

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

A 1-day meeting of the joint PICES/ICES Working Group on *Climate Change and Biologically-driven Ocean Carbon Sequestration* (WG 33) was held from 09:00-17:00 on September 24, 2017 at PICES-2017 in Vladivostok, Russia. The meeting was convened by Co-Chairs Drs. Richard Rivkin and Nianzhi Jiao. Nine PICES members representing Canada, China, Japan, Korea and USA attended (*WG 33 Endnote 1*). The meeting agenda was reviewed by the participants and accepted (*WG 33 Endnote 2*).



WG 33 meeting participants (from left): Jizhong Zhou, Chuanlun Zhang, Koji Suzuki, Nianzhi Jiao, Richard Rivkin, Rui Zhang (behind), Angelica Peña, Curtis Suttle, Sinjae Yoo, Jung-Ho Hyun. Missing from photo: Uta Passow.

AGENDA ITEM 2 **FUTURE-China**

Drs. Jiao and Rui Zhang provided a brief summary about FUTURE-China.

AGENDA ITEM 3 **Review of WG activities and progress to date**

WG members reviewed WG activities since the WG meeting in Hong Kong, June 2016, including activities during the WG science meetings in Qingdao and Beijing in September 2017 (see *WG 33 Endnote 3*), and the progress towards fulfilling Terms of Reference (ToRs). The Co-Chairs proposed a timeline for completing existing ToRs, including progress reports to be submitted to PICES and ICES. In addition, WG members continue group writing of manuscripts and reports that were initiated during the WG science meetings in Qingdao and Beijing.

AGENDA ITEM 4 **PICES-2017 Science Board Symposium**

Dr. Jiao delivered a plenary talk entitled “*Biological mediated carbon cycling and sequestration in the ocean and climate change*”, co-authored with Louis Legendre and Richard Rivkin at the Science Board Symposium (September 25, 2017).



AGENDA ITEM 5

PICES-2017 Topic Session S13

A ¾-day joint PICES-ICES Topic Session (S13) on “*Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services*” took place on September 26, 2017. The convenors were Richard B. Rivkin (PICES/Canada), Louis Legendre (ICES/France), Nianzhi Jiao (PICES/China) and M. Robin Anderson (ICES/Canada). For a list of S13 presentations see [Session and Workshop Summaries for PICES-2017](#).

AGENDA ITEM 6

Fulfilment of WG ToR 3

In accordance with WG 33 ToR 3, “Promote international collaboration for developing new experimental approaches and facilities”, the Co-Chairs of PICES/ICES WG 33, Louis Legendre, Richard B. Rivkin and Nianzhi Jiao have published a high-profile “Food for Thought” paper entitled “Advanced experimental approaches to marine water-column biogeochemical processes” (*ICES J. Mar Sci.* [doi:10.1093/icesjms/fsx146](https://doi.org/10.1093/icesjms/fsx146), 1–13), fulfilling the objectives of the ToR.

AGENDA ITEM 7

New membership

WG 33 requests the addition of Dr. Pavel Tishchenko (Russia) to its membership.

WG 33 Endnote 1**WG 33 participation list**Members

Jung-Ho Hyun (Korea/PICES)
 Nianzhi Jiao (China, Co-Chair/PICES)
 Uta Passow (USA/PICES)
 Angelica Peña (Canada/PICES)
 Richard B. Rivkin (Canada, Co-Chair/PICES)
 Curtis Suttle (Canada/PICES)
 Koji Suzuki (Japan/PICES)
 Chuanlun Zhang (China/PICES)
 Rui Zhang (China/PICES)

WG 33 PICES members unable to attend

China: Ya-Wei Luo, Fengping Wang
 Japan: Youhei Yamashita
 Korea: Keun-Hyung Choi, Eun Young Kwon

Observers

Sinjaee Yoo (Korea)
 Jizhong Zhou (USA)

WG 33 Endnote 2**WG 33 meeting agenda**

1. Opening
2. Summary of FUTURE-China
3. Review of WG activities and progress to date
4. PICES-2017 Science Board Symposium
5. PICES-2017 Topic Session S13
6. Fulfilment of WG ToR 3
7. New membership

WG 33 Endnote 3**Reports on WG 33 activities in 2017**

In 2017, the joint PICES/ICES Working Group on *Climate Change and Biologically-Driven Ocean Carbon Sequestration* organized a series of activities including a science workshop in Qingdao, China, a conference in Beijing (Yanqi Lake), China, and a WG meeting and a topic session during the PICES 2017 Annual Meeting in Vladivostok, Russia. These activities aimed at improving the understanding of ocean carbon sequestration both theoretically and practically. They also supported the goals of the WG which include promoting the practical and theoretical understanding of marine carbon export and sequestration and its potential impact on global climate.

The Yanqi Lake Conference on “*Climate change and biologically driven ocean carbon sequestration*” (September 19–22, 2017, Beijing) was co-chaired by five academicians from four countries: Nianzhi Jiao, Member of the Chinese Academy of Sciences (CAS); Farooq Azam, Fellow of the American Academy of Arts and Sciences; Louis Legendre, Fellow of the European Academy of Sciences; Curtis Suttle, Fellow of the Royal Society of Canada, and Zhengtang Guo, Member of CAS. During the conference, the participants not only made cutting-edge presentations, but also discussed each presentation in-depth.

During the WG’s meeting at PICES-2017 (September 22–October 1, 2017, Vladivostok, Russia), Prof. Jiao introduced recent progress and activities since the WG meeting in Hong Kong in June 2016. WG members discussed the timeline for completing the Terms of Reference (ToRs), the feasibility of extending the WG, and continued group writing. In addition, the WG held a topic session on “*Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services*” at PICES-2017. The session had 11 contributed talks, and was attended by about 50 participants.

As a result of these activities, the WG plans to draft three perspective papers, three invited review papers and a discussion forum in *National Science Review* (IF=8.8), and organize two special issues in *Science China-Earth Science*. Dr. Jiao also reported on a meeting of the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Special Report on Ocean and Cryosphere (October 1–7, 2017, Fiji).

In addition, the Co-Chairs of PICES/ICES WG 33, Louis Legendre, Richard B. Rivkin and Nianzhi Jiao published a high-profile “Food for Thought” paper entitled “Advanced experimental approaches to marine water-column biogeochemical processes” (*ICES J. Mar. Sci.* [doi:10.1093/icesjms/fsx146](https://doi.org/10.1093/icesjms/fsx146)), which fulfills the objectives of WG ToR 3 (Promote international collaboration for developing new experimental approaches and facilities).

Drs. Legendre and Rivkin and WG members Robin Anderson (ICES) and Jung-Ho Hyun (PICES) met during ASLO Aquatic Sciences Meeting in February 2017. Other activities that were related to WG 33 were a MOST project meeting and an MECS IAC meeting held in Qingdao.

Dr. Jiao will co-convene a Theme Session on “*Carbon uptake, ocean acidification, and ecosystems and human impacts*” at the PICES/ICES/IOC/FAO 4th International Symposium on “*The effects of climate change on the world’s oceans*” (June 4–8, Washington, DC, USA).

Below are the details of WG 33 activities for 2017, organized by date.

**MOST project meeting on the “Microbial Carbon Pump”
September 16, 2017, Qingdao**

A meeting was held on September 16, 2017 to review the study of the “Microbial Carbon Pump in China Seas”, supported by the Ministry of Science and Technology (MOST). Attending were WG 33 members Dr. Nianzhi Jiao (Co-Chair/PICES), Louis Legendre (Co-Chair/ICES), Richard Rivkin (Co-Chair/PICES), Curtis Suttle, Rui Zhang and Yawei Luo. Highlights identified by the review panel will be published in the *National Science Review*, a leading journal that aims at reviewing cutting-edge developments across science and technology in China and around the world (with an impact factor 8.8).



**Marine carbon sequestration workshop on “*Mechanisms, modeling and protocols*”
September 17, 2017, Qingdao**

Prof. Nianzhi Jiao hosted the opening of the workshop, and gave a general introduction. The leaders from local host institutions also gave welcome speeches in the opening session. The aim prospective outputs (papers/reports) of the workshop were introduced by Profs Richard Rivkin, Louis Legendre and Nianzhi Jiao. The workshop focused on the following topics: marine carbon sequestration, mechanisms and processes; modeling for carbon sequestration; marine carbon sequestration protocols; and reports needed for the IPCC special report on ocean carbon issues.



**September 17, 2017
Field tours, Qingdao**

Field tours, as part of the workshop, were led by Profs. Jihua Liu, Yao Zhang and Wei Fan, and included a field demonstration of a mesocosm, an artificial upwelling system demonstration and the Mini-MECS (Marine Environmental Chamber System). The participants went to Aoshan Bay by ferry to view the facilities.



**MECS IAC Meeting, Qingdao
September 17, 2017**

A meeting of the International Advisory Committee (IAC) of the Marine Environmental Chamber System (MECS) was held at Shandong University, Qingdao, on September 17, 2017. The convenors were Profs. Lei Jia, Yanjun Liu and Jihua Liu. Prof. Yanjun Liu introduced the MECS with a video. Prof. Louis Legendre, Chair of the IAC, led a discussion following the presentation.



**Yanqi Lake Conference on “Climate change and biologically driven ocean carbon sequestration”
September 19–22, 2017, Beijing**

September 19, 2017

Opening ceremony

The opening ceremony of the Yanqi Lake Conference was held at the Yanqi International Conference Center, Beijing, on September 19, 2017.

The following invited experts participated in the opening ceremony of the Beijing conference and gave addresses: Dr. Hong Wang, Minister of the State Ocean Administration (the Chinese supervising agency for PICES-China), Academician Guanhua Xu, Former Minister the Ministry of Science and Technology of China; Dr. Hong Mei, Deputy Director of Academic Works and Publications Committee of the Academic Divisions of CAS; Dr. Salvatore Arico, Head of Ocean Science Section, Intergovernmental Oceanographic Commission of UNESCO; Mr. Xi Xu, Director of Beijing Municipal Human Resources and Welfare Bureau. Prof. Nianzhi Jiao and Prof. Zhengtang Guo, Members of CAS, co-chaired the opening ceremony.

Prof. Louis Legendre presented the first keynote speech on “*Advanced experimental approaches to marine water-column biogeochemical processes*”, and Prof. Jiao presented the second keynote speech on “*Land-ocean integrated study for carbon sequestration to cope with climate change*”.

The following invited guests were present at the ceremony: Zuoyan Zhu, Member of CAS, former Associate Director of National Natural Science Foundation of China (NSFC), Editor-in-Chief of *Science China*; Ting Li, Director of Administration of the Academic Divisions of CAS; Bei Chen, Deputy Director of Beijing Municipal Human Resources and Social Security Bureau; Minhua Liu, Head of Organization Department of

Beijing Municipal Committee of CPC; Xin Li, Head of Experts Department of Beijing Municipal Human Resources and Social Security Bureau. Invited members of CAS were: Academicians Mu Mu, Dake Chen, Hongfu Yin, and Zhonghe Zhou. More than 40 international experts, including members of the WG 33, and 50 Chinese scholars and students attended this international forum (Appendix 1).

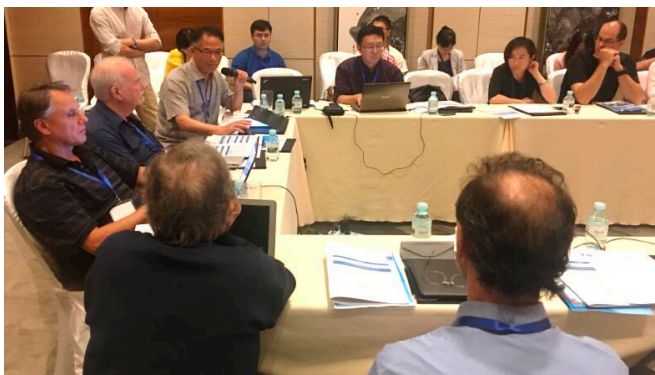


September 20, 2017

Session 1 - Carbon sequestration mechanisms and processes

Session 1 on “*Carbon sequestration mechanisms and processes*” was convened by Profs. Nianzhi Jiao and Louis Legendre. The session included the following presentations:

- Microbial structuring of marine ecosystems: Significance for carbon cycling and climate change (Farooq Azam);
- Climate change and the cycling of refractory dissolved organic carbon in the ocean (Ronald Benner),
- Climate change: Response of phytoplankton to multiple stressors (Uta Passow),
- The biological pump under climate change (Marion Gehlen),
- Heterotrophic prokaryotes control biologically-driven carbon sequestration in highly productive Amundsen Sea Polynya, Antarctica (Jung Ho Hyun).

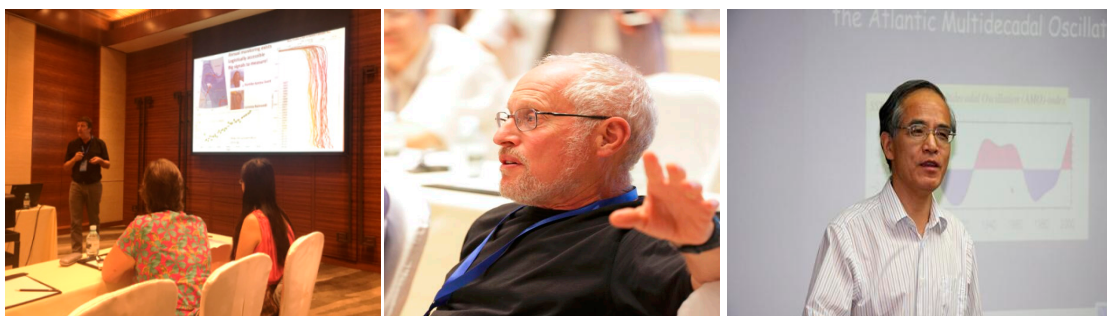


September 21, 2017

Session 2 - Observation and modeling for carbon sequestration

Session 2 on “*Observation and modeling for carbon sequestration*” was led by Profs. Zhengtang Guo and Richard Rivkin. The session included the following presentations:

- Sequestration of carbon and oxygen in high latitude, deep convection regions: process understanding from multidisciplinary, in-situ time-series (Douglas Wallace);
- Holocene paleo-land use and influences on terrestrial carbon (Yanyan Yu);
- Visualizing bacterioplankton succession and bacterial polysaccharide utilization in a coastal sea (Rudolf Amann);
- Are we able to model the microbial carbon pump? Current state and future directions (Luca Polimene);
- An extension of conditional nonlinear optimal perturbation approach and its applications (Mu Mu).



September 22, 2017

Session 3 - Core measurements and protocols

Session 3 on “Core measurements and protocols” was led by Profs. Carol Robinson and Curtis Suttle. The session included the following presentations:

- Viral mediated mortality in marine systems (Curtis Suttle);
- Perspectives in COD and DOC issues: from land to ocean, from science to policy (Nianzhi Jiao);
- Development and applications of high throughput metagenomics technologies to marine biogeochemistry (Jizhong Zhou);
- Plankton respiration - the known unknown? (Carol Robinson);
- Expectations for marine carbon protocols (Yao Zhang).



Each presentation in Sessions 1 to 3 lasted for 20 minutes, and was followed by 5 minutes of discussion. After all presentations, there was a 60 minute general discussion of the session topic.

September 20, 2017, Beijing

***National Science Review* interview**

An interview was convened by Zhonghe Zhou, Member of CAS, in Yanqi Lake on September 20, 2017. It involved seven representative scientists, who included members of Academy of Sciences: Profs. Nianzhi Jiao, Farooq Azam, Louis Legendre, Douglas Wallace, Carol Robinson, Chuanlun Zhang, and Dr. Luca Polimene. The interview focused on the microbial carbon pump, and a resulting “Forum” paper will be published in *National Science Review*.



Appendix 1: Participants list of Yanqi Lake Conference**Invited Guests**

Name	Affiliation
Hong Wang	Minister of the State Oceanic Administration (SOA), China
Gunahua Xu	Former Minister of Ministry of Science and Technology (MOST) China, Member of Chinese Academy of Sciences (CAS)
Hong Mei	Associate Director of Academic Works and Publications Committee of the Academic Divisions of Chinese Academy of Sciences (CAS), Member of Chinese Academy of Sciences (CAS)
Salvatore Arico	Head of ocean science section, Intergovernmental Oceanographic Commission (IOC) of UNESCO
Zuoyan Zhu	Former Associate Director of NSFC, Editor-in-Chief of <i>Science China</i> , Member of Chinese Academy of Sciences (CAS)
Ting Li	Director of Administration of the Academic Divisions of Chinese Academy of Sciences (CAS)
Ronghui Su	Deputy Director of Administration of the Academic Divisions of Chinese Academy of Sciences (CAS)
Xi Xu	Director of Beijing Municipal Human Resources and Social Security Bureau
Bei Chen	Deputy Director of Beijing Municipal Human Resources and Social Security Bureau
Xin Li	Head of Specialist Department of Beijing Municipal Human Resources and Social Security Bureau

International Experts

Name	Affiliation
Farooq Azam	Distinguished Professor at Scripps Institution of Oceanography, USA, Fellow of the American Academy of Arts and Sciences
Louis Legendre	Professor Emeritus at the Pierre & Marie Curie University, Paris, France, and Laval University, Canada, Fellow of the Royal Society of Canada, Academy of Sciences, Fellow of the European Academy of Sciences
Curtis Suttle	Distinguished University Scholar, Earth & Ocean Sciences, Microbiology & Immunology, and Botany, University of British Columbia, Canada, Fellow of the Royal Society of Canada, Academy of Sciences
Ronald Benner	Professor, University of South Carolina, USA, Fellow of the American Geophysical Union
Douglas Wallace	Canada Excellence Research Chair. Professor of Oceanography, Dalhousie University, Canada
Rudolf Amann	Professor, Max Planck Institute for Microbial Microbiology, University of Bremen, Germany
Richard Rivkin	University Research Professor, Department of Ocean Sciences, Memorial University of Newfoundland, Canada
Luca Polimene	Researcher, Plymouth Marine Laboratory, UK
Jizhong Zhou	Professor, University of Oklahoma, USA

Carol Robinson	Professor, University of East Anglia, UK
Uta Passow	Professor, University of California Santa Barbara Santa Barbara, USA
Marion Gehlen	Researcher, Laboratoire des Sciences du Climat et de l'Environnement, France
Jung-Ho Hyun	Professor, Hanyang University, South Korea
Hermanni Kaartokallio	Professor, Finnish Institute of Marine Research, Finland
Eun Young Kwon	Professor, IBS Center for Climate Physics. Pusan National University, Korea
John Batt	Aquatron Laboratory, Dalhousie University, Canada

Chinese Academicians

Name	Affiliation
Nianzhi Jiao	Associate Director of the Earth Science Division, Chinese Academy of Sciences (CAS), Chair Professor, Xiamen University, Member of Chinese Academy of Sciences (CAS), Fellow of Third World Academy of Sciences (TWAS)
Zhengtang Guo	Chair Professor, Institute of Geology and Geophysics, Chinese Academy of Sciences (CAS), Vice President of University of CAS, Member of Chinese Academy of Sciences (CAS)
Mu Mu	Professor, Institute of Oceanology, Chinese Academy of Sciences (CAS), Member of Chinese Academy of Sciences (CAS), Fellow of Third World Academy of Sciences (TWAS)
Dake Chen	Chair Professor, Second Institute of Oceanography, SOA, China, Member of Chinese Academy of Sciences (CAS)
Hongfu Yin	Professor, China University of Geosciences (Wuhan), Member of Chinese Academy of Sciences (CAS)
Zhonghe Zhou	Associate Director of the Earth Science Division, Chinese Academy of Sciences (CAS), Director, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (CAS), Member of Chinese Academy of Sciences (CAS), Foreign Associate member of National Academy of Science, USA

Chinese Experts

Name	Affiliation
Chuanlun Zhang	Professor, Southern University of Science and Technology
Hongyue Dang	Professor, Xiamen University
Yaodong He	Professor, Tianjin University
Fengping Wang	Professor, Laboratory of Microbial Oceanography, Shanghai Jiao Tong University
Chao Li	Professor, China University of Geosciences (Wuhan)
Xiaoxue Wang	Professor, South China Sea Institute Oceanology, Chinese Academy of Sciences (CAS)
Ge Chen	Professor, Ocean University of China
Quan Shi	Professor, China University of Petroleum
Rui Zhang	Professor, Xiamen University

Yao Zhang	Professor, Xiamen University
Xiaoke Hu	Professor, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences (CAS)
Yongyu Zhang	Professor, Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences (CAS)
Jie Xu	Professor, South China Sea Institute of Oceanology, Chinese Academy of Sciences (CAS)
Haibin Wu	Professor, Institute of Geology and Geophysics, Chinese Academy of Sciences (CAS)
Yanyan Yu	Associate Professor, Institute of Geology and Geophysics, Chinese Academy of Sciences (CAS)
Kai Tang	Associate Professor, Xiamen University
Qiang Zheng	Associate Professor, Xiamen University
Yawei Luo	Associate Professor, Xiamen University
Wei Fan	Associate Professor, Zhejiang University
Jihua Liu	Associate Professor, Shandong University
Yantao Liang	Assistant Professor, Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences (CAS)
Nannan Wang	Dr., Xiamen University
Ruanhong Cai	Dr., Xiamen University
Xiaolin Ren	Dr., Institute of Geology and Geophysics, Chinese Academy of Sciences (CAS)
Chen He	Dr., China University of Petroleum
Xiuling Xu	Managing Editor, National Science Review Editorial Office, Science China Press
Weijie Zhao	News Editor, National Science Review Editorial Office, Science China Press
Jianjing Wei	Editor, China Science Daily
Hong Cui	Editor, China Science Daily
Junyi Chen	Journalist, China Ocean News
Ran Huang	Journalist, China Ocean News
Qian Zhang	Research Assistant, University of Chinese Academy of Sciences (CAS)
Qiaodan Weng	Research Assistant, Xiamen University
Yujiao Zhang	Research Assistant, Xiamen University
Xiaotong Yu	Research Assistant, Xiamen University
Yingnan Fu	Research Assistant, Xiamen University
Nannan Zhang	Research Assistant, Xiamen University