2024 Science Board Meeting

Report

(With Governing Council Decisions)

Held in a hybrid format at the Hawaii Convention Center, Honolulu, USA, on November 1 – 2, 2024.

Prepared by Science Board Chair, Dr. Sukyung Kang, and the PICES Secretariat

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Agenda Item 1: Welcome, adoption of agenda

Science Board Chair, Dr. Sukyung Kang, called the meeting to order, welcomed participants, and made introductions.

List of Participant

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
Mitsutaku Makino	HD Chair
Takafumi Yoshida	MEQ Vice Chair
Lei Zhou (online)	POC Chair
Jennifer Jackson	POC Vice Chair
Sung Yong Kim	MONITOR Chair
Yury Zuenko (online)	Russian representative
Guests from PICES Community	
Tetsuo Fujii	PICES Vice-Chair
Yutaka Hiroe	F&A
Tatsuki Oshima (online)	F&A
Hannah Lachance,	AP-ECOP
Hana Matsubara	AP-ECOP
Oleg Katugin (online)	FUTURE-SSC
Kathryn Berry	BECI
Natsumi Okawa (online)	MOFA
Takashi Kamaishi (online)	MAFF
Guests from Strategic Partners	
Alan Haynie	ICES
David Reid	ICES
Jo Foden	ICES
Sinjae Yoo	SCOR
Emily Twigg (online)	SCOR
Janelle Curtis	NPFC, WG47 Chair
Aleksander Zavolokin	NPFC
Naomi Harada	ESSAS
External Review Panel Members	
Eileen Hofmann	Panel Chair
PICES Secretariat	
Sanae Chiba	Deputy Executive Secretary

Agenda Item 2: Reports of PICES Partner Organizations

Representatives of PICES partner organizations participated in the SB meeting either in-person or remotely to update their recent activities and collaboration with PICES.

2.1. International Council for the Exploration of the Sea (ICES)

ICES Executive Secretary Alan Haynie, newly appointed SCICOM Chair David Reid, and Head of Science Department, Jo Foden, updated ICES activities and collaboration with PICES. See ICES-PICES MoU (1998) for the PICES-ICES collaboration framework. ICES and PICES currently share several joint Expert Groups: Section on Climate Change and Marine Ecosystems (S-CCME), WG53 on Small Pelagic Fish (WGSPF), WG45 on Impacts of Warming on Growth Rates and Fisheries Yields (WGGRAFY), and Advisory Panel on United Nations Decade of Ocean Science (AP-UNDOS). Following the disbandment of WG39 in 2022, the newly established Advisory Panel on the Arctic Ocean and the Pacific Gateways (AP-ARC) will collaboratively work with WGICA on an Integrated Ecosystem Assessment for the Arctic Systems. The IOC endorsed the joint ICES/PICES UNDOS program SmartNet in 2021, which will also ensure close cooperation of the organizations over the next decade (see Agenda 5 for SmartNet activity update). Dr Raid was appointed to be an ICES co-chair of SmartNet after his predecessor, Dr. Jörn Schmidt, left ICES in early 2024.

2.2. Scientific Committee on Ocean Research (SCOR)

SCOR President (ended his term at the SCOR Annual Meeting in mid-October) Sinjae Yoo and Executive Director Emily Twigg participated in the SB meeting. Dr. Twigg updated SCOR activities and collaboration with PICES. SCOR and PICES have developed a cooperative model for an international non-governmental organization and a regional intergovernmental organization to share their strengths in championing ocean science. Collaboration between PICES and SCOR is based on the recognition that PICES can play an important role in bringing a North Pacific perspective to the global activities of SCOR. The collaboration is implemented through activities in the following areas:

- Contribution of scientific expertise to relevant international scientific projects of SCOR, e.g. Harmful Algal Blooms (GlobalHAB), IMBeR, SOLAS, GACS (Global Alliance of Continuous Plankton Recorder Surveys), and to SCOR-supported projects, e.g., IOCCP, International Ocean Carbon Coordination Project. PICES has also supported several SCOR Working Groups.
- Reciprocal representation of the SCOR and PICES Executives at annual meetings of the organizations, including the PICES Deputy Executive Secretary as a member of SCOR's Capacity Development Committee.

2.3. North Pacific Fisheries Commission (NPFC)

NPFC Science Committee Chair Janelle Curtis and Science Manager Alexsandr Zavolokin participated in the SB meeting. Dr. Curtis serves as the co-chair of PICES WG47: Ecology of Seamounts. She updated NPFC activities and collaboration with PICES, focusing on the renewal of the NPFC-PICES Collaboration Framework (see Agenda Item 3).

2.4. Ecosystem Studies of Subarctic and Arctic Seas (ESSAS)

ESSAS Chair Naomi Harada updated ESSASS activities and collaboration with PICES. ESSAS has long-lasting collaboration with the PICES community on the North Pacific sub-Arctic and Arctic research, including co-convening sessions and workshops since 2005. The goal of the ESSAS is to compare, quantify and predict the impact of climate variability on the productivity and sustainability of Subarctic and Arctic marine ecosystems. Dr. Harada reported on the upcoming ESSAS Open Science Meeting scheduled in June 2025 in Tokyo, Japan, and requested SB recommendation for PICES funding support for ECOPs to attend the meeting (see Agenda Item 15).

2.5. Current MOUs and Collaboration Frameworks

Responding to the request at ISB-2024, PICES Executive Secretary Dr. Batten reviewed the current collaborative frameworks with strategic partners or MOUs. PICES Deputy Executive Secretary Dr. Chiba briefly explained the current status of the summary report prepared by Dr. Batten. See Appendix 1 for the lists of the existing 9 agreements and their status. In summary, among the listed,

- Four (those with NPFC, IPHC, PSC and APN) have been very recently developed/revised and are active.
- Three (those with ICES, NPAFC, and IOC) have language that is still relevant and are active as of October 2024 (although reviewing the MOUs could be useful).
- Two (with NOWPAP and ISC) should be revisited/revised with a view to stimulating the partnership.

Besides the strategic partners with the official MOUs or Collaboration Frameworks, PICES has more than 50 partner organizations that mutually participate in each other's annual meetings and conduct collaborative research on respective EG and Committee basis. PICES invited observers from a total of 54 partner organizations, and 17 of them sent their representatives to PICES-2024.

Agenda Item 3: Renewal of PICES-NPFC Collaboration Framework *(with GC decision)*

The NPFC-PICES Framework for Enhanced Scientific Collaboration in the North Pacific will end its current 5-year term at PICES-2024. Over the summer of 2024, relevant Committees (FIS and BIO), Secretariat, and NPFC members met to review and revise the Framework. SB revised the Framework for 2024-2029 and recommended GC approve it. See Appendix 2 for the revised Framework. SB reviewed and recommended GC approve the revised Framework *=> GC approved and the old document will be replaced with the new one after it is officially adopted by the NPFC Scientific Committee meeting in December 2024 (GC2024/S/10).*

(Background) NPFC and PICES endorsed the NPFC–PICES Framework for Enhanced Scientific Collaboration in the North Pacific (link) in 2019. The Framework identified three broad areas of joint interest to PICES and the NPFC: (i) support for stock assessment for priority species; (ii) vulnerable marine ecosystems; and (iii) ecosystem approach to fisheries.

Agenda Item 4: FUTURE-SSC Report

FUTURE SSC co-chairs, Drs. Bograd and Na updated FUTURE SSC activities and reported on the outcome of FUTURE Symposium held on October 28 (Mon) during the PICES-2024 and other emerging issues which required SB considerations. See the 2024 Annual Report on the PICES website for the summary of FUTURE activities for PICES-2023 to PICES-2024.

FUTURE Symposium description

PICES has provided leadership in developing a more thorough understanding of the structure, function, and changes of North Pacific marine ecosystems with the support of its flagship scientific programs. The current scientific program on 'Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems' (FUTURE) has been promoting investigations of North Pacific ecosystems with an emphasis on the synergy of social, ecological, and environmental systems (SEES) and processes. Within this SEES framework, FUTURE is focused on developing a better understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems, ecosystem services, and marine-dependent social systems. The FUTURE symposium plans to review its past, assess the present, and discuss the future of FUTURE to better observations, improved awareness of mechanisms of change, and ultimately science for sustainability along with the United Nations Decade of Ocean Science for Sustainable Development and the mission of developing "the science we need for the ocean we want". See the Symposium details in PICES Press Vol 33 (1).

Agenda Item 5: SmartNet and AP-UNDOS Report

SmartNet and AP-UNDOS co-chair, Dr. Bograd, updated SmartNet and AP-UNDOS activities and planning for 2025 as discussed in its business meeting held on October 2nd. See the 2024 Annual Report on the PICES website for the SmartNet and AP-UNDOS activity summary from PICES-2023 to PICES-2024.

UNDOS Conference Barcelona
Major accomplishments include its representation at the UNDOS Conference in Barcelona (April 2024). SmartNet sponsored a satellite event, "What is the Ocean We Want?: SmartNet Global Survey on the General Public's Attitude for Ocean Decade Outcomes" (Project website) (led by Makino), elucidating country-specific public perceptions and prioritization on UNDOS 7 societal outcomes. SmartNet also co-sponsored two well-attended satellite events organized by the Ocean Decade Global ECOP Programme: "Building Ocean Leadership: Fostering Networking, Creativity, and Resilience' and "The Inclusivity We Need for the Ocean We Want." PICES supported the conference participation of three ECOPs representing PICES, including two from SIDS (who reside in PICES member countries). These ECOPs contributed to a range of conference events, including meetings with high-level policymakers, expanding their networks and opportunities for the promotion of ECOPs from SIDS. See PICES Press Articles for the full report.

Planning for 2025
AP-UNDOS submitted a proposal of the SmartNet Implementation Plan for its phase II (2025-2022) seeking PICES program status and SB representation (See Agenda 8). Following the AP-UNDOS request for the appointment of a SmartNet Coordinator at SB/GC-2022/2023, PICES and Ocean Decade International Cooperation Center China (ODCC) drafted MOU on the collaboration framework on UNDOS-related subjects, including the appointment of a SmartNet Coordinator at ODCC (see Agenda 8).

Agenda Item 6: Meeting with the PICES Review Panel Chair, Eileen Hoffman

SB members welcomed the Review Panel Chair, Eileen Hoffman. Dr. Hoffman answered the questions from SB, and they exchanged views on the Review Panel Report recommendation on the transformation of PICES. Dr. Hoffman clarified that the suggested plans, e.g. on the new structure and new program, were examples, and the details should be developed by PICES communities.

Agenda Item 7: Special Project Updates:

7.1. Basin-scale Events to Coastal Impacts: An Ocean Intelligence System for Fish and People (BECI)

BECI Science Director Kathryn Berry updated BECI achievement, including the outcome of BECI Special Workshop held on October 26 at PICES-2024. The major achievement includes the establishment of BECI science team and the development of North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) that could be used to inform transboundary fisheries management under climate change, which links to other global and regional model intercomparison initiatives. BECI organised a special workshop, "*Bringing together models for fisheries management under climate change – Multiple model ensembles and inference to guide decision-making*", during PICES-2024. See PICES Press vol.33 No. 1 for the workshop summary report.

Background: The BECI project (Basin-Scale Events to Coastal Impacts: An Ocean Intelligence System for a Changing World) was endorsed by the United Nations Decade of Ocean Science and Sustainable Development (UNDOS) in 2021. BECI has continued to make progress towards developing a high-level Science and Implementation Plan through a series of international workshops in 2022 and 2023. At the 2023 NPAFC Annual Meeting, the NPAFC adopted their new five-year science plan (2023 – 2027), which will complement BECI research and collaboration. BECI will build off the success of the International Year of the Salmon initiative's (2018 – 2022) High Seas Expeditions, which studied the winter ecology of salmon in the North Pacific Ocean. BECI Receives $1.1M in Funding from the B.C. Salmon Restoration and Innovation Fund (BCSRIF). The funding enables the establishment of a project office and the recruitment of key personnel, such as a BECI Science Director, to complete the science and implementation plans. (https://beci.info/funding_announcement/).

The objective of BECI is to develop an international ocean intelligence system for the North Pacific Ocean that will use enhanced high-tech observations, ocean modeling, data infrastructure and artificial intelligence (AI) to provide timely and targeted information on the impacts of current and future climate events on ocean ecosystems and people. Using salmon as an exemplar species, BECI will ultimately take a modular approach to include all species of interest in the North Pacific Ocean to further develop cross-cutting marine research, modeling, and data synthesis to allow for more effective predictions on marine productivity for key species in the North Pacific Ocean.

7.2. FishPhytO PICES/MAFF Project: Creating a phytoplankton-fishery observing program for sustaining local communities in Indonesian coastal waters.

Project Science Team (PST) co-chair, Mitsutaku Makino, updated the recent activities of FishPhytO, including a summary of the PST meeting on October 30 at PICES-2024, where its Indonesian members virtually joined. Agenda items included a budget report, management of the FishGIS app, activities in Indonesia and discussion on future activities. Dr. Makino reported that the team had identified funding sources to sustain project activities at a minimal level but would continue to seek additional support from various sectors, including academia and philanthropic organizations.

Background

In December 2022, the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan offered to provide funding for a new 3-year PICES project for 2023-2026 following the Ciguatera project. The ideas of the proposal for the new project were discussed during the final Ciguatera PST meeting held in mid-March in Yokohama, Japan. Due to the unexpected termination of funding from MAFF in 2023, the team was seeking alternative funding sources to continue the project.

Objective of FishPhytO is to establish, in collaboration with local fishermen and research institutes and universities, a phytoplankton-fishery observing program in coastal Indonesia by integrating the FishGIS application, developed and refined during the previous two PICES/MAFF projects (2017–2023) with existing automated technologies for detection of toxic benthic Harmful Algal Bloom (HAB) species. The longer-term goal is to provide local communities with the capacity and knowledge to sustainably manage their fisheries resources and ensure seafood safety. The project also aims to identify potential research needs for deploying the FishGIS application in PICES member countries.

Agenda Item 8: SmartNet Proposal

8.1. SmartNet Implementation Plan

AP-UNDOS submits a proposal of the SmartNet Implementation Plan for its phase II (2025-2022), seeking PICES Program status and SB representation. Given that the PICES structure, including the design of the new PICES Program, is expected to undergo transformation following the Review Panel Recommendation Report, SB reviewed the proposal and agreed that the timing was not optimal for recommending it for GC approval. SB Chair, Dr. Kang, suggested deferring the discussion on the proposal to ISB-2025 or SB-2025.

PICES Program Status (excerpt from SmartNet Implementation Plan: see Appendix 3)
"We also seek to clarify and solidify SmartNet's role within PICES with an aim of positioning SmartNet as a key element of the organization's international scientific enterprise as we transition from the current (FUTURE) to a new flagship Scientific Program. The FUTURE Science Program will phase out over the next few years, initiating a transitional period of strategizing about the future of PICES science that coincides with the Ocean Decade (2021-2030). As articulated in the SmartNet proposal for IOC endorsement, the Ocean Decade provides a rare and unique opportunity to demonstrate ICES and PICES leadership on the global stage. We advise that ICES and PICES focus their energy and resources into SmartNet and Ocean Decade activities during this period (SmartNet *Phase II*, 2025-2028) to ensure success of the Programme and firmly position ICES and PICES as leaders within the Ocean Decade and global marine science. The experiences and lessons learned from the implementation of SmartNet will inform new Expert Group(s) tasked with planning the next flagship PICES Science Program and will serve as a catalyst to more equitably share our science with the world. With this motivation, we request to Science Board and Governing Council that SmartNet be designated a PICES Program with representation on Science Board. Similarly, ICES could consider evolving SmartNet into a Strategic Initiative or Operational Group. We note that the plan outlined here is consistent with the recommendations for the future of PICES Science Programs made by the External Review Panel (Hofmann et al., 2024)."

8.2. UNDOS Coordinator *(with GC decision)*

Responding to the AP-UNDOS request for the appointment of a SmartNet Coordinator at SB/GC-2022/2023, PICES and Ocean Decade International Cooperation Center China (ODCC) drafted MOU on the collaboration framework on UNDOS-related subjects, including the appointment of a SmartNet Coordinator at ODCC (see Appendix 4). AP-UNDOS Co-chair, Dr. Chiba, explained the background of the necessity of the coordinator and sought SB's recommendation on the proposal. SB reviewed the proposal and recommended GC approve the collaboration framework between PICES and Ocean Decade International Cooperation Center China (ODCC). *=> GC approved and MOU will be added to the website (GC2024/S/11)*

Background: Proposal for SmartNet Coordinator (PICES-2022/2023)
Coordination Requirement: SmartNet was intended to be the flagship contribution of ICES and PICES to UNDOS; The motivation was to use the legacy, infrastructure, expertise, and networks in both organizations to provide leadership to the Decade. However, the increase in the number of UNDOS activities and the growing size of the community has correspondingly increased the challenge.

SB/GC Decision at PICES-2022: At PICES-2022, SB proposed the establishment of a new scheme for "UNDOS intern" to facilitate the coordination of UNDOS activities within PICES, and between PICES and the various UNDOS entities (national Committees, regional Coordination Centres, other global and regional UNDOS programs, projects and actions, and the IOC). Despite the interest expressed by the Council, no individual has been subsequently identified by a member country. At PICES-2023, the AP-UNDOS co-chairs reiterated their request to both PICES and ICES Secretariats, and PICES Executive Secretary sent an additional message to the national delegates for consideration of voluntary contribution for this position.

Agenda Item 9: Science and Technology Annual Report to Science Board

Science Board, FUTURE and Committees report scientific achievements and progress of TORs of the respective Children Expert Groups since ISB-2024 (~5 min for each EG with a few more min for the EGs whose terms end at PICES-2024). Committees also update their specific achievements if applicable. See the PICES-2024 Annual Report for the details of each EG's activities.

Agenda Item 10: Election of SB Chairs *(with GC decision)*

10.1. SB Chair-Elect

The current SB Chair, Dr. Sukyung Kang, will complete her term at the end of PICES 2025. According to the current SB Chair-elect model, which was agreed in 2018, the new SB Chair shall be elected (as Chair-Elect) one year prior to when the appointment takes effect so that the new Chair can obtain full knowledge on the operation of SB before actually taking over the role. PICES received one nomination, and the information was provided to SB members in advance of PICES-2024. The election took place according to the procedure defined in PICES Rules and Procedure 5 Election, and **Dr. Jennifer Boldt** (DFO, Canada) was elected as the SB Chair-Elect to serve for one year until PICES-2025*. => GC approved the appointment of Dr. Boldt as the SB Chair-Elect (GC2024/S/13).*

10.2. SB Vice Chair

A term of the SB Vice-chair is one year, and they shall be eligible for re-election for a successive term. Current Jeanette Gann ends her 2nd term at PICES-2024, and SB shall nominate a suitably qualified member to be the new SB Vice-chair. The election took place according to the procedure defined in PICES Rules and Procedure 5 Election, and Dr. Akash Sastri (Canada) was nominated and elected as the new SB Vice-Chair to serve for one year until PICES-2025. SB recommended GC approve his appointment*. => GC approved the appointment of Dr. Sastri as the SB Vice-chair (GC2024/S/13).*

Agenda Item 11: Committee Chair Election Results *(with GC decision)*

The election took place during the business meetings of TCODE and POC according to the procedure defined in PICES Rules and Procedure 5 Election and 17: Scientific Readership. SB endorsed the election outcomes as listed in the table below and recommended GC approve the appointment of the new vice chairs. *=> GC approved the appointments of TCODE and POC Vice-chairs (GC2024/S/13).*

Committee	Date of Election	New Chairs

TCODE	Sept 24	Dr. Fangfang Wan (China) was re-elected as the Vice Chair of TCODE Committee (2nd term)
POC	Oct 27	Dr. Jennifer Jackson (Canada) was re-elected as the Vice Chair of POC Committee (2nd term)

Agenda Item 12: Renewal of PICES Metadata Catalogue *(with GC decision)*

TCODE chair, Ms Jeanette Gann, described the proposal of Renewal of PICES Metadata Catalogues submitted by WG52: Data Management. SB acknowledged the urgent need to update PICES metadata information and recommended GC approve the required funds. *=> GC approves the use of up to $6,500 for the work to be done, if the PICES Reserve Fund is adequate at the fiscal year end. If the Reserve Fund is not sufficiently robust, then alternative funds should be sought to cover this task (GC2024/S/12)*

Project Title: Transfer of PICES Metadata Records from old PICES TCODE Geonetwork Catalogue to a New Metadata Catalogue

Background: We've evaluated the current PICES TCODE Catalogue hosted on the Russian Geonetwork server maintained by the late Igor Shevchenko and determined that a new PICES data catalogue is necessary. We recommend creating a PICES community on **Zenodo** (see also **here**): a free, open data repository.

Project Description: This project involves transforming 4,206 FGDC XML metadata files from the old Geonetwork PICES metadata Catalogue into a format that is compatible with a new metadata Catalogue system. The Geonetwork Catalogue is not accessible, but the previous maintainer backed up copies of the metadata records on Google Drive in the format of Federal Geographic Data Committee (FGDC) standard .xml files. The new Catalogue will utilise a different metadata schema, which will require careful mapping and transformation of the existing metadata. The work will also include bulk processing and uploading of the transformed metadata records to the new Catalogue via an appropriate interface, such as a REST API.

Scope of Work: Review and Parse FGDC XML Metadata:
- Review FGDC XML schema.
- Develop and implement code to parse the XML metadata files.
- Handle variations and edge cases in the XML structure.

Mapping FGDC Metadata to the New Catalogue Schema:
- Analyse the metadata schema of the new Catalogue.
- Create a mapping strategy from FGDC to the new schema.
- Implement the mapping logic in the code.

Transform Metadata Format:
- Convert parsed XML data into the required format (e.g., JSON, CSV).
- Ensure that the transformed metadata complies with the new Catalogue's requirements.

Bulk Data Processing:
- Automate the processing of 4,206 files.
- Implement error handling, logging, and testing procedures.
- Test the process on a subset of the files.

Interfacing with New Catalogue System:
- Write code to interact with the new Catalogue's interface (e.g., REST API).
- Handle authentication, upload processes, and error responses.
- Conduct test uploads and finalise the process.

Testing and Validation:
- Validate transformed metadata records against the new Catalogue's requirements.
- Identify and resolve errors or inconsistencies.
- Perform final testing and upload all metadata records.

Timeline:
The estimated timeline for completing this project is 5-8 weeks, depending on the complexity of the new metadata schema and any unforeseen challenges.

Cost Estimate:

Task	Estimated Hours	Hourly Rate (CA$)	Estimated Cost (CA$)
Review and Parse FGDC XML metadata	12	100	1200
Mapping FGDC to New Schema	15	100	1500
Transform Metadata Format	12	100	1200
Bulk Data Processing	8	100	800
Interface with New Catalogue	10	100	1000
Testing and Validation	8	100	800
Total Estimated Cost			**6500**

Agenda Item 13: New Expert Group Proposals

13.1. Section on Marine Plastic Pollution (S-MPP) *(with GC decision)*

MEQ vice-chair, Dr. Takafumi Yoshida described the proposal of a new Section on Marine Plastic Pollution. SB recommended GC approve the establishment of the Section (see full proposal Here). *=> GC approved the establishment of a Section on Marine Plastic Pollution with Terms of Reference as provided and which should be reviewed after five years (GC2024/S/15).*

13.2. Working Group on Best Practices for Using Deep Learning in Processing Plankton Images (WG-DLP) *(Information only)*

BIO Chair, Dr. Akash Sastri, described the planning of a new Working Group on Best Practices for Using Deep Learning in Processing Plankton Images (WG-DLP). Upon the completion of WG48 activities (submission of their final report), the group plans to submit their proposal to ISB-2025 or SB-2025 (see draft proposal Here). SB anticipated this WG would work with ICES Zooplankton Groups and PICES WG 52 on Data Management.

Proposal for a PICES Section on Marine Plastic Pollution

Rationale

The countries surrounding the North Pacific Ocean contain some of the most densely populated regions on the planet. The North Pacific absorbs the burden of this footprint by being the final sink of many pollutants. In terms of plastic pollution, no large open ocean region is more affected than the North Pacific. Despite this, PICES has not had a stable expert group to specifically keep pace with plastic debris and pollutants. The first expert group on marine pollution dates back to the beginning of PICES, with Working Group 2 (see timeline below). In 2017, the Study Group on Marine Microplastics (SG-MMP) was formed and led by Won Joon Shim. Working Group-42: Indicators of Marine Plastic Pollution (https://meetings.pices.int/members/working-groups/wg42) took over where SG-MMP left off. Co-led by Jennifer Lynch and ChengJun Sun, WG-42 was especially productive, with members convening scientific sessions at multiple PICES conferences, co-leading a session at the 2021 ICES annual meeting, and participating and co-leading several sessions at the 7th International Marine Debris Conference in Busan, Korea, in 2022. Also in 2022, members of WG-42 published three peer-reviewed papers summarizing their work identifying indicators of plastic pollution in the North Pacific, which also outlined monitoring guidelines for seawater, beaches, and biota. WG-42 formally concluded in 2024.

The bioindicators work that came out of WG-42 began an international collaboration, The Global Plastic Bioindicators Project, which was endorsed last year as a Project for the UN Decade of Ocean Science under the program SmartNet (an ICES-PICES collaboration). This Project just produced its first paper, which is much aligned with the recently-concluded WG-42. As such, we expect this proposed Section to interact closely with the Advisory Panel on the United Nations Decade of Ocean Science, the Section on Marine Birds and Mammals, as well as our PICES parent Committee, Marine Environmental Quality.

Marine plastic pollution is here to stay. In this world, PICES should have a standing expert group that member nations can consult for longstanding, as well as novel unexpected pollutant pulses, discoveries, and concerns. In concert with other stressors like climate change, pollution may affect living marine resources and human welfare in the PICES region and is thus well aligned with the PICES mission. It is important that PICES keeps pace with plastic pollution research and collaboration on the world stage with other intergovernmental science working groups (e.g., ICES Working Group on Marine Litter https://www.ices.dk/community/groups/Pages/WGML.aspx; GESAMP Working Group 40 http://www.gesamp.org/work/groups/40). To do so, PICES needs to have an expert group that can directly interface with these sister groups in other regions as well as with representatives in PICES member nations.

Terms of Reference

1. Work collaboratively to characterize and understand the flow and impacts of plastic pollutants within the PICES region (i.e., sources and sinks), including, but not limited to, the Great Pacific Garbage Patch.

2. Continue to develop abiotic and biotic indicators of plastic debris and pollutants in the PICES region and develop monitoring plans to assess temporal trends in plastic pollutants as new legislation takes effect (e.g., High Seas Treaty, UN Plastics Treaty). Provide scientific guidance towards the international harmonization of plastics monitoring data within and beyond the PICES region.

3. Plan workshops/sessions/symposia related to plastic pollution and associated toxins, and maintain a community of scientists within PICES that will work together to evaluate and recommend strategies for PICES member nations to engage on plastic pollution issues.

4. Engage professionally with other intergovernmental science organizations (e.g., ICES for the North Atlantic, AMAP in the Arctic, APN in the western and subtropical Pacific, SCAR in the Southern Ocean

etc.), projects (e.g. GPIB, SmartNet), and entities (e.g., SCOR, GESAMP) to accomplish these Terms of Reference.

5. Publish reports on Section accomplishments.

Parent Committee: MEQ

Proposed Chairs

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PICES Working Group Preliminary Proposal

Title
Best Practices for Using Deep Learning in Processing Plankton Images

Acronym
WGDLP

Abstract
Plankton are critical to marine ecosystems, serving as a foundational component of food webs and responding rapidly to environmental changes. Recent advances in deep learning (DL) provide powerful tools for analyzing large datasets generated by plankton imaging systems, enhancing the speed and accuracy of plankton monitoring efforts. However, best practices for applying deep learning in this field have yet to be standardized. This working group (WG) aims to establish best practices for using deep learning to process plankton images. We aim to address key challenges such as building training libraries with appropriate metadata, data storage and availability, species identification, algorithm development and standardizing methods across PICES nations.

The proposed WG will focus on:

- Assessing current deep learning approaches for plankton image analysis.
- Developing standardized protocols for training and validating DL models.
- Establishing libraries and datasets for benchmarking DL algorithms with metadata best practices
- Promoting collaboration and knowledge-sharing among experts in deep learning and plankton ecology.

Scientific Background

With the increasing adoption of imaging systems for monitoring plankton, the need for automated image processing has grown. Traditional manual identification methods are labor-intensive and slow, making deep learning an attractive alternative. DL models, particularly deep learning algorithms, have demonstrated their potential to classify plankton species rapidly and with high accuracy. However, challenges remain, including the need for large annotated datasets, handling species diversity, and ensuring reproducibility across studies. By establishing best practices for applying DL to plankton images, this WG aims to enhance the reliability and comparability of plankton monitoring efforts across PICES regions.

Rationale

Recent advancements in deep learning have led to breakthroughs in automating plankton image classification, but the lack of standardized approaches hinders progress in global monitoring efforts. This WG will develop protocols for:

- Training DL models with diverse plankton datasets.
- Evaluating the performance and accuracy of DL algorithms through intercomparison
- Standardizing image annotation and dataset management practices.

We anticipate this WG will work with ICES Zooplankton Groups, PICES WG 52 on Data Management.

Terms of Reference

This WG will:
1. Review the state of deep learning applications in plankton image analysis.
2. Develop a framework to standardize DL model training, validation, and evaluation.
3. Create shared libraries and benchmarking datasets for testing different DL algorithms.
4. Build a network of scientists working on deep learning and plankton monitoring.
5. Promote international collaboration through PICES and other scientific organizations.
6. Publish a final report summarizing the best practices for using DL in plankton image analysis.

Working plan

Year 1 (2025):

- Hold initial WG meetings to set objectives and divide tasks among members.
- Review current deep learning methods and challenges in plankton image processing.
- Begin developing protocols for standardized DL model training and validation.

Year 2 (2026):

- Expand the collection of annotated plankton images to build a shared dataset.
- Evaluate the performance of different DL algorithms using the dataset.
- Organize a special session at the PICES Annual Meeting to present preliminary findings.

Year 3 (2027):

- Finalize and publish best practices for DL in plankton image analysis.
- Submit a final report summarizing the WG's findings and recommendations.
- Promote the adoption of standardized practices through international collaboration.

Deliverables

- A comprehensive review of deep learning techniques in plankton image processing.
- Protocols for standardized DL model development and evaluation.
- A shared library of annotated plankton images for benchmarking DL algorithms.
- A final report summarizing the WG's findings, published as a PICES scientific report.

Capacity Building

This WG will facilitate collaboration between marine ecologists and data scientists, offering training opportunities and fostering interdisciplinary research. The standardized protocols and datasets developed by the WG will be made available to the scientific community, ensuring that DL applications in plankton monitoring can be adopted globally.

Working Group composition

Needs: Scientists specializing in machine learning, plankton ecology, and optical imaging.

Members from PICES nations, with potential collaborators from ICES and other international organizations. We will continue to invite scientists from South Korea to join the WG.

Full Members (*: co-Chairs)

	Name	Gender	Nation	Area	Roles and contributions
1	Hongsheng Bi*	Male	USA	Western North Pacific	Coordinating to PICES BIO BA Review/Guideline
2	Akash Sastri	Male	Canada	Eastern North Pacific and Arctic Seas	Coordinating to PICES BA Review/Guideline
3	Paul* Covert	Male Early career	Canada	Eastern North Pacific	Ocean Network Canada, Phytoplankton & IFCB
4	Robert Campbell	Male	USA	Prince William Sound	Applications of DL and Case study
5	Satoshi Kitajima	Male	Japan	North Pacific	Building libraries and case study.
6	Dhugal Lindsay	Male	Japan	North Pacific	Applications of different DL systems and case study
7	Kazutaka Takahashi	Male	Japan	North Pacific	Case study
8	Jeff Ellen	Male	USA	Computer science	Overview of metadata, building DL libraries
9	Fang Zhang	Female	China	East China Sea	Building libraries and case study.
10	Haiyong Zheng	Male	China	Computer Science & Informatics	Overview of different deep learning methods.
11	Julie Keister	Female	USA	Zooplankton Ecology	Building libraries and case study
12	Xuemin Cheng*	Female	China	Optics & Image recognition	Review and comparison different DLs.
13	David* Kimmel	Male	USA	Zooplankton Ecology	Applications of DL, building libraries and case study
14	Mark Benfield	Male	USA	Imaging systems	Applications of DL and building libraries.
15	Dr. Gulce Kurtay	Female, early career	USA	IFCB	IFCB & phytoplankton case study

13.3. Working Group on Ocean Negative Carbon Emissions for Carbon Neutralization (WG-OCN) *(with GC decision)*

Dr. Chiba explained the updated background of the proposal of WG on Ocean Negative Carbon Emissions for Carbon Neutralization (WG-OCN). SB recommended the proposal with a revision after ISB-2024, but GC did not approve the 2nd and 3rd revised versions at IGC-2024 in May and Sept 2024 and requested further revision with consultation of the proposed parent committees, BIO and POC. The group prepared the 4th versions at GC-2024 in October (Appendix 5), but GC agreed that, although Marine Carbon Dioxide Removal (mCDR) is one of the topics worth addressing in PICES, the working group TORs did not sufficiently address the requirement and expectations as a PICES working group. GC requested another revision, confirming this would be the last opportunity for the proposal to be approved (see the details on GC comments and final decisions on IGC(1)-2024 Report, IGC(2)-2024 Report, GC-2024 Report. *=> GC requested the resubmission of the proposal to IGC-2024 (3) meeting scheduled in December 2024.*

Agenda Item 14: EG Proposals for SB Recommendation

14.1. Membership Needs/Change *(with GC acknowledgement)*

SB acknowledged the membership requests of each EG and Committee as listed and urged national delegates to consider the appointment of new members at appropriate times. *=> GC acknowledged the membership requests as listed, and respective national delegates are urged to appoint them at a proper time.*

EG (rep. CMT)	Country	Name/Organizations if identified	email
Carry over requests from ISB-2024			
AP-NIS	Japan	Keiji Iwasaki, Nara University (didn't respond)	iwasaki@daibutsu.nara-u.ac.jp
	USA	John Darling, US Environmental Protection Agency	darling.john@epa.gov
AP-SciCom (SB)	Russia	1 – 2 members	
AP-UNDOS (SB)	Russia	Evgenia Kostianaia (IOC), ECOP leader in UNDOS	e.kostianaia@unesco.org
AP-ARC (SB)	Canada	Andrea Niemi (DFO)	Andrea.Niemi@dfo-mpo.gc.ca
	China	Zhongyong Gao	GAO@tio.org.cn
	China	Fang Zhang	
	China	Guangshui Na	
	Korea	Hyoung Chul Shin (KOPRI) (chair)	hcshin@kopri.re.kr
	Korea	Hyoung Sul La (KOPRI)	hsla@kopri.re.kr
	Russia	Yury I. Zuenko	
	Russia	Kirill Kivva	
	USA	Zack Oyafuso	
	USA	Sarah Wise (NOAA) (chair)	Sarah.Wise@noaa.gov
	USA	Elizabeth A. Logerwell	
	USA	Lisa B. Eisner	
WG-50 (POC)	Russia	Nikita Aleksandrovich Chikanov (St. Petersburg State University)	erjey_nik@mail.ru

	Russia	Sergey Prants (Pacific Oceanological Institute, Department of the Ocean and Atmosphere Physics)	prants@poi.dvo.ru
WG52 (TCODE)	USA	Herman Garcia (NOAA)	Hernan.Garcia@noaa.gov
	China	Wan Fangfang,	fangfww15@sina.cn
	China	Han Chunhua (NMDIS)	hanchunhua2008@126.com
	Russia	1 - 2 members	
TCODE	Russia	1 – 2 members	
New requests at SB-2024 from here			
AP-ECOP	Canada	Mary Kevin (PICES intern) Talen Rimmer (Canada)	
	Japan	Toya Hirokawa	
	USA	Lauren Kashiwabara	
AP-UNDOS (SB)	Canada	Brett Johnson (DFO), ECOP, TCODE liaison Talen Rimmer (ECOP), U Victoria,	Brett.Johnson@dfo-mpo.go.ca rimmertalen@gmail.com
	Japan	Naya Sena (ECOP), SIDS rep.	nayacsena@gmail.com
	Korea	SungHyun Nam	namsh@snu.ac.kr
WG-49	Korea	Saranya JS (ECOP)	saranya_js@snu.ac.kr
	USA	Nima Farchadi (ECOP) Young-Ji Joh (ECOP)	nima.farchadi@whoi.edu youngji.joh@noaa.gov
	China	Peng Lian (ECOP)	lanpeng@cafs.ac.cn
WG51 (HD)	Russia	Ekaterina Kurilova (VNIRO Khabarovsk) Oleg N. Katugin (TINRO-Center)	katy_k07@mail.ru oleg.katugin@tinro.vniro.ru
S-MBM (BIO)	Japan	Motohito Ito (U Tokyo) replacing Yutaka Watanuki	
S-CCME (FIS)	Russia	Kiril Kivva Andrey Krovnin	
FIS	China	Peng Sun	sunpeng@ouc.edu.cn
Members who step down			
AP-UNDOS (SB)	USA	Vera Trainer	
AP-NPCOOS (MONITOR)	Japan	Naoki Yoshie	
S-MBM (BIO)	Japan	Yutaka Watanuki	
TCODE	USA	Jill Prewitt *left AOOS and cannot be reached.	
HD	USA	Keith Criddle (HD has 5 USA members)	
HD	USA	Ron Felthoven (HD has 5 USA members)	

14.2. Ex-officio membership request *(with GC decision)*

Dr. Chiba reported the Ex-officio membership requests from EGs as listed. Dr. Chiba confirmed that Dr. Kitakado was nominated by IWC and NPFC and that he agreed to serve both S-MBM and WG53. SB recommended GC approve the appointment of ex-officio members as listed. *=> GC approved the appointment of the ex-officio members as requested (GC2024/S/13).*

EG (Reporting CMT)	Organization to represent	Ex-officio member name & contact
S-MBM (BIO)	IWC	Toshihide Kitakado, Tokyo U of Marine Science and Technology (kitakado@kaiyodai.ac.jp)
WG53 (HD)	NPFC	Toshihide Kitakado, Tokyo U of Marine Science and Technology (kitakado@kaiyodai.ac.jp)
	NPFC	Kazuhiro Oshima, Fisheries Research Institute (oshima_kazuhiro28@fra.go.jp
S-CCME (FIS)	BECI	Viv Tulloch, BECI (Viv.Tulloch@pices.int)

14.3. Change of EG Chairs *(with GC decision)*

Selection and approval of EG Chairs took place according to PICES Rules and Procedures: Rule 17: Scientific Leadership. SB recommended GC approve the appointment of new chairs as listed. *=> GC approved appointments of Expert Group chairs as requested (GC2024/S/13).*

EG (Reporting CMT)	Current Chair to step down	New Chair Name/Country/Organization
AP-NPCOOS (MONITOR)	Naoki Yoshie (Japan)	Jae-Hyoung Park (Korea)
WG52 (TCODE)	N/A (WG has only 1 chair)	Seung-Tae Yoon (Korea) as a 2nd chair (current member)
AP-ECOP (FUTURE)	Hannah Lachance (USA)	TBD
S-CCME (FIS)	Xiujuan Shan (China)	Dongwha Sohn (Korea)

14.4 Extension of the WG Term *(with GC decision)*

SB recommended a one-year extension of the term of WG50. *=> GC approved a one-year extension of WG50 (GC2024/S/14).*

EG (Reporting CMT)	Duration	Rationale
WG50 (POC)	1 year to PICES-2025	WG could not start activity in the most of first year because of delay in membership appointment. It needs one more year to finish review article.

14.5 Change of TOR and AP term *(with GC decision)*

MONITOR Chair, Dr. Sung Yong Kim, reported the request from AP-CREAMS on changes to its TORs as their research interest has been expanding to the surrounding regions of the original target area "East Asian marginal seas" (see the table below). SB agreed with the rationale for the expansion of the target areas and recommended GC approve the change of its TORs. With the current term of AP-CREAMS ending at PICES-2024, AP also requested a 5-year extension of the term. Given that PICES Rules and Procedure 13. iv. does not define the term of APs, and that no active AP has specific terms, SB agreed AP-CREAMS did not need to request the extension of its term.
=> GC discussed the requested expert group extensions and changes to TORs. The decision to revise the ToR for AP-CREAMS is deferred until clarification of the NW Pacific boundary expansion is provided, together with receiving a request for an extension of this AP from SB (or a recommendation to remove any term end date for this AP), which can come at the IGC December meeting. GC also noted that ECOP from all countries, not just Asia, are encouraged to join.

EG (Reporting 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~~

14.6. Intersessional in-person meeting request

FIS Committee Chair, Dr. Jackie King, reported the request for the PICES endorsement on the WG53 Intersessional in-person meeting in February 2024 (see details below). SB recommended GC approve the intersessional meeting. *=> GC approved WG53 to hold an intersessional in-person meeting (GC2024/S/16).*

WG53 Request for Intersessional in-person meeting (no financial support needed)

3-day intersessional meeting (hybrid), February 25-27, 2025, in Lisbon.

- Given that the first WG meeting was held in the North Pacific (at PICES-2024), the location is proposed to allow continued engagement with ICES counterparts.

Goals of the intersessional meeting:

- Continue to develop the working group structure and projects.
- Discuss the logistics and program of the 2026 international symposium in La Paz.

Agenda Item 15: Request for Funding

15.1. Report on Past Travel and Other Funding Support

During the 2024 Intersessional Science Board meeting, under Agenda item 12 “Travel Support Requests”, SB requested information on historic amounts of travel and other funding support to facilitate the discussion and prioritization of amounts to recommend. A subsequent request was made concerning the funds spent when implementing the Governing Council Decisions that resulted from Science Board recommendations. The Executive Secretary agreed to provide a summary of such spending (see Appendix 6 for full report).

15.2 Journal Paper Open Access Fee

Dr. Yoshida reported the S-HAB funding request for the Journal Paper Open Access Fee (see the table below). Because the Open Access Fee request can be considered by SB only after the submission of the manuscript to a journal, SB rejected the request this time.

EG (Rept. CMT)	Citation of paper	Rationale & Fee	Note
S-HAB (MEQ)	“Direct control or suppression of harmful algal blooms in marine waters: current status and future prospects” To be submitted to “Harmful Algae”	A key output of the TCODE/MEQ Topic Workshop (2023) - GlobalHAB International Workshop on Solutions to Control HABs in Marine and Estuarine Waters will be a publication in Harmful Algae titled “Direct control or suppression of harmful algal blooms in marine waters: current status and future prospects”. This manuscript is nearing completion, likely before the PICES Annual Meeting. Harmful Algae is the leading, peer-reviewed international journal for Harmful Algal research. Although Harmful Algae does not normally publish workshop reports, the editor has expressed keen interest in having this keystone work appear in the journal. Having open access to the paper will ensure that University and Government scientists in developing nations can benefit from the workshop findings. Fee: US$ 4610 (CA$ 6310)	* Need manuscript be endorsed by parent CMT to seek SB recommendation

2016/A/13: Policy regarding funding support for Open Access Publication

Council approved the following process for evaluating requests for financial support for Open Access publication in peer-reviewed journals:

i. Is the paper/volume of very broad interest in the scientific community? Science Board to make this determination.
ii. Does the paper/volume represent time-sensitive information that is sought after by a broad scientific community? Science Board to make this determination.
iii. Is the paper/volume a key output product of an Expert Group or PICES-sponsored activity? Science Board to make this determination.
iv. Is the paper/volume a key output product of an activity carried out in collaboration with one of our strategic partners? Governing Council to make this determination, with input from Science Board.
v. Is this a high priority for funding? Science Board shall assign a numeric priority to any requests.
vi. Is this affordable? Finance and Administration Committee to make this determination, in consultation with the Executive Secretary.

* A manuscript needs to be endorsed by parent CMT to seek SB recommendation for Open Access Fee.

15.3. Travel Support Proposal from PICES EGs *(with GC decision)*

Committee chairs reported the travel support requests from respective children EGs, and Dr. Chiba reported the requests from PICES partner organizations. Dr. Chiba explained that the PICES scientist(s) who convene or are invited to the Sessions/Workshops relevant to EG's activities at the international meeting(s), etc. shall be eligible for travel support funds request. She noted that priority should be given to ECOPs for the year 2025 due to the current budgetary constraints. SB prioritised and ranked the proposals based on the importance of the conferences and recommended GC approve the funding supports with consideration of the SB rating: (Score 3: High, 2: Middle, 1: Low). *=> GC endorsed SB ranking and instructed the Secretariat to use the prioritization from SB support travel as much as possible once budget constraints are more certain. Note: While the Trust Fund has typical funds available for 2025 to support ECOP travel, the General Fund budget (for non-ECOPs) is uncertain at this time.*

Requests From PICES Expert Groups (Reporting Committee)			
S-HAB (MEQ)			
Conference title / Date / Location	Recipient name (if identified)	Amount and rational of fund request	SB Rating
Seventeenth Session of the IOC-FAO Intergovernmental Panel on Harmful Algal Blooms (IPHAB-XVII) No information on the 17th meeting on IPHAB website yet 18–20 March 2025, Paris, France	1 S-HAB member, likely Mark Wells (TBD)	CA$ 2500 (airfare + accommodation) The IOC-FAO Intergovernmental Panel on HABs is the global meeting on HABs. PICES is a member and has been represented for over a decade to convey North Pacific HAB issues and to assist in preparation of key reports on HAB issues. PICES has representation (M Wells) on two IPHAB Task Teams: the Task Team on Harmful Algae and Desalination of Seawater, and the Task Team on Fish Killing Microalgae and Ecosystem Effects.	**1.3 (Low-Middle)**
AP-NIS (MEQ)			
Conference title / Date / Location	Recipient name (if identified)	Amount and rational of fund request	SB Rating
12th International Conference on Marine Bioinvasions (ICMB XII) 6-10 October 2025, Madera, Portugal	1 AP-NIS member, likely Thomas Therriault (TBD)	CA$ 2500 (airfare) This conference series takes place about every two years and PICES has been represented on the Scientific Steering Committee since the 7th iteration ensuring topics are relevant to PICES member countries and ensuring active participation of ECS from P	**0.8 (Low)**
	2 ECS from PICES country	CA$ 7000	**1.9 (Middle)**
S-CCME (HD) / AP-UNDOS (SB)/AP-ECOP (FUTURE)			
Conference title / Date / Location	Recipient name (if identified)	Amount and rational of fund request	SB Rating
ICES ASC 15-18 September 2025 Klaipeda, Lithuania	A few ECOP members	CA$ --- (leave it for GC/F&A decision) Send S-CCME ECOP members to attend S-CCME convening Sessions Send AP-UNDOS ECOP members to attend SmartNet convening Workshop	**2.4 (Middle-High)**

Requests From Partner Organizations etc.			
Conference title / Date / Location	Recipient name / contact	Amount and rational of fund request	SB Rating
One Ocean Science Congress (OOSC): Science for Action 4-6 June 2025, Nice France	A few ECOPs from PICES countries (full x 3 or partial support for 6-7 ECOPs)	EUR 6000 (CA$ 9000) OOSC requests PICES to be a congress sponsor, and support ECOP travels. OOSC was held conjunction with 3rd UN Ocean Conference to be held in Nice. **AP-UNDOS** and **AP-ECOP** support the request.	**2.3 (Middle-High)**
ESSAS OSM 2025 24-26 June 2025, Tokyo, Japan	A few ECOPs from PICES countries	CA$ 15000 **AP-ARC** supports the request PICES supported 2017 ESSAS OSM (Norway) with CA$ 15569.	**2.3 (Middle-High)**
GOOD-OARS Summer School 2025 4-11 Nov, 2025 Penang, Malaysia Venue: Centre for Marine and Coastal Studies (CEMACS) **Application portal to be opened soon*	A few ECOPs from PICES countries	CA$ --- (leave it for GC/F&A decision) Relevant to **S-CC** PICES supported travel of 3 ECOPs for 2023 Summer School (approved 4) with CA$ 4229 Sponsor: OARS (Global Acidification Research for Sustainability) GOOD (Global Ocean Oxygen Decade), Organizer: (IOC-UNESCO)	**1.9 (Middle)**

Agenda Item 16: PICES-2025

16.1. Review of Session/Workshop Proposal Selection Protocol

SB reviewed the new timeline (defined by GC2023/S14) for the PICES-2025 Session/Workshop proposal selection and discussed the optimal procedure for the Committees/FUTURE review and ranking of the proposals. SB planned to hold an online business meeting to review the proposals on December 9 (North America)/10 (Asia).

GC2023/S/14: Council approved a new process for 2024 whereby the Session and Workshop proposal deadline is set two weeks after the end of the PICES annual meeting. Committees will work inter-sessionally/by correspondence to review, rank and report to Science Board by the end of November. Science Board will review and provide to GC in early December for approval before year-end.

Date	Action
Nov 15, 2024	Session/Workshop proposal submission due
~ Nov 30, 2024	Committees review & rank proposals (via virtual meeting or email basis)
Dec 9/10	Science Board reviews Committee's' proposal ranking, selects the workshops/sessions for PICES-2025, and recommends them for GC approval (via virtual meeting or email basis)
Dec 12/13	GC makes the decision

16.2. PICES-2025 Proposed Basic Schedule *(with GC acknowledgement)*

Dr. Chiba presented the draft basic schedule for PICES-2025. SB agreed with the presented plan and recommended GC acknowledge the proposed basic schedule of the PICES-2025.

=> GC reviewed the tentative schedule for PICES-2025. Feedback from the community may help inform Annual Meeting structure modifications. The Executive Secretary plans to solicit feedback.

PICES-2025 Proposed Schedule

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 3	Day: EG meetings Evening: CMT meetings
Nov 9 (Sun)	Parallel Workshops x 3	Day: EG meetings Evening: CMT meetings
Nov 10 (Mon)	Opening Session S1 Symposium	
Nov 11 (Tue)	Parallel Sessions x 3	EG meeting, F&A meetings?
Nov 12 (Wed)	Parallel Sessions x 3	EG meetings, F&A meetings?
Nov 13 (Thur)	Parallel Session x 3 Evening: Poster Session	EG meetings
Nov 14 (Fri)	0900-1200 Parallel Session x 3 1200-1240 Closing Session	SB Day 1
Nov 15(Sat)		SB Day2, GC Day1
Nov 16 (Sun)		GC Day2

PICES-2025 Title: Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems

Date: November (7) 8 - 16 **Location:** Yokohama, Japan

Local Organizer: Fisheries Research Agency

Website: TBA

Format: in-person (with a hybrid option for business meetings)

SCOPE: Ecosystems in the North Pacific have been significantly impacted by climate change and human activities. For over 30 years, PICES has established an international scientific network and conducted numerous projects to enhance our understanding of how North Pacific ecosystems respond to such impacts. However, with the recent intensification of climate change and the increase in unpredictable extreme events, previously held understandings may no longer be valid. There is a pressing need for discussions on integrating the latest scientific findings and technologies (e.g., artificial intelligence, remote sensing, biotechnology) by experts from diverse fields, including marine science, environmental conservation, engineering, economics, and social science. Equally important is the collaboration with local fishing communities, policymakers, NGOs, and other stakeholders to explore practical applications of scientific knowledge. PICES-2025 will serve as a crucial platform for exploring innovative approaches to understanding North Pacific ecosystems, helping to chart a path toward climate resilience and sustainable development. Contributions from experienced specialists, as well as groundbreaking ideas from Early and Mid-career Ocean Professionals, are highly encouraged.

Business Meetings
Committees/FUTURE are requested to hold at least one virtual business meeting before the Annual Meeting and one in-person meeting (evening) during the Annual Meeting.

EGs are requested to virtually hold at least one virtual business meeting before the Annual Meeting to discuss items to report or request to SB. The optional in-person business meetings, in addition to the above virtual meetings, would be approved upon request. The proposal for the in-person business meeting will be submitted to the upcoming ISB meeting.

Issues to Consider
The entire meeting duration will be shortened. (2-day workshops instead of 3)

- Hold both oral and poster Committee Paper Sessions (back to the conventional setting)
- Total of 6-day slots for Workshops and a total of 6.5-day slots for Topic Sessions
- Total 2.5-day slots for Committee Paper Session.
- Invited speakers' travel support may not be available due to the budgetary constraint for 2025

Agenda Item 17: Upcoming Capacity Development Events

Dr. Chiba presented the upcoming Capacity Development events.

17. 1. PICES Events

No events organized by PICES EGs were scheduled.

17. 2. Partner Organizations' Activities and Events

17.2.1. SCOR Capacity Development (link)

Sanae Chiba, PICES Deputy Executive Secretary: SCOR CD Committee member (July 2021~)
Core Programmes:

- Visiting Scholars Programme
  Funds for scientists from any country to provide a short training/lecture course at an institution in the developing countries.
  Application for 2025 Scholarship open (submission deadline: December 16, 2024)
- Fellowship Programme (with POGO)
- Travel support for the Conference (proposal must be submitted by the Organization)

To support ECOPs from developing countries
Funded: US$ 6K for participants of 7th ZPS7 (March 2024)
Funded US$ 6K for participants of MSEAS2024 (June 2024)

17.2.2. GOOD-OARS-CLAP-COPAS Summer School 2023

- Date: November 4 – 11, 2025, Penang, Malaysia
- Venue: Centre for Marine and Coastal Studies (CEMACS)
- Sponsor: OARS (Global Acidification Research for Sustainability)
  GOOD (Global Ocean Oxygen Decade), etc.
- Organizing Committee (IOC-UNESCO)
- Application portal to be opened soon
- See Appendix 7 for details. *See Agenda 15: Travel support request.*

Agenda Item 18: PICES-Sponsored Conferences / Symposia

1. MSEAS2024, June 2024, Japan (Report)	5. International Symposium on Small Pelagic Fish, May 2026, Mexico
2. One Ocean Science Congress, June 2025, France	6. 5th Early Career Scientists Conference,2027
3. ESSAS Open Science Meeting, June 2025, Japan	**7.** ECCWO6, 2028
4. ICES Annual Science Meeting, Sept 2025, Lithuania	

Dr. Chiba introduced the recently completed and upcoming PICES-sponsored international conference and symposia.

18. 1. MSEAS 2024 (Post-event report)

Theme: Managing for Sustainable use of the Earth's marine and coastal system

- Date & location: June 3-7, 2024, Yokohama, Japan
- Venue: Pacifico Yokohama North
- Primary Sponsors**:** PICES, ICES, NOAA Fisheries, FRA
- Local Organizer: FRA
- Sessions, Schedule

PICES Member Involvement:
Symposium Convenor: Batten (Secretariat), Hasegawa (FUTURE)
Symposium Coordinators: Chiba (Secretariat)
Local Organizing Committee: Makino (HD), Fujii (PICES Vice-Chair)

See PICES Press 32(2) article for the full report.

18. 2. One Ocean Science Congress (OOSC 2025)

- Theme: Science for Action
- Date & location: June 4-6, 2025, Nice, France
- Primary Sponsors**:** France, Costa Rica
- Local Organizer: IFREMER, CNRS
- Abstract submission: deadline Nov 14
- Town Hall meeting proposal submission: deadline Dec 13
- Theme and Session

PICES Member Involvement:
International Science Committee: Chiba (Secretariat)

OOSC will be held in conjunction with the 3rd UN Ocean Conference (2025 UNOC) scheduled for 9-13 June 2025 in the same venue in Nice. Ten Congress Themes and up to 100 sessions were set to address respective major ocean-relevant International Treaties, such as UNFCCC and GBF. 2000-3000 participants are expected, and ECOPs engagements are particularly encouraged. The OOSC submits a Policy Recommendation to the Ocean Action Panel scheduled during 2025 UNOC. *See Agenda 15: Travel support request.*

18. 3. ESSAS Open Science Meeting,

Theme: Past, Present and Future of Marine Biodiversity and Ecosystems
- Date & location: June 24-26, 2025, Tokyo, Japan
- Local Organizer: National Institute of Polar Research
- Abstract submission: TBA

Topics include Coastal-ocean interactions, Extreme events, Marine heat blobs, Multi-stressors, Biogeochemical cycles, Carbon cycle, Biodiversity, Marine ecosystems, Ocean observation technology, Blue carbon, Blue economy, Food security, Community-based sciences, Co-design of natural and social sciences.
See Agenda 15: Travel support request.

18. 4. ICES Annual Science Conference 2025

- Date: Sept 15-18, Klaipeda, Lithuania
- Local organizer: Klaipeda University
- Conference style: Hybrid

PICES co-convening Session (submitted)**:** Acceptance to be officially announced in October 2024
(S-CCME) Title (TBC)
(SmartNet) Best Practices for Decision Support Tools to Support Climate-Ready Fisheries: Lessons Learned for the UN Decade of Ocean Science for Sustainable Development
See Agenda 15: Travel support request.

18. 5. ICES/PICES/FAO International Symposium on Small Pelagic Fish (SPF) 2026

Theme: Navigating Changes in Small Pelagic Fish and Forage Communities: Climate, Ecosystems, and Sustainable Fisheries
- Date: 4-8 May 2026
- Location: La Paz, Mexico

- FAO, ICES and PICES (IGC-2023) confirm their supports
- Local logistic support: CICIMAR, CIBNOR, CICESE, UABCS, etc.
- Local symposium convenor: Dr. Salvador Lluch-Cota (CIBNOR)
- ICES/PICES WG on SPF convened a 3-day workshop for the preparation of SPF-2026 in La Paz, Feb 12-14, 2024

18.6. 5th ICES/PICES Early Career Scientists Conference (ECS) 2027

ICES and PICES acted as the main organisers of ECS in turn. As the 4th ECS was organized by ICES and held in Newfoundland, Canada, PICES plans to hold the 5th ECS in an Asian nation in 2027.

18.7. ECCWO6: 6th International Symposium on the Effects of Climate Change on the World's Ocean

PICES and co-organizers are continuously seeking opportunities to hold ECCWO6 in South Africa in 2028 and communicating with potential local organizers.

Agenda item 19: Discussion on Review Panel Report Recommendation

Committees and FUTURE were requested to discuss their views on the Review Panel Report Recommendation during their in-person meetings at PICES-2024. SB members shared the perspectives gathered from the Committees. SB reported their feedback to the GC as the collective (but sometimes contradictory) view of SB on the Recommendations shown below. *=> 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).*

Discussion Summary

Role of PICES: Revise to focus on the delivery of 'actionable science information' to member countries, with a revised Science Plan and Mission.

- The term 'actionable science' has no definition and is vague. This term could be interpreted as science advice, which is a role that many of PICES' member nations do not wish to have PICES undertake. This would represent a large departure from PICES' current role, and it should not replace the pure research that forms the Role of PICES. Additionally, each member nation has different scientific advice needs, processes for receiving advice and regulations for implementing advice and managing resources. Given that the PICES Science Plan and Expert Groups rely on multinational membership, focusing on the PICES role to provide science advice would be extremely difficult. We support the recommendation for redesigning NPESR and suggest that a new version could address the recommendation for scientific advice to be provided by PICES. Our Committee acknowledges that the public and resource managers want to know what is going on in the ocean, and PICES does need to provide information for others to make decisions. However, the Committee agreed that there is no need to change the PICES Role, but there is a need to enhance the communication of our science to interested parties in a format that is understandable for each audience.
- There is a need for more science 'action' to address issues around climate, biodiversity, fisheries, community development, etc., and there are scientific advances (modelling, AI) that could provide more actionable science products. It would require agreement amongst the parties that this is the direction to move. A response from GC is required here.
- Create an organisational framework for dialogue between scientists and stakeholders. Propose a new

EG to survey the needs of our member countries (under HD?).

- We understand PICES should tackle global and regional emergent issues at that time, and thus PICES role/structure will be modified based on this. It is required that international organizations contribute to the needs/requests of member countries and/or stakeholders, so we agree to strengthen collaboration/linkage with them.
- The role of PICES be enhanced and expanded to provide transformative and actionable science-based information relevant to the Contracting Parties. We agree with this role of PICES, but the mechanism for inputting member countries' needs/requests to activities of EGs is not clear.
- We agree to restructure PICES EGs. When the new structure is discussed, we will provide our comments on how our committee will change along with the new structure.

Organizational Structure: Revise Committee and Expert Group structure to reflect the revised Science Plan and facilitate more effective communication.

- PICES science has already been transformed (toward interdisciplinary through the SEES approach). What we need to transform is organizational structure/governance system/business protocol to effectively link our science to the needs of the stakeholders, including member countries.
- These recommendations are both tractable and good regardless of the extent of an organizational pivot to more actionable, solution-based science. We believe the current Committees do not function effectively or efficiently.
- An argument against the recommended approach is the desire (known to exist within the community) to maintain some level of strong disciplinary organization (e.g. expert groups focused fully on physical oceanography or fisheries).
- Our Committee members did not support the view that Annual Meetings are too long and need to be shortened. We agreed that the Annual Meetings were too dense, with too many concurrent meetings, workshops and sessions. Shortening the duration of the Annual Meeting would make this worse. One aspect of the Annual Meeting that should be addressed is the poor communication of native English speakers; slides routinely contain too much text for non-English speakers to read while listening to presentations that are delivered too quickly. This is particularly apparent at Business Meetings when Expert Groups often fail to provide concise, easy-to-follow presentations.
- We discussed the proposed replacement of SB with an Integrative Science Plan would reduce the redundancy of having a separate Science Plan Steering Committee; this is however, just rephrasing and the simple suggestion should be that all Committees support the ISP (which they already do) and that SB implements the ISP (which is currently does not). The suggested thematic committees have shortcomings, and we noted that much disciplinary work or membership will be lost with broadly-themed committees.
- The recommendation for PICES to develop and implement simple and efficient means to facilitate communication, cooperation and integration within the organization is something that members and our Committee have been suggesting for quite some time. However, it is disappointing that the Review Committee did not have any specific ideas to achieve this.
- The issue of having a thematic committee; urgent themes would be changed over time.
- Current discipline-based committees cannot address the need for new interdisciplinary EG (an EG must have multiple parent committees, making the reporting procedure complicated and time-consuming)
- Members who are actively considering forming new expert groups are keen to place plans in the context of actionable science activities - most are government scientists and recognize why such relevance is important to their home organizations.
- It was discussed and noted that the combining of MONITOR and TCODE have been proposed in the

past. However, it is not understood why this would be a better system than the one currently managed. Would this just end up with a committee that's twice as large and has twice as much work to do? This may result in longer meetings, lack of expertise and understanding of specific issues. It's possible that some PICES work may not get done as efficiently.

(Questions)

- Where do current committees fit into the new organization?
- What happens to current MOUs and Action Plans? Do these need to be revised?
- Web platform and data portal - who will oversee this activity (development and maintenance): Big effort and expensive.
- The report identifies continued expansion into the Arctic and increased collaboration with Southeast Asian networks. Was there any discussion of increasing the number of member countries? e.g. Mexico?

Integrative Science Program: Phase out FUTURE and develop a new Program based on priorities in the new Science Plan, with a more effective governance structure.

- We agree that PICES should establish a new integrative Scientific Program. However, there are many serious global/regional problems, such as climate change, marine pollution (including marine plastic), UNDOS, etc. It is not clear whether PICES can cover all emergent issues or focus on one or two topics. We hope such matters will be discussed in the near future.
- The establishment of ISP will require significant planning within PICES. It is proposed that we (a) phase out FUTURE within 1-2 years; (b) stand up an expert group to solicit guidance from the PICES community for the development of a new Science Program Plan; and (c) in the meantime, have SmartNet serve as the interim PICES Science Program. SmartNet is driven by the leading objectives of the UN Ocean Decade, which includes many elements recommended by the Panel for a new PICES Science Program: a focus on solution-based science, capacity development and diverse and equitable approaches to tackling issues facing the parties, expansion of geographic focus beyond the PICES convention area, establishment of new strategic partnerships, etc.
- SEES approach will be the key.

Administration: Develop innovative approaches to enhance support to Secretariat through personnel and member country resources.

- Our Committee members did not support the view that Annual Meetings are too long and need to be shortened. We agreed that the Annual Meetings were too dense, with too many concurrent meetings, workshops and sessions. Shortening the duration of the Annual Meeting would make this worse. One aspect of the Annual Meeting that should be addressed is the poor communication of native English speakers; slides routinely contain too much text for non-English speakers to read while listening to presentations that are delivered too quickly. This is particularly apparent at Business Meetings when Expert Groups often fail to provide concise, easy-to-follow presentations.
- Geographic expansion of the Organization (e.g. Mexico, SE Asia), which could contribute to a more substantive scientific enterprise.
- Making the Organization more efficient (e.g. shorter Annual Meetings, clearer product deadlines, more responsive decisions from GC) is good and highly tractable.

Capacity Development: Develop innovative approaches to facilitate capacity development and diverse participation, with a renewed focus on engaging policy and decision-makers.

- The PICES Secretariat needs to have support for greater capacity.

- We understand the need to strengthen capacity development through a partnership with other organizations for developing human resources to keep PICES/EGs activities sustainable, for link with governments/decision makers.
- PICES has already developed strong Capacity Development frameworks, including the ECOP network and funding support.
- Increasing stakeholders like indigenous communities, policymakers, and managers would be a great asset for PICES. Additionally, increasing participation (at least a little bit) by data managers might be helpful for the initiation of new data initiatives.

Others

- We support the establishment of a new Study Group at the Governing Council Meeting 2024 to discuss how to address the Review Committee's recommendations, including feasibility and requirement assessments.
- It would be helpful to make a short descriptive title for each working group (WG DATA, WG HABs, etc.) so that at first glance it is understood the type of work the group is undertaking.

Agenda Item 20: Publication update

20.1. Peer-Reviewed Papers (published) *(with GC decision)*

SB recommended GC approve these publications to be posted on the PICES website. *=> GC approved (GC2024/S/17)*

The respective parent committees confirmed the publications listed are the outcomes of their children Expert Groups' activities.

EG (Rept. CMT)	Citation
AP-UNDOS (SB)	Bograd et al, Advancing the climate-biodiversity-fisheries nexus in the UN Decade of Ocean Science for Sustainable Development, ICES Journal of Marine Science, 2024;, fsae111, https://doi.org/10.1093/icesjms/fsae111
AP-UNDOS AP-ECOP (SB/FUTURE)	Chiba et al. 2024. Knowledge sharing and capacity development to promote early career ocean professionals in small island developing states: The SmartNet Approach. Oceanography, https://doi.org/10.5670/oceanog.2025.108
AP-ECOP (SB/FUTURE)	Roman et al. 2024, Building Bridges for Ocean Sustainability: The Evolution and Impact of the Early Career Ocean Professional (ECOP) Programme. Marine Technology Society Journal, 58(1-2) 8-14(7). DOI: https://doi.org/10.4031/MTSJ.58.1.4
WG48 (BIO)	Bi et al. 2022. Temporal characteristics of plankton indicators in coastal waters: High frequency data from PlanktonScope, Journal of Sea Research, 189:102283. https://doi.org/10.1016/j.seares.2022.102283
S-MBM (BIO)	Shimabukuro et al. (2023) Across the North Pacific, dietary-induced stress of breeding rhinoceros auklets increases with high summer Pacific Decadal Oscillation index. Mar Ecol Prog Ser 708:177-189, https://doi.org/10.3354/meps14276 Okado & Watanuki (2023) Small interannual variability in the body mass of a seabird with high flight costs. Mar Biol 170:122, https://doi.org/10.1007/s00227-023-04271-8 Kumagai et al. (2023) Black-tailed gulls alter their flight height and airspeed according to wind conditions during their coastal commuting trips. Mar Ecol Prog Ser 723: 201–212, doi.org/10.3354/meps14431

	Tomita et al. (2024) Incomplete isolation in the nonbreeding areas of two genetically separated but sympatric short-tailed albatross populations. Endang Species Res 53:213-225 doi.org/10.3354/esr01302 Iida et al (2024) Foraging area, diving and prey chase behaviour of a wing-propelled diver under contrasted prey regimes. Mar Biol 171:1-19. doi.org/10.1007/s00227-024-04411-8 Sakai et al (2024) Foraging areas and trip duration vary with the main prey captured, in a day-foraging/night-provisioning seabird. J Ornithol doi:10.1007/s10336-024-02218-4 Peck et al. 2024. Small pelagic fish: new frontiers in ecological research. Marine Ecology Progress Series. 741: 1–6. DOI: 10.3354/meps14648. PDF Dodson et al. 2024. Long-distance communication can enable collective migration in a dynamic seascape. Scientific Reports. 14: 14857 DOI: 10.1038/s41598-024-65827-2. PDF Clark-Wolf et al. 2024. The capacity of sentinel species to detect changes in environmental conditions and ecosystem structure. Journal of Applied Ecology. DOI: 10.1111/1365-2664.14669. PDF Cimino et al. 2024. Tracked gulls help identify potential zones of interaction between whales and shipping traffic. Marine Ornithology. 52: 61–72. PDF Calambokidis et al. 2024. Biologically Important Areas II for cetaceans within U.S. and adjacent waters – West Coast Region. Frontiers in Marine Science. 11:1283231. DOI: 10.3389/fmars.2024.1283231. PDF Fahlbusch et al. 2024. Submesoscale coupling of krill and whales revealed by aggregative Lagrangian coherent structures. Proceedings of the Royal Society B. 291: 20232461. DOI: 10.1098/rspb.2023.2461. PDF Welch et al. 2024. Selection of planning unit size in dynamic management strategies to reduce human–wildlife conflict. Conservation Biology. e14201. DOI: 10.1111/cobi.14201. PDF
WG43 (FIS)	ICES (2024). Joint ICES-PICES Working Group on Small Pelagic Fish (WGSPF- outputs from 2023 meeting). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.26520394.v2

20.2. Expert Group Final Reports (Science & Technical Reports, etc.) *(with GC decision)*

Committees reviewed and approved documents submitted as the final reports/products of respective children EGs.SB recommends GC approve these reports (see the table below) to be published as their Final Reports.

EG (Reporting CMT)	Type of publication & Title	Next step
WG44 (HD)	PICES Scientific Report Appendix 8	Technical editing and formatting will be done by Secretariat for publication.
WG45 (FIS)	ICES Scientific Reports Joint ICES-PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields (WGGRAFY; outputs from 2023 meeting). ICES Scientific Reports. 6:70. 48 pp. https://doi.org/10.17895/ices.pub.26356351 (published)	Final Report to be posted on WG webpage and PICES Publication webpage.
WG46 (POC)	PICES Scientific Report Appendix 9	GC not approved => the revised version to be submitted to IGC-2024 December
WG42 (MEQ)	PICES Scientific Report Appendix 10	Technical editing and formatting will be done by Secretariat for publication.

Note on the Protocol of WG Final Report Submission and the Timing of Disbandment of WG. (agreed at ISB-2022)

- **Format of the final report** will be typically a PICES Science / Technical Report (PICES Rule) but also be in a various format such as Peer-reviewed Journal Special Issue, Peer-reviewed Journal Review Paper, etc.
- **WG disbands** upon the submission of its Final Report to Secretariat after review and approval of Parent Committee(s).

*=> GC approved the publication of the Final Report of **WG44, WG45** and **WG42,** and these WGs were disbanded (GC2024/S/17). GC did not approve the Final Report of **WG46** (Ocean Negative Carbon Emissions) this time. GC felt that the Executive Summary and Conclusions did not adequately reflect the achievements of the WG and requested the WG to revise their report so that the scientific accomplishments are described in these sections which will allow the report to be more useful.*

20.3. EG Final Report in Progress

Committee chairs of the respective children EGs reported that these Final Reports (see the table below) were in various stages (1. In preparation, 2. Being reviewed by parent Committee, 3. submitted to Secretariat, 4. previously approved by SB and nearly completed).

EG (Reporting CMT)	Type of publication	Stages	Comments
SG-GREEN (SB)	TBC	1. In preparation	
WG47 (BIO)	WG47 will discuss and agree on a plan for the final report during its in-person business meeting at PICES 2024	1. In preparation *aim to submit Spring or Summer of 2025	
WG48 (BIO)	A peer reviewed review paper titled "A primer for underwater plankton imaging systems" on Annual Reviews in Marine Science.	1. In preparation Annual Reviews in Marine Science editorial board will discuss whether to consider this topic during their 2025 spring meeting. If selected, the manuscript is likely to be published in 2027.	If the topic is not selected, they will submit the manuscript to Progress in Oceanography (PO) or the Journal of Plankton Research (JPR) as soon as we receive the outcome in spring 2025.

20.4. Other Products (published)

EG	Citation/link	Comment
WG43	ICES (2024). Joint ICES-PICES Working Group on Small Pelagic Fish (WGSPF- outputs from 2023 meeting). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.26520394.v2	Posted on the WG website.

Agenda Item 21: Other issues

21.1. NPESR IV

At ISB-2024, SB brainstormed the ideas for the next issue of the North Pacific Ecosystem Status Report (NPESR IV). Although there were challenges and lessons learnt through the implementation processes of NPESR III, SB evaluated NPESR as a useful product for the assessment of ecosystem variability in the North Pacific Ocean and stressed the need to develop a new Study Group for planning for NPESR IV without delay. SB members agreed to develop a proposal for the Study Group for NPESR IV to submit at PICES-2024 to seek GC approval. However, as the Review Panel Report became available in August 2024, SB Chair and Secretariat see the revision of NPESR's role and structure included among its recommendations on the future of PICES, and suggest that the NPESR IV plan be discussed as a part of the role of new Study Group on the Review Report recommendation.
=> GC discussed the planning of NPESR IV. Science Board had considered that this would be part of the response to the External Review Committee report, however, GC felt that there was a more urgent need for progress and that it could run in parallel. There was discussion on possible formats of the report, potentially smaller and more frequent, or a live document, but it was recognized that a Study Group needs to be formed to consider the format and mechanism. GC suggests SB submit the new SG proposal without waiting for the progress of the SG Review Recommendation Report (GC2024/S/18)

21.2. ISB-2025 Date

A 3-day ISB-2025 meeting will be held virtually from late April to mid-May 2025. Secretariat will set the date depending on the SB members' availability.

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Appendix 1

PICES Executive Secretary Report on Current Status of MOUs and Collaboration Framework

Report to Science Board on status of MoUs

Science Board requested a review of the current strategic partner collaborative frameworks or MoUs. The table below lists the existing agreements and their status.

Organization	Date Agreement Signed	Status of Cooperation
Intergovernmental Oceanographic Commission (IOC)	1994	The MoU has not been modified since signed in 1994 and is mostly still appropriate/relevant. The reciprocal interaction has been maintained: PICES participates annually in IOC Executive Council/Assembly meetings. PICES supports/participates in IOC activities such as UNDOS, GOOS, GOOD-OARS (via capacity development support), and IODE. IOC co-sponsors the ECCWO Symposium Series as well as some others, and has an ex-officio IODE member on TCODE. However, with a new General Secretary recently in post it would be a good time to revisit the MoU and discuss a revision.
International Council for the Exploration of the Seas (ICES)	1998 then had a joint study group in 2011 to review cooperation.	MoU language is still appropriate. PICES most significant partnership. High-level reciprocal interaction is consistent (SB to SciCom, GC to Bureau) with in-person participation at ASC/Annual meetings. Approximately monthly Secretariat meetings. ICES co-sponsors ALL PICES Symposia series (some are shared and alternate). There is reciprocal sponsorship of sessions at ASC/AM. Many joint expert groups (8 WG, 1 Section, SmartNet).
North Pacific Anadromous Fish Commission (NPAFC)	1998	MoU language is still appropriate. Regular participation in FIS Committee, co-sponsor relevant Symposia (5) and occasional Wshops/sessions at Annual meetings. Partner in the UNDOS-BECI project.
Memorandum of Understanding with the International Pacific Halibut Commission (IPHC)	2000, 2019, and July 6 2024.	Very recently renewed MoU. Regular participant in FIS Committee. Co-sponsor wshops/sessions (3, but all recent)
Northwest Pacific Action Plan (NOWPAP)	2015	Framework for Scientific Cooperation in the North Pacific Ocean written in 2015. Cooperation is mostly with MEQ, particularly HAB/NIS. Have co-sponsored many (15) sessions/workshops at PICES AM from 2011 to 2023. Exec Sec recently met with the person drafting NOWPAPs next mid-term strategy (2025-2030) document and suggested that the Framework is revisited and revised soon, taking into account their new strategy, although much of their work is currently suspended because of geopolitical issues. Other areas of mutual interest may include the Global Biodiversity Framework and BBNJ agreement.
International Scientific Committee for Tuna and Tuna-	2015	The Framework for Cooperation does still apply. This was an active collaboration a few years ago, with a joint WG (WG34) and co-sponsored sessions (2013/14 and 2018) at PICES AM.

like Species in the North Pacific Ocean (ISC)		Invited to participate each year but not certain how active this collaboration is now, and it should be re-invigorated.
North Pacific Fisheries Commission (NPFC)	2019, but revised in 2024 and will be presented at PICES-2024 for approval	The first Framework for Scientific Cooperation has produced strong collaboration with NPFC supporting activities of WG32 and 47 and co-sponsoring sessions/workshops (including financial support). NPFC has also endorsed the BECI project. There has been annual reciprocal participation in FIS/SB and the NPFC SSC meetings in recent years, as well as co-sponsorship of the Small Pelagic Fish Symposia. Over summer 2024 PICES and NPFC members met to review and revise the Framework which will be brought to SB by the FIS Committee at PICES-2024.
Pacific Salmon Commission PSC	2022	This was the first MoU for the PSC. Interaction is via the FIS Committee and quarterly inter-Secretariat calls. PICES has also presented at PSC annual meetings in 2023/24 and PSC members have attended PICES-2023 and -2024. PICES successfully applied for funding from the PSC for the Indigenous workshop at PICES-2023 (W9) and they have voiced interest in co-sponsoring a session, potentially at PICES-2026.
Asia-Pacific Network for Global Change Research (APN)	2023	A recent agreement. APN has a wide geographic coverage and is not only marine focused but the Framework focusses on priorities, including food security and marine plastics through their Pacific sub-regional committee. Interactions so far have been at the Secretariat level with regular (bi-monthly) calls. Capacity development has been a focus, and we were invited to send ECOP to a proposal development training workshop this August. A second will be coming up in the PICES region in 2025.

In summary, of the nine agreements listed here:

- Four (those with NPFC, IPHC, PSC and APN) have been very recently developed/revised and are active.
- Three (those with ICES, NPAFC, IOC) have language that is still relevant and are active (although reviewing the MoUs could be useful).
- Two (with NOWPAP and ISC) should be revisited/revised with a view to stimulating the partnership.

Sonia Batten October 2024

Appendix 2

Revised NPFC-PICES Framework of Collaboration

NPFC – PICES Framework for Enhanced Scientific Collaboration in the North Pacific

Executive Summary
The North Pacific Fisheries Commission (NPFC) and the North Pacific Marine Science Organization (PICES) are inter-governmental organizations with overlapping geographical areas and common scientific interests in the sub-Arctic regions of the North Pacific Ocean. The joint PICES-NPFC Study Group for Scientific Cooperation in the North Pacific Ocean (PICES-NPFC SG) developed a 5-year Framework for enhancing collaboration between the two organizations for the period 2019-2024. As areas of interest and priorities change over time, the joint areas for collaboration will be reviewed and may be updated in 5-year increments. This Framework has been updated to reflect changes in both organizations and to outline priorities for collaboration from 2025-2029.

The first Framework identified three broad areas of joint interest to PICES and the NPFC on which progress could be made from 2019-2024. These areas were (i) support for stock assessment for priority species; (ii) vulnerable marine ecosystems; and (iii) ecosystem approach to fisheries. The first two areas were ranked highest for both PICES and NPFC, and the third area was ranked lower. There were other areas that were discussed, but it was recommended not to pursue these areas due to being a lower priority when the Framework was developed, or they were not aligned with the organizations' research plans and priorities. During the revision in 2024 some cross-cutting areas (e.g., climate change) were incorporated into the three high priority areas and the topics were reviewed to make sure they were still priorities.

The Framework identifies various mechanisms for implementing enhanced collaboration between PICES and NPFC including workshops and joint working groups as the key ones in the near term, but also theme sessions at PICES annual meetings, representation at meetings and/or workshops, and coordination of science plans.

Following approval and implementation from both organizations, routine monitoring of activities will be completed jointly by the Secretariats of PICES and NPFC and reported to the PICES Science Board and the NPFC Scientific Committee on an annual basis during their respective annual meetings.

1.0 Background

The North Pacific Fisheries Commission (NPFC) and the North Pacific Marine Science Organization (PICES) are inter-governmental organizations with overlapping geographical areas and common scientific interests in the sub-Arctic regions of the North Pacific Ocean.

NPFC is a Regional Fisheries Management Organization (RFMO) which came into force on 19 July 2015 after ratification of the Convention on the Conservation and Management of the High Seas Fisheries Resources in the North Pacific Ocean. The objective of the Convention is to ensure the long-term conservation and sustainable use of the fisheries resources in the Convention Area (Figure 1) while protecting the marine ecosystems of the North Pacific Ocean in which those resources occur. The fishery resources covered by the Convention are all fish, molluscs, crustaceans and other marine species caught by fishing vessels within the Convention Area, excluding (i) sedentary species insofar as they are subject to the sovereign rights of coastal states, and indicator species of vulnerable marine ecosystems as listed in, or adopted pursuant to the NPFC Convention, (ii) catadromous species, (iii) marine mammals, marine reptiles, and seabirds, and (iv) other marine species already covered by pre-existing international fisheries management instruments within the area of competence of such instruments. The Commission has several committees that provide information and advice to the Commission for decisions, and is supported by a Secretariat. These committees include the Scientific Committee, the Technical and Compliance Committee, and the Finance and Administrative Committee.

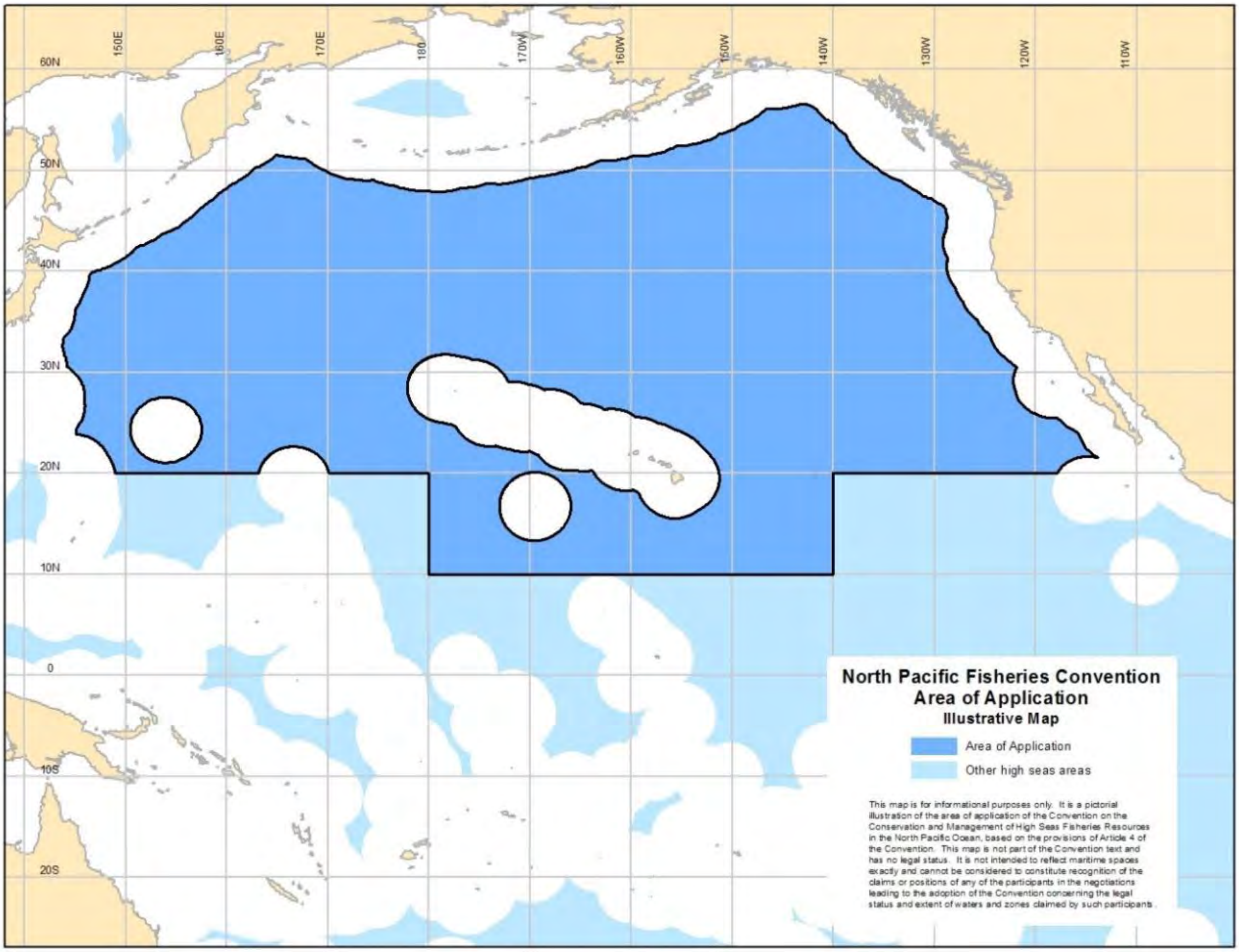

Figure 1: Illustrative Map of the NPFC Convention Area

PICES was established in 1992:

1) to promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources, including but not necessarily limited to research with respect to the ocean environment and its interactions with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna and ecosystems, its uses and resources, and impacts upon it from human activities;
2) to promote the collection and exchange of information and data related to marine scientific research in the area concerned.

The Organization receives recommendations on the science program from the Science Board, which is supported by a number of permanent scientific and technical committees, along with an assemblage of “expert groups.”

The PICES Convention Area is defined as “the temperate and sub-Arctic region of the North Pacific Ocean and its adjacent seas, especially northward from 30 degrees North Latitude, hereinafter referred to as the "area concerned". Activities of the Organization, for scientific reasons, may extend farther southward in the North Pacific Ocean.”

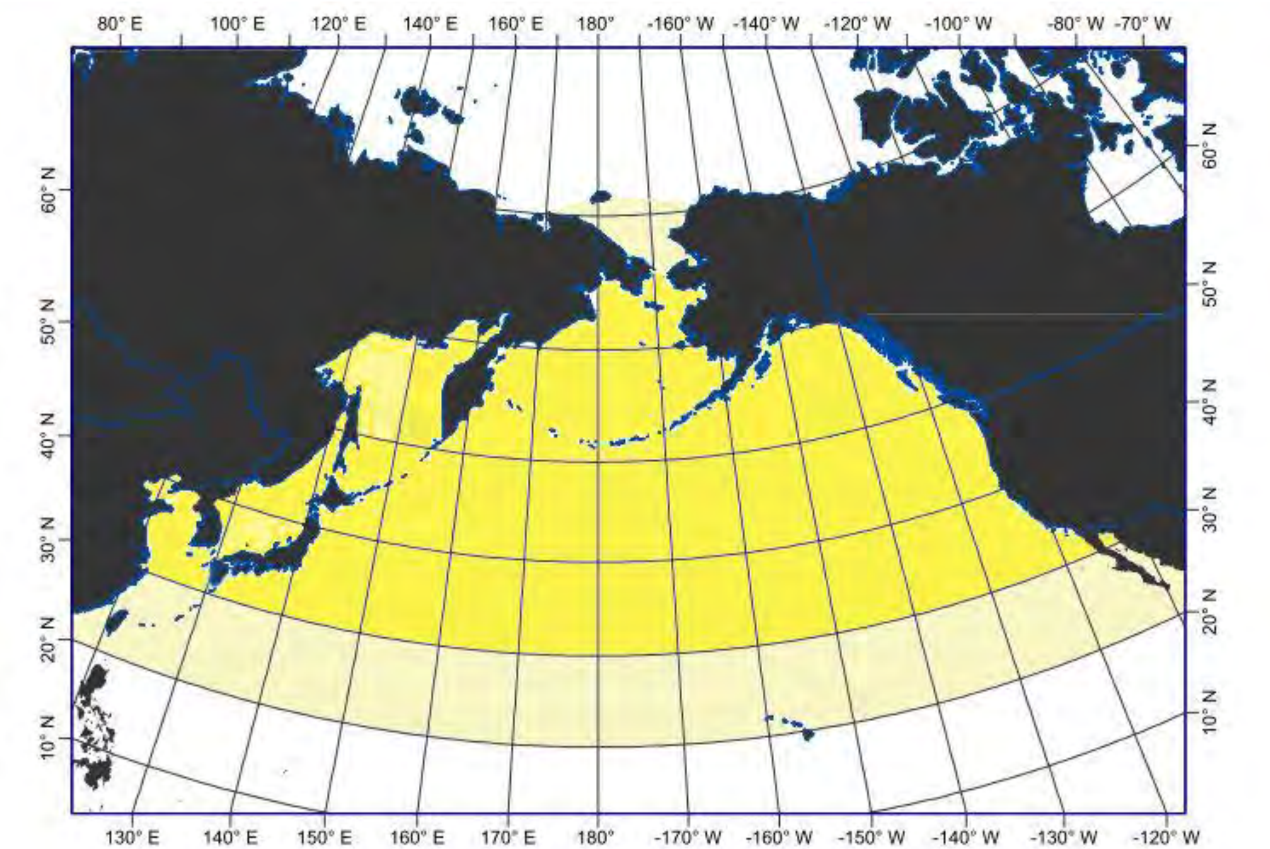

Figure 2: Illustrative Map of the PICES Convention Area

The present PICES members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America, which are also members of NPFC (note: the European Union, Chinese Taipei and Vanuatu are also members of NPFC).

Following a number of informal conversations between the two organizations, it was recognised that there was an opportunity to share and build upon each organization’s expertise and activities through enhanced collaboration in order to more efficiently and effectively meet work plans and priorities. As a result, the joint PICES-NPFC Study Group for Scientific Cooperation in the North Pacific Ocean (PICES-NPFC SG) was established in 2017 to determine if there were scientific areas of mutual interest on which both organizations can collaborate, and if so, to identify mechanisms to jointly implement activities that produce desired products and outcomes for each organization. The product of the Study Group was the first Framework which spanned 2019 to 2024 and in 2024 members of both organizations met to review and update the Framework for 2025-2029.

1.1 NPFC Science Priorities

The NPFC Scientific Committee provides scientific advice and recommendations to the Commission. The primary functions of the Scientific Committee are to (i) regularly plan, conduct, and review the scientific stock assessments of the relevant fisheries resources in the Convention Area; (ii) assess the impacts of the fishing activities on fisheries resources and species belonging to the same ecosystem or dependent upon or associated with the target stocks; (iii) develop a process to identify VMEs and areas of features where VMEs occur or are likely to occur; (iv) review effectiveness of management measures and make recommendations to meet Convention objectives; and (v) develop rules and standards for the collection and sharing of data on fisheries resources and associated ecosystems.

In response to these functions, the NPFC developed a five-year Research Plan that is updated annually and outlines priority research themes, including the rationale and more specific areas of work. These theme areas include (i) stock assessments for target fisheries and bycatch species, (ii) ecosystem approach to fisheries, (iii) vulnerable marine ecosystems, and (iv) data collection, management and security.

Accurate stock assessments are critical in helping to ensure the long-term conservation and sustainable use of fisheries resources in the Convention Area. In NPFC, stock assessments for both pelagic fish (e.g., Pacific saury and chub mackerel) and bottom fish (e.g., North Pacific armorhead, and splendid alfonsino) should strive to understand the current status and trends in production of populations of priority species as well as factors that may affect future trends. Areas of work include developing baseline assessments, reaching consensus on data standards used in stock assessments, and developing a standardized method to provide advice to the Commission. The research plan is intended to guide the work of the Scientific Committee by identifying key research priorities and associated areas of work to be undertaken or maintained. Indeed, the research plan forms the basis for a the NPFC Scientific Committee's five-year work plan.

Making progress on adopting an ecosystem approach to fisheries addresses several articles in the Convention. For example, the Convention makes reference to (i) adopting and implementing measures in accordance with the precautionary approach and an ecosystem approach to fisheries, (ii) adopting management strategies for any fisheries resources and for species belonging to the same ecosystem or dependant upon or associated with the target stocks, and (iii) assessing the impacts of fishing activities on fisheries resources and species belonging to the same ecosystem or dependant upon or associated with the target stocks. Areas of work identified include vulnerable marine ecosystems and understanding ecological interactions among species.

1.2 PICES Science Plan

PICES engages scientists in trans-disciplinary, multi-national collaborations to further collective understanding of the North Pacific's natural systems and enhance ecological and social resilience of marine systems. As part of its vision, PICES aspires to be a leading contributor to global marine science, sought as a valued collaborator to solve current and future management issues as they emerge, and to be recognised as the premier organization for current research and understanding of North Pacific marine ecosystems. The scientific leadership for the organization is through the Governing Council and

Science Board which are supported by the Secretariat. The scientific work of PICES is conducted primarily by expert groups, which consist of (i) working groups, (ii) study groups with a one-to-three-year duration to achieve the results described in their terms of reference, as well as (iii) advisory panels and (iv) sections which provide longer-lived expert groups to maintain specific expertise within PICES. The Scientific and Technical Committees are responsible for the planning and direction of the major disciplinary themes, and for providing general supervision to the expert groups.

The current version of the PICES Strategic Plan (April 2016) is expected to be revised in the near future but at the time of preparing this Framework it outlines six specific goals to meet its vision and advance scientific knowledge. These goals are:

1. Foster collaboration among scientists within PICES and with other multinational organizations, particularly with those that have common goals.
2. Understand the status and trends of marine ecosystems in the North Pacific and improve assessment of the vulnerability and resilience of these ecosystems to pressures from climate and human activities.
3. Understand and quantify how marine ecosystems respond to natural forcing and human activities.
4. Advance methods and tools (e.g., oceanographic models, ecosystem indicators, etc.) to enable new knowledge and improved advice over seasonal to decadal timescales in support of ecosystem-based management.
5. Provide relevant scientific information pertinent to North Pacific ecosystems that is timely and broadly accessible.
6. Engage with early career scientists to sustain a vibrant and cutting-edge PICES scientific community.

PICES activities are further guided by its current integrated science program FUTURE: Forecasting and Understanding Trends Uncertainty and Responses of North Pacific Marine Ecosystems. The goal of FUTURE is to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders, and the public. FUTURE is likely to end within the time frame of this Framework, however, planning for its successor has not yet started.

1.3 Contributions to Other Science Initiatives

Ongoing collaborations between PICES and NPFC contribute to other international science initiatives. One in particular is the UN Decade of Ocean Science for Sustainable Development (The Decade hereinafter) which was launched in 2021 with a 10-year period. The Intergovernmental Oceanographic Commission prepared an implementation plan for the Decade in consultation with Member states, specialized agencies, funds, programmes, and bodies of the United Nations, as well as other intergovernmental organizations, non-governmental organizations and relevant stakeholders. The Decade highlights the need and role of ocean science data and information exchange for sustainable development. With the two main goals of (i) generating the scientific knowledge and underpinning infrastructure and partnerships needed for sustainable development of the oceans, and (ii) providing ocean science, data, and evidence to inform policies for a well-functioning ocean in support of the 2023 Agenda for Sustainable Development, this PICES-NPFC Framework for Collaboration is well aligned with contributing to the Decade.

The Biodiversity Beyond National Jurisdiction (BBNJ) Agreement was adopted on 19 June 2023 and addresses a package of issues under the overall objective of ensuring the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. It has not yet entered into force but four of PICES member countries have signed the Agreement and are in the process of ratification. The agreement will enter into force 120 days after 60 ratifications, with a first Conference of the Parties soon after. The Agreement contains cross-cutting issues that explicitly include strengthening and enhancing cooperation with and among relevant IFBs (relevant global, regional, subregional or sectoral body).

2.0 Objectives

The objectives of this revised Framework are to:

1. Update the scientific interests and objectives of each organization;
2. Identify potential areas and specific topics for scientific cooperation;
3. Identify potential collaborative methods (such as representation at each other's meetings, holding of joint workshops or symposia, development of a Memorandum of Understanding (MOU) between the organizations or other formal agreements, establishment of joint working groups);
4. Clarify practical steps to advance the cooperative activities identified above;
5. Provide advice on how information produced by PICES can be shared and applied in NPFC;

Specifically, for NPFC key objectives include reducing duplication of effort, increasing leveraging of time and resources with PICES, and acquiring impartial scientific information and advice to support policy and decision making within the North Pacific Fisheries Commission's Convention Area. PICES also shares these objectives as well as the objective to be more relevant to Regional Fisheries Management Organizations (RFMOs), such as NPFC, by providing the needed objective scientific advice for decision making. Further, for both organizations, the intent is for productive, mutually beneficial collaborative initiatives, which is to say that the areas for collaboration need to be relevant to both organizations. To support the success of this Framework for Enhanced Collaboration, efforts will be focused on areas that are high priority for both organizations to advance over the next five years.

3.0 Scientific Areas of Joint Interest

The PICES-NPFC SG identified several topics of joint interest and came to consensus on three priority areas from 2019-2024. For each area identified, discussions focused on whether each organization viewed the area to be a priority and the specific interests in the area for each organization. Determining whether the research area was a priority for future collaborative work involved consideration of several criteria including:

- Aligns with organization's goals and objectives and existing research plans and priorities
- Potential outputs/benefits from the work area well-defined and relevant
- The timelines for when scientific results and advice are required
- The level of impact and likelihood that the project outputs will be utilised
- Likelihood of success (i.e., are the project objectives likely to be achieved)

In 2024, representatives from both organizations reviewed, considered and ranked each of these topics for enhanced collaboration from 2025-2029. Table 1 in the Appendix summarizes all scientific areas for collaborations that were considered in 2024, the three areas that were recommended for joint activities from 2025-2029, and potential activities that can be implemented during those years for each area. Below the three priority areas of joint interest are discussed in more detail.

3.1 Support for Stock Assessments for priority species

Stock assessments for target fisheries and bycatch species have the highest priority among the research areas of the NPFC. There are eight fish species and two squid species that are recognized by the NPFC as priority species: Pacific saury (*Cololabis saira*), chub mackerel (*Scomber japonicus*), blue mackerel (*Scomber australasicus*), Japanese sardine (*Sardinops melanostictus*), North Pacific armorhead (*Pentaceros wheeleri*), splendid alfonsino (*Beryx splendens*), sablefish *(Anoplopma fimbria),* skilfish *(Erilepis zonifer),* neon flying squid (*Ommastrephes bartramii*), and Japanese flying squid (*Todarodes pacificus*). Additional species may be added to the NPFC's list of priority species during the next five years. Currently, the highest priorities are Pacific saury and North Pacific armorhead because of their lower catches and abundances (but chub mackerel, Japanese sardine, and neon flying squid are also priorities because of trends in their catches and limited knowledge of their biomass and status. These species are also relevant for many PICES Committees and Working Groups since they are suspected to be very sensitive to environmental changes, in particular during early life history stages. Given that many of the priority species are short lived and their abundance fluctuates significantly year to year, recruitment rate may not be determined by the number of spawners in any deterministic one-way interaction. Rather, oceanography and climate are suggested to be main drivers not only for distribution patterns at different spatial scales but also for survival success. PICES participants have a long history of developing and validating saury, mackerel, sardine and squid distribution models, collecting ecosystem time series observations (ETSO), and using simulation studies to predict the consequences of changes / variability in key environmental parameters on populations in space and time. Thus, the common question to be resolved is what methodologies are most appropriate to incorporate environmental variables, which may affect stock status and distribution estimates, into stock assessments.

3.2 Vulnerable Marine Ecosystems (VMEs)

Internationally, steps have been taken to protect marine biodiversity of vulnerable marine ecosystems (VMEs). According to the International Guidelines for the Management of Deep Sea Fisheries in the High Seas (FAO 2009), the criteria for identifying VMEs are: uniqueness or rarity, functional significance of the habitat, fragility, life-history traits that make recovery difficult, and structural complexity. PICES and NPFC share a common objective of promoting marine research that helps ensure the long-term conservation and sustainable use of the fisheries resources while protecting the marine ecosystems in which these resources occur. There are several areas of possible collaboration between NPFC and PICES on VMEs. Focused research topics may include:

(1) Increasing scientific knowledge of biodiversity associated with known seamounts in the North Pacific, including identification of endemic species and distribution patterns of vulnerable taxa;
(2) Increasing scientific understanding of the functional relationships within the ecosystem, with a special focus on the complex dependency of fishing resources and benthic species within VMEs;
(3) Identification of areas likely to be VMEs in the Convention Area through predictive modeling and empirical observations (visual survey tools, fishery-independent data, where possible, or landed bycatch);
(4) Understanding the impacts of different types of bottom-contact fishing activities on VMVEs and the magnitude and timing of their recovery from those impacts.

These and other research projects on VMEs will (1) contribute towards PICES FUTURE goals to understand how marine ecosystems in the North Pacific respond to climate change and human activities, (2) support decision making regarding significant adverse impacts (SAIs) of bottom fisheries on VMEs, the NPFC's exploratory fishing and encounter protocols, and (3) aid refinement and implementation of NPFC Conservation and Management Measures for bottom fisheries and protection of VMEs in the NW and NE Pacific Ocean.

3.3 Ecosystem Approach to fisheries

The NPFC may adopt, where necessary, conservation and management measures for species belonging to the same ecosystem or dependent upon or associated with the target stocks. Based upon this, the NPFC's Scientific Committee shall assess the impacts of fishing activities on both the targeted fisheries resources as well as species belonging to the same ecosystem or dependent upon or associated with the target stocks. PICES integrates Scientific Programs undertaken by the member nations and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions. There are several active PICES Expert Groups (i.e., Working Group on Climate Extremes and Coastal Impacts in the Pacific, Working Group on Sustainable Pelagic Forage Communities, Section on Climate Change Effects on Marine Ecosystems), projects such as the Basin Scale Events To Coastal Impacts (BECI) project and the Fisheries Oceanography Committee which could make a tremendous contribution in providing advice on the state-of-the-art ecosystem modeling techniques and methods to estimate "health" of the North Pacific in particular in the areas where NPFC's priority species occur and co-occur. Realising that there is an endless scope for research direction in this area, the short-term goal for this collaboration would be to develop a research plan to enable ecosystem considerations to be incorporated into a fisheries management approach.

4.0 Collaboration Mechanisms

There are many potential mechanisms for enhancing collaboration and making progress in the priority areas identified in Table 1. Some of these, which have been utilized in the first Framework or by other organizations in partnership with PICES, include:

- Workshops
- Joint working groups
- Theme sessions at PICES annual meetings
- Representation at meetings and/or workshops
- Coordination of science plans

The five-year reviews should also assess the collaboration mechanisms by identifying which ones were employed, the utility of those mechanisms in achieving desired results, and identify new mechanisms for future joint collaboration.

4.1 Workshops

PICES and NPFC have been co-sponsoring and participating in each other's workshops throughout their mutual history. New and emerging issues often demand innovative and multidisciplinary approaches. The ability to deal with and resolve new concepts is likely to be enhanced by the bringing together of PICES and NPFC expertise in co-sponsored workshops. NPFC held a joint workshop with FAO in March 2018 on *the Protection of Vulnerable Marine Ecosystems in the North Pacific Fisheries Commission Area: applying global experiences to regional assessments* where PICES experts were invited to provide expert input to the discussions. The workshop made recommendations for future work, and these recommendations may be used to establish joint research activities or working groups that can focus on specific objectives. Moreover, there was a joint PICES-NPFC workshop (W11) on *The influence of environmental changes on the potential for species distributional shifts and subsequent consequences for estimating abundance of Pacific saury* that was held at the 2019 PICES Annual Meeting. During the first five-year phase of the Collaboration Framework workshops were one of the mechanisms for collaboration with NPFC Scientific Committee members co-sponsoring a workshop (W1) at the PICES-2022 annual meeting with members of PICES WG47 on "*Distributions of pelagic, demersal and benthic species associated with seamounts in the North Pacific Ocean and factors influencing their distributions*".

4.2 Joint Working Groups

Joint working groups represent one of the most effective mechanisms for collaboration and cooperation when there is a need to focus on a specific topic with specific deliverables defined by terms of reference. In general, joint working groups would be formed following one or a series of meetings and/or workshops that are organised on a common theme. Thus, effective planning is a crucial element of successfully establishing a new and productive working group. Typically, in PICES a working group has a duration of three years. Under this PICES-NPFC Framework, it is recommended that joint Working Groups can be of any duration that is necessary to complete the Terms of Reference, but not longer than three years, except on a case-by-case basis where extensions are required. No joint Working Groups were convened during the first five-year phase but this remains a potential mechanism to be utilized.

4.3 Theme sessions at PICES annual meetings

Joint topic sessions at PICES annual meetings are also a valuable mechanism for collaboration between PICES and NPFC. There are numerous past examples of sessions that PICES has co-convened with other

organizations where the benefits of sharing research findings and expertise have been demonstrated, such as joint sessions with ICES (International Council for the Exploration of the Seas), NOWPAP (Northwest Pacific Action Plan), and ISC (International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean). More recently NPFC has co-sponsored Theme Sessions at PICES annual meetings on:
2023 (S14) Seamount biodiversity: vulnerable marine ecosystems (VMEs) and species associated with seamounts in the North Pacific Ocean.
2022 (S5) Environmental variability and small pelagic fishes in the North Pacific: exploring mechanistic and pragmatic methods for integrating ecosystem considerations into assessment and management.

Convening topics sessions at NPFC Scientific Committee annual meetings is not a mechanism used by NPFC for the review of the science. This is done via Small Scientific Committees (SSCs), Technical Working Groups and Small Working Groups focused on specific areas.

4.4 Representation at meetings and/or workshops

Both PICES and NPFC have a history of having representatives from other organizations participate in meeting and workshops where they can report on their organization's activities of interest. It was recommended that both organizations consider inviting one or more representatives from the other organization to participate in the Scientific Committee (for NPFC) and Science Board (for PICES) to update the bodies on the research activities ongoing and research priorities for the future and this was carried out during the first five-year phase. Many of the science experts that participate in the NPFC Scientific Committee are also members of PICES expert groups, thus representation within each organization is already strong but reciprocal participation allowed for increased visibility of the collaboration.

4.5 Coordination of science plans

To further promote collaboration in many of the activities identified in Table 1, PICES and NPFC could include shared elements in their respective research and work plans.

5.0 Monitoring and Reporting

Following the approval and implementation of this renewed Framework by the respective bodies of PICES and NPFC (i.e., the Science Board and the Scientific Committee), this Framework will continue for a period of five years at which time it will be reviewed to assess the progress on the areas identified in Table 1, and to identify new areas for collaborations. The review should also assess the collaboration mechanisms by identifying which ones were employed, the utility of those mechanisms in achieving desired results, and identify new mechanisms for future joint collaboration.

On an annual basis, there will be a progress report prepared by the Secretariat for each organization that is available for members. This progress report should be common for both, be a summary of all joint activities between PICES and NPFC (including status of activities and actions required to progress on objectives), and be prepared in collaboration by both Secretariats. Further, this progress report will be presented annually at the PICES Science Board (SB) and the NPFC Scientific Committee (SC) annual meetings as part of a standing item on their agendas. If modifications / alterations are required to joint activities to enable enhanced productivity and success, these recommendations will be approved by both the PICES SB and/or NPFC SC (via correspondence if necessary).

For any joint activity that is completed, the co-convenors will prepare a summary report of the activity and it will be available for all members of both organizations.

6.0 Other Considerations

When identifying recommendations for activities under the joint areas for scientific collaboration, other considerations need to be evaluated, including costs to the organizations in terms of financial as well as human capital and time. Some recommendations to alleviate these costs include:

- Using existing travel opportunities to established events, such as PICES and NPFC annual meetings. Economic efficiencies are realised even if the duration at a location must be extended by a day or two.
- Utilise on-line correspondence to the maximum extent to achieve deliverables, to prepare for face-to-face meetings, and to finalise reports.
- Minimise the number of annual meetings and create efficiencies within existing meeting as much as possible.

It is recognised that in certain cases where the work effort is intense (e.g., over a three-day period) to get the desired result, it is more effective to host a separate meeting with the additional financial and human capital costs, since the ultimate goal is to deliver on an objective. When additional costs are required, additional approvals also are likely required via the Governing Council for PICES and the Commission for NPFC.

TABLE 1: Recommended joint PICES-NPFC research areas and associated rank, interest, potential activities, and priority within next five years

Research Area	**PICES Rank**	**NPFC Rank**	**PICES Interest**	**NPFC Interest**	**Potential Activities**	**Priority (5 years)**
Support for Stock Assessments for priority species - How to include environmental variables that may affect stock status and distribution - Higher order modelling approaches that consider variability of multiple parameters	High	High	Methodologies incorporating multiple variables, such as ecosystem time-series observations under North Pacific Ecosystem Status Reports (NPESR)	Methodologies that can enhance estimation of stock status; provide scientific justification for breaks in time series based on regime shifts in indices; science advice on how to best incorporate available information; NPFC adopted a resolution to adapt to climate change and promote resilience in NPFC fisheries	Joint workshop at PICES 2025 to identify specific areas on which to focus considering priority areas, data availability, desired outcomes, etc.; Joint WG(s) to address activities identified in the joint workshop; Sharing scientific results when they become available	
Vulnerable Marine Ecosystems (VMEs) and Significant Adverse Impacts (SAIs)	High	High	Identifying or predicting the distribution of VMEs; Have participated in workshops with NPFC; future considerations on biodiversity of seamounts.	Science support required for analysis of known and likely VMEs in the Convention Area; Use of species distribution models (SDMs) and/or habitat suitability models (HSMs) to support identifying where VMEs are located;	Sharing scientific results when they become available;	

				VMEs assessment is part of Conservation and Management Measures (CMMs) for bottom fisheries and protection of VMEs; Small Scientific Committee (SSC) established to focus on bottom fisheries and VMEs.		
Ecosystem Approach to Fisheries - Scope to be defined but it was agreed to make progress in this area in incremental steps, for example the advice on fishing effort would include target stock status as well as impact of fishing effort on other key stocks, impacts of environmental variability on future target stock abundance, impacts of management decisions on human systems, etc. - There is high potential that activities under "Support for Stock Assessment" will address some of the initial objectives under this area.	Med-high	High	Incorporate environmental variables and biological linkages within ecosystem models; Effort ongoing on advancing ecosystem models to understand impacts of stressors to ecosystem structure and function rather than assessing stock status;	Commitment to formulate a research plan to enable ecosystem considerations to be incorporated into a fisheries management approach; Support UN and FAO interests and commitments; One of the NPFC Scientific Committee's functions is "Assessing the impacts of fishing activities on species belonging to the same ecosystem or dependent upon or associated with the target stocks"	Joint workshop or session in 2025 or later to discuss options for advancing this area. Sharing scientific results when they become available;	
Climate change	High	Medium-High	Impacts on species /	Shifting of fishing areas due to habitat changes;	Ranked medium-high as a priority, but it was decided	

- Factors effecting distributional changes of fish stocks due to changes in the environmental parameters including teleconnections with factors outside of the CA of the NPFC such as melting ice - Impact of ocean acidification - Factors affecting species' life history parameters (e.g., growth and maturity) and productivity			habitats; oceanographic process changes; some activities completed or ongoing (e.g., POC and BIO).	impacts on targeted stocks and distribution; impact of ocean acidification on corals; Integration of climate information into stock assessment and management; Adaptation of reference points and control rules to a changing environment; NPFC adopted a resolution to adapt to climate change and promote resilience in NPFC fisheries	to incorporate relevant project areas under the other three areas above.	
Data management (collection and sharing and security)	High (for sharing scientific results)	High	PICES is developing a new data catalogue to include metadata and PICES-generated data products. This will increase discoverability of data developed by PICES, member	Raw data is not generally accessible to external parties; available data products are accessible on the website depending on the membership in different subsidiary bodies. The NPFC is in the process of developing procedures for data management, including developing	Decided this was not an area where joint work was required. Important to encourage sharing of scientific results.	

			countries and partners but the scope is not yet defined	data templates and a database.		
Management Strategy Evaluation (MSE)	Med	Med		NPFC has started activities on the MSE-based management approach for Pacific Saury and it may be something that NPFC would have interest in pursuing through collaborative work with PICES, but not in the short term	Decided this was not an area that would be a priority for joint work over the next 5 years	

Appendix 3

SmartNet Implementation Plan

Sustainability of Marine Ecosystems Through Global Knowledge Networks (SmartNet): Phase II (2025-2028) Implementation Plan

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9 August 2024

Draft for Science Board, Secretariat Review; Approval at ICES-2024, PICES-2024

1. Motivation, Planning and Endorsement

The UN Decade of Ocean Science for Sustainable Development (Ocean Decade; 2021-2030), sponsored by the Intergovernmental Oceanographic Organization (IOC), provides an unprecedented opportunity to strengthen and expand the collaborative science between ICES and PICES and with other partner organizations. ICES and PICES are scientific organizations that interact and engage with an array of different groups, from academia, policy, civil society, industry, and foundations throughout the Northern Hemisphere, and through partnerships and specific agreements we are also increasing our presence in the Southern Hemisphere. Our two organizations play leading roles in advancing and communicating scientific understanding of marine ecosystems for societal outcomes. Our partnership brings together diverse networks to increase the overall capacity to conduct ocean science in support of sustainable development and to foster the range of skills necessary to support broad and overarching marine science goals. Furthermore, the strategic plans and objectives of both organizations are well-aligned with Ocean Decade objectives, positioning ICES, PICES and their associated networks to play a leading role in addressing Ocean Decade priorities and societal outcomes. With this motivation, an ad-hoc group of ICES and PICES scientists began bilateral discussions in October 2019 to develop a strategic plan to bring about transformational science during the Ocean Decade by building upon our long history of successful partnerships in advancement of marine science.

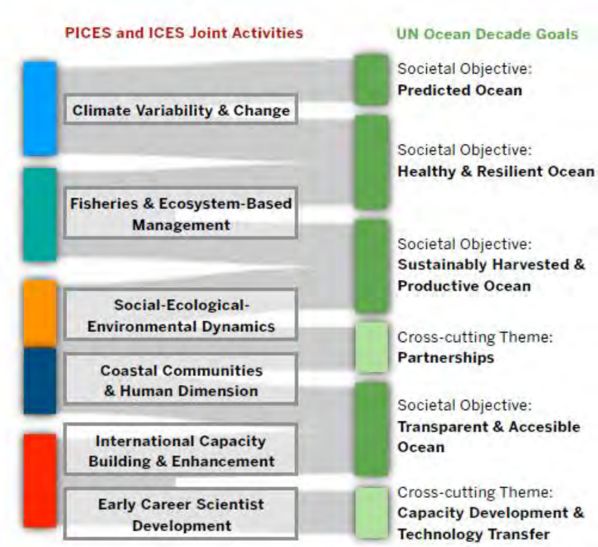

Figure 1: Mapping of ICES and PICES core activities and focus areas onto UN Ocean Decade societal objectives and cross-cutting themes.

Our strategic partnership was formalized in a joint Study Group on the UN Decade of Ocean Science (SG-UNDOS; 2020-2021), which aimed to (a) establish a common strategy for joint activities and provide regional leadership in support of the Ocean Decade; (b) identify and strengthen relationships with partner professional and multilateral organizations to facilitate Ocean Decade engagement; and (c) develop a UN Ocean Decade Programme[1] for endorsement by the IOC. The resulting Programme proposal, titled 'Sustainability of Marine Ecosystems Through Global Knowledge Networks' (SMARTNET), was submitted to the first Ocean Decade Call for Actions in January 2021 (see **Supplement A**), and was among the first set of Actions endorsed by the IOC in June 2021 (see **Supplement B**). SMARTNET aims to support, leverage and expand upon ICES, PICES, and member countries' priorities and initiatives related to the Ocean Decade, by emphasizing areas of mutual research interest and policy needs, including climate change, fisheries and ecosystem-based management, social, ecological and environmental dynamics of marine systems, coastal communities and human dimensions, and communication and capacity development (**Figure 1**). SMARTNET also aims to incorporate strategies to facilitate Ocean Decade cross-cutting inclusivity themes relating to gender equality, early career ocean professional (ECOP) engagement, and significant involvement of indigenous communities and developing nations in the planning and implementation of joint activities.

2. SMARTNET OBJECTIVES AND GOVERNANCE

SMARTNET has two primary objectives: (1) **To convene global partners through knowledge networks to facilitate research, knowledge generation and capacity sharing** in support of sustainable marine ecosystems in a changing climate; and (2) **To leverage and build upon joint ICES-PICES collaborations** to expand our networks and increase resilience of marine & coastal resources and the communities that depend on them. These objectives are closely linked to the Ocean Decade's ten Challenges and seven Desired Outcomes, with a particular emphasis on 'A Productive Ocean', 'A Healthy and Resilient Ocean', 'A Predicted Ocean', and 'An Inspiring and Engaging Ocean'. More broadly, SmartNet objectives are congruent with several of the UN's Sustainable Development Goals: SDG 14 ('Life Below Water'), SDG 13 ('Climate Action'), SDG 2 ('Zero Hunger') and SDG 5 ('Gender Equality').

Figure 2: Intersection of SMARTNET activities within ICES/PICES infrastructure: PICES FUTURE Scientific Steering Committee, and Advisory Panels on UN Decade of Ocean Science, Science Communications, and Early Career Ocean Professionals; and ICES Advisory Committee (ACOM).

[1]A Decade programme is global or regional in scale and will contribute to the achievement of one or more of the Ocean Decade Challenges. It is long-term (multi-year), interdisciplinary and multi-national. A programme will consist of component projects, and potentially enabling activities

To build upon the ICES-PICES enterprise, SMARTNET requires a joint governance structure within the ICES and PICES infrastructure. This is accomplished through the ICES-PICES Ocean Decade (IPOD), which serves as the joint Steering Committee for SMARTNET. In the first phase of SMARTNET (2021-2024), IPOD members were drawn entirely from the broader ICES and PICES communities (**Supplement C**). IPOD members from PICES also serve on PICES' Advisory Panel on the UN Decade of Ocean Science (AP-UNDOS; 2022-present). The terms of reference of AP-UNDOS (**Supplement D**) include the development and governance of SMARTNET, ensuring active collaborations within the Programme across the PICES member nations. In addition, AP-UNDOS has the broader remit of advising and implementing more comprehensive PICES engagement with the Ocean Decade. Within PICES, SMARTNET will facilitate collaboration across several Expert Groups: FUTURE, the flagship Science Program, and the Advisory Panels on the Ocean Decade, ECOPs and Science Communications, all of whose contributions are required for SMARTNET to succeed. The ICES Advisory Committee will also work closely to facilitate SMARTNET engagement across ICES Expert Groups (**Figure 2**).

The objectives of SMARTNET will be achieved through the development and operation of a Global Knowledge Network (GKN) to generate and share knowledge and capacity. This framework has four functional, intersecting components: knowledge production, knowledge sharing, networking and engagement (**Figure 3**), which provides the strategic guidance to implement SMARTNET activities.

- *Knowledge production* comprises the ICES and PICES scientific enterprise and leverages collective organizational infrastructure to advance key scientific topics in marine science. This is exemplified by joint ICES-PICES Expert Groups such as those focused on climate change effects on marine ecosystems (ICES SICCME, PICES S-CCME); impacts of warming on growth rates and fisheries yield (ICES WGGRAFY, PICES WG-45); and sustainable pelagic forage communities (ICES WGSPF, PICES WG-53). SMARTNET will facilitate creation of new joint Expert Groups to address emerging challenges and priorities throughout the Ocean Decade (see Section 3).

- *Knowledge sharing* also leverages the organizational and scientific infrastructure of ICES and PICES, with scientific information communicated through sponsored meetings (ICES/PICES Annual Meetings and associated Workshops and Sessions, International Symposia) and publications (peer-reviewed scientific manuscripts, Scientific Reports, Special Publications, and newsletters such as *PICES Press* and *ICES Cooperative Research Reports*). In addition to the dissemination of scientific knowledge and products, SMARTNET works with Expert Groups to facilitate dissemination of data through Findable, Accessible, Interoperable and Reusable (FAIR) principles (e.g. PICES Technical Committee on Data Exchange, TCODE, aims to establish dialogue to support the Ocean Decade, in particular, its societal outcome of a "transparent and accessible ocean"; similarly for the ICES Data Science and Technology Steering Group, DSTSG).

- *Networking* fulfills the key SMARTNET objective of creating a functioning Global Knowledge Network (GKN) to generate scientific knowledge and share capacity around marine ecosystem sustainability. The long history of ICES and PICES partnerships with national, international and inter-governmental organizations (e.g., PICES MOUs) provides the foundation for this GKN, which SMARTNET will expand beyond the Convention Areas of the North Atlantic and North Pacific represented by ICES and PICES, respectively (although ICES has links with countries in the Global South). A key objective of SMARTNET is to identify new partners and expand the GKN to the Global South, to least developed countries (LDCs) and to Small Island Developing States (SIDS). The Ocean Decade provides new networking opportunities amongst endorsed Actions (Programmes, Projects) which encompass Communities of Practice around key themes (see Section 3).

- *Engagement* focuses on the cross-cutting Ocean Decade objectives of empowering diverse communities, ensuring geographic and gender equity in knowledge generation and capacity sharing, facilitating the career development of ECOPs, and incorporating local and traditional forms of knowledge. By striving for global equity in the generation and sharing of scientific knowledge and implementation of ocean solutions, this element of the Ocean Decade has the potential to be most transformative. SMARTNET actively pursues these cross-cutting themes through developing and sharing capacity with new partners (see Section 3).

The objectives and governance structure described above have guided the activities of SMARTNET since its Ocean Decade endorsement in 2021, leading to substantial progress in fulfilling its goals.

Figure 3: The strategic framework governing the SMARTNET Global Knowledge Network.

3. SMARTNET *PHASE I*: 2021-2024

From Ocean Decade endorsement in June 2021 through 2024, SMARTNET has refined its objectives and governing structure, initiated new partnerships, established an identity, and generated and shared new scientific knowledge through a variety of activities:

A. BUILDING THE GKN

SMARTNET has imitated the building of its GKN through three pathways: (1) expanding or developing new relationships with ICES and PICES network partners; (2) developing informal and formal Communities of Practice amongst endorsed Ocean Decade *Programmes* with overlapping interests and objectives; and (3) bringing in new endorsed Ocean Decade *Projects* under the SmartNet umbrella. SMARTNET representatives participated in the joint PICES-Asia Pacific Network (APN) Study Group on Scientific Cooperation in the Pacific Ocean (SG-PICES-APN; Aug 2021-Feb 2023), culminating in an MOU that outlines avenues of collaboration that incorporate many of the goals and activities of SMARTNET and the Ocean Decade more broadly (**Supplement E**). Additionally, SMARTNET representatives provide leadership to FUTURE, the PICES flagship Science Program. The FUTURE Scientific Steering Committee recently completed the FUTURE Phase III (2021-2025) Science Plan Addendum which explicitly links FUTURE and orients its activities towards the UN Ocean Decade, particularly through SMARTNET (see Section 2 and Figure 2). ICES is also completing an updated 2024-2029 Science Plan, which will articulate links to SMARTNET and Ocean Decade activities. In general, ICES and PICES network partners are inherently part of the SMARTNET GKN and receive updates and other communications through the knowledge sharing activities described above.

The Ocean Decade provides a critical global platform to facilitate global communication and cooperation around marine science and ocean sustainability. SMARTNET has taken advantage of this platform to develop close collaborations with several Ocean Decade endorsed Programmes, including Sustainability, Predictability and Resilience of Marine Ecosystems (SUPREME), Marine Life 2030, Fisheries Strategies for Changing Oceans and Resilient Ecosystems by 2030 (FishSCORE2030), Blue Food Futures, Global Ecosystem for Ocean Solutions (GEOS) and Ocean Biomolecular Observations Network (OBON). These Programmes have formed a Community of Practice around the 'climate-biodiversity-fisheries' nexus, with the aim of sharing scientific advances and tips on navigating Ocean Decade logistics, co-designing collaborative activities, and integrating our individual networks. Four of these Programmes (SmartNet, SUPREME, FishSCORE, BFF) have hosted a monthly webinar series since November 2023 on 'Topics at the Nexus of Climate Change, Fisheries, and Blue Foods'. These webinars reach a global audience and facilitate the co-design of new Ocean Decade activities amongst the four participating Programmes and their networks.

Several newly endorsed Ocean Decade Projects are sponsored by SMARTNET and are explicitly part of the SMARTNET GKN (**Table 1**). These Projects span broad geographic and disciplinary ranges, but all have a focus on finding solutions to critical regional or global issues, in line with the Ocean Decade Challenges. These issues include managing for multiple pressures in regional marine ecosystems, reducing and mitigating the effects of bycatch, disseminating marine and climate information to regional stakeholders, and developing methodologies to quantify the effects of plastic ingestion in marine species.

B. Knowledge Generation and Sharing

SmartNet has taken advantage of scheduled international fora to gather partners at meetings, workshops and satellite events, using these events as the primary pathway to consolidate the GKN and co-design Ocean Decade activities with partners (**Table 2**). In addition to the monthly webinar series described above, these events – both virtual and in-person – have been the primary tool to introduce SmartNet to a global audience and to facilitate the collaborations needed to meet our objectives. The 'climate-biodiversity-fisheries' Community of Practice was formed through the planning and implementation of these events. SmartNet also had a strong presence at the first UN Ocean Decade Conference, held in Barcelona, Spain, in April 2024 – hosting a side event and co-sponsoring two others in collaboration with the Ocean Decade ECOP Programme (Table 2).

A second avenue to widely share SmartNet information is through publications. An early article introduced the objectives of SmartNet in an Ocean Decade-themed special issue of *ECO Magazine* (Trainer et al., 2021), while a more recent publication describes the knowledge- and capacity-sharing strategies of SmartNet in a special issue of *Oceanography* magazine (Chiba et al., in review). A recent SmartNet-led publication, with Community of Practice collaborators, describes the collective capacity and key knowledge gaps within the 'climate-biodiversity-fisheries' nexus, and provides recommendations for future Ocean Decade Actions (Bograd et al., 2024b). Additionally, several articles in *PICES Press* have described the proceedings and outcomes of several of the SmartNet-led and -supported events (Bograd et al., 2023a, 2023b, 2024a; Satterthwaite et al., 2023; Jhugroo et al., 2024).

SmartNet has also contributed to knowledge generation in the Ocean Decade through its global survey on the 'What is the Ocean We Want?'. The refrain of the Ocean Decade is 'The Science We Need for the Ocean We Want'. The SmartNet-led survey seeks to understand 'The Ocean We Want' relative to the 7 Ocean Decade Outcomes, recognizing that there are widely different priorities and

Figure 4: Sketch from the SmartNet 'Ocean We Want Survey' satellite event at the Ocean Decade Conference in Barcelona, Spain, April 2024.

policy needs across cultures and ecosystems. Based on questionnaires designed from the Ocean Decade Implementation Plan, pilot surveys of the general public were conducted in 4 countries (Australia, France, Japan, USA) in 2023, with additional surveys planned in other countries (see Section 4). The expected outcomes from the global survey are threefold: (1) to provide an empirical basis for assessing progress on the Decade Objectives in different regions; (2) to inform SMARTNET'S capacity building strategy to address priority themes for each country, with an emphasis on SIDS and LDCs; and (3) to partner with stakeholders to co-design country-specific ocean advocacy strategies for promoting ocean sustainability. A description of the survey and initial results from the pilot surveys were presented at the SMARTNET-hosted side event at the Ocean Decade Conference in April 2024 (**Figure 4**).

Small Island Developing States (SIDS) have been the focus of SMARTNET'S initial capacity building strategy during *Phase I*. SMARTNET ECOPs from SIDS (Mauritius and Cabo Verde) have led these outreach efforts and developed a list of recommendations to prioritize future activities. These recommendations include inclusion and recognition of SIDS partners; creation of a positive policy environment, with emphasis on empowerment of women and ECOP engagement; improved technical development and science communication to local communities; and financial support from external sources. The initial outreach conducted during *Phase I* will guide SMARTNET capacity-sharing activities in *Phase II* (see Section 4).

C. ECOP DEVELOPMENT

A key objective of SMARTNET from its planning stages was to facilitate active participation by ECOPs in all of its activities. This has arguably been the most successful activity during *Phase I*. ECOPs have contributed leadership to the planning and execution of all of the SMARTNET workshops and events (Table 1), the development of SMARTNET publications, and Programme planning and organization through IPOD, ICES SICCME, and PICES AP-UNDOS and AP-ECOP. PICES ECOPs are members of the IPOD SMARTNET Steering Committee and have taken the lead in SMARTNET'S outreach to SIDS. PICES supported the participation of two PICES ECOPs to the UN Ocean Decade Conference in Barcelona, Spain, in April 2024, where they represented SMARTNET and PICES in several capacities (**Figure 5**). ICES has a Strategic Initiative on Early Career Scientists (SIIECS), and both

Figure 5: PICES delegation at the Ocean Decade Conference in Barcelona, Spain, April 2024. PICES ECOPs Khush Jhugroo (2nd from left), Raphael Roman (3rd from left) and Naya Sena (not shown) represented SMARTNET and PICES in various capacities.

organizations provide significant support for the joint Early Career Scientist Conferences and ECOP/ECS travel support to international fora.

D. ICES-PICES Expert Groups

SmartNet leverages the organizational infrastructure of ICES and PICES to advance work around key scientific themes. During *Phase I*, this has taken the form of incorporating objectives of SmartNet and the Ocean Decade into the goals, terms of reference or anticipated outcomes of relevant Expert Groups. PICES Working Groups 49 (*Climate Extremes and Coastal Impacts in the Pacific*), 50 (*Sub-mesoscale Processes and Marine Ecosystems*), 51 (*Exploring Human Networks to Power Sustainability*), and 52 (*Data Management*) all explicitly mention the Ocean Decade as a motivating influence on their activities. Indeed, the Ocean Decade Challenges and the objectives of SmartNet were motivating factors in the development of WG-49, which is taking a trans-disciplinary approach to understand, predict and communicate the impacts of climate extremes such as marine heat waves and harmful algal blooms. While some of these Expert Groups have a PICES focus, SmartNet provides linkages to ICES and other partners of the GKN and will provide the foundation for new joint ICES-PICES Expert Groups (see Section 4).

4. SMARTNET *PHASE II*: 2025-2028

In *Phase I*, SMARTNET built its organizational structure, developed a strategic framework, expanded its Global Knowledge Network, and initiated activities to meet the objectives of the Programme and the UN Ocean Decade. SMARTNET is poised to expand upon these accomplishments during *Phase II*.

A. PROGRAMME OBJECTIVES AND GOVERNANCE

The *Phase I* SMARTNET objectives and governance structure will largely be retained during *Phase II*. The primary objectives remain:

- **To convene global partners through knowledge networks to facilitate research, knowledge generation and capacity sharing** in support of sustainable marine ecosystems in a changing climate;
- **To leverage and build upon joint ICES-PICES collaborations** to expand our networks and increase resilience of marine & coastal resources and the communities that depend on them.

Likewise, the ICES-PICES Ocean Decade (IPOD) will continue to serve as the Steering Committee for SMARTNET. In Fall 2024, updates to IPOD membership will be implemented to ensure a balance between ICES and PICES representation as well as geographic, disciplinary, gender and career-stage diversity.

To facilitate the prioritization and completion of SMARTNET activities, we will fully implement a set of IPOD Task Teams:

- **Writing Team**: Prepare periodic SMARTNET updates for the ICES/PICES communities; Prepare review articles highlighting SMARTNET events; Prepare peer-reviewed publications; Update and revise the SMARTNET Implementation Plan as needed.
- **Survey Team**: Execute the global 'What is the Ocean We Want?' surveys; analyze, interpret and disseminate survey results in presentations and publications.
- **Outreach Team**: Plan, organize and execute SMARTNET meetings, workshops, webinars and training sessions; Maintain a responsive and informative SMARTNET web presence.
- **Network Team**: Facilitate communications and engagement with the GKN, including the IOC Decade Coordinating Unit, the Decade Collaborative Centers, and Ocean Decade partner Actions and Communities of Practice.
- **Capacity-Sharing Team**: Facilitate communications and engagement with partners beyond the ICES/PICES convention areas; Develop an engagement strategy with

SIDS; Develop an engagement strategy to incorporate traditional knowledge into SMARTNET activities.

Task Teams will be populated with the revised IPOD membership in Fall 2024.

B. PICES PROGRAM STATUS

We also seek to clarify and solidify SMARTNET's role within PICES with an aim of positioning SMARTNET as a key element of the organization's international scientific enterprise as we transition from the current (FUTURE) to a new flagship Scientific Program. The FUTURE Science Program will phase out over the next few years, initiating a transitional period of strategizing about the future of PICES science that coincides with the Ocean Decade (2021-2030). As articulated in the SMARTNET proposal for IOC endorsement, the Ocean Decade provides a rare and unique opportunity to demonstrate ICES and PICES leadership on the global stage. We advise that ICES and PICES focus their energy and resources into SMARTNET and Ocean Decade activities during this period (SMARTNET *Phase II*, 2025-2028) to ensure success of the Programme and firmly position ICES and PICES as leaders within the Ocean Decade and global marine science. The experiences and lessons learned from the implementation of SMARTNET will inform new Expert Group(s) tasked with planning the next flagship PICES Science Program and will serve as a catalyst to more equitably share our science with the world. With this motivation, we **request to Science Board and Governing Council that SMARTNET be designated a PICES Program with representation on Science Board**. Similarly, ICES could consider evolving SMARTNET into a Strategic Initiative or Operational Group. We note that the plan outlined here is consistent with the recommendations for the future of PICES Science Programs made by the External Review Panel (Hofmann et al., 2024).

C. BUILDING THE GKN

Expansion of the **SMARTNET Global Knowledge Network** is the Programme's primary objective. Our focus in *Phase I* was to entrain partners from within the long-established ICES and PICES Networks. In *Phase II*, we will emphasize expansion of the GKN to include organizations and individuals beyond the ICES and PICES Convention Areas, with a particular focus on the Global South and SIDS. Co-design of activities with the Asia-Pacific Network (APN) will be emphasized as an opportune starting point. Networking with SIDS will follow the recommendations identified in *Phase I* (described in Section 3B) and may include jointly-sponsored workshops at relevant international symposia (e.g. ICES/PICES Annual Meetings) and training sessions focused on relevant themes such as the design of observing systems, data processing and dissemination, and linking science products to policy needs. We anticipate the Network and Capacity Sharing Task Teams will work jointly to expand the GKN and facilitate active participation and will also work closely with the Outreach Task Team to optimize communications about SMARTNET activities and opportunities (see below). Attention to the career development of ECOPs – a *Phase I* emphasis - and diversity and inclusion within the GKN will be paramount.

D. SCIENTIFIC FOCI

The scientific themes identified during *Phase I* included the broadest scientific categories for which ICES and PICES have long had expertise and conducted joint activities. These broad themes included climate effects on fisheries and ecosystem-based management, social-environmental-ecological systems, and human dimensions of coastal systems. During *Phase II*, SMARTNET will leverage existing ICES-PICES joint activities to concentrate on a limited number of specific scientific foci. This concentration will ensure that activities respond to identified priorities, have a defined organizational structure, and are likely to produce useful, tractable outcomes that respond to the Ocean Decade Challenges. Initial scientific foci will include:

- Research on the **effects of climate variability and change** on the dynamics of coastal and **marine ecosystems and their living marine resources**, including both historical analyses and climate projections (*leverage Section/Strategic Initiative on Climate Change and Marine Ecosystems; PICES Advisory Panel on Arctic Ocean and Pacific Gateways*).

- Research and advice on the physical forcing, biological impacts and mitigation/adaptation strategies associated with **climate extremes** such as marine heat waves and HABs (*leverage PICES Working Group on Climate Extremes and Coastal Impacts in the Pacific*).

- Research on the **effects of ocean warming on fish growth** and population dynamics (*leverage joint ICES/PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields; Working Group on Sustainable Pelagic Forage Communities*).

- Translation of climate information into **ecosystem management frameworks**, including Ecosystem Status Reports, Integrated Ecosystem Assessments, and Management Strategy Evaluations (*leverage joint ICES/PICES Working Group on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea*).

- Research on public perceptions of and priorities for the Ocean Decade Outcomes based on the SMARTNET **'Ocean We Want' surveys**, which will inform new priority activities.

- **Capacity-sharing** of ICES/PICES science with SIDS and other GKN partners, through scientific fora, scientist exchanges and training sessions (*leverage PICES Working Group on Exploring Human Networks to Power Sustainability*).

The Writing and Survey Task Teams will play key roles in producing and disseminating these scientific activities, with key roles for the other Task Teams as well.

These scientific foci are neither static nor limited, and SMARTNET will retain a nimbleness to pivot to emerging issues as needed. New issues and priorities will be informed through interactions with the GKN. Recommendations and proposals for new joint Expert Groups will be one of the primary tools for SMARTNET to address identified scientific gaps.

E. COMMUNICATIONS AND OUTREACH

SMARTNET will continue to pursue the *Phase I* avenues of communication and outreach established during *Phase II*: the SMARTNET website, informal activity reports (e.g. *PICES Press*), peer-reviewed publications, and network correspondence. An important initial priority will be the expansion of the SMARTNET website to include new content: (a) news and highlights of activities; (b) general Ocean Decade news and updates; (c) descriptions of and links to upcoming meetings, workshops and training sessions; (d) links to reports and publications; and (e) links to Ocean Decade endorsed Projects and other Actions within the GKN, including the 'climate-biodiversity-fisheries nexus' Community of Practice. The Outreach Task Team will have primary responsibility for these activities, along with the organization of meetings, workshops and training sessions.

A key element of *Phase II* will be the recruitment of a **Programme Coordinator** to oversee communication and outreach, which will be supported through the Ocean Decade International Cooperation Center, CHINA. Anticipated responsibilities of the Coordinator include:

- Lead and facilitate progress of the Outreach and Networking Task Teams.
- Lead development of a functional SMARTNET website.
- Facilitate communication and engagement with the GKN.
- Connect ICES/PICES Expert Groups with the activities of SMARTNET and other Ocean Decade Actions.
- Organize workshops, webinars and training sessions.
- Liaise with the IOC Decade Coordinating Unit, Decade Collaborative Centers, and the national Decade committees of ICES and PICES member countries.

Dedicated SMARTNET coordination will result in a higher profile for ICES and PICES within the Ocean Decade and more visible leadership. It would provide a mechanism to facilitate access to ICES/PICES infrastructure to deliver Ocean Decade objectives and result in more effective communication of our activities and outputs. A more rapid awareness of relevant Ocean Decade activities will result in a more effective use of our limited resources and more tangible progress toward meeting the Ocean Decade Challenges than would occur without this coordination. In addition, member countries would benefit through a clearly defined connection between national efforts and international Ocean Decade activities.

F. Anticipated Outcomes

Our current task is to build from the momentum initiated during SmartNet *Phase I* and make significant progress towards our Programme and the Ocean Decade objectives. It is important to recognize that the Ocean Decade is meant to transcend 'business as usual' and to facilitate 'transformative' science with a focus on developing and equitably implementing solutions to the Ocean Decade Challenges (UNESCO-IOC, 2021). With this obligation in mind, SmartNet during *Phase II* will strive for the following **outcomes**:

- Discernable progress towards addressing the Ocean Decade Challenges and implementing the UN Sustainable Development Goals, represented primarily through scientific products.
- Transformation of ICES/PICES science into a stronger global leadership role, with a new emphasis on strategizing and implementing ocean solutions.
- Successful sharing of knowledge and capacity across the Global Knowledge Network, with an emphasis on the Global South and SIDS.
- Successful career development of a new cadre of ECOPs representing gender, geographic and disciplinary diversity.
- Establishment of a stable and functional Global Knowledge Network with the capacity to contribute to ocean research and sustainability beyond the period of the Ocean Decade.

By implementing this plan, we are confident that SmartNet will get us closer to a productive, predicted, healthy and resilient ocean, that is, to the 'Ocean We Want'.

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Table 1: UN Ocean Decade endorsed Projects sponsored by SMARTNET. List as of July 2024.

Endorsement Date	HOST COUNTRY	PROJECT TITLE / DESCRIPTION
March 2023	Germany	sustainMare: Analyses and classifies use of and pressures on marine spaces to provide a scientifically sound basis to create decisions by politics, authorities and the economy.
March 2023	Italy	Cost Action (MAF World): Provide the scientific basis for understanding and preserving Marine Animal Forests (MAFs), to unify different protocols (e.g. mapping, restoration, ecosystem services) to tackle climate change, natural disasters, & food crisis.
June 2023	USA, Global	Global Plastic Ingestion Bioindicators (GPIB): Aims to move beyond baseline assessments of plastic pollution to evaluate trends, risks, and effects to species and ecosystems.
July 2024	Norway	Ghost Fishing Solutions (GFS): Aims to prevent ghost gear, abandoned fishing gear that harms marine life and ecosystems, through innovative technology and practices.
July 2024	Denmark	Klimaatlas: Conveys climate information about future changes and extremes in temperature, precipitation, wind, evaporation, sea level and storm surges in Denmark and serves as one of the primary sources of climate information on land in Denmark.
July 2024	Brazil	INCT Biodiversity of the Blue Amazon (INCT-BBA): A vast Brazilian Project that has established a broad national network of researchers with international collaborators from different fields of knowledge to address specific goals, including basic and applied research, training of human resources qualified in Marine Sciences and scientific dissemination and outreach.
July 2024	Spain	SAFETURTLES: Collaborates with governments and fisheries along the Pacific American coast to facilitate the development of a regulated training system of fishers in best handling and release practices of captured turtles.

Table 2: SMARTNET sponsored or co-sponsored events during Phase 1.

DATE	VENUE	EVENT
April 2022, Washington, DC	Consortium for Ocean Leadership Meeting	Workshop to 'Coordinate Biological Observing Programs in the UN Ocean Decade'
June 2022, Virtual	UN Ocean Decade Satellite Event on 'A Productive Ocean'	SMARTNET: Establishing Global Knowledge Networks to Achieve 'A Productive Ocean' during the UN Decade of Ocean Science for Sustainable Development
September 2022, Busan, Korea	Workshop at PICES-2022 Annual Meeting	SMARTNET: Promoting PICES and ICES Leadership in the UN Decade of Ocean Science for Sustainable Development
April 2023, Atlanta, GA USA	Ocean Visions Biennial Summit	Panelist for 'Leveraging the UN Ocean Decade Framework for Ocean-Climate Solutions'
April 2023, Bergen, Norway	Workshop at Effects of Climate Change on the World's Oceans Conference	The Climate-Fisheries Nexus within the UN Decade of Ocean Science for Sustainable Development: Co-Designing Actions and Solutions for a Productive, Healthy and Resilient Ocean
October 2023, Seattle, WA USA	Workshop at PICES-2023 Annual Meeting	Sharing Capacity and Promoting Solutions for Marine Ecosystem Sustainability within the UN Decade of Ocean Science
April 2024, Barcelona, Spain	UN Ocean Decade Conference	Hosted Side Event on 'What is the Ocean We Want: Global Survey to Understand Perspectives on Ocean Decade Outcomes'
April 2024, Barcelona, Spain	UN Ocean Decade Conference	Co-Sponsored Side Event on 'The Inclusivity We Need for the Ocean We Want', with ECOP Programme
April 2024, Barcelona, Spain	UN Ocean Decade Conference	Co-Sponsored Side Event on 'Building Ocean Leadership: Fostering Networking, Creativity, and Resilience', with ECOP Programme
October 2024, Honolulu, HI USA	Workshop at PICES-2024 Annual Meeting	Exploring international knowledge co-production: Lessons learned from international marine science organizations at the science-policy interface

SMARTNET sponsored event

SMARTNET co-sponsored event

SMARTNET participation at event

SUPPLEMENT A: SMARTNET Proposal submitted to the Intergovernmental Oceanographic Commission for Ocean Decade endorsement in January 2021.

UN Decade of Ocean Science
ICES/PICES Decade Programme
FINAL

Sustainability of Marine Ecosystems through global knowledge networks
(SMARTNET)

Summary description

SMARTNET will establish a global knowledge network (GKN) for ocean science by strengthening and expanding the collaboration of ICES/PICES and partner organizations. It will support and leverage ICES/PICES member countries' activities related to UNDOS, by emphasizing areas of mutual research interest including climate change, fisheries and ecosystem-based management, social, ecological and environmental dynamics of marine systems, coastal communities and human dimensions, and communication and capacity development. It also incorporates strategies to facilitate UNDOS cross-cutting inclusivity themes relating to gender equality, early career engagement, and involvement of indigenous communities and developing nations in the planning and implementation of joint activities.

Countries in which the Programme will be implemented

ICES and PICES Member Countries*, as well as countries and organizations with which we have formal affiliations (e.g. Australia, New Zealand, Chile, Peru, South Africa, UN, FAO, IOC, Regional Fisheries Management Organizations, and Regional Seas Conventions)

The ICES and PICES international scientific platform and cooperation thus goes far beyond our Member Countries, and with potential for this programme to be implemented in countries in both the Northern and Southern hemisphere. We expect to develop partnerships with countries in Africa (e.g. Angola, Mozambique, Sao Tomé and Principe and Cabo Verde), Caribbean and Asia, as well as island nations (e.g., East Timor and Palau), Brazil, and India.

*ICES Member Countries; Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Russian Federation, Spain, Sweden, United Kingdom, United States of America

* PICES Member Countries; Canada, China, Japan, Republic of Korea, Russian Federation, United States of America

High-level objectives

Develop and implement a global knowledge network to support knowledge production and dissemination on the status and future of marine social-ecological systems in support of the UN Sustainable Development Goals.

This knowledge will be used to advance and share scientific understanding of marine ecosystems and the services they provide. We will use this knowledge to generate state-of-the-art advice and evidence for meeting conservation, management, and sustainability goals.

The Strategic Plans and Objectives of both organizations are well-aligned with the objectives of the Ocean Decade and our established networks and existing infrastructure will allow us to build on our experience in successfully conducting joint research across our organizations and scientific communities.

During the latter part of 2020, the Governing Councils of ICES and PICES agreed to establish an ICES–PICES Ocean Decade Steering Committee (IPOD SC) to identify activities central to the science objectives of our organizations and the Ocean Decade.

Key expected outcomes

We will increase understanding of the current state and future development of marine social-ecological systems through collaboration of scientists with diverse partners, including under-represented communities, indigenous populations, and early career ocean professionals. We aim to establish a programmatic infrastructure to facilitate transformative scientific research and exchange of information and technical capacity from developed to developing countries as a key outcome. Science will be communicated in a clear, concise manner to achieve solution-based goals for the “ocean we want”.

The ICES–PICES Decade programme – SMARTNET - will identify and facilitate engagement of partner organizations to implement joint UN Ocean Decade activities and enhance communication and outreach to diverse stakeholders. In particular, we acknowledge the

‘Coastal Indigenous Peoples’ Declaration at OceanObs’19’, and similar initiatives, to “establish meaningful partnerships with indigenous communities, organizations, and Nations to learn and respect each other’s ways of knowing; negotiate paths forward to design, develop, and carry out ocean observing initiatives; and share responsibility and resources”. We will engage with organizations that have capacity to bring traditional/indigenous knowledge into our activities. We will also develop partnerships with organizations active in regions outside our formal membership, working in conjunction with the IOC Decade Coordination Unit.

Activities that will be implemented as part of the proposed Decade Programme

There is a long and productive history of collaboration through joint ICES-PICES working groups (see the list below) working on a wide range of topics including climate change impacts on fish and shellfish, biologically-driven ocean carbon sequestration, and regional integrated ecosystem assessments. SMARTNET will leverage the experience and momentum of these joint working groups to expand our work thematically and geographically. Some working groups have also included other organizations, such as the Arctic-oriented Working Groups, and this practice will be extended under the Decade programme to southern hemisphere organizations to deliver the required expansion. We will also coordinate with Global Stakeholder Fora at an early stage to identify and prioritize programme activities. Working group terms of reference are typically updated after 1-5 years to accommodate changing priorities and emerging issues. This iterative process will allow the Decade programme to be dynamic and to evolve as the Decade progresses. Many current joint working groups already have relevance to the planned Decade Outcomes because they were developed with the SDGs in mind. The IPOD Steering committee will develop initial programme priorities and set update Terms of Reference during 2021.

The programme will also leverage ongoing efforts in ICES and PICES to develop a network of Early Career Ocean Professionals (ECOP). We have already jointly-hosted three international Early Career Scientist Symposia to encourage the participation of ECOP in international scientific investigations and to promote their involvement in the management and stewardship of the marine environment. The fourth in the series is scheduled to be held in Canada in May 2022 and will have an Ocean Decade theme. The Scientific Steering Committee, comprising 9 ECOPS from both organizations and the local host, is meeting in January 2021 to develop the programme for this Symposium.

Plans are underway for a first joint ICES/PICES conference in the autumn of 2023, hosted by the USA, in place of separate organizational annual meetings. We propose that this conference be designated as a formal Decade event which will evaluate the early scientific accomplishments and plan further activities that will be conducted during the Decade. Consistent with the goals of the Decade and ICES/PICES shared priorities, the joint conference will also play an important role in furthering development of ECOP, will include representation from indigenous communities and developing nations, and will recognize the importance of gender equality. A second ICES/PICES event is anticipated, likely in the Southern Hemisphere, towards the later stages of the Decade (2028) to review and synthesize accomplishments, and to identify remaining gaps and needed activities.

Ongoing initiatives:

Joint Working Groups:

Joint ICES/PICES Working Group on Small Pelagic Fish

ICES/ PICES Working Group on Ocean Negative Carbon Emission (WG ONCE)

ICES/PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields (WG GRAFY)

ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment (IEA) for the Central Arctic Ocean

Joint ICES/PICES Working Group on Integrated Ecosystem Assessment of the Northern Bering Sea-Chukchi Sea

ICES/PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems

ICES Council Strategic Initiative/PICES Study Group on the UN Decade of Ocean Science

Symposia:

ICES/PICES/NOAA Marine Socio-Ecological Systems Symposium 2021

ICES/PICES Symposium on Small Pelagic Fish: New Frontiers in Science and Sustainable Management 2022.

ICES/PICES Early Career Scientist Conference 2022

Joint ICES/PICES Conference 2023

Joint multiyear programmes:

International Year of the Salmon (ICES (via NASCO)/PICES/NPAFC/other partners)

Please describe the theory of change that underpins your proposed Decade Programme i.e. how will the activities being carried out achieve the outcomes and objectives that you envisage

The Decade of Ocean Science for Sustainable Development offers a unique opportunity to align efforts and link up with partners outside the current constituency. The IPOD Steering Committee will develop and consolidate a strategic plan to bring about transformational science during the Decade by building upon our long history of successful partnerships in advancement of marine science which have included Regional Fisheries Management Organizations (RFMOs), Regional Conventions and member countries. Beyond that, we anticipate close coordination with a range of stakeholders to identify and prioritize programme activities. Establishment of joint working groups provides opportunities to bring together experts and knowledge holders from different organisations, disciplines and backgrounds in a sustained structure that supports the development of joint publications, activities and projects, but is partly dependent on external funding. In addition, we will use and extend our current evaluation processes for these groups to guide the action or project planning, design and implementation, and to monitor and assess activities to identify impact and achievements. Groups report to the steering structures on a yearly basis and produce science reports in open access report series. These evaluation processes have been enabled us to be resilient and adapt to change over many years of individual and collaborative endeavors.

How will the proposed Decade Programme enhance the sustainability of ocean science initiatives, including infrastructure or individual / institutional capacity, in light of the current Covid-19 pandemic

SMARTNET will support and encourage establishment of joint working groups, workshops and symposia with partners of ICES and PICES in the Southern Pacific and Southern Atlantic and will extend cooperation in the Arctic. The international programme will embrace new working cultures, with emphasis on remote meetings, aimed at greater accessibility with reduced travel to reduce greenhouse gas emissions. The infrastructure to allow these groups to work remotely is already available, and has been greatly enhanced through our actions to transfer marine science training, cooperation, and development activities to remote platforms during 2020.

We acknowledge the educational and economic setbacks brought on by the COVID-19 pandemic and will accelerate our efforts to engage programme partners and stakeholders to accomplish our objectives. This includes the development of an international joint graduate education program and extending our training (short-course) programme.

Coordination / management structure for the proposed Decade Programme

ICES and PICES are international scientific organizations that interact and engage with a diverse range of entities, including academia, government agencies, policy-makers, industry, and NGOs throughout the Northern Hemisphere. Our presence in the Southern Hemisphere through partnerships and agreements is already strong and will increase substantially through the SMARTNET Programme. Our organizations play leading roles in advancing and communicating scientific understanding of marine ecosystems for societal outcomes. They are supported by national contracting parties, have established and sustainable infrastructures, and have demonstrated many decades of success in developing and advancing ocean science. Our partnership brings together diverse networks to increase the overall capacity to conduct ocean science in support of sustainable development and to foster the range of skills necessary to support broad and overarching marine science goals.

The IPOD Steering committee will have initial oversight of joint programme activities. Its terms of reference include identifying strategic partners and activities to be carried out within the programme, and establishing a more permanent oversight body after 2021 that will include international partners. The joint oversight expert body will evolve with the Decade, via periodic review of its terms of reference, assessments of where the programme outputs should be better aligned with the Decade as it matures, and the regular rotation of new personnel into the group. Wide geographic representation is assured through the working group membership policies of both organizations. In accordance with ICES and PICES commitments to increase the involvement of Early Career Ocean Professionals (ECOPs) in working groups, ECOPs will form part of the membership of the oversight body which will confer several advantages: mentorship and career development of the ECOPs by senior scientists, ensuring continuity during the Decade and a lasting legacy when the circle is completed as the ECOPs transition into established scientists and new ECOPs begin to participate in the Programme.

To which Sustainable Development Goal(s) (SDG) will your proposed Decade Programme contribute? Please select a maximum of three SDGs

GOAL 1: No Poverty.

GOAL 2: Zero Hunger

GOAL 3: Good Health and Well-being

GOAL 4: Quality Education

GOAL 5: Gender Equality

GOAL 6: Clean Water and Sanitation

GOAL 7: Affordable and Clean Energy

GOAL 8: Decent Work and Economic Growth

GOAL 9: Industry, Innovation and Infrastructure

GOAL 10: Reduced Inequality

GOAL 11: Sustainable Cities and Communities

GOAL 12: Responsible Consumption and Production

GOAL 13: Climate Action

GOAL 14: Life Below Water

GOAL 15: Life on Land

GOAL 16: Peace and Justice Strong Institutions

GOAL 17: Partnerships to achieve the Goal

How will your proposed Decade programme will contribute to the SDGs selected?

All SDGs are intrinsically interlinked. The proposed framework, in collaboration with partner organisations and the financial support of member countries and donors, will develop and support activities, including working groups, workshops and symposia, which produce and synthesize marine scientific and other knowledge which support SDG 13 with focus on target 13.2 (integrate climate change measures into national policies, strategies and planning), and SDG 14, with focus on 14.2 (sustainably manage and protect marine and coastal ecosystems), 14.4 (effectively regulate harvesting and end overfishing), 14.7 (increase the economic benefits to Small Island Developing States), 14a (increase scientific knowledge, develop research capacity and transfer marine technology). Through this process we will also support targets of other SDGs. The implementation will explicitly focus on gender equality, and more broadly on diversity, equality and inclusion. By extending into regions beyond our traditional regional focus we will enhance knowledge exchange and develop capacity for knowledge production, the SMARTNET Programme will be directly responsive to SDG 17, target 17.6 (Enhance North-South, South-South and triangular regional and international cooperation) and 17.18 (By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States).

How will your proposed Decade Programme contribute to the vision and mission of the Decade?

Both ICES and PICES are uniquely positioned to develop and synthesize science to provide the evidence base to support policy and decision makers to achieve a productive, healthy, safe, and resilient ocean. Their experience in communicating with recipients of advice and extending this expertise in engaging with stakeholders and other ocean actors, will concretely support the identification of both the science we need and the joint objectives for the ocean we want. Both organisations have a commitment and strategies in place to build capacity through engagement with ECOPs and less developed countries which will be expanded and emphasised through the Decade Programme. The joint projects and activities that are already active within the SMARTNET Programme and those to be initiated will produce the knowledge base needed to bring about transformational science and facilitate tractable solutions. Partnering RFMOSs and RSCs are already using scientific evidence and advice provided by existing Working Groups. We will also work with international programmes such as Future Earth to facilitate and promote transdisciplinary research and sustainability studies.

In addition, the SMARTNET Programme will be proactive in recommending and seeking resources to improve ocean observing and ecosystem monitoring activities, particularly in regions around least developed and developing countries. Products developed through SMARTNET activities will assist in the identification of key observing gaps and the promotion of emerging technologies.

To which Decade outcome(s) will your proposed Decade Programme contribute?

Outcome 1: A clean ocean where sources of pollution are identified and reduced or removed.

Outcome 2: A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed.

Outcome 3: A productive ocean supporting sustainable food supply and a sustainable ocean economy.

Outcome 4: A predicted ocean where society understands and can respond to changing ocean conditions.

Outcome 5: A safe ocean where life and livelihoods are protected from ocean-related hazards.

Outcome 6: An accessible ocean with open and equitable access to data, information and technology and innovation.

Outcome 7: An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.

How will your proposed Decade Programme contribute to the Decade outcomes selected?

ICES and PICES Science Plans encompass the goals of UNDOS, with science priorities directly addressing the expected societal outcomes. ICES and PICES have existing capacity and well-developed institutional infrastructures supporting marine science research, responding to societal needs. This is made possible through legally binding conventions and commitments from member countries, recognizing the importance of scientific research and coordination of effort, the importance of relating scientific work to national, regional, and global management objectives, and where possible reconciling resource management and biodiversity conservation objectives. This is evident through the unique and collaborative work of our two organizations, which is further strengthened through cooperation with other partners. This extended network has global reach covering the North Atlantic, North Pacific and Arctic and broad thematic scope within and beyond areas of national jurisdiction. We have developed and continue to develop science in areas such as climate change effects on marine ecosystems, fisheries and ecosystem-based management, the human dimension, and capacity building to improve understanding, estimation and prediction (Outcomes 4, 5, 6) to provide evidence to support a clean, healthy, safe, productive, and resilient ocean (Outcome 1, 2, 3) and promoting work ensuring an accessible, inspiring and engaging ocean (Outcome 7).

To which Ocean Decade Challenge(s) will your proposed Decade Programme contribute?

Challenge 1: Understand and map land and sea-based sources of pollutants and contaminants and their potential impacts on human health and ocean ecosystems, and develop solutions to remove or mitigate them.

Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.

Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.

Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions.

Challenge 5: Enhance understanding of the ocean-climate nexus and generate knowledge and solutions to mitigate, adapt and build resilience to the effects of climate change across all geographies and at all scales, and to improve services including predictions for the ocean, climate and weather.

Challenge 6: Enhance multi-hazard early warning services for all geophysical, ecological, biological, weather, climate and anthropogenic related ocean and coastal hazards, and mainstream community preparedness and resilience.

Challenge 7: Ensure a sustainable ocean observing system across all ocean basins that delivers accessible, timely, and actionable data and information to all users.

Challenge 8: Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides

free and open access for exploring, discovering, and visualizing past, current, and future ocean conditions in a manner relevant to diverse stakeholders.

Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders.

Challenge 10: Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean.

How will your proposed Decade Programme contribute to the Decade Challenges selected?

Sustainability of a healthy and resilient ocean for the benefit of future generations requires evidence-based decision-making. Through an ecosystem-based approach, our Decade programme will facilitate science to develop and implement tools and assessments to support decision-making including the evaluation of cumulative effects and analyses of trade-offs among ocean users (Challenge 1, 2, 3, 4, 10). It will provide ecosystem, fisheries, and aquaculture assessments in new areas (ecosystem description, identification of human pressures, and their effect on key ecosystem components), and will advance good practice in including local, traditional, and stakeholder knowledge (Challenge 2, 3, 5, 10). ICES and PICES already coordinate Northern Hemisphere efforts to understand, estimate and predict the impacts of climate change on marine ecosystems. This work is substantive, diverse and includes themes such as: i) global assessment of the implications of climate change on the spatial distribution of fish and fisheries, and forecasting, ii) seasonal to decadal prediction of marine ecosystems, iii) development and evaluation of socio-economic scenarios, and iv) development of scientific evidence to support decision-making. Current efforts in survey design and technology, data analysis and curation will be extended in cooperation with partners, i.e. regional organisations, stakeholders and member countries (Challenge 6, 7, 8, 9).

To which Decade Objective(s) will your proposed Decade Programme contribute?

Objective 1: Identify required knowledge for sustainable development, and increase the capacity of ocean science to deliver needed ocean data and information

Objective 2: Build capacity and generate comprehensive knowledge and understanding of the ocean including human interactions, and interactions with the atmosphere, cryosphere and the land sea interface.

Objective 3: Increase the use of ocean knowledge and understanding, and develop capacity to contribute to sustainable development solutions.

How will your proposed Decade Programme contribute to the Decade Objective(s) selected?

ICES and PICES have extensive and effective infrastructures and networks of expertise to efficiently develop, synthesize and translate scientific information and products which inform management through a transparent, unbiased, impartial, and independent process, providing the evidence base to inform about status and change of marine ecosystems (Objective 1 and 3). We are already key providers of advice for a broad range of organisations and countries and will expand this expertise in collaboration with existing and new partners (Objective 3). Working groups cover ecosystem science, impacts of human activities, seafood production, conservation and management, emerging technologies and the relationship between sea and society (Objective 2). We will extend these activities to include social and economic information in integrated ecosystem assessments, exploration of tools to evaluate marine socio-ecological systems and develop good practice for the co-creation of the evidence base, including development and evaluation of scenarios and solutions with indigenous people, coastal and local communities, and stakeholders as full partners (Objective 1, 2, 3). Strengthened emphasis on science communication and ocean literacy, as well as ECOP development will be leveraged to disseminate the knowledge and products developed in the programme (Objective 3).

With respect to the Decade Objectives selected above, to which Decade Sub-Objective(s) will your proposed Decade Programme contribute?

1.1: Provide the scientific basis for regular integrated assessments of the state of the ocean and identify priority gaps at different scales and in different geographies to frame efforts in exploration, observations and experimentation.

1.2: Promote new technology development and enhance access to technology to generate ocean data, information and knowledge.

1.3: Enhance and expand existing ocean observing systems across all ocean basins to deliver information on standardized essential ocean variables including social and economic, geological, physical, chemical, bathymetric, biological, ecological parameters, and observations on human interactions with the ocean.

1.4: Develop mechanisms that support community-led science initiatives and the recognition and inclusion of local and indigenous knowledge as a fundamental source of knowledge.

1.5: Undertake regular assessments of the state of ocean science capacity to identify and overcome barriers to generational, gender and geographic diversity, and promote sufficient and sustainable investment.

2.1: Generate a comprehensive inventory, mapping, and understanding of the role and function of ocean components including their human interactions and interactions with the atmosphere, cryosphere and the land sea interface.

2.2: Generate a comprehensive understanding of thresholds and tipping points for ocean components, including human interactions.

2.3: Innovate and expand the use of historical ocean knowledge to support sustainable development solutions.

2.4: Improve existing, and develop new generation ocean models for improved understanding of the past, current and future states of the ocean, including human interactions.

2.4: Improve prediction services and increase predictive capability for oceanic hazards or events including extreme weather and climate.

2.5: Expand cooperation in ocean-related education, training, capacity development and transfer of marine technology.

3.1: Broadly communicate and promote the role of ocean science for sustainable development across diverse stakeholder groups including through formal and information education and an expansion of ocean literacy approaches across stakeholder groups.

3.2: Develop interoperable, open access platforms and applications to share data, information and knowledge in a format that connects knowledge generators and users.

3.3: Undertake interdisciplinary, multi-stakeholder co-design and co-delivery of ocean solutions including policy, decision making, integrated ocean management frameworks, applications and services, and technology and innovation.

3.4: Expand and enhance spatial planning processes to contribute to sustainable development across regions and scales.

3.5: Expand and enhance inclusive and integrated management frameworks and tools, including nature-based solutions, to maintain ecosystem functioning, provide for adaptive processes under changing ocean conditions, and incorporate community values and needs.

3.6: Expand and enhance services, applications and management tools for building and mainstreaming preparedness and adaptive responses to multiple stressors and hazards.

3.7: Expand and enhance tools, applications and services that integrate and facilitate use of data, information, and knowledge on ocean-related natural capital including the social, cultural, environmental, and economic characteristics of the ocean.

How will your proposed Decade Programme contribute to the Decade sub-objectives selected?

ICES and PICES are established intergovernmental platforms for science cooperation with an extended scientific network spanning more than 60 countries, 700 institutes, and a pool of more than 6000 experts (1.1). Science is developed through working groups, annual science meetings and symposia. Activities span across all marine science disciplines, improving the understanding, integrated assessment and prediction of marine socio-ecological systems (2.1, 2.2, 2.3, 2.4). Education and training programmes will be further developed in cooperation with partner organizations to improve capacity development (2.5, 3.1). Mechanisms already allow participation of observers and stakeholders and we will develop a process for including indigenous and local actors (1.4). We will also develop processes to ensure ensuring a diverse, inclusive, and gender balanced working environment and to transfer knowledge and technical capacity from ICES and PICES member countries to least developed and developing countries (1.4, 1.5). ICES and PICES have extensive experience in coordinating joint monitoring programs and developing data and technology science (1.2, 3.2). Our Data Centres already provide data services to a range of organizations, with data, data tools, and data products available online and compliant with commitments to ensure open data access and FAIR principles (1.3, 3.7).

Please check which of the following criteria are relevant to your proposed Decade Programme as far as they are relevant to your proposal:

Accelerate the generation or use of knowledge and understanding of the ocean, with a specific focus on knowledge that will contribute to the achievement of the SDGs and complementary policy frameworks and initiatives.

Is co-designed or co-delivered by knowledge generators and users, and does it facilitate the uptake of science and ocean knowledge for policy, decision making, management and/or innovation.

Will provide all data and resulting knowledge in an open access, shared, discoverable manner and appropriately deposited in recognized data repositories consistent with the IOC Oceanographic Data Exchange Policy[1] or the relevant UN subordinate body data policy. (If you check this criteria, please provide in the question below details of where data will be deposited and where it exists, attach a data management plan.)

Strengthen existing or create new partnerships across nations and/or between diverse ocean actors, including users of ocean science.

Contribute toward capacity development, including, but not limited to, beneficiaries in Small Island Developing States, Least Developed Countries and Land-locked Developing Countries.

Overcome barriers to diversity and equity, including gender, generational, and geographic diversity.

Collaborate with and engage local and indigenous knowledge holders.

How will your proposed Decade Programme contribute to the Decade criteria selected?

Collaborative integrated projects and activities initiated under the SMARTNET Programme will be developed and implemented through partnerships and collaborations in to substantially advance our understanding of processes and phenomena in ocean ecosystems. Access to data will be based on the principle of open data and an adherence to the FAIR principles (Findable, Accessible, Interoperable, Reusable), acknowledging the need to exclude some data from unrestricted access due to sensitivities, such as sensitive location information (e.g. vulnerable marine ecosystems).

Emerging conservation activities will be addressed, including a focus on marine biodiversity in areas beyond national jurisdiction, microplastic pollution, and further advancing a better understanding on the ocean ecosystem functioning under progressive climate change and human impacts.

This will be accomplished with full participation of the new generation of marine researchers, supporting involvement in large-scale international research projects, by invitations to (co-)author publications. This inclusion and participation will extend across international research communities, in an overall effort to promote career prospects and develop the future leadership. All activities will recognize our commitment to pursue a diverse, inclusive, and gender balanced working environment and to ensure transfer of knowledge and technical capacity from developed countries within ICES and PICES to least developed and developing countries.

Please describe how you plan to communicate about your proposed Decade Programme including the main target audiences and methods of communications.

Science communication and ocean literacy are integral components of the work of ICES and PICES. Developing tailored outputs for target audiences using appropriate media will be an important objective for the programme.

Programme progress will be communicated broadly using available Ocean Decade mechanisms, as well as established and developing ICES and PICES channels.

Programme outputs will pursue peer-reviewed publications. Outputs may also be peer-reviewed and quality assured translation of science into policy and management relevant advice (e.g. ICES Viewpoints, see for example here:
http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/vp.2020.01.pdf)

Specific messages resulting from these publications and outputs will be tailored for target audiences at all levels, and across sectors: policymakers; management bodies, scientific community, and the informed public.

Social media will be leveraged to amplify the messages and communicate broadly.

PICES has recently established a Study Group in Science Communications with a specific goal of enhancing the communication of PICES sciences, especially within the context of the Ocean Decade, by broadening the scope of its scientific community to include communication specialists (e.g., designers, journalists, videographers, artists, educators) and policy makers. Specific deliverables include establishing international transdisciplinary opportunities to enhance communication capacity of PICES science, promoting ”green” science and highlighting carbon reduction, especially developing a strategy for PICES meetings to become carbon neutral within the next decade.

ICES has a dedicated Communications team that will be engaged to help convey agreed outcomes and messages, using appropriate media including the ICES website and social media channels.

SUPPLEMENT B: SMARTNET Ocean Decade endorsement letter from the Intergovernmental Oceanographic Commission.

INTERGOVERNMENTAL OCEANOGRAPHIC CO
COMMISSION OCÉANOGRAPHIQUE INTERGO
COMISIÓN OCEANOGRÁFICA INTERGUBERN
МЕЖПРАВИТЕЛЬСТВЕННАЯ ОКЕАНОГРАФИ

UNESCO

UNESCO - 7 Place de Fontenoy - 75352 Paris Cedex 07 SP, France
http://ioc.unesco.org - contact phone: +33 (0)1 45 68 03 18
E-mail: v.ryabinin@unesco.org

Ref. : IOC/VR/21.134/JB/AC/ic 7 June 2021

Dear Madam, Sir,

It gives me a great pleasure to inform you of the endorsement of the Decade Action entitled "No. 90 - Sustainability of Marine Ecosystems through global knowledge networks", which you submitted in response to the Call for Decade Actions No. 01/2020 as a programme of the UN Decade of Ocean Science for Sustainable Development. Please accept my sincere congratulations on this achievement.

The endorsement of your programme is a milestone in your involvement in the Ocean Decade. I would cordially request you to please undertake the following steps:

(i) Please review the attached Charter for Endorsed Decade Programmes, which includes further information on their functioning and roles as part of the Ocean Decade.
(ii) Please review the information on the Ocean Decade Communities of Practice at this link and sign up to one or more of the Communities of Practice that are relevant to your programme. Via that link you will also be asked to respond if you would be willing to play a lead role in co-organising a virtual "meet and greet" between Community of Practice members in coming months.
(iii) Please review the Communications Welcome Pack and provide the name and contact details of a focal point for communications within your team. In coming weeks we will be reaching out to you regarding the official announcement of your Decade Action, and it would be greatly appreciated if you could provide the information requested in the Welcome Pack to allow us to develop social media assets and a factsheet for your programme as soon as possible.
(iv) Please provide the name and contact details of an Early Career Ocean Professional (ECOP) focal point within your team that can be put in contact with the Ocean Decade ECOP Informal Working Group.
(v) Finally, please review, print on your institutional letterhead, and then sign and send the attached acknowledgement letter confirming receipt of this letter and the information contained herein.

.../...

International Council for the Exploration of the Sea (ICES)
Copenhagen V, Denmark
The North Pacific Marine Science Organization (PICES)
Sidney, British Columbia, Canada

Due to formal legal reasons, please kindly be aware of the following disclaimer. Endorsement of your programme does not imply endorsement by the IOC/UNESCO of any business type, product or service. Nothing in or relating to this letter and its attachment shall be deemed a waiver of any of the privileges and immunities of UNESCO. All disputes arising out of or in connection with this letter and its attachment and your acceptance thereof shall be settled by mutual understanding. However, if no amicable settlement can be arrived at, any dispute shall be arbitrated according to the rules defined by the United Nations Commission on International Trade Law (UNCITRAL).

In coming weeks we will also be in touch with you to request additional information to aid in the development of a consolidated resource needs assessment for Decade Actions and to discuss the process of identifying and endorsing projects that will form part of your programme. In the meantime, if you have any questions or require any additional information on the above please do not hesitate to contact us at oceandecade@unesco.org.

Again, on behalf of the entire Ocean Decade Team, please accept my heartfelt congratulations on the endorsement of your Decade Action. Together, let us work towards the ocean we want!

Sincerely,

Vladimir Ryabinin
Executive Secretary, IOC

CHARTER FOR ENDORSED DECADE PROGRAMMES

Congratulations! After a thorough review process following the process outlined in the Ocean Decade Implementation Plan, the Executive Secretary of the Intergovernmental Oceanographic Commission of UNESCO (IOC) has endorsed your Decade Programme as part of the UN Decade of Ocean Science for Sustainable Development (the Ocean Decade).

This endorsement is a recognition that your programme will play a central role in supporting the Ocean Decade mission to catalyse transformative ocean science solutions for sustainable development, connecting people and the ocean, in order to achieve the Ocean Decade vision of 'the science we need for the ocean we want'.

This Charter document sets out the responsibilities of the partners responsible for implementing the programme, as well as providing other useful information and conditions pertaining to the endorsement.

I. DURATION AND SCOPE OF ENDORSEMENT

1. The endorsement of the programme will be valid for the duration that you identified in your submission. If there is a change in the duration of the implementation period of more than six (6) months, please notify the Decade Coordination Unit in writing so that we can determine whether a subsequent endorsement evaluation is required.
2. The endorsement of the programme is for the scope that was detailed in the submission to the Decade Coordination Unit, any subsequent supplementary information provided to the Decade Coordination Unit during the evaluation process, and any conditions or requirements identified in the endorsement letter from the Executive Secretary of the IOC. If you plan any significant changes to the programme, including its strategy, plan and/or partners, please advise the Decade Coordination Unit as soon as possible to that we can determine whether a subsequent endorsement evaluation is required.

II. RESPONSIBILITIES OF AN ENDORSED DECADE PROGRAMME

3. As a Decade Programme, your programme will play a prominent role in delivering against the ambitions of the Ocean Decade and contributing to one or more Ocean Decade Challenge[s]. Specifically, the endorsed programme will be responsible for:
   i. Playing an active and lead role in relevant Communities of Practice via the Global Stakeholder Forum to optimise synergies and collaboration with other Decade stakeholders and thus contribute to the collective impact of the Decade.
   ii. Ensuring close and regular coordination and communication with the relevant Decade coordination structures nominated by the Decade Coordination Unit including Decade Coordination Offices, Decade Collaborative Centres and Decade Implementing Partners. This includes, amongst other issues, provision of information on attached Decade projects, as well as information needed for gap analyses, resources needs assessments, work planning, and annual monitoring and reporting. The Decade Coordination Unit will provide information on the Decade coordination structures relevant to your programme.
   iii. Ensuring coordination across partners in the endorsed Programme. This will include facilitating co-design and co-delivery of programme initiatives to meet the Programme's stated objectives, as well as coordinating work planning, implementation of activities, collation of information on resource needs and monitoring, and contributing to communications and outreach.
   iv. Contributing to gap analyses processes led by the Decade coordination structures and coordination of programmatic input to the development of Calls for Decade Actions at the project level. We may also ask you to provide recommendations and advice to the Decade

Coordination Unit in relation to the requests for endorsement for Decade projects that apply to join the endorsed programme.

v. Working with Decade coordination structures and relevant Network Programmes to catalyse the co-design and co-delivery of new Decade Actions and partnerships that could be attached to the endorsed programme as projects or activities. This will include actively fostering and creating a structure within which new projects can be identified and attached to the endorsed programme once endorsed by the Decade Coordination Unit.

vi. Coordinating communication and collaboration with leads of attached Decade projects in order to ensure coherence in activities and contribution to overall work planning, implementation and monitoring. This will include supporting Decade projects to deliver required monitoring information, and collecting information to inform resource needs assessments and communications products.

vii. Consolidating annual monitoring information at the programme level for sharing with the Decade Coordination Unit in line with the requirements of the Decade Monitoring & Evaluation framework that will be provided to the lead partner of the endorsed programme. The Decade Coordination Unit will provide information on the annual monitoring information that you will need to provide.

viii. Providing regular information on resources needs and gaps for operational and coordination activities. Playing a lead and active role in resource mobilisation efforts for the endorsed programme, and ensuring close and regular coordination and communication with Decade coordination structures in relation to resource mobilisation efforts, achievements and opportunities.

ix. Contributing to communications and outreach activities to engage new partners and new projects and raise awareness of the impact and achievements of the endorsed programme and its component projects.

x. Contributing to regular review processes led by the Decade coordination structures that are envisaged in the Implementation Plan.

III. BENEFITS OF AN ENDORSED DECADE PROGRAMME

4. Your programme will be recognized and showcased on the Ocean Decade website (oceandecade.org), included in Ocean Decade communications materials and assets (e.g. social media channels, reports, Ocean Decade events).

5. As a Decade Programme, you will be able to use the Ocean Decade logo in line with the Ocean Decade Branding Guidelines in relevant materials and assets, including, but not limited to, peer-reviewed papers, reports, programme website, programme materials, press materials and/or social media channels. Please note that you can cannot grant or authorise use of the logo by any third party.

IV. SUSPENSION OR TERMINATION OF ENDORSEMENT

6. Please note that the IOC may terminate this endorsement on the basis of advice from the Decade Advisory Board if there is a failure to fulfil the responsibilities outlined in this Charter or if annual resources needs assessments indicate that despite the best efforts of the Programme Lead and the Decade coordination structures the programme has failed after a reasonable period of time to mobilise sufficient resources to operate as a Decade Programme.

7. Should the endorsement be terminated, you will no longer be able to use the Ocean Decade logo and it must be removed from any programme materials and assets.

8. The Programme Lead may also indicate in writing to the IOC at any time that it no longer wishes to be recognised as an endorsed Decade Programme.

Thank you for your engagement in the Ocean Decade and we look forward to creating the ocean we want by 2030!

ACKNOWLEDGEMENT LETTER – PLEASE PRINT ON YOUR INSTITUTIONAL LETTERHEAD AND SEND A SIGNED COPY TO j.barbiere@unesco.org with copy to a.clausen@unesco.org and oceandecade@unesco.org

Dear Executive Secretary,

I confirm receipt of your letter dated [INSERT DATE] advising of the endorsement of [INSERT PROGRAMME NUMBER AND NAME] as an endorsed programme of the UN Decade of Ocean Science for Sustainable Development. I have read and acknowledge my understanding of the information contained in the letter and the Charter for Endorsed Decade Programmes in the attachment.

I am pleased to advise the name and contact details of:

1. Communications Focal Point
    a. [NAME]
    b. [EMAIL ADDRESS]

2. Early Career Ocean Professionals Focal Point
    a. [NAME]
    b. [EMAIL ADDRESS]

Sincerely,

[SIGNATURE REPRESENTATIVE OF THE LEAD PARTNER OF THE DECADE CONTRIBUTION]

Name: [INSERT NAME]

Title: [INSERT TITLE}

Institution: [INSERT NAME OF LEAD PARTNER INSTITUTION]

Date: [INSERT DATE]

SUPPLEMENT C: ICES-PICES Ocean Decade SMARTNET Steering Committee Membership (July 2024). PICES members serve on the Advisory Panel on the UN Decade of Ocean Science (AP-UNDOS).

Kathryn Berry (BECI, ex-officio)

Steven Bograd (USA, Co-Chair)

Sanae Chiba (SECRETARIAT, Co-Chair)

Emanuele Di Lorenzo (USA)

Kirstin Holsman (USA)

Jennifer Jackson (CANADA)

Khushboo Jhugroo (CANADA)

Sukyung Kang (KOREA, Science Board)

Emily Lemagie (USA)

Li Li (CHINA)

Hyung-Gyu Lim (Korea)

Mitsutaku Makino (JAPAN)

Hanna Na (KOREA)

Fangli Qiao (CHINA)

Raphael Roman (CANADA)

Hiroaki Saito (JAPAN)

Erin Satterthwaite (USA)

Vera Trainer (USA)

Andrea White (Canada)

Sinjae Yoo (Korea)

Silvana Birchenough (UK)

Alan Haynie (SECRETARIAT)

David Reid (SECRETARIAT, Co-Chair)

A. Miguel Santos (PORTUGAL)

Olivier Thibaud (FRANCE)

SUPPLEMENT D: PICES Advisory Panel on the UN Decade of Ocean Science (AP-UNDOS) Terms of Reference (July 2024).

1. Define and promote the joint scientific activities of PICES and partner organizations (including ICES) that will contribute to UN Ocean Decade societal outcomes.

2. Implement the SMARTNET Programme (in partnership with ICES), organize its activities and partnerships, monitor its progress, and communicate updates to the PICES community.

3. Implement a strategy that prioritizes engagement with early career ocean professionals, indigenous communities, developing nations, and recognizes the importance of promoting diversity and gender equity in our activities; Coordinate with FUTURE SSC, AP-ECOP and AP-SciCom to develop these strategies.

4. Develop recommendations for new UN Ocean Decade activities for endorsement by UNESCO-IOC, with new and existing partners, allowing for participation of additional partners throughout the Decade.

5. Develop recommendations for new and existing PICES Expert Groups to implement and maintain SMARTNET and UN Ocean Decade activities, and encourage and support Expert Group participation in all aspects of the UN Ocean Decade.

SUPPLEMENT E: Memorandum of Understanding between PICES and the Asia Pacific Network.

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APN-PICES Collaborative Framework for Scientific Cooperation

Executive Summary

The Asia-Pacific Network for Global Change Research (APN) and North Pacific Marine Science Organization (PICES) are Intergovernmental Organizations with shared goals, particularly in terms of supporting international cooperation in research and capacity development, and partly overlapping geographic regions of focus. The joint APN-PICES Study Group for Scientific Cooperation in the Pacific Ocean (SG-PICES-APN) developed a framework that strives to enhance collaboration between the two organizations. This collaborative framework identifies several broad areas of joint interest to PICES and APN on which progress could be made over the next five years. Research areas relating to climate change (for example; sustainable fisheries, ecosystem services and food security, impacts of extreme events on coastal communities and the need for adaptation and disaster risk reduction) as well as marine plastic debris and microplastics, and downscaling of regional climate models are current foci for both organizations. Two common types of activity that spanned these research areas were also identified, one being the capacity development of early career professionals and the second being the engagement of Local and Traditional Ecological Knowledge (LTEK), a cross-cutting theme for the climate change research areas, in particular.

The framework identifies various mechanisms for implementing enhanced collaboration between PICES and APN including workshops and joint working groups, topic sessions at PICES Annual Meetings, representation at each other's meetings and/or workshops. As areas of interest and priorities change over time, the joint areas for collaboration may be updated.

Following approval from both organizations, routine monitoring of the progress of activities will be completed jointly by the Secretariats of PICES and APN and reported to the PICES Science Board annually, and APN's Intergovernmental Meeting (IGM) and Steering Committee (SC) on a regular basis, respectively.

Background

The Asia-Pacific Network for Global Change Research (APN) and North Pacific Marine Science Organization (PICES) are Intergovernmental Organizations with shared goals, particularly in terms of supporting international cooperation in research and capacity development, and partly overlapping geographic regions of focus.

APN was established in 1996 as an intergovernmental network working towards an Asia-Pacific region that is successfully addressing the challenges of global change and sustainability. A list of the member countries of APN can be found here.

APN's mission is to support a cohesive and interactive community of global change researchers, policymakers, practitioners and civil society across the Asia-Pacific region through innovative and transdisciplinary approaches that draw upon the extensive network of science-policy practitioners. An integral part of its mission is to support and promote the scientific investigations of changes in the Earth's life support systems and their implications for sustainable development in the Asia-Pacific region. The APN contributes to the realization of these investigations through:

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1. Supporting research and science-based response strategies.
2. Effectively linking scientific outcomes with policy mechanisms applicable to all levels of governance and societal sectors in each country.
3. Scientific capacity development within and beyond governments, including affected communities and other members of civil society.

PICES was established in 1992 to:

- **I.** promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources, including but not necessarily limited to research with respect to the ocean environment and its interactions with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna and ecosystems, its uses and resources, and impacts upon it from human activities;
- **II.** promote the collection and exchange of information and data related to marine scientific research in the area concerned.

The Organization receives recommendations on the science program from the Science Board Executive Committee, which is supported by a number of permanent scientific and technical committees, along with an assemblage of "expert groups" with various life-spans. The PICES Convention Area is defined as "the temperate and sub-Arctic region of the North Pacific Ocean and its adjacent seas, especially northward from 30 degrees North Latitude, hereinafter referred to as the "area concerned". Activities of the Organization, for scientific reasons, may extend farther southward in the North Pacific Ocean."

The present PICES members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America. All PICES countries, except Canada, are currently also members of APN.

Development of Collaboration

Reciprocal participation in annual meetings of both organizations in 2020 prompted the recognition of shared priorities and that closer ties, and planning of joint activities, would be mutually beneficial. A joint Study Group (SG) to develop a Framework for Scientific Cooperation was developed and approved by PICES Governing Council in 2021 [GC Decision 2021/S/3] with a Terms of Reference that can be found here: study-groups - PICES - North Pacific Marine Science Organization. Identification and approval of members was hampered by the COVID-19 pandemic, which prevented any in-person meetings and took some time, however, the Study Group had its first online meeting in February 2022. The SG met virtually three more times through 2022 and corresponded online to draft the present Collaborative Framework which was presented to PICES Science Board and Governing Council at PICES-2022. Representatives of both organizations also met in-person at PICES-2022 to discuss next steps. The present Collaborative Framework will be presented for consideration and approval to the APN Steering Committee either via email or on the occasion of its 51st Meeting in early 2023.

Collaborative Framework

APN Science Priorities

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Through support of regional and international cooperation in research on inter- and transdisciplinary global change and sustainability issues particularly relevant to the Asia-Pacific region, APN aims to produce policy–relevant scientific knowledge that can contribute to the implementation of international agendas, such as the UNFCCC's Paris Agreement, Sustainable Development Goals, Sendai Framework for Disaster Risk Reduction, Post-2020 Global Biodiversity Framework, UN Decade of Ocean Science (2021-2030), and the accumulation of scientific knowledge in science-policy assessment bodies such as IPCC, IPBES, etc.

Global change affects all countries, and its impacts and the ability to measure and understand these impacts intersects different disciplines. Therefore, APN strives to address global change and sustainability in a holistic manner that involves active participation of all member countries across a broad spectrum of thematic areas under the global environmental change umbrella, including:

- Climate;
- Biodiversity and ecosystems;
- Air, land, coasts and oceans;
- Food, water and energy;
- Risk and resilience; and
- Human dimensions.

Capacity development of early-career scientists and professionals, and members of other societal groups is vital to enable APN member countries to formulate scientific evidence-based policies. Therefore, APN continuously stives to improve its capacity development agenda through:

- Enhancing efforts in providing support to early-career professionals through tailored research activities;
- Enhancing efforts in providing capacity development to early-career professionals that meet their specific needs, for example, by training them in developing high-quality scientific proposals;
- Continuing to strengthen APN's capacity development programme, CAPaBLE.
- Creating holistic and transdisciplinary capacity development activities on topics of relevance in the Asia-Pacific region.

PICES Science Priorities

PICES promotes transdisciplinary, multi-national collaborations to further collective understanding of the North Pacific's natural systems. As part of its vision, PICES aspires to be a leading contributor to global marine science and to be sought as a valued collaborator in addressing current and future management issues. The first goal of the 2016 PICES Strategic Plan is to "*Foster collaboration among scientists within PICES and with other multinational organizations, particularly with those that have common goals*".

PICES activities have been further guided by its current 10+-year integrated research program FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems). FUTURE is an integrative science program with a goal to understand and communicate the future of North Pacific ecosystems and the potential impacts from human use. More specifically, the program seeks to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders, and the public. FUTURE is in its synthesis phase and is due to end in 2024.

In January 2021 the United Nations launched a Decade of Ocean Science for Sustainable Development (UNDOS), which was seen as a valuable opportunity for PICES to expand its horizons, building on FUTURE's achievements and providing a new iteration of integrated activities. A joint program proposal (SmartNet) was submitted with our sister organization, ICES, in the Atlantic, and was endorsed by the Intergovernmental Oceanographic Commission. SmartNet now forms a major focus within PICES which will last until 2031. It will establish a global knowledge network (GKN) for ocean science by strengthening and increasing the collaboration of ICES/PICES and partner organizations. It will support and leverage ICES/PICES member countries' activities related to UNDOS, by emphasizing areas of mutual research interest including climate change and ecological forecasting, fisheries and ecosystem-based management, and the social, ecological and environmental dynamics of marine systems, including coastal communities. It also incorporates strategies to facilitate UNDOS cross-cutting inclusivity themes relating to gender equality, early career engagement, and involvement of indigenous communities and developing nations in the planning and implementation of joint activities. The governance structure and implementation plan for Smartnet is currently being developed and will develop recommendations for new and existing Expert Groups.

Scientific Areas of Joint Interest

The criterion used to determine topics that are of mutual interest and which to focus on in the short-term was a shared relevance to both Organization's objectives or priority areas. Research areas and activities where collaboration would be desirable were identified (**Table 1**) together with the priority for each organization.

Collaboration Mechanisms

Potential mechanisms for enhancing collaboration between APN and PICES include:

1. Workshops or Topic Sessions at PICES annual meetings

Joint sessions at PICES annual meetings, typically held in October, are an excellent potential mechanism for cooperation between PICES and APN. Most past annual meetings include examples of sessions that PICES has co-convened with other organizations, such as CLIVAR (Climate and Ocean: Variability, Predictability and Change), ICES (International Council for the Exploration of the Sea), IMBER (Integrated Marine Biogeochemistry and Ecosystem Research), NOWPAP (Northwest Pacific Action Plan), and SOLAS (Surface Ocean Low Atmosphere Study), among others. The benefits of sharing research findings in a theme session or sharing expertise in workshops have been demonstrated by these examples.

Topic session proposals from PICES scientists and co-sponsoring organizations should be submitted to the PICES website by the deadline, typically September 1 of the calendar year before the Annual Meeting of interest. Proposals should include: a title, duration (full or half day), session description, list of conveners, sponsoring PICES Scientific Committee(s), co-sponsoring organizations (if any), and whether (and where) a publication is intended. At the Committee meetings at the Annual Meeting in the fall (the year before the meeting of interest), recommendations for which session proposals to support are finalized. The Committee Chairs then present the recommendations to the Science Board (SB) who will evaluate and agree on co-sponsoring of sessions. The agreement will consider not just the scientific excellence and appropriateness of the proposals, but also the financial constraints of funding such sessions. The final list is then submitted to PICES Governing Council for final approval.

2. Joint Working Groups

Similar to the current joint APN-PICES Study Group on Scientific Cooperation in the North Pacific Ocean to develop the present Collaboration Framework, there may be a need to form other joint expert groups to address research priorities. Joint working groups represent one of the most effective mechanisms for collaboration and cooperation when there is a need to focus on a specific topic with specific deliverables defined by terms of reference. In general, joint working groups would be formed following one or a series of meetings and/or workshops that are organized on a common theme. Thus, effective planning is a crucial element in successfully establishing a new and productive working group. Typically, in PICES, a working group has a duration of three years. A proposal for a new working group should be submitted by one of the Committees to PICES Science Board for their review.

3. Conferences and Symposia

Normally, PICES organizes one major symposium per year in addition to its annual meeting. Typically, this symposium is jointly sponsored because of the financial commitments required to organize a major symposium. Organizations seeking co-sponsorship of a symposium by PICES should direct a letter of invitation to the Executive Secretary of PICES that describes the scientific rationale, other co-sponsoring organizations and a summary of roles and financial/in-kind contributions expected of PICES. Significant commitments of resources typically require 2–3 years advance planning. A potential example that may be an opportunity for co-sponsorship by APN is the next in the series of Early Career Scientist conferences (these alternate between ICES and PICES leadership), which would be expected to take place in a PICES country in 2027.

4. Representation at meetings and/or workshops

PICES and APN have a history of having representatives from other organizations participate in the annual meeting, including business meetings of relevant expert groups and workshops, where they can report on their organization's activities of interest and so foster collaboration. It is recommended that both organizations consider inviting one or more representatives from the other organization to participate in the meetings of, for example, the Steering Committee and Subregional Committee for the Pacific (for APN) and Science Board (for PICES) to update those bodies on ongoing research activities and research priorities for the future.

While hindered by the COVID pandemic, APN conducts at least one in-person subregional workshop to train early-career professionals on how to develop and submit effective proposals to APN for funding. In its current round of 2021 proposals, early-career professionals are leading 69% of projects funded by APN. This is a good indicator of its success. As APN's Pacific subregional Proposal Development Training Workshop (PDTW) is expected to be held in the coming year or two and as PICES and APN collaboration is engaging Pacific subregional members of APN, there is a potential opportunity to have a joint Proposal Development Training Workshop on one or more of the topics identified in the introduction. A similar opportunity may also be relevant for North Pacific Countries as well as APN and PICES members overlap. This is an area worth exploring further.

Monitoring and Reporting

Following the approval and implementation of this collaborative framework by the respective bodies of PICES and APN (i.e., the Science Board and the Steering Committee), this framework will continue for a period of five years at which time it will be reviewed to assess the progress on the areas identified in Appendix 1, and to identify new areas for collaborations. The review should also assess the collaboration mechanisms by identifying which ones were employed, the utility of those mechanisms in achieving desired results, and identify new mechanisms for future joint collaboration.

On an annual basis, there will be a progress report prepared by the Secretariat of each organization that is available for its members. This progress report should be common for both organizations, be a summary of joint activities between PICES and APN (including status and actions required to make progress on objectives), and be prepared in collaboration by both Secretariats. Further, this progress report will be presented annually at the PICES Science Board and the APN ~~annual~~ Steering Committee meetings as part of a standing item on their agendas. If modifications/alterations are required to joint activities to enable enhanced productivity and success, these recommendations will be approved by both the PICES Science Board and APN Steering Committee (via correspondence if necessary). For any joint activity that is completed, the co-convenors will prepare a summary report of the activity and it will be available for all members of both organizations.

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Table 1. Recommended joint PICES-APN focus areas with associated rankings and mechanism to achieve progress within 5 years.

Activity or Research Area	PICES Rank	APN Rank	PICES Focus	APN Focus	Mechanism and potential platforms	Priority in next 5 years
Activity: Capacity Development of ECOP. i. UNDOS cross-cutting theme	High	CD of ECPs: high	Major objective of SmartNet (UNDOS program). Major focus area for PICES recently with Advisory Panel on ECOP advisory-panels - PICES - North Pacific Marine Science Organization approved in 2021	One of the goals of APN's 5th Strategic Plan is capacity development, particularly that of early career professionals (ECPs)	1. APN – Capacity development programme (CAPaBLE) is one of the two main pillars of APN's activities; 2. APN's Proposal Developing Training Workshop (PDTW) in the Pacific region may benefit from PICES input if there is a marine theme. 3. Next ICES-PICES ECS Symposium planned for 2027	High, Relevant to UNDOS
Activity: Engaging Local and Traditional Ecological Knowledge i. UNDOS cross-cutting theme ii. Indigenous knowledge in the context of adaptation and disaster risk reduction iii. Indigenous Knowledge in the context of food and water security	High	High (for the Pacific SRC)	Major objective of SmartNet. Some activity at PICES-2022 (W6 for Bering Sea), Also planned for PICES-2023	"Global and indigenous knowledge" was one of the high priority topic areas of P-SCR for the 2021 call for proposals.	Workshops at upcoming events Will be discussed at PICES-APN side meeting in Busan, Sept 2022	High, relevant to UNDOS
Research area: Climate change; sustainable	High	Climate Change:	Major objective of SmartNet, and several	1. Food security (and habitat value)		High, priority research area

fisheries		high	PICES Expert Groups	2. Ecosystem services (non-food related) including cultural services		
Research area: Climate change; impacts of extreme events on coastal communities	High	High	New Working Group (WG49)	Adaptation and disaster risk reduction	Review WG plans as they develop. Look for opportunities to share outputs. Add an APN Ex-officio member	High, priority research area
Research Area: Marine plastic debris and microplastics	High	High	WG42 working-groups - PICES - North Pacific Marine Science Organization will end in 2022 but have indicated there should be a follow-on expert group (possibly a Section) to continue the work and link to Global initiatives	Marine plastic debris and microplastics are one of the focused areas under Goal 1 "Research" of APN's 5th Strategic Plan.	Include APN members in a new Expert Group? Review WG plans as they develop. Look for opportunities to collaborate and share outputs.	Med-high, awaiting outcome of PICES Science Board recommendation on new EG
Research Area: Regional climate model downscaling in the Pacific	High	High	Active area of research in PICES nations; theme of S-CCME; theme of SUPREME and BECI (UNDOS Program/Project)	"Regional climate downscaling in the Pacific" was one of the high priority topic areas of P-SCR for the 2021 call for proposals.	"Regional climate downscaling in the Pacific" will remain a high priority topic of P-SRC for the APN FY 2022 Call for Proposals	High
Research Area: Circular and Ecological Economy	Med	High	Likely of interest to PICES Human Dimensions Committee.	CEE is one of the focused areas under Goal 1 "Research" of APN's 5th Strategic Plan. Circular and Ecological Economy (CEE) is an initiative to enhance sustainable socio-economic activities by drawing on locally		Med-high

				available energies, natural resources, infrastructure, industrial conglomerations, as well as the indigenous culture, particularly in rural areas.		

The Asia Pacific Network-North Pacific Marine Science Organisation (PICES) Collaborative Framework for Scientific Cooperation

The Collaborative Framework for Scientific Cooperation between the APN and PICES comes into effect when signed below by both parties, and will continue for a period of five years at which time it will be reviewed to assess progress.

The Collaborative Framework may be revised at any point as agreed by both parties, and may be renewed for a further period if approved by both the PICES Science Board and APN Steering Committee.

富坂隆史

Signature 17 February 2023 **Date**

Ryuji Tomisaka, Director, Secretariat
Asia-Pacific Network for Global Change Research (APN)
4F, East Building
1-5-2 Wakinohama Kaigan Dori, Chuo-ku,
Kobe 651-0073, Japan
rtomisaka@apn-gcr.org

Signature February 14th 2023 **Date**

Sonia Batten, Executive Secretary,
North Pacific Marine Science Organization (PICES)
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Appendix 4

MOU between PICES and Ocean Decade International Cooperation Center China (ODCC)

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE NORTH PACIFIC MARINE SCIENCE ORGANIZATION
AND
OCEAN DECADE INTERNATIONAL COOPERATION CENTER,
CHINA

The North Pacific Marine Science Organization, hereinafter called “PICES”, and the Ocean Decade International Cooperation Center, China, hereinafter called “the ODCC”;

RECOGNIZING that the North Pacific Marine Science Organization (PICES), exists to:
a) promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources including, but not necessarily limited to, research with respect to the ocean environment and its interaction with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna, and ecosystems, its uses and resources, and impacts upon it from human activities; and
b) promote the collection and exchange of information and data related to marine scientific research in the area concerned;

NOTING that in order to further enhance its institutional capabilities, the PICES seeks to establish and maintain mutually agreed working arrangements with other international organizations that have related objectives;

RECOGNIZING that the Ocean Decade International Cooperation Center (ODCC), China was jointly established by the Ministry of Natural Resources, PRC, the Shandong Provincial People’s Government and the People’s Government of Qingdao Municipality and it aims to become a comprehensive, innovative, and leading international cooperation platform to promote sustainable development of the oceans. The ODCC aims to support the UN Ocean Decade with cross-sectoral collaborative efforts and serves as a Secretariat office for the Chinese National Decade Committee.

The main duties and missions of ODCC include：

a) In-depth engagement in the Ocean Decade.
b) Establish a concentration area for ocean-related international organizations.
c) Construct the East Asia Marine Cooperation Platform.
d) Foster the best practices to support the Ocean Decade.

NOTING that in order to carry out these tasks appropriately and efficiently, the ODCC seeks to establish and maintain mutually agreed working arrangements with other international organizations which have related objectives;

RECOGNISING that the achievement of the objectives of PICES and ODCC will benefit from Cooperation, and DESIRING to put into place arrangements and procedures to promote cooperation in order to support the UN Decade of Ocean Science for Sustainable Development.

NOW THEREFORE, PICES and ODCC, hereinafter called “the Parties”, have agreed to the following:

I. OBJECTIVE OF THIS MEMORANDUM OF UNDERSTANDING

1. The objective of this Memorandum of Understanding (MoU) is to facilitate cooperation between PICES and ODCC (the Parties) with a view to promote the UN Ocean Decade Initiative.

II. AREAS OF COOPERATION

2. Both Parties may establish and maintain consultation, cooperation and collaboration with respect of matters of common interest under the framework of the Ocean Decade, including,

but not limited to:

a) jointly support, incubate, and initiate Decade Actions, ultimately aim to catalyze transformative scientific solutions.

b) ODCC will arrange for a coordinator to support the PICES-ICES UNDOS endorsed program “SmartNet”.

c) jointly organize international conferences or fora on the Ocean Decade.

d) jointly organize training courses or other related activities to build capacity for the younger generation.

e) reciprocal participation with observer status at the relevant meetings of each organization.

III. MODIFICATION

3. This MoU may be modified at any time by the mutual written consent of both sides.

IV. LEGAL STATUS

4. Both Parties acknowledge that this MoU is not legally binding between them.

V. HOLD HARMLESS CLAUSE

5. Each party agrees that it will be responsible for its own acts and the results thereof and shall not be responsible for the acts of the other party thereof.

6. Each Party shall undertake to observe the confidentiality and secrecy of personal documents, information and other personal data received from or supplied to, the other Party during the period of the implementation of this MoU.

VI. COMING INTO EFFECT AND TERMINATION

7. This MoU will continue to operate for 5 years from the date of signing. At that stage the Parties will review the operation of the MoU and decide whether it will be renewed or modified.

a) Either Party may terminate this MoU by giving six (6) months prior written notice to the other Party.

b) This MoU will come into effect on the day of signature.

c) This MoU shall be executed in English in two (2) original copies. Each Party shall receive one (1) original copy, all of which shall be equally valid and enforceable.

VII. SIGNATURES

Signature Date	Signature Date
Chair	Executive Director
North Pacific Marine Science Organization	Ocean Decade International Cooperation Center, China
（PICES）	（ODCC）
9860 W. Saanich Road Sidney,	598 Jinshatan Road, West Coast New Area,
BC V8L 4B2, Canada	Qingdao, Shandong Province
（250） 363-6364	15864234450

Appendix 5

Proposal of New WG-OCN
(4th version)

Ocean Negative Carbon Emissions for Carbon Neutralization (WG-OCN)

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 the escalating climate crisis, achieving global carbon neutralization and adhering to the Paris Agreement's reduction targets are critical. Over the past decades, significant actions have been taken through initiatives such as the PICES/ICES joint WG 33 on "Climate Change and Biologically-driven Ocean Carbon Sequestration" and WG 46 on "Ocean Negative Carbon Emissions (ONCE)." These efforts have identified knowledge gaps and explored new ONCE methods, contributing to the foundation of the Global Ocean Negative Carbon Emissions (Global ONCE) program, recognized by the UN Decade of Ocean Science for Sustainable Development.

The North Pacific, with its significant marine environmental and economic importance, has become a key area for fostering communication and cooperation among stakeholders. The region's unique ecosystems and extensive oceanographic research infrastructure provide invaluable opportunities for advancing ocean negative carbon emissions and carbon neutralization-related scientific methods and engineering technologies.

Achieving global carbon neutrality requires regional-specific solutions that integrate scientific understanding with practical application. WG46 laid the foundation by identifying knowledge gaps in ocean negative carbon emissions (ONCE) and proposing future research directions. Now, WG-OCN will focus on applying and expanding this knowledge within the North Pacific, particularly focusing on technology integration and standardization.

WG-OCN's primary goal is to advance interdisciplinary scientific research on ocean carbon processes, develop sustainable carbon sequestration strategies, and standardize methodologies. Unlike Global-ONCE, which addresses global-level implementation and collaboration, WG-OCN will emphasize region-specific research outcomes that are directly relevant to PICES and its member countries.

- **Distinction from WG46 and Global-ONCE：**

  - Difference from WG46: While WG46 primarily focused on identifying knowledge gaps and setting research directions, WG-OCN will build on these findings by emphasizing the practical application and standardization of ocean negative carbon emissions technologies specific to the North Pacific.

  - Difference from Global-ONCE: Global-ONCE is a broader international initiative aimed at coordinating global efforts in ocean carbon sequestration and carbon-neutral technologies. In contrast, WG-OCN is focused on the North Pacific, contributing regional insights and data to inform global efforts but remaining within PICES scientific mission.

Tentative Terms of Reference

The primary objective of this working group is to enhance scientific understanding and application of ocean negative carbon emissions and carbon neutralization strategies in the North Pacific.

- **ToR 1:** Conduct interdisciplinary research on ocean carbon processes in the North Pacific, with a particular focus on their role in regional climate regulation. This includes examining the interplay between the Biological Carbon Pump (BCP), Carbonate Counter Pump (CCP), Microbial Carbon Pump (MCP), and Solubility Pump (SP).
- **ToR 2:** Evaluate and develop region-specific ocean negative carbon emission strategies. The group will focus on strategies that are practical, scientifically sound, and applicable to the oceanographic and ecological conditions in PICES member regions.
- **ToR 3:** Collaborate with Global-ONCE to ensure that PICES member countries benefit from global advancements in ocean carbon sequestration while contributing regional data and insights. Utilize Global-ONCE's global data to enhance research on the North Pacific, ensuring that regional studies are informed by global trends and findings.
- **ToR 4:** Develop and establish technical standards for ocean carbon monitoring and sequestration technologies, ensuring these standards are in line with international protocols but adapted to PICES regions.
- **ToR 5:** Contribute to public education on climate change and ocean carbon neutralization. WG-OCN will develop and offer open-access public courses (in English, using AI technology) to raise awareness about the global climate crisis and the role of oceans in carbon sequestration.

Annual Work Plan (2024 -2027)

Year 1 (2024-2025):

- Objective: Establish a baseline understanding of ocean carbon cycles in the North Pacific. This will involve gathering and analyzing data from existing PICES observation networks.

- Deliverable: Initial report on North Pacific ocean carbon cycle dynamics and its implications for global carbon sequestration.

Year 2 (2025-2026):

- Objective: Develop and evaluate region-specific ocean negative carbon emission strategies. Experimental studies and model simulations will be conducted to assess the effectiveness of various approaches.

- Deliverable: Review the current research status of ocean negative carbon emissions and carbon neutral technologies in the North Pacific ecosystem.

Year 3 (2026-2027):

- Objective: Finalize and standardize ocean negative carbon emissions methodologies specific to PICES regions. This will provide a framework for future applications of ocean carbon sequestration technologies.

- Deliverable: Final comprehensive report, technical standards, and research briefs.

Expected Deliverables (details)

1. **Review technologies**: Review the current research status of ocean negative carbon emissions and carbon neutral technologies in the North Pacific ecosystem.
2. **Research Papers:** Peer-reviewed papers detailing research on the ocean carbon cycle and negative carbon emissions in the North Pacific. These papers will provide critical insights into region-specific ocean carbon sequestration mechanisms.
3. **Technical Standards:** Development of standardized methods and protocols for carbon sequestration monitoring and management. These standards will be aligned with international guidelines but tailored to the specific needs and conditions of PICES regions.
4. **Public Education:** Launch a public course titled "Habitable Earth," designed to educate the public and university students about the role of oceans in climate change mitigation. The course will be AI-driven and freely accessible to foster broader understanding and engagement.
5. **Final Report:** Comprehensive final report submitted to PICES, summarizing the findings and recommendations of WG-OCN over the three-year term, including proposed next steps for ongoing research and collaboration.

Tentative Members (A-Z)

- **WG Members**

  Nianzhi Jiao /China (Ocean Negative Carbon Emissions)

  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)

  Shigeru Tabeta /Japan (Clean Energy Engineering)

  Moriaki Yasuhara /Japan (Micropaleontology and Climate Change)

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

  Sun Young Kim /Korea (Marine Genetic Ecology)

  Lei Zhou /China (Marine Observation and Remote Sensing)

  Yongyu Zhang /China (Macroalgae Culture)

  Yanli Lei /China (Biodiversity and Global Change)

Appendix 6

PICES Executive Secretary Report on Past Travel and Funding Support

Report to Science Board on past travel and funding support

During the 2024 Intersessional Science Board meeting, under Agenda item 12 "Travel Support Requests", Science Board requested information on historic amounts of travel support, to facilitate the discussion and prioritization of amounts to recommend. A subsequent request was made concerning the funds spent when implementing the Governing Council Decisions that resulted from Science Board recommendations. The Executive Secretary agreed to provide a summary of such spending, which follows below.

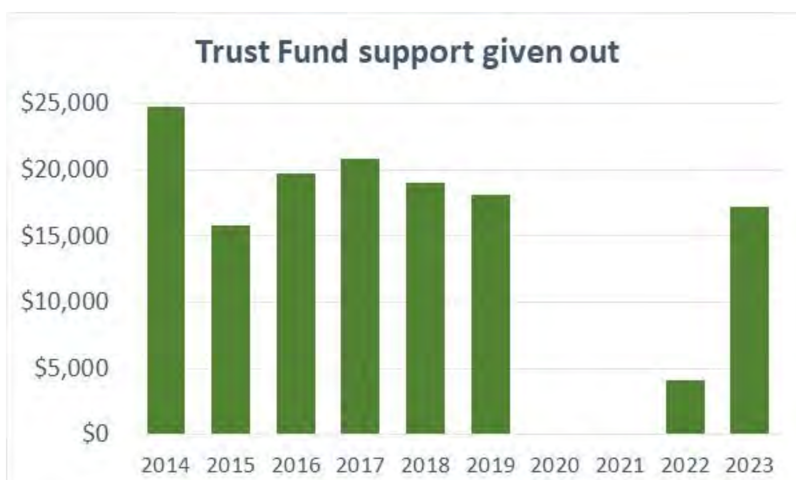
Background

Support for capacity development activities that Science Board reviews (summer schools or supporting Early Career Ocean Professionals to attend international events organized by partner organizations) are funded from the PICES Trust Fund. The balance of the Trust Fund is reset at the beginning of each year to $110,000. It is funded by voluntary contributions and topped-up, when necessary, from the PICES Reserve Fund. The Trust Fund also supports the PICES Intern Program expenses, travel of ECOP to the PICES annual meeting and to other PICES-co-sponsored large international symposia or events. Science Board does not typically make recommendations on the amounts used for these latter purposes (the Finance and Administration Committee reviews the annual expenditures of the Trust Fund) so these items are not included in this report.

Science Board also recommends to Governing Council other financial support priorities and sets a guideline amount. Support for non-ECOP travel, or other items with a cost, comes from the PICES General Fund which is funded by annual fees from member countries and supplemented by the PICES Reserve Fund (typically 12-22% of the annual budget comes from the Reserve Fund). A table is included below which lists the GC Decisions, and the expenditures that resulted from them, during the current Executive Secretary's term.

Trust Fund support for ECOP

Ten years of data were readily available for this analysis. The figure shows annual totals expensed from the Trust Fund. Number of events supported ranged from 0 to 4 per year (the number of individuals per event varies considerably depending on the level of support per individual). A full list of events and amount spent per event is included in the Appendix.



Things to note:

- This analysis does not include events that *were* approved for funding by Science Board, but that either did not happen or had no eligible PICES participants attending in the end (some of this information can be found from the table of GC Decisions below).
- Events were cancelled/postponed during 2020-2022 because of COVID-19. So, 2023 was the first "normal" year since 2019.
- The Trust Fund budget has not changed during this ten-year period, and there is no trend in the annual expenditures. However, since costs have generally risen, we can assume that the number of individuals supported, or the amount of support per individual, has declined.

Governing Council Decisions

The table below shows the GC Decisions taken at each meeting since 2020, and the related expenditures.

The Secretariat does not always know why funds were not requested for travel to an approved event, and could be for a variety of reasons such as a last-minute conflict for the traveler, or a cancelled/postponed event.

For capacity development activities, the Secretariat works with organizers/sponsors of approved events to select eligible ECOP that have applied for the summer school/Symposium/activity according to PICES criteria (citizens or residents of PICES countries). Sometimes PICES transfers funds to the organizer to disburse travel grants, or to support an activity, sometimes PICES transfers the funds directly to the ECOP.

GC Decision	Funds spent (Cad$)	Notes
2024/S/5. • IMBeR IMBIZO7, 22-24 Sept 2024, Morocco. Up to $6,000 for 2-3 eligible ECOP • SOLAS OSC,10-14 November, Goa, India. Up to $6,000 to support 2-3 eligible ECOP • APN Proposal Development Training Workshop, Uva, Fiji, 26-30 August 2024, up to $3,000 to support 1-2 eligible ECOP	$0 $6,000 $3,000	Event cancelled by organizers in June 2024 Approved a list of 7 ECOP from USA, Japan, China and transferred funds (USD $4394) for organizers to provide travel grants ZW (Japan) travel grant
2024/S/6. Contribution to the SPF-2026 Symposium in line with previous support (~$15,000) to be divided between travel support for PICES ECOP from the Trust Fund and from the General Fund towards other costs of the Symposium.	TBD	Symposium scheduled for May 2026
2023/S/12. • 30th Anniversary of the CREAMS program. 2~3 days in July 2024. Partial travel support for 4 participants (3	$3,702	Partial travel support for 3 requested: Lobanov, Wang and Yin

students or ECOPs and 1 invited speaker) up to CA$7,000 • UN Ocean Decade Conference 10-12 April 2024, Barcelona, Spain. Travel support up to CA$ 6,000 for AP-UNDOS Chair and 1 ECOP. • Travel support up to CA$6-7,000 for 2 ECOP in SmartNet side events • ICES ASC 2024, PICES-cosponsored theme session. Partial travel support up to CA$6000 for BIO member and 1 ECOP • S-HAB intersessional meeting member, upto $3,500 from Western NP and 1 ECOP	$6,011 $7,006 $0 $3,163	SB (AP-UNDOS Chair) and 1 ECOP JH (Japan) 2 ECOP KJ, NS (Canada, Japan) BIO member in field & could not attend No ECOP request S-HAB member could not attend. 1 ECOP - YW (China/USA)
2023/S/3. Joining the DataCite Canada Consortium at Tier I, to add DOI to official PICES publications	$101	Joined in January 2024
2023/S/4. Open access publication of WG38	$3,819	Paid Sept 2023
2023/S/5. Science communication videos. Council approved the travel support ($6,000) for a videographer/film-maker to attend PICES-2023 to produce three short videos	$6,000	Kincentric Cinema Media Solutions produced 3 videos from PICES-2023 [Videos - PICES - North Pacific Marine Science Organization]
2023/S/9. Up to $5,000 to support PICES ECOP to participate in the IMBeR ClimEco8 summer school	$1,000 $3,000	Sponsored ECOP food RD (Canada) travel grant
2022/S/10. • GOOD-OARS Summer School, November 6 – 12, 2023, Coquimbo-La Serena, Chile. 2-3 ECOPs up to EUR 5000 • AP-ECOP Virtual International Open Science Training. Travel support for 2 participants of this workshop to attend PICES-2023, up to $7,000 • SC member T. Ono to attend ECCWO5, CA$2745 and 2 ECOP ($6,000) • PICES-ICES workshop on eDNA. $3,000 partial support for 1 ECOP	$4,229 TBD $5,400 $0	4 ECOP initially approved but only 3 travelled in the end (USA/Can) Deferred to PICES-2024 Ono unable to attend. 5 ECOP supported (China/Canada) Not requested

• IPHAB, $3,000 for 1 S-HAB member • Int Conference on Marine Bio-invasions for an ECOP or Convenor $3,000 (deferred from 2020)	$2,969 $0	MW participated Not requested
2022/S/5. SOLAS OSC September 25-29, 2022. US$4,500 to partially support travel of PICES ECOP and/or an ECOP event scheduled during the conference.	$5,823.90	Sponsored ECOP event
2022/S/6. • 7th ICES WGICA Annual Meeting, Oct 11-13 Copenhagen, Denmark. $3,000 partial support for WG39 Chair • WG45 organized session and Joint ICES/PICES WG-GRAFY meeting at ICES ASC. $3,500 for EG45 member/ECOP/Inv speaker	$4,936.43 $0	WG39 Chair participated Not requested
2021/S/16 Virtual registration fee for an ECS to attend and present at Ocean Sciences Meeting 2022	$662.34	MS (USA)
2021/S/17 • AP-CREAMS. Summer school on Ocean turbulence (Prof. Yu Fei, Qingdao, China, Summer 2022). US$9,000 deferred from 2020 • AP-NPCOOS Ocean big data virtual summer school Aug 2022, $15,000 deferred from 2019	$0 $15,000	China still impacted by COVID-19. Event did not occur Virtual event. PICES agreed to provide $15,000 towards Ocean Network Canada's costs for running the event
2021/S/4. SOLAS Summer School in Cape Verde. $10,000 for PICES ECS. Deferred to 2023	$10,000	5 ECOP approved from USA/Canada, Funds transferred to organizers to disburse travel grants
2020/S/10. • WG-39 travel support in the amount of $3000 to attend the WGICA in-person meeting in the Fall of 2021, at ICES HQ • S-HAB $3000 Travel Support for travel for one PICES representative to attend the IOC Intergovernmental Panel on HABs (IPHAB) in 2021	$0 $0	No travel in 2021 because of COVID-19 No travel in 2021 because of COVID-19
2020/S/12. PICES-NPFC 2021 Co-Sponsored course on Vulnerable Marine Ecosystem Indicator Taxa ID. Vladivostok, Russia. Co-sponsorship: up to $15,000	$0	Postponed indefinitely because of COVID-19

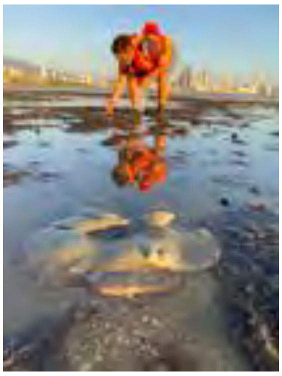
Appendix. List of events where ECOP were supported by the Trust Fund

Activity	Year	Amount
2014 FUTURE OSM	2014	$5,755
2014 IMBER Summer School	2014	$6,030
2014 PICES Summer School	2014	$12,974
ECS-Brazil Symposium and HAB Symposium	2015	$15,798
Training Course on “Freshwater discharge and coastal environments”	2016	$4,610
9th International Marine Bioinvasions Conference	2016	$4,071
IMBER ClimECO5 Summer School	2016	$6,747
CLIVAR Open Science Meeting, Qingdao, China	2016	$4,282
IMBIZO V	2017	$5,230
ESSAS Open Science Meeting	2017	$15,569
FishGIS workshop	2018	$6,047
PICES Summer School	2018	$3,000
IMBeR ClimEco6	2018	$5,000
SOLAS Summer School	2018	$5,000
IMBeR Future Oceans 2	2019	$6,086
SOLAS Open Science Meeting	2019	$6,016
PICES/ICES/NAFO Shellfish Symposium	2019	$6,000
Travel of ECOP to UN Oceans Conference	2022	$4,095
SOLAS Summer School	2023	$10,000
IMBeR ClimEco8	2023	$3,000
GOOD OARS Summer School	2023	$4,229

Appendix 7

GOOD-OARS-CLAP-COPAS Summer School

GOOD-OARS Summer School 2025:
4-11 November 2025, Penang, Malaysia





Directors

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Organizing Committee

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Abstract

The Sixth Assessment Report of the IPCC states that anthropogenic global warming and the influx of excess nutrients and pollution to the ocean must be tackled in order to limit the effects of rising temperatures and decreasing pH and oxygen in the coastal and open ocean. The GOOD-OARS Summer School 2025 is designed to prepare the next generation of ocean scientists that will engage in multidisciplinary research and increase our understanding of the responses of marine ecosystems in the next decades.

A- Scientific content

About GO₂NE/GOOD

Oxygen is critical to the health of the planet. It affects the cycles of carbon, nitrogen and other key elements, and is a fundamental requirement for marine life from the seashore to the greatest depths of the ocean. It is therefore alarming that oxygen levels are rapidly decreasing in the coastal and open ocean, a process called deoxygenation. Deoxygenation is accelerating and getting more severe. This is mainly the result of human activities that are on the one hand increasing global temperatures (CO_2-induced warming) and on the other hand increasing loads of nutrients from agriculture, sewage, and industrial waste, including pollution from power generation from fossil fuels and biomass.

The **Global Ocean Oxygen Network GO$_2$NE**, established in 2016, is committed to providing a global and multidisciplinary view of deoxygenation, with a focus on understanding its multiple aspects and impacts. Through the participation of concerned scientists from across the world, the IOC expert group offers scientific advice to policy makers and stakeholders to counter alarming deoxygenation and to preserve marine resources in the presence of declining oxygen levels. Currently, the members of the core working group represent 21 institutions in 14 countries around the world.

Besides its scientific work and outreach activities, the network aims to facilitate communication with other established networks, working groups, and other UN entities (e.g. IOCCP, GOOS, IGMETS, GOA-ON, GlobalHAB, WESTPAC O$_2$NE), improve observation systems, identify and fill knowledge gaps, and develop deoxygenation-related capacity development activities. GO$_2$NE and colleagues have published several review papers (Breitburg et al., 2018, Garçon et al., 2019, Pitcher et al., 2021, Grégoire et al., 2022, Rose et al., 2024, Roman et al. 2024) and summaries on deoxygenation for policy makers (IOC-UNESCO Technical Series 137, EMB Future Science Brief Ocean oxygen: The role of the Ocean in the oxygen we breathe and the threat of deoxygenation). International conferences on ocean deoxygenation have been co-organised by GO$_2$NE in September 2018 in Kiel, Germany, May 2022 in Liège, Belgium, and in September 2022 in Lima, Peru.

More information about GO$_2$NE can be found at https://www.ioc.unesco.org/en/go2ne. In collaboration with the German SFB754 program and GEOMAR, it initiated the news site **ocean-oxygen.org** to provide information on deoxygenation to scientists, stakeholders and the interested public. It submitted an UN Ocean Decade of Science for Sustainable Development program named **GOOD, the "Global Ocean Oxygen Decade**", (https://www.ioc.unesco.org/en/global-ocean-oxygen-decade), which was endorsed by IOC-UNESCO in summer 2021.

About GOA-ON/OARS

As CO_2 dissolves in seawater, it changes its chemistry, resulting, among other changes, in an increase in seawater acidity (i.e., a decrease in pH). These changes are subtle yet sustained and have been shown to impact several biological processes, such as the construction of calcium carbonate shells and skeletons of many marine organisms.

The Global Ocean Acidification Observing Network (GOA-ON), a network of more than 900 experts from over 100 countries, is committed to achieving three goals related to ocean acidification: to document its status and trends in diverse locations around the world, to understand ecological impacts, and to enable forecasts and early warning capabilities. GOA-ON established a data portal that contains metadata, links to downloadable data, and near real-time data visualizations from ocean acidification monitoring platforms around the world. GOA-ON members contributed to the establishment of the SDG 14.3.1 Methodology under the leadership of the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

GOA-ON's Ocean Acidification Research for Sustainability (OARS), was endorsed as a programme of the UN Decade of Ocean Science for Sustainable Development in 2021. The OARS programme aims to provide society with the observational and scientific evidence needed to sustainably identify, monitor, mitigate and adapt to ocean acidification; from local to global scales. It is building on the work of GOA-ON to further develop the science of ocean acidification by enhancing ocean acidification capacity, increasing observations of ocean chemistry changes, identifying the impacts on marine ecosystems on local and global scales, and providing society and decision makers with the information needed to mitigate and adapt to ocean acidification. GOA-ON and colleagues have most recently published the IOC white paper Ocean Acidification Research for Sustainability - A Community Vision for the Ocean Decade.

More information about GOA-ON can be found at http://goa-on.org.

International collaboration on ocean science in the Western Pacific - IOC WESTPAC

The IOC Sub-Commission for the Western Pacific (WESTPAC) was established in 1989 by IOC/UNESCO to promote international cooperation and to coordinate programmes in marine research, ocean observations and services, as well as capacity building in the Western Pacific and adjacent seas, in order to learn more about the nature and resources of the ocean and coastal areas and to apply that knowledge for the improvement of governance, sustainable development and protection of the marine environment.

WESTPAC currently consists of 22 Member States mainly in East Asia, Southeast Asia, South Pacific and the eastern Indian Ocean, with its membership open to all interested Member States of IOC/UNESCO willing to participate actively in the work of the Sub-Commission.

WESTPAC defines its strategic direction based on priority interests of the Member States in the region, and implements its programmes and activities through strong partnerships with national competent agencies, marine scientific institutes, universities and other international organisations or programmes in the region.

Brief discussion of the subject and relevance

The Earth System has clearly moved far outside the range experienced over the last 700,000 years and is hence operating in a "no-analogue" state. The world's population is continuing to increase, probably reaching 10 billion inhabitants in 2050. Sustained use of resources (food, water, carbon, human health) must be achieved to ensure future prosperity. Simultaneously, greenhouse gas concentrations (CO_2, N_2O, CH_4) are increasing at an unprecedented pace that potentially brings us closer to climate tipping points. The last decades have been the warmest ones over the last 1000 years. Temperatures in the Earth's atmosphere increased by about 1.07 ± 0.2°C over the last century. Sea level rise is a dramatic reality for many inhabitants of our planet, Arctic sea ice and glaciers are melting faster than expected.

The IPCC AR6 states that: "Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming," And, as the ocean has absorbed about 90% of the excess heat created by anthropogenic global warming since the beginning of industrialisation in the 1700s, it is warming as well. Simultaneously ocean oxygen observations since 1960 indicate a decrease of about 2% of the global ocean oxygen inventory. Climate models predict continued deoxygenation of the global ocean in the future.

Increased greenhouse gas concentrations not only result in warming and deoxygenation, they also cause ocean acidification, which has increased by 30% since the beginning of the Industrial Revolution. If the concentration of atmospheric CO_2 continues to increase at the current rate, the oceans will become corrosive to the shells of many organisms by the end of the century. Further, the ocean's capacity to absorb CO_2 from the atmosphere is being degraded by ocean acidification, which will make it more difficult to stabilise atmospheric CO_2 concentrations. How or if marine organisms may adapt to the changes to these changes at multiple levels is not known.

Declining oxygen in the world's ocean and coastal waters is reducing suitable habitat, altering biogeochemical cycles, and may cause feedbacks that further exacerbate deoxygenation and global warming (Isensee et al., 2016; Breitburg et al., 2018). Major advances have been made in understanding patterns, drivers and consequences of ocean deoxygenation, but there is a need to improve predictions at different spatial and temporal scales important to project the provision of ecosystem services provided by the ocean. Improved numerical models of oceanographic processes that control oxygen depletion and the large-scale influence of altered biogeochemical cycles are the basis to predict the magnitude and spatial patterns of deoxygenation in the open ocean, as well as its feedbacks to climate. Developing and verifying the next generation of these models will require increased in situ observations and improved mechanistic understanding at a variety of scales, including how changes in stratification and circulation might affect oxygen content in the water column. Models useful for managing nutrient loads can simulate oxygen loss in coastal waters with some skill, but their ability to project future oxygen loss is often hampered by insufficient data and climate model projections on drivers with an appropriate resolution. Predicting deoxygenation-induced changes in ecosystem services and human welfare needs information based on scaling effects that are measured on individual organisms to populations, food webs, and fish stocks, considering combined effects of deoxygenation and other ocean stressors, and increased research emphasis in developing nations. Reducing effects of other stressors may increase species resilience negatively affected by low oxygen conditions. Ultimately, though, limiting deoxygenation and its negative effects can be only achieved by a dramatic global decrease in greenhouse gas emissions as well as reductions in nutrient discharges to coastal waters (Isensee et al., 2016; Breitburg et al., 2018; IOC-UNESCO Technical Series 137).

New innovative research will be required to increase our understanding of ocean acidification and particularly its impacts. Since the establishment of GOA-ON, many countries and organisations have started to observe ocean acidification, however long-term commitments are required to detect the trends and changes of seawater chemistry. It is important to enable the scientific community to provide ocean data and evidence of known quality, via continuous capacity development and activities related to data quality. The design and implementation of ocean acidification observation must be done in collaboration with data/information producers and end-users. Furthermore, chemical and biological observation must be co-located to not only measure the chemical change but also its impacts. The implementation of the newly established framework for biological observation within the ocean acidification monitoring framework (Widdicombe et al., in review) will provide the possibility to improve predictions of vulnerability and resilience to ocean acidification at all temporal and spatial scales. Future research and observation ought to provide appropriate data and information necessary to the development of societally relevant predictions and projections, employing new technologies such as digital twins, for all ocean 'users' of the impacts of ocean acidification in order to implement adaptation and mitigation by 2030.

Both UN Decade programs GOOD and OARS place particular emphasis on international capacity building as the development of the current generation of young researchers is vital to make immediate significant progress in response to the pressing environmental and societal challenges.

The international school will be held from 4 to 11 November 2025 in Malaysia at the Centre for Marine and Coastal Studies (CEMACS) in Penang National Park. The summer school will integrate ocean deoxygenation and acidification programs to present a comprehensive and in-depth 8-day course while engaging young researchers and students with leading scientists in different components of GOOD/OARS and CEMACS research, and with scientists from SMEs. Students will be engaged via theoretical seminars and practical exercises, laboratory experiments and special sessions, and in informal discussion. The GOOD and OARS vision is to provide scientific knowledge and educate the younger generation of scientists for 'the Ocean we need for the Future we want' (IOC-UNESCO brochure – International Decade of Ocean Science for Sustainable Development').

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Scientific programme

The school will be implemented as follows: three days of lectures followed by three days of field work, practical workshops, and stakeholder engagement activities, and concluding with a final two days of lectures, reporting on fieldwork, and presentations. The 2025 school will bring together 30 - 40 PhD students and early career scientists and approximately 16 pre-eminent international scientists. It will also be open to stakeholders willing to learn more about mechanisms and impacts of deoxygenation as well as monitoring strategies, potential adaptation and mitigation options. A balanced geographic and gender representation will be respected.

Lecture topics around the general issues of ocean deoxygenation and acidification will include:

- Introductions to ocean deoxygenation and acidification
- Coastal and open ocean deoxygenation
- Biological responses to deoxygenation and acidification
- Observing systems for deoxygenation and acidification
- Physical and biological settings of the local marine environment of Penang
- Prediction and modeling of future deoxygenation and acidification
- Perspectives from paleoenvironments
- Data management of biogeochemical data
- Ecosystem modeling
- International coordination and frameworks
- Scientific communication with stakeholders
- Ethics in science

Poster sessions on days 2 and 3 will give students the chance to get to know each other and their individual research topics.

During the final day of the school, each student will give a 5 min presentation for all attendees as part of the Practical Workshop on Communication. We will deliver rewards for the Best Poster and Best Oral Presentation at the end of the School.

The below schedule is subject to change. All items scheduled have been added and allocated to a lecturer / instructor in discussion with summer school organisers, and are to be confirmed as lecturers approve their travel arrangements.

Time	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
9:00		Talk 3: Coastal deoxygenation	Talk 9: Predicting future ocean oxygen and acidification	*Fieldtrip: Biodiversity and blue carbon - seagrass meadow*	*Field trip/Stakeholder engagement: Green Mariculture*	*Field trip: Water quality monitoring and sea jelly abundance*	Talk 14: Science communication: How to interact with press, social media, and NGOs	Group and student presentations
9:30						*Boat trip around the cove: hands-on jellyfish capture & water quality sampling techniques*		
10:00		*Tea break*	*Tea break*				*Tea break*	*Tea break*
10:30	Arrival Penang National Park - Boat to the centre	Talk 4: Open ocean oxygen loss	Talk 10: What and how can we learn from the past? Paleo				*Exercise: Message box*	
11:00								
11:30	Check-in	Talk 5: Biological response to deoxygenation and ocean acidification	Talk 11: Data management of biogeochemical data				Talk 15: Ethics	
12:00				Return to centre		Return to centre		
12:30	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
13:00								
13:30		Talk 6: Designing an observation system to track deoxygenation and ocean acidification	Talk 12: Ecosystem modelling	*Practicals Round 1*	Free afternoon: Trip to Georgetown	*Practicals Round 3*	*Working session on reports*	
14:00	Welcome by summer school directors							
14:30		Talk 7: Local environment focus physical setting ppt 1	Talk 13: Ocean Decade, OARS and GOOD, international frameworks					
15:00	Talk 1: Introduction to deoxygenation							
15:30		*Tea break*	*Tea break*	*Tea break*		*Tea break*	*Tea break*	*Tea break*
16:00	Tea break	Talk 8: Local Environment - focus biology ppt 2	Introduction to practicals	*Practicals Round 2*		*Practicals Round 4*		
16:30	Talk 2: Introduction to ocean acidification							
17:00		Poster snapshots	Poster snapshots					
17:30	*Comms1*	*Comms2*	*Comms3*					
18:00				*Comms4*				

Practical Workshops and stakeholder engagement

Days 4 and 6 of the summer school are devoted to practical workshops. Participants will be introduced to techniques used in modeling, laboratory work, and field sampling (including onboard sampling), and introduced to the use of the most recent oxygen and pH sensors available.

The science communication workshops in the evenings of Days 1 - 4 and concluding with presentations on Day 8 guide students and provide constructive criticism on presenting their research via posters, manuscripts and oral presentations.

Day 5 will be devoted to stakeholder engagement activities with local aquaculture farming and regional policy makers, with a free afternoon in the evening.

The afternoon of Day 7 is set aside for students to work on field and lab reports.

Lecturers

Many members of the Global Ocean Oxygen Network (GO_2NE) and the Global Ocean Acidification Observing Network (GOA-ON) will attend as experts. Lecturers will also include scientists from the region. A full list will be available on final confirmation.

Timeline and selection procedure

The application process will open in September 2024 and will close at the end of October 2024. Students are expected to download the pdf guidelines that will be made available via the application portal, prepare all the information requested in the guidelines, and then fill the linked online forms.

During the 1st half of November 2024, the review process will take place. Reviewers from the scientific committee will examine and mark each application based on the following three criteria 1) Level and suitability of qualifications; 2) Relevance of study and interests to GOOD/OARS themes and 3) Quality of personal statement.

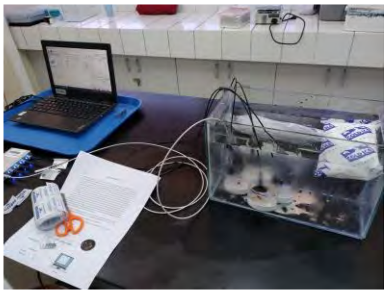
Every applicant will be informed of the outcome of the review process by 15 December 2024 and will register before the end of January 2025.

Anticipated benefits

The Early Career Scientists participating in this school will acquire in an ideal scientific environment the knowledge needed to better understand the future state of the oceans and environmental risks to marine habitats and ecosystems. The GOOD/OARS Summer School 2025 thus will provide to a generation of young scientists the crucible for designing innovative approaches to achieve the societal transition towards the Sustainable Development Goals set out by the United Nations. They will be able to connect and interact with world leading experts in the field in a friendly atmosphere. Practical workshops will allow them to get acquainted with experimental work. The future of the international GO2NE/GOA-ON networks will be created there by setting up fruitful collaborations and interactions.

Below is a mosaic of pictures taken from the GOOD-OARS Summer School 2023 held in Coquimbo/La Serena, Chile to give an idea of the activities which will be held in Penang.









B- Tentative budget

The budget is based on ***40 participants and 16 lecturers***. The GOOD-OARS summer schools so far have been a great success, but they depend upon the generosity of international sponsors and national funding agencies.

Estimated budget

The estimated total budget of the school will 80,000 - 90,000 USD, accounting for 40 students and 16 lecturers, and covering:

- Airfare
- Individual terminal fares where required
- Bus transfer to and from the airport
- Boat transfers to CEMACS
- All meals
- Accommodation
- Facility fees
- Activity fees, including field trips and cruises
- Lab fees and materials
- Any required webpage technical consulting

Funding partners will be requested from within the scientific networks of the members of the GO_2NE and GOA-ON, regional and local agencies, and international scientific funders.

C- Short biographies of School Directors

Dr Véronique Camille Garcon graduated from University of Paris VII in Environmental Sciences (Energy and Pollutions) in 1981 and then became a post-doc fellow at MIT (Cambridge, USA) from 1982 to 1985. Recruited as an Early Career scientist at Centre National de la Recherche Scientifique (CNRS) in 1985, she worked at 'Institut de Physique du Globe de Paris (IPGP)' then moved down to Toulouse with a sabbatical stay at Princeton University in 1995 -1996. She is now back at IPGP with a CNRS Emeritus Senior Scientist status. Her research themes at LEGOS and IPGP aim towards understanding and quantifying processes governing fluxes of carbon, oxygen and associated biogeochemical elements in the ocean, using in situ tracers observations, remotely sensed data, coupled physical biogeochemical modeling and data assimilation techniques.

She was also involved in oceanic biogeochemical climatic monitoring via electrochemical sensor development. She served in the JGOFS SSC, member of the French IFREMER Scientific Committee for 10 years, and in many national (eg. CNRS, National Navy), European (eg. ESF, EC, EGU, ERC), and international scientific instances. She served as Chair of the Scientific Committee of the SOLAS (Surface Ocean Lower Atmosphere Study) project (SCOR, ICACGP, WCRP, Future Earth). She also served as co-director of the International SOLAS Summer Schools in 2003, 2005, 2007 with C. Le Quéré and in 2013 with M. Dai and Director in 2009 and 2011. She was co-Director of the GO_2NE SS2019 summer school in Xiamen, China and the 2023 summer school in La Serena, Chile. She is a member of the Global Ocean Oxygen Network (GO_2NE) initiated by IOC-UNESCO in 2016 and co-Chair of the IOCCP SSG since 2021. She was awarded in 2017 the IOC-UNESCO Anton Bruun Medal.

Professor Dato' Dr. Aileen Tan Shau Hwai, FASc, is the Director of Centre for Marine and Coastal Studies (CEMACS) in Universiti Sains Malaysia; Fellow of Academy Science Malaysia; Executive Director of the Asia-Pacific University-Community Engagement Network (APUCEN) and Vice Chair of UNESCO IOC of Western Pacific. She is also a Board member of the Partnership for Observations of the Global Oceans (POGO). She serves on international steering committees of several organisations such as CoastPredict, Global Ocean Corps, Global Partnership on Plastic and Marine Litter; and EquiSea.

She has been working on the effects of climate stressors (ocean acidification and temperature rise) on the culture of molluscs from the embryonic stage to growout since 2014. She has been an active researcher with many international programmes such as Darwin Initiative (UK), IOC Westpac (UN), JSPS-NaGISA (Japan) and recently with POGO and IOGOOS. Currently, she plays a significant role in moving the agenda of the UN Decade of Ocean Science for Sustainable Development (2021-2030), alongside IOC Westpac.

Her field of expertise is in marine science, specializing in mariculture and conservation of molluscs, promoting "green aquaculture", to create an impactful sustainable income for the local communities, besides creating a balance between profit and environmental protection. She believes strongly in translating her knowledge and benefitting the communities with research findings, creating a better tomorrow for all.

Dr Minhan Dai is a chair professor of marine environmental science at Xiamen University, where he served as the Director of State Key Laboratory of Marine Environmental Science between 2005-2021. His primary research interests include ocean carbon/nutrients biogeochemistry and their coupling with ocean dynamics in the broad context of climatic and environmental changes. He is also well known for his work on marine radiochemistry. Recently, his research scope has expanded to the interface between science and policy. He has published >250 peer-reviewed papers in leading international journals. He was elected an Academician of the Chinese Academy of Sciences in 2017 and won the 2022 Axford Medal Award (by Asia-Oceania Geosciences Society, AOGS in recognition of excellence in geosciences).

He is a member of the expert group of the High-level panel for a Sustainable Ocean Economy, and a council member of the China Council for International Cooperation on Environment and Development (CCICED). He was co-chair of the international program: Surface Ocean and Low Atmosphere Study (SOLAS) during 2011-2013. He is a leading PI of "Coastal Zones Under Intensifying Human Activities and Changing Climate: A Regional Programme Integrating Science, Management and Society to Support Ocean Sustainability (COASTAL-SOS)", which was endorsed by the UN Decade of Ocean Science for Sustainable Development Program (2021-2030) as a project.

Appendix 8

WG44 Final Report

PICES Scientific Report No. xx
2024

Report of Working Group 44 on Integrated Ecosystem Assessment of the Northern Bering and Chukchi Seas

edited by
Elizabeth Logerwell and Kimberly M Rand

October 2024

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Executive Summary

PICES Working Group (WG 44) on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea (NBS-CS) was established in 2019 and extended into 2023 due to COVID restrictions. WG 44 was composed of scientists from PICES member nations: Canada, China, Japan, Korea, Russia and the U.S.A. The US and Russia were co-chairs. WG 44 was also co-sponsored by ICES. The WG 44 produced an inventory of metadata, knowledge, institutions and programs relevant to the development of an Integrated Ecosystem Assessment (IEA) for the NBS-CS Large Marine Ecosystem (LME). In addition to an inventory of data, WG 44 developed ecosystem descriptions from both Indigenous world views and science - Multiple Ways of Knowing (see 2.2) and Shared Conceptual Models (see 2.3). The ecosystem descriptions were further developed into two conceptual models that focused on key components and interactions: Subsistence-Food Security and Climate-Fisheries. Finally, knowledge gaps and future actions to develop an IEA for the Northern Bering Sea-Chukchi Sea LME were described.

1 Introduction

The Northern Bering Sea-Chukchi Sea (NBS-CS) region is experiencing unprecedented ocean warming and loss of sea ice as a result of climate change. Seasonal sea ice declines and warming temperatures have been more prominent in the northern Bering and Chukchi seas as almost all other portions of the Arctic. Chronic and sudden changes in climate conditions in this Arctic gateway are increasingly impacting marine species and food-webs and expanding opportunities for commercial activities (shipping, oil and gas development and fishing), with uncertain and potentially wide-spread cumulative impacts. There are strong concerns about the impacts of climate change and industrial activities, and these impacts may be particularly pronounced in Arctic Indigenous communities that are dependent on the health and stability of the ecosystem. The combination of unprecedented, rapid change and increased interest in the Arctic, specifically the NBS-CS, make this an opportune time for a synthesis of issues and knowledge. The development of an Integrated Ecosystem Assessment can accomplish this synthesis.

To develop the foundation for an IEA the following Terms of Reference and deliverables were adopted by the WG 44 (Appendix 1).

General Terms of Reference:

- Convene an interdisciplinary and international working group membership
- Include Arctic peoples and Indigenous Knowledge systems
- Identify and consult with partners and institutions

Year 1 Deliverables:

- Inventory of metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea Large Marine Ecosystem.

Final Deliverables:

- Ecosystem description from both Indigenous world views and science (shared conceptual models), indicators and hypotheses including knowledge gaps and next steps.

2 WG 44 Achievements with Respect to Terms of Reference

2.1 Inventory of Metadata (Year 1 Deliverable)

This is an inventory of metadata that includes knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea Large Marine Ecosystem. The metadata is provided in Appendix 2. The metadata set describes data for several biological categories: Adult fish, Benthic epifauna, Benthic infauna, Ecosystem modeling, Environmental drivers, Forage fish, Pelagic / Ice algal production, Process links, Zooplankton, Benthic foraging marine mammals, Pelagic seabirds, and General Arctic data. The metadata presented here is not exhaustive but focuses on current data availability online and/or contacts available for data accessibility.

2.2 Ecosystem description from Indigenous world views and science - Multiple Ways of Knowing

2.2.1 Multiple Ways of Knowing

A team within the WG membership was formed to address bringing together Multiple Ways of Knowing in Integrated Ecosystem Assessments (IEA). Led by Sarah Wise, the team consisted of Indigenous knowledge holders and subject matter experts with experience developing and implementing the co-production of knowledge (CPK) framework. Core members were: Raychelle Daniel, Henry Huntington, Rebecca Ingram, Mellissa Maktuayaq Johnson, Nadja Steiner, Sarah Wise, and Eduard Zdor.

The CPK model developed by the Pew Charitable Trusts, Kawerak Inc., and Inuit Circumpolar Council Alaska, (Fig. 1), provided a framework for our initial discussions of multiple knowledge systems and the potential for weaving together Indigenous Knowledge and academic science. Through the course of this work, the team used the framework to guide the operationalization of theoretical concepts around sharing, Indigenous

Knowledge, and practical pathways for ecosystem assessments centered around equitable knowledge sharing and meaningful collaboration.

Fig. 1. The Co-Production of Knowledge wheel (© The Pew Charitable Trusts, Kawerak Inc., Inuit Circumpolar Council Alaska). Source: Daniel and Behe 2017; Yua *et al*. 2022.

The objective of the work on this Terms of Reference (ToR) is to include Indigenous perspectives, Indigenous knowledge, and Indigenous voices from the beginning and throughout, in the process and products—not

incorporated into the “acedemic science” sections, but in parallel, reflecting the importance and value of Indigenous Knowledge as informing IEAs with best available science. This is reflected by including multiple perspectives and knowledge systems at the beginning of the assessment process, which is important.

This work hinges on the understanding that humans are part of the ecosystem; as such, IEAs must incorporate social processes adequately to more fully reflect spatial and temporal linkages and ecosystem drivers. Indigenous Peoples have lived along the coasts of the Bering and Chukchi Seas for thousands of years and continue to collect, test, and refine environmental observations. Drawing from and including multiple knowledge systems improves the depth and breadth of information within the ecosystem assessment for a more robust IEA.

Towards this goal we embarked on an institutional map, or "Lay of the Land." This model identified existing institutional bodies in the Bering Sea/Chukchi sea region, coded for typology (such as educational, political, Indigenous-led, NGO), and mapped connections across spatial scale (i.e., community, regional, state, national, international). Within this map, it is possible to better understand flows of information, social capital, and funds, and gain insight into social networks more broadly. Given the complexity of these networks, a comprehensive model was developed for the Norton Sound region and then expanded across the Bering Sea and Chukchi Sea. An early document describing the "Lay of the Land" was drafted and can be found in Appendix 3. All data was then transferred to interactive modeling software (Kumu) for extensive modeling capabilities. Kumu software was selected because it is free to use, highly customizable, and offers broad accessibility. A parallel database of regional institutions, typologies, and organizational missions was created to feed the Kumu models. This is a living database in that it can be expanded both spatially, and over time.

In order to define the ecosystem holistically through multiple knowledge systems and perspectives, efforts were made to develop Indigenous Conceptual Models (ICMs) using an interdisciplinary methodology, framework, and team (TK holders, scientists, managers). Our objectives were to define the ecosystem; promote enduring transdisciplinary partnerships; bridge knowledge systems to inform ecosystem-based-management; and identify key observations for Bering Sea and Chukchi Sea communities. To support the development of ICM, we held a series of workshops (Workshop I: August 2022 in Anchorage, Alaska; Workshop II: March 2023 in Nome, Alaska; and Workshop III: October 2023 in Seattle, WA).

Workshop I was conducted in Anchorage, Alaska with the core team and other invited knowledge holders. A total of 18 people were invited. Additional funding was secured to provide full travel support and individual stipends for Indigenous Knowledge holders to compensate for their time and knowledge. Unfortunately, complications due to COVID-19 reduced the number of people able to attend in person. Despite the smaller number, or perhaps because of the same number, the workshop was able to meet its objectives and was seen as an overall success. The group suggested an additional workshop at the Annual PICES Meeting in Busan, South Korea that fall. Again, COVID-19 hindered this effort due to travel restrictions and illness so the workshop was rescheduled for the following year (for the Annual Meeting in Seattle, 2023). See Report "Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem" in Appendix 4. Workshop II was conducted in Nome, Alaska at the University of Alaska Fairbanks Northwest Center. The purpose of this workshop was to allow for greater participation beyond select Indigenous knowledge holders and team members. The meeting was open to the public and grounded in regional ecological concerns around fisheries and intersections with fisheries management.

Workshop III was developed in response to community interest in expanding visibility for bridging multiple knowledge systems in ecosystem science to inform management. There was considerable interest bringing Indigenous-led research and perspectives to the PICES scientific community for knowledge exchange to improve ecological understanding and build knowledge networks across practitioners. The team partnered with the Ocean Decade Collaborative Center of the Northeast Pacific to invite Indigenous knowledge holders across the coastal Northeast Pacific from Alaska to California including British Columbia. The workshop was well attended and provided a platform to communicate the importance and feasibility of Indigenous-led ecosystem research. See Report "Multiple Ways of Knowing - PICES 2023 Workshop" in Appendix 4.

Sarah Wise's team along with Indigenous, management, and science partners, have continued to build out the institutional mapping of the NBS-CS ecosystem to illustrate the relationship between humans, institutions, and the ecosystem. Key ideas emerging from the team's work are: there is a need for recognition and support for more Indigenous-led work; there is a need for focus on relationships and relationship-building at the start of any ecosystem assessment; data sovereignty is an important and delicate issue that must be addressed; there is a need for building capacity across institutions; social science methods and approaches allow for greater attention to and understanding of knowledge production, social networks across scale, and the vital role of equity across scientific processes. Future work should include leveraging examples of existing strong partnerships and engagement.

2.3 Ecosystem description from Indigenous world views and science - Shared conceptual models

2.3.1 Methods

The Working Group developed the initial conceptual models during an April 2022 workshop. Three breakout groups of 8-9 WG members were formed to build conceptual models. Each group had a pre-defined topic: Climate change and commercial fisheries (a.k.a. "Climate-Fisheries"); Climate-driven ecosystem change (a.k.a. "Ecological"); and Subsistence-Food Security. Breakout groups were not composed solely of experts in the particular topic. Instead the breakout groups were formed to have a diversity of expertise among climate, fisheries, ecology, subsistence and food security. After the workshop the Climate-Fisheries and Ecological models were combined into one model called "Climate-Fisheries" because of the substantial overlap between the two models. The two models, Subsistence-Food Security and Climate-Fisheries were then further refined to focus on the key components and interactions as determined by the WG members' expertise. WG members also provided literature references to support each interaction. The list of references for each linkage is not comprehensive but was designed as a starting point to further build linkages and identity data gaps.

Mental Modeler was used to build the conceptual models. Mental Modeler is modeling software that helps individuals and communities capture their knowledge in a standardized format that can be used for scenario analysis (https://www.mentalmodeler.com/). Based in Fuzzy-logic Cognitive Mapping (FCM), users can easily develop semi-quantitative models of environmental issues, social concerns or social-ecological systems by defining the important components of a system, and defining the relationships between these components.

2.3.2 Subsistence – Food Security

The Subsistence – Food Security modeling group faced unique challenges, perhaps the largest of which was that the two topics are conceptually ill equipped to fit into linear, forward-flow models. This conceptual model was difficult to build because the final output/intent of the model would impact what elements should be included and focused on. This group's discussions highlighted that all elements within this conceptual model are connected in intricate ways, and changes in temporal and spatial access (e.g., seasonality, species distributions) could strongly impact all relationships in the model. The exercise also felt contradictory to the Indigenous perspectives that shape and rely on the concepts in the model. Lastly, the group did not have time to discuss food sovereignty.

The Subsistence-Food Security conceptual model indicates positive relationships between food availability and security to several community parameters: subsistence, health, food sovereignty and quality of life (Fig. 2 and Table 1). Food security reflects the ecosystem and the society that is attaining food security as part of that ecosystem. In other words, it is more than the production and availability of a certain number of fish, birds, mammals, or invertebrates in good condition. It includes cultural well-being, cultural continuity, and the reciprocal relationships that are essential to being part of a system that sustains a community of humans. The relationship between change in environmental conditions and industrial fishing depends on the rate of climate change. A high climate change scenario was predicted to result in an increase in fisheries potential, whereas a low climate change scenario was predicted to result in no change to fisheries potential (Tai, *et al*. 2019).

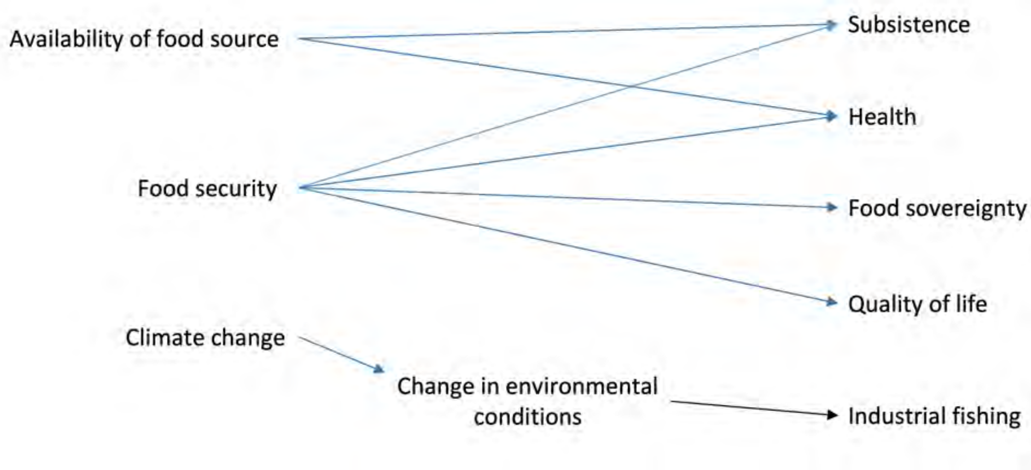

Fig. 2. Subsistence-food security model. Blue arrows indicate a positive relationship, black arrow indicates a variable relationship depending on the rate of change in environmental conditions. See Table 1 for references.

Table 1. Interactions for the Subsistence-Food Security model with references indicated by numbers (see Table 2 for full citations). The drivers/independent variables are listed in the first column. The response/dependent variables are listed in the top row. Merged cells mean that the references describe the effects of drivers on multiple response variables. Blue indicates a positive relationship, gray indicates a variable relationship depending on the rate of change in environmental conditions.

	Subsistence	Health	Food sovereignty	Quality of life	Change in environmental conditions	Industrial Fishing
Availability of food source	2, 3, 4					
Food security	5,6, 7, 8, 9, 10					
Climate change					15, 16, 17, 18, 19, 20, 21, 22, 23	
Change in environmental conditions						14

Table 2. Full citations for references for the Subsistence-Food Security model (shown in Fig. 1 and Table 1).

Number	Reference
2	Steiner NS, *et al*. 2019. Impacts of the changing ocean-sea ice system on the key forage fish Arctic cod (*Boreogadus Saida*) and subsistence fisheries in the Western Canadian Arctic - Evaluating linked climate, ecosystem and economic (CEE) models, Front. Mar. Sci. doi: 10.3389/fmars.2019.00179.
3	Steiner NS, *et al*. 2021. Climate change impacts on sea-ice ecosystems and associated ecosystem services, Elem Sci Anth, https://doi.org/10.1525/elementa.2021.00007.
4	Geoffroy M, *et al*. 2023; The circumpolar impacts of climate change and anthropogenic stressors on Arctic cod (*Boreogadus saida)* and its ecosystem. Elementa: Science of the Anthropocene 5 January 2023; 11 (1): 00097. doi: https://doi.org/10.1525/elementa.2022.00097
5	IPCC-IPBES report (Arctic example in chapter 6); https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-6/
6	Pörtner HO, *et al*. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI:10.5281/zenodo.4782538.
7	Suydam R, and George JC. 2021. Current indigenous whaling. In: J.C. George and J.G.M. Thewissen, eds. The bowhead whale: *Balaena mysticetus*: biology and human interactions. London: Academic Press. p. 519-535.
8	Fall JA. 2018. Subsistence in Alaska: a Year 2017 update. Alaska Department of Fish and Game. https://www.adfg.alaska.gov/static/home/subsistence/pdfs/subsistence_update_2017.pdf
9	ICC-Alaska. 2015. Alaskan Inuit food security conceptual framework: How to assess the Arctic from an Inuit perspective. Technical Report. Anchorage: Inuit Circumpolar Council-Alaska.
10	Gadamus L, and Raymond-Yakoubian J. 2015b. A Bering Strait Indigenous framework for resource management: respectful seal and walrus hunting. Arctic Anthropology 52:87-101.
14	Tai TC, *et al*. 2019. Evaluating present and future potential of Arctic fisheries in Canada, Marine Policy, 108, https://doi.org/10.1016/j.marpol.2019.103637
15	SROCC report, AMAP climate change update, IPCC AR6, IPCC-IPBES working group report climate change and biodiversity. https://www.un.org/en/climatechange/reports
16	The IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), 2019. https://www.ipcc.ch/srocc/
17	AMAP, 2021. Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-makers. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. 16 pp
18	Pörtner HO, *et al*. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. doi:10.5281/zenodo.4782538.
19	Lannuzel D, *et al*. 2020. The future of Arctic sea-ice biogeochemistry and ice-associated ecosystems. Nat. Clim. Chang. 10, 983–992. https://doi.org/10.1038/s41558-020-00940-4.
20	The Working Group I contribution to the Sixth Assessment Report, Climate Change 2021: The Physical Science Basis was released on 9 August 2021. https://www.ipcc.ch/report/ar6/wg1/
21	The Working Group II contribution, Climate Change 2022: Impacts, Adaptation and Vulnerability was released on 28 February 2022. https://www.ipcc.ch/report/ar6/wg2/
22	The Working Group III Contribution , Climate Change 2022: Mitigation of Climate Change was released on 4 April 2022. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/
23	The Synthesis Report , Climate Change 2023: Synthesis Report was released on 20 March 2023 to inform the 2023 Global Stocktake under the United Nations Framework Convention on Climate Change. https://www.ipcc.ch/report/sixth-assessment-report-cycle/

2.3.3 Climate – Fisheries

For the Climate-Fisheries model, the breakout group started with the fisheries that could be impacted by climate change and worked backwards to determine the climate forcing, oceanographic processes and lower trophic links that would impact specific fisheries as well as working forwards to define potential impacts on people (e.g., communities, food safety, commercial fisheries).

The Climate-Fisheries conceptual model illustrates pathways from physical drivers such as ocean temperature, sea ice and transport to nutrients, phytoplankton, lower trophic levels, benthic and pelagic organisms, marine birds and mammals, and community parameters (Fig. 3 and Table 3). In addition, the impacts of climate on the system overall and on species distribution are illustrated (inset) because of the number of published papers describing those relationships.

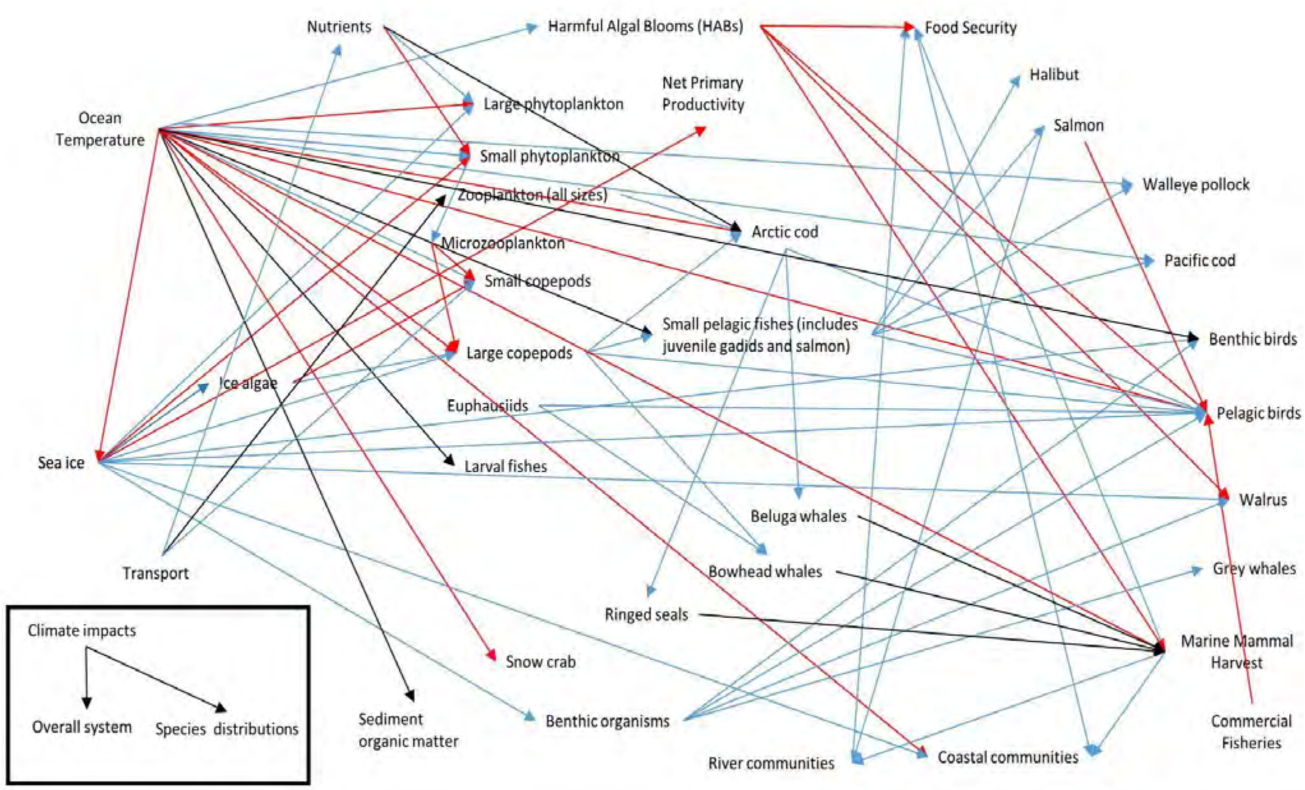

Fig. 3. Climate-fisheries model. Blue arrows indicate a positive relationship and red arrows indicate a negative relationship. Black arrows indicate: a positive or negative relationship depending on taxa; an effect on community structure or distribution; and/or an effect on phenology. See Table 3 for references.

The Climate-Fisheries conceptual model also included several components relevant to the human dimension, such as food security, marine mammal harvest, and coastal and river communities (Fig. 4). Food security is important to both river and coastal communities. There are positive relationships between marine mammal harvest and food security in general and coastal communities specifically (river communities are related to salmon). Marine mammal harvest, in turn, is negatively impacted by warming ocean temperature and increasing Harmful Algal Blooms (HABs); and positively affected by increases in Beluga whales, Bowhead whales and Ringed seals. Loss of sea ice, ocean warming, and other phenomena related to ocean warming have, overall, negative effects on coastal communities due to the disruption of familiar patterns and increased variability (Huntington *et al*., 2021).

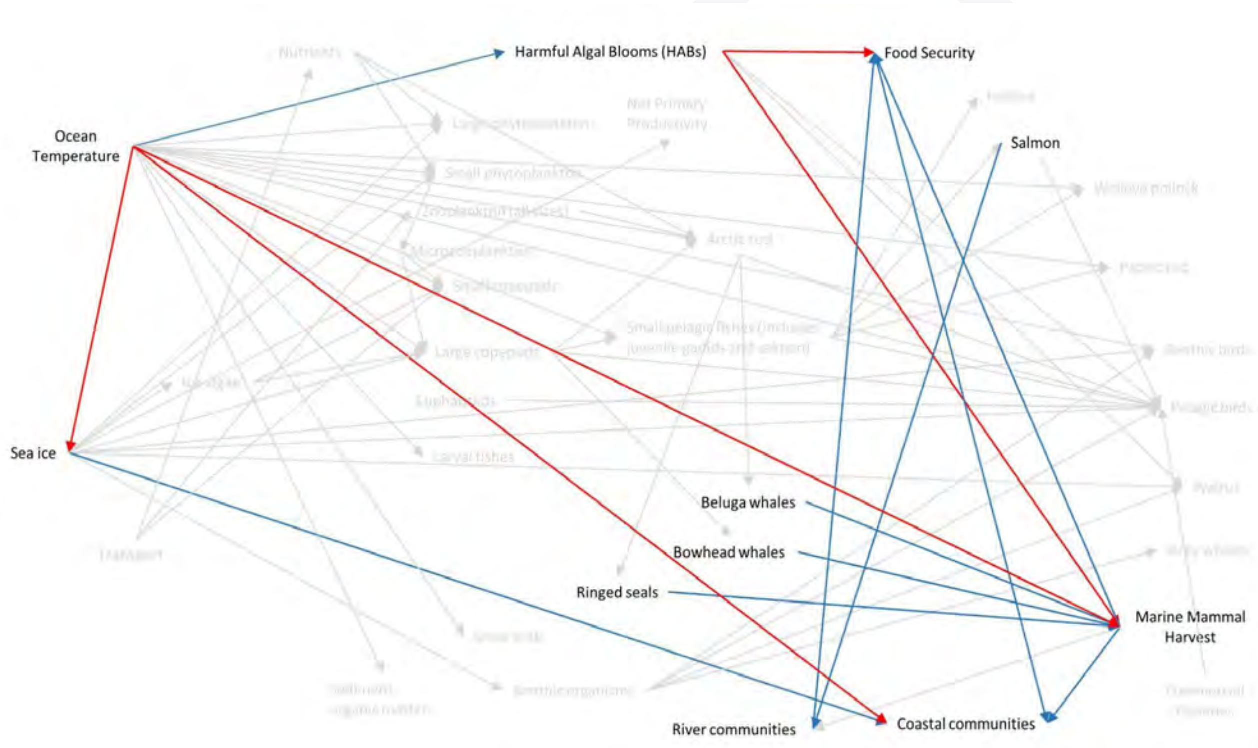

Fig. 4. Climate-fisheries model. Relationships relevant to coastal communities. See Table 3 for references.

Ocean temperature has direct effects on components across the range of trophic levels and habitats (Fig. 5). Many of the relationships are negative, as expected, but a few are positive. Specifically, warming ocean temperatures are expected to have a positive effect on small phytoplankton and small copepods, Harmful Algal Blooms (HABs) and boreal gadids such as walleye pollock and Pacific cod. Ocean temperature can also affect the phenology of phytoplankton (Nielsen *et al*., 2024).

The relationship between ocean temperature and sediment organic matter is neither positive nor negative because field samples and laboratory experiments indicated that the source of carbon may change with warming, to more terrestrial and bacterial carbon (Zinkann, *et al*., 2022). The relationship between ocean temperature and small pelagic fishes is neither positive nor negative because some species show a positive relationship and some negative with increasing temperature. In addition, some studies indicate changes in distribution of fish with increasing temperature (see Table 3 for specific references).

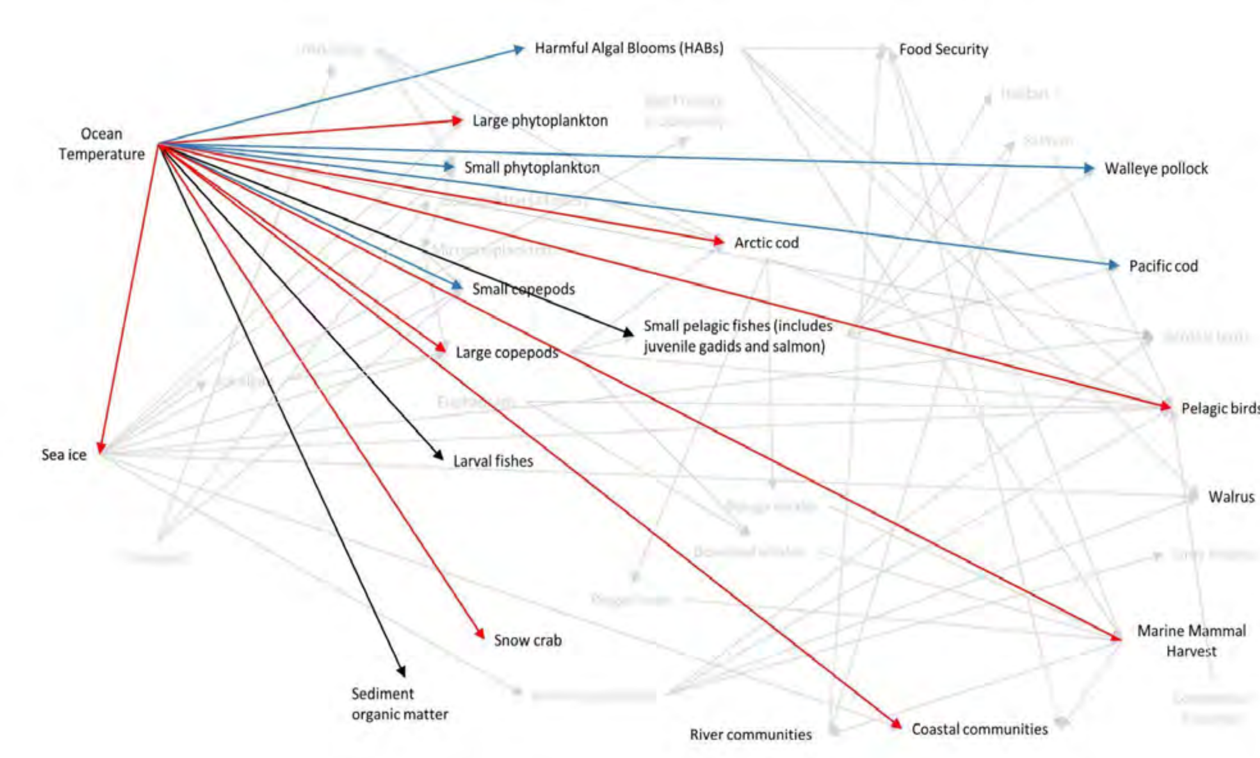

Fig. 5. Climate-fisheries model. Direct effects of ocean temperature. See Table 3 for references.

Not surprisingly, sea ice also has direct impacts throughout the ecosystem (Fig. 6). Decreasing sea ice is expected to negatively impact ice algae, large phytoplankton and large copepods, benthic organisms, marine birds (benthic and pelagic foraging) and walrus. Decreasing sea ice is also expected to directly negatively impact coastal communities. On the other hand decreasing sea ice is expected to positively impact small phytoplankton and net primary productivity.

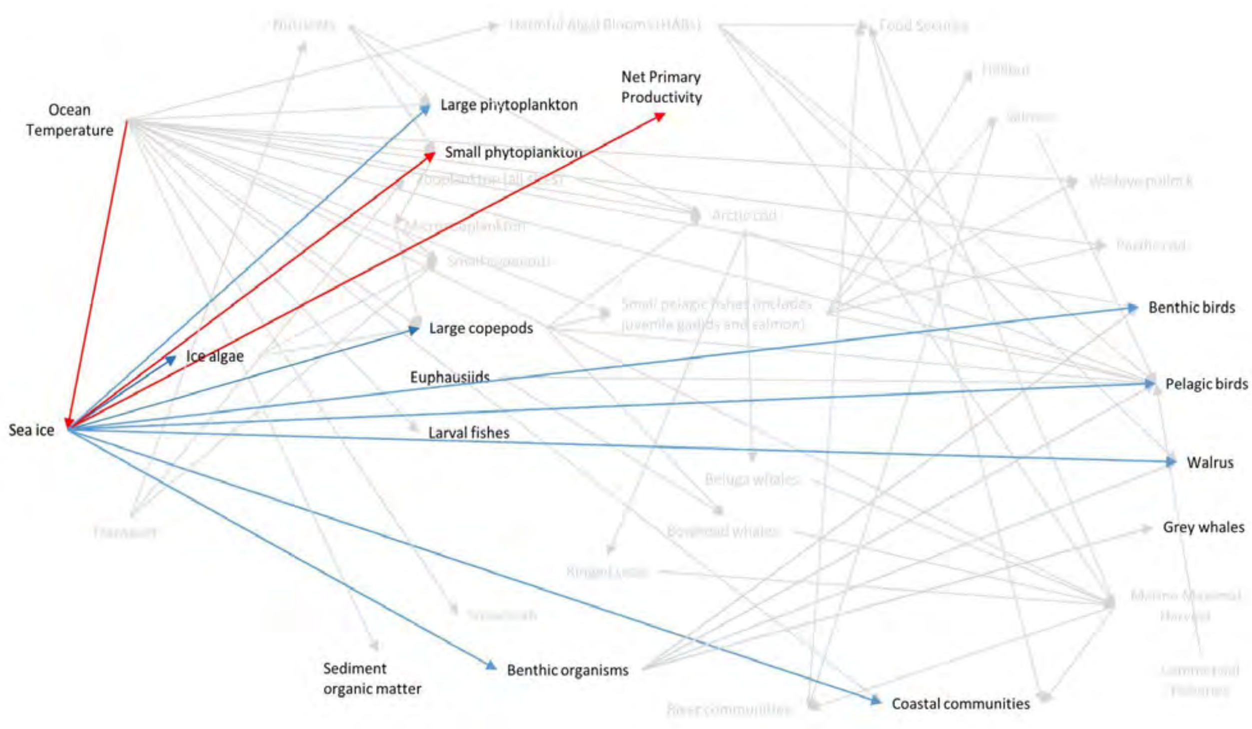

Fig. 6. Climate-fisheries model. Direct effects of sea ice. See Table 3 for references.

Harmful Algal Blooms (HABs) are an increasingly critical concern for NBS-CS coastal communities (Anderson *et al*., 2022). The conceptual model shows that warming ocean temperatures are expected to increase HABs with negative impacts on pelagic birds, walrus, marine mammal harvest and food security (Fig 7).

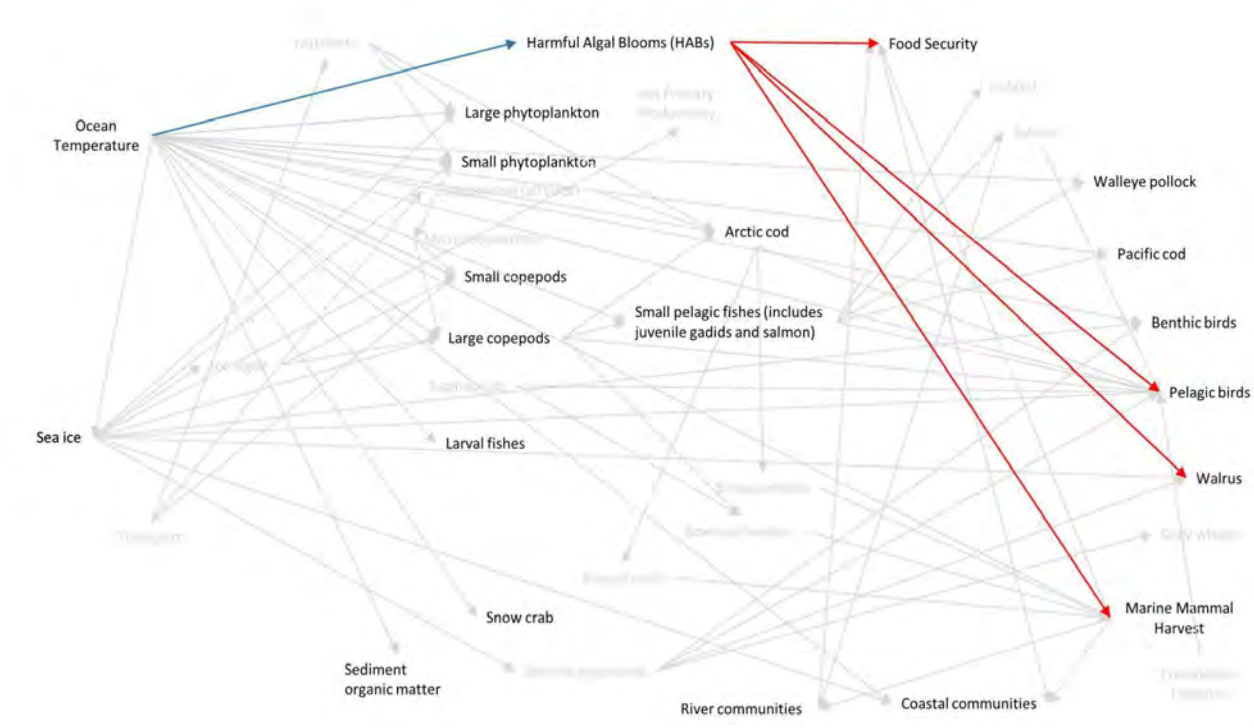

Fig. 7. Climate-fisheries model. Relationships relevant to Harmful Algal Blooms (HABs). See Table 3 for references.

Copepods are central to the food web in the Climate-Fisheries conceptual model (Fig. 8). In the model, large copepods are prey for Arctic cod, small pelagic fishes, pelagic birds and bowhead whales. Small copepods are relatively less important prey items. The size composition of the copepod community shifts to smaller taxa with ocean warming and loss of sea ice. In addition, increased transport increases the abundance of small copepods, some of which may be Pacific taxa. The structure of the food chain is also impacted by ocean warming. Small phytoplankton become relatively more abundant and microzooplankton become a more important player in the food web, decreasing the efficiency of energy transfer to copepods of all sizes. This has been shown for the summer season, in spring large phytoplankton and small and large copepods are directly linked (Gonzalez *et al*., *in revision*).

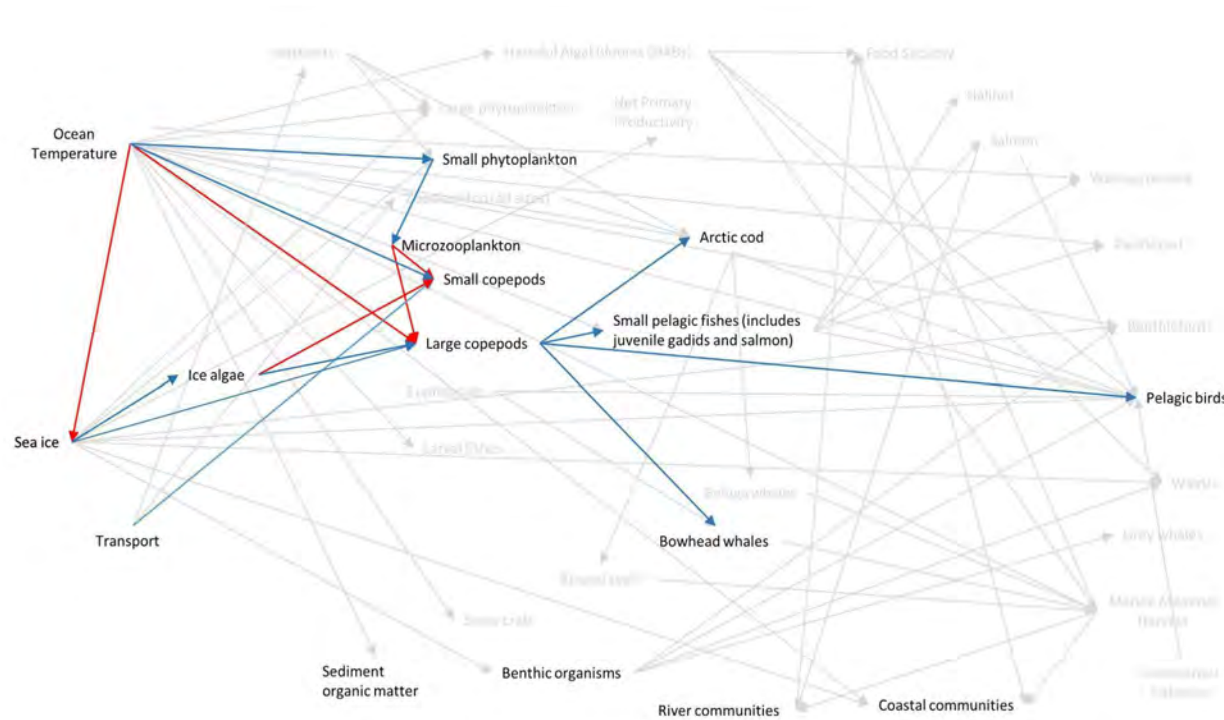

Fig. 8. Climate-fisheries model. Relationships relevant to small and large copepods. See Table 3 for references.

The NBS-CS is regarded as a benthic dominated ecosystem due to strong coupling between pelagic and benthic production (Grebmeier et. al, 1989). The conceptual model shows that benthic organisms are important for benthic and pelagic birds, walrus and gray whales (Fig. 9). Ocean warming and loss of sea ice are expected to have negative impacts on benthic organisms.

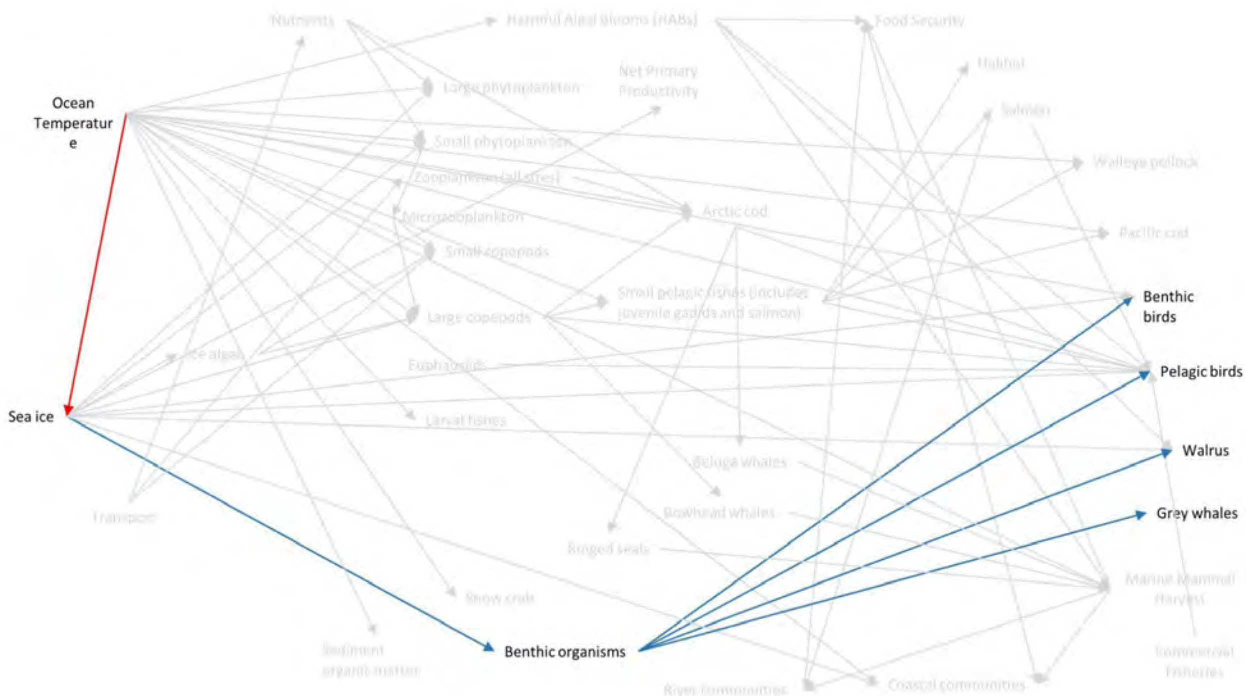

Fig. 9. Climate-fisheries model. Relationships relevant to benthic organisms. See Table 3 for references.

Arctic cod play a central role in the NBS-CS food web. In the conceptual model, they are prey for pelagic birds, Beluga whales and ringed seals (Fig. 10). Arctic cod prey on large copepods, so the direct and indirect effects of ocean temperature, sea ice and transport on copepod abundance, size distribution and food web structure described above affect them as well. The relationship between nutrients and Arctic cod is neither positive nor negative - nutrients have been shown to affect the distribution and community structure of pelagic fish (Cui *et al*., 2009).

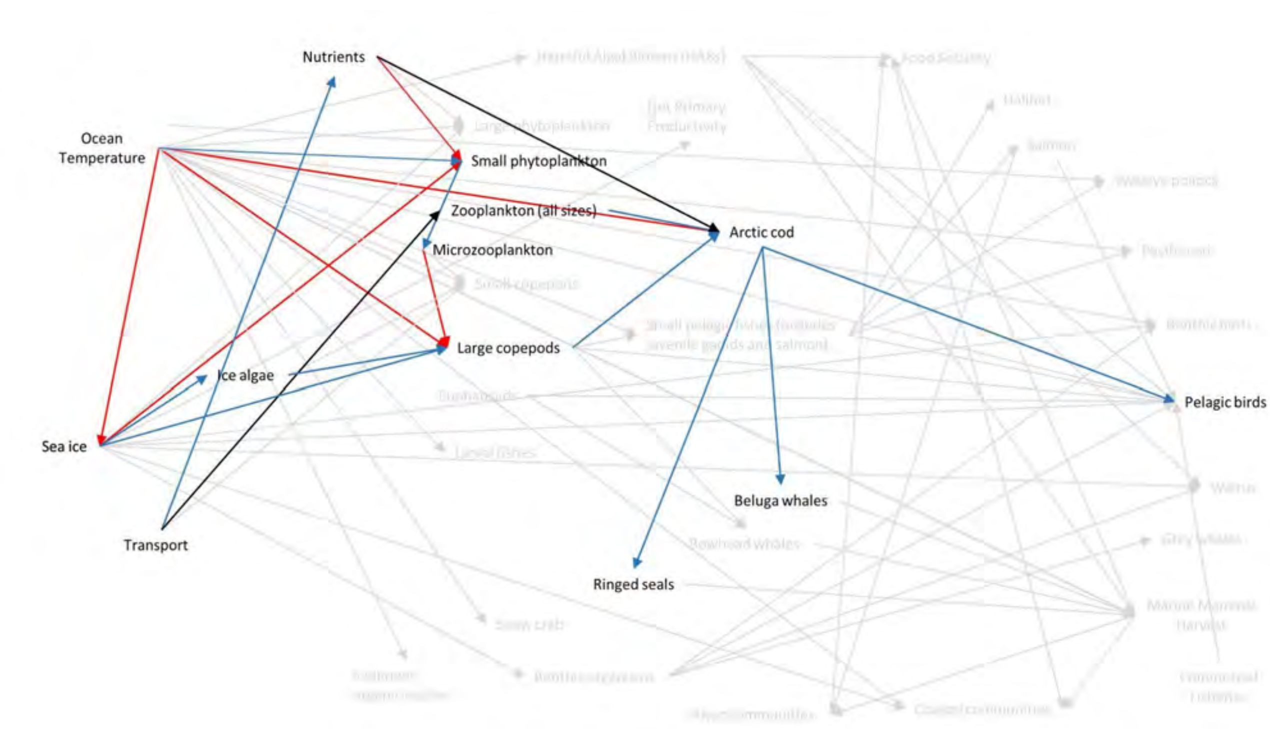

Fig. 10. Climate-fisheries model. Relationships relevant to Arctic cod. See Table 3 for references.

Small pelagic fish other than Arctic cod (including gadids and salmon) are also a key component of the conceptual model (Fig. 11). They are prey for halibut, salmon, walleye pollock, Pacific cod and pelagic birds. They prey on large copepods so the direct and indirect effects of physical drivers on copepod community size structure and food web structure described above impact them as well. The relationship between ocean temperature and small pelagic fish is neither positive nor negative because some species show a positive relationship with temperature and others show a negative relationship. In addition, some studies have documented a change in distribution of small pelagic fish.

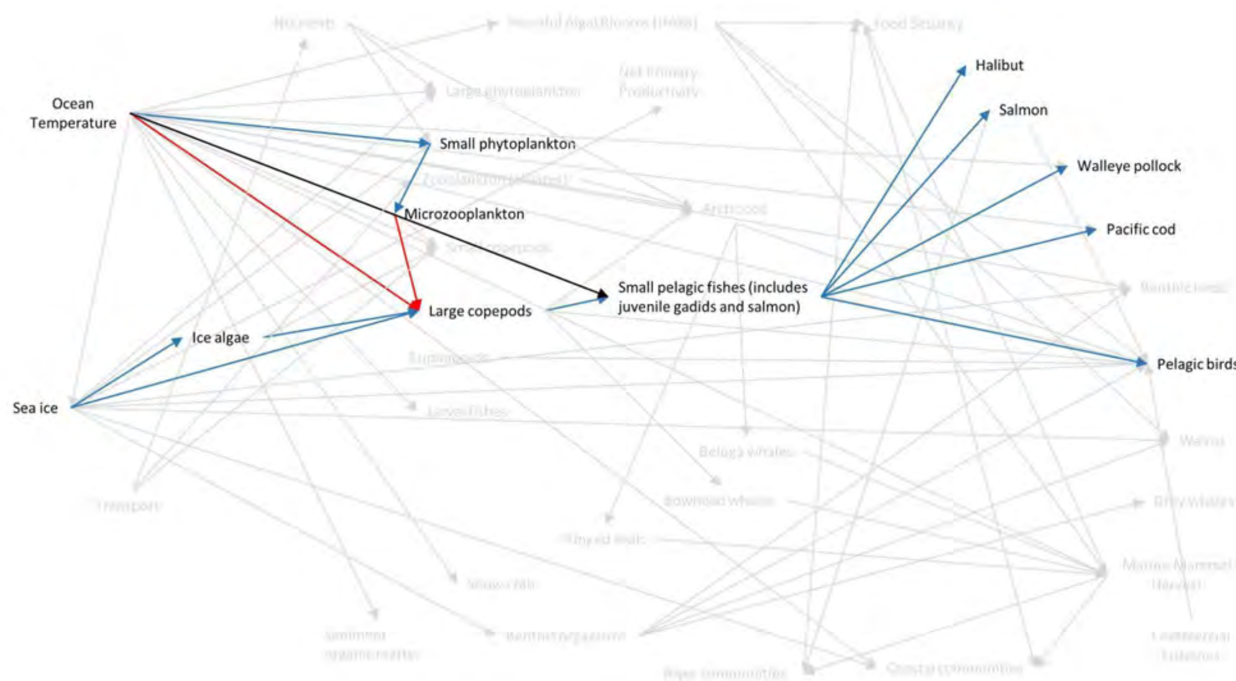

Fig. 11. Climate-fisheries model. Relationships relevant to small pelagic fishes (includes juvenile gadids and salmon). See Table 3 for references.

Pelagic birds appear to be an indicator for several physical and biological ecosystem components (Fig. 12). They are positively related to sea ice, benthic organisms, large copepods and euphausiids, and Arctic cod and other small pelagic fishes. They are negatively related to ocean temperature, HABs, and commercial fisheries. They are also negatively related to pink salmon, which are thought to be competitors with seabirds for shared prey (Springer *et al*., 2014).

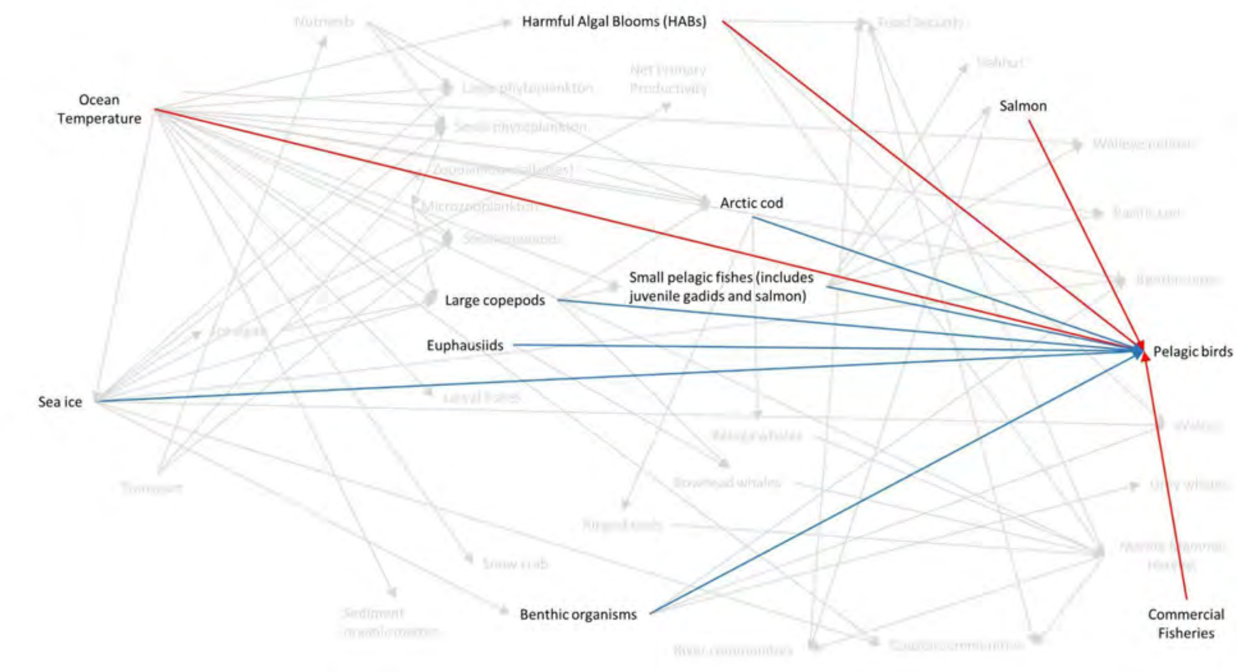

Fig. 12. Climate-fisheries model. Relationships relevant to pelagic birds. See Table 3 for references.

Table 3. Interactions for the Climate-Fisheries model with references indicated by numbers (see Table 4 for full citations). The drivers/independent variables are listed in the first column. The response/dependent variables are listed in the top row. Blue indicates a positive relationship, red indicates a negative relationship. Gray indicates: a positive or negative relationship depending on taxa; an effect on community structure or distribution; and/or an effect on phenology.

	Overall System	Sea Ice	Ice Algae	Coastal Communities	River Communities	Species Distributions
Overall system	5, 6					
Ocean Temperature	115, 117, 118	156, 157		44		
Sea Ice	3		142, 143, 144	44		
Nutrients						
Ice Algae						
Small Phytoplankton						
Microzooplankton						
Zooplankton (general, all)						
Large Copepods						
Transport						
Commercial Fisheries						
Marine Mammal (Harvest)				43	7, 8, 9, 10	
Bowhead whales						
Beluga whales						
Ringed seals						
Salmon					8	
Food Security				11, 43, 130, 134, 139, 140	9	
Coastal Communities	141					
Harmful Algal Blooms (HAB)						
Climate Impacts	19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 115, 117, 118					17, 74, 75, 76, 77
Small Pelagic Fishes (juvenile gadids, salmon)						
Arctic Cod	4					
Euphausiids						
Benthic Organisms						

Table 3 (Continued).

	Food Security	Marine Mammal (Harvest)	Walrus	Grey Whales	Bowhead whales	Beluga whales	Ringed seals
Overall system							
Ocean Temperature		14					
Sea Ice			129				
Nutrients							
Ice Algae							
Small Phytoplankton							
Microzooplankton							
Zooplankton (general, all)							
Large Copepods					152, 153, 154, 155		
Transport							
Commercial Fisheries							
Marine Mammal (Harvest)			10				10
Bowhead whales	7	150					
Beluga whales		151					
Ringed seals		150					
Salmon							
Food Security	9						
Coastal Communities	139,140	139, 140					
Harmful Algal Blooms (HAB)	15, 16, 108	16	16				
Climate Impacts							
Small Pelagic Fishes (juvenile gadids, salmon)							
Arctic Cod						148, 149	146,148
Euphausiids					152, 153, 154, 155		
Benthic Organisms			128	127			

Table 3 (Continued).

	HABs	Sea Ice	Nutrients	Sediment organic matter	Small Phytoplankton	Large Phytoplankton	Net Primary Productivity
Overall system							
Ocean Temperature	108, 14, 107	29, 30, 31, 32, 33, 34, 35		120	40, 116	40, 116	
Sea Ice					109, 119	39, 109, 119	41, 109
Nutrients					40	40	
Ice Algae							
Small Phytoplankton							
Microzooplankton							
Zooplankton (general, all)							
Large Copepods							
Transport			37, 38, 132				
Commercial Fisheries							
Marine Mammal (Harvest)							
Bowhead whales							
Beluga whales							
Ringed seals							
Salmon							
Food Security							
Coastal Communities							
Harmful Algal Blooms (HAB)							
Climate Impacts							
Small Pelagic Fishes (juvenile gadids, salmon)							
Arctic Cod							
Euphausiids							
Benthic Organisms							

Table 3 (Continued).

	Micro-zooplankton	Zooplankton (general, all)	Large Copepods	Small Copepods	Coastal Communities	Benthic Birds	Pelagic Birds
Overall system							
Ocean Temperature			113	19, 20, 113	44	114	17, 45, 78, 79, 84, 85, 86, 90, 91, 103, 105, 106, 114
Sea Ice					43	87, 88, 136	83, 84, 92, 104
Nutrients							
Ice Algae			17	17			
Small Phytoplankton	142						
Microzooplankton			142	142			
Zooplankton (general, all)							
Large Copepods							84, 93, 94, 95, 97, 98, 99, 103, 126
Transport		110		143			
Commercial Fisheries							89, 90
Marine Mammal (Harvest)							
Bowhead whales							
Beluga whales							
Ringed seals							
Salmon							100, 101
Food Security							
Coastal Communities							
Harmful Algal Blooms (HAB)							80, 82
Climate Impacts							
Small Pelagic Fishes (juvenile gadids, salmon)							45, 81, 84, 93, 95, 96, 97
Arctic Cod							93, 95, 104
Euphausiids							84, 93, 94, 95, 97, 98, 99, 102, 103
Benthic Organisms						87, 88, 133, 135, 136	93, 95

Table 3 (Continued).

	Benthic Organisms	Small Pelagic Fishes	Larval fishes	Walleye pollock	Pacific cod	Arctic Cod	Halibut	Salmon	Snow crab (opilio)
Overall system						4			
Ocean Temperature		17, 47, 48, 49, 50, 51, 52, 53, 54, 55, 138	111	52, 57, 63, 65, 65, 124, 125	57, 60, 63, 66	52, 56, 57, 58, 59, 60, 61, 62, 123			112
Sea Ice	127								
Nutrients						138			
Ice Algae						2			
Small Phytoplankton									
Microzooplankton									
Zooplankton (general, all)						137			
Large Copepods		67, 68, 69, 137				137,122			
Transport									
Commercial Fisheries									
Marine Mammal (Harvest)									
Bowhead whales									
Beluga whales									
Ringed seals									
Salmon									
Food Security									
Coastal Communities									
Harmful Algal Blooms (HAB)									
Climate Impacts									
Small Pelagic Fishes (juvenile gadids, salmon)				70, 71	70, 71		70	45, 72, 73	
Arctic Cod									
Euphausiids									
Benthic Organisms									

Table 4. Full citations for references for the Climate-Fisheries model (shown in Fig. 2 and Table 3).

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2.4 Knowledge gaps and next steps

The Food Sovereignty-Subsistence breakout group did not have time to fully explore the role of food sovereignty in their model. Other questions to explore include: How should we evaluate potential new food sources in the context of a traditional framework? Are new resources (e.g., salmon or subarctic groundfish) a potential additional source of subsistence or an unwelcome or at least unfamiliar change? How should we consider these changes in evaluating challenges to maintaining cultural practices and norms? How should we think of these shifts in terms of community resilience? Finally, ensuring that a diversity of perspectives are included in developing a conceptual model is key in creating a model that most accurately reflects the system components and their interrelatedness. The WG's modeling exercise included numerous international scientists with differing expertise. However, the group only contained two or three Indigenous perspectives, and would have been improved with more Native Alaskan voices.

The Climate-Fisheries model focused on trophic interactions (predation or competition) but other interactions with the environment, such as conditions for reproduction, should also be included. In addition, seasonality and phenology were not well-represented in the Climate-Fisheries model.

One next step for this work on conceptual models of the NBS-CS would be to run scenarios to determine how the system might react under a range of possible changes. Mental modeler software can be used for this task. Another next step would be to use the conceptual models to develop a data-driven Integrated Ecosystem Assessment. The inventory of metadata of information sources developed to fulfill WG 44's deliverables provides a guide to current data availability for such an effort.

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Appendix 1 WG 44 Terms of Reference

WG44 Joint PICES/ICES Working Group on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea (NBS-CS)

Original Terms of Reference

Year 1 Deliverables:

- Inventory of metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea LME. PICES or ICES Report. Web-based repository.

Year 2 Deliverables:

- Ecosystem description from both Indigenous world views and science (shared conceptual models), indicators and hypotheses. PICES or ICES Report. Contribution to Arctic Report Card and or ecosystem status report.
- Report on Ecological Objectives (co-produced with PAME).
- Report on Ecological Values Workshop (co-produced with PAME).

Year 3 Deliverables:

- Integrated Ecosystem Assessment for the Northern Bering Sea-Chukchi Sea LME. PICES or ICES Report. Contribution to NPESR. PAME-AMAP-CAFF Report. Contribution to Arctic Report Card.
- Journal articles
- Outreach activities
- Knowledge Gap and Next Steps Report. PICES or ICES Report.

Revised Terms of Reference (May 2023)

Year 1 Deliverables:

- Inventory of metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea LME. (accomplished)

Final Deliverables:

- Ecosystem description from both Indigenous world views and science (shared conceptual models), indicators and hypotheses. PICES Report and/or Journal article. Knowledge Gap and Next Steps Report. PICES Report and/or Journal article.

Appendix 2 WG 44 Arctic Metadata

The first column is a general Arctic research "Category" (e.g. marine mammals, pelagic seabirds, etc.) followed by a generalized "Data Type" description (e.g. trawls, pelagic fishes, etc.). The field "Data Source" refers to a general location of the data and/or the name of the research project. The column "Data Links / Contact(s)" is a hyperlink to the data online as of the printing of this report and if the data is not online or unknown, an agency and last known email contact is provided. Acronym definitions can be found in Appendix 5.

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Adult fish / fish diet, consumption rates	AFSC Stomach Lab	https://www.fisheries.noaa.gov/inport/item/20485
Adult fish / lipid dataset, fish	AFSC ABL	https://www.fisheries.noaa.gov/inport/item/17285
Adult fish / acoustics, adult fish (beam trawls)	ArcticIERP	https://arctic-ierp.portal.axds.co/
Adult fish / bottom trawls / beam trawls	snow crab biomass, abundance, size frequency	https://arctic-ierp.portal.axds.co/
Adult fish / fish catch data	Pelagic trawl catch data	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Adult fish / fish catch data	Pelagic trawl catch data	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com

Category / Data Type	Data Source	Data Links / Contact(s)
Adult fish / herring; possible other fish?	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Adult fish / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Adult fish / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Adult fish / fish biomass, fish abundance	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Adult fish / pelagic fishes	AFSC/RACE/MACE: Pollock Acoustic-Trawl Survey Biennial Bering Sea	https://www.fisheries.noaa.gov/inport/item/28186
Adult fish / pelagic fishes	AFSC/RACE/MACE: Pollock Acoustic-Trawl Survey Biennial Bering Sea	https://www.fisheries.noaa.gov/inport/item/28146
Adult fish / benthic fishes	AFSC/RACE/GAP: Eastern Bering Sea Annual Bottom Trawl Survey	https://www.fisheries.noaa.gov/inport/item/22008
Adult fish / benthic fishes	AFSC/RACE/GAP: Eastern Bering Sea Annual Bottom Trawl Survey	https://www.fisheries.noaa.gov/inport/item/22008
Adult fish / benthic fishes	ArcticIERP	https://www.nprb.org/arctic-program/about-the-program/

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Benthic epifauna / species ID, biomass, abundance, functional traits, sediment	AMBON (MBON Data Portal)	https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversit/ / kbiken@alaska.edu
Benthic epifauna / macrobenthic invertebrates	PacMARS	https://data.eol.ucar.edu/dataset/255.009
Benthic epifauna / biomass, abundance	Various trawls	https://search.dataone.org/view/doi%3A10.5065%2FD67M05ZX
Benthic epifauna / invertebrate pathology, benthic organisms	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Benthic epifauna / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Benthic epifauna / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Benthic epifauna / benthic epifauna, crab	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Benthic epifauna	BOEM	http://arcticstudies.org/

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic epifauna / benthos	SBI Data Access	https://data.eol.ucar.edu/master_lists/generated/sbi/
Benthic epifauna / varies	RUSALCA	https://www.pmel.noaa.gov/rusalca/
Benthic epifauna / varies	ASGARD (Arctic Shelf Growth, Advection, Respiration and Deposition)	https://arctic-ierp.portal.axds.co/
Benthic epifauna / CTD casts	Norton Sound Crab Survey	https://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareanortonsound.shellfish
Benthic epifauna / lipid dataset, invertebrates	AFSC ABL	https://www.fisheries.noaa.gov/inport/item/17285
Benthic epifauna / oceanographic	Arctic IERP	https://www.nprb.org/arctic-program/about-the-program/
Benthic infauna / Species ID, biomass, abundance, functional traits, sediment	Benthic samples; van Veen grabs	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Benthic infauna / benthic infauna	Benthic samples; van Veen grabs	https://data.eol.ucar.edu/dataset/255.076

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic infauna / macroinfauna from CG Healy 2017	Benthic samples; van Veen grabs	https://search.dataone.org/view/doi%3A10.18739%2FA27M0414K
Benthic infauna / invertebrate pathology, benthic organisms	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Benthic infauna / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Benthic infauna	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/search?searchKey=BSIERP&searchType=ALL&max=100&offset=0&order=asc&sort=title
Benthic infauna	BOEM	http://arcticstudies.org/
Benthic infauna / benthos	SBI Data Access	https://data.eol.ucar.edu/master_lists/generated/sbi/
Benthic infauna / lipid dataset, invertebrates	AFSC ABL	https://www.fisheries.noaa.gov/inport/item/17285
Benthic infauna	ArcticIERP	https://www.nprb.org/arctic-program/about-the-program/

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Benthic infauna	AFSC EFH	https://www.fisheries.noaa.gov/foss/f?p=215%3A28
Ecosystem modeling / updated model from Whitehead model	ECOPATh, ECOSIM	https://search.dataone.org/
Ecosystem modeling / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Ecosystem modeling / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Ecosystem modeling / models	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Ecosystem modeling / oceanographic	ArcticIERP	https://www.nprb.org/arctic-program/about-the-program/
Environmental Drivers / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Environmental Drivers / temperature, salinity, currents	Moorings: NBS: M5 (BS-5), M8 (BS-8); Chukchi: C1-9	https://www.pmel.noaa.gov/foci/foci_moorings/mooring_info/mooring_location_info.html

Category / Data Type	Data Source	Data Links / Contact(s)
Environmental Drivers / SST, Ocean color (unreliable north), wind, salinity, sea level	Satellites (MODIS, SeaWIFS)	https://polarwatch.noaa.gov/catalog/
Environmental Drivers / temperature, salinity, currents	Model (ex: ROMS, PAROMS)	https://www.ecofoci.noaa.gov/modeling
Environmental Drivers / sea ice extent	NSIDC	https://nsidc.org/data/explore-data
Environmental Drivers / atmosphere, ocean waves, wind	ERA5 winds (assimilated observational reanalysis)	https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5
Environmental Drivers / sediment, carbon	PacMars	https://arcticdata.io/catalog/portals/DBO
Environmental Drivers / temperature, salinity, many other metrics	Chukchi Ecosystem Observatory (CEO) mooring array (northern CS)	http://research.cfos.uaf.edu/ceo/
Environmental Drivers / monitoring sea ice	Canada (DFO) / Colloborative	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Environmental Drivers / variability and change of the marine ecosystem	Canada (DFO) / DBO	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / Pacific Water inflow to the Arctic	Canada (DFO) /C3O Ships of Opp	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / Pacific Water in the Arctic Basin	University of Manitoba SHEBA Geochemical	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / monitoring sea ice, Pacific water influence	Canada (DFO) / AIM	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / contaminants, stable isotopes	University of Manitoba (SHEBA) Contaminants and Isotopes	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / carbon fluxes, pCO2	University of Manitoba ArcticNet	Fisheries and Ocean Canada (DFO) / andrea.niemi@dfo-mpo.gc.ca
Environmental Drivers / model output particle tracking	NA (modeled dataset)	https://search.dataone.org/view/urn%3Auuid%3Adc3539de-e5b7-45f1-b5fa-62da23db3a16

Category / Data Type	Data Source	Data Links / Contact(s)
Environmental Drivers / alkalinity, attenuation/transmission, carbon dioxide, chlorophyll, conductivity, nitrate, nitrite, oxygen, phosphate, salinity, silicate, stable isotopes, water pressure, temperature	PacMars / Chinare	https://data.eol.ucar.edu/dataset/255.081
Environmental Drivers / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Environmental Drivers / sediment values	The Circum-Arctic Sediment CArbon DatabasE	https://bolin.su.se/data/cascade
Environmental Drivers / extensive bathymetry grid	AFSC/RACE/GAP/Prescott: Norton Sound Bathymetry	https://www.fisheries.noaa.gov/alaska/ecosystems/alaska-bathymetry-sediments-and-smooth-sheets
Environmental Drivers / acoustic monitoring, baseline chemistry, benthic ecology, chemical oceanography, fisheries ecology, marine mammal ecology, physical oceanography, plankton ecology, nutrients, seabirds	CSESP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0124308
Environmental Drivers / oceanographic	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Environmental Drivers / oceanographic	ArcticIERP	https://www.nprb.org/arctic-program/about-the-program/
Environmental Drivers / hydrography, nutrients	NOAA AFSC EMA Program	https://www.ecofoci.noaa.gov/data-links
Environmental Drivers / oceanography, marine chemistry, zooplankton	Russian Federal Research Institute of Fisheries and Oceanography	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Environmental Drivers / temperature, salinity, dissolved oxygen, SiO3, PO4, pH profiles	DVNIGMI -Russian Hydrometeorological Agency	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Environmental Drivers / physical oceanography, marine chemistry, marine biology (zooplankton)	Russian Fisheries Agency - Pacific (TINRO)	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Environmental Drivers / meteorology, partial physical oceanography, chemical oceanography	Hydro Meteorological Agency (HMA)	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Environmental Drivers / varies	Pac. Oceanological Institute (POI FEB RAS)	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com

Category / Data Type	Data Source	Data Links / Contact(s)
Environmental Drivers / sediment chemical characteristics	BOEM	http://arcticstudies.org/
Environmental Drivers / Nutrients	ASGARD	https://search.dataone.org/view/10.24431%2Frw1k6cn
Environmental Drivers / varies	Arctic Data Center General Link	https://arcticdata.io/catalog/data
Environmental Drivers / varies	UAF Data	https://www.uaf.edu/cfos/research/oarc/data-resources/
Environmental Drivers / varies	DBO Lines	https://arcticdata.io/catalog/portals/DBO/Data
Environmental Drivers / varies	Korea Polar Data Center	https://kpdc.kopri.re.kr/search/?q=Arctic&q=Chukchi
Environmental Drivers / sediment, hydrography, oceanography, satellite, other	SBI Data Access	https://data.eol.ucar.edu/master_lists/generated/sbi/
Environmental Drivers / AOOS data in support of the CSESP program	CSESP	https://www.chukchiscience.com/ ; https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0124308

Category / Data Type	Data Source	Data Links / Contact(s)
Environmental Drivers / Chla depth stratified in situ, MODIS (surface optional depth only satellite)	AFSC	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Environmental Drivers / fluorescence, Ice algae	AFSC	https://www.ecofoci.noaa.gov/data-links
Environmental Drivers / total/size fraction chla	BASIS	https://portal.aoos.org/#module-metadata/d4fe79aa-75b6-11e4-956f-00265529168c
Environmental Drivers / water physics, current meter, wind, various	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Forage Fish / distribution, species composition, and abundance, size composition	Shipboard bongo nets	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / Age-0/Age-1 acoustic and midwater trawl	Shipboard nets, moorings, saildrone	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / Acoustics age 0/1 gadids	Moored transducers	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262

Category / Data Type	**Data Source**	**Data Links / Contact(s)**
Forage Fish / Age-1+	Beam Trawls	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / demersal fish community	Beam trawls	University of Alaska Fairbanks / College of Fisheries and Ocean Sciences / fmueter@alaska.edu
Forage Fish / age and growth of saffron cod, Arctic cod, walleye pollock, Pacific cod (NBS only)	Demographics	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / demersal fish community	Beam trawls	University of Alaska Fairbanks / College of Fisheries and Ocean Sciences / fmueter@alaska.edu
Forage Fish / gut contents	Fish diet and consumption rates	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / fish catch data	Pelagic trawl catch data	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Forage Fish / fish catch data	Pelagic trawl catch data	Pacific Fisheries Research Center (TINRO) / zuenko_yury@hotmail.com
Forage Fish / herring	varies	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Forage Fish / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?

Category / Data Type	Data Source	Data Links / Contact(s)
Forage Fish / forage fish abundance, acoustics, biomass	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Forage Fish / pelagic fishes, YOY, forage fish	AFSC/RACE/MACE: Pollock Acoustic-Trawl Survey Biennial Bering Sea	https://www.fisheries.noaa.gov/inport/item/28186
Forage Fish / pelagic fishes, YOY, forage fish	AFSC/RACE/MACE: Pollock Acoustic-Trawl Survey Biennial Bering Sea	https://www.fisheries.noaa.gov/inport/item/28146
Forage Fish / benthic fishes, YOY, forage fishes	AFSC/RACE/GAP: Eastern Bering Sea Annual Bottom Trawl Survey	https://www.fisheries.noaa.gov/inport/item/22008
Forage Fish / benthic fishes, YOY, forage fishes	AFSC/RACE/GAP: Eastern Bering Sea Annual Bottom Trawl Survey	https://www.fisheries.noaa.gov/inport/item/22008
Forage Fish / hydrography, nutrients, zooplankton, chlorophyll, ecosystem, Northern Bering Sea	AFSC EMA	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / fish diet, consumption rates	AFSC Stomach Lab	https://www.fisheries.noaa.gov/inport/item/20485

Category / Data Type	Data Source	Data Links / Contact(s)
Forage Fish / lipid dataset, fish	AFSC ABL	https://www.fisheries.noaa.gov/inport/item/17285
Forage Fish / forage fish, Ecosystem, Northern Bering Sea	NOAA AFSC EMA Program	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Forage Fish / forage fish, pelagic	ArcticIERP	https://arctic-ierp.portal.axds.co/tps://www.nprb.org/arctic-program/about-the-program/
Forage Fish / yellowfin sole juveniles diet, age, lipids, fatty acid	AFSC	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Pelagic/Ice Algal Production / satellite, Chl a/fluorescence, primary production, estimates of size structure	MODIS, SeaWIFS, DBO Sites	https://modis.gsfc.nasa.gov/data/ ; https://oceancolor.gsfc.nasa.gov/SeaWiFS/ ; https://arcticdata.io/catalog/portals/DBO
Pelagic/Ice Algal Production / temperature, salinity, currents	Moorings: NBS: M5 (BS-5), M8 (BS-8); Chukchi: C1-9	https://www.pmel.noaa.gov/foci/foci_moorings/mooring_info/mooring_location_info.html

Category / Data Type	Data Source	Data Links / Contact(s)
Pelagic/Ice Algal Production / shipboard, chlorophyll	AIERP, DBO, BASIS for NBS, etc	pacmars.eol.ucar.edu; http://arcticstudies.org/; https://arcticdata.io/catalog/portals/DBO
Pelagic/Ice Algal Production / size fractionated chlorophyll	ArcticIERP, BASIS	https://arctic-ierp.portal.axds.co/ ; https://portal.aoos.org/#module-metadata/d4fe79aa-75b6-11e4-956f-00265529168c
Pelagic/Ice Algal Production / shipboard; In situ primary production calculations/experiments	ArcticIERP	https://arctic-ierp.portal.axds.co/
Pelagic/Ice Algal Production / shipboard; FlowCam in situ taxonomic ID of large phytoplankton and flow cytometry for abundance of small phytoplankton	ArcticIERP	https://arctic-ierp.portal.axds.co/
Pelagic/Ice Algal Production / microplankton community composition and abundances based on microscopy analyses	Shipboard	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262

Category / Data Type	Data Source	Data Links / Contact(s)
Pelagic/Ice Algal Production / primary productivity, phytoplankton	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Pelagic/Ice Algal Production / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Pelagic/Ice Algal Production / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Pelagic/Ice Algal Production / under ice CTD data; chlorophyll, many variables	NPRB and NSF	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Pelagic/Ice Algal Production / nutrient, sea ice, other	SBI Data Access	https://data.eol.ucar.edu/master_lists/generated/sbi/
Process Links / stable isotopes; Bulk C and N from copepods	ArcticIERP	https://arctic-ierp.portal.axds.co/

Category / Data Type	Data Source	Data Links / Contact(s)
Process Links / stables isotopes; Bulk C and N and compound specific C and N stable isotopes of amino acids (CSIAA) from benthic animals	DBO Sites	https://www.sciencedirect.com/science/article/pii/S0967064517304265
Process Links / stable isotopes; organic carbon and nitrogen in organic fraction of sediments	DBO Sites	https://arcticdata.io/catalog/portals/DBO; http://arcticstudies.org/
Process Links / stable isotopes; Bulk C and N from benthic invertebrates across the Chukchi Sea, also CSI-AA	AMBON (RUSALCA and ASGARD)	https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversit/ / kbiken@alaska.edu
Process Links / lipid/fatty acids; phytoplankon; zooplankton; young gadids	ArcticIERP	Alaska Fisheries Science Center Metadata Library / https://www.fisheries.noaa.gov/inport/item/7262
Process Links / drifting sediment traps / sediment traps at moorings	UAF	https://www.frontiersin.org/articles/10.3389/fmars.2020.548931/full

Category / Data Type	Data Source	Data Links / Contact(s)
Process Links / phytoplankton; zooplankton; microzooplankton; grazing rates	KOPRI cruise	See paper link under notes for several citations to grazing rates
Process Links / microzooplankton (MZ) grazing rates	ASGARD 2017	https://search.dataone.org/data/query=asgard? / mlomas@bigelow.org
Process Links / compound specific C and N stable isotopes of amino acids (CSIAA) from benthic animals	AMBON	https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversit/ / kbiken@alaska.edu
Process Links / possible links	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Process Links / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Process Links / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Process Links / process links, many	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project

Category / Data Type	Data Source	Data Links / Contact(s)
Process Links / water chemistry, stable isotopes, other	SBI Data Access	https://data.eol.ucar.edu/master_lists/generated/sbi/
Zooplankton / distribution, species composition, and abundance	Shipboard bongo nets (AIERP, DBO, EcoFOCI, BASIS)	https://portal.aoos.org/#module-metadata/d4fe79aa-75b6-11e4-956f-00265529168c / david.kimmel@noaa.gov
Zooplankton / distribution, species composition, and abundance	Shipboard bongo nets (ASGARD)	https://search.dataone.org/data/query=asgard? / rrhopcroft@alaska.edu
Zooplankton / distribution, species composition, and abundance	Shipboard bongo nets (AMBON)	https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversit/ / rrhopcroft@alaska.edu
Zooplankton / distribution, species composition, and abundance	Continuous plankton recorder	https://gulfwatchalaska.org/monitoring/environmental-drivers/continuous-plankton-recorder/ ; https://www.fisheries.noaa.gov/inport/item/7262 / louise.copeman@noaa.gov
Zooplankton / gut contents	FOCI and or ABL	https://www.fisheries.noaa.gov/inport/item/12324 / johanna.vollenweider@noaa.gov

Category / Data Type	Data Source	Data Links / Contact(s)
Zooplankton	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Zooplankton / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Zooplankton / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Zooplankton / zooplankton, acoustics, biomass	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Zooplankton / ecosystem, Northern Bering Sea	NOAA AFSC EMA Program	Alaska Fisheries Science Center Metadata Library / ed.farley@noaa.gov
Zooplankton / oceanographic	ArcticIERP	https://www.nprb.org/arctic-program/about-the-program/
Benthic foraging marine mammals / Platform of opportunity sightings provide presence-only information; substrate type data available from ArcticIERP beam trawls	DBO, oil/gas industry (I think JASCO did all of the acoustic monitoring in the NE Chukchi for Shell)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / Line-transect sightings provide data for deriving relative or absolute density	NOAA (N. Friday), IWC POWER (J. Crance)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / PAM - sonobuoys and towed arrays - provide presence-only information and information on noise	NOAA (C. Berchok), IWC POWER (J. Crance)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / photo ID may provide information on stock ID, residence time, life history parameters, and abundance	NOAA (MML - CAEP), IWC POWER (J. Crance)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / Line-transect sightings provide data for deriving relative or absolute density or abundance	NOAA/BOEM (Ferguson), oil/gas industry (LGL)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / Photo ID may provide information on stock ID, residence time, life history parameters, and abundance	ASAMM (Ferguson)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / Imagery - strip transect surveys - may be used to derive estimates of absolute or relative density or abundance	NOAA (P. Boveng)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / imagery - body condition assessment	ASAMM (Ferguson)	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov
Benthic foraging marine mammals / PAM provides presence-only data and information on noise	NOAA (Berchok), UW-APL(Stafford), oil/gas industry	Alaska Fisheries Science Center Metadata Library / jessica.crance@noaa.gov

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / movement rates, distribution, activity states, dive behavior, in situ environmental variables	ADFG (Quakenbush & Citta), NSB DWM, NOAA (P. Boveng), USGS (Fischbach)	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov
Benthic foraging marine mammals / Carcasses may provide a source of energy to pelagic, benthic, and coastal ecosystems	NOAA (Ferguson, K. Savage)	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov
Benthic foraging marine mammals / marine mammals	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP
Benthic foraging marine mammals / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Benthic foraging marine mammals / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / marine mammals	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Benthic foraging marine mammals / Marine mammal, cetacean stranding, cetacean entanglement, vessel strike, pinniped stranding, pinniped entanglement	Alaska Region Marine Mammal Stranding, Cetacean and Pinniped Entanglement, and Nonlethal Vessel Strike Reports, 1904-present	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov
Benthic foraging marine mammals /	Alaska Fisheries Science Center, 2020: AFSC/NMML	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov
Benthic foraging marine mammals / marine mammal; stranding; injury; mortality	Alaska Fisheries Science Center, 2020: AFSC/NMML: Known human-caused marine mammal injury and mortalities from 2007 to present, https://www.fisheries.noaa.gov/inport/item/26375.	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / Aleutian Islands; Arctic Ocean; Atlantic Ocean; Bering Sea; Gulf of Alaska; Pacific Ocean	Alaska Fisheries Science Center, 2020: AFSC/NMML: Platforms of Opportunity Program (POP): 1950 - present, https://www.fisheries.noaa.gov/inport/item/17407.	Alaska Fisheries Science Center Metadata Library / kate.savage@noaa.gov
Benthic foraging marine mammals / Difar; passive acoustics; seismic airguns; sonobuoy; marine mammal	Alaska Fisheries Science Center, 2020: AFSC/MML: Acoustics short-term passive monitoring using sonobuoys in the Gulf of Alaska, Bering, Chukchi, and Western Beaufort Seas, Summer 2007-2018, https://www.fisheries.noaa.gov/inport/item/17346.	http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0138863
Benthic foraging marine mammals / humpback whale; Megaptera novaeangliae; satellite telemetry	Alaska Fisheries Science Center, 2020: AFSC/NMML Location-only satellite telemetry data for North Pacific Humpback Whales in the Bering Sea, 2007 - 2011	http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0138946 https://www.fisheries.noaa.gov/inport/item/28149.
Benthic foraging marine mammals / marine mammal	Whale broad-scale distribution southeastern Bering Sea 2008 (B66)	2008: doi:10.5065/D6MK69W1
Benthic foraging marine mammals / marine mammal	Whale broad-scale distribution southeastern Bering Sea 2010 (B66)	2010: doi:10.5065/D6KK98S3

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from Sir Wilfred Laurier	2011: doi:10.18739/A26688J6H
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from US Coast Guard Cutter Healy (HLY1301)	2012: doi:10.18739/A2P843W2H
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from US Coast Guard Cutter Healy (HLY1201)	2013, Healy: doi:10.18739/A2JH3D285
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from Sir Wilfred Laurier ; 2013	2013 Laurier: doi:10.18739/A22F7JR1W.
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from Sir Wilfred Laurier ; 2014	2014:doi:10.18739/A2XP6V369

Category / Data Type	Data Source	Data Links / Contact(s)
Benthic foraging marine mammals / marine mammal, sea ice, ice cover, sea state, weather	Marine mammal watch, sea ice cover, sea state, weather, and visibility measurements from Sir Wilfred Laurier ; 2015	2015: doi:10.18739/A2T14TP68
Benthic foraging marine mammals / marine mammal	Marine mammal watch from Sir Wilfrid Laurier; 2016	2016: doi:10.18739/A27P8TD2J
Benthic foraging marine mammals / marine mammal	Marine mammal watch from US Coast Guard Cutter Healy (Hly17-02) ; 2017	2017: doi:10.18739/A25Q4RM2M
Benthic foraging marine mammals / acoustics, moorings	JASCO passive acoustics marine mammals	https://search.dataone.org/view/doi%3A10.5065%2FD64Q7S11
Benthic foraging marine mammals / lipid dataset, marine mammals	AFSC ABL	https://www.fisheries.noaa.gov/inport/item/17285
Benthic foraging marine mammals / marine mammal?	ArcticIERP	https://arctic-ierp.portal.axds.co/
Pelagic seabirds / marine seabird habitat, migratory seabird watch	OCSEAP	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:OCSEAP

Category / Data Type	Data Source	Data Links / Contact(s)
Pelagic seabirds / general portal for data	DataOne	https://search.dataone.org/data/query=arctic?
Pelagic seabirds / general portal for data	PacMARS	https://data.eol.ucar.edu/dataset/list?project=364&children=project&category=21
Pelagic seabirds / seabirds	BSIERP, BEST (NPRB and NSF)	https://data.eol.ucar.edu/dataset/list?project=341&children=project
Pelagic seabirds / seabirds	AMBON	https://mbon.ioos.us/#search?type_group=all&tag|tag=ambon-projects&page=1
Pelagic seabirds / seabirds, marine birds	US Fish and Wildlife Service	U.S.A. Fish and Wildlife Service, kathy_kuletz@fws.gov / https://www.usgs.gov/centers/alaska-science-center/science/north-pacific-pelagic-seabird-database?qt-science_center_objects=0#qt-science_center_objects
Pelagic seabirds / seabirds, colonies, breeding birds	US Fish and Wildlife ServiceNorth Pacific Seabird Colony Register	http://axiom.seabirds.net/maps/js/seabirds.php?app=north_pacific#z=3&ll=55.00000,-170.00000
Pelagic seabirds / seabirds, breeding, populations, trends, colonies	US Fish and Wildlife ServiceAlaska Seabird Colony Monitoring	https://www.fws.gov/uploadedFiles/Alaska%20Seabird%20Summary%20Report%202018.pdf

Category / Data Type	Data Source	Data Links / Contact(s)
Pelagic seabirds / waterfowl, geese, ducks, seaducks, loons	US Fish and Wildlife ServiceUSFWS Waterfowl Surveys	https://www.fws.gov/project/waterfowl-breeding-population-and-habitat-survey
Pelagic seabirds / seabirds	ArcticIERP	https://arctic-ierp.portal.axds.co/
Pelagic seabirds / seabirds, breeding, populations, trends, colonies	US Fish and Wildlife ServiceAlaska Seabird Colony Monitoring	https://www.fws.gov/uploadedFiles/Alaska%20Seabird%20Summary%20Report%202018.pdf
Pelagic seabirds / seabirds, St. Lawrence Island, Bering Sea	US Fish and Wildlife ServiceSeabird Monitoring Data from St. Lawrence Island	https://www.fws.gov/project/seabird-science-alaska-sized-scale
Pelagic seabirds / shorebirds, breeding birds	US Fish and Wildlife ServiceMonitoring Shorebird Populations	https://www.fws.gov/project/estimating-alaska-shorebird-populations
General Data Arctic	General Data Arctic	https://arcticdc.org/products/partner-data-products
General Data Arctic	General Data Arctic	https://arcticdata.io/catalog/data

Appendix 3 Lay of the Land

Indigenous-led approaches to support climate adaptation and resilience, and inform management in North Pacific and Arctic

W9 – Workshop Report

PICES Annual Meeting 2023 W9
October 20 & 21, 2023
Elliott Bay Room, Westin Seattle
Seattle, WA, USA

W9 – Workshop Report

Kathryn Sheps and Rebecca Martone, Ocean Decade Collaborative Center for the Northeast Pacific, Sarah Wise, NOAA Alaska Fisheries Science Center,
Rebecca Ingram, Pacific States Marine Fisheries Commission, and
W9 Workshop participants.

The Ocean Decade Collaborative Center for the Northeast Pacific (DCC) and NOAA's Alaska Fisheries Science Center (NOAA) jointly convened a workshop, *Indigenous-led approaches to support climate change adaptation, resilience and informed management in the North Pacific and Arctic*, that was held October 20th and 21st as part of the PICES 2023 Annual Meeting in Seattle, WA. Our aim was to share ways to weave together multiple knowledge systems and identify pathways to expand collaborations and partnerships in ecosystem research, climate change adaptation, and informed management processes.

The conveners set three main objectives for this workshop:

1. Bring together marine and coastal knowledge holders (including Indigenous and Traditional Knowledge holders, climate scientists, and ocean practitioners) to share stories, lessons, and perspectives of living with changing marine ecosystems.

2. Provide a safe space to build relationships, and share stories and lessons learned from Indigenous- led work.

3. Facilitate a cross regional knowledge network of Indigenous Knowledge holders, community leaders, and ocean practitioners to facilitate ongoing collaboration beyond the PICES annual meeting.

The workshop consisted of a one-day "closed door" invitational and participatory deliberative dialogue session, and a second half-day open-door knowledge sharing session open to participation from anyone registered for the PICES Annual Meeting. Participants joined the workshop from across the NE Pacific and beyond: participants included members of Indigenous communities from Washington, British Columbia and Alaska, as well marine scientists and "boundary spanners[1]" from the US, Canada, EU, and Australia.

Day 1

Day 1 started with a blessing, and a shared commitment to productive and collaborative work. The group participated in a comprehensive round of introductions so that participants could learn about the backgrounds and expertise of everyone in the room. During this period, some members reminded the group of the urgency of this work, particularly given the rapid pace and far-reaching effects of climate change on Indigenous communities. There was shared discussion on climate driven impacts on coastal communities in the North Pacific and Arctic including dramatic declines in key subsistence and commercial marine species, increased marine traffic and associated impacts, reduced sea ice, increased storm events (both in

[1] A 'boundary spanner' is an individual who can connect people across social, societal or cultural silos (Hatch *et al., 2022*)

frequency and severity), and changing ecological systems. Indigenous communities are coping with these changes with limited resources and capacity, further exacerbating the harmful effects. The group was reminded that Indigenous coastal communities have been experiencing, engaging with, and learning from ecological changes for millennia: "We are still here and we will continue to adapt." It was agreed that climate research must embrace a commitment to benefit frontline Indigenous communities.

Discussion continued, focusing around collectively addressing two questions:

1) *What are some ways that communities and scientists are weaving Indigenous Knowledge and Western science together to inform climate adaptation and coastal and ocean stewardship?*
2) *What are some of the elements that you think are critical for enabling successful collaboration?*

These questions were considered in open dialogue, as a large group.

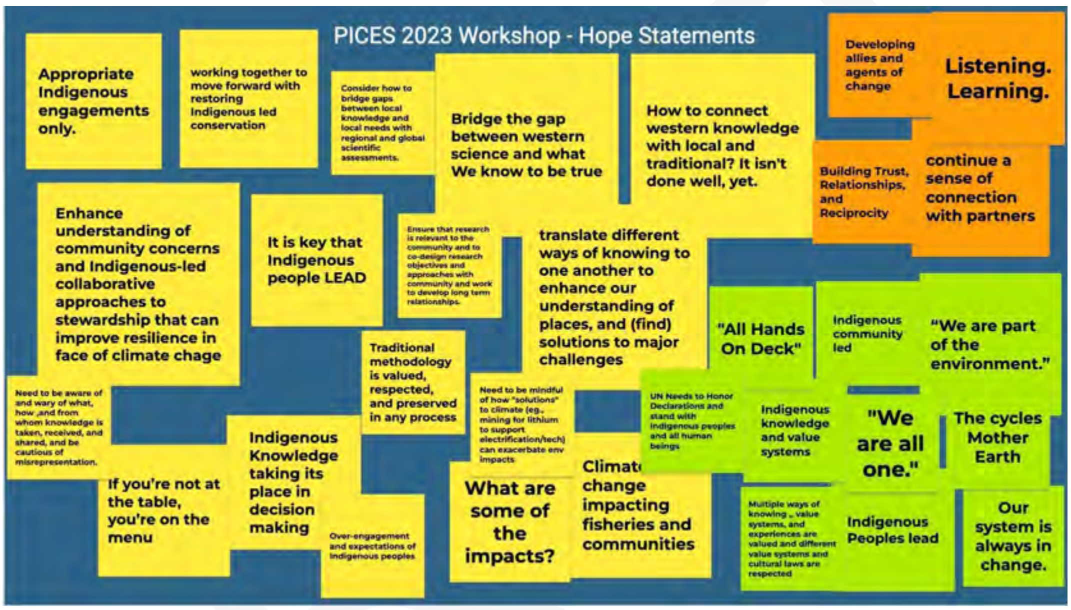

Figure Caption: A jamboard used to capture ideas and messages from participant introductions and intention statements shared on Day 1 of the workshop, we chose to use a jamboard for this portion of the conversation to enable remote/online participants to share their reactions.

Indigenous Knowledge and Knowledge Systems

Participants described their relationships with Indigenous Knowledge and Indigenous Knowledge Systems. People shared a general agreement that Indigenous Knowledge is not a monolithic entity that can just be 'engaged with' or 'blended' with Western science, as one participant described it, "as ingredients in a recipe." Everyone has different knowledge, and people come to know things in different ways based on their own experiences, values, and relationships. Indigenous Knowledge Systems derive from millennia of observation, and place-based relationships in which many Indigenous peoples continue to coexist with plants, animals, elements, environments, and ecosystems, rather than from observations of systems that are viewed or valued as separate from the observer. Participants reported that Indigenous perspectives often view these relationships as intimate, in which human and non-human members are engaged in caring and caretaking relationships with each other.

In this formulation, Indigenous Knowledge Systems are values-based systems, complete within themselves and deeply embedded in cultural understanding and experience, and cannot easily be compared to Western ways of knowing. Often Western knowledge considers values and responsibilities as distinct from observation. When considered from Indigenous perspectives, Western scientific approaches appear to divorce observations from outcomes; its values can be seen as uncaring, or even violent, because of the lack of reciprocities and care relationships.

Discussing the Differences Between Indigenous Knowledges and Mainstream Science

Having established some shared understanding about Indigenous Knowledge Systems and their complexity, the group moved to the question about how to work alongside--or in tandem with--Western scientific knowledge and approaches (see Question 1). Participants talked about their experiences, either their own, or those with which they were familiar, working with multiple knowledge systems. Many people shared that they felt like Western scientists did not fully appreciate or understand the ways in which their requests, or attempts at collaboration were mis-matched with the kinds of knowledge being sought. This included treating Indigenous Knowledge and Indigenous Knowledge Systems as less valid than Western scientific approaches, both due to prejudice, racism, and the continuing impacts of colonialism, as well as the lack of existing best practices, frameworks, or accessible tools to help integrate various worldviews in a scientific rubric. Several participants spoke of a lack of care in the treatment of Indigenous Knowledge, and by extension, Indigenous People are given in some Western scientific approaches. This engaged the curiosity of some participants: what would it mean for oceanographers to not consider themselves apart or separate from the waters and ecosystems they observe and study? How could we bring this kind of relationality into ocean sciences?

Participants discussed the differences in values between Western science and Indigenous approaches. Western science emphasizes broad knowledge sharing and values communication and sharing ideas and results far and wide. This cultural value differs from many cultures, which may link responsibility and obligation with knowledge holding: only those with the permission and teachings to understand how to responsibly care for the knowledge are able to hold and share knowledge. In these contexts, open and liberal communication may not be seen as a positive attribute.

Participants often returned to the idea of Western scientists as needing to listen--in more than one way--to other cultures, perspectives, and ways of seeing the world. This requires not just listening to what community members say, but also understanding broader interrelationships and impacts with ecosystems and people. Participants wanted to be clear that speaking to one community member about a particular piece of work was likely not sufficient for meaningful community engagement. As Indigenous Knowledge Systems are often relational, knowledge in those systems can also be personal and intimate, and community members may disagree about various observations, approaches and protocols. Further, it is important to remember that community members may hold different forms of knowledge relevant to a particular question. In order to meaningfully engage with Indigenous communities when doing research, it is important to engage with the community, and seek perspective and guidance from multiple knowledge holders, rather than rely on one voice, unless directed by the community to do so.

Reciprocity

In order to act as allies for Indigenous communities, Western scientists should be mindful that reciprocity is a core value and necessary for any type of collaborative work. Researchers should consider how they are reciprocating and offering value to the Indigenous communities in which they work. There were many examples mentioned--whether organizing science work so that it is primarily responsive to community needs, ensuring the research tackles questions of importance to communities, supporting community systems in place, and appropriately compensating and crediting community members for their time and contributions. Participants shared experiences where Western scientists asked questions that were seen as not relevant or useful for the community they were engaging. Experiences of extractive work, where scientists ‘take’ or ‘use’ Indigenous Knowledge without permission and without appropriate context were also shared. These experiences lead to poor outcomes for the research, the relationships, and the possibility of future collaborations.

Elements of Successful Collaboration

When asked what elements were necessary for successful collaboration (see Question #2), participants overwhelmingly pointed to the need to address the resourcing of these collaborations, particularly the way science funding can be shared with participating community members and the length of time that scientists are willing to commit to engaging and working within communities. Capacity limitations (whether limitations on funding or labor resources) was a central topic. The need for long-term funding and funding available to support Indigenous participation in initial, early, and ongoing planning stages of work were emphasized. Several participants agreed that longer-term funding and support for Indigenous communities engaged in scientific research helps to create better scientific outcomes, as it allows for the development of checks and balances, as well as gives time and space for Indigenous communities to participate fully. Often community members, especially those working with Guardians or in stewardship positions, are active in multiple projects and fielding requests for further or new collaborations, above and beyond the work they may be doing for their own communities and organizations. This also calls back to the need for collaboration to be reciprocated by Western scientists, as discussed earlier. One way that collaboration and exchange can be reciprocated by Western-based institutions is by providing funding that can be used to build or increase capacity for engagement, participation and collaboration within Indigenous communities.

Building Trust and Equitable Partnerships in Urgent Times

After the lunch break, participants moved into three smaller groups for continuing discussion. Participants engaged in conversation about the kinds of supports needed for different actors to show up for equitable scientific collaborations. Participants also tackled a thorny question: it is often said that relationships are built at the speed of trust, but climate change can present urgent challenges to coastal communities - how can we ensure even urgent needs are met? The conversations across the three breakout groups were substantially different, but touched on some common themes and ideas.

All the groups discussed the need to acknowledge, and address power dynamics in collaborative projects and processes. One group talked about the necessity of Western scientists to acknowledge that bridging the gap between Western and Indigenous perspectives requires respecting the social and cultural values on which those differences in perspectives are based. One participant described this as the difference between managing “a resource” as opposed to managing “a revenue”. Another person described the difference between a “natural resource” and an “ancestor or family member”. Multiple examples of this difference were mentioned by participants. One example is salmon on the Pacific coast, where fisheries management is based on maximizing sustainable yields (as informed by the Western value of profit maximization). In contrast, many Indigenous perspectives focus on human-ecological-salmon relationships, maximizing the livelihoods of the salmon, as well as the many people and other species who depend on them. The group provided additional examples of how differences in values inform both regulatory structures and decision- making, which can lead to real harm for Indigenous communities, further deteriorating trust between communities and researchers

This points to a fundamental difference across multiple perspectives and approaches. It is important to note that many Indigenous People rely heavily on coastal and marine resources: they live with the risk of ecological deterioration in their communities, which directly affects their--and those of their children's and grandchildren's--health, social wellbeing, cultural cohesion, and ecosystem processes. Participants agreed that Indigenous-led research is necessary for more robust and balanced research that can inform improved decision-making across regions. Given the rapid and profound effects of climate change, the urgency for more inclusive and equitable research was recognized. There was acknowledgment of slow changes (such as this workshop at the PICES Annual Meeting); however, it was noted that the speed of change is not equivalent to the speed at which key populations and essential habitats are declining.

Context matters

While there may be some lessons that can be learned in one location and applied to the benefit of people and place in other jurisdictions, participants shared examples about how this tendency to categorize and generalize across locations, ecosystems, and species can lead to inaccurate findings and mistaken understandings. Several participants compared this kind of piecemeal approach to examples of preferred holistic approaches--rooted in Indigenous perspectives--to collaboration. One example was shared about Western scientists trying to communicate about a species of fish, using one of its Indigenous names. The scientists in question did not understand that the name of that fish was only used in certain contexts and locations and not others. This led to confusion among community members and the scientists were unsuccessful at gaining the knowledge they were seeking. Employing more holistic approaches to collaborating with Indigenous Knowledge holders early in research planning and designing critical questions might have avoided this kind of confusion.
Principles of data equity and sovereignty were also discussed. As one participant stressed, "data are key to empowering Indigenous communities." Many talked about the imbalance in how knowledge is viewed and leveraged within Western science. If Western science can 'confirm' what Indigenous Peoples have known and passed down in teaching for generations, this confirmation is sometimes necessary for Indigenous participants to be treated equitably in collaboration with Western scientists. Participants mentioned the OCAP principles (Ownership, Control, Access and Possession) as a critical correction to past data practices
- permission needs to be sought and granted in order to collect data and work in Indigenous lands and waters, and at every stage in the scientific process, from very early stages of articulating a hypothesis all the way through and including authorship to Indigenous collaborators.

Day 2

The final half- day of the workshop provided an opportunity for participants to share the work that they have been involved with in their communities, showcasing examples of Indigenous-led research in ecosystem management, climate change adaptation and resilience. A wide range of project types and approaches were shared from across the NE Pacific and the Arctic in a variety of formats. This agenda was decided upon collaboratively by workshop participants at the end of the first day of discussions, and all workshop participants had the opportunity to share their work with interested members of the PICES community.

After an opening to start us off in a good way, participants from northwestern Alaska shared stories and experiences as climate change has driven substantial social, economic, and ecological changes in their communities. One participant shared his experience of mourning the loss of “the mother ice” every year (the first solid winter sea-ice) and the many resources the ice brings to his marine resource dependent community: walrus, seal, polar bear, among others. The effects of climate change are leading to the uncertain arrival of mother ice, a reduction in the thickness of this ice, and diminished access to these critical species and practices. He also shared teachings that his grandfather directed him to pass along relating to climate change, and the need to protect ecosystems and his way of life so that they are not lost permanently. Another participant shared a short film about Indigenous-led research (Ikaaġvik Sikukun or “Ice Bridges”)[2] that occurred in his community. The project focused on the thickness of sea-ice, examining how decreasing sea ice leads to increased risk, and reduced access to subsistence foods in his community. Not only is the sea-ice less safe to travel on, but decreased mobility leads to decreases in hunting which has real impacts on the food security of his community. Another participant from the Yukon River Drainage Fisheries Association[3] (YRDFA) presented information on several of their collaborative projects with Alaska Native communities in the Yukon region. In partnership with communities along the Yukon River watershed area, YRDFA has conducted research on a range of topics of interest to communities including, invasive species, salmon health, Traditional Knowledge, water quality, and community resilience.

From Haida Gwaii, participants shared work involved in creating a marine planning program based on Haida Knowledge about the oceans: the Haida Gwaii Marine Plan[4], a collaboration between the Council of the Haida Nation and the Province of British Columbia. Another participant shared a recent collaboration between Parks Canada and the Haida Nation, X̱ aayda Gwaay.yaay Ḵuugaay Gwii Sdiihltl’lx̱ a: The Sea Otters Return to Haida Gwaii[5]. This project explored how the recent return of Sea Otters (ku*ḵuu in Haida language) might be understood and related to by the community on Haida Gwaii.

Two presentations from participants focused on the ways in which they were learning from other Indigenous communities in order to find solutions to problems in their own home communities. A member and staff of the Swinomish Indian Tribal Community shared about how learning the ancient Indigenous practice of clam gardens from relatives in British Columbia was leading to a revitalization of knowledge and culture in his Washington State community, which was an emotional and meaningful experience for this

[2] Ice Edge, the Ikaaġvik Sikukun Story: https://www.youtube.com/watch?v=P9RzfGtLWHo

[3] https://yukonsalmon.org/

[4] https://haidamarineplanning.com/initiatives/haida-gwaii-marine-plan/

[5] https://parks.canada.ca/pn-np/bc/gwaiihaanas/nature/conservation/restauration-restoration/kuu

participant[6]. An Indigenous participant from Australia currently living in Washington State discussed how he was learning from communities along the NE Pacific coast, and noted similarities and differences between Indigenous-led approaches to ecosystem and fisheries management across continents: he planned on sharing this experience with Indigenous communities in Australia.

Next, we had a screening of a short film, *Tsunami 11th Relative*, that documents an example of a culturally sensitive coastal resilience project around Tsunami safety on Vancouver Island, BC with the Ka:'yu:'k't'h'/Che:k:tles7et'h', Nuchatlaht, Ehattesaht, Mowachaht / Muchalaht, and Quatsino First Nations. Indigenous elders spoke about their experiences with tsunamis and storms that have affected their coastal community and described how Indigenous Knowledge about tsunamis has helped Western scientists better understand impacts of sea-level rise and coastal hazards on this region, as well as helped develop culturally sensitive disaster response and management plans.

We closed our workshop with words from an Elder from St. Lawrence Island, Alaska, stressing the importance of working together to face the climate crisis, and the consequences of our failures. These words were a call to action and a reminder of the urgency of the work we are doing together, and the need to continue to move forward, despite the complexity and challenges.

Conclusions

We hope PICES continues to equitably engage with Indigenous leaders in the US and Canada, as well as across the North Pacific when designing and implementing research. There are many examples of excellent, rigorous Indigenous-led work happening across the northeast Pacific coast; this workshop was a crucial first step to more equitably include multiple voices and perspectives in marine science. We encourage PICES to engage with Indigenous leaders and boundary spanners in these meetings--as well as on the PICES planning bodies--to support equitable collaborative research.
If PICES, as an organization, is interested in engaging more Indigenous leaders and including more Indigenous approaches:

- It is not appropriate for Indigenous People and perspectives to be siloed in only a few workshops, instead, integrated throughout the committees and working groups;
- PICES already deals with cultural differences, so perhaps it would not be difficult to include additional cultural perspectives;
- Indigenous participants must be supported financially and with other resources - i.e. honoraria for speakers and Indigenous Knowledge holders in addition to travel and accommodation support and stipends - most other participants are part of national delegations, and have other forms of support for their work;
- Engagement and outreach is a big task, but would be an important one - do not leave this to national governments that are often already in conflict with Indigenous communities and First Nations over resource and ecosystem management;
- PICES needs to provide more time for edits and review by participants prior to publication of PICES reports; and,

[6] https://wsg.washington.edu/research/clam-gardens/

- It is important to acknowledge, address, and work to rectify inequities in participation, funding and recognition, and recognize that this work needs to be part of PICES's mission, if it wishes to increase Indigenous participation in PICES working groups and events.

References

Hatch, M. B. A., J. K. Parrish, S. S. Heppell, S. Augustine, L. Campbell, L. M. Divine, J. Donatuto, A. S. Groesbeck, and N. F. Smith. 2023. Boundary spanners: a critical role for enduring collaborations between Indigenous communities and mainstream scientists. Ecology and Society 28(1):41. https://doi.org/10.5751/ES-13887-280141

Appendix 4 Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem

Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem

Workshop
Anchorage, Alaska
August 24-25, 2022

In attendance

Sarah Wise (Facilitator)
Becky Ingram
(Facilitator)

Carolina Behe Lauren
Divine
Ann Fienup-Riordan
Cyrus Harris
Henry Huntington
Vivian Korthuis
Mellisa Maktuayaq Johnson
Richard Slats

Invited but unable to attend

Mabel Baldwin-Schaeffer
Raychelle Daniel

Maija Lukin Delbert
Pungowiyi
Brenden Raymond Yakoubian Julie
Raymond Yakoubian Nadja Steiner
Eduard Zdor

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Summary

The Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem workshop took place on August 24-25, 2022. Participants largely guided discussions on both days, which allowed for agenda topics to be discussed when most relevant and comfortable. Topics included Indigenous Knowledge and worldviews, values and perspectives, changing ecosystems, and current fisheries management processes.

A large portion of the workshop included discussing how current management processes differ from, and can conflict with, Indigenous worldviews. This included the consensus that it is inappropriate to expect these knowledge systems to "fit into" Federal management processes. Some individuals pointed out specific examples of differences, including:

- Resource management often appears to lack any focus on relationship building or the guiding values that a community has.
- Management processes emphasize economic value, but that does not account for cultural meaning or spiritual importance.
- Adapting to changing climates and social states requires flexibility, and often management structures get in the way of community flexibility.
- Large complex models are frequently used in science and management, but they do not accurately represent reality. The ecosystem, and intertwined communities, are not linear as these models suggest.
- A loss of meaning occurs when translation is required (such as translating an Indigenous language into English, or an Indigenous perspective into a Western framework).

In response, participants began discussing and expanding on existing examples to create and shape an equitable process that begins with Indigenous communities. Overall, building and maintaining relationships was emphasized as having a central role in effective and equitable management processes.

Direct actions suggested by this group for Federal fisheries management include involvement of Indigenous community members, supporting youth involvement, creating a professional position to increase capacity for this work, and adding more coordination, communication, and consultation directly with communities in their places. In general, it was agreed that the marine environment cannot be tied to one individual thing, such as food security or economic livelihood. As one person stated, *"We are water people,"* suggesting people's ties to the water are central to existing, and as such, *"the ocean must be protected"*—not only for this generation, but for future generations to come.

As a group, it was recognized that these key points will not be solved overnight. However, we can use the tools and platforms available, as well as create new platforms, to create necessary changes.

Workshop Goals

The aim of this workshop was to discuss multiple ways of knowing the Bering Sea and Chukchi Sea ecosystem and ways to include them in Federal management processes (such as the IEA). The intention of the workshop was to offer a space for Alaska Native cosmologies to lead our thinking through changing marine ecosystems, and shape future steps to inform management.

Workshop Objectives & Expected Outcomes

The workshop objectives and outcomes were reviewed at the beginning of the workshop to gather consensus. The third outcome was added by participants during that review.

Objectives

1. Share stories, lessons, and perspectives on changing conditions in the Bering and Chukchi Sea ecosystems.
2. Identify and explore ways to observe and communicate ecosystem change across groups.
3. Create ideas and guidance for including Traditional Knowledge and Indigenous perspectives in Federal management processes.

Anticipated Outcomes

1. Guidance and tangible steps to weave together multiple knowledge systems in Federal assessment processes (such as the IEA).
2. Gauge support and interest in a follow up meeting.
3. Summary of workshop in the form of 1-page summary and full report summary.

Approach

The Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem workshop took place on August 24-25, 2022. The original agenda included designated sections on each day to focus on discussion questions that had been drafted ahead of time. However, rather than using the agenda as a schedule, it was used as a guide. Participants largely guided discussions on both days, which allowed for agenda topics to be discussed when most relevant and comfortable. Topics of discussion included Indigenous Knowledge, worldviews, values, and perspectives, changing ecosystems, and current fisheries management processes. A large portion of the workshop included discussing how current management processes differ from, and can conflict with, Indigenous worldviews. In response, participants began expanding on existing examples of Indigenous Conceptual Models (e.g., the Circumpolar Inuit Protocols for Equitable and Ethical Engagement) and discussed what would be needed to create a more equitable Federal fisheries management process that begins with Alaska Native communities and their knowledge and worldviews.

Discussion Summaries

The following is a summary of participant discussions that took place over the course of the two day workshop. These summaries are products of reviewing notes and transcriptions from both days. Summaries are not exhaustive and do not encompass everything discussed, but are an effort to present key topics. All quotes come from workshop participants.

In summarizing our findings from this workshop, we have organized ideas and concepts discussed into sections. However, it's important to note that the structure of this report does not necessarily reflect how discussions took place. Participant conversations were all-encompassing rather than focused on individual, discrete topics. We acknowledge that in writing this report, we are separating topics in a manner that may not have happened during the workshop. We do this to help organize and streamline the information for ease of interpretation. We recognize that it is important to remain reflexive in our positions and presentation of this information. Borrowing from one participant, it is critical that we find a way to, *"capture all of those ways of looking at things, rather than the typical fashion of dividing it into little pieces."*

Sharing stories, lessons, and perspectives from Indigenous worldviews

"Tribal voices are a constant."

Workshop participants shared detailed descriptions and examples of what it means to hold an Indigenous worldview. While reading this section it is important to keep in mind the words of a participant who explained that the Bering Sea and surrounding waters mean far more than the words that have been or will be used to describe it. Similarly, another participant stated that having an Indigenous worldview is, *"a prelude to describing the world."* The following paragraphs describe what was shared at the workshop, and also acknowledge that this can only be a limited summary due to the authors' own limitations in understanding. We welcome continued dialogue and input as we grow and share understandings.

> *"When we say health and wellness, this is not just people health and wellness, we always have to explain that, both those things, because we're always trying to translate everything to English."*

Participants emphasized that from an Indigenous worldview nothing is separate, everything is connected, and that all things are possible. This was reiterated many times through messages such as, *"[The ocean is] a part of us and we are a part of the ocean."* The condition of the environment is deeply felt from an Indigenous perspective because of this connection. As another participant described *"[The ocean is a] part of who we are."* Participants explained that this attunement to the ecosystem leads to an understanding that comes from being entwined with and paying attention to the ecosystem across generations and through millennia. The shared and cumulative knowledge that results is *"indirectly transmitted to us as an Indigenous person,"* as one participant explained. None of this can *"be found in a textbook."*

Participants reiterated that *"our air, our land, our sea is our food source,"* which invokes the need and purpose for this connectedness. The ecosystem is not perceived as a resource to be extracted and used, but as part of the self, the community, and the ancestors. One participant explained that a person needs, *"to become a part of the environment in order to safely go in and out to harvest and come back home again."* This also relates to a dominant value that participants expressed in the meeting: the importance of never taking more than you need while hunting, fishing, or gathering. To take more than one needs or can share is both disrespectful and harmful to the ecosystem and ecosystem health. This belief spawned conversation about the motivations underlying various fishing sectors. Participants used
large-scale industrial fishing to highlight the differing value systems across fisheries. People fish for different reasons and are informed by different values. It was brought up that this value is in direct opposition to some commercial fishery operations, such as trawling, which is seen as taking excessive amounts of fish for economic gain, while harming the environment.

Participants also explained that stories are a critical part of communication among Alaska Natives. Stories are a method for sharing information and knowledge about place, family, ways of life, meanings, and the environment. Stories are used to communicate through space and time, such as while traveling to new or different places. As one participant explained:

> *I wanted to add how important stories are, because that's how we communicate when we travel to other places. We come back and we tell stories of all kinds of things, and when we go places, we tell stories of how it is back home. So stories are the methodology in which we provide information through.*

Observing and communicating ecosystem change

As mentioned above, Indigenous communities have been observing ecosystem changes for millennia and stories are a main way that these observations are shared or communicated. In participant opinions, this method is starkly different from Western science methods that underpin Federal management processes researching or addressing ecosystem change. This can lead to an impasse in communication. *"There's so much more meaning in an ecosystem or in the environment that are difficult to describe, they're difficult to communicate because of different perspectives and different languages that we all use."*

In an attempt to translate their messages, community members often *"code-switch,[1]"* a term workshop participants used to describe how Alaska Natives change the way they discuss a topic or share stories to translate information into a non-native language. Some participants explained this process results in a homogenization of the information because the content is filtered, simplified, and distilled, until it lacks much of the true meaning. The information can become uprooted and disconnected, effectively meaningless. The difference in language and meaning can be a wedge when trying to form relationships, build trust, and develop collaborations: a disconnect forms between the researcher/groups asking and the communities sharing.

Participants discussed how various research methods and approaches can increase the divide. For example, scientific models are used to predict and report ecosystem changes in management processes. Predicting changes with models is viewed as incomplete and potentially harmful because they neglect to include many relationships, social bonds, Indigenous Knowledge, Indigenous representation, and diverse values. The models frequently portray 1:1 correlations which do not reflect lived reality.

> *I know there's all kinds of models, so I know it can have fifty things going in and fifty things coming out, but that's a real problem to me because it's still a one to one correlation, like over and over and over again, and it still is neglecting the relationships—whether it's between humans or humans and others—the thing is the relationships.*

These types of models are drastically different from how many Alaska Natives interact with the ecosystem. Knowledge that is derived from generations of lived experience and shared reflection is dynamic and multifaceted, emphasizing observation, interaction, and adaptation. The concept of change is deeply embedded in daily life and ways of knowing the environment. *"The concept of climate change is not new to Indigenous People… We continue to adapt to our environment and we're going to always adapt to our environment."* As one participant explained that while change is constant, there is critical importance to knowing their Indigenous history and identity, and the enduring strength of relationships:

> *If you're strong in your Inupiaq identity then climate change is something you can deal with because we deal with change all the time. If you're not strong in your Inupiaq identity, you have much bigger problems than climate change. And [we have talked] about language, education, community wellbeing, all those kinds of things. Essentially, if [all of that is] taken care of, the relationship with the environment takes care of itself. But if we just focus on the relationship with the environment, we miss everything.*

[1] The practice of alternating between two or more languages or varieties of language in conversation. Encyclopedia Britannica defines code-switching as the "process of shifting from one linguistic code (a language or dialect) to another, depending on the social context or conversational setting".

Participants discussed several examples of ecosystem changes that have resulted in cultural changes in their lifetimes. One participant shared the importance of subsistence foods to health and well-being. For example, elders from their community lost access to traditional foods when a senior living facility became a part of a Federal facility, thus disconnecting them from their culture and community. *"So, our elders moved [to the new facility]. But, unfortunately, their foods didn't. Now, there was something wrong there."* Another discussed how an elder in their community had felt about not being able to teach subsistence to their children. *"We can't go back to where we once held our summer camp, fish camp, to this day we still can't go back there. We have to send our children to fish camps to teach them subsistence."* These changes can be experienced as loss, not just in access to space or nutrition (which are critically important), but of self, identity, and linkages to their community that reverberates across generations.

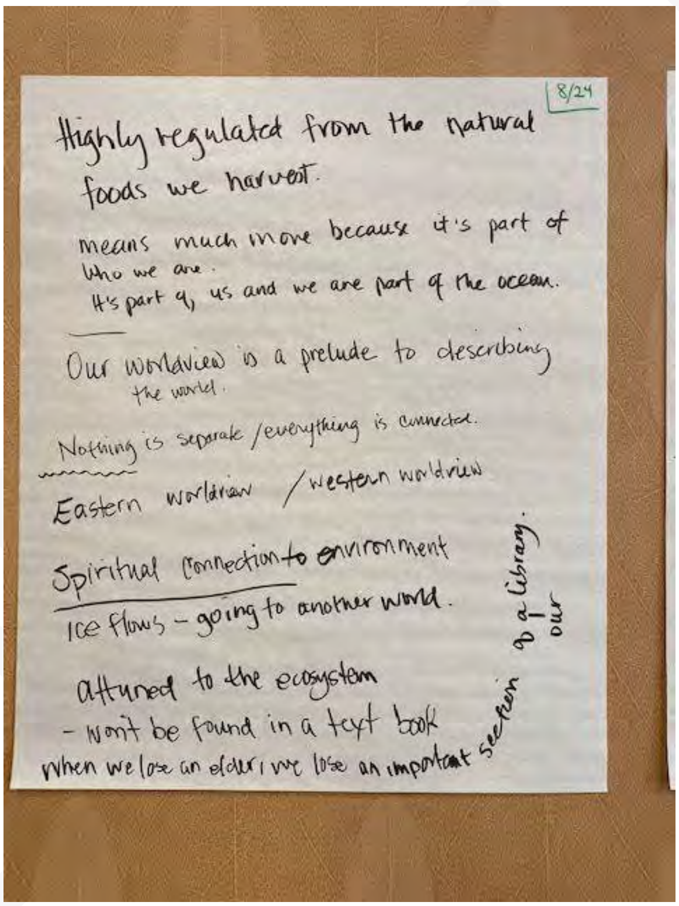

Figure 1: Discussions about traditional foods brought up the juxtaposition that hunting, fishing, and gathering traditional foods is "highly regulated," yet eating those foods is critical because it is part of the fabric of being.

Participant reflections and guidance for including Traditional and Indigenous Knowledge in Federal research and decision-making processes

"A strategy for framing Indigenous Knowledge to be embedded within policies across the Federal government. Right now that's missing."

Participants discussed how Indigenous worldviews differ from, and do not fit into Western perspectives at the center of Federal ecosystem research and decision-making. Of critical importance, one participant explained, *"We didn't come to the coastal areas by mistake. Our Indigenous ancestors chose to settle here. We are survivors."* This sentiment highlighted (among many things) the shared understanding that Indigenous communities survive because of their way of life and worldview (which is embodied in IK). Participants described their understanding of Western science as a way to examine the environment, and control it for a predetermined, "desirable" condition. This differs starkly from *"following the weather and animals"* to connect to the environment, gain sustenance, learn, teach, share, and thrive.

Participants explained it is impossible to isolate one element to decide on the desired condition of the environment without considering the context and linkages across the entire system. Subsistence practice relies on a suite of species which shift in availability and access according to a broad range of factors including, but not limited to: season, weather patterns, gear, skillset, abundance, preference, and regulatory frameworks. Indigenous Knowledge provides valuable information that reflects deeply meaningful Indigenous worldviews to accommodate and respond to environmental changes. Resource policies, however, often develop outside of this realm of knowledge, instead relying primarily on Western science and governance systems. As one participant stated, *"They don't understand our way of life. Yet they have these systems that they impose on our way of life."* Another said to the group that it seems like there seems to be an *"Eastern versus Western"* dynamic, which causes trauma and hardship for Indigenous communities and unsustainable natural resources.

Discussions of how the current research and decision-making process takes place highlighted enduring disparities, inequities, and insufficient communication. The group discussed the need for ongoing relationships across scientists, agency staff, and community members to support frequent and meaningful communication, knowledge sharing, and increased understanding. Research projects can often feel extractive to Indigenous communities if benefits are not clearly outlined well in advance. Linkages to decision-making processes seem arbitrary and biased at times, neglecting the crucial element of human relationships and collaboration which helps to develop and support trust. "*They come into our meetings with their own agenda, and we never get a chance to say anything."*

Participants collectively defined some terms that were central to their understanding of collaboration and the inclusion of multiple knowledge systems. The group saw the degrees of engagement and inclusion as a process, with the goal being Indigenous led science embedded in Indigenous research priorities. They identified terms covering a range of inclusion from no inclusion to full self-efficacy across the process:

> **Sovereignty**: Indigenous-led efforts stemming from Tribal priorities, concerns, and interests. Scientists may be invited into the process, but not lead.
> *"What can tribes do themselves, without having to ask permission?"*

Involvement: Varying degrees of collaboration from invitations to participate to partnerships. Led by Western scientists with Tribal involvement.
"What can tribes be involved in, participate in, invited to…Being able to sit at other people's table."

Colonialism: No engagement with Tribes. Extractive research that seeks to examine Western science priorities. No benefits to the communities.
"What others are doing to Tribes."

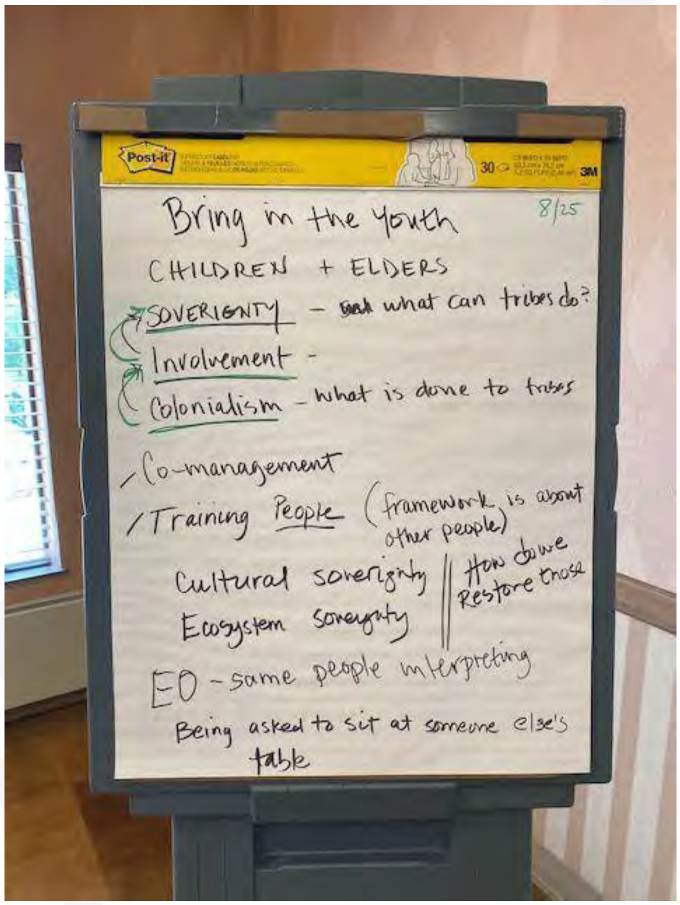

Figure 2: Notes documenting the discussion of the framework of current management processes according to participants.

The group felt the need to continue efforts to move toward greater engagement through relationship building, partnerships, and inclusion of multiple perspectives. It was stated that this process requires learning and knowledge sharing across groups including Western scientists.
Participants saw a role for capacity building: training people to be able to conduct strong collaborative research that supports cultural and ecological sustainability. By first recognizing the value of Indigenous Knowledge and understanding the importance of cultural and ecological sovereignty, people can then develop relationships based on trust that allow for knowledge exchange.

Ways to Move Forward

The points below summarize the values discussed. They represent ideas that came out of workshop discussions, but participants also stressed that these represent only the beginning of this discussion. Each section below is meant to help organize what was discussed, but acknowledge that the sections are not mutually exclusive or exhaustive. There were several concerns about including Indigenous Knowledge in Western science that were discussed throughout the two days. Below are some of the considerations for moving forward as well as key areas of concern.

Alaska Native worldviews and values are the foundation

Participants discussed the need for a bridge or network between the Federal processes and Indigenous communities. Participants agreed this bridge should look like a network built upon several values, rooted in an Alaska Native worldview. Alaska Native cosmologies must lead, rather than follow, during all stages of the process. This will require stepping away from what feels like the standard, Western, homogenized approach to embrace different perspectives and alternative methods.

More than Economic Value

Economic valuation of resources and ecosystem services is an inherently limited and one-dimensional approach to understanding the depth of reliance on and rich meaning of ocean organisms. Monetary value can be used as one metric of a financial relationship. Within the Bering Sea and Chukchi ecosystem, however, there are a range of dynamic and profoundly social processes linking humans with the marine environment and each other far beyond the scope of economic value. To explore these requires looking beyond a simple metric to incorporate other ways of measuring value and meaning. The activity of fishing not only brings cash to a community, but reinforces ties within families and across communities. It provides a means to teach and to learn. The act of fishing and sharing the catch provides meaning, imbuing the time with connection to one's identity as Tribal member, as a provider, as part of something larger than yourself. Additionally, decisions that result in determining economically viable fish inevitably result in other fish and habitat being deemed "not viable," which is a preposterous idea. If more values were included beyond economics, this would be clear.

Relationships are Critical

Participants discussed the importance of relationship building as a cornerstone of this process. Participants also described how these critical relationships exist between humans *and* non-human species. Participants reiterated that conflict is bad for the ecosystem: if people are fighting or not working together, the ecosystem will suffer. Strong, quality relationships indicate strong, healthy ecosystems.

One participant used salmon management as an example of how conflict is actually supported by current management processes. And how, in response to this conflict, salmon species are *"going away." "That's a way our forefathers taught us not to fight."*

In order to build these relationships, face-to-face meetings that happen regularly are very important. Some key steps to building relationships were offered: involving more young people, bringing the work to communities, engaging on each communities' terms, and bolstering network capacity (via financial support, hiring interns, or other means of support).

Responsibility for Solutions

Participants agreed they felt as though the responsibility of sustainable decision-making and cultural survival fell to Indigenous communities without the tools or full authority to enact the changes needed. Despite the sheer scale of the effects of climate change and other disruptions, people discussed how the responsibility of upholding their worldview and way of life falls to small, often underserved, and under-resourced communities. While the drivers of climate change are well outside the scope of rural Arctic, the impacts are felt keenly in these communities. Additionally, Western scientists continue to turn to Indigenous knowledge holders for improved understanding and potential solutions. As one participant said, *"The onus is on us."*

Others agreed that there needs to be a shift to incorporate others in the responsibility for solutions toward adaptation and resilience. Developing strategies that facilitate informing Federal research through Indigenous Knowledge is one step forward. Others suggested training programs and budget mechanisms to build capacity across knowledge holders. Specific examples included: create a job shadow program to engage Indigenous youth; build budgets *"from the ground up"* rather than top-down to ensure adequate funding for building enduring partnerships; develop and utilize grants to support community work; and include paid time off to support subsistence practice within paid positions.

Finally, a large part of responsibility also requires *"doing the homework,"* prior to engaging with Indigenous communities. Long before the design phase of research that occurs in proximity to Tribes, Tribal communities, or resources of interest, researchers should be familiar with existing guidance and protocols in the area. Examples of such protocols are the Circumpolar Inuit Protocols on Equitable and Ethical Engagement, the Native Village of Kotzebue Research Protocol[2], or the forthcoming Local Knowledge, Traditional Knowledge, Subsistence Protocol developed by the North Pacific Fisheries Management Council[3].

Equity in the Process

Participants discussed a need for increased attention, additional strategies, and greater commitment to enhancing equity when working with tribes and Indigenous knowledge holders. This would bring action to the Presidential Memorandums on Indigenous Knowledge and Federal decision making[4].

[2] Principles for the Conduct of Research in the Arctic U NATIVE VILLAGE OF KOTZEBUE RESEARCH PROTOCOL (Adapted from the Principles for the Conduct of Research in the Arctic). 2018, https://policycommons.net/artifacts/1690859/principles-for-the-conduct-of-research-in-the-arctic-u/2422498/ [3] Circumpolar Inuit Protocols on Equitable and Ethical Engagement.

[4] OSTP CEW ITEK Memo 2022. OSTP CEQ IK Guidance 2022. Executive Order 13175 (Consultation and Coordination With Indian Tribal Governments). Executive Order 13985 (Advancing Racial Equity and Support for Underserved Communities Through the Federal Government).

Participants highlighted the need for greater representation of Elders and youth within Federal agencies, getting more youth involved, and increasing representation in research and management across regions. To address equity issues, participants offered several ideas: support community driven processes financially and with expertise; plan meetings far in advance and send notice to everyone involved in written and electronic form; translate documents as necessary; invest in regionally appropriate communication strategies; and hold meetings in communities to facilitate participation and to share the financial and physical burden of travel.

Ongoing Communication

Participants identified a lack of communication between communities and governing bodies. A participant mentioned, "*We all say we were so glad when the consultation rule came out with the Federal agents and their agencies about consulting with a tribe before they do anything.*" They went on to say that despite the consultation rule, communication is still lagging. This leads to frustration and break down in trust: *"But nobody's doing any consultation. They just come back after the fact and they just say this is how it is."* There are structural challenges in communication pathways which create obstacles among parties. Addressing these challenges can improve communication.

Participants stated the need for relationships and trust prior to knowledge sharing. Several people stated that if scientists want to learn how communities are identifying, observing, and responding to change in the ecosystem, they must first develop a relationship with the community. This relationship begins with communication. This requires increasing coordination and consultation with tribes, Tribal Council, and communities themselves. Attention must be given to facilitating communication. Some suggestions include: encouraging tribal members to speak freely in their preferred language or style, following communication protocols that first locate individuals within their family, community, location, and space. Participants agreed that it is inappropriate to transfer or translate knowledge into the language of Western science; rather, it is important to learn within the context of Indigenous worldviews to gain understanding. One participant said, *"How we talk to each other reflects how we're seeing things."* The act of translation into Western scientific narratives can dilute or obscure the meaning. Language is deeply connected to cultural meaning and central to staying connected and maintaining their way of life.

Another level of communication ensures that scientists explain the purpose of their research prior to beginning any work, clearly including how Indigenous Knowledge might be documented, used, included, cited, or shared. Indigenous Knowledge holders reflect cross-generation knowledge sharing, refined, interpreted, and embedded in the broader tribal community social processes. As such, it is essential to gain permission--with the above specifics--from Tribal authorities (e.g., Tribal Councils, Elders, and other relevant parties) prior to sharing IK. Communication also requires asking scientists and decision-makers what may hinder them from understanding information that communities share with them, so that this can be addressed. This highlights the need to discuss, early in the process, the purpose of knowledge sharing, and what may be the outcome, as well as continuing clear communication pathways to support transparency and maintain trust.

One example discussed regarding communication is the linkages between sharing information with researchers and how that information may (or may not) be used for management processes. There may be ambiguity and confusion about how Federal research is used to inform management and the expectation for action. For example, ecological information may be gathered about a specific event, fishery, or region. From the community's perspective, there may be an expectation that the sharing of information will influence future action. The delineation of Federal agencies (across scientific research, regulatory, and management branches) is not always clear. Additionally, multiple entities contact tribes and individuals frequently and with multiple projects, ideas, meetings, requests, and questions. The complexity of just how these agencies nest across the Federal system is not always clearly understood which can lead to unfulfilled expectations and degrading of trust.

Increased understanding in how each of the bodies interact and the distinct roles as they relate to marine resources could help to inform expectations of any knowledge sharing. This also intersects with the topic of how a community benefits from sharing.

Overall, more open and active communication is needed. Increasing communication can also look like using new and innovative approaches such as using social media as a tool and creating space/acceptance for Indigenous authors on papers, discussions, and in consultations.

Reciprocity

The group discussed what reciprocity means in the context of knowledge sharing, which revolves around the ideas of equity, relationships, and communication. One participant described reciprocity as holding a relationship with the environment, in which you give back because the environment is going to give back to you in dynamic and multifaceted ways. They went on to explain that this is in stark comparison to the motive of giving back to the environment for economic reasons, which is perceived as lacking dimension and depth.
Reciprocity suggests the motivation to act with the purpose of taking care or caring for. Acting for the purpose of economic benefits is not reciprocal but extractive, because it lacks the exchange of care component.

The group discussed how it would be beneficial to teach reciprocity, and what it means to be responsive to, versus in control of, the environment. The group emphasized the importance of the community learning to care for the environment. It was stated that one cannot learn these ways in a book or from scientific models. Learning to care is done through the senses, from the body: from watching the wind shift, smelling the ocean, hearing the seabirds, tasting the fish, and listening to knowledge holders imbue meaning into those experiences. In this way, knowledge is living and deeply embedded in the body of knowledge holders.

Reciprocity also means that researchers and managers who interact and collaborate with Indigenous Peoples and communities should—at the minimum—share any results.
Communities want information about the environment around them. Some participants suggested there should be established and agreed upon pathways for this. Participants agreed that one strategy moving forward could be to begin each research effort that involves communities with the following questions:

- How would the community prefer that researchers share results?
- What about this research could the community benefit from the most?
- What does it look like for the work to be effectively and properly communicated with your community?

These core questions offer a basic framework to assist in Federal research processes and assessments such as the IEA.

Creating a "pathfinder" role

Participants discussed the need for a person or position that can act as a bridge across knowledge systems: someone who understands Alaska Native cosmologies and values, but who is able to venture into new areas, gather information, and return to the community to build understanding and create a path forward. One participant described the position as, "a pathfinder." The pathfinder's purpose would be to communicate among communities and Federal agencies to better understand, "what's out there and makes sense for us." The group also said that the first steps would be to determine what skills, attributes, variables, and knowledge this person should hold to ensure bi-directional communication and cooperation among communities and government. The role of a pathfinder underscores the need for trust building and mutual understanding across entities. Such a person would be able to navigate multiple knowledge systems and worldviews to develop a path forward toward shared goals.

Create a guide on ways to consider Indigenous Knowledge alongside Western science

Participants discussed the need for consistent guidance in appropriate Indigenous engagement processes whether in research or resource management. Several people named similar protocols or guidelines used in specific circumstances (such as the Circumpolar Inuit Protocols for Equitable and Ethical Engagement); however, it was agreed there was a need for Federal level guidance with clear action steps. Ideally, this document would reflect multiple perspectives and value systems and provide practical guidance to appropriately and equitably engage with Indigenous

Knowledge. The values listed above are examples of what that framework should include and look like, however it is important to note that this was not intended to be complete or comprehensive. Including guidance on co-production methods would increase understanding, not only of the benefits of co-production approaches, but support the foundational steps necessary for co-production.

Indigenous-led conceptual ecosystem models

Conceptual models are one tool to develop greater understanding of complex ecosystem processes. Conceptual models rooted in Indigenous Knowledge can illustrate important ecological linkages based in Alaska Native cosmologies. The group discussed the potential value of Indigenous conceptual models as a way to bring together multiple knowledge systems. There was support for this idea if the model included additional meaning and could depict relationships. One participant said, *"You could show connections, you can show the relationships, and all of the pieces that need to be paid attention to."* Participants were quick to state, however, that these models would not be sufficient as standalone images. Including the *"right context"* is necessary. It is important to show humans as reciprocal agents within the ecological flow, with both benefits and obligations. One person clarified that the model could show, *"relationships within the system, but I think the relationships between humans is really important, too. You hear this again and again and again from Indigenous communities, that if people are fighting, that doesn't go well for the ecosystem."* In addition, the role of the stories were seen as valuable in deciphering models. It isn't enough to show the linkages; it is important to explain the meaning within relationships. "*I think it's a really good approach because those relationships and values aren't just human, and so really talking about those stories, too. Your relationship with the walrus has all of those too, right?"*

Visual models along with stories can be effective ways to teach and learn about ecological processes in ways that keep meanings intact rather than abstracting select elements, taking them away from the larger context, and rendering them disjointed from Indigenous perspectives, and thus meaningless. One participant described:

> *A unique approach to management is following the weather and the animals, but those things have to be explained, so then if you have [a model as] an imagery for them, then you just explain to them: when we say health and wellness this is not just people health and wellness, we always have to explain that, both those things, because we're always trying to translate everything to English.*

Acknowledging and Addressing Concerns

Several concerns were raised during this workshop. Many have been highlighted above, but we want to ensure they have been explicitly stated since they were raised within discussions.

Indigenous Knowledge is deeply interwoven in Indigenous cultural, historical, and social worldviews. Separating threads of knowledge from this nest of understanding can diminish its meaning and significance. Participants emphasize the need to consider Indigenous Knowledge as valuable in its own right, by itself, independent of other forms of knowledge. One participant explains "[Indigenous Knowledge] *won't be found in a text book, when we lose an Elder, we lose an important section of our library.*"

According to participants, the importance of shared stories are not understood, valued, or prioritized by Western science methods and perspectives, or in management frameworks. *"The Federal management processes are not interested in hearing those stories, lessons, and perspectives and applying them in management processes in a meaningful way."*

It was agreed that Indigenous communities are often asked to answer questions from scientists and managers frequently, as a part of the Federal management process. It is often unclear where the information goes, how it is used, and the result of sharing. Despite sharing stories in response to questions, participants said, *"Our voices are not being heard."* Additionally, after sharing a lot of information, many negative impacts have resulted. As participants stated:

- *"We've been sharing a lot of info, and that info has been used against us. Let's protect us from that."*
- *"Nothing is done with the stories [we share]. They are not being applied in a meaningful way."*
- *"We've provided the negative impacts of bottom trawling to our life. Nothing changes."*

The group also discussed that it is often unclear how sharing knowledge or stories will benefit their communities directly. When knowledge or stories are shared, there is an unspoken promise or agreement that communities will receive something beneficial in return for sharing. Several participants explained that their actual experiences were often very different. Sharing knowledge takes energy, effort, and emotional work. To have knowledge "taken" without any community benefit returned feels extractive.

Finally, participants described frustration with instances when researchers asked narrow questions about a specific topic and did not want responses that diverged from that topic. These instances send a message that if stories do not fit within the Western science research container, they are not valuable and cannot be included. Participants emphasized the importance of bringing together and valuing multiple knowledge systems to increase understanding, particularly given the significant changes the area is undergoing.

Participant Feedback

At the end of the second day, workshop facilitators asked participants for feedback.

In response to what went well and what participants felt they got out of the workshop:

- Open learning environment
- Gathering Indigenous perspectives
- Male and female participants
- “Not being asked to be something that I’m not”
- In person, small group, informal (comfortable), free flowing agenda and flexibility
- “A mix of Indigenous Knowledge bearers and non-Indigenous allies is a strong mix (and male/female mix) for this kind of conversation and advancing this work.”
- Excellent participants
- Flexible agenda
- Taking the time we needed
- Respectful listening
- From notes: open space to let participants say what they came to say

In response to what could/should be done differently:

- Shorter hours
- Extra day if needed (rather than long days)
- Clearer communication about any group activities outside of workshop days (e.g., group dinner)

In response to what should be done next:

- Regional community meeting
- Enthusiasm that this will continue
- Desire for a larger gathering at the next PICES meeting that allows for Indigenous led discussion and relationship building.

Next Steps

During the workshop, participants brought up examples of existing literature, studies, and guides that have been created for scientists and managers to be used as guidance for collaborating, co-production, and partnerships. Examples included the Circumpolar Inuit Protocols on Equitable and Ethical Engagement and co-production frameworks. We believe that these are key in guiding the next steps of the Bering Sea & Chukchi Sea IEA process.

We believe that the IEA process can be reimagined in a way that implements these suggestions for improvement and puts them into practice. The IEA process is traditionally focused on interactions between the social and ecological components of an ecosystem, and lacks the inclusion of multiple epistemologies and knowledge systems. We envision an expansion in which the guidance provided in this workshop shapes future steps focused on:

- Using the IEA process to include synthesis and collaboration.
- Building relationships between communities and organizations (local, regional, national, and multinational), and using these relationships as indicators for the IEA process.
- Reshaping the IEA process so that co-production is integrated throughout (through in-person meetings, increased communication, and supporting the involvement of Indigenous community members in whatever means is best for them/their community).

Appendix 5 Report Abbreviations

Abbreviation	Definition
ABL	Auk Bay Laboratory as part of NOAA NMFS AFSC (USA)
AFSC	Alaska Fisheries Science Center as part of NOAA NMFS (USA)
AMBON	Arctic Marine Biodiversity Observing Network
AOOS	Alaska Ocean Observing System
ASGARD	Arctic Shelf Growth, Advection, Respiration and Deposition
BEST	Bering Sea Ecosystem Study (combined with BSIERP)
BSIERP	Bering Sea Integrated Ecosystem Research Program
CTD	Conductivity, Temperature, Depth recorder
EcoFOCI	Ecological & Fisheries Oceanographic Coordinated Investigations
EFH	Essential Fish Habitat
GAP	Groundfish Assessment Program (as part of AFSC)
IEA	Integrated Ecosystem Assessment
IERP	Integrated Ecosystem Research Program
LME	Large Marine Ecosystem
NBS	Northern Bering Sea
NBS-CH	Northern Bering Sea-Chukchi Sea
NMFS	National Marine Fisheries Service (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
OCSEAP	Outer Continental Shelf Environmental Assessment Program
PacMARS	Pacific Marine Arctic Regional Synthesis
RUSALCA	Russian American Long-term Census of the Arctic
SBI	Shelf-Basin Interactions
SST	Sea Surface Temperature
TINRO	Russian Federal Research Institute of Fisheries and Oceanography
ToR	Terms of Reference
UAF	University of Alaska Fairbanks (USA)
YOY	Young of the year (fishes)

Appendix 6 Meeting Reports from Past Annual Meetings Related to WG 44

PICES-2020, Virtual
Report of Joint PICES/ICES Working Group 44 on Integrated Ecosystem Assessment (IEA) of the Northern Bering Sea - Chukchi Sea (NBS-CS)

PICES-2021, Virtual
Report of Joint PICES/ICES Working Group 44 on Integrated Ecosystem Assessment (IEA) for the Northern Bering Sea - Chukchi Sea (NBS-CH)

PICES-2022, Virtual
Report of Joint PICES/ICES Working Group 44 on Integrated Ecosystem Assessment (IEA) for the Northern Bering Sea - Chukchi Sea (NBS-CH)

PICES-2023, Hybrid
Report of Working Group 44 on Integrated Ecosystem Assessment (IEA) for the Northern Bering Sea - Chukchi Sea (NBS-CH)

PICES-2020 Report

Report of WG 44 on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea

The Joint PICES/ICES Working Group on the *Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea* (WG 44) met for the first time on September 1 and 2, 2020, virtually. All members were present except two from China and one from Korea who were out at sea; and one from Japan who had a conflict with another meeting (*WG 44 Endnote 1*). Nonetheless there was representation from all PICES member countries and ICES. The meeting was co-chaired by Drs. Elizabeth (Libby) Logerwell (USA) and Yury Zuenko (Russia). The meeting agenda was reviewed by members and adopted without revision (*WG 44 Endnote 2*).

AGENDA ITEMS 2, 4

Background, review of Terms of Reference

The goals of this meeting of WG 44 were:

- Review WG44 Terms of Reference
- Introduce the members to each other and discuss potential contributions of each to the IEA
- Discuss the approach and methodology for the IEA. Specifically:
    - The relationship of this WG to other programs/projects
    - Ideas from the NOAA IEA Program (Holsman) and ICES WGIBAR and WGICA
    - The scope of the IEA (What? Who? How?)
- Discuss ways to develop Indigenous knowledge sharing
- Review preliminary inventories of metadata and institutions/programs
- Draft the 2021 Work Plan

AGENDA ITEM 5

Work Plan 2020–2021

WG members developed and finalized the 2020–2021 Work Plan and identified WG members to lead work under each Term of Reference. Deliverables, deadlines, meetings and reports are detailed in *WG 44 Endnote 3*.

Scoping the IEA

The NOAA IEA approach provided a starting point for our discussions on scoping the IEA (Fig. 1). We discussed the first phase of the cycle: defining the system and goals. We developed a draft scoping document which will be finalized over the course of the next year (see the 2021 Work Plan, *WG Endnote 3*).

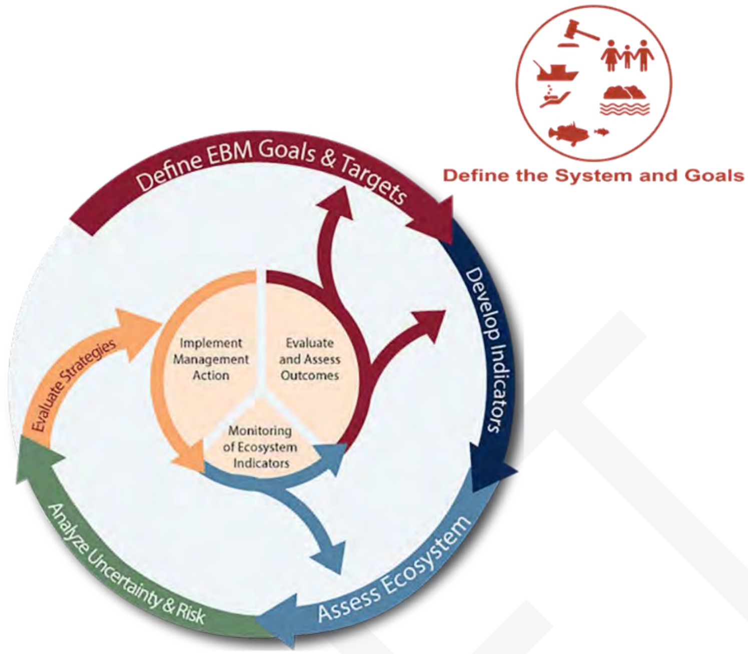

Fig. 1. The NOAA IEA approach (www.integratedecosystemassessment.noaa.gov).

Indigenous knowledge sharing

The co-production of knowledge model developed by the Pew Charitable Trusts, Kawerak Inc., and the Inuit Circumpolar Council Alaska (Fig. 2), provided a framework for our initial discussions of Indigenous Knowledge sharing which will be expanded and finalized as part of our 2021 Work Plan.

Fig. 2. The Co-Production of Knowledge wheel (© The Pew Charitable Trusts, Kawerak Inc. and Inuit Circumpolar Council Alaska).

Before the WG meeting, members were asked to submit metadata on scientific surveys in the NBS-CS using a Google form. Surveys have been conducted by all PICES member countries (Fig. 3). We anticipate that the final inventory (developed during the 2021 Work Plan) will contain many more surveys.

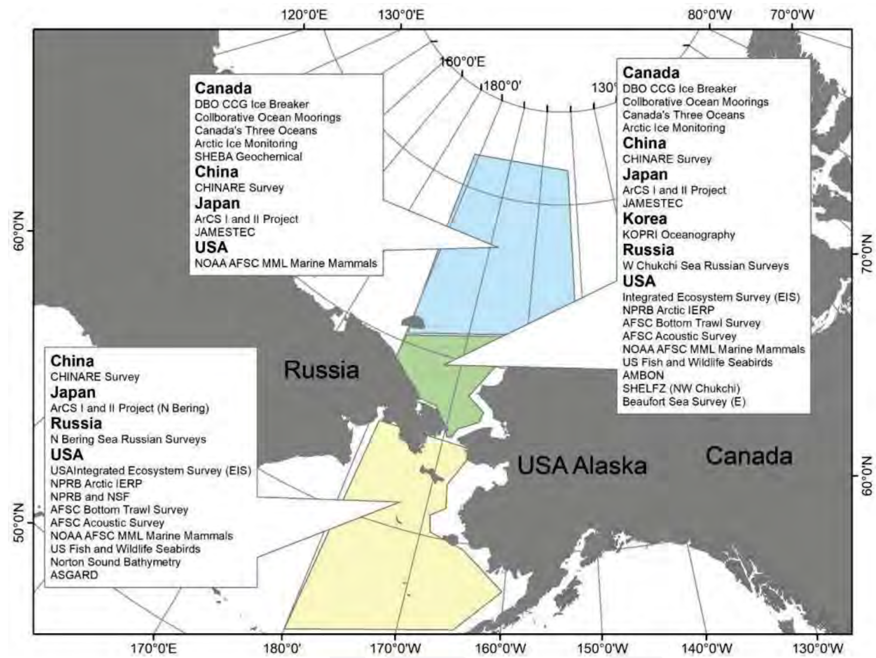

Fig. 3. Preliminary inventory of metadata on scientific surveys in the Northern Bering Sea (yellow), Southern Chukchi Sea (green) and Northern Chukchi Sea and Central Arctic Ocean (blue).

AGENDA ITEM 6
Requests

- Addition of one Japanese member, Kohei Matsuno from Hokkaido University who has expertise in marine environments, and the biology and distribution of zooplankton in the Bering Sea and Chukchi Sea.
- Addition of two Canadian members, Nadja Steiner from DFO Science and Martin Nantel, DFO Pacific Region's Indigenous Science Liaison.
- A 1-day business meeting at PICES-2021.
- Proposal for a ½-day workshop on "*The northern Bering Sea-Chukchi Sea Integrated Ecosystem Assessment: Recent findings, progress, and the way forward*" convened by WG Co-Chairs, Logerwell and Zuenko (*WG 44 Endnote 4*). The goal of the workshop would be to share information among WG 44 members and with other researchers studying the NBS-CS ecosystem. Topics to be discussed are: 1) describe the work on the IEA to date, and 2) recent findings about the NBS-CS ecosystem, especially those that shed new light on the ecosystem's status, changes, and processes. It was recommended by Science Board to combine this workshop with a workshop proposed by WG 39 Joint PICES/ICES/PAME Working Group on an *Integrated Ecosystem Assessment for the Central Arctic Ocean*. WG 44 Co-Chairs have preliminarily agreed to this.
- To extend the term of the WG one year (until 2023). The reason is that the Co-Chairs and members were approved late in year 2020, such that little work could be accomplished during Year 1. The chair's (Logerwell) nomination was approved April 23, 2020. The final, Russian, membership nominations were approved on August 24, 2020, one week before the WG business meeting. The ToRs require 3 full years to complete. This extension has also been requested and granted by ICES.

WG 44 Endnote 1

WG44 Participation List

Members

Elizabeth A. Logerwell (USA, PICES Co-Chair)

Yury I. Zuenko (Russia, PICES Co-Chair)
Matthew Baker (USA)
Lee Cooper (USA)
Raychelle Daniel (USA)
Lisa B. Eisner (USA)
Elena Eriksen (Norway/ICES)
Megan Ferguson (USA)
Takafumi Hirata (Japan)
Kirstin Holsman (USA) Henry
Huntington (USA) Katrin Iken
(USA)
Mellisa Johnson (USA)
Kirill Kivva (Russia)
Kathy Kuletz (USA)
Andrea Niemi (Canada)
Shigeto Nishino (Japan)
Qi Shu (China)
Aleksei Somov (Russia)
Diana Lynn Stram (USA)
Sarah Wise (USA)

<u>Members unable to attend</u>

China: Zhongyong Gao, Changan Xu
Japan: Yutaka Watanuki
Korea: Hyoung Sul La

<u>Observers</u>

Kohei Matsuno (Japan)

WG 44 Endnote 2

WG 44 meeting agenda

September 1, 2020, 18:00-21:00 Pacific Daylight Time (GMT-7)

- Welcome and logistics
- Background of WG 44
- Member Introductions: research interests and possible contributions to the WG (5 minutes each)
- Review WG 44 Terms of Reference (ToR)

September 2, 2020, 18:00-21:00 Pacific Daylight Time (GMT-7)

- Develop Work Plan for Year 2020-21
    - Inventories of metadata and institutions/programs
    - Determine approach and methodology
    - Develop Indigenous knowledge sharing
- Present the preliminary inventories
- Develop a preliminary outline of approach and methodology
- Requests

WG 44 Endnote 3

Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea (NBS-CS) (WG 44) 2020–2021 Work Plan

1. Determine approach and methodology for conducting an IEA in the Northern Bering – Chukchi Sea LME.
    a. Deliverable: Draft "Methods" for IEA publication
        i. Continue editing the scoping document from Day 1 of September business meeting
        ii. Identify goals, objectives, partners
        iii. Develop co-production of knowledge
    b. Deadline: Fall 2021 PICES Annual Meeting
    c. WG Member leads: Holsman, Daniel, Stram
    d. Meetings:
        i. Monthly virtual status report meetings
        ii. Intersessional virtual/in-person workshop (Date and location TBD) to invite partners to give feedback on draft scoping document
    e. Identify a centralized location for draft documents and resources.
2. Compile an inventory of scientific metadata and of institutions and programs
    a. Deliverable: Metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea LME.
        i. PICES or ICES Report summarizing metadata with data gaps identified.
        ii. Google form-based inventory
    b. Deadline: Fall 2021 PICES Annual Meeting
    c. WG member leads: Logerwell, Zuenko
    d. Meetings: Monthly virtual status report meetings
3. Development of Indigenous knowledge sharing with knowledge holders, to facilitate co-production of knowledge while protecting intellectual property as per the UN Declaration on the Rights of Indigenous Peoples (Articles 11.2, 31).
    a. Deliverable: Draft "Methods" for IEA publication
    b. Deadlines: Fall 2021 PICES Annual Meeting
    c. WG Member lead: Wise

    d. Meetings:
        i. Local virtual conversations in Indigenous communities. Possibly in collaboration with PAME EA-EG October and January virtual conversations in Alaska.
        ii. Intersessional virtual/in-person workshop. Possibly in collaboration with PAME EA-EG Value Workshop (Date and location TBD)
4. Reports
    a. Oral reports to PICES parent committees: FIS and HD. September 2020
    b. PICES Annual Progress Report. Due: October 2020

WG 44 Endnote 4

Proposal for a Workshop

"*The Northern Bering Sea-Chukchi Sea Integrated Ecosystem Assessment: Recent findings, progress, and the way forward*"

[later merged with WG 39 workshop] Convenors: Elizabeth (Libby) Logerwell (USA), Yury Zuenko (Russia)

Duration: ½ day

PICES Working Group 44 (WG 44) is undertaking an integrated ecosystem assessment (IEA) of the northern Bering Sea and Chukchi Sea (NBS-CS), a three-year effort that began in 2020. In the first year, WG 44 determined its approaches and methods for conducting the IEA, compiled an inventory of scientific metadata and relevant institutions and programs, and developed a plan for co-production of knowledge with Indigenous partners. At the same time, the region's ecosystem continues to change rapidly and more data and knowledge are being compiled from many active projects and programs. The purpose of this workshop is to share information among WG44 members and with other researchers studying the NBS-CS ecosystem. Doing so will ensure that the IEA incorporates the most up-to-date information and facilitates networking among researchers who may be, or be interested in becoming, contributors to the IEA.

We welcome submissions that (1) describe the work on the IEA to date, and (2) present recent findings about the NBS-CS ecosystem, especially those that shed new light on the ecosystem's status, changes, and processes.

PICES-2021 Report

Report of WG 44 on Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea

The Joint PICES/ICES Working Group on the *Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea* (WG 44) held its second meeting on September 23, 2021, virtually. Twenty-one members were present, representing all member countries (*WG 44 Endnote 1*). The meeting was co-chaired by Drs. Elizabeth (Libby) Logerwell (USA) and Yury Zuenko (Russia). After self introductions, Kim Rand (NOAA) volunteered to act as rapporteur. The meeting agenda was reviewed by members and adopted (*WG 44 Endnote 2*).

AGENDA ITEM 3

Metadata status

The 2021 Work Plan specifies that WG 44 will "Compile an inventory of scientific metadata and of institutions and programs. Deliverable: Metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea LME". Dr. Rand reported that a metadata workbook with multiple spreadsheets by data type (with DATA LINKS when available) called "Arctic_Metadata" is housed on the WG 44 Google drive. Metadata continues to be added on a continuous basis by many scientists as part of several working groups. The spreadsheets are:

- Environmental Variables
- Pelagic Ice Algal Prod
- Process links
- Zooplankton
- Forage Fish
- Adult fish
- Benthic Infauna
- Benthic Epifauna and Crab
- Marine Mammals
- Seabirds
- Data Not Public

AGENDA ITEM 4

Approach and methodology, status and upcoming milestones

Dr. Kirstin Holsman reported on the status of developing the IEA approach and methodology. In 2021 Drs. Holsman, Raychelle Daniel, and Diana Stram completed the draft outline of "Scoping the NBS and Chukchi Sea Integrated Ecosystem Assessment". The outline listed 6 activities to support scoping the IEA:

1) Identify participants in and beneficiaries of IEA activities and products,
2) Identify goals for the regional IEA,
3) Develop conceptual models,
4) Identify key indicators and metrics for each goal and objective for the 5) Identify management advice and products, and
6) Identify the timeline and future steps of the IEA.

The upcoming milestones are:

- 2022–2023: Complete sections within the document
- 2023: Conceptual models
- 2023–2024: Finalize IEA outline and identify next steps

AGENDA ITEMS 5 AND 6
Including multiple ways of knowing the ecosystem and revised timeline

This activity was formally called "Indigenous knowledge sharing". R. Daniel, H. Huntington, R. Ingram, M. Johnson, S. Wise and E. Zdor reported on this activity.
A document describing the "Lay of the Land" has been drafted, containing the following information:

- Key entities
- Specific participants for goal setting and Indigenous Conceptual Models (ICM)
- Workshop protocols
- Opportunities for inclusion

During winter 2021 the group will identify best practices for collaborative goal setting and prepare a shareable draft report.

The upcoming milestones for Year 2 are:

- Coordinate with partners for workshops (January)
  - Bering Strait Festival (August)
  - RAC meetings
  - Arctic Council (October)
  - PAME (September)
  - LKTKS (April)
- Conduct Workshops
  - Conduct a minimum of 3 workshops, 1 virtual and 2 in person. (Spring and summer)
- Collaboratively set goals
- Develop ICM

The preliminary milestones for Year 3 are:

- Synthesize results (January)
- Communicate science
  - Submit journal article on methods (February)
  - Final Report for communities (December)
  - Presentation (s)

AGENDA ITEM 7
NOAA IEA proposal

Dr. Holsman reported that there is travel funding ($15,000) for the FY22-24 plan.

AGENDA ITEM 8

ICES ASC IEA topic session

Dr. Logerwell reported on a proposed topic session for the ICES ASC in September 2022. The proposed title is "Integrating Ecosystem Assessments"[1], and proposed conveners are Libby Logerwell, Paulina Ramirez-Monsalve and Benjamin Planque. The topics of the session would be:
1) how to set IEA objectives (ESEI),
2) how to perform IEAs (methods and tools),
3) how to translate IEAs into advice and
4) how to complete the full IEA cycle.
Talks would be invited on:

- practical aspects and method development
- stakeholder engagement
- inclusion of Indigenous knowledge
- communication of best practices
- progress on moving towards integrated socio-ecological assessments

AGENDA ITEM 9

WG 39/WG 44 joint workshop

A joint WG 39 (*Integrated Ecosystem Assessment for the Central Arctic Ocean*)/WG 44 workshop on "*Integrated Ecosystem Assessment (IEA) to understand the present and future of the Central Arctic Ocean (CAO) and Northern Bering and Chukchi Seas (NBS-CS)*" (postponed from PICES-2021 due to COVID-19), was resubmitted for PICES-2022 (*WG 44 Endnote 4*) and later approved by Governing Council. It will be 1.0 day (0.5 day + 0.5 day). There will be two sessions with focus on CAO and NBS-CS, and a session for joint deliberation will be prepared. The objectives are to discuss present ecosystem processes in the CAO and the NBS-CS based on achievements from existing and future research programs such as MOSAiC and SAS, numerous NBS-CS programs, and Indigenous Knowledge.

AGENDA ITEM 10

WG 44 workshop

A 1-day workshop for PICES-2022 has been proposed (and approved) on "*Bridging multiple way of knowing within an Integrated Ecosystem Assessment (IEA) to understand the social and ecological changes in the Northern Bering and Chukchi Seas (NBS-CS)*" (*WG 44 Endnote 5*). The main objectives for the workshop are to 1) describe linkages and knowledge pathways among regional organizations across scale (*e.g*., Indigenous communities, government agencies, NGOs, research networks, academic institutions) in the NBS-CS, and 2) document meanings, relationships, processes, and values associated with the NBS-CS ecosystem using a framework rooted in Indigenous Knowledge and designed to coordinate diverse perspectives. The results of the workshop will inform the regional NBS-CS IEA process while offering an innovative model for broader knowledge synthesis and co-production.

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[1] This topic session was not approved by ICES to be included in the ASC

AGENDA ITEM 11

2022 Work Plan

The WG members reviewed the Terms of Reference and agreed on a Work Plan for 2022 (*WG 44 Endnote 3*).

AGENDA ITEM 12

Proposals for inter-sessional meetings/co-sponsored events

Not discussed.

WG 44 Endnote 1

WG 44 participation list

Members

Elizabeth A. Logerwell (USA, PICES Co-Chair)
Yury I. Zuenko (Russia, PICES Co-Chair)
Andrea Niemi (Canada)
Nadja Steiner (Canada)
Zhongyong Gao (China)
Changan Xu (China)
Takafumi Hirata (Japan)
Shigeto Nishino (Japan)
Hyoung Sul La (Korea)
Kirill Kivva (Russia)
Matthew Baker (USA)
Lee Cooper (USA)
Raychelle Aluaq Daniel (USA)
Lisa B. Eisner (USA)
Kirstin Holsman (USA)
Henry P. Huntington (USA)
Katrin Iken (USA)
Mellisa Johnson (USA)
Kathy Kuletz (USA)
Diana Lynn Stram (USA)
Sarah Wise (USA)

Members unable to attend

China: Qi Shu
Japan: Kohei Matsuno, Yutaka Watanuki
Russia: Aleksei Somov
USA: Megan Ferguson

Observers

Becky Ingram (USA)
Kim Rand (USA)

WG 44 Endnote 2

WG 44 meeting agenda

1. Welcome, adoption of agenda, appointment of rapporteur
2. Introduce ourselves and guests
3. Metadata, status and upcoming milestones (Kim Rand)
4. Approach and methodology, status and upcoming milestones (Kirstin Holsman)
5. Indigenous knowledge sharing, status and upcoming milestones (Sarah Wise)
6. Revised timeline due to COVID restrictions
7. NOAA IEA proposal (Kirstin Holsman)
8. ICES ASC IEA topic session
9. WG39/WG44 joint workshop
10. WG 44 workshop
11. 2022 Work Plan
12. Proposals for inter-sessional meetings / co-sponsored events

WG 44 Endnote 3

Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea (NBS-CS) (WG 44) 2021–2022 Work Plan

1. Determine approach and methodology for conducting an IEA in the Northern Bering – Chukchi Sea LME.
   a. Activities
      i. Identify participants in and beneficiaries of IEA activities and products
      ii. Identify goals for the regional IEA
      iii. Intersessional Conceptual Model workshop (if funding can be secured from NOAA IEA Program). May need to delay to Year 3.
   b. Deliverable: Scoping document
   c. WG member leads: Wise, Daniel, Huntington, Heflin
   d. Target date: Fall 2022 PICES Annual Meeting
2. Including multiple ways of knowing the ecosystem
   a. Activities
      i. Coordinate with partners for workshops (January)
      ii. Conduct workshops (S*p*ring, Summer and Fall)
      iii. Collaboratively set goals
   b. Deliverable: Indigenous Conceptual Model (October 2022)
   c. WG member leads: Wise, Daniel, Huntington, Heflin
   d. Target date: Fall 2022 PICES Annual Meeting
3. Describe the key physical, biological and human elements of the ecosystem
   a. Activities
      i. Develop shared conceptual models including both Indigenous Knowledge and science (see 1. and 2. above)
         1. Review of hypotheses for ecosystem dynamics
         2. Identify potential indicators of the above key elements
   b. Deliverables: Outline of Ecosystem description from both Indigenous world views and science, indicators and hypotheses
   c. WG member leads: Holsman, Daniel, Stram, Wise, Daniel, Huntington, Heflin o
   d. Deadline: Fall 2022 PICES Annual Meeting (finalize Report in Year 3, delay due to COVID restrictions)

WG 44 Endnote 4

Proposal for a WG39/WG44 joint Workshop on

"Integrated Ecosystem Assessment (IEA) to understand the present and future of the Central Arctic Ocean (CAO) and Northern Bering and Chukchi Seas (NBS-CS)"

resubmitted for PICES-2022

PICES sponsors: SB and FIS

Duration: 1.0 day (0.5 day + 0.5 day). There will be two sessions with focus on CAO and NBS-CS, and a session for joint deliberation will be prepared.

Convenors: Sei-Ichi Saitoh (Japan), Hyoung Chul Shin (Korea), Libby Logerwell (USA), Yury Zuenko (Russia)

Suggested invited speaker: Lis L. Jørgensen (Norway/PAME)

The target LMEs of WG 39 and WG 44 are the Central Arctic Ocean (CAO) and the Northern Bering Sea-Chukchi Sea (NBS-CS) respectively. These two regions are geographically and dynamically connected. The CAO is in rapid transition, driven by North Pacific environmental changes. The rapid loss of sea ice cover has opened up the CAO to a range of activities, including potential fishing opportunities. In this context, the agreement to Prevent Unregulated High Seas Fisheries in the CAO has been signed and will be soon entered into force, which will necessitate joint research and monitoring. The NBS-CS is also experiencing unprecedented warming and loss of sea ice as a result of climate change. Declines of seasonal sea ice and warming temperatures are prominent in the northern Bering and Chukchi seas as in most regions of the Arctic. Chronic and sudden changes in climate conditions in this Arctic gateway are clearly altering the system and its food-webs, and enlarging opportunities for commercial activities (shipping, oil and gas development and fishing), with uncertain and potentially wide-spread cumulative impacts. An integrated ecosystem assessment (IEA) is a useful approach in this circumstance, particularly with substantial science and policy challenges emerging in the Arctic, and thus a coordinated IEA of the CAO and NBS-CS should be a priority. WG 39 has published IEA Report No.1, which provides a description of the ecosystem in the CAO and is beginning to prepare IEA Report No.2, which will deal with impacts from human activities as well as vulnerability characterization. WG 44 was formed in spring 2020 and is just beginning its work. The communication and interaction between WG 39 and WG 44 are warranted to promote overall understanding of the Arctic and neighboring oceans. The main objectives for the workshop are to describe and discuss present ecosystem processes (sources, signals, significance) in the CAO and the NBS-CS based on achievements from existing and future research programs such as MOSAiC and SAS, numerous NBS-CS programs, and Indigenous Knowledge. In addition, it will help to explore and develop future approaches for IEA and jointly organized monitoring in both regions.

WG 44 Endnote 5

Proposal for a Workshop on

Bridging multiple ways of knowing within an Integrated Ecosystem Assessment to understand the social and ecological changes in the Northern Bering and Chukchi Seas at PICES-2022

Duration: 1 day

Conveners: Sarah Wise (USA), Mellisa Johnson (USA), Nadia Steiner (Canada), Yutaka Watanuki (Japan)

Invited speakers: Elder Richard Slats (USA), Lauren Divine (USA)

The target LME of WG 44 is the Northern Bering Sea-Chukchi Sea (NBS-CS) which is undergoing rapid transition caused by climate change. Declines in seasonal sea ice, increased storm events, and warm temperatures are driving substantial changes in socio-ecological systems. New commercial opportunities such as shifting fisheries, oil and gas exploration, increased vessel traffic (shipping and access to land-based natural resources), and Arctic tourism will have uncertain cumulative impacts on coastal communities in the Northern Pacific and beyond. The NBS-CS Integrated Ecosystem Assessment will improve understanding of critical interconnected systems processes and inform decision-making and management. Including Indigenous Knowledge in the IEA provides best available expert knowledge to understand the past, present, and future socio-ecological conditions of the region. Indigenous Peoples across North Pacific communities have relied on marine resources for food security, social cohesion, economic livelihood, and cultural continuity for millennia. Including Indigenous Knowledge in the IEA process will enhance understand of changing social-ecological conditions while offering a longitudinal perspective across generations of ecological experience and observations. Employing a co-production approach, this workshop will generate a collaborative understanding of the multiple ways of knowing, experiencing, using, and valuing the North Pacific ecosystem. The main objectives for the workshop are to 1) describe linkages and knowledge pathways among regional organizations across scale (*e.g*., Indigenous communities, government agencies, NGOs, research networks, academic institutions) in the NBS-CS, and 2) document meanings, relationships, processes, and values associated with the NBS-CS ecosystem using a framework rooted in Indigenous Knowledge and designed to coordinate diverse perspectives. The results of the workshop will inform the regional NBS-CS IEA process while offering an innovative model for broader knowledge synthesis and co-production.

PICES-2022 Report

<u>Report of WG 44 on the Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea</u>

The Joint PICES/ICES Working Group on the *Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea* (WG 44) held its third meeting on August 31, 2022, virtually. Eighteen members were present, representing all member countries (*WG 44 Endnote 1*). The meeting was chaired by Dr. Elizabeth (Libby) Logerwell (USA). After self introductions, the meeting agenda was reviewed by members and adopted (*WG 44 Endnote 2*)

AGENDA ITEM 3

Approach and methodology, status and upcoming milestones

We developed three conceptual models with a team of interdisciplinary and multi-national scientists and with input from a few indigenous representatives. The models were created using Mental Modeler software. The model results will be released in a PICES Report. Our next steps are to finish our IEA scoping document and finalize IEA goals by spring 2023. We are also planning to identify indigenous partners this coming fall and winter.

AGENDA ITEM 4

Indigenous knowledge sharing, status and upcoming milestones

“Multiple Ways of Knowing the Bering Sea-Chukchi Sea Ecosystem” workshop was held August 24–25, 2022 in Anchorage, and convened by Sarah Wise *et al*. Workshop organizers are in the process of transcribing the workshop notes and summarizing the ideas for bringing in Indigenous knowledge into our IEA process. The workshop included discussions about the challenges of terminology and language (*e.g.,* understanding what the term "Indicators" means) and the concept of time. Milestones: Share report from first workshop. Distribute information that is not digital. Organize a larger, more inclusive meeting in 2023 in Seattle, WA.

AGENDA ITEM 5

2023 Work Plan

WG members discussed a draft Work Plan and agreed on milestones and deliverables (*WG Endnote 3*). An extension of WG44's term to fall 2024 was requested to FIS and HD parent committee.

AGENDA ITEM 6

Proposal for new Advisory Panel on Arctic issues

Dr. Logerwell presented a proposal for an Advisory Panel on the Arctic Ocean and the Pacific Gateways, and Terms of Reference (*WG 44 Endnote 4*). WG members discussed its merits. It was generally agreed that this AP may be a natural evolution following WG 44 and so would be timelier after completion of WG 44 activities in 2024. Dr. Alison Deary (NOAA AFSC) was nominated to be an East Pacific co-chair if the proposal is accepted.

AGENDA ITEM 7

Proposals for meetings / co-sponsored events

See *WG 44 Endnote 5*.

WG 44 Endnote 1

WG 44 meeting participation list

Members	Members unable to attend
Libby Logerwell (Co-chair)	Nadja Steiner
Yury Zuenko (Co-chair)	Alexei Somov
Andrea Niemi	Lee Cooper
Zhongyong Gao	Raychelle Danielle
Qi Shu	Lisa Eisner
Changan Xu	Kirstin Holsman
Taka Hirata	Henry Huntington
Kohei Matsuno	Mellisa Johnson
Shigeto Nishino	Kathy Kuletz
Yutaka Watanuki	
Hyoung Sul La	Observers
Kirill Kivva	Julie Kellner
Matt Baker	Ali Deary
Megan Ferguson	Becky Ingram
Katrin Iken	
Jamal Moss	PICES
Diana Stram	Sonia Batten (Executive Secretary)
Sarah Wise	

WG 44 Endnote 2

WG 44 meeting agenda

1. Welcome, adoption of agenda, appointment of rapporteur
2. Introduce ourselves and guests
3. Approach and methodology, status and upcoming milestones (Moss or Logerwell)
4. Indigenous knowledge sharing, status and upcoming milestones (Sarah Wise)
5. 2023 Work Plan; Request extension?
6. Proposal for new Advisory Panel on Arctic issues (AP-ARC)
7. Proposals for inter-sessional meetings / co-sponsored events

WG 44 Endnote 3

_2022–2023 W_ORK PLAN

1. Determine approach and methodology for conducting an IEA in the Northern Bering – Chukchi Sea LME.
    a. Activities
        i. Identify participants in and beneficiaries of IEA activities and products
        ii. Identify goals for the regional IEA
        iii. Intersessional Conceptual Model in person workshop (if funding can be secured from NOAA IEA Program).
        iv. PICES 2023 workshop (title TBD)
    b. Deliverable(s):
        i. Scoping document
    c. WG member leads: Holsman, Daniel, Stram, Moss, Logerwell
    d. Target date: Spring 2023 WG44 virtual meeting
2. Including multiple ways of knowing the ecosystem
    a. Activities
        i. Indigenous Conceptual Model workshop (September 2022)
        ii. PICES 2023 workshop (title TBD)
    b. Deliverable(s) and target dates:
        i. Drafted Elements of Indigenous Conceptual Model (October 2022)
        ii. Final Elements of Indifenous Conceptual Model (Fall 2023)
        iii. PICES 2023 workshop plans (Spring 2023)
    c. WG member leads: Wise, Daniel, Huntington, Heflin
3. Describe the key physical, biological and human elements of the ecosystem
    a. Activities
        i. Develop shared, integrated conceptual models including both Indigenous Knowledge and science (see 1. and 2. above) (start integration discussions at PICES 2023 workshop; continue work through 2024)
            1) Review of hypotheses for ecosystem dynamics
            2) Identify potential indicators of the above key elements
    b. Deliverables: Ecosystem description from both Indigenous world views and science, indicators and hypotheses (Fall 2023)
    c. WG member leads: Holsman, Daniel, Stram, Wise, Daniel, Huntington, Heflin

Note: This work plan accomplishes Years 1 and 2 Activities and Deliverables as detailed in our ToR. A one-year extension will be requested to complete Year 3 Activities and Deliverables in our ToR.

WG 44 Endnote 4

Proposal for an Advisory Panel on the *Arctic Ocean and the Pacific Gateways*

Acronym: AP-ARC

Potential Parent Committee: Science Board (SB), FIS, MONITOR

Term: Nov. 2022-TBD

Background

The Central Arctic Ocean (CAO), that is in between the North Pacific and North Atlantic, is in rapid transition, in interaction with and impacting these waters. It has become more accessible to a range of activities. For example, rapid loss of sea ice cover has opened up the CAO for potential fishing opportunities. In this context, the agreement to Prevent Unregulated High Seas Fisheries in the CAO has been signed and entered into force which will necessitate joint research and monitoring. The Pacific gateway to the CAO, *i.e*., the Northern Bering Sea-Chukchi Sea (NBS-CS) is also experiencing unprecedented warming and loss of sea ice as a result of climate change. Declines of seasonal sea ice and warming temperatures have been more prominent in the northern Bering and Chukchi seas than in the European Arctic. Chronic and sudden changes in climate conditions in this Arctic gateway are clearly reshaping the system and its food-webs, and enlarging opportunities for commercial activities (shipping, oil and gas development and fishing), with uncertain and potentially widespread cumulative impacts.

PICES took upon responsibilities in the CAO issues when it joined the WGICA (Joint PICES/ICES/PAME Working Group on an *Integrated Ecosystem Assessment (IEA) for the Central Arctic Ocean (CAO)*) by establishing WG39 in 2017. In 2019, PICES also established WG44 (Joint PICES/ICES Working Group on *Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea*) in efforts to understand the Arctic system and its impacts to the sub-Arctic and mid-latitude North Pacific. An integrated ecosystem assessment (IEA) is a useful approach that is shared by these two Working Groups, particularly relevant with substantial science and policy needs emerging for the sustainable Arctic. This renders a coordinated IEA of the CAO and NBS-CS as a priority task. In addition, it is of particular significance to developing future approaches for the United Nations Decade of Ocean Science for Sustainable Development in the Arctic Ocean (UNDOS-Arctic), where science for resilience and sustainability is more important than anywhere else in the world oceans. Despite this continuing significance and unfinished commitment to WGICA and also WGIEANBS-CS, WG 39 and 44 will end the term with the closure of PICES 2022 Annual Meeting. In this context, we propose PICES establish AP-ARC to coordinate and integrate PICES scientific activities on the Arctic issues and to further advance the understanding of the Arctic system and linkages and impacts to the North Pacific.

Proposed Terms of Reference (ToRs)

1. Coordinate and promote the joint scientific activities of PICES to further advance the understanding the Central Arctic Ocean and its interaction and linkage with its Pacific Gateways;
2. Convene workshops/sessions to engage those involved in IEA and monitoring of the Arctic Ocean and its Gateways;
3. Represent and coordinate responses of PICES concerning the Arctic Ocean and the connected waters in cooperation with partners and other international organizations, including WGICA (Joint PICES/ICES/PAME Working Group on an *Integrated Ecosystem Assessment (IEA) for the Central Arctic Ocean (CAO)*), and WGIEANBS-CS (Joint PICES/ICES Working Group on *Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea*);
4. Develop recommendations for PICES to better collaborate within PICES and with largerinternational initiatives relevant to the Arctic Ocean including the UN Decade of Ocean Science;

Proposed Co-Chairs (Two west and two east)

Sei-Ichi Saitoh (WG 39) (Japan) - ssaitoh@arc.hokudai.ac.jp
Hyoung Chul Shin (WG 39) (Korea) - hcshin@kopri.re.kr
Alison Deary (USA) - Alison.Deary@noaa.gov
Sarah Wise (WG 44) (USA) - Sarah.Wise@noaa.gov

*Proposed Membership**

Andrea Niemi (WG 44) (Canada)
Nadja Stefanie Steiner (WG 44) (Canada)
Zhongyong Gao (CC-S, WG 39, WG 44) (China)
Guangshui Na (FUTURE-SSC, MEQ, SB, WG 35, WG 39) (China)
Fang Zhang (WG 39) (China)
Hyoung Chul Shin (WG 39) (Korea)
Hyoung Sul La (WG 44) (Korea)
Sei-Ichi Saitoh (WG 39) (Japan)
Fujio Ohnishi (WG 39) (Japan)
Takafumi Hirata (WG 44) (Japan)
Yury I. Zuenko (CREAMS-AP, POC, S-CCME, SG-UNDOS, WG-35, WG-40, WG-44) (Russia)
Kirill Kivva (WG 44) (Russia)
Alison Deary (USA)
Sarah Wise (WG 44) (USA)
Elizabeth A. Logerwell (FIS, WG 44) (USA)
Lisa B. Eisner (MONITOR, WG 44) (USA)
David L. Fluharty (WG-39) (USA)
*This is a tentative membership, in future, almost WG 44 member will join to this AP.

Reference

Skjoldal, H. R. (Ed.). 2022. Ecosystem assessment of the Central Arctic Ocean: Description of the ecosystem. ICES Cooperative Research Reports Vol. 355. 341 pp. https://doi.org/10.17895/ices.pub.20191787

WG 44 Endnote 5

Proposal for a Workshop on

"*Collaborative and knowledge sharing approaches to support climate change adaptation and social-ecological system resilience*"
at PICES-2023 [later merged with

"*Indigenous and community-led approaches to coastal ecosystem resilience in the Pacific*" and renamed as
"*Indigenous and community-led approaches to support climate change adaptation and ecosystem resilience in the North Pacific and Arctic*"]

Convenors: Sarah Wise (USA), Kirstin Holsman (USA), Kathy Mills (USA), Steven Alexander (Canada)

Suggested Invited Speakers: Maktuayaq Johnson (USA), Cyrus Harris (USA), Raychelle Daniel (USA), Richard Slats (USA), Vivian Korthuis (USA)

Duration: 1 day

Fishing communities are on the frontline of climate change. Supporting resilience and climate adaptation requires strong relationship building, trust, and collaborative knowledge creation that centers on multiple knowledge systems including Indigenous perspectives and Traditional Knowledge. While climate empirical change information and observations are abundant, challenges and opportunities remain to match the scale of information to community local needs and regional impacts, and to account for dynamics around community adaptation and response. This interactive workshop builds on Joint ICES/PICES WG 44's work focusing on hearing from Indigenous communities to identify values and actionable guidance to create space for Indigenous Knowledge in marine management processes. Additionally, the workgroup complements a proposed S-CCME open meeting and both the S-CCME and Joint ICES/PICES WG 44 business meetings at the 2023 Annual Science meeting in Seattle. The workshop has two main objectives: 1) share and learn from multiple knowledge systems, processes, and perspectives around climate change and resilience within remote fishing communities; 2) provide examples of and lessons learned from transdisciplinary and collaborative science rooted in strong partnerships, through engagement from multiple stages in its development--from conceptualization, to implementation, toward products and outcomes. The one- day workshop will include a panel of invited Indigenous speakers and transdisciplinary science practitioners, interactive discussion sessions, and time allocated for collaborative creation. We encourage participation from Indigenous Knowledge holders, community members, scientists, and resource managers involved in research projects based in collaborative frameworks. Outcomes of the workshop will include a collaborative report highlighting best practices and/or lessons learned, a peer-reviewed publication on diverse methodological approaches to transdisciplinary work. Other outcomes based on discussion among participants on ways to bring together multiple ways of knowing and multiple types of knowledge, expertise, and experience to inform decision-making to be decided by workshop participants.

The Joint PICES/ICES Working Group on the Integrated Ecosystem Assessment for the Northern Bering Sea - Chukchi Sea (WG 44) held two meetings in 2023, one virtual meeting on August 31; and one hybrid meeting on October 25 during PICES 2023 in Seattle. 13 members were present at the August virtual meeting; and 12 members were present at the October hybrid meeting (6 in person and 6 online). There was also one visitor during the October meeting (WG44 Endnote 1). Both meetings were chaired by Dr. Elizabeth (Libby) Logerwell (USA). After self introductions, the meeting agendas were reviewed by members and adopted (WG 44 Endnote 2).

August 31 Virtual Meeting

AGENDA ITEM 3

Progress on 2023 Revised Work Plan

The chair reminded WG members that the Work Plan and Terms of Reference were revised (and approved) in spring 2023 (WG44 Endnote 3 and Endnote 4). The PICES Secretariat reminded the Chair and WG members that the WG tenure would end in fall 2023 with one year hence to submit the Final Report. The Chair requested that members send references for linkages in the conceptual models in support of the Final Deliverable in the revised Terms of Reference (WG44 Endnote 4). Sarah Wise presented an update on the work of her team on "Including multiple ways of knowing", such as the PICES 2023 workshop.

AGENDA ITEM 4

Requests for Science Board recommendation

There were no proposals for new Expert Groups, of requests for travel support, events, etc.

AGENDA ITEM 5

Plan for PICES 2023 WG meeting

The Chair requested that by the PICES 2023 meeting, the key linkages (annotated with references) for each conceptual will have been identified. WG members decided that the meeting would be used for writing and making the results more concrete. It was noted that several WG members will not be able to attend PICES 2023 due to travel restrictions.

October 25 Hybrid Meeting

AGENDA ITEM 3

Progress on Multiple Ways of Knowing

Sarah Wise gave an update on the activities of her team (Raychelle Daniel, Henry Huntington, Rebecca Ingram, Mellissa Maktuayaq Johnson, Nadja Steiner and Eduard Zdor) working on issues around multiple ways of knowing the NBS-CS ecosystem. The groups overarching goal is to examine EBM goals and targets in a way that bridges multiple knowledge systems. This allows for broader representative goals and understanding, and greater inclusion of meanings. Through a series of workshops, including one held at PICES 2023, Wise's team along with indigenous, management and science partners, have conducted institutional mapping of the NBS-CS ecosystem that illustrate the relationship between humans, institutions and the ecosystem. Key ideas emerging from the team's work are: there is a need for more Indigenous-led work; there is a need for focus on relationships and relationship-building; data sovereignty is an issue to be addressed; there is a need for building capacity; and future work should include leveraging examples of existing strong partnerships and engagement.

AGENDA ITEM 4

Update on AP-ARC

The chair gave an update on the proposed new Advisory Panel on Arctic Issues. WG members expressed interest in recruiting a co-chair with expertise in social sciences. WG members asked how this AP would overlap with other Arctic organizations such as the Arctic Council AMAP Working Group and the Pacific Arctic Group.

AGENDA ITEM 5

Update on timeline, Final Report deadline

The chair reminded WG members that the WG's tenure will end at this meeting and that the Final Report will be due in one year (at PICES 2024).

AGENDA ITEM 7

Finalize conceptual models, key linkages and references

WG members discussed the current status of the conceptual models and plans for finalizing them and preparing the Final Report. It was noted that the Ecological model is essentially contained within the Climate-Fisheries model, so a separate effort to finalize the former model and provide key linkages and references is not needed. Members discussed the idea of integrating all the models into one comprehensive model and then examining specific interactions from the two perspectives (climate-fisheries and subsistence-food security).

WG members expressed interest in publishing a paper on network mapping. Kirstin Holsman will organize bi-weekly meetings with interested members to get the paper off the ground. There is a need to identify a group ready to start working on the analyses for the paper. This core group will lead/work on the manuscript and evaluate confidence in the interactions that have been identified.

Kirstin Holsman gave an overview of Calibrated Confidence Language. The process provides guidance on agreement and confidence when working on multiple knowledge sources (including lived experience and indigenous knowledge). The process combines confidence and documented relationships. For example, you may know there is a link between two things, but don't have much confidence. Or you may know of a strong documented relationship between two things.

AGENDA ITEM 8

Open journaling or breakout groups to start drafting Final Report/Journal paper

The WG agreed that the chair (Logerwell) will create a rough draft/outline of the Final Report, establish a timeline of milestones towards completing the report and identify WG members for specific action items (such as drafting text, preparing figures, assembling references, etc.). WG members were reminded of the key deliverables from the revised ToR (WG 44 Endnote 4): metadata on data sources and institutions (completed); ecosystem descriptions (conceptual models); knowledge gaps; and next steps.

WG 44 Endnote 1

August 2023 WG 44 Meeting Participation list

Members
Libby Logerwell (Chair, USA)
Yury Zuenko
Changan Xu
Lee Cooper

October 2023 WG 44 Meeting Participation list

Members
In person:
Libby Logerwell (Chair, USA)
Kirstin Holsman
Lee Cooper

Taka Hirata
Hyoung Sul La
Matt Baker
Jamal Moss
Lisa Eisner
Shigeto Nishino
Sarah Wise
Nadja Steiner
Andrea Niemi
Henry Huntinton

Changun Xu
Matt Baker
Sarah Wise

Virtual:
Kathy Kuletz
Jamal Moss
Nadja Steiner
Hyoung Sul-La

Observers
In person: Jackie Grebmeier
Virtual: Kim Rand

WG 44 Endnote 3

Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea (NBS-CS) (WG 44)
2022-2023
WORK PLAN
2023-02-10 REVISION

1. Determine approach and methodology for conducting an IEA in the Northern Bering – Chukchi Sea LME. Develop conceptual model(s).
    a. Activities
        i. Identify participants in and beneficiaries of IEA activities and products
        ii. Identify goals for the regional IEA
        iii. April 2023 Intersessional workshop (virtual). Open journaling to outline PICES Press Article
        iv. Individual WG members draft section(s) of Article.
        v. October PICES 2023 meeting: Report on draft of PICES Press Article on conceptual model process and products. Brainstorming contributions to NPRB NBS IERP call for proposals.
    b. Deliverable(s):
        i. PICES Press Article (and journal article?). Fall 2024
        ii. Contribution to NPRB NBS call. TBD (depending on NPRB deadlines)
    c. WG member leads: Moss, Logerwell, Wise
2. Including multiple ways of knowing the ecosystem
    a. Activities
        i. Indigenous Conceptual Model workshop (September 2022)
        ii. PICES 2023 workshop - *Indigenous and community-led approaches to support climate change adaptation and ecosystem resilience in the North Pacific and Arctic (W9)*
    b. Deliverable(s) and target dates:
        i. Drafted Elements of Indigenous Conceptual Model (October 2022)
        ii. Final Elements of Indigenous Conceptual Model (Fall 2023)
        iii. PICES 2023 workshop plans (~~Spring~~ Fall 2023)
    c. WG member leads: Wise, Daniel, Huntington, Johnson

Provide guidance document(s) for future WGs (PICES, ICES, PAME, etc.) to create an IEA product for the NBS-CS. Fall 2024

Appendix 9

WG46 Final Report

PICES Scientific Report

2023

Report of PICES Working Group 46 on Ocean Negative Carbon Emissions (ONCE)

edited by

Nianzhi Jiao, Carol Robinson, Louis Legendre, Douglas Wallace

May 2024

North Pacific Marine Science Organization (PICES)
P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
www.pices.int

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 ocean, and propose future research directions and applications aimed at enhancing 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 negative impacts of ONCE.

In the three years since Working Group 46 was formed, knowledge gaps were discussed in negative carbon emissions in the ocean, especially in the coastal regions, which will help innovation both in theory and technology to achieve ONCE. However, COVID-19 brought challenges to the work, making it impossible to hold in person meetings to promote interdisciplinary exchange. In the face of these difficulties, we made great efforts to organize electronic annual meetings, Co-Chair meetings, and Task Team meetings to exchange ideas and discuss ongoing research results. The group also hosted an "Ocean Negative Carbon Emissions (ONCE) for Carbon Neutralization" Workshop during the 2023 PICES Annual Meeting. An application to create a UN Decade program on Ocean Negative Carbon Emissions was prepared and submitted, and the 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 in 2022.

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.

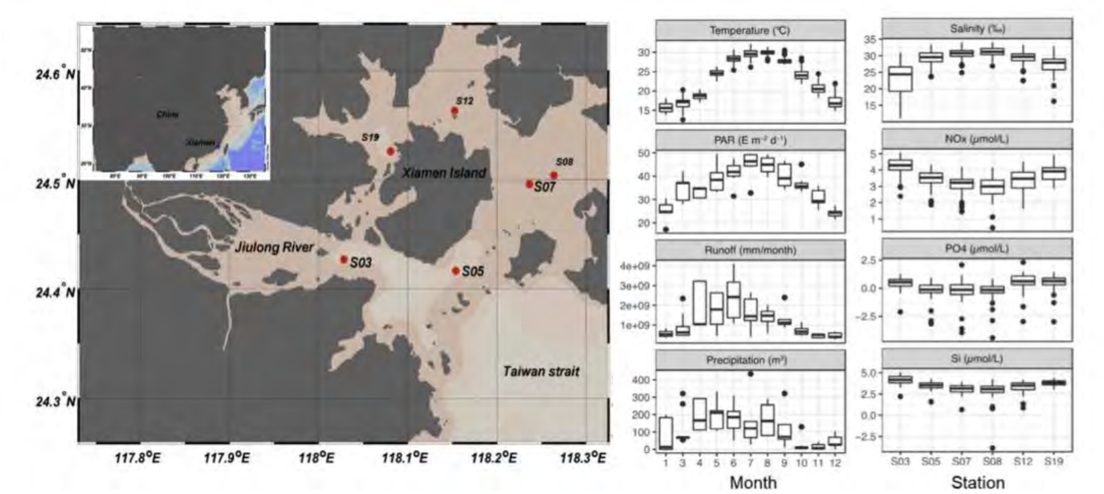

Figure 1. Time-series sampling in the coast around Xiamen, Fujian, China (Wang et al., unpublished.)

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.

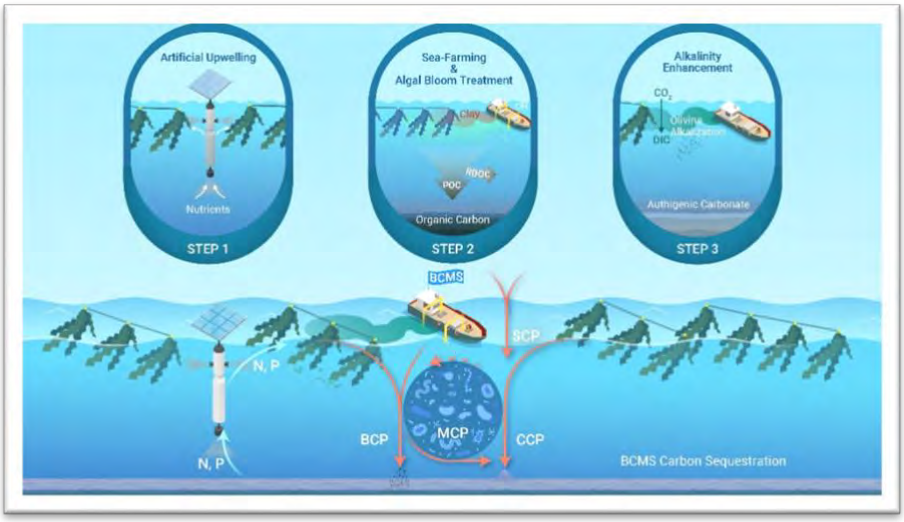

Figure 2. An illustration of the BCMS ecoengineering approaches
POC: Particulate Organic Carbon, RDOC: Refractory Dissolved Organic Carbon, N,P: Nitrogen and phosphorus

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.

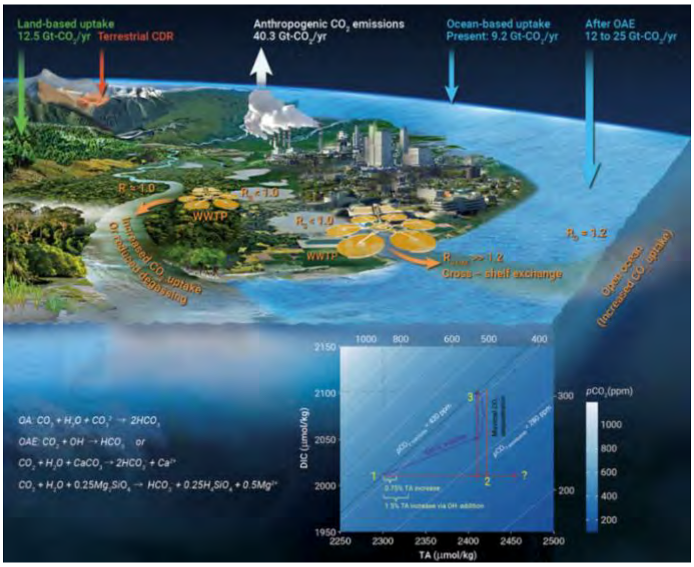

Figure 3. Wastewater alkalinity addition as a novel ocean negative carbon emissions approach

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 was created to identify current knowledge gaps in negative carbon emissions in the ocean, 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 in order to measure carbon-related biogeochemical cycles and analyze interactions between organic and inorganic carbon in the ocean.

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3. Jiao, N., Zhu, C., Liu, J., Luo, T., Bai, M., Yu, Z., ... & Cai, W. J. (2023). A roadmap for Ocean Negative Carbon Emission eco-engineering in sea-farming fields. *The Innovation Geoscience*, *1*(2), 100029.

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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

WG 46 PICES Membership

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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

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

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

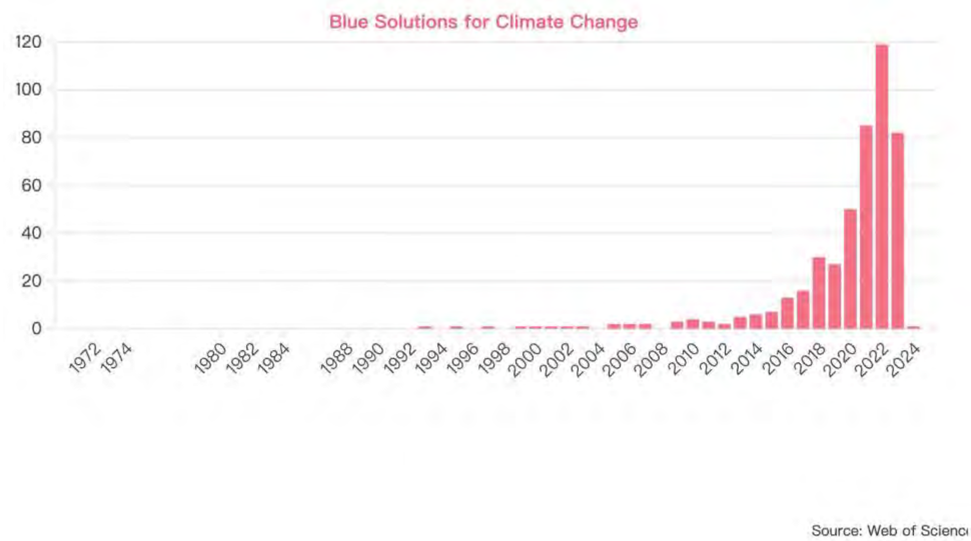

Figure 5. Keyword: “Blue Solutions for Climate Change”

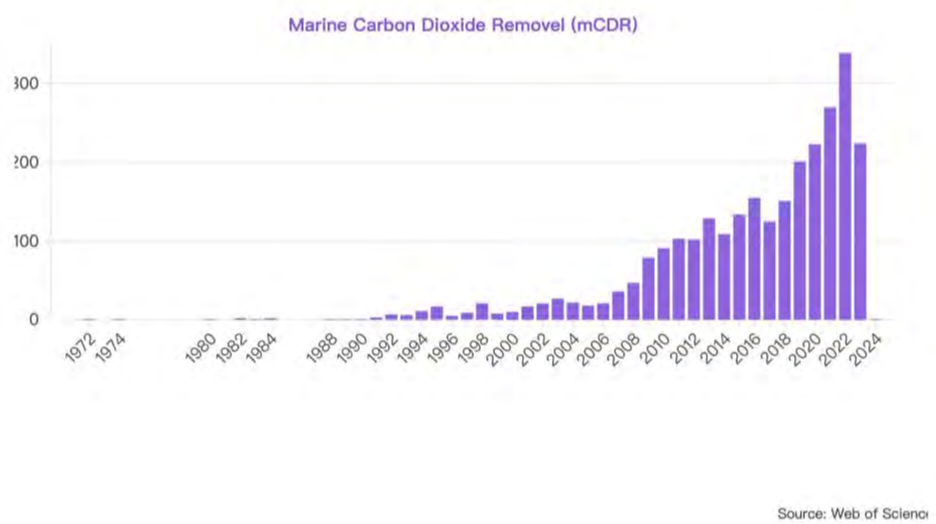

Figure 6. Keyword: “Marine Carbon Dioxide Removel (mCDR)”

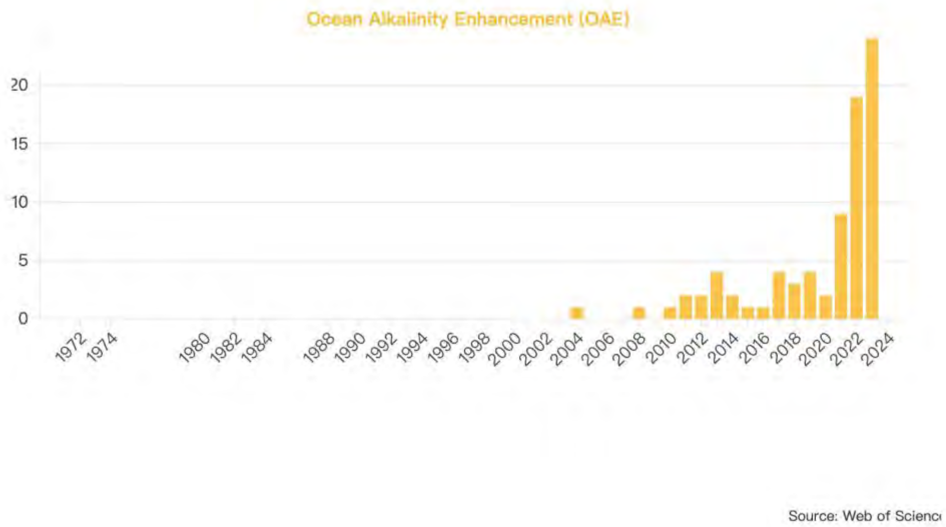

Figure 7. Keyword: "Ocean Alkalinity Enhancement (OAE)"

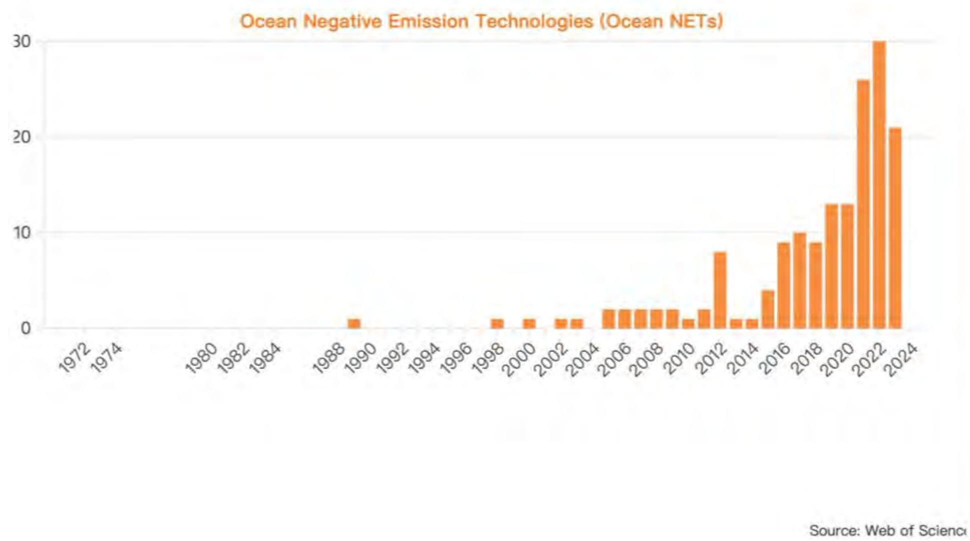

Figure 8. Keyword: "Ocean Negative Emission Technologies (Ocean NETs)"

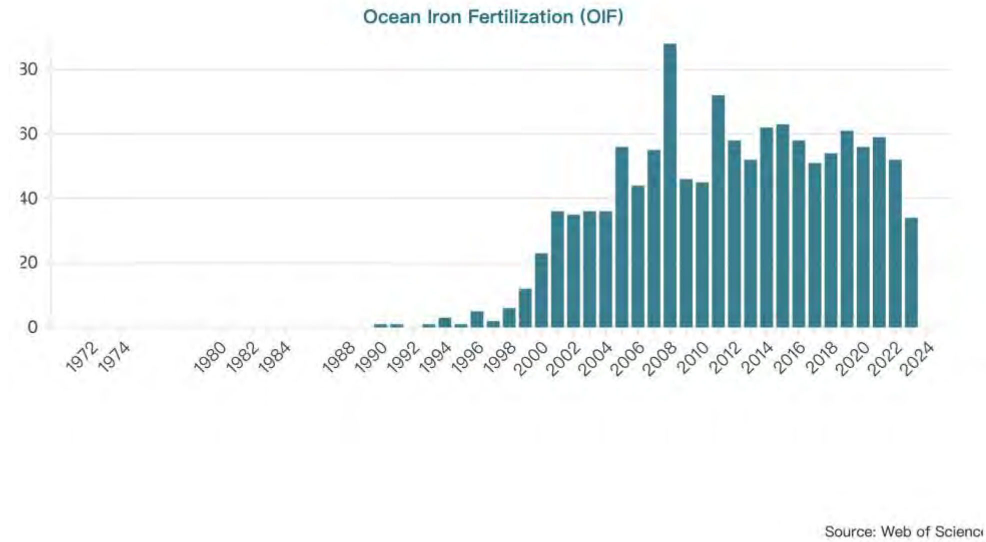

Figure 9. Keyword: "Ocean Iron Fertilization (OIF)"

Appendix 10

WG42 Final Report

PICES SCIENTIFIC REPORT

Report of PICES Working Group 42
on
Indicators of Marine Plastic Pollution

edited by

Chengjun Sun, Jennifer Lynch

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Acknowledgements

The editors would like to thank all the members of WG 42 for their contributions. Thanks to Dr. Won Joon Shim for his pioneering role in the microplastic study group which made this working group possible. We would also like to thank our parent committee MEQ for their support and help. Special thanks to Guangshui Na and Andrew R.S. Ross for their consistent support.
Research work related to this report was supported by the APEC Cooperation Fund of China (No. WJ1323001), Asian Cooperation Fund (No. WJ1223001, WJ0923015), Korea Institute of Ocean Science and Technology (No. EA0014), National Research Foundation of Korea (No. 2017R1E1A1A01073137), and direct support for open access publication fees from the NOAA Marine Debris Program.

Abbreviations and Acronyms

AMAP	Arctic Monitoring and Assessment Program
EcoQO	Ecological Quality Objective
GPGP	Great Pacific Garbage Patch
MMP	Marine Microplastic
MP	Microplastic
NPO	North Pacific Ocean
PNEC	Predicted no-effect concentration
UNEP	United Nations Environment Programme

Executive Summary

Among the myriad challenges we face to maintain a sustainable ocean, plastic pollution comes to the fore as a global concern. It is predicted that by the year 2050 the amount of plastic is going to exceed the total amount of fish in the world ocean. Plastic pollution calls for every country's attention. Of the ten challenges listed by the UN Decade of Ocean Science for Sustainable Development the first is to understand and map land and sea-based sources of pollutants and contaminants, of which plastic and nutrients are the two most important, and develop solutions to remove them or mitigate their potential impacts on human health and ocean ecosystems.

Microplastics (plastics less than 5 mm in size) have attracted a lot of attention as they are widely distributed around the world oceans and pose a lot of potential negative effects on the ecosystem. In 2017, PICES scientists formed a study group on Marine Microplastics (SG-MMP) to begin discussions on how we can best coordinate monitoring of plastic pollution in the PICES region. Succeeding SG-MMP, PICES approved the formation of our working group on Indicators of Marine Plastic Pollution (WG 42) parented by the MEQ Committee in September 2019.

WG 42 has brought together experienced scientists to better understand and evaluate the plastic pollution problem we are facing in the PICES region. WG 42 members actively participated in different activities to achieve the goals described in the terms of reference (ToR). The intensive and coordinated in-depth discussions, communications, information exchanges and idea sharing have helped the group to be very productive. The significant accomplishments of WG 42 include three peer-reviewed papers published in the world-renowned journal *Environmental Pollution*. WG 42 members systematically reviewed the scientific literature on plastic pollution in the seawater, biota, and shoreline in the North Pacific Ocean, provided recommendations and called for a long-term monitoring program for ocean plastic pollution in the region. In addition, the Global Plastic Bioindicators Project led by Dr. Matthew Savoca and involving other WG42 members has been endorsed by the UN Decade of Ocean Science for Sustainable Development. This reports outlines these major accomplishments and findings by WG 42 members and provides useful references to the current plastic and microplastic pollution status in the PICES region.

Although the term of WG 42 is coming to its end, it is clear that the work conducted by the group needs to continue. With increasing plastic production and plastic waste generation globally, more plastic waste is entering the world's oceans, posing more threat to the ocean environment. There are many unknown challenges as well, such as the impacts of those microplastics generated from the plastic debris. We still need more research to better understand and evaluate the impact of plastic pollution, including microplastic pollution, on our ecosystems and find ways to combat the problem. Work conducted by WG 42 can be built upon to achieve better understanding, data generation, information sharing and global progress on marine plastic pollution. With Plastic Pollution Treaty negotiations still underway there is a strong need for monitoring so that, when societal changes are enacted to improve the plastic pollution problem, we can detect the ultimate results (changed levels of plastic pollution in the ocean) and show the successes or shortcomings of those changes.

Introduction

The North Pacific Ocean (NPO) is home to the Great Pacific Garbage Patch (GPGP) which is the largest of the five offshore plastic accumulation zones in the world's oceans. The NPO is incredibly contaminated by floating plastic waste and microplastics coming from every country bordering the Pacific Ocean. Plastic waste comes in all shapes and sizes, from mega plastics to nano plastics. When large pieces of plastic debris enter the ocean gyres, they tend to stay within the gyre until they are further broken down into small plastic particles (microplastics and nanoplastics) under the effects of sun, waves and marine organisms. Since plastic waste in the ocean has no political boundaries, the countries that border the north Pacific must work together to understand the source, transport, fate and impact of the marine plastics on NPO ecosystems.

The goal of WG 42: Indicators of Marine Plastic Pollution is to better understand the current plastic pollution status in the NPO and to find better ways to quantify and monitor marine plastic pollution. Together, WG42 group members thoroughly reviewed publications on the plastic pollution in the NPO and wrote three companion review articles that focus on providing the best monitoring protocols for sample collection and processing in the lab to quantify micro- to mega- plastics in four different compartments of the NPO: seawater, shorelines, sediment, and biota. Data in the NPO were also compared with data collected elsewhere and recommendations towards a target goal that a country could use to manage their waste were also made. Three of the review articles (on seawater, shoreline and biota) have already been published (Appendix 3).

Marine plastic and microplastic pollution is an ever-increasing problem all around the world, and many questions remain to be answered. We hope that our scientifically determined suggestions for monitoring programs in the NPO are implemented and used to best effect across political boundaries for the benefit and conservation of ecosystems in the NPO. We also hope that the review findings and suggestions serve as a model for other regions to adopt and begin region-wide plastic pollution monitoring programs.

WG 42 Achievements with Respect to Terms of Reference

1. *To review pollution (e.g. abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas.*

Macro- and micro-plastics are ubiquitous in the oceans worldwide. They have been found in many different compartments including seawater, sediment, shoreline, biota and the atmosphere. Reported data show that the NPO and its surrounding marginal seas are more polluted than most, apart from the Mediterranean Sea (C´ozar et al., 2014; Isobe et al., 2015; Shim et al., 2018; Isobe et al., 2019). To better understand the current plastic pollution status in the NPO, WG 42 conducted comprehensive literature reviews on the abundance, distribution, composition, and potential impacts and risks of plastics across sizes ranging from mega-, macro- and meso- to micro- and nano-plastics. Below are the major findings and conclusions from review papers focusing on the shoreline, seawater, and biota. For detailed information, please refer to the publish papers listed in Appendix 3.

Review and recommendations for plastic ingestion bioindicators in the North Pacific Ocean

WG 42 members first created a comprehensive inventory of all studies examining plastics in biota in the NPO region and reviewed plastic ingestion in all major taxonomic groups – invertebrates, fish, seabirds, marine mammals and sea turtles. We then assessed the status and plastic ingestion trends in these groups and compared them with data from seven other regions including the South Pacific, North Atlantic, South Atlantic, Arctic, Indian, and Southern Oceans and the Mediterranean Sea. We found that the NPO is among the most polluted world ocean regions and about half of the studied fish and seabird and over three-quarters of bivalves and sea turtles in the NPO contained plastic.

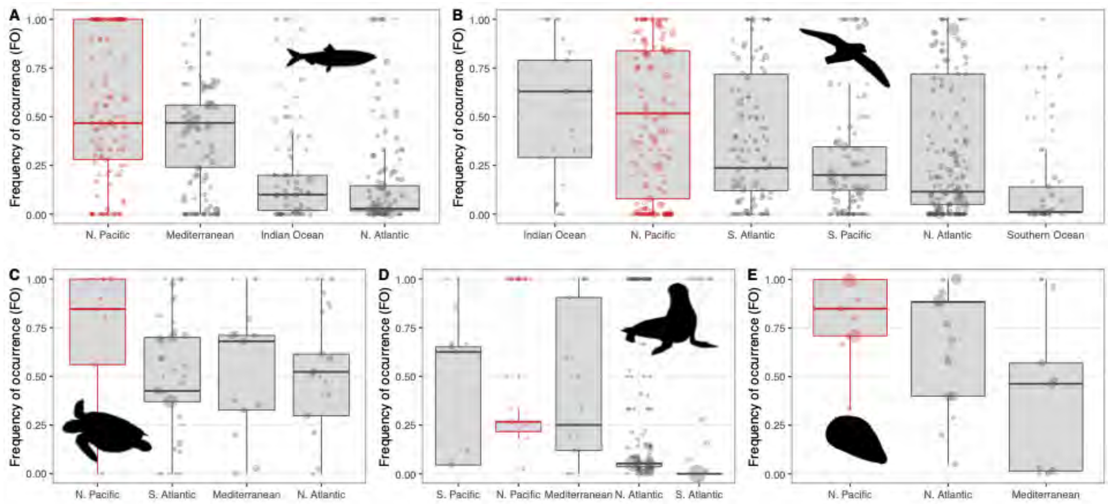

Fig. 1 Frequency of occurrence of plastic ingestion across taxa. A) fishes, B) seabirds, C) sea turtles, D) marine mammals, E) bivalves. The NP is highlighted with red-outlined boxplots, all other regions are in gray. (from Savoca, et al., 2022, Environmental Pollution, 310:119861)

Next, we evaluated 352 species to assess their suitability as bio-indicators of plastic pollution in the NP region and developed a rubric to evaluate the potential use of some species as bio-indicators in the NP. The rubric takes into account 7 main categories including prior sampling, plastic occurrence frequency in the PICES region, species distribution in the PICES region, species distribution globally, threat to humans, residency in the PICES region, and whether or not the species has previously been used as a bio-indicator. Scoring subcategories were listed under each category. A total of 4 points were allocated to each category and each species was scored according to the subcategories. Based on the outcome of the rubric scoring, we proposed a suite of 12 candidate indicator species to monitor NP trends in plastic pollution. These species include invertebrates, fishes, sea turtles and seabirds. For invertebrates, mussel (*M. edulis*), oyster (*C. gigas*) and clam (*V. phillipinarum*) score high. For fishes, long-nosed lancetfish (*A. ferox*), common dolphinfish (*C. hippurus*), and anchovy (*Engraulis spp.*) are among the top bio-indicators. Sea turtles, such as loggerhead sea turtle (*C. caretta*) and green sea turtle (*C. mydas*), and seabirds, such as northern fulmar (*F. glacialis*), Leach's storm-petrel (*O. leucorhoa*), and Laysan and black-footed albatross (*Phoebastria spp.*) are also good bio-indicators. These species can indicate various ecosystem components and cover a wide range of plastic sizes.

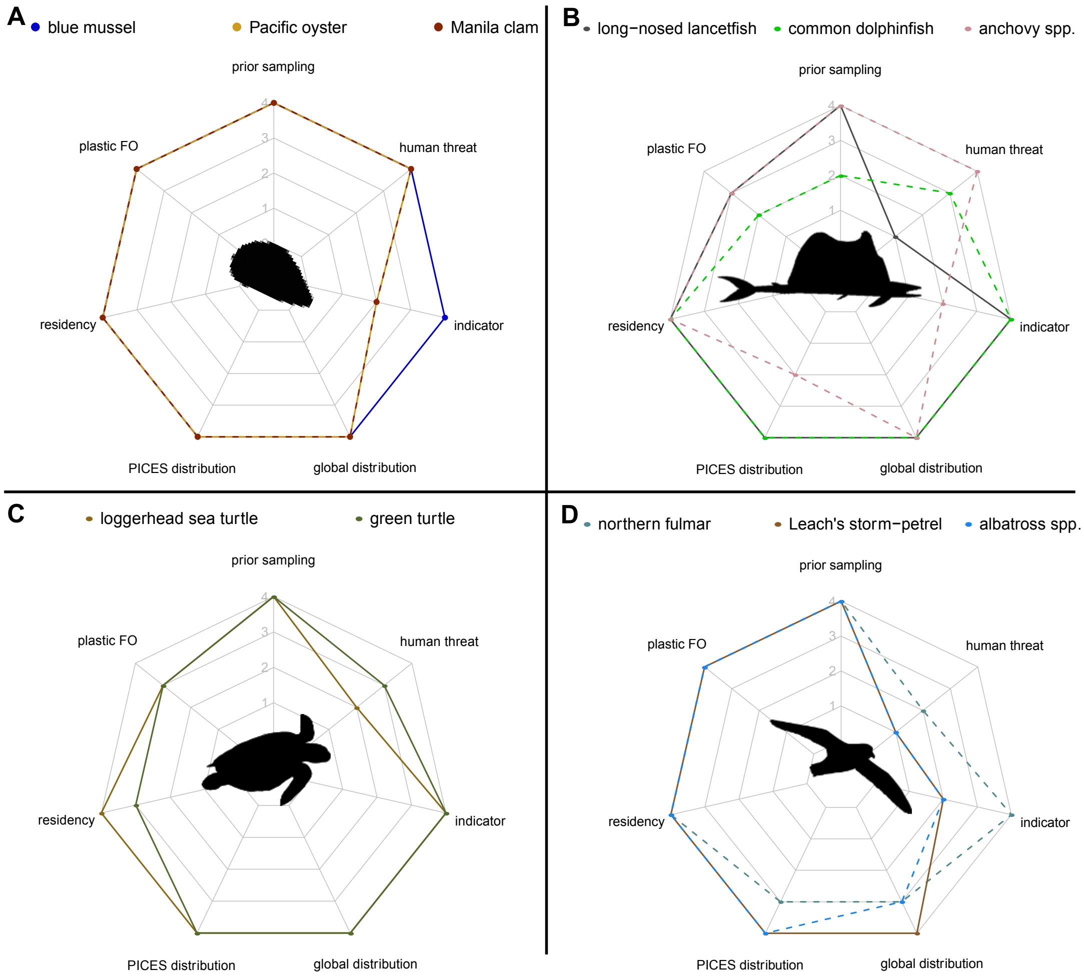

Fig. 2 Bioindicator rubric for top-scoring species by taxa. (from Savoca, et al., 2022, Environmental Pollution, 310:119861)

Finally, we proposed a monitoring strategy for the selected bio-indicators by identifying monitoring goals, proposing harmonized sampling methods with standardized reporting format, and defining ingestion targets (i.e., EcoQO threshold). Our findings and recommendations can help research scientists and resource managers to further coordinate the regional and global research efforts on plastic ingestion bio-indicators. For detailed information, please refer to the attached paper: Savoca, M.S., Kühn, S., Sun, C., Avery-Gomm, S., Choy, C.A., Dudas, S., Hong, S.H., Hyrenbach, K.D., Li, T.-H., Ng, C. K., Provencher, J.F., Lynch, J.M. 2022. Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators. Environmental Pollution, 310:119861.

Review and global comparison of seawater plastic pollution in the North Pacific Ocean

Of the 1178 peer-reviewed papers on microplastics in seawater published between 1972 and 2020, we screened 129 papers with reported mean microplastic abundance values and compiled data from these papers for analysis and comparison. We found that the NPO was the most actively monitored region for microplastics and showed comparatively high levels in the global context.

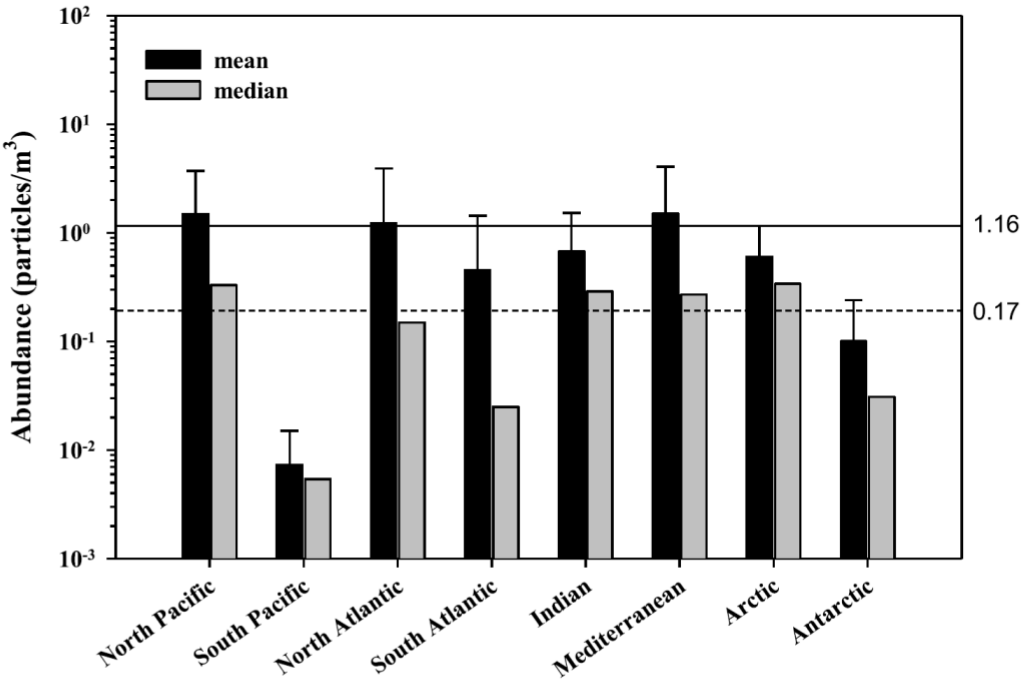

Fig. 3 Average microplastic abundances in global seawater using 300–355 μm mesh sizes. Solid line, average of mean values; Dotted line, average of median values. (from Shim, et al., 2022, Environmental Pollution, 311:119911)

The minimum cut-off size in sampling and/or analysis of microplastics was crucial to the comparison of monitoring data. For regional and global assessments of pollution status across space and time, as well as assessment of ecological risk, we recommend two microplastic monitoring approaches. The first is the net tow method with a mesh size range of 300–355 μm (Tier I) for the long-term monitoring and inter-comparison of surface water, because its large water volume ensures that large-sized microplastic particles (>1 mm) are not missed. The second is large-volume (>100 L) grab or pump sampling (Tier II), which meets the increasing need for the acquisition of small-sized (<300 μm) microplastic abundance data to fully evaluate the ecological risks.

Worth noting is that although microplastic pollution is closely linked with macroplastics, available monitoring data for floating macroplastics and mesoplastics in most oceans are still limited. With the implementation of standardized methods and more specific framework for surveys, increased efforts on floating macroplastics and mesoplastic surveys across the world oceans will facilitate data comparison to gain a complete picture of ocean plastic pollution status. For detailed information, please refer to the attached paper: Shim, W.J., Kim, S.-K., Lee, J., Eo, S., Kim, J.-S., Sun, C. 2022.Toward a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean: Review and global comparison. Environmental Pollution, 311:119911.

Review and recommendations for shorelines plastic pollution in the north Pacific Ocean

Using Web of Science, we conducted a systematic review of literature published between 1970-2020 that reported shoreline debris from countries bordering the NPO. We screened 81 papers that reported shoreline debris density as either a count, mass, or volume of items per specified linear length or area of shoreline, or a count, mass, or volume of items per specified mass of shoreline sediment, or a count, mass, or volume of items per specified volume of shoreline sediment.

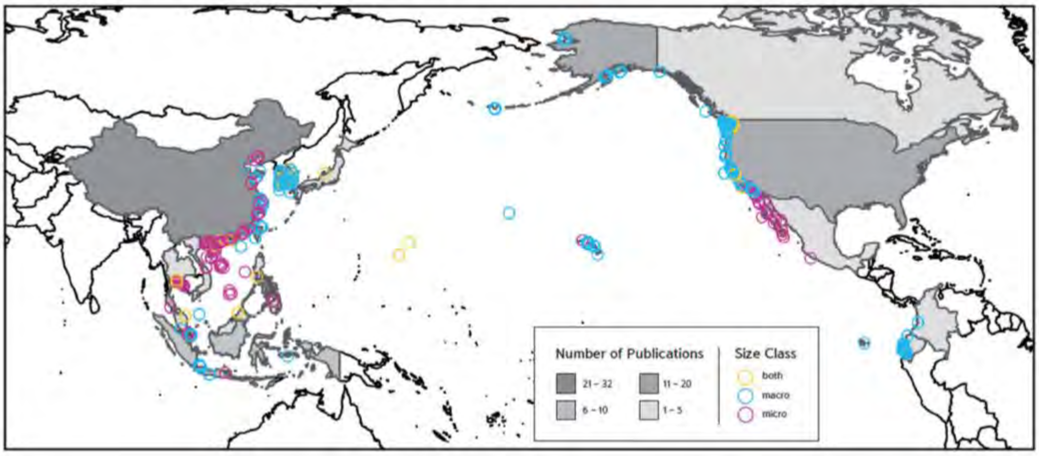

Fig. 4 Summary of 81 studies of shoreline marine debris in the North Pacific Ocean. Countries are gray-shaded (light to dark) based on the number of publications included in the review. (from Uhrin, et al., 2022. Environmental Pollution, 310:119862)

By extracting information from these papers and conducting statistical analysis, we were able to conduct comprehensive statistical analysis on data reporting metrics, sampling methods, sourcing, geographic distribution of macroplastic and geographic distribution of microplastic. We found that, prior to the year 2000, most studies were focused on macroplastics, typically reporting them in terms of item counts per linear meter of shoreline. Around 2008, there was a shift towards more sampling of microplastics.

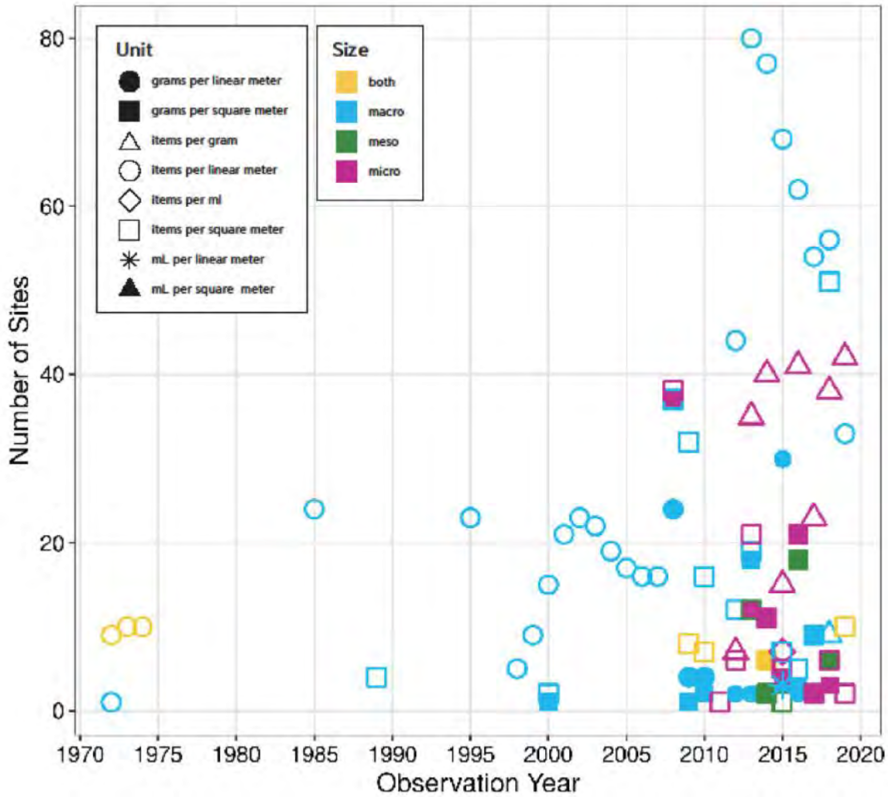

Fig. 5 Reporting of various plastic size classes and units of measurement at 903 sites across the world over time. The year is based on the survey year. (from Uhrin, et al., 2022. Environmental Pollution, 310:119862)

Based on our analysis, we recommend use of a standardized length of shoreline of 100 m and integrating across the width of the beach to allow for reporting debris both as item counts per linear distance (the preferred method) or per area. We also suggest that shoreline surveys focus on all macrodebris (≥2.5 cm). Any threshold value or reduction target for the greater NPO should be informed by basin-wide data collected using comparable methods.

We also need to bear in mind that limited geographic sampling locations, lack of spatial and temporal replication within locations, shortcomings associated with sampling position on a beach, variations in classification of target debris (size classes, material type), and difference in units of measure (counts or mass per unit area or length of shoreline) might have limited the representation of current data. For detailed information, please refer to the attached paper: Uhrin, A.V., Hong, S., Burgess, H.K., Lim, S., Dettloff, K. 2022. Towards a North Pacific long-term monitoring program for ocean plastic pollution: A systematic review and recommendations for shorelines. 2022. Environmental Pollution, 310:119862.

2. *To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas*.

We have identified multiple organismal and non-organismal indicators of plastic pollution, as published in the peer-reviewed papers: *Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators*. Environmental Pollution, 310:119861; *Towards a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean: Review and global comparison*. Environmental Pollution, 311:119911; and *Towards a North Pacific long-term monitoring program for ocean plastic pollution: A systematic review and recommendations for shorelines*. Environmental Pollution, 310:119862. There was very limited information on plastic pollution associated chemicals in the North Pacific and its marginal seas. Therefore, the topic of plastic associated chemicals was not the focus of our work and remains important for future groups to investigate.

3. *To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators*.

We designed a rubric to evaluate species for use as plastic pollution bioindicators, as shown in Fig.1. We consider accessibility as a top priority because no monitoring can be practically conducted without it. We also integrated plastic pollution indicator criteria from GESAMP into our complete rubric to make it comprehensive. Recent research on Alaska Pollock shows that other parameters, such as age of the species, should be considered when selecting bioindicator species (Ding, et al., 2023). Further research on selecting the most appropriate bioindicator species is therefore needed.

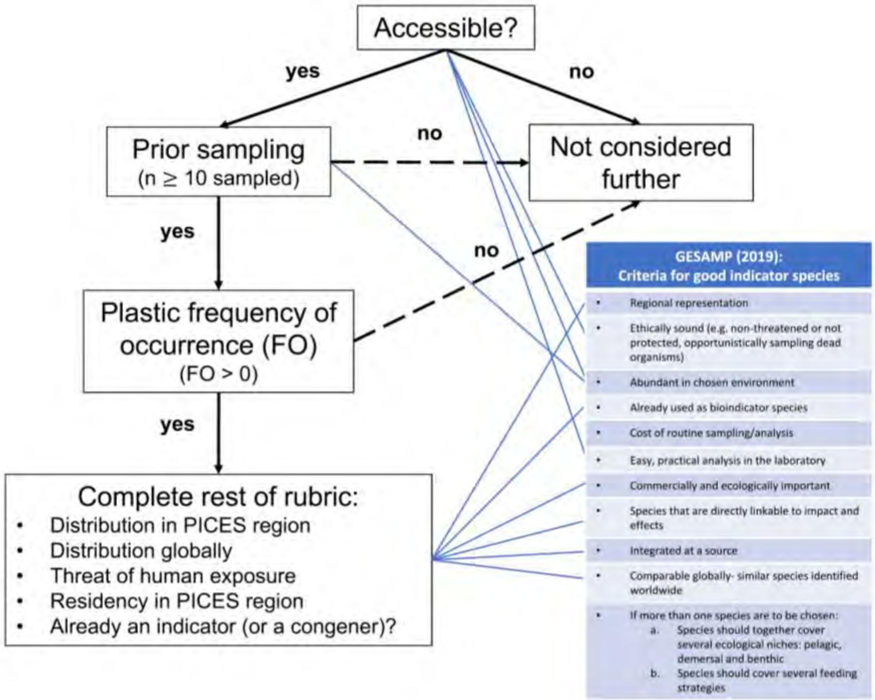

Fig. 6 Flowchart of the rubric evaluation process. (Savoca, et al., 2022, Environmental Pollution, 310:119861)

We evaluated 352 species for their potential to serve as bioindicators of plastic pollution in the NPO. Based on the rubric above, our analysis revealed a suite of 12 species representing a variety of ecosystems and covering a wide range of plastic size classes, making them strong bioindicator candidates. These results help to lay the foundations for developing a comprehensive plastic monitoring program in the NPO.

Category	Score	Description
Prior sampling conducted in the PICES Region	1	0 to 10 individuals sampled (not considered further)
	2	11 to 50 individuals sampled
	3	51 to 100 individuals sampled
	4	>100 individuals sampled
Plastic frequency of occurrence in the PICES region	1	0 (not further considered)
	2	0.01 to 0.24
	3	0.25 to 0.49
	4	≥0.5
Species distribution in PICES region	1	<24% coverage
	2	25–49% coverage
	3	50–74% coverage
	4	≥75% coverage
Species distribution globally	1	found only in PICES region, and no similar species found elsewhere
	2	only found in North Pacific, and few similar species found elsewhere
	3	only found in North Pacific, but many similar species found elsewhere
	4	globally distributed/cosmopolitan
Threat of human exposure	1	not eaten
	2	minor food source
	3	regularly consumed in parts (e.g. fish filets)
	4	regularly consumed whole (e.g. bivalves)
Residency in the PICES region	2	non-resident (migrant)
	4	resident
Is it (or a congener) an indicator (in PICES region or elsewhere)?	2	No
	4	Yes

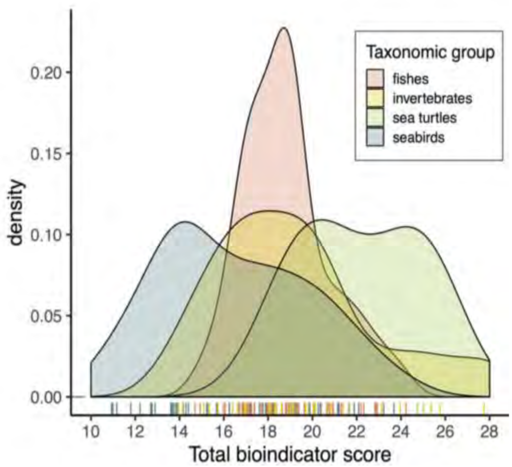

Fig. 7 Rubric for species evaluation as bioindicators and bioindicator scores for different taxonomic groups. (Savoca, et al., 2022, Environmental Pollution, 310:119861)

For seawater plastic pollution monitoring, we recommend two approaches. Tier I is the net tow method with a mesh size range of 300–355 μm for long-term monitoring, because it can catch large-sized microplastic particles (>1 mm). Tier II is the grab or pump sampling method which can fulfill the goal of catching small-sized (<300 μm) microplastic.

For shoreline plastic pollution monitoring, we recommend spatially-balanced survey design, a spatial resolution of 100 m length of beach, multi-year sampling over a minimum of 5 years, replicate samples and analyze all macrodebris on all beaches, at a temporal resolution to be determined. Reported variables should include precise GPS coordinates of the sample locations, time of sampling, sampling site characteristics, depth of sampling, debris size category and the limit of detection, sampling handling, polymer identification for microplastic, and etc.

4. To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal.

WG 42 members Matthew Savoca and Chengjun Sun along with Lev Neretin from NOWPAP convened the session "Environmental Indicators of Plastic Pollution in the North Pacific" at PICES-2019 on October 24, 2019.

WG 42 members Chengjun Sun, Sanghee Hong, and Matthew Savoca proposed a session for PICES 2020 called, "Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific," but the meeting was postponed because of the COVID-19 pandemic. The session took place virtually on October 27, 2021 at PICES-2021.

On September 6, 2021, a jointly convened session on *Advances and Challenges in Marine Litter Pollution* between ICES and PICES was successfully held online during the 2021 ICES annual meeting. WG 42 member Chengjun Sun was the co-convenor, together with Thomas Maes, Francois Galgani, and Andy Booth.

On September 20, 2022 WG 42 members Wonjoon Shim (on-site) and Chengjun Sun (Virtual) successfully convened the session on "Behavior and Fate of Nano- and Microplastics in the Atmosphere and Ocean" during the 7th International Marine

Debris Conference (7IMDC) held in Busan, Korea. Jennifer Lynch (on-site) also convened the session "Chemistry to understand quantities, sources, transport, fate, impacts, and solutions" at 7IMDC.

The intent of the companion review papers was to create a virtual special issue. While we did not accomplish this goal, three review papers were published independently and stand together as a key resource and product from WG 42.

5. Contribute to FUTURE by publishing a final report summarizing results of the Working

It is our hope that this final report summarizes the results of WG 42 for FUTURE.

Conclusions and Future Plans

Working Group 42 was established to identify bio-indicators for different size scales of marine plastic and advance our understanding of plastic pollution in the NPO. We evaluated 352 species for their potential to serve as bio-indicators of plastic pollution in the NPO using a framework developed by us, and identified 12 bioindicator species candidates which represent different ecosystem components and cover a wide plastic size range. Tracking plastic ingestion by these bioindicators will help to assess the plastic pollution status and changing trends in the region.

Other results coming out of WG 42's work has demonstrated that the NPO has unusually high marine plastic abundance and diversity both in the ocean water and on shorelines. However, the lack of standardization with regard to marine plastic and microplastic sampling metrics, indicator species, sample handling protocol and analytical methods, and target goals have made cross comparison very difficult. Therefore, in the published papers, we proposed a series of guidelines for temporal and spatial monitoring of plastic pollution status and assessment of ecological risks. These standardized methods and more real time monitoring data will significantly increase our understanding of marine plastic pollution.

COVID-19 greatly hindered more effective collaboration among member countries and with other countries. The requirement of virtual meetings only limited on-site investigation and hands on training. In spite of this difficulty, we have convened joint topic sessions with ICES and AMAP. Members have actively participated in the International Marine Debris Conference Research and PICES annual meetings. We are hopeful that more collaboration can be carried out from now on.

We recommend that future work should include studies on implementing a long-term marine plastic and microplastic monitoring program in the NPO by implementing the guidelines we have recommended. A follow-up Advisory Panel or Section under PICES on plastic and microplastic bioindicators has been proposed. Continuous research on relevant topics will greatly help to improve ocean health and benefit the United Nations Sustainable Development Goals (SDG) of the world ocean. Close collaboration with the newly adopted Ocean Decade Global Plastic

Bioindicators Project is also recommended to further improve our understanding of marine plastic pollution and employing counter measures to mitigate the problem.

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Savoca, M.S., Kühn, S., Sun, C., Avery-Gomm, S., Choy, C.A., Dudas, S., Hong, S.H., Hyrenbach, K.D., Li, T.-H., Ng, C. K., Provencher, J.F., Lynch, J.M. 2022. Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators. Environmental Pollution, 310:119861.

Shim, W.J., Hong, S.H., Eo, S., 2018. Marine microplastic: abundance, distribution, and composition. In: Zeng, Y. (Ed.), Microplastic Contamination in Aquatic Environments: an Emerging Matter of Environmental Urgency. Elsevier, pp. 1–26.

Shim, W.J., Kim, S.-K., Lee, J., Eo, S., Kim, J.-S., Sun, C. 2022.Toward a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean: Review and global comparison. Environmental Pollution, 311:119911.

Uhrin, A.V., Hong, S., Burgess, H.K., Lim, S., Dettloff, K. 2022. Towards a North Pacific long-term monitoring program for ocean plastic pollution: A systematic review and recommendations for shorelines. 2022. Environmental Pollution, 310:119862.

Appendix 1 WG 42 Terms of Reference

WG 42 term: 2018–2022
Extended 1 year to 2023
Parent Committee: MEQ

1. To review pollution (e.g. abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas;
2. To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas;
3. To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators;
4. To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal;
5. Contribute to FUTURE by publishing a final report summarizing results of the Working

Appendix 2 WG 42 PICES Membership

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Appendix 3 Peer-Reviewed Publications by WG 42

1. **Savoca, M.S.**, **Kühn, S.**, **Sun, C.**, Avery-Gomm, S., Choy, C.A., **Dudas, S.**, **Hong, S.H.**, Hyrenbach, K.D., Li, T.-H., **Ng, C. K.**, **Provencher, J.F.**, **Lynch, J.M.** 2022. Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators. *Environmental Pollution*, 310:119861.

2. **Shim, W.J.**, **Kim, S.-K.**, Lee, J., Eo, S., Kim, J.-S., **Sun, C.** 2022.Toward a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean: Review and global comparison. *Environmental Pollution*, 311:119911.

3. **Uhrin, A.V.**, Hong, S., Burgess, H.K., Lim, S., Dettloff, K. 2022. Towards a North Pacific long-term monitoring program for ocean plastic pollution: A systematic review and recommendations for shorelines. 2022. *Environmental Pollution*, 310:119862.

Appendix 4 Relevant Presentations by WG 42 Members

PICES-2022, Busan, Korea

- New insights into microplastic ingested by the walleye pollock from the Bering Sea
  Sun C.
- Microplastic pollution in Monterey Bay: from water to whales
  Savoca M.S.
- Litter and microplastics monitoring in the Arctic under the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) and links with PICES
  Provencher, J.F., Farmen, E., and Jan Rene Larsen, J.R.

PICES 2021, Virtual

- Using shellfish as potential microplastic pollution indicator
  Sun, C., Ding, J., Li, J., Ju, P., Jiang, F.
- Litter and microplastics monitoring in the Arctic under the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP)
  Provencher, J., Farmen, E., Larsen, J. R.
- Evaluating species as bioindicators for plastic pollution in North Pacific food webs
  Savoca, M.S., Kühn, S., **Sun, C.**, Avery-Gomm, S., Choy, A., **Dudas, S.**, **Hong, S.H.**, Hyrenbach, D., Li, T.-H., Ng, C., **Provencher, J.**, **Lynch, J.**
- Ecological risk assessment of waterborne microplastic particles in the marine environments of Korea
  Shim, W.J., Jung, J.-W., Park, J.-W., Eo, S., Choi, J., Song, Y. K., Cho, Y., **Hong, S.H.**

7IMDC, 2022, Busan, Korea

- Guidelines to monitor plastic pollution and set science-based reduction goals in the North Pacific Ocean
  Lynch, J.M., **Sun, C.**, **Shim, W.J.**, **Uhrin, A.V.**, **Tanaka, S.**, **Savoca, M.S.**
- Harmonized Protocols and Indicator Selection towards Future Microplastic Monitoring
  Sun C.
- Progress Toward Meaningful Monitoring: Confronting the Challenges of Survey Design and Reporting (Technical Session 1.2 - The Future of the Science of Monitoring)
  Uhrin AV, **Hong S**, Burgess H, Lim S, Dettloff K.
- Enhanced Detection and Characterization of Shoreline Marine Debris Using Polarimetric Imagery (Technical Session 3.5 - Satellite and Airborne Remote Sensing of Marine and Coastal Litter)
  Herrera K, Battista T, **Uhrin AV**, Murphy P, Parrish C.

- Marine Debris Removal in the Context of Natural Resource Damage Assessment in the United States (Technical Session 8.14 - Untangling: Innovative Solutions for Species Protection)
  Uhrin AV, Wessel C, Steinhoff M.

International Symposium on Plastics in the Arctic and Sub-Arctic Region, March, 2021, Virtual

- Arctic Monitoring and Assessment Programme's (AMAP) use of the northern fulmar (*Fulmarus glacialis*) as a biomonitor of plastic
  Provencher J.

Session: TS-2.4 Behavior and Fate of Nano- and Microplastics in the Atmosphere and Ocean

Chair: **Wonjoon Shim** (on-site) and **Chengjun Sun** (Virtual)

7IMDC, Sept. 20th, 2022, Busan

Appendix 5 Meeting Report and Topic Session/Workshop Summaries from Past Annual Meetings

2022 PICES Annual Meeting

Virtual
Mon September 12 6-8pm Washington, DC
Mon September 12 noon-2pm Honolulu
Tues September 13 7-9 am Tokyo
Working Group: Indicators of Marine Plastic Pollution (WG-42)

1. Welcome and adoption of agenda (chairs)
2. Achievements of WG-42 (chairs)
   a) Sea surface and water column – Wonjoon Shim
   b) Shoreline – Amy Uhrin
   c) Biota ingestion – Matthew Savoca
   d) 7IMDC presentations
   e) Submitted annual report
   f) Others?

3. Review article updates and discussion (leads)
   a) Sediment and seafloor – Shuhei Tanaka
   b) Overview of all 4, Final report to PICES – Jennifer Lynch

4. Discuss plan for Virtual special issue proposal to *Environmental Pollution*
5. Discuss the imminent expiration and potential future of WG-42
   a) Did you get my email from
   b) Update on the proposal submitted to UN Ocean Decade (Matt Savoca)
   c) Sanae Chiba Sanae.Chiba@pices.int "PICES needs to have a WG on Marine Debris/Plastics. Please take some time to discuss the development of ideas for a new EG and submit the proposal at ISB-2023 or PICES 2023."
   d) gsna2010@163.com "WG 42 will be expired next month please reconsider whether to start a new Expert group(study/working group) about marine debris(including plastic and microplastic) this year. Not only PICES even UN

are very concern about these new pollutants. MEQ strongly suggest and support a new Expert group(study/working group) on marine debris if the proposal could be submitted before deadline."

6. PICES financial request

    a) Open access fees for overview paper

7. Other business (All)

    a) PICES MEQ Business Meeting which is due to take place on Sunday, September 25th (Day 1) and Wednesday, September 28th (Day 2) in Busan, Korea

    b) Postponed: ICES-PICES Joint Science Conference Seattle Oct 23-27, 2023 - ICES Working Group on Marine Litter requests that PICES WG42 submits a joint session at the hybrid event (Amy Uhrin)

2021 PICES Annual Meeting

Virtual

September 22 (12:00-15:00 Hawaii time)

Working Group: Indicators of Marine Plastic Pollution (WG-42)

8. Welcome and adoption of agenda (chairs)
9. Achievements of WG-42 (chairs)
10. Review of WG-42 Terms of Reference and Review article timeline (chairs)
11. Review article updates (leads)

    a) Sea surface and water column – Wonjoon Shim
    b) Shoreline – Amy Uhrin
    c) Sediment and seafloor – Shuhei Tanaka
    d) Biota ingestion – Matthew Savoca
    e) Biota entanglement – Jennifer Lynch

12. Discuss recommended indicators and target improvement goals
13. Discuss plan for review article submission to *Environmental Pollution*
    a) Virtual special issue?
14. Announce 2021 topic session
15. Final report of WG-42 is due to PICES
16. Define future of WG-42
    a) Advisory Panels or Section?
    b) Term of Reference
    c) Chair(s)
17. PICES financial request
    a) Open access fees for one paper – which one?
    b) Conference travel/registrations
        i. PacifiChem
        ii. Ocean Sciences Meeting
        iii. Others

18. Other business (All)

2019 PICES Annual Meeting

Victoria, Canada

October 20 (09:00-18:00)

Working Group: Indicators of Marine Plastic Pollution (WG-42)

October 20, 2019

[09:00 – 12:30] Morning session

1. Welcome and adoption of agenda (chairs)

Welcome members, and introduce the agenda for WG-42 business meeting

2. Presentation of final product from SG-MMP mini-review on microplastic contamination in North Pacific (**Wonjoon Shim**)
3. Introduction of WG-42 mission and ToR (chairs)

Introduce and share background, mission, terms of reference (ToR)

4. Introduction of parent committee, Marine Environmental Quality (MEQ) (**Guangshui NA**)
5. Achievement of WG-42 (chairs)

Summarize the main achievements of WG-42

6. Discuss our ToR, decide if we agree with this as our mission, prioritize tasks and discuss first steps
   - To review micro- and mesoplastic pollution (e.g. abundance, distribution, composition, and potential impacts) in North Pacific and its marginal seas;
   - To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas;
   - To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators (**11:00am Francois Galgani Skype overview of European Union Marine Strategy Framework Directive Good Environmental Status**);
   - To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal (**Matthew Savoca introduce program for the Oct 24 "Environmental indicators of plastic pollution in the North Pacific" session**);
   - Contribute to FUTURE by publishing a final report summarizing results of the Working Group deliberations. (**12:15pm Dr. Horii from FUTURE**)

[12:30 – 14:00] Lunch

[14:00 – 18:00] Afternoon session

7. Implement first steps for priority ToR tasks in breakout groups or together as one big group
   a) To review micro- and mesoplastic pollution (e.g. abundance, distribution, composition, and potential impacts) in North Pacific and its marginal seas; (***discuss next steps – journal selection, need to expand or focus the mini-review, divide up remaining writing tasks***)
   b) To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas; (***create a list of indicators and discuss what we can do with this list***)
   c) To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators; (***discuss pros, cons, and what can be done in the North Pacific***)
   d) To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal; (***1. prepare proposal for PICES 2020 session and decide on chairs (***https://meetings.pices.int/meetings/annual/2020/PICES/scope)***, 2. discuss 2021 PICES meeting, 3. discuss whether an additional workshop is needed, 4. Discuss the idea of a special issue in a journal, which journal, and chairs***)
   e) Contribute to FUTURE by publishing a final report summarizing results of the Working Group deliberations.
8. Discuss adding additional members and chairs to WG-42
9. Schedule future phone/on-line meetings and activities before PICES 2020
10. review of the PICES Data Inventory
11. Other business (All)

Please send comments and recommendations to: Jennifer.lynch@noaa.gov

WG 42 Group meeting (online)

<u>Aug 22, 2023</u>

- Attendees: Miran Kim, Jennifer Lynch, Connie Ng, Matt Savoca, Wonjoon Shim, Amy Uhrin

- Review of achievements
  - Sediment paper update was not available
  - Summary paper update - there are benefits to writing it, but it is not necessary. Perhaps the next group could take this up. Jenn Lynch does not have the time to finish it.
  - Presentations given at the 7th International Marine Debris Conference in Busan, South Korea in September 2022 from the ToR of this working group
    - Uhrin AV, Hong S, Burgess H, Lim S, Dettloff K. Progress Toward Meaningful Monitoring: Confronting the Challenges of Survey Design and Reporting (Technical Session 1.2 - The Future of the Science of Monitoring)
    - Lynch, Sun, Shim, Uhrin, Tanaka, Savoca. Guidelines to monitor plastic pollution and set science-based reduction goals in the North Pacific Ocean
- Discussed a request to MEQ for a new Expert Group

    - Matt Savoca and Amy Uhrin will ask Andrew Ross, the Vice Chair of MEQ, and cc Sanae Chiba, about the process to formalize an Expert Group on plastic pollution. They types of groups include
        - Section (longer term 5+years, more difficult to create)
        - Advisory Panel (easier to create because not all nations must be members)
        - Joint working group with ICES
    - Matt is willing to chair the group. Amy may consider co-chair if the group is joint with ICES, Matt needs help, and two chairs can come from US.
- Discussed proposing a session or workshop for PICES-2024
    - https://meetings.pices.int/meetings#pices-2024
    - The submission deadline is September 22
    - Without knowing the location and dates of the conference, it is too uncertain for us to decide.
    - Without an official Expert Group formed, it is too soon.
- Open discussion
    - Matt Savoca received a marine debris grant from California Sea Grant and OPC - Watershed to Whales, in Monterrey
    - Matt Savoca announced that the UN bioindicators group was approved and is undertaking a review of monitoring programs globally for bioindicators of plastic pollution.
    - Jenn Lynch received a NOAA Sea Grant grant to scale up removal and recycling of marine debris across the Hawaiian Archipelago
    - Amy Uhrin announced that the NOAA Marine Debris Program is sponsoring a working group through the National Center for Environmental Synthesis to tackle the social costs of plastic pollution in the US. The working group will lay the groundwork for determining a robust and scientifically-grounded approach for estimating the dollar value of avoided plastic pollution emissions would allow agencies to understand the benefits of reducing plastic pollution emissions or the social cost of increasing such emissions. The project will also support a post-doc.
    - In addition, the NOAA Marine Debris Program, in collaboration with Western EcoSystems Technology, Inc., is finalizing a spatially-balanced survey design for conducting shoreline monitoring across 10 US regions using the Program's established on-site protocol

(MDMAP). The goal is to contract out the field surveys to begin in 2024, budget pending.

- Wonjoon Shim reported that funding for microplastic research has been cut due to a new Korean President.
- Connie Ng reported that environmental organizations such as World Wildlife Fund has run programs on marine debris removal in Hong Kong.