Report of Joint PICES-ICES Working Group on *Climate Change and Biologically-driven Ocean Carbon Sequestration*

A business meeting of the Joint PICES-ICES Working Group on *Climate Change and Biologically-driven Ocean Carbon Sequestration* (WG 33) was held in Xiamen, China, on December 12, 2016. During this meeting, participants (*WG 33 Endnote 1*) provided a brief overview of their activities and reported the progress of the joint WG in 2016. The meeting was co-chaired by Prof. Nianzhi Jiao, Prof. Louis Legendre, and Prof. Richard B. Rivkin. Below are agenda items and the corresponding discussions during the meeting (*WG 33 Endnote 2*).

AGENDA ITEM 1

Review the WG background and kick-off meeting held in Hong Kong during June 2016

A brief review of the WG background and the kick-off meeting[1], held June 17, 2016, in Hong Kong was provided by the Co-Chairs.

AGENDA ITEM 2

Progress reports from China

(1) *Two China National Key Research and Development Projects*

Two National Key Research and Development Projects involving participation of WG members were approved by the Ministry of Science and Technology of China. These projects on blue carbon were brought into line with the "13th Five-year Plan" (2016~2020) that was enacted by the Chinese government.

The project, led by Prof. Yao Zhang from Prof. Nianzhi Jiao's group (Institute of Marine Microbes and Ecospheres (IME) at Xiamen University), is to study the key processes and the regulatory mechanisms of the ocean carbon sink and its relationship with environment and global climate changes. It is expected to support the sustainable development of marine ecosystem and national carbon emissions trading, by providing an index system for carbon storage, including a series of physical–chemical and biological indices and parameters and protocols of core measurements. The other project, led by Prof. Shucheng Xie from China University of Geosciences, Wuhan, is titled "*Mechanisms of marine carbon storage and carbon, nitrogen and sulfur cycles in response to global change*", which aims at conducting the research under the framework of linking the current and past oceans. It is expected to provide some supporting evidence for the existence of the microbial carbon pump (MCP) in the ancient oceans.

These two ongoing projects have been endorsed by Integrated Marine Biogeochemistry and Ecosystem

[1] The kick-off meeting of the joint WG was held to discuss the Terms of Reference and assignment of tasks.

Research (IMBeR). IMBeR can provide research platforms for the WG members and the research findings from these projects will significantly contribute to the understanding of climate change and the biologically-driven ocean carbon sequestration.

(2) *Blue Carbon proposals to the China State Council and related activities*

A series of Blue Carbon related proposals was submitted to the Chinese central government by Prof. Nianzhi Jiao, including the proposal titled "*Developing Ocean Carbon Sequestration, and fostering carbon trading market*". This proposal was submitted to the China State Council during the 4th session of the 12th National People's Congress held in March, 2016, and was highly valued by authorities. As a result of years of efforts, ocean carbon sequestration has been incorporated into the Chinese national strategy. The document, "*Overall Plan of Ecological Civilization Construction and Reform*", issued by the China State Council, explicitly pointed out that "it is necessary to establish an effective mechanism to increase ocean carbon sequestration". This is an encouraging record for WG members to promote the ocean carbon sequestration at a national level. Moreover, Prof. Jiao, together with international colleagues, has been taking vigorous actions to promote Blue Carbon to be included in the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

Through the efforts of Prof. Jiao, the China Ocean Carbon Alliance (COCA) and China Future Ocean Alliance (CFO) have been formed as platforms for interdisciplinary and cross-paleo-current studies on Blue Carbon, and a series of marine carbon monitoring stations, as well as two petroleum platforms, has been set up along the Chinese coast. With the support of COCA, the International Workshop on Blue Carbon was held in November 2016, Zhejiang University. On behalf of the joint WG, Prof. Rivkin and Prof. Rui Zhang attended the Workshop. Prof. Rivkin presented an invited talk on the importance of the biological carbon pump (BCP) and microbial carbon pump (MCP) as a potential source of Blue Carbon, and co-led in a workshop manuscript on the role of Blue Carbon in Chinese coastal waters and the potential application of artificial upwelling as a mean to enhance carbon sequestration proposed by Prof. Jiao.

(3) *Two Chinese Academy of Sciences consulting projects*

In 2016, Prof. Jiao was awarded two Chinese Academy of Sciences (CAS) consulting projects. Geared to China's national demands for ecological civilization and social public benefits, the CAS consulting projects aim at solving the environmental and related problems that China faces in its development, and providing a communication channel for researchers to propose advice to the Chinese government.

Supported by both CAS and National Natural Science Foundation of China (NSFC), the project of "Developing Strategy in Microbial Oceanography" provides a platform where WG members and other researchers in China will have a forum to discuss basic scientific issues related to climate change themes (that are consistent with the WG themes). The WG members and Chinese colleagues have held four meetings on Microbial Oceanography in Xiamen and Qingdao since December 2015, focusing on progress of microbial oceanography worldwide. The Microbial Oceanography Society was established in November 2016.

The other CAS consulting project is about water environment monitoring and protocol standardization of the

core measurements in ocean carbon sequestration. This project will provide support for the WG Term of Reference (ToR) #2 (See *WG 33 Endnote 3*).

(4) *FUTURE–China and the use of an artificial upwelling system*

The background of PICES' integrated scientific program, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) was introduced to participants during the meeting. With the efforts of WG members, the first national FUTURE program among PICES member countries—FUTURE China—was established, which aims at gathering not only scientists in the marine field but also research institutions from related fields in China. Furthermore, the foundation of FUTURE China will be able to better target the unique eco-environmental problems and national demands of China, such as the anthropogenic influences on coastal ecosystem, and play an important role in solving the eco-environmental problems that commonly exist. Therefore, this scientifically based FUTURE China program is also welcomed by the Chinese government. Profs. Jiao and Rivkin and WG-supporting researchers participated in a practice demo of the FUTURE China program, which was launched in Xiamen in November 2016 and aimed at testing how the artificial upwelling system in the ocean can influence the phytoplankton and carbon sequestration.

As an experimental facility, this artificial upwelling system for phytoplankton and carbon sequestration would be applied to WG ToR#3 on developing new approaches and experimental facilities. Thus the Co-Chairs suggested that the topic on carbon sequestration and carbon capture by an artificial upwelling system could be included in joint WG research plan.

Meeting participants agreed with the proposal by Prof. Jiao to apply artificial upwelling systems to enhance the production of farmed seaweeds for blue carbon sequestration in Chinese coastal waters. The idea is to supplement the nutrient-depleted surface layer, where seaweeds are farmed, with nutrient-repleted deepwater while reducing the risk of eutrophication and algal blooms by the sudden impact of extra nutrients from a turnover of the water column by wind, *etc*. Such ecosystem mitigation processes are allowed by Chinese law and will provide new supporting measures for ecosystem sustainable development.

AGENDA ITEM 3

Presentations on carbon protocols

During the meeting, Prof. Jiao's research group presented research on carbon protocols and the feasibility of launching ocean carbon sequestration into the carbon trading market. It was pointed out that China would launch a national Emissions Trading Scheme (ETS) in 2017 and issue a new regulation on carbon emission trading. Carbon is experimentally traded in 109 cities in 2016, and will be expanded to all cities in China next year, and will offer an opportunity to promote the ocean carbon sink into the carbon market. Therefore, a series studies would be carried out to establish a measuring and monitoring project methodology authenticated by domestic and international organizations. In addition, research on carbon protocols would be conducted by integrating ocean carbon sequestration with ecological compensation measures in China. ICES WG member, Dr. Carol Robinson, is taking a leading role in ToR#2 with the aim of collecting and summarizing protocols of

measuring respiration. ICES WG member, Dr. Elena Garcia-Martin, presented newly started research on current methods to measure plankton and bacterial respiration. She plans to use INT and Winkler techniques to estimate plankton and bacterial respiration along a salinity gradient in an estuary close to Xiamen city, and test hypothesis regarding the influence of organic matter on the accuracy of the INT method.

The Co-Chairs agreed that the joint WG members should be encouraged to give comments and suggestions on the China's carbon protocols, and the way the protocols could be more easily accepted by the international society. Although ocean carbon does not yet exist in the market, ocean carbon trading still has a good basis in China. Thus, the joint WG can take the initiative to implement ocean carbon protocols in China.

AGENDA ITEM 4

Review of Working Group 33 ToRs

Dr. Angelica Peña leads the WG's efforts in modeling (ToR#4), and the members, including Marion Gehlen, Eun Young Kwon, Robin Anderson, Yawei Luo, and Richard Rivkin also contribute to the modeling. Dr. Nannan Wang has been invited by ICES Co-Chair, Dr. Louis Legendre, to join the research in modeling as an ICES Chair-invited member.

AGENDA ITEM 5

Discussion and future plan

The following agreements and conclusions were reached during the WG meeting.

(1) WG 33 should promote the establishment of international communication platforms, such as Gordon Research Conferences/Seminars on Ocean Biogeochemistry and CAS international conference forums, for WG member to exchange ideas and progresses. WG members will try to apply for fund to support these platforms.

(2) Regarding to the joint WG membership, it was agreed to invite additional scientists who conduct research in ocean carbon sequestration to join WG in the near future. Prof. Rivkin mentioned that, according to the ICES rules, Chairs could directly invite members. Profs. Yao Zhang and Nannan Wang have been invited to join the WG on the ICES side.

(3) The joint WG should make full use of projects and platforms already established, widely collect data from literature and simplify unnecessary paperwork. More scientific achievements and papers on ocean carbon sequestration are expected to come out.

WG 33 Endnote 1

WG 33 participation list

Members

Nianzhi Jiao (China, Co-Chair/PICES)
Louis Legendre (France, Co-Chair/ICES)
Richard B. Rivkin (Canada, Co-Chair/PICES)
Ya-wei Luo (China/PICES)
Yao Zhang (China/ICES)
Rui Zhang (China/PICES)
Elena Gracia-Martin (UK/ICES)
Nannan Wang (China/ICES)
Yabin Guo (China/ICES)

PICES members unable to attend

Canada: Angelica Peña
China: Fengping Wang, Chuanlin Zhang,
Japan: Koji Suzuki, Youhei Yamashita
Korea: Keun-Hyubg Choi, Jung-Ho Hyun, Eun Young Kwon
USA: Uta Passow, Curtis Suttle

Observers

Kai Tang (China)
Dapeng Xu (China)
Hongyue Dang (China)
Zilian Zhang (China)
Tingwei Luo (China)

WG 33 Endnote 2

WG 33 meeting agenda

1. Review the WG background and kick-off meeting held in Hong Kong during June 2016
2. Progress reports
3. Presentations on carbon protocols
4. Review of Working Group 33ToRs
5. Discussion and future plans

WG 33 Endnote 3

WG 33 Terms of Reference

1. Document and identify current knowledge about biologically-driven carbon pumps.
2. Compare current approaches and develop standardized protocols for measuring and reporting key parameters and variables during field studies and laboratory experiments on biologically-driven ocean carbon sequestration.
3. Promote international collaboration for developing new experimental approaches and facilities.
4. Integrate results from laboratory and field studies into numerical modeling for forecasting biologically-driven ocean carbon sequestration in the contemporary and future ocean.
5. Hold annual workshops and business meetings at PICES, ICES or both organizations annual meetings.

6. Organize a theme session within a science symposium in year 3 (ca. 2018-19 time frame) to present, discuss and publish forecasts of the effects of climate change on biologically-driven ocean carbon sequestration; The Fourth Climate Effects on the World's Oceans Symposium, tentatively planned for 2018 might be a good venue. Produce a special issue of a scientific journal based on the theme session, or contribute multiple papers to the Symposium special issue.
7. Provide scientific advice to international organizations such as IPCC that might aid in establishing climate policies.
8. Publish a final report summarizing the results of the WG as a jointly published Scientific Report in both PICES and ICES.