Priority list of marine biodiversity metrics to observe from space: synthesis and planning for next steps

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Introduction

This breakout session was proposed to discuss progress on metrics for marine biodiversity. The discussion follows workshops held at IOCS 2023 and ESA's BIOSPACE25 (Feb. 2025).

There is a need to coordinate efforts to identify which products are fit-for-purpose and their maturity. The goal is to identify indicators useful for addressing national needs and international agreements, such as the Convention on Biological Diversity Kunming Montreal Global Biodiversity Framework.

The scope of the IOCS 2025 Breakout workshop was:

1) To discuss progress on ongoing work towards a position paper on the suitability of current ocean colour derived products to monitor biodiversity status and trends in the marine and coastal environments,

2) To discuss/draft/plan the terms of reference for a proposal for a new IOCCG working group, focusing on an evaluation of available monitoring biodiversity (or biodiversity relevant variables) from space, the suitability of products to inform policy, and areas of scientific development needed to develop the missing knowledge.

Session Summary

The session was very well attended (over 80 participants) and was designed to be fully interactive, with most of the time dedicated to discussions (See Agenda below). As the time was mostly dedicated to the discussions, there was no opportunity to discuss the ToR for a working group / task force. A second meeting was organised during the week with those interested in the working group, and it was then agreed that it would be more productive to immediately focus on a community paper.

A questionnaire was designed and circulated before the breakout session (https://forms.office.com/pages/responsepage.aspx?id=PQGlD5ha8EWqhX2-EfhTke-LGVSooQRKrhrL8BL9NexUQUJYN0w1MjM3REpMNUtQU0hWRkNROVZHQiQlQCN0PWcu&route=shorturl). The survey concentrated around three EBV classes: 1) community composition and further refined into products relevant to EBV taxonomic diversity and trait diversity; 2) ecosystem structure and further refined into products relevant to EBV

live cover fraction, ecosystem extent and fragmentation and ecosystem distribution (e.g. seascapes) and 3) Ecosystem functioning and further refined into products relevant to EBV ecosystem phenology and net ecosystem production.

The group was split among two separate Essential Ocean Variables of interest: phytoplankton and habitats, with a majority of participants engaging with the phytoplankton discussion.

Agenda
15' – Introduction to the session and summary of findings from questionnaire- (Victor Martinez)
45' – Break out in two sub-groups of Essential Ocean Variables (EOV)
Discussion on the results from the questionnaire (i.e. validation of the results)
Status, current use and challenges
15' – Break
20' – Summary from subgroups
45' – Break out into two sub-groups of Essential Ocean Variables (EOV)
Discussion on the results of the questionnaire (i.e. validation of the results)
Recommendations moving forward
15' – Summary from subgroups
15' – Synthesis of the recommendations to IOCCG (Victor Martinez)
30' – Plan for submission of IOCCG WG and next steps (Maycira Costa)
phytoplankton (chaired by Victor Martinez),
habitats (seagrass, seaweed, corals, mangroves, saltmarshes) (Chaired by Maycira Costa)

Preliminary results from the survey were presented (Figure 1):

1. Phytoplankton is a main target. Benthic habitat mapping is emerging.

2. Community composition and ecosystem functioning EBV classes accumulated most responses.

3. A preliminary list of priorities has been drafted: primary production, benthic habitat structure, phytoplankton functional groups, phenology, phytoplankton taxonomy, pelagic habitat structure and benthic functional diversity.
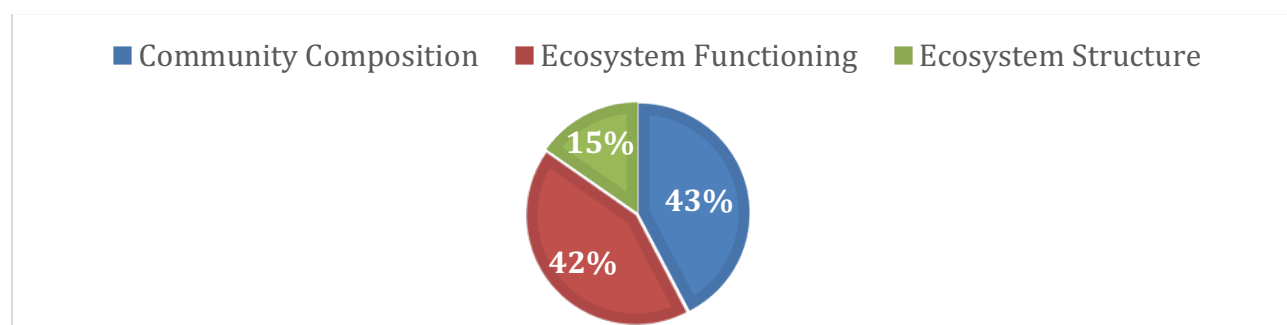
Figure 1: Percentage of responses by EBV class in the survey at the time of the IOCS2025 (Dec-2025)

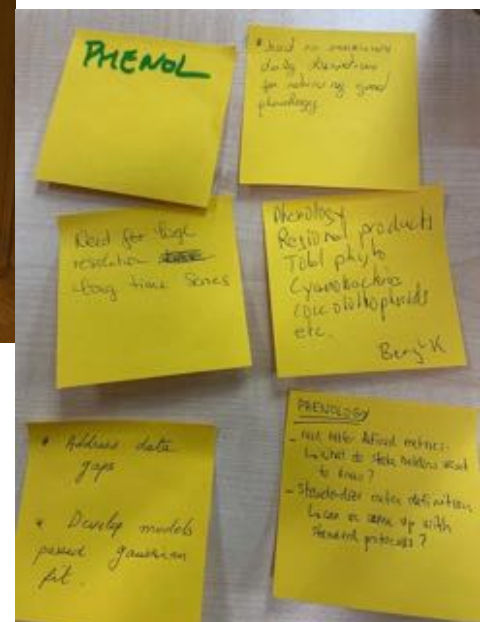Recommendations were collected through notes taken by volunteers and through post-its (Figure 2).

Figure 2: Some of the feedback collected from the workshop participants. Post-its code: Blue: phytoplankton community taxonomical diversity; yellow phytoplankton community trait diversity; pink ecosystem functioning: primary production; darker yellow: ecosystem functioning: phenology

A number of challenges were identified during the workshop:

For Habitats:

1) Technology (Satellite Earth Observation)

   a) Spatial and Temporal resolution are not enough

   b) Spectral bands are limited

2) Methods and algorithms

   a) Atmospheric correction

   b) dealing with water attenuation – tide, turbidity, bathymetry

   c) with labelling data for machine learning/ in situ data

3) Using Satellite Earth Observation to support policy and management

   a) Communication!

For Phytoplankton:

1) Technology (Satellite Earth Observation)

   a) Temporal frequency of hyperspectral data is not enough

   b) Penetration to depth is challenging and would be important in thin layers (HABS) and down to the DCM (PP) and pycnocline (phenology)

2) Methods and algorithms

   a) Lack of collocated optical data with biological data on diversity

   b) Missing fundamental experiments and modelling to investigate the link between optics and diversity , to improve uncertainty characterization and to define the limits of operation of the algorithms

3) Using Satellite Earth Observation to support policy and management

   a) Strong discrepancies within our community on the terminology and

   b) Potential disconnection with marine biology community, policy and management due to language mismatch

   c) Biological diversity has a strong policy drive, and requirements need refining (e.g. biodiversity indices minimum requirements?)

Review of Existing IOCS Recommendations

2023.07.1: Review and gap analysis of sensors/products available to monitor aquatic biodiversity, and translation into indicators relevant for the scientific community and the Convention for Biodiversity/ Kunming Montreal Global Biodiversity Framework in 1.5 years. The paper should serve as a roadmap for space agencies to support over the next 5 years .[Ongoing, plan in place to deliver in the short term-2026]

2023.07.2: Space agencies should support cross-agency work to engage with stakeholders to refine needs/requirements (including spatial, vertical and temporal resolution) for essential biodiversity variables (EBV) and essential ocean variables (EOV). [Not reported]

2023.07.3: Space agencies and the community should ensure mission continuity and climate-relevant datasets for biodiversity. [Actioned, ESA has funded PHYTO-CCI for phytoplankton. Missing coastal pelagic phytoplankton and seabed habitats.]

New IOCS Recommendation(s) (Short term: ~1-2 y; Medium term: ~5 y; Long term: ~>10 y)

IOCS2025.R1.Habitats To address Challenge 1: To the Space Agencies to promote development of Satellite Earth Observation with higher spatial resolution (~ 2-5m) and revisit frequency, with good signal-to-noise and more spectral bands in the long term (constellation?) and lidar.

IOCS2025.R2.Habitats To address Challenge 2: The community (specialists on atmospheric correction) need to consider the atmospheric-bottom reflectance challenge in the medium term with the support from the Space Agencies.

IOCS2025.R3.Habitats To address Challenge 2:The Space Agencies should support research to upscale from field, drone, airborne data to satellite and differentiate species distribution in the medium term.

IOCS2025.R4.Habitats To address Challenge 2: In situ coastal habitat datasets need to be aggregated in repositories and Satellite-derived labelled data for machine learning training in the short term, as part of the tasks from a new IOCCG WG.

IOCS2025.R5.Habitats To address Challenge 3: the Ocean colour community needs to understand the management requirements better, educate management on Satellite Earth Observation and communication of uncertainty in the short term

IOCS2025.R6.Phytoplankton To address Challenge 1: Space Agencies to support GLIMR and/or studies with other geostationary sensors already deployed to investigate high frequency dependence of plankton diversity in the medium term.

IOCS2025.R7.Phytoplankton To address Challenge 1: Vertical extension of Ocean colour passive remote sensing to be complemented with active Satellite Earth Observation (e.g. Lidar) and other methods (e.g. bio-Argo floats) by the community in the long term.

Note special challenge of extending vertically over the continental shelf, where bio-Argo floats don't currently operate.

IOCS2025.R8.Phytoplankton To address Challenge 2: Space agencies should support regional algorithm development and in situ data collection in coastal areas in the presence of different levels of other optically active substances in the medium term.

IOCS2025.R9.Phytoplankton To address Challenge 2: To the Space Agencies to support the collocation of high spatial resolution in situ (as a minimum hyperspectral Remote Sensing reflectance) and laboratory optical data in the medium term for algorithm development.

IOCS2025.R10.Phytoplankton To address Challenge 3: The IOCCG to promote the adoption of the Essential Biodiversity Variables Framework by the satellite Earth Observation community working in the marine environment through the activities of a new IOCCG WG/Task force in the short term (e.g. through workshops).