

Kiel Declaration on Ocean Deoxygenation

Participants of the international conference

“Ocean Deoxygenation: Drivers and Consequences – Past – Present – Future”,

3 – 7 September 2018 in Kiel, Germany organized by:

Kiel Collaborative Research Center SFB 754 and Global Ocean Oxygen Network (GO₂NE – IOC-UNESCO)

The ocean is losing its breath

Oxygen in the ocean supports the largest ecosystems on the planet. It is alarming that the ocean is losing oxygen, termed ocean deoxygenation, primarily due to global warming by greenhouse gas emissions, and pollution by nutrients and organic wastes particularly in coastal waters. We call on all nations, societal actors, scientists and the United Nations to:

- (a) Raise global awareness about ocean deoxygenation through local, regional and global efforts, including interdisciplinary research, innovative outreach, and ocean education.
- (b) Take immediate and decisive action to limit pollution and in particular excessive nutrient input to the ocean.
- (c) Limit global warming by decisive climate change mitigation actions.

Both the Paris Agreement addressing Climate Change and the United Nations' 2030 Agenda for Sustainable Development demand conservation and sustainable use of the ocean, seas and marine resources in order to safeguard ocean ecosystems and their current and future societal benefits. These are severely threatened by ocean deoxygenation.

Scientists assembled at the conference and from around the world agree that:

1. During the past 50 years oxygen-depleted waters have expanded four-fold. Some areas of the ocean have lost up to 40% of their oxygen.
2. The ongoing loss of oxygen from the ocean is a rapidly increasing threat to marine life, the ocean's ecosystems and coastal communities.
3. Global warming impacts ocean oxygen in two ways: the capacity to hold oxygen decreases in warming waters, whilst warming reduces ocean mixing and circulation limiting the supply of oxygen from the atmosphere. Pollution by nutrients and organic waste enhances oxygen demand by increasing biological production and oxygen consumption during decomposition.
4. Deoxygenation disrupts marine ecosystems, affects fish stocks and aquaculture and leads to loss of habitat and biodiversity. It can, in extreme cases, lead to the production of toxic gases when all oxygen in the water has been lost.
5. Deoxygenation can accelerate global warming via enhanced marine production of greenhouse gases under low oxygen conditions.
6. The problem of deoxygenation is predicted to worsen in the coming years under continued global warming and increasing nutrient input to coastal regions as human populations and economies grow.
7. Expanded observation is immediately required for accurate documentation and prediction of ocean oxygen changes, and for improved understanding of its causes and consequences.
8. Strategies to slow and eventually reverse deoxygenation and its ecological impacts need to be co-developed between science and societal actors. This will contribute to the UN Decade of Ocean Science for Sustainable Development.

Conference Chair, Executive Board & Conveners

Prof. Andreas Oschlies, GEOMAR & Kiel University, Kiel, Germany

Prof. Eric Achterberg, GEOMAR & Kiel University, Kiel, Germany

Dr. Patricia Ayon, Marine Institute of Peru, Lima, Peru

Prof. Hermann Bange, GEOMAR, Kiel, Germany

Dr. Denise Breitburg, Smithsonian Environmental Research Centre, Edgewater, MD USA

Dr. Laura Bristow, University of Southern Denmark, Odense, Denmark

Dr. Xavier Capet, CNRS, Paris France

Prof. Minhan Dai, Xiamen University, Xiamen, China

Prof. Anja Engel, GEOMAR & Kiel University, Kiel, Germany

Prof. Katja Fennel, Dalhousie University, Halifax, Canada

Prof. Martin Frank, GEOMAR & Kiel University, Kiel, Germany

Dr. Veronique Garcon, LEGOS, CNRS, Toulouse, France

Prof. Marilaure Grégoire, University of Liège, Liège, Belgium

Dr. Helena Hauss, GEOMAR, Kiel, Germany

Dr. Babette Hoogakker, Heriot-Watt University, Edinburgh, UK

Dr. Kirsten Isensee, IOC-UNESCO, Paris, France

Prof. Samuel Jaccard, University of Bern, Bern, Switzerland

Prof. Klaus Jürgens, Leibniz Institute for Baltic Sea Research Warnemünde, Rostock, Germany

Dr. Rainer Kiko, GEOMAR, Kiel, Germany

Prof. Arne Körtzinger, GEOMAR & Kiel University, Kiel, Germany

Prof. Mojib Latif, GEOMAR & Kiel University, Kiel, Germany

Prof. Lisa Levin, Scripps Institution of Oceanography, University of California, San Diego, CA USA

Prof. Karin Limburg, SUNY, College of Environmental Science & Forestry, Syracuse, NY USA

Dr. S. Wajih A. Naqvi, Kuwait Institute for Scientific Research, Salmiya, Kuwait

Dr. Oscar Pizarro, University of Concepción, Chile

Prof. Martin Quaas, Kiel University, Kiel, Germany

Dr. Renato Quinones, University of Concepción, Concepción, Chile

Prof. Birgit Schneider, Kiel University, Kiel, Germany

Prof. Caroline Slomp, Utrecht University, Utrecht, The Netherlands

Dr. Lothar Stramma, GEOMAR, Kiel, Germany

Dr. Sören Thomsen, LOCEAN-IPSL, Sorbonne University, Paris, France

Prof. Tina Treude, University of California, Los Angeles, CA USA

Prof. Osvaldo Ulloa, University of Concepción, Concepción, Chile

Prof. Martin Visbeck, GEOMAR & Kiel University, Kiel, Germany