4.0 OCEAN CARBON AND OTHER ACTIVITIES

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

IOCCP has been very active in the past year and has numerous new activities underway. The following provides an overview of some of IOCCP's activities. The major activity of IOCCP since the previous SCOR meeting was a workshop on Surface Ocean CO_2 Variability and Vulnerabilities (co-sponsored with SOLAS, IMBER, and the Global Carbon Project) and the second IOCCP Scientific Steering Group meeting (11-14 April 2007, Paris, France). A more detailed report is available at http://ioc.unesco.org/ioccp/Docs/SSGII_final.pdf.

- **Sensor Inventory**

The SSG decided that a Web-based inventory of sensors should be developed using a standard template of information that would include information on the sensor's development status, with additional information about the sensor's success and failure rates, and detailed contact information. IOCCP received encouragement to broaden the catalogue to include essentially all oceanographic instruments. While this is clearly beyond the scope of IOCCP, the SSG decided to investigate the possibility of joining with other organizations to develop a single comprehensive catalogue. After several months of consultation, a large consortium has formed and proposed a 5-day "Symposium on Multi-disciplinary Sensors and Systems for Autonomous Observations of the Global Ocean" (OceanSensors08). Participating groups include the Ocean Research Interactive Observatory Network (ORION), OceanSITES, IOCCP, the GCOS-GOOS-WCRP Ocean Observations Panel for Climate, and the U.S. National Science Foundation. The SSG agreed that IOCCP should be involved with this initiative in order to ensure that carbon and biogeochemistry issues and needs are well-represented and that the eventual development of an on-line guide of sensors will be adapted to sensors of interest to the ocean carbon community. The SSG also decided that is would still be useful for the IOCCP Web site to provide ocean carbon-related information and news updates about the most often used instruments for ocean carbon system measurements.

- **Guide of Best Practices for Oceanic CO_2 Measurement and Data Reporting**

Together with PICES, IOCCP co-sponsored this update of the 1994 DOE Handbook by Andrew Dickson. The manuscript has been sent to the community for comments and review, and should be ready for publication by mid-2007. It will be made available on the CDIAC Ocean CO_2 Web site and hard copies will be printed. In 2002, the SCOR/IOC CO_2 Panel agreed that the manual should be used as the basis for a series of training courses for early career scientists or scientists new to ocean carbon research to encourage the use of common practices and to facilitate global coordination and data syntheses. The SSG agreed that IOCCP should promote training courses based on the revised manual, but should try to get this initiative integrated into existing research programs rather than developing its own stand-alone workshops. IOCCP should focus its activities to promote a core program covering high-quality measurements of basic carbon system parameters and the importance of using standard data / metadata reporting procedures. Liqi Chen's group from the State Oceanic Administration of China might be willing to translate the Guide into Chinese.

- **Coordinated Action for a Carbon Observing System**

IOCCP has been asked to assist with the development of a proposal for the EU Framework Programme 7 called "Coordinated Action for a Carbon Observing System" (COCOS), which will build on the early work of the IGOS partners Integrated Global Carbon Observations theme (in which IOCCP coordinated marine input) and on the network advances made in the EU and CarboEurope. In early March, a planning group met in Rome to develop the initial proposal, which is being developed through 5 work packages:

  - WP1 - Enhancing interoperability of existing networks in land and ocean
  - WP2 - Efficient use of data in models and data assimilation
  - WP3 - Integration of multiple data sources for regional carbon budgets
  - WP4 - Filling in gaps in data of vulnerable global carbon pools and fluxes on land
  - WP5 - Filling in gaps in data of vulnerable global carbon pools and fluxes in the ocean
  - WP6 - The European contribution to a global observing system for carbon

IOCCP is being specifically asked to contribute to WP1, WP5, and WP6, where IOCCP's role would be to ensure that the work of these EU groups is compatible and coordinated with activities and plans in other countries. This proposal aims to fund a series of workshops (10 small, 6 intermediate, 1 large at the end) and some post-doc time for synthesis work and organization of workshops as well as report writing. The proposal and objectives are currently being mapped onto the Global Earth Observations Societal Benefit Areas.

- **International Repeat Hydrography and Carbon (IRHC) Update; Development of an Advisory Group on IRHC co-sponsored by IOCCP, CLIVAR, and SIC**

As a follow-up action from the November 2005 hydrography meeting, it was agreed to establish a small advisory group to develop a cohesive and comprehensive international repeat hydrography and carbon program. The advisory group will be co-sponsored by IOCCP, CLIVAR-GSOP and the SOLAS/IMBER Carbon Group (SIC). The SSG agreed that IOCCP should move forward with the development of the Advisory Group, although noted that the terms of reference for this group need to be refined. The SSG agreed that the principal purpose of this Advisory Group should be to define what the international community wants to see in a comprehensive international repeat hydrography and carbon network, including what information should be compiled and maintained as part of this network, how to develop a single information source and/or data directory for ship-based repeat hydrography, needs for updating the hydrographic program manuals, and how best to coordinate with other programs looking at ocean interior changes such as Argo, CLIVAR, and OceanSITES.

- **Initial North Atlantic Synthesis Meeting and Follow-up**

This workshop was held in Laugarvatn, Iceland on 28-30 June 2006, and brought together 23 participants from 9 countries, with expertise including ship-based hydrography and carbon measurements, physical oceanography, surface pCO_2 variability, CFC and tracer measurements, O_2 on profiling floats, modeling, and data synthesis and management.

Workshop participants developed three coordinated synthesis groups: (1) Arctic and Nordic Seas, (2) Sub-Polar and Sub-Tropical Gyres, and (3) Southern Ocean.

For hydrographic data, the synthesis work is divided into three different groups: North Pacific Ocean (Sabine, Murata, Ishii), Equatorial Pacific Ocean (Feely, Ishii), and South Pacific Ocean (Tilbrook), and a "data manager" (Bob Key). IOCCP has been asked to assist these groups with their activities (e.g., keeping the community informed of progress and helping to make information available on the Web; ensuring international participation; assisting with meetings, etc.). There are also a number of other synthesis activities being planned and it is imperative to ensure that those activities are proceeding in a fashion compatible with the work being done by the Atlantic Ocean synthesis groups. IOCCP may need to provide technical assistance to these groups. The SSG agreed strongly that IOCCP should assist these groups with technical coordination issues, but also pointed out that these new Atlantic efforts also need to be coordinated with ongoing activities in the Pacific, and potential new activities that may be developing in the Indian Ocean in the coming years. The SSG felt that it was appropriate for IOCCP to assist with technical coordination issues as well as to make a strong effort on communications about these activities to the rest of the community.

- **O_2 on Argo Update**

This group developed a white paper that was presented by Nicolas Gruber at the 8th Argo Steering Team meeting held at UNESCO in Paris on 7-9 March 2007. The Argo Steering Team was impressed with the document and the presentation of the proposal, and encouraged its continuation and close coordination with Argo. However, because of concerns about the unknown legal framework of taking O_2 measurements in Exclusive Economic Zones and concerns about impacts of these new floats on the basic Argo network sustainability, the Argo Steering Team stated that it would not be possible to officially endorse this activity as an Argo project. Therefore, in this initial phase, the organization will be managed through a "grass roots" team of the national scientists. At a later stage of development, the group will decide if it requires some sort of higher level organization. IOCCP will continue to promote the development of this activity and closer integration between this project and the ship-based repeat hydrography activity.

- **Underway / Surface CO_2: Surface Ocean CO_2: Variability and Vulnerability (SOCOVV) Workshop**

The workshop, which took place immediately following the SSG-II meeting, developed the following recommendations that have implications for the IOCCP:

  - Chris Sabine will lead a comparison of the global data sets currently being used by different groups to generate seasonal flux maps to examine which data have been incorporated into the datasets and how those data are treated to generate the global compilation. This analysis should provide the information necessary for the community to decide which global data set should be considered the standard global community dataset on which we should continue to build. Based on this, Dorothee

Bakker and Benjamin Pfeil will be asked to provide guidance and assistance to develop appropriate secondary QC procedures.

- Along with this analysis, Chris Sabine will lead an evaluation of the methods used to generate global seasonal flux estimates to understand why there is such a significant discrepancy among them. This may also include involvement of a larger group of investigators to examine and evaluate the various methods for estimating surface CO_2 using satellite data and proxy techniques.
- Once a standard global data set is chosen, the community will be asked to decide on data products that may be produced regularly. A global seasonal pCO_2 map (e.g., without extrapolation of data points, at a high resolution (1° x 1°) for successive years) was discussed. Modelers preferred this product to flux maps, since they will generate fluxes in their models according to their own methods.
- The workshop established surface CO_2 synthesis groups for the North Atlantic (including Arctic), the Pacific, the Southern Ocean, the Indian Ocean, and the Coastal Ocean. Scientists active in the Equatorial and South Atlantic may join the Atlantic synthesis group or create another regional group. These groups were asked to identify key science questions in their regions that require regional and global datasets, and to identify data in their regions that are not yet part of the global data set.
- Workshop participants recognized the need for sustained funding for the global surface ocean pCO_2 network from volunteer observing ships and suggested that an international agreement recognizing the importance of these networks may be required.
- Yukihiro Nojiri presented an overview on the March 2003 intercomparison experiment results and has proposed for the community to carry out another intercomparison experiment in 2008. The SSG was very supportive of this proposal and will follow its development.

- **JCOMM SOT links**

The IOC-WMO Joint Commission on Oceanography and Marine Meteorology (JCOMM) is the group responsible for coordinating of the elements of the global ocean / climate observing system, and includes the VOS network, the XBT network, the SOOP network, the Data Buoy Cooperation Panel, as well as links to research-based groups developing sustained systems such as Argo and OceanSITES. IOCCP is a member of the JCOMM Observations Coordination Group to provide information about the developing network of ocean carbon observations that may one day move towards a sustained system. The Ship Observations Team (SOT) of the JCOMM brings together all ship-based observation groups, and IOCCP has been working with this group for the past 4 years to provide information about the underway CO_2 programs. At its last meeting, the JCOMM SOT was interested to know if the CO_2 lines could provide near-real time temperature and salinity data into their data assembly center system. After a technical presentation and discussions, it was agreed that it was too soon for most operators to comply with this request, but IOCCP agreed that it is important to maintain links with the JCOMM SOT as the systems develop. The SSG agreed that IOCCP should maintain a communication link with this group, but that joint activities are not feasible at this time.

- **Time Series Coordination**

Roger Dargaville presented an overview of the new maps and table inventories developed with CDIAC for time series of carbon measurements. A table of currently active time-series stations measuring ocean carbon has been developed and put on the Web. The table provides information on ship-based stations, permanent moorings, and coastal moorings. IOCCP has been working with CDIAC to try to make data links from these sites. The SSG reviewed the existing maps and tables, and Nick Bates led a discussion about whether the ocean carbon community using time-series stations has coordination needs that are not being met. While IOCCP has been collaborating with the OceanSITES group, it was felt OceanSITES does not have sufficient momentum or visibility in the carbon and biogeochemistry community to generate enthusiasm for the science or development of a coordinated network in the same way as for repeat hydrography or even the VOS carbon network. While all agree that time-series data are both unique and crucial, keeping these sites funded is still precarious. It was noted that carbon and biogeochemistry studies at time-series stations are often sensor limited, and that the upcoming sensor workshop may help. In general, the SSG felt that time-series stations are in "survival mode" and that this is a critical issue for carbon studies, including ocean acidification research. The SSG decided that it is important to re-engage fully with the OceanSITES group, but that IOCCP should also investigate the interest and feasibility of developing an international workshop on carbon and biogeochemistry at time-series stations with the goals of reinvigorating enthusiasm in the community for the unique and critical observing system platforms offered by time series and a network of time-series stations. This workshop should also work to develop a more dynamic and coordinated international science community to promote time series work (both shipboard and using in situ instrumentation) for carbon and biogeochemistry science.

- **Process Studies**

Initially, IOCCP was intended to develop a database of on-going and planned process studies relevant to ocean carbon that could serve as a community source of information. Several early attempts were made, but it became clear that this required some strict guidelines to make the task manageable. As a start, IOCCP has developed a compilation of ocean carbon research being carried out during the International Polar Year. This compilation has been recognized by the IPY secretariat as a contribution to their information system and they provide links to IOCCP pages. The real need for technical coordination in process studies boils down to databases – where are the data from past studies and are those data available in a format useful for future studies? One major issue is that there are currently no agreements on how to record process study data such as rates and fluxes for DOC and POC. While most process studies try to be coherent within themselves, the results of different process studies are not readily comparable. Standards are rarely used, and metadata and information about techniques and methods are crucial. Another issue is simply keeping track of final data from process studies once they have been completed. Without an overview of these activities, it is not possible to facilitate coordination and communication between appropriate groups. While it was agreed that this is probably outside the mandate of the IOCCP, it is sufficiently important that IOCCP should make an effort to assist if no other groups are willing to take this on.

- **Ocean Color**

IOCCP is a partner in the European Space Agency's GlobColour Project, which aims to develop and demonstrate a service supporting global ocean carbon-cycle research. As of today, there are 12 moderate resolution ocean color imagers in orbit (www.ioccg.org/sensors/500m.html), although many of these are pilot missions and do not produce research-quality data. Clearly, there are many ocean color data products from which researchers, educators, students and policy makers can choose. The GlobColour project will provide scientists with a long time series of consistently calibrated global ocean color information, according to requirements specified by the global ocean color user community. GlobColour will also put in place the capacity to continue the ocean color service in the future. IOCCP, working with the International Ocean-Colour Coordinating Group, will serve as links between the ocean carbon community and GlobColour, to provide input into the development of the data products to ensure they are useful for the ocean carbon community. The SSG agreed that it was useful for the community to have the IOCCP continue to work directly with the GlobColour group. However, the product from this project will not radically change or improve information required for ocean carbon cycle models or bring us any closer to being able to estimate ocean CO_2 from remotely sensed ocean color. IOCCP should think about how to promote the creation of marine CO_2 products from satellites. Even though the ocean CO_2 methods are still very much in the research phase, the SSG agreed that the community may benefit greatly from having a targeted workshop to bring together groups working towards this common goal to compare methods, techniques, and results.

- **Coastal Carbon**

At SSG I, the SSG agreed to develop an email discussion list of coastal ocean carbon scientists and modelers to determine what is useful and feasible for information and coordination services for this community. At the IOCCP Open House in September 2005, the North American Carbon Program/Ocean Carbon and Climate Change group outlined some activities dealing with coastal carbon, and later that year, the Global Carbon Project highlighted the need and interest to develop an activity around coastal carbon. While a more coordinated research and observation effort may clearly be needed, it is not clear what technical coordination issues may be helpful and appropriate for the IOCCP to undertake. IOCCP is beginning to integrate coastal monitoring activities into the networks for time series. The SSG agreed that this is a crucial issue for ocean carbon studies, but that is was largely outside of the mandate of the IOCCP. One issue that IOCCP could undertake is the promotion of best practices, standards, and methods for carbon-relevant coastal studies. The SSG agreed that this should be linked to IOCCP's process studies actions.

- **High-Precision Atmospheric CO_2 from VOS Ships**

An email-based working group was developed to investigate the feasibility and utility of installing high-precision continuous atmospheric sensors on VOS in conjunction with the underway pCO_2 network that has been established. Working with Britt Stephens (SIC), Roger Dargaville has assembled a group of experts on the technical aspects of taking high-precision measurements of atmospheric CO_2 and modelers with expertise in the field of interpreting such data. Email discussions have produced a short report on the current status of the measurement technology and the options for modeling studies to assimilate and interpret

the data. Options for instruments include the CSIRO LoFlo and the NCAR AIRCOA instruments. The SSG and SIC discussed the utility of this exercise and suggested that perhaps a more useful exercise would be to look at the best-quality atmospheric CO_2 data already being collected from VOS ships in the Southern Ocean region. It was also felt that the extra cost and effort of installing such instruments on current VOS lines would be greater than the scientific interest for the ocean community, but may have value for the atmospheric community. The SSG remarked that this activity was originally supposed to be led by the SIC, and that perhaps it was an issue that would be best addressed by a more integrated group such as the Global Carbon Project.

- **Mesocosm Guidelines**

The SSG set an action item at SSG-I to assist the SIC Working Group on Climate Sensitivities and Feedbacks to develop guidelines and protocols for mesocosm experiments. Continued discussions of interest and means of implementing this activity have not led to any clear actions. The SSG agreed that this is an issue for the SIC to pursue through its working group if they feel that there is a sufficient need and interest in the community.

- **Communications Services**

One of IOCCP's primary goals is to serve as a communications service for the ocean carbon community. This has been undertaken through the Web-based information databases on observation activities, through the Web and email-based news services, and the email list/bulletin board service. One suggestion has been to develop a brochure that could be passed out at meetings to describe the work and services of IOCCP for groups who may not be familiar with IOCCP. The SSG agreed that there was a need to better communicate the work of IOCCP, but were not enthusiastic about a brochure, stating that people look at them quickly and then throw them away without retaining the "take home" messages. The SSG put forward the idea of developing small business cards instead that would use both sides of the card to communicate the essential message of the IOCCP work, and provide contact information and the Web site address. It was felt that this would be a more direct means of getting people to understand the basic message of our work and lead them to the Web site for further information. The SSG expressed appreciation for the current organization and information content on IOCCP's Web site. Several features that were particularly appreciated were the menu listing based on issues (e.g., observing systems, standards, data, etc.), the quick links to other carbon programs, and the image gallery (useful for teaching purposes and pulling together presentations). The SSG suggested using Google Analytics to track usage statistics and prioritize development and maintenance efforts accordingly. The SSG also expressed their appreciation for the format of the email news bulletins. The SSG liked the quarterly news bulletins and did not feel that they needed to be more frequent. However, the SSG agreed that there is sometimes a need to provide news updates and information to the community more frequently than is possible with the news bulletin, and it is not reasonable to expect that the community will regularly look at the web-site for updates. The SSG suggested a sort of "news flash" system to bring important news updates to people's attention when necessary.

4.2 SCOR/IOC Symposium on the Ocean in a High-CO_2 World

Committee Charge:
The planning committee will determine the scope of the symposium, plan the agenda, develop the list of invited participants, and handle any publications that result from the symposium.

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Peter M. Haugan (Norway)
Patrick Lehodey (France)
Silvio Pantoja G. (Chile)
Hans-O. Poertner (Germany)
Ulf Riebesell (Germany)
Tom Trull (Australia)

IOC Liaison: Maria Hood
IGBP Liaison: Wendy Broadgate
Executive Committee Reporter: Bob Duce

2007 Progress Report on Planning for the Second Symposium on The Ocean in a High-CO_2 World

The purpose of this symposium is to provide an interdisciplinary forum to assess what is known about ocean acidification and priorities for future research. SCOR, IOC, IGBP, and ICSU representatives met with Jim Orr in Paris on 19 June 2006 to finalize the list of members for the planning committee for the second symposium on The Ocean in a High-CO_2 World. The SCOR Executive Committee approved the proposed committee membership and committee met in Feb. 2007 in Monaco to plan the symposium.

Funding for the symposium will be provided by grants from the U.S. National Science Foundation, and contributions from the International Atomic Energy Agency (IAEA) and the Prince Albert II Foundation. The symposium will be held on 6-8 October 2008. The announcement of the symposium has been circulated widely.

The symposium will include both invited and contributed presentations. The meeting organizers seek contributions on relevant topics, including the following:

- Scenarios of ocean acidification
- Effects of changes in seawater chemistry on nutrient and metal speciation
- Ocean carbon system from deep-time to the present to the distant future
- Paleo-chemistry
- Mechanisms of biocalcification
- Impacts on benthic and pelagic calcifiers
- Physiological effects: From microbes to fish
- Adaptation and (micro)evolution
- Fisheries, food webs, and ecosystem impacts
- Biogeochemical consequences and feedbacks to the Earth system
- Economic consequences
- CO_2 disposal

The symposium will include plenary presentations, discussion sessions on research priorities, and a poster session. Because of time limitations, most contributed abstracts will be presented as posters. Manuscripts based on presentations at the symposium can be submitted to a special issue of *Biogeosciences* and research priorities will be published separately for the benefit of ocean scientists and research program managers worldwide. The symposium program and other information about the symposium will be posted at http://iodeweb3.vliz.be/oanet/Symposium2008.html. Relevant dates include:

31 March 2008	Early registration and abstract submissions open
31 May 2008	Abstract deadline
31 July 2008	Early registration closes
31 August 2008	*Biogeosciences* opens for submissions to special section on "The Ocean in a High-CO_2 World II"
6-8 October 2008	**The Second Symposium on The Ocean in a High-CO_2 World**
7 November 2008	*Biogeosciences* closes for submissions to special section

4.3 Other Activities

4.3.1 SCOR Summit 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 infrastructural activities 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 received support from the Alfred P. Sloan Foundation to convene a second meeting of the representatives of these projects, which will be held at the Royal Society (UK) in London in December 2006. Information about the meeting can be found at www.jhu.edu/scor/ProjCoord2.htm. Ed Urban published a short meeting report in EOS to help disseminate a few important findings of the meeting (see article at the end of this section). The Sloan Foundation may provide support for another Project Summit in 2008, if Sloan funds can be matched with funding from other sources.

SCOR Summit of International Marine Research Projects
London, UK
7-9 December 2006

Introduction

The Scientific Committee on Oceanic Research (SCOR) convened a Summit of International Marine Research Projects on 7-9 December 2006 in London (UK). SCOR thanks the Alfred P. Sloan Foundation for its support of this meeting. The purpose of this meeting was to bring together representatives of the major international ocean research and observation projects and programs to discuss common opportunities, issues, and problems. The meeting agenda included several major topics determined in advance to be important inter-project issues, including data management and interactions of projects with World Data Centers; interactions of projects with the Global Ocean Observing System (GOOS); project coordination in the area of Southern Ocean research and bathymetry and International Polar Year activities; project needs for time-series stations; visualization of data; and capacity building. Information about the meeting is available on the meeting Web page (see www.scor-int.org/Project_Summit_2/ProjCoord2).

Meeting participants included representatives from virtually all international marine research projects and programmes (CLIVAR[1], CoML, GEBCO, GEOHAB, GEOTRACES, GLOBEC, iAnZone, IMBER, InterRidge, InterMARGINS, LOICZ, OceanSITES, and SOLAS), and the

[1] Acronyms are defined in Appendix I.

chairs of the Global Ocean Observing System (GOOS) panels.[2] Two other organizations of the International Council for Science (ICSU) also participated, the International Geosphere-Biosphere Programme (IGBP) and the Scientific Committee on Antarctic Research (SCAR). Two World Data Centers (WDCs) were also represented: the World Data Center on Oceanography, Silver Spring and the World Data Center for Marine Environmental Sciences (WDC-MARE).

Profs. Peter Burkill and Bjørn Sundby chaired the meeting on behalf of the SCOR Executive Committee. The meeting was opened by the co-chairs with an explanation of its purpose, followed by a review by Ed Urban of the action items from the previous summit in 2004.

Project Data Management

Presentations were made by SOLAS, IMBER, and GEOTRACES, as the newest SCOR projects, about their data management activities. Peter Burkill asked the projects to tell SCOR what more it could do to help them on this issue.

SOLAS—Jeff Hare reported that SOLAS has formed a data management team, with the incoming chair being Juan Brown of the British Oceanographic Data Centre (BODC). The team includes both scientists and data managers. SOLAS has received a European Cooperation in the Field of Scientific and Technical Research (COST) grant to support the creation of air-sea flux data products for three research areas (parallel to the SOLAS Foci) and create a network of researchers, conduct workshops, and coordinate meetings. It is expected that this activity will help to

1. Consolidate current knowledge of air-sea interactions.
2. Identify gaps and stimulate new research.
3. Provide a framework into which new data and process understanding can be assimilated.
4. Develop tools for production of global air-sea fluxes of climate-relevant compounds.

SOLAS has developed a Web-based system to track national projects that are endorsed by SOLAS (see www.solas-int.org). The SOLAS IPO will handle only metadata at this point, with national data centers handling the actual data (e.g., WDC-MARE will be handling German SOLAS data). SOLAS data will be divided into three classes: (1) geographically/temporally resolved data; (2) data from experiments and mechanistic studies; and (3) models, model documentation, and model output. Information about SOLAS data management can be found at http://www.uea.ac.uk/env/solas/org/DMTT.html, including SOLAS data management principles.

Beatriz Balino cautioned about relying on distributed data management systems when a global integrated database of specific experiments is needed, based on her experience trying to gather and integrate national data resulting from cruises related to the Joint Global Ocean Flux Study (JGOFS). Bob Gelfeld (WDC Oceanography, Silver Spring) added that the World Data Centers sometimes have trouble getting data from the national oceanographic data centers. Ed Harrison (OOPC) commended SOLAS in emphasizing the development of real-time data management.

[2] Participants are listed in Appendix II.

GEOTRACES—Gideon Henderson noted that trace metal data are very sparse and thus GEOTRACES is being designed to provide a worldwide survey of surface-to-seafloor concentrations of trace elements and isotopes. Henderson estimated the GEOTRACES will probably collect less than one million data points, so the scope of data management will not need to be as great as for some other projects. GEOTRACES sponsored a data management meeting in December 2005. The meeting resulted in a draft data policy for GEOTRACES, and recommendations about the data management structure for the project (see http://www.ldeo.columbia.edu/res/pi/geotraces/documents/geotr_DataMant4SSC_final_000.pdf for the meeting report). The report recommends the appointment of a Data Liaison Officer in the eventual GEOTRACES International Project Office (IPO) and the establishment of a GEOTRACES Data Management Committee. The report also recommends "end-to-end" data management, in that cruise metadata would be tracked as soon as a cruise is funded and one person on each cruise should serve as a Data Specialist. GEOTRACES is still working out where its international data management center will be placed, although it is clear that the international office will need to work with individual participating nations and their data centers.

IMBER—Raymond Pollard made the presentation about IMBER data management. He had co-chaired the initial GEOTRACES data management meeting and had since become chair of IMBER's Data Management Committee. (Sophie Beauvais was appointed as Data Liaison Officer [DLO] in May 2006.) Since assuming their responsibilities, Pollard and e Beauvais visited BODC to continue IMBER's planning for its data management. Pollard offered his reflections on the fundamental problems in the data management process:

- Data are not sexy
- Scientists easily agree to the need to deliver data, but the published paper takes priority. And then the next proposal takes priority.
- Data managers are viewed as geeks, who can only cajole, not enforce, data delivery.

How can we raise the profile of data management? How can we persuade scientists to take it really seriously? Pollard has concluded that using "carrots" (incentives) is much more useful than using "sticks" (penalties). Funding must be devoted specifically for data management. And, it is necessary to show project scientists how data management can help them.

IMBER is a relatively young project, but has taken early initiatives on data management, particularly building on the work started by GEOTRACES and the recommendations from the GEOTRACES data management meeting. The IMBER Data Management Committee (DMC) was appointed recently. The DMC includes observationalists, modelers (data users), and data specialists, with the membership balanced to improve communication and mutual understanding. The DMC discussions have started by email, but they will eventually need to meet face to face. (A meeting is scheduled for June 2007.) IMBER manages no projects, so strictly owns no data. This implies that IMBER can encourage, but not enforce, improved standards for both metadata and data. The DMC will need to decide whether to emphasize the minimum (basic metadata) or the maximum (streamlined access to raw data); the answer is probably both. One view says it is hard enough to get decent metadata, so if we can achieve this it will be a major step forward. Another view is that we must aim for accessible, high-quality end data, arguing that nothing is

more irritating than going through a dozen metadata links only to end up at “data - contact PI” - and of course the PI never answers. Possible ways to achieve this could be

- Seamless access to widely distributed data
- Relatively small number of specialist data centers

One example of a specialist data center (specializing in a particular type of data) is the CLIVAR and Carbon Hydrographic Data Office at the Scripps Institution of Oceanography, which evolved from the WOCE Hydrographic Programme Office. Another is COPEPOD, the global zooplankton database. Are these the way forward? The advantages of specialist data centers are that they (1) gather data from individuals into central archives, (2) have the ability to quality check a particular kind of data, and (3) have specialist experience to help individual PIs. Even so, they are useless without long-term funding. A major goal of specialist data centers must be to get scientists and data managers talking to each other and helping scientists by

- Backing up PIs’ data at an early stage, providing security against data loss
- Helping with calibration
- Helping with validation
- Serving as a long-term archive
- Answering requests for data

In summary, the points that IMBER wants to raise for discussion include raising the profile of data management, improving communication (meeting, blogs), developing effective carrots (funding, recognition, support), creating specialist data centers, creating metadata standards (CSR, DIF), and assuring adequate manpower for data management.

Howard Cattle (CLIVAR) raised the CLIVAR experience that it is extremely difficult to get data from PIs, particularly after the data have gone to the national oceanographic data centers. Suzanne Carbotte (InterMARGINS) commented that to counteract the difficulty of getting data from PIs, systems can be developed so data go directly from ships to data centers. (Obviously, this is not appropriate for all types of data.) Colin Summerhayes (SCAR) noted that the Ocean Observations 99 Conference agreed that data should be released in real time. Tom Malone suggested that we need to get more serious about metadata and at least serve it in real time, adopt metadata standards, make data management more than an afterthought, and set up data management processes before the first measurement is taken. Mark Costello (OBIS) responded that the Marine Environmental Data Inventory (MEDI: http://ioc.unesco.org/medi/) provides information about marine metadata and has online tools “to encourage data collectors and scientists to produce metadata descriptions for their datasets.” OBIS has had success in getting data out of the Global Change Master Directory (GCMD). We don’t just care about sending data to data centers, as publications are important. Ed Urban brought up the idea of digital object identifiers (DOIs), which is studied by the International Ocean Carbon Coordination Project (IOCCP) for ocean carbon data sets. DOIs make it easier to publish and cite data sets, so the data originators get the credit for their work.

World Data Centers and Their Interactions with Research Projects

WDC on Oceanography, Silver Spring—Bob Gelfeld introduced the discussion of WDCs by stating that there are more than 50 WDCs for different kinds of data, under the auspices of ICSU. The WDC system was established in 1957 to collect and serve data from the International Geophysical Year. The WDCs

1. Operate for the benefit of the international scientific community.
2. Are maintained by a host country or institution.
3. Accept and store data safely and in good condition.
4. Make freely available information on data holdings.
5. Exchange data among themselves and facilitate data availability.
6. Hold no confidential or security-classified data.
7. Honor proprietary use of data by their originators (not to exceed two years).
8. Provide data to scientists in any country free of charge, on an exchange basis or at a cost not to exceed the cost of copying and sending the requested data.
9. Accept any scientist as a visitor to work on-site with data held by WDC.
10. Report to ICSU, as requested.

The WDC for Oceanography, Silver Spring (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html) started at Texas A&M University in 1957 and was brought into the U.S. National Oceanographic Data Center in 1963. Many nations have limited access to modern communication technologies, so this WDC offers many offline products (e.g., CD-ROMs, DVDs, paper media and publications). Integrated Ocean Observing System (IOOS) data are coming on-line now, and this WDC is designing systems to serve satellite data better. The WDC for Oceanography, Silver Spring, now includes about 29,000 data collections on a number of different parameters. The data are available through Web map services ("rubber banding"). One activity of this data center is the Global Oceanographic Data Archaeology and Rescue (GODAR) project. The goal of GODAR is to "increase the volume of historical oceanographic data available to climate change and other researchers by locating ocean profile and plankton data sets not yet in digital form, digitizing these data, and ensuring their submission to national data centers and the World Data Center system. In addition, data on electronic media that are at risk of loss due to media degradation are also candidates for rescue."[3] To improve data management in the future, it will be important to use time-saving approaches, such as controlled data vocabularies.

Gelfeld listed the kinds of data available from his center, and how these data can be accessed. The World Ocean Database 2005 (WOD05) includes data from almost 8 million stations. Data types delivered include *in-situ* physical, chemical, biological profile and time-series data; satellite products; oceanographic climatologies and analysis products; ecosystem characterization data and information; GIS products; video and still image data; and publications (analog and digital). Requirements for data stewardship include providing content expertise in many different areas (physical, chemical, biological, ecological, satellite…), taking a long-term view, understanding the data management 'big picture', and attending to details. Concerns are that

[3] http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-godar.html

stewardship is time consuming and labor intensive, there often is a lack of resources for stewardship activities, it is difficult to maintain long-term viability of digital files, and metadata management is not for everyone.

World Data Center for Marine Environmental Sciences (WDC-MARE)—Michael Diepenbroek and Hannes Grobe presented information about the World Data Center for Marine Environmental Sciences (WDC-MARE). WDC-MARE is hosted by the University of Bremen Center for Marine Environmental Sciences and the Alfred-Wegener-Institute for Polar and Marine Research. It was established in 2001. WDC-MARE focuses on geo-referenced data related to "biogeochemistry, circulation, and life of present and past oceans," using the system Pangea. The data system operates with an open parameter list. WDC-MARE handles data from international, European Union, and German projects. Diepenbroek and Grobe mentioned some of the recommendations from the Color of Ocean Data meeting (see http://unesdoc.unesco.org/images/0013/001351/135161eb.pdf):

- Close cooperation between stakeholders and data center to ensure that there are no metadata without data and no data without metadata.
- Peer review of datasets becoming part of the curriculum of marine scientists, by giving credit to data providers, by making datasets reviewable and citable, and integrating citations into library catalogs. They provided samples of the use of DOIs for images, distributed samples, ocean profiles and time series. WDC-MARE is participating in Project STD-DOI "Data Publishing" (see http://www.std-doi.de/front_content.php).
- Comprehensive portals that do not lead to metadata nonsense, but directly to data and information (avoid "Error 404"), by using persistent identifiers. It is a time-consuming job to merge datasets, if done after a project is completed; it took one data manager three years to put the JGOFS data into a merged dataset.

The FINO and ANTARES (http://home.antares.ws/) projects will have *in-situ* data going directly into data centers. They mentioned the Open Archives Initiative for metadata and management (http://www.openarchives.org/) and made the following recommendations:

- Data centers need to prepare to serve data and metadata for multiple scopes/communities/stakeholders
- Metadata have to ensure re-usage of data (data publication)
- Complete and consistent metadata fulfill most common standards
- De facto standards and protocols build the mainstream of network development
- Data management has to be an integral part of research (user-driven)
- Data centers should operate like publishers and libraries

Species-based Data

Mark Costello, chair of the Ocean Biogeographic Information System (OBIS) spoke about species-based data. The technology for this system has come from the library science community. OBIS caches data monthly and indexes the data geographically and taxonomically. OBIS is making plans for the end of CoML in 2010, as OBIS is intended to be an ongoing legacy

of CoML. OBIS would like to serve species-specific data from the research projects. It is developing a World Register of Marine Species (WoRMS) as a master list.

OBIS now publishes more than 13 million location records for 78,000 species from more than 200 datasets. All data can be downloaded at no charge from the OBIS Web site. Data come from all kinds of sources, surveys, fisheries, museums and literature, sampling methods, and habitats. OBIS is a distributed data system, with data being regularly cached, and indexed geographically and taxonomically to facilitate data discovery and exploration online. A recent review of ocean biodiversity informatics has been published that describes the technologies and philosophies involved (http://www.int-res.com/abstracts/meps/v316). It has an expanding Regional OBIS Node (RON) network, some nodes of which are also NODCs, located in Australia, Brazil, Canada, China, Chile, Europe, India, Japan, New Zealand, Republic of Korea, South Africa, and USA, and a RON for Antarctica (SCAR-MARBIN).

The minimum and additional data fields used in OBIS data were summarized and copies of the schema made available on the SCOR Web site. Mandatory fields include species names, latitude, longitude, and collection. Optional fields cover record url, record level source (citation), time and date of collection, collector, higher taxon, country or locality name, depth, temperature, life-stage, sex, abundance, weight, and sample size.

Mapping tools, including environmental range mapping, and open-source maps of countries Exclusive Economic Zones and the International Hydrographic Office seas and oceans, were described. OBIS will be a legacy of CoML and is developing its governance, structure, and functions to ensure long-term sustainability. It welcomes offers of data sets for publication, and for people to inform it of datsets that may be available.

Costello noted that OBIS asks SCOR members to

- promote awareness of its data publication facility;
- identify candidate datsets for publication;
- facilitate the development of its community and technical infrastructure through collaboration and communication;
- comment on OBIS website and portal;
- promote need for OBIS to governments and funding agencies;
- encourage data publication through OBIS; and
- compliment those who have published online.

In addition, OBIS request collaboration with SCOR projects as to how to share data and online tools to provide better services to the marine science community.

Research Vessel Cruise Database

Ed Urban updated meeting participants about the status of the Research Vessel Cruise Database being planned by POGO. This idea had been one of the recommendations of the 2004 SCOR Project Summit around the same time that POGO began discussing it. POGO put out a tender for proposals to develop the database and the SeaDataNet proposal was selected. The Alfred P.

Sloan Foundation agreed to support the development of the database. Hannes Grobe expressed concern about a private company managing public data. Ed Urban responded that SeaDataNet was selected because they are already involved in such work for European projects, put in a competitive bid, and got agreement from BODC to maintain the database indefinitely.

Visualization of Data

Murray Brown (IODE Ocean Teacher) presented an introduction to the range of methods for visualization of ocean data. He started by stating that his perspective is that of a teacher, not a researcher. (He has taught students in 52 countries.) For the capacity-building aspects of projects, it is desirable to have simple non-commercial software and to work with PCs rather than Macs, even if Windows is insulting and degrading. The data to work with can be obtained from the IOC Web site (see www.oceanportal.org), as well as other sources.

Brown reminded participants that working with Earth science datasets IS visualization. Both fundamental and complex analyses of the data (and the quality control procedures that precede them) must be viewed graphically in order to understand patterns and relationships, or to identify problems. Brown's credo is that a robust, pre-compiled program that you install with a click and run without hand-holding and grief is a GOOD THING. Loose bits and pieces of source code, requiring licensed platforms, additional libraries, compiling, UNIX system adjustments, de-bugging, INI/BAT file editing, and script writing is BAD. Both fundamental and complex analyses of the data (and the quality control procedures that precede them) must be viewed graphically in order to understand patterns and relationships, or to identify problems.

The visualization paradigm used by IODE OceanTeacher training in Ostend, Belgium is SOURCE->MANAGER->VISUALIZER->YOU. The Source includes datasets "out there" and on hand. The Manager includes dynamic methods to get, subset, re-format, and deliver the source data. The Visualizer is comprised of the user and his/her software. This paradigm comes in three main modes:

> **Mode I**—In this mode, you can actually obtain raw data to work with, often operational data. It is the main paradigm for obtaining data, with no frills. The data sources are typically CDs/DVDs and basic, online collections in basic formats. Visualizers are just about any ocean software with graphics (e.g., Ocean Data View, JOA, GIS ncBrowse, HDFView). With Mode I data, format issues predominate. Climatologies and atlases are a common data source, which often have simple grids, and poor or missing metadata. The data are often in gridded binary format (GRIB), which modelers love, but other oceanographers hate. The data are usually available by some of the worst Web site interfaces on the Web. NetCDF (network Common Data Form) is an interface system to access Mode I data and there are a variety of versions available. NetCDF can be used with Hierarchical Data Format (HDF) but, unfortunately, various versions of HDF are used, even in the same agency (e.g., NASA).
>
> **Mode II**—In this mode, you can get figures based on the data, but not the actual data that are used to produce the figures. This mode mainly applies with GIS systems. The user has limited control over output, as provided by controls and menus available with the

figure. . For example in PNG and JPG figures, the data cannot be captured and underlying shapes and grids ("features") are not exposed. Essentially, the user simply gets pictures of the data from fancy black boxes. Other examples are dynamic "Operational GIS" interfaces based on Open Geospatial Consortium standards, such as the SouthEast Atlantic Coastal Ocean Observing System (SEACOOS) and the OpenIOOS prototypes. Another example are the many java applets that draw maps from underlying, server-side databases. In Mode II, data access issues predominate. There is dominance of a single commercial firm and more copyright hurdles than any other data type, and thus more expense. There is a slow emergence of community "marine GIS", although OpenIOOS and SEACOOS serve as a de facto GIS for now, but for images only. IOC training for Mode II data uses Saga for images and gridding and MapWindow for general use.

Mode III—The source gives you the data (son of OPenDAP). This requires OPeNDAP plus really good client software; all the action is on the client side and there is a nontrivial learning curve. The full potential of OPeNDAP is used for Mode III data. This mode levels the playing field for PCs and work stations, due to stride/step controls. There are data storage and platform capacity issues for model output. Skill and infrastructure issues predominate. The OPeNDAP Data Connector was never completed; some features are available in the Integrated Data Viewer (IDV), but other features are still needed. Catalog maintenance is poor because it's voluntary; the system components are frequently broken. Software solutions tend to be big and complex.

Several technical issues remain in relation to data visualization. There is a need for a basic vector-drawing utility for simple grids. Despite the continued heavy use of GRIB by modelers for output, it is time to move on to something more user-friendly. The OPeNDAP cataloging has stalled and National Virtual Ocean Data System (NVODS) maintenance is unfunded now. The principal NASA site for color and SST data (L2,L3) uses HDF4 and not HDF4-EOS. More generally, there is a divide between high-end technical applications in leading laboratories and the visualization needs of compiler- or library-challenged ordinary folks. Developers need to admit that the Microsoft model is not completely evil. There is an even greater divide between visualization capabilities in advanced institutions and in the developing world. GRIB isn't easy, but it sure does work

In conclusion, Murray Brown stated that format proliferation has slowed down in oceanography, but is not dead. Visualization methods and tools will continue to be scattered and disjointed until we focus on an even smaller family of formats. OPeNDAP-type approaches provide good solutions to MODE 1 and MODE 3 issues. OGC-related work must continue to solve Mode 2 issues. Brown recommended common visualization solutions for the global ocean community, targeting a reasonable computer platform for visualization development. OPeNDAP-type protocols should be robustly supported for all data types. A small family of common formats should be used. A non-proprietary path from data to visualization should be available, even at the expense of early progress. Formal data visualization methods should be taught in all capacity-building activities. All SCOR-sanctioned programs should be involved.

Pat Halpin continued on data visualization, particularly related to a Census of Marine Life activity on this subject. Data and information are not equivalent. Only some information is useful for decision making. We convert data to information to decision support through *analytical workflows*. A data warehouse is not a library. If we want people to use our data we need to convert data warehouses into libraries of useful information and published workflow processes.

Halpin briefly showed the kinds of activities that are carried out under CoML, which shows the scope of data visualization activities needed. OBIS is responsible for CoML data (it also includes data from outside CoML) and is the central system that links CoML projects, Regional OBIS Nodes, and specialized nodes for specific taxons and ecosystem types. Halpin discussed common marine data types and showed examples of how they can be visualized, including instantaneous point observation and effort data; fixed location time-series data; 2-D and 3-D time telemetry tracking; 3D location, time, and environmental sensors telemetry tracking; Photo-ID tracking of individual animals; 3-D passive acoustic location/call data from marine mammals; 3-D animal behavior models; and marine animal habitat models.

Information dissemination and interoperability are important to make it possible to obtain data to visualize. Halpin showed an example of a specialist data center that participates in OBIS, the OBIS-SEAMAP information system. SEAMAP is a world data center for marine mammal, seabird, and sea turtle information. This database includes 185 datasets from 1935 to 2005, including more than 1,100,000 records. The SEAMAP system maintains species data, including natural history information, taxonomic classification, bibliography/Web links, and links to "prey" profiles.

Emerging open-source, open-standards tools provide a functional, open working environment for the ocean biogeographic information community. For example, Internet map service standards are being developed by the Open GIS Consortium. The SEAMAP system provides data discovery metadata, which assists interoperability. Google Map allows quick browsing, easy navigation, and direct access to dataset pages. Google Earth supports any types of data, including effort/telemetry lines. It features informative pop-ups and a link to OBIS-SEAMAP. Halpin showed integration of Google Earth with OBIS-SEAMAP applications, such as turtle nesting trends and seabird colonies abundance time series. It is possible to overlay environmental data, such as monthly sea surface temperature, over the period of survey. Google Earth provides real-time telemetry tracking tools. Halpin showed from the SEAMAP Web site available time-series animations of telemetry data, sea surface temperature, and user-created animations.

Halpin concluded by demonstrating workflow visualization through an example workflow (the transition from data to information) of marine mammal habitat modeling. The motivation of this process is to translate data on marine mammal distributions into useful information for ocean scientists and managers, to create practical tools for marine mammal avoidance, such as reducing ship-whale interactions in shipping lanes and reducing negative impacts of sonar on marine mammals. Two products are linked to achieve these objectives: (1) the archive of observational data of marine mammal sightings in time and space from 1991 to 2002 (including sampling effort and absence data), and (2) a marine mammal modeling and analysis system.

Environmental variables related to sightings are also included in the system, such as sea surface temperature, depth, and distance to shore, the shelf break, and to fronts. Halpin demonstrated how such information could be integrated into a Habitat Modeling Workflow System, using diagnostic tools such as pair plots and histograms, and Receiver-Operator Characteristics curves. Halpin finally discussed GIS Web services for environmental planning, which can yield information such as observations and effort (by dataset and species), range maps, and predictive models. After data have been analyzed, one result can be feedback to data originators, about data quality, gaps in sampling, etc. For example, a "gap analysis" of spatio-temporal data of marine mammals shows, not surprisingly, that data are more plentiful in summer months and that there is a need for more winter data.

Discussion included both Brown's and Halpin's presentations. Ed Harrison noted his view that the first problem is getting data into and out of data archives. We need tools to make integrated databases from data sets. This process should be made more straightforward for more people. Tom Malone also pointed out that many areas of the ocean are still undersampled, so we end up having to fill in the gaps with data generated by models.

Diepenbroek agreed that the general availability of data is the root problem; data that are the basis of many research papers are not available. The distributed aspect of many data is a problem. Data are not delivered to a centralized location in a timely manner and only a few percent of the actual data are archived. Beatriz Balino endorsed this opinion. The main problem is to get data from PIs to data managers. The UK and United States might do a good job at this, but it is more of a problem in other countries. Scientists have to understand the value added by data management. Raymond Pollard suggested that one of the "carrots" to stimulate scientists to put data into data centers would be the provision of good visualization tools. Pollard added that many countries require data resulting from publicly funded research to be archived. Ed Harrison added that we need to get our nations to invest in real-time data management, so that scientists don't bear the cost of this. Tom Malone added that data management should be institutionalized. Jerry Miller gave the example that the U.S. Office of Naval Research-Global requires that data be submitted to a publicly available archive. Michael Diepenbroek suggested that there could be a requirement that data be submitted to an archive before the paper for which the data are used could be published, as is done for molecular data. Mark Costello agreed. We need a system of data publishing and review. In this case, the carrot would be peer recognition and citation of data sets.

Fred Grassle noted that even the best national oceanographic data centers (NODCs) are not funded to provide access to data. For example, data that resulted from U.S. Minerals Management Service grants are hard to retrieve from the U.S. NODC. When data centers are established and funded, there should be a mandate for data to be publicly available and to provide the ability to update data in data archives.

Robin Raine noted that, in a lot of countries, no "stick" exists. Full and accurate metadata should be included with data and transferred to data centers. Data managers need to know where the data are located. Peter Liss responded that sticks can be very effective. Funding agencies can require that data be turned in to get the next grant. Diepenbroek agreed that a top-down

approach is needed. We are having the same discussion we had 15 years ago. Ron O'Dor wondered if it might be more efficient to focus on getting data cruise by cruise, rather than focusing on individual scientists. He suggested that data might be managed starting with research vessels. Ship costs are high and adding data management to them would only cause a relatively small incremental increase in cost. Chris German replied that InterRidge has been trying to keep track of InterRidge cruises, but it has been difficult. Most scientists are protective of their time. The value added by data management must be a benefit to PIs to provide a carrot. It would be good to make people envious that of those whose data are in an archive.

Beatriz Balino stated her belief that every scientist has a moral duty and responsibility to submit the data they generate. Senior scientists should teach this to their students. Howard Cattle suggested that we need to separate data management from information management. CLIVAR holds no data, but they need to provide useful information about CLIVAR data held in national data centers, where they are, and how to get them. We all seem to be re-inventing the wheel. Perhaps we can set out some guidelines to make progress.

Colin Summerhayes noted that the Antarctic science community has the same problem. European Commission grants require data to be put into an archive. IOC signed up to a data policy in 2003, including a clause on open access to data. The countries that agreed need to do what they said they would do. Ed Harrison stated that many nations have entered into agreements in relation to data. Maybe these agreements could be applicable to ocean data.

Tom Malone stated that archives should be set up to allow public access to data. This will have a positive feedback to the scientific community. The Canadian Department of Fisheries and Oceans has implemented a real-time data access capability.

Murray Brown stated that the discussion is covering a lot of different subjects: interoperability, long-term integrity of data, quality control, metadata, versioning, compliance and availability, and infrastructure (methods and manuals). Compliance and availability can be promoted by editors of journals and ship operators.

Fred Grassle stated that there needs to be a method of attribution for each data set. The sticks don't work because some scientists will just go through the motions to meet the minimum requirements. Peter Liss responded that funding agencies should probably be the ones to apply the sticks. The projects have great difficulty in knowing what is done in their names. It might be appropriate to approach the International Group of Funding Agencies for Global Change (IGFA) about this.

Pat Halpin noted that we need recommendations not only on data that will be collected in the future, but also on data that were collected in the past. Karen Heywood suggested that this meeting should endorse DOIs. Michael Diepenbroek added that WDC-MARE has approached Thompson Publishers about tracking DOI impact factors, as is done for scientific papers.

Manuel Barange cautioned that every data policy needs exception clauses (for situations like commercial fisheries data).

Hannes Grobe made two specific recommendations:

1. Scientific data supplementary to publications: Journal editorial boards should require that data on which each publication is based should be archived. *Marine Micropaleontology* already does this (see http://www.elsevier.com/wps/find/journaldescription.cws_home/503351/authorinstructions).[4]
2. Data that are not used for publications: DOIs solve part of the problem by increasing the value of the data to the scientists who generate the data by making the data citable.

Bjørn Sundby stated that there are high-level obligations that must be filtered down to the scientist level, and we need to address the individual PIs by providing suitable carrots, like education on why archiving data is important and how the PIs could benefit. Michael Diepenbroek added that it is important to teach younger scientists and students, to change the attitudes of the community over time.

Julie Hall responded that SCOR should take a high-level approach. Ed Urban stated that we need to approach projects also, to help encourage their scientists to submit their data. Cisco Werner added that where project scientists edit special issues of journals, they can set certain expectations about archiving data. Michael Diepenbroek responded that it is not only SCOR that should push this idea, but other communities should also be pushing, including urging agencies and scientists to set aside adequate funds for data management. Raymond Pollard responded that previous projects have concluded that 5-10% of the project funding needs to be spent for data management. Tom Malone responded that as much as 20% may be needed for data management for observing systems. Peter Liss again suggested that SCOR go to IGFA to present the issue and discuss how to solve the problem that data need to be shared because the ocean is international. SCOR would need to develop a one- to two-page document for IGFA. Colin Summerhayes responded that this is a broader problem than SCOR. Other organizations, including SCAR, could help. Sundby responded that ICSU could be involved also. Beatriz Balino agreed that SCOR should join with other organizations, like IGBP, to tackle this issue. Peter Burkill suggested that if we make an approach to IGFA, we should enlist someone involved in IGFA from one of our countries to take the message

The following individuals were requested/volunteered to help with the next step: Murray Brown, Mark Costello, Michael Diepenbroek, Hannes Grobe, Ed Harrison, Peter Liss, Raymond Pollard, and Cisco Werner.

[4] "If the original data in the submitted manuscript are not available at an internationally recognized electronic database, they must be submitted as tables or as appendices; the latter will be published electronically only. If the data are available on-line, please provide the url."

Global Ocean Observing System

Ed Harrison began this session with a presentation about the Ocean Observing Panel for Climate (OOPC). He noted that there is a whole ocean of data available without going to the scientist who generated the data. Harrison is very supportive of the DOI concept. NODCs and WDCs don't get a lot of support. Stronger linkages of projects and data centers should help everyone. The Global Climate Observing System (GCOS) Implementation Plan recommends the following:

- Sustain proven ocean satellite data streams and in situ activities
- Obtain global coverage with initial surface and subsurface systems
- Improve ocean data system, including telecommunications
- Increase effort on ocean analysis and reanalysis
- Maintain strong linkages with research programs for data collection, new technology, pilot projects, new science, etc.

This plan is widely accepted and endorsed (e.g., by the UN Framework Convention on Climate Change, Group on Earth Observations). Unfortunately, present efforts to develop observation systems depend heavily upon ocean research funds, people, and assets. There is a shortage of national institutions for sustained ocean activities National operational global oceanography is in it infancy; there is a limited operational "pull" for such systems. The real-time data system is essential and is developing well. The portion of GOOS related to climate is about 60% complete now. A potentially big problem is the continuation of satellites important for the ocean research community. Harrison was not sure what to recommend for SCOR to do about this. Oceanographers have not made a big-enough issue of this satellite problem.

OOPC is interested in generating interest in near-real time information about the ocean. Climate indices are one route. These are mostly related to ocean surface parameters at present. OOPC is working with CLIVAR on the development of subsurface indices. The *Bulletin of the American Meteorological Society* has an ocean section in their "state of the climate" report and there were 7 ocean indices included in the 2005 report (the goal is 15 parameters). The climate indices Web site (see http://ioc3.unesco.org/oopc/state_of_the_ocean/index.php) can provide parameters important to the projects. This delivers a range of indices, updated weekly, where possible. Most are ocean surface climate indices and there is a need for development of subsurface indices. It is not always simple to agree to indices because indices inevitably oversimplify. This site has the capability to serve additional indices.

There is not clear evidence that the ocean is warming everywhere. Although 96%+ of the cells in the model grid show temperature changes, not all increase. To get a definitive answer, we have to observe the entire ocean for decades. Predicted sea ice extent shows different decreases depending on the analysis method. The Intergovernmental Panel on Climate Change (IPCC) needs to understand better how large variability is on even decadal time scales. Interannual and decadal variability are large almost everywhere we have observed systematically. Spatial patterns of even multi-decadal trends seem to be complex and roughly balanced in sign. Fifty-year temperature trends are elusive, except at 50 m. Sea ice trends depend on the analysis.

There is no reason anymore to go to sea without checking satellite photos to see if the area is anomalous (e.g., has an eddy passing through it).

Tom Malone reported on developments in coastal GOOS. The purposes of coastal GOOS are to

- Improve the safety and efficiency of marine operations
- Improve forecasts of natural hazards and mitigate their impacts more effectively
- Improve predictions of climate change
- Minimize public health risks
- Protect and restore healthy coastal marine and estuarine ecosystems more effectively
- Sustain living marine resources

The data needed for this system are multi-disciplinary: geophysical, chemical, and biological. Coastal GOOS is seeking interactions with the 12 new GOOS Regional Alliances (GRAs). Coastal GOOS is built from regional GOOS systems and GRAs, to form a Global Coastal Network (GCN). The GRAs, in addition to being the foundation of the GCN, will be research and development incubators, and will set priorities for capacity building within their regions. Members of the GCN will measure common variables (remotely and *in situ*), establish a sparse network of sentinel stations and transects, implement common standards and protocols, and extend and combine coastal observations to basin scales. Malone listed the proposed GCN common variables and the observation requirements for these variables. The implementation of the GCN by the GRAs is just beginning, through two parallel processes: (1) incorporation of existing global programmes (e.g., satellite remote sensing, Global Sea Level Observing Network, Global Coral Reef Monitoring Network) and (2) networking or scaling up of elements developed by GRAs and national GOOS programs (e.g., Continuous Plankton Recorder, harmful algal bloom observing systems, high-frequency radar networks).

The GRAs are taking on five high-priority activities:

1. Engaging industry, academia, and government agencies
    a. In the establishment of a coastal GOOS that
    b. Meets their requirements for data and information
2. Integrating existing assets to meet these requirements
3. Forming partnerships with existing regional efforts that have common interests, for example,
    a. Large Marine Ecosystem Programmes (LMEs)
    b. Regional Seas Conventions
    c. International Council for the Exploration of the Sea
4. Conducting pilot projects that
    a. Build capacity through partnerships between developed and developing nations,
    b. Contribute to building the coastal module, and
    c. Provide data and information used by decision makers
5. Building the GCN

The 3rd GRA Forum was held in Cape Town, South Africa, on 14-17 November 2006, and helped move the implementation of the GCN forward. Regional partnerships with LMEs is a high priority. A series of pilot projects for implementation by partnerships between developed and developing nations were identified:

- Improve forecasts of susceptibility to, and impacts of, coastal flooding on coastal populations, ecosystems, and resources.
- Serve near-real time, blended ocean color products.
- Improve forecasts of coastal circulation through coupled deep ocean–shelf hydrodynamic models.
- Implement Coastal Ocean Data Assimilation Experiments (CODAE).

Discussion was opened in relation to both GOOS presentations. Cisco Werner asked for more specifics about the satellite situation. Ed Harrison responded that there is an appendix in the GCOS report about the satellite timing. Although it is not primarily SCOR's responsibility to worry about satellites, it would be helpful for SCOR to say something. Some of the value of the Argo measurements will be lost without having good altimetry. Peter Burkill asked what SCOR can do practically. Harrison responded that issuing a statement to CEOS from this group (and perhaps also ICSU) would help. The challenges are even more serious for terrestrial satellites. Ed Urban suggested that SCOR could bring up this issue at the IOC Assembly in June 2007. Tom Malone responded that the effectiveness of working through IOC will require contacting Keith Alverson and national delegations beforehand. Julie Hall asked what has happened with the IGOS documents that discussed this issue. Ed Harrison responded that it is not obvious that the IGOS documents have had any effect on these discussions. Beatriz Balino noted that the ocean color situation does not look good, particularly in terms of continuation of IOCCG ocean color maps. Tom Malone responded that the situation is even worse for Case II waters. Harrison noted that no straightforward summary of the satellite situation has been published.

On a different topic, Ron O'Dor noted that CoML has instrumented animals with sensors that are collecting GOOS-relevant data. Are these data making it into models? Harrison responded that this process has been started, but has not gotten very far yet.

Research programs can input to GOOS through OOPC and the GOOS Scientific Steering Committee.

<u>OceanSITES</u>

Uwe Send gave an update on the progress of the OceanSITES activity. He went through the scientific, operational, and technical applications of ocean time series. OceanSITES is a global ocean time-series observatory system under development internationally. It started as a GOOS/CLIVAR/POGO-sponsored (via OOPC/COOP) activity. The system is multidisciplinary in nature, collecting physical, meteorological, chemical, biological and geophysical time-series observations. The goal is to make the data publicly available as soon as received, and quality-controlled by the owner/operator. An International Steering Team provides guidance, coordination, outreach, and oversight for implementation, data management, and capacity building. This team includes 18 scientists operating sites, representing all ocean disciplines. A

pilot system has been defined consisting of all operating sites and those planned to be established within 5 years, subject to evaluation by the Science Team in terms of the qualifying criteria. Two important definitions that OceanSITES is using to define time series are

1. Sustained in-situ observations at fixed geographic locations of ocean/climate-related quantities at a sampling rate high enough to unambiguously resolve the signals of interest.
2. Only truly Eulerian data, that is, no ship sections or underway data, no surveys with vessels or gliders around a site. But PRODUCTS derived from other systems (e.g., transport time series from ferry ADCP sections) would be included in the database.

International coordination is critical for sharing resources, addressing global issues, standardization and harmonization, attracting and serving the user community, data management, visibility, and advocacy. The plan and vision for global ocean time series includes two global data portals (under construction in OceanSITES). The NetCDF format has been defined in consistency with other/prior programs (e.g., ARGO) and with the U.S. Integrated Ocean Observing System's Data Management and Communications philosophy. Multi-disciplinary data from all (public) deep-ocean time-series sites will be available in real-time, with single queries. This goal will be challenging since several communities need to come together. An important approach will be to add value to data by providing products and indicators, for example

- intensity of processes (air-sea fluxes, critical vertical/horizontal exchanges, productivity)
- state and health of the ocean and atmosphere (physics/climate, ecosystem, inventories, chemicals, populations)
- forecast/warning indicators (El Niño, North Atlantic Oscillation, blooms, pollution, earthquakes)

Since the 2005 meeting of the WMO/IOC Joint Commission on Oceanography and Marine Meteorology (JCOMM) in Halifax, OceanSITES has been a recognized component of the global ocean observing system being integrated under GOOS, JCOMM, etc. OceanSITES involvement in Ocean-United and GEO has been agreed. The OceanSITES Data Team met for the first time in February 2006 and agreed on a wide range of issues, approaches, and architectures:

- A data format has been agreed on, modeled after ARGO, consistent with other international and U.S. efforts, using NetCDF
- conventions on architecture and procedures have been established (data assembly centers [DACs], global data assembly centers [GDACs], portals, etc.)
- Coriolis/IFREMER will be one GDAC; OceanSITES is waiting to hear about a NOAA GDAC.
- Sample data are flowing now from
    - WHOI air-sea flux sites
    - ANIMATE/MERSEA sites
    - NOAA/KEO mooring
    - Dickey Bermuda mooring

- MOVE moorings
- MBARI moorings (under way)
- ship hydrography from Hawaii/Bermuda (under way)

- OceanSITES plans to expand and invite others, once the data system and format is demonstrated and operational.
- In the future, it will be a requirement to contribute data publicly, in order to be part of OceanSITES, reflected on implementation maps.

Uwe Send issued an invitation from OceanSITES to other projects present to

- express interests and rationales for specific time-series sites (existing or additional ones);
- cooperate on implementation, maintenance, and operation of sites; and
- cooperate on the data system for time series-type data.

Gideon Henderson expressed an interest from GEOTRACES in sites where water samples are actually collected, so that GEOTRACES sections might be passed through those sites. Jeff Hare added that SOLAS would be interested in sites where gas species and nutrients are measured. Peter Burkill asked if it is possible for OceanSITES to add new sensors at existing sites. Uwe Send replied that it might be possible to offer moorings to which sensors could be added. Julie Hall stated that communication between OceanSITES and IMBER is important. Are OceanSITES metadata available? Send responded that metadata will increasingly be available on the OceanSITES Web site. Mike Sparrow commented that OceanSITES and CLIVAR share the desire to have data released as soon as possible. Peter Burkill summarized the discussion by saying that the bottom line is that OceanSITES is up and running and should continue interactions with the projects.

ACTION: Projects to interact with OceanSITES directly in relation to their measurements of interest and their needs for time-series measurements.

Southern Ocean/International Polar Year (IPY)

Each project presented information about their IPY plans. Gideon Henderson stated that two German/Dutch cruises in the Southern Ocean will be a GEOTRACES contribution to IPY. There are also proposals for French, Japanese, Australian, and Spanish cruises in the Southern Ocean as part of GEOTRACES. Manuel Barange reported that there are two clusters of IPY activities related to GLOBEC: ICED in the Southern Ocean and ESSAS in the Arctic Ocean.

For iAnZone, Karen Heywood added that the Synoptic Antarctic Shelf-Slope Interactions Study (SASSI) will start in 2007. SASSI will have a group of short sections (potential interactions with GEOTRACES?) from Antarctica into the Southern Ocean (see http://roughy.tamu.edu/sassi/). The project is targeting Antarctic nations that do not yet do a lot of oceanography on their way to their bases. SASSI is focused on physical oceanography, but is keen to develop collaborations with scientists in other disciplines. In addition to SASSI sections, there will be some moorings, which could link with OceanSITES. Most of the moorings are not funded yet but, if established, some would return data from under the seasonal ice in winter. Most SASSI activities will collect

water samples. SASSI activities are awaiting funding decisions in most of the nations that would like to participate. The hydrographic sections are more likely to be funded than the moorings. One of the rationales for SASSI is to study the significant freshening of the Ross Sea. Heywood invited meeting participants to attend the iAnZone meeting in Bergen, Norway in 2007. Ed Urban asked if there are still berths available on SASSI cruises and Karen Heywood answered that SASSI is encouraging all SASSI cruises with empty berths to make them available to scientists from outside SASSI.

Mike Sparrow presented CLIVAR's plans for IPY. CLIVAR is planning the Climate of Antarctica and the Southern Ocean **(**CASO) project (see http://www.clivar.org/organization/southern/CASO/index.htm). CASO aims to tackle some important unknowns:

- Obtain the first circumpolar snapshot of the Southern Ocean, including physical, ecological and biogeochemical properties.
- Measure the circumpolar extent and thickness of Antarctic sea ice through an annual cycle for the first time.
- Observe the sub-ice ocean circulation, water mass properties, and biological distributions.

They would like to have multidisciplinary transects as part of CASO. They have quite a few funded sections already, particularly northward extensions of SASSI sections. There is some modeling involved. They are working on developing under-ice Argo floats. Many sections won't be done on ice breakers, so the southern extent of the sections will be limited. Using marine mammals as sensors is a promising approach. Their IPY Observing System would include

- Synoptic multi-disciplinary transects
- Sea ice volume
- Enhanced sea ice drifter array
- Ocean circulation under sea ice
- Enhanced Southern Ocean Argo
- Enhanced meteorological measurements
- Ice cores from high-accumulation rate coastal sites
- Process studies

It is intended that there be a Southern Ocean Observing System continued after IPY, including 2- to 5-year repeated sections, 6+ short sections repeated, and moorings/stations on select sections. This system would help to begin to measure the variability of the system.

Chris German reported for InterRidge, which has work on the Gakkai Ridge (Arctic Ocean) planned for summer 2007, using AUVs. There are two ridges in the Southern Ocean and hydrothermal signals have been known from them since 1999-2000. InterRidge and CoML ChEss are planning two joint cruises to the Southern Ocean ridges. It is known that the Atlantic, Pacific, and Indian ocean ridges have very different vent ecosystems, so there is great interest in finding out how the Southern Ocean vent ecosystems relate to the others. These cruises will be

very interdisciplinary and will take place in 2008 and beyond. Paul Tyler is the key contact person. Peter Burkill noted that GEOTRACES would probably be interested in these cruises and German responded the InterRidge is working with GEOTRACES.

Colin Summerhayes suggested that it is useful to summarize ocean-related IPY activities and showed a list of SCAR-related IPY activities (see Appendix III), some of which are components of SCOR-sponsored projects. Mark Costello noted that SCAR-MARBIN has begun publishing biological data through OBIS and can facilitate such publication for scientists working in the Antarctic. Summerhayes continued with a summary of the activities of the SCAR/SCOR Expert Group on Oceanography. This group has established linkages with the projects with planned Southern Ocean research. The intention is to transition the group over time to a fully multidisciplinary group. (It is focused now on physical oceanography.) The results from the group's most recent meeting (July 2006) include

- Web site for data and products;
- More work needed to populate the Web site with data;
- Some progress in collating physical oceanographic data - e.g., Ocean-READER at the British Antarctic Survey;
- Need to maintain the WOCE Southern Ocean atlas database;
- Need to encourage data submission to CLIVAR DACs;
- Good progress developing interdisciplinary research (ICED);
- Need stronger links between ICED, SOLAS and IMBER, and ICED and WCRP;
- Slow progress in bathymetry (IBCSO) (now improving with hire at AWI);
- Need to improve the bathymetric database and data exchange;
- Twenty Southern Ocean programmes accepted as leads for IPY cluster projects;
- Support for proposed SCOR Fe-enrichment working group;
- Need to consider carbon cycling and ocean acidification issue; and
- Need to take a primary role in developing a Southern Ocean Observing System (SOOS) (linking with GOOS, POGO, CCAMLR, JCOMM, etc.).

The work of the Expert Group in 2007 will focus on planning for a workshop in Bremen, October 2007, to draft the SOOS plan. A SOOS is sought as one of the legacies of the IPY. Information will be collected in advance from observation providers about ongoing and possible future activities, gaps, and priorities; as well as from potential users about requirements. The draft plan outline will be completed by the end of March 2008 for review by the wider community at the SCAR OSC in St Petersburg, Russia, in July 2008.

Bathymetry

Karen Heywood stated that accurate bathymetry is an issue for iAnZone for sampling, modeling, and deploying moorings. Tidal models do not work well around Antarctica. Most ships are equipped to take these measurements, but don't collect and report them. Suzanne Carbotte noted that bathymetric data are available from the United States, but often not from other nations. Heywood responded that the Germans are collecting bathymetric data routinely from their ships. Chris German added that the PIs of most cruises won't normally collect multibeam data, but we could encourage them to do so. Can they take slightly different tracks on each transit, so as to

cover more bottom area? This would require an international clearinghouse for this data. Colin Summerhayes responded that such a clearinghouse can be found at http://www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html. Ed Harrison asked if the geoid is known well enough and, if not, should the ships also be routinely collecting gravity data? Colin Summerhayes responded that gravimetry and magnetics are important, but the highest priority is for bathymetry.

ACTION: Peter Burkill asked Summerhayes, German, and Heywood to put together a recommendation on this topic (see Appendix IV for draft recommendations).

Capacity Building

Ed Urban presented SCOR capacity-building activities and then the projects and other organizations were given the opportunity to share what they are doing in capacity building. CoML representatives reported that CoML has submitted a proposal to the Global Environment Facility (GEF) to create marine biodiversity centers of excellence. CoML has regional implementation committees and Ron O'Dor offered CoML assistance in any SCOR capacity-building activities.

ACTION: A suggestion was made that there should be a meeting of people from different organizations responsible for capacity building in the ocean sciences, as well as a catalog of marine capacity-building activities and resources. Murray Brown offered to build a catalog.

The linkages between SCOR and the marine projects needs to be tight in the area of capacity building. SCOR should consider having some project people on its Committee on Capacity Building. The international project offices (IPOs) often have good information and are the front line for capacity building.

Chris German brought up the example of the value of developed country scientists going to developing countries (InterRidge has used this approach) and Ed Urban responded that this approach came up at the SCOR General Meeting a few months ago also and he will seek permission from NSF to use this approach. Jeff Hare stated that is it hard for IPOs to find small amounts of money for its conferences and perhaps SCOR could help by coordinating requests. Ed Urban responded that he did not think this approach would work. Bjørn Sundby noted that Venu Ittekkot, the new chair of the SCOR Committee on Capacity Building, will be the focal point for SCOR capacity-building activities.

Colin Summerhayes reported that SCAR has been developing a capacity-building strategy and has a small committee overseeing this subject. SCAR has a fellowship program to help individuals go from Antarctic institutes in developing countries to similar institutes in developed countries, as well as to participate in Antarctic research during IPY. SCAR is a partner in a virtual university (the International Antarctic University; see http://www.iai.utas.edu.au/). Eventually, this university would like to offer Masters degrees in polar science. SCAR uses its biennial meetings and conferences as another opportunity for capacity building.

Robin Raine reported that one of the more successful activities of GEOHAB to date has been the HABWATCH meeting (see http://www.obs-vlfr.fr/habwatch/). GEOHAB will seek to involve developing country scientists from Asia in its activities through a special session in conjunction with the March 2007 GEOHAB SSC meeting. Fred Grassle reported that CoML/OBIS has developed nodes in developing countries; these nodes seem to be self-sustaining for now.

Bjørn Sundby shared his experience that getting a small amount of seed money for a meeting in Sri Lanka was difficult, and that it might be easier (for some sources) to ask for a larger amount of funding. Tom Malone added that at the GRA meeting, participants emphasized that capacity building must be in their backyards. Murray Brown responded that IODE has certified instructors in 12 countries and this seems like a good approach. Sundby noted that Chile has been very successful in developing its oceanography system and can be a model and a source of inspiration. Colin Summerhayes mentioned that there are UNESCO Chairs in many developing countries. (There are presently 595 UNESCO Chairs. Some are ocean-related, in Chile, Georgia, Germany, Mozambique, Russia, Spain, and Sudan.)

Bjørn Sundby suggested that the projects deal directly with the SCOR Committee on Capacity Building. Julie Hall responded that IMBER has a small capacity-building committee that has developed a policy for IMBER capacity-building activities. Its goal is to make sure that IMBER activities include capacity building and have coordinated efforts with EUR-OCEANS on summer schools and their Floating University. IMBER has received funding from SCOR to help developing country scientists attend the continental margins open science meeting in 2007. Manuel Barange added that GLOBEC does not have a capacity-building committee or policy. But, there is a network with developing countries through GLOBEC science. Robin Raine noted that, in relation to harmful algal blooms, IOC has run training programs in developing countries and in Denmark, so that people are getting trained in HAB science. Beatriz Balino added that IGBP does its capacity building primarily through the projects, although IGBP would probably be interested in participating in a capacity-building committee. Sundby agreed that SCOR should work with IGBP in this area. CLIVAR does its capacity building through WCRP, according to Howard Cattle, including receiving funding for this purpose. CLIVAR encourages its groups to include members from developing countries, particularly for activities related to monsoon science. The Indian Ocean panel with GOOS has good developing country participation. In Africa, the African Monsoon Multidisciplinary Analyses (AMMA) is co-sponsored by CLIVAR. They recently ran a capacity-building workshop on climate prediction for Africa. CLIVAR meeting organizers encourage participants to bring their data to the workshop to help them analyze it.

Bjørn Sundby summarized. Most or all projects/organizations at this meeting are involved in capacity building. There is a lot of experience we can draw on. We should think broadly and not be patronizing in our approaches. It is a good idea to have a SCOR focal point. How do we fund these activities? It makes sense to have a dual approach of bringing some developing country scientists to developed countries for training, but also to send some teachers to developing countries.

Bob Gelfeld responded that IODE has networks all over the developing world. Bjørn Sundby noted that CoML has regional OBIS nodes and implementation committees. Ron O'Dor added that the CoML NaGISA project is working in many developing countries. Peter Burkill added that there will be both bottom-up (Murray Brown's Web site) and top-down (the SCOR Committee on Capacity Building) approaches that can be applied.

Project Web sites

Ed Urban presented the results of the review of project Web sites done by Elizabeth Gross (see Appendix V). Bob Gelfeld stated that the current thinking is that it should only take 2 to 3 clicks to find any desired piece of information on a Web site. Murray Brown added that there is a trend for Web sites to be non-hierarchical. But, with such non-hierarchical structures, you don't know if you have seen everything you need to see. Ron O'Dor stated that it is helpful to make Web sites accessible through Google. Manuel Barange reminded participants that there is a difference in Web sites for service providers versus those for projects; the latter are usually more like a reference library. Barange appreciated having objective feedback on the GLOBEC Web site. Referring to science highlights on Web sites, Barange noted the GLOBEC approach of picking some key GLOBEC-related publications from the past year and building a story around a key figure from each publication. Ron O'Dor responded that CoML has also found that one image is worth many words. Colin Summerhayes stated that the culture of SCAR is not to focus on scientific highlights, so he has to encourage SCAR scientists to provide this kind of information for the SCAR Web site. Karen Heywood found the review to be very useful and asked if it could be repeated in a few years. Mark Costello suggested that projects might also want to create entries for Wikipedia. (Some projects, for example GLOBEC, already have Wikipedia entries.) Ed Urban concluded the discussion by stating that Elizabeth Gross can provide more detailed comments to any project wanting these.

ACTION: Repeat Web site review in two to three years.

Marine Habitat Classifications

Mark Costello introduced this topic. OBIS and GEOSS need marine habitat classifications to report on ecosystem conditions. The perspective of habitat and range depend on the type of organism being considered, requiring different sampling methods. OBIS is considering expert-defined regions. Many different regional classification systems have been developed in the past. It will be necessary to develop standard vocabularies and dictionaries, and the creation of semantic ontologies to link terms. Ed Urban noted that GEO has an ongoing Ecosystem Classification Working Group. Julie Hall noted that there has been a tremendous amount of work in LOICZ on coastal classifications. Pat Halpin added that it irks ecologists when the word "habitats" is used when what people mean is "ecosystems." Pelagic habitats are all dynamic. Costello agreed that "habitats" is used loosely; the term "biotopes" is probably better. OBIS has expert defined regions searchable on its website already for EEZ, sea areas, Longhurst pelagic provinces, and other areas; and has more in development.

Bjørn Sundby asked if there were any recommendations. Mark Costello responded that this presentation is primarily to make projects aware of this activity and to provide a chance for feedback from the projects. Pat Halpin remarked that one of the limitations of ecosystem

analysis data is the lack of absence and sampling effort data. Ron O'Dor noted that predictive tools combine biological and physical data, which should be reflected in habitat or ecosystem classifications. Julie Hall stated that Marsden Squares are not necessarily a good way to classify areas because many people don't know what these are. OBIS and others should include a definition of Marsden Squares when they are used. Bob Gelfeld responded that Marsden Squares are used widely by the World Meteorological Organization and each square has a unique code.

Carbon Offsetting for Project Meetings

Ed Urban opened the discussion by stating that this topic has been mentioned increasingly by the projects and is being used by some of them. He asked Manuel Barange to summarize GLOBEC's experience with carbon offsetting. Barange explained that the primary rationale behind carbon offsetting is to put an extra cost on travel to meetings to help meeting organizers and participants consider conducting fewer face-to-face meetings. The secondary rationale is, when organizations feel that it is necessary to have meetings, the carbon dioxide related to participants' travel should be offset by contributions to a reputable organization that is investing in projects that will result in a reduction in CO_2 emissions of a roughly equivalent amount. Jeff Hare responded that he is not sure that this approach will have a significant impact on the rise in atmospheric CO_2. Barange acknowledged this point, but added that the idea is to get scientists thinking more about the carbon emissions of their travel. Chris German expressed an interest in learning how GLOBEC selected the carbon offsetting company it is using. Barange responded that GLOBEC wanted to select a company in the UK so that they could visit the office. About 200 organizations and businesses use the company they use (ClimateCare: http://www.climatecare.org/). Howard Cattle added that WCRP is doing the carbon offsetting centrally for all of its projects. Chris German cautioned that the technology may not be up to the task of replacing large face-to-face meetings with remote methods (e.g., Web cams). Pat Halpin asked why GLOBEC makes participating scientists pay for the offsetting costs, rather than the project paying. Barange responded that it is not clear whether GLOBEC's grants, for example from NSF, would pay for these costs. Ed Urban confirmed this point. Hare asked what has been the response to the GLOBEC approach. Barange responded that 100% of participants in GLOBEC's SSC meeting earlier in the year donated part of their reimbursements to offset the carbon emissions of travel to their meeting. They are still tracking the responses for other meetings.

Conclusions/Recommendations

Peter Burkill began the summary discussion by stating that several items were discussed in the meeting as information items and did not necessarily result in recommendations. Data and satellites seem to be the major issues from this meeting, so they would be dealt with first.

Data—Cisco Werner, Ed Harrison, Mark Costello, and Michael Diepenbroek were assigned to further develop this issue. The major issue seems to be getting data into data centers. The important aspects of this issue are (1) to get journals to instruct their editors that papers will not be published/accepted until the data on which the paper is based are placed into an appropriate permanent archive, (2) getting data from cruises into data centers, and (3) the role of IPOs in getting project data into data centers.

The preamble of the recommendation should state why data should be shared. The recommendation should define agency and PI responsibilities and describe the infrastructure needed, and the need to work through journals, agencies, national requirements, and IGFA. The recognition/reward system should ensure that data are available, traceable, accessible, and citable. The document should recommend a SCOR Panel to develop the DOI idea for marine research projects.

Murray Brown stated that DOIs for data is a long-standing idea. Julie Hall added that this Panel should consider what is being done in the genetics community in relation to data and publications. Gelfeld stated that we need more information about DOIs before recommending that projects adopt them. Peter Burkill responded that the proposed Panel should investigate DOIs. Jeff Hare added that more information is available at www.DOI.org. Jerry Miller noted that one idea that should be discussed is versioning. Mark Costello noted that DOIs are similar to ISSNs and ISBNs. Karen Heywood suggested that model outputs should be included in this approach to make model outputs citable and available. Chris German noted that the electronic journal *Geochemistry, Geophysics, Geosystems* already provides the possibility for publishing "data briefs" that "report previously unpublished data, with appropriate documentation, accompanied by a minimum of interpretation and discussion" (see http://www.agu.org/journals/gc/). It was decided that a recommendation to journal editors would wait until after the Panel has completed its work.

Peter Burkill asked what other organizations should be involved? Colin Summerhayes responded that this is a collective issue. Howard Cattle noted that WCRP is setting up a data management committee. Burkill asked whether there should be a letter to other organizations to inform them about SCOR's plans and ask them if they want to be involved. Summerhayes supported this approach, so that other organizations can address the same issue together. Chris German added that this will also give us an opportunity to find out what other organizations are doing. Fred Grassle mentioned that ICSU has a committee called the Committee on Data for Science and Technology (CODATA) and that we should find out if it is doing anything about DOIs. Robin Raine reiterated his point about the importance of making data sets citable. Funding authorities in the United States and United Kingdom might be amenable to requiring data to be put into data archives, but this will be more difficult to achieve in other countries in Europe and elsewhere, so greater incentives are needed.

ACTION: SCOR to send letter to other organizations regarding their interest in participating on a Panel to make recommendations about data publication, including incentives for data publication[5].

[5] Use of DOIs is only a technical mechanism for reliably referencing electronic resources (and also scientific data). This could be achieved with any type of persistent identifiers (URN, HDL etc.). DOIs provide the advantage of being a brand that is increasingly used. However, the real idea behind DOIs is finding a reliable way of publishing and citing scientific data. The STD-DOI project (www.std-doi.de) has been running now for three years. The DOI registry for scientific data has been working on a routine basis for more than one year. Several World Data Centers and various data providers are using this facility; a recent new "customer" is the International Ocean Drilling Project. The group running the STD-DOI project is very active in spreading the idea of data publication; data

ACTION: Determine what other organizations are doing related to DOIs.

The letter to the funding agencies should be written very carefully. NSF does not strictly enforce its policy on data submission, largely because of a lack of staff to monitor compliance. Having DOIs would make the policy easier to enforce. Ed Harrison added that the issue of national policies should be considered, and a percentage of project funds that should be devoted to data management should be specified. Peter Burkill asked whether national funding agencies should be reached through national SCOR committees. He also asked what projects could do to help get data into data archives. IMBER and GEOTRACES have adopted the idea of a Data Liaison Officer, to help make this happen. Manuel Barange responded that it depends on the project. Although it is important to have data archived and available, the fisheries data issue is difficult for GLOBEC, which is why they focus on metadata management. Julie Hall added that IMBER is taking data seriously, by establishing a Data Management Committee and appointing a Data Liaison Officer in the IPO. The IMBER Data Management Committee is debating whether to handle data or only metadata. IMBER may produce data products later. Chris German stated that InterRidge does not have a data policy. InterRidge is a loose federation of national programs that need specialist databases. At the meeting it was thought that the British Oceanographic Data Centre (BODC) does not accept InterRidge-type data from the UK. Subsequently, BODC have confirmed that following a recent reassessment of roles and responsibilities it is its intention to deal with such data in the future. It was noted that the U.S. RIDGE program can now accept international data. It is helpful to have specialist databases spread around the world. Howard Cattle suggested that perhaps one recommendation to the IPOs would be to make their data management activities and data more visible on their Web sites. Manuel Barange added that projects should consider the legacy of their data and should check the metadata links. Robin Raine reported that, because of the multiple different data types, GEOHAB Core Research Projects don't think they can do project-wide data management. Therefore, GEOHAB will establish a centralized metadatabase. Peter Burkill asked Howard Cattle and Manuel Barange to come up with a recommendation to IPOs.

Ed Harrison stated that we need to ensure that the ocean science community has invested in interoperability tools, which will require money and staff to accomplish. Burkill asked how this could be achieved. Murray Brown suggested that this group should recommend that the OPenDAP activity be reinvigorated.

ACTION: Ed Harrison and Murray Brown to speak with Cornillion and Hanken about OPenDAP and report back to Urban on their response.

ACTION: SCOR to form a Panel on DOIs, based on recommendation from Werner et al.

ACTION: A recommendation to IPOs should be developed by Cattle and Barange.

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publication in the context of DOIs was presented during the most recent IODE meeting in Ostende and will be a topic at the next IODE meeting in Trieste.

Satellites—Peter Burkill asked whether we should involve organizations beyond SCOR in the letter. The sensors most at risk and most important to the ocean research community are the sensors for altimetry, color, and microwave sea surface temperature **(verify).** Harrison and Urban will develop the letter for review by meeting participants after the meeting. Burkill asked if anyone wanted to add anything to the concerns expressed before. Murray Brown responded that the EOS satellite is important for ocean color and sea surface temperature, so we should say something about it.

Ed Harrison presented a draft statement from this meeting. The statement needs to be reviewed by satellite experts. When completed, it should be sent to GEO, ICSU, the Committee on Earth Observing Satellites (CEOS), the UN Framework Convention on Climate Change (UNFCCC), and satellite agencies worldwide. Colin Summerhayes suggested sending the letter to CEOS national representatives and other key people in the space agencies. Pat Halpin suggested that high-level people in the agencies may not understand the problem of lack of continuity of any given sensor. Bjørn Sundby asked for a list of the appropriate addresses. Jerry Miller stated that the letter could be strengthened by specifying which sensors are most in danger. Murray Brown suggested emphasizing that currently scheduled projects studying climate change will suffer if these sensors are not available. Colin Summerhayes stated that, after an introductory statement, the letter should focus on ocean color and altimetry. Ron O'Dor asked whether such a letter could feed into Oceans.United. There was a consensus that such a letter should be a product of this meeting. Ed Harrison will be the focal point and we will send the draft letter back to the meeting participants. He stated that this would add the international ocean community's voice to the voice of the climate community. Ed Urban offered to help with the letter.

ACTION: Revise letter and send draft to participants.

ACTION: Participants to send addresses of national space agency and other contacts to receive the satellite letter.

Bathymetry—Colin Summerhayes developed a preamble from the SCOR WG 107 report on ocean bathymetry, and from recommendations of the SCAR/SCOR Expert Group on Oceanography that resulted from the group's meeting in Hobart earlier in 2006 (see Appendix IV).

Jerry Miller commented that if he were doing ocean science, he would want to travel on tracks with known bathymetry, rather than deviating the ship's course a bit to cover a new track. Colin responded that that would be an understandable decision. Pat Halpin noted that nothing in the statement speaks to a final product of the data. Manuel Barange asked whether ocean bathymetry is within SCOR's purview. Chris German responded that the SCOR angle is to make the point the having better bathymetry in the Southern Ocean will help SCOR-related projects. IBSCO is pulling together data and we can stimulate the filling in of gaps in observations. Murray Brown cautioned that existing maps have been put together with haphazard data. Fred Grassle suggested that this recommendation should go to POGO also. Dave Monahan commended the work of the people who put together this statement. GEBCO fully supports all

the proposed recommendations and is prepared to continue to update its maps and grids of depths through the incorporation of data so submitted.

Capacity Building—Two actions were repeated:

ACTION: The projects and their IPOs should feed information into and interact with the new SCOR Committee on Capacity Building.

ACTION: Murray Brown will develop a Web-based catalog of ocean capacity-building activities.

Other Comments—Jerry Miller noted that he will soon be the editor of *EOS* for ocean science, and would be interested in receiving articles on the issues discussed here. Colin Summerhayes suggested putting a report of this meeting in *EOS*.

ACTION: Circulate a participant contact list after the meeting.

An update on progress on the action items from this meeting is given at http://www.scor-int.org/Project_Summit_2/Action_Items.htm.

This report will be considered by SCOR and will be distributed to SCAR, IOC, IGBP, POGO, and other organizations that could help implement these recommendations.

Appendix I - Acronyms

AUV	autonomous underwater vehicle
AWI	Alfred Wegener Institute for Polar and Marine Research
BODC	British Oceanographic Data Centre
CACGP	Commission on Atmospheric Chemistry and Global Pollution
CASO	Climate of Antarctica and the Southern Ocean
ChEss	Biogeography of Chemosynthetic Ecosystems (ChEss) project (CoML)
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CLIVAR	Climate Variability project (WCRP)
CoML	Census of Marine Life
COOP	Coastal Oceans Panel (GOOS)
COST	Cooperation in the Field of Scientific and Technical Research (EU)
DAC	data assembly center
DOI	digital object identifier
EUROCEANS	European Network of Excellence for Ocean Ecosystem Analysis
GCN	Global Coastal Network (GOOS)
GCOS	Global Climate Observing System
GDAC	Global Data Assembly Center
GEBCO	General Bathymetric Chart of the Oceans
GEF	Global Environmental Facility
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms Programme
GEOTRACES	an international study of the global marine biogeochemical cycles of trace elements and their isotopes (SCOR)
GIS	geographic information system
GLOBEC	Global Ocean Ecosystem Dynamics Project (SCOR, IGBP, and IOC)
GODAR	Global Oceanographic Data Archaeology and Rescue
GOOS	Global Ocean Observing System
GRA	GOOS Regional Alliance
HAB	harmful algal bloom
HDF	Hierarchical Data Format
iAnZone	International Antarctic Zone Programme
IBSCO	Group on International Bathymetric Chart of the Southern Ocean
ICED	Integrating Climate and Ecosystem Dynamics (IMBER and GLOBEC)
ICSU	International Council for Science
IFREMER	Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea)
IGBP	International Geosphere-Biosphere Programme
IGFA	International Group of Funding Agencies for Global Change Research
IHDP	International Human Dimensions of Global Change program (ICSU)
IMAGES	International Marine Aspects of Global Change project
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research Project
InterMARGINS	An international and interdisciplinary initiative concerned with all aspects of continental margin research.
InterRidge	An initiative for international cooperation in ridge-crest studies
IODE	Intergovernmental Oceanographic Data and Information Exchange
IOOS	Integrated Ocean Observing System
IPCC	International Panel on Climate Change
IPO	International Project Office
ISBN	International Standard Book Number
ISSN	International Standard Serial Number
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JGOFS	Joint Global Ocean Flux Study (SCOR and IGBP)

LME	Large Marine Ecosystem
LOICZ	Land-Ocean Interactions in the Coastal Zone project (IGBP, IHDP)
MarBEF	EU Network of Excellence on Marine Biodiversity and Ecosystem Functioning
NaGISA	Natural Geography in Near Shore Areas
NASA	National Aeronautics and Space Administration (USA)
NetCDF	network Common Data Form
NODC	national oceanographic data center
OBIS	Ocean Biogeographic Information System
OceanSITES	A worldwide system of long-term, deepwater reference stations measuring dozens of variables and monitoring the full depth of the ocean from air-sea interactions down to 5,000 meters.
OOPC	Ocean Observations Panel for Climate (GOOS)
OPenDAP	Open-Source project for a Network Data Access Protocol
OpenIOOS	Grass-roots partnership effort to support integration of the various activities involved in collection of observations and making predictions of the coastal environment, including contributions from federal agencies and research institutions, supported by the Integrated Ocean Observing System
POGO	Partnership for Observations of the Global Oceans
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SEACOOS	SouthEast Atlantic Coastal Ocean Observing System
SeaDataNet	Pan-European infrastructure for Ocean & Marine Data Management
SSC	Scientific Steering Committee
SOLAS	Surface Ocean – Lower Atmosphere Study (SCOR, IGBP, WCRP, CACGP)
SOOS	Southern Ocean Observing System
WCRP	World Climate Research Programme
WDC	World Data Centre
WDC-MARE	World Data Center for Marine Environmental Sciences
WOCE	World Ocean Circulation Experiment
WOD05	World Ocean Database 2005
WoRMS	World Register of Marine Species

Appendix II - Meeting Participants

Dawn Ashby	GLOBEC Data Manager
Beatriz Balino	IGBP Deputy Director, Natural Sciences
Manuel Barange	GLOBEC Executive Officer
Sophie Beauvais	IMBER Data Liaison Officer
Emily Breviere	SOLAS IPO
Murray Brown	IODE Ocean Teacher
Peter Burkill	UK SCOR, Meeting Co-chair
Susan Carbotte	U.S. Ridge2000/U.S. MARGINS
Howard Cattle	CLIVAR Director
Mark Costello	Chair, OBIS International Committee
Michael Diepenbroek	World Data Center for Marine Environmental Sciences
Robert Gelfeld	World Data Center on Oceanography, Silver Spring
Chris German	InterRidge
Fred Grassle	CoML Scientific Steering Committee Chair
Hannes Grobe	World Data Center for Marine Environmental Sciences
Julie Hall	IMBER Scientific Steering Committee Chair
Pat Halpin	Census of Marine Life
Jeff Hare	SOLAS Executive Officer
Ed Harrison	GOOS Ocean Observations Panel on Climate
Gideon Henderson	GEOTRACES Scientific Steering Committee Co-chair
Karen Heywood	iAnZone
Peter Liss	SOLAS Scientific Steering Committee Chair
Tom Malone	GOOS
Jerry Miller	Consortium for Oceanographic Research and Education
David Monahan	GEBCO
Ron O'Dor	CoML Senior Scientist
Raymond Pollard	IMBER Data Management Committee Chair
Robin Raine	GEOHAB Scientific Steering Committee Chair
Sylvie Roy	IMBER Executive Officer
Uwe Send	OceanSITES
Mike Sparrow	CLIVAR
Colin Summerhayes	SCAR Executive Director
Bjørn Sundby	SCOR President, Meeting Co-chair
Ed Urban	SCOR Executive Director
Cisco Werner	GLOBEC Scientific Steering Committee Chair

Appendix III - SCAR-Related IPY Projects

Area	No.	Short Title	PI	Body
SO	8	Synoptic Slope Study (SASSI)	K.Heywood	AGCS
	34	Climate and Coastal Communities	D.Abele	EBA
	53	Census of Antarctic Marine Life (CAML)	M.Stoddart	EBA
	66	Antarctic Benthic Deep Sea (ANDEEP)	A.Brandt	EBA, CAML
	70	Upper Ocean: Africa to Antarctica	A.Luis	CASO, AGCS
	83	Marine Biodiversity Information Network (MarBIN)	C. De Broyer	EBA, CAML
	93	ICEFISH	C. Verde	EBA, CAML
	131	Antarctic Marine Ecosystems (AMES)	V.Siegel	EBA, CAML, CCAMLR
	132	Climate-Southern Ocean (CASO)	S.Rintoul	AGCS
	137	Evolution and Biodiversity in the Antarctic (EBA)	G.Di Prisco	EBA, CAML, AMES
	141	Antarctic Sea Ice	S. Ackley	AGCS
	304	Drake Passage Seasonality	V.Alder	CAML, EBA
	329	Polar Ecosystems and Contaminants	W.Pollard	EBA
Bipolar	13	Sea level and Tidal Science	P.Woodworth	AGCS
	23	Atlantic Thermohaline Circulation	T. Gammelsrod	AGCS
	35	Tracer Chemistry (GEOTRACES)	H. de Baar	ICED
	52	Passive Acoustic Observations	J. Hildebrand	EBA, CAML
	71	Aquatic microbiology	G. Bratbak	EBA
	92	Integrated Climate and Ecosystems (ICED)	E. Murphy	EBA, CAML
	153	Marine Mammal Exploration	K Kovacs	CAML, EBA

Appendix IV – Review of Project Web sites

REPORT OF A SUBJECTIVE REVIEW OF WEB SITES OF SCOR-SPONSORED AND AFFILIATED PROGRAMS AND ACTIVITES OF MAJOR PARTNERS FOR THE "OCEAN SUMMIT" MEETING.

Elizabeth Gross

As part of its grant for the project summit meeting, the Sloan Foundation included a small amount of funds for a review of project Web sites. The sites reviewed are those given on the SCOR web site at http://www.jhu.edu/scor/ProjCoord-front.htm.

The idea of this review was not to rank Web sites in comparison with each other - i.e., this is not a contest - but to identify general problems and areas where Web sites could be strengthened to improve their usefulness to a targeted scientific audience and to the ocean science community as a whole. If I cite specific examples for praise or criticism, this is meant to be helpful. I did not take into account the staff and resources available to each program to support Web site development and maintenance. It was obvious to me that some programs had funds and specialized staff to dedicate to Web site development and maintenance, although others do the best they can without jeopardizing the funds they need to support their science activities. Both approaches have merit.

A general criticism is that many of the Web sites do not fit on a standard 800 by 600 pixel screen, so that a user is constantly forced to scroll from side to side to find things. This is especially bad on the IMAGES Web site, which is divided into frames with more than one vertical scroll bar needed to find things. I think this problem arises because Web sites tend to be designed by people who use larger than standard computer screens than most of us. Our departmental computer specialist says this is just bad practice and it frustrates users of poorly designed Web sites.

Another general criticism is that few programs are using their Web sites to promote real science highlights. CoML does this extraordinarily well, right on their home page (by "home page", I mean the main, or front, page of a Web site). GLOBEC does it well too, but their science highlights are buried until a heading called "Products". For some Web sites, perhaps new science highlights are not appropriate (e.g., the observing systems). It may be too soon to expect other programs (e.g., GEOTRACES) to be producing science highlights. In summary, few programs are communicating real excitement about what they are doing!

Another personal pet peeve is the use of large, slow to load pdf files to show very basic information. For example, looking for a simple explanation of LOICZ, the ideal route would seem to be to click on "LOICZ in Brief". After some delay a pdf file of the awkwardly shaped (for a Web site), 2 page LOICZ brochure appears - with the back page first and the looked-for brief explanation hidden until you realize that you need to go to page 1!

A final general comment is that major topic headings can be misleading. To cite one example - there is a very good explanation of the history, rationale and objectives of InterRidge on their

Web site, but I only found it by accident, under the link entitled “Organisation”. I would usually look at the organizational link if I wanted information on the structure of the program, membership of the SSC, etc. The InterRidge background information would be better placed under a link called “About InterRidge”. I had many experiences of finding things in unexpected or inappropriate locations, only because I was taking the time to look at Web sites very carefully. A busy scientist might become frustrated and give up, when a more effectively designed Web site could grab his/her interest and provide the general information most people are looking for on their first visit to a Web site.

Another example of this is the LOICZ Data Policy statement. For all programs I looked for a clearly stated policy on data issues. I found it for LOICZ, quite by accident, under a link entitled “How to get involved”. My reasonable expectation was that I would find it under the section on Data. For SOLAS, I found an out-of-date section on data management by clicking on a link in their organizational chart.

During this review I have concluded that all sites should have the following basic headings on their home pages:

- About xxxx - for general background information about the program - the program should be described in brief without requiring a reader to download an entire Science Plan to find out what it’s about
- Organization - for structural and administrative information
- Science - recent research highlights (excitement!) and more detail on the scientific program - here it would be appropriate to link to sections of a detailed Science Plan.
- Data - separate from the Science section. Should include a clear statement on data management policy, clear information as to how to get data from the program, information on cruises, metadata, contacts, etc.
- Contact information - IPO, not the SSC members
- Calendar - for lists of meetings and other events
- News
- Publications (or Products) - can include presentation materials, newsletters, reports

The GLOBEC Web site is a good example of one that has used this format well. So has CLIVAR and others to a greater or lesser extent.

Ideally, all program Web sites should include presentation materials (providing appropriate permissions have been obtained), as well as a section that interprets the program’s findings for the non-scientist - the “public outreach” aspect. Some programs have done a good job of providing educational materials.

We will be sending very brief comments specific to each Web site to the projects; I would be pleased to expand them and send them to you individually if you think this would be helpful. In reading these reviews, please recall that some programs rely completely on the willingness of a volunteer scientist to create and maintain a Web site at no cost, while others have staff and funding for this purpose.

Appendix V – Proposed Recommendations on Southern Ocean Bathymetry

MULTI-BEAM BATHYMETRIC DATA IN SUPPORT OF OCEANOGRAPHY

Bathymetric data are important for geological, geochemical and geophysical analysis, the identification of habitats, and as a critical controlling parameter on the output of advanced ocean circulation and tidal models. Following from that, they provide essential underpinning to many, if not all, SCOR research programs. Bearing this in mind, this SCOR Project Summit makes the following recommendations, which are informed by the deliberations of SCOR Working Group 107 (see http://www.scor-int.org/Publications/WG107Report.pdf), and reinforced by recent recommendations of the SCAR/SCOR Oceanography Expert Group (see http://www.clivar.org/organization/southern/expertgroup/Expt_group_2.pdf). We regard these recommendations as universally applicable to all SCOR-related research, but of particular importance at this time, in the context of the International Polar Year, for the most poorly surveyed seafloors of the Arctic and Southern Oceans.

Recommendations:

1. SCOR should write to funding agencies worldwide to urge that they:

   (i) encourage project scientists to incorporate in their proposals requests to collect and process multi-beam bathymetric data;
   (ii) fund multi-beam bathymetry data acquisition and processing on all research vessels equipped with multi-beam echo-sounders, whether on transit or on location; and
   (iii) work with PIs to ensure that data are subsequently submitted together with track data to the World Data Center for Marine Geology and Geophysics .

2. Project scientists should be urged by their project Scientific Steering Committees to ensure that multi-beam bathymetric data are collected and processed throughout all stages of their research cruises, regardless of the lead priorities of their scientific mission, and made available to the World Data Center for Marine Geology and Geophysics.
3. Recognising that the World Data Center for Marine Geology and Geophysics makes available through the Internet searchable maps showing the distribution of already collected multi-beam data (http://www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html), to assist in future cruise planning and to avoid duplication, project scientists should be encouraged to

   (i) to use such maps in planning cruise tracks so as to further contribute to the building of the bathymetric database, by filling gaps, and
   (ii) (ii) allocate sufficient time on transit for gaps to be filled, for example by steaming a path parallel to but separate from any previously occupied survey line.

The resulting data will be extremely useful to groups compiling bathymetric maps, such as the International Bathymetric Chart of the Southern Ocean (IBCSO), which will contribute to the General Bathymetric Chart of the Oceans (GEBCO).

These recommendations should be taken as SCOR policy on multi-beam bathymetric data collection and exchange, should be conveyed to POGO for the attention of laboratory directors, and should be published in *EOS* along with the other major recommendations of the SCOR Project Summit.

Action Items from Project Summit

(status as of 18 July 2007)

Time Series

ACTION: Projects to interact with OceanSITES directly in relation to their measurements of interest and their needs for time-series measurements.
UPDATE: List of OceanSITES sites, with location information, parameters measured, and contacts, transmitted to meeting participants (see http://www.scor-int.org/Project_Summit_2/oceansites%20all%209_8_06.xls).

Bathymetry

ACTION: Summerhayes, German, and Heywood to put together a recommendation on this topic.
UPDATE: Letter prepared, presented at meeting, and included in meeting report. Letter was sent to IGFA representatives in countries participating in SCOR and SCAR, as well as to the SCOR and SCAR representatives in those nations.

Capacity Building

ACTION: The projects and their IPOs should feed information into and interact with the new SCOR Committee on Capacity Building.
UPDATE: Bjorn Sundby and Ed Urban met with chair of Committee on Capacity Building on March 31 to discuss next steps for the committee. Wajih Naqvi, leader of IMBER's capacity-building activity, as added to the committee as a project representative.

ACTION: Murray Brown will develop a Web-based catalog of ocean capacity-building activities.
UPDATE: Prototype pages have been developed by Brown and are being reviewed by meeting participants and the organizations/projects for whom pages are listed. See http://www.scor-int.org/Capacity_Building/index.htm.

Satellites

ACTION: Revise letter and send draft to participants.
UPDATE: Letter is under revision by Ed Harrison, with assistance from Ed Urban, Erik Lindstrom, and Jean-Louis Fellous. The satellite issue was included in the *EOS* article and the supplement to it. Ed Urban has contacted a colleague in the White House Science Office, who says this issue is important to them and they would be interested in receiving the letter as soon as possible. GEOTRACES letter on satellites posted on meeting Web site (see http://www.scor-int.org/Project_Summit_2/GEOTRACES_Satellite_Letter.pdf). Other projects and organizations are welcome to send their own letters to SCOR regarding the importance of satellites to their projects.

ACTION: Participants to send addresses of national space agency and other contacts to receive the satellite letter.
UPDATE: Participants should forward the addresses to the SCOR Secretariat.

Project Web sites
ACTION: Repeat Web site review in two to three years.
UPDATE: This action will be pursued in relation to the next Project Summit.
Data

ACTION: SCOR to send letter to other organizations regarding their interest in participating on a Panel to make recommendations about the issue of data publication and persistent identifiers for data.
UPDATE: Awaiting description of panel to send to other organizations that might be interested. Issue raised in *EOS* article.

ACTION: SCOR to form a Panel on DOIs, based on recommendation from Werner et al.
UPDATE: Awaiting a description of panel.

ACTION: Determine what other organizations are doing related to DOIs.
UPDATE: Preliminary contact has been made with several organizations and information is being compiled by Ed Urban.

ACTION: Ed Harrison and Murray Brown to speak with Cornillion and Hanken about OpenDAP and report back to Urban on their response.
UPDATE: Progress unknown.

ACTION: A recommendation to IPOs should be developed by Cattle and Barange.
UPDATE: Progress unknown.

Other
ACTION: Circulate a participant contact list after the meeting.
UPDATE: Completed.

4.3.2 Panel on New Technologies for Observing Marine Life

Terms of Reference:

- To review the Census of Marine Life (CoML) Research Plan and make recommendations about technologies that could be applied to CoML projects.
- To communicate with CoML project leaders on a regular basis to discuss project technology needs.
- To identify and bring to the attention of the international community of fisheries scientists, marine biologists and others, the potential benefits of emerging technologies in the detection of marine life.
- To explore the relative merits of different technologies and identify those that deserve further research based on their potential for making significant contributions to the detection of marine life.
- To summarize the Panel's discussions on its Web site and in published articles, so as to make it as widely available as possible.

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Geoff Arnold	UK
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Gaby Gorsky	FRANCE
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Antonio Pascoal	PORTUGAL
Heidi Sosik	USA
Song Sun	CHINA-Beijing
Bob Ward	AUSTRALIA

Liaisons

William Karp	ICES and NOAA
Ron O'Dor	CoML
Peter Pissierssens	IOC
Edward Vanden Berghe	IODE Group of Experts on Biological and Chemical Data Management and Exchange Practices)

Executive Committee Reporter: Annelies Pierrot-Bults

The Panel met most recently in Kobe, Japan in conjunction with Techno-Ocean 2006 and an international conference of the CoML program's Natural Geography in Shore Areas (NaGISA) project. The Panel convened a special session at the Techno-Ocean meeting to attract technology companies to work on CoML-related issues. The special session focused on tagging technologies and autonomous underwater vehicles (AUVs) as they could be applied to CoML projects. The 2007 meeting of the panel will be held in 2007 in Auckland, New Zealand after the CoML All Projects Meeting there. The Panel is re-evaluating its Web site to ensure that it is useful to the Panel, CoML, and the broader community.

SCOR Panel on New Technologies for Observing Marine Life
Meeting #3

Kobe, Japan
18-20 October 2006

Meeting Summary

Panel Members Attending: Geoff Arnold, Elgar de Sa, Gaby Gorsky, John Gunn, and Bob Ward
Regrets: David Farmer, Antonio Pascoal, Alex Rogers, Heidi Sosik, and Song Sun
Others Attending: Simon Allen (CSIRO), Jesse Ausubel (Sloan Foundation), Mark Hindell (Univ. of Tasmania), Ron O'Dor (CoML Secretariat), and Ed Urban (SCOR)

Objectives of the Meeting, Review of Agenda, and Actions Since Last Meeting

The Panel chair, Elgar de Sa, opened the meeting by asking participants to introduce themselves. De Sa reviewed the agenda and Ed Urban reviewed the actions since the last meeting and action items remaining. Urban also showed the Panel the PowerPoint presentation that he made to the Census of Marine Life (CoML) Scientific Steering Committee (SSC) the previous week. Jesse Ausubel, from the Sloan Foundation, which provides support for the Panel, stated that he wants the Panel to feel free to stimulate the projects to use new technologies, including technology that will be standardized to make technology less expensive and/or easier to use. The Panel's tasks may evolve over time. It should follow the paths that it thinks will have the maximum benefit to CoML projects and CoML's legacy. The Panel could challenge CoML projects to provide feedback on their technology needs each year. It would be useful for scientists providing different kinds of observations to push together for new measurements. Ausubel suggested that GOOS could prepare a timeline for each year from 2011 to 2025 to identify what biological measurements could be included in GOOS. Ed Urban responded that the Panel and the GOOS Scientific Steering Committee could work together on this. There is already a precedent for the GOOS physical measurements, in terms of the percentage implementation of planned measurements by year.

Special Joint Session with Techno-Ocean 2006

The Panel co-sponsored a special session with Techno-Ocean 2006 on technologies related to CoML and spent time beforehand preparing for the presentations. This session was chaired by Jesse Ausubel, who introduced CoML to the audience and related the importance of new technologies to CoML. The first presentation was on electronic tag technologies and was given by John Gunn and Geoff Arnold. Gunn pointed out that satellite technologies only work with tags for animals that spend a significant amount of time at the surface each day, such as salmon sharks. He added that there is a great need to link tag data with oceanographic data; Argo floats are too far apart and spend too much time in the deep ocean to be useful for understanding marine life. Arnold noted that tidal data can help in geolocation for tagged animals that sit stationary on the bottom in tidally influenced areas.

The second presentation, on potential applications of autonomous underwater vehicles (AUVs) to CoML projects, was given by Elgar De Sa and Simon Allen. De Sa spoke about "Application of AUVs with Optics to CoML projects." He noted that there are 58 different AUVs that have been developed or are under development (see www.ausi.org/auvs/auvs.html). They range in size from very large ones to small ones that can be deployed by one or two people. Users of AUVs include remote sensing users (for sea-truthing measurements), oceanographic institutions, municipal corporations in coastal states, navy and defense laboratories, archaeological departments, the shipping industry, the offshore oil industry (for rig inspection), rapid EIA for e-governance, and BHEL. De Sa presented the technical specifications of the AUV (Maya) that he has been developing at the Indian National Institute of Oceanography. Maya is a small AUV that can carry the following science payloads: CTD, oxygen optode, radiometers, camera, and fluorometer. De Sa showed vertical dive profiles of dissolved oxygen, chlorophyll, turbidity, and temperature from Maya diving at Idukki Dam.

AUVs can dive to programmed depths, measure sensor variables while in motion, yo yo in the water column to map in three dimensions, perform mission transects below the sea surface, and avoid obstacles. AUVs use the following types of navigation:

- Open-ocean navigation with fixed LBL transponders
- Navigation with USBL—noise and alignment are problems
- Terrain-based navigation using SLAM (Simultaneous Localization and Mapping). SLAM uses AUV sensors, for example, sonar and camera, to fix unique features in an underwater environment. SLAM then attempts to "close the loops" on dead reckoned errors by recognizing these features through correspondence matching. SLAM uses loop closures and minimization criteria to continuously improve localization and mapping. SLAM works in real time and is the key to true autonomous navigation. Applications of SLAM include monitoring of coral reefs, study of hydrothermal vents and seamounts, and seabed photography.
- Low-cost navigation with Doppler Log, GPS, and Compass
- Inertial Navigation – too expensive

The types of optical instruments deployed on AUVs to date include cytometers, dissolved oxygen optodes, nutrient sensors, optical radiometers, Flowcams, turbidity sensons, and fluorometers. Examples of the use of optics on AUVs include

- the deployment of a cytometer on Autosub[6]
- deployment of an optical phytoplankton discriminator on REMUS to detect harmful algal blooms[7]
- the Shadowed Image Particle Profiling Evaluation Recorder (SIPPER) is being deployed on a 21-inch diameter AUV. SIPPER includes two line-scan cameras and two collimated laser light sheets. This allows a resolution of 4,096 pixels per line and 23,000 lines scanned/sec. Objects are back-illuminated for better depth of field, higher f number, and lower power consumption. A shadowed image is captured in two dimensions; computers reconstruct a 3-D image. The resolution is a 15-25 um particle size.

AUVs can also carry non-optical imaging instruments, such as acoustic devices. For example, AutoSub has been used to map krill under sea ice in the Antarctic.[8]

Drawbacks of AUVs include their present inability to conduct long-distance navigation (but this is under development), power constraints that limit long missions, acoustic communications are difficult in shallow waters, hovering is difficult (except for specialized UUVs like ABE, Woods Hole), and they are unstable cruising just below the sea surface.

De Sa concluded by noting how AUVs could benefit CoML projects. Already, AUVs can be used to monitor blooms of phytoplankton and zooplankton with fluorometers and cytometers, and other environmental factors with Doppler Sonar Navigation, GPS and Compass. Zooplankton can be imaged by large AUVs like AUTOSUB, which could be applied by CMarZ. Remaining challenges for AUVs include perfection of terrain-based navigation (SLAM), which will open up new opportunities for CoML projects to apply optical and other sensing to coral reefs (CReefs), seeps and vents (ChEss), and seamounts (CenSeam). The development of long-endurance AUVs with new power sources is another challenge that, when solved, will present new opportunities for observing marine organisms. Another new potential is the use of multiple coordinated AUVs, which could be used for mapping the distribution of organisms, and associated chemical and physical properties.

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[6] Cunningham, A., D. McKee, S. Craig, G. Tarran, and C. Widdicombe. 2003. Fine-scale variability in phytoplankton community structure and inherent optical properties measured from an autonomous underwater vehicle by JMS 43:51-59.

[7] Improved monitoring of HABs using autonomous underwater vehicles (AUV) (I.C. Robbins et al, Center of Coastal Marine Science, California Polytechnic State University)

[8] A.S. Brierley, P.G. Fernandes, M.A. Brandon, F. Armstrong, N.W. Millard, S.D. McPhail, P. Stevenson, M. Pebody, J. Perrett, M. Squires, D.G. Bone, and G. Griffiths. 2002. Antarctic Krill Under Sea Ice: Elevated Abundance in a Narrow Band Just South of Ice Edge. *Science* 8 March 2002 295: 1890-1892 [DOI: 10.1126/science.1068574].

Simon Allen entitled his presentation "The Need—Building Smaller Pyramids". He noted that AUVs are important because more observations of the global ocean are needed for a variety of purposes. The key to deploying more AUVs is to make them less expensive to build and deploy, including capital, logistical, and information development costs. Deploying low-cost AUVs will require taking the many steps from observing something for the first time to being able to afford to undertake those observations routinely, as well as managing the disconnect between observational science and the science of observing. Recent marine technology and equipment successes at CSIRO include

- **Redesign of deployment and attachment methods for whale shark tagging**—The results are 100% deployment success (6/6), which has never before been achieved. 5 of the 6 tags are still transmitting after 5 weeks. The longest tag attachment has been 3 months, which also was never achieved previously. One of the 6 tags was recovered and all archived data were recovered. This should prove to be a remarkable data set, although it has not yet been analysed.
- **MUFTI (MUlti Frequency Towed Instrument)—**This instrument contained repackaged commercial instruments for deployment underwater. They have increased the sensitivity of measurements compared with previously available instruments, yielding better fish stock analysis.
- **Benthic Laboratories—**Used for *in situ* benthic respiration analysis.

Existing towed systems used by CSIRO have the following features:

- Fiber optic cabling (provides real-time imagery for the ROV pilot)
- Digital stereo video (surface recorded, calibrated)
- Digital stills (trigger, instant preview)
- USBL: geolocation of data
- Navigation camera
- Remote electronic control
- Telemetry: depth, altitude, wire out
- Data: CTD, fluorometer

CSIRO deploys two ROV versions: (1) a "shallow system"—portable system – fishing vessels; wire to operate at ~500 m and (2) a "deep system" –large vessel platform; wire to operate at ~1500 m. WHOI has developed an ROV that can operate to 11,000m.

The majority of marine research technology development has been point or small area focused. However, the greatest advances in understanding in terms of impact in recent years have been made by broad area technologies. CSIRO has tested an AUV called NUI Explorer. It is estimated that it can perform surveys 10 times faster than a comparable ROV, although this AUV was damaged by the ship in the first day and the full testing could not be accomplished. Allen showed video of a low-cost AUV they are developing. It has stereo vision-based navigation and data collection, and is designed to hover and work close to the seabed.

Following these presentations, there was an opportunity to view the poster session and displays of ocean equipment at the Techno-Ocean meeting. Following this break, two presentations were given by industry representatives:

1. Outline of Microfocus X-ray CT and Its Application for Ocean Technology
   Dr. Akira HIRAKIMOTO and *Mr. Satoru IGUCHI* (Shimadzu Corp. Kyoto, Japan)
2. Current technologies of oceanographic data sensors
   Dr. Shoichirou Konashi (Alec Electronics, Kobe, Japan)

This session was chaired by Yosihisa Shirayama, the chair of the CoML Natural Geography in Shore Areas (NaGISA) project. Shirayama opened the session by presenting the technical challenge of describing the large number of species that are being discovered in some CoML projects.

Following the presentations, there was a panel discussion, with questions from the panel members to each other and from the audience. The panel included Allen, Arnold, Ausubel, De Sa, Gunn, Hirakimoto, Konashi, and Urban.

Encyclopedia of Life

Jesse Ausubel described to the panel his work on developing a proposal for an Encyclopedia of Life, which is planned to be a Web page for each know species (there are approximately 200,000 marine species). This idea was first proposed by E.O. Wilson. There were several workshops and conferences to explore the idea, but it didn't take off. Perhaps the Internet was not quite ready at that time. In 2005, Wilson contacted the MacArthur Foundation, which contacted Ausubel in his Rockefeller University capacity. Ausubel told his MacArthur Foundation contact that he thought the vision was good and the timing was right, given the success of the Wikipedia. Anyone with an interest in a species could start a thread, which could be improved later. Ausubel is chairing a small planning group to develop a proposal for the MacArthur Foundation. This group involves CoML people and some natural history museum leaders. They have prepared a short concept paper, technical specifications, and a mock-up Web site (see http://names.ubio.org/pleary/EOL/EOL_demo.html). The proposal would be for US$40 million over five years.

More recently, aggregation technology (also known as "mash-up technology") has been developed. The proposed activity would use a combination of Wiki and aggregation technologies. The species pages would be user configured. An initial activity would be to scan scholarly literature from the past, which is being done by the Biodiversity Heritage Library (BHL; see http://www.bhl.si.edu/). They are trying to form a "union catalog" that would allow a rationale scheme for digitizing literature. Intellectual property rules differ by countries, but many of the BHL institutions hold the copyrights to the original articles. CoML would like to create the provisional Web pages for all 200,000 of the known marine species, and then would encourage experts to improve the pages. They have negotiated an agreement with Google and GenBank that if a nucleotide sequence is put into Google, it will automatically search GenBank. Ausubel asked for the Panel's support of the concept and help in developing support for it.

Simon Allen stated that if the pages would be machine readable, an image acquired by an AUV/ROV could be checked against pages for help in identifying species. Gaby Gorsky asked how aggregation technology deals with junk literature. Jesse Ausubel responded that the Wiki approach allows quality control and improvement of information.

Data Visualization

Jesse Ausubel reported on CoML plans for a workshop on data visualization. Communicating information visually is important and now includes screens from normal size to personal digital assistant (PDA) size. The Framework Group for the CoML 2010 report has recommended that CoML should consider producing many short animations. There are a variety of standardization issues related to colors, icons, ways to use buttons/sliders, map projections, how passage of time is shown, etc. Ausubel noted that the visualization of ocean data could attract an industry audience. Ron O'Dor added that a large challenge, because of the limits of geolocation capabilities, is to figure out how to turn individual profiles, such as from marine mammals, into models of the ocean. John Gunn noted that computer game developers have a lot of tools that we don't know about, which Ausubel confirmed, and offered his contacts in that industry.

The following information was received from Pat Halpin for the meeting, based on discussions initiated at the last CoML2010 meeting:

At the last CoML2010 Framework committee meeting (9/18-19/2006 at St. Johns, Newfoundland), Jesse Ausubel asked Mike Fedak and Pat Halpin to take the lead on organizing an upcoming workshop on visualization technologies for CoML. The general charge is to organize a focused workshop highlighting emerging mapping, computer graphics and visualization technologies that would be directly useful for communicating CoML activities and findings to the public. The goal is to hold the workshop within the next year.

Participants in the workshop would include key individuals from a variety of CoML projects involved in a range of data visualization and communications media issues. Halpin would like to expand the participation in the workshop to bring in resources from outside of the existing CoML community, specifically inviting experts from the computer graphics, scientific publications and media industries to help us further develop our visualization products. The most useful outcomes of a workshop would be:

(1) identify high-impact visualization methods already in use by CoML projects;
(2) acquire critical reviews from external visualization, publications and multimedia experts;
(3) identify common technologies, protocols, visualization formats to help standardize CoML products; and
(4) develop a plan to coordinate the development of visualization efforts for 2010

Halpin has begun making contacts in the data visualization field (see http://vis.duke.edu/ and http://vis.duke.edu/Facilities/visroom/visualization_room.html, and http://vis.computer.org/vis2006/). The meeting could be hosted at the data visualization laboratory at Duke University. The Scripps Institution of Oceanography also has a 3D

visualization center and the University of British Columbia has a new ocean modeling visualization center that could be involved in the activity. Halpin has had contacts with TOPP already and would like to gain inputs from a variety of CoML projects as the initiative is developed.

The Panel offered help on planning and conduct of the workshop and will contact Pat Halpin to offer assistance. Jesse Ausubel stated that he hopes some Panel members would attend the workshop. John Gunn will contact Fedak and Halpin about Panel interest in the workshop. Gaby Gorsky emphasized that data visualizations must be able to show the uncertainty in our knowledge, rather than just trying to present attractive pictures that ignore or misrepresent uncertainty.

Mark Hindell added that the St. Andrews data visualization system is geared toward Argo, but is now setting up the ability to use it with Google Earth. Elgar de Sa asked if OBIS has visualization tools. Ausubel answered that the main job of OBIS is to collect spatially referenced data, although it does have a simple mapping tool built in.[9]

Panel Web site

Ed Urban presented the existing Web site and a potential (simpler) new front page to it. He stated his opinion that the main audience of the Web site is the CoML projects and the main purpose to help inform them of technologies that could be useful to them and to share technologies among them. Urban expressed that the existing CoML Technology Web site (see http://www.coml.org/edu/tech/t1.htm) is quite informative and geared toward the public, and there is no reason to duplicate that site. Elgar de Sa stated that the existing Panel Web site is very advanced (more so than an HTML-coded Web site) and has a lot of useful features. He has an instruction sheet for uploading files, images, and URLs. Urban suggested that we get the code from the Web site developers and move it to University of Rhode Island or elsewhere, since the Web site developer has been so reluctant to make the changes that we have been asking for for the past 1.5 years. De Sa suggested that we give them until the end of the year to make the requested changes and to change the managers of the Web site after that, if necessary. The Panel Web site could be a clearinghouse for information for other related groups, such as all the tagging groups, listing upcoming conferences, manufacturers, etc.

Panel Terms of Reference

Panel members and Jesse Ausubel agreed that the existing Panel terms of reference are still valid.

Panel Connections with GOOS and GEO

Ausubel reported that David Farmer, a member of the Panel has volunteered to advance ocean issues in the Global Earth Observing System of Systems (GEOSS) process. Jim Baker is

[9]Comment from Alex Rogers: It strikes me that the visualization and tagging areas have overlap. If we could generate a 3d GIS map of the oceans with excellent 3D visualization then positioning of tags from temperature and other data as well as lat / long fix may improve positioning. It is also likely to reveal a lot about animal distributions if combined with modeling of environmental preferences (e.g through ENFA). Such a map would required detailed bathymetry and depth-stratified physical data including temp, salinity, oxygen, aragonite saturation state etc.

working with Farmer to accomplish this goal through personal meetings and changes to GEOSS documents. Ausubel explained the Global Earth Observations (GEO) initiative and its relationship to the Global Ocean Observing System (GOOS). Ed Urban reminded the Panel that one legacy of its work could be to help GOOS develop its biological aspects. John Gunn reported that he is now a member of the GOOS SSC and he thinks it would be useful for the Panel to put some effort into helping GOOS with its biological activities. The Panel agreed and will address this issue at its meeting in Auckland, New Zealand in conjunction with the CoML All Program meeting (see below).

Panel Focus Areas

The Panel continues to focus its activities in a few specific areas, including molecular techniques, electronic tags, and AUVs. In addition to the information presented in the special session with Techno-Ocean, there were two presentations at the Panel meeting on these focus areas.

Mark Hindell made a presentation about emerging statistical and data issues with electronic tags and how to approach these problems:

- Data integration—This is the issue of integrating tag data with environmental data
- Problems with location—This is the largest problem with electronic tags, how to geolocate the animal position and represent the uncertainty in the location appropriately.
    - "The location problem"—Uncertainty in location occurs at all space scales for most animals that spend most of their time below the water surface, because the locations are inferred from sparse communications with satellites. In between these known locations, it is necessary to make inferences about the path of the animal through time. At least a partial solution can be achieved by using all of the data available, including supplied uncertainty (e.g., from ARGOS communications), ancillary data sources, and behavioural models that predict the most likely path of an animal based on what is known about their behaviour at certain times of the year, certain phases of their feeding and reproductive cycles, their genders, how fast they can swim, do they avoid (or are attracted to) certain environmental conditions, etc. The combination of these data can be best achieved under a Bayesian framework. Ed Urban added that it would be helpful to provide an "envelop of uncertainty" to express statistical uncertainties, as is done sometimes when presenting regression lines.
    - Geo-location—The problems related to geo-location are unquantified uncertainty, the tendency to have only one location per day, and problems that arise with using sun angle on the equinoxes (latitudes are particularly difficult to determine). Again, data of different types can be used together, including light data. Each twilight section can be used as an independent source of data, integrated with all other sources of data. ARGOS data provide an animal's location to within about 5 km.
    - Detection of areas of concentration of marine species is an important application of tagging. The most common approach is to use simple overlays of the tracks of tagged animals to see what areas feature the high density of tracks. Using this method still raises the issue of how to deal with spatial uncertainty. A slightly more sophisticated method is to show the time spent in various areas, using raster-based

analysis. Finally, identification of hotspots can be improved using behavioural models and employing fractal analysis, first passage time, and state-space models
- Visualisation—An increasingly common approach is to plot animal tracks on Google Earth maps.

John Gunn noted that taggers are focusing on patterns now, but need to understand how tagged animals can help us understand their basic biology. We can't deploy enough tags to answer some kinds of questions. Emergent properties of compiled individual data are now important. We need to use complex system models, without driving a result with Bayesian priors. We tend to look at sea-surface temperature and think the situation is simple, that is, that temperature is the primary control on the distribution of organisms. When we look at three-dimensional temperatures, however, we see that the temperatures that animals experience are very different.

Gaby Gorsky presented a review of the application of vision systems to AUVs. He presented a list of AUVs and gliders, including those with vision/optics:

Bio-optical Sensors
- Slocum gliders (http://www.webbresearch.com/slocum.htm)--has optical sensors, but not yet cameras.
- Video Plankton Recorder (VPR: http://www.whoi.edu/instruments/viewInstrument.do?id=1007)—The VPR collects digital images, but they are difficult to use for taxonomic purposes.
- ASTER^{X}—This is a French AUV capable to 3000 m. It can include a camera, including a digital "smart camera" to visualize zooplankton in blue water.
- Gavia (http://www.gavia.is/)--has a camera and light, but not high definition.
- Cytosub (http://www.cytobuoy.com/)—has *in situ* video and fluorescence analysis of particles. It includes scanning flow cytometry. High-definition television (HDTV) is beginning to be used on such vehicles, as very small HDTV cameras are being developed.
- HAB Buoy (http://www.cis.plym.ac.uk/cis/projects/HABBuoy.html)--could be put into mid-sized AUV
- DIDSON (Dual Frequency Identification Sonar: http://www.apl.washington.edu/programs/DIDSON/DIDSON.html)-- can be used in turbid water.

In the near future, the NEREUS will be deployed, which can be used in AUV and ROV mode. The bio-optical profiler will probably include a video camera in a few years. Dave Checkley has put a laser optical plankton counter (LOPC) on a profiler. Stereovision of individual organisms may not be possible. Holography may be applicable on AUVs. The visual capabilities on ROVs and AUVs is moving from 2-D to 3-D (x-ray and confocal). And, finally, intelligent AUVs are being developed, that can adapt their sampling and route based on analysis of conditions and events. The miniaturization of sensors will allow more sensor deployments.

Jesse Ausubel stated that it is important for relevant CoML projects to be aware of these developments. Ron O'Dor asked about the application of gliders for observing marine life.

Simon Allen responded that gliders are mostly for ocean basin-scale applications. The Office of Naval Research is purchasing 300 of them. They can be used for passive detection of marine mammals and can be used in depths as shallow as 50 m.

Panel Publications Under Development

The Panel has two types of publications. The first is exclusively for the Web site and these publications can be updated periodically, if desired. The first of these is on "Is Molecular Biology the Magic Bullet for Tackling Marine Biodiversity?", by Alex Rogers and Bob Ward. A second article is on "Electronic tagging of marine animals", by John Gunn and Geoff Arnold is being developed.

A second type of article are those published in hard copy. The first of these is an article on "Potential of AUVs as new generation ocean data platforms" by Elgar Desa, R. Madhan, and P. Maurya, published in *Current Science* Vol 90, No. 9, 10 May 2006. Another article is under development by Gaby Gorsky on "Optical profilers for marine ecology." This article is being targeted for publication in *Sea Technology*.

Finally, Ed Urban is developing an article on satellite communications options for oceanographic applications, including animal tagging. Urban shared the draft with the Panel. It will either be published on the Panel Web site or will be submitted to *EOS* or *Sea Technology*, depending on reactions to it by friendly reviewers. Urban will circulate the document to the Panel again when it is closer to completion.

Review of Research Proposals/Plans

The Panel discussed four CoML project research plans that had been submitted to the CoML Scientific Steering Committee and approved earlier in the year, to attempt to provide technology advice to the projects. Jesse Ausubel emphasized that the purpose was not to review the plans, because they had already been reviewed and accepted. In general, there was not enough detail in the documents to know exactly what technologies are being used and how, making it difficult to review the plans. But the Panel provides a few comments below. It would be useful to find out what technological innovations or breakthroughs each project has achieved. Also needed are methods to do species identifications without collecting every organism. CoML has requested that the Panel review the Technologies document in preparation for its revision for the 2007 CoML All Program Meeting and the Panel has started this review.

Census of Marine Zooplankton—The Census of Marine Zooplankton (CMarZ) project was presented by Gaby Gorsky. (Sun Song is a member of the CMarZ steering group, but was not at the Kobe meeting.) Gorsky presented the goals and main aspects of CMarZ. A recent CMarZ-dedicated cruise used a Mocness net to deep water. No imaging systems were used. (The necessity of at-sea barcoding depends on the taxon involved. The morphology of some groups is destroyed by acetone, although in these cases, more tissue-friendly DNA preservatives can be used **(e.g., DESS- define**).) There was an advantage that freshly collected organisms could be identified and barcoded without being put in preservative first. Gorsky stated that optical methods could be useful to increase the information gathered by CMarZ and for the study of gelatinous organisms, which do not fare well in nets. Bob Ward wondered why CMarZ is not

using the Barcode of Life Database (BOLD) to store their COI data, because BOLD has a lot of tools that can be used with data stored there. There should be a list of recommended sequences for different taxa. Bob Ward will contact Ann Bucklin about this.

Census of Diversity of Abyssal Marine Life (CeDAMar)—CeDAMar is using the Nautile submersible. John Gunn asked whether baited cameras might be used by CeDAMar in some areas Alex Rogers responded by email that baited cameras have been deployed in the abyssal ocean and are useful for attracting and estimating the density of scavengers. Also, video surveys could be a good adjunct to actual collections.

Census of Antarctic Marine Life (CAML)—CAML is still organizing, particularly for IPY. It looks like the project is going to have a significant barcoding activity. The proposal is a bit thin on technical details. Panel members suggested that CAML could use ROVs, AUVs, and gliders. If this is of interest to CAML, the Panel could gather information about platforms that can be used in the Antarctic. Will tagging be done in CAML or through TOPP? Elgar de Sa noted that CAML should be aware of the video observations being made by Italian scientists through holes in the ice. Simon Allen suggested that the ALESTAR platform can operate in AUV model. Other options for Antarctic use are ROVs that are cabled to the ship for data transfer, but have their own power supplies. These ROVs allow use of fiber optic cables, which make it possible to decouple ROV movements from movements of the mother ship to a greater degree than is possible when an ROV is powered from the ship also.[10]

Continental Margin Ecosystems on a Global Scale (CoMARGE)—The panel suggested that specimens could be collected by ROV for barcoding and voucher specimens.[11]

Census of Seamounts (CenSeam)—Alex Rogers reviewed the CenSeam renewal proposal between the meetings of the Panel and provided comments to the Sloan Foundation. He found that the most significant weakness of the programme that has come to light over the last year is the lack of shiptime for CenSeam researchers to expand their research activities into areas of the ocean in which seamounts are poorly studied. We need to ask CenSeam if they implemented the previous Panel recommendations.

<u>Proposal for SCOR Working Group on Automatic Plankton Visual Identification</u>
Ed Urban distributed to the Panel a proposal for a new SCOR working group on Automatic Plankton Visual Identification, and asked for Panel comments. Gaby Gorsky explained why such a project would be desirable. He stated that this is a good idea, in general, although it is probably too early to settle on the ZOOIMAGE system. It would be better to have some kind of objective analysis of the 4-6 existing systems before settling on one. Having a common system would avoid the problem of losing samples before they are analyzed, because they can be

[10] Comment from Alex Rogers: The ROV ISIS will be deployed in the Antarctic off the Peninsula in January 2007.

[11] Comment from Alex Rogers: They could also be collected by surface-deployed sample gears such as trawls, dredges and corers. Note that for infauna it may be desirable to divide samples and preserve in DNA-friendly and morphology-friendly ways.

analyzed quickly. It will be important in this activity to assemble information from other fields that use image analysis, such as security and medicine.[12]

Reports on Meetings Attended by Panel Members

Between annual Panel meetings, members attend associated meetings on behalf of the Panel and are expected to report back to the panel on relevant information gathered and any actions that the Panel should take.

International Underwater Robotics Workshop (8-12 Nov. 2005 in Genoa, Italy)—Elgar de Sa and Antonio Pascoal attended this meeting and de Sa gave a report about it. There is a lot of activity on coordinating motions of AUVs and gliders, from groups at MIT, in Portugal, and at the Naval Postgraduate School in Monterey, California, USA. The marine robotics community has two groups, both of which were represented at the meeting:

- Implementation of vehicle technology and applications to bathymetry mapping of coastal zones, marine life in hydrothermal vents , seamount mapping, and in inspection and surveillance of ports and harbors.
- The other group works on the mathematical theory of AUV coordination and control, neural network based control theory, terrain navigation and extended Kalman filter applications.

There is a special issue of a journal coming out of this workshop.

7th IFAC Conference on Maneouvering and Control of Marine Craft (20-22 September 2006 in Lisbon, Portugal)—Elgar De Sa attended this meeting and Antonio Pascoal was the convener. It focused on the future of AUVs and ROVs. The plenary sessions focused on marine robots as advanced tools for marine science, coordination and control of multiple vehicles, underwater navigation, future developments and applications of marine robotics, and control of design models of marine vessels.

CoML Barcoding Meeting (15-16 May 2006 in Amsterdam, Netherlands)—Panel members Bob Ward and Sun Song attended this meeting and Ward was on the planning committee for it. Ed Urban also attended. CMarZ acknowledged the Panel's contribution to the barcoding meeting in its annual report to the CoML SSC.

11th Deep-Sea Biology Symposium (9-14 July 2006 at Southampton, UK)—Alex Rogers attended this meeting and provided a written report about it. There was no suggested actions for the Panel from this meeting.

CoML SSC Meeting (13-14 October 2006, Nara, Japan)—Ed Urban attended this meeting and reported on SCOR activities of interest to CoML (CoML is affiliated to SCOR). As part of this presentation, he gave the CoML SSC an update about Panel activities. The SSC seemed pleased with the Panel's work. They asked that the Panel give some attention to the problem of geo-location for electronic tags and asked that the Panel add an expert on data visualization. Urban suggested that the Panel should be involved in planning the technology session at the CoML All Program meeting in New Zealand in November 2007.

[12] Comment from Alex Rogers: I agree this is a useful project. However, surely we should also consider ways in which to gain meaningful data on fast-movers in the oceans such as squid. This could link up with AUV technology.

Panel Representation at Future Meetings

International Marine Acoustic Telemetry 2006 (5-9 November 2006 in Leigh, New Zealand)—John Gunn reported that this meeting has been cancelled or postponed.

CMarZ Steering Group meeting (5-8 November 2006 in Tokyo, Japan)—Sun Song is a member of the CMarZ Steering Group and will attend this meeting.

Tagging Meeting in Monterey (7-9 March 2007)—John Gunn and Geoff Arnold will participate in this meeting. One of the purposes will be to get tagging scientists and tag manufacturers together.

Second International Symposium on Tagging and Tracking Marine Fish with Electronic Devices (8-12 October 2007, in San Sebastián, Guipúzcoa, País Vasco, Spain)—The Panel will offer to help with this meeting, either as a co-sponsor, by having a session, or by some other means.

Microbiology Meeting in Cochin, India—Bob Ward will attend, as there is a session on barcoding. **Bob, please provide a few details and whether there should be any Panel action.**

4th International Zooplankton Production Symposium (May 28, 2007 - Jun 01, 2007 in Hiroshima, Japan)—Gaby Gorsky will be attending this meeting.

Additions/Replacements to Panel

As mentioned earlier, the CoML SSC asked the Panel to add a data visualization expert. There was also some uncertainty about whether Heidi Sosik is interested in remaining on the Panel. Ed Urban will check on this. Other ideas included someone who works on gliders, someone from MBARI, and Marsh Youngbluth from the Harbor Branch Oceanographic Institution,

Members Assigned to CoML Projects

Jesse Ausubel suggested that Ron O'Dor and Ed Urban be more proactive about building linkages between the panel and projects, including appointing project liaisons. The project liaisons were updated, although some projects still need a liaison.

ArCOD:
CAML: Bob Ward
ChEss: ??
CeDAMar: Alex Rogers
CenSeam: Alex Rogers
CmarZ: Sun Song, Gaby Gorsky
CoMarge: Simon Allen (not a panel member)
CReefs: Elgar Desa, Bob Ward
GOMA: David Farmer
ICoMM: Heidi Sosik
MAR-ECO: Gaby Gorsky
NaGISA: Ed Urban (not a panel member, but willing to liaise with this group)
POST: David Farmer
TOPP: John Gunn, Geoff Arnold

Plans for Next Panel Meeting

The next panel meeting will be held in conjunction with the Census of Marine Life 3rd All Program Meeting, in Auckland, New Zealand in November 2007. Panel members will participate in project meetings before the main CoML meeting and will meet afterward to discuss contributions of biological measurements to GOOS and other Panel business:

- Attend meetings of CoML projects on 12-13 Nov.
- Attend public event on 14 Nov.
- Attend All Program Meeting on 15-16 Nov.
- Hold Panel meeting on 17 Nov.

Action Items

Actions Items Left Over from Frankfurt Meeting

Actions	Who	By when
Update de Sa PowerPoint slides to include all 14 CoML projects	Urban	In progress
Make suggestions of new Panel members: industry, acoustics, satellite technology, visualizations	Panel	Jan. 31
Look for a nanotechnology meeting to send a Panel member or two to.	All	Continuing
Investigate what panel could do in terms of advancing image analysis applications	Gaby	
Web site actions: • List all the CoML projects on the top navigation bar • Work on copyrights for materials on site • Still need to populate the site. Panel members can load information themselves or can ask Ed or Elgar to do it.	Elgar Ed Panel	ASAP In progress
New Action Items from Kobe Meeting		
Provide feedback to Jesse Ausubel on Encyclopedia of Life Plan, when ready to review	All	
Contact Pat Halpin to offer Panel help with the data visualization workshop	John Gunn	ASAP
Synergy Web site developers to make all the requested changes	Elgar	By Dec. 31
Panel Web site • Make sure that the Rogers/Ward article is posted correctly • Are there usage statistics for the site? Add Google Analytics? • Link barcoding site to Panel Web site	Elgar Elgar	ASAP

Publications Under Development • Gorsky paper on optical technologies • Gunn paper on tags • Urban paper on satellite communications		
Advice to CoML Projects • Panel members to review new assignments of project liaisons • Panel members to read the CoML Methodologies report and original research plan for their assigned project(s) • Contact Ron O'Dor about technology people on the individual projects	All All Ed	ASAP Feb. 15 Done, awaiting a response
Panel Membership • Determine Heidi Sosik's interest in remaining on Panel • Add expert in data visualization	Ed Ed to consult with Ausubel and O'Dor	Done, awaiting a response By Dec. 31
Upcoming Meetings • Will Sun Song be attending the CMarZ Steering Group meeting in November? • Second International Symposium on Tagging and Tracking Marine Fish with Electronic Devices – Offer Panel assistance	Ed, Sun John, Geoff	Report received
All Program Meeting in New Zealand • Offer Panel Assistance with Technology Session	Elgar, Ed	ASAP
Panel Meeting in New Zealand • Plan a session on biological obs. for GOOS. John Gunn will write up a short description of a proposal for a brainstorming session.	John	
Add Keith Alverson and John Field (GOOS) to Panel email list	Ed	Done
Contact Ann Buckin about putting together a list of recommended sequences for different taxa	Bob	
Ask CenSeam if they have implemented Panel recommendations	Ed? Or Alex?	

4.3.3 SOLAS/INI Workshop on Anthropogenic Nitrogen Impacts on the Open Ocean

Anthropogenic Nitrogen Impacts on the Open Ocean

Scientific Rationale

A workshop entitled "Anthropogenic Nitrogen Impacts on the Open Ocean was held at the University of East Anglia in Norwich, UK from November 17-21, 2006. This workshop was developed by the Surface Ocean Lower Atmosphere Study (SOLAS) and the International Nitrogen Inititative (INI) and was sponsored by the Scientific Committee on Oceanic Research (SCOR), the US National Oceanic and Atmospheric Administration (NOAA), and the European Science Foundation (ESF).

Nitrogen is an essential nutrient in both terrestrial and marine ecosystems. Most of the nitrogen in the atmosphere and ocean is present as N_2 and is available only to diazotrophs, a restricted group of prokaryotes. Most organisms can only use reactive nitrogen (N_r, also termed fixed nitrogen), which includes oxidized, reduced and organic forms of nitrogen. In much of the ocean N_r limits net primary production - the conversion of inorganic carbon to organic carbon, with the degree of limitation varying significantly across the world ocean. Reactive nitrogen enters the ocean via rivers, N_2-fixation by diazotrophs, and deposition from the atmosphere. It is removed via N_2 formation by denitrification and anaerobic ammonium oxidation, nitrous oxide and ammonia emissions, and burial of organic matter in sediments. Human activities have severely altered many coastal ecosystems by the increasing input of anthropogenic nitrogen through rivers, direct discharges from wastewater treatment facilities, etc., resulting in extensive eutrophication. Less well known is that human activities also result in the addition of large quantities of atmospheric nitrogen species to the ocean - not only in the coastal zone but also in offshore and mid-ocean regions.

Of the total primary production in the ocean, ~80% is supported by nutrients regenerated within the shallow surface mixed layer, and much of the rest (termed new production) is fuelled by nitrate regenerated at depth from sinking organic matter and subsequently supplied to the euphotic zone via physical transport. However, only external (to the ocean) sources of reactive nitrogen that reach the surface of the ocean can impact the steady-state balance of the biologically mediated flux of CO_2 across the air-sea interface. The two sources of external fixed nitrogen in open ocean regions are biological N_2-fixation and atmospheric deposition. The primary objective here was to evaluate the potential impact of this increasing anthropogenic atmospheric nitrogen deposition on oceanic productivity and biogeochemistry and its possible climatic implications.

Preliminary Conclusions

While there has been extensive investigation of the impact of human-derived nitrogen species on the terrestrial environment, and an increasing realization of the importance of anthropogenic sources of nitrogen in the coastal environment, there has been very little work on determining the effect of anthropogenic nitrogen on open ocean biological and chemical systems and feedbacks within these systems. For example, direct changes in marine productivity may occur due to atmospheric deposition of anthropogenic nitrogen to the open ocean, and the additional organic carbon generated could have an impact in regions where dissolved oxygen concentrations are already low.

Human activities do result in the addition of large quantities of fixed nitrogen to the open ocean from the atmosphere, and this has significantly increased in recent years. From 1860 to 2000 the total atmospheric deposition of reactive nitrogen to the ocean increased by a factor of ~3.4, whereas the anthropogenic fraction increased by over a factor of 9. By 2000 anthropogenic nitrogen deposition to the ocean was over 80% of the total deposition from the atmosphere. This fraction is expected to continue to grow in the future. At the present time the atmospheric input of anthropogenic fixed nitrogen, primarily as NO_3^-, NH_4^+ and organic nitrogen, is ~54 Tg yr^{-1}, and this accounts for about one third of the external nitrogen supply to the open ocean globally, the rest being from N_2-fixation. It is estimated that this anthropogenic atmospheric deposition can account for up to ~3% of the annual new marine biological production in the open ocean, or ~0.3 Pg C yr^{-1}. This is comparable in magnitude to that supported by marine biological N_2-fixation. Anthropogenic nitrogen inputs from the atmosphere to the ocean also have potentially important climatic implications. Roughly 10% of the present anthropogenic carbon uptake by the ocean (as CO_2) may result from this fertilization of the ocean by the atmospheric flux of human-derived nitrogen. The input of atmospheric anthropogenic nitrogen also results in the production of ~1.5 Tg yr^{-1} of the greenhouse gas nitrous oxide, approximately one third of its total estimated emission from the ocean and about one quarter of the emission of this gas from all human activities. The decrease in radiative forcing from increased CO_2 uptake outweighs the increase in radiative forcing from increased N_2O emissions by up to ~50%. These effects are expected to show a moderate increase in the future.

Practicalities

The workshop consisted of a series of plenary talks among the relatively small group of participants (31), followed by open and focused discussion of the issues of importance to the community. At the end of the workshop it was decided that products would include a major synthesis paper for submission Science (or Nature), as was done for the recent workshop led by Jickells et al. (2005) on global iron connections between the desert, the oceans and climate, with possibly one or two more detailed papers submitted to more specialized journals. Co-Chairs for the workshop were an oceanographer (Julie LaRoche, Germany) and an atmospheric chemist (Robert Duce, USA). The co-chairs were responsible for the development of the agenda for the meeting, including the topics to be covered (atmospheric transport and transformation, deposition and modelling, marine transport and N dynamics, etc) and were largely responsible for the selection of the workshop participants, who were selected on the basis of their scientific standing and ability to contribute to the task, paying particular attention to gender and inclusion of scientists from less developed countries (of which several made substantial contributions to the workshop).

The total cost of the workshop was approximately $32,000 (31 participants; travel, subsistence, accommodations, publications, administrative assistance, etc). Funds for this purpose were obtained from the SOLAS International Project Office ($5000), SCOR ($15000), NOAA ($5000), and the ESF (about $6500).