

6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

- 6.1 Intergovernmental Oceanographic Commission (IOC), p. 6-1** *Burkill*
- 6.2 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), p. 6-1** *Urban*
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GESAMP
Joint Group of Experts on the
Scientific Aspects of Marine
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GESAMP Working Group 38
ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS
2016 Report to SCOR from the Co-Chairs of Working Group 38

Brief History of WG 38

Recognition continues to grow concerning the impact of the atmospheric input of both natural and anthropogenic substances on ocean chemistry, biology, and biogeochemistry as well as climate. In the 1980s GESAMP formed a working group sponsored by WMO, UNESCO/IOC, and UNEP that developed a comprehensive review of the input of atmospheric trace species to the global ocean (GESAMP, 1989). That benchmark effort led to a scientific publication in *Global Biogeochemical Cycles* in 1991 that for more than 15 years was the state-of-the-art reference in this area, leading to over 1400 citations in the literature. That paper is now 25 years old, and a new overall look at this issue was needed.

For this reason Working Group 38 was formed during 2008 and it held its first meeting at the University of Arizona, Tucson, AZ, in December, 2008. Subsequent meetings were held at IMO in London in 2010, and Malta in 2011. Sponsors of those initial WG 38 efforts included WMO, IMO, SCOR, SIDA, the European Commission Joint Research Centre, the University of Arizona, and the International Environment Institute at the University of Malta.

Following the initial terms of reference, as a result of the first working group meetings five scientific papers were published in the scientific literature. These are:

- 1) Okin, G., A. R. Baker, I. Tegen, N. M. Mahowald, F. J. Dentener, R. A. Duce, J. N. Galloway, K. Hunter, M. Kanakidou, N. Kubilay, J. M. Prospero, M. Sarin, V. Surapipith, M. Uematsu, T. Zhu, "Impacts of atmospheric nutrient deposition on marine productivity:

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roles of nitrogen, phosphorus, and iron”, Global Biogeochemical Cycles, 25, GB2022, doi:10.1029/2010GB003858, (2011).

- 2) Hunter, K.A., P. S. Liss, V. Surapipith, F. Dentener, R. A. Duce, M. Kanakidou, N. Kubilay, N. Mahowald, G. Okin, M. Sarin, I. Tegen, M. Uematsu, and T. Zhu, “Impacts of anthropogenic SO_x, NO_x and NH₃ on acidification of coastal waters and shipping lanes”, Geophysical Research Letters, 38, L13602, doi:10.1029/2011GL047720 (2011).
- 3) Kanakidou, M., R. Duce, J. Prospero, A. Baker, C. Benitez-Nelson F. J. Dentener, K.A. Hunter, N. Kubilay, P. S. Liss, N. Mahowald, G. Okin, M. Sarin, K. Tsigaridis, M. Uematsu, L.M. Zamora, and T. Zhu, “Atmospheric fluxes of organic N and P to the ocean”, Global Biogeochemical Cycles, 26, GB3026, doi:10.1029/2011GB004277, (2012).
- 4) Schulz, M., J. M. Prospero, A. R. Baker, F. Dentener, L. Ickes, P. S. Liss, N. M. Mahowald, S. Nickovic, C. Pérez García-Pando, S. Rodríguez, M. Sarin, I. Tegen, R.A. Duce, “The atmospheric transport and deposition of mineral dust to the ocean - Implications for research needs”, Environmental Science and Technology, 46, 10,390-10,404 (2012).
- 5) Hagens, M., K.A. Hunter, P.S. Liss, and J.L. Middelburg, “Biogeochemical context impacts seawater pH changes resulting from atmospheric sulfur and nitrogen deposition”, Geophysical Research Letters, 41, doi:10.1002/2013GL058796 (2014).

Recent Activities of WG 38

Additional terms of reference for continued work of GESAMP WG 38 were approved in 2012 to address issues related to the impact of the atmospheric deposition of anthropogenic nitrogen to the ocean. The additional tasks added were briefly as follows:

- A. Update the geographical estimates of anthropogenic nitrogen deposition to the global ocean;
- B. Re-evaluate the impact of atmospheric nitrogen deposition on marine biogeochemistry;
- C. Provide a more reliable estimate of the impact of atmospheric anthropogenic nitrogen deposition on the production of additional nitrous oxide in the ocean and its subsequent emission to the atmosphere;
- D. Evaluate the extent to which anthropogenic nitrogen delivered to the coastal zone via rivers, atmospheric deposition, etc. is transported to the open ocean; and
- E. Make a detailed estimate of the input and impact of anthropogenic nitrogen in the area of the Northern Indian Ocean and the South China.

To address these new terms of reference, a highly successful workshop on The Atmospheric Deposition of Nitrogen and Its Impact on Marine Biogeochemistry was held at the University of East Anglia in Norwich, United Kingdom, from 11 to 14 February 2013. This newest work by WG

38 was supported by WMO, IMO, SCOR, the University of East Anglia, and the US National Science Foundation. Since the Norwich workshop several additional papers has been published:

- 6) Kim, T.-W., K. Lee, R.A. Duce and P.S. Liss, “Impact of atmospheric nitrogen deposition on phytoplankton productivity in the South China Sea”, *Geophys. Res. Lett.*, **41**, 3156-3162, doi: 10.1002/2014GL059665 (2014).
- 7) Somes, C.J., A. Landolphi, W. Koeve, and A. Oschlies, “Limited impact of atmospheric nitrogen deposition on marine productivity due to biogeochemical feedbacks in a global ocean model”, *Geophys. Res. Lett.*, 4500–4509, doi: 10.1002/2016GL068335 (2016).
- 8) Kanakidou, M., S. Myriokefalitakis, N. Daskalakis, G. Fanourgakis, A. Nenes, A.R. Baker, K. Tsigaridis, and N. Mihalopoulos, “Past, Present, and Future Atmospheric Nitrogen Deposition”, *J. Atmos. Sci.*, **73**, 2039-2047, doi:10.1175/JAS-D-15-0278.1 (2016).

Four additional papers are in preparation, and all should be submitted before the end of the summer. This includes a major summary paper on our current understanding of the impact of atmospheric nitrogen deposition on marine biogeochemical cycling, led by Tim Jickells, and a paper comparing observation and model-based estimates of atmospheric nitrogen deposition to the ocean, led by Alex Baker. These papers are as follows:

- 9) Jickells, T.D., Buitenhuis, E., Altieri, K., Baker, A.R., Capone, D., Duce, R.A., Dentener, F., Fennel, K., Kanakidou, M., LaRoche, J., Lee, K., Liss, P., Middelburg, J. J., Moore, J.K., Okin, G., Oschlies, A., Sarin, M., Seitzinger, S., Sharples, J., Suntharalingam, P., Uematsu, M., Zamora, L.M., “A re-evaluation of the magnitude and impacts of anthropogenic atmospheric nitrogen inputs on the ocean”, To be submitted to Global Biogeochemical Cycles or Biogeosciences by August 2016.
- 10) Baker, A.R., M. Kanakidou, K. Altieri, N. Daskalakis, G. Okin, S. Myriokefalitakis, F. Dentener, M. Uematsu, M. Sarin, R. Duce, J. Galloway, W. Keene, A. Singh, L. Zamora, J.-F. Lamarque, S.-C. Hsu, S. Rohekar, J. Prospero, “Atmospheric nitrogen deposition to the oceans: observation- and model-based estimates of dry (aerosol) deposition”, To be submitted to Biogeosciences or Global Biogeochemical Cycles by August, 2016.
- 11) Sharples, J., J. J. Middelburg, K. Fennel, and T. D. Jickells, “Physical controls on riverine delivery of nutrients and carbon to the oceans”, To be submitted to Global Biogeochemical Cycles or Biogeosciences during the summer of 2016
- 12) Zamora, L., P. Suntharalingam, A. Singh, M. Sarin, S. Bikkina, L. Resplandy, S. Seitzinger, S. Schmidtko, and H.W. Bange, “N₂O emissions from the Northern Indian Ocean: the role of atmospheric and riverine nitrogen inputs”, To be submitted to Global Biogeochemical Cycles by August, 2016.

Once again WG 38 organized a session on atmospheric input of chemicals to the ocean for the 2016 EGU meeting, held in Vienna, Austria in April – “Air-sea Exchanges: Impacts on

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Biogeochemistry and and Climate”. A number of oral and poster papers at this session were presented by a combination of WG 38 members and other scientists. WG 38 member Maria Kanakidou was honored by being awarded the Vilhelm Bjerknes Medal, and she presented the medal lecture as part of this symposium.

Robert Duce, representing WG 38, participated in the 3rd Scientific Steering Committee of the WMO Global Atmosphere Watch Programme (GAW), held in Geneva in March, 2016. Tim Jickells, Robert Duce, and Alex Baker represented WG 38 at the WMO/GAW International Workshop on the Nitrogen Cycle in April, 2016, presenting three papers on various WG 38 efforts on nitrogen inputs to the ocean.

Future Activities of WG 38

At the meeting of GESAMP at IOC in Paris in September, 2015, GESAMP approved two new workshops for WG 38, assuming that appropriate funding could be obtained. These two simultaneous workshops are related to the changing acid/base character of the global atmosphere and ocean and the impact of these changes on certain air/sea chemical exchange processes. One workshop, “*Changing Atmospheric Acidity and the Oceanic Solubility of Nutrients*”, will focus on how the changing atmospheric acidity will affect the solubility, and thus bioavailability, of such aerosol-derived nutrients as iron and phosphorus when they are deposited in the ocean from the atmosphere. This workshop has the following Terms of Reference:

- Review and synthesize the current scientific information on the solubility of aerosol-associated key biogeochemical elements, the biogeochemical controls on aerosol solubility, and the pH sensitivity of those controls.
- Consider the likely changes in solubility of key species into the future and the potential biogeochemical consequences of such changes.
- Identify the key future research needs to reduce uncertainties in predictive capability in this area.
- Publish the results of this activity in the open peer-reviewed scientific literature.
- Interact with, and provide information to, leading relevant international groups including the Future Earth core projects SOLAS, IGAC and IMBER; SCOR, particularly its GEOTRACES program; and WMO programs such as GAW.

The second workshop, to be held at the same time and location, is “*Impact of Ocean Acidification on Fluxes of non-CO₂ Climate-Active Species*”, and it will focus on the impacts of ocean acidification on the oceanic sources of a range of non-CO₂ gaseous species, as well as aerosol precursors, that are influential in regulating radiative forcing, atmospheric oxidizing capacity and atmospheric chemistry. This workshop has the following Terms of Reference:

- Review and synthesize the current science on the direct impacts of ocean acidification on marine emissions to the atmosphere of key species important for climate, and atmospheric chemistry.

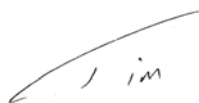
- Identify the primary needs for new research to improve process understanding and to quantify the impact of ocean acidification on these marine fluxes (i.e., provide recommendations on the specific laboratory process studies, field measurements and model analyses needed to support targeted research activities on this topic).
- Publish the results of this activity in the open peer-reviewed scientific literature.
- Provide input to and interact with national and international research programs on ocean acidification (e.g., UKOA, NOAA-OAP) and with relevant WMO programs (e.g., Global Atmosphere Watch (GAW)) to build on their recent relevant activity in achieving the above objectives.

We see potential synergies between these two workshops, and individuals will have the opportunity to attend some sessions of both workshops. The workshops will take place at the University of East Anglia (UEA) in Norwich, United Kingdom from February 27 through March 2, 2017. We have obtained financial support for these workshops from WMO, IMO, SCOR, NSF, and UEA, and SOLAS is also sponsoring the workshops. We expect a total of about 25-30 people to attend these invitation-only workshops.

A potential third upcoming activity of WG 38 is an assessment of the impact of nitrogen on the marine environment as a contribution to the Integrated Nitrogen Management System (INMS). INMS is a global targeted research project with the aim to provide clear scientific evidence to inform future international nitrogen policy development. INMS's core funding comes from the Global Environment Facility (GEF) (the environment funding mechanism of the United Nations System) with the United Nations Environment Program (UNEP) as the Implementing Agency and the UK Natural Environment Research Council (Centre for Ecology and Hydrology) as the Executing Agency acting on behalf of the International Nitrogen Initiative (INI). WG 38 is in an excellent position to bring together observational scientists and atmospheric modeling groups to address these issues. Funding for this effort would come from the INMS.



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