

## REPORT OF THE SECTION ON *CARBON AND CLIMATE*

The meeting of the Section on *Carbon and Climate* (CC-S) was held from 09:00–13:00 on October 24, 2010 in Portland, U.S.A. under the chairmanship of Drs. James Christian (Canada) and Toshiro Saino (Japan). They welcomed members and observers to the meeting (*CC-S Endnote 1*). The agenda was adopted unanimously (*CC-S Endnote 2*).

### AGENDA ITEM 2

#### **Membership**

Since the PICES 2009 Annual Meeting, two additional members were appointed to CC-S. Dr. Minhan Dai of Xiamen University, representing China, and Dr. C.T. Arthur Chen as an *ex-officio* member representing IGBP. A new member (Dr. Dong-Jin Kang) representing Korea was proposed and later formally appointed as Prof. Kyung-Ryul Kim has left CC-S. An additional *ex-officio* member, representing SOLAS (Dr. Yukihiro Nojiri), will be proposed. Subsequent to the meeting, the United States made an additional membership change, adding Dr. Burke Hales and removing Dr. Steve Emerson.

### AGENDA ITEM 3

#### **CC-S achievements in the past 12 months**

##### *PACIFICA Carbon Data Synthesis*

Substantial progress was made on the PACIFICA data synthesis in 2010. Dr. Toru Suzuki (Japan) implemented the CARINA algorithms and created a web site for the output. A subset of CC-S members met in Tokyo in early June, and began to evaluate the output. At the 2010 PICES Annual Meeting another data synthesis workshop was held in the 2 days prior to the CC-S meeting, which was chaired by Dr. Masao Ishii (Japan) and Dr. Robert Key (U.S.A.). This workshop continued the work of the June meeting, evaluating data adjustments recommended by the CARINA algorithms. A detailed summary of this workshop is found in the section for the POC/BIO Workshop (W5) on “*Carbon data synthesis (III)*” in the Session Summaries section of the PICES-2010 Annual Report. The final PACIFICA data products will be completed in the coming year and a topic session presenting scientific analyses of these will be proposed for the 2012 Symposium on “*Effects of climate change on the world’s oceans*”.

### AGENDA ITEM 4

#### **Reports of collaborating organizations and agencies**

Reports were given on several international programs relevant to the mandate of CC-S, including IOCCP (Kozyr, Nojiri), GO-SHIP (Ishii, Miller), and SOCAT (Nojiri).

Dr. Key reported that CARINA is completed and all results and products are available from CDIAC.

The SOLAS-IMBER Working Group on *Ocean Acidification* is proposing a Workshop to “*Design global ocean acidification/carbon observing system*” in late 2011 or early 2012. CC-S recommends that PICES co-sponsor this workshop, and further recommends that it be held in Yeosu in 2012 in concert with the Symposium on “*Effects of climate change on the world’s oceans*”.

### AGENDA ITEM 5

#### **Future meetings and activities**

CC-S has existed for 5 years and has recently presented an interim report to POC and BIO detailing its accomplishments and providing background material and a rationale for reauthorization (*CC-S Endnote 3*).

## CC-S-2010

For the PICES 2011 Annual Meeting, CC-S decided not to request any workshops or topic sessions but will propose a topic session for the Symposium on “*Effects of climate change on the world’s oceans*” in Yeosu, Korea scheduled for 2012. A full day for the CC-S meeting is requested at the 2011 PICES Annual Meeting to ensure time for extended discussion of progress on planned activities, including completion of PACIFICA, marginal seas, and analysis of SOCAT data.

### CC-S Endnote 1

#### CC-S participation list

##### Members

James Christian (Canada, Co-Chairman)  
Minhan Dai (China)  
Andrew Dickson (U.S.A.)  
Hernan Garcia (U.S.A.)  
Masao Ishii (Japan)  
Sophia Johannessen (Canada)  
Alex Kozyr (U.S.A.)  
Kitack Lee (Korea)  
Kyung-Ryul Kim (Korea)  
Lisa Miller (Canada)  
Akihiko Murata (Japan)  
Tsuneo Ono (Japan)  
Toshiro Saino (Japan, Co-Chairman)  
Toru Suzuki (Japan)

##### Observers

Alex Bychkov (PICES)  
Joaquim Goes (U.S.A.)  
Dong-Jin Kang (Korea)  
Robert Key (U.S.A.)  
Naohiro Kosugi (Japan)  
Yuichiro Kumamoto (Japan)  
Toshiya Nakano (Japan)  
Yukihiro Nojiri (Japan)  
Daisuke Sasano (Japan)  
Elena Ustinova (Russia)  
Luis Valdés (IOC)

### CC-S Endnote 2

#### CC-S meeting agenda

1. Opening, (Christian, Saino)  
Review and adopt agenda
2. Membership
3. CC-S achievements in the past 12 months  
PACIFICA Data Synthesis  
Report on progress of PACIFICA and remaining business (Ishii, Key)
4. Reports of collaborating organizations and agencies  
SOCAT (Nojiri)  
IOCCP/GCP (Kozyr)  
CLIVAR/GO-SHIP (Ishii, Miller)  
CARINA (Key, Kozyr)
5. Future meetings and activities  
CC-S extension: next 5 years  
Goals and objectives  
Revise terms of reference?  
Plan for presenting to POC/BIO/SB

### CC-S Endnote 3

#### 5-year review of CC-S activities

The Section on *Carbon and Climate* (CC-S) was created in the fall of 2005 to establish a more permanent body to carry on the collaborative work that was initiated by the (now disbanded) Working Groups on *Carbon Dioxide in the North Pacific* (WG 13; 1997–2002) and on *Biogeochemical Data Integration and Synthesis* (WG 17; 2001–2005). The activities and plans of the Section were reviewed by the parent committees at PICES-2010, where the Section was requesting reauthorization for a further 5 years. CC-S has two parent committees, the Physical Oceanography and Climate Committee (POC) and the Biological Oceanography Committee (BIO). Drs. James Christian (Canada) and Toshiro Saino (Japan) have chaired the Section since its inception.

#### Membership

CC-S has members from all PICES nations and an *ex-officio* member (Dr. C.T.A. Chen) representing the International Geosphere–Biosphere Project (IGBP). Current total membership is 23 with national representation in the range from 2 to 6 members (see *CC-S Endnote 1*).

#### CC-S achievements

##### *Topic Sessions at PICES Annual Meetings*

Through its parent committees, CC-S sponsored topic sessions at the 2007 and 2009 PICES Annual Meetings. The first was “*Decadal changes in carbon biogeochemistry in the North Pacific*” in Victoria, Canada in 2007 where Drs. Christian and Saino were the session convenors. Dr. Taro Takahashi (Columbia University, U.S.A.) was the invited keynote speaker. The organizers received about two dozen abstracts representing all of the member countries. The best poster presentation for all sessions sponsored by POC and its subsidiary bodies was given to Chun-Ok Jo (Korea) who participated in the session. Results from this session were published as a special section of the *Journal of Oceanography* (see under Publications).

A second topic session was held in Jeju, Korea in 2009 entitled “*Anthropogenic perturbations of the carbon cycle and their impacts in the North Pacific*”, also chaired by Drs. Christian and Saino. The invited speaker was Dr. Richard Zeebe (University of Hawaii, U.S.A.). The session was well attended (80 recorded attendees).

Both sessions drew large audiences and large numbers of presenters. This attests to widespread interest in carbon biogeochemistry at PICES Annual Meetings and the need for the continued presence of a formal body dedicated to these topic areas.

##### *Publications*

CC-S oversaw the publication of the *Guide to Best Practices for Ocean CO<sub>2</sub> Measurements* (PICES Special Publication Number 3 in 2007 (also listed as IOCCP Report #8). The Guide is now used worldwide and is considered to be the definitive reference for the ocean CO<sub>2</sub> system. It could easily be argued that it is the single most influential document published by PICES during these 5 years. The Guide is freely available in electronic form from the Carbon Dioxide Information and Analysis Center (CDIAC) at [http://cdiac.ornl.gov/oceans/Handbook\\_2007.html](http://cdiac.ornl.gov/oceans/Handbook_2007.html).

CC-S members coordinate the distribution of printed copies of the guide in PICES countries; Drs. Alex Kozyr (U.S.A.) and Toru Suzuki (Japan) are responsible for their distribution in non-PICES countries. The guide has been translated and published in Korean is currently being translated into Chinese and Spanish, with other translations expected on a volunteer basis. CC-S members also coordinate verification of the accuracy of the translation and aid the volunteer translators in maintaining consistency of formatting and presentation.

CC-S sponsored a Special Section of the *Journal of Oceanography*, published in 2009 (volume 65, number 5) with Drs. Saino, Christian, Kitack Lee, and Christopher Sabine serving as Guest Editors.

#### *PACIFICA data synthesis*

The most significant undertaking of CC-S is the data synthesis project known as PACIFICA. PACIFICA has collected biogeochemical data (DIC, TA, nutrients, oxygen, salinity) from more than 200 cruises in the Pacific and implemented a set of algorithms for crossover analysis that permit the construction of a basin-wide, consistently calibrated data set. The PACIFICA algorithms were adapted from CARINA and implemented by Dr. Suzuki. The output was made available to all participants via WWW who reviewed and discussed it throughout 2010. A workshop was held in Tokyo, Japan in June and another in Portland, U.S.A. at PICES-2010 to review the results and make collective decisions about adjustments to raw data.

This database will be an important legacy of CC-S and PICES for the Pacific Ocean scientific community. It contains several important innovations relative to previous efforts. Most of the cruises are recent (post-WOCE), and data quality is generally higher than in the WOCE era, especially for total alkalinity. In addition, the inclusion of time-series programs from Lines P and 137°E means that an unprecedented amount of temporal information has been included. Completion and publication of the data and publication of scientific analyses using the data are unfinished business and will occupy much of the Section's time for the next 1–2 years. Scientific analyses of the data are expected to be presented at the Symposium on “*Effects of climate change on the world's oceans*” in 2012 (see below on upcoming symposia).

#### **Future plans**

##### *Contribution to FUTURE*

The Science Plan of PICES' integrative science program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) notes that “natural and anthropogenic pressures are causing the oceans to acidify, while pollution, extirpations, invasive species, anoxia, habitat loss, and exploitation affect the coastal zones”, and suggests that “Region-specific assessments of topical issues (e.g., harmful algal blooms, eutrophication, native and alien species range changes, anoxia, and ocean acidification)” will be one of the key “anticipated benefits and products” of FUTURE. It is clear that ocean acidification, deoxygenation and productivity will be key issues for FUTURE and for Pacific Ocean science over the next 5–10 years. In PICES, much of the scientific expertise on these issues – particularly acidification – resides within CC-S. The Section anticipates a shift in focus from carbon biogeochemistry toward biological impacts of ocean acidification; the terms of reference were revised in 2008 to reflect this (see *CC-S Endnote 4*). CC-S also anticipates particularly strong involvement with COVE-AP but will likely play an important role in AICE-AP and SOFE-AP as well.

##### *Participation in upcoming international symposia*

The second Symposium on “*Effects of climate change on the world's oceans*” (co-sponsored by PICES, ICES, and IOC) will be held in Yeosu, Korea in May 2012 in conjunction with Ocean Expo 2012. CC-S Co-Chair, Dr. Christian, is on the Scientific Steering Committee. The third Symposium on the “*Ocean in a high-CO<sub>2</sub> world*” will be held in the fall of 2012 in Monterey, California. CC-S member, Dr. Richard Feely, (U.S.A.) is on the International Steering Committee. CC-S will sponsor topic sessions at one or both of these conferences.

##### *pCO<sub>2</sub> and pH data analysis and archiving*

PACIFICA focused primarily on discrete (bottle) data (DIC, alkalinity, nutrients, oxygen). A parallel international effort known as Surface Ocean Carbon Atlas (SOCAT) has been conducting synthesis of continuous underway pCO<sub>2</sub> data. While there is no need to duplicate this effort for our region, there is a need for CC-S members to take the lead on analysis and publication of SOCAT results for the North Pacific. These scientific analyses will be a focus of the Section's activities. Furthermore, many historic pH data sets are not properly archived. Properly documenting and archiving these data is necessary and will be a future CC-S objective.

*Data synthesis for marginal seas*

While PACIFICA focused primarily on the open ocean, a similar data synthesis effort will be undertaken for the marginal seas of the North Pacific and possibly the Pacific sector of the Arctic Ocean.

*Contribution to RECCAP*

The **REgional Carbon Cycle Assessment and Processes (RECCAP)** project is an international effort to develop a global carbon budget by synthesizing oceanic, terrestrial, and atmospheric carbon studies. CC-S members, Drs. Masao Ishii and Feely, are leading the oceanic synthesis effort for the Pacific Ocean. Contributions to RECCAP will be an important CC-S activity from 2010–2015.

*Summary of objectives for 2010–2015*

1. Complete and publish scientific analyses arising from PACIFICA data synthesis.
2. Proceed with data synthesis and intercalibration efforts for marginal seas and scientific analyses of these data.
3. Assess the measurement uncertainty required for CO<sub>2</sub> measurements in coastal regions, and identify suitable measurement techniques (and their associated quality control procedures) that are able to achieve these. Where practical, these proposed techniques should be tested through collaborative studies, and appropriate Standard Operating Procedures prepared.
4. Conduct analyses of the SOCAT surface ocean pCO<sub>2</sub> data base for the North Pacific region and coordinate synthesis and archiving of pCO<sub>2</sub> data from ongoing programs in PICES member countries. Contribute to the global data synthesis effort through RECCAP and related programs.
5. Document, archive, and quality control historical pH data and conduct retrospective analyses of ocean acidification.
6. Coordinate and encourage research into ocean acidification and hypoxia and their biological and ecosystem impacts.

**CC-S Endnote 4**

**CC-S Terms of Reference**  
(bold indicates 2008 revisions)

1. Coordinate and encourage ongoing and planned national and international syntheses of carbon cycle research studies in the North Pacific and, where necessary and appropriate, for the larger Pacific basin;
2. Ensure effective two-way communication with other international scientific groups that have a responsibility for the coordination of ocean carbon studies, such as the International Ocean Carbon Coordination Project (IOCCP), CLIVAR/CO<sub>2</sub> Repeat Hydrography and the SOLAS/IMBER implementation group for carbon research;
3. Review the existing information on carbon cycling in the North Pacific, including anthropogenic carbon, the biological pump, impacts **of ocean acidification** on marine biota, and possible feedbacks to atmospheric greenhouse gases; identify gaps in our knowledge, and make prioritized recommendations for future research;
4. Periodically review the status of the methodology of CO<sub>2</sub> measurements, including the preparation of standards and reference materials, and advise on inter-calibration and quality control procedures;
5. Identify suitable data sets on the oceanic CO<sub>2</sub> system in the Pacific region as they become available, and recommend the mechanisms of data and information exchange;
6. Carry out and publish (in the refereed literature) basin-scale syntheses of carbon cycling in the North Pacific, including new data whenever appropriate, and encourage scientific interpretation of these evolving data sets;
7. Organize symposia, workshops, or Annual Meeting sessions on **the carbon cycle, ocean acidification**, and climate studies in the North Pacific.