BioSpace25 - Biodiversity insight from Space
10 - 14 February 2025 | ESA-ESRIN | Frascati - Italy

“Marine Ecosystems”

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- Speakers:
  - ❑ 75% male; 25% female
  - ❑ 6 Countries

- Statement of «the most common» problem:

scaling up «fine scale» in situ biodiversity traits (i.e., EBVs) using remote sensing to describe marine ecosystem structure and functioning

- 8 talks:
  - ❑ from phytoplankton traits (6) to birds, sharks and mammals (2)
  - ❑ all using in situ biodiversity data (including new technologies and hyperspectral)
  - ❑ 2 case studies based on genetics
  - ❑ 1 global-scale, 1 basin-scale, 6 regional-scale studies
  - ❑ use of AI (2)
  - ❑ link between biodiversity monitoring and marine circulation / sst fronts
  - ❑ seascape analysis

Main messages from speakers

- Cross-disciplinarity is fundamental to push marine biodiversity monitoring and ecosystem description from space (e.g., remote sensing, biology, physics, AI).

- Integration with in situ biodiversity data is needed (but data need to be standardized!)

- Integration with environmental data is also important to detect and identify specific diversity traits

Conclusions and recommendations

- Push inter-disciplinarity (including capacity building)
- High spatial-temporal resolution of hypespectral imagery (dedicate to the marine environment)
- More in-situ data needed, in particular in under-sampled areas
- Use of AI, seascape-based analysis and integration with ecosystem and biogechemical modelling to scale up ecosystem analysis (also below the surface!)
- Work more tightly, and facilitate interactions, with OBIS, GBiOS, GEO Atlas etc
- Facilitate open access to large datasets of sub-meter optical imagery, particularly for endangered species

Others

- **Recommendations for conference organizers:**
- Provide travel funding/scholarships for participants from developing countries
- Implement real-time feedback mechanisms (e.g., post-session surveys)
- Promote Q&A sessions/round tables after each session

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Scaling image-based marine plankton biodiversity using dynamic satellite seascapes: a contribution of the Southeast U.S. Marine Biodiversity Observation Network

E. Montes[1,2], M.T. Kavanaugh[3], T. Christian[1,2], R. Cohn[1,2], F. Muller-Karger[4], L.R. Thompson[1,5], C. Kelble[1]

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Future work and recommendations

Outlook:

- Integrate CPICS data with other imaging datasets, e.g. IFCB
- eDNA metabarcoding to expand taxonomic range: microbes and higher trophic levels (invertebrates, fish, mammals).
- Develop seascape-based biodiversity indicators.

Recommendations:

- Standardizing field protocols and metadata for imaging datasets.
- Enhancing access to automated classifiers for imaging observations.
- Publishing imaging data on OBIS.

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Mediterranean 4D seascape based on phytoplankton phenology detected from satellite observations: patterns and drivers

4DMED-sea

ESA Contract No. 4000141547/23/I-DT

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Conclusions

- Consistence with D'Ortenzio's bioregionalization, with key differences in cluster definition and coastal region inclusion.
- Coherence analysis identified distinct stable and variable areas.
- Circulation patterns and gyres likely drive interannual variability.
- Depth-based clustering showed significant differences from surface clustering, except in specific areas.
- Further research is needed to explore bio-physical surface interactions beyond chlorophyll and link phenology with deeper layers, improving marine resource management.

Absorption diversity of bloom-forming phytoplankton species:

Toward hyperspectral remote sensing identification of red tide events?

Maria Laura ZOFFOLI

Pierre GERNEZ, Victor POCHIC, Amalia Maria DETONI, Martin HIERONYMI, Henning BURMESTER, Tristan HARMEL, Thomas LACOUR, Rüdiger ROETTGERS

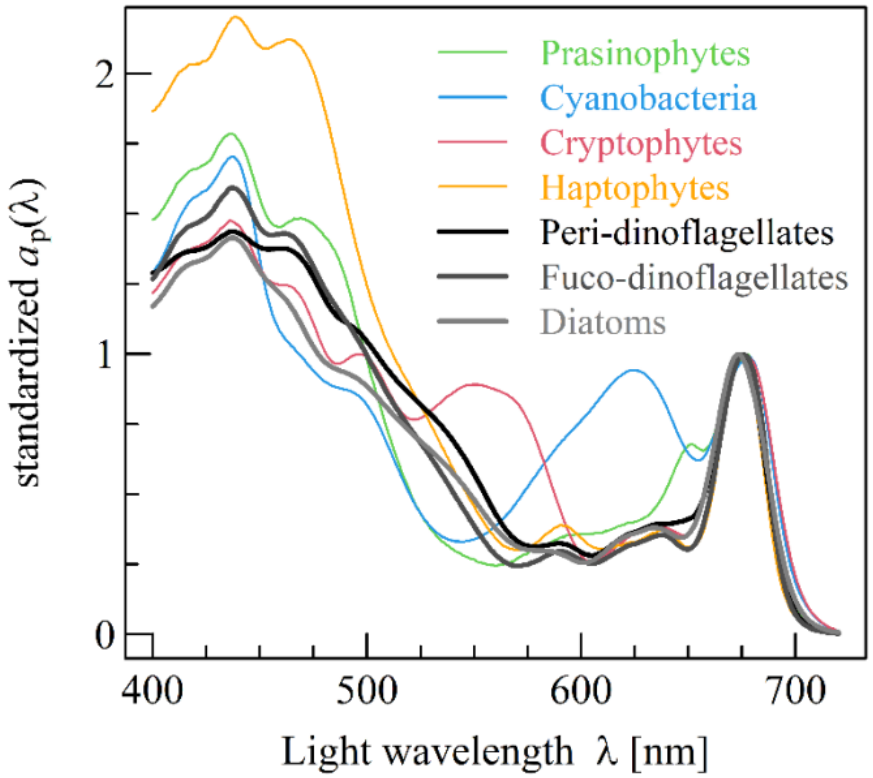
Nantes Université · Ifremer · CNR ISMAR Istituto di Scienze Marine · Helmholtz-Zentrum hereon · magellium · CSIC Consejo Superior de Investigaciones Científicas

Conclusion

Previous studies shown that cyanobacteria, cryptophytes, and prasinophytes could be distinguished due to their unique pigments and absorption signature.

Here, we confirmed it and further demonstrated that **4 additional types of blooms could be distinguished at taxonomic class level using hyperspectral absorption measurements**:

1) Haptophytes
2) Peridinin-bearing dinoflagellates
3) Fucoxanthin-bearing dinoflagellates
4) Diatoms and/or raphidophytes



Next steps

Analyze library of hyperspectral Remote-sensing reflectance $R_{rs}(\lambda)$. Such library could be obtained from:

1) *In situ* $R_{rs}(\lambda)$ acquired during highly concentrated "monospecific" blooms
2) Satellite $R_{rs}(\lambda)$ extracted from bloom images

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Phytoplankton assemblage structure off southwestern Iberia:

Combining complementary approaches to assess variability and underlying drivers/predictors

Maria João Lima, Ana B. Barbosa
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Conclusions

- Diatoms and dinoflagellates dominated at coastal stations, while cyanobacteria surpassed dinoflagellates further offshore
- Winter-spring: diatom dominance; summer-autumn: cyanobacteria and dinoflagellate dominance
- UI, NO_2 and SPM were the best predictors of variability in the structure of the phytoplankton assemblage
- RS-based algorithms need further refinement and validation to be applied at regional scales

Next steps

- Estimate NO_3^- concentrations in the study area from *in situ*/satellite-retrieved water temperature, SiO_4^{4-}, and/or Chl-a concentrations using empirical regressions
- Apply multivariate analysis with model-derived NO_3^- concentrations
- Explore specific bloom events

Recommendations for conference organizers:

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Linking satellites to genes to estimate phytoplankton community structure from space

Roy El Hourany[1], Juan Pierella Karlusich[2,3], Pedro Junger[2], Lucie Zinger[3], Hubert Loisel[1], Marina Levy[4], and Chris Bowler[3]

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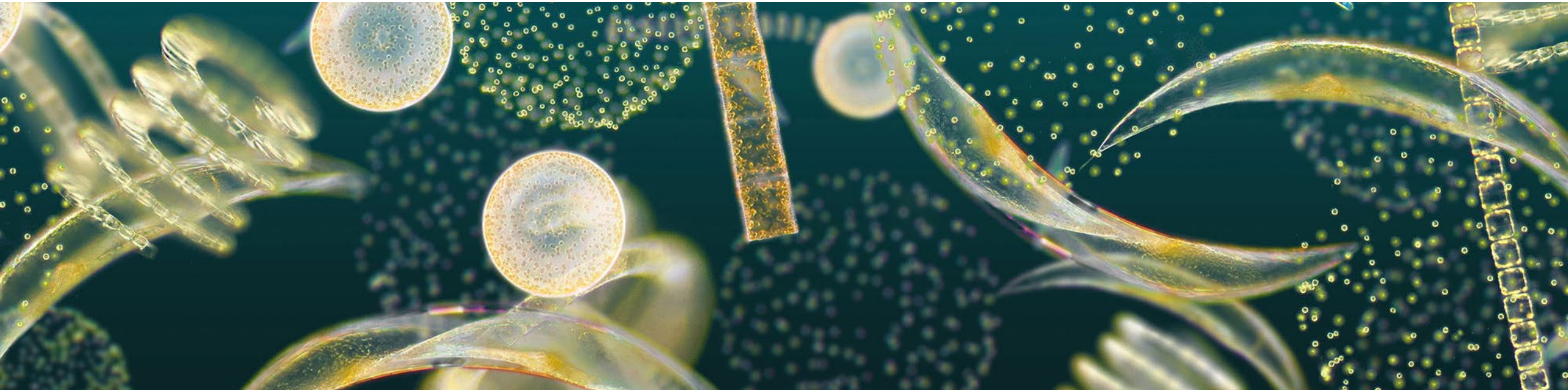
Recommendations

- Integrate, harness cross-disciplinary expertise, push forward collaborations to better observe diversity from space
- AI and machine learning technics can solve non-linear, intricate problems such as the homogenization of multi-source data, to extract common patterns between remote sensing and ground truth data
- Incorporate and elaborate EBVs linked to the oceanic ecosystem



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A satellite-genomics approach to explore phytoplankton iron ecophysiology in the global ocean

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Conclusions

- We found **patterns** of gene and transcript abundances **consistent with biogeochemical models**, **iron concentration measurements**, and **satellite remote sensing**, suggesting these ratios can work as good **genomic proxies for iron limitation in the ocean**

- We used the prevalence of phytoplankton genes and transcripts involved in iron responses to develop **maps of inferred nutrient stress** across the global ocean. The ***metaT* predictions** were **more coherent with bottle experiments.**

- The ***metaT* indexes correlated better** with **iron in-situ measurements** in *Tara* Pacific

- Although we highlight the need for <u>increasing in-situ observations</u>, our workflow provides the foundation for **linking genomics and remote sensing** to monitor phytoplankton iron nutritional status in the global ocean

ENS ÉCOLE NORMALE SUPÉRIEURE | PSL RESEARCH UNIVERSITY PARIS | IBENS Institut de Biologie de l'Ecole Normale Supérieure

Perspective & Recommendations

- **Perspective:** to generate an enhanced dataset of genes and transcripts mapped in more metagenomes and metatranscriptomes to train machine learning algorithms linking genomic and remote sensing data

- **Recommendations:**

1. The **transcript ratios** are **good proxies of phytoplankton stress,** and can inform **EBVs (physiology),** which can be **linked to remote sensing metrics**

2. We highlight the need for <u>increasing recurrent in-situ observations (DNA & RNA sequencing)</u>, **particularly in underrepresented ocean regions**, to improve predictions of phytoplankton diversity & physiology

3. Keep **working together in inter-disciplinary efforts**

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Relationships between shelf-sea fronts and biodiversity studied using Earth observation data

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PML Plymouth Marine Laboratory
University of Aberdeen
Prifysgo Bangor University
The Crown Estate

Future work and recommendations

Future work

- Complete statistical analysis to answer: How much, where and when do ocean fronts influence marine biodiversity?
- Describe results and uncertainties to The Crown Estate to ensure effective impact on marine spatial planning, informing future offshore windfarms.

Key recommendations

- Accelerate use of **ocean fronts within OBIS, GBiOS, GEO Atlas** as an efficient partial proxy for marine biodiversity.
- To assist in achieving **GBF Target 3** (30% protection by 2030) and the UN High Seas Treaty (Biodiversity beyond national jurisdiction).

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Large-scale automated detection of Humpback and Gray whales in satellite imagery using deep learning for conservation monitoring off California

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Conclusions and findings

- Large number of detections:
  - Gray whale detections covered the entire coast of California.
  - 3500 gray whales + 1500 humpback whales were detected with opportunistic blue and fin whales.
- Gray whale migration occurs offshore in a significant manner:
  - Offshore migration route through the Channel Islands featured more detections than coastal route.
  - Highest densities - 6 to 9.27 whales per square kilometers- were found near the Farallones Islands(offshore), Point Conception and north of Eureka (coastal).
  - Median distance to the continental coast was found to be approximately 5.86 km. Detections furthest away from the coast were made within the Channel Islands with a peak value at 57.2 km, 52 other detections were over 35 kilometers, possibly farther than typically expected for gray whales.
- Seasonality of detections: Repeated detections of humpback whales in November was later than expected by prior knowledge. This information can impact the design of vessel speed reduction programmes in Southern California.

Recommendations

- Facilitate open access to large datasets of submeter optical imagery, particularly for endangered species