# Summary of Scientific Sessions and Workshops At PICES-2023

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| Workshop 6 | Developing an integrative conceptual framework of urban impacts on marginal ocean ecosystems |
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| Workshop 8 | Nurturing future generation in fisheries and marine environment science: Collaboration with PICES and Asia Fisheries and Marine Environment Leaders Program (AFIMA Leaders Program) |
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| Workshop 10 | Towards climate-informed ecosystem-based fisheries management by building international collaborations and standardizing indicators |
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## Session 1: Science Board Symposium

### Connecting Science and Communities for Sustainable Seas

**Convenors:**
Sukyung Kang (SB), Steven Bograd (FUTURE), Jeanette C. Gann (TCODE), Xianshi Jin (FIS), Sung Yong Kim (MONITOR), Mitsutaku Makino (HD), Hanna Na (FUTURE), Andrew Ross (MEQ), Akash Sastri (BIO), Lei Zhou (POC)

**Background**

PICES-2023 occurs just a few years into the United Nations Decade of Ocean Science for Sustainable Development and is a chance to assess PICES progress to date and set a path for the rest of the Decade. The meeting will focus on developing and strengthening PICES diverse partnerships, building on existing joint activities and promoting cross-fertilization. Priorities for PICES within the Decade focus on climate change, fisheries and ecosystem-based management, social, ecological and environmental dynamics of marine systems, coastal communities, traditional ecological knowledge and human dimensions. Opportunities to engage new partners, especially around the cross-cutting themes of Early Career Ocean Professionals, diverse communities, and engaging with local and Indigenous communities are especially encouraged.

**List of papers**

*Oral presentation*

1. (**Invited**) Across the boundary: Internationally coordinated science and action is required to tackle chemical pollution in marine ecosystems. Matthew Savoca.
2. Toward regional marine ecological forecasting using global climate model predictions from subseasonal to decadal timescales: bottlenecks and recommendations. Shoshiro Minobe; Antonietta Capotondi; Michael G. Jacox; Masami Nonaka; Ryan R. Rykaczewski.
3. Projected abundances of key fisheries in the Pacific Arctic under future climate: Potential biological and economic implications. Irene D. Alabia; Jorge Garcia Molinos; Takafumi Hirata; Daiju Narita; Toru Hirawake.
4. (**Invited**) Application of a Social–Ecological–Environmental System Framework to address and manage future climate change impacts on threatened killer whales and their Pacific salmon prey. Vivitskaia J.D. Tulloch; Tara G. Martin.
5. Ocean Negative Carbon Emissions: A regional and global effort to mitigate climate change. Nianzhi Jiao; Carol Robinson; Douglas Wallace; Louis Legendre
6. Contributions of NOAA's EcoFOCI program to climate science and ecosystem-based fisheries management. Julie Keister; Phyllis Stabeno; Libby Logerwell; Heather Tabisola; David Kimmel; Emily Lemagie; Lauren Rogers; Calvin Mordy; Lisa Eisner; Kelia Axler; Deana Crouser.
7. How will China's stressed marine fisheries respond to climate change impacts? A social-ecological analysis of vulnerability and risk. Yunzhou Li; Ming Sun; Xiangyan Yang; Molin Yang; Kristin M. Kleisner; Jason S. Link; Katherine E. Mills; Feiyan Du; Yiping Ren; Yi Tang; Yong Chen.
8. Pathways to Good Research: Partnerships on Equal Footing. Misty B. Peacock; Rosa M. Hunter; Dave Oreiro.
9. Five actionable pillars to engage the next generation of leaders in the co-design of transformative ocean solutions. Erin V. Satterthwaite; Valeriya Komyakova; Natalia G. Erazo; Louise Gammage; Gabriel A. Juma; Rachel Kelly; Daniel Kleinman; Delphine Lobelle; Rachel Sapery James; Norlaila Binti Mohd Zanuri
10. "SEAturtle" PICES special research project (209-2023): What we learned on sea turtles of Jeju Island for the last 5 years and what we should do in future. Taewon Kim; Soojin Jang; Mi-Yeon Kim; Byung-Yeob Kim; Kyugsik Jo; Sookjin Jang; Jibin Im; George Balazs; Hideaki Nishizawa; Connie Ka Yan NG; George Shillinger; Michelle María Early Capistrán.
11. Utilizing cooperative fisheries research to better understand harmful algal blooms along the Oregon coast. Raquel Gilliland; Maria Kavanaugh; Jennifer L. Fisher; Lori Cramer; Anna E. Bolm..

12. Ocean changes reflected in oyster biological characteristics through comparison of oyster cultured in Japanese coastal waters between 990 and 2022. Yumeng Pang; Tsuneo Ono; Takehiro Tanaka.
13. Representing fisheries' footprints in marine spatial planning suitability analyses for offshore wind energy development. Authors: Kelly S. Andrews; Blake Feist; J. Lilah Isé; Justin Ainsworth; Jessica Watson; Delia Kelly; Caren Braby.

*Poster presentation*

1. Presuming the pathways of sea turtles by using δ8O values from commensal barnacle shells. Kyungsik Jo; Jeongmin Kim; Byung-Yeob Kim; Sook-Jin Jang; Taewon Kim.
2. Examining the socioeconomic vulnerability of coastal Alaskan communities to temperature dependencies in Pacific cod's spatial distribution. Sarah Stone; Lorenzo Ciannelli; Sarah Wise; Kirstin Holsman.
3. (**Cancelled**) Vulnerability assessment of costal urban expansion and modelling green spaces to quantify extreme weather events. Adnan Arshad; Muhammad Ashraf; Ristina S. Sundari; Mahmood-ul-Hasan.
4. A model for evaluating links between salmon smolt ocean entry size and timing and early marine predation risks in a dynamic ocean. Kelly Vasbinder; Jerome Fiechter; James J. Anderson; Jarrod Santora; Nate Mantua; Steve Lindley; David Huff; Brian Wells
5. Remote impacts of low-latitude oceanic climate on coastal upwelling in a marginal sea. Seongho Lee; Jeong Yeob Chae; Jae-Hun Park; Young Taeg Kim; Boonsoon Kang; Chang-Woong Shin; Ho Kyung Ha.
6. The governance systems different, but biological diversity connected and challenges common: Exploring potential cooperation of MPAs using Japan, the Philippines, and Palau as case studies. Iwao Fujii; Mitsutaku Makino.
7. Effects of ocean acidification on growth and body compositions of Snow crab Chionoecetes opilio assessed by indoor culture experiments. Youngbeen Hwang; Hyeonmi Bae; Sang-Woo Kim; Jeong-Min Shim; Jaehyeong Yang; Hae-Kun Jung; JeongHee Shim.
8. (**Cancelled**) Evaluating the Effects of Embankments and Polder Systems on Community Well-being and Coastal Ecosystems in Mitigating Tidal Floods in Jakarta. Alfita P. Handayani; Heri Andreas; Dhota Pradipta.
9. Toward a less plastic ocean: Connecting science and communities. Shin-ichi Ito; Yoshimasa Matsumura; Haodong Xu; Nobuhiro Ogawa; Kazumi Hayama; Misuzu Asari
10. (**Cancelled**) FishSCORE: Fisheries Strategies for Changing Oceans and Resilient Ecosystems – Building global resources and networks for climate-resilient fisheries. Katherine E. Mills; Kristin Kleisner; Claire Enterline.
11. (**Cancelled**) Marine ecosystems and sustainable development. Ferdenant Mkrtchyan.
12. Engaging Early Career Ocean Professionals (ECOPs) in East Asia: Insights from 2022-2023 surveys in China, Japan and South Korea. Raphael K. Roman; Chunhua Jiang; Kotaro Tanaka; Yushi Morioka; Minkyoung Kim; Jae-Hyoung Park.
13. (**Cancelled**) Towards a respectful and sustainable long-term marine monitoring program in Gwaii Haanas, a cooperatively managed protected area in northern British Columbia, Canada. Lynn Lee; Chantal Vis.
14. Implementation and Strategic Planning for Connecting Science and Communities for Sustainable Seas: Case studies in dissemination of Ciguatera Fish Poisoning (CFP) in Gili Matra Lombok, Indonesia. Suhendar I Sachoemar; Mitsutaku Makino; Alexander Bychkov; Mark L. Wells; Shion Takemura; Naoki Tojo; Arief Rachman; Shinta Leonita; Ratu Siti Aliah; Haryanti.

## Session 2: BIO/POC/TCODE Topic Session

### Applications of Deep Learning Systems in Marine Science

**Convenors**
Hongsheng Bi (USA), Haiyong Zheng (China), Julie Keister (USA), David Kimmel (USA)

**Background**

Marine science is entering the big data era where deep learning will have an increasingly far-reaching impact. The combination of deep learning and unprecedented amounts of data generated from different instruments and modeling platforms will enable scientists to address complex issues in biology, ecosystem science, climate, as well as physical and chemical interactions. Although deep learning has made great strides, it is still only beginning to emerge in many fields of marine science, especially towards representative applications and best practices.

The cutting-edge techniques of deep learning in marine science mainly utilize Convolutional Neural Networks and Transformers for applications in underwater vision, such as plankton classification and coral reef detection. These techniques leverage the data collected by in situ optical or acoustic imaging sensors a. Our session seeks contributions that provide examples of applications of deep learning across marine science. Our goal is to share state-of-the-art science that serves to facilitate the convergence of deep learning and marine science and improve our ability to analyze heterogeneous and multi-source oceanographic data.

**List of papers**

*Oral presentation*

1. **(Invited)** Increased usage of deep learning systems in marine ecology. Jean-Olivier Irisson
2. Fourier transform near infrared spectroscopy of otoliths coupled with deep learning to improve age prediction. Irina M. Benson; Thomas E. Helser; Beverly K. Barnett
3. Estimation of total length composition of fish detected as non-occluded using a smartphone application and deep learning techniques. Yasutoki Shibata; Yuka Iwahara; Masahiro Manano.
4. Fish identification through deep learning using only non-occluded fish. Yuka Iwahara; Yasutoki Shibata; Masahiro Manano; Tomoya Nishino; Hiroki Yaemori; Ryosuke Kariya.
5. Automated video processing to support commercial fishing innovation in the walleye pollock (Gadus chalcogrammus) fishery in Alaska. Katherine C. Wilson; Moses Lurbur; Noëlle Yochum
6. Habitat classification in the Gulf of Alaska based on acoustic surveys using deep learning. Karuna Agarwal; Chris Rooper; Kresimir Williams
7. Semantic segmentation of Pacific hake aggregations in water column echograms. Valentina Staneva; Wu-Jung Lee; Zhongqi Miao; Emilio Mayorga.
8. Advancing mussel habitat mapping in rocky intertidal ecosystems using high-resolution UAV Imagery and deep learning techniques. Taylor Denouden; Pramod Thupaki; Will McInnes; Alyssa Gehman.
9. A novel approach to retrieve vertical profiles from PIES data using a deep neural network and its application to the northwestern Pacific Ocean. Jeong-Yeob Chae; Jae-Hun Park.
10. Enhanced climate downscaling for the Northeast Pacific using deep learning methods. Albert J. Hermann; Kenneth O. Coyle; Emily L. Norton; Wei Cheng; Kelly A. Kearney; Darren J. Pilcher; Martin Dorn; Kirstin K. Holsman.
11. Using Ecotaxa to assess phenological variability of winter predator-prey dynamics between ichthyoplankton and zooplankton in Beaufort Inlet, North Carolina, USA. Naomi A. Jainarine; Rebecca G. Asch.
12. Fine-scale spatial patterns of gelatinous zooplankton in the Northern Gulf of Alaska. Hannah E. Kepner; Thomas B. Kelly; Russell R. Hopcroft.
13. Beyond transfer learning: An implementation guide to optimally. Jeffrey S. Ellen; Mark D. Ohman.
14. Beyond transfer learning: An implementation guide to optimally leveraging ancillary images in automated classification of plankton. Jeffrey S. Ellen; Mark D. Ohman

15. Microplanktonic assemblages in the spring East China Sea: An approach with a frugal plankton imaging system coupling with EcoTaxa. Satoshi Kitajima; Fabien Lombard; Koh Nishiuchi; Sachiko Horii; Chiyuki Sassa; Toshiyuki Tanabe.
16. Rapid plankton biomass assessment in coastal waters. Hongsheng Bi; David G Kimmel; Xuemin Cheng.
17. Big data mining and fusion towards resources evaluation of deep-sea polymetallic nodules. Weilu Li; Jinkun Yang; Fangfang Wan

*Poster presentation*

1. An integrated deep learning-based approach for fishing vessel classification using AIS data. Xin Cheng; Fan Zhang; Jintao Wang; Xinjun Chen.
2. Automating the acoustic detection of Arctic ringed seal vocalizations using deep learning. Karlee E. Zammit; William Halliday; Fabio Frazao; Stan Dosso
3. Analysis and projection of long-term sea level change around the Korean Peninsula. Gwang Ho Seo; Kwang-Young Jeong; Hyun-Ju Oh; Yang-Ki Cho; Yu-Kyeong Kang

## Session 3: FIS/TCODE/FUTURE/POC/MONITOR Topic Session

### Responses of Small Pelagic Fish to Extreme Events in Pacific Ecosystems

**Convenors:**
Ryan R. Rykaczewski (USA), Haruka Nishikawa (Japan), Sukgeun Jung (Korea)

**Background**

Populations of small pelagic fish are valuable resources for human communities around the Pacific Rim and an important forage base for higher predators in marine food webs. Describing the relationship between patterns of decadal scale ocean-atmosphere variability and these important fish populations has been a long-standing goal of the scientific community. Oceanographic conditions in recent years, however, have been marked by some notable "extreme events" that exhibited characteristics that differ from the lower-frequency patterns of change previously investigated. Coastal marine heatwaves, hypoxia, harmful algal blooms, and other types of episodic events can have severe socioeconomic consequences and have become the target of ecosystem prediction efforts. To improve our understanding of the mechanisms through which extreme climate events can influence important coastal resources, we invite presentations that investigate the responses of small pelagic fish populations to extreme conditions. Topics might include ecological responses to intense, episodic events in comparison to lower-frequency patterns of change; shifts in population distributions and habitat compression; change in prey or predator abundance; and impacts on coastal fisheries and human communities.

**List of papers**

*Oral presentation*

1. (**Invited**) Significant impact of ocean current variability on marine heatwaves: Case studies in the northwestern Pacific Ocean. Toru Miyama; Yasumasa Miyazawa; Hakase Hayashida; Yu-Lin K. Chang; Sergey Varlamov; Ruochao Zhang.
2. (**Cancelled**) Capelin condition and abundance through multiple heatwaves in Alaska. Robert Suryan; Johanna Page; Fletcher Sewall; Jacek Maselko; Edward Farley; Ellen Yasumiishi; James Murphy; Alexander Andrews.
3. Trophic shifts and energetic responses in small pelagic fishes during prolonged marine heatwaves in the Northern California Current. Richard D. Brodeur; Elizabeth A. Daly; Mary E. Hunsicker; Kaitlyn Osborne; Yi Gong; Todd W. Miller; Olivia Burnip.
4. Trophoscapes of predatory fish reveal biogeographic structuring, spatial dietary overlap, and inform fisheries bycatch patterns. Brian K. Wells; Jarrod A. Santora; Joseph J. Bizzarro; Alicia Billings; Richard D. Brodeur; Elizabeth A. Daly; John C. Field; Kate E. Richerson; James T. Thorson.
5. Should I stay or should I go? Participation, species target, and landing location choices in the U.S. West Coast Coastal Pelagic Species fishery. Felipe Quezada; Desiree Tommasi; Stephen Stohs; Isaac Kaplan; Barbara Muhling.
6. Archived DNA reveals marine heatwave-associated shifts in fish and zooplankton assemblages. Zachary Gold; Ryan Kelly; Andrew Olaf Shelton; Andrew Thompson; Kelly Goodwin; Ramón Gallego; Kim M. Parsons; Luke Thompson; Dovi Kacev; Paul Barber; Erin Satterthwaithe; Noelle Bowlin; Rasmus Swalethorp; Nastassia Patin; Susanna Theroux; Brice Semmens.
7. (RECORDED) Influence of extreme cold and warm oceanographic events on larval fish assemblages in the southern region of the California Current off Mexico. Gerardo Aceves-Medina; Sylvia Patricia Adelheid Jiménez-Rosenberg.
8. (RECORDED) Predicting abundance distribution of Vinciguerria lucetia larvae during extreme thermal scenarios in the southern portion of the California Current System. Rubén Esteban García-Gómez; Gerardo Aceves-Medina; Héctor Villalobos; Sylvia Patricia Adelheid Jiménez Rosenberg; Reginaldo Durazo.
9. (**Invited**) Recent population explosion and mass killing of Pacific sardine in the western North Pacific in relation with climate change and fisheries management. Sukgeun Jung.
10. Spatial distribution of arctic sand lance related to the physical environment. Matthew Baker; Alex De Robertis; Robert Levine; Daniel Cooper; Edward Farley.

*Poster presentation*

1. Predicting larval northern anchovy (Engraulis mordax) abundance across space and time. Luke A. Bobay; Moritz S. Schmid; Robert K. Cowen; Su Sponaugle.

## Session 4: FUTURE/MEQ/MONITOR Topic Session

### The Oceanographic, Ecological and Societal Impacts Arising from Extreme Weather and Climatic Events in Coastal Regions

**Convenors:**
Misty Peacock (USA), Pengbin Wang (China), Moonho Son (Korea), Charles Trick (Canada), William P. Cochlan (USA)

**Background**

Climate drivers have and continue to strongly influence the physical and biogeochemical properties of ocean surface waters, and these effects become magnified during extreme events. Coastal regions are particularly sensitive to extreme events. In addition to being affected by the onshore movement of anomalous oceanic water, coastal regions are subject to rapid fluctuations in precipitation-driven runoff as well as mixing associated with nearshore wind patterns. The increasing occurrence of extreme change in nearshore waters can intensely influence nutrient supply, dramatically altering ocean ecology in ways that can cause extensive socioeconomic stress. The outcomes of these integrated processes vary widely given the complexity of drivers, magnitudes and dynamics of change, making it difficult to proactively identify problems in time to take steps towards mitigation. Nevertheless, better understanding of past extreme events, and the nature of associated ecological and socioeconomic impacts, will provide the foundation for developing prediction and response strategies. This topic session will help to inform the Working Group 49: Climate Extremes and Coastal Impacts in the Pacific by helping to develop a census of historical climate extreme events around the Pacific Rim to describe their characteristics, identify potential climate and ocean drivers, and catalog the ecological and socioeconomic consequences (ToR#). The session also addresses the UN Decade of Ocean Science for Sustainable Development goal towards developing a common framework for improving conditions for sustainable development of the Ocean. We welcome papers that address the oceanographic, ecological, and socioeconomic outcomes associated with extreme events in coastal oceans and particularly encourage papers that seek linkages among two or more of these aspects that help to illustrate the underpinnings of ecological and socioeconomic responses to extreme events.

**List of papers**

*Oral presentation*

1. (**Invited**) Patagonian fjords dealing with extreme Harmful Algal Blooms (HABs): Lessons and challenges in a changing climate. Jorge I. Mardones
2. Ecosystem impacts of record-breaking 2020 summer marine heatwaves in the South China Sea. Jingjing Zheng; Peng Xiu; Xueming Zhu; Xuanliang Ji; Shan Gao.
3. Spatio-temporal variation of largescale harmful algal blooms with Karenia selliformis in Pacific Coastal Waters off southeast Hokkaido, Japan after marine heatwaves. Satomi Takagi; Hiroshi Kuroda; Yukiko Taniuchi; Takuya Nakanowatari; Hiromi Kasai; Takuya Ohnishi; Natsuki Hasegawa; Tsuyoshi Watanabe; Tomonori Azumaya
4. (**Cancelled**) Large-scale drivers of Northeast Pacific marine heatwaves. Antonietta Capotondi; Matthew Newman; Tongtong Xu; Emanuele Di Lorenzo.
5. (**Cancelled**) Spatio-temporal variation in zooplankton community composition in the southern Salish Sea: Changes during the 205–206 Pacific marine heatwave. Amanda Winans; BethElLee Herrmann; Julie E. Keister.
6. Using otoliths to understand how marine heatwaves affect fish growth. Jessica Randall; Steve Swearer; Emily Fobert; Bryan Black; John Morrongiello.
7. Non-stationary relationships between climate and fisheries in the California Current and Gulf of Alaska. Megan L. Feddern; Eric J. Ward; Mary Hunsicker; William H. Satterthwaite; Curry J. Cunningham.
8. Analyzing oceanographic data to understand the threats faced by BC salmon: Focus on Heterosigma akashiwo and climate factors. Svetlana Esenkulova; Vera Pospelova; Rich Pawlowicz; Nicky Haigh; Jayaprabandh Pudota; Isobel Pearsall.

9. Southern Salish Sea (U.S.) ocean acidification and hypoxia extremes in response to major heat and runoff anomalies during a seasonal 204–208 cruise time-series: Multi-stressor implications for sensitive species. Simone R. Alin; Jan A. Newton; Richard A. Feely; Dana Greeley; Samantha Siedlecki.
10. Community informed social indicators for the California Dungeness Crab Fishery under whale entanglement mitigation regulations. Rachel Seary; Steven Bograd; Theresa Burnham; Megan Cimino; Elliott Hazen; Rosemary Kosaka; Aaron Mamula; Barbara Muhling; Jarrod Santora; Cameron Speir; Heather Welch.
11. Comparison of biodiversity of ARMS installed in Jeju Island through metabarcoding technique and morphological classification assay. Hyun-Sung Yang; Gun-Tak Yoon; Chulhong Oh; Heung-Sik Park; Do-Hyung Kang.
12. Evolution of nutrient structure and associated changes in harmful algal blooms in coastal waters off Korea Peninsula over the last few decades. Guebuem Kim; Hyeong Kyu Kwon; Sojin Park; Moonho Son.
13. Harmful Algal Species in the East China Sea and their possible respondence to climate change via a global vision. Pengbin Wang; Jiarong Hu; Junjie Zheng; Ruoyu Guo; Xinfeng Dai; Douding Lu.
14. Advancing an integrated understanding of land-ocean connections in shaping the marine ecosystems of Coastal Temperate Rainforest ecoregions. Brian P.V. Hunt; Simone R. Alin; Allison Bidlack; Heida Diefenderfer; Jennifer M. Jackson; Colleen Kellogg; Peter Kiffney; Kyra St. Pierre; Eddy Carmack; William C. Floyd; Eran Hood; Alex R. Horner-Devine; Colin Levings; Cristian Vargas.
15. (**Cancelled**) Bottom marine heatwaves along the continental shelves of North America. Dillon J. Amaya; Michael G. Jacox; Michael A. Alexander; James D. Scott; Clara Deser; Antonietta Capotondi; Adam S. Phillips.
16. Development of an operational forecasting system for marine ecosystem in the China seas. Guimei Liu; Shan Gao; Xuanliang Ji; JingJing Zheng.

*Poster presentation*

1. (**Cancelled**) Climate risks on blue foods value chain of Bangladesh: Impacts and responses. M Minhazul Islam and Md. Tariqul Alam.
2. Monitoring nutrients and Fluorescent Dissolved Organic Matter (FDOM) to predict the outbreaks of Paralytic Shellfish Poisoning (PSP) in Jinhae Bay, Korea. Hanbyul Lee, Hyeong Kyu Kwon, Jihyun Park, Cheolmin Baek, Jaehee Lim, Moonho Son and Guebuem Kim.
3. Vulnerability assessment of Korean fisheries to Climate Change. Moo-Jin Kim, In-Seong Han, Joon-Soo Lee and Do-Hoon Kim.

## Session 5: POC/MONITOR Topic Session

### Multi-scale ocean processes and their impacts on marine ecosystems

**Convenors:**
Yisen Zhong (China), Bo Qiu (USA), Sung Yong Kim (Korea), Tetjana Ross (Canada)

**Background**

Oceanic processes exhibit distinct characteristics on different temporal and spatial scales, spanning from chaotic turbulence, intense internal waves, complex fronts and filaments to energetic mesoscale eddies and basin-wide circulations. The unique properties of different processes impact the distribution, transport, and conversion of various biogeochemical tracers as well as the microscopic marine organisms that form the base of the marine food web. In recent decades, many studies have been devoted to this interdisciplinary field, especially focusing on the oceanic meso- and submeso-scales, but there are still knowledge gaps in understanding how these multi-scale oceanic processes configure marine ecosystems, i.e., building the connection between the physical environment and sustainable use of the marine resources, which is in alignment with the UN Decade's SDG 4. We invite general studies providing new insights on multi-scale physical processes, scale interactions, and their impacts on the marine ecosystem. Biogeochemical studies related to the physics are also strongly encouraged in this session.
List of papers

*Oral presentation*

1. Submesoscale processes-induced vertical heat transport modulated by oceanic mesoscale eddies. Changming Dong, Yisen Zhong, Qingyue Wang.
2. Observations of upstream-downstream connectivity of the Kuroshio Current variability in the East China Sea. SeungYong Lee, Hanna Na, Hong Sik Min, Dong Guk Kim, Hirohiko Nakamura, Ayako Nishina.
3. Seasonal cycle of the confluence of the Tsugaru Warm, Oyashio, and Kuroshio currents east of Japan. Sachihiko Itoh, Eisuke Tsutsumi, Eiji Masunaga, Takashi. T. Sakamoto, Kazuo. Ishikawa, Daigo. Yanagimoto, Yasuhiro. Hoshiba, Hitoshi. Kaneko, Daisuke Hasegawa, Kiyoshi Tanaka, Hideki Fukuda, Toshi Nagata.
4. (**Cancelled**) Processes that influence bottom temperatures along the west coast of the US and Baja Peninsula. Michael Alexander, James Scott, Michael Jacox, Dillon Amaya, Leah Wilczynski.
5. A Regime Shift of the Kuroshio Extension System after 2018. Bo Qiu.
6. Impact of warm eddy on sea level rise in the frontal region of the East/Japan Sea. KyungJae Lee, Jae-Hyoung Park, Young-Gyu Park.
7. Effects of tidal forcing on the frontal dynamics of the Changjiang River plume. Shuangzhao Li, Yisen Zhong, Meng Zhou, Zhaoru Zhang.
8. Role of submesoscale cyclonic eddies generated at the south of Yaku Island, Japan. Gloria Silvana Duran Gomez, Takeyoshi Nagai, Toru Kobari, Hirohiko Nakamura.
9. Velocity structure functions derived from submesoscale surface currents over marginal seas. Tran Thi My Hong, Jae Il Kwon, Yong-Gyu Park, Kyunghoi Kim, Jun Myoung Choi.
10. Role of submesoscale and microscale mixing processes in the Kuroshio flowing south of Kyushu. Takeyoshi Nagai, Duran Gomez Silvana Gloria, Saito Hiroaki, Ogawa Hiroshi, Kobari Toru, Naoki Yoshie, Hirohiko Nakamura.
11. How the Kuroshio Extension entrains the surrounding water masses off Sanriku. Daisuke Hasegawa, Takahiro Tanaka.
12. (**Cancelled**) Subsurface nutrients, not upwelling strength, control projected productivity changes in the California Current System. Michael G. Jacox, Michael Alexander, Dillon Amaya, Steven Bograd, Nathali Cordero Quiros, Dianne Deauna, Hui Ding, Jerome Fiechter, Mercedes Pozo Buil, Ryan Rykaczewski.
13. Using pollock larvae distributions to explore ocean processes in the Western Gulf of Alaska. Emily P. Lemagie, Lauren Rogers, Jens Nielsen.

14. Submesoscale stirring as a crucial mechanism maintaining subsurface chlorophyll maxima within cyclonic eddies. Haijin Cao, Mara Freilich, Xiangzhou Song, Zhiyou Jing, Baylor Fox-Kemper, Bo Qiu, Robert D. Hetland, Fei Chai, Dake Chen.
15. Potential predictability of environmental drivers in Community Earth System Model Decadal Prediction Large Ensemble for a fisheries size and functional type model. Hyung-Gyu Lim, Colleen Petrik, Kristen Krumhardt, Matthew Long, Zhoumin Chen, Charles Stock, Jong-Yeon Park.
16. Effects of seasonal variation of mesoscale eddy off the central coast of Peru on the distribution of anchovy eggs and larvae. Sonia Danielle Postigo Montero, Diego Andre Otero Huaman, Gloria Silvana Durán Gómez, Takeyoshi Nagai.
17. Mesoscale eddies regulate habitat distribution of neon flying squid in the Northwest Pacific Ocean. Yuchen Zhang, Wei Yu, Xinjun Chen, Mo Zhou, Chunling Zhang.
18. Distribution of acoustically detected marine organisms across Kuroshio Extension front associated with physical and biogeochemical environments. Hikaru Homma, Daisuke Hasegawa, Takahiro Tanaka, Yuji Okazaki, Takeshi Okunishi.
19. Feedbacks between bottom boundary biogeochemistry and ecosystem metrics in a regional biogeochemical model intercomparison in the Bering Sea. Kelly A. Kearney, Albert Hermann, Wei Cheng.
20. Asymmetry in seasonal mixed layer transitions with respect to coastal upwelling strength between Northern and Southern Hemisphere and its influence on marine ecosystem. Diego Andre Otero Huaman, Takeyoshi Nagai.

*Poster presentation*

1. Surface Chlorophyll and temperature anomalies induced by Mesoscale Eddies and geostrophic strain in the Arctic Norwegian Sea. Huizi Dong; Meng Zhou; Roshin P. Raj; Walker O. Smith; Jr. et al.
2. The formation of the T-S relationship in the Kuroshio Extension region. Yuki Ikeda; Takeyoshi Nagai.
3. Spatiotemporal characteristics of the cyclonic eddies generated between the Kuroshio and the coast of Japan during 2000 – 2020. Diego Alonso Dante Pinglo Rodriguez; Takeyoshi Nagai.
4. Vertical changes in phytoplankton size structure assessed through in-situ measurements, a profiling crawler and random forest modelling. Jens M. Nielsen; Lisa B. Eisner; Sun Bak-Hospital; Priscila K. Lange; Jeanette Gann; Michael W. Lomas; Calvin W. Mordy; Phyllis Stabeno; Noel Pelland
5. Seasonal and interannual variation of Atlantidae heteropods off the western coast of Baja California, Mexico. María Moreno-Alcántara; Gerardo Aceves-Medina; Bertha E. Lavaniegos; J. Martín Hernández-Ayón; Sylvia P.A. Jiménez-Rosenberg; Jaime Gómez-Gutiérrez.
6. (**Cancelled**) Characterization of the fish larvae community off ENSENADA in the southern California Current, and its interaction with local and interannual variability. Sylvia P. A. Jiménez-Rosenberg; Gerardo Aceves-Medina.

## Session 6: MEQ Topic Session

### The complex reality of managing Non-indigenous Species (NIS) in the North Pacific

**Convenors:**
Thomas Therriault (Canada), Carolyn Tepolt (USA)

**Co-sponsors:**
Coastal Restoration Society
Washington Crab Team
Washington Department of Fish and Wildlife

**Background**

Non-indigenous species (NIS) can cause ecological and economic damage to coastal marine ecosystems and are a threat to biodiversity, ecosystem services, and the livelihood of coastal communities around the North Pacific. The spread of marine NIS has increased in the last decade due to globalization and other related human activities and climate change. This has sparked an increased awareness about the threats NIS pose and the need for better management and policy to mitigate their impacts, especially in already stressed coastal environments. Once such example is the spread of European Green Crab (Carcinus maenas) along the west coast of North America where management efforts have recently ramped up. Further, it was quickly realized that management needed to be coordinated and inclusive, especially over large spatial scales. Similarly, despite considerable species-specific knowledge, many scientific gaps were identified (from monitoring and early detection to control and eradication) and successful management interventions were only possible via collaborative networks including agencies, Indigenous groups, and a variety of stakeholders. This topic session will explore the complexities of managing NIS from different perspectives and will not be limited to only Green Crab. The goal is to share experiences around successes and challenges of managing marine NIS, especially those that span different spatial scales or jurisdictions, and how these challenges were resolved or not. This will allow generalizations that will be helpful for PICES member countries managing marine NIS.

**List of papers**

*Oral presentation*

1. (**Invited**) Bringing back ecological balance through an indigenous perspective. Joshua Charleson.
2. (**Invited**) South coast European green crab control project. Crysta Stubbs.
3. Identifying management needs for European green crab in British Columbia, Canada. Thomas W. Therriault, Brett R. Howard, Renny Talbot, Christine Spice, Mark Potyrala.
4. Introduced subtropical ship hull seaweed, *Colaconema formosanum* (Rhodophyta): Species description and ecophysiological characterization. Hyung Woo Lee, Ye Rim Kim, Ju-Hyoung Kim, Young Jun Song, Young Sik Kim, Eun Ju Kang, Min Gui Jung, Kyungsoon Shin, Jung-Hoon Kang, Seung Ho Back, Bonggil Hyun.
5. Genomic tracking during the earliest stages of a marine invasion. Carolyn K. Tepolt, Emily W. Grason, P. Sean McDonald, Thomas W. Therriault.
6. Multiple larval sources for Oregon and coastal Washington green crab populations. Sylvia Behrens Yamada, Carolyn Tepolt, Alan Shanks.
7. Investigating the basis of thermal tolerance of a rapidly spreading crab. Yaamini R. Venkataraman, Sara Shapiro, Sarah Zuidema, Julia Kelso, Mikayla Newbrey, Lauren Stephenson, Carolyn Tepolt.
8. Ecological impacts of the invasive European green crab (*Carcinus maenas*) in Washington. Benjamin Rubinoff, Jeff Adams, Emily Grason, Kate Litle, P. Sean McDonald, Alex Stote.
9. (**Invited**) Management, monitoring, and research on European green crab (*Carcinas maenas*) on the Makah Reservation. Adrianne Akmajian.
10. (**Invited**) Increasing trapping capacity to address invasive European green crab (*Carcinus m*aenas) in Lummi Sea Pond and Lummi Nation Tidelands. Bobbie Buzzell, Nicholas Jefferson, Shawn Evenson.

11. Challenges, lessons learned, and advantages of large-scale collaborative management actions targeting the European green crab, *Carcinus maenas*, in Washington state. Brian Christopher Turner, Chelsey Buffington, Lennah Shakeri Mohar.
12. Community science for the early detection of European green crab (*Carcinus maenas*). Lisa Watkins, Jeff Adams, Emily Grason, Aina Hori, P. Sean McDonald, Staci McMahon, Kate Litle, Benjamin Rubinoff, Alex Stote.
13. Top-down control of invasive European green crabs by Southern sea otters in central California. Rikke Jeppesen, Edwin Grosholz, Catherine de Rivera, Tim Tinker, Brent Hughes, Ron Eby, Kerstin Wasson.
14. Developing a quantitative basis for management targets for non-indigenous marine species. Edwin D. Grosholz.
15. The transition from resistance to acceptance: Controlling a marine invasive species in a changing world. Abigail Keller, Perry de Valpine, Tim Counihan, Carl Boettiger.
16. Science to support management of marine bioinvasions; A case study of invasive European green crab (*Carcinus maenas*) in Washington. P. Sean McDonald, Jeff Adams, Emily Grason, Kate Litle,Benjamin Rubinoff, Alex Stote.

*Poster presentation*

1. Research outcomes on core elements to establish biological risk assessment protocols for in-water cleaning of Ship's biofouling. Bonggil Hyun; Pung-Guk Jang; Jung-Hoon Kang; Kyoungsoon Shin.

***The report below was modified from the article in the PICES Press 2024 Winter Issue.***

**Session Overview**

Non-indigenous species (NIS) can cause ecological and economic damage to coastal marine ecosystems and are a threat to biodiversity, ecosystem services, and the livelihood of coastal communities around the North Pacific. The spread of marine NIS has increased in the last decade due to globalization and other related human activities and climate change. This has sparked an increased awareness about the threats NIS pose and the need for better management and policy to mitigate their impacts, especially in already stressed coastal environments. One such example is the spread of European Green Crab (*Carcinus maenas*) along the west coast of North America where management efforts have recently ramped up. Further, it was quickly realized that management needed to be coordinated and inclusive, especially over large spatial scales. Similarly, despite considerable species-specific knowledge, many scientific gaps were identified (from monitoring and early detection to control and eradication) and successful management interventions were only possible via collaborative networks including agencies, Indigenous groups, and a variety of stakeholders. This topic session will explore the complexities of managing NIS from different perspectives and will not be limited to Green Crab. The goal is to share experiences around successes and challenges of managing marine NIS, especially those that span different spatial scales or jurisdictions, and how these challenges were resolved or not. This will allow generalizations that will be helpful for PICES member countries managing marine NIS.

**Summary of Presentations**

This full day topic session on invasive species management efforts was held on Thursday, October 26, 2023 starting at 9:00 Pacific Daylight Time at the Westin Hotel in Seattle, WA. The session was composed of four invited presentations with an emphasis on local Indigenous efforts and 12 contributed oral presentations and one poster presentation. Early Career Ocean Professionals (ECOPs) were well represented in this session, including multiple invited speakers. Given the ongoing spread and intense management of European Green Crab (EGC) along the west coast of North America, many presentations were focused on these efforts. Further, taking advantage of local expertise, a special one day workshop was orchestrated on Friday October 27, 2023 to discuss how EGC efforts along the west coast might be better coordinated and information shared across multiple jurisdictions and levels of government to improve management decision making.

The session got underway following a brief overview by the convenors. The first invited presentation set the stage for the importance of Indigenous engagement in resource management decisions like combating invasive species as Joshua Charleston (Coastal Restoration Society, Canada) gave an overview of some of the differences (and

challenges) in working with both Traditional {Ecological} Knowledge and Western Science. He spoke of the importance of early and transparent engagement and showcased examples of conservation efforts on the west coast of Vancouver Island that have been successful due to building of long-term relationships that foster collaboration and capacity building. Josh was followed by the second invited speaker in the morning session, Crysta Stubbs (Coastal Restoration Society, Canada) who introduced participants to a multi-year industrial-scale control trapping effort in Clayoquot Sound (open system) and Sooke Basin (closed system) to better understand how important First Nation sites can be protected (or at least damage mitigated) from the impacts of the significant ecological and socio-economic impacts of EGC. To date, more than 616,000 EGC have been removed from core trapping sites and information on changes in Catch-per-Unit-Effort (CPUE) and biological characteristics (sex, size, etc.) are informing management decisions with the idea that this first-of-its-kind data will inform actual Management Plans for EGC in British Columbia. The next speaker, Thomas Therriault (Canada) provided an overview of the interface between Aquatic Invasive Species (AIS) Science and AIS Management at Fisheries and Oceans Canada. He used three examples (with differing levels of success) where Science developed specific advice for managers to improve management outcomes. These included the development of mixed models to identify early detection sites for EGC in Canadian waters of the Salish Sea, lab and mesocosm work towards identifying management thresholds for EGC, and the need for additional management control levers beyond trapping. One take away from this work was the need for Science and Management to work collaboratively to identify needs and prioritize research most likely to influence management decisions.

After the morning break, Hyung Woo Lee (Korea) gave an interesting presentation on an introduced seaweed in Korea that likely arrived via commercial vessel biofouling. Using molecular methods in conjunction with physiological experiments the team was able to identify the species and determine the optimal temperature and light intensity for its growth. This has important implications for understanding how widespread this species may become in the future as it is typically considered a subtropical species but the frequency of reports of such species in more northern regions of Asia has been increasing with global climate change. Carolyn Tepolt (USA) was the next speaker and she introduced participants to the importance of genomic adaptation and variation in contributing to the massive spread of EGC along the west coast of North America. Due to their long larval phase, EGC are considered very good dispersers and the molecular work suggests a genetic basis for successful invasion dynamics in this species. There are some examples where EGC populations are isolated at specific sites such as Seadrift Lagoon in California or Sooke Basin in British Columbia but most molecular evidence suggests widespread mixing that is likely facilitating invasion success and may ultimately see EGC more widely distributed throughout the Gulf of Alaska. Sylvia Yamada (USA) next spoke to the importance of the Davidson Current to larval dispersal in EGC. This warm-water mass flows from south to north and until 2015 the temperature associated with this current was a relatively good predictor of EGC recruitment strength, especially in estuaries of Oregon. However, following successive warm water events including the notorious “blob” marine heatwave this pattern broke down completely rendering it nearly impossible to predict strong recruitment events for ECG along the west coast of North America. Following along the temperature tolerance theme, Yaamini Venkataraman (USA) discussed the importance of both evolutionary adaptation and acclimatory plasticity in shaping temperature tolerance in EGC and that both factors likely contribute to the global success of this invader. Using multiple experimental temperature regimes to mimic chronic stress she tested physiological differences in EGC to explore plasticity in the species and its potential genetic basis. She found that the species was highly plastic, with good survival over 6-7 weeks of chronic exposure to both 5ºC and 25ºC. Measures of sublethal performance suggested there may also be a genetic basis for the broad temperature tolerances of EGC, contributing to their invasion success from California to Alaska. Relatively speaking, EGC are a fairly well-studied marine invader but our understanding of their impacts, especially on west coast ecosystems, contains critical gaps. Using an extensive dataset compiled by Washington Crab Team and its citizen science volunteer program, Ben Rubinoff (USA) suggested a framework by which the impacts of EGC can be characterized at the individual, population, and community level. This hierarchy would allow a greater understanding of EGC impacts across the range of invasion on the west coast of North America. Of note, three key species that are known to be impacted by EGC all appear in their diet. Thus, in addition to the indirect impacts of EGC via habitat loss, EGC are directly consuming important native species that have additional consequences for native ecosystem structure and function. One extension of this work would be the ability to have a standardized metric of EGC impacts that would inform management about what level of intervention may be required depending on the context – something that is currently lacking in existing management schemes.

Following the lunch break the session re-convened with two more invited presentations again focused on work being led by Indigenous communities impacted by this high risk invader. Adrianne Akmajian (Makah Tribe, USA) spoke

of the cultural need for access to marine resources that are being impacted by EGC and the consequences to the Makah Tribe. Given these varied consequences, the Tribe has developed a broad program that includes monitoring spread, control trapping to minimize impacts, and research to better understand EGC impacts at a local scale, including the impact on traditional Indigenous food resources such as salmon and Dungeness crab. The main estuary that has been invaded on Makah land is large and complex and EGC are having different impacts across this landscape. Of special concern is the frequency and extent of incursion of EGC into the river portion of this estuary on the outer coast of Washington State. Adrianne was followed by Bobbie Buzzel (Lummi Nation, USA) who provided an "inland" perspective of the EGC invasion in the Salish Sea with a special focus on the Lummi Sea Pond which has become an invasion hotspot of note. Originally designed to enhance aquaculture production this artificial enclosure now boasts some of the highest densities of EGC on the west coast of North America. Again, Bobbie spoke of the importance of this area for their Tribe and the resources in the area being impacted, especially bivalves, Dungeness crab, and eelgrass. As with Makah, the Lummi Nation has initiated a large-scale trapping program to remove EGC from the system and to monitor crab numbers outside of the Sea Pond. Removal efforts have been spectacular but the threat remains. The shallow, warm conditions of the Sea Pond make it an ideal incubator for young EGC so removal efforts are ongoing and linked to other efforts in Washington State. The next speaker, Brain Turner (USA) further elaborated on some of these efforts. He noted the history of the Emergency Measures introduced by the Governor of Washington State that allocated considerable funding to combat the imminent threat posed by EGC in state waters. One of the major activities was to establish a Research Task Force to identify critical information gaps and methods to fill them. The ultimate plan is to be able to transition from Emergency Measures to ongoing EGC Management by 2025.

After the afternoon break and a chorus of Happy Birthday, Lisa Watkins (USA) introduced participants to the Washington Crab Team's extensive monitoring work. This citizen science volunteer effort is aimed at engaging local stakeholders in the early detection of EGC throughout coastal Washington State. The network has more than 260 trained volunteers that are doing trapping, moult searches, and shoreline evaluations several times per year. The basis of this program is the need for citizen science to inform management decision-making via better data, advocacy and education, and mutual trust. Monitoring includes recording data not just on EGC but also on all other species collected, leading to better volunteer engagement and education in areas where EGC has not yet been found, and to a richer data set that can be used for a range of research questions (and was the foundation for Ben Rubinoff's research, described in an earlier talk). Interestingly, this network has found not only EGC but also *Palaemon macrodactylus*, another invader in the area highlighting this type of engagement can have additional value-added. The next speaker, Rikke Jeppesen (USA) presented a novel aspect of invasion science: the potential implications of a recovering top predator (sea otters) on invasive EGC populations in Elkhorn Slough, CA. Like elsewhere along the west coast of North America, sea otter were extensively over-harvested causing drastic population collapses. Conservation efforts have seen the species recover in some areas although coastwide recovery is still a ways away! Interestingly Rikke was able to show that in parts of the Slough where otter populations are high, EGC populations are contained and where otter populations are low EGC are doing quite well. The intersection of conservation management and invasive species management is new but this work suggests that it may be possible to strategically manage for multiple goals if the objectives are clearly identified. This led to two additional talks about the need for clearly setting management objectives and how to improve decision support. The first, Ted Grosholz (USA), suggested the invasion community needs to do a better job of characterizing the relationship between ecosystem impacts and invasive species density that removes the context-dependency so often embedded in these studies. His analysis suggested that this relationship might not be as context dependent as the literature suggests and that new research should aim to improve our understanding of invasion impacts based on the size of the invading population rather than the broad ecosystem characterization that is more common. Following this, Abby Keller (USA) then introduced the audience to the Resist vs. Accept Framework. This theoretical modeling approach is meant to optimize decision making and identify thresholds beyond which continued investment of resources is unlikely to result in change such that stakeholders should learn to live with the outcome even when it is less than desirable. One challenge of this approach for invasive species management is that the outcomes are far from certain and so managers need to use caution in setting the threshold between resisting and accepting as there are some schools of thought that suggest marine invasions are virtually impossible to manage effectively! The final speaker of the day was Sean McDonald (USA) who suggested that invasive species research has become increasingly siloed and ultimately less effective for meeting management needs (although see talks by Therriault and Turner). This has been characterized by some as the Knowing-Doing Gap. Given that invasions are predicted to continue and increase globally and that resources will always be limiting, it is imperative that scientific research focus on those topics that are most likely to inform management decisions. Ideally this would be done in collaboration with Indigenous

communities and stakeholders such that the priorities are mutually agreed-upon and clearly articulated, and that everyone knows how the results can and will be used.

Following the invited and contributed oral presentations there was time allocated to discussing invasive species management challenges (recognizing most participants were west coast EGC experts). Overall, session participants agreed that engagement with Indigenous communities was critical and ultimately management success will depend on their continued collaboration on management measures. Although there has been considerable effort in both Canada and the USA to better understand EGC invasion dynamics along the west coast of North America, there are several major gaps that remain. For example, we have yet to identify management thresholds that could be used to either initiate a control effort or identify when control efforts should be changed or abandoned. Like other invaders, the ECG invasion along the Pacific coast of North America has several elements of context-dependency but there are promising tools and approaches that can be used to make larger-scale ecosystem comparisons and learn from others undertaking detection, control, or management efforts. The co-convenors concluded the session by noting EGC technical discussions would continue the next day and that AP-NIS had planned to hold a broader session on AIS in the Pacific at the next PICES Annual Meeting.

**Photo:** Session 6 participants

## Session 7: BIO/POC/MONITOR Topic Session

### Ocean acidification and deoxygenation in ocean margin ecosystems: causes and consequences for ecosystems and fisheries

**Convenors:**
Tsuneo Ono (Japan), Alexander Kozyr (USA)

**Background**

Ocean acidification and deoxygenation are well documented in open ocean waters, but also affect ocean margins including coastal waters. The causes of these changes, however, are far more complex than in open ocean waters. Interaction of open ocean waters and coastal waters along ocean margins creates further complex variations, most of which have not been well documented by current ocean monitoring. Responses of ocean margin ecosystems to acidification and deoxygenation can also be different from the open ocean because species in ocean margin ecosystems are adapted to a wide range of natural pH/oxygen variation. Complex water-mass dynamics along ocean margins can also generate locally-specific pH/oxygen environments, that can either act as refuges or as areas of enhanced impact. This session aims to gather information on observed or projected changes in pH and oxygen concentration on ocean margins including coastal areas, its causes and interaction with the open ocean, biological responses, and consequences to fisheries.

**List of papers**

*Oral presentation*

1. A century of change in the California Current: Quantifying the impact of anthropogenic climate change on ocean acidification. Mary Margaret Stoll, Curtis Deutsch, Hana Jurikova, James Rae, Anne Gothmann, Simone Alin, Alex Gagnon.
2. Spatiotemporal variability of exposure to low pH conditions in the central California Current region. Jerome Fiechter, Julia Cheresh.
3. Buffering capacity minima in coastal–estuarine waters: Implications for ocean acidification trajectories and ecosystem management. Simone R. Alin, Richard A. Feely, Brendan Carter, Samantha Siedlecki, Jan Newton, Jeannette E. Waddell, Ervin "Joe" Schumacker.
4. Oceanographic observations in and around Gwaii Haanas, Haida Gwaii, British Columbia from 2016 to 2022. Jennifer M. Jackson, Amanda Timmerman, Alex Hare, Andrea Hilborn, Sarah Rosen, Charles G. Hannah, Stephen Page, Skil Jaada, Lynn Lee.
5. A coupled circulation-biogeochemical model to study deoxygenation in the Canadian Pacific continental margin. Angelica Peña, Isaak Fine, Di Wan.
6. High-resolution climate projections of ocean acidification for the main Hawaiian Islands. Lucia Hosekova, Tobias Friedrich, Brian Powell, Guangpeng Liu, Jacob Gunnarson, Malte Stuecker.
7. The diel and seasonal heterogeneity of carbonate chemistry and dissolved oxygen in three types of macroalgal habitats. Huiru Li, Hanbi Moon, Ju-Hyoung Kim, Haryun Kim
8. Coastal hypoxia in Pearl River estuarine waters: Why isn't it worse?. Kedong Yin, Jiangzhang He.
9. Skillful multiyear prediction of marine habitat shifts jointly constrained by ocean temperature and dissolved oxygen. Zhuomin Chen, Samantha Siedlecki, Matthew Long, Colleen Petrik, Charles Stock, Curtis Deutsch.
10. Inshore hypoxia alters abundance and distribution of zooplankton in the northern California Current. Elena Conser, Moritz S Schmid, Su Sponaugle, Robert Cowen.
11. In situ observations of zooplankton show changes in abundance and swimming speed in response to environmental stress. Amy C. Wyeth, Daniel Grünbaum, Julie E. Keister, Deana Crouser.
12. Effects of ocean acidification on plankton in the Salish Sea. Karyn Suchy, Debby Ianson, Susan Allen, Jan Newton, Simone Alin.
13. Impacts of ocean acidification and deoxygenation on zooplankton communities in an estuarine fjord. Haila Schultz, Julie Keister, Jan Newton, BethElLee Herrmann, Olga Kalata, Ali Chase.

14. Acidification effects on Dungeness crab: Experiments, models and population uncertainty. Paul McElhany, D. Shallin Busch, Mike Maher, Danielle Perez, Kate Rovinski.
15. Modeling ocean acidification in the Bering Sea to support long-term planning and management of the largest U.S. Fishery. Darren J. Pilcher, Jessica N. Cross, Elizabeth Siddon, Esther Kennedy, Linquan Mu, Natalie Monacci, Kelly Kearney, Albert Hermann, Wei Cheng.

*Poster presentation*

1. Observing ocean acidification for Alaska's fisheries. Natalie M. Monacci; A. Andrews; S. Bell; J.N. Cross; B. Ferriss; J. Keister; W.C. Long; E. Kennedy; C. Mordy; L. Mu; D. Pilcher; S. Porter; E. Siddon; A. Spear; P. Stabeno; F. Teevan-Kamhawi.
2. Mapping of deoxygenation trend in the subsurface waters of the East China Sea. Tsuneo Ono.
3. (**Cancelled**) Vertical distribution of fish larvae, in the oxygen minimum zone off southern México (December 2020). Sylvia P.A. Jiménez-Rosenberg; L. Sánchez-Velasco; F.J. García-De León; E.D. Ruvalcada-Aroche; E.

## Session 8: MEQ Topic Session

### Session on the Occurrence and Ecological Impact of Emerging Pollutants in the Coastal Marine Environment

**Convenors:**
Guangshui Na (China), Ning Liu (Korea), Yegor Volovi (Japan), Peter Kershaw (U.K.), Ruijing Li (China)

**Background**

United Nations Decade of Ocean Science for Sustainable Development (202-2030) make "Clean Ocean" one of its priority development areas, which includes identifying, quantifying and reducing pollution sources and removing pollutants from the ocean. The Session on the Occurrence and Ecological Impact of Emerging Pollutants (Persistent Toxic Substance, Resistance Gene and Marine Debris, et al.) in the Coastal Marine Environment has the following 2 objectives: First, to review the situation and to discuss the information gap and deficiencies in occurrence and evaluation on the emerging pollutants and its impact on marine ecosystem in the North Pacific. Second, to exchange the new technique and methodology for monitoring and assessment of emerging pollutants, and to discuss the development trends and research priorities. The main topics of the Session include the following: () The current situation of emerging pollutants on marine ecosystems in North Pacific. (2) The new technique for the analysis of emerging pollutants in marine environment. (3) The assessment on the ecological impact of emerging pollutants. The Session will invite experts in the relevant field, and welcome the reports on the research and progress in the above topics.

**List of papers**

*Oral presentation*

1. (**Invited**) Paradigm shift for environmental and biological monitoring with a focus on the OPFRs. Jae-Eun Lim, Hyo-Bang Moon.
2. Global Eutrophication Watch: A cost-effective interactive assessment of coastal eutrophication on the cloud. Genki Terauchi, Joji Ishizaka.
3. An overview of microplastic pollution in the North Pacific region. Chengjun Sun, Jennifer M. Lynch, Matthew S. Savoca, and Won Joon Shim, Amy V. Uhrin.
4. Emerging contaminants of concern, new Persistent Organic Pollutants and Polycyclic Aromatic Hydrocarbons (PAHs) in endangered southern resident killer whales (Orcinus orca) from the Northeastern Pacific. Kiah Lee, Stephen Raverty, Paul Cottrell, Lauren Cottrell, Brendan Cottrell, Dana Price, Zeinab Zoveidadianpour, Juan José Alava.
5. (**Cancelled**) Behavior of antibiotic resistance genes in the pristine environment: A case study in Ny-Alesund of Arctic. Guangshui Na, Qin Shu, Hui Gao, Ruijing Li, Shuaichen Jin.
6. Toxic effects of single and combined exposures to nanoplastics and bisphenol A on the marine medaka. Fuwei Yu, Ying Wang, Fei Jin, Yi Cong, Jingwen Chen, Juying Wang.
7. Identifying the external N and Hg inputs to the Geum Estuary along the Yellow Sea in Korea. Haryun Kim, Hae Sun Kim, Tae-Wook Kim, Seung Hee Han.
8. Arctic Ocean sediments plays a role as important current and future sinks for marine microplastics missing in the global microplastic budget. Seung-Kyu Kim, Ji-Su Kim, So-Young Kim, Nan-Seon Song, Heoung Sul La, Eun Jin Yang.
9. Distribution and sources of microplastics in the Beibu Gulf using in-situ filtration technique. Zuhao Zhu, Kazi Belayet Hossain, Huihua Wei, Renming Jia Xiaofeng Gao, Haiyan Jin, Xingyong Xu, Minggang Cai.

*Poster presentation*

1. Green tide development associated with submarine groundwater discharge and land-based aquaculture farm effluent in the Bangdu bay, Jeju, Korea. Taehee Lee; Young Baek Son; Hyung Jeek Kim.

2. Timing of changes in phytoplankton communities and attachment to plastic plates after nutrient addition in mesocosm experiments. Seung Ho Baek; Chung Hyeon Lee; Young Kyun Lim; Ji Nam Yoon.
3. Weathering extent and further fragmentation potential of microplastics in environmental samples. Jun-Hyuk Shin; Zhexi Tian; Ji-Su Kim; Seung-Kyu Kim.
4. Fate and mass budget of microplastic in the Beibu Gulf, the Northern South China Sea. Xingyong Xu; Zuhao Zhu; Kazi Belayet Hossain; Huihua Wei; Renming Jia; Xiaofeng Gao; Haiyan Jin; Minggang Cai
5. Assessing potential drivers for microplastic ingestion by myctophids caught near the Columbia River mouth. Olivia Boisen; Scott Heppell; Susanne Brander; Richard Brodeur.
6. Integrated numerical modeling of multi-fraction sediment and radioactivity transport in the West Sea of Korea. Kyung Tae Jung; Kyeong Ok Kim; Chang-Wook Park; Kyong-Hwan K.
7. Establishment of a safety management system for marine biotoxins: Tetrodotoxin. Nobuhisa Kajino; Hyun-Ki Hong; Bong Ki Park; Hyung-Bae Jeon; Jihyun Lee; Wan-Ok Lee; Kwang-Sik Choi.

## Session 9: BIO/FIS Topic Session

### Understanding the implications of body size change for stock productivity and fisheries management

**Convenors:**
Shin-ichi Ito (Japan), Paul Spencer (USA), John Morrongiello (Australia), Chenying Guo (ECOP, China)

**Background**

Everyone loves photos of the big fish that didn't get away. However, warming oceans often mean that young fish grow more quickly but reach smaller adult sizes. This equates to a loss of yield in commercial fisheries. Scientists are working together to assess the magnitude of the shrinking fish problem in different regions and determine what this means for sustainable fisheries management now and in the future. Warming seas can affect fish body sizes, with major implications for size-structured marine ecosystems, species interactions and fisheries productivity. Synchronous shifts toward smaller adult body sizes in marine fish have already been detected in several rapidly warming areas. Yet, the mechanisms underpinning the temperature size rule (TSR; higher temperatures result in smaller body sizes) remain debated and most fisheries models do not routinely account for the expected temperature-dependent trends in growth. Understanding the impacts of temperature-driven changes in body size on reproduction and maturity is critical if we want to predict shifts in stock productivity. Novel monitoring programs are needed to provide managers with the appropriate information to detect and quantify any body size change that is occurring. Lastly, fisheries management plans need to adequately account for the implications of shifting fish body sizes and ensure harvest strategies are flexible enough to ensure stock productivity in a rapidly changing world. We propose a session that will: ) synthesise ecological and empirical knowledge about trends in fish and other ectotherms' growth rates and body sizes, and how this can be incorporated into monitoring programs; 2) explore the utility of new assessment models that allow for time-varying and environmentally driven trait parameters 3) assess the potential impacts of temperature-induced body size change on fisheries yields in the future ocean 4) Discuss management options to addressing the impacts of rapid temperature-induced changes in stock productivity.

**List of papers**

*Oral presentation*

1. (**Invited**) Non-linear growth-temperature relationship leads to opposite response to warming in cold versus warm populations. Max Lindmark, Jan Ohlberger, Anna Gårdmark.
2. (**Cancelled**) Emerging changes in size structure and overwintering success for juvenile Pacific cod (*Gadus macrocephalus*). Benjamin J. Laurel, Mary Beth Rew Hicks, Steven Barbeaux, Louise A. Copeman.
3. Comparison of juvenile Pacific salmon abundance, distribution, and body condition between Western and Eastern Bering Sea using spatiotemporal models. Aleksey Somov, Edward V. Farley, Jr., Megan V. McPhee, Ellen M. Yasumiishi.
4. Spatiotemporal trends in weight and its potential implications for stock assessments. Andrea N. Odell, Marissa L. Baskett, Kristin N. Marshall.
5. Mechanisms of change in weight-at-age in Gulf of Alaska groundfish and forage fish under warming: Insights from an ecosystem model. Alberto Rovellini, André E. Punt, Isaac Kaplan, Elizabeth Fulton, Kerim Aydin, Baptiste Alglave, Matthew Baker, Meaghan Bryan, Gemma Carroll, Bridget Ferriss, Melissa A. Haltuch, Adam Hayes, Albert Hermann, Elizabeth McHuron, Szymon Surma, Martin Dorn.
6. Fish weight reduction due to intra- and interspecific competition altered by climate change. Zhen Lin, Ito Shin-ichi.
7. Marine Heatwaves alter the size, age, diet, and growth of juvenile Pacific Cod in Gulf of Alaska nursery habitats. Hillary L. Thalmann, Benjamin J. Laurel, Jessica A. Miller.
8. The potential role of enhanced selective mortality during marine heatwaves. Jessica A. Miller, L. Zoe Almeida, Hillary Thalmann, Rebecca Forney, Ben Laurel.

9. Can the temperature size rule help us predict fisheries productivity in a changing climate?. Jennifer Bigman, Benjamin Laurel, Krista Oke, Lewis Barnett, Kelly Kearney, Wei Cheng, Darren Pilcher, Al Hermann, Kirstin Holsman, Lauren Rogers.
10. Deciphering the molecular basis of temperature-induced growth changes in Pacific halibut (*Hippoglossus stenolepis*) to improve our understanding of growth variation in a changing North Pacific Ocean. Josep V. Planas, Andrew Jasonowicz, Anna Simeon, Crystal Simchick, Dana Rudy, Emma Timmins-Schiffman, Brook L. Nunn, Anita Kroska, Nathan Wolf, Thomas Hurst.
11. Climate, fish body growth, mortality, and fisheries management for Korea chub mackerel. Saang-Yoon Hyun, Jinwoo Gim, Heejoong Kang.
12. Implications of changing body size in Chinook salmon for population productivity and fishery management. Jan Ohlberger, Daniel Schindler, Ben Staton.
13. Fish grow faster to a smaller size under intense exploitation and warming waters with mixed impacts on fishery productivity in China. Cody Szuwalski, Alice Lee, Lee Qi, et. Al.
14. Effects of faster growing on fisheries management reference points. Fan Zhang, Jiangfeng Zhu.
15. Operationalizing the impact on stock assessments of size-selective fishing's effect on body size. Richard Methot, Ian Taylor, Richard McGarvey.
16. Best practices for modeling time-varying growth in state-space stock assessments. Cole C. Monnahan, Giancarlo M. Correa, Jane Sullivan, James T. Thorson.
17. Modeling spatial and temporal growth patterns with single- and multi-area fisheries stock assessment models. Paul D. Spencer, Carey R. McGilliard, Meaghan D. Bryan.
18. Changes in copepod size in response to warm and cold conditions during spring in the Eastern Bering Sea. Deana C. Crouser, Jan Ohlberger, Grant Woodard and, David G. Kimmel.

*Poster presentation*

1. **(Cancelled)** (S9-P) (ECOP) Unveiling unselective fishing in China: A nationwide meta-analysis of multispecies fisheries. Ming Sun; Yunzhou Li; Yong Chen.
2. Development of a bioenergetics and population dynamics coupled model: A case study of chub mackerel. Ziqin Wang; Shin-ichi Ito; Itsuka Yabe; Chenying Guo.

**Photo 1**. Presentation of Jessica Miller, chaired by an ECOP convenor, Chenying Guo at S9

***The report below was modified from the article in the PICES Press 2024 Winter Issue.***

**Session 9 Overview**

The session had 1 invited talk, 16 contributed oral talks and 1 poster from delegates spanning a wide range of career levels, starting from recent Masters graduates to prominent researchers. The session had 10 presentations of ECOPs (Early Career Ocean Professional) including the invited presentation of Dr. Max Lindmark and a ECOP, Dr. Chenying Guo, co-convened the session. This article reports the session itself in addition to Chenying's participation in the session, including her impressions. The session attracted over 100 attendees.

1) ***Synthesize ecological and empirical knowledge about trends in fish***:
Max Lindmark proposed two important questions: "Physiological responses to warming are not linear?" and "Do responses to temperature differ among populations within species?". Max showed an example of the weight response of Eurasian perch monitored at 12 areas in the Black Sea, which include two areas artificially warmed by discharge from nuclear power plants. The unusually large temperature gradient demonstrated non-linear temperature effect on the weight: positive (negative) temperature effects on growth in the coldest (warmest) area. Deana Crouser reported the size decline of large copepods in the Bering Sea and hence biomass of them which potentially influence the fish production in the area. Andrea Odell investigated the effect of data sources on characteristics of weight-at-age variation using weight-at-age data of Pacific Hake and showed some inconsistency due to sampling biases, which indicates importance of modeling application to reduce the effects of the sampling biases. Zhen Lin demonstrated synchronized fish weight decline in the western North Pacific in 1980s and 2010s with a strong influence of density effects. Cody Szuwalski presented historical data reconstruction which were surveyed from literatures over 1500 entries spanning 89 species. Sufficient data were available for 4 species and the analysis revealed increasing growth rates, smaller maximum sizes, and increases in natural mortality for the 50 years. These changes have resulted in increases in productivity as seen through yield per recruit for some stocks and decreases for others.

2) ***Explore the utility of new assessment models***
Aleksey Somov applied Vector Autoregressive Spatio-Temporal package (VAST) to standardize and interpolate the data of salmon juveniles in the Western and Eastern Bering Sea and found out stronger impacts of temperature on salmon juveniles in the Eastern Bering Sea. Alberto Rovellini used a whole-of-ecosystem model ATLANTIS to investigate the potential mechanisms to weight change of forage and ground fishes in the Gulf of Alaska and suggested that the decreased plankton productivity is a potential driver to decrease the fish weight reduction and ecosystem food web change. Josep Planas identified genes and proteins in skeletal muscle of halibuts responding to temperature-induced manipulation and developed molecular assays to measure the growth marker genes in skeletal muscle which can be applied to the wild fishes. Saang-Yoon Hyun applied a state-space length-based assessment model to chub mackerel as a framework to explore the effect of warming on yield-per recruitment and optimal fishing intensity. Richard Methot presented about the Stock Synthesis (SS3) assessment program which incorporated size-selective fishing effects. Richard reported that the SS3 approach is also able to estimate the correct average maximum size of fish in the population, while also estimating the realized average size after the effect of size-selective fishing. Cole Monnahan introduced the Woods Hole Assessment Model (WHAM) platform which expanded the applicability of state-space assessment models by including size-specific data and modeling mean size and weight-at-age. The WHAM is still on the development stage but it should be valuable for stocks where length data are a key source of information, variation in growth is an essential part of the dynamics of the assessed stock, or when linking climate variables to growth in hindcasts or forecasts is relevant. Paul Spencer compared how complex spatial growth patterns can be accounted for with either spatially-structured assessment models which internally estimate growth parameters, or simpler one-area models in which spatially-averaged estimates of size at age are estimated outside the model. The results suggest that complex interactions between spatial and temporal patterns may be better addressed with multi-area models.

3) ***Assess the potential impacts of temperature-induced body size change on fisheries yields***
Hillary Thalmann showed the marine heatwaves (MHWs) influences on juvenile Pacific cod diets and growth. The fish were larger and older during MHWs and growth was moderately faster during MHWs which indicated additional drivers such as size-dependent selection in the nursery. Jessica Miller suggested greater size-selection during MHWs and importance of change in selection intensity as a potential mechanism contributing to changes in

age and size associated with warming using the same dataset of Hillary. Jennifer Bigman investigated temperature and oxygen influences on weight-at-age of fished in the Gulf of Alaska and found consistent temperature and oxygen influences on species but complexity in the temperature size rule to predict fisheries productivity. Ziqin Wang introduced a bioenergetics – population dynamics coupled model to investigate impacts of environments on fish growth and population.

4) ***Management options to addressing the impacts of rapid temperature-induced changes in stock productivity***
Jan Ohlberger showed a case study on Chinook salmon and suggested importance of accounting for demographic trends when estimating reference points to improve management performance and reduce conservation risks. Jan also suggested that conservation of population demographic structure may be critical for sustaining productive fish populations. Fan Zhang demonstrated effects of increased body growth and earlier maturation on MSY-based reference points (BMSY and FMSY), unexploited reference points (B0) and yield-per-recruit reference points (FMAX) using bigeye tuna as an example. The highlighted the importance to consider changing population vital rates and non-stationary population dynamics when implementing reference points in fisheries management.

**Conclusions**
A series of the presentations providing the evidence of importance of temperature impacts on growth, body size, survival, food availability, maturity and reproduction, which are critical for predict shifts in stock productivity. The session also indicated importance of long-term novel monitoring to detect and quantify body size change which should be shared with managers. Facing to global climate change, fisheries management plans need to adequately account for the implications of shifting fish body sizes. In addition, harvest strategies should be flexible enough to ensure stock productivity facing to increasing extreme events

**Photo 2**. WG-GRAFY (Impacts of Warming on Growth Rates and Fisheries Yields) dinner at Seattle.

**Impression of S9 by Chenying Guo (a ECOP co-convenor)**

It is not the first time I participate in PICES, but it was my first time serving as a convenor for an international science meeting. I co-convened the Session 9, which aimed to understand the implications of body size change for stock productivity and fisheries management. In this report, I will reflect on my first experience as a convenor, highlighting the main challenges, achievements, and lessons learned from the meeting.

I am profoundly grateful for Drs. Paul Spencer, John Morrongiello and Shin-ichi Ito inviting me as an ECOP convener. Compared to other co-convenors, I had less experience in drafting session proposals and inviting the speakers. I participated in the discussion via email but still felt that I made a limited contribution to this session. On the other hand, I realized that improving the ability of synthesizing a session topic, as well as building a broad network with researchers of various backgrounds, was important and beneficial for a scientist in early career.

The next challenge was preparing the agenda and rating the ECOP Financial Support Priority. I really appreciated that I received the financial support for PICES meeting when I was a student. Therefore, I knew the importance of financial support to ECOPs, especially for those who had no or few budget for international meeting. I rated the priority cautiously, to make sure more ECOP could get opportunities to share their results in PICES meeting without heavy financial burdens. It was a challenging work for me at the first time. Making presentation schedule was also a challenge. The order of the presentation could be decided by research target, area, method, etc., but it would be complicated if you were considering two or more features of an abstract. After reading through all the abstracts submitted to S9 and discussing with other convenors, we decided the presentation order by observations, modeling, stock assessment.

As an extension of ICES/PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields (WGGRAFY), many S9 presenters had known each other before and set up a cooperative relationship before PICES meeting. To increase the opportunities for communication, as well as greeting people who were new to S9, we convenors organized a dinner before session 9. Although I did not participate in WGGRAFY before, I got familiar with S9 members and knew more details about their research, which helped me moderating the presentations in S9.

The timetable of S9 was divided into 4 parts, and I chaired the part after morning coffee break and afternoon coffee break. Although I was nervous, I tried my best moderating the presentations and discussions and managing the time constraints. Our sessions attracted a diverse and engaged audience, with lively discussions and feedback from the participants. I learned a lot from the session members, speakers, and attendees, who shared their knowledge, insights, and experiences on temperature size rule and the effect of climate change on fish growth as well as fisheries. I also gained valuable skills and confidence in leading and facilitating scientific sessions. However, I also realized that there is room for improvement, for example, adding a summary of the main points and recommendations by the end of the oral presentation. I believe I could do better next time.

Chenying Guo (guochenying@scsio.ac.cn) is a Postdoctoral fellow in State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Sciences. She conducted laboratory experiments for fish swimming and respiration and built up a growth-migration model of fish species based on the experiments. Chenying is an ECOP in PICES.

## Session 10: MONITOR Topic Session

### Improved detection and understanding of factors affecting changes in North Pacific forage communities and implications to ecosystems

**Convenors:**
David McGowan (USA, ECOP), Matthew Baker (USA), Jennifer Boldt (Canada), Akinori Takasuka (Japan), Motomitsu Takahashi (Japan)

**Background**

Forage species serve an important intermediate trophic role in marine ecosystems, yet an understanding of how they drive trophodynamics in the North Pacific remains poorly known. The species composition, condition, and availability of forage species to predators can be sensitive to physical and biological changes and variable production at lower trophic levels. Forage populations are prone to large variations in production, which can affect their availability to predators. North Pacific forage species include both commercially and non-commercially exploited taxa including small pelagic fishes (e.g. herring, sardines, anchovies, smelts, and sand lance), early life stages of groundfish, salmon, and crabs, mesopelagic fishes, and other important invertebrates (e.g. squids, euphausiids). In marine ecosystems where the most abundant forage species are unexploited taxa or life stages, detecting changes in species composition, abundance, and distribution is often particularly challenging due to a lack of directed monitoring, and may have profound ecological and socio-economic impacts at the ecosystem level. An improved understanding of how changes in the abundance and distribution of unexploited forage species impacts exploited species and other predators is critical for commercial interests, as well as for economic and food security of Indigenous and coastal communities in the North Pacific. This session welcomes contributions focused on: . Improvements in monitoring and data synthesis of forage species – particularly unexploited taxa and life stages – such as integrating multiple data sources (surveys, predator diets), gear modifications for improved retention of forage species, advances in monitoring tools (biogeochemical and genetic analyses, autonomous vehicles), and inclusion of traditional or local ecological knowledge; 2. Describing changes in forage communities and impacts on predators; 3. Advances in knowledge about interspecific interactions and bottom-up and top-down processes that affect forage species used to inform ecosystem-based fisheries management or reduce uncertainties in stock assessments and population forecasts of exploited species.

**List of papers**

*Oral presentation (Day 1)*

1. (**Invited**) Consideration of the population dynamics of sardines in the western and eastern North Pacific on the basis of isotope chronologies. Tatsuya Sakamoto.
2. Tradeoffs between shifts in phenology and geography among early life history stages of fishes in response to environmental changes in the Eastern Pacific. Katherine Dale, Lorenzo Ciannelli, Jerome Fiechter, Mercedes Pozo Buil, Rubén Esteban García Gómez, Sylvia P. A. Jiménez-Rosenberg, Gerardo Aceves-Medina, Andrew Thompson, John C. Field, Toby Auth, R. Ian Perry, Lauren Rogers, Rebecca Howard, Rebecca Asch.
3. Widespread shifts in phenology of fish early life stages associated with warming in Alaska. Lauren A. Rogers, Kelia Axler.
4. Genetic identification of early larvae of grenadiers (family Macrouridae) in the Bering Sea and Gulf of Alaska and spatial modeling of larval transport in the Bering Sea. Melanie M. Paquin, Morgan S. Busby, Wei Cheng, Carol Ladd, Ashlee A. Overdick, Edward D. Cokelet, Phyllis J. Stabeno.
5. Mapping the distribution of forage fish in coastal British Columbia using environmental DNA. Loïc Jacquemot, Colleen T.E. Kellog, Matthew A. Lemay, Rute Clemente-Carvahlo, Shaorong Li, Angela Schulze , Kristi Miller-Saunders, Brian P.V. Hunt..
6. It is worse than you think: Implications of spatial and trophic overlap between juvenile salmon and sablefish in the inshore surface waters of the Northern California Current. Elizabeth A. Daly, Brandon E. Chasco, Cheryl A. Morgan, Brian J. Burke, Kaitln E. Osborne.

7. Toward identifying the critical ecological habitat of larval fishes: An environmental DNA window into fisheries management. Erin V. Satterthwaite, Andrew E. Allen, Robert H. Lampe, Zachary Gold, Andrew R. Thompson, Noelle Bowlin, Rasmus Swalethorp, Kelly D. Goodwin, Elliott L. Hazen, Steven J. Bograd, Stephanie A. Matthews, Brice X. Semmens.
8. Expanding perspectives in marine mammal research: Leveraging eDNA metabarcoding for enhanced understanding of three-dimensional species distribution. Tania Valdivia Carrillo, Amy Van Cise, Kim Parsons, Megan R Shaffer, Ally Im, Ryan Kelly.
9. Using environmental DNA to reveal the influence of environmental factors on the forage fish community compositions. Xueding Wang, Zeshu Yu, Marty Kwok-Shing Wong, Jun Inoue, Susumu Hyodo, Higuchi Tomihiko, Atsushi Tsuda, Shin-ichi Ito.
10. Metabarcoding analysis on trophic sources of mesozooplankton during spring phytoplankton bloom in the neighboring waters of the Kuroshio Current. Ayane Taniguchi, Toru Kobari, Gen Kume, Mutsuo Ichinomiya, Tomohiro Komorita, Junya Hirai.
11. Gelatinous zooplankton prey is important for supporting early survival and growth of skipjack tuna in the western North Pacific Ocean. Toru Kobari, Kotone Yamaguchi, Yayoi Yamada, Mai Yamashita, Gen Kume, Katsuya Kumura, Yuichi Tsuda, Hidetoshi Kiyofuji.
12. Dietary and spatial overlap among jellyfish and small pelagic fish in the eastern Bering Sea during warm ocean conditions. Mary Beth Decker, Richard Brodeur, Emily Fergusson, Wesley Strasburger, Kristin Cieciel.
13. Species composition of mesopelagic fish catches in the coastal NE Pacific Ocean and the presence of potentially indigestible lipids. Catherine J. Stevens, Stéphane Gauthier, John F. Dower, Micah Quindazzi, El Hobson, S. Kim Juniper.
14. Using marine fatty acid data to estimate the nutritional quality of micronektonic organisms in the British Columbia coastal ocean. Dilan Sunthareswaran, Anna K. McLaskey, Ian Forster, Brian P.V. Hunt.
15. Patterns in nutritional traits across environmental conditions in the North Pacific. Alana M. Krug-MacLeod, Elan J. Portner, Miram R. Gleiber, Natasha A. Hardy, Zachary Roote, C. Anela Choy, Larry B. Crowder, Stephanie J. Green.
16. Assessing the influence of starvation mortality relative to advective losses across El Niño and La Niña years for an ecologically important fish of the California Current System. Mark Matthew Morales.
17. Alternative management strategies for forage fish communities: Implications for dependent predators and fishers under climate change uncertainty. Pierre-Yves Hernvann, Isaac C. Kaplan, Barbara Muhling, Stefan Koenigstein, Robert P. Wildermuth, Elizabeth A. Fulton, Felipe Quezada-Escalona, Nerea Lezama-Ochoa, Peter Kuriyama, Owen R. Liu, Desiree Tommasi.

*Oral presentation (Day 2)*

18. (**Invited**) Persistent spatiotemporal patterns between seabird and small pelagic fish communities provide early indications of ecosystem change. Mayumi Arimitsu, John Piatt, Jim Thorson, Suzann Speckman, Sarah Schoen, Caitlin Marsteller, Sam Stark.
19. Sampling North Pacific forage fishes with midwater trawls: behavior observations, retention, and other considerations. Kresimir Williams, David McGowan.
20. How accurately and precisely can fisheries-independent surveys assess phenological change among forage fishes? Rebecca G. Asch, Katherine E. Dale, Lorenzo Ciannelli, Toby D. Auth, John C. Field, Mary E. Hunsicker, Michael G. Jacox, Sylvia P. A. Jiménez-Rosenberg, R. Ian Perry, Lauren A. Rogers, Andrew R. Thompson, Brian K. Wells.
21. Using predator diets to inform forage fish distributions and interannual trends. Kayla Gunther, Matthew Baker, Kerim Aydin.
22. A model-based approach to improve estimates of distribution and abundance for data-limited forage species. David McGowan, Darin Jones, Kresimir Williams.
23. Integrating survey data to explore if Pacific hake diets reflect variation in the prey community of the California Current Ecosystem. Elizabeth M. Phillips, Alicia Billings, Julia Clemons.
24. Effects of Distribution and Abundance of Small Pollock on Fish Predators and Northern Fur Seals. Ivonne Ortiz, Kirstin Holsman, Kerim Aydin, Elizabeth McHuron, Jeremy Sterling, Nicholas Bond.
25. Pacific salmon trophic interactions in the subarctic gyres. Szymon Surma, Evgeny A. Pakhomov, Brian P.V. Hunt,, Genyffer C. Troina, Joanne Breckenridge, Kerim Y. Aydin.

26. (**Cancelled**) Ecosystem models to evaluate the role of trophic vertical exchange processes on forage and predator productivity within oceanic ecosystems. Jim Ruzicka, Stacy Calhoun-Grosch, Jesse Van Der Grient, Jacob Snyder, Réka Domokos.

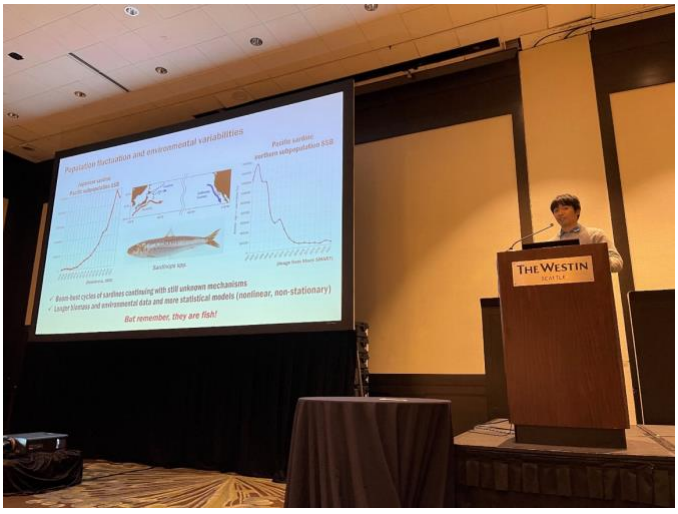
*Poster presentation*

1. Growth and food requirement of chub mackerel Scomber japonicus larvae in the northern Satsunan area, southern Japan. Hiroki Oba, Toru Kobari, Taichi Shigemura[3], Kazuhiro Shiozaki, Mutsuo Ichinomiya, Tomohiro Komorita[4] and Gen Kume.
2. (**Cancelled**) Did Southeast Alaska provide refuge for juvenile salmon during recent marine heatwaves? Mariela K Brooks, Emily Fergusson, Matthew Rogers, Wesley W Strasburger and Robert M Suryan.
3. Shifts in the distribution, size structure, and feeding of Arctic cod early life stages in a changing Pacific Arctic. Kelia E. Axler Jesse F. Lamb, Esther D. Goldstein, and Alison L. Deary

***The report below was modified from the article in the PICES Press 2024 Winter Issue.***

**Session Overview**

During the 1.5 day session, there were 25 oral presentations (including two invited talks) and 2 poster presentations. Of these, there were 11 oral and 2 poster presentations by Early Career Ocean Professionals. On Day 1, conveners provided an introduction to the session, which was followed by an invited talk presented by Tatsuya Sakamoto, and then 16 oral presentations. On Day 2, Mayumi Arimitsu presented the second invited talk, followed by 7 oral presentations and a closing discussion. Oral and poster presentations covered most of those topics solicited. One gap that was not covered was the inclusion of traditional or local ecological knowledge to improve monitoring and data synthesis of forage species. A talk that would have addressed this topic was submitted and accepted to this session; however, the speaker was not approved for travel by their institute.





**Photos**: Tatsuya Sakamoto, Instituto Português do Mar e da Atmosfera (Portuguese Institute for the Sea and Atmosphere, IPMA), Portugal (left) and Mayumi Arimitsu, US Geological Survey Alaska Science Center, USA (right).

Session topics and main takeaway messages from S10 presentations:

1. Improvements in monitoring and data synthesis of forage species:
    a. integrating multiple data sources (surveys, predator diets)
        i. Spatio-temporal models can be used to integrate and account for differences among multiple surveys and account for variable sampling effort in space and time to estimate species abundance and distribution. This helps address questions about potential competition or predation interactions, shifts in spatial distribution and phenology, and the effects of climate change. In the California Current, spatio-temporal models of long-term larval fish sampling programs indicate that larval fish species navigate the tradeoff between shifting location vs phenology differently. Sea surface height and temperature were found to be important predictors of the center of gravity of some species, with species at lower latitudes more sensitive to shifts. In the Gulf of Alaska (GOA) and Eastern Bering Sea (EBS), larval groundfish size in late spring varied with temperature but there was no broad evidence for long-term trends in size-at-date. To improve estimates of abundance of data-limited, non-target forage species, spatio-temporal models that combined both acoustic and bottom trawl surveys were developed and compared to single survey (acoustic) methods. In the northern GOA, joint species distribution models of seabirds and forage fish reveal that seabirds have a strong response to forage fish density and distribution. Spatio-temporal models applied to trawl survey data provided insights into potential competitive interactions modulated by climate change. Climate driven increases in California Current coastal ocean temperatures could be changing juvenile sablefish distributions, resulting in higher spatial and trophic overlap that could negatively impact juvenile Pacific salmon through competition for food.
        ii. Ocean circulation model simulations used in conjunction with biological samples were used to determine likely origins and transport of larval grenadiers, a data-poor species. The impact of climate change on larval grenadier transport and the fact that larvae cross between multiple large marine ecosystems has implications for fisheries management.
        iii. The examination of the abundance and diets of fish and gelatinous organisms improves the understanding of trophodynamics of ecosystems in the context of increasing ocean temperatures. In the EBS, jellyfish and small pelagic fishes showed low spatial overlap, implying minimal competition in August; however, in areas of high overlap competition could be important in some months. Groundfish diets provide indicators of distribution and abundance of their prey (forage fish). In the EBS, northward movement of forage species and changes to predator-prey overlap were attributed to increased temperature. Off of the west coast of North America, Pacific hake acoustic survey data and hake diets provide indicators of euphausiid abundance and distribution.
        iv. Design- and model-based estimates were compared to understand the effects of survey design and timing on the ability to detect shifts in species phenology.
    b. gear modifications for improved retention of forage species,
        i. A combination of survey techniques and advanced technologies can leverage an existing survey to provide value-added estimates of forage fish. Pocket nets and a stereo camera were mounted on a trawl net used during an acoustic-trawl survey to inform selectivity curves and escapement and abundance estimates of forage fish species.
    c. advances in monitoring tools (biogeochemical and genetic analyses, autonomous vehicles), and
        i. Isotope analyses can improve the understanding of forage fish population structure and dynamics. For example Pacific Sardine eye lens isotope analyses can be used to test population structures and otoliths isotope analyses provide clues to growth rates. Early life history stages of sardine populations in the western and eastern North Pacific have different metabolic and growth rates corresponding to contrasting temperature variations, which could explain their opposing population abundance trends.
        ii. Indicators of prey quality include lipids, energy density and protein vary among species, life history stage, and region. Off the west coast of Canada and northern US, acoustic trawl surveys and fish lipid analyses revealed the quality of mesopelagic fish as prey. On a mass basis, myctophids contained more total lipid than any other fish family. However, some store lipids as wax esters, which poorly digested

and are associated with poor growth. In addition, interspecific and regional variability in fatty acid profiles of fish and invertebrates indicate trade-offs when consuming any single species.

iii. eDNA metabarcoding can be used to identify the presence of marine mammals and their prey species and the persistence and distribution of eDNA in the water in the California Current. eDNA metabarcoding can also improve the understanding of ecosystem trophodynamics. For example, copepods were identified as important hubs in the food web and that many omnivorous mesozooplankton groups are not strongly dependent on diatoms and dinoflagellates in neighboring waters of the Kuroshio Current. Metabarcoding of fish stomach contents can reveal the previously underestimated importance of some prey items. For example, this method revealed that protozoans and gelatinous zooplankton are major prey items of early life stages of skipjack tuna in the western North Pacific.

2. Describing changes in forage communities and impacts on predators;

   a. Several talks identified changes in the forage fish communities and potential interactions with and impacts on predators. For example, joint species models of seabirds and forage fish in the northern GOA indicated that more abundant seabird species require higher density patches of forage fish. In the EBS, the spatial overlap of small-sized Walleye Pollock and the foraging range of their predators, Northern Fur Seals, provides different and additional information on the dynamics of small pollock that informs an ecosystem-based approach to fisheries management.

3. Advances in knowledge about interspecific interactions and bottom-up and top-down processes that affect forage species used to inform ecosystem-based fisheries management or reduce uncertainties in stock assessments and population forecasts of exploited species.

   a. A mechanistic modeling framework was applied to identify the relative importance of food web-dependent vs. transport-dependent recruitment mechanisms modulated by environmental conditions.

   b. Ecosystem trade-offs can be explored under different management rules and climate change scenarios, with a climate-informed ecosystem management strategy evaluation using an Atlantis end-to-end ecosystem model.

   c. A suite of ecological metrics can be computed from Ecopath with Ecosim models to quantify Pacific salmon trophic interactions. Results suggest there are top-down impacts on salmon by sharks as well as intra- and interspecific competition among salmon in the North Pacific.

## Session 11: BIO Topic Session

### Anticipated and realized effects of climate change on predatory fish, birds, and mammals of the North Pacific

**Convenors:**
William Sydeman (USA), Elliott Hazen (USA), *corresponding*, Patrick O'Hara (Canada)

**Background**

Measurements and models tell us that Earth's climate is changing rapidly, yet the rates of change in warming as well as spatial shifts in isotherms (i.e., the "velocity of climate change"), vary among ecosystems of the North Pacific. Species responses to climate change vary in relation to life-history traits including foraging and migration ecology, which determine adaptive capacities (e.g., abilities to shift location or prey switch with changes in habitat). While there have been many species-specific assessments of responses relative to observational and predicted ocean change, the impact of climate change on complex ecological relationships (e.g., predator-prey dynamics) and ecosystem structure and connectivity is not well understood. Moreover, recent research has suggested that maintaining healthy top predator populations may help mitigate the effects of climate change on ecosystem functions. Therefore, for this session, we solicit interdisciplinary studies on observed or predicted climate change and responses of predatory fish, marine birds, and mammals. We will focus on how climate change is affecting the North Pacific's top marine consumers directly or indirectly through trophic interactions (for example, how metabolic changes in predatory fish may be making them more of less susceptible to changes in food resource availability). Transdisciplinary modeling and observational studies are encouraged.
List of papers

**List of papers**

*Oral presentation*

1. (**Invited**) Observed and projected changes in the North Pacific relevant to marine ecosystems. Nicholas Bond.
2. (**Invited**) Future changes in habitat suitability, foraging grounds, and energy dynamics of North Pacific albacore. Barbara A. Muhling, Stephanie Snyder, Jong-Yeon Park, Catherine F. Nickels, Rebecca Whitlock, Charles A. Stock, Elliott L. Hazen, Heidi Dewar, Desiree Tommasi, Barbara A. Block.
3. Applying traits to explore climate-driven variability in albacore tuna resource use in the California Current Large Marine Ecosystem. M. Gleiber, N. Hardy, P.Y. Hernvann, C. Morganson, C. Nickels, B. Muhling, E. Portner, B. Wells, R. Brodeur, T. Auth, J. Santora, S. Glaser, D. Madigan, E. Hazen, M. Jacox, S. Bograd, L. Crowder, S. Green.
4. (**Invited**) Long-term changes in the spatial distribution of Steller sea lions around Hokkaido Island, Japan. Kaoru Hattori, Takeomi Isono, Yoko Goto.
5. (**Invited**) Climate conditions mediate the costs and benefits of migration strategies in a North Pacific marine top predator, the northern elephant seal. Briana Abrahms, Elliott L. Hazen, Steven J. Bograd, Justin S. Brashares, Patrick W. Robinson, Kylie L. Scales, Daniel E. Crocker, Daniel P. Costa.
6. (**Invited**) Climate change in NW Pacific and prey and reproductive performance of surface feeding and diving seabirds. Yutaka Watanuki, Risa Sakai, Aya Kumagai, Jumpey Ookado, J.B. Thiebot.
7. Assessing seabird distributional shifts in response to climate change in the Gulf of Alaska and Bering Sea. Brian Hoover, Gammon Koval, William J. Sydeman.
8. Changes in North Pacific ocean conditions and seabird productivity understood through comparison to other northern hemisphere ecosystems. Helen Killeen, William J. Sydeman, Sarah Ann Thompson, Trond Kristiansen, Gammon Koval, Erendira Ceballos, Alexis De la Torre, Amelia Grevin, Brian Hoover, Marisol García-Reyes.
9. Projections of climate change impacts on California Current predators and food webs. Isaac C. Kaplan, Pierre-Yves Hernvann, Owen Liu, Chris Harvey, Karma Norman, Barbara Muhling, Desiree Tommasi, Jameal Samhouri.

10. Modeling resilience and its limits from phytoplankton to salmon: Learning from Atlantic–Pacific comparisons at four trophic levels. Neil S. Banas, Agnes Olin, Trevor Sloughter, Fabian Grosse, Graeme Diack, Emma Tyldesley, Aidan Hunter, Colin Bull.
11. Comparing functional diversity and redundancy with species diversity and turnover across scenarios to identify climate refugia for marine megafauna in the Northeast Pacific. Elena Gissi, Jamie McDevitt-Irwin, Kristin Kaschner, Kathleen Kesner-Reyes, Eliott Hazen, Rosalia Santoleri, Fiorenza Micheli.
12. The thermal corridor hypothesis: An experimental oceanographic approach to understanding the effects of ocean warming to North Pacific Loggerhead Sea Turtles. Bianca Santos, Dana Briscoe, George Balazs, Jeffrey Polovina, Jeffrey Seminoff, Alberto Abreu-Grobois, Masanori Kurita, Masanori Mori, Denise Parker, Marc Rice, Tomomi Saito, Calandra Turner Tomaszewicz, Noah Yamaguchi, Larry Crowder.
13. Examining distributional shifts of spawning and feeding migrations of Pacific cod in Alaska with Satellite popup tags. Susanne McDermott, Julie Nielsen, Charlotte Levy, Kimberly Rand, Liz Dawson.
14. Northward habitat expansion of whale shark (Rhincodon typus) in the Western Pacific region. Soeon Ahn, Dongwha Sohn.
15. Impacts of global warming on transport and dispersal of the Pacific bluefin tuna in early life stages. Kuan-Mei Hsiung, Yutaro Tonomura, Yoichi Miyake, Yulina Hane, Shingo Kimura.
16. Understanding factors influencing species sentinel ability for climate change, pollution nd human health. Elliott L. Hazen, Matthew S. Savoca, T.J. Clark-Wolf, Max Czapanskiy, Peter M. Rabinowitz, Briana Abrahms.

*Poster presentation*

1. The effects of climate change-induced environmental variability and fishing operation on the spatiotemporal distribution of bigeye tuna in the Pacific Ocean. Hongyu Lin, Jintao Wang, Jiang Feng Zhu, Xinjun Chen.
2. Climate-projected ecosystem responses in the Northern California Current Ecosystem: Insights from a climate and eco-physiology linked end-to-end model. Caren Barceló, James Ruzicka, Mike Jacox, Mercedes Pozo Buil, Jerome Fiechter, Pierre Yves Hernvann, Alberto Rovellini, Elizabeth Daly and Lorenzo Ciannelli.
3. (**Cancelled**) Evaluating trade-offs between management actions to prevent the decline of endangered resident killer whales and their salmon prey using multi-species ecosystem models. Vivitskaia J.D. Tulloch, Cathryn C. Murray, Hem N. Morzaria-Luna and Tara G. Martin.
4. Connectivity of sea turtles in Jeju Island of Republic of Korea to the populations in the Western Pacific. Sook-Jin Jang, Kyungsik Jo, Soojin Jang, Hideaki Nishizawa, Miyeon Kim, George Balazs, Jibin Im, Hoyoung Suk, Byung-Yeob Kim and Taewon Kim.
5. (**Cancelled**) Generalists, specialists, and shifting seas: Phenological match and mismatch, diet diversity, and anthropogenic change in seabirds. Amy Miles, Thomas P. Hahn, John Wingfield, Marcel Holyoak, Michael Johns[2], Heather Major, Anthony Diamond[3] and Joshua Hull.
6. Juvenile Albacore Tuna (*Thunnus alalunga*) diet variability and resilience in the northern California Current Large Marine Ecosystem. Catherine F. Nickels, Elan J. Portner, Owyn Snodgrass, Barbara Muhling, and Heidi Dewar.
7. Challenges to monitor cetacean abundances in changing ocean environment. Yu Kanaji**,** Hikari Maeda, Hiroko Sasaki and Hiroshi Okamura.
8. Improving population dynamics modellings for small cetaceans in the western North Pacific with biological information. Hikari Maeda**,** Yu Kanaji and Hiroshi Okamura
9. Overwintering behavior of green sea turtles in a temperate habitat. Soojin Jang**,** Kyunsik Jo, Mi Yeon Kim, Byeong Yeob Kim, Geroge H. Balazs, Connie Ka Yan Ng[5], George Schillinger[6], Michelle María Early Capistrán[7], Jibin Im and Taewon Kim.
10. (**Cancelled**) Climate and fishery effects on the size spectrum for an ever-changing food web in the Gulf of Alaska. Cheryl L Barnes**,** Martin W Dorn, Timothy E Essington, Carey R McGilliard, André E Punt, and Jonathan CP Reum.
11. Increased temperature decreases starvation resiliency in first feeding Sablefish (*Anoplopoma fimbria*). H. William Fennie, Steven M. Porter, Kelia A. Axler and Alison L Deary.
12. Understanding what drives marine lipid accumulation in Chinook Salmon. Jacob E. Lerner and Brian P. V. Hunt.

## Session 12: Topic Session

### Shining light on essential fish habitat in data-limited Pacific regions

**Convenors:**
Kisei Tanaka (USA), Jessica Perelman (USA), Justin Suca (USA), Mackenzie Mazur (Canada), Jennifer Samson (USA), Xu Zeng (China)

**Background**

Essential Fish Habitat (EFH) is a key ecosystem-based fishery management component required to be described and identified in all fishery management plans. As habitat degradations often lead to declines in overall abundance and diversity of living marine resources (LMRs), one of the main areas of emphasis in current ecological research is the delineation and refinement of EFH toward higher levels of detail, from presence-absence of certain species (Level ; the lowest) to production and vital rates by habitat (Level 4; the highest). The central and tropical Pacific regions contain commercially and recreationally important bottom fishes (e.g., snappers, groupers), pelagic fishes (e.g., billfish), crustaceans, and coral reef-associated taxa. Field research and in situ data collection efforts are often limited due to the region's vast size and small-scale spatial complexity. This paucity of data, particularly relating to spatio-temporal trends of LMRs, is effectively hindering the delineations of EFH beyond species presence and density (Levels & 2). This session invites presentations highlighting approaches to inform EFH delineations, specifically in regard to fish density, growth and reproductive dynamics, and habitat-specific production rates in a data-limited environment. We particularly welcome types of research that ) use quantitative and statistical approaches to generate relative abundance maps using multiple data sources, 2) support tactical EFH relevant decision-making and longer-term strategies (e.g., harvest control rules, marine protected areas), 3) evaluate the robustness of methods that forecast changes in LMR productivity and distribution, and 4) attempt to integrate environmentally heterogeneous habitats, species domains, and species' interactions into understanding EFH-relevant processes (e.g., density, reproduction, and productivity) at multiple scales. We encourage both application case studies and theoretical and integrated 33odelling approaches to improve EFH delineations.

**List of papers**

*Oral presentation*

1. (**Invited**) The use of Species Distribution Models for projecting future distributions of marine species: strengths, limitations and future perspectives. N Lezama-Ochoa, H Welch, S Brodie; B Muhling, O R. Liu; M Cimino, M Pozo Buil, M Jacox, J Fiechter, S Benson, K Forney, E Becker, H Dewar, D Palace, P Hernvann, I Kaplan, N Farchadi, C Braun, R Lewison, S Bograd, E Hazen.
2. (**Invited**) Evaluating the sensitivity of mariculture species to heatwaves and mapping aquaculture areas using species distribution models. Yu-Yang Zhang, Shuang-En Yu, Chao-Yi Ma, Xiao-Lu Zhu, Liang Zhang, Lin-Zuan Ma, Yun-Wei Dong.
3. (**Invited**) Zoning effects on fish populations in a multi-use marine protected area. Xu Zeng, Yue Liu, Shouyu Zhang, Cong Zeng, Dongyan Han, Kisei R. Tanaka, Makenzie Mazur, Ling Cao.
4. (**Cancelled**) (**Invited**) Modeling spatial trends in coral reef fishery resources across the Pacific Islands Region. Jessica N. Perelman, Kisei R. Tanaka, Justin J. Suca, Thomas A. Oliver.
5. Using archival tags and mechanistic movement models to estimate habitat utilization for mobile species. James T. Thorson, Julie Nielsen, Kevin Siwicke.
6. Projecting future seasonal distribution of chub mackerel (*Scomber japonicus*) under continued ocean warming in the Yellow and East China Seas. Minkyoung Bang, Dongwha Sohn, Jung Jin Kim, Wonkeun Choi, Elliott Lee Hazen, Sukyung Kang, Chan Joo Jang.
7. Delta downscaling as a tool to create flexible, high-resolution climate change projections for the global ocean. Owen R. Liu, Isaac C. Kaplan, Pierre-Yves Hernvann, Mercedes Pozo Buil, Alberto Rovellini, Jameal Samhouri.
8. Projecting future catch distributions of chub mackerel (*Scomber japonicus*) in Korean waters under the CMIP6 forcing scenarios. Dongwha Sohn, Minkyoung Bang, Jung Jin Kim, Chan Joo Jang, Sangil Kim.

9. Advancing Essential Fish Habitat in Alaska using an ensemble approach to species distribution modeling. Jodi L. Pirtle, Ned A. Laman, Jeremy Harris, Megsie C. Siple, Jim T. Thorson, Skylar R. Bayer, Mason J. Smith.

*Poster presentation*

1. (**Cancelled**) Mapping the potential for offshore aquaculture of salmonids in the Yellow Sea. Shuang-En Yu, Shuang-Lin Dong, Zhi-Xin Zhang, Yu-Yang Zhang, Gianluca Sarà, Jie Wang and Yun-Wei Dong
2. (**Cancelled**) Sensitivity in uku (Aprion virescens) larval dispersal patterns to simulated spawning location and environmental conditions throughout the main Hawaiian Islands. Justin J. Suca, Andrea L. Schmidt, Johanna L.K. Wren, Donald R. Kobayashi, Jonathan L. Whitney, Kisei R. Tanaka, and Gabriella N.M. Mukai.
3. Essential Fish Habitats in the Western Bering Sea. Vladimir Kulik, Dmitry Sokolenko, Mikhail Goryunov and Viktor Nadtochy.
4. Evaluating the impact of temperature on hindcasting and forecasting shrimp distributions in British Columbia. Mackenzie Mazur.
5. (**Cancelled**) Assessing reef fish abundance and diversity in the Mariana Archipelago: Insights from a spatiotemporal model and NOAA's National Coral Reef Monitoring Program. Kisei R. Tanaka, Jessica N. Perelman, Justin Suca, and Tye L. Kindinger.

## Session 13: Topic Session

### Operational forecasts to improve recruitment prediction in fish stock assessments

**Convenors:**
Kiva Oken (NOAA, USA), Eric Ward (NOAA, USA), Kristin Marshall (NOAA, USA), Mary Hunsicker (NOAA, USA), Brice Semmens (USA), Lisha Guan (China)

**Background**
Understanding the environmental drivers of fish recruitment has been a major area of research for more than a century. In an era of non-stationary ocean conditions, quantifying these relationships is essential for robust management of fish populations. Recently, a number of studies have demonstrated that fish recruitment can be forecasted over short periods of time using covariates related to larval densities, data from similar species, and/or raw or derived environmental time-series. A variety of emerging computational methods have also been used to improve forecasts and assess their skill, including linear, non-linear and non-parametric approaches. While the forecasting skill of these methods can be surprisingly high, the path towards using these forecasts within traditional fisheries stock assessments remains unclear. Challenges include dealing with large numbers of possible environmental drivers, non-stationary relationships, complex estimation models that already integrate many data sources, incorporating non-parametric methods into stock assessment's likelihood-based framework, and the sometimes weak relationships between single drivers and recruitment.

We propose a topic session bringing together international experts from fisheries and management organizations in PICES member nations and beyond to focus on approaches and the utility of forecasting recruitment in a management setting. The session will include two components, with session (A) focused on current approaches, best practices, and challenges for forecasting fisheries recruitment and session (B) focusing on using forecasting approaches in an assessment model or management setting. Each session will consist of 5-6 speakers (2.5 hours) and will end with an invited panel discussion. Each panelist will kick off the session with a 3-5 minute lightning talk, reacting to topics covered in the session and / or discussing provocative ideas for future work.

**List of papers**

*Oral presentation*

1. (**Invited**) Evaluating new computational methods for detecting non-stationarities and forecasting recruitment with applications to Pacific salmon. Carrie Holt, Brendan Connors, Andrew Edwards, Lyse Godbout, Dan Greenberg, Luke Rogers, Catarina Wor, Yi Xu.
2. Introducing a novel stock-specific indicator of salmon survival in the marine environment. Brian J. Burke.
3. Non-stationary environmental indicators related to Pacific Northwest Chinook and coho salmon marine survival. Neala W. Kendall, Benjamin W. Nelson, Mike Haggerty, Mike Crewson, Dave Beauchamp, Diego Holmgren, Casey Ruff.
4. Environmental conditions at Chum salmon feeding and wintering grounds: Potential effects on survival at sea. Irene D. Alabia, Sei-Ichi Saitoh, Takafumi Hirata, Yasuyuki Miyakoshi, Fumihiro Takahashi, Masahide Kaeriyama.
5. Evaluating the short- and long-term performance of six forecasting methods on West Coast and Alaska groundfish recruitment. Emily L. Sellinger, Andre E. Punt, Cody Szuwalski, Mark Scheuerell, Richard Methot.
6. Integrating climate effects in multiple population processes for fisheries projections: an example with snow crab in the eastern Bering Sea. Cody Szuwalski, Baptiste Alglave, Maxime Olmos, Andre Punt, Matthieu Veron.
7. (Recorded) Revealing climate impacts on recruitment drivers through application of Dynamic Factor Analysis, a coastal pelagic fish case study. Robert P. Wildermuth, Desiree Tommasi, Charles Hinchliffe, Stefan Koenigstein, Peter Kuriyama, Isaac Kaplan, Andrew Thompson, Noelle Bowlin, Mercedes Pozo Buil, Michael G. Jacox, Steven J. Bograd, Barbara Muhling.

8. Evaluating the utility of pre-recruit abundance indices of year-class in stock assessments of West Coast rockfishes. John Field, Vladlena Gertseva, Toby Auth, E.J. Dick, Melissa Haltuch, Mary Hunsicker, Tanya Rogers, Keith Sakuma, Jarrod Santora, Nick Tolimieri.

*Poster presentation*

1. (Cancelled) Leveraging ecological indicators to improve recruitment forecasts. Mary Hunsicker, Kristin Marshall, Kiva Oken, Brice Semmens, Melissa Haltuch, John Field, Andrew Thompson, Nick Tolimieri and Eric Ward.
2. (Cancelled) Environmentally-driven recruitment forecasts for Pacific Hake, Kristin N. Marshall, Eric J. Ward, Mary Hunsicker, Kiva Oken, Aaron Berger, Kelli Johnson and Cathleen Vestfals.
3. Using environmental drivers to improve the accuracy of fisheries population models. Rachael Ren, Kiva L. Oken and André E. Punt.

## Session 14: BIO Topic Session

### Seamount biodiversity: vulnerable marine ecosystems (VMEs) and species associated with seamounts in the North Pacific Ocean

**Convenors:**
Janelle Curtis (Canada), Mai Miyamoto (Japan, ECOP), Devon Warawa (Canada, ECOP), Sam Georgian (USA, ECOP), Akash Sastri (Canada), Chris Rooper (Canada)

**Background**
There are tens of thousands of seamounts worldwide and their abundance is greatest in the North Pacific Ocean. The ecology of only a few has been studied, in part because of how deep and remote most seamounts are. The difficulty in studying the ecology of seamounts means that they are poorly understood habitats in terms of the pelagic, demersal, and benthic species that they support. These are unique habitats for deep-sea organisms and many seamounts are biodiversity hotspots with relatively high rates of endemism. They can host diverse communities of benthic filter feeders, including corals and sponges. Some dense communities of biogenic organisms on seamounts are recognized as vulnerable marine ecosystems (VMEs), in part because they can support high biodiversity and provide critical habitats for socioeconomically important fishes and invertebrates that attract commercial fishing and other anthropogenic activities. The biodiversity of fishes is high on seamounts; almost 800 species of fish have been recorded from seamounts, representing half of the orders of fishes. As such, seamounts are important sources of food. New and readily available data can be integrated to better understand factors that influence the distribution and trends in seamount biodiversity, including those related to oceanic fronts and eddies and to future climate-change scenarios. This proposed topic session will focus on improving our understanding of seamount biodiversity and exchanging ideas on methods to identify VMEs and areas likely to be VMEs. As such, it will lay the foundation for WG-47's activities to identify potential indicators for assessing and monitoring the biodiversity of pelagic, demersal, and benthic taxa associated with seamounts.

**List of papers**

*Oral presentation*

1. (**Invited**) Methods and challenges for identifying VMEs and monitoring biodiversity on seamounts: A personal perspective from the South Pacific Ocean. Ashley Rowden.
2. Association analysis of Seamount benthos for identifying the validity of VME indicator taxa based on scientific sampling survey. Mai Miyamoto, Masashi Kiyota.
3. Using visual surveys and distribution models to identify vulnerable marine ecosystems on seamounts in the North Pacific Fisheries Commission Convention Area. Devon R. Warawa, Janelle M. R. Curtis , Chris N. Rooper, Samuel Georgian, Jessica Nephin, Jackson W. F. Chu, Sarah Dudas, Anders Knudby.
4. Patterns of deepsea coral and sponge monitoring groups on Northeast Pacific seamounts: Management Implications. Megan A. Davies, Cherisse Du Preez, Amanda E. Bates.
5. Distribution, abundance and size structure of deep-sea corals and sponge communities on seamounts in international waters of the NE Pacific Ocean. Christopher N. Rooper, Pamela Goddard, Christina Conrath, Cynthia Wright, Kim Rand, Vanessa Lowe.
6. Monitoring cold-water corals and sponges in changing ocean conditions: a case study in the Canadian Pacific. Lindsay Clark, Cherisse Du Preez, Amanda E. Bates.
7. Bathyal biogeography of North Pacific seamounts. Les Watling.
8. Bathyal megafaunal assemblages of the Musicians Seamounts. Caroline Edmonds, Les Watling.
9. Spatial distribution and community structure of benthic megafauna from two seamounts in the northwest Pacific. Chailinn Park, Yujin Kim, Se-Jong Ju.
10. Environmental DNA as a potential tool for the understanding of demersal ichthyofauna in seamounts: A case study from the Emperor Seamounts area. Motoomi Yamaguchi, Kota Sawada, Yumiko Osawa, Mai Miyamoto, Bungo Nishizawa.
11. Coral biodiversity and genetic resources of West Pacific seamount, Godin Guyot. Seonock Woo, Yejin Jo.

12. Application of environmental DNA metabarcoding approach to reveal biodiversity of seamounts in the northwestern Pacific Ocean. Eun-Bi Kim, Youngtak Ko, Yeon Jee Suh.
13. (Cancelled) Fish biodiversity monitoring in extreme environments: A case study of fish in the Southern Ocean. Yehui Wang, Chunlin Liu, Mi Duan, Wenchao Zhang, Shuyang Ma, Jianchao Li, Jianfeng He, Yongjun Tian.
14. Flow around seamounts and larval retention: Revisiting the Taylor cone. Tetjana Ross, Cherisse Du Preez, Debby Ianson.
15. Variability in zooplankton biomass and nutritional quality above Northeast Pacific seamounts, with application to marine conservation efforts. Daniel M. Labbé, Akash R. Sastri, Cherisse Du Preez, Julian A.C. Smith, John F. Dower.

*Poster presentation*

1. The Microbial communities associated with the deep sea stalked barnacle. Seonock Woo, Won Gi Min and Jae Kyu Lim.
2. Habitat mapping to understand deep sea benthic communities and ecosystem. Won-Gi Min, Min-Su Woo and Dongsung Kim.
3. The first report of deep-sea scallop *Propeamussium investigatoris* (E. A. Smith, 1906) from the seamount OSM 9-1 in the Western Pacific. Jong-Seop Shin, Ki-Seong Hyeong, Kwang-Sik Choi.

## BIO Contributed Paper Session

**Convenors:**
Akash Sastri (Canada), David G. Kimmel (USA)

**Background**

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. Variations in phytoplankton biomass, size structure, and primary production in a warming Arctic. Lisa B. Eisner, Silvia Gonzalez, Michael W. Lomas, Calvin W. Mordy, Jens M. Nielsen, Dean A. Stockwell.
2. Opposite responses in chlorophyll-a in the Yellow Sea and East Sea LME. Sinjae Yoo.
3. Dominance of the naked ciliates in the microplankton community during the post-bloom season in the Oyashio region, western subarctic Pacific. Mutsuo Ichinomiya, Yuichiro Nishibe, Yuji Okazaki, Mitsuhide Sato, Kazutaka Takahashi.
4. Inter-specific differences outweigh seasonal variability in zooplankton trophic markers, revealing distinct roles within a complex food web. Anna K. McLaskey, Ian Forster, Brian P.V. Hunt.
5. (Cancelled) Exploring the temporal and spatial dynamics of zooplankton in the Salish Sea using environmental DNA. Andreas Novotny, Colleen Kellogg, Matt Lemay, Brian P.V. Hunt.
6. Differentially expressed genes associated with food availability and field expression levels in *Neocalanus plumchrus* (Calanoida: Copepoda). Takuya Ohnishi, Yukiko Taniuchi, Hiromi Kasai, Hiroomi Miyamoto, Taiki Fuji, Satoshi Suyama.
7. Geographical and seasonal variation of mesozooplankton community around Japan. Kazuaki Tadokoro, Kou Nishiuchi.
8. Epipelagic zooplankton dynamics during International Year of the Salmon winter surveys of the NE Subarctic Pacific (2019, 2020, & 2022). Joanne K. Breckenridge, Brian P. V. Hunt, Evgeny A. Pakhomov.
9. Rapid Zooplankton Assessment: Developing a tool to apply zooplankton information to ecosystem-based fisheries management. David G. Kimmel, Deana C. Crouser, Colleen E. Harpold, Jesse F. Lamb.

*Poster presentation*

1. Lipid acids contents of zooplankton community in the Kuroshio and its neighboring waters. Reo Ishimaru, Toru Kobari, Gen Kume, Ayako Nishina, Hirohiko Nakamura.
2. Feeding impacts of micro- to mesozooplankton on phytoplankton community in the Kuroshio and its neighboring waters. Ayaka Morimitsu[1], Mutsuo Ichinomiya[2], Gen Kume[1], Tomohiro Komorita[2], and Toru Kobari.
3. An new species of copepod, *Mesocalanus n*. sp. (Calanida, Calanidae), from the Coastal Aters of Korea. Su-Jin Ju, Won-Gyu Park and Hae Won Lee.
4. An underwater glider observation of phytoplankton photosynthetic activity using a Fast Repetition Rate Fluorometer (FRRF) Takahiro Tanaka, Daisuke Hasegawa.
5. Metavirome Profiling and Dynamics of the DNA Viral Com-munity in Seawater in Chuuk State, Federated States of Micronesia. Seung Won Jung, Kang Eun Kim, Hyun-Jung Kim, Taek-Kyun Lee.
6. Covariance of Marine Nucleocytoplasmic Large DNA Viruses with Eukaryotic Plankton Communities in the Sub-Arctic Kongsfjorden Ecosystem: A Metagenomic Analysis of Marine Microbial Ecosystems. Kang Eun Kim, Hyoung Min Joo, Taek-Kyun Lee, Hyun-Jung Kim, Yu Jin Kim, Bo Kyung Kim, Sun-Yong Ha and Seung Won Jung.

7. Hypoxia tolerance of *Calanus marshallae*: Implications for its future distribution in the Northern California Current System. Kristofer K. Bauer, Felipe S. Barreto.
8. Exploring the impact of harmful algal bloom species Karenia selliformis on the survival and grazing of copepods from the Pacific region of southeastern Hokkaido, Japan. Takuya Ohnishi, Yukiko Taniuchi, Tsuyoshi Watanabe, Tomoyuki Shikata, Hiromi Kasai.
9. Preliminary results of multi-year diet analysis project of Walleye Pollock (Gadus chalcogrammus) in the Western Gulf of Alaska, USA. Jesse F. Lamb, David G. Kimmel, Lauren A. Rogers.
10. Developing a fiberization process for the common cordgrass from salt marsh plant. Sohyun Park, Junsung Noh.
11. Immediate and gradual effects of typhoons on the blooms of harmful dinoflagellate *Margalefidinium (=Cochlodinium) polykrikoides* in Korean coastal waters.Young Kyun Lim, Seung Ho Baek, Giseop Lee, Bum Soo Park, Hong-Yeon Cho, Jin-Yong Choi.
12. Differential response of the copepods, Calanus glacialis and *Pseudocalanus* spp. to recent warming in the Chukchi Sea. Adam H. Spear, David G. Kimmel.
13. Assessment of $CO_2$ removal potential of Neopyropia aquaculture beds. Hanbi Moon, Ju-Hyoung Kim, Haryun Kim.
14. Assessment of carbon storage capacity of oyster, *Magallana gigas* in Korean aquaculture farms. Du-young Jung, Hyeong-Gi Kim, Bong-Oh Kwon and Jong Seong Kim.
15. Spatiotemporal distribution of subtidal meiofaunal and macrofaunal assemblages along the southern coast of Korea. Hyein Kim, Seohee Lim, TaeLim Kim, Kanghyun Lee, Hyeong-Gi Kim.
16. (Cancelled) Understanding the mechanisms linking large-scale climate indices to zooplankton biomass in the Strait of Georgia, Canada, using a modelling approach. Karyn Suchy, Elise Olson, Susan Allen.
17. Population structure of *Caprella scaura* (Amphipoda: Caprellidae) on *Sargassum thunbergii* at Cheongsapo, Busan in Korea. Gi Beom Ryu, Won-Gyu Park.
18. Research on development of macrobenthic community analysis through genetic classification. Jin-Young Seo, Mi Kyung Bae, Kyoungsoon Shin.
19. Origin and distribution of the floating Sargassum in the Yellow and East China Sea. Seongbong Seo, Young-Gyu Park, Jun Myoung Choi, Young-Je Park, Kwangseok Kim, Jin Hwan Hwang.
20. (Cancelled) Spatio-temporal shifts in copepod communities in the southern Salish Sea, 2014-2022. BethElLee Herrmann, Amanda Winans, Julie Keister, Kimberle Stark, Micah Horwith.
21. Using two biochemical methods to characterize in situ secondary production in the waters around Vancouver Island. Liam D. Hubbert, Akash R. Sastri, John F. Dower.
22. Red tide events promote an increased zooplankton biodiversity. Chi-une Song, Hyeongwoo Choi, Dayu Wiyati Purnaningtyas, Seung Won Jung, Don Hyug Kang, Sung Kim, Choong-gon Kim, Youn-Ho Lee, Seong-il Eyun.
23. Host-specificity of the Roseobacter clade towards Margalefidinium polykrikoides blooms: Insights from field studies. Bum Soo Park, Jin Ho Kim, Zhun Li, Myung-Soo Han, Joo-Hwan Kim.
24. Changes in distribution of detectable environmental DNA of cetaceans in hydrodynamic models due to shedding rate representation. Elizabeth Brasseale, Nicolaus Adams, Elizabeth Andruszkiewicz, Allan, Parker MacCready, Stephanie Moore, Kim Parsons, Megan Shaffer, Jilian Xiong, Ryan P. Kelly.
25. Winter marine predator community structure in the northern Antarctic Peninsula ecosystem. Max Czapanskiy, Jarrod Santora, Kim Dietrich, Elliott Hazen, Megan Cimino, Christian Reiss.

## FIS Contributed Paper Session

**Convenors:**
Xianshi Jin (China), Jackie King (Canada)

**Background**

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. Sex- and maturity-specific distributions of eastern Bering Sea snow crab (*Chionoecetes opilio*). Rebecca A. Howard, Michael A. Litzow, Lorenzo Ciannelli, Emily Ryznar.
2. An example of Digital Twin of the Ocean: build and utilize a digital representation of the fish behavior in a fish farming cage. Haruka Nishikawa, Daisuke Matsuoka, Yasushi Nishimori, Takeharu Yamaguchi, Masanori Ito, Yoshitaka Watanabe, Daisuke Sugiyama, Tatsu Kuwatani, Yoichi Ishikawa.
3. Estimating the abundance and uncertainty of multiple species in an acoustic-trawl survey using a spatially informed Bayesian inverse approach. Samuel S. Urmy.
4. Size-explicit species distribution models for marine fishes. Lorenzo Ciannelli, Rebecca Howard, Rebecca Asch, Katherine Dale, Lauren Rogers, Lewis Barnett, Mary Hunsicker.
5. Decadal-scale variation in juvenile salmon growth from the Northern California Current (2000 – 2022). Brian Beckman, Meredith Journey, Cheryl Morgan, Brian Burke.
6. (Recorded) Otolith microchemistry profiles revealing the life history and population connectivity of Pacific saury (*Cololabis Saira*) in the Northwest Pacific Ocean. Wenjia Li, Chi Zhang, Chang Cao, Yongjun Tian.
7. Expanded measurements of bottom temperatures aid predictions of Pacific cod spawning habitat in the Bering Sea. Phyllis Stabeno, Jennifer Bigman, Albert Hermann, Kirstin Holsman, Kelly Kearney, Ben Laurel, Calvin Mordy, Lauren Rogers, Thomas Van Pelt.
8. Juvenile snow crab habitat and changes in distribution, density, and thermal occupancy during a period of ocean warming in the Chukchi Sea. Daniel Cooper, Katrin Iken, Elizabeth Logerwell, Emily Ryznar, Louise Copeman.
9. Do fishers go where the fish go? A retrospective analysis on the pollock fishery in the Eastern Bering Sea. Qi Lee, Alan C. Haynie, Caitlin Allen-Akselrud, James N. Ianelli, James T. Thorson, Ray W. Hilborn, Andre E. Punt.

*Poster presentation*

1. Interannual variability of the pollock stock, spatial differentiation and fisheries in the northern Bering Sea. Mikhail A. Stepanenko, Elena V. Gritsay.
2. (Cancelled) An assessment of the historical population trends of Crassostrea tulipa at the coast of West Africa. Gabriella A. Yeboah, Edem Mahu, Stephania A. Wiafe.
3. Feeding habits of skinnycheek lanternfish *Benthosema pterotum* larvae, metamorphosing larvae, and juveniles in the semi-enclosed Kagoshima Bay, southern Japan. Shinsaku Kato, Toru Kobari, Gen Kume.
4. Complete mitochondrial genome of Deima validum and *Oneirophanta mutabilis* (Holothuroidea: Synallactida: Deimatidae): Insight into deep-sea adaptation in the sea cucumber. Wendan Mu, Xingyong Xu, Jun Liu, Haibin Zhang.
5. Community structure of demersal fishes off the Okhotsk coast of Hokkaido in relation to environmental forcing. Orio Yamamura, Shin-ya Inoue, Tomonori Hamatsu.
6. The Fisheries Integrated Modeling System: A collaborative approach to stock assessment model development. Christine C. Stawitz, Andrea M. Havron, Matthew Supernaw, Bai Li, Kristan Blackhart, Richard D. Methot, Patrick D. Lynch.

7. Adaptive improvement of habitat suitability index (HSI) model for skipjack tuna in the western North Pacific using real-time ocean forecast and AIS vessel position data. Hiromichi Igarashi, Hiroto Abe, Sei-Ichi Saitoh.
8. Effects of the Oregon offshore wind energy project and temperature-driven population distribution shifts of Pacific hake on Oregon's hake fishery. Jake Marshall, Mary Hunsicker, Michael Malick, Lorenzo Ciannelli, Lori Cramer.
9. (Cancelled) Trophic life histories of sablefish from birth through maturation as inferred by eye lens stable isotopes. Matthew Rogers, Wil Licht, Mariela Brooks, Katy Echave, Jacek Maselko, Todd Miller, Cara Rodgveller, Fletcher Sewall.
10. Using simulation studies to inform threshold detectability in the California Current System. A. Raine Detmer, Chris Harvey, Mary Hunsicker, Kristin Marshall, Jameal Samhouri, Eric Ward.
11. (Cancelled) Visualizing species distribution changes with the NOAA Fisheries Distribution Mapping and Analysis Portal (DisMAP). Melissa A. Karp, Roger Griffis, Patrick Lynch, Tim Haverland, John Kennedy, Venkat Sunkara, Kevin Craig, Elliott Hazen, Isaac Kaplan, Don Kobayashi, Scott Large, Wendy Morrison, Hassan Moustahfid, Malin Pinsky, Phoebe Woodworth-Jefcoats.
12. Improving species distribution models through a physiologically based approach: oxygen and temperature effects on groundfish distributions. Julia Indivero, Sean C. Anderson, Lewis A.K. Barnett, Timothy E. Essington, Eric J. Ward.
13. The pelagic species trait database, an open data resource to promote trait-based fisheries research. Miram R. Gleiber, Natasha A. Hardy, Zachary Roote, Caitlin J. Morganson, Alana Krug-Macleod, Iris George, Cindy Matuch, Cole B. Brookson, Larry B. Crowder, Stephanie J. Green.
14. (Cancelled) Regional and annual variation in the lipid storage of juvenile Bering Sea snow crab during a recent period of environmental warming. Louise Copeman, Erin Fedewa, Michelle Stowell, Samantha Mundorff, Jens Nielsen.
15. International Year of the Salmon Ocean Observing System. Brett T. Johnson, Tim van der Stap
16. Pacific anchovy (*Engraulis japonicus*) dispersal during the early life stages in the coastal areas in Korean waters using Lagrangian simulations. Dongwha Sohn, Yong-Yub Kim, Dong-Heon Seong, Valérie Le Guennec, Sangil Kim.
17. Effects of sedimentation during early-life rearing on phenotypic outcomes and gene expression in coho salmon (*Oncorhynchus kisutch*). Carina Lai, Sean M. Rogers
18. (Cancelled) Understanding and predicting the spatiotemporal overlap of Pacific hake and constraining species in the hake fishery. Mary Hunsicker, Derek Bolser, Aaron Berger, Lorenzo Ciannelli, Michael Malick, Kristin Marshall, Jake Marshall.
19. (Cancelled) Approaches to stock enhancement in crab trap by comparing different light-emitting diode and baits. Wei-Yu Lee, Kuo-Wei Lan, Muhamad Naimullah, Khor Wai Ho, Mohd Fazhan Mohd Hanafiah.
20. The characterization of viral hemorrhagic septicemia virus in marine fishes. Umair Shivji, Sean Rogers.
21. (Cancelled) Exploring the effects of harvest pressure on fish growth across an environmental gradient. Jessica Randall, Steve Swearer, Emily Fobert, Bryan Black, John Morrongiello.
22. Spatial growth variability in marine fish: Example from Northeast Pacific groundfish. Vladlena Gertseva, Sean E. Matson, Jason Cope.
23. Diel vertical migration in a pelagic forage fish associated with benthic substrates. Matthew Baker, TS Smeltz, Kresimir Williams, Casey Greufe, Jonathan Chapman, Megan Ewing, Julia Glassy, Eva Hasegawa, Katie Cieri, Rick Towler.
24. The Impacts of the Pacific Marine Heatwave on Recruitment of Fish Species. Savannah Clax, Andrew Thompson, Will Fennie.

## HD Contributed Paper Session

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

**Background**

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. Fishers' perception on armored catfish (P*terygoplichthys* spp.) invasion: Ecologic and socioeconomic impacts in an estuarine protected area in Guatemala. María A. Schoenbeck, Emily Pineda, Yasmin Quintana, Fernando Castillo-Cabrera.
2. Understanding local residents' perceptions of blue carbon-based marine park in the context of long-term management and its feasibility. Jinvo Nam, Junsung Noh, Sohyun Park.
3. Human-centered data management for a prevalent type of fisheries data. Gottfried Pestal, Tatiana Tunon.
4. Economic and Environmental Evaluation of Kelp fishery with Hakodate City, Hokkaido Prefecture as a case study. Hajime Tanaka, Atsushi Watanabe, Mitsutaku Makino.
5. Methods and application of marine ecological product accounting in China. Keliang Chen, Zihao Wang, Liang Yue, Qingsheng Li.
6. Transition of consumer preference for seafood sustainability in Japan. Hiroki Wakamatsu, Juri Hori, Tsutom Miyata, Yoshioki Oozeki.
7. Framework for regional downscaling of climate modelling based on a co-designed traditional seasonal calendar, with the community of Ulukhaktok. Patrick Farnole, Allen Pogotak, Nadja Steiner, Mark Stoller, Adam Monahan.
8. The role of local organizations in community participation in marine ecosystems management: a perspective from Small Island Developing States. Naya Sena, Mitsutaku Makino.

*Poster presentation*

1. Assessing the benefits of mangroves in flood reduction in coastal communities using InVEST Coastal Vulnerability model. Chinomnso C. Onwubiko, Frederick Ato Armah, Denis Worlanyo Aheto.
2. (Cancelled) Assessment of environmental degradation in two coastal communities of Ghana using Driver Pressure State Impact Response (DPSIR) framework. Charles Abimbola Faseyi, Michael K. Miyittah, Levi Yafetto.
3. (Cancelled) Studies on the use of locally available (Coxs Bazar and Saint Martin) renewable seaweed wastes as compost organic fertilizer resources. Roy Durlave.
4. Synergies between gender equality and sustainability in coastal fisheries resource use. Hana Matsubara, Mitsutaku Makino.

## MEQ Contributed Paper Session

**Convenors:**
Guangshui Na (China), Andrew RS Ross (Canada)

**Background**

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. Evaluation of special representativeness of microplastic sampling methods using a non-hydrostatic particle tracking model. Ziqin Wang, Yoshimasa Matsumura, Shin-ichi Ito.
2. Distribution and fate of microplastics in the coastal marine environment, South Korea. Ji-Su Kim, Jun-Hyuk Shin, Zhexi Tian, Nan-Seon Song, Seung-Kyu Kim.
3. Occurrence, Source, and Transfer Fluxes of Organophosphate Esters in the South Pacific and Fildes Peninsula, Antarctic. Ruijing Li, Hui Gao, Shuaichen Jin, Xindong Ma, Guangshui Na.
4. Effects of wastewater from the in-water cleaning of ship hulls on planktonic and attached microalgae. Young Kyun Lim, Seung Ho Baek, Moonkoo Kim, Ji Nam Yoon, Zhi Yang Soon, Kyoungsoon Shin.
5. Allelopathic effect on the harmful bloom-forming microalgae: insights into the inhibitory allelopathic compounds of extracts from macroalga Pyropia haitanensis. Vishal Patil, Lu Huang, Junrong Liang, Lin Sun, Dazhi Wang, Yahui Gao, Changping Chen.
6. (Cancelled) Comprehensive Assessment of eutrophication in Xiamen Bay and its implications for management strategy in Southeast China. Yang Luo, Jinwen Liu, Jianwei Wu, Zheng Yuan, Jiwei Zhang, Chao Gao, Zhiyu Lin.
7. (Cancelled) Emerging trends in harmful algal blooms: Insights from distribution patterns along pakistan's coastline and adjacent areas. Sonia Munir, Jun Sun, Steve L. Morton, Zunaira Shahzad.
8. Harmful algal biotoxins in British Columbia coastal waters. Andrew Ross.
9. Investigating the distribution of Azadinium (Dinophyceae) species responsible for shellfish poisoning in two distinct Pacific regions: Korean coastal waters and Puget Sound, WA, USA. Joo-Hwan Kim, Urban Tillmann, Nicolaus G. Adams, Vera L. Trainer, Bum Soo Park.
10. Risk of the superposition of *Phaeocystis globosa* and *Pleurobrachia globosa* on cold source water of nuclear power plant. Chunjiang Guan, Jingfang Zhang, Lu Yang, Wenliang Teng.* Poster & Oral

*Poster presentation*

1. Risk of the superposition of *Phaeocystis glob*osa and *Pleurobrachia globosa* on cold source water of nuclear power plant. Chunjiang Guan, Jingfang Zhang, Lu Yang, Wenliang Teng. .* Poster & Oral
2. Effects of microplastics on different developmental stages in *Acartia omorii* (Copepoda, Calanoida). Ye Ji Lee, Won-Gyu Park, Hee-Jin Kim.
3. The Olympic Region Harmful Algal Bloom (ORHAB): A powerful partnership to mitigate HABs. Anthony Odell, Vera Trainer.
4. Can the sxtA4 gene diversity be associated with variation in paralytic shellfish toxin production in the toxic dinoflagellate *Alexandrium pacificum*? Bum Soo Park, Ji Yeon Sung, Dong Han Choi, Yeongjung Lee, Young-Eun Kim, Jae Ho Choi, Jae Hoon Noh, Hyeon Ho Shin.
5. (Cancelled) Comprehensive understanding of the life history of *Heterosigma akashiwo* (Raphidophyceae): Integrating in situ and in vitro observations. Joo-Hwan Kim, Jin Ho Kim, Bum Soo Park.
6. Phytoplankton community and HABs species in the Beibu Gulf detected by metabarcoding approaches. Junjie Zheng, Jiarong Hu, Pengbin Wang, Ruoyu Guo, Ruifang Wang, Xinfeng Dai, Douding Lu.

## POC Contributed Paper Session

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

**Background**

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*

No oral presentations

*Poster presentation*

1. Impact of mesoscale eddies on particulate organic carbon flux in the western subarctic North Pacific. Ryo Dobashi, Hiromichi Ueno, Nozomi Matsudera, Isao Fujita, Tetsuichi Fujiki, Makio C. Honda, Naomi Harada.
2. An imporoved estimate of submesoscale surface kinematic and dynamical properties obtained from concurrent Lagrangian surface drifter observations. Sung Yong Kim, Jinwhan Kim.
3. Seasonal and interannual variability of the latent heat flux in the northwestern Pacific Ocean according to ERA5 reanalysis data. Dmitry Lozhkin, Georgy Shevchenko.
4. Wintertime marine extreme temperature events modulate phytoplankton blooms in the North Pacific through subtropical mode water. Yong-Jin Tak, Hajoon Song, Jong-Yeon Park.
5. (Cancelled) The source of the summertime shelfbreak current off the west coast of North America. Charles G. Hannah, Roy Hourston, Richard E Thomson, Hauke Blanken.
6. Evaluation of mixed layer depth simulation performance in the Korean waters using numerical models. Heeseok Jung, Wonkeun Choi, Chan Joo Jang.
7. Evaluation of marine heatwave biases in the North Pacific Ocean simulated by the CMIP6 model. Wonkeun Choi, Heeseok Jung, Chan Joo Jang.
8. Asymmetries between phases of Atlantic multi-decadal variability in the CMIP6 model. Haedo Baek, Dong Eun Lee, Young-Gyu Park, Yeong-Ho Kim, Eun Young Lee, Yochanan Kushnir.
9. Satellite-data temperature-salinity framework to characterize the California Current System. Marisol García-Reyes, Gammon Koval, Jorge Vazquez-Cuervo.

**IPHC Special Session**

## The International Pacific Halibut Commission: 100 years of science-based fishery management

**Convenors:**
Josep Planas (IPHC, USA), David T. Wilson (IPHC, USA)

**Background**

In 923, the Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea was signed by Canada and the United States of America (U.S.A) in response to conservation needs. The International Pacific Halibut Commission (IPHC), initially named the International Fisheries Commission, was established as an intergovernmental organisation by this Convention that came into effect on 2 October 924, constituting the first international agreement for joint management of a marine resource. Therefore, for the last 00 years, the IPHC has been successfully managing the Pacific halibut resource for Canada and the U.S.A. through the application of rigorous science, innovation, and the implementation of international best practice. This session is intended to celebrate the first 00 years of the IPHC by highlighting past and current scientific activities that have supported the management of the Pacific halibut fishery in the Northeastern Pacific Ocean.

**List of papers**

*Oral presentation*

1. (**Invited**) The International Pacific Halibut Commission: 100 years of science-based fishery management decision making. David T. Wilson.
2. (**Invited**) Hundred years of Pacific halibut management in the context of global events. Barbara Hutniczak.
3. (**Invited**) Migration, MSE and management: the wonder world of Pacific halibut. Piera Carpi, Ian Stewart, Allan Hicks.
4. More than fifty years of management strategy evaluation at the International Pacific Halibut Commission. Allan C. Hicks.
5. The long path to ensemble-based stock assessment. Ian Jeremy Stewart.
6. Fishery-Dependent Data Collection at the International Pacific Halibut Commission. Monica M. Thom.
7. The IPHC's fishery-independent setline survey: A historical review and a look to the future. Ray Webster.
8. International Pacific Halibut Commission Fishery-Independent Setline Survey (FISS). Kayla Ualesi
9. Biological and Ecological Research at the International Pacific Halibut Commission. Josep V. Planas

*Poster presentation*

*No Poster presentations*

## General Poster Session

1. Emergent Constraint for Future Decline in Arctic Phytoplankton Concentration. Kyung Min Noh, Hyung-Gyu Lim, Eun Jin Yang, Jong-Seong Kug.
2. An assessment of sessile benthic communities in Jeju Island off the south coast of Korea using Autonomous Reef Monitoring Structures. Kyeong-Tae Lee, Taihun Kim, Taeho Kim, Chulhong Oh, Do-Hyung Kang, Hyun-Sung Yang.
3. Dietary analysis of the ducks flying to Japanese tidal flats in winter and evaluation of impact on the ecosystem. Tomohiro Komorita, Daisuke Fudaka, Rikuto Honda, Tetsuro Agusa, Shigeki Takano, Megumu Fujibayashi, Takehisa Yamakita.
4. Can satellite image detect seabirds and waterfowls on waters?. Sae Sakai, Yutaka Watanuki.
5. Reduction of atmospheric N deposition to the Yellow Sea of Northeastern Pacific Ocean for COVID-19 period. Chae-Un Park, Seongjun Bae, Hye Seon Kim, Dongwoo Yang, Haryun Kim.
6. A Traits-based Approach to Assess Aquaculture's Contributions to Food, Climate Change and Biodiversity Goals. Aleah Wong, Andrea Y. Frommel, Rashid U. Sumaila, William W.L. Cheung.
7. A study on revision of regulations to promote bio-materialization of the Fishery Processing Industry's residue. Soeon Ahn, Dunkhee Jang, Soo-jun Heo, Seungjae Back, Chullhong Oh.
8. (Cancelled) Ringed seals' (Pusa hispida) exposure to underwater shipping noise in the Canadian Arctic. Deborah L. Sharpe, William D. Halliday, David J. Yurkowski, Steven H. Ferguson, Stephen J. Insley, Francis Juanes.
9. Introduction to the Ieodo Ocean Research Stations (Ieodo-ORSs) and Korea Hydrographic and Oceanographic Agency (KHOA) Research Activities. Kwang-Young Jeong, Gwang Ho Seo, Seok Jae Kwon, Junyong Jeong, Hyun-Sik Ham, Hye-Jin Park, Jeong Joong Bae, Hyun-Ju Oh.
10. Vocal behaviour of ringed seals (Pusa hispida) in the western Canadian Arctic. Mariana Barbosa, William D. Halliday, Annika F. Heimrich, Stephen J. Insley, Stan E. Dosso.
11. (Cancelled) Indicators of pelagic forage community shifts related to the abundance of tropical tunas by climate effect in the Western Indian Ocean. Ting-Yu Liang, Yan-Lun Wu, Kuo-Wei Lan, Muhamad Naimullah, Lu-Chi Chen.
12. Regional assessment of sustainable development goal 14 in the North East Asia: Focusing on its implications and impacts on the semi-enclosed seas. In Joo Yoon.

***NOTE: workshop reports are modified from the articles in the PICES Press 2024 Winter Issue (W1, W2, W3, W4, W5, W6, W9, W10, W11) or Summer issue (W7).***

## W1: TCODE/FUTURE/HD Topic Workshop

### Creating Concise and Compelling Fact Sheets to Amplify your PICES work

**Convenors:**
Natsuko Nakayama (Japan), Tammy Norgard (Canada), Vera Trainer (USA), Sugimoto Aoi (Japan), Andrea White (Canada), Alexandra Davis (Canada)

**Invited Speakers**:
Julie Claussen (Fisheries Conservation Foundation, USA)
Maggie Mooney-Seus (Alaska Fisheries Science Center, AK, USA)
Sayaka Sogawa (FRA, Japan)

**Workshop Summary**

This workshop was organized by the Advisory Panel on Science Communications (AP-SciCom) members, Tammy Norgard, Vera Trainer, Natsuko Nakayama, Andrea White, Alexandra Davis, and led by the invited speakers: Julie Claussen and Sogawa Sayaka. The goal for this PICES 2023 TCODE/FUTURE/HD Topic Workshop: "Creating Concise and Compelling Fact Sheets to Amplify your PICES work" was to create Fact Sheets that would educate and advertise the work of PICES expert groups who play a significant international role in understanding the science of the North Pacific Ocean. It is often difficult for newcomers to grasp the organizational structure, mandates, and activities of the various PICES expert groups. Fact sheets can be used to make an outstanding first impression, educate community members and target audiences and increase organizational recognition about the value and relevance of scientific work being conducted under PICES. Fact Sheets provide an easy overview and are especially useful for graduate students and early career scientists. Moreover, creating Fact Sheets challenges PICES scientists to analyze the goals and objectives of their expert groups, and to efficiently describe their achievements concisely and clearly.

Prior to the workshop, templates were constructed to serve as guides and to present a unified look for all PICES Fact Sheets. In addition, a planning form was sent to expert group chairs, enabling them to outline the essential information to use in their Fact Sheets.

During the workshop, our invited speakers, Julie Claussen and Sayaka Sogawa, shared their expertise in communicating scientific knowledge clearly and effectively. Julie Claussen, of the Fisheries Conservation Foundation and the American Fisheries Society Science Communication Training Team, provided details on developing concise messaging for Fact Sheets using the ABT (And – But - Therefore) narrative structure. PICES expert groups have a wide array of activities, research, and results to share, yet distilling that information down to a manageable level to convey the main message can be difficult. The first decision to make when constructing a Fact Sheet is deciding what the target audience needs to know. Participants were asked to consider: does the audience have knowledge of the PICES organization, or will the focal audience be from outside the organization? Does the audience have specific scientific knowledge (for instance, would they know the background about nutrient availability), or is some basic information needed first? Deciding on the make-up of an audience and considering their background and level of knowledge will drive the amount of detail that needs to be presented.

Participants were then asked to consider the main goals for preparing a Fact Sheet. Three distinct goals were presented: 1) capturing the audience's attention, 2) making sure they understand the information, and 3) providing the audience with a "hook", something to remember. In today's world of competing information and short attention spans, we need to change how we tell our science stories. Scientists tend to organize our information around facts, yet presenting only the facts makes it difficult for broader audiences to pay attention, understand, and remember our message. One way to help achieve these goals is to use the ABT framework. This framework provides a basic structure to organize our science stories and has been scientifically shown to capture the reader's attention through the balance of facts, suspense, and resolution. The framework starts with "And", which provides the background

that is relevant to the target audience and sets the stage for the topic. The second part of the framework is "But", which is the problem we are presenting. The key here is focusing on one over-arching problem instead of a series of issues. And last is "Therefore", which is the solution or actions that address the problem.

The next presentation focused on visuals. The group looked at examples that would either amplify a message or detract from the main goals. Participants were asked to consider various element sin their graphics that would help an audience pay attention, understand, and remember their fact sheet information, including image quality, rule of thirds, contrast and color, font considerations, single versus multiple photos, etc.

A lively discussion followed on the PICES Fact Sheet template design. The group was in strong agreement that each fact sheet should only be 1 page. Participants spent some time working on simplifying a layout (see examples, below) that would make it reader friendly for all PICES countries. It was agreed that if readers wanted more information, the Fact Sheets should refer them to a main contact or a webpage.
Sayaka Sogawa, Japan Fisheries Research and Education Agency Socio-Ecological Systems Division, provided the group with a case study on her research program and how she organized her information about her program for a fact sheet. Participants were able to see how she selected her focal areas and what key actions she wanted to highlight. The group also discussed barriers that can exist when translating information into English and the need to consider language barriers when constructing PICES Fact Sheets.
During the workshop, there was an insightful discussion on the need for a Fact Sheet focused on PICES. Even for those attending PICES meetings, there exists confusion on the organizational structure of PICES and the work that it does. In addition, people felt there needed to be a short statement on "Who is PICES" on each Fact Sheet. Participants had great insight on the purpose of working group and section Fact Sheets, how they could be marketed and who these should be directed to. This led to a discussion on the PICES "brand". The workshop participants recommended that branding consistency guidelines and a marketing strategy for PICES should be discussed in the future.

Expert group co-chairs will be contacted by the Workshop organizers, who will provide a Fact Sheet template and instructions for constructing one-page Fact Sheets for each PICES expert group. The goal is to have these completed by the end of PICES2024. Fact Sheets will be shared on the PICES website and social media and will be available to send to potential colleagues and new partners.

## W2: TCODE/FUTURE/HD Topic Workshop

### Sharing Capacity and Promoting Solutions for Marine Ecosystem Sustainability within the UN Decade of Ocean Science

**Convenors:**
Steven Bograd (USA), Kirstin Holsman (USA), Hannah Lachance (USA)

**Invited Speakers**:
Hakase Hayashida (Application Laboratory, JAMSTEC, Japan)
Khush Jhugroo (Hakai Institute, Canada)

**Co-sponsors:**
ICES

**Workshop Summary**

At PICES-2023 in Seattle, WA, United States, SmartNet, FUTURE, TCODE, HD and AP-ECOP hosted a Workshop titled "Sharing Capacity and Promoting Solutions for Marine Ecosystem Sustainability within the UN Decade of Ocean Science", to provide updates on SmartNet, and other UN Decade of Ocean Science for Sustainable Development (UNDOS or UN Ocean Decade) activities and facilitate a broad discussion within the PICES community on possible collaborations, next steps and contributions to the UNDOS goals. Here we present a few highlights from the workshop.

The workshop opened with an overview of the workshop objectives and agenda, provided by co-convener Steven Bograd (USA). Co-convener Hannah Lachance (USA) then provided a brief overview of the UN Ocean Decade highlighting the outcomes, levels of endorsement, general structure, etc. Both Steven and Hannah provided a refresher and update on several UNDOS programmes including Sustainability of marine Ecosystems through Global Knowledge Networks (SmartNet), Sustainability, Predictability, and Resilience of Marine Ecosystems (SUPREME), Marine Life 2030, Fisheries Strategies for Changing Oceans and Resilient Ecosystems by 2030 (FishSCORE 2030), Global Ecosystem for Ocean Solutions (GEOS), and Empowering Women for the UN Decade of Ocean Science for Sustainable Development (Empowering Women).

Following the overviews we dove into the invited speakers, starting with Dr. Hakase Hayashida (Japan), who presented on "Operational climate and ocean forecasting at the application Laboratory, JAMSTEC". Dr. Hayashida's presentation gave an overview of the regional forecasting capacities that have been developed at the Japan Agency for Marine-Earth Science and Technology. After Dr. Hayashida, Dr. Matt Savoca (USA) presented on the UN Ocean Decade endorsed project titled "Global Plastic ingestion Bioindicators" which sits under the SmartNet programme. This project aims to define a list of indicator species to help monitor the effects of plastic ingestion in global marine ecosystems. Next up we heard from Dr. Alison Deary (USA) who provided a brief overview of PICES 2023 Workshop 10: "Towards climate-informed ecosystem-based fisheries management by building international collaborations and standardizing indicators" which occurred at the same time as our workshop but covered several relevant topics to the UNDOS actions participating in workshop 2. After the workshop 10 overview, we returned to our list of speakers and heard from Professor Wonho Yih who presented on "UNDOS Implementation Research Group, a new born program of Korea MOF for international cooperation." This presentation highlighted Korea's national contributions to the UN Ocean Decade including a new effort to fund 10 biennial research projects ('23-'28) where each project will include 1 mentor scientist and 2 early-settlement scientists after post-doctoral research.

Our next invited speaker was Dr. Kushboo Jhugroo (Canada) who presented on "Ocean sustainability through collaboration: SmartNet, Small Island Developing States (SIDS), Least Developed Countries (LDCs), Early Career Ocean Professionals (ECOPs)." Dr. Jhugroo's presentation highlighted challenges facing SIDS and her last slide, which highlighted potential collaboration areas, fuelled the afternoon discussion portion of our workshop. We took the 7 potential areas of collaboration identified through Dr. Jhugroo and Frank Mirobo's survey and discussed as a

group how PICES could possibly leverage its existing structure and expertise to help meet some of the needs. The potential areas of collaboration (in **bold**) and discussion around them are summarized below:

1. **Ocean literacy through engaging storytelling**
    a. PICES and UNDOS networks could be leveraged to share stories
    b. The film developed at PICES 2023 will be an excellent resource to share within and beyond the PICES community
    c. Bottom up collaboration and communication is needed
        i. PICES 2022 video training
        ii. Ocean Art at PICES meetings (2022 and 2023)
        iii. Community connections
2. **Establishment of a mentorship program**
    **a.** Expand PICES mentorship program to include a virtual mentorship component to reach more mentors/mentees both within and beyond PICES member countries
3. **Development of exchange programs at advanced institutions**
    a. Having ECOPs/SIDS/LDCs engaged with PICES scientists could lead to connections, collaboration and exchanges at advanced institutions
    b. PICES has a visiting scientist program that is open to PICES member countries
    c. PICES also has collaborations with POGO and SCOR which also have exchange programs
4. **Invitations to enhance integration at workshops, trainings, conferences, etc.**
    a. Tula DCC have ECOP specific time within webinars where the speaker and ECOPs have specific time together at the end of the webinar; they also have ECOP facilitators
    b. PICES has occasional summer school trainings as well (see here for list of past trainings)
5. **Insights or experiences with data sharing and creating data depositories**
    a. While PICES is not a data depository (data is held in national locations), PICES does have a data strategy in development that will help encourage and facilitate data sharing
    b. NOAA-MOF are working on making data more findable. Worth connecting to this and other similar efforts
    c. Translating data was flagged as an additional hurdle
6. **Seeking diverse funding opportunities for research and event attendance**
    a. Generating a list of grants/funding opportunities and/or jobs that could be circulated on a regular basis was raised
        i. The Ocean Decade Collaboration Center Northeast Pacific is working on this for the Northeast Pacific
    b. SmartNet could be well poised to reach out to foundations that like to fund SIDs to support this need
7. **Participation in research vessel voyages inclusive of ECOPS from SIDS and LDCs**
    a. PICES member countries could be encouraged to include a wider range of participants beyond later career government only professionals.
    b. PICES has at least two advisory panels focused on coordinating surveys (AP-NPCOOS and AP-CREAMS) so expressing this request to those groups could be beneficial.
    c. The need to connect early to co-develop research in SIDs and LDCs was flags vs just coming to their EEZ without a commitment to co-develop and provide a training opportunity for local professionals
    d. Hanna Na mentioned there is a Korean cruise every year

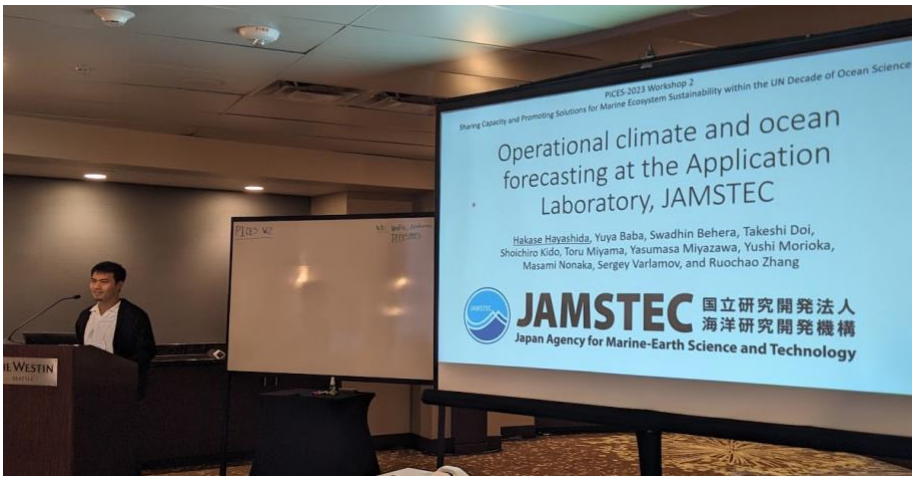



**Photo 1**: Invited Speaker, Dr. Hakase Hayashida (Japan), presented on "Operational climate and ocean forecasting at the application Laboratory, JAMSTEC".

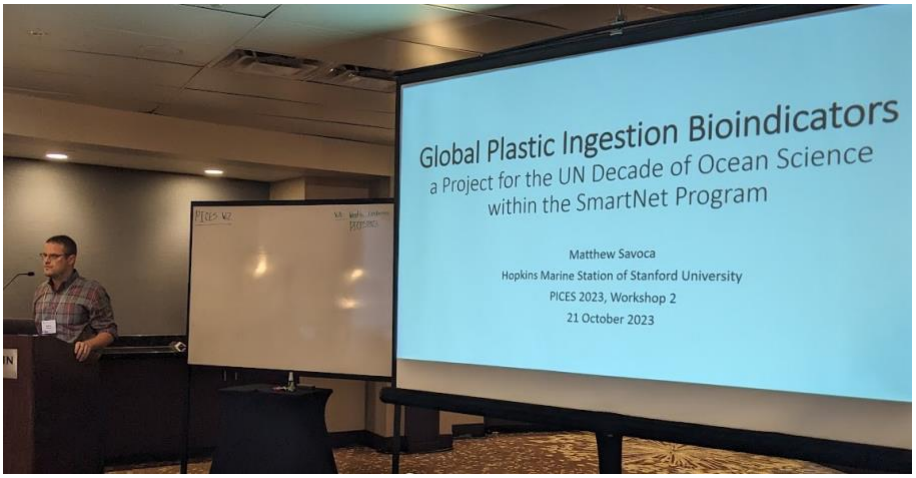



**Photo 2**: Dr. Matt Savoca (USA) presented on the UN Ocean Decade endorsed project titled "Global Plastic ingestion Bioindicators" which sits under the SmartNet programme.


**Photo 3**: Professor Wonho Yih (Korea) presented on "UNDOS Implementation Research Group, a new born program of Korea MOF for international cooperation."


**Photo 4**: Invited Speaker, Dr. Kushboo Jhugroo (Canada), presented on "Ocean sustainability through collaboration: SmartNet, Small Island Developing States (SIDS), Least Developed Countries (LDCs), Early Career Ocean Professionals (ECOPs)"

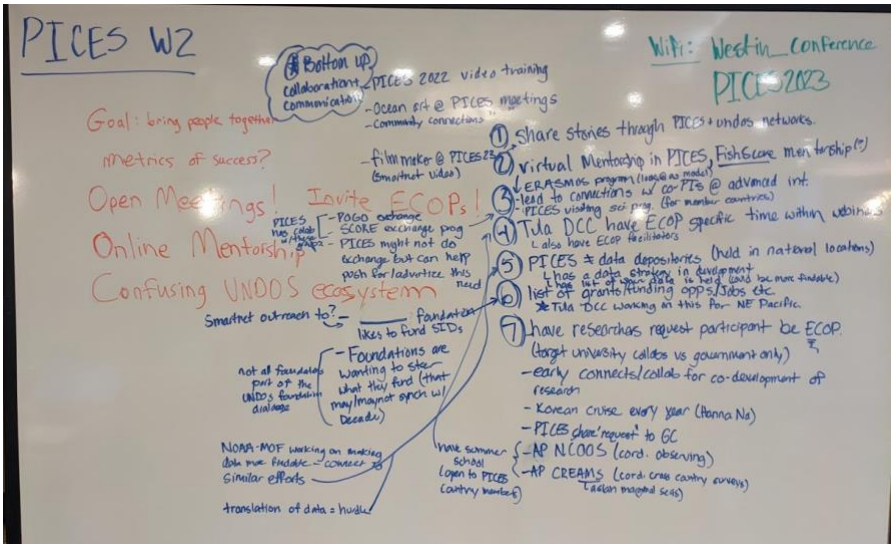



**Photo 5**: Whiteboard exercise to see how PICES and PICES member countries could help meet the potential for collaboration items outlined in Dr. Jhugroo's presentation.

**Photo 6**: Workshop 2 participants

## W3: TCODE/MEQ Topic Workshop

### GlobalHAB International Workshop on Solutions to Control HABs in Marine and Estuarine Waters

**Convenors:**
Vera Trainer (USA), Quay Dortch (USA), Marc Suddleson (USA), Pengbin Wang (China), Natsuko Nakayama (Japan), Don Anderson (USA), Mark Wells (USA), Heather Raymond (USA), Hae Jin Jeong (Korea), H. Dail Laughinghouse (USA)

**Invited Speakers**:
Nobuharu Inaba (Civil Engineering Research Institute for Cold Region, Public Works Research Institute, Japan)
Jorge Mardones (Center for Harmful Algal Studies, Instituto de Fomento Pesquero, Chile)
Tae Gyu Park (National Institute of Fisheries Science (NIFS), Korea)
Kathryn Coyne (University of Delaware, USA)
Heather Raymond (College of Food Agricultural and Environmental Sciences, Ohio State University, USA)
Zhiming Yu (Institute of Oceanology, Chinese Academy of Sciences (IOCAS), China)

**Co-sponsors:**
GlobalHAB, NOWPAP, SCOR

**Photo**: Workshop Participants. (Left to right) **Front row**: Nobuharu Inaba, Dail Laughinghouse, Javier Paredes Mella, Michelle Lepori-Bui, Colleen Kellogg, Ruoyu Guo, Natsuko Natayama, HoGeun Jang, Vera Trainer
**Center row**: Pengbin Wang, Misty Peacock, *Natasha Melo Buckiewicz*, Svetlana Esenkulova, Heather Raymond, Quay Dortch, Genki Terauchi, Kathy Coyne, Jorge I. Mardones, Taegyu Park, Yoichi Miyake.
**Back row**: Megan Schulz, Takafumi Yoshida, Don Anderson, Marc Suddleson and West Bishop (remote), Kevin Claridge, Andrew Ross, Charles Trick.

**Workshop Summary**

The workshop titled "GlobalHAB International Workshop on Solutions to Control HABs in Marine and Estuarine Waters" was held for 2 days (October 21 and 22, 2024) at the PICES 2023 conference in Seattle, WA, USA, jointly sponsored by GlobalHAB, NOAA and PICES. The workshop was specifically designed to focus only on the small number of harmful algal bloom (HAB) control methods that have been tested in marine and estuarine waters and explore solutions to technical, environmental compliance and public perception challenges. To clarify, control methods focus on the organisms themselves, either killing them or removing cells and toxins from the water. An example is the use of clay spray to control fish-killing HABs, such as *Cochlodinium polykrikoides* which has caused mass mortalities of aquacultured fish, especially in the western Pacific.

The societal desire to have access to a greater variety of safe and effective bloom control options has become more urgent given the continued development of coastal regions for aquaculture, tourism, and other uses that are impacted by HABs. This workshop provided a forum for international dialogue to foster *in situ* experimentation, and support assessments of social, economic, and environmental costs and benefits of various approaches to control HABs in marine and estuarine waters. A discussion of strategies for navigating environmental compliance in different countries highlighted the ways that national regulatory policies could be adjusted to quicken the pace of developing safe and effective HAB control approaches worldwide.

Nearly 30 participants with expertise in research, development, and deployment of control in in estuarine and marine environments. Specific examples were discussed, including natural and modified clay dispersal (Korea, Japan), viruses (Japan), algicidal bacteria isolated from coastal lagoons (USA), algicidal bacteria associated with seagrasses and seaweeds (Japan), and bubble curtains (Chile). Presenters shared how they resolved technical and environmental compliance hurdles to enable in situ deployments and the group explored various solutions to common barriers. Freshwater cyanobacterial HAB experts shared examples of control methods in inland lakes and reservoirs and offered strategies to help marine and estuarine researchers navigate environmental compliance issues such as permitting and application licensing. An industry partner raised awareness of additional research requirements that may enable companies to bring control methods into the marketplace.

A follow-up intersessional writing workshop is planned for February 2024 to summarize the worldwide approaches in HAB control as both a commentary and a scientific report in peer-reviewed scientific journals.

## W4: FUTURE/HD/POC Topic Workshop

### Changing social-ecological-environmental system of the North East Asian Marginal Seas: New challenges for integrative marine science

**Convenors:**
Vyacheslav Lobanov, Russia (AP-CREAMS, MONITOR), SungHyun Nam, Korea (AP-CREAMS, POC), Mitsutaki Makino, Japan (HD), Takafumi Yoshida, Japan (MEQ)

**Invited speaker:**
Hiroaki Saitoh (University of Tokyo, Japan)

**Co-sponsors:**
NOWPAP

**Background**

AP-CREAMS, Advisory Panel for a CREAMS (Circulation Research of East Asian Marginal Seas)/PICES Program in East Asian Marginal Seas, organized a half-day workshop on changing social-ecological-environmental system of the North East Asian Marginal Seas: New challenges for integrative marine science on 20 October 2023.
The western North Pacific is one of the areas of the global oceans which is most affected by climate change and anthropogenic impacts. On the other hand, people who live in this region use and strongly depend on the resources/services from the ocean. For sustainable use of ocean resources and services, it is important to study the climate and anthropogenic impacts on marine ecosystems and to develop a strong link between marine science and socio-economic requirements.
This workshop aims to

- Provide a forum to discuss all aspects of marine science
- Clarify a vision of international comprehensive marine research in this region that meets the current needs of society.

**Summary of presentations and discussion**

Workshop was held from 9:00-12:00 on 20 October. Unfortunately Dr. Lobanov, corresponding convenor could not participate in the workshop due to a visa problem, and Dr. Makino could not join the event because he had other business meeting held in parallel. Some oral presentations were also cancelled due to either visa or flight problems, as well.

The workshop was started with a brief introduction by Dr. Nam, including the outline of the workshop and an announcement of absence of some participants. Dr. Hiroaki Saito (University of Tokyo, Japan), invited speaker, introduced one of the best practices on collaboration among scientists of the South East Asia region; Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystem (CREPSUM) supported by Japan Society for the Promotion of Science.

Goals of CREPSUM are to establish an international science and education network for the Southeast Asia marine ecosystems, to progress marine ecosystems studies on emerging issues for conservation and sustainable use of marine ecosystem services, and to contribute to UN Decade of Ocean Sciences and UN SDG 14 targets. The members of this project published many field guides, identification guides and scientific papers and use them for promotion of capacity building for young scientists and local stakeholders. Dr. Saito shared his experience in developing such human network for facilitating the research and development on marine ecosystems and integrative marine science targeting the Southeast Asia.

Ms. Saranya J.S (Seoul National University, Korea), one of early career ocean professionals (ECOPs) gave a talk entitled “Unraveling the types and dynamics of marine heatwaves in the East Sea (Japan Sea)”. The impact of marine heatwaves (MHWs) to marine ecology in surface and subsurface in East/Japan Sea was dynamically assessed

using a numerical simulation model with in-situ observations, and unsupervised machine learning clustering techniques. The results identified three types of MHWs in the region, implying significant influences on marine ecosystems and human societies in the region under warming climate.

Dr. Zeyu Zeng (University of British Columbia, Canada) made a presentation entitled "Climate change alters social-ecological trade-offs in achieving ocean futures' targets". To predict the impacts of climate change on marine ecosystems in the East China Sea and the northern South China Sea, Ecopath with Ecosim model was used. The maximum potential economic benefits from fishery were predicted to increase with future climate change scenarios; however, the uncertainty for rebuilding the ecological robustness by climate changes would increase at the same time.

Dr. Hanna Na (Seoul National University, Korea) gave a talk entitled "Potential predictability of skipjack tuna (Katsuwonus pelamis) catches in the Pacific island countries". The statistical relationship between the skipjack tuna catches in the Western Central Pacific and ocean environmental variables in El Niño and La Niña climate conditions was investigated, and it was suggested that the subsurface temperature or near surface salinity can be a better predictor of ecosystem and the skipjack tuna catch variability. The presentation provides an example of connections between hydrographic/environmental study and fisheries/ecosystems.

In the presentation by Dr. Peng Sun (Ocean University of China, China), "The Effects of Selective Harvest on Exploited Population and Economic Benefits", she introduced an investigation of the stow net size-selective harvest using Bio-Economic Model, and showed that the mesh size of stow net fishing gives the most important variable effect on the economic value of small yellow croaker. For sustainable use of small yellow croaker resources, it is recommended to enlarge the mesh size as much as possible, even with high fishing mortality. The presentation provides an example of connections between fisheries/ecosystems and social-economic studies.

After these five presentations, meeting participants discussed and shared relevant information on the need of communication between science and stakeholders, led by Dr. Yoshida. This workshop aims to contribute to various global targets such as UN Decade of Ocean Science and UN Sustainable Development Goals in the North East Asian Marginal Seas. To achieve such global targets, central/local governments and all stakeholders should implement measures for sustainable ocean development based on scientific information. However, the existing networking effort between science and socio-economics is not sufficient due to limited opportunities and financial support. Scientists are expected to make more efforts not only to study marine science but also to develop more communication networks among the various stakeholders including the government.

**List of presentations:**

1. Hiroaki Saito (Japan) - Marine ecosystems in Southeast Asia: Status, emerging issues and scientific contribution for the sustainable use (invited talk)
2. Saranya J.S. (Korea) - Unraveling the types and dynamics of marine heat waves in the East Sea (Japan Sea)
3. Zeyu Zeng (Canada) - Climate change alters social-ecological trade-offs in achieving ocean futures' targets
4. Hanna Na (Korea) - Potential predictability of skipjack tuna (Katsuwonus pelamis) catches in the Pacific Island countries
5. Peng Sun (China) - The Effects of Selective Harvest on Exploited Population and Economic Benefits

## W5: BIO/MEQ Topic Workshop

### Bio-indicators of meso to global scale marine pollution: techniques for integration and standardization

**Convenors:**
Yutaka Watanuki (Japan), Patrick O'Hara (Canada, DFO), Mirian Kim (Korea), Andrew Ross (Canada)

**Invited Speakers:**
Jennifer C. Hoguet (National Institute of Standards and Technology (NIST), USA)

**Background**

Rates of discharge of pollutants including heavy metals, persistent organic pollutants (POPs), and plastics are increasing despite concerted effort to control them. Many of these pollutants are transported through air and water currents from a diversity of sources, then deposited in remote regions, including Arctic and Antarctic Seas, impacting ecosystem health in these regions. During past PICES meetings, MEQ and BIO (MBM-AP, which is now S-MBM) co-convened workshops and symposia in relation to the status and impacts of marine pollution. This workshop aims to develop standardized techniques to monitor the level of pollution in the remote regions where conventional sampling is difficult by using bioindicators (MBMs, Sea Turtles, Fish, Squid, Mussels, and species from other taxa that can be used potentially as a pollution bioindicator) as in situ samplers, producing indicator data of ecosystem health. For example, MBMs are useful bio-indicators of marine pollution as they bio-accumulate and magnify the low concentration of pollutants found in water to levels that are more easily detectable and measurable. As well, pollutant concentrations measured in MBM species can be considered average pollution levels integrated across a range of spatial scales, from meso to global, depending on life-history traits of the bio-indicator species. However, using MBMs as bioindicators for various pollutants requires the standardization of techniques for measuring and reporting concentration of each pollutant in each tissue for each species, as a suite of magnification factors, as well as differing half-lives among toxins, affect concentrations. Not all possible sentinel species occur in all subregions of the North Pacific, and for this reason we need to integrate further the concentration of pollutants in various tissues from various species. For example, plastic loading in stomachs of Northern Fulmar has been used successfully as indicator of plastic pollution in Europe and northern North Pacific, but this species does not occur in the south-central N Pacific. In this workshop, we plan to review and compare approaches used for detecting and measuring pollutants in different tissues in various species. We also welcome original works on multiple tissues of a single species or those on a single tissue from multiple species. We will discuss the approach for standardization and integration of the concentration of pollutants in the tissue of MBMs and the other possible sentinel organism for the North Pacific.

**PRESENTATION SUMMARY**

W5 was held on 20 Oct 2023 as planned (See attached Table 1). Unfortunately two presentations were cancelled; Fernanda Ferreira Paula Landim, et al. and Lauren Roman and Denise Hardesty. After the workshop they kindly send presentation and information of their talks and we put these in this report. We had 10 attendants in the room and 3 on-line participants (see below for participant details, Table 2). The followings are outline of the talks, question and answers and general discussion.

**Yutaka Watanuki** (corresponding convenor) introduced the workshop, explaining that Marine Birds and Mammals (MBM) are useful indicators of marine pollution as they bioaccumulate environmental pollutants and are able to integrate exposure across a range of spatial and temporal scales. To use them as global and long-term indicators, we used species and individuals with different trophic level, age, sex, distribution, and migration. Therefore, each pollutant, tissue and species represent a suite of biomagnification factors such as trophic level, sex and age of the sampled individual, migration, sample component (e.g. part of stomach), and cause of death (e.g. by-catch vs. stranding). For example, many factors are known to affect occurrence, size and mass of plastics in the stomach of seabirds so these cause biases (Table 3) when we use such information as indicator of spatial -temporal variation of marine plastic pollution. Hence, the use of MBM as bioindicators requires standardization of techniques for measuring and reporting pollutant concentration.

**Jennifer Hoguet** (invited speaker) described the Seabird Tissue Archival and Monitoring Project (STAMP), a long-term standardized specimen collection biobank managed by the US National Institute of Standards and Technology (NIST). This biorepository, which has been running for more than 20 years, contains over 100,000 samples. Seabirds are good indicators of bioaccumulated contaminants and, in particular, their eggs are conveniently packaged, easy to collect and handle, decompose slowly, and provide an index of parental offloading of toxins?. Eggs from seabird colonies are therefore collected, banked at STAMP, and analyzed for anthropogenic environmental contaminants. Control material has also been prepared from Murre eggs for quality assurance/quality control (QA/QC) of contaminant analysis by NIST and other labs. Contaminants measured in samples from the Gulf of Alaska include mercury (Hg), polychlorinated biphenyls (PCBs), and legacy pesticides such as 4,4'-DDE. Requirements for a long-term and successful biobank like STAMP include appropriately trained staff, a stable environment (e.g. temperature, humidity, light) monitored around the clock, consistent and standardized procedures (e.g use of Field Data Sheets to record egg collection and measurement, and the separation and storage of eggs components), a detailed inventory, and a formal tissue access policy.

**Jennifer Provencher** talked about an ecosystem approach to monitoring physical litter and microplastics, with a focus on Arctic Monitoring and Assessment Program (AMAP) guidelines. The steps used to establish a monitoring plan include prioritization, documentation (of the accumulation of litter and/or microplastics), and the implementation of standardization or harmonized protocols. As well, it is important to ensure that low effort is required to establish sampling, that appropriate methods are currently available and/or aligned with monitoring activities outside the (Arctic) study region, and that historical data are made available (in several Arctic regions). The AMAP priority recommendations for monitoring were (1) immediate trend monitoring, (2) initial baseline mapping/future trend monitoring, and (3) the need for sampling measurement and development. The AMAP exercise was captured in a Summary (4 pages), Monitoring Plan (24 page) and Technical Guidelines (244 pages). Jennifer also mentioned a related Special Collection in Arctic Science (open access) and a Litter and Microplastic Expert Group (LMEG) co-chaired by Canada and Norway, as well as scope for joint/overlapping indicators between PICES and ICES. In response to a question from co-convener Patrick O'Hara, Jennifer said that not many whale species are suitable for monitoring in the Arctic since they don't appear to accumulate plastics (which appear mainly in their scats).

**Stephanie Avery-Gomm** talked about progress towards a long-term monitoring program for plastic pollution, including a review and recommendations for plastic ingestion bioindicators. She mentioned the different types of monitoring (baseline, trend, compliance, effects, risk-based, source and surveillance) and assessing the status of plastic ingestion by North Pacific marine organisms, based on Frequency of Occurrence (FO) for plastic ingestion across taxa and taking into account method and spatial biases. She also introduced a flowchart or rubric evaluation process developed by PICES Working Group 42 to identify bioindicator species, starting with an initial screening that included a series of Yes/No questions about accessibility (e.g. common, available and/or by-caught?), prior sampling (n > 10 sampled?) and frequency of occurrence of plastics in the species (FO > 0?). If the answer to all three screening questions is Yes then the rest of the rubric can be completed, including questions regarding species distribution (in the North Pacific and globally), the threat of human exposure, residency in the (PICES) region, and whether or not the species (or a congener) is already used as a bioindicator. Using this approach, practitioners identified the long-nosed Lancet Fish, Blue Mussel, Green Turtle, and Northern Fulmar as the principal bioindicator species representing different North Pacific ecosystems. Stephanie also mentioned the Global Plastic Ingestion Bioindicators (GPIB) project sponsored by UNDOS, which aims to coordinate research on plastic ingestion by marine wildlife and evaluate all species with a record of plastic ingestion.

**Soojin Jang** spoke about external morphology monitoring of wild marine mammals and their use as indicators of ocean health, given that marine mammals are a generally long-lived taxa and include top-level predators of the ocean food chain. It is possible to measure pollutants (heavy metals, organic contaminants) in stranded animals via analysis of biopsies. However, extrinsic skin markings can serve as manifestations of disease or (severity) of injury, while drones can be used to collect images from which the identity, sex, age, and skin markings of living animals can be determined. The properties of these skin markings (i.e., shape, severity, permanence, distribution on the body, and changes over time) can be related to regional environmental changes and unusual events. Categories include natural marks, skin lesions, tumors, scars and abrasions due to contact with sharp objects, vessels, propellers, fishing gear, etc. Examples include tattoo disease (caused by foxvirus), entanglements (which are often fatal to cetaceans and other marine mammals), and boat strikes (which are related to the number and operation of

marine vessels). In summary, morphological changes in marine mammals can be related to changes in environmental conditions, the spread of infectious diseases, and the degree of interaction between specific individuals, providing a way to evaluate population health and assess anthropogenic inputs. Pros include the ability to understand changes over time and identify habitat changes at the population levels while cons include the amount of effort required and the limitations of using a drone, or a camera alone, to collect the required images.

**Miran Kim** talked about the use of invasive and non-invasive methods to assess plastic debris ingestion by seabirds, which are an abundant and widely distributed group of predators that forage at sea/on the coast and ingest plastic, making them good bioindicators for this type of marine pollution. Invasive methods include the (opportunistic) analysis of stomach contents while non-invasive methods include analysis of pellets and degustations (which are relatively easy to sample). In a Korean study to compare these two approaches the shape, size and composition (polymer type, as determined by FTIR) of microplastic particles from pellet, bolus, and stomach contents were determined. Swinhoe's storm petrels were found to accumulate plastics in their stomachs (primarily as fragments in bolus and stomach contents) whereas for black-tailed gulls the FO was highest in pellets, suggesting that gulls can excrete plastics more effectively that petrels. The ingested plastics were composed mainly of polypropylene and polystyrene. To summarize, pellets (non-invasive method) were good for monitoring plastic ingestion in gulls whereas stomach contents (invasive method) were better for monitoring plastics in petrels.

**Yutaka Watanuki** described the analysis of mercury (Hg) in pelagic seabird feathers as a potentially useful indicator of marine pollution. Feathers are easy to store and to sample at bird colonies, and are equilibrated with blood contents at the time they are replaced. Streaked shearwaters replace both their primary and tail feathers from the inside out. The outermost (R6) tail feathers are the most suitable for monitoring Hg in wintering area, since Hg content of each feather reflects exposure during the 2-week molting period of that feather in late winter. Hence, later-wintering Hg content of R6 tail feathers could be a good indicator of exposure. Linking individual birds to their wintering areas was subsequently used to create and coarse-scale Hg pollution map at the meso-scale (~500 km). However, it is necessary to consider a number of bias factors including age, sex and trophic level. Birds were not aged so instead, 40 individuals were tracked for up to 2 years and accumulation of R6 [Hg] in consecutive two years was analysed. R6 [Hg] in 2021 was found to correlate with R6 [Hg] in 2022, suggesting that age is not a significant biasing factor, while the absence of a correlation between R6 [Hg] and a $\delta^{15}N$ suggests that trophic level also does no bias HG content. Sex bias may be controlled using a linear relationship although there is a need to measure, and normalize for, Hg in the environment.

**Fernanda Ferreira Paula Landim (given by e-mail),** We have Fernandas presentation, which basically suggests using automated techniques with computer vision to measure plastics in samples (using the Saturna system) and standard colour wheels for colour. Lauren would even go so far as to say we should be RBG scaling (i.e., three measures of intensity) rather than classifying into preset categories (i.e., colour wheel). Cross-contamination is often an issue, particularly with microplastic samples was another issue.

## GENERAL DISCUSSION

**Standardization of sampling and analytical techniques** Development/adoption of standard procedures, methods (esp. those used elsewhere) is needed, especially for characterizing plastics. Generate control materials for method development and validation (both for plastic characterization and for contaminant loading). Also associated contaminants may serve as indicators for type of plastic debris. Jennifer Lynch is looking for suggestions as to the most sought-after material/microplastic type for the preparation of control materials. Imaging flow cytometry (incl. with imaging flow cytobots, or IFCBs) is an emerging tool for detecting and measuring microplastics (e.g. use fluorescence, morphology to characterize and differentiate between plankton and microplastics). Plastic pollution in the ocean is really a 3-D problem and there is clearly a need for more boat-based research for investigating plastic with depth. How seabird samples help this problem is unknown.
In general, stable storage conditions, managed access to samples, materials are needed. Also overlap/harmonization of species, methods, standards, protocols are needed. Need to use blanks and appropriate storage containers to account for variability between projects.

**Choice of sample types and bioindicator species.** Samples can represent groups of species, groups of contaminants, spatial distributions, and timing (e.g. shearwater tail feathers). Criteria/rubric to screen bioindicator species for specific (classes of) pollutants.

**Effects of pollutants in marine ecosystems**. Marine birds and mammals can indicate impacts of pollutants on ecosystem. Could log condition of bioindicator species when samples are collected, and relate to pollutant loading. Blocking of GI tract is a potentially lethal effect of plastics, whereas endocrine-disrupting chemicals (EDCs) associated (and ingested) with plastics could produce sub-lethal effects, along with physical transfer of microplastics into tissues.

**Consider biasing factors**. Age, sex, trophic level. Half-life of pollutants in the tissue.
Spatial and temporal scales. Eggs represent pollution in areas where individual birds feed (even though eggs are collected at the same location). eggs represent exposure just prior to egg-laying (parental offloading? What proportion? Differs between species?). Not easy to identify the place and time of exposure, but if we know the ecology of the species then that is valuable/useful information. Chemical additives of plastics in the stomach of seabirds are transported into their tissues (subcutaneous fat, liver, blood). Detecting and quantifying these chemicals in the preen grand oil can be used as an index for determining global pattern of plastic pollution, after considering various biasing factors that might affect their utility as such an index

**Table**. Workshop 5 Participant list

| **Name** | **Affiliation** | **In-person/online** |
|---|---|---|
| Yutaka Watanuki | Hokkaido University | In-person |
| Patrick O'Hara | Environment and Climate Change Canada (ECCC) | In-person |
| Miran Kim | Seabird Lab of Korea | In-person |
| Jennifer Hoguet (invited) | National Institute of Standards and Technology | In-person |
| Andrew Ross | Fisheries & Oceans Canada | In-person |
| Kaoru Hattori | *Japan* Fisheries Research and Education Agency (FRA) | In-person |
| Motomitsu Takahashi | FRA | In-person |
| Yu Kanaji | FRA | In-person |
| Hikari Maeda | FRA | In-person |
| Rolf Ream | National Oceanic and Atmospheric Administration | In-person |
| Jennifer Provencher | ECCC | Online |
| Stephanie Avery-Gomm | ECCC | Online |
| Ken Morgan | ECCC | Online |

## W6: MEQ Topic Workshop

### Developing an integrative conceptual framework of urban impacts on marginal ocean ecosystems

**Convenors:**
Brian Hunt (Canada), Kathryn Sobocinski (USA), Yoonja Kang (Korea)

**Invited Speakers:**
Angela Danyluk (City of Vancouver, BC, Canada)
Emily Howe (The Nature Conservancy, WA, USA)

**Background**

Coastal oceans are global hotspots for marine productivity, reflected in high primary producer biomass and fisheries yields. Contributing to this productivity is land-ocean connectivity, including freshwater and material contributions from land that can modify hydrodynamics and enhance micro and macronutrients concentrations. Among marine environments, coastal oceans are also uniquely vulnerable to human impacts. Approximately 40% of the human population lives within 100 km of the coast. The anthropogenic impacts associated with human settlement and development can disrupt critical land-ocean linkages. Urbanization, a pervasive form of land use change, has wide ranging effects, including shoreline modification, pollution, and changes to freshwater runoff and the quantity and quality of material flux to the ocean. However, while localized studies have examined specific urban impacts, a unified concept of urban oceans is lacking. Such a concept needs to take into account the interacting effects of the geographic, climatic and oceanographic setting of the urban environment, history of urbanization and associated impacts, and the backdrop of climate change and sea level rise. This workshop reviewed the state of the knowledge of urban oceans through 1) presentations from diverse knowledge holders that specifically addressed the interactions between cities and coasts, focusing on case studies from the North Pacific, and 2) breakout and plenary discussion of key interactions / processes at the city-coast interface. In addition, the workshop participants explored the role of different knowledge types in understanding urban oceans, and challenges and solutions to sustainable urban oceans.

**PRESENTATIONS SUMMARY**

**Angela Danyluk** [invited] Sea2City design challenge
Presented a case study from Vancouver, British Columbia, of how coastal cities can plan a resilient community and restore ecosystem health. Discussed the role of community engagement, through workshops and visual tools, to convey a vision for what the future can look like – important for the public and urban planners alike. Highlighted the importance of awareness of sea-level rise and the urgency to develop flexible adaptation strategies. Critically, this presentation highlighted the need for a decolonization approach and inclusion of

indigenous and community perspectives and values in identifying baselines, project design, and evaluation of success.

**Emily Howe** [invited] Salish sea stormwater
Presented work from Washington and Oregon on estimating and mapping stormwater discharge, a fast-growing source of water pollution due to continued growth of impervious surfaces. Provided insights into the role of green infrastructure in mitigating stormwater outflow. Highlighted the importance of setting objectives for species conservation based on data, and tailored to different scales, i.e., matching scales of management objectives to the landscape scale of the organism. Emphasized the importance of visualizations to convey the message – using accessible google earth platform.

**Kate Menzies** [invited] Tsleil-Waututh Nation's approach to understanding urban impacts on Burrard Inlet
Underscored the legal obligation of the Tsleil-Waututh Nation to protect Burrard Inlet (Vancouver, British Columbia), heavily impacted by colonization through cumulative effects of shoreline change, habitat loss, contamination, and fisheries. This severely impacted the Tsleil-Waututh Nation's way of life, e.g., seafood no longer safe to eat. Discussed the role of shifting baselines in setting restoration targets, and presented efforts being led by the Tsleil-Waututh Nation to establish the pre-contact baseline for Burrard Inlet. Objective to have a safe and sufficient harvest. Ways to get there include proactive restoration, research and monitoring, policy development and collaborative decision making, increasing Tsleil-Waututh Nation's visibility on lands and waters, and improving the Tsleil-Waututh Nation's member access to lands and waters.

**Jacques White** Salish Sea Survival Project
Presented an overview of the Salish Sea Marine Survival Project, including findings on top-down and bottom-up effects on salmon survival. Identified the importance of cumulative and synergistic effects in salmon survival. Highlighted that estuarine habitat is critically important—estuaries with higher intact habitat have higher salmon survival. Gave examples of compost boxes to filter stormwater and remove 6PPD-Quinone, and shoreline softening to improve habitat.

**Hem Nalini Morzaria-Luna** Assessing cumulative impacts in Puget Sound
Gave an overview of Atlantis model development for Puget Sound. Forward simulation is being used to assess vital signs. Some questions being addressed are impacts of ocean warming on food webs, ecosystem impacts of jellyfish aggregations, and ecosystem effects of contaminants and nutrients derived from land / freshwater inputs.

**Junsung Noh** Living Shoreline and Sustainable Saltmarsh Planting in the Green-living Tech, South Korea
Gave an overview of a "Coastal new deal" – testing salt marsh restoration to provide habitat that will sequester carbon, soften shorelines to protect against erosion with sea level rise, and support oyster production: Green living (plants), blue living (oysters), soft living (softening shorelines). Needs a trio of science, policy, and media to be successful. A self-sustaining mesocosm system being used to test living shorelines.

**Eliza Heery** Does the luxury effect occur in urban marine ecosystems?
Luxury effect: as wealth increases biodiversity increases; attributable to green space in affluent areas. Is this happening in the marine environment? Processes of marine urbanization do not occur equally across the seascape - luxury effect, e.g., access to shorelines and environmental justice; spatial distribution of pollution, wastewater; zoning policy consequences for ecosystem services received.

**Kathryn Sobocinski** Urban Seas are Hotspots of Stress in the Anthropocene Ocean
Discussed pressures faced by urban environments globally, and highlighted the importance of cumulative impacts at the ecosystem level. Local oceanographic environment is critical to the effects of urban drivers, determined by tidal flows, currents, freshwater inputs, etc.. Urban seas problems are solved on land (policy on lands), and solutions span disciplines, domains of knowledge and jurisdictional boundaries, i.e., complex systems that necessitate complex solutions.

*Speed talks – posters*

**Dilan Sunthareswaran** Using Fatty Acids to Profile Particulate Organic Matter from Urban Sources and Measure its Uptake into the Food Web in Vancouver, BC

**Sadie Lye** Using Stable Isotopes to distinguish and trace stormwater to particulate organic matter (POM) in the urban ocean in Burrard Inlet, Vancouver B.C.

**Yoonja Kang** Coastal warming heightens direct impacts of seawater temperature on nutrients near aquaculture farms

**Hyeong-Kyu Kwon** Significant contributions of fish-farm activities to the distributions of nutrients and trace elements in the coastal water off Jeju Island, Korea

## KEY TAKEAWAYS FROM PRESENTATIONS

There were several emergent themes from the presentations. These included the need for intersection of science with social science, to include the human perspective. Understanding the scale of the problem in space and time is critical, as well as the interconnectedness that leads to cumulative effects and species-to-ecosystem impact. The complexity of these urban ocean systems extends across the entire social-ecological system, e.g., stakeholders and rightsholders in these environments are diverse, have varied jurisdictions and motivations and need to be included in restoration/regenerative uses. Visualization and storytelling are powerful tools to convey information to diverse parties and bring them together on common goals.

## DISCUSSION

**Breakout session 1: State of the knowledge - Interactions / processes at city-coast interface**

- **How do cities impact coasts?**

Impacts could broadly be divided into direct environmental impacts, e.g. shoreline modification, pollution (light, biogeochemical, etc.), operating at different spatial and temporal scales, from species to ecosystem level; and indirect effects of regulations, policy, governance. Highlighted that urban impacts are socio-ecological in nature, e.g., impact on people's access to resources, cultural practice.

- **How do coasts impact cities?**

Coasts attract people to cities, affecting population growth and density, while influencing and supporting cultural practice, economies and food systems. Coasts confer city resilience to environmental extreme stressors, e.g., tsunamis, and climate change.

- **What are the critical knowledge gaps?**

There is a gap in regulations between land and sea—regulatory power ends on the land. Indicators of urban impacts on the ocean are still largely missing, in part due to a lack of thresholds for species and ecosystems effects. There is a lack of consensus on baselines to guide targets for urban ocean health, and a risk of shifting baseline syndrome. Identification of urban ecosystem services would help in setting targets, even if some of these services would only benefit certain sectors. There is a need to incorporate Indigenous knowledge in guiding objectives, and involvement in co-decision making. How do we get policy makers / enforcers / planners in on conversations about healthy oceans?

**Breakout Session 2: What is the role of different knowledge types?**

Having different knowledge types and perspectives at the table can identify different problems / solutions. Indigenous knowledge and stewardship has a critical role in attaining and sustaining healthy urban oceans, and should be included equally with other types of knowledge in planning for and implementing goals.

- **What are the challenges with connecting different knowledge types?**

Different vocabularies require extra effort in communicating and listening, while weaving together different knowledge types is challenging – how can this be done well? Bringing different sectors together can be very challenging but once established can become self-sustaining, and can build trust over time. Having a clear vision when starting efforts can be foundational to define knowledge gaps and barriers.

There is a high demand on Indigenous knowledge and there is a need to be sensitive to over-capacity. Furthermore, care needs to be taken to use Indigenous knowledge without being extractive, including involvement in planning, decision making, and management process.

**Group Discussion: What do solutions to healthy urban oceans look like?**

Solutions need to start with goal setting, e.g., being able to eat food from the urban ocean. Solutions should be inclusive of different perspectives, knowledge types, stakeholders and rightsholders; and need to be flexible to change in climate, values and information. Solution frameworks need to be prepared for things to get worse—long term planning.

## NEXT STEPS

The participants of Workshop 6 expressed interest in developing and funding an active working group to formalize an integrative conceptual framework of urban impacts on marginal ocean ecosystems.

**Additional Workshop participants**
Natasha Buckiewicz (University of British Columbia, Canada; workshop assistant)
Anna McLaskey (University of British Columbia, Canada)
Anu Rao (Tsleil'Watuth Nation, Canada)
John (Tsleil'Watuth Nation, Canada)
Lindsey Ogston (Tsleil'Watuth Nation, Canada)
Hayley Crozier (Tsleil'Watuth Nation, Canada)
Cora denHartigh (Tsleil'Watuth Nation, Canada)
Isobel Pearsall (Pacific Salmon Foundation, Canada)
Liz Duffy (Long Live the Kings, USA)
Rebecca Martone (Tula Foundation, Canada)
+5-8 participants in the morning session presentations

## W7: FIS Topic Workshop

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

**Convenors:**
Josep Planas (USA), Mackenzie Mazur (Canada), Naoki Tojo (Japan), Roman Novikov (Russia)

**Invited Speakers:**
Philina English (Pacific Biological Station, Fisheries and Oceans Canada, DFO, BC, Canada)
Allan Hicks (International Pacific Halibut Commission (IPHC), Seattle, WA, USA)
Noëlle Yochum (Fishing Innovation and Sustainability, Trident Seafoods, Seattle, WA, USA)

**Co-sponsors:**
IPHC

**Background**

The North Pacific Ocean is a large and productive ecosystem that is characterized by strong interdecadal climate variability. This Ocean basin supports a number of fish species of great ecological, as well as economical, importance. A successful PICES FIS-Workshop, that was co-sponsored by the International Pacific Halibut Commission (IPHC) at the 2019 PICES Annual Meeting (W2), To address important current topics related to the biology and fishery of Pacific halibut and interacting species in the North Pacific Ocean, two FIS Workshops have taken place in previous PICES Annual Meetings (in 2019 and 2022) to bring together researchers, scientists and managers from countries that are invested in this resource. An important outcome of these workshops was the need to increase the application of integrative approaches to improve our understanding of the biology and management of widely-distributed species, such as Pacific halibut, in the North Pacific Ocean, requiring a high level of cooperation at the international level. Therefore, to achieve these goals and as a step forward in addressing key areas of cooperation between PICES and IPHC as described in the current MoU between the two organizations, a third Workshop took place at the 2023 PICES Annual Meeting (W7) to address emerging issues in key flatfish species with broad distribution across the entire North Pacific Ocean. The theme of this Workshop was aimed at 1) devising strategies for data sharing on fishing efforts and management of flatfish species across the North Pacific Ocean, and 2) promoting international collaborative studies to improve our knowledge on movement of flatfish populations and potential distribution changes of flatfish and other interacting species in the face of climate variability.

**Workshop Summary**

This one-day Workshop (W7) was held on October 22, 2023, and the session was opened by Dr. Josep Planas who welcomed the participants and provided a brief introduction to the Workshop. The session featured 3 invited presentations and 9 regular oral presentations. The various presentations covered specific topics related to *a)* assessing the effects of environmental variabilityon the Pacific halibut fishery (English, Hicks, Webster, Young), *b)* food webs and productivity (Surma, Wolf), *c)* population genomics (Jasonowicz), *d)* parasitic infections (Kroska), *e)* bycatch and depredation (Yochum, Christie, Dykstra), and *f)* reproductive biology (TenBrink, Jones).

After the presentations, a discussion session took place among participants. The discussed topics included next steps for methods to understand the impact of climate change on flatfish species, improved understanding of the impacts of climate change on flatfish and implications for fisheries management, the inclusion of impacts of climate change in to flatfish stock assessments, heightened information sharing on biology and ecology of key flatfish species and on stock assessment and management strategies for flatfish among countries of the North Pacific rim, and the need for establishing working international collaborations among North Pacific rim countries to improve available information on connectivity and distribution changes of flatfish species in the face of climate change. The discussion session ended with support from participants for the submitted proposal of a fourth Workshop to be held at the 2024 PICES Annual Meeting in Honolulu.

**List of Presentations**

Invited Speaker: *Identifying the impacts of warming waters on British Columbia's groundfish productivity.* – Dr. Philina English, Fisheries and Oceans Canada

Invited Speaker: *Managing the Pacific halibut (Hippoglosssus stenolepis) fishery while considering historical and future changes in the environment.* – Dr. Allan Hicks, International Pacific Halibut Commission

Oral Communication: *Environmental conditions on the Pacific halibut fishing grounds obtained from a decade of coastwide oceanographic monitoring, and the potential application of these data in stock analyses*. **–** Dr. Raymond Webster, International Pacific Halibut Commission, USA

Oral Communication: *Investigating food web and groundfish community structure in the eastern Gulf of Alaska*. **–** Dr. Szymon Surma, University of British Columbia, Canada

Oral Communication: *Exploring the relationship between diet and size-at-age in Pacific halibut.* **–** Dr. Nathan Wolf, Alaska Pacific University, USA

Oral Communication: *Will a warming subarctic Bering Sea favor yellowfin sole production?***–** Dr. Cynthia Yeung, NOAA Fisheries, USA

Oral Communication: *Whole-genome sequencing to investigate population structure and dynamics of Pacific halibut in the northeast Pacific Ocean.* **–** Mr. Andrew Jasonowicz, International Pacific Halibut Commission, USA

Oral Communication: *Exploring the relationship of Ichthyophonus exposure to infection prevalence and severity in wild-caught Pacific halibut.* **–** Ms. Anita Kroska, Alaska Pacific University, USA

Invited Speaker: *Conservation engineering approaches for mitigating Pacific halibut (Hippoglossus stenolepis) bycatch: biology, behaviour, and technology*. – Dr. Noelle Yochum, Trident Seafoods

Oral Communication: *Testing of a semi-demersal longline to reduce yelloweye rockfish bycatch in a U.S. West Coast Pacific halibut longline fishery.* **–** Mr. Gregory C. Christie, Pacific States Marine Fisheries Commission, USA

Oral Communication: *Gear-based approaches to protecting Pacific halibut captured on longline gear from removal by marine mammal depredation.* **–** Mr. Claude Dykstra, International Pacific Halibut Commission, USA

Oral Communication: *Delineating yellowfin sole (Limanda aspera) reproduction in the northern Bering Sea provides information across the eastern Bering Sea continental shelf.* **–** Mr. Todd TenBrink, NOAA Fisheries, USA

Oral Communication: *Update of maturity-at-size and -age for Pacific halibut (Hippoglossus stenolepis) using histological analysis.* **–** Mr. Colin Jones, International Pacific Halibut Commission, USA

## W8: FIS Topic Workshop

### Nurturing future generation in fisheries and marine environment science: Collaboration with PICES and Asia Fisheries and Marine Environment Leaders Program (AFIMA Leaders Program)

**- Report to be submitted -**

**Convenors:**
Sangchoul Yi (South Korea), Raphael Roman (Canada), Dohoon Kim (South Korea), Liu Yang (China)
Shigenoubu Takeda (Japan)

**Invited Speakers:**
Nadiah Wan Rasdi (Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu (UMT), Malaysia)

**Background**

Asian waters are an important sea area with a relatively small area intensively used by Korean, Chinese, and Japanese fishing boats, which is exposed to overfishing of fishery resources and severe marine pollution. For the sustainable use of fishery resources and the protection of the marine environment, the understanding of the joint management by all countries concerned and the formation of a consensus for cooperation are necessary. With such recognition, leading universities in the field of fisheries and marine environment in Korea, China and Japan came together to create a joint education program for future young scientists. The program is Asia Fisheries and Marine Environment Leaders Program (AFIMA Leaders Program), aiming to nurture future professionals for the joint management of fishery resources and the marine environment in Asian waters. During upcoming session, we will introduce PICES to session participants (representatives from our partner universities and graduate students), connecting the global scientific community and AFIMA leaders program universities (i.e., faculty of Pukyong National University in Korea, Ocean University of China, and Nagasaki University in Japan, University of Malaysia, Terengganu).

## W9: TCODE/HD Topic Workshop

### Indigenous and Community-Led Approaches to support climate change adaptation and Ecosystem Resilience in the North Pacific and Arctic

**Convenors:**
Rebecca Martone (Canada), Kathryn Sheps (Canada), Sarah Wise (USA), Natalie Ban (Canada), Sanae Chiba (PICES Secretariat), Kirstin Holsman (USA, S-CCME, AFSC-NOAA), Kathy Mills (USA, SICCME, GMRI), Steve Alexander (Canada, DFO)

**Invited Speakers:**
Yutaka Watanuki (Japan), Patrick O'Hara (Canada, DFO), Mirian Kim (Korea), Andrew Ross (Canada)

**Co-sponsors:**
ICES, PSC

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

**Objectives**

The conveners set three main objectives for this workshop:

1. Bring together marine and coastal knowledge holders (including Indigenous and Traditional Knowledge holders, climate scientists, and ocean practitioners) to share stories, lessons, and perspectives of living with changing marine ecosystems.
2. Provide a safe space to build relationships, and share stories and lessons learned from Indigenous-led work.
3. Facilitate a cross regional knowledge network of Indigenous Knowledge holders, community leaders, and ocean practitioners to facilitate ongoing collaboration beyond the PICES annual meeting.

**Workshop Summary**

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

**Day 1**

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

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

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

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

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

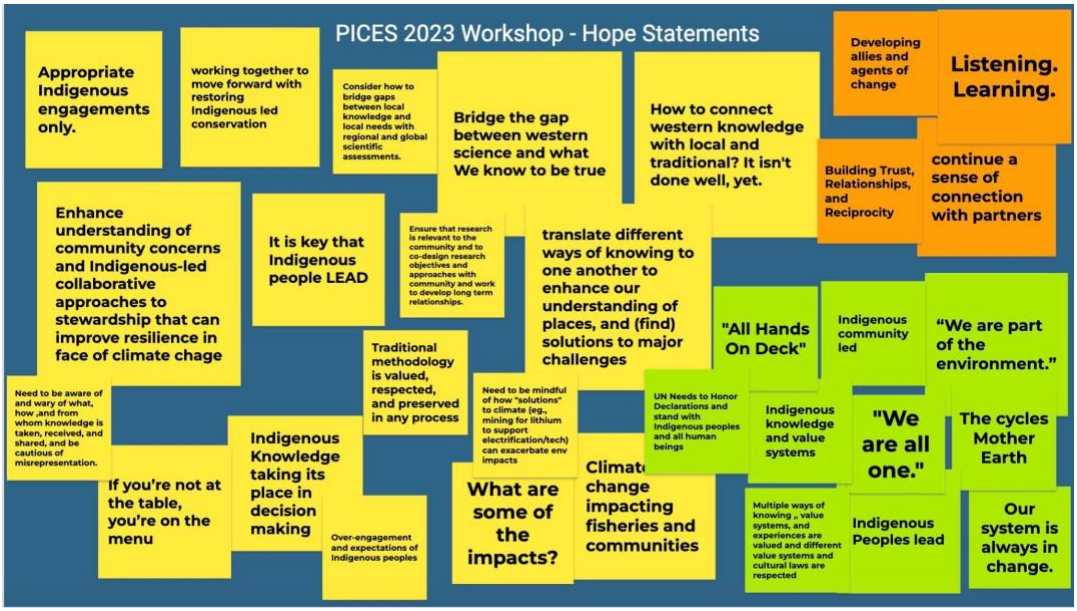



**Figure Caption**: A jamboard used to capture ideas and messages from participant introductions and intention statements shared on Day 1 of the workshop, we chose to use a jamboard for this portion of the conversation to enable remote/online participants to share their reactions.

*Indigenous Knowledge and Knowledge Systems*

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

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

*Discussing the Differences Between Indigenous Knowledges and Mainstream Science*

Having established some shared understanding about Indigenous Knowledge Systems and their complexity, the group moved to the question about how to work alongside--or in tandem with--Western scientific knowledge and approaches (see Question 1). Participants talked about their experiences, either their own, or those with which they were familiar, working with multiple knowledge systems. Many people shared that they felt like Western scientists did not fully appreciate or understand the ways in which their requests, or attempts at collaboration were mis-matched with the kinds of knowledge being sought. This included treating Indigenous Knowledge and Indigenous Knowledge Systems as less valid than Western scientific approaches, both due to prejudice, racism, and the continuing impacts of colonialism, as well as the lack of existing best practices, frameworks, or accessible tools to help integrate various worldviews in a scientific rubric. Several participants spoke of a lack of care in the treatment of Indigenous Knowledge, and by extension, Indigenous People are given in some Western scientific approaches. This engaged the curiosity of some participants: what would it mean for oceanographers to not consider themselves apart or separate from the waters and ecosystems they observe and study? How could we bring this kind of relationality into ocean sciences?
Participants discussed the differences in values between Western science and Indigenous approaches. Western science emphasizes broad knowledge sharing and values communication and sharing ideas and results far and wide. This cultural value differs from many cultures, which may link responsibility and obligation with knowledge holding: only those with the permission and teachings to understand how to responsibly care for the knowledge are able to hold and share knowledge. In these contexts, open and liberal communication may not be seen as a positive attribute.

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

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

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

and exchange can be reciprocated by Western-based institutions is by providing funding that can be used to build or increase capacity for engagement, participation and collaboration within Indigenous communities.

**Building Trust and Equitable Partnerships in Urgent Times**

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

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

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

*Context matters*
While there may be some lessons that can be learned in one location and applied to the benefit of people and place in other jurisdictions, participants shared examples about how this tendency to categorize and generalize across locations, ecosystems, and species can lead to inaccurate findings and mistaken understandings. Several participants compared this kind of piecemeal approach to examples of preferred holistic approaches--rooted in Indigenous perspectives--to collaboration. One example was shared about Western scientists trying to communicate about a species of fish, using one of its Indigenous names. The scientists in question did not understand that the name of that fish was only used in certain contexts and locations and not others. This led to confusion among community members and the scientists were unsuccessful at gaining the knowledge they were seeking. Employing more holistic approaches to collaborating with Indigenous Knowledge holders early in research planning and designing critical questions might have avoided this kind of confusion.

Principles of data equity and sovereignty were also discussed. As one participant stressed, "data are key to empowering Indigenous communities." Many talked about the imbalance in how knowledge is viewed and leveraged within Western science. If Western science can 'confirm' what Indigenous Peoples have known and passed down in teaching for generations, this confirmation is sometimes necessary for Indigenous participants to be treated equitably in collaboration with Western scientists. Participants mentioned the OCAP principles (Ownership, Control, Access and Possession) as a critical correction to past data practices - permission needs to be sought and granted in order to collect data and work in Indigenous lands and waters, and at every stage in the scientific process, from very early stages of articulating a hypothesis all the way through and including authorship to Indigenous collaborators.

**Day 2**

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

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

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

Two presentations from participants focused on the ways in which they were learning from other Indigenous communities in order to find solutions to problems in their own home communities. A member and staff of the Swinomish Indian Tribal Community shared about how learning the ancient Indigenous practice of clam gardens from relatives in British Columbia was leading to a revitalization of knowledge and culture in his Washington State community, which was an emotional and meaningful experience for this participant[6]. An Indigenous participant from Australia currently living in Washington State discussed how he was learning from communities along the NE Pacific coast, and noted similarities and differences between Indigenous-led approaches to ecosystem and fisheries management across continents: he planned on sharing this experience with Indigenous communities in Australia. Next, we had a screening of a short film, *Tsunami 11th Relative*, that documents an example of a culturally sensitive coastal resilience project around Tsunami safety on Vancouver Island, BC with the Ka:'yu:'k't'h'/Che:k:tles7et'h', Nuchatlaht, Ehattesaht, Mowachaht / Muchalaht, and Quatsino First Nations. Indigenous elders spoke about their experiences with tsunamis and storms that have affected their coastal community and described how Indigenous Knowledge about tsunamis has helped Western scientists better understand impacts of sea-level rise and coastal hazards on this region, as well as helped develop culturally sensitive disaster response and management plans.

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

[3] https://yukonsalmon.org/

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

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

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

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

**Conclusions**

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

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

**References**

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

## W10: FIS/BIO/POC/TCODE/FUTURE Topic Workshop

### Towards climate-informed ecosystem-based fisheries management by building international collaborations and standardizing indicators

**Convenors:**
Kirstin Holsman (USA), Alison L. Deary (USA), Lewis Barnett (USA), Xiujuan Shan (China), Kathy Mills (USA), Alan Baudron (UK), Sukgeun Jung (Korea)

**Invited Speakers:**
Kathy Mills (Gulf of Maine Research Institute, GMRI, USA)
Kalei Shotwell (Alaska Fisheries Science Center, NOAA, USA)

**Co-sponsors:**
ICES

**Background**

Climate change is having profound impacts on marine ecosystems and fisheries. According to the latest IPCC assessment, climate change is intensifying, and some changes are irreversible on the scale of human lifetimes. Marine ecosystems and associated fisheries will therefore continue being impacted by climate change in decades to come, posing a growing risk for global food security and socioeconomic benefits. Additionally, high-latitude ecosystems such as the Arctic, are experiencing unprecedented changes in ocean conditions (e.g., ocean heating, loss of sea ice, rising sea levels) that have impacted biological and ecological processes, societal and traditional uses of Arctic natural marine resources, and economic activity including tourism, shipping, and oil and gas exploration. Despite the clear need to mitigate climate-induced risks and to adapt to future climate change, accounting for climate impacts when developing fishery management plans and policies remains challenging. For instance, despite ongoing efforts, the EU's Common Fisheries Policy still has a low adaptability to climate change.

The emergence of ecosystem-based fisheries management (EBFM) has shown that it is possible to account for external drivers such as environmental conditions and/or predation when managing a fishery. A challenge to detecting, monitoring, and communicating changes in environmental conditions in an EBFM framework is that sampling methodology is not often standardized, which complicates regional and international syntheses. Stakeholders are also increasingly involved in the management process and can provide hands-on knowledge crucial in shaping policies to manage marine resources. By connecting science among international collaborators and Indigenous communities, we are better poised to detect, monitor, and respond to changing environmental conditions. These recent advances towards holistic fisheries management provide steppingstones towards climate-informed EBFM. In coordination with an ICES ASC session, we held an interactive workshop to discuss emerging issues around climate-informed EBFM, build relationships with international partners, and promote cross-fertilization especially when generating robust indicators to monitor climate change.

The 1.5-day workshop was a hybrid format that included a mix of 10-minute "spark" oral presentations, 20-minute oral presentations, and discussion sessions on the following topics:

- Case studies of accounting for climate impacts in management measures & showcasing policies applied 'in practice'
- Best practices and approaches for considering large-scale and long-term climate impacts
- Reconciling long-term projections and short-term tactical management
- Advances needed for climate-ready fisheries management to be widely adopted
- Data standardization, its application to ecosystem-based management, and the optimization of sampling platforms to monitor climate change across a variety of ecosystems and trophic levels.

**Workshop Summary**

Over the day and a half workshop, participants heard 21 presentations. The breakdown of talks included two 30-minute invited presentations, one by Kathy Mills (Gulf of Maine Research Institute (GMRI)) and a second by Kalei Shotwell (National Oceanic and Atmospheric Administration (NOAA), Alaska Fisheries Science Center (AFSC)). Six presentations were 20-minute standard conference style talks and an additional 13 talks were 10-minute spark presentations. Presenters were affiliated with 8 different institutions and three countries. The institutions included four different NOAA (US) offices (three fisheries science centers and the Pacific Marine Environmental Laboratory), US Fish and Wildlife Service (US), GMRI (US), Japan Fisheries Research and Education Agency at Hokkaido National Fisheries Research Institute, and the National Marine Environmental Forecasting Center (China). For the afternoon of day 1, we averaged 30-35 in-person participants with an additional 3-4 virtual attendees. On day 2, we averaged 21 participants in-person with an additional 2 virtual attendees.

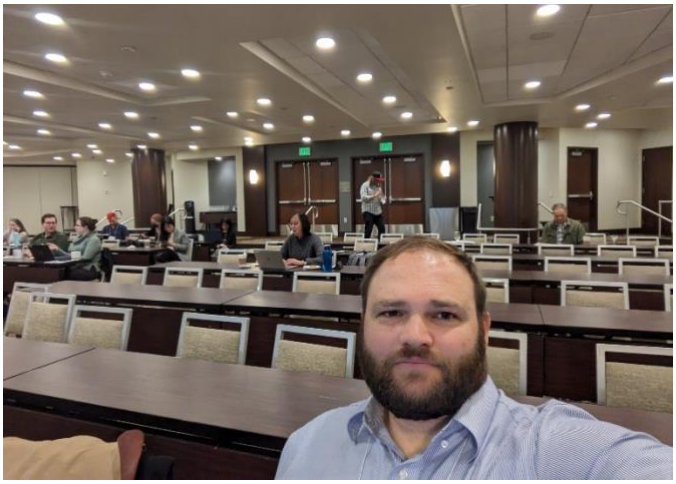

**Photo 1**. Convenor Lewis Barnett (NOAA, AFSC) taking a selfie as a break comes to an end during the workshop.

Despite the need for integrating climate information into ecosystem-based fisheries, many hurdles exist for implementation. With that in mind, we built six discussion sessions into the agenda to stimulate conversation across participants, to engage with speakers directly, to break down communication barriers, and to openly discuss strategies to improve data standardization. In the summary below, we highlight some of the themes from the discussion sessions and take-home messages from our invited speakers. The workshop was also organized into two parts: Part A focused on climate-informed EBFM modelling and coordination on day 1 through mid-morning on day 2 and Part B focused on EBFM data standardization. Due to the number of talks, we will not provide a summary of each talk. However, if this is of interest, please email the convenors, Alison Deary (alison_deary@fws.gov), Kirstin Holsman (kirstin.holsman@noaa.gov), Lewis Barnett (lewis.barnett@noaa.gov), and Kathy Mills (kmills@gmri.org), and we will provide a copy of the detailed notes from the workshop.

A few themes emerged during Part A's discussion session on day 1 that focused on (1) the skills needed to meet climate-informed fisheries management goals, (2) the strategies to break down barriers and to improve intellectual accessibility to climate topics, and (3) the education needed to build trust within inter- and trans-disciplinary fields, as well as with stakeholders. Further expanding on the discussion theme 3, to best integrate climate information into a fisheries management framework, climate scientists need to learn about the fisheries management process and engage with it at various levels to understand how information is used to inform decisions and to identify where flexibilities exist in the framework. Additionally, the science associated with climate and fisheries is evidence-based, meaning that as the best available science in support of both fields is updated, changes to fisheries management are often required. Without proper education and mentorship, these changes can be deemed as the initial process being incorrect, when instead it is evidence of the incorporation of new data. Some of the suggestions offered to address the themes discussed included NOAA's National Marine Fisheries Services Open Science coordinator position, which has been filled by Eli Holmes. With this role, Eli will be identifying the technical limitations and skills needed to facilitate open, collaborative, and reproducible science.

The morning of day 2 (Part A) brought a presentation on the implementation of two tools, Ecosystem Status Reports and Ecosystem Socio-Economic Profiles, that complement each other to fill a known gap in the communication of ecosystem information to make climate-informed management decisions. A theme of the subsequent discussion focused on tradeoffs between strategic, long-term projections (end of century) and tactical, short-term projections (this year) and the application of each type of projection to EBFM. Tactical projections are emphasized during the stock assessment process each year to determine the following year's catch (i.e., what are the conditions this year that will impact next year's catch). However, multi-year data are valuable because they provide context of patterns

and their trajectory, which are not incorporated into the stock assessment model. Although these multi-year patterns may not change a tactical decision, they do call attention to factors that are relevant across stocks when considering long-term climate-ready fisheries. Additionally, synthesis approaches that engage with diverse partners can mitigate internal data limitations that exist within each partner's organization to generate a robust and continuous product. It is also important to develop products at the appropriate scale for specific regions and communities, which aligns well with earlier discussed themes related to accessibility and trust by providing products that are most relevant for partners based on their needs. This discussion concluded Part A of the workshop.


**Photo 2**. Convenor Kirstin Holsman (NOAA, AFSC) presenting during the workshop.

Mid-morning of day 2, the workshop shifted to focus on the theme of EBFM data standardization (Part B), which was sub-divided into spark presentations focused on (1) Modelling and ecosystem synthesis, (2) Benthos, and (3) Fish. Discussion sessions were nestled between each sub-division, facilitating conversations related to the guidance provided in the spark presentations, cited needs, and questions raised by the presenters. Discussions were engaging and oftentimes related to themes from discussion during Part A, such as technical skills needed to robustly standardize ecosystem data products and the limitations to standardization, which are often associated with human resources and infrastructure. However, institutional changes are underway to train individuals in the skills needed to build and curate public data repositories to support open and transparent science. When implemented, standardization during sample collection, analysis, and the communication of ecosystem information maximizes efficiencies, streamlines workflows, is reproducible, generates best practices for the field, and creates stronger partnerships. Additionally, a benefit of standardized approaches that are collaborative and in support of open science is that they leverage expertise across a wider network, creating a broad foundation and accelerating advancement across the field. A lesson that was highlighted during the discussion was the value of thinking about uses of ecosystem products by engaging with stakeholders early and frequently. This approach often maximizes efficiency, prioritizes objectives based on shared needs, and is rewarding. Aligned with topics from Part A, it builds trust with stakeholders and increases accessibility to ecosystem data.

The workshop concluded with a synthesis discussion facilitated by Ali Deary, Lewis Barnett, and Kirstin Holsman. Communicating uncertainty is important even though models do well at capturing the trend, as extreme events are more difficult to predict. However, projections are valuable in the context of climate-ready fisheries because they are tools for thinking about potential future scenarios. A closing thought was related to the power of networking and how open research communities stimulate rapid evolution of methods within a field by providing a venue to build upon each other's work, which is necessary to assess the influence of climate change on fisheries at appropriate spatial and temporal scales.

## W11: SB Workshop

### Science advances needed to understand our "new ocean"

**Convenors:**
Francisco Werner (USA)
Shin-ichi Ito (Japan)
Salvador E. Lluch Cota (Mexico)

**Background**

Oceanic environments are changing rapidly in response to climate forcing. During the past two decades we have witnessed unprecedented and perhaps sustained or irreversible modifications of ocean physics (e.g., occurrence of marine heat waves – MHWs, stratification), biogeochemistry (e.g., changes in pH levels, oxygen minimum zones – OMZs), populations' redistribution (e.g., latitudinal shifts, migration patterns), as well as ecosystem structure and function (e.g., changes in the food web and energy flows related to shifts in planktonic communities). In some ways, these changes have resulted in a "new ocean".

Our oceans have also become more crowded through the growing presence of multi-sectoral uses (e.g., commercial and recreational fisheries, aquaculture, renewable energy, etc.). As such, we are at a point where not only do we need to study and understand our "new ocean", but we also need to develop novel ways of sampling, observing, and quantifying it. Fortunately, significant advances in our ability to sample and quantify our ocean's new states have resulted from a robust evolution in observational (e.g., uncrewed systems, molecular approaches, satellite/remote sensing) and analytical (e.g., high-performance computing, artificial intelligence/machine learning – AI/ML, etc.) capabilities. Workshop W11 focused on framing questions that can help define the next levels of understanding of our "new ocean", as well as identifying the challenges in doing so. We aimed to prioritize questions that we need to take on as a scientific community and discuss our capabilities to address these. Questions guiding the discussion included:

1. What should our science foci be in the study of our rapidly evolving "new ocean" (and its integration in the broader Earth system)?
2. Do we have the necessary observational and analytical capabilities, either existing or within reach? and if not, where should we direct our investments?
3. Do we have the necessary human capabilities/training to address these challenges? And if not, where should we direct our investments?
4. What are the biggest obstacles to be solved to address these challenges?
5. How could PICES and partner scientific communities contribute/engage? How do we sustain needed efforts beyond the present UN Decade of Ocean Science?

**Workshop Summary**

The workshop was held over one full day on October 22, 2023. The first half-day included invited presentations on the state of our science to help identify and focus future questions and needs. The workshop started with a brief introduction by **Drs. Cisco Werner and Shin-ichi Ito** (unfortunately **Dr. Salvador Lluch-Cota** was unable to attend), outlining the background and a brief discussion of the workshop's objectives. Following the opening welcome, **Dr. Fei Chai** gave the first presentation on *"The new ocean: Physics and biogeochemistry"*. He noted the impacts of ocean warming and marine heatwaves, extreme events (typhoons and winter storms), declining oxygen and hypoxia due to coastal eutrophication, and the need for sustained biogeochemical (BGC) observations on autonomous platforms, and modeling. **Dr. Sukyung Kang** followed with a presentation on *"The new ocean: Living marine resources".* She stressed the importance of Electronic Monitoring (e.g., collected on commercial fisheries vessels); the need for collaborative research in the implementation of AI/ML and modeling; enhancing technical capacity development, e.g., through intensive training courses; accessible data sharing and standardization; and for monitoring networks extending from marine organisms to marine environments.

**Dr. Jan Newton** then gave a presentation on *"The new ocean: Modernizing our observational capabilities".* Her presentation highlighted the need for consideration of the whole ecosystem, including humans, and the importance of forging long and trusted partnerships with stakeholders & rightsholders. She discussed the value of cutting across institutional boundaries (academia, federal, tribal & local governments), as well as non-governmental and community-based organizations. She underscored the importance of capacity building and the need to tightly couple observations with modeling and with societal needs, ending with the provision of accessible information products, co-designed with users. **Dr. Charles Hannah** elaborated on *"The new ocean: Modernizing our methods of analysis"* and stressed the need to focus on extreme events and to look for nonlinear relationships and casual pathways (with AI/ML being part of a rapidly expanding toolbox). He advised not to expect current ecosystem states to last, i.e., that marine ecosystems are complex adaptive systems and that functional relationships will change**.**

**Dr. Momoko Ichinokawa** then presented on "*The new ocean: Modernizing our management advice."* She highlighted challenges including the need to further quantify uncertainty, especially for ecosystem uncertainties related to estimating fish populations, e.g., (i) how will uncertainty be estimated? and (ii) how will alternative assumptions result in different predictions? She also noted that modelling and evaluation processes are integrated processes involving different types of science, hence the importance of building capacity and networking between generalists and specialists. In her presentation, she echoed earlier calls for the importance of good communication between scientists and stakeholders. **Dr. Charlie Stock** was unable to attend in person, but his contribution on "*The new ocean: Prediction within an Earth System context"* addressed points including that (i) effective "new ocean" predictions must rest on mechanistic and empirical foundations; (ii) the "new ocean" arises from multiple drivers/impacts, generating questions across space and time scales; (iii) regional frameworks need to generate coastwide predictions and projections that probabilistically span the range of ocean futures; (iv) improved coastal observing systems needed to underpin these activities; and (v) the link from physics/BGC to ecosystem impacts is challenging, but we know enough to get started and build on new tools (observations, AI/ML, models). The final invited presentation was that of **Hana Matsubara** on "*The new ocean: ECOP perspectives".* She identified possible barriers for ECOPs (Early Career Ocean Professionals) to participating in "new ocean" research and management activities. Among the barriers noted were: (i) lack of funding and career opportunities, (ii) lack of community interactions and networking, (iii) language, and (iv) capacity development. Recommendations included: actively integrating ECOPs into research funding applications/proposals, co-authorship on papers, and collaboration with ECOPs from other nations.

In the afternoon's open session, **Drs. Werner and Ito** summarized the overall presentations and discussions. Five breakout groups were formed based on the recommendation of Dr. Wu-Jung Lee (an ECOP) and were asked to rank their top 2 or 3 priorities needed to address the "new ocean" – using the above trigger questions as needed. Many excellent ideas were generated, including:

- *External communication of the idea of the "new ocean."* While the scientific community is aware of the evolving properties, impacts, and uncertainties of our "new ocean", e.g., MHWs, ocean acidification, OMZs, etc., these need to better communicated to the broader public. A recommendation was to support the idea of producing a peer-reviewed Opinion, or Perspectives piece that can be transmitted to the general public and to policymakers. Corollary ideas included:
    - Focusing on how PICES can transform the way it communicates science, and the need to incorporate communication specialists to increase public awareness and support for what the "new ocean" has/will entail.
    - Developing capacity within PICES for transdisciplinary communication and communication to lay audiences. Not only communication by and to specialists, but also to include generalists and people who are not focused on the sciences but who can work across disciplines.
    - Integration of ECOPs in such capacity development, communication, and transdisciplinary work.

- *Modernize PICES data to address "new ocean" questions.* There was general agreement among W11 participants that data sets need to be modernized (e.g., be AI/ML-ready), and accessible in standardized electronic formats. This would facilitate their use in analyses, inclusion in data assimilative models, and applied to address integrative questions and build on previous PICES programs [e.g., the CCCC (or four

C's) Program[7]], or considered in the development of new programs [e.g., BECI (Basin-scale Events to Coastal Impacts; https://beci.info)].

- *Science-to-policy-relevance of "new ocean" reports and assessments.* In addition to communicating about the "new ocean", the idea of focusing PICES on making the best use of existing data and model output for informing policy decisions was endorsed. A suggested approach was to create a "data heroes/ambassadors" group that could improve data-accessibility by building-up and preparing existing data sets and model output for use by all (scientists, modelers, policy analysts, etc.). It was also agreed that the data and associated analyses should – where possible – be relevant to establishing links from science to policy and policy to action. Examples of new data-uses include:

    - PICES' North Pacific Ecosystem Status Reports (NPESRs): modernizing data sets and framing the NPESRs around the *"new ocean"* could result in a more focused and timelier production of the reports.
    - PICES' assessment and communication of the impacts of the "new ocean" on urgent topics (e.g., how to sustainably obtain food from the North Pacific) as in similar IPCC fact-sheets.

Finally, it was noted that incorporating ECOPs with strengths in communication and data utilization and sharing not only brings new expertise and perspectives to the initiatives but also contributes to human capabilities/training to understanding the 'new ocean'.

**Concluding remarks.** We close by sincerely thanking all Workshop 11 participants for their active, thoughtful, and candid participation, including insightful contributions from ECOPs. The "new ocean" W11 workshop generated many excellent ideas, most of which can be implemented. Some can be acted on in the short term (such as the completion of a communication Perspectives paper on the "new ocean"), while others, such as revisiting a 4-C's-like program, or other newer related programs, might take a few years. It was also clear from the W11 discussions that the participants agreed on the need to increase *the size and the diversity* of our international – PICES – community to take advantage of the breadth of ideas that our groups (scientists, communities with local/traditional ecological knowledge, ECOPS, managers, decision/policymakers, etc.) bring to the table. Integration of these approaches will result in better use and interpretation of rapidly evolving technologies, and together with improved model-data integration, to advance actionable predictive capabilities to help the communities that depend on the understanding and the information we generate about the "new ocean".

Group photo from the 2023 *"Science advances needed to understand our rapidly changing ocean environments"* Workshop (W11). Not all attendees are in the picture.

[7] See Batchelder and Kim (2008) Lessons learned from the PICES/GLOBEC Climate Change and Carrying Capacity (CCCC) Program and Synthesis Symposium, *Progress in Oceanography*, **77**:83-91.

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