Summary of Scientific Sessions and Workshops At PICES-2025

List of Sessions/Workshops (with the links to the pages)

Topic Session 1	Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems
Topic Session 2	Changing Ecosystem Structure Under Global Climate Change: Monitoring, Detecting, Modelling, and Socio-Ecological Impacts
Topic Session 3	Interactions of Variability and Change in the North Pacific
Topic Session 4	Responses of Small Pelagic Fish Communities to Recent Climate Regime Shifts and Climate Extremes
Topic Session 5	Climate Extremes and Coastal Impacts in the Pacific
Topic Session 6	Incorporation of Climate and Ecosystem Impacts in Stock Assessment Advice: Discussion of Current Approaches and Challenges, and Charting a Path Forward
Topic Session 7	The Impact of Oceanographic Processes on Ecosystems Supporting Fisheries Production in Boundary Current Regions
Topic Session 8	How Can Ecosystem-Scale Information be Used to Improve Our Understanding of Climate Change Impacts, and Support Management and Conservation in the North Pacific?
Topic Session 9	Marine Plastic and Microplastic Pollution in the North Pacific
Topic Session 10	Multiscale Physical, Biological and Ecosystem Dynamics Under Conventional and Carbon-Dioxide Removal Based Climate Scenarios
Topic Session 11	Applying Innovative and Established Approaches to Assess the Resilience of the Early life Stages of North Pacific Fishes to Changing Oceanographic Conditions
Topic Session 12	Understanding the Linkages Between Forage Species and Top Predators and How They May Affect Resilience in North Pacific Ecosystems
Topic Session 13	Cancelled: Shifting Institutional Culture to Develop Climate Solutions With Open Science and Open Data
Topic Session 14	The Status and Future of Urban Oceans of the North Pacific - Pathways to Resilient and Sustainable Coastal Cities
Topic Session 15	The Rise of Bibliometric Analyses to Address Sustainability Solutions Through a Human Dimension Lens
Topic Session 16	Radiocarbon Studies in the North Pacific and its Marginal Seas

Topic Session 17 (Poster only)	What Can we Learn About the Occurrence of Karenia spp. Blooms in the North Pacific?
Contributed Paper Sessions	BIO, FIS, HD, MEQ, POC
Workshop 1	Climate-Ready Fisheries Management: Reviewing Effective Strategies for Developing Decision Support Tools
Workshop 2	Intercomparison of North Pacific Zooplankton Time Series
Workshop 3	Present and Future Pressures and Human Activities in the Arctic Ocean and Pacific Gateways
Workshop 4	Building Framework for Cross-Community Conversation Between Natural Carbon Cycles and Marine Carbon Dioxide Removal
Workshop 5	Basin-Scale Processes Linking Western and Eastern Pacific Dynamics and Biogeochemistry
Workshop 6	Effective Strategies Across Ocean Data Lifecycles: Enhancing Ocean Data Management and Mobilization
Workshop 7	Response of Top Predators to Unusual Oceanographic, Climatic and Anthropogenic Events in the North Pacific
Workshop 8	Engaging with Local and Traditional Knowledge Holders to Co-Design Ocean Science in Pacific Small Island Developing States
Workshop 9	Applying a Cumulative Effects Framework to Explore Actionable, Social-Ecological Solutions for Climate Extreme Event Impacts Across the North Pacific
Workshop 10	An Examination of Shelf Data collected by Moorings and Other Fixed Stations in the North Pacific Ocean
Workshop 11	Harnessing Environmental DNA (eDNA) for Early Detection and Monitoring of Marine Invasions in the Face of Climate Change

Session 1: Science Board Symposium

Innovative Approaches and Applications to Foster Resilience in North Pacific Ecosystems

Convenors
Sukyung Kang (SB Chair), Jennifer L. Boldt (SB Chair Elect), Akash Sastri (BIO, SB Vice-Chair), Steven Bograd (AP-UNDOS), Hanna Na (FUTURE), Jackie R. King (FIS), Mitsutaku Makino (HD), Thomas W. Therriault (MEQ), Lei Zhou (POC), Sung Yong Kim (MONITOR), Jeanette C. Gann (TCODE)

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

List of papers

Oral presentation

1. (Awardee) (ECOP) From dreaming to doing: My journey with mentors. Minkyoung **Kim**
2. (Awardee) (ECOP) Shifting the narrative of meaningful early-career engagement in global science-policy collaborations. Raphael **Roman**
3. (Awardee) (ECOP) Spatial transitions of coastal fishing infrastructure and socio-ecological systems in Hokkaidō, Japan**.** Nozomi **Ihara** and Takayuki Shiraiwa
4. (ECOP) Movement-informed projections of Bristol Bay red king crab predict seasonal shifts in distribution to inform spatial management decisions. Sean B. **Hardison**, Erin Fedewa, Leah Zacher, James T. Thorson, Michael A. Litzow, Franz Mueter
5. Near real-time monitoring from mobile oceanographic platforms for dynamic management of acoustically active taxa. Kimberley T.A. **Davies**, Katherine Indeck, Mark F. Baumgartner, Delphine Durette-Morin, Catherine R. Edwards, Leila Fouda, Katherine L. Gallagher, Laurence Lecavalier, Jacqueline McSweeney, Erin Meyer-Gutbrod, Neal R. Pettigrew, Lesley H. Thorne, Fred Whoriskey
6. (ECOP) Development of a deep learning-driven framework to analyze fishing vessel activities using automatic identification system data**.** Fangcheng **Han**, Yang Liu, Hao Tian, Jianchao Li, Yongjun Tian
7. (ECOP) Effort in, assessment confidence out: Does survey effort matter to stock assessment outcomes**.** Elizabeth **Perl**, Ian Taylor, Emily Markowitz, Derek Bolser
8. "Salmon are life" - Indigenous knowledge and ecosystem stewardship along the Kuskokwim River. Kevin **Whitworth**, Megan **Williams**, Terese Vicente, Justin Leon, Jeremy Davies, Henry Huntington, Patricia Chambers, Kristen Maxie, Courtney Carothers, Nick Jacuk and Jon Ross
9. Tritium in the western North Pacific: Natural tendencies and new challenges. Vyacheslav **Lobanov**, Vladimir Goryachev, Aleksandr Sergeev, Maxim Budyansky, Danila Sokolov and Daniil Kalyuzhny
10. (ECOP) Recreational fisheries as indicators of change: Species range shifts from NOAA's Marine Recreational Information Program paired with economic trends. Rachel E. **Roday**, Rileigh E. Hudock, Aaron

B. Carlisle, and Edward A. Hale Galbraith, R. Ian Perry, Douglas L. Draper, James J. Ruzicka, Eric P. Bjorkstedt, and Roxanne R. Robertson

Poster presentation

1. (QR-Poster) (ECOP) Studies on the use of locally available renewable seaweed wastes from Cox's Bazar and Saint Martin as compost organic fertilizer resources. Durlave **Roy**
2. (ECOP) Improving costal marine habitats in the northern Yellow Sea: The role of artificial reefs on macrobenthic communities and eco-exergy. Wenmeng Zheng, Minpeng Song, Lu Wang, Wenyu Zhang, Zhu Li, Lixin Zhu, Wude Xie, Zhenlin Liang, Zhaoyang **Jiang**
3. (ECOP) The pelagic species trait database: An open data resource to support trait-based ocean research**.** Miram R. **Gleiber**, Natasha A. Hardy, Zachary Roote, Zackary Tandy, Caitlin J. Morganson, Alana Krug-Macleod, Iris George, Cindy Matuch, Cole B. Brookson, Elan J. Portner, Elizabeth A Daly, C. Anela Choy, Catherine F. Nickels, Barbara A. Muhling, Brian K. Wells, Richard D. Brodeur, Toby D. Auth, Jarrod A. Santora, Sarah M. Glaser, Daniel J. Madigan, Elliott L. Hazen, Michael G. Jacox, Steven J. Bograd, Larry B. Crowder and Stephanie J. Green
4. (QR-Poster) (ECOP) Effects of oceanographic conditions and longer-term climate patterns on the catch and by- catch rates in Hawai‘i’s longline fisheries. Justin J. **Suca**, Johanna L.K. Wren, Ryan R. Rykaczewski, Robert Ahrens, Donald Kobayashi, Phoebe A. Woodworth-Jefcoats, Zachary Siders, Heather Welch and Elliott Hazen
5. (ECOP) Larval dispersal networks between coral reefs in the Nansei Islands, Japan. Naoki **Saito**, Hiroki Kise, Yuichi Nakajima and Akira Iguchi
6. (ECOP) Evaluating the economic impact of the allowable-catch transfer system on fishers: A case study of set-net fisheries in Ishikawa prefecture. Shintaro **Kodaka**, Nobuyuki Yagi, Yutaro Sakai
7. (ECOP) High-resolution ecological habitat modeling for the US West Coast and its application for place-based resource management. Marine **Lebrec**, Keith VanGraafeiland, Holly Woytak, Kristy McQuaid, Amelia Bridges and Henry Ruhl

Session 2: BIO/FIS/HD/ POC/MONITOR/FUTURE Topic Session

Changing Ecosystem Structure Under Global Climate Change: Monitoring, Detecting, Modelling, and Socio-Ecological Impacts

Convenors:
Shin-ichi Ito, *Corresponding* (Japan), Jennifer L. Boldt (Canada), Julie Keister (USA), Minkyoung Kim (Korea), Vyacheslav B. Lobanov (Russia), Feng Zhou (China)

Description
Under global change, warmer temperatures, deoxygenation/hypoxia, acidification, eutrophication, and sea level rise are impacting marine ecosystems. In addition, extreme events such as marine heatwaves, flooding/droughts, tropical storms etc. are occurring more frequently and with stronger amplitudes. These forcings, individually or in combination, influence the geographic distribution, phenology, and growth of marine biota in species-dependent ways that should result in ecosystem structural change through linear or nonlinear processes. Improved understanding of the current and future impacts of multiple pressures on marine ecosystems is needed, particularly, the mechanisms and linkages, data products, mitigation strategies, and linkages with societal needs. However, it is difficult to monitor the entire structure and energy-flow through food webs to detect these changes. New technologies and tools are needed to better understand impacts of multiple and cumulative pressures on ecosystem structure and function. Advances in tools and technologies that improve ecosystem monitoring including, but not limited to: automated environmental DNA and RNA systems, which seamlessly capture ecosystem structure from viruses to marine mammals; advanced optical sensors; machine learning algorithms; and artificial intelligence applications that can analyse limited time-series data or model shifts in species distributions, energy flows or phenology. In addition, predictive modeling tools are emerging to forecast future ecosystem changes, while socio-ecological assessment methods are needed to understand the broader impacts on fisheries, communities, and ecosystem services.

This session aims to assess and discuss the changing marine ecosystem in terms of societal needs as well as all aspects of marine science (physical, chemical, biological oceanography and fishery science), including: describing the current state of knowledge of marine ecosystem structural change under ongoing climate change using advanced tools and technologies; assessing the potential to predict future structural change, consequences of marine ecosystem change, and socio-ecological needs; linking marine science to societal needs; and identifying knowledge gaps. One day of the session will focus on presentations that cover integrative marine science approaches in the Asian Marginal Seas. For the second day, we welcome talks from all regions of the North Pacific. The session outcome should clarify a vision of international comprehensive marine research for the UN Ocean Decade that meets current societal needs.

List of papers

Oral presentation

1. (**Invited**) Aquatic biodiversity monitoring: ANEMONE and ANEMONE Global. Yuki **Minegishi**
2. (**Invited**) Long-term changes in marine heat waves around the Korean peninsula: Impacts on marine ecosystems, fisheries, and societies. SungHyun **Nam**, J.S. Saranya, Panini Dasgulta
3. (ECOP) Mind the gap - The need to integrate novel plankton methods alongside ongoing long-term monitoring. Matthew M. **Holland**, Luis Felipe Artigas, Angus Atkinson, Mike Best, Eileen Bresnan, Michelle Devlin, Dafne Eerkes-Medrano, Marie Johansen, David G. Johns, Margarita Machairopoulou, Sophie Pitois, James Scott, Jos Schilder, Rowena Stern, Karen Tait, Callum Whyte, Claire Widdicombe and Abigail McQuatters-Gollop
4. (ECOP) Using the Continuous Plankton Recorder to detect and monitor Alexandrium catenella in the Bering Sea. Clare **Ostle**, Sonia Batten, Martina Brunetta, David G. Johns, Keelan C. Lawlor, Francesca Loro, John Nelson, Akash Sastri, Rowena Stern, Marianne Wooton and Sarah Zimmermann
5. (ECOP) Copepod grazing and prokaryotic decomposition amplify the effect of diatom-dinoflagellate regime change on Biological Carbon Pump efficiency. Xiao **Ma**, Kevin B. Johnson and Chaolun Li
6. (ECOP) Ocean freshening driven by warming threatens the Arctic hyperiid amphipod *Themisto libellula*. Hyein **Seo**, Byeongyoung Park, Boongho Cho, Youbin Koo, Taewon Kim

7. (ECOP) Exploring public awareness of adaptation to changing marine environment under climate change. Sarina **Bao**, Hiroya Abe, Azusa Okagawa and Hiroya Yamano
8. Development of a biogeochemical modeling approach to investigate present and potential future impacts of ocean acidification in Tokyo Bay, Japan. Lawrence Patrick C. **Bernardo**, Masahiko Fujii, Tsuneo Ono, Michiyo Yamamoto-Kawai, and Atsushi Kubo
9. Reshaping frontiers: Potential climate-induced adaptation or tropicalization of apex pelagic predators in the Indian and South Atlantic Oceans. Ming-An **Lee** and Sandipan Mondal
10. Future projection of jellyfish bloom potentials in Japan. Kentaro S. **Suzuki**, Masamichi Ohba and Yasuyuki Nogata
11. (ECOP) Heavy precipitation-induced Yangtze River runoff greatly regulates heterotrophic prokaryotes production and growth-limiting resources in the northern East China Sea. Yong-Jae **Baek**, Bomina Kim, Hyo-Keun Jang, Seok-Hyun Youn, Heejun Han, Sang-Heon Lee, Hugh W. Ducklow, Sung-Han Kim and Jung-Ho Hyun
12. (ECOP) Positive loops of regenerated nutrients produced by bloom degradation as promoting another blooms. Eunbi **Lee**
13. (ECOP) Lipidomic perspectives on post-bleaching mortality of Acropora tenuis exposed to thermal and cold stress. Kazuma **Uesugi**, Takashi Nakamura, Mie Shimojima, Mariko Kawahigashi, Shinya Kaneko and Haruko Kurihara
14. (ECOP) Effects of ocean acidification and freshening on the physiology, behavior, and shell integrity of the limpet *Cellana toreuma*. Hyojin **Chang**, Hyein Seo, Youbin Koo, Jeonghee Shim and Taewon Kim
15. (ECOP) Environmental DNA method in open ocean revealed environment dependent distribution patterns of small pelagic fish. Zeshu **Yu**, Shin-ichi Ito, Marty Kwok-Shing Wong, Jun Inoue, Sk. Istiaque Ahemd, Tomihiko Higuchi, Susumu Hyodo, Sachihiko Itoh, Kosei Komatsu and Hiroaki Saito
16. Climate-induced seasonal shift in copepod density in shallow water estuaries. Cai-lian Liu, Jian Zhao, Dong Liang, Jun-xiao Wang, Wen-jing Liu and Hong-sheng **Bi**
17. (ECOP) The essential role of large research vessels in marine ecosystem observations and ocean sustainability. Erin V. **Satterthwaite**, John C. Field, Andrea J. Fassbender, Gerardo Aceves-Medina, Steven J. Bograd, Elliott L. Hazen, Nastassia V. Patin, Zachary Gold, Katherine A. Barbeau, Danie Kinkade, Adam Shepard, Rasmus Swalethorp, Andrew Thompson, Henry Ruhl, Brice Semmens
18. Biogeochemical properties of shallow-water CO2 seeps on Himeshima Island and Showa Iwojima Island, Japan. Masahiko **Fujii**, Tsuneo Ono, Makoto Yamada, Manabu Ooue, Takeru Ito, Jen-Han Yang, Yu Horiuchi, Hisashi Oiwane, Masahide Wakita, Shigeki Wada
19. (ECOP) Using Vessel Monitoring Systems data to characterize movement patterns of the Pacific Salmon ocean troll fishery in response to variable oceanographic conditions on the West Coast of the U.S.. Catherine **Courtier**, Aaron Mamula and Cameron Speir
20. (ECOP) Modeling the future distribution of Yellowfin and Bigeye Tuna in the Pacific Ocean using sdmTMB and Habitat Suitability Index. Yan-Lun **Wu**, Wei-Pin Hsu, Ting-Yu Liang and Kuo-Wei Lan
21. (ECOP) Stochastic assembly processes drive fish diversity patterns in the northwestern Pacific: Insights from environmental DNA. Huiguo **Yan**, Jianchao Li, Wei Shi, Yuru Li, Shuyang Ma, Peng Sun and Yongjun Tian
22. (ECOP) Spatial patterns of ecosystem function in Chinese coastal waters based on phytoplankton resource use efficiency. Junyue **Wang** and Haifeng Gu
23. Recent 25 years of environmental change in the northwestern Pacific observed by satellite radiometers. Hiroshi **Murakami**
24. (ECOP) Development of a high-sensitivity qPCR method of harmful Dinophysis spp. using synthetic oligonucleotides. Su-min **Kang**, Xu Wang, Ha Eun Kim, Yun Na Eun, Joon-Baek Lee, Bum Soo Park, Tae Gyu Park, Suk Hyun Youn and Jin Ho Kim

25. (ECOP) The past, present, and future of the Ocean Tracking Network supporting the global telemetry community. Cassandra **Hartery** and Robert Lennox
26. Chinese coastal ecosystem in the climate changing environment. Song **Sun**
27. Potential habitat shifts of chum salmon at sea under contemporary climate. Irene D. **Alabia**, Sei-Ichi Saitoh, Jorge García Molinos, Takafumi Hirata, Yasuyuki Miyakoshi, Fumihiro Takahashi, Hiromichi Ueno and Masahide Kaeriyama
28. A novel quantified UAV and AI-based remote sensing approach for jellyfish population monitoring. Fang **Zhang**, Shuo Wang, Song Sun and Hongsheng Bi
29. (ECOP) Promoting joint satisfaction among stakeholders for managing Japanese fisheries using coupled bio-socioeconomic models. Yi **Huang**, Mikko Heino and Ulf Dieckmann
30. (ECOP) Machine learning projections of top predator distribution shifts under climate change scenarios. Ting-Yu **Liang**, Chun-hua Qiu, Duan-Zhou Shao, Kuo-We, Lan, Po-Yuan Hsiao
31. (ECOP) Monitoring shifts in nearshore zooplankton community structure using high-throughput imaging tools. Deniz **Coskuner**, Svetlana Esenkulova, Genyffer Triona, Stephany Moore and Brian Hunt
32. (ECOP) Using exposure indices to examine how climate variability influences the spatial distribution and abundance of Portunid crabs in the Southern East China Sea. Irene Chia Ling **Lim**, Yan-Lun Wu, Wei-Pin Hsu, Muhamad Naimullah, Wei-Yu Lee, Lu-Chi Chen and Kuo-Wei Lan
33. (ECOP) Difficulties in identification of small centric diatoms. Mariia A. **Shulgina**, Olga G. Shevchenko
34. (ECOP) Species-specific ENSO responses of commercial fish in the northern South China Sea under climate warming scenarios. Po-Yuan **Hsiao**, Kuo-Wei Lan and William W.L. Cheung
35. (ECOP) Climate change impacts on ecological connectivity of Marine Protected Areas in the Yangtze River estuary and adjacent waters. Han Dong, Xu **Zeng**, Jian Ma, Guodong Li, Zhenkun Bian, Qingqiang Ren, Wei Huang, Jiangning Zeng
36. (ECOP) Genome-scale shifts in bacterial communities across diatom bloom phases. Royoung **Park**, Joo Hwan Kim, Kang-Hyun Park and Bum Soo Park
37. (ECOP) Long-term variability of spring phytoplankton bloom phenology in the Bering Sea in 1998–2024. Aleksandra **Malysheva**, Kirill Kivva and Aleksandra Sumkina
38. Freshwater cyanotoxins in marine seafood: A One Health concern. Misty B. **Peacock**, Megan Schulz, Kira Walters, Steffan Kinley, Rosa M. Hunter
39. (ECOP) Potential habitat distribution of yellow croaker (Larimichthys polyactis) in Korean waters: Past and future. Minkyoung **Bang**, Hee Seok Jung, Dongwha Sohn, Wonkeun Choi, Hwan Sung Ji, Sangil Kim, Sukyung Kang and Chan Joo Jang
40. Ocean Networks Canada's ocean monitoring programs as a change detection array in the North Pacific. Lucianne M. **Marshall**, Kohen Bauer, Hannah Kosichek, Kiyomi Holman, Élise Beaudin, Megan Kot, Edward A Mason, and Maia Hoeberechts
41. Response of fish biodiversity to climate change in the Northwest Pacific Ocean. Shuhao **Liu**, Yang Liu, Shang Chen

Poster presentation

1. Frontal eddies in the northwestern Japan Sea: Lagrangian analysis and ship observations. Sergei **Prants**, Aleksander Udalov, Vyacheslav Lobanov, Svetlana Ladychenko and Anatoly Salyuk
2. Assessing the state of marine biodiversity in the Northeast Atlantic. Abigail **McQuatters-Gollop**, Laurent Guerin, Anita Gilles, Matthew Holland, Christopher Lynam, Ian Mitchell, Paul Stebbing, Ulrike Schuckel, Cristina Vina-Herbon and the OSPAR COBAM 2017 Biodiversity Assessment Team

3. (ECOP) Seasonal dynamics of phytoplankton in Chernyshev Cove (Peter the Great Bay, the Sea of Japan). Kirill O. **Tevs**, Olga G. Shevchenko
4. (ECOP) Parameter identification and optimization of an ocean biogeochemical model for sub-seasonal to seasonal prediction. Hakase **Hayashida**, Takeshi Doi, Haruto Fujishima, Shoichiro Kido and Yasumasa Miyazawa
5. A novel Indicator of anthropogenic infuence on the fluctuability and stability of phytoplankton community composition. Haozhen Liu, Jianzhang He, Kedong Yin
6. (ECOP) Potentially toxic phytoplankton species in the coastal waters off the eastern part of Russkiy Island (Peter the Great Bay, the Sea of Japan). Kirill O. Tevs, Ulyana A. **Eliseikina**, Anna A. Ponomareva
7. (ECOP) Food availability drives contrasting responses of fauna diel vertical migration in the northwestern Pacific. Xiaoyi **Zhang**, Zhaohui Chen, Haihong Guo, and Hongju Chen
8. Monitoring ocean acidification for ecosystem assessment and management. Natalie M. **Monacci**, Simone R. Alin, Darcy Dugan, Li-Qing Jiang, Alex Kozyr, Darren J. Pilcher and Adrienne J. Sutton
9. (ECOP) Opposite latitudinal biodiversity gradient in the open ocean generated by transition zones: Insights from fish distribution in the Northwest Pacific. Yuan **Lin**, Zeshu Yu, Sk Istiaque Ahmed, Xueding Wang, Tomihiko Higuchi, Itsuka Yabe, Marty Kwok-Shing Wong, Sachihiko Itoh, Eisuke Tsutsumi, Hiroaki Saito, Kosei Komatsu, Atsushi Tsuda, Yusuke Kawaguchi, Eitarou Oka, Hajime Obata, Yuki Minegishi, Hideki Fukuda, Jun Inoue, Susumu Hyodo and Shin-ichi, Ito
10. Harmful impacts of climate change on the ecophysiological traits of ciguatera-causing dinoflagellates. Nari **An**, Tae Yeon Yin, Eun Young Yoon and Yeong Du Yoo
11. (ECOP) Phytoplankton community response to climate stress in an advanced ocean-biogeochemical model. Hyojeong **Kim**, Hajoon Song, Stephanie Dutkiewicz, Junwoo Lee, Ibrahim Hoteit and Yixin Wang
12. Long-term drivers of spring bloom dynamics in the northern Gulf of Alaska and impacts on planktonic community structure. Jerome **Fiechter**, Ludivine Conte, Suzanne Strom, Russell Hopcroft, Seth Danielson, and Ana Aguilar-Islas
13. (ECOP) Long-term sea level rise rates in the southwestern East Sea (Japan Sea) from 1993 to 2023: Focusing on thermosteric and halosteric effects. Seungsoo **Kim**, Young-Gyu Kim, KyungJae Lee and SungHyun Nam
14. (ECOP) Habitat distribution patterns and overlap characteristics between tunas and sharks in the western and central Pacific Ocean. I-Hsun, **Hsieh**, Kuo-Wei, Lan, Yan-Lun, Wu, Ting-Yu, Liang, and Wei-Pin, Hsu
15. A numerical study on the larval dispersal and potential connectivity of coral reefs around the coast of Hainan Island. Junying **Zhu**, Qianqing Zhou, Yan Wang, Xiaoyan Chen
16. (ECOP) Carbon dynamics in a eutrophic estuary: Riverine organic matter overrides nutrient-induced sinks. Siyu **Zhang**, Liuqian Yu, Zheng Chen
17. (ECOP) Trophic shifts driven gelatinous zooplanktons modify the energy pathways within planktonic communities. Sun-Hee **Lee**, Hyeon Kim, Jung-Hoon Kang
18. (ECOP) Transcriptomic analysis of intraspecific differentiated survival strategies of the dinoflagellate Heterocapsa triquetra. Byung Don **Joo**, Kang-Hyun Park, Jeong Won Kim, Jeongah Shin, Kyeong Ha Lee, Jiyeon Sung, Bum Soo Park
19. (ECOP) Variations on the distribution and abundance of apex predators in response to Indian Ocean Dipole events in the Indian Ocean. You-De **Lin**, Ting-Yu Liang, Kuo-Wei Lan Duan-Zhou Shao and Chun-hua Qiu
20. Seasonal variations of marine toxicity in relation to environmental factors and phytoplankton communities in Korean coastal waters. Tae Yeon **Yin**, Nari An, Eun Young Yoon and Jaeyeon Park
21. Winter ocean–atmosphere heat flux variability in the Barents and Bering Seas. Aleksandra A. **Sumkina**, Kirill K. **Kivva**, Aleksandra S. Malysheva
22. (ECOP) Quantifying the controls on biological carbon pump efficiency: Temperature and planktonic food web structure in the oligotrophic South China Sea. Zhouxiao **Liu**, Liuqian Yu and Zheng Chen

23. New record of the iravadiid gastropod *Wakauraia sakaguchii* (Kuroda & Habe, 1954) from Korean salt marshes. Sungtae **Kim** and Jae-Sang Hong
24. Disentangling climate forcing effects on pelagic marine ecosystem dynamics using Bayesian causal inference. Juan Carlos **Molinero** and Sun-Hee Lee
25. Integrating video annotations for multiscale marine biodiversity monitoring using Ocean Networks Canada's Coastal Community Observatories. Lucianne M. **Marshall**, Sofia **Jimenez**, Kiyomi Holman, Hannah Kosichek, Jessica Phillips and Vanessa Stewart
26. Influence of the river runoff from volcanic catchments of the Kamchatka Peninsula to the environment of the adjacent Pacific Ocean. P.Yu. **Semkin**, G.Yu. Pavlova, Sh. Jiang, O.A. Ulanova, Yu.A. Barabanshchikov, M.G. Shvetsova, Y. Xu, J. Zhang, V.B. Lobanov
27. (QR-Poster) Extraction, characterization, and cytotoxicity assessment of collagen from the tomato jellyfish (*Crambione mastigophora*). Balu Alagar **Venmathi Maran**, Thyviaah Anandhan and Nurzafirah Mazlan

Session 3: POC/FUTURE Topic Session

Interactions of Variability and Change in the North Pacific

Convenors:
Michael Jacox, *Corresponding* (USA), Allison Cluett (USA), Haruka Nishikawa (Japan)

Description
Climate change is disrupting our perception of relationships between large-scale climate and marine ecosystems. For example, over the past decade, a signature of basin-wide warming has confused long-standing correlations between North Pacific variability (e.g., the PDO) and regional temperatures. This disconnect is forcing us to re-evaluate the nature of historical climate-ecosystem relationships, and the relative importance of absolute temperature vs other climate processes in driving ecosystem change. Variability occurring on top of long-term trends will increasingly push environmental conditions into novel territory, but the frequency and severity of resulting impacts will depend on whether those impacts are tied to absolute thresholds, to the rate of change, or to some interaction between short-term disturbances and the background conditions on which they occur. Teasing apart the roles of variability and long-term change is increasingly important as we aim to project the fate of marine ecosystems under future anthropogenic forcing.

In this session we invite contributions related to interactions between variability and long-term change in the North Pacific, particularly the relative and combined effects of transient events and secular trends. We welcome work on the physical climate system, chemistry, biology, and ecological and socioeconomic responses.

List of papers

Oral presentation

1. (**Invited**) Quantifying temporal beta diversity across marine assemblages experiencing variable trajectories of community change. Ileana **Fenwick** and Janet Nye
2. **(**ECOP) Interannual to decadal variability of the ocean heat content in the western North Pacific and its nonstationary relationship with major climate modes. Suna **Cho** and Hanna Na
3. **(**ECOP) Monthly to sub-annual variability of sea surface temperature and thermal fronts in the Kuroshio meander system. Yin-Zhang **Kuo**, Mubarak Mammel, and Ming-An Lee
4. (ECOP) Drivers of historical multi-decadal compound change for the northern California Current System. Samantha **Siedlecki**, Yifan Zhu, Felipe Soares, Dipti Hingmire, Parker MacCready, Simone R. Alin, Richard A. Feely, Francis Chan, Craig M. Risien, Jeannette E. Waddell, and Jan Newton
5. Linking circulation change to decadal–multidecadal ocean heat content anomalies in the central North Pacific via budget-based decomposition. Satoshi **Osafune** and Shinya Kouketsu
6. (ECOP) Spatially heterogeneous ecosystem responses to marine heatwaves in the Northeast Subarctic Pacific. Christina Eunjin **Kong**, Philippe D. Tortell
7. (ECOP) Spectral clustering-based identification of shifting and emerging EKWC pathways. Eun Young **Lee**, Dong Eun Lee, Hye-Ji Kim, Haedo Baek, Young Ho Kim and Young-Gyu Park
8. Impacts of the 2025 Los Angeles urban wildfire on the Californian coastal ecosystem. Julie **Dinasquet**, Douglas S. Hamilton, Rasmus Swalethorp, Elisa Bergas-Masso, Emna Braham, Noelle Bowlin, Gracie Calla, Dante Capone, Nichole Ruiz, Gabriella Tanoto
9. (ECOP) Inherent non-stationarity in the dominant patterns and regional impacts of North Pacific climate variability. Allison A. **Cluett**, Michael G. Jacox, Steven J. Bograd, and Mercedes Pozo-Buil

Poster presentation

1. (ECOP) Decrease in oxygen concentration in the intermediate layer in the northwest Pacific Ocean. Anna S. **Kurnosova**, Egor Yu. Malygin

2. Impact of the marine heatwave in the Oyashio region in 2022/23 on dissolved oxygen and subduction. Yoshimi **Kawai**, Eitarou Oka, Kanako Sato, Shigeki Hosoda and Shoichiro Kido
3. (ECOP) Interannual assessment of the dynamics of the Bering Sea water in the Chukchi Sea. Valerii Filipson
4. (ECOP) Climate variability of volume, heat and salt fluxes through the Bering Strait. Denis **Ignatev** and Svetlana Gordeeva
5. From simulation to projection: The North Pacific SST variability in CMIP6. Euihyun **Jung**, Heeseok Jung and Chan Joo Jang

Session 4: BIO/FIS/MONITOR Topic Session

Responses of Small Pelagic Fish Communities to Recent Climate Regime Shifts and Climate Extremes

Convenors:
Motomitsu Takahashi, C*orresponding* (Japan), Akinori Takasuka (Japan), Chris Rooper (Canada), Rebecca Asch (USA), Susana Garrido (Portugal)

Co-sponsor: ICES

Description
Forage communities including small pelagic fish and squid are key components that link plankton and predators in marine food webs. These species exhibit large fluctuations in abundance and the dominant species can alternate from one dominant species to another with changing environmental variables. Previous hypotheses, however, may not explain responses of small pelagic fish communities to the recent climate phases including marine heat waves and unconventional regimes. Understanding the mechanisms of the population fluctuations and main drivers of the variability is essential to fill the gap of ecological knowledge on their critical role as consumers of plankton and the main prey for predators, and to develop strategies for sustainable use of small pelagic fish species.

We welcome contributions that investigate the drivers of recent dynamics, including the impacts of climate change, on small pelagic fish communities. We also welcome studies contributing to enhancing knowledge of the role of small pelagic fish on trophic webs, including modelling approaches that aim at better prediction of the response of small pelagic fish communities to environmental changes. New advances in the assessment and monitoring of small pelagic fish species that aim towards obtaining more accurate and efficient data are welcome, as well as advances of small pelagic fish species assessment, particularly those integrating Ecosystem-Based Fisheries Management. Finally, studies on the socio-economic impacts of small pelagic fish communities are also encouraged, including methodological advances in integrated biological-economic models, and models of fishing community response and adaptation to climate.

List of papers

Oral presentation

1. (**Invited**) Unconventional sea surface temperature regime around Japan in the 2000s–mid-2010s and beyond: Potential influences on major fisheries resources. Hiroshi **Kuroda**
2. Diet and prey fields and predatory and competitive interactions in early-stage pelagic fishes in the Chukchi Sea. Matthew **Baker**, Natalia Kuznetsova, Robert Levine, Igor Grigorov, Edward Farley
3. (ECOP) Possible phenotypic responses to geographical range expansion of tropical small pelagic fish in the Northwest Pacific. Alexanra A. **Bagarinao-Regalado**, Kaito Inoue, Wilfredo L. Campos and Shin-ichi Ito
4. (ECOP) Where and how do pacific saury Cololabis saira migrate and grow after hatching? Daisaku **Suda**, Satoshi Suyama, Taiki Fuji, Shigeho Kakehi, Toyoho Ishimura and Shinichi Ito
5. Recent expansion of tropical small pelagic fish in Japanese coastal waters: Case studies of Encrasicholina punctifer and Sardinella aurita. Mikio **Watai**, Minoru Sashida, Tomoyuki Saguchi, Satoshi Suzuki, Chinatsu Watanabe, Naoaki Kono, Yoshioki Oozeki and Mami Saito
6. Changing spawning phenology of European sardine, Sardina pilchardus, off the northern limit of the Canary upwelling ecosystem: Relationship with recruitment strength. Susana **Garrido**, Laura Wise, Daniela Silva, Ana Machado, Cristina Nunes
7. (ECOP) Gear-specific CPUE decline and distributional shift of Mene maculata as early indicators of ecosystem change in the Taiwan Strait. Ipsita **Biswas**, Sandipan Mondal, Arpita Ghosh, Alakesh Pradhan, Yi-Chen Wang and Ming-An Lee

8. (ECOP) Integrating fishery-dependent and independent data to model sardine distribution under environmental variability in Portuguese waters. Daniela **Silva**, Raquel Menezes, Gonçalo Araújo, Ana Machado, Renato Rosa, Ana Moreno, Alexandra Silva, Susana Garrido
9. (ECOP) Understanding the origin and migration route of Japanese sardine collected off California in 2022 using daily increments and stable isotopes in otoliths. Tatsuya **Sakamoto**, Emmanis Dorval, Toyoho Ishimura, Shin-ichi Ito, Gary Longo, Matthew Craig, and Brad Erisman
10. A literature review of studies relating environmental conditions to Japanese sardine (Sardinops melanosticta) in the North Pacific Ocean. Chris **Rooper**, Jon Brodziak, Janelle Curtis, Libin Dai, Karolina Molla Gazi, Zhengyan Jiang, Oleg Katugin, Don Kobayashi, Vladimir Kulik, Quiyun Ma, Shuya Nakatsuka, Kazuhiro Oshima, Alex Zavolokin
11. (Pre-recorded) (ECOP) Preliminary projection of distribution shift for Pacific saury in the Northwestern Pacific Ocean under climate change. Zi **Yang**, Libin Dai, Chris Rooper, Toshihide Kitakado, Siquan Tian

Poster presentation

1. ENSO-driven synchronous variations in fishery dynamics and habitat distribution of Scomberomorus spp. off Taiwan. Lu-Chi **Chen**, Kuo-Wei Lan, Jinn-Shing Weng and Chen-Te Tseng
2. (ECOP) Seasonal influence of extreme climate events and SST variability on pelagic fisheries vulnerability in the Bay of Bengal. Monika **Makwana** and Unmesh Patnaik

Session 5: HD/POC/MONITOR/FUTURE Topic Session

Climate Extremes and Coastal Impacts in the Pacific

Convenors:
Antonietta Capotondi, *Corresponding* (USA), Shoshiro Minobe (Japan), Saranya JS (Korea), Charles Hannah (Canada), Chan Joo Jang (Korea)

Co-sponsors: CLIVAR, WCRP LHA EPESC

Description
Over the past several decades, extreme climate events (ECEs) have caused devastating and long-lasting ecological and socio-economic impacts on both global and regional scales. ECEs include both extreme physical conditions (e.g., marine heatwaves) as well as biogeochemical extremes (e.g., ocean acidification, deoxygenation, harmful algal blooms, coral bleaching). Although the episodic nature of these events may be due to natural causes, their extreme character is exacerbated by the changing background conditions associated with global warming. These events affect marine ecosystems at all trophic levels mainly through shifts in habitat distribution, biodiversity, and communities, resulting in the destruction of coastal biogenic habitats. A deepened understanding of the complexity of these impacts, which may unfold over time, is needed, requiring continued analyses of the conditions that followed past events.

Since mid-2023, the Earth's climate has exhibited exceptional heating conditions, which can truly be called "global boiling." Among the world's oceans, the highest sea surface temperature anomalies have occurred in the Kuroshio-Oyashio region, with anomalies extending from the East Asian marginal seas to the central North Pacific across the International Dateline. Understanding these unprecedented recent conditions in terms of natural processes and/or anthropogenically forced warming, is of paramount importance for the PICES community.

To advance prediction efforts, updated statistical characterizations of ECEs (e.g., in terms of intensity, frequency, duration, and three-dimensional evolution) are needed, together with a more accurate identification of their driving mechanisms, both local and remote, natural or anthropogenic. Improved characterization and understanding of compound events, i.e., the co-occurrence of different types of physical and/or biogeochemical extremes, are also needed.

This session intends to provide a platform to compare and contrast the processes underpinning the development of physical/biogeochemical ECEs across different Pacific regions.

In this session, we welcome contributions on ECEs and related compound events on the following topics: 1) Physical and biogeochemical processes associated with extreme events in the Pacific, 2) Subsurface events and their relationship with surface ECEs, and 3) Prediction and projection of extremes. Studies focusing on recent physical or biogeochemical extremes are especially welcome.

List of papers

Oral presentation

1. (**Invited**) Intense marine heatwaves off Japan induced by the persistent Kuroshio large meander and the recent extreme northward-meandering Kuroshio Extension. Shusaku **Sugimoto**, Atsushi Kojima, Tatsuya Sakamoto, Yuma Kawakami and Hideyuki Nakano
2. (**Invited**) (ECOP) Recent marine heatwaves in the East China Sea: Mechanisms and future risk under climate change. Hyoeun **Oh**, Jung-Eun Chu, Yongchim Min, Go-Un Kim, Jongmin Jeong, Suchan Lee, Jaeik Lee, and Jin-Young Jeong
3. The seasonal blue carbon prediction system "SINTEX-F2bio": Preliminary results. Takeshi **Doi**, Yuya Baba, and Hakase Hayashida
4. Subsurface marine heatwaves on the Pacific coast of Canada. Charles **Hannah**, Kejia Wang, Cynthia Bluteau, Richard Thomson
5. A new dynamic regime in the Kuroshio/Kuroshio extension and the North Pacific climate system after 2018. Bo **Qiu** and Shuiming Chen
6. (ECOP) Unraveling the coupled dynamics of marine and terrestrial heatwaves with typhoons during summer 2018. Saranya **J.S**, SungHyun Nam and Panini Dasgupta
7. Surface and subsurface dynamics of Northeast Pacific marine heatwaves. Antonietta **Capotondi**

8. (ECOP) Source water masses as a driver of ecosystem structure in the northern California Current. Mercedes **Pozo Buil**, Isaac Schroeder, Steven Bograd, Jennifer Fisher, Samantha Zeman, Antonietta Capotondi, Melanie Fewings, Elliott Hazen, Michael Jacox, Nicole Lovenduski, Samuel Mogen, Craig Risien, Ryan Rykaczewski, Andrew Scherer, Ted Strub
9. (ECOP) Changes in phytoplankton composition driven by TC-induced mixing. Junwoo **Lee**, Hajoon Song, Hyojeong Kim and Stephanie Dutkiewicz
10. Surface marine heatwave prediction skill in the Canadian Seasonal to Inter-annual Prediction System (CanSIPS). Elise **Olson**, Bill Merryfield, Julia Velletta, Hayley Dosser, Parsa Gooya, Krysten Rutherford and James Christian
11. Exploration and practice of applying DeepSeek to marine disaster prevention and control along China's coast. Luyao **Han** and Fangfang Wan
12. Long-term changes in marine environment at a coastal station in Japan over 47 years. Kiyoshi **Tanaka** and Kunio Kutsuwada
13. Evolving patterns of the Kuroshio large meander 2017–2024: Characteristics and environmental impacts. Toru **Miyama**
14. Generation processes of extreme surface waves off the Sanriku coast of Japan in the western North Pacific. Kosei **Komatsu** and Hanyuan Gong
15. Learning a Laplace Neural Operator (LNO) for subseasonal marine heatwave prediction. Dong Eun **Lee**, Eun Young Lee, Duk-Soon Oh, HyeJi Kim, Haedo Baek, Minsu Song, Myungmo Kang, and Soowon Choi
16. (ECOP) Estimation and validation of the short- and long-wave radiation using GOCI-2 data. Taekyun **Kim**, Giseop Lee and Hongyeon Cho
17. Exceptional heat and basin-scale connections in the Kuroshio-Oyashio region in the early 2020s. Shoshiro **Minobe**
18. (ECOP) Modeling the response of the ocean carbon cycle to marine heatwaves in the eastern North Pacific. Yumi **Abe**, Takamitsu Ito, Amanda Timmerman, Christopher T. Reinhard and Joseph P. Montoya
19. (ECOP) Impacts of North Atlantic SST forcing on the Kuroshio Extension and its implications for recent unprecedented ocean warming in the Northern Pacific. Yoko **Yamagami**, Hiroaki Tatebe, Tsubasa Kohyama, Shoichiro Kido, and Satoru Okajima
20. Statistics of marine heatwave parameters in the Sea of Okhotsk. Kirill K. **Kivva**, Chen Yurou, George P. Moury

Poster presentation

1. (ECOP) Efficient biological shelf pump enhances organic carbon export in the Southern Sea of Okhotsk. Huailin **Deng**, Kazuya Ono, Aiko Murayama, Tomohiro Nakamura, Shinzou Fujio, Daigo Yanagimoto, Youhei Yamashita, Koji Suzuki and Jun Nishioka
2. Identification and delineation of key control areas for storm surge disasters in Zhoushan City based on loss perspective. Ziyan Guo, Yang **Luo**, Jianwei Wu
3. (ECOP) Sea ice-derived iron fuels the spring phytoplankton bloom in the southern Sea of Okhotsk and the Coastal Oyashio region. Momoka **Imai**, Aiko Murayama, Kazuya Ono, Koji Suzuki, Hiroshi Kuroda, Takenobu Toyota, Youhei Yamashita, Kay I. Ohshima and Jun Nishioka
4. Determinant factors of massive spring bloom event of Oyashio region: Roles of Coastal Oyashio water intrusion and mesoscale eddy. Takuya **Nakanowatari**, Hiroshi Kuroda, Takashi Setou, Hung-Wei Shu, Shoko Abe, Taira Nagai, Ryu Saiki, Jun Nishioka, Tomohiro Nakamura, Humio Mitsudera
5. (ECOP) Typhoon-induced nitrous oxide consumption in coastal open waters and its climate implications. Shangjun **Cai**, Fajin Chen, Sihai Liu, Qibin Lao, Chunqing Chen
6. (ECOP) Tidal regulation mechanism of frontal convergence/divergence in the Changjiang River plume. Shuangzhao **Li**, Yisen Zhong, Meng Zhou and Lixin Qu

Session 6: FIS Topic Session

Incorporation of Climate and Ecosystem Impacts in Stock Assessment Advice: Discussion of Current Approaches and Challenges, and Charting a Path Forward

Convenors:
Saang-Yoon Hyun, *Corresponding* (Korea), Kirstin Holsman (USA), Melissa Karp (USA), Zhen Lin (Japan)

Description
Stock assessments are an essential part of sustainable fisheries management, using models to represent fishing and biological processes such as recruitment, growth, natural mortality, and selectivity, to evaluate the current state of the population (e.g., how much is in the population now), what is likely to be there in the near future, and how best to harvest it without imperiling future reproductive success and yield. Growing evidence suggests that changing environmental conditions can cause variations in population processes which violate the assumptions of stationarity often relied on in traditional stock assessment methods. However, to date, very few stock assessments globally have been able to successfully integrate environmental and ecological impacts into their population models, despite the flurry of research on the topic. This session provides a forum to summarize and discuss the current practices and challenges of assessing fish stocks in changing environments from experts around the world, consider the impact changing environmental conditions have on the reliability of management advice from stock assessment models, present emerging developments, and discuss what's needed to increase uptake of environmental information in stock assessments and advice moving forward.

Oral presentation

1. (ECOP) Coupling bioenergetics and population dynamics models to simulate population dynamics of Japanese chub mackerel: Early life history analysis and future applications. Ziqin **Wang**, Shin-ichi Ito, Shike Gao, and Chenying Guo
2. Problems of the Pacific cod stock assessment in the western Bering Sea in relation to temporal warming. Vladimir **Kulik** and Andrey Savin
3. (ECOP) A spatial-temporal stock assessment of the Korean chub mackerel (Scomber japonicus) with environmental conditions being incorporated. Taeyeon **Kim**, Saang-Yoon Hyun and Sukyung Kang
4. (ECOP) Forecasting Japanese butterfish catches in Taiwan using Pacific climate oscillation indices: Implications for sustainable fisheries management. Arpita **Ghosh**, Sandipan Monda, Alakesh Pradhan, Ipsita Biswas, Yu-kai-Chen and Ming-An Lee
5. (Pre-recorded) (ECOP) Evaluating the impact of age data on flatfish stock assessment and management under varying environmental conditions. Mackenzie **Mazur**

Poster presentation

1. (ECOP) Modeling the population dynamics of Pacific saury considering migration. Rentaro **Mitsuyu** and Toshihide Kitakado
2. (ECOP) Application of recurrent neural networks for model-free time series analysis in fisheries stock assessment. Rintaro **Hiwatashi** and Toshihide Kitakado

Session 7: BIO/MONITOR Topic Session

The Impact of Oceanographic Processes on Ecosystems Supporting Fisheries Production in Boundary Current Regions

Convenors:
Toru Kobari, *Corresponding* (Japan), Gen Kume (Japan), Akash Sastri (Canada), Hui Liu (USA), Hanna Na (Korea)

Description
Sustainable fisheries require a better understanding the responses of oceanographic processes and ecosystems to climate change and anthropogenic forcing. In the PICES regions, high fisheries production appears around the eastern and western boundary currents. In recent years, there has been increasing evidence that various environmental conditions specific to these boundary currents (e.g., meandering, frontal eddy, turbulent mixing, island mass effect) stimulate biological production. Such oceanographic features might foster high fisheries production, however, we still have little knowledge of how fisheries stocks are influenced by varying ecosystem-level responses.

This session will share and review new information for understanding how oceanographic processes affect fisheries stocks through lower trophic levels of ecosystems in boundary current systems. In particular, we encourage presentations and discussions using experimental, observational, and modeling approaches linking oceanographic and ecosystem-level processes to fisheries recruitment and productivity. This session will generate key questions about regime shifts in fishery stock fluctuations and stimulate fruitful debates to solve them through international collaborations.

List of papers

Oral presentation

1. (**Invited**) (ECOP) Submesoscale eddy induced nitrate upwelling and effect on biological production in the upstream Kuroshio current. Silvana **Duran** and Takeyoshi Nagai
2. (**Invited**) Spawning responses of anchovy and sardine to environmental factors in different ecosystems: Comparative approaches from international collaboration projects. Akinori **Takasuka**
3. (ECOP) Larval fishes encounter favorable prey availability? Testing Match-Mismatch hypothesis in major feeding grounds around the Kuroshio. Honoka **Ito**, Eisuke Tsutsumi, Gen Kume, Masafumi Kodama, Mutsuo Ichinomiya, Tomohiro Komorita and Toru Kobari
4. (ECOP) Comparisons of fatty acid contents between zooplankton and fish larvae in the Kuroshio and neighboring waters. Nao **Kominato**, Reo Ishimaru, Masafumi Kodama, Gen Kume, Masaharu Hanai, Asuka Nitta, Naoki Kabeya and Toru Kobari
5. (ECOP) Growth and feeding requirements of Japanese sardine Sardinops melanostictus larvae in the northern Satsunan area, southern Japan. Akinori **Osawa**, Toru Kobari, Masafumi Kodama, Mutsuo Ichinomiya, Tomohiro Komorita, Iára Torres Cabrera, Haruka Takagami, Akari Oshima and Gen Kume
6. (ECOP) Assessing the impact of oceanographic field variability on the spatial distribution of chub mackerel in the northwestern Pacific fishing grounds. Maria **Lebedeva**, Maxim Budyansky and Tatiana Belonenko
7. (ECOP) Assessing the impact of oceanographic field variability on the spatial distribution of chub mackerel in the northwestern Pacific fishing grounds. Maria **Lebedeva**, Maxim Budyansky and Tatiana Belonenko
8. Spatial assessment of the impact of Kuroshio branch intrusion on the spring phytoplankton bloom in Kagoshima Bay using GCOM-C SGLI. Tomohiro **Komorita**, Eisuke Tsutsumi, Mitsuhiro Toratani, Mutsuo Ichinomiya, Toru Kobari, Gen Kume, Hiroto Higa
9. Bloom formation by the colony-forming diatom Thalassiosira diporocyclus in the neighboring waters along the Kuroshio Current, North Pacific Subtropical Gyre, and its global distribution. Mutsuo **Ichinomiya**, Tomohiro Komorita, Megumi Mori, Gen Kume, Akimasa Habano, Yoichi Arita, Fumihiro Makino, Toru Kobari
10. (ECOP) Exploring the impact of typhoons on the feeding ecology of small to medium sized fish in the southwestern waters of Taiwan based on trawl catches. Chang-Shuo **Ji** , Yi-Chen Wang
11. (ECOP) Ecological impact of aplanochytrid protists as a source of DHA for copepods in the marine environment. Tomi **Morimoto**, Yoko Hamamoto, Takanori Shono, Mayumi Ueda, Akira Kuwata, Yukiko

Taniuchi, Hiroshi Kuroda, Kazuaki Tadokoro, Yuki Tsujimura, Toshiki Miyaoka, Taichi Mogi, Ryosuke Nakai, Satoshi Nagai, Tomoko Matsumoto, Jun Kikuchi and Daiske Honda

12. Oceanographic influences on zooplankton dynamics with implications to fisheries in the northern Gulf of Mexico. Hui **Liu**
13. Distribution of marine organisms associated with physical and biogeochemical environments observed off the Pacific coast of Tohoku, Japan. Hikaru **Homma**, Daisuke Hasegawa, Takahiro Tanaka, Yuji Okazaki and Takeshi Okunishi
14. Impacts of the Kuroshio nutrient stream on the high productivity in the Kuroshio-Oyashio interfrontal zone. Kosei **Komatsu** and Yutaka Hiroe
15. (ECOP) Behavioral responses of skipjack tuna to river-influenced water in the East China Sea. Soya **Sakuma**, Hiroto Abe, Takayuki Matsumoto, Hidetada Kiyofuji

Poster presentation

1. Phytoplankton growth is stimulated by mixing of coastal waters advected to the Kuroshio. Toru **Kobari**, Nozomi Kirino, Ayaka Morimitsu, Naoki Yoshie, Masafumi Kodama, Gen Kume
2. (ECOP) Geographical variations in zooplankton standing stocks, productivity and taxonomic composition to mixing of coastal waters into the Kuroshio. Honoka **Miwa**, Masahiro Kodama, Gen Kume, Masafumi Kodama and Toru Kobari
3. (ECOP) Impacts of ocean warming on sex ratio of yellow striped butterfish *Labracoglossa argentiventris* around the Izu Islands, Japan. Junichi **Iijima** and Akinori Takasuka
4. (ECOP) Reconstruction in gelatinous zooplankton by climate change and environmental stressors in Daya Bay, China. Pengli **Xiong** and Kaizhi Li
5. (ECOP) Spatio-temporal patterns of holoplanktonic mollusc assemblages and indicator species of hydrodynamic conditions in the northwestern South China Sea. Junce **Liang** and Kaizhi Li
6. (ECOP) Feeding and reproductive ecology of skinnycheek lanternfish Benthosema pterotum in Kagoshima Bay, southern Japan. Atsuto **Uchida**, Syunta Omura, Toru Kobari, Masafumi Kodama, Hiroki Yasuma and Gen Kume
7. (ECOP) Zooplankton biomass variability from ADCP backscattering strength data at the East China Sea stations. Muyan **Jiang**, Xinyu Guo, Naoki Yoshie and Toru Kobari
8. (ECOP) Environmental and biological factors influence on small and medium fish feeding ecology in the southwestern waters of Taiwan, Western Pacific Ocean. Yi Chen **Wang**
9. (ECOP) Epifaunal assemblage and food web structures of the floating *Sargassum* in the Satsunan area: Spatiotemporal change during the drifting process. Haruki **Inoue**, Shuhei Tsuda, Ayane Taniguchi, Fumihiro Makino, Takafumi Azuma, Mutsuo Ichinomiya, Tomohiro Komorita, Gen Kume, Toru Kobari and Masafumi Kodama
10. (ECOP) How do fish larvae avoid dietary overlapping in the Kuroshio and its neighboring waters? Yuta **Yoshida**, Ayane Taniguchi, Masafumi Kodama, Gen Kume, Mutsuo Ichinomiya, Tomohiro Komorita and Toru Kobari
11. (ECOP) High-resolution SWOT altimetry observations of the island mass effect in the Kuroshio Current. Shiliang **Shan** and Daisuke Hasegawa
12. (QR-Poster) (ECOP) What does 100 billion gallons of freshwater do to an estuary? Howard P. **Dunleavy**, Paul Miller, John White, Michael Dance, and Steve Midway
13. Recent changes in oceanographic conditions in the Northwestern Pacific and their potential impacts on the migration and reproduction of sardine, mackerel and saury. Elena **Ustinova**, Viktor Filatov and Yuri **Zuenko**

Session 8: FUTURE Topic Session

How Can Ecosystem-Scale Information be Used to Improve Our Understanding of Climate Change Impacts, and Support Management and Conservation in the North Pacific?

Convenors:
Vivitskaia Tulloch, *Corresponding* (Canada), Peng Sun, *Corresponding* (China), Phoebe Woodworth-Jefcoats (USA), Dongwha Sohn (Korea)

Description
Climate change significantly affects ocean ecosystems, altering species distributions and abundance, which disrupts food webs and trophic interactions. This can impact prey availability and population viability, highlighting the need for ecosystem-based management in marine species and fisheries, especially given the large scales at which climate change processes operate. Species like Pacific saury, tuna, Pacific herring and salmon, which migrate across multiple jurisdictional boundaries, and play important roles in North Pacific food webs, face additional management challenges. Coordinated international efforts are necessary to align research and management with the larger scales at which transboundary species, fisheries, and climate processes are distributed.

Integrating broad ecosystem-scale information into management or conservation decisions is inconsistent across the North Pacific, with gaps and bright spots evident. While efforts to understand climate change impacts on marine species at broader scales are increasing — using tools like ecosystem models, agent- or individual-based models, species distribution models, cumulative impact and climate vulnerability assessments — there is a need to better connect this research with decisions, particularly for transboundary species.

This session will feature representatives from member nations discussing current ecosystem-scale research on climate impacts in the Pacific. We invite experts, managers, and stakeholders to share their experiences, challenges, and successes in integrating scientific ecosystem-scale knowledge into decision making for fisheries, conservation, and other sectors. Roundtable discussions will follow each presentation block to review the state of ecosystem-scale research in the North Pacific and identify key needs for translating this research into actionable management advice under climate change.

The goal is to highlight ongoing ecosystem-scale research on transboundary species, and identify some of the tools, information, and approaches that have been most effective for informing climate change impacts and relevant decisions in the region.

This session will be convened by ECOPs across the North Pacific, and builds on ecosystem modelling discussions from the PICES-2024 workshop on 'North Pacific ecosystem model ensembles', addresses S-CCME terms of reference and will contribute to outputs of the proposed PICES-2025 workshop on 'climate-ready fisheries management'.

List of papers

Oral presentation

1. (**Invited**) Investigating the impacts of climate and fishing on fish populations and ecosystems in China's shelf seas using multiple models. Yongjun **Tian**, Peng Sun and Wei Shi
2. (**Invited**) (ECOP) Climate change risks to marine ecosystems and fisheries: FishMIP insights for the North Pacific. Denisse **Fierro-Arcos** and Julia L. Blanchard
3. (ECOP) Contrasting patterns and regulations of spawning behaviors under different management regimes of striped bass in the HRE ecosystem. Xindong **Pan** and Yong Chen
4. (ECOP) Risk and resilience: Assessing multi-species climate vulnerability in the Gulf of Alaska. Isabelle **Galko**, Cheryl L. Barnes, Paul D. Spencer, Jodi L. Pirtle, Marysia Szymkowiak, Al Hermann, Alberto Rovellini, Mason Smith and Benjamin Williams
5. (ECOP) Bridges and barriers to dynamic ocean management: Insights from scientific, fishing, and shipping vessel communities. Emily C. **Nazario**, Merceline San Luis, Elliott L. Hazen, Amber Rhodes, Nerea Lezama-Ochoa, Rachel Seary, Melissa R. Cronin, and Katherine L. Seto
6. (ECOP) Mechanism and evolution of regional endothermy in fishes. Min **Xu**, Baosheng Wu, Xiaoyan Xu and Yunkai Li

7. Diel vertical movement patterns of blue sharks in the Northwest Pacific Ocean revealed by satellite tags. Yunkai **Li**, Honglin Zhang, Yongfu Shen
8. (ECOP) Identifying mesoscale fronts and their effects on fisheries under climate change. Qinwang **Xing**, Haiqing Yu, Wei Yu and Xinjun Chen
9. Significance of water properties for prediction of the Pacific saury occurrence in Russian catches. Vladimir **Kulik**, Aleksei Baitaliuk, Oleg Katugin, Maxim Budyansky and Michael Uleysky
10. (ECOP) The changing catch: Seasonal migrations and climate sensitivity of mahimahi in Hawai'i's fisheries. Jessica N. **Perelman**, Justin J. Suca, Ryan R. Rykaczewski, Donald R. Kobayashi
11. (ECOP) Dynamic response of *Thichiurus japonicus* early growth to climate change and its management approach. Fengming **Lv**, Peng Sun, Jianchao Li and Yongjun Tian
12. (ECOP) Disentangling the roles of climate and fishing in the Newfoundland and Labrador cod collapse. Zeyu **Zeng**, Alannah Wudrick, Tyler D. Eddy
13. (ECOP) Size-specific winter distribution changes of large yellow croaker (Larimichthys crocea) in the East China Sea. Ling **Yang**, Xijie Zhou and Shin-ichi Ito
14. (ECOP) Projecting the poleward habitat expansion of whale sharks (*Rhincodon typus*) in the West Pacific and the East Indian Ocean in response to climate change. Soeon **Ahn**, Kwang-Sik Choi and Dongwha Sohn
15. Promise or peril in a warming ocean? An emergent migratory pathway leads North Pacific loggerhead sea turtles (Caretta caretta) into the Northern California Current System. Dana K. **Briscoe**, Larry B. Crowder, George H. Balazs, Jeffrey A. Seminoff, Alberto Abreu-Grobois, Catherine A. Lee Hing, Laura Jim, Masanori Kurita, Masanori Mori, Denise M. Parker, Marc R. Rice, Tomomi Saito, Bianca S. Santos, Calandra N. Turner Tomaszewicz, Noah Yamaguchi, and Jeffrey J. Polovina
16. (ECOP) Life history traits and bioenergetic trade-offs of key commercial species in the East China Sea under climate change. Wenbo **Deng**, Alaia Morell, Nicolas Barrier, Peng Sun
17. (Pre-recorded) (ECOP) Forging the trident: Modelling open subarctic Pacific ecosystems in three currencies. Szymon **Surma**, Evgeny A. Pakhomov, Brian P.V. Hunt, and Kerim Y. Aydin

Poster presentation

1. Species distribution modeling: the importance of zero caches in fishery for the chub mackerel (*Scomber japonicus*). Vladimir **Kulik**, Aleksei Baitaliuk, Oleg Katugin, Maxim Budyansky and Michael Uleysky
2. Abundance indices of the chub mackerel (*Scomber japonicus*) in the EEZ of the Russian Federation. Igor **Chernienko** and Emiliya Chernienko

Session 9: MEQ/TCODE Topic Session

Marine Plastic and Microplastic Pollution in the North Pacific

Convenors:
Chengjun Sun, *Corresponding* (China), Matthew Savoca (USA), Mafalda de Freitas (USA)

Description
Marine plastic and microplastic are top pollutants of concern under Sustainable Developmental Goal 14 "Life Below Water" and the first challenge in the UN Decade of Ocean Science program. With fast-developing technology and research, our understanding of the status and impacts of marine plastic and microplastic pollution is advancing quickly. Since the North Pacific and its marginal seas are known to be more contaminated by meso- and microplastics than many other regions, research conducted in this region will enable us to better evaluate and assess the potential impacts of marine plastic and microplastic pollution on the ecosystem. This session welcomes any research related to the advances in monitoring, modeling, assessment, policy, and trend analysis on marine plastic and microplastic pollution. We are also interested in the future effects of the UN Plastic Treaty, which are in the final stages of negotiation. In addition, we welcome researchers who wish to build on the PICES plastic pollution community and better support the UN Ocean Decade on this important issue.

List of papers

Oral presentation

1. (**Invited**) Long-term changes in the of large and small microplastic in western North Pacific. Kazutaka **Takahashi**
2. Seafloor litter pollution in Japan and South Korea detected by a citizen science initiative. Pierpaolo **Consoli**, Danilo Malara, Gaia Grasso, Valentina Costa, Valentina Sciutteri, Cristina Pedà, Fabio Figurella, Ian Campbell, Emily Deery and Franco Andaloro
3. (ECOP) The necessity of power analysis to effectively monitor microplastics contamination in fish. Rikki **Clark**, Bonnie Hamilton, Jennifer Provencher, and Mark Mallory
4. Plastic pollution monitoring in coastal environments in northern and western Canada. Jennifer **Provencher**, Jessie Wilson, Natasha Neves, Alex Jardine, Jackie Dawson, and Mark Mallory
5. (ECOP) The crucial role of rainfall in microplastic transfer from terrestrial to marine environments. Youna **Cho**, Sang Hee Hong, Sung yong Ha, Gi Myung Han and Won Joon Shim
6. Dancing with the eddies: Microplastics in the northwestern Pacific Ocean. Chengjun **Sun**, Jinfeng Ding, and Dejun Dai
7. Vertical flux of microplastics in the deep Sea within the Kuroshio Extension Recirculation Gyre. Takahito **Ikenoue**, Ryota Nakajima, Satoshi Osafune, Eko Siswanto, and Makio C. Honda
8. (ECOP) Fragmentation of nano- and microplastics from conventional and biodegradable plastics by photooxidation in water. Soeun **Eo**, Young Kyoung Song, Sang Hee Hong, and Won Joon Shim
9. (ECOP) Microplastic contamination across trophic levels: Insights from benthic ecosystems and large marine animals. Byeongyong **Park** and Taewon Kim
10. The reliability of methods and environmental implications of test materials in microplastic and nanoplastic study. Huahong **Shi**
11. (ECOP) Zoop to poop and sediment scoops: Microparticles in the gray whale food web in the North Pacific. Lauren M. **Kashiwabara**, Julia I. Parker, Jennifer E. Van Brocklin, Katherine Lasdin, Lisa Hildebrand, Leigh G. Torres, Susanne M. Brander
12. It's time for science-based recommendations to be used to inform action on plastic chemicals in the global treaty. Susanne M. **Brander**, Kala Senathirajah, Marina O. Fernandez, Judith S. Weis, Eva Kumar, Annika Jahnke, Nanna B. Hartmann, Juan José Alava, Trisia Farrelly, Bethanie Carney Almroth, Ksenia J. Groh, Kristian Syberg, Johanna Sophie Buerkert, Amila Abeynayaka, Andy M. Booth, Xavier Cousin, Dorte

Herzke, Laura Monclús, Carmen Morales-Caselles, Andrea Bonisoli-Alquati, and Rana Al-jaibachi, Martin Wagner

13. Considerations for reducing human exposure to microplastics from consumption of fish. Xiaoxia **Sun**, Liujiang Meng, Shan Zheng
14. Sources of marine debris in Hawai‘i. Jennifer **Lynch**, Katherine Stevens, Rachel Nakamoto, Clare Collins, Paige White, Harley Wahl, Raquel Corniuk, Andrew McWhiter, Kevin O’Brien, James Morioka, Scott McCubbins, Cynthia Welti, Barbara Wiedner, Carl Berg, Hank Lynch, Eric Kingma, Cheryl King, Megan Lamson, Sarah-Jeanne Royer, and Mafalda de Freitas
15. (ECOP) Hawai‘i’s ALDFG Bounty Program: Harnessing partnerships to prevent, monitor, and remove marine debris for recycling. Katherine **Stevens**, Raquel Corniuk, Eric Kingma, Mafalda de Frietas, Harley Wahl and Jennifer Lynch
16. (ECOP) Overlapping patterns of microplastics, seabirds, and zooplankton in the North Pacific. Brian A. **Hoover**, Clare Ostle, Helen Killeen, Veronica Padula, Gammon Koval, Sarah Ann Thompson and Bill Sydeman
17. (ECOP) Estimating the social cost of plastic pollution. Marisa Morse, Adam Domanski, Erin **Murphy**

Poster presentation

1. (ECOP) Quantifying microplastic loads from stormwater runoff using pyrolyzer-GC/MS: A case study from a coastal urban creek in South Korea. Sung Yong **Ha**, Youna Cho, Gi Myung Han, Un Hyuk Yim and Sang Hee Hong
2. Assessment of microplastic pollution in the surface offshore waters of South Korea (East Sea) using a continuous underway sampling method. Gi Myung **Han**, Sung Yong Ha, Youna Cho, Mi Jang, Un Hyuk Yim and Sang Hee Hong
3. (QR-Poster) Characteristics of microplastics in different matrices in Chinese typical coastal area. Shan **Zheng**, Xiaoxia Sun, Yongfang Zhao, Junhua Liang, Mingliang Zhu
4. (ECOP) Pollution meets nutrition: Investigating microplastics and fatty acid composition in marine fish. Chan Yong **Jing**, Chia-Ying Anderin Chuang, Ching-Ping Lu, Ting-Hsuan Chang and Min-Hsuan Lee

Session 10: POC/FUTURE Topic Session

Multiscale Physical, Biological and Ecosystem Dynamics Under Conventional and Carbon-Dioxide Removal Based Climate Scenarios

Convenors:
Takeyoshi Nagai, *Corresponding* (Japan), Zhiwei Zhang (China), Mark Wells (USA), Tatjana Ross (Canada), Lixin Qu (China), Hiroaki Saito (Japan)

Description
Marine ecosystems are shaped and modulated by a wide range of oceanic phenomena, at scales ranging from millimeters to 10,000 kilometers of oceanic gyres, so predicting climate-driven changes requires research across multiple spatiotemporal scales and disciplines. Rapid increase in innovative, machine learning tools can provide new insights into multiscale and multidisciplinary interactions in the ocean. These technological advances have also helped to project climate-driven changes in marine ecosystems, some of which are already being observed and expected to be greatly magnified by the end of the century. Changes in regional wind patterns, surface stratification, marine heat waves, and seasonal phenologies are combining to alter oceanographic conditions, with associated impacts on marine biogeochemistry, ecology, and fisheries in ways that threaten ecosystem services and indigenous and cultural traditions. These changes are tightly linked to multiscale-multidisciplinary processes that include, among others, gyre-scale nutrient streams; meso- and submesoscale eddies and fronts impacts on air-sea interaction, plankton and fisheries; meso- and submesoscale eddy induced upwelling, subduction and lateral transport of biogeochemical tracers; submesoscale instabilities in the boundary layers and associated microscale turbulence, near-inertial waves and internal tides that influence the mixing and distributions of marine ecosystem properties. Machine learning tools not only facilitate the study of the multiscale-multidisciplinary oceanic processes, but are well suited for application to fisheries and climate change. Marine-based carbon dioxide removal (mCDR) is being considered for both nearshore and offshore environments to help mitigate the impact of climate change. Although exploratory thus far, implementation of mCDR strategies would lead to unique alterations of future ocean conditions; a topic ripe for machine learning tools. This session invites all contributions from experimental, observational, numerical, and theoretical research relating to multiscale-multidisciplinary oceanic processes influenced by climate change, as well as those exploring new tools such as mCDR and that adopt machine learning initiatives. We also welcome submissions delving on the practical implementation of measures that are based on scientific and indigenous knowledge to help build a better multiscale-multidisciplinary understanding of marine ecosystems.

List of papers

Oral presentation

1. (**Invited**) Mesoscale and submesoscale dynamics and their control of ocean alkalinity enhancement efficiency. Xing Zhou, Annalisa **Bracco**, Takamitsu Ito, Christopher T. Reinhard
2. (Pre-recorded) Subseasonal effects of coastal trapped waves in the northern region of Peru. Valeria **Panduro Rivero** and Takeyoshi Nagai
3. (Pre-recorded) Application of dimensional reduction in the training of Machine Learning-based emulators for biogeochemical downscaling of the Northeast Pacific ocean. Albert J. Hermann
4. Research on the intraseasonal to interannual variability of oceanic pCO_2 and its regulating mechanism in the South China Sea. Miaoyin **Zhang**, Xuanliang Ji, Xueming Zhu
5. (ECOP) Energy cascade in ocean frontogenetic zones. Xinyi **Wang**, Lixin Qu, Zhiyu Liu, Bo Qiu, Jihai Dong, Hailong Liu and Duo Shu
6. (ECOP) Submesoscale Coherent Vortices (SCVs) in the upstream Kuroshio: Insights from high-resolution no tide/tide simulations and in-situ observations. Silvana **Duran** and Takeyoshi Nagai
7. (ECOP) Seasonal modulation of submesoscale flows by upwelling-favorable winds and their effects on primary production in the Humboldt Eastern Boundary Upwelling System under climate change scenario. Diego Andre **Otero Huaman** and Takeyoshi Nagai

8. Instability-intensified phytoplankton blooms from meso- to submesoscales in the eutrophic Taiwan Strait. Zhonghua **Zhao**, Shuh-Ji Kao, Yuwu Jiang, Lie-Yauw Oey, Huijie Xue and Bangqin Huang
9. (ECOP) Submesoscale processes triggered by tropical cyclones and their role in temperature recovery of cold wakes. Huaxin **Wang** and Zhiwei Zhang
10. (ECOP) Assessing the efficiency and biogeochemical impacts of marine carbon dioxide removal in high-resolution simulations of the Salish Sea. Abigale **Wyatt**, Matt Long, Alicia Karspeck, Scott Bachman, Nora Loose, Sara Nawaz, Giulia Belotti, David Branigan, Pierre Damien, Jeroen Molemaker
11. (ECOP) Topographically generated submesoscale processes in the Tokara Strait revealed by a high-resolution model. Shuya **Wang**, Shoichiro Kido, Xinyu Guo, Yasumasa Miyazawa and Sergey M. Varlamov
12. A new parameterization scheme of ocean submesoscale processes and its implementation in an eddy-resolving model in the North Pacific. Zhiwei **Zhang**, Jinchao Zhang, Bo Qiu and Zhe Feng
13. (ECOP) Quantification of nutrients and dissolved organic carbon transport in the mesoscale eddies: Insights from dual water isotopes. Fajin **Chen**, Qibin Lao, Sihai Liu, Guangzhe Jin
14. Diapycnal fluxes of nutrients in the North Pacific Subtropical Gyre. Chuanjun **Du**, Minhan Dai, Zhiyu Liu, Zhendong Hu, Jin-Yu Terence Yang, Kuanbo Zhou, Hongyang Lin, Zhongwei Yuan, Lifang Wang, Tao Huang, Liguo Guo, Zhe Wang and Shuh-Ji Kao
15. Freshwater-driven alkalinity increase regulates carbon dynamics in the Yellow and East China Seas. Kitack **Lee**, Chang-Ho Lee, Joon-Soo Lee, In-Seong Han and Kwang-Young Jeong
16. (ECOP) Exploring ocean turbulence structure using high-resolution topography data. Yusuke **Sasaki** and Ichiro Yasuda
17. (ECOP) Estimating blue carbon sequestration potential of *Magallana gigas* in Korean aquaculture farms. Hyeong-Gi **Kim**, Tae-Lim Kim, Bong-Oh Kwon, Junsung Noh, Jong Seong Khim

Poster presentation

1. (ECOP) High-resolution tidal current simulation in the Seto Inland Sea for tidal stream energy applications. Shiying **Lin** and Xinyu Guo
2. (ECOP) Impacts of global warming on Peruvian ocean stratification and its implications. Kelly Sofia **Manyahuillca Gutierrez**, Takeyoshi Nagai and Diego Andre Otero Huaman
3. Constrained forward energy transfers at ocean submesoscale fronts. Lixin **Qu**, Xinyi Wang and Zhiyu Liu
4. The impacts of typhoon processes on submarine groundwater discharge (SGD) and its nutrient supply in Zhanjiang Bay, China. Guangzhe **Jin**, Fajin Chen, Ziyang Shi, Xin Lin
5. (ECOP) Vertical hydrological process as a primary driver of organic matter dynamics in the frontal zones. Sihai **Liu**, Chunqing Chen, Qibin Lao, Shangjun Cai, Xuan Lu and Fajin Chen
6. (ECOP) The impact of ocean fronts on the dynamics of dissolved organic matter and their implications for carbon sequestration. Qibin **Lao**, Fajin Chen*, Guangzhe Jin, Sihai Liu
7. Influence of spatial location, vegetation, and benthic macroinvertebrate on organic carbon storage and removal in brackish wetlands. Chae-Lin **Lee**, Dong-Sik Ahn, Sungtae Kim, Taehyun Lee, Su-Young Jeoung, Chang-Su Kim, and Jae-Won Yoo
8. (ECOP) How do oceanic suspended particulate matter and transparent exopolymer particles turn into aggregates?: A process of driving the biological pump in the western North Pacific oceans in summer. Techngong **Tang**, Yoko Iwamoto, and Kazuhiko Takeda
9. (ECOP) Relationships between benthic macroinvertebrate communities and environmental factors in brackish wetlands. Taehyun **Lee**, Chae-Lin Lee, Dong-Sik Ahn, Sungtae Kim, Su-Young Jeoung, Chang-Su Kim and Jae-Won Yoo
10. Mixing induced nutrient supply in the Kuroshio on the sloping bottom boundary in the Okinawa Trough. Jiaxue **Gao**, Kazuki Ikeda, Yuki Ikeda, Takeyoshi Nagai

Session 11: FIS/BIO Topic Session

Applying Innovative and Established Approaches to Assess the Resilience of the Early life Stages of North Pacific Fishes to Changing Oceanographic Conditions

Convenors:
Tatsuya Sakamoto, *Corresponding* (Japan), Miram Gleiber, *Corresponding* (Canada), Kelia Axler (USA), H. Will Fennie (USA), Masahiro Nakamura (Japan), Elena Conser (USA)

Description
The challenges facing successful management of North Pacific marine fisheries are intensifying under rapidly changing climate and ocean conditions. Understanding the drivers of recruitment variability has become vital for sustainable fisheries management because small changes in early survival translate to large fluctuations in recruitment. By studying how survival during the early life stages (eggs, larvae, and juveniles) responds to environmental change, we can elucidate the mechanisms underlying adult population dynamics. However, while early survival is known to be strongly affected by environmental conditions, novel oceanographic conditions magnified by climate change are causing unexpected responses in fish populations (i.e., altered mortality, phenology, distribution, growth, and diet). The aim of this session is to explore the factors influencing the early life stages of North Pacific fishes in response to present and future climate variability. We welcome abstract submissions for research that applies emerging (e.g., in situ imaging, artificial intelligence, eDNA) and/or established (e.g., stable isotopes, otolith microchemistry and microstructure, nutrition, diet analyses, biophysical modeling) approaches to enhance our ability to study the complex early life histories of fishes. By integrating a combination of methods, researchers can gain a more comprehensive understanding of the factors influencing fish early life stages and their implications for recruitment variability to improve the resiliency of fisheries management in a rapidly changing North Pacific ecosystem. All 4 conveners are Early Career Ocean Professionals (ECOP).

List of papers

Oral presentation

1. (**Invited**) Trophic efficiency in early life: A mechanism for fish recruitment in a changing ocean. Rasmus **Swalethorp**
2. (ECOP) Patterns of juvenile fish assemblages in the surf zones of tropical sandy beaches. Wentong **Xia**, Zhongbo Miao, Ying Lu, Jinhui Hu and Songguang Xie
3. (ECOP) Growth-development trade-offs constrain feeding success in Japanese anchovy larvae. Shota **Tanaka**, Daichi, Murayama, Masahiro Nakamura, Michio Yoneda and Akinori Takasuka
4. Ontogenetic shifts in diet and their relationship to growth in Pacific saury (Cololabis saira) larvae in the North Pacific. Taiki **Fuji**, Hiroomi Miyamoto, Junichi Abo and Mikio Watai
5. (ECOP) In situ imaging reveals the impact of upwelling associated hypoxia on larval fishes, their predators and prey. Elena **Conser**, Su Sponaugle, Moritz S. Schmid, Jami Ivory, Nicholas F. Howard and Robert K. Cowen
6. Sensitive microbial shifts during early life stages of chum salmon: Implications for a warming ocean. Subrata Kumar Ghosh, Marty Kwok-Shing Wong, Susumu Hyodo and Koji **Hamasaki**
7. (ECOP) Experimental evaluation of the complex linkages between early growth and survival in pelagic fishes. Masahiro **Nakamura**, Yasuhiro Kamimura, Sho Furuichi, Shota Nishijima, Michio Yoneda, Nozomi Nishiumi, Mayu Inokuchi, Akinori Takasuka
8. Future climate impacts on early marine salmon growth in the California Current Ecosystem. Jerome **Fiechter**, Kelly Vasbinder, Nathan Mantua, Jarrod Santora and Brian Wells

9. Larva proposes, current disposes: Larval distribution of two snow crab species (*Chionoecetes opilio* and C. japonicus) in the western Sea of Japan. Kay **Sakuma**, Yosuke Igeta, Takeo Yamamoto, Yasutoki Shibata, Taketoshi Kodama, Naoto Honda
10. (ECOP) Temporal and spatial overlap between larval northern anchovy (Engraulis mordax) and their zooplankton prey. Luke A. **Bobay**, Robert K. Cowen, Toby D. Auth, Richard D. Brodeur and Su Sponaugle
11. Modeling climate change impacts on anchovy larval growth and survival in Korean waters. Dongwha **Sohn**, Heeseok Jung, DongHeon Seong, Youngkil Hwang, Hwan-Sung Ji, Chan Joo Jang, Sukyung Kang, and Sangil Kim
12. (ECOP) Dispersal strategies of larval fishes in the central California Current: Implications for recruitment resilience under climate change. Helen **Killeen**, Steven Morgan, David Gold and John Largier
13. Shifting phenology in a warming ocean: Temporal and spatial variability in hatching of Pacific Cod in the northern Gulf of Alaska. Nick Strait, Alisa Abookire, Ben Laurel, Mike Litzow, and Jessica **Miller**
14. Assessing the spawning migration history of southern flounder (Paralicthys lethostigma) based on otolith microchemistry. Rebecca G. **Asch**, Justin Mitchell, Patrick Harris, Joseph Luczkovich and Roger A. Rulifson
15. (ECOP) Application of deep learning for identification and measurement of zooplankton and fish eggs. Lauren N. **Block**, Achim Gädke, Julie E. Keister, Kelia E. Axler, and David G. Kimmel

Poster presentation

1. (ECOP) Hydrodynamic dispersal and population structure of the prowfish (Zaprora silenus) in the North Pacific. M.D. **Kolobukhova**, D.S Kurnosov
2. (ECOP) Growth and starvation tolerance in reared Japanese anchovy Engraulis japonicus larvae. Daichi **Murayama**, Shota Tanaka, Masahiro Nakamura, Michio Yoneda and Akinori Takasuka
3. (ECOP) Feeding ecology of flathead grey mullet and longspine snipefish larvae and juveniles in the Kuroshio Current region in winter. Hikaru **Shimada**, Taro Taniguchi, Shota Tanaka, Mikio Watai, Junji Kinoshita, Chiyuki Sassa, Hiroshi Kuroda, Takeshi Okunishi, Tohya Yasuda and Akinori Takasuka
4. (ECOP) Latitudinal differences in Age at First Maturity of largehead hairtail (Trichiurus japonicus) under climate change. Congxian **Chen**, Peng Sun, Guankui Liu and Yongjun Tian
5. (ECOP) Morphological development and its relationship to feeding habits in juvenile *Sebastes cheni*. Keito **Yamamoto** and Takeshi Tomiyama
6. (ECOP) Running the gauntlet: Assessing juvenile salmonid migrations in an urban nearshore environment with eDNA. Grace K. **Melchers**, Spencer Taft, Loïc Jacquemot and Brian P.V. Hunt

Session 12: FIS/BIO Topic Session

Understanding the Linkages Between Forage Species and Top Predators and How They May Affect Resilience in North Pacific Ecosystems

Convenors:
Jim Ruzicka, *Corresponding* (USA), Elliott Hazen (USA), Brian Hunt (Canada), William Sydeman (USA), Minkyoung Bang (Korea), Motohiro Ito (Japan)

Co-sponsor: ICES

Description
Forage species (invertebrate micronekton, squid, small pelagic fish, and juvenile/age-0 piscivorous fish) are a critical linkage between plankton production and upper trophic levels (piscivorous fish, seabirds, and marine mammals). "Bottom-up" processes affecting forage species can affect the distribution, productivity, and survival of upper trophic level species. "Top-down" predation pressure can also affect forage species, and ultimately the structure, function, and resiliency of North Pacific ecosystems. Characterizing and quantifying these linkages is critical to ensuring human food security, conserving robust predator populations, developing innovative approaches to reduce human-predator conflicts, and enacting effective ecosystem-based management. Identifying when these linkages are weakened or broken may allow for early warning of ecosystem state shifts and loss of ecosystem services.

We invite observational and modeling studies concerning linkages in the dynamics of forage and predator species. These include, but are not limited to:

- Observed relationships between forage and predator time-series of biomass, survival, or productivity metrics;
- Investigations into top-down controls by predators upon forage species and bottom-up controls by forage species upon predators;
- Investigations of the effects of environmental variability, extreme events, and climate change on species distributions, phenologies, habitat compression or expansion, and habitat overlap leading to changes in encounters between predator and forage populations;
- Studies of shifts in available forage and diets among predator species and competition between predators; and
- Studies of the effects of forage quality on upper trophic level productivity and survival.

The aim of this session is to explore the role of forage/predator linkages on the productivity and dynamics of both forage and top predator communities; how recovery of top predators may influence other ecosystem components, fisheries, and ecosystem services; identifying potential ecosystem carrying capacities for predators; anticipating new human wildlife conflicts such as recent fisheries entanglements of baleen whales; and how management and conservation measures can be improved.

List of papers

Oral presentation

1. (**Invited**) Pelagic forage fish and seabirds under the regime shifts: A case study in the western North Pacific. Yutaka **Watanuki**
2. (**Invited**) Views from top predator fishes: Do top predator fishes decide their distribution by environment or forage species. Shin-ichi **Ito**
3. The yearly changes of prey species and prey consumption by common minke, sei and Bryde's whale in the western North Pacific since 2000. Tsutomu **Tamura**, Tatsuya Isoda, Satoshi Suyama and Yoshihiro Fujise
4. Effects of noise on Pacific sand lance *Ammodytes personatus* with implications for their avian predators. Nora V **Carlson**, Meredith Anne Vaillancourt White, Jose Tavera, Patrick D O'Hara, Matthew R Baker, Douglas F Bertram, Adam Summers, David A Fifield and Francis Juanes

5. Feeding habit of adult Pacific bluefin tuna in the Sea of Japan. Yuko **Hiraoka**, Hiroshige Tanaka, Shuuyo Watanabe and Yukio Ishihara
6. (ECOP) A counter-intuitive fishery response to climate-driven forage dynamics: The bigeye paradox in the Pacific Ocean. Jihwan Kim, Anna Conchon, Maxime Lalire, Laurène Merillet, Olivier Titaud1, Blanca Orue, Mi Kyung Lee, Hyejin Song, Hanna Na, and Dahye **Lim**
7. (ECOP) Foraging traits reveal climate-driven variability in albacore tuna resources in the NE Pacific. Miram R. **Gleiber**, Natasha A. Hardy, Caitlin J. Morganson, Catherine F. Nickels, Barbara A. Muhling, Elan J. Portner, Brian K. Wells, Toby D. Auth, Richard D. Brodeur, Jarrod A. Santora, Elliott L. Hazen, Michael G. Jacox, Steven J. Bograd, Pierre-Yves Hernvann, Sarah M. Glaser, Daniel J. Madigan, Larry B. Crowder, and Stephanie J. Green
8. (Pre-recorded) (ECOP) Ecological importance of forage groups in the pelagic ecosystems of the subarctic Pacific. Szymon **Surma**, Evgeny A. Pakhomov, Brian P.V. Hunt, and Kerim Y. Aydin
9. (ECOP) Establishing baselines, risks, and mechanisms of thiamine deficiency in British Columbia Chinook salmon. Jacob E. **Lerner** and Brian P. V. Hunt
10. Predation impact on early life stages of Northern anchovy by juvenile salmon in the eastern North Pacific Ocean. Richard D. **Brodeur** and Elizabeth A. Dal
11. Population-level survival impacts of Harbour seal predation on juvenile Pacific salmon, and the mechanistic links. Haley **Oleynik** and Murdoch McAllister
12. Temporal shifts in salmon-killer whale synchrony reveal complex predator-prey linkages. Andrew W. **Trites**, Taryn Scarff, and Tess McRae
13. (ECOP) Post-release predation on hatchery-reared spotted halibut (Verasper variegatus) monitored using acoustic predation tags. Kazushi **Sumino**, Toshihiro Wada, Yuto Funaki, Junya Uryu, Takahiro Yamanobe, Manabu Kume, Risako Sakai, Daisuke Maeyashiki, Kenji Kurato, Daisuke Andoh, Yushi Arai, Kanato Ogiso, Junichi Takagi, Yoh Yamashita, Nobuaki Arai and Hiromichi Mitamura
14. Food for thought: Using predators as samplers to identify foraging landscapes in the Gulf of Alaska. Peri **Gerson**, Cheryl Barnes, Jessica Miller, Jodi Pirtle, Jonathan Reum and James Thorson
15. Interdecadal shifts in seabird distributions relative to the velocity of climate change in the Northeast Pacific Ocean: A long-term observational study. William J. **Sydeman**, Brian H. Hoover, Gammon Koval, Sarah Ann Thompson, Marisol García-Reyes, Mayumi Arimitsu, John F. Piatt, and Katherine J. Kuletz
16. On recent increase of the pacific cod feeding stock in the northwestern Bering Sea. Yury **Zuenko**, Andrey Savin, Eugene Basyuk

Poster presentation

1. (ECOP) Inter-specific overlaps of foraging sites and diet in three sympatric seabirds breed in Tai Island, Tsugaru strait, Japan. Mikage **Yamamoto**, Hikari Ozawa, Kazuhiko Hirata, Tastuki Kojima, Shunsuke Nibe and Motohiro ito
2. (ECOP) Continuous use of mesopelagic micronectons by coastal surface-feeding black-tailed gulls: A case study. Motohiro Ito, Hikari Ozawa, Tatsuki **Kojima**, Kazuhiko Hirata
3. (ECOP) Diet and foraging area selection of Rhinoceros auklet on Todojima Island, Hokkaido, Japan. Tatsuki **Kojima**, Jumpei Okado, Kentaro Kazama, Yutaka Watanuki, Shunsuke Nibe and Motohiro Ito

Session 13: TCODE Topic Session

Shifting Institutional Culture to Develop Climate Solutions With Open Science and Open Data (Cancelled)

Convenors:
Elizabeth Holmes, *Corresponding* (USA), Julie Lowndes (USA), Noriko Shoji (USA), Jeanette Gann (USA, TCODE, NOAA Fisheries)

Description
"To address our climate emergency, we must rapidly, radically reshape society. We need every solution and every solver."- Ayana Elizabeth Johnson & Katharine Wilkinson, All We Can Save.
In 2024, a series of authors from US federal science agencies (NOAA Fisheries, NASA, EPA) led by Openscapes wrote a paper on how an Open Science and Open Data cultural shift is needed to bring 'all hands on deck' to accelerate collaboration and innovation to solve pressing issues presented by rapid ocean climate change. This session will explore how Open Science and embracing data and code collaboration activities helps accelerate research and innovation essential to respond to changes in the ocean environment.

NOAA Fisheries is investing $34M in data modernization, workforce development, in part through Open Science. What exactly are they doing, and why? We'll share stories of how Open Data accelerates science advice for internal teams, stakeholder groups, and far beyond (since it is openly available to all). Speakers will share their stories to help show what is possible when teams and agencies embrace sharing of data and code with an eye towards re-use and interoperability. Further, speakers will share how their teams started making this transition to Open Science by building trust and skills along with their new collaborative workflows.

In science, reshaping requires formidable technical (cloud, coding, reproducibility) and cultural shifts (mindsets, hybrid collaboration, inclusion). This session will present speakers from across government agencies and academia that are exploring better and more efficient ways of working and not being too entrenched in our bureaucracies to do better science, support colleagues, and change the culture at our organizations. We share much-needed success stories and action for what we can all do to reshape science.

Session 14: MEQ/HD Topic Session

The Status and Future of Urban Oceans of the North Pacific − Pathways to Resilient and Sustainable Coastal Cities

Convenors:
Brian Hunt, *Corresponding* (Canada), Kathryn Sobocinski (USA), Takafumi Yoshida (Japan)

Description
Coastal oceans are global hotspots for marine productivity and biodiversity that have supported human subsistence, industry, culture and social systems for millennia, into the present day. Contributing to this socio-ecological richness is land-ocean connectivity, where freshwater and nutrients enhance coastal productivity and create a tapestry of coastal habitat. However, among marine environments, coastal oceans are also uniquely vulnerable to anthropogenic disturbance. Approximately 40% of the global human population lives within 100 km proximity of coasts, and many of our largest cities are located at the land-ocean interface. Urbanization is a pervasive form of land use change that has wide ranging expressions, including shoreline modification, pollution, changes to freshwater runoff, and the quantity and quality of material flux to the ocean. These changes can disrupt critical land-ocean linkages and processes, and the socio-ecological systems that they support, solutions for which can only occur through a holistic understanding of the dynamic interplay between cities and their adjacent oceans. For this session, we welcome presentations that address the ecology of urban oceans; how urban associated stressors and activities shape coastal ocean ecosystems (habitat, species to communities, direct and cumulative effects); the ecosystem services provided by oceans to cities; pathways to resilient and sustainable urban oceans, including monitoring strategies, metrics and indicators of ocean health that can inform benchmarks and restoration; approaches to connecting science to decision making and policy; and the interplay of all of these with climate change. We encourage presentations representing different knowledge types, stakeholders and rightsholders.

List of papers

Oral presentation

1. (**Invited**) Ecosystem modeling of Tokyo Bay for climate resilience and ecological restoration. Akio **Sohma**
2. (**Invited**) Characteristics of macrozoobenthic community structure at natural and anthropogenically disturbed tidal flats along the highly urbanized Osaka Bay Coast, Japan. Gen **Kanaya**, Takeshi Yuhara, Rei Akahoshi, Hironori Higashi, Misuzu Aoki, Ryoko Ueno, So Ishida, Satomi Kamimura, Kotaro Kan, Kenji Kato, Genki Kobayashi, Tsunenori Koga, Osamu Miura, Masanori Taru, Tomoo Unagami and Hiroyuki Yokooka
3. (ECOP) Utilizing satellite imagery to monitor the spatial-temporal distribution of aquaculture activities in coastal areas. Tianwei **Mou**, Yang Liu, Chunlin Li and Zixu Yin
4. (ECOP) Artificial seaweed on a fishing-port seawall restores abundance and diversity of marine amphipods in human-altered coastal areas. Takuma **Matsumoto**, Nobuharu Inaba
5. (ECOP) Pacific Herring (*Clupea pallasii*) spawning-site abandonment: marine vegetation deficits as local barriers, not broad constraints. Jacob Takumi **Dingwall**, Jessica Qualley, Amanda Bates, Matthew Thompson
6. SATOUMI creation in the Nanao Bay, Japan. Takafumi **Yoshida**, Genki Terauchi, Takashi Oba
7. (ECOP) Diversity amidst adversity: Investigating nearshore fish diversity metrics along a spectrum of urbanization and development. Grace K. **Melchers**, Loïc Jacquemot, Spencer Taft, Emily Rubidge, Xiaoping He, Brian P.V. Hunt
8. (ECOP) Assessment of seasonal trophicity of Amur Bay (the Japan/East Sea) through hydrochemistry and plankton communities. Anna S. **Kurnosova**, Mariia A. Shulgina, Ksenia V. Radchenko

9. (ECOP) Applying Bayesian network analysis to explore Okinawa coastal fishers' perceptions of climate change impacts on well-being. Jamila Rodrigues, Shun **Kageyama**, Yi Huang, Hiroaki Sugino, Kazumi Wakita, Xiaozi Liu, and Ulf Dieckmann
10. (Pre-recorded) (ECOP) Power to the ports: How cities could advance marine conservation in the North Pacific Ocean. Szymon **Surma**
11. (ECOP) Research on the application of visual sensory characteristics of land crabs in ecological conservation. Li-Ya **Tseng**, Wei-Yu Lee, Jheng-Jhang Li,Ying-Pin Cheng and Kuo-Wei Lan
12. Estimating the influence of river nutrients on the eelgrass via the coastal-offshore seamless simulation. Haruka **Nishikawa**, Yoshimasa Matsumura, Masao Kurogi, Dai Yamazaki, Hiroyasu Hasumi
13. Quantifying and tracing material flux from Vancouver (British Columbia, Canada) to the coastal ocean, and its fate and impacts in the marine ecosystem. Sadie Lye, Dilan Sunthareswaran, Anna K. McLaskey, Brian P.V. **Hunt**
14. How do we measure positive change in urban seas? An example using cumulative effects evaluation for salmon habitat restoration from Washington, USA. Kathryn L. **Sobocinski**, Mike LeMoine, Heida Diefenderfer, Josh Chamberlin, Correigh Greene, Tish Conway-Cranos, Jason Hall, John Delaney, Ginny Broadhurst
15. (ECOP) Effects of riverine discharge on planktonic food web in a temperate estuarine bay. Jae-bin **Jang**, Mianrun Chen, Hee Yoon Kang, Changseong Kim, Hyoseup Jang, Yoonja Kang and Chang-Keun Kang

Poster presentation

1. (ECOP) Discussion on key issues regarding the promotion of large-scale utilization of seawater desalination in coastal cities of China. Hao **Guo**, Yu Zhang, Menghan Jiang, Chong Chen, Jianhua Yin and Peng Zhao
2. Community-led governance strategies for sustaining particulate matter-mitigating green spaces in coastal industrial complexes. Jinvo **Nam**
3. (ECOP) Human impact affects seaweed beds inside bays through rivers: Case study of Yamaguchi Prefecture, Japan. Shojiro **Amano** and Mitsutaku Makino
4. (ECOP) Technological innovation and regional development patterns of China's marine economy (2000–2023). Yuheng Zhao, Boxiao Zhang, Yicheng **Fu**
5. (ECOP) A study on university students' attitudes toward mangrove-based blue carbon coastal walkway. Jihun **Choi** and Jinvo Nam
6. (ECOP) Toward the development of coastal resilience assessment frameworks in South Korea: Insights from stakeholder perceptions and policy implications. Seungwon **Lee**, JinvoNam

Session 15: HD Topic Session

The Rise of Bibliometric Analyses to Address Sustainability Solutions Through a Human Dimension Lens

Convenors:
Shion Takemura, *Corresponding* (Japan), Jo Foden (ICES, Denmark), Raphael Roman (Canada)

Co-sponsors: ICES, FRA

Description
This session will build off research conducted by the Human Dimensions Committee which explored research conducted in PICES from 1992-present to understand program and expert group networks and connections to ocean science and management for the UN Ocean Decade (Takemura et al. submitted). This earlier work explored bibliometric and text analyses to innovate and integrate the human dimensions in ocean science in novel ways. This session expands on this work by seeking to identify growth and challenges of bibliometric methodologies (including text, content, network analysis), and highlight examples of interdisciplinarity and the co-production of knowledge in support of ocean sustainability using these methods. We will engage researchers from various disciplines to share developments and mobilize knowledge across disciplines, particularly related to the ocean sciences and resource management. Invited speakers and participants from a wide range of fields of study will share novel research that converges on vexing problems in ocean science and management. A structured discussion will be incorporated in the session to allow time for the community of practice to exchange ideas. The session will be conducted in collaboration with ICES' Science Impact and Publications Group to explore opportunities to expand research activities with ICES via PICES' Working Group 51.

List of papers

Oral presentation

1. (**Invited**) Conserving ecosystem integrity: Ecological theory as a guide for marine protected area monitoring. Anya Dunham, Josephine C. Iacarella, Karen L. **Hunter**, Sarah C. Davies, Sarah Dudas, Katie S. P. Gale, Emily Rubidge and Stephanie K. Archer
2. (**Invited**) Quantifying the scientific landscape of marine research: Insights from bibliometric and content analyses. Szymon **Smoliński**
3. (ECOP) Scientific mapping of marine species under the changing climate: Past perspectives, current conundrums, and future potential. Mohamad Nor Azra
4. In your impact era: Tracking your science-policy influence. Abigail **McQuatters-Gollop** and Shravan Raghu
5. (ECOP) Bridging academic gaps and emerging technologies in Taiwan's sustainable fisheries: Insights from bibliometric and qualitative analyses. Kuo-Wei **Yen**, Chia-Hsiang Chen, Han-Yang Lin, Yung-Chieh Chiu, Wei-Chuan Chiang
6. (ECOP) Social network analysis of partnership structure under the UN Ocean Decade Actions. Kotaro **Tanaka**, Atsushi Watanabe, and Mitsutaku Makino
7. (ECOP) Opportunities and challenges of Japan's new anti-IUU policy: Insights from national stakeholder groups. Toya **Hirokawa**, Juri Hori, Minako Iue, Wakao Hanaoka, Benjamin Thompson and Mitsutaku Makino
8. (ECOP) Visualizing the annual transition of ocean policy in Japan using text mining. Mengyao **Zhu**, Kotaro Tanaka, Tomonari Akamatsu
9. A systematic review and bibliometric assessment of extreme climate events in the North Pacific to document key drivers, impacts, and indicators for coastal communities. Hiroki **Wakamatsu**, Karen Hunter, Helen Killeen, Steven Bograd, Antonietta Capotondi, Chan Joo Jang, Sung-Yong Kim, Daniel Lew (deceased), Jian Ma, Mackenzie Mazur, Shoshiro Minobe, Robert Suryan, Marysia Szymkowiak

10. Toward multi-modal metrics: Bridging bibliometrics, AI, and public narrative. Hiroaki **Sugino**, Taro Oishi, and Nobuyuki Yagi
11. (ECOP) Evolving interdisciplinary and international social networks: Insights from Canada's Department of Fisheries and Oceans in the Pacific Region (1990–2025). Raphael **Roman** and Karen Hunter

Poster presentation

1. The rise of bibliometric analyses to address sustainability solutions through a human dimension lens. Nikki Furmanek, Szymon **Smoliński**, Ruth Anderson, Silvana Birchenough, Krishia Desabelle-Mulligan, Jo Foden, Nils Olav Handegard, Colm Lordan, Jan Jaap Poos, Dave Reid, Barbora Valach-Rasul and Nathalie A. Steins

Session 16: POC Topic Session

Radiocarbon Studies in the North Pacific and its Marginal Seas

Convenors:
Minkyoung Kim, *Corresponding* (Korea), Fang Ling (China), Baozhi Lin (China), Shigeyoshi Otosaka (Japan)

Description
Understanding carbon cycling in the North Pacific and its marginal seas is critical for elucidating past ocean dynamics, assessing regional impacts of environmental changes, and predicting future alterations due to global warming. Radiocarbon (^{14}C) serves as an intriguing tracer for deciphering carbon cycling in the ocean.

This topic session invites papers addressing: 1) studies on modern and geological time scale studies; 2) studies of particulate and/or dissolved carbon studies; 3) marine, freshwater, and groundwater systems in the North Pacific and its marginal seas; and 4) any new experimental, modeling, statistical approaches to radiocarbon analysis.

Our session conveners include three members who are ECOPS, with Minkyoung Kim (the corresponding convenor) serving as co-chair of AP-ECOP and AP-CREAMS. This session aims to 1) bring together researchers who are interested in using radiocarbon to understand the ocean carbon cycling and the multiple factors that determine the distribution and preservation of carbon in the ocean; and 2) expand our networks for future collaborations under the PICES umbrella.

Additionally, this session will contribute to the FUTURE and POC initiatives, enhancing our understanding of the PICES region's response to climate change. Presenters will be encouraged to connect their work with all participants and PICES expert groups. If there is sufficient interest, we plan to organize a synthesis paper on radiocarbon studies in the North Pacific and its marginal seas.

List of papers

Oral presentation

1. (**Invited**) Studies on oceanography in the Northwestern Pacific using radiocarbon. Yusuke Yokoyama
2. POC transport to the interior of the basin in the Tsushima Warm Current region of the Japan Sea. Shigeyoshi **Otosaka**, Yoko Ishiyama, Shigeaki Kojima, Taku Wagawa, Yusuke Kawaguchi, Itsuka Yabe, Taketoshi Kodama, Takehiro Shimonaka, Jan Meissner, Charlotte Schnepper, Negar Haghipour, and Timothy I. Eglinton
3. (ECOP) Radiocarbon signatures of long-term sinking particles collected in the Northwest Pacific (Ulleung Basin). Minkyoung **Kim**, Young-Il Kim, Negar Haghipour, Timothy I. Eglinton
4. (ECOP) Aged dissolved organic carbon supply through submarine groundwater discharge in Jeju Island, South Korea. Ling **Fang**, Hee A Kim, Jeonghyun Kim, Peng Cheng, Yeongjin Ryu, Guebuem Kim, and Minkyoung Kim
5. (ECOP) Radiocarbon characteristics of dissolved organic carbon in the East Sea (Japan Sea) revealed by serial UV-oxidation experiments. Sunmin **Oh**, Taehee Na, and Jeomshik Hwang

Poster presentation

1. (ECOP) Dynamics of dissolved organic carbon in the western North Pacific Ocean revealed by radiocarbon. Youwen **Jiang**, Yui Sakai, Yusuke Yokoyama, Yosuke Miyairi, Hiroshi Ogawa, Hajime Obata and Shigeyoshi Otosaka
2. Particle flux in the central Yellow Sea in summer. Hyung Jeek **Kim**, Dong Han Choi, Jeomshik Hwang

Session 17: MEQ Topic Session

What Can we Learn About the Occurrence of *Karenia* spp. Blooms in the North Pacific?

Convenors:
Mark Wells, *Corresponding* (USA), Pengbin Wang (China), Charles Trick (Canada)

Description
Karenia blooms have caused major economic and human impacts in western Pacific regions over the past few decades. Although they have been largely absent along eastern Pacific shores, several *Karenia* blooms recently have appeared there, raising questions about whether an expansion of their common range is underway. The underlying drivers of bloom development still are unknown, though they clearly are linked to warm and stratified surface waters. There is concern then that climate-driven increasing ocean temperatures and stratification are leading conditions to become more favorable for *Karenia* bloom development, especially at higher latitudes. This warming may have contributed to *Karenia* blooms recently appearing along eastern Pacific shores. Given that another common HAB species—*Heterosigma akashiwo*—shares many characteristics with *Karenia* spp., including motility (i.e., the ability to maximize light and nutrient availability), cyst formation and mixotrophy, it is particularly important to understand how these traits may contribute to *Karenia* spp. success over other phytoplankton under warming conditions. Accelerating our understanding of the potential trends in *Karenia* bloom expansion and intensification will hinge upon collaborative research, new monitoring approaches, and initiatives. We seek to begin this enhanced effort by welcoming presentations on the findings from laboratory, field and monitoring studies, along with the perspectives they generate, of *Karenia* blooms in both the Pacific region and elsewhere. Through intercomparison of these observations and ideas we hope to gain critical insights into the underlying mechanisms driving these blooms, and thereby help us address the environmental challenges posed by *Karenia* blooms in the North Pacific.

List of papers

Poster presentation

1. Field trial of kelp bed introduction to enhance algicidal bacterial supply for biological control of *Karenia mikimotoi* bloom in a fishing port. Nobuharu **Inaba**, Takuma Matsumoto, Mizuna Ii and Sawako Shirai
2. The role of biological interactions during bloom outbreak of *Karenia mikimotoi* in northern Fujian, China. Haifeng **Gu**, Hao Luo

BIO Contributed Paper Session

Convenors:
Akash Sastri (Canada), Toru Kobari (Japan)

Description
The Biological Oceanography Committee (BIO) has a wide range of interests spanning from molecular to global scales. BIO targets all organisms living in the marine environment including bacteria, phytoplankton, zooplankton, micronekton, benthos and marine birds and mammals. In this session, we welcome all papers on biological aspects of marine science in the PICES region. Contributions from early career scientists are especially encouraged.

List of papers

Oral presentation

1. (ECOP) Distribution, abundance, and grazing impact of Salpa fusiformis in relation to environmental conditions in Korean waters. Md Abidur Rahman **Sourav**, Seung Won Jung, Jun-Seok Lee and Keun-Hyung Choi
2. (ECOP) Metagenomic insights into the stronger ecological coupling between particle-attached prokaryotes and eukaryotic plankton. Jia **Luo**, Xiao Ma and Chaolun Li
3. (ECOP) Quantitative assessment of mortality in the short-neck clams based on carbon budget in the Midorikawa River tidal flat: Effects of predation and freshwater discharge. Rikuto **Honda**, Tatsuya Ozaki, Nana Yamashita, Shoutaro Kobayashi, Tomohiro Komorita, Katsumasa Yamada and Takehisa Yamakita
4. (ECOP) Quantification of bioturbation by black sea bream (Acanthopagrus schlegelii) in tidal flats of the Yatsushiro Sea using UAV imaging and environmental DNA. Risa **Hayashi**, Tomohiro Komorita, Rikuto Honda, Tatsuya Ozaki, Ryutei Inui and Ryohei Nakao
5. (ECOP) Year-round habitat use of black-footed albatrosses from the western North Pacific, and their distribution overlap with fisheries. Bungo **Nishizawa**, Jean-Baptiste Thiebot, Fumio Sato, Naoki Tomita, Daisuke Ochi, Akinori Takahashi and Yutaka Watanuki
6. (ECOP) Primary production of microphytobenthos enhanced by submarine groundwater discharge (SGD): Comparison between muddy and sandy tidal flats. Tatsuya **Ozaki**, Rikuto Honda, Risa Hayashi, Hiroshi Koba, Ryo Sugimoto, Sosuke Otani, and Tomohiro Komorita
7. An atypical phytoplankton bloom observed off the Sanriku coast using a multi-wavelength excitation fluorometer integrated into a UCTD profiling system. Daisuke **Hasegawa**, Taketoshi Kodama, Hikaru Homma, Yuji Okazaki and Dudsadee Leenawarat
8. (ECOP) Shifts in phytoplankton and bacterioplankton communities induced by simulated freshwater intrusion near ice shelves in the Pacific sector of the Southern Ocean. Jaeho **Choi** and Chung Yeon Hwang
9. (ECOP) Selective aerosolization of marine prokaryotes at the air–sea interface in the Western North Pacific. Yutaka **Okamoto**, Yoko Makabe-Kobayashi, Youta Sugai, Yoko Iwamoto, Koji Hamasaki
10. Effects of ocean acidification on biological vitality and behavior of Disk abalone *Haliotis discus hannai*. Jeonghee **Shim**, Youngbeen Hwang, Hyeonmi Bae, Hae-Kun Jung and In-Seong Han
11. (ECOP) Stage classification of female gonadal development and estimation of egg production rates of *Paracalanus orientalis* (Copepoda: Calanoida) in Sagami Bay, Japan. Rikuto **Hashimoto**, Aruku Kawano, Yoshiki Takayama and Shinji Shimode

Poster presentation

1. (ECOP) Prediction of the impact of climate change on the reproduction of the sea urchin *Mesocentrotus nudus*—Toward future scenarios of fisheries availability. Satomi **Takagi**, Tomonori Azumaya, Natsuki Hasegawa
2. Geographical and seasonal variations of copepod communities from Ise-Mikawa Bay to offshore waters affected by the warm Kuroshio Current. Sayaka **Sogawa**, Kazuaki Tadokoro, Kazuhiro Aoki and Rentaro Nakashima
3. (QR-Poster) Diverse giant viruses obtained from coastal area. Rui **Zhang** and Yucheng Xia
4. Deep sea coral, biodiversity of seamount in West Pacific. Seonock **Woo**, Yejin Jo, Nayoung Lee, Minui Kim
5. (ECOP) Seasonal and latitudinal variations in material flux by epipelagic zooplankton in the western North Pacific: An application of imaging analysis. Zhikun **Yang**, Dongwoo Kim, Sota Komeda and Atsushi Yamaguchi
6. (ECOP) Utilization of imaging analysis devices to evaluate the diel vertical distribution of oceanic copepods in the Oyashio region during winter. Sojin **Ryu**, Dongwoo Kim and Atsushi Yamaguchi
7. (ECOP) Analysis of imaging data on the population structure, vertical distribution, and growth of two dominant oceanic copepods: *Metridia pacifica* and *Eucalanus bungii* in the western subarctic Pacific. Tian Gao, Zhikun **Yang** and Atsushi Yamaguchi
8. (ECOP) High species richness observed in hyperiid amphipods in Suruga Bay, Japan. Sena **Kameyama**, Akiyuki Kenmochi, Takashi Yoshikawa, Rumi Sohrin, Hiroyuki Matsuura, Yumiko Obayashi, Dhugal J. Lindsay and Jun Nishikawa
9. (ECOP) Proteomic insights into molecular mechanisms of nitrogen deficiency-induced chlorosis in the red alga *Pyropia yezoensis*. Hee Yoon **Kang** and Chang-Keun Kang
10. Comparison of microzooplankton grazing rates and phytoplankton growth rates at two sites in Korea and their application to marine ecological modelling. Jaeyeon **Park**, Seung Joo Moon, Eun Young Yoon, Jun-Ho Hyung, Hangy Lee, Nari An, Taeyeon Yin
11. Three tropical epiphytic dinoflagellate species recently found in Korean coastal waters. Jaeyeon Park, Seung Joo **Moon**, Jun-Ho Hyung, Hangy Lee, Yeong Du Yoo, Moo Joon Lee
12. Vertical distribution of zooplankton in the surface layer of the Mixed water region. Yuji **Okazaki**, Daisuke Hasegawa, Hikaru Homma, and Takahiro Tanaka
13. Assessing barcoding completeness by taxonomic group and ocean region using the MetaZooGene Atlas and Database (MZGdb). Todd D. **O'Brien**
14. Single-cell analysis of marine bacterial surface properties and their potential impact on biogeochemical cycles. Yosuke **Yamada**
15. Different properties of extracellular proteases in the subarctic and subtropical western North Pacific. Rikuto Urakubo, Yumiko **Obayashi**, Mitsuhide Sato, Taketoshi Kodama and Koji Hamasaki
16. Population prediction of moon jellyfish based on the strobilation effective accumulated temperature. Nan **Wang**, Dongjie Guo, Yantao Wang and Chaolun Li
17. (ECOP) Spatial variation in microplankton community structure in relation to hydrography in the northern Japan Sea and Okhotsk Sea using PlanktoScope. Daichi **Arima** and Satoshi Kitajima
18. (ECOP) Seasonal and interannual variations in mesozooplankton community structure in the inner part of Suruga Bay, Japan: Effects of the Kuroshio large meander. Akiyuki **Kenmochi**, Hiroyuki Matsuura, Takashi Yoshikawa, Rumi Sohrin, Yumiko Obayashi, and Jun Nishikawa
19. (ECOP) Model-based assessment of nutrient management and its impact on nori (*Porphyra yezoensis*) cultivation in the Seto Inland Sea. Ryuhei **Hosokawa**, Naoki Yoshie, Xinyu Guo, Hirotaka Kiyasu and Tsuyoshi Onitsuka

20. (ECOP) Species-specific characteristics in ammonium excretion rates of large marine copepods revealed by a highly sensitive analytical method. Yuino **Senta**, Kanako Amei, Yuji Okazaki, Hikaru Homma, Daisuke Hasegawa, Takahiro Tanaka, Taketoshi Kodama, and Kazutaka Takahashi
21. Seabird migration corridors in the northwestern Pacific, and their overlap with wind farms. Jean-Baptiste **Thiebot**, Ui Shimabukuro, Jumpei Okado, Nobuo Kokubun, Yutaka Watanuki and Akinori Takahashi

FIS Contributed Paper Session

Convenors:
Jackie King (Canada), Naoki Tojo (Japan)

Description
This session invites papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Fishery Science Committee (FIS).

List of papers

Oral presentation

1. (ECOP) Impact of offshore fishery decline on coastal fisheries: An analysis of the Hokkaido, in Japan. Seiichi **Takeuchi**, Nobuyuki Yagi and Yutaro Sakai
2. Applications and prospects of satellite remote sensing in fisheries and aquaculture. Yang **Liu**
3. AIS-based estimation of fishing gear recovery within the Japan-Korea Northern Interim Measures Water in the Sea of Japan. Rui **Saito**, Akane Yoshikawa, Tomohito Miyashita and Masaya Iida
4. (ECOP) AIS-based estimation of fishing grounds and operational drivers in the NPFC convention area: Effects of oceanic conditions and fishery resource abundance on vessel operations. Kazuo **Ishikawa**, Rui Saito, Tomohito Miyashita, Kenji Takasaki
5. (ECOP) Environmental Drivers of Shark CPUE in NOAA GulfSPAN Survey (1994–2024). Aracelis **Jimenez**, Annsli Hilton, Dean Courtney, Elizabeth Babcock
6. Enhancing ecosystem stability through efficient operation of hatcheries releasing juvenile pacific salmon with a prolonged freshwater period of life. Elena V. **Shulgina**, Vsevolod N. Leman, Evgeny V. Esin
7. (ECOP) Effectiveness of quota transfer in the set-net fishery of Ishikawa Prefecture: A structural estimation approach to fisherman's behavior. Kazushi **Uotani**, Nobuyuki Yagi and Yutaro Sakai
8. (ECOP) Comparing the sand lances' kinematics of locomotion in sand and in water. Issei **Fujita**, Makoto Tomiyasu and Yasuzumi Fujimori
9. (Pre-recorded) Automation of sockeye salmon scale age interpretation. Robert W. **Campbell** and Rachel Ertz
10. Population genetics reveals structure at several levels in "cosmopolitan" mesopelagic fish species. Carolyn **Tepolt**, Rayna Hamilton, Sara Shapiro, Annette Govindarajan, Joel Llopiz
11. (ECOP) An overview of Pacific Arctic marine fauna borealization and the novel approach for process quantification. Pavel O. **Emelin**, Alexey A. Somov, Aleksandr N. Starovoitov and Oleg A. Ivanov

Poster presentation

1. (ECOP) Spatial distribution and oceanographic drivers of Japanese anchovy (*Engraulis japonicus*) in Peter the Great Bay, Japan/East Sea (summer 2024). Vladimir Polyanichko, Anna **Kurnosova**
2. (ECOP) Assessment of mixed herring aggregations in the Bering Sea. Denis **Kurnosov**, Svetlana Saveleva
3. (ECOP) Population genetic structure of Baird's beaked whale around Japan based on mtDNA analysis. Akihito **Kondo**, Hideyoshi Yoshida, Hikari Maeda, Yu Kanaji, Masashi Sekino, Naohisa Kanda and Hiroto Murase
4. (ECOP) Life history characteristics of blacktip grouper *Epinephelus fasciatus* around Koshikishima Island, southern Japan. Takeru **Yokogawa**, Kalisiana Marama Matakiviti, Yoshihiro Harada, Toru Kobari, Masafumi Kodama and Gen Kume

5. (QR-Poster) An ecosystem-based assessment of the Bering Sea pollock recruitment and spatial distribution. Mikhail A. **Stepanenko**, Elena V. Gritsay
6. (ECOP) Abundance indices for the autumn and winter-spring cohorts of neon flying squid based on Japanese driftnet surveys. Bungo **Nishizawa**, Hajime Matsui, Suguru Okamoto and Kazuhiro Oshima
7. (ECOP) Feeding cessation physiologically enhances red tide resistance in aquacultured fish. Koki **Mukai**, Ryoko Yano, Saho Kitatsuji, Takuro Hotta, Hideki Yamazaki, Yuki Takai, Takeshi Hano, Toshiyuki Nishimaki, and Tomoyuki Shikata
8. Population genomic structure of Pacific halibut in the Northeast Pacific Ocean. Andrew J. Jasonowicz and Josep V. **Planas**
9. Spatial and temporal patterns of maturity for female Pacific halibut (*Hippoglossus stenolepis*) as estimated by histological assessment of female ovarian development. Colin L. Jones, Ray A. Webster, Ian J. Stewart, Allan C. Hicks and Josep V. **Planas**
10. Environmental changes in the seasonal migratory grounds of Japanese pink salmon in recent decades. Irene D. Alabia, Sei-Ichi **Saitoh**, Takafumi Hirata, and Yasuyuki Miyakoshi
11. Mesopelagic fish assemblage in the time-series station K2, western subarctic Pacific. Minoru **Kitamura** and Naofumi Murata
12. Spawning season and maturity rate of Japanese amberjack (Seriola quinqueradiata) in the waters off San'in, Nagasaki and in the East China Sea. Yuka **Morita**, Seishiro Furukawa, Mitsuo Nyuji, Akira Kurashima
13. The Ayan-Shantar population of the red king crab (Paralithodes camtschaticus) abundance dynamic. Igor **Chernienko** and Emiliya Chernienko
14. (QR-Poster) (ECOP) Evaluating the impact of a fishing-gear data management system on fishery productivity. Ryunosuke **Kuwano**, Nobuyuki Yagi and Yutaro Sakai
15. Temperature-dependent growth modeling for pre-flexion Pacific cod larvae. Hwahyun Lee1 and Dongwha **Sohn**
16. Conceptual Model for Sailfish (Istiophorus platypterus) in the Eastern Pacific Ocean. Rosa M. **Runcie**, Carolina V. Minte-Vera, and Mark N. Maunder
17. (ECOP) Changes in skipjack tuna CPUE in the equatorial Pacific and its relationship with ENSO and fishing methods. Dahye **Lim**, Hanna Na, Mi Kyung Lee and Chang-Sin Kim

HD Contributed Paper Session

Convenors:
Mitsutaku Makino (Japan), Karen Hunter (Canada)

Description
This session invites papers addressing the promotion, coordination, integration and synthesis of research activities related to the contribution of the social sciences to marine science, and to facilitate discussion among researchers from both the natural and social sciences. We invite abstract submissions on any of these topics (HD).

List of papers

Oral presentation

1. Methodologies for assessing the quantity, quality and value of marine ecosystem assets. Shang **Chen**, Shuai He, Shuhao Liu
2. (ECOP) Broadening the sustainable seafood movement — Systemic and enabling approaches to transform blue food. Malin Jonell, Abigayil **Blandon**, Julian Feine and Sofia Käll
3. (ECOP) Assessing barriers to establishing OECMs in exclusive fishing rights areas in Taiwan: A qualitative study of expert and fisheries association representative perspectives. Chung-Ling Chen, Pei-Yu Chen and Xiang-Nong **Jian**
4. (ECOP) Estimation of willingness to pay and evaluation of purchasing environment effects for certified seafood: Evidence from an in-person choice experiment with real purchases. Mina **Fukagawa**, Takeshi Sato, Nobuyuki Yagi and Yutaro Sakai
5. Stakeholder perception assessment on the adjustment of regulatory measures in the Chaohjing Marine Conservation Area. Jyun-Long **Chen**, Wei-Chen Chang and Xiang-Nong Jian
6. Sustainability of the outreach program for encouraging harmonious use of fish stock resources: Sustainable, Healthy and "Umai" Nippon seafood (SH"U"N) Project. Yoshioki **Oozeki**, Hiroya Sugisaki, Juri Hori, Hiroki Wakamatsu and Mitsutaku Makino
7. (ECOP) An Analysis of the effectiveness of fisheries management in Japan using panel data. Akane **Ushijima**, Nobuyuki Yagi, Yutaro Sakai

Poster presentation

1. (ECOP) Bridging ocean science and fisheries: Smart technologies for identifying fishery grounds of wild juveniles for yellowtail farming. Tsumugi **Sakano**, Eisuke Tsutsumi, Gen Kume, Ayako Nishina, Hirohiko Nakamura, Hirofumi Sumoto, Hikaru Endo, Masafumi Kodama, Yuji Sakuno, Shinichiro Kako, Toru Yamashiro, Toru Kobari
2. (ECOP) Meta-frontier analysis of Japanese fisheries by data envelopment analysis for interval data. Ryutaro **Kamiyama**, Keita Abe, Takefumi Fujimoto and Yutaro Sakai
3. (ECOP) Marine protected area management: Enhancing effectiveness through stakeholder participation in Taiwan and Japan. Shu-Chiang **Huang**, Mitsutaku Makino and Yi Chang
4. (ECOP) Exploring coastal fishers' ideas about climate change, the future of the fishing industry, and fishers' wellbeing. Jamila **Rodrigues**, Shun Kageyama, Yi Huang, Hiroki Sugino, Kazumi Wakita and Ulf Dieckmann
5. (ECOP) Development and application of a coastal resilience assessment model. Seungwon **Kang**, Moonsuk Lee
6. (ECOP) A study on the evaluation of marine climate change monitoring and forecasting activities. Kyuwon **Hwang**, Seungwon Kang, Chulyong Lee and Moonsuk Lee
7. Importance of information in digitalized wholesale fisheries markets based on user attributes in case of Nishinihon Uoichi. Yosuke **Fujii**

8. (ECOP) Challenges to the local participation in the "Umigyo" initiative for revitalizing the shrinking fishing villages: A case of Ainan town, southern Japan. Seishiro **Sakita**, Takahiro Hamabe, Kana Takeyama and Yosuke Shimizu
9. (ECOP) Port states taking charge: National legislative responses to the Agreement on Port State Measures in fisheries governance. Zuanbin **Mo**, Nobuyuki Yagi, Xin Pan, Yutaro Sakai
10. A perspective from Mauritius: Learning from cases of adaptive management in North Pacific fisheries communities. Kirtee Nekram, Naoki **Tojo** and Vinesh Emrith

MEQ Contributed Paper Session

Convenors:
Thomas W. Therriault (Canada), Takafumi Yoshida (Japan)

Description
Papers are invited on all aspects of marine environmental quality research in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Marine Environmental Quality Committee (MEQ).

List of papers

Oral presentation

1. (ECOP) OCPs and PCBs level in organs of Pacific salmon from the Sea of Okhotsk, Russian Part of Northwest Pacific. Aleksandra D. **Borovkova**, Maksim M. Donets, Maksim A. Belanov, Anna V. Litvinenko, Vasiliy Yu. Tsygankov
2. (ECOP) Microplastic–alga interactions: The role of Heterosigma akashiwo and Chattonella marina in aggregation, sinking, and resuspension dynamics. Kavindu Dhananjaya **Sudusinghe**, Seung Ho Baek, Young Kyun Lim, Chung Hyeon Lee, and Sang Hee Hong
3. (ECOP) Impact of submarine groundwater discharge and aquaculture effluent on green tide outbreaks in Jeju Island, Korea. Jinjoo Lim, Sang Rul Park and Jeonghyun **Kim**
4. (ECOP) Rethinking brine discharge: Should concentrated pollutants be regulated? Insights from China. Hanwen **Song**, Changsheng Peng, Xiaoqing Zhang, Donghong Wang, Junrui Cao, Shenghui Wang, Wenxi Xiang

Poster presentation

1. OCPs and PCBs level in commercial fish species (herring, flounder, pollock) from the Sea of Okhotsk. Vasiliy Yu. **Tsygankov**, Maksim M. Donets, Aleksandra D. Borovkova, Maksim A. Belanov, Anna V. Litvinenko
2. (ECOP) Biological regulation of microplastic aggregation and vertical transport by *Chattonella marina*: Implications for sinking dynamics and resuspension stability. Seung Ho Baek, Kavindu Dhananjaya **Sudusinghe**, Young Kyun Lim, Chung Hyeon Lee, and Sang Hee Hong
3. Temporal dynamics of microalgal biomass and community structure on plastic polymers under nutrient-enriched conditions. Seung Ho **Baek**, Chung Hyeon Lee, Young Kyun Lim
4. Effects of temperature and salinity on germination of resting cysts of toxic dinoflagellate *Alexandrium catenella* (Group I) in Jinhae-Masan Bay, Korea. Hyeon Ho **Shin**, Zhun Li, Kyung Ha Han, Da Bin Choi
5. (ECOP) Visual and chemical cues of plastics influence the behavioral decisions and feeding attempts of ghost crabs (*Ocypode stimpsoni*). Sojung **Kwon**, Soohyun Lee, YouBin Koo and Taewon Kim
6. Microbial synergistic degradation potential of PE/PP in urban river sediments. Lihua **Niu**, Yamei Chen and Yi Li
7. Performance and risk validation of an in-water hull cleaning system under real port conditions. Bonggil **Hyun**, Seung Wong Jung, Ju-Hyoung Kim, Jang-seu Ki, Ok Hwan Yu, Kyoungsoon Shin
8. (ECOP) Radon-222-based estimation of submarine groundwater discharge and associated nutrient and carbon fluxes in the coastal waters off Daebu and Jebu Islands, South Korea. Minjun **Kim**, Kevin E. Prasetyo, Hyebin Kim, Yujeong Choi, Tae-Hoon Kim, Hanbyul Lee and Hyung-Mi Cho
9. (ECOP) Meiofaunal biofouling on marine plastic debris during golden tide events: Focus on potentially risky species. Minju **Kim**, Hyeon Kim, Hyun-Jung Kim and Jung-Hoon Kang

POC Contributed Paper Session

Convenors:
Lei Zhou (China), Jennifer M. Jackson (Canada)

Description
Papers are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Physical Oceanography and Climate Committee (POC).

List of papers

Oral presentation

- AI-driven typhoon monitoring: Integrated systems using R/V Zhu Haiyun and blue whale UUVs. Yongling Zhu **Zhu**, Dake Chen
- (ECOP) Short-term sea surface current prediction using a Physics-Informed 3D-CNN model: A case study in the East/Japan Sea. Ho-Jeong **Ju**, Jeong-Yeob Chae, Young Taeg Kim, Min-su Kim, Byoung-Ju Choi, and Jae-Hun Park
- (ECOP) Estimation of water exchange between the Bering Sea and the Pacific Ocean through the Near Strait using GLORYS12V1, GOFS 3.1 and JCOPE2M. Sofia P. **Khudyakova**, Tatyana V. Belonenko, Maxim V. Budyansky and Michael Yu. Uleysky
- Impact of mesoscale eddies on diurnal internal tide propagation in the Northwestern Pacific from observations. Kang-Nyeong **Lee**, Jae-Hun **Park**, Chanhyung Jeon, Hong Sik Min, Xiao-Hua Zhu, Chuanzheng Zhang, and Zhongxiang Zhao
- Tow-yo motion analysis of an underwater environmental sensor probe using an autonomous surface vehicle winch system. Terubumi **Saito**, Daisuke Hasegawa, and Hikaru Homma
- Scale dependence of horizontal diffusion coefficient in the Kuroshio region. Kosei **Komatsu**
- Multi-month prediction of summertime hypoxia occurrence in the bottom of Funka Bay, Japan, with a focus on the wintertime surface heat flux. Hiroto **Abe**, Chihiro Miki, Hiroji Onishi, Atsushi Ooki and Tetsuya Takatsu

Poster presentation

1. A non-interpolated estimate of horizontal spatial covariance from scalar velocities irregularly sampled at time-varying locations. Sung Yong **Kim** and Jinwhan Kim
2. (ECOP) Radium isotopes as tracers of submarine groundwater discharge and upwelling dynamics in Posiet bay (Autumn 2024). Vladislav A. **Krasikov**, Alexandr N. Charkin, Andrey E. Leusov
3. Subsurface eddy diffusivity across the Pacific. Sachihiko **Itoh**, Hitoshi Kaneko, Shinya Kouketsu, Takeshi Okunishi, Eisuke Tsutsumi, Hiroshi Ogawa and Ichiro Yasuda
4. Correlation between organic carbon regeneration and methane flux in mid-Yellow Sea sediments. Taehee **Lee**, Kihwan Lee, and Hyung jeek Kim
5. Subsurface warming associated with Pacific Summer Water transport toward the Chukchi Borderland in the Arctic Ocean. Miaki Muramatsu, Eiji Watanabe, Motoyo Itoh, Jonaotaro Onodera, Kohei Mizobata and Hiromichi **Ueno**
6. Effect of warm eddies on a maintenance of a main spawning region of snow crab (*Chionoecetes opilio*) in the Western part of the Sea of Japan. Yosuke **Igeta**, Kei Sakuma, Takeo Yamamoto, Shoko Abe, Taku Wagawa, Taira Nagai, and Naoki Hirose
7. Could recent variability in the flow of the Tsushima Warm Current be a factor in the shifted distribution of larvae and juveniles of autumn cohorts of Japanese common squid (*Todarodes pacificus*) toward the continental side in the Sea of Japan? Shoko **Abe**, Yosuke Igeta, Taira Nagai, Suguru Okamoto and Hisae Miyahara

8. Influence of water mass variability on double diffusion in the East Sea. Woo J. Lee, Ho K. **Ha**, Baek M. Kim, Kwang Y. Jeong, Young T. Kim, Min S. Kim, and Young H. Park
9. Swell waves directionally selected at the bay mouth of rias facing the western North Pacific. Kosei **Komatsu**, Takaki Fujii and Kiyoshi Tanaka
10. Possible effect of nocturnal hypoxia on the trade-off between blue carbon and fish production in eelgrass bed. Jun **Shoji**
11. Estimation and interannual variation of blue carbon in eelgrass beds in Wakasa Bay, Japan. Kanata **Iseki**, Naoto Ietsugu and Jun Shoji
12. (ECOP) Marine ecosystem modeling of estuarine nutrient dynamics with a benthic–pelagic coupling module: A case study of the Tonegawa Estuary. Yan **Wang**, Toshimi Nakajima, L. Shogo Urakawa, Yoshimasa Matsumura and Sachihiko Itoh
13. (ECOP) ENSO-driven variabilities in the surface cross-frontal flow and poleward heat advection in the ACC Pacific sector. Hajin **Song**, Jae-Hun Park, Jeong-Yeob Chae, Kathleen A. Donohue, D. Randolph Watts, Ahyoung Ku, Kiduk Kim, Tae-Wan Kim, and Jisoo Park
14. Tidal and residual currents in the inner shelf of East China Sea detected from underway ADCP observations. Yan Wang, Yisen **Zhong**, Shuangzhao Li
15. Evaluation of mixed layer depth in Korean Waters based on reanalysis data focused on Spatial and interannual variability. Heeseok **Jung** and Chan Joo Jang

W1: FIS/HD/POC/MONITOR/TCODE/TCODE Workshop

Climate-Ready Fisheries Management: Reviewing Effective Strategies for Developing Decision Support Tools

Convenors:
Steven Bograd, *Corresponding* (USA), Kirstin Holsman (USA), Mitsutaku Makino (Japan), Hanna Na (Korea), Kathryn Berry (Canada), Viv Tulloch (Canada), Erin Satterthwaite (USA), David Reid (Denmark)

Co-sponsor: ICES

Invited Speaker:
Beth Fulton (CSIRO, Australia)

Description
Building networks to share knowledge and capacity is essential to understand, forecast, manage, and adapt to climate-driven changes in marine ecosystems and their associated fisheries. The UN Decade of Ocean Science for Sustainable Development (Ocean Decade; 2021-2030) provides a unique opportunity to convene global partners to address challenges associated with climate change, marine ecosystem health, and food security. The Ocean Decade Programme 'Sustainability of Marine Ecosystems Through Global Knowledge Networks' (SMARTNET), jointly sponsored by PICES and ICES, works with S-CCME and other Programmes to advance the 'climate-fisheries' nexus within the Ocean Decade. In this workshop, we will explore decision support tools needed to implement effective fisheries management and adaptation strategies in a changing climate. We invite a broad array of participants, across international and management organizations, to: (1) explore the various mechanisms used to integrate environmental information into ecosystem-based fisheries management; and (2) review the existing tools/systems, gaps and pathways forward for climate-ready fisheries management (including data streams, models, information infrastructure, communication avenues, co-development practices, governance frameworks). This workshop will build upon the PICES-2024 workshop on the 'science-policy interface' and the ICES-2025 theme session on 'climate-ready fisheries'. An outcome of this Workshop will be a white paper outlining effective strategies for supporting international climate-ready fisheries management.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

The United Nations Decade of Ocean Science for Sustainable Development (Ocean Decade; 2021-2030) provides a unique opportunity to convene global partners to address challenges associated with climate change, marine ecosystem productivity and health, and food security. The joint ICES-PICES Ocean Decade Program SmartNet (Sustainability of Marine Ecosystems Through Global Knowledge Networks), together with the Ocean Decade Project BECI (Basin Scale Events and Coastal Impacts), convened a workshop at PICES-2025 to share examples and assess our collective capacity to integrate climate information into decision support tools to advance ecosystem-based fisheries management. This workshop follows a previous SmartNet-co-sponsored workshop on the 'Science-Policy Interface' at PICES-2024 in Honolulu in October 2024 as well as an oral session on 'Climate-Ready Fisheries Management in the UN Decade of Ocean Science for Sustainable Development' at the ICES Annual Science Congress in Klaipeda, Lithuania, in September 2025.

The Workshop began with a recorded invited talk by Beth Fulton (CSIRO, Australia), who highlighted a variety of tools, frameworks, and models to assess and predict climate impacts on Australian fisheries. Karen Hunter (Fisheries and Oceans Canada) described the development and application of a resilience framework and survey tool to assess climate considerations in Canadian fisheries management. Marria Peduto (University of Washington, USA) examined the role of advocacy coalitions in the management of Bering Sea fisheries, while Heather Welch (University of California Santa Cruz, USA) described the use of the vessel monitoring system (VMS) to monitor fishing fleets as sentinels of climate-driven species redistributions. Finally, Kathryn Berry (Basin-scale Events and Coastal Impacts (BECI), Canada) reviewed BECI's North Pacific Ocean Knowledge Network Dashboard, an online platform that aggregates information about North Pacific datasets, models, and assessments. Following the presentations, the speakers took part in a panel discussion with workshop participants.

In the afternoon, workshop participants separated into several breakout groups to conduct 'conversation cafes' around the themes of identifying barriers to incorporating climate information into fisheries management and,

specifically, how PICES can make our science useful and actionable to managers and stakeholders. The conversation cafes are designed to hear the viewpoints of all participants, with the aim of finding consensus on a few key messages. Participants pointed out the requirement for two-way communication between science and management and identified strategies PICES can employ to facilitate this communication, including through targeted sessions that allow the co-design of 'actionable' science. As in similar discussions at the ICES Annual Science Conference (ASC) session, participants emphasised the importance of building trust among scientists, fishers, and managers, and recognised that this can take significant time and effort. Participants also acknowledged the critical importance of effectively assessing and communicating risks and uncertainty in any climate-informed management process.

Conducting similar discussions at the ICES-ASC and PICES-2025 provided a glimpse of how climate information is being integrated into fisheries management across diverse settings, revealing various examples and opinions and providing a unique opportunity to assess the capacities, gaps, barriers, and pathways forward for climate-ready fisheries management. These discussions will continue, and a potential outcome of the ICES Session and PICES Workshop will be a white paper outlining effective strategies for supporting international climate-ready fisheries management.

Workshop 1 Convenors and Speakers.

W2 BIO/MONITOR Workshop

Intercomparison of North Pacific Zooplankton Time Series

Convenors:
Akash Sastri, *Corresponding* (Canada), Julie Keister (USA), , Kazuaki Tadokoro (Japan), Satoshi Kitajima (Japan),

Invited Speaker:
Todd O'Brien (USA)

Description
North Pacific zooplankton time series provide early and rapid biological indicators of response to climate-ocean variability and extreme events (e.g. marine heatwaves) occurring with increasing frequency. This practical workshop seeks to explore zooplankton time series of biomass and/or abundance of indicator species or groupings in each PICES region. The intent is to facilitate regional inter-comparison of zooplankton time series by identifying common indicators useful at broader scales relevant to the North Pacific. We propose a one-day workshop divided into: 1) an invited talk by Todd O'Brien (NOAA) providing an introduction and overview of the time-series tools on the COPEPODITE website; 2) contributed talks representing zooplankton time series from as many PICES regions as possible; 3) a hands-on portion inviting participants to bring and standardize their data set using the COPEPODITE website tools, for which the invited speaker will be on hand to help participants use the tools; 4) initial inter-comparisons of patterns among time-series. The goal will be to examine if similar patterns in zooplankton time-series are found across PICES regions and across climate events. Standardized data could be placed in a shared drive and analyses done by participants for a future session/workshop. This workshop will lay the foundation for formation of a North Pacific zooplankton time series expert group in the near future

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Topic Workshop 2, *Intercomparison of North Pacific Zooplankton Time Series*, was convened on Saturday, November 8th, 2025. This workshop was proposed and supported through the PICES Biological Oceanography (BIO) Committee and the Technical Committee on Monitoring (MONITOR). The workshop structure and objectives emerged from discussions during Workshop 1 at PICES-2024, *North Pacific plankton time series data analyses and synthesis*, where participants decided to propose and convene a practical workshop exploring common applications of analytical tools for North Pacific plankton time series analysis. The practical workshop explored zooplankton time series of biomass and/or abundance of indicator species or groupings in each PICES region. The intent was to facilitate regional intercomparison of zooplankton time series by identifying common indicators useful at broader scales relevant to the North Pacific. The one-day workshop was divided into: 1) an invited talk by Todd O'Brien, who provided an introduction and overview of the time series tools on the COPEPOD's Interactive Time-series Explorer (COPEPODITE) website; 2) contributed talks representing zooplankton time series from multiple PICES regions; and 3) a hands-on portion and discussion led by the invited speaker guiding participants on data set standardization using the COPEPODITE website tools. The goal was to examine whether similar patterns in zooplankton time series are found across PICES regions and across climate events.

Oral presentation summaries
Our invited speaker, **Todd O'Brien** (USA), presented a talk titled, *Visualizing spatiotemporal trends and variability in plankton and their environment*. This presentation laid the groundwork for the workshop goals of bringing together North Pacific zooplankton researchers for planned time series syntheses. Todd covered the history of large-scale plankton time series reporting, starting with ICES Working Group on Zooplankton Ecology status reports (2000-present), workshops at Zooplankton Production symposia (2003, 2024, 2025), and multiple international working groups and collaborative activities such as the Scientific Committee on Oceanic Research (SCOR) Working Group 125 (*Comparisons of Zooplankton Time Series*) and the International Group for Marine Ecological Time Series (IGMETS) (2013-2018). This historic perspective also addressed how visualization of plankton time series methods has developed from basic scalar plots to more informative spatial-temporal data treatments and visualizations using online tools arising from multiple international efforts. The talk was wide ranging, addressing the efficacy of different statistical treatments of time series, including the advantages and disadvantages of log-transformation and approaches used for trend detection, as well as other practical considerations surrounding challenges, capabilities, and approaches

used for the intercomparison of different time series. These challenges were directly applicable to North Pacific time series and addressed concerns and solutions for time series of differing year lengths, sampling frequencies, gear types and towing, mesh sizes, and taxonomic resolutions. The goal of the workshop was inclusivity of time series, and our invited speaker provided detailed suggestions for approaches (use of time windows, abundance ratios, etc.) to address some of the incompatibility issues. Todd also led the afternoon hands on part of the workshop, where he detailed potential approaches for useful synthesis and visualization which were ultimately adopted for this report.

Seohwi Choo (Korea) presented *Zooplankton behavioral segregation and vertical positioning in a stratified summer Ulleung Basin: diel variation in functional composition across ecological boundaries*. This talk addressed hypotheses surrounding physical (thermocline depth and deep chlorophyll maximum depth) and biological (trait-based) factors influencing the presence and extent of diel vertical migration (DVM) throughout the water column. The objectives of the study were: 1) quantitative classification of diel behavioral patterns; 2) demonstration of how species-specific behavioral strategies are related to biological traits and physical ocean structure; and 3) determine how zooplankton partition ecological space under physical constraints shaped by competition predation tradeoffs. Sampling was carried out every six hours in July 2021 in the deep (2000 m) Ulleung Basin (36º 44’ 19”N, 131º 15’ 35”E). Conductivity, Temperature, Depth (CTD) sensor data and taxonomic enumeration of net tows was used to quantify DVM extent and estimate ecological boundaries of zooplankton species and functional groupings. The study identified variable DVM patterns associated with functional groupings (i.e., moderate upper water column DVM of small migratory species associated with the Deep Chlorophyll Maximum (DCM)), large amplitude migration of larger species groups, and groups resident in both the upper water column (‘Production Consumption zone') and lower layers (‘Intermediate Processing zone’). Insights from the analyses represent valuable context for biogeochemical interpretations of long-term, depth-resolved, zooplankton time series.

Deniz Coskuner (Canada) presented a talk titled, *A decade of nearshore zooplankton dynamics and oceanographic variability in the Strait of Georgia*. This was a presentation of a multi-year, nearshore, zooplankton time series collected as part of a citizen science program in the Salish Sea. Sampling took place on a sub-monthly basis at a deep and shallow station in Malaspina Strait between 2018 and 2024. Zooplankton production at these sites is considered important to early ocean phase juvenile salmon in the Salish Sea. Preserved samples were enumerated using a ZooScan and images were classified into major taxonomic groups or species where possible. Assemblage composition was partitioned by both abundance and biomass. Overall, both abundance and biomass were greatest in 2019 and dominated by large calanoid copepods (>2mm) and small calanoid copepods (<2mm), respectively.. The interannual variability of both assemblage composition and biovolume anomalies was relatively high, with patterns departing from deep-water sampling in the nearby Strait of Georgia. (D. Coskuner, S. Esenkulova, A. McLaskey, G. Triona, S., and B. Hunt)

Hiroomi Miyamoto (Japan) presented a talk titled, *Copepod responses to ocean warming in the transition region of the North Pacific: Insights from two decades of community temperature and body size changes*. This presentation described the variability of the copepod assemblage in the subtropical-subarctic transition region of the western North Pacific. Important physical descriptors of regional variability are the Pacific Decadal Oscillation (PDO) and the incidence of marine heatwaves (MHW). Critically, PDO failed to describe variability of SST in the transition region post 2010. The Fisheries Research Agency (FRA, Japan) started the early summer time series of zooplankton in an area extending north from the subarctic/subtropical transition zone between the western/central subarctic North Pacific (~145ºE to ~150ºW; 4500 km) in 2003. This study explored interannual variation of the community temperature index (CTI) and community size index (CSI). High CTI values correspond to an increased proportion of warm-affinity species, whereas a greater proportion of large copepods is reflected by a proportionally greater CSI value. In the western region of the sampling grid, SST warming was unrelated to PDO and reflected by greater CTI and reduced CSI values. Similar patterns were observed with negative PDO associated with SST warming associated with warm-affinity copepods of smaller body size. The degree of tropicalization and deborealization of the western warming area was greater than that of the eastern PDO warming area. Differences between regions are associated with dominant food web structure (classical diatom versus complex microbial food webs). Similar patterns were found with analysis of the CPR time series in the NE Pacific and the 2013-2014 MHW (the ‘Blob’). (H. Miyamoto, K. Tadokoro, T. Fuji, S. Suyama, V. Ernesto, G. Chust)

Kazuaki Tadokoro (Japan) presented a talk titled, *The Change in the Mesozooplankton Community Structure After the Mid-2010s in the Oyashio and Transition Waters, Western North Pacific*. This presentation documented how the mesozooplankton communities in the Oyashio current and transitional waters region off the east coast of Japan reflects

a northward shift of the Kuroshio current occurring in the mid-2010s. Monitoring changes to plankton composition and productivity is critical in this region because of the role of zooplankton as prey for multiple fisheries, especially Pacific saury. The observation period for this study was 2007-2023 and relied on high frequency sampling (five surveys/year) and detailed taxonomic enumeration. Dominant species within four statistically distinct groups were classified: two cold water groups; a warm water group; and a transitional group. Overall, the relative proportion of warm-water species increased in all survey months after 2010 and the expansion of transitional waters between the Oyashio and Kuroshio currents. The biomass of cold-water prey species, Neocalanus spp., has decreased since the mid-2010s. An earlier peak timing for N. plumchrus was also noted and is potentially related to warming trends in July. Meandering of the Kuroshio can exert significant ecosystem impacts and warrants continued monitoring. (K. Tadokoro and the A-line team)

Samantha Zeman (USA) presented *Indicators of ocean variability from Newport Hydrographic Line data*. This presentation was an overview of the long-term (1996-present), biweekly, Newport Hydrographic Line time series and recent trends. The line is a cross-shelf transect situated off the Oregon (USA) coast in the northern California Current System. Sampling includes a full suite of physical, chemical, and biological oceanographic measurements at seven stations with a focus on a midshelf station, NH-5. The location, sampling frequency, and plankton taxonomic resolution provide multiple sensitive indicators of water mass and prey availability for juvenile sablefish, rockfish, salmon, and forage fish and ecosystem status reporting. The long-term time series identified a seasonal transition of downwelling to upwelling by dominance of warm- to cold- water copepods and years/ periods during which transitions are weak or absent, reflecting broad-scale climate variability. Similar long-term analyses of phytoplankton dynamics are also underway. The presentation concluded with an overview of how multiple zooplankton time series along the west coast of North America responded to the 2015/2016 Northeast Pacific Marine Heatwave (Fisher et al. 2020 PICES Press, 28, 1). An excellent example of motivation and utility for similar syntheses across the North Pacific. (K. Jacobson, J.L. Fisher, S.M. Zeman, A. Bolm, and J. Bowman)

Akash Sastri (Canada) presented *Fisheries & Oceans Canada Zooplankton Monitoring Along Line P : A Coastal-Offshore Transect*. This presentation reviewed a long-term (1997-present), seasonally resolved zooplankton time series along the Line P oceanographic transect. The line P transect, made up of 27 stations, starts in productive coastal waters (Southern Vancouver Island shelf) and ends at Ocean Station Papa (50°N, 145°W) in the central, high-nutrient, low-chlorophyll Gulf of Alaska. Fisheries & Oceans Canada (DFO) carries out detailed taxonomic enumeration of samples collected at 7-8 stations representative of coastal shelf, transitional offshore, and oligotrophic offshore conditions along the ~1400 km line. Annual biomass trend updates are presented in DFO's State of the Pacific Ocean annual report. The presentation compared zooplankton along the inner and outer transect segments. Large calanoid copepods (primarily Neocalanus spp.) typically dominate the total biomass during the late spring/early summer period. Along the outer line, increased biomass of subarctic copepods indicates cool conditions, whereas an increase in subtropical species suggests warm conditions. Similarly, on the continental shelf and shelf break, higher biomass of endemic species points to cool conditions, while a greater abundance of Southern California Current species signifies warm conditions. The outer and inner zooplankton time series are generally co-varying, but basin-scale events such as the marine heatwave in the mid-2010s were evident offshore nearly two years before large compositional changes were observed along the coast. (A. Sastri, M. Galbraith, K. Young, S. Kafrissen, J. Smith, and R. I. Perry)

North Pacific zooplankton time series synthesis

The practical component of the workshop was led by Todd O'Brien, who guided participants through the time series analysis tools available on the Coastal and Oceanic Plankton Ecology, Production, and Observation Database (COPEPOD) website. Practical considerations for future syntheses of North Pacific zooplankton time series were discussed, including methods for inclusion of short- and longer- time series and useful indicator variables. The consensus at the conclusion of the meeting was to compare temporal trends of anomaly ratio time series for multiple time windows (TW) relevant to each time series. The figures illustrate this approach. Copepod abundance (Figure 1) and total sample biomass (Figure 2) for each time series were uploaded to the COPEPOD toolkit (https://www.st.nmfs.noaa.gov/copepodite) by each data contributor. Anomaly time series were calculated by the toolkit according to the ICES method (O'Brien and Oakes 2020). The toolkit output includes a variety of analyses and visualization for environmental variables. Here, we focused on sign and significance of temporal trend for each anomaly time series, as illustrated in Figures 1 and 2. This was a preliminary effort to visualize trends for multiple North Pacific zooplankton time series using these analytical tools. Overall, copepod abundance time series in coastal waters are trending upward, while offshore time series have trended down for the longest temporal windows (20, 25,

and 30 years). The 2009-2023 period (TW 15) was characterized by the greatest rate of warming in the Northeast Pacific, and the abundance of copepods in both coastal and offshore time series trended up. The most recent temporal window, 2014-2023, is characterized by a decreasing trend for offshore sites and the M2 time series on the southeast Bering Sea shelf. Trends for zooplankton biomass anomaly time series for all sites were not especially variable across each time window, with biomass trending down for all sites except Line 8, Shelikof Strait, inshore Line P (Southern Vancouver Island shelf), and the Newport Hydrographic Line shelf stations.

One objective of the workshop was to explore approaches to compare time series of varying duration, differing sampling methods/gear, and taxonomic resolution. This comparison of multiple time series in the NE Pacific captures synchrony of decadal trends in keeping with expectations for coastal and offshore communities in the NE Pacific. Increased spatial coverage and inclusion of additional groupings (e.g., climate indicator groups, functional trait groups) are next steps.

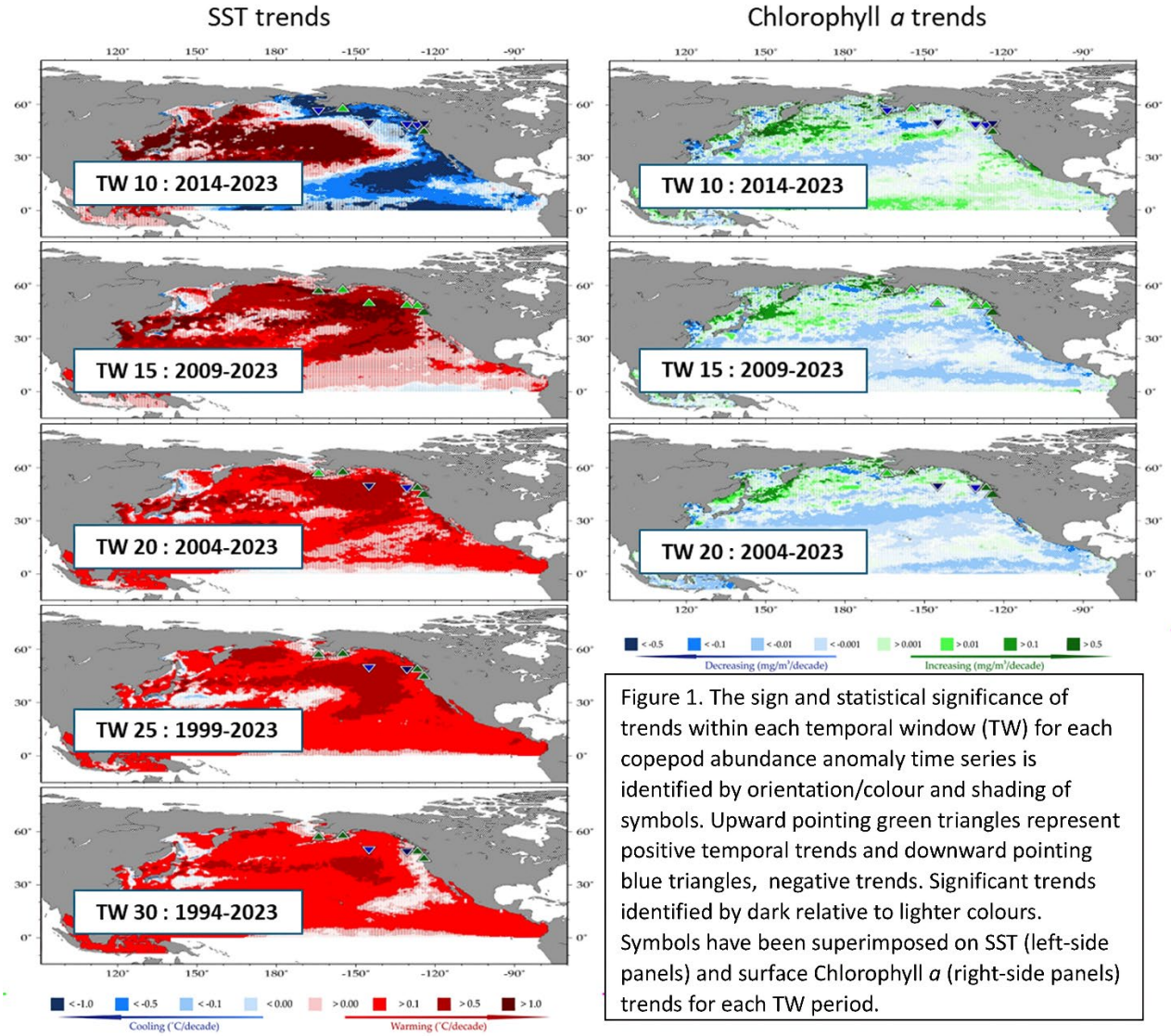

Figure 1. The sign and statistical significance of trends within each temporal window (TW) for each copepod abundance anomaly time series is identified by orientation/colour and shading of symbols. Upward pointing green triangles represent positive temporal trends and downward pointing blue triangles, negative trends. Significant trends identified by dark relative to lighter colours. Symbols have been superimposed on SST (left-side panels) and surface Chlorophyll *a* (right-side panels) trends for each TW period.

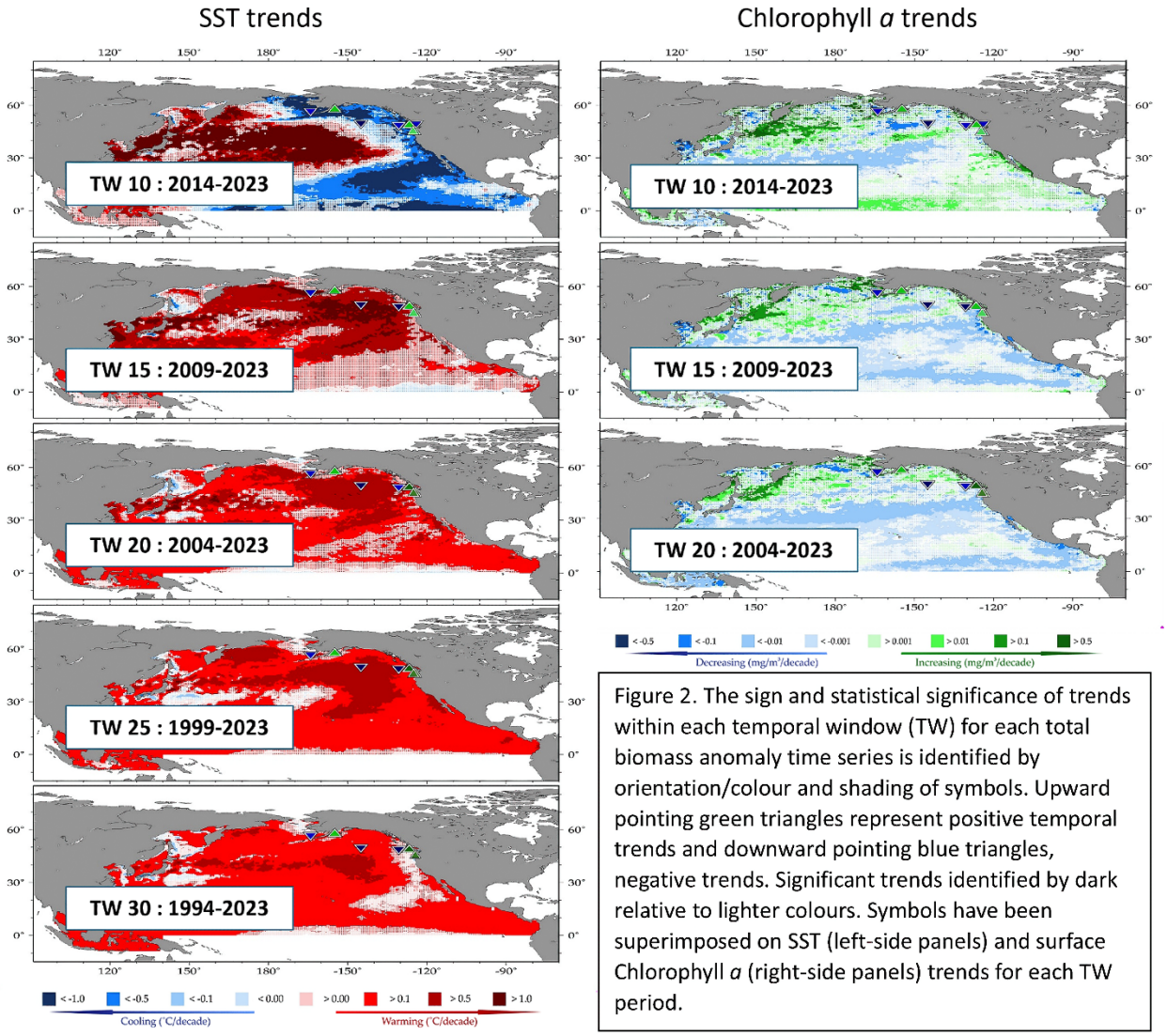

Figure 2. The sign and statistical significance of trends within each temporal window (TW) for each total biomass anomaly time series is identified by orientation/colour and shading of symbols. Upward pointing green triangles represent positive temporal trends and downward pointing blue triangles, negative trends. Significant trends identified by dark relative to lighter colours. Symbols have been superimposed on SST (left-side panels) and surface Chlorophyll *a* (right-side panels) trends for each TW period.

Data contributions and reference

- Line 8 (Shelikof Strait) and M2 (SE Bering Sea shelf) plankton time series. Ecosystems and Fisheries-Oceanography (EcoFOCI) project, Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory, NOAA.
- Newport Hydrographic Line: NH05 and NH25 plankton time series, Northwest Fisheries Science Center (NOAA) and Oregon State University.
- Malaspina Strait plankton time series, Pacific Salmon Foundation (PSF) Citizen Science Oceanography Monitoring Program.
- Line P plankton time series, Pacific Plankton Ecology program, Ecology and Biogeochemistry, Fisheries and Oceans Canada.
- O'Brien, T.D., & Oakes, S.A. (2020). Visualizing and exploring zooplankton spatio-temporal variability. In Zooplankton Ecology (pp. 192-224). CRC Press (Taylor & Francis Group)

W3: HD/MEQ/FUTURE Workshop

Present and Future Pressures and Human Activities in the Arctic Ocean and Pacific GatewaysPresent and Future Pressures and Human Activities in the Arctic Ocean and Pacific Gateways

Convenors:
Sei-Ichi Saitoh, *Corresponding* (Japan), Sarah Wise (USA), Jennifer M. Jackson (Canada), Nadja Stefanie Steiner (Canada), Hyoung Chul Shin (Korea), Thomas Therriault (Canada)

Co-sponsor: ICES

Invited Speakers:
Martine van den Heuvel-Greve (Wageningen Marine Research, Netherlands), Natsuhiko Otsuka (Hokkaido University and The Okhotsk Sea Ice Museum of Hokkaido, Japan)

Description
Ecological monitoring of the Pacific Arctic conducted over the past decades has shed light on the impacts of climate change driven warming and reduced sea-ice conditions to Arctic marine ecosystems. Over the period of 1974-2014, the date of summer sea ice retreat has occurred earlier at a rate of approximately -0.7 d/yr. The years 2017-2019 were identified as anomalously warm in the Northern Bering and Chukchi Seas and were further characterized by substantial winter sea ice loss. Additional physical changes in the Pacific Arctic include increased heat transport of Pacific water through the Bering Strait, occurrences of marine heat waves, and increased storm activities in the High Arctic. These physical conditions drive multiple ecological impacts spanning the entire Arctic ecosystem from phytoplankton and marine bacteria to marine mammals and ultimately Indigenous and First Nations Peoples throughout the region including Central Yup'ik, Cup'ik, St. Lawrence Island Yupik, Unangan, and Iñupiat. Indigenous communities in the region rely heavily on the marine ecosystem for sustenance, social cohesion, and cultural values.

Climate change is a large-scale phenomenon which underlies multiple regional pressures that affect human activities and the marine ecosystem. Accelerating climate change effects individual ecosystem stressors, the intensity of the pressures on the ecosystem, and the linkages among these.

Additional pressures such as increased marine traffic, harmful algal blooms, invasive species, noise, contamination, litter, hypoxia, ocean acidification and microplastics impact the marine ecosystems of the Pacific-Arctic and its gateways.

To adequately understand the drivers, evolution and impacts of these various pressures, how they interact with each other, and how those interactive changes impact Arctic communities, it is important to develop and support trans-disciplinary and collaborative approaches using knowledge co-production methods. The interweaving of academic and Indigenous knowledge systems is a key component in this effort. In this workshop, we will focus on present and future pressures and human activities in the Arctic Ocean and Pacific Gateways in alignment with PICES activities with discussions around the evolution of climate-change related pressures acting on the ecosystems. We will identify available information on non-climatic pressures, understanding available knowledge tools, academic and Indigenous, and how to appropriately apply them to achieve a holistic view of the pressures and their impacts, and identifying equitable adaptation/policy/conservation pathways.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

A full-day workshop, aimed at reporting on and enhancing the understanding of current and future pressures and human activities in the Arctic Ocean and Pacific Gateways, took place on November 9th, 2025. The event was held both in-person and online at the annual PICES meeting in Yokohama, Japan, and was collaboratively organized by the Advisory Panel on the Arctic Ocean and the Pacific Gateways (AP-ARC), Working Group on Climate Extremes and Coastal Impacts in the Pacific (WG49), the Human Dimensions Committee (HD), the Marine Environment Quality Committee (MEQ), and the Advisory Panel on the United Nations Decade of Ocean Science (AP-UNDOS). The workshop was attended by over 20 participants, with 6 online. The workshop was chaired by Sei-Ichi Saitoh on site and by Nadja Steiner with support from Hyoung-Chul Shin online.

Background

Ecological monitoring of the Pacific Arctic conducted over the past decades has shed light on the impacts of climate change-driven warming and reduced sea-ice conditions on Arctic marine ecosystems. Over the period of 1974-2014, the date of summer sea ice retreat has occurred earlier at a rate of approximately -0.7 days/year. The years 2017- 2019 were anomalously warm in the Northern Bering and Chukchi Seas, which were further characterized by significant loss of winter sea ice. Additional physical changes in the Pacific Arctic include increased heat and volume transport of Pacific water through the Bering Strait, occurrences of marine heat waves, and increased storm activities in the High Arctic (e.g., AMAP, 2024). These physical conditions drive multiple ecological impacts that span the entire Arctic ecosystem, influencing organisms from phytoplankton and marine bacteria all the way to marine mammals. This directly affects Indigenous and First Nations peoples across the region, whose communities rely heavily on the marine ecosystem for their sustenance, social cohesion, and cultural values.

Climate change is a large-scale phenomenon, which drives multiple regional pressures that affect human activities and the marine ecosystem. Accelerating climate change affects individual ecosystem stressors, the intensity of the pressures on the ecosystem, and the linkages among these. Additional pressures, such as increased marine traffic, harmful algal blooms, invasive species, noise, contamination, litter, hypoxia, ocean acidification, and microplastics, also impact the marine ecosystems of the Pacific Arctic and its gateways.

To adequately understand the drivers, evolution, and impacts of these various pressures, as well as how they interact with each other and affect Arctic communities, it is important to develop and support transdisciplinary and collaborative approaches that utilize knowledge-based co-production methods. Interweaving academic and Indigenous Knowledge Systems is a key component in this effort. This workshop focused on current and future pressures, as well as human activities in the Arctic Ocean and Pacific Gateways, in alignment with PICES activities. Two invited speaker presentations were followed by a selection of general talks and two discussion sessions, which are described below.

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Presentations

Invited speaker **Martine van den Heuvel-Greve** presented on the Central Arctic Ocean (CAO) ecosystem: current pressures, vulnerabilities, and knowledge gaps, a summary of the ICES-PICES-PAME (Protection of the Arctic Marine Environment) working group. The speaker reported on the Integrated Ecosystem Assessments published in 2022 and 2025. The 2025 report synthesized human pressures (Jørgensen et al. 2025) and climate change as a pressure was only included briefly, as the group is planning a separate dedicated report on future climate change scenarios in the CAO. Instead, the subject matters included contaminants, noise, marine litter, species extraction, physical seabed disturbance, and others. They identified several gaps, such as the biology and ecology of endemic species, vulnerability and resilience, and trends. The Working Groups' next step is to develop the CAO future climate scenario report. The report will include topics such as what is needed for commercial species to establish in the CAO, vulnerable and fragile species and habitats, and impacts from exploratory fisheries. The work is very relevant for AP-ARC, as it suggests that pressures in CAOs are more advanced and intense than the gateways.

Invited Speakers **Natsuhiko Otsuka** and **Sei-Ichi Saitoh** presented on the Northern Sea Route and its pressure in the Pacific Arctic. They highlighted the Chukchi Sea area, where there is increased trans-Arctic shipping (increases in cargo, ship numbers, and ship types) due to ice reduction and strong warming. Increases are identified mostly on the Russian side (such as in the Kara Sea), but also in the Northwest Passage (NWP). Here, the increasing vessel traffic is mostly from private cruising, but cruise ships (with a brief reprieve during the COVID-19 pandemic) and cargo ships are increasing as well. It was noted that ship speeds are like those outside the Arctic for open water, even with ice. Strong impediments of bulk carriers by ice were reported, with many becoming unable to sail and require icebreaker rescue. In addition, there are increased tanker spills due to unpredictable harsh weather and human error. It was noted that different characteristics of oil, such as viscosity, require different treatment in cold conditions and no effective methods have been developed for spills on ice. The Arctic Council's collaboration on Marine Oil Pollution Preparedness and Response in the Arctic (MOSPA) for preparing for oil spill pollution was mentioned in this context. Regarding stressors on mammals due to shipping, it was highlighted that in the Arctic the Sound Fixing and Ranging (SOFAR) channel is shallower than in other oceans (30-300 m vs 500-1000 m). This creates more overlap with marine mammal dive patterns; additionally, vessel strikes and restricted manoeuvrability of large vessels were noted.

General presentations began with the Utilisation of nutrients transported from the Bering Sea to the Chukchi Sea by **Yury I. Zuenko**. A quantitative evaluation of nutrient fluxes was presented, evaluating the Russian Federal Research Institute of Fisheries and Oceanography's (TINRO's) sur veys. Clear differences in nutrient concentration and consumption (surface vs subsurface) were found in 2010 vs 2020, where stronger currents in 2020 led to less primary production.

Yuanxin Zhang presented on the multi-model assessment of future ice-algal production in the Chukchi Sea from the Ice Algae Model Intercomparison Project Phase 2 (IAMIP2), showing differences in ice algae projections despite common forcing. The Japanese model exhibits strong photoinhibition, which reduces future algae production but also indicates much higher light levels. The Canadian model shows an initial increase in ice algae in the second, mid-century, period, while the other two show decreases for both periods. Nutrient decline is stronger in the Japanese and Australian models. Sensitivity studies with the Japanese model show that the light treatment can change the pattern to increase in the second phase followed by a decrease, highlighting the strong impact of the light parameterisation.

Irene D. Alabia presented on future distribution shifts of fisheries resources in subarctic and Arctic seas. They mentioned unclear predictions about future primary production, which mostly show increases, and noted that top predators are gaining species faster than midlevel predators. They developed environmental and climate layers (SST, SIC, bottom t, etc.) to run a random forest species abundance model which correlates environmental layers with species changes. They found that fish abundance centres are shifting, along with changes in catch potential (suggested increase), primarily north of the Bering Strait (based on their evaluation of the Bering and Chukchi Seas). Additionally, they project changes in maximum catch, revenue, and profit potential in fishing grounds, which are expected to decline under high-emmissions climate change scenario SSP5-85. The presenter noted that increases in catch potential do not lead to economic increases due to shifts in species, but impacts vary across species.

Takafumi Hirata reported on the response of the Arctic marine ecosystems to multiple stressors, highlighting many anthropogenic pressures through shipping. They developed a linear response impact model (environmental change vs environmental forcing) which showed relatively high ecosystem sensitivity, higher sensitivity in gateways, and highest in the Atlantic gateway. In general, they observe more anthropogenic pressure in the Atlantic and more environmental pressures in the Pacific.

Lis L. Jørgensen, representing the Arctic Council's Ecosystem Approach to Management Working Group, presented on ecosystem-based management within the rapidly changing Arctic. This group focuses on the sustainable use of goods and services and the comprehensive, integrated management of human activities, utilizing both the best available scientific and traditional knowledge. They underscored the need to identify and address issues critical to the health of the ecosystem, emphasizing the importance of better reflecting the perspectives of local people. Specifically, they mentioned the necessity to better involve the Arctic Council's Permanent Participants. They also highlighted relevant work being conducted within the 18 Large Marine Ecosystems (LMEs), through the PAME Environmental Assessment (EA) Guidelines, and in the context of major conferences. The presentation further stressed the importance of describing biological and physical components (including human aspects), setting clear ecological objectives, and assessing the current state, alongside cultural, social, and economic values. Additionally, they pointed out the need to transition from linear to circular processes. In efforts to improve how local voices are heard, they reported on an EA workshop focused on Arctic peoples' values and valuation, with a written report expected soon. Their future work will concentrate on fisheries and pollution.

Marina Lomaeva presented on Japanese and Russian participation in North Pacific fisheries regulation following 2022. She outlined the dynamic relationship between Arctic bilateral activities, collaborations, and annual negotiations. Her presentation noted the impact of external factors on these interactions, alongside the presence of disparate system approaches and uneven resilience.

Lastly, **Shigeto Nishino** introduced the efforts underway for the second expedition of the Synoptic Arctic Survey (SAS). During the recent SAS expedition, Japan, Korea, Canada, and the USA organized collaborative cruises to cover the Pacific Arctic. These cruises identified low omega ($CaCO_3$ saturation states) and low oxygen waters on the Chukchi Plateau. These waters exhibited a core at the bottom, with a possible source from the East Siberian Sea shelf, and were also found to be influenced by Atlantic source waters traveling into the region. The urgent need for a station was mentioned. Additionally, the contribution of SAS to the implementation plan of the Central Arctic Ocean (CAO)

Fisheries Agreement's Joint Program of Scientific Research and Monitoring (JPSRM) was highlighted. It was also noted that large-scale changes, such as silicate decreases, had occurred just before the first SAS expedition (SAS1). The second SAS expedition (SAS2) is planned for 2030.

Discussion sessions

Discussion 1: Inter-weaving traditional knowledge and academic science and holistic views linked to science

Guiding Questions for Discussion 1:

a. How and where are knowledge systems different?
b. What does the interweave of traditional knowledge and academic science mean for you?
c. What type of traditional knowledge-academic science collaborations are you aware of?
d. Are you aware of limitations to collaborations with Indigenous peoples? If so, what are they?
e. Are the collaborations you know of addressing climate change? If so, how?
f. Are there limitations in discussions of climate change in these collaborations?
g. How can the integration of different knowledge systems enhance climate science and support adaptation and mitigation efforts?

During the introduction, distinct perspectives on human ecosystem interactions were emphasized. Traditional Knowledge (TK) typically encompasses varying scales of time perception, rooted in an orally recorded past and closely linked to local experiences. This approach differs from the academic world's often more extractive view of ecosystem services, which considers them primarily as benefits to humans. In contrast, Indigenous groups maintain a holistic view that integrates humans as an intrinsic part of the ecosystem, thus fostering reciprocal relationships (e.g., Tedesco et al., 2025). The Indigenous Resilience Report (IRR) (Reed et al. 2024) was also cited, highlighting the crucial need to "recognise, highlight and elevate Indigenous Knowledge, rights, expertise, issues, perspectives and experiences concerning climate change and its impacts within Canada" and states that "Indigenous Knowledge Systems and lived experiences are essential components of climate action" (Reed et al. 2024).

It was highlighted that understanding and responding to Arctic change requires a diverse set of tools. Examples of collaborations and crossovers between traditional knowledge (TK) and academic science were discussed. These included various initiatives such as community-based monitoring, which encompasses tracking species condition, harvesting numbers, stomach contents, sea ice thickness (via SMART-ICE), temperature, salinity, oxygen, and acidification. Further examples involved mapping exercises that utilized fuzzy logic approaches, the creation of a traditional knowledge calendar that links TK with environmental conditions across seasons, and the co-development and management of marine protected areas. The Ulukhaktok traditional knowledge calendar (Farnole et al. 2024) was presented as a detailed example of merging Indigenous traditional knowledge and academic science tools in a co-production approach to better understand climate change impacts on subsistence harvesting. Discussions suggested the need for additional calendars or similar initiatives that bridge different knowledge systems. Several participants shared their experiences and projects involving Indigenous groups, emphasizing that the majority of these projects and interactions are primarily focused on addressing the impacts of climate change. Participants collectively noted the essential requirement of establishing long-term collaborations to foster trust. They also stressed the importance of regular interactions for consultations and project reviews, and particularly emphasized the critical need to actively listen to what Indigenous groups themselves want from a project. The discussion itself was characterized by strong interest and active participation.

Discussion 2: Gaps and international collaboration

Guiding Questions for Discussion 2

a. What information on climate pressures/stressors is lacking?
b. What type of information are we missing regarding non-climatic pressures on the Arctic Ocean and Pacific Gateways?
c. How can we use PICES/AP-ARC or other international collaborations to fill those gaps?
d. Are there ways to enhance these international collaborations?
e. How can we enhance North-South/Indigenous-academic collaborations?

The presentations above highlighted key pressures in the CAO and the gateways, ranging from shipping to species ecology, climate projections, and political issues. The 2025 Integrated Ecosystem Report on human pressures addresses many of the pressures and gaps that are also relevant in the Arctic gateways. It was discussed how both

working groups could better connect. A discussion focused on data pointed out the need for improved joint data management and faster options for postprocessing and sharing data, particularly for large collaborative experiments, such as SAS analytics platform. A data workshop was suggested, combining the various working groups as well as the PICES data Working Group. Such a workshop was later discussed at the AP-ARC meeting; however, both AP-ARC and the PICES/ICES/PAME Working Group on an Integrated Ecosystem Assessment (WGICA) felt that they didn't have the expertise and capacity to organise such a workshop.

Summary

The workshop provided an excellent summary of current pressures and recommended improved collaboration between the Advisory Panel on the Arctic Ocean and the Pacific Gateways (AP-ARC) and Central Arctic Ocean (CAO) working groups. While their content interests are very similar, their regional foci differ. However, strong connectivity exists through the key influence of the Arctic gateways and surrounding seas on the CAO. Consequently, a workshop proposal focusing on these connections has been submitted for the PICES 2026 annual meeting in Nanaimo, Canada.

Discussions also revealed several gaps concerning the ecology and biology of Arctic species, particularly regarding their vulnerability, resilience, and trends. The importance of collaborative research was highlighted (e.g., the Synoptic Arctic Survey (SAS), and the inclusion of Arctic Council permanent participants), and challenges influencing research due to broader geopolitical contexts were noted.

Talks and discussion sessions emphasized the need to better integrate Indigenous knowledge holders and improve knowledge co-production approaches. Participants specifically highlighted the importance of processes such as building long-term trust, ensuring multiple interactions between academic researchers and Indigenous knowledge holders, and actively listening to the needs, concerns, and wishes of Indigenous partners. Additionally, participants expressed concerns about data management and underscored the need for a dedicated workshop to support effective data collation, management, and sharing.

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W4: BIO/POC Workshop

Building Framework for Cross-Community Conversation Between Natural Carbon Cycles and Marine Carbon Dioxide RemovalBuilding Framework for Cross-Community Conversation Between Natural Carbon Cycles and Marine Carbon Dioxide Removal

Convenors:
Tsuneo Ono, *Corresponding* (Japan), Alexander Kozyr (USA), James Christian (Canada), Kitack Lee (Korea)

Invited speakers:
Yanli Lei (Institute of Oceanology (ISO), CAS, China), Masao Ishii (Meteolorogical Research Institute, Japan), Kenta Watanabe (Port and Airport Research Institute, Japan)

Description
Marine carbon dioxide removal (mCDR) technologies have emerged as a promising tool for mitigating climate change. This technology is closely entangled with natural carbon cycles, and its impact on biogeochemical cycles of carbon, oxygen, and nutrients must be thoroughly assessed throughout its development process. However, implementation of this technology is not straightforward due to the transdisciplinary nature of this complicated issue. It is necessary to facilitate better communication and develop a dialogue between the disciplines involved including social scientists, engineers, and oceanographers.

In PICES countries, research on mCDR is still in its early stages, and there is currently no established communication channel between natural carbon cycle scientists and mCDR researchers. To address this, we are hosting a workshop to bring together experts from all fields. Representatives from several existing cross-disciplinary communication programs like the Global Ocean Acidification Observing Network (GOA-ON) CDR working group and the Deep-Ocean Stewardship Initiative (DOSI) will also participate. Throughout the workshop, we will share information on what each mCDR program is doing, what mCDR communities require from the natural carbon cycle community, and how we can develop a consistent dialogue between the two communities.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Background
Marine carbon dioxide removal (mCDR) technologies have emerged as promising tools for mitigating climate change. However, implementation is not straight forward due to the transdisciplinary nature of this complicated issue. This technology is closely entangled with natural carbon cycles, and its impact on biogeochemical cycles of carbon, oxygen, and nutrients must be thoroughly assessed throughout its development process.

This workshop was held as the Section on Carbon and Climate's (S-CC's) first attempt to address issues around implementing mCDR technology. The main purposes of this workshop were to:

- Share minimum knowledge on ongoing activities in mCDR communities among PICES countries.
- Start systematic dialogue between mCDR scientists and natural ocean carbon scientists.
- Propagate information obtained through this workshop (e.g., publishing PICES report).

Twelve in-person and two online participants from the US, Canada, Japan, Korea, and China attended the workshop. Ten participants were from the community of natural biogeochemical oceanography, while two participants were from the mCDR and fisheries communities, respectively.

Part 1: Exhibition of ongoing mCDR programs in PICES region
Section 1. List of ongoing mCDR projects and protocols in PICES region
Prior to the workshop, S-CC members had created the following three lists to grasp what was ongoing in mCDR communities among PICES countries:

i. List mCDR projects now in progress in the North Pacific.
ii. List research for mCDR methodologies and risk assessment.
iii. List protocols/manuals for each mCDR technology.

Information from each country was submitted by S-CC members and workshop presenters. Additional information was collected from various mCDR portals (e.g., Ocean Visions) and international carbon credit distributors (e.g., ISOMETRIC). For lists i) and ii), only projects and research that are led by PICES countries were

collected. Projects outside of the North Pacific were excluded. For list iii), on the other hand, all protocols/manuals were collected regardless of leading country and applicable area.

As a result, 12 ongoing projects, 29 pieces of research, and 18 protocols/manuals, were collected. Tsuneo Ono analysed the collected information and presented the results. The main findings were as follows:

- Few projects/studies were focused on nutrient fertilization technology; one international scientist group is now evaluating iron fertilization and its protocols.
- A mCDR project applying artificial upwelling technology that plans carbon removal on the scale of a million metric tons is ongoing in China. However, no protocols have been authorized for this technology internationally. The Chinese group is now creating protocols, and it will soon be opened for international discussion.
- Six projects applying blue carbon technology (BC) are now ongoing in Japan and Korea. The planned carbon absorption for all these projects is at a level of kilotonnes per year (KtC/y) or lower. Half of these projects lack biogeochemical scientists as members. Several protocols are already established for BC technology in different countries and/or communities.
- Out of all PICES countries, there are 14 research projects focused on BC. All these studies are working on BC methodology, and no studies are ongoing for risk assessment.
- Six projects applying Ocean Alkalinity Enhancement (OAE) and Direct Ocean Carbon Capture (DOC) technologies are now ongoing in the US and Canada. Planned carbon absorption is also at the level of kilotonnes per year or less for all projects. Five out of six projects lack biological scientists as members, whereas their protocols contain clauses for biological assessment and measures for minimizing biological impacts.
    - Several protocols are already established for this technology in different countries and/or communities.
    - 13 researchers in PICES countries are working on OAE. Two studies focus on methodology, eight studies examine biological effects, and two studies address both aspects.
- While no protocol has been established for artificial upwelling technology, all other mCDR technologies (nutrient fertilization, including iron, BC, OAE and DOC) already have more than one protocol. These protocols seem to be segregated by countries, ocean areas, and communities, although the boundary among them is not officially established.
- In addition to the protocols for each mCDR technology, a general protocol exists for the measurement, report, and verification (MRV) of CDR technologies (ISO 14064- 2). Additional general protocols for marine-specialized CDR technologies are also now under construction (ISO/TC 8 WG15). Natural ocean science communities have general protocols for ocean measurements (IOCCP protocols for essential ocean variables), but it is not certain whether the observation methods of ocean variables described in various mCDR protocols are consistent with those in the IOCCP protocols.

Section 2. Quantification of organic carbon storage and CO_2 removal by coastal macrophytes

Following the general review and analyses in Section 1, Kenta Watanabe introduced a detailed description of the blue carbon project now ongoing in Japanese coastal areas, with the introduction of international collaboration in BC communities. The Japanese government recently conducted a national project to develop BC quantification methodologies for greenhouse gas (GHG) inventories and blue carbon credit schemes. The basic concept involves estimation of CO_2 removal by multiplying the area of the macrophyte habitat by its net primary production per unit area and its carbon storage rate. Several studies have been conducted within this program to determine the carbon storage rate for each type of macrophyte bed. These studies assume that once most of the carbon is captured through macrophyte production it is decomposed after the plants die, while a certain portion is stored through sedimentation, or as recalcitrant carbon, or is transported to the deep sea. In these studies, Kenta Watanabe has estimated the amount of dissolved organic carbon that is produced by macrophytes and stored within the ocean as a recalcitrant fraction with a lifetime of over 100 years (rDOC). He estimated that about 4.3% and 8% of net primary production is stored as rDOC in macroalgal and eelgrass beds, respectively, based on the studies conducted in various Japanese coastal areas. The percentage of all other long-lived organic fractions against net primary production was similarly determined throughout this project, and the sum of them determined the carbon storage rate. Based on the results of this project the Japanese government will include it in the coastal blue carbon values of the national GHG inventories since 2023.

Watanabe also introduced a recent activity by the World Association for Waterborne Transport Infrastructure (PIANC) to develop guidelines on the relationship between blue carbon and waterway transport infrastructure. This guideline, to be published in 2026, covers infrastructure operations, flood protection measures, dredging and its

effective use, the contribution to climate change mitigation and adaptation, nature-based solutions, and the carbon credit market. He also introduced activities of the United Nations Global Ocean Decade Program for Blue Carbon in Nov. 2023. This UN Decade program has a technical working group consisting of 30 blue carbon scientists, two regional hubs, five endorsed, and two affiliated projects. The group is currently drafting a paper on Priority Issues for BC Research in the Next Decade, Capacity Building in Developing Countries for BC Research, and Contributions to Policy and Social Implementation. In this draft, they updated ten blue carbon research challenges assessed seven years ago by Macreadie et al. (2019). The highest priority was focused on managing blue carbon ecology to support coastal communities, while integrating traditional ecological knowledge and emphasizing the essential role of social legitimacy in enabling scalable, long-lasting outcomes. Additional priorities were focused on developing cost-effective restoration methods, improving the accuracy of GHG flux estimates, quantifying the impacts of human activities on carbon cycling, and integrating co-benefits such as biodiversity, coastal protection, and nutrient cycling into natural capital frameworks. Simplifying carbon crediting standards and refining data collection approaches while maintaining transparency and accountability were essential to underpin climate policy and market instruments. Emerging technologies like remote sensing, machine learning, and data-sharing platforms were highlighted as transformative tools to fill knowledge gaps and scale solutions globally. Collectively, these priorities highlighted the complexity of blue carbon science and the need for interdisciplinary approaches.

Section 3. High alkalinity input into the Yellow Sea

Kitack Lee introduced a recent observation-based program in Korea regarding natural ocean alkalinity enhancement. The Yellow Sea and the adjacent East China Sea are characterized by significant temporal variation caused by high seasonal sea surface temperature (SST) variability and high biological productivity. These areas also receive large amounts of nitrogen input from the continent, and as a result, limiting nutrients have gradually changed from nitrogen to phosphorus in this region. To understand temporal variations of the carbon cycle connected by these changes in biological conditions, Korea and China conducted a collaborative monitoring study of ocean carbon parameters in the Bohai Sea, Yellow Sea and northern East China Sea. Prof. Wei-dong Zhai (China) conducted cruises from 2012 to 2018, while POSTECH and the National Institute of Fisheries Science (Korea) coconducted cruises from 2015 to present. Combined time series data showed a linear decrease of salinity at the rate of -0.18 decade^{-1} and a linear increase of alkalinity at the rate of 3.9 μmol kg-1 decade-1. Detailed analysis indicated that these linear changes are caused by the increased influx of Huanghe River water that has high alkalinity compared to the Changjiang River water. Temporal change of pH in Yellow Sea water caused by this freshwater-driven alkalinity increase was estimated as +0.001 decade^{-1} based on the thermodynamic calculation. This rate is far smaller than the estimated pH, however, changes by anthropogenic dissolved inorganic carbon (DIC) increased (-0.006 decade^{-1}) and SST increased (-0.022 decade^{-1}). Therefore, we may consider this process as a sort of natural ocean alkalinity enhancement. The audience additionally pointed out that this process may have an effect on the temporal changes of aragonite saturation state (Ω arag) in the Yellow Sea as a result of increasing alkalinity and water temperature trends.

Section 4. Discussions

After the presentations, the initial discussion centered mainly on mCDR projects currently being implemented. Two questions were proposed by the moderator (Tsuneo Ono) and discussed by participants.

Q1: Most OAE projects are being implemented without biological oceanographers. Similarly, half of BC projects are being implemented without biogeochemical oceanographers. Are these situations safe, as long as they follow protocols that were created with the participation of both biological and biogeochemical scientists?

Jim Christian pointed out that biological oceanographers and biologists are distinct groups, and biological oceanographers are often not trained in areas directly related to impacts, especially on benthic macrofauna. Even when a biologist is included among the OAE project members, it doesn't necessarily mean that they specialize in the biological impacts of OAE. The same can be said for biogeochemical oceanographers for BC projects. We thus need to get more detailed information to understand the actual commitment of 'OAE-capable biologist' and 'BCcapable biogeochemical scientist' in current projects.

Fiona Hogan added an additional point that not only biologists but also fisheries scientists and/or local fisheries communities should be involved in any mCDR projects. We realized that most ongoing mCDR projects have strong cooperation with local communities, including the fisheries sector, but rarely involve them as the official members of the project. This means that local communities do not have the final say in the project's decisions, which may become problematic for future extensions of mCDR technologies.

In any case, the participants agreed that the participation of biological, biogeochemical, and fisheries scientists is essential for mCDR technologies since each mCDR project must tailor its approach to the specific conditions of the implementation area, and this requires specialized knowledge from the experts in each field. Participants also pointed out that a wide range of measurement parameters are needed for both biological and biogeochemical assessment of each project, and such measurements cannot be executed without experts in each field.

Q2: No studies are projected for risk assessment of natural Blue Carbon technology. Is it unnecessary? Or do we need some studies?

Kenta Watanabe expressed his opinion that a part of natural Blue Carbon technology (e.g., protection of natural seaweed beds) will not need biological risk assessment. Most BC projects in Japan and Korea protect natural seagrass/seaweed ecosystems, which is why risk assessment studies for BC are uncommon in these countries. However, he pointed out that risk assessment studies are essential for artificial BC technologies (e.g., kelp harvesting). Yanli Lei also pointed out that the International Standard Organization (ISO) divides mCDR into three categories: natural mCDR, artificial mCDR, and GHG reduction technologies. Natural BC technologies and artificial BC technologies should be clearly differentiated.

Part 2: Towards coordination and regulation of mCDR activities with natural carbon cycle studies

Section 1. From science to standards: The International Standard Organization's Working Group 15 in the Technical Committee 8 (ISO/TC8/ WG15) and the international pathway for ocean based negative carbon emissions

Yanli Lei started the second session by introducing her recent activities with the International Standard Organization (ISO) to create a series of standards for mCDR technologies, as well as several ongoing mCDR projects in China under the umbrella of the Global-ONCE (OCean Negative Carbon Emissions) program.

Under the increasing pressure of global warming, not only scientific and political sectors but also industrial and commercial sectors have started promoting mCDR technologies. For example, the International Maritime Organization (IMO) published a strategy paper in 2018 which declares that GHG emissions from global shipping will be reduced by at least 50 % by 2030, and zero emissions will be achieved in the second half of this century. In 2023, IMO published an additional strategy paper to enhance common confidence to achieve net zero GHG emissions from international shipping by around 2050. The European Union (EU), on the other hand, created the EU Border Adjustment Mechanism (CBAM) in 2023. This mechanism levies carbon emission fees that interlock with carbon footprints on all goods entering the EU and, hence, reducing carbon footprints, including purchasing carbon credits, becomes a practical matter of consideration in the industrial/commercial sectors. These circumstances now push mCDR technologies forward strongly and that is why we need international standards for promoting/ implementing them.

ISO now consists of 174 countries, where 827 committees and subcommittees take care of standards development in various issues. ISO has already created several series of standards for measurement/estimation methods of greenhouse gas emission (ISO 14064), as well as general principles and requirements for bodies that validate/ verify GHG emission estimates (ISO 14065). The standards for mCDR, or ocean negative carbon emission (ONCE), are now discussed in Working Group 15 in the Technical Committee 8 (ISO/TC8/WG15) that Lei chairs. This working group consists of 33 countries, and five of PICES member countries participate. Lei already submitted a community draft of the first part of this standard series (Part 1: Terminology, Guidelines, and Requirements), and this draft will be discussed and evaluated through the summer of 2026. The second part of this standard will be for the measurement/assessment procedures that are commonly used for various mCDR technologies, and the community draft for this part will be submitted by the end of 2025. Detailed protocols for each mCDR technology will be described in the third part of this standard.

Lei also presented an outline of the Global-ONCE, a UN Decade project that consists of 78 partners from 33 countries. This project conducts a series of global collaborative scientific research projects, as well as platform/demonstration projects for various mCDR technologies, including land-ocean integrated ecosystem engineering, artificial upwelling and seaweed farming, and OAE via wastewater plants. Several participants asked about monitoring and assessment methods for the artificial upwelling project in China. Lei answered that detailed protocols for artificial upwelling, including its MRV process, are now in development within the ONCE group and will be published elsewhere.

Section 2. Standards for Measurement Methods of Essential Ocean Variables in UNESCO IOC Global Ocean Observing System (GOOS)

Masao Ishii introduced ongoing standard protocols for several essential ocean properties. The International Ocean Carbon Coordination Project (IOCCP) had established a number of the essential ocean variables (EOVs) that are needed to understand the current ocean environment and its long-term changes, including the ocean carbon cycle. IOCCP had created detailed protocols of the measurement and data quality control for each EOV, and these protocols are now endorsed by the Global Ocean Observing System (GOOS). GOOS defines EOVs as "the minimum set of ocean variables that are needed to assess ocean state and variability for important global ocean phenomena, and to provide essential data for applications that support societal benefit." GOOS currently identifies various categories of EOVs: 12 physical EOVs (sea state, ocean surface stress, sea ice, sea surface height, sea surface temperature, surface currents, sea surface salinity, subsurface salinity, ocean surface heat flux, and ocean bottom pressure); 10 biogeochemical EOVs (oxygen, nutrients, inorganic carbon, transient tracers, particulate matter, nitrous oxide, stable carbon, stable carbon isotopes, and dissolved organic carbon); 10 EOVs on biology and ecosystems (phytoplankton biomass and diversity, zooplankton biomass and diversity, fish abundance and distribution, sea turtle abundance and distribution, seabird abundance and distribution, marine mammal abundance and distribution, coral cover and composition, seagrass cover and composition, macroalgal canopy cover and composition, and mangrove cover and composition); and two cross-disciplinary EOVs (ocean color and ocean sound). Each EOV has its specification sheet on the GOOS home page, where the required accuracy/ uncertainty of measurement as well as the required areal/temporal coverage and resolution suitable for each target ocean process are described. Each specification sheet also contains links to international measurement protocols, links to suitable data repositories, and links to already-existing data products and references. For the case of carbon parameters (inorganic carbon, alkalinity, pH and pCO_2), the PICES Special Publication "Guide to Best Practices for Ocean CO_2 Measurements" acts as the current practical international measurement protocol. Ishii presented the content of this CO_2 measurement guide, demonstrating how detailed descriptions should be included in the protocol to maintain satisfactory accuracy and precision over time.

In the discussion, a participant questioned whether the measurement protocols of GOOS EOVs are employed by mCDR community members. Kenta Watanabe said that his group usually follows protocols linked in GOOS-EOV spreadsheets, but not all groups follow these protocols because of technical difficulty. Yanli Lei also pointed out that GOOS EOVs' protocols will be referred to in the making of ISO/TC8/WG15 standard drafts part 2.

Section 3. From Deck to Data: Fishermen's Knowledge Steering Research and Governance

Fiona Hogan made the final presentation of the workshop by introducing two projects that link scientists to fishermen's societies. The Fisheries Knowledge Trust was built to help the fishing industry and researchers collaborate on projects that help regulators make better decisions about changing oceans and the coastal economies. Gaps in available information sometimes cause the fishing industry and scientists to struggle with understanding the current status. Individual fishers' data is often unstandardized and confidential, and government-run data collection systems often lack satisfactory areal/ temporal resolution. The fishing industry also has in-depth empirical knowledge of the local ecology and local cultural/social circumstances, both of which are often overlooked by governments and researchers. The Fisheries Knowledge Trust aggregates oceanic and fisheries data from the fishing industry and implements quality control measures to create a scientifically reliable database. The databases created are then made available to specifically named analysts with the approval of data providers. Through this process, this system turns fishers' insights and data into scientifically defensible products. This framework has already been used to evaluate conflicts between the fisheries industry and offshore wind projects in the New York Bight and will also be effective in future mCDR plant developments.

Hogan has also been involved in a project aimed at increasing fishers' literacy on mCDR technologies and building networks among the fishing communities and the mCDR communities. In this project, participants from the fishing industry were required to watch a 40-minute introductory video on mCDR technologies. Participants then attended two 2-hour roundtable sessions to discuss the following topics:

- What are the characteristics of 'responsible' mCDR from a fisheries standpoint?
- How should the findings from mCDR research be communicated to stakeholders in accessible, understandable ways?
- Are there any spatial tools or approaches that you would recommend for planning mCDR research and deployment? Or any tools that you would not recommend?
- At what stage in mCDR research project planning should project leads begin engaging the fishing community?
- What is the right balance between offering affected communities a voice from the start versus burdening them with participation fatigue before a project is even sure to happen?

Key outcomes obtained through the roundtable were as follows:

- Fishermen are interested in being involved in each step of the mCDR process.
- Building trust is critical.
- Co-production of knowledge is a way to build that trust.
- Fishers hold specialized local knowledge critical to any mCDR effort.
- Fishers have a spectrum of views based on their own experience – one can't speak for all.

As a result of this project, the members created several guidance memoranda for better engagement of fishing communities with mCDR projects. The mCDR project should engage commercial fishers as co-producers of information rather than recipients. The fishing communities should also be involved in the mCDR project in its planning and permitting stage for effective governance of fishery-sensitive mCDR development. Key components in the governance of fishery-conscious mCDR projects include transparency, systematic enforcement of compliance with monitoring, ecologically focused planning, effective spatial planning, and clarification of the fishing industry's role, particularly addressing fishing community concerns about fair access to the sea and the mitigation of side effects.

Finally, Hogan listed the following points for effective engagement of the fishing community in mCDR:

- All engagement and outreach should be public.
- Meetings should accommodate the varying schedules of the fishing industry; lost fishing time equates to lost income.
- All marine development would benefit from the direct incorporation of the fishing industry in project design and review. It would be beneficial to consult the fishing industry as early in the process as possible and to maintain that engagement throughout the duration of the project.
- Fishers can be considered/hired as consultants to provide necessary expertise and outreach to the fishing industry, but their independence must be maintained.
- Inclusive project design can improve at-sea operations and safety. This can be achieved by hiring fishing industry members as consultants during the design phase or contracting fishing vessels to deploy scientific equipment, collect scientific data, and transport researchers.
- No "tick the box exercises" – the fishing industry wants good faith and direct involvement in the process developed to govern mCDR to ensure equitable outcomes and maintain the sustainability of marine ecosystems. There is concern among the fishing industry that large corporations will have more control over outcomes given their financial power.
- Benefits and uncertainties should be openly discussed with the fishing industry and general public – not doing so could be interpreted as hiding potential outcomes.

Section 4. Discussions

The second discussion session focused on existing protocols for each mCDR technology. The following questions were proposed by the moderator and then discussed.

Q1: Currently, several protocols co-exist in mCDR technology. Are these consistent? If not, who makes consistency among these?

Kenta Watanabe explained that he is aware of several protocols co-existing with BC technology, but he personally uses standard Japanese protocols and is not familiar with the detailed differences between them and other protocols. Yanli Lei pointed out that the parallel existence of local protocols is not an issue, because each mCDR technology must be localized in its implementation to accommodate local circumstances. ISO standards usually contain some space for such localization, but all localized protocols should not exceed the limit of flexibility that is described in the standards. We realized that no international group had examined consistencies or conflicts among these co-existing protocols, and no one currently determines whether such inter-protocol variability is within the scientific tolerance range. We must develop such an international management system of mCDR protocols, and PICES may contribute to developing such international groups.

Q2: We already have observation protocols for EOVs. Does the ocean observation methodology currently described in each mCDR protocol match with this?

Kenta Watanabe explained that his group usually follows GOOS-EOV protocols, but not all groups do so because of technical difficulties. Masao Ishii pointed out that several measurement protocols are co-listed in the specification sheet of some EOVs, and users can choose different protocols depending on the required uncertainty. Each mCDR protocol can therefore select a different measurement protocol depending on its objective, while the user must understand why the protocol chose this measurement method. In addition to the above two questions, Fiona Hogan pointed out that current mCDR protocols often lack detailed methodologies for side effect assessment. Most mCDR protocols contain chapters for evaluation and/or mitigation of side effects, but the content tends to be too abstract, and hence it is difficult to assess its achievements. Not only MRV protocols for carbon storage but also for each side effect assessment should be included in future mCDR protocols, and PICES may contribute by fostering development of such protocols.

Concluding remarks and future plan

Tsuneo Ono explained the planned following activities for this workshop. He will further update the mCDR project list until the end of 2025, and then he will make a report of the list for publication as a PICES Report. He requested the participants to submit additional information for mCDR projects and research that are ongoing in the PICES boundaries.

Throughout this workshop, the participants shared knowledge on the current status of ongoing mCDR projects/research in PICES areas, as well as the current development status of its protocols. Several protocols are currently coexisting for most mCDR technologies, but no group has carefully examined their internal consistency. In addition, most current protocols lack detailed MRV methods for side effect assessment. At the implementation level, several mCDR projects are working without experts in either biogeochemical or biological science. However, the participants need further detailed information and discussions for the above three major current problems. Some mCDR activites may have been missed from the discussion, as not all PICES member countries were represented at the workshop. Situations in non-PICES countries (e.g., ICES countries) also need to be understood to discuss practical future actions. For these reasons, the participants agreed to hold the second workshop in PICES 2026, hopefully with ICES co-hosting.

W5: POC/FUTURE Workshop

Basin-Scale Processes Linking Western and Eastern Pacific Dynamics and Biogeochemistry

Convenors:
Charles Hannah, *Corresponding* (Canada), Fei Chai (China), Shoshiro Minobe (Japan), Steven Bograd (USA), Mercedes Pozo Buil (USA)

Description
The goal of the workshop is to develop schematic diagrams describing the mechanisms through which basin-scale processes drive biogeochemical variability across the Pacific on interannual, decadal and secular timescales influencing variability and long-term changes over 50- to 100-year periods. A specific example would be a sketch showing how variability in the wintertime ventilation in the NW Pacific affects the oxygen concentration in the California Undercurrent in the eastern Pacific (what are the pathways and timescales). These schematics would then form the basis for testable hypotheses that could be examined using models and data in a future PICES Working Group. The ultimate goal is to link basin scale circulation variability to the water properties that affect coastal ecosystems. This would provide a potential basis for forecasting on a variety of time scales.

The workshop would have 2 outputs: 1) a set of schematics showing how basin-scale processes drive variability for specific biogeochemical variables (e.g. dissolved oxygen, nitrate, phosphate, silicate, and iron) across the Pacific; and 2) a proposal for a PICES Working Group to test the validity of the hypotheses represented by the schematics.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Background
The goal of the workshop was to develop schematic diagrams describing the hypothesized mechanisms that drive basin-scale biogeochemical variability across the North Pacific on interannual, decadal, and secular timescales. A specific example would be a sketch illustrating how variability in the wintertime ventilation in the Northwest Pacific affects the oxygen concentration in the California Undercurrent in the eastern Pacific, including the relevant pathways and timescales. These schematics could then serve as the basis for testable hypotheses to be examined using models and observational data in a future PICES Working Group. The ultimate goal is to link basinscale circulation variability to the water properties that affect coastal ecosystems, providing a basis for ecological forecasting across time scales.

Workshop Summary
The workshop, structured as two half-day sessions (Sunday and Tuesday), was highly successful. Its design allowed participants time to reflect on the first day's presentations and discussions and to prepare for the second day. There were no invited speakers; instead, each participant was allotted a two-slide presentation to share their ideas related to the workshop theme. This format proved very effective, enabling a broad range of ideas and processes to be presented efficiently and stimulating discussion early in the workshop.

A large portion of the discussion focused on identifying the sources of oxygen input to the subpolar gyre, the relative magnitude of each contribution to the subpolar gyre's oxygen budget, and whether the magnitude of any temporal trends were known. Participants agreed that a literature review would be an important next step to assess what is the current state of knowledge on the topic of the oxygen inputs. The group also discussed macronutrients (nitrate, silicate, phosphate) and micronutrients (e.g., iron) and their respective roles in productivity and oxygen dynamics.

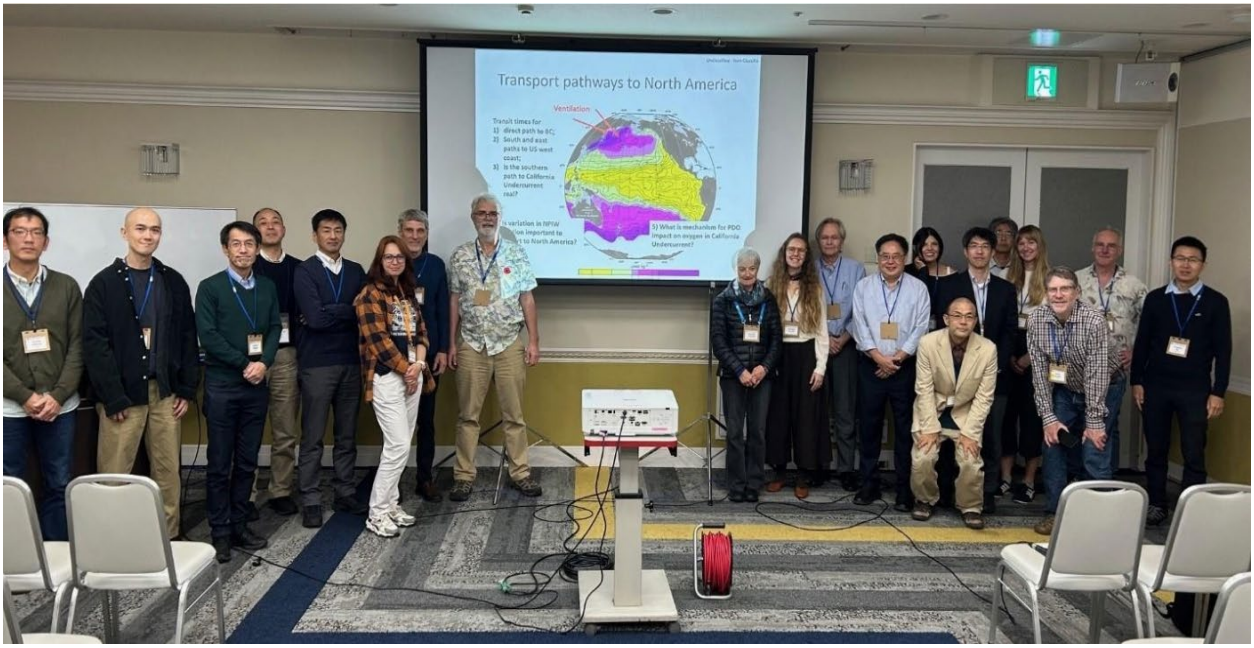
An important part of the workshop focused on building a shared understanding among participants on how the eastern and western North Pacific are connected. The key points were:

- The eastward transport associated with the subpolar and subtropical gyres carries water properties from the western to the eastern North Pacific. The narrow continental shelves in the eastern North Pacific then provide tight coupling between the shelf and the open ocean. However, not all the processes in the eastern Pacific originate from the west. The California Undercurrent connects the eastern North Pacific with the tropical Pacific and this connection is crucial for oxygen dynamics on the shelf.
- Connections from the east to the west are more indirect, with the main pathway being oceanic Rossby waves, which can impact primary production in the western Pacific through changes in the depth of the nutricline.

- The continental shelves and marginal seas in the western North Pacific are broader than those in the east, and the coastal areas are less tightly coupled to the open ocean. As a result, hypoxia events are more locally forced and less affected by large-scale variability in the open North Pacific.

Draft sketches were developed for the oxygen inputs and transports, as well as for the drivers of biogeochemical variability. While useful discussion tools, they remain unfinished.

The workshop concluded with participants supporting the development of a proposal for a PICES Working Group to pursue the goals of the workshop.



W6: TCODE/FUTURE Workshop

Effective Strategies Across Ocean Data Lifecycles: Enhancing Ocean Data Management and Mobilization

Convenors:
Erin Satterthwaite, *Corresponding* (USA), Tim Van Der Stap (Canada), Jeanette Gann (USA, TCODE), Steve Diggs (USA), Kathryn Berry (Canada), Talen Rimmer (Canada), Noriko Shoji (USA), Julia Schmid (Canada, BECI), Fangfang Wan (China), Seung-tae Yoon (Korea)

Invited Speaker:
Toru Suzuki (Japan Hydrographic Association, Japan)

Description
The objectives of the workshop are to: 1) review and enhance the conceptual diagram developed during the last workshop, 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" to "The objectives of the workshop are to: 1) explore effective strategies and practical steps across the data lifecycle, considering the unique data management, integration, and mobilization challenges of various ocean data types, focusing on metadata handling, 2) review and enhance the conceptual diagram developed during the last workshop.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Introduction
The workshop, titled 'Effective Strategies Across Ocean Data Lifecycles: Enhancing Ocean Data Management & Mobilization,' was held on November 9, 2025, at the PICES Annual Meeting in Yokohama, Japan. Approximately 20 participants attended, representing a diverse set of countries: Japan (60%), Canada (20%), USA (7%), China (7%), and Republic of Korea (7%). Participants contributed a wide range of expertise—biological, physical, chemical, as well as cultural, economic, and social—and worked with multiple data types, primarily observational data, but also remote sensing, imagery, data products, and eDNA.

Data
• Can take many forms: Observations, measurements (numbers), images, videos, acoustic files, text, and other forms of recorded information
Metadata
• "Data about data"
• Describes content, quality, and context of a dataset
• Helps data be found, understood, and reused
• Typically includes the what, where, when, who, how, why, and units
Data Publishing
• Making data publicly available, accessible, and citable
• Shared through recognized repositories or platforms
• Includes metadata and documentation
• Ensures data can be discovered, understood, reused, and credited

Metadata to support data sharing in the North Pacific
This year's workshop built on last year's efforts at PICES 2024 to develop a shared data pipeline within the North Pacific marine science community (PICES Press 2024). This workshop focused on metadata, which is the often-overlooked foundation of data recoverability and reuse. High-quality, machine-readable metadata clarifies what data are collected and why, and supports AI, automation, and large-scale research.
The workshop aimed to: **1) identify practical solutions for metadata creation, standardization, and sharing, and 2) to facilitate cross-regional synthesis of marine data.**

Enhancing linkages across the ocean data lifecycle

The invited talk by Dr. Toru Suzuki from the Marine Information Research Center of Japan explored improving linkages of the oceanographic data lifecycle across observing, management, and research systems (IOC Manual and Guides 99 UNESCO, 2025). Dr. Suzuki emphasized how data move between observing platforms, data management centers, and predictive modeling systems, and highlighted the critical role of metadata in making data FAIR (Findable, Accessible, Interoperable, Reusable) and CARE compliant (Collecting Accurate and Robust Equity data). For example, clearinghouses and portals for accessing oceanographic data exist, such as ERDDAP, OBIS, and the PICES Metadata Federation. He also discussed challenges in balancing completeness of metadata with historical limitations, defining mandatory versus optional elements, and automating metadata generation.

Dr. Suzuki highlighted the importance of metadata, which is "data about data" and captures the essential details of who collected the data, what was measured, when and where it was collected, why it was collected, and how it was obtained. This information underpins the discoverability and long-term usability of data, particularly as datasets grow in complexity and are increasingly used in AI and automated analysis.

Metadata as a foundational step for bringing together data from across the North Pacific

The session used the North Pacific Ecosystem Status Report (NPESR) and the Basin-scale Events and Coastal Impacts (BECI) as a case study. These efforts aim to bring together data from across the North Pacific to understand status and trends of marine ecosystems and to improve decision-making and responses to these changes. NPESR and BECI face key challenges in synthesizing North Pacific data, including non-standardized metadata, time intensive manual processing, and difficulties comparing information across regions. Zooplankton data were used as a case study because they are a core biological indicator, collected across all regions, and link ocean conditions to fisheries productivity.

Standardized metadata is essential to make North Pacific zooplankton data truly discoverable

Upon searching for datasets, participants identified several challenges in accessing and using metadata for biological data, particularly zooplankton. Compared to physical variables, biological metadata is less standardized and more difficult to locate since it tends to be spread across many repositories within PICES countries. Data were mainly findable in institutional and national repositories, and OBIS was identified as a strong global biodiversity repository. Participants noted that the ability to access some repositories was difficult and that language barriers hindered data discoverability. For example, some Korean zooplankton datasets were only discoverable when searched using the Korean term for zooplankton – no datasets were found when using the English word "zooplankton". This highlighted the need to support the development of multilingual search capabilities to improve visibility and accessibility across the North Pacific datasets. Additional challenges included inconsistent vocabularies and non-standard variable names. Also, the effort and time needed to convert data to standardized formats like DarwinCore was highlighted as a barrier, because it is labor-intensive and many programs may lack the capacity to do this.

Despite these challenges, participants recognized opportunities to improve metadata usability and findability. Leveraging and connecting to global platforms such as OBIS and IOD nodes can provide broader access. Promoting consistent vocabularies and standardized metadata can improve interoperability and discoverability across regions, highlighting the value of global platforms like OBIS and IOD nodes and metadata aggregators like ODIS.

The remainder of the workshop used interactive activities to explore the full workflow of creating and sharing a high-quality metadata record across PICES countries. Participants explored the steps of compiling core metadata information (Step 1a), selecting appropriate metadata standards (Step 1b), exploring tools to streamline metadata creation (Step 2), and producing publishable, reusable metadata (Step 3). This process illuminated a few key findings: 1) there is general agreement on what is needed for core metadata information, 2) metadata standards vary across countries and programs, although some global standards exist, 3) metadata generation can be streamlined with novel tools coupled with human oversight, and 4) metadata is published in a range of repositories across the North Pacific, although there is opportunity to federate existing metadata.

General agreement on what is needed for core metadata information

There was strong agreement across groups on core metadata requirements (Table 1). Key qualities of good metadata described by the workshop participants included: the use of controlled vocabularies, clarity, informativeness, adherence to FAIR principles, domain appropriateness, thorough descriptions, and easy accessibility. Quality control level and processing state (raw vs. processed) were recognized as important for context for users. Date/time standardization emerged as particularly important given by different national conventions. Provenance information (data license, funding source, collectors) was also consistently identified as essential for proper data reuse and attribution. Finally, assigning a Digital Object Identifier (DOI) to the dataset has been highlighted in past workshops and PICES expert group discussions (e.g., TCODE) as a potential incentive for data sharing.

Metadata standards vary across countries and programs, although some global standards exist
There is little overlap in metadata standards across countries, as many standards vary by program or agency (Table 2). For example, in some cases countries rely on agency or institution specific databases (e.g., CMOC, KODC, KOEM, NCEI) rather than a single national standard. In many cases, metadata standard selection is often driven by repository requirements and national infrastructure rather than scientific community consensus. Yet, some countries do use globally recognized frameworks such as ISO 19115, CF conventions, or Darwin Core, which could provide opportunities for improved interoperability and more consistent metadata practices across the region.

Table 1. List of minimum fields for metadata
Necessary Metadata

- Data license – how the data can be used
- Acknowledgment of funding
- Responsible institute / organization
- Contacts for the dataset (Principal investigator(s); data manager)
- Acknowledgment of data collectors
- Sampling location (latitude/longitude) / geographic information (coordinates, system e.g., WGS84)
- ISO date and time (year, month, day, timezone)
- What was measured (parameters / taxon)
- Units • Vessel / platform used
- Gear type, instrument make/model, and specifications (e.g., mesh size)
- Calibration information/date
- Duration of sampling (if relevant)
- Sample preservation
- Sampling methods / protocols
- Depth range – mean, minimum, maximum/ hauled depth

Nice-to-Have Metadata

- Quality control level – raw or processed data
- More detailed description of methods
- Taxonomic standard – e.g., WoRMS identifiers
- Data version / version manager
- DOI for the dataset

Although this perceived lack of alignment may simply reflect that our workshop captured only a subset of the metadata standards used across the North Pacific, it is also possible that the misalignment is real. Additional information from other countries and domains is needed to complete Table 2 and to improve our understanding of the North Pacific metadata landscape. Future work could also assess whether the metadata standards and repositories identified in this workshop are broadly applicable across PICES countries.

There is a need to understand and bring together the diversity of metadata standards currently in use across PICES countries. **For example, 1) PICES could work to develop a "guidance document" for what to include in metadata and could suggest international metadata standards to follow or standard vocabularies; 2) further efforts could dive deeper into the specifics of the metadata standards in use within each country (e.g., is there alignment across different standards); and could 3) cross-walk between various fields across countries (e.g., make sure that keywords zooplankton are findable across languages).**

Table 2. List of metadata standards used for different data types across PICES countries, as indicated by workshop participants.

Standards	Canada	Japan	China	Korea	Russia	USA
Ecological data	Government of Canada records management metadata standard (GC RMMS)	case by case	CMOC	KOEM dataset	*TBD - Did not have representation at the workshop*	EML
Chemical data	-	BODC (vocab PO1)	NEAR-GOOS delayed mode database	Korean Marine Environment Management Corporation	*TBD - Did not have representation at the workshop*	WOCE quality codes
Physical data	-	DarwinCore	Ocean Data Information Network for the Western Pacific	-	*TBD - Did not have representation at the workshop*	c-f vocabulary

Metadata tools can streamline metadata generation but need to be coupled with human oversight

In many cases, metadata fields and the information contained in them are shaped by multiple factors, including the instruments that generate the data (e.g., the metadata that is generated as part of a CTD instrument), historical or legacy practices from long-term monitoring programs, and the metadata or data standards required by mandated repositories such as those specified by funders.

Increasingly, metadata generating tools offer support and ability to easily create, manage, or share metadata.

Metadata generation tools can be grouped into four main types:

1. Repository interfaces (e.g., ERDDAP, OBIS, and Zenodo) that provide structured input forms, templates, auto-filled fields, or APIs and the ability to export standardized formats like ISO 19115 or Dublin Core.
2. Template and manual editors guide users through creating metadata records (e.g., QSphere supports ISO 19139 compliance).
3. Metadata brokers or harvesters, such as ODIS and GEO, aggregate, translate, and expose metadata from multiple sources, harvesting records, converting them into common schemas, and improving discoverability and interoperability across local and global networks. These metadata brokers are something that PICES could continue to develop partnership with to further develop its role as a coordinator of science and data across the North Pacific.
4. Finally, AI-assisted metadata tools (e.g., DataCite), aim to automatically extract metadata from datasets, publications, or code, identifying elements such as titles, keywords, and geographic coverage, suggesting controlled vocabulary terms, automating tedious tasks, and enhancing consistency across records.

Tool availability and accessibility vary widely and are not available in all regions. The choice of the specific workflow or tool depends on institutional context, infrastructure, and resources, but the main shared opportunity lies in leveraging automation and AI to reduce labor. Accurate input of basic information is the most critical factor and the metadata quality ultimately depends on careful human oversight. Automation and digital logging can reduce human error and improve efficiency, but AI tools can introduce mistakes if not carefully validated. Since all approaches to generating metadata face challenges, including technical setup, rigid standards, and variable data quality, there is, therefore, a clear need for making sure to have strong quality control final checks to ensure accuracy through strong quality control, interoperability, and shared standards.

Metadata exists across North Pacific repositories, with opportunity to federate existing metadata

Publishing metadata and data within the North Pacific (non-PICES specific data)

Our workshop highlighted the fact that data generated within PICES member countries are published in multiple repositories that have different foci and scales (e.g., institution, national, or international repositories) and domain/level of specificity (Table 3). For example, some repositories are more "specialist" and focus on a particular domain and take the information in a standardized way (e.g., OBIS focuses on occurrence records and uses

DarwinCore). Other repositories are more "generalist" repositories that take many different types and quality of data and are more heterogeneous like Zenodo.

We found that in some cases data are published or fed into international repositories (e.g., OBIS/GBIF), but in most cases data are being shared in more domain specific institutional or national repositories (Table 3). This highlighted the need for providing guidelines for publishing metadata (e.g., what, where, and how to publish) to make data more findable and interoperable across the North Pacific for connecting institutional and national repositories to international repositories (e.g., OBIS, OIH), and metadata brokers/aggregators (e.g., ODIS).

Table 3. Sample list of repositories where researchers from PICES countries currently publish metadata/data, as indicated by workshop participants.

Standards	Canada	Japan	China	Korea	Russia	USA
Ecological data	opengov.ca CIOOS ecotaxa technical reports data publications	OBIS ODIS DarwinCore	-	PPF1 file (National Marine Ecosystem Monitoring Program)	-	ERDDAP, NCEI OBIS/GBIF
Chemical data	-	-	-	-	-	ERDDAP, NCEI
Physical data	-	-	-	KPDC	-	ERDDAP, NCEI

Publishing metadata and data associated with PICES expert groups and special projects

PICES-related data often consist of integrated datasets or information generated as expert groups which are often leveraging or utilizing existing data (e.g., synthesis efforts). PICES coordinates the science in the North Pacific region and each expert group manages its own data. In some cases, PICES supports direct data collection, such as part of PICES special projects. For datasets generated as part of PICES expert groups, PICES suggests publishing the metadata (and in some cases data) for those datasets in Zenodo. The goal is to make sure that, at a minimum, the metadata is findable by the PICES community and can point to the dataset (whether that lives in Zenodo or another repository). In cases where data from many countries, institutions, or programs are brought together, data provenance and ownership remain with member countries and institutions, but the integrated dataset can be published as part of a PICES expert group (e.g., in Zenodo) with attribution to the initial datasets that feed into the integrated dataset.

Conclusion & next steps

We found that **there is general agreement on the core metadata information needed across PICES member countries. However, standards vary widely across countries, programs, and agencies, with limited overlap, but some global standards do exist. Metadata tools can help generate metadata, but human oversight is still essential. Metadata already exists across North Pacific repositories which presents an opportunity to federate and integrate resources to increase accessibility and enhance interoperability**.

The diversity of metadata standards and repositories across PICES countries presents both challenges and opportunities. Moving forward, efforts could:

1. **Expand regional engagement to further assess the data landscape across the North Pacific.** This will likely require gathering input from additional countries and domains to ensure comprehensive coverage and improved discoverability across the North Pacific. Future efforts could assess if the metadata standards and repositories identified in this workshop are broadly applicable across PICES countries, and build on this work to get more information on existing metadata standards used across countries within each domain (e.g., oceanographic, chemical, ecological).
2. **Align and harmonize metadata standards across PICES countries to make data more findable and interoperable**. This will likely require **evaluating which globally recognized metadata standards (e.g., ISO 19115, Darwin Core, CF conventions) can be broadly adopted**. In cases where global standards cannot be used, guidance for those fields is needed and will likely require **cross-walking program-, agency-, and country-specific standards**. Ultimately, PICES could provide guidance on globally recognized

standards (e.g., ISO 19115 for date/time, WGS84 for coordinates) and suggest appropriate vocabularies where global standards are not feasible.

3. **Collaborate with metadata brokers or harvesters (e.g., ODIS)** to help aggregate, translate, and expose metadata from diverse sources across the North Pacific. This can help to federate and connect repositories to integrate metadata from multiple institutional, national, and international repositories.
4. **PICES can continue to provide guidance to PICES associated groups (e.g., expert groups) and member countries on how to share metadata and data**. For example, this could involve developing a guidance document that specifies key metadata elements and recommends appropriate international standards and controlled vocabularies.

We hope to continue bringing together the North Pacific marine data science community to advance these efforts. Moving from interest to coordinated action, through clear ownership, defined roles, and established timelines, can also help ensure that North Pacific data are more accessible, interoperable, and usable across countries and domains, and can build on existing technology, people, and resources working on efforts across the North Pacific.

W7: BIO Workshop

Response of Top Predators to Unusual Oceanographic, Climatic and Anthropogenic Events in the North Pacific

Convenors:
Yu Kanaji, *Corresponding* (Japan), Rolf Ream (USA), Patrick O'Hara (Canada), Motohiro Itoh (Japan), Kaoru Hattori (Japan)

Invited Speakers:
Vladimir Burkanov (North Pacific Wildlife Consulting LLC, RNGO "Marine Mammal Council", USA/Russia), Jennifer Provencher (Environment and Climate Change Canada)

Description
Marine top-predators such as marine birds and mammals (MBMs) both respond to and affect entire food-webs through top-down and bottom-up trophic linkages. As well, these organisms tend to be large charismatic organisms that are relatively easy to monitor making them tractable indicators of ecosystem health and change. The detection of biological changes in these animals has proven them to be strong indicators for identifying the effects on long-term (e.g. global warming), mid-term (e.g. basin-scale regime shifts and Kuroshio meandering), and short-term (e.g. marine heat waves) changes in physical and biological oceanography. They have also been used to indicate levels of pollution in regions of their world previously thought to be pristine. S-MBM has focused on the key roles of top-predators in marine ecosystems, and our monitoring data and interdisciplinary collaboration has highlighted the scientific needs to identify changes in ocean ecosystems and to predict those responses in future. In recent years, unprecedented events that can trigger massive die-offs have been observed in MBMs, and because of their ecological roles, these die-offs have ecosystem level implications One example is Avian influenza viruses (AIVs), which was recently reported to cause rapid mass die-offs for Peruvian pelicans (Pelecanus thagus) and South American sea lions (Otaria flavescens) in the south Pacific. Also, in the western North Pacific, northern fur seals (Callorhinus ursinus) experienced an AIV-caused mass die-off in 2023. Other events such as heat waves and harmful algae blooms (HABs) can also affect an ecosystem widely through trophic linkages. This session will present some case studies of significant health responses by top predators to unusual oceanographic, climatic, or anthropogenic events. We further discuss how we detect, prevent, and address large scale mortality events, and other serious health impacts, that can have wide-reaching ecosystem implications (e.g., impact on fisheries, or agricultural systems).

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Workshop summary
This workshop, held on Saturday, November 8, 2025, was convened by the Section on Marine Birds and Mammals (S-MBM) and sponsored by the Biological Oceanography Committee (BIO). Our main scope was to address unusual mortality events (UMEs) under changing oceanographic and climatic environments. Workshop participants focused on the status of the Avian Influenza Virus (AIV), with a particular emphasis on Highly Pathogenic Avian Influenza (HPAI) strains and how these viruses spread across North America and between wild marine and terrestrial birds, domestic birds, and mammals.

Participants also discussed other sources of UMEs, such as harmful algal blooms and the underlying oceanographic mechanisms leading to UMEs for marine birds and mammals (MBMs). Although the workshop did not concentrate specifically on UMEs as indicators of oceanographic and climatic environments associated with climate change, our discussion on UMEs and HPAI led to insights regarding the use of UMEs as indicators of large-scale processes in genera.

Two invited speakers presented the status of AIV spread in Russia and Canada, respectively. Before transitioning to the contributed talk session, two members from S-MBM and BIO provided information on the status in Japan and South Korea. Following these status reviews, we discussed how to effectively monitor virus infections and spread. The contributed paper covered a slightly different perspective, presenting an idea for a fishery-dependent survey system to monitor unusual biological responses of dolphin species to changing oceanographic conditions. Overall, the workshop resulted in a comprehensive review of AIV spread and other UMEs covering a wide range across the North Pacific. We also held productive discussions about developing monitoring programs and networks for sharing information and coordinating efforts.

Presentation summaries

Yu Kanaji (Japan) presented an introductory talk that provided background information for the workshop. He introduced recent unusual oceanographic events on three scales: long-term and wide-scale events (e.g., global warming); mid-term and meso- to basin-scale events (e.g., PDO regime shifts and Kuroshio meandering); and short-term and local-scale events (e.g., ocean heatwaves). He provided examples from previous and ongoing research projects regarding MBMs' responses to these oceanographic events. Identifying the spread of AIV as a direct cause of UMEs under unusual oceanographic conditions, he then introduced specific topics and speakers for the workshop.
Vladimir Burkanov (USA) presented an invited talk titled "*Unprecedented mass mortality of marine mammals and seabirds on Tuleny Island, Sakhalin, Russia, in 2023.*" This presentation reported UMEs among northern fur seals (*Callorhinus ursinus*), Steller sea lions (*Eumetopias jubatus*), common murres (*Uria aalge*), and black-legged kittiwakes (*Rissa tridactyla*) on Tuleny Island in late July and August 2023. He noted that these UMEs were preceded by unusually warm conditions that may have been associated with climate change. He showed videos of animals exhibiting tremor symptoms, which would be useful for diagnosing disease and distress. In addition to Tuleny Island, the status of Russia's coastal waters was briefly reviewed.

Jennifer Provencher (Canada) presented an invited talk titled "*Assessing exposure to avian influenza in seabirds in Canada.*" She introduced a national monitoring program involving a highly collaborative, multi-partner research network across Canada that has focused on detecting and tracking the virus across species for many years. Using such sophisticated monitoring systems, they revealed past and current situations regarding AIV (focusing on HPAI strains) spreading across North America and among taxa. The presentation concluded that many seabird species can suffer UMEs caused by HPAI, and susceptibility differs by region and species, which may influence how monitoring and surveillance are prioritized. In response to a question about the linkages between AIV and climate change, Dr. Provencher indicated that there is increasing documented evidence that viruses persist longer in cool, moist environments and that climate change is causing shifts in the distributions and migratory patterns of many avian species. Both habitat changes and avian species redistribution, in turn, impact how AIV spreads and persists across the globe. Additionally, stress caused by climate change in birds can affect their immune systems and resistance to AIV infection.

To add information beyond Russia and Canada/USA, **Kaoru Hattori** (Japan) and **Miran Kim** (South Korea) presented special talks. Both Japan and South Korea face similar situations where AIVs have already been identified in many wild birds. Manuals and guidelines for handling dead birds for further virus inspections exist. Additionally, along the coast of Hokkaido, pinnipeds and sea otters infected with AIVs were detected, yet the manuals have not adequately covered procedures for marine mammals. They concluded that the establishment of monitoring systems and public awareness about AIV are urgently needed.

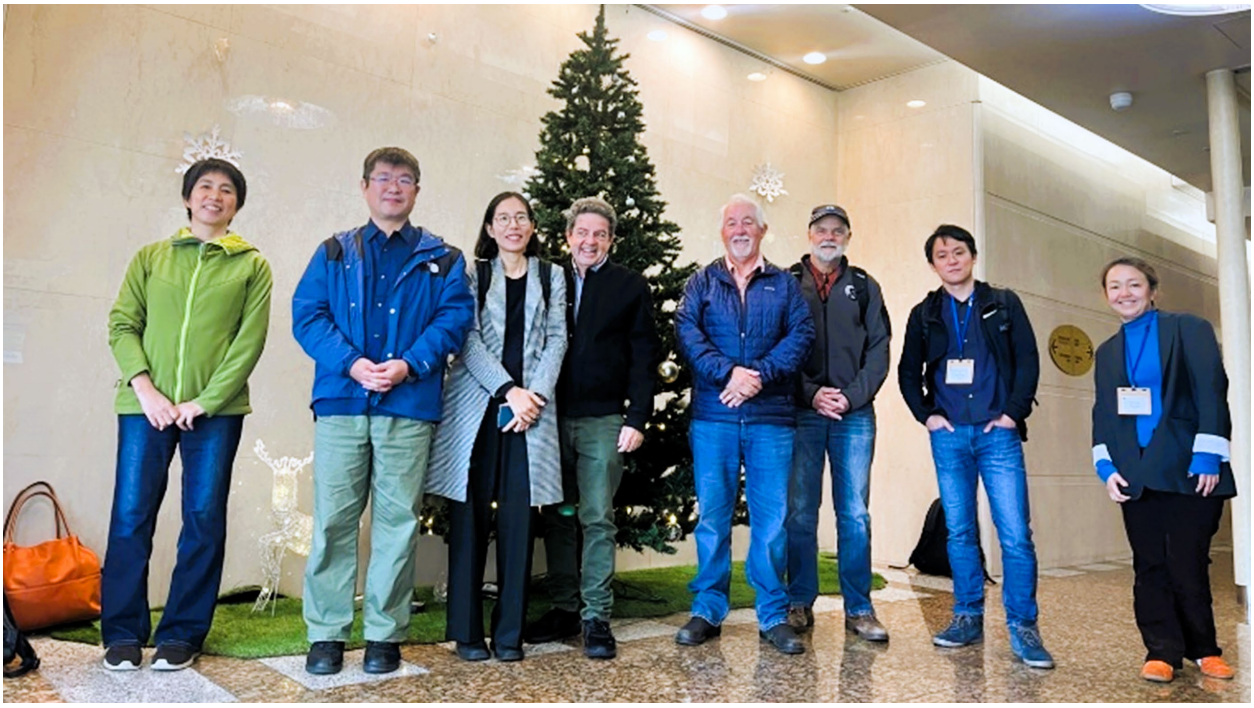
Hikari Maeda (Japan) presented a talk titled "*Monitoring of life history parameters of small cetaceans: framework to monitor population dynamics of top-predators.*" In the coastal waters off Japan, Kuroshio meandering is a key oceanographic factor potentially controlling ecosystem structures and the health conditions of marine animals. Based on long-term collection and analyses of specimens collected by fisheries, they reported that no clear tendency was detected in life history parameters for two delphinid species. However, it is considered that such fishery dependent surveys provide cost-effective and sustained surveillance, not only for monitoring population status but also for providing a biomonitoring tool to detect unusual events, including both changes in oceanography and viral infections.

Key take-home messages

1. MBMs are susceptible to changes in ambient environments, and thus UMEs can provide early warnings for unusual oceanographic and epidemiological events beyond the conservation of these species
2. Comprehensive and standardized monitoring:
   - Establish data baseline before UME
   - Increases the detection probability of UMEs
   - Useful for estimating the magnitude of event
   - Useful for tracking recovery following event or mitigation efforts
3. Linkages to Human Health and Agri/Aquaculture
   - Network development
   - Shared data

- Early warning systems
- Responses go beyond environmental/conservation goals

4. Citizen science including data collected by industry (poultry industry or fishery data for example):
    - Sufficient monitoring is difficult without support from citizens and/or industry potentially affected by UMEs
5. Despite looming threat, countries do not develop comprehensive monitoring system and/or network until after experiencing UME (such as HPAI and/or changes in oceanography related to climate change).
6. Standardized techniques and safe operating procedures (particularly for HPAI, but also for using MBMs as biomonitoring tools) have been developed and can be shared with countries interested in developing their own monitoring networks



W8: HD/TCODE/FUTURE Workshop

Engaging with Local and Traditional Knowledge Holders to Co-Design Ocean Science in Pacific Small Island Developing States

Convenors:
Raphael Roman, *Corresponding* (Canada), Naya Sena, *Corresponding* (Japan), Khush Jhugroo (Canada), Steven Bograd (USA), Mitsutaku Makino (Japan), David Reid (ICES, Denmark), Saurav KC (APN-ECAP, Nepal), Rieko Tamura (APN, Japan),

Co-sponsors: ICES, APN, OPRI

Invited Speakers:
Alicia Edwards (Marshall Islands Marine Resources Authority (MIMRA), Marshall Islands), Chris Leong (Research Institute for Humanity and Nature, Japan), Cherie Morris (University of the South Pacific, Fiji), Hilda Sakiti-Waqa (University of the South Pacific, Fiji), George Carter Sala (Australian National University, Australia), Hideyuki Shiozawa (Island Nations Division of Ocean Policy Research Institute (OPRI), Japan), Meshach Sukulu (World Fish, Solomon Islands)

Description
The UN Decade of Ocean Science for Sustainable Development (UN Ocean Decade; 2021-2030) provides a unique opportunity to convene global partners to address challenges associated with climate change, marine ecosystem health, and food security. The Ocean Decade Programme 'Sustainability of Marine Ecosystems Through Global Knowledge Networks' (SMARTNET), jointly sponsored by ICES and PICES, works with several other Programmes to advance knowledge generation and sharing to support ocean sustainability, with an emphasis on coordination and collaboration with Small Island Developing States (SIDS).

In this Workshop, we will highlight the role of local and traditional knowledge from Pacific SIDS in shaping ocean science. This knowledge, rooted in cultural practices and environmental stewardship, offers unique insights that complement and blend with scientific approaches, making it essential for effective ocean management and climate resilience in SIDS.

We aim to convene ocean scientists, practitioners, stakeholders, and rightsholders from Pacific SIDS with members of the PICES, ICES, OPRI-SPF, and APN communities to assess the opportunities, priorities, methods and challenges for co-designing ocean science in SIDS. We will explore a wide variety of interdisciplinary issues of immediate concern to SIDS, including sustainable fisheries, ecosystem services, food security, plastic pollution, impacts of climate extreme events on coastal and island communities, and disaster risk reduction.

We will synthesize local and traditional knowledge frameworks from Pacific SIDS to optimize strategies for actionable science, trust building, and respectful collaborative practices. A tangible outcome of this Workshop will be a white paper outlining good practices for the co-design and implementation of ocean science in Pacific SIDS.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Introduction
The United Nations Ocean Decade provides a unique opportunity to convene global partners to address challenges associated with climate change, marine ecosystem health, pollution, and food security. Jointly sponsored by PICES and its sister organization ICES, the SmartNet Program (Sustainability of Marine Ecosystems Through Global Knowledge Networks) works with several other Ocean Decade Programs to advance knowledge generation and sharing for ocean sustainability, with a particular emphasis on coordination and collaboration with Small Island Developing States (SIDS)—often rightly described as "Big Ocean States." Led by SmartNet's Early Career Ocean Professional (ECOP) SIDS members and allies within and beyond PICES, including Naya Sena (AP-UNDOS) and Raphael Roman (AP-ECOP, AP-UNDOS) as corresponding convenors, the vital yet underrepresented role of local and traditional knowledge from Pacific SIDS was, for the first time, successfully brought to the attention of the PICES community. This occurred during a full-day workshop on November 9, 2025. This knowledge, rooted in cultural practices and environmental stewardship, provides unique insights and place-based experiences that complement conventional scientific approaches and are essential for effective ocean management and climate resilience in SIDS.

To assess the opportunities, priorities, methods, and challenges for co-designing ocean science in SIDS, the workshop convenors invited eight speakers representing key institutions across the Pacific and beyond: Alicia Edwards (Reimaanlok Program, Republic of the Marshall Islands; national coordinator of the conservation area planning framework), Meshach Sukulu (WorldFish, Solomon Islands), Cherie Whippy-Morris (University of the South Pacific, Fiji; APN Project), Hilda Sakiti-Waqa (University of the South Pacific, Fiji), Chris Leong (Research Institute for Humanity and Nature, Fiji national residing in Japan; APN project), Hideyuki Shiozawa (Island Nations Division, Ocean Policy Research Institute of the Sasakawa Peace Foundation, Japan), Rieko Tamura (Asia-Pacific Network for Global Change Research, Japan), and Sāla Dr. George Carter (Australian National University Pacific Institute; Samoan scholar and traditional chief). In addition, a ninth speaker, Pieter Romer (Ocean Networks Canada), was added to the agenda.

Together, they highlighted a range of interdisciplinary issues of immediate concern to SIDS and shared good codesign practices along with examples of transdisciplinary projects involving local and indigenous communities. These projects included those on submarine groundwater discharge, community-based fisheries resource management and ecotourism, climate change impacts and nature-based solutions (NbS), community governance and collective decision-making, maritime heritage preservation, ocean monitoring, and data sovereignty (e.g., CARE principles for Indigenous data governance).

Crucially, this workshop wouldn't have been possible without the invaluable financial support of the Ocean Policy Research Institute (OPRI) of the Sasakawa Peace Foundation and the Asia-Pacific Network for Global Change Research (APN), which covered the travel, accommodation, and other expenses of all invited speakers. This success is a testament to the value of international collaboration and co-design from inception. This momentum will continue to be strengthened beyond the 2025 PICES Annual Meeting in Yokohama, Japan.

Workshop summary

The workshop highlighted the growing need for **co-design** as a core scientific approach within PICES and the broader ocean science community. Participants emphasized that today's rapidly evolving climate and ocean challenges require deeper, more genuine cooperation across disciplines, sectors, and knowledge systems. Co-design is not only a methodology but also a mindset of shared responsibility, in which scientists, institutions, community leaders, and practitioners work collaboratively from the earliest stages of research. The discussions stressed that effective co-design depends on building trust, breaking down institutional silos, and creating long-term spaces for dialogue—particularly across regions connected by shared ocean systems.

The workshop also points out the value of **integrating diverse knowledge systems**, especially in regions such as the South Pacific, where local communities, practitioners, and researchers hold centuries-old knowledge of ocean stewardship. Although PICES focuses primarily on the North Pacific, participants noted that the Pacific is one interconnected ocean, and many challenges—such as climate impacts, coastal resilience, ocean governance, and financial needs—are **transversal across regions**. Strengthening engagement with SIDS, recognizing their lived relationships with the ocean, and valuing communityled initiatives were identified as essential steps for more equitable and effective ocean science. Participants also noted that "local expertise" includes local academics, local Non-government Organizations (NGOs), local project leaders, and early-career researchers who are experts in their contexts and should be included meaningfully as partners rather than peripheral contributors.

Finally, the workshop itself served as a **practical demonstration of co-design**. It was only made possible through extensive cooperation among multiple organizations, including OPRI, APN, the PICES Secretariat, the ICES Secretariat, Japan's Fisheries Research and Education Agency (FRA), and volunteers from the University of Tokyo.

Key outcomes from the survey & breakout groups

At the start of the workshop, participants were invited to complete a short online survey as a baseline to understand the diversity of perspectives in the room and identify recurring challenges and expectations regarding codesign practices. Later in the day, following the invited presentations and plenary discussions, participants were divided into four breakout groups for a series of structured, interactive exercises. These activities included a **challenge-ranking exercise**, where groups evaluated the most significant barriers to co-design approaches, especially in the SIDS context, followed by a **Solutions Lab**, where they collaboratively proposed practical actions and pathways for different sectors (eg., communities, researchers, governments, NGOs, and private sector). Together, the survey and breakout sessions provided both quantitative and qualitative insights that shaped a holistic understanding of the workshop's key outcomes.

The combined results of the survey and group discussions reveal a strong and consistent foundation of support for co-design approaches. Survey responses demonstrated that most participants were already familiar with codesign principles, with **65.4% reporting that they have used or planned to use co-design methods in their work**. An

overwhelming **88.5% identified engagement with local and traditional knowledge holders as highly important**, and **100% agreed or strongly agreed** that such knowledge should be integrated into ocean science. Participants also shared candid reflections in the open-ended question, emphasizing that meaningful co-design requires **time-intensive relationship-building, careful management of expectations**, and **genuine recognition of Indigenous leadership**. Several respondents noted that Traditional Ecological Knowledge (TEK) should not simply be "integrated" into mainstream academic science but respected as a **parallel and equally valid knowledge system**—a view that strongly aligns with current literature on Indigenous governance and coproduction of knowledge.

The survey further highlighted the **key challenges** experienced in implementing co-design approaches. The most frequently cited barriers included **lack of funding or institutional support (50%), difficulty balancing scientific and local perspectives (50%), language and communication barriers (38.5%), limited time or human resources (34.6%), power imbalances between researchers and communities (34.6%), and trust or engagement issues (34.6%)**. These patterns echoed the themes that emerged during the breakout groups. In the first activity, each group ranked the perceived challenges of co-design, and despite coming from different institutional backgrounds—community representatives, researchers, government officials, and NGOs—their rankings were highly convergent. Participants consistently noted that insufficient funding, short project timelines, communication gaps, and a lack of institutional incentives for co-designed work remain structural obstacles that hinder respectful collaboration and long-term engagement.

Building on this, the second breakout activity, the **Solutions Lab**, generated a range of practical and context specific proposals to address these barriers. Drawing on the collective expertise in the room, participants developed **possible solution scenarios for different sectors and rights holders**, identifying actions that could strengthen co-design processes across scales. For local **communities**, proposed solutions included strengthening local governance structures, engaging local youth as translators and communicators, and using participatory processes to identify shared priorities. Some groups also suggested **crowdfunding mechanisms** as a way to support small-scale community initiatives where formal funding is limited. For academic **researchers**, participants recommended avoiding technical jargon, co-developing communication and engagement plans, preparing funding proposals jointly with communities, and investing in training to better understand cultural protocols and ethical considerations. Proposed actions for the **government sector** focused on increasing support for bilingual facilitators and knowledge brokers, creating national policies that recognize Traditional and Indigenous knowledge, and establishing institutional frameworks that embed co-design in decision-making processes. Finally, for **NGOs and the private sector**, participants emphasized potential roles as conveners and translators, suggesting that these actors could sponsor co-designed initiatives, invest in local capacity development, and help bridge communication gaps across sectors.

Overall, the alignment between the survey results and the breakout discussions demonstrates a shared understanding of both the promise and the complexity of co-design in Pacific SIDS. The survey provided an important baseline, capturing participants' perceptions, experiences, and concerns, while the breakout sessions allowed these ideas to be contextualized through collective problem-solving. Together, these outcomes highlight not only the **consistency of challenges**—such as funding gaps, time constraints, communication difficulties, and structural inequities—but also the **collective creativity and readiness** of stakeholders to address them through concrete, transdisciplinary collaborative solutions.

These insights will form the foundation for deeper analysis in a forthcoming scientific publication and will help shape future co-designed initiatives across the PICES community and its partners.

Next steps and actionable deliverables

Follow-up roundtables were informally organized on November 10 and 12, 2025, further strengthening the collaborative spirit generated during the workshop and allowing participants to provide feedback, identify next steps, and begin shaping a network of scholars and practitioners committed to knowledge integration and regional bridge-building. As a policy recommendation, participants encouraged PICES to continue creating platforms and opportunities that elevate diverse voices, foster inter-regional exchanges with Pacific SIDS, and support co-designed initiatives that meaningfully value local and traditional knowledge. Doing so will reinforce PICES' leadership in inclusive ocean governance and contribute to solutions that benefit not only the North Pacific but also the wider ocean community.

Moving ahead, the conveners aim to sustain and build on the momentum established in Yokohama through several concrete actions.

First, they intend to co-produce a **scientific paper** in collaboration with the workshop speakers, ensuring that the workshop's insights—spanning technical, cultural, and community-driven perspectives—are synthesized through a genuinely co-designed authorship process. Second, the team will continue preparing for a **highly interactive, slide-free workshop** at the 2026 PICES Annual Meeting in Nanaimo, Canada, designed to weave together scientific, artistic,

cultural, Indigenous, and practice-based ways of knowing. These activities will be complemented by a series of **online dialogues, webinars, and virtual networking events** planned for the months leading up to Nanaimo to ensure continuity and avoid the loss of momentum that often occurs between annual meetings. Such efforts underscore the conveners' commitment to nurturing long-term institutional and interpersonal bridges, promoting equity, recognizing diverse knowledge systems, and fostering shared ownership of ocean challenges and solutions.

Overall, the intention is to ensure this workshop is not a one-off event but part of a longer process that supports ongoing collaboration and creates space for different knowledge systems to contribute meaningfully. By doing so, we hope to continue strengthening this network and help build a more connected and supportive ocean community.

Workshop 8 group photo. Photo credits: Toya Hirokawa

W9: HD/FUTURE Workshop

Applying a Cumulative Effects Framework to Explore Actionable, Social-Ecological Solutions for Climate Extreme Event Impacts Across the North Pacific

Convenors:
Karen Hunter, *Corresponding* (Canada), Helen Killeen (USA), Hiroki Wakamatsu (Japan), Chan Joo Jang (Korea), Antonietta Capotondi (USA)

Description
Extreme Climate Events (ECEs) occur with regularity across the North Pacific. Physical ocean and atmospheric events cascade into ecological anomalies such as harmful algal blooms, marine species die offs, and changes in the distribution and abundance of species. These physical and ecological dynamics often have direct consequences for social systems requiring management such as through fishery closures or expansion, damage to infrastructure and property, and health problems. Currently, many resource management and policy frameworks do not yet handle the impacts of ECEs. In this workshop, participants will explore ECE case studies in the North Pacific to outline drivers, and their ecological and societal impacts using a cumulative effects framework (DSPIR: drivers, pressures, states, impacts, responses). Case studies will be derived from an ongoing bibliometric review conducted by Working Group 49 to census North Pacific ECEs. The DSPIR framework has been broadly applied to identify management and policy actions related to environmental problems. It draws out interactions between state changes and human impacts to identify where the system experiences shifts in ecosystem services and societal benefits and starts to identify suitable responses to control the adverse effects of the drivers and pressures. Participants will also link knowledge generated in the workshop to the PICES-specific SEES (social-ecological environmental system) framework. The SEES framework can help identify how PICES can streamline ECE science activities and solutions for the North Pacific. The workshop will aim to generate information for researchers and decision-makers to enable actionable solutions and build understanding of the similarities and differences in outcomes across different ECEs. Tentative outcomes of the workshop include publication(s) documenting case studies and contribution to Working Group 49's final report.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Introduction
PICES Working Group on Climate Extremes and Coastal Impacts in the Pacific (WG49) (Figure 1) aims to address multidisciplinary aspects of climate extreme events, including their physical drivers, attribution to climate change, predictability on seasonal to interannual timescales, and impacts on coastal marine ecosystems and the coastal communities reliant on their ecosystem services. This workshop was part of a multi-step process to investigate a WG49's principal objective: gaining a better understanding of the drivers and impacts of extremes under changing climate conditions.

Extreme Climate Events (ECEs) occur with regularity across the North Pacific. Physical oceanographic and atmospheric events often cascade into ecological anomalies such as harmful algal blooms, marine species die-offs, and changes in the distribution and abundance of species. These physical and ecological dynamics frequently have direct consequences for social systems, requiring management interventions such as fishery closures or expansion, causing damage to infrastructure and property, and leading to health problems. Leveraging the preliminary results of a bibliometric analysis on ECEs conducted by WG49, this workshop explored North Pacific case studies to identify drivers and their ecological and societal impacts within a cumulative effects framework. We will highlight interactions between physical pressures and their impacts to identify associated shifts in ecosystem services and societal benefits. The workshop explored possible indicators for future monitoring and discussed responses that could help de-escalate future potential impacts.

Workshop Activities:

- Present the bibliometric analysis and workshop plan.
- Provide a draft causal progression for ECE case studies.
- Conduct an exercise for participants to provide feedback on what the literature review reveals about each event.
- Have participants expand upon and clarify the possible cumulative causal progression for the event(s).

Workshop Materials
Five research papers from the corpus created through WG49 Bibliometrics Team literature review. Numbers refer to the row number in the Literature Corpus - DPSIR extraction spreadsheet.

- #42: Causes of 2022 summer marine heatwave in the East China Seas
- #43: Marine Heatwave Stress Test of Ecosystem-Based Fisheries Management in the Gulf of Alaska Pacific Cod Fishery
- #159: Coastal hypoxia response to the coupling of catastrophic flood, extreme marine heatwave and typhoon: a case study off the Changjiang River Estuary in summer 2020
- #279: Seasonality and response of ocean acidification and hypoxia to major environmental anomalies in the southern Salish Sea, North America (2014-2018)
- #335: Widespread and increasing near-bottom hypoxia in the coastal ocean off the United States Pacific Northwests.

Figure 1. WG49 Partial membership group photo, PICES 2025.

Meeting Notes
Presentations on WG49's ECE literature review and related bibliometric analysis were delivered to approximately 12 participants.

Workshop convenors then invited participants to contribute to an exercise of manually reviewing selected literature retrieved from the corpus obtained via a systematic literature review. Our initial objective was to assess the feasibility of manually extracting complex ECE information from a diverse body of literature covering various ECE types. Our second objective was to solicit feedback from workshop participants on how to refine our framework for clarity and ensure that extracted information aligns with WG49's terms of reference.

We asked participants to align pieces of ECE information in a selected published paper with a cumulative effects framework: the Driver-Pressure-State-Impact-Response (DPSIR) framework. The DPSIR framework illustrates cause-effect relationships, termed 'causal chains,' among its component categories. Originally developed for aquatic ecosystem management (EEA 1995; OECD 1993), it has since undergone numerous iterations (e.g., DAPSIR, DAPSIWRM) and been applied in various forms to resource management (e.g., Menegon et al. 2018; Piet et al. 2021; Choi et al. 2025) by marine management bodies. DPSIR was chosen over other available cumulative

effects frameworks for its relative ease of application to a wide variety of situations and its link to management contexts. Basing the workshop's extraction exercise on a defined framework enabled participants to guide their review process, selecting appropriate information related to each DPSIR category.

Workshop participants provided useful feedback for refining and revising our text extraction workflow. Participants highlighted the need for clarity regarding the distinctions between drivers and pressures, as well as impacts and responses. They also argued that the state and impact aspects of causal chains can be biological, physical, or social in nature, and that review participants should have clear guidance on how to delineate between these for consistency. It was suggested that this could be managed using dropdown menus in the Excel template designed for the extraction test. Participants also suggested that reviewer expertise could supplement what can be extracted from each text. While some papers offer potential explanations for their results, these should be included with a clear and distinct approach from the main findings.

While the review extracts indicators for each DPSIR aspect, participants suggested extracting both primary and supporting indicators from texts (e.g., supporting indicators might have low statistical significance). Finally, participants requested additional resources to aid their interpretation of the workflow, including: a definitions document for consultation, a 'questions' column in the extraction template to highlight queries or concerns during review, and draft figures illustrating how the review results will be visualized and interpreted in the resulting manuscript.

Each selected paper was assigned to 2-3 participants. Twenty minutes were allotted to review the paper contents and identify/record information and indicators related to DPSIR categories (Figure 2). Findings were then shared with the group. Discussion of the findings proved helpful in identifying the strengths and pitfalls of the approach. This workshop demonstrated that aligning manual extraction from literature with a clearly defined framework like DPSIR is beneficial for such a process. A list of action items for project leads helped clarify the necessary steps to support a manageable and well-designed manual extraction. Workshop participants also gained important insights into completing systematic and manual literature review exercises more generally. We also garnered interest from several participants to assist with the manual review of over 330 papers. This review is the next step in the research process.

Participants also contributed to a discussion regarding temporal mismatch in ECE events, where some event types are defined as anomalies, while others are considered a gradual shift towards a permanent change in conditions. It was decided that while the literature review step was designed to omit papers documenting monitoring observations (such as seasonal patterns in ECE variables), all remaining papers within the corpus—regardless of whether they described an 'anomalous' event—would be considered in the assessment.

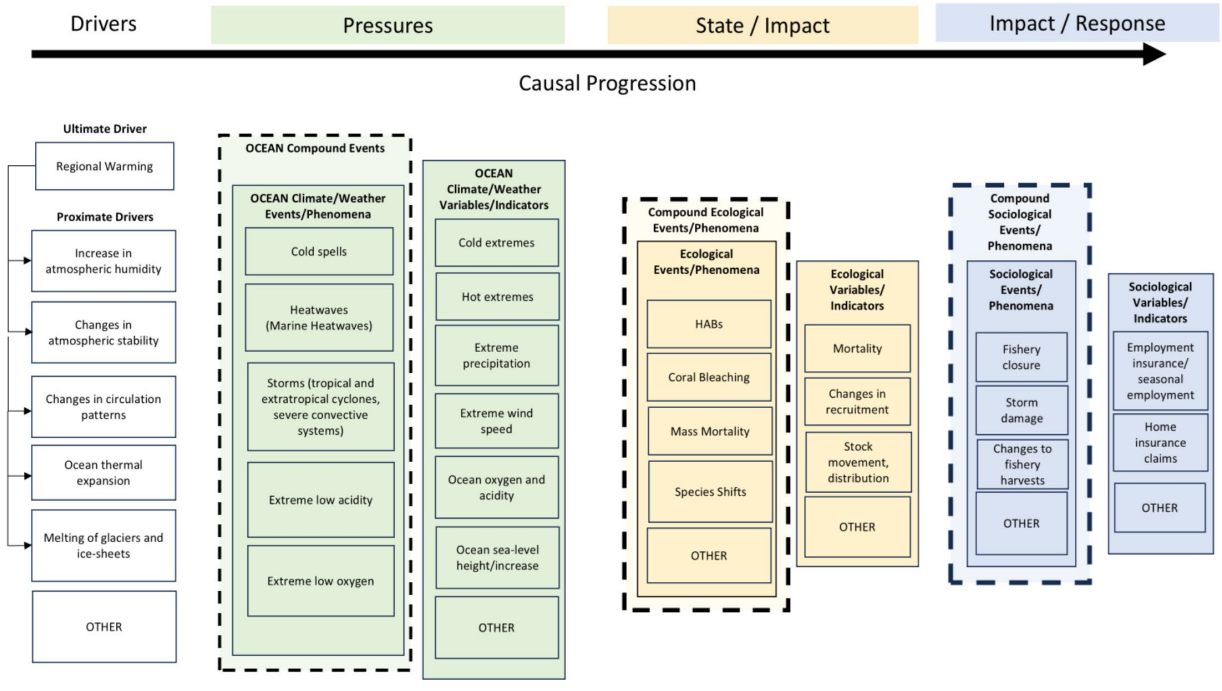


Figure 2. Representation of causal progression of extreme climate events from drivers to responses applied to DPSIR framework categories.

Action Items

- Ensure clear definitions for all DPSIR categories; clarify with examples of driver vs pressure and impact vs response.
- Establish a clear rule for anecdotal and supplementary information.
- Provide structure in assessment to identify primary vs supporting indicators.
- Clarify framework vs pressure.
- Ensure clear definition of state: biological, physical, or both?
- Social indicators, biological impact / state category would benefit from dropdown menu approach to select the preferred DPSIR category.
- Include a questions column to allow reviewers to identify their issues or problems with a specific paper or interpretation.
- Draft figures to determine the right level of detail.
- OAH 'event' caveat, but determined based on discussion to include OAH papers.

The manual review of the corpus assembled through the synoptic literature review will proceed with the goal of finalizing the results by summer 2026. This will support a final PICES 2026 workshop where analysis of these results can be shared with WG49 and associates to produce a final paper by the WG49 Bibliometrics team.

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W10: POC/TCODE/MONITOR Workshop

An Examination of Shelf Data collected by Moorings and Other Fixed Stations in the North Pacific Ocean

Convenors:
Jennifer Jackson, *Corresponding* (Canada), Alex Harper (USA), Jack Barth (USA), Charles Hannah (Canada), Sung Yong Kim (Korea), Jae-Hyoung Park (Korea)

Invited Speaker:
Amandine Schaeffer (University of New South Wales, Australia)

Description
Marine heatwaves (MHW) are becoming increasingly common in the North Pacific, fundamentally altering ecosystems and upending well-established climate indicators (i.e. ENSO, PDO). While the drivers of MHW and other extreme conditions (including ocean acidification and hypoxia) in the open ocean are relatively well-understood, little is known about how these extremes form or are advected in shelf and coastal waters. For example, subsurface MHWs can linger for several years in coastal waters after an open ocean event yet the causes of this persistence remain poorly understood. Near-shore climate signals are difficult to assess due to heterogenic variability and natural dynamics, including both regular (e.g. tidal) and synoptic (e.g. wind events, freshwater inflow) events impact the coastal waters. The dynamic nature of shelves result is waters that can rapidly modify over relatively short time scales. Mooring and other fixed station (e.g. shore stations, bottom-landers) data are collected at a high frequency, normally on the order of minutes to hours, so are an ideal way to examine processes that occur at most time scales. A discussion the 2024 AP-NPCOOS business meetings found that each PICES nation has collected mooring data on their shelves for at least the past 20 years. By examining these time series together, we could learn about the formation, advection, and dissipation of climate extremes in North Pacific shelf waters.
We propose a workshop at PICES 2025 that will focus on jointly examining the shelf mooring and fixed-site data collected from each PICES nation. It is anticipated that the first half of the workshop will focus on information sharing, with both updates from each member country to complete an overview of available mooring shelf data with a focus on long (i.e. greater than 20 year) time series and invited speakers from the eastern and western Pacific. The second half of the workshop will focus on methods to systematically examine the data with the focus on data products for publication.

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Workshop summary
The Advisory Panel on North Pacific Coastal Ocean Observing Systems (AP-NPCOOS) convened a half-day workshop that brought experts together to examine the characteristics, mechanisms, and observational challenges of marine heatwaves (MHWs) in shelf and coastal regions, based on long-term mooring data. The workshop highlighted that while surface marine heatwaves are well documented due to the widespread use of satellite-derived sea surface temperature (SST), those occurring below the surface—particularly in shelf regions—remain much less understood, despite growing evidence that they can strongly affect marine ecosystems.

An invited keynote presentation by Dr. Amandine Schaeffer underscored the global increase in the frequency, duration, and intensity of MHWs over recent decades, emphasizing their severe negative impacts on marine ecosystems. She demonstrated the critical value of long-term, high-frequency shelf mooring observations using a 28-year daily in situ temperature record from the Australian continental shelf near Sydney. These observations revealed multiple vertical classes of MHWs— including surface, subsurface, and vertically extensive events—each associated with distinct physical drivers such as atmospheric forcing, wind-driven downwelling, and warm-water intrusions from boundary currents.

The workshop underscored the importance of subsurface observations, noting that SST alone cannot capture vertical structure, while Argo floats lack sufficient temporal resolution for shelf processes. Long-term mooring data, with sampling intervals ranging from minutes to hours, were identified as essential for diagnosing MHW dynamics across a wide range of time scales. Discussions also addressed methodological challenges, including climatology construction, the treatment of trends, mixed sampling strategies, and the need for consistent MHW definitions between surface and subsurface layers.

National presentations provided overviews of available long-term mooring and coastal monitoring data. Comparative analyses of mooring records along the west coast of North America revealed widespread subsurface MHWs, strong spatial variability, and sensitivities to baseline selection. Canadian analyses using extreme value theory demonstrated that warm events are increasingly dominant and that subsurface MHWs can persist for exceptionally long durations. Japanese monitoring efforts highlighted both the strengths of nearshore surface observations and the challenges associated with deploying shelf moorings in regions influenced by strong currents. Korean results demonstrated a clear linkage between subsurface MHWs, current variability, and large-scale climate indices, illustrating the value of integrating physical circulation data with temperature observations.

A central theme of the workshop was the need for coordinated synthesis across regions. Participants discussed the development of a shared data inventory, standardized analysis approaches, and collaborative frameworks to compare MHW characteristics across the North Pacific. The workshop concluded with strong interest in continued collaboration, including regular online meetings, potential synthesis papers, and followup workshops coordinated with WG-49 and other PICES expert groups. Overall, the workshop highlighted the critical role of shelf mooring observations in advancing the understanding of subsurface marine heatwaves and laid the groundwork for a more integrated North Pacific perspective on extreme ocean conditions.

Keynote speaker Dr. Amandine Schaeffer (University of New South Wales, Australia).

W11: MEQ Workshop

Harnessing Environmental DNA (eDNA) for Early Detection and Monitoring of Marine Invasions in the Face of Climate Change

Convenors:
Satoshi Nagai, *Corresponding* (Japan), Keun-Hyung Choi (Korea), Seongjun Bae (Korea), Joseph R. Krieger (USA)

Invited Speakers:
Keiji Iwasaki (Nara University, Japan), Tadasi Kajita (Ryukyu University, Japan)

Description
Non-indigenous species (NIS) pose significant ecological and economic risks to marine ecosystems, further intensified by globalization and climate change. Global climate change has reshaped species distributions, increasing the likelihood of new introductions and invasions, with a noticeable rise over the last decade. Despite prevention efforts, species continue to be introduced requiring effective and cost-efficient early detection strategies. This workshop will explore the application of environmental DNA (eDNA) and environmental omics techniques for detecting and monitoring NIS in the North Pacific and beyond, aligning with PICES' mission to enhance marine science and promote sustainable resource management. The workshop will review the global landscape of eDNA and environmental omics monitoring, examining their strengths and limitations for detecting NIS, while emphasizing the need for standardized approaches. Additionally, it will investigate the impact of climate change on NIS patterns and how these advanced detection techniques can improve monitoring accuracy, supporting PICES' focus on understanding climate-related shifts in marine ecosystems. The workshop aims to foster collaboration by creating a platform for sharing best practices, methodologies, and lessons learned, reinforcing PICES' commitment to capacity building and scientific exchange among member nations. Lastly, it will discuss how data from eDNA and environmental omics can be effectively integrated into management strategies, bridging the gap between science and policy to enhance ecosystem resilience and biodiversity protection. Although the focus will be on NIS we recognize molecular techniques are of interest to the PICES community broadly and so invite participation where eDNA and omics approaches have been used for other applications (conservation monitoring, stock assessment, etc.).

NOTE: The workshop report below is modified from the articles in the PICES Press 2026 Winter Issue

Background
This workshop focused on the growing challenge of marine non-indigenous species (NIS) driven by climate change and globalization. Topics covered included the application of environmental DNA (eDNA) and environmental omics technologies for early detection and monitoring of NIS. Discussions covered the strengths and limitations of these approaches, the need for methodological standardization, and the influence of climate change on NIS dynamics in the North Pacific. The workshop also aimed to facilitate knowledge sharing and capacity building among participating countries, as well as the translation of eDNA and omics data into effective management and policy strategies. In addition, the session welcomed contributions on broader applications of eDNA and omics, including biodiversity conservation monitoring and fisheries stock assessment.

Summary
The program consisted of two invited talks, eight contributed oral presentations, and one poster presentation. Topics included eDNA-based detection of mangrove-associated fishes and other organisms, identification of harmful algal bloom species, monitoring of deep-sea corals, differences in taxonomic resolution when using various reference databases, species identification of fish eggs, detection of Ciona species, novel DNA extraction techniques, and a historical overview of marine invasions in Japan. Lively discussions followed each presentation, contributing to a highly productive and engaging workshop.
Given the rapid advancements in eDNA and omics technologies, the convenors expressed interest in planning a follow-up workshop in the next two to three years.

Agenda for Workshop 11
09:05-09:45 Harnessing eDNA metabarcoding for transregional biodiversity monitoring: Lessons from JSPS Core-to-Core and ANEMONE Global. – Prof. Tadashi Kajita, Ryukyu University, Japan.

09:45-10:05 Evaluating the effectiveness of eDNA for assessing the diversity of octocoral communities in the twilight zone, including fisheries important species – Dr. Kenji Takata, The University of Tokyo, Japan.

10:05-10:25 Quantitative monitoring and spatial detection of ascidians using environmental DNA – Dr. Seongjun Bae, National Marine Biodiversity Institute of Korea, Korea.

10:55-11:15 Molecular approaches to enhancing fish egg monitoring in the Pacific waters off Japan – Dr. Mikio Watai, Japan Fisheries Research and Education Agency (FRA), Japan.

11:15-11:35 QuickConc: A highly sensitive eDNA concentration method with cationic-assisted capture – Mr. Tomohiro Kuroita, AdvanSentinel Inc., Japan.

11:35-11:55 Comparative analysis of eDNA-based taxonomic assignment in micro eukaryotes from Mombetsu using different databases – Dr. Satoshi Nagai, FRA, Japan.

11:55-12:15 Risk assessment of paralytic shellfish toxins from Alexandrium species in Japan based on multiple analyses: Diversity, toxin production, and seasonal occurrence revealed by environmental DNA– Dr. Tomohiro Nishimura, FRA, Japan.

14:10-14:50 Invited Speaker: Island biogeography of marine nonindigenous species in Japanese Waters – Dr. Keiji Iwasaki, Nara University, Japan.

14:50-15:10 Spatiotemporal dynamics of Karenia selliformis during the 2021 harmful algal bloom along the Pacific coast of Hokkaido, Japan – Dr. Tsuyoshi Watanabe, FRA, Japan.

15:10-15:30 High-throughput DNA metabarcoding for zooplankton community analysis –Prof. Keun-Hyung Choi, Chungnam National University, Japan.

15:50-16:10 DNA metabarcoding and reference DNA sequence databases toward a better understanding of marine zooplankton biodiversity in the western North Pacific Ocean– Dr. Junya Hirai, The University of Tokyo, Japan.