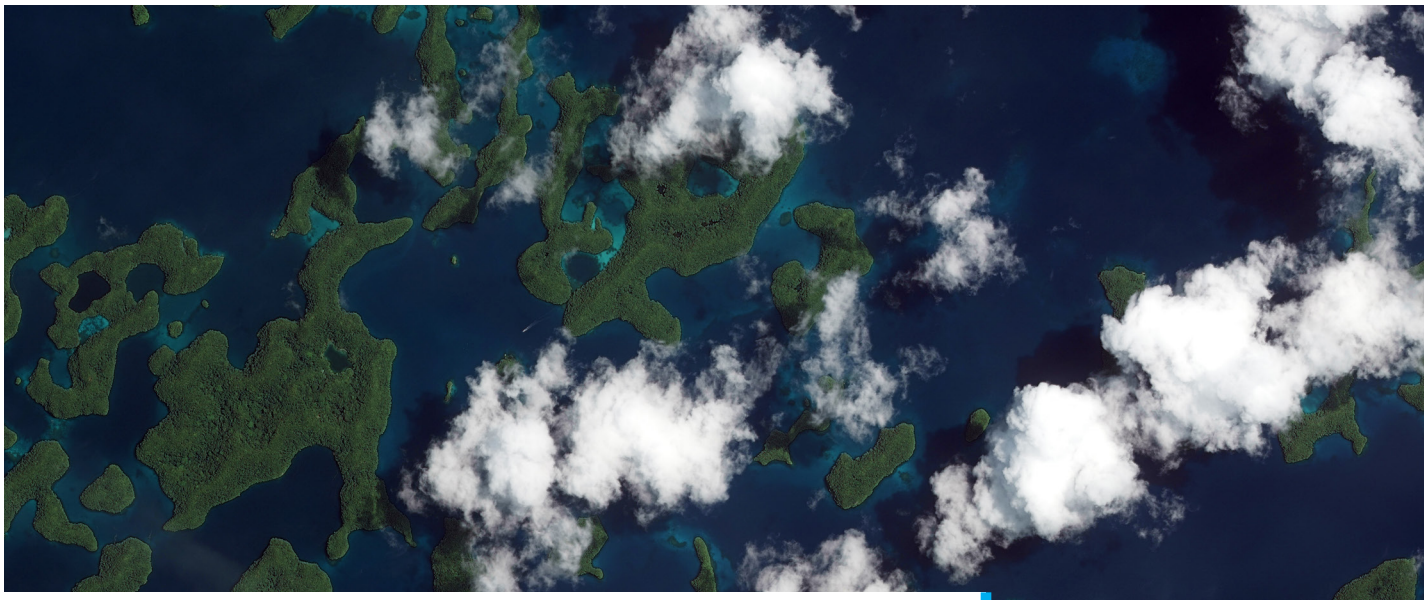


Call for Idea Submissions

Advancing the **Representation of the Ocean** in the **Planetary Boundary Framework**

Over geological time, the ocean has been the great regulator of Earth system state: the ocean has functioned both as a buffer and an amplifier of climate change throughout Earth's history, exchanging heat and greenhouse as well as other gases with the atmosphere while redistributing heat around the planet. Its role in regulating atmospheric oxygen concentrations has been important for the evolution of life on land while its role in the regulation of atmospheric greenhouse gas concentrations is a major driver of Glacial-Interglacial variations in these gases. In the context of current climate change, the ocean has acted as a critical buffer that slows the warming of Earth's surface, by absorbing more than 25% of anthropogenic CO_2 and over 90% of the excess heat from global warming.

These ocean processes are, however, not yet clearly captured in the Planetary Boundary framework. The Planetary Boundary framework currently identifies nine key processes that are essential for sustaining the stability and resilience of the Earth system. The framework seeks to define and quantify the extent of anthropogenic disturbances of these processes, providing thresholds that, if respected, would allow Earth to remain in a 'Holocene-like' state (for more details see **Richardson et al. 2023** and **Caesar et al. 2024**).

To further develop the framework and accurately reflect the ocean's critical role in shaping planetary conditions, we invite ocean experts to submit ideas for advancing the representation of the ocean in the Planetary Boundary framework.

Fundamental Ocean Functions in the **Earth System**

As a starting point for the discussions, we highlight that the ocean has two critical roles that impact the Earth system state:

01 · Heat storage and transport.

Currently, the framework addresses the planetary heat energy budget under the Climate Change Boundary, using two control variables: atmospheric CO_2 concentration and radiative forcing.

Could one or more new variables be added to capture ocean processes, or can a separate boundary be identified?

02 · Element exchange with the atmosphere.

The ocean continually exchanges gases with the atmosphere, driven by pressure gradients and temperature variations.

The air-sea CO_2 flux has been a substantial factor in past climate changes throughout Earth's history. Both biological and physical processes contribute to this flux. While the physical processes are closely linked to the boundaries of Climate Change and Ocean Acidification, the current control variables do not capture the potential role of ocean processes at the global scale.

Are there other metrics that would suit this purpose, or is this planetary impact best captured when considering interactions between the existing Planetary Boundaries?

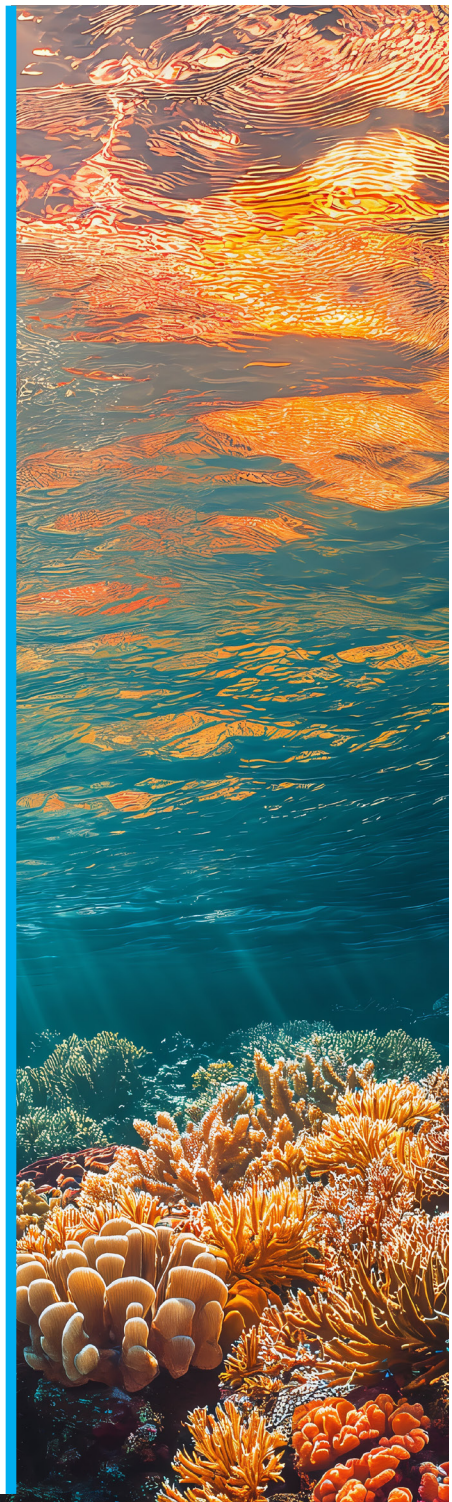
Deoxygenation of the Anthropocene ocean is well recognised (e.g., Oschlies et al. 2018). Changes in ocean-atmosphere oxygen exchange have potential implications at the planetary level. Likewise, aquatic deoxygenation can have global consequences for Biosphere Integrity. A recent study (Rose et al. 2024) has suggested **aquatic deoxygenation** as a potential Planetary Boundary.

Should and, if so, how can deoxygenation be accounted for in the Framework, i.e., as an independent boundary? Or as a control variable?

Marine Biosphere Integrity

As a consequence of the ocean heat and carbon uptake, seawater is acidifying, ocean heat dynamics are changing, and the integrity of the marine biosphere is deteriorating. While the loss of genetic diversity in the ocean is captured in the current configuration of the Biosphere Integrity Planetary Boundary (although likely underestimated due to sparse data), a control variable for **functional marine biosphere integrity** is still missing (see discussion in Richardson et al., 2023).

Can (a) more appropriate metric(s) be identified for evaluating the state of functional marine biosphere integrity?

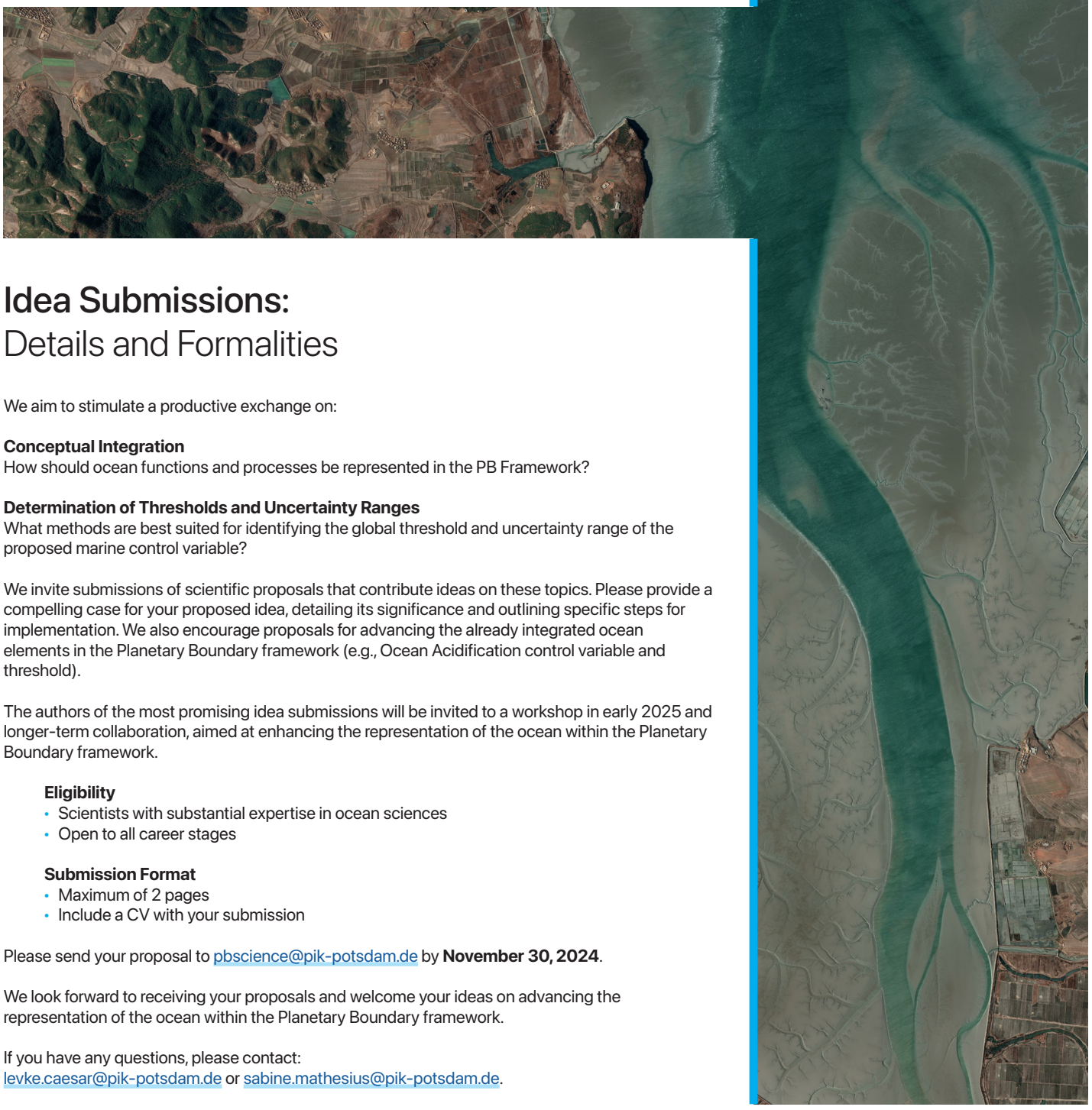


Further Considerations
for the **Planetary Boundary Framework**

Anthropogenic changes are to some extent addressed by the Biogeochemical Flows Planetary Boundary, referring to eutrophication.

Is this adequate or are other metrics required?

Additional suggestions are encouraged if there are aspects we may have overlooked. However, these ideas should focus on Earth System functions rather than solely addressing marine changes or anthropogenic stressors.



Idea Submissions:
Details and Formalities

We aim to stimulate a productive exchange on:

Conceptual Integration
How should ocean functions and processes be represented in the PB Framework?

Determination of Thresholds and Uncertainty Ranges
What methods are best suited for identifying the global threshold and uncertainty range of the proposed marine control variable?

We invite submissions of scientific proposals that contribute ideas on these topics. Please provide a compelling case for your proposed idea, detailing its significance and outlining specific steps for implementation. We also encourage proposals for advancing the already integrated ocean elements in the Planetary Boundary framework (e.g., Ocean Acidification control variable and threshold).

The authors of the most promising idea submissions will be invited to a workshop in early 2025 and longer-term collaboration, aimed at enhancing the representation of the ocean within the Planetary Boundary framework.

Eligibility
- Scientists with substantial expertise in ocean sciences
- Open to all career stages

Submission Format
- Maximum of 2 pages
- Include a CV with your submission

Please send your proposal to pbscience@pik-potsdam.de by **November 30, 2024**.

We look forward to receiving your proposals and welcome your ideas on advancing the representation of the ocean within the Planetary Boundary framework.

If you have any questions, please contact:
levke.caesar@pik-potsdam.de or sabine.mathesius@pik-potsdam.de.

References

Caesar, L., Sakschewski, B., Andersen, L. S., Beringer, T., Braun, J., Dennis, D., ... & Rockström, J., (2024), **Planetary Health Check Report 2024**. Potsdam Institute for Climate Impact Research, Potsdam, Germany.

Oschlies, A., Brandt, P., Stramma, L., & Schmidtko, S. (2018). **Drivers and mechanisms of ocean deoxygenation**. Nature Geoscience, 11(7), 467-473.

Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., ... & Rockström, J. (2023). **Earth beyond six of nine planetary boundaries**. Science advances, 9(37), eadh2458.

Rose, K. C., Ferrer, E. M., Carpenter, S. R., Crowe, S. A., Donelan, S. C., Garçon, V. C., ... & Breitburg, D. (2024). **Aquatic deoxygenation as a planetary boundary and key regulator of Earth system stability**. Nature Ecology & Evolution, 1-7.