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## 4.1 IOC/SCOR International Ocean Carbon Coordination Project (IOCCP)

### International Ocean Carbon Coordination Project Progress Report for SCOR, August 2009

#### Projects

#### **The Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP)**

##### Background

Both the CLIVAR community and the ocean carbon community recognize the urgent need for better coordination of planning, implementation, standardization, data synthesis and interpretation efforts for hydrography. The hydrography community also recognizes that today's hydrography programs address different issues than were addressed during the World Ocean Circulation Experiment (WOCE) era; issues that require a more integrated approach in terms of variables measured, sampling strategy, and integration of ship-based sampling with other platforms such as Argo and time-series stations. The IOCCP and CLIVAR, in collaboration with the joint SOLAS-IMBER carbon working group, developed the Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP) to bring together interests from physical hydrography, carbon, biogeochemistry, Argo, OceanSITES, and other users and collectors of survey data to consider how future global ship-based hydrography can build on the foundations established by the global surveys of GEOSECS, WOCE, JGOFS, and CLIVAR.

GO-SHIP held its first meeting in November 2007 with the following Panel members: Masao Fukasawa (JAMSTEC, Japan), Chris Sabine (NOAA, USA), Bernadette Sloyan (CSIRO, Australia), Toste Tanhua and Arne Koertzinger (IfM-GeoMar, Germany), Gregory Johnson (NOAA, USA), and Nicolas Gruber (ETH, Switzerland). The Panel agreed to the following Terms of Reference:

- i. To develop the scientific justification and general strategy for a ship-based repeat hydrography network, building on existing programs and future plans, that will constitute the core global network, post-CLIVAR; considerations should include:
  1. a set of basic requirements to define a coordinated repeat hydrography network (e.g., sample spacing, repeat frequency, recommended core measurements, etc.);
  2. an inventory of existing and planned sections that meet those criteria;
  3. an assessment of other observing programs that can either contribute to or use hydrography data (e.g., Argo, OceanSITES, GEOTRACES, etc.);
  4. an assessment of data release needs to meet research and operational objectives;
  5. an inventory of on-going or planned scientific synthesis activities (basin and global) that might benefit from closer collaboration; and

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6. guidelines for the transition from the CLIVAR hydrographic program to the new system, including sections, data and information management, and synthesis activities.
- ii. To develop guidelines for a single global information and data center for ship-based repeat hydrography;
  - iii. To review and provide guidance on the need to update the WOCE hydrographic programme operations manual, including a review and update of data quality control issues.

The Panel agreed that the main deliverables (e.g., guidelines for a coordinated repeat hydrography network and information center and the updated operations manual) would be developed for the OceanObs09 conference in September 2009, where the guidelines would be published as a Community White Paper.

The IOCCP SSG at its 3<sup>rd</sup> meeting (October 2008) noted that the OceanObs09 should mark the end of the mandate for the GO-SHIP Panel and that continuation of the effort to develop a global strategy, post-CLIVAR, will depend on the response of the community to the white paper at the conference, and particularly on having a few champions in the community to step forward to agree to lead the development of a coordination project. The SSG also agreed that coordination is needed now, especially an email list to allow rapid communication with the international hydrography community, and a Web-based bulletin board/news service. The SSG set an action time to develop a communication/coordination activity for repeat ship-based hydrography as an interim activity until the GO-SHIP strategy is published and follow-up activities are developed.

### Status

An email list ([go-ship@lists.unesco.org](mailto:go-ship@lists.unesco.org)) was established in March 2009 and an email was circulated widely inviting interested scientists to subscribe to the list. At present there are 133 subscribers. The list has been used to distribute the GO-SHIP community white paper and to share information about cruise plans and updates.

A draft strategy was developed by the GO-SHIP Panel in late February and distributed on the email list for review and comments by the wider hydrography community. At present, 32 scientists commented on the draft and/or provided text and are listed as co-authors. The first draft was submitted to the OceanObs09 conference organizers on 31 March for open community review. Final reviews are due by 20 August and the final conference white paper is due by 1 September.

The final strategy is significantly longer than requested for the OceanObs09 conference. The conference organizers have agreed to let GO-SHIP publish the full document in electronic form, but have requested that a short version be submitted for the final print version (which will provide a URL reference to the full version).

The update of the hydrographic manual is approximately 60% complete, with 7 of 17 chapters still pending. The chapters have been made available for open community review at CDIAC

(<http://cdiac3.ornl.gov/hydrography/>). Hood has contacted each of the authors of the pending chapters once per month since February, and all respond that they intend to submit their chapters. The most recent request emphasized that the chapters should be made available by the time of the OceanObs09 conference.

A Web page for the work of the GO-SHIP panel has been developed on the IOCCP Web site. Initial collaborations for development of a comprehensive information center with the CLIVAR and Carbon Hydrographic Data Office (CCHDO) at the Scripps Institution of Oceanography have been slow to materialize. At present, a URL has been created ([www.goship.ucsd.edu](http://www.goship.ucsd.edu)), which simply re-directs to the IOCCP site. Discussions with Steve Diggs and Jim Swift at Scripps indicate that they are still keen to serve as the main information center for this activity. However, the initial agreement was made with the understanding that the IOCCP project office staff would have access to maintain and update the site. Because of the system being used at Scripps for this site (Linux with Ruby / Rails); it will not be possible for IOCCP staff to have any direct control over the site.

For more information: visit the Web site ([www.ioccp.org](http://www.ioccp.org)) > Hydrography > GO-SHIP

### **The Surface Ocean CO<sub>2</sub> Atlas (SOCAT) Project**

#### **Background**

At the “Surface Ocean CO<sub>2</sub> Variability and Vulnerability” (SOCOVV) workshop in April 2007, co-sponsored by IOCCP, SOLAS, IMBER, and the Global Carbon Project, participants agreed to establish a global surface CO<sub>2</sub> data set that would bring together, in a common format, all publicly available surface fCO<sub>2</sub> data for the surface ocean. This activity has been requested by many international groups for many years, and has now become a priority activity for the marine carbon community. This data set will serve as a foundation upon which the community will continue to build in the future, based on agreed data and metadata formats and standard 1<sup>st</sup>-level quality-control procedures, building on agreements established at the 2004 Tsukuba workshop on “Ocean Surface pCO<sub>2</sub> Data Integration and Database Development”. This activity also supports the SOLAS and IMBER science plans and their joint carbon implementation plan.

This data set is meant to serve a wide range of user communities and it is envisaged that, in the future, two distinct SOCAT data products will be made available:

1. a 2<sup>nd</sup>-level quality-controlled, global surface ocean fCO<sub>2</sub> (fugacity of CO<sub>2</sub>) data set following agreed procedures and regional review, and
2. a gridded SOCAT product of monthly surface water fCO<sub>2</sub> means on a 1° x 1° grid with no temporal or spatial interpolation.

An extended 1<sup>st</sup>-level quality-controlled data set has been developed as part of the EU CARBOOCEAN project, where Benjamin Pfeil and Are Olsen (Bjerknes Centre for Climate Research) have compiled the publicly available surface CO<sub>2</sub> data held at CDIAC (Carbon Dioxide Information Analysis Center) and other public data into a common format, 1<sup>st</sup> level

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quality-controlled, database based on the IOCCP-recommended formats for metadata and data reporting. The first SOCAT data compilation (version 1.1), available in May 2008 to SOCAT participants, already includes data from more than 10 countries, producing an initial database composed of more than 1250 cruises from 1972 to 2007 with measurements of various carbon parameters.

A small technical meeting was held in Bremen, Germany, on 5 December 2007 (associated with the 3<sup>rd</sup> CARBOOCEAN Annual Meeting) to agree on 1<sup>st</sup>-level QC for the data set and to decide on a way forward for the 2<sup>nd</sup>-level QC issues.

The IOCCP, along with CARBOOCEAN and the SOLAS-IMBER Joint Carbon Group, held a 2<sup>nd</sup> technical workshop (SOCAT-2 meeting) at UNESCO, Paris, on 16-17 June 2008 to develop internationally agreed 2<sup>nd</sup>-level quality-control procedures and to discuss the coordination of regional scientific groups to conduct the 2<sup>nd</sup>-level quality control analyses. For more information, please refer to the background document SOCAT-II Report.

[http://ioc3.unesco.org/ioccp/Docs/SOCAT2\\_Final2.pdf](http://ioc3.unesco.org/ioccp/Docs/SOCAT2_Final2.pdf)

### Status

The SOCAT dataset now contains more than 2,100 cruises from 1968-2007. Benjamin Pfeil and Steve Hankin have agreed that the best way to access the dataset is to keep each cruise as an individual file and to use a LAS system to serve all the data. The regional groups will use LAS to download data, based on definitions of regional boundaries.

Regional groups were tasked with identifying missing datasets from SOCAT version 1.1. The identified regional groups and chairs are:

- Atlantic and Arctic Ocean – Schuster, Lefèvre
- Indian Ocean – VVSS Sarma
- Pacific Ocean – Feely, Nojiri
- Southern Ocean – Tilbrook, Metzl
- Coastal seas – Borges, Chen.
- Global group – Bakker, Olsen, Sabine, Pfeil, Metzl

### SOCAT QC-II Definitions of Regional Boundaries as of June 2009

1. **Tropical Pacific** -- Between 30°S and 30°N, between North America and Asia. The boundary between the Indian and the Pacific oceans is Malaysia, Sumatra, Java, and Timor and a line at 130°E to Australia through the Timor Sea.
2. **North Pacific** -- North of 30°N and between North America and Asia, including cruises that go north of Alaska into the Arctic Ocean.
3. **Southern Ocean** -- Everything south of 30°S
4. **Indian Ocean** -- North of 30°S, bounded on the east by the line described above, and on the west by Africa and the Suez Canal.

5. **Atlantic Ocean** -- North of 30°S including the Mediterranean Sea, Black Sea, Barents Sea, and Labrador Sea.
6. **Coastal (a.k.a. "continental margins")** -- All ocean surface within 400 km of land\* excluding the Southern Ocean Region.

\* The intent of the various working groups was to exclude the margins around small, isolated islands, so the Distance-To-Land variable is calculated from a 20-minute resolution land mask that was altered (through guidance from Burke Hales) to eliminate such islands. The altered land mask retains New Zealand, Iceland, and Madagascar as "land" and Caribbean islands that show up at the 20-minute resolution, as well as other islands like Tasmania, Sri Lanka, Japan, etc. The following islands were explicitly masked out: Reunion/Mauritius, New Caledonia, Vanuatu, Solomon Islands, Manus Island (N of New Guinea), Galapagos, Smith Island (Indian Ocean; Bay of Bengal), Hawaii, Azores, South Georgia, Macquarie (south of NZ), French Southern and Antarctic Lands.

The various regional groups have met to evaluate the initial data quality, learn to use the LAS tools for conducting 2<sup>nd</sup> level quality control, and determine a course of action for performing the 2<sup>nd</sup> level quality control checks. The Coastal group meeting was held in Kiel in January 2009 with financial support assembled by the SOLAS International Project Office from various sources, including the European COST Action 735. The Pacific regional group met in March 2009 at the Tsukuba, Japan, funded by the National Institute for Environmental Studies Institute and IOCCP. The Atlantic, Indian, and Southern ocean regional groups met in June at the University of East Anglia supported by COST (SOLAS), and IOCCP and IMBER.

*For more information:* visit the web-site (<http://www.ioccp.org/>) > Workshops and Meetings

## **Workshops and Meetings**

### **Changing Times: An International Ocean Biogeochemical Time-series Workshop**

#### Background

Time-series studies comprised a major component of the Joint Global Ocean Flux Study and are providing a continuing legacy of biogeochemical observations over time frames that are now becoming long enough to examine a range of climate forcing. The Hawaii Ocean Time-series, Bermuda Atlantic Time Series and Carbon Retention In A Colored Ocean time-series, for example, now have collected almost twenty years' of data, including a wide array of biogeochemical observations in different ocean regions. Literally hundreds of publications have come from the time-series sites and an entire generation of scientists has had some connection to these sites.

Despite repeated acknowledgement by the international community that time-series stations are critical for understanding the processes controlling ocean carbon and biogeochemical cycles, maintaining funding support for these platforms has been difficult. Without a coordinated

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network of scientists using the stations in an organized effort, the community has become dispersed, and research carried out on the stations has focused more on individual PI-based investigations or sensor development. Without international support, it is possible that many stations will not continue in the future.

In 1999, an international group of scientists formed the OceanSITES program to develop a coordinated, interdisciplinary international network of stations, research programs, and scientists to sustain and enhance the use of time-series observations. Although the physical oceanographic community is strongly tied into OceanSITES, the biogeochemical community is not well connected.

To support and strengthen the ocean carbon and biogeochemical time-series effort, the IOCCP, OceanSITES, and the Partnership for Observations of the Global Ocean (POGO) sponsored a workshop at the Scripps Institution of Oceanography on 5-7 November 2008. The workshop brought together 40 participants from 17 different countries to review the scientific rationale for sustained time-series observations of carbon and biogeochemistry; the value of networking observations; existing global regional, and national programs; needs, interests and emerging issues; technology and development issues; and collaborations and networking needs, interests and possibilities.

The workshop consisted of plenary talks, brief presentation of time-series stations from all 17 countries represented at the meeting, and break-out groups to compile basin-scale observing system information, to identify the major science drivers and development priorities for the next 5-10 years, and to identify regional needs and opportunities for networking and coordination.

### Status

While many of the carbon and biogeochemistry time-series stations were appropriate for coordination within the OceanSITES framework (e.g., open-ocean, Eulerian, and open data policy), other stations and biogeochemical observation programs were not. The workshop participants agreed to work in collaboration with OceanSITES where appropriate, but also to develop an inventory of all carbon and biogeochemistry observing programs to facilitate coordination and communication among them. The inventory would be restricted to observation programs that are meant to be long term, and would not include process studies or one-time experiments. Discussion is scheduled for the IOCCP SSG meeting in Jena, Germany on 14 September 2009 on moving forward with the inventory.

***For more information:*** visit the Web site  
(<http://ioc3.unesco.org/ioccp/Time%20series/ChangingTimes.html>)

## **Standards for Ocean Acidification Research and Data Reporting**

### Background

The need for standardized protocols and reporting of data has been highlighted at numerous ocean acidification workshops over the past few years. Common methods are crucial if we are to

identify differences (or lack thereof) in calcification among various taxa, regions, and over time. It is also imperative that data be reported in a manner that will be comprehensible and accessible to scientists several decades from now if changes are to be detected. Specifically, the international research community needs to establish agreed protocols for calcification rate measurements and mesocosm/perturbation experiments, as well as for protocols for data reporting.

The European Project on Ocean Acidification, the IOCCP, the U.S. Ocean Carbon and Biogeochemistry Program, and the Kiel Excellence Cluster the “Future Ocean” co-sponsored a workshop to develop a guide of best practices and data reporting for ocean acidification research. The workshop was held from 19-21 November 2008 at the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in Kiel, and brought together approximately 40 scientists from the EU, United States, Japan, Korea, China, and Australia.

Sessions included carbonate chemistry, experimental design of perturbation experiments, measurements of CO<sub>2</sub>-sensitive processes, and data reporting and usage. Break-out and writing groups focused on three major issues:

1. Carbonate system measurements, manipulations and experimental CO<sub>2</sub>/ Ω levels;
2. Measurements of calcification processes, data normalization, reporting and archiving; and
3. Measurements of CO<sub>2</sub>-sensitive processes (other than calcification), data normalization, reporting and archiving.

#### Status

The workshop produced a guide for “Best Practices in Ocean Acidification Research and Data reporting” (U Riebesell, V Fabry, J-P Gattuso, Eds.). The guide is intended as a reference to provide guidance for research in the rapidly growing field of ocean acidification. The guide was open for community review until 15 July 2009. All scientists were invited to provide comments and suggestions on any aspect of the guide.

**For more information:** visit the Web site

(<http://www.epoca-project.eu/index.php/Home/Guide-to-OA-Research/>)

### **International Nutrients Scale System Workshop**

#### Background

The comparability and traceability of data on nutrients in the global ocean are fundamental issues in marine science, particularly for studies of global climate change. Our community has been continuing to improve the comparability of nutrient data in many ways, including by intercomparison experiments and the development of nutrient reference materials. However, as *Climate Change 2007 – The Physical Science Basis* (IPCC 2007) stated, adequate comparability and traceability have not yet been achieved. The IPCC 2007 report comments as follows on nutrient comparability: “Using the same data set extended to the world, large regional changes in



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nutrient ratios were observed (Li and Peng, 2002) but no consistent basin-scale patterns. Uncertainties in deep ocean nutrient observations may be responsible for the lack of coherence in the nutrient changes. Sources of inaccuracy include the limited number of observations and the lack of compatibility between measurements from different laboratories at different times (Bindoff et al., 2007).”

The IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (IOC, 1993) drew attention to an urgent need for certified reference seawater for nutrients. Dickson (2001) drew attention to the need to develop certified reference seawater covering several determinants in a single bottle. During the World Ocean Circulation Experiment (WOCE) period, the WOCE Hydrographic Program Planning Committee (WHPPC) recognized the importance of worldwide comparability of WOCE nutrient data.

In the 1990s, several studies of nutrients were organized under the ICES umbrella. These studies were well documented (see Amino et al., 1995 and Aoyama, 2006 for details). In Europe, this led to the setting up of QUASIMEME (Topping, 1997), which annually validates the procedures of individual laboratories. But this system is inadequate for supporting the traceability that is required to link measurements from day to day in order to improve the overall precision within a laboratory or to achieve a known level of comparability among different laboratories.

In 2000 and 2002, the U.S. National Oceanic and Atmospheric Administration and the National Research Council of Canada (NOAA/NRC) conducted two intercomparisons to certify MOSS-1 (Willie and Clancy, 2000; Clancy and Willie, 2003). However, adequate comparability and traceability of nutrient data have not yet been achieved. Various efforts have been made to change it, but these have been on too small a scale to meet the needs of the global community in measuring nutrients in seawater.

In 2003, Michio Aoyama, of the Meteorological Research Institute, Japan, organized an intercomparison study that included 18 laboratories (Aoyama, 2006; Aoyama et al., 2007). In 2006, Aoyama organized a second intercomparison study that included 55 laboratories worldwide (Aoyama, 2008). Both studies clearly showed that the global use of reference materials for nutrients in seawater would greatly improve the comparability of nutrient data worldwide. In early 2007, Aoyama visited the National Oceanography Centre in Southampton to discuss the results of the inter-calibration. The European participants in the inter-calibration and other interested nutrient chemists were also invited to attend discussions at NOC.

An International Workshop on Chemical Reference Materials in Ocean Science was held in Tsukuba, Japan, on 29 October to 1 November 2007. It focused on the measurement of nutrients and of ocean CO<sub>2</sub> parameters. The current status of available chemical reference materials, especially for nutrients in ocean science were discussed, and the participants agreed to start a collaborative program, called the International Nutrients Scale System (INSS), to establish global comparability and traceability. The agreements at the workshop in Tsukuba 2007 marked an epoch in the history of nutrients comparability.

### Status

The IOCCP co-sponsored and hosted the INSS workshop on 10-12 February 2009 at UNESCO headquarters in Paris. This workshop, led by Dr. Michio Aoyama, followed several workshops and intercomparison experiments held over the last several years to establish nutrient standards for marine science. The INSS organizers included Michio Aoyama, Andrew Dickson, David Hydes, Akihiko Murata, Jae Oh, Patrick Roose, and Malcolm Woodward.

The meeting brought together 37 participants from 11 countries to update the manual of nutrient analyses by the INSS group, review the usage of nutrient data and carbonate system data in oceanography, summarize the 2008 reference materials intercomparison experiments, plan for a short-term stability experiment in 2009-2011, and to hear reports on reference materials development from several groups. A workshop report is in preparation.

The group is also finalizing its “Recommendations for the determination of nutrients in seawater to high levels of precision and inter-comparability using Continuous Flow Analysers” as a contribution to the GO-SHIP project to revise the WOCE Hydrographic Program manual.

To carry out the INSS work outlined, including the development of a review of the status of QC techniques for ocean biogeochemistry measurements, the organizers submitted a proposal for the establishment of a joint ICES-IOC working group. This proposal was approved by the 25<sup>th</sup> IOC Assembly in June 2009.

***For more information:*** Visit the INSS Web site at: [http://www.mri-jma.go.jp/Dep/ge/2009INSSworkshop/2009inss\\_workshop\\_index.html](http://www.mri-jma.go.jp/Dep/ge/2009INSSworkshop/2009inss_workshop_index.html) or the GO-SHIP manual site to review the Recommendations chapter and standard operating procedures at: <http://cdiac3.ornl.gov/hydrography/>

### **OceanObs09 White Papers**

#### Background

Almost a decade has passed since the OceanObs'99 symposium played a major role in consolidating the plans for a comprehensive ocean observing system, able to deliver systematic global information about the physical environment of the ocean. For the first time in history, the global ocean is being observed routinely and systematically by means of satellite and in situ techniques.

It is now critically important to establish an international framework that will sustain the present system, evolve it to respond to increasing needs, and help it realize the full extent of its benefits across all stakeholders. It is equally important to present a clear vision extending the present observing system to include comprehensive and routine observations, information and services on the biogeochemical state of the ocean and the status of marine ecosystems.

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The World Climate Research Programme (WCRP), the Global Ocean Observing System (GOOS), and the Global Climate Observing System (GCOS) have called for the OceanObs'09 conference, charging the organizers to address the issues raised above and to help lay out a path for sustaining the benefits of ocean information and services in the coming decade. OceanObs'09 will be held in Venice, Italy, on 21-25 September 2009 ([www.oceanobs09.net](http://www.oceanobs09.net)).

## Status

The IOCCP provided coordination support for two contributed white papers to the conference:

1. Repeat Hydrography – the IOCCP-CLIVAR Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP) developed a white paper outlining a strategy for interdisciplinary repeat hydrography entitled “Global Ocean Ship-based Hydrographic Investigations Project (GO-SHIP)” by Hood et al. (2009); and
2. Carbon VOS network – the IOCCP scientific steering group developed a community white paper outlining a strategy for carbon measurements on commercial Volunteer Observing Ships entitled “A global sea surface carbon observing system: assessment of sea surface CO<sub>2</sub> and air-sea CO<sub>2</sub> fluxes” by Schuster et al. (2009).

*For more information:* visit the Web site ([www.oceanobs09.net](http://www.oceanobs09.net)).

## **Project Office**

### **New IOCCP Director**

Dr. Kathy Tedesco was appointed by the Intergovernmental Oceanographic Commission of UNESCO and the Scientific Committee on Oceanic Research as the new director of the IOCCP, effective 2 April 2009. Maria Hood continues to work part-time for the IOCCP as a consultant.

Kathy came to the IOCCP from the U.S. Geological Survey in St. Petersburg, Florida where she was working as an oceanographer for the past two years. Prior to this, she served as Program Manager for the Global Carbon Cycle Program (GCC) in the Climate Program Office at the National Oceanic and Atmospheric Administration. Her work involved planning future research directions for GCC, drafting program plans, administering peer review of proposals and research projects, recommending and managing funded research, and reporting on performance and accomplishments. She represented NOAA on the Carbon Cycle Interagency Working Group under the U.S. Climate Change Science Program, along with representatives from more than ten federal agencies, coordinating carbon cycle research through linked interdisciplinary research elements and crosscutting activities.

Kathy received her Ph.D. in geological oceanography from the University of South Carolina. Her dissertation research focused on the calibration of paleoenvironmental proxies from the Cariaco Basin time-series station and their application to paleoclimate reconstructions. Kathy is currently conducting a sediment trap experiment in the northern Gulf of Mexico to understand Holocene

climate history of the region. In addition, she has participated in more than twenty-five coring and hydrographic research cruises.

### **IOCCP Scientific Steering Group Meeting**

The IOCCP Scientific Steering Group will meet in Jena, Germany on Monday, 14 September 2009 during the International Carbon Dioxide Conference 8 (ICDC8). Members (2008-2010) include Chris Sabine (NOAA / PMEL, USA)-Chair, Masao Fukasawa (JAMSTEC, Japan), Dorothee Bakker (UEA, UK), Pedro Monteiro, (CSIR, South Africa), Melchor Gonzalez (U. Las Palmas, Spain), Ute Schuster (UEA, UK), Toste Tanhua (IfM-Geomar, Germany), Alex Kozyr (CDIAC, USA), and Yukihiro Nojiri (NIES, Japan).

The meeting will focus on three major projects: GO-SHIP, SOCAT, and times series. Decisions will be made on how to move forward with a time-series database following the Changing Times workshop, the release date for the SOCAT dataset, and the follow-up of GO-SHIP, including support of a major workshop in 2010.

In addition, invitations have been extended to Doug Wallace (SOLAS), Julie Hall (IMBER), Ed Urban (SCOR), Niki Gruber (SOLAS-IMBER Carbon (WG2) and Nicolas Metzl (SOLAS-IMBER Carbon WG1). The IOCCP will discuss future collaborative efforts between the IOCCP and SOLAS-IMBER Carbon (SIC) Working Groups.

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#### 4.2 Symposia on The Ocean in a High-CO<sub>2</sub> World

2009 Progress Report on Follow-up for the Second Symposium on  
The Ocean in a High-CO<sub>2</sub> World and Planning for the Third Symposium

**2008 Symposium**—The 2008 Symposium was held a few weeks before the 2008 SCOR General Meeting and was reported on there. Since that time, several publications have resulted from the symposium:

- *Monaco Declaration*—This product was not planned before the symposium, but the idea was raised by a participant and Prince Albert II of Monaco supported the idea and the opportunity was used. The declaration was released at the ASLO meeting in Nice, France in January 2009 and received a lot of press.
- *Summary for Policymakers*—A *Summary for Policymakers* was completed in July 2009. IGBP laid out and printed this product as an in-kind contribution to the symposium.
- *Research Priorities Report*—This report is a summary of the science of the symposium, including detailed accounts from the three breakout groups.
- *Oceanography Magazine* article—A summary of the *Research Priorities Report* was produced for a special issue of *Oceanography Magazine*. SCOR took the lead on this product and the article is in review.

All of these products are, or will be, available on the [www.ocean-acidification.net](http://www.ocean-acidification.net) Web site.

**2012 Symposium**—Fund raising has begun for the third symposium in the series, planned for 2012. In addition to fund raising, the next steps will be

- Agreeing to who will co-sponsor the symposium
- Agreeing among co-sponsors as to the chair
- Putting out a request for bids to host the symposium
- Forming the Symposium Planning Committee

### 4.3 Other Activities

#### 4.3.1 SCOR Summits of International Marine Research Projects

Large-scale ocean research programs and projects are sponsored by several different international organizations, each with a different focus. For example, SCOR covers all areas of ocean science, IGBP focuses on biological and chemical aspects of global change, the World Climate Research Programme (WCRP) focuses on physical aspects of global change, and IOC brings together national governments to sponsor research and infrastructure related to aspects of ocean science that are of greatest importance to society. Some research programs, such as the Census of Marine Life and InterRidge, are independent but affiliated with related organizations. The programs and projects have interacting interests, but because they are not all sponsored by a single organization, they do not typically come together to discuss opportunities for cooperative activities and ways to address common concerns. The programs and projects tend to operate under tight budgets and are usually reluctant to spend their funds for coordination meetings. SCOR has received support from the Alfred P. Sloan Foundation to convene three project summits, in 2004 (see [http://www.scor-int.org/Project\\_Summit\\_1/ProjCoord.htm](http://www.scor-int.org/Project_Summit_1/ProjCoord.htm)), 2006 (see [www.jhu.edu/scor/ProjCoord2.htm](http://www.jhu.edu/scor/ProjCoord2.htm)), and 2009 (see [http://www.scor-int.org/Project\\_Summit\\_3/ProjCoord3.htm](http://www.scor-int.org/Project_Summit_3/ProjCoord3.htm)).

**Follow-up from 2006 Summit**—See Section 4.3.3 below.

**2009 Summit**—The 2009 SCOR Project Summit was held on 30 March to 1 April in Newark, Delaware (USA), hosted by the SCOR Secretariat. Topics included data management/data publication/project data legacy, capacity building, observing technology/ocean biology observatories, project visibility/publicity, modeling, and interactions with intergovernmental organizations. SCOR received funds to pay for a smaller number of participants than in the past, with the expectation that the projects and other organizations would send some participants at their own expense. Projects did not send representatives at their own cost, but some organizations did.

## Summary

**Participants:** Bob Anderson (GEOTRACES), Dawn Ashby (GLOBEC), Emily Breviere (SOLAS), Michael Dagg (PICES), Wolfgang Fennel (SCOR Executive Committee), Elizabeth Gross (SCOR), Julie Hall (IMBER), Eileen Hofmann (SCAR/SCOR Expert Group on Oceanography), Venu Ittekkot (SCOR Committee on Capacity Building), Adi Kellermann (ICES), Raphe Kudela (GEOHAB), Patricia Miloslavich (CoML), Reiner Schlitzer (GEOTRACES Data Management and Modeling), Bjørn Sundby (SCOR Executive Committee), Nancy Targett (University of Delaware), Kathy Tedesco (IOCCP), Ed Urban (SCOR), Luis Valdes (IOC), Edward vanden Berghe (OBIS), and Cisco Werner (SCOR/IODE Data Publication Activity).

Wolfgang Fennel and Bjørn Sundby co-chaired the meeting on behalf of the SCOR Executive Committee. Fennel welcomed everyone and stated that the primary goal of the meeting was to improve cooperation among large-scale projects and between them and intergovernmental organizations. Ed Urban reviewed logistical arrangements and changes to the agenda. Most presentations from the meeting are available at [http://www.scor-int.org/Project\\_Summit\\_3/PC3-Agenda2.htm](http://www.scor-int.org/Project_Summit_3/PC3-Agenda2.htm).

Meeting participants discussed the following topic:

- Project Publication and Visibility
- Interaction with Intergovernmental Organizations
- Education, Outreach, and Capacity-Building
- Project Interactions with GOOS, OceanSITES, time-series stations
- Census of Marine Life Synthesis, Next Steps, and Potential Role of Research Projects—Patricia Miloslavich made this presentation
- Update on Project Data/Metadata Management Activities—Edward Vanden Berghe provided an update on OBIS in this session
- Project Modeling Activities
- Principles for Developing New Large-Scale Research Projects

The following action items resulted from the meeting:

### Project Publication and Visibility

**Actions:** Projects to sign up for each others' newsletters and provide links to each others' web site.

Ed Urban will create a page on the SCOR Web site that will provide links to project newsletters. Projects should consider adding their projects to Wikipedia. Programs to send brief messages to Ed when their newsletters are available, including contents. Ed to forward these messages via the SCOR email list, which does not overlap too much with projects' lists.

**Update:** Newsletters are being added to the project portal at <http://www.scor-int.org/ProjCoord-front.htm> as they are received. Links to project Wikipedia pages are also being added to this page.

Interaction with Intergovernmental Organizations (IGOs)

**Actions:** Projects to seek cooperation with IGOs on summer schools. Projects to consider jointly sponsored sessions at PICES and ICES meetings. IGOs to invite projects to their meetings to present posters, etc. Could also use their conferences for targeted symposia. Investigate a theme session at ICES annual meeting on lessons learned from international projects nearing completion (GLOBEC, CoML).

Education, Outreach, and Capacity Building

**Actions:** Ed Urban to keep projects informed of SCOR capacity-building activities.

Ed Urban to add PICES, ICES, and IOC liaisons to SCOR Committee on Capacity Building, and add Murray Brown as a liaison from OceanTeacher. Invite projects to next CB Committee meeting and add liaisons to committee.

**Update:** Alex Bychkov and Adi Kellermann were asked to identify liaisons to the SCOR Committee on Capacity Building. Murray Brown has agreed to serve as a liaison.

Shared Webcasting Service/Software

**Action:** Sophie Beauvais and Ed Urban to investigate cost of various Webcasting services/software and to keep projects informed. Seek permission from SCOR to provide service/software to projects. Use taped lectures in SCOR's general capacity-building strategy.

**Update:** Ed has started discussions with Sophie about this and they are working on a proposal to SCOR. Interested projects will test GoToMeeting on 2 Sept. as a result for Webinars and online meetings.

Project Interactions with GOOS, OceanSITES, time-series stations

**Action:** SCOR Panel on New Technologies for Observing Marine Life to present results of Workshop on Ocean Biology Observatories at OceanObs09 and participate in panel discussion. Encourage SCOR WG proposal on Ocean Observation Simulation Experiments.

**Update:** Waiting for official invitation from OceanObs'09 to Technology Panel. Discussed the idea of a SCOR working group on Ocean Observation Simulation Experiments and disseminated the idea through the SCOR email list, but there was no interest in submitting a proposal.

Update on Project Data/Metadata Management Activities

**Action:** Projects to notify their communities about IMBER Data Management Cookbook and ask for comments. Discuss inter-project meeting (next summit?) on data management. Ed Urban to keep projects informed of progress of SCOR WGs: 125, 131, 132.

SCOR/IODE Data Publication Activities

**Action:** Ed Urban to contact PICES TCODE committee. Ed Urban to update projects about activity at end of 2009. Ed Urban to further explore willingness of *PLoS One* to handle data publications, create a "hub" for data or data publications.

**Update:** Ed Urban contacted Bernard Megrey, chair of the PICES Technical Committee on Data Exchange (TCODE) regarding SCOR data publication activities, but received no response.



# 4-16

## POGO Research Cruise Database

**Actions:** Projects to encourage their scientists to submit their cruises to the database. Ed Urban to request database to include project labels for cruises.

**Update:** There is already a “projectname” in the database.

## Project Modeling Activities

**Action:** Explore benefit to a cross-project modeling meeting (e.g., community models). Does anyone want to take the lead on this? Should we have a meeting focused on it?

## Conference Manager Software

**Action:** Elizabeth Gross to send Conference Manager response to projects that use it.

## Principles for Developing New Large-Scale Research Projects

**Action:** Ed Urban to convey draft principles to SCOR Executive Committee and co-sponsors for discussion/modification.

**Update:** Will be discussed at SCOR Executive Committee meeting in October 2009.

## Additional Topics Raised by Projects

**OceanObs’09:** Projects to transmit information about the meeting to their communities and ask for ideas for new working papers to fill the gaps. Projects should consider endorsing OceanObs.

**Future Project Summits:** Convene on approximately 2-year basis. Focus on specific topics (with outside expertise), with options to raise other topics. Might have email or Web conferences on more frequent basis if it seems useful. Web conferences would need extra preparation of background papers. Consider conducting with SCOR meeting, but might be a problem because of length of time away. Meetings could be designed to feed into other efforts, like OceanObs, IPCC, etc.

## SCOR meetings draw international ocean scientists to UD

1:55 p.m., April 27, 2009—Traveling from as far as New Zealand and Germany, ocean scientists recently gathered at the University of Delaware for the Third SCOR Summit of International Marine Research Projects. The event provided the visitors -- more than 15 representatives from major global ocean research and observation projects -- an opportunity to discuss common opportunities and issues.

The March 30-April 1 summit was organized by the Scientific Committee on Oceanic Research (SCOR), which promotes international cooperation related to oceanographic research and is housed at UD's College of Marine and Earth Studies (CMES). Approximately 300 scientists from 35 nations are involved in SCOR activities.

During the summit, which was sponsored by the Alfred P. Sloan Foundation, participants touched on topics including data management and specific projects such as the Census of Marine Life. One of the event's sessions was devoted to ways SCOR can enhance its capacity building efforts, activities to stimulate the development of ocean research in developing countries.

SCOR is well known for such programs. It has been doing them since the early 1960s, shortly after SCOR was formed by the International Council for Science. Today, about 25 percent of countries that participate in SCOR are from the developing world, including Brazil, Chile, China, Ecuador, India, Pakistan, Peru, South Africa and Turkey.

With so much ocean research being conducted on a global scale, it is important to involve scientists from developing countries, said SCOR Executive Director Ed Urban.

"It is to every country's benefit if we can help train scientists throughout the world," he said.

SCOR's current capacity building efforts include providing journal articles and books to libraries in 33 countries and offering travel grants for developing country scientists to attend ocean science meetings. During a typical three-year grant cycle, approximately 250 individual scientists from 45 countries receive full or partial travel support to attend meetings. SCOR also includes developing country scientists in all of its groups.

At the summit, participants discussed the development of regional graduate schools of oceanography, which would bring together a critical mass of resources to provide ocean science education in developing regions. They also received an update on several different summer schools for graduate students that provide up to two weeks of intensive ocean science training.

"We generated new ideas and excitement about our capacity building efforts," Urban said. "We learned there is a lot of interest in attracting more involvement from scientists in Africa, Latin America, Southeast Asia and other developing regions, so I look forward to seeing the outreach efforts of SCOR and our partners continue to expand."

Next month, another group of international scientists will visit UD for a SCOR event, this time for a workshop on aquatic viral ecology. The May 14-16 event will be hosted by the SCOR Working Group on The Role of Viruses in Marine Ecosystems.

For more about SCOR, visit [[www.scor-int.org](http://www.scor-int.org)]. To learn about CMES, visit [[www.ocean.udel.edu](http://www.ocean.udel.edu)].

Article by Elizabeth Boyle

### UDaily is produced by the Office of Communications & Marketing

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# 4-18

## 4.3.2 Panel on New Technologies for Observing Marine Life

### Terms of Reference:

1. Write cross-project synthesis of technology used by CoML projects, for publication as a special issue of a peer-reviewed journal or a book.
2. Write a synthesis paper or chapter, also placed on the Panel Web site, that will summarize (for a wide audience) the state of the art of technologies for observing marine life, including the limits of knowledge.
3. Plan and convene a Workshop on ocean biology observatories in conjunction with the OceanObs09 meeting in Venice, Italy (see <http://www.oceanobs09.net/>).
4. Revise and maintain Panel Web site, with information for the research and observations community, and for the public.
5. Oversee two activities on electronic tags that have been proposed as part of the CoML synthesis: (1) Developing New Tag Technologies – Integrating the Marine Animal Tracking Products from TOPP and POST and (2) Animals as Ocean Sensors in the Global Oceans.

### Chair:

Alex Rogers  
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Tel: 44-(0)20 7449 6669  
E-mail: [Alex.Rogers@ioz.ac.uk](mailto:Alex.Rogers@ioz.ac.uk)

### Members

No official membership has been established, but the following have been active to date:

Mairi Best (Canada)  
David Farmer (USA)  
Chris German (USA)  
John Gunn (Australia)  
Pat Halpin (USA)  
Marlon Lewis (Canada)  
Rubens Lopes (Brazil)  
Edward Vanden Berghe (USA)

A greater number of people have been active as authors of the synthesis papers and participants in the Workshop on Ocean Biology Observatories.

**Executive Committee Reporter:** Missy Feeley

## SCOR Panel on New Technologies for Observing Marine Life Activities in 2008-2009

### 2009 Panel Meeting

The Panel's meeting in 2008 was held in Newark, Delaware (USA). The main objectives of the meeting were to (1) plan the papers for a special journal issue to synthesize the technological achievements of the Census of Marine Life (CoML) and (2) to plan a Workshop on Ocean Biology Observatories. All other aspects of the Panel's work were also discussed.

*Cross-project synthesis of technology used by CoML projects*—This activity will document technologies used by CoML projects, particularly in terms of technologies that CoML has advanced. This synthesis will take the form of a special issue of *Public Library of Science (PLoS) One*. This journal is open access and has been selected by several other CoML projects as the venue for their final publications. The overall theme of the synthesis is the “transparent ocean” that results when technology is used to extend our observational capabilities.

*Workshop on Ocean Biology Observatories*—For some time, physical oceanographers have been able to make intensive and extensive observations on a wide range of time and space scales using drifters, moored buoys, towed devices, autonomous vehicles, and, of course, satellite instruments. With a few exceptions (e.g., ocean color satellite sensors), marine biologists have not had access to advanced technologies that match those available for physical measurements, although a number of biological instruments have been developed by individual scientists for experimental purposes. The development of long-term biological monitoring programs in the ocean is critical in monitoring the impacts of climate change and other human impacts on marine ecosystems. This workshop will identify what the marine science community regards as the most pressing needs in terms of long-term biological observations. (Such information is available in documents related to GOOS and national observing systems, but needs to be pulled together and updated.) Workshop participants will then identify the most promising technological advances to meet these needs (both those technologies adopted by CoML projects already and complementary technologies that have not yet been used by the projects) and initiate activities to stimulate their transition to use as ocean biology observatories. The workshop will result in a summary publication and a more detailed science and implementation plan. The workshop will evaluate the needs of the marine science community in terms of long-term monitoring of biological parameters (beyond measurements of chlorophyll) and to assess different technologies for observing marine life. It will propose how available and developing biological measurements could be combined within single nodes or at single sites to produce synergistic observation benefits and to decide on the appropriate scale and distribution of such nodes globally. A node might include moored observation instruments, with autonomous vehicles that use the node as a home base, regular visits by manned platforms, and access to satellite data for the site. The Ocean Tracking Network GOOS pilot project developed from the CoML POST and TOPP projects under the umbrella of the CoML Canada Committee will be a test of some of these technologies. The Panel's workshop will promote long-term biological monitoring and assist collaboration among scientists and managers interested in such monitoring.

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This workshop will be held just before the OceanObs09 meeting in Venice, Italy (see <http://www.oceanobs09.net/>). The agenda for the workshop is shown below. A member of the Panel, John Gunn, will summarize the results of the workshop at OceanObs and in a paper as part of the OceanObs special issue.

*Panel Web site*—The Panel's Web site is its major vehicle for disseminating information. The site includes short descriptions of key technologies, including key references, links to other information about the technologies, relevance for CoML projects, and other information that is useful for the CoML projects and the broader community of ocean scientists. The Panel includes on its Web site synthesis information about molecular techniques, animal tags, and other technologies important within and beyond CoML. In the next period, the range of technologies covered will be increased and the existing technology information on the CoML Web portal designed for the public will be integrated with the Panel's more technical information. The Panel Web site has been re-designed by the CoML Education and Outreach team at the University of Rhode Island to make it a more useful resource for the CoML community and the public. The Web site will include links to existing technology-relevant sites and documents. New information will be added as part of the Panel's continued work.

*Oversight of Other Cross-Cutting CoML Activities*—The Panel is overseeing two activities on electronic tags that have been proposed as part of the CoML synthesis: (1) Developing New Tag Technologies – Integrating the Marine Animal Tracking Products from TOPP and POST and (2) Animals as Ocean Sensors in the Global Oceans. The Panel's role is to help tie these activities into the overall synthesis of CoML-related observation technologies, and to ensure that the recommendations from the Panel's workshop on tag geolocation are considered. The Panel will provide technical oversight of these activities. SCOR is assisting with logistics and handling reimbursements to meeting participants, as well as providing financial oversight of the activities.



Workshop on Ocean Biology Observatories  
Mestre, Italy  
16-18 September 2009

### 16 September (Wednesday)

9:00 a.m. Introduction – Alex Rogers

**Goal of Workshop:** Bring together biologists, observing community, and technological community to develop ocean biology observatories that could address the grand challenges of observing ocean life and its response to global change.

**Definition of an ocean biology observatory:** The definition will be broad, including a sustained, integrated system from a broad range of platforms that can support existing and emerging technologies for observing marine life and its interaction with the ocean and broader Earth system. The observatory

components will include platforms, instrumentation, data management and analysis. Observatories could include fixed-point moorings (cabled or autonomous), animals as oceanographers, measurements from Volunteer Observing Ships, AUVs/ROVs/HOVs, drifters, CPRs, Ocean Tracking Network, satellites, among other platforms and technologies.

9:30 a.m. **Plenary Session 1 (Moderator: Alex Rogers)**

What parameters do we need to observe to understand the response of ocean biology to global change and the impacts of biological changes on the Earth system? What collection of observations is needed?

9:30 a.m. Modeling and observations: How do they interact (parameterization to data assimilation)?  
- *Katja Fennel*, Dalhousie University and *Philippe Cury*, IRD, France

11:00 a.m. Morning Break

11:30 a.m. Thresholds/tipping points/regime shifts/forecasting extreme events – *Francisco Chavez*, Monterey Bay Aquarium Research Institute

12:15 a.m. Introduction to Breakout Groups

Breakout Groups

1. Observational approaches to ocean acidification and oxygen depletion (Chair: *John Volkman*, Rapporteur: *Scott Bainbridge*)
2. Observational approaches to community structure, from microbes to zooplankton (Chair: *Bengt Karlson*, Rapporteur: *Rubens Lopes*)
3. Observational approaches to distribution and movement of marine organisms in relation to physical/chemical structures (Chair: *Dan Costa*, Rapporteur: *Ron O’Dor*)
4. Observational approaches to changes in trophic structures (chair: *Hans Paerl*, Rapporteur: *Bob Gissiner*)
5. Observational approaches to changes in benthic dynamics (Chair: *Carlo Heip*, Rapporteur: *Kate Larkin*)

Each of the 5 groups will develop a report that will discuss and document

- Background and context for observing approaches related to the group’s topic
- Need for systematic long-term measurements over large scales
- What are the priority observations to address this issue?
- Where should the observations be made and at what frequency and duration?
- Observational technologies now available and on the horizon, and gaps in available sensors to address the need

12:45 p.m. Lunch

1:45 p.m. **Breakout Session 1**

3:30 p.m. Afternoon Break

4:00 p.m. Resume Breakout Session

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6:00 p.m. Adjourn for the day  
Reception and Poster Session at Hotel

## 17 September (Thursday)

9:00 a.m. **Plenary Session 2**

What are the global change issues that we need to address and the observational approaches required? –  
*Skip McKinnell*, PICES, Session Chair

9:00 a.m. Observational approaches to ocean acidification – *Andrew Dickson*, Scripps Institution of Oceanography

9:30 a.m. Observational approaches to oxygen depletion – *Denis Gilbert*, Fisheries & Oceans Canada

10:00 a.m. Observational approaches to community structure, from microbes to zooplankton –  
*Kendra Daly*, University of South Florida

10:30 a.m. Observational approaches to distribution and movement of marine organisms and changes in ocean properties – *Barbara Block*, Stanford University

11:00 a.m. Morning Break

11:30 a.m. Observational approaches to vertical movements of predators and prey in relation to physical/chemical structures – *Martin Biuw*, Norwegian Polar Institute

12:00 p.m. Observational approaches to changes in benthic dynamics –  
*Paul Snelgrove*, Memorial University

12:30 p.m. What is the marginal benefit of putting in place ocean biology observatories? What chance is there for ocean biological observatories to make a difference? – *Steve Rintoul*, CSIRO, Australia

1:00 p.m. Lunch

2:00 p.m. **Breakout Session 2**

4:00 p.m. Afternoon Break

4:30 p.m. Resume Breakout Session

6:00 p.m. Adjourn for the Day

## 18 September (Friday)

- 9:00 a.m.     **Plenary Panel discussion:** John Gunn, moderator
- 10:00 a.m.     Reports back from yesterday's breakout sessions
- 11:00 a.m.     Morning Break
- 11:30 p.m.     **Plenary Discussion:** What are the common features among the reports from the six working groups?
- 1:00 p.m.     Lunch
- 1:30 p.m.     **Breakout Session 3**
- How can different observational approaches be integrated and what advantages would be gained?
  - What kinds of intercalibrations and validations are needed among sensors of the same type, as well as different approaches?
  - How can these activities be funded, particularly sustained observations?
  - How can data be integrated, delivered, and visualized?
- 3:30 p.m.     Afternoon Break
- 4:00 p.m.     Final Report Back from Breakout Groups
- 5:30 p.m.     **Closing**  
Schedule and action items for production of special issue and science and implementation plan

#### 4.3.3 SCOR/IODE Data Publication Activity

*Urban*

A recent action to follow-up from the 2006 SCOR Project Summit is an activity being conducted jointly by SCOR and the International Oceanographic Data and Information Exchange (IODE) program. The following activities have occurred as part of this project:

- Meeting in Oostende, Belgium in June 2008, on the topic of data publication (see <http://www.scor-int.org/Publications/wr207.pdf>)
- Presentation about the project by Ed Urban on behalf of the sponsors and chair at the Fall AGU meeting in December 2008.
- Lunch meeting at AGU with editors of ocean science journals to discuss the ideas presented in the workshop report.
- Follow-up meeting in Oostende in March 2009 to develop pilot projects:
  - The Marine Biological Laboratory/Woods Hole Oceanographic Institution Library is working with the Biological and Chemical Oceanography Data Management Office (BCO-DMO) on a pilot project on how libraries and data centers could work together to provide the digital backbone for traditional journal publications, ensuring that data sets have appropriate associated metadata and are easily accessible.



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- The British Oceanographic Data Centre is working on a pilot project to repackage existing data holdings into data sets appropriate for assignment of persistent identifiers to provide a mechanism for concrete links to scientific publications.
- Submission of a draft article to *EOS* in June 2009 (see below). The article has been accepted for publication.

The progress of the pilot projects will be reviewed at the end of 2009 to determine the next steps in the activity.

The following is the draft of the article prepared for *EOS*, which gives a good overview of this activity, being conducted jointly between SCOR and IODE.

### **Data Publication: A New Approach for Ocean Sciences?**

Roy Lowry, Ed Urban and Peter Pissierssens

Data are collected from ocean science activities that range from a single investigator working in a laboratory to large teams of scientists cooperating on large, multinational, global ocean research projects. What these activities have in common is that all result in data, some of which are used as the basis for publications in peer-reviewed journals. However, two major problems regarding data remain:

- Much data that are valuable for understanding ocean physics, chemistry, geology, biology and how the ocean operates in the Earth system are never archived or made accessible to other scientists. Data underlying traditional journal articles are often difficult to obtain.
- When scientists do contribute data to databases, their data become freely available, with little acknowledgement and with no contribution to their career advancement.

The Scientific Committee on Oceanic Research (SCOR) and the International Oceanographic Data and Information Exchange (IODE) of UNESCO's Intergovernmental Oceanographic Commission (IOC) are discussing how to provide better access to ocean data through increased submission to approved, open, on-line resources. New infrastructure and new approaches to data publication could help scientists who observe the ocean and model its processes. Most importantly, it is now timely to

- Increase the availability of data used to create figures, tables, and statistical analyses in traditional journal articles.
- Reinforce linkages between data lodged in data centres and science publications, particularly "data briefs".
- Encourage the publishing of journals that specialize in "data publications" or "data briefs."

Data publications are short descriptions (as little as a few paragraphs of text), not interpretations, of data sets. They provide persistent pointers to the data in an approved data repository as well as references citable in papers that use the data, and in authors' curricula vitae.

Journals in the ocean sciences that already welcome such publications include *Marine Micropaleontology*; *Geochemistry*, *Geophysics*, *Geosystems*; *Ecological Archives*, and *Earth System Science Data*.

Other journals also acknowledge the benefits of submitting the data underlying traditional publications to approved databases. In 1993, AGU first established a Policy on Referencing Data in and Archiving Data For AGU Publications (see [http://www.agu.org/pubs/policies/data\\_policy.shtml](http://www.agu.org/pubs/policies/data_policy.shtml)). The policy emphasizes the importance of authors submitting data that are the basis for their papers to a recognized data archive, and states AGU's commitment to ensuring the long-term archiving and protection of data. Data sets associated with articles are available at [http://www.agu.org/pubs/esupp\\_browse.html](http://www.agu.org/pubs/esupp_browse.html) and access to these data does not require membership in AGU or subscription to an AGU journal. Submission of data associated with journal publications is standard practice in other domains such as molecular biology, in which the gene sequences that are described in peer-reviewed publications must be submitted to GenBank or related archives.

SCOR and IODE are working with editors and publishers of journals that publish papers in ocean science to discuss how to implement greater use of data publication.

To archive and serve data related to journal publications, additional infrastructure in the data management system is required, which must be implemented with minimal costs to avoid impeding the publication process (see Figure 1 in the supplementary material (add link?)). The e-Repository technology developed by the digital library community delivers some of the needed functionality. However, it does not provide the value added—in terms of harmonisation with other data in the system, quality control and metadata enhancement—associated with the IODE network of national data centers. A workable compromise would be to use e-Repository technology for the ingestion “front ends” of data centers that serve ingested data sets “as is” in the short term, as well as serving value-added data sets through existing data management infrastructure in the medium and long terms. This new infrastructure should improve the data publication review process through closer collaboration between data centers and journal editors. SCOR and IODE are working with existing data centers, libraries, and journals to promote the development of the infrastructure required to provide ocean sciences publications with an effective “digital backbone”. Ongoing cooperative activities are along three lines:

1. We are continuing to work with editors of ocean science journals to establish pilot projects along the lines described in the supplementary material.
2. The Marine Biological Laboratory/Woods Hole Oceanographic Institution Library is working with the Biological and Chemical Oceanography Data Management Office (BCO-DMO) on a pilot project on how libraries and data centers could work together to provide the digital backbone for traditional journal publications, ensuring that data sets have appropriate associated metadata and are easily accessible.

## 4-26

3. The British Oceanographic Data Centre is working on a pilot project to repackage existing data holdings into data sets appropriate for assignment of persistent identifiers to provide a mechanism for concrete links to scientific publications.

The work flow diagram described in the supplementary material will be revised as we gain experience from the pilot projects. Important questions raised by the reviewers include

- What should be the details of quality control in data centers? A simple action would be to ensure that submitted data are machine readable. Other actions might be to ensure that data sets include a minimal set of metadata.
- What happens to data associated with articles that are not published? Such data may still be valuable to other scientists and archiving should ensure that the data originator receives appropriate credit.
- What processes will be needed to ensure that data are archived, assigned a persistent identifier, and accessible before the associated paper is published? The timing is especially important as the publication process becomes faster and review drafts of papers become available through electronic publishing.
- What are the rights and responsibilities of data archives during the review process, in terms of data release, data protection, timing, etc.
- What existing persistent identifier should be assigned to data referenced in journal articles? Digital object identifiers (DOIs) have become an almost de facto standard in journal publishing, but other options exist. Whichever identifier is used, the issue of the “least publishable unit” for assignment of an identifier must be tackled.

More details about the SCOR/IODE activity are available at <http://www.iode.org/datapublishing>. The authors welcome input on this topic from the geoscience community.

