2024 December Intersessional Science Board Meeting Report

Held online: December 9 (North America), December 10 (Asia)

(with GC decisions to SB recommendations as of December 12 and 19)

Prepared by Science Board Chair, Dr. Sukyung Kang, and the PICES Secretariat in January 2025)

Date and Time

Beijing, China	Tue, Dec 10, 2024, at 8:00 am CST
Tokyo, Japan	Tue, Dec 10, 2024 at 9:00 am JST
Seoul, South Korea	Tue, Dec 10, 2024 at 9:00 am KST
Vladivostok, Russia	Tue, Dec 10, 2024 at 10:00 am VLAT
Vancouver/Seattle.	Mon, Dec 9, 2024 at 4:00 pm PST
Washington DC	Mon, Dec 9, 2024 at 7:00 pm EST
Honolulu,	Mon, Dec 9, 2024 at 2:00 pm HST

List of Participants

Science Board	
Sukyung Kang	Science Board Chair
Jeanette Gann	Science Board Vice-Chair, TCODE Chair
Steven Bograd	FUTURE SSC Co-Chair
Hanna Na	FUTURE SSC Co-Chair
Akash Sastri	BIO Chair
Jackie King	FIS Chair
Thomas Therriault	MEQ Chair
Lei Zhou	POC Chair
Jennifer Jackson	POC Vice Chair
Sung Yong Kim	MONITOR Chair
Yury Zuenko	Russian representative
PICES Secretariat	
Sanae Chiba	Deputy Executive Secretary

*HD Chair, M. Makino, was absent from the meeting and delegated the decision-making authority to the SB Chair.

Agenda

1. PICES-2025 Session & Workshop selection
2. Revised TOR of AP-CREAMS (pending item from GC-2024)
3. NPESR IV planning
4. SB Feedback on Review Panel Report Recommendation
5. Other Items

Agenda Item 1. PICES-2025 Session & Workshop selection

1.1. Confirmation of PICES-2025 Session/Workshop schedule

Following the new protocol for the Topic Session & Workshop proposal selection timeline adopted by GC-2023, 23 Topic Session proposals and 16 Workshop proposals were submitted by the deadline of two weeks after the Annual Meeting. The submission number was larger than usual years, implying that the community had sufficient time to develop ideas during the Annual Meeting. To accommodate as many qualified proposals as possible, SB discussed the options of the basic schedule of PICES-2024. With the Secretariat's confirmation of the availability of the venue rooms, SB agreed to hold up to four parallel Workshops and Sessions a day. SB opted to hold half-day oral Committee Paper Sessions to encourage ECOPs, particularly students, to present their studies rather than adding extra time slots for Topic Sessions.

Basic schedule of PICES-2025 (updated Jan 2025)

Session/WS planning		
~ Jan 2025	Sessions/WS are selected	
March-June	Call for abstracts and Financial support request. Invited speakers confirmed	Website open upon the abstract call
~ August	Presentations and detailed schedule confirmed	
Pre-PICES-2025 Online Business Meetings		
late Sept ~ early Oct	EG online business meeting	Report to Parents CMT
early Oct ~ 25 Oct	Committees (& FUTURE) online business meeting	Review Children EG Reports
PICES-2025 in-person Meeting		
Date	**Session/WS (In-person)**	**Business Meeting (Hybrid)**
Nov 8 (Sat)	Parallel Workshops x 4	Day: EG meetings Evening: CMT meetings
Nov 9 (Sun)	Parallel Workshops x 4	Day: EG meetings Evening: CMT meetings
Nov 10 (Mon)	Opening Session S1 Symposium	
Nov 11 (Tue)	Parallel Sessions x 4	EG meeting, F&A meetings?
Nov 12 (Wed)	Parallel Sessions x 4 Evening: Poster Session	EG meetings, F&A meetings?
Nov 13 (Thur)	Parallel Session x 4	EG meetings
Nov 14 (Fri)	0900-1200 Parallel Session x 4 1200-1240 Closing Session	SB Day 1
Nov 15(Sat)		SB Day2, GC Day1
*Nov 16 (Sun)		GC Day2

**SB and GC meeting schedules may change, and PICES-2025 may end on Nov 15 (Sat). SB to discuss the feasibility of alternative SB schedule options at ISB-2025 to be held in May 2025.*

1.2. Selection of PICES-2025 Session/Workshop proposals *(with GC decision)*

Each standing Committee ranked proposals in advance of the ISB meeting. Based on the Committees' ranking, balance of the topics, and relevance to PICES, SB selected the Topic Sessions and Workshops for PICES-2025. Some proposals with a similar focus were encouraged to merge for a good synergy effect. Some SB members questioned the fairness of the current Committee ranking methods, and Secretariat suggested SB propose and establish alternative, more effective, and fair ranking methods at ISB-2025.

SB recommended GC approve the selected list of Topic Sessions and Workshop for PICES-2025 => *approved by GC (**2023/S/20**)*

Selected Workshops

- The total available time slots are 8 x 1-day. The final duration of each Workshop will be allocated by summer 2025, depending on the design and structure of each and SB ranking.

Workshop No.	corresponding convenor	Convenors PICES EGs	Title	sponsor Committees (TBC)	Sponsor Organizations (TBC)
W1	Steven Bograd	SB POC AP-ECOP AP-UNDOS FUTURE-SSC	Climate-Ready Fisheries Management: Reviewing Effective Strategies for Developing Decision Support Tools	FIS, HD, POC, TCODE, MONITOR, FUTURE	ICES
W2	Akash Sastri	SB BIO AP-NPCOOS WG-48	Intercomparison of North Pacific Zooplankton Time Series	BIO, MONITOR	
W3	Sei-Ichi Saitoh	AP-ARC	Present and future pressures and human activities in the Arctic Ocean and Pacific Gateways	MEQ, HD, FUTURE	
W4	Tsuneo Ono	CC-S	Building framework for cross-community conversation between natural carbon cycles and marine carbon dioxide removal	POC, BIO	
W5	Charles Hannah	POC AP-NPCOOS	Basin-scale processes linking western and eastern Pacific dynamics and biogeochemistry	POC, FUTURE	
W6	Erin Satterthwaite	AP-ECOP AP-UNDOS SG-GREEN WG-52 FUTURE-SSC	Effective strategies across ocean data lifecycles: Enhancing ocean data management & mobilization	TCODE, FUTURE	Hakai Institute/Tula Foundation
W7	Yu Kanaji	S-MBM, WG-53	Response of top predators to unusual oceanographic, climatic and anthropogenic events in the North Pacific	BIO	
W8	Raphael Roman	AP-ECOP AP-UNDOS WG-51	Engaging with Local & Traditional Knowledge Holders to Co-Design Ocean Science in Pacific Small Island Developing States	HD, TCODE FUTURE	ICES, APN
W9	Karen Hunter	HD WG-49	Applying a cumulative effects framework to explore actionable, social-ecological solutions for climate extreme event impacts across the North Pacific	HD, FUTURE	
W10	Jennifer Jackson	POC AP-UNDOS AP-NPCOOS	An examination of shelf data collected by moorings and other fixed stations in the North Pacific Ocean.	POC, TCODE, MONITOR	
W11	Satoshi Nagai	MEQ AP-NIS	Harnessing Environmental DNA (eDNA) for Early Detection and Monitoring of Marine Invasions in the Face of Climate Change	MEQ,	

Selected Topic Sessions

- S1: Science Board Symposium to be held on Monday afternoon on the conference theme: Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems.
- The total available time slots are 12 x 1-day, and the final duration of each Session will be allocated by summer 2025 depending on the number of abstracts submitted to each and SB ranking.
- SB requests to merge some relevant proposals (indicated by blue).

Session No.	corresponding convenor	Convenors PICES EGs	Title	sponsor Committees (TBC)	Sponsor Organizations (TBC)
S2	Shin-ichi Ito	S-CCME AP-ECOP WG-45	Changing ecosystem structure under global climate change: monitoring, detecting, modelling, and socio-ecological impacts	HD, POC, MONITOR, FUTURE	WESTPAC (AMS), GOOS (NEAR-GOOS)
	SungHyun Nam	POC, CREAMS-AP	Changing Asian Marginal Seas: from marine science to societal needs, current challenges for integrative science and UN Ocean Decade		
	Feng Zhou	MONITOR	Deoxygenation and ocean acidification in a changing climate		
S3	Michael Jacox		Interactions of variability and change in the North Pacific	POC, FUTURE	
S4	Motomitsu Takahashi	BIO S-CCME WG-53	Responses of small pelagic fish communities to recent climate regime shifts and climate extremes	FIS, BIO, MONITOR	ICES
S5	Antonietta Capotondi	WG49	Climate Extremes and Coastal Impacts in the Pacific	HD, POC, MONITOR, FUTURE	CLIVAR, WCRP LHA EPESC
	Amber Holdsworth		Innovative methods for understanding and predicting ocean extremes		
S6	Melissa Karp		Incorporation of climate and ecosystem impacts in stock assessment advice: Discussion of current approaches and challenges, and charting a path forward	TBC (FIS?, HD?)	
S7	Toru Kobari	BIO	The impact of oceanographic processes on ecosystems supporting fisheries production in boundary current regions	BIO, MONITOR	
S8	Vivitskaia Tulloch	BECI	How can ecosystem-scale information be used to improve our understanding of climate change impacts, and support management and conservation in the North Pacific?	FUTURE	
S9	Chengjun Sun	WG-42 FUTURE	Marine plastic and microplastic pollution in the North Pacific	MEQ, TCODE	
S10	Takeyoshi Nagai	WG-50	Multiscale physical, biological and ecosystem dynamics and their variabilities under climate change	POC, FUTURE	
	Zhiwei Zhang		Meso- to small-scale dynamical processes and their influences on air-sea interactions and marine ecosystems		
	Mark Wells	HAB-S SG-GREEN	Changing Ecosystems in the North Pacific: Projections and Mitigation		
S11	Kelia Axler		Applying Innovative and Established Approaches to Assess the Resilience of the Early Life Stages of North Pacific Fishes to Changing Oceanographic Conditions	TBC (FIS, BIO?)	
S12	Jim Ruzicka		Understanding the linkages between forage species and top predators and how they may affect resilience in North Pacific ecosystems.	TBC (FIS?)	
S13	Elizabeth Holmes		Shifting institutional culture to develop climate solutions with Open Science and Open Data	TCODE	
S14	Brian Hunt	WG-53	The status and future of urban oceans of the North Pacific–pathways to resilient and sustainable coastal cities	MEQ	
S15	Shion Takemura	HD WG-51	The rise of bibliometric analyses to address sustainability solutions through a human dimension lens	TBC (HD?)	ICES
S16	Minkyoung Kim	AP-ECOP CREAMS-AP	Radiocarbon studies in the North Pacific and its marginal seas	TBC	
S17	Mark Wells	HAB-S SG-GREEN	What can we learn about the occurrence of Karenia spp. blooms in the North Pacific?	MEQ	GlobalHAB, IOC ICES etc.

Agenda Item 2. Revised TOR of AP-CREAMS (GC decision deferred from GC-2024)

SB discussed the rationale of AP-CREAMS having a term following the comment at GC-2024. Considering that PICES Rules and Procedure does not require a term for APs and no other APs have a specific term, SB agreed to remove the term of AP-CREAMS. (**AP shall be disbanded at the discretion of the SB*. PICES Rule & Procedure Rule 13 iv). SB confirm that the proposed area of Northwestern Pacific and marginal seas includes the wider areas of the western North Pacific, including the western Bering Sea, and that it does not define specific boundaries. AP-CREAMS emphasises the interaction of physical, chemical and biological processes between the East Asian marginal seas and the wider western North Pacific regions.

EG (Rpt CMT)	Description and Rationale of Changes
AP-CREAMS (MONITOR)	(current) 1. To coordinate programs to study marine ecosystem and its variability in the East Asian marginal seas in the PICES area, under global changes, both natural and anthropogenic; effect of long-term and extreme changes in the abiotic and biotic environments of this region. (suggested revision) 1. To coordinate programs to study marine ecosystem and its variability in the Northwestern Pacific and marginal seas in the PICES area, under global changes, both natural and anthropogenic; effect of long-term and extreme changes in the abiotic and biotic environments of this region. Additional item 5. To provide more opportunities for ECOPs to join ~~particularly from Asian countries~~

SB recommended GC approve the removal of the AP-CREAMS term and the revised TORs
=> GC deferred its decision to IGC-2025, suggesting further clarification of the new target area and the development of the revised action plan with its rationale of expansion of the target areas. GG agreed to remove the term upon approval of the revised action plan at IGC-2025.

Agenda Item 3. NPESR IV planning

Following the suggestion at GC-2024 **(GC2024/S/18),** SB agrees to draft the proposal for a new Study Group on NPESR IV by ISB-2025 or SB-2025. SB requests that GC (the New SG on Response to the Review Panel Recommendation) share information if they discuss the NPESR IV plan to ensure efficiency in its development process and avoid duplicate efforts.

Agenda Item 4. SB Feedback on Review Panel Report Recommendation

GC requested SB to revisit and discuss their response to the External Review Committee recommendations, focusing on considerations based on the science perspective only for each recommendation, and to provide a report to GC as soon as practicable **(GC2024/S/19).** SB Chair and Secretariat drafted the SB statement as requested based on the discussion at SB-2024 and the Committees' comments, asked SB members' input on it, and submitted it to GC. The final version was submitted to GC in February 2025. (**Appendix 1**)

Agenda Item 5. Other Items *(with GC Decision)*

5.1. Revised proposal of New Working Group Ocean Negative Carbon Emissions for Carbon Neutralization (OCN)

SB recommended the proposal at ISB-2024. GC repetitively requested the revision to be submitted at IGC in May and September 2024, GC-2024 and finally at IGC in December 2024. Although the group submitted the revised versions accordingly, *GC didn't approve the final version of the proposal (**Appendix 2**) and the establishment of the new WG (**2024/S/22**)* (see the details on GC comments and final decisions on IGC(1)-2024 Report, IGC(2)-2024 Report, GC-2024 Report and IGC(3) Report).

2.3. Final Report of Joint PICES/ICES Working Group 46 on Ocean Negative Carbon Emissions (ONCE)

SB recommended the Final Report of WG46 to be published as a PICES Scientific Report at SB-2024, but GC requested WG at GC-2024 to revise its Executive Summary and Conclusions sections to adequately address the achievements of the WG. The WG submitted the revised version to IGC in December (**Appendix 3**), but *GC did not approve its publication as a PICES Scientific Report as the revision did not sufficiently respond to GC's comments (see the details on GC comments and final decisions on GC-2024 Report and IGC(3) Report)*. Given the GC's final decision, the WG46 Final Report will be posted on the WG page of the PICES Website as grey literature.

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Appendix 1

SB Feedback to Review Panel Report

GC-2024 request to SB
GC requested SB to revisit and discuss their response to the External Review Committee recommendations, focusing on considerations based on the science perspective only for each recommendation, and to provide a report to GC as soon as practicable in the new year (GC2024/S/19).

Science Board Feedback on Review Report Recommendation to submit to the Governing Council

January 2025

Summary

- Science Board (SB) agrees that PICES should clarify and emphasise its role in promoting evidence-based decision-making for stakeholders, including member countries. SB calls for the establishment of an organisational mechanism to accelerate co-design and co-production, enabling the delivery of Actionable Science with the Governing Council (GC).
- SB agrees on the need for committee restructuring to make PICES science fit-for-purpose operationally and calls for careful consideration of the new structure to balance discipline-specific knowledge to enhance interdisciplinary collaboration to address urgent societal issues.
- SB suggests the new Integrative Science Program be established based on a Socio-Environmental-Ecological-Systems (SEES) framework, with focused themes, clear timelines and tangible deliverables.
- Across all three subjects above, SB requests the new "Study Group (SG) on Review Recommendation Response (tentative name)", comprising the selected members of GC, to facilitate sufficient communication with SB to ensure the co-design and co-production of new PICES science.
- SB recognises PICES capacity development efforts have been strengthened in recent years and are on track to achieve the Recommendation.

1. PICES Role

1.1. On Implementation of Actionable Science

Understanding that "Actionable Science" is the science to urge evidence-based decision and policy-making to solve social, environmental, and ecological challenges facing the world ocean, SB agrees to emphasise the PICES' role in implementing "Actionable Science".

Although not explicitly stated as its role in the Convention, PICES science has been practising "Actionable Science" on issues such as climate–ocean interactions, biodiversity conservation, and fisheries management. We have addressed societal needs by producing scientific outcomes and products, including tools (mobile app of Ciguatera project), model projections, and indicator development. Ecosystem/environmental assessments including NPESR and ADRIFT Report have provided useful information to Regional Fisheries Management Organisations (RFMOs) and for the regional management of member countries. We have provided North Pacific perspectives to international bodies such as the IPCC and IPBES, contributing to policy-setting under international treaties, which our member countries are committed to achieving. However, these contributions have primarily been made through the activities of individual Expert Groups (EGs) and/or on an ad hoc basis (e.g., special projects). To implement "Actionable Science" more operationally and proactively, PICES

needs to establish an organisational mechanism to enable the co-production and co-design of the science plan.

1.2. Needs for co-design/co-production mechanism

To effectively implement and deliver actionable science, SB believes that improved communication with GC members is essential. Because there will be differences of opinion in member countries as to how far we go, having national delegates and scientists from each member country meet and discuss can only go so far. In PICES, science plans are developed through a bottom-up process, driven by the creative and free ideas of groups of scientists, which is a valuable tradition. However, in the current structure, SB lacks opportunities to receive input from the GC during this process. As a result, the scientific community is informed of GC decisions on their plans without understanding the specific needs of respective member countries. Establishing mechanisms to enhance communication between SB/EGs and the GC—such as ad hoc dialogues or the creation of an EG to conduct a systematic survey on national demands—could help address this issue (e.g., SG on Actionable Science or co-production).

1.3. On useful products for stakeholders

PICES EGs have recently held workshops focusing on stakeholder engagement and science-policy interface (e.g. W5 at PICES-2024), inviting guests from partner organisations such as ICES and RFMOs. We have heard their clear and increasing demand for more useful and findable PICES information resources, including scientific reports, assessment reports and data. SB strongly agrees with the Review Report Recommendation on the need to revise the NPESR format to be more user-oriented, thereby strengthening their engagement and communication. SB will establish a new SG to design NPESR IV in 2025 to address the stakeholders' needs. We would like to ensure GC's thoughts on NPESR IV (if any) will be shared with the SG from the early phase of the planning to allow the co-design of the report (e.g., including a few GC members in SG).

As for the PICES role as a data provider, PICES has already begun transforming in recent years. TCODE and WG52 on Data Management revised the PICES data management policy to align with the global data sharing principles. They are developing the PICES metadata repository protocol and data portal/hub to make our data findable for users while respecting feasibility and member countries' data-sharing policies, e.g. development of usable data interface via collaboration with BECI project. SB hopes for continued support of member countries in establishing a new PICES data protocol.

1.4. On the basic but Innovative science

There will be various paths forward to strengthen the PICES capacity for Actionable Science. While learning from cases of similar intergovernmental organisations, including ICES, SB believes PICES should develop its own model, considering the unique nature of the North Pacific and the diverse perspectives and business practices of our member countries. Although the focus of PICES science has already shifted from basic to applied science (Takemura et al., submitted), SB still sees the value in the PICES role in fostering international collaboration on basic and focused disciplinary science, too. Innovative scientific findings and technologies derived through basic science can bring game-changing solutions to regional and global challenges.

2. PICES Structure

2.1 On restructuring Committees: discipline basis to thematic basis

The FUTURE study reports the transformation of PICES science from a primarily disciplinary to a more interdisciplinary focus in the past decades (Takemura et al., submitted). This is reflected in the topics of recent EGs and Sessions/Workshops at our Annual Meeting which are becoming more interdisciplinary to deliver fit-for-purpose science. In the current hierarchical structure, multiple committees with relevant disciplines must oversee the activities of those EGs, making the reporting process from EGs and guidance by Committees complicated and exhaustive. Given this challenge, SB agrees to revise the current committee structure and function to efficiently implement "Actionable Science." However, careful consideration will be needed on how to restructure the committees from the current discipline-based structure to thematic basis* as recommended by the Report (**the recommended plan actually shows two thematic committees: climate and oceans, ecosystems with humans and two functional committees: Monitor and Data, Status and Predictions).*

First, as urgent socio-ecological topics change over time, themes for committees must be selected with a broad and long-term perspective. Second, the new committees should be established not merely by merging existing committees, and the balance of committee members' expertise and roles should be clearly identified. Admitting there has not been enough communication and coordination among current Committees, the proposed thematic committees may face the same risk of siloing without enhancing cross-committee coordination. Lastly, while agreeing that the new structure should highlight specific themes to address and functions to advance, SB considers the guidance from experts with deep knowledge of specific disciplines to still be highly valuable for PICES. To ensure the new committee structure accelerates actionable science, SB requests GC to facilitate sufficient communication with SB in its development process.

2.2 Alternative new Committee structures

Given the Review Panel clarifies that the suggested new Committee Structure is an example, SB suggests some alternative ideas for the new Committee Structure. * *Though this is not a consolidated SB suggestion, SB believes sharing alternative examples may still be useful for GC's early brainstorming.*

Themes aligning High-level International Ocean Science Directives

The goals and targets of high-level international ocean science directives such as SDG 14, UNDOS (and Vision 2030), are set to address ocean challenges that the global community is facing and contribute to the achievement of various international treaties, e.g. Paris Agreement, KM-GBF, BBNJ Agreement, Plastic treaty and various international fish stock agreement (so solution basis). PICES's commitment to these global challenges will be more visible and streamlined by establishing thematic committees aligned with these goals/targets. Example themes: Climate variability and change (and ocean-based solutions), Sustainable fisheries (or food security), Ecosystem health (including pollution, and community resilience and adaptability), Observation and data, Innovative (basic) science, etc.

Enhance cross-committee communication

Some SB members suggest that the current discipline-based committee structure could still deliver actionable science if cross-committee communication and activity coordination are improved. However, maintaining this structure would require revising the current inefficient EG-Committee reporting protocol (see 2.1).

3. Integrative Scientific Programme

3.1 On the roles of ISP and SB

In the Recommendation, part of the role of the new Integrative Scientific Programme (ISP) seems to be redundant with the current SB role, e.g., coordinating and governing committees' activities and PICES science plan. SB feels it is not fully clear if this implies that SB is expected to act as the ISP Steering Committee and implement ISP (which FUTURE SSC currently does). Assuming that ISP will replace FUTURE to be the next PICES flagship science programme and that SB and ISP SC will remain separate bodies as they currently are (as SB believe they should be), their roles must be clarified to avoid redundancy.

3.2 On the topic of ISP

FUTURE has integrated EGs into its Socio-Environmental-Ecological-Systems (SEES) framework, which has enhanced collaborations between EGs and promoted an interdisciplinary approach to PICES science. While a new ISP can effectively be developed with the SEES approach as a conceptual framework, it needs to set achievable, tangible deliverables with a clear timeline based on priorities in the new PICES Science Plan. SB has not reached an agreement on ~~PICES needs to decide~~ whether ISP should be a decadal program or a series of shorter programs with more focused (short-term) goals to address urgent societal issues. If it is a decadal program, milestones with tractable deliverables should be set for every three or four years. Again, co-design and co-production practices involving science, governance, and administrative bodies of PICES should be implemented for the planning of ISP.

3.3. Other thoughts on new ISP development

** These are individual ideas from SB members, not consolidated SB suggestions. However, SB believes sharing these ideas may still be useful for GC's early brainstorming.*

Example of short-term ISP: evolved from WG49

One possibility is to expand the activities of WG 49 (Climate Extremes and Coastal Impacts in the Pacific). Recognising the increased risk of more frequent and more severe extreme events within the Pacific domain, WG 49 was established to provide a suite of potential solutions to these climate-driven changes through the integrated SEES approaches. Because it ranges from basic science to interdisciplinary science (consequences of climate extremes on fisheries, ecosystems, and coastal communities), a short-term ISP with a focus on climate extremes could evolve from WG 49 ~~could be developed as a short-term ISP~~.

Coordination of ISP and SmartNet

The Report does not specifically elaborate on the role of PICES in UNDOS or SmartNet in the new PICES structure and ISP. SmartNet is a UNDOS-endorsed programme representing ICES and PICES, and its implementation plan includes many elements recommended by the Panel for a new ISP: a focus on solution-based science; capacity development; diverse and equitable approaches to tackling issues facing the parties; expansion of geographic focus beyond the PICES convention area; establishment of new strategic partnerships; and various cross-cutting challenges. With no other current or suggested

Committees leading cross-cutting challenges, such as ocean literacy, science communication, ECOP promotions, and wider community engagement, SmartNet should be given proper status in the new PICES Science Plan, at least by 2030. The roles of the new ISP and SmartNet should be carefully coordinated to minimize duplication of efforts and maximize synergy.

4. Capacity Development

PICES has emphasised Capacity Development frameworks, including the promotion of ECOPs with the Trust Fund scheme and technical training workshops. The scheme was particularly enhanced with the establishment of AP-ECOP and AP-SciCom since 2021/2, as seen in the various events they organised during Annual Meetings and intersessionally, e.g. mentor-mentee programme, science-policy training workshops, and introduction to PICES by AP-ECOP, and the Trilogy workshops on practical science communication skills by AP-SciCom (2022-2024). SmartNet (see previous section) plays a pivotal role in championing the engagement of ECOPs and experts from new partner organisations in PICES core activities, including their EG membership. Thus, the Recommendation items are already being put into practice.

5. Administration

While PICES EGs are proposing creative activities, e.g. the development of new data-sharing protocols (see 1.3), Science community events, ECOP promotions (see 4.), and summer schools, they often struggle with a lack of support/resources from PICES to implement those plans. SB strongly supports the Review Report recommendations that enhance PICES' ability to provide actionable science, such as *"Recommendation 4.3: allowing PICES Governing Council members to delegate nominations to their Science Board representatives to expedite the process and eliminate unnecessary delays*". Additionally, SB agrees on the importance of mobilizing human resources through partnerships with other organizations to strengthen PICES capacity.

On the new Committee structure, SB stresses that, whatever the new structure will be, consideration should be given to an operational level (e.g. on EG reporting protocol) to prevent administrative redundancy which could impede the smooth delivery of actionable science.

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Appendix 2

Proposal of New Working Group, WG-ONCE (ver. 5)

(Revised on December 11, 2024)

Proposal for a new PICES Working Group on Ocean Negative Carbon Emissions for Carbon Neutralization (OCN)

Group Type: Working Group
PICES Acronym: WG OCN
Parent Committees: POC, BIO
Term: 2024-2027

PICES Chair:
Nianzhi Jiao /China
PICES Co-chair:
Russell T. Hill /USA

Background, Goals and Motivations

Facing an escalating climate crisis, achieving global carbon neutrality is essential to meet the emission reduction targets of the Paris Agreement. Over the past decades, significant efforts, such as the PICES/ICES Joint Working Group 33 (Climate Change and Biologically-Driven Ocean Carbon Sequestration) and WG46 (Ocean Negative Carbon Emissions, ONCE), have made remarkable progress. These initiatives identified knowledge gaps, explored new ONCE methods, and laid the foundation for the Global Ocean Negative Carbon Emissions (Global-ONCE) project, which has been recognized under the UN Decade of Ocean Science for Sustainable Development.

The North Pacific, with its unique ecosystem and extensive marine research infrastructure, provides invaluable opportunities to advance scientific approaches and engineering technologies for ocean negative carbon emissions and carbon neutrality. In August 2024, ISO/NP 25283-1, titled "Ocean Negative Carbon Emissions and Carbon Neutralization—Part 1: General Guidelines and Requirements," was successfully initiated by the OCN Chair in collaboration with international experts from the Americas, Europe, Asia, and Africa. This standard will provide a unified technical framework and collaboration platform for global ocean negative carbon emissions technology, marking a significant milestone in the field. WG-OCN will build on the achievements of WG46 and collaborate directly with global experts to contribute to Ocean Negative Carbon Emissions and Carbon Neutralization.

- **Distinction from WG46 and Global-ONCE：**
  - Difference from WG46: WG46 primarily focused on identifying knowledge gaps and setting research directions. WG-OCN builds on these achievements by emphasizing the practical application and standardization of ocean negative carbon emissions technologies, specifically tailored for the North Pacific region.
  - Difference from Global-ONCE: Global-ONCE is a global initiative aimed at coordinating worldwide efforts. WG-OCN focuses on regional research in the North Pacific while providing critical regional insights and data to support the development of ISO/NP 25283-1.

Terms of Reference (ToR)

- **ToR 1: Conduct interdisciplinary research on ocean carbon processes in the North Pacific**, focusing on the roles of the Biological Carbon Pump (BCP), Carbonate Counter

Pump (CCP), Microbial Carbon Pump (MCP), and Solubility Pump (SP) in regional climate regulation.

- **ToR 2: Develop and evaluate region-specific carbon sequestration strategies**, ensuring they are scientifically robust and aligned with the oceanographic and ecological conditions of PICES regions.
- **ToR 3: Collaborate with international experts** to support the development and refinement of ISO/NP 25283-1, ensuring that WG-OCN's findings directly contribute to the standard's formulation and practical application.

Annual Work Plan (2024 -2027)

Year 1 (2024-2025):

- Objective: Establish a baseline understanding of ocean carbon cycles in the North Pacific.

- Tasks: Collect and synthesize data from PICES observation networks; complete the Working Draft (WD) of ISO/NP 25283-1.

- Deliverable: Technical review report on regional ocean carbon dynamics; submission of ISO/WD 25283-1.

Year 2 (2025-2026):

- Objective: Develop and evaluate region-specific carbon sequestration strategies.

- Tasks: Conduct experimental studies and apply simulation models to assess the feasibility and impact of these strategies; advance ISO/NP 25283-1 to the Committee Draft (CD) stage.

- Deliverable: Peer-reviewed publications and a comprehensive report on the current status of ocean negative carbon emission technologies; submission of ISO/CD 25283-1.

Year 3 (2026-2027):

- Objective: Finalize methodologies and frameworks for regional applications.

- Tasks: Collaborate with ISO experts to integrate findings into the Draft International Standard (DIS) of ISO/NP 25283-1; develop standardized protocols for carbon monitoring and management.

- Deliverable: Final report summarizing methodologies, technical standards, and collaboration opportunities; submission of ISO/DIS 25283-1.

Expected Deliverables

1. **Technical Review：** Comprehensive analysis of the current state of ocean negative carbon emissions and carbon neutralization technologies in the North Pacific.
2. **Research Publications:** Peer-reviewed articles detailing findings on carbon sequestration in the PICES region.
3. **Technical Standards:** Development of standardized protocols for carbon monitoring and management, incorporated into the ISO/NP 25283-1 standard through the completion of WD, CD, and DIS stages.
4. **Final Report:** A comprehensive report summarizing three years of research findings, including recommendations for future research and international collaboration.

Coordination with Other PICES Committees

To ensure alignment with PICES' broader mission, WG-OCN will liaise with:

- MEQ Committee: Addressing the environmental quality implications of ocean carbon sequestration strategies.

- Carbon and Climate Section: Integrating research on carbon cycling and climate impacts with ongoing PICES initiatives.

Tentative Members (A-Z)

- **WG Members**

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  Russell T. Hill /USA (Marine microbiology)

  Curtis Suttle /Canada (Marine Viruses and Ecology)

  Boris Wang /Canada (Trade and Application of Marine Carbon Neutral Technologies)

  Hongsheng Bi /USA (Fisheries Oceanography and Imaging systems)

  Michael Gonsior /USA (Photochemistry, Dissolved Organic Matter Diversity)

  Feng Chen /USA (Marine Microalgae Ecology and Environmental Science)

  Jeremy Testa /USA (Eutrophication and Ocean Acidification)

  Mark L. Wells /USA (Marine biochemistry)

  Shigeru Tabeta /Japan (Clean Energy Engineering)

  Moriaki Yasuhara /Japan (Micropaleontology and Climate Change)

  Tsuneo Ono /Japan (Marine environment and fisheries resource)

  Jung-Ho Hyun /Korea (Sediment Biogeochemistry and Microbial Oceanography)

  Sun Young Kim /Korea (Marine Genetic Ecology)

  Kyung-Hoon Shin /Korea (Marine science and convergence engineering)

  Taewon Kim /Korea (Ocean Science)

  Lei Zhou /China (Marine Observation and Remote Sensing)

  Yongyu Zhang /China (Macroalgae Culture)

  Yanli Lei /China (Biodiversity and Global Change, ISO/TC8/WG15)

Appendix 3

Final Report of WG46

PICES Scientific Report

2024

Report of Joint PICES/ICES Working Group on

on

Ocean Negative Carbon Emissions (ONCE)(WG-46)

edited by

Nianzhi Jiao, Carol Robinson, Louis Legendre, Douglas Wallace

May 2024

North Pacific Marine Science Organization (PICES)
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PICES Scientific Reports

Published since 1993, the PICES Scientific Report series includes final reports of the PICES expert groups, proceedings of PICES workshops, data reports and reports of planning activities. Formal peer reviews of the scientific content of these publications are not generally conducted.

PICES Scientific Reports can be found at:
https://meetings.pices.int/publications/scientific-reports

This report was developed under the guidance of the PICES Science Board. The views expressed in this report are those of working group members.

Front cover:
The logo of Global ONCE, a UN Decade programme. The three connected arrows indicate the integration of three ocean carbon sequestration mechanisms, i.e. the microbial carbon pump (MCP), the biological pump (BP), and the carbonate counter pump (CCP).

This document should be cited as follows:

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Table of Contents

Executive Summary

Working Group 46 on Ocean Negative Carbon Emissions (ONCE) was proposed as a Joint Working Group of PICES and ICES participants. The main purpose of the group was to identify current knowledge gaps in negative carbon emissions in the oceans, and propose future research directions and applications to the enhancement of ocean negative carbon emissions. The Terms of Reference for the Working Group proposed that working group members discussed the theoretical basis, implementation guidelines, and evaluation of the benefits, challenges and impacts of ONCE.

In the three years since Working Group 46 was formed, knowledge gaps were discussed in negative carbon emissions in the oceans, especially in the coastal regions, which will help innovation both in theory and technology to achieve ONCE. The group member organized electronic annual meetings, Co-Chair meetings, and Task Team meetings to exchange ideas and discuss ongoing research results. A roadmap for Ocean Negative Carbon Emission eco-engineering in sea-farming fields was proposed by parts of WG members resulting Global Ocean Negative Carbon Emissions (Global-ONCE) Program was approved by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational Scientific and Cultural Organization (UNESCO) in the framework of the United Nations' call for Decade Actions of Ocean Science for Sustainable Development and the United Nations Decade Initiative Plan, which reviewed the mechanisms of carbon pumps behind this scenario. A future research direction was proposed with wastewater alkalinity addition to the enhancement of ocean negative emissions. An UN-decade program was proposed and endorsed with the name of Global Ocean Negative Carbon Emissions (Global-ONCE).

Introduction

In addition to drastic cuts in emissions of fossil fuel derived carbon dioxide (CO_2) into the atmosphere, ocean negative carbon emission (ONCE) approaches will be necessary to capture and sequester the CO_2 from residual emissions to reach the Paris Agreement to limit global warming to 2.0°C or perhaps even 1.5°C by the end of this century. The ocean has a large capacity to sequester carbon and has absorbed approximately 25% of the CO_2 produced by fossil fuel combustion and cement production since the beginning of the industrial revolution. Ocean Negative Carbon Emissions (ONCE) have the potential to contribute to negative emissions, which require us to understand the mechanisms and processes involved.

The majority of the organic carbon in the ocean is in the form of refractory dissolved organic matter (DOM), the amount of which is equivalent to the total inventory of atmospheric CO_2. The previous PICES/ICES Joint Working Group -33 on "Climate Change and Biologically-driven Ocean Carbon Sequestration" highlighted the importance of microbial processes in the production of refractory DOM (RDOM) in the ocean. However, there are significant gaps in knowledge between understanding of these natural processes of sequestration and their potential application as a negative emission technology. In addition, our knowledge gaps of other ocean carbon sequestration mechanisms and processes, such as the solubility pump, the carbonate pump, and the different components of the biological pump, limits their potential application, individually or jointly, for mitigating climate change.

The PICES/ICES Joint Working Group WG46/WGONCE on Ocean Negative Carbon Emissions (ONCE) was formed with the aim of identifying current knowledge gaps in negative carbon emissions in the ocean, and proposing future research directions and applications to the enhancement of negative carbon emissions. The Working Group was designed as a joint effort to link the science, assessment, and management communities, and thus to enhance our understanding of ONCE. WG46/WGONCE aimed at promoting interdisciplinary exchanges among different research communities by bringing together experts with backgrounds in ocean science (biological, biogeochemical, chemical, and physical oceanography) and engineering, to develop theoretical bases, provide guidelines, and evaluate the implementation of ONCE, chaired by scientists from both the PICES and ICES communities.

WG 46 Achievements with Respect to Terms of Reference

1. Identify current knowledge gaps in negative carbon emission in the oceans.

Two working group task teams TT1a and TT1b were formed towards this Term of Reference. TT1a focused on reviewing and proposing terminologies and definitions that were consistent with "nature-based" solutions ('natural climate solutions'– defined by Griscom et al. 2017 – referring to terrestrial habitats/coastal blue carbon), while TT1b aimed at comparing the assumptions and conclusions of existing studies on proposed ONCE methods to summarize some key questions that are worthy of global attention.

As part of discussions within TT1a we reviewed a recent publication by Doug Wallace – working group co-chair – discussing how terminologies were contributing to enabling or impeding funding of ONCE approaches in different nations, and compared the terminologies used within the most recent reports and plans published in the nations represented by working group members.

Within TT1b we reviewed a number of recent publications, including : Gattuso et al., 2021, the Ocean Visions roadmaps (https://oceanvisions.org/work/ocean-based-carbon-dioxide-removal/) and the US Ocean Carbon and Biogeochemistry program summer workshop presentations (https://web.whoi.edu/ocb-workshop/ocb2021-negative-emissions/), the US National Academies of Sciences, Engineering and Medicine research strategy for ocean carbon dioxide removal (CDR) (https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration#sectionWebFriendly), and the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (Chapter 5) (https://www.ipcc.ch/srocc/)

A collation / consensus of the knowledge gaps identified in these publications includes:

1) How to attribute additional CO_2 removal to a particular intervention? The knowledge of variability in current carbon sequestration, modeling, and *in situ* tools for evaluation and attribution, and the design of controlled field and modeling experiments are necessary.

2) How to quantify the effectiveness of the CO_2 removal? This may be achieved by applying *in situ* tools for monitoring the stability and longevity of CO_2 removal as part of long-term controlled field experiments;

3) How to quantify/prevent any detrimental environmental impacts? To investigate unexpected indirect effects, appropriate monitoring and attribution protocols need to be developed as part of the design of controlled field and modeling experiments.

2. Propose future research directions and applications to the enhancement of

negative carbon emissions;

(1) Developing additional long-term time series stations to observe carbon sequestration in representative coastal and offshore waters.

The task team TT2 and part of TT3 addressed this Term of Reference. The key issues that were addressed were:

1) Investigation on the possibility of setting up a global network of ocean time-series stations not only for observations but also for understanding ONCE processes by deliberately planning for them to be sites for experimentation/intervention.

2) As part of research by some of the WG members on ONCE approaches, integrated carbon sequestration experimental platforms were set up in the subtropical sea near Xiamen, Fujian, China and a coastal aquaculture area near Qingdao, Shandong, China.

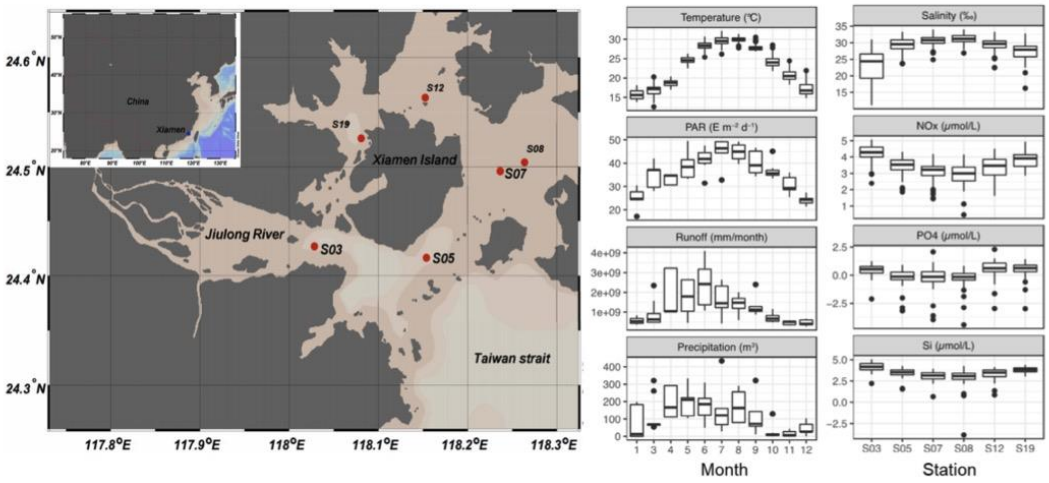

Figure 1. Time-series sampling in the coast around Xiamen, Fujian, China (Wang et al., unpublished.)

3) One Working Group member (Douglas Wallace, PICES WG Co Chair) has been involved in developing a multidisciplinary ocean time series station in Halifax, Canada, with a combination of innovative experiments, a testbed for the development of new technologies and long-term monitoring of marine carbon cycling.

(2) Proposing integrated experimental studies to better understand carbon sequestration under paleo-, current and future oceanic conditions.

Task team TT3b was formed to address this Term of Reference. Some Working Group

members proposed potential experimental studies on ONCE mechanisms in aquaculture fields through the following approaches (Figure 2):

1) Clean energy-driven artificial upwelling to bring up high nutrient containing water from the lower part of the water column to the euphotic zone to enhance carbon fixation and boost an algal bloom;

2) Application of clay minerals such as modified montmorillonite to draw down the bloom biomass;

3) Enhance microbial metabolic processes which increase alkalinity under hypoxic conditions;

4) Application of an alkaline mineral such as olivine to induce carbonate precipitation.

These combined abiotic and biotic processes should work together to achieve comprehensive carbon storage in the form of particulate organic and inorganic carbon burial and recalcitrant dissolved organic carbon, thereby simultaneously maximizing the efficiency of organic carbon sequestration in the aquaculture fields and other coastal areas. Through careful investigations of ONCE approaches, integrated carbon sequestration experimental studies were conducted in the subtropical sea near Xiamen, Fujian, China and a coastal aquaculture area near Qingdao, Shandong, China.

A paper entitled "A roadmap for Ocean Negative Carbon Emission eco-engineering in sea-farming fields" by some WG members was published on ONCE approaches, namely BCMS[1]. A comprehensive BCMS-based ONCE eco-engineering roadmap is proposed in this paper towards achieving the twin goals of enhancement of the carbon sink alongside remediation of the ecosystem. BCMS would be best implemented in sea-farming fields.

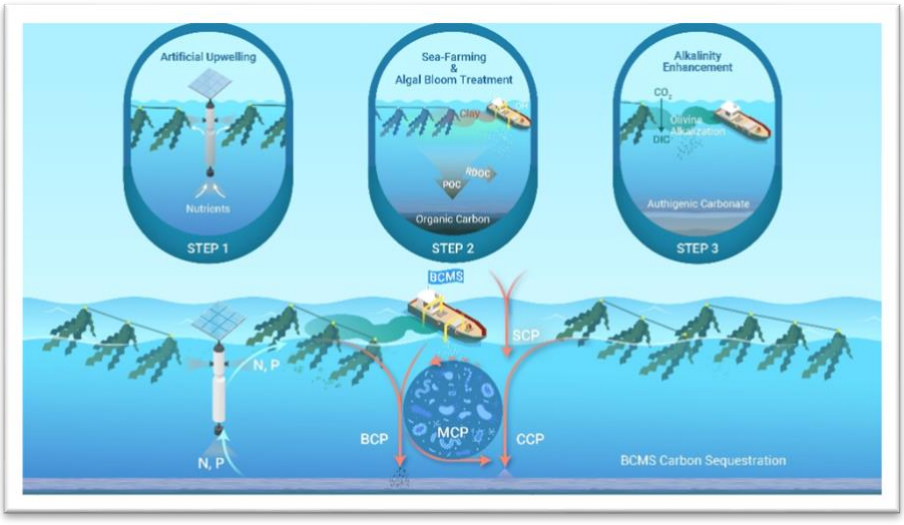

Figure 2. An illustration of the BCMS ecoengineering approaches
POC: Particulate Organic Carbon, RDOC: Refractory Dissolved Organic Carbon, N,P: Nitrogen and phosphorus

Another approach to remove CO2 is the utilization of alkalinity minerals (e.g., Olivine, Brucite) in sewage and acidification oceanic regions to increase carbon sequestration. This method can dissolve alkaline minerals from natural environments, thereby significantly enhancing carbon sequestration and helping to mitigate ocean acidification. This approach offers a practical and scalable solution to contribute to the global effort to combat climate change.

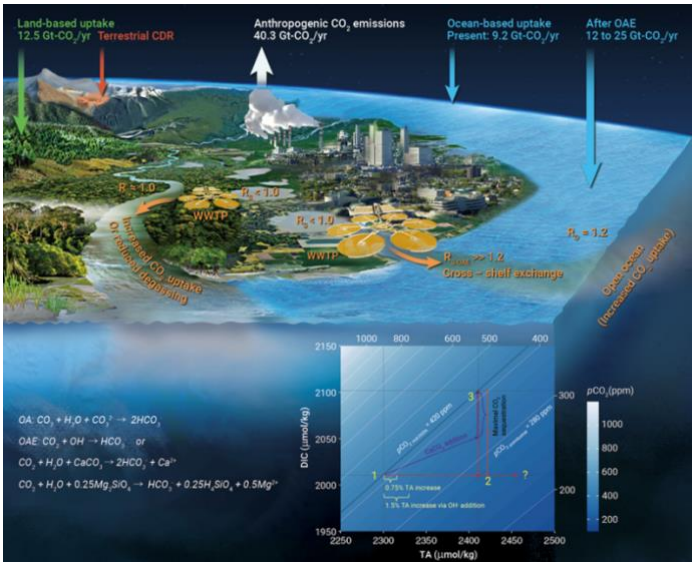

Figure 3. Wastewater alkalinity addition as a novel ocean negative carbon emissions approach

The state-of-the-art experimental facilities can contribute to proposed OAE factory studies and carbon storage mechanisms, such as the Marine Environmental Chamber System (MECS), which is presently under construction in Qingdao, Shandong, China, and the Aquatron Laboratory located at Dalhousie University in Canada. These facilities simulate natural environment, provide high frequency sampling for multiple biological, chemical and physical samples, to find the best practice.

Figure 4. Research strategies for ocean carbon storage mechanisms and effects[3]

(3) Proposing an international collaborative project or program dedicated to ocean negative carbon emissions.

An international collaborative program, named the Global Ocean Negative Carbon Emissions (Global-ONCE) Program was officially approved and launched on World Oceans Day, 8 June 2022. This is a significant initiative approved by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). It is in the framework of the United Nations Decade of Ocean Science for Sustainable Development.

The Global-ONCE program is led by five leading research organizations[2], the North Pacific Marine Science Organization (PICES), the International Council for the Exploration of the Sea (ICES), the Surface Ocean-Lower Atmosphere Study (SOLAS), the Integrated Marine Biosphere Research (IMBeR) network, and the World Climate Research Program (WCRP China). The partners involve 79 universities or institutions from 33 countries.

The key objectives of Global ONCE are: 1) Construction of a network of coastal and ocean study sites and experimental infrastructure; 2) Provision of the science, technology and governance frameworks for assessment, implementation and monitoring of adaptation and mitigation approaches; 3) Improved technical and personnel capacity and ocean literacy; and 4) Improved ocean-climate mitigation and adaptation strategies, policies and governance.

Global-ONCE will undertake and facilitate the science required to evaluate and implement eco-technological interventions, including learning from paleo-oceanic carbon processes to predict the future, restoring impacted marine ecosystems, fostering nature-based systems of land-sea integrated management, upwelling manipulation, microbial-driven comprehensive carbon sequestration, adjustment of nutrients, dissolved oxygen and pH. At this stage, the Global-ONCE program is planning to develop an international network of field stations and research facilities; co-design interdisciplinary collaborative research; develop an evaluation framework for mitigation and adaptation approaches; co-ordinate capacity building; facilitate equitable policy, governance and societal understanding.

Conclusions and Future Plans

Working Group 46 identified parts of the current knowledge gaps in negative carbon emissions in the oceans, published papers, and propose future research directions and applications to the enhancement of CO_2 sequestration. Research by Working Group members have addressed the aims set out under the initial Terms of Reference. One of

our commitments lies in establishing long-term time series stations, such as Xiamen Time-series Station, to measure carbon-related parameters, which was open access for the general public.

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4. Liu, J., Robinson, C., Wallace, D., Legendre, L., & Jiao, N. (2022). Ocean negative carbon emissions: A new UN Decade program. *The Innovation*, *3*(5).

5. Jiao, N.,, & Dai, M. (2022). Research strategies for ocean carbon storage mechanisms and effects. *Chinese Science Bulletin*, *67*(15), 1600-1606.

Appendix 1

WG 46 Terms of Reference

WG 46 term: 2020-2023
Extended 1 year to 2024
Parent Committee: BIO and POC

1. Identify current knowledge gaps in negative carbon emission in the oceans.
2. Propose future research directions and applications to the enhancement of negative carbon emissions including the items below:
   (1) Developing additional long-term time series stations to observe carbon sequestration in representative coastal and offshore waters.
   (2) Proposing integrated experimental studies to better understand carbon sequestration under paleo-, current and future oceanic conditions.
   (3) Proposing an international collaborative project or program dedicated to ocean negative carbon emissions.

Appendix 2

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Appendix 3

Publications Related to WG 46 Research

(1) WANG, Yuze, et al. (2021). Advocating eco-engineering approach for ocean carbon negative emission. Bulletin of Chinese Academy of Sciences (Chinese Version), 36(3), 279-287.

(2) Jiao, N (2021) Developing Ocean Negative Carbon Emission Technology to Support National Carbon Neutralization, Bulletin of Chinese Academy of Sciences (Chinese Version) 36. DOI: https://doi.org/10.16418/j.issn.1000-3045.20210123001

(3) Cai, W. J., & Jiao, N. (2022). Wastewater alkalinity addition as a novel approach for ocean negative carbon emissions. The Innovation, 3(4), 100272.

(4) Liu, J., Robinson, C., Wallace, D., Legendre, L., & Jiao, N. (2022). Ocean negative carbon emissions: A new UN Decade program. The Innovation, 3(5), 100302.

(5) Jiao, N. et al. (2020). Microbes mediated comprehensive carbon sequestration for negative emission in the ocean. National Science Review 7: 1858-1860.

(6) Jiao, N. et al. (2021). Excessive greenhouse gas emissions from wastewater treatment plants by using the chemical oxygen demand standard Science China Earth Science 65: 87-95.

(7) Wang, F. et al. (2021). Technologies and perspectives for achieving carbon neutrality

(8) Jiao, N., Luo, T., Chen, Q., Zhao, Z., Xiao, X., Liu, J., ... & Robinson, C. (2024). The microbial carbon pump and climate change. *Nature Reviews Microbiology*, 1-12.

Appendix 4

Relevant Presentations by WG 46 Member

<u>The WG held an "Ocean Negative Carbon Emissions (ONCE) for Carbon Neutralization" Workshop on October 24 in Seattle during the 2023 PICES Annual Meeting.</u>

The chief scientist of Global ONCE, Prof. Nianzhi Jiao delivered the opening remarks, Prof. Curtis Suttle, Fellow of the Royal Society of Canada, along with ONCE Working Group member Prof. Jung-Ho Hyun, presented reports during the workshop. The event facilitated academic discussions among experts, scholars, early-career professionals, and students from the USA, South Korea, Canada, China, and other countries.

<u>The WG annual meeting was held in Xiamen 5-7 November</u>

The 2023 Annual meeting of Working Group (WG) 46 the Joint PICES/ICES Working Group on Ocean Negative Carbon Emissions was held in Xiamen, China and online from November 5 to 7, 2023. The meeting was chaired by the four co-chairs, namely, Prof. Nianzhi Jiao, who is Global ONCE's co-chair and Chief Scientist, Prof. Carol Robinson from the University of East Anglia and Global ONCE's co-chair, Dr. Douglas Wallace, who is a Fellow of the Royal Society of Canada, and Prof. Louis Legendre, who is a Fellow of the European Academy of Sciences. There were 12 members plus 3 observers (WG 46 Endnote 1) in attendance. During the meeting, past activities and ToR of the WG were reviewed. Updates on the progress made by each task team were provided, and two joint reports were discussed, and work began on drafting them. The agenda for the meeting is presented as WG 46 Endnote 2. The first joint report focuses on "Advancements in Ocean Negative Carbon Emissions Research: What is Happening, and What Comes Next?" The second report addresses "Environmental Changes Potentially Caused by mCDR.

Appendix 5

Meeting Report and Topic Session/Workshop Summaries from Past Annual Meetings

PICES-2021

PICES-2021, Shanghai, China

- Reviewing recent activities and gatherings of the WG, and build upon the rationale for WG 46.
- Updating on the progresses made by each task team within the WG are provided and discussing further steps for WG 46.

Kick-off Meeting, due to COVID-19, on July 8, 2021

- To introduce the rationale for establishing WG 46 and clarify the objectives (terms of reference).
- Creating task teams to address the ToRs.
- Discussing a logo design and setting up Working Group website: https://meetings.pices.int/members/working-groups/wg46.

Co-Chairs' meeting,2021

- Discussing the structure, specific arrangements, and length of the annual meeting.
- Prof. Jiao also shares the updates on ONCE progress in China.

Meeting of the Chinese members sub-group,2021

- Sharing progress made towards the scientific objectives of WG 46.
- Discussing tasks on preparations for the WG annual meeting.
- Views on the next steps to assist in the achievement of WG objectives are also exchanged.

Task team 2 meeting

- Using data from coastal and open ocean time-series and macrocosm facilities to assess proposed ocean negative carbon emission models.
- Members discuss the links between TT2 and TT1 and highlight the knowledge gaps related to time-series.
- TT2 agrees that instead of proposing a new time-series station, it is more feasible for the TT to take advantage of the international nature of the Working Group to re-define the capabilities of time-series by focusing on the need of carbon measurement bases on the established time-series.

Task team 3a meeting

- The aim of the meeting is to propose integrated experimental studies to better understand carbon sequestration under paleo-, current and future oceanic conditions.
- Considering the travel restrictions due to the pandemic, it would be too difficult for members to conduct field investigation altogether in the near future, but TT3a would like to collect experimental designs and ideas from all the members of WG46.
- Further clarifies the deliverable of TT3a in which research directions need to be prioritized based on funding availability, readiness of implementation, research interest of the members, policies in different regions, etc.

The meeting of task team 3b

- Participating members agree to narrow down the scope of methods for discussion to ensure more in-depth exploration and original findings.

PICES-2022

Background

Working Group 46, a joint PICES/ICES Working Group on Ocean Negative Carbon Emissions (ONCE), was established with all members being officially assigned on April 6, 2021. Due to COVID-19, four meetings were convened virtually, including one meeting to plan a side event at the UN Ocean Conference (Nianzhi Jiao, Carol Robinson, and scientists in related fields), a side event at the UN Ocean Conference, one meeting of the WG Co-Chairs and one 2022 annual business meeting.

The 2022 annual meeting, online conference

- Reviewing the past activities and meetings of the WG, updating on the progress made towards achieving the Terms of Reference (ToRs) and discussing further steps for the WG.

2022 activities and actions towards achieving Terms of Reference

1. UN Ocean Decade Program Global ONCE

- Objectives of Global ONCE, some of which are an extension of those of WG 46:
  1) Develop an international network of field stations and research facilities;
  2) Develop an evaluation framework;
  3) Develop capacity and ocean literacy and
  4) Facilitate equitable policy and governance.
- The objective of WG 46 to propose an international program on ocean negative carbon emissions has been achieved.

2. UN Ocean Conference side event

- The aim of the side event was to discuss how ocean carbon storage and negative emission technologies contribute to the UN Sustainable Development Goals, to stimulate discussion and to encourage people to get involved in Global ONCE.

3. ONCE – progress in China

- Five Missions of ONCE in China, funded by MOST (Ministry of Science and Technology of China):

1) Developing innovative research Scientific Goal: Use a combination of BCP (Biological Carbon Pump)-CCP (Carbonate Counter Pump)-MCP (Microbial Carbon Pump) to achieve synergistic carbon storage.

2) Construction of ONCE research platforms (RPs)

RP1: Marine Environmental Chamber System;
RP2: Intelligent Simulation System of Marine Platform;
RP3: Oceanic Residence Research Platform;
RP4: Seabed Scientific Observation Network;
RP5: Marine Ranching Facilities.

3) Demos in the field for ONCE approaches

Demo 1: Land-Ocean Integrated Eco-engineering;
Demo 2: Seaweed Farming Environment–Artificial Upwelling;

Demo 3: Ocean Alkalinity Enhancement–Wastewater Treatment Plants.

4) International communications

5) Science popularization: ONCE Virtual Lab for Earth System Science

4. Talks at PICES-2022, Busan, Korea

- Prof. Nianzhi Jiao and Dr. Rui Zhang presented at the POC and BIO meetings via Zoom and requested the establishment a new working group to continue the activities after the term of WG46.

5. Report to ICES 2022 [to be submitted end 2022], completed ToR

- Dr. Jihua Liu prepared a draft of the 2022 Interim Working Group e-evaluation for WG members to edit and update progress made.

6. Review actions towards achieving ToR

Planned deliverables WG 46 include:

1) Research papers, journal special issues or sections and reviews of the science related to ocean based negative carbon emission approaches;

2) A proposal for future research directions in ocean based negative carbon emissions;

3) An outreach product for the general public; and

4) A final report for ICES and PICES summarizing the results of the Working Group.

Appendix 6

Literatures/Publications filtered by year for keywords related to ocean negative carbon emissions in Web of Science

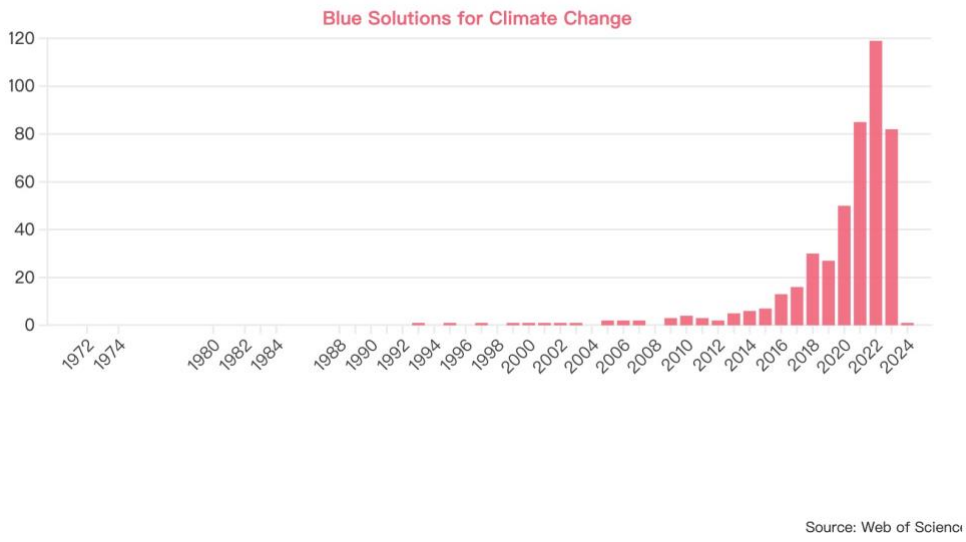

Figure 5. Keyword: “Blue Solutions for Climate Change”

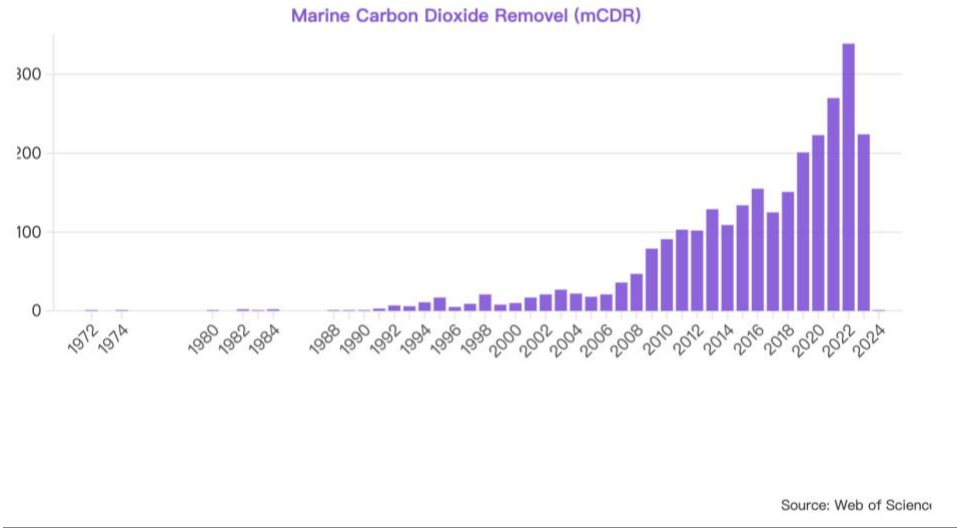

Figure 6. Keyword: “Marine Carbon Dioxide Removel (mCDR)”

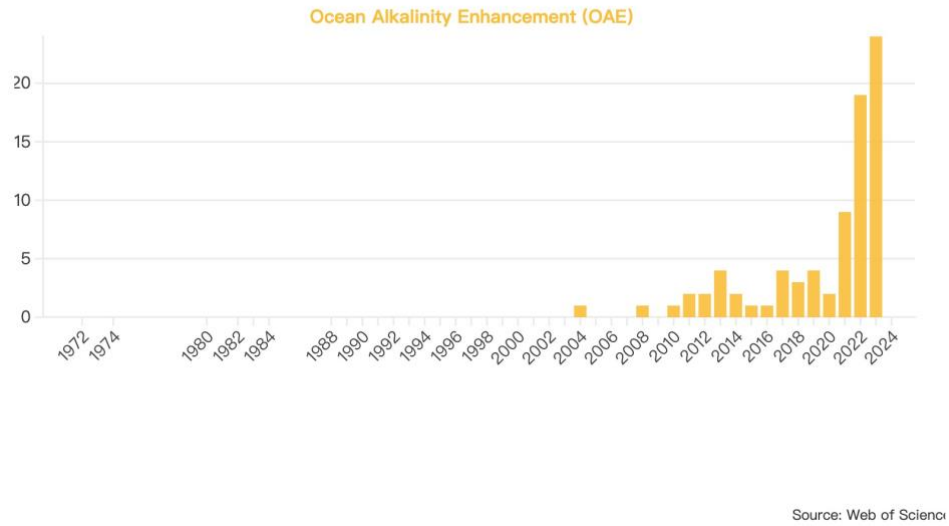

Figure 7. Keyword: “Ocean Alkalinity Enhancement (OAE)”

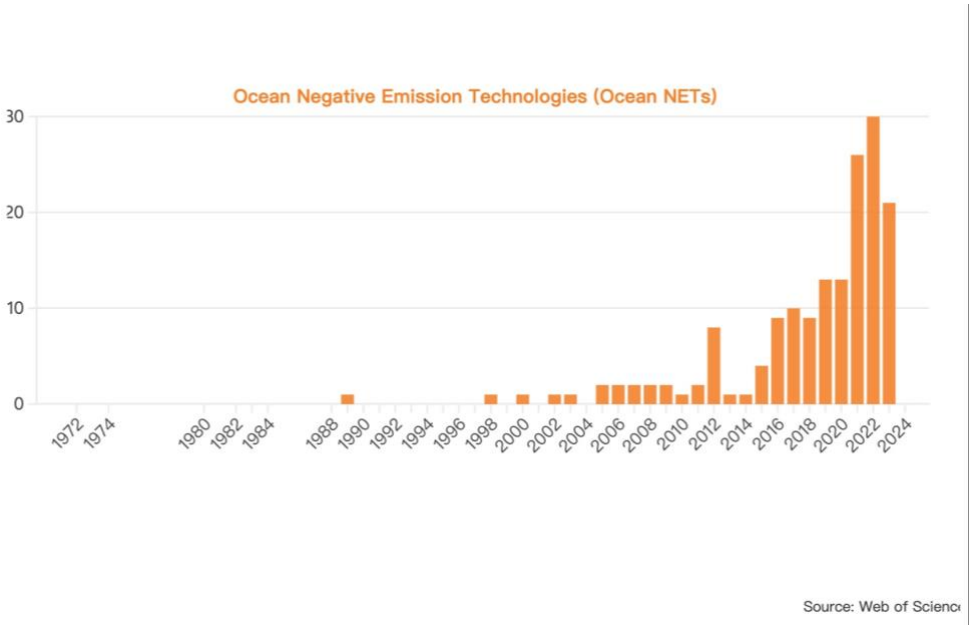

Figure 8. Keyword: “Ocean Negative Emission Technologies (Ocean NETs)”

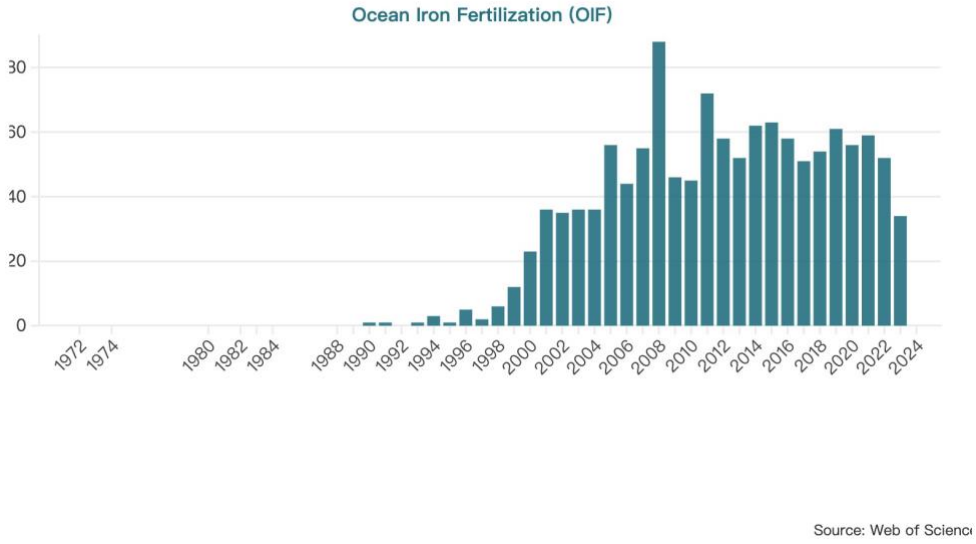

Figure 9. Keyword: “Ocean Iron Fertilization (OIF)”