

### CLIVAR and Ocean Carbon

Submitted by the International Ocean Carbon Coordination Project (see EOS article by Sabine and Hood).

One of the priority areas of the new International Ocean Carbon Coordination Project (a pilot project of the SCOR-IOC Advisory Panel on Ocean CO<sub>2</sub> and the IGBP-IHDP-WCRP Global Carbon Project <http://ioc.unesco.org/ioccp>) is to promote the integration of large-scale carbon studies into the planning activities of international research programs such as CLIVAR. At the January workshop of the IOCCP, the group set an action item "to develop a statement to the CLIVAR community about the need for carbon and tracer measurements on specific repeat sections, to establish a closer dialogue with CLIVAR planning of repeat section work in each basin, and to promote the appointment of carbon representatives to the CLIVAR regional panels." Similar statements have been made at CLIVAR meetings. The following action items were developed at SSG-11:

#### **OCEAN CARBON**

11. *Atlantic and Pacific ocean sector panels to identify a panel member to liaise with the ocean carbon community. (Southern Ocean already has Chris Sabine).*
12. *ICPO to identify a staff member to act as a point of contact with the ocean carbon community and to maintain the website information of planned activities.*
13. *The ocean sector panels through their identified members (see action 11) to coordinate with IOC carbon group (M. Hood) on CLIVAR requirements for deep ocean hydrography in each basin; Panels to invite M. Hood to their meetings; ICPO with Maria Hood and ocean sector panels to identify a suitable (scientific and implementation) oversight mechanism similar to the WOCE Hydrographic Programme Planning Committee.*

We would like to support CLIVAR in carrying out these actions and propose the following way forward:

***For item 11:*** The Need for CLIVAR Carbon Coordination at the Basin-Panel Level  
***We propose:*** The suggested method for meeting these needs is through the inclusion of a carbon representative (nominated by the IOCCP, for approval by CLIVAR) on each of the CLIVAR basin panels and inclusion in higher-level discussions concerning data management activities. These representatives will be responsible for providing a carbon perspective on CLIVAR issues and for pointing out where collaborative carbon/CLIVAR activities should be promoted at a regional level.

#### *For Discussion*

Certain national efforts to coordinate carbon and tracer measurements with CLIVAR, or CLIVAR-type programs, are now quite well developed. This is the case, for example, in the USA, and to some extent in Canada and Germany. There is still a need, however, to improve this coordination at the international level. For example, it remains common in certain countries to plan deep ocean hydrographic cruises (involving collection of CTD, O<sub>2</sub>, and nutrient data) without

close contact being made at the planning stage with groups that might be able to use these data to examine carbon-related questions. We expect this will also apply to other measurement platforms and campaigns within CLIVAR (e.g. VOS lines, moorings, etc.) that can be used to address smaller scale variability in the carbon cycle.

To ensure that the optimal set of measurements are being made from suitable CLIVAR cruises and platforms, improved carbon-CLIVAR coordination is required at the international level. As an example of the coordination problems being faced, the US Repeat Hydrography CLIVAR/carbon group has been contacted by international colleagues about providing support for critical measurements of carbon and other tracers on non-US cruises. To facilitate decisions concerning priorities for funding these international collaborations, program managers and scientists need to be provided with a clear delineation of the measurements required and a clear indication of critical gaps or overlaps in sampling plans. To this end, the IOCCP has recently compiled a draft of international plans for carbon and tracer measurements on repeat hydrographic sections and other platforms (<http://ioc.unesco.org/ioccp>). We recommend that the IOCCP work collaboratively with CLIVAR to integrate carbon program activities into the CLIVAR planning and implementation and, in particular, the planning of specific cruises for the next 10 years and an analysis of likely gaps and overlaps in national plans. As a closely related issue, the IOCCP can provide the necessary forum for making general decisions concerning the critical carbon-related measurements and necessary measurement quality on CLIVAR cruises. This is an issue that the US CLIVAR/CO<sub>2</sub> group is currently struggling with (see *Annex 1 / US Repeat Hydrography core and ancillary measurements, this document*).

Another issue that is of concern to CLIVAR/Carbon coordination effort is data management and integration. In these areas, there are numerous parallels and shared requirements among the needs of CLIVAR and carbon scientists concerning data management. A coordinated approach that is closely integrated with CLIVAR should therefore be developed for the assembly, archival and distribution of carbon data that are collected in conjunction CLIVAR activities.

***For item 12:*** Identifying a CLIVAR IPO staff member to act as a point of contact for carbon and to maintain information about planning activities

***We propose:*** The IOCCP is willing to facilitate the CLIVAR/Carbon integration by working closely with the CLIVAR IPO (focal points Maria Hood – *IOCCP* and Katy Hill - *CLIVAR IPO*) to develop the necessary support and information infrastructure for the carbon program and to function as the formal coordination body for this effort. This effort has already begun.

***For item 13:*** Development of an oversight mechanism

***We propose:*** The carbon experts on the panels would serve as direct scientific and implementation planning links between CLIVAR and the IOCCP community. These representatives, along with the IOCCP executive committee including Howard Cattle and Katy Hill, would serve as a communication forum and oversight mechanism for carbon work in CLIVAR.

Sincerely,

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IOCCP Project /  
CO<sub>2</sub> Panel  
Technical Officer

**Doug Wallace**  
IfM-Uni. Kiel  
CO<sub>2</sub> Panel Chair

**Chris Sabine**  
NOAA / PMEL  
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**Dick Feely**  
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(**NOTE:** the following annex, which originated with the planning of the US CLIVAR/Carbon repeat hydrography program and is still under revision by that group, can serve as a draft for an initial approach to international CLIVAR-Carbon coordination activity. **It should be understood that this list has NOT been approved by the international community at this time.**)

## ANNEX I

### US REPEAT HYDROGRAPHY PROGRAM IN SUPPORT OF CLIVAR AND THE CARBON CYCLE SCIENCE PROGRAM CORE AND ANCILLARY MEASUREMENTS LIST

*-----DRAFT-----*

**Level I core measurements** (mandatory on all cruises; suggested standard for international collaborators; measured at highest spatial resolution practical; funded through the omnibus proposal across all cruises). Rationale based on measurements required to directly quantify change in ocean carbon inventory, estimate anthropogenic CO<sub>2</sub> empirically, characterize large-scale water mass ventilation rates, constrain horizontal heat, freshwater, C, N, and O<sub>2</sub> transports and/or net divergence, and provide on-going basis for model evaluation.

DIC dissolved inorganic carbon (DIC)  
Total Alkalinity (TALK)  
CTD pressure, temperature, conductivity (salinity)  
CTD oxygen (sensor)  
Bottle salinity  
Nutrients by standard auto analyzer (NO<sub>3</sub>/NO<sub>2</sub>, PO<sub>4</sub>, SiO<sub>3</sub>)  
Dissolved oxygen (O<sub>2</sub>)  
Chlorofluorocarbon tracers CFC-11, -12, -113  
Tritium-<sup>3</sup>He  
Total organic carbon  
Total organic nitrogen  
Surface underway system: T, S, pCO<sub>2</sub>  
ADCP shipboard  
ADCP lowered

**Level II recommended measurements** (highly desirable on subset of US cruises; may be collected on coarser station spacing; coordinated with the core effort but funded by separate proposals either on a cruise by cruise basis or by specific measurement). Rationale related to large-scale carbon cycle and/or ventilation; specific rationale listed after measurement; possibly on coarser spatial resolution than Level I but on all cruises.

pH	(internal carbonate system consistency)
discrete pCO <sub>2</sub>	(internal carbonate system consistency)
<sup>14</sup> C by AMS	(bomb penetration; southern ocean circulation changes; may need to repeat only on 20 year time-scale)
CCl <sub>4</sub> and SF <sub>6</sub>	(to extend range of age tracers further back in time (CCl <sub>4</sub> ) and into the future (SF <sub>6</sub> ))
del <sup>13</sup> C of DIC	(independent measure of anthropogenic CO <sub>2</sub> uptake and inventory changes)
Fe/trace metals	(others? Zn? Al for dust? There are three sampling approaches)

- on "regular" rosette
- Teflon/plastic water sampler hanging below CTD
- Separate Kevlar wire; separate casts)

CTD  
transmissometer (POC distribution; ambiguity as to calibration; regional?)

More complete surface underway system: nutrients, O<sub>2</sub>, Chl, DIC, surface skin temperature

**Level III ancillary measurements** (on opportunity and space available basis; not to significantly interfere with Level I or II effort; may be regional or specific to individual cruise; extramural funding).

Chlorophyll

Primary production (on-deck incubations)  
HPLC pigments (phytoplankton community composition)

Experimental continuous analyzers (as they develop and can go full depth)

del <sup>15</sup>N NO<sub>3</sub> (nutrient utilization)

<sup>32</sup>Si

<sup>18</sup>O of H<sub>2</sub>O

NH<sub>4</sub>

Low level nutrients

Total organic phosphorus (difficult to measure??)  
(similar to AMT line; algorithm

Upper ocean optical profile development/validation; short cast; needs to be coherent with biological sampling)

del <sup>17</sup>O of O<sub>2</sub> (gross primary production)

methyl halides (linkages to SOLAS)

DMS (linkages to SOLAS)

ADCP (multibeam) (optimized for (biological) particle enumeration)