ICES/PICES Working Group on Climate Change and Biologically-driven Ocean Carbon Sequestration (WGCCBOCS)

2015/MA2/SSGEPD05 The **ICES/PICES Working Group on Climate Change and Biologically-driven Ocean Carbon Sequestration** (WGCCBOCS), chaired by Nianzhi Jiao*, China, Louis Legendre*, France, and Richard Rivkin*, Canada, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2016	17 June (kick-off meeting)	Hong Kong, China	Interim report by 31 December to SSGEPD	
	2 November	San Diego, USA		
Year 2017	July (TBA)	Newfoundland, Canada	Interim report by Date Month to SSGXXX	
Year 2018	October (TBA)	Xiamen, China	Final report by Date Month to SSGXXX	

Overview

Carbon sequestration is among the important earth-ecosystem services provided by the oceans. Atmospheric CO_2 that is taken up by phytoplankton can be transformed by the pelagic food webs into various organic materials, some of which are exported from the surface and sequestered in coastal shelf sediments and the deep ocean, or partly transformed into long-lived dissolved organic compounds. This ICES/PICES Working Group will promote interdisciplinary exchanges among the research communities by bringing together experts who have experience using observational, experimental and modeling approaches to characterize and assess one or more of the biologically-driven ocean carbon pumps and their environmental and climate consequences. The working group has long term objectives of improving prediction and advice for climate policy and adaptation in the environment of changing climate.

1 Link the studies on different biologically-driven ocean carbon pumps
   1.1 Review current understanding of the three types of these pumps: the biological carbon pump (i.e. soft tissue pump), the carbonate pump, and the microbial carbon pump, and the controlling mechanisms for these pumps;
   1.2 Review current estimates of the magnitude of these pumps;
   1.3 Review and propose potential interaction pathways among these pumps;
   1.4 Foster collaborations among scientists in studying the interaction of these pumps.
2 Integrate different approaches to study biologically-driven ocean carbon pumps
   2.1 Review current available experimental and modelling approaches to characterize and assess these pumps;
   2.2 Identify the ability of the existing approaches to study and quantify the interactions among pumps;
   2.3 Propose new approaches to studying the interactions among pumps.
3 Improve prediction and advice for climate policies that are related to biologically-driven ocean carbon pumps

3.1 Foster collaborations in developing numerical models to predict the impact of climate change on these pumps;

3.2 Explore and where possible quantify the potential effects of climate change on the ecosystem services supported by the carbon pumps

3.3 Provide an operational framework within which scientists could formulate advices on climate policy to international organizations.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Document and identify current knowledge about the biologically-driven carbon pumps	To review and study the interactions among the carbon pumps and to predict how they may change in an evolving climate; To advance the understanding of the relationship among the carbon pumps; To review key processes and assess biological factors and environmental variables that control carbon sequestration in the ocean.	EPD 1, 3, 4	1.5 years	Review paper during year 2
b	Develop standard monitoring protocols	It is essential to review and 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.	IEOM 25, 27, 28	3 years	Review papers and technical report in year 3
c	Promote international collaboration for developing new experimental approaches and facilities	Current approaches are not adequate to comprehensively study the interactions of these ceabon pumps. New experimental approaches and facilities are needed to better quantitatively address important processes that control ocean carbon pumps and carbon sequestration.	EPD 1, 4, EPI 11, 13	3 years	Plans for new experimental approaches and facilities
d	Explore techniques for prediction of biologically mediated carbon sequestration in oceans	Integrate results from laboratory and field studies into numerical modeling for forecasting biologically-driven ocean carbon sequestration in the contemporary and future ocean.	EPD 3, 4, EPI 11, IEA 22	3 years	Recommend improvements to models integrating biologically-mediated carbon pump processes.
e	A science symposium	Organize a science symposium in year 3 to present, discuss and publish forecasts of the effects of climate change on biologically-driven ocean carbon sequestration; provide scientific advice to international organizations such as	2EPD 3, 4, EPI 11, IEA 22	1 year	Specal issue of a scientific journal

	IPCC to aid in establishing climate policies.

Summary of the Work Plan

Year 1	(1) Hold a initial organizational meeting. (2) Review and document current understanding of the mechamisums the pumps, the estimate of the magnitude of the pumps, and the extisting approachs. (3) Propose and plan the future directions of research and new approaches and facilities. **(4)** Develop concenptual models.
Year 2	(5) Hold an annual meeting to review the progress. (6) Continue to develop new approaches. (7) Recommend improvements to numerical models for integrating biologically-driven carbon pump processes.
Year 3	(1) Continue to develop and review the new approaches. (2) Continue to recommend improvements to numberical models and review their results concerning the biologically mediated sequestration of carbon in oceans. (3) Hold a scientific symposium to review the outcome of the WG, and draft the final report of the WG and the advice of climate policy to international organizations.

Supporting information

Priority	The current activities of this Group will support science advice to the relevant organizations (ICES, PICES, etc) on issues related to the impacts of climate change on the capability of the ocean to sequestrate anthropogenic carbon, and its consequences on the marine ecosystem functionality.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group will be supplied from institutional resources and will have no impact on ICES or PICES.
Participants	The Group is normally attended by some 20–25 members plus possibly invited experts. The attached list of proposed working group members is provisional, and subject to approval and recommendations for change by ICES and PICES.
Secretariat facilities	No resources are requested from ICES or PICES.
Financial	All costs for suppot personnel will be supplied through institutional resources.. See below for details and financial responsiblities or support personnel. The symposium organizers (year 3) may approach ICES and PICES for support for the symposium in due time.
Linkages to ACOM and groups under ACOM	Provision of the best available advice on the implications of climate change for the sequestration of carbon (ecosystem service) by the ocean.
Linkages to other committees or groups	The proposed WG is relevant to the WG on Interactive, Physical-biological and Ecosystem Modelling (WGIPEM), and the WG on Phytoplankton and Microbial Ecology (WGPME), but distinct in its missions.
Linkages to other organization	This WG will be a joint WG between ICES and PICES.

Recommended Members

The recommended members listed below are provisional and have not yet committed to serve on the Working Group

(1) ICES members

Robin Anderson (Canada), **Female**, Scientist at Fisheries and Oceans Canada, expertise in quantitative aquatic ecology, the microbial loop and carbon cycling in the oceans, effects of human activity on marine habitat, aquaculture, marine tailings disposal and drilling wastes at offshore oil sites. Email: M.Robin.Anderson@dfo-mpo.gc.ca

Bo Barker Jørgensen (Denmark), Male, Professor at Aarhus University, expertise in marine biogeochemistry and microbial ecology on the deep sub-seafloor biosphere, sulfur and methane cycling and microorganisms in marine sediments, "cryptic sulfur cycle" in the methane zone, the controls on methane fluxes and their sensitivity to climate change. Email: bo.barker@bios.au.dk

Louis Legendre (France, co-chair), Male, Professor at Laboratoire d'océanographie de Villefranche, expertise in biological oceanography and marine biogeochemistry, numerical ecology, and philosophy of science, blending theoretical studies, laboratory research, and fieldwork in the Atlantic, Pacific and Arctic Oceans, and in the Mediterranean Sea. Email: legendre@obs-vlfr.fr

Marion Gehlen (France), **Female**, Scientist at Laboratoire des Sciences du Climat et de l'Environnement, expertise in biogeochemical ocean modeling, marine ecosystems and biogeochemical cycles under anthropogenic pressure, linking impacts of climate change across the foodweb up to higher trophic levels, predictability of changes in marine biogeochemistry and ecosystems. Email: gehlen@lsce.saclay.cea.fr

Rudolf Amann (Germany), Male, Scientist at Max Planck Institute for Marine Microbiology, expertise in analysis of the diversity, quantitative composition and function of marine microbial communities based on nucleic acid techniques including genomics. Email: ramann@mpi-bremen.de

Ulf Riebesell (Germany), Male, Professor at GEOMAR Helmholtz Centre for Ocean Research Kiel, expertise in Marine biogeochemistry, pelagic ecosystems, plankton physiology and ecology, ocean acidification, warming, and deoxygenation. Email: uriebesell@geomar.de

Corina Brussaard (Netherlands), **Female**, Scientist at Royal Netherlands Institute for Sea Research, expertise in the interaction between viruses and their hosts in relation to climate change, and more specifically on how this interaction is affected by environmental factors, such as CO_2 concentration and temperature, the availability of nutrients and light. Email: Corina.Brussaard@nioz.nl

Yngvar Olsen (Norway), Male, Professor at Norwegian University of Science and Technology, expertise in physiology and ecology of marine phytoplankton, the zooplankton food web and environmental aspects of marine aquaculture and the farming of seaweed. Email: yngvar.olsen@ntnu.no

Carol Robinson (United Kingdom), **Female**, Professor at University of East Anglia, expertise in the role of marine bacteria, phytoplankton and zooplankton in the global cycling of carbon and oxygen, measurement of seawater dissolved inorganic carbon and CO_2 sink, carbon flux in the ice-ocean-plankton systems, cycling of carbon through the marine microbial foodweb. Email: carol.robinson@uea.ac.uk

Adrian Burd (United States of America), Male, Professor at University of Georgia, expertise in marine biogeochemical modeling, studying how different marine systems function and how they might change under changing environmental and climate conditions, focusing particle flux and coastal systems. Email: adrianb@uga.edu

Ronald Benner (United States of America), Male, Professor at University of South Carolina, expertise in the carbon, nitrogen, and phosphorous cycles in aquatic environments, using experimental and geochemical approaches to characterize biogeochemical processes and the roles of microorganisms as key players in the transformations of C, N and P. Email: benner@mailbox.sc.edu

(2) PICES members

Angelica Peña (Canada), **Female**, Scientist at Fisheries and Oceans Canada, expertise in numerical modeling of marine ecosystem and biogeochemistry, marine new production and carbon export in form of particle flux, marine ecosystem response to climate change. Email: Angelica.Pena@dfo-mpo.gc.ca

Curtis Suttle (Canada), Male, Professor at University of British Columbia, expertise in marine virology (one of the World's leading marine virologists), studying the role of marine viruses in nutrient and energy flow in the oceans. Email: csuttle@eos.ubc.ca

Richard Rivkin (Canada, co-chair), Male, Professor at Memorial University of Newfoundland, expertise in biological oceanographic processes, studying nutrient metabolism, photoadaptations of photosynthesis, carbon metabolism and cell division of phytoplankton, procaryotic and eukaryotic microheterotrophs, and the regulation of bacterial growth and loss. Email: rrivkin@mun.ca

Nianzhi Jiao (China, co-chair), Male, Professor at Xiamen University, expertise in marine microbial ecology and biogeochemistry, carbon cycles and sequestration by microbes, one of the key members proposing the microbial carbon pump, co-chairman of a SCOR working group. Email: jiao@xmu.edu.cn

Fengping Wang (China), **Female**, Professor at Shanghai Jiao Tong University, expertise in Microbial ecology and microbial participated biogeochemical cycles in the deep subsurface biosphere; environmental adaption mechanisms of extremophiles. Email: fengpingw@sjtu.edu.cn

Chuanlun Zhang (China), Male, Professor at Tongji University, expertise in geomicrobiology and biogeochemistry, integrating molecular DNA-, lipid biomarker- and stable isotope- approaches to study the mechanisms and pathways of carbon and energy metabolisms in the deep sea gas hydrates and mid-ocean ridge hydrothermal vents. Email: archaeazhang_1@tongji.edu.cn

Toshi Nagata (Japan), Male, Professor at University of Tokyo, world's leading researcher in dissolved organic matter in deep oceans, also expertise in marine microbiology and biogeochemistry. Email: nagata@aori.u-tokyo.ac.jp

Koji Suzuki (Japan), Male, Professor at Hokkaido University, expertise in microbial oceanography, marine plankton, biogeochemical and material circulation, biological diversity, metagenomic analysis, physiological ecology and remote sensing. Email: kojis@ees.hokudai.ac.jp

Sang-Jin Kim (Korea), Male, Scientist at Korea Ocean Research & Development Institute, expertise in management for genome resources of marine and extreme organisms. Email: s-jkim@kordi.re.kr

Eun Young Kwon (Korea), **Female**, Professor at Seoul National University, expertise in marine biogeochemical modeling, comparing effects of different marine carbon pumps in sequestrating carbon. Email: ekwon76@snu.ac.kr

Vladimir Shulkin (Russia), Male, Scientist at Pacific Geographical Institute, Russian Academy of Sciences, expertise in geochemical aspects of environmental problems in the coastal areas from the watersheds through the rivers and estuaries to the sea, including contamination by trace metals, excessive load of nutrients and related eutrophication issues, assessment of the water ecosystems quality. Email: shulkin@tig.dvo.ru

Phoebe Lam (United States of America), **Female**, Professor at University of California Santa Cruz, expertise in marine geochemistry focusing on the role that marine particles play in the biogeochemical cycling of major and minor elements in the ocean such as carbon, iron, and other trace elements. Email: pjlam@ucsc.edu

Uta Passow (United States of America), **Female**, Researcher at University of California Santa Barbara, expertise in biological oceanography, studying mechanisms of the functioning of different marine biological carbon pumps under climate change. Email: uta.passow@lifesci.ucsb.edu

Working Group Support Personnel

Secretaries and Logistics

Rui Zhang, Marine ecology. Xiamen University, China. Email: ruizhang@xmu.edu.cn

Ya-Wei Luo, Biological oceanography and ecological modeling. Xiamen University, China. Email: ywluo@xmu.edu.cn

Technical and Data

Two PhD trained researchers housed at Xiamen University, China will provide technical and data analytical support for the Working Group.