6.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

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6.1 Intergovernmental Oceanographic Commission

The two organizations have a variety of joint projects that have been discussed under previous agenda items, including

- Global Ocean Ecosystem Dynamics (GLOBEC) Project
- Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Program
- International Ocean Carbon Coordination Project (IOCCP)
- Symposium on the Ocean in a High-CO_2 World

Bjørn Sundby and Ed Urban attended the IOC Executive Council meeting in June 2008 to represent SCOR. Sundby and Urban made the following interventions at the IOC meeting on behalf of SCOR and/or ICSU:

Intervention on Future of IOC Document

Thank you, Mr. Chairman. I am speaking on behalf of the International Council for Science (ICSU) and the Scientific Committee on Oceanic Research (SCOR). We read the document on the Future of IOC with great interest, and we note that IOC faces the same pressures as other international organizations in the fields of ocean and environmental sciences: there is much more work that needs to be done than can be accomplished with funds that are available from traditional sources. It is not easy to raise funds from non-traditional sources, so we cannot depend on this approach as the sole alternative.

The strategy that has worked well for SCOR during the last fifty years is to engage in strategic cooperation with other organizations with similar interests. In fact, during this time, SCOR and IOC have a history of pooling staff and financial resources to conduct joint activities on the ocean's role in global change, the ocean carbon cycle, harmful algal blooms, data management, oceanographic standards, and other issues. It may not be common knowledge among all of the IOC member states, but SCOR contributes resources and staff time adding up to about US$180,000 per year to activities that we conduct with IOC. The present version of the Future of IOC is strong on cooperation with other intergovernmental organizations, but says little about cooperation with non-governmental organizations such as ICSU and SCOR. We hope that the productive partnership between IOC and SCOR remains healthy and strong during the next fifty years.

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Intervention on Iron Fertilization

Thank you Mr. Chairman,
I would like to bring to the attention of the Executive Council of IOC that the Scientific Committee on Oceanic Research of ICSU, better known as SCOR, has set up a working group on the Legacy of Iron Fertilization Experiments. The mandate of the working group is to bring together data from previous iron enrichment experiments and use them to make quantitative comparisons among experiments that were not possible before. The merged data set from these experiments will be freely available from the Biological and Chemical Oceanography Data Management Office in the United States. The work of the group is well underway. The activities of the working group on the legacy of iron fertilization will be a valuable contribution to IOC's work on iron fertilization.
Thank you.

Intervention on GOOS

Thank you, Mr. Chairman. On behalf of the International Council for Science, ICSU, and SCOR, we thank I-GOOS and the GOOS Scientific Steering Committee for their excellent work. SCOR will be working with GOOS and the Census of Marine Life in the coming year to develop a workshop on GOOS biological observations.

SCOR and IOC worked together to develop and approve past versions of the equation of state of seawater, and SCOR looks forward to IOC consideration and approval of the new equation of state of seawater at next year's General Assembly. We suggest that the chair of the SCOR/IAPSO Working Group 127 on the Equation of State of Seawater, Dr. Trevor McDougall of Australia, be invited to the General Assembly to present the proposed standard and explain its significance. WG 127 is producing a series of scientific publications that will serve as the foundation for the new equation of state. The working group is consulting with the worldwide ocean science community on the implications of adopting a new standard, as referenced by Canada earlier, and is seeking official approvals of the new standard from appropriate intergovernmental bodies, including IOC.

6.1.1 Global Ocean Observing System (GOOS)

Ocean Observations and Services Section Overview
Keith Alverson, Head of Section

Observing the global oceans is a big task. Too big, believe it or not, even for the Ocean Observations and Services (OOS) section of IOC, through the efforts of our member states, to handle alone. Thus, over the past decade we have developed a wide range of partnerships with international and intergovernmental programs whose mandates overlap to some degree with our own core mission of observing the global oceans and, from this observational base, enabling the provision of services of benefit to society. As an indicator of the vital importance of these many partnerships to the success of OOS programs, this year's annual report section overview is dedicated primarily to them.

The **World Meteorological Organization (WMO)** is without doubt our primary partner. Indeed WMO is a co-sponsor of two of the three programs in the OOS section – JCOMM and GOOS. Through WMO, OOS programs maintain a vital link to the meteorological community and meteorological agencies in our member states. Like all clichés, the commonly heard paradigm that oceanographers are following in the footsteps that the meteorological community laid down about 40 years ago, is based on some nuggets of truth. Indeed, the meteorological community developed a convention underpinning their intergovernmental work at the WMO in 1947 whereas an oceanographic equivalent for the IOC does not yet exist (see IOC 2006 Annual report page 35). Similarly the meteorological community has been observing the Earth's atmosphere in a systematic, sustained manner backed by intergovernmental cooperation for more than 50 years and ingesting these observations into numerical forecast models delivering societal services for more than a decade. Similar activities in the ocean are carried out primarily as research projects by academics. Just as developing countries are developing widespread wireless communication networks, leapfrogging the need to build and maintain costly fixed line infrastructure, the ocean community is much better off working with, and deriving benefit from, but not trying to reproduce, many of the advances developed by our meteorological colleagues.

For example, the global ocean observing system has long been a beneficiary of the WMO Global Telecommunications System (GTS). Due to the rapidly increasing density of in-situ observation platforms as well as increasing need for near real time data transmission, the community has at times been frustrated with limited capacity for data transmission over the GTS and the lack of long term stewardship of and open access to data that goes out over the GTS. The oceanographic community must contribute to, and cooperate with, WMO as these weaknesses are improved through the ongoing development of a WMO Integrated Information System and Integrated Global Observing System (WIGOS/WIS). Of course, developing a comprehensive ocean observing system is substantially more challenging than the analogous atmospheric problem, for both political and scientific reasons. On the political level, there is a relative lack of empowerment of national institutions analogous to national met services with a clear ocean-

observing mandate. On a technical level, the opacity of seawater to electromagnetic radiation inhibits the effectiveness of both remote sensing from satellites and communications with and amongst in-situ observing system platforms, requiring maintenance of a diverse, remote and extensive array of satellites along with Eulerian and Lagrangian in-situ monitoring platforms. Furthermore, the majority of observations continue to be funded and conceived in a hypothesis driven, process oriented, research funding driven mode with few truly operationally funded and operated observing system components. To help ameliorate these weaknesses, the oceanographic community stands to gain enormously from participating fully in the WMO lead development of an integrated information system and global observing system.

The Joint Technical Commission on Oceanography and Marine Meteorology (JCOMM) continues to be a primary mechanism for cooperation with WMO. IOC and WMO jointly sponsor the commission and many of its panels derive strong inputs from both the oceanographic and meteorological communities. The array of 1250 drifting surface buoys, for example, provides surface air pressure measurements from the atmosphere alongside sea surface temperature and surface ocean drift data from the ocean. Both data sets are valuable to both communities. Although the JCOMM structure is unnecessarily top heavy, with ample room to improve the cost effectiveness of the meetings of the commission and of its subsidiary working structure at the top, at the level of the working groups at the bottom of the structure, real synergy is being developed. In the January 2008 issue of the monthly Bulletin of the WMO, Mike Johnson, in his article entitled *Implementing the Global Ocean Observing System* nicely sums up the value of JCOMM stating that “Bringing together the oceanographic and marine meteorological observing networks under the JCOMM umbrella has demonstrated the effectiveness of a systems approach to Earth Observation.” In addition to JCOMM, in 2007 the OOS section took the lead in IOC’s engagement with a number of additional programs co-sponsored with WMO including the World Climate Research Program (WCRP) and the Global Climate Observing System (GCOS). The OOS head of section is now representing IOC in the ongoing review of the World Climate Research Program (WCRP).

There remain a few voices in the oceanographic milieu expressing caution against ceding our ground (well really our water) to the WMO. Fears exist of infringement on the IOC mandate by an aggressive WMO, perhaps even through the infamous clause (Article 26, paragraph c) in its convention giving WMO a mandate to ‘take over from any other international organization or agency, the purpose and activities of which lie within the purposes of the Organization.’ Such concerns are ill founded. OOS engagement with WMO remains one of our most valuable assets.

The **United Nations Environment Program (UNEP)** is also a co-sponsor of GOOS. UNEP, through its Regional Seas Program and Large Marine Ecosystems GEF projects, for example, has a clear requirement for ocean observations and services. UNEP goals such as sustainable development of coastal resources and assessment of marine ecosystem change simply cannot occur without sustained monitoring of the marine environment. As UNEP’s global ocean observing system, GOOS must be continuously challenged to meet the ocean observing requirements for relevant UNEP programs. One prerequisite for such a challenge to be met is an

increase in the current degree of UNEP engagement as a sponsor of GOOS.

Interaction with the **Food and Agriculture Organization (FAO)** has also been limited to date. IOC member states and GOOS committees have discussed at various meetings, with various results, the idea of merging the GOOS Panel for Integrated Coastal Observations (PICO) with the FAO sponsored coastal panel of the Global Terrestrial Observing System (GTOS) in order to develop synergies between our existing independent efforts. The idea has assumed many forms, but one suggestion has been that this panel would be something akin to the OOPC panel for ocean climate observations co-sponsored by GOOS, GCOS and WCRP. Discussions on the potential integration of the GOOS coastal module with FAO and/or UNEP efforts, possibly through joint sponsorship, remain a possibility for future development.

In May 2007, the OOS head of section stepped down after a year long term as co-chair from IOC of the **Integrated Global Observing Strategy Partners (IGOS-P)** as well as chair of the **United Nations Interagency Coordination and Planning Committee for Earth Observations (ICPC)**. Members of the ICPC include FAO, UNESCO, IOC, UNEP, WMO and ICSU. As sponsors of the global observing systems these agencies formed the ICPC in order to provide the observing systems with strategic guidance, increase their visibility and facilitate implementation of their mandates. The terms of reference for the committee are to ensure interagency coordination and collaboration in the realm of Earth Observing Systems including preparing joint inputs to the Group on Earth Observations (GEO). In 2007 IOC turned over chairmanship of the ICPC to UNESCO, but continues its active engagement through our joint participation in the ICPC and this sunset year of operation for the IGOS Partnership as it transitions its efforts into the umbrella of the **Group on Earth Observations (GEO)**.

The OOS director and professional staff continued to represent IOC and GOOS respectively as participating organizations in GEO in 2007, including at the Cape Town Ministerial Summit and Plenary, thereby ensuring continued support and recognition of GOOS as the oceanic component of the **Global Earth Observing System of Systems (GEOSS)**. GEO was conceived as a way to increase the political recognition of the importance of earth observations by concentrating on societal benefits rather than, as had often previously been the case, constituent thematic observing systems, such as GOOS for the oceans, or even technical elements, such as individual satellite altimeters and in-situ tide gauge networks for sealevel monitoring. Through enhanced political recognition of societal benefits, it was hoped that GEO would enhance national support for the underlying observations themselves. As *Nature* stated in its editorial pages on 24 Feb. 2005: “Ultimately, GEOSS must make the case for, and oversee, an upgrading of systems such as GCOS and GOOS.”

Unfortunately, given the woefully low political presence at the GEO Ministerial, and little if any evidence yet available of enhanced support for GOOS via the GEO process, it is not at all clear that the founding aspirations will be achieved. One change that GEO has enabled, and touts as a success, is the transition of IGOS Partners themes into GEO. This transition was a process that the OOS head of section led and supported during his tenure as chair of the IGOS Partnership since, irrespective of whether GEO eventually does succeed, it was manifestly clear that asking the community to participate in two organizations with entirely overlapping participants and mandates was an enormous inefficiency. The transition of the IGOS Ocean Theme, which is co-chaired by the OOS head of section, has been very smooth. The strategy setting role of the ocean theme team within IGOS has been seamlessly replaced by GOOS inputs to GEO, supported and complimented by numerous partners in the informal grouping of GEO participating organizations with primarily ocean oriented mandates known as '**Ocean United**.'

Often OOS programs are accused of concentrating on in-situ observations at the expense of, or without full recognition of the value of, remote sensing. This could not be further from the truth. Remote sensing is an integral component of the GOOS. As such, the OOS head of section represented both IOC and GOOS as independent associates of the **Committee on Earth Observing Satellites (CEOS)** during 2007. At the 2007 CEOS plenary, the OOS head of section "confirmed continued IOC and GOOS engagement with CEOS and in particular expressed strong support for the Ocean Surface Topography Constellation." Additionally, the OOS head of section represents IOC on the **Coordination Group for Meteorological Satellites (CGMS)**. Although financial constraints did not allow IOC participation in the 35th CGMS meeting in 2007, the IOC has periodically, since taking up membership in 1991, provided working documents supporting oceanographic remote sensing missions to the group.

As highlighted in the OOS overview section of the 2005 annual report: "To be effective, GOOS needs to break down the often cited, but unhelpful, distinction between research and operations. A comprehensive ocean observing system simply cannot exist without the full engagement of the oceanographic research community". To this end we work with several international groups that bring the interests of this community as both providers and users of global ocean observations. The **Partnership for Observation of the Global Oceans (POGO)** brings together oceanographic research institutions worldwide to promote long-term co-operation in comprehensive global ocean observations. POGO provides a very important link to these oceanographic research institutions given that much of the sustained observing system is in fact being maintained through their efforts, not by the operational government agencies that come together at meetings of the intergovernmental committee for GOOS. GOOS has worked particularly extensively and effectively with POGO in the GEO context, for example in the development of the ChloroGIN pilot project to promote in situ measurement of chlorophyll in combination with satellite derived estimates. Additionally, the OOS head of section represents IOC and GOOS at annual POGO meetings of participating institute directors.

At the grass roots, working scientist level, OOS works in the context of groups such as the **American Geophysical Union (AGU)** and **International Union of Geodesy and Geophysics (IUGG)** including its **International Associations for the Physical Sciences of the Oceans (IAPSO) and Meteorology and Atmospheric Sciences (IAMAS)** all of which co-exist with GOOS in the family of members and programs of the **International Council for Science (ICSU)**. In 2007, for example, the OOS section head served on the Ocean Sciences Executive Committee of the AGU and on the executive committee of IAMAS in his capacity as president of the International Commission on Climate (ICCL). As part of these activities GOOS organized a plenary Union session "Global Earth Observing Systems" as well as an associated regular scientific session at the IUGG XXIV General Assembly "Earth, Our Changing Planet" which drew more than 4000 scientists to Perugia, Italy, during the first two weeks of July.

In 2007, due to the vacant head of science section post at IOC, the OOS section additionally took on liaison duties for IOC with **World Climate Research Program (WCRP)** and the **International Geosphere Biosphere Program (IGBP)**. Thus, the OOS head of section represented IOC as a sponsor at the 28th WCRP Joint Steering Committee meeting and continues to serve on the ICSU/WMO/IOC/IGFA panel carrying out an ongoing review of the WCRP. Finally, the OOS section has taken the lead IOC role in participation in the **International Polar Year (IPY)** in 2007, including representing IOC in an ex-officio capacity on the WMO/ICSU Joint Scientific Committee for the IPY. In an effort to ensure a sustained observational legacy arises from the burst of interest in polar research the IOC, through GOOS, is one of thirteen international science partners in the **Sustained Arctic Observing Network Initiating Group (SAON-IG)**, www.arcticobserving.org, and is working together with the **Scientific Committee for Antarctic Research (SCAR)** and **Scientific Committee for Ocean Research (SCOR)** on development of a Southern Ocean Observing System (SOOS).

Without a doubt, many of our partner organizations have been left out of this brief report. This is of course due to space limitations, not any limitation on the number of partners providing benefit to OOS programs. National agencies and regional alliances, for example, play an enormously important role in implementing OOS programs. Though sometimes frustrated by financial and human resource constraints limiting our capacity to engage as much as we would like with the wide number of partners we work with, OOS takes the opportunity of this year's annual report to pay tribute to, and thank them all. In conclusion, it is clear that OOS programs and our member states cannot design, sustain or implement the global ocean observing system in isolation. Our only chance at success is in leveraging the good will of our many partners in this endeavor.

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Table of relevant websites for Partner Organizations listed in this report

AGU	http://www.agu.org/sections/oceans
CEOS	http://www.ceos.org/
CGMS	NA
FAO	http://www.fao.org
GEO/GEOSS	http://www.earthobservations.org
IAMAS	http://www.iamas.org
IAPSO	http://iapso.sweweb.net
ICPC	NA
ICSU	http://www.icsu.org
IGBP	http://www.igbp.kva.se
IGOS-P	http://www.igospartners.org
IPY	http://www.ipy.org
IUGG	http://www.iugg.org
Ocean United	http://www.ocean-partners.org/oceanunited.htm
POGO	http://www.ocean-partners.org/
SAON-IG	http://www.arcticobserving.org/
SCAR	http://www.scar.org
SCOR	http://www.scor-int.org
UNEP	http://www.unep.org
WCRP	http://wcrp.wmo.int/wcrp-index.html
WMO	http://www.wmo.int

Meetings organized and supported by OOS Staff included:

- The 8th meeting of the **Argo** Steering Team, 7-9 March, Paris, France;
- The 19th session of the IOC Committee on the International Oceanographic Data and Information Exchange (**IODE**), 12-16 March, Trieste, Italy;
- The 10th meeting of the Global Ocean Observing System (**GOOS**) Scientific Steering Committee, 13-16 March, Seoul, Korea;
- 12th Session of the Ocean Observations Panel for Climate (**OOPC**), 2-5 May, Paris France;
- The 14th Sesssion of the Integrated Global Observing Strategy Partners (**IGOS-P**), 30 May, Paris, France;
- The 10th Session of the Global Sea Level Observing System (**GLOSS**) Group of Experts, 5-8 June, Paris, France;
- The 8th Session of the Intergovernmental Committee for the Global Ocean Observing System (**GOOS**) 13-16 June, Paris, France;
- High Level Scientific Workshop on the Critical Role of Satellite Remote Sensing Applications for Africa's Sustainable Development, 30 May – 1 June, Paris, France;

- **JCOMM** Scientific and Technical Symposium on Storm Surges, 2-6 October, Seoul, Korea;
- The 6th meeting of the Joint Commission on Oceanography and Marine Meteorology (**JCOMM**) Management Group, 3-6 December, Paris, France.

Outreach publications co-authored by OOS staff included:

Alverson, K. "Why the World Needs a Global Ocean Observing System" in *The Full Picture*, Tudor Rose, 76-78, 2007.

Baker, J. et al. "The Blue Planet – Observations of the Global Oceans" in *The Full Picture*, Tudor Rose, 72-75, 2007.

Brundrit, G. et al. "New Marine Observing Systems around Africa" in *The Full Picture*, Tudor Rose, 92-94, 2007.

Alverson, K. Why the World Needs a Global Ocean Observing System, *The Marine Scientist*, 21, 25-28, 2007.

Summerhayes, C. et al, "Observing the Polar Oceans during the International Polar Year and Beyond" *WMO Bulletin*, 56(4) 270-283.

Allison, I. et al. "The Scope of Science for the International Polar Year 2007-2008", World Meteorological Organization, WMO/TD-No. 1364, 79 pgs, 2007.

A new set of three one-page brochures on GOOS, JCOMM and IODE for broad distribution.

Reports published by OOS included:

Southern Ocean Observing System Interim Report. GOOS Report no.168.

Report of the 8th Session of the Intergovernmental Committee for the Global Ocean Observing System. GOOS Report no. 165

Report of the 10th session of the Scientific Steering Committee of the Global Ocean Observing System. GOOS Report no. 161

Third GOOS Regional Forum Report. GOOS Report no. 159

Presentations and Exhibitions made by OOS staff included:

GOOS-Africa Exhibition, GEO Ministerial Summit 27-30 November, Cape Town, South Africa

Ocean United Exhibition, GEO Ministerial Summit, 27-30 November, Cape Town, South Africa

Plenary 'union' presentation at the International Union of Geology and Geophysics (IUGG) Congress, 3 July, Perugia, Italy.

This list of 2007 activities and publications comprises selected highlights. Comprehensive lists of all meetings, publications, reports and presentations are available on the GOOS, IODE and JCOMM websites.

6-10

Sustaining an Arctic Ocean Observing System as a Legacy of the International Polar Year.
Keith Alverson

Is the Arctic Ocean a vast, beautiful, wild and unsullied natural refuge or small, fragile and vulnerable body of water suffering the brunt of global warming? The only way to know is through observation. In the early 20th century, those following Admiral Peary and his competitors in their scramble to be the first humans to set foot on the North Pole would certainly have claimed the former. The science that was being done in and around the Arctic Ocean at the time was largely one of discovery and exploration. To some extent, the Arctic Ocean remains an unexplored refuge today. For example, a recently produced global map of human impact on marine ecosystems resulting from a variety of climatic and non-climatic drivers (Figure 1, Halpern et al, 2008) suggests the entirety of the meager 3.7% of the world oceans that can be classified as 'very low impact areas' occur in the Arctic and Southern oceans.

But the Arctic Ocean is changing fast. In 2007, summer minimum sea ice extent in the Northern Hemisphere plummeted to a record low. The average extent of sea ice in the Arctic for the month of September stood at 4.28 million km^2, shattering the previous absolute minimum of 5.32 million km^2 measured on 20-21 September 2005 (Stroeve et al, 2008). As summer sea ice melts, the dark waters of the Arctic will become increasingly exposed to light and air. This will have an immense environmental impact, through the well known 'ice albedo feedback' associated with reduced surface albedo, as well as through dramatic increases in exchanges of heat, moisture and greenhouse gases across the air-sea interface which can be expected to radically alter the climate, environment and ecosystems in the region. On May 14th, 2008 the Polar bear became the first species placed on the U.S. Interior Department endangered species list not because of an actual measured population decline – numbers have roughly doubled since the 1960's - but in response to projected future global warming and an associated loss of sea ice habitat for this iconic top marine predator. Environmental changes in the Arctic ocean have also been reported to threaten walrus and several species of whale.

Today, Arctic vulnerability to climate change and other human impacts is a clear cause for concern. How can the scientific community best bring its expertise to bear in addressing this concern? I argue that the answer is to provide sustained and integrated monitoring of the integrated Arctic system, including of course its ocean. Only from such monitoring can we understand Arctic system changes well enough to test hypotheses and make appropriate policy decisions at the national and international levels. Even as the International Polar Year (IPY, 2007-9) first began, the Global Ocean Observing System's satellites, tide gauges and drifting ice moored buoys were already systematically observing the Arctic Ocean twenty-four hours a day and providing publicly accessible data in near real time (Figure 2, Summerhayes et al, 2007). Several ambitious IPY projects are improving this level of data availability. These include both improvements to existing networks – for example projects to enhance the number of ice drifting buoys in operation and to broaden the Argo float network into ice covered waters – as well as the development of new networks - for example through deployment of an integrated Arctic Ocean Observing System (iAOOS) and arrays of acoustic curtains for monitoring the movements of

tagged fish and marine mammals. A major challenge will be to sustain some of these IPY efforts in the future as a legacy of the IPY and a contribution to the Global Ocean Observing System.

One of the greatest differences in ocean sciences in the Arctic between Peary's day and today has been the shift in our observations from discovery, to sustained and systematic monitoring. This monitoring is increasingly important in the context of another mad dash towards the pole – this time not for the glory of discovery, but for the use of resources. Indeed, the social, political and economic landscape in the Arctic is changing as fast, or faster, than the natural one. Russia, the world's largest country and second largest oil producer is currently preparing the observational data to back up its existing claim under the United Nations Law of the Sea Treaty, that the Lomonosov Ridge, which crosses much of the Arctic Ocean, is an extension of its continental shelf, and hence an extension of its exclusive economic zone. With 9 to 10 billion tons of fuel equivalent, roughly the same as Russia's existing total oil reserves, estimated to exist below the Arctic seabed, the stakes are high. Adding fuel to the fire, on August 2, 2007 a Russian submersible engaged in observation research in the Arctic Ocean planted a titanium flag on the seabed 4200 meters below the North Pole.

The United States is also no stranger to offshore Arctic Oil and Gas reserves – the U.S. Minerals and Management Service website announced on February 6, 2008 the completion of the first Chuckchi Sea sale since 1991, comprising a total of $3.4 billion in leases bid by seven major oil companies – a surprisingly large increase compared to past sales indicating industry confidence that long standing environmental controversies are manageable, that the Alaskan Arctic has substantial potential, and that production activity will soon be increasing markedly off the Alaskan coast. One of the beauties of lobbying for an integrated observing system is that it is one of the few major policy investments that can be strongly supported on both sides of this environment/development controversy since environmentalists need monitoring to ensure accurate environmental impact statements with real teeth and the offshore industry needs it to protect their infrastructure from inclement ocean and atmospheric conditions.

Meanwhile, in the speech from the throne on October 16, 2007 the Canadian Government stated that as "part of asserting sovereignty in the Arctic" it "will complete comprehensive mapping of Canada's Arctic seabed" and it plans to defend Canadian sovereignty in the North with new Arctic patrol ships, expanded aerial surveillance, and expansion of the Arctic Rangers in order to guard Canada's Far North and the Northwest Passage. This emphasis on Arctic sovereignty has already had substantial consequences in the private sector. For example, when Canada blocked a $1.3 billion dollar bid for its space equipment and satellite maker by a US company in part due to the fact that Radarsat-2, which was launched last October and provides high resolution sea ice information to the world scientific community, was promoted by the government as a critical component of Canada's efforts to assert its control of the Arctic. Indeed, in the summer of 2007, the Northwest Passage – itself both a subject of conflicting territorial claims as well as a potentially lucrative shipping route, was free of ice for the first time since records began. In addition to Canada and Russia, Denmark, Norway and the United States all also have coasts

within the Arctic Circle, making for numerous potentially conflicting claims.

Natural variability, especially in the Arctic, is large. Winter 2008 was colder than average and, in some regions, sea ice extent expanded substantially. Summer 2008 may well have far more extensive sea ice than 2007 did. But Pandora has done her work and political and economic interest in the ever more accessible Arctic cannot be put back in the box. Climate extremes are not new, especially in the Arctic, which from a global perspective even has an extreme mean. What is new is the magnitude of human and financial vulnerability to extremes. Globally, increased development, primarily in rich countries, and population pressure, primarily in low lying developing countries mean that it does not matter, as far as adaptation measures are concerned, whether or not there is conclusive proof that 'extreme events' are becoming stronger or more frequent, because we know that our vulnerability to them has increased. As the Arctic opens to human development, in a warming background climate, it will face both increasing vulnerabilities - increases in expensive infrastructure such as shipping and oil platforms – and increasing population pressure. These combined changes will also add to the vulnerability of the Arctic's indigenous populations. Thus, it is a critical time for Arctic Ocean science to move beyond being carried out in remote wilderness and published in remote journals. Scientists must now take up the challenge of making their work visible and relevant to multilaterally agreed policy decisions that can shape the kind of Arctic that humanity would like to have in the coming century.

Under pressure from both the rapidly developing political landscape as well as the rapidly changing climatic situation, the Global Ocean Observing System is working with its member states and sponsor agencies, the Intergovernmental Oceanographic Commission of UNESCO, UNEP, WMO and ICSU to put in place, and sustain, an Arctic Ocean Observing System to provide the observational underpinnings to understand and predict the changing climate while simultaneously ensuring that neither the Arctic environment nor Arctic societies are the losers in a Wild West-like scramble for resources that could compromise universal access to, and benefit from, the Arctic Ocean. This system can only be maintained through multilateral governmental commitments (Alverson and Baker, 2006) and these have regrettably not yet materialized to any large extent.

Research and implementation plans driven by science priorities abound, but what is needed now is sustained monitoring driven not by a "science push" but by the pull from derived societal benefits, primarily among these the protection of humankind's Arctic heritage in the face of the accelerating transformation of environmental, social and cultural landscapes across the Arctic. Thus, Arctic Ocean scientists need to engage their expertise in driving the political processes that will shape the future Arctic. To this end, UNESCO, as part of its Strategy for Action on Climate Change and with the sponsorship of Prince Albert II of Monaco, is initiating a comprehensive analysis of the multilayered and multiform interactions connecting global and Arctic processes though an international and interdisciplinary approach. An initial meeting in early 2009, timed to coincide with the conclusion of the International Polar Year, will bring together natural scientists, economists, social and human scientists, legal experts, circumpolar indigenous

peoples, and representatives from environmental NGOs, industry and concerned countries. Partnership in this effort will be sought from a wide range of interested intergovernmental and international organizations. UNESCO, for its part, will facilitate the participation of Member States from outside the Arctic region that will nevertheless be impacted by the changes anticipated in the polar regions and will provide an intergovernmental forum with foci on sustainable development, environmental ethics, indigenous peoples and knowledge, intangible heritage, Arctic World Heritage and coordinated international monitoring of the Arctic Ocean as a component of its Global Ocean Observing System.

On December 1, 1959, shortly after the successful conclusion of the International Geophysical Year of 1957-8, twelve nations signed the Antarctic Treaty in Washington D.C. to ensure "in the interest of all mankind that Antarctica shall continue for ever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord." What better success could the International Polar Year have than to bring nations together show their mutual resolve to protect, preserve and sustainably manage our Arctic heritage by supporting an integrated and sustained observing system for the Arctic.

References:

Alverson and Baker (2006) Taking the Pulse of the Oceans, Science, 314:1657.

Hapern et al (2008) A Global Map of Human Impact on Marine Ecosystems, Science, 319: 948-52.

Stroeve, J. et al (2008), Arctic Sea Ice Extent Plummets in 2007, Eos Trans. AGU, 89(2), 13.

Summerhayes, C. et al (2007), “Observing the Polar Oceans during the International Polar Year and Beyond” *WMO Bulletin*, 56(4) 270-283.

6.2 North Pacific Marine Science Organization (PICES)

SCOR and PICES: Continuing Connections

Report at the 2008 SCOR General Meeting
October 22-24, 2008
Woods Hole, Massachusetts, USA

The North Pacific Marine Science Organization (PICES) is an intergovernmental scientific organization and its current membership includes Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America. The Organization was established in 1992 to: (i) promote and co-ordinate marine scientific research in the northern North Pacific and adjacent marginal seas; (ii) advance scientific knowledge about the ocean environment, global weather and climate change, living resources and their ecosystems, and the impact of human activities on them; and (iii) promote the collection and rapid exchange of scientific information on these issues. Information on the Organization and its activities can be found on the PICES website at http://www.pices.int.

Continuing and extending collaboration between SCOR and PICES is based on the recognition that PICES could play an important role in bringing a North Pacific perspective to the global activities of SCOR, and that by participating in these activities, PICES could advance its own scientific agenda. PICES is a major regional participant in the Global Ocean Ecosystem Dynamics (GLOBEC) project, through the PICES/GLOBEC Climate Change and Carrying Capacity (CCCC) Program. PICES also contributes to other SCOR-sponsored international large-scale ocean research projects, including the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER), the Surface Ocean-Lower Atmosphere Study (SOLAS), and the Global Ecology and Oceanography of Harmful Algal Blooms Program (GEOHAB), to ocean carbon activities supported by SCOR, and several SCOR working groups. Dr. Bjørn Sundby (President of SCOR) attended PICES XVI (October 2007, Victoria, Canada) as an observer to discuss ongoing and future collaborations between the two organizations. This report covers the period from the 2007 SCOR Executive Committee Meeting (August 26–28, 2007, Bergen, Norway) to the present.

LARGE-SCALE OCEAN RESEARCH PROGRAMS CO-SPONSORED BY SCOR

Global Ocean Ecosystem Dynamics project (GLOBEC)

- The PICES Climate Change and Carrying Capacity (CCCC) Program provides a mechanism for integrating national GLOBEC research programs in the North Pacific and is a regional component of the international GLOBEC effort.
- Drs. Francisco E. Werner (GLOBEC SSC Chairman) and Ian Perry (GLOBEC SSC Chairman-elect) attended PICES XVI (October 2007, Victoria, Canada) as observers to brief

the Science Board on GLOBEC's synthesis and integration efforts and discuss PICES' involvement in these activities.

- GLOBEC provided US$5,000 to co-sponsor the Topic Session on "*Towards ecosystem-based management: Recent developments and successes in multi-species modeling*" at PICES XVI by covering travel costs of one invited speaker and two early career scientists.
- The PICES/GLOBEC Symposium on "*Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis*" was held April 19–21, 2006, in Honolulu, U.S.A. A special issue of *Progress in Oceanography* (Guest Editors: H. Batchelder and S. Kim) from the symposium was published in June 2008 (Vol. 77, Nos. 2–3, pp. 83–268), and is considered as a part of GLOBEC synthesis effort.
- PICES and GLOBEC worked together, with ICES as the third major international sponsor, to organize the 4th International Zooplankton Production Symposium on "*Human and climate forcing of zooplankton populations*" (May 28–June 1, 2007, in Hiroshima, Japan). A special issue of the *ICES Journal of Marine Science* (Guest Editors: M. Dagg, R. Harris, L. Valdés and S.-I. Uye) from the symposium was published in April 2008 (Vol. 65, No. 3, pp. 277–495). Selected papers on krill presented at the symposium will be published as a special issue of *Deep-Sea Research II* (Guest Editors: W. Peterson and S. Kawaguchi) in early 2009.
- PICES co-sponsored two symposia led by GLOBEC, "*Climate impacts on oceanic top predators*" (December 3–7, 2007, La Paz, Mexico) and "*Coping with global change in marine social-ecological systems*" (July 8–11, 2008, in Rome, Italy), by covering travel costs of two invited speakers for the former event and a member of the symposium Distinguished Closing Panel for the latter.
- GLOBEC contributed to the PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" (May 19–23, 2008, Gijón, Spain) by preparing the Book of Abstracts.
- PICES agreed to co-sponsor the 3rd GLOBEC Open Science Meeting (June 22–26, 2009, Victoria, Canada) by providing up to $10,000 in travel support for invited speakers (preferably from the Pacific) and up to $5,000 in travel support for early career scientists from PICES member countries to attend the meeting, and by assisting in local arrangements for this event to be held at the location of the PICES Secretariat.
- Dr. Manuel Barange (GLOBEC Executive Director) will attend PICES XVII (October 2008, Dalian, China) as an observer to (1) provide an update on discussions within a GLOBEC–IMBER Transition Task Team on a way forward for international marine ecosystem science after the completion of GLOBEC in December 2009, and (2) outline plans on the 3rd GLOBEC Open Science Meeting to the Science Board and liaise on logistics for this meeting with the PICES Secretariat.

Ecosystem Studies of Subarctic Seas (ESSAS)

- PICES and ESSAS, a regional program initiated by GLOBEC in 2005, share the goal of developing comparative studies of the sub-arctic seas and understanding how climate

variability affects their productivity and ability to support sustainable commercial and subsistence harvests.

- In May 2005, PICES co-sponsored and served as the local organizer for the GLOBEC Symposium on "*Climate variability and sub-arctic marine ecosystems*" held in Victoria, Canada. A special issue of *Deep-Sea Research II* (Guest Editors: G.L. Hunt, K. Drinkwater, S.M. McKinnell and D.L. Mackas) from the symposium was published in December 2007 (Vol. 54, Nos. 23–26, pp. 2453–2969).
- Drs. Kenneth Drinkwater and George Hunt (ESSAS SSC Co-Chairmen) attended PICES XVI (October 2007, Victoria, Canada) as observers and addressed several PICES Committees on potential areas of cooperation between ESSAS, and its U.S. component for the Bering Sea (BEST), and PICES.
- PICES agreed to co-sponsor the 3rd Annual Meeting of ESSAS (September 15–19, 2008, Halifax, Canada) by covering travel costs of invited speakers from the North Pacific to attend a workshop on "*Model comparisons of the ESSAS regions*" and a workshop on "*Regional climate predictions*" to be convened at this meeting.
- Two joint PICES/ESSAS workshops, "*Status of marine ecosystems in the sub-Arctic and Arctic seas – Preliminary results of IPY field monitoring in 2007 and 2008*" and "*Marine ecosystem model inter-comparisons*", will be held at PICES XVII (October 2008, Dalian, China).
- Drs. Drinkwater and Hunt will attend PICES XVII as observers of ESSAS and BEST, respectively, to discuss approaches for collaboration between ESSAS and PICES after the completion of GLOBEC.

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

- Issues of marine biogeochemistry and food webs will be important components of the new integrative scientific program of PICES, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific **E**cosystems). FUTURE will be launched in 2009, and it is expected that PICES will become a major regional participant in IMBER.
- Dr. Julie Hall (IMBER SSC Chairman) attended PICES XVI (October 2007, Victoria, Canada) as an observer and addressed the BIO Committee on potential areas for cooperation between IMBER and PICES.
- A 1½-day joint PICES/IMBER Topic Session on "*End-to-end foodwebs: Impacts of a changing ocean*" will be convened at PICES XVII (October 2008, Dalian, China).
- PICES was present as an observer at this year's IMBER SSC meeting (May 2008, Cape Town, South Africa), and IMBER will send an observer to PICES XVII to continue discussions on collaboration between the two organizations.

Surface Ocean-Lower Atmosphere Study (SOLAS)

- The main research area for collaboration between PICES and SOLAS has been impact of iron on biogeochemistry and marine ecosystems.
- Three international meso-scale iron enrichment experiments in the Subarctic Pacific were developed under the umbrella of PICES, through its Advisory Panel on the *Iron Fertilization*

Experiment in the Subarctic Pacific Ocean (IFEP-AP), and conducted between 2001 and 2004. The results of the first two experiments, **S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamics **S**tudy (SEEDS-I) and **S**ubarctic **E**cosystem **R**esponse to **I**ron **E**nrichment **S**tudy (SERIES), were published in special issues of *Progress in Oceanography* (2005, Vol. 64, Nos. 2–4, pp. 91–324) and *Deep-Sea Research II* (2006, Vol. 53, Nos. 20–22, pp. 2005–2454), respectively. A special issue of *Progress in Oceanography* (Guest editors: A. Tsuda, M. Wells, M. Uematsu and H. Saito) from the SEEDS-II experiment will be published in late 2008 or early 2009.

- After the completion of its terms of reference, IFEP-AP was disbanded in 2007, and a new Working Group (WG 22) on *Iron Supply and its Impact on Biogeochemistry and Ecosystems in the North Pacific Ocean* was established (http://www.pices.int/members/working_groups/wg22.aspx). It is expected that WG 22 will work closely with various expert groups on ocean fertilization, including SOLAS Implementation Group 1 on *Biogeochemical Interactions and Feedbacks between Ocean and Atmosphere* and SCOR Working Group 131 on *The Legacy of* in situ *Iron Enrichment: Data Compilation and Modeling*. The first WG 22 meeting will be held at PICES XVII (October 2008, Dalian, China).
- Dr. Shigenobu Takeda (SOLAS SSC member) represented SOLAS at PICES XVI (October 2007, Victoria, Canada) and will serve in this capacity again at PICES XVII.

Global Ecology and Oceanography of Harmful Algal Blooms Program (GEOHAB)

- Responding to interest in sharing information from active science and management HAB programs in each of its member countries, and to achieve the appropriate level of coordination and collaboration among these countries, PICES established, in 2003, a Section on *Ecology of Harmful Algal Blooms in the North Pacific* (see http://www.pices.int/members/sections/HAB.aspx for TOR and reports). It is expected that through this Section, PICES will participate in international collaborations, including GEOHAB.
- In June 2005, IOC and PICES signed a formal agreement to establish a partnership in systematically compiling, storing and presenting on-line, records on harmful algal events. A similar agreement was also signed between IOC and ICES. Event records will be compiled and stored annually in the format specified in the harmful algal event database (HAE-DAT). The HAE-DAT partnership is open to other appropriate and complementary regional organizations so as to achieve global coverage of HAE-DAT. Building a common data resource will allow inter-comparison of HAB species composition and the magnitude of environmental and economic impacts.
- Since 2005, the PICES HAB Section has been convening an annual series of workshops, "*Review of selected harmful algae in the PICES region*", to document the existing knowledge on the eco-physiology of HAB species that impact all, or most, countries in the North Pacific. The previous workshops, held in conjunction with PICES Annual Meetings, focused on *Pseudo-nitzschia* and *Alexandrium* (PICES XIV, 2005, Vladivostok, Russia),

Dinophysis and *Cochlodinium* (PICES XV, 2006, Yokohama, Japan), *Heterosigma akashiwo* and other harmful raphidophytes (PICES XVI, 2007, Victoria, Canada), and *Karenia* and *Prorocentrum* (PICES XVII, 2008, Dalian, China). These workshops are normally preceded by a ½-day laboratory demo on cell and toxin identification and detection methods/technique. We intend to continue this series, and GEOHAB is invited to play an active role in the future workshops.

- A Topic Session on "*The relative contributions of off-shore and in-shore sources to harmful algal bloom development and persistence in the PICES region*" was convened at PICES XVI, and a Topic Session on "*Species succession and long-term data set analysis pertaining to harmful algal blooms*" will be held at PICES XVII. Both sessions are directly related to GEOHAB activities.

OCEAN CARBON ACTIVITIES SUPPORTED BY SCOR

International Ocean Carbon Coordinated Project (IOCCP)

- IOCCP, co-sponsored by SCOR and UNESCO–IOC, promotes the development of a global network of ocean carbon observations for research through technical coordination and communication services, international agreements on standards and methods, and advocacy and links to the global observing systems. PICES, through its Working Groups on *CO_2 in the North Pacific* (WG 13, 1998–2001) and *Biogeochemical Data Integration and Synthesis* (WG 17, 2002–2005), and now through the Section on *Carbon and Climate* (2006–present), has long been acting as a regional coordinator for these activities.
- A 1-day Topic Session on "*Decadal changes in carbon and biogeochemical systems in the North Pacific*" was convened at PICES XVI (October 2007, Victoria, Canada). This session is directly related to IOCCP and IMBER activities. Selected papers from the session will be published as a section (Guest Editors: T. Saino, J.R. Christian, K. Lee and TBA) in a regular issue of *Journal of Oceanography* in 2009.
- Drs. Christopher Sabine (IOCCP SSC Chairman) and Maria Hood (IOCCP Director) attended PICES XVI and addressed relevant PICES Committees on potential areas for cooperation between IOCCP and PICES.
- IOCCP and PICES co-sponsored the publishing of the "*Guide to best practices for ocean CO_2 measurements*", as PICES Special Publication No. 3 and IOCCP Report No. 8 (Eds. A.G. Dickson. C.L. Sabine and J.R. Christian), in December 2007. The guide is available on-line from the CDIAC (Carbon Dioxide Information Analysis Center) Ocean CO_2 Program web-site in individual chapters or as a whole electronic document, and hardcopies are also available upon request from PICES and CDIAC. To increase the use of the Guide, volunteers are being sought to assist with translations of the Guide to languages other than English.
- IOCCP maintains the Ocean Acidification Network web-site and assists with implementation of the *Ocean in a High CO_2 World* symposium series co-sponsored by SCOR, IOC, IAEA and IGBP. PICES agreed to organize, jointly with ICES, a Theme Session on "*The effects of*

ocean acidification on fisheries and ecosystems" at the International Symposium on "*The Ocean in a High CO_2 World – II*" to be held October 6–8, 2008, in Monaco.

SCOR WORKING GROUPS

Working Group 125 on *Global Comparisons of Zooplankton Time Series*

PICES strongly supported the formation of SCOR Working Group 125 on *Global Comparisons of Zooplankton Time Series* and agreed to provide funding for an associate member from the North Pacific (Dr. Harold P. Batchelder, Oregon State University, U.S.A.) to participate in its activities. Two meetings of SCOR WG 125 were held in conjunction with symposia co-organized/co-sponsored by PICES, the 4th International Zooplankton Production Symposium on "*Human and climate forcing of zooplankton populations*" (May 2007, Hiroshima, Japan) and the International Symposium on "*Effects of climate change on the world's oceans*" (May 2008, Gijón, Spain).

Proposed Working Group on *Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time-Series Observations*

PICES would like to offer its strong support to a proposed SCOR Working Group on *Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time-Series Observations*. Analysis of long-term data sets has provided the basis for many important insights into the changes occurring in marine systems and, as the proposal indicates, there are many phytoplankton data sets from diverse parts of the globe that warrant a comparative examination. This examination will undoubtedly supply important information on teleconnections and other complex mechanisms operating in today's changing ocean climate. It is clear that the suggested analyses will greatly improve our understanding of marine responses to climate change, natural or anthropogenic. We consider the proposed Working Group as a logical methodological continuation of SCOR WG 125 and, if this Working Group is approved, PICES will nominate and support an associate member to serve on the group (Dr. Sinjae Yoo, Korea Ocean Research and Development Institute, Republic of Korea).

Working Group 131 on *The Legacy of* in situ *Iron Enrichment: Data Compilation and Modeling*

In 2007, a new Working Group (WG 22) on *Iron Supply and its Impact on Biogeochemistry and Ecosystems in the North Pacific Ocean* was established by PICES to a) promote better understanding of natural and anthropogenic iron supplies to the North Pacific and their impact on biogeochemistry and ecosystems, and b) facilitate closer ties among various research communities (aerosol, physical oceanography, biology, chemistry and modeling) to better integrate new findings and to provide needed feedback to help coordinate research activities. The terms of reference for WG 22 can be found at http://www.pices.int/members/working_groups/wg22.aspx. The achievement of some of these terms of reference depends strongly on how successful SCOR Working Group 131 on *The*

Legacy of in situ *Iron Enrichment: Data Compilation and Modeling* is in accomplishing its task of compiling a database for open access (via the Internet) of the completed iron-enrichment experiments, and it is expected that PICES WG 22 and SCOR WG 131 will work closely in carrying out their activities. PICES is prepared to consider co-sponsoring a joint meeting to work out the details of bringing together the data sets in a way that will make preparation of the database possible.

SCOR TRAVEL GRANTS

PICES is very grateful for the continuing support from SCOR for scientists from countries with "economies in transition" to attend SCOR-relevant sessions/workshops at PICES Annual Meetings and international symposia co-organized by PICES. This year, SCOR provided US$7,500 for the symposium on "*Effects of climate change on the world's oceans*" (May 19–23, 2008, Gijón, Spain) and committed US$5,000 for PICES XVII (October 24–November 2, 2008, Dalian, China).

The following two requests are submitted for consideration of the SCOR Executive Committee for 2009:

- Travel support at the level of US$5,000–7,500 is requested for scientists from countries with "economies in transition" from the Pacific Rim to attend SCOR-relevant sessions/workshops at PICES XVIII to be held October 23–November 1, 2009, in Jeju, Republic of Korea. The overall theme for PICES XVIII is "*Understanding ecosystem dynamics, pursuing ecosystem approaches to management*", and the scientific program for this event will be finalized in October 2008 at PICES XVII in Dalian, China.
- Travel support at the level of US$4,000–5,000 is requested for early career scientists from countries with "economies in transition" to attend a 4-day PICES Summer School on "*Satellite Oceanography*" to be held August 23–27, 2009, in Seoul, Republic of Korea. In this course, principles and applications in three major areas (optical, infra-red and microwave) of satellite oceanography will be introduced to students who have little experience in the field (focus will be on Asian countries). In addition to lectures and seminars, hands-on training of image processing will be provided.

6.3 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

Background information - GESAMP

The 35th session of GESAMP was held in Accra, Ghana, 13-16 May 2008, hosted by the United Nation Industrial Development Organization (UNIDO) at the Interim Guinea Current Commission. During the session, the work of the six active working groups was reviewed by GESAMP. In addition, a new working group on "Global trends in pollution of coastal ecosystems: retrospective ecosystem assessment" was approved in principle. And a number of external requests were addressed. Finally, Dr. Tim Bowmer was elected new Chairman of GESAMP, and Dr. Lawrence F. Awosika and Dr. Sandor Mulsow were elected co-vice chairmen.

GESAMP is actively involved in the 'Assessment of Assessments' phase of the UN Regular Process in several different ways. On request from the lead agencies (UNEO and IOC of UNESCO), GESAMP established a Task Team to produce a review of assessments and studies related to pollution in the open ocean. The Task Team delivered its report to the lead agencies in March 2008, and it will be published in the GESAMP Reports and Studies series after external peer-review and editing.

On 1 October 2007 the Executive Committee decided to establish a GESAMP Office, hosted by the International Maritime Organization (IMO) in London. Currently, the Office is manned by a GESAMP Officer seconded by the Swedish Maritime Administration, and can be contacted through e-mail: gesamp@gesamp.org, or telephone +44 (0)20 7463 4139.

SCOR is providing funding for the first meeting of the following GESAMP working group.

GESAMP Working Group 38

The Atmospheric Input of Chemicals to the Ocean

BACKGROUND AND CONTEXT FOR THE WORKING GROUP

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.

The atmospheric input of chemicals to the ocean is closely related to a number of important global change issues. For example, a recent workshop in Norwich, UK, sponsored by SCOR and SOLAS (Surface Ocean/Lower Atmosphere Study, sponsored by SCOR, IGBP, CACGP, and WCRP) found that 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_2 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_2O, a powerful greenhouse gas that could offset as much as 2/3 of the decrease in radiative forcing from the increased drawdown of CO_2. 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; Mahowald et al., 2005A). 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_2 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. While the atmospheric input of nitrogen species and iron are currently topics of greatest interest, 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.

The atmospheric deposition of the critical nutrient phosphorus, which is a co-limiting nutrient in some marine areas, is a particularly important topic (Mills et al., 2004). For example, as pointed out in the recently completed Duce et al. (2008) paper on atmospheric nitrogen deposition, atmospheric reactive nitrogen deposition, in the absence of significant atmospheric deposition of phosphorus, may exacerbate phosphorus-limitation of N_2-fixation. The long-term effect of atmospheric nitrogen deposition on N_2-fixation depends on whether P or Fe limits N_2-fixation and on the supply ratio of bioavailable N:P:Fe derived from atmospheric deposition.

Atmospheric deposition of phosphorus is apparently much less perturbed by human activity than reactive nitrogen. Hence the overall impact of atmospheric deposition is likely to be a shift in the N/P balance of surface waters. However, we emphasize that we have very little data available on chemical forms of atmospheric phosphorus or of their fluxes to the ocean (e.g., see Baker et al., 2003 and 2006) or to the terrestrial biosphere (e.g., see Mahowald et al., 2005B). Thus this is an important issue not only for the marine enviroment, but also for the terrestrial environment.

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.

It is proposed that GESAMP Working Group 38 - The Atmospheric Input of Chemicals to the Ocean - be initiated to address the issues outlined above and to enhance the interaction of the marine community with these developing atmospheric programs. There should be representatives of both of the above WMO programs in the membership of Working Group 38 if possible. In addition, SOLAS is addressing a number of the scientific questions that are very relevant to the Terms of Reference of Working Group 38. It is suggested that Working Group 38 also have representation from SOLAS in its membership.

TERMS OF REFERENCE FOR THE WORKING GROUP

Based on the discussion above, 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

To address these issues, individuals with the following expertise are required as members of the working group: atmospheric chemistry, marine biogeochemistry, air/sea chemical exchange, atmospheric and marine dust and iron, nitrogen, and phosphorus measurement and modeling, general atmospheric transport modeling, precipitation chemistry measurement and modeling.

WORK PLAN FOR THE WORKING GROUP

Some preliminary efforts have already taken place as part of the development of the working group. The entire working group is expected to have two meetings, and it would also work intersessionally by correspondence.

Preliminary Activities of the Working Group

One of the proposed Co-Chairs of the Working Group (RD) participated in the WMO Sand and Dust Warning System meeting in Barcelona, Spain in November, 2007. At this meeting dust research forecasting scientists met with the user and observation community. RD was able to provide information to the participants on the importance of the input of dust and other chemicals to the ocean and also to learn about the plans for the development of the Sand and Dust Warning System and how GESAMP Working Group 38 might interact with that effort. In February, 2008 RD participated in the WMO Precipitation Chemistry Data Synthesis and Community Project Meeting in Las Vegas, NV. Again he provided information on the importance of accurately measuring the input of chemicals to the ocean and discussed the plans of the Precipitation Chemistry Project and how it could interface with GESAMP Working Group 38. The importance of a review of atmospheric phosphorus deposition to the earth's surface was discussed. Plans for the activities of Working Group 38 were also reported at the meeting of GESAMP 35 in Accra, Ghana, 12-17 May 2008

First Working Group Meeting

The first meeting of Working Group 38 will be held at the University of Arizona, Tucson, AZ, USA. Individuals will arrive in Tucson on 10 December, and the meeting will be from 11-14 December, ending at about noon on the 14th. Dr. William Sprigg of the University of Arizona is hosting this meeting for the Working Group.

At the first meeting the following would be accomplished:

1) Evaluate our current understanding of the input to the ocean of atmospheric iron (dust) and nitrogen species, with the goal of ascertaining a) if any additional reviews or syntheses of available data are necessary; b) if any specific types and/or locations of chemical measurements are necessary; and c) if current models of the atmospheric transport and deposition of iron and nitrogen species to the ocean are adequate, and if they are not, what kinds of changes need to be made. As necessary, determine how these issues should be addressed intersessionally.

2) Discuss the development of an in-depth review of phosphorus from the atmosphere to the ocean and the terrestrial environment. An outline for such a review should be drawn up and intersessional tasks should be assigned for the preparation of preliminary short draft papers on critical issues that would be addressed by the review. There should also be discussions about whether there are any additional substances that might be of sufficient importance to be considered for a later similar type of review, such as sulfur dioxide.

3) Evaluate how the working group can most effectively provide information and advice to the WMO Sand and Dust Storm Warning and Assessment System relative to the forecasting of dust inputs from the atmosphere to the ocean. Assign intersessional tasks to members for this if necessary.

4) Evaluate how the working group can most effectively provide information and advice to the WMO Precipitation Chemistry Data Synthesis and Community Project that will enable that project to develop better estimates of the input of chemicals to the ocean via precipitation. Assign intersessional tasks to members for this if necessary

Second Working Group Meeting:

The second meeting of Working Group 38 would be held in the fall of 2009 or early 2010 at some location in Europe, probably WMO in Geneva. At the second meeting the following would be accomplished:

1) A report would be finalized that would address the four issues outlined above. Much of the text of parts 1), 3), and 4) would have been completed before the second working group meeting. Preliminary short papers under part 2) would also be completed before the meeting. The primary goal of the second meeting would be to complete a comprehensive review of the atmospheric deposition of phosphorus to the earth's surface and its impacts.

2) The working group would once again assess the need for additional reviews of the input of substances from the atmosphere to the ocean, and if it decided that such were needed, it would approach GESAMP and other sponsors about possibly continuing the efforts of the working group for another session.

Peer Review and Report Publication

The Working Group report will be subject to peer review according to the GESAMP Rules of Procedure. Potential reviewers will be identified by the Lead agency with the assistance from the GESAMP Office and other sponsors, and the peer review process is expected to take place in late 2009 or the first months of 2010, leading to an estimated publication date of mid 2010, subject to review and approval by GESAMP and other sponsors.

The report of the meeting would be published as part of the GESAMP Reports and Studies series, but it is very likely that the phosphorus review would also be published as a separate peer-reviewed journal article, in which case the reviewers would be selected by the journal.

ADMINISTRATIVE ARRANGEMENTS

Sponsors, Budget, and Funding

The Lead agency for Working Group 38 will be WMO. A GESAMP Trust Fund has been developed between WMO and other contributing partners for the support of this working group. This trust fund will be used to support:

- Participation of members of GESAMP Working Group 38 in meetings related to the working group activities;
- Implementation of tasks recommended by Working Group 38; and
- Production of publications and reports documenting outcomes and benefits of Working Group 38 activities.

WMO will support Working Group 38 to the extent of $7,500 in 2008 and $10,000 in 2009. WMO will also handle the administrative responsibilities of the working group. As a co-sponsor, IMO has indicated that it will support Working Group 38 to the extent of $10,000 in 2008 and probably additional support in 2009. The GESAMP Office has indicated that SIDA (Swedish International Development Agency) will provide support for participants from developing countries in Working Group 38 to the extent of $20,000 total for 2008 and 2009. Other agencies or organizations are cordially invited to become co-sponsors of Working Group 38.

Working Group Chairpersons and Membership

The proposed Chairpersons would be Prof. Robert Duce from the United States and Prof. Peter Liss from the United Kingdom. Both of these individuals have had extensive experience in the area of air/sea exchange of chemicals and have participated in earlier GESAMP reports

addressing similar issues.

The proposed membership of the working group was selected considering the types of expertise needed, as outlined on page 3. The membership would be as follows, with expertise indicated in parentheses:

Robert Duce - United States - Co-Chair (atmospheric/marine chemistry, air/sea exchange)
*Peter Liss - United Kingdom - Co-Chair (atmospheric/marine chemistry, air/sea exchange)
Alex Baker - United Kingdom (marine chemistry, atmospheric deposition of metals and nutrients to the ocean)
[&]Frank Dentener - Italy (atmospheric transport and deposition modeling)
Keith Hunter - New Zealand (marine biogeochemistry ocean surface microlayer chemistry,)
Maria Kanakidou - Greece (atmospheric chemistry)
*Nilgun Kubilay - Turkey (atmospheric organic nitrogen and mineral dust)
Natalie Mahowald, United States (dust and phosphorus transport and deposition modeling)
Greg Okin - United States - (nutrient dynamics in the ocean)
Joseph Prospero - United States (atmospheric mineral dust measurements, transport and impacts)
Manmohan Sarin - India (deposition of nitrogen and other atmospheric species)
[$]Ina Tegen - Germany (atmospheric dust measurements and modeling)
*Mitsuo Uematsu - Japan (marine and atmospheric chemistry measurements and modeling)

(*SOLAS contact) ([&]WMO Precip Program contact) ([$]WMO Sand and Dust Storm Warning and Assessment System contact)

Technical Secretary for the Working Group

The Technical Secretary for Working Group 38 will be Dr. Slobodan Nickovic of the World Meteorological Organization.

REFERENCES

Baker, A.R., S.D. Kelly, K.F. Biswas, M. Witt, and T.D. Jickells, “Atmospheric deposition of nutrients to the Atlantic Ocean”, Geophys. Res. Lett., 30, 2296 (2003).

Baker, A.R., T.D. Jickells, K.F. Biswas, K. Weston, and M. French, “Nutrients in atmospheric aerosol particles along the Atlantic Meridional Transect”, Deep-Sea Research II, 53, 1706-1719 (2006).

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).

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).

GESAMP, "The atmospheric input of trace species to the world ocean", Reports and Studies, GESAMP, 38, 111pp, 1989.

Jickells, T.D., Z. S. An, K. K. Andersen, A. R. Baker, G. Bergametti, et al., "Global iron connections between desert dust, ocean biogeochemistry, and climate", Science, 308, 67-71 (2005).

Mahowald N. M., A. R. Baker, G. Bergametti, N. Brooks, R. A. Duce, T. D. Jickells, N. Kubilay, J. M. Prospero, I. Tegen (2005), Atmospheric global dust cycle and iron inputs to the ocean, Global Biogeochem. Cycles, 19, GB4025, doi:10.1029/2004GB002402 (2005A).

Mahowald, N, P. Artaxo, A.R. Baker, T.D. Jickells, G. Okin, J.T. Randerson, and A. Townsend, "Impacts of biomass burning and land use on Amazonian atmospheric phosphorus cycling and deposition", Global Biogeochem. Cycles, 19, GB4030 (2005B).

Mills, M.M., C. Ridame, M. Davey, J. LaRoche, and R.J. Geider, "Iron and phosphorus co-limit nitrogen fixation in the eastern tropical North Atlantic, Nature, 429, 292-294 (2004).

Position of SCOR and GESAMP on Deliberate Nutrient Additions to the Ocean

At the 2007 SCOR Executive Committee meeting, it was decided that SCOR should issue a statement about the large-scale ocean iron fertilization experiments that are intended to test commercial carbon sequestration. GESAMP requested to be involved, so SCOR and GESAMP worked together to create a statement, which was released on 4 March 2008:

Position of SCOR[1] and GESAMP[2] on Deliberate Nutrient Additions to the Ocean

Deliberate fertilization of the ocean, until recently a subject of mostly scientific interest, has caught the attention of the commercial sector because of its potential to sequester carbon and to increase the production of living marine resources. To be effective for either of these purposes, eventual fertilization would add iron or nitrogen to large areas of the world's ocean. Proposals to realize the potential of ocean fertilization on such scales suffer a major weakness: one does not know how the oceanic ecosystem will respond. Current understanding of how the ocean operates is increasing rapidly, but is still not sufficient to predict the effects of large-scale nutrient manipulations.

Field experiments, carried out in various parts of the world ocean to study the role of iron in ocean ecosystems, have not been able to demonstrate a significant net increase in carbon export to the deep ocean on short or long time scales. These experiments have also raised important and, as yet, unanswered questions about changes in community structure. Ocean fertilization on any significant scale will (by design) impact the species succession and the ecosystem structure and function in the affected areas. Furthermore, the impacts of fertilization are unlikely to be confined to

1 SCOR is an international nongovernmental organization created in 1957 by the International Council for Science to promote international cooperation in all areas of ocean science (see www.scor-int.org).

2 GESAMP is an independent group of experts, formed in 1969, that advises the United Nations (UN) system on the scientific aspects of marine environmental protection. It is sponsored by eight UN organizations with responsibilities for the marine environment and provides a mechanism for coordination and collaboration among them (see www.gesamp.org).

the specific region that receives the fertilizer. Ocean currents mix and move water continuously and so can transport nutrients, the resulting biomass, and decomposition products beyond the target areas, with unknown consequences. Inadvertent anthropogenic additions of nutrients to the coastal ocean are presently causing significant problems such as hypoxia, anoxia and harmful algal blooms. At the present, the long-term consequences of ecosystem alterations from nutrient additions are unforeseeable and may be harmful. The effects of deliberate large-scale nutrient addition may therefore range from the desired and positive to the unintended and negative.

The Scientific Committee on Oceanic Research (SCOR) of the International Council for Science and the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) of the United Nations agree that any deliberate large-scale addition of nutrients to the ocean must be conducted in such a way that the outcomes of these experiments are statistically quantified and independently verified with respect to but not limited to:

- Changes in new primary production and total community respiration rates at the fertilization site and “downstream” of the site;
- Assimilative capacity of selected ocean regions;
- Changes in the drawdown of carbon dioxide from the overlying atmosphere, and carbon dioxide and essential macro-nutrients (P, N, and Si) from the surface waters;
- Changes in the production of carbon dioxide and other gases relevant to climate change (e.g., nitrous oxide, methane, and dimethyl sulfide) in surface and mesopelagic waters;
- Changes in denitrification rates within the oxygen minimum zone;
- Changes in the production of toxins that might be detrimental to other organisms, for example, by harmful algal blooms;
- Changes in the export of carbon to a depth where sequestration for at least 100 years is likely;
- Changes in pH and oxygen concentrations in the water column;
- Changes in biomass, composition, and biodiversity of phytoplankton, bacteria, and zooplankton, and recruitment of fish and shellfish; and
- Changes in food web structure.

To be scientifically credible the design and implementation of large-scale nutrient addition experiments must be transparent and the results must be clearly stated and made available to the scientific community and the general public. Transparency is essential, because any appearance of lack of independence from vested interests lowers the credibility of the results among ocean scientists, environmental organizations, policymakers, and potential investors in carbon credits. Carbon credits for fertilization should not be allowed unless and until reliable methods have been developed to estimate and verify the amount of carbon actually sequestered, and side effects have been properly understood and taken into account. We commend efforts by some commercial ventures to create codes of conduct and obtain outside reviews. It is essential that each stage of these experiments is reviewed by well-qualified experts free of vested interests. The goal of any new experiment on the effects of nutrient addition should be to increase our understanding of ocean processes at adequate spatial and temporal resolution; experiments should build on the lessons and the insights of previous experiments.

For further information please contact:

General Questions about the Scientific Committee on Oceanic Research (SCOR) and SCOR's interests in this topic: Prof. Bjorn Sundby, SCOR President (Canada)—Can be reached at +1 514 398-4883.

General Questions about the Joint Group of Experts on the Scientific Aspects of Marine Environment Protection (GESAMP) and GESAMP's interests in this topic: Dr. Michael E. Huber, Chairman of GESAMP(Australia)— Can be reached at +61 7 3244 7336.

Questions about the effects of iron in ocean ecosystems:
Dr. Ken Buesseler, Senior Scientist, Woods Hole Oceanographic Institution (USA, but on sabbatical in New Zealand) — Can be reached at +64 2 1056 0521 between 9 a.m. and 5 p.m. (New Zealand time).

Questions about iron chemistry in the ocean: Prof. Tim Jickels, School of Environmental Sciences, University of East Anglia (United Kingdom)—Can be reached at +441603 593117.

General questions about GESAMP: Fredrik Haag, GESAMP Officer, International Maritime Organization (United Kingdom), Can be reached at +44 20 7463 4139, or through gesamp@gesamp.org.

This statement contains views expressed or endorsed by members of SCOR and GESAMP who act in their individual capacities; their views may not correspond with those of their sponsoring organizations or Governments.

The statement fed into the London Convention meeting mentioned in the IOCCP report earlier in this section. Ed Urban and Fredrik Haag published a short article in EOS alerting the ocean science community to the statement:

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Organizations Urge Caution on Ocean Fertilization Experiments

The idea of stimulating ocean primary production to draw down atmospheric carbon dioxide and/or enhance production at higher trophic levels is not new. However, recent proposals to fertilize the ocean with iron or urea as part of commercial carbon sequestration and/or food production schemes have stimulated the ocean science community to publish papers and other statements documenting the community's views on this topic [see *Buesseler et al.*, 2008; *Glibert et al.*, 2008]. While some are upbeat that commercial carbon sequestration through stimulating ocean primary production will help offset fossil fuel emissions, others worry that fertilizing the ocean will not result in the hoped-for sequestration and/or will have significant adverse environmental consequences

A position statement was released on 4 March 2008 by two international organizations concerned with ocean science: the nongovernmental Scientific Committee on Oceanic Research (SCOR) and the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), the latter an independent, interagency advisory body for the United Nations system. According to the statement, "Current understanding of how the ocean operates is increasing rapidly, but is still not sufficient to predict the effects of large-scale nutrient manipulations."

The statement focuses on the need for transparency and independent review of large-scale nutrient enrichment experiments and identifies specific parameters that should be monitored in such experiments. SCOR and GESAMP feel that such measures will help provide the information necessary for governments to decide whether ocean fertilization is a viable way to sequester carbon and will help identify and quantify any environmental impacts.

The statement, as well as pathways to further information, can be found at http://www.scor-int.org/SCOR-GESAMP.pdf.

References

Buesseler, K. O., et al. (2008), Ocean iron fertilization: Moving forward in a sea of uncertainty, *Science*, *319*(5860), 162, doi:10.1126/science.1154305.

Glibert, P. M., et al. (2008), Ocean urea fertilization for carbon credits poses high ecological risks, *Mar. Pollut. Bull.*, in press.

—ED URBAN, Scientific Committee on Oceanic Research (SCOR), College of Marine and Earth Studies, University of Delaware, Newark; E-mail: Ed.Urban@scor-int.org; FREDRIK HAAG, Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), GESAMP Office, International Maritime Organization, London, U.K.