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PICES Science in 2024: Notes from the Science Board Chair

Sukyung Kang

According to the World Meteorological Organization (WMO), the year 2024 is on track to be the warmest year on record following an extended streak of exceptionally high monthly global mean temperatures. Today, we are in an urgent situation to find solutions to diverse and profound challenges, including the climate crisis. At this point, the PICES-2024 Annual Meeting was held at the Hawaii Convention Center, a premier state-of-the-art facility located in Honolulu, USA, from October 28 to November 1, for the first time in 20 years. This year's Annual Meeting was very special in many other ways. It was the first PICES Annual Meeting to be organized solely by the Secretariat without a host country. I would like to express my sincere appreciation to the Secretariat for their hard work and impeccable preparation. The structure of this year's meeting was different from previous years. We held a FUTURE symposium on Monday instead of a Science Board symposium and organized a Special Panel on Friday instead of the usual committee paper session. This change was made to explore the scientific progress already achieved and to guide our efforts in identifying gaps and setting priorities for future research.

I am confident that all participants would agree that it was a truly unforgettable meeting, both scientifically and scenically. We engaged participants in cutting-edge research and collaboration through workshops, sessions, and poster presentations. It is clear to me that our PICES scientific community is thriving, with strong friendships, fruitful collaborations among scientists, and research that is dynamic, at the forefront, and highly regarded.

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Let's recap PICES-2024 by the numbers. In total, PICES-2024 welcomed 549 attendees from 23 countries. These attendees included 214 in-person Early Career Ocean Professionals (ECOPs), making up 39 % of attendees, along with observers from 16 international and regional organizations and programs. There was a FUTURE symposium, 12 topic sessions, 9 workshops, 5 contributed paper poster sessions and 5 other events. The Whova app, which we have been using since last year, was widely used, with 88 % of attendees using it for meeting management and networking.

The Annual Meeting gives PICES an opportunity to recognize individuals and groups who have made significant contributions to our organization. The PICES Chair Award was given to Dr. Mike Seki (USA) for his long and dedicated involvement with PICES since the early 2000s. The Wooster Award was presented to Prof. Shin-ichi Ito (Japan) for his high level of expertise, broad understanding of marine science, and sincere and fair attitude. The Zhu-Peterson Early Career Scientist Award was presented to Mr. Raphaël Kevin Roman (Canada), a co-chair of the Advisory Panel on Early Career Ocean Professionals (AP-ECOP) and an active member of the Advisory Panel on the United Nations Decade of Ocean Science (AP-UNDOS) and Working Group on Exploring Human Networks to Power Sustainability. Finally, the PICES Ocean Monitoring Service Award (POMA) was given to the EC1 Program at Seoul National University (Korea). EC1 is a moored observational program that has consistently collected long and continuous time-series data in adjacent waters to Korea since 1996. The participants at the Opening Session were in a celebratory mood, praising the achievements of these three individuals and one group with long-lasting applause (More details of the award recipients are presented in the following article).

Highlights of Annual Meeting

PICES-2024 covered many relevant marine science issues under the theme "The Future of PICES: Science for Sustainability in 2030". The keywords that ran through the Annual Meeting were "actionable" and "communication".

Before the annual meeting the Study Group on Generating Recommendations to Encourage Environmentally-Responsible Networking (SG-GREEN) organized a beach clean-up with the Waikiki Aquarium. The event aimed to foster collaboration in creating the "Ocean We Want", aligning with PICES' commitment to environmental stewardship. This activity engaging with local organizations offered opportunities to contribute to the preservation of local natural beauty and marine ecosystems.

Waikīkī Beach Clean up at PICES 2024 organized by PICES SG-GREEN and the Waikiki Aquarium.

The Basin-scale Events to Coastal Impacts (BECI), a UN Ocean Decade project led by the PICES and North Pacific Anadromous Fish Commission (NPAFC), held a special workshop to enhance regional marine ecosystem modelling in a changing climate. FUTURE/SmartNet had a topic workshop on exploring international knowledge co-production and the science-policy interface to explore how international organizations/programs are working to bridge the science-policy interface. The workshop underscored the importance of co-production in addressing sustainability challenges and proposed actionable steps to enhance PICES's contributions to the science-policy interface.

The Science Board (SB) symposium, traditionally held on Monday, was replaced by the FUTURE symposium. The FUTURE symposium was led by two co-chairs, Drs. Steven Bograd and Hanna Na. FUTURE celebrated what it brought to PICES and the North Pacific marine science community during Phase II of the program and assessed the strengths, weaknesses, accomplishments, and gaps. Panel discussions paved the path forward for PICES science.

Other topic sessions held this year focused on climate extremes and coastal impacts, the observational frontier for understanding oceans and ecosystems, the changing ocean carbon cycle, plastic pollution research, non-indigenous species, impacts of warming on fish growth, harmful algal blooms, and more. Also, we had a session to review the past, present and future of the Circulation Research of East Asian Marginal Seas (CREAMS) program.

FUTURE Symposium presentations and panel discussion.

One of most important activities at PICES-2024 was to hold a "Special Panel" to discuss the PICES External Review Report. The objective of the external report was to ensure that PICES is evolving in line with global marine science priorities and to get input on what changes could be made to make PICES more relevant, as it has been 30 years since much of our infrastructure was put in place. The report was released to the PICES scientists last summer. During the panel the chair of the external review committee, Prof. Eileen E. Hofmann, presented summary recommendations and identified five high-priority areas (role, organizational structure, integrative science program, administration, and capacity development) that are considered essential to PICES future. After that, Dr. Erin Satterthwaite shared the workshop results on PICES knowledge co-production at the science-policy interface followed by Prof. Hanna Na delivering the FUTURE symposium outcomes. Prof. Enrique Curchitser, PICES Chair, discussed the next steps in PICES looking forward. Finally, Dr. Ian Perry moderated a panel discussion featuring members of the PICES community and representatives from external stakeholder groups. This was a very important and spirited discussion on the future of PICES which provided a positive atmosphere to end the week. The newly formed Study Group on External Review Report Response under GC and Science Board will revisit and discuss this further.

Special Panel discussing the PICES External Review Report.

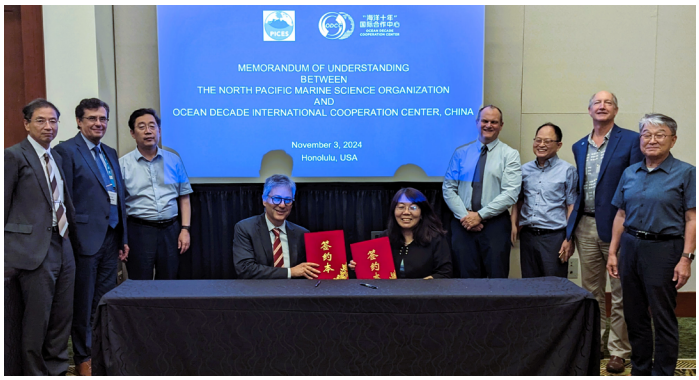
A Halloween-themed poster session added a creative and festive element to the meeting. Halloween costume competition winners were celebrated in various categories, including "Ocean," "Scary," and "Wacky." During the meeting, all attendees enjoyed oral and poster presentations and lively discussions.

Halloween poster session.

Expanding Strategic Collaborations

PICES has many strategic partners to advance its mission of promoting and coordinating marine scientific research and addressing challenges in the North Pacific. These partnerships are critical for achieving global, regional, and local environmental goals. The North Pacific Fisheries Commission (NPFC) is one of them. PICES and NPFC have developed a five-year framework to strengthen cooperation between the two organizations for the period 2019-2024. This framework was updated this year to reflect changes in both organizations and to outline priorities for collaboration from 2025-2029. During the 2024 revision some cross-cutting areas (e.g., climate change) were incorporated into the three previous high-priority areas: support for stock assessment for priority species, vulnerable marine ecosystems, and the ecosystem approach to fisheries.

The UN Decade of Ocean Science holds significant importance as it aligns closely with PICES' mission to advance marine science, foster international collaboration, and address pressing ocean-related challenges. Sustainability of Marine Ecosystems through global knowledge Networks (SmartNet) is a joint PICES and ICES program endorsed by the UN Decade. With the increase in the number of UNDOS activities and the growing size of the community, the need for a SmartNet coordinator has emerged. PICES and the Ocean Decade International Cooperation Center, China (ODCC) signed a memorandum of understanding to facilitate cooperation between PICES and ODCC with a view to promote the UN Ocean Decade Initiative. ODCC will arrange for a coordinator to support the SmartNet program. I hope to lift the challenges that SmartNet has faced through this cooperation.



MOU between PICES and ODCC.

Upcoming PICES activities

At PICES-2024, Governing Council agreed to support one new Section on Marine Plastic Pollution (S-MPP). S-MPP will keep 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 (WGML); GESAMP Working Group 40).

During the meeting there were elections for the Science Board Chair. I am happy to announce that Science Board unanimously elected Dr. Jennifer Boldt (Canada) as Chair-elect, which means she will assume my position at the end of my term following PICES-2025. Drs. Fangfang Wan (China) and Jennifer Jackson (Canada) were re-elected as the Vice Chairs of the Technical Committee on Data Exchange (TCODE) and the Physical Oceanography and Climate Committee (POC). I sincerely acknowledge their valuable contributions to their committees and look forward to their future endeavors. At the conclusion of PICES-2024, Prof. Enrique N. Curchitser (USA) completed his term as Chair of PICES. We recognized his strong leadership and contributions to the organization.

Looking ahead in 2025, we have several exciting PICES relevant international symposia. The One Ocean Science Congress (OOSC 2025) will be held in Nice, France from June 4-6, 2025. 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 are set to address respective major ocean-relevant International Treaties. Another international meeting, ESSAS Open Science Meeting, will take place in Tokyo, Japan from June 24-26, 2025. Topics include coastal-ocean interactions, extreme events, marine heat blobs, multi-stressors, biogeochemical cycles, the carbon cycle, biodiversity, marine ecosystems, ocean observation technology, blue carbon, the blue economy, food security, community-based sciences, and co-design of natural and social sciences. Finally, our next Annual Meeting (PICES-2025) will take place in Yokohama, Japan, with the theme "Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems". I look forward to seeing you in Yokohama and/or other venues of PICES-hosted events in 2025.

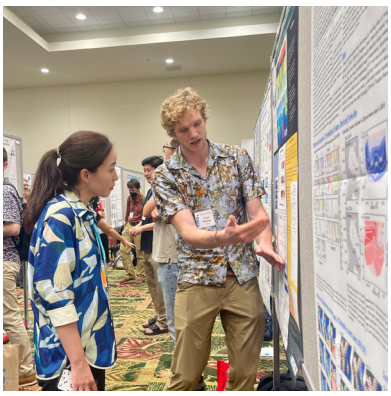
Sukyung Kang
Science Board Chair

PICES-2024

Oct 26 - Nov 1, 2024
Honolulu, USA

The FUTURE of PICES: Science for Sustainability in 2030













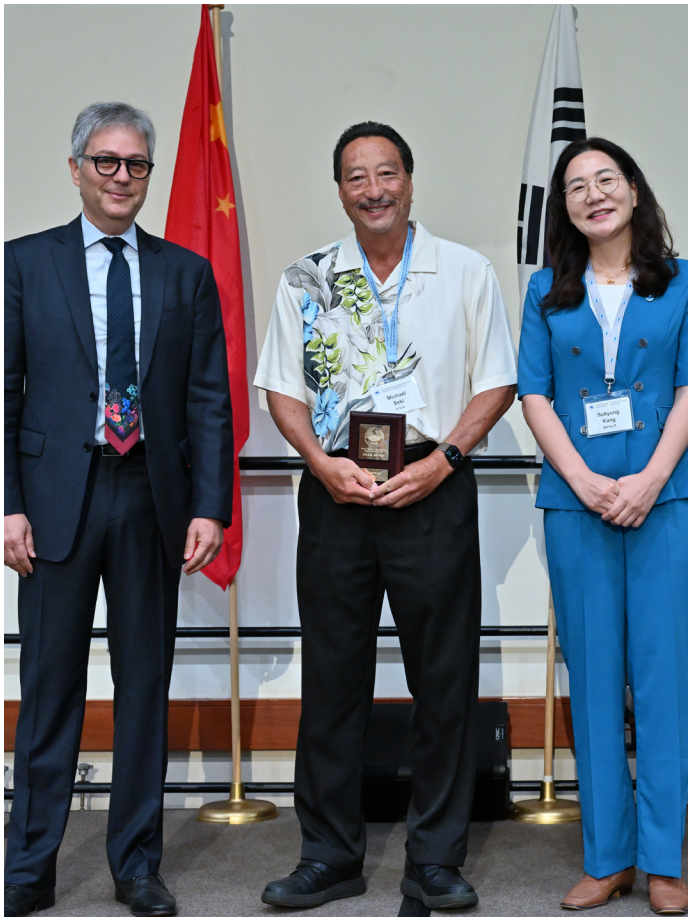
PICES 2024 Award Recipients

PICES Chair Award

The PICES Chair Award was established in 2016. It is given to honor individuals for their sustained contributions to the development of the organization, aligning with the PICES Convention's mission: to promote and coordinate marine scientific research to advance scientific knowledge of the area concerned and of its living resources, and to promote the collection and exchange of information and data related to marine scientific research

PICES-2024 Chair Awardee:

Mike Seki



Mike has had a long and dedicated involvement with PICES since the early 2000's and exemplifies what the Chair Award honours. He has actively participated in expert groups and science activities, served as an invited speaker, and contributed to numerous Annual Meetings.

"Mike is a terrific colleague, always willing to listen and lend his counsel. He immersed himself in PICES activities, both in official sessions and team-building activities at PICES science gatherings and Annual Meetings." - Jack Barth

As a member of several PICES Expert Groups (Advisory Panel on Micronekton Inter-Calibration Experiment, WG14, BIO Committee), Mike contributed his expertise on micronekton (small aquatic organisms that drift in the water column) and played a significant role in planning field programs to evaluate the efficacy of different sampling techniques in the North Pacific. His work, which included three micronekton sampling gear experiments conducted between 2004 and 2007, was summarized in PICES Scientific Report No. 38 (2010).

In the most recent decade, Mike has been an active PICES leader, serving on the Finance and Administration (F&A) Committee from 2014-2023 and chaired the committee from 2020-2023. With his leadership, the Finance and Administration Committee conducted their responsibilities efficiently. His reports to Governing Council were always clear and helpful in reaching consensus, even in challenging circumstances. Mike's final contribution before retiring was sitting as the United States National Delegate to the Governing Council from 2020-2023.

Congratulations Mike!

PICES Wooster Award

In 2000, PICES Governing Council approved the Wooster Award, named in honour of Professor Warren S. Wooster – a principal founder and the first Chairman of PICES, and a world-renowned researcher and statesman in the area of climate variability and fisheries production. The Award selection criteria are sustained excellence in research, teaching, administration or a combination of the three in the area of North Pacific marine science. Special consideration is given to individuals who have worked in integrating the disciplines of marine science, and preference is given to individuals who were or are currently actively involved in PICES activities.

PICES-2024 Wooster Awardee:

Professor Shin-ichi Ito

The recipient of the PICES-2024 Wooster Award is Dr. Shin-ichi Ito, a Professor at the Atmosphere and Ocean Research Institute (AORI) at the University of Tokyo (UTokyo), where he leads the Fisheries Environmental Oceanography group in the Department of Living Marine Resources.

Dr. Ito earned his Ph.D. in 1995 from Hokkaido University and subsequently joined the Tohoku National Fisheries Research Institute (TNFRI) within the Fisheries Research Agency of Japan. During his early career, his main interest was physical oceanographic process in the subarctic North Pacific, especially the Oyashio-Kuroshio Interfrontal Zone.

In 2002, Dr. Ito became Chief Researcher at TNFRI and began significant contributions to PICES as Co-Chair of the MODEL Task Team, under the Climate Change and Carrying Capacity Program (CCCC). With MODEL, he contributed to a lower trophic level model known as NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography), which is a powerful tool to understand ecosystem dynamics and has been utilized in various PICES activities. He also developed NEMURO.FISH, a highlight of the PICES CCCC and FUTURE programs. As a leading scientist of the Japanese A-line monitoring program, Dr. Ito successfully improved the data quality of aggregated coastal marine observation data, and developed a user-friendly platform to visualize ocean status and forecasts. For his development of a sea-temperature prediction method, Dr. Ito was awarded the Honors of Zenkoku Jouchou Kai (Association of the Directors of Prefectural Fisheries Experimental Stations) in 2005. He began his current role at the University of Tokyo in 2014, where he continues to focus on variability in the ocean environment and effects on marine ecosystem resources. He continues to make significant contributions to PICES.

As with all PICES Awardees, the selection of Dr. Ito was kept confidential, aside from the selection committee members, the Secretariate, and nominators, until the Annual Meeting Opening Ceremony. As part of the celebration, friend and colleague, Dr. Hiroaki Saito created and narrated a memorable video telling the story of Dr. Ito's life and accomplishments. Dr. Ito's wife, Hisayo, and three children, Shiori, Takumi, and Wakana, also joined the celebration team and provided heart-warming messages for the video.

NEMURO Mafia

Dr. Ito and his wife, Hisayo

"It has been 40 years since I met you, and I have always respected your attitude to science and your consideration for your colleagues around you. Despite your busy schedule, you make time for our family, which allows us to enjoy our days to the fullest. Thank you! Please take care of yourself and continue to devote yourself to your science." – Hisayo

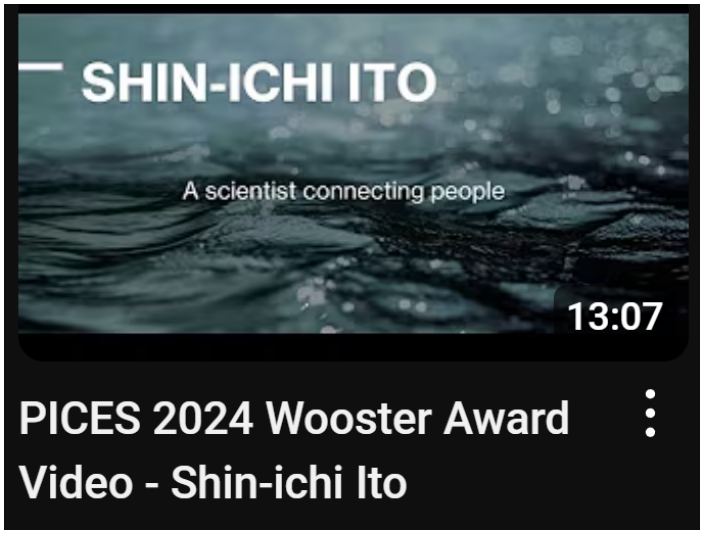
"*Congratulations Dad! I always respect you how hard you work at your job. Thank you so much for helping me in my veggie field even though you are so busy. I love you! Stay healthy and happy!*" – Shiori

"*Congratulations on winning the Wooster Award! I have always respect you for the dedication to work and devotion to our family. Learning about your dream and seeing how you are contributing to the advancement of marine science have inspired me to work hard at my job as well. I am truly grateful that you were so kind to watch over me when I stumbled with difficulty. You always support me. I hope you will be fulfilled in your work and daily life!*" – Takumi

"*Congratulations Dad! In my childhood, I remember seeing ships and interacting with fish with you, which were unusual and fun experiences. It was Dad who got me interested in research, and I always respect your attitude towards the work. Please take care of yourself and enjoy your research!*" – Wakana

In the words of Dr. Hiroki Saito "we can't wait to see his next success in science, education, and scientific contribution to society. Congratulations Shin-ichi!"

Please view Dr. Ito's video by Dr. Hiroaki Saito on PICES YouTube Channel



@PICES_MarineSci

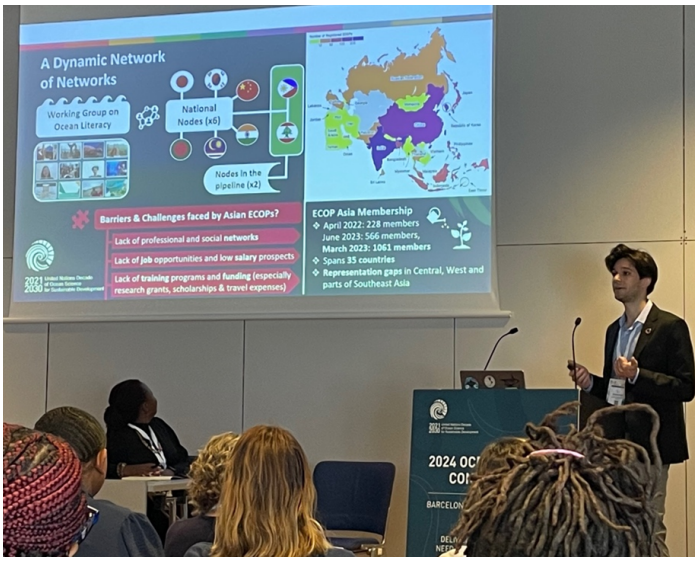
Zhu-Peterson Award

The Zhu-Peterson Award was established in 2019, named in honor of the late Professor Minguan Zhu , formerly of the First Institute of Oceanography, State Oceanic Administration (now known as the Ministry of Natural Resources) in China, and the late Dr. William Peterson, formerly of the Northwest Fisheries Science Center of NOAA in the USA. Both Professor Zhu and Dr. Peterson were strong advocates for encouraging early career marine scientists to engage in PICES activities. This award is presented annually to an early career scientist who has conducted innovative research at the forefront of science relevant to the PICES mission, as outlined in the PICES Convention. Professor Zhu trained many graduate students and early career scientists, who carry on his legacy of honest enthusiasm for cooperative approaches to marine science research. Dr. Peterson was cherished by his students, technicians, and early career professionals within PICES, who regarded him as a "great teacher, and a fun, humble, and inspiring mentor." Zhu and Peterson passed away far too early in their prime, while still actively engaged in their scientific interests. PICES honors their memories and contributions through this award.

PICES 2024 Zhu-Peterson Awardee:

Raphaël Kevin Roman

Raphaël Roman is currently a consultant for the Intergovernmental Oceanographic Commission of UNESCO, where he leads the coordination of the Asian Node of the Early Career Ocean Professionals (ECOP) Program. His research interests are diverse, encompassing new economic thinking, social-environmental well-being, sustainable ocean governance, and biodiversity conservation. He is passionate about interdisciplinary research approaches and about engagement at the science-policy interface.



After completing his graduate studies in public policy and global affairs at the University of British Columbia, Raphaël's research took him to Japan where he studied small-scale fisheries in developed countries to inform global solutions to ecological and socio-economic sustainability challenges. Now, back in Canada, he continues his research activities while expanding his leadership roles in international organizations.

Raphaël continues to be an enthusiastic and productive member of the PICES community, which greatly benefits from his unique skill-set and experience in building international partnerships. Quickly taking on a leadership role, Raphaël helped establish, and is now Co-Chair of, the very active Advisory Panel on ECOPs. Raphaël also serves as a member of the Advisory Panel on the Ocean Decade (AP-UNDOS), the ICES-PICES Ocean Decade SMARTNET Steering Committee, and Working Group 51 on 'Exploring Human Networks to Power Sustainability'.

Congratulations Raphaël!

PICES Ocean Monitoring Service Award (POMA)

The PICES Ocean Monitoring Service Award (POMA) aims to recognize organizations, groups, and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring, data management, and innovative advances in ocean monitoring. The award also strives to enlighten the public on the importance of those activities as fundamental to marine science. It draws attention to an important aspect of the PICES Convention that is not so much in the limelight: "to promote the collection and exchange of information and data related to marine scientific research in the area concerned."

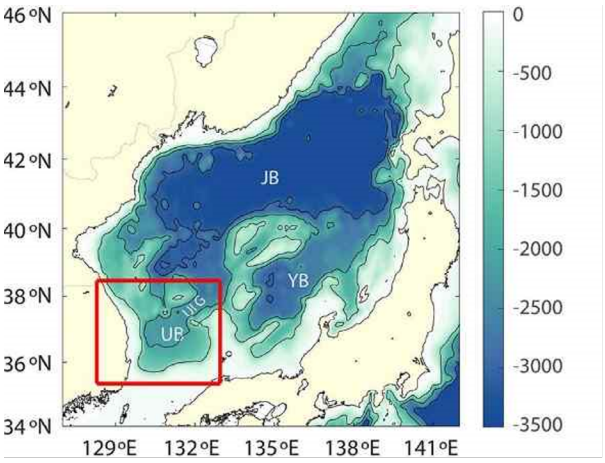
POMA Awardee:

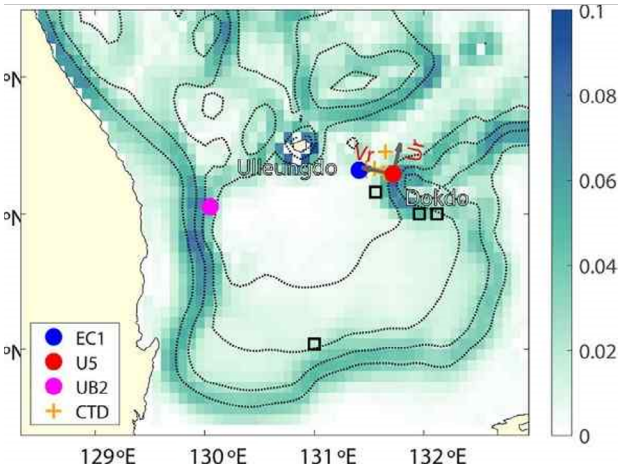
EC1 Program at Seoul National University

Initiated in 1996, EC1 is a moored observational program that has consistently collected long and continuous time-series data. EC1 data are currently being used to study physical and biogeochemical processes in the region, including but not limited to different wave dynamics, mesoscale eddies, fronts, turbulent mixing, water circulation and transport across the UIG, deep and bottom water formations, basin-to-basin water exchange, ventilation and meridional overturning circulation, their impacts on biogeochemistry, as well as the physicochemical properties of seawater.

Many Early Career Ocean Professionals (ECOPs) have the opportunity to calibrate, perform quality control and quality assurance, and process and analyze the data collected from the EC1 mooring and oceanographic surveys

Congratulations to all scientists at the EC1 Program at Seoul National University!





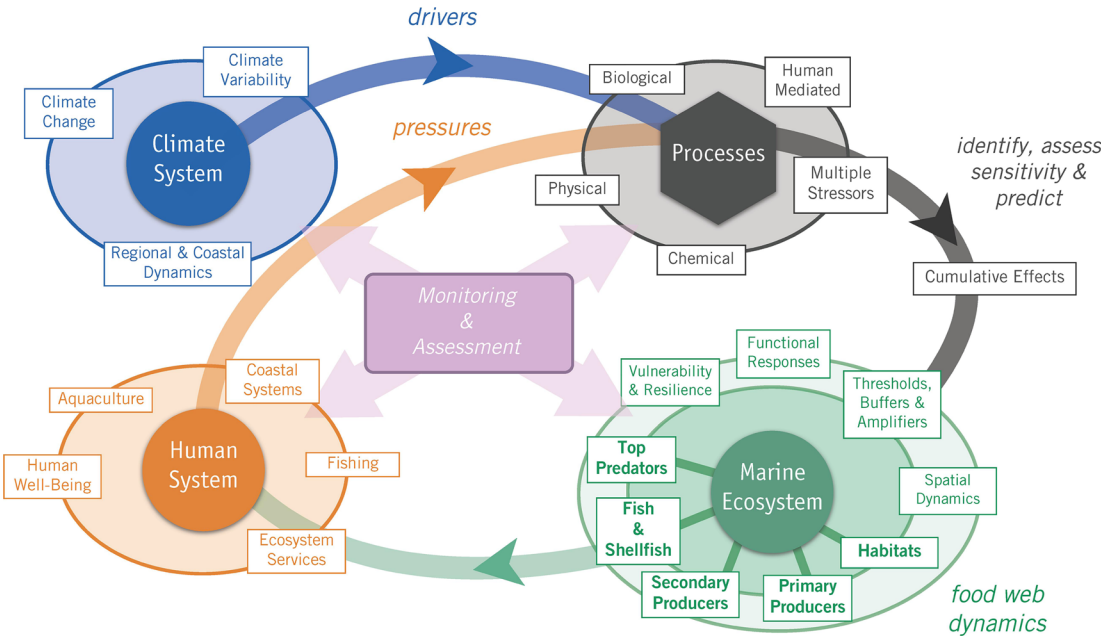
FUTURE Science Program ECOP SEES Award

The objective of the ECOP SEES Award is to encourage the recognition and application of the Social-Ecological-Environmental System (SEES) approach and engage early career scientists in PICES. The SEES approach fosters a common transdisciplinary language and knowledge base among diverse experts, enabling the development of better integrated end-to-end models. Central to the understanding of these systems is integrated long-term, and sustained, monitoring and assessment. This framework enables the discovery of interactions among, and across, disciplinary dimensions to facilitate and understand large-scale ecosystem changes and resulting impacts both ocean-wide and on coastal communities. The FUTURE Scientific Steering Committee (SSC) provided travel support for the awardee to participate in the PICES Annual Meeting.

FUTURE ECOP SEES 2024 Awardee: Rachel Seary

Dr. Seary received a Ph.D. in Geography from the University of Cambridge in 2019. She then moved to the USA to study the California Current Ecosystem, where she is currently a researcher at the University of California, Santa Cruz, and the NOAA Ecosystem Science Division in Monterey, California. Rachel is interested in the connections between humans and the marine environment, focusing on balancing biodiversity conservation with sustaining ocean resources essential for food, economic stability, and well-being amid changing environmental and regulatory contexts. Her research investigates social-ecological challenges for fishing communities through participatory approaches. She is an active member of PICES WG-51 on Exploring Human Networks to Power Sustainability.

Congratulations Rachel!



The North Pacific Social–Ecological–Environmental System (SEES) approach (FUTURE schematic). The SEES Framework enables understanding of the combined system elements of the Climate System, Processes, Marine Ecosystem, and the Human System (Figure 1 from Bograd et al. 2019).

PICES 2024 Early Career Ocean Professionals (ECOP) Best Presentation Awards

Biological Oceanography Committee

Best Oral: Katherine Dale

Eastern Pacific fish spawning patterns demonstrate mixed spatiotemporal tradeoffs in response to environmental changes

S7-Social, economic and ecological implications of recoveries, range expansions and shifting distributions of marine birds, mammals and fish

Best Poster: Hikari Ozawa

The intra- and inter-specific overlaps of foraging sites and diet in sympatric seabirds breed on the colonies in the Tsugaru strait, Japan

BIO-Contributed Poster

Fishery Science Committee

Best Oral: Juliette Champagnat

A new approach to integrate multiple environmental covariates into state-space stock assessments

S11-Impacts of warming-induced changes in body sizes on marine fish ecology and their consequences for ecosystems and associated fisheries

Best Poster: Alexanra Regalado

A tropical sardine in a temperate environment: Understanding the biology of Sardinella lemuru in the northern waters of Japan

FIS-Contributed Poster

Human Dimensions Committee

Best Poster: Hana Matsubara

Synergies between gender equality and sustainability in coastal fisheries resource use: Case studies in Japan

HD-Contributed Poster

Marine Environmental Quality Committee

Best Oral: Kengo Egami

The role and impact of salp blooms on the removal of floating small microplastics in the Kuroshio, south of Japan

S9 - Recent advances in plastic pollution research in the North Pacific

Best Poster: Nicole McHugh

Investigating the spatial and temporal patterns of microplastics in the Fraser River and Burrard Inlet (British Columbia, Canada)

S9 - Recent advances in plastic pollution research in the North Pacific

Physical Oceanography and Climate Committee

Best Oral: Nima Farchadi

Data integration improves model performance in a changing climate

S2 - S-CCME/SICCME session on innovation in using integrated approaches to detect and manage for the effects of climate change tipping points and critical thresholds in marine ecosystems

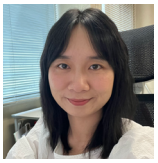
Best Poster: Daiki Ito

Frontogenesis elevates the maximum chlorophyll a concentration at the subsurface near the Kuroshio during well-stratified seasons

POC-Contributed Poster

Technical Committee on Monitoring

Best Oral: Shujuan Xia



Long-term changes in demersal community structure of an urban bay: Transition from bottom-heavy to top-heavy pyramids

S4 - Observational frontier and new studies for understanding of ocean and ecosystem

Best Poster: Huizi Dong

Anomalous edge warming and high biomass in high-latitude oceanic eddies driven by submesoscale ageostrophic motions

S4-Observational frontier and new studies for understanding of ocean and ecosystem

Technical Committee on Data Exchange

Best Oral: Mayr Margaret Stoll

Leveraging 4-dimensionally mapped ocean biogeochemistry data products to Inform species distribution modeling

S4-Observational frontier and new studies for understanding of ocean and ecosystem

Best Poster: Deniz Coskuner

Temporal dynamics of near shore zooplankton communities in the Strait of Georgia: Implications for ecosystem health

S4-Observational frontier and new studies for understanding of ocean and ecosystem

The FUTURE Symposium at PICES-2024

Hanna Na and Steven J. Bogard

The theme of the PICES-2024 Annual Meeting was 'The FUTURE of PICES: Science for Sustainability in 2030'. Since 2009, the 'Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems', or FUTURE, has been the PICES flagship Science Program. A key objective of the Annual Meeting was for the PICES community to take a step back and evaluate the status of PICES science, and to embark on a new scientific path to better fulfill our goal of understanding of the combined consequences of climate change and anthropogenic pressures on marine ecosystems, ecosystem services, and marine-dependent social systems. The theme of PICES-2024 was inspired, in part, by the ongoing UN Decade of Ocean Science for Sustainable Development (Ocean Decade), for which PICES plays a leadership role through its SmartNet Program, and its mission to develop 'the science we need for the ocean we want'. The theme is also well aligned with the recently completed PICES External Review Panel Report.

To introduce the theme of the Meeting, PICES-2024 opened with the full-day, plenary FUTURE Symposium. This Symposium comes a full decade after the first FUTURE Open Science Meeting, also held in Hawaii (Kona, April 2014), that launched FUTURE's new vision to investigate and understand the climate and anthropogenic impacts on North Pacific marine ecosystems with an emphasis on the synergy of social, ecological, and environmental systems (SEES) and processes. Steven Bograd and Hanna Na kicked off the Symposium with introductory remarks (Figure 1), noting that, 10 years after the initial FUTURE Open Science Meeting, we are here to: (1) celebrate what FUTURE has brought to the PICES and North Pacific marine science communities; (2) assess the strengths and weaknesses, as well as accomplishments and gaps, of the Program; and (3) take our lessons learned from FUTURE to pave the path forward for PICES science. It was noted that FUTURE has accomplished a lot during its tenure as flagship Science Program:

- Facilitated Trans-disciplinary Science Collaborations
- Implemented a Social-Ecological-Environmental-Systems Approach to PICES Activities
- Expanded Human Dimensions into PICES Activities
- Provided Assessment of Key Organizational Strengths and Gaps

The first set of Symposium speakers provided details on many of these accomplishments. Shin-ichi Ito (see Figure 2 for Symposium speakers) provided a history of PICES science, describing the motivations and process of transitioning from the first Science Program, 'Climate Change and Carrying Capacity' (CCCC; 1995-2009) to FUTURE. This was followed by two presentations that reviewed the evolution of the scientific enterprise within FUTURE. Hanna Na, in collaboration with Jennifer Boldt, presented the FUTURE Product Matrix, which provides

Figure 1. FUTURE SSC Co-Chairs Hanna Na and Steven Bograd kicking off the FUTURE Symposium at PICES-2024.

an evaluation of the scientific products developed during the FUTURE period and links these products to each of the key FUTURE scientific questions. The Product Matrix thus provides a summary of which fundamental scientific questions were best or least addressed, allowing for an assessment of Program achievements and gaps. Continuing with this theme, Shion Takemura described a study he led that uses keywords from the historical PICES abstract archive to demonstrate the evolution of PICES science from CCCC (disciplinary scientific processes) to FUTURE (inter-disciplinary research and inclusion of human dimensions). Finally, Mitsutaku Makino, current Chair of the Human Dimensions Committee, presented on the renewed emphasis, and critical importance, of integrating human dimensions throughout the PICES scientific enterprise.

Speakers following the lunchbreak provided overviews of a few key scientific advances made during the FUTURE period. Mary Hunsicker reviewed the work of the FUTURE-sponsored Working Group 36 on 'Common Ecosystem Reference Points across PICES Member Countries', which analyzed ecosystem reference points within regional PICES-area ecosystems. Helen Killeen and Hiroki Wakamatsu provided an overview of the work being conducted in the FUTURE-sponsored Working Group 49 on 'Climate Extremes and Coastal Impacts'. Following these science presentations, we celebrated the critical role that Early Career Ocean Professionals (ECOPs) have played in advancing science and collaborations with FUTURE and PICES more generally. The current Chairs of the Advisory Panel on ECOPs (AP-ECOP), Minkyoung Kim, Hannah Lachance, Hana Matsubara, and Raphaël Roman, gave a fantastic review of the great work they have accomplished, including new strategies to recruit, welcome, and retain ECOPs into the PICES community. We were then treated to the invited presentation from this year's FUTURE SEES ECOP award winner, Rachel Seary, who summarized her work on incorporating the SEES approach into her research on supporting ocean sustainability. We then had a presentation from Nakayama Natsuko who described the work of the Advisory Panel on Science Communications (AP-SciCom), which has been an active area of emphasis within PICES in recent years.

Following this wonderful set of speakers, we conducted a Panel Discussion on the progress, challenges, and lessons learned from FUTURE. Steven Bograd led the discussion with several distinguished panelists who represented each PICES member country and the Secretariat: Sanae Chiba (Secretariat), Jennifer Boldt (Canada), Fangli Qiao

Figure 2. Speakers at the FUTURE Symposium: (top, from left) Shin-ichi Ito and Shion Takemura; (middle, from left) Mitsutaku Makino, the AP-ECOP Co-Chairs (Hana Matsubara, Minkyoung Kim, Hannah Lachance and Raphael Roman), and Mary Hunsicker; (bottom, from left) Nakayama Natsuko, and Rachel Seary (this year's winner of the FUTURE SEES ECOP Award).

(China), Shin-ichi Ito (Japan), Sinjae Yoo (Korea), Vladimir Radchenko (Russia), and Ryan Rykaczewski (USA). The Panel engaged in a lively discussion around a few leading questions (below) and took questions from the audience:

1. What do you think is the most significant contribution FUTURE has made to the PICES and North Pacific marine science communities?
2. What were the biggest barriers in achieving FUTURE's scientific objectives?
3. How should PICES science be transformed in the future?

The panelists agreed that one of the most significant accomplishments of FUTURE was its facilitation of inter-disciplinary work across PICES, including the implementation of the SEES approach. The panelists also recognized that the FUTURE Science Plan was overly ambitious, which limited the ability to accomplish some key objectives. For example, questions on ecosystem resilience and vulnerability would be difficult to answer within the life cycle of FUTURE.

Finally, Cisco Werner (Figure 3), USA Governing Council member and one of the original developers of the FUTURE Program, closed the Symposium with some personal remarks on the accomplishments and lessons learned from FUTURE. He also primed the audience to review the PICES External Review Panel Report and to think about what should come next for PICES science, echoing the theme of PICES-2024. His remarks resonated with the audience, which engaged in a long and lively discussion until we were compelled to break for the Welcome Reception. We thank all of the Symposium speakers and panelists, as well as the highly engaged PICES community, for a very successful FUTURE Symposium!

Figure 3. Cisco Werner closing out the FUTURE Symposium at PICES-2024.

Sunset in O'ahu, USA

PICES 2024 Session and Workshop Reports

S3 - Advanced tools to monitor, observe, and assess small pelagic fish populations in support of ecosystem based fisheries

Jennifer Boldt (Canada), Rebecca Asch (USA), Matthew Baker (USA), Chris Rooper (Canada), Dongwha Sohn (Korea), and Kresimir Williams (USA)

Background

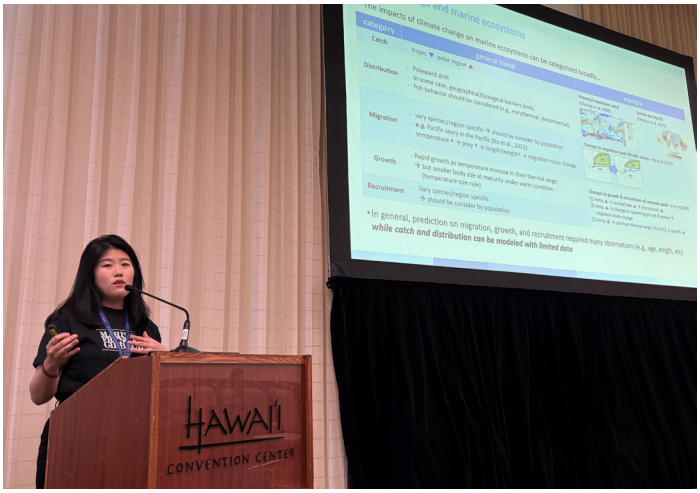
Small pelagic fish are important components of fisheries and marine ecosystems worldwide, comprising greater than 30% of worldwide capture fisheries. Yet for many species there is limited information on the consequences of climate change and multiple stressors on these populations. Information on pelagic fish distribution, habitat use, and the environmental and anthropogenic pressures that affect them is required for sustainable and ecosystem-based approaches to fisheries management. Recent advances in technologies, empirical analytical tools, and models can lead to better observations and improved understanding of the pelagic forage community (including fish and squid). This session focused on studies that elucidate the effects of climate change and other pressures on the distribution and productivity of small pelagic fish and squid through advanced sampling technologies and analytical and modeling tools to improve our ability to predict and sustainability manage these populations.

Session Summary

During the 1-day topic session, there were 16 oral presentations (including two invited talks) and 6 poster presentations. Of these, half (8) of the oral presentations and 1 of the poster presentations were by Early Career Ocean Professionals (ECOPs). At the beginning of the session the conveners provided an introduction to the session, as well as an overview of the newly formed Joint ICES-PICES Working Group on Sustainable Pelagic Forage Communities (WG53). This introduction was followed by an invited talk presented by Vaneeda Allken that described her work to use deep-learning techniques to automatically detect, identify and measure small pelagic fishes photographed by a camera system mounted inside a trawl net. Vaneeda and co-authors found good agreement in identification, enumeration and size distribution between the camera system and trawl catches. Vaneeda detailed many of the challenges confronted in developing her Artificial Intelligence (AI) algorithm and provided constructive suggestions on how others can overcome similar challenges. This presentation was followed by 5 additional talks that integrated camera images and AI to improve our ability to automatically measure items ranging from curved fish to otoliths.

Following this set of presentations on AI and optics, the next set of presentations examined the distribution of small pelagic fish species using a number of novel methods. New techniques, such as eDNA and novel applications of oceanographic equipment such as gliders, provided insights into the distribution of small pelagic fish. A second invited talk by Minkyoung Bang began the afternoon session; her work included climate projections and species distribution models for small pelagic fish and squid. Minkyoung used an ensemble modeling approach to project future seasonal changes that could considerably affect distribution and spawn timing of small pelagic species under climate change scenarios. Other session talks that employed species distribution modeling in combination with advanced technologies and model outputs to project the current and future distributions (and projection uncertainty) of small pelagic fish followed the invited speaker. The final two oral presentations used ecosystem models in novel ways (e.g., vertically and horizontally integrated models) with applications to improve ecosystem management.

Invited speaker Vaneeda Allken, Institute of Marine Research, Bergen, Norway.



Invited speaker Minkyoung Bang, Korea Institute of Ocean Science and Technology, Busan, Korea.

The poster presentations highlighted additional applications of image-based sampling and artificial intelligence, eDNA, passive acoustic monitoring, species distribution modeling, trait-based models and phenology studies, all of which incorporated advanced technologies.

Session topics and main takeaway messages from S3 presentations include:

1. Improvements in monitoring and data synthesis of forage species:
    a. The use of stereo-cameras and artificial intelligence is allowing better monitoring of small pelagic fish species.
        i. The time required to conduct fish identification and counting has been a major hurdle to widespread implementation of image-based techniques.
        ii. Image-based techniques are applicable to more than just counting and measuring fish.
    b. Advances in eDNA and other molecular techniques can improve our ability to monitor small pelagic fish quickly and efficiently:
        i. eDNA data can be used to complement traditional survey data sources.
        ii. Naturally occurring isotopic composition can provide insights into patterns such as migration that have typically been relegated to tags. This is important given that the small size of many forage fish makes satellite and acoustic tagging challenging.

2. Describing changes in small pelagic species (fish and squid) distributions and communities:
    a. Advanced technologies (such as eDNA and passive acoustic monitoring) can be integrated into species distribution models to provide better estimates of small pelagic fish distributions.
    b. Advances in species distribution modeling allow both better projections of future species distributions and also allows us to measure the variance of these projections.
    c. Trait-based analyses, phenology trends, climate change models, ecosystem models and ocean observations using advanced technologies can improve our ability to predict future changes.

Other speakers in Session 3: top row, from left to right: Matt Baker, Talen Rimmer, Masahiro Manano, Yasutoki Shibata, Yuka Iwahara, Yuan Lin, Brian Wells; bottom row, from left to right: Dongwha Sohn, Yehui Wang, Jens Nielsen, Caitlin Akselrud, Tatsuya Sakamoto, Isaac Kaplan, Jim Ruzicka.

PICES 2024 Session and Workshop Reports

W1 - North Pacific plankton time series data analyses and synthesis

Akash Sastri (Canada), Julie Keister (USA), Kazuaki Tadokoro (Japan), Xuelei Zhang (China), and Samantha Zeman (USA)

Workshop Summary

Topic Workshop 1, *North Pacific plankton time series, data analyses, and synthesis* was convened on Sunday, October 27, 2024. This workshop was proposed and supported through the PICES Advisory Panel on North Pacific Coastal Ocean Observing Systems (AP-NPCOOS). The workshop was originally motivated by a successful collaboration to address broad-scale synchrony of North American coastal zooplankton response to the extreme 2015/2016 marine heat wave. This effort involved synthesis of ten zooplankton time series along the west coast of North America (northern Gulf of Alaska to northern California) by Jennifer Fisher from Oregon State University and others (2020; PICES Press Vol. 28, No. 1). The workshop convened at this year's annual meeting aimed to build on this initial effort and expand the spatial coverage to include both the eastern and western subarctic Pacific.

We invited PICES-region plankton monitoring groups to develop a common understanding of the practical and analytical similarities and differences of our respective plankton time series. In keeping with this goal, we solicited presentation and discussion of non-standard but complementary sampling methods (biochemical, imagery, acoustics etc.) in addition to more conventional net tow-based time-series of zooplankton diversity and biomass. The half-day workshop activities were mostly based on presentations with discussion centering on planning of future collaborative activities. The two invited speakers represented long-term observational programs in the western/central and eastern subarctic Pacific regions. The six submitted presentations addressed: region-specific responses to extreme warm (and cold) years/events; statistical treatment of zooplankton time-series; recognizing and reconciling challenges of long time series; and exploring the sensitivity of finely resolved time series to environmental perturbation. Finally, we had a short but productive discussion centered on writing a follow-up workshop proposal and addressing the appetite for a PICES expert group focused on North Pacific zooplankton time series.

Presentation Summaries

Hiroomi Miyamato (Japan) presented an invited talk, *Zooplankton community change in the transition and subarctic regions of the North Pacific Ocean from 2004 to 2023*. This presentation focused on broadscale monitoring of zooplankton sampled in early summer in an area extending north from the subarctic/subtropical transition zone in the western/central subarctic North Pacific (between 145°E - 150°W; 4500 km). Patterns of diversity, presence/absence, and abundance were analyzed to highlight variability of community composition north and south of the subarctic boundary. Communities north and south of the boundary were associated with cool and warm temperatures, respectively. Within each north or south community, assemblages tended to be more associated with phytoplankton biomass. Recent warm years, 2019, 2020, 2022, and 2024, were associated with large salp

blooms in the transition zone and were associated with dominance of amphipods (*Themisto* sp.) instead of the large calanoid copepod, *Neocalanus plumchrus* in diets of Pacific Saury. The southern boundary of *N. plumchrus* in the region was displaced to the north in warm years and described by a negative correlation with Pacific Decadal Oscillation (PDO). Moreover, the zone of highest *N. plumchrus* density has moved northward continuously, totaling 3° over the course of the time series. Analysis of the broader zooplankton community indicates a progressive 'subtropicalization' of the transition zone and its sensitivity as an indicator of long-term climate change.

David Kimmel (USA) presented an invited talk, *Development and application of zooplankton time-series for use in ecosystem based management in Alaska*. This presentation walked workshop participants through the NOAA Alaska Fisheries Science Center (AFSC) zooplankton program, its relevance to ecosystem based fisheries management and lessons learned as the program has evolved. The geographical scope of AFSC plankton monitoring is vast (much of the Alaska EEZ, 3.77 million km^2) with ichthyoplankton time series starting in 1981. David introduced the team of experts (and expertise) responsible for maintaining the historical Bering Sea monitoring program started in the 1990's and focused attention on paths to: i) establishing rapid enumeration and timely reporting of useful zooplankton metrics for fisheries managers ii) standardization for gear changes; iii) establishing robust time series from spatially variable sampling; and iv) development of plankton imaging and molecular techniques for monitoring. This presentation amply covered the workshop objectives and provided valuable examples and practical insight toward the goal of comparing and reporting on North Pacific plankton time series.

Shinataro Yoshida (Japan) presented a talk titled, *Spatial changes in zooplankton communities within the western subarctic Pacific during summers 2000-2020: Comparison between warm and cold years and with data from the eastern subarctic Pacific*. This presentation analyzed spatial and interannual trends from a long-term (2001-2020) set of continuous plankton recorder (CPR) tows during the summer in the western subarctic Pacific. This time series was also compared to a similar time series in the eastern subarctic Pacific, yielding an east-west comparison. The focus of analyses was on spatial differences of diversity and abundance between cold and warm years as defined by the PDO. In the western subarctic Pacific, spatial heterogeneity of diversity (number of statistical groupings) was greater during cool periods and attributed in part to mesoscale eddies. Whereas during warm phases, especially within wide warm areas, diversity was limited and more homogenous. Warm phases were dominated by warm-water indicator species and were hypothesized to 'mask' eddy effects. CPR time series differ from traditional ship-based monitoring because sampling is limited to the near surface. However, they are key to plankton monitoring in the North Pacific because they capture larger patterns of spatial variability (40°N to 54°N) not often approached by ship based methods.

Julie Keister (USA) presented, *Differential response of zooplankton to warm events in the Salish Sea, Northern Gulf of Alaska, and Bering Sea*. The talk presented comparisons of zooplankton time series from the northern (Gulf of Alaska, northern Bering Sea, southeast Bering Sea) and southern (Strait of Juan de Fuca and Puget Sound) northeast subarctic Pacific. These time series all support fisheries science and management, however, they vary in length, sampling frequency, and sampling methods. Interannual patterns of temperature across this broad space are similar and provide for exploring broad-scale coherence of zooplankton sensitivity to climate variability. Julie presented annualized abundance time series for a variety of indicator groupings standardized with Z-scores. Total copepod abundance anomalies for northern time series varied with time and temperature regime whereas patterns for southern time series was less clear. Differential responses to warm and cool temporal stanzas for copepod species (*Calanus marshallae, C. pacificus,* and *Acartia longiremis*) with 'northern' and 'southern' geographic affinities were also more closely tied to regional response. Efforts to resolve broad scale coherence of zooplankton to climate may be limited when considering temperature alone.

Outside the Hawaii Convention Center in Honolulu, USA

Russell Hopcroft (USA) presented a talk titled, *A quarter century of observations along the Seward Line: the good, the bad, and the ugly of long time-series.* He provided an overview of the ecological insights and lessons learned from regional oceanographic time series in the NE subarctic Pacific. Long-term zooplankton sampling along the Seward line, northern Gulf of Alaska, started in 1997 and takes place each May and late summer/fall. Seasonality in this region is strong, with cooler years favoring spring blooms of large phytoplankton supportive of zooplankton production; whereas, phytoplankton blooms in warm years occur later and are composed of smaller, poor quality prey for crustacean zooplankton. Some challenges of long time-series include recognition that sampling effort, consistency, and data quality varies with time and that long time-series were not necessarily designed for current applications. Problems may not be recognized until new analytical approaches are applied. For instance, multivariate analyses are particularly sensitive to incorrect weight conversions, inconsistencies in species identification, and/or naming conventions; requiring alignment to the lowest common level. An ability to recognize and remedy time-series issues requires regular assessment for biases and anomalies and careful curation of the original collections.

Atsushi Yamaguchi (Japan) presented a talk titled, *Interannual changes of zooplankton assemblages in the western subarctic Pacific based on Continuous Plankton Recorder during 2001-2020: Analysis by GDM and future prediction*. This presentation explored seasonal patterns of zooplankton community composition as measured with Continuous Plankton Recorders (CPRs) across a broad portion of the western subarctic Pacific during the 2001-2020 period. Regime shifts were identified for environmental data sets, sea surface temperature (SST), sea level anomaly (SLA), and chlorophyll *a*. The large zooplankton dataset was partitioned into seven community types and three zooplankton taxonomic groups. The seven community types were clearly distinguished and aligned with space, time, and sea surface properties. Long-term shifts of SST, regime changes, were most clearly associated with summer and fall community composition, and tied to changes in the abundance of *Neocalanus plumchrus*. This study used General Dissimilarity Modeling to identify SST and SLA as environmental factors exerting the strongest influence on community composition. Finally, twenty year forward predictions using the general dissimilarity models suggest a significant reorganization of zooplankton community spatial patterns with season and a 1°C and 0.04 m increase in SST and SLA, respectively.

Hongsheng Bi (USA) presented, *Unveiling the impact of winter storms on the dynamics of zooplankton populations in shallow estuaries.* This study introduced the workshop participants to a copepod time series captured with a moored plankton imaging instrument, the PlanktonScope. This shadowgraph imaging instrument was moored from a research pier at the mouth of the Patuxent River, Maryland. The abundance and sizes of the copepod, *Eurytemora* spp. (key for striped Bass recruitment) were followed on a high frequency, real-time basis starting in February 21, 2023. Sampling at this frequency is not feasible with traditional nets and was used to detect fine-scale variation of abundance associated with episodic winter storm events during late winter and early spring. This time series was sufficiently dense for assessing the performance of a deep-learning, zero-shot for time-series forecasting application. A successful validation of the forecast against recent observations using copepod density, temperature and salinity anomalies demonstrated the utility of relatively short, but finely resolved time series not feasible with traditional methods.

Akash Sastri (Canada) presented a talk titled, *Seasonal and monthly scale plankton sampling along the southwestern coast of Vancouver Island, British Columbia, Canada.* This talk wrapped up the submitted presentations for the workshop. The presentation focused on both a long (1979-present) and a short (2022-present) zooplankton time series located along the west coast of Vancouver Island in the NE subarctic Pacific. This region lies in the transitional zone between the equatorward flowing California Current and the poleward flowing Alaska Current. Zooplankton composition and biomass in this area are subject to variation in the position of the transitional streamline and strong seasonality in timing and intensity of upwelling and downwelling. The long-term southern Vancouver Island (SVI) shelf/slope time series represents a sensitive biological indicator of climate-ocean variability because of placement in a transition zone. The biomass composition (lipid rich vs. poor) and peak biomass timing continue to reflect warm and cool conditions associated with changes in broad-scale circulation. The short time series, located east of SVI, in Barkley Sound, is a new euphausiid-centric time series focused on characterizing variation of a key prey item for juvenile Coho and Chinook salmon populations. Monthly sampling provides local information on prey availability/timing for early marine phase salmon not resolved with the SVI seasonal scale surveys.

Honolulu, USA

PICES 2024 Session and Workshop Reports

W5 - Exploring international knowledge co-production and the science-policy interface

Erin Satterthwaite, Steven Bograd, Mitsutaku Makino, Hanna Na, Sonia Batten, Sanae Chiba, and Jörn Schmidt

Individually, we are one drop.
Together, we are an ocean.
~Ryunosuke Satoro

Sponsors: FUTURE, SmartNet
Co-sponsor: ICES

Rationale and Background

We are increasingly aware of the urgent need for solutions to address the complex challenges confronting society. The process of knowledge co-production has gained increasing attention for generating policy-relevant, solutions-oriented, and socially robust knowledge and is consistently discussed as one of the most effective strategies for mobilizing knowledge in the context of evidence-informed policy and practice.

There are many terms for this process (Figure 1), but most have similar goals of collaboration, sharing, bringing together diverse forms of knowledge and generating knowledge, action, and solutions (e.g., participatory and collaborative approaches like co-production, co-design, co-creation and mutual learning). Specifically, knowledge co-production for ocean sustainability is an interactive, participatory process that brings together diverse actors to collectively generate, integrate, and apply knowledge to address complex sustainability challenges.

Figure 1. A teardrop displaying some of the many terms related to participatory and collaborative approaches.

There is growing recognition of the need for collaborative approaches to knowledge generation and use internationally, including within the United Nations (UN) and other intergovernmental processes and increasingly within PICES. This workshop idea was born out of a UN workshop aboard the Statsraad Lehmkuhl (PICES Press 2024 pg66) and evolved throughout discussions with the PICES community over the course of the past year.

The questions we wanted to answer with this FUTURE and SmartNet-sponsored workshop were:

- What does knowledge co-production look like in international organizations?
- How could this be applied within the context of PICES?

Introduction

The workshop, "Exploring international knowledge co-production: Lessons learned from international marine science organizations at the science-policy interface", brought together 27 diverse participants across countries, knowledge producers and users, career stages, and organization types who engaged in invited presentations, a panel, interactive activities, and group discussions (Figure 2).

The goals of the workshop were to: 1) Understand how other international organizations conceptualize the process of working at the science-policy interface, 2)

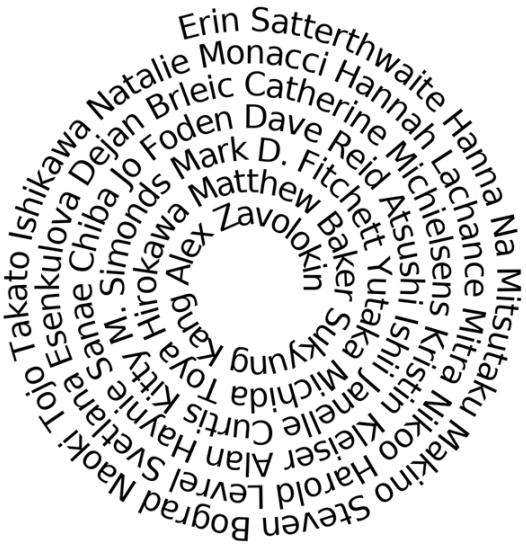


Figure 2. A spiral of workshop participant names.

Identify effective strategies and practices for knowledge co-production in international organizations, 3) Evaluate the current use of PICES information and explore opportunities for enhancing its application.

Challenges of Knowledge Co-Production in International Organization

The journey toward effective knowledge co-production may present challenges and may not always be the best approach for a given context. Some of the main challenges identified were limited resources, limited data or knowledge sharing, a lack of incentives to engage or goals being misaligned, a reluctance to engage due to lack of interest or training, or the unavailability of venues or structures for building relationships and sharing across sectors or communities.

Strategies for Knowledge Co-Production in International Organizations

We also identified effective strategies for knowledge co-production and mutual learning in international organizations that align with previously published strategies (Satterthwaite et al. 2024). Through the invited presentations and interactive activity we identified some key summarized points:

Build and maintain relationships. The importance of building and maintaining relationships – which takes time– and ensuring that we have repeated and sustained interactions to build trust was highlighted. Trust is important because it can foster openness, transparency, and effective communication. The PICES Annual Meeting and workshops, including this one, have been a great step in this process. Additionally, diverse venues and groups to discuss information needs, establish shared interest, assess gaps, and broaden engagement in a "big tent" style approach was identified as particularly important.

Assess who should be included and broaden engagement. Related to this, defining who should be included is important. Our North Pacific community is a broad range

of actors interested in, engaged with, and or affected by activities in the North Pacific. This can include those who have a stake, share, right, or interest. This requires working within and among a diversity of perspectives, across career stages, generations, disciplines, regions, and cultures. It also includes a range of people including science, policy, industry, education, local and traditional knowledge, and boundary-spanning organizations.

Contextualize engagement and establish clear expectations for engagement. Next, the importance of understanding the context of engagement and scoping resources and knowledge available was highlighted. Then setting clear goals, roles, and communication strategies, clear expectations of contributions, and establishing clear agreed upon guidelines for the process and how the knowledge will be produced and used.

Collaborate, adapt, and learn. Finally, in enacting the process the workshop participants thought it was important to ensure there is co-ownership of knowledge through collaboration and that the information is relevant, timely, has practical application, and that the process is adaptable and iterative through mutual learning.

Current State of PICES at the Science-Policy Interface

The PICES Secretariat (Sanae Chiba) and a panel of representatives from partner organizations that included regional fishery management organizations, national representatives, and science and funding organizations shared their perspectives on where PICES is in this voyage focused on the science-policy interface. PICES influence on decision making is indirect and primarily communicated through scientific outputs of PICES Expert Groups and Special Projects related to country and regional management as well as commitments to international treaties. There was a call for establishment of clear protocol and organizational structure for effective community engagement that includes knowledge users to align the scientific outputs with the needs of resources managers.

Needs Identified by PICES Users

The panel of PICES users was selected to address uses and needs of PICES information at the climate-fisheries nexus. The panelists included: Matt Baker, North Pacific Research Board (NPRB); Aleksandr Zavolokin, North Pacific Fisheries Commission (NPFC); Catherine Michielsens, Pacific Salmon Commission (PSC); Mark Fitchett, Western Pacific Regional Fishery Management Council (WPFMC); Ryan Rykaczewski, NOAA Pacific Islands Fisheries Science Center and University of Hawaii, USA; and Sukyung Kang, National Institute of Fisheries Science, Korea.

The needs identified by the panel of PICES users were related to climate variability and change in relation to fisheries management, early warning and environmental indicators, emerging fisheries, equity, environmental justice and local/traditional knowledge, and climate-related displacement. The types of products that users needed were one pagers, 2 slide summaries, factsheets, actionable tools, and data repository links.

Additionally, non-academic PICES users suggested that in some cases writing can be too technical, making it difficult to clearly communicate key findings and main points. Thus, a need for clearer communication practices was expressed. To address this, PICES could consider creating a communications style guide to help members write more effectively for non-technical audiences (e.g., plain language guidelines).

Future Directions

Looking ahead, workshop participants emphasized the importance of strengthening existing relationships and partnerships, such as those outlined in established Memoranda of Understanding (MOUs), while also identifying and addressing any gaps in collaborations. They highlighted the need to create dedicated venues for dialogue, enabling input from a diverse North Pacific community to better understand preferred engagement methods and assess collective needs. To foster inclusive collaboration, participants proposed developing a more structured approach to engagement within PICES. This could include refining the organizational structure, forming new expert groups, and organizing joint workshops and working groups to facilitate meaningful interaction. Additionally, they underscored the value of enhancing knowledge and capacity sharing, both within PICES and among partner organizations. Key strategies included improving systems for data and information sharing and offering training courses to support co-design efforts and build collaborative capacity.

We hope that this work serves as another stepping stone on the path toward cross-sector, transdisciplinary international science collaboration and look forward to seeing how this work evolves together in the coming decade.

Acknowledgments

We, the co-conveners, are grateful to the invited speakers (Kristin Kleisner, EDF; Alan Haynie, ICES; Jorn Schmidt, WorldFish; Kentaro Ando, WESTPAC; and Sanae Chiba, PICES), invited panelists (Matt Baker, North Pacific Research Board (NPRB); Aleksandr Zavolokin, North Pacific Fisheries Commission (NPFC); Catherine Michielsens, Pacific Salmon Commission (PSC); Mark Fitchett, Western Pacific Regional Fishery Management Council (WPFMC); Ryan Rykaczewski, NOAA Pacific Islands Fisheries Science Center and University of Hawaii, USA; and Sukyung Kang, National Institute of Fisheries Science, Korea), and participants (Figure 2). We are also grateful to the PICES Secretariat and PICES community for the thoughtful and stimulating discussions.

PICES 2024 Session and Workshop Reports

W6 - Co-creating a shared framework for ocean data management: Finding common ground on terminology

Erin Satterthwaite, Naomi Boon, Jeanette Gann, Tim Van Der Stap

Sponsors: MONITOR/TCODE

Co-sponsors: Northeast Pacific DCC, ECOP Canada

Background

The goal of the workshop, "Co-creating a shared framework for ocean data management: Finding common ground on terminology", was to develop a shared framework and language for effective ocean data management. In ocean science, the data framework and key terminology is often interpreted differently across, and even within, disciplines, meaning that often scientists are not "speaking the same language" when it comes to data processing, management, mobilization, and best practices. To our knowledge, there is currently no consistent conceptual model or framework for the data lifecycle in ocean science. Through presentations and interactive discussions, the workshop was designed to collaboratively construct a common vocabulary and framework for ocean data concepts, which will serve to enhance science collaboration, streamline processes, and elevate data utilization.

Workshop Overview

The workshop brought together about 25 ocean professionals, representing individuals from PICES member countries, various disciplines (e.g. physical oceanography and fisheries scientists), and positions (policy analysts and research directors) within ocean science and management. During the context setting at the beginning of the workshop, the co-convenors shared a "basic shared framework" of 'stages' and 'outputs' (Diagram 1) to give the participants something to react to, and start thinking about the stages, outputs, and overall terminology used in their own subject areas. Metadata was not listed specifically in the shared framework, but was brought up in following group discussions.

Following the context setting, two keynote speakers provided presentations on topics related to marine data lifecycle management.

Invited Presentations

Steve Diggs (University of California Curation Center, California Digital Library, USA) presented an overview of climate-related data issues within and beyond the UC system, highlighting the importance of open data and reviewing the various stages of the research data lifecycle, along with the importance of establishing clear terminology to enhance collaboration and transparency. This includes:

- Standardized language for sampling, processing, and validation enhances collaboration and reproducibility;
- Standardized terms for analysis and visualization helps make data products accessible across disciplines;
- A shared framework with unified technology can create a scalable, sustainable foundation for global climate and ocean data resilience.

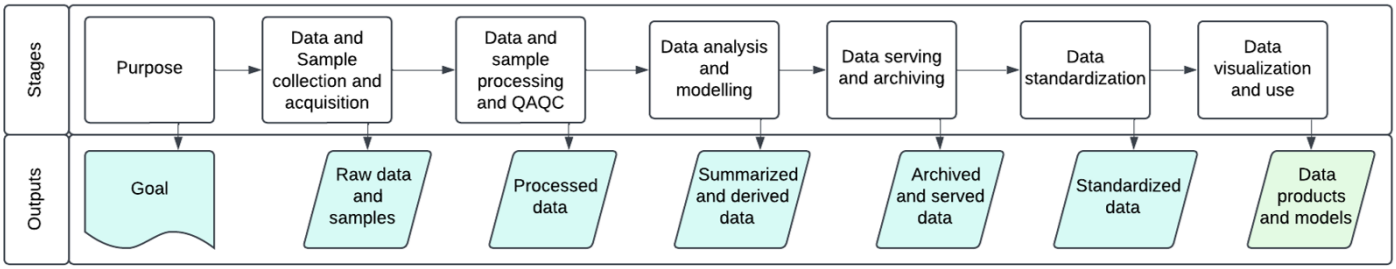


Diagram 1. Basic initial shared framework presented to workshop participants at the start. The conceptual diagram shows the stages (top row) and outputs (in teal, bottom row) from each stage to be discussed among participants.

Professor Chun-hua Han (National Marine Data and Information Service, China) shared insights into how they have developed infrastructure around marine data lifecycle management. Key aspects of their data management system include:

- The full data life-cycle (from data aggregation to data value added services);
- Marine data governance
- Marine data asset management
- Marine data sharing and exchange management
- Marine data integrated management
- Marine data architecture management
- Marine data standardization management

Professor Han outlined four key prospects for the management of the marine data lifecycle; which included 1) expanding marine data resources, 2) making full use of modern technologies such as big data and cloud computing, 3) improving marine big data technology, and 4) strengthening international cooperation on marine big data.

Ocean Data Lifecycle

After these insightful presentations, there was a series of interactive discussions around constructing a conceptual ocean research framework, defining what different stages and outputs fall within this workflow. Each stage was listed on a poster and hung up on the wall and participants were encouraged to discuss among themselves what key terms, steps, important considerations, practices, and outputs are relevant within each stage, and whether they thought any stages were missing. The participants put their ideas and suggestions on sticky notes on the posters before a discussion with the larger group where people shared their ideas, suggestions, and feedback.

Overall there was agreement on the terminology of the stages of the basic shared framework (Diagram 1), but there was considerable discussion on cross-cutting themes, the steps outlined within stages, and various outputs. This discussion led to a co-designed shared ocean data lifecycle by the end of the workshop (Diagram 2).

Cross cutting themes

The group identified several cross-cutting themes, outputs or areas of important consideration (Diagram 2) that were missing from the original basic framework, and which apply to multiple stages across the model, such as:

- Build collaboration and partnerships

  Work with key partners to establish shared objectives, define the scope of data collection and promote multiple uses from one data collection. This may require MOUs, collaborative agreements and shared leadership, depending on the scope of the project.

- Documentation

  Documentation is a cross-cutting output at all stages of the data framework and may be more exhaustive than metadata. For example, documentation may include more of the historical background and explain how methods have changed over time.

- Metadata

  Metadata was also defined as a cross-cutting output across many stages of the data framework to provide information about the data. For example, the data owner, location, when the data was collected, geographic scope, data curator, data variables, and file size.

- Data standardization

  While data standardization was also included as a separate stage, there was discussion as to whether it was a concept that was applicable to multiple stages of the workflow. Data need to be standardized to a minimum level to ensure consistency, accuracy, and compatibility. There's a need to be more purpose-driven in our standardization, rather than doing it ad hoc. Data standardization relies on ontologies, controlled vocabularies and existing best practices for each data type.

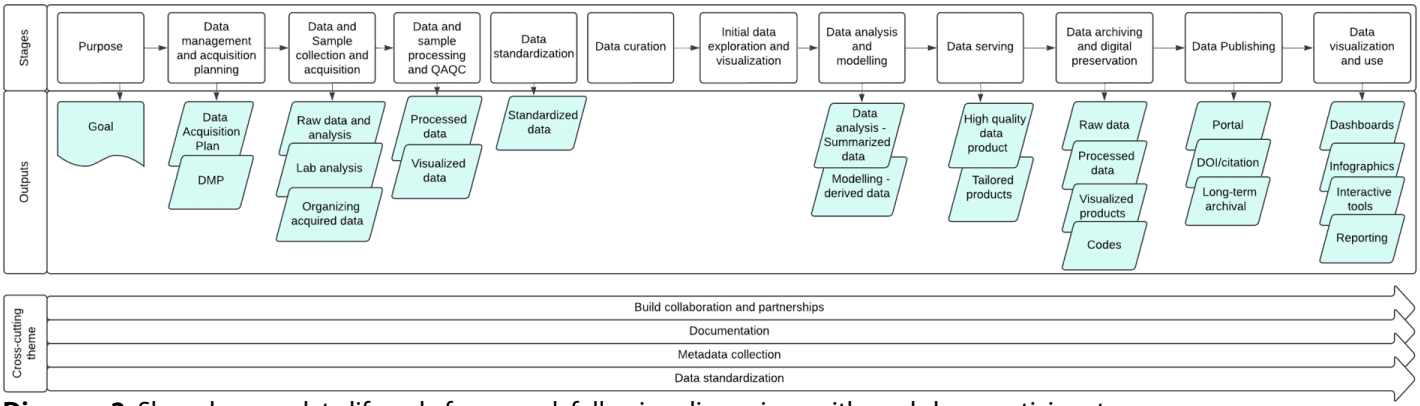


Diagram 2. Shared ocean data lifecycle framework following discussions with workshop participants.

Stages

The group also described 12 stages of the ocean data lifecycle that included key terminology, outputs, and important considerations (Diagram 2, top). These stages included:

Purpose:

- In advance of data collection or acquisition it is important to plan how the data will be collected, understand the context and scope of data collection, and to start working on a data management plan for the data. This can involve articulating a hypothesis, setting objectives, and understanding the scope and extent of data collection.
- Articulate the research question and define the strategy for data collection, analysis, and representation.
- Understand the management needs and the purpose behind data collection (e.g., curiosity, answering specific questions).
- It is advantageous to consider how one data collection could lead to multiple uses of the data and to plan for this from the beginning of a project.

Data management and acquisition planning:

- Define the scope and extent of data collection, ensuring high-quality acquisition.
- Assemble best practices and identify key collaborators, partners, and schedules.
- Ensure proper prioritization and a solid data acquisition plan.

Data and sample collection and acquisition:

- Gather raw data/samples, ensuring that collection is standardized and includes photos for context.
- Field conditions should be documented to supplement numerical data.

Data and sample processing and QA/QC:

- Organize, process, and conduct quality assurance/quality control (QA/QC) checks at various levels (0, 1, 2).
- Ensure full documentation of data processes and use of flags for erroneous data.

Data standardization:

- Standardization involves creating practices based on a wide range of projects and datasets to ensure consistency and interoperability across various data sources.
- Standardize data for consistency, compatibility, and accuracy, ensuring it is not ad-hoc but purpose-built to meet specific needs.
- Utilize controlled vocabularies and ontologies to ensure consistency and cross-cutting compatibility in datasets.
- While maintaining minimum standardization is acceptable due to rapid advancements in technology, it should align with existing standards and best practices across data centers.

Data curation:

- Curate and store data in appropriate formats, making it accessible for long-term use and ensuring reversibility of processed data.
- Implement proper data curation systems (e.g., Ocean Info Hub) and establish clear distinctions between raw and processed data.
- Proper data curation projects can become part of a sustainable and interoperable digital ecosystem

Initial data exploration and visualization (domain or technical users):

- Exploring and visualizing data can be used for different purposes (e.g., initial exploration or public presentation).
- It is important to define the purpose and anticipated audience of data exploration (products), such as whether it is to identify outliers or to visualize data for the general public or the research team (if visualization is for a general/non-domain user then see *Data visualization/use (by non-domain users)* below.
- For example, initial data exploration and visualizations for domain users can be used to identify appropriate modelling or analysis approaches or to provide a more general summary before more detailed analysis and modeling.
- Provide atlases or dashboards to visualize data effectively for different audiences.

Data analysis and modeling:

- Conduct data analysis before modeling, providing summaries and insights to guide further steps.
- Active feedback from colleagues enhances the sensemaking process, leading to more refined data.

Data serving:

- Data serving is crucial for ensuring the secure long-term archiving of information.
- Scientists should aim to serve up data through trusted sources, preferably with a user-friendly interface (depending on anticipated audience).
- Develop user-friendly interfaces for both technical and non-technical users.

Data archiving and digital preservation:

- Ensure data is securely archived and accessible
- Archive data in formats that support long-term preservation, including version control and metadata documentation.

- Provide accessible, well-documented data archives to ensure reproducibility.

Data publishing:

- Data publishing is vital for ensuring the long-term archival of data.
- Data publishing should result in making data more easily accessible and findable. For example, by providing a unique digital object identifier (DOI) or citation for the work and be published in a long term archive.
- Data published to repositories should be accessible through data portals.

Data visualization and use (by non-domain or non-technical users):

- Use charts, maps, and diverse visual formats to make complex data more understandable for various audiences.
- Provide clear, accessible tools like dashboards, infographics, factsheets, and interactive visualizations for easy data exploration and interaction.
- Consider language barriers and adjust presentations to ensure that data are effectively communicated to both technical and non-technical users.

Further important discussions on the stages & outputs of the ocean data lifecycle

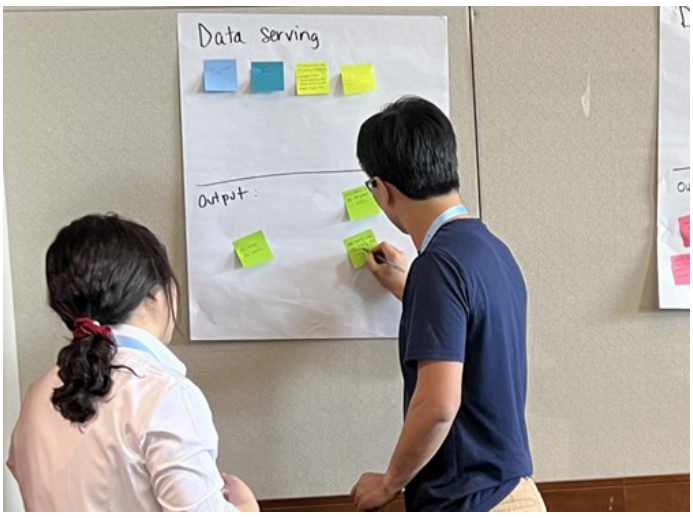
Some issues that stood out included differences in viewing the QA/QC process, with some participants outlining an iterative process with multiple levels (0, 1, 2) of QA/QC. Additionally, the data analysis/modeling stage was viewed by some as two separate stages, while the order of other stages like data serving may be better situated before or after analysis/modeling depending on the user and the data type.

Data standardization is viewed differently depending on the data type involved, and standards for particular data types need to be considered. Regardless, themes of standardizing for consistency, compatibility, and accuracy were important. Some data types are more easily standardized than others (i.e. oceanographic data from instrumentation versus fisheries data or eDNA data). Furthermore, some participants viewed data visualization as a step within the QA/QC portion of the workflow, while others saw it as part of the analysis/modeling and/or visualization and use.

Conclusions and Next Steps

Overall, given the range of backgrounds, cultures and familiarity with data management in ocean science, there were very productive conversations around the different stages and outputs that could be included in a conceptual framework, as well as discussions around key terminology, important considerations and practices, and cross-cutting themes that are applicable throughout the ocean data framework. Where our initial conceptual model included 7 stages (Diagram 1), our framework at the end of the workshop included 12 stages with insightful key terminology, outputs, and important considerations (Diagram 2).

This workshop was a step forward towards creating a shared framework for effective ocean data management, and agreeing upon general, shared terminology on the phrases that make up the framework. A future workshop (potentially at PICES-2025) will build upon this with the aim of refining the existing framework and discussing effective strategies and important considerations for managing and mobilizing diverse data types in ocean science. The 2025 workshop will aim to: 1) review and enhance the conceptual diagram developed in 2024 and 2) explore effective strategies and practical steps across the data lifecycle, considering the unique data management, integration, and mobilization challenges of various ocean data types, as well as metadata handling. Overall, this work aims to lay a foundation for improved data practices within and across PICES, the UN Ocean Decade, and the broader international marine science community.



Dr. Erin Satterthwaite is the California Cooperative Oceanic Fisheries Investigations (CalCOFI) Coordinator with California Sea Grant at Scripps Institution of Oceanography. She conducts research relevant to sustainable marine resources in the context of a changing climate and engages with key stakeholders within California, nationally, and internationally within the North Pacific. She is a marine ecologist who works at the interface of use-inspired marine research, policy engagement, and science communication to advance ocean knowledge for sustainability. She is interested in ocean sustainability issues related to marine biodiversity, fisheries and mariculture, social-ecological systems, citizen science, and ecosystem oceanography. She is currently supporting initiatives to include underrepresented voices – such as early career professionals – into global policy processes, to coordinate biological ocean observations in support of the Global Ocean Observing System, and is utilizing environmental DNA to better understand biodiversity patterns in the California Current.

Jeanette Gann is an oceanographer with the Ecosystem Monitoring and Assessment (EMA) program at the Alaska Fisheries Science Center (AFSC) in Juneau, Alaska with more than 15 years of experience working in Alaska's large marine ecosystems (LMEs). Her focus is on phytoplankton ecology and bottom-up processes in the Bering Sea and Gulf of Alaska via fisheries-oceanographic surveys. She is the current chair of the PICES Technical Committee on Data Exchange, is a member of PICES working group 52 on DATA, and previously worked as a member of the IODE sponsored Ocean Data and Information Group (DIG) as part of the UN Ocean Decade.

Naomi Boon is a Project Manager at the Tula Foundation, based in Victoria, B.C., Canada. She manages a wide range of projects with a focus on coastal science in British Columbia, and coordinates workshops and scientific trainings led by the Hakai Institute. Naomi has extensive experience with ocean data management and is passionate about developing data training for Early Career Ocean Professionals (ECOPs). She has a MSc International Development Studies and a BSc Marine Biology from the University of St Andrews.

Tim Van Der Stap
I am a Scientific Data Specialist at the Hakai Institute (Campbell River, Canada). I am passionate about open science and making data - particularly biodiversity data - available and accessible. At the Hakai Institute we conduct research on the coastal margin of British Columbia, collecting a wide range of complex data, such as geospatial, oceanographic, genomic, and nearshore taxonomic data. I am involved in our institutional data management and mobilization practices, which includes developing data pipelines for a range of data types, fostering a culture of strong scientific data management documentation, maintaining our Hakai Catalogue, and keeping up-to-date with the latest data and metadata standards and best practices, with a particular focus towards standardizing marine biodiversity data to Darwin Core.

Wave at sunrise
Credit: Thomas Horig/Ocean Image Bank

PICES 2024 Session and Workshop Reports

W7 - Integrating biological research, fisheries science and management of flatfish species in the North Pacific Ocean in the face of climate and environmental variability

Josep Planas (corresponding; USA), Mackenzie Mazur (Canada), Naoki Tojo (Japan), and Roman Novikov (Russia)

Background

The North Pacific Ocean is a large and productive ecosystem that supports a number of fish species of great ecological, cultural, and economic importance and is characterized by strong interdecadal climate variability. To address important current topics related to the biology, ecology, and, management of flatfish species in the North Pacific Ocean, three Fishery Science Committee (FIS) Workshops have taken place in previous PICES Annual Meetings (in 2019, 2022 and 2023) to bring together researchers, scientists, and managers from countries that are invested in these resources. An important outcome of these workshops was recognizing the need to enhance the application of integrative approaches to improve our understanding of the biology and management of widely distributed species, such as Pacific halibut, in the North Pacific Ocean. This requires a high level of international cooperation. Therefore, to achieve these goals and as a step forward in addressing key areas of cooperation between PICES and the International Pacific Halibut Commission (IPHC) as described in the renewed MoU between the two organizations, a fourth flatfish Workshop took place at the 2024 PICES Annual Meeting (W7) to address emerging issues in key flatfish species with broad distribution across the entire North Pacific Ocean. The theme of this workshop focused on: 1) developing strategies for data sharing regarding fishing efforts and the management of flatfish species across the North Pacific Ocean, and 2) promoting international collaborative studies to enhance our understanding of the movement of flatfish populations and potential changes in their distribution, along with other interacting species, in the context of climate variability.

Summary

This half-day Workshop (W7) was held on October 26, 2024. The session was opened by the corresponding convenor Dr. Josep Planas who welcomed the participants and provided a brief introduction to the Workshop. The session featured one invited speaker and four other oral presentations. The various presentations covered topics related to climate impacts on productivity and recruitment relative to fish populations, including flatfish, (Ma, English), biomass and distribution data (e.g. fishery-independent surveys), inputs to fisheries management (Ciannelli, Pan), and importance of revised maturity schedules in stock assessment of a key flatfish species (Planas).

After the presentations, a brief discussion session took place among Workshop participants. Discussion topics included the importance of continued monitoring efforts in collecting environmental data, fishery-independent data (e.g., surveys), and fishery-dependent data to improve our current understanding of the impacts of climate change on flatfish populations and implications for fisheries management. The need for establishing working international collaborations among North Pacific rim countries to improve available information on connectivity and distribution changes of flatfish species in the face of climate change was also discussed. The session ended with support from participants for the submitted proposal of a fifth Workshop to be held at the 2025 PICES Annual Meeting in Yokohama, Japan.

Invited Speaker

Dr. Shuyang Ma (Institute of Marine Research, Bergen, Norway)

Agenda for Workshop 7

14:00-14:10 Welcome and Introduction to the Workshop

14:10-14:40 Invited Speaker: *How to explore climate-induced fish population dynamics? – conceptual frameworks and statistical advancements.* – Dr. Shuyang Ma, Institute of Marine Research, Bergen, Norway.

14:40–15:00 Oral Communication: *Can nearshore surveys improve management of flatfishes with coastal habitat dependencies?* – Dr. Lorenzo Ciannelli, Oregon State University, Corvallis, Oregon, USA (PRE-RECORDED).

15:00-15:20 Oral Communication: *How are environmental conditions influencing productivity of Petrale Sole in Canada?* – Dr. Philina English, Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada.

15:20-15:40 Coffee Break

15:40–16:00 Oral Communication: *Non-Linear Catchability and Optimal Fisheries Management Target.* – Dr. Minling Pan, NOAA Pacific Islands Fisheries Science Center, Honolulu, Hawaii, USA.

16:00-16:20 Oral Communication: *Spatial characterization of histology-based maturity estimates for female Pacific halibut in the Northeastern Pacific Ocean.* – Dr. Josep Planas, International Pacific Halibut Commission, Seattle, Washington, USA.

16:20-16:40 Discussion

PICES 2024 Session and Workshop Reports

W8 - Science Jam: Bridging the gap between science and social media to communicate PICES accomplishments with the world

Advisory Panel on Science Communications (AP-SciCom)

Convenors

Natsuko Nakayama (Japan), corresponding
Hannah Lachance (USA)
Tammy Norgard (Canada)
Raphael Roman (Canada)
Vera L. Trainer (USA)
Sayaka Sogawa (Japan)
Devon Warawa (PICES Secretariat)
Phoebe Woodworth-Jefcoats (USA)

Background

Scientists are increasingly aiming to communicate their research to a broader audience, encompassing both interdisciplinary scientists as well as non-scientists, such as the general public, stakeholders, policymakers, and resource managers. Effectively engaging this wider audience requires the science community to communicate beyond traditional scientific formats such as conference talks, poster sessions, and journal publications. Therefore, one of the goals of PICES Advisory Panel on Science Communications (AP-SciCom) is to provide PICES members with training on communication tools, methods, and channels that will facilitate better sharing of scientific knowledge between scientists and non-scientists, as well as between scientists alike.

Past science communication workshops organized by AP-SciCom at PICES Annual Meetings have focused on video creation (2021), using the "And, But, Therefore" approach to structure science stories (2022), and fact sheet development (2023). To give PICES members further support on developing these methods, AP-SciCom held several mini workshops that revisited some of those topics as well as explored the world of social media in science.

Workshop Overview

W8 "Science Jam" was held over three 30 minute morning coffee breaks. Attendees were invited to the workshop room during break, along with their coffee/tea/snacks, to learn about a specific science communication topic each day. The topics covered include:

Session 1: Science Communication and the "ABT" method (Oct. 29)

Session 2: Fact sheets (Oct. 30)

Session 3: Social media (Oct. 31)

Each session started with a short presentation, followed by a participant activity, and time for discussion at the end. There was an average of about 20 participants at each session. Participants asked questions actively at each session and contributed to the end discussion by sharing personal experiences, diving deeper into questions, and brainstorming ideas.

Session 1: Science Communication and the "ABT" Method

In the first session, we started with an overview of past PICES science communication activities, before delving into a refresher on the powerful story telling structure called "And, But, Therefore (ABT)". The ABT storytelling structure was developed by a marine scientist turned filmmaker, Andy Olson, in his book "Huston, we have a narrative". It is an effective way to communicate in an engaging and compelling way, by drawing connections between different parts of the information. Scientists tend to communicate by listing all the details, data, and results on top of each other. This turns into an "and, and, and" structure that our brains are less likely to engage with. Using this narrative structure can help scientists deliver their knowledge and research in a way that any audience; including the public, policy makers, and even other scientists; is more likely to understand, retain, and act on.

After the presentation, workshop organizers used their own research to provide examples of the ABT structure. Then participants had opportunity to create a narrative for their research. Workshop facilitators walked around to answer questions and participants were invited to share their ABT narrative with the group.

Session 2: Fact Sheets

The second session focused on using "fact sheets" as a science communication product. At PICES-2023, AP-SciCom organized a larger workshop on fact sheets, where much more detailed information and training was provided (See workshop report in PICES Press Winter 2024

edition). The objective was to give PICES members a tool to advertise and share PICES science, with the goal of creating a fact sheet for each of PICES expert groups. This year's workshop provided PICES members another opportunity to learn more about them, ask questions, and get individual support from the PICES communication team.

The main purpose of the fact sheet is to communicate Expert Group key points in a consistent, clear, and concise format, and connect the reader to find more information. They can be used to effectively communicate the work of Expert Groups to a variety of audiences that PICES needs to engage, and increase organizational recognition about the value and relevance of scientific work being conducted under PICES. They also provide a simple way to communicate PICES science to potential collaborators and aid them in identifying with which Expert Groups they are most closely aligned, while at the same time sparking interest and encouraging them to ask for more information. PICES fact sheets will be published on the PICES website, under Publications.

The revised fact sheet template used in this year's workshop is available for all PICES members to use on the AP-SciCom page of the PICES website, under Products. The current version is an Adobe fillable form, which simplifies the process and streamlines consistent formatting (Figure 1a). The main sections include: 1) Introduction, 2) The Issues, 3) Current work. The "More Information" section is also important so the reader can easily learn more, find related resources, and know who to contact. As an example, AP-SciCom created a fact sheet for PICES as an organization (Figure 1b), which was also presented at the poster session.

After the overview presentation, participants were given fact sheet template handouts and time to start creating their own. There was also time for discussion and questions. Using fact sheets as a communication tool was well received by participants, especially when provided with a simple and structured template.

Session 3: Social Media

The last session focused on using social media as a channel for science communication. Social media can be used, among many things, to spread your research more widely to have a greater impact; build collaborations with other scientists; or keep updated with current research. We looked at some of the research done on using social media as a platform for science, such as the impact it can have on spreading awareness. Social media research also looks at the dynamics and trends of different social media networks, which can be helpful in choosing which to share your research on.

We gave a short overview of some networks, starting with the ones PICES currently uses. This includes Youtube, X (formerly Twitter), Facebook, and Linkedin. Each of these differ in terms of their general audience and the format content is produced in (eg. Video content on YouTube versus short written text on X). While these platforms are available and used widely in North America, Raphael

Figure 1. Fact Sheet resources: **(A)** Fact sheet template and **(B)** PICES Fact sheet that was provided as an example and presented as a poster in the poster session.

Roman described platforms that are more commonly used in Asia, including KakaoTalk, LINE, WhatsApp, WeChat and Weibo. We noted that social media trends change rapidly and that focusing on recent research and information that will best reflect the current state of social media. As an example, PICES started an account on Blue Sky shortly after this workshop.

After the presentation, participants had the opportunity to practice making their own social media post. Each participant was asked to choose a platform of their choice to post on and choose one of the two prompts provided to create a post about: Option 1 – "PICES members research highlights" (describe your own research in 3 sentences or less) or Option 2 – "PICES-2024 takeaways" (describe a key point you will take home from PICES 2024). Participants had the option to use their own existing social media accounts or have the facilitator post on their behalf via the PICES account. During the activity workshop organizers were available to answer questions and facilitate discussion.

To get a sense of what participants preferences are, we displayed a Slido Poll asking "What is your preferred Social Media Platform for following PICES"? We had responses from 13 participants, out of the 15 present, who could choose one or more from the list of platform options (Figure 2). YouTube had the greatest number of votes, followed by X and Linkedin.

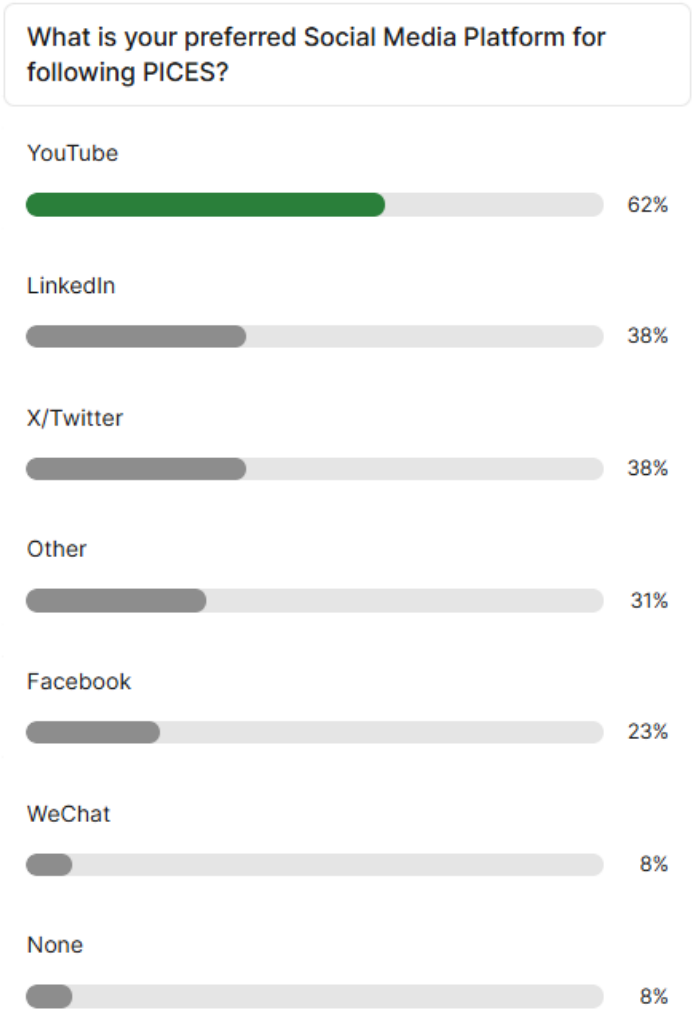
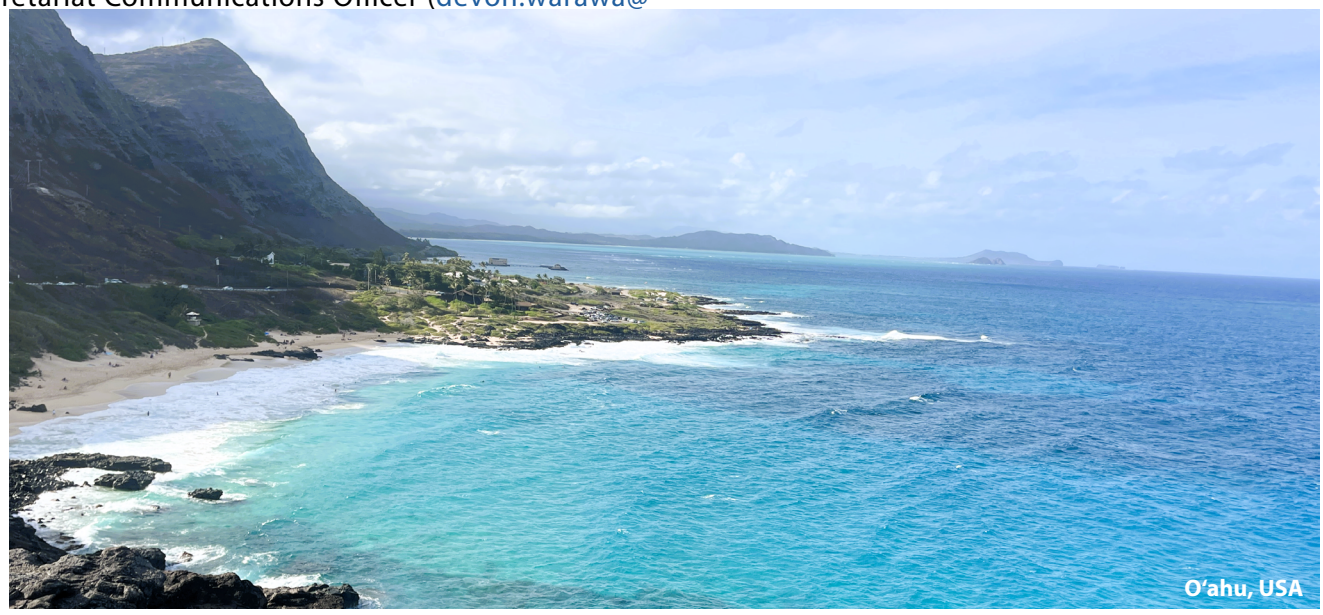


Figure 2. Results of a Social Media Survey of workshop participants preferred social media platform for following PICES.

Conclusions

A recurring theme throughout PICES-2024 was the importance of science communication. Many workshop participants expressed a keen interest in building their science communication skill set and gave positive feedback about the workshop. AP-SciCom is here to continue providing the PICES community with science communication skills, tools, and resources needed. Please contact AP-SciCom (https://meetings.pices.int/members/advisory-panels/AP-SciCom) or Devon, the PICES Secretariat Communications Officer (devon.warawa@pices.int), for any ideas or request for communication support.


O'ahu, USA

PICES-2024 Reports

Basin Scale Events & Coastal Impacts (BECI) Workshop Report

Kathryn Berry, Viv Tulloch, Kirsten Holsman, Phoebe Woodworth-Jefcoats

Introduction

Predicting marine ecosystem and species responses to climate change is not easy and presents significant methodological challenges. Current modelling approaches and the robustness of their predictions is variable due to selection of climate models, future emissions scenarios, differences in climate information integration by ecological models, and structural differences in ecosystem model configurations. This uncertainty and variability is inherent within the estimation and prediction of climate change impacts, how they will be distributed, and how they will vary across species and fisheries and constrain our ability to make robust decisions.

While still in the planning stages of its work, the Basin Scale Events & Coastal Impacts (BECI) project convened a workshop on October 26, 2024, as part of the PICES Annual Meeting, to address some of the issues constraining our ability to understand and manage climate impacts in the North Pacific. The BECI workshop had four objectives:

1. **Community:** to bring together scientists with existing work or work-in-progress related to ecosystem, biophysical, and multi-species marine modelling approaches in the North Pacific which include, or have the capacity to include, fisheries and climate/environmental drivers;
2. **Knowledge:** to better understand existing efforts in the North Pacific to model regional marine ecosystems in a changing climate;
3. **Tools:** to review different models and assess their candidacy for inclusion in a proposed North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME), a key BECI initiative, and develop potential approaches for building out the NOMEME;
4. **Future:** to scope some of the challenges and opportunities associated with moving forward with ecosystem-scale research pertaining to climate change and fisheries management in the North Pacific.

Representatives from all six PICES member countries (Japan, China, Korea, Russia, USA, and Canada) attended the workshop, including representatives from Regional Fisheries Management Organizations (RFMOs) as well as modellers of oceanographic systems, marine ecosystems, and fisheries (see list of attendees at the end of this article). The workshop began with an introduction to the BECI project, followed by two invited speakers: Kirstin Holsman (Alaska Fisheries Science Center, NOAA) and Phoebe Woodworth-Jefcoats (Pacific Islands Fisheries Science Center, NOAA).

Setting the Context: Basin-Scale Events & Coastal Impacts (BECI)

The BECI project was co-developed by PICES and the North Pacific Anadromous Fish Commission (NPAFC) and is endorsed by the United Nations Decade of Ocean Science. PICES provides administrative hosting for the project, which is currently funded by the BC Salmon Restoration and Innovation Fund. BECI is focused on better understanding the impacts of climate change, which is significantly impacting the world's oceans and marine resources, including exploitable fish stocks across the North Pacific. BECI's overarching goal is to support ocean and coastal management under increasing climate variability by providing future-focused decision support based on advanced transboundary ocean and climate change science. There is a need to coordinate international efforts across the North Pacific to assess biological impacts of climate-driven changes to future marine resources, particularly for transboundary species and common fishery resources. BECI will build on the existing international partnerships of PICES and NPAFC to bring people together to work as a collective. Because the North Pacific is so large, BECI is strategically focused on fishes and regions of interest and hopes to launch coordinated working groups to enhance scientific progress and collaboration on issues that extend beyond areas of national jurisdiction.

BECI's first three initiatives are focused on modelling and data integration:

1. The North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) - the focus of the October 26th workshop;
2. Ensemble models of salmon scenarios to inform fisheries management and conservation of linked species of concern;
3. The North Pacific Ocean Integrated Information System (NPOISS), a framework for a federated and integrated information system to bring together environmental, climate, and fisheries data from across the North Pacific, including all six PICES member states.

All three initiatives aim to improve data sharing capacity and collaborative efforts, enhance the interoperability of diverse data sets, enable scientific synthesis, and make robust scientific predictions about the state of the North Pacific Ocean and the critical fisheries species who call it home. The outputs of BECI will support a variety of on-going projects, including enabling and supporting PICES annual ecosystem status reporting and strengthening engagement with and collaboration between PICES scientists, projects, and working groups.

Setting the Context: North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME)

Viv Tulloch, BECI's Modelling lead, spoke about the NOMEME initiative, the need for greater certainty in the face of climate change, as well as some of the ways the BECI team is proposing to move forward with this work in the next few years. Multi-model or ensemble approaches can reduce uncertainty and improve reliability of predictions. The NOMEME that has been proposed will combine multiple disparate marine ecosystem models (MEMs) linked to climate drivers, to help support and guide fisheries management decisions under uncertainty. This builds on work currently underway by colleagues in the global Fisheries and Marine Ecosystem Model Intercomparison Project (Fish-MIP), and the National Oceanic and Atmospheric Administration's (NOAA) Climate Ecosystems and Fisheries Initiative (CEFI), to reduce the uncertainty around some climate-ready fisheries decision making. A stepwise approach was proposed for the NOMEME for bringing together the regional models across the North Pacific, increasing in complexity and capacity/resource needs. The three stages include:

Stage 1 – Cross-regional comparison of existing regional models to inform common broad ecological indicators.

Stage 2 - Update/develop new models and ensembles addressing research needs and knowledge gaps; rigorous historical model calibration, standardised inputs, and model evaluation to address uncertainty (as per Fish-MIP, CEFI, the Alaska Climate Integrated Modeling Project (ACLIM), and the Gulf of Alaska Climate Integrated Modeling Project (GOA-CLIM).

Stage 3 - Management strategy evaluation/scenarios of alternative futures.

Tulloch explored the ways BECI proposes to help with decision-making in the North Pacific ecosystems and fisheries by following principles of decision science to reduce as much uncertainty as possible. One way to think about the work that BECI proposes is as a toolkit that addresses the needs, values, and concerns at regional scales, with relatively standardised approaches, so that a basin-scale understanding is possible. Starting from clear objectives articulated by collaborators, partners, and decision-makers, such as RFMOs in the region, we can help coordinate efforts and build a suite of tools to help answer key questions and provide information to help guide and support decision-making.

Setting the Context: Building on Other Collaborative Initiatives – CEFI and FishMIP

NOAA's Climate Ecosystems and Fisheries Initiative (CEFI)

Kirstin Holsman spoke next about NOAA's Climate Ecosystems and Fisheries Initiative (CEFI), a US-wide initiative to develop climate-ready ecosystems and fisheries advice. CEFI is comprised of four connected decision-support pillars: a suite of robust forecasts and projections of ocean conditions for use in developing climate-informed advice; the operational capacity to assess risks, evaluate options, and provide advice on adaptation to changing conditions; increasing decision-maker capacity to use climate-informed advice to reduce risks and increase resilience of marine resources and the communities that depend on them; and validation and innovation through continuous observations and research. Each of these pillars is focused regionally to provide culturally specific information and advice to those who need it most in a rapidly changing world.

NOAA's Alaska Fisheries Science Center leads the regional CEFI work in the North Pacific, specifically building on the work of ACLIM and GOACLIM projects, which aim to inform Alaskans about the risks of climate change, especially on fish and fisheries, and enable the evaluation of a range of adaptation strategies. The experience of the snow crab collapse was sudden and destabilizing in Alaskan communities and it is hoped that the increased funding for CEFI provided via the Inflation Reduction Act will help provide necessary and timely climate-ready advice to help avoid similar losses in the future.

Community engagement has been a hallmark of this work in Alaska, so that communities, decision-makers, fishers, Alaska Native Tribes, and other stakeholders had appropriate culturally sensitive information to guide their decisions about marine ecosystem health and population abundance of key species that are relevant economically and culturally, and that climate advice is well-matched to the needs of the community. Multiple types of scenario planning are investigated, including quantitative, operational or event driven, goal-oriented or normative, and strategic management scenarios, allowing for specific advice to be developed from modelling. Of resonance to BECI's goals is the work happening to better understand the impacts of climate change on salmon and the communities that depend on the Yukon River. It incorporates both scientific and traditional ways of knowing about the Yukon River Drainage system to deliver culturally competent scientific advice and predictions.

Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP)

Phoebe Woodworth-Jefcoats was the final invited speaker, and discussed her work with the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP), an international collaboration of ecosystem modellers working to bring together diverse MEMs to better understand and project the long-term impacts of climate change on fisheries and marine ecosystems. Phoebe summarized the work of the FishMIP project in the North Pacific. FishMIP utilizes an ensemble modelling approach to compare the results of multiple ecosystem models when those models are forced by a standard group of environmental and climate inputs and simple fishing scenarios. Marine ecosystem models can vary widely in what ecosystem components are represented and linked

together. Comparing the results when those models are forced by standard drivers and scenarios can help elucidate differences, strengths, and weaknesses of various models in specific scenarios and regions. Currently, FishMIP is running simulation experiments to evaluate how well models detect past ecosystem and fisheries changes. FishMIP is part of the Intersectoral Impact Model Intercomparison Project (ISIMIP), which offers a framework for comparing how models from diverse sectors and scientific disciplines respond to standard climate forcing and scenarios. The environmental and climate forcing data that FishMIP modellers use in their comparisons is freely available from the ISIMIP platform, as well as from FishMIP modellers directly. Additional collaborators and modellers are invited to join this effort, which has already demonstrated success in informing policy and management (Blanchard and Novaglio, 2024).

Discussion

Discussion during the workshop was open and free-flowing, allowing participants opportunities to share their knowledge and experience and learn from one another. Members of the BECI project team took notes during these discussions and the following is a summary of some of the key themes that were discussed throughout the workshop.

Fisheries Species of Interest

Important fished species in the North Pacific mentioned by the participants included Pacific salmon (*Oncorhynchus* spp.), Pacific halibut (*Hippoglossus stenolepis*), Pacific hake (*Merluccius productus*), Pacific bluefin tuna (*Thunnus orientalis*), Japanese and Pacific sardine (*Sardinops spp.*), and Pacific saury (*Cololabis saira*). These species vary regionally in their importance (e.g. between the Northeast and Northwest Pacific), but all face transboundary issues and have at least some reliance on open ocean environments, making them good focal species for BECI.

Pacific salmon are significant species of interest in the North Pacific and have a complex, anadromous life history. Since salmon stock assessments are conducted for individual stocks, it was suggested by some participants that regional or basin-scale approaches may be too large in scale and that approaches to understanding salmon dynamics based on individual stocks, populations, or conservation/management units should be considered. Other participants noted a range of conservation and management actions that can be informed using ecosystem models, not simply stock assessments, and highlighted the need for ecosystem-scale research to adequately understand salmon ecology and apply an Ecosystem

Figure 1. Workshop presenters and attendees

Approach to Fisheries Management (EAFM). Salmon are complex to research and to model appropriately, as they have both freshwater and saltwater components in their life histories and, while well studied in coastal ecosystems, much less is known about the fate of salmon in the open ocean beyond boundaries of national jurisdiction.

Participants agreed that sardines (*Sardinops* spp.) might also be an important fisheries group across the North Pacific. Japanese sardine (*S. melanostictus*) is an important fished species in Japan and was also recently detected off the West Coast of the United States. Pacific sardine (*S. sagax*) is of interest to fisheries in Canada (British Columbia), the USA (especially California), and Mexico (Baja California). This might help to make further north-south and east-west connections among models, as well as increasing collaborations between modelling communities and decision-makers along the California Current and on either side of the Pacific. Pacific saury are also very important to fisheries in the Western Pacific, and they are known to occur offshore in the Eastern Pacific (e.g., the southern Gulf of Alaska), but much less is known about their fate in the Northeastern Pacific because they are not commercially valuable there. Participants suggested that surveying and modelling Pacific saury might provide key insights into forage fish populations and predator-prey dynamics across the Pacific.

Scale: Basin Scale and Regional Approaches

While individual stock assessments and models are mostly adequate for their purposes, there is little existing work to connect local/individual stock assessments and models into wider analyses at the scale at which many species are distributed, as well as the scales at which climate change is operating and affecting marine environments and species. Transboundary research, and work to fill the gaps between population-level assessments and connect individual ecosystem models, will increase in importance in the coming years. There is a need to better include, understand, and assess data for both stock assessment and environmental indicators beyond boundaries of national jurisdiction.

Transboundary Fish Populations

Participants acknowledged that there are real gaps in understanding the movement and population structure of transboundary fish populations and in modelling them accurately across the North Pacific Basin. They discussed ways that BECI might be able to contribute to solving some of those issues. The complexity of salmon life histories, combined with the siloed data repositories and non-standardized data and models across the North Pacific nations, means that while we know that salmon are moving across the boundaries of national jurisdictions, and into new niches they had not previously exploited, it is difficult to make decisions based on the patchwork of data and models that are available. There is a mismatch between the scales of climate change, the scales at which species are distributed and moving, the scales and scope of current modelling efforts, and the scales at which managers need information and are making decisions. This will require a concerted and collaborative effort across nations and management agencies to improve and resolve. Participants highlighted a clear need to connect relevant researchers along the eastern North Pacific to address these challenges.

For many species, coordination of regional modelling work would be critical to inform knowledge gaps and management questions. Several participants shared about the difficulties collaborating internationally for several reasons, including present geopolitical situations, differences in management frameworks, international policies, and a lack of data sharing. As a result, decisions are made to manage fisheries at a national level when only part of the story is known. Although ecosystem models are ideal for addressing these issues, it was suggested that even sharing or obtaining better biological data on species abundance and distribution between the Northwest and Northeast Pacific would be very useful for management, especially in the case of transboundary species such as halibut. Currently, it is hoped that genomics work will help to better understand the size and extent of halibut populations in the Western Pacific, but this information is a real gap in current management practices.

Time Scales of Interest

Representatives from RFMOs participating in the workshop were asked about the time scales that are relevant for their management decision processes. For halibut management, the actionable or tactical advice period would be useful in three-year horizons, while strategic advice is considered over a longer term - up to 100 years of prediction of halibut populations can be useful for management processes.

Pacific Salmon Treaty negotiations occur every nine years. Fisheries stocks and environmental conditions are changing faster than our management processes and both the USA and Canada need to better understand the implications of changing environmental conditions. If the countries involved understood the future of fisheries in the North Pacific, then negotiations would be more meaningful. Without that clear picture of the future, countries are negotiating without really understanding what they are fighting for. In that sense, advice fit for long-term management strategy is useful as far out as can be accurately predicted.

Participants raised that the decadal scale might be useful to inform both fisheries management and to understand and predict regime shifts and tipping points. This is especially the case when understanding interactions with competitor, predator, or prey species for the target fishery populations. An example was given by a participant about the length of sardine booms. The length of time that the sardine population booms and then recedes in the North Pacific might be a helpful signal to predict as it may allow for better understanding or prediction of fish density and predator-prey dynamics. Further, participants agreed that predictions on the scale of the next 10-20 years are of particular interest: global predictions have

long suggested a pause or change in the rate of warming in the North Pacific, but that has not been observed in all locations across the North Pacific. A better, more precise, understanding of the rates of change in the North Pacific Ocean would be helpful.

A participant shared that in their work engaging coastal communities there is less interest in long-term predictions, which are more difficult for community groups to contemplate. Indigenous communities are wanting short-term advice and predictions about fisheries stocks, as well as hyper-local or downscaled advice. For these audiences and end-users, basin-scale and long-term information and advice is helpful to understand, but less useful operationally.

Data Integration

There is a need for data integration across the North Pacific to make any modelling endeavor work. Currently data is a patchwork, especially beyond borders of national jurisdiction. If starting from an ensemble of regional models in the Northeast Pacific, there will be a real need to understand data availability to parameterize and force models in the Western Pacific to ensure accuracy across the basin. Participants also discussed the lack of data standardization even across regions in the Northeast Pacific: Alaska is especially data rich, and NOAA makes all its data publicly accessible, but there may be differences across states and the USA-Canadian border. Canadian First Nations, Alaska Native Tribes, and other Indigenous communities own their own data and may be willing to share some access to data for specific questions but may not be willing to make that data publicly accessible, or even accessible to managers and scientists within a federated framework. Participants agreed that there are methods to employ in order to solve some of these challenges, however.

Vancouver Island
Photo by Valesca de Groot

Currently, RFMOs are managing transboundary fish species, making do with the data they have available. Accessing data from other countries and from beyond areas of national jurisdiction would be helpful, as currently only a patchwork of data from the open ocean is available. A participant described this as trying to explain the plot of a story while only reading alternate chapters. Another BECI initiative is to develop a framework for a North Pacific Ocean Integrated Information System, so BECI will hopefully be able to support data integration in the future. Participants agreed that if a project affiliated with PICES takes this on, it may have salutary benefits for the PICES community.

Modelling Approaches and Drivers

Participants discussed some of the attributes of different global climate models that can be used as drivers for the NOMEME model ensemble. The relevance, suitability, and utility of using global climate model outputs for the North Pacific versus waiting for downscaled high-resolution outputs (in development by CEFI) were discussed, as well as the need for standardised environmental inputs across ecosystem models to enable adequate comparison of outputs. One participant suggested that it might be less important to get the specific environmental drivers all matching correctly, and more important to get the ecosystem relationships and structure of the food web right. This is where ensemble methods will play a key role. Participants discussed some needs around better interconnection between different models, modelling communities, and even breaking silos among researchers. For complex salmon life cycles, there is a real need to connect the freshwater (estuarine and river) models and marine models of salmon stocks. Some participants thought that this might be useful, even for marine-only species (such as saury, halibut, and hake) because it might lead to better understanding of riverine and estuarine inputs into the coastal ocean and how these mediate open ocean signals. There is plenty of great estuarine and river modelling happening for salmon across the Northeast Pacific, but the models do not all "talk to each other" nor do the researchers working on them. Additionally, participants agreed that there were more models needed to predict and understand salmon dynamics in the open ocean basin, as opposed to in the coastal ocean, shelf and slope, which are better studied.

Collaboration

Discussions throughout the workshop concluded that there is a plethora of models to build a model ensemble from in the Northeast Pacific, and that this would be a good first step towards thinking about building a model ensemble for the whole of the North Pacific. It was also suggested that BECI's work in building a NOMEME can identify gaps where more specific models might be necessary or useful. The information gained from a well-executed model ensemble in the Northeast Pacific can also be utilized to determine where the next efforts should be made to improve data or models, or which knowledge

gaps need to be better understood to improve future work. Participants agreed that the NOMEME should not attempt to reinvent the wheel, but rather to lean on existing networks and communities of researchers to join in a large-scale collaboration.

For BECI to succeed, the team will need to build effective working groups and collaborations to contribute to the end goals. Participants shared some ideas about how BECI might incentivize collaboration, including ensuring that collaborator's needs and time are respected, that the collaborators have opportunities to raise their own profiles both within the collaboration and in the wider scientific community, and that the collaborators involved understand and agree to be accountable to each other. The urgency to understand climate change's impact on North Pacific fisheries may accelerate these collaborations. Participants agreed that climate change's significant effects on fish survival and marine resource-dependent communities provide strong motivation for this work. As one participant stated, we have already seen the snow crab and Atlantic cod fisheries collapse. We are now past the 'nice to know' phase and into the 'need to know' phase.

Workshop outcomes and next steps

A key goal of the workshop was to bring together the community of ecosystem modellers in the North Pacific who were attending the PICES Annual Meeting. Workshop participants were encouraged to review and contribute to a working draft database that summarizes recent ecosystem models across the North Pacific that include fisheries management and/or have the capacity to include climatic drivers. A map detailing the spread of these ecosystem models across the North Pacific Ocean was generated after the workshop, identifying some of the spatial overlap and gaps in ecosystem modelling efforts to date (Figure. 2).

This map and the models represented therein will be used to guide and inform next steps of the project, including choice of focal region and species for a pilot regional NOMEME protocol. We are continuing to engage with modelers, researchers and practitioners working in the North Pacific on ecosystem-scale problems relating to fisheries and climate change. A virtual discussion group will be initiated in early 2025 bringing together these modelers, researchers and practitioners to advance the

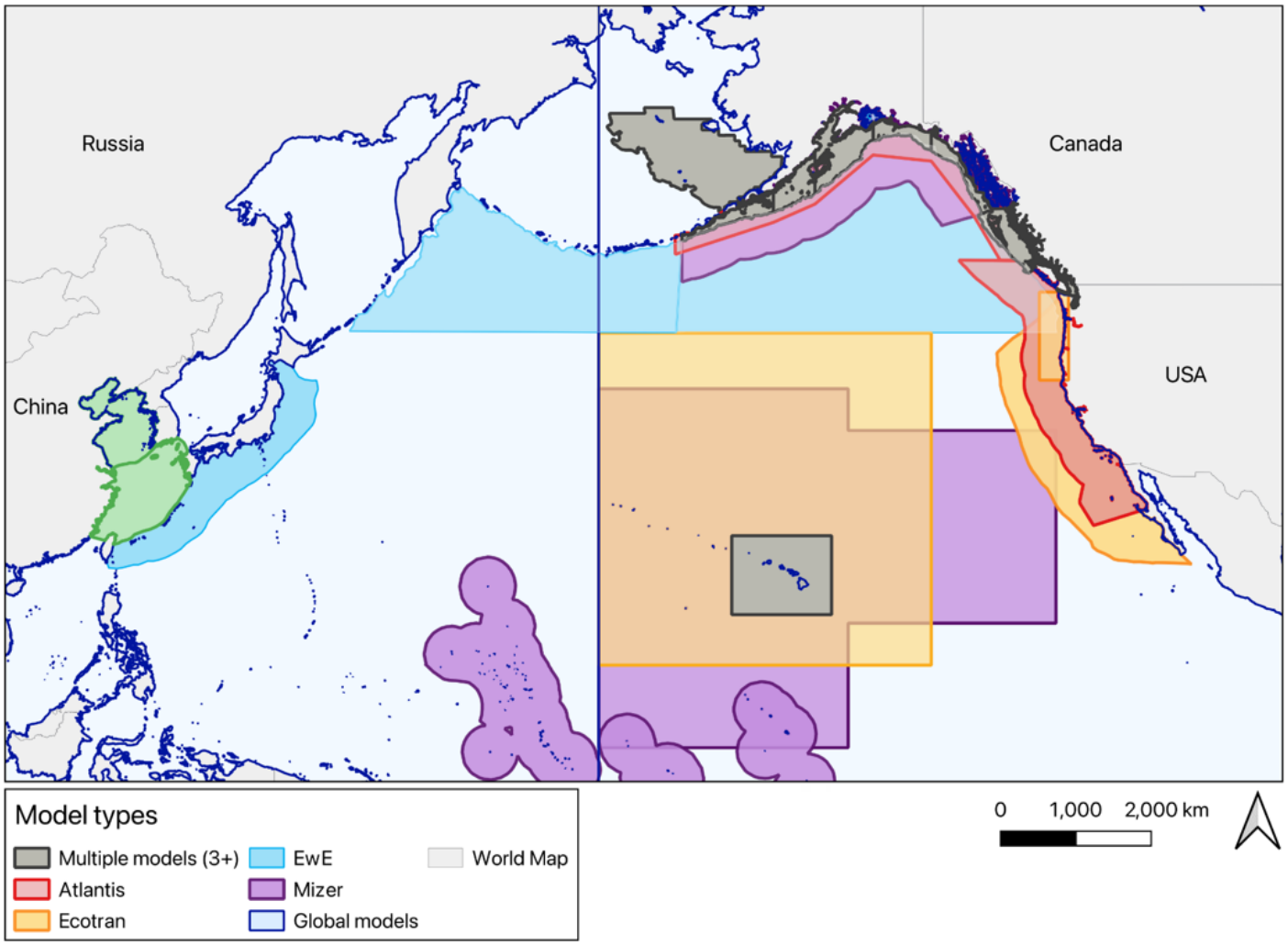


Figure 2. Known regional marine ecosystem models in the North Pacific suitable for inclusion in the proposed model ensembles (references for models included here are available by request and are not listed here due to space limitations).

BECI initiatives, including building out the NOMEME protocol for the east Pacific, with eventual expansion to the west Pacific region.

Conclusion

The BECI project represents a critical and collaborative effort to address the urgent challenges facing North Pacific marine ecosystems in the era of climate change. By bringing together scientists from all nations within PICES, the project is already helping to build a community focused on ecosystem-scale insights and solutions for fisheries management and conservation. The North Pacific Ocean Marine Ecosystem Model Ensemble (NOMEME) is not just a technical endeavor, but a strategic approach to understanding transboundary fish populations, reducing uncertainty in climate predictions, and supporting decision-makers across different regions and communities. As the project moves forward, its success will depend on continued collaboration, data integration, and a shared commitment to addressing the profound environmental changes transforming marine ecosystems. With the urgency underscored by recent fisheries collapses and rapid climate shifts, BECI's work transitions marine science from a "nice to know" to a "need to know" phase, offering hope for more informed and adaptive management of our precious marine resources.

References

Blanchard, J.L. and Novaglio, C., eds. 2024. Climate change risks to marine ecosystems and fisheries –Projections to 2100 from the Fisheries and Marine Ecosystem Model Intercomparison Project. FAO Fisheries and Aquaculture Technical Paper, No. 707. Rome, FAO. https://doi.org/10.4060/cd1379en

NB – references for models included in Figure 2 are available by request and are not included here due to space limitations.

Workshop Participants

Name	Affiliation	Country
Kathryn Berry	BECI, Science Director	Canada
Viv Tulloch	BECI, Project Scientist	Canada
Kathryn Sheps	BECI, Engagement Lead	Canada
Phoebe Woodworth-Jefcoats	NOAA Pacific Islands Fisheries Science Center	USA
Kirstin Holsman	NOAA Alaska Fisheries Science Center	USA
Jim Ruzicka	NOAA Northwest Fisheries Science Center	USA
Isaac Kaplan	NOAA Northwest Fisheries Science Center	USA
Szymon Surma	Institute for Oceans and Fisheries, UBC	Canada
Cheryl Barnes	Oregon State University	USA
Jon Reum	NOAA Alaska Fisheries Science Center	USA
Shin-ichi Ito	Atmosphere and Ocean Research Institute, University of Tokyo	Japan
Lisa Crozier	NOAA Northwest Fisheries Science Center	USA
Hyung-Gyu Lim	Korea Institute of Ocean Science and Technology	South Korea
Peng Sun	College of Fisheries, Ocean University of China	China
Hing Ling Chan	NOAA Pacific Islands Fisheries Science Center	USA
Josep Planas	International Pacific Halibut Commission	USA
William Stanbury	North Pacific Anadromous Fish Commission	USA
Francisco Werner	NOAA	USA
Matt Baker	North Pacific Research Board	USA
Jackie King	DFO	Canada
Enrique Curchitser	PICES	USA
Vladimir Radchenko	NPAFC (past affiliation)	Russia
Stephen Latham	Pacific Salmon Commission	Canada
Jim Thorson	NOAA Alaska Fisheries Science Center	USA
Dongwha Sohn	Pusan National Universty	South Korea

Kathryn Berry

Kathryn has over 10 years of international professional experience, spanning marine research, environmental management, science leadership, and program management. Her research contributed to the understanding of pressures facing the Great Barrier Reef and other urban and remote coastal environments especially related to climate change and deteriorating water quality linked with human activities, such as agriculture, shipping, and emerging contaminants (e.g., microplastics and persistent organic pollutants). She completed her PhD in 2017 at James Cook University, and the Australian Institute of Marine Science (AIMS) in Australia. Kathryn has worked in research, environmental consulting, and for Canadian provincial (British Columbia) and federal (Department of Fisheries and Oceans) governments.

Viv Tulloch

Viv is a decision scientist and ecological modeller, interested in the intersection of multiple stressors including climate change within and between complex dynamic systems, species and humans. Over the last 13 years she has worked in research, environmental consulting, and collaborated with government and non-government agencies worldwide including most recently Fisheries and Oceans Canada and the Wildlife Conservation Society Canada, to solve conservation and resource management problems. Viv was granted the prestigious Banting Postdoctoral Fellowship in 2019 to work on ecosystem models of salmon and killer whales with the Conservation Decisions Lab at the University of British Columbia, Canada. She completed her PhD in 2016 at the ARC Centre of Excellence for Environmental Decisions at the University of Queensland, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia

Kirstin Holsman

With a focus on Alaska fisheries, Dr. Holsman's research involves development of quantitative methods to support climate-informed Ecosystem Based Management, including methods to identify climate risk, adaptation, and resilience in ecosystems and marine communities. This includes multiple collaborations to develop and implement climate-informed stock assessment models for fish species, Integrated Ecosystem Assessments, bioenergetics and food-web models, and field studies of climate and fishery effects on marine ecosystems. Dr. Holsman is co-lead investigator on the Alaska Climate Integrated Modeling Project (ACLIM), a multidisciplinary collaboration to evaluate climate-change impacts on the Bering Sea ecosystem (from physics to fishing communities) under various future management and climate scenarios

Phoebe Woodworth-Jefcoats

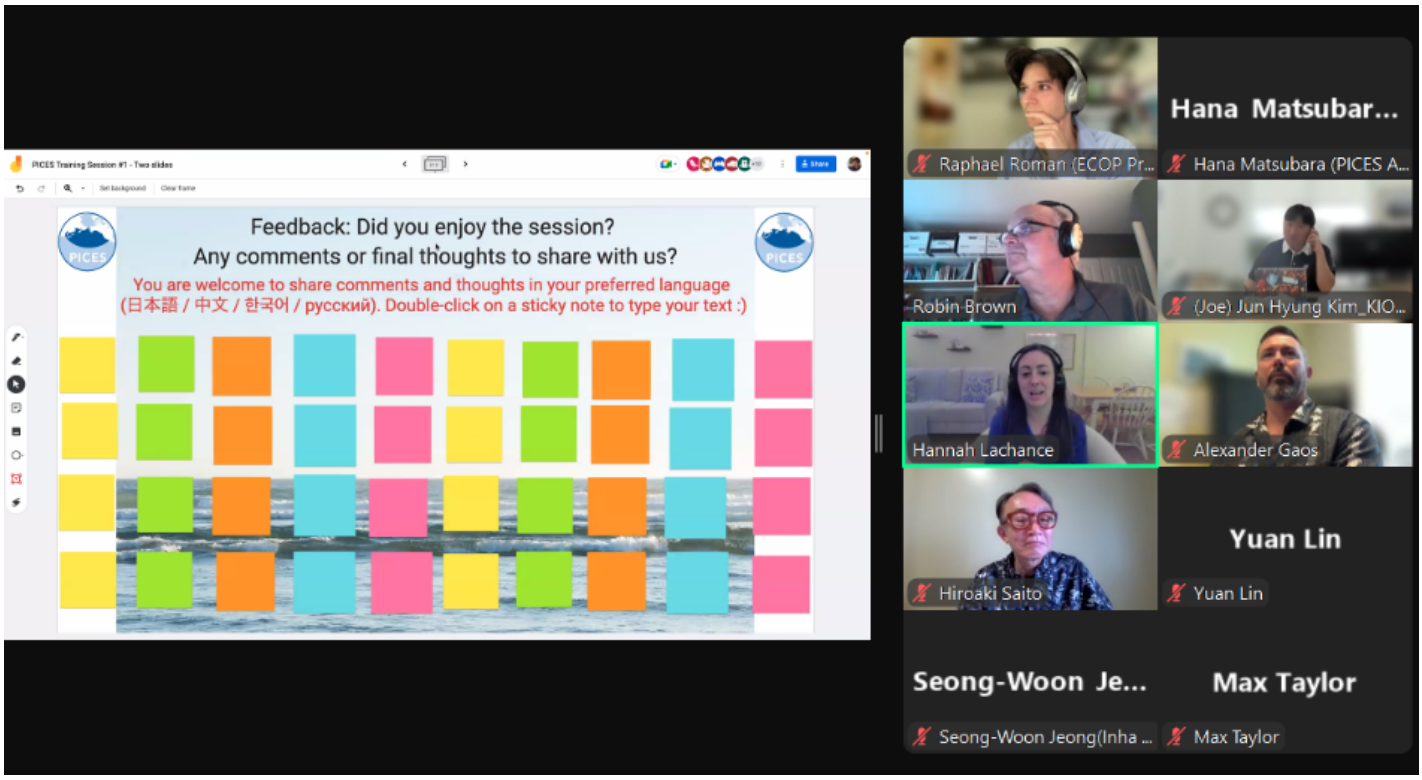
Dr Woodworth-Jefcoats is a research oceanographer with NOAA's Pacific Islands Fisheries Science Center, based in Honolulu, Hawaii. Her research interests include ecosystem impacts of climate variability and change, size-based approaches to ecosystem analyses, and understanding variability in pelagic marine fisheries. Dr Woodworth-Jefcoats received her doctorate from the University of Hawaii.

BECI

Basin-Scale Events & Coastal Impacts

International Open Science Training: An Ocean Decade-Endorsed Activity Co-led by PICES Early Career Ocean Professionals (ECOPs)

Raphael Roman, Yuan Lin, Hana Matsubara, Hannah Lachance, Max Taylor, Seong Woon Jeong, and Vishal Patil



Screenshot taken during Session 1: "International Collaboration and Science Diplomacy", featuring invited speakers, ECOP co-moderators, and volunteers (September 26, 2024).

Introduction

Co-designed by several PICES Expert Groups, the idea for this free virtual training emerged during a brainstorming session at the 2022 PICES Annual Meeting in Busan, Republic of Korea. Postponed to 2024, the training was endorsed as a United Nations Ocean Decade Activity and successfully leveraged PICES' extensive network and expertise across the North Pacific region, strengthening transboundary relationships, discovering new international projects and initiatives, and building bridges between knowledge generators and users. The primary goal was to promote intercultural dialogue and explore rarely discussed, practical perspectives on various aspects of international collaboration through three dedicated 2-hour sessions: **(1) International Collaboration and Science Diplomacy** (*September 26-27*), **(2) International Data Management** (*September 30 - October 1*), and **(3) Science Communications** (*October 9-10*). A total of 445 people registered from all over the world, with 214 participating in at least one of the three live sessions. Zoom recordings and presentation materials from our panelists have been made publicly available on the webpage of the PICES Advisory Panel on Early Career Ocean Professionals (AP-ECOP) here: https://meetings.pices.int/members/advisory-panels/AP-ECOP.

Although the audience primarily consisted of ECOPs from the North Pacific region—namely Canada, Japan, the Republic of Korea, and the USA—the training was open to individuals from any country and at any career stage. Remarkably, several attendees joined us from Africa, Latin America, Oceania, and Southeast Asia. For each session, we invited four speakers who each had a dedicated 10-12 min time slot, including two from Japan and the Republic of Korea (West Pacific) and two from Canada and the USA (East Pacific). Presentations were followed by an engaging and interactive panel session, encouraging dialogue, active learning, and questions from attendees. We notably experimented with Slido, a dynamic audience engagement tool to gather live feedback through three different types of questions: "*multiple choice*", "*word cloud*", and "*open text*". These virtual sessions ran smoothly thanks to the invaluable support of four dedicated and passionate ECOP volunteers from China, Japan, the Republic of Korea, and the USA. By taking notes, introducing speakers, co-moderating sessions, and managing the chat and Q&A boxes on Zoom, the volunteers not only ensured the success of this virtual training but also honed new skills, demonstrating why they were nominated as special ECOP travel grantees. This recognition afforded them the opportunity to attend the 2024 PICES Annual Meeting in Honolulu, USA.

Session 1: International Collaboration and Science Diplomacy

During the first session, our four panelists discussed and shared their real-world experiences on the following topics:

- What does effective and successful international collaboration across different countries look like?
- Key considerations when initiating international scientific projects with colleagues from different cultures,
- How can ECOPs contribute to science diplomacy and what experience do they need to succeed in this field?
- Strategies for maintaining effective communication to foster long-term relationships.

We had the immense privilege of welcoming **Mr. Jun Hyung Kim**, an international cooperation expert based at the Korea Institute of Ocean Science & Technology (KIOST) in Busan, Republic of Korea; **Professor Hiroaki Saito** from the University of Tokyo in Japan; **Mr. Robin Brown**, current advisor and retired Executive Secretary of PICES in Victoria, Canada; and **Dr. Alexander Gaos**, a research ecologist with the Marine Turtle Biology and Assessment Program (MTBAP) at the NOAA Pacific Islands Fisheries Science Center in Hawai'i, USA.

When attendees were introduced to the concept of Science Diplomacy, the most frequently mentioned words were *"collaboration"*, "*communication*", "*relationships*", and *"respect"* (Figure 1). Other highlighted keywords included *"network", "mutualistic", "knowledge sharing", "connection", "friends", "teamwork", and "altruistic"*. Additionally, several participants emphasized the importance of *"context", "boundaries", "compromise", "etiquette",* and *"politics"* in fostering science diplomacy, noting that building trust in such efforts often requires patience and understanding.

As noted by Mr. Jun Hyung Kim, political challenges at home and abroad can sometimes affect scientific collaboration. He also emphasized the significant role played by cultural differences, giving the example of Korean "*pali-pali*" culture, which prioritizes immediate results and quick decision-making, usually coming from senior professionals. By contrast, decisions take longer and are more methodical and democratic in "Western" countries.

Prof. Hiroaki Saito shared key challenges in international science collaboration, such as differing interests, competition, mistrust, funding restrictions, strong opinions, and political conflict. He also described the functioning of the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) and highlighted a few key IOC funded projects, including Argo, the Tsunami Programme, and GEBCO Seabead 2030. Prof. Saito praised PICES for its foresight, leadership, supportive atmosphere, and the strong science diplomacy skills of its members, recognizing it as one of the most successful platforms for international scientific collaboration. In situations of conflict, Prof. Saito advised us to keep communication channels open and approach problems from unique directions. Diplomacy can leverage science to improve challenging situations. He emphasized the importance of being prepared, learning from history, staying resilient, and remaining optimistic.

For Mr. Robin Brown, effective science collaboration is an intimate and personal endeavor. He contrasted the more transactional approaches often seen in Europe and North America with the relationship-focused cultures prevalent in Asia, acknowledging significant regional variations. These cultural differences influence the required outputs and necessitate distinct communication standards. Robin emphasized the need for greater institutional support and funding opportunities for ECOPs to travel and build personal connections, while also recognizing concerns over carbon emissions originating from air travel.

Figure 1. Word cloud displaying responses to the question: "What is the first word that comes to mind when you hear 'Science Diplomacy'?" Note: The more frequently a word is mentioned, the larger it appears in the word cloud. A total of 61 responses were collected.

Finally, Dr. Alexander Gaos transported us to his diverse sea turtle conservation efforts across Latin America, Southeast Asia, and the Pacific Islands. His central message was that all interactions require relationships, regardless of their longevity. For Alexander, successful collaborations include finding new partners, scheduling regular meetings, having face-to-face interactions, and setting clear goals and activities. He concluded with a call to action for ECOPs, encouraging them to get involved in international collaboration and science diplomacy. "*It is a growing area, and as we get more integrated, we will need more international professionals. There are so many opportunities out there!*".

Overall, here are some key learning outcomes shared by attendees at the end of the session: "*Build trust through effective communication", "To have good collaborations remember that researchers are people too", "A lot of opportunities out there, just jump in", "Don't be afraid to reach out to international future collaborators in your field".*

Session 2: International Data Management

In the second session, we explored various topics of discussion related to data management, such as:

- Advanced skills in data governance, including data sharing protocols, interoperability, and compliance with international standards,
- Data management best practices,
- Challenges and gaps that exist between stakeholders generating data and end-users,
- What strategies can be used to build capacity in data governance, particularly in organizations with limited resources and access to data infrastructures?

We had the honor of welcoming **Ms. Jeanette Gann**, an oceanographer with the Ecosystem Monitoring and Assessment program at the Alaska Fisheries Science Center in Juneau, Alaska; **Mr. Brett Johnson,** a biologist and data architect who leads the Data Stewardship Unit in the Pacific Region Science Branch of Fisheries and Oceans Canada (DFO); **Professor Atsuhiko Isobe**, from the Research Institute for Applied Mechanics in Kyushu University, Japan; and **Professor Seung-Tae Yoon**, a physical oceanographer and field observation expert at Kyungpook National University in Korea.

This session was attended by a diverse audience of scientists, as exemplified by the type of data they had the most experience with, including "*socio-economic data*", "*fisheries data", "acoustic data", "eDNA", "coral proteomic data", "ship-based observation data", "satellite data", "salmon spawner-recruit data",* and of course *"messy data"*. Most people considered data to be *"information", "observations",* or anything else related to science, such as "*field work*", "*results*", and *"experiments"*. Other interpretations of data included "*signs*", "*symbols*", "*raw knowledge*", "*values*" and "*rice of scientist*"—perhaps a creative interpretation implying the fundamental or humble nature of data in scientific work.

According to Ms. Jeanette Gann, the most commonly encountered data management challenges are (i) skills, (ii) funding, and (iii) changing data. She emphasized the importance of always having a data plan and encouraged scientists to start to think about data from the very beginning. This includes considering data collection strategies, quality assurance and control, and metadata storage. In addition, openly sharing your information and data products (e.g., codes and models) can enhance findability, accessibility, and reusability, whether through open-access manuscripts or developer platforms such as GitHub. Jeanette also underscored the need for dedicated data platforms to host different types of data, such as oceanographic data, fisheries data, etc.

Mr. Brett Johnson shared practical insights on data governance and how to build trust across borders. He highlighted the importance of clarifying governance early and setting clear expectations at the outset of a project—for example, by establishing distinct central teams dedicated to science and data. When integrating and standardizing your own data, leveraging existing international frameworks and standards is a smart approach to ensure interoperability. Finally, as Brett aptly noted: "*Nothing builds trust better than working together in the field.*"

Prof. Atsuhiko Isobe introduced the Atlas of Ocean Microplastics (AOMI), a microplastic data-sharing project funded by Japan's Ministry of the Environment. Launched on May 9, 2024, AOMI is freely available, allowing users to upload and download data via its website. AOMI features multi-level datasets on microplastic abundance in the global upper ocean, though significant data gaps persist

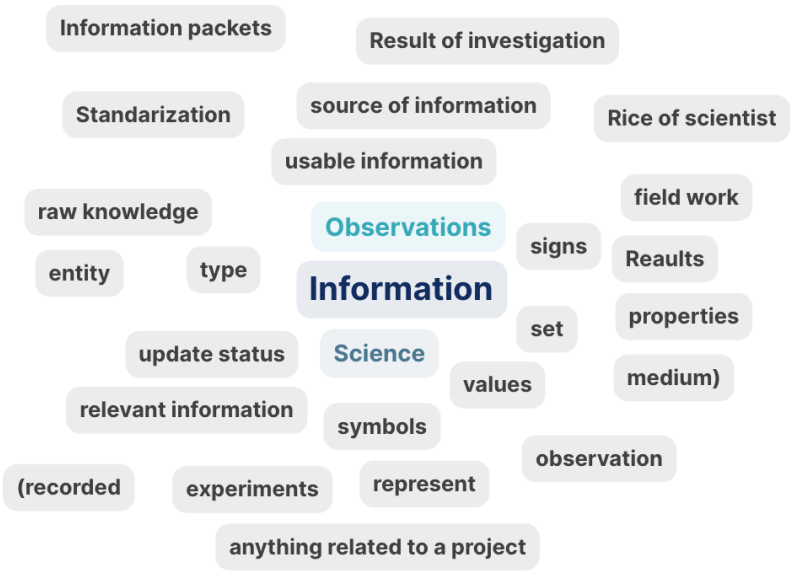


Figure 2. Word cloud displaying responses to the question: "What do you consider data?" Note: The more frequently a word is mentioned, the larger it appears in the word cloud. A total of 40 responses were collected.

in the northern Indian Ocean and Southeast Asian seas. Prof Isobe noted the complexity of comparing metrics across countries and emphasized the need for standardized guidelines and integrated datasets from laboratory research, numerical models, and field surveys, which he is pioneering through AOMI.

Finally, Prof. Seung-Tae Yoon focused on data management in the Republic of Korea, highlighting systemic challenges such as frequent turnover of the person in charge, difficulties in managing the raw data, conservative data practices, and prioritization of military and political interests. Given the intensifying impacts of climate change, it is crucial to investigate ocean responses using in-situ observational ocean data, which is publicly available on the websites of the Korea Oceanographic Data Center (KODC) and Korea Polar Data Centre (KPDC). To ensure successful data management practices, Prof. Yoon recommended closer cooperation between government, data management teams, and research project members.

Several open-access repositories and databases were shared by both panelists and participants, which can be useful resources for finding existing data protocols. We have compiled a list here: Ocean Biodiversity Information System (OBIS), Global Biodiversity Information Facility (GBIF), The Global Ocean Observing System (GOOS), Atlas of Ocean Microplastics (AOMI), Ocean Data and Information System (ODIS), AquaDocs, International Oceanographic Data and Information Exchange (IODE), Korea Oceanographic Data Center (KODC), Korea Polar Data Center (KPDC), US National Science Foundation Data Guide, and NOAA Data Strategy.

Session 3: Science Communications

In the final session of our training, we focused on several guiding questions and topics of interest related to science communication, namely:

- Effective forms/formats of science communication for reaching non-scientific audiences,
- How to communicate with international collaborators,
- How to create transparent outputs to inform policy and societal change,
- Advice and tips for communicating as or with non-native English speakers.

We were joined by **Ms. Hannah Lachance**, our former AP-ECOP co-chair and the International Fisheries Science Specialist in support of NOAA Fisheries, USA; **Ms. Tammy Norgard,** the co-chair of AP-SciCom and Section Head of the Marine Spatial Ecology and Analysis Section with Fisheries and Oceans Ecosystems Science Division in Nanaimo, Canada; **Ms. Devon Warawa,** the current Communications Officer for the PICES Secretariat in Victoria, Canada; **Professor Minkyoung Kim**, AP-ECOP co-chair and an Assistant Professor at Kyungpook National University, Korea; and **Professor Hiromi Yokoyama**, Deputy Director of the Kavli Institute for the Physics and Mathematics of the Universe at the University of Tokyo, Japan.

When attendees reflected on the challenges and opportunities in science communication, frequently mentioned words included *"language"*, *"understanding"*, *"delivery"*, and *"simplification"* (Figure 3). Other highlighted keywords were *"storytelling"*, *"audiences"*, *"demographics"*, and *"collaboration."* Participants emphasized the importance of translating complex concepts into plain language, tailoring messages to different audiences, and fostering appreciation and mutual understanding to enhance the effectiveness of science communication.

Ms. Hannah Lachance underscored the importance of starting with a clear situational analysis, considering "*who, what, when, where, and why*" before crafting messages. She shared actionable tips for designing visuals: keep them

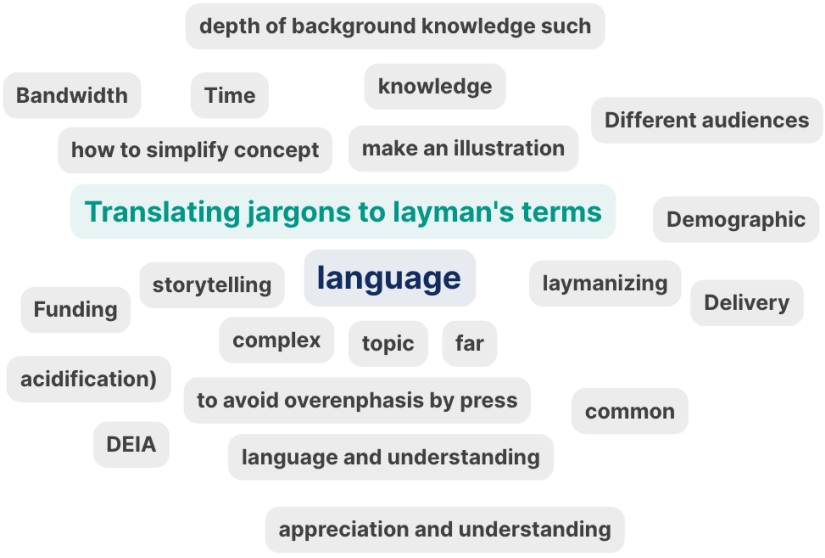


Figure 3. Word cloud displaying responses to the question: "What is the biggest challenge you have with your Science Communication for your work?" Note: The more frequently a word is mentioned, the larger it appears in the word cloud. A total of 31 responses were collected.

simple, align elements neatly, and limit the color palette to maintain focus. Pre-testing messages with a non-expert audience, such as friends or family, was another strategy she recommended to ensure clarity and appeal.

Ms. Tammy Norgard presented a compelling case study from the Canadian government's Pacific Seamount Scientific Expedition. Through the use of social media, the initiative reached over 2.47 million individuals and captured the interest of 130 countries. By incorporating engaging videos, Tammy's team successfully enhanced public awareness and participation in ocean science, proving the power of digital tools in connecting science with global audiences.

"*Science communication should be compelling*" Ms. Devon Warawa emphasized. She introduced the ABT (And, But, Therefore) storytelling framework, which structures messages to engage audiences effectively. By combining this approach with various platforms—social media, websites, and publications—Devon demonstrated how to expand the reach of scientific messages while ensuring they resonate with diverse groups.

Prof. Minkyoung Kim highlighted the challenges and strategies in communicating across cultures. Tailoring messages for specific audiences is essential, whether the goal is to inform policymakers, engage stakeholders, or connect with fellow scientists. She stressed the importance of simple language, clear visuals, and active networking through conferences and fellowships. Minkyoung also encouraged ECOPs to see themselves as bridges between diverse communities, fostering inclusive communication.

Prof. Hiromi Yokoyama focused on the critical role of trust in science communication, especially during crises like COVID-19. By leveraging frameworks such as ELSI (Ethical, Legal, and Social Implications) and RRI (Responsible Research and Innovation), scientists can ensure their work remains ethical and socially responsible. Hiromi also advocated for two-way communication with the public, emphasizing transparency and a commitment to understanding diverse values.

Communications planning wheel presented by Ms. Hannah Lachance (Adapted from NOAA Fisheries/Vanguard Communications Strategic Communications Training)

In response to "*language*" being the most frequently identified challenge in science communication by participants, the panelists shared some good practices for overcoming language barriers. These included ideas such as sharing documents in advance, using visual materials such as diagrams, photos, and videos, creating real-time meeting notes with tools such as Google Documents, and establishing language operation guidelines for speaking English slowly with simple grammar.

Here are some key insights attendees gained from the session: "*Tailor your communication*", "*Engage through visuals and stories*", "*Collaborate effectively*", "*Build trust*", "*Seize opportunities*".

Conclusion

Here are the main takeaways that we would like to share from this training:

1. Relationships are important,
2. Don't be afraid to reach out to international future collaborators in your field. Embrace opportunities and communicate your goals clearly,
3. Use existing data protocols and start working on a good data strategy from the outset,
4. Strive for global standardization and interoperability of metadata,
5. Find the right platform to reach your audience,
6. Keep communicating science to the global community, and
7. Be respectful and build long-lasting trust.

Overall, this free online training was very successful and received positive feedback from several active ECOP participants who joined us from around the world. Here are some quotes:

"*Kudos to the organizers for a well-planned and well-run session! It isn't always easy to 'manage' a group of scientists"; "I loved this! So informative, and inspiring! Thank you!!!!"; "Very informative, and so many great links were shared that I've saved for further exploration! And kudos to the phenomenal panelists and hosts."; "Great speakers and projects. Excellent dynamic for participants interaction"; "Enjoyed it very much. Rarely get an opportunity for discussing such diverse examples".*

Given the success of this virtual training, the AP-ECOP team, in collaboration with partners outside of PICES, may consider organizing a future in-person, hands-on workshop focusing on similar topics with a more interactive and practical approach.

Raphael Roman has a BSc in Economics from the University of Montreal and a Master of Public Policy and Global Affairs from the University of British Columbia. His interests are broad and range from new economic thinking and social-environmental well-being, to sustainable ocean governance and biodiversity conservation. He is passionate about interdisciplinary research approaches and about engagement at the science-policy interface, where I believe early career ocean professionals (ECOPs) have a key role to play.

As such, and in the context of the UN Decade of Ocean Science for Sustainable Development (2021-2030), he hopes to increase representation of the social sciences within the themes of the conference, while encouraging more inter- and transdisciplinary sessions and workshops that can offer intellectually stimulating exchanges across disciplines, sectors and geographies.

Hana Matsubara is a Ph.D. candidate at the Graduate School of Agriculture and Life Sciences, University of Tokyo conducting study on interaction between gender equality in coastal communities and community-based sustainable marine resource use. Experienced working as Associate Expert for international cooperation in fisheries development at Japan International Cooperation Agency (JICA) for a year and JICA volunteer for the promotion of Community-Based Resource Management in the Solomon Islands for two years. Currently the co-chair of the Advisory Panel on ECOPs (AP-ECOP).

Max Taylor is a senior at the University of Florida in the US, majoring in microbiology. She studies parasitic nemertean worms in blue crabs and the biological dynamics of Psuedo-nitzschia blooms. In her free time, Max runs Girls For Science Magazine, a publication dedicated to helping aspiring girls build science communication skills for their future STEM careers. She hopes to start a PhD program in the fall.

Seong Woon, Jeong is a doctoral student in Coastal Ocean Observation Laboratory, Department of Ocean Science at Inha University, Korea. He received both his bachelor's and master's degrees from the same institution. His research focuses on the impacts of extreme events, including typhoons, human-controlled freshwater discharge, local scour by offshore platform, and climate change on coastal environments such as tidal flat, estuary, and bay. In particular, his work explores benthic sediment dynamics (erosion and deposition), hydrodynamic processes, and their influence on biological productivity. He actively collaborates with multidisciplinary teams and has presented his findings at international conferences, including Ocean Science Meeting (OSM) and Pacific-Asian Marginal Seas (PAMS) Meeting. Looking forward, he aims to expand his research on the long-term impacts of climate change on coastal ecosystems through international collaboration.

Yuan Lin is a second-year PhD student in the Marine Biological Resources Department at the Atmosphere and Ocean Research Institute of the University of Tokyo. She is also a recipient of the Spring-GX and JSPS research fellowships. Her current research focuses on using environmental DNA technology to study the distribution and diversity dynamics of fish communities in complex marine environments, particularly in systems like the Kuroshio-Oyashio currents. Yuan is dedicated to promoting the vision of equal survival opportunities for all. By exploring patterns of marine fisheries distribution and preserving biodiversity, she aims to contribute to the creation of a sustainable "blue granary" and support human development.

CREAMS 30th anniversary & CSK-II Joint Workshop

SungHyun Nam and Vyacheslav B. Lobanov

Background

An international program on Circulation Research of East Asian Marginal Seas (CREAMS) started in 1993 and now has celebrated its 30th anniversary. The CREAMS was the first international marine science program in the region and it significantly promoted collaboration between marine scientists of border countries as well as their colleagues from other parts of the world. Now CREAMS is a part of The North Pacific Marine Science Organization (PICES), and is heading for a 'Creative' Research of East Asian Marginal Seas to become multidisciplinary science program, along with the companion program of UNESCO Intergovernmental Oceanographic Commission (IOC) Sub-Commission for the Western Pacific (WESTPAC) – Healthy, Productive and Sustainable Asian Marginal Seas (AMS) program .

On the other hand, the Cooperative Study of the Kuroshio and Adjacent Regions (CSK) was active from 1965 to 1979 and played a significant role in advancing the understanding of general oceanography and fisheries in the Kuroshio and adjacent regions by strengthening the research capabilities of many countries in the area. The IOC/WESTPAC established the CSK-II as its regional program in 2021, which was endorsed as one of the UN Decade of Ocean Science (hereafter UN Ocean Decade) for Sustainable Development (2021-2030) Projects in 2022.

The East Asian Marginal Seas, neighboring the Kuroshio, are one of the most affected areas in the global ocean by climate changes and anthropogenic impacts. There have been considerable advances in exploring these seas over a few decades under the CREAMS and CSK programs. Being initially focused on research of water circulation and ventilation, the CREAMS program evolved into biogeochemical and ecosystem research and now is seeking a way to be a more socio-economic oriented program along with the AMS program. The CSK-II aims to enable ocean research communities and other relevant ocean stakeholders to co-design and co-implement integrated and multidisciplinary investigations, research, and analysis on the Kuroshio and its adjacent regions, to improve regional weather forecasts and climate predictions and inform fisheries and aquaculture management.

This workshop summarized and shared the knowledge and experience in water dynamics, biogeochemistry, ecosystems, and their variability at multi-scales, and discussed the future directions of research in the area moving toward a focus on multidisciplinary science underlying the Kuroshio and its neighboring marginal seas. It is especially important to identify links between marine sciences and socio-economic requirements in the area to, develop an integrative program for future research in this region to corresponding the UN Ocean Decade targets in a rapidly changing climate.

Participants

There were ~70 participants in total from 4 generations of scientists (Figure 1). The participant list includes a former professor Kuh Kim (first row 9th from the left in the group photo, past chair of PICES Science Board; 2004-2007, past chair of PICES POC committee; 2001-2004) who initiated the CREAMS program with former Profs./Drs. Yury N. Volkov (Russia), Mikhail Danchenkov (Russia), Masaki Takematsu (Japan), Jong-Hwan Yoon (Japan), and Kyung-

Figure 1. Workshop participants (group photo).

Ryul Kim (Korea). Although Profs./Drs. Volkov, Danchenkov, Takematsu, Yoon, and Kim could not join the workshop in person, participants expressed their joy and gratitude for the kind messages, including hand-written notes and memorable photos (Figure 2)". There were many Early Career Ocean Professional (ECOP) participants as well as mid-career and senior ocean professionals who were, or are, involved in CREAMS, AMS, and CSK-II programs. Their academic backgrounds are mostly in oceanography (physical, chemical, biological, and geological) and in fisheries, but a few historian and social scientists also joined the workshop.

Results

The workshop consisted of welcoming remarks and greetings, introduction of relevant scientific programs to overview and sharing of the history/contexts, four scientific sessions to review past and on-going activities, ECOPs' flash talks, two sessions to plan future works, and a panel forum to discuss ways toward better international collaboration in the future.

On the morning of Day-1 (July 25), the workshop started with welcoming remarks with messages from those who initiated the CREAMS program representing Korea, Japan, and Russia, and from those who represent CSK and CSK-II program, chaired by Prof. SungHyun Nam (first row 16th from the left in the group photo). Prof. Kuh Kim welcomed all participants and shared his greetings for the 30th anniversary of the CREAMS program. Then Profs. Hong-Ryeol Shin (first row 15th from the left in the group photo) and Tomoharu Senjyu (first row 14th from the left in the group photo) delivered memorable photos and Profs. Takematsu and Yoon delivered Japanese greeting messages that were kindly translated to English and Korean (Figure 2). Dr. Vyacheslav B. Lobanov (first row 10th from the left in the group photo) presented Drs. Volkov's and Danchenkov's greetings with Russian hand-written message and its translation, as well as memorable photos (Figure 2). The greeting message from the CSK and CSK-II programs was delivered by Dr. Kentaro Ando (first row 4th from the left in the group photo).

After these greetings and a coffee break in the morning, an overview and overall history (particularly the early phase) of the CREAMS program were presented by Prof. Kuh Kim with a timeline (Figure 3). He demonstrated ground-breaking observations in waters between Korea and Japan, in the early phase of CREAMS (CREAMS-I and CREAMS-II where the latter is also known as the CREAMS/JES program as a new program of the United States funded by the Office of Naval Research to support detailed observations and development of numerical models for the region by 15 US investigators). These early activities were also introduced in PICES Press (Winter 1997 and Summer 1998 editions). Then the CREAMS/PICES program was initiated in 2005 and the CREAMS program became an official program of PICES (AP-CREAMS started). Major findings of the CREAMS

Figure 2. Greeting messages from those who initiated CREAMS program in Korea, Japan, and Russia.

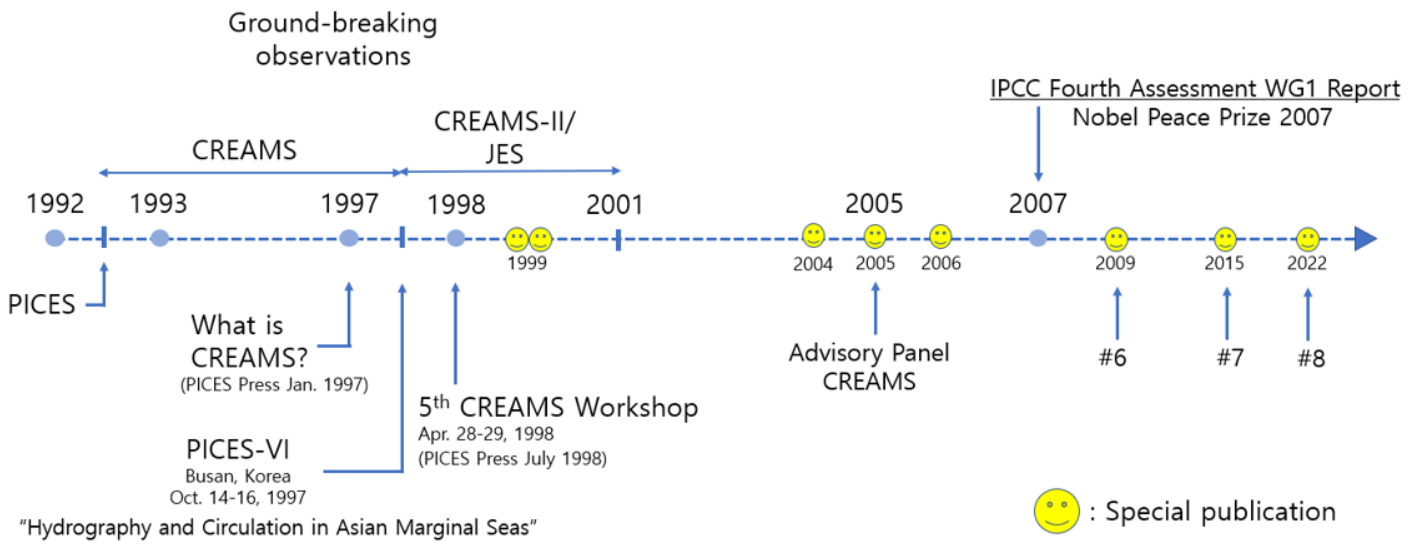


Figure 3. Timeline of the CREAMS program.

program, such as changes in the sea's ventilation system, were also shared through the IPCC Fourth Assessment Working Group 1 Report (2007) as well as special issues of scientific journals and a book published in 2016. There have been 7 journal special issue publications in total (from 1999 to 2022).

The relevant UNESCO/IOC WESTPAC programs – AMS and CSK (both CSK and CSK-II) programs were introduced by Prof./Drs. SungHyun Nam and Kentaro Ando. They presented general background and past and on-going activities related to those programs aligned to the CREAMS/PICES program. Then, historian Sungeun Kim (second row 8th from the left in the group photo), overviewed a history of regional science collaboration with a title of "Bridging over the troubled water: Transnational cooperation in East Asian Oceanography, 1985–2005", sharing results of his research with CREAMS as a valuable historical case study. In particular, he provided insights on the relationship between geopolitics and geoscience.

During the two days, participants shared knowledge and lessons learned through 30-years of research focused on the East Asian marginal seas via four scientific sessions. Former professor Kyung-Il Chang (second row 2nd from the right in the group photo, past chair of PICES POC committee; 2010-2016) overviewed the East Asian Seas Timeseries (EAST)-I project, where a holistic view of the seas' ecosystems was summarized. Then, past activities for specific aspects, disciplines, cruises, and processes were presented by Prof./Dr. Tomoharu Senjyu, Dong-Jin Kang (first row 12th from the left in the group photo), Vyacheslav B. Lobanov, Guebuem Kim (first row 7th from the left in the group photo), Pavel Tishchenko (first row 11th from the left in the group photo), Shinichiro Kida (third row 3rd from the right in the group photo), and Xiaopei Lin (first row 3rd from the left in the group photo). On-going activities for the research of these seas were presented by Prof./Drs. Hanna Na (first row 2nd from the left in the group photo), Tomoharu Senjyu, Jeomshik Hwang (second row 5th from the left in the group photo), Xiaopei Lin, Yuqi Yin (third row 1st from the left in the group photo), and Ran Wang (third row 2nd from the left in the group photo).

On the late afternoon of Day-1, 16 ECOPs (mostly graduate students and a few post-doctoral researchers or assistant professors) shared their on-going studies via a Flash Talks session. The geographic areas of interest of these studies cover the whole marginal seas aligned to the CREAMS program (Figure 4). A wide range of processes, such as meanders of Kuroshio and its branches; deep-sea transport variability; marine heatwaves; mesoscale and submesoscale eddies; typhoons; internal waves/tides; near-inertial oscillations; turbulent mixing; ocean carbon; and biogeochemistry, were touched on and discussed during the session.

To better plan future international collaborations under increasing geopolitical hurdles, there were two Future Plan sessions – one for data management and the other for integrative/multidisciplinary science. Profs./Drs. Yong-Gyu Kim (first row 8th from the left in the group photo), Minkyung Kim (second row 6th from the left in the group photo), Kentaro Ando, Sungeun Kim, Takafumi Yoshida (third row 2nd from the right in the group photo), Jae-Hun Park, and Yonho Yih (second row 9th from the left in the group photo) suggested ways to promote international collaborations to better share and manage the data/information and to better link to the society by applying more integrative approaches; for example, the social-environmental-ecological system (SEES) approach. Finally, panel members stressed future directions of international collaboration for the East Asian marginal seas via CREAMS/PICES and other international initiatives such as UN Ocean Decade, as well as relevant programs including AMS; CSK-II; and NOWPAP, highlighting the importance of continued supports by stakeholders.

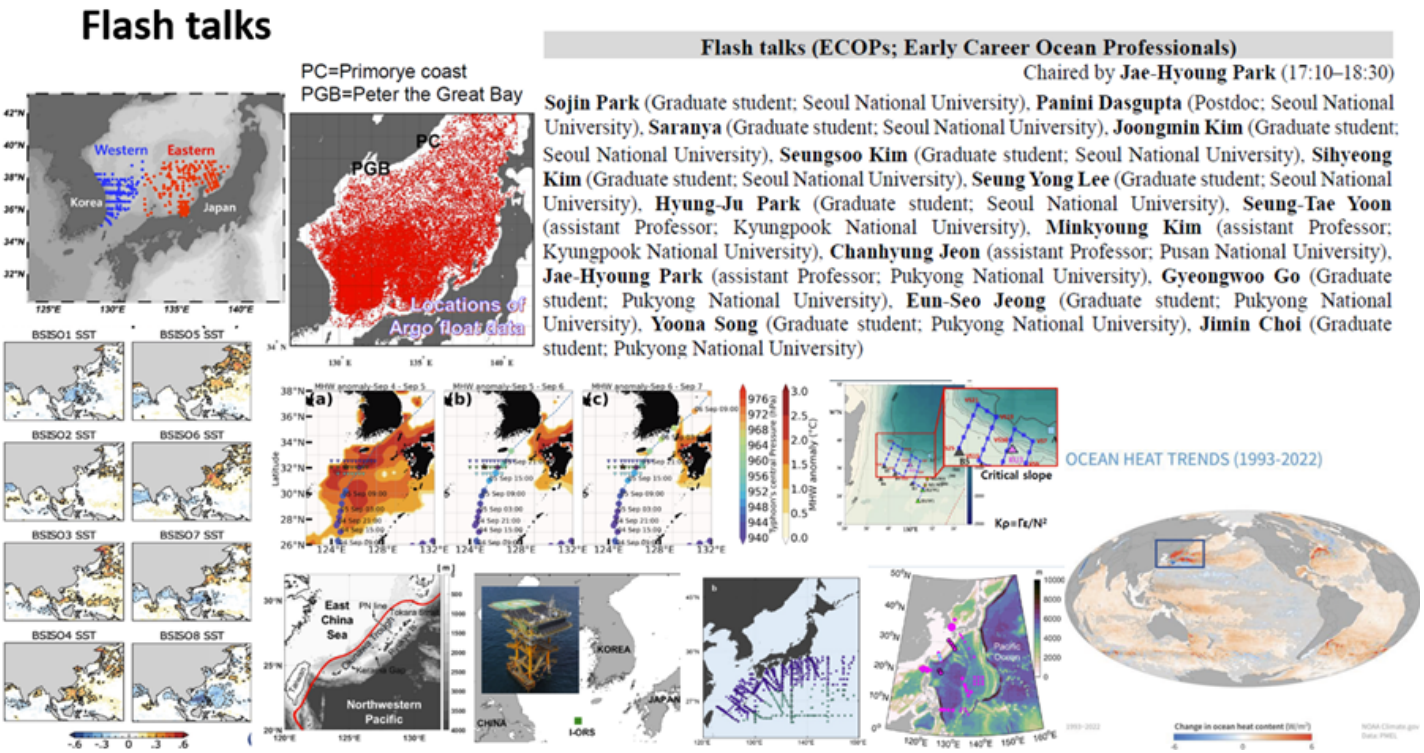


Figure 4. Examples of ECOPs presentations during the Flash Talk session, demonstrating geographic areas of interest.

Take-home messages

Through the two full-day workshops, participants celebrated the 30th anniversary of the CREAMS program; learning from and enjoying the brilliant achievements and significant scientific outcomes of the program over the decades. Participants were aligned in their understanding of the research contexts of these marginal seas and gained a good understanding of the birth, history, major scientific findings, breakthrough outcomes, past and present activities, and potential directions of the future CREAMS program. The long-lasting support of the CREAMS program is becoming increasingly important, particularly under changing climate and geopolitical conditions. In the future, we need to improve our efforts in data and information management systems targeting the East Asian marginal seas, and adopt more SEES approaches to provide new ocean-based solutions for society.

SungHyun Nam (namsh@snu.ac.kr) is a physical oceanographer and professor at School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University (SNU), Korea. His research covers physical oceanographic processes that affect climate, ocean and global biogeochemistry, marine ecosystems, fisheries, underwater acoustics, and cryosphere. Within PICES, SungHyun serves as co-chair of the AP-CREAMS and member of POC Committee. He was a member of Young Korean Academy of Science and Technology (Y-KAST), and received awards from SNU for excellent teaching (2018), outstanding research (2020), and excellent education (2023). SungHyun received a B.S. (1999), M.S. (2001), and Ph.D. (2006) from SNU, and worked as a senior researcher (2006-2008) at Agency for Defense Development, Korea, and a post-doctoral fellow and assistant project scientist (2008-2014) at Scripps Institution of Oceanography, USA. He joined 70+ cruises, published 90+ journal articles, wrote 10+ books. He was born and grew up in Seoul, Korea.

Vyacheslav (Slava) Lobanov (lobanov@poi.dvo.ru) is a physical oceanographer, ex-director of V.I.Il'ichev Pacific Oceanological Institute of Russian Academy of Sciences, located in Vladivostok, Russia. He joined PICES in 1993 and participated in various PICES expert groups including chairmanship of POC Committee and co-chairmanship of AP-CREAMS. He joined CREAMS in 1998 and organized 12 international cruises under this program. He is also a member of IOC/WESTPAC projects CSK-2, Asian Marginal Seas and NEAR-GOOS.

Freshening of the Subarctic Pacific Ocean

Frank Whitney

In 1987, I first joined Line P surveys which head from the Canadian coast near Victoria, British Columbia to Ocean Station P (OSP, 50 N, 145 W). I led this program through JGOFS (Joint Global Ocean Flux Study) and WOCE (World Ocean Circulation Experiment) until I retired in 2006. I am convinced the data collected on the Line P surveys and at OSP are essential in understanding the changes occurring throughout the subarctic Pacific. Last winter (2022-2023), I updated my data files and began looking in more detail at a freshening trend that has long interested me.

The eastern Subarctic Pacific Ocean is gradually becoming fresher, both in its surface layer and down to a depth of at least 1500 m. Ocean Station P is a good representative site for this body of water, sitting south of the upwelling Alaska Gyre and north of the Subarctic Current. Sampling since 1956 provides details of this freshening (Figure. 1a). The surface layer shows the strongest salinity decrease, which is in large part due to the shoaling of the winter mixed layer (Freeland, 2012), but a more gradual freshening is evident to a depth of at least 1500 m (Figure. 1b). This depth corresponds to the maximum density of Okhotsk Sea Intermediate Waters (OSIW) as they flow into the northwest Pacific. This is the major ventilation site in the North Pacific Ocean (e.g. Whitney et al., 2007). Since about 2007, surface salinity at OSP has been declining more rapidly. Using trends in Figure 1b, I estimate freshwater inputs of 5 mm y^{-1} between depths of 0-150 m and an additional 13 mm y^{-1} between depths of 150-2000 m.

To help understand these changes, I assessed trends in rainfall and river discharge, expecting metered rivers to capture glacial melt in summer brought on by warming. The Alaska/Northern British Columbia ice fields have been a major contributor to sea level rise brought on by summer melt (Zemp et al. 2019), accounting for 30% of the global rise between 1961-2016 and losing water at an average rate of 73 km^3 y^{-1} between 2006-2016. The next largest source, the Greenland ice fields, contributed ~13%.

Using the National Centers for Environmental Prediction (NCEP) reanalysis data for the period 1948 to 2023, I assessed trends in precipitation over broad areas of the western (Okhotsk Sea), central (Bering Sea) and eastern (Alaska Gyre) subarctic Pacific (Table 1). The eastern subarctic and adjoining coasts receive the highest rainfall amounts and show an annual increase of 2 mm y^{-1} or 7.9 km^3 over the entire area. Trends in the central area are not significantly different than zero and precipitation is decreasing over Okhotsk Sea and eastern Russia. Ren and Riser (2009) estimated that near OSP, precipitation (1230 mm y^{-1}) greatly exceeds evaporation (490 mm y^{-1}).

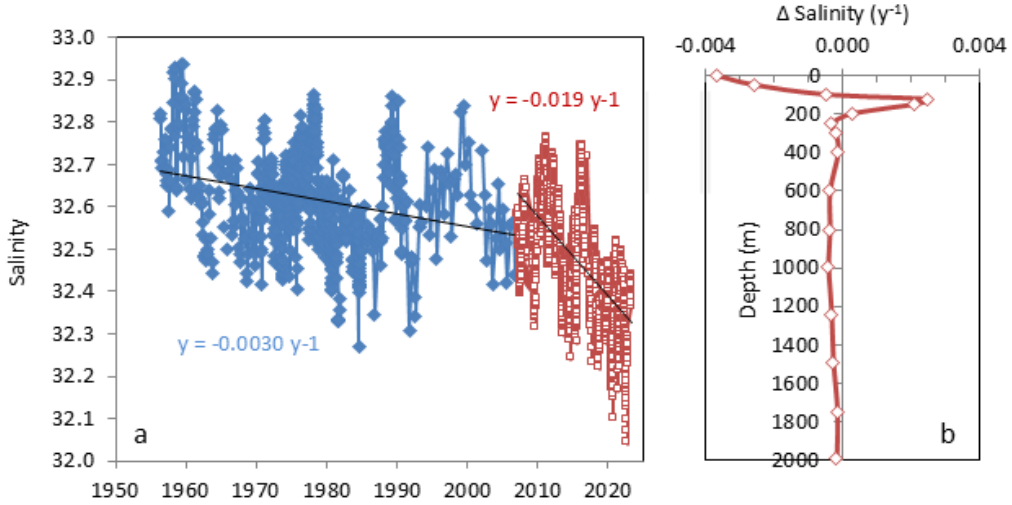


Figure 1. (A) Salinity in the upper 10 m at Ocean Station P, 1956 to 2023 (survey sampling data (◊) from waterproperties.ca and NOAA moorings data since 2007 ( ) from pmel.noaa.gov) with slopes shown; **(B)** linear trends in salinity at fixed depths from surface to 2000 m over the same period.

Table 1. Annual precipitation rates and trends from 1948 to 2022 over three subarctic Pacific areas of 4 million km^2 each. Data from psl.noaa.gov.

Regions, 47-60N	Av. annual mm y^{-1}	Av. total for area km^3 y^{-1}	Trend for area km^3 y^{-1}
NW, 135-170E	780	3120	-1.8
Central, 170E-155W	970	3880	0.9
NE, 155-120W	1240	4960	7.9

The mountains of southern Alaska and northern British Columbia contain a massive glacial ice field, discharging fresh water into the northeast Pacific and Bering Sea as it melts. World glaciers were stable in the 1970s and 1980s. In 1990, Alaskan glaciers began losing significant amounts of water; in at least 10 of the following 33 years the annual loss exceeded 100 km^3 (WMO, 2024).

The change in annual Yukon River discharge (at 63 N), between 1976-85 (199 ± 23 km^3) and 2013-22 (230 ± 27 km^3), is about 30 km^3 (Figure 2). Daily discharge data shows the increase is due largely to an elevated flow in summer, undoubtedly due to glacial melt. I had thought the Columbia River, discharging at 46 N in the northern USA, was the major source of fresh water to the Northeastern Pacific (av. 206 km^3 y^{-1} at Port Westward, 2013-22). However, the Yukon River now exceeds it, as warming temperatures release water from the Alaskan ice fields. As a result of the Yukon River flowing into the Bering Sea near the Bering Strait, much of its water will enter the Arctic Ocean. The many smaller rivers flowing south out of the Alaskan mountains will also have increased flow due to melt and these rivers enter the northeast Pacific directly. The most recent data estimates an Alaskan glacial melt rate of 100 km^3 y^{-1} between 2017-2023 (https://wgms.ch/sea-level-rise/). The Yukon River accounts for only ~30 of this 100 km^3 y^{-1} glacial loss.

What these data suggest

Freshening trends seen at OSP are fairly common throughout the subarctic Pacific (e.g. Durack and Wijffels, 2010) and into the North Pacific Intermediate Water (NPIW), a water mass formed along the subarctic front and flowing southward towards the equator (Wong et al., 1999). Freshening is evident over the entire period of OSP data collection, and likely has been an ongoing process over the many thousands of years since the last ice age. I use OSP data to estimate the annual fresh water supply to the upper 2000 m of the subarctic Pacific and its marginal seas, an area of 10 million km^2.

If an average salinity decrease of 0.0003 y^{-1} in the upper 2000 m of the water column were common to the entire subarctic Pacific, it would require a fresh water input of ~90 km^3 y^{-1}. Export southward into the NPIW would increase this volume. The largest source is precipitation falling on the ocean and adjacent land, totaling ~12,000 km^3 y^{-1} over the areas covered in table 1. The contribution from Alaskan glaciers is small in comparison, but is a relatively new source and may explain the drop in surface salinity seen at OSP since 2006. As glaciers freshen the mixed layer, I would expect an increased impact on the winter production of dense water in the Okhotsk Sea, which is already freshening due to warming and decreased ice production (Nakanowatari et al., 2007). Weakening OSIW production is a major factor in oxygen declines seen below the mixed layer across the subarctic Pacific (e.g. Whitney et al., 2007). Any further freshening of this water will decrease the depth to which these waters penetrate throughout the North Pacific with impacts on oxygen supply, especially to the continental shelf habitat where rich benthic ecosystems thrive.

Apologies to the many authors I did not cite who have contributed so much to my understanding of subarctic Pacific circulation, especially those describing processes in the Okhotsk and Bering Seas, and in NPIW formation along the subarctic front.

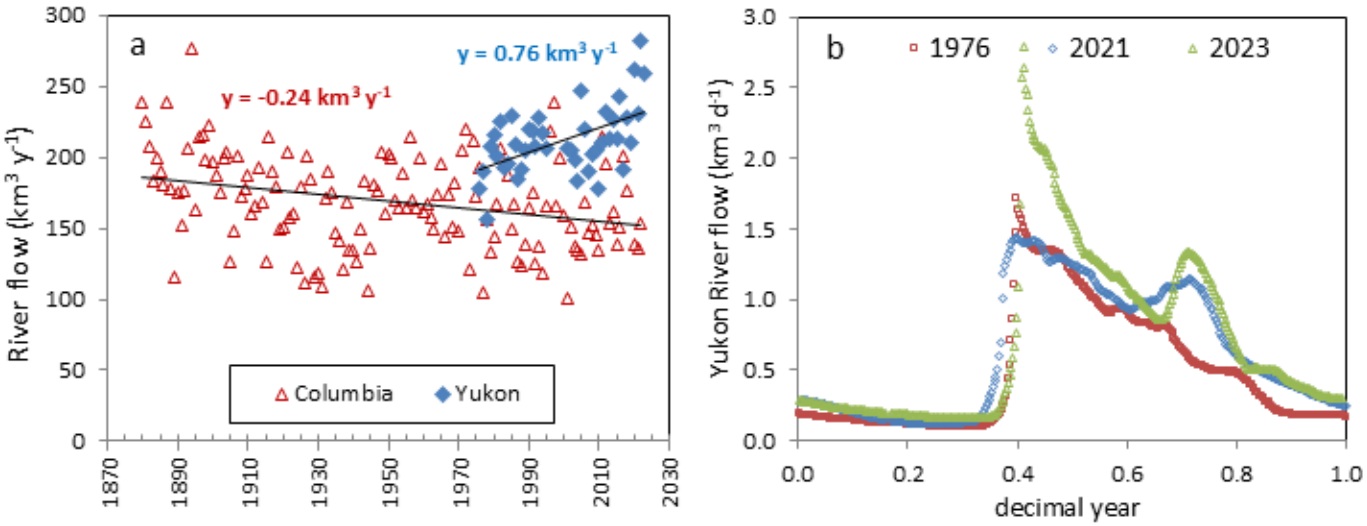


Figure 2. (A) Annual river flow for Columbia River at the Dalles and Yukon River at Pilot Station. Ocean discharge from the Columbia (Port Westward gauge) is 30% higher than that recorded at the Dalles but the time series is spotty. Linear trends show a decline in Columbia and an increase in Yukon flows; **(B)** Daily flow for the Yukon River at Pilot Station for selected years. Note increased volumes in summer of 2021 and 2023 compared to 1976, undoubtedly a result of glacial melt (waterdata.usgs.gov).

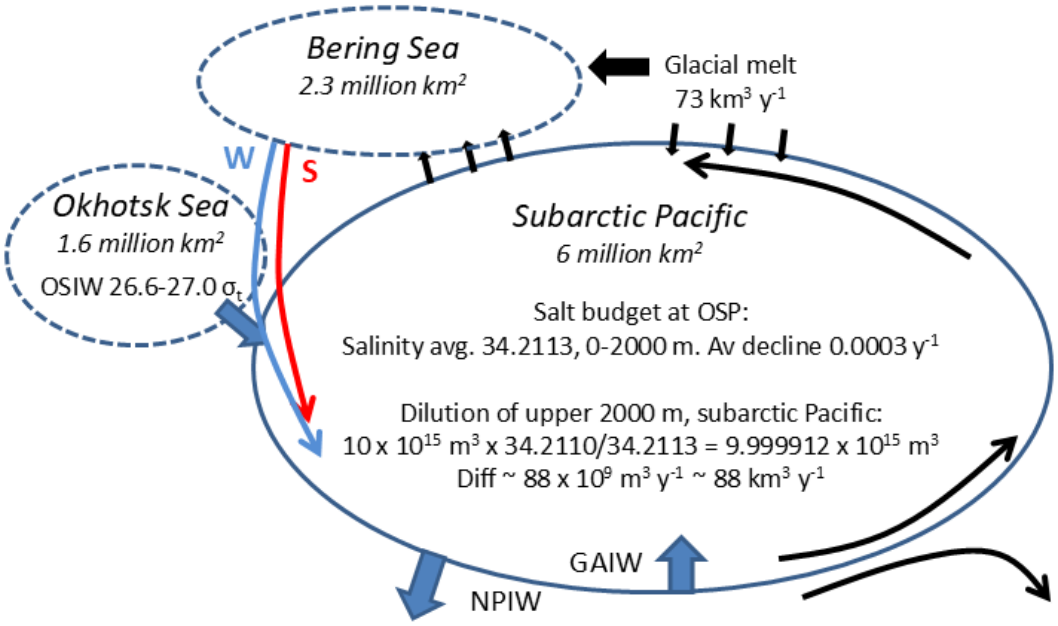


Figure 3. Schematic diagram of the Subarctic Pacific and marginal seas. Intermediate depth waters include OSIW (Okhotsk Sea Intermediate Water), NPIW (North Pacific Intermediate Water) and GAIW (Gulf of Alaska Intermediate Water). OSIW outflow from Okhotsk requires substantial inflow of Bering water in winter (W) but not in summer (S, Katsumata and Yasuda, 2010). A simple salt budget for the upper 2000 m based on observed changes at OSP estimates an annual freshwater input of 88 km^3. Arrows show directions of flow.

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Frank Whitney

My career in oceanography spanned 1969 to 2006, first as an assistant to Ed Grill, a chemical oceanography professor at University of British Columbia, then as a manager of a UBC field site for the CEPEX program (Controlled Ecosystem Pollution Experiments, with Tim Parsons, Paul Harrison, and others) and finally as a chemist with Fisheries and Oceans Canada (with C.S. Wong). I retired in 2006 but stayed active in research for another decade. More recently, instead of looking down into oceans, I've begun looking up into the skies as a very amateur astrophotographer.

International Year of the Salmon Pan Pacific Expedition

Laurie Weitkamp, Evgeny Pakhomov, Katie Howard, and Sara Gilk-Baumer

During February–April 2022, an international fleet of five ships from the USA, Canada, and Russia conducted a coordinated survey of Pacific salmon high seas habitats across 2.5 million km^2 of the North Pacific Ocean (Figure 1). The overall goal of the expedition was to demonstrate the utility of an international pan-Pacific winter ecosystem survey to understand how increasingly extreme climate variability in the North Pacific Ocean and accompanying changes in the physical environment, influence the abundance, distribution, migration, and growth of Pacific salmon and associated nekton, including lower trophic levels that serve as the salmon prey base.

Across all five ships, a total of 156 CTD casts, 167 zooplankton tows (115 vertical bongo, 42 Tucker trawl, and 32 Juday net tows), 109 surface trawls, 19 gillnet, and 17 long line sets were completed at 131 stations between February 1 and April 1, 2022 (Pakhomov et al. 2023; Weitkamp et al. 2024). Here, we provide brief summaries of three types of biological sampling: the zooplankton community, the overall catch by trawls, and the stock origins of the salmon caught. More papers have been published, or are underway, describing the many details of information gathered during the expedition.

Zooplankton

The taxonomic composition of zooplankton during the winter 2022 expedition was similar to what was previously recorded in February 1996 and 1997 along the Line P transect (Goldblatt et al. 1999), with copepods and chaetognaths dominating by biomass (Breckenridge et al. *submitted*). Moreover, the winter species composition appeared comparable to composition observed in summer, with some regional anomalies and additional presence of early copepodites of *Neocalanus* and *Calanus* (Goldblatt et al. 1999). Greater densities of mesozooplankton during winter 2022 were observed along the Alaska Gyre margins, in particular its southern and southeastern periphery, and coincided with increased water temperatures (Figure 2). The center of the gyre was characterized by decreased temperatures and elevated nutrient concentrations suggesting upwelling and increased proximity to the core of the gyre and coincided with low to modest zooplankton standing stocks (Figure 2).

The basin-scale geographic pattern of zooplankton assemblages generally paralleled the division between the Transitional and Central Subarctic oceanographic domains (Dodimead et al., 1963). In the study area, cluster analysis of genus abundance separated samples largely along a temperature gradient. Clusters were broadly grouped into cool (< 7°C) and warm (> 7°C) assemblages (Figure 3B). Cool assemblages were dominated by subarctic taxa, and their composition suggested a broad coherence in zooplankton structure north of the bifurcation of the North Pacific Current (NPC). Warm assemblages were primarily associated with the NPC bifurcation and were characterized by a mix of Subarctic, California Current, and Transition Zone taxa. According to the Longhurst (1995) regionalization, the cool assemblage was representative of zooplankton occurring within the eastern Pacific Subarctic Gyres Province, while the warm assemblage corresponds to the California Current Province (Figure 3A). Both assemblages also widely corresponded to a recent phytoplankton-based bioregionalization that identified two regions with unique phytoplankton dynamics (Konik et al. 2024). It appears that the NPC carries warm-water zooplankton eastward across the Pacific be-

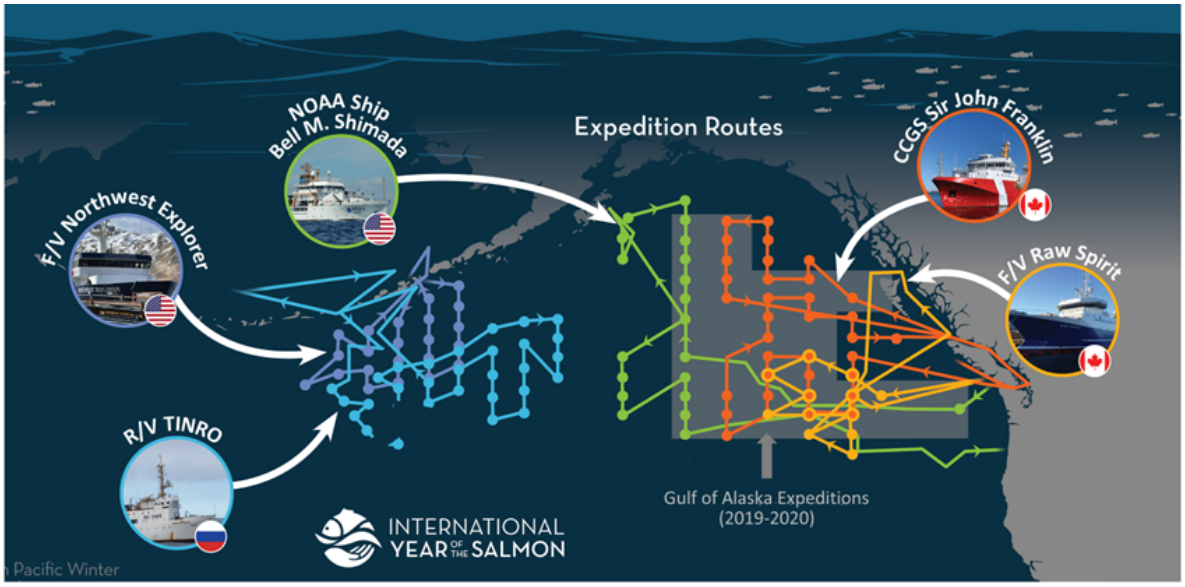

Figure 1. Map showing the ship tracks for the five ships involved in the 2022 Pan Pacific Expedition across the central and eastern North Pacific Ocean. The light gray area was sampled during 2019 and 2020 Gulf of Alaska winter expeditions.

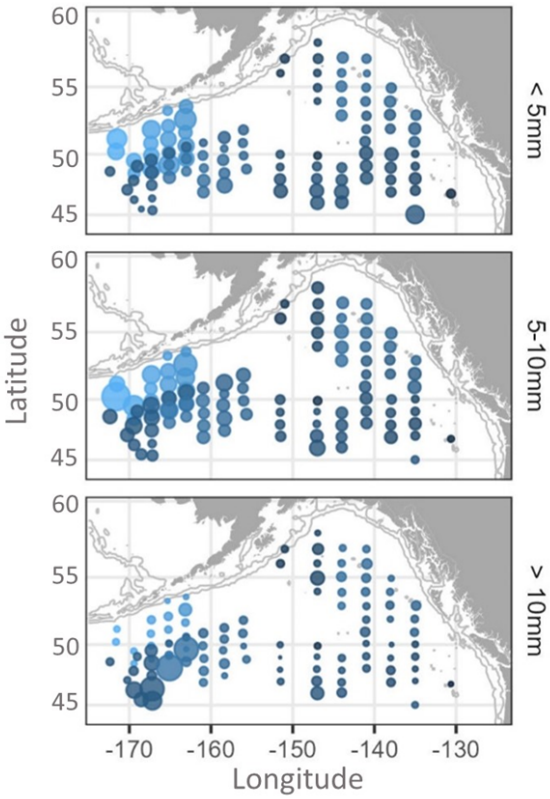

Figure 2. Distribution of mesozooplankton size-binned biomass (dry weight in mg m^{-2}) collected using bongo nets in the top 250 – 300 m during winter 2022. Bubble size indicates biomass and bubble colour indicates the day of year (DOY) that the sample was collected.

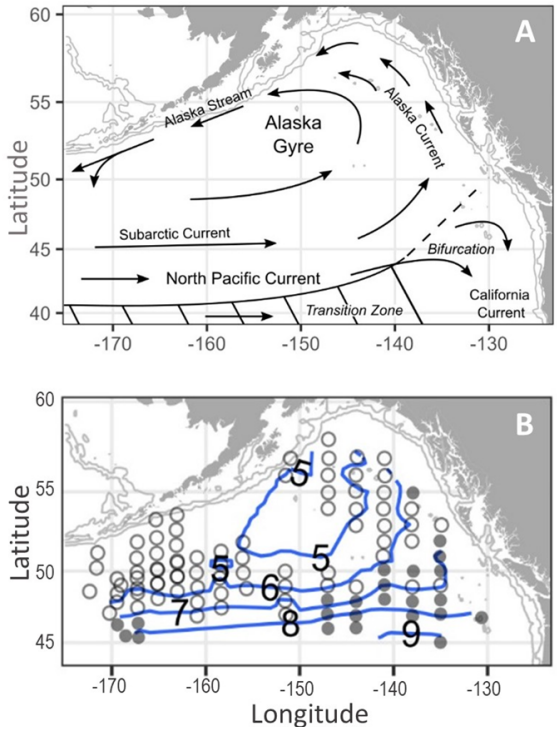

Figure 3. Map of surface circulation in the eastern Subarctic Pacific; **(A)** redrawn and modified from Peterson et al. 2017 and cool and warm assemblage samples plotted over the contours of the maximum temperature; **(B)** that occurred in the depth range of 10 – 300 m.

fore it bifurcates into the Alaska and California Currents. During the winter, poleward currents transport additional warm-water zooplankton taxa from the coastal waters of California to the Eastern Subarctic Pacific (Peterson et al., 2002; Mackas et al., 2004).

Winter biomass values were higher in warm assemblages, which was driven by small (<5 mm) taxa, specifically small copepods, appendicularians, and pteropods. Small copepods of southern origin are considered to be of lower nutritional value than larger, subarctic species (Lee et al., 2006; Mackas et al., 2007). Total biomass at larger (> 5 mm) size bins did not differ between our warm and cool assemblages (Figure 4). However, juvenile and adult euphausiids, which are important prey items for forage fish and salmonids, were represented significantly higher in cool assemblages (Bollens et al. 2010; Brodeur et al. 2019).

Variation in zooplankton abundance, biomass, and composition across the Alaska Gyre suggests that the size, location, and strength of rotation of the gyre influences the distribution of zooplankton taxa and biomass across the region. During the winter to early spring, variability in zooplankton structure and standing stock are driven by water temperature and the position of the NPC, as well as its bifurcation dynamics. The apparent relationship between zooplankton distributions and general circulation implies that current positioning and strength of the Alaska Gyre influences the composition and distribution of zooplankton biomass across the oceanic eastern Subarctic Pacific.

Trawl Catches

Across the fleet, fishing with surface trawls yielded 2,785 kg of fish, squid, and jellyfish, representing 47 taxonomic groups and 27,638 individuals (due to breakage, jellyfish were weighed but not enumerated). These catches included five species of Pacific salmon (sockeye, chum, coho, pink, and Chinook salmon), 17 species of non-sal-

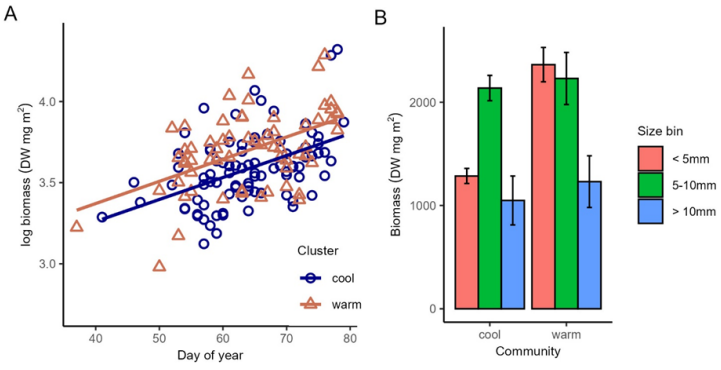

Figure 4. Log_{10}-transformed zooplankton biomass (dry weight in mg m^{-2}) vs. day of year over the sampling period; **(A)** Station-specific biomass values were restricted to winter sampling dates and are coded by warm and cold cluster groups. Comparison of mean zooplankton biomass (dry weight, mg m^{-2}) in three size bins between warm and cool cluster samples; **(B)** Error bars represent ±1 standard error of the mean.

monid fishes, 13 taxa of squid, and 8 jellyfish taxa (Weitkamp et al. 2024).

A total of 2,364 Pacific salmon and steelhead were caught across all sampling gears (trawls, gillnets, and longlines). For surface trawls, sockeye and chum salmon were caught most frequently and had the highest abundances (Figure 5). Catches of pink, coho, and especially Chinook salmon by trawls were infrequent, smaller, and largely at southern stations. Given that pink salmon are the most abundant salmon species in the North Pacific (Ruggerone and Irvine 2018), their low abundance was unexpected. All salmon species were widely dispersed throughout the study area, but there were apparent north-south differences in catch, consistent with known differences in temperature preferences (e.g., Myers et al. 2016, Langan et al. 2024). Only three non-salmonid fishes (threespine stickleback, northern lampfish, and blue lanternfish) were regularly caught across the study area (Figure 6)

Other commonly caught taxa in the trawls included myctophids, gonatid squids, and jellyfish (Figure 6), which were widely but patchily distributed across the study area. Four species of jellyfish (water *Aequorea sp*., moon *Aurelia* sp., fried egg *Phacellophora camtschatic*a jellies, and northern sea nettle *Chrysaora melanaster*) were caught at over half of the trawl stations and contributed roughly half of the total biomass caught in trawls. Three squid species (Boreopacific armhook squid *Gonatopsis borealis*, Boreal clubhook squid *Onychoteuthis borealijaponica*, and Minimal armhook squid *Okutania anonycha*) were caught in at least 20 % of trawls. As expected, most myctophids and squid were caught at night, while other species were either more common during the day, or equal between day and night. Several papers are in preparation describing the details and implications of this unique ecosystem.

Salmon Genetics

Genetic analysis of individual salmon using single nucleotide polymorphisms (SNPs) with lab- and species-specific baselines was conducted by the Alaska Department of Fish and Game (ADF&G), Fisheries and Oceans Canada (DFO), and NOAA Fisheries' Northwest (NWFSC) and Alaska Fisheries Science Centers (AFSC) using existing lab protocols and the *rubias* R package (Moran and Anderson 2018). Reporting groups were chosen based on the leave-one-out cross validation methods from Anderson et al. (2008) to obtain high assignment probabilities across baselines. These methods often resulted in broad-scale reporting groups for some species (e.g., pink salmon), but were much finer for others (e.g., sockeye salmon). Here, we provide genetic stock composition information for the most numerous Pacific salmon species in International Year of the Salmon expedition catches: chum, sockeye and pink salmon. Consensus assignments by two genetics labs (ADF&G and DFO) were reported for chum salmon, while sockeye and pink assignments were generated solely by ADF&G.

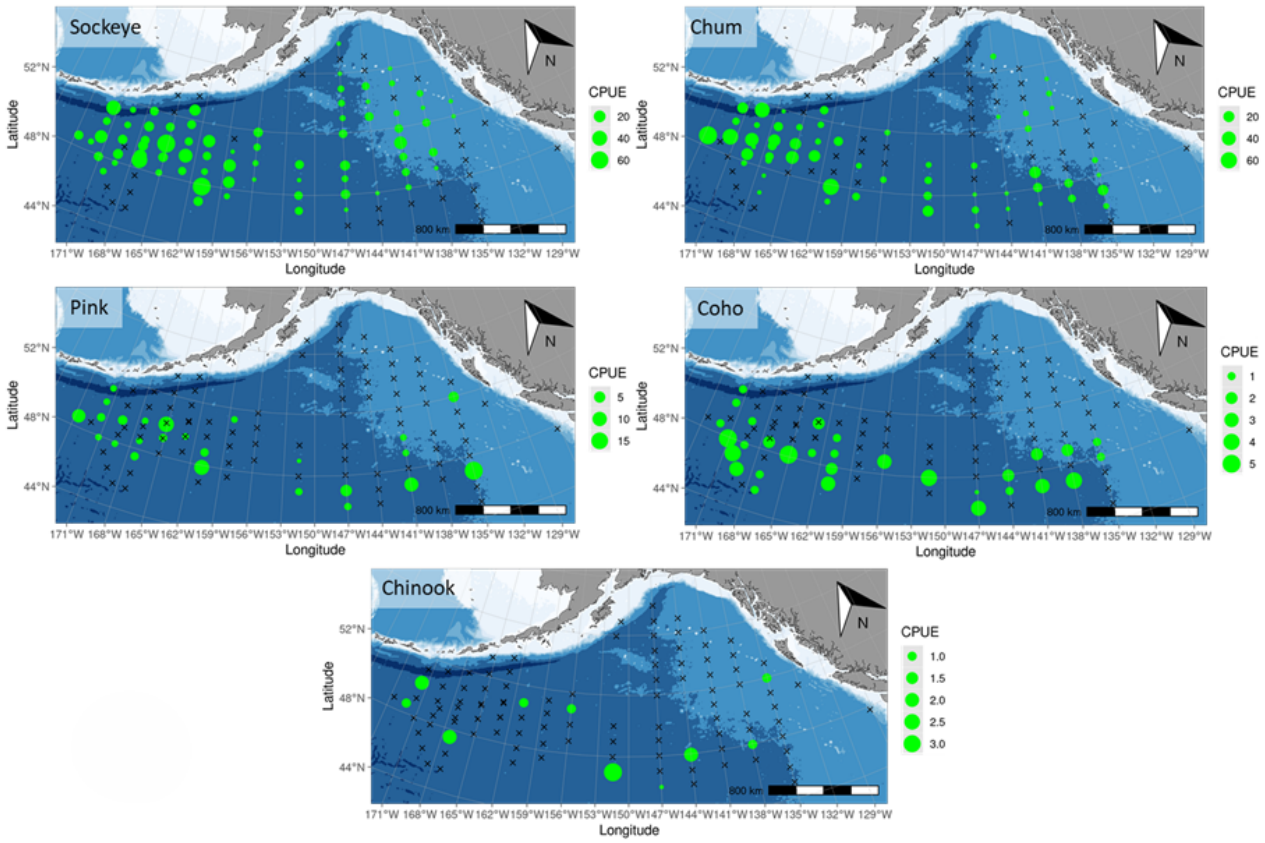

Figure 5. Maps showing the distribution and abundance of sockeye, chum, pink, coho, and Chinook salmon caught by trawls across the study area in 2022. Note the different scales on each map; X indicates zero catch.

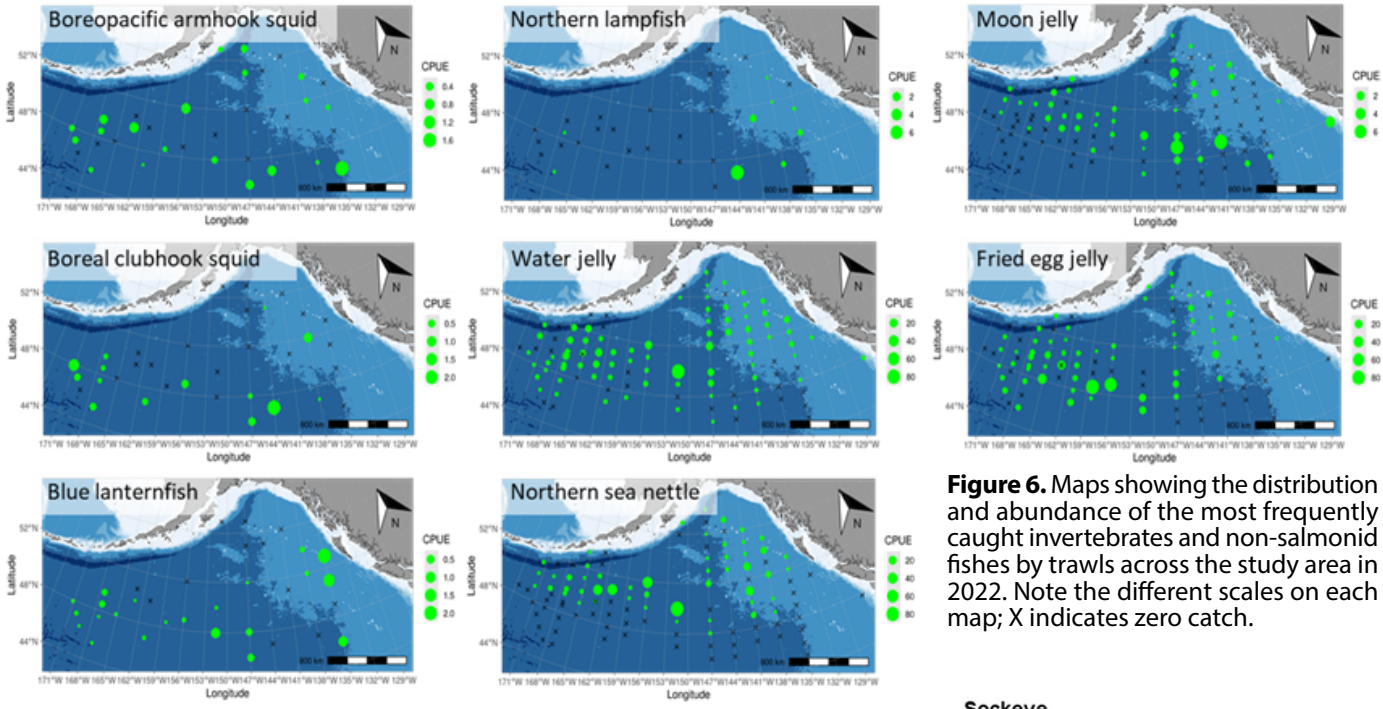

Figure 6. Maps showing the distribution and abundance of the most frequently caught invertebrates and non-salmonid fishes by trawls across the study area in 2022. Note the different scales on each map; X indicates zero catch.

Genetic assignment of individuals to reporting groups indicated Pacific salmon caught during the survey represented stocks from around the Pacific Rim. There was a general tendency for Asian and western Alaskan populations to be found in the western part of the study area (caught by F/V Northwest Explorer and R/V TINRO), and Gulf of Alaska and Pacific Northwest populations in the eastern part (caught by R/V Bell M. Shimada, R/V Franklin, and F/V Raw Spirit). Chum and pink salmon showed the strongest clines in stock compositions moving from western to eastern samples (Figure 7). Interestingly, one odd-year pink salmon from the Asia/Beringia region was captured by the F/V Northwest Explorer. Most sockeye salmon originated from western Alaska and Bristol Bay, but also included fish from all other reporting groups; with fish from Russia in the western part of the study area, and from British Columbia/Washington in the eastern part of the study area (Figure 7).

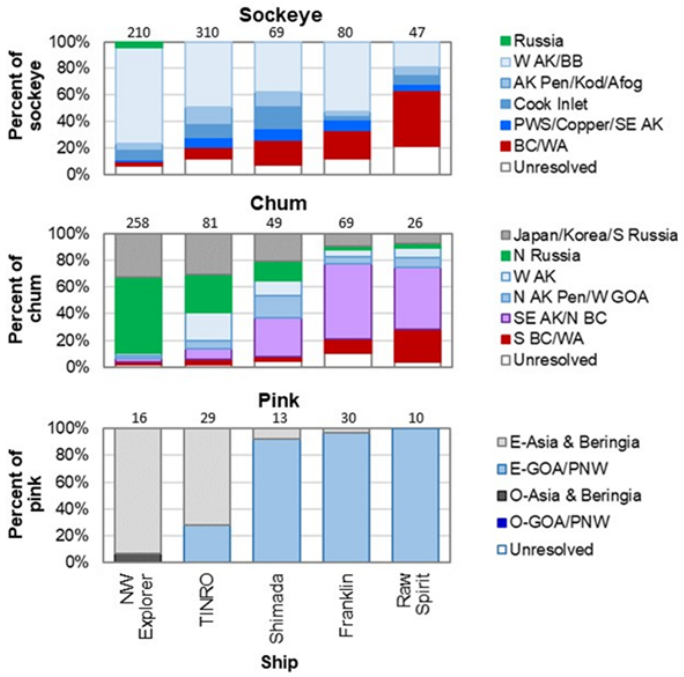

Figure 7. Individual assignment results from the 2022 Pan-Pacific Expedition to genetic stock identification reporting groups organized by species and ship. Numbers above each column are the number of salmon analyzed. Pink salmon stocks are separated between even (E) and odd (O) year groups. Abbreviations are AK: Alaska; BC: British Columbia; WA: Washington; S: South; N: North; W: West; E: East; SE: Southeast; Pen: Peninsula; GOA: Gulf of Alaska; BB: Bristol Bay; Kod: Kodiak; Afog: Afognak; PWS: Prince William Sound; PNW: Pacific Northwest. 'Beringia' includes populations originating from rivers on both shores of the Chukchi and Bering seas. Samples reported and assigned to reporting groups passed genotyping quality control and had a >80% assignment probability or consensus assignments between labs. Fish labeled as "unresolved" resulted from assignment probabilities < 80% or a lack of consensus in assignments between labs.

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Regional Reports

The Northeast Pacific: Update on Marine Heatwave Status

Andrea Hilborn, Lu Guan, Charles Hannah, and Tetjana Ross

During 2024, marine heatwaves (MHWs) in the Northeast Pacific (NEP) exemplified the push and pull between global warming, which tend to increase MHWs, and climate modes like La Niña, which tends to decrease MHWs. 2024 has been a dynamic year, with both strong warm and cold anomalies over shelf waters along the west coast of North America. As we close out the year, we see patterns generally consistent with the Oceanic Niño Index (e.g., Niño region 3.4) being Neutral (La Niña since May). However, since mid-December 2024, warm anomalies have been strengthening and MHW and class surface waters have been expanding northward in the NEP. Given that 2024 is expected to be the global warmest year on record, with the January to September mean air temperature sitting at 1.54 C above the pre-industrial average, we will see whether the connection between ENSO and NEP sea-surface temperatures (SSTs) remains (WMO, 2024).

The year 2024 began with MHW conditions hugging the western coastline of North America, spanning shelf waters from Alaska south to California (see PICES, 2024, Figure 1, page 48). This pattern dissipated during April, while a large, anomalously warm water mass entered the southwestern NEP. Later in April, surface waters over the continental shelf were cooler than usual. The magnitude of warm anomalies (and MHWs) present in the NEP reduced in June, before expanding and extending north-eastward across the NEP to central / northern British Columbia (BC) and southern Alaska waters (Figure 1A). However, further south along the shelf, cold anomalies (greater than -2°C) persisted until late July. During August (Figure 1B), a large MHW expanded and entered the Canada and USA shelf waters once again, encompassing over half of the area of the Canadian and USA Exclusive Economic Zones (EEZs). As discussed further in the California Current MHW Tracker, this pattern is both spatially and temporally consistent with late summer MHW observations from recent years (California Current MHW Tracker, 2024). There was a slight reprieve from MHW conditions in September, then a very large MHW extended north in October encompassing approximately half of the NEP (Figure 1C). In the final months of 2024, warm anomalies have been present, but generally not very strong, and variable in location (Figure 1D). Generally, south of 43°N, SSTs have been warmer than usual, with large areas classified as MHWs. Over the last few weeks of the year the anomalies have been increasing across the NEP (not shown).

On the larger scale, we are currently experiencing ENSO neutral conditions, with a short-lived La Niña expected. This La Niña is predicted to be weak and would be quite late compared to the timing of a more "normal" arrival. As discussed in the recent NOAA ENSO blog (Becker, 2024), only two La Niñas within the last 75 years have developed between the months of October and December! Similarly, while the key ENSO monitoring region has cool surface temperatures, the Pacific Ocean in general is much warmer than usual for this time of year when considering the 1991-2020 SST average. Characteristics of La Niña have been present in the atmosphere, such as stronger than average Walker Circulation, but have yet to transfer to the ocean as measured by traditional indices. The combination of warm global temperatures, warm offshore SSTs, and the predicted weak La Niña over the next few months, makes it likely that either average, or warmer than average, ocean surface temperatures will persist in the NEP. Globally, forecasts are predicting a slight decline in the surface area of the ocean experiencing MHW conditions. As of November 2024, the percent of the surface ocean in MHW status finally dipped below 30% for the first time since early 2023. Previously, only once has 30% of the global ocean in MHW status been breached since the start of SST monitoring with satellites, for a brief period in early 2016 (NOAA PSL, 2024).

Vancouver Island
Photo by Lydia Walton

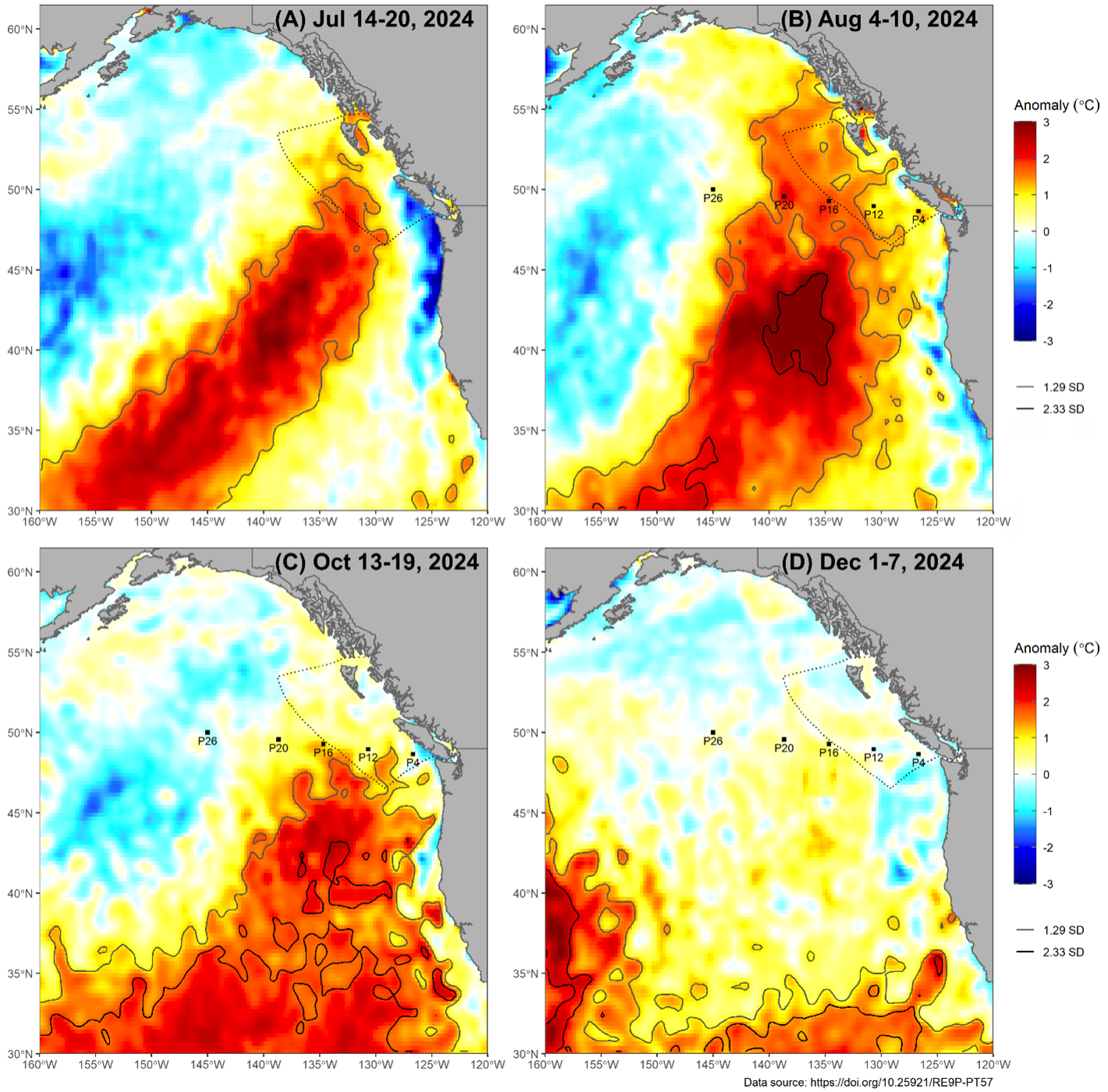

Figure 1. NOAA OISST anomaly from the weeks of July 14th **(A)**, August 4th **(B)**, October 13th **(C)**, and December 1st **(D)**, with standard deviations corresponding to the 90th and 99th percentiles (black contours, labelled 1.29 and 2.33 SD) from the 1991-2020 climatology. Selected stations along Line P are labelled as black squares, and the Canadian Exclusive Economic Zone is indicated with a dashed line. Data sourced from https://doi.org/10.25921/RE9P-PT57 and analyzed by the authors. These plots update weekly at https://github.com/ios-osd-dpg/Pacific_SST_Monitoring.

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Dr. Charles Hannah is a senior Research Scientist for Fisheries and Oceans Canada based at the Institute of Ocean Sciences in Sidney, BC. His research program is focused on the oceanography of the central and north coast of British Columbia and he is currently leading a program of moored observations along the British Columbia continental shelf. Within PICES he is member of the Advisory Panel on North Pacific Coastal Ocean Observing Systems (AP-NPCOOS).

Dr. Tetjana Ross is a Research Scientist at the Institute of Ocean Sciences, Fisheries and Oceans Canada, in Sidney, BC. She is an ocean physicist who develops new ways to observe the ocean – from observing ocean mixing using sound to taking photographs of zooplankton in turbulence. Nowadays, she rarely goes to sea, sending robots out to do the work for her: both gliders and Argo floats (i.e., she currently leads the Pacific component of DFO's Argo and glider programs). In PICES she is member of the Technical Committee on Monitoring and the Working Group on Submesoscale Processes and Marine Ecosystems. (WG 50). In PICES she is member of the Technical Committee on Monitoring and the Working Group on Sub-mesoscale Processes and Marine Ecosystems (WG-50).

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Regional Reports

Western North Pacific: Current Status and Developments

Sea surface temperature in the 2024 warm season

Sakamoto Kei (the Japan Meteorological Agency)

The western North Pacific was characterized by positive anomalies of sea surface temperature (SST) in the wide area between 30°N and 45°N throughout the warm season (June-September) in 2024 (Figure 1). In the latitude band centered on 40°N, which corresponds to the boundary between the subtropical and subpolar gyres, positive anomalies of over +4°C were observed in the area from 140°E to 180°E. In July, positive anomalies were also widely observed in the area from 20°N to 30°N, south of Japan. The SST in this area was the highest for July since 1982, when the satellite SST analysis by the Japan Meteorological Agency (JMA) became available. This may have contributed to the record high air temperatures in the Okinawa Islands.

Continuing from the previous season, significant positive anomalies in the areas east of Sanriku and southeast of Hokkaido, Japan were seen in the warm season in 2024. For example, in September, wide areas were covered by positive anomalies exceeding +4°C (Figure 2(A)). This is thought to be due to the northward shift of the Kuroshio Extension since 2023 (Figures 2(B) and (C)). In addition, a warm eddy was detached from the Kuroshio Extension in May 2024 and has stayed southeast of Hokkaido, which is also thought to have contributed to the high SST. Due to these factors, the ocean interior temperature has also continued to be significantly higher than normal. In September, positive anomalies exceeding +10°C were analyzed in the range of depths of 50 to 200 m. There are concerns about impacts on the marine environment, such as the distribution of fishery resources.

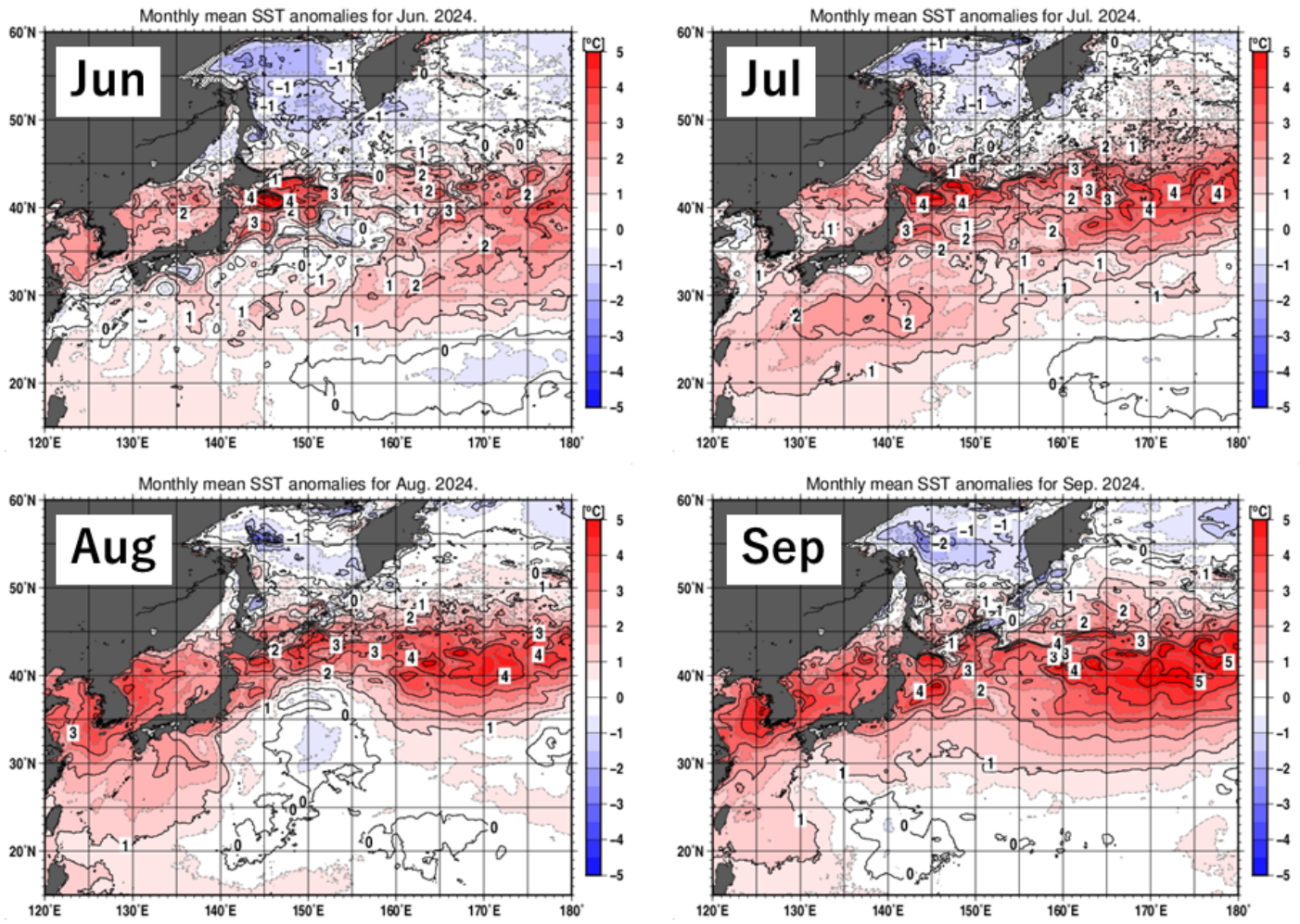


Figure 1. Monthly mean SST anomalies from June to September 2024. Monthly mean SSTs are based on JMA's HIMSST (High-resolution Merged satellite and In-situ data Sea Surface Temperature). The anomalies are deviations from the 1991-2020 SST climatology.

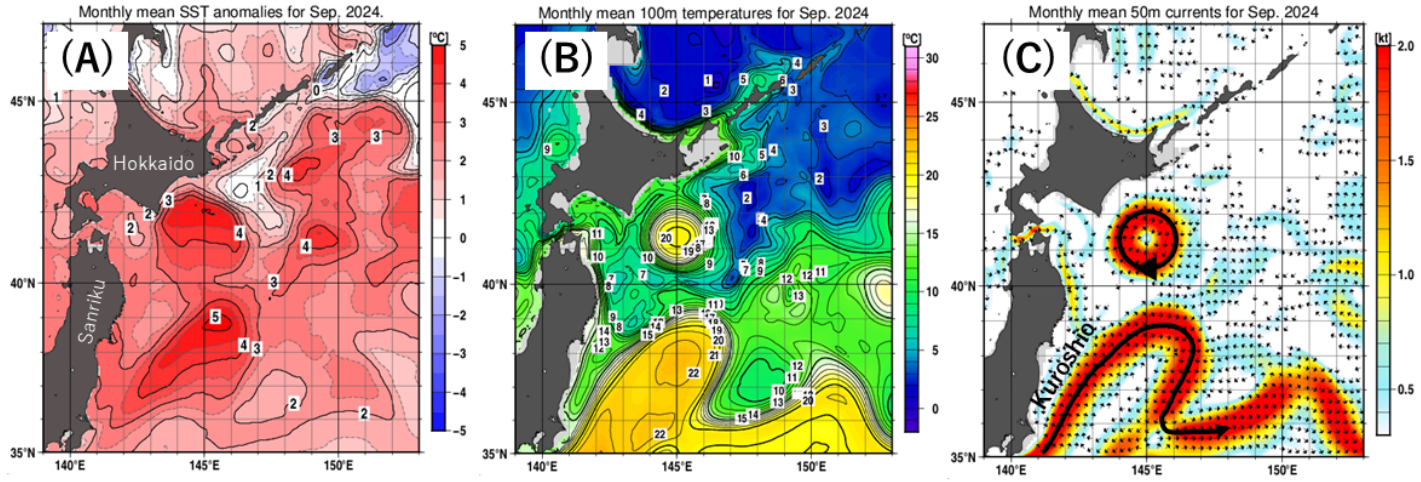
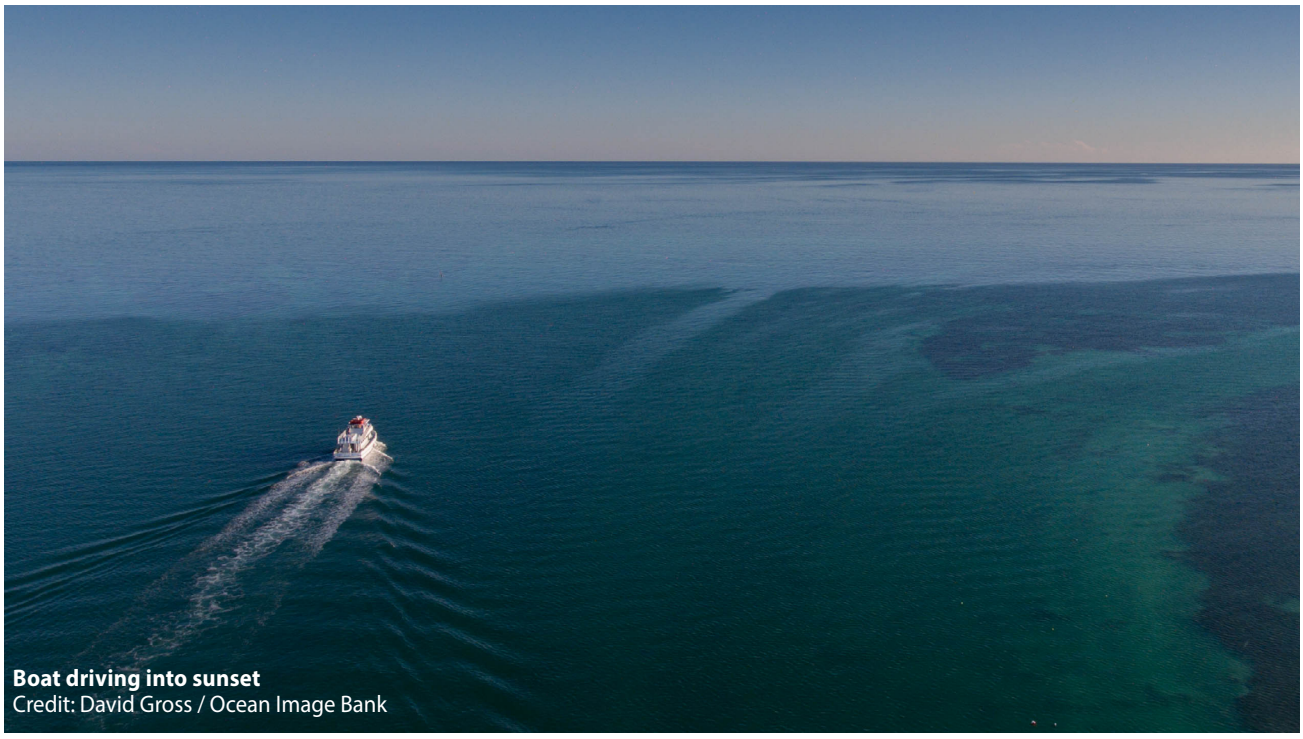


Figure 2. (A) SST anomaly, **(B)** 100m-depth temperature, and **(C)** 50m-depth current velocities in September 2024 in the area east of Japan. The data of (A) are the same HIMSST analysis as in Figure 1, and those of (B) and (C) are the analysis of the Japanese Coastal Ocean Monitoring and Forecasting System "MOVE-JPN" operated by JMA. The thick black lines in (C) indicate the flow path of the Kuroshio Extension and a warm eddy detached from it.

Dr. Kei Sakamoto is a senior forecaster at the Office of Marine Prediction of the Atmosphere and Ocean Department of the Japan Meteorological Agency, in Tokyo, Japan.



Boat driving into sunset
Credit: David Gross / Ocean Image Bank

Regional Reports

The Bering Sea: Current Status and Recent Trends

Emily Lemagie and Elizabeth Siddon

Winds and Sea Surface Temperature

Storms in the late spring and into summer of 2024 increased vertical mixing over the Bering Sea shelf, resulting in a cool SST anomaly and warmer than average mid-water column temperatures, as heat was distributed throughout the water column (Figure 1). Strong monthly mean winds May–August 2024 reflect the impact of these individual storm events. Historical mean summertime winds are weak and variable. Cool SST anomalies following sea ice retreat strengthened over this period, covering much of the shelf. These cool surface anomalies did not recede until autumn.

Despite cool SST anomalies in spring and summer 2024, depth-averaged temperatures were near the long-term average, similar to 2023 temperatures (Figure 2). Water column temperature measurements from the NOAA EcoFOCI M2 mooring site (since 1995), provide insight into why the spring and summer 2024 SST was so cool: winds from storms in the spring and summer supported a deeper than average mixed layer. These mixing events exchanged heat between the warmer surface and cooler bottom water (Figure 3a). M2 is situated along the 70 m isobath on the southeastern Bering Sea shelf and provides a representation of the biophysical conditions of the middle shelf (50–100 m depths). This site includes a surface buoy equipped with a profiling crawler (Prawler) that continuously collects high resolution physical and biological water column measurements.

Historically, the summertime mean mixed layer depth at M2 is ~20 m deep (Figure 3a). From the onset of thermal stratification over the middle shelf domain, the mixed layer depth remains constant in the absence of strong storms to deepen the interface. Storms in May and June 2024 had mixed the water column to 40 m, exchanging heat throughout the water column, and leading to weaker than average seasonal stratification. Storms throughout the summer maintained a deeper mixed layer, even as summer stratification developed. The surface layer reached depths >30 m by September; 50% deeper than the historical mean.

In 2024 there was also anomalous timing and magnitude of the seasonal phytoplankton blooms, which are a foundation of the marine food web (Figure 3b). The spring bloom occurred later than the long-term mean (Nielsen et al., 2024), and the fall bloom in early September was almost a month earlier than historic averages (Siegler et al., 2014). Overturning of the water column from wind-driven mixing introduced nutrients into the surface layer and contributed to the early onset of the fall bloom.

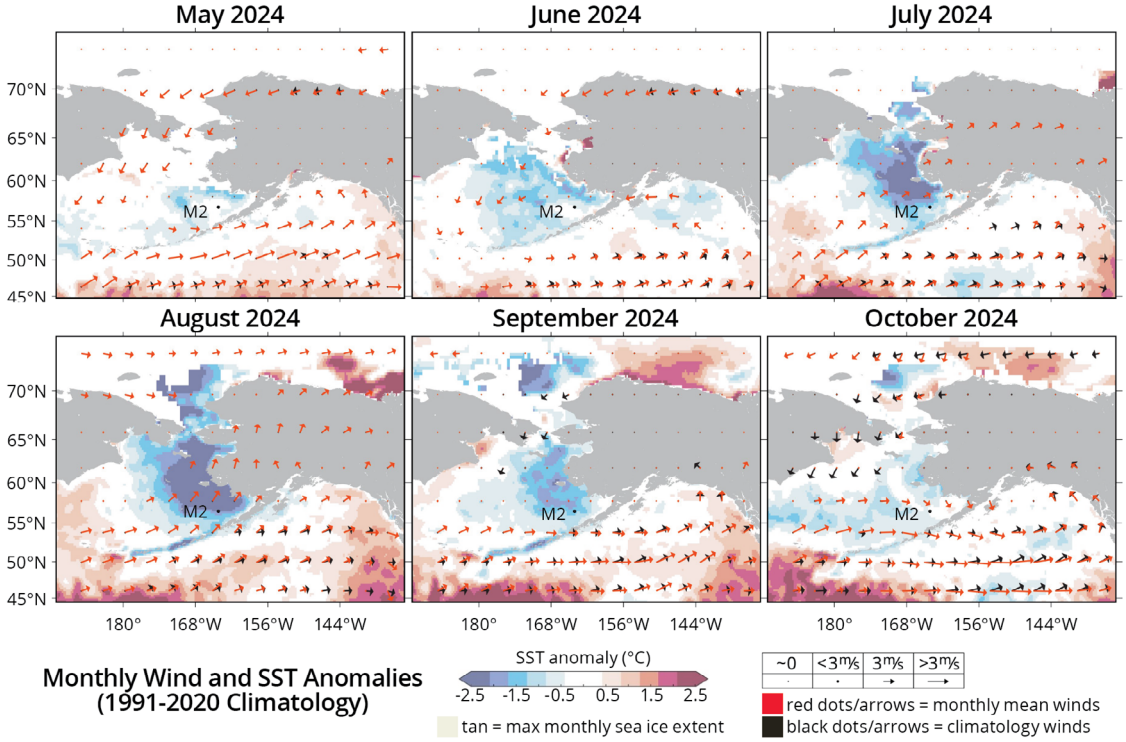


Figure 1. Monthly mean maps of sea surface temperature (SST) anomalies and surface winds. Monthly climatological winds (black) are compared to monthly mean winds (red). The climatological period is from 1991–2020. SST data are from the NOAA High-resolution Blended Analysis of Daily SST and Ice (OISST), and 10-m wind data are from the NCEP/NCAR Reanalysis II; both are available from NOAA's Physical Sciences Laboratory.

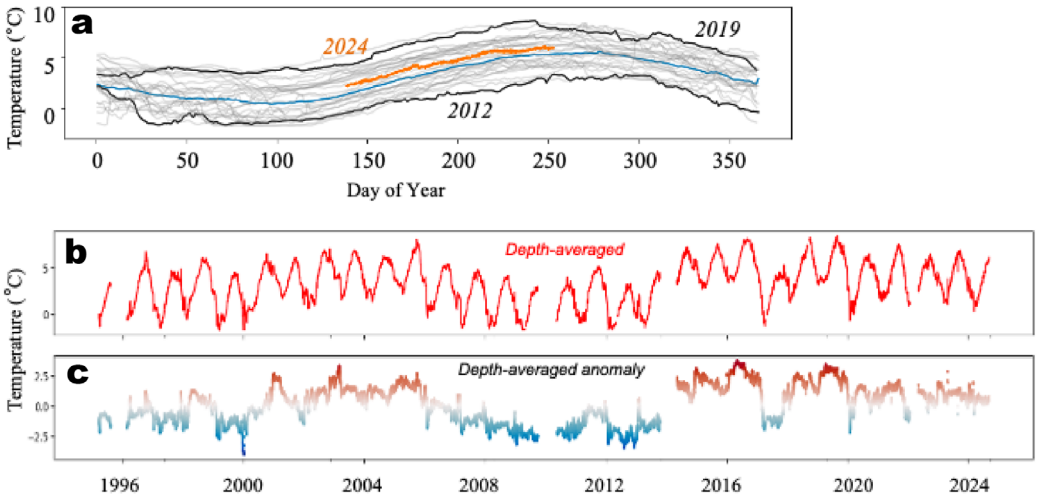


Figure 2. (A) Annual cycle of depth-averaged temperature at M2. The blue line is the time-average and the orange line is the summer 2024 time series. **(B)** Depth-averaged temperatures and (c) depth-averaged temperature anomaly measured at M2 from 1995-2024. Time-averages are from 1995-2010.

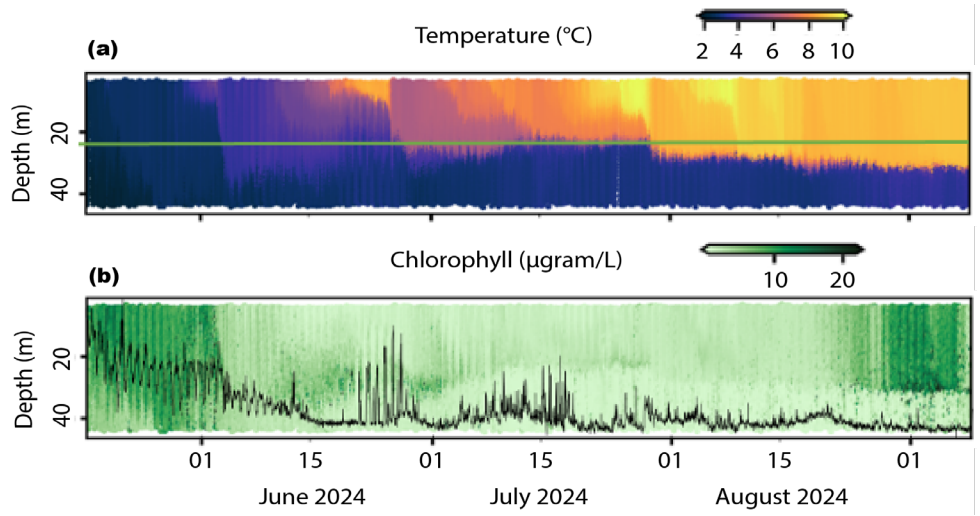


Figure 3. (A) Temperature measured at M2 during 2024. The green line indicates 20 m, which is the long-term mean summer mixed layer depth. **(B)** Observed chlorophyll a concentrations. Measurements made using the profiling crawler (Prawler) at mooring M2 in the southeastern Bering Sea.

Bering 10K summer hindcast update

The model hindcast from the Bering 10K Regional Ocean Modeling System (ROMS) captured the same patterns as observed at M2, and provides further insight into the spatial distribution of bottom temperatures and the summer cold pool. Bottom temperature across the Bering Sea shelf in 2024 showed mixed characteristics of a neutral or warm year (Figure 4). The mean simulated southeastern Bering Sea shelf bottom temperature on July 1 was 2.82 °C, only 0.05 °C above the climatological (1970-2024) mean of 2.76 °C. The 2024 cold pool index, defined as the proportion of the southeastern shelf that has a bottom temperature below a particular threshold (O'Leary et al., 2020; Thorson, Ciannelli & Litzow, 2020), of 0.26 is a value characteristic of neutral/warm years (relative to the climatological mean of 0.36). However, the coldest waters were isolated to the northern part of the southeastern shelf, as is more characteristic of a warm year, with a 0 °C cold pool index of only 0.02 (versus 0.11 mean). Our year-by-year cluster analysis was somewhat inconclusive; as a non-extreme year, 2024 shared many characteristics with other near-neutral years but we found no particularly strong analogue years for easy comparison.

Despite these warm/neutral conditions at depth, simulated SST values from ROMS were cooler than average from May through August across much of the southeastern shelf, reflecting similar cool surface anomalies seen in satellite measurements and at the M2 mooring. These cool anomalies were present only in the surface values, with total integrated water column temperature remaining near the long-term climatological mean throughout the spring and summer, and with bottom temperatures near or above the long-term mean.

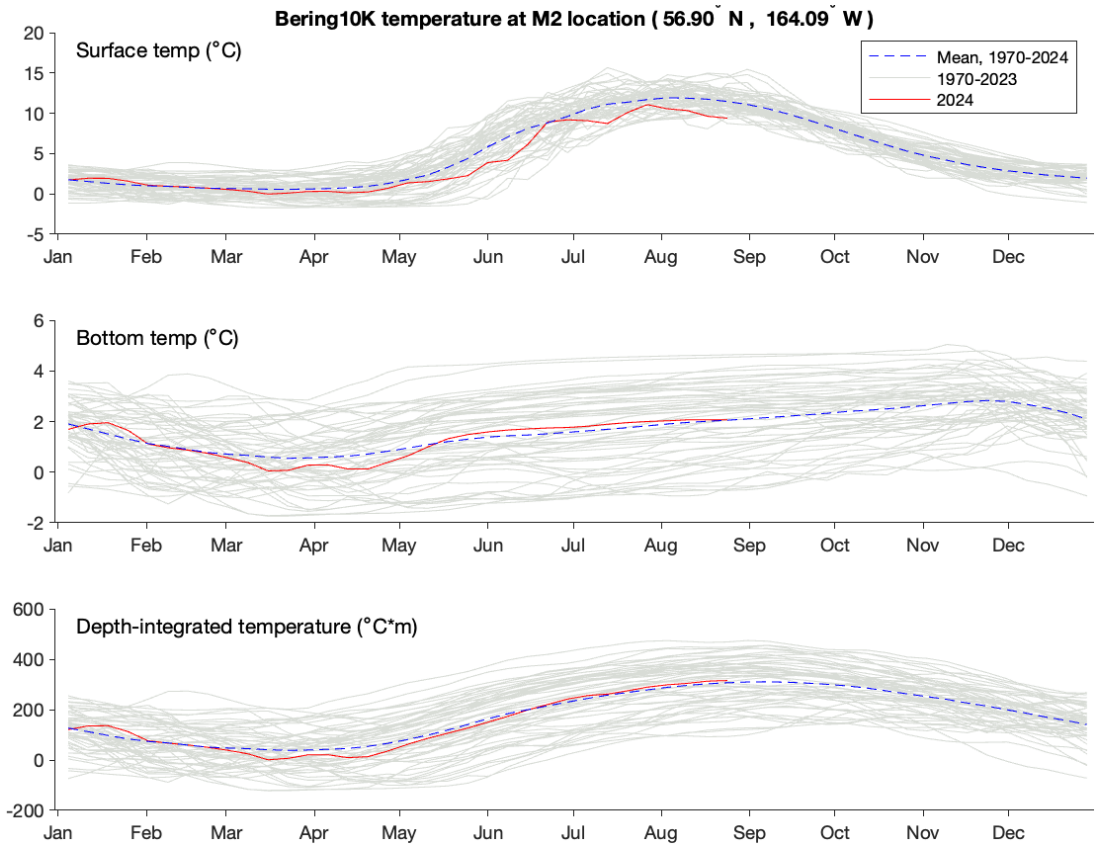


Figure 4. Surface, bottom, and depth-integrated temperature (°C*m) at M2 from the Bering 10K model. Gray lines are 1970-2023 temperatures, with the mean over this period represented by the dashed blue lines. The red lines are 2024 temperatures.

Carbon dioxide dynamics at the M2 surface mooring

A moored autonomous pCO_2 system (MAPCO2TM) observes CO_2 dynamics at the seawater-air interface at the NOAA EcoFOCI M2 mooring site in the southeastern Bering Sea (Figure 5). The CO_2 record, which began in 2011 led by the University of Alaska Fairbanks, monitors the difference between the partial pressure of carbon dioxide (ΔpCO_2) in seawater and air (pCO_2 sw - pCO_2 air). The surface ocean in this region is on average a natural sink for CO_2, as indicated by the negative ΔpCO_2 values.

Preliminary data from 2024 are on track with seasonal trends and show the expected drawdown of seawater pCO_2 associated with primary production. Atypical deployments in 2021 and 2023 extend the record into the winter months and show positive ΔpCO_2 values. This indicates the region has seasonal outgassing, making the surface

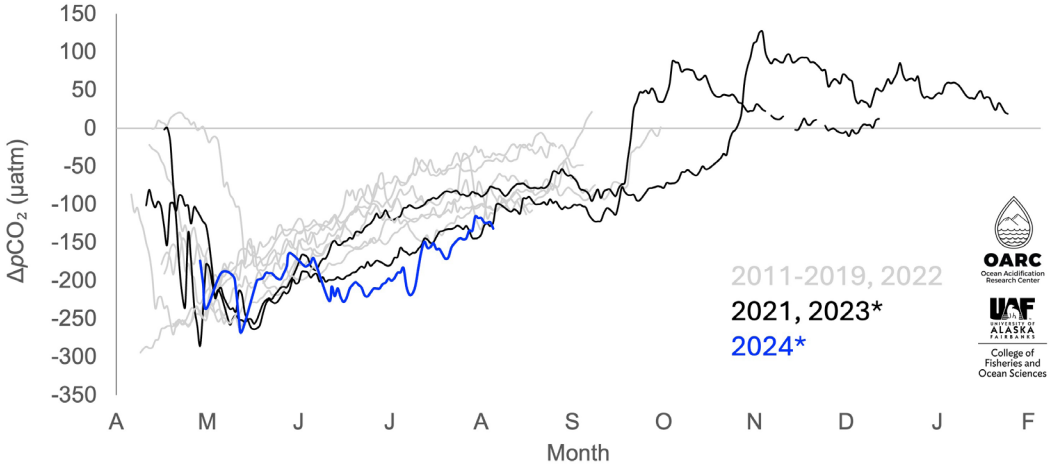


Figure 5. Difference between partial pressure of carbon dioxide (ΔpCO2) in seawater and air, 1 m above and below the seawater-air interface. The full record shows data from 2011 to 2019, 2022 (gray); 2021 and 2023* (black), and 2024 (blue). Years marked with an asterisk are raw data, all other years are final and public (Monacci et al., 2023).

ocean a temporary source of CO_2 to the atmosphere. Areas of high variability like the southeastern Bering Sea require a long record to detect the anthropogenic trend of increasing seawater CO_2, the driver of ocean acidification. Other observations of the marine carbonate system show this region is vulnerable to ocean acidification due to the natural proximity to biological thresholds and the accumulation of the anthropogenic CO_2 in seawater globally. Final data are public and support regional model development, including the Bering10K (e.g., Pilcher et al., 2024), as well as national and global synthesis products.

Acknowledgments

Many thanks to the scientists who helped create this report: Drs. Phyllis Stabeno and Emily Lemagie (NOAA-PMEL) provided the M2 observations; Dr. Kelly Kearney at UW-CICOES and NOAA-AFSC provided information on water column temperature from the Bering 10K Regional Ocean Modeling System (ROMS); Natalie Monacci (UAF) provided the summary of carbon dioxide dynamics.

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Jellyfish in Prince William Sound, Alaska
Credit: Ron Watkins / Ocean Image Bank

PICES by the Numbers: PICES-2024 Survey Synthesis

Sonia Batten

Annual Meeting Survey

The survey was intended to capture thoughts related to the External Review Panel's recommendation for a shorter annual meeting. The survey was sent to 737 people comprising registered attendees of PICES-2024, as well as members of PICES expert groups who were not registered. The survey was sent out about two weeks after the end of the meeting, ten days were allocated for responses, and a reminder was sent with three days remaining. Responses were anonymous but responders were asked to select their career stage and sector of PICES.

There were 120 responses by the closing date (Nov 29) representing 16% of the recipients. The apparent average response rate for "customer satisfaction" surveys is 10-30% so this was on the low side, but typical (especially considering that not all recipients were available during the short time frame we gave for a response).

In terms of composition, responders were quite evenly split between career stages and there was good representation of the sectors of the PICES community (Figure 1).

Responses to Survey Questions

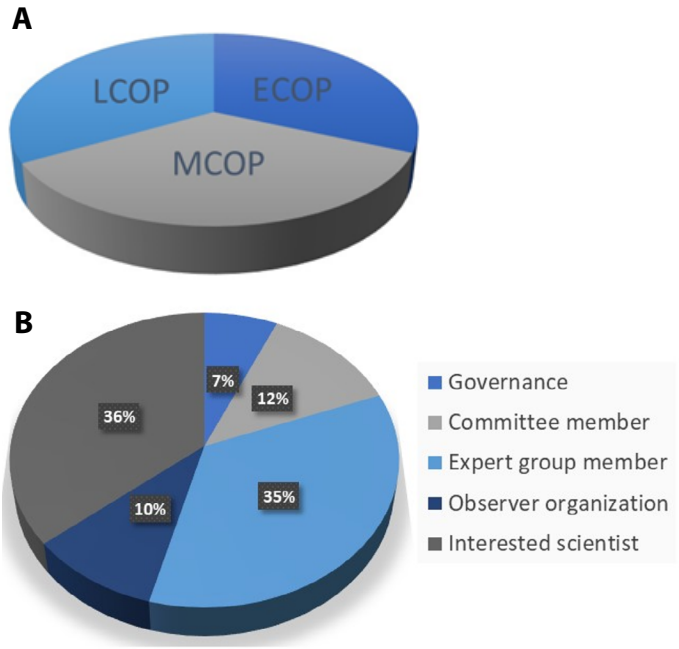


Figure 1. Composition of survey responders broken down by **(A)** career stage: Late Career Ocean Professional (LCOP), Mid Career Ocean Professional (MCOP), and Early Career Ocean Professional (ECOP) and **(B)** sector of PICES.

Q1. Length: PICES-2024 was shorter than other annual meetings have been in the past two decades, with workshops and expert group business meetings on the preceding weekend only and 4.5 days of sessions.

83% of responders thought that this was about right, with 17% feeling it was still too long. There was only a little variability between career stages (Figure 2).

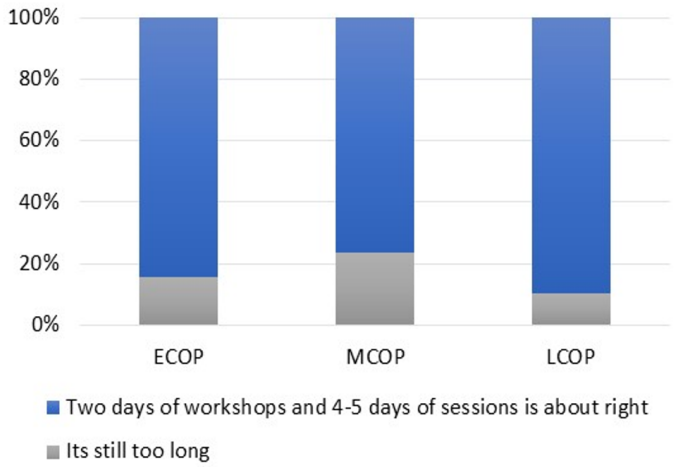


Figure 2. Meeting length responses grouped by career stage of responder: Late Career Ocean Professional (LCOP), Mid Career Ocean Professional (MCOP), and Early Career Ocean Professional (ECOP)

Q2. Plenary Session and Symposium: After the opening ceremony on the Monday, there is a plenary session with a Science Board Symposium (although in 2024 this was the FUTURE Symposium instead).

59% of responders felt that it was important to have a plenary session/science symposium on the first day, with 35% replying that they would prefer to have parallel sessions on the first day after the opening ceremony if it meant a shorter meeting. Of the 6% that provided a comment, there was some support for a shorter plenary session (perhaps 1-3 high level talks), allowing for a half-day of parallel sessions on the Monday afternoon. However, some expressed a desire to have a Panel, an ECOP showcase, and to be flexible rather than have a rigid format.

Q3. Topic Sessions: PICES-2024 topic session days (Tues-Thurs) each had three parallel sessions.

61% of responders thought that it would be better to have more parallel sessions if the meeting had to be shorter, while 32% thought it would be better to have fewer sessions overall, and no more than 3 parallel sessions. There were different views on what an "optimum" number

of parallel sessions might be, with suggestions ranging from 2 to 5. Generally, 3 was seen as a good compromise, while some felt it could be pushed to 4. Some comments also suggested merging topic sessions to create a multi-disciplinary session, keeping it to 3 parallel sessions, but only for a half a day each to fit in more topics (so 6 sessions a day). However, it was acknowledged that fewer sessions would likely attract fewer speakers/attendees.

Q4. Poster Session: The PICES Poster session is typically on the Thursday evening (although posters are displayed for the three days before this).

Two thirds (66%) of responders thought that one session on the Thursday works OK, and 21% thought one session was OK but would like it to be earlier in the week (Figure 3). 11% thought that there should be more than one poster session. Comments provided included suggestions to have it earlier in the day (since meeting days are so long and people have jet-lag/care-giving duties/health issues). There were some differences between career stages with almost half of ECOPs preferring a change from the current practice.

Q5. Business Meetings: Expert groups have business meetings online ahead of time, but many also have an in-person meeting as part of the annual meeting. A shorter meeting might not be able to accommodate as many business meetings.

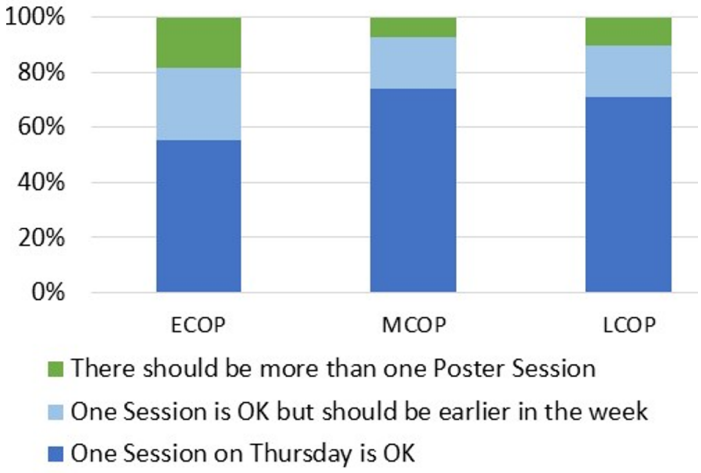
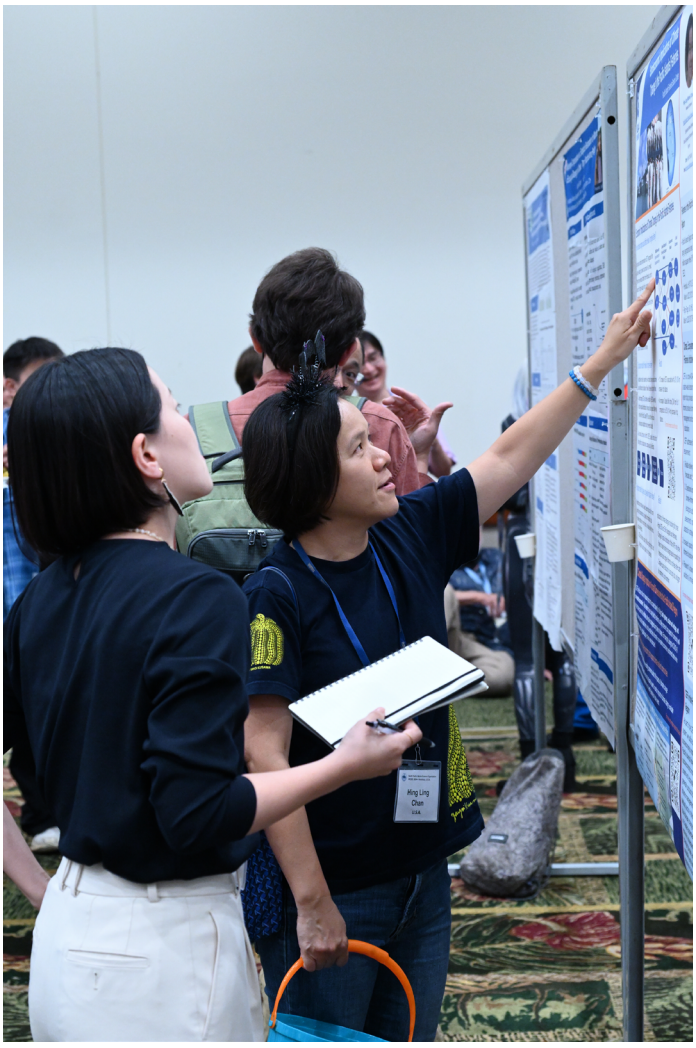


Figure 3. Poster session responses grouped by career stage of responder: Late Career Ocean Professional (LCOP), Mid Career Ocean Professional (MCOP), and Early Career Ocean Professional (ECOP)

Responders could pick multiple answers for this question. Making progress on expert group work and bringing in new people were selected as the most important reasons for in-person business meetings at the annual meeting (Figure 4). For over a third of people, having a business meeting was also necessary for them to be able to attend the annual meeting. Less than half of responders thought that business meetings should be hybrid or only online ahead of time. Additional comments provided included



the importance of in-person business meetings as a way to collect balanced national perspectives, to have clear communication (especially important for non-native English speakers) and to progress collaboration.

Q6. Committee Paper Sessions: At PICES-2024 Committee paper sessions were poster-only to allow for the Special Panel in plenary on the Friday morning.

Responses were split into even thirds (Figure 5) about future Committee Paper Sessions.

Q7. Cosing Session: We typically end the science component at lunchtime on Friday with a short closing session.

75% of responders felt that this was OK, 16% preferred that it end after a full day on Thursday to make the meeting shorter, and 9% thought we should have a full day on the Friday. Some comments suggested a few people will always leave early, no matter when it ends.

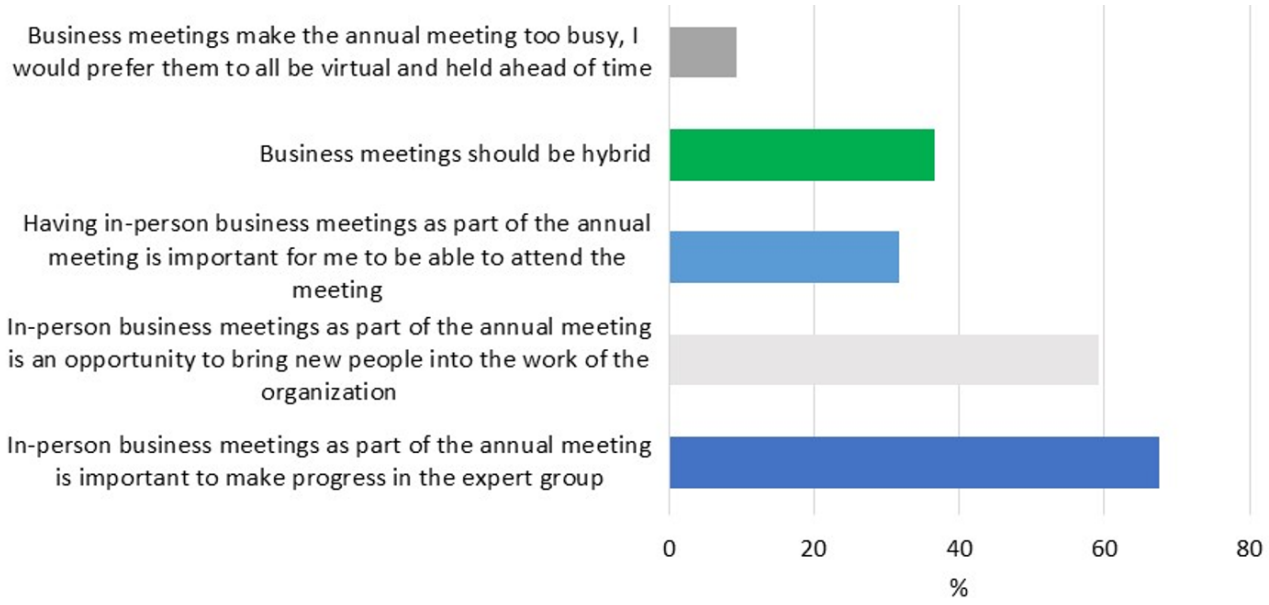


Figure 4. Various responses to the business meeting question along with the percentage of each response.

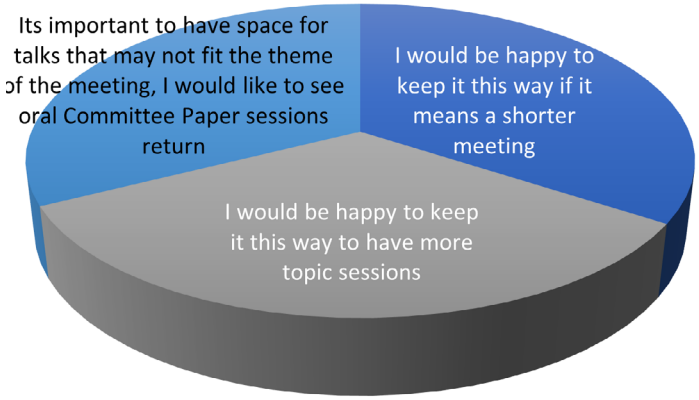


Figure 5. Responses about poster-only committee paper sessions.

Conclusion

The overall impression is that the length and format of PICES-2024 was OK for the majority of people, though of course there is always room for improvement. We also have useful input if further shortening or adjusting is required – for example in the number of parallel topic sessions we should hold depending on how many proposals there are – and we can make some tweaks (venue permitting) that may improve some things for many, such as a poster session earlier in the week and potentially an ECOP mixer/social event if resources permit. We are grateful to everyone who took the time to provide their feedback, which will be used by Science Board and Governing Council in planning upcoming annual meetings.

Vancouver Island
Photo by Lydia Walton

PICES Events Calendar

Ocean Visions Biennial Summit 2025

Vancouver, BC, Canada
March 25-27, 2025
https://oceanvisions.org/events/summit-2025/

One Ocean Science Congress (OOSC 2025)

Nice, France
June 3-6, 2025
https://one-ocean-science-2025.org/

GOOD-OARS Summer School 2025

(Global Ocean Oxygen Decade - Ocean Acidification Research for Sustainability)

Penang, Malaysia
November 4-11, 2025
https://penangsummerschool2025.usm.my/

PICES-2025 Annual Meeting

"Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems"

Yokohama, Japan
November 7-16, 2025
https://meetings.pices.int/

PICES/ICES/FAO International Symposium

"Navigating Changes in Small Pelagic Fish and Forage Communities: Climate, Ecosystems, and Sustainable Fisheries"

La Paz, Mexico
May 4-8, 2026

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Please see submission guidelines and previous issues on our website.
Deadlines are June 1st and December 1st for Summer and Winter volumes, respectively.

Thank you for your contributions!

Macro photo of coral, Okinawa, Japan
Credit: Shawn Miller / Ocean Image Bank

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