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

Scientific Steering Group Members (2008-2010)

Chair	Chris Sabine, NOAA / PMEL (USA)
Repeat Hydrography	Masao Fukasawa, JAMSTEC (Japan)
Surface Ocean CO2 Data	Dorothee Bakker, UEA (UK)
Underway pCO2 Measurements	Pedro Monteiro, CSIR (South Africa)
Time Series Stations	Melchor Gonzalez, U. Las Palmas (Spain)
Surface Flux Maps / Data Assimilation	Ute Schuster, UEA (UK)
Ocean Interior Data	Toste Tanhua, IfM-Geomar (Germany)
Data and Information Management	Alex Kozyr, CDIAC (USA)
Integrated Greenhouse Gas Monitoring Networks	Yukihiro Nojiri, NIES (Japan)
SOLAS / IMBER carbon coordination group focal points:	Jean-Pierre Gattuso, CNRS-UPMC (France) Nicolas Gruber, ETH-Zurich (Switzerland) Nicolas Metzl, LOCEAN-IPSL, CNRS (France)

PROJECT COORDINATOR: Dr. Kathy Tedesco, UNESCO-IOC (k.tedesco@unesco.org)

SPONSORS

UNESCO - Intergovernmental Oceanographic Commission
Dr. Kathy Tedesco, UNESCO - IOC

Scientific Committee on Oceanic Research
Dr. Ed Urban, SCOR

THE INTERNATIONAL OCEAN CARBON COORDINATION PROJECT (IOCCP)
A joint project of SCOR and IOC and an affiliate program of the Global Carbon Project.
Project Coordinator: Kathy Tedesco, Intergovernmental Oceanographic Commission - UNESCO

_____NEWSLETTER No. 28, Summer 2010_____

*** The Ocean in a High-CO_2 World Symposium 2012 international planning committee and venue selected
*** Guide to Best Practices for Ocean Acidification Research and Data Reporting now available online
*** LDEO Database Version 2009 now available from CDIAC
*** Surface Ocean CO_2 Atlas (SOCAT) Project Update
*** Recent Workshops
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PACIFICA Workshop, Tokyo, Japan

www.ioccp.org

Third Symposium on The Ocean in a High-CO_2 World international planning committee and venue selected

A consortium of institutions and organizations from Monterey, California has successfully bid to host the third symposium on The Ocean in a High-CO_2 World in autumn 2012. The symposium aims to attract more than 300 of the world's leading scientists to discuss the impacts of ocean acidification on marine organisms, ecosystems, and biogeochemical cycles. It will also cover socio-economic consequences of ocean acidification, including policy and management implications.

The symposium is sponsored by the Scientific Committee on Oceanic Research (SCOR), Intergovernmental Oceanographic Commission (IOC) of UNESCO, and International Geosphere-Biosphere Programme (IGBP), which selected the Monterey consortium from eight bids to host the meeting. The international Planning Committee is led by Prof. Dr. Ulf Riebesell of the Leibniz Institute of Marine Sciences (Germany), and the local organization is led by Dr. Jim Barry of Monterey Bay Aquarium Research Institute and supported by a consortium of institutions.

The symposium is the third in a series and will build on the successes of the Paris and Monaco symposia in 2004 and 2008, respectively. The Paris meeting was seminal in identifying the magnitude of ocean acidification for marine ecosystems and the outcomes of the Monaco symposium, focusing on the advances in knowledge of the affects on marine organisms, also made an impact on a broader audience through a Summary for Policymakers and the Monaco Declaration.

The international planning committee will meet in December 2010 to develop the scientific program for the symposium. Please contact Ed Urban (Ed.Urban@scor-int.org) if you would like to provide ideas for symposium topics. Inputs will be collated and provided to the planning committee.
More information: http://www.ocean-acidification.net/
To subscribe to email updates: secretariat@scor-int.org

International Planning Committee
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Claire Armstrong, Univ. of Tromsø, Norway
Peter Brewer, Monterey Bay Aquarium Research Institute, USA
Ken Denman, Fisheries and Oceans Canada
Richard Feely, National Oceanic and Atmospheric Administration, USA
Kunshan Gao, Xiamen Univ., China
Jean-Pierre Gattuso, Observatoire Océanologique Laboratoire d'Océanographie, France
Dan Laffoley, Natural England and the International Union for Conservation of Nature, UK
Yukihiro Nojiri, National Institute for Environmental Studies, Japan
James Orr, Laboratoire des Sciences du Climat et l'Environnement, France

Hans-Otto Poertner, Alfred Wegener Institute, Germany
Carlos Eduardo Rezende, Universidade Estadual do Norte Fluminense, Brazil
Daniela Schmidt, Univ. of Bristol, UK
Anya Waite, Univ. of Western Australia

Sponsor Representatives
Wendy Broadgate, International Geosphere-Biosphere Programme (wendy@igbp.kva.se)
Kathy Tedesco, Intergovernmental Oceanographic Commission of UNESCO (k.tedesco@unesco.org)
Ed Urban, Scientific Committee on Oceanic Research (Ed.Urban@scor-int.org)

Guide to Best Practices for Ocean Acidification Research and Data Reporting now available online

Ocean acidification is an undisputed fact. The ocean presently takes up one-fourth of the CO_2 emitted to the atmosphere from human activities. As this CO_2 dissolves in the surface ocean, it reacts with seawater to form carbonic acid, increasing ocean acidity and shifting the partitioning of inorganic carbon species towards increased CO_2 and dissolved inorganic carbon, and decreased concentration of carbonate ion. While our understanding of the possible consequences of ocean acidification is still rudimentary, both the scientific community and society at large are increasingly concerned about the possible risks associated with ocean acidification for marine organisms and ecosystems.

As this new and pressing field of marine research gains momentum, many in our community, including representatives of coordinated research projects, international scientific organisations, funding agencies, and scientists in this field felt the need to provide guidelines and standards for ocean acidification research.

To initiate this process, the European Project on Ocean Acidification (EPOCA) and the Intergovernmental Oceanographic Commission (IOC) jointly invited over 40 leading scientists active in ocean acidification research to a meeting at the Leibniz Institute of Marine Science (IFM-GEOMAR) in Kiel, Germany on 19-21 November 2008. At the meeting, which was sponsored by EPOCA, IOC, the Scientific Committee on Oceanic Research (SCOR), the U.S. Ocean Carbon and Biogeochemistry Project (OCB) and the Kiel Excellence Cluster "The Future Ocean", the basic structure and contents of the guide was agreed upon and an outline was drafted. In the following months, the workshop participants and additional invited experts prepared draft manuscripts for each of the sections, which were subsequently reviewed by independent experts and revised according to their recommendations. Starting 15 May 2009, the guide was made publicly available for an open community review. The final version of the guide is now published:

Riebesell U., Fabry V. J., Hansson L. and Gattuso J.-P. (Eds.), 2010. Guide to best practices for ocean acidification research and data reporting, 260 p. Luxembourg: Publications Office of the European Union.

It is available free of charge on the EPOCA web site (http://www.epoca-project.eu/index.php/Home/Guide-to-OA-Research/). It is envisioned to revisit and possibly revise the guide to accommodate new developments in the field in a few years' time. Please contact Lina Hansson (hansson@obs-vlfr.fr) at the EPOCA project office to obtain printed copies of the guide.

We are very grateful to all colleagues who have committed their precious time to the preparation of this guide as chapter editors, lead and contributing authors, and reviewers. On behalf of the writing team, Ulf Riebesell, Victoria J. Fabry, Lina Hansson and Jean-Pierre Gattuso (editors)

LDEO Database Version 2009 now available from CDIAC

Approximately 4.75 million measurements of surface water partial pressure of CO_2 obtained over the global oceans during 1968-2009 are listed in the Lamont-Doherty Earth Observatory (LDEO) database, which includes open ocean and coastal water measurements. The data assembled include only those measured by equilibrator-CO_2 analyzer systems and have been quality-controlled based on the stability of the system performance, the reliability of calibrations for CO_2 analysis, and the internal consistency of data. To allow re-examination of the data in the future, a number of measured parameters relevant to pCO_2 measurements are listed. The overall uncertainty for the pCO_2 values listed is estimated to be +/- 2.5 µatm on average.

For simplicity and for ease of reference, this version is referred to as 2009, meaning that data collected through 31 December 2009 has been included. It is our intention to update this database annually. There are 42 new cruise/ship files in this update. In addition, some editing has been performed on existing files so this should be considered a "V2009" file. Also we have added a column reporting the partial pressure of CO_2 in seawater in units of Pascals.

The data presented in this database include the analyses of partial pressure of CO_2 (pCO_2), sea surface temperature (SST), sea surface salinity (SSS), pressure of the equilibration, and barometric pressure in the outside air from the ship's observation system.

The global pCO_2 data set is available free of charge as a numeric data package (NDP) from the Carbon Dioxide Information Analysis Center (CDIAC) (http://cdiac.ornl.gov/oceans/LDEO_Underway_Database/). The NDP consists of the oceanographic data files and this printed documentation, which describes the procedures and methods used to obtain the data.

Takahashi, T., S.C. Sutherland, and A. Kozyr. 2010. Global Ocean Surface Water Partial Pressure of CO_2 Database: Measurements Performed During 1968-2009 (Version 2009). ORNL/CDIAC-152, NDP-088(V2009). Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, doi: 10.3334/CDIAC/otg.ndp088(V2009). - Alex Kozyr (CDIAC)

Surface Ocean CO_2 Atlas (SOCAT) Project Update

The Surface Ocean CO_2 Atlas (SOCAT) is an international effort to create a global database of the fugacity of carbon dioxide (fCO_2) in oceanic surface waters (http://www.socat.info/). Two data products will be made available as part of SOCAT: 1) a uniform, quality-controlled surface water fCO_2 data set and 2) a gridded monthly, global product with no interpolation. These SOCAT products will enable scientists to study temporal and spatial variations in oceanic CO_2 and will provide a validation and baseline for modelling studies. Regular updates of the SOCAT products are envisaged.

The SOCAT effort depends on the submission of high-quality carbon data to the Carbon Dioxide Information Analysis Center (CDIAC) by scientists across the globe, recalculation of fCO_2 following a well-defined protocol and quality control of the data by SOCAT participants. The data compilation is an ongoing process, so data can be submitted at any time for inclusion in the next SOCAT version. The Live Access Server (LAS) provides access to the vast data set to SOCAT participants during quality control and will allow the public to explore and download the data and gridded products once released. The current version of SOCAT (version 1.3) contains 7.6 million recalculated fCO_2 values from 2175 voyages between 1968 and 2007. The participants aim to finish the quality control of SOCAT version 1.3 by 1 October 2010. The first public release of the SOCAT products (version 1.3) is planned for early 2011.

This large effort has several key figures, notably Benjamin Pfeil, Are Olsen (University of Bergen, Norway), Steven Hankin, Jeremy Malczyk, Denis Pierrot (National Oceanic and Atmospheric Administration, USA), the regional group leaders and the global team. SOCAT is supported by UNESCO-IOC/SCOR-IOCCP (Scientific Committee on Oceanic Research - International Ocean Carbon Coordination Project), SOLAS (Surface Ocean – Lower Atmosphere Study) and IMBER (Integrated Marine Biogeochemistry and Ecosystem Research). Support for SOCAT workshops has also been received from European Union COST Action 735, NIES (National Institute for Environmental Studies, Japan) and CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia).
- Dorothee Bakker (University of East Anglia, UK)

Recent Workshops

SOCAT Southern Ocean Regional Workshop, Hobart, Australia

The SOCAT Southern Ocean Regional Workshop, sponsored by IOCCP, SOLAS/IMBER, and CSIRO was held June 16-18, 2010 in Hobart, Australia. During three days, both Southern Ocean and Indian Ocean SOCAT groups (15 participants) met to discuss progress on SOCAT Quality Control in these regions (including updated information from the Pacific SOCAT group), revisiting new LAS tools developed for SOCAT, as well as science issues to be conducted in the following months (e.g. RECCAP, IPCC AR5...) and future observations.

Given the analysis already performed by different regional PIs for the past few months, the Southern and Indian Ocean groups agreed to finalize the QC2 analysis before October 2010. It has also been proposed to release the SOCAT version 1 in April 2011.

The Southern and Indian ocean SOCAT meeting in Hobart was supported by IOCCP, SOLAS and CSIRO, and national support from Japan and France.

Many people at CSIRO-Hobart contributed to the success of this meeting; I would like to address a special thank you to Kristina Paterson and Bronte Tilbrook.

A complete report of this meeting will be soon posted on the IOCCP, SOCAT, SOLAS and IMBER websites

-Nicolas Metzl (LOCEAN/IPSL) and Bronte Tilbrook (CSIRO)

PACIFICA data synthesis workshop, Tokyo, Japan

Twenty experts on hydrographic/chemical observations and data management from Canada, Korea, Japan and the United States met in Tokyo on 2-4 June 2010 to discuss the 2nd-level quality control of PACIFICA. PACIFICA is the synthesized database of CO_2 and its related parameters for the interior of the Pacific Ocean. It now includes data sets from 265 cruises including the total of 14 cruises of CLIVAR Repeat Hydrography and many of several repeat lines such as 137°E, Line-P, station KNOT and A-line that is not in GLODAP.

Following the agreements in the previous workshop held in Jeju, Korea, in October 2009 as a part of PICES annual meeting, the studies on data in order to quantify systematic difference in the reported values, i.e., 2nd level QC, has been started on the basis of the cross-over analyses for the data from deep in the ocean. Thanks to Toste Tanhua and Steven van Heuven, who developed Matlab routines for the cross-over analysis in CARINA project, PACIFICA is also using the same routines for its efficient cross-over analyses and the inversions.

In this workshop, the selection of "Core Cruise" settings for the variety of variables for cross-over analysis, weighting in the inversions, minimum adjustments and so on that are

potentially unique to the Pacific Ocean were discussed on the basis of the oceanographic and methodological knowledge and several preliminary runs of cross-over analyses. The status of the QC of the ocean CFC data and that of data collection and some 2nd-level QC activities in the marginal seas were also reported. Finally, action items toward the completion of 2nd-level QC were discussed and agreed. The next workshop of PACIFICA is planned as part of the PICES annual meeting in October this year in Portland, USA, to complete the 2nd-level QC. PACIFICA is to be publicly available from Marine Information Research Center (MIRC) in Japan and Carbon Dioxide Information and Analysis Center (CDIAC) in USA.
-Masao Ishii (MRI-JMA)

4.2 Symposia on The Ocean in a High-CO_2 World

The importance of the ocean in the carbon cycle and the interactions between atmospheric carbon dioxide and carbon in the ocean have been understood for many decades at a basic level. For example, Roger Revelle stimulated monitoring of atmospheric carbon levels in 1957 by establishing the Mauna Loa CO_2 observatory, and Revelle, N.W. Rakestraw, and others formed the second SCOR working group, on Carbon Dioxide in the Ocean soon after that, in 1958. SCOR and IOC took up the issue of the ocean carbon cycle in the decades that followed, with efforts continuing to the present. SCOR approved the Joint Global Ocean Flux Study (JGOFS) in 1987 as a SCOR project and the International Geosphere – Biosphere Programme (IGBP) accepted JGOFS as its first core project in 1989. By the time JGOFS was completed in 2003, our understanding of the ocean carbon cycle had improved considerably (Fasham et al., 2003).

The ocean science community, in general, believed that the ocean carbonate system was so well buffered that on short time scales atmospheric CO_2 would not diffuse into the ocean fast enough to significantly affect ocean pH. However, a few individuals began modeling and observations in the 1990s that indicated otherwise. The SCOR/Land-Ocean Interactions in the Coastal Zone Working Group 104 on Coral Reefs and Environmental Change--Adaptation, Acclimation, or Extinction produced a special issue of *American Zoologist* in 1999 that highlighted potential effects of pH on corals (e.g., Gattuso et al.,1999 and Kleypas et al., 1999b). A highly cited *Science* paper by Kleypas et al. (1999a) was published a few months later. Caldeira, Sarmiento, and others began to model the effects of atmospheric CO_2 invasion on the ocean carbon cycle and Caldeira and Wickett (2003) published an influential *Nature* paper in which the term "ocean acidification" was first used.

The focus of SCOR and IOC on ocean acidification grew out of concerns about the scientific basis of ocean carbon sequestration, through surface ocean fertilization and deep ocean injection of CO_2. NSF awarded SCOR funding in 2002 for an international symposium on this topic. SCOR invited IOC to co-sponsor the symposium. The planning committee determined that, in addition to including the topic of carbon sequestration science, the symposium should include a focus on what would happen to the ocean in a world in which atmospheric CO_2 increases in the absence of carbon sequestration. Thus was begun the symposium series on The Ocean in a High-

CO_2 World. The first symposium was held in Paris at UNESCO Headquarters in 2004 and attracted about 125 participants. Papers from the symposium were published in a special issue of the *Journal of Geophysical Research-Oceans* in 2005 and the symposium was summarized in articles in *Oceanography* magazine (Cicerone et al., 2004a) and *EOS* (Cicerone et al., 2004b). The results of discussions were given in greater detail in a Research Priorities Report (see http://www.ocean-acidification.net/Symposium2004/Symp2004Docs/Research%20Priorities%20Report-Final.pdf). Papers from the symposium contributed to a Special Report on Carbon Capture and Storage by the Intergovernmental Panel on Climate Change: (http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm).

SCOR and IOC determined that they should hold such a symposium once every four years, as long as the issue is important to the scientific community and policymakers. Allowing four years between symposia makes it possible to accumulate a critical mass of research on ocean acidification. The second symposium was held in Monaco in 2008 and attracted about 225 participants; the International Atomic Energy Agency and IGBP joined as co-sponsors. A Research Priorities Report (http://www.ocean-acidification.net/Symposium2008/ResearchPrioritiesReport_OceanHighCO2WorldII.pdf), *Oceanography* magazine article (Orr et al., 2009), and Summary for Policymakers were produced from the meeting. The symposia have played an important role in creating bridges among different subdisciplines of ocean science that are relevant to ocean acidification, but which don't often meet together. The attention given to ocean acidification by the ocean science community after the 2004 symposium is partially due to the fact that that symposium was the first time biologists and chemists met together to discuss ocean pH. All the materials from the past two symposia can be found at http://www.ocean-acidification.net/. We are now planning the third symposium, for 2012, co-organized by SCOR, IOC, and IGBP, to be held in Monterey, California.

Decreases in surface ocean pH have been detected at many long-term ocean observation sites and the chemistry of ocean acidification is well known. There is now a great deal of research being conducted on the affects of ocean acidification on calcification and development of individual organisms, but research on populations and ecosystems is still lacking. A re-discovered issue at the time of the 2008 symposium in Monaco was the effects of decreasing pH on sound in the ocean, which could have a dramatic impact on the communications of baleen whales and some other organisms. Other relatively unexplored areas of research relate to the economics and sociology of ocean acidification. One of the major jobs of the committee planning the 2012 symposium will be to identify areas of ocean acidification research that need greater attention and to design the symposium in a way that these areas are highlighted, while also giving adequate attention to topics that have been the focus of research in the short time since this research area emerged. The planning committee will use several sources of information to help select the topics and speakers for the 2012 symposium, including the recent special issue of *Oceanography* magazine, a report recently issued by the U.S. National Research Council (*Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*), the topics identified as a result of the first NSF Ocean Acidification Request For Proposals (RFP):

(molecular/cellular, high-latitude, and paleoceanographic aspects of ocean acidification); suggestions from the research community; and documents from the national research projects on ocean acidification of other nations.

SCOR and IGBP co-sponsor two research projects with activities relevant to ocean acidification, the Surface Ocean – Lower Atmosphere Study (SOLAS) and the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. The activities of SOLAS focus on CO_2 dynamics at the air-sea interface, and physical and chemical processes in the surface ocean related to entry of CO_2 to the ocean carbon cycle and transfer to biological processes. IMBER activities related to carbon focus on chemical-biological interactions and flux of carbon below the surface ocean layer. SOLAS and IMBER have published a plan describing how their carbon research activities interact and have formed a specific inter-project committee on ocean acidification, the SOLAS-IMBER Ocean Acidification committee. This committee aims to serve as a mechanism for coordinating national and regional ocean acidification research, such as sponsored as part of the U.S. Ocean Carbon and Biogeochemistry program, the German BIOACID program, the European Project on Ocean Acidification (EPOCA), and similar research efforts in the United Kingdom, Japan, and elsewhere. The 2012 symposium will provide an excellent opportunity for synergy among these activities, both through the symposium and side events.

The sponsors of the 2012 symposium issued a request for bids to host the symposium and received eight bids, from institutions and consortia of institutions. The proposals were assessed by a panel consisting of representatives of the three meeting sponsors (SCOR, IOC and IGBP) and the chair of the planning committee for the symposium. The bids were compared based on the suitability of meeting facilities and practical arrangements, overall costs per participant, relative carbon footprint of the meeting, contributions of financial and in-kind support, opportunities for outreach and policy engagement, and the likely long-term impact of holding the meeting in each location. The panel discussed the proposals over a period of several months, gathering additional information when necessary to clarify how individual bids compared with each other. All proposals were of high caliber and satisfied most of the requirements. However, the panel decided that the Monterey proposal was most in line with the ambitions of the sponsors and led by a strong consortium of organizations providing both scientific and organizational support, combined with strong financial sponsorship.

<u>Symposium Components</u>
We anticipate that we will organize the 2012 symposium in a similar way to the 2008 symposium, with the following components:

1. Plenary Presentations—Most of the symposium will be devoted to plenary presentations, to provide a forum for the global community of scientists working on research related to ocean acidification to share their research results. About half of the plenary presentations will be selected by the planning committee as review presentations on aspects of ocean acidification that the committee wants to ensure are discussed in the symposium. The

other half of the presentations will be selected from contributed abstracts. In the 2008 symposium, the contributed oral presentations covered mainly research results.

2. Poster Presentations—It will be impossible for everyone who wants to share research results to make a plenary presentation, so we will again provide an opportunity for all participants to present information in poster form. We will set aside time for one or more designated poster sessions and will seek arrangements that will allow us to make the posters available for viewing at other times also. The abstracts submitted will be reviewed and evaluated by planning committee members.
3. Discussion Session(s)—An important part of the past two symposia has been the discussion sessions, focused around identifying priority research, observations, and other aspects for which international community consensus needs to be developed.
4. Outreach and Education—The first symposium recommended forms of outreach needed to reach policymakers and the public, and the second symposium used some of these approaches. We anticipate that there will be one-half to one full day after the science sessions which will be tailored to reach policymakers and the public. In the second symposium, this took the form of a science summary, presentations on socioeconomic aspects of ocean acidification, a presentation by Prince Albert II of Monaco, and a session in French for local school teachers. We are seeking specific foundation funding for this aspect of the symposium, and IGBP and IOC will lead planning for this component of the symposium. The Monterey bid included the offer to fund 5 teachers to participate in the symposium. Part of the proposed NSF funding will be used to support the participation of 25 early career scientists and students/scientists from under-represented groups. The planning committee will set up a subcommittee (including individuals representing the local hosts) to develop this aspect of the meeting. The symposium organizers will make a special call for graduate students, early career scientists, and scientists from under-represented groups to submit applications for support to participate in the symposium. (We will consult with professional societies for help and universities for assistance in reaching under-represented groups.) Applications will be evaluated based on a submitted abstract, seeking to balance geographic location of the recipients, expertise, and gender, with attention to participation of under-represented groups. Provision of travel support will be subject to approval of an abstract for an oral or poster presentation. (The 2008 symposium included several oral student presentations, based on their selection for a small number of oral presentation slots. The student presentations were of uniformly high quality.) Successful applicants for travel support will be assigned a mentor who will work with them before, during, and after the symposium to ensure the maximum benefit to them from their participation in the symposium.

<u>Symposium Products</u>

We have developed different products for the different audiences that we have targeted with the results of the past symposia:

- Special Issue of a Peer-Reviewed Journal—We believe that it is important to stimulate the publication of research results on ocean acidification in the peer-reviewed literature

and that there is value in producing a special issue associated with each symposium. For the first symposium we published a special issue of the *Journal of Geophysical Research-Oceans*. For the second symposium, papers have been published in the open-access journal *Biogeosciences* (see http://www.biogeosciences-discuss.net/special_issue43.html). One of the tasks of the planning committee will be to select the journal in which papers for the third symposium will appear.

- Research Priorities Report—We produced a Research Priorities Report for each of the first two symposia, primarily from the discussion sessions, but which also including any obvious themes from the plenary sessions and posters. These documents are intended for use by the scientific community and by program managers. They are not printed in hard copy, but are posted on the www.ocean-acidification.net Web site.
- Summary Article for Scientific Community—We published a summary of the Research Priorities Report for the ocean science community in *Oceanography* magazine for each of the two previous symposia.
- Summary for Policymakers—This was a new publication from the second symposium, intended to provide a non-technical document for non-scientists, to summarize what the scientists on the planning committee believed were the most important facts to convey to policymakers. More than 10,000 copies were distributed worldwide and high demand resulted in a second print run. IGBP led the production of this document. In addition, the summary has been translated into French and Spanish by IOC and all language versions are available on the Web at http://www.ocean-acidification.net/.

All of the symposium components and products will be discussed by the Planning Committee at its meeting in Monterey in December 2010.

Symposium Timeline

30 April 2010—A request for bids to host the symposium was issued last year and bids were due by 30 April 2010.

July 2010—The planning committee chair and representatives of the three sponsoring organizations evaluated the bids and selected the location of the symposium in mid-July 2010. (The process is described earlier).

2-3 December 2010—The Planning Committee members will meet at the symposium venue in Monterey for two days to

- review the facilities where symposium events will occur;
- plan the structure, topics, and invited speakers for the symposium (including alternates);
- determine how the process for abstract review and selection of submitted oral presentations will be run;
- specify the products that will result from the symposium;
- develop a detailed timeline leading up to the symposium;

- work out details of the responsibilities of the international planning committee in relation to those of the local hosts and of sponsor staff in relation to planning committee members;
- develop a subcommittee to handle the program of travel awards for early career and under-represented group scientists;
- develop a plan to seek funding for travel awards for developing country scientists who may not qualify as early-career scientists; and
- determine the dates for the symposium (if this is not done by the time of the meeting).

January 2011—The planning committee will extend invitations to plenary speakers and fill in for any speakers who decline.

Spring-Summer 2011—A meeting Web site will be set up, with instructions for registration and submission of abstracts. The travel support program for early career scientists will be announced at this time.

Autumn 2012—The dates for the symposium will be set to avoid related meetings and to meet the availability at the host's facilities, but will most likely be set in Autumn 2012. After the actual dates are known, these will be advertized widely and we will develop a more detailed timeline for specific aspects of logistical planning, based on our experience with previous symposia.

Symposium Planning Committee

SCOR, IOC, and IGBP have agreed to a 14-member Planning Committee for the 2012 Symposium, chaired by Ulf Riebesell. Five of the members were on the planning committees for the first and/or the second symposium, giving us a good mixture of past participants and new ones. The committee includes representation from the major ocean acidification research and policy activities worldwide.

Category	Name	Country
Carbonate chemistry observation		
	Richard Feely—Leader of U.S. interagency activities	USA
	Yukihiro Nojiri—Leader of Japanese activities	Japan
Carbon Cycle Modeling		
	Jim Orr—served as vice-chair of the 2004 symposium and chair of the 2008 symposium	France

Marine organisms sensitive to acidification		
Macroalgae, phytoplankton	Kunshan Gao	China
Phytoplankton and corals	Anya Waite	Australia
Corals and other calcifiers	Jean-Pierre Gattuso—Chair of the European Project on Ocean Acidification and the SOLAS-IMBER Ocean Acidification committee. Member of the planning committee for the 2008 symposium	France
Fish and Physiology	Hans-Otto Poertner—Member of the planning committees for the 2004 and 2008 symposia	Germany
Fish and Marine Ecosystems		
Ecosystem modeling	Ken Denman	Canada
Biogeochemistry		
Pelagic	Ulf Riebesell (Chair)—Chair of the German BIOACID project and member of the National Research Council committee on ocean acidification. Member of the planning committee for the 2008 symposium	Germany
Organic geochemistry	Carlos Eduardo Rezende	Brazil
Paleocarbon/$CaCO_3$ Chemistry		
Foraminifera	Daniela Schmidt	UK
Sound in the Ocean		
	Peter Brewer—member of the planning committee for the 2004 symposium and member of the ORRAP Ocean Acidification Task Force	USA

Fisheries Impact / Socioeconomics		
	Claire Armstrong	Norway
Policy		
	Dan Laffoley—Chair of the EPOCA Reference Users Group	UK

4.3 Other Activities

4.3.1 Phytoplankton Pigments in Oceanography

The revision of the 1997 book *Phytoplankton Pigments in Oceanography* is nearing completion. Suzanne Roy (Canada) is the lead editor and has been working diligently to complete the volume and submit it to Cambridge University Press by the end of summer 2010. Funds have been contributed by the institutions of the co-editors, making it possible to order a significant number of copies for free distribution.

In 1997, SCOR and UNESCO sponsored a volume on phytoplankton pigments entitled "Phytoplankton Pigments in Oceanography: Guidelines to Modern Methods". This volume was edited by Drs S.W. Jeffrey, R.F.C. Mantoura and S.W. Wright and resulted from the activities of SCOR Working Group 78. The 1997 volume went out of print a few years after publication (about 2000 copies were sold), which prompted UNESCO Press to print another 500 copies in 2005.

In April 2006, SCOR sponsored a workshop of pigment specialists from around the world, to examine updates in this field. This workshop was hosted by Dr Fauzi Mantoura and IAEA in Monaco. The updates that were identified include new advances in the taxonomy of marine phytoplankton (several new algal groups have been described since 1997), new analytical tools such as mass spectrometry (not currently used for pigment analysis before the 1997 edition), and new applications for pigments. The outcome of this meeting was a consensus that an update of the original 1997 volume was urgently needed, and a new editorial team was selected: Suzanne Roy, Carole Llewellyn, Einar Skarstad Egeland, and Geir Johnsen.

Recent discoveries on several new algal classes particularly for the picoplankton category (smallest sized algae) and on new pigments are outlined in the first chapter of the new volume. These discoveries have benefited from improvements in culturing, microscopic and molecular methods (see, for example, the new Intergovernmental Oceanographic Commission – IOC – Manuals and Guides, no. 55, on Microscopic and Molecular Methods for Quantitative Phytoplankton Analysis, edited by B. Karlson, C. Cusak and E. Bresnan).

The many recent advances in methodologies examined in the new volume include wider application of liquid chromatography-mass spectrometry and developments and updates on the

mathematical methods used to exploit pigment information and extract the composition of phytoplankton communities. The importance of high-quality chromatographic data for pigment determinations is highlighted, particularly when pigments are used for remote-sensing applications and algorithm development. Mathematical tools have been developed also to extract information from absorption or fluorescence spectra without prior separation of the various pigments by a chromatographic technique; some applications are reviewed in the book and interested readers can find supplementary information in an upcoming book on chlorophyll fluorescence edited by D.J. Suggett, O. Prasil and M.A. Borowitzka, entitled "Chlorophyll *a* Fluorescence in Aquatic Sciences: Methods and Applications" (Springer, in press).

There is increasing recognition of the impact that environmental change has on the biological productivity, biodiversity and microbial cycling in the ocean. Knowledge of pigments in the aquatic environment is critical to understanding these fundamental aspects and is also a key complement to the rapidly advancing fields of remote-sensing of pigments from space and environmental monitoring, particularly for coastal regions. Monitoring is particularly important for the study of harmful algal blooms (HABs). These often toxic blooms are a growing problem in many coastal regions of the world, for reasons not entirely clear but that may be related to eutrophication, ballast transport, aquaculture, and climate change. The book gives an outlook on the use of pigments for the remote-sensing detection of HABs in coastal regions.

The 1997 volume was considered an extremely useful handbook by most users. The book was not developed as a textbook for university students; it was addressed rather to aquatic scientists interested in analyzing and using pigments to trace algae in their study systems, for example, in relation to environmental monitoring, climate change, remote sensing, biogeochemical, ecological and biodiversity studies. The aim is the same with the new volume, making it an indispensable tool for professionals and students who wish to analyze and research all areas in relation to aquatic pigments. The publication of this volume has been financially supported in large part by SCOR, with additional support from the following institutions: Université du Québec à Rimouski (Canada), Plymouth Marine Laboratory (UK), Norwegian University of Science and Technology (Norway) and International Atomic Energy Agency (Monaco).

4.3.2 Panel on New Technologies for Observing Marine Life

Terms of Reference:

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

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Members

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

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

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

Executive Committee Reporter: Missy Feeley

Interim Report for the SCOR Panel on New Technologies for Observing Marine Life

The Alfred P. Sloan Foundation awarded funding to the Scientific Committee on Oceanic Research (SCOR) in 2008 to conduct four different activities related to the Census of Marine Life (CoML):

1. SCOR Panel on New Technologies for Observing Marine Life
2. SCOR Project Summit (including Census of Marine Life and its Ocean Biogeographic Information System)
3. CoML cross-cutting project on Animals as Oceanographers
4. CoML cross-cutting project to bring together the tag technologies of the CoML Tagging Of Pacific Predators and Pacific Ocean Shelf Tracking projects

The progress of each of these activities will be described below.

1. **SCOR Panel on New Technologies for Observing Marine Life**

The Panel is working on the best means to publicize the legacy of the Census related to the development and use of observing technology and to provide a resource to the ocean observing community and the public. The original plan was to produce a special issue of a peer-reviewed journal. However, this approach was changed in the past year to two related activities: (a) updating and providing greater detail at Census Technology pages (see http://www.coml.org/investigating/home) and (b) commissioning a few forward-looking papers that will propose how to advance the use of Census observing technologies in the future.

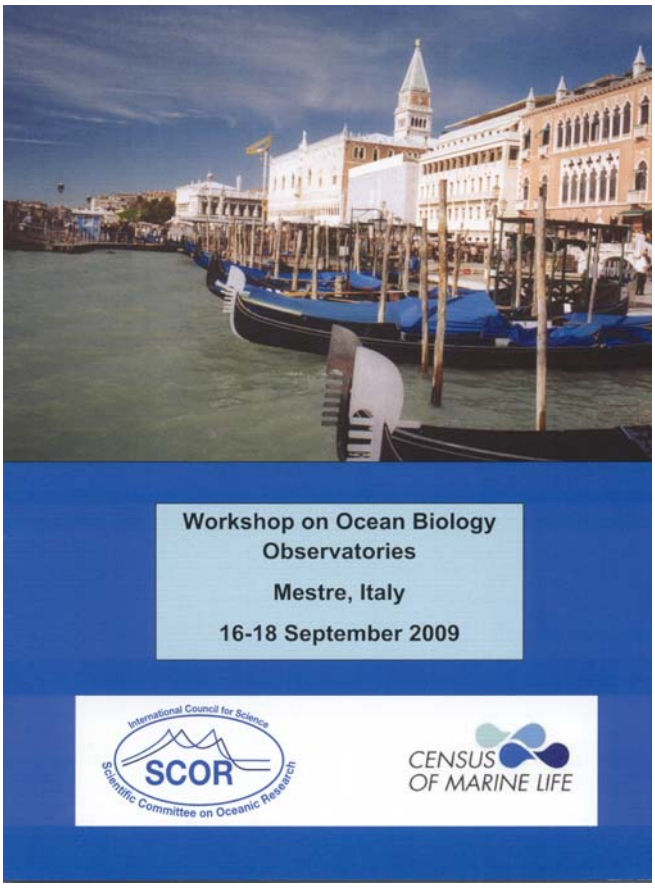
1. There are currently 37 different pages for Census-related technologies. Several new technologies will be added (e.g., marine barcodes, D-Tags, 454 pyrosequencing, the Continuous Plankton Recorder, Argo, etc.) and some pages will be expanded (e.g., the High-Definition Video page with information about the new technology developed for the *Oceans* film). The Census community has been asked to help with updating the technology pages and several responses were received. SCOR has hired a consultant to help with the updates. The grant has also paid for re-design of the SCOR Technology Panel Web site.

   The papers commissioned relate to future merging of Argo and biologging data and to the use of data from fixed arrays and pop-up acoustic tag data (e.g., data from the Pacific Ocean Shelf Tracking and the Ocean Tracking Network) in stock assessments.

   New autonomous technologies have brought about a revolution in the last decade. Engineering has provided us with instruments that let us observe the ocean interior in high resolutions previously only achieved by satellites covering the sea surface. The biggest leap forward was the Argo float program, which is now a functional global observing system for the subsurface ocean providing about 9,000 temperature, salinity and depth profiles every month. Argo is now valued as a major contributor to the Global

Ocean Observing System (GOOS). The data quality and its spatial coverage are still improving, especially in the high latitudes. Recent advances in miniaturized sensors with lower energy consumption has made possible the development of animal-borne instruments measuring animal's behavior and parameters of the animals' environment, providing the tools to integrate information about biology and ecosystems into the ocean observing strategy. While Argo is now the major provider of key ocean physics variables, the biological component within GOOS is still in its infancy. We have commissioned a paper to explore the existing technologies focusing on animal-borne sensors and how they can contribute to a comprehensive ocean observing system together with the Argo program. A strategic approach will be presented, which needs to be put in place to satisfy the increased need for ocean data in ways that both technologies provide increased coverage and improved resolution, and at the same time achieve the best possible cost effectiveness.

Data from acoustic tags are useful for stock assessment questions such as estimating immigration/emigration and delineating stock structures. A more subtle possibility is that acoustic tag data could tell us about patterns of schooling. One of the main problems with stock assessments at present is that they use acoustic data from sonar to calibrate catch data (sonar can be done independently of the fishery, so it isn't biased by the patterns of the fishermen), but species identification is difficult and stock assessment scientists don't really understand how aggregation (i.e., schooling at different densities) may affect their estimates of abundance. One of the main strengths of acoustic tags is that they can be used in small-bodied animals, and an array of receivers like POST is designed to help figure out where and when mortality happens in the ocean. This is critical to management and may be very useful for forecasts of adult returns, but may or may not be directly relevant to stock assessment, depending on what other data are available. As another example, acoustic tagging has shown that adult green sturgeon clearly move far more than was realized, which certainly affects population estimates because it means we have one or two big populations rather than a lot of smaller populations. However, adults are hard to census and the population growth rate depends on the numbers of juveniles that recruit to the population. In this case, acoustic tag data may be useful for two things: 1) making mark/recapture-based estimates of adult survival rates (because no good estimate is possible from catch records) and 2) figuring out more about where juveniles go and what their survival rates are; we know almost nothing about them.



Another major activity of the Panel in the past year was the Workshop on Ocean Biology Observatories, which took place in Mestre, Italy just before the OceanObs'09 meeting in Venice. This workshop brought together 63 biologists and representatives of the observing and technology communities to discuss ocean biology observatories that could address the challenges of observing ocean life and its response to global change. There was good representation of Census scientists at this meeting. The presentations and discussion group summaries are available at http://www.scor-int.org/OBO_Workshop.htm. The outcome of the workshop was presented at the OceanObs meeting by John Gunn. A chapter in the OceanObs volume (in press) by John Gunn, Alex Rogers, and Ed Urban summarizes the discussions from the workshop.

2. **Third SCOR Project Summit**

Some funding from this grant was allocated to the third SCOR Project Summit. The previous two summits were sponsored by the Sloan Foundation also. 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. Representatives of the Census and OBIS participated. The recommendations of the summit were given in last year's report. One recommendation that was implemented was to lease access to a Web-based meeting service (GoToMeeting and GoToWebinar) for SCOR-funded projects. This was done using SCOR funds. The projects are still testing the system to determine whether the license to use the

system should be renewed for another year. The data publication activity that resulted from an earlier project summit (also funded by the Sloan Foundation) is still underway. Two workshop reports have been published (see http://www.scor-int.org/Publications/wr207.pdf and http://www.scor-int.org/Publications/wr230.pdf) and an article was published in *EOS*. The project has put out a challenge to marine data centers and libraries to implement pilot projects in data publication and the results of this exercise will be reported at an appropriate meeting in late 2010 and/or early 2011. This project was started by SCOR and the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission. (IODE will be the new home of OBIS after 2010.) The MBLWHOI Library has joined the effort and the project is reaching out to other libraries, national oceanographic data centers, and editors of ocean science journals.

3. **CoML cross-cutting project on Animals as Oceanographers**

The meeting of this group was held in August 2008. The leader of the activity requested that the remaining funds be spent to implement a NASA-based system to access data from the Tagging of Pacific Predators project (TOPP). As this was not planned to be an international activity, the request was denied.

4. **CoML cross-cutting project to bring together the tag technologies of the CoML Tagging of Pacific Predators and Pacific Ocean Shelf Tracking projects**

Two meetings were held among Pacific Ocean Shelf Tracking (POST) and TOPP project PIs to discuss how to implement this project, at the Long Beach Census Synthesis Meeting in February 2009 and at a meeting in conjunction with the Ocean Sciences meeting in February 2010. An opportunistic meeting was also held between two tag manufactures in conjunction with the OceanObs meeting in October 2009. The aim of these meetings was to discuss how to make it possible for tags used by the POST and TOPP systems to communicate. This goal has not yet been achieved, in part because of competition between manufacturers, but progress is being made toward the goal, particularly now, as the Ocean Tracking Network is being implemented. A tentative agreement has been reached by a tag company and university scientists to deploy second generation "business card" tags (BCTs) on Sable Island, Nova Scotia. These will detect interactions between seals and tagged cod and relay the data directly to satellites. The Ocean Tracking Network (OTN) has budgeted to supply BCTs and satellite tags. This second deployment of BCTs was originally planned for 2010, but funding delays made it impossible to deliver tags in time for the tagging window.

4.3.3 SCOR/IODE Data Publication Activity *Urban*

What was to become the SCOR/IODE initiative on data publication started in December 2006 at the Second SCOR Summit of International Marine Research Projects (see http://www.scor-int.org/Project_Summit_2/ProjCoord2.htm). The meeting brought together representatives of most large-scale international ocean research projects (e.g. SOLAS, GEOTRACES, IMBER, GLOBEC, etc.). The meeting considered what constituted the major barriers to data sharing and greater data submission to national and global databases and identified a need to create a formal process to ensure that scientists get credit for releasing their data and for every time the data are

used by others. To this aim, the meeting recommended that SCOR form a Panel on Ocean Data Publication and Incentives.

In 2008, SCOR and IODE began to work together on this issue and the "SCOR/IODE Workshop on Data Publishing" (17-18 June 2008, IOC Project Office for IODE) was organised. The objectives of the meeting were to

1. Describe current status of data citation and publication in oceanography;
2. Identify problem areas;
3. Identify interoperability issues of current data citation and publication practices; and
4. Formulate suggestions to address problem areas.

The meeting concluded that the following actions were needed:

1. Build new infrastructure and new approaches to data publication;
2. Increase the availability of the data used for figures, tables and statistical analyses in traditional journal articles;
3. Encourage the expansion of journals which specialize in “data publications” or “data briefs”; that is, journals where data/datasets are described rather than interpreted. Requirement for data repositories to serve as archive of data related to journal articles;
4. Use persistent identifiers to anchor data in repositories to be used/published in publications; and
5. SCOR and IODE to work with existing data centers to promote the development of data repositories at the institutional, national and/or regional level.

The report of the meeting is available as IOC Workshop Report No. 207 at http://www.iode.org/wr207.

In December 2008, a meeting was organized with ocean science journal editors in San Francisco, USA with representatives present from *Earth System Science Data* (ESSD), *Fisheries Oceanography*, *Earth and Planetary Science Letters*, *Journal of Geophysical Research-Oceans*, *Biogeosciences* and *Progress in Oceanography*. Written input was received also from the *Journal of Plankton Research Oceanography*, and *Palaeoceanography*. The meeting came to the following conclusions:

1. The effort was worthwhile and many of the editors consulted want to stay involved in the discussions and participate in the development of the ideas;
2. The idea of the peer review of datasets requires more discussion and careful consideration;
3. The process of publication of data briefs or other stand-alone papers describing data sets is being tested by ESSD. The SCOR/IODE effort should focus for now on issues related to providing the digital backbone for data related to traditional publications;
4. More attention needs to be given to how digital object identifiers (DOIs) can best be used to link journal articles and datasets; and
5. It is important to know whether fields outside ocean sciences are pursuing data publishing.

In March 2009 (IOC Project Office for IODE, Oostende, Belgium, 9-11 March 2009) a meeting was held to develop use cases. The meeting included participants from BCO-DMO, BODC, WDC-MARE, IODE, and Elsevier. The use cases identified were:

- Use Case 1: Creating data publications from existing and future holdings at national data centres.
- Use Case 2: Providing the "digital backbone" for traditional journal publications.

Pilot projects were chosen to test the processes for data publication in the two cases. While BODC worked on developing Use Case 1, a meeting was organized by the MBLWHOI Library in Woods Hole, Massachusetts, USA to further develop the pilot project for Use Case 2.

A meeting was convened by SCOR and IODE, plus the Marine Biological Laboratory/Woods Hole Oceanographic Institution Library (MBLWHOI Library) on 2 April 2010 to advance the two use cases that had been developed over the past two years by the SCOR/IODE activity on data publication. The meeting noted progress in the two use cases, on publishing data related to traditional journal articles and data held by data centers, and made plans for future cooperation between data centers and libraries. A plan was developed for a "challenge" to data centers and libraries to test the role of libraries as the "digital backbone" for archiving of data underlying the tables and figures in traditional journal publications. The results of this challenge will be reported to the data management community at the ICSU Committee on Data for Science and Technology's 22nd International Conference in October 2010 and to the ocean science community at the AGU Fall Meeting in December 2010. The report from the 2 April meeting is available at http://www.scor-int.org/Publications/wr230.pdf.

4.3.4 Workshop on an International Quiet Ocean Experiment *Urban*

Update on Scoping Meeting for an International Quiet Ocean Experiment

The Scientific Committee on Oceanic Research (SCOR) and Partnership for Observation of the Global Oceans (POGO) were awarded funding from the Alfred P. Sloan Foundation to convene an exploratory workshop on the concept of an International Quiet Ocean Experiment.

Background

Even in the absence of humans, the ocean is noisy. Low-frequency sound can travel great distances—thousands of kilometers—so low-frequency sound generated in one place can be heard in far distant locations. Examples of natural low-frequency sound include undersea earthquakes and landslides, storm-induced turbulence, and low-frequency vocalizations of large baleen whales. As the frequency of sound increases, the distance of its transmission decreases, so that higher frequency sounds—such as sounds made by toothed whales, fish, snapping shrimp, bubbles breaking, and ice cracking—travel shorter distances, meters to perhaps a few kilometers, depending on the source strength. Comparative noisiness of different areas of the ocean are generally known—for example, Northern Hemisphere ocean basins are generally noisier than Southern Hemisphere basins—but information about high- and low-noise areas on a more local

level is less available. In some cases, the information is known by navies, but not published in any publicly available source.

The advance of human culture has greatly increased sound in the ocean. At first it was just the slapping of oars and wake creation of sailing ships. With the Industrial Revolution, however, came the noise of ship engines, sonar, seismic soundings, long-distance communication, and others. Noise from natural sources (e.g., thunder) and human activities (e.g., "sonic booms" and other aircraft noise) can also enter the ocean from the atmosphere. Sounds from human activities add to both the background average sound field from natural sources, and to the peak intensity. For most of these activities (e.g., shipping, surface vessels, submarines, scientific research, and oil and gas exploration and exploitation), the sounds are primarily below frequencies of 1000 hertz (Hz). Shipping is the predominant source of human-generated sound in the ocean at frequencies below a few hundred Hz, although other human activities can have more localized impacts. The cumulative effects of added sound on marine organisms is unknown, but many groups have been convened, in the United States and elsewhere, to document what is known about such effects (e.g., NRC, 1994, 2000, 2003, 2005). Oil exploration companies and navies have been required in recent years to change their operations to minimize suspected noise impacts on marine mammals.

It is known that many marine species rely on sound to a greater extent than light for communicating, navigating, sensing their environment and intra- and inter-species interactions, because the ocean is more transparent to sound than to light. However, it has proven difficult to determine the sensitivity of marine mammals to different frequencies of sound. In some cases, particularly for small pinnipeds and toothed whales, hearing has been tested directly using methods that measure the brain waves evoked by specific sounds (e.g., Cook et al., 2006) and indirectly by training marine mammals to respond to sounds with specific behaviors (e.g., Ridgway et al., 2001). It is much harder to test the sound sensitivities of larger toothed whales and baleen whales. The strongest evidence that baleen whales can hear at low frequencies is their tendency to vocalize at frequencies below 100 Hz. Also, gray whales, bowhead whales, and others have been observed to change their swimming paths in response to low-frequency sound. There is some evidence that intense sounds may cause strandings of some toothed whales, particularly beaked whales (Jepson et al., 2003). Little is known, however, about how increased sound levels affect other marine organisms and marine ecosystems.

Understanding of sound in the ocean is even more important now, as the effects of pH on sound levels in the ocean have recently been "re-discovered" (Brewer et al., 1995; Hester et al., 2008). Ocean acidification has emerged as a public policy issue in the past five years, as increasing atmospheric carbon dioxide enters the ocean, increasing the ocean's acidity; the effect of pH on borate and carbonate molecules in seawater reduces the ability of these molecules to absorb sound.

There is no direct evidence that human-generated noise in the ocean has caused the populations of any organisms to decline, but increased noise levels from ocean acidification and increasing human activities could have future effects that should be anticipated. Increasing sound in the ocean is an understudied aspect of global change that deserves greater attention.

SCOR and POGO will convene a workshop to begin an exploration of what could be learned about the effects of sound on marine organisms if the ocean could be quieted for a limited period; the workshop will explore the idea of an International Quiet Ocean Experiment (IQOE). Such an experiment will leverage previous investments of the Sloan Foundation in the Census of Marine Life (particularly observing assets developed) and could stimulate the Global Environmental Change programs of the International Council for Science (particularly the World Climate Research Programme and the International Geosphere-Biosphere Programme) to tackle the issues of increasing sound pollution. An important aspect of the workshop could be to document what is known about relative noisiness of different areas of the ocean.

Work Plan

The workshop will include discussions on:

1. Should the IQOE be conducted?
2. Could the IQOE be conducted?
3. Would the IQOE be conducted?
4. How could the IQOE be fit within the context of an intensive period of ocean observations?

The workshop will begin with some introductory presentations, on topics such as

- What are the characteristics of the ambient and human-influenced sound fields in the ocean?
- What do we know about the effects on marine organisms of human-induced noise in the ocean?
- How is the human-induced noise different from what is assumed to be the natural background noise level?

The workshop will then divide discussions into three parts (the development of the Sloan Foundation-sponsored Census of Marine Life followed this approach):

1. Should the experiment be conducted? Would enough be learned to justify a major effort? Convincing shipping and oil exploration companies, navies, and others to reduce or stop activities for any period of time will require making convincing arguments that the benefits to science would outweigh the economic costs. Some example questions to stimulate this discussion include

    - What could be learned if the ocean could be temporarily quieted (globally or regionally) that could not be learned from laboratory and other focused experiments?
    - Could such an experiment help develop the predictive model of acoustic effects on marine mammal populations recommended by NRC (2005)?

2. Could the experiment be conducted? This discussion will approach the issues of whether such an experiment would be technically feasible and, if so, what would be the operating parameters. Some potential questions include

- How long would the ocean need to be quieted for different experimental purposes?
- How much would anthropogenic noise have to be decreased for different experimental purposes?
- What kinds of measurements, both of sound and animal behavior (and physiology), should be made, and where? These discussions might be focused on the organisms most likely to be significantly affected.
- What would be required to achieve the needed noise reduction?
- What receivers worldwide could be used to measure changes in ambient and natural sound sources during the experiment? The Ocean Tracking Network that emerged from the Census of Marine Life could provide an important array of receivers.
- Could the current generation of tags deployed on marine organisms by the CoML Tagging of Pacific Predators project aid the experiment? What changes would need to be made to make such tags more useful to achieve the goals of the experiment? The workshop would include some discussion about whether the current generation of animal-based tags could be used to help monitor the effects of an IQOE, in terms of both received sound and animal vocalizations and, if not, what advancements in tags would be necessary. DTAGs could be a particularly useful technology (Johnson et al., 2009).
- Would there be merit in focusing on certain ocean basins or comparing results in different basins, pairing high- and low-sound areas, or making measurements in areas set aside as quieted areas for the duration of the experiment?

3. Would the experiment be conducted? If the experiment were scientifically interesting and valid, and technically feasible, is it likely that sound emitters could be convinced to turn off their sound sources for long enough to meet the goals of the experiment?

The experiment could be one component of a larger initiative to focus significant resources on the ocean for one day of measurements. What else could be measured in a single day that would provide meaningful new information, when combined with measurements of sound-related parameters?

A planning committee of 7 members was set up by SCOR and POGO to work out the details of the proposed workshop. POGO and SCOR have approved two co-chairs, one with marine mammal expertise (Ian Boyd, Sea Mammal Research Unit, Scotland) and one with acoustical expertise (George Frisk, Florida Atlantic University, USA). We anticipate that about 20 individuals would need to be invited to create a critical mass of experts, but we may open participation to anyone interested. We would like to get input from the planning committee on this issue.

Location
The workshop will be held at the University of Rhode Island.

Timeline and Outcomes
The workshop will be held in October 2010. The following timeline will be followed:

- By 28 February—Identify planning committee
- By 30 June—Complete invitation list and extend invitations, select location and venue
- 27-29 October—Hold workshop
- By 1 December—Draft article for *Oceanography* magazine and other articles

The primary outcome of the workshop will be an article in *Oceanography* magazine describing the concept and potential benefits of an International Quiet Ocean Experiment and the barriers that must be overcome to conduct such an experiment. The article will be summarized in an editorial in a major science journal and a press release.

Legacies and Partnerships
The most important legacy will be the article, which could serve as a foundation for additional planning for an International Quiet Ocean Experiment. The activity will increase the partnership between SCOR and POGO, and will also provide neutral ground for scientists, environmental groups, government agency representatives, and companies to discuss an innovative approach to studying the effects of sound on ocean organisms.

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