



GESAMP

Joint Group of Experts on the
Scientific Aspects of Marine
Environmental Protection

GESAMP 52/4/7

20 June 2025

ENGLISH ONLY

52nd Session
Agenda item 4

PLANNING OF GESAMP ACTIVITIES

Climate change and greenhouse gas related impacts on contaminants in the ocean

Report of the Chair of Working Group 45

Introduction

1 Following the Working Group meeting hosted by IOC-UNESCO in Paris, France, in November 2023, Working Group members and invited experts continued their collaboration in the development of three scientific manuscripts as planned. These outputs represent significant progress since GESAMP's 51st session in September 2024.

Recent progress

2 The first manuscript, on "Climate change drives persistent organic pollutant dynamics in marine environment", was published in *Communications Earth & Environment* in May 2025 (authors: Pamela D. Noyes, Daniele Miranda, Gabriel Oliveira de Carvalho, Alessandra Perfetti-Bolaño, Yago Guida, Fábio Barbosa Machado Torres, João Paulo Machado Torres, Karina S.B. Miglioranza, Vanessa Hatje, and Ricardo O. Barra).

Abstract: Understanding climate change impacts in combination with other anthropogenic stressors, such as chemical pollution, is critical to identifying vulnerable marine ecosystems. This paper presents a systematic review and conceptual model mapping evidence of the marine environmental fate and biological effects of persistent organic pollutants with shifting climate drivers. Increasing ice melt, atmospheric deposition, and sediment remobilization are altering persistent organic pollutant dynamics in northern polar environments but with data gaps elsewhere. While limited to fish and invertebrates, principal biological effect pathways involve reduced survival and perturbed thermal regulation and bioenergetics, notably in some populations residing in more heavily polluted and thermal edge habitats. Associated food web shifts with climate change are also altering persistent organic pollutant bioaccumulation among some marine mammal and seabird populations and assemblages. The evidence suggests potential ecological deterioration in some areas with many unknowns underscoring the need for advancing experimental and modeling tools to evaluate these complex interactions.

3 The second manuscript, on 'Effects of climate change on river and groundwater nutrient inputs to the coastal ocean', is currently under review after the revised version submitted to *Communications Earth & Environment* (authors: C. Richardson, B. Peucker-Ehrenbrink, S. Wyatt, A. Bourbonnais, V. Hatje, C. Frey, T. Sanders, D. E. Varela, and A. Paytan).

Abstract: Rivers and groundwater are major sources of nutrients to the global coastal ocean. Climate change is expected to impact nutrient exports from river basins and coastal aquifers through alterations to both hydrological and nutrient cycling processes. In this Review, we identify and summarize how climate change impacts, like changes in precipitation, increased cryosphere melt, and sea level rise, are likely to affect water discharge and nutrient concentrations in rivers and coastal groundwater, which ultimately

control inputs to the coastal ocean. Additionally, we document key limitations in current understanding of climate-related changes to nutrient fluxes, especially in coastal groundwater basins. The impacts of climate change will also interact with local anthropogenic impacts, highlighting the need for studies spanning local to global scales for better understanding and improve predictions of future nutrient fluxes from these hydrological pathways.

4 The third manuscript, on ‘The effects of climatic impact-drivers on biogeochemical cycles in oxygen deficient and dead zones’, is going through the final phase for submission to *Communications Earth & Environment*, in June 2025 (authors: Annie Bourbonnais, Claudia Frey, Shea Wyatt, Caroline P. Slomp, Karen Casciotti, Christina Richardson, Adina Paytan, Diana E. Varela, Tina Sanders, Vanessa Hatje).

Abstract: Oxygen deficient zones (ODZs), where oxygen consumption greatly exceeds the supply, are economically and ecologically important. ODZs are associated with eastern boundary upwelling systems in the Pacific and Atlantic Ocean where nutrient inputs and productivity are high and circulation is poor. Other major ODZs are located in the Arabian Sea and the Bay of Bengal. ODZs can also be found in the marginal seas permanently or seasonally, such as the Black and Baltic Seas and some coastal zones (example, the Gulf of Mexico, and restricted fjords and basins). Climate change has both direct and indirect effects on the oxygen content of seawater thereby contributing to ocean deoxygenation. Deoxygenation owing to climate change and ongoing anthropogenic stressors will in turn impact marine biogeochemical cycles of nitrogen, phosphorus and silicon. In this Review, we discuss the impacts of climate change on ODZs and dead zones and identify key knowledge gaps and future research directions. Climatic impact-drivers expected to affect marine ODZs and associated nutrient cycles include changes in temperature, wind speed, and precipitation. These impact-drivers will alter marine processes relevant to ODZs, including higher sea surface temperatures that reduce gas solubility, increase stratification and respiration, and circulation changes that intensify upwelling, amplifying greenhouse gas production. These changes are likely to increase bioavailable N loss and sedimentary P remobilization. ODZs have increased in size over the past decades and are expected to increase further, with socio-economic and ecological consequences. The temporal and spatial resolution monitoring programs (example, sensors on autonomous platforms) are needed to better understand the effects of climate impact-drivers on deoxygenation and biogeochemical fluxes within the ODZs.

5 The following manuscripts have been published by the working group to date:

- .1 “Emergent interactive effects of climate change and contaminants in coastal and ocean ecosystems”; Hatje V, Sarin M, Sander S G, Omanovic´ D, Ramachandran P, Völker C, Barra R O and Tagliabue A; *Front. Mar. Sci.* (2022) 9:936109; doi:10.3389/fmars.2022.936109
- .2 The effect of climate change on sources of radionuclides to the marine environment”; Justin P. Gwynn, Vanessa Hatje, Núria Casacuberta, Manmohan Sarin & Iolanda Osvath; *Communications Earth & Environment* (2024) 5:135; doi.org/10.1038/s43247-024-01241-w
- .3 “Climate change driven effects on transport, fate and biogeochemistry of trace element contaminants in coastal marine ecosystems”; Rebecca Zitoun, Saša Marcinek, Vanessa Hatje, Sylvia G. Sander, Christoph Völker, Manmohan Sarin, Dario Omanović; *Communications Earth & Environment*; (2024) 5:560; <https://doi.org/10.1038/s43247-024-01679-y>
- .4 “Climate change drives persistent organic pollutant dynamics in marine environment”; Pamela D. Noyes, Daniele Miranda, Gabriel Oliveira de Carvalho,

Alessandra Perfetti-Bolaño, Yago Guida, Fábio Barbosa Machado Torres, João Paulo Machado Torres, Karina S.B. Miglioranza, Vanessa Hatje, and Ricardo O. Barra; *Communications Earth & Environment*; (2025) 6:363;
<https://doi.org/10.1038/s43247-025-02348-4>

6 The Group's Terms of reference and list of members are set out in annexes 1 and 2, respectively.

Action requested of GESAMP

7 GESAMP is invited to consider the information provided and to decide as appropriate.

ANNEX 1

WG 45 Members

Name	Country	Subject
Sarin Manmohan (Co-chair) Chair, since Feb 2024	India	Ocean biogeochemistry, Atmospheric input of chemical constituents to ocean
Elisabeth Holland	Fiji	Climate change
Sylvia Sander	Germany	Biogeochemistry, metal speciation
Annie Bourbonnais	United States	Nutrients
Pamela Noyes	United States	Ecotoxicologist, organic pollutants, climate change
Nuria Casacuberta	Switzerland	Radiotracers, Ocean circulation, SPM fluxes
Ricardo Barra	Chile	Persistent organic pollutants
Dario Omanovic Co-chair, since Feb 2024	Croatia	Trace elements, speciation, speciation modeling
Alessandro Tagliabue	United Kingdom	Modeler, ocean biogeochemistry, trace elements
Christoph Voelker	Germany	Physical oceanography, modeling
Justin Gwynn	Norway	Radiochemistry
Previous members		
Vanessa Hatje (Chair until Jan 2024)	Brazil	Marine pollution, blue carbon ecosystems, Biogeochemistry

ANNEX 2

Terms of Reference for WG 45

- 1 Critically review existing research on:
 - .1 The effect of changes in ocean physics and chemistry on the speciation, cycling, fate and bioavailability of diverse contaminants including trace elements, radionuclides, organic pollutants and nutrients.
 - .2 The effect of such changes on important coastal and marine resources.
- 2 Identify knowledge gaps.
- 3 Make recommendations for future research directions on the effect of changes in ocean physics and chemistry on the speciation, cycling and bioavailability of diverse contaminants including trace elements, radionuclides, organic pollutants and nutrients.
- 4 Develop a plan for publication and dissemination of the findings of the WG.
- 5 Propose additional work relevant to the topic of the WG that may be useful for the Sponsoring Organizations and which could be carried out by the WG beyond what is listed above.

ANNEX 3

Experts contributing to the review articles

Sub-group - Organic Pollutants	
Name	Country
Begoña Jimenez	Spain
João Torres	Brazil
Rainer Lohmann	United States
Daniele Miranda	United States
Rolland Kallenborn	Norway
Fabio Torres	Brazil
Yago Guida	Brazil
Gabriel O de Carvalho	Brazil
Sub-group - Nutrients	
Name	Country
Adina Paytan	United States/Israel
Cristina Richardson	United States
Claudia Frey	Switzerland
Caroline Slomp	Netherlands
Karen Casciotti	United States
Tina Sanders	Germany
Cristina Richardson	United States
Sub-group - Metals	
Rebecca Zitoun	Germany
Saša Marcinek	Croatia
