

## **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: Maria Hood, Intergovernmental Oceanographic Commission - UNESCO

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NEWSLETTER No. 4, May 2004

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### **CLIVAR / IOC Indian Ocean Panel Meeting Report**

The 6th Asian-Australian Monsoon Panel and 1st Indian Ocean Panel joint panel meeting was held from 18-20 February at the Indian Institute of Tropical Meteorology, Pune, India. Bronte Tilbrook, CSIRO Australia attended the meeting to represent the carbon hydrography work in the region. This was the first meeting of the group, and while the initial focus of the Panel is on the Tropical Indian Ocean, the mandate of the IOP covers the whole Indian Ocean basin and there are numerous activities in the region. The IOP is currently developing a plan for a tropical mooring array (15S to 10N).

Tilbrook noted that while the coverage of the carbon lines is probably sufficient for storage change measurements, we may need to optimize the lines for transport estimates. The mooring array represents a good opportunity to integrate CO<sub>2</sub> measurements into the array at the beginning of the planning process and the carbon community should stay closely involved with the IOP. Dileep Kumar (NIO) has been leading work on time series and underway measurements in the Arabian Sea and Bay of Bengal, and his group will be a crucial focal point for these future activities.

Tilbrook submitted the following report, which will be integrated into the IOP meeting report:

#### Carbon and CLIVAR interactions in the Indian Ocean.

Bronte Tilbrook, CSIRO Marine Research, Hobart Australia.

The JGOFS/WOCE CO<sub>2</sub> survey of the oceans during the 1990's has dramatically improved understanding of the ocean storage of anthropogenic CO<sub>2</sub> and the air-sea exchange of CO<sub>2</sub>. The results show that between 1800 and 1994 the anthropogenic CO<sub>2</sub> storage in the Indian Ocean, north 50S, is about 20 PgC of 118 +/- 19 PgC of the total ocean storage. Most of the storage in the Indian Ocean is in mode and intermediate waters, with the pattern being strongly influenced by the shallow overturning circulation. Surface underway measurements of CO<sub>2</sub> have also provided the first patterns of the air-sea fluxes of CO<sub>2</sub> in all the major ocean basins. Carbon cycle researchers are building on these results to develop a program aimed at documenting and understanding how the air-sea exchange and storage of CO<sub>2</sub> is evolving in the ocean. The work is coordinated through the International Ocean Carbon Coordination Project (IOCCP), which is jointly sponsored by IOC, SCOR, and the Global Carbon Project. The IOCCP assists in the design and implementation of the

carbon research and in building links to IGBP and WCRP programs. The research has two key observational themes; repeat hydrographic sections and surface observations (time series and ship of opportunity).

Repeat hydrographic section work aims to determine changes in CO<sub>2</sub> storage and associated transports on decadal scales. The work is closely integrated with CLIVAR activities and is aligned with the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) program of IGBP and SCOR. Understanding the role of the overturning circulation in controlling the storage pattern and how it might change will benefit from interaction between CLIVAR and IOCCP. Information on Indian Ocean sections planned or recently completed is available at:

<http://ioc.unesco.org/ioccp/hydglobal.htm>. Three sections with CO<sub>2</sub> measurements have been completed since 2000 in the subtropical Indian Ocean. The USA proposes to complete meridional sections along WOCE I9N and I7N in 2009. Chokepoint sections in the Indian sector of the Southern Ocean are also planned by Australia (I9S, 2005) and the USA (I6S, 2008). The distribution of the sections is designed to allow the storage to be calculated for the Indian basin and most follow WOCE sections. Extra coverage in the tropical Indian Ocean would be useful including a section across the Indonesian throughflow.

The surface observation network aims to resolve seasonal to interannual changes in the air-sea flux of CO<sub>2</sub> on a basin scale to 0.2 PgC/yr. The work is aligned with the Surface Ocean - Lower Atmosphere Study (SOLAS), and the coverage in the Indian Ocean needs to be developed. The French OISO program (Metzl, LBCM) has a winter-summer sampling program in the central Indian Ocean between Reunion Island, Amsterdam Island and Kerguelen Island. India carries out a program of time series and underway measurements in the Arabian Sea and Bay of Bengal (Kumar, NIO). With the exception of measurements on one Japanese cruise each austral summer down east Indian Ocean (Hashida, NIPR) there is no other routine coverage of surface carbon in the Indian Ocean. Intergration of the CO<sub>2</sub> measurements with XBT lines and new time series moorings in the region are two ways to substantially improve coverage.

### **Summary of the Ocean in a High CO<sub>2</sub> World Symposium**

Approximately 120 scientists gathered at the UNESCO headquarters in Paris, France from May 10-12 to discuss the likely consequences of increasing oceanic CO<sub>2</sub> concentrations on marine biogeochemistry and ecosystems, and the potential consequences of purposeful ocean carbon sequestration activities. The symposium was designed to gather information about the known impacts of increasing atmospheric CO<sub>2</sub> on the ocean, to develop research priorities to study these future impacts, and to discuss what is known about the potential environmental impacts of proposals to use the ocean to sequester excess atmospheric CO<sub>2</sub>. Invited papers from the symposium are in preparation for publication in a special issue of the Journal of Geophysical Research-Oceans, and research priorities outlined at the symposium will be published separately. The Program and Abstract book are now available on the symposium Web-site.

The symposium generated a great deal of enthusiasm and the planning committee is preparing both a press release for the general public and a brief technical communication for publication in a scientific journal.

The limited observations, research, and modeling conducted to date predict that in a high-CO<sub>2</sub> world, the ocean is likely to be more acidic, more stratified, have lower concentrations of surface nutrients, less oxygen, and phytoplankton will experience increased exposure to sunlight at the surface ocean as a result of weakened vertical mixing. These changes are likely to have significant impacts on many

species and change the composition of biological communities in ways that are not yet understood or predictable. Taken together with temperature increases from increasing atmospheric CO<sub>2</sub> concentrations, many present-day coral reefs may be eliminated by 2050.

On the issue of ocean carbon sequestration, symposium participants concluded that, although much progress has been made in understanding potential effectiveness and effects of ocean carbon sequestration through iron fertilization experiments and modeling studies, the level of our knowledge is presently insufficient to assess the environmental impacts or effectiveness of these techniques. This type of information is needed to evaluate large-scale commercial ocean carbon sequestration activities. Unfortunately, it has become clear that some commercial companies are not willing to wait for the necessary research to be completed, and may attempt to demonstrate their effectiveness without regard to potential and long-term environmental impacts. The scientific community must be able to respond to questions of potential impacts and benefits of proposed mitigation techniques, and to the perhaps more serious issue of the ecosystem impacts we will see as a result of the current trend toward an increasingly acidic ocean.

There were many suggestions for follow-up activities and research priorities outlined at the symposium. The final report of the symposium is being prepared and will be made widely available as soon as possible.

Further reading: Symposium Web-site

### **IGOS Integrated Global Carbon Observation Theme Finalized**

At the recent meeting of the Committee on Earth Observing Satellites (CEOS-SIT 14) and the Integrated Global Observing Strategy (IGOS) Partnership, the Integrated Global Carbon Observation (IGCO) Theme was finalized and published. The IGCO Theme Team has now been requested to produce a 5 years implementation plan. A new IGCO implementation steering committee is being formed under the direction of the IGCO Chair, Philippe Ciais. IGOS has requested this document to be prepared within 1 year in order to contribute to the Global Earth Observations process. NOTE: The IOCCP Project Office has a limited number of hard-copies of the report. Please contact Maria Hood ([m.hood@unesco.org](mailto:m.hood@unesco.org)) to receive a copy.

Further reading: The Integrated Global Carbon Observation Theme: A strategy to realise a coordinated system of integrated global carbon cycle observations. (pdf 2.5 MB); IGOS Partners / IGCO Web Site.

### **US Ocean Carbon and Climate Change Implementation Strategy Published**

The US Carbon Cycle Science Program has released the Ocean Carbon and Climate Change (OCCC): An Implementation Strategy for U.S. Ocean Carbon Research, prepared for the U.S. Carbon Cycle Scientific Steering Group and the Interagency Working Group, by the Carbon Cycle Ocean Interim Implementation Group, Scott C. Doney, Chair and Editor. This implementation strategy outlines plans for the global ocean carbon observing network, multi-disciplinary process studies, data synthesis and numerical modeling activities, technology development, and international coordination.

An interim scientific steering committee is being formed and the establishment of Project and Data Management Offices is being planned.

Further Reading: Implementation Strategy (posted on US CCSP Web)

### **GCOS 10 year implementation plan begins review period**

A draft Implementation Plan for the Global Observing Systems for Climate in Support of the UNFCCC has been prepared in response to a request from the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) at its ninth session, held in Milan, Italy from 1 to 12 December 2003. The plan has been developed by a group of authors under the leadership of GCOS, and in cooperation with its partners. The plan is being made available for open review by governments and scientists through direct notification and through this posting on the GCOS Web site.

Comments are invited, but must be submitted to the GCOS Secretariat ([gcossjpo@wmo.int](mailto:gcossjpo@wmo.int)) no later than 9 July 2004, in order that the document can be finalized for submission to SBSTA at its twenty-first session later this year. Please refer to the paragraph numbers in the document when submitting proposed additions, deletions or other modifications.

The IOCCP, working with the GCOS-GOOS-WCRP Ocean Observations Panel for Climate, submitted observing system information for the ocean carbon activities listed in the plan. Please send any comments on these activities directly to the IOCCP Project Coordinator ([m.hood@unesco.org](mailto:m.hood@unesco.org)).

Further Reading: GCOS Draft Implementation Plan for the Global Observing Systems for Climate (on GCOS Web)