Summary of Scientific Sessions and Workshops At PICES 2021

Session 1: Science Board Symposium

Towards a shared vision of sustainable marine ecosystems

Convenors:
Vera L. Trainer (SB), Steven Bograd (FUTURE), Jeanette C. Gann (TCODE), Xianshi Jin (FIS), Sukyung Kang (FUTURE), Sung Yong Kim (MONITOR), Emanuele Di Lorenzo (POC), Mitsutaku Makino (HD), Guangshui Na (MEQ), Akash Sastri (BIO), Igor Shevchenko (Russia)

Background
PICES is well-positioned as a northern hemisphere leader of multi-national collaborations to further our understanding of the ocean's natural systems, to contribute "the science we need for the ocean we want" for the United Nations Decade of Ocean Science for Sustainable Development. The international scientific platforms and cooperation mechanisms that PICES scientists have created with organizations and individuals from around the world will now be expanded to strengthen ocean science research and collaboration among countries in the Northern and Southern hemispheres. This will further our scientific progress in understanding climate change impacts, ecosystem-based fisheries management approaches, biologically-driven ocean carbon sequestration, and regional integrated ecosystem assessments including social, ecological and environmental dynamics of marine systems and coastal communities. Strategies for communicating our science and applying scientific building blocks toward solutions to mitigate the impacts of climate change are also critical for preserving our oceans and the coastal communities that depend upon its bounty. Papers that describe these broad scientific ideas and also incorporate strategies to facilitate PICES Ocean Decade cross-cutting inclusivity themes relating to gender equality, early career ocean professional engagement, and significant involvement of indigenous communities and developing nations are encouraged

List of papers
Oral presentation

1. **Identifying changes of research focuses and potential collaborations in PICES toward the UN Decade of Ocean Science for Sustainable Development (UNDOS)**. Shion Takemura , Karen Hunter2 and Mitsutaku Makino

2. **Phytoplankton community composition in the Gulf of Alaska determined using CHEMTAX and OLCI Sentinel 3 satellite data.** Vishnu P Suseelan , Hongyan Xi, Justin Del Bel Belluz, Midhun shah Hussain, Astrid Bracher, and Maycira Costa

3. **The evolving efforts of PICES early career ocean professionals to foster international, intergenerational and cross-sectoral engagement in the North Pacific and beyond.** Raphael Roman, Erin Satterthwaite, Hannah Lachance, Aoi Sugimoto and Cameron Freshwater

4. **Basin-scale Events to Coastal Impacts (BECI): An ocean intelligence system for a changing world** Mark Saunders, Brian Riddell, Jacques White, Robert Day, Steven Bograd, Robin Brown, Vladimir Radchenko

E-Poster presentation

1. **Promoting cooperation of monitoring, control, and surveillance for IUU fishing in the Asia-Pacific.**
2. Iwao Fujii1, Yumi Okochi, and Hajime Kawamura

3. **Delineation of marine bioregions of British Columbia and Southeast Alaska using Sentinel-3 Chlorophyll-a data and self-organizing maps.** Christian Marchese, Brian Hunt, Fernanda Giannini, Matthew Ehrler, Derek Jacoby, and Maycira Costa2

4. **Jellyfish nuisances reshuffling local fishery patterns and ecological communities in the Korean peninsula.** Sun-Hee Lee, Juan Carlos Molinero, and Jiang-Shiou Hwang,4

5. **Ecological characteristics of phytoplankton community in the East China Sea.** Luo Minbo, Jian Tingting, Zhang Heng, and Wang Yunlong

6. **Effects of climate variability on the catches and habitat suitability variations of three swimming crabs in the Taiwan Strait,** Muhamad Naimullah, Yan-Lun Wu, Ming-An Lee,2 and Kuo-Wei Lan,2

7. **The structure of fishery resources and construction of ecosystem model in the southwestern waters of Taiwan.** Wen-Hoa Lee, Kuo-Wei Lan, Che-Chen Chuang, and Wei-Yu Lee

8. **Explore the simultaneous characteristics of abundance and habitats of tuna species in the Pacific Ocean.** Je-Wei Sheu, Kuo-Wei Lan, Yan-Lun Wu, and Po-Yuan Hsiao

9. **Analyze the relationship between the fishing conditions of *Scomberomorus* species and changes in forage species around the waters of Taiwan.** Yu-Lin Li, Lu-Chi Chen, Cheng-Hsin Liao, and Kuo-Wei Lan

10. **Integrated assessment of ocean acidification risks to pelagic calcifiers in the northern high latitudes: Regional comparison of exposure, sensitivity and adaptive capacity.** Nina Bednarsek, Kerry-Ann Naish, Richard Feely, Claudine Hauri, Katsunori Kimoto, Albert J.Hermann, Christine Michel, Andrea Niemi, Darren Pilcher

Session 2: POC Topic Session

Global warming patterns and multiscale climate variability in the North Pacific

Convenors:
Jian Ma (China), Emanuele Di Lorenzo (USA), Kyong-Hwan Seo (Korea)

Background
Climate change and compounding anthropogenic pressures pose a risk to marine social-ecological systems. Of increasing concern is the potential for systems to rapidly shift (often irreversibly) to new states in response to pressures. In some cases, such shifts can occur abruptly without much warning, despite years of mounting pressure and apparent system resilience. These nonlinear inflection points in pressure-response relationship, -- i.e. “tipping points”--, are defined by the IPCC SR15 as “critical thresholds in a system that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the change is irreversible.” Identifying singular or compound, nonlinear, or contextual tipping points is of paramount importance to the IPCC as the likelihood of crossing tipping points increases with atmospheric carbon, climate instability, and ecological sensitivity, posing a significant risk for ecological and human wellbeing. Tools and methods for managing systems prone to tipping points are important for national, regional, and local resource management and climate adaptation. While identifying tipping points is challenging, there are multiple recent approaches that advance this objective, especially in terms of multivariate tipping points. We propose a topic session that will a) explore emergent tools and approaches for identifying multivariate thresholds and tipping points, 2) explore existing and potential social and ecological tipping points and responses, and 3) review approaches for managing systems prone to tipping points. This topic session will bring together international experts from oceanographic, ecological, and social sciences to compare methodologies and synergies across systems. Of particular focus will be methods to promote adaptation and resilience to climate change in marine systems increasing pushed towards extremes and tipping points.

List of papers
Oral presentation

1. **(Invited) Role of the Indo-Pacific oceanic channel dynamics in ENSO development and global climate change.** Dongliang Yuan, Xiang Li, Zheng Wang, Jing Wang, Ya Yang, Xiaoyue Hu, Yao Li, Xia Zhao, Corry Corvianawatie, Adhitya Kusuma Wardana, Dewi Surinati, Adi Purwandana, Mochamad Furqon Azis Ismail, Praditya Avianto, Dirhamsyah, and Zainal Arifin

2. **Multidecadal oceanographic variability over the Bering Sea Inner Shelf.** Emily Lemagie, Phyllis Stabeno, Kelly Kearney, and Wei Cheng,

3. **Preliminary assessment of simulated tropical Pacific SST warming based on CMIP models.** Xinyou Zhang, and Lin Liu,

4. **Resilience to climate variability of nutrient delivery and primary productivity in a coastal sea.** Susan Allen, Elise Olson, Ben Moore-Maley and Karyn Suchy

5. **Application of remote sensing to study the correlation of climate variability with air-sea CO exchange to develop Sea-Level Variability Forecasting Models (SLVFM) over tropical oceanic regions.** Virendra Goswami

6. **Predictability and Empirical Dynamics of Fish Indicators in the North Pacific.** Gian Giacomo Navarra, Emanuele Di Lorenzo and Ryan Rykaczewski

7. **Climate-induced fluctuations in primary production required in summertime upwelling ecosystems around the Taiwan Bank.** Po-Yuan Hsiao, Kuo-Wei Lan, Ming-An Lee and Cheng-Hsin Liao

E-Poster presentation

1. **Synchronous changes in potential habitats of *Trachurus murphyi* and *Dosidicus gigas* off Chile in relation to regime shift of Pacific Decadal Oscillation.** Wei Yu, Zhiping Feng and Xinjun Chen

2. **Ocean acidification in the Pacific off Mexico: How to change the pH values across various regions.** Luz de Lourdes A. Coronado-Alvarez, J. Martín Hernández-Ayón, T.Leticia Espinosa-Carreón2 and Orión Norzagaray-López

3. **Decadal climate indices effect on the spatiotemporal distribution in Indo-Pacific yellowfin tuna population.**Yan-Lun Wu, Kuo-Wei Lan,2 , Karen Evans, Muhamad Naimullah, Lu-Chi Chen, Po-Yuan Hsiao, Che-Chen Chuang , and Wei-You Lee

4. **The fishery dynamics of narrow-barred spanish mackerel (*Scomberomorus commerson*) related to oceanographic factors in the southern East China Sea.** Lu-Chi Chen, Kuo-Wei Lan, Jinn-Shing Weng and Chen-Te Tseng

5. **The annual variations of grey mullet (*Mugil cephalus*) population in related to changed sea surface temperature and multiscale climate indices in the Northwest Pacific Ocean.** Che-Chen Chuang, Ming-An Lee, Po-Yuan Hsiao, Yan-Lun Wu

6. **Developing Synergies between the U.N. Southern Ocean Task Force and the North Pacific: A Safe Ocean.** Thomas Y.Chen

Session 3: POC Topic Session

Upper ocean energetics from mesoscale, submesoscale to small-scale turbulence in the North Pacific

Convenors:
Yisen Zhong (China), Sung Yong Kim (Korea), Bo Qiu (USA), Yusuke Uchiyama (Japan)

Background
The ocean circulation is characterized by turbulence on a wide range of scales from a few centimeters to thousand kilometers. The energy balance is achieved by transferring energy from planetary-scale forcing to microscale dissipation. One of the major efforts that have been made during the recent decades is to understand how the energy is transferred from mesoscale, submesoscale to small-scale turbulence. In particular, a full spectrum of oceanic submesoscale works bridge the gap between mesoscale and small-scale by discovering forward energy cascade at this range. The submesoscale dynamics are most active in the upper ocean. They are spawn in the mesoscale eddies generated by large-scale flow instability, or near the ocean front including plume front in the coastal water. The predictability and sensitivity of the numerical forecast models that include such processes is still unclear. This session invites all studies from mesoscale, submesoscale to small-scale (including

surface/internal waves, boundary layer processes, etc) that contribute to the understanding of energy cascade in the PICES region as well as their applications in the ocean prediction system. We also welcome research about the impact of those processes on the transport of heat, carbon or other biologically or climatically important tracers in the upper ocean.

List of papers

E-Poster presentation

1. **Signal of near inertial waves in Peter the Great Bay, the Japan/East Sea, from ADCP data measured at the WaveScan stationary buoy.** Olga Trusenkova, Vyacheslav Lobanov and Alexander Lazaryuk

2. **Seasonal variation of the surface Kuroshio intrusion into the South China Sea evidenced by satellite geostrophic streamlines.** Yisen Zhong, Meng Zhou, Joanna J.Waniek, Lei Zhou, and Zhaoru Zhang

3. **Impact of submesoscale currents on the vertical transport of nutrient in the East China Sea.** Qicheng Meng, Jiliang Xuan and Feng Zhou

4. **Eddy kinetic energy variability of the Kuroshio Extension and its upstream-downstream connectivity.** Seungyong Lee, Hanna Na and Young-Gyu Park2

5. **River-induced submesoscale processes in a southwest Pacific shelf sea and similarities to a northeast Pacific shelf sea.** Khushboo Jhugroo, Joanne O'Callaghan, Craig Stevens, Jennifer Jackson, Stephanie Waterman, Jody Klymak, Tetjana Ross6 and Charles Hannah6

6. **Diurnal shelf waves in the area of South Kuril Islands from TOPEX/Poseidon satellite altimetry data.** G.Shevchenko and A.Tsoy

Session 4: HD/FUTURE Topic Session CANCELLED

How the studies on human dimensions can contribute to meet the seven societal needs of the Decade of Ocean Science?

Convenors:

Mitsutaku Makino (Japan), Karen Hunter (Canada)

Background

The UN Decade of Ocean Science says that "the Decade will bolster scientific research and innovative technologies to ensure science responds to the needs of society", and indicates the following six specific needs from the society to the ocean science; 1) A clean ocean where sources of pollution are identified and removed, 2) A healthy and resilient ocean where marine ecosystems are mapped and protected, 3) A predictable ocean where society has the capacity to understand current and future ocean conditions, 4) A safe ocean where people are protected from ocean hazards, 5) A sustainably harvested ocean ensuring the provision of food supply, and 6) A transparent ocean with open access to data, information and technologies. Clearly, each need includes the academic questions/issues closely relating to the human dimensions. For example, what is the "clean" or "healthy" ocean? Who will decide it? What kind of "predictability" or "safety" do we need? How can "transparency" be achieved? Are they different among countries or societies? What is the cross-scale compatibility from the human community level to the Pacific Basin level? How much can the society pay for that?, etc., etc. This Topic Session welcomes studies about these questions/issues. Based on the oral presentations, we will have discussions about how the human dimension researches can link and add values to the natural science research activities to meet above six societal needs. The outcome of this Topic Session is expected to show the direction of PICES HD Committee activities in the next decade.

Session 5: BIO/POC Topic Session

Atmospheric nutrient deposition and microbial community responses, and predictions for the future in the North Pacific Ocean

Co-sponsor: SOLAS
Convenors:
Jun Nishioka (Japan), Huiwang Gao (China), Santiago Gassó (USA), Kitack Lee (Korea), Maurice Levasseur (Canada), Guiling Zhang (China)

Background
Atmospheric deposition is an important nutrient source for marine ecosystems, with consequences for local, regional, and global biogeochemical cycles, as well as the climate system. This session focuses on natural and anthropogenic atmospheric nutrient inputs to the North Pacific Ocean. Microbial communities respond to SB-2019 SB 19 changing atmospheric inputs, which may result in significant effects on the marine carbon and nitrogen budgets, as well as on atmospheric carbon dioxide uptake. Key questions to be addressed within this theme are: How do biogeochemical and ecological processes interact in response to natural and anthropogenic material input from the atmosphere across costal and open ocean regions? How do global warming, ocean acidification, and other anthropogenic stressors synergistically alter the uptake of atmospheric nutrients and metals by marine biota in different oceanic regions? What is the prognosis for the future? We welcome new interdisciplinary presentations and active discussions on physical, chemical, and biological sciences both from the ocean and atmospheric fields in this session.

List of papers
Oral presentation

1. **Impact assessment of deposition of atmospheric nitrogen compounds to the surface chlorophyll-a concentration over Northwestern Pacific Ocean.** Fumikazu Taketani, Maki N.Aita, Takashi Sekiya, Kazuyo Yamaji, , Kohei Ikeda, Kazuhiko Matsumoto, Makio C.Honda, Kosei Sasaoka, Yugo Kanaya

2. **The distribution and diversity of antibiotic resistance genes in aerosols between a coastal site and marine sites.** Shijie Jia, and Huiwang Gao,

3. **The response of phytoplankton in the oligotrophic and eutrophic waters of the Yellow Sea to the addition of haze in spring.**Qin Wang, Chao Zhang, Haoyu Jin, and Huiwang Gao,

4. **Estimation of the contribution of combustion Fe in marine aerosols over the North Pacific using Fe stable isotope ratios.** Minako Kurisu**,** Kohei Sakata, Mitsuo Uematsu, Akinori Ito, and Yoshio Takahashi

5. **The concentrations and depositions of atmospheric particles nutrient into the China adjacent seas.** Jiao Wang, Jie Zhang, Xiao huan Liu, Baoshuang Liu and Huiwang Gao

6. **Dry nitrogen deposition to the eastern Indian Ocean during boreal autumn and its impact on the primary production.**Yoko Iwamoto, Katsuhiro Kawamoto, Fumikazu Taketani, Kazuhiko Matsumoto, Makio C.Honda, Eko Siswanto, Yugo Kanaya, Takashi Sekiya, Maki N.Aita and Kazuyo Yamaji

E-Poster presentation

1. **Distinct impacts of dust and haze particles on marine phytoplankton.** Chao Zhang, Qiang Chu, Yingchun Mu, Xiaohong Yao, and Huiwang Gao

2. **Impact of atmospheric deposition on the utilization of dissolved organic phosphorus by phytoplankton in the Pacific Ocean.** Haoyu Jin, Chao Zhang and Huiwang Gao

3. **Nutrient consumption by diatom in darkness below the euphotic zone during spring bloom in Funka-bay, Hokkaido, Japan.** Sachi Umezawa, Manami Tozawa, Daiki Nomura, Yuichi Nosaka and Atsushi Ooki

4. **Seasonal Asian dust transport to the western subarctic Pacific based on the cathodoluminescence analysis of single quartz grains.** Kana Nagashima, Hajime Kawakami, Koji Sugie, Tetsuichi Fujiki, Yoko Iwamoto, and Maki Noguchi

Session 6: S-CC Topic Session

Connecting knowledge of ocean deoxygenation in coastal and offshore regions of the North Pacific

Convenors:
Alex Kozyr (USA), Tsuneo Ono (Japan), Tetjana Ross (Canada)

Background
Ocean deoxygenation is the loss of oxygen in the ocean resulting from ocean warming, which reduces oxygen solubility and increases oxygen consumption and stratification, thereby reducing the mixing of oxygen into the ocean interior. Ocean deoxygenation exacerbates coastal hypoxia and the expansion of oxygen minimum zones globally. Hypoxia is known as a severe threat to ocean ecosystems and fisheries resources, in both offshore and coastal regions. Decreasing oxygen in seawater is caused by several processes such as increase of water temperature, changing ocean circulation and stratification, changes in production and remineralization of organic matter, and coastal eutrophication. The main cause of oxygen decline varies regionally, and sometimes multiple processes contribute. Multiple causes make it difficult to get a comprehensive understanding of ocean deoxygenation at the various scales from coastal regions to ocean basins. PICES S-CC is planning a new program to collect an inventory of oxygen monitoring programs, as well as data and knowledge obtained from them, that are ongoing among the PICES countries. At the commencement of this program, we convene this session to gather information on ongoing ocean deoxygenation and oxygen variability studies and the resulting scientific knowledge, in both the coastal and offshore North Pacific . For this purpose, we encourage attendees to present studies of detection of deoxygenation, as well as causes of oxygen variability, at the various scales from coastal regions to ocean basins in this session. We also welcome studies of impacts of deoxygenation and hypoxia on ocean ecosystems and/or fisheries.

List of papers
Oral presentation

1. **Isopycnal shoaling causes interannual variability in oxygen on isopycnals in the subarctic Northeast Pacific.** Ahron Cervania and Roberta Hamme

2. **Drivers of oxygen trends and variability in the Northeast Pacific.** Ana C. Franco, Debby Ianson, Tetjana Ross, Roberta C. Hamme, Adam H. Monahan, James R. Christian, Marty Davelaar, William K. Johnson, Lisa A. Miller, Marie Robert, and Philippe D.Tortell,

3. **Variability in oxygen within the coastal region of Queen Charlotte Sound: Seasonal patterns, spatial trends, and implications for the marine carbonate system.** Benjamin O'Connor, Stephanie Waterman, Wiley Evans, Jennifer Jackson, Charles Hannah, Hayley Dosser and Alex Hare

4. **Identification of a seasonal subsurface oxygen minimum in Rivers Inlet, British Columbia.** Jennifer M.Jackson, Sophia Johannessen, Justin del bell Belluz, Brian P.V.Hunt, and Charles G.Hannah

5. **Continuous monitoring and future projection of ocean warming, acidification, and deoxygenation on the subarctic coast of Hokkaido, Japan.** Masahiko Fujii, Shintaro Takao, Takuto Yamaka, Tomoo Akamatsu, Yamato Fujita, Masahide Wakita, Akitomo Yamamoto and Tsuneo Ono

6. **Impact of natural and anthropogenic deoxygenation on the habitat distribution of Pacific Halibut.** Ana C.Franco, Hongsik Kim, Hartmut Frenzel, Rashid Sumaila, Curtis Deutsch, Philippe D.Tortell,

7. **Interactive effects of ocean deoxygenation and acidification on demersal fish in early life stages.** Makiko Yorifuji, Masahiro Hayashi, Masaru Shionoya, Miki Kawata, Yusuke Watanabe, and Tsuneo Ono

8. **Evaluation of the effects of ocean acidification and deoxygenation on eggs of Japanese whiting, Sillago japonica: An approach based on comprehensive gene expression analysis.** Akira Iguchi, Masahiro Hayashi, Makiko Yorifuji, Miyuki Nishijima, Taiga Kunishima, Tomoko Bell, Atsushi Suzuki, and Tsuneo Ono

E-Poster presentation

1. **Application of E-TRIX index for evaluation of eutrophication in the Amur Bay, as a background for its bottom layer deoxygenation.** A.S.Kurnosova and V.I.Matveev

Session 7: FUTURE/POC Topic Session

Predictions of extreme events in the North Pacific and their incorporation into management strategies

Co-sponsor: CLIVAR
Convenors:
Samantha Siedlecki (USA), Jing-Jia Luo (China), Ryan Rykaczewski (USA)

Background
Marine ecosystems of the North Pacific are susceptible to episodic, extreme events of various types, including marine heatwaves, periods of hypoxia/anoxia or corrosive conditions, and harmful algal blooms (HABs). There is rising concern that these events may become more common and/or severe in the future. Extreme events can have a marked impact on ecosystem resources and societal use of the coast environment with consequences for recreation, human and ecosystem health, aquaculture productivity, and the distribution, composition, and productivity of marine fisheries. While our ability to predict ecosystem changes and societal impacts has improved in recent years with improved understanding of coupled physical, biological, and social dynamics, the episodic nature of extreme events and the rarity at which they have been observed challenge attempts to forecast their occurrence. However, the severe ecological and societal consequences of these extreme events make them desirable targets for predictions that enable proactive management. PICES WG-40 aims to identify, diagnose, and quantify predictable response in North Pacific marine ecosystems that arise from regional and large-scale climate processes. In this session we will seek contributions that highlight advances in the prediction of extreme events (e.g., temperature, oxygen, pH, HABs), the characterization or identification of mechanisms responsible for their individual or co-occurrence, and the strategies to incorporate those predictions into management. This topic is relevant to the first three ToR of WG40, but also to ToR #4 (exploring integration of predictions in the management of ecosystem services), which has received somewhat less attention in our previous activities. This proposed session is intended to advance the terms of reference of WG-40 and build on strong momentum from (1) the ECCWO session "From prediction to projection: the role of seasonal to decadal forecasts in a changing climate", (2) the PICES 2018 session "Ecological responses to variable climate changes and their applicability to ecosystem predictions", (3) the CLIVAR-PICES 2019 workshop "Towards an integrated approach to understanding ecosystem predictability in the North Pacific," (4) the PICES 2019 sessions "Marine heat waves in the North Pacific: Predictions and impacts in coastal regions," "Coastal ocean modelling in the North Pacific," and "Advances in North Pacific marine prediction", and (5) a planned FUTURE-sponsored workshop on social impacts of extremes at the 2020 PICES annual meeting. Outside of PICES-associated meetings, this proposed session also leverages efforts of NOAA's Marine Prediction Task Force (MPTF) whose lifespan matches that of WG-40 (2017-2020) and whose intent is to improve seasonal forecasts for management of living marine resources. Co-sponsorship We seek POC and FUTURE cosponsorship for this session. We envision this session being offered in coordination with a FUTUREsponsored workshop exploring the social impacts of extreme events in the context of the SEES framework.

List of papers
Oral presentation

1. **Recent advances in measuring and predicting the occurrence and impacts of harmful algal biotoxins in British Columbia coastal waters.** Andrew R. S. Ross, Blair Surridge, Harry Hartmann, Mackenzie Mueller, Ovi Haque, Tim Hewison, Nicole Frederickson, Stewart Johnson, Ryan Shartau, Lenora Turcotte, Andrea Locke, Melissa Hennekes, Nina Nemcek, Hayleigh Shannon, Akash Sastri and R. Ian Perry

2. **The next decade of ocean acidification research in the Bering Sea: What we've learned and what's coming next.** Jessica N. Cross, Darren Pilcher, Hongjie Wang, Elizabeth Siddon, Natalie Monacci, W. Christopher Long, and Esther Kennedy6

3. **Tropical influence on the development of Northeast Pacific marine heatwaves.** Antonietta Capotondi, Matthew Newman, Tongtong Xu and Emanuele Di Lorenzo

4. **Co-occurrence of California drought and northeast Pacific marine heatwaves under climate change.** Hui Shi, Marisol García-Reyes, Michael G.Jacox, Ryan R.Rykaczewski, Bryan A.Black, Steven J.Bograd, and William J.Sydeman

5. **Detecting and identifying saxitoxin-producing algae in the Salish Sea.** Brandi Cron Kamermans and Melissa Peacock

6. **Extreme events in the thermal state of the Far-Eastern Seas and adjacent waters of the Northwestern Pacific.** Elena Ustinova

E-Poster presentation

1. **The effects of ocean data assimilation on North Pacific marine heatwave prediction.** Huihang Sun, Yiguo Wang, and Jingjia Luo

Session 8: MEQ Topic Session

Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific

Convenors:
Chengjun Sun (China), Sanghee Hong (Korea), Matthew Savoca (USA),

Background
The North Pacific and its marginal seas are heavily polluted with plastics. It is important to develop environmental indicators of plastic pollution to determine baselines, set targets, and project risk to species and ecosystems. The goal of this session is to continue to identify indicators – both biotic and abiotic – of plastic pollution, and to move beyond the development of indicators to determine how we can use indicators to determine baselines in the North Pacific. Environmental indicators will also prove important to project risk from plastics to the ecosystem. Risk may be assessed by the quantity or abundance of plastic particles, or as the concentration of plastic associated pollutants in organismal tissues. Research presented in this topic session will help us elucidate the status and trends of plastic pollution and their environmental impacts in the North Pacific to better allow comparisons to other regions globally. This science-informed approach will allow us to make informed decisions for plastic usage and litter management policies.

List of papers
Oral presentation

1. **Evaluating species as bioindicators for plastic pollution in North Pacific food webs.** Matthew S.Savoca, Susanne Kühn, ChengJun Sun, Stephanie Avery-Gomm, Anela Choy, Sarah Dudas

2. **Assessing impacts of plastic accumulation in Laysan Albatross (*Phoebastria immutabilis*) chick growth and body condition.** K.David Hyrenbach, Dan Rapp, Sarah Youngren, and Paula Hartzell

3. **Field measurements reveal the risk of microplastic ingestion by filter-feeding megafauna.** Shirel R.Kahane-Rapport , Max F.Czapanskiy, James A.Fahlbusch, Ari S.Friedlaender, John Calambokidis, Jeremy A.Goldbogen, and Matthew S.Savoca

4. **Occurrence and risk assessment of microplastics in various shellfish from the two major coastal cities of China.** Jinfeng Ding, Jingxi Li, Chengjun Sun, Fenghua Jiang and Peng Ju

5. **(Invited) Widespread plastic ingestion in an abundant pelagic fish species, *Alepisaurus ferox*, across the subtropical North Pacific.** Anela Choy, Sierra M.Byrne, Jennifer A.T.K.Wong-Ala, Elan J.Portner, and Phoebe A.Woodworth- Jefcoats

6. **Ecological risk assessment of waterborne microplastic particles in the marine environments of Korea.** Won Joon Shim, Jae-Woong Jung, June-Woo Park, Soeun Eo, Jinsoo Choi, Young Kyoung Song, Youna Cho, and Sang Hee Hong

7. **First estimates on the amount of water-borne microplastics entering the ocean from the Korean Peninsula.** Seung-Kyu Kim, Hee-Jee Lee, and Ji-Su Kim

8. **Prevalence of small high-density microplastics in continental shelf and deep-sea waters of East Asia.** Soeun Eo, Sang Hee Hong, Young Kyoung Song, Gi Myung Han, Seongbong Seo and Won Joon Shim,

9. **(Invited) Polyolefins and the effect of biofouling on their sinking behaviours in the oceanic water column.** Sarah-Jeanne Royer, Kayla C.Brignac, and Laurent Lebreton

10. **(Invited) Litter and microplastics monitoring in the Arctic under the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP).** Jennifer F. Provencher, Eivind Farmen and Jan Rene Larsen

11. **Using shellfish as potential microplastic pollution indicator.** Chengjun Sun, Jinfeng Ding, Jingxi Li, Peng Ju, and Fenghua Jiang

E-Poster presentation

1. **A close relationship between microplastic contamination and coastal area use pattern.** Mi Jang, Won Joon Shim, Youna Cho, Gi Myung Han, Young Kyoung Song and Sang Hee Hong

2. **Microplastics and microfibers in surface waters of Monterey Bay National Marine Sanctuary, California.** Lauren M. Kashiwabara, Shirel R.Kahane-Rapport, Chad King, Marissa DeVogelaere, Jeremy A.Goldbogen, and Matthew S.Savoca

3. **Importance of seasonal sea ice in the western Arctic Ocean to the Arctic and global microplastic budgets.** Seung-Kyu Kim, Hee-Jee Lee, Ji-Su Kim, Sung-Ho Kang, Eun-Jin Yang, Kyoung-Ho Cho, Zhexi Tian, and Anthony Andrady

4. **Importance of point source to microplastic accumulation in Antarctic environment.** Ji-Su Kim, Seung-Kyu Kim, and In-Young Ahn

Session 9: FUTURE/POC/TCODE Topic Session

Applications of artificial intelligence to advance the understanding of North Pacific ecosystems

Convenors:
Charles Hannah (Canada), *corresponding*
Igor Shevchenko (Russia)
Jinkun Yang (China)
Naoki Yoshie (Japan)

Background
The development and application of artificial intelligence (AI) and machine learning to marine science issues is advancing rapidly. The combination of modern instrumentation with real time delivery, satellite data streams, biogeochemical model output, and shipboard data collection, means that many marine ecosystems are data rich but information poor. AI offers the opportunity to speed up the process of turning data into information that can be used for decision making, but also has advantages over more traditional statistics for detecting patterns and offers the potential to find meaningful ecological relationships between ecosystem state variables for which there is no theoretical framework to connect them. For this session we encourage submissions that use AI for investigating the important drivers/variables in ecological datasets, as well as computer vision applications dealing, for instance, with satellite imagery, acoustics, plankton, and corals/sediment. We invite submissions at all levels of biological organization (individuals to ecosystems), and are particularly interested in studies that integrate different types of observation technology and data types. Papers focusing on methodological

advancements, ecosystem applications and the data management processes required to get ecosystem related data into forms that make it easy to use the new tools. Other information. Support: POC, TCODE, FUTURE This session is not focused on a particular problem but rather seeks to have a lively session that would help identify more practitioners of these modern tools who are already working on PICES related problems. The proposed science session is an outcome from the very successful PICES 2019 Workshop on Application of Machine Learning to Ecosystem Change Issues in the North Pacific. This Science session would continue the process of building an AI community within PICES This session is a contribution to 2 of the PICES Strategic goals • Goal 4: Advance methods and tools. Machine learning and AI are new tools with enormous potential that should be explored in the PICES context. • Goal 6: Engage with early career scientists to sustain a vibrant and cutting edge PICES scientific community. Big data and AI represent the cutting edge of the process to convert data into information in the modern world, therefore encouraging the development and application of these new tools is one way to attract early career scientists to PICES.

List of papers

Oral presentation

1. **Enhanced dynamical downscaling of global climate projections to regional scales using Machine Learning.** Albert J.Hermann, and Emily L.Norton,

2. **Auto-detection of marine mammals from drone photos based on deep learning.** Lu Sun, Tao Xia and Xuelei Zhang

3. **Fine-scale interannual distributions of meso-zooplankton in the Northern California Current.** Moritz S.Schmid, Kelsey Swieca, Su Sponaugle, and Robert K.Cowen

4. **Using the PICES TCODE catalog service.** Igor I. Shevchenko,

5. **Disentangling climate impacts on Sockeye Salmon population dynamics using machine learning.** Yi Xu, Mike Hawkshaw, Caihong Fu, David A.Patterson, Roy Hourston, Peter Chandler and Carrie Holt

6. **Projected changes in the potential habitat distribution of Japanese anchovy (*Engraulis japonica*) in Korean waters from a maximum entropy model.** Minkyoung Bang, Chan Joo Jang, Dongwha Sohn, and Jung Jin Kim

7. **A Linear Inverse Model Approach to Comprehensively Examine Marine Heatwaves.** Tongtong Xu, Emanuele Di Lorenzo, Matthew Newman, Antonietta Capotondi, and Samantha Stevenson

8. **Using Machine Learning (ML) to study the timing of renewal evens in Douglas Channel, British Columbia, Canada.** Di Wan, Pramod Thupaki, and Charles Hannah

E-Poster presentation

1. **Application of multivariate statistical analysis to vertical profiles of oceanographic characteristics on the example of moorings in Peter the Great Bay, the Japan/East Sea.** Olga Trusenkova

2. **Unsupervised Machine Learning for ocean profile classification and outlier detection using the Pacific Ocean temperature-conductivity-depth profile data.** Steven E.Zhang, Riham Elhabyan and Di Wan2

3. **Big data processing algorithms and environmental indicators in multi –channel monitoring systems.** Ferdenant A.Mkrtchyan and Vladimir Yu. Soldatov

4. **Data Lakes for Ocean Data - How CIOOS is enabling data-science and AI research projects in the North East Pacific.** Pramod Thupaki and Ray Brunsting

5. **Machine learning methods for chub mackerel fishing area forecasting in the northwestern Pacific Ocean.** Igor Chernienko and Emiliya Chernienko

6. **About problems of the biocomplexity of marine ecosystems on the example of the Okhotsk Sea.** Ferdenant A. Mkrtchyan

Workshop 1: BIO/FIS Topic Workshop

Can we link zooplankton production to fisheries recruitment?

Convenors:
Toru Kobari (Japan), Hui Liu (USA), Karyn Suchy (Canada)

Background
Sustainability of fisheries requires a better understanding of stock dynamics and resilience to environmental and anthropogenic forcing. Zooplankton play a vital nexus between primary producers and higher level consumers and are thus highly relevant to fisheries production and ecosystem functions. Understanding the impact of trophic relationships on the nutrition of larvae and foraging fishes is a critical step needed to forecast the stock response and resilience to environmental changes. However, limited attention has been paid to the role of zooplankton in sustaining fisheries production, which is largely because routine measurements of secondary production remain rare. This workshop will discuss prospective ways for understanding functional and structural roles of secondary production on fisheries dynamics and production. In particular, we encourage presentations and discussions on research using experimental, observational and modelling approaches linking zooplankton productivity and fish larvae and foraging fishes.

Summary
The 1-day workshop was convened to discuss aspects of the linkage of zooplankton production to fisheries recruitment. The workshop objective was to understand functional and structural roles of secondary production on fisheries dynamics and production. This workshop was virtual using Zoom and thus all topics were presented using pre-recorded MS PowerPoint or video files. It held the following 11 presentations and 37 attendees from four countries: Canada, USA, Japan, and Russia.

1. Community structure of fish larvae associated with advections of the Kuroshio and its neighboring waters. Yusuke Manako
2. Comparison of plankton community structure, standing stocks and productivity along the Kuroshio at the Tokara Strait. Toru Kobari.
3. Distribution, feeding habits, and growth of chub mackerel, Scomber japonicus, larvae during a high-stock period in the northern Satsunan area, southern Japan. Gen Kume.
4. Evaluating pathways of environmental association with mesozooplankton and fisheries production. Lian Kwong.
5. How to adapt growth and productivity of fish larvae to the Kuroshio. Tomoko Kusano.
6. Importance of gelatinous zooplankton on plankton food web in the Kuroshio based on metabarcoding analysis. Yusuke Tokumo.
7. Model-based spatiotemporal variability in mesozooplankton productivity in the Salish Sea. Karyn D. Suchy
8. Promising perceptions of linking zooplankton production to fisheries dynamics. Hui Liu.
9. Source of coastal waters advected to the Kuroshio using particle-tracking experiments on high-resolution coastal ocean model. Shin Kazuno
10. The Tortoise and the Hare: distinct early growth strategies in a nearshore groundfish persist in the seasonally variable Northern California Current. Megan N. Wilson
11. The effect of zooplankton community composition on variability of trophic transfer efficiency in the NE Pacific. Theresa A. Venello

To stimulate discussions on each presentation among the participants and to focus workshop objectives during the limited discussion time (1 hour), co-convenors prepared another platform (Google Drive) before this workshop that all presentation files were uploaded and any attendees could post their questions, comments and suggestions on them. This platform might be useful for non-native speakers to understand their questions, comments and suggestions and to provide their answers to them.

The workshop discussions were focused on the two questions, Q1) “what are necessary for zooplankton to evaluate fishery dynamics and production?” and Q2) “what are advantages/disadvantages for current zooplankton production methodologies and measurements to be linked with fishery dynamics and production?”. To achieve effective and efficient discussions, co-conveners asked all presenters to provide their ideas to these questions before workshop. Main points of their ideas were summarized as follows.
Q1: What are necessary for zooplankton to evaluate fishery dynamics and production?
For evaluating fishery dynamics and production, we need spaciotemporal data sets

- ✓ with application to monitoring activities for accumulating production data sets in time and space
- ✓ with high spatiotemporal resolution using ecological modelling on ocean dynamics

We also need taxon-based data sets

- ✓ breaking down to taxonomic levels as a proxy of food availability for fishes
- ✓ expanding to non-crustacean groups or major functional groups for differential prey preference
- ✓ to focus specific taxonomic groups having significantly trophodynamics hub among various trophic pathways

After sharing these ideas from presenters, many comments and suggestions were provided from attendees to this workshop. As a major issue for this workshop question, our discussions were focused on the availability of zooplankton production rates for fish recruitments and stock assessments based on time-series data sets. While zooplankton production rates are rare among the time-series currently available in the PICES region, all attendees shared that direct measurements of zooplankton rate process are crucial for understanding mechanistic link of fish recruitments and stock assessments to lower trophic levels. As these issues were associated with the second question, we moved to the next discussion.

Main points of the ideas to the second question from presenters were summarized as follows.

Q2: What are advantages/disadvantages for current zooplankton production methodologies and measurements to be linked to fishery dynamics and production?

As advantages, zooplankton production data sets

- ✓ are directly comparable to fish population dynamics or fishery stocks through larval growth and survival
- ✓ provide information to understand biological mechanisms
- ✓ are representative of carrying capacity for fish populations

As disadvantages,

- ✓ zooplankton production data sets are still low resolution in time, space and taxa
- ✓ measurement methodologies are tedious and time-consuming for operation and not practical to generate time-series

As described above, direct measurements on zooplankton production rates are always desired for stock assessments of various fishes since these rates are representative of biological mechanisms. However, many attendees felt that these disadvantages made data accumulation and utilization difficult. Co-chairs of PICES Working Group 37 introduced the two practical approaches based on the WG scientific reports, zooplankton production rates estimated with the empirical and physiological models applicable to time-series and direct measurements with biochemical approaches like enzyme activities in time-series.

Giving the extensive discussions, co-conveners mentioned that the continuous scientific activities are needed to link zooplankton production to fish recruitment and/or stock assessment through some approaches in future. As one of them, all attendees were informed on 1-day session proposed for the PICES 2022 Annual Meeting in Korea.

Fig. 1. Attendees of Workshop 1 during the PICES 2021 Annual Meeting

Workshop 2: FIS Topic Workshop

Pelagic and forage species – predicting response and evaluating resiliency to environmental variability

Convenors:
Matthew Baker (USA), Brian Hunt (Canada), Hui Liu (USA), Elizabeth Siddon (USA)

Background
Climate and environmental variability influence pelagic ecosystems with direct and indirect impacts on pelagic and forage fish populations. These species are particularly responsive to shifts in the physical environmental and the phenology of biological production at lower trophic levels. Forage fish are also the link between planktonic food webs and higher trophic levels in the global ocean. Despite their critical role in North Pacific ecosystems, forage fish have remained understudied due to the majority of research resources and effort being focused on the predatory species that they support. This knowledge gap is increasingly pressing as the North Pacific advances into new climate and ocean modes. This workshop built on the 2018 Session in Yokohama, Japan, and related collaborations, to share results on trends in pelagic and forage fishes in the North Pacific, including work using experimental, observational, and modeling approaches.

This 2021 workshop aimed to use the North Pacific as a case study for global forage fish responses to climate change and determine the attributes important in understanding how different populations respond in similar or divergent ways to common drivers. Two overarching themes were examined, (1) adaptation/resiliency, and (2) forecasting, to better define our current state of knowledge.

Summary
Experts from around the North Pacific convened for a one-hour session. Regional presentations were used as a springboard for discussion around the objectives outlined above, focusing on the following objectives:

- Define our current state of knowledge
- Identify data gaps, research needs and tools and models to further research in this area
- Develop a hierarchical/ranked list of short- and long-term research priorities

As a final product from this work, we plan to develop a manuscript that synthesizes research on the influence of climate and environmental variability on forage fish populations in the North Pacific, and provides guidance on ways to rank and prioritize data gaps, as a step towards focusing direction for short and long-term research objectives.

This workshop convened forage fish researchers from around the North Pacific and used regional presentations as a springboard for discussion on common ecosystem drivers, similarities, and dissimilarities among regions. Discussions aimed to further identify data gaps, research needs, and useful tools and models to further research. The workshop recruited participants from throughout the Pacific (Canada, Chile, China, PR, Japan, Korea, Mexico, Taiwan, R.O.C, USA), including participants from a 2018 PICES session on the Influence of climate and environmental variability on pelagic and forage species (see attachment S11 Monitor Session, Convenors: Matthew Baker (USA) corresponding, Sei-Ichi Saitoh (Japan), Mary Hunsicker (USA), Elizabeth Siddon (USA)); researchers who had submitted abstracts for talks and posters to this 2021 workshop (see attachment; https://meetings.pices.int/publications/presentations/PICES-2021); and other researchers and regional experts that had expressed interest in participating (see attachment on participants). The workshop agenda (see attachment) began with introductions and an overview of the workshop themes. Polls (see attachment) were conducted in advance of the session on two separate themes

- State of the knowledge (what do we know?)
- How do we synthesize information about forage fish dynamics and apply it (e.g., forecasting)

The results of the first poll were detailed and presented to workshop participants. Subsequently, PICES staff coordinated the separation of participants into four breakout groups, each led by one of the workshop convenors. The first breakout session focused on “important themes and insights related to adaptation and resiliency”. Following the breakout discussions, participants gathered in plenary and the convenors summarized the discussion from each breakout session. The results of the second online poll were then presented to workshop participants and breakout sessions and subsequent plenary discussion were held on the theme of “advances and challenges to understanding mechanisms and forecasting”. The workshop closed with a discussion on synthesis and next steps for the group.

Here are summaries of the discussions:

Session I – State of the knowledge (what do we know?)

How well do we understand forage fish response to environment?

- Requires nuanced answer as there are many species; some we know a lot about and others not
- Most well understood system is the California current

What are the top drivers of forage fish populations?

- Physical system and plankton quality and quantity (interactions are important, increased temperatures may allow for increased growth but only in the presence of abundant prey)
- MHW and increased metabolic demands (increased top-down pressure)
- Thermal habitat
- Critical habitat
- Environmental variability and interactions with phenology of critical life stages (bottom-up)
- Predation and either relative intensity of predation pressure or spatial overlap with predatory species (top-down)
- Both top-down and bottom-up drivers and their interactions are important
- Interspecies competition among forage species, jellies, and early life stage fishes of a similar trophic level
- Critical life stages and associated stage-specific mortalities
- Foraging arena theory
- Larval dynamics and early life history

What is the most important data gap in understanding forage fish response to environmental variability?

- Understanding productivity patterns in the system (primary production)
- Understanding secondary production (zooplankton)
- Patchiness of sampling versus patchiness in space in time of fish distirbutions
- Lack of understanding in what we are missing in their dynamics (beyond season, e.g., winter)
- Understanding constraints to use of available data (are we extrapolating beyond the data)
- Understanding how environmental conditions influence recruitment, including emergence timing, larval and juvenile mortality and growth dynamics related to necessary minimum for persistence
- Understanding the influence of environmental forcing and variability on recruitment, mortality, and interspecies competition at critical life stages
- Lack of data (data gaps are large for most species)
- Gaps in the data (e.g., temporal gaps, spatial gaps, diet)
- Research and management is focused on commercial species, not other forage species
- Understanding relative importance and interactions between bottom up and top down processes

What is the most important short-term research priority?

- Hard to know where to start
- Lack of information outside of summer period
- Identify critical periods and life stages
- Data collection and indices of abundance, condition, and population dynamics
- Accurate indices for relative abundance (populations rise or fall relative to environmental trends)
- Understanding biological rates at levels sufficient to inform models (e.g., growth rates, age structure)

What is the most important long-term research priority?

- Increased sampling footprints in both space and time
- Development of predictive models for distribution, abundance and recruitment
- Maintenance and enhancement of line surveys (biophysical interactions, plankton)
- Understanding potential for adaptation/resiliency
- Forecasts and projections of abundance and distribution
- Dealing with issues related to non-stationarity
- Understanding resilience and adaptability (what pace of change are forage fish able to keep up with)
- Developing framework to inform management

Session II – How do we synthesize information about forage fish dynamics and apply it

What are the threats to forage fish populations?

- Climate change and fisheries; climate much more nuanced; reduction, consumption,
- Climate change and phenology (seasonality and changes in match-mismatch dynamics)
- Climate change and influence on transport, stratification and phenology
- Interactions with fisheries

- Aquaculture fisheries (growth of aquaculture a threat)
- Human impacts (e.g., exploitation, deep-sea mining effects on micronekton)

What knowledge sources / systems should be included and monitored for understanding forage fish?

- Environmental indices, targeted to inform recruitment, mortality, growth
- Spawning dynamics and habitats
- Interspecies competitive effects
- Recruitment indices
- Age and growth data
- Identifying critical life history stages
- Integrated observing systems: surveys and satellites
- Local knowledge (e.g., insights from fisherman may depend on the scale of the system)
- Index standardization able to bridge across biases in data streams
- Predators as samplers (e.g., predatory fishes, seabirds)

What are the challenges to understanding and managing forage fish populations?

- Competition interactions
- Relationships are non-stationary (seemingly robust relationships breakdown over time)
- Understanding where correlations fall apart - is this a reflection of spurious correlations OR real effects that reflect a shift in the system dynamics
- Lack of mechanistic understanding for processes
- Past may not inform present or future
- How to pull apart interactions of prey/predators (e.g., understanding effect of distribution, targeting prey or predator avoidance)

What knowledge sources / systems should be included and monitored for understanding forage fish?

- Interaction with industry - talk to people on the water, talk to industry
- Importance of incorporating different perspectives (communities/fishermen)
- Solicit and use traditional knowledge to set Bayesian priors
- Building trust
- eDNA
- Acoustics
- Robots
- Simultaneous integration of multiple sampling approaches (e.g., drone/trawl/acoustics)
- Diet-based estimators / samplers of predator diets from surveys or catch

How might that be expanded / What are limitations?

- Predators as samplers
- Remote sensing (acoustics, gliders, buoys; limitations=biomass estimates)
- eDNA (presence/absence indices; limitation = no relative abundance)
- Spatially indexed - spatial temporal - covariance from various indices
- Hard to get traction with stakeholders
- How to be inclusive of different types of knowledge

What are ways to incorporate information from different knowledge streams or data sources?

- How to address constraints related to spatial and temporal resolution
- How to integrate datasets not designed to complement each other
- How to address known biases in one area by employing data streams in others
- Environmental indices targeted to inform life history relevant to recruitment, mortality, growth
- Ecosystem status reports
- Spawning dynamics and habitats
- Interspecies competitive effects
- Recruitment indices
- Age and growth data
- Standardization of indices
- Identifying critical life history stages
- Use of fisheries observers as a resource
- Potential to use indices to distill multiple data types from different knowledge types
- Use diet studies of predators (e.g., groundfish/salmonids) as a way to develop indices
- Incorporate local and traditional knowledge

- Use spawning indices and beach surveys conducted at community level
- Direct targeted surveys to pelagic environment
- Use acoustics to better estimate pelagic and forage species
- Moored camera arrays - residence time

How can synthesized information be applied to a management or applied context?

- Management strategy evaluation – simultaneously consider targets for multiple stakeholders
- Management strategy evaluation – explicitly account for large areas of uncertainty and disparate sources of information
- Early warning system from people on the water (fisherman)
- Importance of building trust
- Improve and expand survey design
- Define and identify opportunities for collaborative research
- US talking about forage fish being incorporated into conservation management; Magnuson Stevens act (including forage fish – given role / importance in ecosystems)

Parallel Initiatives

- ICES/PICES Forage fish symposium November 2022
- ICES / PICES forage fish working group
- Project getting together information on diets of forge fish consumers (Ric Brodeur/Brian Wells) Integrated pelagic ecosystem survey – collect diet data and monitor forage species (Jennifer Boldt; https://waves-vagues.dfo-mpo.gc.ca/Library/40780156.pdf)

Workshop Participants

Anne Beaudreau (University of Washington, USA), **Brian Hunt** (University of British Columbia, Canada) **Carolina Lang** (Instituto de Fomento Pesquero, Valparaíso, Chile), **Che-Chen Chuang** (National Taiwan Ocean University, Taiwan, ROC), **Chris Rooper** (DFO, Canada), **David McGowan** (NOAA-AFSC, USA), **Dongwha Sohn** (Pusan National University, Korea), **Eleni Petrou** (University of Washington, USA) **Elizabeth Siddon** (NOAA-AFSC, USA), **J. Coronado-Álvarez** (Universidad Autónoma de Baja California, México), **Jennifer Boldt** (DFO, Canada), **Jim Ruzicka** (NOAA, USA), **Kelsey Swieca** (Oregon State University, USA), **Matthew Baker** (NPRB, USA), **Ryan Rykaczewski** (NOAA-PIFSC, USA), **Steven Bograd** (NOAA-SWFSC, USA), **Wei Yu** (Shanghai Ocean University, Shanghai, China), **Yan-Lun Wu** (National Taiwan Ocean University, Taiwan, ROC), **Yi Xu** (DFO, Canada), **Hui Liu** (Texas A&M University, USA)

Workshop Presentations and Posters

1. Decadal climate indices effect on spatiotemporal distribution in Indo-Pacific yellowfin tuna. Yan-Lun Wu, Kuo-Wei Lan , Karen Evans, Muhamad Naimullah, Lu-Chi Chen, Po-Yuan Hsiao, Che-Chen, Chuang, Wei-You, Lee
2. Annual variations of grey mullet related to sea surface temperature and multiscale climate indices. Che-Chen Chuang, Ming-An Lee, Po-Yuan Hsiao, Yan-Lun Wu
3. Catch rate and distribution of narrow-barred spanish mackerel in relation to oceanographic factors. Lu-Chi Chen, Kuo-Wei Lan, Jinn-Shing Weng and Chen-Te Tseng
4. Ocean acidification in the Pacific off Mexico. Luz de Lourdes A. Coronado-Álvarez, J. Martín Hernández-Ayón, T. Leticia Espinosa-Carreón and Orión Norzagaray-López
5. Oceanographic and trophodynamic underpinnings of larval anchovy success in the northern California Current. Kelsey Swieca, Su Sponaugle, Moritz Schmid and Robert Cowen
6. Impact of environmental variability on jack mackerel spawning grounds in the Southeast Pacific. Carolina Lang and Villy Christensen
7. Effects of environmental variability on the spatial dynamics of common squid in Korean waters. Dongwha Sohn Sangil Kim, Minkyoung Bang, Changsin Kim and Jung Jin Kim
8. Response of abundance and distribution of a top predator squid to short-lived eddies in the Eastern Equatorial Pacific. Wei Yu, Xingnan Fang and Xinjun Chen

Workshop Agenda

Introductions – Workshop Themes
Results of Online Poll 1 [poll available during introduction]
Breakout Session: Important themes and insights related to adaptation/resiliency
Plenary [report of discussions from Convenors]
Results of Online Poll 2 [poll available during introduction]
Breakout Session: Advances and challenges to understanding mechanisms and forecasting
Plenary [report of discussions from Convenors]

Synthesis and Next Steps

Online Polls

Poll 1: State of the knowledge (what do we know)

- How well do we understand forage fish response to environment?
- Rank in order of importance physical, chemical, biological (could include fisheries) drivers of forage fish populations
- What are the top two drivers of forage fish populations?
- What is the most important data gap in understanding forage fish response to environment?
- What is the most important short-term research need?
- What is the most important long-term research need?

Poll 2: How do we synthesize information and apply it (integrating, synthesizing, forecasting)

- List the top three most important drivers of future forage fish populations.
- What are the most important knowledge bases / systems for understanding forage fish?
- What are ways to incorporate information across different knowledge or data streams
- How can synthesized information be applied to a management or applied context
- What are the critical links to the human dimension?
- What is the primary motivation for supporting forage fish research?

Survey Results

Table 1. Survey respondents (n=9)

Category	**Sub-category**	**Number**
Position	Academia	4
	Government	5
Expertise	Biological oceanography	3
	Fisheries oceanography	5
	Genetics	1
Geographic region	North East Pacific	8
	Bering Sea, Chukchi Sea	1
Interest in contributing to synthesis paper	Yes	4
	Maybe	5

Table 2. Summary of answers to survey questions (9 respondents).

Question	**Answer**
How well do we understand forage fish responses to environmental variability? [scale 1 (not well) - 5 (very well)]	2.55
What are the top drivers of forage fish populations? List up to three, in order of importance.	Food webs: food availability; Habitat: Environmental conditions, e.g., SST, circulation, phenology; Predation; Competition; Fishing Pressure
What is the most important data gap in understanding forage fish response to environmental variability?	Overwintering Ecology; Nearshore populations; Trophic Interactions; Predation across life stages; Movement / habitat use; Seasonal data; Food quality effects; Environment effect on recruitment.
What is the most important short-term research priority?	Effect of food availability on production; Coordination & integration of zooplankton and forage fish sampling; Effect of food quality; Habitat use across life stages; Ecosystem approach; Indices of abundance
What is the most important long-term research priority?	Role of forage fish in ecosystems; Predictive models of abundance and distribution; Climate change impacts on productivity; Increase sample frequency; Environmental forcing of recruitment, mortality, and interspecies competition at critical life stages; Improving data availability and inter-disciplinary collaboration.

What are the top impending threats to forage fish populations? List up to three, in order of importance.	Increasing predators; Climate change - warming, shifting trophic environment, phenology change; Overfishing; Habitat degradation;
What knowledge sources/systems should be included and monitored for understanding forage fish?	Pelagic fish surveys; Forage fish diets; Predator diets; Oceanography; Traditional / local ecological knowledge; Genetics; Commercial fisherman; Local communities; Remote sensing
What are ways to incorporate information from different knowledge or data sources?	Time series analysis; Modeling; Review papers; Interdisciplinary approaches; Feedback from non-scientists; Multi-disciplinary / multi-knowledge holder workshops where knowledge types are equally weighted.
How can synthesized information be applied to a management or applied context?	Provide indices of pre-recruit abundance to managers; Forecasting models; Precautionary approach for critical ecosystem resource; Give more weighting to knowledge type other than fisheries science; Provide indices and tools driven by the needs of multiple stakeholders.
How are forage fish important people?	Food resource across trophic levels; Ecosystem support; Commercial fisheries; Livelihood; Culture; Economy; Tourism; Aquaculture; Ecosystem services; Early warning of change - "sea canary".
What is the primary motivation for supporting forage fish research?	To be able to inform ecosystem based fishery management; Critical ecological role; Livelihood; Fisheries.

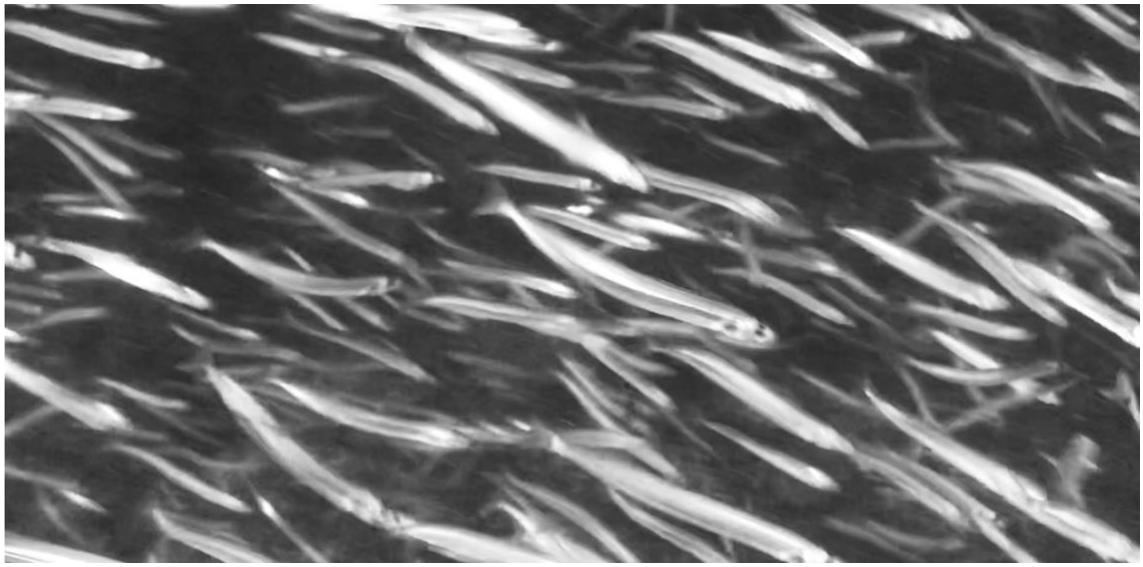


Photo. M.Baker

Workshop 3: BIO Topic Workshop CANCELLED

Anthropogenic stressors, mechanisms and potential impacts on Marine Birds and Mammals

Convenors:
Miran Kim (Korea)
Patrick D. O'Hara (Canada), *corresponding*
Yutaka Watanuki (Japan)

Background
Anthropogenic stressors, such as climate change, plastic pollution, discharged toxins, fishery interaction, noise pollution, and offshore wind farms impact marine birds and mammals, affecting their distributions and abundances. These stressors can act directly or indirectly on marine birds and mammals, and can pose a considerable challenge for marine conservation. Understanding how stressors affect marine birds and mammals is an important step in estimating and mitigating against these threats.

The aim of this workshop is to improve our understanding of anthropogenic stressors, and how they affect marine birds and mammals throughout the North Pacific Ocean. One of the main outcomes of the workshop will be the development of a Pathways of Effects style heuristic or conceptual model describing how stressors act on marine birds and mammals. Workshop participants will be invited to discuss a PICES region-by-region assessment of stressor importance, and how mechanisms of impact may differ among regions.

Workshop 4: AP-NPCOOS/MONITOR/TCODE/BIO/FUTURE Topic Workshop
Monitoring Essential Biodiversity Variables in the coastal zone

Convenors:
Jack Barth (USA), Charles Hannah (Canada), Vyacheslav Lobanov (Russia), Hanna Na (Korea), Naoki Yoshie (Japan)

Background
The goals of FUTURE and UN Decade of Ocean Science require systematic and sustained observations of marine ecosystems, especially in the coastal regions where the interactions between humans and the marine environment are most intense. The Advisory Panel on North Pacific Coastal Ocean Observing Systems is responsible for advising PICES on the linkages between coastal ocean observing systems and the PICES FUTURE Science Program. We propose a Workshop to address the question of how the PICES community plan to measure the Essential Biodiversity Variables (EBV; Miloslavich et al 2018 DOI: 10.1111/gcb.14108) and make them available to the community (the essence of Coastal Ocean Observing Systems). The workshop will provide a basis for identifying gaps in observing systems relative to FUTURE's goals of providing a synthesis of knowledge on : a) ecosystem resilience and vulnerability; b) ecosystem response to natural and anthropogenic forcing; and c) future ecosystem change. We will solicit contributions that will address the following questions: 1) what is the current state of monitoring EBVs in each PICES country; 2) what new technologies are being developed which will help monitor EBVs (e.g. eDNA, satellite mapping of macro algae); 3) which technologies are moving beyond the pilot stage to the mature stage; and 4) what is the state of the art in getting EBVs into databases and getting them out via user friendly interfaces? The primary output from the workshop is expected to be a journal article describing the current state of the art in both the measurement of EBVs in the coastal zone and in making the data widely available.

Summary
Essential Biodiversity Variables (EBVs) are needed to understand complex changes in biodiversity. Examples of EBVs include allelic diversity, population abundance, species distribution, phenology, taxonomic diversity, habitat structure, etc. The EBVs for the ocean are distinguished from the Essential Ocean Variables (EOVs) that we are currently measuring to understand biomass, diversity, and abundance of the marine ecosystem. These biology and ecosystem EOVs are part of a larger set of EOVs measured worldwide that include physical, geochemical, and cross-disciplinary variables like temperature, oxygen, and ocean sound. Understandably, the EBVs and EOVs are complementary, and the EBVs need to be integrated into an EOV observation network. The observation communities are encouraged to harmonize monitoring systems for delivering regular and timely data on the ecosystem changes by identifying the EBVs, clarifying their relationship to the EOVs, and establishing how they should be sampled and measured in the coastal zone.

There is not yet a consensus about what to monitor among the various EBVs and how to monitor them. Moreover, there is not yet sufficient consistency in the national or regional biodiversity monitoring system and sharing of information. In order to address this issue within the PICES community, the following key questions were asked at this workshop: 1) what is the current state of monitoring EBVs in each PICES country, 2) what new technologies are being developed which will help monitor EBVs (e.g., eDNA, satellite mapping of macro algae), 3) which technologies are moving beyond the pilot stage to the mature stage, 4) what is state of the art in getting EBVs into databases and getting them out via user friendly interfaces, and 5) what are national perspectives on the societal and sciences goals of the various EBVs?

A novel workshop structure was used by PICES this year. All of the talks were prerecorded and participants watched the talks before the meeting. This allowed the workshop itself to be devoted to discussion and planning. In addition to watching the talks, participants were encouraged to read three papers so that there was a common understanding of EBVs and EOVs (Pereira et al. 2013, Miloslavich et al. 2018, and Muller-Kruger et al. 2018).

There were 12 contributed talks (see the list below), and they spanned the spectrum from the need for alignment between science requirements and policy goals to the details of computing several classes of EBVs from zooplankton data. Six of them presented examples focusing on the coastal zones in the eastern North

Pacific. From their informative talks, it was identified that different organizations and projects have adopted diverse measurements, but some important biodiversity dimensions, such as genetic diversity, are often (or mostly) missing. There were three talks introducing the monitoring program outside the eastern North Pacific: a monitoring program targeting tidal flats in the western North Pacific, the national marine ecosystem monitoring program in Korea, and the Arctic observing network, respectively. Another two talks analyzed the monitoring system globally, particularly, a talk by Dr. Erin Satterthwaite presented how to link marine ecosystem data to action with the context of climate change and in the context of developing the global observing system for marine life. Finally, there was one talk on how to deliver the information to the end-users.

The workshop started with welcoming the participants and introducing the goal of the workshop, which includes a journal article describing the current state of the art in both the measurement of EBVs in the coastal zone and in making the data widely available. After the introduction, each presenter reviewed and discussed important points from their presentations. More than 30 people, including the presenters, participated in the plenary discussions and the smaller breakout groups. One of the key issues for the group discussion was understanding the distinction between the EOVs and the EBVs. Many of the participants have agreed that the EOVs are the better framework for discussing the ocean observing systems, whereas the EBVs are how societal goals, such as the ecosystem framework for management, are framed. At a high level, the EOVs are the ocean state variables that can be measured, and the EBVs are the biodiversity variables that get computed using the EOVs. Thus, ***systematic ocean observing systems are essential to delivering both EOVs and EBVs***.

The primary output from the workshop is expected to be a journal article. To this end, 12 participants have agreed to contribute to the paper, and a paper outline has been started using Google Docs. The paper will be structured using the five questions above. This workshop was supported by MONITOR, TCODE, BIO, and FUTURE. Convenors were Charles Hannah (Canada), Hanna Na (Korea), Jack Barth (USA), Vyacheslav Lobanov (Russia), and Naoki Yoshie (Japan).

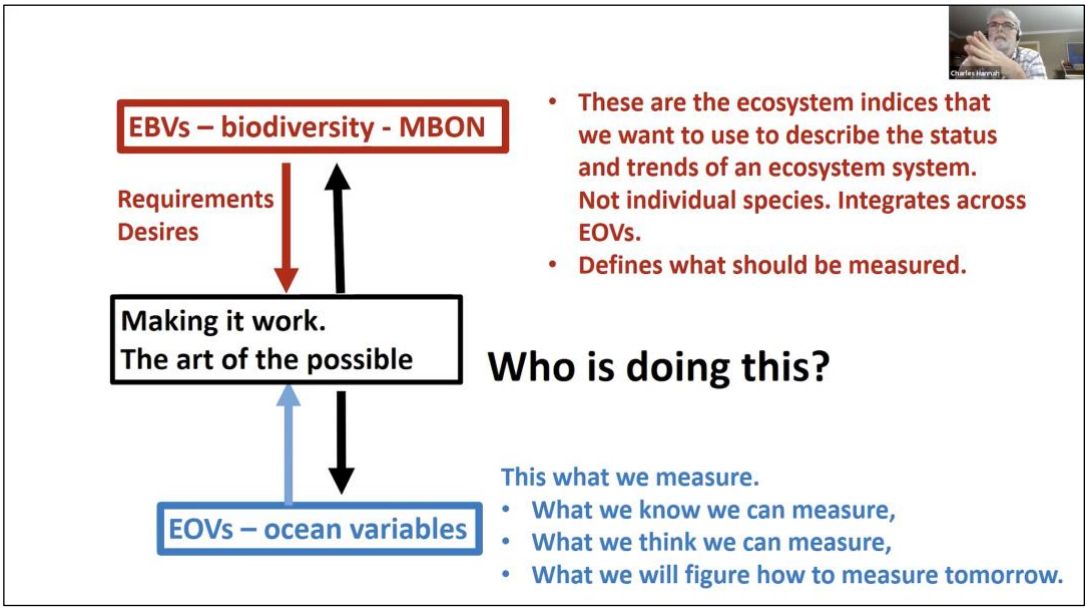


Figure 1. Schematic of one way to think about the relationship between EBVs and EOVs presented at the workshop.

List of the presentations and presenters

1. Characterizing phytoplankton phenology patterns in the Northeast Pacific coastal waters using the GlobColour Project (Sejal Pramlall)
2. Assessment of the distribution of tidal flats in the Northwest Pacific region (Takafumi Yoshida)
3. Overview of the National Marine Ecosystem Monitoring program in Korea (Young Nam Kim)
4. Contributions of fisheries surveys to monitoring essential ocean, climate, and biodiversity variables: A synthesis from the U.S. West Coast (Natalya D. Gallo)
5. Adoption and implementation of Seagrass Essential Ocean Variables (EOVs) (Margot Hessing-Lewis)
6. High temporal resolution phytoplankton compositions and environment drivers in the northern Salish Sea, British Columbia, Canada (Justin A. Del Bel Belluz)
7. "Wishing I'm Fishing": OceanView - A fisherman's lifelong app (Chieh Hsu)

8. Sustaining Arctic Observing Networks: A Roadmap for Arctic Observing and Data Systems (SAON-ROADS) (Sandy Starkweather)
9. Integrating coastal zooplankton monitoring programs into an Essential Biodiversity Variable (EBV) framework: Current status, challenges, and new developments, for Canada's west coast (Akash Sastri)
10. Marine Biodiversity Observing in the Northern California Current: Understanding changing plankton community composition and seascape habitats (Maria T. Kavanaugh)
11. Linking marine ecosystem data to action within the context of climate change: Toward developing the global observing system for marine life (Erin V. Satterthwaite)
12. Mobilizing essential salmon biodiversity variables collected by the Hakai Institute Juvenile Salmon Program via the Canadian Integrated Ocean Observing System (Brett Johnson)

Key references

Pereira et al. 2013. Essential biodiversity variables. Science, 339(6117), 277-278. https://www.science.org/doi/full/10.1126/science.1229931

Miloslavich et al. 2018. Essential ocean variables for global sustained observations of biodiversity and ecosystem changes. Global Change Biology, 24(6), 2416-2433. https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14108

Muller-Karger et al. 2018. Advancing marine biological observations and data requirements of the complementary essential ocean variables (EOVs) and essential biodiversity variables (EBVs) frameworks. Frontiers in Marine Science, 5, 211. https://www.frontiersin.org/articles/10.3389/fmars.2018.00211/full

Workshop 5: FUTURE Topic Workshop

Engaging Early Career Ocean Professionals in PICES to further the next generation of integrated ocean sustainability science

Convenors:

Erin Satterthwaite (USA), Aoi Sugimoto (Japan), Pengbin Wang (China)

Background

Intergenerational diversity is central to sustainability since it relies on meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. As such, early career ocean professional (ECOP) engagement is a central focus of PICES and the UN Decade of Ocean Science for Sustainable Development (2021-2030) since emerging ocean leaders bring fresh ideas, sustained engagement and scientific cooperation, and diverse perspectives to the next chapter of scientific discovery.

Within the context of PICES, ECOPs are self-identified individuals who are in the process of, or within 10 years of, completing their professional training in areas relevant to ocean knowledge or within 5 years in their current position. We specifically use the term ‘professional’ to be inclusive of both researchers and practitioners. Broadly, the ECOP community is anyone interested in facilitating the professional development and support of ECOPs, and thus is inclusive of all career stages.

An ECOP community is necessary to foster the development and engagement of professionals in ocean-related sectors, especially in the context of international collaboration. It takes time to learn, understand, and become integrated into complex, intergovernmental structures, as well as to develop the individual relationships and skills necessary to participate effectively. By involving ECOPs from the inception of ideas for new PICES expert groups and other planning processes, allowing for shared development and ownership, they are more likely to feel invested in and willing to support the design, implementation, and adaptation of science Also, the sustainability of organizations relies on retaining and sharing institutional knowledge between people at different career stages. Finally, diverse perspectives allow for thinking more “outside the box,” which provides valuable sources of innovation and will help to renew and regenerate PICES and its collaborative organizations. This visionary thinking, coupled with the experience and insight of scientists in mid- to late career stages, could transform the organization and address global challenges related to ocean sustainability & environmental stewardship.

Since its inception in 2020, the Study Group on ECOPs (SG-ECOP) has been actively engaged across a variety of initiatives within PICES and in cooperation with international partners, such as ICES, ECOP Asia, and the Global ECOP Program. Most recently the SG-ECOP has increased its international engagement by participating in a range of UN Decade of Ocean Science for Sustainable Development (2021-2030) activities. One outcome of the SG-ECOP has been to identify opportunities for engagement and key needs of the community. Some of the needs expressed by ECOPs have been: 1. to connect and get to know each other, 2. to

better understand the nature of interdisciplinary and international scientific collaborations within PICES, and 3. to integrate their research interests within PICES through a new mentorship program.

Summary

In line with these needs, during the PICES 2021 Annual Meeting, the ECOP workshop, "Engaging Early Career Ocean Professionals in PICES to further the next generation of integrated ocean sustainability science", brought together about 52 ECOPs and experienced, seasoned mentors from all PICES countries for interviews and networking sessions.

The workshop began with a keynote presentation by the Governing Council Chair, Enrique Curchitser, where he shared an overview of PICES, how it functions, and ideas for how ECOPs might best contribute to the organization. He highlighted that, "PICES can be like a 'family' – you tend to develop friendships and collaborations with the folks you see often".

> "PICES can be like a 'family' – you tend to develop friendships and collaborations with the folks you see often"
>
> ~Enrique Curchitser
> *PICES Governing Council Chair*

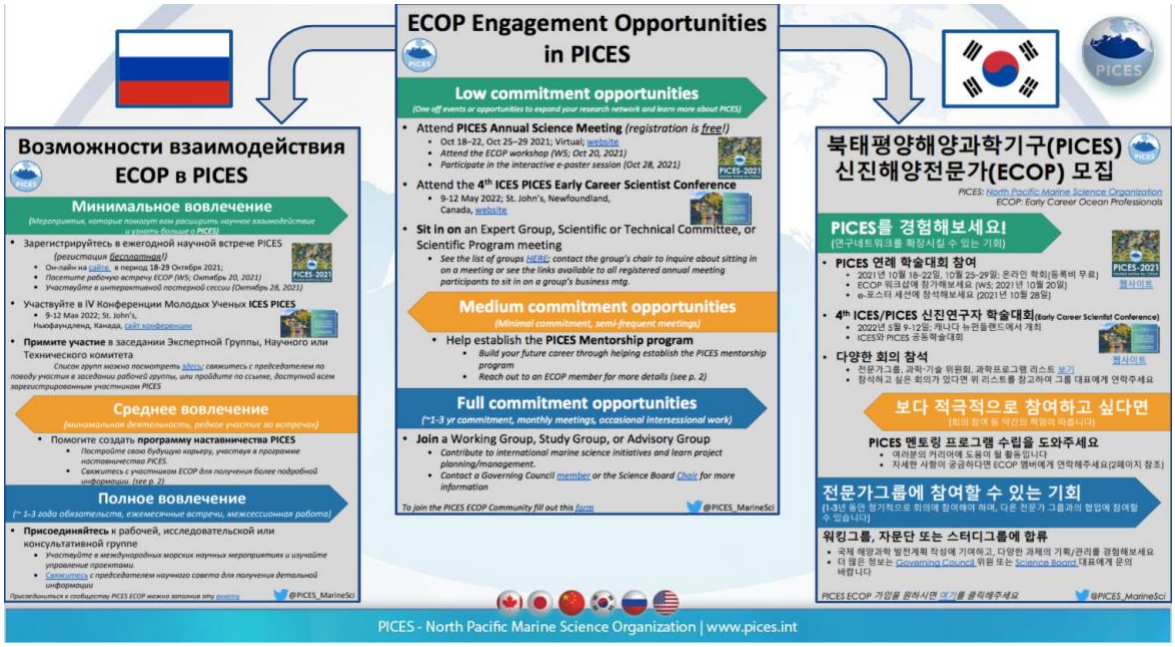
Following the PICES keynote address, Raphael Roman, SG-ECOP member, gave an introduction to the study group ("ECOP 101") and its engagement within PICES. He presented the results of a recent survey distributed among the PICES community, and showcased the key needs and goals identified and shared by PICES ECOPs in their shiny new engagement plan. In addition to the SG-ECOP outcomes listed above, the survey identified increased involvement within PICES via science communication initiatives, diversity, equity, and inclusion (DEI) activities, interdisciplinary collaborations or public policy engagement as important to the PICES ECOP community. He closed by highlighting some important action items proposed for PICES ECOPs in 2022, such as the upcoming ECOP Advisory Panel and plans to develop a North Pacific ECOP node of the Global ECOP Programme. All ECOPs are welcome!

The core of the workshop was focused around 'Ask a PICES Veteran' sessions which showcased PICES mentors around 4 topics including: 1. Marine Ecosystems: Se-Jong Ju and Shin-ichi Ito; 2. PICES Structure: Vera Trainer and Enrique Curchitser; 3. International collaboration: Andrea White and Steven Bograd; and 4. Human Dimensions/Science Communication: Natalie Ban and Lori Waters. These sessions emphasized how the PICES mentors initially got involved in PICES, their path within PICES, and their advice for engaging within PICES to further international science collaborations. A few pieces of advice were highlighted throughout the sessions:

- *Get to know expert group leads & national delegates*. In order to participate and get more involved in PICES, reach out to expert group leads and get to know your national delegates. Mentors highlighted the value of asking PICES mentors, including expert group leads, national delegates, and other PICES members, for help in connecting with other people.
- *Participate in working groups & committees*. Participation in working groups is really helpful. After that, the next steps (becoming a chair/leader) can follow naturally. For example, Steven Bogard shared that the physical oceanography and climate committee (POC) was his first opportunity to become an active member within PICES.
- *Enjoy the social events*. Participate in poster sessions, working groups, and social activities that lend themselves to more casual conversations. For example, enjoy the sporting event during the Annual Meetings. The sporting events allow for more personal communications and help to build friendships beyond science.
- *Embrace serendipity & collaboration*. You may not know how the journey will unfold or the connections you make, but after some time, you may begin to weave a shared path with your peers and colleagues from different countries.
- *Apply the Social-Ecological-Environmental-Systems (SEES) framework in the context of your work*. Recently, the FUTURE programme developed a framework of integrating social-ecological-environmental systems (SEES) within PICES to encourage communication and cross-disciplinary work. An early career award was recently created to encourage ECOPs to apply the SEES approach in their work. The winner of this award will receive full travel funding to attend the next Annual Meeting and an oral presentation at the opening plenary session.

To conclude the session, Hannah Lachance, SG-ECOP member, shared some of the engagement opportunities for ECOPs in PICES which included: **1.** Joining the ECSC4 conference (May 9-12, 2022), an excellent way for ECOPs to expand their networks, not only in the North Pacific but also across the North Atlantic, and will help

build invaluable global connections; **2.** Sit in on an expert group, scientific or technical committee, or scientific program meeting, **3.** Help establish the PICES mentorship program, **4.** Join the business meeting of an Expert Group, such as a Working Group, Study Group, or Advisory Group, and express your interest in their work. Through these efforts we are also working to craft personalized invitations and encouraging more inclusive, accessible and welcoming language (i.e., sharing important operational and scientific highlights in all 5 official languages).



In closing, as one of the PICES mentors said, "There is definitely greater recognition of the value of diverse ideas and intergenerational conversations, with multiple demonstrated benefits to research projects and initiatives – The times are changing, which is good!". We are grateful to the mentorship and support during the ECOP workshop and are looking forward to the next chapter of diverse engagement within PICES.

Some of the Participants from the workshop

Some of the ECOP Study Group members

ECOP Study group logo

- End of the Report -