



36th session  
Agenda item 5.6

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## **PLANNING OF GESAMP ACTIVITIES: THE ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEAN**

### **Report of the GESAMP Working Group 38**

#### **BACKGROUND**

1 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 the World Meteorological Organization (WMO), UNESCO, and the United Nations Environment Program (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 (Duce, Liss et al., 1991) that for more than 10 years was the state-of-the-art reference in this area, leading to over 500 citations in the literature. However, the information in those reports is now almost 20 years old, the documents are clearly out of date, and much new information on this topic is now available. A number of important environmental issues persist in this area and in many cases are considered to be more serious than previously thought, and new issues have arisen.

2 The atmospheric input of chemicals to the ocean is closely related to a number of important global change issues. For example, the increasing input to much of the ocean of atmospheric anthropogenic nitrogen species, including nitrate, ammonia, and water-soluble organic nitrogen, may cause a low level fertilization of the ocean that could result in an increase in marine 'new' productivity of up to ~3%. This in turn could cause a possible sequestering of up to 0.3 Pg C/yr of atmospheric CO<sub>2</sub> in the ocean, which would affect the radiative properties of the atmosphere and thus climate (Duce et al., 2008). The atmospheric input of this anthropogenic nitrogen may also lead to the increased oceanic production and emission of N<sub>2</sub>O, a powerful greenhouse gas that could offset as much as 2/3 of the decrease in radiative forcing from the increased drawdown of CO<sub>2</sub>. In addition, the recognition that much of the oceanic iron, which is a limiting nutrient in many areas of the ocean, originates from the atmospheric input of minerals as a result of the long-range transport of sand and dust has catalyzed an intense interest in the atmospheric and marine chemistry of iron, its chemical form, and rate of input to the ocean (Jickells et al., 2005). The transport of mineral dust and iron affects the large areas of the global ocean where iron is the limiting nutrient. There is also a close connection with climate here, as a windier and dryer climate would result in increased quantities of iron entering the ocean, with its consequent impact on marine productivity and thus both CO<sub>2</sub> drawdown and dimethyl sulfide release, both of which in turn would provide a climate feedback. In both of these examples (nitrogen and iron), the fates of these substances and changes in their fluxes in the future are potentially related to climate and climate change. The input of other substances that may have an impact on the ocean, such as phosphorus, lead, cadmium, and POPs, may also be of concern, but

have had little focused study to date. In addition, there is little information about whether inputs of sulfur dioxide from the atmosphere can add to the ocean acidification occurring by rising levels of carbon dioxide. Such sulfur dioxide input may be particularly critical in heavily trafficked shipping lanes and/or offshore of industrialized land areas.

3 The development of atmospheric models and measurement programs to simulate the long-range transport and deposition of chemicals to the Earth's surface has expanded significantly in the last twenty years. The concern and interest of the marine community about atmospheric inputs to the ocean has also grown significantly, as outlined above. However, to date there has been relatively little interaction between the atmospheric and oceanic communities in this area. There is now an excellent opportunity for the inclusion of atmospheric transport and deposition studies to the ocean in new and developing atmospheric research and monitoring programs. For example, WMO is developing plans to initiate new, and improve existing, measurement and modeling programs in the areas of precipitation chemistry. WMO is also developing a Sand and Dust Storm Warning and Assessment System that links products of operational research forecasts of sand and dust to users. Until now there has been little involvement of the marine community in either of these efforts, although clearly both would be of significant interest and value to the ocean sciences.

### **TERMS OF REFERENCE FOR WORKING GROUP 38**

4 The Terms of Reference of Working Group 38 are as follows:

- ❖ Assess the need for the development of new model and measurement products for improving our understanding of the impacts of the atmospheric deposition of nitrogen species and dust (iron) to the ocean;
- ❖ Review the present information on the atmospheric deposition of phosphorus species to both the marine and terrestrial environments, considering both natural and anthropogenic sources, and evaluate the impact of atmospheric phosphorus deposition on marine and terrestrial ecosystems. Consider whether such a review of any other substance would be useful.
- ❖ Work with the WMO Sand and Dust Storm Warning and Assessment System and with the WMO Precipitation Chemistry Data Synthesis and Community Project to evaluate the needs of the marine community and assist in clearly articulating them in the development of these WMO efforts

### **FIRST MEETING OF WORKING GROUP 38**

5 The first meeting of Working Group 38 took place at the University of Arizona, Tucson, Arizona, USA from 10-14 December 2008. This meeting was organized and supported by the Global Atmosphere Watch (GAW) and the World Weather Research Programme (WWRP) of WMO, with additional support from SCOR, IMO, the Swedish International Development Agency, and the University of Arizona. Twelve of the 15 members of the Working Group were able to attend that meeting. Nations represented by membership on the Working Group include China, Germany, Greece, India, Italy, Japan, New Zealand, Thailand, Turkey, the United Kingdom, and the United States.

During the meeting the Working Group addressed these three charges in detail. Charges 1) and 2) were addressed by gathering information for separate papers/documents that the working group will write in the areas of phosphorus, nitrogen, sulfur, iron and organic matter deposition from the atmosphere to the ocean. The tentative titles of these three papers are:

- “The shifting importance of limiting nutrients in the surface oceans”
- “Atmospheric organic material and the nutrients it carries to the ocean”
- “SO<sub>2</sub>, NO<sub>x</sub>, and their impact on ocean acidification”

6 Three subgroups were formed to address these three topics, and detailed outlines and responsibilities for various parts of these documents have been developed. The co-authors of these 3 papers are working throughout the intercessional period gathering all the data and information necessary to complete the papers, with draft sections being written during this intercessional period. Several of the papers are now well along in this process. Working Group 38 will meet again in early 2010 to complete these discussions and prepare the papers for publication.

7 Charge 3 was addressed by the development during the meeting of two letter reports, including recommendations. These letter reports addressed the issues outlined in Charge 3) and have been submitted to GESAMP for review and will ultimately be submitted by GESAMP to WMO by April, 2009.

8 The second meeting of GESAMP Working Group 38 will be during the week of January 11, 2010 at IMO in London.

## REFERENCES

- Duce, R.A., J. LaRoche, K. Altieri, K. Arrigo, A. Baker, et al., “Impacts of atmospheric anthropogenic nitrogen on the open ocean”, Science, **320**, 893-897 (2008).
- Duce, R.A., P.S. Liss, J.T. Merrill, E.L. Atlas, P. Buat-Menard, et al., "The atmospheric input of trace species to the world ocean," Global Biogeochemical Cycles, **5**, 193-259 (1991).
- Jickells, T.D., Z. S. An, K. K. Andersen, A. R. Baker, G. Bergametti, N. Brooks, J. J. Cao, P. W. Boyd, R. A. Duce, K. A. Hunter, et al., “Global iron connections between desert dust, ocean biogeochemistry, and climate”, Science, **308**, 67-71 (2005).