Intergovernmental Oceanographic Commission

Workshop Report No. 214

Initial Atlantic Ocean Carbon Synthesis Meeting

Laugarvatn, Iceland
28-30 June, 2006

IOCCP Report Number 5

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Abstract:
One of the five major objectives of the EU CARBOOCEAN integrated project is the quantification of decadal-to-centennial large-scale Atlantic and Southern Ocean carbon inventory changes. Operationally this implies a need to quantify the Atlantic and Southern Ocean carbon sink, and its decadal change, through highest accuracy measurement of the changing inventories of inorganic carbon and carbon-related tracers. With this CARBOOCEAN project objective and the larger international context in mind, CARBOOCEAN took the lead in initiating a workshop to identify key approaches, interested research groups and new data sets relevant to an international synthesis effort for the Atlantic Ocean. The IOCCP joined CARBOOCEAN to assist in making this an international effort, linking North American and EU scientists through partnerships for data exchange and joint scientific analyses.

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1. INTRODUCTION TO THE WORKSHOP

The WOCE / JGOFS hydrographic program of the 1990s provided a global survey of hydrographic properties in the global ocean and the first quasi-synoptic snapshot of the state of the global ocean. Based on this effort, it was possible to estimate the global ocean inventory of anthropogenic CO_2 for the mid-1990's to ± 20%. However uncertainties remain concerning possible bias in these estimates and additional key questions remain to be addressed, including: what processes control uptake, where does it occur, will uptake change in the future under possibly changed climate, circulation and ecosystem conditions, and what are the natural and anthropogenic changes in oceanic heat and freshwater inventories ?

An observing strategy suited to addressing these questions was the subject of the International Repeat Hydrography and Carbon Workshop, co-sponsored by JAMSTEC, the IOCCP and CLIVAR, in November 2005. At this workshop, it was emphasized that data syntheses addressing these questions require an integrated approach that brings together modeling and observations from multiple platforms carried out in each ocean basin.

Further, one of the five major objectives of the EU CARBOOCEAN integrated project is the quantification of decadal-to-centennial large-scale Atlantic and Southern Ocean carbon inventory changes. Operationally this implies a need to quantify: “the Atlantic and Southern Ocean carbon sink, and its decadal change, through highest accuracy measurement of the changing inventories of inorganic carbon and carbon-related tracers. Atlantic and Southern Ocean data would then be integrated into a coherent global data base. The ability of prognostic models to represent the observed changes for a reliable now-cast would be assessed against the data-based syntheses.” The science delivery associated with this objective is “a large scale assessment of the ocean carbon storage”.

With this CARBOOCEAN project objective and the larger international context in mind, CARBOOCEAN took the lead in initiating a workshop to identify key approaches, interested research groups and new data sets relevant to an international synthesis effort for the Atlantic Ocean. The IOCCP joined CARBOOCEAN to assist in making this an international effort, linking North American and EU scientists through partnerships for data exchange and joint scientific analyses.

Specific goals for this workshop were:

- To identify the ocean carbon and related data that have been collected in the Atlantic Ocean (including Arctic and Southern Ocean sectors) that will contribute to a synthesis of ocean carbon, heat and freshwater transport and storage;
- To document the plans and interests of individual research groups for conducting scientific analysis of ocean carbon and other hydrographic data;
- To establish collaborations between groups based around key science questions;
- To assess progress with compilations of Atlantic carbon and other hydrographic data (e.g., CARINA data) being carried out as part of CARBOOCEAN;
- To discuss comparisons of methods to estimate anthropogenic CO_2.
- To make plans for an Atlantic Ocean synthesis using new integrated and multi-disciplinary approaches, outlining as far as possible joint collaborations, data sharing, data management, quality-control and co-authorship issues.
- To address issues and needs for common methodologies and approaches to be used for syntheses that will be carried out in other basins to ensure a globally-consistent approach

Participants also recognized the need to document how far the community has come in answering key questions about issues such as ocean carbon, heat, and freshwater transport, uptake and storage, and ventilation using data obtained from ship-based hydrography, and to identify gaps in knowledge, concerns and challenges for future observational programs.

The meeting was hosted by Jon Olafsson of the Marine Research Institute of Iceland, and held at Laugarvatn, Iceland from 28-30 June 2006. The meeting brought together 23 participants from 9 countries with expertise ranging from ship-based carbon hydrography, physical oceanography, surface pCO_2 variability, CFC and tracer measurements, O_2 on profiling floats, modeling, and data synthesis and management (see Participants List, Section 7)

The basic structure of the Workshop was:

1. Science presentations: recent developments on the basis of individual synthesis/analysis efforts;
2. Status reports and sharing of relevant prior experience with large-scale synthesis efforts;
3. Establishment of working groups, including allocation of synthesis effort;
4. Discussion and planning of synthesis within working groups.

2. SCIENCE HIGHLIGHTS

Jon Olafsson and Thorarinn S. Arnarson (MRI, Reykjavik, Iceland) Overview of Icelandic CO_2 Research
The main features of work in the Irminger Sea west of Iceland and to the north in the Iceland Sea were described. This has included:

- Time series stations occupied 4 times a year since 1983.
- Studies of seasonal variations in the two regions and calculated air-sea fluxes.
- Underway pCO_2 measurements.

The data are sufficient to document the seasonal cycle of pCO_2 in the waters around Iceland and the long-term as well as interannual variability of surface water pCO_2 in the region.

Scott Doney (WHOI, Woods Hole, USA). The Changing Carbon Balance of the Atlantic from a Model Perspective.
The current ocean carbon sampling strategy for the ocean interior relies on infrequent reoccupations based on decadal-scale hydrographic surveys. Calculating long-term secular changes in anthropogenic carbon and related biogeochemical tracers using this approach is complicated by natural variability, which is large on these scales. Results of numerical experiments suggest that existing empirical techniques (C*, eMLR, etc) provide useful, but incomplete, corrections, especially in regions of mode water and intermediate mode water formation, and when long-term secular trends are considered. Work is underway on historical model hindcasts and data assimilation with biogeochemistry that may help address the representativeness of observations and the design of improved sampling approaches.

Terry Joyce (WHOI, Woods Hole, USA). The Changing Hydrographic Balance of the Atlantic Ocean.
Changes in the North Atlantic since the end of WOCE are dominated by the cessation of strong convection in the Labrador Sea and the reduction in formation of mode waters in both the subtropical and subpolar gyres. This can be traced to changes in the NAO in the first case, while the second is surprising since the usual NAO sea-saw favors weak mode water production either in the subtropical gyre or western subpolar gyre, but not both at the same time. This has import for changes in both the potential vorticity and dissolved oxygen of ventilated parts of the N. Atlantic.

Ute Schuster (UEA, Norwich, UK) Air-Sea Fluxes: Is the North Atlantic Air-Sea CO_2 Flux Decreasing ?
Based on a collection of measurements mainly from volunteer observing ships, the sea surface pCO_2 in the North Atlantic has been increasing faster than the atmospheric pCO_2 over the last 10 to 15 years, particularly in the eastern mid-latitudes and the sub-polar gyre. This implies a reduction in the uptake of atmospheric CO_2 by the North Atlantic. Reasons for this change are as yet unclear. A synthesis of temporal and spatial changes of sea surface pCO_2 is needed, as well as of the underlying biological (photosynthesis and respiration), chemical (e.g., Revelle Factor), and physical (circulation and ventilation) properties influencing sea-surface pCO_2 and air-sea flux of CO_2. The estimation of the air-sea flux is critical due to the question of wind-speed to be used and hence needs to be studied in detail.

Are Olsen (University of Bergen, Bergen, Norway). Carbon Storage in the Greenland-Iceland-Norwegian Seas.
Are Olsen synthesized some recent results on pCO_2 changes in the sub-polar gyre and the Nordic Seas over the last few decades. The results suggest that in the Atlantic waters, the pCO_2 is increasing at a greater rate than in the atmosphere due to anthropogenic carbon input. Theses observations are reconcilable with a large lateral supply of anthropogenic carbon from further south. This is supported by estimates of the ^{13}C Suess effect, and so the Arctic Mediterranean Seas (“the Nordic Seas”) appear to be an important region for transfer of anthropogenic carbon from the surface to the deep ocean.

Alison Macdonald (WHOI, Woods Hole, USA). Carbon Transports in the Atlantic.
Combining long-line zonal hydrographic transects in an inverse box model which computes estimates of horizontal and vertical circulation, interior source / sink terms, and air-sea fluxes, it is found that:

- although the underlying estimate of the circulation can effect the estimates of contemporary and natural TIC transport, the form of the constraints, in particular, the inclusion of the tracer O* can strongly affect estimates of net transport across some sections.
- combining sections from both the north and south Atlantic produces a fairly strong net northward transport of C_{ant} throughout the Atlantic in qualitative agreement with individual estimates and model analyses.
- estimates of storage and air-sea fluxes would benefit from non-zero analyses.
- understanding the variance of the transports on a variety of space and time-scales is paramount to understanding the uncertainty in the transport estimates themselves.

Doug Wallace (IFM-GEOMAR, Kiel, Germany). Decadal Carbon Storage in the North Atlantic Sub-Tropical Gyre.
This presentation focused on analysis of the Meteor 60/5 cruise data. The cruise had deliberately re-sampled stations in the mid-latitude North Atlantic that had previously been occupied in 1981 during the US-led TTO expedition. The data quality of both cruises permitted an analysis of the multi-decadal change in carbon concentrations. In particular, the cruise permitted testing of the “extended multiple linear regression” technique of assessing carbon changes. In addition, CFC data collected on the cruise were used to estimate anthropogenic carbon using the “transit-time-distribution” approach. A method for extrapolating decadal changes in carbon to total inventory estimates of anthropogenic carbon was applied. Overall, the two completely different and independent approaches to anthropogenic carbon content gave very consistent quantitative results and the qualitative distributions matched the distribution of CFCs and CCl_4 very closely. Comparisons with the delta-C* technique gave similar inventories but some significant differences in the depth-distribution of the inventory, especially in the deepest waters.

Reiner Steinfeldt (University of Bremen, Bremen, Germany). Atlantic CFC Data and Synthesis.
In the framework of CARBOOCEAN, CFC data are used to infer the parameters of Transit Time Distributions (TTDs) and from the TTDs the inventory of anthropogenic CO2. These estimates have been made for two time frames, the WOCE period (the 1990s) and the post-WOCE period (i.e. after the year 2000). The spatial coverage of the CFC WOCE data set is good, whereas later on large data gaps in the South Atlantic exist. The WOCE data and a great part of the post-WOCE data have been quality controlled. The determination of TTD parameters from CFC is a difficult task. Some constraints on the parameters may be obtained from the temporal CFC increase at repeated sections or by simultaneous measurements of different CFC components (CFC-11/CFC-12 in conjunction with CFC-113 and CCl_4). First estimates of the inventory of anthropogenic CO_2 for the Labrador Sea Water (LSW) in the Subpolar North Atlantic look encouraging. The hydrographic findings (ceasing of LSW ventilation after 1997 and large formation of the lighter Upper Labrador SeaWater (ULSW) later on) are reflected by a constant Cant inventory of LSW and a large increase within the ULSW between 1997 and 2003.

Aida Rios (IIM, Vigo, Spain). CARBOOCEAN Work Package 9 Report
The work carried out in the CARBOOCEAN WP9 was presented here. One of the objectives of WP9 is to establish optimal methods to assess anthropogenic CO_2 inventories and temporal change. The presentation showed the results of an intercomparison exercise using 5 different approaches to C_{ant} estimation applied to a common data set from a long meridional section extending from Arctic to the Southern Ocean. Overall some considerable agreement among the approaches was found: however results from the different approaches diverged at high latitudes.

Marco Vazquez-Rodriguez (IIM, Vigo, Spain). On Anthropogenic Carbon Calculation Methods.
A revision of the delta-C* back-calculation method for determining oceanic anthropogenic carbon (Cant) has been developed. The proposed improved method (φCTº) is later applied to Atlantic modern sections. The main progress has been the use of the 100 to 200 meter depth sub-surface layer data as the only reference in C_{ant} estimation. This layer is found to reliably represent the water column from the carbon system and water mass variability point of view. Preformed total alkalinity (TAº) and air-sea disequilibrium (delta-C_{dis}), defined as the difference between the preformed total inorganic carbon and the theoretical C_T in equilibrium with the atmosphere, are parameterized using conservative variables. Silicate is used as an Antarctic water mass tracer. For water masses under the 5 ºC isotherm (86% of the Atlantic's volume) the TAº and delta-C_{dis} are calculated through an Optimum Multiparameter (OMP) mixing analysis combined with the obtained parameterizations. The temporal variability of TAº and delta-C_{dis} is considered: the increase of surface alkalinity can account for 3.5% of the C_{ant} signal in a given sample, while results in this study show a 4 µmol kg^{-1} average decrease modulated by delta-C_{dis}. The obtained C_{ant} distribution for the Atlantic Ocean is in agreement with previous results. Compared to other authors, slightly higher C_{ant} values are estimated for the Northern Hemisphere while results for the Southern Ocean match very well those obtained through more local studies. Overall, the calculated Atlantic C_{ant} inventory of 59.2 ±13.2 Pg-C is in accordance with outputs from Global Ocean Biogeochemical models.

Fiz Perez (IIM, Vigo, Spain) Carbon Storage in the North Atlantic Sub-Polar Gyre.
Results from historical OVIDE cruises (2002, 2004 and 2006) were presented and compared in terms of oxygen and anthropogenic carbon content to previous cruises (FOUREX, AR7E and TTO). Results highlighted the different ventilation regimes having large impacts on regional C_{ant} inventories (Irminger sea).

Mario Hoppema (AWI, Bremerhaven, Germany) Carbon Storage in the Southern Ocean.

Anthropogenic carbon calculations were presented using the back-calculating technique of Chen, which resulted in very low C_{ant} inventories for the Southern Ocean (Weddell Sea). This was confirmed by the delta-C* technique. Reasons for this are the CO_2 flux inhibition by the sea ice and dilution by water masses void of C_{ant}. In the Weddell Sea, there seems to be no good correlation between C_{ant} and CFCs, but in the synthesis by Sabine et al., they correlate strongly. Lo Monaco et al. introduced the oxygen disequilibrium in the water mass formation region and found much higher C_{ant} inventories. Constant air-sea CO_2 disequilibrium, constant Redfield ratios, and simple or no mixing are assumptions that are not necessarily valid in the Southern Ocean. We need a robust method for C_{ant} calculation specific for the Southern Ocean.

Claire Lo Monaco (L'OCEAN, Paris, France). Carbon Storage in the Southern Ocean I.
Most data-based and model estimates indicate low inventories of anthropogenic CO_2 south of 50°S, while relatively large amount of CFCs are observed in recently ventilated Antarctic Bottom Water. In order to investigate this paradox we estimated the distribution of anthropogenic CO_2 along WOCE line I06 using a back-calculation technique corrected for taking into account the oxygen disequilibrium in ice-covered waters. Our results show that this oxygen correction leads to much higher inventories south of 50°S, therefore suggesting an important role for Antarctic Bottom Water formation as a sink for anthropogenic CO_2.

Niki Gruber (ETH, Zürich, Switzerland). Carbon Storage in the Southern Ocean II.
Quantitative estimates of the air-sea CO_2 flux in the Southern Ocean have remained uncertain owing primarily to the lack of surface pCO_2 observations. The inversion of ocean interior observations permits us to overcome this limitation as well as to separate the total air-sea CO_2 flux into a natural and anthropogenic CO_2 component. The inversion, as well as a greatly expanded pCO_2-data based estimate point toward a substantially smaller present CO_2 sink in the Southern Ocean than previous estimates (0.3 to 0.4 Pg C yr^{-1}). We attribute this small sink to a near cancellation between a substantial outgassing of natural CO_2 and a strong uptake of anthropogenic CO_2. Hindcast modeling studies show that this mean flux may vary by up to nearly 80% from year to year, with about 30% associated with the Southern Annular Mode. Most of the flux variations are driven by anomalies in surface ocean DIC, brought about by wind-induced changes in upwelling.

Arne Körtzinger (IFM-GEOMAR, Kiel, Germany). The Story from Carbon-13.
Average surface ocean $\delta^{13}C$ decrease during last two decades: -0.018 ‰ yr^{-1}. Depth-integrated $\delta^{13}C$ decrease during last two decades: -15.0±3.8 ‰ m yr^{-1}. Direct comparisons of decadal trends (1981-1993-2003) yielded similar results as the more robust MLR approach. Anthropogenic perturbation $\delta^{13}C$ extends all the way to the bottom in subpolar latitudes, to ~1000 m in subtropics, and <400 m in tropics. Using the ratio of $\delta^{13}C/CO_2$ perturbation ratio of -0.024 ‰ (µmol/kg)-1 by Körtzinger et al. (2003) the depth-integrated $\delta^{13}C$ decrease yielded an anthropogenic CO_2 uptake of 0.44±0.11 Pg C yr^{-1}. The average air-sea $\delta^{13}C$ disequilibrium of 0.7 ‰ explains only half of the depth-integrated $\delta^{13}C$ change in the N. Atlantic, the other half must be due to near-surface meridional transport from the south.

3. STATUS REPORTS AND LESSONS LEARNED

3.1 OXYGEN ON ARGO

Nicolas Gruber (ETH, Zürich, Switzerland).
The objective of the Friends of Oxygen on Argo group is to develop a technical white paper outlining scientific interests and technical feasibility issues of a pilot project of oxygen sensors on Argo profiling floats. The primary scientific objective is to determine seasonal to decadal-time changes in sub-surface oceanic oxygen storage and transport, in order to:

- Detect changes in ocean biogeochemistry (Miner's canary bird of climate change)

- Improve atmospheric O_2/N_2 constraint on ocean/land partitioning of C_{ant}
- Determine seasonal to interannual net remineralization rates as a proxy for export production;
- Help interpretation of variations in water mass ventilation rates;
- Provide data (initial conditions, evaluation) for ocean biogeochemical models;
- Help interpretation of sparse data from repeat hydrographic surveys.

There are a number of technical issues that need to be examined to determine the technical feasibility of this:

- Accuracy, long-term stability of sensors;
- Cost (sensor, calibration, etc);
- Impact on float life-time;
- Deployment;

Development of the project would be carried out as a 2-stage process: a pilot project phase followed by full-scale deployment. For the pilot project, the goal is to test instruments and concept, determine long-term precision and accuracy in situ over a large concentration gradient, determine impact on float-life:

- 20-50 floats in one area;
- Several floats with two sensors;
- Repeat shipboard visits with discrete Winkler profiles;
- Associated with a time-series study site? (eastern subtropical Atlantic (ESTOC) or subarctic Pacific Station P)?

3.2 STATUS OF CARBON RESEARCH IN THE USA

Richard Feely (NOAA/PMEL, Seattle, USA).
The U.S Ocean Carbon and Climate Change (OCCC) Program consists of a carbon observing network composed of the CLIVAR/CO_2 Repeat Hydrography Survey, the VOS underway pCO_2 measurement program, the North American Carbon Program coastal carbon network, and the ocean sites time series of carbon measurements. The process studies that are still in the planning phase include the upper water column process studies, mesopelagic process studies, continental margin studies that link with the North American Carbon Program, and the air-sea gas exchange process study in the South Atlantic. The CLIVAR/CO_2 Repeat Hydrography Program is well underway with almost half the cruises completed. The preliminary results indicate that uptake of anthropogenic carbon in the Pacific is possibly higher than the Atlantic, which may be related to decadal changes in rate of carbon assimilation. We are observing basin-to-basin differences in the rate of anthropogenic carbon uptake and the resulting changes in aragonite and calcite saturation state. We are using shipboard underway pCO_2 measurements in concert with satellite-based SST, chlorophyll and wind data to provide seasonal changes of the air-sea exchange of CO_2 in the global oceans. The preliminary results provide an estimate of $\pm$ 0.2 Pg C yr^{-1} (1 sigma) for the interannual variability of the air-sea exchange of carbon dioxide for the global oceans. Our OCCC Program has data management, and data synthesis and modeling components that are just under development.

3.3 STATUS OF CARBOOCEAN DATA MANAGEMENT

Benjamin Pfeil (University of Bergen, Bergen, Norway).
Most of the data gathered within the first year of the project has been delivered to CARBOOCEAN data management. Many PIs also released historical data that are being made available via the CARBOOCEAN data portal. In total, historic data from more than 180

cruises have been delivered to the data management. Public data are being transferred to the CDIAC in order to have all carbon related data in the appropriate World Data Center.

All data are available online from the CARBOOCEAN data portal (http://dataportal.carbooean.org) while intellectual property rights are being obeyed. The data portal includes data from the three data centers: CDIAC, IFREMER and WDC-MARE. It is the first global distributed networked database that has successfully been initiated.

3.4 LESSONS FROM THE GLODAP PROJECT

Chris Sabine (NOAA PMEL, USA) and Bob Key (Princeton, USA) led a discussion session on their experience with the GLODAP synthesis (see Key et al., 2004). They outlined the lessons learned during this project, noting that the most difficult aspect was simply getting the data, and that this exercise was only made possible because someone (Bob Key) took the data sets in many different formats and pulled them together in one location and common format. Another critical aspect of the synthesis was a careful review of the data quality. Having the proper metadata to document analysis procedures and the use of certified reference materials was a great benefit for evaluating data quality.

One lesson learned was that it's much easier to do a final synthesis when you have consistency in the measurement approaches. For example, the data collected during the Indian Ocean survey were much easier to evaluate because the same parameters were measured on each leg with consistent quality assurance procedures. The Pacific data, on the other hand, were much more difficult to evaluate because each leg had different parameters measured at a range of sample densities with much less documentation of methods and reference material analyses. Groups won't always agree on what to measure, but need to aim for consistency. The use of CRMs was the single best way of assessing data quality and consistency between cruises. However, enough CRMs need to be analyzed throughout the cruise to get a robust assessment (ideally one CRM per station). Another important element is the cross-over analyses. This makes a big difference for assessing the quality of the data, and groups need to be aware of what other cruises have been done and where existing lines are being crossed. Every reasonable effort should be made to take samples when you cross over or close to those points, and this is something that needs to be considered while planning the cruise rather than blindly sticking to a straight line approach.

The GLODAP synthesis and evaluation methods evolved over time, but the participants met regularly to discuss findings, discussions of methods, etc., taking advantage of other meetings at every opportunity. Much of this work is simply not possible by email. Nutrients got brought in after-the-fact and were not done as well, but this new North Atlantic synthesis group needs to worry about nutrients early on. All assessments were done in close association with the original measurement PI. Multiple assessment approaches were developed in an attempt to determine the most robust assessments possible. There were a few cases in GLODAP where the PI did not agree with the adjustments made to the dataset, but the group had to make tough decisions when the different assessments indicated an adjustment was necessary to make the data set consistent. It is important to always keep the synthesized adjusted data separate from core data.

This synthesis approach requires a lot of time and effort, but by discussing ahead of time which science papers individuals would lead, we determined that those who would benefit the most from the synthesis would lead the quality control work. Different people led the actual evaluations of different parameters (e.g., DIC, Alkalinity, etc), but comparisons and discussions among the groups often highlighted common problems that were actually associated with the hydrography itself. For GLODAP we reviewed the list of papers people would write every time because interests and intentions to actually carry out the work changed with time and to ensure that all those interested in collaborating were properly involved in the whole process. While this worked well for GLODAP it will be more complex for CARBOOCEAN because of the international nature and size of the groups. However, given the amount of data available and the complexity of interpreting changes in the Atlantic careful quality control and good communication will be even more important. One of the early agreements of the group was that the major science articles (Science, Nature, etc) would be co-authored by all participants in the synthesis effort. This should be a founding rule to maintain.

The GLODAP project focused on one basin at a time, without really thinking ahead to the global synthesis. The North Atlantic group should work to establish a good method to apply in Atlantic that will be applicable to other basins. Most EU groups won't be active in Pacific or Indian, so having non-EU scientists involved in the North Atlantic synthesis is important for consistency with the other basins. It is also equally important to get physical oceanographers involved, since many of the GLODAP discussions were based on physical oceanography.

Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J.L. Bullister, R.A. Feely, F.J. Millero, and T.-H. Peng, A global ocean carbon climatology: Results from GLODAP. *Global Biogeochem. Cycles*, 18, GB4031, doi:10.1029/2004GB002247, 2004.

3.5 STATUS AND LESSONS FROM THE CARINA PROJECT

Bob Key (Princeton, USA) provided an update on the data synthesis efforts for the CARINA data set and merging the water column data of CARINA with the GLODAP collection. CARINA was an essentially informal, unfunded project (organized by Ludger Mintrop and Douglas Wallace of Kiel) whose aims were:

- to bring together research groups that measure CO_2 in the Atlantic Ocean;
- to create an inventory of CO_2 measurements that had been carried out in the Atlantic Ocean;
- to make available also yet unpublished data to the data contributors;
- to form working groups, that cooperate on various aspects of the CO_2 system in the Atlantic;
- to exchange actual information concerning CO_2 research in the Atlantic and assist in future cooperation;

It is fair to say that primarily for reasons of funding (i.e. a lack of), only the first three of the CARINA objectives were realized. The result was the assembly of a large collection of useful, previously unavailable data. However no funds were available to allow the data contributors to quality-control these data sets or to work on them.

Within CARBOOCEAN, progress continues on the CARINA data assembly and, importantly, the quality assessment and analysis. Currently the collection includes data from 80 cruises that took place between 1980 and 2004. Primary quality control (metadata and precision/flagging) is already about 80% complete, however secondary QC is still needed for all parameters on all cruises. **It was agreed at the workshop that data from all cruises that were completed before the end of December 2004 would be included in the public CARINA data set immediately.** Users of these public data should be aware that the data may contain questionable or incorrect data and may not be internally consistent with respect to calibrations. A revised, corrected data set is likely to emerge from the activities of the synthesis working groups (see below).

Bob Key's experience in working with this dataset for the North Atlantic and beginning to deal with secondary QC provides valuable advice for the North Atlantic synthesis working groups as they begin to think about their data synthesis methodologies. He provided the following guidelines being used with the CARINA data set that may be useful to consider:

Quality Control Issues
Primary QC includes verification that the data are "final" followed by flagging outliers or suspect values (using WOCE conventions). The flagging is based on precision of each parameter for each cruise. Primary QC also includes verification of cruise metadata including pertinent publications. Secondary QC involves application of objective procedures to determine systematic errors for each parameter of each cruise. This is an accuracy assessment. The procedure is subjective because data are evaluated relative to a subset which has been deemed "correct". The work division was broken down by parameter (Temperature and Salinity; Oxygen and Nutrients; Carbon data) and Geographic Area (North of Iceland; South of Iceland). Secondary QC Methods include:

1. Crossover analysis (assumes stationary conditions for deep water at a given location);
2. Multiple Linear Regression (assumes that the combined influence of chemistry, biology, physics is constant with time);
3. Basin-wide MLR;
4. Isopycnal (assumes properties change smoothly in space on a given surface);
5. Internal Consistency (carbon system over determined);
6. New methods which consider the inherent time variability of the region;

Data Reporting Issues
Agreeing on and adopting standard methodology and reporting will greatly facilitate any future data synthesis efforts. One of the most important issues, yet often most ignored, is the adoption of standard practices for water column sampling and reporting. While it is recognized that long-standing habits are sometimes difficult to overcome, the difference for data synthesis can mean months of saved time for each cruise if recorded using standard methods. Key offered the following guidelines to facilitate synthesis efforts:

1. Number stations sequentially (pure numeric)
2. At each station record:
   - Station Number
   - Location (3-4 decimal precision)
   - Day, Month, Year (Time)
   - Bottom Depth (uncorrected PDR reading)
   - Maximum sampling pressure
   - Height above bottom (if known)
3. Number casts sequentially, starting with 1 for each station
4. Number each Niskin bottle (Murphy's Law suggests 1:N is the best choice).
5. Record (and keep) station, cast, bottle as the unique identifier. Unique ID numbers are an alternative, but not as good.

Some further suggestions and guidelines for recording measurements:

- Pressure is a basic measured quantity(record to 1 decimal); Depth iscalculated (reported as integer).
- Report T,S to 4 decimals. Preliminary T,S are ok for carbon calculations, but are NOT "good enough" for synthesis activity.
- Report Nutrients (2 decimal) and oxygen (1 decimal) in micromoles per kilogram.
- WOCE standards for other parameter precision and units.
- Report all measurements and assign a flag value of 2, 4 or 6 to each of your measurements (2=nominal, 4=known bad, 6=result of replicate analysis).
- Correct DIC and Alk to CRM (suggested only).

As part of the CARINA project, Key has compiled an extensive bibliography of literature associated with the data and techniques used in the programs that contribute to the dataset.

The group agreed that this was an extremely valuable resource that should be made available on the CARBOOCEAN portal and should be continued for all new cruises.

4. INTRODUCTION TO WORKING GROUPS

In order to prepare for the working groups, an overview of the potential syntheses to be conducted with the data was obtained. Each of the research groups represented at the workshop was asked to identify their main scientific interest for an Atlantic synthesis of carbon- and carbon-related data. This identified the following issues (listed in no particular order and with no names attached):

- Changes in saturation state of ocean with respect to aragonite and calcite
- Inventory of anthropogenic carbon and decadal changes in NADW based on TTDs
- Meridional transport of anthropogenic carbon in the North Atlantic
- Anthropogenic carbon inventory and uptake in the Southern Ocean, with specific interest in the Weddell Sea
- Carbon uptake and storage in the Nordic Seas; how anthropogenic carbon is brought into the region and how this may change with changes in circulation and climate; also ^{13}C Suess effect in the North Atlantic.
- Changes in ventilated waters in the North Atlantic, including all varieties of mode water and LSW, and the associated circulation changes.
- Anthropogenic carbon in the Southern Ocean, longer term sampling issues and observing system design
- Understanding whether or not we can measure transport of carbon (natural and anthropogenic) for the whole Atlantic but with a particular focus on the Nordic Seas.
- Comparison of surface pCO_2 trends and air-sea fluxes to transport/storage issues in mid-latitude North Atlantic;
- Comparison of different anthropogenic carbon estimation techniques
- Long term trends in O_2 inventories in North Atlantic; timescales of variability and how variability is linked to ventilation and supply pathways of oxygen, including LSW formation.
- Variability in natural and anthropogenic carbon in the Nordic seas; source waters for NADW and anthropogenic C and rate of change; also pH changes and aragonite/calcite saturation changes
- Long term changes in O_2 content and relation to changes in carbon; starting with N.Atlantic water "South of Iceland".
- Examine repeats of A16 lines to look at decadal changes in C, O_2, and nutrients and changes in physics; whole Atlantic (south of Iceland). Long term interest is to develop framework to evaluate models vs observations (variability, secular trends)
- Carbon changes in North Atlantic south of Iceland: storage term for comparison with transport estimates (sub-tropical; sub-polar gyre)
- Inventory of anthropogenic carbon and comparison with models over the whole Atlantic, including north of Iceland
- Anthropogenic carbon and O_2 ventilation in LSW; carbon in sub-polar gyres from the OVIDE lines.
- MLR approach to look at decadal inventories along specific lines; using Argo data as a way to extrapolate lines to basins

In the end it was clear that the scientific interests of many participants were quite similar but tended to break down along regional / geographical lines. These divisions of interest may also correspond well to the interests and expertise of potential partners in the physical oceanography community (e.g. the ASOF community that works primarily north of 60 N). It was also clear that the work associated with the proposed syntheses is considerable and may benefit from the geographical separation of effort already applied in the CARINA quality-control (see above). Based on this, and considerations arising from the GLODAP and CARINA experiences, the following Working Groups were developed:

1. "Southern": The Atlantic, south of approximately 16º N, with a very clear emphasis on the Southern Ocean
2. Northern: The Atlantic North of 60º N (Nordic Seas and Arctic)
3. "Middle": The North Atlantic Sub-polar and Sub-tropical gyres

Consideration was also given to establishing an "Overarching Analysis Group" but this did not meet during the workshop. Likely some level of overall coordination will be needed, but at a later date once the 2nd level QC has been completed. Bob Key is a member of each working group to provide guidance and consistency amongst the groups.

The South Atlantic Ocean region, including the tropical/equatorial Atlantic, was identified as a problem area. There are few if any available new data collected in this region since WOCE. Exceptions are Japanese data collected along 30ºS (WOCE A10) in 2003; a limited number of stations collected during the FICARAM cruises (by the Vigo group). This is barely sufficient data to initiate a new group synthesis activity and there were relatively few people present at the Workshop who expressed an interest in tackling this issue. **Chris Sabine and Aida Rios will work together to try to examine this issue and raise interest amongst the community.** Some new data are likely to be available soon: for example the Kiel group has recently completed (July 2006) a combined carbon and CFC section along the equator.

The working groups subsequently met and were charged with answering the following questions for reporting in plenary:

1. Identify WG "leaders". The following were identified: Northern: Are Olsen; Southern: Mario Hoppema; Middle: Toste Tanhua (who was at sea but has subsequently accepted this task).
2. Identify other key collaborators, including those with expertise related to physical oceanography, Argo, and time-series data sets; plan to get those people involved.
3. Identify / refine key questions for the regions
4. Identify data sets; discuss "exact" boundaries; and who is going to do what (e.g. who will address quality control for which parameters)
5. Identify collaborations on synthesis papers and topics; who will do what?

5. WORKING GROUP REPORTS

5.1 ARCTIC AND GIN SEAS

1. Identify Working Group Leader(s): Are Olsen, University of Bergen

2. Identify other key collaborators, including those with expertise related to physical oceanography, Argo, and time-series data sets; plan to get those people involved.
The working group comprised a mixture of mainly chemical oceanographers and one physical oceanographer. It was noted that key data holders and several persons potentially interested in the carbon-synthesis were not present. A number of additional key persons were identified and will be contacted to join the working group.

Chemical Oceanographers Present

Thorarinn Arnason (thorarn@hafro.is)
Jon Olafsson (jon@hafro.is)
Are Olsen (are.olsen@gfi.uib.no)

Truls Johannessen
Bob Key

Physical Oceanographers Present
Alison Macdonald (amacdonald@whoi.edu)

3. Identify / refine key questions for the regions.
The group is to remember that "synthesis" is the keyword. Therefore the aim is to build and take advantage of a combined, synthesized dataset. Analysis of individual cruise results should continue as quasi-independent activities by PIs, but the working group activity should operate at a bigger scale (i.e. the basin scale).

Key questions:

1. The large available data allow for the contribution of the high-latitude Atlantic and Arctic to the global Cant inventory to be determined systematically. A suitable method for C_{ant} estimation in the region must be developed. How much C_{ant} is there and what is its spatial distribution?

2. How does C_{ant} enter the region (e.g. by advection; uptake) and how is it transferred downwards? (e.g. open ocean convection, sinking, brine-rejection, plume entrainment), interior/boundary issues:

3. How much is transferred to adjacent basins and how (advection, mixing).

4. What is the rate of change (both present and future, in all the various aspects above) and how is this related to circulation /climate change vs. C_{ant} accumulation (e.g. buffer factor change).

5. What are the associated changes in saturation state of carbonate minerals?

6. What are the future measurements we need to answer the above questions?

Notes:
Many of these questions involve links to climate change questions (e.g. issues related to the "Blue Arctic" and the MOC slowdown). Many require comparison with models.
Unclear for the Arctic is the potential role/importance of DOC changes associated with climate change and altered river input, water temperatures, etc.

4. Identify data sets; discuss "exact" boundaries; and who is going to do what (e.g. who will address quality control for which parameters)
Data collected through the end of 2005 should be included in the synthesis.
Region:
From the Bering Strait – across the Arctic- down to the Greenland-Iceland-Scotland ridge (nominally 60ºN). Includes the Canadian Arctic Archipelago and Baffin Bay so that the southern boundary is Davis Strait. The logical transport boundaries for this group are therefore the Bering Strait and a shared boundary with the "middle" working group at the Davis Strait and the Greenland-Iceland-Scotland Ridge system. In terms of marginal sea coverage, the North Sea and Baltic belong most naturally to this system (although carbon budgets for the North Sea are being worked on in other parts of CARBOOCEAN). Hence a transport boundary across the English Channel may also link this working group to the "Middle" group.

Datasets:

In making a table of data, the approach should be: look for the carbon data first. Assemble the $T/S/O_2$ data as needed (here a connection to Hydrobase may be useful).

All data to be used in the synthesis should be delivered to Bob Key by December 2006. These data are to include:
Bergen CO_2 data from GIN Seas. Delivered
Icelandic data: GIN Seas & Irminger and Iceland Sea time series. These data are presently being delivered via Benjamin Pfeil (CARBOOCEAN data).
Arctic Ocean data from Leif Anderson.
Possibly Russian alkalinity data from the Barents Sea and other regions.
Norwegian data: Institute of Marine Research nutrient data.

2nd level QC of these data.

Questions to ask of the data-collecting PI:
Did you correct your data to CRM?
What calibration scale was used (in particular for pH.)?
Temperature

In order to approach 2nd level QC it was suggested to identify a "trial region" and work on that first. Including consideration of approaches, software, techniques, etc.. Approaches outlined in the GLODAP report can be used as a starting point.

Specific Responsibilities – the working group outlined the following variables and developed a list of possible leaders for each. The working group will contact the nominees and develop a final list shortly:

- Discrete pCO_2
- Total Alkalinity
- Total Carbon
- pH
- Nitrate/Phosphate/Silcate
- DOC
- Oxygen
- T&S
- $\delta^{13}C$
- $\delta^{18}O$
- CFCs – CCl_4
- Other tracers

5. Identify collaborations on synthesis papers and topics; who will do what?
It was suggested that a further meeting is needed in early 2007 to decide these issues. Start to write in 2007.

5.2 NORTH ATLANTIC SUB-POLAR AND SUB-TROPICAL GYRES

1. Identify Working Group Leader(s): Toste Tanhua (IFM-GEOMAR) (was at sea during workshop; therefore represented at workshop by Doug Wallace)

2. Identify other key collaborators, including those with expertise related to physical oceanography, Argo, and time-series data sets; plan to get those people involved.
The group identified chemical and physical oceanographers whose expertise and interests match those of this group. The group agreed to write letters to formally invite participation of

those listed. Collaborating scientists will be requested to hand in relevant data to the working group if they want to join in the synthesis effort.

Chemical and physical oceanographers present in this group:
Doug Wallace
Niki Gruber
Terry Joyce
Arne Körtzinger
Ute Schuster
Pete Brown
Steven van Hooven
Reiner Steinfeldt
Dick Feely
Chris Sabine
Fiz Perez
Bob Key

3. Identify / refine key questions for the regions
The following topics were identified, each of which could be the subject of at least one scientific paper based on the data collection and would be co-written by members of the working group:

1. New data allow the Mediterranean contribution to the worldwide C_{ant} inventory to be estimated.
2. Depth-distribution of C_{ant} and C_{ant} accumulation over past several decades. Associated changes in lysoclines, saturation state, etc.
3. What is the variability of dissolved oxygen in the region? What factors drive the variability?
4. To what extent can the basin-scale anthropogenic carbon budget, including the regional C_{ant} uptake from the atmosphere, be "closed" based on transport and storage estimates over decadal timescales?
5. What are the shifts in LSW ventilation and what affect do they have on carbon content (anthropogenic / natural) of this water mass
6. What is the variability of other Mode waters (e.g. 18º water) and the effect on the carbon budget?
7. Related to 5 and 6: do the water mass ventilation pathways of both the sub-tropical and sub-polar gyres vary in concert? What are the prospects for further spin-down of the sub-polar gyre?
8. A preliminary comparison suggests that the C_{ant} inventory increase in the Atlantic appears to be smaller than in the Pacific. Is this difference real or an artefact?
9. Is organic carbon storage important for the carbon budget?
10. How do MOC variability and changes in heat content affect the carbon balance? What effect on the carbon budget and (ultimately) on the air-sea flux of CO_2?

4. Identify data sets; discuss "exact" boundaries; and who is going to do what (e.g. who will address quality control for which parameters)
The "fuzzy" domain for this working group was set as 16ºN to 60ºN and therefore includes the North Atlantic sub-tropical and sub-polar gyres, as well as the Labrador and Mediterranean Seas. In terms of "boxes" suited to transport and storage calculations, this allows the extensive water mass transport estimates made at c. 24.5ºN, as well as transport estimates across Davis Strait and the Greenland-Iceland-Scotland ridge systems to be used to define inputs and outputs. A transport boundary with the "Northern" working group at the English Channel is also assumed.

In terms of data resources for this working group, the following key data resources were identified:
GLODAP data from the region (”done”)
“original” CARINA data (still needs secondary QC, some cruises still missing)
US CLIVAR-CO_2 Repeat Hydrography (A16, A20, A22; available)
Two UK Cruises (36ºN and 24.5ºN; essential to add to CARINA collection)
Meteor 60/5 (recently submitted to CARINA collection)
Meteor 54 data from the Mediterranean (recently submitted to CARINA collection)
OVIDE data from 2002 and 2004 (2006 occupation data are too recent)
AR7W (Canadian data; check availability)
AR7E (Pelagia 2005)(need to be added to CARINA collection)

The CARINA collection will accept all relevant cruise data collected up to December 2005. **Data MUST be delivered before 31-12-2006** .PLEASE fill in Bob's cruise table when delivering data. Bob/Benjamin will make maps to point out which cruises still need to be delivered.

In general it was noted that there is very good coverage from this region of the Atlantic, including many crossovers useful for QA/QC of the data. There may be fewer crossovers within the Labrador Sea although even here data collected by Canadian and German groups are available for comparison. Some difficulties in performing 2^{nd} level QC of the data will arise due to the significant temporal variability in water mass characteristics in the region.

Specific responsibilities were outlined for the following variables. The working group will contact the leaders nominated for each:

- Oxygen data
- DIC data
- Alkalinity / pH data
- T,S data
- Nutrient data
- CFCs

These specific responsibilities for doing 2nd level QC of the data are associated with specific interest in tackling some of the relevant scientific issues listed above.

In order to start working on these data, it was agreed to start with the GLODAP report and assess to what extent the GLODAP approaches meet the needs of this working group.
Time-series data were identified as being especially important: Terry Joyce and Scott Doney are to enquire concerning availability of BATS data up to the end of 2005. CARBOOCEAN partner Melchor Gonzales will be approached re: ESTOC data.

It was agreed that work would start as soon as possible. Most likely during the last quarter of 2006. A meeting in Spring 2007 was envisioned. However alternatives to meetings were discussed. In particular, possibilities of on-line collaboration and meetings are to be explored.

5. Identify collaborations on synthesis papers and topics; who will do what?
The implications of the assignment of 2nd level quality control tasks outlined above is that these people who invest the time and effort in the checking and documentation on the combined data set can take the lead in writing synthesis papers on these variables (in collaboration with other members of the working group).

5.3 SOUTHERN OCEAN

1. Identify Working Group Leader(s): Mario Hoppema (AWI, Bremerhaven)

2. Identify other key collaborators, including those with expertise related to physical oceanography, Argo, and time-series data sets; plan to get those people involved.
Members of the Southern Ocean group present at the meeting were:
Mario Hoppema (chair)
Aida Rios
Claire Lo Monaco
Andrew Lenton
Bob Key

Other possible collaborators which were discussed during the working group sessions; these people will be contacted soon about joining the working group.

Initially, in the working group, it was decided to limit the area of investigation to the Atlantic and Indian sectors of the Southern Ocean, to stick close to the emphasis of the CARBOOCEAN proposal. However, during the following plenary session it was suggested to include the entire Southern Ocean, because this would make more scientific sense, for example for making large-scale Cant inventories. In that case, more names are added to the list of potentially interested investigators.

It may be a compromise to first contact some very key people for these additional regions. If they are positive and are willing to contribute their data within a reasonable time (set by our working group, probably until the end of 2006), we may give the final "go" for this extension. However the priority for CARBOOCEAN investigators remains the focus on the Atlantic and Indian Ocean sectors.

3. Identify / refine key questions for the regions
Which is the optimal method for determining Cant in the Southern Ocean?
It has become clear that the Southern Ocean with its ice cover in water mass formation regions must be treated differently. We will also rely on the work done during WP9 of CARBOOCEAN

- Determine a regional and whole Southern Ocean inventory of Cant using as many data as possible. This is the main goal, but first we must possess the right method for this.
- Compare Cant with CFCs, look at regional differences in relationships. Is there agreement between the inventories of CFC and Cant?
- Comparison of observed data to modelled data. Sensitivity of the region to physical changes?
- Separating Cant from natural DIC changes

More questions are to be formulated during the further development of the project.

4. Identify data sets; discuss "exact" boundaries; and who is going to do what (e.g. who will address quality control for which parameters)
As already mentioned above we will in principle consider the whole circumpolar Southern Ocean as our area of investigation. To the north the region is limited by the Subtropical Front (roughly about 35°S).

Data sets/cruises

G signifies included in GLODAP data set.

OISO 1998-now (Paris)
Indigo 1985-1987 (Paris) – G
Geosecs – G
AJAX 1984 – G
Several Polarstern cruises 1992-2005 – not all in G
Meteor 1990
A17 – Cither (French/Spanish cruises) – G
A14 - Cither (French/Spanish cruises) – G
A13 - Cither (French/Spanish cruises) – G
FICARAM
I06 30°E line 1996 (French), 2002 (Spanish)
Fruela data (from Bransfield Strait)

There are definitely more data sets. The working group will search for these. Chris Sabine will be asked for the U.S. data (which possibly most of them are in GLODAP). Andrew Lenton will try to find out more about the Australian and New Zealand data. Mario Hoppema will make a Table with all cruises and the parameters measured during it.
Initially it was suggested to include only data from cruises that were completed prior to the end of 2004.

However following the other working groups formed during the workshop, the group will accept new cruises to the data base until the end of 2006. This to include data collected up until the end of 2005 if at all possible. Primary Quality Control (QC) must be finished until that date. Secondary QC may start either in 2007 or, if possible, earlier. During the second half of 2006 the members will do final processing of their data (if necessary) for incorporating it in the Southern Ocean data base.

Because the membership of working group is still relatively small, we adopted the strategy that all investigators will work on all parameters per cruise for secondary QC. We may change this approach if deemed necessary.

5. Identify collaborations on synthesis papers and topics; who will do what?
The group felt that it needed to first contact other scientists about participating in the working group before outlining collaborations. This should be accomplished by early 2007.

6. ACTION ITEMS LIST

Many of the key action items are to take place within the working groups. These working groups should develop their own lists of specific action items that can be compared via a common net-based working area on the CarboOcean web-site. The following general list of action items was developed at the meeting:

1. The Middle Working Group needs to look at Bates & Gruber paper to see what carbon was doing during the 1997-2003 period with respect to changes in ventilation presented by Terry.

2. It was noted during the science presentations that there remains a need for a set of standard approaches to air-sea flux calculations, choice of wind products, etc, that everyone will use as a point of comparison, in addition to their own “favourite” parameterizations. This need is to be communicated to those working in the more appropriate Theme of CARBOOCEAN dealing with air-sea fluxes (leader: Andy Watson). **Ute Schuster and Dick Feely are the appropriate workshop attendees to communicate this need.**

3. Bob Key has collected a useful list of publications associated with the CARINA data set. This **bibliography to be made available via the CARBOOCEAN data portal (Benjamin Pfeil).** The bibliography should be maintained, annotated and added to in order to support the working groups.

4. There needs to be some semi-formal communication with relevant CLIVAR groups and physical oceanographers concerning the carbon synthesis effort being undertaken. This can be done on an individual basis by the working groups. **Doug Wallace to write short description and send copy of workshop report to relevant CLIVAR group leaders.**

5. Nutrient standards – use of MLR approaches to examining carbon concentration changes rely heavily on accurate nutrient data collected at different time periods by different groups. The accuracy levels required for this application are at least the levels specified by WOCE and may be even more demanding. Quality problems have multiple sources including: the nature of the analytical methods used, the wide dynamic range of concentrations encountered, and the competing interests of potential users of the data (biologists' need for sensitivity at ultra-low-levels compared to need of some chemical oceanographers for ultra-high accuracy at high concentrations). Experience suggests that there still remain major uncertainties with nutrient data calibration that need to be addressed urgently. This issue requires international effort and coordination. Two measures can be suggested to individual laboratories to improve the precision and accuracy of nutrient analyses:

1. Subscribe and work according to a laboratory performance program, e.g., QUASIMEME AQ-1 Nutrients in sea water (http://www.quasimeme.org/)
2. A laboratory reference material, LRM (Aminot and Kérouel, 1998) can be regularly produced and compared to the QUASIMEME materials. The LRM should be run with each batch of samples.

    Reference; Aminot, A. and Kérouel, R., 1998. Pasteurization as an alternative method for preservation of nitrate and nitrite in sea water samples. Mar. Chem., 61: 203-208.

No specific workshop attendee was assigned this problem as it lies a little outside of the carbon synthesis task and the nature of the problem will become clearer as the working groups start the 2nd level QC. Suggestion: Wallace, Olafsson, Key and Feely (or Wanninkhof) develop a strategy off-line. This could, for example, become an issue that can be tackled by the EurOcean network of excellence in its next phase.

6. **Make a public release of the CARINA data set,** defined as all cruises up to end of December 2004 **(see CARINA discussion above). Key, Kozyr, Pfeil.**

7. Most of the subsequent synthesis work can take place in the working groups. These groups must: identify their extended membership; proceed with final assembly of their respective data sets; initiate 2nd level QC; finalize an initial list of scientific papers and potential contributors; etc.. **Responsible: working group leaders (Olsen, Tanhua, Hoppema).**

8. The GLODAP effort was associated with numerous face-to-face meetings to discuss individual data sets. Funding for this travel for the large number of geographically-groups involved in the Atlantic synthesis is not available. The workshop discussed possible enhanced use of internet working areas for this purpose. Specifically: **Benjamin Pfeil will establish working areas and discussion areas for the working groups via the CARBOOCEAN data portal. Consideration should be given to use of Wiki's or other groupware internet software solutions for use by the working groups.**

ANNEX I

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No.	Title	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand, 24-29 September 1973 UNDP (CCOP),	E (out of stock)
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (UNESCO Technical Paper in Marine Sciences, No. 20).	E (out of stock) S (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean; Monte Carlo, 9-14 September 1974.	E,F E (out of stock)
4	Report of the Workshop on the Phenomenon known as 'El Niño'; Guayaquil, Ecuador, 4-12 December 1974.	E (out of stock) S (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources; Kingston, Jamaica, 17-22 February 1975	E (out of stock) S
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Suva, Fiji, 1-6 September 1975.	E
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/UNESCO/ EAC; Nairobi, Kenya, 25 March-2 April 1976.	E, F,S, R
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters; Penang, 7-13 April 1976	E (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience; Mauritius 9-13 August 1976.	E, F, S, R
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring; Monaco, 14-18 June 1976	E, F E (out of stock) R
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976.	E, S (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976	E (out of stock), S
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects; Fort-de-France, Martinique, 28 November-2 December 1977.	E, F, S
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area; Port of Spain, Trinidad, 16-18 January 1978.	E, S
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas; Abidjan, Côte d'Ivoire, 2-9 May 1978	E, F
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific; Santiago de Chile, 6-10 November 1978.	E (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	E, F, R
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS); Moscow, 9-11 April 1979.	E
17 suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System; Moscow, 2-6 April 1979.	E
18	IOC/UNESCO Workshop on Syllabus for Training Marine Technicians; Miami, U.S.A., 22-26 May 1978 (UNESCO reports in marine sciences, No. 4 published by the Division of Marine Sciences, UNESCO).	E (out of stock), F, S (out of tock), R
19	IOC Workshop on Marine Science Syllabus for Secondary Schools; Llantwit Major, Wales, U.K., 5-9 June 1978 (UNESCO reports in marine sciences, No. 5, published by the Division of Marine Sciences, UNESCO).	E (out of stock), S, R, Ar
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources; Bandung, Indonesia, 17-21 October 1978	E
21	Second IDOE Symposium on Turbulence in the Ocean; Liège, Belgium, 7-18 May 1979.	E, F, S, R
22	Third IOC/WMO Workshop on Marine Pollution Monitoring; New Delhi, 11-15 February 1980.	E, F, S, R
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific; Tokyo, 27-31 March 1980.	E, R
24	WESTPAC Workshop on Coastal Transport of Pollutants; Tokyo, Japan, 27-31 March 1980.	E (out of stock)
25	Workshop on the Inter-calibration of Sampling Procedures of the IOC/ WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters; Bermuda, 11-26 January 1980.	E (Superseded by IOC Technical Series No.22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region; Mexico City, 24 September- 5 October 1979.	E, S
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Nouméa, New Caledonia, 9-15 October 1980.	E
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes. Lima, 20 April-5 May 1980.	E
29	WESTPAC Workshop on Marine Biological Methodology; Tokyo, 9-14 February 1981.	E
30	International Workshop on Marine Pollution in the South-West Atlantic; Montevideo, 10-14 November 1980.	E (out of stock) S
31	Third International Workshop on Marine Geoscience; Heidelberg, 19-24 July 1982.	E, F, S
32	UNU/IOC/UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E, F, S
32 Suppl.	Papers submitted to the UNU/IOC/ UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR); Halifax, 26-30 September 1963.	E
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa); Tenerife, 12-17 December 1963.	E, F, S
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific; Suva, Fiji, 3-7 October 1983.	E
36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, Portugal, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984	E
37	IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs; Colombo, 8-13 July 1985.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific; Suva, Fiji, 24-29 September 1985.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	First International Tsunami Workshop on Tsunami Analysis, Prediction and Communications, Submitted Papers; Sidney, B.C., Canada, 29 July-1 August 1985.	E
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2); Dakar, Senegal, 28 October-1 November 1985.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, Submitted Papers; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brasil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, France, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988.	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness,	E

No.	Title	Languages
	Observation and Instrumentation. Submitted Papers; Novosibirsk, USSR, 4-5 August 1989.	
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September-2 October 1988.	E
62	Second Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC ad hoc Expert Consultation on Sardine/ Anchovy Recruitment Programme; La Jolla, California, U.S.A., 1989	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November-1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Submitted Papers; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, U.S.A., 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, U.S.A., 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, U.S.A. 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, France, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	E
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria, 30 September – 4 October 1991	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, U.S.A., 17-18 July 1993.	E
91	Hydroblack'91 CTD Intercalibration Workshop; Woods Hole, U.S.A., 1-10 December 1991.	E
92	Réunion de travail IOCEA-OSNLR sur le Projet « Budgets sédimentaires le long de la côte occidentale d'Afrique » Abidjan, côte d'Ivoire, 26-28 juin 1991.	E
93	IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global Warming. Dhaka, Bangladesh, 16-19 November 1992.	E
94	BMTC-IOC-POLARMAR International Workshop on Training Requirements in the Field of Eutrophication in Semi-enclosed Seas and Harmful Algal Blooms, Bremerhaven, Germany, 29 September-3 October 1992.	E
95	SAREC-IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 23-25 November 1993.	E
96	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Zanzibar, United Republic of Tanzania, 17-21 January 1994.	E
96 Suppl.	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 1. Coastal Erosion; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
96 Suppl	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 2. Sea Level; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
97	IOC Workshop on Small Island Oceanography in Relation to Sustainable Economic Development and Coastal Area Management of Small Island Development States; Fort-de-France, Martinique, 8-10 November, 1993.	E
98	CoMSBlack '92A Physical and Chemical Intercalibration Workshop; Erdemli, Turkey, 15-29 January 1993.	E
99	IOC-SAREC Field Study Exercise on Nutrients in Tropical Marine Waters; Mombasa, Kenya, 5-15 April 1994.	E
100	IOC-SOA-NOAA Regional Workshop for Member States of the Western Pacific - GODAR-II (Global Oceanographic Data Archeology and Rescue Project); Tianjin, China, 8-11 March 1994.	E
101	IOC Regional Science Planning Workshop on Harmful Algal Blooms; Montevideo, Uruguay, 15-17 June 1994.	E
102	First IOC Workshop on Coastal Ocean Advanced Science and Technology Study (COASTS); Liège, Belgium, 5-9 May 1994.	E
103	IOC Workshop on GIS Applications in the Coastal Zone Management of Small Island Developing States; Barbados, 20-22 April 1994.	E
104	Workshop on Integrated Coastal Management; Dartmouth, Canada, 19-20 September 1994.	E
105	BORDOMER 95: Conference on Coastal Change; Bordeaux, France, 6-10 February 1995.	E
105 Suppl.	Conference on Coastal Change: Proceedings; Bordeaux, France, 6-10 February 1995	E
106	IOC/WESTPAC Workshop on the Paleographic Map; Bali, Indonesia, 20-21 October 1994.	E
107	IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III; Dona Paula, Goa, India, 6-9 December 1994.	E
108	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Paris, France, 9-12 May 1995.	E
108 Suppl.	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Submitted Papers; Paris, France, 9-12 May 1995.	E
109	First IOC-UNEP CEPPOL Symposium; San José, Costa Rica, 14-15 April 1993.	E
110	IOC-ICSU-CEC regional Workshop for Member States of the Mediterranean - GODAR-IV (Global Oceanographic Data Archeology and Rescue Project) Foundation for International Studies, University of Malta, Valletta, Malta, 25-28 April 1995.	E
111	Chapman Conference on the Circulation of the Intra-Americas Sea; La Parguera, Puerto Rico, 22-26 January 1995.	E
112	IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (GESREM) Workshop; Miami, U.S.A., 7-8 December 1993.	E
113	IOC Regional Workshop on Marine Debris and Waste Management in the Gulf of Guinea; Lagos, Nigeria, 14-16 December 1994.	E
114	International Workshop on Integrated Coastal Zone Management (ICZM) Karachi, Pakistan; 10-14 October 1994.	E
115	IOC/GLOSS-IAPSO Workshop on Sea Level Variability and Southern Ocean Dynamics; Bordeaux, France, 31 January 1995	E
116	IOC/WESTPAC International Scientific Symposium on Sustainability of Marine Environment: Review of the WESTPAC Programme, with Particular Reference to ICAM, Bali, Indonesia, 22-26 November 1994.	E
117	Joint IOC-CIDA-Sida (SAREC) Workshop on the Benefits of Improved Relationships between International Development Agencies, the IOC and other Multilateral Inter-governmental Organizations in the Delivery of Ocean, Marine Affairs and Fisheries Programmes; Sidney B.C., Canada, 26-28 September 1995.	E
118	IOC-UNEP-NOAA-Sea Grant Fourth Caribbean Marine Debris Workshop; La Romana, Santo Domingo, 21-24 August 1995.	E
119	IOC Workshop on Ocean Colour Data Requirements and Utilization; Sydney B.C., Canada, 21-22 September 1995.	E
120	International Training Workshop on Integrated Coastal Management; Tampa, Florida, U.S.A., 15-17 July 1995.	E
121	Atelier régional IOC-CERESCOR sur la gestion intégrée des zones littorales (ICAM), Conakry, Guinée, 18–22 décembre 1995	F
122	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996	E
123	Second IOC Regional Science Planning Workshop on Harmful Algal Blooms in South America; Mar del Plata, Argentina, 30 October–1 November 1995.	E, S
124	GLOBEC-IOC-SAHFOS-MBA Workshop on the Analysis of Time Series with Particular Reference to the Continuous Plankton Recorder Survey; Plymouth, U.K.,4-7 May 1993.	E
125	Atelier sous-régional de la COI sur les ressources marines vivantes du Golfe de Guinée ; Cotonou, Bénin, 1-4 juillet 1996.	E

No.	Title	Languages
126	IOC-UNEP-PERSGA-ACOPS-IUCN Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden. Jeddah, Saudi Arabia, 8 October 1995.	E
127	IOC Regional Workshop for Member States of the Caribbean and South America GODAR-V (Global Oceanographic Data Archeology and Rescue Project); Cartagena de Indias, Colombia, 8-11 October 1996.	E
128	Atelier IOC-Banque Mondiale-Sida/SAREC-ONE sur la Gestion Intégrée des Zones Côtières ; Nosy Bé, Madagascar, 14-18 octobre 1996.	E
129	Gas and Fluids in Marine Sediments, Amsterdam, the Netherlands; 27-29 January 1997.	E
130	Atelier régional de la COI sur l'océanographie côtière et la gestion de la zone côtière ;Moroni, RFI des Comores, 16-19 décembre 1996.	E
131	GOOS Coastal Module Planning Workshop; Miami, USA, 24-28 February 1997	E
132	Third IOC-FANSA Workshop; Punta-Arenas, Chile, 28-30 July 1997	S/E
133	Joint IOC-CIESM Training Workshop on Sea-level Observations and Analysis for the Countries of the Mediterranean and Black Seas; Birkenhead, U.K., 16-27 June 1997.	E
134	IOC/WESTPAC-CCOP Workshop on Paleogeographic Mapping (Holocene Optimum); Shanghai, China, 27-29 May 1997.	E
135	Regional Workshop on Integrated Coastal Zone Management; Chabahar, Iran; February 1996.	E
136	IOC Regional Workshop for Member States of Western Africa (GODAR-VI); Accra, Ghana, 22-25 April 1997.	E
137	GOOS Planning Workshop for Living Marine Resources, Dartmouth, USA; 1-5 March 1996.	E
138	Gestión de Sistemas Oceanográficos del Pacífico Oriental; Concepción, Chile, 9-16 de abril de 1996.	S
139	Sistemas Oceanográficos del Atlántico Sudoccidental, Taller, TEMA;Furg, Rio Grande, Brasil, 3-11 de noviembre de 1997	S
140	IOC Workshop on GOOS Capacity Building for the Mediterranean Region; Valletta, Malta, 26-29 November 1997.	E
141	IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan; Bangkok, Thailand, 25-28 February 1997.	E
142	Pelagic Biogeography ICoPB II. Proceedings of the 2nd International Conference. Final Report of SCOR/IOC Working Group 93; Noordwijkerhout, The Netherlands, 9-14 July 1995.	E
143	Geosphere-biosphere coupling: Carbonate Mud Mounds and Cold Water Reefs; Gent, Belgium, 7–11 February 1998.	E
144	IOC-SOPAC Workshop Report on Pacific Regional Global Ocean Observing Systems; Suva, Fiji, 13-17 February 1998.	E
145	IOC-Black Sea Regional Committee Workshop: 'Black Sea Fluxes' Istanbul, Turkey, 10-12 June 1997.	E
146	Taller Internacional sobre Formacíon de Capacidades para el Manejo de las Costas y los Océanos en le Gran Caribe, La Habana, – Cuba, 7–10 de Julio de 1998 / International Workshop on Management Capacity-Building for Coasts and Oceans in the Wider Caribbean, Havana, Cuba, 7–10 July 1998	S/E
147	IOC-SOA International Training Workshop on the Intregration of Marine Sciences into the Process of Integrated Coastal Management, Dalian, China, 19-24 May 1997.	E
148	IOC/WESTPAC International Scientific Symposium – Role of Ocean Sciences for Sustainable Development Okinawa, Japan, 2-7 February 1998.	E
149	Workshops on Marine Debris & Waste Management in the Gulf of Guinea, 1995-97.	E
150	First IOCARIBE-ANCA Workshop Havana, Cuba, 29 June-1 July 1998.	E
151	Taller Pluridisciplinario TEMA sobre Redes del Gran Caribe en Gestión Integrada de Áreas Costeras Cartagena de Indias, Colombia, 7-12 de septiembre de 1998.	S
152	Workshop on Data for Sustainable Integrated Coastal Management (SICOM) Maputo, Mozambique, 18-22 July 1998	E
153	IOC/WESTPAC-Sida (SAREC) Workshop on Atmospheric Inputs of Pollutants to the Marine Environment Qingdao, China, 24-26 June 1998	E
154	IOC-Sida-Flanders-SFRI Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA project) Capetown, South Africa, 30 November-11 December 1998.	E
155	Science of the Mediterranean Sea and its applications UNESCO, Paris 29-31 July 1997	E
156	IOC-LUC-KMFRI Workshop on RECOSCIX-WIO in the Year 2000 and Beyond, Mombasa, Kenya, 12-16 April 1999	E
157	'98 IOC-KMI International Workshop on Integrated Coastal Management (ICM), Seoul, Republic of Korea 16-18 April 1998	E
158	The IOCARIBE Users and the Global Ocean Observing System (GOOS) Capacity Building Workshop, San José, Costa Rica, 22-24 April 1999	E
159	Oceanic Fronts and Related Phenomena (Konstantin Fedorov Memorial Symposium) – Proceedings, Pushkin, Russian Federation, 18-22 May 1998	E
160	Under preparation	
161	Under preparation	
162	Workshop report on the Transports and Linkages of the Intra-americas Sea (IAS), Cozumel, Mexico, 1-5 November 1997	E
163	Under preparation	
164	IOC-Sida-Flanders-MCM Third Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA Project), Cape Town, South Africa, 29 November – 11 December 1999	E
165	An African Conference on Sustainable Integrated Management; Proceedings of the Workshops. An Integrated Approach, (PACSICOM), Maputo, Mozambique, 18 –25 July 1998	E, F
166	IOC-SOA International Workshop on Coastal Megacities: Challenges of Growing Urbanization of the World's Coastal Areas; Hangzhou, P.R. China, 27 –30 September 1999	E
167	IOC-Flanders First ODINAFRICA-II Planning Workshop, Dakar, Senegal, 2-4 May 2000	E
168	Geological Processes on European Continental Margins; International Conference and Eight Post-cruise Meeting of the Training-Through-Research Programme, Granada, Spain, 31 January – 3 February 2000	E
169	International Conference on the International Oceanographic Data & Information Exchange in the Western Pacific (IODE-WESTPAC) 1999, ICIWP '99, Langkawi, Malaysia, 1-4 November 1999	***under preparation***
170	IOCARIBE-GODAR-I Cartagenas, Colombia, February 2000	***under preparation***
171	Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks, Toulouse, France, 10-11 May 1999	E
172	(*Under preparation*)	
173	The Benefits of the Implementation of the GOOS in the Mediterranean Region, Rabat, Morocco, 1-3 November 1999	E, F
174	IOC-SOPAC Regional Workshop on Coastal Global Ocean Observing System (GOOS) for the Pacific Region, Apia, Samoa, 16-17 August 2000	E
175	Geological Processes on Deep-water European Margins, Moscow-Mozhenka, 28 Jan.-2 Feb. 2001	E
176	MedGLOSS Workshop and Coordination Meeting for the Pilot Monitoring Network System of Systematic Sea Level Measurements in the Mediterranean and Black Seas, Haifa, Israel, 15-17 May 2000	E
177	*(Under preparation)*	
178	*(Under preparation)*	
179	*(Under preparation)*	
180	Abstracts of Presentations at Workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, USA, 23-27 April 2001	E
181	*(Under preparation)*	
182	*(Under preparation)*	
183	Geosphere/Biosphere/Hydrosphere Coupling Process, Fluid Escape Structures and Tectonics at Continental Margins and Ocean Ridges, International Conference & Tenth Post-cruise Meeting of the Training-through-Research Programme, Aveiro, Portugal, 30 January-2 February 2002	E
184	*(Under preparation)*	
185	*(Under preparation)*	
186	*(Under preparation)*	
186	*(Under preparation)*	
187	Geological and Biological Processes at deep-sea European Margins and Oceanic Basins, Bologna, Italy, 2–6 February 2003	E
188	Proceedings of 'The Ocean Colour Data' Symposium, Brussels, Belgium, 25-27 November 2002	E
189	Workshop for the Formulation of a Draft Project on Integrated Coastal Management (ICM) in Latin America and the Caribbean (LAC), Cartagena, Colombia, 23–25 October 2003 Taller de Formulación de un Anteproyecto de Manejo Costero Integrado (MCI) en América Latina y el Caribe (ALC), Cartagena, Colombia, 23–25 de Octubre de 2003	E F ***(electronic copy only)***
190	First ODINCARSA Planning Workshop for Caribbean Islands, Christchurch, Barbados, 15–18 December 2003	E ***(electronic copy only)***
191	North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes — International Conference and Twelfth Post-cruise Meeting of the Training-through-research Programme, Copenhagen, Denmark, 29–31 January 2004	E
192	Regional Workshop on Coral Reefs Monitoring and Management in the ROPME Sea Area, Iran I.R., 14–17 December 2003	E ***(under preparation)***
193	Workshop on New Technical Developments in Sea and Land Level Observing Systems, Paris, France, 14–16 October 2003	E ***(electronic copy only)***
194	IOC/ROPME Planning Meeting for the Ocean Data and Information Network for the Central Indian Ocean Region	***(under preparation)***
195	Workshop on Indicators of Stress in the Marine Benthos, Torregrande-Oristano, Italy, 8–9 October 2004	E
196	International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, Paris, France, 3–8 March 2005	E
197	Geosphere-Biosphere Coupling Processes: The TTR Interdisciplinary Approach Towards Studies of the European and North African Margins; International Conference and Post-cruise Meeting of the Training-Through-Research Programme, Morocco, 2-5 February 2005	E
198	Second International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean, Grand Baie, Mauritius, 14–16 April 2005	E
199	International Conference for the Establishment of a Tsunami and Coastal Hazards Warning System for the Caribbean and Adjacent Regions, Mexico, 1–3 June 2005	E
200	Lagoons and Coastal Wetlands in the Global Change Context: Impacts and Management Issues — Proceedings of the International Conference, Venice, 26–28 April 2004 (*ICAM Dossier N° 3)*	E
201	Geological processes on deep-water European margins - International Conference and 15th Anniversary Post-cruise Meeting of the Training-Through-Research Programme, Moscow/Zvenigorod, Russian Federation, 29 January–4 February 2006	E
202	Proceedings of 'Ocean Biodiversity Informatics': an international conference on marine biodiversity data management Hamburg, Germany, 29 November–1 December 2004	E
203	IOC-Flanders Planning Workshop for the formulation of a regional Pilot Project on Integrated Coastal Area Management in Latin America, Cartagena de Indias, Colombia, 16–18 January 2007	*E* ***(electronic copy only)***
204	Geo-marine Research along European Continental Margins, International Conference and Post-cruise Meeting of the Training-through-research Programme, Bremen, Germany, 29 January–1 February 2007	E
205	IODE/ICAM Workshop on the development of the Caribbean marine atlas (CMA), United Nations House, Bridgetown, Barbados, 8–10 October 2007	E ***(electronic copy only)***
206	IODE/JCOMM Forum on Oceanographic Data Management and Exchange Standards, Ostend, Belgium, 21–25 January 2008	*(Under preparation)*
207	SCOR/IODE Workshop on Data Publishing, Ostend, Belgium, 17–18 June 2008	*(Under preparation)*
208	JCOMM Technical Workshop on Wave Measurements from Buoys, New York, USA, 2–3 October 2008 (IOC-WMO publication)	*(Under preparation)*

No.	Title	Languages
209	Collaboration between IOC and OBIS towards the Long-term Management Archival and Accessibility of Ocean Biogeographic Data, Ostend, Belgium, 24–26 November 2008	*(Under preparation)*
210	Ocean Carbon Observations from Ships of Opportunity and Repeat Hydrographic Sections (IOCCP Reports, 1), Paris, France, 13–15 January 2003	E ***(electronic copy only)***
211	Ocean Surface pCO_2 Data Integration and Database Development (IOCCP Reports, 2), Tsukuba, Japan, 14–17 January 2004	E ***(electronic copy only)***
212	International Ocean Carbon Stakeholders' Meeting, Paris, France, 6–7 December 2004	E ***(electronic copy only)***
213	International Repeat Hydrography and Carbon Workshop (IOCCP Reports, 4), Shonan Village, Japan, 14–16 November 2005	E ***(electronic copy only)***
214	Initial Atlantic Ocean Carbon Synthesis Meeting (IOCCP Reports, 5), Laugavatn, Iceland, 28–30 June 2006	E ***(electronic copy only)***