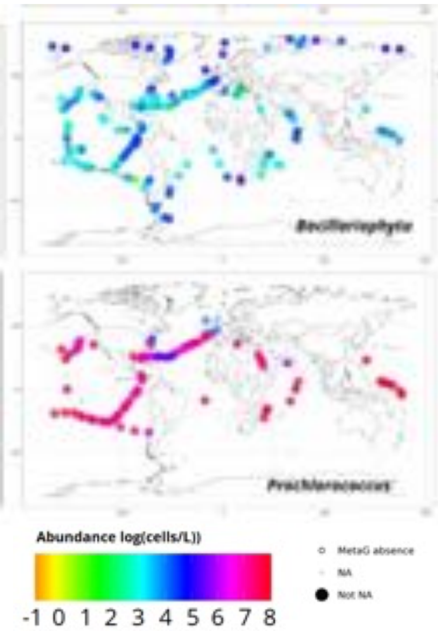
From DNA to Cell abundance to Carbon

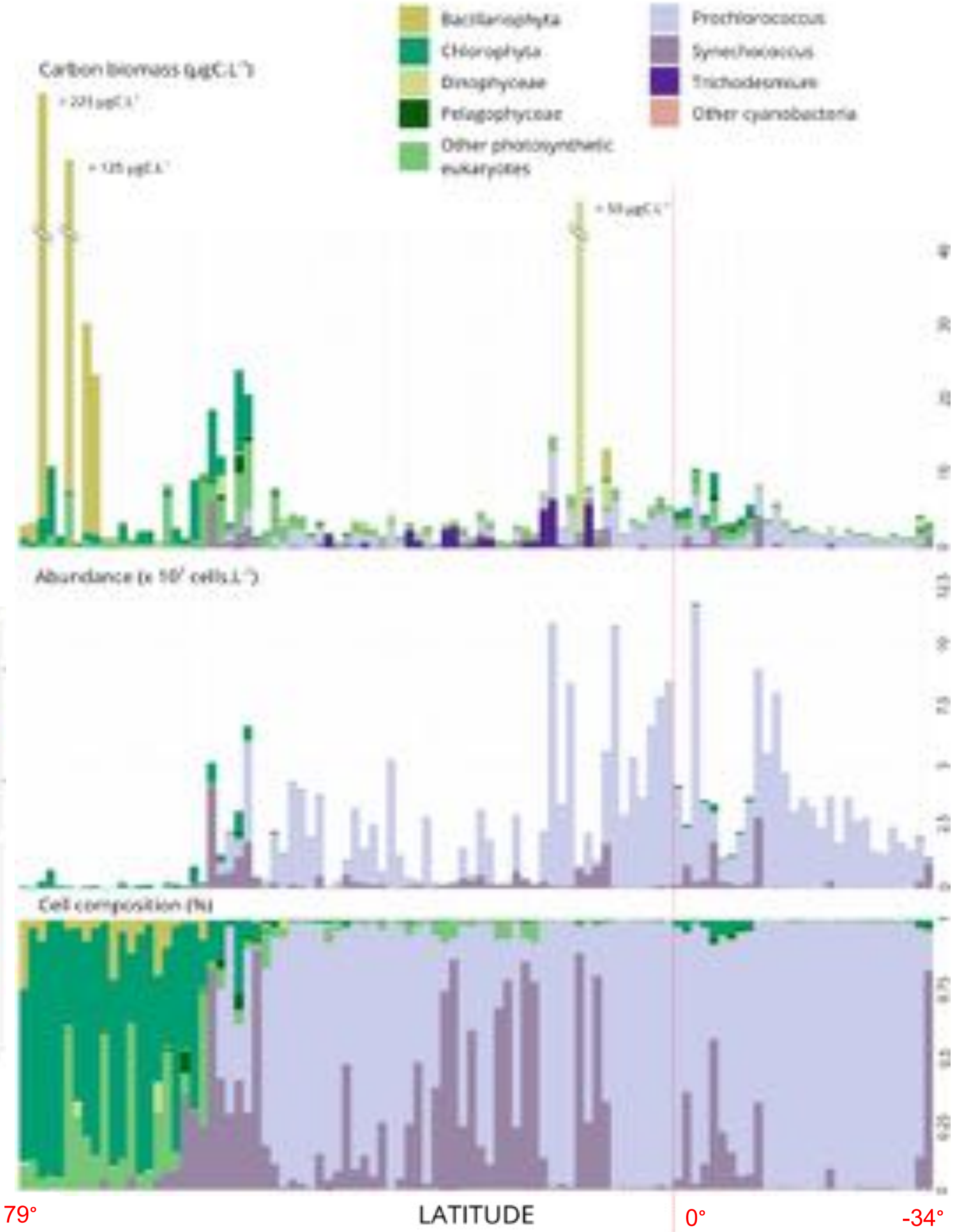
Latitudinal variation in phytoplankton community composition derived from metagenomic-based quantification of *psbO*-lineages, estimated cell abundance, and carbon biomass across global ocean regions, revealing differing patterns among the three metagenomic-based estimates.

Integrated over the 0.2–2,000 µm plankton size range at surface stations from Tara *Oceans,* Tara *Oceans Polar Circle, and* Tara *Pacific.*

TARA OCEANS
2009 - 2014

tara PACIFIC
2016 - 2018





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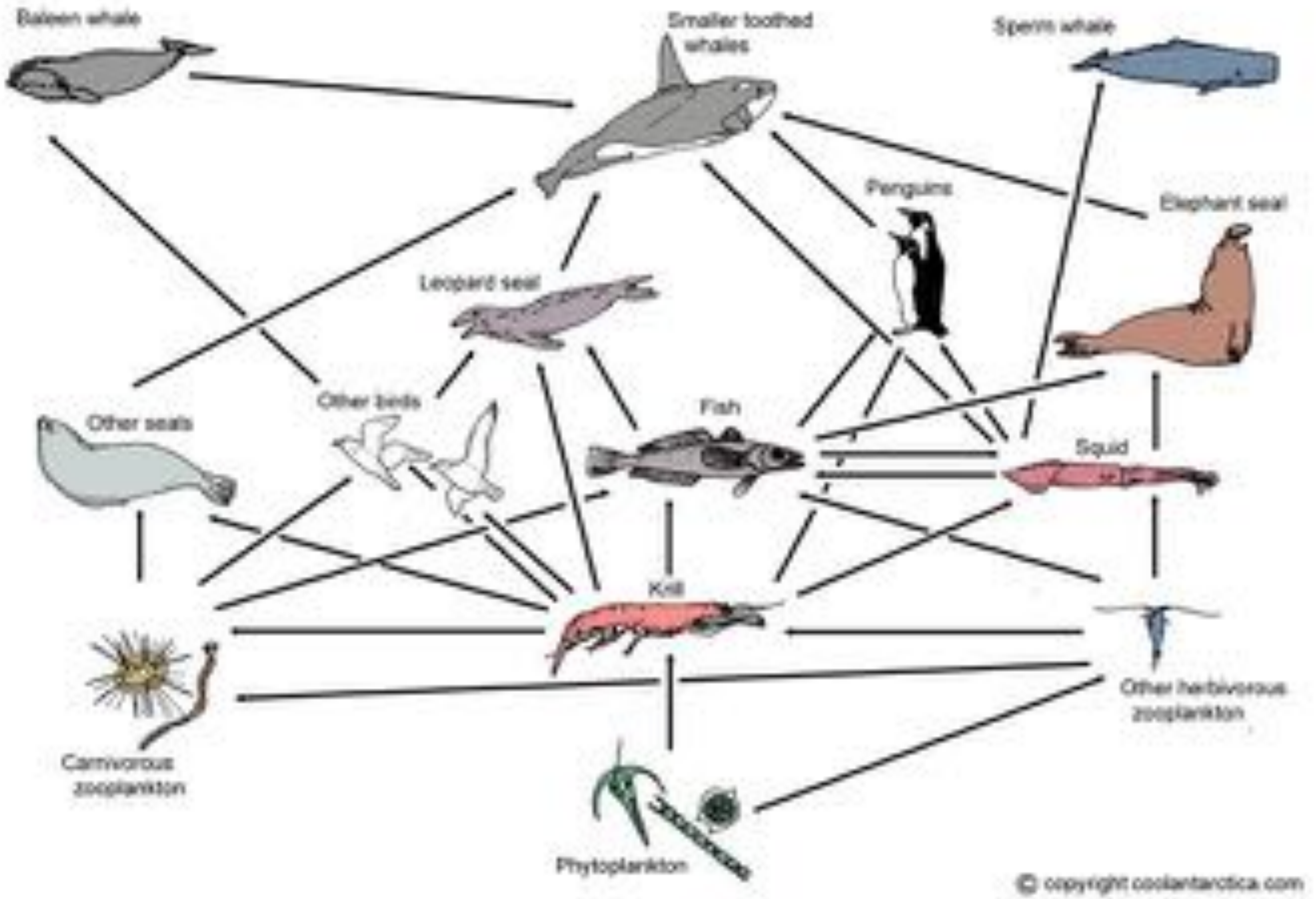
Where are we going with this?

From phytoplankton to predators:
can community composition from space tell us about the food web?



Can PCC, mapped from satellites, tell us something about the trophic state of the system and the potential for higher trophic levels?

From phytoplankton to predators:
can community composition from space tell us about the food web?


communications biology

Article

Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

From phytoplankton to predators:
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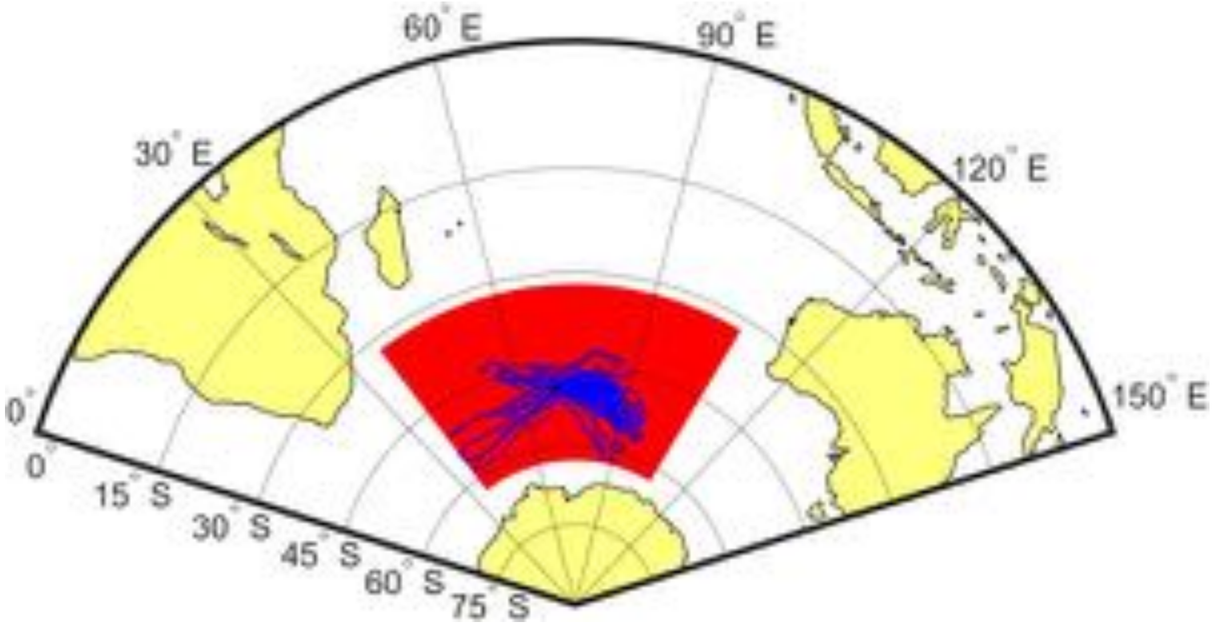
Accelerometer data from October to January for each year from 2010 to 2020.



Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

From phytoplankton to predators:
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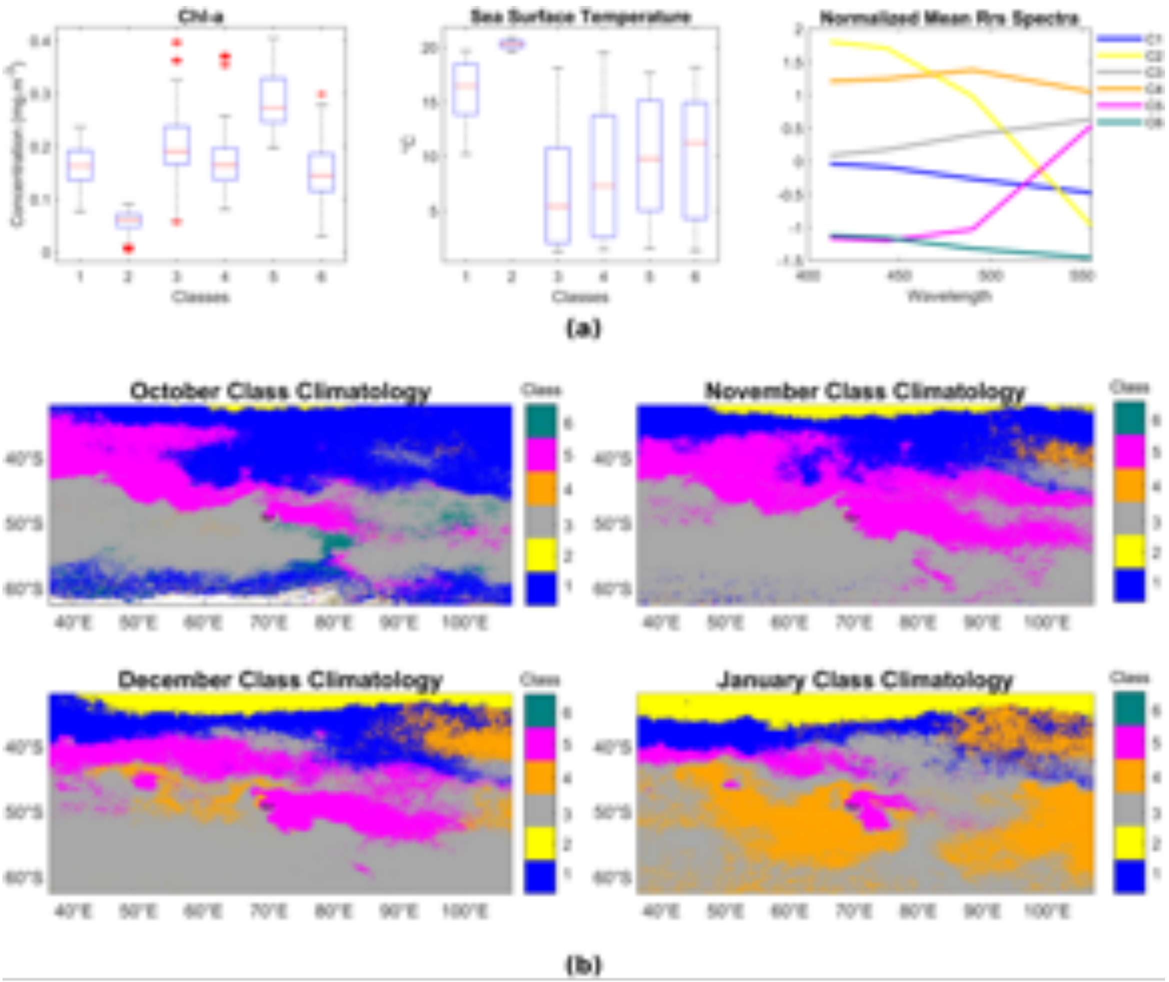
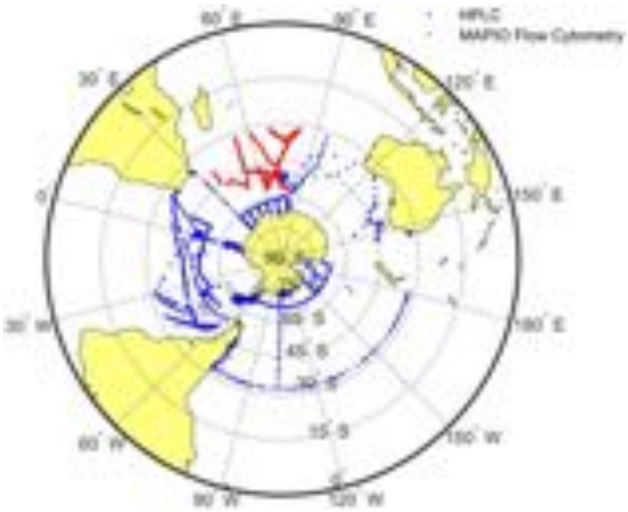
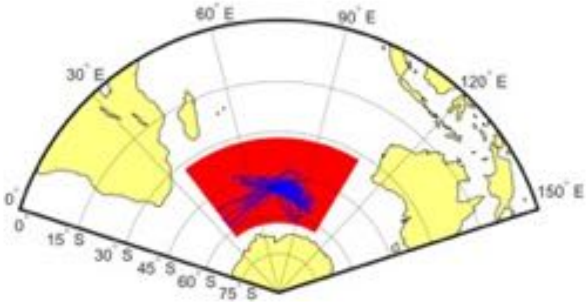
Characterization of the water-type classes in terms of the satellite data in addition to a monthly class climatology over the area of interest.







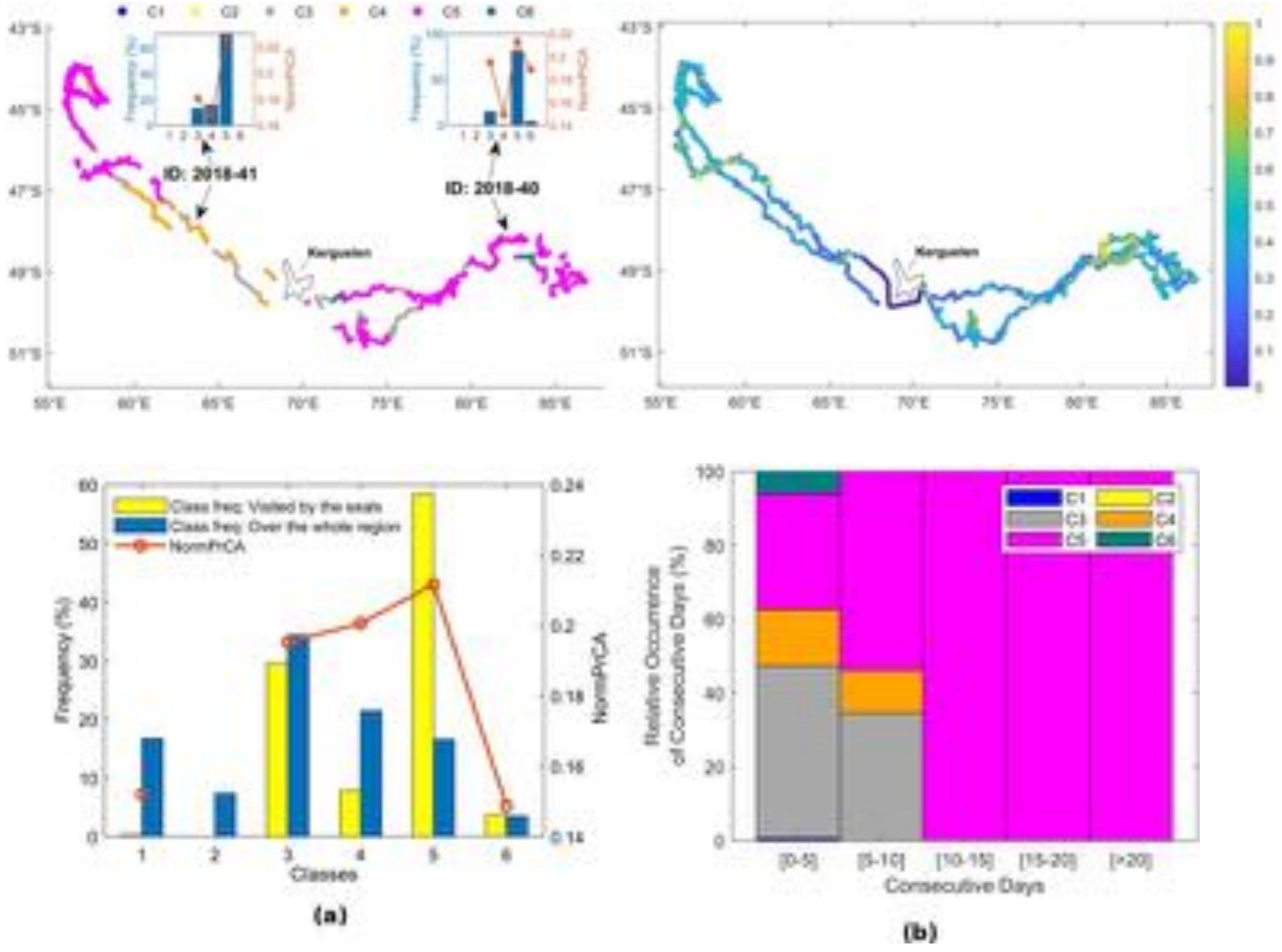
From HPLC and Cytometry data: C5= Productive waters, Diatom-dominated

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

From phytoplankton to predators:
can community composition from space tell us about the food web?

Southern Elephant Seals tend to:

1. Seek productive waters, dominated by diatoms
2. Forage significantly well in such waters
3. Stay in them for an extended period.



(a).The frequency of class occurrence in the whole region (blue bars) and in the regions visited by the seals (yellow bars) in addition to the average normalized PrCA per class. (b).The relative occurrence of consecutive days per class, based on 79 SES.

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology,

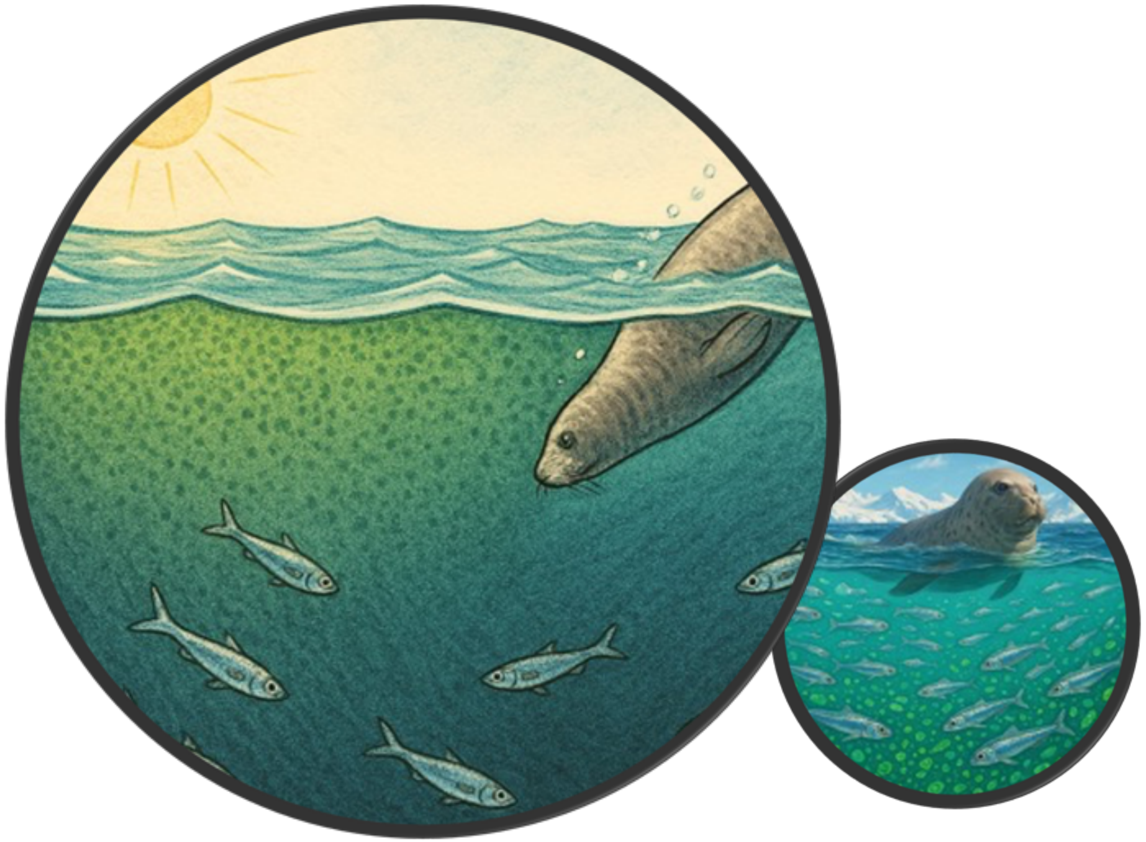
How does a PCC, dominated by diatoms, affect the foraging activity of elephant seals?

How does a PCC, dominated by diatoms, affect the foraging activity of elephant seals?

1) An increase in phytoplankton biomass increases the availability of prey to the SES

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

How does a PCC, dominated by diatoms, affect the foraging activity of elephant seals?



2) Increases in the phytoplankton abundance result in a shading effect underneath the surface and draw myctophids, the main prey of SES, to shallower depths, thus facilitating the vertical access to prey for the seals during the day.

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

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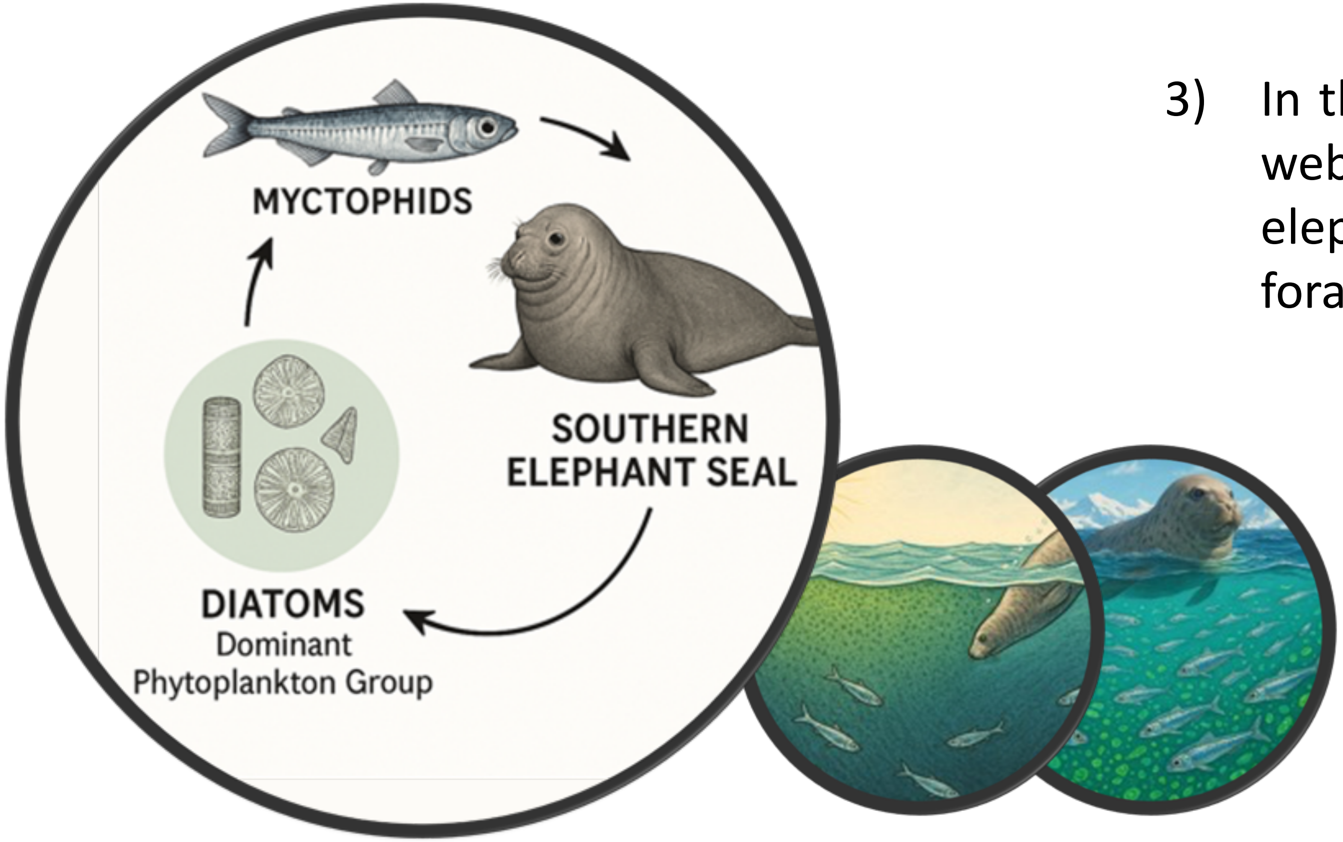
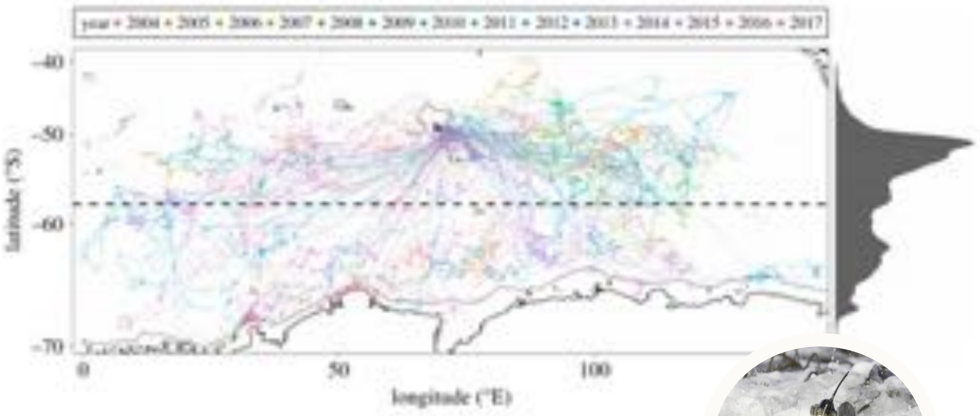


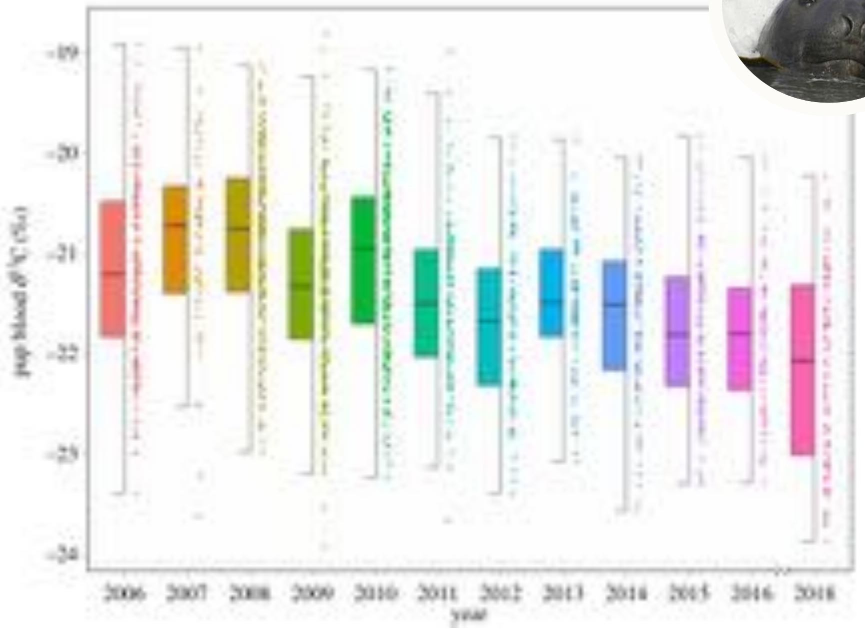
3) In the presence of diatoms, a food web more favorable to the elephant seals is formed and better foraging conditions are observed.

Sari El Dine, et al., 2025, Influence of the phytoplankton community structure on the southern elephant seals' foraging activity within the Southern Ocean, Comm Biology

Decadal changes in blood $\delta^{13}C$ values, at-sea distribution, and weaning mass of southern elephant seals from Kerguelen Islands

Julie Mestre[1,2], Matthieu Authier[3,4], Yves Cherel[1], Rob Harcourt[5], Clive R. McMahon[5,6,7], Mark A. Hindell[7], Jean-Benoît Charrassin[8] and Christophe Guinet[1]

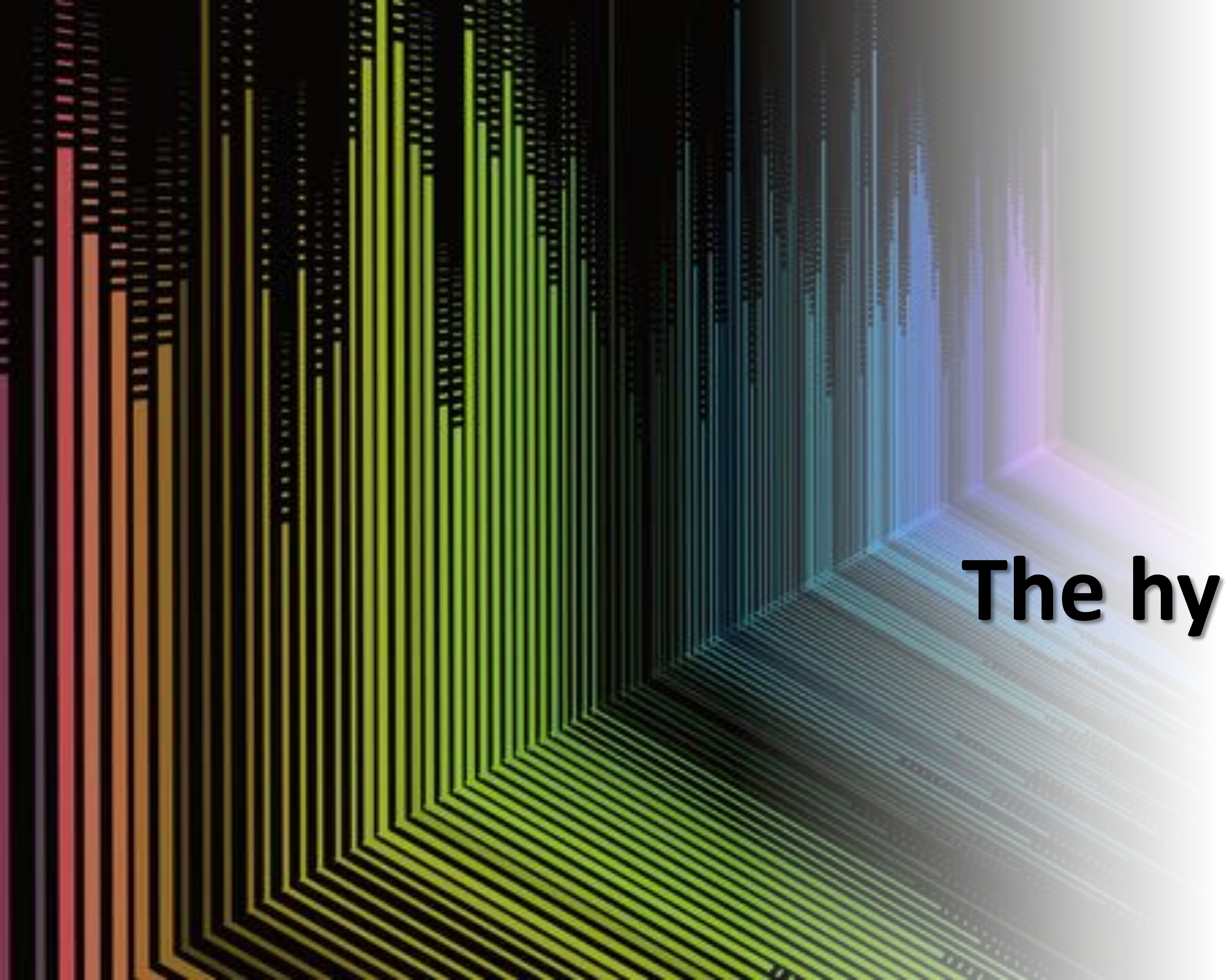




- Suggesting that **changes in primary production and/or the composition of phytoplankton communities** could be driving the $\delta^{13}C$ decrease,

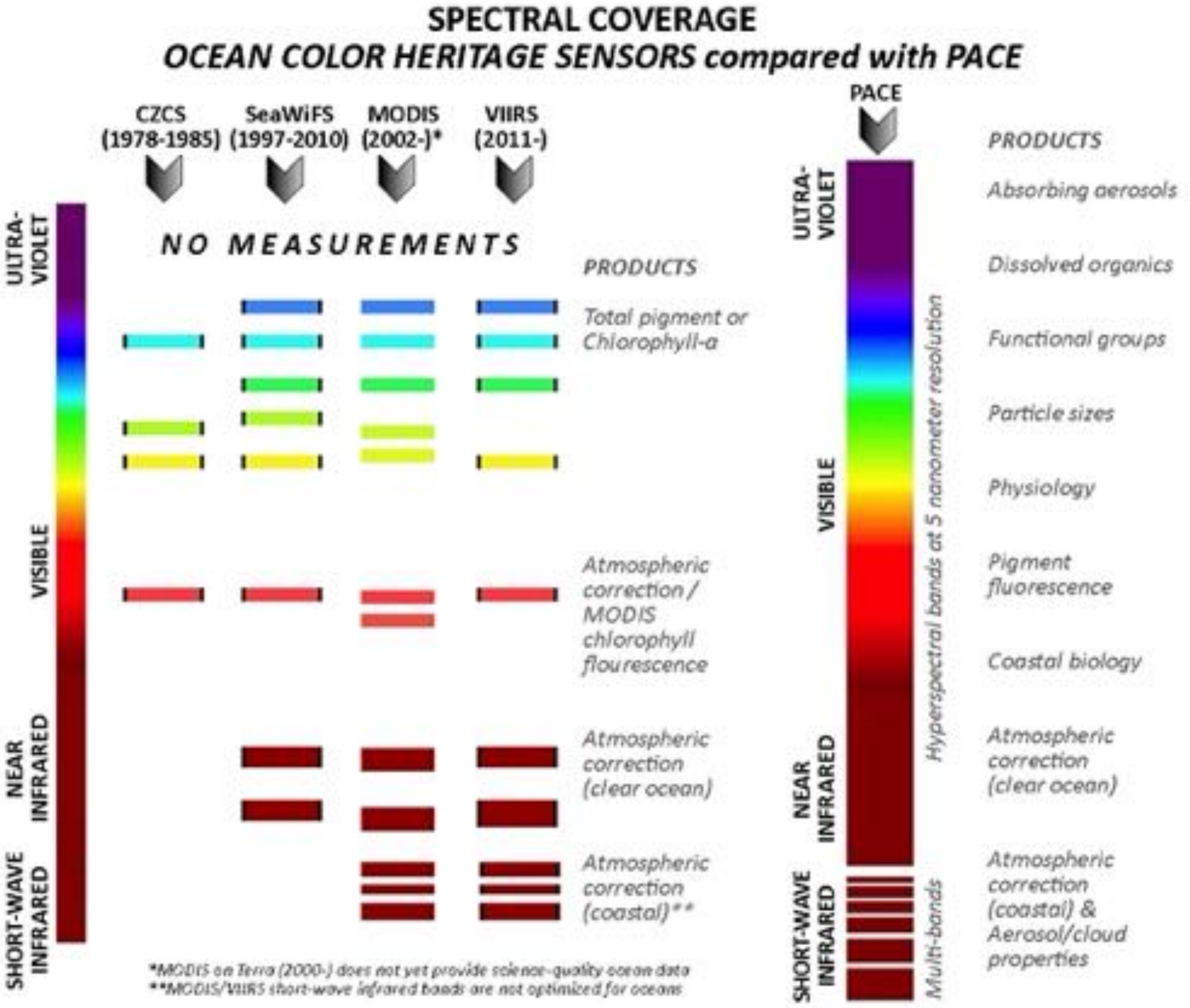
- especially **which phytoplankton groups dominate:**

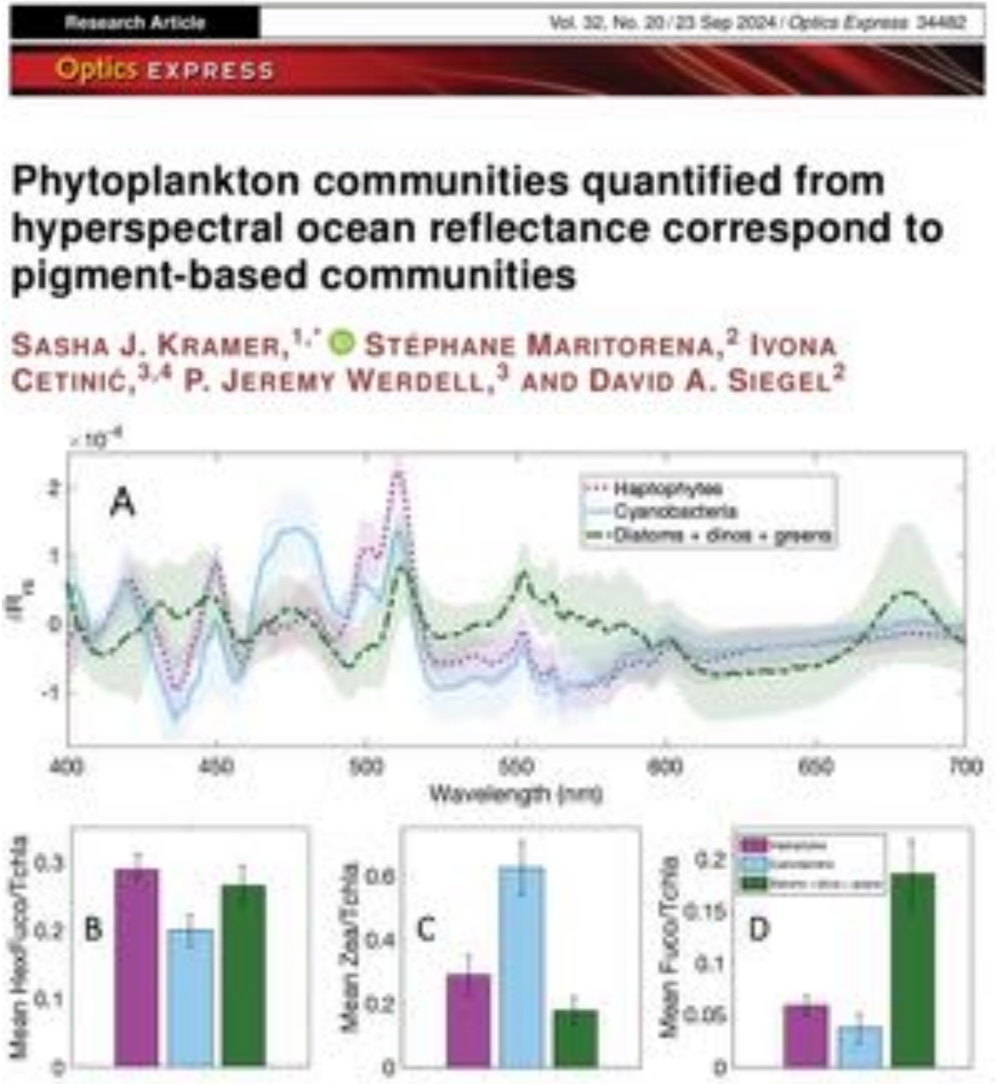
^{13}C-rich diatoms vs ^{13}C-depleted nano- and picophytoplankton



The hyperspectral era

The hyperspectral era



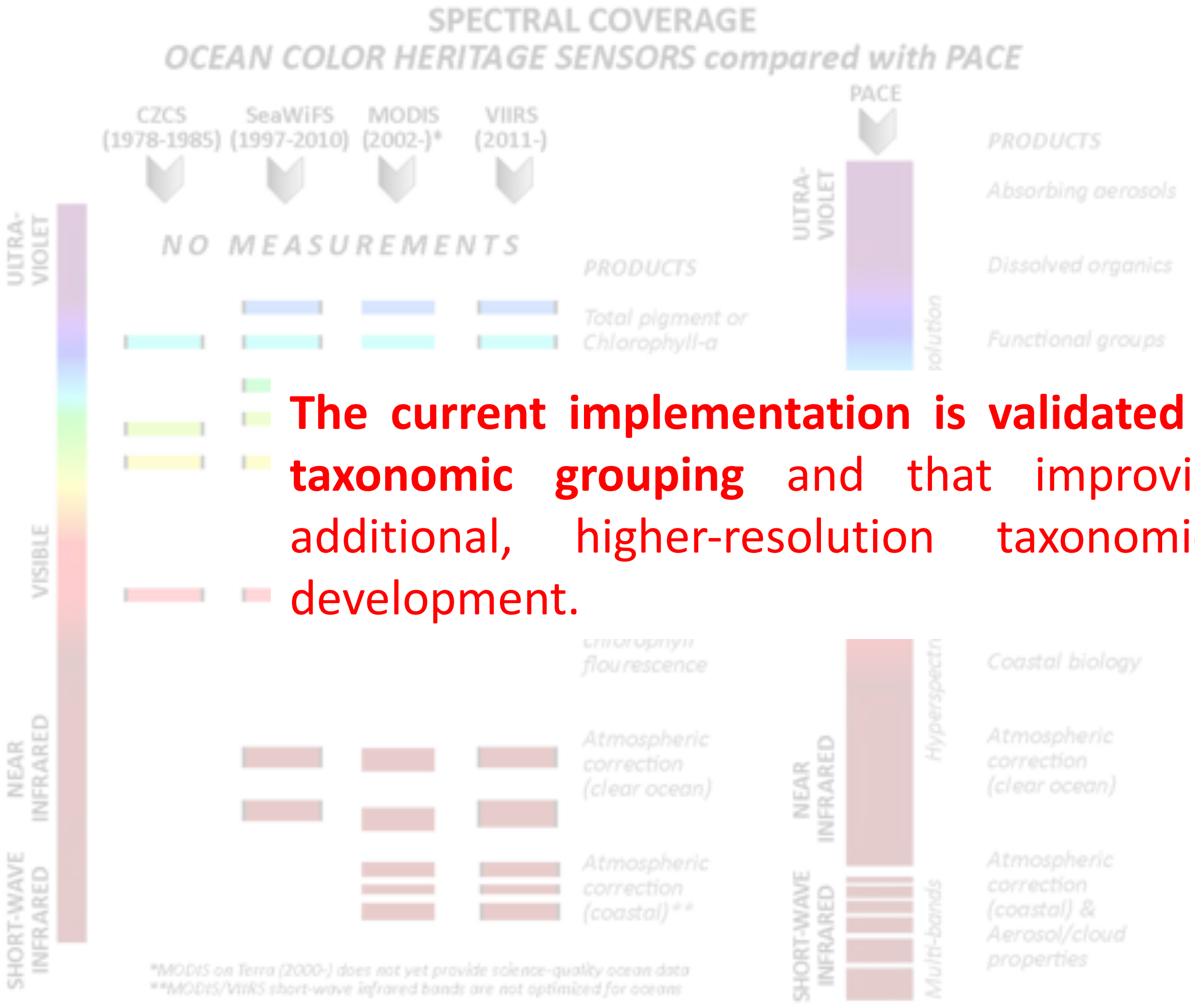

Research Article | Vol. 32, No. 20 / 23 Sep 2024 / Optics Express 34482

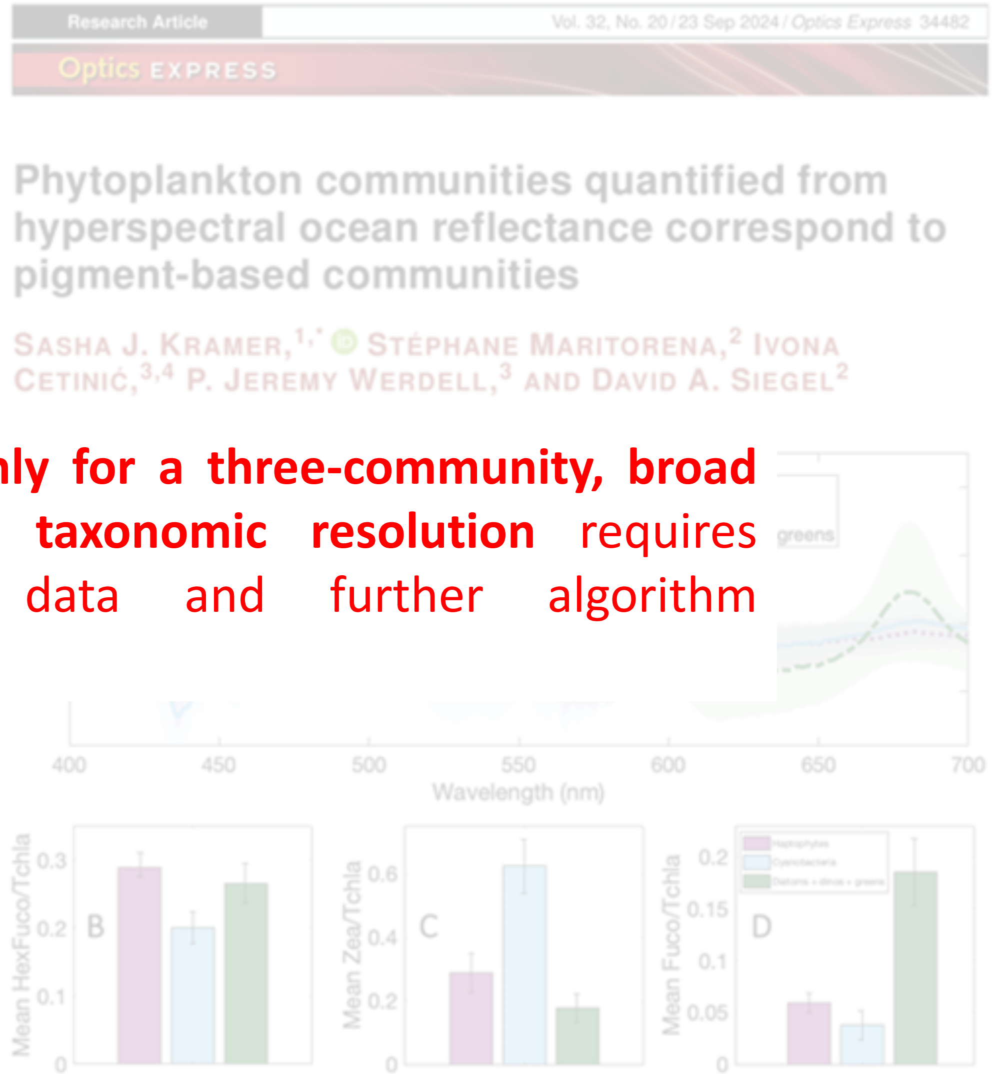
Optics EXPRESS

Phytoplankton communities quantified from hyperspectral ocean reflectance correspond to pigment-based communities

SASHA J. KRAMER,[1,*] STÉPHANE MARITORENA,[2] IVONA CETINIĆ,[3,4] P. JEREMY WERDELL,[3] AND DAVID A. SIEGEL[2]

The hyperspectral era



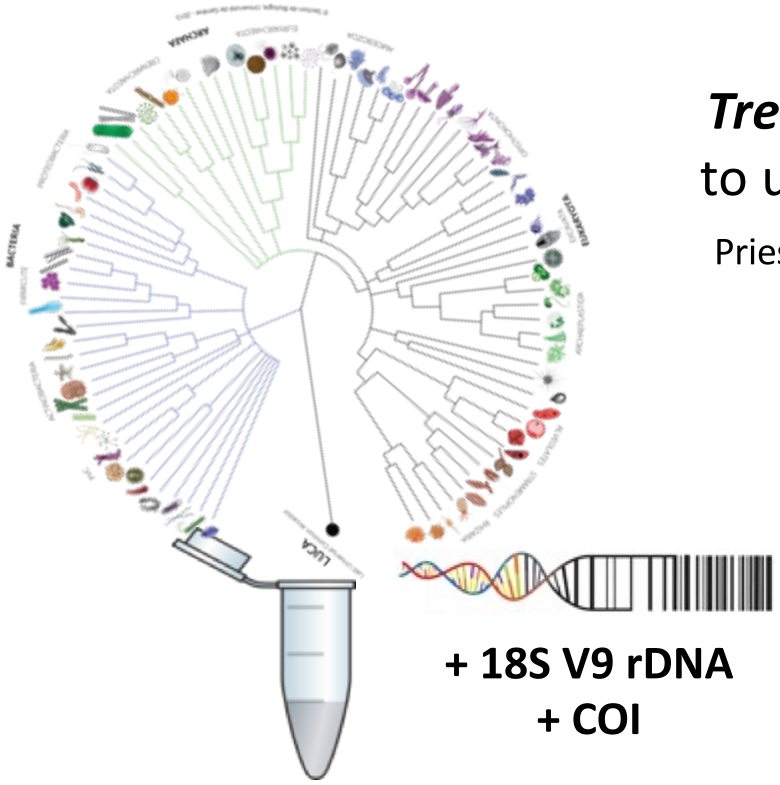


The current implementation is validated only for a three-community, broad taxonomic grouping and that improving **taxonomic resolution** requires additional, higher-resolution taxonomic data and further algorithm development.

Towards Hyperspectral - Genomics Synergy

- Co-located omics, optics and environmental measurements for algorithm development

- Testbeds for future operational 'biodiversity from space' products



+ 18S V9 rDNA
+ COI

The JEDI marker
***Tree-of-life* scale single-PCR**
to uncover total biodiversity.
Priest, Henry, et al. 2025

PlanktoSpace

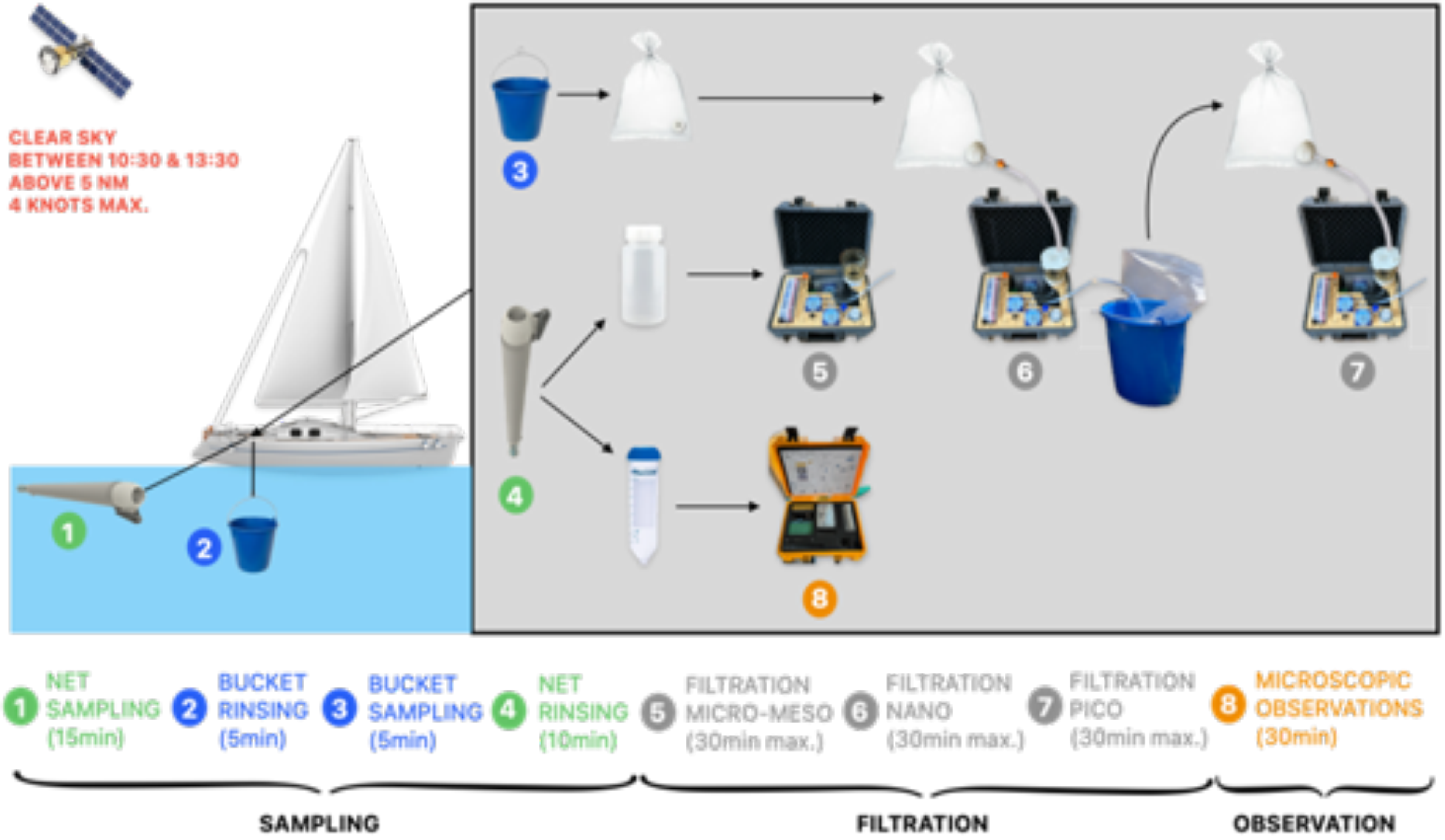
Plankton Planet · cnrs · Sorbonne Université · The University of Maine · ulco Université Littoral Côte d'Opale · LOG · Genoscope · PML Plymouth Marine Laboratory · NASA · esa

Optimizing global environmental sampling *vs* cost

Poster #190

20 kits for 2 years

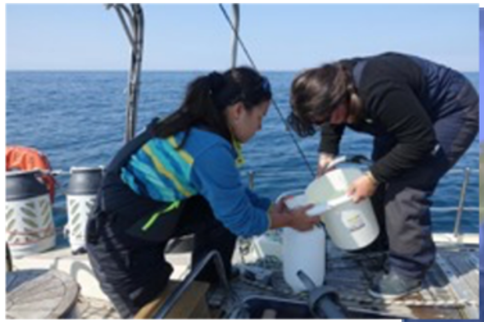
‘matchup’ *in-situ* biodiversity datasets from c.a. **1,200 sites** covering the world ocean



Optimizing global environmental sampling *vs* cost

Poster #190

WORKING
WITH
SEATIZENS

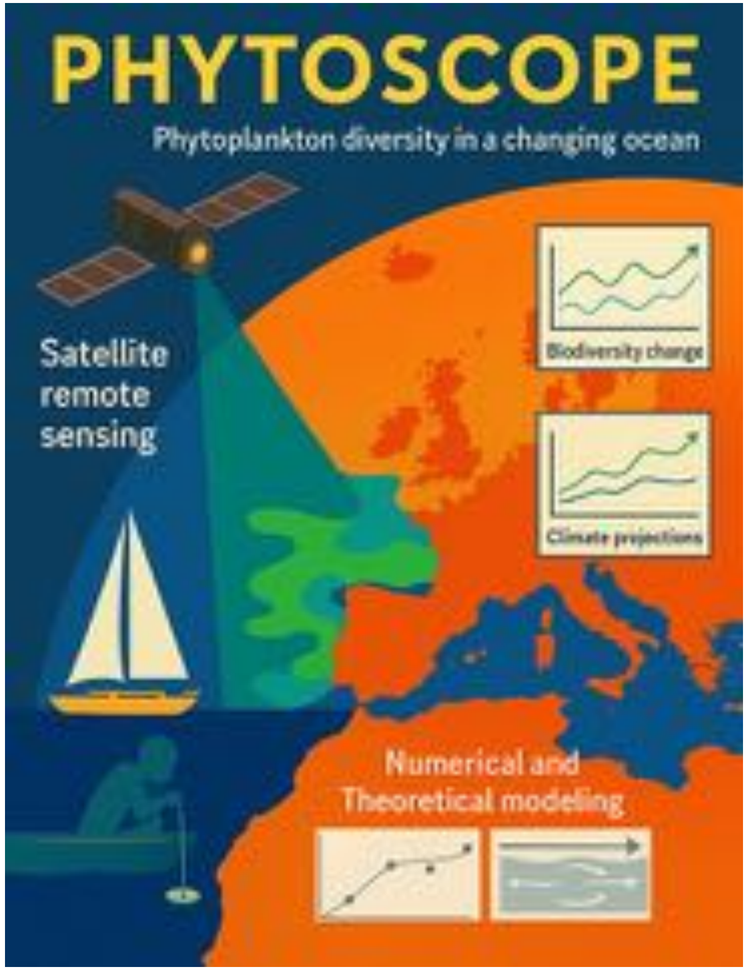


Current sailing tracks

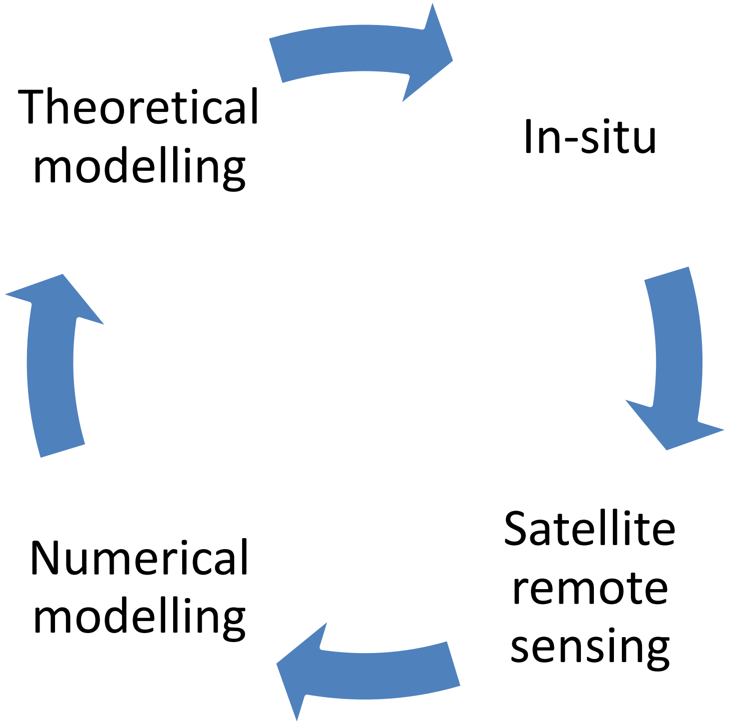
Tutorial videos and pedagogical contents

https://www.youtube.com/watch?v=nbQNYxE-2ww

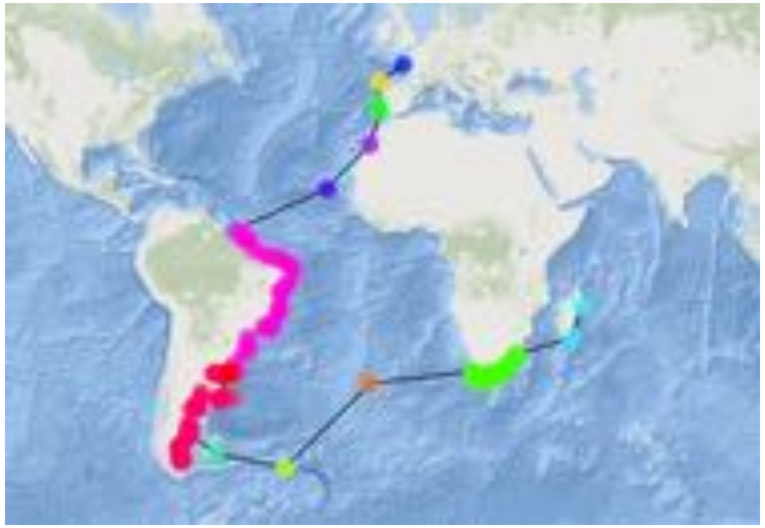
PHYTOSCOPE & ODPE–AASTRES: New Data for Phytoplankton Biodiversity



PHYTOSCOPE (2026-2029), funded by the BNP Paribas Climate and biodiversity initiative, integrates in-situ, satellites, models and theory to understand and predict climate-driven shifts in phytoplankton communities.



PHYTOSCOPE & ODPE–AASTRES: New Data for Phytoplankton Biodiversity



AASTRES campaign stations map

PHYTOSCOPE (2026-2029), funded by the BNP Paribas Climate and biodiversity initiative, integrates in-situ, satellites, models and theory to understand and predict climate-driven shifts in phytoplankton communities.

AASTRES sailing campaign 2026: 5–6-month

High-resolution in situ measurements along the route:

- Flow cytometry, Fluoroprobe, metabarcoding (PlanktoSpace kit)
- CTD profiles, nutrients, T/S, chlorophyll-a
- Hyperspectral radiometry

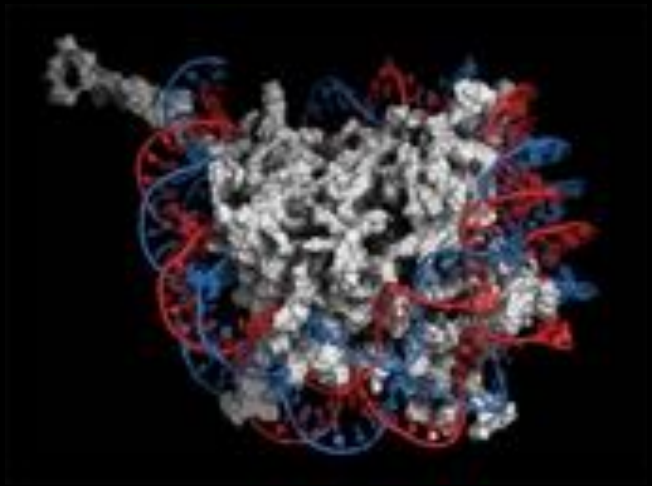
Biodiversity is multi-dimensional and multi-scale: no single observing system is sufficient.

Open Questions and recommendations for Biodiversity from Space

- Which marine biodiversity Essential Variables can we robustly and routinely infer from EO?
- How do we turn these advances into actionable services for conservation and management?

- Importance of an open, cross-disciplinary consortium, merging biology, ecology, physics, data science, and modeling expertise

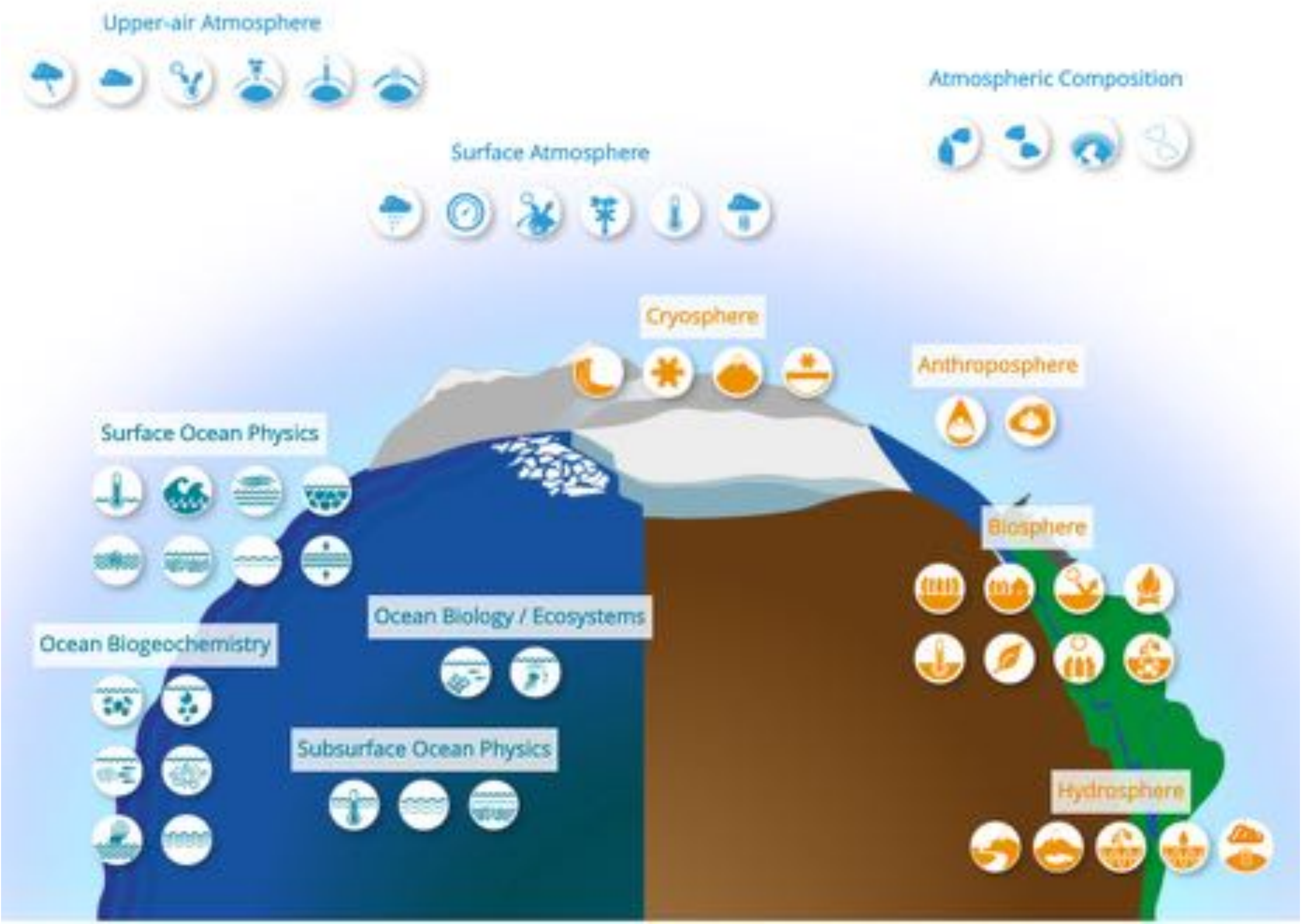
From genes to satellite pixels,
biodiversity is irreducibly multidimensional, and hierarchical, showing a different face every time we change scale, perspective, or question.



International Ocean Colour Science Meeting 2025
Advancing Global Ocean Colour Observations

Thank you!

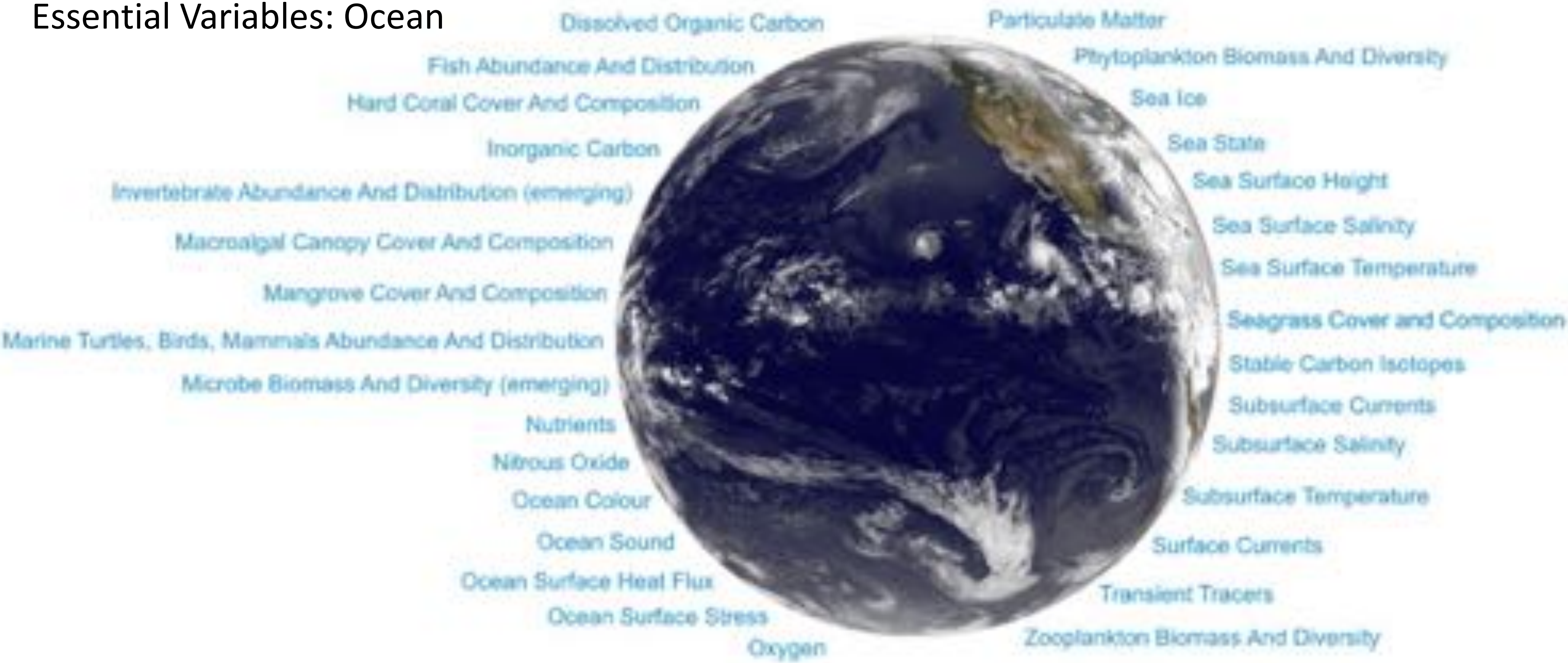
Questions and Answers



From Essential Climate Variables to Biodiversity Essential Variables: Climate

Essential Climate Variables as defined by the Global Climate Observing System; there are 54 focused on the atmosphere, cryosphere, ocean, anthroposphere, biosphere, and the hydrosphere.

From Essential Climate Variables to Biodiversity Essential Variables: Ocean



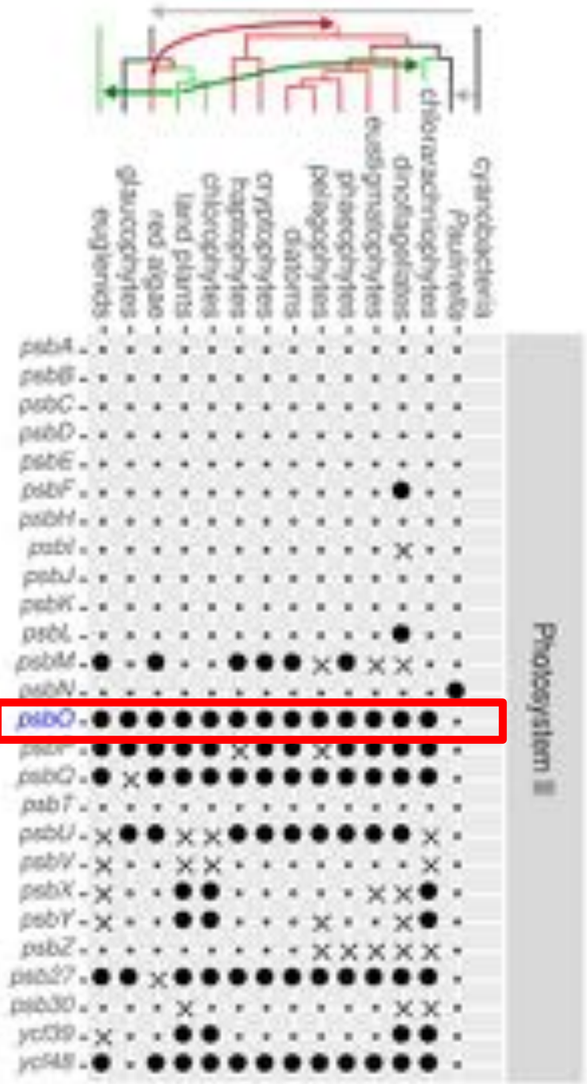
EOVs are focused on the physics of the ocean system, the biogeochemistry, and the biology and ecosystems.

Linking Omics and Satellites:
Searching for an unbiased approach using metagenomics

The *psbO protein*; a core subunit of photosystem II (PSII), unique to organisms that carry out oxygenic photosynthesis.

The *psbO* is a single-copy gene, present in both eukaryotes and prokaryotes groups

= Proxy of cell abundance

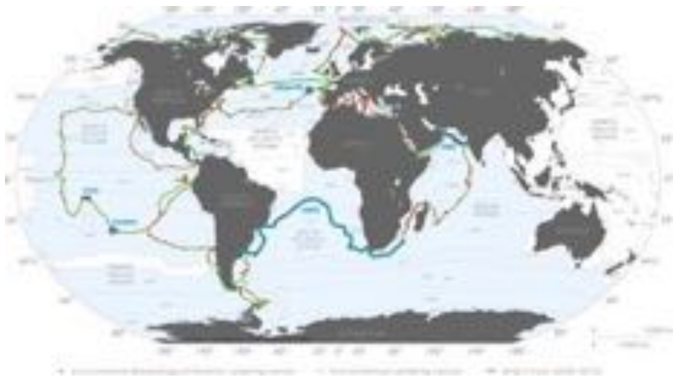


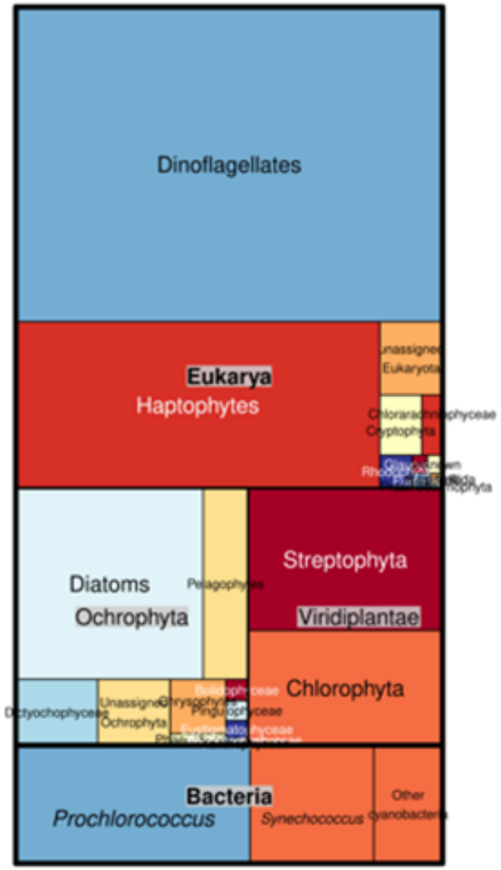
FROM THE COVER

MOLECULAR ECOLOGY RESOURCES WILEY

A robust approach to estimate relative phytoplankton cell abundances from metagenomes

Juan José Pierella Karlusich[1,2] | Eric Pelletier[2,3] | Lucie Zinger[1,2] | Fabien Lombard[2,4,5] | Adriana Zingone[6] | Sébastien Colin[2,7,8] | Josep M. Gasol[10] | Richard G. Dorrell[1] | Nicolas Henry[2,11] | Eleonora Scalco[6] | Silvia G. Acinas[10] | Patrick Wincker[2,3] | Colomban de Vargas[2,8] | Chris Bowler[1,2]



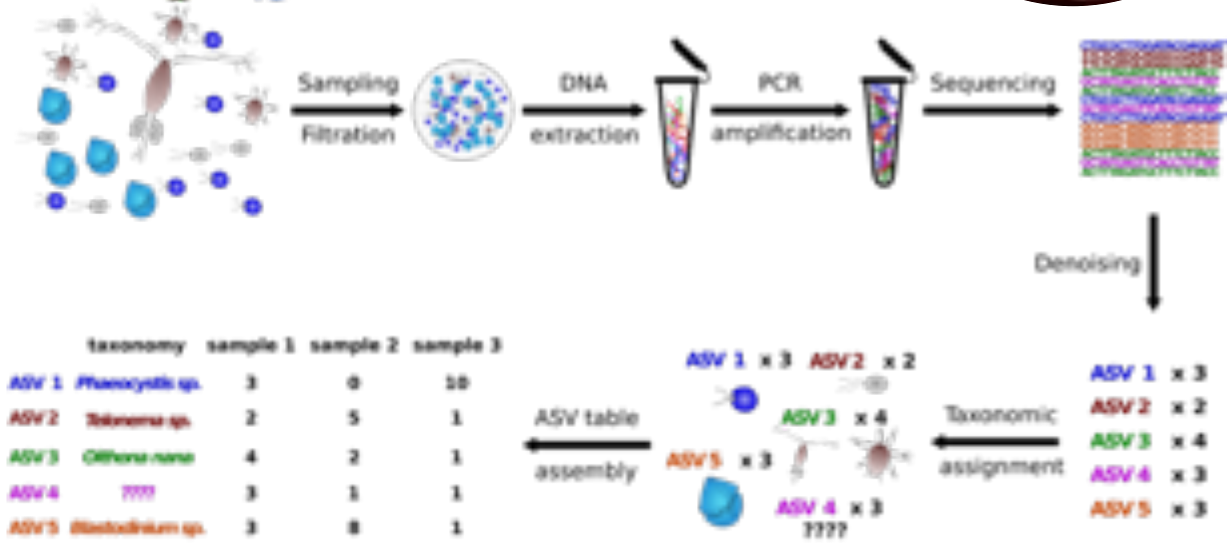


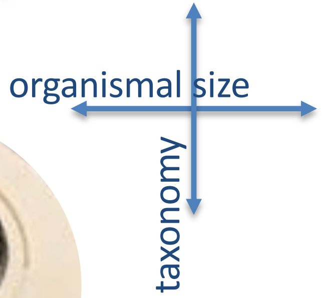
Curated database of >18k unique *psbO* sequences

Pierella et al., 2022, https://doi.org/10.1111/1755-0998.13592

pico- / nano-

micro- / meso-

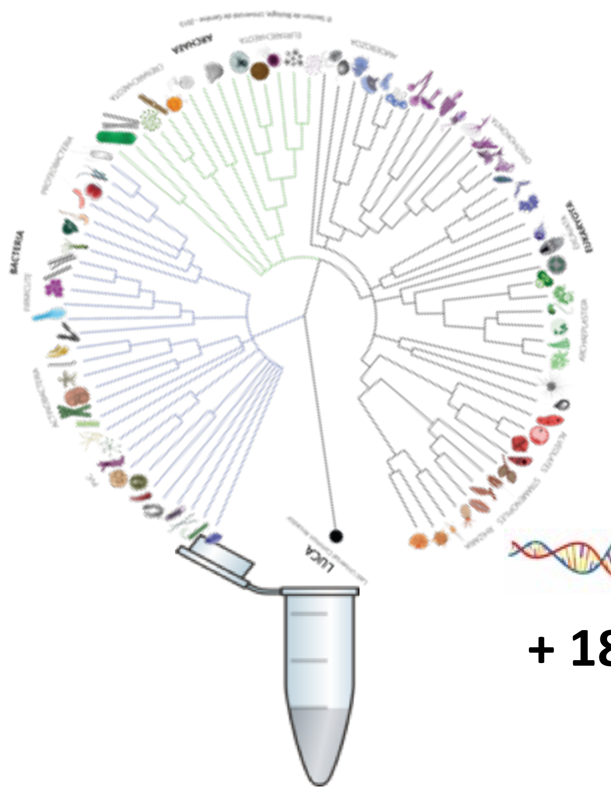




TREE-OF-LIFE SCALE BIODIVERSITY DATA

The JEDI marker

***Tree-of-life* scale single-PCR** to uncover total biodiversity.



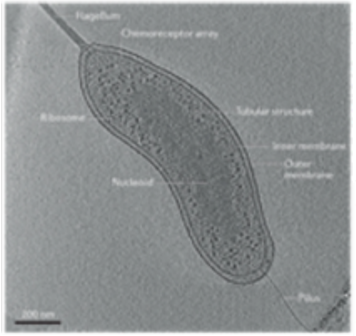
+ 18S V9 rDNA
+ COI

The JEDI marker as a universal measure of planetary biodiversity
Priest, Henry, et al. 2025
https://www.biorxiv.org/content/10.1101/2025.08.11.669668v1

The JEDI marker as a universal measure of planetary biodiversity

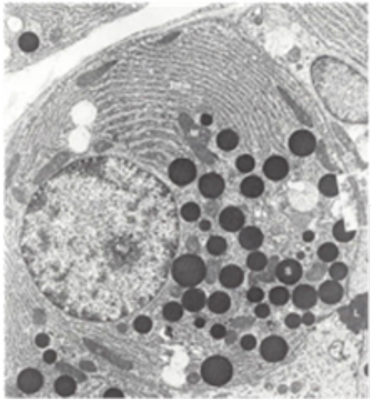
Taylor Priest, Nicolas Henry, Thomas Weber, Laurine Planat, Coralie Rousseau, Simon M. Dittami, Yi-Chun Yeh, David M. Needham, Hans-Joachim Ruscheweyh, Fabienne Rigaut-Jalabert, Nathalie Simon, Sarah Romac, Florence Le Gall, Thomas Beavis, Kevin Moog, Alice Moussy, Corinne Da Silva, Caroline Belser, ECOMAP team, TREC expedition team, Mobile Laboratory team, Jan Korbel, Raffaele Siano, Julie Poulain, Patrick Wincker, Paola Bertucci, Peer Bork, Jed A. Fuhrman, Flora Vincent, Shinichi Sunagawa, Colomban de Vargas

doi: https://doi.org/10.1101/2025.08.11.669668



Une cellule de *Vibrio* imagée cryo-microscopi électronique (Oikonomou et al. 2016)

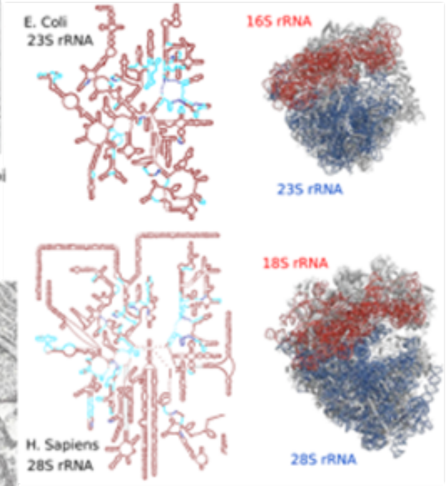
Une cellule animale du pancréas



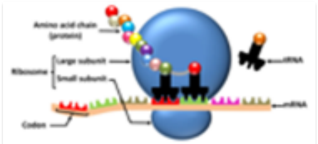
Ribosome .. La molécule universelle du vivant

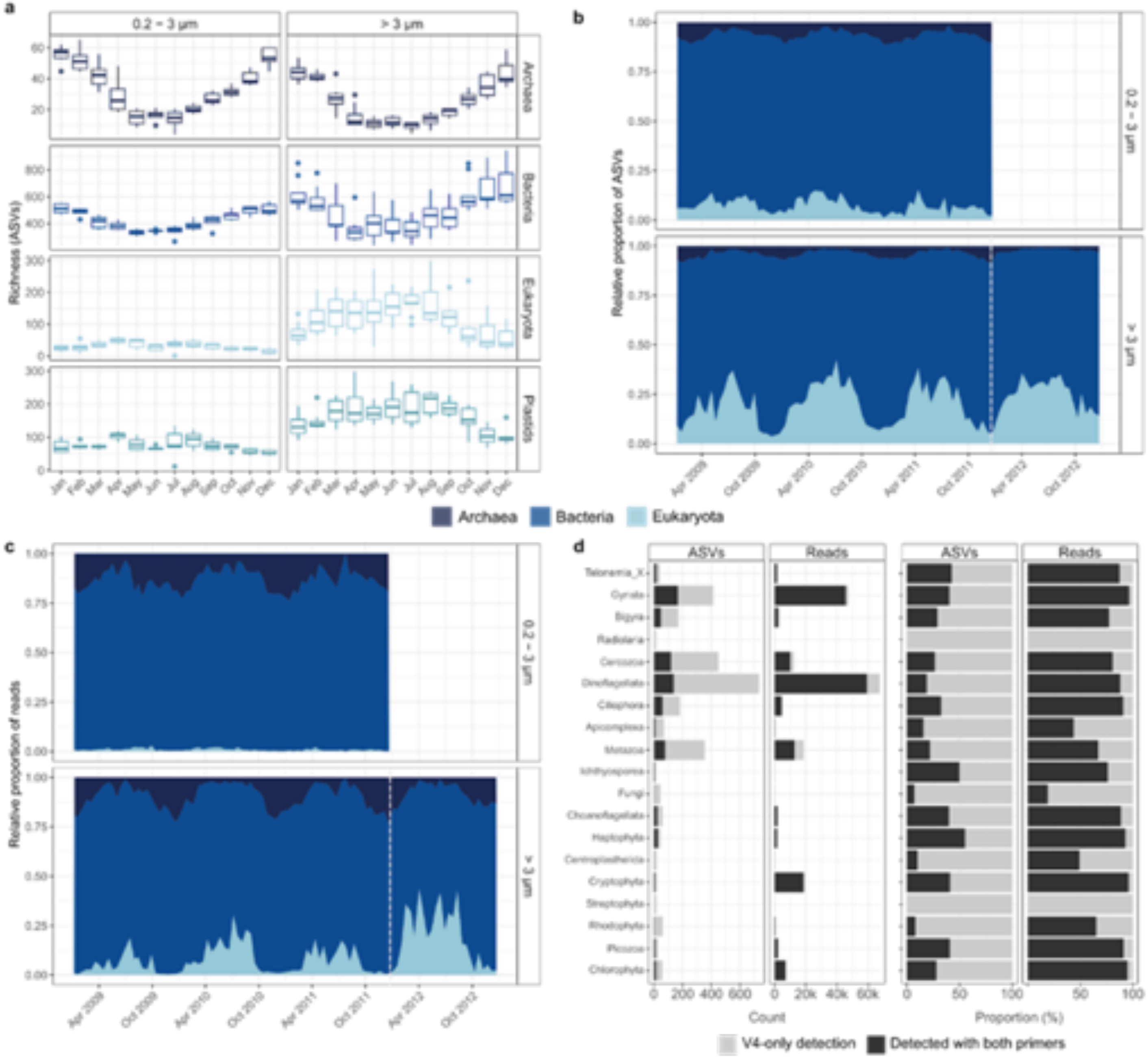
Structure secondaire de la séquence d'ARN

Structure 3D



Poitevin et al. 2020





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Journal of Marine Systems

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

Linking oceanographic conditions to foraging behaviour of southern elephant seals by characterising mid-trophic levels with an animal-borne echosounder

Marius Molinet [a,b,*], Antoine-Peio Uhart [a], Nadège Fonvieille [a,b], Jade Chevassu [a], Clément Castrec [a], Martin Tournier [a], Didier Goulet-Tran [a], Mathilde Chevallay [a], Ziad Sari El Dine [b,c], Baptiste Picard [a], Roy El Hourany [c], David Nerini [b], Christophe Guinet [a]

[a] Centre d'Etudes Biologiques de Chizé, UMR 7372, CNRS, La Rochelle University, 79360 Villiers-en-Bois, France
[b] Aix Marseille Univ., Toulon University, CNRS, IRD, MIO UM 110, Marseille, 13288, France
[c] Laboratoire d'Océanologie et de Géosciences, Univ. Littoral Côte d'Opale, Univ. Lille, CNRS, IRD, UMR 8187, LOG, 62930 Wimereux, France