



GO₂NE Marine Reoxygenation Workshop

10-11 September 2024

UNESCO Headquarters, Paris, France



GO₂NE
Global Ocean Oxygen NETwork

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Abbreviations

CBD	United Nations Convention on Biological Diversity
CH ₄	Methane
CO ₂	Carbon Dioxide
COP	Conference of the Parties
GHG	Greenhouse Gas
GO ₂ NE	Global Ocean Oxygen Network
GOA-ON	Global Ocean Acidification Observing Network
GOOD	Global Ocean Oxygen Decade
IOC-UNESCO	Intergovernmental Oceanographic Commission of UNESCO
N ₂ O	Nitrous Oxide
NO ₃ ⁻	Nitrate
OMZ	Oxygen Minimum Zone
PO ₄ ³⁻	Phosphate
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
XMAS	Xiamen Symposium on Marine Environmental Sciences 2025

List of Participants

GO₂NE* Co-Chair**

In person:

David Austin	Global Principal Natural Treatment Systems Water Market Solutions, USA
Laurent Bopp	CNRS - Laboratoire de Météorologie Dynamique , France
Denise Breitburg*	Smithsonian Environmental Research Center, USA
Anna Canning	Lhyfe SA, France
Daniel Conley	Lund University, Sweden
Erica Ferrar	University of California, USA
Bo Gustafsson	Stockholm University, Sweden
Astrid Hylén	University of Antwerp, Belgium
Rudy Lamond	Air Liquide, France
Ming Li	University of Maryland Center for Environmental Science, USA
Andreas Oschlies**	GEOMAR, Germany
Caroline Slomp**	Radboud University, The Netherlands
Jeremy Testa	University of Maryland Center for Environmental Science, USA
Doug Wallace	Dalhousie University, Canada
Moriaki Yasuhara*	The University of Hong Kong, China

IOC Secretariat (in person):

Kirsten Isensee	IOC-UNESCO, Paris, France
Jeremy Sterling	IOC-UNESCO, The Netherlands
Henrik Enevoldsen	IOC-UNESCO, Copenhagen, Denmark

Online participation:

Lennart Bach	University of Tasmania, Australia
Minhan Dai*	Xiamen University, China
Boris Dewitte	Center for Advanced Studies in Arid Zones, Chile
Alexander Galan	Universidad Católica del Maule, Chile
Véronique Garçon*	CNRS, Institut de Physique du Globe de Paris, France
Marilaure Grégoire*	Liège University, Belgium
Dimitri Gutierrez*	Instituto del Mar del Peru, Peru
Karin Limburg*	SUNY College of Environmental Science and Forestry, USA
Ivonne Montes*	Instituto Geofísico del Perú, Peru
Aileen Tan Shau Hwai*	Centre For Marine & Coastal Studies, Universiti Sains Malaysia, Malaysia
Joanna Waniek	Leibniz Institute for Baltic Sea Research (IOW), Germany

1. Background

The Co-Chairs of the GO₂NE expert working group led a workshop on marine reoxygenation at UNESCO Headquarters, Paris, France, on September 10-11, 2024. Under the auspices of the IOC-UNESCO, the workshop convened members of the GO₂NE working group, external experts on the science of ocean oxygen, and engineering and scientific specialists with experience of small-scale marine and freshwater reoxygenation.

2. Opening and objective

IOC-UNESCO Executive Secretary Vidar Helgesen welcomed participants and introduced the meeting. The GO₂NE Co-Chairs Andreas Oschlies and Caroline Slomp outlined the workshop objective - a discussion of marine reoxygenation techniques, their feasibility, and their environmental effects. The recommendations for potential and planned reoxygenation deployment will be published as an opinion piece and in a peer-reviewed journal.

3. Contexts and suggested approaches for marine reoxygenation

Participants gave short presentations providing insights on specific geographical regions experiencing deoxygenation, environmental concerns, and reoxygenation methodologies. Approaches presented focused on direct interventions increasing the oxygen content in low oxygen areas.

Andreas Oschlies	- Peru/Chile OMZ
Caroline Slomp	- Deoxygenation in Dutch managed marine coastal systems
Doug Wallace	- St. Lawrence Estuary, Canada
Bo Gustafson and Daniel Conley	- Baltic Sea
Jeremy Testa, Denise Breitburg and Ming Li	- Approaches for reoxygenation in Chesapeake Bay, USA
Laurent Bopp	- Modelling reoxygenation
Anna Canning	- Lhyfe engagement in H ₂ sector and reoxygenation
Rudy Lamond	- Air Liquide engagement in H ₂ sector and reoxygenation
David Austin	- Reoxygenation potential and engineering solutions

4. Recommendations for research on, and possible deployment of, marine reoxygenation

The workshop produced a set of guiding questions for consideration before, during, and after a potential marine reoxygenation experiment(s). The guiding questions would inform both site selection of a potential reoxygenation intervention, as well as the development of a field study and related assessment framework. It should be noted that almost all points below may be dependent on the context of an individual potential site of deployment. These points will be used by the group under the leadership of the Co-Chairs to draft recommendations for publication. The publication will also provide a summary of previously conducted experiments/field studies using different technologies to increase the oxygen content in coastal waters, e.g. artificial downwelling. Furthermore, it will be clearly stated that reoxygenation techniques are not a replacement for greenhouse gas emission reductions and measures to reduce the input of nutrients to marine waters.

Guiding questions:

What is the motivation to aim for reoxygenation? (Other aspects of environmental change, such as warming and acidification are not addressed)

What is to be achieved?

What should already be known before field experiments?

What should be known, measured, observed during field and laboratory experiments?

What are considerations for governance, coordination, and ethics?

What are recommendations for best practices and some general considerations

5. Next steps

The Co-Chairs, supported by the IOC secretariat, will create first drafts of the below before seeking input from meeting participants and collaborating to finalise. Participants and the secretariat will disseminate the recommendations of the workshop at existing meetings and conferences.

Dissemination at meetings	CBD Ocean Day, 21 Oct – 1 Nov, 2024 XMAS 2025 ocean deoxygenation session, 14 – 17 Jan, 2025 One Ocean Science Congress, 4 – 6 June, 2025 UN Ocean Conference 9 – 13 June, 2025
Publications	Perspective piece by mid - EOS request to be sent by GO ₂ NE co-chairs mid-October, if request approved full article will be shared with participants of the meeting One-page produced for meetings and conferences Peer reviewed paper in 2025 - Nature / Biogeosciences / other

Agenda

Tuesday 10 September 2024

09:30	Opening and welcome	Vidar Helgesen (Executive Secretary, IOC-UNESCO), Andreas Oschlies and Caroline Slomp (GO ₂ NE co-chairs)
09:45	Introduction of the workshop objective and messaging	Andreas Oschlies and Caroline Slomp (GO ₂ NE co-chairs), Kirsten Isensee (IOC-Secretariat)
10:00	Tour de Table	all
10:45	Coffee break	
11:15	Suggested approaches for marine reoxygenation Short presentations by participants (5 min max) providing insights for different geographical regions, environmental concerns and methodologies. Group discussion	Andreas Oschlies (Peru/Chile OMZ) and Caroline Slomp (Netherlands) (GO ₂ NE co-chairs), Doug Wallace (St.Lawrence Estuary), Daniel Conley/Bo Gustafson (Baltic Sea), Jeremy Testa, Denise Breitburg, Ming Li (Chesapeake Bay), Laurent Bopp, all
13:00	Lunch break	
14:00	Approaches for coastal reoxygenation cont'd Suggestions from practitioners and the industry	Anna Canning, Rudy Lamond, David Austin
15:15	Coffee break	
15:45	Impacts of Reoxygenation - lessons learned from what has been done so far, including marine carbon dioxide removal technologies and freshwater reoxygenation Objective: Identification of monitoring principles and best practices to follow	Caroline Slomp, David Austin, Anna Canning, all
17:30	End of the day	

Wednesday 11 September 2024

09:30	Recap Day 1	GO ₂ NE Co-Chairs
10:00	Identification of key knowledge gaps, including spatial differences	all
10:45	Coffee break	
11:15	Drafting of recommendations for research on, and possible deployment of marine reoxygenation Possible outputs: Scientific opinion piece/recommendations and a short brief/leaflet (audience: decision/policy makers)	all
13:00	Lunch	
14:00	Next steps, messaging, and timeline	Jeremy Sterling, Kirsten Isensee (IOC-Secretariat)
15:00	End of the day	